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by

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Abstract

To acquire a language, second language learners must process many factors at one time. Some of those factors include working memory capacity and the ability to identify morphemes at the end of words. Native English speakers and bilingual speakers who learned English as a second language were tested with a grammaticality judgment task, size judgment task, and a listening through noise task. In general, working memory capacity seemed to affect bilingual speakers and not native speakers. On the grammaticality judgment task, native speakers scored higher than bilingual speakers. On the listening through noise task, native speakers also scored higher than bilingual speakers. Both groups guessed more plural words than third-person present agreement or past tense words. Native speakers tended to score higher on semantically predictable sentences while both native speakers and bilingual speakers scored higher on syntactically unpredictable sentences. For both native speakers and bilingual speakers, bound morphemes were harder to hear than words without morphemes. Working memory capacity impacted bilingual speakers, and the ability to detect morphemes impacted the grammatical skills of both native speakers and bilingual speakers.

Identification of Morphemes and the Effect of Memory Load on Second Language Learning

Research has shown that learning a second language may be one of the hardest things to do for someone who learns a second language as an adult, even suggesting that there is a Critical Period Hypothesis that limits language learning to the period before puberty (Johnson & Newport, 1989). The Critical Period Hypothesis states that someone below the age of puberty can learn a second language fluently. However, after puberty near the age of 12, one's ability to learn a second language becomes impeded. According to the Critical Period Hypothesis, children learn more quickly and remember more of the second language than adults. Evidence from past research has supported the Critical Period Hypothesis. In particular, Johnson and Newport (1989) found that a group of second language learners who learned English between the ages of three and seven scored similarly to a group of native English speakers, but subsequent age groups differed from the native speakers and the 3-7 age group. They also reported no systematic relationship between age and grammaticality test scores after puberty, supporting the Critical Period Hypothesis because the age effects on the grammaticality judgment task happened before puberty. The scores slowly decreased in a systematic matter until the children reached puberty. Then, the scores decreased sporadically. After puberty, second language learners did not attain grammaticality scores as high as second language learners that learned the second language before puberty (Johnson & Newport, 1989).

Besides the Critical Period Hypothesis, another factor of language learning is the learner's age of arrival. Age of arrival, or AOA, is defined as the age that a second language learner moved to reside in a country that speaks the second language. AOA affects subsequent performance on language learning abilities, regardless if the second language speaker arrives in the second language country before or after puberty. Many researchers have found age effects to

exist for younger speakers and for older speakers as well. For both younger learners under the age of 12 and older learners over the age of 12, there is a negative correlation between age and grammaticality judgment task scores, i.e. the later in life that someone arrives in a country that speaks the second language as a dominant language, the worse he or she performs on grammaticality judgment tasks of the second language (Flege, Yeni-Komshian, & Liu, 1999; McDonald, 2000). If the Critical Period Hypothesis was supported, then the researchers would have seen no age effects after puberty, but there were age effects seen for all ages. Therefore, a certain critical time period to learn a language was not supported. On the other hand, because age effects were found, there is support that AOA affects someone's language learning ability.

Another possible explanation for the reason second language learners perform worse than native speakers is a reduced L2 memory capacity in the second language. Working memory capacity is the ability to process and store information at the same time. Second language learners may have to use more of their memory capacities to focus on the general meaning of the sentences, such that they may miss a few words or sounds. Having more information tax the working memory capacity may affect someone's second language performance. In fact, researchers have found that second language learners that score higher on working memory tests are more likely to also score higher on second language tests that measure reading, speaking, and writing (Kormos & Safar, 2008). Even participants that learn artificial languages in the lab tend to score higher on grammar tests if they also score higher on working memory tests (Martin & Ellis, 2012). Since processing grammar involves processing words, inflectional markers, word order, and other syntactic markings, judging grammar places a high demand on someone's ability to process information. If someone has a larger working memory capacity and can process

more things, then he or she is more likely to process grammar more efficiently than someone can process fewer items at a time (Martin & Ellis, 2012).

A few researchers have looked at late learners' ability to decode words and keep information in their working memory capacities. In one particular study done by McDonald, a size judgment task was used to measure working memory capacity. Participants heard lists with a varying number of nouns, and then they repeated the list of words from the smallest physical object to the largest physical object. Age effects were again found in this study, such that the later a second language learner was exposed to English, the fewer English words the second language learner remembered and categorized correctly (McDonald, 2006). The fact that second language learners remembered fewer words suggests that they may have smaller working memory capacities in their second languages. However, it may be that second language learners do not have smaller memory capacities in their second language, but instead allocate more of their working memory capacities to the processing of words in their second languages compared to how much working memory they allocate in their first languages. Past researchers have found that working memory affects the production of vocabulary but not comprehension (Martin & Ellis, 2012). Therefore, perhaps second language learners remember fewer words because they have to think about how to pronounce one word and may forget other words in the process unlike native speakers who can remember and pronounce words without difficulty.

Another aspect of second language learning is the use of cues from the environment. Those cues can either come from the semantics of the sentence or the syntax of the sentence. Semantic predictability involves using words surrounding an unknown word to predict the unknown word. In fact, past research has found that people tend to read and process sentences faster when the words are semantically predictable (Roland, Yun, Koenig, & Mauner, 2012).

When words commonly occur in similar contexts, the words are more likely to be read and processed faster. For example, the word “bark” is usually associated with the word “dog.” Therefore, the sentence “The dog barked” will be processed faster than “The cat barked.”

Syntactic predictability involves using information to predict inflectional morphemes, or bound morphemes, on the end of plural nouns or verbs. Second language learners typically find words easier to learn than bound morphemes. For example, it is much easier to recognize the word “dog” rather than just the “s” on “dogs.” For plurals, syntactic cues involve phrases that include the indefinite article “a” or numbers that indicate either singularity or plurality. “Three” in front of “three dogs” indicates the plurality of the word. However, some cues are unpredictable, such as the article “the.” The article “the” involves no phrases involving numbers, so it is difficult to predict whether the noun will be singular or plural. For verb tenses, cues may be adverbs. When adverbs that indicate time, such as “today” and “yesterday,” are available in sentences, second language learners tend to notice these cues before they notice bound morphemes on the verbs (Ellis & Sagarra, 2011). It’s much easier to use adverbs than bound morphemes because adverbs are more salient than bound morphemes. The adverbs are longer and easier to hear than a shorter sound, such as –s or –ed.

Another possible explanation for poor grammaticality judgment skills may be the detection of speech-related sounds, especially morphemes. Second language learners may easily misunderstand some words with bound morphemes. For example, if someone asked a second language learner to bring the pens, but the second language learner heard “pen” instead of “pens,” then he or she may misunderstand the request, leading to a deficit in pens. Someone may even misunderstand the bound morphemes on the end of a verb, which would change the meaning of the sentence. If someone hears “The buses arrive” rather than “The buses arrived,” then he or she

may assume that the bus will be arriving soon rather than the bus has already arrived. This inability to identify bound morphemes affects someone's ability to understand language and process it. If someone can't perceive the morphemes, then he or she may not be able to determine if it is a grammatical or ungrammatical sentence. Native speakers who hear sentences that are overlaid with noise are less likely to judge the sentence correctly (McDonald, 2006). This result suggests that if native speakers incorrectly categorize sentences when their ability to hear the morphemes is challenged, then second language speakers may also categorize the sentences incorrectly if they can't identify the morphemes in the words. When given parts of a word and asked to identify the word, researchers found that when compared to native speakers, late learners needed to hear more parts of the words before the late learners were able to identify the word (McDonald, 2006).

Second language learners may have more trouble distinguishing between the morphemes of the second language. Past studies have found that bound morphemes, i.e., –s or –ed, tend to be harder for people to identify than free morphemes, such as whole nouns and verbs that do not have morphemes on the ends. However, these studies have focused on children since morphological development emergences during childhood. Chinese native speakers from kindergarten to grade 3 showed a higher awareness in the Chinese language for free morphemes that could function as words by themselves than bound morphemes that could not function by themselves. The researchers suggested it was easier to identify the free morphemes since the free morphemes function as one unit, but the bound morphemes function as part of a unit (Hao, Chen, Dronjic, Shu, & Anderson, 2013). These findings suggest that identifying bound morphemes may be a hard task for both native and bilingual speakers. If it is a hard task for native speakers, then it is also likely to be a hard task for bilingual speakers.

Further research with children suggests that some bound morphemes may be harder to learn than others. Davison and Hammer (2012) studied bilingual Spanish-English children. The children either spoke Spanish first or spoke Spanish and English at the same time. All of them were of Puerto Rican descent. The morphemes were considered acquired when the children used them correctly 90% of the time. The children mastered prepositions and article forms first, reinforcing the idea that free morphemes are easier to learn than bound morphemes. In general, most children mastered plurals and the present progressive tense after two years. However, they tended to struggle with third person singular regular and irregular tenses and also with past tense. These data may suggest that second language learners may have trouble with some bound morphemes, such as third person singular –s and past –ed but not with others, such as plural –s. The researchers suggested the children struggle more with third person singular and past tense morphemes because the morphemes in English and Spanish are different. They struggle less with plurals because the morphemes are similar in English and Spanish (Davison & Hammer, 2012).

On the other hand, other studies have shown that almost all language learners struggle more with third person singular and past tense, regardless of their first language. Two second language learners of English can have different first languages, such as Vietnamese and Spanish, but still struggle with similar structures, including plurals and past tense structures even though Spanish has these structures but Vietnamese does not. Usually, second language learners of English struggle with determiners, plurals, pronouns, and verb tenses (Johnson & Newport, 1989; Flege, et al., 1999; McDonald, 2000; McDonald, 2006). Word order tends to be very easy for all second language learners of English.

In this study, a size judgment task was used to measure working memory and its impacts on answering grammatical sentences. The grammaticality task of this study focused on three

difficult structures with bound morphemes: regular structures of plurals, third-person singular tense, and past tense. It also used the easiest structure, word order, as a control structure. Sentence length was also varied to investigate the effects of increased memory load. A listening through noise task was created with the plural, third-person present agreement, and past tense constructions to test someone's ability to hear bound morphemes while stressed. The task used semantic predictability and syntactic predictability as well as words with bound morphemes and words without bound morphemes. If someone can hear bound morphemes better, then he or she may be better at judging grammar.

It was predicted that native speakers' performances on the grammaticality judgment task would not correlate to their working memory capacities. Bilingual speakers, however, were predicted to do better on the grammaticality judgment task if they had larger working memory capacities. In the grammaticality judgment task, native speakers were expected to perform better than bilingual speakers. Native speakers were also expected to perform similarly on plurals, third-person present agreement, past tense, and word order structures. However, bilingual speakers were expected to score worse on plurals, third-person present agreement, and past tense structures but score well on word order. In the listening through noise task, it was predicted that native speakers would perform better than bilingual speakers in general. Semantic predictability and syntactic predictability sentences were predicted to be easier than sentences that were semantically unpredictable and syntactically unpredictable. Finally, it was also predicted that native speakers and bilingual speakers would guess more words without bound morphemes correctly than words with bound morphemes.

Methods

Participants

A total of 43 subjects participated in the study. Twenty-six of them were native English speakers, whose first language was English, and seventeen of them were bilingual speakers who either learned English as a second language or learned English at the same time as their other first language. In the native English group, two speakers were left out of the analysis. One of those speakers was exposed to Spanish and English at birth although she spoke English first and then Spanish a few years later. The other speaker experienced auditory and speech problems when she was a child and required a hearing aid. These speakers were left out because their experiences significantly differed from the other native English speakers in the study.

In the native English group, ages ranged from 18-29, and the mean was M = 20 years old. Five were male and nineteen were female. All of them spoke English 85%-100% of the time each day. Most only spoke English fluently and also learned a foreign language or two in a classroom. Only two had significant exposure to other languages outside the classroom besides English, and the language that they had significant exposure to was Spanish. One speaker lived in Brazil for about 5-6 years as a child, and another speaker learned Spanish in a naturalistic setting from a friend's mother in the United States.

In the non-native English group, which will be referred to as the bilingual group from now on, there were ten males and seven females. Only four bilingual speakers were born and raised in the U.S. They began to learn English at the age of four-years-old in kindergarten classrooms in the United States. The rest of the bilingual speakers moved to the U.S. in between the ages of 5 to 27. Their current ages ranged between 19 to 32 years old, and the mean age was M = 23 years old. All of the bilingual speakers lived in the U.S. without interruption for at least

two years. They spoke English 35%-98% of the time each day. Six bilingual speakers spoke an Eastern Asian language as a first language (Chinese, Vietnamese, or Korean), seven speakers spoke Spanish as a first language, and four speakers spoke other languages that differed from Eastern Asian languages, and Spanish (Yoruba, Urdu, Russian, and Arabic). Nine of the thirteen speakers who moved to the U.S. had learned English in a foreign language classroom before moving to the U.S.

Materials

Grammaticality judgment task

There were a total of 128 sentences; 32 sentences tested each of four constructions: plurals, third-person present agreement tense, past tense, and word order. Within each construction, there were sixteen short sentences and sixteen long sentences. The short sentences had 4-7 words while the long sentences had 10-14 words. In the plural construction, only regular plurals were used. In the third-person present agreement and past tense constructions, only regular verbs were used. In the word order construction, only names and nouns that could not be confused with verbs or plurals were used as grammatical subjects. For sentences with bound morphemes (plurals, third person agreement, and past tense), an equal number of unvoiced and voiced versions of the morpheme were used in both the short and long versions of the sentences.

For each construction, there were eight grammatically correct sentences and eight grammatically incorrect sentences. Each grammatical sentence had a grammatically incorrect counterpart sentence for a total of sixteen sentences altogether. The grammar mistake always occurred in the fourth word of the sentence, except for sentences testing word order. For all constructions except word order, morphemes that indicated plurality or tense were missing from grammatically incorrect sentences. For word order, grammatically incorrect sentences were

made by moving the subject of the sentence to the end of predicate. Examples of the sentences can be seen in Table 1.

Eight past sentences were dropped from the analysis. The preposition that followed the verb blended with the verb and made the verb sound like it had an –ed on the end. Two plural sentences were dropped from the analysis because they were coded incorrectly in the program. Two present sentences were dropped from the analysis because they were also coded incorrectly. For all of the dropped sentences, the sentences were dropped in pairs. Both the grammatical and ungrammatical versions were dropped from the analysis.

Listening through noise task

All of these sentences were grammatically correct, and all of them had the same added noise level of -18db. The added noise was a white noise sound that sounded like static and had a "ssss" sound. There were a total of 72 sentences--24 for each grammatical construction of the sentences: plurals, third-person present agreement, and past tense. Within each grammatical construction, the final word was either semantically predictable or semantically unpredictable, and the inflectional form of the final word was either syntactically predictable or syntactically unpredictable. Each construction had six exemplars in each of the four cells formed by crossing semantic and syntactic predictability. Within each of these cells, half of the morphemes were unvoiced and half were voiced. Just like in the grammaticality judgment task, only regular plurals were used in the plural construction, and only regular verbs were used in the third-person present and past tense constructions. Examples of the sentences can be seen in Table 2.

Plurals: The semantically predictable plural sentences were made by using an adjective that is commonly associated with the subject of the sentence before the noun of the subject. It also included a target plural in the predicate at the end of the sentence that is commonly

associated with the subject of the sentence. For example, “The Olympic athlete won four medals” is semantically predictable for the sentence final word “medals.” The semantically unpredictable plural sentences were made by using a common adjective that is typically associated with emotions or people and also with a generic noun in the subject, such as “man” or “woman.” The semantically unpredictable sentence used the same target noun as the semantically predictable sentence counterpart, but it used a different adjective. For example, “The angry woman stole four medals” is semantically unpredictable for “medals.” Syntactically predictable plural sentences were made by using indefinite articles or phrases that determined if the target noun was expected to be singular or plural. In syntactically predictable sentences in which a singular target noun was expected, the phrase “a single,” “only one,” or “a” was used before the target noun. If the target noun was plural, then phrases indicating plurality, such as “three,” “a few,” “many,” and “four,” were used. For example, “The baby drank a single bottle” is syntactically predictable. In syntactically unpredictable sentences, only the indefinite article “the” was used, regardless if the target noun was singular or plural. For example, “The intelligent students passed the test” is syntactically unpredictable. Half of the sentences ended in singular target nouns while the other half ended in plural targets. All of the sentences were 6-7 words long.

Third-person agreement: The semantically predictable third-person agreement sentences were made by using an adjective in the subject before the noun that is commonly associated the target verb that was located at the end of the sentence. Animals and humans were used as the subjects in the sentences. For example, “The absent-minded teacher forgets” is semantically predictable. The semantically unpredictable present sentences were made by using common adjectives usually not associated with the target verb. The semantically unpredictable sentences used the same target noun as the semantically predictable sentence counterpart. For example,

"The happy fish forgets" is semantically unpredictable. Syntactically predictable present sentences were made by using animals and common words for people that have regular plural forms, like "teacher" and "kitten." The verb form could be predicted based on the singularity or plurality of the subject. For example, "The short child falls" is syntactically predictable. Syntactically unpredictable sentences were formed by using animals that had the same singular and plural forms, such as "sheep" and "deer." The verb form could not be predicted based on the subject. For example, "The clumsy deer falls" is syntactically unpredictable. Half of the target verbs were third-person singular and the other half were third-person plural. All of the sentences were four words long.

Past tense: The semantically predictable past tense sentences were made similarly to the semantically predictable third-person agreement sentences by using an adjective in the subject that is commonly associated with the target verb. Animals and humans were again used as the subjects in the sentence, but in the past sentences, all of the subjects were plural. For example, "The fussy babies cried" is semantically predictable. Semantically unpredictable sentences were created by using adjectives that weren't commonly associated with the target verbs. For example, "The tiny kittens cried" is semantically unpredictable. Syntactically predictable sentences were made with phrases that indicated if the verb was in present tense or past tense. For present tense, the phrases were "now," "today," "right now," or "presently." For the past tense, the phrases were "yesterday," "last night," "three days ago," and "last week." For example, "Yesterday the guard dogs barked" is syntactically predictable. The syntactically unpredictable past sentences were made by removing the time marking phrase but using the same verb and adjectives as the syntactically predictable sentences. For example, "The guard dogs barked" is syntactically unpredictable. Half of the target verbs were past tense and the other half were present tense.

Present tense was used in the past section because with plural subjects, present tense verbs have the same stem as past tense verbs without a bound morpheme attached to the end of the verb. The sentences each contained 4-8 words.

Procedure

When participants first walked in, they were greeted by the experimenter. Then they were given a consent form and informed of the four tasks of the experiment. All of the participants, regardless if they were native speakers or non-native speakers, completed the experiment in the same order: the grammaticality judgment task, the size judgment task, the questionnaire, and the listening through noise task. Finally, they were debriefed on the purpose of the experiment. Native speakers completed the tasks in 30-35 minutes while non-native speakers completed the tasks in 40-45 minutes.

Grammaticality judgment task

A grammaticality judgment task was administered orally to the participants through a computer. Then participants heard a sentence and were asked to press the "C" key if it was grammatically correct and the "I" key if it was grammatically incorrect. The "C" was actually the "1" key on the alphabetical keyboard while the "I" was the "0" key on the alphabetical keyboard. The "1" and "0" keys were covered with stickers that said "C" and "I" respectively. The participants heard each sentence once and were only given one chance to decide if the sentence was grammatically correct or not right after they heard the sentence.

Size judgment task

Participants heard lists of words and then repeated a reorganized list of words to the experimenter. They reorganized the words in terms of physical size of the object, from the smallest object to the largest object. For example, if a participant heard, "shirt, sock, bed," he or

she would tell the experimenter, "sock, shirt, bed." The participants were told to do their best and remember as many words as possible. If they said a word not on the list, the word was noted. However, only the words in the list were counted in the analysis. Each word they remembered counted as one point, regardless of the order the speakers repeated the words. They heard each list only once, and had to repeat a reorganized list right after they heard the unorganized list. There were four sizes of lists: three words, four words, five words, and six words. Each list size had three lists for a total of 12 lists.

Listening through noise task

During the listening through noise task, participants heard a sentence overlaid with noise and then repeated the last word of the sentence to the experimenter. After repeating the word they heard, participants hit the space bar to go to the next sentence. They heard each sentence once.

If the participant repeated the correct stem of the word and the correct bound morpheme, then the participant received one point. If either the stem or the bound morpheme was incorrect, the participant was awarded zero points.

Results

Participants' Experience

No correlations were found between the size judgment task and the bilingual participants' age of arrival, age of first exposure to English, the number of years that the speakers studied English, and the speakers' self-reported fluency. On the other hand, only age of arrival correlated with the overall total score on the listening through noise task, $r = -0.650$, $p<0.01$. No other correlation was found for the bilingual speakers. No correlations were analyzed for monolingual speakers since monolingual speakers all had the same age of arrival, age of first exposure, and

number of years studied. Please see table 3 for correlations between bilingual participants and experience.

Correlations between the tasks

For native speakers, the size judgment task did not correlate with either the long or short sentences in the grammaticality judgment task. The size judgment task did not correlate with the listening through noise task either.

For bilingual speakers, the size judgment task correlated with the long sentences of the grammaticality judgment task and also the listening through noise task. Bilingual speakers who scored higher on the size judgment task were also likely to score more accurately on the long sentences in the grammaticality judgment task and were also more likely to guess more words correctly on the listening through noise task. There was no correlation between the size judgment task and the short sentences. Please see table 4 for correlations.

Grammaticality judgment task

The grammaticality test had a 2 (length) x 4 (construction) x 2 (grammaticality) x 2 (group) design. A repeated measures ANOVA was used to calculate the results, and a Bonferroni post-hoc test was used to compare the means. There was a main effect between groups, $F(1, 39) = 5.372$, $p<0.05$. Native speakers performed more accurately than bilingual speakers ($M = 0.879$, $M = 0.820$). There was a main effect for grammar construction, $F(3, 117) = 29.227$, $p<0.01$. The participants scored significantly higher on word order than any other construction ($M = 0.934$). They scored the next to highest on the plural construction ($M = 0.873$) and past tense construction ($M = 0.826$). The plural construction and past tense construction scores did not differ from each other. The participants scored the lowest on the third-person present agreement ($M = 0.766$).There was a main effect for length of the sentences, $F(1, 39) = 6.177$, $p<0.05$.

Participants answered more short sentences correctly (M = 0.863) than long sentences (M = 0.837). There was also a main effect for grammaticality, $F(1, 39) = 32.528$, $p<0.01$. Participants scored higher on grammatical sentences (M = 0.912) than ungrammatical sentences (M = 0.787).

An interaction occurred between the grammaticality of the sentence and the group type, $F(1, 39) = 6.915$, $p<0.05$. Native speakers and bilingual speakers scored similarly on the grammatical sentences (M = 0.913, M = 0.912), but the bilingual group scored worse on ungrammatical sentences (M = 0.729) compared to the native speakers (M = 0.845). There was a two-way interaction between the construction of the sentence and the grammaticality, $F(3, 117) = 14.683$, $p<0.01$. The participants scored higher on the grammatical sentences than the ungrammatical sentences for the plurals, present third-person agreement, and past tense constructions, but they scored about the same on the grammatical sentences and ungrammatical sentences for the word order construction. Please see table 5 for means. There was another interaction between the length of the sentence and the construction, $F(3, 117) = 17.465$, $p<0.01$. Participants performed better on short sentences for the plural construction and the past tense construction. They performed similarly on short and long sentences on the present third-person agreement and word order constructions. Please see table 6 for means.

There was a three-way interaction between the construction, the grammaticality, and the groups, $F(3, 117) = 3.364$, $p<0.05$. Both the native speakers and the bilingual speakers scored higher on grammatical sentences the ungrammatical sentences for the plural construction, past tense construction, and third-person present agreement construction. However, native speakers scored better on ungrammatical sentences for the word order construction while bilingual speakers scored better on grammatical sentences for the word order construction. Please see table 7 for means.

Listening through noise task

The listening through noise task was a 3 (construction) x 2 (semantic predictability) x 2 (syntactic predictability) x 2 (group) design. The data was analyzed with a repeated measures ANOVA. A Bonferroni post-hoc test was used to compare the different means. Some of the means in the listening through noise task may seem very small. In fact, the task was very difficult with most participants scoring 20-30 correct answers out of 72 total answers. The means presented in this section are based on the cell variables in the study. Therefore, the max score is a total of six. There was a main effect of group, $F(1, 39) = 7.768$, $p<0.01$. On average, native speakers guessed more words correctly ($M = 2.368$) than bilingual speakers ($M = 1.995$). There was a main effect for the semantic predictability, $F(1, 39) = 20.000$, $p<0.01$. Participants answered more semantically predictable sentences correctly ($M = 2.374$) than semantically unpredictable sentences ($M = 1.989$). There was also a main effect of syntactic predictability, $F(1, 39) = 12.371$, $p<0.01$. The participants guessed more syntactically unpredictable sentences correctly ($M = 2.028$) than syntactically predictable sentences ($M = 2.335$). There was also a main effect for grammar construction, $F(2, 78) =30.940$, $p<0.01$. The participants scored significantly better on the plural sentences ($M = 2.796$) compared to the past ($M = 1.935$) and present sentences ($M = 1.814$). There was no significant difference between the means of the past and present sentences.

An interaction was found between semantic predictability and group, $F(1, 39) = 5.324$, $p<0.05$. The native speakers scored much higher on the semantically predictable words than the bilingual group. In fact, semantic predictability seemed to make a difference for the native speakers but not for the bilingual speakers. Please see table 8 for a list of means. There was another interaction between the semantic predictability and construction, $F(2, 78) = 18.999$,

$p<0.01$. Participants guessed many more semantically predictable plural words and fewer semantically predictable third-person present agreement words. However, they guessed an equal number of past tense words in semantically predictable and semantically unpredictable sentences. Please see table 9 for means.

A three-way interaction occurred between semantic predictability, syntactic predictability, and construction, $F(2, 78) = 5.654$, $p<0.01$. For the plural construction, participants guessed more semantically predictable words regardless if the sentence was syntactically predictable or unpredictable. For the third-person present construction, participants guessed more words in syntactically unpredictable sentences but scored similarly on both the semantically predictable sentences and the semantically unpredictable sentences. Participants scored similarly on syntactically predictable sentences that were semantically predictable rather than semantically unpredictable sentences. For the past tense construction, participants guessed more semantically unpredictable words when the sentences were also syntactically predictable. They scored similarly on syntactically unpredictable past sentences, regardless of semantic predictability. Please see table 10 for means.

For the morphology of the listening through noise task, the max score of one section was 12 since half of the sentences had morphemes and half of them did not. There was a main effect of group, $F(1, 39) = 8.220$, $p<0.01$. Native speakers scored higher ($M = 4.729$) than bilingual speakers ($M = 3.971$). There was a main effect of construction, $F(2, 78) = 30.922$, $p<0.01$. Participants scored much higher on plural sentences ($M = 5.592$) and lower on third-person present agreement sentences ($M = 3.869$) and past tense sentences ($M = 3.588$). There was no significant difference between the third-person present agreement construction and the past tense

construction. There was a main effect of morphology, $F(1, 39) = 40.009$, $p<0.01$. Participants guessed more words without morphemes ($M = 5.608$) than words with morphemes ($M = 3.092$).

There was also an interaction between the construction and morpheme, $F(2, 78) = 16.615$, $p<0.01$. Participants guessed many more words without morphemes for the plural construction, followed by the third-person present tense construction. Participants guessed about the same amount of words with morphemes and without morphemes for the past tense construction. Please see table 11 for means.

Discussion

Correlations between the bilingual participants' age of arrival, age of exposure, number of years studied, and self-reported fluency were found for the size judgment task and the listening through noise task. In general, past research has found that although bilingual speakers may be exposed to languages before they move to the countries that speak their second languages, until the speakers have significant exposure to the languages in the countries of the second languages, then they may not acquire the languages very proficiently. Bilingual speakers who arrive earlier in a second language country tend to acquire more of the second language than bilingual speakers who arrive later (Johnson & Newport, 1989; Flege, et al., 1999; McDonald, 2000). Furthermore, the grammaticality judgment task in this experiment also significantly correlated with age of exposure, number of years studied, and self-reported fluency. Only one section of longer sentences correlated with age of exposure, number of years studied, and self-reported fluency, and three sections of shorter sentences correlated with age of exposure, years studied, and self-reported fluency. Therefore, it may be the more bilingual speakers study or are exposed to easy material, such as short sentences, the more likely they are to do well on easier questions or stimuli. Harder material may require a different type of exposure or may require

more cognitive skills that bilinguals cannot learn from studying easy examples or being exposure to simple sentences in the classroom.

The hypothesis that working memory capacity would not affected native speakers' ability to perform on the grammaticality judgment task was supported. The hypothesis that working memory does affect bilingual speakers was supported for long sentences in the grammaticality judgment task. The correlations for the bilingual speakers between the size judgment task and the grammaticality judgment task were expected. Past research has found that working memory capacity affects a bilingual speaker's score in a reading test, a speaking test, and a writing test (Martin & Ellis, 2012). If a bilingual speaker has a smaller working memory capacity, he or she may be less able to guess the correct word during the first few pieces of the word (McDonald, 2006). Therefore, when more information taxes a bilingual speaker's working memory capacity, he or she is less likely to judge grammar well and process words through noise as well.

The hypothesis that native speakers would perform better than bilingual speakers on the grammaticality judgment task was supported. However, the hypothesis that native speakers would perform similarly on all grammar constructions was not supported. The hypothesis that bilingual speakers would perform better on word order and worse on plurals, third-person present agreement, and past tense was partly supported. The main effect of grammar construction shows that both native speakers and bilingual speakers find word order to be the easiest construction. Next, the participants found plurals and past tense to be equally difficult. Third-person present agreement was found to be the most difficult structure. The word order construction may be the easiest because word order in English is very rigid. The number of different possibilities for word order structures is very limited compared to languages without rigid word order. However, the other structures have more possibilities and variables. Fewer options may mean that speakers

spend fewer resources deciding word order grammaticality. Plurals may be easier than present tense and past tense because plurals are their own category. Plurals also have a limited number of bound morphemes compared to verbs, only –s or –es unless they are irregular. Therefore, they may be easier than verb tenses. Verb tenses may be the hardest structures because both present tense verbs and past tense verbs are considered verbs. Therefore, the speakers must first determine the tense and then determine the endings. Because there are more possibilities and choices that the native and bilingual speakers must make for third-person present agreement and past tense constructions, those constructions are harder to learn.

The hypothesis that semantically predictable sentences would be easier than semantically unpredictable sentences was partially supported. According to the interaction between semantic predictability and group, native speakers were able to use semantic predictability but bilingual speakers were not able to. Since the three constructions were chosen because they are difficult and the noise taxed the bilingual speakers' working memory capacities, the bilingual speakers may not have been able to process semantic predictability. Their resources were overloaded with information already. Therefore, they couldn't process all the cues that they were given as well as the native speakers.

The hypothesis that both native speakers and bilingual speakers would score better on syntactically predictable sentences was not supported. Participants performed better on syntactically unpredictable sentences than syntactically predictable sentences. Perhaps syntactic cues were very difficult to process through noise since some of them contained bound morphemes themselves. Theoretically, the plural construction should have been the easiest construction for the use of syntactic cues. The cues for plural words are number words that are located right in front of the target plural. The cues are also more salient than a bound morpheme since the cues are free morphemes. However, maybe participants could not process the cues

through the noise. The past tense construction should have also been a bit easier to use because the cue for past tense verbs was a free morpheme time order word. However, perhaps the distance between cue and the verb made the cue hard to process, especially since the participants were stressed in this study. Finally, third-person present agreement cues should have been the hardest to use. On the end of third-person present cues, there was a bound morpheme, –s. That –s may have been hard for participants to process even though the cue was right in front of the verb. The overlaying noise may have stressed the participants' working memory too much, such that neither native speakers nor bilingual speakers were able to use syntactic predictability, or the noise covered up the sound of the cue, preventing the speakers from using the information. This research suggests that syntactic predictability may be harder to process through noise than semantic predictability. However, the stimuli may not have worked properly for syntactic predictability since the results contradict past research.

The hypothesis that participants would guess more words without morphemes than words with morphemes was supported. Morphemes are hard to process through noise. Also, the –s morpheme on the plural and third-person present agreement constructions may have been harder to process since in the interaction between construction and morpheme, there is a larger difference between the means of words without morphemes and with morphemes in the plural and third-person present agreement constructions. For the past tense construction, participants guessed about the same number of words with and without morphemes. This may suggest that while the constructions are hard to process through noise in general, the type of noise and sound of the morpheme may interact and make processing more difficult.

One limitation could have been the stimuli itself. Many participants reported that they sentences were too hard to hear through the noise. In fact, most participants scored around 20-30 correct answers out of 72 questions. Better results might have been found if the stimuli were

easier to hear. Less noise would have stressed the participants less and possibly made the semantic and syntactic cues easier to process.

More analysis could have been done with the listening through noise task. Many speakers, both native and bilingual speakers answered with similar words although it wasn't the correct word. For example, many participants answered "jogs" when the sentence was "The startled runner jumps." They also answered "dropped" when the sentence was "The started deer jumps." Perhaps there is something in the noise that makes listeners process a certain sound over another. Many times native and bilingual speakers guessed the correct word stem but guessed the wrong bound morpheme. For example, they guessed "crying" when the sentence said, "The fussy babies cried." This data could be further analyzed to see if native listeners may hear more stems correctly but still have trouble hearing the inflectional bound morphemes.

Overall, most of the hypotheses were supported. Native speakers did perform better than bilingual speakers. Working memory capacity affects bilingual speakers more than native speakers. Despite working memory capacity, both native speakers and bilingual speakers performed better on the plural construction and past tense construction than the third-person present agreement tense. Therefore, plurality and past tense may be an easier construction than third-person present tense. The noise in the listening through noise experiment may have taxed the participants' ability to process cues, especially syntactic cues. However, native speakers used semantic cues while bilingual speakers did not. Therefore, semantic cues may be easier to process than syntactic cues when speakers are more stressed by their environment. It seems that noise does affect speakers' abilities to perceive semantic and syntactic cues as well as bound morphemes.

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Appendix

Table 1.

Sentences used in the grammaticality judgment task

Type	Correct	Incorrect
Plural - short	The boy saw three dogs in the park.	The boy saw three dog in the park.
Plural - long	The boy saw three dogs in the park by the large old gray water fountain.	The boy saw three dog in the park by the large old gray water fountain.
Present Third-person - short	The brown cow remains in the meadow.	The brown cow remain in the meadow.
Present Third-person - long	The brown cow remains in the meadow by the open, broken, rusty metal gate.	The brown cow remain in the meadow by the open, broken, ruined metal gate.
Past - short	Yesterday the dog growled at the thief.	Yesterday the dog growl at the thief.
Past - long	Yesterday the dog growled at the thief from the first open living room window.	Yesterday the dog growl at the thief from the first open living room window.
Word Order - short	Tiffany stepped on a broken picture frame.	Stepped on a broken picture frame Tiffany.
Word Order - long	Tiffany stepped on a broken picture frame in her very messy, dirty living room.	Stepped on a broken picture frame in her very messy, dirty living room Tiffany.

Table 2.

Example sentences used in the listening through noise task

Type	Semantically Predictable – Syntactically Predictable	Semantically Unpredictable – Syntactically Predictable	Semantically Predictable – Syntactically Unpredictable	Semantically Unpredictable – Syntactically Unpredictable
Plurals - morpheme	The Olympic athlete won four medals.	The angry woman stole four medals	The Olympic athlete won the medals.	The loud woman stole the medals.
Plurals – no morpheme	The Olympic athlete won a single medal.	The angry woman stole a single medal	The Olympic athlete won the medal.	The loud woman stole the medal.
Present Third-person - morpheme	The absent-minded teacher forgets.	The happy teacher forgets.	The absent-minded fish forgets.	The happy fish forgets.
Present Third-person - no morpheme	The absent-minded teachers forget.	The happy teachers forget.	The absent-minded fish forget.	The happy fish forget.
Past-morpheme	Three days ago the fussy babies cried.	Three days ago the tiny kittens cried.	The fussy babies cried.	The tiny kittens cried.
Past - no morpheme	Presently the fussy babies cry.	Presently the tiny kittens cry.	The fussy babies cry.	The tiny kittens cry.

Table 3.

Significant correlations between the grammaticality judgment task and bilingual speakers' reports of age of arrival, age of exposure, years studied, and self-reported fluency

	Age of Arrival	Age of Exposure	Years Studied	Self-reported fluency
Size Judgment Task	-0.274	0.186	0.253	0.280
High plural grammatical	-0.176	0.157	0.190	-0.398
High plural ungrammatical	-0.267	-0.099	0.233	0.367
High present grammatical	-0.095	-0.074	0.021	0.093
High present ungrammatical	-0.246	-0.194	0.339	0.522*
High past grammatical	-0.491*	-0.275	0.501*	0.573*
High past ungrammatical	-0.287	-0.483*	0.402	0.538*
High word order grammatical	-0.184	-0.211	0.155	0.582*
High word order ungrammatical	-0.368	-0.346	0.412	0.761**
Low plural grammatical	0.019	-0.054	0.173	0.055
Low plural ungrammatical	-0.418	-0.275	0.470	0.306
Low present grammatical	0.064	-0.357	-0.371	0.025
Low present ungrammatical	-0.658**	-0.490*	0.6380**	0.638**
Low past grammatical	-0.770**	-0.216*	0.503*	0.604*
Low past ungrammatical	-0.294	-0.548	0.512*	0.459
Low word order grammatical	-0.125	-0.227	-0.157	0.024
Low word order ungrammatical	-0.296	-0.004	0.348	0.246
LTN Total Score	-0.650**	0.129	0.316	0.310

* significant at the 0.05 level

** significant at the 0.01 level

Table 4.

Correlations between the size judgment task and short and long sentences of the grammaticality judgment task and the listening through noise task for bilingual speakers

	Size judgment task
Short sentences	0.186
Long sentences	0.587*
Listening through noise	0.492*

* significant at the 0.05 level

Table 5.

Estimated marginal means for the interaction between construction and grammaticality in the grammaticality judgment task

	Grammatical	Ungrammatical
Plurals	0.942	0.805
Third-person present	0.855	0.677
Past	0.924	0.729
Word Order	0.929	0.938

Table 6.

Estimated marginal means for the interaction between sentence length and construction in the grammaticality judgment task

	Short	Long
Plurals	0.921	0.826
Third-person present agreement	0.745	0.789
Past tense	0.862	0.791
Word Order	0.924	0.944

Table 7.

Estimated marginal means for the interaction between construction, grammaticality, and group in the grammaticality judgment task

	Grammatical	Ungrammatical
Native Speakers		
Plural	0.955	0.841
Third-person present	0.844	0.740
Past	0.922	0.840
Word order	0.931	0.961
Bilingual Speakers		
Plural	0.929	0.768
Third-person present	0.866	0.614
Past	0.926	0.618
Word order	0.927	0.915

Table 8.

Estimated marginal means for the interaction between semantic predictability and group in the listening through noise task

	Semantically Predictable	Semantically Unpredictable
Native Speakers	2.660	2.076
Bilingual Speakers	2.088	1.902

Table 9.

Estimated marginal means for the interaction between semantic predictability and construction in the listening through noise task

	Semantically Predictable	Semantically Unpredictable
Plurals	3.3279	2.313
Third-person present	2.086	1.783
Past tense	1.756	1.872

Table 10.

Estimated marginal means for the interaction between semantic predictability, syntactic predictability, and construction in the listening through noise task

	Semantically Predictable	Semantically Unpredictable
Syntactically Predictable		
Plurals	2.949	2.424
Third-person present	2.061	1.463
Past	1.493	1.777
Syntactically Unpredictable		
Plurals	3.610	2.201
Third-person present	2.112	2.103
Past	2.020	1.967

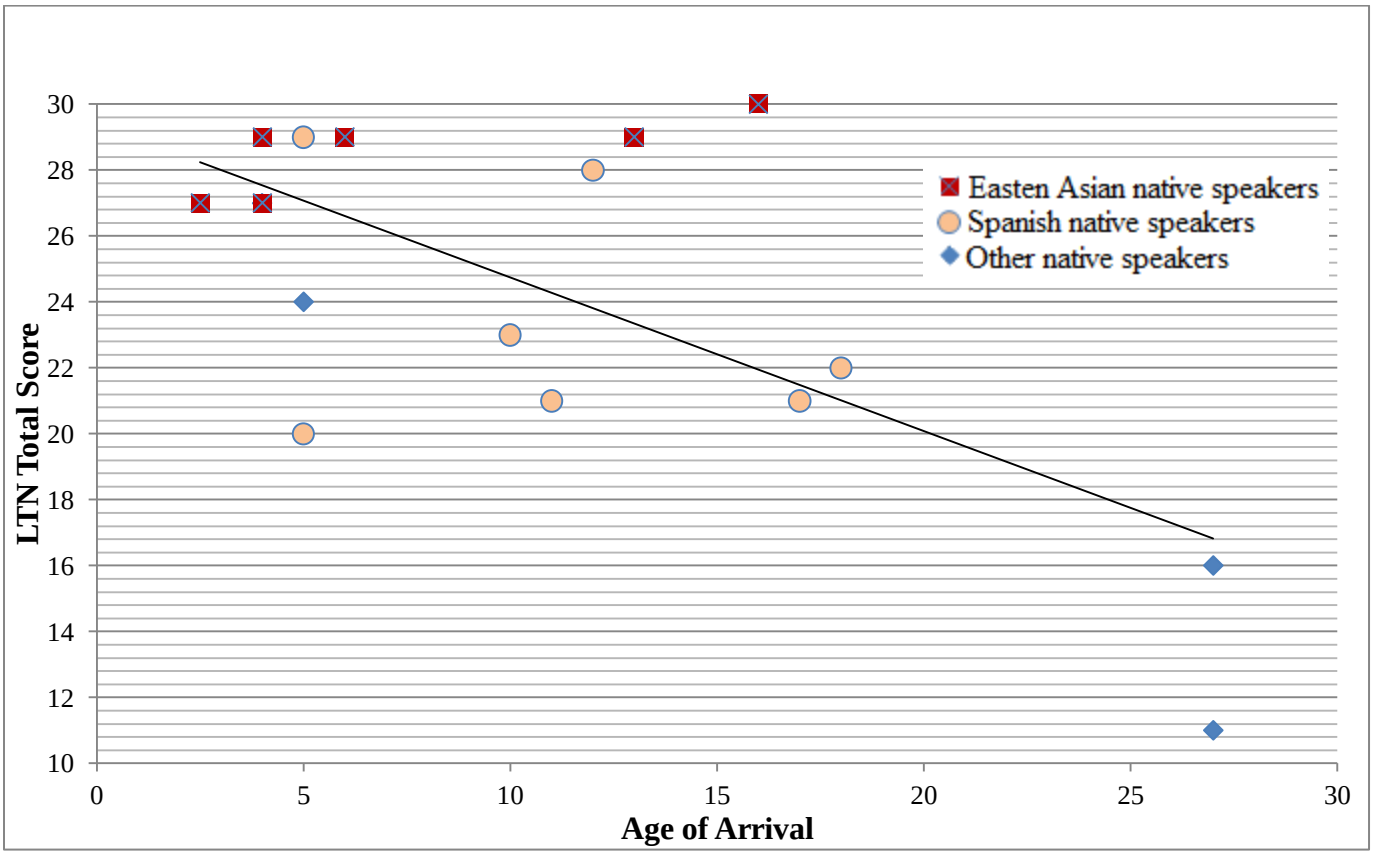
Table 11.

Estimated marginal means for the interaction between construction and morpheme in the listening through noise task

	With morpheme	Without morpheme
Plurals	3.194	7.990
Third-person present	2.996	4.743
Past	3.085	4.092

Figure 1.

Significant exposure for bilingual speakers



*One blue diamond is not shown because it overlaps with a red box and a cross at (4,27).