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PREDICTION ON ENGLISH-SPEAKING CHILDREN'S CHINESE SPOKEN WORD LEARNING: CONTRIBUTIONS OF PHONOLOGICAL SHORT-TERM MEMORY

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The primary purpose of this study is to investigate whether children's phonological short-term memory (PM) could predict their ability to learn Chinese as a foreign language. Based on the working memory model from Baddeley and his colleagues (e.g., Baddeley & Hich, 1974; Baddeley, 2003), the role of PM in foreign language learning has been well-established. However, previous research has only involved related pairs of languages. This study chose Mandarin Chinese, a language phonologically distinct from English, as the target language and American children who had no previous exposure to Chinese as participants. A battery of measures was administered to test 37 fourth-grade children's PM and Chinese spoken word learning ability. The results confirmed that children's PM could independently predict their Chinese spoken word learning, suggesting that PM might be language-independent and thus explicit instruction on PM might be helpful for young learners. As one of the first to examine the role of PM in young children's learning of a tonal foreign language such as Chinese, this study opens new areas for future research endeavors that have the potential of enriching understanding of PM in children's learning of foreign languages. It also provides new insights in curricula design and instructional practices for teaching foreign languages.

Keywords: *phonological short-term memory, tonal foreign language, Chinese spoken word learning, young children*

INTRODUCTION

Vocabulary development is of critical importance in second or foreign language (L2) learning. Previous studies reported a strong link between learners' vocabulary and overall comprehension in L2 learning (Nation 1993; Perfetti, 1985; Read 1997). While the importance of vocabulary in L2 learning has been valued, a substantial set of studies has focused on investigating the factors that might be involved in vocabulary development. It has been reported that phonological short-term memory (PM), a component in Baddeley's working memory model, has superior predictive power on lexical and oral fluency development of L1 and L2 for children as well as adults (e.g., Atkins, Baddeley, 1998; Baddeley, Gathercole & Papagno, 1998). Additionally, PM plays an even more important role in L2 learning (Baddeley, Gathercole & Papagno, 1998; Cheung, 1996; Dufva &Voeten, 1999; Hu, 2003; Masoura & Gathercole, 1999; Service, 1992; Service & Kohonen, 1995). The report in previous studies makes sense since without a stored specification of the phonological structure of a word, a learner can neither recognize the word spoken by others nor produce that word in spontaneous speech.

Learning to say new words in an L2 imposes a heavier phonological load for learners especially young learners since L2 learning does not contain much meaningful information that can be chunked by relying on the existing phonotactic and morphological knowledge. Therefore, children's performance in L2 learning is directly constrained by their PM; those with poor PM seemed to perform poorly on learning L2 vocabulary (Gathercole & Baddeley,1990). We all might be familiar with the phenomenon that with the same exposure to a new language, some children can learn it more efficiently than others. A critical question thus is, can PM be an underlying factor accounting for children's individual differences in L2 vocabulary learning?

Although substantial evidence has demonstrated that the PM was responsible for vocabulary learning, especially when the vocabulary consists of highly unfamiliar phonological structures such as L2 vocabulary, the contribution of PM will be greatly reduced by the involvement of confounders such as L1 mediation, participants' prior exposure to L2, etc. Based on the first-language-mediation mechanism, L1 knowledge influences **n**on-native language learning (Chen & Leung, 1989). The more similar the two languages are, the more mediation L1 might bring to L2. Unfortunately, not all the previous studies tightly controlled or paid attention to the confounding effect of L1 language knowledge on L2 word learning, as will be illustrated in the following section. Therefore, the role of PM in L2 word learning might be over exaggerated in literature. To fill this gap, a study of more distinct languages should be pursued.

LITERATURE REVIEW

The term "working memory" refers to a multi-component brain system which temporarily stores and manipulates information necessary for performing complex cognitive tasks such as language comprehension and reasoning (e.g., Baddeley & Hitch, 1974). The two most frequently cited working memory models are proposed by Baddeley (1986, 2000), and Danemman and Carpenter (1980). Whereas the former has been mainly employed in studies on the functions and interactions of the phonological loop, the latter has been primarily used on the operationalization of the executive function. The present study relies on Baddely's model since the focus here is PM, a subcomponent of the phonological loop.

Baddeley's latest working memory model is comprised of four components: the phonological loop, the visuospatial sketchpad, the episodic buffer, and the central executive. The phonological loop is specialized for the temporary maintenance and processing of verbal material by holding phonological information over a few seconds before the memory trace fades or can be refreshed by rehearsal (Baddeley, 2003). Its capacity is limited by the number of chunks and different types of material being more or less chunkable (Miller, 1956). The visuospatial sketchpad similarly holds and manipulates visual and spatial material (Baddeley & Hich, 1974). As a pathway to long-term memory and the other components of the working memory (Pickering, 2006), the episodic buffer allows verbal and visual information to be constructively combined with that from long-term memory into integrated chunks (Baddeley, 2000). The central executive is an attention control system that coordinates information from the subsidiary storage systems, maintains relevant information, and suppresses irrelevant information in complex higher-order thinking (Baddeley, 2003; Swanson, 2011). Despite the fact that each of the four components has a unique function, they work together in task performing. Given that our focus is children's L2 spoken word learning, the phonological loop will be mainly discussed in this study.

The phonological loop is composed of two semi-independent subcomponents: a phonological store that temporarily holds phonological input and an articulatory rehearsal that maintains the decaying representation. The phonological loop is primarily a language learning device (Baddeley, 2003). The phonological short-term memory (PM) is the ability to temporarily retain and process verbal information, which depends entirely on the function of the phonological loop (Kaushanskaya &Yoo, 2012).

Over the years, numerous empirical studies have shown that PM is strongly linked with three important language abilities: vocabulary acquisition, reading, and language comprehension during the early school years (Gathercole, Willis, & Baddeley, 1992). Drawing largely on Baddely and Gathercole, researchers have widely agreed on the association between children's PM and their early vocabulary learning (e.g Baddeley, 1986; Gathercole, Brown, & Pickering, 2003). Also, much evidence from literature has shown that PM could strongly predict children's overall L1 vocabulary acquisition (see Baddeley, Gathercole, & Papagno, 1998, for a review) in that children with great PM produced longer and more semantically and syntactically complex utterances (Adams & Gathercole, 1995, 2000; Blake, Cannon, Lisus, & Vaughan, 1994) and were better at learning novel words (Gathercole, Hitch, Service, & Martin, 1997). The findings again confirmed the role of PM in vocabulary learning: it mediates the processing of novel speech input by temporarily representing it in the phonological loop and making it possible to construct a more stable sub-lexical representation in long-term memory (Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddele, 1989, 1990).

The focus in the present study is on L2 vocabulary learning. Numerous studies have shown a positive correlation between PM and L2 vocabulary learning proficiency (e.g., Dufva & Voeten,1999; Service, 1992; Masoura &Gathercole,1999). For example, Service and her colleagues have extended the relationship between PM and L1 vocabulary learning to L2 in a series of studies of learning English words by Finnish elementary school children (e.g., Service,1992; Service &Kohonen, 1995). The same result was also duplicated by Masoura and Gathercole (1999) with Greek native speakers and Cheung, et al. (1996) with Cantonese native speakers in learning English was as L2 in both studies.

As discussed above, the evidence from previous studies generally supported that PM could robustly predict children's overall L2 achievement, especially on lexical and oral fluency development (e.g. Service & Kohonen, 1995). Two reasons might account for this conclusion: one is that PM is important in developing the phonetic recoding strategy that is necessary for the early reading (Gathercole & Baddeley, 1993) and another is that PM might mediate long-term storage of phonological information which is involved in vocabulary development (Baddeley, Papagno, &Vallar, 1988; Gathercole & Baddeley, 1989; Baddeley, 1990).

Interestingly, the role of PM in L2 vocabulary learning seems to be more robust than in the L1 (e.g., Gathercole & Baddeley, 1990). This is probably because the task of constructing a more stable lexical representation of the unfamiliar sound enables PM to be more active in L2. Whereas temporary phonological encoding and storage skills were involved in learning new words, L2 vocabulary learning does not contain much meaningful information that can be easily stored in chunks by using existing phonotactic and morphological knowledge. Hence, children's performance is more directly constrained by their PM capacity. Those with poor or impaired PM would consequently perform poorly due to their slower learning speed and/or inaccuracy of learning outcome on processing unfamiliar input (Gathercole & Baddeley, 1990).

Although there is a general agreement in the literature that PM could facilitate the development of productive L2 vocabulary skills during childhood, to what extent PM could contribute to L2 vocabulary learning could be argued. For example, an issue that comes from the findings of Service and Kohonen (1995), Masoura and Gathercole (2005), and French and O'Brien (2008) is that all L1s involved (i.e. Finnish, Greek, French, respectively) were not phonologically distant from the target L2 (i.e., English). Moreover, all the participants had studied English before the research started. This makes L1 mediation a possible influence on L2 vocabulary learning.

The effect of L1 mediation on L2 learning has been discussed in previous studies. For example, Snowling and her colleagues (1991) argued that it was familiarity with structure of the target L2, instead of PM, that could better explain the association with L2 learning. In line with Snowling et al., Masour and Gathercole (1999) pointed out that shared PM could not exclusively account for L1 and L2 vocabulary learning. Adding to this, in a study involving Chinese students Cheung (1996) found that PM significantly predicted L2 vocabulary learning for the lower vocabulary group but not the more advanced vocabulary group, and attributed this to the advanced group's possession of more sophisticated long-term L2 structure knowledge. It is generally believed that L2 new words were learned via associations with L1 words at the initial stage of L2 learning, and any existing knowledge about the structure of a language could boost the immediate memory performance for "nonwords" in that language (Gathercole, Service, Hitch, Adams, & Martin, 1999; Vaskevitch, Luce, Charles-Luce, & Kemmerer, 1997). It seems the ease of learning L2 new words is strongly influenced by the stability of representations of native vocabulary. Consequently, if an L2 is more similar as children's native langue, the L2 probably has more opportunity to get support from lexical phonological knowledge in learning. This might also explain why conflicting results on the relation between PM and L2 vocabulary learning have been reported in previous studies. As explained by Gathercole and Thorn (1998),

> The evidence here points to a strong relation between familiarity with a language and phonological loop function, and it indicates that temporary maintenance of novel phonological forms is likely to be constrained by the availability of both language-specific knowledge and phonological loop capacity. A consequence is that short-term retention of the sounds of new words is likely to be considerably poorer for words in an unfamiliar language than in the native tongue. Given the importance of the phonological loop in mediating long-term phonological learning reviewed earlier, new words in an unfamiliar language will therefore also be harder to learn. (p. 155)

While the association between PM and the actual L2 word learning has been established in a few studies after removing the effects of confounders such as phonological awareness and prior L2 knowledge (e.g., French, 2006), many studies did not tightly control the confounders. The specific features of the L1 might determine the manifestations related to L2 word development (Bishop & Snowling, 2004). It is thus necessary to check the types of L2 in previous research and be cautious in interpreting the results. Unfortunately, as discussed in the previous section, a review of literature shows that English was used most frequently as the target L2, but the L1s were not from a distant language family.

Summing up, the research has demonstrated the importance of PM in language learning. Although the role of PM in L2 learning has been valued, most research investigated the effect of PM on L2 learning with the L1 not being distant from the L2. The findings from previous studies thus should be interpreted cautiously. A critical question is about the nature of PM in L2 study: is PM language-independent?

Despite the fact that previous studies attempt to investigate the "cross-linguistic" aspects of language processes, there has been less effort to explain whether the relationship between L2 vocabulary development and PM is comparable to that observed in L1 vocabulary development. The first-language-mediation mechanism indicates that L1 knowledge influences L2 learning (Chen & Leung, 1989), suggesting that the more similarity between two languages, the more influences the first language will bring to the target language. Thus, the role of PM might be over exaggerated in L2 word learning, if mediation is involved.

Kim (2014) investigated the role of PM in learning two distinct languages (Korean and English) by recruiting adult heritage language learners and foreign language learners. Kim found that PM capacity was more important than home language exposure, and suggested that PM may be language-independent. However, the participants in that paper were adult second language learners (aged from 18 to 31), and they all attained at least an elementary level of proficiency in the target language. Although there is no common argument agreed by all the research on the relationship between age and second language acquisition, many studies have found that adults have more advantages in learning foreign languages than young children (e.g., Snow & Hoefnagel-Hohle,1982;Singleton,1998). This is probably because adult participants' metacognitive skills (e.g., learning strategies) are more developed than that of children, and thus facilitate their learning of foreign languages (e.g., Anderson, N.J., 2002; Chamot, 2005). Additionally, the adult participants in Kim's study were at the intermediate level of the target language when the experiment was conducted, and L2 proficiency levels could affect the importance of memory skills (DeKeyser & Juffs, 2005). To avoid overemphasizing the effect of PM in language learning when results do not support it, clearer acknowledgement of the role of prior linguistic knowledge is required. Therefore, when investigating the effect of PM on L2 word learning, an L2 that is distinct from the L1 should be chosen as the target language. More important, future studies should simultaneously control the involvement of potential confounders such as their participants' prior experience with L2, the use of metacognitive skills. Had the correlation between PM and L2 vocabulary acquisition been established by satisfying the conditions above, the results could be more convincing.

To fill the gap in literature, the present study investigated the effect of PM on the Chinese spoken word learning of the young English-speaking children who had never been exposed to Chinese before the study. Considering that both English stress and Chinese tone might be affected by PM and they are crucial in learning the languages they represent, this study also explored the relationship between English stress and Chinese tone. If such a correlation can be established, it might lead to cross-language facilitation. This study could also contribute to the understanding of how PM underpins children's L2 vocabulary development. Pedagogically, the findings from the present study will also have implications for teaching an L2 which is distinctive from the L1.

RESEARCH QUESTIONS

The research questions for the present study are as follows:

1. How do high PM learners compare to low PM learners in every task measure? Can PM account for better performance of young English-speaking children's Chinese spoken word learning?
2. What is the role of PM in children's performance of the English stress and the Chinese tone? Is there any correlation between the performance of the English stress and the Chinese tone?
3. Is PM language-independent in affecting the children's learning of a distinct foreign language?

METHODS

Participants

A total of thirty-two 4th graders (18 girls and 14 boys, mean age=10.5 years, age ranged 10-11 years) from three classes across two Midwestern school districts in America participated in this study. The communities surrounding these districts have mixed socioeconomic and educational backgrounds and were ethnically diverse. All participants spoke American English as their primary language, and they had not been exposed to Mandarin before. None of the participants had listening or speaking difficulties.

Materials and Design

A battery of tests was given in the following order: Baseline English Reading Test, phonological short-term memory tests (digit span, English nonword repetition, Chinese nonword repetition), and Chinese word learning test.

Baseline English reading comprehension test. The Level 4 Gates- MacGinitie Reading Test (MacGinitie, MacGinitie, Maria & Greyer, 2000) was used to test the participants' baseline English reading ability.

Digit span. The participants listened to the recording of the digits and recalled immediately in the exact order digits were presented. The test started with 3 digits and ended with 7 digits. Digits were random samples without replacement from 1 to 9. There were 3 trials at each length and the test would stop if participants made 2 out of 3 mistakes. The final score was marked as the longest string of digits that participants could correctly recall.

English nonword repetition. The stimuli consisted of 40 English-like nonwords varying in length from 2 to 5 syllables. The nonwords were taken from the Children's Test of Nonword Repetition (Gathercole, Willis, Baddeley, & Emsile, 1994) and modified to serve this study. Each nonword was pronounced twice: with stress (i.e., normal way) and without stress (i.e., suppressed way). For example, whereas a two-syllable nonword, *ballop*, should be pronounced as /ˈbæləp/ with stress falling on the first syllable under the normal condition, it would be read as / bæləp/ with each phoneme equally stressed under the suppressed way (i.e., pronounced without stress). The total number of the original 40 nonword items thus became 80 and were divided evenly into two blocks. In each block half of the nonwords were pronounced with stress and another half without stress. For example, if a word was pronounced without stress in Block A, then it had to be pronounced with stress in Block B, and vice versa. Each nonword was shown only once in one block: either with stress or without stress. Moreover, stress and order was counterbalanced in the two blocks, and the nonwords in each block were presented in a random order to the participants during the study. The stimuli were recorded in a laptop with a 3-second interval between each two nonwords. The participants individually listened to each item and then immediately repeated the item within the 3-second interval. Immediate self-corrections were credited as a correct response (See Appendix B).

Chinese nonword repetition. The test consisted of 46 Chinese nonwords varying in length from one-syllable to four-syllables. The different length of syllables represent different level of challenges: the longer the length is, the more challenging it could be. Thus, the number of nonwords for each length in our study was uneven (10, 10, 20, 6). Specifically, the one- and two-syllable nonwords were used for the warm-up purpose, the three-syllables were for differentiating, and the four-syllables were expected to be the most challenging nonwords. The test started with one-syllable nonwords and then with longer syllables. Similar to each English nonword, each Chinese nonword was pronounced in two ways: with native tones vs. without native tones (also named as "nonwords with flat tone", by regarding the Chinese nonwords pronounced with the first tone as without native tones). For example, the three-syllable Chinese nonword, *ban2 liu3 hou1* (with tones as indicated) would be pronounced as *ban1 liu1 hou1* under the situation of flat tones. The method of balancing the tone and syllable of Chinese nonwords was similar as what was described in the English nonwords (See Appendix C).

Chinese word learning. This task measured the participants' ability to learn Chinese. Whereas none of the participants knew how to say these words in Chinese before the study, they were familiar with the English meaning of these words. Moreover, this study avoided the Chinese phonemes that sound most challenging for English speakers, such as the onsets *x, c*, and the rimes *ang, eng,* and *ong* (See Appendix D).

During the experiment, an English-Chinese paired-associate learning task was first presented; each participant was instructed that they would recall the corresponding Chinese words after the presentation. Then, each participant was presented with 8 pairs in 10 learning trials and the order was randomized in each trial. The words were divided evenly into two groups with each having 1 one-syllable word, 2 two-syllable words, and 1 three-syllable word. The Chinese Word Learning Task was separated into three sessions: Session One for the first group of four words, Session Two for the second group of another four words, and Session Three was the final test for the 8 words. Due to the scope limitation, only the result for the Session Three final test was analyzed as indices of Chinese spoken word learning.

Scoring and Coding

The repetition of both the English and Chinese nonwords was scored with two different approaches. In Approach One, the participants could not earn any credits until they correctly repeated both the stress/tone and the rest of the pronunciation for each nonword. However, the participants in Approach Two were only penalized for the mistakes they made in each specific condition. That is to say, stress/tone and the rest of the pronunciation for each nonword were scored separately and independently in Approach Two. By scoring stress/tone separately and independently, Approach Two might allow a finer analysis for investigating the influence of stress and tone on nonword repetition.

For example, each English nonword repetition was divided into two parts: pronunciation and stress (when the original English nonword had stress), pronunciation and stress (when the stress of the original English nonwords was purposely taken out). Phoneme substitutions, omissions, and additions were scored as incorrect. The number of nonwords correctly repeated was counted as the total score. The final scores in both approaches were percentage scores calculated by dividing the number of nonwords correctly repeated by the total number of nonwords.

The grading of Chinese nonword repetition was similar as that of English. For example, each Chinese nonword repetition was transcribed and analyzed under four conditions in Approach Two: Chinese pronunciation (with tone), Chinese tone (with tone), Chinese pronunciation (without tone) and Chinese tone (without tone). In addition, while all alternations in tone and phoneme productions resulted from the use of phonological rules typical of English were scored as correct considering that Chinese was not the L1 for the participants, any mistake from the onset, rime or tone would be scored as incorrect.

To ensure the reliability of the coded data, all the recordings were transcribed and scored by three native speakers for that language, and they all were trained in broad phonetic transcription and scoring rules. The inter-rater reliability was 92%**.**

Several internal reliability analyses were carried out on the PM measures. In general, all the tests showed internal consistency. In Approach One, Cronbach's alpha values were .56 for English nonword repetition with stress, .62 for English nonword repetition without stress, .84 for Chinese nonword repetition with tone, .98 for Chinese nonword repetition without tone, and .53 for Chinese word learning. The comparatively low reliability for English nonword repetition with stress might be explained by the ceiling effect caused by the two-syllable English nonword. The two-syllable nonwords were consequently excluded from further data analysis. For the same reason, the one- and two-syllable Chinese nonwords were excluded from the final data analysis.

While no outlier was detected in the two approaches for Chinese nonword repetition and Chinese word learning, a four-syllable English nonword, *blonterstaping*, was identified as an outlier (Studentized Residual = 3.10) and thus deleted from final data analysis. It should be noted that each of the 8 Chinese words displayed good composite reliability since Cronbach alpha was .73 when combining pronunciation and tone, though it was .41 for pronunciation and .53 for tone when separating them.

Procedures

All the tests, except for the Baseline English Reading Comprehension, were administered individually and recorded on a laptop to play back to students. The participants were required to repeat immediately exactly what they heard from the recording of digit span, English and Chinese non-word repetition. However, in the Chinese word learning task, the participants first listened to the 8 new Chinese words only once and then were required to recall them upon hearing them in English in the following 10 test trials. It should be pointed out that before the Chinese non-word repetition and Chinese word learning task, two short introduction lessons were provided to help familiarize participants with basic Chinese phonological structure (e.g., pronunciation and tone).

RESULTS

Data in this study were analyzed under two approaches that varied according to the way the tests were scored. As described above, whereas in Approach One stress/tone was combined with pronunciation for scoring, stress/tone was separated from pronunciation in Approach Two. See Table 3 and Table 4 for the descriptive statistics and the correlation table for Approach One. See Table 5 and Table 6 for descriptive statistics and the correlation table for Approach Two.

Approach One: Pronunciation and Stress/Tone Scored Together

Stress, syllable length and English nonword repetition. A two-way ANOVA was conducted to analyze the influence of stress and syllable length on the English Nonword Repetition. As shown in Figure 1 below, the English nonword repetition with stress outperformed the English nonword repetition without stress, $F(1, 31) = 13.22$, $P<.001$, $\eta^2 = .12$.

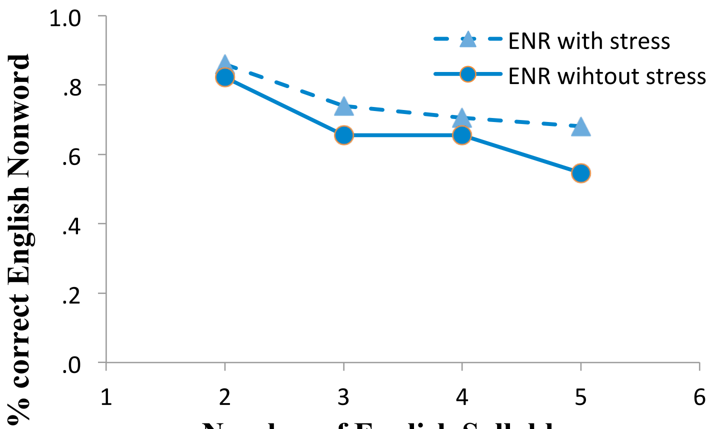

Figure1. ***English Nonword Repetition as Function of Syllable Length & Stress***
Note: The horizontal axis represents 2-, 3-, 4-, and 5-syllable English nonwords. The vertical axis represents proportion correct of performance on English nonword repetition.

In addition, the English nonword repetition became worse with longer syllables, F (3, 93) = 27.96, p < .01, η^2= .32. Surprisingly, the five-syllable English nonword repetition outperformed the four-syllable. In addition, the simple main effect of stress was evaluated as a function of syllable length by using the Bonferroni correction. The result indicates that the effect of stress on the English nonword repetition was not significant for two-syllable nonwords, t (31) = 1.46, p >.10, d=.26, but it was significant for three-syllable, t (31) = 2.35, p <.05, d=.41; four-syllable, t (31) = 1.81, p <.10, d=.32; and five-syllable nonwords, t (31) = 2.98, p <.05, d=.52. To sum up, whereas English stress could significantly increase the English nonword repetition, syllable length could significantly decrease it. Furthermore, the stress effect on the English nonword repetition was more significant with the increase of syllable length.

Tone, syllable length, and Chinese nonword repetition. Similarly, a two-way ANOVA examined the effect of syllable length and tone on the Chinese nonword repetition.

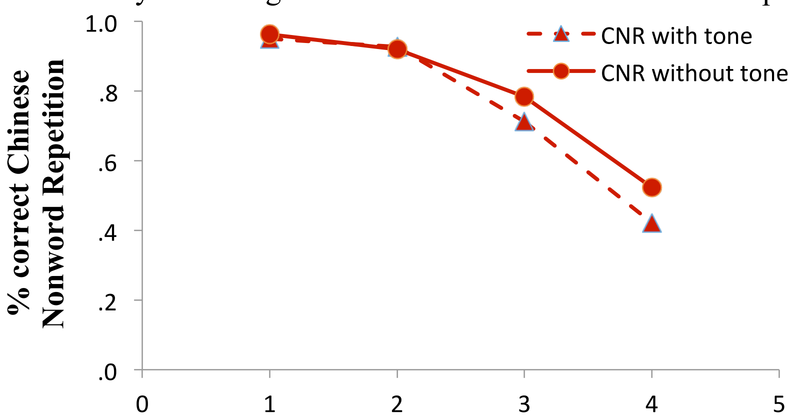

Figure 2. ***Chinese Nonword Repetition as Function of Syllable Length & Tone***
Note: The horizontal axis represents 1-, 2-, 3-, and 4-syllable Chinese nonwords. The vertical axis represents proportion correct of performance on Chinese nonword repetition.

As Figure 2 above shows, the Chinese nonword repetition without tone outperformed the Chinese nonword repetition without tone, F (1, 31) =18.15, P<.001, η^2=.065. Moreover, the Chinese nonword repetition decreases with the syllables length, F (3, 93) = 173.70, p < .001, η^2=.065. Furthermore, the interaction between syllables length and tone was significant, F (3, 93) = 8.59, p < .001, η^2=.056. With the Bonferroni correction, paired-sample t-tests indicated that the tone effect on Chinese nonword repetition was not significant for one-syllable, t (31) = -.94, p>.05, d=.17 and two-syllable nonwords, t (31) = .60, p>.05, d=.11; but significant for three- and four-syllable nonwords, t (31) = -3.99, p <0.001, d=.71 and t(31) = -3.79, p <0.001, d=.67 respectively. In conclusion, the results suggested that all the factors here, tone, syllable length and their interaction, could account for the difference on the Chinese nonword repetition.

Language, tone, stress, and number of syllabus. A three-way ANOVA was used for examining the effect of language (Chinese vs. English), Chinese tone vs. English stress, and the length of syllables (2, 3 and 4 syllable). As Figure 3 below indicates, although no significant main effect for language could be found, the simple main effect of syllable length was significant, F (2, 62) = 127.69, p <.001, and the interaction between the two was significant, F (2, 62) = 47.81, p <. 001. The result indicated that the repetition on the Chinese nonwords was worse than that of the English nonwords when the syllable increased. Moreover, the interaction between language and tone/stress was significant, F (1, 31) = 26.39, p <. 001, suggesting that the Chinese nonword repetition without tone significantly outperformed the Chinese nonword repetition with tone, and the English nonword repetition with stress significantly outperformed the English nonword repetition without stress. The interactions among language, stress/tone, and number of syllables were also significant, F (2, 62) = 4.18, p <.05.

A paired t-test was also conducted to compare the English and Chinese nonword repetition at each syllable by using the Bonferroni correction. As shown in Figure 3, the Chinese nonword repetition significantly outperformed the English nonword repetition at the two-syllable, t (31) = -5.21, p <.001. While no significant difference can be found at the three-syllable, t (31) = -1.65, p = .11, at the four-syllable the English nonword repetition was significantly higher than the Chinese nonword repetition, t (31) = 5.46, p <.001. The result shows that syllable length affects the Chinese nonword repetition more than the English nonword repetition.

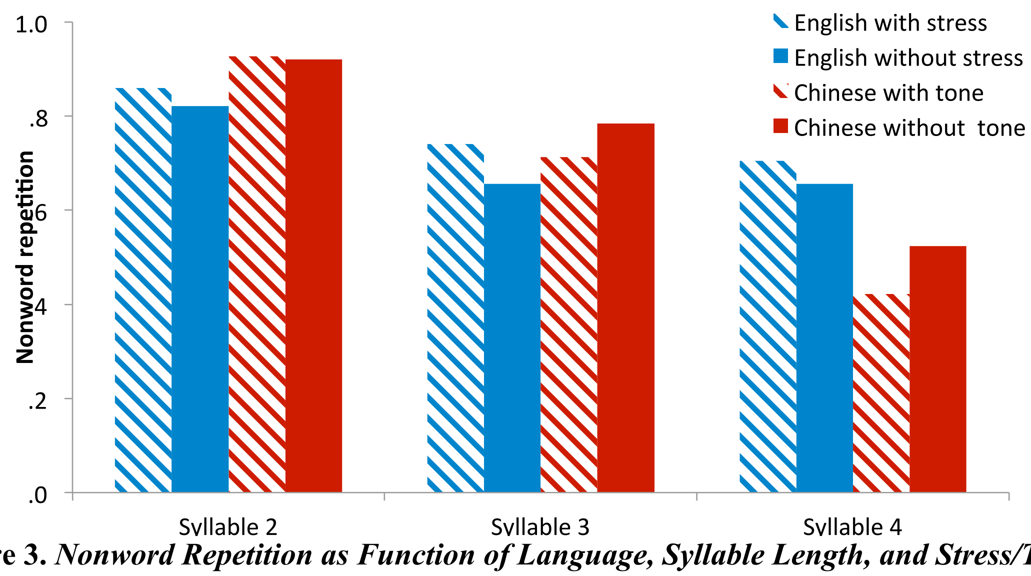

Figure 3. ***Nonword Repetition as Function of Language, Syllable Length, and Stress/Tone***

Putting all the results together, whereas English stress might facilitate the English nonword repetition, Chinese tone probably hinders the Chinese nonword repetition. In addition, with syllable increases, both the English and Chinese nonword repetition became worse though the latter was more sensitive to the syllable length.

Predictors of Chinese word learning. The predictors of the Chinese word learning were investigated via the multiple regression analyses. As shown in Table 1a below, in the Model One step-wise model selection, both the Chinese nonword repetition with tone and the English nonword repetition with stress are strong predictors, together accounting for 34% of the total variance in the Chinese word learning. Specifically, 22% and 12% of the total variance could be explained respectively by the former and the latter. Both the two predictors were measures for PM, thus a regression analysis was conducted to calculate the commonality between them.

Reversing the order of the two predictors for the step-wise model showed that about 20% of the variance could be explained by the English nonword repetition with stress and 14% by the Chinese nonword repetition with tone. The commonality contribution between the two predictors was 8%, indicating that 8% of the total variance could be explained by their overlap. The result also indicates that the unique contribution of the Chinese nonword repetition with tone was 14%, and the unique contribution of the English Nonword Repetition with stress was 12%.

Model One	ΔR2	Beta	t	Sig.
CNR (with tone)_S34	0.22	0.39	2.50	0.02
ENR(with stress)_S345	0.12	0.36	2.36	0.03

	ΔR2	Beta	t	Sig.
ENR (with stress)_ S 345	0.20	0.36	2.36	0.03
CNR(with tone)_ S34	0.14	0.39	2.50	0.02

Table 1a. ***Multiple Regression analyses of performance on Baseline English Reading, Phonological Working Memory, & Chinese Word Learning (N=32)***

It should be noted that an alternative model is almost as good as this model when the Chinese nonword repetition with tone and the English nonword repetition without stress were predictors, where 33% of the total variance could be explained (20% and 11% respectively) as indicated by the Model Two in Table 1b below.

It seems that no matter with stress or without stress, the English nonword repetition could predict Chinese word learning. Whereas stress facilitated the repetition of the overall English nonwords, further analysis is needed to investigate how the facilitation works. Furthermore, one of the research questions of the present study was to investigate the relationship between the English stress and the Chinese tone, thus decomposing the performance of the English stress and Chinese tone from the whole pronunciation is necessary. Thus, Approach Two was used in the present study for a finer analysis.

Model Two	ΔR2	Beta	t	Sig.
CNR (with tone)_S 34	0.22	0.43	2.82	0.01
ENR (w/o stress)_S345	0.11	0.34	2.24	0.03

	ΔR2	Beta	t	Sig.
ENR (w/o stress)_S 345	0.15	0.34	2.24	0.03
CNR(with tone)_ S 34	0.18	0.43	2.82	0.01

Table1b. ***Multiple Regression analyses of performance on Baseline English Reading, Phonological Working Memory, & Chinese Word Learning (N=32)***

Approach Two: Pronunciation and Stress/Tone Scored Separately

In this approach, English stress and Chinese tone were separately scored to demonstrate their independent effect on the nonword repetition. Taking the English nonword repetition as an example, the repetition of each nonword was transcribed and analyzed under four conditions: the English stress (with stress), the English pronunciation (with stress), the English stress (without stress), the English pronunciation (without stress).

Table 5 (see Appendix A) displays the performance on the English reading and PM measures by using this separated scoring. Whereas the correct repetition of English stress was higher on the stressed nonwords (i.e., English stress with stress) than unstressed nonwords (i.e., English Stress without stress), the reproduction of Chinese tone was better when all the syllables were in flat tone (i.e., Chinese tone without tone) than when the tone of the syllables varied (i.e., Chinese tone with tone).

To find out possible predictors for Chinese word learning, multiple regression analyses were conducted. As shown in the Model One of Table 2 below, the strongest predictors by step-wise model selection were the English pronunciation without stress and the Chinese pronunciation with tone, altogether explaining approximately 43% of the total variance (30%, 13% respectively). Reversing the order of the two predictors to the step-wise model selection also showed that 43% (25%, 18% respectively) of the total variance could be explained by the two predictors. The commonality between the two was 12%, indicating that 12% of the total variance could be explained by their overlap. Moreover, the unique contribution of the English pronunciation without stress is 18% and the unique contribution of Chinese pronunciation with tone is 13%.

Model One	ΔR2	Beta	t	Sig.
English Pronunciation (w/o stress)_S345	0.30	0.44	3.01	0.01
Chinese Pronunciation (with tone)_S34	0.13	0.37	2.52	0.02

Model Two	ΔR2	Beta	t	Sig.
Chinese Pronunciation (with tone)_S34	0.25	0.37	2.52	0.02
English Pronunciation (w/o stress)_S345	0.18	0.44	3.01	0.01

Table2. Multiple Regression Analyses of performance on Baseline English Reading, Phonological Working Memory, & Chinese Word Learning

In conclusion, comparing the results in Approach Two with that in Approach One, it seems that the former could explain more variance of the Chinese word learning. Therefore, the two predictors in Approach Two might have more predictive power for Chinese word learning. Careful examination of the two predictors shows that both can be considered as a less familiar phonological feature for English-speaking children.

DISCUSSION

The primary purpose of this study was to investigate whether children's PM could predict their ability to learn Chinese as an L2. This study has two special contributions: it is the first to examine the role of PM in learning a tonal L2 such as Chinese, and the participants had no prior exposure to the target L2 before this study. These two features help minimize the possible effect of L1 mediation in L2 learning.

The major finding in this study is that the repetition of both Chinese and English nonwords helped predict the Chinese spoken word learning. The prediction is strongest when the performance on the stress and tone was scored separately and independently. Consistent with previous studies (e.g., Kim, 2014), this study shows that both L1 and L2 nonword repetition could predict L2 spoken word learning though the two languages differ greatly. This finding is more convincing than the result from previous studies since those studies did not purposely minimized the effect of L1 mediation in L2 word learning.

A second major finding is that less familiar nonwords could better predict children's ability to learn new L2 words since the learning of less familiar nonwords had to rely more on temporary storage function when less lexical support is available from long-term memory. The relevant existing knowledge can help increase chunk size, reduce the memory load, and thus enhancing PM efficiency (Miller, 1956); however, less familiar items containing more novel phonological forms could decrease chunk size, increase the memory load, and thus hindering PM efficiency. This finding converges with the conclusions from the previous studies (Gathercole, Willis, Emslie, & Baddeley, 1991; Yuzawa, Saito, Gathercole, Yuzawa, & Sekiguchi, 2010).

Furthermore, this study found that the English stress and the Chinese tone displayed contrast effects (facilitating vs. hindering) in processing the nonwords, which is consistent with the mediation effect discussed in the previous section. Despite the fact that tonal pattern is an integral part of each word for native speakers acquiring Mandarin, this functional association between segmental structure and pitch contour does not exist in non-tonal speakers' linguistic behavior. Consequently, the participants probably had a lack of sensitivity to tonal categories, and they might suffer from L1 interference since their knowledge on the function of pitch in the English stress and intonation systems might highly influence their perception on Mandarin tones. Therefore, while the English stress helped organize and facilitate the temporary storage of phonological input in English nonword repetition, the Chinese tone was new and created a huge challenge for the participants in Chinese nonword repetition. For that reason, even if other phonological aspects between English and Chinese were equal, the supra-segmental differences, such as the difference between the English stress and the Chinese tone, still would make it challenging for the English-speaking children to learn spoken Chinese. Therefore, this study concluded that English stress was not correlated with Chinese tone. This finding could be supported by Wang (2006) since different patterns in perceiving and producing Mandarin tones were found between the native and non-native speakers.

Also, this study reported a word length effect on the repetition of the English and Chinese nonwords, which is parallel with the findings in the literature (e.g., Gathercole, Willis, Emslie, &

Baddeley, 1991; Baddeley, Gathercole, Papagno, 1998). It is generally assumed that the longer words are, the longer they take to be processed. This pattern changes though when words or letter patterns become so well learned that they are recognized as visual or audio wholes rather than individual phonemes or letters (Zhang, Lin, Wei & Anderson, 2014). Neither the participants' L1 nor L2 reached the automatized level in this study, thus the word length effect holds.

Additional evidence for the mediation effect comes from the result that shows when the PM task became more challenging, the repetition of English nonword is easier than that of Chinese. The participants' prior knowledge of English morphemes and phonotactics might facilitate their chunking, and such facilitation might be more challenging for nonwords with longer syllables. In contrast, the participants did not know any Chinese morphemes in the Chinese nonwords. Repeating the 2- and 3-syllable nonwords was probably still within their PM capacity, thus the nonwords could be readily chunked. However, the Chinese nonwords with longer syllables such as the 4-syllable might sound like a string of arbitrary syllables for the participants; thus, it might be very challenging to chunk them for efficient processing.

Several caveats must be considered when interpreting the results of this study. One limitation has to do with other cognitive covariates (e.g., phonological awareness) that might be correlated with both PM and Chinese word learning. This study might also be limited by the number of participants in analyzing the effects of PM on language processing. Furthermore, the measures of PM used in this study might be improved. For example, the English nonword repetition test might be revised to avoid the performance ceiling, and more Chinese words could be included in the Chinese word learning and to extend the Chinese learning task over several sessions to make it less demanding for the participants.

To our knowledge, this study might be the first to investigate the Chinese word learning ability of English-speaking children who had no prior exposure to Chinese from the perspective of PM. Together with the findings in Kim (2014), the results extend the association of PM from related languages to phonologically distinct languages. The findings in the present study are thus both theoretically and practically significant. Theoretically, the finding fills the gap of the previous studies by showing that without the support of long-term lexical, morphological, and phonotactic knowledge, PM can still predict L2 word learning. This result suggests that PM serves as a general mechanism predicting the learning of novel sound, regardless of the similarity between L1 and L2 and prior knowledge of the L2. This finding is consistent with previous results that the PM system can predict L2 learners' abilities in processing the new input in L2 learning and expands our understanding of the role of PM in L2 learning.

The ability to identify words based on phonological information is one of the most actively investigated aspects of word identification (e.g., Daneman & Stainton, 1991; Liberman & Mattingly, 1989). Research has linked a deficiency in phonological processing skills (e.g., PM, phonological awareness, phonological retrieval) to word-recognition difficulties in reading an alphabetic orthography (for a review, see Catts, 1989; Wagner & Torgesen, 1987) as well as logographic orthography (Hu & Catts, 1998). Therefore, working memory for written material is primarily phonological in nature (Anderson, 2010), suggesting that working memory capacity is also important in reading. Therefore, our conclusion that PM could predict children's Chinese spoken word learning adds weight to the PM effect in general L2 learning including reading.

For practical purposes, the present study provides implications for curricula design and instructional practices for teaching Chinese. Chinese is considered as one of the critical languages by the U. S. government and increasingly American K-12 schools are planning to offer Chinese programs. It is necessary to understand what can predict children's Chinese learning, so educators can seek strategies to help children. The finding that both the English stress and the Chinese tone can predict children's Chinese spoken word learning implies that teachers might develop children's sensitivity to stress and/or tone to help them learn Chinese more efficiently. Specifically, teachers can try the following strategies in curricula design and instructional practices: practicing reasonable number of stress/tone items each time to reduce the demand for children's PM load, reviewing stress/tone items frequently to increase children's exposure to them, trying various strategies such as rhythm, tone twisters and songs to potentially reinforce children's memory trace for difficult stress/tone items.

CONCLUSION

The present study confirmed the findings from previous studies on PM by demonstrating an association between the English-speaking children's PM and their Chinese spoken word learning proficiency. A special feature of this study is that it minimized the confounding effect of L1 mediation in L2 learning thus leading to the conclusion more convincing than that of similar studies conducted previously without doing this. Despite the huge differences between English and Chinese, this study still found that both English and Chinese nonword repetition could predict the English-speaking children's Chinese spoken word learning. Furthermore, the phonological feature that was less familiar to English-speaking children demonstrated more predictive power for Chinese word learning. Finally, English stress and Chinese tone displayed contrast effects in processing the nonwords: while the former facilitated the processing of nonwords, the latter hindered it.

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APPENDIX A: *Tables*

Approach One

Table 3 *Means, Standard Deviations, Maximums Possible, Minimums, and* Ranges (N=32)

	Mean	SD	Maximum Possible	Actual Minimum	Range
English Reading Comprehension	.65	.23	1	.09	.91
Auditory Digit Span	5	.76	7	4	3
ENR with stress (syllable345)	.71	.11	1	.38	.52
ENR without stress (syllable345)	.62	.14	1	.38	.45
CNR with tone (syllable 34)	.63	.14	1	.38	.51
CNR without tone (syllable 34)	.71	.13	1	.42	.51
Chinese Word Learning	.45	.16	1	.06	.69

Note: 1. ENR = English nonword repetition, CNR = Chinese nonword repetition
2. Both English nonword repetition and Chinese nonword repetition use **PERCENTAGE** score
3. English nonword repetition with 3-, 4-, & 5-syllable nonwords
4. Chinese nonword repetition with 3- , & 4-syllable nonwords
5. The number of Chinese words correctly recalled in the final round was used as index of Chinese word learning

Table 4 *Pearson Inter-correlations among English Reading Comprehension, Phonological Working Memory Measures and Chinese Word Learning (N=32)*

		1	2	3	4	5	6	7
1	English Reading	_						
2	Auditory Digit Span	.28	_					
3	ENR with stress (syllable_345)	.19	.25	_				
4	ENR without stress (syllable_345)	.47**	.48**	.31	_			
5	CNR with tone (syllable_ 34)	.00	.47**	.22	.11	_		
6	CNR without tone (syllable_ 34)	.15	.55**	.36*	.15	.78**	_	
7	Chinese Word Learning	.19	.34	.45*	.39*	.47**	.39*	_

* P< .05; ** P< .01

Note: 1. ENR = English nonword repetition, CNR = Chinese nonword repetition
2. Both English nonword repetition and Chinese nonword repetition use PERCENTAGE score
3. English nonword repetition use 3-, 4-, & 5-syllable nonwords
4. Chinese nonword repetition use 3-, & 4-syllable nonwords
5. The number of Chinese words correctly recalled in the final round was used as index of Chinese word learning

Approach Two
Table 5 *Means, Standard Deviations, Maximums Possible, Minimums, and Ranges (N=32)*

	Mean	*SD*	*Maximum Possible*	*Actual Minimum*	*Range*
English Reading	*.65*	*.23*	*1*	*.09*	*.91*
Auditory Digit Span	*5.00*	*.76*	*7*	*4*	*3*
ENR_345_pro_stress	*.71*	*.11*	*1*	*.38*	*.48*
ENR_345_Stress_Stress	*.99*	*.02*	*1*	*.93*	*.07*
ENR_345_pro_w/o stress	*.70*	*.12*	*1*	*.45*	*.41*
ENR_345_stress_w/o stress	*.90*	*.11*	*1*	*.62*	*.38*
CNR_34_pro_Tone	*.74*	*.12*	*1*	*.46*	*.46*
CNR_34_Tone_Tone	*.79*	*.11*	*1*	*.57*	*.40*
CNR_34_pro_w/o Tone	*.73*	*.11*	*1*	*.50*	*.43*
CNR_34_Tone_w/o Tone	*.94*	*.08*	*1*	*.71*	*.29*
Chinese Word Learning	*.45*	*.16*	*1*	*.06*	*.69*

* P< .05, ** P< .01 (2-tailed).
Listwise N=32

Note:
CNR = Chinese Nonword Repetition
ENR = English Nonword Repetition

Table 6 *Pearson Inter-correlations among Initial English Reading, Phonological Working Memory Measures and Chinese Word Learning (N=32)*

	1	2	3	4	5	6	7	8	9	10	11
English Reading	_										
Auditory Digit Span	.28	_									
ENR_345_pro_stress	.22	.30	_								
ENR_345_Stress_Stress	-.12	-.14	-.16	_							
ENR_345_pro_w/o stress	.57**	.44*	.44*	-.32	_						
ENR_345_stess_w/o stress	-.01	.17	-.02	.18	-.14	_					
CNR_34_pro_Tone	.01	.49**	.41*	-.23	.29	-.22	_				
CNR_34_Tone_Tone	.10	.41*	.18	.03	.37*	-.11	.73**	_			
CNR_34_pro_w/oTone	.13	.61**	.41*	-.07	.29	-.09	.87**	.61**	_		
CNR_34_Tone_w/oTone	.16	.25	.33	-.01	.40*	-.14	.56**	.60**	.61**	_	
CWL_N	.19	.34	.51**	-.31	.55**	-.18	.50**	.42*	.38*	.41*	_

Note: CNR = Chinese Nonword Repetition ENR = English Nonword Repetition

APPENDIX B-1: *English Nonwords (Block A)*

Item No.	Nonwords	Pronunciation	Student answer		Note
			Correct( )	Wrong ( )	
59	Defermication				
130	Bannifer				
37	Skiticult				
132	Brasterer				
35	Frescovent				
48	Stopograttic				
49	Woogalamic				
58	Voltularity				
140	Blonterstaping				
27	Rubid				
123	Glistow				
142	Contramponist				
36	Glistering				
134	Doppelate				
152	Detratapillic				
121	Bannow				
39	Trumpetine				
144	Fenneriser				
46	Pennerriful				
28	Sladding				
25	Pennel				
47	Perplisteronk				
45	Loddenapish				
143	Empliforvent				
151	Confrantually				
120	Ballop				
38	Thickery				
55	Sepretennial				
131	Barrazon				
29	Tafflest				
124	Hampent				
150	Altupatory				
122	Diller				
141	Commeecitate				
26	Prindle				
153	Pristoractional				
56	Underbrantuand				
133	Commerine				
154	Reutterpation				
57	Versatrationist				

Adapted from "The Children's Test of Nonword Repetition: A test of phonological working memory," by Gathercole, S., Willis, C., Baddeley, A., and Emslie, H, 1994, Memory, 2, p. 103-127.

APPENDIX B-2: *English Nonwords (Block B)*

Item No.	Nonwords	Pronunciation	Student answer		**Note**
			Correct( )	Wrong ( )	
139	Trumpetine				
43	Empliforvent				
127	Rubid				
33	Commerine				
44	Fenneriser				
146	Pennerriful				
54	Reutterpation				
22	Diller				
126	Prindle				
158	Voltularity				
20	Ballop				
41	Commeecitate				
23	Glistow				
42	Contramponist				
136	Glistering				
34	Doppelate				
125	Pennel				
40	Blonterstaping				
155	Sepretennial				
148	Stopograttic				
128	Sladding				
159	Defermication				
149	Woogalamic				
51	Confrantually				
137	Skiticult				
21	Bannow				
50	Altupatory				
31	Barrazon				
135	Frescovent				
147	Perplisteronk				
157	Versatrationist				
138	Thickery				
145	Loddenapish				
32	Brasterer				
156	Underbrantuand				
24	Hampent				
30	Bannifer				
53	Pristoractional				
129	Tafflest				
52	Detratapillic				

APPENDIX C-1: *Chinese Nonwords (Block A)*

1-syllable	2-syllable	3-syllable	4-syllable
mō	nǔ tài	Gē diù mù	Yáo' óu pìn biǎo
bǎ	*Tōu wā*	*Māo lān kōu*	*Kē niāo wān fā*
niū	Mán pěi	*gēi tī līn*	Pài' ěi lāo kán
yǒu	Lī nāo	Pěn gòu fó	*Dā bū kēi huō*
pào	*Bīn gāi*	*Wēn kuō nī*	*Mēi dōu hāo gū*
hēn	Dǎo huǎ	*Nēi lūn kuā*	Bāi tuí lā nè
léi	*Fān bō*	*Fēi guī tuō*	
wāi	Dú 'í	Bán liǔ hōu	
dān	*Mēn kā*	*Bī fōu hē*	
fū	*Hēi lān*	Hǎ mái děi	
		Dēn lōu hāi	
		Tà lú piào	
		Mín diàn hū	
		Wō tē yīn	
		Dā mī bēn	
		Bāo pò yē	
		Kāo gā lē	
		Lài nín ' é	
		Tú fēn pá	
		Yǎ pū gàn	

APPENDIX C-2: *Chinese Nonwords (Block B)*

1-syllable	2-syllable	3-syllable	4-syllable
dān	Fàn bō	Mào làn kǒu	*Pāi' ēi lāo kān*
hèn	*Mān pēi*	*Bān liū hōu*	Mēi dòu hào gú
lēi	Bīn gāi	Dā mī bén	*Yāo' ōu pīn biāo*
mō	*nū tāi*	*Lāi nīn' ē*	Dǎ bù kèi huō
bā	*Dū 'ī*	*Bāo pō yē*	Kě niāo wán fā
fǔ	Mēn ká	gēi tǐ lín	*Bāi tuī lā nē*
niú	*Lī nāo*	Kǎo gā lè	
yōu	Tòu wà	Bǐ fóu hě	
wài	*Dāo huā*	*Yā pū gān*	
pāo	Héi làn	*Mīn diān hū*	
		Néi lún kuà	
		Hā māi dēi	
		Wèn kuō nī	
		Pēn gōu fō	
		Wǒ tè yǐn	
		Dén lōu hǎi	
		Tū fēn pā	
		Tā lū piāo	
		Gē diū mū	
		Fèi guǐ tuō	

APPENDIX D-1: *Chinese Word Learning (Group One)*

0	dog **gǒu**	aunt **ā yí**	apple **píng guǒ**	rice **dà mǐ fàn**
1	aunt **ā yí**	dog **gǒu**	rice **dà mǐ fàn**	apple **píng guǒ**
2	rice **dà mǐ fàn**	aunt **ā yí**	apple **píng guǒ**	dog **gǒu**
3	apple **píng guǒ**	rice **dà mǐ fàn**	dog **gǒu**	aunt **ā yí**
F 4	dog **gǒu**	apple **píng guǒ**	aunt **ā yí**	rice **dà mǐ fàn**
5	aunt **ā yí**	dog **gǒu**	rice **dà mǐ fàn**	apple **píng guǒ**
6	rice **dà mǐ fàn**	aunt **ā yí**	apple **píng guǒ**	dog **gǒu**
7	apple **píng guǒ**	rice **dà mǐ fàn**	dog **gǒu**	aunt **ā yí**
8	dog **gǒu**	apple **píng guǒ**	aunt **ā yí**	rice **dà mǐ fàn**
9	aunt **ā yí**	dog **gǒu**	rice **dà mǐ fàn**	apple **píng guǒ**
10	rice **dà mǐ fàn**	aunt **ā yí**	apple **píng guǒ**	dog **gǒu**

APPENDIX D-2: *Chinese Word Learning (Group Two)*

group 2				
0	tiger **hǔ**	hair **tóu fà**	we **wǒ mēn**	glass **bō lí bēi**
1	we **wǒ mēn**	tiger **hǔ**	glass **bō lí bēi**	hair **tóu fà**
2	tiger **hǔ**	hair **tóu fà**	we **wǒ mēn**	glass **bō lí bēi**
3	hair **tóu fà**	glass **bō lí bēi**	tiger **hǔ**	we **wǒ mēn**
F4	glass **bō lí bēi**	we **wǒ mēn**	hair **tóu fà**	tiger **hǔ**
5	we **wǒ mēn**	tiger **hǔ**	glass **bō lí bēi**	hair **tóu fà**
6	tiger **hǔ**	hair **tóu fà**	we **wǒ mēn**	glass **bō lí bēi**
7	hair **tóu fà**	glass **bō lí bēi**	tiger **hǔ**	we **wǒ mēn**
8	glass **bō lí bēi**	we **wǒ mēn**	hair **tóu fà**	tiger **hǔ**
9	we **wǒ mēn**	tiger **hǔ**	glass **bō lí bēi**	hair **tóu fà**
10	tiger **hǔ**	glass **bō lí bēi**	hair **tóu fà**	we **wǒ mēn**

APPENDIX D-3: *Chinese Word Learning (Final Test)*

English-Chinese	apple **píng guǒ**	hair **tóu fà**	tiger **hǔ**	rice dà mǐ fàn	dog **gǒu**	aunt **ā yí**	glass **bō lí bēi**	we **wǒ mēn**