ABSTRACT

WORKING MEMORY DIFFERENCES BETWEEN MONOLINGUALS AND BILINGUALS

The purpose of the current study was to explore whether there was a significant difference between the monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in phonological short-term memory and complex verbal working memory, after accounting for vocabulary, general intelligence, and sentence comprehension. Contrary to predictions, no significant differences between the numbers of languages spoken and ethnic/racial groups in phonological short-term memory or complex verbal working memory in primary analyses were found. Secondary analyses indicated that ethnic/racial groups predicted performance on all memory tasks. In addition, the number of languages spoken and whether English was participants’ first language predicted complex verbal working memory.

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WORKING MEMORY DIFFERENCES BETWEEN MONOLINGUALS AND BILINGUALS

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Psychology in the College of Science and Mathematics California State University, Fresno

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CHAPTER 1: INTRODUCTION

There has been an enormous amount of research on working memory (WM), and the current study further examined whether there is a difference in working memory between monolinguals and bilinguals. Working memory is referred to as temporarily storing and processing information (Baddeley & Hitch, 1974). According to Kormos and Safar (2008), the framework of WM is very important because it is continually utilized to perform complex cognition such as reasoning and learning languages at different stages of acquisition. Since its conceptualization in the later part of the last century, WM has been shown to be an important concept especially in language learning (Sternberg, 1994).

In a study examining polyglots, operationally defined as those who are fluent in at least three languages, and non-polyglots, operationally defined as those speaking two languages fluently, Papagno and Vallar (1995) found that polyglots scored significantly higher on phonological short-term memory (STM) tasks than non-polyglots. Phonological STM has been of great interest to researchers in the fields of psychology, education, and speech and language (Wagner, Torgesen, & Rashotte, 1999). Phonological STM, or the use of phonological information in STM, is important for everyday mental functioning. Phonological processing plays an essential role in the sound structure of a person’s oral language (i.e., listening and speaking) and in processing written language (i.e., reading, writing and spelling; Wagner & Torgesen, 1987). Phonological processing is also a determinant of differential scores on cognitive tasks (Kyllonen & Christal, 1989); and thus, it is widely explored in the field of learning and memory. Furthermore, coding and maintaining information in complex verbal WM, the process of
translating concepts to a phonological form, is necessary for a person to learn how to read and acquire vocabulary (Sternberg, 1994).

Similar to the Papagno and Vallar (1995) study, the purpose of the current study was to examine components of working memory, phonological STM, and complex verbal WM. It was predicted that monolinguals, operationally defined as those speaking only English, would perform significantly worse than bilinguals, operationally defined as those speaking two languages (i.e., English and another language), in phonological STM and complex verbal WM.

Whereas the population of the Papagno and Vallar (1995) study consisted of only female Italian participants, the current study examined external validity by allowing generalization to a larger population by including men and women from three ethnic/racial groups: Caucasians, Mexicans and Southeast Asians. The previous three groups were selected based on their representation as some of the largest ethnic groups at Fresno State (Institutional Research, Assessment & Planning [IRAP], 2009a).

Originally, the current study was most interested with the Hmong sample, due to the fact that there is no single writing system accepted by the Hmong (Kan & Kohnert, 2005). It was only recently, about 50 years ago, that written forms of languages were developed in their culture. However, due to an inadequate number of Hmong participants who met the criteria of the current study, specifically, English as a first language, other Southeast Asian groups were included: Laotians (n = 4), Vietnamese (n = 3), Filipinos (n = 2), and Cambodians (n = 1; IRAP, 2009b).

According to Kormos and Safar (2008), auditory digit span and non-word repetition tasks are some of the most widely used phonological short-term memory measures. In addition, Kormos and Safar stated that reading span tasks and digit
span backward tasks are measurements of “complex” and “verbal” WM. For the purpose of the current study, the following tasks were used, digit span forward (Wechsler, 1997) to examine phonological STM, and two complex verbal WM tasks: digit span backward (Wechsler, 1997) and the Reading Span Test (RST; Daneman & Hannon, 2001). The RST was also used to determine sentence comprehension, because the main goal of this task was to read sentences and recall the last word of each sentence. It was predicted that there would be no significant differences between monolinguals and bilinguals on sentence comprehension.

The current study also included a vocabulary test, the French-Kit References Test (French, Ekstrom, & Price, 1969), and a general intelligence test, Raven’s 1962 Advanced Progressive Matrices (Raven’s APM; Raven, 1962), in order to parallel the methods of the Papagno and Vallar (1995) study which measured vocabulary (vocabulary subtest of the Wechsler Adult Intelligence Scale; Wechsler, 1955), and general intelligence (Raven’s 1938 Progressive Matrices; Raven, 1954). However, Papagno and Vallar found no significant differences between polyglots and non-polyglots on either vocabulary knowledge in the participants’ native language, Italian, or on the general intelligences test. It was predicted that there will be no significant differences between monolinguals and bilinguals on either vocabulary knowledge or general intelligence as well.

Although the current study used the Papagno and Vallar (1995) study as a foundation, changes and additions to further investigate the relationship between the number of languages spoken and WM included: six new groups, further investigation of the WM model, and exploration of the bilingual sample in secondary analyses.

These changes are important in order to further explore the relationship between the number of languages spoken and WM, because the number of
languages spoken plays an essential role in everyday cognition (Kormos & Safar, 2008), and learning a second language has many benefits (Bialystok & Craik, 2010). According to Kovelman, Baker, and Petitto (2008), support for speaking only one language versus bilingualism has been a concern for educators for decades due to the belief that bilinguals who have had early exposure to two languages might have language confusion, or even life-long problems with linguistic knowledge. However, Kovelman et al. showed that bilinguals can have two different linguistic systems, or monolingual-like systems processing two languages in one brain. The current study attempted to find support for bilingualism by predicting that bilinguals would perform better on phonological STM and complex verbal WM tasks than monolinguals.
CHAPTER 2: LITERATURE REVIEW

In this chapter, the literature related to working memory (WM) is outlined and discussed. First, research on memory is briefly examined but focused more extensively on the WM model, then its phonological loop component is examined in more detail. Next, WM capacity measures and the relationship between WM and language learning are discussed. Then, the Papagno and Vallar (1995) study that found a significant difference in phonological short-term memory (STM) due to the number of languages spoken is discussed. After that, vocabulary, general intelligence and sentence comprehension is discussed as covariates. Then, the population of interest for this study is described. Finally, further exploration of the bilingual sample is explained as it is examined in secondary analyses.

Memory

Memory involves encoding, storing and retrieving information (Jonides et al., 2008). According to Jonides et al., there are two main views of looking at memory models: a multistore model (Atkinson & Shiffrin, 1971) in which short-term memory (i.e., short retention duration); is qualitatively different from long-term memory (i.e., long retention duration), and a unitary-store model in which STM and long-term memory (LTM) are represented on a single quantitative continuum. The multistore model suggests that STM and LTM are separate systems that are architecturally different with distinct representation. However, the unitary-store model suggests that STM and LTM do not have distinct representation, and instead, differ based on the level of activation and process of these representations. Earlier accounts of memory research supported a unitary-store model; however, by the 1960s there was more evidence supporting a multistore model (Baddeley, 2002b). Although there are still debates by memory
theorists over this fundamental issue (Nee, Berman, Moore, & Jonides, 2008), for the purpose of this study, the multistore model of memory will be examined more extensively.

In the 1960s, memory as a unitary construct was questioned, and the concepts of short-term (primary) memory and long-term (secondary) memory were proposed as two separate systems of memory (Baddeley, 2002b). It was proposed that STM refers to retaining information for a short period, whereas LTM refers to retaining information for a longer period. This idea was examined by looking at patients who had neuropsychological problems. It was believed that patients who had damage to the temporal lobes and the hippocampi appeared to have two types of memory, limited LTM but normal STM. And, patients who had damage to the perisylvian region of their left hemisphere appeared to have two types of memory as well, limited STM but normal LTM. These findings suggested that information flows from the environment to a limited capacity short-term store. The longer information stays in this store, the more likely it will be transferred to LTM, thus supporting a multistore model of memory.

Based on the multistore model of memory, Baddeley and Hitch (1974) conducted several experiments to further investigate the two systems of STM and LTM. However, their focus was on STM. In one of their experiments, they attempted to block STM in normal patients by having participants recall digit sequence in addition to performing another task (e.g., learning, reasoning or comprehending) that was assumed to depend heavily on STM. They found that when there was an additional task, thought to impair STM, there was an increase in length of digit sequence recalled, suggesting an interaction between STM and LTM (Baddeley, 2002b). That is, information from performing another task would be stored in STM, whereas recalling digits would be stored in LTM. This
delay between STM and LTM led to a new idea—working memory. Baddeley and Hitch proposed that WM includes both temporarily storing information (e.g., having patients recall digit sequence) and processing information (performing another task). That is, they conceptualized WM from extending STM (the storing component of memory) to include a processing component, the manipulation of STM information (Masson & Miller, 1983).

**Working Memory Model**

Several years after Baddeley and Hitch conceptualized STM to WM in 1974, the term WM has been cited in 16,154 papers in either their titles or abstracts between 1980 and 2006 (Joindes et al., 2008). Baddeley and Hitch’s (1974) model of WM supports a multistore view of memory by research concerned with the separation of STM from LTM.

Unlike STM, which traditionally is regarded as a passive storage buffer (Lehman & Tompkins, 1998), working memory includes both temporarily storing information and processing information, and has four components: (1) the central executive component, (2) the visuospatial sketchpad subsystem, (3) the articulatory (subsequently phonological) loop subsystem, and (4) the episodic buffer (Baddeley, 2002b). Originally, Baddeley and Hitch (1974) proposed a three-component system that included the first three components, but in 2002, Baddeley added the fourth component in order to address the problem of integrating information from the subsystems (the visuospatial sketchpad and phonological loop) and LTM. The following will explain each of the components in further detail.
The Central Executive Component

According to Sternberg (1994), the main component is the central executive, which is concerned with a limited capacity of attentional resources to do mental work. Despite limited research and theoretical exploration of this component, the central executive is important for several reasons. It is an essential factor in learning and retrieval of information. It is a source of individual differences in memory. It initiates mental processes such as decision making. And, it initiates rehearsals for transferring new information into LTM.

As the attentional controller, the central executive is assisted by two subsidiary systems, the phonological loop and the visuospatial sketchpad (Baddeley, 2002a). The central executive has the capacity (although limited) of attentional resources to do mental work, and then it gives a second task to one of the subsystems. Although these subsystems aid the central executive component, they have distinct functions of their own: the visuospatial sketchpad subsystem is concerned with visual and spatial information, and the phonological loop is concerned with acoustic and verbal information (Sternberg, 1994). Thus, the two subsystems are independent because they re-circulate information without interfering with each other or the central executive component.

In addition to the central executive making decisions as to how the visuospatial sketchpad and phonological STM subsystems should be used, the central executive also allows the subsystems to drain resources from its control system when they are overloaded (Ashcraft, 1998). However, the central executive does not have the ability to drain mental resources from the visuospatial sketchpad or the phonological loop when it is overloaded. When resources are drained from the central executive, ongoing activity of the central executive such as language acquisition is interrupted.
Visuospatial Sketchpad Subsystem

As mentioned previously, the visuospatial sketchpad subsystem is concerned with visual and spatial information, specifically spatial orientation, holding and rotating mental images. For example, one way of coding and maintaining information in WM is by making mental pictures (Sternberg, 1994). The visuospatial component is a multi-component system (Baddeley, 2002a). It activates neuropsychological activities in the occipital lobe (the visual component), and it activates the parietal regions (the spatial component; Smith & Jonides, 1996). Thus, the visuospatial component temporarily maintains and manipulates information in addition to providing solutions to visuospatial problems. Finally, the sketchpad component provides a link between visual and spatial information accessed through the senses or from LTM (Baddeley, 2002a).

The Phonological Loop Subsystem

According to Kormos and Safar (2008), the most extensive research on the WM model components has been on the phonological loop (or phonological STM) subsystem. There are two components of the phonological loop: (1) a phonological store and (2) an articulatory rehearsal system. These two components are dependent on each other; that is, the phonological store is responsible for holding information in phonological form, and the articulatory rehearsal system maintains decaying representations in the phonological store (Baddeley, Gathercole, & Papagno, 1998). Information in the phonological store is assumed to decay over a period of two seconds unless it is refreshed by the articulatory rehearsal system (Wagner et al., 1999). The main role of this subsystem is phonological processing, retaining verbal information over short periods of time.
There are four main pieces of evidence supporting the phonological loop: (1) the phonological similarity effect, (2) the word length effect, (3) articulatory suppression, and (4) the irrelevant speech effect (Baddeley & Hitch, 1994). According to Ashcraft (1998), because of the phonological similarity effect, reasoning and language acquisition speed decrease when stimulus sentences are phonetically similar (e.g., a word in a sentence starting with the letter B precedes a word starting with the letter V) versus words in sentences that are phonetically dissimilar (e.g., a word in a sentence starting with the letter M precedes a word starting with the letter R). That is, because the sound of the letter B is similar to the sound of the letter V, versus the sound of the letter M being dissimilar to the sound of the letter R, speed of reasoning and language acquisition increases when the latter stimulus is presented because there is less confusion when words sound different.

The word length effect refers to the relationship of immediate serial recall with the length of items being retained (Baddeley, 2002a). There is higher accuracy in recall when the task is a sequence of short words such as wet, car, cry, air, versus a task with a sequence of longer words such as pounding, crocodile, direction, attention. In addition to a decrease in performance accuracy with longer words, the word length effect allows for greater forgetting due to slower rehearsal of longer words. According to Baddeley, Lewis, and Vallar (1984), the word length effect disappears due to the third piece of evidence, articulatory suppression. Articulatory suppression refers to performance being impaired when irrelevant words or sounds such as the word the are uttered during immediate serial recall. That is, elimination of irrelevant words or sounds should increase immediate serial recall. Finally, the irrelevant speech effect refers to impairment
in immediate verbal recall when the spoken material that the participant is instructed to ignore (Baddeley & Hitch, 1994; Colle & Welsh, 1976).

The current study was especially concerned with the first three supporting pieces of evidence because according to Papagno, Valentine, and Baddeley (1991), they influence the acquisition of foreign vocabulary. With the previous four pieces of evidence supporting the phonological loop, the following will discuss in detail the main role of the phonological loop, or otherwise referred to as phonological processing.

**Phonological processing.** There are three levels of phonological processing: (1) acoustic energy level, (2) phonetic level and (3) phonological level (Wagner et al., 1999). The first level is varying waves of acoustic energy by frequency which can be captured in a spectrogram, an instrument that measures utterance of a person’s speech (Funatsu, Imaizumi, Fujimoto, Hashizume, & Kurisu, 2008). At the phonetic level, speech is represented by the strings of phones (sets of speech found in languages). A phone represents some form or combination of articulatory gestures. Articulatory gestures might be here you place your tongue in your mouth, how you position your lips, if you have your mouth closed or opened, or whether your vocal cords are vibrating. For example, there is a different articulatory gesture, or combination of gestures, when you say the words pit, tip and spit. Finally, at the phonological level, related phones combine to form phonemes. The phonemes help discriminate differences in speech sounds, signaling differences in meaning (Wagner et al., 1999). Certain letters of the English alphabet belong to different English phonemes (Halmos, 2007). For example, if the letter b in the word “bat” was replaced by the letter m, another
word, “mat” will be created that will mean something completely different and thus, the letters b and m belong to different English phonemes.

In addition to three levels of phonological processing, according to Wagner et al. (1999), there are three kinds of phonological processing that are essential for mastery of written language: (1) phonological awareness, (2) rapid naming and (3) phonological memory. First, phonological awareness (or language meta-awareness) is when a person is aware and has access to the sound structure of oral language (Mattingly, 1972). Children who are aware of sound structure have an advantage when reading the printed forms of a language. For children who have a weaker phonological awareness, their performance in reading has been shown to increase with reading approaches that are systematic and have explicit instruction in phonological awareness, and strategies to increase phonetic decoding skills (Felton, 1993; Wagner et al., 1999). Second, rapidly naming things, such as objects, digits or letters, requires efficient retrieval of phonological information in LTM. Someone who has poor performance on rapid naming tasks is said to have difficulty reading fluently (Wagner et al., 1999).

Finally, phonological memory refers to coding information phonologically in the phonological loop (Wagner et al., 1999). Phonological memory deficiency does not interrupt reading or listening to words that are already in the individual’s vocabulary. However, phonological memory impairments interrupt reading or listening when learning new written and spoken words (Gathercole & Baddeley, 1990). Therefore, coding information in phonological form in WM helps when learning or trying to decode new words (Wagner et al., 1999). Thus, this study was specifically designed to explore phonological memory and its influence on language learning.
The Episodic Buffer Subsystem

Although the phonological loop has been the component studied the most, the final characteristic Baddeley (2002a) described as the episodic buffer subsystem has made great improvements to the model. As mentioned previously, Baddeley added the episodic buffer in order to address the problem of integrating information from the subsystems (visuospatial sketchpad and phonological loop) and LTM, in order to allow for active maintenance and manipulation of information. The episodic buffer represents a storage system with two components. First, the episodic component holds integrated episodes or scenes. Second, the buffer component acts as an interface between the subsystems. Information is retrieved from the buffer through conscious awareness, thus allowing multiple sources of information to be considered simultaneously. The episodic buffer assumes some of the functions of the central executive in the original model, but is purely mnemonic in character; while the central executive is a purely attentional system.

Although there have been modifications to the original framework of Baddeley and Hitch’s 1974 WM model, it is still regarded as an important and essential model with 7,339 citations to the first author, Alan Baddeley (Jonides et al., 2008). The current study further investigated the WM model by looking at its relationship with language learning between the number of languages spoken.

Working Memory Capacity

In order to measure WM, it is important to understand WM capacity. Working memory capacity identifies how much information a person can store and process. Just and Carpenter (1992) stated that WM is determined by how much WM capacity one has. Common measurements of WM capacity include digit and word span tasks, that measure the number of digits or words individuals
can retain (STM component of WM) respectively, while they are being forced to attend to some other part of memory or the environment (manipulation component of WM; Unsworth & Engle, 2007). Thus, individual differences on WM capacity tasks result from differences in participants’ ability to maintain information in their STM and their ability to retrieve information from their LTM.

According to Sternberg (1994), the following cognitive tasks are dependent upon the role of WM capacity: following directions, vocabulary learning, note taking, writing, and reading comprehension. Sternberg stated that those who have higher WM capacity are better able to: (1) follow more complex directions because they can keep more information in WM; (2) deduce the meaning of unusual words from a context; (3) predict the number of words, complex propositions and main ideas during note taking; (4) write better because one can hold more information in WM while simultaneously manipulating that information effectively; and (5) have higher reading comprehension because one can retain earlier information in WM and integrate that information to aid comprehension.

Thus, participants who perform poorly on complex WM span tasks (e.g., reading span tests) are considered to have lower WM capacity, and individuals who perform well on WM span tasks are considered to have higher WM capacity (Unsworth & Engle, 2007). Performances on complex WM span tasks show that low WM capacity individuals are worse at actively maintaining information than high WM capacity individuals. For example, high WM capacity individuals will perform better than low WM capacity individuals on tasks that require them to maintain and generate correct responses when novel information is presented, because low WM capacity individuals are more likely to become susceptible to having their attention captured by distractors. Thus, low WM capacity individuals are expected to perform worse on complex WM span tasks because they have a
harder time maintaining information in their STM and generating cues that could enable them to retrieve items from their LTM.

It is important to examine individual differences in WM capacity through performance on WM tasks and other higher order constructs. Unsworth and Engle (2007) stated that higher order constructs such as reading comprehension and learning tend to be correlated with WM capacity. The current study examined language learning, a higher order construct, and its relationship with WM capacity.

**Working Memory and Language Learning**

Language learning is considered a higher order construct because it requires processing information, such as sequences of symbols that are produced over time (Just & Carpenter, 1992). That is, specific components of language learning include storage and complex sequential computations of information, similar to the components of WM. Thus, language learning is a good example of WM, because in order to process complex information, language acquisition requires extensive storage of partial and final products. Individual differences in second language acquisition factors are based upon affective traits (e.g., motivation, language learning anxiety, and self-confidence), personality-related traits (e.g., openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability), and cognitive traits (e.g., intelligence, foreign language aptitude, and WM; Kormos & Safar, 2008).

Linguistic abilities greatly influence human cognitive processes. For example, speaking two languages regularly contributes to cognitive abilities (Bialystok & Craik, 2010). However, bilingualism was not always considered in a positive way. Bialystok and Craik stated that there were even warnings against retardation of children due to speaking two languages. According to Bialystok
and Craik, a different perspective on bilingualism was born and changed the modern era of bilingual research with Peal and Lambert’s 1962 research. Peal and Lambert found that bilinguals outperformed monolingual children on several measures. This finding was just the start of the modern era of bilingual research.

Since the 1960s, several studies have supported bilingualism, including a recent study conducted by Stern (2002), in which he showed the continuous advantages of bilingualism through the concept of “cognitive reserve.” Cognitive reserve refers to the idea that active engagement in stimulating and intellectual, social and physical activities will help to protect against cognitive decline. Bialystok, Craik, and Freedman (2007) examined whether bilingualism protected against cognitive decline. They assumed that there are continuous advantages for bilinguals into older age. They asked if continued advantages of bilinguals protect against challenges with age such as dementia. They found that age of dementia onset was four years later for those who were bilingual than those who were monolingual.

Other studies have suggested a relationship between the number of languages spoken and cognition. For example, Just and Carpenter (1992) stated that WM plays a central role in many forms of complex thinking including language learning. That is, language-based learning disorders influence language acquisition and memory (Isaki, Spaulding, & Plante, 2008). Also, Montgomery (2000) found that children with developmental language disorders have WM deficits. In addition, Wagner et al. (1999) asserted that limitations to WM are very important to consider especially due to children’s performance on phonological processing tasks that predict reading performance. Finally, Papagno and Vallar (1995) found a significant difference in phonological STM due to the number of languages spoken.
The Papagno and Vallar (1995) Study

Papagno and Vallar (1995) compared the performance of ten female Italian polyglots, operationally defined as those who can speak at least three languages (including Italian) fluently, versus 10 female Italian non-polyglots, operationally defined as those speaking two languages (including Italian) fluently. Papagno and Vallar were interested in two WM components: the verbal (or phonological) subsystem and the visuospatial subsystem. In addition, they looked at LTM, general intelligence and vocabulary knowledge in the participants’ native language, Italian. They were specifically interested in phonological STM and its role in the acquisition of new words or foreign languages. They based their study on two important implications of phonological STM. First, phonological STM plays an important role in the acquisition of new words by adult normal participants (or those without any medical or mental problems). Second, phonological STM is not limited to understanding the acquisition of new words by adults, but extends to understanding developmental vocabulary learning.

Some previous studies provided support for Papagno and Vallar’s (1995) implications in regards to phonological STM. Vallar and Baddeley (1984) conducted a neuropsychological case study of a patient who had a cerebrovascular lesion in the left hemisphere of his brain resulting in abnormally lower phonological STM capacity, and thus, a pathologically lower auditory-verbal span. The patient could not acquire new words, but could learn pairs of familiar words (Baddeley, Papagno, & Vallar, 1988). Second, Baddeley et al. (1984) found similar support in normal participants (or those without a neuropsychological problem) by showing that the similarity effect, word length effect, and the articulatory suppression reduce phonological STM. There is strong evidence that these three effects selectively interfere with learning of new words; however, there
is less interference when learning pairs of familiar words (Papagno et al., 1991). Third, Gathercole and Baddeley (1989) found that children’s’ performance on a phonological STM task, non-words repetition, was a main predictor of the subsequent acquisition of vocabulary. The results were consistent in both native and foreign languages.

Based on the previous three studies and Papagno and Vallar’s (1995) two implications in regards to phonological STM as stated above, they examined polyglots and the relationship between phonological STM and the acquisition of vocabulary in foreign languages. They hypothesized that polyglots would perform better on phonological STM tasks and learning new words than non-polyglots. Second, they hypothesized that such performance would not be related to differences in general intelligence or learning skills and thus, they also examined participants’ general intelligence and learning skills.

Participants were 10 Italian female polyglots between the ages 21 and 25 years old ($M = 23.1$ years old; Papagno & Vallar, 1995). They were students in the Foreign Language Faculty of the Catholic University of Milan, Italy. All of the polyglots had begun studying their foreign languages when they were 11 years old. Half of the polyglots spoke four languages fluently and the other half spoke three languages fluently. The comparison group included 10 Italian female non-polyglots between the ages of 22 and 25 years old ($M = 23.2$ years old). They were students from the Philosophy Faculty of the Catholic University of Milan, Italy. The non-polyglots began studying one foreign language when they were 11 years old. All of the participants were told that the study concerned their verbal memory and non-verbal reasoning skills. All of the participants’ parents were Italian, and all of the participants were born and lived in Italy. None of the parents were bilingual or polyglots. Also, none of the participants had failed any primary
or secondary school examinations (Papagno & Vallar, 1995). According to
Kormos and Safar (2008), this sample was considered a composite of highly
motivated students who had good cognitive capacities. All of the participants
were final-year university students working on their theses. They had to complete
all of their exams, including a test measuring the acquisition of foreign languages,
with good marks in order to work on their theses.

Participants were given six tasks measuring: (1) vocabulary knowledge in
the native language, Italian, (2) general intelligence, (3) visuospatial STM, (4)
visuospatial learning, (5) verbal learning, and (6) phonological STM (Papagno &
Vallar, 1995). They used the Vocabulary Knowledge in the Native Language:
Vocabulary Subtest of the Wechsler Adult Intelligence Scale to measure
vocabulary knowledge in their native language, Italian. They used Raven’s 1938
Progressive Matrices to measure general intelligence. They used Corsi’s Block-
Tapping Test to measure visuospatial STM and visuospatial learning. Two
conditions were used to measure verbal learning, word-word and word-nonword
paired associate tasks, to explore paired-associate learning of words and new
words. Papagno and Vallar measured phonological STM with an auditory digit
span and a non-word repetition task. According to Kormos and Safar (2008),
these two tasks are some of the most widely used phonological STM tests.

Papagno and Vallar (1995) found a significant difference on the two
phonological STM tests. Polyglots scored significantly higher than non-polyglots
on the auditory digit span, and on the non-word repetition. Their results supported
the idea that participants who scored higher on the phonological STM tasks have
an easier time learning languages. Papagno and Vallar concluded that
achievement in foreign language acquisition is a good predictor of performance on
phonological STM tasks. Polyglots also scored higher on the word-nonword
condition of the paired-associate learning test measuring verbal learning. Thus, polyglots were better able to acquire new Russian words than non-polyglots. There was no significant difference between polyglots and non-polyglots on tasks measuring general intelligence, visuospatial STM, visuospatial learning, vocabulary knowledge in the native language, or the word-word condition of the paired-associate learning test. Given the outcome of Papagno and Vallar’s study, the relationship between WM, more specifically phonological STM in addition to complex verbal WM, between monolinguals and bilinguals was examined in the current study.

Although Papagno and Vallar (1995) found significant results when comparing polyglots to non-polyglots on memory tasks, there were several limitations to their study. First, they had a small sample size, 20 participants. Second, their small sample size only consisted of one ethnic group, Italians. Third, they only examined female participants. Fourth, they had participants between the ages of 21 and 25 years old only. Fifth, their population consisted of participants who were considered highly motivated with good cognitive capacities only, thus, not leaving room for a range of participants with different academic levels. Finally, measures similar to the auditory digit span that they used have been criticized to have insufficient reliability (Dempster & Corkill, 1999) and thus, inconsistent validity (Engle, 2010).

In order to overcome these challenges, the current study had a goal to collect at least 30 participants from three distinct ethnic/racial groups who were monolingual and bilingual (i.e., at least 180 participants). The three groups included a diverse population of participants who were Caucasian, Mexican-American, and Southeast Asian-American. Also, the current study included both male and female participants with the only age restriction being that they were at
least 18 years old. In addition, the population for the current study consisted of students from several academic levels. That is, the subject pool included any students who met the minimum criteria to participate, instead of including only those who were final-year university students working on their theses as Papagno and Vallar (1995) did. Finally, in order to have more reliable and valid measures, a phonological STM task, digit span forward (DSF), in addition to complex verbal WM tasks, digit span backward (DSB) and Reading Span Test (RST) were examined. All three tasks are explained in more detail in the following section after an explanation of three components of memory.

**Measures of Working Memory in the Current Study**

According to Baddeley (2002a), there are three components to memory: encoding when information is registered, storage where information is maintained over time, and retrieval when information is accessed. Encoding is studied by looking at different ways to present information (e.g., orally versus visually) and/or looking at different ways in how the information is processed during learning. Storing is studied by measuring forgetting. Retrieval is studied by measuring recognition or recall. An example of recognition is when a participant is asked whether a stimuli was presented or not (yes/no recognition) or a participant is asked to identify a previously presented item from a set of two are more novel stimuli (forced-choice recognition). An example of recall is when the participant is asked to reproduce the stimuli previously presented without any choices. For this study, auditory and visual information was encoded. Storing was measured through forgetting. And, retrieval was measured as recall.

The purpose of the current study was to explore whether there is a difference in certain aspects of memory, phonological STM and complex verbal
WM, due to the number of languages spoken. Complex verbal WM was explored in addition to phonological STM because there has been criticism of simple span tasks (e.g., DSF) being insufficiently reliable (Dempster & Corkill, 1999) and thus, inconsistently valid (Engle, 2010). Engle and Kane (2004) suggest more complex span measures such as Daneman and Carpenter’s (1980) RST to be at least moderately reliable and consistently valid. Furthermore, Engle (2010) argued that more complex tasks such as the RST are reliable and valid predictors of a range of higher-level and real-world cognitive tasks.

It is important to differentiate between simple span tasks and complex span tasks. According to Unsworth and Engle (2007), complex span tasks (e.g., RST) are considered more “complex” because participants are required to store information (words) over a short time span while engaging in a processing activity (reading), whereas simple span tasks (e.g., DSF) are considered “simple,” because participants are only required to remember items (numbers) without engaging in processing activity.

The Digit Span Tests of the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III)

The Wechsler Adult Intelligence Scale-Third Edition (WAIS-III) is an intelligence assessment that was first published in 1939 as Form I of the Wechsler-Bellevue Intelligence Scale (WBI; Wechsler, 1997). Due to the popularity of the WBI, an alternate form, Form II, of the Wechsler-Bellevue Intelligence Scale (WBII) was published in 1946 (Quereshi, 2003). In 1955 it was revised and renamed the Wechsler Adult Intelligence Scale (WAIS), and in 1981 it was revised again as the Wechsler Adult Intelligence Scale-Revised (WAIS-R). Finally, in 1997, the WAIS-III was published as a clinical instrument that is
administered individually to assess intellectual ability of adults, ages 16 through 89. Although the latest version of the Wechsler Adult Intelligence Scale is the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV), the WAIS-III was used for the current study due to accessibility.

The WAIS-III provides normative data, updated test materials, test content, and administration procedures in addition to retaining the features of the previous versions (Wechsler, 1997). There are 14 subtests that measure different forms of intelligence. The Digit Span subtest requires temporarily storing and manipulating stored information, thus measuring WM. It requires that participants repeat verbatim a number sequence, forward for the digit span forward (DSF) task and in reverse for the digit span backward (DSB) task.

The WAIS-III has three intelligence quotient (IQ) scores: (1) Verbal, (2) Performance and (3) Full Scale (Wechsler, 1997). The WAIS-III subtests can be organized into the Verbal scale and the Performance scale. The Digit Span IQ scores are part of the Verbal scale. For more refined domains of cognitive functioning, the WAIS-III subtests can be grouped into four Index scores: (1) Verbal Comprehension (VCI), (2) Perceptual Organization (POI), (3) Working Memory (WMI), and (4) Processing Speed (PSI). The Digit Span subtests are categorized under the WMI.

In accordance with Just and Carpenter’s (1992) theory, there are small negligible differences in comprehension among participants when the comprehension task is easy (e.g., DSF). However, when comprehension is harder or more demanding, (e.g., DSB), there are larger differences between individuals. The current study used both digit span measures because the DSF is historically a prototypical measure of STM (Engle, 2010). The DSB task was examined as well.
because, according to Kormos and Safar (2008), digit span backward tasks are measures of “complex” and “verbal” WM.

Reading Span Test (RST)

Although there have been other WM assessments since Baddeley and Hitch first conceptualized the term working memory in 1974, the most prominent and frequently used assessment is Daneman and Carpenter’s (1980) RST (Whitney, Arnett, & Driver, 2001). This test was designed to measure WM and two of its components, storage and processing. Daneman and Carpenter (1980) found a strong correlation between reading span and the Verbal Scholastic Aptitude Test (SAT), between .5 and .6 in various experiments (Masson & Miller, 1983; Just & Carpenter, 1992).

The original RST was designed such that sentences were written on cards and the participants were asked to read aloud unrelated sentences within a set (Daneman & Carpenter, 1980). This assessed the processing component of WM. After a set of sentences, the participants came across a blank card with three red question marks on it prompting the participants to start recalling the last word in each of the preceding sentences (Noort, Bosch, Haverkort, & Hugdahl, 2008). This assessed the storage component of WM (Montgomery, 2000). Daneman and Carpenter also structured the test so that the levels (number of sentences in each trial) increased after each trial. They scored the test by measuring the number of correct final words that could be recalled. Thus, WM was measured by the maximum number of sentences each participant recalled while maintaining perfect recall of the final words (Montgomery, 2000). However, almost three decades since its original version, Friedman and Miyake (2005) stated that there is no one
specific way to score WM span tasks; nor is there a specific way to administer the test.

Friedman and Miyake (2005) examined different scoring methods of the RST by looking at distributional characteristics, reliability, and criterion validity. They administered the test by giving participants six trials at each of the four levels, for a total of 84 words to be recalled. The structure of their test gave them the opportunity to look at split-half reliability, internal consistency, test–retest reliability, and reliability with versions of the test with fewer trials per level (e.g., administering three trials per level, or only looking at the first half of the task). They also examined four scoring methods: (1) total words, (2) proportion words, (3) correct set words, and (4) truncated span. Total words was scored as the total number of words recalled correctly. Proportion words was scored as the average for each trial. Correct set words was scored as the total number of words recalled correctly only if everything was recalled correctly in each level. Truncated span was scored as the highest level recalled correctly.

They found the first two scoring methods, total words and proportion words, provided normal distributions, were reliable and had large correlations with reading comprehension measures. However, the latter two scoring methods, correct sets words and truncated span, were less reliable and had smaller correlations with reading comprehension and Verbal SAT. Therefore, they concluded that the first two scoring methods were superior to the latter two.

Friedman and Miyake’s (2005) experiment demonstrated how modifications have changed the results of the RST. Other modifications that could change the results or measures of the RST include: making changes to the way sentences are presented, variations in the amount of time participants can read the
sentences, and different methods of administering the trials (sets of sentences) and levels (number of sentences per trial).

There is also a newer version of the RST (Daneman & Hannon, 2001). According to Noort et al. (2008), Daneman and Hannon’s version has made progressive improvements to the original test. For example, in the original RST, participants were asked to recall the last words of each sentence in a set that was read aloud. In the 2001 version, participants are required to do the same as the original model. However, they must also respond to whether or not the sentences make sense (see RST in chapter 3 for more details).

In summary, three tasks were used in this study to measure memory: the DSF was administered to measure phonological STM, and the DSB and the newer version of the RST, as described above, were administered to measure complex verbal WM. Also, in order to examine similar findings in the Papagno and Vallar (1995) study, the *French Kit Vocabulary Test: Part I and Part II* was administered to measure vocabulary knowledge in the native language, English, and Raven’s Advanced Progressive Matrices was administered to measure general intelligence.

**Controlling for Vocabulary, General Intelligence and Sentence Comprehension**

There was no significant association between polyglots and non-polyglots on a task measuring vocabulary knowledge in the native language in Papagno and Vallar’s (1995) study. However, other studies have suggested that having a larger vocabulary size might be due to more efficient memory that helps when learning words (Cain, Lemmon, & Oakhill, 2004). In addition, Bialystok and Feng (2009) stated that vocabulary plays an important role in verbal performance and memory.

However, Bialystok and Feng (2009) found that bilinguals scored lower on vocabulary, while bilinguals scored the same on a memory task involving
proactive interference. Proactive interference involved verbal processing and executive control, in which participants were required to retrieve recent items that had been impaired by prior exposure to similar information to those items. Bialystok and Feng also suggested that although bilinguals may have scored lower than monolinguals in vocabulary, they compensate for their weaker language proficiency when they have the same or better executive control on memory tasks. Thus, the current study was interested in whether or not there would be significant association between monolinguals and bilinguals in vocabulary.

As well, there was no significant association between polyglots and non-polyglots in general intelligence in Papagno and Vallar’s (1995) study. According to Abrahamsson and Hyltenstam (2008), language learning varies between individuals, and it is acquired by an individual’s language learning aptitude. Language learning aptitude refers to an innate and relatively fixed talent when learning languages. Language learning aptitude has been found to be relatively independent of factors such as general intelligence (Ross, Yoshinaga, & Sasaki, 2002). Measuring general intelligence has made an important impact in the field of psychology and education over the last century with the development of intelligence tests and the scientific method (Foxcroft, Roodt, & Abrahams, 2001). For the current study, Raven’s Advanced Progressive Matrices (APM) was administered to measure general intelligence. Before Raven’s APM, there had been criticism of intelligence tests for relying on language and verbal ability, thus, non-verbal tests such as Raven’s APM were developed. According to Grieve and Viljoen (2000), because this intelligence test is non-verbal, it can measure mental abilities without influences from linguistic, educational and cultural factors. Therefore, because Raven’s APM measures mental abilities without influencing whether you are monolingual or bilingual, the current study predicted no
significant association between general intelligence and monolinguals and bilinguals.

Finally, sentence comprehension was also controlled when examining differences between monolinguals and bilinguals in phonological STM and complex verbal WM. Sentence comprehension was measured by the number of sentences comprehended on the RST. When measuring sentence comprehension, it refers to the ability of building mental structures of the sentence being read (Gernsbacher, 1996). Building mental structures requires enhancement of relative information, as well as suppression of irrelevant information. Enhancement of relative information activates information that is necessary to create the foundation of new structures while suppressing irrelevant information.

Stothard and Hulme (1992) found no significant difference in reading comprehension between those who were considered poor comprehenders (participants with poor reading comprehension skills) versus a control group that consisted of participants within the same chronological-age in short-term and working memory skills. They argued that there is no association between working memory processes and poor comprehension. The current study was interested in examining the relationship between memory tasks and sentence comprehension. Based on Stothard and Hulme’s findings, it was predicted that there would be no association between the memory tasks and sentence comprehension.

**Population of Interest**

Kormos and Safar (2008) found that, with some WM studies, a relatively small number of participants are used. For example, Papagno and Vallar (1995) included 20 female participants. However, to gain more external validity by generalizing to a larger population, three larger participant groups from different
ethnic/racial groups who were monolingual or bilingual were included in the current study. These three ethnic/racial groups were chosen due to their large representation at Fresno State.

In addition, these three ethnic/racial groups were chosen to address Bialystok and Craik’s (2010) important question: does speaking two related languages, such as English and Spanish, have a greater (or lesser) advantage versus speaking two unrelated languages, such as English and Chinese? Thus, the current study included the following groups: (1) Caucasian monolinguals, (2) Mexican monolinguals, (3) Southeast Asian monolinguals, (4) Caucasian bilinguals, (5) Mexican bilinguals, and (6) Southeast Asian bilinguals.

In fall 2009, 55% of the students in the Department of Psychology at Fresno State identified themselves as Hispanic (43%), Asian (11%), or International student (1%); and 29% identified themselves as Caucasian (IRAP, 2009c). Similarly, 51% of the total University enrollment in fall 2009 were students who identified themselves as Asian, Hispanic, or international students (IRAP, 2009a). The following is a breakdown of total University enrollment in fall 2009: White (35%), Hispanic (34%), Asian (15%), Other/Unknown (8%), African American (5%), International (2%), and American Indians (1%).

The five largest Asian student populations in fall 2009 were Southeast Asian (16%), Indian (13%), Filipino (12%), Japanese (6%), and Chinese (6%; IRAP, 2009b). Although Southeast Asian was listed as an option when deciding which category Asian students identify with the most, other Southeast Asian nationalities [i.e., Laotians (4%), Cambodians (4%), Vietnamese (4%), and Thai (0.2%)] were listed separately as well.

One Southeast Asian nationality that was excluded from the Fresno State “Headcount by Race with Asian and Hispanic Ethnicities” breakdown (IRAP,
2009b) was the Hmong. Previously before fall 2009, there were no statistics on the Hmong (unlike other Asian ethnicities as mentioned above) by Fresno State due to limitations within the California State University data collection system (Rudd & Fernandez, 2009). However, as of fall 2009, Rudd and Fernandez were able to provide separate and more specific statistics on the Hmong in accordance with the coding categories of the United States Census. They stated that the campus community at Fresno State was often interested in the demographics of the Hmong. For the purpose of this study, the Hmong sample is particularly of great interest due to their large population in the Central Valley of California (Cerhan, 1990). Seven percent of new undergraduate students at Fresno State in fall 2009 were Hmong (Rudd & Fernandez, 2009), and 47% of new Asian students were of Hmong descent.

The Hmong were also of interest for the current study because of their history and culture, especially due to their historically lack of education. Hmong are a mountain dwelling tribe who come mostly from the country Laos and other parts of Southeast Asia (North Vietnam and Thailand; Cerhan, 1990; Tatman, 2004). Although most Hmong come from Laos, they do not have their own country, they do not consider themselves Laotian, and they do not adapt much to the Laotian culture. The Hmong have a cultural practice and tradition that is very different from other Asian nationalities (Cerhan, 1990). According to Cerhan, by western standards, Hmong are considered primitive, having had little contact with industrialized cultures until the 1950s due to the breakout of civil wars in Laos.

Due to their lack of contact with industrialized cultures, the Hmong had no written language until recently. Instead, their education consisted of oral passing of practical knowledge, tradition, and special training (e.g., embroidery) by their elders (Cerhan, 2000). Currently, they do not have a single writing system
accepted by all members of their culture. It was only recently, about 50 years ago, that written forms of languages were developed in their culture. Their most popular written form of language in the United States is that of Roman Popular Alphabet (Kan & Kohnert, 2005).

Rudd and Fernandez (2009) found that in fall 2009, 47% of new Hmong undergraduates reported that their parents never attended high school. The following is a breakdown of other groups whose parents never attended high school: Hispanic (23%), Other Asians excluding Hmong (14%), and African American (1%). Also, Rudd and Fernandez found that 57% of Hmong parents have a combined annual income of less than $24,000. The following is a breakdown of other groups whose parents have a combined income of less than $24,000 a year: African American (37%), Other Asians excluding Hmong (28%), Hispanic (27%), American Indian (11%), and White (5%).

Thus, originally of most interest for examining phonological STM and complex verbal WM between monolinguals and bilinguals was the Hmong population due to their: lack of a writing system in their culture, parents never attending high school and parents’ low socioeconomic status. However, as data collection proceeded, it was discovered that most Hmong students at Fresno State did not meet the criteria, for the current study (English as a first language and being born in the United States). For most Hmong, Hmong was their first or only language, and most Hmong bilinguals were not born in the United States. Therefore, after looking at the student demographics (IRAP, 2009a), the Hmong group was expanded to include all who considered themselves Southeast Asian, due to a similarity in spoken language.

The current study also included Hispanics who have a large population at Fresno State (34%; IRAP, 2009a). Within the Hispanic population, three
nationalities were identified: Mexican-American (83%), Puerto Rican (0.6%) and Cuban (0.3%); excluding those who referred to themselves from regions (as opposed to nationalities) of Hispanic descent: Other Hispanic (13%), Central American (2%), and South American (1%). The current study only explored Mexican-Spanish speaking participants, as opposed to including other Spanish speaking ethnic/racial groups such as Puerto Rican-Spanish speakers or Cuban-Spanish speakers due to the large population of Mexican-American students versus Puerto Rican and Cuban students.

**Bilingualism in Secondary Analyses**

**English and Spanish versus English and Southeast Asian Bilinguals**

As previously stated, because Bialystok and Craik (2010) raised an important question of whether two related languages, such as English and Spanish, would have a greater (or lesser) advantage versus speaking two unrelated languages, English and Chinese, the current study conducted secondary analyses exploring whether there was a difference in phonological STM and complex verbal WM between similar languages spoken (English and Spanish) and dissimilar languages spoken (English and Southeast Asian Languages). It was predicted that there would be significant differences between bilinguals who speak English and Spanish versus bilinguals who speak English and a Southeast Asian language in phonological STM and complex verbal WM because of the phonological similarity effect.

Ashcraft (1998) stated that reasoning and language acquisition speed decreases when sentences are phonetically similar versus words in sentences that are phonetically dissimilar. Thus, it was predicted that there would be a difference
between bilinguals who speak similar languages, English and Spanish languages, versus dissimilar languages, English and a Southeast Asian language, due partially to the similarity effect, which influences the speed of reasoning. In addition, language acquisition increases in dissimilar bilinguals because when sentences are phonetically dissimilar (i.e., English and a Southeast Asian language), there is less confusion when words sound different, as opposed to words sounding the same (i.e., English and Spanish languages).

**Early versus Late Bilinguals**

The current study was also interested in examining early bilinguals (those who were brought up in a bilingual home) versus late bilinguals (those who learned a second language [L2] through schooling later in life). Baker and Trofimovich (2005) asked if there is a difference in the organization of the phonetic systems (the sounds of one’s speech) based on the age at which bilinguals learn their L2 (early versus late bilinguals). Their results indicated that age was one of the factors that influenced differences in phonetic systems between early and late bilinguals. More specifically, their results indicated that early bilinguals were better at producing distinct acoustic realizations of English and the Seoul dialect of Korean vowels than late bilinguals. Guion (2003) also found that early bilinguals are more likely to produce distinct acoustic realizations of both their L1 and L2 sounds.

Baker and Trofimovich (2005) also found that early bilinguals had a bidirectional influence, whereas late bilinguals had a unidirectional L1 influence on L2. For example, late bilinguals’ L1 heavily influenced how their L2 was produced. However, it is unidirectional because late bilinguals’ L2 did not have an influence on how their L1 was produced. According to Flege (1995), the
Speech Learning Model (SLM) infers differences between early and late bilinguals’ speech in L2 because L1 and L2 interact differently based on the age when L2 is learned. The underlying principle of the SLM is that the chances of bilinguals’ L1 and L2 influencing each other are lower in early bilinguals than in late bilinguals (Walley & Flege, 1999). As Hazan and Barrett (2000) stated, for early bilinguals, their L1 is still developing and thus, the likelihood of early bilinguals’ L1 influencing their L2 is less likely to happen.

When considering bilinguals as participants in a study, it is important to explore differences within that sample. In the current study, it was predicted that there would be a significant difference between bilinguals who speak similar languages and bilinguals who speak dissimilar languages due to the similarity effect. Also, while most studies explored simultaneous early bilinguals only, or those who learned their L2 at least by the age of four (or earlier), Baker and Trofimovich (2005) noted that it is also important to examine late bilinguals. In the current study, it was predicted that there would be a significant difference between early and late bilinguals based on the SLM as described above.

**Research Questions for Primary Analyses**

**ANCOVA Using the Small Sample: Those Who Were Born in the United States and English was Their First Language**

1. Is there a significant difference in phonological short-term memory (as measured by the digit span forward task [DSF]) between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those born in the United States and English was their first language?
2. Is there a significant difference in complex verbal working memory (as measured by the digit span backward task [DSB]) between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those born in the United States and English was their first language?

3. Is there a significant difference in complex verbal working memory (as measured by the Reading Span Test [RST]) between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those born in the United States and English was their first language?

ANOVA of the Covariates Using the Small Sample

4. Is there a significant difference in vocabulary between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American for those born in the United States and English was their first language?

5. Is there a significant difference in general intelligence between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American for those born in the United States and English was their first language?

6. Is there a significant difference in sentence comprehension between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American for those born in the United States and English was their first language?
Research Questions for Secondary Analyses

ANCOVA Using the Entire Sample:
Those Who Were Born or Not Born in the United States and English was or was Not Their First Language

7. Is there a significant difference in phonological short-term memory (as measured by the DSF task) between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension?

8. Is there a significant difference in complex verbal working memory (as measured by the DSB task) between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension?

9. Is there a significant difference in complex verbal working memory (as measured by the RST) between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension?

ANOVA of the Covariates Using the Entire Sample

10. Is there a significant difference vocabulary between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian?

11. Is there a significant difference in general intelligence between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian?

12. Is there a significant difference in sentence comprehension between monolinguals and bilinguals who are Caucasian, Mexican, or Southeast Asian?
ANCOVA of Other Independent Variables (Gender, Born in the United States, and English as the First Language) Using the Entire Sample

13. Is there a significant difference in phonological short-term memory (as measured by the DSF task) between men and women, those who were or were not born in the United States, and those whose first language is or is not English after accounting for vocabulary, general intelligence, and sentence comprehension?

14. Is there a significant difference in complex verbal working memory (as measured by the DSB task) between men and women, those who were or were not born in the United States, and those whose first language is or is not English after accounting for vocabulary, general intelligence, and sentence comprehension?

15. Is there a significant difference in complex verbal working memory (as measured by the RST between men and women, those who were or were not born in the United States, and those whose first language is or is not English after accounting for vocabulary, general intelligence, and sentence comprehension?

ANCOVA of Similar Languages Spoken versus Dissimilar Languages Spoken Using All Bilinguals

16. Is there a significant difference in phonological short-term memory (as measured by the DSF task) between bilinguals who speak similar languages English and Spanish and dissimilar languages English and a Southeast Asian language after accounting for vocabulary, general intelligence and sentence comprehension?

17. Is there a significant difference in complex verbal working memory (as measured by the DSB task) between bilinguals who speak similar languages English and Spanish and dissimilar languages English and a Southeast Asian
language after accounting for vocabulary, general intelligence and sentence comprehension?

18. Is there a significant difference in complex verbal working memory (as measured by the RST) between bilinguals who speak similar languages English and Spanish and dissimilar languages English and a Southeast Asian language after accounting for vocabulary, general intelligence and sentence comprehension?

**ANCOVA of Early versus Late Bilinguals Using All Bilinguals**

19. Is there a significant difference in phonological short-term memory (as measured by the DSF task) between early bilinguals (those who were brought up in a bilingual home) and late bilinguals (those who learned a second language through schooling later in life) after accounting for vocabulary, general intelligence and sentence comprehension?

20. Is there a significant difference in complex verbal working memory (as measured by the DSB task) between early bilinguals and late bilinguals after accounting for vocabulary, general intelligence, and sentence comprehension?

21. Is there a significant difference in complex verbal working memory (as measured by the RST) between early bilinguals and late bilinguals after accounting for vocabulary, general intelligence, and sentence comprehension?

**Multiple Regressions Using the Entire Sample**

22. Do the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, when the second language was learned, gender, age, vocabulary, general intelligence, or sentence comprehension significantly predict phonological short-term memory (as measured by the DSF task)?
23. Do the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, when the second language was learned, gender, age, vocabulary, general intelligence, or sentence comprehension significantly predict complex verbal working memory (as measured by the DSB task)?

24. Do the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, when the second language was, gender, age, vocabulary, general intelligence, or sentence comprehension significantly predict complex verbal working memory (as measured by the RST)?
CHAPTER 3: METHODS

The purpose of the study was to explore whether there was a difference in phonological short-term memory (STM) and complex verbal working memory (WM) between monolinguals and bilinguals of Caucasian, Mexican, or Southeast Asian descent.

Participants

Most of the participants were recruited on a voluntary basis using Fresno State’s Psychology 10 - Introduction to Psychology subject pool, but a few were from Fresno State’s Psychology 144 - Research Designs and Experimental Methods subject pool and other classes. These students signed up on SONA, an on-line Experiment Management System. Participants from the Introduction to Psychology subject pool received credit toward completion of a class requirement as compensation for their participation. Psychology 144 participants received extra credit as compensation for their participation. Other volunteers were recruited from the Department of Modern and Classical Languages and Literatures. These participants were recruited on a voluntary basis. The goal was to have at least 30 Caucasian monolinguals, 30 Mexican-American monolinguals, 30 Southeast Asian-American monolinguals, 30 Caucasian bilinguals, 30 Mexican-American bilinguals, and 30 Southeast Asian-American bilinguals who were born in the United States and spoke English as their first language (L1).

Three-hundred and five individuals participated in the study. After removing any outliers ($n = 1$), those who were under the age of 18 ($n = 18$) and participants who did not fit the criteria ($n = 12$): Caucasian, Mexican, or Southeast Asian, there were 274 participants. There were 59 (22%) Caucasians. Forty (68%) Caucasians considered themselves monolingual and 19 (32%) Caucasians
considered themselves bilingual. There were 129 (47%) Mexicans. Thirty-one (24%) Mexicans considered themselves monolingual and 98 (76%) Mexicans considered themselves bilingual. There were 86 (31%) Southeast Asians. Eighteen (21%) Southeast Asians considered themselves monolingual and 68 (79%) Southeast Asians considered themselves bilingual.

Overall, 89 (32%) participants considered themselves monolingual and 185 (68%) participants considered themselves bilingual. Figure 1 shows the breakdown of participants. Of the 86 Southeast Asians, 65 were Hmong. Ten (15%) Hmong considered themselves monolingual and 55 (85%) Hmong considered themselves bilingual.

![Figure 1. Number of monolingual and bilingual participants within each ethnic/racial group for the entire sample.](image)
There were 84 (31%) men and 190 (69%) women. Participants’ age ranged from 18 to 27 years old ($M = 19.32$, $SD = 1.76$) and the modal age was 18 years old.

After removing any outliers ($n = 1$), those who were under the age of 18 ($n = 18$), and participants who did not fit more specific criteria ($n = 12$): (1) born in the United States and (2) English as their L1, there were 134 participants. This sample will be called the *small sample* and will be used for primary analyses. There were 54 (40%) Caucasians. Thirty-nine (72%) Caucasians considered themselves monolingual and 15 (28%) Caucasians considered themselves bilingual. There were 64 (48%) Mexican-Americans. Thirty (47%) Mexican-Americans considered themselves monolingual and 34 (53%) Mexican-Americans considered themselves bilingual. There were 16 (12%) Southeast Asian-Americans. Six (38%) Southeast Asian-Americans considered themselves monolingual and 10 (62%) Southeast Asian-Americans considered themselves bilingual.

Overall, 75 (56%) participants considered themselves monolingual and 59 (44%) participants considered themselves bilingual. Figure 2 shows the breakdown of participants in the small sample. Of the 16 Southeast Asian-Americans, 8 were Hmong. All Hmong participants in this sample considered themselves bilingual.

There were 43 (32%) men and 91 (68%) women in the small sample. Participants’ age ranged from 18 to 27 years old ($M = 19.59$, $SD = 2.10$) and the modal age was 18 years old.
Figure 2. Number of monolingual and bilingual participants within each ethnic/racial group for the small sample.

Design and Procedure

Individuals were able to participate in the study based on their responses to the Pre-Screening Measure (see Appendix A) that addressed: (1) whether they were Caucasian, Mexican, or Southeast Asian, and (2) whether they considered themselves monolingual or bilingual. For the purpose of this study, monolingual was operationally defined as speaking only English. Bilingual was operationally defined as speaking English and one other language. Caucasian bilinguals were operationally defined as participants who considered themselves fluent in English and fluent in a second language (L2) that was either Spanish or French. Mexican
bilinguals were operationally defined as participants who considered themselves fluent in English and Spanish. And, Southeast Asian bilinguals were operationally defined as those who considered themselves fluent in English and a Southeast Asian language (e.g., Laotian, Vietnamese, Tagalog, or Khmer; IRAP, 2009b).

The study took up to 60 minutes; that is, the examiner stopped administrating the tests after 60 minutes even if participants did not finish all tests ($n = 8$ for those who did not finish all tests). First, participants were asked the questions from the Pre-Screening Measure (Appendix A). If they qualified, participants were given an Informed Consent Form (Appendix B) to read and sign. Third, participants filled out a Demographic Questionnaire (Appendix C). Then, participants took the following six tests: (1) French-Kit Vocabulary Test (FKVT): Part I, (2) digit span forward task (DSF), (3) FKVT: Part II, (4) digit span backward (DSB), (5) Raven’s Advanced Progressive Matrices (Raven’s APM), and (6) the Reading Span Test (RST), in that order. Given the number of tests and length of the study, participants were asked if they would like a break after the Raven’s APM. The DSF was administered to measure phonological STM. The DSB was administered to measure complex verbal WM. The RST was administered to measure complex verbal WM and sentence comprehension. The FKVT: Part I and Part II were administered to measure vocabulary knowledge in English. And, Raven’s APM was administered to measure general intelligence.

All of the individuals participated in the study in research labs in the Department of Psychology at Fresno State. Participants sat facing the examiner across a table. An extra computer monitor sat between the participant and the examiner, facing the participant. The extra monitor was controlled by the examiner from the main laptop during the entire study. Participants viewed stimuli for the phonological STM and complex verbal WM tasks on the extra
monitor. The examiner was not allowed to give any feedback or make eye contact with the participant during any task. All directions were read by the examiner from a corresponding script.

The author and 10 Research Assistants (RAs) administered and/or graded the measures. The RAs were trained by the author and a professor at Fresno State on how to administer and grade the measures. Nine RAs ran participants. One of those nine also graded the measures. There was one RA who served only as a grader for the entire duration of data collection. Data collection took a period of 1 year.

The independent variables were the number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian). The dependent variables were performance on the short-term phonological memory task (DSF) and performance on complex verbal memory tasks (DSB and RST). The covariates were vocabulary knowledge in English (FKVT: Part I and Part II), general intelligence (Raven’s APM), and sentence comprehension (number of sentences comprehended on the RST).

**Instruments**

Each participant answered questions on the Demographic Questionnaire, and then took the following six measures: (1) FKVT: Part I, (2) DSF, (3) FKVT: Part II, (4) DSB, (5) Raven’s APM, and (6) the RST.

**Demographic Questionnaire**

Participants were asked age, sex, race (including specific ethnic group), major, student status (Psychology 10 student, upper division student, graduate student, or other), and whether they were born in the United States. The Demographic Questionnaire also had self-report questions asking participants
about their language skills: whether English was their L1 and whether they were bilingual. For those who considered themselves bilingual, they were asked: (1) how many languages they could speak fluently, (2) how many languages they could write fluently, (3) how they would rate each language they could speak fluently on a scale of 1 to 5 (1 = somewhat fluent to 5 = very fluent), (4) how they would rate each language they could write fluently on a scale of 1 to 5 (1 = somewhat fluent to 5 = very fluent), (5) how they learned their L2, and (6) how many years they had been learning their L2. Participants could choose one or all of the following options in regard to how they learned their L2: (1) since I was born, (2) from courses I took during junior high school, (3) from courses I took during high school, or (4) from courses I took in college.

**French-Kit Vocabulary Test (FKVT)**

There were two parts to the FKVT, Part I and Part II (French et al., 1969). The FKVT was used to test participants’ knowledge of word meanings in English. These tests are part of the Kit of Reference Tests for Cognitive Factors Test (Kit). Tests from the Kit are factor pure and easily administered (Tarter, Sheldon, & Sugerman, 1975). In addition, the Kit has been frequently used and researched, providing extensive comparative possibilities (Marsella & Golden, 1980).

French et al. (1969) stated that because the tests were created for the single purpose of factorial research, reliability and validity were not provided. However, they also suggest that the use of their tests will ordinarily provide for what the named factors are. That is, the FKVT, Part I and Part II should measure student knowledge in word meanings.

Each test was administered independently. For each part, participants had 4 minutes to complete 18 multiple-choice vocabulary questions. All 18 items were
presented on a single sheet of paper. Participants were told to look at each item with five lettered options below. One of the five lettered options had the same meaning or nearly the same meaning as the word above the lettered options. Participants were asked to mark their answer by circling the letter of the answer that they selected.

Each test was scored using the following equation:

\[ \text{Score Correct} = \frac{\text{Right} - \text{Wrong}}{\text{Choices} - 1} \]

The maximum Score Correct for the FKVT: Part I was 18 points. The maximum Score Correct for the FKVT: Part II was 18 points. The scores for both parts were added together to get a Total Score for the vocabulary test. The maximum Total Score was 36.

**Digit Span Subtest**

The Digit Span subtest has two tasks, digit span forward (DSF) and digit span backward (DSB; Wechsler, 1997. According to Dempster and Corkill (1999), simple span tasks such as the DSF are insufficiently reliable and thus, according to Engle (2010), inconsistently valid. However, because Papagno and Vallar (1995) examined simple span tasks such as the DSF to measure phonological STM, and because the simple span tasks are historical and prototypical measures of STM (Engle, 2010), DSF was examined in the current study. In addition, DSB was also examined in the current study because, according to Kormos and Safar (2008), digit span backward tasks are measures of “complex” and “verbal” WM. The DSB has been shown to have an internal consistency reliability of 0.90 (Prokosch, Yeo, & Miller, 2004).
The DSF and DSB were administered independently. The DSB was administered even if the participant obtained a score of 0 (see scoring method below) on the DSF. For both tasks, participants heard a series of number sequences that increased in length. For each DSF sequence, the participant was required to repeat the numbers in the same order as presented. For each DSB sequence, the participant was required to repeat the number sequence in reverse order.

**Digit Span Forward (DSF).** Before administering Trial 1 of Set 1, the examiner said, “You are going to hear some numbers from the screen. Listen carefully, and when you see a blue screen on the computer, I want you to say the numbers as you heard them. Just repeat the numbers you heard from the screen. For example, the computer will say 3-4, and when the blue screen appears, you would say 3-4. Do you have any questions?” After answering any questions, the test began.

Presentation of the digits was at the rate of one per second in a monotone, male, recorded voice. After a digit sequence, a blue screen appeared prompting participants to repeat the numbers they heard. The number sequences had two digits for Set 1 and increased by one digit per set to nine digits in Set 8. That is, Set 1 was comprised of 2 digits, Set 2 was comprised of 3 digits, Set 3 was comprised of 4 digits, etc. There were two trials for each set. Both trials of each set were administered even if the participant passed (i.e., correctly repeated) the first trial. The task was discontinued after a score of 0 on both trials of any set. On the DSF Scores Sheet, a check mark was given if the participant could recall the numbers in the correct order, and an X was marked if they repeated the numbers in the incorrect order or they could not recall any or all numbers. Each
set was scored one point as follows: one point if the participant passed both trials, 0.5 point if the participant passed only one trial and zero points if the participant failed both trials. Scoring started with two points, corresponding to the number sequences having two digits for the first set, and thus, ended with 9.5 total possible points, corresponding to the number sequences having nine digits for the last set.

**Digit Span Backward (DSB).** Before administering Trial 1 of Set 1, the examiner said, “Now you are going to hear some more numbers from the screen. But, this time when you see a blue screen on the computer, I want you to say the numbers you heard backwards. For example, if you hear 7-1-9 and you see a blue screen, what would you say?” If the participant responded correctly (i.e., 9-1-7), the examiner would say “That’s right” and proceed to Trial 1 of Set 1. However, if the participant responded incorrectly, the examiner provided the correct response and said “No, you would say 9-1-7. It said 7-1-9, so to say it backwards and you would say 9-1-7. Now try these numbers. Remember, you have to say them backwards: 3-4-8.” Whether or not the participant responds correctly (i.e., 8-4-3), the examiner proceeded to Trial 1 of Set 1. After answering any questions, the test began.

Presentation of the digits was again at the rate of one per second in the same monotone, male, recorded voice. After digit sequences, a blue screen appeared prompting participants to repeat the numbers they heard in opposite order. The sequences began with two digits for Set 1 and increased by one digit per set to eight digits in Set 7. That is, Set 1 was comprised of 2 digits, Set 2 was comprised of 3 digits, Set 3 was comprised of 4 digits, etc. There were two trials for each set. Both trials were administered even if the participant passed (i.e., correctly repeated the sequence backwards) the first trial. The task was
discontinued after a score of 0 on both trials of any set. On the DSB Scores Sheet, a check mark was given if the participant recalled the numbers in the correct backwards order, and an X was marked if they got the numbers in the incorrect backwards order or they could not recall any or all numbers. Each set was scored one point as follows: one point if the participant passed both trials, 0.5 point if the participant passed only one trial and zero points if the participant failed both trials. Scoring started with two points, corresponding to the number sequences having two digits for the first set, and thus, ended with 8.5 total possible points, corresponding to the number sequences having eight digits for the last set.

**Raven’s Advanced Progressive Matrices (Raven’s APM)**

Raven’s Progressive Matrices (RPM) was developed in 1938 in order to evaluate mental abilities of recruits in the United Kingdom military (Israel, 2006; Mills & Ablard, 1993). This assessment tool was measured independent from military recruits’ educational background, and it has been one of the most successful measures that addresses inductive reasoning and analogical tasks in a non-verbal (linguistically minimized) format (Israel, 2006). According to Grieve and Viljoen (2000), because the assessment tool is non-verbal, it can measure mental abilities without influences from linguistic, educational and cultural factors. Therefore, the RPM is used extensively throughout the world because it has been successful at measuring non-verbal intelligence without influences by culturally-specific factors (DeShon, Chan, & Weissbein, 1995).

In 1962, the Advanced Progressive Matrices (APM) was developed to account for individuals who had higher levels of intelligence (e.g., adults, college students, etc.; Mills & Ablard, 1993). Set II of this latter version was used for the current study. According to Rushton, Skuy, and Fridjhon (2003), Set I and Set II
have the same presentation of items, however, in Set II, the items increase in
difficulty more steadily. Also, Set II was administered without training or
familiarization of the 12 items in Set I due to the assumption that participants
could complete the test forgoing training and familiarization from Set I.

Raven’s APM has been shown to have good reliability with test-retest
reliabilities ranging between 0.76 and 0.90, and internal consistency estimates
ranging between 0.8 and 0.9 (Israel, 2006). According to Rushton et al. (2003),
Raven’s APM is reliable and valid across a range of different populations.

For Raven’s APM (Raven, 1962), participants were given a Test Booklet
and an Answer Sheet. Participants recorded their answers on the Answer Sheet.
They were not allowed to write in the Test Booklet. Before administering the test,
the examiner said:

“For this test, you will record your answers on the answer sheet
provided. You may NOT write in the test booklet. You will have 10
minutes to complete as many problems as you can. We are interested in
accuracy not speed, so it is not important that you finish the test, but rather
that you get as many correct as you can in 10 minutes. The items start out
easier and get more difficult as you progress.

These items are 3x3 matrices with the bottom right piece missing. Your
goal is to find the piece that completes the patterns. Let’s look at the
example together. For this item, you’ll notice that the first row has 1 line
each, the second row has 2 lines each, and the first two pieces of the third
row have 3 lines each. As well, each row and column have one set of lines
that are solid, one that are dashed, and one that are squiggly. Finally, you’ll
notice that in the first column the lines go side-to-side, in the second
column the lines are straight up and down, and in the third column the first
two pieces are diagonal. Thus, we want to look for what piece would complete these three patterns: it needs three, dashed, diagonal lines… Therefore, the correct answer is number 7. So, you would go to your answer sheet and circle the number 7. Do you have any questions?”

After answering any questions the participants had, the examiner continued. “Please remember not to make any marks in the actual test book. You have 10 minutes to complete as many problems as accurately as possible. You may begin.”

The test was discontinued after 10 minutes. There were 36 questions with 8 possible choices worth one point each. The maximum score on Raven’s APM was 36 points.

**Reading Span Test (RST)**

For the RST (Daneman & Hannon, 2001), participants saw a series of unrelated sentences on the computer screen. They were asked to read each sentence aloud, identify if the sentences made sense or not, and eventually, recall the last word of each sentence in a set. Before administering the test, participants had to complete three practice sets in order to make sure that they did not have any questions and that they understood the following directions:

“In this task, you will be presented with a series of unrelated sentences on the computer. The goal is to remember the last word in each sentence. Whenever a sentence is presented to you, you are to read the sentence out loud. Some of the sentences make sense, and some of the sentences do not make sense. After you finish reading the sentence, I want you to quickly say “Yes” if the sentence makes sense or “No” if the sentence does not make sense. When you are deciding whether or not the sentences make
sense, go with your first instinct. Once you say “Yes” or “No” I will advance to the next screen. Read the next sentence aloud and say “Yes” or “No.” Once a blue screen appears I want you to repeat the last words for the previous sentences. Try to repeat them in order as best you can. The number of sentences will increase periodically throughout the test. We will do some practice first to make sure you don’t have any questions. Feel free to ask any questions during these practice sentences.”

Thus, participants were required to read each sentence aloud. Some of the sentences made sense and some of the sentences did not make sense. After reading each sentence aloud, participants were required to say “Yes” if the sentence made sense or “No” if the sentence did not make sentence. The screen was not advanced until the participant said “Yes” or “No.” After a series of unrelated sentences, a blue screen appeared to prompt the participants to repeat the last words from the previous sentences in order. Although participants were prompted to try to repeat them in order, the examiner counted the words they recalled correctly even if they were not in order.

One sentence was shown at a time, and each sentence ended in a different word. The number of sentences increased periodically throughout the test. The number of sentences per set began with two sentences per trial in the first set and increased to six sentences per trial in the fifth set. That is, the first set had five trials of two sentences, the second set had five trials of three sentences, etc. There were five trials in each set, resulting in 100 sentences. The pace of advancing to the next screen was controlled by the examiner at a speed that would not allow participants to rehearse the words but gave them enough time to read the sentence aloud at a comfortable pace and then say “yes” or “no” (Daneman & Carpenter,
The examiner went through as many sets until the 60-minute testing session ended.

On the RST: Score Sheet, a circle was put around the letter Y if the participant responded with “Yes” to whether the sentence made sense (sentence comprehension, as measured by number of sentences comprehended on the RST). A circle was put around the letter N if the participant responded with “No” to whether the sentence made sense. And, a circle was put around the word if the participant was able to recall the word after seeing a blue screen. There were 100 sentences to be read aloud, and each word recalled was worth one point. Thus, the maximum score on RST was 100 points. Total words method of scoring is considered to have good reliability with test-retest reliabilities ranging between 0.72 and 0.73, and internal consistency estimates ranging between 0.7 and 0.95 (Friedman & Miyake, 2005; Tirre & Peña, 1992).

The number of sentences correctly identified as making sense and not making sense was counted. There were 100 sentences to be read aloud that either made sense or not. Each word correctly identified as making sense or not was worth one point. The maximum score for sentence comprehension was 100 points.

**Research Hypotheses for Primary Analyses**

**ANCOVA Using the Small Sample:**
*Those Who Were Born in the United States and English was Their First Language*

**Hypothesis 1.** Bilinguals and those who are Caucasian will have higher phonological short-term memory (as measured by the DSF task) than monolinguals and those who are Mexican-American and Southeast Asian-
American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language.

**Hypothesis 2.** Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the DSB task) than monolinguals and those who are Mexican-American and Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language.

**Hypothesis 3.** Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the RST) than monolinguals and those who are Mexican-American and Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language.

**ANOVA of the Covariates Using the Small Sample

**Hypothesis 4.** There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in vocabulary for those who were born in the United States and English was their first language.

**Hypothesis 5.** There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in general intelligence for those who were born in the United States and English was their first language.
Hypothesis 6. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in sentence comprehension, for those who were born in the United States and English was their first language.

Research Hypotheses for Secondary Analyses

ANCOVA Using the Entire Sample: Those Who Were Born or Not Born in the United States and English was or was Not Their First Language

Hypothesis 7. Bilinguals and those who are Caucasian will have higher phonological short-term memory (as measured by the DSF task) than monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension.

Hypothesis 8. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the DSB task) than monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension.

Hypothesis 9. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the RST) than monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension.
ANOVA of the Covariates Using the Entire Sample

Hypothesis 10. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in vocabulary.

Hypothesis 11. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in general intelligence.

Hypothesis 12. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in sentence comprehension.

ANCOVA of Other Independent Variables (Gender, Born in the United States, and English as the First Language) Using the Entire Sample

Hypothesis 13. There will be a significant difference in phonological short-term memory (as measured by the DSF task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension.

Hypothesis 14. There will be a significant difference in complex verbal working memory (as measured by the DSB task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension.
Hypothesis 15. There will be a significant difference in complex verbal working memory (as measured by the RST task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension.

Hypothesis 16. There will be a significant difference in phonological short-term memory (as measured by the DSF task) between bilinguals who speak English and Spanish and bilinguals who speak English and a Southeast Asian language after accounting for vocabulary, general intelligence and sentence comprehension.

Hypothesis 17. There will be a significant difference in complex verbal working memory (as measured by the DSB task) between bilinguals who speak English and Spanish and bilinguals who speak English and a Southeast Asian language after accounting for vocabulary, general intelligence, and sentence comprehension.

Hypothesis 18. There will be a significant difference in complex verbal working memory (as measured by the RST) between bilinguals who speak English and Spanish and bilinguals who speak English and a Southeast Asian language after accounting for vocabulary, general intelligence, and sentence comprehension.
Hypothesis 19. There will be a significant difference in phonological short-term memory (as measured by the DSF task) between early bilinguals (those who were brought up in a bilingual home) and late bilinguals (those who learned a second language through schooling later in life) after accounting for vocabulary, general intelligence and sentence comprehension.

Hypothesis 20. There will be a significant difference in complex verbal working memory (as measured by the DSB task) between early bilinguals and late bilinguals after accounting for vocabulary, general intelligence and sentence comprehension.

Hypothesis 21. There will be a significant difference in complex verbal working memory (as measured by the RST) between early bilinguals and late after accounting for vocabulary, general intelligence and sentence comprehension.

Multiple Regressions Using the Entire Sample

Hypothesis 22. The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the second language was learned will predict phonological short-term memory (as measured by the DSF task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict phonological short-term memory (as measured by the DSF task).

Hypothesis 23. The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the
second language was learned will predict complex verbal working memory (as measured by the DSB task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict complex verbal working memory (as measured by the DSB task).

**Hypothesis 24.** The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the second language was learned will predict complex verbal working memory (as measured by the RST task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict complex verbal working memory (as measured by the RST).
CHAPTER 4: RESULTS

Primary Analyses

ANCOVA Using the Small Sample:
Those Who Were Born in the United States and English was Their First Language

Hypothesis 1. Bilinguals and those who are Caucasian will have higher phonological short-term memory (as measured by the DSF task) than monolinguals and those who are Mexican-American and Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANCOVA was conducted with DSF as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican-American, or Southeast Asian-American) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. As predicted, vocabulary, general intelligence and sentence comprehension were not significantly associated with the dependent variable. Contrary to prediction, there was no main effect for number of languages spoken or ethnic/racial group. Also contrary to predictions, there was no significant number of languages spoken by ethnic/racial group interaction on the DSF. See Table 1 for a summary of these results.

Hypothesis 2. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the DSB task) than monolinguals and those who are Mexican-American and Southeast Asian-
Table 1. Analysis of Covariance of the Digit Span Forward Using the Small Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>3.09</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>1.26</td>
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<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.04</td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>.46</td>
</tr>
<tr>
<td>Languages Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.01</td>
</tr>
<tr>
<td>Error</td>
<td>125</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Note. * p < .05.

American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANCOVA was conducted with DSB as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican-American or Southeast Asian-American) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. As predicted, general intelligence and sentence comprehension was not significantly associated with the dependent variable. Contrary to prediction, one of the covariates, vocabulary, was significantly associated with the dependent variable, F(1, 125) = 4.63, p < .05, partial $\eta^2 = .036$. Contrary to predictions, there was no main effect for number of languages spoken or ethnic/racial group. Also contrary to prediction, there was no significant number of languages spoken by ethnic/racial group interaction on the DSB. These results are summarized in Table 2.
Table 2. Analysis of Covariance of the Digit Span Backward Using the Small Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>4.63*</td>
<td>.036</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>2.28</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td>Languages Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>125</td>
<td>.98</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p < .05.

Hypothesis 3. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the RST) than monolinguals and those who are Mexican-American and Southeast Asian-American after accounting for vocabulary, general intelligence, and sentence comprehension for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANCOVA was conducted with RST as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican-American, or Southeast Asian-American) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. As predicted, vocabulary and general intelligence were not significantly associated with the dependent variable. Contrary to prediction, one of the covariates, sentence comprehension, was significantly associated with the dependent variable, F(1, 123) = 9.08, p < .05, partial η² = .069. Contrary to predictions, there was no main effect for number of
languages spoken or ethnic/racial group. Also contrary to prediction, there was not a significant number of languages spoken by ethnic/racial group interaction for the RST. These results are summarized in Table 3.

**Table 3. Analysis of Covariance of the Reading Span Test Using the Small Sample**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
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<td>3.80</td>
<td></td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>1.86</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>9.08*</td>
<td>.069</td>
</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.33</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>Languages Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>123</td>
<td>170.55</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p* < .05.*

**ANOVA of the Covariates Using the Small Sample**

**Hypothesis 4.** There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in vocabulary for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANOVA was conducted with vocabulary as the dependent variable. Ethnic/racial group (Caucasian, Mexican-American, or Southeast Asian-American) and the number of languages spoken (monolingual or bilingual) were the independent variables. As predicted, there was not a significant main effect for number of languages spoken. Contrary to prediction, there was a significant main effect for ethnic/racial group, F(2, 128) = 5.32, *p* < .05, partial η² = .077. Tukey’s post hoc procedure indicated
that Caucasians (M = 17.76, SD = 5.15) scored significantly higher than Southeast Asian-Americans (M = 14.52, SD = 3.43). These results can be seen in Figure 3.

![Graph showing vocabulary mean score separated by ethnic/racial group.](image)

**Figure 3.** Vocabulary mean score separated by ethnic/racial group.

There was not a significant difference in vocabulary between Caucasians and Mexican-Americans. Also, there was not a significant difference between Mexican-Americans and Southeast Asian-Americans. As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction for vocabulary. These results are summarized in Table 4.
Table 4. Analysis of Variance of Vocabulary Using the Small Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>5.32*</td>
<td>.077</td>
</tr>
<tr>
<td>Ethnic/Racial Group x Language Spoken</td>
<td>2</td>
<td>.66</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>128</td>
<td>19.94</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *p* < .05.

**Hypothesis 5.** There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in general intelligence for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANOVA was conducted with general intelligence as the dependent variable. Ethnic/racial group (Caucasian, Mexican-American, or Southeast Asian-American) and the number of languages spoken (monolingual or bilingual) were the independent variables. As predicted, there was not a significant main effect for number of languages spoken. Contrary to prediction, there was a significant main effect for ethnic/racial group, $F(2, 128) = 3.45, p < .05$, partial $\eta^2 = .051$. Tukey’s post hoc procedure indicated that Caucasians ($M = 15.63, SD = 3.55$) scored significantly higher than Mexican-Americans ($M = 13.63, SD = 3.69$). These results can be seen in Figure 4.

There was not a significant difference in general intelligence between Caucasians and Southeast Asian-Americans. Also, there was not a significant difference between Mexican-Americans and Southeast Asian-Americans. As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction for general intelligence. These results are summarized in Table 5.
Figure 4. General intelligence mean score separated by ethnic/racial group.

Table 5. Analysis of Variance of General Intelligence Using the Small Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
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<tbody>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>3.45*</td>
<td>.051</td>
</tr>
<tr>
<td>Ethnic/Racial Group x Languages Spoken</td>
<td>2</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>128</td>
<td>13.05</td>
<td></td>
</tr>
</tbody>
</table>

Note. * $p < .05$. 
Hypothesis 6. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican-American, or Southeast Asian-American in sentence comprehension, for those who were born in the United States and English was their first language. A 2 x 3 between-subjects ANOVA was conducted with sentence comprehension as the dependent variable. Ethnic/racial group (Caucasian, Mexican-American, or Southeast Asian-American) and the number of languages spoken (monolingual or bilingual) were the independent variables. As predicted, there was not a significant main effect for number of languages spoken. Contrary to prediction, there was a significant main effect for ethnic/racial group, $F(2, 128) = 4.62$, $p < .05$, partial $\eta^2 = .067$. Tukey’s post hoc procedure indicated that Caucasians ($M = 93.72$, $SD = 4.55$) scored significantly higher than Mexican-Americans ($M = 89.22$, $SD = 11.08$) and Southeast Asian-Americans ($M = 87.31$, $SD = 7.40$). These results can be seen in Figure 5.

There was not a significant difference in sentence comprehension between Mexican-Americans and Southeast Asian-Americans. As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction for sentence comprehension. These results are summarized in Table 6.

Secondary Analyses

ANCOVA Using the Entire Sample:
Those Who Were Born or Not Born in the United States and English was or was Not Their First Language

Hypothesis 7. Bilinguals and those who are Caucasian will have higher phonological short-term memory (as measured by the DSF task) than
Figure 5. Sentence comprehension mean score separated by ethnic/racial group.

Table 6. Analysis of Variance of Sentence Comprehension Using the Small Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$F$</th>
<th>partial $\eta^2$</th>
</tr>
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<tbody>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.36</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>4.62*</td>
<td>.067</td>
</tr>
<tr>
<td>Ethnic/Racial Group x Language Spoken</td>
<td>2</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>128</td>
<td>75.02</td>
<td></td>
</tr>
</tbody>
</table>

*Note. * $p < .05$.  

Error bars: 95% Confidence Interval
monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with DSF as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to predictions, two of the covariates, vocabulary, F(1, 265) = 6.71, p < .05, partial $\eta^2 = .025$, and general intelligence, F(1, 265) = 6.19, p < .05, partial $\eta^2 = .023$, were significantly associated with the dependent variable. As predicted, sentence comprehension was not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for number of languages spoken or ethnic/racial group. Also contrary to prediction, there was not a significant number of languages spoken by ethnic/racial group interaction for the DSF. These results are summarized in Table 7.

Table 7. Analysis of Covariance of the Digit Span Forward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
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</thead>
<tbody>
<tr>
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<td>6.71*</td>
<td>.025</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>6.19*</td>
<td>.023</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
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<td>1.12</td>
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</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>2.41</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
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<td>.64</td>
<td></td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.96</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>265</td>
<td>.89</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p < .05.
Hypothesis 8. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the DSB task) than monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with DSB as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to predictions, two of the covariates, vocabulary, F(1, 265) = 11.84, p < .05, partial η² = .043, and general intelligence, F(1, 265) = 7.48, p < .05, partial η² = .027, were significantly associated with the dependent variable. As predicted, sentence comprehension was not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for number of languages spoken or ethnic/racial group. Also contrary to prediction, there was not a significant number of languages spoken by ethnic/racial group interaction on the DSB. These results are summarized in Table 8.

Table 8. Analysis of Covariance of the Digit Span Backward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>11.84*</td>
<td>.043</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>7.48*</td>
<td>.027</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.38</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.74</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>265</td>
<td>.92</td>
<td></td>
</tr>
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</table>

Note. * p < .05.
Hypothesis 9. Bilinguals and those who are Caucasian will have higher complex verbal working memory (as measured by the RST) than monolinguals and those who are Mexican and Southeast Asian after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with RST as the dependent variable. The number of languages spoken (monolingual or bilingual) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Since Levene’s test for equality of variances was found to be violated, $F(5, 264) = 3.32$, $p < .05$, equality of variance was not assumed. As predicted, vocabulary and general intelligence were not significantly associated with the dependent variable. Contrary to prediction, one of the covariates, sentence comprehension, $F(1, 261) = 24.33$, $p < .05$, partial $\eta^2 = .085$, was significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for number of languages spoken or ethnic/racial group. Also contrary to prediction, there was not a significant number of languages spoken by ethnic/racial group interaction on the RST. These results are summarized in Table 9.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$F$</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
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<td>3.66</td>
<td></td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>2.74</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>24.33*</td>
<td>.085</td>
</tr>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>2.63</td>
<td></td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.81</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>261</td>
<td>131.27</td>
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</tr>
</tbody>
</table>

*Note.  * $p < .05.$
ANOVA of the Covariates Using the Entire Sample

Hypothesis 10. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in vocabulary. A 2 x 3 between-subjects ANOVA was conducted with vocabulary as the dependent variable. Ethnic/racial group (Caucasian, Mexican, or Southeast Asian) and the number of languages spoken (monolingual or bilingual) were the independent variables. As predicted, there was not a significant main effect for number of languages spoken. Contrary to prediction, there was a significant main effect for ethnic/racial group, $F(2, 268) = 17.17$, $p < .05$, partial $\eta^2 = .114$. Tukey’s post hoc procedure indicated that Caucasians ($M = 17.67$, $SD = 5.03$) scored significantly higher than Mexicans ($M = 15.54$, $SD = 4.10$) and Southeast Asians ($M = 12.81$, $SD = 4.26$). These results can be seen in Figure 6.

Figure 6. Vocabulary mean score separated by ethnic/racial group.
As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction with vocabulary. These results are summarized in Table 10.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>17.17*</td>
<td>.114</td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.79</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>268</td>
<td>191.15</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *p* < .05.

**Hypothesis 11.** There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in general intelligence. A 2 x 3 between-subjects ANOVA was conducted with general intelligence as the dependent variable. Ethnic/racial group (Caucasian, Mexican, or Southeast Asian) and the number of languages spoken (monolingual or bilingual) were the independent variables. As predicted, there was not a significant main effect for number of languages spoken. Contrary to prediction, there was a significant main effect for ethnic/racial group, \( F(2, 268) = 3.82, p < .05, \) partial \( η^2 = .028 \). Tukey’s post hoc procedure indicated that Caucasians (\( M = 15.32, SD = 3.95 \)) scored significantly higher than Mexicans (\( M = 13.02, SD = 4.00 \)). These results can be seen in Figure 7.

There was not a significant difference in general intelligence between Caucasians and Southeast Asians. Also, there was not a significant difference between Mexicans and Southeast Asians. As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction with general intelligence. These results are summarized in Table 11.
Figure 7. General intelligence mean score separated by ethnic/racial group.

Table 11. Analysis of Variance of General Intelligence Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
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<tr>
<td>Languages Spoken</td>
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<td>2.18</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>3.82*</td>
<td>.028</td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.71</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>268</td>
<td>14.66</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *p < .05.*
Hypothesis 12. There will be no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian in sentence comprehension. A 2 x 3 between-subjects ANOVA was conducted with sentence comprehension as the dependent variable. Ethnic/racial group (Caucasian, Mexican, or Southeast Asian) and the number of languages spoken (monolingual or bilingual) were the independent variables. Since Levene’s test for equality of variances was found to be violated, $F(5, 268) = 5.50$, $p < .05$, equality of variance was not assumed. Contrary to prediction, there was a significant main effect for the number of languages spoken, $F(1, 268) = 4.39$, $p < .05$, partial $\eta^2 = .016$, with monolinguals ($M = 90.88$, $SD = 7.79$) scoring significantly higher than bilinguals ($M = 84.98$, $SD = 11.86$). These results can be seen in Figure 8.

![Figure 8. Sentence comprehension mean score separated by number of languages spoken.](image_url)
Contrary to prediction, there was a significant main effect for ethnic/racial group, $F(2, 268) = 12.42, p < .05$, partial $\eta^2 = .085$. Tukey’s post hoc procedure indicated that Caucasians ($M = 93.53, SD = 4.57$) scored significantly higher than Mexicans ($M = 86.99, SD = 11.32$) and Southeast Asians ($M = 82.20, SD = 11.49$). These results can be seen in Figure 9.

![Figure 9. Sentence comprehension mean score separated by number of languages spoken.](image)

As predicted, there was not a significant number of languages spoken by ethnic/racial group interaction with general intelligence. These results are summarized in Table 12.
Table 12. Analysis of Variance of Sentence Comprehension Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>1</td>
<td>4.39*</td>
<td>.016</td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
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<td>12.42*</td>
<td>.085</td>
</tr>
<tr>
<td>Language Spoken x Ethnic/Racial Group</td>
<td>2</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>268</td>
<td>104.67</td>
<td></td>
</tr>
</tbody>
</table>

Note. * $p < .05$.

ANCOVA of Other Independent Variables (Gender, Born in the United States, and English as the First Language) Using the Entire Sample

Hypothesis 13. There will be a significant difference in phonological short-term memory (as measured by the DSF task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 2 x 2 between-subjects ANCOVA was conducted with DSF as the dependent variable. Gender, whether participants were born in the United States, and whether English was their first language were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to predictions, two of the covariates, vocabulary, $F(1, 263) = 4.29$, $p < .05$, partial $\eta^2 = .016$, and general intelligence, $F(1, 263) = 5.10$, $p < .05$, partial $\eta^2 = .019$, were significantly associated with the dependent variable. As predicted, sentence comprehension was not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for gender, whether participants were born in the United States, or whether
English was their first language. Also contrary to predictions, there were no significant interactions. These results are summarized in Table 13.

Table 13. Analysis of Covariance of the Digit Span Forward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>4.29*</td>
<td>.016</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>5.10*</td>
<td>.019</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.74</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Born in the United States</td>
<td>1</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>English as First Language</td>
<td>1</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US</td>
<td>1</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>Gender x English as First Language</td>
<td>1</td>
<td>1.17</td>
<td></td>
</tr>
<tr>
<td>Born in the US x English as First Language</td>
<td>1</td>
<td>.96</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US x English as First Language</td>
<td>1</td>
<td>.69</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>263</td>
<td>.88</td>
<td></td>
</tr>
</tbody>
</table>

Note. * p < .05.

Hypothesis 14. There will be a significant difference in complex verbal working memory (as measured by the DSB task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 2 x 2 between-subjects ANCOVA was conducted with DSB as the dependent variable. Gender, whether participants were born in the United States, and whether English was their first language were the independent variables. Vocabulary, general intelligence, and sentence
comprehension were the covariates. Contrary to predictions, two of the covariates, vocabulary, \( F(1, 263) = 6.83, \ p < .05, \) partial \( \eta^2 = .025, \) and general intelligence, \( F(1, 263) = 9.57, \ p < .05, \) partial \( \eta^2 = .035, \) were significantly associated with the dependent variable. As predicted, sentence comprehension was not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for gender, whether participants were born in the United States, or whether English was their first language. Also contrary to predictions, there were no significant interactions. These results are summarized in Table 14.

Table 14. Analysis of Covariance of the Digit Span Backward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>( F )</th>
<th>partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>6.83*</td>
<td>.025</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>9.57*</td>
<td>.035</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.71</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>.16</td>
<td></td>
</tr>
<tr>
<td>Born in the US</td>
<td>1</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>English as First Language</td>
<td>1</td>
<td>1.98</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US</td>
<td>1</td>
<td>.34</td>
<td></td>
</tr>
<tr>
<td>Gender x English as First Language</td>
<td>1</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Born in the US x English as First Language</td>
<td>1</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US x English as First Language</td>
<td>1</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>263</td>
<td>.93</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *\( p < .05. \)
Hypothesis 15. There will be a significant difference in complex verbal working memory (as measured by the RST task) between men and women, those who were or were not born in the United States, and those whose first language was or was not English after accounting for vocabulary, general intelligence, and sentence comprehension. A 2 x 2 x 2 between-subjects ANCOVA was conducted with RST as the dependent variable. Gender, whether participants were born in the United States, and whether English was their first language were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Since Levene’s test for equality of variances was found to be violated, F(7, 262) = 4.38, p < .05, equality of variance was not assumed. Contrary to predictions, vocabulary, F(1, 259) = 4.21, p < .05, partial $\eta^2 = .016$, was significantly associated with the dependent variable. As predicted, general intelligence was not significantly associated with the dependent variable. Contrary to prediction, sentence comprehension, F(1, 263) = 27.29, p < .05, partial $\eta^2 = .095$, was significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for gender, whether participants were born in the United States, or whether English was their first language. Also contrary to predictions, there were no significant interactions. These results are summarized in Table 15.

| ANCOVA of Similar Languages | Spoken versus Dissimilar Languages Spoken Using All Bilinguals |

Hypothesis 16. There will be a significant difference in phonological short-term memory (as measured by the DSF task) between bilinguals who speak English and Spanish and bilinguals who speak English and a Southeast Asian
Table 15. Analysis of Covariance of the Reading Span Test Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>4.21*</td>
<td>.016</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>27.29*</td>
<td>.095</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>Born in the US</td>
<td>1</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>English as First Language</td>
<td>1</td>
<td>.62</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US</td>
<td>1</td>
<td>2.31</td>
<td></td>
</tr>
<tr>
<td>Gender x English as First Language</td>
<td>1</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>Born in the US x English as First Language</td>
<td>1</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Gender x Born in the US x English as First Language</td>
<td>1</td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>259</td>
<td>129.31</td>
<td></td>
</tr>
</tbody>
</table>

Note. * p < .05.

language after accounting for vocabulary, general intelligence and sentence comprehension. A between-subjects ANCOVA was conducted with DSF as the dependent variable. Whether bilinguals speak similar languages (English and Spanish) or dissimilar languages (English and a Southeast Asian language) was the independent variable. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to prediction, vocabulary was significantly associated with the dependent variable, F(1, 139) = 5.96, p < .05, partial η² = .041. As predicted, general intelligence and sentence comprehension were not significantly associated with the dependent variable. Contrary to prediction, there was not a significant main effect for similar versus dissimilar languages spoken. These results are summarized in Table 16.
Table 16. Analysis of Covariance of the Digit Span Forward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>5.96*</td>
<td>.041</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>Similar/Dissimilar Languages Spoken</td>
<td>1</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>139</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05.

Hypothesis 17. There will be a significant difference in complex verbal working memory (as measured by the DSB task) between bilinguals who speak English and Spanish and bilinguals who speak English and a Southeast Asian language after accounting for vocabulary, general intelligence, and sentence comprehension. A between-subjects ANCOVA was conducted with DSB as the dependent variable. Whether bilinguals speak similar languages (English and Spanish) or dissimilar languages (English and a Southeast Asian language) was the independent variable. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to prediction, vocabulary was significantly associated with the dependent variable, F(1, 139) = 8.39, p < .05, partial η² = .057. As predicted, general intelligence and sentence comprehension were not significantly associated with the dependent variable. Contrary to prediction, there was not a significant main effect for similar versus dissimilar languages spoken. These results are summarized in Table 17.

Hypothesis 18. There will be a significant difference in complex verbal working memory (as measured by the RST) between bilinguals who speak English
Table 17. Analysis of Covariance of the Digit Span Backward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>8.39*</td>
<td>.057</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>3.68</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>Similar/Dissimilar Languages Spoken</td>
<td>1</td>
<td>3.02</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>139</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. * p < .05.

and Spanish and bilinguals who speak English and a Southeast Asian language after accounting for vocabulary, general intelligence, and sentence comprehension. A between-subjects ANCOVA was conducted with RST as the dependent variable. Whether bilinguals speak similar languages (English and Spanish) or dissimilar languages (English and a Southeast Asian language) was the independent variable. Vocabulary, general intelligence, and sentence comprehension were the covariates. As predicted, vocabulary and general intelligence were not significantly associated with the dependent variable. As predicted, sentence comprehension was significantly associated with the dependent variable F(1, 136) = 24.78,  p < .05, partial η² = .154. Contrary to prediction, there was not a significant main effect for similar versus dissimilar languages spoken. These results are summarized in Table 18.

**ANCOVA of Early versus Late Bilinguals Using All Bilinguals**

**Hypothesis 19.** There will be a significant difference in phonological short-term memory (as measured by the DSF task) between early bilinguals (those who
were brought up in a bilingual home) and late bilinguals (those who learned a second language through schooling later in life) after accounting for vocabulary, general intelligence and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with DSF as the dependent variable. When the second language was learned (early or late bilinguals) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to predictions, one of the covariates, vocabulary, $F(1, 165) = 8.19$, $p < .05$, partial $\eta^2 = .047$, was significantly associated with the dependent variable. As predicted, general intelligence and sentence comprehension were not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for when the second language was learned or ethnic/racial group. Also contrary to prediction, there was not a significant when the second language was learned by ethnic/racial group interaction on the DSF. These results are summarized in Table 19.

**Hypothesis 20.** There will be a significant difference in complex verbal working memory (as measured by the DSB task) between early bilinguals and late
Table 19. Analysis of Covariance of the Digit Span Forward Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>8.19*</td>
<td>.047</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td>When L2** was Learned</td>
<td>1</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>When L2** was Learned x Ethnic/Racial Group</td>
<td>2</td>
<td>.91</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>165</td>
<td>.80</td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$.  
** L2 meaning second language

bilinguals after accounting for vocabulary, general intelligence and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with DSB as the dependent variable. When the second language was learned (early or late bilinguals) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. Contrary to predictions, two of the covariates, vocabulary, $F(1, 165) = 9.90$, $p < .05$, partial $\eta^2 = .057$, and general intelligence, $F(1, 165) = 5.50$, $p < .05$, partial $\eta^2 = .032$, were significantly associated with the dependent variable. As predicted, sentence comprehension was not significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for when the second language was learned or ethnic/racial group. Also contrary to prediction, there was not a significant when the second language was learned by ethnic/racial group interaction on the DSB. These results are summarized in Table 20.
Hypothesis 21. There will be a significant difference in complex verbal working memory (as measured by the RST) between early bilinguals and late after accounting for vocabulary, general intelligence and sentence comprehension. A 2 x 3 between-subjects ANCOVA was conducted with RST as the dependent variable. When the second language was learned (early or late bilinguals) and ethnic/racial group (Caucasian, Mexican, or Southeast Asian) were the independent variables. Vocabulary, general intelligence, and sentence comprehension were the covariates. As predicted, vocabulary and general intelligence were not significantly associated with the dependent variable. Contrary to prediction, one of the covariates, sentence comprehension, F(1, 162) = 22.60,  p < .05, partial $\eta^2 = .122$, was significantly associated with the dependent variable. Contrary to predictions, there was not a significant main effect for when the second language was learned or ethnic/racial group. Also contrary to prediction, there was not a significant when the second language was learned by
ethnic/racial group interaction on the RST. These results are summarized in Table 21.

Table 21. Analysis of Covariance of the Reading Span Test Using the Entire Sample

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>1.58</td>
<td></td>
</tr>
<tr>
<td>General Intelligence</td>
<td>1</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>1</td>
<td>22.60*</td>
<td>.122</td>
</tr>
<tr>
<td>When L2** was Learned</td>
<td>1</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>2</td>
<td>2.42</td>
<td></td>
</tr>
<tr>
<td>When L2** was Learned x Ethnic/Racial Group</td>
<td>2</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>162</td>
<td>123.73</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *p < .05.*

** L2 meaning second language

Multiple Regressions Using the Entire Sample: Those Who Were Born (Or Not Born) in the United States and English was (Or was Not) Their First Language

Hypothesis 22. The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the second language was learned will predict phonological short-term memory (as measured by the DSF task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict phonological short-term memory (as measured by the DSF task). A multiple regression was conducted predicting performance on the DSF task from the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first
language, when the second language was learned, age, gender, vocabulary, general intelligence, and sentence comprehension. As predicted, the regression was significant, \( F(10, 163) = 3.01, p < .05, R^2 = .16 \). Contrary to prediction, number of languages spoken, born in United States, English as their first language, and when the second language was learned were not significant predictors of the dependent variable. As predicted, ethnic/racial group, \( \beta = .18, t(163) = 2.0, p < .05 \), was a significant predictor. As predicted, age, gender, general intelligence, and sentence comprehension were not significant predictors. Contrary to prediction, vocabulary, \( \beta = .20, t(163) = 2.21, p < .05 \), was a significant predictor. These results are summarized in Table 22.

Table 22. Multiple Regression of the Digit Span Forward Using the Entire Sample

<table>
<thead>
<tr>
<th>Model</th>
<th>( \beta )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>.09</td>
<td>1.21</td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>.18</td>
<td>1.98*</td>
</tr>
<tr>
<td>Born in the United States</td>
<td>-.03</td>
<td>-.33</td>
</tr>
<tr>
<td>English as First Language</td>
<td>-.14</td>
<td>-1.66</td>
</tr>
<tr>
<td>When Second Language was Learned</td>
<td>.14</td>
<td>1.72</td>
</tr>
<tr>
<td>Age</td>
<td>.05</td>
<td>.68</td>
</tr>
<tr>
<td>Gender</td>
<td>-.03</td>
<td>-.34</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.20</td>
<td>2.21*</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>.10</td>
<td>1.22</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>.06</td>
<td>.73</td>
</tr>
</tbody>
</table>

*Note. * \( p < .05 \).
Hypothesis 23. The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the second language was learned will predict complex verbal working memory (as measured by the DSB task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict complex verbal working memory (as measured by the DSB task). A multiple regression was conducted predicting performance on the DSB task from the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, when the second language was learned, age, gender, vocabulary, general intelligence, and sentence comprehension. As predicted, the regression was significant, $F (10, 163) = 3.43, p < .05, R^2 = .17$. Contrary to prediction, number of languages spoken, born in United States and when the second language was learned were not significant predictors of the dependent variable. As predicted, two of the variables, ethnic/racial group, $\beta = .20, t(163) = 2.25, p < .05$, and English as the first language, $\beta = -.18, t(163) = -2.08, p < .05$, were significant predictors. As predicted, the variables: age, gender, and sentence comprehension were not significant predictors. Contrary to predictions, vocabulary, $\beta = .23, t(163) = 2.62, p < .05$, and general intelligence, $\beta = .20, t(163) = 2.47, p < .05$, were significant predictors. These results are summarized in Table 23.

Hypothesis 24. The variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, and when the second language was learned will predict complex verbal working memory (as measured by the RST task). The variables: gender, age, vocabulary, general intelligence, and sentence comprehension will not predict complex verbal working memory (as measured by the RST). A multiple regression was conducted
Table 23. Multiple Regression of the Digit Span Backward Using the Entire Sample

<table>
<thead>
<tr>
<th>Model</th>
<th>β</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>.06</td>
<td>.87</td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>.20</td>
<td>2.25*</td>
</tr>
<tr>
<td>Born in the United States</td>
<td>-.10</td>
<td>-1.24</td>
</tr>
<tr>
<td>English as First Language</td>
<td>-.18</td>
<td>-2.08*</td>
</tr>
<tr>
<td>When Second Language was Learned</td>
<td>.05</td>
<td>.62</td>
</tr>
<tr>
<td>Age</td>
<td>.05</td>
<td>.61</td>
</tr>
<tr>
<td>Gender</td>
<td>-.01</td>
<td>-.07</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.23</td>
<td>2.62*</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>.20</td>
<td>2.47*</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>-.12</td>
<td>-1.37</td>
</tr>
</tbody>
</table>

*Note. * p < .05.

predicting performance on the RST task from the variables: number of languages spoken, ethnic/racial group, born in the United States, English as their first language, when the second language was learned, age, gender, vocabulary, general intelligence, and sentence comprehension. As predicted, the regression was significant, F (10, 160) = 8.81, p < .05, R² = .36. As predicted, number of languages spoken, β = .16, t(160) = 2.46, p < .05, ethnic/racial group, β = -.19, t(160) = -2.33, p < .05, and English as their first language, β = -.16, t(160) = -2.02, p < .05, were significant predictors of the dependent variable. Contrary to predictions, born in the United States and when the second language was learned were not significant predictors. As predicted, age, gender, vocabulary, and general intelligence were not significant predictors. Contrary to prediction, sentence
comprehension, $\beta = .36$, $t(160) = 4.75$, $p < .05$, was a significant predictor. These results are summarized in Table 24.

Table 24. Multiple Regression of the Reading Span Test Using the Entire Sample

<table>
<thead>
<tr>
<th>Model</th>
<th>$\beta$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages Spoken</td>
<td>.16</td>
<td>2.46*</td>
</tr>
<tr>
<td>Ethnic/Racial Group</td>
<td>-.19</td>
<td>-2.33*</td>
</tr>
<tr>
<td>Born in the United States</td>
<td>.05</td>
<td>.76</td>
</tr>
<tr>
<td>English as First Language</td>
<td>-.16</td>
<td>-2.02*</td>
</tr>
<tr>
<td>When Second Language was Learned</td>
<td>-.04</td>
<td>-.49</td>
</tr>
<tr>
<td>Age</td>
<td>-.00</td>
<td>-.04</td>
</tr>
<tr>
<td>Gender</td>
<td>-.11</td>
<td>-1.73</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.07</td>
<td>.94</td>
</tr>
<tr>
<td>General Intelligence</td>
<td>.06</td>
<td>.81</td>
</tr>
<tr>
<td>Sentence Comprehension</td>
<td>.36</td>
<td>4.75*</td>
</tr>
</tbody>
</table>

*Note. * $p < .05$. 
CHAPTER 5: DISCUSSION

Summary of Results

The current study provided additional knowledge of understanding number of languages spoken with respect to phonological short-term memory (STM) and complex verbal working memory (WM). Contrary to predictions and perhaps due to lack of homogeneity of sample, primary analyses showed no significant difference between monolinguals and bilinguals who are Caucasian, Mexican or Southeast Asian after controlling for intelligence, vocabulary and sentence comprehension. Contrary to the current study, Papagno and Vallar (1995) found significant differences with the number of languages spoken and phonological STM. In comparison, the participants in their study were considered a composite of highly motivated students who had good cognitive capacities (Kormos & Safar, 2008). The results of the current study might have differed from the Papagno and Vallar study due to limited opportunities for collecting highly motivated participants with good cognitive capacities. Thus, the lack of significant differences could have resulted from poor sampling. In 2010, 62.5% of Fresno State first time freshmen failed the English Placement Test (EPT). Of the first time freshmen, 80% of the Asian population, 72% of the Hispanic population, and 41% of the Caucasian population failed the EPT (IRAP, 2010). This general lack of college level English skills could help explain the lack of significant findings in the current study. Results indicated that participants in this study have similar phonological processing levels despite differences in the number of languages they speak, and despite differences in their ethnicity/race.

Contrary to predictions, primary analyses indicated a significant relationship between ethnic/racial groups and the covariates: vocabulary, general
intelligence and sentence comprehension. Tukey’s post hoc procedure indicated that Caucasians scored significantly higher than Southeast Asian-Americans in vocabulary. Caucasians also scored significantly higher than Mexican-Americans in general intelligence. Finally, Caucasians scored significantly higher than Mexican-Americans and Southeast Asian-Americans in sentence comprehension. These results are consistent with IRAP reporting of test scores within these populations, and imply that ethnicity/race of participants is important to consider when examining vocabulary, general intelligence and sentence comprehension. Perhaps different ethnic/racial groups could have scored higher if the tasks were in their native language, instead of English. This might have been a problem especially on the vocabulary and sentence comprehension task where the vocabulary words and sentences might have been unfamiliar to Mexican-Americans and Southeast Asian-Americans, whereas they might have been more familiar to Caucasians. But, it should also be noted that while significant differences were found, the effect sizes were extremely small. Thus, significant differences could be due to large sample sizes rather than actual differences.

Although secondary analyses further analyzed all of the participants in the current study by including those who were or were not born in the United States (primary analyses only examined participants born in the United States), and including participants whose first language (L1) was English and those whose L1 was not English (primary analyses only examined participants whose L1 was English), results in secondary analyses echoed primary analyses.

Secondary analyses also examined the bilingual sample, and explored possible predictors of phonological STM and complex verbal WM. Contrary to predictions, there was no significant difference within the bilingual sample when exploring bilinguals who speak English and Spanish versus bilinguals who speak
English and a Southeast Asian language. The similarity effect did not seem to influence participants in the current study when examining similar versus dissimilar bilinguals. A possible explanation of no significant difference could be the lack of an efficient examination of balanced bilingualism, proficiency in both languages (Girbau & Schwartz, 2008). It would be interesting if examining differences between similar and dissimilar bilinguals would provide better results if a pre-balanced bilingualism test was administered prior to conducting analyses. Instead of a pre-balanced bilingualism test, the current study had participants self-report how they felt about their fluency in their first and second languages.

There was also no significant difference between early bilinguals (those who were brought up in a bilingual home) versus late bilinguals (those who learned a second language [L2] through schooling later in life). Although previous research has shown that it is more likely for early bilinguals to perform better than late bilinguals because the chance of bilinguals’ L1 and L2 influencing each other are low in early bilinguals (Walley & Flege, 1999), this did not hold true for the current study. As Girbau and Schwartz (2008) stated, variation in bilingual proficiency is different across different ethnic/racial groups across the United States. Thus, Girbau and Schwartz suggested looking at other factors such as language instruction at school versus language instruction from home, language spoken at home and with friends, if there were any language deficits, participants’ socioeconomic status (SES), and the amount of time participants were exposed to the languages they speak. It would be interesting to see the results after these factors were taken into account prior to examining differences between early and late bilinguals. However, that data was not collected in the current study.

Finally, secondary analyses used multiple regression to examine the predictive capability of the IVs and covariates on phonological STM and complex
verbal WM. As predicted, ethnic/racial group was a significant predictor for all three memory tasks. In addition, whether or not English was participants’ L1 was a significant predictor of memory for the digit span forward (DSF; which measured phonological STM) and the digit span backward (DSB; which measured complex verbal WM). Finally, the number of languages spoken (monolingual/bilingual) was a significant predictor of the Reading Span Test (RST; which measured complex verbal WM).

Investigation of ethnic/racial group, English as the L1 and the number of languages spoken is important when examining memory in order to understand why there are differences in performance on a wide variety of tasks. By exploring ethnic/racial group, researchers can predict which memory task certain ethnic/racial groups perform better (or worse) on. This is helpful for researchers when they have to administer tasks to specific ethnic/racial groups. Considering whether English was participants’ L1 is very important because poor scores might be a result of participants not understanding or comprehending tasks that are not in their native and more proficient language. Finally, the number of languages a person speaks is a predictor of the RST and thus, a predictor of performance on complex verbal WM tasks. This is important in the field of linguistic ability and memory because it demonstrates how being monolingual or bilingual might have advantages (or disadvantages) when memory is a required task.

However, it should be noted that although these variables were significant predictors, the regression equation might have been significant because, like correlations, regressions are very sensitive to large sample size (Hays, 1994). Thus, the current study could have had different results in the regression analyses than in the ANCOVA and ANOVA analyses solely because of the large sample size and not because of a true difference or relationship.
In summary, the results of this study did not mirror Papagno and Vallar’s (1995) findings. This difference could be the result of many factors. First, the tasks used in both studies were not exactly the same. Papagno and Vallar measured phonological STM, and in the current study, more reliable and valid complex tasks to measure WM (DSB and RST) were used in addition to measuring phonological STM. Also, general intelligence was measured using an updated version of Raven’s Progressive Matrices in the current study, versus Raven’s 1938 Progressive Matrices that was used by Papagno and Vallar. Also, Papagno and Vallar examined vocabulary knowledge by examining a vocabulary subset of the Wechsler Adult Intelligence Scale, and different vocabulary words from the French-Kit Vocabulary Test (FKVT) were used in the current study.

Second, the populations of interest were different. Papagno and Vallar (1995) examined female Italian non-polyglots versus female polyglots, but the current study examined male and female monolinguals versus bilinguals. It is possible that Papagno and Vallar found significant differences because their population required all of the participants to be fluent in at least two languages, whereas those who were bilingual versus those who were monolingual were examined in the current study. Also, Papagno and Vallar were interested in only female Italian participants, whereas three distinct male and female ethnic/racial populations were examined in the current study providing more external validity by allowing generalization to a larger population. Perhaps there would have been different results if the current study only examined one ethnic/racial group that is close to Italians, and if the current study only observed female participants.

Third, incongruities could be due to differences in motivation and education levels. Participants in the current study were general lower level college students, whereas participants in the Papagno and Vallar (1995) study were
considered highly motivated students with good cognitive capacities. According to Kormos and Safar (2008), participants in the Papagno and Vallar study had already passed their primary and secondary school examinations; one of which was a test measuring the acquisition of foreign languages for polyglots. In addition, all of the participants were final-year university students who were working on their theses. It is possible that Papagno and Vallar found significant differences because of their criteria for highly motivated students, whereas anyone who considered themselves qualified by self-report were included in the current study. Also, most of the participants in the current study were from the Introduction to Psychology subject pool, consisting of students who were typically freshmen or sophomores, and not at graduate level working on their theses. Thus, the implication is that participants in the current study cannot be fairly compared to participants in the Papagno and Vallar study.

**Limitations of the Study**

While this study has contributed to the literature on the interaction between working memory and the number of languages spoken, there were some limitations to the study. Criteria such as English as the L1, born in the United States, and parents speaking English and the same L2 limited collecting the goal of at least 30 Hmong monolinguals and 30 Hmong bilinguals. Most Hmong participants did not report English as their L1, and some of the participants were not born in the United States. Thus, they were eliminated from the final sample. It would have been interesting to investigate the difference in phonological STM and complex verbal WM between monolingual and bilingual Hmong participants due to their lack of written forms of language until recently.
Overall, the size of certain samples was not ideal. Generally speaking, a minimum of 30 participants is expected within any group (Hays, 1994). However, there were less than 30 Southeast Asian bilinguals or monolinguals (as discussed previously) or Caucasian bilinguals. Criteria for Caucasian bilinguals included those who spoke English and either Spanish or French as a second language. Unfortunately, there were not many students in the Introduction to Psychology subject pool who fit these criteria.

It would be better to collect students from a different subject pool where the three ethnic/groups met criteria for the study. That is, although 305 participants were recruited, only 135 were used when testing the primary hypotheses. One hundred and seventy participants were eliminated from the primary analyses in order to control for group membership and other criteria. In spite of Fresno State having a rich diversity of potential participants, controlling participants based on certain criteria made recruitment of participants very challenging.

There were also methodological limitations. First, long testing sessions might have caused fatigue in participants toward the latter part of the study. That is, fatigue might have influenced poor scores on the RST. Overall, looking at less ethnic/racial groups, setting better criteria for inclusion and exclusion of participants, and having better methodology should be considered for future studies.

When analyzing the bilingual sample, there were a few limitations that should be addressed in future studies. First, when examining similar bilinguals (bilinguals who speak English and Spanish) versus dissimilar bilinguals (bilinguals who speak English and a Southeast Asian language), a balanced bilingualism test should be administered. As stated above, self-report of how participants felt about their fluency in their first and second languages should be
replaced with a valid test measuring their proficiency in both languages. Second, when examining early bilinguals (those who were brought up in a bilingual home) versus late bilinguals (those who learned a L2 through schooling later in life), it is also important to measure participant’s proficiency in their L1 and L2 prior to conducting analyses. In addition, other limitations for this analysis could be lack of controlling other information such as: language instruction at school, language instruction from home, language spoken at home and with friends, if there were any language deficits, participants’ SES, and the amount of time participants were exposed to the languages they speak (Girbau & Schwartz, 2008).

**Future Directions**

While this study contributes some interesting results regarding WM and language learning, future studies need to be conducted to further investigate this relationship. Because Papagno and Vallar (1995) found significant differences between non-polyglots and polyglots, it would be interesting to conduct future studies comparing those who speak two languages versus those who speak more than two languages as well. It would be interesting to collect data from participants who are multilingual and compare them to the bilingual groups of the current study to see if similar results to the Papagno and Vallar study are possible.

For other future studies, it would be better to focus on fewer ethnic/racial groups. It is possible that by focusing on fewer ethnic/racial groups, researchers could have had more power for each group. In addition, it would be noteworthy to further investigate the Southeast Asian population because there are several distinct nationalities within Southeast Asia. For example, it would be interesting to compare the Hmong population to the Vietnamese population because both groups use a Romanized alphabet system (Wright, 2002) but one has had a written
language for much longer than the other. Furthermore, future studies could explore whether there is a significant difference between the Hmong and Laotian populations, because many Hmong come from the same country as Laotians (Laos), but unlike Hmong, Laotians use an Indian Sanskrit writing script (Rogers, 1999).

With the RST recognized as the most prominent and frequently used WM assessment (Whitney et al., 2001), there is still a lot of room for further investigation of this task. The current study used the total words scoring method discussed in chapter 2 of this paper. Future studies could examine data from the current study by using different scoring methods, such as proportion words, correct set words, or truncated span. Fortunately, the complexity of the RST, as well as the diversity of participants in the current study, allows for many directions for future studies.

Future studies should also explore significant relationships between phonological STM and complex verbal WM with the covariates: vocabulary, general intelligence and sentence comprehension. Unlike the Papagno and Vallar (1995) study, the current study found several significant relationships between the memory task and the three covariates. Researches should examine why there might be a consistent relationship with the covariates. Although the current study was thorough in examining its primary hypotheses and furthering the study with the inclusion of secondary analyses, there is still room for more analyses and evaluation of the 305 participants and their performance on six tests.

**Implications of the Study**

Investigation of WM is important in cognitive psychology in order to understand why there are differences in performance on a wide variety of tasks. In
fact, Guigon and Burnod (1995) stated there is hardly any task that does not
involve STM, making it a fundamental component of cognition. In addition,
exploring how other variables such as the number of languages spoken,
vocabulary, general intelligence, and sentence comprehension can influence
performance on WM is important in cognitive psychology. In this study, there
was no significant difference between monolinguals or bilinguals. These results
indicate that participants might have similar phonological processing. With
similar phonological processing, this study supports previous studies by showing
no compromising of performance on memory task despite concerns and previous
beliefs that bilinguals who have early exposure to two languages might have
problems with linguistic knowledge. Bilinguals are capable of performing just as
well as monolinguals if not better, as Papagno and Vallar (1995) found. Results of
the current study also support the Kovelman et al. (2008) study by dispelling
previous beliefs that bilinguals who have had early exposure to two languages
might have language confusion, or even life-long problems with linguistic
knowledge. Because there was no significant differences, bilinguals did not have
language confusion and thus, could not have scored lower than monolinguals.

There were several results indicating a significant relationship between the
memory tasks and the covariates, vocabulary, general intelligence and sentence
comprehension. The consistent relationship between the dependent variables and
the covariates leaves room for a lot of implications. For example, why was
vocabulary more significantly associated with the memory task than general
intelligence and sentence comprehension? Also, are monolinguals better at certain
tasks as measured by the covariates than bilinguals?

Unlike the Papgno and Vallar (1995) study, the current study found
significant association between vocabulary and working memory tasks. Perhaps
efficient memory for learning words is due to having a larger English vocabulary (Cain et al., 2004). Bialystok and Feng (2009) stated that vocabulary plays an important role in verbal performance and memory, perhaps this explains the consistent relationship between the dependent variables and vocabulary. Second, Bialystok and Feng found that bilinguals scored lower than monolinguals in vocabulary. This helps to answer the question of monolinguals having a better vocabulary than bilinguals. However, while bilinguals perform lower than monolinguals, Bialystok and Feng stated that bilinguals compensate for their weaker language proficiency by scoring the same on memory tasks. As for the current study, there was no significant difference between monolinguals and bilinguals in vocabulary, thus, further analyses could not be conducted to compare results to Bialystok and Feng’s study.

The current study also found significant association between general intelligence and the memory task in several analyses. Although Ross et al. (2002) stated that language learning aptitude has been found to be independent of general intelligence, it is important to examine the significant relationship between general intelligence and phonological STM and complex WM in the current sample. It would be interesting to further analyze the relationship of general intelligence and phonological STM and complex verbal WM with the rich sample of participants in the current study; especially because Raven’s APM is a test designed to counter criticisms of an intelligence test relying on language, education and cultural factors (Grieve & Viljoen, 2000).

Contrary to predictions, it was not surprising that sentence comprehension was significantly associated with the RST in all of the analyses. It seems reasonable that participants’ performance was dependent on whether or not they correctly comprehended the sentences in the RST. Perhaps the ability of building
mental structures of the sentences being read helped participants when they were required to recall the last words of each sentence. In addition, participants may have had an easier time building structures of the sentences by enhancement of relative information and or suppression of irrelevant information while recalling the last words of each sentence. It would be interesting to further analyze the relationship of this covariate and complex verbal WM when it is measured by the RST because sentence comprehension was significantly associated with the RST in all of the analyses, and it was only occasionally associated with complex verbal WM and never phonological STM.

**Difference between Ethnic/Racial Groups**

The current study showed a significant difference among ethnic/racial groups in vocabulary, general intelligence and sentence comprehension. This implies that ethnic/racial group is a very important factor when measuring vocabulary, general intelligence and sentence comprehension. For all three, the current study showed that Caucasians scored significantly higher than Mexicans and Southeast Asians, consistent with IRAP’s reports on other standardized tests taken by Fresno State students. This leaves room for a lot of interpretation. For example, although the current study controlled for having English as a first language, will the results still be the same if Mexicans were allowed to take the test in Spanish and Southeast Asians were allowed to take the tests in their Southeast Asian language? According to Girbau and Schwartz (2008), tasks such as the non-word repetition task that measure WM have been created in several different languages including Spanish because of results in studies indicating phonological working memory and information processing are less efficient in L2 than L1 (Ardila, 2003). Girbau and Schwartz suggested that it is very important to
consider allowing students to take tests in the language they are most familiar with.

In addition, in order to fairly say that Caucasians perform better than Mexicans and Southeast Asians on the memory task after Mexicans and Southeast Asians have the opportunity to take the task in the language they are most familiar with for future studies, it is also important to consider other external variables. Girbau and Schwartz (2008) stressed the importance of considering other factors such as language instruction at school. This is important to consider especially due to lack of educational training for certain participants who come from areas of lower SES.

In conclusion, with a better understanding of differences in memory based on the number of languages spoken, we can understand how people perform on tasks by using verbal communication to recall information (Engle, 2010). Examining working memory differences also helps us understand ourselves by exploring performance on everyday tasks such as recalling information at home for domestic purposes, recalling information at school for academic purposes, or recalling information in social settings for personal relationship purposes. The implications of this study support the exploration of WM, the number of languages spoken and their interaction in order to better understand cognition and ourselves.
REFERENCES
REFERENCES


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APPENDIX A: PRE-SCREENING MEASURE
Pre-Screening Measure

Are you Caucasian, Hispanic or Southeast Asian?

If NO ➞ Tell them they are not eligible for this study.

CAUCASIAN

Do you consider yourself bilingual?

If YES ➞ Eligible.
If NO ➞ Not eligible.

HISPANIC

Do you speak only English fluently or Do you speak both English and Spanish as a result of your family speaking both fluently?

If YES for either ➞ Eligible.
If NO ➞ Not eligible.

SOUTHEAST ASIAN

Do you speak only English fluently or Do you speak both English and a second language as a result of your family speaking both fluently?

If YES for either ➞ Eligible.
If NO ➞ Not eligible.
APPENDIX B: INFORMED CONSENT FORM
INFORMED CONSENT

You are invited to participate in a study conducted under the auspices of Dr. Jennifer L. Ivie and the Department of Psychology, California State University, Fresno (CSUF). The principal investigator is Mary Vongsackda. The study is entitled, Working Memory Differences between Monolinguals and Bilinguals. If you decide to participate in this study, please carefully read the information provided below prior to signing the consent form. This document describes the study and your rights as a participant in this research.

1. **Description of Research:** This study is designed to further explore the correlation between working memory and language skills. Your name will not be on any of the forms on which you answer these questions, so confidentiality and the absolute security of the answers you provide are completely assured. However, you do not have to answer any question you do not want to, and you may withdraw from the research without penalty at any time.

2. **Risks and Discomforts to the Research Participants:** There is minimal risk to research on this project. No other discomforts or hazards associated with this research have been identified.

3. **Benefits to Research Subjects:** We cannot guarantee the research participant will receive any benefits from participating in this study. But everyone who helps with this work will be contributing directly to the body of knowledge concerning working memory and language skills.

4. **Alternative Procedures:** No disease or dysfunction will be treated, so alternative procedures are not applicable.

5. **Confidentiality of Research Data:** Absolute confidentiality of data and records will be maintained. Names will not be maintained with data protocols, and informed consent forms will be kept separate from data. All raw data and forms will be kept under locked secure conditions and destroyed five years after collection.

6. **Compensation of Research Subjects:** N/A

7. **Information Resources Available to Research Subjects:**
   - Questions Regarding the Nature of the Research: Mary Vongsackda - 559.486.0469 or Dr. Jennifer L. Ivie - 559.278.2083.
   - Questions Regarding the Rights of Research Subjects the CSUF Committee on the Protection of Human Subjects: 559.278.2083
   - Questions Regarding Research-Related Injuries: There should be no danger of such injuries, but any such enquiries should be directed to Mary Vongsackda or the Committee on the Protection of Human Subjects.

8. Over the 2009 course of this year, between 150-180 volunteers, depending on initial results, are expected to participate.

9. Your participation in this project is completely voluntary. Your decision whether or not to participate will not prejudice your future relations with CSUF. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. The Human Research Committee of the CSUF Department of Psychology has reviewed and approved the procedures for the present research.

10. You may have a copy of this form to keep.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE, HAVING READ THE INFORMATION PROVIDED ABOVE.

Participant’s Name (Please Print) _________________________________________________________

Date___________   Participant’s Signature__________________________________________________

Project Director’s Signature (Mary Vongsackda) _____________________________________________
APPENDIX C: DEMOGRAPHIC QUESTIONNAIRE
Demographic Questionnaire

1. What is your age? ___________

2. What is your sex?
   a. Male
   b. Female

3. What is your ethnicity?
   a. African American
   b. American Indian or Alaska Native
   c. Asian American
   d. Caucasian
   e. Hispanic/Latin origin
   f. Native Hawaiian or Pacific Islander
   g. Other (Please specify) ____________________

4. Please indicate which group you identify with the most (e.g., Mexican, Hmong, etc.).
   a. Caucasian
   b. Mexican
   c. Hmong
   d. Other (Please specify) ____________________

5. What is your current major(s)?
   ________________________________

6. Please indicate your student status:
   a. Psychology 10 student
   b. Upper division student
   c. Graduate student
   d. Other _____________________________
7. Were you born in the United States?
   a. Yes
   b. No

8. Is English your first language (that is, is English your native language)?
   a. Yes
   b. No, my first language is ____________________________

9. Do you consider yourself bilingual (that is, do you speak and/or write more than one language fluently)?
   a. Yes
   b. No (please skip the following questions)

10. How many languages do you speak fluently? ________

11. How many languages do you write fluently? ________

12. Please indicate which language(s) you speak fluently and circle your fluency based on the following scale (1 = somewhat fluent to 5 = very fluent).

   Language(s) you speak fluently..................Rating of fluency......

   __________________...............................1  2  3  4  5
   __________________...............................1  2  3  4  5
   __________________...............................1  2  3  4  5
13. Please indicate which language(s) you write fluently and rate your fluency based on the following scale.

Language(s) you write fluently ............. Rating of fluency ........

_____________________________ .......................... 1 2 3 4 5
_____________________________ .......................... 1 2 3 4 5
_____________________________ .......................... 1 2 3 4 5

14. How did you learn the second language (Please circle all that apply)?
   a. Since I was born (Please skip the following question)
   b. From courses I took during junior high school
   c. From courses I took during high school
   d. From courses I took in college

15. Approximately, how many years have you been studying the second language (Please approximate to the closest year; e.g., 1 year, 2 years, etc.)?
   ________ year(s)
California State University, Fresno

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California State University, Fresno will clearly identify your name as the author or owner of the submission and will not make any alteration, other than as allowed by this license, to your submission. By typing your name and date in the fields below, you indicate your agreement to the terms of this distribution license.

Mary Vongsackda

Type full name as it appears on submission

04-29-11

Date