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The Relationship Between Chinese Character Recognition Strategies and the Success of Character Memorization for Students of Mandarin Chinese

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ABSTRACT

An abstract of the thesis of Hui-yen Emmy Chen for the Master of Arts in TESOL presented January 21, 2000.

Title: The Relationship between Chinese Character Recognition Strategies and the Success of Character Memorization for Students of Mandarin Chinese

The purpose of this study was to examine the relationship between beginning Chinese language students' character memorization and the strategies they used for the recognition of Chinese characters. In the experiment, a new character teaching approach, the phonetic-ideograph strategy, was introduced to all the subjects during two quarter terms. Subjects participated in the study were divided into two groups depended upon their language backgrounds: the phonographic group and the morphographic group. All the subjects in the phonographic group were English speakers and subjects in the morphographic group were Japanese speakers. All the subjects received the same treatment in the study.

Two main questions were addressed in this study: 1) whether the phonetic-ideograph strategy was a better strategy to facilitate character recognition and retention. 2) whether there was a difference between character

processing strategies used by phonographic students and morphographic students. The results in this study demonstrated that a significant positive correlation was detected between student's performance on pronunciations and on meanings of characters in retention tasks. In other words, phonetic-ideograph strategies seem to be effective for most of the subjects in recognizing and memorizing characters.

There was also a difference illustrated between the performance of phonographic students and of morphographic students. The phonographic group seemed to rely more heavily on characters with phonetic radicals than characters without. The morphographic group seemed to show more tolerance for processing characters without phonetic radicals than the phonographic group. Perhaps, the results indicated that there might have been a transfer of orthographic processing strategies underway from students' first languages to their second languages.

THE RELATIONSHIP BETWEEN CHINESE CHARACTER RECOGNITION STRATEGIES AND THE SUCCESS OF CHARACTER MEMORIZATION FOR STUDENTS OF MANDARIN CHINESE

by

Hui-yen Emmy Chen

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CHAPTER I

INTRODUCTION

The purpose of this study was to examine the relationship between beginning Chinese language students' character memorization and the various strategies for recognition of Chinese characters. Two issues were addressed: 1) Strategies for orthographic processing of Chinese characters. 2) The language transfer hypothesis.

There are two types of orthographic systems: phonographic and morphographic. Phonography is a writing system in which each grapheme represents a sound unit. Morphography, on the contrary, is a system in which each grapheme represents a morpheme. Chinese writing is usually considered to be morphographic. However, more than 80% of Chinese characters contain phonological clues. (Perfetti, Zhang, and Berent, 1992) These phonological clues are also termed "phonetic radicals" or "phonetic stems." The term "phonetic radical" is used in this study. Students participating in the study were introduced to Chinese characters from the very beginning, including learning about many of the characters' phonetic radicals. The first set of questions, about Character processing strategies, revolved around whether students relied more on the pronunciations of characters to memorize their meanings, or whether they mostly employed visual strategies to memorize the meanings of characters.

The second issue involves the language transfer hypothesis. In recent years, the language transfer hypothesis has shifted its attention to learners' cognitive strategies. It predicts that foreign language learners will transfer orthographic processing strategies from their first language (L1) into their reading of foreign languages. (Koda, 1990) Generally speaking, students from phonographic writing backgrounds depend more heavily on phonological representation in their reading of foreign-language material than do students from morphographic writing backgrounds. (Mori, 1997) The apparent lack of systematic phonological representation in Chinese writing may impede Chinese character recognition for phonographic students. On the other hand, students from morphographic backgrounds may not experience the same kind of difficulties in reading Chinese. From this assumption, the performance of students from different orthographic backgrounds was compared and analyzed in terms of different verbal processing strategies in this study.

Background of the problem

The character writing system has been considered one of the most difficult aspects of learning Mandarin Chinese, especially for students from phonographic writing backgrounds. The rich graphic information (i.e. complicated stokes) contained in characters often overwhelms learners of Chinese as a foreign language (CFL), and it takes a long time with much practice to memorize each individual character's pronunciation and meaning. There are two main methods for teaching

Chinese characters: the Fen-San Method and the Concentrated Character Recognition Method (CCRM). The traditional approach, the Fen-San method, mainly focuses on the "classifiers" or semantic radical portion of each character. In other words, it introduces students to Chinese characters based on the meaning alone. On the contrary, the CCRM introduces characters in groups according to their shapes, sounds, and meanings. In this way, students can associate groups of characters that are related in appearance and pronunciation. Thus, CCRM, unlike the traditional approach, provides a systematic way for students to recognize the phonetic clues between characters.

CCRM was examined by Tsai (1997) in Chinese as a foreign language classroom settings with English-speaking students who were learning Chinese as a foreign language. Ninety-eight phonetic radicals were introduced to students in the CCRM experimental group. Students exposed to CCRM significantly outperformed students of the Fen-San method in the recognition of character pronunciation. This indicates that students in the experimental group were able to apply phonetic-ideograph strategies in the character naming task. To use the phonetic-ideograph strategy is to utilize phonetic radicals to access the pronunciations of characters. For example, if students can apply phonetic-ideograph strategy, they can pronounce unfamiliar characters, such as 鋼 *gang* "steel," 剛 *gang* "hard," and 崗 *gang* "peak " by knowing the phonetic radical 岡 *gang*. The character 岡 is an ideograph, but in 鋼, 崗 and 剛 it serves as a phonetic radical, while 金, 刂 and 山 are the semantic radicals or meaning classifiers. Although Tsai (1997) found that students who can apply phonetic-ideograph strategies performed highly accurately in the character pronunciation recall test, whether learners of Chinese heavily relied on pronunciation to memorize the meanings of characters was still a question for the researcher. Therefore, the current research further investigated the relationship between students' ability to apply phonetic-ideograph strategies and the ability to recall characters' meanings.

Over the course of history, Chinese characters became not only the writing system of Mandarin Chinese (Standard Chinese), but also of Japanese, Korean, and most Chinese dialects. The history of Chinese characters as a nationally unified writing system dates back as far as 213 B.C, during the Chin dynasty, when the first unification of characters was undertaken by Li Si (Lehmann, 1975). Because of the unification of characters, various Chinese spoken dialects that are mutually unintelligible share the same writing system. In addition, Japanese and Korean borrowed Chinese characters to form their own writing systems. Chinese characters, referred to as *kanji,* coexist with a syllabary, referred to as *kana,* to make up the Japanese orthography. Korean refers to Chinese characters as *hanja,* and has also developed a syllabic writing system, the hangul, from Chinese characters. The influence of Chinese characters in Asian language writing systems causes the CFL students with different writing backgrounds to have different styles of Chinese character recognition. Therefore, students from Japan were categorized in the morphographic group in this study. Mori (1997) found that learners of Japanese from different writing backgrounds used different processing strategies in character recognition. In Mori's study, when American students memorize Japanese kanji characters, they rely more heavily on phonological information within the characters than do Chinese and Korean students. Therefore, the researcher in the study was also interested in finding out two tendencies: 1) whether students of Chinese are likely to transfer their L1 orthographic processing strategies in the recognition of Chinese characters, and 2) whether the phonetic-ideograph strategy in Chinese character recognition might favor students from a phonographic language background more than students from a morphographic language background, and therefore help ease the task of western language speakers learning to read Chinese.

Rationale and need for the study

The basic design principles for human writing systems can be divided into three categories: logographic, syllabic, and alphabetic. The Chinese writing system has been described as a logographic system, "a morpheme-syllable writing system." (Mori, 1997, p.70) The difference between these systems is in the basic unit of representation. For example, in alphabetic languages, ideally each grapheme represents a phoneme, and a phoneme represents only a sound, not a meaning. In comparison, each basic unit in logographic languages presents a morpheme, and it corresponds to both meaning and sound. Midway between those two systems is the syllabary. In a syllabary, each unit presents a syllable, and does not necessarily carry any meaning. An example of this are Japanese kana characters. Readers from two different orthographic backgrounds very likely would develop different visual information processing strategies. For example, phonographic readers may tend to develop a phonological strategy in reading. In comparison, morphographic readers might develop a strategy to recognize a meaningful morpheme regardless of its pronunciation.

Research on orthographic processing in reading has been furnished recently by psychologists, (psycho)linguists, and reading educators. From the earlier theories on direct visual access and phonological mediation to a dual-route hypothesis (combining both visual and phonological strategies), word recognition strategies are mostly discussed and examined with regards to first-language readers. For example, Perfetti and Zhang (1991;1992;1995) claim that phonological recoding in word recognition is an automatic process even in a logographic language, such as Chinese. This indicates that the recognition of Chinese characters cannot bypass phonology. In several previous experiments on the phonetic-ideograph strategy, the results showed that students who employed this strategy could access pronunciations as well as meanings of characters more efficiently (Ye, 1990). Ye reported that in an experiment carried out in Jing-Shun elementary school in Mainland China, students were using the phonetic-ideograph strategy (CCRM) in the classroom in 1985. The results showed that second grade students successfully mastered 2,200 to 2,500 characters by the end of their second year. In contrast to the previous second grade students, the students under the CCRM experiment mastered

1,000 to 1,300 more characters. However, it should be noted that recalling meaning is a far easier process while reading in a native language than reading in a foreign language.

Perfetti and Zhang (1995) state that a phonological representation of a Chinese character is expected to exist in the working memory of a Chinese reader, since the working memory capacity is greater for phonologically encoded materials than for non-phonologically encoded materials. Through learning semantic radicals and phonological radicals together, students presumably will perform better in the memorization of characters. Students who know how to access phonological information in characters presumably will hold characters longer in memory than the students who do not know how. It has been supported in Tsai's experiment (1997) that students who are taught using the phonetic-ideograph strategy perform better in recognition of character pronunciation than students who are taught in the traditional semantic-radical method. The researcher in the current study was further interested in finding out if the phonetic-ideograph strategy was a more efficient way of facilitating students' memory retention of characters' meanings than the visual strategy. The study operated on an unfamiliar character learning section and tested students on unfamiliar characters, as opposed to the previous research which only focused largely on familiar characters. Not only did this study concentrate on unfamiliar characters, but it also examined the ability to recall both pronunciations and meanings, while earlier studies focused on pronunciations.

Language transfer has been a concern for quite some time in the field of second language acquisition. Recently, the interest has shifted to the influence of L1 experience on L2 learners' cognitive processing strategies. As mentioned above, students from different writing systems seem to operate with different word recognition strategies. The researcher believed that reading in CFL provided a chance to investigate if students from different orthographic backgrounds transfer their cognitive processing strategies in FL learning because of the nature of the Chinese characters. There are a number of phonologically accessible and inaccessible characters in Chinese orthography. Even characters with phonetic radicals can still be phonologically inaccessible, because some phonetic radicals have lost their function of presenting pronunciation over time. For example, for the character 晷 *gui* has the phonetic radical 咎 *jiu.* Therefore, this situation provides a good opportunity of examining if students from different orthographic backgrounds use different memorization strategies. Students from alphabetic languages were assumed to memorize characters that contain phonological clues better than characters that do not. Students from morphographic writing backgrounds were assumed to perform equally well with both types of characters.

In the current experiment, the phonetic-ideograph strategy to enhance character memorization was introduced to students. The phonetic-ideograph strategy primarily focuses on the students' awareness of the phonological component of an individual character, which is closely related to the phonological recognition strategy. Since the phonetic-ideograph strategy focuses on phonetic radicals in characters, it is supposed to help students access the pronunciation of a character by identifying the phonetic radical. Therefore, the researcher believed if students were able to apply phonetic radicals to unfamiliar characters, it minimized the need for rote memorization of characters and their pronunciations. For most native Chinese speakers, rote memorization has been thought to be the most common strategy for learning characters and their pronunciations (Leong,1997). A character is memorized as a unit along with its pronunciation. However, rote memorization takes a huge amount of time, especially for students from alphabetic languages. Therefore, the researcher believed that by introducing the phonetic radicals of characters to students from alphabetic languages, the students could memorize characters more efficiently and retain characters more successfully over a longer term, because the phonological information was more quickly accessed. In addition, by analyzing characters into smaller units, semantic and phonetic radicals, students could utilize the radicals even in unfamiliar characters, and also reduce some of the workload in memorization of characters.

Research Hypothesis

There were two main research questions in the study. The first question was whether or not the phonetic-ideograph strategy could benefit students in memorizing characters' meanings. The basis of the question was the assumption that students who could pronounce unfamiliar characters utilized the phonetic-ideograph strategy. If students could not pronounce unfamiliar characters, the students were assumed to have applied other strategies to memorize characters, i.e. a visual memorization strategy. Based on this logic, there would be a significant positive correlation between pronunciation scores and meaning recall scores if the phonetic-ideograph strategy could be of benefit in character memorization.

The second research question was whether students from different orthographic backgrounds applied different orthographic processing strategies. In order to investigate this issue, the experiment contained two types of characters: phonologically accessible and phonologically inaccessible. Hypothetically, students from morphographic writing backgrounds are less dependent on phonological clues in characters than those from phonographic backgrounds. Therefore, morphographic students would be likely to show no difference on two types of character recall tests; on the other hand, the phonographic students would show a difference. There are four research hypotheses in the study:

1. **There will be a significant positive correlation between the pronunciation scores of characters and the meaning scores of characters in an immediate recall test.**
2. **There will be a significant positive correlation between the pronunciation scores of characters and the meaning scores of characters in a long-term recall test.**

3. **Phonographic students will tend to show a difference in recognizing the meanings of phonologically accessible and phonologically inaccessible characters.**
4. **Morphographic students will tend to show no difference in recognizing the meanings of phonologically accessible and phonologically inaccessible characters.**

CHAPTER II

Literature Review

There have been many types of writing systems across the spectrum of spoken languages. The writing systems of human languages are primarily divided into two categories: phonography and morphography. In a phonographic writing system, each grapheme represents a sound unit; for example, a syllable in a syllabary (e.g. Japanese *kana*) and a phoneme in an alphabet (e.g. English). Morphography, on the other hand, is a writing system in which each grapheme presents a meaningful element, also termed a morpheme. For example, a Chinese character is generally associated with semantic information.

In different writing systems, readers gradually develop different orthographic processing strategies. For alphabetic language readers, a dual-route model is a widely accepted view that posits two separate processes for accessing the meaning of words. One of the processes is to use grapheme to phoneme correspondence (GPC) rules to get to the meaning of a printed word through its sound. The other process is that a reader can arrive at the mental lexicon by identifying a whole word visually (Baron, 1973). Readers who identify English words directly from their visual appearance are metaphorically said to be " Chinese" (Tzeng, O.J. L. & Hung, D.L., 1980). However, several recent reading psychological studies have provided some evidence of phonological codes in logographic languages. They claim that orthographic processing can not bypass the phonology. (Perfetti, C. A., Zhang, S., & Berent, I., 1992)

This study investigates whether the phonological information in Chinese characters can benefit students of Chinese in memorizing characters, and also analyzes the transfer of orthographic processing strategies in the recognition of Chinese characters by students of different L1 backgrounds. Three important issues are discussed in the literature review: the nature of Chinese language system, the role of phonological codes in word recognition and memory, and processing strategies in different orthographies.

The nature of Chinese writing system

As a writing system, Chinese has been described as "logograpgic" by Carr (1986). That is, each graphic symbol represents a word. However, this description is more suitable for classical Chinese than for the modern Chinese. Recently Defrancis (1989) has further proposed the term "morphosyllabic" to emphasize the phonetic component of Chinese characters, because a character generally represents a morpheme and a syllable. On the other hand, the traditional classification of the Chinese writing system for almost two thousand years is *Shuowen Jiezi,* the first book that categorizes Chinese characters, which has six classes of characters: pictographs, ideographs, compound ideographs, loan characters, phonetic compounds, and *zhuanzhu* (figurative expansion of meaning).

Chao (1968) also distinguishes five classes, excluding *zhuanzhu,* which only includes a few characters and whose nature is obscure:

1. Pictographs are characters that originated from pictures of objects.
2. Ideographs are diagrammatic indications of ideas, as in 上 *shang* "up", 下 *xia* "down", and 一 *yi* "one", 二 *er* "two", 三 *san* "three".
3. Compound ideographs are characters in which the meaning of the whole is a combination of the meanings of its parts. For example, 明 *ming* "bright", consisting of 日 *ri* "sun" and 月 *yue* "moon".
4. Loan characters are originally from pictographs. A loan character is one used for its phonetic value to represent a homophonic word. For example, 來 *lai*, is originally from a pictographic character that means "grain", and came to represent a homophonic word "come".
5. Semantic-phonetic compounds are by far the most common types of Chinese characters. Each character from this class consists of two parts: a semantic radical and a phonetic radical. The former gives a general clue of the character's meaning, and the later gives a clue to the pronunciation of the character. For example, 情 *qing* "emotion" consists of the semantic radical, 心 *xin* "heart", and the phonetic radical, 青 *qing*.

Within the six classes of *Shouwen Jiezi*, Zhou (1978) states an estimate of less than 18% that are either pictographic or ideographic. Most words are written as compound characters, estimated at 82%. Hoosain (1991) also points out that approximately 80-90% of characters are semantic-phonetic compounds, and the number of the compound characters are still increasing. Since the semantic-phonetic compound characters are the focus of the current study, the next section will introduce more detailed information on the compound characters.

The semantic-phonetic compound characters and the effectiveness of phonetic radicals

Within the compound characters, Huang and Wang (1992) report that there are 214 possible semantic radicals, and Perfetti, Zhang, and Berent (1992) give an estimate of 188. The difference between these two estimates may be due to the difference between traditional characters and simplified characters. The number of phonetic radicals within compound characters, on the other hand, is estimated around 800 to 1300 in some previous studies. Shoothill (1942) classified 4300 characters on the basis of 895 phonetics. Also, a Chinese scholar, You-quang Zhou (1978) presents a study in which he identifies 1348 phonetic radicals. Zhou also points out that only 39% of compounds actually provide the correct pronunciation, and the remaining 61% deviate from the pronunciations of the phonetic radicals. However, Jackson, Lu, and Ju (1994) explain and illustrate phonetic radicals as in Table I:

> A phonetic radical may occur alone with one meaning or in compound with various semantic radicals with diverse meanings.

Whatever the context in which it occurs, a phonetic radical is likely to be pronounced similarly. When they do not indicate the full pronunciation of a character, phonetic radicals often signal the rime part of a character's sound (p.75).

Characters Sharing a Phonetic Radical

Character	Pronunciation	Meaning
情	/tsɪ́əŋ/	feeling
請	/tsɪ̌əŋ/	invitation
精	/dʒɪ̄əŋ/	essence, good at
倩	/tsə̀n/	beautiful

Homophone Characters with Different Phonetic Radicals

Character	Pronunciation	Meaning
鮭	/guē/	salmon
規	/guē/	rule
鬼	/guē/	ghost
貴	/guē/	expensive

Characters Sharing a Semantic Radical

Character	Pronunciation	Meaning
洗	/ɕǐ/	wash

海	/ hǎɪ /	**sea**
河	/ hə́ /	**river**
池	/ tsɿ́ /	**pond, pool**

Table I Examples of similarities and differences in meanings and pronunciations of semantic-phonetic compound characters with shared and distinct elements.

Perfetti, Zhang, and Berent (1992) examine the relationship between the phonemic and semantic values in compound characters and the frequency of use of compound characters:

> Both phonemic and semantic components appear to be more reliable for low frequency compounds than high frequency compounds. This conclusion comes from a sample of 300 compounds taken from three frequency ranges, as indicated in Chinese frequency dictionary (1986). (p. 236)

They also found that the relationship between the number of single characters and compounds, and their frequency was even more significant. Among the sample of 300 characters, they found about 84% of characters were compounds. The percentage of compounds, compared with single characters, increases with decreasing frequency: '62% of high frequency characters, 93% of medium frequency characters, and 98% of low frequency characters were compounds.' (p. 237) Therefore, as the frequency decreases, a Chinese reader is not likely to encounter a single character that gives no clue in pronunciation. By the same token, when a Chinese reader encounters a compound, it is more likely to give the reader reliable information for pronunciation and meaning.

Defrancis (1984) classifies three different types of phonetic radicals based on the usefulness of the phonetic radicals in guessing the pronunciations of characters. The most useful phonetic radicals are those that are completely identical to the pronunciation of the whole word. The second most useful ones are those that are identical except for tone. The marginal ones are those which correspond only in some of the segmental phonemes. He further examined the occurrence of phonetic compound characters in a cross section of 500 characters out of the 4,719 different characters that were found to occur in a frequency count running test. He states some interesting observations:

> In our total sample of 500 characters, 91 (18 percent) are independent phonetics and 394 (79 percent) are phonetic compounds, leaving only 15 (a mere 3 percent) with no phonetic aspect at all. High-frequency characters include fewer phonetic compounds than do rare characters. Conversely, the characters of highest frequency, such as the first hundred, are strikingly represented by phonetics functioning as independent characters. (p.108)

The result of Defrancis also shows that decreasing rank order of frequency results in a decreasing number of independent phonetics but a greater number of phonetic compounds, especially compounds with useful phonetics. From this experiment, the compound characters with useful phonetic radicals make up a high proportion of the total characters.

As this result shows, a reader with a knowledge of phonetic radicals in Chinese characters is highly likely to guess correctly the pronunciation of any unknown characters he or she encounters in reading. However, with the help of the phonetic radicals, whether a reader can recognize the meaning of the characters more rapidly is still in question. What is the role of phonetic radicals in memorizing and recognizing characters? Does this phonological information help readers to process Chinese characters more efficiently? In the next section, I will take a close look at the role of phonological codes in reading and memory from previous research in psychology and linguistics.

The role of phonological codes in word recognition

The role of phonological codes in word recognition has been a major concern in the field of reading research. The relationship between phonological awareness and the acquisition of reading skills has been extensively examined among children in alphabetic writing systems. Several studies have shown a strong correlation between phonological processing mechanism and reading proficiency. For example, Levy (1975) suggests that the phonetic recoding process in reading plays an important role in maintaining words in memory for the purpose of sentence comprehension.

Another experiment dealing with the role of phonological processing for beginning readers (cited in Huang, 1992, Liberman, Shankweiler, Liberman, Fowler, and Fischer, 1977) was designed to ask children to remember letter strings of rhyming and nonrhyming consonants. Children were divided into superior, marginal, and poor readers based on the test scores of a word recognition test. The findings suggest that the better recall of the superior readers is associated with their more efficient use of phonological recoding.

This line of research has been extended into readers from logographic writing systems. In Chinese, for instance, it has been considered that phonological processing does not need to occur during word identification, because Chinese characters represent the meaning directly and can not be pronounced by grapheme-phoneme correspondence rules. Access to the meaning of Chinese characters has been thought to be more direct and easier by visual processing than by phonological processing. For instance, in a widely cited experiment of Rozin et al. (1971), they believed the idea that Chinese characters map into speech at the level of words rather than of phonemes, so people must be able to read without speech recoding. They decided to teach a group of second-grade school children with reading problems some Chinese characters. They hypothesized that while learning Chinese characters, children did not need to break down the word into phonemes to sound it out; therefore they should be able to read Chinese with little problem. The results seemed to support their hypothesis.

However, researchers, such as Perfetti, and Zhang (1991), recently suggest an alternative route to word recognition, an automatic activation model, which exists in both alphabetic and non-alphabetic languages. In contrast to the early dual-route model, the automatic activation model proposes that the phonological code of a word is activated automatically and non-optionally during word recognition (Hoosain, Tan and Peng, 1995). Perfetti and Zhang (1991) studied phonological processing in reading Chinese characters by using a backward masking and a forward masking priming experiment, which produced evidence for early phonemic activation in Chinese word recognition. Their findings indicated that phonological information was immediately available, as part of character identification and that semantic activation did not occur earlier than phonological activation.

More evidence comes from a study using a phonological confusion task (Hu and Catts, 1992). The researchers employed the task to explore whether or not beginning readers of Chinese activate phonological codes while reading Chinese characters. They asked twenty first graders and twenty third graders to read phonologically similar and dissimilar character strings. After reading each string, subjects were required to identify characters from among a set of recognition items. Three major findings in the study showed that subjects used phonological codes while identifying Chinese characters:

> 1) Subjects recognized fewer phonologically similar characters than phonologically dissimilar ones; 2) The phonological confusion effect varied with degree of phonological similarity among the characters read. Characters having the same rhyme and same tone were recognized less accurately than characters of the same rhyme but different tones, which in turn were recognized less accurately than characters of different rhymes and different tones; 3) Silent reading and oral reading resulted in similar patterns of phonological confusion, indicating that similar codes were activated during the two reading conditions. (p.323)

With several experiments indicating phonological recoding as a universal process, researchers, such as Perfetti and Zhang have proposed a "Universal priciple" to support phonological activation across writing systems. However, whether phonological recoding is necessarily involved in word recognition and reading is still controversial among researchers. Meyer and Ruddy (1973) propose a middle ground, a parallel horse-race model. They claim that lexical memory is accessed through both visual and speech representation of a word. The phonemic codes will affect reaction time only when the speech route locates the lexical entry first. The lexical entries can be accessed by both phonemic codes and visual codes.

Tzeng, Hung, and Garro (1978) asked subjects to read Chinese characters which contain phonetic components and characters which are pictographic in origin.

They found significant left visual field superiority in subjects' recognition performance, which suggests that both types of characters are processed first in the right hemisphere. The right hemisphere is recognized to be superior in performing visual and spatial tasks. Tzeng et al. summarize their studies and various other studies and comment:

> Our view is that even if the thesis that lexical access can occur directly from visual input is valid in reading individual Chinese characters, it if possible that phonemic recoding may still be needed at a later stage (e.g., the working memory stage) of text comprehension. There are at least three reasons why phonemic recoding might be needed at the working memory stage. One is that maybe the storage component operates efficiently only if the representation of the lexical information is in a phonemic code (Atkinson and Shiffrin 1968). Another reason is that the process involved in the parsing and abstraction of syntactic structures may be able to function only on phonemic codes (Kleiman 1975:325). The third reason is that phonemic coding might transform the text into a motor program which would operate at a higher speed (Hardyck and Petrinovich 1970). (p.298-298)

This comment provides a nice linkage to the next topic I would like to address, the role of phonological codes in memory. In the next section, I will discuss in more detail the function of phonetic codes and semantic codes in both short-term and long-term memory.

The role of phonological codes in memory

Memory research conducted in the late 1950s throughout the 1960s often emphasized that an adult human subject tended to recode visually presented stimuli into phonological memory codes (Kroll, 1975). For example, Conrad (1964) found a high correlation between memory intrusion errors and perceptual errors. The memory intrusion errors were made during recall of visually presented stimuli, and the perceptual errors were made while listening to the same stimuli presented aurally. The findings showed that the names of the subjects' recall errors tended to sound like the names of the stimuli no matter how the stimuli were presented, visually or aurally.

Kintsch and Buschke (1969) also provided evidence that visually presented memory stimuli were often remembered acoustically. They presented lists of 16 words containing either homophone pairs or unrelated words. After each list, one of the words in the sequence was presented as a probe for subjects to recall the word that had followed the probe word in the list. They found that the recall was poorer when the list contained homophones. Dale and Gregory (1966) presented a distractor experiment to show the amount of interference caused by acoustically similar distractors presented during a memory retention test. They found that subjects' memory is often worse when the words in the distractor task sound like the names of the visually presented memory stimuli.

A mass of the memory research, including the studies mentioned above, mainly deals with the issue of short-term memory. Short-term memory is presumed to last from few seconds to several minutes after training. Short-term memory is also presumed to initiate the long-term process. As long as it endures, short-term memory continues to stimulate the development of long-term memory (Squire, 1975). A considerable amount of evidence suggests that short-term memory is primarily acoustical in nature (Murdock, 1968; Murdock & Walker, 1969; Conrad & Hull, 1968). On the other hand, long-term memory has been recognized as a semantic modality. Baddeley (1966) reported that long-term memory was found to be impaired by the semantic but not acoustic similarity, and stated as follows:

> It seems then that whereas STM (short-term memory) relies very largely on acoustic coding and is relatively unaffected by the semantic content of the message to be stored,... LTM (long-term memory) uses semantic coding extensively,... though not exclusively. (p.308)

The view that short-term verbal retention is from a phonetic modality while long-term verbal retention is from a semantic modality is widely accepted in the psychological literature. However, scholars, like Wickelgren (1965) proposed a different view that suggests the semantic coding can appear in short-term memory as well as long-term memory, and vice versa. Over all, the greater involvement of phonetic coding in short-term memory for processing and retention of linguistic stimuli is still the prevailing assumption.

Another important reason for studying phonological codes is that the capacity of short- term memory for acoustically encoded stimuli is greater than for visually encoded ones (In Mori, 1997. Baddeley, 1981;Baddeley & Hitch, 1974; Vallar & Baddeley, 1984). Baddeley (1966b) had claimed that phonological encoding provided a trace in short-term memory superior to what visual encoding process can offer. Later, Posner and Keele (1967) echoed this claim in a reaction-time experiment. They first showed the subject a memory letter and then, following a brief retention interval, a test letter. Immediately after seeing the lest letter, the subject had to identify as rapidly as possible if the memory letter and the test letter had the same name. The result showed that the subjects responded most rapidly when the memory and test letters were visually identical with an extremely short retention interval. When the retention interval lasted over 1.5 sec, the subjects responded as quickly to name-same, case-different pairs (i.e. "A" and "a") as to name-same, case-same pairs (i.e. "A" and "A"). This experiment concluded that the visual memory trace seems to drop off rapidly in short-term memory. With slightly longer retention intervals, the subjects were apparently using some nonvisual memory code in short-term memory.

Tzeng and Wang (1983) further showed that not only English-speaking readers but also Chinese readers use phonological codes to access short-term memory. These studies suggest a new function of phonological codes: It is primarily to facilitate the registration of information in short term memory in reading, instead of for the function of lexical access. Furthermore, research in reading indicates that segmental information must be held in short term memory in order to be integrated into higher verbal process, such as syntactic and discourse analysis; therefore, a longer and more complex linguistic passage can be comprehended. Recent short-term memory studies reported that the memory performance of Chinese speakers was impaired more by phonological than graphic similarity. (Mou & Anderson, 1981; Yik 1978) These reading studies suggest that readers use phonological codes to store information in short-term memory, regardless of their language backgrounds.

Processing strategies in different orthographies

Orthography is defined by Scheerer as the relation between a script and its language (1986, In Katz & Frost, 1992). In the earlier chapter, I described two main types of writing systems: Phonographic and morphographic. Indo-European Languages, such as English, are recognized as having phonographic writing systems. Chinese is typically identified as morphographic writing systems. Orthography of Japanese is mixed with phonographic and morphographic systems. Therefore, in the present chapter, I will further discuss different characteristics of Chinese, Japanese and English orthography. Then, I will present some previous literature that discussed different reading processing strategies used with different orthographies.

Chinese: Logographic-phonetic

At one point, Chinese was recognized as logographic writing system. However, a pure logograghic writing system indicates that the orthography has no phonetic component. A reader would have to remember, without a phonetic cue, a pronunciation for each of several thousand logographs. Defrancis (1989) claimed that a pure logography would not suffice for categorizing Chinese; therefore, the term, logographic-phonetic was proposed. It strongly emphasized the phonetic components of Chinese characters.

In Chinese orthography, a character specifies a unique spoken morpheme. Words may consist of one or more characters, so they are either mono-morphemic or poly-morphemic. Chinese morphemes are mainly monosyllabic, and since the combinations of possible syllables are limited, there is a high number of homophones in the language. Therefore, Chinese orthography has to distinguish the different meanings of morphemes that sound alike, or it is impossible for a reader to determine the meaning of each homophone, except from a sentential context.

Japanese: Syllabic

In contrast to Chinese, spoken Japanese is polysyllabic and is composed of regular syllable-like components, called moras. Therefore, Japanese orthography, *kana (hiragana and katakana)*, represents the syllabic spoken system. Mori (1998) states:

> An ideal example of a phonography is Japanese kana, consisting of 48 syllable signs, each of which, together with some diacritical devices, provides a complete syllabic representation of Japanese language. (p.70)

However, *kana* alone does not complete Japanese orthography. Since there is a great deal of homophones in the language, the use of *kana* alone presents problems to readers in Japanese. There is another main component of Japanese orthography, *Kanji*, literally meaning Chinese character. *Kanji* is routinely mixed with the use of the kana in Japanese writing system. Different characters are used to represent homophones to distinguish different meanings in writing. An interesting point of *kanji* is that a single character is associated with multiple pronunciations ("On" or Sino-Japanese readings and "Kun" or native Japanese readings). The correct reading of a given character is to a large extent determined by the context. Therefore, Japanese kanji is claimed to be more phonologically ambiguous than Chinese. In both Chinese and Japanese kanji, there is a "reading-aid" to help beginning readers be familiar with the pronunciations of characters (i.e. "pin-yin" in Chinese and "furigana" in Japanese).

<u>English: alphabetic</u>

English has less homophony and more polysyllabic morphemes than Chinese and Japanese. In addition, the structure of the English syllable is generally more complex than Chinese and Japanese, containing a large number of phonologically accessible clusters. English, for example, is said to have at least 8000 syllables in its phonology, compared to Chinese, which has less than 1300 (Defrancis 1989). Because of the vast amount of syllables, English orthography is less suitable for representation by a syllabic system than by an alphabetic system. An alphabet generally represents phonemes which offers a sound-spelling correspondence in alphabetic languages. However, the sound-spelling correspondence is not always regular in some languages, i.e. English. All alphabetic languages can be classified as having deep or shallow orthographies, according to the transparency of their letter-to-phoneme correspondence. Katz and Frost (1992) further explain:

> An orthography in which the letters are isomorphic to phonemes in the spoken word (completely and consistently), is orthographically shallow. An orthography in which the letter-phoneme relation is substantially equivocal is said to be deep (e.g., some letters have more than one sound and some phonemes can be written in more than one way or are not represented in the orthography). Shallow orthographies are characteristic of languages in which morphemic relatives have consistent pronunciations. (p.71)

The orthography of Hebrew, for example, is said to be deep. In Hebrew, all diacritics that represent nearly all the vowels and are used to distinguish some of the consonants are omitted in writing. In strong contrast to Hebrew orthography is the Serbro-Croatian orthography. Serbro-Croatian, a major language of Balkan Peninsula, is said to have a shallow orthography. In Serbro-Croatian orthography, each letter represents only one phoneme, and each phoneme is represented by only one letter. English orthography lies between Hebrew and Serbo-Croatian. The sound –spelling correspondence is not always consistent in English, for instance, identical pronunciations for different spellings (i.e., PEEL and DEAL) and same spellings for different pronunciations (i.e., HEAL and HEALTH). Therefore, English is classified to be a deep orthography.

After an overview of different types of orthographies, we start to understand that readers in different orthographies may use different reading strategies. For example, readers in shallow orthographies may easily process a word through phonological coding. In contrast, deep orthographies may encourage a reader to process printed words by the word's visual graphic structure. Tzeng and Hung (1981) also indicate that orthographies vary considerably in the demands they place on the reader. They further explain,

> Compared with Vietnamese, English is a rather deep orthography and thus demands greater phonological development on the reader's part. It is quite possible that differences in orthographies along this dimension affect the use of speech recoding

> in silent reading. If the written forms on the page stand in a regular relationship to the sounds of language, the reader may use the grapheme-sound rules to help derive the meanings of words. Such a path would be difficult for readers of Chinese to follow, but it would be very possible for readers of English. (p.250)

Reading research, mainly in alphabetic languages, has extensively investigated the relationship between phonological skills and reading comprehension skills (Bradley & Bryant, 1983; Liberman & Shankweiler, 1989). In a longitudinal study, German children were tested on phonemic awareness in kindergarten (Naslund & Schneider, 1991). The measure was used as predictor of later reading comprehension and decoding ability in second grade. The results were that German children with poor phonemic awareness performance in kindergarten were poorer at comprehension, and slower at decoding in second grade than those with better phonemic awareness performance.

Recently reading research in developmental psychology has extended interest to readers in non-alphabetic languages. Hanley and Huang (1997) investigated the relationship between performance on tests of phonological awareness and learning to read Chinese. They performed an experiment comparing eight-year old children learning to read Chinese in Hong Kong and Taiwan with children learning to read English in the U. K. The results showed that phonological awareness was significantly correlated with reading test scores in both

Chinese and British children. The study also revealed that the nature of phonological awareness skills differed in the Chinese and British children. For instance, Children in Hong Kong showed a better result in deleting the initial phoneme from words starting with consonant clusters than British children. On the other hand, British children performed better than Chinese children at deleting the initial phoneme from words starting with a single consonant. Researchers explained the result in terms of the Chinese and British children's familiarity with different syllable structures, and with different types of orthographies.

Due to the different internal structures of writing systems, it is believed that the strategies used to derive phonological codes from visual presentation may vary from language to language. Research in second language acquisition also provides some evidence to support the idea that L2 learners transfer L1 linguistic experiences (i.e. orthographic processing strategies) to L2 learning.

Koda (1988, 1989, 1990) examined the phonological processing abilities of native English readers, and of Arabic, Spanish, and Japanese learners of English. Arabic and Spanish learners represented nonnative phonographic groups, and Japanese students represented a nonnative morphographic group. Subjects were tested on their ability to process phonologically inaccessible symbols. The results indicated that the performance of both the native English group and nonnative phonographic groups was inferior to the nonnative morphographic group in the tasks of the absence of phonological clues. From the results, Koda claimed that students in the phonographic groups depended heavily on the phonological clues available in the visual presentations. On the other hand, students in the morphographic group used different strategies to process phonologically inaccessible symbols. The transfer of L1 reading strategies to L2 reading was suggested in the study.

Mori (1997) also argued that the students from different writing backgrounds used different strategies in *Kanji* recognition. A number of pseudo-Kanji characters were constructed. One set of characters was combined with Japanese *kana* that gave students phonological information. The other set of characters was compounds of semantic radicals and unpronounceable graphemes, which did not indicate any phonological information. In the recognition tasks of the pseudo-characters, students from phonographic backgrounds more easily remembered the phonologically accessible characters than the phonologically inaccessible characters. In contrast, the absence of phonological clues didn't hinder the memory performance of students in the morphographic group. Thus, Mori argued that L2 learners from a morphographic writing system use more flexible strategies for phonological decoding for new characters than learners from a phonographic language background.

Researchers in reading generally believe that readers from different orthographic groups operate under different phonological processing strategies. However, to what degree are the phonological processing strategies different? With different degrees of the phonological recordability (i.e., how systematically the graphemic representation can be converted into the phonological representation), several different reading strategies were investigated among phonographic languages. Some examples of these are lexical analogy, grapheme-phoneme correspondence (GPC) rules, and a combination of the two (Coltheart, 1978; Glushko, 1979; Henderson, 1985; Patterson & Morton, 1985; Rosson, 1985). As noted earlier, readers who can operate GPC rules tend to be better readers in alphabetic languages.

Conversely, how do readers from the morphographic writing systems operate phonological recoding strategies? The most common strategy is memory search (Koda, 1990). In memory search, the graphic representation serves as primary activator to obtain its phonological code. Although some people argue that some Chinese characters consist of phonetic radicals that give phonological information, the phonetic radicals themselves are single characters. To obtain the pronunciations of phonetic radicals still requires going through memory search first. Therefore, phonological information of Chinese characters is not completely visually accessible.

However, memory search is not the only strategy used by morphographic readers. In fact, morphographic readers often encounter a lot of characters that they have never seen before, as well as some pronunciations of characters that they can not recall. It is highly possible that alternative strategies are also available for morphographic readers when they have to deal with the characters that do not exist in their memory. Koda (1990) pointed out a longitudinal study that investigated the acquisition of Kanji among Japanese children. The study showed when children encountered an unfamiliar character, they used the sound of the radical within the character, or they borrowed the sound of another character that is either related to, or visually similar to the target character. The study indicates that when the identification of a character fails in memory search, alternative strategies will be applied. Also, there is a famous Chinese saying for reading characters: 有邊讀邊，沒邊讀中間 (If there is a pronounceable side within a character, read the side. If neither side is pronounceable, read the middle component.) This strategy is similar to the method, CCRM, which introduces phonetic radicals to students to facilitate reading, or possibly memorization.

In sum, previous studies have supported the idea that phonographic readers depend more heavily on the phonological information presented in visual presentations than do morphographic readers. This analysis has led to one of the initial research questions in the current study: when phonetic radicals are not available in characters, will recognition performance of phonographic readers be much more impaired than that of morphographic readers?

CHAPTER III

METHOD

This study was designed to be a correlation study, which two classes of university students participated in. Students' performances were not compared across or between groups, but instead were correlated within each individual. The present project originally was inspired by Tsai's (1997) master thesis. In Tsai's experiment, she used phonetic-ideograph strategies to teach CFL (Chinese as a foreign language) students in an experimental group to recognize the pronunciation of characters, and used a more traditional approach with a control group. However, in the current study, the phonetic-ideograph strategies were introduced to all students in the beginning Chinese program as a part of their curriculum.

General Design of the Study

This project was designed to be carried out at the end of the second quarter-term of the beginning Chinese program. The beginning Chinese program consists of three quarters. In the first quarter, students ideally should master 246 Chinese characters. The number of characters taught increases to 362 characters by the end of the second quarter-term. Students also received concomitant instructions about the phonetic radical and the semantic radical while learning each new character. The instruction on phonetic-ideograph strategies basically helped students to distinguish semantic radicals and phonetic radicals within characters. In addition, students were trained to pronounce characters by their phonetic radicals. Eighty-five phonetic radicals and sixty-two semantic radicals were introduced to students. The 85 phonetic radicals are also characters themselves. For example, the phonetic radical, 亡 *wang*, is in such characters as 忘 *wang* "forget" and 妄 *wang* "false", but it is also a character which means "to die". This is the kind of phonetic radical that students during the first quarter were expected to become familiar with in order to treat them as pronunciation clues within characters.

Starting in the first quarter, subjects received a half-hour of instruction on basic phonetic-ideograph strategies every week. By the end of the second quarter, students had been exposed to the phonetic-ideograph strategies for about six months. The researcher expected that the students would treat the phonetic radicals as elements within characters, instead of as individual characters. This research was dependent on this condition and was designed to test if students were able to apply the phonetic-ideograph strategies in character learning and memory retention.

Subjects

This study was conducted on college students who were enrolled in Chinese classes at the beginning level at a public university in Oregon. At the beginning level, most students have little or no knowledge of Mandarin Chinese. The investigator was introduced to students as the Chinese character instructor, and was in charge of any questions related to characters starting from the first quarter-term of the school year. All subjects received the same formal instruction on semantic and phonetic radicals in Chinese characters. Students' first-language backgrounds were English and Japanese. The English-speaking students were considered to be the phonographic group, and the Japanese-speaking students were the morphographic group. There were 18 English-speaking students, and 5 Japanese-speaking students participating in the study.

On the first day of class in the first quarter, students were informed that the experiment would be conducted at the end of the second quarter. Also, subjects were well informed that their performances and test scores in the experiment would not affect their course grades in any way. The participation in the research was entirely voluntary. All subjects received the same treatment throughout the experiment.

Materials

Two character-learning sets were designed by the researcher for data collection purposes. The characters chosen for the learning section were rare ones, unfamiliar to all students including native readers of Japanese. All the test characters were chosen from two Chinese dictionaries, 辭源修訂本 and 大辭典. One set of characters consisted of phonologically accessible characters, which means characters containing phonetic radicals. The other set consisted of phonologically inaccessible characters, which means characters not containing phonetic radicals (see Appendix B and C). The lists were assembled in two steps: first, fifty-three phonologically inaccessible characters and fifty-four phonologically accessible characters were chosen by the researcher. Second, three Japanese graduate-level students and three fourth-year Chinese students tested the character lists to insure that they were likely to be completely unknown to the experiment subjects. The Japanese students and advanced Chinese students were asked to cross out all characters that they already knew. A total of 30 characters, 15 from each set, were chosen.

The average number of brush strokes for the two sets of characters was 18.4. Compared to the average number of brush strokes in the lexicon, which is about 12, the characters chosen in the learning session are unusual and complex. The reasons for choosing complex characters were to avoid characters which Japanese subjects already know and to ensure that the phonetic radicals correspond perfectly to the pronunciations. Rare and complex characters have undergone fewer shifts in pronunciations and usage than the more common characters; therefore they tend to have the same pronunciations as their phonetic radicals. For instance, 黐 *li* and its phonetic radical 离 *li*, 鬟 *huan* and its phonetic radical 睘 *huan*, 霤 *liu* and its phonetic radical 留 *liu*, are all perfect homonyms. Along with each character the character's meaning was provided in English, but the pronunciation was not provided. These two character learning sets were used in a learning session for students to memorize them.

The character sets served as the basis for two written tests. One was an immediate character recognition test and the other was a long-term recall test that was conducted in the second week after the immediate recognition test. The two tests (see Appendix D and E), based on the 30 characters from the learning sets, were designed in the same format containing a blank space for the character's pronunciation and another blank space for its meaning. Each test contained two separate sections: phonologically accessible characters (Section I) and phonologically inaccessible characters (Section II). The total number of characters for each test was 20, of which ten were phonologically accessible and ten were not. Since subjects were not likely to access the pronunciations for phonologically inaccessible characters without having being given any rule to apply, trying to provide pronunciations for those characters might cause some frustration. Therefore, subjects were required to fill in pronunciations only for the phonologically accessible characters. Subjects were told to present characters' pronunciations by the Pin-yin system, and indicate the characters' meanings in English. The Pin-yin system, which has been standardized in Mainland China since the 1960s, transcribes Chinese pronunciation with alphabetic spellings. Subjects in the study had been required to read and write and master the Pin-yin system in the first two weeks of the program.

Research Procedures

There were three major procedures in this study: the character learning session, the immediate character recognition test, and the long-term character recall test.

These procedures were given to the subjects during their regular class-time. Students in the same class learned characters and took tests together. The learning session and the immediate test were given in the eighth week of the second quarter-term, and the long-term test was given in the tenth week. There were 12 days between the immediate test and the long-term test.

Character learning session:

During the character learning sessions, all subjects were asked to memorize the meanings of characters presented on an overhead projector, character by character (examples see Appendix F). Each character was shown for fifteen seconds to all subjects in a same order. The characters were mixed randomly between phonologically accessible and inaccessible characters. After all the characters were shown, each character was shown again, in the same order, at the rate of ten seconds per character. After completing the second showing of characters, the researcher showed all the characters again, in a random order, each character for five seconds. Thus, students in this session were exposed to each character three times, for a total of thirty seconds each.

Immediate recall test:

Immediately after the learning session, students were given the immediate character recognition test. There were two sections in the test: section I contained characters with phonetic radicals and section II contained characters without phonetic radicals. In section I, both pronunciation and meaning of each character were tested. Subjects were informed that they could fill in more than one answer for the pronunciations, since most phonetic radicals imply more than one pronunciation. In section II, only the meaning of each character was tested. The test format remained the same as section I which had blanks for both pronunciations and meanings. Students were told that it was not required to fill in the pronunciation in the section II; however, guessing the pronunciation was encouraged. Twenty characters were randomly chosen to test the subjects from the 30 characters in the learning session. Ten characters were left out to minimize the chance of guessing. The subjects were given 10 to 15 minutes to finish the test.

Long-term recall test:

The long-term recall test was conducted twelve days after the immediate character test. Students received no coaching or review before the test was given. In addition, there was no special instruction on phonetic-ideograph strategies in the period between the immediate character test and the long-term recall test. All subjects received only the information from the regular class textbooks, from which all references to character structure had been removed. The format of the long-term recall test was similar to the immediate character test. All characters contained in the long-term recall test were chosen from the learning session, and the majority of characters overlapped with the immediate character test. The total number of characters in the long-term test was also 20, ten for each section.

Subjects were also given 10 to 15 minutes to finish the test. The data of this study was collected from both tests.

Data analysis and scoring

Subjects' ability to apply the phonetic-ideograph strategies was shown in the written pronunciation test. Subjects indicated the pronunciations of characters by the Pin-yin system. Each correct pronunciation was counted as two points. Since the phonologically accessible characters were carefully chosen so that the phonetic radicals perfectly corresponded to the pronunciations, there was supposed to be only one correct pronunciation for each character. However, in many cases, the phonetic radicals only cue the rhymes of the pronunciations. Therefore, the correct rhymes (finals) of the pronunciations were counted as one point, and the correct initials of the pronunciations were counted as one point. In the meaning recall test, each correct meaning was counted as two points. However, the students' responses for character meanings only needed to be similar to the English translations provided by the researcher. For example, the character /liang/ and the meaning"to oberve" were provided by the researcher. However, students' answers, such as "to watch" or "to see", were accepted by the researcher. In the case of the character 鬟 /huan/ "a female servant", answers, such as "female" or "girl", were not accepted as correct answers. The total scores for the immediate and for the long-term test were sixty points.

In both the immediate and long-term recall tests, the Pearson's product-moment correlation coefficient was used to measure the relationship between subjects' pronunciation test scores and their meaning test scores. In each language group, a two-sample t-test was used to measure the relationship between the meaning scores in phonologically accessible characters and in phonologically inaccessible characters.

CHAPTER IV

RESULTS

In this chapter, the Pearson product-moment correlation coefficient is used to measure the correlation between subjects' pronunciation scores and their meaning test scores. The probability level used for rejecting the hypotheses is .05. If the p value is .05 or less, the hypotheses are not rejected, and vice versa.

In the two language groups (English speaking group and Japanese speaking group), the t-test was used to measure the relationship between the meaning scores in phonologically accessible characters (Type I characters) and in phonologically inaccessible characters (Type II characters). The t-test was used to compare the mean difference between the two groups. In other words, one t-test was used to compare meaning scores between Type I and Type II characters in the phonographic group (English speakers), and one was used to compare the scores between the two types of characters in the morphographic group (Japanese speakers). The probability level used to reject the hypotheses is also .05.

Research Hypotheses

There were two major measures operating in the study: one immediate test and one long-term test. The statistical results of the two tests are reported in this chapter. The tests were administered in order to test students on: 1) their ability to use the phonetic-ideograph strategy for decoding characters' pronunciations, and efficiency at learning the meaning of a character; 2) long-term retention of characters; 3) different orthographic processing strategies. There are four hypotheses in the study:

1. There will be a significant positive correlation between the pronunciation scores of characters and the meaning scores of characters in the immediate recall test.
2. There will be a significant positive correlation between the pronunciation scores of characters and the meaning scores of characters in the long-term recall test.
3. Phonographic students will tend to show a difference in recognizing the meanings of phonologically accessible and phonologically inaccessible characters.
4. Morphographic students will tend to show no difference in recognizing the meanings of phonologically accessible and phonologically inaccessible characters.

General Statistics

Relationship between pronunciation recall and meaning recall

Immediate recall test (section I):

A descriptive result of the first section in the immediate recall test for all subjects is reported in Table 1. Subjects scored from 0 to 20 points out of 20 total points with a mean of 8.2174 points in character pronunciation recall. In character meaning recall, subjects scored from 6 to 20 points out of 20 total points with a mean of 15.8261 points.

The relationship between the pronunciation scores and the meaning scores is shown in Table 2. It indicates a correlation coefficient of 0.552, and p value of 0.003 ($p< 0.05$). Therefore, it shows all students demonstrated a significant positive correlation between the pronunciation scores and the meaning scores at a 0.05 significance level (one-tailed).

Table 1.
Descriptive Statistics in the immediate recall test (section I)

	N	Minimum	Maximum	Mean	Std. Deviation
pronunciation score (section I)	23	.00	20.00	8.2174	7.7633
meaning score (section I)	23	6.00	20.00	15.8261	4.9327

Table 2.
Correlations between pronunciation scores and meaning scores in the immediate recall test (section I)

		Meaning score
Pronunciation score	Pearson Correlation	. 552*
	Sig. (one-tailed)	.003

*. Correlation is significant at the 0.05 level

In Figure 1, the relationship between pronunciation scores and meaning scores is also demonstrated. It clearly shows a positive correlation between the two measurements. Students who have a higher pronunciation score have a higher meaning score. Therefore, the first hypothesis is supported.

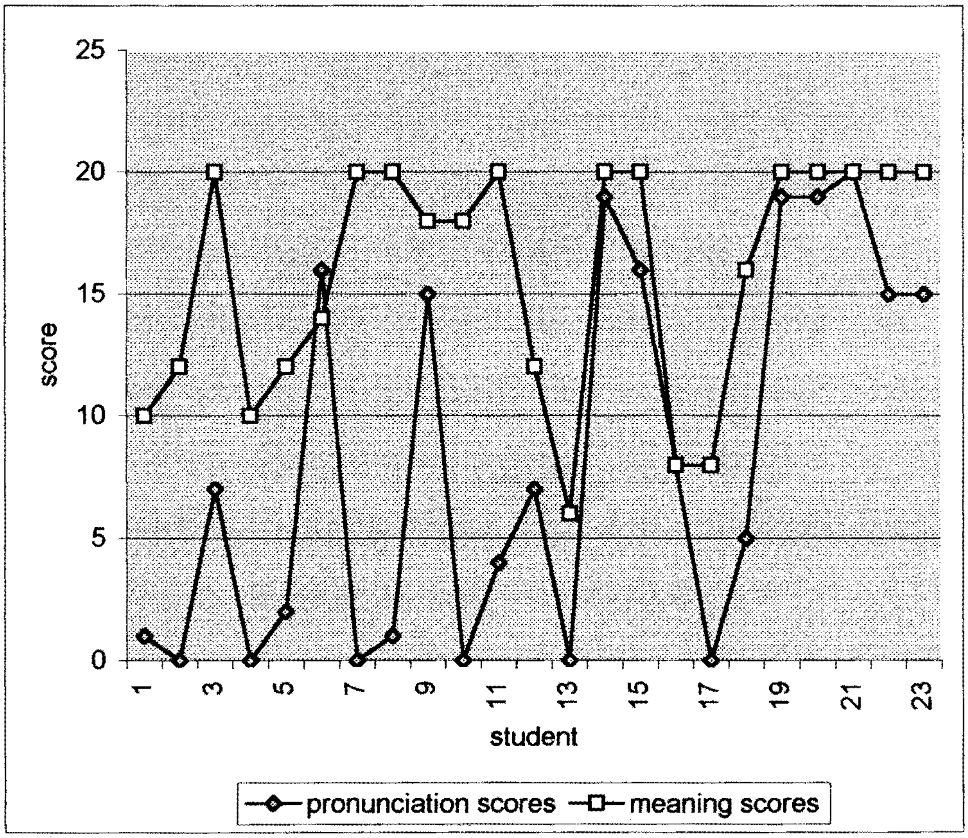

Figure 1. The relationship between pronunciation scores and meaning scores in the immediate recall test (section I)

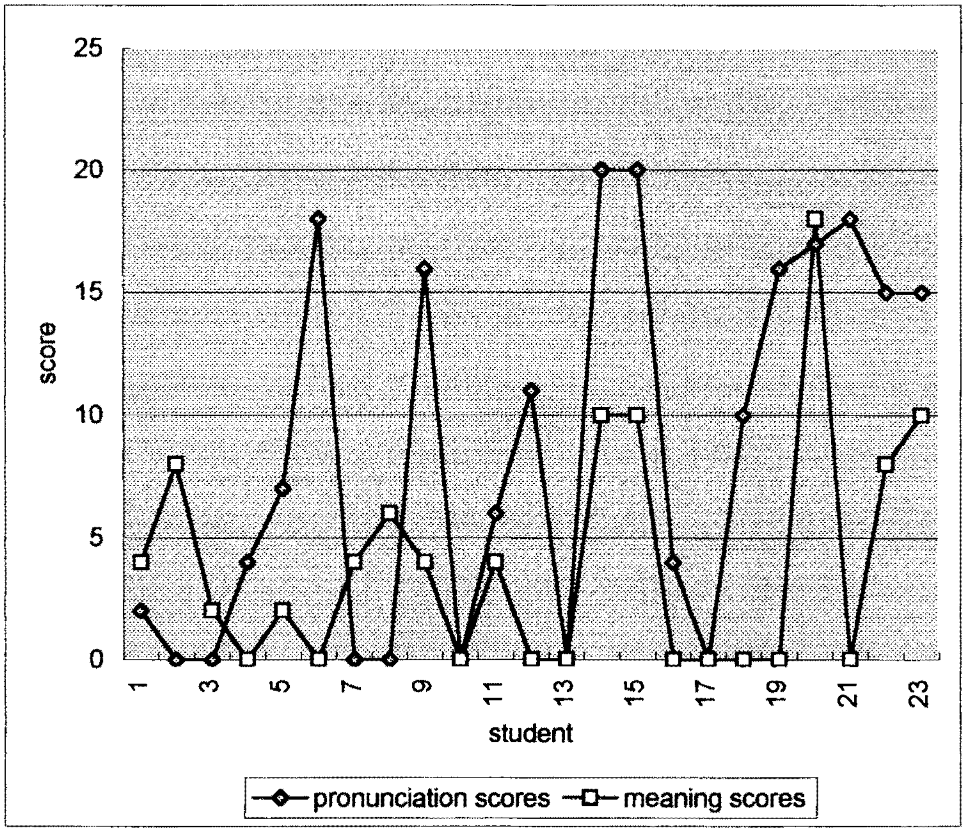

Figure 2. The relationship between pronunciation scores and meaning scores in long-term recall test (section I)

Long-term recall test (section I):

The results of long-term recall test are reported in Table 3. The pronunciation score ranges from 0 to 20 out of total 20 points with a mean of 9.3043. The meaning score ranges from 0 to 18 out of 20 points with a mean of 3.9130. The correlation between pronunciation scores and meaning scores is shown in Table 4.

Table 3.
Descriptive Statistics in the long-term recall test (section I)

	N	Minimum	Maximum	Mean	Std. Deviation
Pronunciation (long-term)	23	.00	20.00	8.6522	7.7437
Meaning (long-term)	23	.00	18.00	3.9130	4.8045

Table 4.
Correlations between pronunciation scores and meaning scores in the long-term recall test (section I)

		Meaning score
Pronunciation score	Pearson Correlation	. 375*
	Sig. (one-tailed)	.039

*. Correlation is significant at the 0.05 level

There was a correlation coefficient of 0.375, and p value of 0.039 ($p<0.05$). This result also demonstrated a significant positive correlation between pronunciation scores and meaning scores at a 0.05 significance level (one-tailed). Figure 2 shows the relationship between pronunciation scores and meaning scores. Compared to Figure 1 (immediate recall), the tendency that students who had higher pronunciation scores had higher meaning scores is not as clear in Figure 2 (long-term recall). Note that the correlation coefficient between pronunciation scores and meaning scores in the long-term recall test is 0.149 lower than in the immediate recall test.

Meaning scores between Type I and Type II characters in the phonographic group

Immediate recall test:

As seen in Table 5, English-speaking subjects achieved a mean score of 14.6667 out of 20 total points for Type I characters and a mean score of 12.3333 for Type II characters. A t-test was used to detect a difference in English-speaking subjects' performance between the two types of characters. Table 6 shows a p value of 0.016 ($p<0.05$), which indicates a significant difference in the meaning scores between Type I characters and Type II characters for English speaking subjects.

Table 5.
Descriptive Statistics of meaning scores of the phonographic group in the immediate recall test

	N	Minimum	Maximum	Mean	Std. Deviation
meaning score (Type I)	18	6.00	20.00	14.6667	4.9941
meaning score (Type II)	18	.00	20.00	12.3333	7.2029

Table 6.
t-test on meaning scores of the phonographic group between Type I and Type II characters.

			Pair 1
			Meaning scores
Paired Differences	Mean		2.3333
	Std. Deviation		3.7101
	Std. Error Mean		.8745
	95% Confidence Interval of the Difference	Lower	.4884
		Upper	4.1783
t			2.668
df			17
Sig. (2-tailed)			.016

Long-term recall test:

In the long-term recall test, English speaking subjects achieved a mean score of 3 out of a total of 20 points for the type I characters, and a mean score of 1.6667 for the type II characters. (see Table 7) Also as shown in Table 8, the t-test produced a p value of 0.029 ($p<0.05$), which indicates a significant difference between recognizing the two types of characters. From both recall tests, a significant difference between the two types of characters is shown. Therefore, the third hypothesis, phonographic students tend to show a difference in recognizing the meanings of the two types of characters, is supported.

Table 7.
Descriptive Statistics of meaning scores of the phonographic group in the long-term recall test.

	N	Minimum	Maximum	Mean	Std. Deviation
meaning score (Type I)	18	.00	10.00	3.0000	3.5147
meaning score (type II)	18	.00	10.00	1.1111	2.5870

Table 8.
t-test on meaning scores of the phonographic group between Type I and Type II characters

			Pair 1
			Meaning scores (Type I and Type II)
Paired Differences	Mean		1.8889
	Std. Deviation		3.1039
	Std. Error Mean		.7316
	95% Confidence Interval of the Difference	Lower	.3454
		Upper	3.4324
t			2.582
df			17
Sig. (2-tailed)			.019

Meaning scores between Type I and Type II characters

in the morphographic group

Immediate recall test:

Japanese subjects performed a mean score of 20 out of total 20 points for both Type I and Type II characters. Therefore, there was no difference between recognizing Type I and Type II characters. The t-test was not able to produce in this measure (see Table 9). From this observation, it can be seen that morphographic subjects exhibited no difference in the recognition of both types of characters.

Table 9.
Descriptive statistics of meaning scores of the morphographic group in the immediate recall test

	Mean	N	Std. Deviation	Std. Error Mean
meaning score (type I)	20.0000	5	.0000	.0000
meaning score (type II)	20.0000	5	.0000	.0000

a The correlation and t cannot be computed because the standard error of the difference is 0.

Long-term recall test:

Japanese subjects produced a mean score of 7.2 in Type I characters, and a mean score of 6.4 in Type II characters (see Table 10). In Table 11, a p value of 0.587 ($p>0.05$) was produced in the t-test. It indicated that there is no significant difference between recognizing Type I and Type II characters for Japanese subjects. From both the immediate and the long-term tests, there was no significant difference found in the recognition of the two types of characters for Japanese subjects. Therefore, the fourth hypothesis, that morphographic students tend to show no difference in recognizing both types of characters, is supported.

Table 10.
Descriptive Statistics of meaning scores of the morphographic group in the long-term recall test.

	N	Minimum	Maximum	Mean	Std. Deviation
meaning score (type I)	5	.00	18.00	7.2000	7.5631
meaning score (Type II)	5	2.00	18.00	6.4000	6.6933

Table 11.
t-test on meaning scores of the morphographic group between Type I and Type II characters.

			Pair 1
			Meaning scores (Type I and Type II)
Paired Differences	Mean		.8000
	Std. Deviation		3.0332
	Std. Error Mean		1.3565
	95% Confidence Interval of the Difference	Lower	-2.9662
		Upper	4.5662
t			.590
df			4
Sig. (2-tailed)			.587

CHAPTER V

DISCUSSION AND CONCLUSION

This chapter discusses the statistical results of all the measurements being used in the study. There are four hypotheses in the study. The first and second hypotheses state that there will be a positive correlation between characters' pronunciation scores and meaning scores in both immediate and long-term recall tests. The third and fourth hypotheses state that there will be a difference between the meaning scores of Type I and Type II characters in the phonographic group, and there will not be a difference between the meaning scores of Type I and Type II characters in the morphographic group. The results in Chapter IV showed that all the hypotheses posed in the study were supported. Characters' pronunciation scores correlated positively with the characters' meaning scores. A difference between Type I and Type II characters was detected in the phonographic group, but no difference was detected in the morphographic group.

There are also some interesting observations to be found in comparing the results of the immediate recall test and the long-term recall test. However, there was no hypothesis made about such results. It is also important to note the difference between the phonographic group and the morphographic group, and furthermore to interpret the significance of the findings in these two groups.

Interpretation of the correlation between the pronunciation scores and the meaning scores in the immediate recall test.

The results showed a positive correlation between the pronunciation scores and the meaning scores in the immediate recall test, which means that a student with a higher pronunciation score generally has a higher meaning score. It is assumed that the phonetic-ideograph strategies were used by students when they answered the pronunciations correctly or partially correctly, since the pronunciations of characters in the learning session were not provided. Since the higher pronunciation scores correlated with the higher meaning scores, this indicates that the phonetic-ideograph strategies helped the meaning recall. However, other processing strategies were also observed in individuals. In Figure 1 (p. 49), there were two students who scored 0 points out of total 20 points in the pronunciation part, but 20 points and 18 points out of total 20 points in the meaning part. The two students apparently did not use phonetic-ideograph strategies to decode the characters' pronunciations; therefore, it was assumed that the two students might operate under a visual strategy. This is consistent with the results of Coltheart (1978). Coltheart demonstrated that English speakers identified irregularly spelled words by a direct visual access to a lexicon. In other words, English speakers used a visual strategy to process phonologically inaccessible verbal materials. The two students mentioned above demonstrated that characters were recognized efficiently by a visual strategy in a short period of time. There are another seven students with low pronunciation scores (1 to 10 points) and moderate meaning scores (10 to 15 points). Perhaps this indicates that there still exists a good deal of uncertainty as to how to memorize a character. Many students might be processing characters with a mixture of strategies.

A similar result was found in a pilot study conducted by the researcher in the first quarter term of the program; however, in the pilot study, the majority of students exhibited high meaning scores with low pronunciation scores. Students were assumed to rely heavily on visual processing strategies. There are several experimental studies that yielded similar conclusions. Hayes (1988) found that non-native learners of Chinese pay much more attention to graphic features of characters than native speakers of Chinese. Cziko (1980) also reported that there was still heavy reliance on visual processing strategies for beginning readers in alphabetic second languages.

Since the current experiment was carried out in the second quarter of the program, students had more time to familiarize themselves with the phonetic radicals as phonological clues within characters. The tests clearly demonstrate those students' increased ability to use phonetic-ideograph strategies: more than half of the students were able to utilize those strategies to memorize characters. In addition to this test result, it seems to imply that a certain amount of instruction and practice may be needed before students can effectively use the phonetic-ideograph strategies. A positive correlation was shown between pronunciation scores and meaning scores; thus, the phonetic-ideograph strategies may be recognized as an efficient way of memorizing characters.

Interpretation of the correlation between the pronunciation scores and the meaning scores in the long-term recall test

The results from this measurement also show a positive correlation between the pronunciation scores and meaning scores. It indicates that students with a higher pronunciation score also have a higher meaning recall score. However, the correlation decreased to 0.375 compared to 0.552 of the immediate recall test. The phonetic-ideograph strategy in the long-term recall test was not as effective as in the immediate recall test since the correlation is weaker in the long-term recall test. This result shows that the phonetic codes seem not to facilitate the memorization of characters in the long-term memory as well as in the short-term memory. Baddeley (1966) indicated that the nature of short-term memory relied heavily on phonetic coding, but on the other hand, long-term memory seemed to be affected primarily by semantic codes. The result of the current study seems to echo Baddeley's description.

There is also another phenomenon observed in the long-term recall test: students tended to remember the pronunciations of the characters better than the meanings. There were four students who had high pronunciation scores (15-20 points) with low meaning scores (0-5). Two students had full points (20 points) in the pronunciation section and only 10 points in the meaning section. It is assumed that these students have not really acquired the phonetic-ideograph strategy to memorize the characters. Instead, they only use the strategy to guess the pronunciations of characters. From the data, there is basically no student who had an impressively high meaning score with an extremely low pronunciation score. Students who were assumed to have used the phonetic-ideograph strategies were better than students who used other strategies not only in recalling the pronunciation but also the meaning.

In the immediate recall test, we monitor two students who scored 0 points in the pronunciation part, but 20 points and 18 points in the meaning section. The two students again performed 0 points in the pronunciation section in the long-term recall test; however, their meaning scores dropped to 4 points and 0 points this time. In other words, they never had any idea how to pronounce the characters, and forgot their meanings as well within twelve days or less. This observation may indicate that the visual strategy is not effective in the meaning retention in the long run. Research on visual memory, such as Murdock and Walker's free recall experiment (1969), also demonstrated the brevity of visual memory trace. They asked subjects to remember lists of items that were either presented acoustically or visually. Then subjects were asked to recall the items in the retention task. The result showed that auditory presentation of list items seemed to be memorized better than visual presentation. Therefore, word recognition in a brief period of time may be accomplished efficiently by the visual processing strategy, but the visual trace dropped out quicker in one's memory than the phonological trace.

Differences in processing strategies between the phonographic group and the morphographic group

The hypothesis is that students who are from different language backgrounds will show a difference between the two types of characters, phonologically accessible and phonologically inaccessible. However, the distinction between phonographic students and morphographic students is not strictly dichotomous. For instance, English-speaking students have some experience with logographic symbols (i.e. the Arabic numerals). Some researchers, such as Kleiman (1975) also claim that experienced readers of English recognize a word as a whole image rather than phonemes. Japanese-speaking students, with knowledge of the *kana* syllabary already use some phonographic strategies of reading. Regardless of this condition, the extent of Japanese-speaking students' exposure to morphographic scripts is much greater than English-speaking students. Therefore the difference between these two groups is still believed to be meaningful. The following is a discussion of the results from t-tests measured between Type I and Type II characters for both the phonographic group and the morphographic group.

<u>In the immediate recall test:</u>

The mean score of the phonographic students in the type I character is 14.6667, and the mean score in the type II character is 12.3333. The t-test showed a significant difference on meaning scores between Type I and Type II characters. It seems to indicate that the absence of the phonological clues in Type II characters impeded the phonological processing among the phonographic CFL students.

In contrast, the morphographic students showed no difference on recalling the two types of characters. The mean score for both types of characters is 20 points. It indicates that the absence of phonetic radicals did not impair the performance in recalling meanings of characters. Morphographic students might not need to depend on acoustic strategies to memorize the new characters in a short time period. Also, morphographic students in this study are experienced learners of characters; therefore, they seem to be good at initial learning of novel characters.

In the long-term recall test:

The mean score of the phonographic students in the type I characters is 3.00, and the mean score of the type II characters is 1.11. There is also a difference detected by the t-test, the significant level is 0.019, which is smaller than 0.05. It indicates that the characters with phonological information are retained longer than the characters without the phonological information in phonographic students' memory. Also, as mentioned in the literature review, a number of researchers believe that the short-term memory is in a phonetic modality; therefore the phonetic codes have been thought to help registering information in short-term memory. The longer the short-term memory persists, the stronger and more durable the long-term memory will be (Squire, 1975). The great facilitation of phonetic codes in short-term memory eventually helps the development of the long-term process.

Therefore, the positive correlation between pronunciations and meanings in the phonographic group is observed both in the immediate and long-term recall tests of the current study. It also conforms to previous studies, which claim that the capacity of memory for phonologically encoded stimuli is greater than for visually encoded ones.

On the other hand, the morphographic students' mean score for the type I characters is 7.20, and for the type II characters is 6.40. The significant level of the t-test is 0.587, which is greater than 0.05; therefore the difference between the two types of characters is not significant. There are a couple interpretations of this result. The first interpretation would be that morphographic students simply do not use acoustical strategies to memorize the characters. However, this interpretation is not convincing, because the morphographic students' scores on the pronunciation part range from 15 to 18 points out of total 20 points. From this, it can be assumed that morphographic students use the phonetic-ideograph strategies while memorizing the characters: because they had not been told the pronunciations beforehand, the only way they could have guessed the pronunciations correctly would have been through using the phonetic-ideograph strategies.

Under the circumstance that morphographic students do process the phonological codes while memorizing the characters, the researcher poses a second interpretation: morphographic students might use a mixed strategy in memorizing the characters. For characters with phonological clues, the morphographic subjects operate the phonetic-ideograph strategy, but for characters without phonological clues, they might operate the visual strategy to memorize. In addition, the morphographic students seem to be very efficient of using the visual strategy to memorize the meanings of characters. It is assumed that the morphographic students are more effective than the phonographic students in using the visual strategy alone to identify the characters.

However, the results from the statistics can not really tell us what kind of strategies the morphographic students use, or how the strategies used by morphographic students differ from those of the phonographic students. The purpose of this study is not to identify the strategies used by the students, but to demonstrate the effects of different first-language backgrounds in the leaning of characters.

Observations between the immediate recall test and the long-term recall test

Twelve days after the immediate recall test, students participated in the long-term test. In the period between the immediate test and the long-term test, there was no formal instruction on phonetic-ideograph strategies at all.

One interesting observation about the two tests is that the meaning scores drop dramatically from the immediate test to the long-term test. The mean score in the immediate test is 15.83, and 3.91 in the long-term test. However, the pronunciation scores stay very close in these two tests. The mean score in the immediate test is 8.22, and the mean score in the long-term test is 8.65. From this observation, it can be assumed that the students might use the strategy only as a general rule for pronouncing characters, and the pronunciations of characters have not yet been associated with the meanings of characters in the long term. The performance of meaning retention in the long-term test may be better if the subjects are experienced and advanced learners of Chinese with a good foundation of sound and graphic relationship.

Another observation concerns the morphographic group. The mean of the meaning scores in the immediate test is 20 points out of a total 20 points for both types of characters; however, the mean score in the long-term test is 7.2 for Type I characters and 6.4 for Type II characters. Compare to the phonographic students, the morphographic students are much better at remembering characters in a short term since they show a perfect score in memorizing characters in the immediate recall test. However, in the long-term recall test their recall scores fall off dramatically. Morphographic students seem to retain the phonologically accessible characters better than the phonologically inaccessible ones over the long run. This observation echoes that phonologically coded materials seem to be favored over visually coded materials in memory.

The pronunciation scores in the immediate test, on the other hand, stay very similar to the ones in the long-term test. There are two students who had 0 points in the meaning section of the long-term test with high pronunciation scores (see Figure 2, student 19 and 21). This observation seems to tell us that morphographic students also pay a lot of attention to phonological clues while memorizing novel characters. However, the phonetic-ideograph strategies seem not to be effective in the long-term test for those two students in memorizing the meanings. One interpretation for this observation is that the morphographic students used the phonetic-ideograph strategies to learn the pronunciations, but they used other strategies (i.e. visual strategies) to memorize the meanings. For example, the students might try to use semantic radicals to memorize meanings. Since the characters are rare characters and the semantic radicals are very abstract, students failed to recognize the characters after a longer period of time. In contrast, the meaning score is very high in the immediate test, because the visual strategies can be really effective in a short period of time, as mentioned earlier.

Limitation for experimental design

Acquiring any kind of learning strategy often requires time to practice and become a skillful learner. The phonetic-ideograph strategies were only taught for two quarter-terms in this experiment. Also, the subjects were the beginning learners of Chinese who had just encountered the overwhelming task of learning Chinese characters. The result might be more convincing if the experiment could be carried out during the whole school year or postponed until students had a more fundamental character background.

Another limitation of this study is that the experiment was only carried out on beginning learners of Chinese. It would also be interesting to introduce the phonetic-ideograph strategy to intermediate or advanced students, and test the effectiveness of the strategy in meaning retention compared to its effectiveness on beginning students. In addition, the long-term test took place a week before the final week. Students might pay much more attention on preparing the final examinations, instead of studying phonetic-ideograph strategies.

Finally, the number of subjects in the study was limited, especially the number of subjects in the morphographic group. Under this situation, although the statistical results were significant, they were not powerful. Therefore, a larger number of subjects should be recruited for future research to see if a more convincing result can be obtained.

Conclusions

This study focused on two important issues: 1) the relationship between knowing the pronunciations of characters and the ability to recall characters. 2) the transfer of processing strategies in orthography from L1 to L2. Findings in this study show that there is a positive correlation between knowing the pronunciations and meaning retention in both short and long periods of time. Moreover, according to the findings, students from phonographic backgrounds perform differently in processing phonologically accessible characters and phonologically inaccessible characters. Students from morphographic backgrounds show no difference in processing the two types of characters. Therefore, the current study surmises that there is a transfer of processing strategies in orthography from L1 to L2.

Implications for CFL teaching

Learning Chinese characters is considered to be a very difficult aspect of studying Mandarin Chinese, especially for students from alphabetic language backgrounds. The written presentation in Chinese contains a lot of graphic information; therefore, beginning learners often rely heavily on a visual strategy to memorize the characters. This leads to a real question of teaching Chinese as a foreign language: how do we help students to pay less attention or more appropriate attention to visual characteristics of characters?

As discussed above, students who can utilize the phonetic-ideograph strategies generally are better able to recall meanings. The phonetic-ideograph strategy provides students with phonological clues to characters. Theoretically, students can develop a better phonological decoding skill, instead of dwelling excessively on the printed characters. By utilizing the phonetic-ideograph strategy, students can relate the pronunciations and meanings of characters much easier. Moreover, the current study shows that characters with phonetic radicals are retained in one's memory much longer than characters without. Various previous studies also demonstrate that visually presented verbal materials are often remembered phonologically in memory. In other words, to help students to develop a foundation of sound and graphic relationships is a crucial and effective way of teaching characters.

The phonetic-ideograph strategy seems to be especially effective with phonographic students, since phonographic students are used to obtaining phonological hints from the print in their L1 writing system. However, the current study also indicates that students from morphographic backgrounds utilize the phonetic-ideograph strategy in learning the pronunciations. Nevertheless, morphographic students apparently use a different strategy to process those characters without phonological clues. They are not as sensitive as the phonographic students to the phonological accessibility of characters. In other words, phonographic students may have a harder time than morphographic students when it comes to memorizing characters that do not contain overt phonological hints. This finding suggests that teachers of Chinese or other logographic languages should pay more attention to the differences between orthographic backgrounds when designing any teaching materials or class activities.

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Appendix A

Informed Consent form

CONSENT FORM

I, ______________________________, agree to take part in this research project on the relationship between Chinese character recognition strategies and the success of character memorization for students of Mandarin Chinese.

I understand that the study involves a thirty-minute learning session on Chinese characters, one immediate recall test and one long-term recall test. Hui-yen Emmy Chen has told me that the purpose of this study is to investigate the effectiveness of the phonetic-ideograph strategies on character recognition and retention.

Hui-yen Chen has offered to answer any questions I have about the study and what I am expected to do. She has promised that all information I give will be kept confidential to the extend permitted by law, and that the names of all people in the study will be kept confidential.

I understand that I do not have to take part in this study, and that I may withdraw from this study without affecting my course grade or my relationship with Portland State University.

I have read and understand the above information and agree to take part in this study.

Date:__________________ Signature:

____

If you have any concerns or questions about your participation in this study, please contact either the Human Subject Research Review Committee, Office of Research and Sponsored Project, 111 Cramer Hall, Portland State University, (503) 725-8182, or Hui-yen Chen, at 1955 NW Hoyt st. #22 Portland, OR 97209, (503)241-0175.

Appendix B

Phonologically accessible characters (Type I)

Type I: phonologically accessible characters

1.	黐	li	glue
2.	鬟	huan	female servant
3.	趢	lu	walking fast
4.	鏢	biao	blade
5.	飜	fan	turn over
6.	麖	jing	big deer
7.	粿	guo	cookie/pastry
8.	皰	pao	acne
9.	龔	gong	to supply
10.	魌	qi	ugly
11.	顰	pin	to wrinkle
12.	饎	xi	meal
13.	霤	liu	water dripping
14.	貗	lou	female pig
15.	瓪	fan	broken bricks

Appendix C

Phonologically inaccessible characters (Type II)

Type II: phonologically inaccessible characters

1.	[illegible]	liang	to observe
2.	[illegible]	ji	angry
3.	䶵	chi	an ancient music instrument
4.	鬷	zong	gathering
5.	麁	cu	rough
6.	嫠?	liu	to grab something
7.	鎪	sou	to engrave
8.	贇	yun	beautiful
9.	鬻	zhu	to boil
10.	[illegible]	rui	wither, die (for plants)
11.	薧	hao	graveyard
12.	奰	bei	huge
13.	[illegible]	huo	big holes
14.	[illegible]	zhai	strong
15.	[illegible]	mei	compatible

Appendix D

Immediate recall test

Immediate recall test　　　　　　　　　　Name:

	Character	Pin-yin	Meaning
1.	黐	________	________
2.	鏢	________	________
3.	飜	________	________
4.	齙	________	________
5.	[illegible]	________	________
6.	顰	________	________
7.	饎	________	________
8.	趢	________	________
9.	鬟	________	________
10.	霤	________	________

Character	Pin-yin	Meaning
11. 	____________	____________________
12. 	____________	____________________
13. 	____________	____________________
14. 	____________	____________________
15. 	____________	____________________
16. 	____________	____________________
17. 	____________	____________________
18. 	____________	____________________
19. 	____________	____________________
20. 	____________	____________________

Appendix E

Long-term recall test

Long-term recall test Name:

Character	Pin-yin	Meaning
1. 趢	____________	____________________
2. 鬟	____________	____________________
3. 麖	____________	____________________
4. [illegible]	____________	____________________
5. 顰	____________	____________________
6. [illegible]	____________	____________________
7. 瓯	____________	____________________
8. 縭	____________	____________________
9. [illegible]	____________	____________________
10. 龔	____________	____________________

Character	Pin-yin	Meaning
11. 	____________	____________________
12. 	____________	____________________
13. 	____________	____________________
14. 	____________	____________________
15. 	____________	____________________
16. 	____________	____________________
17. 	____________	____________________
18. 	____________	____________________
19. 	____________	____________________
20. 	____________	____________________

Appendix F

Examples of characters shown in the learning session

覄

to observe

[illegible]

blade