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Access of Phonological Information from Reading Chinese Characters: Position vs. Function

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Abstract

Taft and Zhu (1997) reported that characters containing a radical occurring in the typical position were recognized faster than those containing one occurring in an atypical position. However, this typicality effect was only evident in radicals that occurred on the right within a character. Feldman & Siok (1997) challenged this claim and found that when radical function was considered, a typicality effect was observed in both the left and right positions for phonetic radicals. In order to investigate the role of radical position and function in Chinese pseudocharacter naming, the positional specificity of the phonetic radicals used in this study were controlled such that some predominantly appears in either the left or right position, while some appears in both positions with approximately the same frequencies. The results showed a typicality effect on the reading responses in both the left and right positions, but readers tended to rely on right radicals in extracting phonological information even though some phonetic radicals rarely occur on the right.

Introduction

Psycholinguistic research has largely focused on investigating lexical processing in alphabetic scripts like English. Since individual letters in alphabetic scripts could be translated into one or more phonemes (Arduino & Burani, 2004), phonology could be computed sublexically by means of grapheme-to-phoneme conversion (GPC), thus enable unfamiliar words with regular letter-to-sound correspondences, as well as pseudowords, to be read aloud. It was found that the speed and accuracy of word naming in English were affected by the interaction between word frequency and regularity of letter-to-sound correspondences (Jared, 1997). Regular words were named faster and more accurately than exception words, but this effect was only found in low frequency words. On the other hand, the effect of spelling-sound consistency, i.e. the consistency of a letter pattern's pronunciations in different words, was observed in both high and low frequency words (Jared, 2002).

In contrast, lexical processing in Chinese has not been studied nearly as extensively as alphabetic scripts. Chinese is a logographic system in which each character is composed of a square pattern of strokes that was believed to be phonologically opaque (Allport, Chen & Marshall, 1996). Unlike English words, which are composed of alphabets arranged from left to right, Chinese characters may appear in different configurations of components (Chen, 1996). Radicals may appear in various positions within a character, but most radicals appear predominantly in a specific position within a character. More than 80% of Chinese characters are phonetic compounds that consist of a semantic radical and one or more phonetic radicals (Chen, 1996). The semantic radical roughly indicates the meaning of the character and usually appears on the left, while the phonetic radical provides information about the characters' pronunciation and usually appears on the right. Although this relationship between position and function holds true for most horizontally configured phonetic compound characters (e.g. 伴 /pun6/ contains the phonetic radical 半 /pun3/ on the right), this positional property is sometimes reversed (e.g. 朗 /lɔŋ5/ contains the phonetic radical 良

/lœŋ4/ on the left).

Since Chinese characters are not composed of components that correspond to phonemes in English, the GPC in alphabetic scripts is not possible in Chinese (Lee, Tsai, Su, Tzeng & Hung, 2005), and it was believed that phonology of Chinese characters could only be accessed through holistic processing of characters. However, as phonetic radicals provide information about phonetic compound characters' pronunciations, despite that only 26.3% of phonetic compounds' pronunciation is identical to that of their phonetic radicals (Feldman & Siok, 1997), a relationship does exist between orthography and phonology in Chinese.

There is increasing evidences suggesting that sublexical processing is possible in reading logographic scripts, and regularity and consistency play an important role in Chinese character naming. In a character naming study, Lee et al. (2005) found that the regularity effect was only observed in naming low frequency characters, whereas the effect of consistency was observed in naming high and low frequency characters. Fang, Horng and Tzeng (1986) also found significant consistency effect on Chinese character and pseudocharacter naming. The naming latencies of inconsistent characters and pseudocharacters were significantly longer than consistent ones. Also, it was found that high-consistency pseudocharacters generated a higher percentage of pronunciations that conformed to the dominant pronunciation, while low-consistency pseudocharacters generated a larger number of alternative pronunciations. Such findings matched those reported in the English literature, indicating that the phonological information inherent in phonetic radicals is activated in the naming process (Lee et al., 2005).

Recently, some researchers attempted to use the interactive-activation model to explain character processing in Chinese. Originally, the model explains lexical access in alphabetic scripts as an interactive process among hierarchical levels representing the visual features, letter units and word units (Taft, 1991). Taft and Zhu (1997) adopted this model to explain lexical processing in Chinese, and proposed that the levels of strokes, radical units and

character units were equivalent to the three hierarchical levels in alphabetic scripts mentioned earlier.

Taft and Zhu (1997) hold the view that ‘positional information is built into the representation of a radical such that a radical can have different frequency characteristics depending on its position in the character’ (p. 772). In other words, they believed that the same radical is represented independently at the radical level when it occurs in different positions within various characters. In a lexical decision experiment, they found that only the frequency of radicals that appear on the right of phonetic compounds affect character decision responses, and they interpreted this as support for the claim that the effect of radical frequency was position-sensitive. The findings (Taft, Zhu & Peng, 1999) that individuals rarely mix up characters with transposable radicals (e.g. 杏 and 呆) in both recognition and naming were also interpreted as evidence to independent representation and activation of left and right radicals.

The phonetic radical activation hypothesis proposed by Saito, Masuda and Kawakami (1998) also supported the claim that the position in which a radical appears affects character recognition. In a source-probe characters matching experiment, they found that when the source and probe characters shared the same right radicals (e.g. 伴 and 畔), the false alarm rate was significantly higher than that in the left-radical consistency condition (e.g. 略 and 畔) or when the source and probe characters share the same radical occurring in different positions (e.g. 判 and 畔). They interpreted the results as support for the claim that the phonetic information of right radicals is activated in character recognition.

However, the position-sensitive character processing account was challenged in a study by Feldman and Siok (1997). They investigated the role of radical function in character recognition by counting the frequency of semantic and phonetic radicals separately. They found that characters that contained high frequency semantic (or phonetic) radicals were recognized significantly faster than those contained low frequency semantic (or phonetic)

radicals. However, the effect of semantic radical frequency was only evident when the radical occurred in the left position. On the other hand, no position effect was observed for phonetic radicals. Therefore, they concluded that the effect of radical frequency and position (left vs. right) on character recognition was sensitive to radical function (semantic vs. phonetic).

With reference to the predictions from the phonetic radical activation hypothesis proposed by Saito et al. (1998), it is predicated that the readers would assign the dominant or alternative pronunciations associated with the right radicals, regardless of whether they are phonetic or semantic radicals. Also, according to Taft and Zhu (1997), who found that character decision times were affected by positional frequency of right radicals, it is predicated that readers would be able to name character stimuli containing phonetic radicals occurring in the typical position more easily than those occurring in the atypical position. However, this effect of typicality will only be observed when a phonetic radical's typical position is on the right, but not for those that predominantly appears on the left.

Nonetheless, as Feldman & Siok (1997) found that when radical function was considered, the effect of position for semantic and phonetic radicals differed, an effect of typicality of a phonetic radical's position of occurrence should be observed such that readers would be more confident in the accuracy of their responses when a phonetic radical occurs in its typical position within a stimulus. However, instead of a position-dependent effect as proposed by Taft and Zhu (1997), the typicality effect observed should be the same when the phonetic radicals appear in either the left or right position.

The present study was motivated by the findings that right radical frequency affected character decision times (Taft & Zhu, 1997) and the phonetic information of right radicals were activated during character recognition (Saito et al., 1998), as well as the conflicting findings that the effect of phonetic radical frequency on visual recognition of Chinese characters was not position-dependent (Feldman & Siok, 1997). As the majority of previous studies only investigated the issue of lexical processing involved in character recognition, the

present study aimed to investigate whether phonological information in Chinese pseudocharacters was activated according to the position that a radical unit assumes or to the function of individual radical units regardless of the position of occurrence. By means of reading aloud pseudocharacters, which are non-existing characters with legal orthographic constructions, the character naming process could be revealed since the pseudocharacters' pronunciations must be achieved through activation at a sublexical level (Ding, Peng & Taft, 2004; Fang et al., 1986).

In order to avoid possible confounding between radical position and function, radicals with ambiguous function, i.e. those that may appear as phonetic and semantic radicals in different characters (e.g. the radical 火 /fɔ2/ is a semantic radical in the character 燒 /siu1/, and serve as a phonetic radical in the character 伙 /fɔ2/) were not used in this study. As reported by Taft and Zhu (1997), the character decision times were not affected by the total radical frequency when positional frequency was controlled. Therefore, instead of total radical frequency, the positional token frequency of phonetic radical stimuli was used in this study, thus resulting in a group of phonetic radicals with ambiguous positional specificity (those that occur in both left and right positions with similar frequency) and a group with unambiguous positional specificity (those that occur predominantly in either left or right position).

The effect of consistency in pseudocharacter naming was also investigated. By definition, consistency refers to the diversity of pronunciations in a family of phonetic compounds containing the same phonetic radical. Readers would be able to assign the dominant or alternative pronunciations to most pseudocharacters because the phonological representations within the activation region would be activated. Nonetheless, readers would be expected to demonstrate a tendency to assign the dominant pronunciation in the family to consistent pseudocharacters, while inconsistent ones would be expected to activate a larger number of phonological alternatives (Fang et al., 1986). Also, readers should be more

confident about the accuracy of the pronunciation they assigned to a pseudocharacter with a consistent phonetic radical due to lack of or limited activation of competing phonological alternatives (Fang et al., 1986).

Stated generally, by selecting phonetic radicals with unambiguous function and controlling the phonetic radicals' positional token frequency and degree of consistency, the present study investigated the following questions: (1) whether the activation of phonological information inherent in phonetic compound characters during pseudocharacter naming is position- or function-sensitive, and (2) whether the consistency effect of phonetic radicals would be evident in pseudocharacter reading such that readers would demonstrate lower confidence in naming low consistency pseudocharacters and generate more diverse reading responses than in naming high consistency ones.

Method

Participants

The participants were thirty undergraduate students, 11 males and 19 females, recruited from a pool of students at The University of Hong Kong. All participants were native speakers of Cantonese. Their ages ranged from 20 to 23 years. They participated in this study on a voluntary basis.

Materials

The stimuli were 80 horizontally configured pseudocharacters, all of which were composed of a semantic and a phonetic radical. Radicals with ambiguous function, i.e. those that may serve as both semantic and phonetic radicals, were not used in this study. Positional properties of the phonetic radicals were manipulated and resulted in two groups of 20 phonetic radicals. The term *unambiguous phonetic radicals* will be used to refer to phonetic radicals that predominantly appear in either the left or right position in phonetic compounds containing them, while *ambiguous phonetic radicals* refer to those that appear in both left and right positions with approximately the same frequencies. In order to determine whether a

phonetic radical has ambiguous or unambiguous positional specificity, the ratio between the token frequency that they appear in the dominant position and the total token frequency of all horizontally configured members in the family was calculated. For the unambiguous group, the positional dominance ratio was 0.8 or above, whereas the ratio was 0.35-0.65 for the ambiguous group.

To examine the effect of consistency, each of the two aforementioned groups of phonetic radicals were further divided into two subgroups according to their consistency values, thus resulting in four subsets: 1) unambiguous/high, (2) unambiguous/low, (3) ambiguous/high, and (4) ambiguous/low. To compute the consistency values of the phonetic radicals, characters containing the same phonetic radical were identified from *Li shi Zhong wen zi dian* (1980), and unfamiliar ones were eliminated. The consistency values of phonetic radicals were obtained by dividing the token frequency of all characters with the dominant pronunciation by the total token frequency of all characters in the family. The consistency values of the low consistency group ranged from 0.5-0.75, and those in the high consistency group ranged from 0.85-1.0.

All of the phonetic radical stimuli were combined with two different non-freestanding semantic radicals (e.g. ), thus a total of eighty pseudocharacters were created. Each phonetic radical appeared in two different stimuli in which they appear on the right in one item and on the left in the other. Therefore, each of the unambiguous phonetic radical appeared in an atypical position in one item, whereas ambiguous phonetic radicals appeared in a typical position in both stimuli because they appeared in both positions with approximately the same frequencies. The criteria for phonetic radical selection and illustrative examples are shown in Table 1.

Table 1

Examples of phonetic radicals differing in position ambiguity and consistency

	Ambiguous phonetic radical		Unambiguous phonetic radical	
	Left	Right	Typical	Atypical
High consistency				
Phonetic radical	良		君	
Consistency value	0.85		0.98	
Dominant pronunciation	/lɔŋ6/		/kw^{h}ɐn4/	
Total frequency of occurrence in each position	102	186	218	32
Position dominance rating	0.65		0.87	
Example of pseudocharacter	剋	線	剮	悓
Low consistency				
Phonetic radical	半		其	
Consistency value	0.54		0.75	
Dominant pronunciation	/p^{h}un3/		/k^{h}ei4/	
Total frequency of occurrence in each position	165	131	1082	102
Position dominance rating	0.56		0.91	
Example of pseudocharacter	邦	豺	郪	祺

Procedures

Participants were tested individually in a small room. Experimental materials were presented on a computer screen in black against a white background. Each item was approximately 7.5cm × 8cm (width × height). Participants were seated in front of the

computer at a distance of approximately 50cm.

Eighty pseudocharacters were presented to each participant in random order. In each trial, a stimulus was presented in the center of the screen for the participants to name. The naming responses were transcribed with International Phonetic Alphabets (IPA) online by the experimenter, and uncertainties regarding the responses were resolved by listening to the audio recording recorded with a JNC SSF-F3005 digital audio player.

After a response was made, the participants were asked to give a rating from 1-10 on how confident that he/she was that their pronunciation was correct (1 = least confident, 10 = most confident). The rating was recorded online by the experimenter.

Data Analysis

There were two dependent variables in this study: reading responses and confidence ratings regarding the participants' confidence about the accuracy of their responses. The participants' responses were classified into seven types according to the relationship between the response and the possible pronunciations associated with phonetic compound characters sharing the same phonetic radical as the pseudocharacter stimulus. An example of phonetic radical used in this study and its phonetic compound neighborhoods are shown in Table 2. The definitions of the seven response types are shown in Table 3.

Table 2

An example of phonetic radical and its phonetic compound neighborhoods

	Phonetic radical	Phonetic compound neighborhoods				
		Dominant pronunciation	Alternative pronunciations			
Character	谷	卻	浴	欲	俗	裕
Pronunciation	/gʊk7/	/kʰœk8/	/jʊk9/	/jʊk9/	/tsʊk9/	/jy6/
Token frequency	/	635	26	65	77	24

Table 3

Definitions of response types

Response types	Definitions
Legitimate responses	
Dominant pronunciation	Pronunciations that possess the highest token frequency in the family
Alternative pronunciation	Pronunciations present in the family, but not the dominant one
Illegitimate responses	
Orthographic	Pronunciations not present in the family, but were visually similar to the stimuli
Signific	Pronunciations of characters containing the same semantic radical, but not visually similar to the stimuli
Reading aloud of phonetic radical	Pronunciations of the phonetic radicals, but the pronunciation itself is not a possible pronunciation in the family
Unrelated	Pronunciations that were not related to the family either phonologically or orthographically
No response	No pronunciation was assigned

Responses from each subject were transcribed in IPA by the experimenter. Another trained rater randomly transcribed 20% of the data (i.e. 6 subjects) in IPA and classified the responses into one of the seven response types.

Previous research found that the dominant pronunciation influenced the pronunciation of

pseudocharacters, and the proportion of responses conformed to the dominant pronunciations was significantly higher for high-consistency pseudocharacters than those with low consistency (Fang et al., 1986). Therefore, further analyses were carried out on the proportions of production of dominant pronunciations between high and low consistency conditions using simple chi-square tests.

The confidence ratings for pseudocharacters containing ambiguous and unambiguous phonetic radicals were analyzed separately. Two-way and three-way ANOVA were carried out for the ambiguous and unambiguous group respectively.

Results

The results from pseudocharacters containing ambiguous phonetic radicals would be presented first, followed by those from the unambiguous group. In each section, the percentages of each response type would be presented first, followed by the presentation of results from chi-square tests on the frequencies of dominant pronunciations and the statistical analyses of the confidence ratings.

Pseudocharacters containing ambiguous phonetic radicals

Pseudocharacters containing ambiguous phonetic radicals were subdivided according to the phonetic radicals' consistency (high vs. low) and position of occurrence (left vs. right). For simplicity, pseudocharacters with the phonetic radical occurring on the left and a semantic radical occurring on the right will be referred to as *Phon-Sem*, and those with the phonetic radical occurring on the right will be referred to as *Sem-Phon*. The following four subgroups were resulted after the subdivision: (i) high/Phon-Sem, (ii) low/Phon-Sem, (iii) high/Sem-Phon, and (iv) low/Sem-Phon. The inter-rater reliability on transcription was 98.6%, and that on the assignment of response types was 97.9%. The percentages of various response types are shown in Table 4.

Table 4

Percentage of each response type for the ambiguous group

Response types	Percentage (Frequency)			
	High/ Phon-sem	Low/ Phon-sem	High/ Sem-phon	Low/ Sem-phon
Dominant pronunciation	36.3% (109)	35% (105)	41.7% (125)	18.0% (54)
Alternative pronunciation	43% (129)	26.3% (79)	42.7% (128)	51.7% (155)
Orthographic	1.0% (3)	0.6% (2)	1.7% (5)	0% (0)
Signific	6.0% (18)	7.3% (22)	0% (0)	0.3% (1)
Reading aloud	7.7% (23)	24.3% (73)	10.3% (31)	27.7% (83)
Unrelated	5.7% (17)	5.3% (16)	3.3% (10)	2.0% (6)
No response	0.3% (1)	1.0% (3)	0.3% (1)	0.3% (1)

The results indicated that dominant and alternative responses were dominant among the seven response types in all conditions. Simple chi-square tests were carried out for the left and right conditions to determine whether the differences between the distribution of dominant pronunciations in high and low consistency groups were statistically significant. The results indicated that the effect of consistency was significant when ambiguous phonetic radicals occurred in the right position (i.e. in Sem-Phon stimuli), ($\chi^2 = 40.14$, df = 1, $p = 0.000$), but not when they appeared on the left (i.e. in Phon-Sem stimuli) ($\chi^2 = 0.12$, df = 1, $p > 0.05$).

As it was observed that the proportion of “signific responses” was higher when the phonetic radicals occurred in the left position, simple chi-square test was carried out to compare the distribution of “signific responses” between the Phon-Sem and Sem-Phon conditions. It was found that the number of “signific responses” was significantly higher when the phonetic radicals occurred in the left position, ($\chi^2 = 39.82$, df = 1, $p = 0.000$).

Two-way ANOVA was employed to analyze the confidence ratings of the ambiguous group in order to determine the main effects of position and consistency of phonetic radicals, as well as their interaction effect. The mean confidence ratings for the different conditions are presented in Table 5.

Table 5

Mean confidence ratings for pseudocharacters with ambiguous phonetic radicals with different consistency and positions of occurrence

	Left condition (Phon-Sem)	Right condition (Sem-Phon)
High consistency	4.00 (SD = 1.6)	4.51 (SD = 1.5)
Low consistency	4.05 (SD = 1.6)	4.60 (SD = 1.6)

It was found that the main effect of position was significant, [$F(1, 29) = 21.53$, $p = 0.000$], which suggested that participants were significantly more confident in the accuracy of their pronunciations when the phonetic radical occurred in the right position than in the left position. The main effect of consistency was not significant, and neither was the interaction effect between position and consistency ($p > .05$).

Pseudocharacters containing unambiguous phonetic radicals

Pseudocharacters containing unambiguous phonetic radicals were subdivided according to the phonetic radicals' consistency (high vs. low) and typicality of position of occurrence (typical vs. atypical), thus resulting into four subgroups: (i) high/typical, (ii) low/typical, (iii) high/atypical, and (iv) low/atypical. The inter-rater reliability on transcription was 98.3%, and that on the assignment of response types was 97.6%. The percentages of various response types are shown in Table 6.

Table 6

Percentage of each response type for the unambiguous group

Response types	Percentage (Frequency)			
	High/Typical	Low/Typical	High/Atypical	Low/Atypical
Dominant pronunciation	40.3% (121)	39.3% (118)	30.0% (90)	21.7% (75)
Alternative pronunciation	39.3% (118)	36.3% (109)	41.7% (125)	48.0% (144)
Orthographic	0.7% (2)	1.7% (5)	0.3% (1)	3.3% (10)
Signific	6.3% (19)	3.0% (9)	4.3% (13)	2.3% (7)
Reading aloud	11.0% (33)	13.0% (39)	20.3% (61)	12.3% (37)
Unrelated	2.0% (6)	5.0% (15)	3.3% (10)	8.0% (24)
No response	0.3% (1)	1.7% (5)	0% (0)	1.0% (3)

Similar to ambiguous phonetic radicals, we found that dominant and alternative responses were dominant among the seven response types in all conditions concerning unambiguous phonetic radicals. Simple chi-square tests indicated that the differences between the distribution of dominant pronunciations in high and low consistency groups were insignificant in both typical and atypical conditions ($p > 0.05$), suggesting that the consistency effect on reading responses was insignificant. The effect of typicality of the phonetic radicals' positions of occurrence, however, was significant. The differences between the proportion of dominant pronunciations in the typical and atypical groups were significant in the high consistency condition, ($\chi^2 = 7.02$, df = 1, $p < 0.05$), and also in the low consistency condition, ($\chi^2 = 14.12$, df = 1, $p < 0.05$)

Since it was observed that the consistency effect on reading responses was significant when ambiguous phonetic radicals occurred in the right position, but not in the left position, the typical and atypical groups were combined and divided according to the position in which the unambiguous phonetic radical occurred (i.e. left vs. right). The recalculated percentages

of various response types are shown in Table 7.

Table 7

Percentage of each response type for the unambiguous group (Phon-Sem vs. Sem-Phon)

Response types	Percentage (Frequency)			
	High/ Phon-Sem	Low/ Phon-Sem	High/ Sem-Phon	Low/ Sem-Phon
Dominant pronunciation	34.7% (104)	31.3% (114)	35.7% (107)	26.3% (79)
Alternative pronunciation	37.7% (113)	40.0% (120)	43.3% (130)	44.3% (133)
Orthographic	0.7% (2)	1.3% (4)	0.3% (1)	3.7% (11)
Signific	10% (30)	4.7% (14)	0.7% (2)	0.7% (2)
Reading aloud	14.0% (42)	6.3% (19)	17.3% (52)	19% (57)
Unrelated	3.0% (9)	7.3% (22)	2.3% (7)	5.7% (17)
No response	0% (0)	2.3% (7)	0.3% (1)	0.3% (1)

Similar to ambiguous phonetic radicals, simple chi-square tests indicated that the differences between the distribution of dominant pronunciations in high and low consistency groups were significant when phonetic radicals with unambiguous positional specificity occurred in the right position (i.e. in Sem-Phon condition), ($\chi^2 = 6.11$, df = 1, $p < 0.05$), but not on the left (i.e. in Phon-Sem condition) ($\chi^2 = 0.72$, df = 1, $p > 0.05$). This indicated that the consistency effect was only significant when unambiguous phonetic radicals appeared on the right.

The difference between the distribution of "signific responses" between the Phon-Sem and Sem-Phon condition was also compared since a position effect was observed for this response type in the ambiguous group. It was found that the effect of position was significant, ($\chi^2 = 36.23$, df = 1, $p < 0.05$), but no effect of typicality was observed ($\chi^2 = 3.53$, df = 1, $p > 0.05$).

A three-way ANOVA was employed to analyze the confidence ratings for the unambiguous group to determine the main effects of position, typicality and consistency of phonetic radicals, and also their interaction effects. In order to separate the effect of position from that of typicality and consistency, each of the four conditions were subdivided into two groups according to the phonetic radicals' position of occurrence (left vs. right). The mean confidence ratings for stimuli containing unambiguous phonetic radicals occurred in their typical and atypical positions are presented in Table 8.

Table 8

Mean confidence ratings for pseudocharacters with unambiguous phonetic radicals with different consistency and positions of occurrence

	Typical position		Atypical position	
	Left condition (Phon-Sem)	Right condition (Sem-Phon)	Left condition (Phon-Sem)	Right condition (Sem-Phon)
High consistency	4.00 (SD = 1.6)	4.67 (SD = 1.6)	3.86 (SD = 1.4)	4.41 (SD = 1.5)
Low consistency	3.66 (SD = 1.6)	4.07 (SD = 1.2)	3.73 (SD = 1.3)	4.66 (SD = 1.3)

The main effect of position was significant, [$F(1, 29) = 46.03$, $p = .000$], so was that of consistency, [$F(1, 29) = 9.13$, $p < .05$]. The results suggested that participants were significantly more confident in naming pseudocharacters when the phonetic radical occurred in the right position than in the left position. They were also more confident in naming pseudocharacters with high consistency than those with low consistency. The main effect of typicality did not reach significance.

The interaction effect between typicality and consistency was also significant (refer to Figure 1), [$F(1, 29) = 6.61$, $p < .05$]. The Tukey HSD procedure indicated that when the phonetic radical occurred in the typical position, the confidence rating for the high consistency group was significantly higher than that for the low consistency group ($p < .05$).

No significant difference was found between the confidence ratings for the high and low consistency groups when the phonetic radical occurred in the atypical position ($p > .05$). Neither the interaction of position × typicality nor of position × consistency was significant ($p > .05$).

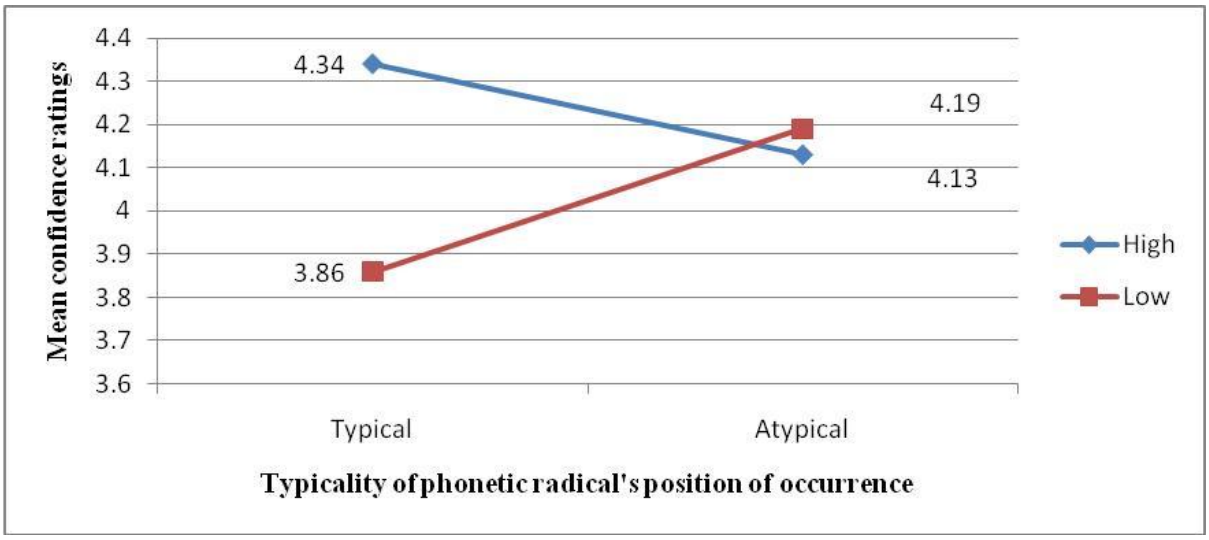

Figure 1 Mean confidence ratings for unambiguous pseudocharacters with different consistency and typicality of position of occurrence

Summary of All Findings

In both the ambiguous and unambiguous groups, the percentage of dominant responses was significantly higher in the high consistency condition than that in the low consistency condition, but this consistency effect was only observed when the phonetic radicals occurred in the right position, but not in the left position. Also, the subjects made fewer signific responses and were more confident in naming Sem-Phon stimuli than Phon-Sem stimuli. While the confidence ratings were significantly affected by the phonetic radicals' position of occurrence (left vs. right), the effect of the typicality of their position of occurrence (typical vs. atypical) was not significant.

Discussion

The results obtained from the groups of pseudocharacters containing phonetic radicals with ambiguous and unambiguous positional specificity suggested that readers demonstrated

a reliance on right radicals to extract phonological information in character naming. This was consistent with the phonetic radical activation hypothesis proposed by Saito et al. (1998), indicating that the phonological information of right radicals were not only activated in the character recognition process, but also in the character naming process.

According to Taft and Zhu (1997), the typicality of a radical's position would affect character decision times, and it took longer to recognize a character when its right radical rarely occurs in that position. With reference to this argument, readers should be more confident in reading pseudocharacters containing phonetic radicals occurring in a typical position than in an atypical position, and this typicality effect should only be observed in the right position, but not in the left position. However, this claim was not supported by the results, which indicated that the subjects were equally confident in naming stimuli with unambiguous phonetic radicals occurring in the typical and atypical conditions.

The major factor that appeared to determine how phonology is activated during pseudocharacter naming was position. However, instead of the positional specificity of individual radicals, the position effect observed in this study seems to be related to the readers' knowledge about the systematic relationship between position and function in horizontally configured phonetic compounds.

According to Feldman & Siok (1997), it is estimated that about 75% of phonetic compounds have a semantic radical on the left and a phonetic radical on the right. In other words, the Sem-Phon stimuli represent the typical configuration of horizontally configured characters, and right radicals tend to provide information about a character's pronunciation. As Taft and Zhu (1997) pointed out, 'the position of a radical in a Chinese character tends to be confounded with its function' (p.764), and the effect of this special relationship between function and position have been reflected in the results of this study.

In the ambiguous group, the pseudocharacters contained phonetic radicals that occur in the left and right position with approximately the same frequencies. However, despite the

similar frequencies of occurrence in both positions, it was found that the subjects were significantly more confident in the accuracy of their responses when the phonetic radical occurred on the right than on the left. Similar results were obtained in the unambiguous group, in which the subjects were significantly more confident in naming Sem-Phon stimuli, even if some phonetic radicals rarely appear in the right position.

In addition, the difference in the proportion of "signific responses" between Phon-Sem and Sem-Phon stimuli for both ambiguous and unambiguous groups further demonstrated this position effect in character naming. According to the interactive-activation model, each component within a phonetic compound character would activate an independent set of orthographic and phonological forms sharing the same component, and this activation should be position-sensitive (Fang et al., 1986; Taft & Zhu, 1997). For example, when the pseudocharacter 豺 is presented, the representations of all characters sharing the semantic radical 豸 on the left and those with the phonetic radical 半 on the right would be activated. If there were no preference concerning from which position phonological information should be extracted, the proportion of "signific responses" in the left and right conditions should be approximately the same. However, the results obtained from both the ambiguous and unambiguous groups reflected a positional preference of right over left.

In the Phon-Sem conditions, some readers assigned pronunciations of characters that share the same semantic radical as the stimuli despite orthographic dissimilarity. A common example of this type of response was reading the stimuli 刮 (or other stimuli with the semantic radical 刂) as /pit9/ or /kwat8/, the pronunciation of the character 别 and 刮 that share the same semantic radical on the right. This type of response also occurred in Sem-Phon stimuli, e.g. 豺 was read as /p^{h}au3/, the pronunciation of the character 豹 sharing the same semantic radical on the left. However, we found that the proportion of

"signific responses" in the Phon-Sem condition was significantly higher than that in the Sem-Phon condition for both the ambiguous and unambiguous groups.

This difference between the proportion of "signific responses" in Phon-Sem and Sem-Phon conditions could be interpreted as evidence for a positional preference in activating phonological representations at the radical level. The fact that the subjects made "signific responses" in both conditions indicated that when a stimulus was presented, the left and right radicals activated two independent sets of position-specific orthographic and phonological forms sharing the same component, which was consistent with the predictions from Taft and Zhu (1997), in which they suggested that the same radical occurring in different positions were represented independently. Since most of the phonetic compound characters have the phonetic radical on the right, it is plausible that the subjects overgeneralize this knowledge to all unfamiliar characters (e.g. ). However, when Phon-Sem stimuli were presented (e.g. ), it might be more difficult to discard the activations that share the same semantic radical on the right because the subjects tended to rely on right radicals to obtain phonological information about a character, thus resulted in a larger number of "signific responses" in this type of stimuli. The increased competition among a larger number of phonological alternatives also explained why the subjects were more confident in naming pseudocharacters with phonetic radicals in the right than in the left position.

Nevertheless, as suggested by Feldman & Siok (1997), the role of radical function should not be ignored. Despite that the results have demonstrated a preference of right phonetic radical over left in extracting phonological information, the majority of reading responses were legitimate responses conforming to the dominant or alternative pronunciations within the activation region. Therefore, it appears that the subjects were able to distinguish phonetic radicals from semantic radicals and utilized the former in assigning

pronunciations to the pseudocharacters in most cases. However, there is an alternative account to explain why legitimate responses constituted the majority of reading responses in all conditions. Since the semantic radicals used in this study were non-free-standing radicals with unambiguous function, they do not carry any phonological information in principle. Therefore, when a stimulus was presented, the subjects could only resort to the only component that provided phonological information, i.e. the phonetic radical, in all conditions.

Another factor that appeared to affect the access of phonology in the character naming process was the typicality of the phonetic radicals' position of occurrence. Although it was found that the subjects were equally confident in naming stimuli with phonetic radicals occurring in the typical and atypical positions, a comparison between the distribution of dominant pronunciations in the typical and atypical conditions suggested that when a phonetic radical appeared in its typical position, the subjects were more prone to assign the dominant pronunciation to the stimuli. This finding indicated that the typicality of a phonetic radical's position does affect the way in which phonological information is extracted in the reading process. When a phonetic radical occurs in its typical position, the phonological representation of the dominant pronunciation would be stronger, thus increasing the chance of activating the dominant pronunciation.

Nonetheless, as mentioned earlier, the subjects were more confident in extracting phonological information from right radicals even if the radical rarely appears on the right. This seemingly contradictory finding perhaps reflected that although the typicality of a phonetic radical's position of occurrence does affect the extraction of phonology in the reading process, perhaps such an effect is not as strong as the subjects' tendency to rely on right radicals for phonological information of a character.

In short, the present findings seem to support the predictions from Saito et al. (1998) that the phonological information of right radicals was activated in the reading process. Also, the typicality effect reflected in the significant difference in the distribution of dominant

pronunciations between the typical and atypical position was consistent with the predictions from Feldman & Siok (1997). In other words, when radical function was considered, the typicality effect was not a position-dependent one as reported by Taft and Zhu (1997), but rather the same for both Phon-Sem and Sem-Phon conditions. However, the typicality effect observed in this study was not as strong as that of the subjects' reliance on right radicals in extracting phonological information.

The second issue investigated in this study was the effect of consistency in pseudocharacter naming. According to previous findings (Fang et al., 1986; Lee et al., 1995), consistency effect should be observed such that the subjects should demonstrate a tendency to assign the dominant pronunciations to high consistency pseudocharacters, while the reading responses should be more diverse for the low consistency pseudocharacters. This prediction was generally supported by the results, in which the effect of consistency was observed for all types of pseudocharacters, regardless of the degree of positional specificity of the phonetic radicals.

In both the ambiguous and unambiguous groups, the proportion of dominant pronunciations was significantly higher in the high consistency group than in the low consistency group, but this pattern was only observed when the phonetic radical occurred on the right. This position-dependent effect of consistency should not be interpreted as contradictory to previous findings. In previous researches (Fang et al., 1986; Lee et al., 1995), the phonetic radicals' position of occurrence within the stimuli was not controlled, and the majority of stimuli had the phonetic radical on the right. Therefore, this bias in the radicals' position of occurrence may have obscured the position-dependent consistency effect. The present finding can be interpreted as an interaction between the effect of position and consistency. As discussed earlier, when a phonetic radical occurred on the left, it would be difficult for the subjects to discard the phonological information activated by characters containing the same semantic radical on the right because the subjects tended to extract

phonological information from right radicals. Due to the increased competition from these phonological alternatives, the subjects were likely to randomly select a pronunciation corresponding to one of these activated forms when they were under pressure to read aloud a stimulus.

A significant interaction effect between typicality and consistency in the subjects' confidence ratings was also observed in the unambiguous group. In the typical condition, the subjects were more confident in naming high than low consistency stimuli. However, the consistency effect became insignificant when the phonetic radicals appeared in their atypical positions. This finding could also be accounted for by the difference in the strength of a phonetic radical's representation between the typical and atypical positions. In the atypical condition, the phonological representation of the dominant pronunciations is presumably weaker when compared with that in the typical condition. Due to the lack of a particularly strong phonological representation within the activation region, the subjects would not demonstrate high confidence in assigning a particular pronunciation to a stimulus, thus no consistency effect was reflected in the confidence ratings in the atypical condition.

To conclude, this study showed a positional preference of right over left radicals in extracting phonological information in the character naming process. Although the typicality of phonetic radicals' position affected the way readers assign a pronunciation to a pseudocharacter, the readers were in general more confident in extracting information from right radicals, even though some phonetic radicals rarely occur on the right. Secondly, the consistency effect observed in this study was a position-dependent one, such that no consistency effect was observed when the phonetic radicals appeared on the left.

As mentioned before, since the semantic radicals used in this study were non-free-standing semantic radicals with unambiguous function, the phonetic radicals were the only source of phonological information in the stimuli used in this experiment. Therefore, in order to investigate whether readers could distinguish between phonetic and semantic

radicals and to decide from which component phonological information should be extracted, future investigation may make use of different free-standing semantic radicals that appear in various positions within a character. Secondly, the effect of radical position in phonetic compounds in other configurations also deserves attention. The present study only investigated how readers extract phonological information in horizontally configured phonetic compounds. Given that phonetic compounds may also appear in different configurations, including vertical (e.g. 杏), or even involve more than two components (e.g. 術), and as the relationship between radical position and function is less systematic in these characters (Feldman & Siok, 1997), the effect of position may be different from that observed in this study.

In short, investigations into the areas suggested above, as well as the findings from this study, should lead to a more thorough understanding of the character naming process in Chinese.

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Appendix 1 Pseudocharacter stimuli used in the pseudocharacter naming experiment

Pseudocharacters with ambiguous phonetic radicals				Pseudocharacters with unambiguous phonetic radicals			
Phon-Sem		Sem-Phon		Phon-Sem		Sem-Phon	
Dominance rating							
0.50-0.75	0.85-1.0	0.50-0.75	0.85-1.0	0.50-0.75	0.85-1.0	0.50-0.75	0.85-1.0
邦	⿰皀刂	⿰豸半	⿰糸艮	⿰谷旡	⿰奚阝	⿰扌谷	⿺辶奚
⿰令卩	⿰牙卩	⿺辶令	⿰衤牙	⿰其卩	⿰君刂	⿰彳其	⿰忄君
⿰單刂	⿰是乚	⿰彳單	⿰冫是	⿰予阝	⿰离乚	伃	⿰冫离
⿰倉乚	⿰冊阝	⿰糸倉	⿰氵冊	⿰豈卩	⿰堇旡	⿰扌豈	⿰糸莫
⿰重刂	⿰熏旡	⿰冫重	⿰彳熏	⿰开乚	⿰孝乚	⿰礻开	⿰豸孝
⿰豦乚	⿰委刂	⿰衤豦	⿰豸委	漻	⿺辶分	⿰翏卩	⿰分刂
⿰害阝	邡	⿰冫害	⿰忄方	⿰彳商	⿺辶咸	⿰商卩	⿰易阝
⿰粦刂	⿰原旡	僯	⿺辶原	⿰亻瞿	悏	⿰瞿卩	⿰夾卩
⿰㡭旡	⿰岡乚	⿰扌㡭	⿰亻岡	⿰豸易	⿰衤堇	⿰區旡	⿰堇刂
⿰虫旡	⿰古卩	忳	⿰扌古	⿰糸畐	⿰礻尞	⿰舌乚	⿰孝旡