Does Partial Radical Information Help in the Learning of Chinese Characters?

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1. Introduction

Learning to read is "fundamentally metalinguisitic" (Nagy & Anderson, 1998). Metalinguisitc awareness is the ability to identify and reflect on the structural features of language (Shu & Anderson, 2000). Learners need to be aware of the basic units of the spoken language, the basic units of the writing system, and how to map the two systems. Metalinguisitc awareness includes phonological awareness, morphological awareness, syntactic awareness, and semantic awareness. Research has demonstrated a strong relationship between metalinguistic awareness and reading development (Nagy & Anderson, 1998; Shu & Anderson, 2000). Phonological awareness and morphological awareness are the two most basic classes of metalinguistic awareness. Over the past decades, it has been well established that phonological awareness and morphological awareness play key roles in the learning of alphabetic languages. Phonemic awareness has been proved to be a strong predictor of reading achievement. (Goswami & Bryant, 1990; Nagy & Anderson, 1998); morphological awareness in alphabetic languages contributes to reading achievement and plays an increasingly important role in reading achievement in alphabetic languages (Carlisle, 2000; Nagy, Berninger, Abbott, & Vaughan, 2003).

However, the nature of the metalinguistic insights that are important for reading depends upon the writing system (Li, Anderson, Nagy, & Zhang, 2002). In alphabetic writing systems, the crucial insight is that letters represent phonemes, while in Chinese (a logographic writing system), characters do not directly encode phonological information like alphabetic languages. Instead, Chinese characters encode character-to-syllable and character-to-morpheme correspondences. Consequently, the crucial insight for Chinese is different from that of alphabetic languages. The metalinguistic insights for learning Chinese are less well established. In Chinese, an estimated 80%-90% of modern Chinese characters are semantic-phonetic compound characters that contain two major components: a semantic component, which is called radical, and a phonetic component, which is called phonetics. Written Chinese contains about 200 radicals which give the information related to the meaning of the character, and contains 800 phonetics which give information about the character's pronunciation (Shu, Chen, Anderson, Wu, and Xuan, 2003). Based on the characteristics of these 80%-90% of characters, phonological and radical awareness certainly should play important roles in Chinese reading.

Previous L1 studies (Shu & Anderson, 1997; Ho, Ng & Ng, 2003) and L2 studies (Taft & Chung, 1999; Shen & Ke, 2007) show that radical awareness (i.e., the functional understanding of the radical's role in forming Chinese characters and using this knowledge to learn novel characters) helps Chinese character learning and plays an important role in reading development in both first and second language acquisition. In addition, previous research on the morphographic processing of Chinese characters (Taft & Zhu, 1995; Feldman & Soik, 1997; Zhou & Marslen-Wilson, 1999) shows that characters are recognized via the activation of their component radicals. However, semantic radicals do not provide the meaning of whole characters, and they can only provide partial information. The degree of semantic transparency is different from one character to another. Semantic transparency is defined as "the contribution of a radical to the meaning of a semantic-phonetic

 Selected Proceedings of the 2011 Second Language Research Forum, ed. Erik Voss et al., 162-172. Somerville, MA: Cascadilla Proceedings Project.

compound character" (Shu, et al., 2003). The more relevant information a radical provides, the more transparent the character is. For example, radicals "木 (tree)" and "犭(animal)" provide obvious and direct clues to character meanings of "松 (pine)" and "狗 (dog)" and provide weak or indirect clues to character meanings of "村(village)" and "猎(hunt)", thus, "松 (pine)" and "狗 (dog)" are more transparent characters than "村(village)" and "猎(hunt)". So far, it is not clear how the character transparency affects character learning. Also, most previous research in first (Shu & Anderson, 1997; Ho, Ng & Ng, 2003;) and second language reading （Taft & Chung, 1999; Shen & Ke, 2007) is limited to the character and word level by using tests such as radical identification tests and character meaning inference tests. Therefore, another feature that remains unclear is how radical awareness is applied in character learning in context.

The present study explored whether and how partial radical information in different transparency levels helps in the acquisition of characters presented both in isolation and in context. Based on the investigation of Shu et al. (2003), Chinese radicals can provide partial information for 65.6% of 2,570 characters taught in 6 years of elementary school in China. Therefore, whether and how different types of partial information help Chinese character learning can provide valuable direction and significantly affect the method of character instruction.

2. Studies of Radical Awareness and Context Effect in Chinese

For phonetic awareness, previous research (Shu, Anderson, and Wu, 2000; Ho & Bryant 1997) has shown that the regular phonetic component strongly helps pronunciation. Students performed much better on characters with regular phonetic components for both familiar and unfamiliar characters than on characters with irregular and bound phonetic components. Although only 23% of the compound characters are entirely regular, Anderson, Li, Ku, Shu, and Wu (2003) and He, Wang, & Anderson (2005) show that children can use the partial information to learn character pronunciations and that phonological awareness generally facilitates learning. Research on Chinese radical awareness is less developed. The radical component in the semantic-phonetic compounds can be an independent character, such as 木 (tree) and 山 (mountain), or a bound form which only occurs within characters, such as 氵(water) and 扌(hand). Although semantic radicals do not predict the meaning of the whole character, they can provide useful information on the meaning of the whole character as noted above. For example, the radical "木" implies that the characters with it may be related to "tree", and "山"implies that the characters with it may be related to "mountain". Therefore, previous studies reviewed below show that radical awareness helps Chinese character learning and plays an important role in reading development in both first and second language acquisition.

2.1. Radical Awareness in First Language Acquisition

Research studies in first language acquisition show that radical awareness facilitates Chinese character learning. Shu & Anderson (1997) investigated 292 Chinese children in the first, third, and fifth grades, who participated in one of two experiments testing radical awareness. In the experiment, children were presented with two-character words familiar to them from oral language but had never seen them before in print. One of the characters was written in Pinyin, while the other was written in a Chinese character. The children were asked to select one character from among four to replace the Pinyin. For example, the students saw the two-character word "tong2 孔", which means the pupil of the eye. Then they were asked to choose from "瞳 (pupil), 撞(bump), 僮(boy servant), 潼(place name)". The four characters have the same sound components but different radicals. The correct answer is "瞳 (pupil)", which contains the radical related to eye "目". The result showed that third graders and fifth graders were able to select the characters containing the correct radicals even when the characters were unfamiliar to them, which means that the third and fifth graders were aware of the relationship between a radical and the meaning of a character; the first graders were not able to select the characters containing the correct radicals, showing that they had not yet developed a clear ability to utilize the semantic information in radicals. Also, the result showed that children rated as good readers by their teachers displayed more radical awareness than children rated as poor readers.

Ho, Ng & Ng (2003) investigated the significance of radical awareness in Chinese reading development by investigating 20 grade 1, 20 grade 3, and 20 grade 5 Chinese children in Hong Kong. They did semantic-relatedness judgment, semantic-category judgment, and Chinese pseudo character meaning judgment tests. Their results differed from Shu & Anderson's: for semantic-related judgment tests, the results showed that the children had gained some radical awareness by third grade; but for semantic-category judgment and Chinese pseudo character meaning judgment tests, even first graders showed some radical awareness.

No doubt, radical awareness plays an important role in reading development in first language acquisition. However, what the developmental characteristics are and what the right time to give explicit instruction for radical awareness is, is still waiting for more research.

2.2. Radical Awareness in Second Language Studies

Research in second language acquisition also shows that radical awareness has a positive association with novel character learning. The studies, related to L2 radical awareness learning, include Taft & Chung (1999) and Shen & Ke (2007). These studies provide positive evidence that learners' radical knowledge contributes to character learning. Taft & Chung (1999) investigated whether character learning is facilitated when radical structure is given prominence rather than being disregarded as is typically taught. Taft & Chung (1999) show that radical knowledge of Chinese compound characters helps beginning learners to memorize those characters. Twenty-four compound characters were presented to Australian participants without prior exposure to Chinese, and each character, along with its meaning in English, was presented three times. Then the participants were presented with these characters again and were asked to write down the meaning of each character. The participants were divided into 4 groups. Groups 1, 2, & 3 learned the radicals which are contained in the compound characters at various stages in the learning process (before the character was presented to them; at the early time of their learning; at the late time of their learning). Group 4 didn't get any training. The results showed that groups 1, 2, & 3 used their radical knowledge in recalling the meanings of the characters and performed better than group 4. In addition, group 2 performed better than the other groups, which indicates that the most effective method of teaching radicals is to emphasize the radical structure of a character at the time that that character is first encountered, when the links between character and radicals can be readily constructed. This study provides positive evidence that learners' radical knowledge contributes to character learning.

Based on these positive results, Shen & Ke (2007) conducted a study to investigate the developmental trends of nonnative learners' radical awareness across instructional levels. A positive association was observed between the development of radical knowledge application skills and Chinese word acquisition. Participants were 236 nonnative adult learners of Chinese enrolled in first to fourth year Chinese classes at nine U.S. colleges. This study included four tests: a radical perception test (decompose the compound characters); a radical knowledge test (the sound and the meaning of the radical); a radical knowledge application test (novel character meaning inference); a vocabulary test (from recently learned lessons). The results showed that for radical perception skill, students made a dramatic progress after only one year of study. However, students' radical knowledge increased significantly but gradually with more learning. For example, even after 3 years of study, only a 70.95% mean accuracy rate for radical knowledge was observed. With respect to radical knowledge application, the results indicated that students can apply radical knowledge accurately after two years' study. The study indicated that radical knowledge and radical knowledge application do not develop synchronously across learning levels, but radical knowledge application skills and Chinese word acquisition are positively correlated.

2.3. Context Effect on Chinese Reading

Both first and second language learners receive limited classroom instruction on vocabulary development; fortunately, incidental learning from context in unstructured reading has been shown to be an important source of vocabulary enrichment (Jenkins, Stein, & Wysocki, 1984; Nagy, Anderson, & Herman, 1987; Fukkink, Blok, & de Glopper, 2001; Frishkoff, Perfetti, & Collins-Thompson,

2010). This implies that learners are exposed to new words in meaningful contexts and are able to understand their meanings. However, the experimental results of context effect in reading are mixed and complicated. Wysocki and Jenkins (1987) examined children's ability to infer unknown words through morphological analysis and did not find evidence that students actually combined morphological information with contextual clues even for transparent words in contexts that provide strong cues. Likewise, Fischer (1994) examined German high school students who inferred unknown English words and found that learners relied heavily upon word definition and did not use contextual clues to infer the unknown words. However, some studies did demonstrate the context advantages to some extent. Bensoussan & Laufer (1984) and Huckin & Bloch (1993) show that when learners saw an unknown word, they first inferred the meaning from word form, i.e., word stem, prefix, and suffix. When their morphological analysis failed, they resorted to contextual clues. In addition, Bensoussan & Laufer (1984), McKeown (1985), and Huckin & Bloch (1993) suggested that because of the insufficient linguistic knowledge of low-proficiency learners, they are less likely to use contextual clues to infer novel word meaning.

Little research has been done on logographic languages. The results support context can provide informative direction for character learning. Shu, Anderson, & Zhang (1995) investigated children's natural learning of word meanings during reading in a study involving 317 Chinese children in third and fifth grades. The children read one story and then completed a test on the meaning of novel words in the story they read and in another story they did not read. The results showed a significant incidental learning effect on the novel words in both grades. However, only fifth graders were affected by morphological transparency: morphologically transparent words were better learned than opaque words. Mori & Nagy (1999) and Mori (2003) explored the roles of context and word morphology in learning Kanji compound words of Japanese. In her studies, Japanese language learners interpreted unknown compounds consisting of familiar characters under three conditions: words in isolation, contextual clues only, and both word morphological and contextual clues. The results showed that learners performed better in the condition that combined morphological and contextual information. The findings suggest that the contextual information and word morphology play different roles in learning novel Kanji words. Learners mostly learn new words in context. Although the studies on logographic languages focused on word learning in context, they can provide informative direction for character learning in context.

In summary, the above studies illustrate how learners' radical awareness affects their character learning without distinguishing characters in different transparency levels; they also show that the context effect is complicated, depending on morphological transparency and learners' proficiency levels.

The present study examined whether and how partial radical information helps in the acquisition of characters both in isolated and contextual conditions. It also explored whether and how partial radical information helps in the acquisition of characters in learning Chinese as a second language.

3. Present Study

3.1. Aims of the Present Study

The aim of the present study was to investigate whether and how different semantic clues help character learning in order to provide direction for a more effective method of character instruction. More specifically, the present study asked the following research questions:

a. Does semantic transparency affect novel character meaning inference in isolation? (transparent vs. semitransparent characters)

b. Does partial radical information help in inferring novel character meaning in isolation? (transparent + semitransparent vs. single-unit characters)

c. Does semantic transparency affect novel character meaning inference in context? (transparent vs. semitransparent characters)

d. Does partial radical information help in inferring novel character meaning in context? (transparent + semitransparent vs. single-unit characters)

Based on previous research, it was predicted that (1) transparent and semi-transparent radical information would help character learning presented both in isolation and in context, and (2) context would facilitate character learning.

3.2. Methods

3.2.1. Participants

Thirty-seven first year students at the University of Pittsburgh Chinese program were recruited to participate in the study. Only native speakers of alphabetic languages who had never learned Japanese or Korean before were qualified for the test. Data were collected at the end of March, which means learners almost finished a whole academic year of Chinese learning. The Chinese language program consists of two 50-minute lecture classes and five 50-minute recitation classes per week. Namely, there are seven 50-minute sessions per week for a student who registers in the Chinese program. Only simplified characters are taught in the University of Pittsburgh Chinese program, but students are allowed to choose traditional characters as long as they consistently use one system. Learners were paid $10 as compensation.

3.2.2. Materials

Based on the character transparency, Shu et al. (2003) classified the 2,570 characters listed in 12 volumes of the *Elementary School Textbooks* (1996) taught in Beijing and elsewhere into 8 categories and 4 types. The categories are explained by Shu, et al. (2003, p37) as follows:

1. The character has exactly the same meaning as its radical. For example, both the character 嘴 and its radical 口 mean mouth.
2. The character belongs to the category that its radical represents. For example, 妈 (mother) is a 女 (female).
3. The meaning of the character is directly related to the meaning of its radical. For example, the character 橱 (cabinet) is related to the radical 木 (wood).
4. The meaning of the character is indirectly related to the meaning of its radical. For example, the character 浮 (float) has something to do with its radical 氵 (water).
5. The extended meaning of the character is directly related to the meaning of its radical. For example, the original meaning of the character 请 is *visit*. The extended meaning is *invitation*, which is directly related to the meaning of the radical 讠 (say).
6. The extended meaning of the character is indirectly related to the meaning of its radical. For example, the original meaning of 距 is *the toe of a cock*. It is extended to mean distance. Its radical 足 means *foot*. Therefore, the extended meaning is indirectly related to the meaning of its radical.
7. The meaning of the character is unrelated to the meaning of its radical. For example, the character 软 (soft) is unrelated to its radical 车 (vehicle).
8. It is difficult to define the radical of a character because of simplification or other reasons (e.g., 从 *crowd*).

Shu et al. grouped the eight categories into three levels according to semantic transparency: transparent (categories 1, 2, and 3), semitransparent (categories 4, 5, and 6), and other (categories 7 and 8). The proportions of each category of compound characters are displayed in table 1(calculated based on Shu et al.'s table 9, P.37).

Table 1
Proportion of Different Levels of Transparency of Semantic-Phonetic Compound Characters

Type	Transparent			Semitransparent			Other	
Proportion	.58			.30			.13	
Semantic category	1	2	3	4	5	6	7	8
Proportion	.01	.33	.25	.19	.05	.06	.09	.04

We first selected 15 frequent radicals from the first-year Chinese textbook used at the University of Pittsburgh, and then chose 15 transparent and 15 semitransparent characters with the 15 target radicals for the character meaning inference tasks both in the isolated and the contextual conditions. These characters were chosen based on the proportion of each category among the compound characters. Specifically, we chose 15 transparent characters for both conditions based on the ratio of the first three categories, which is about 0: 9: 6. Namely, 15 transparent characters in the character meaning inference task in the isolated condition consisted of 9 characters from the 2nd category and 6 from the 3rd category, and the same arrangement was used for the task in the contextual conditions. Likewise, we chose 15 semitransparent characters for both conditions based on the proportion of each category among the semitransparent characters (about 10: 2: 3). Namely, 15 characters in the character meaning inference task in the isolated condition or the contextual condition consisted of 10 characters from the 4th category, 2 from the 5th category, and 3 from the 6th category. Therefore, 45 characters in each character inference task included 15 transparent characters (9 from the 2nd category and 6 from the 3rd category), 15 semitransparent characters (10 from the 4th category, 2 from the 5th category, and 3 from the 6th category), and 15 characters without radicals (i.e., single-unit characters) as the control items. By doing this, we intended to simulate the different types of novel characters that learners encounter in the real world and also simulate the character-learning conditions in the real world.

3.2.3. Test design

Task 1: radical meaning test

As we mentioned above, 15 frequent radicals, which had been taught in the previous semester, were chosen from the first-year Chinese textbook used at the University of Pittsburgh. Learners were asked to select the meanings in English for the 15 target radicals from a table with 30 candidates. This task served as a screening test. If a learner made errors on some radicals, then his/her responses to those radicals were excluded from the subsequent data analyses. Test examples are shown below:

1. 亻 relates to ( ) 2. 衤 relates to ( )

1.knife	2. female	3. clothes	4. earth	5. money
6. hand activity	7. horse	8. food	9. bamboo	10. farmland
11. fire	12. mouth	13. claw	14. sickness	15. person

The first radical in the example is related to “person”; the second is related to “clothes”. For this task, the learner needs to know each radical’s meaning to select the right choice.

Task 2: character meaning inference task in isolated condition

Target novel characters in this task were chosen from the classification list of Shu et al. (2003). Learners were presented with 3 novel characters in each test item and asked to circle the character that best fits the meaning provided in English. There were 15 transparent target characters, such as example (a), and 15 semitransparent target characters, such as example (b), each of which has one of the 15 target radicals, plus 15 single-unit characters, such as example (c), totaling 45 items in task 2. For example:

a. A kind of tool: spade or shovel
   摽　　蹄　　铲

b. To cast metal
铸　　踢　　捷
c. Pottery
丸　　缶　　曲

For this task, learners need to apply understanding of semantic radicals to learn new compound characters and infer the character meaning at the character level.

Task 3: character meaning inference task in contextual condition

As in the previous task, target novel characters in this task were chosen from the classification list of Shu et al. (2003). Learners were presented with a sentence in English, but the sentence includes an unknown Chinese character as in the example below. As in Task 2, there were 15 transparent target characters in 15 sentences, such as example (a), and 15 semitransparent target characters in 15 sentences, such as example (b), each of which has one of the 15 target radicals, plus 15 single-unit characters, such as example (c), totaling 45 characters/items in task 3. The sentences containing the target characters were carefully designed so as to represent sentential contexts that were comprehensible to the target students and still sounded natural to native speakers. Two English native speakers helped in balancing the possibility of choices that are contextually appropriate. In this task, there were also three choices for each novel character, each of which contained a target radical: one is correct both in terms of radical and context (+C +R); one is only correct in terms of radical (–C +R); one is only correct in terms of context (+C –R). For single-unit characters, the three choices were designed as follows: two were contextually correct, but only one was the correct choice; one was the meaning of an orthographically similar character. For example:

a. Many people like eating 藕.
i. a kind of meat　ii. a kind of cactus　iii. a kind of vegetable
(“meat” +C –R; “cactus” –C +R; “vegetable” +C +R)
b. He 藏 behind the tree.
i. is lush　ii. hides　iii. smokes
(“is lush” –C +R; “hides” +C +R; “smokes” +C –R)
c. His lips look 乌.
i. chapped　ii. like a bird’s　iii. blue
(“chapped” is contextually right; “like a bird’s” is an orthographically interaction; “blue” is the right choice)

For this task, learners need to combine both the radical and contextual information to select the correct choice. They need to apply their knowledge of semantic radicals for learning new compound characters and infer their meanings at the sentence level.

3.2.4. Procedure

After learners finished Tasks 1 to 3, they were given a character list which included all the characters in the tests. They were asked to circle any characters they knew, and they also filled out a language background investigation form.

3.2.5. Data screening criteria

Basically, three criteria were used for data screening. First, students from an alphabetic language background were included, while native speakers of languages that use logographs - which are Chinese characters, Hanja (Chinese character used in Korean) and Kanji (Chinese character used in Japan) - were excluded, as were students who had had prior study or other related experience in such languages. Second, if learners indicated in task 1 that they did not know the meaning of some radicals, then the characters that contained those radicals in the inference tasks were excluded. Finally, we had 30 out of 37 qualified students who were from an alphabetic language background and hadn’t learned

Japanese or Korean before. (5 students had parents or one parent who was from China; 1 student from an alphabetic language background had learned Japanese 5 years before; 1 student had lived in China for half a year). Third, because some learners indicated that they knew some target characters, those characters in the tests were excluded. In the collected data, 2 participants had previously learned 2 target characters and 3 participants had learned 1 character prior to the data collection.

4. Analysis and Results

All data were calculated based on the accuracy percentage first. Six mean scores and 6 standard deviations (SD) for three transparency levels (i.e., transparent, semitransparent, single-unit character) across two inference conditions (isolated and contextual) are presented in Table 2.

Table 2
Descriptive statistics for 6 different conditions

	Isolation		Context	
	%	SD	%	SD
Transparent	88.7	.08	89.8	.12
Semitransparent	67.8	.13	46.0	.22
Single-unit	36.5	.11	34.8	.10

*N =30

There seems to be differences in the mean accuracy scores among the three transparent levels. In the two conditions, transparent characters induced higher accuracy scores than semitransparent characters, which induced higher accuracy scores than single-unit characters. However, the accuracy rates between the two conditions do not consistently show differences. Specifically, the accuracy rates for the transparent and single-unit characters were not different between the two conditions (88.7% and 89.8% in the isolated and contextual conditions, respectively for the transparent characters, and 36.5% vs. 34.8% for the single-unit characters). The difference in the semitransparent characters between the two conditions did not show the same pattern (67.8% and 46.0% in the isolated and contextual conditions, respectively). The participants performed more poorly in context than in isolation for the semitransparent characters. According to these descriptive statistics, we might see that the transparency effect does not differ across conditions, but the contextual effect differs across transparency levels.

A one-way within-subjects ANOVA was performed to test the effect of transparency in isolation. The results show that the scores of novel character meaning inference tasks are significantly different among the three transparency levels in isolation, $F(2, 58) = 177.300$, $p < .01$, partial $\eta^2 = .859$. In order to find the source of the differences, post-hoc pairwise comparisons were performed using Bonferroni adjustment. Students achieved significantly higher scores on the transparent characters ($M = 88.7\%$, $SD = .006$) than on the semitransparent characters ($M = 67.8\%$, $SD = .017$), $p < .01$, and they achieved significantly higher scores on the semitransparent characters than on the single-unit characters ($M = 36.5\%$, $SD = .012$), $p < .01$.

Likewise, the same procedure was used for inference performance in the contextual condition. A one-way within-subjects ANOVA was performed to test the effect of transparency in context. The results showed that the scores of novel character meaning inference task were significantly different among the three transparency levels in context, $F(2, 58) = 128.075$, $p < .01$, partial $\eta^2 = .815$. Post-hoc pairwise comparisons showed that the students achieved significantly higher scores on the transparent characters ($M = 89.8\%$, $SD = .014$) than on the semitransparent characters ($M = 46.0\%$, $SD = .044$), $p < .01$, and they achieved significantly higher scores on the semitransparent characters than on the single-unit characters ($M = 34.8\%$, $SD = .010$), $p = .020$.

In order to find the pattern of the differences in the scores across the three transparency levels between the two inference conditions, paired t-tests were conducted to compare the scores between the two conditions at each transparency level. The results showed that there was a significant difference between the two conditions for the semitransparent characters, $t(29) = 5.114$, $p < .01$; no

difference was found between the two conditions for the transparent or single-unit characters. These results seem to indicate that context information may impede the learning of semitransparent characters, but not affect meaning inference of the transparent and single-unit characters in the present study.

We also analyzed errors in the meaning inference tasks in the contextual condition. All incorrect responses to the transparent and semitransparent characters were classified into radical-based or context-based errors. The error analysis reveals that 74.6% (47/63) of the inference errors were radical-based for semitransparent characters, whereas 41.2% (7/17) were radical-based for transparent characters. These results seem to indicate that learners may depend more heavily on contextual information in inferring the meaning of semitransparent characters.

5. Discussion

This section is organized according to the previously mentioned research questions. In terms of the first research question—does semantic transparency affect novel character meaning inference in isolation? (transparent vs. semitransparent characters)—obviously, our results showed that a transparent relationship between a character's radical information and its meaning helped learners perform better on the transparent characters than on the semitransparent characters. The transparent relationship helps learners infer the novel character meaning more easily based on their radical knowledge. This implies that semantic transparency affects the learning of novel characters.

The second question is whether partial radical information helps in inferring novel character meaning in isolation (transparent/ + semitransparent vs. single-unit characters). The results demonstrated that partial radical information in transparent and semitransparent characters helps novel character learning. The study showed that in isolation participants performed better on both the transparent and semitransparent characters than on the single-unit characters. This indicates that even though radical information does not provide the meaning of whole characters and that they only provide partial information to the whole character directly or indirectly, partial information can nevertheless facilitate the learning of Chinese character in isolation. The third question is whether semantic transparency affects novel character meaning inference in context (transparent vs. semitransparent characters). The results demonstrated that the learners performed much better on the transparent characters than on the semitransparent characters. This finding is consistent with that from the first research question and further supports the suggestion that semantic transparency affects character learning. The last question is whether partial radical information is helpful in inferring unknown character meaning in context. The results did not show any contextual benefit for the transparent and the single-unit characters. Instead, our data revealed that contextual information interfered with novel character learning when it involves semitransparent characters. This is inconsistent with the results of previous research (Shu, et al., 1995), in which contextual information facilitated the learning of unknown words. The results from this study could be explained by the suggestion of Bensoussan & Laufer (1984), McKeown (1985), and Huckin & Bloch (1993): low proficiency learners first infer novel word meanings based on their stems and affixes, and resort to contextual clues only when the morphological analysis fails; that their insufficient linguistic knowledge impairs their ability to infer word meanings from context. According to these researchers, for transparent characters, learners can obtain the meaning of novel characters using exclusively morphological analysis, i.e. radical information, easily and succeed in inferring the meaning from the radicals, so they do not need the contextual information. Thus, low proficiency learners do not take advantage of contextual information. For semitransparent characters, it is hard for learners to get semantically relevant information from radicals, and so they do not rely on radical information and resort to contextual information, especially when the context was given in participants' native language as in this study. The error analysis on the semitransparent characters demonstrated that learners made errors mainly due to overreliance on contextual information. For the single-unit characters, it is hard to explain why participants did not get any benefits from context compared to the isolated condition. They performed equally in the two conditions. In short, when the radical provides useful clues to the meaning of whole characters, learners depend more on radical information in novel character inference; when it is hard to tell the relation between the meaning of a whole

character and its radical, learners only depend on context and disregard radical information. Therefore, the context effect varies from one character to another depending on the degree of semantic transparency.

The pedagogical implications are that teaching compound characters componentially may be more effective than teaching them holistically. Because the component of compound characters, i.e. radical, helps in character learning, devoting some instruction to radical awareness and to character components may help new character learning and benefit learners more than exclusively focusing on characters themselves. In addition, the result that radicals of transparent characters contribute more to unknown character meaning inference than those of semitransparent characters also suggests that teachers should treat transparent and semitransparent compound characters differently, and that teaching transparent characters componentially may be more beneficial to learners of Chinese. Further, whether semitransparent characters should be taught componentially should be more directly explored in further research.

6. Conclusion

The present study demonstrated that although semantic radicals only provide partial information on the meaning of whole characters, it helps the acquisition of characters presented both in isolation and in context. Also the study showed that semantic transparency contributes to novel character learning. These findings of the study provide important pedagogical implications. First, teaching compound characters componentially may be more effective than teaching them holistically. Second, raising learners' radical awareness would be helpful in leading them to become independent learners. Third, semantically transparent and semitransparent characters should possibly be taught differently in the classroom due to the transparency effect. These hypotheses need to be tested more directly through experiments involving teaching Chinese compound characters using different methods.

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Selected Proceedings of the 2011 Second Language Research Forum: Converging Theory and Practice

edited by Erik Voss,
Shu-Ju Diana Tai, and Zhi Li

Cascadilla Proceedings Project Somerville, MA 2013

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ISBN 978-1-57473-458-4 library binding

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Wang, Jing and Keiko Koda. 2013. Does Partial Radical Information Help in the Learning of Chinese Characters? In *Selected Proceedings of the 2011 Second Language Research Forum*, ed. Erik Voss et al., 162-172. Somerville, MA: Cascadilla Proceedings Project. www.lingref.com, document #2914.