

SEMANTIC VS. PHONETIC DECODING STRATEGIES IN NON-NATIVE  
READERS OF CHINESE

by

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## ABSTRACT

This dissertation examines the effects of semantic and phonetic radicals on Chinese character decoding by high-intermediate level Chinese as a Foreign Language (CFL) learners. The results of the main study (discussed in Chapter #5) suggest that the CFL learners tested have a well-developed semantic pathway to recognition; however, their phonological pathway is not yet a reliable means of character identification. Semantic radicals that correctly pertain to character meaning facilitated reaction time in semantic categorization tasks (Experiment #1), while radicals that had no immediately interpretable relation to character meaning had a strong inhibitory effect. The relative accuracy of phonetic radicals (for predicting the whole-character's pronunciation) did not measurably improve homonym recognition (Experiment #2). Subjects were then tested to determine their default processing modes in Chinese character reading. In a lexical decision task (Experiment #3) wherein semantic radicals or phonological components were blurred to delay recognition, surprisingly, the subjects were significantly slower in identifying pseudo-characters when the phonological component was blurred, indicating that, despite having unreliable phonological pathways to character recognition, the subjects were still utilizing that strategy first. These results were mirrored in a sentence reading task (Experiment #4) wherein a single character had either a blurred semantic radical or phonological component. This tendency to use the less developed pathway is explained as a default means of attempting character recognition as a result of subjects gleaned orthographic information from the densely packed phonological component and

as a result of L1 (English) interference predisposing subjects to phonological decoding strategies.

Such a study on CFL learner reading processes is an important step towards ameliorating CFL teaching methodologies. For this reason, the author contrasts the data on CFL learners with data taken from similar experiments with native Chinese speakers (in Chapter #6) in order to demonstrate concrete differences in character reading processes which should affect teaching practices between the two groups. The author concludes the dissertation by making targeted recommendations for CFL pedagogical practices based upon the results of the study on the effect of character-internal features on reading patterns by non-native readers of Chinese (Chapter #8).

## CHAPTER 1.

# THE CHINESE WRITING SYSTEM

There are numerous myths and misconceptions about the Chinese character system, which have caused its nature to be poorly understood by those who do not speak/read/write Chinese, and some of these misconceptions have even been accepted by literate Chinese natives. The first commonly-banded myth about the Chinese writing system is that it is a pictorial writing system. While pictographs do indeed exist in the Chinese language, they are actually a very small percentage of the written corpus. Likewise, some (e.g., Besner, Daniels, & Slade, 1982; Huang & Jones, 1980: cited in Hoosain, 1991) contend that the Chinese character system is composed of ideographs, claiming that all Chinese graphic symbols represent a meaning directly. Hoosain (1991) appropriately derides this idea as similar to labeling Arabic numerals as being ideographic, “because each Arabic numeral represents a number directly without doing so through a more primary representation of sound...” (p.9). The Chinese character system today is most commonly referred to as a *logographic* system, although even that designation has received some criticism as this would indicate that each word in the language is represented by a separate character, but, as we will see, Chinese “words” are usually represented by 2-3 characters (Shu & Anderson, 1999). It is much more accurate to describe Chinese characters as *morphemes*. Characters can actually be separated into 4 different symbol classes: 1) pictographs, 2) indicatives, 3) ideographs, and 4) semantic-phonetic compounds. Pictographic characters’ forms match their meaning closely, and

these are usually amongst the first characters studied by both natives and L2 learners. They include such characters as 日 (sun), 月 (moon), and 山 (mountain). Indicatives (which are sometimes classified together with ideographs) express abstract ideas via a non-arbitrary sign, such as in the numbers 1, 2, & 3 (一, 二, and 三, respectively) or the words 上 (above/up) and 下 (below/down). Ideographs juxtapose two or more graphic elements to indicate a new meaning, such as by combining two of the character 木 (tree/wood) to make 林 (grove/woods), three to make 森 (forest), or by combining two graphic elements – e.g., combining 禾 (grain) and 火 (fire) to make 秋 (autumn). It is in these three categories that iconic properties of characters are most apparent, but all combined, they make up as little as 10% of the actual written corpus of Chinese (Hoosain, 1991). The iconic nature of these characters is still a great help in learning and character retrieval. A study by Luk and Bialystok (2005) indicates that even adults with no prior knowledge of Chinese could correctly guess the meanings of highly iconic characters (by matching the character to one of two photographs) with a high degree of accuracy.

The last category, semantic-phonetic compounds, comprises the vast majority of the characters in the Chinese corpus, with estimations from 81% (Chen, Allport, & Marshall., 1996) to 90% (Hoosain, 1991) of all characters belonging to this class. Additionally, the proportion of semantic-phonetic compounds, relative to other character types, has been increasing through the history of written Chinese (Zhu, 1987). These characters are formed by joining together a character with a related meaning (the



"semantic" element or "radical") and another character (the "phonetic" element) to indicate its pronunciation. For example, 氵 water + 沐 mù = 沐 mù "to wash one's hair."

The radical (semantic root) portion of the character is usually, but not always, located either above or to the left-hand side of the character, and is used for: 1) identifying semantic elements (e.g., in the character 媽 [ma: "mother"], the semantic radical, located on the left-hand-side, is 女 [nu: "girl"]); and 2) looking up entries in dictionaries. The phonological component is usually located below or to the left of semantic elements (but exceptions do occur). The reliability of these phonetic radicals are highly variable -- some characters, such as 媽 [ma -- shown above], possess true indications to their pronunciation (馬 [ma: "horse"]), whereas other characters' pronunciation may differ considerably, depending upon combination with various semantic elements: i.e., 工 [gong]: 紅 [hong], 江 [jiang], 杠 [gang], 扛 [kang]. This compositional structure of the characters causes Chinese readers to develop reading strategies quite different from those of English readers (or readers of other alphabetic scripts).

The Chinese character system (see example in Fig. 1.1) is characterized by a high volume of symbols, as each word in the language must be represented by a separate symbol or a grouping of symbols. For example, it is estimated that one must learn approximately 5000 separate characters in order to read a Chinese newspaper and twice that in order to comprehend college textbooks (Cipollone, Keiser, & Vasishth, 1998). This incurs a relative disadvantage to the writing system as it takes years of schooling in order to achieve high literacy skills, but the advantage is that, because the characters are

not tied to pronunciation, anyone versed in the characters can read – regardless of the language the person speaks. For example, speakers of Mandarin, Cantonese, or Hokkien – three distinct Chinese languages – would be able to read the same newspaper<sup>1</sup>, despite their inability to converse directly with one another (Cipollone, Keiser, & Vasishth, 1998). Chinese characters are used by all Chinese language groups, as well as such diverse languages as Japanese, Korean, and previously by Vietnamese peoples as well.

你	是	美	國	人	嗎?	(Are you American?)
ni	shi	mei	guo	ren	ma	
you	are	[America]	person	question	marker	

FIG. 1.1 An example of Chinese

<sup>1</sup> Note that formal Chinese writing is usually based upon Mandarin grammatical and syntactical norms, and thus, speakers of other dialects essentially learn to read and write Mandarin, while pronouncing characters according to the norms of their own dialect. Transcribing a language like Cantonese as spoken would yield text which is a bit opaque to the average Mandarin speaker given some of the differences in syntax and specialized characters needed to express common words not used in Mandarin.

## CHAPTER 2.

# NATIVE SPEAKERS' CHARACTER LEARNING AND READING SCHEMES

### *Child learning strategies*

Given the high volume of characters required for functional literacy in logographic writing forms such as Chinese, it is not surprising that literacy requires a substantial investment of time and effort. There is no real way around simply memorizing the thousands of characters that make up the writing system. Native Chinese speakers tend to learn their reading and writing skills through rote, word-by-word memorization, and frequent repetition (Chan, 1999). This is not to say that there are not strategies to facilitate learning. There are, and the L2 learner should be made aware of them as early as possible. L1 speakers of Chinese exhibit a large reliance on visual information in word decoding strategies (Chikamatsu, 1997). Children learning Chinese demonstrate a greater eye for minute detail than do their English-learning peers. This reflects the nuance attached to the Chinese writing system. Pine, Huang, and Song (2003, p.6) state:

*One of the most obvious areas that has emerged is the specificity with which the Chinese children talked about characters, their detailed noticing of signs within signs of their literacy system. By the end of first grade, the children in this study report a type of knowledge and way of learning that includes the ability to notice highly detailed, small nuances of the dense character structures. This appears to be very different from learning strategies employed by Western beginning readers who often focus on beginning sounds and letter/sound associations from preschool years.*

Chinese-speakers also focus on semantic recognition of characters, as opposed to phonology (Pine, Huang, & Song, 2003). Characters have meanings; they do not carry fixed pronunciations. This is the feature that allows Chinese characters to be effectively applied to a variety of languages, both within and outside of the Chinese language family (Murphey, 2001). While some researchers have argued that Chinese readers may potentially bypass phonology completely (Zhou, Shu, Bi, & Shi, 1999), others, such as Perfetti & Tan (1999), argue that all printed word forms, be they alphabetic or logographic, arouse phonological information as part of recognition. Nonetheless, recognition of semantic information embedded in characters can be developed as a learning strategy. L1 and L2 learners of Chinese or other logographic writing forms should be taught and encouraged to develop metalinguistic awareness strategies. Shu and Anderson (1997) determined that learners of Chinese made extensive use of knowledge of character radicals for determining semantic information. Literate readers also made use of radicals for recognizing less commonly used characters. Highly literate speakers can also make use of phonological information sometimes embedded in characters (usually in the form of a character that has the same pronunciation as one of its parts, such as in the examples把, 爸, and 巴, all of which are pronounced as “*ba*”). However, Shu and Anderson (1997) found this to be little used by lower-level learners. In native speakers, this strategy is not observed in a consistent manner until sixth grade (by which point most average children would meet government standards of basic literacy). This strategy would not be useful to L2 learners until they had hit a quite advanced level. Still, learners should be made aware that phonological cues are sometimes embedded

within characters.

Recall strategies for logographic writing systems also differ somewhat from other writing systems. Kinesthetic methods, whereby a learner traces a character with the finger in the air, or with a pencil about an inch above the paper, are commonly employed (Pine, Huang, & Song, 2003). This recall method is commonly taught to Chinese children as they are studying character writing. It is essential to teach children the proper stroke order, as the combination of strokes forming individual characters must be executed in a pre-determined order so as to maintain proper spacing. Structural analysis (analysis of simple character combinations to make complex characters) is another commonly used recall method. Chinese speakers use both strategies while speaking to clarify homophones or to “spell” proper names (and thus distinguish between similar sounding characters).

Retention and recall of characters correlates with frequency of use (Shen, 2005). For the L2 learner, beginning reading is largely limited by word knowledge. Unlike in phonetic-based scripts, logographic characters are largely known or unknown. If unknown, the beginning reader will have no way of guessing meaning or pronunciation with any surety, and each 1% of unknown words in a text is estimated to cause a 2-4% decrease in text comprehension (Shen, 2005). More advanced readers can make use of knowledge of semantic or phonological clues embedded in radicals, but even then, it can be difficult to guess the meaning (beyond a broad semantic category) of unknown characters.

Interestingly, there is evidence that how Chinese writing is taught to native

speakers has a tremendous effect upon their reading processes. Lyon (1998) maintains that learning to read necessarily entails learning phonemic awareness, and numerous studies show a relationship between phonological awareness and L1 reading ability (e.g., Adams, 1990; Share & Stanovich, 1995; Siegel, 1993: cited in Strauss, 2005). In the People's Republic of China, children are introduced to *Pinyin*, a Roman Alphabet-based system of writing Chinese sounds (together with tone markers), in the first few weeks of the first grade (Pine et al., 2003). Chinese characters are introduced starting about 2-3 months after that, and the two systems exist side-by-side during the first year. During the next few years, as children increase their store of characters, the Pinyin is gradually dropped. Taiwan, likewise, uses a phonetic system to mediate character learning in early childhood literacy education (although they use the native Chinese *zhuyin* transcription system which consists of 37 markers which correspond to syllable onsets and rimes). Hong Kong, however does not make use of any phonological notation, instead teaching through a "look and say" methodology wherein the entire character is presented as a whole unit. Thus, in the Mainland and Taiwan, children are explicitly taught phonetic principles (although it may well be considered going too far to compare such to English learning programs like Phonics, as words are never analyzed at the phonemic level – just onset and rime) while Hong Kong children are not. Investigating the effect of teaching methods on reading processes, Schofield and Chwo (2005) found significant differences between Taiwanese and Hong Kong readers. Phonological distracters were found to have a higher interference effect on Taiwanese readers than on Hong Kong readers in character recognition tests, and the opposite effect was found with graphic distracters, which

slowed Hong Kong readers' performance more than their Taiwanese counterparts'. The same effect of lower phonological sensitivity on the part of the Hong Kong readers was found to have carried over to English literacy. Leong, Pui, and Tan (2005) also found that learning success in reading Cantonese (the Chinese language/dialect of Hong Kong) is strongly correlated with orthographic processing skills (especially compared to phonological). Like effects were also found by Holm and Dodd (1996), who compared tests of ESL phonological awareness between groups of students from PRC, Hong Kong, Vietnam, and Australia, and found that the Hong Kong students had the most difficulty processing non-words and demonstrated the least phonological awareness. This was hypothesized to be a direct result of transferring their L1 literacy processing skills (which deemphasized phonology in favor of whole word recognition) to their L2 studies.

### *Chinese "Words"*

The concept of a "word" as a linguistic unit is actually a source of some debate in Chinese. The Chinese script employs even spacing between characters, but does not break sentences up into what most Westerners would recognize as word units. All Chinese will agree that words are often composed of more than one character, but where those breaks between conceptual units should be made is not entirely clear. In principle, we can see the dilemma by looking at pre-literate children or illiterate adults. Phonemes and words overlap in speech, and it is unsurprising that pre-literate children do not understand the concept of a word. Illiterate (English L1) adults, likewise, would have trouble identifying the number of words in "tenacious" vs. "ten calves," for instance.

However, literate English-speaking adults can clearly and unanimously decide where to draw the word boundaries in a phrase like “doyouwanttogooutforpizza”. Not marking word boundaries, Chinese did not even have a term for ‘word’ until the beginning of the 20<sup>th</sup> century when it was ‘imported’ from Western sources (Packard, 1998). In word segmentation tasks, Chinese speakers will delineate word boundaries inconsistently with other Chinese as well as with themselves in other segmentation tasks (Hoosain, 1992). Tsai, McConkie, and Zheng (1998: cited in Bassetti, 2005) found that Chinese readers who learned through the medium of Pinyin would act differently from those who had only learned *hanzi* characters in segmentation tasks, indicating that some exposure to word-spaced writing can affect the concept of ‘words.’ Bassetti (2005) points out that word identification is complicated by the fact that Chinese characters, in principle morphemic, often represent more than a single morpheme. She offers the example of 生, which can act as a verb in 她生孩子了 (“she gave birth to a baby”), but can also act as the second morpheme in 陌生人 (“stranger”) or the third morpheme in 研究生 (“graduate student/researcher”), and thus one could argue that 生 “gives the false impression that [it] represents a lexical item, when in fact it is the written representation of different homophonic morphemes” (p. 339). Bassetti (2005) tested a group of L1 and L2 Chinese subjects (all L2 subjects’ L1 was English, and all had a high level of Chinese character reading proficiency), asking them to segment sentences into individual words. She found that English learners of Chinese segmented the sentences into significantly shorter word lengths than the Chinese natives and had significantly higher agreement rates. For example, the phrase “十七世紀的歐洲” [shi qi shi ji de ou zhou](17<sup>th</sup> century



Europe) was segmented by most English natives thusly: 十七\*世紀\*的\*歐洲, [shiqi\*shiji\*de\*ouzhou] whereas Chinese subjects mostly segmented the phrase as 十七世紀的\*歐洲 [shiqishijide\*ouzhou] or 十七世紀\*的\*歐洲 [shiqishiji\*de\*ouzhou] (i.e., both segmentations parse “17<sup>th</sup> century” as a single word); however, multiple other interpretations were offered. Post-test interviews found different segmentation criterion on display, with most English L1 subjects reporting the use of translation as the primary means of determining words, whereas Chinese subjects would divide phrases into subject and predicate parts, and then look for smaller units – but obviously still phrases like “17<sup>th</sup> century” could be easily construed to be inseparable units. Other subjects reported deciding that dictionary entries could be counted as single words, but Bassetti notes that via that criteria 中華人民共和國 (the People’s Republic of China) would be considered to be one word. Other researchers have tried to offer usable definitions of the Chinese word. Packard (2000) has offered two such suggestions, saying that words may be seen as output of a word formation rule; although he readily admits that Chinese lacks a clear set of formation rules, and thus it would be incredibly difficult to define what processes impact word formation. The better suggestion, perhaps, is that words be defined as syntactic free forms, wherein a word is any potential occupant to a free syntactic slot.

The other factor impacting the concept of word recognition is morphemic processing. There has been much research indicating the morphological effects of word recognition processes across languages, including Chinese (Peng, Li, & Liu, 1994; Zhang & Peng, 1992). At issue is whether the fact that a character can represent multiple morphemes (as discussed above) would impact how characters are recognized in word

contexts. Peng, Liu, and Wang (1999) found positive priming effects for words that employ the same character but different morphemes (e.g., 快 in 快活 “happy” vs. 快速 “fast”). Likewise, Zhou, Taft, and Shu (1995: cited in Taft, Liu, & Zhu, 1999) found that characters that are used only for syllabic value – mostly found in loanwords – eg., 沙 “sand” in 沙發 “sofa” (pronounced “sha fa”) – would still prime semantically unrelated words with a common character: e.g., 沙堆 “sand pile,” **but only** in masked priming tasks. When the prime was in full view, there was no facilitation. This seems to indicate that despite the fact that characters can represent multiple morphemes, they are all activated by the orthographic overlap in masked priming; however, native readers seem to be able to “block” semantically unrelated forms used for phonetic value when the prime is visible.

### *On-line Processing in Chinese*

While the space that Chinese occupies in the larger frameworks of individual reading theories will be discussed in detail below (Question #2), one would be remiss to neglect mention here of the similarities and differences observed between individual character access and text reading. First, one must wonder if the above described lack of consensus as to what constitutes a word has any effect on Chinese reading rates and comprehension. Indeed, psychologists have tended to assume, probably based upon traditional Western-influenced definitions of what constitutes a ‘word,’ that Chinese text processing would necessarily entail a separate word segmentation process before

beginning word identification (e.g., Hoosain, 1992). However, this is easily shown not to be the case as, if it were true, one would expect to see slower reading rates in Chinese readers as they would be spending additional time on word segmentation in addition to decoding tasks. In fact, researchers have shown that reading rates of Chinese readers, measured in number of words per minute (with words defined via translation) is approximately the same as in English (Sun, Morita, & Stark, 1985). What must be understood in order to understand Chinese processing is that the standard (Western) assumption of the word as the basic unit of orthographic framing does not apply. In Chinese, the basic framing unit is the individual character (Hoosain, 1992). How then does the Chinese reader know how to separate characters into semantically meaningful units? There is evidence to suggest boundary identification, instead of preceding word identification, may actually result from word identification. It has been theorized that the lexicon is consulted to match input strings online, and algorithms are employed to resolve ambiguity based mostly on semantic reasoning (e.g., Chen & Liu, 1992). Miao (1999) found that Chinese tend to weigh processing of ambiguity in favor of semantic feasibility, in lieu of word order. This could result in each recognized character immediately activating possible next characters – much like as in the Interactive Activation Model proposed by McClelland and Rumelhart (1981). Chen (1999) found evidence that suggests that semantic, lexical, or syntactic violations in Chinese sentences do not cause a “slow-down” until roughly 3 characters later, suggesting that meaning was being constructed online via character by character reading, and that pre-lexical word segmentation was not likely to be occurring.

Still, there is evidence of word effects in Chinese reading. Chen and Au Yeung (1993: cited in Chen, 1996) found that reading time increased significantly with several word-level variables, including words with a high number of individual characters, words presenting new concepts in text, and word boundaries. Chen (1987) likewise found significant word superiority effects in a character deletion task. Response times were significantly shorter and fewer errors were produced when characters were embedded in words rather than non-words. It is clear that, despite some ambiguity in the concept of a word, at the processing level, Chinese readers are still recognizing multiple character strings as independent units.

This is not to say that a fair amount of ambiguity is not possible in Chinese writing. Indeed, the nature of character combinatory rules makes misparsing rather easy to achieve. While the majority of these can be easily resolved online via consultation with syntactic or semantic factors, some cases cannot be easily resolved. For example, the sentence 這些花生長得很快了 (*zhe xie hua sheng zhang de hen kuai le*) can be interpreted (correctly) two different ways. 花, by itself, means “flower(s),” but can be combined with 生 to mean “peanut(s).” Likewise, 長 means “to grow” but it can also be combined with 生 while retaining the same meaning. Thus, the sentence could be parsed as either “these peanuts grew very fast” or “these flowers grew very fast” (Chen, 1996). Similar ambiguity can be found in the use of the Chinese reflexive 自己 (*zi ji*) as in sentences such as 哪個媽媽怕她兒子對自己生氣 (that mother fears her son is mad at her/himself) the reflexive could be seen as pointing back to either the mother or the child.

### *Cerebral Asymmetries in Chinese Reading*

If we accept that Chinese characters are decoded via different processes than alphabetic scripts, we would expect to find differences in brain activity, and that, in fact, is what we discover. Tham, Liow, Rajapakse, Leong, Ng, Lim, and Ho (2005), performing fMRI tests on Chinese-English bilingual/biscriptals, found distinct regions of activation for Mandarin in the left and right frontal lobes, the left temporal lobe, and the occipital lobe during tests of phonological processing in reading tasks. Dong, Nakamura, Okada, Hanakawa, Fukuyama, Mazziotta, and Shibasaki (2005) found that semantic tasks yield bilateral activation in the inferior frontal and occipito-parietal regions, whereas phonological activities caused more left-lateralized activation in the inferior frontal and parietal regions. Older studies indicated some considerable differences from English reading. Hatta (1977) demonstrated that Japanese subjects exhibited a left visual field (LVF) and thus right hemispheric (RH) advantage in *kanji* (Chinese Character) recognition, which contrasted with a right visual field (RVF), left hemispheric advantage for *kana* (Japanese syllabary) recognition. Bierderman and Tsao (1979) found that the Stroop effect in Chinese is more pronounced (i.e., produces more interference) than in English, and postulate that this is possibly because character processing may have some right-hemisphere-dominant processes that literally ‘compete for space’ with color processing. The semantic processing aspects of Chinese character processing certainly would lend credence towards such a view.

### CHAPTER 3.

## PROCESSING MODELS IN CHINESE

#### *Processing Chinese: A dual route model*

The Chinese character system presents a challenge to traditional letter-recognition-based models of word recognition. The fact that Chinese does not have "letters", but rather employs a complex set of characters -- each possessing a meaning and a pronunciation -- suggests that the initial decoding process for the Chinese reader would vary significantly from that of readers of alphabetic languages. A general agreement exists among most theorists that at least two processes are involved in reading (e.g., Coltheart, 1978): reading via the semantic representation of the word, and via a non-lexical procedure of grapheme-phoneme conversion (Bi, Han, Weekes, & Shu, 2007). This has been conceptualized in terms of what has become known as the *dual route model* or 'standard' model (Patterson & Morton, 1985). In principle, this can be summarized as two co-existing, parallel lexical access pathways, one of which retrieves words via pronunciation (the phonological route), and the other retrieves whole words from the mental lexicon (the lexical route). This latter route has often been characterized as a semantic route to lexical access. Various studies have supported the existence of both pathways to word recognition. The fact that readers (of alphabetic scripts) can pronounce nonsense words, such as "wug," clearly indicates the existence of a phonological route to word identification (i.e., independent of meaning); and semantic priming studies, as well as studies with deep dyslexic subjects (who produce semantic

substitutions in reading) suggest a semantic route to access as well. The nature of the Chinese character system offers reading specialists a unique opportunity to compare semantic and phonological activation in reading directly -- a comparison which is not easy to manipulate or to measure in most languages written in alphabetic scripts. In alphabetic-phonemic languages, the systematic mapping of sound to symbol makes phonological activation a relatively reliable means of word recognition compared with semantic recognition strategies. Indeed, semantic and orthographic correlation in alphabetic systems is largely arbitrary (e.g., *light*, *bright*, and *sight* seem to overlap both semantically and orthographically, but *night*, *tight*, and *right* have no immediately-intuitive connection). Alphabetic scripts' systematic phoneme mapping makes the phonological route a more intuitive, and indeed, more reliable means of word recognition. In alphabetic scripts, the semantic route is theorized to recognize words mostly based upon *shape* (both phonological shape and orthographic shape) (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), which certainly helps to explain why treatments such as alternating case (e.g., "iSn'T tHiS StRaNgE?) have been shown to delay comprehension (e.g., Fisher, 1975; Smith, 1969: both cited in Akamatsu, 2005). Chinese characters, by contrast, (in the case of semantic-phonetic compounds, at least) have pertinent semantic information directly embedded within the character. This potentially makes the semantic route a much more useful alternative to the phonological route than it is in alphabetic scripts, and thus, Chinese may actually be one of the best means for studying the activation of this semantic route. Copious research suggests that both semantic and phonological routes are highly active in Chinese character processing

tasks.

In the Chinese writing system, semantic (as well as phonological) information may be embedded within the character itself. This supports the possibility of a dual route to lexical recognition from visual presentation of a character: one being indirect through recognition of the word's phonology, and the other being direct access between orthography and semantic category (Zhou & Marslen-Wilson, 2000). Such a dual route to character recognition would have immediate benefits if decoding is conducted in a "Search Model" such as that described by Forster (1976). It would allow for simultaneous, parallel searches based upon different aspects of a character, thus minimizing search time. In a homonym-dense language such as Chinese, putting semantic constraints on a phonetic search would be particularly useful. The absence of grapheme-phoneme correspondences in Chinese script makes some modification of the non-lexical route necessary in order to explain Chinese character processing, though, as sublexical phonological processing *has* been detected in Chinese character decoding. The embedded phonetic component featured in many characters has been found to activate pronunciation (Perfetti & Tan, 1998; Shen & Forster, 1999; Tan, Hoosain, & Siok, 1996; Zhou & Marslen-Wilson, 2000; Zhou et al., 1999), and thus, characters whose phonetic components are accurate indications of pronunciation should be named faster and more accurately than characters with irregular phonetic components. However, as Chinese characters are not assembled from phonemes, and the phonetic correspondence of character pronunciation with the phonetic component is so low, the non-lexical route as originally conceived cannot adequately explain how characters are



read. Shu, Meng, Chen, Luan, & Cao (2005) note that the model fails to explain oral reading of Chinese characters because:

*...the model assumes that lexical representations are not needed to read aloud. Instead, the subsymbolic units of the script are used to generate a verbal output for words and nonwords. Given that oral reading in Chinese is likely to involve contact with lexical representations as well as sublexical units, it is not clear how their theoretical position would explain reading in Chinese (p.314).*

Fortunately, Weekes, Chen, and Yin (1997) have proposed a language-specific adaptation of the dual-route model that will accommodate Chinese script processing. This ‘triangle’ model contains three levels of representation – semantic, orthographic, and phonological – all linked via two bi-directional pathways: the semantic pathway and the non-semantic pathway. While the semantic pathway is basically a renamed lexical route, the nonsemantic pathway varies from the nonlexical route in that it allows for phonological representation at both the character *and* the sublexical level. One of the immediate, practical applications of such a model is that it helps to explain how dyslexia disrupts the reading process. Given this model, we can readily theorize surface Chinese dyslexics to be exhibiting impairment to the nonsemantic pathway, and deep dyslexics to be exhibiting impairment to the semantic pathway.

#### *Differences between Dyslexia in Chinese and English*

One of the immediately apparent differences between dyslexia in Chinese vs. in alphabetic scripts is that phonological dyslexia is not a recognized phenomenon. There are three commonly identified major subtypes of dyslexia: surface dyslexia, phonological dyslexia, and deep dyslexia (e.g., Coltheart, 1978; Marshall & Newcombe, 1973).

Surface dyslexics manifest their condition in over-regularization errors. They have difficulty in reading irregular words, but display normal ability in reading regular words and nonwords (i.e., they will pronounce “pint” as rhyming with “mint”). By contrast, phonological dyslexics will have no trouble reading regular and irregular words, but have considerable trouble reading nonwords. Deep dyslexia is characterized by semantic substitution errors (e.g., reading “road” for “street”), and they are also have trouble reading nonwords (Shu, Meng, Chen, Luan, & Cao, 2005). While surface and deep dyslexia is found amongst Chinese readers, the nature of the Chinese character system precludes the reading of pseudocharacters. While non-existent characters can certainly be created, as the orthography lacks any direct sound-symbol correspondence, such characters would be devoid of any discernable pronunciation. Indeed, any task designed to test for such would just be a test of reading the phonetic component, and any anomalies would likely be more due to surface dyslexia. Yin and Weekes (2003) note that, while one can hypothesize how such a case could happen (i.e. via mild damage to nonsemantic pathways), such a case has never been reported, and indeed, if it were ever found, it would constitute an important discovery as it would contradict claims (e.g., Weekes, Coltheart, & Gordon, 1997) that phonological dyslexia is caused by impairment to a grapheme-phoneme conversion route which could not be expected to exist in Chinese. It could well be possible that the necessary impairment exists in a comparable segment of Chinese society, but that it has never manifested itself due to the unique properties of Chinese script. One could theorize, however, that those so impaired could possibly manifest the condition in ESL or other alphabetically-written foreign language

learning contexts.

### *Correlating Skill-Deficits in Chinese Dyslexics*

While some forms of dyslexia are absent from Chinese speaking populations, it is still possible to find surface and deep dyslexia. However, due to the differences between the Chinese character system and alphabetic scripts, reading impairments in Chinese manifest themselves in some unique ways. This, alongside the lack of grapheme-phoneme conversion in Chinese (which is still recognized as a causal factor in many impairments in reading alphabetic scripts), has caused some researchers to look for alternative causes for the impairment. The study of dyslexic Chinese children has focused on two different causal suspects: the children's phonological skills and their visual skills (Ho, 2003).

As has been discussed previously in Chapter 2, developing visual skills and fine detail discernment are critical skills in the initial stages of Chinese character learning. Thus, poor visual skills could cause reading problems for learners of the Chinese character system. Woo and Hoosain (1984), studying this hypothesis, found that dyslexic Chinese children were more susceptible to visual-distractor errors in Chinese character recognition tasks than average readers. The same test found no difference between the two groups when it came to phonological distractors. The dyslexic children also scored significantly lower on the Frostig Developmental Test of Visual Perception (which tests eye-motor coordination, figure-ground, constancy of shape, position in space, and special relationships), supports the researchers' claim that the dyslexic children's disability lay in

their basic visual perception skill. This avenue of research certainly bears closer investigation. Particularly if visual perception impairment is suspected to be a limiting factor only in the literacy attainment of logographic languages like Chinese, it would be highly valuable to conduct studies on CFL learners and attempt to establish any correlation between visual perception skill and ultimate Chinese literacy attainment.

Much more research has been conducted on the relationship between Chinese learners' phonological skills and reading impairments. Despite the lack of direct grapheme-phoneme conversion in Chinese, there is some evidence which strongly suggests that phonological awareness still plays a role in Chinese character reading, and that a deficit thereof can negatively impact literacy attainment. Huang and Zhang (1997) found that dyslexic Chinese 2<sup>nd</sup> graders performed significantly worse than other children on tests of initial phoneme deletion, sound categorization, and tone detection. Ho, Law, and Ng (2000) found the same inferior performance in tests of onset and rhyme detection. While it seems clear that dyslexic Chinese learners do possess limited phonological skills, still other researchers have argued that this may not be the only, or even the primary, cause. Ho, Chan, Chung, Lee, and Tsang (2007) found deficits in dyslexic children's phonological processing abilities, but nevertheless also found that orthographic skills were a better predictor of Chinese character reading skill than phonological skills. Chan, Ho, Tsang, Lee, and Chung (2006) found that orthographic knowledge, naming speed, and phonological memory were all found to be accurate predictors of reading and writing impairment.

Aside from perceptual skills, it is worth exploring the problems which can stem

from poor phonological memory (Aaron, 1989: cited in Ho, 2003). Zhang, Zhang, Chang, and Zhou (1997: cited in Ho, 2003) reported that Chinese dyslexic children demonstrated inferior results in Short Term Memory tests such as digit memory. Ho and Lai (1999) applied word repetition tasks in order to test the phonological memory of 8-year-old dyslexic Chinese children and found that they performed significantly worse than control groups, suggesting that dyslexic children may struggle to maintain phonological representations in short term memory, which is likely to have negative effects on vocabulary acquisition and reading development. Researchers have also suggested a predictive link between phonological retrieval ability and dyslexia. Ho and Lai (1999), conducting a naming task, found that dyslexic Chinese subjects retrieved the names for digits, colors, pictures, and written characters more slowly than control groups.

### *Neurological Differences in Chinese Dyslexics*

Considering the differences in neurological-level reading processes between Chinese and English, we could expect that these structural differences would affect dyslexic readers. Indeed, studies have shown that there are considerable differences in the cortex of Chinese and English dyslexic readers. Siok, Niu, Jin, Perfetti, and Tan (2008), using vowel-based morphometry (VBM), analyzed brain activation images of Chinese dyslexic subjects, comparing them with controls. They found that the regional gray matter volume of the left middle frontal gyrus was significantly smaller in the dyslexic group. This stands in sharp contrast to the patterns of diminished regional gray matter in posterior brain systems previously observed in dyslexic readers of alphabetic

scripts. This correlates with the Tham, et al. (2005) study which showed readers of Mandarin having higher activation levels in the left frontal lobes. Siok et al. (2008) also found differences between dyslexic and normal Chinese subjects in several other brain regions, but only the left middle frontal gyrus exhibited both functional and morphological anomalies. This area of the brain is suspected of playing an important role in Chinese reading due to the arbitrary relationship between character forms and their pronunciation. This region of the brain is thought to be responsible for the allocation and coordination of working memory resources, and thus may come into play in reading/writing tasks (Siok et al., 2008). There is also some suggestion that this region may be more involved in Chinese reading than in alphabetic scripts due to specific learning strategies. The repetitive drills by which Chinese children learn characters through endless copying may well work to train this area of the brain by forming a close association between reading performance and hand writing skills, which are mediated by the left middle frontal region (Siok et al., 2008).

#### *Semantic vs. Phonological Decoding in Chinese Reading*

The suggestion of a dual route to accessing the meaning of Chinese characters, however, begs the question of whether the two routes are equal in importance, or whether one route is privileged over the other. In alphabetic languages, we can surmise that both semantic and phonetic search models exist -- at least in theory -- but the reliable phonologically-based organization of the alphabetic scripts obviously predisposes the reader to phonetic search patterns. Chinese writing, with a large proportion of characters

having both phonological and semantic information directly embedded in the character, could potentially allow either. Indeed researchers have found evidence of separate search patterns, depending upon task type (see below: Priming Studies), but there is much debate as to whether there is a *default* reading strategy that tips towards semantic or phonetic interpretation. Given that roughly 81% (Chen, et al., 1996) of the character corpus is made up of semantic-phonetic compounds, which would permit such search patterns, it does seem that these would be primary decoding schemes for Chinese reading.

In any case, it is implausible to completely discount the importance of semantic mediation of character-recognition. Phonetic radicals in Chinese characters are unreliable indicators of pronunciation. Fan, Gao, & Ao (1984) estimated that only 26.3% of all semantic-phonetic compounds have a phonetic radical that is an accurate indicator of pronunciation. Additionally, when frequency is taken into account, the percentage of semantic-phonetic combinations that are pronounced identically to their phonetic portions falls further to a mere 18.5% (Zhu, 1987). Hoosain (1991) notes that "the phonetic cuing function of phonetics is not rule governed, and the pronunciation of the phonetic itself, after all, has to be learned individually. This is quite distinct from the situation with the representation of sound by letters of the alphabet." (p. 11) In contrast, variable rates of accuracy from 65% (Fan, 1986: cited in Feldman & Siok, 1999) to 90% (Jin, 1985, cited in Feldman & Siok, 1999) have been found for specific semantic radicals, and most, if not all, semantic radicals are significantly more reliable than the 26% for the phonetic radicals. While the reliability of semantic radicals as predictors of semantic grouping varies from character to character, 100% of dictionary entries under semantic radicals

such as 魚 [yu : fish] and 鳥 [niao : bird] fit their respective categories. Additionally, when considering a lexical access model, the smaller corpus of semantic radicals (approximately 200) vs. phonetic radicals (roughly 800 according to Taylor & Taylor, 1983), would suggest that lexical searches utilizing the smaller number of semantic radicals would be inherently more efficient than searches based upon the much larger group of phonetic radicals.

It is clear that having a transparent semantic indicator embedded into a word would be advantageous for recognition, and, that being the case in Chinese, it seems apparent that literate Chinese take full advantage of this fact when reading. The semantic radical plays a vital role in Chinese decoding tasks, and in fact may be playing a primary role in character recognition (over the phonetic component). Among the roughly 200 semantic radicals in the modern Chinese corpus, on average, about 20 semantic-phonetic compounds are formed from each semantic radical, but there is high fluctuation amongst individual radicals (Feldman & Siok, 1999). The semantic radical 手, meaning “hand,” for example, appears in 328 character compounds, but the radical “body,” 身, appears in only 6 (Feldman & Siok, 1999). Semantic radicals can have clear relation to character meaning, such as 口 (“mouth”) in the compound 唱 (“sing”), but they can also be quite opaque, such as 飾 (“decorations”), which uses the semantic radical 食 (“food”).

Phonetic components, on the other hand, are more numerous and less precise. Zhu (1987) openly states that the semantic cueing function of the semantic radical is stronger than the phonetic cueing function of the phonetic component. Papp, Newsome, and Noel (1987) found that Chinese readers only maintained 13% accuracy when asked



to guess the pronunciations of low-frequency, unknown characters. Still, they constitute useful information when phonetically transparent. For example, in the above mentioned case of the word 唱 *chang* (“sing”), the character is constructed by putting the semantic radical 口 (“mouth”) with the phonetic component 昌, which, meaning “prosperous,” has no connection to singing, but instead lends its pronunciation, *chang*, to the character compound (note: the two characters do vary in tone).

*Priming Studies: Evidence of dual routes to character decoding*

Chinese word-recognition should be primed via presentation of semantically related stimuli if there is a direct route between orthography and semantic information. Some studies have indeed supported this hypothesis (e.g., Zhou & Marslen-Wilson, 2000). Feldman and Siok (1999) found that character recognition was significantly facilitated by semantically related primes with the same radical, as compared to primes that were semantically unrelated but had the same radical, or primes that were semantically related but had a different radical. Flores d’Arcais (1992) found interference effects from semantic radicals in a categorization task wherein the semantic radical was closely related to the meaning of the other character, but the whole characters were completely different. Ding, Peng, & Taft (2004), likewise, found significant facilitation for primes that shared the radical with the target; however, they only found priming when the test character component was in the same spatial position within both the prime and the target (e.g., 柏 would not prime 柏, even though both contain the submorphemic unit 白).

On the other hand, Perfetti and Tan (1998) made the strong claim that phonological activation precedes semantic activation in Chinese reading (this result had been found previously by Tan, Hoosain, & Siok, 1996) and argues that these phonological priming effects support a universal principle that printed words in all languages and scripts are all identified, at least in part, via phonological representations (Perfetti, Zhang, & Berent, 1992); however, this idea has faced some criticism. Zhou and Marslen-Wilson (2000) found that phonological priming effects were only attained for prime durations of 200msec. Shen & Forster (1999), likewise, found that phonological priming in Chinese is task-dependent, and thus, tasks such as word naming inadvertently bias subjects towards a phonological mediation of character reading. Zhou, Marslen-Wilson, Taft, and Shu (1999) found that semantic priming effects appear earlier than homophone priming in lexical decision tasks, although homophone priming yielded faster results in naming tasks. Semantic priming effects were also strong in naming tasks for single character words, but not for compound words (i.e., multiple character words). Wu and Liu (1997) found that phonological activation only follows the encoding of both the phonetic and the semantic radicals. Seidenberg (1985) only found facilitation from the phonetic component in low frequency words (which makes sense as lower frequency correlates with higher phonological transparency on the part of the phonetic component). Finally, a non-priming study by Liu (1983) wherein character quadrants were deleted and subjects were asked to identify the character by the remaining  $\frac{3}{4}$ , found that upper quadrants were more critical than lower quadrants, and that left quadrants were more so than right quadrants. A missing upper left-hand quadrant correlated with the highest error rate.

Given that the majority of semantic radicals are located on the left hand side or upper area of a character (although, they can also be on the right hand side, below, around, or inside a character), this was interpreted as indicating that the semantic radical was a critical component for character identification. Taken as a whole, the evidence seems to indicate that both the semantic and the phonetic components of semantic-phonetic character compounds can serve towards lexical access, but that 1) both components must be consulted to ensure reading accuracy, and 2) the semantic radical, as the more accurate and essential of the two, seems to hold a “privileged status” in character identification.

## CHAPTER 4.

# LEARNERS OF CHINESE AS A FOREIGN LANGUAGE

### *Chinese L2 Instructional Methods*

As the economic engine of China has increased in power and recognition during the last 20 years, the field of Chinese as a Foreign Language (CFL) has grown exponentially, both in Chinese-speaking and in non-Chinese-speaking countries. Indeed, this author has noted with some approval that Chinese language programs, which were exceedingly rare in US universities when he was an undergraduate student in the early-mid 90's, have become a common fixture in universities and junior colleges across the USA (and have even made in-roads in some elementary and secondary school systems). As this trend towards greater prominence and availability of Chinese language study develops, there will be more and more call for study on the learning processes of CFL learners, to identify and circumvent problems in acquisition of the L2. Some common difficulties encountered by CFL learners (with alphabetically transcribed L1s) include the high volume of characters needed for basic literacy skills, the lack of phonetic information in such characters, and the subtle variation possible between characters. It is unsurprising, therefore, that many L2 Chinese learners struggle with learning to read and write Chinese characters. Wang (1998) identifies four prevailing approaches to teaching Chinese literacy in a CFL context. The first approach is an attempt to stimulate L2 learners' sensitivity to visual detail via explicit instruction of the role of semantic radicals and phonetic components (xing/sheng). Various researchers (e.g., Liu, 1983, Itoo, 1979:

cited in Wang, 1998) have argued that radicals should be taught early on in order to facilitate dictionary use (Chinese character dictionaries are arranged via classification by their radical, and listed in order of the number of strokes). Liu (1983) also suggests introducing the phonetic component early on, in order to facilitate learners' ability to recognize and utilize character-internal features for character decoding and identification. This approach has been criticized on two main grounds (Wang, 1998): first, that phonetic components are accurate predictors of character pronunciation most commonly when found in low-frequency characters, and are thus not very useful to the L2 learner and easily forgotten; secondly (and most critically), semantic and phonetic character components are notoriously unreliable clues – especially in high-frequency characters.

The second approach pointed out by Wang (1998) (and, anecdotally, the method that I, personally, have most often encountered in my years spent in the arenas of Chinese and Japanese learning and teaching) is to conscientiously ignore both semantic radicals and phonetic components, and to begin by teaching a number of high-frequency characters. Proponents of such an approach (e.g., DeFrancis, 1984) argue that after learners have learned a “critical mass” of characters, they will individually unlock the ability to analyze characters according to their semantic and phonetic components. To date, no consensus exists on exactly how many characters are required to reach this “critical mass” (Wang, 1998). Additionally, the same critiques from the first approach apply. If the high-frequency characters are the least accurate in terms of semantic radical and (especially!) phonetic components, how, exactly, does one expect students to recognize patterns when they are not there?

The third approach emphasizes phonological mediation – that the sound quality of individual characters should be stressed. This is based upon the psycholinguistic research that stresses that phonological recoding is an intrinsic part of the reading process, no matter what orthographic system is being read (e.g., Perfetti et al., 1992). Still, this claim has come under attack as phonological activation might well be *a product* of character recognition and not a causal factor. Whether phonological mediation actually aids recognition is still a matter of debate.

The fourth strategy is really a “non-strategy,” that is: not teaching characters. There is a school of thought in the CFL teaching community that, Chinese literacy being as time-consuming a task as it is, classroom time is put to better use developing students’ oral language proficiency, and that until students reach a *critical mass* of vocabulary, that literacy learning should be staved off. Some teachers are arguing delaying character learning until at least the third year of language study which allows students to activate background knowledge when learning written characters, instead of having to simultaneously learn pronunciation, writing, and meaning (Wang, 1998). This holds especially true for Japanese as a foreign language (JFL) learners, as Japanese *kanji* (Chinese characters used in Japanese) can change pronunciations depending on character combinations. Fortunately Japanese language learners can first use the native Japanese syllabic script to build vocabulary before attempting *kanji*, and Chinese learners can make use of *roma pinyin* (a method of transcribing Chinese using the Roman alphabet) or *zhuyin fuhao* (a system of phonetic markings, common in Taiwan).

Variations in teaching practices abound, and are much affected by teachers’ own

feelings towards Chinese character learning. Wang (1998), reporting the opinions of “Lin Laoshi,” an instructor of first-year Chinese at an American university, notes that the instructor “felt sorry” for the students, and thus did not have high expectations for the students’ character learning. The teacher conspicuously avoided overt character instruction in class and justified her decision thusly: 1) she felt that the department-mandated-curriculum-demands were too high as is, so classroom time was better spent on vocabulary and grammar learning; 2) she believed that character study was sufficiently an individually-focused activity that it should not be the focus of group study; 3) she agreed with the notion that a certain level of oral proficiency was necessary before students would derive much benefit from character study; and 4) she disagreed with departmental requirements to teach traditional characters, and believed that students would be able to more easily learn simplified script (as is used in Mainland China). Wang (1998) points out that this mix of pity, empathy, and resentment towards the demands of the prescribed curriculum manifested itself in the classroom interaction, with the teacher having rather low expectations for students’ Chinese character production, and with the Chinese language being “treated as an academic subject, rather than a system for communication. The four skills were taught separately in distinct sequence and discrete points, and were tested as such” (p.77).

### *Teaching Radical Awareness in Chinese Literacy Pedagogy*

As mentioned before, many have proposed before that Chinese character education should include explicit and early instruction on the nature and use of semantic and phonetic radicals (e.g., Liu, 1983, Itoo, 1979: cited in Wang, 1998), however such an

approach to literacy instruction has never been embraced *en masse* by any major educational body. Literacy instruction for native Chinese speakers, in fact, continues much the way that it has since the beginning of mass educational efforts at the beginning of the 20<sup>th</sup> century, with rote learning of characters arranged largely in order of 1) complexity (i.e., stroke count); and 2) frequency (e.g., 是, the verb “to be” would normally be presented long before 找, “to search,” even though it has 9 strokes, as compared to the latter’s 7). Some native Chinese speakers have told me that some teachers, on their own initiative, will give clues to learners – often in the way of mnemonic devices and stories (e.g., breaking down a character into its components in a story format) – which may facilitate native speakers in determining the role that semantic and phonetic radicals play in the character system, but it is rare to find anyone who was taught radicals in any systematic way (other than learning how to use a character dictionary).

One may reasonably wonder, then, how Chinese natives come to recognize the semantic and phonetic function and value of their respective radicals. It is here that DeFrancis’ (1984) argument of the “critical mass” of characters gains some credence, as there does seem to be a fairly uniform progression of awareness of semantic and phonetic function as character knowledge increases – in both native and non-native learners. In natives, for instance, Ho, Ng, & Ng (2003), in a study on 1<sup>st</sup>, 3<sup>rd</sup>, and 5<sup>th</sup> grade children in Hong Kong, found that learners began to acquire “knowledge of character structure, position, semantic category, and sound value of radicals from about Grade 1” (p. 849), and that learners could accurately make predictions of semantic category from radicals



from Grade 3. Shu and Anderson (1997) similarly found that consistent use of the semantic radical for character identification purposes began around Grade 3, and that consistent use of the phonetic radical began at Grade 6. By contrast, the Ho, et al. (2003) study found that, by Grade 3, learners were just as apt to use the phonetic radical in tasks of pseudo-character naming.

In the case of CFL learners, it seems that the methodology of character instruction is largely the same as for native speaking children, albeit often a bit more haphazard (due to less consistent instruction). While CFL learners are taught stroke order, there is rarely any attempt to teach the strokes in isolation, as is standard for native 1<sup>st</sup> grade instruction. CFL curricula and materials usually arrange characters to be learned in order of complexity and frequency, much like that used in native instruction. Texts, such as the *Integrated Chinese* (Cheng & Tsui publishers – 2006) series used at the University of Arizona almost invariably begin character instruction by teaching pictorial and indicative characters, followed by a steady build-up of semantic-phonetic compounds. The compounds, however are typically presented to coincide with dialogues and vocabulary lists, and thus will have little or no explicit arrangement according to radicals (some texts will have supplementary vocabulary lists which have more overlapping radical structure). Explicit instruction in the role and function of radicals is rare; however it is suspected that, like with native speakers, as their vocabularies increase, CFL learners do become aware of the semantic and phonetic functions of these radicals. The degree of their ability to use semantic and phonetic radical knowledge for character recognition purposes, however, has not been measured previous to the current study (see Chapter 5).

### *L1-L2 Literacy Learning Transfer*

Studies from the last quarter century have consistently shown a link between L1 and L2 literacy development. Chu-Chang (1981), Robson (1981, cited in Penfield, 1986), and others have shown that L1 literacy skills accelerate L2 literacy development. L1 and L2 literacy skills are often seen to be interdependent – as manifestations of a common underlying proficiency. High levels of L1 proficiency help L2 acquisition, and conversely, high proficiency in L2 has positive effect on L1 development (BournotTrites, 2005). While L1 and L2 literacy will always share some basic elements, the processes involved are different. Nonetheless, many researchers treat L2 literacy as merely a ‘slowed-down’ version of L1 literacy (Singhal, 1998).

*“While it is true that the L1 and L2 reading process have similarities, it is also important to recognize that many factors come into play, which in turn make second language reading a phenomenon unto itself. Despite the similarities between reading in an L1 and reading in an L2, a number of complex variables make the process of L1 different from L2” (Singhal, 1998).*

The transfer of L1 literacy skills to the target L2, however, does not happen automatically. While basic encoding/decoding skills are always transferable, higher skills may be specific to a language or writing script. Evidence has shown that someone learning an L2 that bears a different written script will often have to learn different reading strategies to compensate. Koda (1997) states that different L1 orthographic properties produce qualitatively different word processing and recognition procedures. These will affect L2 reading through transfer. She also states that difficulties in L2 orthographic processing lead to word misidentification, which reduces one's ability to guess the meaning of unknown words from context. Teachers need to be aware of these

differences in learning strategies when teaching a target language to students whose L1 is written in a different script. Learners need to be made aware that the strategies that they use reflexively in their L1 may not be the best means of acquiring literacy skills in the target language.

Given the massive differences between English and Chinese scripts, it is no wonder that English L1 learners of Chinese face difficulties in learning to read and write Chinese characters. While some skills of L1 literacy will apply to learning any L2 – e.g., pre-reading skills of directionality, sequencing, ability to distinguish shapes and sounds, and the knowledge that written symbols correspond to oral language and can be decoded in order and direction (Lessow-Hurley, 1990) – many of the script-dependent skills that English L1 CFL learners picked up while learning to read and write their L1 will not be of much assistance when learning Chinese. Particularly, one of the key components of alphabetic literacy, that characters or character combinations represent the speech sounds of their languages (Cipollone, et al., 1998) is invalid for Chinese. For this reason, beyond simply teaching literacy, the goal of CFL teachers should be first to instill language specific *literacy learning strategies* in their students. The current study (described in the next chapter) is a first attempt to use psycholinguistic metric techniques for ascertaining the Chinese reading processes of intermediate-advanced level CFL learners. By discovering the dominant decoding strategies of CFL learners as they read Chinese script, we will be better able to offer concrete pedagogical suggestions for improving CFL literacy education by being able to reinforce the reading strategies that *work* for L2 Chinese reading, as well as by being more able to give explicit instruction to learners

concerning the reading processes that they either are not using at all or have not sufficiently developed to be a viable reading strategy.

## CHAPTER 5.

# THE CURRENT STUDY

### **Section 1:**

#### **Overview**

Given the recent rise in popularity and availability of Chinese language study, it has become increasingly possible and important to analyze CFL learners as a population, distinct from native speakers of Chinese. As Chinese language classes increase in number, it becomes incumbent upon educators and researchers to investigate how to facilitate the language acquisition of CFL learners. Literacy acquisition concerns immediately come to the forefront of researchable questions, considering the vast differences between Chinese and Western scripts. Given the tendency for L2 Chinese instructors to teach literacy in ways resembling those used for teaching native Chinese children, it is important to figure out whether or not western CFL learners' literacy learning strategies actually approximate those of native speakers or not. Allowing sufficient exposure to the language, will CFL learners eventually develop the same strategies exhibited by natives, or do they develop along their own, distinct path(s)? From a pedagogical standpoint, it is vital to know whether or not the literacy instructional techniques employed by CFL instructors are having the intended effects and benefits for the CFL learners, or whether they are merely being ignored by the learner (or, potentially even harming the learner).

This study has been designed to measure and contrast CFL learners' reliance on semantic vs. phonological decoding strategies when reading Chinese characters. The study is split into four different experiments which will help to answer the following questions: 1) Have intermediate-advanced level CFL learners developed the ability to correctly utilize semantic radical information to facilitate character recognition (thereby indicating an emerging semantic pathway); 2) Can they correctly utilize phonological information embedded in the phonetic component (thereby indicating an emerging phonological route to character recognition); 3) Which of the two pathways is the dominant means of character recognition; and finally, 4) Do strategies vary between isolated character recognition and sentence reading? After reviewing the results of the study and the implications for CFL literacy development, the results will be contrasted with those of native speakers engaged in similar tasks in chapter 6.

## **Section 2:**

### **Experiment #1: Semantic Categorization Task**

As we've seen, most Chinese characters are formed by combining a semantic radical with a phonetic component. While the semantic radical often reliably indicates some semantic properties of the character/word, some characters containing semantic radicals have no intuitive connection with the meaning of the character. Thus, orthographically similar semantic radicals do not always indicate a similar semantic category. Likewise, some characters lack the semantic radical one would naturally suspect would be used to classify them, given their meaning. In Figure 5.1, we see an

illustration of this variable semantic-orthographic relationship with the radical 氵 [*shui*: water]. This lack of consistency between form and meaning makes it possible to test whether semantic priming in Chinese is form-dependent. This experiment was designed to ascertain whether L2 Chinese readers' character recognition speed would be facilitated or impeded respectively by the presence or lack of semantic radicals which are accurate representations of semantic category. If these CFL learners' speed of character processing is dependent upon the relative "semantic validity" of the radical, it would therefore follow that these L2 learners were developing semantic pathways to character recognition.

	Semantic radical is a true representation of semantic category	Semantic radical is <b>not</b> a true representation of semantic category (i.e., orthographic relation only)	Character has semantic similarity to target, but lacks the semantic radical.
Target semantic radical: 氵 [ <i>shui</i> : water]	湯 [tang] soup	法 [fa] law	雨 [yu] rain

FIG. 5.1 Illustration of semantic radicals.

## Method

### *Subjects*

As the experiment testing required subjects to have a relatively high level of vocabulary and character recognition ability, the minimum testing standards were that subjects either have completed 4 full years of Chinese language study in the U.S. or 2 full years of study + 1 year of living abroad in a Chinese-speaking country. Given the

difficulty of finding subjects with a sufficient level of proficiency, it was necessary to recruit from several different universities. The 30 subjects tested were all native English speakers, and were recruited from the University of Arizona, Arizona State University, Utah State University, and Brigham Young University. The latter three schools were particularly identified for subject recruitment activities due to two factors which were (correctly) theorized to facilitate the recruitment and ameliorate the overall performance results of subjects. These factors were: 1) The presence of Chinese Flagship Programs on the ASU and BYU campuses; and 2) The prevalence of Mormons at BYU and USU, and thus the ability to identify and recruit former LDS missionaries to Taiwan. In fact, of the 30 subjects recruited, a plurality – 23 – of the recruits were former LDS missionaries to Chinese-speaking areas. All but four of the subjects had study/living experience abroad in either Taiwan or Mainland China, and all had continued their studies of the Chinese language after their return. The number of years of Chinese language study averaged just over 4 years, but ranged from a low of 3 (2 years of study abroad + 1 year of study stateside) to 20 years (graduate work in the U.S. and on-and-off living experience throughout the Chinese-speaking world). Subjects were given a pre-test of reading and character recognition to determine eligibility for recruitment for the study. Subjects had the option of testing with simplified or traditional characters, depending upon their own expertise and proficiency. While, in an idealized research world, it would have been nice to balance the number of subjects testing in each script, given the considerable difficulty of merely finding enough subjects with the requisite level of Chinese reading ability, I took whoever was eligible and willing, and thus the balance between the scripts ended up



with 17 subjects being tested in traditional script compared to 13 being tested in simplified. All subjects were paid an honorarium for participating in the study plus a small bonus if they maintained an 80% or higher rate of accuracy throughout the tasks. All subjects had normal or corrected-to-normal vision and all but one were either undergraduate or graduate students and between 21 and 25 years of age (the one exception was well into middle age). The subjects completed all four experimental tasks (Ex. 1-4) during a single session, averaging 1 ½ hours, and the order of tasks was varied evenly across subjects.

#### *Heterogeneity in Subject Pool*

Due to the relative rarity of high-proficiency non-native Chinese readers in North America, it must be acknowledged that the experimenter had to be ready to accept some differences in the subject pool. In particular, the means of Chinese acquisition between the ex-LDS missionary subjects and other subjects should be noted. The LDS missionaries would have acquired the bulk of their knowledge of the language in a Chinese-speaking community (e.g., Taiwan) and would have been placed in a Chinese speaking community within 3 months of beginning language study, whereas the non-LDS subjects had uniformly studied the language at least two years before spending time in Chinese-speaking countries. Additionally, the type of study could be qualitatively different. While LDS missionaries typically spend at least an hour a day on language learning while in the field, and have access to native-speaker instructors during their 21 months spent in-country, the amount of instruction vs. self/group study and the emphasis placed on literacy instruction may vary wildly between individual assignments –

although, the same can typically be said for U.S.-based CFL classroom instruction. Also, literacy study is usually aimed at being able to access LDS scriptures in the Chinese language (for proselytizing purposes), and thus literacy motivations and the higher vocabulary acquired may differ significantly from that of non-LDS students of Chinese (e.g., non-LDS students may have concentrated on more business/professional related vocabulary acquisition). While the subject requirements and pre-test were designed to make the subject pool as homogeneous as possible, the impact of individual motivations for Chinese language study on eventual literacy attainment cannot be understated, and should be kept in mind in interpreting the results of this study.

#### *Design and Materials*

The experiment consisted of 28 different semantic categories, each containing four single-character test words. The subjects were shown a semantic category (e.g., "water," "animal," etc.) which was followed by the presentation of four characters, one at a time. The subjects were tasked to determine quickly whether each character fit within the target semantic category or not. All categories and characters were presented and reaction times were measured with DMDX (Forster & Forster, 2003). Four character conditions were used: 1) S+R+: characters with semantic radicals that accurately indicated semantic category (i.e., "yes" response); 2) S-R+: characters with semantic radicals related to the target category, but actually unrelated to the whole character's actual meaning (i.e., "no" response); 3) S+R-: characters that fit the semantic category but did not possess the radical normally associated with said category (i.e., "yes" response); and 4) S-R-: a negative control category, wherein the character had no relation --

semantically or orthographically -- with the target category. In Figure 5.2., we can see examples of the four condition types using the semantic category of *four footed animals*. An additional 12 filler categories (each containing 4 target words), having variable correct response rates (e.g., 3/1 yes/no or 4/0 yes/no) were presented in order to prevent subjects from recognizing a 2 “yes” / 2 “no” answer ratio. Thus, altogether, the subjects reviewed 160 characters in 40 different categories.

Mammal /Animal	Condition 1: Semantically relevant and possesses associated radical (S+R+)	Condition 2: Possesses associated radical but not semantically relevant (S-R+)	Condition 3: Semantically relevant but does not possess associated radical (S+R-)	Prime Condition 4: Negative Control (S-R-)
Associate radical:	狼 [lang] wolf	獲 [huo] capture	虎 [lao] tiger	哥 [ge] older brother

FIG. 5.2. Illustration of Experiment #1 test conditions

### *Procedure*

The subjects were shown the semantic category (e.g., "water," "wood," etc.) immediately followed by 4 individual target words in randomized order, which they were asked to categorize as belonging to that semantic category or not. The simplified character tests were generated in SimSun script and the traditional character tests with MingLiU script (these are, to date, the only fonts for their respective character styles that function with the DMDX programming platform). The target characters were presented in a size 20 font on a 1280x800 pixel display area. Presentation of stimuli and recording

of reaction time were controlled via DMDX (Forster & Forster, 2003). After each response, feedback on accuracy and reaction time appeared (e.g. "correct: 820 milliseconds"). Category presentation was self-timed (i.e., would stay up until the subject pushed a button to clear), and test characters were displayed for a maximum of 4000 milliseconds (or until subjects responded). English language instructions and 4 target language practice categories (i.e., 16 semantic categorization decisions) were presented prior to test items.

### Results of Experiment 1

Mean reaction times across the 4 priming conditions are shown in Table 5.1. The experiment showed strong effects for semantic priming and delay based upon the validity of the semantic radical as an indication of semantic category. Given that standard testing

TABLE 5.1  
Mean Reaction Times (m sec.) and Error Rates (percentage) across  
4 conditions in Experiment 1.

Conditions	RT m sec.	Error %	Facilitation of R+
Condition S+R+	940	20.8	+35 (vs. Cond. #3)
Condition S-R+	1102	42.4	-63 (vs. Cond. #4)
Condition S+R-	975	26.9	--
Prime Condition S-R-	1039	18.2	--

methods disallow comparison between positive and negative answers, Condition S+R+ was only analyzed with Condition S+R- and Condition S-R+ was only compared to Condition S-R- (i.e., positive answers were compared to ascertain whether the presence of the overt semantic marker facilitated recognition time, and negative answers were compared to see whether the “false” semantic marker would retard reaction time).

*Comparison of conditions S+R+ and S+R- (effect of a semantically relevant radical):* A significantly faster response time was found when the S+R+ condition is compared to the S+R- condition, indicating that the presence of a semantically relevant radical facilitating recognition of the character's semantic grouping.  $F_1(1,21)=6.30, P<0.02$ . Subject error rate also showed significance,  $F_{sub\ error}(1,21)=9.33, P<0.01$ . Correlating the results with the frequency rate of the characters,  $r(54) = -0.19, p > .08.$ , shows a trend towards faster response when the semantically relevant radical was present *even when* the corresponding character lacking the relevant radical had a higher frequency.

*Comparison of conditions S-R+ and S-R- (effect of a non-semantically relevant radical):* The presence of a non-semantically relevant radical in the S-R+ condition slowed subject response time and increased errors when compared to the S-R- condition (control).  $F_1(1,21)=4.35, P<0.05; F_2(1,54)= 5.20, P<.03$ ; error analysis:  $F_{sub\ error}(1,21)=47.80, P<0.01, F_{item\ error}(1,54)=15.85, P<0.01$ . Correlation with frequency rates,  $r(54) = -0.16, p > .12$ , showed no real effect of character frequency compared to presence of the radical.

### **Discussion of Experiment 1**

The results of the experiment support the claim that CFL learners are utilizing the semantic radical in the decoding process, and the fact that the relative accuracy of the semantic radical as an indicator of semantic class does facilitate recognition indicates that these CFL learners were using a semantic pathway, according to the type described by Weekes, Chen, and Yin (1997). The presence of a semantic radical does facilitate decoding as long as the radical is a clear indicator of the semantic category of the whole character. When the meaning of the character varied significantly from that of the radical, there was a clear pattern of impairment of reading times and accuracy.

### **Section 3:**

#### **Experiment 2: Homonym Recognition**

Given that Chinese characters contain phonetic information, as well as semantic information, it is important to explore the effect that this phonetic component has on reading processing. While the phonetic component has a relatively lower rate of correspondence with actual character pronunciation, there is still evidence that native speakers make use of it in character processing and identification, thus making use of a phonological route for decoding (e.g., Perfetti & Tan, 1998; Zhou & Marslen-Wilson, 2000; Shen & Forster, 1999; etc.). Given that L1 speakers of languages with alphabetic script would be predisposed to phonological processing schemes, one could well expect that this could be the dominant route for L2 speakers of Chinese; however, the variability in pronunciations of characters with the same phonetic component – especially amongst

the most common characters in the Chinese corpus – is bound to frustrate the L2 learner. While L2 learners of Chinese from alphabetic L1 backgrounds are likely, in their early stages of L2 development, to have struggled to find some phonological aspect to Chinese characters, the real question that we need to ask ourselves is how much time does it take, and how many characters acquired does one need to learn, in order to develop a reliable phonological route to recognition. Figure 5.3 below illustrates the phonetic component of characters. The following experiment was designed to probe whether accurate phonetic character components would facilitate whole-character recognition.

	Phonetic component accurately represents pronunciation of character	Phonetic component <b>does not</b> accurately represent pronunciation of character	Character pronounced like target, but does not share any orthographic components
Target phonetic component: 工 [gong]	功 [gong]	紅 [hong]	宮 [gong]

FIG. 5.3. Illustration of phonetic components in Chinese characters

## Method

### *Subjects*

The same participants from Experiment #1 above were used in the following study.

### *Design and Materials*

The test consisted of a total of 120 pairs of Chinese characters, with thirty pairs of each of the following relationships: (illustrated in Fig. 5.4 below): 1) P+C+: are

pronounced the same and share the same phonetic component; 2) P-C+: are pronounced differently but share the same phonetic component; 3) P+C-: are pronounced the same but have no orthographic components in common; and 4) P-C-: are pronounced differently and have no orthographic components in common (control).

	Condition 1: Same Pronunciation and same phonetic component (P+C+)	Condition 2: Different pronunciation but same phonetic component (P-C+)	Condition 3: Same pronunciation but not the same phonetic component (P+C-)	Prime Condition 4: Negative Control -- no relation (P-C-)
Character pair	安 氨 [an] [an]	位 泣 [wei] [qi]	丰 風 [feng] [feng]	往 根 [wang] [gen]

FIG. 5.4. Illustration of Experiment #2 test conditions

### *Procedure*

One hundred and twenty character pairs were displayed – one pair at a time – and subjects were asked to indicate whether or not the characters were homonyms. The simplified character tests were generated in SimSun script and the traditional character tests with MingLiU script – all at size 20 font. Presentation of stimuli, as well as recordings of reaction time was controlled via DMDX (Forster & Forster, 2003). Character pairs were displayed until subjects responded or would time out after 4000 milliseconds. After each response, feedback specifying accuracy and reaction time appeared. Instructions and 8 practice items were presented prior to test items.



## Results of Experiment 2

Mean reaction times across the 4 priming conditions are shown in Table 5.2.

TABLE 5.2  
Mean Reaction Times (m sec.) and Error Rates (percentage) across  
4 conditions in Experiment 2.

Conditions	RT m sec.	Error %	Facilitation of R+
Condition P+C+	1255	26.8	+33 (vs. Cond. #3)
Condition P-C+	1433	36.3	-35 (vs. Cond. #4)
Condition P+C-	1289	30.2	--
Prime Condition P-C-	1398	13.6	--

*Conditions P+C+ and P+C- (comparison of presence of accurate phonetic component):*

Despite the fact that we see in the above Table that the presence of a phonologically reliable phonetic component yielded an average facilitation of 33 milliseconds, this did not prove to be a significant effect:  $F_1(1,18)=2.65, P>0.12$ ,  $F_2(1,58)=1.0, P>0.32$ , and there was no significant effect on error rate:  $F_{sub\ error}(1,18)=1.54, P>0.75$ ,  $F_{item\ error}(1,58)=0.05, P>0.83$ . Correlation of character frequency with reaction times yielded a significant effect,  $r(58) = -0.40, p < .01$ , which one might initially suspect could be biasing the results and preventing any significant finding for the presence of the phonetic component; however, given that the frequency rates of the P+C+ and P+C- character sets'

frequency rates correlated significantly with each other,  $r(58) = 0.22$ ,  $P < .05$ ; and that reaction times for both conditions *individually* correlate strongly with their respective frequency rates, P+C+:  $r(28) = -0.34$ ,  $P < .04$ ; P+C-:  $r(28) = -0.47$ ,  $P < .01$ ; we can reasonably surmise that reaction time was highly dependent upon the relative frequency of characters, but that orthographic overlap (i.e., the presence or absence of a phonetically indicative phonetic component) made no significant impact on reaction time.

*Conditions P-C+ and P-C- (comparison of presence of inaccurate phonetic component):*

There was, however, a significant inhibitory effect from having a phonetic component embedded in a character which did not accurately indicate the whole character's pronunciation:  $F_1(1,21) = 4.35$ ,  $P < 0.05$ ,  $F_2(1,54) = 5.2$ ,  $P < 0.03$ . This inhibitory effect also corresponded with an increase in error rate for the characters with the inaccurate phonetic components:  $F_{sub\ error}(1,21) = 47.8$ ,  $P < 0.01$ ,  $F_{item\ error}(1,54) = 15.85$ ,  $P < 0.01$ .

Correlation of character frequency with reaction times showed no significant effects,  $r(58) = .02$ ,  $p > .43$ .

## **Discussion of Experiment 2**

How do we make sense of these results wherein it seems the subjects could not make constructive use of the accurate phonetic components, but were nonetheless misled by the inaccurate ones? It seems to indicate that the subjects were aware that the phonetic component had phonological value, and that they were attempting to use it to inform their decisions on accessing the phonology of characters, but that their character

expertise was still not sufficiently advanced to employ this strategy at a level to achieve accuracy rates that exceeded those of chance. The evidence indicates that the subjects' phonological route is essentially still under construction, and that subjects' use of character-internal phonological is still shaky-at-best. This corresponds with what Shu and Anderson (1997) discovered in their studies of L1 Chinese children. They found that L1 Chinese children typically could correctly employ semantic radical knowledge to reading tasks at a much earlier stage in reading development than they could the phonological information embedded in the phonetic component. L1 Chinese children typically began uniformly recognizing and utilizing semantic information by 3<sup>rd</sup> grade, whereas most children did not start to use the phonetic information reliably until about 6<sup>th</sup> grade. Given that the average length of Chinese study by subjects is just over 4 years, one could intuit that they are operating comfortably in the L1 2<sup>nd</sup>-4<sup>th</sup> grade range, as far as literacy tasks are involved. It's entirely possible that if the tests were repeated with a more highly fluent/literate L2 Chinese population, that we would see an emergent phonological route comparable to a 6<sup>th</sup> grade or higher L1 child learner.

## **Section 4**

### **Experiment 3: Lexical Decision Task**

The above two experiments seem to indicate that the L2 Chinese learners tested have developed a semantic route for character decoding and are aware of the phonological information present in the phonetic component, but have yet to master its use to be able to take full advantage of the phonological route in character decoding.

However, before assuming that this means that the semantic path is the default means of character decoding for L2 learners, we must examine subject reading processes in a task that will not inherently bias subjects towards either semantic or phonological processing strategies. Towards that goal, the subjects completed a lexical decision task designed to indicate whether they were making more use of the semantic radical or the phonetic component in distinguishing real characters from pseudo characters.

## **Method**

### *Subjects:*

The same participants from Experiments #1 and #2 above were used in the following test.

### *Design and Materials*

A total of 30 pseudo-characters and 30 true characters were used in this task. Pseudo characters were constructed by arranging the semantic radical and the phonetic component from existing characters in combinations that, while legal, don't exist in the Chinese character corpus (see Fig. 5.5). Both traditional and simplified versions of the pseudo characters were constructed (and care was taken to ensure that the character was nonexistent in both scripts). Semantic radicals and phonetic components occupied their normal positions within the pseudo characters (e.g., a radical like 氵 "water" would only be normally seen on the left hand side -- never on top or on the right) -- and thus, readers

would be unable to recognize a pseudo character solely based upon reasons of orthographic illegality (i.e., the characters violated no orthographic constraints of Chinese, but nonetheless were nonsense words). Images were created using the GIMP GNU Image Manipulation Program ([www.gimp.org](http://www.gimp.org)) and stored as \*.bmp files. True characters, likewise were created as \*.bmp files.



FIG. 5.5. Example of Pseudo-character

All characters (true and pseudo) were then used to create two different blurred versions: one with a blurred semantic radical, and one with a blurred phonetic radical. The GIMP software blur feature "Gaussian Blur" level 7 was used to attain the desired amount of high frequency filtering. Such blurring would impede recognition of that character part, and require a higher amount of focus on that part. In effect, the blurring was designed to delay the initiation of semantic and phonological search patterns, respectively, and the resultant time difference between blurring would allow us to recognize whether lexical searches were initiated from the blurred or un-blurred portion. See Fig. 5.6. for an example of blurring. All characters were created in a 20pt. font in SimSun or MingLiU script (according to whether they were simplified or traditional, respectively), fitting on an 80x80 pixel background.

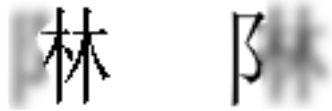


FIG. 5.6. Examples of a pseudo character with blurred semantic radical (R) and blurred phonetic component (L)

The characters were presented with DMDX (Forster & Forster, 2003) with a maximum presentation time of 4000 milliseconds. Subjects were split into 2 groups, each receiving a different experiment script, via standard counterbalancing procedures. In the first script, half of the presented characters had blurred semantic radicals, and the other half had blurred phonetic components -- and all were presented in a randomized order. In the other script, the blurring effect was reversed, so that a character with a blurred semantic radical in the first script would now have a blurred phonetic component, and vice versa.

### *Procedure*

Participants were shown a total of 60 characters (30 pseudo-characters and 30 true characters) and were asked to indicate (by pressing either a [YES] key or a [NO] key) whether or not the given character was an existent character in the Chinese language. All presentation and reaction time was controlled as before with DMDX, and instructions were given along with six practice items before testing began.

### Results of Experiment 3

Upon initial analysis, there was little statistical difference in subject performance between the two conditions (blurred semantic radical and blurred phonetic component). The only effect of note was a significant increase in subject error rate when the phonetic radical was blurred:  $F_{sub\ error}(1,20)=5.18, P<0.04$ . However, when the results for the true characters vs. the pseudo characters were separated, the picture became clearer. For true characters, there was no significant difference between the two test conditions, but when identifying fake characters, the subjects' response time was delayed by an average of 17.5 milliseconds when the phonetic component was blurred. The results were significant, indicating that the identification of pseudo characters was slower for characters containing a blurred phonetic radical:  $F_1(1,16)=0.34, P<0.01$ ;  $F_2(1,14)=9.58, P<0.01$ ; and the error rate increased as well:  $F_{sub\ error}(1,16)=4.50, P<0.05$ .  $F_{item\ error}(1,14)=7.29, P<0.02$ .

Separating results by whether the subjects had been tested in traditional script or in simplified script was further revealing. Subjects tested in traditional script tended to respond more slowly than those tested in simplified script when the phonetic component was blurred, closely approaching statistical significance:  $F_1(1,5)=5.16, P<0.06$ ; however, the subject error rate did increase significantly for those testing in traditional script vs. simplified:  $F_{sub\ error}(1,8)=6.49, P<0.04$ .

### Discussion of Experiment 3

At first, it may seem contradictory that – while in the homonym recognition study,

subjects seemed incapable of making reliable use of the phonetic component – in this lexical decision task they appear to be favoring it over the semantic radical. That we see a difference in the processing of subjects tested in traditional vs. simplified script, however, may give us some clue as to what is going on. In fact, these results are quite the opposite of what one would expect if one were to argue that the subjects were using a phonological route to character recognition. Simplified script makes more use of reliable phonetic components than does traditional script; in fact, regularization of character-internal phonological features was one of the major components of character simplification. So why are readers of traditional script slower accessing characters when the phonological component was blurred? The likely answer is that, instead of using the phonological component for its phonetic value, subjects relied more on the phonetic component because, as compared to semantic radicals, phonetic components tend to have more strokes, and thus have more orthographic information embedded. To revisit the “triangle model” (Weekes, et al., 1997), the third side of the triangle is orthographic, and it appears that the subjects may be dependent upon the stroke-dense phonetic component for its graphemic value (i.e., they may be looking at the sub-radical level for information that would be useful for character identification). Simply put, the subjects may have rejected both semantic and phonological pathways for the lexical decision task, and instead focused upon whole grapheme recognition. The phonetic component, often being considerably more complex, would thus require more processing time to recognize through the blur. Characters in simplified script, often having a less complex phonetic component, would take less processing time to mentally “unblur.” In this account, the



phonetic component would be acting as a sort of “anchor” for reading, being decoded for orthographic value before moving on to the semantic radical.

In order to shed some light on the impact of blurring on decoding orthographic information, a series of post hoc tests were conducted correlating reaction times with the number of strokes in the blurred section of the character. As would be suspected if subjects were using a strategy that entailed “unpacking” stroke information from the unblurred character component, correlation between the number of strokes in the phonetic component and reaction time when the phonetic component was blurred was significant,  $r(58) = .25, p < .03$ ; and correlation between the number of strokes in the semantic radical and reaction times when said radical was blurred was also significant,  $r(58) = .23, p < .04$ . Differences emerge, however, when one correlates the *ratio* of strokes in the phonetic component and semantic radical (i.e., p/s) with the reaction times with their respective blurred parts. The ratio of strokes in the phonetic component to strokes in the semantic radical neared significance when correlated with reaction times when the phonetic component was blurred,  $r(58) = .20, p > .06$ ; however, there was a (non-statistically relevant) negative correlation between the ratio of strokes in the semantic radical to strokes in the phonetic radical (i.e., s/p) with reaction times when the semantic radical was blurred,  $r(58) = -0.15, p > .12$ . This indicates that recognition times tend to increase as the phonetic component becomes increasingly more complex, no matter which part of the character is blurred, which strongly suggests that the subjects are unpacking orthographic information by strokes, starting with the phonological component. Correlating all stroke ratios to *rt* yielded no significant effects,  $r(118) = -0.10, p > 0.13$ .

## **Section 5:**

### **Experiment 4: Sentence Reading Task**

The previous three experiments tested recognition of characters in isolation, but most real-life reading tasks involve reading words/characters in sentence and phrasal contexts. Evidence supports the assertion that the processes utilized in sentence decoding are more complex than that of single-word recognition (e.g., Chee, Tan, & Thiel, 1999; Miller & Isard, 1963; etc.), and, as such, one would be remiss not to test Chinese reading patterns in a sentence context. As most modern reading models incorporate means of decoding both semantic and graphophonemic information, and as syntactic, logical, and semantic inference can all help the reader to “bootstrap” meaning (Goodman, 1970; Rummelhart, 1977; Labarge & Samuel, 1974, etc.), it would be shortsighted to make strong assertions about the character recognition strategies of reading Chinese script without looking at sentence context decoding. Still, the unique characteristics of Chinese script make it an interesting case for study, as, unlike in alphabetic languages, the basic framing unit of the Chinese language is the character – not the word (Hoosain, 1992). Additionally, Chinese word and phrase distinction is made more problematic by the lack of spaces (i.e., all characters are equally spaced in the sentence) and even punctuation (especially in older texts), so decoding strategies could be at more of a character level than at a phrasal or word level.

## Method

### *Subjects:*

The same participants from Experiments #1 -3 above were used in the following test.

### *Design and Materials*

A total of 20 of the true characters from the lexical decision task were chosen for the task. Twenty sentences were composed – each designed to feature one of the chosen true characters in a logical, contextual fashion. The sentences were presented on DMDX (Forster & Forster, 2003), in 12 point font in SimSun or MingLiU script (according to whether they were simplified or traditional, respectively). The sentences were presented one character/word at a time, and the target character was presented as a \*.bmp file with a blurred semantic radical or phonetic component as above in Experiment #3. All sentences were structured so that the target character would be located in the latter half of the sentence, so that sentence context would be established before the test character was presented. In addition, 20 comprehension questions were composed (one for each test sentence). See figure 5.7 for an example of sentence and comprehension question.

*Sentence:* 。北京**往**飛機正飛

*Translation:* The plane is flying **toward** Beijing.

*Comprehension Question:* 飛機從北京來嗎?

*Translation:* Is the plane coming from Beijing?

FIG. 5.7. Example of test sentence (test character bolded) and comprehension question.

### *Procedure*

Test sentences were presented to the subjects on the DMDX platform. The sentences were presented one character/word at a time in a moving window display format, and subjects were instructed to press the right SHIFT key immediately following positive comprehension of each character/word as it was presented. If they did not understand the character, they could either push the left SHIFT key or wait for 4 seconds for the system to time out. Thus, decoding time was measured for each character/word in the sentence, including the blurred test character. Each character remained visible for a maximum of approximately 3200 m sec. (or would disappear upon pushing the right SHIFT key). At the conclusion of each test sentence, the words “Comprehension Question” were flashed (in English) on the screen for 3200 m sec., followed by the presentation of a comprehension question, testing whether the subject fully understood the test sentence or not. The comprehension question stayed on the screen for a full 4 seconds. Instructions and a practice sentence/question were presented before testing began. Subjects were separated into two groups, with each group having an opposite combination of 10 test characters with a blurred semantic radical and 10 test characters with a blurred phonetic component via standard counterbalancing procedure.

### *Results of Experiment #4*

As one would readily expect, there was a marked (however non-statistically relevant) acceleration in reading time as the sentence progressed, seeming to indicate that

subjects were successfully anticipating upcoming information based upon sentence context. However, given that there was no effort made to keep all words in each sentence context to a similar level of word frequency (instead, vocabulary employed was chosen specifically according to the criterion of being readily identifiable by CFL learners at the 4<sup>th</sup> year+ level of study – thus, while word frequency never veers towards the truly “infrequent,” there is still a large range between frequency between “easy” and “medium” level vocabulary that was used), this may not have been a relevant finding. Thus, more study of Chinese reading patterns would be highly recommended. As for the target (blurred) characters, which were matched according to word frequency, and are thus more apt for statistical comparison, as in Experiment #3, we find the results skewed towards a slower processing speed when the phonetic components were blurred. The average reading speed for characters with blurred phonetic components was 64 m sec. slower than that of characters with blurred semantic radicals. Furthermore, the results were statistically significant:  $F_1(1,18)=6.12, P>0.03, F_2(1,9)=5.11, P>0.05$ ; however, there was no significant effect on error rate (which was to be expected, as the task was merely to press the button upon recognizing the character – no decision was being made which could force an error). Once again, we can see that the majority of this effect came from the subjects who were tested using traditional characters vs. simplified characters. The subjects tested with traditional characters averaged a 97 m sec slower response time on characters with blurred phonetic radicals vs. blurred phonetic components; whereas subjects tested with simplified characters only averaged a slowdown of 14 m sec. Statistical comparison of the results, showed no significant difference however.

TABLE 5.3  
Mean Reaction Times (m sec.) for recognition of blurred character in sentence  
reading task

	CFL Learners' Reaction time (ms)
Blurred Semantic Radical	1080
Blurred Phonetic Component	1144

#### *Discussion of Experiment #4*

As in experiment #3, the seeming incompatibility between the findings in experiment #2 and here are most likely indicative that the subjects, instead of employing a phonetic route, are likely searching at the stroke level in the phonetic component in order to decode the character. As in experiment #3 above, the fact that the subjects tested with traditional script, having phonetic components which are often *less accurate* predictors of phonology than that in simplified script, were more delayed by blurring of the phonetic component is a strong indication that the phonetic component is being employed for something other than phonemic value. The more concentrated number of strokes inherent to most phonetic components would be consistent with this interpretation.

While this would be the most logical interpretation, given the results of the preceding experiments, it is well worth mentioning another tantalizing possibility. The task itself, with the individually presented characters, may have inadvertently lent itself to a “reading aloud” strategy that emphasized phonology. Indeed several subjects were observed to be reading the sentences under their breath. The sentence format does lend itself to this sort of decoding; however, we still face the lack of congruency with the

results of experiment #2, and we are left with the fact that even if the task biased subjects towards a phonological interpretation, their lack of mastery of analysis of the phonetic components of characters makes it unlikely that even in a phonology-driven task that they were deriving much value from the phonological interpretation of these character-internal components.

## **Section 6:**

### **General Discussion**

Given the results of the four experiments, a picture begins to emerge of how CFL learners process Chinese characters. While there is much left to answer, and the picture is still incomplete, we can infer from the results that CFL learners, by this stage of acquisition, have by-and-large mastered the use of the semantic route of character decoding; however, the learners, while seemingly aware of the potential use of a phonological route to character recognition, are still clumsy with its application, and cannot reliably use this route for character reading tasks.

In an attempt to answer the third research question concerning which lexical route was dominant at this stage of learning, the lexical decision task yielded results which, at first glance, seem to contradict the conclusion that subjects have not yet developed a fully functional phonological route. This was explained as the subjects being dependent upon the densely-packed stroke information inherent in many phonetic components for recognition purposes. It could well also be interpreted that English L1 subjects, being used to phonological routes of recognition in their L1, are indeed defaulting to

phonological routes of recognition, therefore explaining the sizeable delay when the phonetic component was blurred, but were stymied by their lack of ability to successfully employ the phonological route to character recognition, and thus fell back to either semantic or graphemic strategies. In essence, the evidence seems to indicate that the subjects are indeed defaulting to a (highly fallible) phonological route, often encountering an “error” message in processing, and then proceeding to alternate strategies.

The sentence comprehension task evidenced the same sort of contradiction with experiment #2, but is likely indicative of the same sort of task order as in #3 above. The evidence seems to indicate reliance upon the phonetic component, which could be used for its graphemic value, even if the subjects cannot take full advantage of its phonological properties. It’s likely, that, as in the lexical decision task, subjects actually were *first* trying to decode the character phonetically, but when/if that failed, moving on to other strategies.

Thus we begin to see a picture of the CFL learner – who is crippled by overreliance on a reading strategy that he/she doesn’t have full control over. The learner has mastered semantic processing skills, but this seems to be employed as a secondary measure. Phonological processing strategies, while dominant (likely due to L1 literacy learning strategies), are still too weak to be of substantial use in reading tasks. It would be of interest to conduct similar studies on native Chinese-speaking child literacy learners to see if a similar effect would be found, or if they initially orient themselves towards semantic processing strategy dominance. In any case, it would probably prove highly beneficial to CFL learners to have targeted instruction on semantic processing strategies



to help them more consciously employ this strategy while their phonological route is still being developed.

## **CHAPTER 6.**

# **COMPARING L2 CHINESE LEARNERS TO NATIVE SPEAKERS**

### **Section 1:**

#### **Review of Native Speaker Study**

In 2008, the author, together with Dr. Thomas Bever, ran a series of experiments, similar in task to those described in Chapter 5, on *native speakers* of Chinese. The goal was to determine whether Chinese natives favored semantic or phonological routes to character interpretation. In order to get a full grasp of the significance of the previously described study on CFL learners, it is useful to compare the results to those of native speakers engaged in the same tasks. First, I will describe the experiments and their results:

#### **Experiment 1b: Semantic Categorization**

##### **Method**

##### *Subjects*

Thirty-six subjects -- all native speakers of Mandarin from the People's Republic of China (PRC), participated in this experiment. All were currently-enrolled students at the University of Arizona at the time of the experiment. Both undergraduates and

graduate students were used in this experiment. All subjects had normal or corrected-to-normal vision. Subjects were recruited via advertisement on a local Chinese-language online discussion forum, and all were given monetary compensation for their participation in this study.

### *Design and Materials*

The testing design was the same as in Experiment #1 in Chapter #5, except that it consisted of **38** different semantic categories, and an additional 12 filler categories and targets were presented in order to prevent subjects from recognizing patterns.

### *Procedure*

Subjects were shown a semantic category (e.g., "water," "wood," etc.), followed by 4 individual target words in random order which they were asked to categorize as belonging to that particular semantic category or not. The characters were all generated in SimSun script (only simplified script was used, as all subjects were from PRC), with target characters presented in a size 20 font on a 1024x768 pixel display area. Presentation of stimuli and recording of reaction time were controlled via DMDX (Forster & Forster, 2003) with a maximum presentation stimuli time of 4000 milliseconds. After each response, feedback on accuracy and reaction time appeared (e.g. "correct: 790 milliseconds"). Instructions and 4 practice categories (16 semantic categorization decisions) were presented prior to test items.

## Results of Experiment 1b

Mean reaction times across the 4 priming conditions are shown in Table 6.1.

There were strong effects associated with the semantic radical discussed in detail below.

*Conditions S+R+ and S+R- (comparison of effect of a semantically relevant radical):* A significantly faster response time was found when the characters with semantically relevant radical (S+R+) are compared to the characters without such an indicative radical (S+R-), indicating that the presence of a semantically relevant radical facilitated recognition of the character's semantic grouping.  $F_1(1,31)=29.07, P<0.01$ . Subject error rate also showed significance,  $F_{sub\ error}(1,31)=41.32, P<0.01$ . Item analysis approaches significance, at  $F_2(1,68)= 3.96, P<.05$ .

TABLE 6.1  
Mean Reaction Times (m sec.) and Error Rates (percentage) across  
4 conditions in Experiment 1b.

Conditions	RT m sec.	Error %	Facilitation of R+
Condition S+R+	749	12.9	+47 (vs. Cond. #3)
Condition S-R+	874	19.9	-58 (vs. Cond. #4)
Condition S+R-	796	20.9	--
Prime Condition S-R-	816	7.0	--

*Conditions S+R+ and S+R- (comparison of effect of a semantically relevant radical):* A significantly faster response time was found when the S+R+ condition was compared to the S+R- condition, indicating that the presence of a semantically relevant radical facilitated recognition of the character's semantic grouping.  $F_1(1,31)=29.07, P<0.01$ .

Subject error rate also showed significance,  $F_{sub\ error}(1,31)=41.32, P<0.01$ . Item analysis approaches significance, at  $F_2(1,68)= 3.96, P<.05$ .

*Conditions S-R+ and S-R- (comparison of effect of a non-semantically relevant radical):*

The presence of a non-semantically relevant radical in the S-R+ condition slowed subject response time and increased errors when compared to the S-R- condition (control).

$F_1(1,31)=13.02, P<0.01$  and  $F_{sub\ error}(1,31)=41.32, P<0.01$ . Subject error rate differences were also significant,  $F_{sub\ error}(1,31)=41.32, P<0.01$ . Item analysis:  $F_2(1,68)= 6.46, P<.014$ .

### **Discussion of Experiment 1b**

These results support the hypothesis that there is a semantic route for Chinese character decoding. The presence of a relevant semantic radical facilitated semantic categorization -- *as long as the radical was a correct indicator of semantic category*. In the S-R+ condition, where the entire character does not fit the target semantic category, despite possessing a related semantic radical, there was a clear pattern of impairment. Thus the semantic radicals are helpful to character recognition *only when they act as true semantic indicators*. This finding complements the results from priming studies which have obtained semantic priming in Chinese reading (Zhou & Marslen-Wilson, 2000,

Feldman & Siok, 1999).

## **Experiment 2b: Homonym Recognition**

### **Method**

#### *Subjects*

The same participants from Experiment #1b above were used in the following study.

#### *Design and Materials*

The testing materials were largely similar to that of Experiment #2 in chapter 5, but contained a larger character pool – including more difficult (low frequency) characters than were used for testing the CFL learners. The test consisted of a total of 184 pairs of Chinese characters. All character pairs fit into one of the following four types of relationships (illustrated in Fig. 4 below): 1) P+C+: are pronounced the same and share the same phonetic component; 2) P-C+: are pronounced differently but share the same phonetic component; 3) P+C-: are pronounced the same but have no orthographic components in common; and 4) P-C-: are pronounced differently and have no orthographic components in common (control).

### *Procedure*

Subjects were shown 184 different pairs of Chinese characters and were asked to indicate whether or not the characters were homonyms. The characters were generated in SimSun script at size 20 font. Presentation of stimuli, as well as recordings of reaction time was controlled via DMDX (Forster & Forster, 2003) with a max. presentation time of 4000 milliseconds. After each response, feedback specifying accuracy and reaction time appeared. Instructions and 8 practice items were presented prior to test items.

### **Results of Experiment 2b**

Mean reaction times across the 4 priming conditions are shown in Table 6.2.

TABLE 6.2  
Mean Reaction Times (m sec.) and Error Rates (percentage) across  
4 conditions in Experiment 2b.

Conditions	RT m sec.	Error %	Facilitation of R+
Condition P+C+	886	5.7	+24 (vs. Cond. #3)
Condition P-C+	1059	13.1	-56 (vs. Cond. #4)
Condition P+C-	910	6.9	--
Prime Condition P-C-	1003	5.3	--

*Conditions P+C+ and P+C- (comparison of presence of accurate phonetic component):*

The presence of an accurate phonetic component showed significant facilitation effects,  $F_1(1,35)=4.65, P<0.04, F_2(1,90)=1.54, P<0.22$ , but there was no significant effect on error rate. Still, it seems apparent that the orthographic overlap of the shared phonetic component helped in identifying the two characters as homonyms.

*Conditions P-C+ and P-C- (comparison of presence of inaccurate phonetic component):*

There was a strong significant inhibitory effect from having a phonetic component embedded in a character which is not indicative of the whole character's pronunciation:  $F_1(1,35)=42.35, P<0.01, F_2(1,90)=17.73, P<0.01, \min F(1,125) = 12.49, p<0.01$ . This inhibitory effect corresponded with a rise in error rate as well:  $F_{sub\ error}(1,35)=54.34, P<0.01, F_{item\ error}(1,90)=11.50, P<0.01$ .

## **Discussion of Experiment 2b**

These results complement those of the 1st experiment testing effects of semantic variables. Like the semantic radicals, phonetic components facilitate the relevant kind of processing, but only when accurate. When the phonetic component is an inaccurate indication of how to pronounce the character, there are slower response times, and larger error rates. Shen and Forster (1999) argued that Chinese decoding strategies may well be task-dependent, and that is certainly arguable in this case. A semantic categorization task would inherently bias test-takers towards semantically-based reading strategies, and a homonym recognition study would push one to use phonetic strategies.



### **Experiment 3b: Lexical Decision Task**

The preceding studies and prior research show that native Chinese readers can utilize both semantic and phonetic routes for lexical access, as best fits the lexical processing task. The major research question for this study, however, was which route dominates in a strategy-neutral task. Thus, we conducted a lexical decision task (as in Experiment #3, chapter 5) in order to measure whether participants predominantly used either the semantic radical or the phonetic component of compound characters in identifying words. As Chinese characters can only be recognized by consulting both kinds of radicals, a holistic lexical decision task does not logically impel recognition towards one radical or the other. To study this, we experimentally manipulated physical “informativeness” of individual radicals, making it possible to identify which part of the character was more critical for decoding. In this task, the characters presented for identification as actual or pseudo-characters were specially treated by blurring either the semantic radical or the phonetic component. The results were analyzed to determine whether one component would impede lexical decision time more than the other when blurred.

### **Method**

#### *Subjects:*

The same participants from Experiments #1b and #2b above were used in the following test. The order of presentation of this task, along with experiments #1b and #2b (described above,) was randomized.

### *Design and Materials*

Materials were created as in Experiment #3 in chapter 5. A total of 48 pseudo-characters and 50 true characters were used in this task. The characters were manipulated to blur either the semantic radical or the phonetic component and presented in 20 font SimSun script on DMDX (Forster & Forster, 2003) as in Experiment #3 in chapter 5.

### *Procedure*

Participants were shown a total of 98 characters (48 pseudo-characters and 50 true characters) and were asked to indicate by pressing either a  [YES] key or a  [NO] key (the Right SHIFT and Left SHIFT keys, respectively) whether or not the given character was an existent character in the Chinese language. All presentation and reaction time was controlled as before with DMDX, and instructions and practice items were presented before testing began.

### **Results of Experiment 3b**

There was a small but note-worthy impairment effect for blurred semantic radicals relative to blurred phonetic components. Both groups responded more slowly in the case of blurred semantic radicals. The differences were small:  $Z_{blurred\ phon} = -0.04$ ,  $Z_{blurred\ semantic} = +0.03$ , for an average difference of 10.2msec slower response when the semantic radical was blurred; and this effect approaches significance:  $F_1(1,26)=4.12$ ,  $P<0.05$ . *Subject error rate*, however, is where an effect becomes clear. The subject error rate indicates that subjects made significantly more errors when the semantic radical was

blurred than when the phonetic component was:  $F_{sub\ error}(1,26)=7.80, P<0.01$ . Item analysis showed no significant effects:  $F_2(1,39)=2.3, P<0.14, F_{item\ error}(1,39)=3.24, P<0.08$ .

TABLE 6.3  
Mean Reaction Times (m sec.) for Lexical Decision Task

	Native Speakers of Chinese Reaction time (ms)
Blurred Semantic Radical	735
Blurred Phonetic Component	725

### Discussion of Experiment 3b

These results indicate a small but definite preference for using semantic information in a strategy-neutral reading task. This would suggest that, for the average Chinese reader, the semantic route to lexical access is dominant over the phonetic one. These results are particularly striking as one considers that the phonetic component often (but not always) contains more strokes than the semantic radical, and thus the information degradation effect from the blurring might well be more pronounced. Also, in terms of total stroke-count, a blurred semantic radical would thus usually contain a higher percentage of unblurred information than a blurred phonetic component. In other words, responses were slower and error rate higher with blurred semantic radicals even though the reader had *more total unblurred strokes to analyze*. These results affirm Peng's (1982) studies showing that covered or missing information in the top-left part of the character (where semantic radicals are much more likely to be) caused a significantly higher rate of character misreading or inability to identify than any other character

quadrant. One must note that Taft and Zhu (1997) have previously argued that the radicals in a compound character are processed serially from left-to-right, and thus one may be tempted to dismiss the results as simply showing that blurring the left-hand portion of the character has a more significant inhibitory effect on character recognition than blurring the right-hand side. However, it is important to take into account that these results were consistent for radicals that were positioned on the top of the character, as well as radicals that frequently appear on the right-hand side.

It is further important to remember that the small differences between the blurred sides are to be expected. Chinese characters can only be identified holistically, so it would be impossible to properly identify a character without taking both the semantic and phonetic parts into consideration. However, the difference in error rate when the semantic radical is obscured should give one some pause before assigning both character parts equal weight in the decoding process.

## **Experiment 4b: Sentence Reading Task**

### **Method**

#### *Subjects:*

This test was not part of the original study conducted by this author and Dr. Thomas Bever in 2008. Instead, it was conducted concurrently with the CFL learner study, described in chapter 5, in order to give native speaker measurements with which to compare the data from the CFL learner Sentence Reading Task. As such, the subjects are

mostly different from those tested in Experiments #1b-3b, as described above. For this task, 30 native Chinese speakers (all from either PRC or Taiwan) were recruited from the University of Arizona and the Tucson community. All subjects were high school graduates, and either university students, university graduates, or graduate students, and had normal or corrected-to-normal vision. Both traditional and simplified character scripts were available, but given that all but two of the subjects were from PRC, there were insufficient numbers of subjects tested in traditional script to make a valid comparison between the two.

#### *Design and Materials*

Same as in Experiment #4, in Chapter 5.

#### *Procedure*

Identical with Experiment #4, in Chapter 5, except individual character presentation time was faster – 1600 m. sec. as compared to 3200 m. sec. with the non-native subjects tested in Ch. 5.

#### *Results of Experiment #4b*

While subjects averaged a 35 m. sec. longer recognition time for characters with a blurred phonetic component, as compared to characters with a blurred semantic radical, this was not statistically significant. Indeed, when data was analyzed individually,

roughly 1/3 of subjects actually took longer to process the characters with blurred semantic radicals. There was no clear, uniform pattern of processing.

### **Discussion of Experiment 4b**

The lack of results, in and of itself, is a significant finding when compared to the slight leaning towards semantic interpretation in Experiment #3. It appears that native speakers may be using both phonetic and semantic decoding strategies intermittently, depending upon individual character features and the amount of semantic boost that they get from sentence context. It can also be inferred that some of the subjects were skewed towards a phonetic processing scheme due to use of a reading aloud strategy (which was over-heard by the researcher in roughly half the subjects – exact figures were not maintained for this). The results definitely warrant further study.

## **Section 2:**

### **Comparison of Results**

Now, we can analyze the findings of the reading patterns of CFL learners, and compare them directly with those of native speakers. (Note: Table 6.3 below directly compares the test means between native and non-native Chinese readers.)

### **Experiment 1: Semantic Categorization**

Both native and non-native Chinese readers demonstrated strong facilitation effects when the semantic radical gave accurate information about meaning, and strong

Table 6.4  
Summary of all 4 Experiments: contrasting native and nonnative Chinese readers

Semantic Categorization Task		
Radical Type	CFL Learners Reaction time (ms)	Native Speakers of Chinese Reaction time (ms)
Semantically relevant and possesses associated radical	940	749
Possesses associated radical but not semantically relevant	1102	874
Semantically relevant but does not possess associated radical	975	796
Negative Control	1039	816

Homonym Recognition Task		
Phonetic Component Type	CFL Learners Reaction time (ms)	Native Speakers of Chinese Reaction time (ms)
Same pronunciation and same phonetic component	1255	886
Different pronunciation but same phonetic component	1433	1059
Same pronunciation but not the same phonetic component	1289	910
Negative Control	1398	1003

Lexical Decision Task		
	CFL Learners Reaction time (ms)	Native Speakers of Chinese Reaction time (ms)
Blurred Semantic Radical	1080	735
Blurred Phonetic Component	1108	725

Sentence Reading Task		
	CFL Learners Reaction time (ms)	Native Speakers of Chinese Reaction time (ms)
Blurred Semantic Radical	1080	481
Blurred Phonetic Component	1144	516

inhibitory effects when it did not. The native speakers, of course, having a much more sophisticated grasp of the language, and a more highly developed semantic route, were faster all-around, and showed stronger facilitation and weaker inhibitory effects than did the CFL learners.

### **Experiment 2: Homonym Recognition**

This experiment displayed one of the most dramatic differences between the two groups, as the native speakers, evidencing strongly developed phonological routes to character recognition, displayed strong facilitative and inhibitory effects, according to the accuracy of the phonetic component as an indicator of pronunciation. By contrast, the CFL learners displayed only inhibitory effects for similar phonetic components that are pronounced differently, but **did not** display any facilitative effects for phonetic components that accurately depicted pronunciation. This seems to indicate that the CFL learners tested were still in the process of constructing a phonological route to character recognition, and that, even though they were aware of the possible phonemic value of the phonetic component, they were nevertheless incapable of taking full advantage of it. By correlation with native speakers, this seems to place the CFL learners in a position much like native children somewhere between elementary grades 3 and 6, where, according to Shu and Anderson (1997), Chinese children made full use of semantic radical knowledge in reading tasks, but were inconsistent and inaccurate in employing knowledge of phonetic components.



### **Experiment 3: Lexical Decision Task**

The results of the Lexical Decision Task also varied wildly between native and nonnative speakers – largely due to the undeveloped nature of the phonological route in CFL learners. The results are almost starkly opposite – with the native speakers leaning slightly towards a semantic processing scheme throughout the lexical decision task, and the nonnative speakers being more delayed in recognition when the phonetic component was blurred. This split in processing strategies is likely due to two factors: experience and L1 interference.

First, as one would well expect, the massive advantage that the native speakers have in language fluency, vocabulary, and reading experience allows them the luxury of fully developed decoding strategies, and permits them to choose the most efficient character recognition scheme when reading. In this lexical decision task, their slight preference for semantic recognition strategies is most probably explained by the simple mathematical imbalance between the number of semantic radicals (approximately 200) vs. phonetic radicals (roughly 800 according to Taylor & Taylor, 1983) in the Chinese corpus, which thus makes a semantic search strategy a more efficient means of lexical search in this task. By contrast, the CFL learners, with a more impoverished vocabulary, less solid grounding in use of semantic radicals, and limited use of the phonological route were at a sizeable disadvantage in the task. Still, it was surprising to find that these subjects were more negatively affected by blurring the phonetic component than by blurring the semantic radical. Upon first reflection, it would seem natural that, lacking full use of the phonological route, that subjects would be heavily skewed towards

semantic processing in the task. This, of course, was not the case. As discussed in chapter 5, it's likely that subjects were highly dependent upon sub-radical level graphic cues in the densely-concentrated strokes in the phonetic component.

It's also highly likely that the CFL learners' negative performance when the phonetic component was blurred is indicative of L1 interference. Given that English, as an alphabetic language, is more conducive to phonetic processing schemes than semantic ones, the subjects may actually initially default to looking for phonetic information first, instead of employing semantic radical-based search strategies. Despite the fact that, at this stage of L2 development, they have a substantially *better* grasp of semantic radical knowledge than phonetic component knowledge, the subjects seem to inherently gravitate towards a phonological interpretation, and only when that route fails do they try an alternate route. This finding is significant as it suggests some inherent difference in processing skills between native and non-native speakers –not merely indicative of a lack of language fluency, but rather that L1 reading processes are not fully suppressed in L2 reading. While CFL learners' performance largely mirrors that of native children, it would be interesting to see how native children would perform on this lexical decision task. Likewise, it would be enlightening to run the study on extremely high-proficiency CFL learners to ascertain whether or not this L1 interference is ever truly suppressed, and if CFL learners' reading processing skills would ever truly become “native-like” from the psycholinguistic perspective.

#### **Experiment 4: Sentence Reading Task**

The major observed difference between the native and nonnative subjects was that while native subjects showed no clear preference for any one processing scheme in sentence reading, the nonnative subjects showed a significant impairment when the phonetic component was blurred. As discussed before, while, in light of the CFL learners' performance in the homonym recognition study, it appears that the nonnative subjects were not sufficiently proficient to make full use of the phonemic information embedded within the phonetic components, they seem to be reliant on the high-stroke-density portion of the character for recognition purposes, and likely still check for possible phonetic information first in their search process order due to L1 influences on literacy strategy development. This study, along with Experiment #3 (Lexical Decision Task,) would be the most fruitful to run on mid-elementary school age native speaker populations to determine whether the results attained by the nonnative speakers are simply a matter of lack of character proficiency (and thus similar to those of L1 child learners) or are due to L1 interference (and thus indicative that CFL learners are, from a psycholinguistic standpoint, a class unto themselves).

## **CHAPTER 7.**

### **DISCUSSION OF FINDINGS**

#### **Section 1:**

##### **General Discussion**

The results of the four experiments indicate a profound difference in reading processing strategies between native and non-native speakers of Chinese, and this should have tremendous pedagogical implications for CFL program administrators and teachers. Some comparisons can be made between CFL learners and native Chinese child learners: both groups develop a semantic processing route more quickly than the phonological processing route, which enables them to accurately extrapolate semantic information about the character from the semantic radical. Such skills could be further developed through explicit instruction on radical awareness and use, but such instruction is currently rare amongst CFL instructors and curricula.

However, the data also suggests that CFL learners are probably not equivalent to native child literacy learners. In the arena of phonological processing there appear to be deep differences. In the above studies, CFL learners were at an obvious disadvantage being compared to adult native speakers, and thus it may be more appropriate to compare their development to that of native child learners. Certainly, the development of the semantic pathway well in advance of a functional phonological pathway is reminiscent of the native Chinese-speaking elementary-aged literacy learner, but anecdotally, at least, we still see some differences. Whereas Shu and Anderson (1997) found that, in the lower

grades, students made very little use of the phonological information embedded in the phonetic component, in the studies described here, we saw that CFL learners consistently *attempted* to make use out of the phonetic component, but were frequently stymied by their own lack of proficiency in this regard. While this comparison is inexact, given the differences in the tasks described between the current study and the Shu and Anderson (1997) study, still it would well warrant repeating the current study across several grade ranges of native Chinese-speaking elementary school children in order to verify the strong suspicion that this eagerness to make use of the phonetic component is in fact behavior unique to the L2 Chinese reader.

## **Section 2:**

### **Would explicit instruction help?**

If the CFL learner does in fact demonstrate an innate bias for phonological processing schemes, then does that mean that we should explicitly teach and stress phonological processing strategies in CFL curricula? This has been argued before, as early as Liu (1983); however, this approach has been largely abandoned due to criticism that phonetic character components are notoriously unreliable – especially in high-frequency characters (Wang, 1998). Thus, while one can argue that teaching phonological decoding strategies would “play to the strengths” of many CFL learners (at least those who come from alphabetic L1 literacy backgrounds), as a practical matter, the argument falls short, as phonological processing know-how would be abstract and impractical until the students reached the very upper echelons of Chinese language study.

How about teaching semantic processing strategies explicitly? This is certainly not a novel suggestion. Various researchers (e.g., Liu, 1983, Ito, 1979: cited in Wang, 1998) have argued that radicals should be taught early on in order to facilitate dictionary use (Chinese character dictionaries are arranged via classification by their radical, and listed in order of the number of strokes), but one could certainly add weight to the argument by pointing out that targeted instruction in radical use would also facilitate lexical classification and access, and ultimately help learners to establish a stronger semantic path to recognition. This argument is made all the stronger by the evidence from this study which seems to confirm that, as in the case of native Chinese-speaking child literacy learners, CFL learners successfully utilize the semantic pathway to character recognition well in advance of solidifying the phonological pathway. The very fact that we see accurate use of a semantic pathway to character recognition in intermediate-advanced level CFL students suggests that such a strategy is intuitive, useful, and comprehensible to students from a relatively modest level of literacy. It indeed becomes curious why CFL learners still seemed to default to their limited phonological processing skills rather than using the semantic pathway as a primary processing scheme in the lexical decision and sentence reading tasks. While it would be interesting to know whether it is even possible to change what appears to be an L1 literacy-induced, inherent bias in processing schemes, it would certainly be beneficial to facilitate via instruction the processing scheme that is functional the earliest, and thus develop the reading processes of CFL learners to more accurately resemble those of native Chinese children.

## CHAPTER 8.

### CONCLUSION: RECOMMENDATIONS FOR PEDAGOGICAL IMPROVEMENT IN CFL INSTRUCTION

Of course, one of the primary benefits of an increased understanding of the development of CFL learners' Chinese (L2) literacy is the opportunity for improvements in CFL pedagogical practices. Given the massive differences between English and Chinese scripts, it is no wonder that English L1 students of Chinese face difficulties in learning to read and write in Chinese. While some skills of L1 literacy will apply to learning any L2 – e.g., pre-reading skills of directionality, sequencing, ability to distinguish shapes and sounds, and the knowledge that written symbols correspond to oral language and can be decoded in order and direction (Lessow-Hurley, 1990) – many of the script-dependent skills that English L1 CFL learners picked up while learning to read and write their L1 will not be of much assistance when learning Chinese. Particularly, one of the key components of alphabetic literacy, that characters or character combinations represent the speech sounds of their languages (Cipollone, Keiser, & Vasishth, 1998) is invalid for Chinese. For this reason, beyond simply teaching literacy, the goal of CFL teachers should be first to instill language specific *literacy learning strategies* in their students. Towards this end, I would like to offer some recommendations to best improve the teaching of Chinese literacy in American classrooms and, particularly, in the university context.

## **Pedagogical Recommendations**

### *Teach radicals explicitly*

The most basic, and possibly most important, concept that this study adds to our knowledge on the field of Chinese literacy instruction is that native speakers and CFL learners are different populations with very different character processing strategies, and therefore should require differing instructional techniques. The results indicate that CFL learners have substantially less skill in using a phonological route to character recognition than do native speakers, but that they are still more prone to attempting to base character decisions on the phonetic component than are native speakers. The default model of instruction, whereby strategies are simply assumed to develop naturally over the course of time *sans* explicit mention in the classroom (Wang, 1998) seems to be falling short, and unduly penalizes CFL learners. The test results showed that, although learners seemed to have acquired sufficient skill to accurately use semantic processing schemes, they weren't utilizing it, and the phonological processing scheme that they were trying to use was insufficiently developed to be effective for decoding. In essence, by denying CFL learners explicit assistance in transitioning to literacy learning strategies better suited to acquiring and decoding Chinese characters, present pedagogical methodologies may be retarding the development of CFL reading potential by a significant margin. This suggests that CFL learners could benefit greatly from radical-based instruction, designed to help them to 1) learn to take full advantage of the (more quickly developed) semantic path to character recognition; and 2) develop a more fully functional phonological path to recognition.



While calls for explicit teaching of semantic radicals have faced some criticism in the past (Wang, 1998), I believe that the critiques of such an approach are short-sighted as they concentrate on the concurrent instruction of the phonetic component. While accuracy rates of phonetic components are, indeed, abysmal for high-frequency characters (i.e., the characters L2 learners most need to know), semantic radicals are much more regular, having accuracy rates that make them much more useful tools in decoding – e.g., from 90% (Jin, 1985: cited in Feldman & Siok, 1999) to 65% (Fan, 1986: cited in Feldman & Siok, 1999). Given that Chinese L1 learners start to regularly utilize semantic clues upwards of 3 years earlier than phonetic clues (Shu & Anderson, 1997), it would be reasonable to assume that L2 learners would also derive substantial benefit from clear instruction on embedded semantic information. Furthermore, as certain radicals have higher accuracy than others, and also certain radicals correlate with higher degrees of phonetic component-accuracy, such knowledge can be taught explicitly.

My recommendation for implementing a radical-based curriculum would be as follows: Character study would begin by teaching the most frequent 60-100 radicals (which contain most of the pictographs and indicatives which often are found at the beginning of Chinese instruction), along with their associated meanings. This would not be as daunting as it may sound. Consider that most beginning Japanese as a foreign language students are required to learn the 100 characters that make up the two syllabary systems during the first 1-2 months of instruction. Once these characters were mastered, subsequent character learning would be arranged in groups according to radicals, with students learning lists of semantically-grouped vocabulary from one or two different

radicals each unit. While one could readily object here that such isolated vocabulary lists (e.g., learning twenty different types of trees) is not the most stimulating way to learn a language, unit vocabulary lists could easily accommodate a few frequency-based characters to compliment oral learning. The key would be to have each unit correspond logically to a radical, and hence to employ copious semantically linked vocabulary (e.g., dialogues set in a forest could easily discuss different trees). It would also be advantageous to explicitly point out the frequency with which characters containing a given radical correspond to the implied semantic sense of the radical. Thus, a CFL learners would know, for example that a character containing the radical 魚 is almost certain to have some direct connection to fish, whereas a character containing the radical 王 is unlikely to be directly semantically relatable to its meaning “king.”

The advantages of such an approach to CFL literacy development methodology should be readily apparent. By grouping vocabulary presentation according to their semantic radical, the learner will gain a deeper awareness of the radicals’ role in character reading, which will enhance development of the semantic route to recognition, and will make the learner more prone to use that strategy in reading tasks. Teaching radicals will give students both important semantic clues to character composition, and also help to develop an eye for character patterns and details. Curiously, such a strategy for teaching characters may also help to develop a stronger phonological route to recognition, as such semantic radical-based vocabulary lists could easily be made to contain several strong examples of accurate phonological components. This would expose learners to more characters with phonetic components that are accurate predictors of whole character

pronunciation over a shorter period of time than often happens when characters are presented according to word frequency (as is the case in most text series). Phonetic components could be introduced *conceptually* at this time, but with the caveat that students should not expect to see much in the way of phonetic regularity until much higher stages of character literacy. In later years of coursework, phonetic components could be revisited as vocabulary instruction reaches a threshold wherein the phonetic components of the characters studied have a higher degree of accuracy.

While these recommendations are made with L1 speakers of alphabetically transcribed languages in mind, it is likely that they would remain valid, if not even more important for L1 speakers of languages that are written with a syllabary-based writing system (e.g., Cree, Cherokee, etc. – notably excluding Japanese, as Japanese L1 speakers already use Chinese characters) as they would have a much more strongly developed reliance on phonological representation in writing. Likewise, one would expect to find stronger phonological reliance by native speakers of languages with more shallow alphabetic orthographies (e.g., Finnish, Italian, etc.); however, to confirm such would require specific testing of these groups.

#### *When to begin character learning*

The first issue to tackle in the attempt to revise and to improve CFL pedagogical methods is when students should begin learning the character system. Certainly, having well-developed oral vocabulary benefits literacy learning. Laufer (1997) presents evidence showing that the size of the reader's active vocabulary is the key for all types of literacy, with a threshold vocabulary of about 5000 lexical items needed before L1

reading strategies like guessing from context can be effectively transferred to L2 reading. Indeed, this has led to repeated suggestions that programs should focus on oral Chinese development and not begin literacy instruction for as long as two years of initial instruction. Unfortunately, this is not altogether practical – especially in US university contexts – as it presupposes a long-term commitment to Chinese language study which will not always be the case. While in an elementary school program, where one could reasonably assume that students will continue to follow the Chinese curriculum for 6+ years – one could easily decide to forego character learning in favor of first building oral language competency, university programs are hampered by the fact that the bulk of (non-major) language students will be enrolled in language coursework for only two years (if that!). Thus spending years working on oral fluency before introducing literacy is not a feasible option. Most university programs, instead, will introduce Chinese characters immediately or within the first month. Most textbooks present content initially in both *hanzi* (Chinese characters) and *pinyin*, and the pinyin is gradually phased out later in the book (chapters which are frequently not reached until 2<sup>nd</sup> semester). Characters are often presented in the same order as they would be to native speakers (i.e., L1 Chinese child learners), with frequently seen characters presented initially along with basic characters presented in order of number of strokes (i.e., building in order of complexity). It may not be feasible or practical to delay overt character instruction in the American university setting until the beginning of the second semester at the latest. More can be done, however, about *how* characters are presented.

### *Additional recommendations*

#### Explicitly teach strokes

Chinese children are taught early-on the 23 strokes in Chinese writing and are also given explicit instruction on stroke order as they learn individual characters in the early grades (Pine, et al., 2003). While stroke order is often reviewed at the beginning of CFL literacy instruction, the breadth of the explicit instruction pales in comparison to that given to Chinese children who will often continue to receive stroke-by-stroke instruction on characters for the first few *years* of elementary school. Children are taught the names of individual strokes, and are instructed how to analyze the composition of characters' individual features, stroke-by-stroke. Such instruction would obviously help to develop the attention to visual detail that Chinese character recognition requires.

#### Regularly use characters in classroom instruction

Wang (1998) reports that this was a regular *complaint* amongst “Lin Laoshi’s” students: that she overused *pinyin* (i.e., Chinese spelled in Roman characters) in the classroom. Exposure is a critical component of literacy learning of any type, and in an L2 context, it can be difficult to maximize one’s exposure to the written language. Thus, teachers must make use of every opportunity to expose students to Chinese characters. All blackboard writing should be in *hanzi* complemented with *pinyin* at first. Once characters have been taught explicitly or have been seen enough that teachers can reasonably assume that students will recognize them, teachers can and should drop the use of *pinyin* on those specific characters.

### Keep realistic expectations of character learning

The curriculum of the first year Chinese program observed by Wang (1998) mandates the teaching/learning of 600 characters by the end of the first year, in addition to developing aural and oral skills. This goal, while certainly ambitious, is not altogether grounded in reality, but is unfortunately far from uncommon. Usually, these numbers are based upon a desire in the department for students to be able to attain basic literacy (2500 characters – Pine et al., 2003) in a 4 year course series. By comparison, native speakers of Chinese, who already have fully-developed oral language skills and who live in a text-rich environment ideally suited for character reinforcement, take a full six years to learn the 2500-3000 characters needed for basic literacy (Wang, 1998). Pine et al. (2003) note that children in PRC only learn 160 characters during their first semester of schooling. Japanese children learn a total of only 881 kanji during the entirety of their elementary school education (and then another 969 in junior high) (Wang, 1998). Considering the additional cognitive and environmental hurdles faced by the L2 learner who must learn characters concurrently with vocabulary, instead of applying the characters to already well-established oral vocabulary, Wang (1998) rightly calls for departments to reconsider how many characters they can reasonably expect learners to acquire. While departments may not want to admit it, not many students are going to keep up with such overly zealous character learning goals. A much more modest number of characters – say between 100 and 200 for first year instruction – with more time spent on explicit character instruction would better allow students to solidify the basics of character writing, and character learning goals could be moderately increased with each subsequent

year of instruction.

## **Conclusion**

Given the growing popularity of Chinese as a Foreign Language study, this is probably just the first of many empirical studies on Chinese text processing by non-natives. There is certainly still much to be learned about Chinese character decoding processes by both native and non-native speakers. As this research showed substantial differences in their processing schemes, my own next step will be to test native Chinese child learners, to be able more accurately to contrast the native and non-native data, and to verify whether the CFL learners' over-reliance on their as-of-yet under-developed phonological processing scheme is (as suspected) a trait inherent to CFL learners from alphabetical L1 backgrounds, or if this is a feature common to native Chinese children at this stage in literacy development. Prior results in tests of semantic radical/phonetic component awareness (such as the Shu and Anderson 1997 study) have indicated that prior to 6<sup>th</sup> grade, Chinese children are likely to favor semantic processing schemes. Given the inherent differences between the reading processes of CFL learners and native speakers, the field of CFL instruction needs to take the results of studies such as this into consideration when designing a curriculum for Chinese literacy development. Whereas most CFL programs are based largely upon techniques for teaching native children, concrete evidence of differences between native and nonnative processing schemes should indicate a need to develop different instructional techniques to capitalize on the advantages that CFL learners bring to character decoding and to strengthen weak areas.

Studies such as this are an important first step in modernizing and improving the rapidly growing field of CFL instruction.



## REFERENCES

- Adams, M. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.
- Akamatsu, N. (2005). Effects of second language reading proficiency and first language orthography on second language word recognition. In V. Cook & B. Bassetti (Eds.), *Second language writing systems* (pp.238-259). Clevedon, UK: Multilingual Matters Ltd.
- Bassetti, B. (2005). Effects of writing systems on second language awareness: Word awareness in English learners of Chinese as a foreign language. In V. Cook & B. Bassetti (Eds.), *Second language writing systems* (pp.335-356). Clevedon, UK: Multilingual Matters Ltd.
- Besner, D., Daniels, S., & Slade, C. (1982). Ideogram reading and right hemisphere language. *British Journal of Psychology*, 73, 21-28.
- Bi, Y., Han, Z., Weekes, B., & Shu, H. (2007). The interaction between semantic and the nonsemantic systems in reading: Evidence from Chinese. *Neuropsychologia*, 45(12), 2660-2673.
- Bierderman, I., & Tsao, I.C. (1979). On processing Chinese ideographs and English words: Some implications from Stroop- test results. *Cognitive Psychology*, 11, 125-132.

- Bournot-Trites, M., & Tellowitz, U. (2005). *Report of current research on the effect of the second language learning on first language literacy skills*. Retrieved 3/21/05 from the Association canadienne des professeurs d'immersion website at <http://acpi.scedu.umontreal.ca/pdf/report.pdf>
- Chan, D.W., Ho, C.S.H., Tsang, S.M., Lee, S.H., & Chung, K.K.H. (2006). Exploring the reading–writing connection in Chinese children with dyslexia in Hong Kong. *Reading and Writing, 19*(6), 543-561.
- Chan, S. (1999). The Chinese learner – a question of style. *Education and Training, 41*(6/7), 294-304.
- Chee, M. W., Tan, E. W., & Thiel, T. (1999). Mandarin and English single word processing studied with functional magnetic resonance imaging. *The Journal of Neuroscience, 19*(8), 3050-3056.
- Chen, H.C. (1987). Character detection in reading Chinese: Effects of context and display format. *Chinese Journal of Psychology, 29*, 45-50.
- Chen, H.C. (1996). Chinese reading and comprehension: A cognitive psychology perspective. In M.H. Bond (Ed.), *The handbook of Chinese psychology*. Oxford, NY: Oxford University Press.
- Chen, H.C. (1999). How do readers of Chinese process words during reading for comprehension? In J., Wang, A.W., Inhoff, H.C., Chen (Eds.) *Reading Chinese script: a cognitive analysis* (pp. 257-278). Mahwah, N.J.: Lawrence Erlbaum Associates.

- Chen, Y.P., Allport, D.A., & Marshall, J.C. (1996). What are the functional orthographic units in Chinese word recognition: the stroke or the stroke pattern? *The Quarterly Journal of Experimental Psychology* A49(4), 1024–1043.
- Chen, K. J., & Liu, S. H. (1992). Word identification for mandarin Chinese sentences. *Proceedings of the Fifteenth International Conference on Computational Linguistics*, Nantes, 101-107.
- Chikamatsu, N. (1996), 'The effects of L1 orthography on L2 word recognition', *Studies in Second Language Acquisition*, 18, 403-432.
- Chu-Chang, M. (1981). The dependency relation between oral language and reading in bilingual children. *Journal of Education* 163:1, pp. 30-55.
- Cipollone, N., Keiser, S.H., & Vasishth, S. (1998). *Language Files* (7<sup>th</sup> ed), pp. 448-456. Columbus, OH: The Ohio State Univ. Press.
- Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood (Ed.), *Strategies of information processing* (pp. 151-216). San Diego, CA: Academic Press.
- Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, 108, 204-256.
- DeFrancis, J. (1984). *Beginning Chinese reader* (2nd Ed.). New Haven: Yale University Press.

- Ding, G., Peng, D., & Taft, M. (2004). The nature of the mental representation of radicals in Chinese: A priming study. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*, 530–539.
- Dong, Y., Nakamura, K., Okada, T., Hanakawa, T., Fukuyama, H., Mazziotta, J. C., & Shibasaki, H. (2005). Neural mechanisms underlying the processing of Chinese words: An fMRI study. *Neuroscience Research* *52*, 139–145.
- Fan, K.Y., Gao, J.Y., & Ao, X. P. (1984). Pronunciation principles of the Chinese character and alphabetic writing scripts. *Chinese character reform*, *3*, 19-22. Beijing: National Commission of Chinese Character Reform (In Chinese).
- Feldman, L.B. & Siok, W.W.T. (1999). Semantic radicals in phonetic compounds: Implications for visual character recognition in Chinese. In J., Wang, A.W., Inhoff, H.C., Chen (Eds.) *Reading Chinese script: a cognitive analysis* (pp. 19-35). Mahwah, N.J.: Lawrence Erlbaum Associates.
- Flores d'Arcais, G.B. (1992). Graphemic, phonological and semantic activation processes during the recognition of Chinese characters. In H.C. Chen & O.J.L. Tzeng (Eds.), *Language processing in Chinese* (pp. 37-66). Amsterdam: Elsevier.
- Forster, K. I. (1976). Accessing the mental lexicon. In R.J.Wales & E.Walker (Eds.). *New Approaches to Language Mechanisms*. (pp 257-287). Amsterdam: North-Holland.
- Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, *35*, 116-124.

- Goodman, K.S. (1970). Reading: A psycholinguistic guessing game. In H. Singer, & R.B. Ruddell (Eds.), *Theoretical models and processes of reading*. Newark, Delaware: International Reading Association, 259-271.
- Hatta, T. (1977). Recognition of Japanese kanji in the left and right visual fields. *Neuropsychologia*, 15, 685-688.
- Ho, C.S.H. (2003). Reading acquisition and developmental dyslexia in Chinese: A cognitive perspective. In N. Goulandris (Ed.), *Dyslexia in different languages: Cross-linguistic comparisons* (pp. 277-296). Philadelphia, PA: Whurr Publishers.
- Ho, C.S.H., Chan, D.W., Chung, K.K.H., Lee, S.H., & Tsang, S.M. (2007). In search of subtypes of Chinese developmental dyslexia. *Journal of Experimental Child Psychology* 97, 61-83.
- Ho, C.S.H. & Lai, D.N.C. (1999). Naming-speed deficits and phonological memory deficits in Chinese developmental dyslexia. *Learning and Individual Differences* 11, 173-186.
- Ho, C. S.-H., Law, T. P.-S., & Ng, P. M. (2000). The phonological deficit hypothesis in Chinese developmental dyslexia. *Reading and Writing*, 13, 57-79.
- Ho, C. S.-H., Ng, T.-T., & Ng, W.-K. (2003). A "radical" approach to reading development in Chinese: The role of semantic radicals and phonetic radicals', *Journal of Literacy Research*, 35(3), 849-878.
- Holm, A., & Dodd, B. (1996). The effect of first written language on the acquisition of English literacy. *Cognition*, 59, 119-147.

- Hoosain, R. (1991). Psycholinguistic implications for linguistic relativity: A case study of Chinese. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Huang, H.S. & Zhang, H.R. (1997). An analysis of phonemic awareness, word awareness and tone awareness among dyslexia children. *Bulletin of Special Education and Rehabilitation* 5, 125-138.
- Koda, K. (1997). Orthographic knowledge in L2 lexical processing: A cross-linguistic perspective. In J. Coady & T. Huckin (Eds.), *Second language vocabulary acquisition* (pp. 35-52). Cambridge: Cambridge University Press.
- Laberge, D. & Samuel, S.J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology*, 6, 293-323.
- Leong, C. K., Pui, W. C., & Tan, L. H. (2005). The role of sensitivity to rhymes, phonemes and tones in reading English and Chinese pseudowords. *Reading and Writing*, 18(1), 1-26.
- Lessow-Hurley, J. (1990). *The foundations of dual language instruction*. New York: Longman.
- Liu, I.M. (1983). Cueing function of fragments of Chinese characters in reading. *Acta Psychologica Taiwanica*, 25, 85-90.
- Luk, G. & Bialystok, E. (2005). How iconic are Chinese characters? *Bilingualism: Language and Cognition*, 8, 79-83.
- Lyon, G.R. (1998). Why reading is not a natural process. *Educational Leadership*, 55, 14-18.

- Marshall, J. C., & Newcombe, F. (1973). Patterns of paralexia: A psycholinguistic approach. *Journal of Psycholinguistic Research*, 2, 175–199.
- McClelland, J.L. & Rumelhart, D.E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review*, 88(5), 375-407.
- Miao, X.C. (1999). Sentence understanding in Chinese. In J., Wang, A.W., Inhoff, H.C., Chen (Eds.) *Reading Chinese script: a cognitive analysis* (pp. 279-295). Mahwah, N.J.: Lawrence Erlbaum Associates.
- Miller, G.A., & Isard, S. (1963). Some perceptual consequences of linguistic rules. *Journal of Verbal Learning and Verbal Behavior*, 2, 217-228.
- Murphey, R. (2001). *East Asia: A New History*. New York, NY: Addison-Wesley Educational Publishers Inc.
- Packard, J.L. (1998). Introduction. In J.L. Packard (Ed.), *New Approaches to Chinese Word Formation: Morphology, Phonology and the Lexicon in Modern and Ancient Chinese* (pp. 1-34). Berlin, New York: Mouton de Gruyter.
- Packard, J. (2000). *The Morphology of Chinese*. Cambridge, UK. Cambridge University Press.
- Papp, K.R., Newsome, S.L., & Noel, R.W. (1984). Word shape's in poor shape for the race to the lexicon. *Journal of Experimental Psychology: Human Perception and Performance*, 10, 413-428.

- Patterson, K.E. & Morton, J. (1985). From orthography to phonology: An attempt at an old interpretation. In K.E. Patterson, J.C. Marshall, & M. Coltheart (Eds.), *Surface Dyslexia: Neuropsychological and Cognitive Studies of Phonological Reading* (pp. 335-359). Hove, UK: Lawrence Erlbaum Associates.
- Penfield, J. (1986). ESL literacy and the new refugees: Priorities and considerations. *Adult Literacy and Basic Education*, 10 (1), pp. 47-57.
- Peng, D.L., Li, Y.P., & Liu, Z.Z. (1994). Identification of the Chinese two character word under repetition priming condition. *ACTA Psychologica Sinica*, 26, 393-400.
- Peng, D.L., Lui, Y., & Wang, C.M. (1999). How is access representation organized? The relation of polymorphemic words and their morphemes in Chinese. In J., Wang, A.W., Inhoff, H.C., Chen (Eds.) *Reading Chinese script: a cognitive analysis* (pp. 65-89). Mahwah, N.J.: Lawrence Erlbaum Associates.
- Perfetti, C.A., & Tan, L.H. (1998). The time course of graphic, phonological, and semantic activation in Chinese character identification. *Journal of experimental psychology. Learning, memory, and cognition* 24(1). 101-118.
- Perfetti, C.A. & Tan, L.H. (1999). The Constituency Model of Chinese word identification. In J. Wang, A.W. Inhoff, & H.C. Chen (Eds.), *Reading Chinese Script: A Cognitive Analysis*. NJ: Lawrence Erlbaum Associates, Publishers.
- Perfetti, C.A., Zhang, S., & Berent, I. (1992). Reading in English and Chinese: Evidence for a 'universal' phonological principle. In R. Frost & L. Katz (Eds.), *Orthography, Phonology, Morphology, and Meaning* (pp. 227-248). Amsterdam: North Holland.



- Pine, N., Huang, P., & Song, H. R. (2003). Decoding strategies used by Chinese primary school children. *Journal of Literacy Research* 35, 777-812.
- Rummelhart, D.E. (1977). Toward an interactive model of reading. In S. Dornic (Ed.), *Attention and performance VI* (pp. 482-509). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Scholfield, P. & Chwo, G.S.M. (2005). Are the L1 and L2 word reading processes affected more by writing system or instruction? In V. Cook & B. Bassetti (Eds.), *Second language writing systems* (pp.215-237). Clevedon, UK: Multilingual Matters Ltd.
- Seidenberg, M. S. (1985). The time course of information activation and utilization in visual word recognition. In D. Besner, T. G. Waller, & E. M. MacKinnon (Eds.), *Reading research: Advances in theory and practice* (pp. 199-252). New York: Academic Press.
- Share, D. L., & Stanovich, K. E. (1995). Cognitive processes in early reading development: Accommodating individual differences into a model of acquisition. *Issues in Education: Contributions from Educational Psychology*, 1, 1-57.
- Shen, H.H. (2005). Linguistic complexity and beginning-level L2 Chinese Reading, *Journal of the Chinese Language Teachers Association*, 40(3). 1-28.
- Shen, D., & Forster, K. (1999). Masked phonological priming in reading Chinese words depends on the task. *Language and Cognitive Processes* 14(5/6), 429-459.
- Shu, H., & Anderson, R. C. (1997). Role of radical awareness in the character and word acquisition of Chinese children. *Reading Research Quarterly* 32(1), 78-89.

- Shu, H., & Anderson, R. C. (1999). Learning to read Chinese: The development of metalinguistic awareness. In J. Wang, A. Inhoff, & H. C. Chen (Eds.), *Reading Chinese Script: A Cognitive Analysis*. Hillsdale, NJ: Erlbaum.
- Shu, H., Meng, X.Z., Chen, X., Luan, H., & Cao, F. (2005). The subtypes of developmental dyslexia in Chinese: Evidence from three cases. *Dyslexia* (10769242), 11(4), 311-329.
- Singhal, M. (1998). A Comparison of L1 and L2 Reading: Cultural Differences and Schema. *The Internet TESL Journal*, Vol. IV, No. 10. Available online at <http://iteslj.org/Articles/Singhal-ReadingL1L2.html>
- Siok, W.T., Niu, Z.D., Jin, Z., Perfetti, C.A. & Tan, L.H. (2008). A structural-functional basis for dyslexia in the cortex of Chinese readers. *Proceedings of the National Academy of Sciences of the United States of America*, 105(14), 5561-5566.
- Strauss, S.L. (2005). *The linguistics, neurology, and politics of phonics : silent "E" speaks out*. Mahwah, N.J. : Lawrence Erlbaum, 2005.
- Sun, F. C., Morita, M., & Stark, L. W. (1985). Comparative patterns of reading eye movement in Chinese and English. *Perception and Psychophysics*, 37, 502-506.
- Taft, M., Liu, Y., & Zhu, X.P. (1999). Morphemic processing in reading Chinese. In J., Wang, A.W., Inhoff, H.C., Chen (Eds.) *Reading Chinese script: a cognitive analysis*. Mahwah, N.J.: Lawrence Erlbaum Associates.
- Tan, L.H., Hoosain, R., & Siok, W.W.T. (1996). Activation of phonological codes before access to character meaning in written Chinese. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 43-54.

- Taylor, I., & Taylor, M.M. (1983). *The psychology of reading*. New York: Academic Press.
- Tham, W.W.P., Liow, S.J.R., Rajapakse, J.C., Leong, T.C., Ng, S.E.S., Lim, W.E.H., & Ho, L.G. (2005). Phonological processing in Chinese–English bilingual biscriptals: An fMRI study. *NeuroImage* 28(3), 579-587.
- Wang, S.C. (1998). A study on the learning and teaching of hanzi - Chinese characters. *Working Papers in Educational Linguistics* 14(1), 69-102.
- Weekes, B. S., Chen, M. J., & Yin, W.-G. (1997). Anomia without dyslexia in Chinese. *Neurocase*, 3, 51–60.
- Weekes, B. S., Coltheart, M., & Gordon, E. V. (1997). Deep dyslexia and right hemisphere reading: A regional cerebral blood-flow study. *Aphasiology*, 11, 1139–1158.
- Woo, E.Y.C. & Hoosain, R. (1984). Visual and auditory functions of Chinese dyslexics. *Psychologia*, 27, 164-170.
- Wu, J.T., & Liu, I.M. (1997). Phonological activation in pronouncing characters. In H.C. Chen (Ed.), *The cognitive processing of Chinese and related Asian languages* (pp. 47-64). Hong Kong: Chinese University Press.
- Yin, W. G., & Weekes, B. S. (2003). Dyslexia in Chinese: Clues from cognitive neuropsychology. *Annals of Dyslexia*, 53, 255–279.
- Zhang, B.Y. & Peng, D.L. (1992). Decomposed storage in the Chinese lexicon. In H.C. Chen & O.J.L. Tzeng (Eds.), *Language processing in Chinese*. Amsterdam: North-Holland.

- Zhou, X., & Marslen-Wilson, W. (2000). The relative time course of semantic and phonological activation in reading Chinese. *Journal of Experimental Psychology* 26(5), 1245-1265.
- Zhou, X., Shu, H., Bi, Y. & Shi, D. (1999). Is there phonologically mediated access to lexical semantics in reading Chinese? In Wang, J., Inhoff, A.W. & Chen, H.C. (Eds.), *Reading Chinese Script: A Cognitive Analysis* (pp. 135-171). NJ: Lawrence Erlbaum Associates, Publishers.
- Zhu, Y. P. (1987). *Analysis of cueing functions of the phonetic in modern Chinese*. Unpublished paper, East China Normal University (in Chinese).