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Semantic radical knowledge and word recognition in Chinese for Chinese as foreign language learners

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Abstract

In the present study, we examined the relation of knowledge of semantic radicals to students' language proficiency and word reading for adult Chinese-as-a-foreign language students. Ninety-seven college students rated their proficiency in speaking, listening, reading, and writing in Chinese, and were administered measures of receptive and productive knowledge of semantic radical position and function. A latent variable for language proficiency was constructed based on the number of semesters in Chinese courses, and students' self-rating in Chinese. Two language proficiency groups were reliably formed. Students with higher language proficiency had significantly better performances on all the measures of knowledge of semantic radicals and word recognition. Furthermore, the receptive and productive knowledge of semantic radical position and productive knowledge of semantic radical function were positively related to word reading after controlling for proficiency level. Productive knowledge of semantic radical function was uniquely and positively related to word reading after accounting for proficiency level and other measures of semantic radical knowledge.

Keywords: Chinese as foreign language, language proficiency, radical knowledge, word reading, semantic radicals

Achieving a high level of word reading and spelling requires word-specific memories of the orthographic, phonological, and semantic constituents of words (Perfetti, 1992). Numerous studies have shown the importance of connections between these constituents, particularly the connection between phonological and orthographic constituents for languages that employ alphabetic writing systems (e.g., most European languages; see Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). However, recently attention has been increasingly paid to semantic processing in word reading (Nation & Snowling, 2004; Ricketts, Nation, & Bishop,

2007), including morphological processing[1] (e.g., Carlisle, 2003; Carlisle & Stone, 2005; Kuo & Anderson, 2006; Verhoeven & Carlisle, 2006). In the present study, we focus on the relations between knowledge of semantic radicals and word reading for students who learn Chinese as a Foreign Language (CFL). Radicals are unique orthographic units of Chinese (Ding, Peng, & Taft, 2004; Feldman & Siok, 1999), and capture orthographic, semantic, and phonetic information, all of which are critical constituents of words.

Radicals are defined as "the smallest, meaningful orthographic units that play semantic or phonetic roles in compound characters" (Shen & Ke, 2007, p. 99). In other words, radicals are recurring structural patterns that convey both semantic and phonetic information (e.g., Ho, Ng, & Ng, 2003; Jackson, Everson & Ke, 2003). Semantic radicals give clues to the semantic category of the compound characters (characters that could be decomposed into radicals, e.g., 洋, /yáng/, which is composed of 氵 and 羊) whereas phonetic radicals give clues to the pronunciations of the compound characters, although meaning of the whole character and the semantic radical, and the pronunciation of the whole character and the phonetic radical do not always match. There are approximately 200 semantic radicals and 800 to 1,100 phonetic radicals (Hoosain, 1991; Shu & Anderson, 1999). Characters made up of radicals are called compound characters (Shu & Anderson, 1999) and more than 80% of modern Chinese characters consist of compound characters (Shu & Anderson, 1999). Thus, one's knowledge of radicals might be an important predictor of word reading skills in Chinese. However, studies on knowledge of radicals are limited in general, but particularly so for CFL learners. In the present study, we addressed this inadequacy in the literature and examined relations of four aspects of radical knowledge (receptive and productive knowledge of position and function of semantic radicals) to word reading (i.e., character recognition) for adult CFL learners.

In the present study, we use the term *knowledge of radicals* or *radical knowledge* [2] to refer to "the understanding of the role of radicals in forming Chinese characters" (Shen & Ke, 2007, p. 100). We targeted particularly the knowledge of the semantic radicals, the knowledge about the meaning-cueing function and the positional regularities of semantic radicals. Although research on the development of knowledge of radicals in first language (L1) environment and a few studies in second language (L2) or foreign language (FL) acquisition context have been carried out, no agreement has been reached concerning theoretical categorization of radical knowledge. Some researchers consider radical knowledge as a form of orthographic awareness (e.g., Jackson, Everson, & Ke, 2003) whereas others have categorized it as morphological awareness (Li, Anderson, Nagy, & Zhang, 2002). In the present study we take both perspectives. That is, knowledge of radicals involves both orthographic awareness and morphological awareness. After all, radicals encode both the orthographic (e.g., positional regularity) and morphological information (e.g., semantic radical function). This special feature of radicals in Chinese may be the reason for the importance of radical knowledge in literacy acquisition of Chinese (see below) just as morphological awareness and orthographic awareness are both good predictors of literacy development in languages with alphabetic writing systems (e.g., Carlisle, 2000; Cunningham, Perry, & Stanovich, 2001; Kim, 2010). A recent study by Tong and McBride-Chang (2010) showed that radical knowledge was uniquely and positively related to word reading for grade 2 Hong Kong students after accounting for orthographic, phonological and morphological factors.

Radicals have two major features: (a) radicals usually have habitual positions within characters,

and (b) they function to encode semantic information or phonetic information of characters. These two special features give rise to two aspects of radical knowledge—knowledge of radical position, and knowledge of the function of radicals. Of our concern is the knowledge of semantic radicals, the component that conveys the semantic information of characters. Furthermore, we included both receptive and productive tasks of semantic radical knowledge on position and function.

Knowledge of Radical Position

Instead of appearing randomly within a compound character, most semantic radicals have stable positions. The combinations of radicals follow either a horizontal or vertical sequence. Some semantic radicals only appear on the left side of the compound character, some on the right, some at the top and some at the bottom. For example, radical 亻 only appears on the left, as in characters 他, 伯, and 仪. Radical 攵 only appears on the right, as in characters 教, 数, and 枚. Examples of semantic radicals that appear at the top include 艹, 宀, 竹. An example of a radical that only appears at the bottom is 心 (e.g., 思, 想, 念). Any violation of the positional regularity will lead to an illegal or wrong character (Shu & Anderson, 1997). This is very similar to the regularity of orthographic patterns in English (e.g., 'ck' is found at the end, but not in the beginning of a word; Cassar & Treiman, 1997).

Radical positional regularity constraints have important implications for character recognition in Chinese (Chen, Allport, & Marshall, 1996). Just as letter combinations that abide by orthographic regularities have a perceptual advantage over random letter strings, a similar effect with characters and pseudocharacters (characters that follow positional regularity constraints) has been documented in a few studies (Chan & Nunes, 1998; Shu & Anderson, 1999). Previous research has demonstrated that skilled readers of Chinese are sensitive to the position of radicals within characters (Chen et al., 1996), and children gradually acquire knowledge of the positional regularity of radicals over the elementary school years (Ho, Ng, & Ng, 2003; Shu & Anderson, 1999).

Research on CFL learning showed that the positional regularity of radicals is acquired in the beginning phase of development. Wang, Perfetti and Liu (2003) explored 15 first-year CFL learners' knowledge of the structural composition of characters. They found that these first-year CFL learners rejected non-characters containing illegal radical forms faster and more accurately than those containing legal radicals in illegal positions, which in turn were rejected faster and more accurately than those containing legal radicals in legal positions. This finding was replicated by another study with 15 different CFL learners in the same programs (Wang, Liu & Perfetti, 2004). Studies in both L1 and L2 development suggest that learners gradually acquire the knowledge that characters are composed of radicals and that radicals follow positional regularities, and this suggests the saliency of radicals over strokes in character composition.

Knowledge of Function of Radicals

The functional aspect of radical knowledge concerns with how semantic radicals encode and specify the meaning of characters and how phonetic radicals cue the pronunciation of characters (Ho, Ng, & Ng, 2003). Chinese language learners' knowledge of radical function was

documented in both L1 and L2 reading research. Shu and Anderson (1999), for instance, investigated knowledge of semantic radicals among a group of 220 Hong Kong elementary school students. These children were presented with 90 two-character words, which were familiar, recently learned (words that were learned in the last two lessons of the class) or unfamiliar to them. Each word was written as a character plus a pinyin spelling (a phonetic alphabetic system adopted to help students pronouncing unfamiliar characters). The children were asked to circle a character among four choices to replace the pinyin spelling for each word. The correct choice contained a semantic radical that was consistent with the meaning of a two-character word. It was found that students of average or above-average reading ability from both third and fifth grade were able to use semantic radicals to derive the meaning of unfamiliar characters whereas students of below-average reading ability from third and fifth grade and all students from first grade could not. The performances in familiar character selections, however, did not differ for students in different grades. This study suggested that while young and emergent readers treated compound characters as unanalyzable wholes, more mature readers were aware of the meaning-conveying function of semantic radicals and could decompose characters into radicals and use semantic radicals to make inferences about the meanings of unfamiliar characters.

Knowledge of function of phonetic radicals was examined with Chinese first and second graders in Hong Kong by Ho and Bryant (1997). This study revealed that children named phonologically-regular Chinese characters (characters whose phonetic radicals have same pronunciations with the whole characters) more accurately than irregular characters (characters whose phonetic radicals have different pronunciations from the whole characters). The study also showed that most of the errors in naming were the result of using phonetic radicals for pronouncing whole characters. Hence, these findings suggested that Chinese first and second graders do rely on phonetic radicals for sound cues in naming Chinese characters. Chan and Nunes' (1998) study explored knowledge of function of both semantic and phonetic radicals. In this study, 60 Hong Kong children, aged from 4 to 9, were engaged in a creative writing task and a picture-naming task. The children were provided with 12 radicals (both semantic and phonetic radicals) together with six pictures and were asked to form six characters to describe and name the pictures. The creative writing task was designed to test children's understanding of the meaning-conveying function of semantic radicals while the naming task was designed to test children's understanding of the sound-cueing function of phonetic radicals. It was hypothesized that older students would have a better understanding of the functions of radicals as reflected in better performances in the writing task and the naming task. Results confirmed this hypothesis.

Despite these previous studies, there is a gap in the literature about the relation of knowledge of radicals to word reading in Chinese. Previous studies of radical knowledge in L1 acquisition described above targeted Hong Kong students who use traditional Chinese characters and speak Cantonese, which are both different from simplified Chinese characters and mandarin used in mainland China. The simplified character set is mainly used in Mainland China and Singapore. However, Taiwan, Hong Kong, and many overseas Chinese communities continue to use the traditional character set. Additionally, Cantonese has a completely different linguistics system from Mandarin and is used in a few provinces and areas including Hong Kong, Macau and some overseas Chinese communities while Mandarin is the lingua franca of Mainland China and Taiwan. Thus, it remains an empirical question whether the findings from previous studies with

children learning to read in L1, particularly learning to read traditional Chinese characters, can be generalized to adult CFL learners learning simplified Chinese characters. Recently, Shen and Ke's (2007) study investigated the CFL learners' developmental trajectory of semantic radical knowledge on function, and showed that knowledge of semantic radical function improved across years of study from one to four years, and that there was a positive and moderate correlation between radical knowledge and word reading (r = .46) among CFL learners who learned simplified Chinese characters.

Present Study

Research has shown that a radical is an important processing unit for adult skilled readers in character recognition (Chen et al., 1996; Feldman & Siok, 1999; Taft, Zhu, & Peng, 1999). However, most existing studies have focused on exploring radical knowledge among Chinese-as-L1 learners (but see Shen & Ke, 2007) and only a few studies have been conducted from an L2/FL perspective. Thus, it will be informative to examine whether adults who are literate and skilled in alphabetic writing systems (e.g., English) attend to radicals that do not exist in their L1 system, and whether students' radical knowledge is related to their word reading in Chinese. The graphic forms and spatial configuration of Chinese characters are in stark contrast with most alphabetic systems (Wang et al., 2003).

In the present study we extend the previous studies in several ways: (a) first by exploring the relation between language proficiency with knowledge of semantic radicals among CFL learners, (b) then by examining 4 types of this knowledge (i.e., receptive and productive knowledge of radical position and function) to explore the nature of the relation between knowledge of semantic radicals and word recognition[3], and (c) by investigating the shared and unique relations of various radical knowledge tasks to word recognition in Chinese. First, in the few studies that have explored the radical knowledge among CFL learners, exposure time was the only factor that was considered, but in the present study we included both exposure time (i.e., number of semesters) and students' self-reported rating of their proficiency in reading, writing, speaking and listening[4] to measure language proficiency. Although the standardized tests like HSK (Hanyu Shuiping Kaoshi), ACTFL (American Council on the Teaching of Foreign Languages) and AP (Advanced Placement) Chinese were available on the market, they were not very popular among the students and none of them had ever taken these tests before. Another reason to use self-rating and exposure time to determine the learners' Chinese proficiency is that the participants were from 10 different classes, and each of these class curricula emphasized different aspects of the language skills. As a result, the grades they got from their respective Chinese classes may not be comparable. Second, previous studies (e.g., Chan & Nunes, 1998; Ho & Bryant, 1997, 1999; Wang et al., 2005, 2006) included either receptive or productive tasks of radical knowledge and/or measures of position or function, but not all four types of knowledge about radicals (i.e., receptive and productive task of radical position and function) comprehensively. The present study only examined the function of semantic radicals because it has been shown that the awareness of the sounding-cueing function of phonetic radicals develops much slower than that of the semantic radicals (Jackson, Everson, & Ke, 2003) and that learners need to acquire quite a large vocabulary to gain knowledge of phonetic radicals (Shen & Ke, 2007). The following were guiding research questions in the present study:

1. Do CFL learners with higher Chinese language proficiency have a higher level of knowledge about semantic radicals than students with lower Chinese language proficiency?
2. Is knowledge of semantic radicals significantly related to word recognition for CFL learners? What are the unique relations of knowledge of semantic radicals with word recognition in Chinese?

For the first research question, it was hypothesized that CFL learners with higher proficiency would have higher levels of knowledge about semantic radicals than students with lower proficiency, given findings from L1 reading acquisition that students in higher grades have higher levels of radical knowledge than those in lower grades (Chan & Nunes, 1998). It was also hypothesized that knowledge of semantic radicals would be positively related to word recognition for CFL learners based on in L1 literacy acquisition studies (Ho, Ng, & Ng, 2003; Li et al., 2002). We speculated that productive knowledge of semantic radicals might be uniquely related to word recognition over and above receptive knowledge of semantic radicals similar to findings for phonological awareness and word reading for English-speaking children (Schatschneider et al., 1999).

Method

Participants and Sites

A pilot study was conducted with 25 CFL learners who were very similar to the students in the primary study to ensure suitability of the researcher-developed instruments (e.g., the internal reliability). These 25 participants were given all four tests (three radical tests and one reading test) and finished all of them within a Chinese class session one semester earlier than the primary study and they were excluded from the primary study afterwards. The participants of the primary study were college students at a public university in the southeastern part of the United States. Ninety-seven college students (49 male, 48 female) who were taking CFL courses participated in the study. Their ages ranged from 18 to 28, with a mean of 20.59. All of them had studied Chinese as a foreign language for more than one semester before they participated in the study. Ninety-one of them learned English as the L1, two had Spanish, one had German, and two had Vietnamese as the native language. Some of them learned a language other than Chinese as an L2, and these second languages were Spanish, Dutch, Creole, Urdu, Tagalog, and Vietnamese. The participating students came from 10 Chinese classes at the university, which included three Elementary II classes, two Intermediate Chinese classes, one Chinese Grammar & Composition class, one Business Chinese II class, one Chinese Short Story & Essay class, and one Intermediate Grammar & Writing class. These 10 classes were taught by five Chinese native speakers. According to the curriculum review, class lesson plans, and personal informal interviews with the teachers, semantic radicals were not taught explicitly to these students.

Measures

A background information questionnaire and four measures were administered. Four dimensions of knowledge of semantic radicals (i.e., receptive and productive knowledge of position and

receptive and productive knowledge of semantic function) were assessed using three tasks. Students were also administered a word recognition test. Reliability (i.e., internal consistency) estimates were all acceptable or good ($\alpha s \geq .75$; see Table 1).

Self-rated Chinese Proficiency

In the background information questionnaire, students were asked to rate their proficiency in Chinese and English in listening, speaking, reading, and writing. The rating was on a 6-point Likert scale ranging from 1 (*poor*) to 6 (*excellent*). Rating on English was included to see how students rate their English language proficiency, given that the vast majority of students' L1 was English. Not surprisingly, students uniformly rated their English proficiency to be very high (majority indicated 6). In the analysis, students' perceived self-rated proficiency in Chinese was used as well as the number of semesters in taking Chinese classes (as a proxy for exposure time) to construct a language proficiency variable.

Receptive Task of Radical Positional Regularity

A character legality decision task (see Appendix A) was designed to measure the learners' receptive knowledge about the radical positional regularity. It is similar to a lexical decision task, which is widely used research paradigm in studying various basic processes in word identification (Wang, Perfetti, & Liu, 2003). A total of 40 noncharacters (20 of them conform to the positional regularity and 20 of them violate the positional regularity) were presented to the students. The participants were asked to judge the legality of these written noncharacters. All the radicals involved in the legality decision task had already been covered in the participants' Chinese classes. This task was adapted from Lu (1992) and included radicals of high combinability, like 亻, 氵, and 扌, and low combinability such as 卜, 弓, and 礻. Combinability is defined as the ability to combine semantic radicals with phonetic radicals in forming a compound character (Feldman & Siok, 1999).

Receptive Task of Semantic Radical Function

A character-meaning matching task (see Appendix B) was adapted from Shen and Ke (2007), and aimed at measuring the learners' implicit awareness about semantic radicals. Participants were presented with a word in English and three choices of Chinese characters, and asked to select a character that corresponded to the meaning of the English word. The three Chinese characters shared the same phonetic radical yet differed from one another in their semantic radicals. It is believed to measure the receptive knowledge of the semantic function of semantic radicals. If the student picked the correct character, they get one point. A total of 15 items were included in the task.

Productive Task of Position Regularity and Function of Semantic Radical

The character writing task (see Appendix C) was used to measure the participants' productive knowledge about positional regularity and the meaning-cueing function of semantic radicals. Fifteen unfinished characters with their corresponding meanings in English were presented to the participants. Students were asked to finish writing the characters. As there are many cases of

synonyms (characters with similar meanings) in Chinese, the pinyin forms of the target characters were provided. One point was awarded if the participants put a radical in the correct place regardless of its identity, and the score from this was used for the productive knowledge of semantic radical position. One point was awarded if the participants provided correct semantic radicals regardless of the position, which was used as the score for the explicit awareness of semantic radical function.

Word Recognition Task

In the word recognition task, the students were asked to provide the pinyin forms of 20 words[5] which consisted of one or two characters. These 20 words were from 21 lessons covered in their classes at the university, taken from the textbook *Integrated Chinese* (Yao et al., 2007). These 20 words were selected as they were composed of the radicals that are most familiar to the students, and which were supposed to be mastered by all students according to the teachers of these students. The participants learned all 20 of these words during their first two semesters of Chinese study at the university. Participants received a score of zero if they were not able to provide the right onset and rhyme of the word in Pinyin. The tones were not assessed because tones posed extreme difficulties to CFL learners. One point was awarded for a correct pinyin form. In the case of the two-character recognition, 0.5 point was awarded if the participants gave a correct answer to one character. The first author and one Chinese native speaker graded the answers and the inter-rater reliability is .95. The differences were found in the character writing task, where the students' handwritings of several characters were not so legible. Differences were solved and agreements were reached after discussions were done.

Procedure

Students from 10 Chinese classes were recruited to participate in the study. The participation was on the voluntary basis. Students finished all the tasks in the present study within 25 minutes during one session of their class. These tasks were presented on paper to all the participants. The students were taught Mandarin with simplified Chinese characters. As is typical in a CFL setting, no one had exposure to the target language outside the classroom (Zhao, 2009).

Results

Descriptive statistics

The descriptive statistics are presented in Table 1. The students self-rated their proficiency (from 1 to 6, in which 1 stands for the least skilled and 6 stands for the most skilled) in various aspects of Chinese (i.e., speaking, listening, reading and writing). The scores, on average, ranged from 3.08 to 3.78. Correlations among the variables are presented in Table 2. The relations among all four measures of radical knowledge were moderate to strong ($.52 \leq rs \leq .89$), and the relations between word recognition and the four measures of radical knowledge were also moderate to strong ($.57 \leq rs \leq .82$). Students' self-rated proficiency on reading, speaking, listening, and writing were moderately correlated with word recognition ($.35 \leq rs \leq .41$).

Table 1. *Descriptive statistics of the full sample*

	α	Mean (*SD*)	Minimum	Maximum
Semester of study	--	3.46 (1.66)	2	8
Chinese reading self-rating	--	3.22 (1.11)	1	5
Chinese speaking self-rating	--	3.08 (1.18)	1	5
Chinese listening self-rating	--	3.37 (1.28)	1	6
Chinese writing self-rating	--	3.78 (1.12)	1	6
Receptive position	0.85	30.16 (1.12)	16	40
Receptive function	0.75	10.52 (3.07)	2	15
Productive position	0.86	8.55 (4.24)	0	15
Productive function	0.85	7.02 (4.03)	0	15
Word recognition	0.88	8.44 (4.48)	0	18

Table 2. *Correlations between variables*

	2	3	4	5	6	7	8	9	10
Semester	-.03	.24*	.39**	.04	.46**	.51**	.48**	.49**	.52**
Reading	---	.47**	.42**	.72**	.27**	.34**	.21*	.37**	.37**
Speaking		---	.71**	.51**	.28**	.26*	.26*	.25*	.35**
Listening			---	.42**	.34**	.35**	.38**	.36**	.41**
Writing				---	.35**	.38**	.23*	.39**	.36**
Receptive position					---	.70**	.52**	.67**	.62**
Productive position						---	.58**	.89**	.77**
Receptive function							---	.60**	.57**
Productive function								---	.82**
Word recognition									---

Note. * $p < .05$, ** $p < .01$, Semester = Number of semester of Chinese study; Reading = self-rated reading proficiency; Speaking = self-rated speaking proficiency; Listening = self-rated listening proficiency; Writing = self-rated writing proficiency

A Latent Class Analysis (LCA) was conducted using MPLUS 5.1 (Muthén & Muthén, 2007) to determine Chinese language proficiency of the participants because standardized Chinese tests scores were unavailable to determine one's Chinese language proficiency level. LCA is a statistical method that enables characterization of multidimensional discrete latent variables from a cross-classification of two or more observed categorical variables (McCutcheon, 1987). LCA is frequently used when one is interested in classifying study participants based on a set of interrelated categorical measures (McCutcheon, 2002).

For the present study, the Chinese language proficiency latent variable was created by using the following observed variables: the number of semesters of Chinese study, and self-rated proficiency in Chinese reading, speaking, listening, and writing. In order to determine the number of proficiency levels for these CFL learners, model fit statistics such as AIC and BIC were compared for different models. BIC and AIC are the most common relative model fit

statistics for nonnested model (Henson, Reise & Kim, 2007) and a model with lower BIC and AIC is preferred to a model with higher BIC and AIC (McCutcheon, 2002). In addition, the Vuong-Lo-Mendell-Rubin likelihood ratio test provides a standard of comparison for ascertaining the numbers of classes in the model (Duncan, Duncan, & Strycker, 2006). Results showed that a 3-class model had the lowest BIC and AIC, while a 1-class model had the highest BIC and AIC. Yet the Vuong-Lo-Mendell-Rubin likelihood ratio test for 2 versus 3 classes turned out to be non-significant ($p > .05$), which indicated that the more parsimonious 2-class model should be preferred. Based on this model fit information, the 2-class model was adopted.

This two-class latent class model classified 46 participants into the first class (lower proficiency) and 51 into the second class (higher proficiency). The descriptive statistics by proficiency group are presented in Table 3. The second class had higher mean scores in all five observed variables ($ps < .01$).

Table 3. *Descriptive statistics by Chinese language proficiency groups*

	Beginning (*N*=46)		Intermediate (*N*=51)		*F* (*df*)	Cohen's
	Mean (*SD*)	Min-Max	Mean (*SD*)	Min-Max	*F* (1, 95)	d
Semester	2.98 (1.06)	2-7	3.90 (1.96)	2-8	---	---
Reading	3.22 (1.01)	1-5	4.29 (.97)	2-6	---	---
Speaking	2.33 (.76)	1-3	4.02 (.68)	3-5	---	---
Listening	2.17 (.88)	1-4	3.90 (.73)	3-5	---	---
Writing	2.67 (1.08)	1-6	4.00 (1.11)	2-6	---	---
Receptive position	28.72 (6.33)	17-39	31.47 (5.79)	16-40	5.01*	.46
Productive position	7.46 (4.11)	0-14	9.53 (4.15)	0-15	6.08*	.51
Receptive function	9.57 (3.11)	2-15	11.37 (2.79)	5-15	9.12*	.62
Productive function	5.83 (3.74)	0-14	8.10 (4.02)	0-15	8.26*	.59
Word recognition	6.85 (4.38)	0-16	9.88 (4.10)	3-18	12.41*	.72

Note. *$p < .05$, **$p < .01$, Receptive position = a receptive task of radical position; Productive position = a productive task of radical position; Receptive function = a receptive task of radical function; Productive position = a productive task of radical function

Research Question 1: Do CFL learners with higher language proficiency have a higher level of radical knowledge than students with lower language proficiency?

A one-way ANOVA was conducted to determine if high-proficiency CFL learners had a higher level of radical awareness than low-proficiency CFL learners. As shown in Table 3, the ANOVA tests for all the four semantic radical knowledge tasks were statistically significant ($Fs \geq 5.01$, $ps \leq .03$). These suggested that the high-proficiency CFL learners had a higher level of radical knowledge than the low-proficiency CFL learners. The effect sizes (i.e., Cohen's D) were medium in size, ranging from .46 to .62.

Research Question 2: Is knowledge of semantic radicals related to word recognition for CFL learners? What are unique relations of knowledge of semantic radicals with word recognition in Chinese?

Four multiple hierarchical regression analyses were conducted for the word recognition outcome measure. As seen in Table 4, the main effects of the semantic radical knowledge tasks were all statistically significant after accounting for proficiency level and interaction term ($ps < .05$)

except for the implicit functional radical awareness task (p = .64). The interaction terms were not statistically significant for any of the predictors.

Table 4. *Results of regression models in which various semantic radical knowledge tasks predicted word recognition in Chinese* (N = 97)

	B (Std. Error)	β	t
Receptive task of position as a main predictor			
Intercept	-8.85 (5.49)	NA	-1.60
Proficiency level	3.21 (3.61)	.36	.89
Receptive position	.48 (.18)	.66	2.61*
Receptive position * Proficiency level	-.04 (.12)	-.19	-.37
Productive task of position as a main predictor			
Intercept	-2.45 (2.00)	NA	-1.23
Proficiency level	2.90 (1.32)	.32	2.19*
Productive position	1.03 (.23)	.98	4.57***
Productive position * Proficiency level	-.17 (.14)	-.34	-1.23
Receptive task of function as a main predictor			
Intercept	-.39 (4.12)	NA	-.10
Proficiency level	.59 (.40)	.41	1.51
Receptive function	.49 (2.78)	.06	.18
Receptive function * Proficiency level	.11 (.25)	.20	.44
Productive task of function as a main predictor			
Intercept	-1.50 (1.61)	NA	-.93
Proficiency level	1.21 (.22)	1.09	5.48***
Productive function	2.55 (1.07)	.29	2.39*
Productive function * Proficiency level	-.22 (.14)	-.40	-1.62

Note. * p < .05, *** p < .001, Receptive position = a receptive task of radical position; Productive position = a productive task of radical position; Receptive function = a receptive task of radical function; Productive function = a productive task of radical function

Table 5. *Results o f regression model in which various radical awareness tasks predicted word recognition in Chinese simultaneously* (N = 97)

Variables	B (Std. Error)	β	t
Intercept	-1.58 (1.59)	---	-.99
Receptive position	.05 (.06)	.08	.91
Productive position	.15 (.14)	.14	1.07
Receptive function	.12 (.11)	.09	1.14
Productive function	.63 (.14)	.59	4.37***
Proficiency level	.93 (.54)	.10	1.71

Note. *** p < .001, Receptive position = a receptive task of radical position; Productive position = a productive task of radical position; Receptive function = a receptive task of radical function; Productive function = a productive task of radical function

In order to examine the shared and unique relations of knowledge about semantic radicals with word reading, all the four semantic radical knowledge measures (i.e., receptive and productive knowledge of radical positions and receptive and productive knowledge of semantic radical function) and Chinese proficiency were entered into the model simultaneously. As shown in Table 5, productive knowledge about the function of semantic radicals remained positively

related to word recognition after accounting for the effects of the other three measures of semantic radical knowledge and Chinese proficiency. None of the other three semantic radical knowledge tasks were significantly related to word recognition after accounting for the effects of other semantic radical knowledge tasks.

Discussion

The primary purpose of this study was to examine semantic radical knowledge levels among CFL learners who differ in Chinese proficiency, and to explore the unique relation between knowledge of semantic radicals and word recognition among CFL learners. The present study explored both receptive and productive knowledge of the positional regularity and function of semantic radicals (the meaning-cueing function of semantic radicals) among CFL learners who differed in their Chinese proficiency levels. To our best knowledge, the present study is the first to include all four aspects of semantic radical knowledge: receptive and productive positional semantic radical knowledge and receptive and productive functional semantic radical knowledge.

The first research question of the present study addressed the relation between language proficiency and knowledge of semantic radicals. The results showed that higher-proficiency CFL learners had higher levels of semantic radical knowledge than lower-proficiency CFL learners. This higher level of radical knowledge was demonstrated in all the semantic radical knowledge tasks. This finding extends previous studies by directly investigating the relation between self-rated language proficiency and knowledge of semantic radicals for CFL learners. Although it was shown in L1 literacy acquisition studies that older students have higher levels of radical knowledge than younger students (e.g., Chan & Nunes, 1998; Ho, Ng, & Ng, 2003; Shu & Anderson, 1997), this positive relation between age and radical knowledge in L1 literacy acquisition is not comparable to the significant relation between Chinese language proficiency and radical knowledge in the present study because L1 readers in different grades differed not only in radical knowledge but also in cognitive maturity. Thus, it is difficult to tease out development of cognitive maturity from language proficiency in L1 studies with children in different grades. In the present study, all the 97 participants were college students who had the highly developed conceptual sophistication of adults and were already literate in their L1 (i.e., English). The findings of the present study suggest that CFL learners who are skilled in an alphabetic system and have a higher Chinese proficiency level are better at decomposing characters into radicals and that semantic radicals may have a better representation in their memory even without explicit radical instruction (the authors confirmed with the Chinese teachers of these participants that radicals had not been explicitly taught to them during their Chinese studies at this university). The results of this study provide some support for the hypothesis that CFL learners learn characters as a whole and may not decompose characters into radicals in the beginning phase, but as they develop their proficiency, they treat characters as decomposable configurations in Chinese (Jackson, Everson, & Ke, 2003).

The descriptive analyses showed that the CFL learners in the present study had a better understanding of the positional regularities of semantic radicals than the functional regularities as the mean percent correct was higher for the positional semantic radical knowledge tasks (both receptive and productive) than for the functional semantic radical awareness tasks, and a further

paired t-test showed a significant difference. This was true regardless of the students' proficiency levels. These results converge with previous studies of CFL reading acquisition (Wang et al., 2003) and Chinese L1 literacy acquisition (Ho, Ng, & Ng, 2003), supporting the argument that the acquisition of positional and functional semantic radical knowledge may develop at a different pace.

The second primary focus of the present study was the unique relation between knowledge of semantic radicals and word recognition among CFL learners. The results showed significant relations between word recognition and semantic radical knowledge, except for receptive knowledge of semantic radical function after accounting for the effect of Chinese proficiency. These findings have also been documented in L1 literacy acquisition (e.g., Ho, Ng, & Ng, 2003; Packard et al., 2006) and the present study extends it to adult CFL learners. The significant relation for both L1 and L2 learners may be attributed to the importance of semantic radicals in character formation and character processing in Chinese. As indicated earlier, semantic radicals carry orthographic and morphological information in Chinese. They follow positional constraints and they have meaning-cueing functions. As they recur in different characters, they are likely to have processing saliency and are stored as units in memory. Previous studies demonstrated that the frequency of radicals affected the reaction time and accuracy of the whole characters with regard to word processing (e.g., Ding, Peng, & Taft, 2004; Taft et al., 1999; Zhou & Marslen-Wilson, 1999), and that learners were gradually able to decompose characters into radicals and began to generate characters (wrong characters that do not exist with right semantic and phonetic radicals) by combining semantic radicals with phonetic radicals (Jiang & Liu, 2001; Ma, 2007). Coupled with these previous studies, the findings of the present study suggest that radicals may be activated in character recognition in Chinese and an important predictor for character recognition for adult CFL learners. The lack of additional contribution of receptive knowledge of function of semantic radicals after controlling for the effect of language proficiency among CFL learners may be due to the fact that character-meaning-matching tasks emphasize the meaning of characters, and all three choices differ in their semantic radicals, thus helping participants draw more attention to the meaning-cueing function of the semantic radicals. Further study may incorporate meaning-matching tasks that have choices that deemphasize the function of semantic radicals.

The present study extends our understanding of knowledge of semantic radicals by systematically examining the four aspects of semantic radical knowledge. A widely adopted practice has been to distinguish two aspects of semantic radical knowledge, namely, the positional radical knowledge and functional radical knowledge (e.g., Ho et al., 2003; Shen & Ke, 2007). In the present study, the receptive and productive knowledge of positional regularity and function of semantic radicals tended to be strongly related to word recognition (*rs* =. 57 to .82, *ps* < .01) whereas Shen and Ke's (2007) study showed a moderately positive correlation ($r = .46$, $p < .001$) for both the one-year group and two-year group CFL learners. The differences in strengths of associations might be attributed to the fact that we teased apart the receptive and productive aspects of radical knowledge.

Furthermore, in the present study, productive knowledge of semantic radicals was the only significant unique predictor of word reading in Chinese after accounting for the effects of other radical knowledge measures and language proficiency. This result suggests that although

semantic radical knowledge in general is related to word recognition in Chinese (Table 4), various semantic radical knowledge tasks may require different levels of control and type of knowledge to be analyzed, and these variations may matter in the extent of relation with word recognition. Productive semantic radical knowledge requires one to know the meaning and meaning-cueing function of semantic radicals, to retrieve correct radicals, and to apply this knowledge in character writing. Thus, this task may tap into a higher level of semantic radical knowledge than does receptive knowledge of semantic radical function. Receptive knowledge of semantic radicals, on the other hand, requires one to choose among several semantic radicals the right one with the desired meaning. It will be important to examine in future studies whether similar patterns of relations can be found between receptive and productive semantic radical knowledge for position and function of radicals for developing readers in L1 contexts.

Limitations and Implications

One limitation of the present study is the exclusion of phonetic radical knowledge. Although previous studies have shown that learners' awareness of the sound-cueing function of phonetic radicals develops much more slowly than the awareness of the meaning-cueing function of semantic radicals (Ho, Yan, & Au, 2003; Jackson, Everson, & Ke, 2003) due to the high inconsistency between the pronunciations of the phonetic radicals and those of characters (Shu, 2003), it would have been illuminating to include this aspect of radical knowledge in the present study. In addition, word recognition was assessed by using the pinyin score in the present study due to a resource constraint. This is different from the conventional method of word recognition research where a reading-aloud task is used. Furthermore, in addition to students' perceptions of their own proficiency in Chinese, it would have been informative to have direct measures of Chinese language proficiency, although such measures are not currently available. Finally, a future study should examine the interrelations of semantic radical knowledge with other metalinguistic skills which have been shown to be important in word recognition in Chinese such as morphological awareness and phonological awareness (Huang & Hanley, 1995; McBride-Chang & Kail, 2002, McBride-Chang et al., 2005, Tong & McBride-Chang, 2010).

The findings of the present study suggest a positive relation of knowledge of semantic radicals and word reading in Chinese for CFL learners. In line with a preliminary finding from Taft and Chung (1999), which showed a positive effect of knowledge of semantic radicals on character recognition, these results preliminarily suggest a potential benefit of explicit instruction on radicals and radical knowledge in CFL classrooms. Future studies are needed to investigate ways to promote radical knowledge in L1 and CFL classrooms.

In addition, we should be cautious when interpreting the results of the present study about the relation between knowledge of semantic radicals and word recognition. The present study mainly deals with characters with transparent semantic radicals, where the meaning of semantic radicals gives a clue to the semantic category of the characters, while in Chinese there are many characters that are composed of opaque semantic radicals, which appear unable to hint the meanings of the characters. Further studies will need to include proportionally right numbers of characters with transparent and opaque semantic radicals.

Notes

1. In the present paper, we assume that morphological processing is part of semantic processing, given that vocabulary is believed to be an important source of morphological awareness (Kuo & Anderson, 2006), and studies have shown high correlations between vocabulary and morphological awareness, in fact showing that they are a single latent variable (Wagner, Muse, & Tannenbaum, 2006; Wagner, Spencer, & Muse, 2011).

2. We use the two terms interchangeably.

3. We use "word reading" and "word recognition" interchangeably.

4. GPA was considered and included in the preliminary analysis, but excluded in the final analysis due to the small variation in participating students' GPA (the vast majority received A or A-).

5. In the present study, scores on students' pinyin forms are reported. However, it should be noted that when analysis was conducted incorporating scored from both pinyin forms and meanings, the results were essentially the same as those reported in the present paper.

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Appendix A

Character Legality Task

Character Legality Task

Below you will see some handwritten characters that you may have never seen before. Please use your knowledge about character structures and decide whether they are written correctly. If yes, write a **T** in the parenthesis, if no, write a **F** in it.

Appendix B

Character-Meaning Matching Task

Below you will see some unfamiliar characters. Use your radical knowledge to figure out the one that matches the meaning given to the left and ***circle*** *it.*

Meaning	Character		
1. To see	堵	睹	赌
2. To mix	伴	拌	绊
3. emotion	蜻	晴	情
4. Peak	峰	锋	烽
5. Oak	像	橡	蟓
6. To translate	译	峄	驿
7. To bite	钉	叮	盯
8. Sunshine	浑	挥	晖
9. Sleeve	妯	抽	袖
10. To grill	**烤**	拷	栲
11. Pan	娲	蜗	锅
12. Grave	纹	坟	汶
13. To irrigate	绕	浇	娆
14. To spring, to jump	跃	沃	袄
15. To cry	坞	钨	呜

Appendix C

Character Writing Task

*Below each of the following **bold** characters is **missing** a radical. Add this missing radical according to the meaning and pronunciation given.*

	Pinyin	Meaning	Character
1	mèi mei	younger sister	**未** **未**
2	**chàng** gē	to sing	**昌** 歌
3	xué **xiào**	school	**学** **交**
4	**kù** zi	Pants	**库** 子
5	**shuō**	To say; to speak	**兑**
6	sān diǎn **zhōng**	Three o'clock	三点 **中**
7	**xiǎng**	To think, to want	**相**
8	**dǎ**	To hit; to strike	**丁**
9	chī **fàn**	To have a meal	吃 **反**
10	**shuì** jiào	To sleep	**垂** 觉
11	**tiào** wǔ	To dance	**兆** 舞
12	**dǒng**	To understand	**董**
13	**rè**	Hot	**执**
15	pí **jiǔ**	Beer	**啤** **酉**
16	**shí** jiān	time	**寸** 间

Appendix D

Word Recognition

*Please give the **Pinyin** and **Meaning** of the following 20 words.*

	Pinyin	Meaning
1. **晚上**		
2. 球		
3. 漂亮		
4. 念		
5. 妈妈		
6. 椅子		
7. **踢**		
8. 衬衫		
9. 眼睛		
10. 星期		
11. 茶		
12. 洗澡		

13. 抱
14. 喝
15. 卧室
16. 这个
17. 饿
18. 认识
19. 钱
20. 城市

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