Psycholinguistic Aspects of Word Recognition in Chinese Orthography

by

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## ABSTRACT

This thesis is a study of psycholinguistic aspects of word recognition in Chinese orthography, a writing system structured along a principle that is very different from alphabetic or syllabic ones Because of its logographic nature, assumptions have been made that the reading of Chinese characters must be silent and require an orthography-specific mechanism, that is, it utilizes only a direct, visual route However, this assumption is not supported by most of the experimental studies reviewed here, such as studies of phonological recoding and the neurolinguistic evidence (hemispheric functioning)

With respect to phonology, there are two issues to be clarified, one concerns the recognition of single characters, the other has to do with the higher level of reading retention of the previously read material in working memory, syntactic parsing at both micro- and macro-levels, and semantic interpretation/integration of overall text The componentiality inherent in most of the Chinese characters (semantic-phonetic compounds) allows the possibility for character readers to make use of the principle of analogy to get a character's pronunciation Moreover, when it comes to reading a complete sentence or whole paragraph, sound recoding is regarded as part of the human information processing and as a universal strategy in sustaining the Short-Term Memory, regardless of the orthographic differences

However, this does not mean that logographic and alphabetic orthographies are processed in exactly the same way Memory research and various versions of the Stroop interference test suggest, for instance, the greater involvement of

visual/spatial memory for characters Words presented in logographs are interpreted and elaborated at the morphemic/semantic level so that visual traces seem to exert a greater power

The results from hemispheric function research also lend support to the orthography-independent view that reading of Chinese demands phonological recoding Since characters are also linguistic symbols, the processing of which require sequential analysis and different levels of abstraction, there is no reason to believe that they should be handled by a different part of the neural mechanism, that is, the right hemisphere

Overall, this thesis looks at the similarities and differences between two different orthographies--Chinese and English,-- and advocates a common strategy for lexical access, the principle of analogy, in which visual and phonological pathways are equally emphasized and are interdependent

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# Contents

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# Chapter One: Introduction

This thesis is an inquiry into the impact of the characteristics of Chinese writing systems on reading in general, and on word recognition in particular. In addition to the relevant literature for Chinese and English, pertinent findings for Japanese are also reviewed, since Japanese sheds light on the issues from the perspective of another type of script, i.e., a mixture of syllabary *Kana* and logographic *Kanji*. The deployment of these orthographic features in Chinese is unique and serves as a testing ground for several important issues in psycholinguistics, namely, the structure of the mental lexicon and the determination of the basic linguistic units in lexical access and word recognition.

Though written scripts all serve to transcribe spoken languages, they differ as to which levels the orthographic symbols map from the speech flow. For example, English orthography is usually said to preserve the morphophonemic identity of words, and does not have an efficient one-to-one correspondence between grapheme and phoneme for that reason. On the other hand, the nature of Chinese orthography follows morphosyllabic principles, so that each character represents a morpheme or a minimum meaningful linguistic unit whose pronunciation is roughly equivalent to a phonetic English syllable. Thus, this thesis sets out to find the differences and similarities in lexical access and word recognition for these radically different language types, in the areas of phonological code activation, lexical access, memory patterns, and neurolinguistic research findings.

The recognition and pronunciation of words has been one of the central

topics in both reading research and psycholinguistics. Word recognition may be the basic sub-component on which all other comprehension processes depend, thus offering insight into what the defining features for learning to read are. Other processes in reading, such as syntactic parsing, sentence comprehension and so on, may exert a relatively weak influence on the recognition of vocabulary, so that skilled word recognition may be sorted out from other contextual factors, standing as a relatively free module and thus be studied in isolation (Besner & Humphreys, 1991). Word recognition also stands at the interface between higher-order cognitive processes such as text comprehension, and the physical fact of eye movements in scanning written input. Finally, this basic research in word recognition sheds light on questions such as what the defining features of reading disorders are (e.g., developmental and acquired dyslexia), and whether or not they are language-specific or universal.

One of the reasons for the intense psycholinguistic focus on lexical access strategies in successful word recognition is that a series of processing stages which is characteristic of their relevant theoretical models allows access to different knowledge representations. The experimental tasks designed for them are complex enough to be interesting while at the same time they are circumscribed enough to make discovery feasible. An influential example of one such model is the logogen model in its revised form (e.g., Morton & Patterson, 1980). This model hypothesizes that words in the mental dictionary exist in a form which incorporates separate stored representations of orthographic, phonological, and semantic information

Different tasks used in word recognition models attempt to tap into these different levels of representation. However, this attractive feature of multi-stage architecture, with each stage open to testing, may also be subjected to criticism. In fact, the results of task performance cannot be mapped onto the assumed "functional architecture" without a certain fuzziness as to which level is being tapped (Besnor & Humphreys, 1991). For example, lexical decision tasks may involve checking for the meaningfulness of the letter string, or for their visual familiarity, in addition to checking the level of the orthographic lexicon. Although in theory a task may tap into a specific processing stage, in reality, the performance may be based on several stages whose precise contribution is hard to pin down (Besner & Humphreys, 1991).

In order to gain a better understanding of how the nature of a writing system like Chinese affects the process of word recognition, a minimum knowledge of Chinese orthography in its relation to these activities is necessary. Therefore, the next chapter, Chapter Two, briefly delineates the properties of Chinese characters, whose meaning-based characteristics have long made it an object of fascination for Western poets and philosophers like Leibniz, Hegel, Fennolosa, Pound, Eisenstein and Derrida. But the long tradition of Western misrepresentation of the Chinese writing system--either with 'hyperbolic admiration' or 'ethnocentric scorn' has only fed fruitless and unscientific speculation. The linguistic properties of Chinese characters in reality include the design features of componentiality and monosyllabicity. Componentiality reflects the fact that semantic-phonetic compounds, which comprise the majority of the characters, contain at least two

parts, a sound-cuing and a meaning-conveying element Monosyllabicity reflects the fact of a relatively small number of different syllables, there are only about 400 syllables in Mandarin, some of which are very similar phonetically, and this leads to an abundance of homophones The visual-spatial characteristics of *hanzi*, that is, the fact that they are square-shaped and equally spaced, are also examined since they affect the visual acuity, directional scanning, and eye movements relevant to reading

Chapter Three reviews the relevant literature The first part reviews several word recognition models, which can roughly be classified as single- and double-route models The former claim the separate visual and phonological routes, whereas the latter emphasizes the interaction of both, and the activation of phonological representation In other words, lexical and sublexical knowledge are distributed in the same connections in a single-process network The realization that word recognition can be achieved without phonological mediation gives rise to the formulation of a dual-route hypothesis, in which there is a direct, visual pathway to the meaning of a word This direct route may supersede or complement the phonologically mediated route, thus offering two possible pathways, or two routes in the process of lexical access leading to successful word recognition

We will see later in Chapter Three that the division between lexical and non-lexical processes, which confound linguistic definition and psychological processes, is a major criticism of the dual-route hypothesis Single-route models include the Activation-Synthesis Model proposed by Glushko (1979), Seidenberg's (1985) Time-

Course Model, and the most recent one, the Parallel Distributed Processing (PDP) model of Seidenberg & McClelland (1989) Instead of positing separate orthographic and phonological processes operating independently and in parallel, the single-route models emphasize a single interactive process of orthographic and phonological activation

Therefore, the next sub-section of Chapter Three looks at visual and phonological processing, followed by a section on eye-movement studies Cross-linguistic studies of eye movements during reading shows that the directional scanning is largely determined by the language experience, and that the smaller saccade length made by Chinese readers is tied to the physical features of the characters The lower level of processing (e g , the perceptual processing that is affected by the orthographic variations) must reflect the central processing mechanisms that are more or less universal

The second part of Chapter Three looks at the influence of context on the process of word recognition, and the interaction of both Studies in the 1960s and 1970s claimed that skilled readers use context to guess the upcoming words in a text (e g , Smith, 1971) In other words, skilled readers may employ more top-down than bottom-up information in the word recognition task However, recent researchers have challenged this hypothesis with findings that good readers are better than poor readers at word recognition, either in or out of context

Until very recently, most word recognition tasks and the resulting models were developed for alphabetic languages like English However, for these models to

have generalizability and validity, it is necessary to include other language data as experimental stimuli Thus, Chapter Four examines some findings and results for Chinese The issues reviewed here include visual and phonological processing in Chinese word recognition, its slightly different memory patterns from most alphabetic languages, and cerebral functioning in the light of orthographic variations Although recent studies have demonstrated the involvement of phonology in character processing, many of them (e g , Perfetti & Zhang, 1991) tend to use tasks in which the activation of phonology is helpful (e g , naming) Thus, tasks that are more neutral in nature (e g , semantic categorization tasks) are necessary before the role of phonology can be generalized However, in common with the findings of the interference task (e g , incongruity in sound is found to interfere with synonym judgements, and vice versa in a synonym and homophone interference task), the findings of the semantic categorization, naming, and lexical decision tasks for lexical access of the Chinese characters is that the visual or graphemic coding is the primary stage of reading Chinese (e g , Perfetti & Zhang, 1991, Leck et al , 1995)

This visual saliency is also reflected in memory patterns (e g , Liu et al , 1992) In addition, two research lines concerning cerebral lateralization, which indirectly support the orthography-dependent or orthography-independent hypothesis, are also reviewed Leong et al (1985), for example, show that visual laterality with normal subjects varies with orthographic, phonological, and semantic processing demands required by the experimental tasks On the other hand, working with

aphasic or dyslexic patients, Sasanuma (1974) has reported the selective impairment of Japanese *Kanji* and *Kana* This, coupled with the evidence found in Chinese deep and surface dyslexia (Yin et al , 1992), appears to support the dual-route model for a non-alphabetic writing system like Chinese as well

Chapter Five draws conclusions and summarizes the various viewpoints of lexical access and word recognition for Chinese, and comments on methodological challenges to the selection of stimulus material and the way subject populations have been deployed in cross-linguistic studies The type of stimuli, differing along the dimension of frequency or imageability, and the specific task imposed, rather than script factors *per se*, gives rise to different results This final chapter on conclusions also points out some possible implications for this line of research in future work

# Chapter Two: Chinese Orthography

## 2.1 The Origin of Chinese Characters

This chapter provides some relevant background information necessary for the investigation into how a logographic system like Chinese affects the perceptual and linguistic processing of words. Orthographic knowledge, which is multifaceted and crucial for reading, includes the knowledge of individual symbols, their identities, how they are mapped onto the speech form, their common, uncommon, or unpermissible sequencing patterns, and finally, their history of development.

Writing arose as the drawings of concrete, depictable objects or acts, evolving from that into an easily replicated system which provided a graphic representation of speech. It is important to distinguish between graphs that are drawings of things, standing for the things themselves, and those standing for the names of things they represent. The former, however simplified and standardized, cannot be called true writing (Boltz, 1994). According to Iversen (1961), the turning point at which true writing was created and was separated from pictographic art was reached with the realization that "artistic representations of individual objects could convey not only the visual associations, but also association of sound, which could be read and understood as words (1961: 12)." This was a mental leap necessary for the progress toward phonetic writing, and depends on the realization of this possibility by the reader/writer, having less to do with the objective, independent features of the graphs themselves. DeFrancis (1989) notes that the essential function underlying true writing is sound representation, although orthographic symbols can differ as to

which level of a written unit maps onto a spoken unit In the case of Chinese, whose writing system is usually said to be logographic, the relationship between orthography and meaning is closer than the relationship between orthography and phonology seen in many alphabetic languages

Keightly (1987) suggests that writing may have developed in the Aegean as a means of dealing with technological problems of mensuration or the calculation of proportion in bronze casting He then extends the possibility of such a connection to China, especially in the east coast cultures, where a "componential cast of mind" (1987 112) could be recognized The literature in archaeology (e g , Chang, 1977) has shown that two distinct patterns of ceramic-making were found in China Northwest and East Coast Whereas the process of ceramic-making in the former is holistic, with the products more practically shaped, by coiling and shaping at one time, the process of ceramic-making in the latter is prescriptive and componential, indicating deliberation and control, more attention to the measure of the parts, and piecing them together Being a cognitive anthropologist, and believing that "material culture expresses and also influences social activities and ways of thinking" (p 109), Keightley attempts to link artifacts to the people's mentality According to him, habits of thought that are manifested in one area of life also encourage similar mental approaches in others Therefore, when finding out the interesting contrasts between the ceramic traditions in the Northwest and East Coast

of China, he sees the rising of the writing system of Shang[1], which is characterized by the combination of a *radical* and *phonetic*, as another manifestation of the similar mental dispositions

It is not known exactly when Chinese characters originated In the "Commentary on the Appended Phrases" *Xici Zhuan*, 繫詞傳, one of the commentaries on the 'Book of Changes' *Yi Jing*, 易經, we read the legend that on of the three sage-kings, *Fu Xi*, 伏羲, invented the Eight Trigrams, which were later considered to be the origin of Chinese writing However, these trigrams with their binary features were thought to be symbols embodying the dynamic forces of the cosmos, not signs representing speech sounds Another legend has it that *Cang Jie*, 倉頡, a historiographer around the time of 'Yellow Emperor' *Huang Di*, 黃帝 (around 3000 BC), invented writing after observing birds' and beasts' footprints

At any rate, the earliest samples of Chinese characters dated from around 2000 B C By then, more than 400 characters or symbols were already in use, representing numerals and clan names painted or carved on the pottery or bones Most of the characters are of simple, geometric shapes Early philologists of the last century found more than 2000 characters inscribed on turtle shells and animal bones which are dated back to the Shang Dynasty (16th-11th Century BC) (Norman, 1988) Many

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[1]According to many scholars, these two major cultural complexes have independent inventions or origins, however, they fused gradually By 4000-3000 BC, the East Coast traits began to intrude into the region of the Northwest Consequently, the emergence of Shang culture (ca 2000 BC) can be seen as this convergence, mainly of elements from the East

of them are still legible today

One can perhaps get a sense as to why the Chinese writing system is usually considered directly related or connected to things or meanings rather than to sounds, and why the phonetic values of characters are largely ignored, by looking at the legends concerning how they were invented Note that neither of the legends said or even implied that its creator (*Fu Xi* or *Cang Jie*,) first invented spoken words and then represented them with written characters or that such characters were used to represent spoken words already extant Furthermore, Chinese writers (especially traditional ones) have never had a bias against written language in favor of speech In the early sixth century AD, *Liu Xie* , 劉勰 , posited that human *wen* 文 ("writing" or "literature") is parallel to natural *wen* 文 ("pattern" or "configuration," such as those of constellations, geographical formations, and so on) As a matter of fact, a philosophical world-view that seeks to preserve the connection between a graph and its meaning is, as Boltz (1994) has argued, deeply engrained in Chinese thinking To the literate, the relation between the signifier and signified was determinate, extended from the ordered relationship between the cosmos and the natural world This 'conservative' philosophy, according to Boltz, is also partially responsible for the halt in its evolution toward becoming a phonetic writing

### 2.1.1. Six Principles of Character Formation

The literary tradition of the West is haunted by the logocentrism

(synonymous, in fact, to phonocentrism) that Derrida (1977) defines as the bias in favor of speech over writing But it is largely absent in Chinese thinking As a matter of fact, ancient Chinese writers generally did not differentiate between oral and written forms of language, when they did, it is usually the latter that they valued more This absence of phonocentrism and even the presence of graphocentrism can partly be accounted for by the principles underlying the formation of characters Traditional Chinese etymologists have postulated six such principles of character formation Two of these concern variant forms and phonetic loans, which are nearly obsolete, and are not very relevant here Therefore, we only consider the first four principles here

1 Pictographs, the oldest category, are mostly iconic representations of concrete objects, such as 'sun', 日, 'moon' 月, and 'mountain' 山 In some of the characters, their iconic origins are still detectable, but the majority have lost their iconicity during the course of evolution This kind of character formation principle has a great limitation, since lots of things are not able to be expressed by pictures, even simplified, generalized ones In modern day Chinese, fewer than 3% of the characters are of this type (DeFrancis, 1984)

2 Simple ideographs express relational or abstract concepts that cannot be easily depicted by pictures For example, the characters for 'up' 上, and 'down' 下 are simple ideographs They sometimes are a point on top of pictographs, showing which part is meant by the characters For example, 刀 'knife' is a pictograph, whereas 刃 'blade', by pointing out the part it indicates, becomes a simple

ideograph

3 Compound ideograms or pictograms are characters the meanings of which are hinted at by the combination of two simple pictograms or ideograms A good example of this category would be the character for 'arm' or 'force' 武, which combines the character for 'stop' 止, and that for 'weapon' 戈, or the character for 'bright' 明, which combines the character for 'sun' 日, and that for 'moon' 月 Occasionally, a compound ideograph is made by reduplication For instance, the character for tree/wood 木 repeated twice is forest 林 and three times is dense forest 森 It is this type of character that Sergei Eisenstein (1942) compares incorrectly to his cinematographic principle of montage, which according to him, is characterized by collision, i e , the higher synthesis of the antagonistic thesis and its antithesis He is right in drawing the parallel between both, namely that, "by the combination of two graphically depictable objects is achieved the representation of something graphically undepictable (1942 29) " However, he is partly mistaken in that compound ideographs are not the composites of two opposites Instead, they are a juxtaposition of two related but usually independent simple ideographs or pictographs [2]

4 The largest and most important category is that of semantic-phonetic compound The provenance of semantic-phonetic compounds is the turning point

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[2] In this respect, composite ideograms are more like Pudovkin's notion of montage as 'linkage' than Eisenstein's notion of that as 'collision' or 'conflict' (Eisenstein, 1942)

for the Chinese writing system, which has become productive thereafter Semantic-phonetic compounds, which comprise more than 97% of the characters today (DeFrancis, 1984), have two parts a *phonetic*, hinting at its pronunciation, and a *radical*, giving clues to its meaning or semantic category A *phonetic* is usually a character by itself, chosen for its phonetic value, while being disassociated from its meaning Today, the sound-cuing accuracy of a *phonetic* ranges from total to partial to none, Some compounds have an identical pronunciation with their *phonetics*, e,g, 羊 'goat or sheep' and 洋 'ocean', both pronounced as *yang* with second tone, some differ from their *phonetics* in tones, e g , 口 'mouth' and 扣 'button', both pronounced *kou*, but with third and fourth tone, respectively, others are identical only in the rhyme, e g , 可 'permission' and 河 'river', pronounced as *ke* and *he*, with third and second tone, respectively, and still others have no relationship at all, e g , 卑 'humble' and 牌 'sign or medal', pronounced as *bei* and *pai*, with first and second tone, respectively Similarly, the meaning-conveying *radicals* are not always consistent and reliable Moreover, the same elements can occasionally function as *phonetics* in some compounds (e g , the character 'horse' 馬 in the character for 'mother' 媽 ) but as *radicals* in others (e g , the same element in the character for 'to drive' 駕 ) By compounding sound-cuing *phonetics* and meaning-conveying *radicals*, however, many characters have been created since antiquity (Leong, 1986) Therefore, this category is the most productive in new character formation, e g , in introducing loan words, or in representing newly coined words in the various

Chinese dialects The *radicals* are also used in compiling dictionaries, phone books, or other arbitrary word lists According to the more formal searching procedure, a reader should begin by looking up the *radical* of a word, followed by searching the number of strokes used to write the rest of it, this is the traditional way in which one locates a character in a dictionary[3]

## 2 2 Characteristics of Written Chinese

The structure of a logograph like a Chinese character is said to be based more on meaning than on sound In this section, we explore some of the properties of characters The characters that are most relevant here are semantic-phonetic compounds, which occupy the majority of the lexicon A part of the graphemic element is used as a phonetic cue A *phonetic*, in isolation, is like a normal character standing on its own However, for some historical reasons (e g , sound change through space and time), as well as the inherent inaccuracy of the semantic-phonetic compound principle, such as lack of a homophonous graph to serve as *phonetics*, these elements are often unreliable guides to phonology Over the total distribution of the character types, the success rate of sounding out the whole character based on its *phonetic* is 39% (Zhou, 1978) [4] The other part (usually on the

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[3]This is no longer so today In the mainland, *pinyin* is used mostly

[4]This estimation only holds true for Mandarin If other dialects are taken into consideration, the sound-cuing function of the *phonetics* may be even smaller For instance, the character for 'wrap' 包 is pronounced as *bao* in Mandarin as the same in Taiwanese, yet, the semantic-phonetic compound character 'carry' 抱, with

left-hand side) of the phonogram is used as a *radical*, which provide clues to its semantic category And for historical reasons of semantic change, these *radicals* are not always reliable in giving correct semantic information The classification of semantic-phonetic compounds is usually a philological one, in other words, *radicals* may provide an etymology that is not necessarily preserved in modern usage

Chinese characters are morphosyllabic in nature Each symbol or character represents a morpheme or minimal meaningful linguistic unit equivalent to the English syllable A 'character' *zi* 字 as the smallest functional unit is distinguished from a 'word', *ci* 詞 as the smallest immediate constituent in a sentence Unlike most of the alphabetic languages, whose perceptual units also serve as the basic constituents in syntax, i e , a word in a sentence, there are no more spatial indications as to the boundary other than the equal space between each characters Although being psychologically real, the notion of word, for example, the number of it in a sentence, is inherently fluid and varies from reader to reader A Chinese word may be monosyllabic or polysyllabic, consisting of one or more characters Furthermore, even though Chinese characters can be used independently in the text as monosyllabic words, they can almost always join other characters to form multi-syllabic words with distinctive meanings For example, 'flower' 花 is a single-character word in the following sentence 這朵花真漂亮 meaning 'this is a beautiful flower', but it can also join other characters to form such different words as

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this same character as *phonetic*, is pronounced as 'bao' in Mandarin, preserving the phonetic value, but is pronounced as 'po', in Taiwanese

'to spend' 花費, 'fancy' 花俏, and 'unfaithful, promiscuous' 花心, etc In the case of multisyllable words, the same character may be used at the beginning or at the end of such words, and is very likely to have up to hundreds of combinations An example is the character 工 for 'work' given by Leong (1973) As the beginning of bi-syllabic words, there are 49 combinations for this character such as 'worker' 工人, 'salary' 工資, 'workers' organization' 工會, and as the end, there are around 89 combinations, such as 'odd job' 零工, 'manual' 手工, etc Thus, with a corpus of around 3500 characters, a Chinese speaker can build a reasonably large repertoire

Furthermore, Chinese is described as an isolating language, in which a character represents a morpheme[5] This type of language is as opposed to an inflectional language where words can have fused suffixes in which the individual morphemes cannot be sorted out, or as opposed to an agglutinative language where such morphological suffixes may be individually added or not (Leong, 1973) For instance, "the man", "a man", "men", and "men's" are equally represented by the character 人, depending on the context, in which the use of classifiers helps to disambiguate this possible confusion, whereas in English, a word such as 'take', yields a family of related words when inflected 'takes', 'taking', 'took', 'taken', etc

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[5]Some exceptions are words of transliteration in which the whole foreign word is represented by a corresponding number of Chinese characters, e g , 'Victoria' is sound-translated as 維多利亞 *wei-duo-li-ya* , but none of the characters function as an independent morpheme here In addition, binding words such as 蚯蚓 *qiuyin*, whose either character only ever occurs in that specific word, may count as only one morpheme with the whole words (see Taft & Zhu, 1995)

Because characters can hardly be recognized as a given part of speech out of context, this flexibility and fluidity makes it possible for speakers of the language to build their own linguistic repertoire

Another unique feature of the Chinese language is the abundance of homophones in the lexicon The historic simplification of the Chinese syllables, in which syllable final consonants /-p, -t, -k, -m/ disappeared, and in which initial voiced consonants merged with the voiceless ones, contributes to the relatively small number of syllables (Hua Lin, PC) In modern day Mandarin, there are more than 400 segmentally distinct syllables, and no more than 1300 if tones are taken into account (Hua Lin, PC) However, often each of the numerous homophones has its unique orthographic structure Although frequent as single-syllable words, homophones are less frequent in multisyllabic words, reducing the confusion in listening In a running text or discourse, the ambiguity of homophones can usually be solved by clues from context

### 2.2.1 Visual-Spatial Characteristics of Written Chinese

The basic building block for the Chinese character is stroke The number of strokes in a character can range from 1 to 30,[6] and there are more than 15 manners of construction (see Huang & Wang, 1992) The fact that either dimension can vary to a large extent makes the structure of characters highly complicated Furthermore,

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[6] This number only holds for medium to high-frequency characters in modern-day usage According to *Kangxi* dictionary, which contains around 60,000 character entries, there are characters as complex as 100 strokes (Hua Lin, PC)

as each character is constructed by strokes, it is supposed to take up the same square-shaped space, regardless of the stroke numbers. The square-shaped and equally spaced features make it possible for a Chinese written text to be arranged either horizontally or vertically, by columns or by rows. The preference of directional scanning for the inherently flexible Chinese script is largely determined by the variable of language experience.

Although very symmetrical and often artistic, the layout of Chinese text does not provide much spatial cuing when compared with that available in the alphabetic languages. This layout of Chinese has some interesting implications with regard to visual encoding and scanning, and this will be discussed in the next chapter on eye movements.

**2.3. The Spread of Chinese Orthography**

The advantage of a logographic script is that it does not have to be determined by the spoken language, in the sense that an alphabet is governed by its spoken form. The pronunciation of the character can change in different regions and periods of time, yet, their identity or meaning remains more or less the same. However, this advantage only comes at the expense of the resistance to becoming an alphabetic writing. At any rate, the non-alphabetical, isolating nature of the Chinese writing system made it possible for other nations with different language structures to borrow its script, though with certain modifications. Centuries ago, these characters were adopted for Korean, Japanese, and Vietnamese. Since the sound

systems of these languages are very different from that of Chinese, certain problems arose in adopting the characters to transcribe these spoken languages. Consequently, reasonable revision had to be made. Today, North Korea and Vietnam have stopped using characters, but Japan and South Korea still maintain them to a certain degree.[7] In addition to the characters, they also use sound-based systems (*kana* and *hangul*, respectively) to overcome the problems. Take Japan for example. Japanese has been said to belong to the Altaic language family, as do Korean, Mongolian, and Turkish (Miller, 1980). As a consequence of borrowing the scripts from a different language, Japanese has evolved two sets of pronunciation for *Kanji*, namely the *On* and *Kun* reading. One uses a Japanese pronunciation and the other uses an approximation of once-current Chinese pronunciations. Moreover, they have invented two sets of syllabary-based scripts, *katakana* and *hiragana*, to accommodate function words and loan words. These three script types co-exist in ordinary Japanese texts, with their proportions varying according to differences in text genre. The mixture of three different scripts allows readers to take advantage of the visual distinctions among the script types and what they jointly represent. During reading, Japanese readers search from *Kanji* to *Kanji*, not only because of its visual complexity, but also because *Kanji* are largely used to transcribe content words.

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[7]The usage of Chinese characters is not uncontroversial, though, and language reforms have been proposed throughout the history of character usage (see Gottlieb, 1995). The usage of *Kanji* was associated with the label of anti-progress. The outcry for language reform has been most heard since after World War I, when Japanese reformers blamed the employment of Chinese characters for their scientific, technological backwardness compared to the Western world.

Commercial advertisers in Japanese also take advantage of the scripts by manipulating differences in script types. For example, advertisers will write a word usually represented with *Kanji* in the *Kana* syllabary, so that this visual unconventionality catches the readers' attention.

**2.4. Misrepresentation and Misconception of Chinese Characters**

Although the essential function of writing is to represent speech, there is still a large divergence between the two. Such divergence does not merely indicate two systems representing the same level of meaning in different ways, but in effect carries differences along with them, with speech being easier and more spontaneous, and writing more distanced and endowed with greater power. Through writing, humanity is able to be released from the constraint of linearity, which spoken form inevitably imposed. However, many philosophers have argued the pros and cons of the debasement of this outer form of language known as writing. According to the mimetic concept of language, written words are always secondary signifiers; they are further removed than speech from what is conceived in the inner recesses of the mind, and are dead, empty shells from which the living voice is absent (Liu, 1988). When it comes to the evaluation of logographic writing systems such as Chinese, written language is even further removed for such philosophers. For example, an ideographic language like Chinese bears little potential for metaphysical thinking for a philosopher like Hegel, who would rank Chinese as inferior to Western alphabetic languages because "it does not express the

individual sound, neither presents the spoken words to the eye, but only represents the ideas themselves by signs " In contrast, more modern critical analysts such as Derrida seek to deconstruct exactly this metaphysics focused on phonetic writing (Derrida, 1976) He reproaches these scriptophobes for their phonocentrism, suggesting that by giving priority to the oral discourse, they have ignored the trace, which is all the more powerful because it does not require presence but instead represents the absence It is of great interest that Chinese writing system has long held a degree of power over the imagination of Westerners The speculations of poets and philosophers alike demonstrate the recurrent temptation of those who feel both masters and slaves to words to escape from the prison-house of language Here, it is through writing, toward and against speech, that one finds a way out However, as long as an exact understanding is not available, ignorance feeds speculation Leibniz, who was searching for a universal writing system for all peoples speaking different languages, took Chinese, with a few modifications, as an almost perfect model However, he was only partly right to the extent that the structure of written Chinese merely suits the dialects within itself, and is not itself a system of universal ideas

As for poets, the Chinese writing system, which says things beyond the shells of words, serves as an object of fascination and imagination The ideographical dream abolishes the prisons of language and seeks to rediscover the harmony of the world buried in the drawing, with history inscribed, as well Perhaps the extreme example in this uninformed debate was Ezra Pound's (1956) self-indulgent

development of 'graphic poetics' based on a profound misunderstanding of Chinese character assignments Pound essentially saw in Chinese characters what he wanted to see there, dissecting Chinese script into possible pictographic components He was invariably fascinated by the images he 'discovered' there, however, in doing so, he ignores the radicals that are meant to be *phonetics*, that is, they function as guides to characters' pronunciation instead of being a philosophical element, on which to be contemplated For example, the component 真, 'true, genuine', pronounced as *zhen*, with the first tone, functions as *phonetics* in the character 慎, 'scrupulous', pronounced as *shen*, with the fourth tone Pound, seizing upon the 'eye' image (there is a little 目, 'eye' inside this *phonetic* 真), interpreted the whole character as indicating 'the eye [at the right] looking straight] into the heart' (the *radical* of 慎 is 忄[8] *xin* 'heart') For another example, the Chinese character *xi* 習 'to practice' is composed of an element 羽 meaning 'feather' on the top of 'white' 白, but does not mean 'white feather ' This character appears in the first sentence of the *Confucian Analects*, translatable as "The Master says to learn and to practice from time to time--is this not a joy?" However, Pound seized upon the 'feather' image in his fevered vivisection of characters, and rendered the line as "Studying with the seasons winging past, is this not pleasant?" (Pound, 1956 9) Undoubtedly, this is

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[8]Some constituents/*radicals* differ in format when they appear on their own, as a character, and when they serve as a constituent pattern in a composite character In some cases, these can differ as much as A and *a* (e g , 忄 and 忄 , 人 and 亻 ), in others, the difference is primarily one of compression, somewhat like K and *k* (e g , 木 and 木 , 日 and 日 )

vivid poetry, but it is faulty translation and typical of the 'licencia poetica' indulged in by commentators on the nature and scope of Chinese orthography

Some western scholars thought that Chinese also developed very early a system of 'shorthand' language called *wenyan*, because this written system never seems to have a correspondence with a spoken form, mainly on account of its extremely condensed and monosyllabic style which, if imitated in spoken discourse, would be almost totally unintelligible This disassociation of spoken and written form, according to many writers, for example, *Lin Yu Tang* 林語堂, is responsible for the low literacy rate in ancient China, and has indirectly lead to the docile character of the Chinese people, since literacy is the preliminary step to certain kinds of self-consciousness and self-awareness However, neither *wenyan* nor poetic language in general is any kind of 'shorthand' language, whose interpretation must be elaborated at great length True, the rendering of a line of ancient Chinese poetry may need some elaboration before being understood in present-day Mandarin, let alone in other languages, as we can see in numerous translations of ancient Chinese poems and prose into English versions Since those translators believe that it is a 'shorthand' language, they therefore feel obliged to make it 'longhand', thus turning a poem into a prose, an essay, adding syntactic markers, prepositions that indicate the spatial relations here and there, etc They try very hard to impose English syntax and habits of logical thinking on Chinese poems, in order to make them intelligible But in doing so, they usually ignore the life and vitality within the poem, whose structure implies a different set of perspectives,

concerned with life, with universe, time, or with reality itself

Another widespread notion is that reading Chinese is silent, and occurs without undergoing speech recoding at any point However, the activity of word recognition in Chinese must resemble reading in any other language, and poses the reader with the linguistic task of comprehending the meaning of the successive signs It is not an "archaeological act of digging up some obscure etymological roots from underneath a thick layer of distancing abstraction" (Zhang, 1985 387)

A misguided application of the notion that reading Chinese is silent can be seen in the attempt to remediate dyslexic children by teaching them to read through Chinese characters For example, Rozin et al (1977) attribute the failure of dyslexic children to learn to read English to the highly abstract nature of phonemes, as opposed to the logographic or syllabic systems which map sounds into the level of morphemes or syllables Since Chinese characters were assumed to be more visually organized in terms of whole units, whole tutoring sessions were devoted to the English translation of Chinese characters in logographically presented sentences The children did learn to recognize the word units in these several sentences, with no knowledge of syntax or phonology involved However, a follow-up study by Stevenson (1984) rightly points out that the children in the study did not meet the definition of reading disabilities, since they were second-graders reading at the level of first-graders, and that the results only demonstrate that readers can easily acquire some logographic units through paired-association learning

There is a theoretical possibility that different orthographic systems, with

different relationships between speech and script, may give rise to the different patterns of reading difficulties In a sense, the transcription starts at the deepest level, the conceptual gist, then shifts gradually outward to the surface level, the sound This pattern of development seems to parallel that of cognitive development in children At each step, the unique and concrete ways of representing meaning give way to a smaller, but more general set of written symbols As the number of symbols in the script decreases, the abstractness of the relationship between script and speech increases (Tzeng & Hung, 1981) Therefore, beginners of English are required for greater phonological awareness and maturity in text decoding

However, Rozin et al 's study was premised on a still contested assumption, which came from the result of an unreliable survey The rarity of reading disability in school children reported in languages adopting syllabic and logographic systems (Matika, 1968, Tzeng & Hung, 1980) may be closely tied to the cultural factors instead of merely to orthography *per se* The evidence, thus, cannot be taken too seriously, for assessments were often crude and usually lacked cross-cultural controls In many research surveys, questionnaires were sent to school teachers, and questions were framed in a manner far from satisfactory Needless to say, the evidence to date will not tell the whole story, especially in societies where social pressures keep schools conscious of their public image [9] In short, stronger evidence still remains to

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[9]The often cited 99% literacy rate is provided by the Japanese ministry of Education, and was said to present nothing more than the primary school enrollment (see Brown, 1991) Furthermore, the concept of literacy is especially

were framed in a manner far from satisfactory. Needless to say, the evidence to date will not tell the whole story, especially in societies where social pressures keep schools conscious of their public image.[9] In short, stronger evidence still remains to be obtained with more appropriate cross-cultural controls before deciding whether or not reading disability (at least at the perceptual level) may be specifically related to orthographic variations.

Having provided a general understanding of the Chinese writing system, we set out to review some literature pertaining to the current trends in word recognition study, starting with the process of lexical access.

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[9]The often cited 99% literacy rate is provided by the Japanese ministry of Education, and was said to present nothing more than the primary school enrollment (see Brown, 1991). Furthermore, the concept of literacy is especially nebulous in Japan, where two distinct but intermingled writing systems (*kanji* and *kana*, whereas within *kana*, *hiragana* and *katakana* can be further distinguished) co-exist. The Japanese Ministry of Education counts anyone literate as long as he has the slightest reading ability of any of the three scripts (Brown, 1991).

# Chapter Three: Literature Review

## 3.1 Word Recognition Models

The path to word recognition begins when a printed word which is confronted by the reader is then processed for meaning. The process by which this takes place, and the various factors influencing the speed and accuracy with which lexical decisions are made, are typically subsumed under what are called lexical access procedures. There have been various word recognition models, but they can be classed into two types of explanatory models: double-route and single-route models. In addition to the relative importance placed upon the roles of visual and phonological information in the lexical access procedure, an essential difference between dual-route and single-route models is the difference between rules and activation.

### 3.1.1 Dual-Route Models

The earliest dual-route models (e.g., Coltheart, 1978, Morton and Patterson, 1980) claimed that there are two distinct routes to a word's meaning. One is called the phonological route and the other the visual route. In the phonological route, a printed word is first converted into a phonological representation, which in turn serves as a mediating point for semantic recoding. The phonology in this route is named 'assembled (prelexical) phonology' because the orthographic features of a word are matched against phonological units in order to generate the word's phonological representation. In the lexical route, phonological recoding is not

required prior to the interpretation of the word's meaning, but by a visual, direct hit on the lexical address, hence the term 'addressed (post-lexical) phonology' In this view, some words which the reader has learned are represented as directly accessible entries in the mental lexicon which can be thus retrieved when the visual representation is encountered Logographs such as Chinese characters that do not have Grapheme-Phoneme-Correspondence (GPC) rules have been used as support for the existence of the visual route Readers can, nevertheless, also read aloud the pronounceable letter strings by way of using correspondence between graphemes and phonemes

In addition to capturing the intuition that access to phonology is not obligatory in word recognition, the two-mechanism model of reading is also supported by the neuropsychological syndrome of acquired dyslexia (Marshall & Newcombe, 1973, Patterson & Marcel, 1977, Shallice & Warrington, 1975) At first glance, the two basic categories of patients who acquire reading disabilities after brain damage seem to demonstrate the independent existence of visual and phonological mechanisms of reading "Deep" or "phonological" dyslexics pronounce and recognize familiar words but are unable to assign any reasonable pronunciation to novel letters strings These patients apparently have an intact visual access mechanism with a loss of the phonological rules "Surface" dyslexics, however, are characterized by regularization error, whereby words which have exceptional

pronunciations tend to be regularized in reading[10] These dyslexics show a loss of the direct, visual route, while the phonological route remains intact A natural interpretation for the pattern observed seems to be that the different tasks are subserved by the separate neural mechanisms, such that these mechanisms can be selectively impaired Adopting a modular view of the cognitive systems provides a natural way of explaining the interesting pattern of double dissociation

Influential as it is in the area of word recognition, the dual-route model is not without its criticisms In fact, there are even criticisms of its application to an alphabetic language like English, in which readers are supposedly able to have two routes at their disposal The major criticism of the standard dual-route model is that in the indirect, phonological route, phonology can only be assembled by the application of Grapheme-Phoneme-Correspondence rules, which explicitly deny the involvement of lexical knowledge The only role for lexical knowledge in the dual-route model is in the process of retrieving whole-word phonological or semantic representations (see Henderson, 1982) However, there is abundant evidence for the influence of lexical knowledge even on the pre-lexical stage of phonological assembly For example, Waters et al's study (1984) showed that children (grade

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[10]Marcel (1980), however, thought that the standard descriptions of the dyslexic categories are misleading He carefully reanalysed the dyslexic patients' responses and criticized the usual "cursory and restricted" analyses of these primary data Marcel's reanalysis suggested that there are considerable lexical influences in the responses of the surface dyslexics, and that their responses are too idiosyncratic to be explained as the malfunctioning or restricted functioning of GPC rules He thus rejects the standard two-mechanism model of reading and proposes that the two dyslexic syndromes arise as impairments at different points in a unitary reading process

three) read aloud high frequency regular words more accurately than they do low-frequency regular words, although both of the categories utilize many of the same GPC rules. And this frequency effect is unlikely to be totally attributable to the lexical route, either, because the children made fewer errors on regular than on exception words (both high and low frequency). These results suggest that children use GPC rules, which are not replaced by the convenience of the lexical route.

As Hung et al. (1984) have pointed out, many model builders were entrapped in a circular reasoning, which incorrectly assumes that linguistic descriptions must have corresponding knowledge of language structure, which then provides independent evidence for the proposed mechanism or route to assess this knowledge. The arguments against the "psychological reality" evidence for spelling-to-sound rules apply equally well to this clinical evidence. Deep dyslexic patients may have lost the knowledge of spelling-to-sound structure, but there is no basis for concluding that this knowledge must have been represented as a set of abstract spelling-to-sound rules. Connectionism, the prevailing paradigm in modern cognitive psychology, would argue that these abstract rules are the conscious analyses of the external observers and that the organism which perform the skill is not rule-governed.

As was mentioned, this general concept of dual-route architecture in reading has not gone unchallenged. In the next section, we will briefly review some alternatives proposed in reaction to the above concept.

### 3.1.2 Single-Route Models

The basic premise in the single-route model is that different linguistic codes are processed in parallel, and the association between script and speech is the key to explaining frequency effect, regularity effect, and the interaction of both (Seidenberg & McClelland, 1989). The single-route model has been realized in a number of discrete theoretical frames, and we will briefly survey these related, but far from unified, approaches to lexical access. Among these influential approaches, we may consider the Synthesis-Activation Model proposed by Glushko (1979), the Time-Course Model by Seidenberg (1985), the Parallel Distributed Processing (PDP) Model by Seidenberg *et al.* (1989), and the Restrictive-Interactive Model proposed by Perfetti (1992).

According to Glushko (1979), regular and irregular words, as well as pseudo-words, are pronounced through similar strategies arising from orthographic and phonological knowledge. His model suggests that any letter string, regardless of the lexical status, activates a multitude of stored orthographic shapes and their phonological associations. It appears that several different types of higher-level orthographic structure are relevant to pronunciation, not just individual graphemes. A synthesis process is then assumed to integrate all of the available information and produce an appropriate pronunciation. For example, if the word is *gave*, a couple of possibilities which contains the orthographic form *-ave*, along with their corresponding pronunciations may be activated (e.g., have, cave, etc.). The correct pronunciation of *gave* is then synthesized from the competing

information in the activation region One of the implications is that words with various phonological possibilities take longer to name than words with only one phonological possibility This model also make further distinctions among regular words themselves Regular and consistent words like *mail* yield shorter naming latencies than regular but inconsistent ones, because all words ending with *-ail* have the same pronunciation on this body or rhyme segment Regular but inconsistent words like *maid* have longer response times because not all words ending with *-aid* have the same pronunciation The same distinction applies to pseudo-words (e g , *zail* and *zaid*) Various studies have shown that inconsistency slows down the naming latency This has often been cited as evidence against dual-route models, especially for the result of pseudo-words if all non-words are pronounced by applying the GPC rules, how does the word *said* come to influence the naming of *zaid*?

Underlying this synthesis-activation mechanism is the principle of analogy Analogy is an old notion in linguistics and in psychology, being repeatedly invoked to explain such phenomena as linguistic productivity, language change, and concept formation (Raimo, 1977) The notion of analogy, however, rests on a more basic idea of similarity--words that are similar to the novel words can presumably serve as analogies to it In other words, this rationale is based on the assumption that all the transcoding from orthography to phonology involves the activation of a lexicon that serves the conversion of orthographic pattern into word phonology This approach, I suppose, is more applicable to Chinese characters (for the reasons that

will be discussed in the next chapter)

Seidenberg's time course model (1985) of word recognition emphasizes the single interaction process, with the orthographic and phonological information being generated over different times, rather than positing separate orthographic and phonological mechanisms operating in parallel, as in dual-route models In two studies, he found that a large pool of high frequency words are recognized on a visual basis Phonology, according to him, only enters into the processing of low-frequency words Recognition of a word, however, begins with the extraction of the visual information from the input, then it activates its phonological representations Thus phonological access lags behind visual analysis

Another more computational single-route model for word recognition is the Parallel Distributed Processing (PDP) model proposed by Seidenberg & McClelland (1993), whose precursor is the Interactive-Activation Model of word perception (McClelland & Rumelhart, 1981) It was developed with the goal of using a minimal architecture in which the learning aspect played a dominant role The larger framework assumes that reading words involves the computation of three types of codes orthographic, phonological, and semantic Each of these codes is assumed to be a distributed representation, that is, to be a pattern of activation distributed over a number of primitive representational units Processing in the model is assumed to be interactive, that is, word processing can be influenced by the contextual factors arising from syntactic, semantic, and pragmatic constraints, although the scope and locus of these effects is a matter of current debate Also, at least some of these types

of information constrain the construction of the representation at, say, the semantic level. The simulation model that has actually been implemented has three layers: the orthographic input, the phonological output, and the hidden units in between. Hidden units, according to the model, are where learning occurs. By manipulating the parameters in hidden units, the model can successfully simulate the learning behaviors and the reading problems found in various kind of dyslexia.

The Restrictive-Interactive Model proposed by Perfetti (1992) is a hybrid model that combines the two important features of the major theories of word identification, namely, the interaction of information sources and restrictions on these interactions. According to him, there are both autonomous and interactive components in the identification of words. The lexicon is an isolable language subsystem. Some operations in this subsystem, such as word recognition, are highly impenetrable to the sources outside of the processes. However, information inside them can be highly interactive. Thus, interactive and autonomous processes coexist. It is just a matter of where the constraints are. The multiple resources have similar activation networks along the line of the interactive model (by Rumelhart & McClelland, 1981), yet, a critical feature of the Restricted-Interactive Model is that it places specific constraints on the interactions. It allows the interaction of information inside the lexicon, e.g., letters, phonemes, and words, and excludes the influence of imported knowledge (contextual factors) on lexical access. According to this model, therefore, skilled word recognition is supposed to be context-free, impervious to expectations and belief.

It appears that what were once considered as opposing and contrasting views, namely, dual-route and analogy models, are becoming difficult to distinguish. To generate a prelexical phonology is not to restrict the code to individual letters and their sounds, but instead, to allow different sizes of letter group to activate their speech-based counterparts, as well. According to Just and Carpenter (1987), several levels of phonological codes could be activated by printed words: codes associated with individual letter and letter pairs, with consonant clusters, with syllables, and with morphemes. A word like *time* may activate different sound units: its initial, its coda, or its rhyme. Furthermore, since not all phonological codes have the same lexical connection and strength, those codes that are most associated with a pattern would receive the strongest activation. Thus, a multiunit activation process makes the prelexical phonology more realizable. However, it does so at the expense of moving towards a visually based code. In order to activate a code as large as a syllable, a reader must have directly stored its sound. If the unit of the prelexical phonological code start to resemble a lexical unit, then the two routes become indistinguishable. In the context of alphabetic languages, however, use of analogy can be one way of taking advantage of the spelling-sound relations. Use of analogy and use of component correspondences both require analysis of printed and spoken words into parts.

On the other hand, the architecture of the PDP model, with its hidden units, is criticized as being too powerful to be meaningful. Besides, the simulation part of the model is limited only to the pronouncing of monosyllable words. Although it

assumes interaction beyond the word level (e g , syntactic and semantic levels), those processes are considered to be more pertinent to the overall comprehension rather than the identification or pronunciation of the single word

### 3 2 Visual and phonological processing in word recognition

In the literature of word recognition, qualitative, two-stages of phonological involvement have been discussed (i e , prelexical vs postlexical stages, or assembled vs addressed phonology) Pre-lexical, or assembled phonology refers to the derivation of pronunciation by way of the use of grapheme-phoneme correspondence, and its existence is supported by the findings in alphabetic languages such as English On the other hand, postlexical phonology utilizes the direct, visual route, and functions as a phonological mediator for skilled readers, assisting them in maintaining information in working memory

There are several types of evidence in favour of a phonological encoding hypothesis For example, Meyer, Schvaneveldt and Ruddy (1974) carried out a lexical decision task with English words, and found that a letter string that sounds like a real word (e g , *brume*, which is a phonological pseudoword), induces longer decision time than a non-word, which does not resemble a real word in pronunciation (e g , *brune*) Furthermore, subjects were presented with pairs of English words and were to answer "yes" if both were real words, but "no" if otherwise The reaction times were faster if the pairs of words shared both visual and phonological features (e g , BRIBE-TRIBE) than when the pairs of words only

shared visual features, but contradicted in the pronunciations of vowels with the same spelling (e g , FREAK-BREAK) The latter condition requires even longer reaction time than control (e g , BRIBE-HENCE) [11] The results were interpreted as showing that pre-lexical phonology is involved, because the employment of phonological recoding takes place for the first item, this influences the manner in which the second item is recoded The employment of a backward-masking paradigm also demonstrates the involvement of the pre-lexical phonology (e g , Perfetti et al , 1992) The backward-masking paradigm is similar to the priming paradigm, but with a crucial difference In priming, a word called the 'prime' is presented long enough to be processed Then a 'target' word is presented, with the reaction time to be measured Thus, the priming effect attained (whether semantic or phonological) is supposed to be post-lexical, for the prime is entirely processed However, in backward masking, the word replacing the prime is shown for less time than it takes to recognize the word, thus creating a situation in which any effect must be considered "pre-lexical" The phonological effect, in this case, lies in the reinstating of the partially evoked, yet not totally recognized target

In contrast, many studies have obtained results that instead support the existence of a direct route, in addition to phonological coding, for alphabetic and

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[11]However, Shulman et al (1978) showed the flexibility of phonological recoding by having words discriminated from pseudo-words or random letter strings In the former trial, the pattern of results was similar to that reported by Meyer et al (1974), whereas the latter observed no phonological priming effects These results were taken to mean that phonological recoding is not universal and is perhaps task-demand rather than process-demand

syllabic words The history of this line of research on visual information begins with Baron (1973), who, in an early experiment, asked subjects to read short phrases and decide whether they made sense or not Some of the incorrect phrases included a homophonic word that made the phrase sound legal, e g , "Don't dew it " Baron reasoned that if phonological encoding is a prerequisite to lexical access, then it would take longer to refuse the homophonic pseudo-phrase as incorrect However, the results proved otherwise it takes more or less the same time to reject both homophonic pseudo-phrases and the incorrect, control phrases Therefore, she concluded that phonological recoding was not a prerequisite Kleiman (1975), in a similar spirit, demonstrated that access to the lexicon did not rely on prelexical phonological recoding, which usually occurred for facilitating comprehension in working memory Seidenberg's (1985) naming test with English words found no difference in naming latencies between phonologically regular and exception words with high frequency and familiarity In contrast, for words with low frequency and familiarity, Grapheme-Phoneme-Correspondence rules appears to have some influence, so that the processing of regular, low frequency words were faster than their irregular counterparts

Yamada et al (1990) also showed the use of the orthographic lexicon in reading *Kana* words by adding variables, such as word length, visual familiarity (by presenting the words usually written in *hiragana* in *katakana*), lexical role (words and nonwords), and vocal interference (silent or concurrent vocalization) to the lexical decision task A direct, visual route is thought to be independent of word

length, while an indirect, phonological route is assumed to be affected by this variable. The results showed that, contrary to popular views, Japanese *kana* can be lexically accessed by processes either of assembled phonology or via the visual orthographic lexicon. A visual orthographic basis for *kana* reading exists in Japanese readers when the words are visually familiar. Furthermore, the number of items in the sight vocabulary appears to be one of the aspects that distinguishes skilled from less skilled readers.

Visual recoding of a written text also includes the processing of spatial layout of the text and the other physical properties of the printed words. In alphabetic scripts, for example, this information entails the case, size, and the spacing between words, in addition to the content of words. These features of spatial layout are important because they can affect the reading process and readers' performance (this effect will be discussed in detail in the next section).

The controversy over whether skilled readers are visual readers, capable of turning orthographic information directly into meaning without the mediation of phonology, has been tested by words or sentences spelled in alternating cases (McClelland, 1976). The results show that skilled readers are less affected by visual irregularity and unfamiliarity than less skilled readers are. From this fact, researchers infer that skilled readers must be taking advantage of phonological information rather than using visual information alone, otherwise, the processing of a word would have been disrupted by visual intervention of alternating cases. On the contrary, it is the less skilled readers who are visual readers, for they are

easily affected by an unfamiliar pattern. However, there might be a crucial fact that is left out in this argument, that is, the flexibility of human processing mechanisms, as one path is blocked or disrupted, the other will take over the task in question and compensate. The more skilled the reader is, the more this ability is manifested.

Furthermore, the study of visual information processing within fixation points indicates that the visual array is rather completely processed, during each fixation. It appears that visual features are not minimally sampled in order to confirm "hypothesis" but are instead rather exhaustively processed, even when the word is highly predictable (see Balota et al., 1985). In contrast to the speculations by early top-down models, for example, "the better reader barely looks at the individual words on the page" (Smith, 1973, 190), the sampling of visual information, as indicated by fixation points, is relatively dense.

There is thus a mild paradox. Phonological processes appear to be unnecessary, under certain conditions, for skilled reading, yet they are characteristic of beginning reading, especially for those who learn quickly. A reasonable way out of this paradox is to suggest a skill acquisition model based on differences between expert adult readers and novice children (e.g., Gough & Hillinger, 1980). Phonological processes are especially important for beginning reading because the child must learn to map print to speech sounds. Through extended practice at lexical access, attention to phonemic correspondences of letters drop out, and perception of letter patterns automatically activates word concepts. The transition from novice to expert probably requires extensive practice, just as in other areas of

cognitive skill, such as chess. The result of this practice can be described as the replacement of generalized phonemic-based rule sequences with specific, unified, word recognition productions.

### 3.3. Eye movement during reading

Further information regarding the role of phonology in reading is provided by eye-movement studies. Eye movements during reading stands between the level of preliminary sensory input and the higher levels of cognitive mechanisms, thus providing interesting insights with respect to lexical access, word recognition process, and reading comprehension.

#### Visual acuity and directional scanning

Freeman (1980) reported that random letter strings presented in horizontal rows were better seen by native speakers of English than if they were arranged vertically. However, this pattern seems to hold only for American children who had learned to read and for language material; it disappeared with preliterate children and with non-language material such as grating test targets, or circles having gaps at the top, bottom, left, or right. On the contrary, Freeman did not find such a horizontal-vertical difference with native Chinese speakers reading characters, apparently because of the flexible directionality of Chinese texts allowed by the square-shaped structure of the characters. Chinese-Americans who had not yet learned to read and write Chinese exhibited the same visual directional

preference as the other American subjects However, their performance pattern with English seems to be modified by their Chinese learning experience, i e, from a dominant horizontal preference to a more balanced one Both cases seem to suggest that reading Chinese has a fundamental effect on the visual processing which is usually expected to be data-driven or bottom-up Similarly, learning an alphabetic language such as English has influence on the preference of directional scanning As a matter of fact, in Chen and Chen's (1988) follow-up study with the bilingual undergraduates from Hong Kong, there was an advantage for the horizontal direction in speed reading A comparison study of eye movement conducted by Sun et al (1985) for horizontally and vertically arranged Chinese text also indicates that modern Chinese readers are more at home with the former, due to a shift from vertical to horizontal text in the second half of the century[12]

These studies on directional scanning either in Chinese or in English suggest that language experience is a significant variable The inherently flexible direction of flow for the Chinese script, the unique historical change from a traditional vertical to a horizontal direction of print more prevalent in the modern time, and foreign language learning experience all suggest that preferred scanning direction changes with reading experience and habit

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[12]This shift took place only in mainland China, while places like Taiwan still maintain the traditional vertical arrangement However, the arrangement of textbooks in colleges and universities, especially in the area of natural science, is mostly horizontal The major reason is that they are translated from originals which are often in English

**Eye movement in reading**

Eye movements take place where there is more to see than can be met in one fixation of the eye. Sun et al. (1985) found that English readers and Chinese readers reading horizontally-arranged text showed similar eye-movement patterns in an identical reading task and material. This similarity implies that the printed languages have been adapted to fit the ideal visual object for the fovea, including the comprehension of visual spatial information, such as spacing, cases, and other physical properties of words. Foveal vision, within which we can see things clearly, covers only a small span of about 2 degrees of visual angle, corresponding to about eight letters (typically one and half English words) or a couple of Chinese characters, when viewed under normal conditions. Materials in parafoveal or peripheral vision, which is beyond the immediate area around the fixation point are not seen as well, but it is still possible to discern the crude shapes of things within a couple of dozen or so letter spaces (see McConkie & Rayner, 1975).[13] The two main variables in eye movements determining reading speed are the saccade length (the distances between eye fixations during reading) and the duration of fixation pauses of the eye. Normally, actual eye movements during reading occur in saccades, which were

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[13]The utilization of parafoveal vision lies mostly in the level of abstract-letter code (see Rayner & Pollatsek, 1989). It is also tied to the demands placed on the individual's basic cognitive resources. According to Mackworth's (1965) classic notion of tunnel vision, the useful visual field shrinks when a heavy load is placed on the central processing system. For example, when the foveal task demands are great, the utilization of parafoveal information decreases in a tunnel-vision type fashion. Therefore, parafoveal processing is not constant but varies with foveal load, both of which are, in turn subject to the frequency variable (Balota & Rayner, 1991).

characterized as discontinuous, erratic, and sometimes long jumps. In addition to the forward saccadic movements, the eyes show a return sweep at the end of each line, going to the beginning of another. The direction of eye movement can also be regressed to preceding words for clarification. In reading Chinese, a relevant factor is worthy of note. Hoosain (1991) and Chen (1994) have both noted that modern printed Chinese (it is more so with the classical texts) is denser than the English equivalent, so that a printed message takes up less space. Hoosain (1991) also noticed that the translation passages in some bilingual journals show an asymmetry in length. English is usually 50% or 60% longer than the Chinese version. This density alone would mean that a Chinese reader finishes the same message quicker than his English counterpart, for the reader of Chinese is able to see proportionally more of the text with any one fixation. That is, the perceptual span in terms of content information covered is greater. However, there are other factors coming into play which make the picture less simple as that!

It was estimated that, on average, an English word in the text is equivalent to 1.5 Chinese characters. When this 1.5 factor is taken into account, the span distance (saccade length) is approximately 1.8 English words for English readers. However, they are different in visual angles. When measured in the same visual angle, however, the average saccade length for the Chinese readers is about 15% smaller than that for English readers (Peng, Orchard, and Stern, 1983). It means that Chinese readers usually make more saccades per line than do English readers.

The durations of the fixational pauses are very similar for the subjects reading

Chinese horizontal text and subjects reading English horizontal text, however Therefore, when saccades are measured in terms of the number of linguistic words covered between fixations, Chinese and English readers cover comparable ground One explanation offered for this balanced set of results, despite the greater information density of the Chinese text, is that there is a central processing mechanism that has a functional limit on how much information can be taken in and absorbed at a time (Hoosain, 1991) Consequently, the speed of eye movements has to be adjusted to accommodate this bottleneck higher up in the cognitive mechanism There could be other explanations for the failure of eye movements in reading Chinese to be faster, despite the fact of higher density This has to do with the visual configuration of the characters In the case of English, when the eyes are fixed at any point of the text, parafoveal vision provides information about the general length and shape of the words to come next In other words, the visual information gathered on the current fixation may not be sufficient for identification of words in the parafoveal or peripheral vision, but will nevertheless prime or lower the activation threshold for the word Coupled with what has been processed so far, this preliminary information enables readers to decide when and where to fixate the eye next The availability of word shape and length information is found to be useful (Rayner, 1975; Harber, Harber, and Furlin, 1983)

However, a good deal of such peripheral information is absent from the Chinese text There are no word boundaries other than regular spacing between individual characters Each unit is square, box-like in shape, and thus with fewer

ups and downs than alphabetic letters. In addition to the absence of peripheral information in the form of varying shapes, the high spatial frequency of Chinese text further renders the sensory information in the more degraded peripheral vision even less distinctive (see Ho & Hoosain, 1989).

Furthermore, it has been noted that Chinese readers are capable of showing "pursuit-like" eye movements which are not found in the English readers. This unique pattern may reflect the three way script-sound-meaning relationships in the Chinese writing system. When Shen (1927) compared the reading of Chinese texts printed horizontally and vertically, he found that saccades had a tendency to glide into a continuous line when subjects read vertical text, but this did not happen with horizontal text. At that time, vertical arrangement of a Chinese text was the norm. Half a century later, Stern (1978) also reported a subject who displayed the pursuit-like eye movements in reading horizontally arranged Chinese paragraphs[14]. He attributed this to the search for direct access to meaning in Chinese. However, these are two cases out of the very few studies in eye movements during Chinese reading,

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[14]In a follow-up study, this pursuit-like pattern is not replicated, however. Ten native Chinese readers, all undergraduate or graduate students at Washington University, were asked to read two short stories, one in Chinese and one in English. They were told that they were to read for "pleasure" and would not be tested for comprehension. Eye movements were recorded. But the pursuit-like pattern found in the previous subject was only infrequently found in the latter group. It is unknown whether task difficulty, length of line, levels of reading skill, or anxiety about the testing situation were responsible for the differences. Interestingly, the Chinese students, in reading English, seemed to unconsciously carry over the habit of reading Chinese. The eye camera found them to make more saccades per line (10 in average as opposed to the 4 averaged by American readers). Although these Chinese students had more than 10 years of English learning experience, their original reading styles appears to persist.

suggesting that the validity and generality of their conclusions awaits further investigation.

Despite the lack of visual acuity differences for characters arranged in either direction, there is a greater similarity of eye movement patterns in terms of fixation durations and reading rate between English and Chinese. According to Sun et al. (1985), this similarity is perhaps due to gradual optimization in order to serve the visual processes that occur while successively scanning or glancing over a scene. Consequently, linguistic visual processes may be assumed to be derived from these more general functions of vision. Similar reading behaviors across scripts also support the thesis that higher mechanisms for information processing are impervious to the orthographic variations.

**3.4. Influence of context: To what extent is the process of word recognition affected by the context?**

According to the Restricted-Interactive model, word identification and recognition is autonomous and almost context-free, but there have been suggestions that semantic context influences recognition via two processes that act independently and that have different properties. One is an automatic activation process, the other is a conscious attention process (Just and Carpenter, 1987). The automatic process is fast-acting, and does not use attentional capacity, nor does it affect the retrieval of information from memory location unrelated to that activated by the context (Stanovich, 1981). Thus, such a process rapidly results in a contextual

activation effect but does not cause an inhibitory effect on the access of unrelated word concepts, even when a word is incongruent with its preceding context For example, the processing of the word *doctor* does not inhibit the subsequent access of an unrelated word like *bread*

On the other hand, the other expectancy process--the conscious attention process is slow-acting and deliberate It utilizes attentional capacity, and inhibits the retrieval of unrelated, but not necessarily contradictive, information or word concepts

Some studies focus on the effect of sentence context on the speed of visual word recognition measured by reaction time For example, in Stanovich's study (1981), subjects were presented with sentence contexts that had their terminal words deleted After a 1 5-sec exposure of the context, a target stimulus of a single word that could either be congruous or incongruous appeared with the previous context A third condition served as control with no context presented The results indicated that all three groups of subjects showed significant context facilitation effects of faster reaction times in the congruous condition than in the no context condition However, the magnitude of the contextual facilitation effect does not increase with age In fact, there is a slightly negative correlation between age and this effect, indicating that a larger facilitation effect is associated with lower reading ability Furthermore, sentences presented in incongruous conditions did not affect skilled readers (college students in their subject group), but such an incongruence has inhibition effects for the less skilled readers in grades 4 and 6 Word recognition in

skilled readers is so rapid that a word is processed before the conscious attention stage can have any inhibition effect Only the automatic activation process is more likely to facilitate the recognition of individual words In other words, word recognition speed for older and better readers are so rapid that the influence of contextual factors is greatly reduced In contrast, word recognition speed for younger and poorer readers is slow relative to the speed of contextual mechanisms Context, therefore, has a substantial influence on the word recognition process for these individuals Stanovich and West (1979) have suggested that the differences between good and poor readers might be fruitfully examined in terms of compensatory model of reading subskill organization In this framework, higher level processes compensate for deficiencies in lower level processes Thus, relying more on contextual information seems to be one of the strategies that poor readers use to compensate for their deficiencies in word recognition processing (West and Stanovich, 1978) It is, in fact, not much unlike the prediction of the Restricted-Interactive model, which predicts that, for skilled readers, context confirms the meanings that are obtained from the identification of words, but only modestly influences the identification itself It is the less skilled readers who depend on context more for the process of word recognition

The notion of "skill" is especially important in cognitive science, if we consider automatic word recognition as a basic skill for reading Skilfullness seems to be a basic property of any kind of complex mental activity Perception, language comprehension and production, and everyday thinking are good illustrations of this

property The execution of the skill is not improved by the conscious knowledge of their particular components, and as Polanyi (1962) puts it, these particulars should always remain beyond one's focal awareness The skilful performances are goal-directed and automatic, for if one pays too much attention to their particulars, the whole execution is liable to collapse By focusing too much on the particulars, one destroys the sense of context, which alone can properly evoke the appropriate sequence of procedures An example would be the performance of people who first try to speak a foreign language, even after a long period of learning, production is usually clumsy, slow, effortful, and demands a lot of attention Ironically, they are usually much more aware of those particulars (e g , the pronunciation of words and their stress patterns, or looking for words and consciously combining them into sentences according to the rules they have learned) than native speakers of that language Native speakers, on the other hand, with automaticity at the basic, individual word level, can save time and direct reflective attention to the overall construction of the text It is perhaps fair to say that reading depends on the recognition at the lexical, or even sublexical level, but at the same time, transcends them as the particulars Only when this basic skill becomes automatic and demands our attention to the least degree, does the whole performance turn into a meaningful text

# Chapter Four: Results for Chinese[15]

## 4.1 Visual Code Activation of Characters

The effects of orthographic variations on word recognition have been discussed extensively, but there is no consensus with respect to consistent results or conclusions. It is undeniable, however, that the sound-to-meaning relationship is prior to the script-to-meaning relationship, when viewed from either the perspective of the historical development of languages or first language acquisition by most individuals. The fact is that the basic principles by which orthographies are structured differ, with some having a closer relationship between script and sound (alphabetic writing systems), and others showing closer relationships between script and meaning (logographic systems). This suggests the plausibility of the "dual-route processing" model first introduced in the 70's (e.g., Baron, 1973, Coltheart, 1978), a model which posited that both phonological and visual information are involved in the process of word recognition, with relative weighting attributable to factors such as word frequency, familiarity, subjects' reading ability, and orthographic depth. The strongest evidence for this claim is seen in the differences reported for Stroop interference. Biederman and Tsao (1979) first noted that Chinese subjects are slower to name the color of characters in conflicting colored ink than English

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[15]A large part of this chapter has appeared in the proceedings of the Ninth North American Conference on Chinese Linguistics, entitled 'An overview of Chineseword recognition models' by Kathy Hwang, Joseph Kess, and Tadao Miyamoto.

subjects, suggesting more Stroop interference[16] in the Chinese version of the task The greater Stroop interference experienced by Chinese subjects cannot be attributed to their bilingualism, since previous studies have found bilinguals to show less Stroop interference than monolinguals (Tzeng & Wang, 1983) What might cause this longer naming latency for Chinese subjects? Perhaps direct access to meaning from the visual stimuli, in addition to the recognition of color information, are functions assigned to the right cerebral hemisphere (Pennal, 1977, as cited by Biederman & Tsao, 1979) In Chinese, Stroop processing of characters and color information causes more interference because they are simultaneously executed by the same right hemisphere mechanism Reading English is mainly a left hemisphere activity, and in the English version of the Stroop test, such a conflict is largely absent Chinese orthography seems to predispose a reader of Chinese towards configurational processing of the ideograph, while a reader of English cannot refrain from applying an abstract rule system to reading a word (Biederman & Tsao, 1979 131) [17] Shimamura (1987), using a symbol version of the Stroop interference task, showed that logographic symbols are identified more quickly than

[16]Stroop interference, in which color names are written in different colored inks, and subjects are asked to name the color of the inks, is to show the automaticity of reading It has been known that a fluent reader cannot avoid activating the semantic code of the word upon seeing it Eventually, the subjects experience the interference between the processing of the visual and the verbal information in the Stroop test

[17]There is disagreement in the methodology used, material selected, and the interpretation provided for the results (see Benson, 1991) Scientific explanations too quickly rely on the widespread belief that Chinese orthography provides more direct access to meaning than to sound

phonetic symbols, yet appear to elicit greater Stroop effects than phonetic systems, despite the fact that the latter are named faster Taken together, these results suggest differential access to meaning and phonology More recently, Leck et al (1995) have also shown that visual information plays an important role in recognition of compound as well as simple characters

In Hue and Erickson's study (1988) of Short-Term Memory (STM), they found that low-frequency radicals and characters whose pronunciations are largely unknown tend to be coded visually, and are therefore also more subject to the visual interference Further, visual memory alone has very limited capacity in STM On the other hand, for high-frequency characters, the dominant form for STM is the verbal code Thus, the processing of this category of orthographic symbols is usually not affected by orthographic complexity

However, there have been some suggestions that the different sides or quadrants of the Chinese characters do not convey the same kind or amount of information I M Liu (1983) compared reading times and errors for characters with different quadrants missing, and found that the parts in the top and left locations have greater cuing power This finding was demonstrated with longer times and more errors in reading characters which had these parts missing

### 4 2 Phonological Processing

Although characters do not carry cues to sound in the same way that alphabets do, this does not mean that characters are completely devoid of phonetic

cues or that they are read without speech recoding Nor does it imply that meaning is automatically derived from the perceptual characteristics of the individual characters In fact, if we compare the efficacy of the semantic radicals in conveying meaning against that of phonetic radicals in communicating sound, the latter is far more efficient than the former Only some two hundred *radicals*, as compared to over one thousand *phonetics*, are regularly used (Coulmas, 1989 104) Numerous experiments since Tzeng et al (1977) have demonstrated that phonology does play a role in reading Chinese, depending on the cognitive processing task posed and the level of processing required (see Kess and Miyamoto, 1997, for an overview) The notion that reading Chinese is silent and requires orthography-specific cognitive mechanisms is not particularly supported by the literature

It is well-known that a majority of Chinese characters are semantic-phonetic compounds in which a part of graphemic element is used as phonetic clue A phonetic radical, in isolation, is like a normal character standing on its own However, for some historical reasons (e g , sound change), these radicals are often unreliable guides to phonology, some regular characters (e g , 橋 *qiao* 'bridge') are pronounced like their *phonetics*, while other irregular characters (e g , 扮 *ban* 'to make up' is pronounced differently from its *phonetic* 分 *fen* 'pulling apart') are not Over the whole distribution of the character types, the successful rate of sounding out the whole character based on its *phonetic* is 39% (Zhou, 1978) The fact that some *phonetics* are more consistent phonetic clues than others provides a testing ground for examining the role of the phonetic component in a phonogram during

the perception of Chinese characters It is reasonable to think that since the overall cuing function of the phonetics is no more than 40%, readers may learn to ignore the phonetic cue On the other hand, there is evidence that pronunciation errors made by beginning readers are related to the degree of consistency exhibited by the phonetic elements (Tzeng *et al* , 1988) In fact, reading off the *phonetic* within the target character is a common strategy when an unfamiliar character is confronted

Perfetti & Zhang (1992) observed an interesting relationship between regularity (predictability) in terms of phonology or semantics and frequency As has been mentioned, the percentage of complex characters in which the *phonetics* provide the correct pronunciation is only 39%, and is less than 35% for the high- and medium-frequency complex characters As in English, where high-frequency words tend to be the least regular, so does the reliability of *radical* and *phonetic* in Chinese characters decrease with the frequency In other words, for both the phonetic and semantic values of components of compound characters, there appears to be an interesting relationship with frequency Both phonetic and semantic components appear to be more reliable for low frequency compounds than for high-frequency compounds This conclusion comes from a sample of 300 compounds taken from three frequency ranges, based on a Chinese frequency dictionary 頻率詞典 (1986)

There is also an interesting correlation between the decomposability of a character and its frequency From a sample of 300 characters in the same frequency dictionary, Perfetti & Zhang (1992) found that nearly 84% were semantic-phonetic

compounds More interestingly, the percentage of compounds, as opposed to that of single characters, also increases with the decreasing frequency 62% of high frequency characters, 93% of medium frequency characters, and 98% of low frequency characters are compounds That means as frequency decreases, readers are more likely to encounter compounds, and those compounds are more reliable in giving cues to sound and meaning This relationship between phonemic and semantic validity, as well as frequency, is of great value in oral reading and comprehension (Tzeng et al , 1988) Moreover, lexical access strategies will be affected by the nature of the processing task posed, as well as the specific features of the stimulus in respect to the task requirements For example, word features, (as in high/low frequency and concrete/abstract), and contextual features, (as in script type), may be a better predictor as to which route is travelled during lexical access (see Seidenberg, 1985)

Experiments probing the involvement of phonology in character processing have been conducted in several paradigms, but have relied mainly on the lexical decision and naming tasks When examining subjects' performance in these two tasks using alphabetic stimulus words (in either deep or shallow orthography), two results are typically found In English, naming is usually faster than lexical decision, and the frequency of words makes for a greater difference in the lexical decision task (Foders and Chambers, 1973, Katz and Feldman, 1983) A very different pattern is shown, however, when Chinese subjects are tested with characters Here naming is always slower than lexical decision, and word frequency effects are larger in the

naming task (Wu, Chou, and Liu, 1993). These differences suggests that different activation strategies may be invoked by different orthographies. Readers of English cannot easily refrain from making use of the phonological system inherent in a phonemic script, while readers of Chinese find it easier to take advantage of the closer relationship between orthography and meaning. There is another possible reason as to why lexical decision is faster with Chinese characters, there is no pronounceable non-word in Chinese, because of its logographic, non-alphabetic structure.

Many studies, while demonstrating the involvement of phonology, have adopted tasks where the activation of sound is helpful, and thus reduce the generalizability of the universal phonology hypothesis. The evidence for phonological activation would be more convincing if it were found in tasks more neutral in nature. That is, tasks involving interference and semantic categorization should not bias the subjects into thinking phonologically ahead of time.

In the recognition of English words, there is robust evidence of a phonological interference effect, suggesting an important role for phonological information in lexical access in this language. However, the exact source of interference is hard to identify, because of the confusion of orthographic and phonological information in English arising from the relatively systematic mapping between symbols and sounds. In Chinese, on the other hand, there are many homophones which are visually distinct, as well as visually similar characters with very different pronunciations. Here the dimensions of the relationship between

phonology and orthography are very different Leck et al (1995) contrasted the role of visual and phonological information in the lexical access of Chinese characters, applying the semantic categorization paradigm originally developed by Van Orden (1987) for English words Their controlled investigation of the role of visual and phonological information in activating meaning found that the recognition of simple Chinese characters, which contain strokes that are not separable, depended primarily on visual information In contrast, the recognition of semantic-phonetic compound characters relied equally on visual, phonological, and semantic information

Modelling after Meyer et al 's lexical decision task mentioned in the previous chapter, Cheng and Shih (1988) produced further evidence for the involvement of phonological processes in lexical decision, using a similar test with Chinese characters Comparable to the English situation, they found that subjects took longer to decide if character pairs are real when they were visually similar but phonologically dissimilar But faster times were observed for visually dissimilar but phonologically similar pairs In short, the effect of phonological similarity was much more significant than that of visual similarity and was found to be independent of it These results were taken to show that phonological recoding takes place prior to the lexical decision However, as Chikamatsu (1996) points out, acoustic coding might have been involved in this kind of study Acoustic coding, according to her, is always the primary strategy for maintaining linguistic material in STM, regardless of the script types However, acoustic coding is not the same as

the phonological coding used to translate visual input into the word's pronunciation before getting at its meaning. Since acoustic coding is universal, the similar results in English and Chinese are not a surprise. Even if phonological activation really plays an important part in reading Chinese, we still need to know whether this phonological coding takes place at a post-lexical, pre-lexical, or at-lexical stage. Some of the following studies offer insights into this crucial question about the time course of lexical access.

**Pre-lexical Phonology**

Tan et al. (1995) demonstrated that phonological activation can occur prior to semantic activation in a backward masking paradigm where character targets were followed by a graphic mask, a semantic mask, a phonological mask, or a control mask. Their results in a first experiment showed only graphemic, but not phonological or semantic effects, when the target and the mask were exposed for 50 and 30 msec., respectively. This, of course, suggests that visual feature processing is the first stage in Chinese character recognition. The results of a second experiment extended the time to 60 and 40 msec. for the target and the mask, respectively, to check for a timing asynchrony between phonological and semantic activation. A significant phonological masking effect was observed for high-frequency targets, but a semantic mask effect was absent. These results confirm that frequency of characters and exposure duration are two important variables when measuring timing asynchrony and the effects of semantic and phonological masks. The

authors conclude that phonological activation can be pre-lexical for high frequency characters

**Lexical or Post-lexical Phonology**

Perfetti and Zhang (1991) adopted masking and priming procedures to investigate when phonological processing plays a role in Chinese character identification and whether it is pre- or post-lexical A masking experiment found little facilitatory effect, other than that produced by graphemic masks sharing similar visual features with target characters This is consistent with the standard finding that the visual coding is the primary stage in reading Chinese The lack of phonological effects in the backward masking test, in contrast to their presence in the priming experiments, suggests that phonology accompanies lexical access but does not precede it The results of masking tests parallel the constraints of the Chinese writing system, which does not encourage phonological coding sublexically and thus shows no pre-lexical phonology The results of these priming experiments suggest that phonological naming is really a by-product of character identification, and is assumed to be post-lexical

Perfetti and Zhang's (1995) experiment employs homophone and synonym interference tasks in order to test for phonological activation as part of word identification itself Incongruity in sound was found to interfere with synonym judgments, and vice versa This homophonic interference weakens the support for the strong form of the meaning-without-phonology hypothesis, since there is no

explanation for it in a word identification route which relies only on visual-semantic processing To eliminate the possibility that homophonic interference is due to long exposure of the characters, a second experiment varied stimulus onset asynchrony at 90, 140, 260, and 310 msec , respectively Homophone judgments showed no meaning interference at the shortest stimulus onset asynchrony, but synonym judgment tasks showed phonological interference occurring from 90 msec onwards This certainly shows that Chinese readers do not bypass phonology, and that they are affected by phonological interference in the absence of semantic interference The Chinese writing system does not encode sublexical graphemic units in the same way that alphabetic systems do, the phonology activated here probably involves "the name of the word as a whole depending on its identification" (p 31) Their results shift the question of pre- or post-lexical phonology in Chinese to one of "at-lexical phonology," in which phonology participates as an integral part of lexical access

Lam et al (1991) offers an interesting twist to the question of phonetic activation in reading Chinese Since Chinese characters can be read with more than one dialectal pronunciation, bidialectal readers will have two sets of phonetic values stored in their memory Consequently, interference effects will occur in phonologically-oriented tasks Subjects were therefore of two types Chinese adults from Hong Kong who had acquired Cantonese as their first dialect and who had learned Mandarin as their second dialect at some later time, Chinese adults from Taiwan who had acquired Mandarin as their first dialect and who know no

Cantonese To get the subjects to read quickly and silently, a same/different decision task was adopted in which four sets of word pairs were permuted by the same or different pronunciations in Mandarin and Cantonese For each pair of Chinese characters, the subjects had to decide whether the two characters had the same pronunciation in a given dialect The prediction, that phonological activation in the first dialect is more automatic and would cause confusion in second dialect decisions, was supported by differences in reaction times, as well as the percent of correct answers and the transfer patterns in errors Although the Cantonese speakers in this study were fluent in Mandarin, both groups were faster and more accurate in reading their first dialect Very simply, native Cantonese speakers find it hard to suppress the Cantonese pronunciation of characters, even when asked to use only Mandarin, and this tendency results in processing difficulty

To sum up, several strands of empirical evidence converge on the thesis that characteristics of the Chinese character allow a direct relationship between meaning and orthography Phonological activation, though important in reading, may occur lexically or even post-lexically, but not pre-lexically Putting it another way, what writing systems seem to constrain is the level at which phonology is activated, but not its occurrence In accounting for the various and even sometimes contradictory results, we may find that most of them are actually task-specific Therefore, a multi-variant approach which takes all the intralinguistic, contextual factors into consideration may be necessary

**Naming by Analogy**

Some studies lend support to the applicability of the Activation-Synthesis Model to the naming of Chinese characters Fang, et al (1986) tested Glushko's (1979) model using Chinese characters, reasoning that if English and Chinese revealed similar consistency effects, pronunciation processes might be orthography-independent In their experimental studies, they asked fluent readers to name lists of characters which were all phonographs Every character in List 1 contained phonetic stems with very consistent phonetic cues (e g , 錶 *biao*ˇ 'watch', which has the same pronunciation and tone as its *phonetic*, 表 *biao*ˇ 'show' Furthermore, almost every phonogram that shares the same *phonetic* is pronounced *biao*ˇ, such as 婊 'prostitute', 俵 'to distribute', 裱 'to mount') Characters in List 2 contained a phonetic stem which was less consistent (e g , 碑 *beiˉ* 'monument' has the same pronunciation and tone with its *phonetic* 卑 *beiˉ* 'humility', whereas 牌 *pái* 'sign' does not) Characters in List 3 were all pronounced differently from the phonetic stem (e g , 扮 *bàn* 'to make up' is pronounced very differently than its *phonetic* 分 *fēn* 'to divide', and so is 盼 *pan* 'to look forward to') The result was as expected reaction times were shortest for List 1 characters, with List 2 significantly longer, reaction times were longest for List 3 Lien (1985) replicated these results and further demonstrated that naming a compound with a consistent phonetic stem is faster than naming a neutral character which is never used as phonetic stem, and this is, in turn, faster than naming of a semantic-phonetic compound with an inconsistent

phonetic stem. The results conform to the predictions of the Activation-Synthesis Model, suggesting that there is a common mechanism for reading aloud in both Chinese and English. Possible differences in naming latencies between English words and Chinese characters should be due to the structural properties of the orthographies rather than the processing mechanism.

Such a procedure of generating phonological code by analogy depends largely on a network of lexical connections. The idea of lexical connection suggests that a linguistic unit is understood and remembered in terms of another. Similar to the way that any stored knowledge is organized, lexical storage is also governed by diverse organization patterns. Just as morphemes are connected by the semantic field they belong to, so do phonological connections exist by forming associations based on phonological similarity. Thus, there is a major concept standing as nucleus, with other related words clustering around it. The relationships among words are set up according to their shared features. Ultimately, the recurring morphological patterns which emerge from the intrinsic organization of the lexicon serve as the basis for schemas, which are an accumulation of shared features. Every time a new word is acquired, it incorporates the existing, related schema. This method of representing segmentation in terms of sets of connections enables us to conceptualize the internal structure of a word as a set of relations with other words. Therefore, with the sound association of the common *phonetics*, and the knowledge of the orthographic structure, Chinese readers can generate (or successfully guess) the pronunciation of a number of characters that share the same *phonetic*, without

rote memorizing them, since many semantic-phonetic compounds do at times contain reliable guides to pronunciation The principle of analogy is responsible for two other categories of character formation, analogous characters and phonetic loans[18], in addition to semantic-phonetic compounds In the tradition of historical linguistics, analogy also plays an important part in the language change

### 4.3 Perceptual Units in Reading

Although mature Chinese readers have little difficulty naming and recognizing Chinese characters, many researchers have investigated what comprise their structural units Chinese text is a sequence of graphic signs that can be divided up in different ways Although strokes are the minimum building blocks, they are seldom themselves the focus of attention during reading Other larger units that are made up of strokes include radicals, characters, words, and so forth A versatile character can be combined with other characters to build multisyllabic words or can stand as a monosyllabic word on its own In other words, it can act either as a bound morpheme or as a free morpheme Therefore, the question comes down to the problem of which is the basic perceptual unit in Chinese reading? Is it the character, whether as a word by itself or as part of a word Or is it the word, which can be

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[18]According to the Han dynasty scholar, *Xu Shen* in Shuo Wen Jie Zi, 轉注 analogous or derived characters, are pairs of characters which share the same semantic radical and therefore have the similar meaning 假借, phonetic loans, for example, are seen in characters 麥 *mai* 'wheat' , and 來 *lai* 'to come', both pronounced as /lai/, which were homophones in Archaic Chinese The character for the former, which is originally the pictograph for 'wheat' was loaned for the latter, because the iconic representation is easier for 'wheat' than for 'to come '

composed of multi-syllable characters? The question can be posed in a different manner, namely, is it sensory integration information or linguistic information that is crucial to perception (Hoosain, 1991)

Some studies have adopted the illusory conjunction paradigm, which is an attempt to show how graphic migrations reflect orthographic structures Treisman and Schmidt (1982) showed the size of migratory units by showing subjects brown circle and pink triangle Under the condition of diverted or overloaded attention, a subject might see a brown triangle and a pink circle The illusory conjunctions can also be letters or letters cluster (Treisman & Souther, 1986) For instance, given the words 'live' and 'hark', a subject might see 'lark.' A similar design, with slight modifications, could also be adopted in testing for Chinese, despite the fact that elements in a character are laid out in spatial configuration rather than being spelled out horizontally Migration of components occurs as in Lai and Huang's (1988) experimental study Three characters were presented in each stimulus constellation (e g ,陕, 倍, 侠) The assumption is that if component migration occurs, subjects would report seeing a new, recombined character (e g , 陪) The third character in the display serves as a contextual cue (mask, illusion) to facilitate the component migration in forming the new character The idea being that, the simultaneous presentation of the above three characters will encourage the component separation of 陕 and 倍 When these two characters are encouraged to dissociate to form the character 侠, the remaining free-floating components are easier to glue together as

陪 Besides, a priming character was shown prior to the presentation of the trial, relating to the dimensions of sound or semantics or to an irrelevant character (e g , 作 or 裴 ), the introduction of which is not expected to create much difference in the formation of illusory conjoining Finally, subjects were shown the target (which is a recombined, illusory character), and were asked if they saw it in the three-character display The results showed that subjects did sometimes report having seen the recombined, target character, indicating that the illusory conjunction occurs However, the effects of priming and context were found not to be significant The authors concluded, therefore, that this phenomenon is automatic and mainly bottom-up, because it is impervious to the top-down influencing[19]

In another illusory conjunction study, Fang and Wu (1989) hypothesized that frequently encountered patterns are likely to be treated as integral units by our perceptual systems Elements (components of characters, but not necessarily the nameable radicals) with high unit-frequency, such as 荒 and 子, are perceptually more resistant to separability than those with low unit-frequency Consequently, the former are less likely to be erroneously conjoined with components from other characters to form an illusory character In fact, it is very likely that the exact size of visual unit selected, whether it is a distinctive feature, letter, spelling pattern (as in alphabetic languages) or radical, character (as in logographic systems) or word,

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[19]Top-down processing refers to the constructions readers impose upon texts as they read, whereas bottom-up processing focuses on what might be built up from the processing of individual words

depends upon several factors, such as readers' skill, familiarity with the word, and purpose for reading

### 4 4 The Correlations Among Frequency, Context, and Orthographic Effect

In English, it is usually found that the word reading time increases with the length of the word (e g , Haberlandt and Graesser, 1985) It is generally thought that the movement of the eyes is influenced by the length of the word to the right of the fixation a longer eye movement is necessary for longer words on the right (Rayner, 1979) However, there are also complicating factors For example, Bernhardt (1984) found that beginning L1 readers have fewer difficulties with longer words, such as "alligator" that are visually distinctive and of higher imagery than words that are shorter and graphically similar, such as "they", "them", "this", and "that", although they appear more frequently in text

In a seminal and provocative paper, Gough and Hilinger (1980) asserted that learning to read should be considered an "unnatural art " According to their two-stage model of the earliest stage of reading acquisition, the first stage was one of paired-associate learning utilizing salient visual features as minimal cues For example, children learning the word 'dog' might associate with the initial letter, 'hole in the middle,' or with the last one, 'tail at the end ' In this stage, words are acquired naturally and spontaneously (from the surrounding environment, such as on TV, in an advertisement, or on cereal boxes) However, as this strategy is not very productive when children confront more and more new items, it is gradually

replaced by fully analytic processing--where words are fully segmented, both visually and phonologically Unlike in the first stage, fully analytic processing is not natural and usually requires intervention from outside Thus, there is a discontinuity in word recognition and acquisition

When it comes to a non-alphabetic language such as Chinese, what is the situation like? As mentioned earlier, every character under usual conditions occupies the same square-shape and is equally spaced, there is no character longer or higher than the others However, the number of the strokes which compose each character may vary Therefore, questions related to the effects of orthographic complexity in terms of stroke number arise[20] There have not been consistent findings for the orthographic complexity effect on Chinese word recognition Several factors might affect the results One is the depth of processing with respect to memory access, and another is the number of manipulated strokes (Huang & Wang, 1992) Change in either one of these two dimensions may yield different conclusions Moreover, the distinction between high and low complexity may be rather arbitrary, one's high complex characters may be another's simple characters, as is the case with frequency variable

Testing with Japanese adults, for example, Kawai (1966) reported that reading

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[20]There are however, different measurements for functional orthographic units Chen, Allport, and Marshall (1996) propose another criterion for measuring orthographic complexity By comparing the response speed for the "same-different" trial in pairs of Chinese characters, they present evidence that the visual analysis of Chinese characters by skilled readers is based on well-defined orthographic constituents, which are recurrent, integral stroke-patterns, instead of the individual strokes

errors were fewer with the high complex *Kanji* (more strokes) than with low complex ones. With regard to frequency, high frequency *Kanji* were more easily recognized than the low frequency ones. He concludes that orthographic complexity *per se* does not control the process of word recognition in proficient readers of characters (see also Taylor and Taylor, 1983). However, Yeh and Liu (1972) found that orthographically complex characters were harder to process than simple ones, because the recognition threshold is prolonged as the number of strokes increases.

Recently, Leong et al. (1987) studied the interaction of printed frequency and stroke complexity effects on Chinese word recognition processes by both skilled and less skilled readers. Needless to say, performance on high frequency words is significantly better than that on low frequency words. Moreover, the simple stroke (fewer than 10) characters were processed better than the complex stroke (more than 11) characters. However, upon closer analysis, it is the low frequency words that contributed to much of the difference. That is, for high frequency characters, the orthographic complexity effect is not significant. For less skilled readers, low frequency, complex-stroke characters were processed significantly slower and less accurately than high frequency counterparts. On the contrary, complex-stroke characters did not hinder the processes of word recognition for skilled readers.

There is indeed evidence that more complex entities are recognized better. Examining short-term memory (STM) for Chinese characters and radicals, Hue & Erickson (1988) obtained the unexpected finding that there was better recall of the high-complex radicals, suggesting that as the strokes within a character increase,

distinctive graphemic patterns which may serve as useful retrieval cues begin to emerge The Recognition-by-Component (RBC) model also claims that additional components in complex objects offer the redundancy gain to memory representations The notion of redundancy gain is that a large number of components might generate functionally emergent features (Pomerantz, 1981) that enhance memory representations

As Huang and Wang (1992) pointed out, the seemingly opposite findings can perhaps be reconciled in the U-shaped curve of complexity effect in object recognition observed by Huanget al (1991) Manipulating the range of the object *geons* (for geometrical ions)[21] from 2 to 15, they found that the bottom part of the U shape spanned from 4 to 9 geons It may be argued that character recognition bears some resemblance to object recognition, with the complexity effect being one of them (Huang & Wang, 1992) Therefore, within the critical value, orthographic (structural) complexity might be helpful in the faster recognition of characters However, difficulties in sampling a minimal set of distinctive features in a more complex character arise when the stroke numbers exceed that range The mean stroke numbers for the simple and complex radicals chosen in Hue and Erickson's study was 2 62 and 6 92, respectively In contrast, in Yeh and Liu (1972), the number ranges from 7 33 to 18 88 The former might fall into the first half of the U shape, which is supposedly cut off around 7, and the latter into the second half

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[21]Geons can be modeled by generalized cones, which is "the volume swept out by a cross section moving along an axis (Biederman, 1987 120) "

In short, for high frequency and high familiarity characters, orthographic complexity (within a certain range) not only does not hinder the processing, but has facilitation effects under certain situations. It is only for the low-frequency and low-familiarity characters that orthographic complexity slows the reaction time. Moreover, the issue is also tied to the language proficiency of the subjects. In a study comparing L1 and L2 learners of Chinese, Sun (1992) concluded that L1 readers demonstrated the same accurate and rapid processing on both high- and low-number strokes characters. The L2 readers, especially the less proficient group, suffered from the high complexity of strokes. A comparison across context-free to contextual word recognition studies further suggests that the graphic information in a character can be processed to a lesser degree in the presence of context, perhaps because of the redundancy gain provided by the context.

### 4.5 Memory Patterns for Characters

The relationship between script and meaning of Chinese characters is also reflected in memory access patterns. Since the visual route is the one that is more frequently travelled in Chinese, it is readily initiated when input is encountered. In a recall task with Chinese and English words, Tzeng & Wang (1983) found that both lists showed primacy and recency effects, that is, the beginning few items and the last few items are recalled better than the middle ones for both Chinese and American subjects. While the recency effect shows itself in the oral modality for both languages, the first few items were recalled better when presented orally in English,

but visually in Chinese This distinctive finding seems to suggest that characters are more readily coded visually under certain conditions At the very least, the visual code provides useful cues for the recall of items, which are not available in the phonological mode

Chen and Juola (1982) also provide some evidence for this view Subjects were tested along three basic dimensions of written words graphemic, phonemic and semantic If the hypothesis that logographic writing systems demand a greater dependence on visual strategies than phonetically-based systems (see Sasanuma, Itoh, Kobayashi, and Mori, 1980) is valid, then the memory access strategies activated by different writing systems should be uniquely emphasized in retaining information about Chinese characters and English words Whereas graphemic and phonemic similarity tend to be correlated in English, it is not the case in Chinese Therefore, an initial visual scaling was conducted to measure the visual properties for both data groups After the properties of word pairs in both groups were evaluated, a second experiment further tested the memory representations for both English and Chinese A word was presented shortly before the exposure of a pair of words Subjects were to select one of the pair of words that was phonemically, graphemically or semantically similar to the word seen previously The result shows a significant superiority in graphemic recognition for Chinese characters, whereas the coding for English words seems to be a more integrated one, wherein the graphemic, the phonetic and the semantic aspects all play comparable parts Although different dimensions are initially emphasized or activated by the two

orthographic types, the authors do note that cognitive processes in later stages of information processing, such as reading for comprehension, are probably more similar and relatively independent of the type of orthography

However, visual or phonological superiority may be correlated with factors other than orthography *per se* Hue & Erickson's (1988) paper reveals that short-term memory storage for high- and medium-frequency Chinese characters, whose pronunciations are presumably well-known, is mainly verbal and not unlike that for English On the other hand, memory representations for low-frequency characters are retained in their visual form and are very limited Their first experiment investigated immediate memory for simple characters that also function as radicals Three variables were manipulated orthographic complexity (more than or less than four strokes? e g , 金 and 人 , respectively), linguistic frequency (can this simple character/*radical* be used as an individual character? e g , 金 can, while 亲 can not), and inter-character frequency (is this simple character a component of many or few characters? e g , 人 is of high intercharacter-frequency, while 親 is of low) As expected, for high-frequency radicals whose pronunciations are well-known, there was little effect of inter-character frequency and complexity, but both were significant for low-frequency radicals Furthermore, recall errors of the high-frequency radicals included homophones, indicating more interference from verbal than visual items The opposite, however, was true for low-frequency radicals, and errors for these low-frequency items were incomplete or partial

radicals, indicating that they are coded visually and have a very limited memory capacity

Similar interactions of complexity and frequency were obtained for compound characters in a second experiment As expected, high- and medium-frequency characters were stored verbally and were interfered with more by verbal than visual items Recall for the low-frequency characters was poor, and significant differences between two intervening tasks were not found Then, another experiment extended visual exposure and found increased recall for low-frequency characters, suggesting that these items were affected much more by intervening visual context

The ubiquity of homophones, which nevertheless have unique characters in Chinese, may also contribute to this visual superiority in memory, and Zhang et al's (1984) experimental results demonstrate this point In one experiment, they compared the recall of high-frequency single-character and two-character words, using the Serial Anticipation method After the initial presentation of the whole list in sequence, subjects had to begin trying to anticipate which item followed which other item in subsequent presentations For two-character words, there was no difference between visual or oral presentation, but for the single-character words, visually presented items required less time to remember and resulted in better recall The author's explanation is that, for single-character words, homophones fill the lexicon, and sound coding without visual cues is not sufficient to identify, let alone remember, the words On the other hand, homophones for two-character

words are less common, and so the orally presented items fare as well as the visually presented ones

The hypothesis that the visually distinctive features of Chinese characters result in different memory access patterns was tested in a series of ten experiments by Liu and Wu (1992) Their detailed inquiry into possible differences in representational, storage, and recall strategies between English words and Chinese characters revealed that the visual superiority found for Chinese characters cannot be attributed simply to script differences but may be accounted for by a variety of interactive factors largely linked to frequency

For example, their experiments 1 to 5 disprove the thesis that the unique orthographic characteristics of Chinese logographs (e g , picture-like quality, high discriminability) are responsible for their visual input superiority in recall And their experiments 6 to 10 offer another explanation for the visual superiority effect, namely, the differential frequency account This interpretation assumes that if a set of words is encountered more frequently in reading than in speech, then their visual traces will be stronger and more available than their auditory traces, thus giving rise to better visual memory For example, in Experiment 6, 50 bilingual subjects were presented with lists of two-syllable, high imagery (concrete)English words, and were asked to write down as many of the displayed words as possible The results indicate that the earlier items invoked visual superiority whereas the recency effect translated into auditory superiority for the later items These findings mirror those obtained for Chinese logographs, and might be explained by the fact

that English, as a foreign language for the Chinese subjects, was experienced more commonly in print than in speech As a consequence, visually presented English words produced better recall This frequency explanation also holds for different sets of words in the very same language That is, certain sets of Chinese words are experienced more frequently in the context of print than in speech, and should thus produce better recall in their visual presentation When the experiment employed textbook-words and newspaper-words as stimuli, this explanation was borne out for Chinese itself

Experiment 10 is also worth citing, for its novel use of two different groups of Chinese subjects, a group of Beijing natives who spoke only Mandarin and a group of Fujian natives who were bidialectal Both groups read the same stimuli in Standard Mandarin, and as predicted, visual superiority was more significant for the Fujian natives The explanation for this follows the same line of reasoning as above, and goes as follows being bidialectal, they speak the Min dialect at home while switching to Mandarin in formal schooling contexts While the two dialects differ so much as to be mutually unintelligible, they are nevertheless united by the same written form Visual superiority thus arises as a result of subjects' superior experience with the written form of Mandarin

In sum, the study of memory access patterns reveals that low-frequency items are coded visually more often than high-frequency ones, and the memory span for this type of representational storage is much shorter However, even here the visual memory will not last long without the assistance of phonological memory,

and it is the combination of visual and phonological memory cues that stay with Chinese readers. There are several studies showing that too much phonological similarity in short-term storage can cause confusion, and thus affect the recall (e.g., Erickson et al., 1977, Xu, 1991). The difference in the memory patterns is, therefore, quantitative rather than qualitative.

### 4.6. Neurolinguistic Aspects of Character Processing

The involvement of visual memory in processing logographs suggested by differing strategies for memory access is complemented by neurolinguistic findings. Using the tachistoscopic presentation of orthographic stimuli for visual half-field recognition with normal subjects, the earliest findings suggested that phonetic-based scripts tend to show a right visual field, left hemisphere (RVF-LH) superiority, while logographic systems show the opposite, namely, a left visual field, right hemisphere (LVF-RH) superiority. There are, however, recent challenges to these findings from the perspective of both stimuli type and methodology. For example, we now know that task-specific characteristics are related to hemispheric specialization, and that visual laterality preferences vary with different levels of processing. It is also influenced by perceptual factors such as visual angle, luminance, and, perhaps most important, the length of exposure time. Rather than linguistic factors being responsible for different findings for lateralization patterns between Chinese and alphabetic languages, it is more likely that the interaction of task type, exposure time, and stimuli type produce differences in reaction times.

In 1979, Tzeng et al had already drawn attention to the need to view lateralization patterns in terms of task characteristics, instead of orthographic characteristics Their early experimental probes demonstrated that not all orthographic characteristics are easily captured by the simple dichotomy of alphabetic vs logographic For example, two-character Chinese words exhibit higher perceptual thresholds, longer exposure times must be given for a comparable performance, and these in turn produce LH superiority All such findings notwithstanding, the reading and interpretation of Chinese requires communication from both sides of the brain, and Tzeng et al 's work shows this clearly A first experiment presented Chinese subjects with 80 characters, which had to be named as fast as possible, one at a time Two types of characters were employed, those known as semantic-phonetic compounds and those known as pictographic types The visual exposure to the characters was adjusted for each subject, according to his or her identification threshold, and ranged from 20 to 70 msec (the average was 40 msec ) A strong LVF-RH superiority was observed regardless of the script type, but for the processing of multi-character words, a RVF-LH superiority was found These results suggest that surface differences in script types is levelled by the later employment of linguistic techniques which require sequential and hierarchical analysis Furthermore, the locus of lateralization was not on the visual stimulus or the script form *per se*, but was dependent on the nature of task requirements

This left hemisphere advantage for multi-character Chinese words is not

invariable, however A right hemisphere advantage arises in a rather extreme combination of conditions, as is shown by Keung and Hoosain (1989) Their results suggest that the interaction of several perceptual factors plays an important role in laterality preferences during word recognition Hasuike et al's (1986) review of previous work also notes that studies which report a right hemisphere advantage tend to use state-limiting conditions, that is, a wider visual angle, lower luminance, and shorter exposure time, all of which affect the quality of the information to be processed and which favor the right hemisphere For example, low frequency words with high stroke numbers are better recognized as words when they are presented in the left visual field (LVF)

Leong et al 's study (1985) demonstrates that visual laterality is affected by cognitive levels in the processing of Chinese characters These results also demonstrate that laterality is not orthography-specific, but varies with the orthographic, phonological, and semantic processing demands imposed by the experimental tasks given to subjects One experiment showed single Chinese characters and their pseudo-character mirror images to subjects and asked them to identify them This task, essentially a pattern matching task, did not show significant differences in both visual fields Experiment 2 employed a phonological task, so that subjects had to respond if the visually presented characters had the same sound as a target character given orally by the experimenter The accuracy ratings showed a significant RVF advantage, with a higher percentage of positive response Experiment 3 carried the inquiry to still another level of processing, the

semantic evaluation of single Chinese characters Subjects were asked to respond by pressing a "yes" or "no" key, once they had determined the semantic compatibility of each visually presented word to a target character given orally by the experimenter Here again the overall results demonstrate the significant effects of RVF presentation

In sum, a comprehensive review of the reported results suggests that the laterality preferences associated with visual-field findings are very much subject to the perceptual requirements of the experiment themselves The purported LVF-RH superiority for Chinese characters is not as simple as that!

**Pathological Studies in Clinical Context**

Pathological studies of language loss and language deficit also offer insights into what must be happening in processing *hanzi* by normal subjects under normal conditions We know from Sasanuma's early work (1975) that the ability to use *kana* and *kanji* in Japanese can be selectively impaired, depending on the type of aphasia In general, lesions in the temporal-cortex are associated with greater impairment of phonetic-based writings, whereas lesions in the posterior, occipito-parietal areas are associated with greater impairment of logographic writing, whose processing is said to depend more on the visual input (Hung and Tzeng, 1981) Yet this does not mean that there are separate brain centers for different script types An alternative to a strict compartmentalization view is found in the dual-route model which posits two functionally separate mechanisms underlying lexical and

sublexical reading, respectively Lexical reading is assumed to be associated with *kanji*, while sub-lexical reading is assumed to be associated with *kana* reading

Of course, there is also the basic question of whether the same script (*hanzi* in Chinese and *kanji* in Japanese) functions the same way in the two languages Just because they are both logographic in origin, do Chinese and Japanese readers process them in the same way? It seems that the answer is "no" here For one thing, Japanese *kanji* are mainly used for the lexical morphemes, and thus stand in contrast with *kana* which is used to represent grammatical morphemes Moreover, Japanese reading is not really comparable to Chinese characters where only one written form exists One gets a sense of this when reviewing eye movement studies In Japanese, saccades range from *kanji* to *kanji*, using these content points as stepping stones in reading for comprehension In Chinese, where there is only one script, saccade patterns and fixation points seem to be largely determined by the visual complexity of characters (Yang, 1994) And, of course, there is the problem of *on*-reading vs *kun*-reading in Japanese, depending upon the Chinese vs Japanese origins of the word The pronunciations for *kanji* characters in Japanese can be many, and essentially depend on the context in which they are found, whereas in Chinese the number of multiple pronunciations are far fewer

A review of some work on acquired dyslexia in Chinese sheds light on the possible application of the dual-route model to Chinese processing explanations Yin et al (1992) expected that eleven brain-damaged Chinese patients in their study would show patterns similar to the alphabetic readers based on Marshall and

Newcombe's (1973) discrimination between deep and surface dyslexia in alphabetic languages Surface dyslexia in alphabetic languages is characterized by regularization errors made in reading, that is, they are able to read regularly spelled words as well as non-word strings, but are unable to read irregular words This particular pattern is taken to suggest damage to the lexical route

Dyslexics who do not make regularization errors can instead be classified into two sub-classes

(1) the first sub-class exhibit "phonological" dyslexia because they have no problem with real words, but do have difficulty with novel letter strings This pattern of impairment is taken as evidence that sublexical route has been impaired, while mapping from the whole word is relatively intact

(2) the second sub-class exhibit "deep dyslexia" because they make semantic errors with real words, in addition to the inability to read non-words For example, they read DINNER for FOOD or UNCLE for COUSIN For these dyslexics, the sublexical route is severely impaired, and the lexical route has also been affected

Although Chinese is a non-alphabetic script, characters usually contain a phonetic that provides information on pronunciation, that ranges from none to partial to total Since the phonetic cue is employed by normal readers to construct the phonological shape of unfamiliar characters, a series of reading tests were devised for the patients in Yin et al 's study Each patient was asked to read aloud 40 common regular characters whose pronunciation was predictable from the phonetic, 21 irregular characters whose pronunciation was not predictable from the

phonetic, 12 common phonetic radicals, and 14 pseudo-semantic-phonetic compounds which were invented by having a real phonetic in its legally correct position

The results showed that these patients could also be categorized as surface and deep dyslexics by the definitions given above, although 'phonological' dyslexia seemed to be lacking as a type The surface dyslexic group made a high proportion of regularization errors, but were able to use the sublexical information, even relying on it too much though that information was inappropriate Those characters where only an intact lexical route would have yielded a correct pronunciation were read sublexically Although all patients made semantic errors, the greater proportion of them were made by the deep dyslexic group And this group made semantic errors regardless of the types of the target characters, whereas the surface dyslexic group did so only when the target characters lacked a phonetic This finding seems to support Newcombe and Marshall's (1980) suggestion that the independent availability of phonological representation--the sublexical route--of the written word can serve as a check on the output of the lexical routine that utilizes the semantic system Furthermore, none of the deep dyslexic patients were able to read pseudo-characters aloud, whereas the surface dyslexic patients were able to read more than 40% of them on average The differences were partly reflected in the reading of phonetic component in isolation As for the regular and irregular characters, the deep dyslexic group showed comparable performance on both, while that of surface dyslexic favoured the former

One case within the deep dyslexic group is worthy of note A patient tried, after leaving the hospital, to help his recovery by reading a dictionary According to the record, only about 8% of his reading vocabulary in *hanzi* was accompanied by the correct pronunciation This showed that knowledge of the sound of the characters can be dissociated from their meaning Further examination of the data showed an interesting dissociation The patient could read some 18 characters when they were in compound forms, but failed to read the phonetic contained in them, even when both had identical sounds On the other hand, he could read 82 characters as single-graphs, but failed to read the compound characters in which the single-graphs functioned as phonetics, despite their same pronunciation This dissociation suggests that the patient always read characters as single units, and could not utilize the phonetic component to pronounce the combination forms, because for him, there was no relationship between the phonetic and the compound of which it is a part

These findings from instances of language deficit in alphabetic, syllabic, and logographic systems seem to suggest the universal applicability of the dual-route model As a matter of fact, double dissociations have played a powerful role in much theorizing about modularity[22] in cognitive neuropsychology If each of the

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[22]Different authors define "modules" or "modularity"slightly differently For example, Foder's modules (1983) are "domain specific, innately specified, hard-wired, informationally encapsulated " By contrast, Coltheart (1985) adopted none of these traits, although the model he described would be regarded as modular in nature by information-processing theorists However, a common thread that runs through the various usage of the term "module" seems to be that the cognitive system is composed of components, that the function of each components can be

two tasks, in this case, lexical and sublexical routes, can be selectively impaired by brain damage to individuals, there seems to be a good reason to believe that the two tasks are executed by different mechanisms However, this logic is predicated on certain assumptions about the structure of the cognitive system--that it is composed of independent modules, each dedicated to specific functions (Plaut, 1995)

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characterized independently of the functions of other components, and that these components can be selectively impaired (Plaut, 1995) The modular system discussed in this thesis refers specifically to lexical and sublexical routes to word recognition

# Chapter 5 : Conclusions

The intention of this thesis has been to provide an overview and then a synthesis of contrasting views, in the hope of clarifying the complex issues at the heart of the controversy over lexical access and word recognition in the Chinese mental lexicon

A central issue in word recognition research concerns the extent to which skilled readers rely on phonological mediation for lexical access A strategic variation account might be able to reconcile the seemingly opposed findings This explanation emphasizes flexibility in decoding, whereby either the orthographic or the phonological code can be selectively biased, depending on which one produces the maximum benefit for the task In the context of alphabetic writing, Shulman et al (1978), adopting a lexical decision paradigm, found that when words were to be discriminated from pseudo-words, there were considerable phonological effects However, when words were set against consonants or random letter strings rather than pseudo-words, no phonological priming effects were obtained These results were taken to mean that phonological recoding is not a universal strategy even in alphabetic languages, and is perhaps an option rather than a requirement of reading, that is, it is a task demand rather than a process demand More recently, Monsell et al (1992) showed similar results with list composition manipulation, which had exception words (exceptional spelling-sound correspondence, e g , *shoe, police*) and pseudo-words (whose pronunciations can be derived from Grapheme-Phoneme-Correspondence rules, although some items have more than one reasonable

pronunciation, e g , *pinnow, wilch*) in the pure or mixed blocks It was found that both exception words and pseudo-words were named faster in the pure blocks as compared to the mixed blocks, indicating that subjects were able to take advantage of advance knowledge about whether they would be required to name an exception word or pseudo-word Milota et al (1997) also show that skilled readers have control over phonological coding mechanisms by using semantic priming in a lexical decision task In a trial where all previous non-words were replaced by pseudo-homophones, subjects learned to disregard the phonological information because it hindered their overall performance Therefore, the utilization of the visual, direct pathway is not uniquely tied to the reading of Chinese characters

In Chinese and related logographic systems, on the other hand, readers of characters may or may not take advantage of the phonetic radicals embedded in the semantic-phonetic compounds This often depends on the familiarity of the individual character to the reader If the character is a very familiar one, the reader may reach the pronunciation directly without having to go through the sublexical route (in this case, guessing from its *phonetic*) On the other hand, if the character to be named is an unfamiliar one whose pronunciation is unknown or forgotten, then, the *phonetic* embedded in the character should play an important role in giving cues to the pronunciation

Laterality preferences are similar, in that they depend largely on the cognitive tasks posed rather than on the stimuli type alone In other words, "the locus of cerebral lateralization cannot be on the logographic symbols *per se*" (Tzeng, 1979

500) Therefore, the right hemisphere involvement with single character displays under certain circumstances does not reveal much about the process of reading In fact, there is very little evidence, from either experimental or clinical results, that lends support to the right hemisphere dominance in processing Chinese logographs (see Tzeng & Hung, 1988) When larger units (two- or more-character words) were displayed, a universal left hemisphere participation is clearly seen This is due to the analytical ability required in addition to the phonological activity involved, for Chinese characters are not processed in any picture-like fashion, instead, they are linguistic symbols that should be sequentially analyzed at different levels of abstraction, just like any alphabetic languages, and they therefore show a left hemisphere superiority

Although the mechanisms utilized during reading are more or less universal, there are still some notable differences in visual processing between alphabetic and logographic systems One of the major differences that emerges is the greater reliance on visual memory among character readers This, however, may have far-reaching influences Reading habits and perceptual orientation in the first language may affect second or third language learning (evidence of this influence comes from Stroop Interference tests, from memory patterns, and from eye-movement patterns during reading) A potential implication of these findings for teaching written Chinese as a L2 to speakers from alphabetic orthographies, is that strategies which are not used very often in the native languages can be taught and emphasized to compensate for potential weaknesses in written Chinese It is

natural for speakers of alphabetic languages to demonstrate their analytical ability in utilizing phonological codes, (i e , sound dependency), whereas their spatial configuration abilities (i e , visual dependency) to recognize characters might be relatively poor and ignored in L2 acquisition

The arguments from neuropsychology for independent mechanisms (visual vs phonological routes to word recognition) come from dissociation, or more precisely, from double dissociation (i e , the impairment of X, but not Y, and vice versa) An English example will be that patients classified as "surface dyslexics" can read with relative success regularly spelled words and novel letter strings (pseudo-words), but have difficulty with irregularly spelled words like *pint* Since in general, the accurate reading for them depends on the degree of regularity, words with exceptional spelling such as *yacht* are the hardest (Shallice et al , 1983) Patients who fall into another class labelled as "phonological dyslexics", by contrast, are able to read regularly and irregularly spelled words, as long as they are real, but have special difficulty reading novel words with which they are unfamiliar and pseudo-words (Marshall & Newcombe, 1973) However, it is unclear if the two types of dyslexia, with the claimed complementary syndromes, can be cited as evidence for the two-route hypothesis of word recognition For one thing, the classification of the patients into either category is not without problem, regardless of the writing systems they use, as there seldom exist pure cases At any rate, the dissociation is hardly all or none, in most reported cases, performance is neither zero on the damaged category of stimuli nor completely normal on the supposedly preserved

class In surface dyslexia, the nature of the errors when reading single words is attempted appeared to be largely determined by the spelling-sound regularity of the words, regular words are read much more accurately than irregular ones According to Marshall & Newcombe's (1973) data, however, the errors they committed involved more than the misapplication of the GPC rules (including the phoneticization of the silent grapheme, e g , *listen*--> 'liston', stress shift, and other contextual rules) Therefore, this syndrome cannot provide the evidence for the psychological existence of GPC rules (Marcel, 1980) Patients' attempts at reading words, while mostly incorrect, do show lexical influence For example, concrete nouns are read better than abstract nouns, which are, in turn, easier than adjectives and verbs (Marcel, 1980) Phonological dyslexia, the syndrome of which is thought to make a pair of double dissociation with surface dyslexia, however, is missing as a type in Chinese (Yin, 1992) Since a clear-cut compartmentalized (functionally differentiated) view does not do justice to the symptoms and data, naming by analogy (one of the single-route models outlined on p 31-2, 63-5) seems to be a more workable hypothesis

In addition, the inference from double dissociation to modularity is based on the assumption that the former presupposes the latter As a matter of fact, modularity seems to provide an interpretation so natural to double dissociation that this theoretical perspective has completely dominated the field of cognitive neuropsychology However, the inference is valid only if the modular system is the only system that can give rise to double dissociation A number of different types of

processing systems that are not naturally described as modular, or are only partially modular, yet could still give rise to double dissociations, have been depicted, e g , partially overlapping regions (Shallice, 1988 255) Therefore, it is premature to conclude that double dissociation provides incontrovertible evidence for the dual-route hypothesis or against a single-route network

There is also a more general difficulty in treating syndromes that arise as a consequence of brain damage as if they resulted from the deletion of a single functional pathway without any rearrangement of the rest of the system A disease is seldom a mere loss or excess, and there is 'always a reaction on the part of the organism or individual, to restore, to replace, to compensate for and to preserve its identity"(Sacks, 1986 4) Therefore, problems arise when the results obtained from clinical settings are generalized to the normal population Even if we accept the subtractive method as a working hypothesis, the assertion of separate sources need not be taken as the postulation of parallel and independent pathways (Shallice, 1988) There have been many criticisms of this kind of leap from dissociations to isolable subsystems As Shallice (1988) points out, in inferring the properties of an original system from a changed one, neuropsychologists share the conceptual error that characterizes the work of many archaeologists In archaeology, it is at least possible to find some existing societies whose material condition was roughly comparable to an ancient one under investigation, suggesting that they could serve as concrete examples about the legacies an ancient society might have left (e g , Hodder, 1982) However, there is no concrete model out there for

neuropsychologists to make reference to, but those that people have constructed The hypothesis of modularity, as some critics argue, may reflect the limitation of human understanding about the world more than the properties of the world *per se* More recent accounts point to connectionist explanations, in which two routes are treated as two representations operating interactively rather than independently However, there is still a considerable way to go before understanding how the connectionist model can be extended to the computation of longer words, as well as to other aspects of word reading (since current connectionist models have no implemented semantic system), and finally, to the entire process of reading

To conclude, there are a number of crucially interrelated issues in the debate about Chinese word processing, but they essentially come down to the question of the uniqueness of lexical access strategies in Chinese word recognition Chinese orthography does not predispose the readers to non-phonological, right-hemispheric activity as previously thought If anything, the question is closely linked to the manner of presentation, the type of stimulus materials, the processing task required of subjects, and finally, the contextual factors providing the psycholinguistic environment for the task In this respect, we can expect that universal cognitive strategies will be adduced in lexical access and word recognition in Chinese, but we can also expect that Chinese will evidence differences in the degree to which bottom-up, initial perceptual procedures will be invoked in contrast to top-down, conceptually-driven procedures A final resolution awaits, however, further results from the various word recognition models as well as eye-movement

studies to create a more general model of reading, a model which accommodates both the similarities and differences found in systems like Chinese and English

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Author [redacted]

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