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The Effects of Bilingualism, Modality, and Concreteness in Foreign Language Vocabulary Learning

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THE EFFECTS OF BILINGUALISM, MODALITY, AND CONCRETENESS

IN FOREIGN LANGUAGE VOCABULARY LEARNING

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Dedication

I would like to dedicate my thesis work to my family and friends. To my parents for always encouraging me and spiritually being with me throughout my time in school at the U.S. To my friends from California and from El Paso, they have supported me throughout this program. I would also like to thank my mentor, Dr. Wendy Francis, for always supporting and caring about me. Their supports have meant very much to me. I always appreciate all they have done, and without them, it was impossible to complete my thesis work.

THE EFFECTS OF BILINGUALISM, MODALITY, AND CONCRETENESS

IN FOREIGN LANGAUGE VOCABULARY LEARNING

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Abstract

The present study investigated claims in previous research that bilinguals may have an advantage over monolinguals in learning vocabulary in an unfamiliar language, but only if learning through the more proficient language. The present study examined whether bilingual adults learn new language vocabulary more efficiently than monolingual adults and whether language dominance or proficiency impacts associative memory performance. English monolinguals (n = 48), English-Spanish bilinguals (n = 48), and Spanish-English bilinguals (n = 48) learned Japanese words paired with English translations and completed cued-recall and associative-recognition tests. In contrast to previous research, there was no bilingual advantage in learning new vocabulary, and there was no effect of language dominance. Nevertheless, English proficiency (but not Spanish proficiency) affected bilingual memory performance. As expected, concrete words were remembered more accurately than abstract words, and visual study let to more accurate memory than auditory study. The effects of word concreteness and learning modality did not vary across language groups or degree of proficiency. The findings suggest that bilingualism does not facilitate learning new language vocabulary in adults, but higher proficiency in the language bilinguals use to learn facilitates associative-memory performance.

Table of Contents

List of Tables

List of Figures

Chapter 1: Bilingual Paired Associate Learning

Learning a new language as an adult is difficult. It is important, therefore, to study factors that impact adult foreign language learning, particularly in terms of how previously acquired language(s) might influence learning. The main purpose of this study is to examine the effects of bilingualism on associative-memory performance when adults attempt to learn vocabulary in a new language by pairing the new words with their translation equivalents in a known language. In addition, this study examines whether bilingualism changes the effects of word concreteness and learning modality on associative-memory performance.

1.1 Acquisition of foreign language vocabulary through paired-associate learning.

One of the fundamental processes of foreign language learning is to form conceptual associations between words in a new language and their meanings. This can be accomplished by becoming familiar with new word forms and linking them with previously acquired word forms in a known language that is already associated with the target concepts. These processes facilitate forming new conceptual associations between words in a new language and their meanings. Paired-associate learning (PAL) is a simple task that can be used to form these conceptual associations, and researchers have used this method to examine basic mechanisms of word learning and forgetting, in particular how new associations are formed, retrieved and forgotten in human memory (e.g., Crowder, 1976; McGuire, 1961; Stoddard, 1929). In PAL studies, people are asked to remember newly formed associations between words in pairs. One way to test this learning is a *cued recall* test, in which people are asked to recall one member of the pair when the other member of the pair is given as a cue. For example, *apple - desk* and *dog-glass* are studied, and later, *apple* and *dog* are presented as cues to recall *desk* and *glass*, respectively. Another way to test memory for the association is an *associative recognition* test, in which a word pair (either a learned pair, such as *apple-desk*, or a re-arranged pair, such as *apple-glass*) is displayed and people are asked

to distinguish whether the words were studied together or not. (Sometimes completely new pairs of words are also presented in the associative recognition test sequence but are not part of the measurement of associative learning.) Both tests are thought to require retrieval of the association, and the cued-recall test additionally requires bringing the cued word to mind.

To date, most studies of PAL have focused on monolingual populations. Prior studies have found that direction of learning (forward or backward translations) impacts associative memory performance in foreign language vocabulary learning (e.g., Schneider, Healy, & Bourne, 2002; Griffin & Harley, 1996). The direction of learning is either *forward translation* (familiar–unfamiliar word pairs) or *backward translation* (unfamiliar–familiar word pairs). The monolingual studies have found that immediate cued recall is more difficult for forward translations, in which people recall unfamiliar words in response to familiar cue words, than for backward translations, in which people recall familiar words in response to unfamiliar cue words. Nevertheless, forward translations yielded better performance on a one-week delayed test than on the immediate test, whereas backward translations yielded worse performance on the delayed test (Schneider et al., 2002). Thus, learning in a more difficult way enhances long-term associative learning.

There are a growing number of PAL studies that have compared monolingual and bilingual performance in learning novel vocabulary (Bogulski, Bice & Kroll, 2018; Kaushanskaya & Marian, 2009; Kaushanskaya & Rechtzigel, 2012; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). In these studies, bilinguals outperformed monolinguals in novel word learning on both cued recall and associative recognition tests. This bilingual advantage does not appear to depend on the degree of similarity between the two known languages such that Chinese-English bilinguals outperformed English-speaking monolinguals (Kaushanskaya & Marian, 2009). These previous studies suggest that bilinguals have an advantage in associative learning of foreign vocabulary. However, these prior studies had inadequate matching of monolingual and bilingual samples (e.g., each language group learned a different target language or participant characteristics were not reported) and small sample sizes. For this reason, the previous results are not definitive, and the present study approached this question in a more rigorous manner.

Another reason to further investigate this question is that it is not clear why tests of associative memory should exhibit a bilingual advantage when tests of item memory do not. Indeed, bilinguals do not typically outperform monolinguals in free recall of word lists (e.g., Fernandes, Craik, Bialystok, & Kreuger, 2007; Francis, Arteaga, Liaño, & Taylor, in press; Francis et al., 2018; Harris, Cullum, & Puente, 1995), and the bilingual advantage in recognition memory was observed only for the non-dominant language (Francis & Strobach, 2013).

1.2 Concreteness effects in memory.

Word concreteness refers to the extent to which a word implies features of objects that can be experience by the senses, and this is a semantic variable that influences word learning. Concrete words (e.g., desk and apple) are processed more quickly and learned more accurately compared to abstract words (e.g., faith and fault) in a wide variety of memory tasks (e.g., Paivio, Walsh, & Bons, 1994; Sadoski, Goetz & Fritz, 1993). This phenomenon is called *the concreteness effect*. There are two theoretical explanations for why concrete words have a learning advantage over abstract words. According to *dual coding theory*, concrete words are processed through both verbal and image-based systems, whereas abstract words are processed through a verbal system only because it is difficult to form mental images of abstract words (Paivio, 1986, 1991; Paivio & Desrochers, 1980; Paivio et.al., 1994; Kounios, 1994). Thus, dual-coding theory assumes that having two levels of encoding allows concrete words to be retrieved more easily than abstract words because there are two possible retrieval routes. An alternative explanation comes from *context-availability theory*, the idea that a person's background knowledge and the contextual situations where a word is used have a great impact on word comprehension and memory (de Groot, 1989; Grondin, Lupker, & McRae, 2009; Schwanenflugel & Shoben, 1983; Schwanenflugel, Akin, & Luh, 1992). According to context-availability theory, concrete words more easily activate associated information from prior knowledge relative to abstract words, and this ease of activation allows concrete words to be processed more quickly, encoded more richly, and retrieved more accurately.

The concreteness effect is found in both monolingual and bilingual population on learning paired words. Pairs with novel words were recalled and recognized more accurately and quickly when the familiar words were concrete rather than abstract (e.g., de Groot, 2006; van Hell & Mahn, 1997). In foreign language vocabulary learning, concrete words were less likely than abstract words to be forgotten across a one-week internal (de Groot & Keijzer, 2000). Furthermore, higher degrees of concreteness have been associated with better free recall and standard item recognition of studied words (e.g., Paivio, 1991).

Concrete and abstract words have been treated differently in models of bilingual lexical processing and memory. For example, Paivio and Desrocher (1980) expanded the dual coding theory to accommodate bilingual lexical processing and memory. The *bilingual dual coding theory* assumes that the image representation is accessed through both languages, thus leading to greater representational overlap across languages for concrete words, although this model does not include amodal conceptual representations.

An alternative theoretical treatment has been the *distributed feature model,* which was developed to explain bilingual lexical-semantic organization (see Figure 1; de Groot, 1992; van Hell & de Groot, 1998). This model specifically focuses on lexical and semantic representation in bilinguals and suggests that word meanings are represented as distributed features at the conceptual level and that the type of word influences the extent to which features are shared across languages. Translation equivalent words share some but not all semantic and lexical features in semantic and lexical systems that are shared by the two languages. The degree to which lexical and semantic features are shared between languages is assumed to impact bilingual lexical processing.

The distributed feature model has been cited as an explanation for why translation was faster for concrete words than for abstract words (de Groot, 1992; Van Hell & de Groot, 1998). The reasoning is that abstract words were more likely than concrete words to be used in different contexts across languages and have fewer common features, and therefore, concrete words and their translations activated larger sets of common features than abstract words and their translations. Furthermore, even highly proficient bilinguals translated concrete words more

4

quickly, suggesting that abstract words elicited different patterns of word activation in the two languages (van Hell & de Groot, 1998).

The distributed features model has also been used to explain word-learning performance differences between monolinguals and bilinguals (Kaushanskaya & Rechtzigel, 2012). However, it is still an open question whether the strength of the concreteness effect differs for monolinguals and bilinguals and how bilingual language proficiency impacts the strength of this effect on novel word learning tasks. Bilinguals have mental representations at the lexical level in two languages for each word. Also, translations of concrete words are more likely to activate the same or similar sets of conceptual features across languages than abstract words. If the semantic overlap is greater for concrete relative to abstract translation equivalents, bilinguals would be expected to have an advantage over monolinguals in learning concrete words but not abstract words.

A previous study showed larger concreteness effects in bilinguals than in monolinguals in paired-associate learning of novel words (Kaushanskaya & Rechtzigel, 2012). The auditory nonword stimuli were not phonologically similar to either language. Participants learned each nonword paired with an English word and subsequently completed a cued recall test in which the nonword was given as a cue and they were to produce the corresponding English translation. Bilinguals learned concrete words more accurately than monolinguals, but the language groups did not differ in learning of abstract words. The researchers concluded that the lexical-semantic representation might have been activated more strongly in bilinguals than in monolinguals when participants were exposed to words with richer semantics, and this stronger activation led to stronger concreteness effects in bilinguals. However, it should be noted that, in this study, the bilingual participants had unusually high English proficiency (their English language assessment scores were equivalent to those of the English monolingual participants), and the sample size was small (n = 22 per group). Therefore, the question of whether the concreteness effects in novel-word learning are generally stronger for monolinguals and bilinguals is not fully resolved. These previous studies did not test whether the concreteness effect depends on bilingual language

proficiency. The present study will address these questions to better understand the impact of bilingual experience and language proficiency on the word concreteness effect.

1.3 Cross-modal activation and modality effects in memory.

Visual and auditory inputs are involved in word comprehension. When a word is presented visually, the orthographic word-form is accessed first and then the corresponding lemma and/or concept are accessed to comprehend the word. When a word is presented auditorily, on the other hand, the phonological word-form is accessed first and then the corresponding lemma and/or concept are accessed (e.g., Dijkstra & Van Heuven, 2002; Green, 1998). In both visual and auditory comprehension, there is also the possibility of cross-modal activation. In monolingual studies, a reading event can automatically activate not only the corresponding orthographic word-form but also the corresponding phonological word-form (e.g., Borowsky, Owen, & Fonos, 1999; Naish, 1980; Perfetti, Bell, & Delaney, 1988). Similar activation can occur for spoken words so that phonological inputs activate orthographic word-forms (e.g., Seidenberg & Tanenhaus, 1979; Ziegler & Ferrand, 1998; Slowiczek, Soltano, Wieting, & Bishop, 2003), but this activation is less reliable and less automatic (Borowski et al., 1999). Consistent with this asymmetric cross-modal activation pattern, word pairs were learned faster and more accurately when the word stimuli were presented visually rather than auditorily (e.g., Baddeley, Papagno, & Vallar, 1988; Papineau & Lohr, 1981). Interestingly, this co-activation of orthographic and phonological word forms from visual representation occurs even when reading unfamiliar words (Baddeley et al., 1988). This finding would presumably generalize to bilinguals in associative learning with foreign language vocabulary, although no previous studies have examined how the modality effect might differ for monolinguals and bilinguals on associative-learning tasks with unfamiliar words.

Previous monolingual studies have investigated modality differences in learning and memory, and most have supported a visual advantage in learning and memory tasks. Besides inherent differences in presentation of visual and auditory word stimuli (parallel and serial, respectively), another explanation for the visual advantage is the automatic phonological activation

that occurs when words are read (e.g., Baddeley et al., 1988). Bilingual research has shown that cross-modal activation from orthography to phonology is stronger relative to the opposite direction (Schwartz, Kroll, & Diaz, 2007). Furthermore, bilinguals have word form representations in two languages for each word concept, which allows the possibility of cross-language activation. Indeed, bilinguals are thought to activate both languages during visual or auditory exposures in either language (e.g., Blumenfeld & Marian 2007; Schwartz et al., 2007; Segalowitz & Hulstijn, 2005; Ju & Luce, 2004). The strength of this cross-language activation varies across language proficiency levels such that that the cross-language activation becomes greater and more automatic as the proficiency level increases (Blumenfeld & Marian 2007; Segalowitz & Hulstijn, 2005). In addition, bilinguals co-activate both languages while they process meanings of non-cognate words in their non-dominant language although the semantic processing of non-cognates in their dominant language does not appear to elicit the automatic co-activation of their non-dominant language (Blumenfeld & Marian 2007). The degree of cross-language activation depends on encoding modality. For example, a previous study found that visual word exposures elicited greater cross-language activation than auditory word exposures (Ju & Luce, 2004). Thus, the two languages in highly proficient bilinguals are automatically activated, and the strength of this cross-language activation is greater for visual words than auditory words.

Furthermore, bilinguals exhibit activation that simultaneously crosses modalities and languages. Bilinguals identify visual words more accurately when the words are preceded by a homophonic prime in the other language, and this cross-language activation of orthographic items to phonology does not depend on the orthographic similarity between the two languages (Brysbaert, Van Dyck, & Van de Poel, 1999; Gollan, Forster, & Frost, 1997). In addition, both orthographic and phonological word forms were activated in both languages when bilinguals performed single-language word recognition tasks (Dijkstra, Grainger, & Van Heuven, 1999). Thus, bilinguals not only have cross-modal activation similar to that of monolinguals, but they additionally activate both languages during word exposures in any one language. The degree of parallel language activation depends on language proficiency and modality of word presentation.

Although automatic cross-language activation appears to affect on-line lexical processing (Blumenfeld & Marian 2007), such results do not necessarily imply that it impacts learning or long-term memory so as to benefit bilingual relative to monolingual memory performance. Indeed, as explained previously, simple tests of item memory like free recall generally did not show more accurate performance in bilinguals, making it difficult to reason why cross-language activation would nevertheless lead to a bilingual advantage in tests of associative memory.

The present study examined how encoding modality (visual or auditory) impacted associative-memory performance across language groups. All language groups were expected to exhibit an advantage for visual learning over auditory learning, as in previous monolingual research (Baddeley et al., 1988; Dean, Yekovich, & Gray, 1988; Nelson, Balass, & Perfetti, 2005). The degree of cross-language activation is impacted by language proficiency level and learning modality types such that the activation becomes greater as language proficiency is higher and greater when words are presented visually rather than auditorily (Blumenfeld & Marian 2007; Segalowitz & Hulstijn, 2005). Therefore, an application of the distributed feature model would predict a greater visual advantage for bilinguals relative to monolinguals because bilinguals experience both cross-modal and cross-language activation.

1.4 The present study.

The main purpose of the present study was to provide a rigorous test of whether bilinguals would exhibit better performance on PAL of foreign language vocabulary than monolinguals when unfamiliar words were given as cues to produce familiar words. Furthermore, we examined 1) whether language proficiency or language dominance impacted associative memory performance, 2) whether the strength of the concreteness effect varied across the language groups or across language proficiency levels within bilinguals, and/or 3) whether the strength of modality effects varied across the language groups or language proficiency levels. Data were collected from English monolinguals, English dominant bilinguals and Spanish dominant bilinguals who were well matched on age, education level, socioeconomic status, and non-verbal cognitive ability (see

8

Table 1). We also manipulated word concreteness and learning modality within participants. In the study phase, participants studied word pairs from an unfamiliar language (Japanese) paired with their corresponding translation equivalents in English. The word pairs were either concrete words or abstract words that were learned either visually or auditorily. After each study phase, a cued recall test was given in which the unfamiliar (Japanese) words were given as cues, and participants recalled the corresponding English words. After all four study-test phases were completed, an associative recognition test was administered in which participants indicated whether each displayed Japanese-English word was correct or incorrect, based on the word pairs they had studied.

1.5 Method.

1.5.1 Power and sample size.

The language group was a between-subjects factor, and concreteness and modality were within-subjects factors. The power analysis showed that to have power of .80, we required 128 participants in total to detect medium sized pairwise group differences ($f = .25$), which means at least 43 participants were required in each language group. Due to counterbalancing considerations requiring a multiple of 8 in each group, we tested 48 participants in each language group, which yielded power of 85% to detect a medium effect.

1.5.2 Participants.

The participants were English-speaking monolinguals and Spanish-English bilinguals ($N = 144$), and each language group had 48 participants. All participants were recruited from the University of Texas at El Paso (UTEP), and they received course credits or $10 per hour for research participation. The median age was 20 years, and 89% of participants reported Hispanic ethnicity. We administered the Woodcock-Munoz Language Survey-Revised (WMLS-R) in both English and Spanish to assess individual proficiency in both languages (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). Two subtests were administered: Picture Vocabulary and Verbal Analogies. This assessment provides scores for each subtest. The scoring program used

these scores to compute an oral language composite score for each language, which was then converted to an age-equivalency score. English monolingual participants had to obtain an age-equivalency score of at least 10 years on oral language in English, but less than 6 years in Spanish to qualify to participate in the present experiment. Bilingual participants had to score at least 8 years on oral language in both English and Spanish. Bilingual participants whose English score was higher than their Spanish score were classified as English-dominant bilinguals; those whose Spanish score was higher than their English score were classified as Spanish-dominant bilinguals.

To show that there was no difference in non-verbal cognitive ability across language groups, the Woodcock-Johnson III Test of Cognitive Abilities (WJ-III) was used to assess non-verbal cognitive ability (Woodcock, McGrew, & Mather, 2001). Three subtests (Spatial Relations, Picture Recognition, and Planning) were administered. The scoring program used these subtests to compute a composite visuo-spatial reasoning score, which was then converted to an age-equivalency score. The age-equivalency score represents the average age at which a monolingual native speaker achieves the same performance level. The language assessment and cognitive scores are presented in Table 1.

There were five participants who completed at least part of the computerized protocol but were disqualified. Two participants were excluded because it was discovered that they had lived in Japan and studied Japanese for more than one year. One participant, who participated as an English monolingual because he/she did not speak Spanish), was excluded because he/she did not acquire English until adulthood. Two participants were excluded because of failure to follow instructions. Replacements were made for all excluded participants to preserve counterbalancing.

Table 1: Participant Characteristics

Characteristic	English Monolinguals (N=48)	English-Spanish Bilinguals (N=48)	Spanish-English Bilinguals (N=48)
Median Age	20.0	21.0	20.0
English Picture Vocabulary[a]	16.7	15.4	10.0
English Verbal Analogies[a]	20.9	21.1	15.8
English Oral Language[a]	18.0	16.9	11.6
Spanish Picture Vocabulary[a]	2.6	10.6	14.2
Spanish Verbal Analogies[a]	5.0	15.8	20.2
Spanish Oral Language[a]	3.0	11.7	16.5
Spatial Relations[b]	17.5	19.1	17.1
Picture Recognition[b]	17.5	16.0	16.6
Planning[b]	19.2	20.4	20.7
Visual-Spatial Think[b]	18.9	19.3	17.5
Median Parental Education	Graduated College	Some College	Graduated College

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

[b]Scores indicate mean age-equivalency levels for performance on the WJ-III (Woodcock et al., 2001).

1.5.3 Design.

This experiment formed a 3 (language group) x 2 (word concreteness) x 2 (modality) mixed-design. The language group was either English monolinguals, English-dominant bilinguals, or Spanish-dominant bilinguals. There were four task conditions tested for each language group. The word stimuli were either concrete or abstract in meaning. The modality of stimulus presentation at study and test was either visual or auditory. The measured variables were accuracy in the cued-recall tests and discrimination (d') scores and response times in the associative recognition tests.

1.5.4 Stimuli.

Stimuli included 40 words in Japanese and their English translations. None of the Japanese word stimuli had cognates, homographs, or homophones in English or Spanish. The English word stimuli were selected from two published sources where word concreteness levels were normed (Altarriba, Bauer, & Benvenuto, 1999; Tokowicz & Kroll, 2007). Half of the words were concrete words; the other half were abstract words. Concrete and abstract word sets were matched on word frequency. Frequencies of the English stimulus words were obtained from the SUBTLEX-US database (Brysbaert & New, 2009). Although Spanish words were not presented, we obtained the frequencies of the translation equivalents in Spanish using SUBTLEX-ESP (Cuetos-Vega, González-Nosti, Barbón-Gutiérrez, & Brysbaert, 2011) to be sure that frequency levels were comparable in English and Spanish. Mean word frequencies and concreteness ratings are given in Table 2. The 20 concrete words were randomly assigned to two sets of 10 words, and the 20 abstract words were randomly assigned to two sets of 10 words. One set of words of each type was assigned to the visual modality, and the other was assigned to the auditory modality. The assignment of item sets to modalities was counterbalanced across participants.

Japanese words were written in the Roman alphabet on visual trials. Auditory stimuli were recorded by a female native Japanese speaker for the Japanese words and by a female native English speaker for the English words, and the sound files were edited using Praat software (Boersma & Weenink, 2010). The order of word pairs was set as Japanese-to-English (e.g. *washi-eagle*) because previous studies of novel word learning found that learning in backward translation was easier than forward translation when people recalled familiar words in response to familiar cue words immediately after they learned (e.g., Schneider et al., 2002). Each cued-recall test was administered immediately after each study phase.

Table 2: Mean frequency and rated concreteness of word stimuli

	English Frequency	Spanish Frequency	Concreteness
Concrete words	95.46	87.35	6.17
Abstract words	95.06	90.18	3.62

Note. Frequencies of English words were obtained from the SUBTLEX-US database (Brysbaert & New, 2009), and frequencies of Spanish words were from the SUBTLEX-ESP (Cuetos-Vega et al., 2011). Concreteness levels were obtained from two published sources (Altarriba et al., 1999; Tokowicz & Kroll, 2007).

1.5.5 Apparatus.

Stimuli were presented on an Apple Macintosh computer monitor, and PsyScope X software was used to program the experiment (Cohen, MacWhinney, Flatt, & Provost, 1993). A set of headphones was used to present the auditory stimuli. Accuracy and RTs were measured using an ioLab Systems button box.

1.5.6 Procedure.

Participants were tested individually in a small room in sessions lasting approximately 90 minutes. After completion of the informed consent form, the WMLS-R language assessments in English and Spanish were administered to assess whether participants qualified for the experiment and which language was dominant. Participants also completed three questionnaires (strategy, language background and demographic questionnaires) after the main computerized tasks. The strategy questionnaire asked participants to explain what strategies they used to remember pairs and whether any different strategies were applied on different tasks. Lastly, the tests of cognitive abilities were administered.

1.5.6.1 Training phase.

All participants began with a training phase before the main computerized tasks in order equate participants on their level of knowledge of Japanese pronunciation rules. During training,

an experimenter explained that all Japanese words were written in the Roman alphabet but that the pronunciation rules differed from the rules of English and Spanish pronunciation. Specifically, words containing the letters h, j or z were used as examples, and participants practiced the pronunciation with the experimenter until they felt comfortable pronouncing the words. After the training, participants began the main experiment which was composed of four study-test cycles: a list of concrete words with visual presentation, a list of concrete words with auditory presentation, a list of abstract words with visual presentation, and a list of abstract words with auditory presentation. The order of the modality and concreteness cycles was counterbalanced across participants.

1.5.6.2 Study phase.

This was a self-paced study. Participants were instructed to learn as many Japanese-English word pairs as possible because they would have a test to recall the English translation words later. Each pair of Japanese-English words was displayed in the center of the screen or played over a set of headphones. Visual word stimuli stayed on the computer screen, and auditory word stimuli were available for replay by pressing the "r" key until participants pressed a spacebar to display the next pair. Participants repeated the displayed pair three times as accurately as possible: in the visual conditions, they wrote out the pair silently on a notepad three times, and in the auditory conditions, they repeated the pair aloud three times. Participants turned the notepad page after each word pair and were not allowed to review what they wrote earlier. Once participants finished repeating the pair three times, they pressed a spacebar to display the next pair. A list of the word pairs was cycled three times with three different random orders within a study phase. Thus, each word pair was randomly displayed three times, and participants repeated each pair a total of nine times.

1.5.6.3 Cued-recall test.

A cued-recall test was administered after each study phase. Japanese words were given as cues, and participants produced the corresponding English words. The test stimuli and the response types were consistent with the study conditions. Specifically, the visual Japanese words stayed in

14

the center of the screen, and participants wrote their English responses on the notepad. The auditory Japanese words could be replayed when participants wanted to hear the word again, and they recalled the English words aloud. The experimenter noted their responses on a worksheet with the correct translations. All studied items were tested, and the order of items was randomized.

1.5.6.4 Recognition test.

A pair recognition test was administered after all study-test cycles were completed. The recognition test was divided into two blocks, with forty experimental trials in each block. Half of the studied pairs were randomly selected from each study list (five pairs per list) and were assigned as correct pairs in the first block. The remaining half (the other twenty pairs) were assigned as incorrect pairs. The incorrect pairs were randomly re-arranged such that English translations were paired with incorrect Japanese words, and no new words were presented at test. In the second block, the assignment was switched such that the pairs that were initially assigned as incorrect pairs in the first block were assigned as correct pairs in the second block, and the pairs that were initially assigned as correct pairs in the first block were assigned as incorrect pairs in the second block. On the recognition test, a Japanese-English word pair was displayed in the center of the screen, and participants indicated whether the pairing was correct or incorrect, based on what they had studied throughout the experiment. They pressed a "c" key to indicate that the English translation was correct or an "n" key to indicate that it was incorrect. All studied items were displayed once in each block, and the order of items was randomized within each block.

1.6 Results.

1.6.1 Approach to analysis.

Memory performance on the cued-recall task and the associative recognition task were analyzed for all language groups. All of the responses were included in the analyses. Table 3 represents recall accuracy, hit rates, false alarm rates, and d' for all conditions – d' was computed for each participant in each condition using hit rates and false alarm rates. Within each group, these scores were submitted to 2 (modality) x 2 (word concreteness) repeated-measures ANOVAs. The

language dominance group and individual English proficiency scores were also included in analyses to examine the language proficiency effect on foreign language learning. Figure 2 shows accuracy in the cued-recall tests for each language group, and Figure 3 shows discrimination (d') performance in the associative recognition tests of each language group. Figure 4 and 5 show how recall accuracy and discrimination (d') in associative recognition performance varies across English proficiency levels in monolinguals and bilinguals. A summary of the group comparisons is given in Table 4.

1.6.2 Monolinguals.

1.6.2.1 Cued recall accuracy.

Recall was significantly higher for visual stimuli than for auditory stimuli, $F(1, 47) = 44.14$, $MSE = 1.35$, $p < .001$, $\eta_{2p} = .48$, and recall was higher for concrete words than for abstract words, $F(1, 47) = 16.11$, $MSE = .79$, $p < .001$, $\eta_{2p} = .26$. However, the effects of modality and word concreteness did not interact ($F < 1$), consistent with previous monolingual studies (e.g., Janssen, 1975; Neath, 1997).

1.6.2.2 Pair recognition accuracy.

When indicating whether the presented word pair was correct or incorrect, discrimination was higher for visual words than for auditory words, $F(1, 47) = 154.76$, $MSE = 128.47$, $p < .001$, $\eta_{2p} = .77$. However, the tendency for better discrimination for concrete words than for abstract words did not reach significance, $F(1, 47) = 3.90$, $MSE = 6.35$, $p = .054$, $\eta_{2p} = .08$, and the interaction of modality and concreteness was not significant, $F(1, 47) = 1.34$, $MSE = .92$, $p = .25$, $\eta_{2p} = .03$. To better understand the locus of the modality effect, hit rates and false alarm rates were analyzed separately.

Monolinguals had higher hit rates when they learned the pairs visually rather than auditorily, $F(1, 47) = 103.98$, $MSE = 1.24$, $p < .001$, $\eta_{2p} = .69$. However, there was no difference between concrete and abstract words, $F(1, 47) = 1.27$, $MSE = .029$, $p = .27$, $\eta_{2p} = .03$. The effects of modality did not differ across word concreteness levels ($F < 1$).

16

False alarm rates were higher for auditory than for visual learning conditions, $F(1, 47) =$ 54.82, $MSE = 1.53$, $p < .001$, $\eta^2_p = .54$, and higher for abstract than for concrete words, $F(1, 47)$ $= 5.42$, $MSE = .15$, $p = .02$, $\eta^2_p = .10$. A significant interaction of modality and word concreteness, $F(1, 47) = 8.43$, $MSE = .10$, $p = .006$, $\eta^2_p = .15$, indicated that the concreteness effect in false alarm rates was stronger in auditory than in visual learning conditions. Thus, in visual learning conditions, monolinguals had higher hit rates and lower false alarm rates than in auditory learning conditions, a pattern known as the *mirror effect* (e.g., Glanzer & Adams, 1985). Also, false alarm rates for abstract words were higher for auditory than for visual learning conditions.

1.6.3 Comparisons of bilingual groups.

1.6.3.1 Analyses for bilingual comparisons.

We conducted further analyses for the bilingual data to examine the effects of language proficiency. First, we conducted ANOVAs with the language dominance groups (English dominant and Spanish dominant) as a between-subjects factor to see whether the language dominance would impact memory performance. Secondly, we conducted ANCOVAs with English proficiency scores (WMLS oral language composite scores) as a continuous variable to examine whether language proficiency was a significant predictor of associative memory performance in bilinguals.

1.6.3.2 Recall accuracy analysis by language dominance group.

Recall accuracy did not differ for English-dominant (ED) and Spanish-dominant (SD) groups ($F < 1$). Both bilingual groups had higher recall accuracy for visual than for auditory learning conditions [ED: $F(1, 47) = 26.61$, $MSE = .87$, $p < .001$, $\eta^2_p = .36$; SD: $F(1, 47) = 29.97$, $MSE = 1.35$, $p < .001$, $\eta^2_p = .39$], but the strength of the modality effect did not differ significantly across bilingual groups ($F < 1$). Both bilingual groups recalled concrete words better than abstract words [ED: $F(1, 47) = 38.85$, $MSE = 1.67$, $p < .001$, $\eta^2_p = .45$; SD: $F(1, 47) = 35.76$, $MSE = 1.56$, $p < .001$, $\eta^2_p = .43$], but the strength of the concreteness effect did not differ significantly across

bilingual groups ($F < 1$). Modality and concreteness effects did not interact, and there was no three-way interaction ($Fs < 1$).

1.6.3.3 Discrimination analysis by language dominance group.

English-dominant and Spanish-dominant groups did not differ in overall discrimination accuracy ($F < 1$). The two bilingual groups had a visual advantage on the recognition task [ED: $F(1, 47) = 101.02$, $MSE = 79.88$, $p < .001$, $\eta_{2p} = .68$; SD: $F(1, 47) = 86.97$, $MSE = 89.40$, $p < .001$, $\eta_{2p} = .65$], and they recognized concrete words more accurately than abstract words [ED: $F(1, 47) = 11.86$, $MSE = 14.58$, $p = .001$, $\eta_{2p} = .20$; SD: $F(1, 47) = 24.09$, $MSE = 29.69$, $p < .001$, $\eta_{2p} = .34$]. However, the strengths of the modality and concreteness effects on discrimination did not differ significantly across bilingual groups [modality: $F < 1$; concreteness: $F(1, 47) = 1.26$, $MSE = 1.57$, $p = .27$, $\eta_{2p} = .01$]. The effects of modality and concreteness did not interact, and there was no three-way interaction ($Fs < 1$). To better understand the loci of the modality and concreteness effects, hit rates and false alarm rates were analyzed separately.

Hit rates did not differ for English- and Spanish-dominant groups, $F(1, 47) = 1.69$, $MSE = .04$, $p = .20$, $\eta_{2p} = .02$. Hit rates were higher in the visual learning conditions for both groups [ED: $F(1, 47) = 40.56$, $MSE = .64$, $p < .001$, $\eta_{2p} = .46$; SD: $F(1, 47) = 42.68$, $MSE = .55$, $p < .001$, $\eta_{2p} = .48$], and hit rates were higher for concrete words [ED: $F(1, 47) = 9.23$, $MSE = .13$, $p = .004$, $\eta_{2p} = .16$; SD: $F(1, 47) = 8.52$, $MSE = .19$, $p < .001$, $\eta_{2p} = .15$]. However, the strengths of the modality and concreteness effects in hit rates did not differ significantly across groups ($Fs < 1$). The interactions of modality and concreteness on hit rates were not significant [ED: $F(1, 47) = 1.60$, $MSE = .01$, $p = .21$, $\eta_{2p} = .03$; SD: $F(1, 47) = 1.$, $MSE = .01$, $p = .27$, $\eta_{2p} = .03$], and the three-way interaction was not significant, $F(1, 47) = 2.94$, $MSE = .03$, $p = .09$, $\eta_{2p} = .03$.

False alarm rates did not differ across groups ($F < 1$). False-alarm rates were higher in auditory than in visual learning conditions [ED: $F(1, 47) = 50.57$, $MSE = 1.21$, $p < .001$, $\eta_{2p} = .52$; SD: $F(1, 47) = 76.62$, $MSE = 1.55$, $p < .001$, $\eta_{2p} = .62$]. The false-alarm rates were higher for abstract than for concrete words [ED: $F(1, 47) = 7.27$, $MSE = .24$, $p = .010$, $\eta_{2p} = .52$; SD:

$F(1, 47) = 16.67$, *MSE* = .40, $p < .001$, $\eta_{2p} = .26$]. However, the strengths of the modality and concreteness effects in false-alarm rates also did not differ across bilingual groups (*F*s < 1). The interactions of modality and concreteness on false alarm rates were not significant [ED: $F < 1$; SD: $F(1, 47) = 2.41$, *MSE* = .05, $p = .13$, $\eta_{2p} = .05$], and the three-way interaction was not significant, $F(1, 47) = 1.76$, *MSE* = .04, $p = .19$, $\eta_{2p} = .02$.

Together, these results show that bilinguals exhibited a visual advantage and a concrete word advantage on the associative recognition task. Specifically, bilinguals had higher hit rates and lower false-alarm rates in visual than in auditory learning conditions and higher hit rates and lower false-alarm rates for concrete than for abstract word pairs. Thus, bilinguals exhibited mirror effects for presentation modality and concreteness. In addition, learning of foreign language vocabulary, as measured by cued recall and associative recognition tests, does not depend on whether the new words are learned through a dominant or non-dominant language.

1.6.3.4 Recall accuracy analysis by English proficiency.

In the next set of analyses, we tested whether proficiency in English predicted the accuracy of foreign language vocabulary learning through English. Indeed, bilinguals with higher English proficiency showed more accurate cued recall than those with lower English proficiency, $F(1, 94)$ = 11.69, *MSE* = 1.38, $p < .001$, $\eta_{2p} = .11$. However, English proficiency was not associated with the strengths of the modality or concreteness effects in cued recall [modality: $F < 1$; concreteness: $F(1, 94) = 1.69$, *MSE* = .07, $p = .20$, $\eta_{2p} = .02$]. The three-way interaction was not significant, $F(1, 94) = 1.69$, *MSE* = .05, $p = .20$, $\eta_{2p} = .02$.

1.6.3.5 Discrimination analysis by English proficiency.

Discrimination performance was higher for bilinguals with higher English proficiency than for those with lower English proficiency, $F(1, 94) = 14.75$, *MSE* = 42.64, $p < .001$, $\eta_{2p} = .14$. English proficiency was not associated with the strengths of the modality or concreteness effects [modality: $F < 1$; concreteness: $F(1, 94) = 2.42$, *MSE* = 2.99, $p = .12$, $\eta_{2p} = .03$], and there was no three-way interaction ($F < 1$).

Bilinguals with higher English proficiency had higher hit rates than those with lower proficiency, $F(1, 94) = 13.23$, $MSE = .31$, $p = .001$, $\eta_{2p} = .12$. However, English proficiency was not associated with the strengths of the modality and concreteness effects on hit rates [modality: $F < 1$; concreteness: $F(1, 94) = 1.06$, $MSE = .02$, $p < .31$, $\eta_{2p} = .01$]. The three-way interaction was not significant, $F(1, 94) = 1.37$, $MSE = .01$, $p = .25$, $\eta_{2p} = .01$.

Bilinguals with lower English proficiency had higher false alarm rates than those with higher proficiency, $F(1, 94) = 7.89$, $MSE = .48$, $p = .006$, $\eta_{2p} = .08$. English proficiency was not associated with the strengths of the modality and concreteness effects on false alarm rates [modality: $F < 1$; concreteness: $F(1, 94) = 1.96$, $MSE = .06$, $p = .17$, $\eta_{2p} = .02$], and there was no three-way interaction ($F < 1$). Taken together, these results suggest that higher proficiency levels in the language used to learn new words enhance both cued recall and associative recognition performance in foreign language vocabulary learning.

1.6.3.6 Recall accuracy analysis by Spanish proficiency.

In the next set of analyses, we tested whether proficiency in Spanish (the uninvolved language) predicted the accuracy of Japanese vocabulary learning through English. The accuracy of cued recall performance did not differ due to proficiency in Spanish, $F(1, 94) = 3.82$, $MSE = .49$, $p = .054$, $\eta_{2p} = .04$. Spanish proficiency was not associated with the strengths of the modality or concreteness effects in cued-recall ($Fs < 1$), and the three-way interaction was not significant ($F < 1$).

1.6.3.7 Discrimination analysis by Spanish proficiency.

Discrimination performance was higher for bilinguals with higher Spanish proficiency than for those with lower Spanish proficiency, $F(1, 94) = 4.21$, $MSE = 13.48$, $p = .043$, $\eta_{2p} = .04$. Spanish proficiency was not associated with the strengths of the modality or concreteness effects ($Fs < 1$), and there was no three-way interaction ($F < 1$).

English proficiency did not impact their hit rate performance, $F(1, 94) = 1.96$, $MSE = .05$, $p = .17$, $\eta_{2p} = .02$. Also, English proficiency was not associated with the strengths of the modality

and concreteness effects on hit rates ($Fs < 1$). The three-way interaction was not significant, $F(1, 94) = 1.38$, $MSE = .012$, $p = .24$, $\eta_{2p} = .014$.

Bilinguals with lower Spanish proficiency had higher false alarm rates than those with higher proficiency, $F(1, 94) = 4.91$, $MSE = .31$, $p = .029$, $\eta_{2p} = .05$. English proficiency was not associated with the strengths of the modality and concreteness effects on false alarm rates ($Fs < 1$), and there was no three-way interaction ($F < 1$). Taken together, the results suggest that proficiency levels in the uninvolved language do not influence recall performance but higher proficiency levels in the language enhance associative recognition performance, especially when they make decisions for incorrect pairs.

1.6.4 Comparisons of monolingual and bilingual groups.

1.6.4.1 Analyses for the group comparison.

Further analyses compared monolingual to bilingual performance. In these analyses, all three language groups were included, and the monolingual group was compared to English-dominant and Spanish-dominant bilinguals in separate sets of planned comparisons. These analyses examined whether bilinguals exhibited advantage(s) in associative learning of foreign language vocabulary and whether either modality or concreteness impacted memory performance differentially across language groups.

1.6.4.2 Recall accuracy in the group comparison.

Monolingual and bilingual cued recall accuracy did not differ ($Fs < 1$). The strength of the modality effect also did not differ across groups ($Fs < 1$). The strength of the concreteness effect did not differ across the groups [monolinguals vs. ED: $F(1, 141) = 1.78$, $MSE = .08$, $p = .18$, $\eta_{2p} = .01$; monolinguals vs. SD: $F(1, 141) = 1.15$, $MSE = .05$, $p = .29$, $\eta_{2p} = .01$]. There were no three-way interactions across involving language group ($Fs < 1$).

1.6.4.3 Discrimination analysis in the group comparison.

Discrimination performance (d') on the associative recognition test was analyzed including all of the language groups. Recognition accuracy did not differ for monolinguals and bilinguals (Fs < 1). The strength of the modality effect did not differ reliably across groups [monolinguals vs. ED: $F(1, 141) = 3.31$, $MSE = 2.87$, $p = .07$, $\eta_{2p} = .02$; monolinguals vs. SD: $F(1, 141) = 1.70$, $MSE = 1.48$, $p = .19$, $\eta_{2p} = .01$]. The strength of the concreteness effect also did not differ across groups [monolinguals vs. ED: $F < 1$; monolinguals vs. SD: $F(1, 141) = 2.91$, $MSE = 4.01$, $p = .09$, $\eta_{2p} = .02$]. There were no three-way interactions [monolinguals vs. ED: $F(1, 141) = 1.01$, $MSE = .68$, $p = .32$, $\eta_{2p} = .01$; monolinguals vs. SD: $F(1, 141) = 1.66$, $MSE = 1.12$, $p = .20$, $\eta_{2p} = .01$].

Hit rates were higher for English-dominant bilinguals than for monolinguals, $F(1, 141) = 5.52$, $MSE = .16$, $p = .02$, $\eta_{2p} = .04$, but hit rates did not differ between monolinguals and Spanish-dominant bilinguals ($F < 1$). The strength of the modality effect in hit rates did not differ reliably between monolinguals and English dominant bilinguals, $F(1, 141) = 3.43$, $MSE = .05$, $p = .07$, $\eta_{2p} = .02$. However, monolinguals showed stronger modality effects in hit rates than Spanish-dominant bilinguals, $F(1, 141) = 4.86$, $MSE = .07$, $p = .03$, $\eta_{2p} = .03$. Specifically, monolinguals had slightly higher hit rates for visual pairs but lower hit rates for auditory pairs relative to Spanish dominant bilinguals. The concreteness effect did not differ for monolinguals and bilinguals [monolinguals vs. ED: $F < 1$; monolinguals vs. SD: $F(1, 141) = 1.55$, $MSE = .03$, $p = .22$, $\eta_{2p} = .01$]. There were no three-way interactions [monolinguals vs. ED: $F < 1$; monolinguals vs. SD: $F(1, 141) = 1.70$, $MSE = .02$, $p = .19$, $\eta_{2p} = .01$].

False alarm rates did not differ across monolingual and bilingual groups [monolinguals vs. ED: $F(1, 141) = 1.43$, $MSE = .09$, $p = .24$, $\eta_{2p} = .01$; monolinguals vs. SD: $F < 1$]. The strength of the modality effect in false-alarm rates did not differ for monolinguals and bilinguals (Fs < 1). The strength of the concreteness effect also did not differ between monolinguals and bilinguals [monolinguals vs. ED: $F < 1$; monolinguals vs. SD: $F(1, 141) = 1.21$, $MSE = .03$, $p = .27$, $\eta_{2p} = .01$]. The three-way interactions were not significant [monolinguals vs. ED: $F(1, 141) = 3.37$, $MSE = .06$, $p = .07$, $\eta_{2p} = .02$; monolinguals vs. SD: $F < 1$].

Therefore, in the comparison between English monolinguals and English dominant bilinguals, English dominant bilinguals had higher hit rates than English monolinguals but false-alarm rates did not differ between the two language groups. In the comparison between English monolinguals and Spanish dominant bilinguals, the visual advantage in hit rates was greater for English monolinguals than Spanish dominant bilinguals; however, no such interaction was found in false-alarm rates.

1.6.5 Comparison of associative strategies across groups.

We also compared study strategies of monolinguals and bilinguals to investigate whether monolinguals and bilinguals used the same or different strategies to learn new language vocabulary. Individual study strategies were categorized either of the following: 1) word association/mediator use, 2) repetition, 3) imagery, 4) sentence formation, 5) translation, 6) spelling out, 7) self-testing, 8) memorization of first letter, 9) no specific strategy, and 10) multiple strategies. (Multiple strategies indicate any combination of the above strategies.) Strategies of word association, sentence formation and translation were considered as associative strategies in the present study, and we calculated the pooled associative strategy for each language group to see the proportion of participants who reported at least one associative strategies. Table 5 represents the percentage of use of each associative strategy and pooled associative strategy for each group. Table 6 represents the percentage of use of each non-associative strategy and multiple strategies.

According to the strategy reports, bilinguals used associative strategies more than monolinguals (45.8% for EM, 77.1% for ED, and 70.8% for SD) although all groups reported more than one strategies to the same degree (22.9% for EM, 29.2% for ED, and 27.1% for SD). Monolinguals reported the repetition strategy more than bilinguals; however, the other non-associative strategies were used in the similar proportions across the language groups. Within bilinguals, Spanish-dominant bilinguals used Spanish words more than English-dominant bilinguals to associate with word stimuli, but the other strategies were used in the similar

proportions. The strategy analysis suggests that the use of associative strategies did not enhance bilingual learning of foreign language vocabulary.

1.7 Discussion.

The present study used the paired-associate learning method to address five questions: 1) whether bilinguals learn new language vocabulary better than monolinguals when the unfamiliar words are given as cues, 2) whether language proficiency or language dominance impacts associative memory performance, 3) whether the strength of the concreteness effect differs across the language groups or across language proficiency levels within bilinguals, and/or 4) whether the strength of modality effects differs across the language groups or language proficiency levels. Findings from the three language groups were consistent, in that all language groups showed more accurate memory for concrete words than for abstract words and more accurate memory for words learned in the visual rather than auditory modality. Word concreteness effects were independent of learning modality in both monolinguals and bilinguals. This finding is consistent with previous monolingual research, suggesting word concreteness levels are not modality-specific (e.g., Janssen, 1975; Neath, 1997).

1.7.1 Monolingual-bilingual differences in foreign vocabulary learning.

A primary question that motivated the present research was whether bilinguals would learn foreign-language vocabulary more efficiently than monolinguals who were matched on age, education, parent education, and non-verbal cognitive ability. Cued recall accuracy and associative recognition detection scores (d') did not differ between English-speaking monolinguals and Spanish-English bilinguals. This finding is consistent with one prior study in which bilinguals who learned foreign language vocabulary via their less proficient language did not outperform monolinguals (Bogulski, Bice & Kroll, 2018), whereas this finding is inconsistent with prior studies in which bilinguals outperformed monolinguals (e.g., Kaushanskaya & Marian, 2009; Kaushanskaya & Rechtzigel, 2012; Van Hell & Mahn, 1997) and bilinguals learning via their more

proficient language outperformed monolinguals (Bogulski et al., 2018). We considered several possible explanations for the discrepancies were considered.

First, we considered the possibility that the average time taken to study each word pair might have differed across language groups due to the self-paced nature of the study task. If monolinguals had taken more time to study each item, they could have used the extra time to compensate for less efficient learning and offset their hypothesized disadvantage in accuracy. We conducted additional analyses to compare mean study times across groups and conditions (given in Table 3). The analyses revealed no differences in study time across language groups [monolinguals vs. ED: $F(1, 141) = 1.08$, $MSE = 21796138$, $p = .30$, $\eta_{2p} = .01$; monolinguals vs. SD: $F < 1$]. The results of this analysis refuted the contention that monolinguals may have studied longer than bilinguals to compensate for less efficient learning.

Second, because monolinguals lived in an environment that regularly exposes residents to both English and Spanish, we considered recent claims that monolinguals who are regularly exposed to other languages process new language words differently than monolinguals who are not exposed to any other languages (Bice & Kroll, 2019). In that study, monolingual English speakers living in English-only (n = 18) and linguistically diverse environments (n = 16) learned unfamiliar Finnish words through pairings with their English translation equivalents and pictures. It should be noted, however, that this study did not report tests of how well participants learned the associations between Finnish and English words or between Finnish words and their meanings, because the focus was on learning to detect a novel vowel contrast. Nevertheless, behavioral results were reported for a test of item recognition in which participants had to indicate simply whether Finnish words had been studied or not, and no group differences were observed. Although item recognition and associative recognition do not always follow the same patterns, the results do not support the claim that language environments impact how well monolinguals commit foreign vocabulary to memory (Bice & Kroll, 2019). It therefore seems unlikely that daily exposure to Spanish spuriously enhanced monolingual performance in the present study.

Two other factors provide more plausible explanations of the inconsistency between the present study and prior research. First, some studies did not match their samples or conditions adequately. For example, they did not match samples on age and/or education levels or had monolinguals and bilinguals learn through different known languages and/or acquire vocabulary from different new languages (Kaushanskaya & Rechtzigel, 2012; Bogulski et al., 2018; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). The present study, however, included monolingual and bilingual participants who were well-matched on demographic characteristics, lived in the same city, and learned the same new language vocabulary words through the same known language using the same method (and exactly the same materials).

Second, some of the previous studies had small sample sizes (Kaushanskaya & Marian, 2009; Kaushanskaya & Rechtzigel, 2012; Bogulski et al., 2018; Papagno & Vallar, 1995), resulting in unstable sample means that may not have been adequately representative of the targeted populations. In contrast, the present study had 48 participants in each group, more stable means, and power of 85% to detect medium-sized group differences. Taking these factors into consideration, the present results suggest that bilinguals do not have an advantage over monolinguals in forming new associations with foreign language vocabulary when certain characteristics of monolinguals and bilinguals are well-matched.

1.7.2 Language dominance and proficiency effects in foreign vocabulary learning

Differences among bilinguals were investigated in terms of both language dominance and English proficiency scores. First, we focused on the effect of language dominance in vocabulary learning, because a previous study suggested that bilinguals are better able to learn foreign vocabulary through the dominant language (Bogulski et al., 2018). The prior study had three groups of bilingual participants that learned Dutch words through English, and they performed associative recognition tests. English was the dominant language for one of the bilingual groups (English-dominant English-Spanish bilinguals), whereas English was the nondominant language for another group (Chinese-dominant Chinese-English bilinguals). Another group included a

mixture of Spanish-dominant and English-dominant bilinguals (11 Spanish-dominant and 8 English-dominant bilinguals). Bilinguals who learned through their second language did not exhibit more accurate performance than monolinguals. Only the bilinguals with English as their dominant first language outperformed English monolinguals in accuracy. However, interpretation of this finding is complicated by the fact that English-Spanish bilinguals took about 50% longer to study the word pairs, which suggests that their superior performance may be a consequence of study time rather than their knowledge of another language. In the present study, English-dominant bilinguals showed neither greater accuracy nor longer average study times relative to monolingual English speakers, so with similar study times, there were no accuracy differences at test. Consistent with the previous study, bilinguals who learned foreign vocabulary through their less proficient language did not outperform monolingual speakers. In contrast to the previous study, neither the accuracy measures nor study time depended on whether English was the dominant or non-dominant language.

Explanations for the inconsistency in the effects of language dominance across studies include group differences other than language dominance and assessment of proficiency. In the prior study (Bogulski et al., 2018), over three quarters of the English dominant bilinguals had been exposed to Spanish after age 10 (the range of age was 0 to 16), whereas the Spanish dominant bilinguals had been exposed to English at mean age 6.58 (no report for the range of age), and the Chinese-English bilinguals had been exposed to English at mean age 11.71 (from 9 to 15). Furthermore, eight out of nineteen Spanish-English bilinguals were determined to be dominant in English. While the dominance of participants in the English-Spanish and Chinese-English groups seems clear based on language history, the dominance of participants in the Spanish-English group was based on self-report measures. Thus, the interpretation of their results is not clear.

However, based on the results of the prior study, we wondered whether absolute levels of language proficiency might be the critical factor in bilingual performance rather than dominance relative to another language, and also considered that a continuous objective measure might be more sensitive than a binary dominance classification. In the prior study (Bogulski et al., 2018) an

exploratory analysis showed that the self-reported English proficiency of the Spanish-English bilinguals (n = 19) was reliably associated with their associative recognition accuracy. In the present study, we examined the associations of objective measures of proficiency in each language with cued recall and associative recognition accuracy with 96 participants. When English proficiency was treated as a continuous variable, language proficiency effects emerged such that participants with higher English proficiency had more accurate performance on both the cued recall and associative recognition tests. In contrast, Spanish proficiency was not reliably associated with accuracy of cued recall although bilinguals with higher Spanish proficiency had more accurate performance on the associative recognition tests. The effect size of language proficiency effects on associative recognition was larger for the involved language proficiency in both experiments (η_{2p} = .14) than for the uninvolved language proficiency (η_{2p} = .04). These dissociative language proficiency effects suggest that bilingual associative-learning performance depends on proficiency in the language that is used during learning but does not depend on their proficiency in other languages or their relative proficiency across their two languages (i.e., language dominance).

1.7.3 Concreteness effects in foreign language vocabulary learning

The distributed features model explanation of concreteness effects in lexical processing and memory (Paivio & Desrocher, 1980), based on greater semantic overlap for concrete than for abstract words, led to predictions about possible interactions of concreteness with language status. Specifically, under this model, concreteness effects would be expected to be larger for bilinguals than for monolinguals because of greater activation of the lexical-semantic network (Kaushanskaya & Rechtzigel, 2012). The results of the present study, however, were inconsistent with this prediction, in that that the strength of the concreteness effects in cued recall and associative recognition tests did not differ across language groups and did not vary as a function of language dominance or English proficiency. This inconsistency raised the question of whether the interaction found in the previous study is restricted to auditory encoding conditions. An

28

additional analysis that was restricted to data from the auditory encoding conditions showed the same pattern as the original analysis, with concreteness effects that did not differ across language groups (Fs < 1). These findings provide no evidence that activation of lexical-semantic representations is greater for bilinguals than for monolinguals during foreign language vocabulary learning or that such activation would enhance performance at test.

These findings suggest that the distributed feature model (de Groot, 1992; van Hell & de Groot, 1998) does not help to explain concreteness effects in explicit memory. This model was first developed to understand bilingual lexical processing, assuming that the sets of lexical and semantic features that are shared between two languages influence bilingual lexical processing. The more sets that are shared, the more quickly and accurately bilinguals process information or exhibit cross-language activation. This model has been applied to explain concreteness effects in bilingual lexical processing based on the idea that concrete words have more conceptual overlap than abstract words. Bilinguals would therefore have more lexical-semantic links than monolinguals, because bilinguals have two languages that are shared in their mental representations and would activate the links more strongly than monolinguals during lexical processing. As in previous studies, the present study also found that memory for foreign vocabulary is more accurate for concrete words than for abstract words (e.g., de Groot, 2006; van Hell & Mahn, 1997). However, monolinguals and bilinguals demonstrated the concreteness effects to the same degree. Thus, the results of the present study do not support the application of the distributed feature model to explain concreteness effects in explicit memory.

1.7.4 Modality effects in foreign language vocabulary learning.

The strength of modality effects was also examined across the language groups, and we examined whether it was impacted by language dominance or language proficiency. We expected that the modality effect would be greater for bilinguals than for monolinguals, and the effect of language dominance was observed in the effect because of cross-modal activation and cross-language activation. However, the modality effect did not differ across language groups or vary

with language dominance or English proficiency. Because previous studies that exhibited a bilingual advantage used auditory presentation for either the novel words or all paired words (e.g., Kaushanskaya & Marian, 2009; Kaushanskaya & Rechtzigel, 2012), we ran an additional analysis on data from the auditory learning conditions only to see whether a bilingual advantage would emerge. No such advantages emerged [monolinguals vs. English dominant (recall): $F < 1$; monolinguals vs. English dominant (recognition): $F(1, 141) = 1.835$, $MSE = 3.400$, $p = .178$, $\eta^2_p = .013$; monolinguals vs. Spanish dominant (recall): $F < 1$; monolinguals vs. Spanish dominant (recognition): $F < 1$]. These findings give no evidence regarding the strength of cross-modal activation in bilinguals and suggest two possible properties of cross-modal activation. The first possibility is that cross-modal activation does not vary across language groups. The second possibility is that cross-modal activation does vary across groups, but these differences do not impact learning and memory. The present study does not discriminate between these two interpretations, but it suggests that the strength of the visual advantage is comparable for monolinguals and bilinguals.

1.8 Conclusion

The results of the present study provide no evidence to support the contention that bilinguals have an advantage relative to monolinguals in paired-associate learning of foreign language vocabulary when the unfamiliar words are used to cue recall of the familiar words. Furthermore, we found that proficiency in the language used for learning, rather than language dominance, predicts associative learning of foreign vocabulary. Thus, the associative-memory performance of monolinguals and bilinguals does not differ, but bilinguals with higher proficiency in the language they use have an advantage over bilinguals with lower proficiency in the language.

Table 3: Mean (SE) paired-associate memory performance.

Language Group Modality Concreteness	Recall (%)	Hit rate	FA rate	d' score	Study time (s)
English Monolinguals					
Visual					
Concrete	79.4 (2.9)	.911 (.02)	.119 (.02)	3.22 (.18)	20.03 (.62)
Abstract	67.7 (3.3)	.893 (.02)	.128 (.02)	3.00 (.18)	21.62 (.55)
Auditory					
Concrete	63.8 (3.7)	.757 (.02)	.252 (.03)	1.72 (.17)	6.28 (.29)
Abstract	49.8 (3.5)	.726 (.03)	.353 (.03)	1.15 (.15)	6.37 (.26)
English Dominant					
Visual					
Concrete	79.0 (3.0)	.938 (.01)	.125 (.02)	3.32 (.16)	19.95 (.61)
Abstract	61.0 (3.8)	.903 (.02)	.202 (.03)	2.74 (.19)	21.49 (.54)
Auditory					
Concrete	66.3 (3.7)	.839 (.02)	.289 (.03)	2.00 (.17)	6.42 (.29)
Abstract	46.9 (3.6)	.771 (.03)	.355 (.03)	1.48 (.19)	6.54 (.29)
Spanish Dominant					
Visual					
Concrete	80.8 (2.8)	.932 (.01)	.103 (.02)	3.43 (.17)	19.70 (.52)
Abstract	63.1 (3.7)	.851 (.02)	.161 (.02)	2.58 (.20)	21.08 (.51)
Auditory					
Concrete	62.9 (3.8)	.804 (.02)	.250 (.03)	1.97 (.18)	6.68 (.29)
Abstract	45.6 (2.7)	.764 (.02)	.378 (.03)	1.27 (.17)	6.80 (.30)

Note. This table shows mean recall accuracy, hit rates, false alarm (FA) rates and d' scores in each condition for each language group. The last column represents the mean time taken to study each word pair in the indicated condition.

Table 4: Group comparison on associative memory performance.

Group Comparison Test Type	Recall	Hit rate	FA rate	d'
ED vs. SD				
Overall	--	--	--	--
Modality	--	--	--	--
Concreteness	--	--	--	--
Interaction	--	--	--	--
Bilingual Proficiency				
Overall	higher > lower	higher > lower	higher > lower	higher > lower
Modality	--	--	--	--
Concreteness	--	--	--	--
Interaction	--	--	--	--
EM vs. Bilinguals				
Overall	--	EM < ED	--	--
Modality	--	EM > SD	--	--
Concreteness	--	--	--	--
Interaction	--	--	--	--

Note. EM, ED and SD indicate English monolinguals, English dominant bilinguals and Spanish

dominant bilinguals. FA rates indicate false alarm rates on the recognition task.

Table 5: Use of associative strategies.

Language Group	Word Association (%)	Sentence Formation (%)	Translation (%)	Pooled (%)
EM	41.7	10.4	--	45.8
ED	58.3	12.5	14.6	77.1
SD	29.2	10.4	39.6	70.8

Note. EM, ED, and SD indicate English monolinguals, English dominant bilinguals, and Spanish dominant bilinguals. Translation strategy indicates Spanish words were used to study. Each strategy also contains people who reported multiple strategies. Pooled indicates the percentage of participants who reported at least one associative learning strategies.

Table 6: Use of non-associative strategies.

Language Group	Repetition (%)	Imagery (%)	Spelling Out (%)	Self-test (%)	First Letter (%)	No Specific (%)	Multiple (%)
EM	31.3	18.8	8.3	2.1	2.1	18.8	22.9
ED	20.8	12.5	2.1	0.0	2.1	10.4	29.2
SD	14.6	12.5	2.1	0.0	4.2	16.7	27.1

Note. EM, ED, and SD indicate English monolinguals, English dominant bilinguals, and Spanish dominant bilinguals. Self-test strategy indicates participants tested themselves before the cued recall. First letter strategy indicates all first letters of unfamiliar words were remembered. Multiple strategies indicate more than one strategies were reported. Each strategy contains participants who reported multiple strategies.
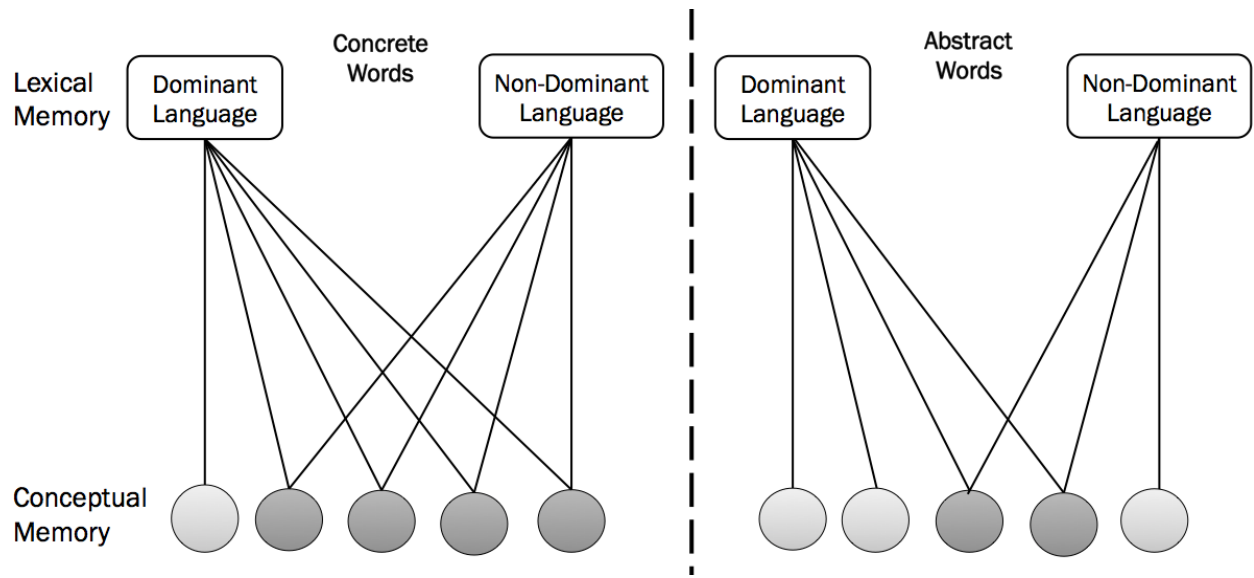
Figure 1: The distributed feature model (de Groot, 1992; van Hell & de Groot, 1998).
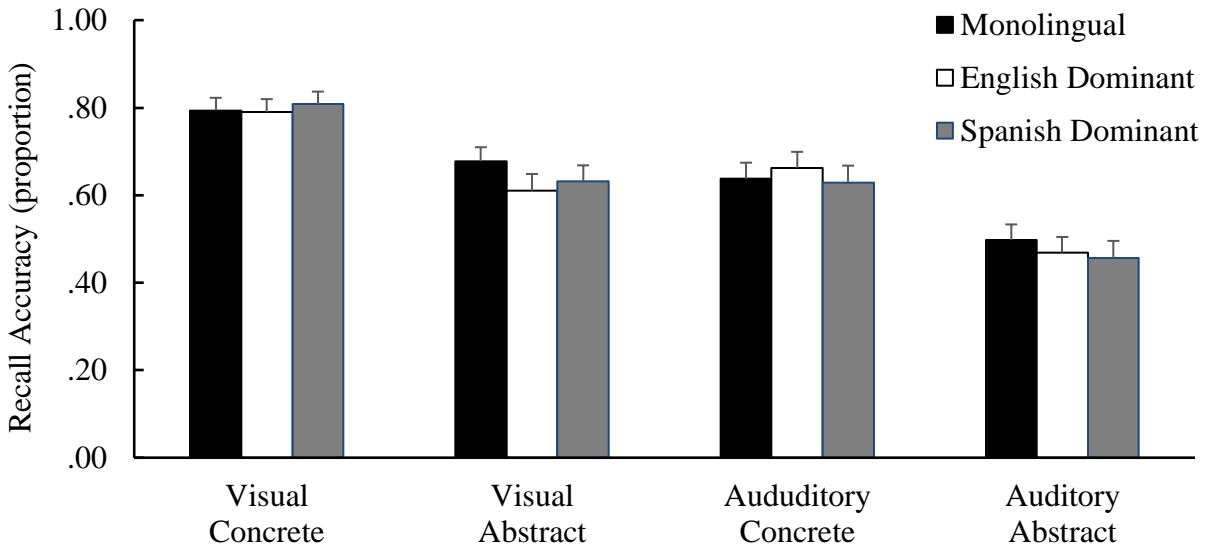
Figure 2: Mean accuracy in cued recall as a function of language group, study modality, and concreteness. Error bars indicate standard errors of the mean.
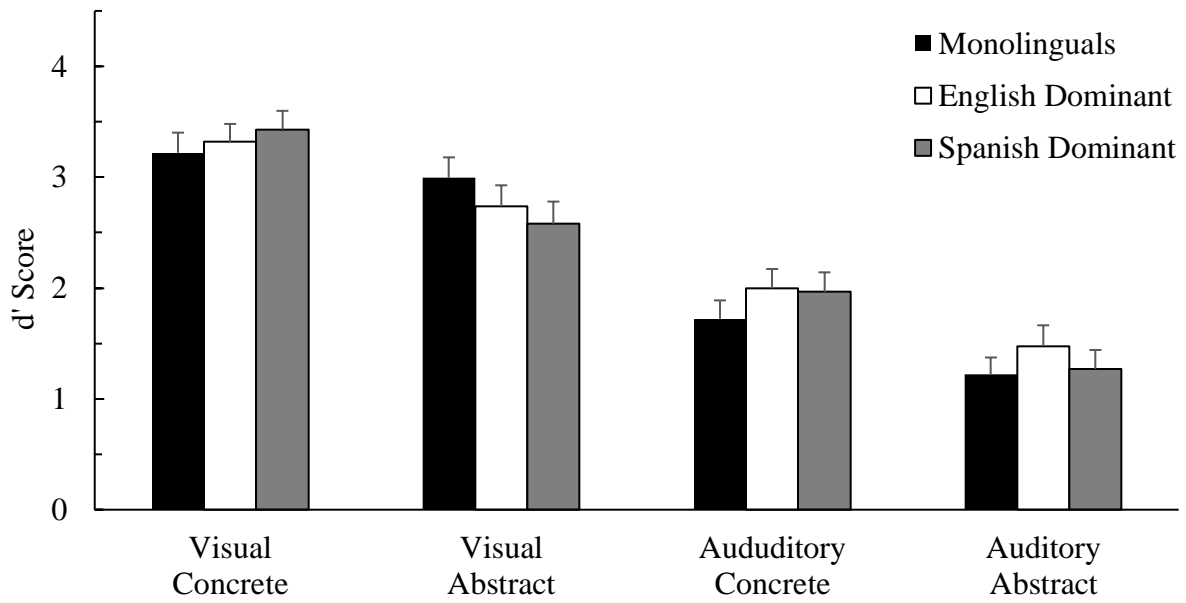
Figure 3: Discrimination d' scores in the associative recognition test. Error bars indicate standard errors of the mean.
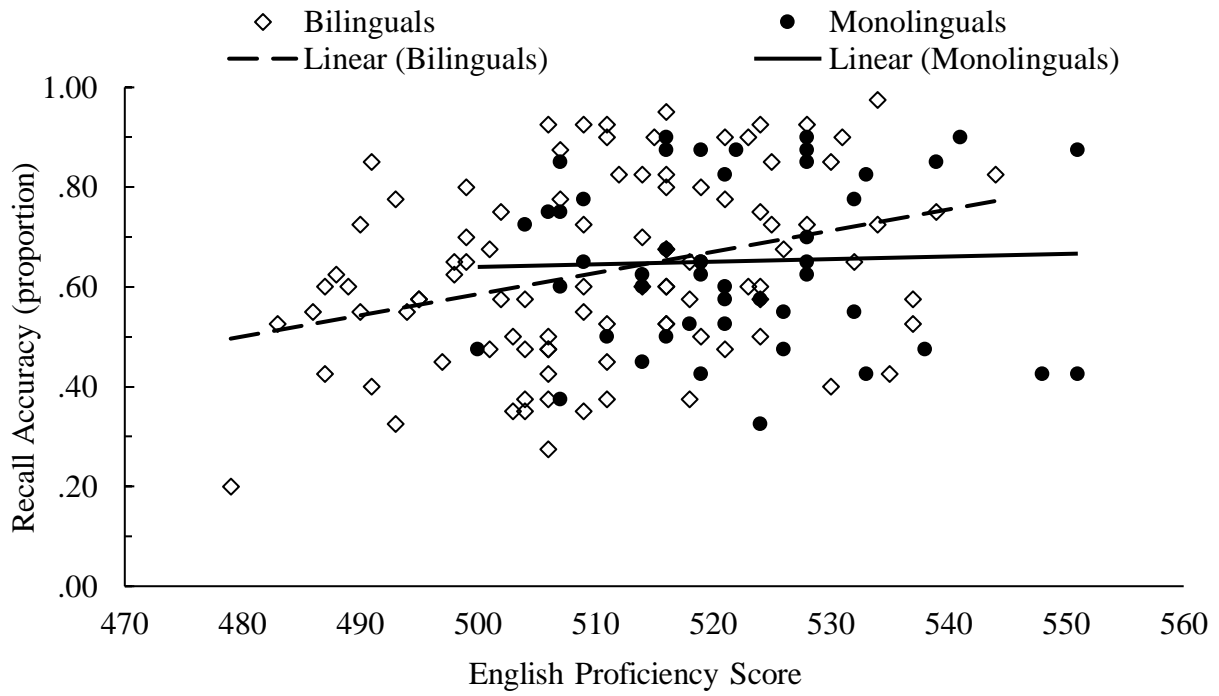
Figure 4: Linear associations between English proficiency scores and recall performance in monolinguals and bilinguals. The English proficiency scores are the W scores on the WMLS-R (Woodcock et al., 2005).
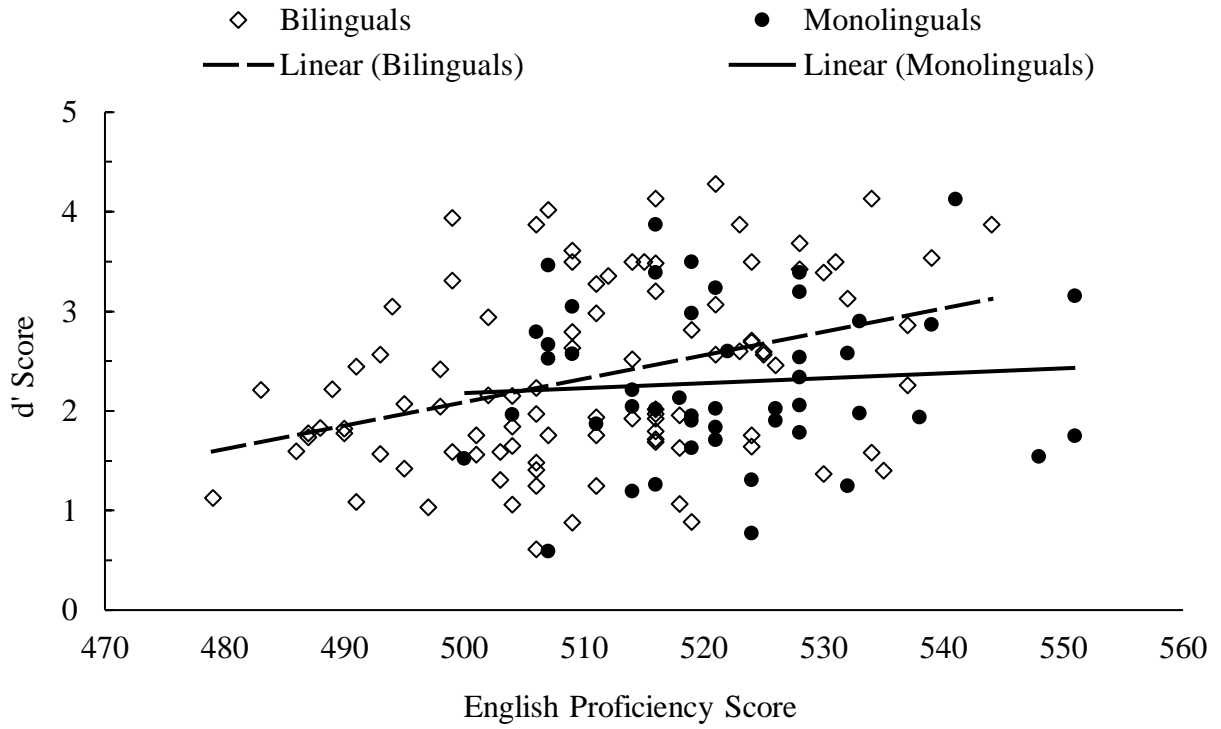
Figure 5: Linear associations between English proficiency scores and d' score in monolinguals and bilinguals. The English proficiency scores are the W scores on the WMLS-R (Woodcock et al., 2005).

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Vita

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