EFFECTS OF BILINGUALISM ON NOVEL WORD LEARNING IN VARIABLE CONTEXTS

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This study examined the bilingual advantage at novel word learning in variable contexts, including different language, minimal pair, and background frequency conditions. Participants included English monolinguals and Telugu-English bilinguals. These participants were tested on the same novel word learning task in three artificial languages with sounds from Ewe (English-like), Khmer (Telugu-like), and Arabic (Foreign). In the learning block of these languages, background frequency was manipulated so that each object was paired with a frequent and infrequent background. Participants were tested using a forced-choice procedure, with objects in either a minimal pair or non-minimal pair condition. Bilingual participants also completed the Language Experience and Proficiency Questionnaire in order to determine differences in their proficiency. Results showed that bilingual individuals have an advantage in mean accuracy at novel word learning of words with marked and foreign phonetic contrasts, supporting a combination of both the language-universal and bilingual cognitive theories of bilingual advantages in novel word learning and phonological awareness. Additionally, results showed a greater cost in reaction time in the marked language contrast in bilingual individuals compared to monolingual individuals. This suggests that bilingual individuals have a greater tendency to sacrifice time for accuracy. There was no relationship between mean accuracy or reaction time and background frequency or speaking and understanding proficiency. These variables may not have been salient enough to result in distinct differences in the dependent variables.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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1.0 INTRODUCTION

In several ways, an individual who grows up bilingual experiences the world differently from someone who grows up monolingual. Individuals who grow up bilingual are confronted with two different language systems to reconcile from the start of their language learning journey. As they grow, they are expected to know which language is being spoken to them and suppress the other language. When they speak, they must be sure to choose words from the correct language. On the other hand, a monolingual person has only one set of words and sounds with which to communicate. The various implications of these differences have been studied in psycholinguistic research. For example, bilingual individuals appear to have advantages in executive functioning, including more efficient conflict monitoring, cognitive control, active inhibition, and learning of symbolic information (Abutalebi et al., 2012; Blumenfeld & Adams, 2014; Costa et al., 2008). In the linguistic domain, it also appears bilingual individuals have an advantage compared to monolingual individuals, demonstrating better performance on metalinguistic tasks, enhanced phonological awareness, and more accurate novel word learning (Antoniou et al., 2015; Galabmos & Goldin-Meadow, 1990; Kaushanskaya & Marian, 2009).

Nonetheless, research is still conflicted about the source and extent of the bilingual advantage. Although it appears that bilingual individuals have a robust advantage at novel word learning, it is unclear what the source of that advantage is (Kaushanskaya and Marian, 2009; Nair et al., 2016; Papagno and Vallar, 1995). Researchers have suggested that enhanced phonological awareness could be the source of this word learning advantage; however, the nature of the phonological awareness advantage has not been sufficiently researched (Antoniou et al., 2015). In addition, little research has been done examining the use of active inhibition during verbal tasks in bilingual individuals, so it is unclear if that cognitive difference contributes to the novel word learning advantage. Finally, it is unclear if there is a relationship between the strength of bilingual proficiency and the nature of the bilingual advantage.

Thus, the bilingual advantage in novel word learning and phonological awareness, and the enhanced ability to actively inhibit irrelevant information, along with bilingual proficiency are particularly relevant to the current study. The goals of the present study are to determine the role of phonological awareness and the role of domain-general active inhibition in aiding the novel word learning advantage in bilingual individuals, as well as to assess the relationship between the strength of bilingual proficiency on novel word learning performance.

1.1 NOVEL WORD LEARNING ADVANTAGE

Novel word learning is the ability to acquire new words. Robustly, previous research has shown that bilingual individuals have an advantage for novel word learning (Papagno & Vallar, 1995; Kaushanskaya & Marian, 2009a; Kaushanskaya and Rechtzigel, 2012; Nair et al., 2016).

An early study on novel word learning by Papagno and Vallar (1995) investigated vocabulary learning in Italian polyglots versus non-polyglots by using a paired-associate learning test. This examined the participants' ability to acquire novel Russian words. These Russian words were two and three syllables, and they were paired with concrete, high-frequency Italian words. Participants were presented the paired stimuli via auditory presentation, and they were tested via recall. Polyglots displayed a higher learning rate, demonstrated by higher recall, for these nonwords. They also displayed higher short-term memory performance. This led Papagno and Vallar to suggest that the multilingual advantage to novel word learning could be attributed to enhanced phonological memory.

Later studies were more interested in looking at the advantage at novel word learning in early bilingual individuals, or those who learned their second language in a natural environment early in life. In their 2009a study, Kaushanskaya and Marian examined the bilingual advantage in novel word learning in English-Spanish and English-Mandarin bilinguals. The participants learned novel words based on an artificial phonological system constructed with four English phonemes and four non-English phonemes. Participants learned the words by hearing them over headphones and reading their written English translations on a computer screen. They were tested using recall and recognition tasks both immediately after learning and after a one week delay. The results showed a bilingual advantage for all performance measures compared to monolingual participants. Notably, these participants were also given a test of digit-span to assess phonological memory, and both monolingual and bilingual participants scored similarly. Thus, this study could not attribute the bilingual advantage in novel word learning to enhanced phonological memory. Rather, the experimenters posit that it is possible that the bilingual advantage could be a result of enhanced phonological awareness. They suggest that bilingual individuals may encode phonologically unfamiliar information more efficiently than monolingual individuals because of early exposure to two phonological systems. This early exposure may have resulted in a more tolerant adult phonological system in bilingual individuals that can better encode unfamiliar phonological information.

1.1.1 Phonological Awareness

Phonological awareness is the ability to consider and manipulate the components and structures of a language's sounds (Anthony & Francis, 2005). If bilingual individuals have an advantage at this, then this could, in part, explain their advantage at novel word learning. However, previous research has shown mixed results on the effects of bilingualism on phonological awareness.

There has been some research that suggests that bilingual individuals show enhanced phonological awareness through phonetic discrimination tasks (Enomoto, 1994; Kuo et al., 2016). In the 1994 study, Enomoto conducted an experiment that focused on judgments of durational differences between a minimal pair of words /iken/ and /ikken/. These words differed only in their stop gap duration (that is, how long the stop consonant between the vowels lasted). The experiment was conducted with 10 early-level Japanese learning adults, 5 of whom were monolingual, and 5 of whom were bilingual. The individuals with bilingual experience had varied linguistic backgrounds: a couple of speakers knew Italian and English, meaning they spoke a second language where stop gap duration resulted in meaning differences, and the rest of bilingual speakers knew languages in which stop gap duration differences did not alter meaning. The results of this study showed that not only bilingual individuals with specific linguistic experience to the duration contrast, but also any second language linguistic experience, demonstrated increased perceptual performance compared to monolingual participants. In addition, a later study by Kuo et al. (2016) found bilingual groups outperformed monolingual peers on an onset awareness task that measured the detection of a voicing contrast. This was assessed using an odd-man-out task, in which participants listened to three single syllable words and would indicate which one contained a different onset. Bilinguals displayed enhanced performance, suggesting greater phonological awareness.

On the other hand, studies have also been conducted which show no increased sensitivity in bilingual individuals in discrimination of sounds compared to their monolingual peers (Lambert & MacNamara, 1969; Davine et al., 1971). A study by Lambert and MacNamara (1969) examined the differences between French-English bilingual and English monolingual children on a variety of factors, including phonological awareness. To test phonological awareness, they presented 53 pairs of Russian syllables to the children and asked them if the items in the pairs were the same or different. The results of this experiment showed no reliable differences between bilingual and monolingual children. These results suggest that bilingual individuals do not have an advantage at phonological awareness. A couple of years later, however, a similar study found slightly different results. Davine et al. (1971) looked at differences between English monolingual and English-French bilingual children by examining initial phoneme sequences. In this experiment, participants heard two sounds, separated by a delay, and they were asked if the sounds were the same or different. The researchers found that bilingual individuals were more sensitive to sequences that were found in their second language compared to monolingual individuals, but this sensitivity did not generalize to foreign sequences, where they performed similarly to monolingual children.

These mixed findings for phonological awareness advantages in bilinguals suggest that something more complex is happening. Thus, the nature of the bilingual advantage in phonological awareness may be more particular, following the logic of the bilingual cognitive, language specific, or language universal theories.

1.1.1.1 Bilingual Cognitive, Language-Specific, Language-Universal Theories

Research in bilingualism has proposed a few theories to attempt to explain the nature of the phonological awareness advantage in bilinguals (Antoniou et al., 2015).

The broadest theory is the bilingual cognitive theory. This theory posits that just being bilingual aids an individual in acquiring novel words, compared to monolingual peers. This theory is supported by the idea that the general cognitive advantages associated with bilingualism, such as improved cognitive control and active inhibition (discussed further in section 1.2), result in a general advantage at novel word learning. Essentially, cognitive advantages may allow bilingual individuals to focus on the relevant phonological information that they are trying to learn, without conflicting information from their native languages. The theory suggests that this general novel word learning advantage exists regardless of what phonetic feature is being learned because simply being bilingual offers these individuals the cognitive advantages needed to focus on relevant information during word learning. It is consistent with findings by Kaushanskaya and Marian (2009a). In this study, researchers taught novel words with unfamiliar phonemes to English monolinguals, English-Spanish bilinguals, and English-Mandarin bilinguals. They found that both groups of bilinguals had an advantage at learning the novel words, compared to the monolingual group, regardless of the presence of sounds similar to their native languages.

On the other hand, it is possible that if a sound system similar to the native languages of bilingual individuals was used to create stimuli for studies in novel word learning, words with those similar sounds might be easier to learn than others. This idea forms the basis of the language specific theory, which suggests that because bilingual individuals have knowledge of a wider variety of phonetic features, they may be more easily able to learn new, but related, features. Support for the language-specific theory is based in models of speech perception, such as the Native Language Magnet Theory, which is discussed in section 1.1.1.2. The language-specific theory is consistent with findings of Antoniou et al. (2015). In the second half of this study, experimenters recruited English monolinguals, Mandarin-English bilinguals, and Korean-English bilinguals. These individuals were taught two artificial languages, one of which was Mandarin-like and one of which was Korean-like. These artificial languages consisted of phonemes which were unfamiliar to all participants. The researchers found that both bilingual groups showed an advantage for novel word learning in the Mandarin-like language; however, they found that only Korean-English bilinguals showed an advantage for learning novel words in the Korean-like language. This supports the language-specific hypothesis, in that the Korean-English bilingual individuals performed better in a contrast similar to their native language. However, these results are complicated. Because both groups performed similarly well, and better than monolingual participants, on the Mandarin-like language, this offers support to the bilingual cognitive hypothesis, which suggests that simply being bilingual facilitates novel word learning. In addition, although the Korean-English bilingual participants performed better in the Korean-like artificial language, all groups did perform poorly in learning this language in particular. This offers some support for a third hypothesis.

The language universal hypothesis suggests that regardless of linguistic experience (that is, whether one grows up monolingual or bilingual) some phonetic features are inherently easier or harder to learn than others. This could be due to a natural ranking in terms of their perceptual salience or markedness to listeners. Evidence for this hypothesis can be seen in a study on cross-language speech perception in adults by Polka (1991). This study examined English listeners' perception of Hindi retroflex versus dental place of articulation in four different contexts, and it found significant differences in perceptual difficulty between these contrasts. Thus, there is evidence that certain sounds may be intrinsically more difficult to learn than others.

Ultimately, the findings of Antoniou et al. (2015) offer an amalgamation of all three of these theories as an explanation for the bilingual advantage in novel word learning. They suggest that bilingual individuals have a general advantage at novel word learning, supporting the bilingual cognitive hypothesis; however, certain contrasts are harder to learn than others, supporting the language-universal hypothesis, and in these hard contrasts, language-specific experience may aid in learning, supporting the language-specific hypothesis.

1.1.1.2 Native Language Magnet Theory

The native language magnet theory forms the theoretical backing for the language-specific hypothesis of the bilingual advantage in phonological awareness. The theory, proposed by Kuhl (1993), examines the way that people interact with novel phonemes. She provided evidence for the theory by performing a cross-language study with English and Swedish infants. She used the American English vowel /i/ and the Swedish vowel /y/ and created variants of these sounds. These sounds were then presented to the infants, and Kuhl found that American infants found variants of /i/ more similar to the /i/ prototype than Swedish infants, and Swedish infants found variants of the /y/ prototype more similar to the /y/ prototype than American infants. This suggests that native language sounds act as metaphorical magnets when foreign sounds are introduced to a listener. In the case of bilingual individuals, exposure to two languages results in the creation of more native language prototypes that can act as magnets. Thus, when learning novel stimuli, it may be easier for bilingual individuals to learn language-specific information because this novel information can be easily mapped to native language magnet, or prototypical, sounds already in their native phonologies.

1.2 COGNITIVE CONTROL AND ACTIVE INHIBITION

Bilingual individuals have daily experience suppressing irrelevant information when communicating. Because they have two language systems they are able to use, bilingual individuals are forced to suppress irrelevant words when they speak. This practice with suppressing irrelevant information has been shown in research to generalize to greater strength in areas of cognitive control (Costa et al., 2008; Bialystok et al., 2004).

A study done by Costa et al. (2008) examines the generalization of cognitive control in bilinguals, resulting from managing two languages during speech comprehension and production, to their attentional networks by using the attentional network task (ANT). The study was conducted with 100 Spanish-monolingual and 100 Catalan-Spanish bilingual individuals. The ANT is a combination of a reaction time task and the flanker task. This involves participants indicating whether a central arrow points to the right or left, in the presence of two flanker arrows pointing in either the same or different directions. Responses on this task were used to examine executive control. A key finding from this study is that bilingual individuals experienced less interference from incongruent flankers than monolingual individuals. This suggests that bilinguals outperform monolinguals in tasks that require cognitive control, or actively inhibiting unrelated information.

Active inhibition is the ability to ignore irrelevant details, and it appears that bilingual individuals have enhanced active inhibition in both verbal and nonverbal tasks (Bartolotti & Marian, 2012; Bialystok, 1999; Bialystok & Viswanathan, 2009; Green, 1998).

1.2.1 Verbal Tasks

Bilingual individuals appear to display enhanced active inhibition when confronted with certain linguistic tasks. For example, an early 1990 study by Galambos & Goldin-Meadow examined the effects of growing up bilingually on metalinguistic awareness. To test this, the researchers compared 32 Spanish monolingual children, 32 English monolingual children, and 32 Spanish-English bilingual children. The children were told sentences with grammatical errors, and they were to correct the error and explain why the original sentence was incorrect. In the pre-school level of participants, the researchers found that bilingual children were more effectively able to filter out the semantic content of the sentence and focus on syntactic errors. Thus, while many of the pre-school aged monolingual children corrected the sentence "Boy plays with dolls" as "*the girl* plays with dolls," offering a content-oriented response, many of the bilingual children were able to provide the grammar-oriented answer: "*the* boy plays with dolls." These findings suggest that bilingual individuals have an advantage at active inhibition in linguistic tasks, as they are able to effectively ignore semantic information when asked to make syntactic corrections.

Another study looked at enhanced active inhibition in verbal tasks in bilingual individuals during novel word learning. A study by Bartolotti and Marian (2012) examined cross-linguistic interference during language learning. The study consisted of 12 Spanish-English bilingual individuals and 12 monolingual English speakers. These participants were taught an artificial language consisting of 24 words which followed the phonotactic rules of both English and Spanish. The words were then assigned to a picture; however, each translation overlapped phonologically with the English name of another picture. An example of this is the word *acorn* is translated as *shundo*; however, another picture in the stimuli is of a *shovel*. Participants were tested on their learning by being presented with target and distractor word pictures on a screen and being played the target word over headphones. The eye-tracking results for the study show that bilingual individuals looked at competitor pictures less than monolingual individuals. This difference suggests that bilingual individuals have a greater ability to manage cross-language information, or to focus on the relevant task at hand. This requires the skill of active inhibition, which appears strongest in bilingual participants.

It also appears that there are neurological differences between monolingual and bilingual individuals that suggest a bilingual advantage at active inhibition (Marian et al., 2014). This study consisted of 17 Spanish-English bilingual individuals and 18 English monolingual individuals. The experimental task consisted of 20 competitor sets, which comprised of an English target word, a competitor with phonological overall with the onset of the target word, and two filler items with no phonological overlap. An example of the target and competitor are *candy* and *candle*. These stimuli were paired with simple black and white line drawing representations. The results from the fMRI testing in this study showed that bilingual individuals displayed less cortical activation than monolingual individuals during the task. This offers evidence for enhanced abilities at active inhibition as it appears bilingual individuals can "successfully reduce activation of task-irrelevant regions, thereby efficiently modulating sustained attention mechanisms to manage competition" (p. 115). Ultimately, it appears that bilingual individuals have more efficient neural processing when confronted with linguistic competition, offering evidence to support greater active inhibition abilities during verbal tasks.

1.2.2 Nonverbal Tasks

Evidence that bilingual individuals have greater active inhibition abilities in verbal tasks suggests that there is a domain-specific advantage to being bilingual. However, studies have also shown that there could be a domain-general advantage to being bilingual, demonstrated through enhanced active inhibition in nonverbal tasks (Bialystok, 1999; Bialystok & Viswanathan, 2009; Garbin et al., 2010).

A study by Bialystok and Viswanathan (2009) looked at differences in components of executive control, including active inhibition, between bilingual and monolingual children. The study included 30 monolingual English speakers, 30 bilingual children in Canada, and 30 bilingual children in India. The children in this study participated in the faces task. A trial in this task begins with a symmetrical face appearing on the center of a computer screen flanked by two boxes on either side of it. After 1 second, the eyes in the face turn either green or red, and they remain that way for 500ms. The face then disappears, leaving only the boxes on the sides of the screen. After 200ms, an asterisk appears for 150ms in one of the boxes. The children’s task is to press the key on the same side as the box if the eyes had been green and on the opposite side if the eyes had been red. To add complexity to the task, the colored eyes could be looking straight ahead or toward either of the two boxes. Trials in which the eyes looked away from the target response created interference. There was a greater cost associated with presentation trials including gaze shift compared to those with straight eyes in monolingual individuals compared to either of the two bilingual groups. The success of bilingual children to inhibit the desire to select the box that was being looked at in the gaze-shift trials suggests that bilinguals had an advantage in trials with conflict, and their advantage was in the form of demonstrating successful active inhibition of irrelevant stimuli in order to correctly respond to the task at hand.

Another study examined the neurological basis of the bilingual advantage at nonverbal active inhibition (Gabin et al., 2010). The study included 21 Spanish monolingual individuals and 19 Spanish-Catalan bilingual individuals who participated in a non-verbal task switching paradigm. Participants in this experiment were presented with a figure on a white background. The figure could differ in shape (square or circle) and color (red or blue). A written label was presented at the same time as the stimulus, above it, which indicated if participants should pay attention to the shape or color of the figure. Participants had to press one button if the figure was a circle or red, and another button if the figure was a square or blue. In addition, there were two types of trials. Half were non-switch trials, where the target category remained the same successively (shape-shape, or color-color) and half were switch trials where the target category would change (shape-color or color-shape). Although monolingual individuals had slower reaction times for the switch trials, bilinguals did not display a time difference between trials. This suggests that bilingual individuals were able to successively inhibit irrelevant information and focus on the task at hand more efficiently than monolingual individuals. This is supported by the fMRI data in this study. Monolingual individuals had much more widespread brain regions activated than bilingual individuals. Bilingual data showed more specific brain activity, associated with regions linked to bilingual language control. Thus, it appears the practice of active inhibition in bilingual language use could generalize to enhanced active inhibition in nonverbal areas.

1.3 EFFECT OF LEVEL OF PROFICIENCY IN BILINGUAL SPEAKERS

There have been mixed findings on the effect of level of proficiency in bilingualism and the strength of the bilingual advantage on tasks. An understanding of this effect is important because it allows us to understand how much experience an individual must have with a second language in order to display linguistic or cognitive benefits. Intuitively, it would seem that greater experience or skill with a second language would offer more of an advantage in tasks like phonological awareness or active inhibition, as these individuals have more practice dealing with differing phonologies or inhibiting certain information. Nonetheless, research is conflicted on whether a relationship between bilingual proficiency and the magnitude of the bilingual advantage exists.

A study by Bialystok and Barac (2012) found no relationship between level of bilingual proficiency and performance on metalinguistic tasks. The experimenters conducted two studies. The first consisted of a study of 100 children enrolled in a Hebrew immersion school. These children spoke varying languages at home, but they were all taught in Hebrew in school. They were asked to participate in a metalinguistic task called the Wug task, in which they are presented a picture which is named using a nonword, and they were asked to manipulate the nonword according to the morphological rules of English. The second study consisted of 80 children from a French immersion school. These children also spoke varying languages at home, but were all taught French in school. These were asked to participate in a metalinguistic task judging sentence grammaticality. These children were given a sentence and asked to identify if it was syntactically correct, regardless of the sentence's semantic content. In both studies, there was no relationship between the degree of bilingual proficiency and performance on these metalinguistic tasks.

On the other hand, other studies have found conflicting results. A study by Tse and Altarriba (2015) studied bilingual individuals of varying levels of self-rated proficiency and their performance on the Stroop task. The Stroop task involves reading color words written in varying colors of ink, wherein the color of the ink could be congruent or incongruent with the color word. This was administered in separate blocks of asking participants to read just the color word, to name the different inks of color, and then a mixed block. The researchers did find higher proficiency aided bilingual individuals in color naming, resulting in smaller asymmetries between the color naming and word reading tasks; however, there was no advantage for degree of proficiency in the mixed block.

A study specifically examining novel word learning did find a relationship between bilingual proficiency and performance (Nair et al., 2016). This study involved three groups: Tamil-only monolingual individuals, Tamil-English early bilinguals, and Tamil-English late bilinguals. Early bilinguals were individuals who were exposed to their L2 before the age of 5. Late bilinguals were individuals who were introduced to their L2s in school. Late bilinguals had overall significantly lower proficiency scores than early bilinguals. The groups were taught Hindi words and tested using a picture-naming task and identification task. The results showed that bilingual individuals had a novel word learning advantage over monolingual individuals, and that early bilingual individuals (who had higher proficiency) did better at the task than late bilingual individuals.

Thus, these conflicting findings suggest that it is important for future studies to consider level of proficiency and strength of the bilingual advantage. In particular, for this study, it is important to consider level of proficiency of bilingualism because it could influence the nature of the bilingual advantage at novel word learning. It is possible that more proficient bilingual individuals may be better equipped to inhibit irrelevant stimuli and learn phonologically novel information (giving them a greater novel word learning advantage according to the bilingual cognitive hypothesis), or they may be more experienced with their native language contrasts facilitating their learning of phonetically similar but novel sounds (giving them a greater advantage at novel word learning according to the language specific hypothesis).

1.4 SUMMARY

Research that has been done on novel word learning and bilingualism thus far demonstrates clear differences between bilingual and monolingual individuals. Specifically, studies have shown that bilingual individuals have an advantage for novel word learning (Papagno & Vallar, 1995; Kaushanskaya & Marian, 2009a; Kaushanskaya and Rechtzigel, 2012; Nair et al., 2016). Although research for this learning advantage is clear, the mechanism behind it is not. There have been conflicting findings regarding the bilingual advantage in phonological awareness contributing to the novel word learning advantage. There has been mixed evidence supporting the bilingual cognitive, language-specific, and language-universal theories of phonological awareness (Kaushanskaya & Marian, 2009; Antoniou et al., 2015; Polka, 1991). Thus, further research needs to be done on novel word learning in bilingual individuals, with specific attention to the phonology of the novel words, in order to examine the impact of phonological awareness on the novel word learning advantage. Additionally, research seems to suggest that the bilingual advantage could be domain-general, as bilingual individuals seem to demonstrate advantages at active inhibition in domain of nonverbal tasks (Bialystok, 1999; Bialystok & Viswanathan, 2009; Garbin et al., 2010). However, there has not been research to see if this domain-general advantage could extend into the task of word-learning. Thus, further research needs to be done to see if a domain-general advantage to being bilingual could be advantageous during a linguistic task. Finally, research has demonstrated mixed findings regarding the effect of level of proficiency in bilingual speakers and the strength of the bilingual advantage. Thus, more research should be done on the level of proficiency of bilingual individuals and their relative advantage.

The present study will thus attempt to contribute new information to the existing body of research on bilingualism. Bilingual and monolingual individuals will participate in a novel-word learning task that is structured to test the three theories of phonological awareness: bilingual cognitive, language-specific, and language-universal. In addition, background instability during novel word learning will be used to test domain-general active inhibition during learning. Bilingual individuals will complete the Language Experience and Proficiency Questionnaire to see if there is a relationship between level of proficiency and strength of the novel word learning advantage (Marian et al., 2007)

2.0 CURRENT STUDY: GOALS AND QUESTIONS

The present study aims to expand upon the work of Antoniou et al. (2015) which examines the bilingual advantage in phonetic learning in speakers of English and East Asian languages. The current study aims to answer the following questions:

1. Is there a bilingual advantage in novel word learning?
2. Is the nature of the bilingual advantage in learning words with non-native phonetic contrasts consistent with the bilingual cognitive, language-specific, or language-universal hypothesis?
    a. Do bilingual individuals show greater accuracy and faster reaction times in all artificial languages, supporting the bilingual cognitive hypothesis?
    b. Do Telugu-speaking bilingual individuals show greater accuracy and faster reaction times in a Telugu-like artificial language only, supporting the language specific hypothesis?
    c. Do both bilingual and monolingual speakers show greater accuracy and faster reaction times for artificial languages with more common sound contrasts compared to less common sounds, supporting the language-universal hypothesis?
3. Is there an added bilingual advantage in novel word learning when there is an additional cognitive load during learning?
    a. Do bilingual individuals show greater accuracy and faster reaction times for novel words learned in infrequent backgrounds compared to monolingual individuals, suggesting a domain-general advantage in learning?
4. Does bilingual proficiency affect the degree of the novel word learning advantage?

To answer these questions, the study included two groups of participants. One group consisted of monolingual individuals and the other group consisted of Telugu-English bilingual individuals. The bilingual group completed the Language Experience and Proficiency Questionnaire to account for proficiency and exposure differences in the participants' second language (Marian et al., 2007). All participants completed a computerized word learning task in three artificial languages, each designed to test a specific kind of phonetic awareness advantage. In addition, within each language, word learning was made more difficult through a changing background behind objects in order to test whether bilingual individuals would display a domain general advantage during a verbal task. Response times and accuracy of the trials in each of the artificial languages were analyzed to determine what kind of bilingual advantages may exist in word learning. Ultimately, the results of this study should help inform literature on different learning styles in bilingual and monolingual individuals. In addition, it will add to literature attempting to identify the mechanisms responsible for the bilingual advantage.

2.1 HYPOTHESES AND PREDICTIONS

Given the findings of previous research, we expect bilingual participants to have an advantage at novel word learning. We expect this advantage to be attributable to enhanced phonological awareness. If bilingual participants have an advantage in phonological awareness that is bilingual cognitive in nature, then we expect they will have higher accuracy and faster reaction times in all language conditions. If bilingual participants have an advantage in phonological awareness that is language-specific in nature, then we expect they will have higher accuracy and faster reaction times than monolingual participants only in the Ewe and Khmer conditions. It is also possible bilingual participants do not have a phonological awareness advantage: if bilingual participants do not have an advantage in phonological awareness, suggesting phonological learning is language-universal in nature, then bilingual and monolingual participants will perform similarly on the different language conditions. Both groups should show an advantage for more common phoneme contrasts (Ewe fricative voicing, Khmer consonant aspiration) and a disadvantage for less common phoneme contrasts (Arabic velar versus uvular consonants). We also expect that bilingual individuals have an advantage at active inhibition during learning. If bilingual individuals have an advantage at active inhibition during learning, then we expect higher accuracy and faster reaction times than monolingual participants in the infrequent background trial conditions. Finally, we expect that higher speaking proficiency and higher understanding proficiency, as self-reported in the Language Experience and Proficiency Questionnaire, will be positively correlated with accuracy and negatively correlated with reaction times.

3.0 METHOD

3.1 PARTICIPANTS

Participants were divided into two main groups: monolingual and bilingual speakers. Members of both groups were required to be between the ages of 18 and 60 years old, be fluent speakers of English, have normal or corrected-to-normal vision and hearing, and have no language impairment or prior history of speech-language condition or other neurological, neuropsychiatric condition that could cause language problems. Bilingual participants were additionally required to be natively bilingual in Telugu and English, defined by being exposed to both languages within the first year of life and retaining comprehension and conversational proficiency at the time of testing. All participants were current university students.

3.1.1 Recruitment

Participants were recruited in two ways. Monolingual participants were recruited from a course in the Communication Science and Disorders department at the School of Health and Rehabilitation Science at the University of Pittsburgh. These participants received 1 point of extra credit in the course for their participation. Bilingual participants were recruited via word-of-mouth at the University of Pittsburgh and in the greater Pittsburgh area, and they did not receive compensation of any kind for their participation.

3.1.2 Demographics

A total of 34 participants completed this study. The monolingual speaker group had 18 participants (all female), and the bilingual speaker group had 16 participants (14 female; 2 male). The mean age of the monolingual participants at the time of testing was 22.1 (SD=4.8), ranging from 20 to 39 years old. The mean age of the bilingual participants at the time of testing was 20.6 (SD=1.7), ranging from 18 to 24 years old. Within the bilingual group, all participants began acquiring both languages (English and Telugu) within the first year of life. Their self-rated speaking proficiency ranges from 3-10, and their self-rated understanding proficiency ranges from 7-10 (10 being the highest for both measures, on a scale from 0-10). More detailed information about the speaking and understanding proficiency of the bilingual participants in their second language, Telugu, can be seen in the table below.

Table 1: Second Language Characteristics of Bilingual Participants. Speaking and Understanding Proficiency = self-rated measured, on a scale of 0-10 (0 being none; 5 being adequate; 10 being perfect).

Participant	Speaking Proficiency	Understanding Proficiency
121	5	10
122	7	8
123	3	8
124	7	9
125	10	10
126	6	9
127	8	9
128	5	8
129	7	9
130	8	9
131	8	9
132	9	9
133	6	9
134	4	7
135	7	7
136	8	10

3.2 MATERIALS

3.2.1 Screening Tests

All participants enrolled reported English as their primary language and having no prior history of hearing disorders or any neurological, neuropsychological, or neuropsychiatric conditions that could cause language problems. Additionally, all participants completed a personal information questionnaire that provided information about the participants' age and language background. Finally, all participants underwent a pure-tone bilateral hearing screening of pure tones 500, 1000, 2000, and 4000 Hz at 40dB using a standard audiometer with over-the-ear headphones.

3.2.2 Experimental Tasks

Upon completion of the screening procedures, bilingual participants were given the Language Experience and Proficiency Questionnaire as a measure of individual differences in language exposure, comprehension, and production (Marian et al., 2007). Verbal instructions were given about how to complete the questionnaire for their second language, Telugu. They completed a pencil-and-paper version of the questionnaire prior to beginning the computerized experimental tasks.

In order to obtain information about novel word learning in bilingual versus monolingual individuals, an experiment, based on a word learning study by Antoniou et al (2015), was designed with a total of 3 sets of stimuli. These stimuli consisted of three artificial languages. Each language consisted of four minimal pairs, resulting in eight words per language. All of the words were monosyllabic /CV/ structures which ended in either /i/, /e/, /u/, or /o/. The consonants used in each language were novel to both English and Telugu speakers, so all participants had to learn new phonemes. These consonants differed based on a single phonetic feature to examine the nature of phonological awareness in word learning.

The first artificial language was an English-like language, which explored the fricative voicing contrast, which is found in English, but not in Telugu. These stimuli contained the consonants /β/ vs /ɸ/, which are bilabial fricatives. The stimuli were recorded by a female professor at the University of Pittsburgh who spoke Ewe, in which the sounds /β/ and /ɸ/ are natively found. This condition served as a control because both English monolinguals and Telugu-English bilinguals are familiar with the fricative voicing contrast, and it served to see if a general bilingual advantage existed in word learning. The second artificial language was a Telugu-like language, which explored the aspiration contrast, which is found in Telugu, but not in English. These stimuli contained the consonants /c/ and /c^h/, which are palatal plosives. The stimuli were recorded by a male who spoke Khmer, in which the sounds /c/ and /c^h/ are natively found. This condition served to see if a language-specific phonological advantage existed in bilinguals for novel word learning. The third artificial language was a foreign language, which explored the velar/uvular contrast, which is found in neither Telugu nor English. These stimuli contained the consonants /ɣ/ and /ʁ/, which are voiced fricatives. The stimuli were recorded by a male professor at the University of Pittsburgh who spoke Arabic, in which the sounds /ɣ/ and /ʁ/ are natively found. This condition served to see if the language-universal theory held for novel word learning, meaning regardless of one's linguistic background, Arabic would be the most difficult to learn, followed by Khmer, then

Ewe. This is because the language-universal hypothesis theorizes that certain phonetic contrasts are more difficult to learn than others intrinsically. This difficulty is reflected in their relative markedness, or how common they are across languages. More marked sounds are found in fewer of the world's languages. Arabic is the most marked of these three artificial languages because the uvular/velar contrast is found in the least of the world languages; thus, this contrast is the most difficult to learn. Evidence for this comes from the UCLA Phonological Segment Inventory Database (UPSID), which shows that 18.4% of its languages have uvular sounds, while 26.39% of its languages have aspirated sounds, and 50.78% of its languages have voiced fricative sounds (Maddieson & Precora, 1989). Finally, a practice language was also created for participants to be familiarized with the word learning and testing protocol prior to beginning the three experimental languages. This practice condition explored nasals, which are found in both Telugu and English, and it used sounds found in both languages. The stimuli contained consonants /m/ and /n/, and they were paired with vowels /u/ and /a/. All auditory stimuli were then normalized and noise was removed via the Normalize and Noise Removal tools in Audacity.

The auditory stimuli were then paired with visual stimuli, or objects. These objects were found using the Bank of Standardized Stimuli, or BOSS (Brodeur et al. 2014). The objects were arbitrarily chosen, but were items that were familiar to participants, like a dog, snowman, or mug. Each object was edited into two different solid colored backgrounds, which would be repeated frequently or infrequently to examine cognitive control during word learning. Participants would need to ignore the changing colored background to effectively learn the object and auditory stimuli pairings. This was done to see if the bilingual advantage in novel word learning was domain-general.

The test was programmed and run using Psychology Software Tools's E-Prime 2.0 software package (Schneider, Eschman & Zuccoloto, 2002) on a Dell laptop. The experiment was set up so that individuals would do the experimental task in a practice language, and then in the three artificial languages in a random order. Each language contained two blocks. The first block was a word learning phase, in which participants would be presented the stimuli. They were presented each of the eight words 12 times in blocked repetitions at 3.5s per presentation. The minimal pairs were presented one after another. All words were monosyllabic /CV/ structures, so minimal pairs, in the context of this experiment, were words that differed in one critical consonant feature. Each individual object was presented 3 times in the infrequent background and 9 times in the frequent background, with the order of presentation of the different background trials being random. Participants did not have to press anything during this time.

They would then enter a screen with instructions for the testing block, in which they were presented two objects on a screen and heard a word. They had to press "c" if the word referred to the object on the left and "n" if the word referred to the object on the right. For every language, participants responded to a total of 96 trials. 48 of these trials were in non-minimal pair conditions. In this condition, general word learning was being examined. Thus, participants heard a target word and saw the corresponding target object on the screen, along with an object that did not belong in the minimal pair – meaning the words corresponding to the on-screen objects had different initial consonants and vowel endings. Within these 48 non-minimal par trials, 24 trials were pairs of words in their frequent background, and 24 trials were pairs of words in their infrequent background. This served as a control to see if general word learning was taking place within the languages. This serves as a control because it does not examine the more difficult learning involved in the distinction between specific phonetic contrasts. Thus, performance for accuracy in this condition is expected to be high, and this would suggest that people were successfully learning the words. This would allow us to interpret poorer performance in the minimal pair condition to be a result of the more difficult phonetic contrasts, not a lack of word learning. Subsequently, the remaining 48 trials were in the minimal pair condition. This means that participants heard a target word and saw the corresponding object on screen, along with an object that differed only on a single phonetic feature in the consonant (fricative voicing in Ewe, aspiration in Khmer, and velar versus uvular in Arabic) and shared the same vowel ending. Compared to the non-minimal pair condition, performance in accuracy is expected to drop, as this condition contains contrasts which are more difficult to learn. Within these 48 minimal pair trials, 24 trials were minimal pairs in their frequent background, and 24 trials were minimal pairs in their infrequent background. This can further be broken down into the 4 minimal pairs in each background condition being repeated 6 times each. All of these trials were presented in a random order. The background condition allowed analysis of whether the bilingual advantage is domain general. The minimal pair condition allowed analysis of the nature of the phonological awareness advantage in novel word learning. After completion of all three languages, participants had responded to a total of 288 test trials.

The participants' accuracy and response time for each item were recorded by the E-prime software and later exported into Microsoft Excel and R for data analysis. The overall design of the experiment is depicted in Figure 1.

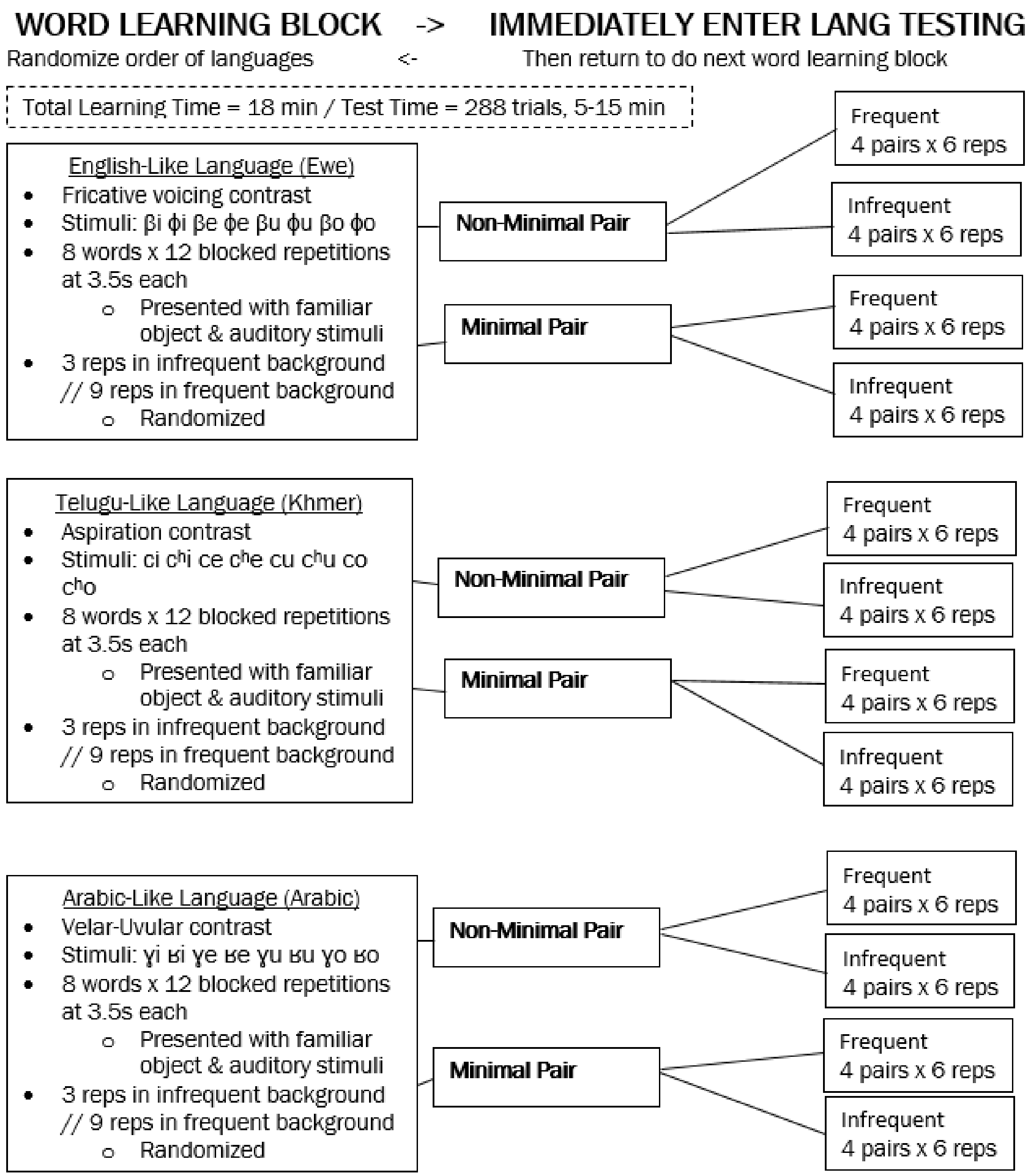

Figure 1. Experimental Task Design

3.3 PROCEDURE

3.3.1 Screening

Participants were asked to fill out a questionnaire asking about their personal and language history. All participants also completed a hearing screening of pure tones at 500, 1000, 2000, and 4000 Hz at 40dB bilaterally. Finally, bilingual participants completed a paper and pencil version of the Language Experience and Proficiency Questionnaire (Marian et al, 2007). Bilingual participants needed to indicate they grew up bilingually in order to proceed with the study.

3.3.2 Experimental Tasks

Once the screening procedures were complete, participants began the computerized experimental task on a Dell laptop. They began with a shortened practice task, which contained sounds unrelated to the study. This language had 4 words instead of 8, and it contained 16 testing trials instead of 96. Prior to beginning the practice task, they were given verbal instructions for both the learning and testing block of the experiment. When these were understood, they began the practice task, which also contained written instructions prior to the learning and testing blocks respectively. Upon completion of the practice task, the participants would then complete each of the three experimental languages in a predetermined random order. The learning time for each language was six minutes. For each language, the testing block consisted of 96 trials, taking participants about five to fifteen minutes to complete. Participants were encouraged to take breaks between languages and between learning and testing blocks within languages.

Upon completion, monolingual participants were compensated with one point of extra credit in a communication science and disorders course. Bilingual participants did not receive compensation for their involvement in the study.

4.0 DESIGN AND ANALYSIS

This was an experimental study which used a mixed between-participants and within-participants design. Within-subject independent variables included the language, minimal pair, and background frequency conditions. The between-subjects independent variable was involvement in one of the participant groups: bilingual or monolingual. The dependent variables were accuracy and reaction time. Accurate responses indicated a participant had chosen the correct object from two on-screen choices after hearing a learned word, ignoring the background color of these objects.

Along with accuracy and reaction time, self-reported second language understanding and speaking proficiency were analyzed via LEAP-Q responses. These data were used to examine individual differences on the bilingual participants' performances on the tasks.

Two dependent variables were analyzed using mixed effects regression models. Accuracy data were analyzed through logistic mixed effects regression models, which analyzed the likelihood of people to make a correct response. Reaction time data were analyzed with linear mixed effects regression models, which looked at how quickly people responded. Both types of models were run using the lme4 package in the statistical program R (Bates et al., 2015).

5.0 RESULTS

5.1 ACCURACY RESULTS

Overall, bilingual and monolingual accuracy across all versions of the testing task were similar. Mean bilingual accuracy was slightly higher, with a mean of 88.4% (SD=32.0%) compared to mean monolingual accuracy with a mean of 86.7% (SD=33.9%).

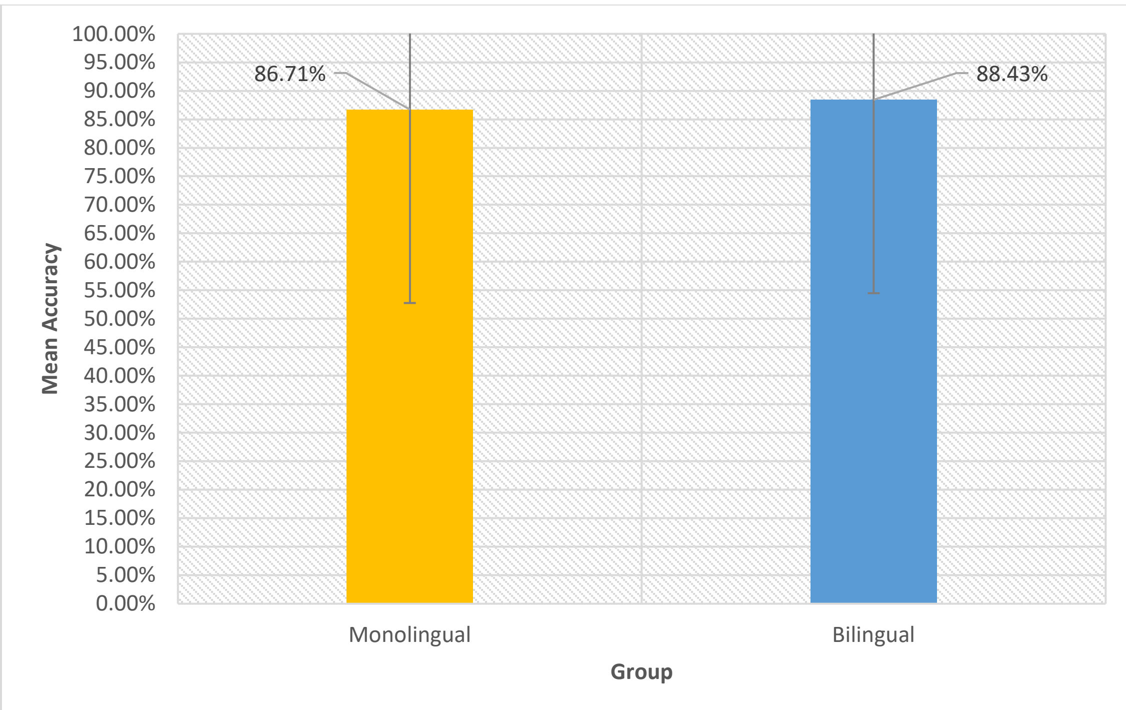

Figure 2. Mean Accuracy vs. Group

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for group (bilingual and monolingual). It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). The results did not show overall significant differences in novel word learning between bilingual individuals and monolingual individuals (z=-0.961, p>0.1). Thus, more detailed accuracy analysis is needed to determine whether there were between-group differences in performance.

Individuals performed better in the non-minimal pair condition than the minimal pair condition. In the non-minimal pair condition, bilingual individuals had 94.4% accuracy (SD=23.0%) and monolingual individuals had 92.8% accuracy (SD=25.8%). In the minimal pair condition, bilingual individuals had 82.5% accuracy (SD=38%), and monolingual individuals had 80.6% accuracy (SD=39.5%). Overall, bilingual individuals had slightly higher accuracy in each condition than monolingual individuals.

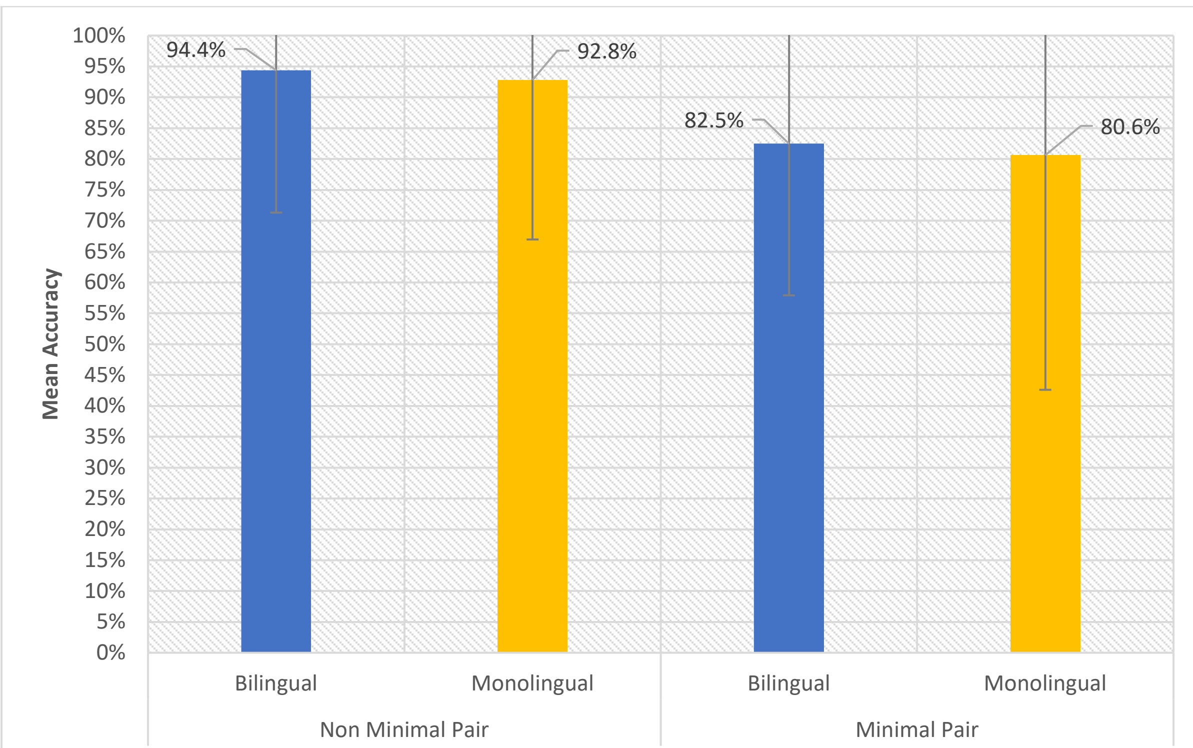

Figure 3. Mean Accuracy vs Minimal Pair

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for condition (minimal pair versus non-minimal pair), group (bilingual versus monolingual), and their interaction. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There was a significant main effect for the minimal pair condition (z=-12.706, p<0.0001), but no effect for group (z=1.275, p>0.1), and no interaction (z=-1.097, p>0.1). Participants were thus reliably less accurate in the minimal pair condition than the non-minimal pair condition. The advantage in mean accuracy that people show for the non-minimal pair condition, which was much higher than chance levels (50%), is evidence that people in both groups learned the novel words. The disadvantage for the minimal pair conditions is expected, as it tests novel word learning in the context of more specific phonological contrasts. These results show that the experiment produced successful overall word learning in both groups, and that testing in minimal pairs effectively challenged both groups. There was not a reliable difference between the monolingual and bilingual participants' disadvantage for the minimal pair condition.

The data for background frequency were very similar between groups and conditions. In fact, groups appeared to perform slightly better in the infrequent-background condition than the frequent condition. Within the infrequent condition, mean bilingual accuracy was 89.3% (SD=31%), and mean monolingual accuracy was 87.1% (SD=33.6%). Within the frequent condition, mean bilingual accuracy was 87.6% (SD=33%), and mean monolingual accuracy was 86.4% (SD=34%).

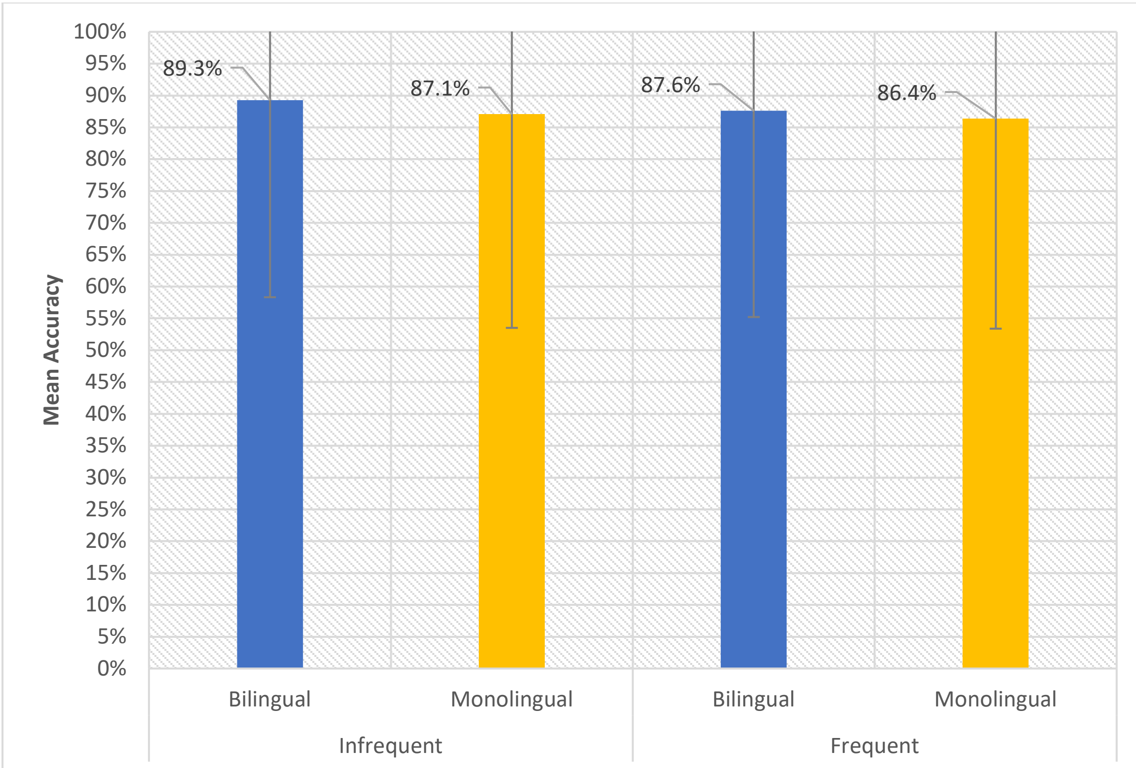

Figure 4. Mean Accuracy vs Frequency

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for condition (frequent versus infrequent background), group (bilingual versus monolingual), and their interaction. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There were no statistically significant effects in this analysis for any condition: for frequency $z=-0.766$, $p>0.1$, for group $z=1.136$, $p>0.1$, or for their interaction $z=-0.862$, $p>0.1$. Thus, there are no reliable differences between the frequent and infrequent background condition, or between bilingual and monolingual performance in these conditions.

To look at more specific differences between group's mean accuracy in languages, the data for the languages within the minimal pair condition only is relevant. As shown in figure 2, there are no differences between groups in overall language learning, and in figure 3, performance is near ceiling in the non-minimal pair condition; however, it is significantly different in the minimal pair condition. Thus, this analysis considers mean accuracy of bilingual and monolingual participants, within the minimal pair trials of Ewe, Khmer, and Arabic. Both groups perform similarly well on the Ewe, or English-like, condition: bilinguals have a mean accuracy of 92.8% (SD=25.9%), and monolinguals have a mean accuracy of 93.9% (SD=24.0%). Monolinguals slightly outperform bilinguals in the Khmer, or the Telugu-like condition: bilinguals have a mean accuracy of 78.5% (SD=41.0%), and monolinguals have a mean accuracy of 80.4% (SD=40.0%). Finally, bilinguals outperform monolinguals in the Arabic, or foreign-like, condition: bilinguals have a mean accuracy of 76.8% (SD=42.4%), and monolinguals have a mean accuracy of 68.3% (SD=46.6%).

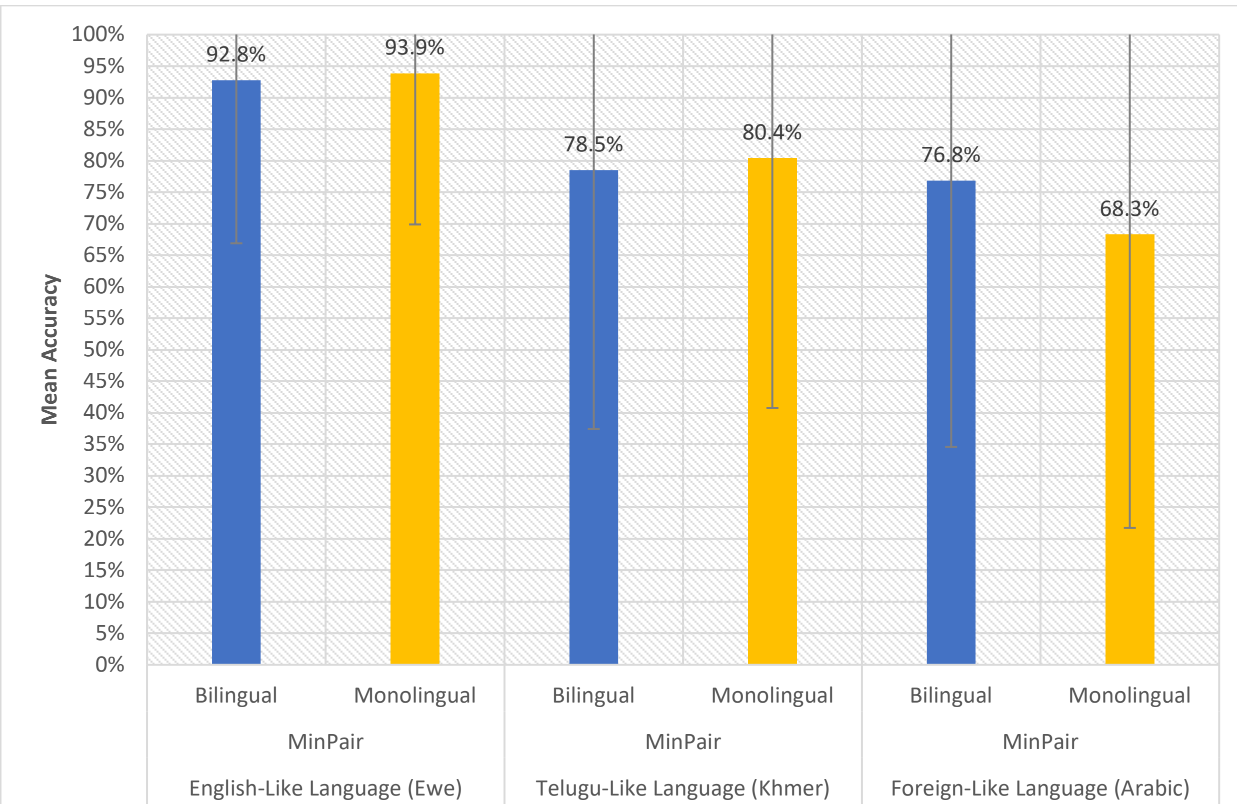

Figure 5. Mean Accuracy vs Minimal Pair Languages

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained only minimal pair data and fixed effects for language (Ewe, Khmer, Arabic), group (bilingual and monolingual), and their interaction. Reference, or dummy coding, was used for all fixed effects. The model also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). For group, bilingual was taken as the reference. To examine the different phonological awareness hypotheses, different language conditions were taken as reference categories.

To examine the language-specific hypothesis, bilingual performance in the Arabic condition was taken as the reference, with two contrasts: Arabic vs. Ewe and Arabic vs. Khmer. Because of the dummy coding used for fixed effects, main effects of language (Arabic vs. Ewe; Arabic vs. Khmer) were interpreted as the effects of these differences for bilingual speakers only (which was the reference for group). Similarly, main effects for group were interpreted as the differences between monolingual and bilingual speakers for Arabic (which was the reference for language). Results showed that bilingual performance was significantly more accurate in the Ewe condition ($z=8.186$, $p<0.0001$), but not significantly different in the Khmer condition ($z=0.811$, $p>0.1$) compared to Arabic. This does not support the language-specific hypothesis, as bilingual performance should be similarly better in the Ewe and Khmer condition compared to their performance in Arabic. Monolingual performance was worse than bilingual performance in the Arabic condition ($z=-2.028$, $p<0.05$). There were also significant interactions between language and group. There was a larger difference in monolingual than bilingual performance for the Ewe-Arabic contrast ($z=2.471$, $p<0.05$) and for the Khmer-Arabic contrast ($z=3.375$, $p<0.001$). These interactions suggest that monolingual individuals are more affected by the difference between Arabic and Ewe and Arabic and Khmer than bilingual individuals. Put slightly differently, bilingual individuals showed a smaller disadvantage than monolinguals in learning the Arabic phoneme contrast compared to the Ewe and Khmer contrasts.

To examine the language-universal hypothesis, bilingual performance in Ewe was taken as the reference, with two contrasts: Ewe vs. Arabic and Ewe vs. Khmer. Because of the dummy coding used for fixed effects, main effects of language (Ewe vs. Arabic; Ewe vs. Khmer) were interpreted as the effects of these differences for bilingual speakers only (which was the reference for group). Similarly, main effects for group were interpreted as the differences between monolingual and bilingual speakers for Ewe (which was the reference for language). Results showed that bilingual individuals performed significantly worse in Arabic ($z=-8.186$, $p<0.0001$) and Khmer ($z=-7.535$, $p<0.0001$) compared to the Ewe condition. There was no group difference in mean accuracy in the Ewe condition ($z=0.201$, $p>0.1$). There was a significant interaction between language and group. There was a larger difference in monolingual than bilingual performance for the Ewe-Arabic contrast ($z=-2.470$, $p<0.05$), but not for the Ewe-Khmer contrast ($z=-0.039$, $p>0.1$). This interaction suggests that monolingual individuals were more affected by the difference between Ewe and Arabic than bilingual individuals; however, both groups experienced a similar increase in difficultly in the Khmer condition. This begins to support the language-universal hypothesis, as Arabic is clearly harder than Khmer, which is harder than Ewe for all groups; however, this does not explain the bilingual advantage in the Arabic condition. This is because according to the language-universal hypothesis, more difficult contrasts should be more difficult to learn for speakers regardless of their linguistic background (whether they grew up monolingual or bilingual); thus, for the language-universal hypothesis to hold, monolingual and bilingual participants should have displayed an equal increase in difficulty from Ewe to Arabic.

Last, to examine the bilingual cognitive hypothesis, bilingual performance in Khmer was taken as the reference with two contrasts: Khmer vs. Arabic and Khmer vs. Ewe. Because of the dummy coding used for fixed effects, main effects of language (Khmer vs. Arabic; Khmer vs. Ewe) were interpreted as the effects of these differences for bilingual speakers only (which was the reference for group). Similarly, main effects for group were interpreted as the differences between monolingual and bilingual speakers for Khmer (which was the reference for language). Results showed bilingual performance was not significantly different from Khmer in the Arabic condition ($z=-0.811$, $p>0.1$), but it was in the Ewe condition ($z=7.535$, $p<0.0001$). Monolingual performance did not differ from bilingual performance significantly in the Khmer condition ($z=0.201$, $p>0.1$). This is not consistent with the predictions of bilingual-cognitive hypothesis, as bilingual participants do not display a robust word learning advantage in every condition. There was also no interaction for group performance in the Ewe-Khmer contrast; however, there is one for group performance in the Arabic-Khmer contrast, suggesting monolinguals did find the Arabic condition more difficult to learn than Khmer compared to bilingual individuals. ($z=-3.375$, $p<0.001$).

5.2 REACTION TIME RESULTS

Overall, mean monolingual reaction time across all versions of the task was quicker than mean bilingual reaction time. Monolingual reaction time had a mean of 1651.4ms (SD=1010.3), and mean bilingual reaction time had a mean of 1765.5ms (SD=1302.7).

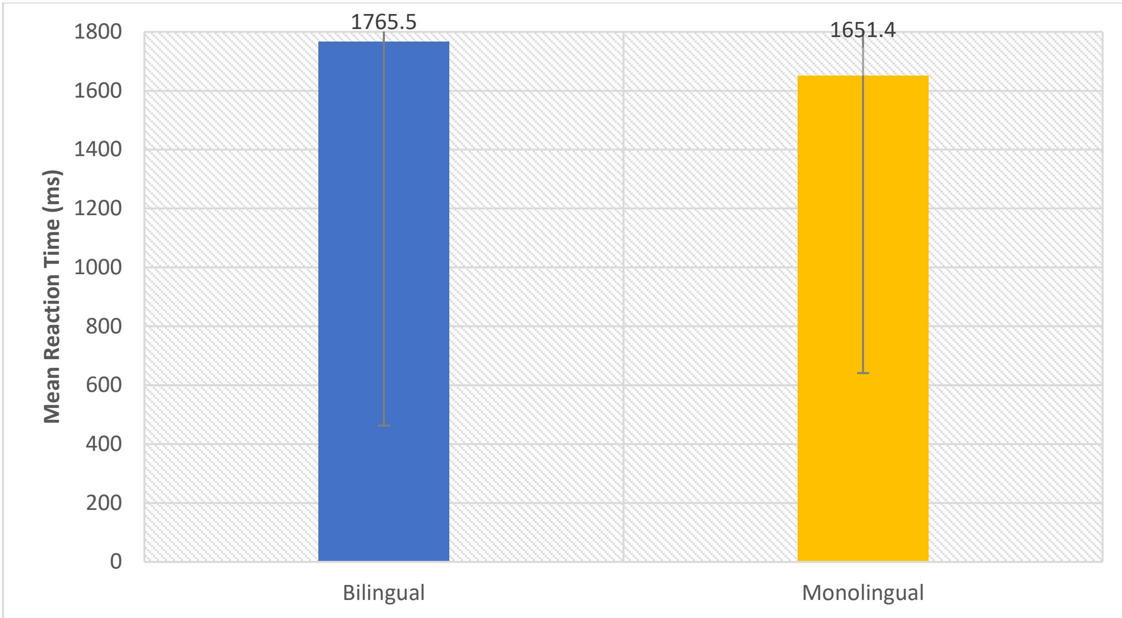

Figure 6. Mean Reaction Time vs Group

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model contained a fixed effect for group (bilingual and monolingual), and it had a maximum random-effects structure that allowed convergence (which included random intercepts for participants and trials). There are no statistically significant differences between groups on overall reaction time (t=-1.171). Thus, the data needs to be examined under more specific conditions.

Individuals took longer to respond in the minimal pair condition than the non-minimal pair condition. In the non-minimal pair condition, bilingual reaction time was 1676.4ms (SD=1080), and monolingual reaction time was 1631.3ms (SD=952). In the minimal pair condition, bilingual reaction time was 1854.6ms (SD=1487), and monolingual reaction time was 1671.5ms (SD=1065). In both conditions, monolinguals showed faster reaction times.

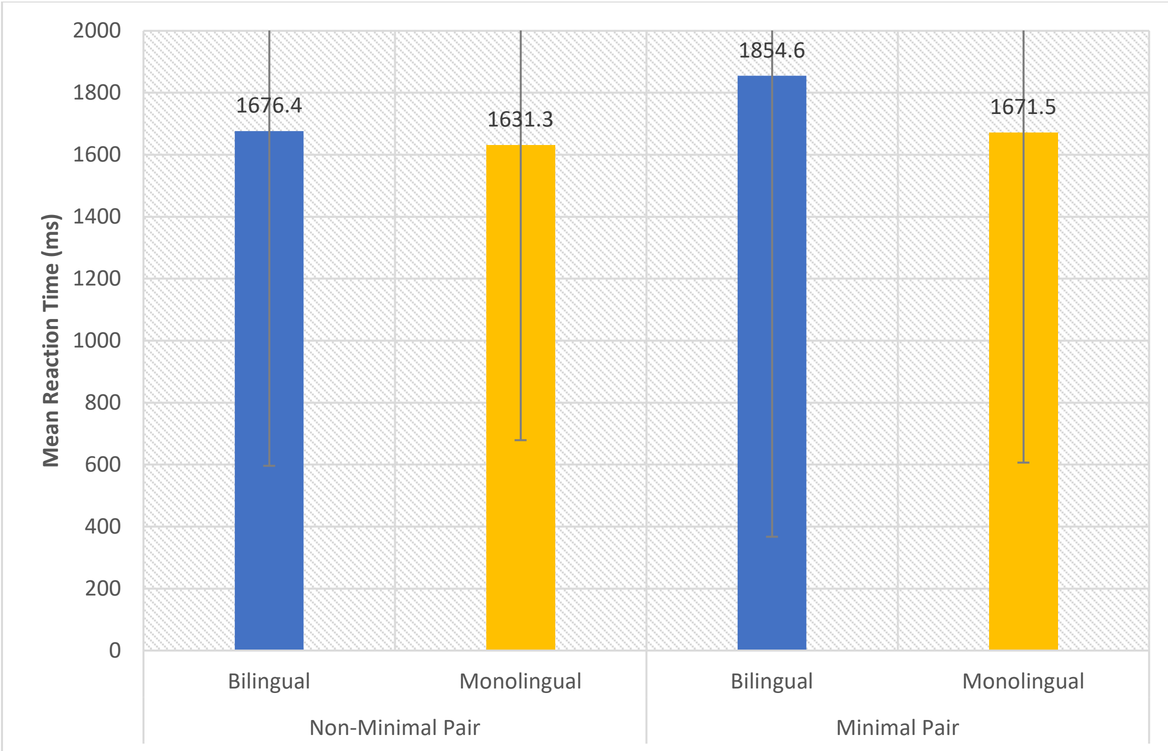

Figure 7. Mean Reaction Time vs Minimal Pair

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model contained fixed effects for group (bilingual and monolingual), condition (minimal pair versus non-minimal pair), and their interaction, and it had a maximum random-effects structure that allowed convergence (which included random intercepts for participants and trials). There were no statistically significant differences in this model for condition (t=1.573) or group (t=0.5170); however, there was a significant interaction effect (t=2.938), suggesting that bilingual individuals were more negatively impacted in their reaction time in the minimal pair condition than monolingual individuals. This finding was unexpected, as bilinguals were expected to find the minimal pair condition easier than monolingual individuals, which would manifest in faster reaction times. However, this may suggest that bilingual individuals have a greater tendency to sacrifice speed for accuracy; thus, they spent more time choosing answers in the minimal pair condition.

Groups did not show differences between the frequency conditions in mean reaction time. Bilingual individuals had a mean reaction time of 1762.3ms (SD=1349.5) in the infrequent condition and 1768.7ms (SD=1254.5) in the frequent condition. Monolingual individuals had a mean reaction time of 1664.5ms (SD=1060.76) in the infrequent condition and 1638.3ms (SD=957.2) in the frequent condition.

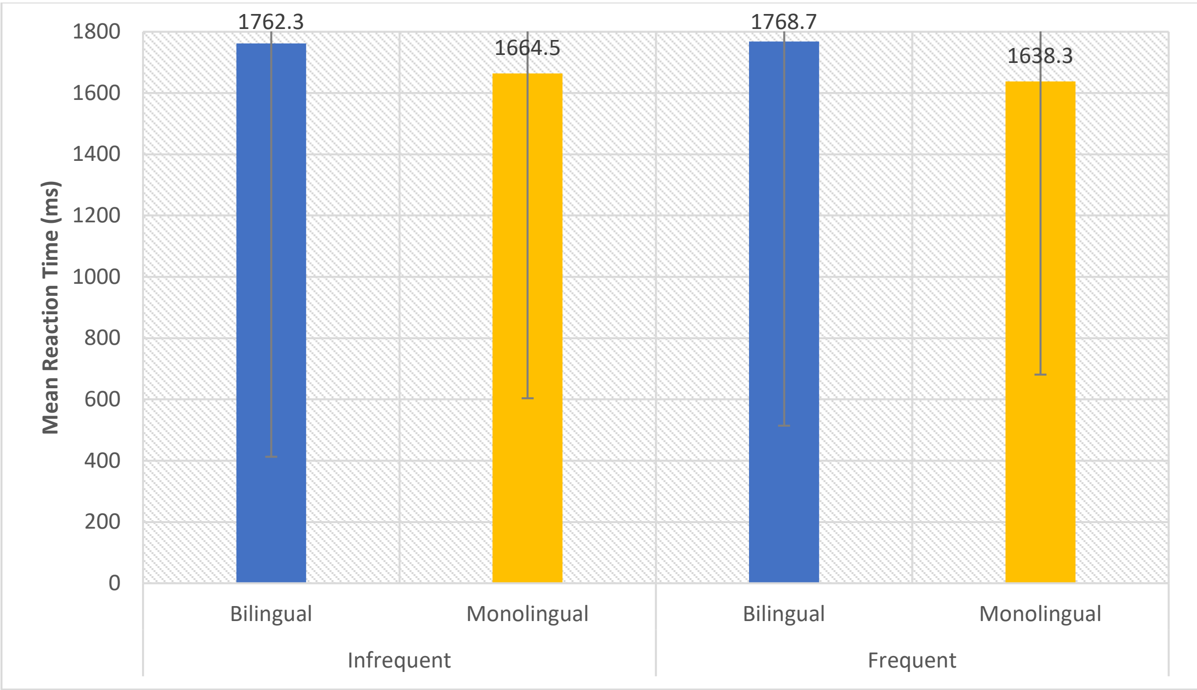

Figure 8. Mean Reaction Time vs Frequency

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model contained fixed effects for group (bilingual and monolingual), condition (frequent versus infrequent background), and their interaction, and it had a maximum random-effects structure that allowed convergence (which included random intercepts for participants and trials). There were no significant main effects or interactions found: for frequency t=-0.671, for group t=0.975, or for their interaction t=0.787. Thus, there are no reliable effects of background frequency on reaction times.

To look at more specific reaction time differences between languages, the data for the languages within the minimal pair condition only is relevant, as statistical significance emerged only in the interaction showing bilingual performance in the minimal pair condition was affected more than monolingual performance. Thus, the following data contains mean reaction times for the groups in the minimal pair condition only. Both bilingual and monolingual individuals had similar reaction times in the Ewe, or English-like, condition: bilingual individuals had a mean reaction time of 1508.4ms (SD=1018.6), and monolingual individuals had a mean reaction time of 1508.1ms (SD=927.3). Monolingual individuals had faster reaction times in the Khmer, or Telugu-like, condition: bilingual individuals had a mean reaction time of 1947.5ms (SD=1855), and monolingual individuals had a mean reaction time of 1720.7ms (SD=1173.8). Monolingual individuals also had faster reaction times in the Arabic, or foreign-like condition: bilingual individuals had a mean reaction time of 2086.2ms (SD=1383.2), and monolingual individuals had a mean reaction time of 1776.6ms (SD=1055.1).

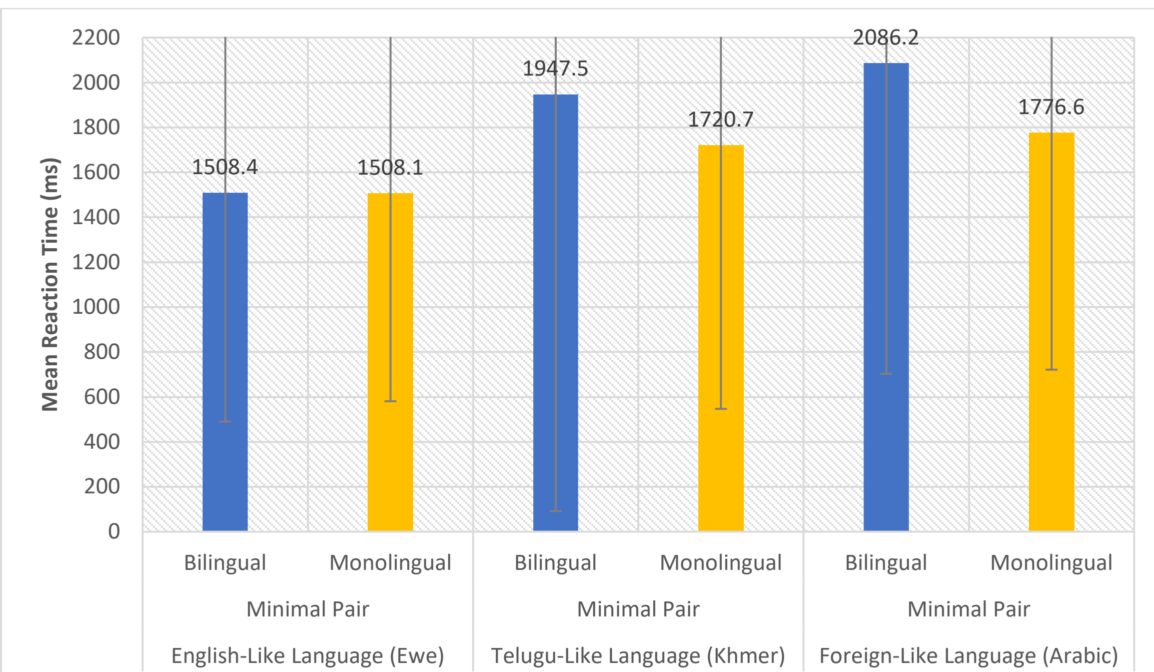

Figure 9. Mean Reaction Time vs Language in Minimal Pair

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model, with only minimal pair data, contained fixed effects for group (bilingual and monolingual), language (Ewe, Khmer, and Arabic), and their interaction. Reference, or dummy coding, was used for all fixed effects. The model also had a maximum random-effects structure that allowed convergence (which included random intercepts for participants and trials). For group, bilingual performance was taken as the reference. To examine the different hypotheses of phonological awareness, different languages were taken as references.

To examine the language-specific hypothesis, bilingual performance in the Arabic condition was taken as the reference, with two contrasts: Arabic vs. Ewe, and Arabic vs. Khmer. Because of the dummy coding used for fixed effects, main effects of language (Arabic vs. Ewe, Arabic vs. Khmer) were interpreted as the effects of these differences for bilingual speakers only (the reference for group). Similarly, main effects of group were interpreted as the differences between monolingual and bilingual speakers for Arabic (the reference for language). Results showed that bilingual performance was significantly faster for Ewe ($t=-9.049$) and Khmer ($t=-2.063$). This follows the logic of the language specific hypothesis, suggesting that Ewe and Khmer are easier for bilinguals to learn than Arabic. Monolingual performance compared to bilinguals was significantly faster in the Arabic condition ($t=-2.384$). There was a significant interaction for language and group. There was a larger difference between bilingual and monolingual performance for the Ewe-Arabic contrast. There was no significant difference for the Arabic-Khmer contrast.

To examine the language-universal hypothesis, bilingual performance in the Ewe condition was taken as a reference, with two contrasts: Ewe vs. Arabic, and Ewe vs. Khmer. Because of the dummy coding used for fixed effects, main effects of language (Ewe vs. Arabic, Ewe vs. Khmer) were interpreted as the effects of these differences for bilingual speakers only (the reference for group). Similarly, main effects of group were interpreted as the differences between monolingual and bilingual speakers for Ewe (the reference for language). Bilingual performance was significantly slowed in the Arabic (t=9.049) and Khmer (t=7.026) conditions compared to the Ewe condition. This follows the logic of the language-universal hypothesis, suggesting that Khmer and Arabic are more difficult to learn than Ewe. There was no significant difference for group in the Ewe condition (t=-0.241). There were significant interactions for language and group. There were significant differences between bilingual and monolingual performance on the Arabic-Ewe contrast (t=-3.032) and Khmer-Ewe contrast (t=-2.244), suggesting that monolingual individuals were less affected in reaction time than bilingual individuals by the switch from Ewe to different languages.

To examine the bilingual cognitive hypothesis, bilingual performance in the Khmer condition was taken as a reference, with two contrasts: Khmer vs. Arabic, and Khmer vs. Ewe. Because of the dummy coding used for fixed effects, main effects of language (Khmer vs. Arabic, Khmer vs. Ewe) were interpreted as the effects of these differences for bilingual speakers only (the reference for group). Similarly, main effects of group were interpreted as the differences between monolingual and bilingual speakers for Khmer (the reference for language). Bilingual performance was significantly slower for the Arabic condition compared to Khmer (t=2.063) but faster for Ewe (t=-7.026). There was no statistically significant difference in performance in Khmer between groups (t=-1.835). Because there was not a robust bilingual advantage in every condition, this is not consistent with the predictions of the bilingual cognitive theory. There was a significant interaction between group and language. Bilingual and monolingual performance was significantly different in the Ewe-Khmer contrast (t=2.244), but not the Arabic-Khmer contrast (t=-0.806), suggesting that monolingual individuals were more affected by the switch between Ewe and Khmer than bilingual individuals.

5.3 LEAP-Q DATA

Bilingual participants self-rated their speaking and understanding proficiency in their second language, Telugu, using the Language Experience and Proficiency Questionnaire. This allowed them to rate their proficiency on a scale from 1-10 (0 being none; 5 being adequate; 10 being perfect). Their self-rated speaking proficiency scores ranged from 3-10, with an average of 6.75 (SD=1.84). Their self-rated understanding proficiency scores were higher and ranged from 7-10, with an average of 8.75 (SD=0.93).

Figure 12, below, examines the relationship between self-rated speaking proficiency (from the Language Experience and Proficiency Questionnaire) and mean accuracy. There is a large amount of variability in mean accuracy across levels of self-rated speaking proficiency.

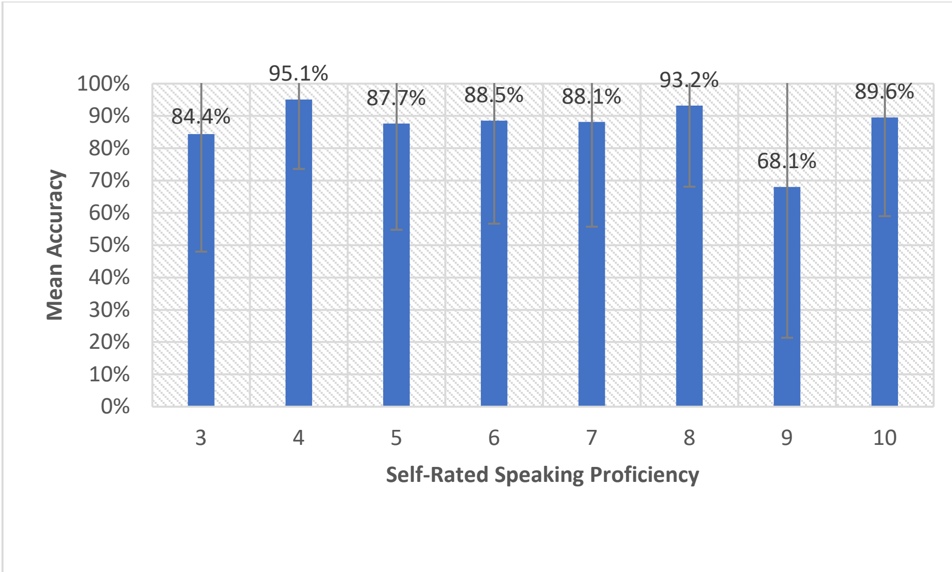

Figure 10. Mean Accuracy vs Speaking Proficiency

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for speaking proficiency. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There is no statistically significant relationship between overall mean accuracy and self-rated speaking proficiency ($z=0.232$, $p>0.1$).

Figure 13, below, examines the relationship between self-rated understanding proficiency and accuracy. The mean accuracy for individuals with a self-rated understanding proficiency of 7 was 96.4% (SD=18.6), which is higher than those with self-rated understanding proficiencies of 8, 9, or 10.

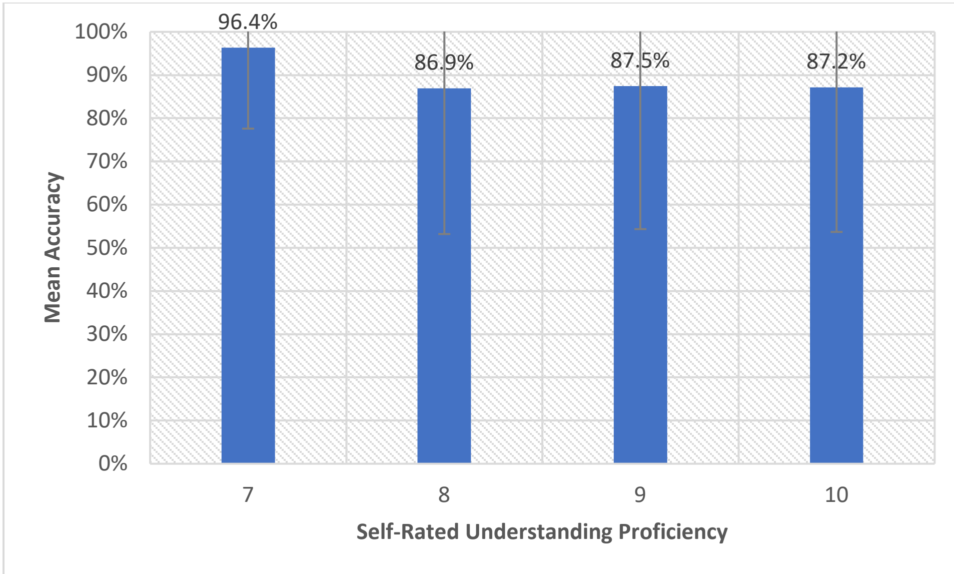

Figure 11. Mean Accuracy vs Understanding Proficiency

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for self-rated understanding proficiency. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There is no statistically significant difference between mean accuracy and self-rated understanding proficiency ($z=-1.254$, $p>0.1$).

Figure 14, below, examines the relationship between self-rated speaking proficiency and accuracy within the language conditions. Again, there is a large amount of variability between self-rated speaking proficiency and performance within each language condition.

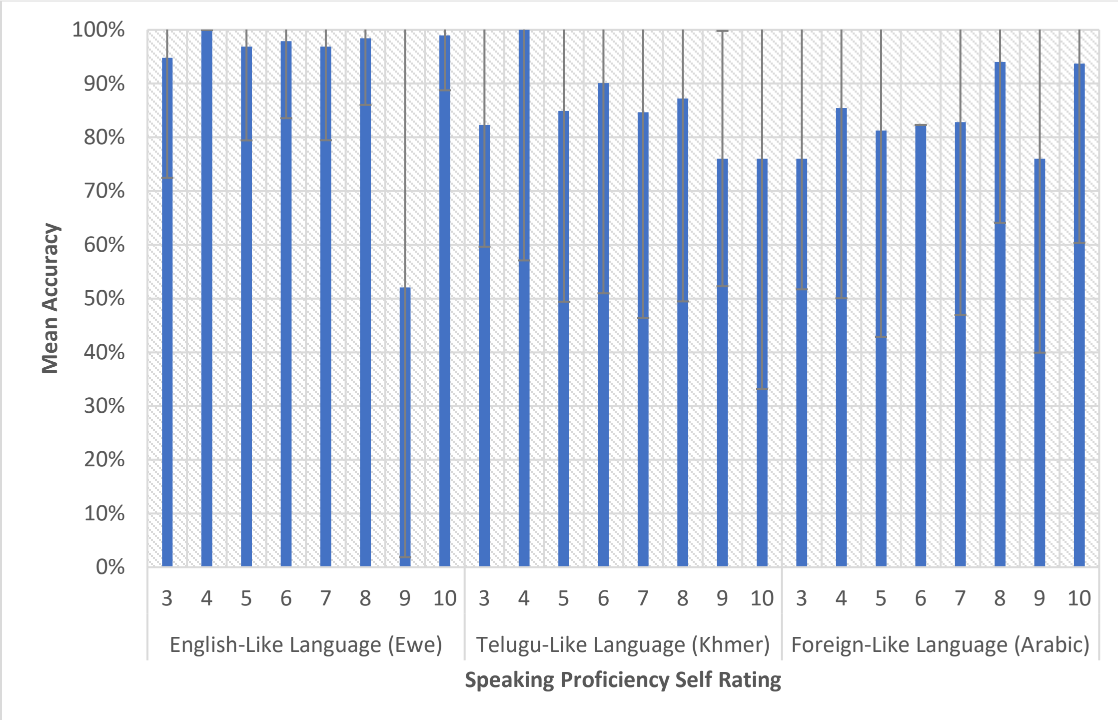

Figure 12. Mean Accuracy vs Speaking Proficiency in Language Conditions

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for self-rated speaking proficiency and language condition. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There was no statistically significant relationship between speaking proficiency and Khmer ($z=-0.484$, $p>0.1$) or Arabic ($z=1.578$, $p>0.1$). There was a weak relationship between speaking proficiency and Ewe ($z=-1.962$, $p<0.05$). This is a negative relationship, suggesting that individuals with lower speaking proficiency had higher mean accuracy. This is a surprising finding, as it would be expected that mean accuracy would increase with higher speaker proficiency, as those individuals have more experience with both languages, and thus may display more benefits in terms of bilingual advantages.

Figure 15, below, examines the relationship between mean accuracy and understanding proficiency within the language conditions. There is a large amount of variability among mean accuracy for the understanding proficiency ratings in each language condition.

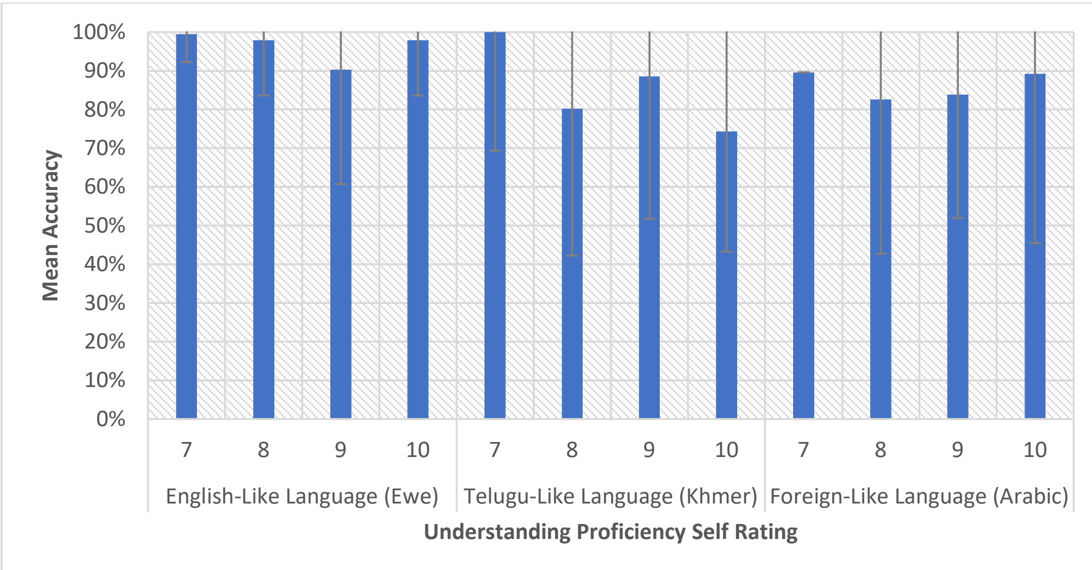

Figure 13. Accuracy vs Understanding Proficiency in Language Conditions

To analyze these results statistically, logistic mixed-effect regression models were run using the glmer function in lme4 in R. The model contained fixed effects for self-rated understanding proficiency and language condition. It also contained a maximum random-effects structure that allowed convergence (including random intercepts for trials and participants). There is a negative relationship between understanding proficiency and mean accuracy in Ewe ($z=-2.539$, $p<0.05$). There is no significant relationship between understanding proficiency and Khmer ($z=-1.483$, $p>0.1$) or Arabic ($z=0.073$, $p>0.05$).

Figure 16, below, examines the relationship between mean reaction time and self-rated speaking proficiency. There is variability among speaking proficiency and reaction time.

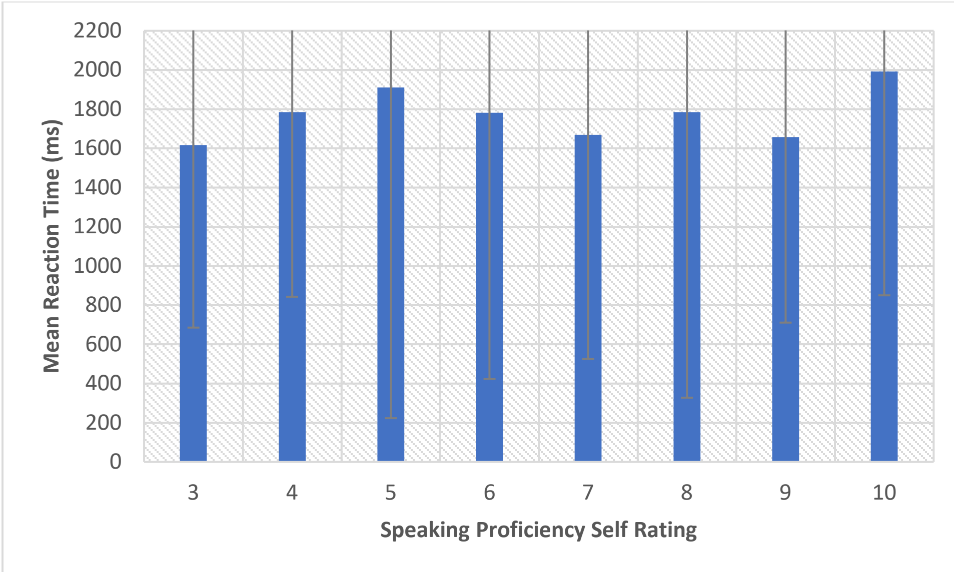

Figure 14. Mean Reaction Time vs Speaking Proficiency

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model contained a fixed effect for speaking proficiency self-rating, and it had a maximum random-effects structure that allowed for convergence (which included random intercepts for participants and trials). There was no statistically significant difference between speaking proficiency and reaction time (t=0.218).

Figure 17, below, examines the relationship between mean reaction time and self-rated understanding proficiency. The data suggests that as understanding proficiency self-rating increases, so does reaction time.

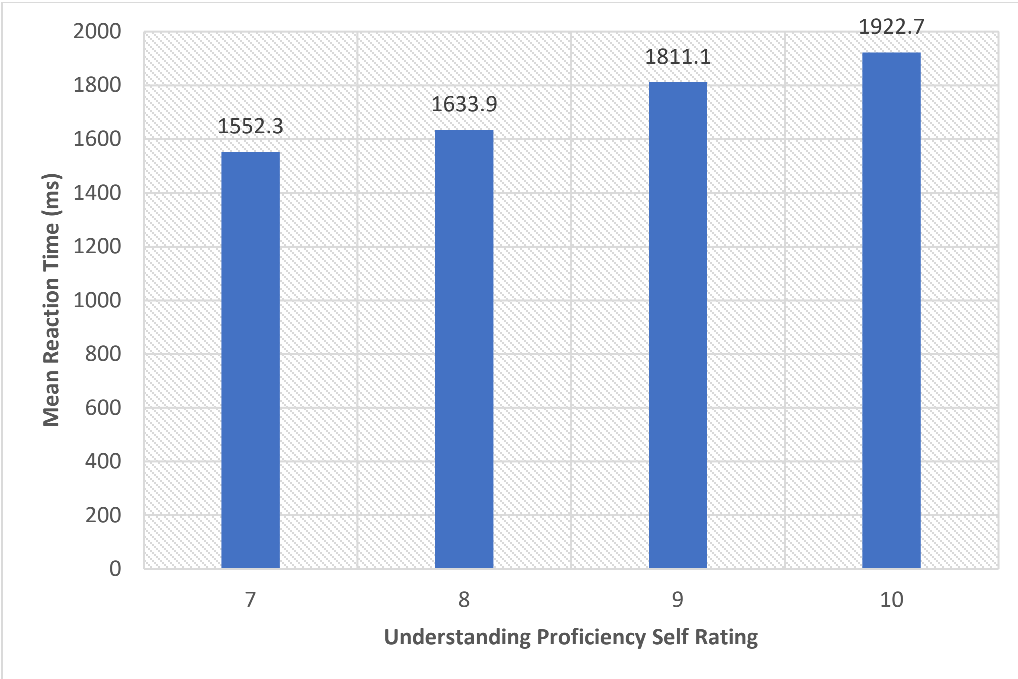

Figure 15. Mean Reaction Time vs Understanding Proficiency

To interpret these results statistically, linear mixed-effect regression models were run using the lmer function in lme4 in R. This model contained a fixed effect for understanding proficiency self-rating, and it had a maximum random-effects structure that allowed for convergence (which included random intercepts for participants and trials). There was no statistically significant relationship between understanding proficiency and mean reaction time ($t=0.218$).

There were no statistically significant relationships between speaking or understanding proficiency and mean reaction time within the language conditions.

5.4 SUMMARY OF RESULTS

The following is a summary of the results for reaction time and accuracy among the language conditions for the bilingual and monolingual groups.

Table 2. Summary of Results

	Bilingual			Monolingual		
	Non-Minimal Pair		Minimal Pair	Non-Minimal Pair		Minimal Pair
Mean Accuracy	94.40%		82.50%	92.80%		80.60%
Mean RT (ms)	1676.4		1854.6	1631.3		1671.5
	Frequent		Infrequent	Frequent		Infrequent
Mean Accuracy	87.60%		89.30%	86.40%		87.10%
Mean RT (ms)	1768.7		1762.3	1638.3		1664.5
	Ewe	Khmer	Arabic	Ewe	Khmer	Arabic
Mean Accuracy	92.80%	78.50%	76.80%	93.90%	80.40%	68.30%
Mean RT (ms)	1508.4	1947.5	2086.2	1508.1	1720.7	1776.6

6.0 DISCUSSION

6.1 ACCURACY

Overall accuracy results did not show a general bilingual advantage for novel word learning. There were no statistically significant differences in group performance on overall accuracy or within the minimal pair versus nonminimal pair conditions. This does not appear to be consistent with previous research on novel word learning in which a robust bilingual advantage for novel word learning was found, or with the bilingual cognitive hypothesis, which suggests that bilingual individuals have an overall advantage at novel word learning compared to monolingual individuals (Papagno & Vallar, 1995; Kaushanskaya & Marian, 2009a).

However, group differences do emerge when accuracy is analyzed within the different language conditions (Ewe, Khmer, and Arabic), suggesting that enhanced phonological awareness in bilingual individuals may be contributing to the bilingual advantage in novel word learning. Specifically, bilingual individuals do not show statistically significant differences from monolingual individuals in mean accuracy in the Ewe or Khmer conditions; however, they do demonstrate higher accuracy in Arabic. Similarly, there are no statistically significant interaction between group and the Ewe-Khmer contrast, suggesting that both groups have similar difficulty in Khmer compared to Ewe; however, there are interactions between group and the Arabic-Ewe and Arabic-Khmer contrast, suggesting bilingual performance is significantly less negatively impacted in the Arabic condition than monolingual performance. Additionally, for monolingual individuals, accuracy is highest in Ewe, then Khmer, then Arabic. Yet, for bilingual individuals, accuracy is highest in Ewe, but accuracy in Khmer and Arabic are equal. This does not support the language-specific hypothesis because bilingual individuals do not perform better in Khmer than Arabic. According to the language-specific hypothesis, the bilinguals should display an advantage in word learning in Khmer and Ewe only because these languages contain phonologically similar sounds to Telugu and English; however, Arabic, which contains unfamiliar sounds, should not be as easy to learn as the other two languages. These results also do not support the language-universal hypothesis, because while monolingual individuals displayed higher accuracy in Ewe, followed by Khmer, then Arabic, bilingual individuals showed similar performance in both Arabic and Khmer. According to the language-universal hypothesis, certain contrasts should be more difficult to learn than others regardless of linguistic experience; however, these results show differences based on linguistic experience (whether one grew up monolingual or bilingual). If the language-universal theory held, the bilingual group would be expected to perform better in Khmer than Arabic, like the monolingual individuals. These results also do not support the bilingual cognitive hypothesis because bilinguals only display higher accuracy compared to monolingual individuals in the Arabic condition. The expected pattern if the bilingual cognitive hypothesis were true would be higher bilingual accuracy in all of the language conditions because this theory suggests that the cognitive advantages of being bilingual result in an overall word learning advantage compared to monolinguals, regardless of the contrasts being learned.

Thus, it appears a combination of these theories may account for the advantage of bilingual individuals in novel word learning. There is truth to the language-universal theory, shown through monolingual performance in the different language conditions and the sounds' relative markedness. Again, the differences in the relative markedness of sounds can be demonstrated by their presence in the world's languages: more marked sounds, which are more difficult to learn, are found in fewer languages. Voiced fricatives, found in 50.78% of the languages in the UPSID database, are less marked than aspirated sounds, found in 26.39% of UPSID languages, which are less marked than uvular sounds, which are present in 18.4% of UPSID languages (Maddieson & Precoda, 1989; Reetz, n.d.). This suggests the velar-uvular contrast in Arabic is harder to learn than the aspiration contrast in Khmer which is harder to learn than the fricative voicing contrast in Ewe. Bilingual performance in particularly difficult contrasts appears to be aided not by language-specific phonological awareness, because the advantage exists in the foreign (Arabic) contrast. This could suggest that perhaps general bilingual cognitive advantages aid bilingual individuals in learning words with particularly difficult phonetic contrasts, and in focusing on the relevant phonetic features needed for word learning. Another, potentially more plausible conclusion is that being bilingual does increase your phonological awareness, and this advantage is easiest to observe when learning very marked sounds. This would explain the similar performance between bilinguals and monolinguals in learning less marked sounds, and the distinct bilingual advantage at learning unfamiliar but marked sounds. This theory may be more plausible because there is no evidence suggesting that the bilingual cognitive theory holds in this experiment: bilingual individuals did not have a robust advantage at novel word learning overall, so there is no evidence that they are benefiting from ignoring irrelevant stimuli and focusing on relevant information. These overall findings contradict the findings of Antoniou et al. (2015) which also suggest that certain contrasts are more difficult to learn than others, but that language-specific experience may aid learning in the difficult contrasts.

Finally, there appears to be no significant learning differences in groups regardless of words being paired with a frequent or infrequent background. Because there was no meaningful variance in accuracy in this condition, it is possible that the background differences in the frequent and infrequent background were not salient enough to distract learners.

6.2 REACTION TIME

Overall reaction time results did not show a bilingual advantage for novel word learning. In fact, a significant interaction showed that bilingual individuals performed more slowly in the minimal pair condition, compared to the non-minimal pair condition, than monolingual individuals.

More group differences emerge when reaction times are analyzed within the specific language conditions. Bilingual and monolingual performance was not significantly different in the Ewe or Khmer condition; however, bilingual individuals were significantly slower than monolingual individuals in the Arabic condition. Overall, performance was fastest in Ewe, which was faster than Khmer, which was faster than Arabic. There were significant group and language interactions in the Ewe-Arabic and Khmer-Arabic contrasts, but not in the Ewe-Khmer contrast, suggesting that bilingual individuals were most significantly slowed in the Arabic condition compared to monolingual individuals. Interestingly, while bilingual performance was slower in the Arabic condition, their mean accuracy was higher. Thus, it is possible that bilingual individuals displayed a greater tendency, compared to monolinguals, to sacrifice speed for accuracy: they spent more time in the test trials of the foreign contrast condition to achieve higher accuracy. This could be because the bilingual group perceived a difference between velar and uvular sounds (which enabled higher accuracy in performance); however, perception of this difference, which was novel and unfamiliar, was difficult. Thus, perceiving this contrast came at a cost, resulting in higher reaction times. On the other hand, the monolingual group may not have perceived this contrast at all, resulting in their reduced accuracy.

Finally, there appears to be no significant learning differences in reaction times in groups regardless of words being paired with a frequent or infrequent background. Thus, it appears background differences in the frequent and infrequent background were not salient enough to impact learners' reaction times.

6.3 LEAP-Q

Results from the Language Experience and Proficiency Questionnaire, including mean self-rated speaking proficiency and mean self-rated understanding proficiency, were used to determine if degree of bilingual proficiency affected the degree of the bilingual advantage in novel word learning. Ultimately, there was no relationship between bilingual proficiency and performance. This could be attributed to the fact that all of the bilingual participants recruited in this study were early bilinguals: they were all exposed to their second language, Telugu, within the first couple of years of life. Thus, regardless of the varying levels of proficiency that these individuals self-reported on the LEAP-Q, there may be no meaningful variance in their levels of proficiency, as all grew up to be relatively balanced bilinguals.

6.4 LIMITATIONS AND FUTURE DIRECTIONS

A limitation of this study was the lack of salience of the frequent and infrequent background colors during the novel word learning task. Because the backgrounds were simply random colors behind simple objects, participants did not have to clue into the background to aid themselves during learning. Thus, no meaningful information regarding domain-general bilingual cognitive advantages could be offered by this study.

Another limitation is a lack of diversity related to proficiency levels of the bilingual group. Because all the participants in the bilingual group of this study were relatively balanced bilinguals, there was no meaningful information that could be discerned from their LEAP-Q responses and corresponding performance on mean accuracy and reaction time measures.

This leads into a potential future direction for study, which could continue to examine the relationship between the novel word learning advantage in bilingual individuals with varying levels of speaking or understanding proficiency. This could offer more information about bilingualism that may be relevant to future generations of bilingual children, who may be exposed to less of their second languages in the future.

Additionally, future research could be done with more striking backgrounds during the novel word learning task. Rather than colors, these backgrounds could include scenes that are relevant to the object, so that individuals may be more tempted to rely on these background during the task. This could offer information about the domain-general bilingual advantage and its role during linguistic tasks.

7.0 CONCLUSION

The findings of this study suggest that bilingual individuals may have an advantage over monolingual individuals at learning novel words with difficult phonetic contrasts. This finding offers some support to the language-universal theory of phonological awareness, which suggests that there are certain phonetic contrasts that are more difficult to learn than others, regardless of a person's linguistic experience. However, even though the Arabic contrast is more difficult, bilinguals display an advantage at learning it compared to monolingual individuals. The bilingual advantage at learning this foreign contrast could be attributed to the bilingual cognitive theory of phonological awareness, that suggests that cognitive advantages to being bilingual may make bilingual individuals have a more tolerant phonological system and a better ability to focus on relevant stimuli during learning. Thus, the findings of this study support a combination of both the language-universal and bilingual-cognitive theories of phonological awareness, which may aid in novel word learning.

Additionally, reaction time results of the study show that bilingual individuals are more likely to trade off reaction time in favor of accuracy, compared to monolingual individuals. This is seen through their significant slowing in both the minimal pair condition compared to the non-minimal pair condition, and in the Arabic condition compared to the other languages. This means that bilingual individuals display a greater tendency to sacrifice speed for accuracy than monolingual individuals. This could be a result of perception of the velar-uvular contrast by bilingual individuals that enabled their higher accuracy, which may not have been perceived by monolingual individuals.

The findings of this study also show no relationship between background frequency or speaking and understanding proficiency on mean accuracy or reaction time. Future research with more salient backgrounds and more diversity in bilingual proficiency levels is needed to determine if these conditions affect the bilingual advantage.

Ultimately, the finding that bilingual individuals have an advantage at novel word learning in difficult phonetic contrasts shows that there are certain linguistic advantages to being bilingual. As more and more of the population grows up bilingually, it is important for the field of speech-language pathology to understand what differences exist between bilingual and monolingual individuals to provide the most relevant and effective assessments and treatments possible.

APPENDIX A

NOVEL WORD LEARNING TASKS

This appendix provides the presentation scripts used to present the novel word learning and testing stimuli during the experiment and the linguistic stimuli used in each of the artificial languages. The presentation scripts were presented visually on a laptop screen prior to word learning and word testing in each artificial language. The linguistic stimuli were presented via headphones, while a corresponding picture was presented visually on a laptop screen. Each testing session consisted of 96 trials, totaling 288 trials across the three artificial languages.

A.1 PRESENTATION SCRIPTS

A.1.1 Language Learning Block

Welcome to the experiment!

In this part of the experiment, you will be learning new words.

You will see photos of objects in different backgrounds, and you will hear an unfamiliar word paired with the object.

In total, you will hear 8 words, each repeated 12 times.

Your task is to try to remember the word naming each object. You will see a screen with a "+" between objects. You will not have to press anything for the experiment to proceed in this section.

Press any key when you are ready to begin!

A.1.2 Language Testing Block

In this part of the experiment, you will see two objects on the screen. You will hear one object name.

Your task is to identify to which object the name refers.

Please press the key "c" if the object is on the left, and press the key "n" if it is the object on the right.

Press any key when you are ready to begin!

A.2 STIMULI

The practice stimuli were: /ma/, /na/, /mu/, /nu/.

The English-like stimuli were: /βi/, /ɸi/, /βe/, /ɸe/, /βu/, /ɸu/, /βo/, /ɸo/.

The Telugu-like stimuli were: /ci/, /c^hi/, /ce/, /c^he/, /cu/, /c^hu/, /co/, /c^ho/.

The Arabic-like stimuli were: /ɣi/, /ʁi/, /ɣe/, /ʁe/, /ɣu/, /ʁu/, /ɣo/, /ʁo/.

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