Title

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Direct Visual Access is the only Way to Access the Chinese Mental Lexicon

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Abstract

We argue for a view that, for written Chinese, direct visual access is the only way to access information stored in the mental lexicon. Phonology plays no role in initial lexical access and has limited effect on access to lexical semantics. Evidence supporting this view is adduced from three sets of experiments that either failed to detect any phonological effect in lexical access, or failed to prove that the phonological effects obtained are pre-lexical in nature, or demonstrate successfully the presence of orthographic effect in lexical access. We conclude that words in the lexicon can be accessed in different ways, depending on the general configurations of the writing systems in different languages.

Introduction

The process of human language understanding begins with mapping of the sensory input onto underlying form representations in the mental lexicon, as the basis for access to stored semantic and syntactic properties. For written language, the traditional dual-route models of reading (e.g., Coltheart, 1978) assume that this mapping process (or initial lexical access) can be conducted in two ways. One is by a direct visual access route, where visual features in the input are projected directly onto underlying orthographic representations, which are in turn related to the activation of stored phonological representations and lexical semantic properties. The other is by a phonologically mediated process, where the orthographic input is first transformed, perhaps through grapheme-phoneme conversion rules, into a phonological code which in turn is used to access lexical phonological representations and semantic and syntactic properties. Connectionist models of reading (e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996), on other hand, discard the localist assumption of lexical entry and the independent, rule-based routes from orthography to phonology. Instead, the lexicon is assumed to be a distributed network in which the knowledge of a word's spellling, pronunciation, meaning etc. is represented as activation patterns over a set of units. The same units are used to encode different words. Lexical processing is just the computation and production of different patterns of activation over sets of units used to represent the information in demand. As far as the activation of semantic properties is concerned, connectionist models share with dual-route models the assumption that the meaning of a word can be activated in two ways, either by direct visual access or via the activation of phonological representations. However, recent years have seen the emergence of a different view. According to this theory (e.g., van Orden, 1987; Lukatela & Turvey, 1994a, 1994b), phonological mediation is the *predominant* process in lexical access, if not the only process. In initial access, phonology is computed from the visual input and mapped onto underlying lexical or semantic representations in the lexicon. Orthographic information is then used to refine the lexical activation begun by phonology. Direct visual access either does not exist, or plays only a minor role in lexical access.

In this paper, we argue for a different view of lexical access, not for English but for Chinese. We will provide experimental evidence which demonstrates that, for written Chinese, direct visual access is the only way for information stored in the lexicon to become available. Phonology plays *no* role in initial lexical access. It is either a consequence or a by-product of the visual access. In other words, there is no such thing as "pre-lexical" phonology or phonological recoding in reading Chinese. Moreover, we argue that access to lexical semantics is predominantly conducted by direct visual mapping from orthography to semantic representations. Although phonological representation may be automatically activated, due to the activation of orthographic representation in initial lexical access, it is normally *not* or *not efficiently* used to mediate the access to meaning. Direct visual access is a psychological consequence of the logographic Chinese writing system which has evolved to represent the meaning rather than the sound of the language (Wang, 1973)[1].

As pointed by van Orden, Pennington, & Stone (1990), unambiguous evidence for direct visual access has been

[1] In this language, the basic meaningful units in the writing system are characters. With some exceptions, each character corresponds to one morpheme and has one pronunciation (i.e., a syllable with a specific tone). Because different characters may have the same pronunciation, homophonic morphemes in this language are common rather than exceptional. Most words in the language are either monomorphemic words or disyllabic (two-character) compounds.

scarce or non-existent. One reason for this may be because orthography and phonology are necessarily confounded in alphabetic languages and their effects on lexical access are difficult to separate. Instead, researchers have followed the rationale that if an explicit manipulation of phonology does not produce a detectable effect on word recognition, it is then taken as evidence of visual processes in lexical access. In the present research, we first follow this logic and demonstrate that similar experimental manipulations that produce reliable phonological effects on visual word recognition in alphabetic languages fail to affect the recognition of Chinese words, while semantic or orthographic effects are consistently observed in the same experiments. We further demonstrate that the presence of phonological effects under certain circumstances does not invalidate our claim of direct visual access. Rather, it strengthens our view that phonology in reading Chinese is a by-product of initial lexical access. Furthermore, we present direct evidence of visual effects in lexical access. Such a demonstration of pure orthographic effects is made available through the separation of orthography and phonology in the Chinese writing system. Taken together, the data support our view that direct visual access is the only route into the Chinese mental lexicon in visual word recognition. The issues of access to lexical semantics and the architecture of the Chinese mental lexicon are discussed in the last section.

The Absence of Phonological Effects

Since van Orden (1987), experimental tasks that tap into lexical semantic representations have become some of the major tools for investigating the role of phonology in lexical access. These tasks share the advantage that subjects are not required to attend specifically to the phonological component of visual input and any phonological effect arising from this task is likely to be due to an automatic process in lexical access. In a set of primed naming experiments (Table 1), Lukatela & Turvey (1994a) found that facilitatory effects for words like *frog* can be obtained not only when they are preceded by their semantic associates (e.g., *toad*) but also when they are preceded by words that are homophonic with the associates (e.g., *towed*). This phonologically mediated semantic priming between *towed* and *frog* is taken as strong evidence that, for English, an orthographically deep language, initial lexical access is phonologically constrained. A phonological code is computed from the orthographic input of *towed* and used to access all the corresponding phonological representations (including *toad*) in the lexicon. Lexical activation spreads to other semantically related lexical items (e.g., *frog*) and leads to a facilitatory priming in naming.

We conducted a set of experiments with similar designs (see Table 1) to examine whether phonologically mediated semantic priming could be obtained in Chinese as well. In Experiments 1 and 2, we used both naming and lexical decision tasks and concentrated on two-character compound words. Words like 卫生 (wei(4) sheng(1)[2], *hygiene*) were preceded by their semantic associates (e.g., 洁净, jie(2) jing(4), *clean*), or by words homophonic with the associates (e.g., 捷径, jie(2) jing(4), *shortcut*), or by unrelated words. There were no orthographic or phonological similarities between primes and targets. As shown in Table 2, there was no phonologically mediated priming effect in either task despite a significant semantic priming effect. Subsequent experiments on single character words with a similar experimental design also failed to find a phonologically mediated semantic priming for words like *towed* and *frog*. If we accept that the presence of a priming effect between *towed* and *frog* in English demonstrates the existence of pre-lexical phonology and phonologically mediated lexical access, the absence of such an effect in Chinese implies that pre-lexical phonology and phonological access process do not exist or do not play a major role in the logographic language.

Semantic	Mediated	Control	Target
TOAD	TOWED	TOLLED	FROG
洁净	捷径	流放	卫生
jie(2)jing(4)	jie(2)jing(4)	liu(2)fang(4)	wei(4)sheng(1)
(clean)	*(shortcut)*	*(banish)*	*(hygiene)*
歌	鸽	锤	舞
ge(1)	ge(1)	chui(2)	wu(3)
(song)	*(pigeon)*	*(hammer)*	*(dance)*

Table 1 Experimental designs of mediated semantic priming

When we turn to more direct manipulation of phonology, we do not see a phonological effect in lexical access either. In a study investigating morphological, orthographic and phonological structures in the Chinese mental lexicon, we examined the priming effects between visually presented two-character compound words which shared one critical

	Semantic	Mediated	Control
Lexical Decision	*581*	*620*	*623*
	(2.7)	*(6.6)*	*(4.9)*
Naming	*609*	*621*	*626*
	(2.1)	*(1.8)*	*(2.7)*

Table 2 Mean response latencies (msec) and error percentages for compound words.

[2] The pronunciations of Chinese characters are presented in Pinyin (the Chinese alphabetic system). The numbers in brackets represent tones of syllables.

		Morpheme	Homograph	Homophone	Control
Experiment 1	Visual-Visual	*606*	*648*	*637*	*644*
		(3.7)	*(7.1)*	*(6.8)*	*(7.1)*
	Masked	*563*	*583*	*611*	*609*
		(5.1)	*(9.1)*	*(10.1)*	*(8.1)*
Experiment 4	Visual-Visual		*676*	*653*	*651*
			(2.3)	*(2.4)*	*(2.9)*
	Masked		*653*	*661*	*655*
			(6.6)	*(7.5)*	*(4.8)*

Table 3 Mean response latencies (msec) and error percentages. Homograph constituents were also homophonic in Experiment 1, but not in Experiment 4.

homophonic morpheme (Table 3)[3]. A target word (e.g., 华贵 hua(2) gui(4), *luxurious*) was preceded by either a compound sharing a morpheme with it (e.g., 华丽 hua(2) li(4), *gorgeous*), or a word having a homographic constituent (e.g., 华侨 hua(2) qiao(2), *overseas Chinese*), or a word (e.g., 滑翔 hua(2) xiang(2), *glide*) whose critical morpheme shared only the pronunciation with the critical morpheme in the target, or a totally unrelated word (e.g., 完整 wen(2) zheng(3), *intact*). In a lexical decision task (SOA=100 msec), no priming effects were observed for words that just had homophonic but non-homographic morphemes, whether primes were masked or not (see Experiments 1 in Table 3). In contrast, the morphological/ semantic priming effects were consistently observed and an orthographic effect was revealed when the primes were masked (SOA=57 msec).

	Semantic	Homophonic	Control
Visual-Visual	*604*	*634*	*645*
	(3.6)	*(7.6)*	*(7.8)*
Masked	*575*	*597*	*597*
	(3.2)	*(5.7)*	*(4.7)*
Naming	*611*	*599*	*621*
	(2.1)	*(2.4)*	*(2.4)*

Table 4 Mean response latencies (mesc) and error percentages. SOA = 57 msec in the masked priming lexical decision experiment. SOA = 100 msec in both visual-visual priming lexical decision and naming experiments.

Experiments conducted on Chinese compound words that have more phonological overlap than just one syllable also failed to reveal any phonological priming effects in masked and unmasked visual priming lexical decision tasks. This held not only for words like 管理 (guan(3) li(3), *manage*) and 惯例 (guan(4) li(4), *usual practice*) that had the same segmental elements but differed on lexical tones, but also for truly homophonic compounds like 捷径 (jie(2) jing(4), *shortcut*) and 洁净 (jie(2) jing(4), *clean*). In contrast, the semantic priming effect was consistently observed (see Table 4). The fact that semantic effects can be readily obtained but phonological effect are constantly missing while similar tasks for English and French have produced robust priming effects for homophones like *towed* and *toad* (e.g., Grainger & Ferrand, 1994), indicates that logographic and alphabetic words are accessed in different ways. While lexical access for English may be purely phonological, lexical access for Chinese can only be conducted via direct visual access in visual word recognition. Phonology seems play no role in the initial access process.

The Presence of Phonological Effects.

This is not to say that phonological effects in the visual recognition of Chinese words cannot be observed in certain circumstances. However, these effects do not demonstrate a pre-lexical phonology and phonologically mediated access process, although they may imply that phonological information associated with characters is automatically activated as a consequence of visual lexical access. The presence of phonological effects is more likely when the experimental tasks emphasize the use of phonological information or allow subjects more time to make responses.

Thus, although we did not observe any priming effects between compound words having homophonic but non-homographic morphemes (as in the Homophone conditions in Table 3), we did find a phonological effect for compounds having homographic but non-homophonic morphemes (e.g., 重复 chong(2) fu(4), *repeat*; and 重量 zhong(4) liang(4), *weight*). An inhibitory effect was observed for such words in a visual-visual priming lexical decision task and no significant priming was obtained when the primes were masked (see the Homograph condition of Experiment 4 in Table 3). This pattern of homograph priming is in sharp contrast with the homograph priming in Experiment 1, where homographic characters were also homophonic in primes and targets

[3] For an auditory-auditory priming version of these experiments, see Zhou & Marslen-Wilson (1995).

(e.g., 华侨 hua(2) qiao(2), *overseas Chinese*, and 华贵 hua(2) gui(4), *luxurious*). From this comparison and from the absence of any effects in the Homophonic conditions, it is clear that the effect of phonology on visual recognition of compound words must be based on orthography. Phonology comes into play only when there is sufficient orthographic overlap between primes and targets and when orthographically based lexical access has been started. In other words, no orthography, no phonology.

The phonological effect on Chinese word recognition was also revealed in a naming task. Although we did not find any priming effect between homophonic compound words (e.g., 捷径 jie(2) jing(4), *shortcut* and 洁净 jie(2) jing(4), *clean*) using the lexical decision task, we did observe a facilitatory effect when the naming task was used on the same set of words (see Table 4). Superficially, the facilitatory effect in the naming task replicated what Lukatela and Turvey (1994b) found for English. However, we have a different explanation for the effect in Chinese. While Lukatela and Turvey account for their data in terms of pre-lexical phonology, we specify the effect in Chinese as due to the activation of stored phonological representation in the lexicon and the use of phonological information in the naming task. When target words are presented, the projection of orthographic information onto the lexicon leads to the re-activation of the phonological representations that are shared by primes and targets. The naming of the targets could be more easily executed when primes and targets are homophones than when they are non-homophones. An important moral here is that any phonological priming effect in naming Chinese could be post-lexical and any arguments of pre-lexical phonology based on these data could be fundamentally flawed.

The Presence of Orthographic Effects

Our argument so far for a direct visual access in recognizing Chinese words has come either from the failure of phonological manipulation in producing significant effect or from the failure of demonstrating that the phonological effect obtained is pre-lexical. This null effect evidence is not weak when it is compared with experimental evidence from English in which similar manipulations do produce reliable phonological effect. Nevertheless, we need to demonstrate more directly that the orthographic structure of Chinese words determines lexical access and lexical activation.

Orthographic priming effects can be obtained between compound words having homographic and homophonic morphemes, relative to their phonological control (Table 3). However, this effect might not be pure orthographic because there are phonological relations between primes and targets and hence the appearance of the orthographic effect could be dependent on these phonological relations even though these relations alone do not produce significant priming. In a more stringent experiment in which only structurally simple characters were used, we examined the priming effect between words that are orthographically similar but phonologically and semantically different (e.g., 由 you(2), *because of*; and 申 shen(1), *express*). A significant inhibitory effect was obtained in a primed naming task. This effect can only be visual since no phonology or sublexical phonology is involved. It indicates that, at least for simple characters, lexical access is visual.

Orthographic effects were also obtained for complex characters. A typical complex character is composed of a semantic radical - which, for many characters, indicates the semantic category of the complex character and a phonetic radical - which itself is a character. Although the phonetic radicals could indicate the pronunciation of the complex characters, in most cases, they do not, creating "irregular" complex characters. In a primed naming study in which we used phonetic radicals (e.g., 也 ye(3), *also*) as primes and "derived" irregular complex characters (e.g., 她 ta(1), *she*) as targets, we varied systematically the frequencies of radicals and complex characters. which were not semantically related and had different pronunciations. In Experiment 1, we manipulated the frequencies of complex targets while keeping the frequencies of their radical primes constant. In Experiment 2, we varied the frequencies of radical primes while keeping the frequencies of the complex targets constant. It is clear from Table 5 that there were strong interactions between the frequency manipulations and the naming latencies of the complex characters. (This pattern of priming effects differed dramatically from that between phonetic radicals and complex characters sharing segmental elements but differing on tones.) Since there were no phonological relations between radicals and complex characters, the pattern of priming effects can only be explained in terms of direct visual access and the competition between lexical representations activated by orthographic input.

Manipulation	Frequency	Test	Control
Target	High	*707*	*617*
		(13.3)	*(4.9)*
	Low	*675*	*653*
		(4.2)	*(5.9)*
Prime	High	*629*	*609*
		(4.4)	*(1.2)*
	Low	*650*	*616*
		(5.9)	*(3.7)*

Table 5 Orthographic Priming between Non-homophonic Phonetic Radicals and Complex Characters. High=high frequency targets (or primes); Low=low frequency targets (or primes). SOA=100 msec.

Almost all existing arguments for pre-lexical phonology in reading Chinese depend on the observation that, for about one third of complex characters in the language, the phonetic radical of a complex character could represent the sound of the whole character. But how and from where does the reader retrieve the phonological information carried by the phonetic radical? The regularity or consistency effects obtained by Seidenberg (1985) and others suggest that there is a decomposition process in lexical access for complex characters in which lexical form representations that correspond to or are related to the phonetic radicals are activated. In a recent study using a semantic priming task we demonstrated more directly that, not only the decompositional access can activate phonological information, the semantic representations of phonetic radicals are also activated when the complex characters are processed. The naming of a character, say 牛 (niu(2), *ox*), was not only facilitated by its semantic associate 马 (ma(3), *horse*), but also by the complex character 冯 (feng(2), a family name) which was not semantically related with 牛 and which had 马 as its phonetic radical. The naming of 冯 (feng(2)) was delayed not only by the previous presence of its radical 马 (ma(3)), but also by the presence of 牛 (niu(2)). However, there is no evidence that this sublexical processing is phonological in nature and the access of the complex characters depends on this sublexical processing. To us, the influence of sublexical processing on naming latencies of complex characters is because both the orthographic input of the complex character as a whole and the phonetic radical part of the input are used to access the corresponding orthographic representations in the lexicon. The phonological and semantic properties of the complex characters and radicals (and perhaps other related items) are consequently activated. The competition or mutual support between the activated phonological representations leads to the regularity or consistency effect in the naming task. Clearly, sublexical processing, just like lexical level processing, is orthographic in nature, having nothing to do with pre-lexical phonology.

Discussion

The data we collected from on-line studies on visual recognition of Chinese words clearly demonstrate that access to the Chinese mental lexicon can only be carried out through the direct visual access. There is no "pre-lexical" phonology in reading Chinese. Moreover, the activation of semantic properties is also orthographically constrained. There is little evidence in our experiments that the meaning of a word is accessed by the activation of its lexical phonological representation alone: *towed* does not prime *frog* in Chinese. The phonological influence on the activation of semantic properties must be coupled with the activation of appropriate orthographic representations. These arguments lead us to a following model of lexical representation and lexical processing for Chinese, where the solid lines indicate the passing of activation between representations and the broken line between semantic and orthographic representations indicates the weak effect of phonology on the activation of lexical semantics[4].

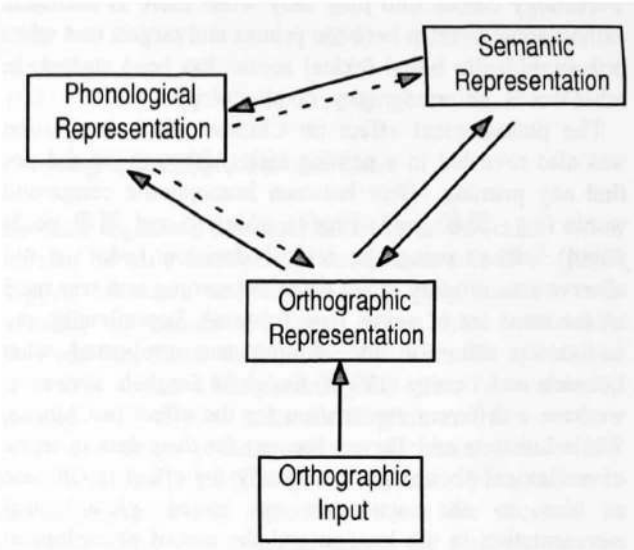

Figure 1 A model of lexical processing in reading Chinese

As it can be seen, this model closely resembles the connectionist structure of lexical representation and processing for alphabetic languages (e.g., Seidenberg & McClelland, 1989). However, we are neutral here about whether the lexical knowledge should be represented distributedly or locally in the Chinese mental lexicon. According to our model, visual input maps directly onto orthographic representations, whose activation automatically leads to the activation of semantic and phonological representations. The relative time course of phonological and semantic activation depends on a number of factors, such as word frequency and the density of semantic features. On the other hand, the phonological activation alone cannot to lead to a significant activation of semantics. One reason for this asymmetry of semantic activation from orthography and from phonology is that while the mapping from orthography to meaning is easy and straightforward, i.e., one-to-one mapping, the mapping from phonology to semantics is usually difficult, since a syllable may represent many homophonic morphemes in the language.

Our model is broadly consistent with most of the data from studies using other experimental tasks (e.g., Perfetti & Zhang, 1991; 1995; Tan, Hoosain, & Peng, 1995). These studies have shown the predominant orthographic effect

[4] Of course, the model illustrated here leaves out many details. See Zhou, Marslen-Wilson, Shu, Bi, & Tang (1996).

and the automatic activation of phonology in reading Chinese. They has also shown the earlier activation of phonology than semantics. Although we are not sure about the latter finding because the experiments may have a few design flaws, we can live with it since the earlier activation of phonology does not necessarily mean that access to meaning is phonologically mediated. The activation of semantics and the activation of phonology could be in parallel, having no causal relations.

Our argument for a direct visual access to the Chinese lexicon and the dominant role of orthography in access to meaning contrasts with the claims made by van Orden et al. (1990), Lukatela & Turvey (1994a, 1994b) and others about lexical access in English. However, we see these two views complementary rather than contradictory. The logographic writing system was designed to fit with the integrity[5] of the spoken form (i.e., syllable) of Chinese morphemes and with the cognitive demand of differentiating homophonic morphemes. A character is usually specific, so that it can differentiate homophonic morphemes efficiently. It also corresponds directly with the syllable, rather than with a phonological unit smaller than the syllable. These characteristics leave no room for "pre-lexical" phonology and little room for an inefficient mediated access to meaning. On the other hand, although an alphabetic system may not have such direct differential power and, by design, could not reflect the integrity of the syllable in Chinese, it is efficient in representing complex sound. A small unit in the written form of a word corresponds to a small unit in the spoken form of the word, and this correpondence is systemantically used in other words. The analyses of small units in visual input leads to automatic phonological activation. This property permits the efficient use of phonology in reading and in access to meaning. It is not an accident that lexical access is primarily orthographically constrained in reading logographic Chinese but primarily phonologically constrained in reading alphabetic English. Words in the lexicon can be accessed in different ways, determined by the general configurations of the writing systems in different languages.

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[5] The integrity of the syllable comes from the fact that a syllable in Chinese has a simple structure with no double consonants and with only two possible syllable-ending consonants (for Mandarin Chinese). The tone, which is used to differentiate lexical items, is carried by the whole syllable rather than by a smaller segment. Moreover, there is no or little interaction between segments of different syllables in continuous speech.