THE TRANSFER EFFECT OF FIRST LANGUAGE METALINGUISTIC SKILLS ON SECOND LANGUAGE LEARNING OF CHINESE AND SPANISH

By

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ABSTRACT

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Metalinguistic skills, such as phonological awareness and rapid naming, have been found to facilitate first language learning in languages with a transparent orthography such as Spanish. On the other hand, metalinguistic skills such as visual-spatial memory have been correlated with first language learning of non-alphabetic languages such as Chinese. However, there are no studies that have correlated these metalinguistic skills of first language to learning outcomes of both alphabetic and non-alphabetic second languages. The current study investigated how different metalinguistic skills in English speakers will facilitate the acquisition of a different second language (i.e. Spanish and Chinese). Our study revealed a significant language effect in both meaning learning and pronunciation learning with Spanish reaching a higher accuracy level than Chinese. We found a significant learning effect for meaning from day 1 to day 5 in both languages. Our results also demonstrated a significant learning effect for Chinese pronunciation from day 1 to day 5, but not for Spanish. Several metalinguistic skills in first language were found to predict Spanish pronunciation learning, but not Chinese learning, including phonological awareness, rapid naming, visual spatial skills, and verbal working memory. Direct comparison showed that rapid naming was significantly more correlated with Spanish pronunciation learning than Chinese pronunciation learning. This may be due to greater similarity between L1, English, and L2, Spanish, than that between English and Chinese. These findings suggest a faster learning rate and a greater predictive relationship between L1 metalinguistic skills and L2 learning outcome when L1 and L2 are similar.

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KEY TO ABBREVIATIONS

First Language L1

Second Language L2

INTRODUCTION

A substantial body of evidence from studies on language acquisition argued that alphabetic language speakers with strong phonological awareness (Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Denton, Hasbrouck, Weaver, & Riccio, 2000; Carlisle, Beeman, Davia, & Spharim, 1999) and rapid naming skills (Lindsey, Manis, & Bailey, 2003; Siddaiah & Padakannaya, 2015) increase their success in becoming proficient in reading an alphabetic language. This is because an alphabetic language consists of a systematic mapping system between orthography and phonology. However, studies have demonstrated that in native Chinese speakers, there may be different skills, such as visual-spatial memory skills, that predict Chinese reading ability (Siok & Fletcher, 2001; Tavassoli, 2002). This emphasis on visual-spatial skills is likely due to Chinese being a logographic language with a complex spatial layout and an arbitrary mapping system between orthography and pronunciation.

Frameworks of language ‘transfer’ have been evidenced in second language acquisition. Wang, Koda, and Perfetti (2003) conducted a study that examined the transfer effects from L1 to L2, in which the authors compared Korean-English bilinguals and Chinese-English bilinguals on English word reading. The finding was that Korean-English speakers showed greater reliance on phonological information while Chinese-English bilinguals showed greater reliance on orthographic information, suggesting that the reading strategies and processing skills used for L1 can be somehow transferred to L2. Some studies also found that high phonological awareness skills in L1-Spanish can also predict greater learning outcomes of L2-English (Durgunoglu et al., 1993; Denton et al., 2000; Carlisle et al., 1999). However, no research has been conducted to compare whether different metalinguistic skills predict reading in learning different L2s. The level of similarity between L1 and L2 orthographic mapping systems may determine which metalinguistic skills play an important role in learning different L2s. The current study will examine what abilities used for L1 (English) are correlated to learning outcomes in different L2s, depending on whether L2 has a transparent orthography, such as Spanish, or a logographic orthography, such as Chinese.

Phonological Awareness

According to Bialystok (2001), phonological awareness is the understanding of the sound units that make up words. This ability to segment word sound is vital in learning how to read. To master alphabetic script, one must demonstrate an ability to analyze the word's structure and to recognize that words are composed of phonemes (Koda, 2007). This ability to segment words facilitates the capability to map sounds to the language's orthography which in turn aids reading. Regular alphabetic languages have consistent mapping between grapheme and phoneme, thus readers rely heavily on phonemic analysis (Koda, 2007). Many studies have demonstrated that phonological skills contribute to second language learning particularly for alphabetic languages. Durgunoglu et al. (1993) indicated that a child with strong reading and phonological awareness skills in Spanish will usually recognize English words and pseudowords with more ease. Furthermore, a study review indicated that development of phonological awareness skills in English is facilitated by high level of phonological awareness in Spanish, which in turn enables success in learning to read English in Spanish native speakers (Denton et al., 2000). Carlisle et al. (1999), examined Hispanic bilinguals in grades 1-3 and reported that phonological awareness and vocabulary size in both L1 and L2 demonstrated a strong correlation to overall reading proficiency in L2. In other words, children with strong phonological awareness in L1 will have a better achievement in L2. Taken together, there is strong evidence that phonological awareness in L1, Spanish, transfers to L2 English, both of which are alphabetic languages. However, to our knowledge no studies have examined how phonological awareness in English influences learning to read Spanish as an L2.

Unlike Spanish, Chinese does not have a phoneme-grapheme correspondence and a whole character is matched to a whole syllable. However, phonological awareness skills have also been found to be important in learning to read Chinese in native speakers (Siok & Fletcher, 2001; Ho & Bryant, 1997). Ho and Bryant (1997) concluded that when learning to read Chinese as an L1, children progress from a visual phase to a phonological phase. Furthermore, Ho and Bryant (1997) explained that the phonetic component in Chinese characters are recognized and used through their phonemic system thus developing a relationship between phonological awareness skills and learning to read. However, there are also studies that suggest phonological awareness is not as essential in Chinese reading acquisition as in alphabetic languages (Ku & Anderson, 2003; Li, Anderson, Nagy & Zhang, 2002). To our knowledge, no studies have examined whether phonological awareness skills play a role in learning Chinese as a second language with alphabetic L1 background.

Rapid Naming

Rapid naming is a task that is typically used to measure ones' speed in naming objects, numbers, and letters (Siddaiah & Padakannaya, 2015). Rapid naming has been proposed as having a unique impact on reading abilities as it is considered to tap other cognitive functions that phonological awareness does not (Wolf & Bowers, 1999). For a shallow language such as Spanish, studies have found that rapid naming predicts reading capabilities. One such study conducted by Lindsey et al. (2003) examined Spanish-speaking, English-language learners and indicated slow rapid naming in Spanish, was correlated with poor reading abilities in both Spanish and English. Siddaiah and Padakannaya (2015) revealed that, although phonological awareness aptitude predicts learning to read in most languages, rapid naming is more important in shallow or transparent languages such as Spanish. Due to the usual one to one relationship between orthography and phoneme in transparent languages such as Spanish, reading accuracy can usually reach ceiling, while reading fluency is more sensitive to individual variability (Siddaiah & Padakannaya, 2015). No studies have been conducted looking at rapid naming skills influence on acquisition of Spanish as an L2.

As with Spanish, rapid naming has also been correlated with learning of Chinese. Liao, Georgiou, and Rauno, 2007 compared rapid naming and Chinese character recognition accuracy and fluency in Chinese speaking children in grade 2 and 4. Children in grade 2 demonstrated a correlation with rapid naming skills and Chinese character recognition fluency and children in grade 4 demonstrated correlations with both Chinese character recognition fluency and accuracy (Liao et al., 2007). Pan, McBride, Shu, Liu, and Zhang, 2011 also conducted a study examining rapid naming skills in native Chinese children and concluded that reading fluency in Chinese was predicted by rapid naming skills and suggested that there are differences in literacy acquisition for Chinese compared to languages with a more regular alphabetic orthography. No studies have been conducted looking at rapid naming skills influence on acquisition of Chinese as an L2.

Visual Spatial Memory

Although phonological awareness has been found to play a role in learning to read Chinese in some studies, much research has indicated that visual spatial memory plays a more significant role in learning languages that are more visually involved (complex graphemes), such as Chinese. As previously mentioned, Chinese is a logographic language that is made up of multiple strokes and forms, which are spatially and visually complex and related to one another (Mo, Yu, Seger, & Mo, 2015; Flaherty, 2003). Results of a study conducted by Tavassoli (2002) revealed a greater spatial memory for Chinese speakers than for English speakers in real and nonsense words. Tavassoli (2002) explained the results by stating that Chinese logographs rely more on visual memory hence the spatial memory advantage. Neuroimaging studies have revealed greater involvement of the bilateral ventral visual cortex (Mo et al., 2015) and reduced involvement of the phonological decoding areas for reading Chinese compared to alphabetic languages (Bolger, Perfetti, & Schneider, 2005; Tan, Laird, Karl, & Fox, 2005; Cao, Brennan, Booth, 2014). Furthermore, these studies indicated the bilateral ventral visual cortex is involved in orthographic processing and object recognition, which are essential for Chinese language learning (Bolger, Perfetti, & Schneider, 2005; Tan, Laird, Karl, & Fox, 2005; Cao, Brennan, Booth, 2014). Taken together, the visual form and pronunciation of each character is essentially memorized in Chinese (Flaherty, 2003), hence revealing the importance of a Chinese learners' visual spatial memory is significant. As with all other metalinguistic skills, we were unable to find any studies looking at visual-spatial memory skills in learning Chinese as an L2.

Transfer

When learning a second language, continuous interactions between languages and continuous adjustments to distinct demands from each language are implied, because unlike L1 reading, L2 reading involves dual-language implications (Koda, 2007). Logically, one can assume that a transfer in knowledge between L1 and L2 can occur if the L1 and L2 have similar orthographic backgrounds and thus helps language learners achieve reading proficiency more rapidly than L2 learners with an unrelated orthographic background to L1 (Koda, 1989). Findings from Koda's 1989 study on language transfer suggested that in languages with similar orthographic systems, L1 orthographic knowledge facilitates development of L2 reading fluency. Durgunoglu et al. (1993) confirms Koda's results in their study, which concluded that phonological awareness abilities in Spanish transferred to English and thus L2 English children were able to read English words more easily. Together these studies suggest that transfer between languages can facilitate the acquisition of a second language when acquiring a L2 with similarity to L1.

In summary, every language has a different orthographic system which taxes different abilities more heavily than others. For a language such as Spanish which has a more regular mapping system between its orthography and phonology, both phonological awareness and rapid naming abilities are important for reading. On the other hand, Chinese is a logographic system that has an arbitrary mapping between orthography and phonology. Therefore, it relies heavily on visual spatial skills for reading. Skills in phonological awareness, rapid naming, and visual spatial memory in English speakers learning a L2 may predict success of L2 learning to a different degree depending on which L2 it is. For example, visual spatial memory skills may play a more important role in Chinese learning while phonological skills may play a more important role in Spanish learning, and rapid naming may be important in both.

Learning Conditions

In addition to metalinguistic skills and transfer effect, it is also important to take into consideration the learning techniques in which students learn words in a new language. To investigate these effects, in this study, participants learned the training words in three conditions, viewing, phonological, and writing. Viewing will serve as the control condition as we are interested in the effects of writing and phonological learning. We are interested in how these conditions facilitate the acquisition of Spanish and Chinese differently.

Phonological. As Cao et al., (2013) stated, alphabetic languages have a more intimate relationship between orthography and phonological representations, making phonological training very important for the acquisition of such languages. It appears that learning to read in an alphabetic language requires learners to perceive speech as a sequence of segments (Read, Yun-Fei, Hong-Yin, & Bao-Qing, 1986). A study conducted by Treiman and Baron (1983) demonstrated that providing training in phonemic analysis to English speaking children aided in learning to read. A number of studies have employed phonological training as reading remediations for children with reading difficulties in alphabetic languages (). However, no studies have been conducted on the effects of phonological training in learning to read Spanish. Nor are there studies that compared how phonological training benefits Chinese learning differently than Spanish learning.

Writing. An individual's writing abilities have been linked to skilled reading (Tan, et al., 2005). Chinese studies (Chung, Ho, Chan, Tsang, & Lee, 2010; Siok & Fletcher, 2001) found that Chinese reading is correlated with orthographic awareness rather than phonological awareness, which may be due to writing assisting in establishing a motor memory trace to recall characters (Shadmehr & Holcomb, 1997). Cao et al., 2013 found that writing learning is more efficient than phonological learning for English learners of Chinese. However, studies have also found the advantages of writing learning in alphabetic languages (James, & Gauthier, 2009; Longcamp, Zerbato-Poudou, & Velay, 2005), suggesting that the writing advantage is not specific to Chinese.

Current study

Our current study aims to close some gaps in the current literature by analyzing how different metalinguistic skills found to be correlated with L1 learning are correlated with L2 learning of the same language. This thesis study has a with-in subject design comparing English language learners of two extreme languages, Spanish and Chinese, as L2s. It is also the first study to use different learning conditions during training to assess the impact on learning rate of the two L2s.

This study is motivated by the question of whether there are differences in the rate of learning for different L2s and if these depend on the similarities between L1 and L2. The different L2s, Chinese and Spanish were chosen in the current study, because they represent different extremes. Chinese represents a very opaque language. These are languages that have an arbitrary mapping system between orthography and phonology. While Spanish represents a very transparent language meaning orthography and phonology have a very intimate relationship.

We expect a similar learning rate on meaning for Chinese and Spanish or a slower rate for Chinese due to the unfamiliarity of orthography. We expect to see a faster rate of learning for the sound of written Spanish words than Chinese characters as Spanish has a more intimate relationship between orthography and phonology as opposed to Chinese as well as a more similar orthography to English.

Another research question explored in this thesis study was, whether different metalinguistic characteristics are correlated with the learning outcomes in different L2s. This question was developed to see if the metalinguistic skills that have been found to be correlated with first language acquisition are also correlated with second language learning. We expect a significant positive correlation between scores in the visual spatial task (the Corsi Block Tapping Test) and Chinese learning outcome. We expect a positive correlation between phonological awareness (CTOPP-subtests) and Chinese language learning outcomes. We expect a positive correlation between phonological awareness tests and the learning outcomes of Spanish. In addition, we also anticipate a positive correlation between rapid naming and Spanish learning.

Lastly, this thesis study also explored if there are interactions between learning conditions and second language learning. This question was developed to look at writing and phonological conditions. We expect that writing learning is more helpful than phonological learning for Chinese (Shadmehr & Holcomb, 1997; Chung et al., 2010; Siok & Fletcher, 2001). However, both phonological and writing training are helpful for learning of alphabetic languages (Treiman &Baron, 1983).

RESEARCH DESIGN AND METHODS

Participants

The participants were 16 native English speaking MSU undergraduate students who were enrolled in elementary level Chinese classes offered by Michigan State University, so that we ensure that the participants had an understanding of Pinyin, a system used to transcribe the pronunciation of Chinese characters, and were able to write Chinese characters, because one learning condition is through character writing. All participants met the following criteria: 1) age was between 18-40 years old, 2) native English speakers with minimal experience of other languages, 3) no experience with Chinese or Spanish before MSU, 4) right handed, 5) no learning disabilities, 6) no ADHD, 7) no neurological disorders, and 8) no medication affecting the central nervous system. Participants were asked to read and sign an informed consent form before the initiation of the experiment. To reduce attrition, the participants were paid $10 an hour for each behavioral session and $25 dollars for the fMRI session.

Behavioral Testing

Participants underwent an hour of behavioral testing on the first day including tests of phonological awareness, rapid naming, working memory, English reading proficiency, and visuospatial skills. Subtests of elision, blending words, and phoneme isolation from the Comprehensive Test of Phonological Processing 2 (CTOPP-2) were administered to assess the participants' phonological awareness; subtests of rapid digit naming, and rapid letter naming from CTOPP-2 were used to assess rapid naming skills. Verbal working memory was tested using forward and backwards digit span. To assess English reading fluency and decoding skills, both the reading fluency and the word-attack subtests from the Woodcock Johnson Test of Achievement (WJ-III) were used. To assess visuospatial skills, participants completed the Corsi

Block Tapping Test, originally developed by Corsi (1972). In this task, the participants are shown predetermined sequences/patterns of block tapping then they had to mimic the sequences in forward and backward order. The sequences initiate very simple and became more complex as the participant continues to answer correctly. According to Kessels, Zandvoort, Postma, Kappelle, and Haan (2000), visuospatial memory is tested with the increase of sequence/pattern length.

During the behavioral testing session, participants filled out the Language Experience and Proficiency Questionnaire (LEAP-Q). The LEAP-Q provides information about which language/s the participants are familiar with and at what ages they became exposed and proficient in the language/s. Participants took a pretest, which ensured that participants were not familiar with the Chinese characters or Spanish words they will be receiving training on.

Training Procedures

After the initial behavioral testing, participants completed at least 10 days of training in which they learned 72 words in Chinese and 72 words in Spanish. Training occurred in three different learning conditions (i.e. writing training, phonological training, and passive viewing training) with 24 words in each condition. Table 1 provides an example of how the learning was counterbalanced in order to avoid a condition effect that was driven by different words used in different conditions. The pattern demonstrated in Table 1 was followed for the rest of the participants. Appendix A and B provide the words used for both languages divided by week 1 and week 2. Words in each learning condition varied by subject. For example, 1/3 of the words in Chinese were in the phonological training for 1/3 of the participants but in the writing condition for another 1/3 of the participant. Participants were assigned a group (A, B, or C) that determined which stimuli were in each condition. In addition, we assigned each participant to a different week (1 or 2), which was done to counterbalance the words presented in week 1 and week 2. To counterbalance, the order of language training and condition administered varied day to day (Table 1). In order to ensure the amount of learning each day is appropriate, participants only learned a total of 36 words in each language during the first five days of training, and during the last five days the participants learned the rest of the 72 words. However, in order to keep the words first learned in memory, we included the first 36 words in the post-test of the second week and provided feedback on their responses.

Table 1. Training Procedure Counterbalanced.

	Subject	A001	B002	C003	A004	B005	C006	A007	B008
	Week	1	2	1	2	1	2	1	2
Phonological		1st	2nd	3rd	1st	2nd	3rd	1st	2nd
Writing		2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Viewing		3rd	1st	2nd	3rd	1st	2nd	3rd	1st

Table 2. Example of training administration of counterbalanced language and learning conditions.

Day 1			**Day 2**	
Chinese	**Spanish**		**Spanish**	**Chinese**
Phonological	Phonological		Passive Viewing	Passive Viewing
Writing	Writing		Phonological	Phonological
Passive Viewing	Passive Viewing		Writing	Writing

Material characteristics. Chinese characters were evenly distributed into the different conditions by number of strokes, frequency of English translation and word class. Spanish words were matched across conditions based on number of letters, frequency in English translation, and word class using the MRC psycholinguistic database from the University of Western Australia, which is described by Fearnley (1997) as a program that analyzes words according to word length, number of syllables and phonemes, and other psycholinguistic criteria. Words in both Chinese and Spanish were also evenly distributed into each group depending on what word class they belong to (i.e. noun, verb, adverb). The order of learning Chinese and Spanish and the order of the training conditions were counterbalanced across participants and across days of training.

Learning procedures. The training procedure the subjects went through during each training day was as follows (Figure 1). They saw a welcome screen telling them which training they will be working on. They then saw the Spanish word or Chinese character with a recording of the pronunciations. The recordings for the Chinese words were done by a native Chinese speaker. The recordings for the Spanish words were also done by a Spanish native speaker. After this slide the participants saw the English translation after which they were asked to say the word once. Next, they were shown a slide that reminded them of what training they are in and gave them instructions to say the word 3 times (phonological condition), write the word 3 times (writing condition), or view the word for 10 seconds (viewing condition). Once they would hit the spacebar they had 10 seconds to perform the task. In the Chinese phonological condition, participants heard the Chinese pronunciation again and saw the character with the pinyin concurrently on the screen. For the Spanish phonological condition, participants heard the syllable again and saw the word simultaneously on the screen. The training procedures were not recorded. For each word, this trail was repeated (back to back) twice in each session and each slide appeared on the screen for 800ms except the task slide, which was 10 seconds long.

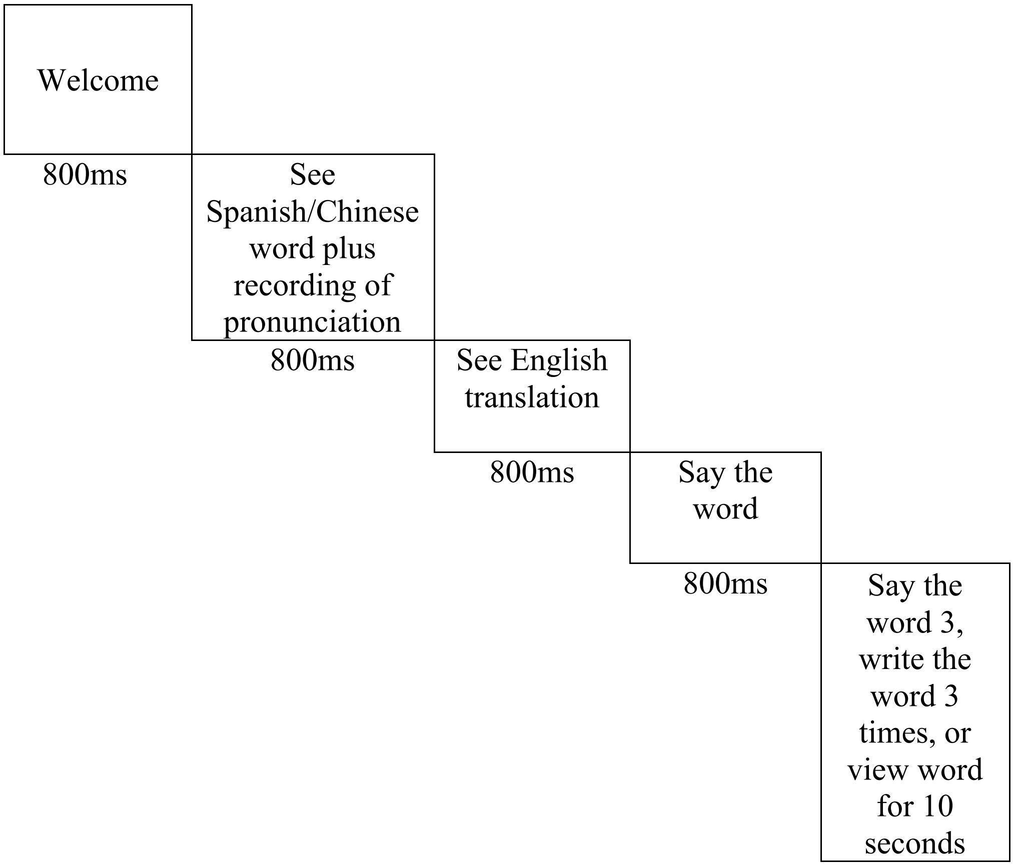

Figure 1. Outline of Training Procedure. The figure above represents the basic outline the participants saw during the training procedures.

Testing procedures. After each training session, participants had a computerized post-test. The computerized post-test included a meaning recall task and a pronunciation task. In the meaning tasks participants were shown a Spanish word or a Chinese character and they had to provide the English translation. In the pronunciation post-tests the participants were shown a Spanish word or a Chinese character and they had to provide the correct pronunciation for the word or character shown. All responses were recorded by E-prime and scored offline by an experimenter. The post-test in week one only included the words being taught that week. However, in the second week, the post-test included both words learned in week one and words taught that week. This was done to prevent participants forgetting words from week one. After the participants' response, the participants were provided with feedback regardless of participants' response. Each training-testing session took approximately one hour.

Data Analysis

The meaning post-tests were graded by undergraduate students working in the lab. The meaning task of the post-test were graded by giving the participants a 1 if the translation was correct and a 0 if the translation was incorrect. The Spanish pronunciation task was grade by a Spanish native speaker. The Chinese pronunciation task was graded by 2 Chinese native speakers and their grading correlation is (r = .861, $p < .001$). We chose one native Chinese speaker's grading for our data analysis to be consistent with the Spanish grading. For the pronunciation task, responses were graded according to the following scale: if no response was said or the response was completely incorrect the participant received a 0, if the response was less than 50% correct they received a .33, if the response was 50% or more than 50% correct, the participant received a .66, and if the response was 100% correct the participant received a 1. Because the participants learning different words every 5 days, the learning curves were constructed using the average of only the new words learned each week (e.g. new words scores in day 1 and 6 will be averaged, etc.).

ANOVAs of language (Chinese, Spanish) by learning conditions (writing, phonological, passive viewing) by learning sessions (day1, day2, day3, day4, day5) were conducted separately on the meaning post-test and pronunciation post-test to reveal any differences in the learning rate in the two languages and the three learning conditions. The ANOVA analysis will answer our first research question: whether there is different learning rate depending on the similarity to the L1 and the third research question: learning condition effect in different languages.

To determine if metalinguistic abilities are correlated with the learning outcome of L2, our second research question, the participants' behavioral testing scores, of phonological awareness, rapid naming skills, verbal working memory, and visual spatial memory were correlated with each training day post-test scores. Because day 1 demonstrated the biggest variability across subjects, we only looked at the correlations between day 1 post-test scores and four behavioral tests including phonological awareness test, elision, a rapid naming test, rapid digit naming, a verbal working memory test, digit span, and our visual spatial test, Corsi.

In addition, post-test scores were broken down into different learning conditions (i.e. phonology, writing, and passive viewing) and analyzed for learning condition learning rate and correlation with behavioral scores, to answer our third research question looking at the interaction between learning conditions and second language learning. To determine if the correlation was higher in one language/condition than the other, we conducted comparisons between two correlation coefficients (Cohen & Cohen, 1983; Preacher, 2002) (http://www.quantpsy.org/corrtest/corrtest.htm).

RESULTS

Learning Rate-Meaning

A repeated-measure ANOVAs of language (Chinese, Spanish) by learning conditions (writing, phonological, passive viewing) by learning sessions (day 1, day 2, day 3, day 4, day 5) was conducted for meaning (Table 3) to reveal any differences in the learning rate in the two languages and three learning conditions. We also created a line graph to illustrate the learning rate for meaning (Figure 2) of both Spanish and Chinese.

For meaning, we found a significant main effect of language ($F(1,12) = 32.733$, $p<.001$, effect size = .732), with Spanish being more accurate than Chinese. There was also a significant main effect of learning condition ($F(2, 24) = 4.326$, $p<.05$, effect size = .265). Viewing demonstrated higher accuracy than writing ($t(13) = 2.57$, $p < .05$), but no difference from phonological learning ($t(13) = 2.045$, *ns*). On the other hand, phonology and writing showed no significant difference ($t(13) = .56$, *ns*). Figure 3 demonstrates the learning course for both languages in each condition over 5 days. A significant main effect of days ($F(4,48) = 118.992$, $p<.001$, effect size = .908) was also found, where each day demonstrated an increase from the previous day (Table 4). With multiple comparisons corrections all days passed the new p- value ($p = 0.0125$).

Table 3. Repeated-Measure ANOVA for Spanish and Chinese Meaning.

Source	F	Sig.
Language	32.733	< .001
Learning Condition	4.326	.025
Days	118.992	< .001
Language * Learning Condition	.779	.470
Language * Days	.834	.511
Learning Condition * Days	.565	.804
Language * Learning Condition * Days	.768	.632

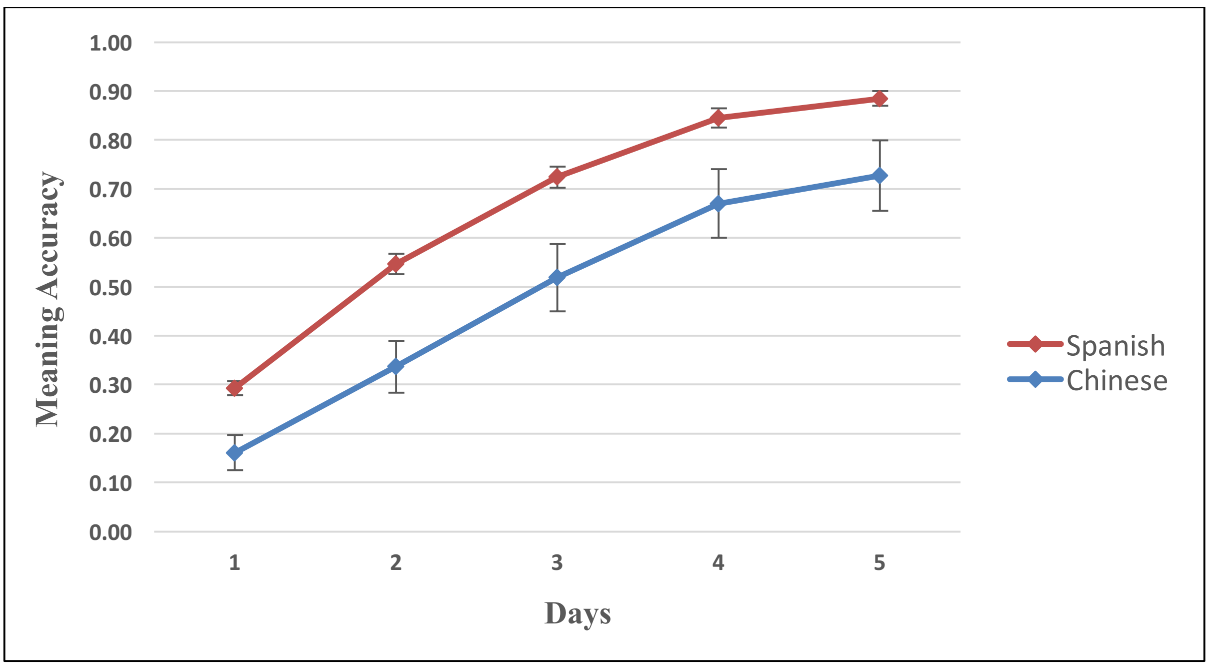

Figure 2. Spanish and Chinese Meaning Post-Test Scores. The line graph above shows that Spanish had a higher accuracy than Chinese in the meaning recall task.

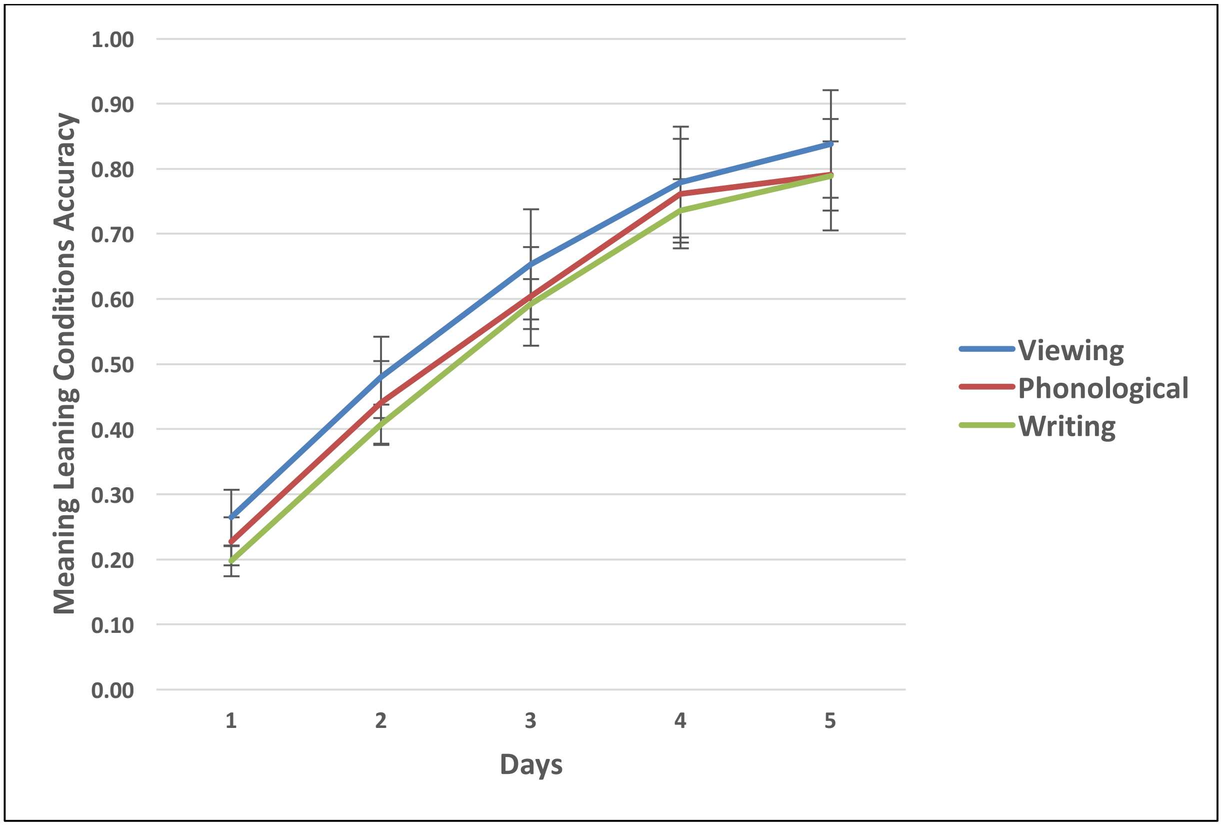

Figure 3. Spanish and Chinese Meaning Conditions. The line graph above shows that viewing had a higher accuracy than writing. All the other comparisons between conditions were not significant.

Table 4. Main Effect of Days for the meaning recall task.

Days	t-value	p-value
1<2	-8.385	< .001
2<3	-4.032	.002
3<4	-5.552	< .001
4<5	-5.111	< .001

Learning Rate - Pronunciation

A repeated-measure ANOVAs of language (Chinese, Spanish) by learning conditions (writing, phonological, passive viewing) by learning sessions (day 1, day 2, day 3, day 4, day 5) was conducted for pronunciation (Table 5) to reveal any differences in the learning rate in the two languages and three learning conditions. We also created a line graph to illustrate the learning rate for pronunciation (Figure 4) of both Spanish and Chinese.

For pronunciation, we found a significant main effect of language (F (1,13) = 159.433, p<.00, effect size = .925), where Spanish was higher than Chinese in pronunciation recall. The repeated measure ANOVA demonstrated a significant main effect of days (F (4,52) = 38.734, p<.001, effect size = .749). As with meaning this simple effect analysis reveal that both languages had an increase in accuracy each day from the previous day (Table 6). With multiple comparisons corrections all days passed the new p- value (p = 0.0125). We found a significant interaction between language and days (F (4,52) = 27.218, p<.001, effect size = .677). Simple analysis revealed that the interaction is driven by significant improvement in Chinese but not Spanish (Table 7 & 8).

Table 5. Repeated-Measure ANOVA for Spanish and Chinese Pronunciation.

Source	F	Sig.
Language	159.433	< .001
Learning Condition	.658	.526
Days	38.734	< .001
Language * Learning Condition	.862	.434
Language * Days	27.218	< .001
Learning Condition * Days	.366	.936
Language * Learning Condition * Days	.684	.705

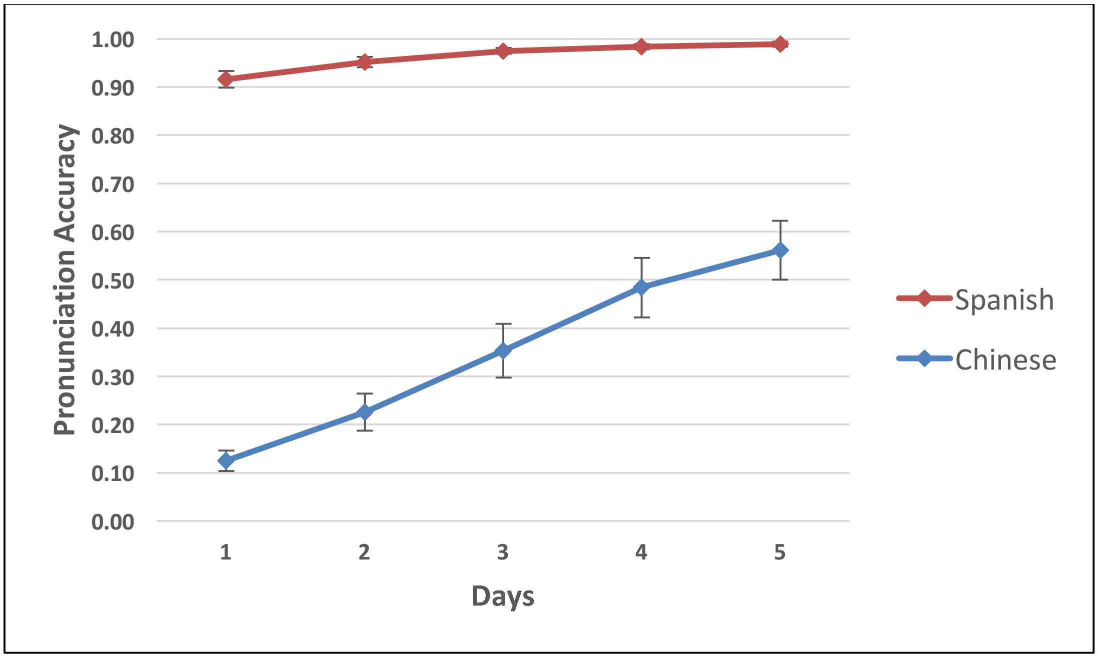

Figure 4. Spanish and Chinese Pronunciation Post-Test Scores. The line graph above shows that Spanish had a higher accuracy than Chinese.

Table 6. Main Effect of Days for the pronunciation recall task.

Days	t-value	p-value
1<2	-4.909	< .001
2<3	-3.778	.002
3<4	-4.389	.001
4<5	-4.500	.001

Table 7. Spanish pronunciation learning effect.

Language	Days	t-value	p-value
Spanish	1<2	-1.61	0.132
	2<3	-0.94	0.362
	3<4	-2.12	0.054
	4<5	-1.77	0.100

Table 8. Chinese pronunciation learning effect.

Language	Days	t-value	p-value
Chinese	1<2	-4.92	0.000
	2<3	-4.37	0.001
	3<4	-3.88	0.002
	4<5	-4.30	0.001

Metalinguistic Skills

To determine if metalinguistic abilities were correlated with the learning outcomes of L2, post-test results were correlated with scores from the behavioral testing. Correlations were conducted with post-tests accuracy in Spanish and Chinese meaning recall and behavioral testing scores as well as post-test accuracy in Spanish and Chinese pronunciation recall and behavioral testing scores. Specifically, we calculated correlations between day 1 post-test accuracy and behavioral testing from four tests, phonological awareness (elision), rapid naming (rapid digit naming), visual spatial test (Corsi), and digit span, as accuracy on day 1 had the highest variability across subjects. No correlations were found between Spanish and Chinese meaning recall and behavioral testing scores. However, significant correlations were found with Spanish (Table 8) pronunciation recall and behavioral testing. Elision, rapid naming, Corsi, and digit span forward were positively correlated with first day's pronunciation recall in Spanish (r = .676, $p < .01$; r = .520, $p < .05$; r = .617, $p < .05$; r = .592, $p < .05$; respectively). With multiple comparisons corrections only elision passed the corrected p-value ($p = 0.0125$) threshold (marked bold in Table 9). We found no correlations with Chinese pronunciation recall. To determine if the correlation was higher in Spanish than in Chinese we compared the correlations in Chinese and Spanish for all four behavioral tests and only rapid naming showed a significant difference between languages (z =-1.647, p < .099 for elision; z = -2.274, p < .023 for rapid naming; z = -1.821, p < .069 for Corsi; z = -1.174, p < .240 for digit span forward).

Table 9. Correlations between Pronunciation recall and behavioral tests for Chinese and Spanish

Language		Elision	Rapid Digit Naming	Corsi Forward	Digit Span Forward
Spanish	Day 1	**.676****	.520*	.617*	.592*
Chinese	Day 1	.146	-.341	-.026	.197

*p < .05
**p < .01

Learning Conditions

We were interested in examining whether different metalinguistic skills predict learning outcome in different learning conditions. Thus we decided to break down each post-test into different learning conditions and correlate the scores for each condition with behavioral testing scores. No correlations were found with any of the three conditions in Chinese meaning and Spanish meaning.

On the other hand, when we correlated Spanish pronunciation recall in each learning condition with behavioral testing, we revealed many significant correlations. Spanish pronunciation accuracy for words in the viewing condition (Table 10) was positively correlated with elision (r = .565, p < .05), rapid digit naming (r = .499, p < .05), Corsi (r = .572, p < .572), and digit span (r = .673, p < .01). Only digit span passed multiple comparisons correction (p = .05/4 = .0125) (marked bold in Table 11). In the phonological condition (Table 10) for Spanish pronunciation accuracy, a positive correction was found with elision (r = .518, p < .05), rapid naming (r = .576, p < .05), and corsi forward (r = .605, p < .05). However, no correlation was found with digit span forward (r = .368, *ns*) and none of the behavioral tests survived the multiple comparison correction (p = .05/4 = .0125). Lastly, a positive correlation was found with Spanish pronunciation writing condition (Table 10) and elision (r = .665, p < .01), rapid digit naming (r = .522, p < .05), corsi forward (r = .713, p < .01) and digit span forward (r = .542, p < .05). When we conducted the multiple comparison correction, both elision and Corsi forward passed (p = .05/4 = .0125) (marked bold in Table 10).

To identify if there were significant differences of the correlation among the 3 conditions we conducted the following comparisons. For the comparisons between viewing and phonological learning, with all four behavioral tests, we found no significant difference amongst them (z = 0.17, p < 0.865 for elision; z = -0.277, p < 0.782 for rapid digit naming; z = -0.129, p < 0.898 for Corsi; z = 1.097, p < .273 for digit span forward). The comparison between viewing and writing learning demonstrated the same results, no significant difference (z = -0.412, p < .680 for elision, z = -0.079, p < .937 for rapid digit naming; z = -0.619, p < 0.536 for Corsi; z = 0.533, p < .594 for digit span forward). Lastly, for the comparison between writing and phonological learning, results again demonstrated no significant difference between them (z = -0.582, p < .560 for elision, z = 0.197, p < .844 for rapid digit naming; z = -0.49, p < 0.624 for Corsi; z = -0.563, p < .573 for digit span forward).

Table 10. Correlations between each learning condition and behavioral tests for the Spanish Pronunciation task. Bold cells represent correlations that passed a multiple comparisons correction.

	Elision	Rapid Digit Naming	Corsi Forward	Digit Span Forward
Viewing Day 1	0.565*	0.499*	0.572*	**0.673****
Phonological Learning Day 1	0.518*	0.576*	0.605*	0.368
Writing Day 1	**0.665****	0.522*	**0.713****	0.542*

*p < .05
**p < .0125

As opposed to the significant correlations found for Spanish pronunciation learning conditions and behavioral testing, correlations in Chinese pronunciation were not significant (Table 11). More specifically for Chinese pronunciation viewing condition correlation, the results are as follows, day 1 and elision (*r* = .055, *ns*), rapid digit naming (*r* = -.170, *ns*), corsi forward (*r* = .223, *ns*), and digit span forward (*r* = .063, *ns*). The Chinese pronunciation phonological condition day 1 and behavioral testing again demonstrated no significant; elision (*r* = -.041, *ns*), rapid digit naming (*r* = -.410, *ns*), Corsi forward (*r* = -.247, *ns*) and digit span (*r* = .214, *ns)*. Finally, the writing condition for Chinese pronunciation day 1 and elision (*r* = .249, *ns)*, rapid digit naming (*r* = -.239, *ns*), Corsi forward (*r* = .339, *ns*), and digit span forward (*r* = .242, *ns*). To identify if there were significant differences in the correlations among the 3 conditions we conducted further comparisons, but no significant differences were found.

Table 11. Correlations between each learning condition and behavioral tests for the Chinese Pronunciation task.

	Elision	Rapid Digit Naming	Corsi Forward	Digit Span Forward
Viewing Day 1	0.055	-0.17	0.223	0.063
Phonological learning Day 1	-0.041	-0.41	-0.247	0.214
Writing Day 1	0.249	-0.239	0.339	0.242

To identify if there were significant differences in the correlations between the two languages, we conducted the following comparisons. For the correlation of pronunciation recall after the viewing learning with all four behavioral tests, we found no significant difference between Chinese and Spanish ($z = 1.428$, $p < 0.153$ for elision; $z = 1.757$, $p < 0.0790$ for rapid digit naming; $z = 1.034$, $p < 0.301$ for Corsi; $z = 1.838$, $p < 0.066$ for digit span forward). The comparison between languages for the phonological learning condition revealed a significant difference for correlation with Corsi ($z = 2.327$, $p < 0.019$ for Corsi), and no significant differences for the correlations with other measures ($z = 1.5$, $p < 0.133$ for elision; $z = 0.539$, $p < .589$ for rapid digit naming; $z = 0.412$, $p < 0.680$ for digit span forward). For the writing learning condition, we discovered a significant difference between Spanish and Chinese in rapid digit naming ($z = 2.008$, $p < .044$), but not in the other behavioral tests ($z = 1.336$, $p < 0.181$ for elision; $z = 1.319$; $z = 0.187$, $p < 0.301$ for Corsi; $z = .879$, $p < 0.379$ for digit span forward). In summary, for the phonological learning condition, Corsi was more positively correlated with Spanish pronunciation recall than Chinese pronunciation recall. For the writing learning, rapid naming was more positively correlated with Spanish pronunciation recall than Chinese pronunciation recall.

DISCUSSION

Learning a second language is a challenge for many people; however, many studies have identified certain metalinguistic skills that can facilitate the acquisition of an L2. This study attempted to close the gaps in literature and to test if previous findings for L1 learning are the same for L2 acquisition in adults. We taught English native speakers an alphabetic language, Spanish, and a logographic language, Chinese, to identify how learning would be different depending on the type of language being taught.

Language differences in the learning rate

When learning the meaning of words in different L2s, Chinese and Spanish, we expected participants to have a similar rate of learning for both languages and as expected both languages demonstrated a steady increase in learning throughout the week. However, Spanish meaning learning reached a higher proficiency than Chinese meaning. This could be due to the complexity of the Chinese characters' visual forms compared to the Spanish words, and the familiarity of orthography for Spanish.

Due to the similarities in orthography between Spanish and English and the more intimate relationship between orthography and phonology that Spanish has, we expected Spanish pronunciation to have a faster rate of learning than Chinese pronunciation, which was exactly what we found. Both languages demonstrated a steady increase in accuracy throughout the training days. However, Chinese pronunciation had a significant increase in accuracy day by day (Table 5), while Spanish pronunciation did not (Table 4). We attribute this to the subjects reaching high accuracy levels in Spanish early in the week (Figure 3).

Correlations with metalinguistic skills

Correlations for the meaning task. The correlations between meaning total post-test scores and the behavioral testing scores did not demonstrate any correlations for Chinese or Spanish, even when broken down into different conditions (viewing, phonology, and writing). This may be because all of the behavioral testing used, except for Corsi, were phonological tests.

Correlations for the pronunciation task. We found positive correlations between Spanish pronunciation post-test scores from day 1 and behavioral tests including elision, rapid digit naming, Corsi forward, and digit span. However, after multiple comparison correction, only the correlation with elision was significant. This is consistent with previous findings. For an alphabetic language such as Spanish, both phonological awareness (Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Denton, Hasbrouck, Weaver, & Riccio, 2000; Bialystok, 2001) has been found to facilitate language learning. The correlation suggests that there is a transfer effect of phonological awareness from English L1 to Spanish L2.

On the other hand, we did not find correlation between visual-spatial skills and Chinese learning or phonological awareness with Chinese learning as expected. Previously, Chinese learning has been linked to strong visual-spatial and phonological awareness skills in L1 (Siok & Fletcher, 2001; Ho & Bryant, 1997). However, our findings suggest that there is no transfer effect between the alphabetic language, English and the non-alphabetic language, Chinese. English learners of Chinese may use a non-alphabetic strategy such as remote memorization to learn Chinese word pronunciation, therefore phonological skills do not contribute to the learning. Our fMRI data collected with this project suggests that there is greater activation in the bilateral inferior frontal gyri for Chinese pronunciation recall while there is greater activation in the bilateral superior temporal gyri for the Spanish pronunciation recall.

Direct comparison revealed a significantly higher correlation between rapid naming and pronunciation recall in Spanish than in Chinese. This is consistent with previous studies that showed a significant correlation between rapid naming and Spanish reading (Lindsey, Manis, & Bailey, 2003; Siddaiah & Padakannaya, 2015). Even though some studies also suggest that rapid naming is significantly correlated with Chinese reading performance (Ho et al., 1997; Ho & Lai, 1999; McBride-Change & Ho, 2000), our study is the first to show that for English speaking learners of L2, rapid naming is more important for Spanish reading than Chinese reading.

We found that different metalinguistic skills play an important role in different learning conditions for Spanish pronunciation learning. For words learned in the passive viewing condition, correlations with all four of the behavioral tests, elision, rapid digit naming, Corsi, and digit span forward were significant, however, only digit span was significant after correction. This suggest that when learning Spanish word pronunciation, subjects' verbal working memory plays an important role in the passive viewing learning condition. For words learned in the phonological condition, no correlation was significant after correction. For words learned in the writing learning condition, the correlations with elision and Corsi were significant after correction. This finding suggests that writing does not only rely on visual spatial processes, but also phonological processing. This is consistent with a previous finding demonstrating that handwriting facilitates both orthographic and phonological processing (Cao, et al., 2013).

Direct comparisons between the two languages in the correlations for each learning condition have revealed two significant differences. For the phonological learning condition, Corsi was more positively correlated with Spanish pronunciation recall than Chinese pronunciation recall. This may be because visual spatial skills help to learn Spanish orthography more than Chinese orthography in the phonological learning condition where there is no extra training on orthography. In other words, visual spatial skills represented in Corsi cannot handle the complexity of Chinese orthography. When orthography is acquired, phonology can be more easily connected with orthography. For the writing learning, rapid naming was more positively correlated with Spanish pronunciation recall than Chinese pronunciation recall. As previous studies have suggested that writing facilitates the connection between orthography and phonology in learning Chinese (Guan et al., 2011; Cao et al., 2013), our study adds to the literature that in writing learning, rapid naming skill are more strongly correlated with Spanish pronunciation learning outcome than Chinese pronunciation learning outcome.

Learning conditions

We were expecting that our writing condition would be more helpful than phonological learning for Chinese as many studies have demonstrated that writing is more helpful than phonological training when learning Chinese (Shadmehr & Holcomb, 1997; Chung et al., 2010; Siok & Fletcher, 2001). Because both phonological and writing trainings have been found helpful for learning of alphabetic languages (Treiman &Baron, 1983) we were expecting to see some differences in writing and phonological condition in Spanish learning compared to Chinese learning. However, we did not find an interaction between learning conditions and language as expected, suggesting that the differences of learning conditions are similar in learning Chinese and Spanish. We found a main effect of learning condition in the meaning recall with a higher accuracy in the viewing condition than the writing condition. This may be because in the writing condition, more attention is directed to orthography while in the viewing condition, participants have a better opportunity to attach meaning to the word they are viewing on the screen.

Limitations

Some limitations that we saw with this study were that most of the behavioral testing was phonological testing. Future studies should include more nonverbal language tests. The condition effects were not as expected in the behavioral data although there was a condition effect in our fMRI data from our bigger study. This could be because the behavioral tests were not sensitive enough. The post-test also provided a reaction time, not yet analyzed, which may demonstrate an interaction between language and learning conditions that we did not see in the behavioral tests. Also, although this is the first study that simultaneously teaches two different languages this could also be a limitation because these languages can interact with each other in the brain, which might explain why there were differences in our finding compared to previous studies.

Conclusion

In summary, participants reached a higher learning accuracy in Spanish meaning and pronunciation tasks compared to Chinese meaning and pronunciation tasks. No correlations were found with Spanish and Chinese meaning recall, which may be due to the phonological nature of most of our behavioral tests. On the other hand, Spanish pronunciation total post-test scores, as excepted, were correlated with phonological awareness and rapid naming, even when we broke down the post-test into learning conditions. Chinese pronunciation total post-test scores were not correlated with any of our behavioral tests not even when broken down into learning conditions. In short, transfer was demonstrated between both alphabetic languages (English and Spanish), but no transfer was noted between an alphabetic language and a logographic language. We were not able to find any learning condition effects.

APPENDICES

APPENDIX A

Spanish Training Words

Week 1 words

Spanish Word	**English Translation**
abeja	bee
cordero	lamb
cazador	hunter
daño	damage
costumbres	customs
escama	flake
nube	cloud
escuchar	listen
llorar	cry
afilado	keen
ciego	blind
caro	expensive
arbusto	bush
pala	spade
oruga	caterpillar
alcantarilla	sewer
odio	hatred
martillo	hammer
oreja	ear
piel	skin
sonrisa	smile
elevar	raise
luz	light
amarillo	yellow

interior	inside
acantilado	cliff
carga	burden
jamon	ham
enano	dwarf
pollo	chicken
ráfaga	gale
vaca	cow
sanar	heal
salida	exit
levantar	lift
temeroso	fearful

Week 2 words

Spanish Word	**English Translation**
cancion	song
humo	smoke
leche	milk
luna	moon
sombra	shadow
jabón	soap
seda	silke
ladrón	thief
sentarse	sit
sorpresa	surprise
show	show
débil	weak
repollo	cabbage
espina	thorn
guantes	gloves

pared	wall
tapete	rug
tragar	swallow
bañarse	bathe
sofocar	stifle
despertar	awaken
rubor	blush
crudo	raw
orgulloso	proud
carnero	ram
ruido	noise
cera	wax
juguete	toy
barco	ship
deseo	wish
escupir	spit
dormir	sleep
derretir	melt
suave	soft
embarazada	pregnant
sospechoso	suspicious

APPENDIX B

Chinese Training Words

Week 1 words

Chinese Character	**English Translation**	**Pinyin**
残	incomplete	cán
怵	timid	chù
舱	cabin	cāng
巢	nest	cháo
虮	louse	jǐ
荚	pod	jiá
坤	earth	kūn
鞘	scabbard	qiào
团	cluster	tuán
迸	spurt	bèng
毕	finish	bì
觫	dissatisfy	hú
矬	short	cuó
霏	dense	fēi
翅	wing	chì
罘	net	fú
鲽	flounder	jiān
筊	rope	jiǎo
轮	wheel	lún
律	rule	lǜ
弎	three	sān
憋	stifle	biē
冲	rush	chōng
警	warn	jǐng
旷	spacious	kuàng
庵	temple	ān

帛	silk	bó
贡	tribute	gòng
魂	soul	hún
鸠	dove	jiū
吭	throat	káng
瓫	basin	pén
琦	jade	qí
䌷	elicit	chōu
妨	hinder	fáng
踉	stagger	liàng

Week 2 words

Chinese Character	English Translation	Pinyin
勤	diligent	qín
佻	frivolous	tiāo
料	material	liào
礽	happiness	réng
豚	pig	tún
饴	syrup	yí
银	silver	yín
刧	plunder	jié
搴	lift	qiān
屈	surrender	qū
甾	disaster	zāi
骒	mare	kè
狰	hideous	zhēng
挚	sincere	zhì
裳	clothes	shàng
翁	grandfather	wēng
穸	tomb	xī
隅	corner	yú
札	letter	zhá

砍	chop	kǎn
飨	offer	xiǎng
询	inquire	xún
褰	pants	qiān
势	tendency	shì
眬	misted	lóng
牲	sacrifice	shēng
骰	dice	tóu
岘	hill	xiàn
雄	male	xióng
斋	diet	zhāi
毡	fur	zhān
聘	employ	pìn
允	allow	yǔn
酢	toast	zuò
帖	notice	tiě
毯	blanket	tǎn

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