Computational Linguistics and Chinese Language Processing
Vol. 18, No. 3, September 2013, pp. 1-20

Implicit Priming Effects in Chinese Word Recall: The Role of Orthography and Tones in the Mental Lexicon

Nian Liu*

Abstract

This paper explores the relative contributions made by orthography, syllabic segment, and lexical tone in the word recognition and retrieval process. It also challenges recent assumptions regarding the role of orthography and tones in mental lexicon architecture. Using an implicit priming paradigm, a word recognition experiment was conducted with native speakers of two tonal languages, Chinese and Vietnamese, that use a logographic orthography and a phonetically-based orthography, respectively. Contradicting prior findings, response time differences indicate that orthography plays a crucial role in the word recognition process, a finding that has implications for Chinese language teaching.

Keywords: Orthography, Tones, Word Recall, Chinese Teaching

1. Introduction

Chinese is one of the few existing languages that use a logographic writing system. In addition, it uses four lexical tones to distinguish otherwise identical words. Neither of these features is shared by Indo-European languages, which makes teaching Chinese to native speakers of these languages a difficult task for teachers and a painstaking process for learners.

There has been abundant literature discussing efficient ways of teaching all aspects of Chinese as a second language, including tonal pronunciation (Miracle, 1989; McGinnis, 1997; Wang *et al*., 1999; Li, 2007) and character writing (Everson, 1998), as well as grammar points. Many of these pedagogical methodologies certainly pave the way to learning Chinese, yet, even with intensive training and practicing of the target language, Chinese second language (L2) learners still have a difficult time achieving native-like language proficiency. Therefore, the fundamental issue in improving L2 Chinese speakers' proficiency lies not only in teaching methods, but also in the language knowledge within each of the learners.

* Department of Modern Languages, Literatures and Linguistics, University of Oklahoma, U.S.A.
E-mail: nian.liu@ou.edu

The major difficulty in learning Chinese as a second language usually concerns the acquisition of tones and characters. How can tones be recognized and produced by L2 Chinese speakers if these phonological features are not used in distinguishing meaning in their native languages? Also, how are characters to be read by L2 Chinese learners if the writing symbols are, for the most part, not logically associated with the phonology, as the writing symbols are in an alphabetic language? How is each word represented in the mental lexicon of an L2 speaker? Do they use the same strategies for processing and producing words as native speakers?

In addressing this query, this paper explores the role of orthography and tones in the word recall process in terms of the way word entries are stored in the mental lexicon and how they are retrieved in word recognition and production.

Considerable research on lexicon architecture has been done on Indo-European languages, with English and Dutch commanding most of the attention. Nevertheless, Chen, Chen, and Dell (2002) examined the relative contribution of three potential structural components in Mandarin Chinese to investigate lexicon architecture. They used an implicit priming paradigm, in which exposure to a series of syllables (embedded in real words) that share a set of features can serve to prime other words with similar syllables and facilitate their recall, as measured by response time (RT). To take an English example, after being exposed acoustically to a series of words, like *season*, *ceiling*, and *secret*, people identify and name the word *Caesar* more quickly, because all of these words share the same onset, which creates a priming effect.

In Mandarin's orthography, individual syllables are represented by symbolic characters in logographic form. In their experiment, Chen *et al*. (2002) examined the implicit priming effect of different components of Mandarin Chinese. The first characters of the response words were controlled-response words in a set under the homogeneous condition shared some features (*i.e*., syllable + tone + orthography in the 3-way syllable Match condition and syllable + tone in the 2-way syllable Match condition), whereas, in the heterogeneous condition, which served as the baseline, none of the three components were shared. They found that the word recall response time was shortened by 53 milliseconds over baseline times (659 ms-606 ms) for Mandarin words that shared phonological segments (音节), lexical tones (音调), and written characters (汉字) (3-way syllable match). Chen *et al*. then demonstrated that priming from syllables that shared segments and tones, but not characters (2-way syllable match) resulted in 46 milliseconds of response time improvement over the baseline (664 ms-618 ms). They concluded that the combination of segment and tone is a critical unit in lexical representation; therefore, it is a vital component in the lexicon architecture for tonal languages. Based on a series of experiments that using the same paradigm but different materials in combining segment, tone and orthography, they also argued that, due to the relatively small

difference between RTs for the 3-way match versus the 2-way match, orthographic characters should not be considered a significant architectural component.

The current study is motivated by two objectives. The first is to see if, because of its logographic orthography, Chinese is unique among tonal languages in how priming effects function in it. The second is to re-examine the minor role to which Chen *et al*. relegated orthography in lexicon architecture. From these objectives, two researchable questions emerge. (1) Is the apparently significant combination of segment and supra-segmental tone a common unit, equally important in the word recognition process for all tonal languages? Or does the process differ in Chinese due to its logographic writing system? (2) To what extent does orthography facilitate the word recognition task in a tonal language whose written characters do not actually add any information that could be used during the retrieval process? To answer these questions, it is useful to introduce another language to serve as a baseline. Vietnamese serves the inquiry purposes well in that, like Mandarin, it is a tonal language, but, unlike Mandarin, it uses a phonetically-based orthography. Therefore, it is used as a control language in this experiment, which is designed to partially replicate Chen *et al*.'s design and method using both Mandarin and Vietnamese.

2. Experiment

The study consists of two phases designed as separate experiments: a Mandarin implicit priming experiment and a Vietnamese implicit priming experiment. The Mandarin participants each saw four sets of words in four different permutations of a 2 x 2 factor design, one set for each of the four lexical tones in Mandarin. The Vietnamese participants each saw six sets of words in two different conditions, one set for each of the six lexical tones in Vietnamese. The following sections on procedures and materials give a detailed description of these conditions.

2.1 Participants

Ten native Mandarin speakers and 10 native Vietnamese speakers were recruited for the test. Each participant was given a small financial compensation for their time (approximately 15 minutes) and effort.

2.2 Procedure

The experiments were programmed in E-Prime. A Dell computer with a 17-inch monitor was used. The experiments were conducted in a sound booth, and the stimuli were displayed on the computer screen. Both the Mandarin and Vietnamese experiments followed the same sequence of steps. Each word set was presented in two phases: a learning phase and a testing phase.

2.2.1 The Learning Phase

In this phase, the participant was presented with a complete set of four word-pairs. The participant was instructed to take as long as required to memorize the words in the set. When the participant was finished with the memorization task, he or she proceeded to the testing phase.

2.2.2 The Testing Phase

In this phase, a fixation cross first appeared on the screen for one second to draw the participant's attention to the center of the screen, where a prompt word would appear. Then, one of the prompt words from the just-learned set was selected at random and displayed in the center of the screen. The participant spoke the corresponding response word, which was semantically related to the prompt word, into a microphone as quickly as possible. The microphone was connected to a serial-response box (SR-box) that sensed the moment the participant began a verbal response. The response time (RT) in milliseconds from the moment the prompt word was displayed to the onset of verbal response was recorded, and a new fixation cross appeared on the screen to announce the start of a new trial and, subsequently, the random selection of another prompt word from the word set. A digital recorder recorded each participant's response. Each of the four word-pairs in a set appeared four times for a total of 16 trials in each set for each condition. Thus, there were a total of 256 trials per participant in the Mandarin experiment (16 x 4 tone sets x 4 conditions) and 192 trials per participant in the Vietnamese experiment (16 x 6 tone sets x 2 conditions). A practice session containing eight trials was given before the experiment began.

2.3 Materials

2.3.1 Mandarin Experiment

Following the methodology employed by Chen *et al*. (2002), a 2 x 2 factor experimental design was used. For each condition, four sets of word-pairs were assembled, with four word-pairs in each set. Each pair consisted of a two-syllable prompt word and a two-syllable response word. The two words in a given pair were semantically related to facilitate ease of memorization; for example, a prompt word 生意 'business' is related to the response word 客户 'client'.

The first factor, syllable match type, consists of two conditions, a 3-way Match condition and a 2-way Match condition. In the 3-way Match condition, the first syllables of the response words all share the same segment, tone, and character. For instance, the response words for the word-pairs in Word Set 4 were 客户 *ke4-hu4* 'client,' 客人 *ke4-ren2* 'guests,' 客厅 *ke4-ting1* 'living room,' and 客栈 *ke4-zhan4* 'hotel'. The initial syllable for each has the

same segment, *ke*; the same tone, tone 4 (high-falling); and the same written character, 客. In the 2-way Match condition, the first syllables of the response words in a single word set have different written characters, but still match in segment and tone, such as *xi2* - that is, *xi* with tone 2 (rising) - written as: 席, 媳, 习, and 袭.

Each of these two conditions, 3-way and 2-way, was also crossed with the other factor, set type, which has two conditions, Homogeneous and Heterogeneous. In the Homogeneous condition, each response word in a set is configured in the manner described above, that is, by matching the other response words in a set in all three features or in only two features. In the Heterogeneous condition, the first syllables of the response words in a set have different segments, different tones, and different written characters. In this way, the Heterogeneous condition serves as the baseline by providing a test of recall time under control conditions where words are not matched by component features. Table 1 shows a sample word set for each of the 2 x 2 conditions. A full list of stimuli for the Mandarin experiment can be found in Appendix 1.

Table 1. Sample word sets for the Mandarin experiment.

	Homogeneous Condition		**Heterogeneous Condition**	
	Prompt	Response	Prompt	Response
3-way syllable match	*sheng1-yi4* 生意 business	*ke4-hu4* 客户 client	*zhang1-qian1* 张骞 ancient character	*xi1-yu4* 西域 Tibet
	kuan3-dai4 款待 host	*ke4-ren2* 客人 guest	*zhuang1-jia1* 庄稼 crop	*fei2-liao4* 肥料 fertilizer
	sha1-fa1 沙发 sofa	*ke4-ting1* 客厅 living room	*fu4-jing1* 负荆 carry wipes	*qing3-zui4* 请罪 ask for punishment
	long2-men2 龙门 name of a hotel	*ke4-zhan4* 客栈 hotel	*sheng1-yi4* 生意 business	*ke4-hu4* 客户 client
2-way syllable match	*xia4-tian1* 夏天 summer	*xi2-zi3* 席子 cooling mats	*bing1-dai4* 冰袋 ice bag	*qing1-liang2* 清凉 cool
	feng1-su2 风俗 custom	*xi2-guan4* 习惯 custom	*feng1-su2* 风俗 custom	*xi2-guan4* 习惯 custom
	di2-ren2 敌人 enemy	*xi2-ji1* 袭击 attack	*wu1-mie4* 诬蔑 defame	*fei3-bang4* 诽谤 slander
	gong1-po2 公婆 parents in law	*xi2-fu4* 媳妇 daughter-in-law	*shu1-ji2* 书籍 book	*ke4-ben3* 课本 textbook

Four sets of word-pairs were assembled for the 3-way condition, and four sets were assembled for the 2-way condition. Each of the four sets focused on one of the four lexical tones in Mandarin. Thus, each tone was represented equally throughout the stimuli. The same word-pairs were used in the Heterogeneous condition as in the Homogeneous condition, except that the pairs in the heterogeneous set were created by drawing one word from each of the homogeneous sets, ensuring that no two heterogeneous response words shared any features.

2.3.2 Vietnamese Experiment

The same general configuration of materials was used for Vietnamese as for Mandarin. In other words, sets of four prompt and response word-pairs were assembled, with the first syllables of response words carrying matching features within each set. Nevertheless, there were two major differences that resulted from a linguistic difference between Mandarin and Vietnamese. First, there was no conceivable way to construct a 2-way condition. Since Vietnamese uses a phonetic alphabet, it is never the case that a given segment-tone can be expressed by more than one written symbol. Thus, only a 3-way condition is supportable in the Vietnamese experiment. Of course, the set type factor, consisting of Homogeneous (matching syllable features) and Heterogeneous (no matching features) conditions, still was used with the Vietnamese word sets, as with Mandarin. Second, Vietnamese has six lexical tones (see Appendix 3). So, in order to ensure equal distribution across the tonal spectrum, six Vietnamese word sets were assembled for each condition. Table 2 shows sample word sets for the two conditions in the Vietnamese experiment. A full list of the stimuli used in the Vietnamese experiment can be found in Appendix 2.

Table 2. Sample word sets for the Vietnamese experiment.

	Homogeneous Condition		**Heterogeneous Condition**	
	Prompt	Response	Prompt	Response
3-way syllable match	*hợp lý* logical	*phải chăng* reasonable	*con chim* bird	*cánh chuồn* wing
	đanh trống to beat down	*phải đòn* get a spanking	*lờ đi* ignore	*mặc thây* leave alone
	tình yêu romantic love	*phải lòng* to be just	*tình yêu* romantic love	*phải lòng* to be just
	lạnh lẽo wintery	*phải gió* caught in a draft	*ấn nút* to press a button	*lăn tay* to take fingerprints

3. Results

First, the incorrect answers were eliminated from the data. Also, any answers that were more than 2.5 SD from that participant's mean RT were excluded, resulting in approximately 12.5% of the data being eliminated. No participants or items were excluded because of low accuracy rates. The dependent measure is the RTs for the response words. A within-subjects analysis of variance was computed to determine the significance of the difference in RTs by condition.

The data from the Chinese experiment showed the following pattern (Figure 1). In the word recall process, participants had longer reaction times for the 3-way (syllable, tone, and orthography) Match than for the 2-way (syllable and tone only) Match condition, $F(1, 9) = 2.728$, $p = 0.023$. More surprisingly, participants had longer RTs in the Homogeneous (3-way and 2-way together) condition than in the Heterogeneous (Non-match) condition, although the difference was not statistically significant, $F(1, 9) = 1.509$, $p = 0.166$, contrary to Chen *et al.*'s (2002) results. A closer one-by-one check confirmed that all of the participants were faster in the Heterogeneous (Non-match) condition. In other words, no priming effect was found.

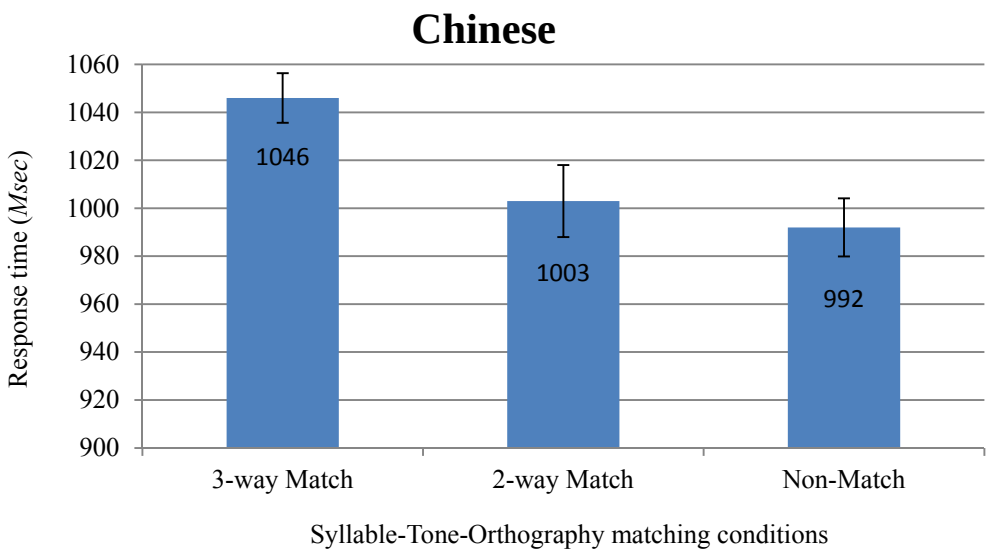

Figure 1. Mean reaction times (in milliseconds) of Chinese word recall. Note: Error bars indicate standard error.

In contrast, the Vietnamese group showed the opposite pattern, as can be seen in Figure 2, in that the Homogeneous condition had a stronger priming effect compared to the Heterogeneous condition, $F_1(1, 9) = 15.99$, $p = 0.03$.

A comparison between the two target language groups, Chinese and Vietnamese, is shown in Figure 3. A 2-way repeated measures ANOVA, with Condition (Homogeneous and Heterogeneous) as a within-subjects factor and Language as a between-subjects factor, was

performed to detect differences between the recall strategies of the Chinese and Vietnamese groups. The result shows a large main effect of Language $F(1, 18) = 33.78$, $p < 0.01$, which indicates that the Chinese speakers generally performed much faster in the experiment. More importantly, there is an interaction effect between Language and Condition, $F(1, 18) = 18.64$, $p < 0.01$, suggesting that the Chinese and Vietnamese groups were indeed using different word recall strategies.

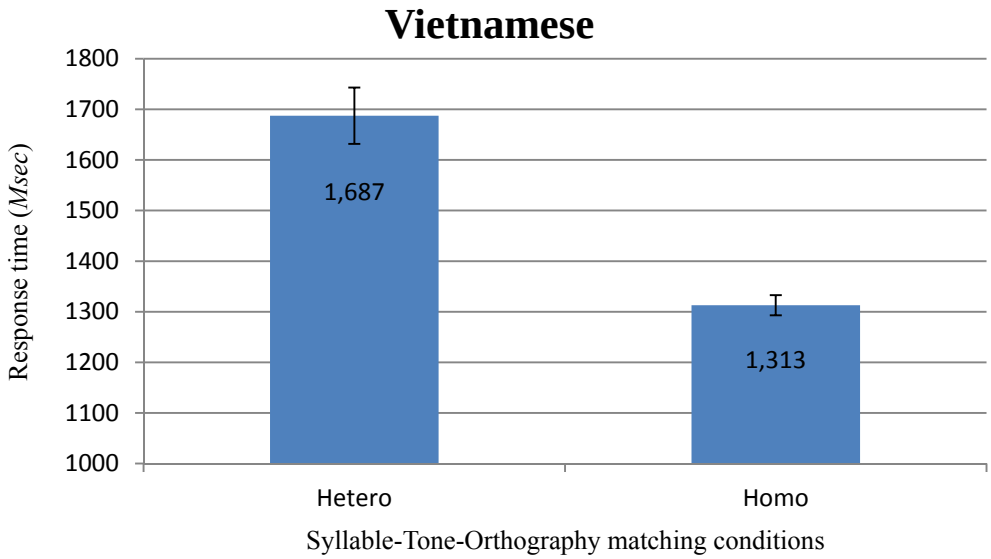

Figure 2. Mean reaction times (in milliseconds) of Vietnamese word recall. Note: Error bars indicate standard error.

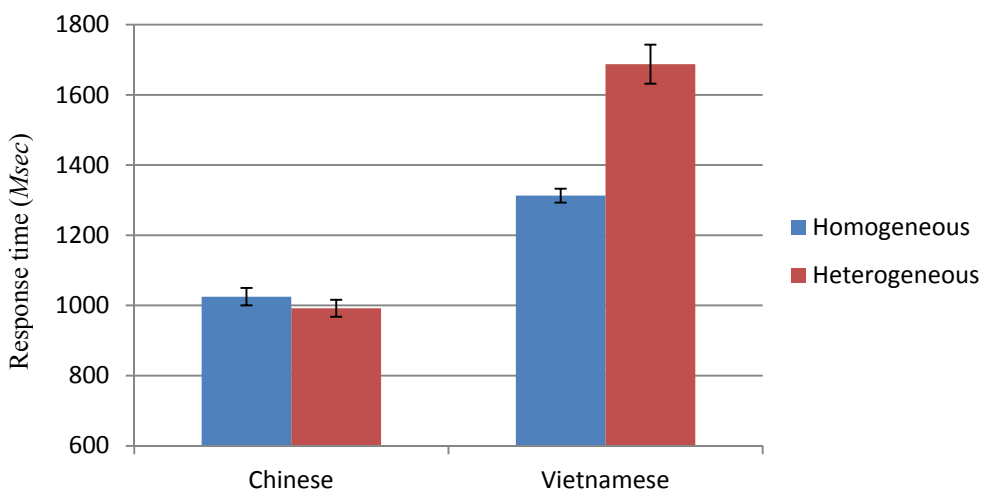

Figure 3. Comparison of reaction times (in milliseconds) between Chinese and Vietnamese word recall.

3.1 Discussion

The experiment testing Chinese speakers did not replicate the results of Chen *et al*.'s (2002) study, and there is a large gap between the average response times revealed in these two experiments (about 1000 ms in this study and 600+ ms in Chen *et al*.). The author attributes this apparent difference to two possible reasons. First, the response-time-measuring methodology employed in this study was not identical with that used by Chen *et al*. More specifically, participants in Chen *et al*.'s study were facing an arbitrary cutoff time of 1000 milliseconds. In their experiment, if "no response was initiated within 1000 ms of the presentation of the cue word" (p. 757), a feedback tone would sound and the trial would be terminated automatically. In other words, this setting eliminated all potential responses that were longer than 1000 milliseconds, regardless of individual differences in performing the word recall task. Although adding time pressure in psycholinguistic experiments is a common manipulation and might urge participants to focus and respond more quickly, it is not clear why an arbitrary cutoff time of 1000 ms was chosen. The current experiment, instead, set the cutoff time in the data analysis stage instead of the testing phase, and it was set according to each participant's average response times and standard deviations. This methodological difference is probably the main reason for the large difference in response times. Second, the participants in the two experiments were drawn from different language backgrounds. Although Mandarin Chinese was the mother tongue of the participants in both experiments, Chen *et al*.'s participants were mainly from Taiwan while the ones in the current study were from mainland China. There should be minimal influence resulting from this demographic difference, yet this factor may be worth our attention.

Considering the above differences, there are two main preliminary findings from this experiment, each with implications for alternative interpretations of Chen *et al*.'s results that ultimately may provide evidence for or against the relative importance of the three components as structural units in lexicon architecture. First, neither the Chinese 2-way Match condition nor the 3-way Match condition produced priming. Moreover, the 2-way Match condition resulted in faster RTs than the 3-way Match condition. This suggests that orthography may have played a major role in the implicit priming test, and that the logographic nature of Mandarin characters adds an extra layer of processing load in word production tasks. Second, although the Chinese participants had longer reaction times in the Heterogeneous condition than in the Homogeneous condition, the Chinese group showed a significant advantage in word recall times compared to their Vietnamese-speaking counterparts in all conditions. It is possible that unexpected phonological differences might be involved in these cross-linguistic findings, but, given the fact that Mandarin Chinese and Vietnamese are both tonal and monosyllabic, the difference in RTs is highly likely to be due to the different orthographies the two languages employ. In general, the graphic dimension of the

Chinese writing system may add an identifying element to the configuration of a mental lexical representation, which is absent in Vietnamese orthography. Mandarin orthography may provide an extra symbolic or iconic dimension that goes beyond the representation of morphemic or prosodic aspects to become a component in the word recognition mechanism for Mandarin speakers. This finding adds evidence in support of a suggestion made in some previous studies (Biederman & Tsao, 1979; Treiman *et al*., 1981) that Chinese characters invoke meaning much quicker than words in an alphabetic language. The current study supports the idea that the Chinese and Vietnamese speakers were using different word retrieval processes. More specifically, by using a logographic writing system that has no relationship to the pronunciation of words, the Chinese speakers may have developed integrated lexical entries that facilitate their word recognition process. They can give a brief glance at the character and recall all of the factors related to it, such as sounds and tones. Using an alphabetical writing system, the Vietnamese speakers have to read a sequence of letters, which relate to the words' sound and tone combinations, in their word processing. Without an additional indexing logographic symbol, they may have separate entries for syllable and tone, since the two elements are presented separately in the writing (prosodic components of Vietnamese words [tonality] are represented by diacritical marks above vowel symbols in Vietnamese writing. See Appendix 2). This may cause the delay in their word recognition process shown in this experiment.

4. General Discussion

4.1 Lexicon Architectures and Implications in Language Teaching Methodology

As mentioned in the introduction, I believe that the difficulty that learners, especially the native speakers of Indo-European languages, face in learning Chinese lies in the inherent difference between first language acquisition and second language acquisition. More specifically, it seems intuitively true that using an alphabetic native language would form the habit of focusing solely on the syllable part of the word and would prevent the speakers from taking syllable, tone, and orthography as an integrated word entry.

Research regarding the processes involved in word recognition has developed along diverse pathways, producing various theoretical models that address the nature and architecture of the human mental lexicon. They run the gamut from early approaches based on pure frequency of occurrence, such as the LOGOGEN model (Morton, 1969), to more recent and more elaborate mechanisms of activation, such as those proposed by the Distributed COHORT model of Gaskell & Marslen-Wilson (1997) and the NEIGHBORHOOD activation model of Luce & Pisoni (1998). They also have reflected the modular versus interactive debate with such theories as the Autonomous View of Norris *et al*. (2000) in his MERGE

model and the connectionist approach taken by the TRACE model (McClelland & Elman, 1986). Even though some researchers have argued for no substantial representation of word forms in the mental lexical at all, as in Goldinger's conceptualization of episodic memory (1998), still the so-called traditional approach in describing the word recognition process has persisted. In their article "Spoken Word Recognition," Dahan and Magnuson (2006, p. 253) have defined a traditional approach that conceives of the lexicon as the "mapping of the speech input onto abstract lexical representations, with abstract units standing for the word's subcomponents, the phonemes, mediating this mapping." A crucial factor in determining the nature and function of the lexicon architecture is the identification of the number of components that comprise the structure of a single lexical representation. An even more fundamental question is whether the collection of components is universal across languages or whether a subset of such components may be language-specific.

Based on the results of this experiment, I propose that there are differences in the lexicon architectures between lexical tone languages with characters (*i.e.*, Chinese), lexical tone languages without characters (*i.e.*, Vietnamese), and non-lexical tone languages (for example, Dutch). It is possible that, in a native Chinese speaker's mind, every word (character) is an integrated entry consisting of three indispensable elements: the phonological segment, tones, and orthography, which are fused together and form a single entry. In contrast, in a Vietnamese speaker's mental lexicon, each word entry is a combination, in which the phonological segment is the major element of the construction and tones are likely attached to the phonological segment as supra-segmental elements. Orthography, as a direct combination of segment and tones, does not act as an independent element in the mental lexicon. As for non-lexical tone languages, such as Dutch, only segment is involved in the word retrieval process, as it represents the alphabetic orthography, and lexical tone is simply not an element in these languages.

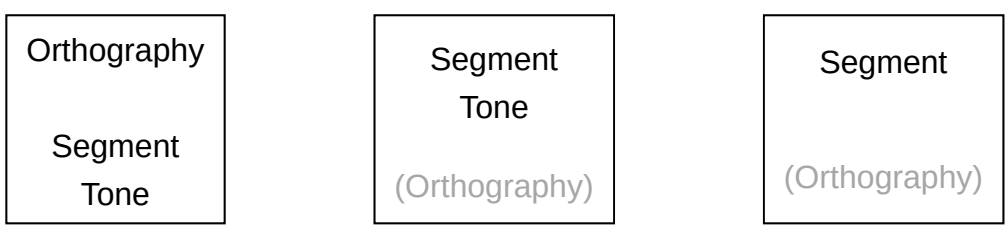

Figure 4. Possible lexical representations in speakers' mental lexicon of lexical tone language with characters (left), lexical tone language without characters (middle), and non-lexical tone language (right).

If this is the case, then we can speculate that speakers of languages that do not offer an ideographic character writing system may, when learning Chinese, build a different lexicon architecture than that of native Chinese speakers, due to transfer from their first language.

More specifically, they may have a poly-variant schema (presented graphically in Figure 5), in which segment, tone, and orthography form a loose combination, and in which segment is the major element of the construction. The tones are attached to the phonological segment, while orthography is a peripheral element and plays a very limited role in the storing and retrieving process. This hypothesis is supported by previous studies that have shown that L2 Chinese speakers may process tones and characters differently than L1 speakers. Wang *et al*. (2001) discovered that Mandarin tones are predominantly processed in the left hemisphere by native Mandarin speakers, whereas they are bilaterally processed by American English speakers with no prior tone experience. In addition, Hayes (1988) claimed that native and non-native Chinese speakers may use different strategies in reading Chinese characters. More specifically, the strategy used by native Chinese readers for holding words in short-term memory was acoustically oriented, in that they immediately associated the symbol with a particular sound, while the non-native Chinese readers rely more on graphic processing.

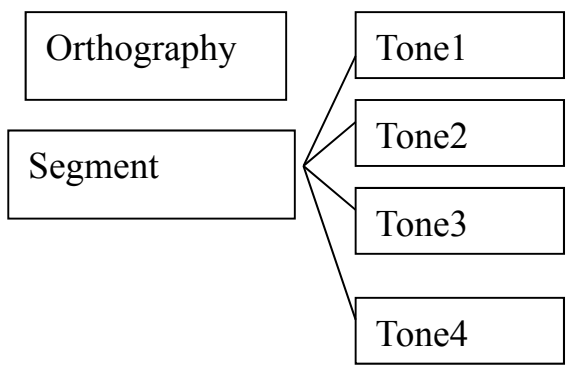

Figure 5. Possible lexical representations in L2 Chinese speakers' mental lexicon.

Therefore, teachers of Chinese need to find ways, through our teaching practice, to prevent our students from forming habits of neglecting orthography and marginalizing tone information. Intuitively, it may seem easier for the learners to learn through acquiring the familiar syllable forms, which are like those that exist in their own language, and later learn the new and unfamiliar tonal features. Nevertheless, it is not feasible to first introduce only syllables (*e.g*., *ma*), and later teach the four lexical tones and ask the students to try to pair the syllable with each of the four tones (ma1, ma2, ma3, ma4). Learning these elements in such an order would be likely to cause students even more difficulty in the later stages of learning, since the students may lose the initial opportunity to form an integrated combination of syllable and tone, as the Chinese native speakers do. All teachers of Chinese as a foreign language can probably recall from time to time encountering students who can pronounce the syllable correctly but constantly make mistakes on the tones, which is probably the consequence of the students' learning syllables and tones separately. Hence, I propose that it may be better for teachers to initially ask the students to only imitate word pronunciation in a

repeated manner, without even introducing the notion of tones. This extreme method might be hard to practice, but it would avoid emphasizing the tone features separately from the phonological segment. The goal would be to duplicate the natural learning process in first language acquisition and to help the students form native-like word entries in their lexicon as much as possible.

Regarding the role of writing systems, the experiment proved, through comparison with another tonal language, Vietnamese, which uses an alphabetic writing system, that the special logographic characters employed in Chinese have a facilitation effect in word recall. This result is instructive for teachers in that it points to the benefits of introducing orthography simultaneously with the teaching of the segment and tone when students are already very familiar with the pronunciation of a certain word. In addition, it emphasizes the fact that, for each lesson, introducing too many characters will actually lower the rate of learning, because students will not have enough time to integrate the characters they just learned with pronunciation, and instead will probably rely more heavily on sound noting systems (such as *pinyin*), which may further discourage them from remembering characters. Moreover, as soon as they master the characters, the students should be encouraged to read texts *sans* pinyin in order to fortify their memory of integrated mental lexical entries.

To conclude, the preliminary results of this study suggest that Chinese teachers should pay careful attention to the teaching order of the three main elements in Chinese. The best strategy might be to introduce syllable and tone for each word simultaneously, and only when the recognition of the two are stable to teach the writing of characters.

4.2 Limitations and Possible Future Studies

Revisiting Chen *et al.*'s (2002) experiment, this study limited its examination to the relationship of orthography to a conceptual amalgam of segment and tone in word recall. This experiment partially replicates the design of Chen *et al.*'s (2002) study and adds Vietnamese as a testing group in order to explore the mental lexicon representations of Chinese speakers; however, there are interesting discrepancies between the findings described here on implicit priming effect and those of Chen and colleagues. The current study suggests that orthography affects word retrieval processes, while it was considered to have a minor role in the mental lexicon in Chen *et al.*'s study.

Clearly, however, the experimental methodology employed in both studies has room for improvement. For example, semantic relationships between cue words and response words were inconsistent. In some pairs, the cue words may be more closely related to their response words than in other pairs. As a result, reliance on compound word form can give rise to inadequate control over testing materials. In addition, the experimental design actually required both perception and production, and using a task combining these processes may

have complicated the results, which can hardly be considered to only measure word recognition independent of the production process.

Therefore, the author hopes that more data can be collected using fine-tuned methods, such as an eye-tracking paradigm (Cutler *et al*., 2006) in the near future. To test the proposed model of mental lexicon representation showed in Figure 5, I intend to conduct a word recognition-based experiment employing an eye-tracking paradigm that relies on mono-morphemic picture stimuli, thus avoiding any confusion due to the use of compound forms. I will further isolate the effects of word production by collecting the percentages of eye-gazes toward target and control pictures as dependent variables. Once the effects of orthography are satisfactorily isolated or eliminated, the author intends to probe more deeply into the specific nature of the segment-tone combination. For instance, in a more recent study, Xu and Speer (2007) report the results from a cross-modal priming experiment that led them to conclude that "prosodic tonal information is not processed at a separate 'toneme level' from the 'phoneme level' during lexical access. Instead, lexical tone is an integrated component of the auditory signal used in Mandarin word recognition." I find this conclusion to be consistent with my own theoretical position on the role of tonality in the process of word recognition (although it seems somewhat speculative, given the limited and problematic nature of their stimulus materials, which rely on sandhi-driven tone changes). In a word, the employment of new methodologies will hopefully provide more definitive answers in the ongoing discussion, yielding stronger evidence and more meaningful implications in the field of teaching Chinese as a second language.

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Appendix 1: Mandarin Word Sets

	Word Set		Prompt	Meaning	Response	Meaning
3-way Syllable Match	**Set 1**	1	shui3-guo3 水果	*fruit*	xi1-gua1 西瓜	*watermelon*
		2	zhang1-qian1 张骞	*ancient character*	xi1-yu4 西域	*west land*
		3	mian4-shi4 面试	*interview*	xi1-zhuang1 西装	*suit*
		4	da2-lai4 达赖	*Dalai Lama*	xi1-zang4 西藏	*Tibet*
	Set 2	5	jie2-shi2 节食	*diet*	fei2-pang4 肥胖	*fat*
		6	guo3-shi2 果实	*fruit*	fei2-shuo4 肥硕	*big*
		7	zhuang1-jia1 庄稼	*crop*	fei2-liao4 肥料	*fertilizer*
		8	xi3-zao3 洗澡	*take a bath*	fei2-zao4 肥皂	*soap*
	Set 3	9	sheng1-bing4 生病	*become ill*	qing3-jia4 请假	*leave of absence*
		10	wei4-min2 为民	*for the people*	qing3-ming4 请命	*request*
		11	gong1-zhu3 公主	*princess*	qing3-an1 请安	*inquire after*
		12	fu4-jing1 负荆	*carry wipes*	qing3-zui4 请罪	*ask for punishment*
	Set 4	13	sheng1-yi4 生意	*business*	ke4-hu4 客户	*client*
		14	kuan3-dai4 款待	*host*	ke4-ren2 客人	*guests*
		15	sha1-fa1 沙发	*sofa*	ke4-ting1 客厅	*living room*
		16	long2-men2 龙门	*name of a hotel*	ke4-zhan4 客栈	*hotel*

	Word Set		Prompt	Meaning	Response	Meaning
2-way Syllable Match	**Set 5**	17	bing1-dai4 冰袋	*ice bag*	qing1-liang2 清凉	*cool*
		18	zi1-sha1 自杀	*suicide*	qing1-sheng1 轻生	*suicide*
		19	kun1-chong2 昆虫	*insect*	qing1-ting2 蜻蜓	*dragonfly*
		20	shu1-cai4 蔬菜	*vegetable*	qing1-jiao1 青椒	*green pepper*
	Set 6	21	xia4-tian1 夏天	*summer*	xi2-zi3 席子	*cooling mat*
		22	feng1-su2 风俗	*custom*	xi2-guan4 习惯	*habit*
		23	di2-ren2 敌人	*enemy*	xi2-ji1 袭击	*attack*
		24	gong1-po2 公婆	*parents-in-law*	xi2-fu4 媳妇	*daughter-in-law*
	Set 7	25	zhu1-bao3 珠宝	*jewelry*	fei3-cui4 翡翠	*emerald*
		26	dao3-guo2 岛国	*island country*	fei3-ji4 斐济	*Fiji*
		27	wu1-mie4 诬蔑	*defame*	fei3-bang4 诽谤	*slander*
		28	chan2-mian2 缠绵	*lingering*	fei3-ce4 悱恻	*sorrowful*
	Set 8	29	sha1-fa1 沙发	*sofa*	ke4-ting1 客厅	*living room*
		30	ren4-zhen1 认真	*serious*	ke4-ku3 刻苦	*painstaking*
		31	kun4-nan2 困难	*difficulty*	ke4-fu2 克服	*conquer*
		32	shu1-ji2 书籍	*book*	ke4-ben3 课本	*textbook*

Appendix 2: Vietnamese Word Sets

Word Set	Prompt	Meaning	Response	Meaning
set 1				
1	con chim	*bird*	cánh chuồn	*wing*
2	thủy thủ	*sailor*	cánh buồm	*sail*
3	màu đỏ	*red*	cánh hồng	*rose petal*
4	bàn chân	*foot*	cánh tay	*arm*
set 2				
5	món cá	*fish*	mặc ngư	*squid*
6	lờ đi	*ignore*	mặc thây	*leave alone*
7	dẫ cho	*although*	mặc dũ	*although*
8	đồng ý	*to agree*	mặc ước	*tacit agreement*
set 3				
9	hợp lý	*logical*	phải chăng	*reasonable*
10	đanh trống	*to beat down*	phải đòn	*get a spanking*
11	tình yêu	*romantic love*	phải lòng	*to be just*
12	lạnh lẽo	*wintery*	phải gió	*caught in a draft*
set 4				
13	cuôn giấy	*a scroll of paper*	lăn cù	*to roll*
14	chết trận	*to die in battle*	lăn đùng	*to drop dead*
15	gian khổ	*tribulation*	lăn lộn	*to experience hardship*
16	ấn nút	*to press a button*	lăn tay	*to take fingerprints*
set 5				
17	tiền lãi	*dividend*	đồ lợi	*to seek profit*
18	trái cây	*fruit*	đồ ăn	*food*
19	bức tranh	*painting*	đồ hoạch	*drawing*
20	đại học	*college*	đồ đệ	*student*
set 6				
21	đường giao	*intersection*	ngã tư	*crossroads*
22	rơi xuống	*to collapse*	ngã gục	*to be set up*

23	kết cục	*conclusion*	ngã ngũ	*concluded*
24	bất đồ	*unexpectedly*	ngã ngửa	*to be shocked*

Appendix 3: Explanation of Chinese and Vietnamese Orthographic Tone Marks

Chinese

Tone #	Description	Diacritical Mark	Example	Meaning
1	High level tone	Horizontal bar	mā	*mother*
2	Rising tone	Left to right rising slant	má	*hemp*
3	Dipping tone	falling slant connected with rising slant	mǎ	*horse*
4	High falling tone	Left to right falling slant	mà	*scold*

Vietnamese

Tone #	Description	Diacritical Mark	Example	Meaning
1	High level tone	No mark	ma	*ghost*
2	High rising tone	Left to right rising slant	má	*mother*
3	Low falling tone	Left to right falling slant	mà	*that*
4	Dipping tone – low to mid	Question mark (no dot)	mả	*tomb*
5	High broken tone – low to high	Tilde	mã	*horse*
6	Low broken tone – low to lower	A dot below the vowel	mạ	*burgeon*