

Radical Awareness and Applications in Chinese Literacy Acquisition for Heritage and Non-Heritage Speakers of Chinese

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Abstract: The Chinese orthographic system presents many unique features not found in alphabetic orthographies. Among these differences is the existence of the radical, a subcomponent of Chinese characters. Radicals can serve as either phonetic or semantic cues within characters, and although the degree to which radical and character are related may vary, sensitivity to the positional and functional features of radicals can be useful for readers in accessing such cues. Thus, in learning to read Chinese, an awareness of radicals may enable more reliable inferences about novel characters and relate to one's overall strength as a reader. This paper synthesizes ten studies on the topic of Chinese-language radical awareness, its features and development, and its relationship to aspects of literacy acquisition, such as character recognition and overall reading ability. Five questions guided this research process, which are delineated in a subsequent section. The findings of the following studies indicate a strong correlation between readers' radical awareness and components of literacy acquisition, for both heritage Chinese speakers and non-heritage learners of Chinese. An additional finding was the fact that readers tend to rely on semantic radicals, over phonetic radicals, in decoding novel characters. The studies also corroborated evidence that the development of word-reading, and morphological knowledge in general, for readers in Chinese proceeds in distinctive stages, with the acquisition of structural knowledge preceding functional knowledge. The significance of these collective findings includes the pedagogical implication that explicit instruction on radicals would confer benefits for both young L1 speakers and non-heritage learners in the process of learning to read Chinese.

Keywords: radical awareness, heritage learners, non-heritage learners.

摘要: 中文书写系统具有很多其它书写系统没有的特征。这其中一点就是部件。部件可以作为声旁或者形旁。虽然这些部件和整字的关系有别，但是对部件的位置和功能的敏感性对中文学习者识字有用。因此，在阅读能力的学习过程中，部件意识对生词词义的猜测有价值并和学习者的整体阅读能力有关。本文综述有关中文部件意识、其特征及发展的文章来回答五个研究问题。结果发现华裔和非华裔学习者的部件意识和他们的阅读能力有很强的相关。此外，学习者倾向于通过形旁而不是声旁来推测陌生词的词义。本文还发现总体来说，对生词的阅读能力的发展和语素知识的发展有不同的阶段，是由词内结构知识发展到对功能知识的掌握。关于中文阅读能力的教学，我们发现对部件的显性教学也有助于中文为母语的儿童和非华裔成人提高阅读能力。

关键词: 部件意识，华裔学习者，非华裔学习者

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Introduction

Alphabetic versus logographic orthographies & paper overview

There has been much attention, both popular and scholarly in nature, devoted to the topic of how the Chinese writing system differs from many others, particularly from alphabetic orthographies. The Chinese writing system is logographic and morphosyllabic; that is, written characters, the logographs, represent whole words or phrases, and each unit is representative of both a syllable and a morpheme. This is in contrast to the alphabetic principle, which organizes individual letters in an alphabet in relation to certain speech sounds. Because of this, the process of learning to read in an alphabetic orthography largely emphasizes phonemes, or individual speech sounds, and mapping sounds to letters and vice versa (Chan, 2013). But Chinese is not alphabetic, as characters represent whole morphemes and syllables. However, this does not mean characters cannot be broken down into parts — characters are made up of radicals, and radicals are comprised of strokes. In order to provide a foundational understanding of these Chinese orthographic components and prepare to discuss the studies at hand, I will begin this paper by offering an overview of the basics of Chinese orthography at three different levels of structure: radical, character, and word. Then, I will define radical awareness and briefly address the ongoing debate as to whether radical awareness is representative of morphological knowledge or orthographic knowledge. I will describe gaps in existing literature on this topic and present the synthesis questions that guided my research, before explaining methodology and coding scheme and then proceeding with the bulk of the synthesis. The paper will conclude with a section on significance and pedagogical implications, as well as a final appendix that contains a table of the coded studies.

Basics of Chinese orthography

To precede this paper's discussion of Chinese-language radical awareness, a brief overview of some basics of the Chinese writing system will provide a useful foundation. Three levels of structure are addressed here: the radical, the character, and the word. Radicals are individual units comprised of strokes, which are used to form complete characters. The majority of Chinese characters, over 80%, are made up of two or more radicals (Tong et al., 2017; McBride, 2016). Specifically, these characters are known as semantic-phonetic compound characters, because they consist of both semantic radicals, associated with meaning, and phonetic radicals, associated with pronunciation. In compound characters with the dominant left-right internal structure, the semantic radical is typically found on the left side of the character, and the phonetic radical usually appears on the right (McBride, 2016). The character 洋 yáng, meaning *ocean*, is an example: the left-hand component 氵 denotes water, while the right-hand component 羊 is pronounced yáng, the same pronunciation as the whole character. The character 蜻 qīng, meaning *dragonfly*, is another semantic-phonetic compound: the left component 虫 denotes insect, and the right component 青 is pronounced qīng. In the Chinese orthography, there are approximately 800 phonetic radicals and 200 semantic radicals (Hoosain, 1991). It is important to note that the pronunciation of a phonetic radical does not necessarily match the pronunciation of the character in every aspect; they can differ in tone, initial, or final (or a combination of these), but the radical may nevertheless provide valuable clues. Likewise, the relationship of semantic radicals to the meaning of the whole character is not always perfectly transparent or intuitive. According to one study by Shu et al. (2003), 58% of semantic radicals under review were classified as transparent, or having a meaning directly related to the meaning of the character, while 30% were categorized as semitransparent and 9% were categorized as opaque, or having nothing to do with the character's meaning. Despite

some variability in how reliable the information provided by radicals is, however, the nature of the Chinese language makes recognizable radicals a highly useful tool — Chinese has just approximately 400 possible syllables, or 1200 when tones are taken into account (Shu & Anderson, 1997). Many of these syllables share similar written forms — take, for example, 请, 清, and 情 — differentiated only by their semantic radical. Given this great deal of overlap, the fact that the majority of characters contain cues to their meaning is useful to readers in disambiguating homophonous and near-identical characters. Besides radicals and characters, the final level of structure to be addressed here is the word. The word, in Chinese, represents the same conceptual thing as a word in an alphabetic orthography, but they are slightly more difficult to define in that words can be comprised of either one or more characters, and boundaries between words in Chinese are not separated in print. Just as most characters are comprised of two or more radicals, most Chinese words — approximately 65% — are comprised of two or more characters (McBride, 2016). Above, I said that Chinese is morphosyllabic, and this is true in most cases, but in discussing Chinese morphology, it is important to make the technical distinction that not *all* individual syllables in Chinese correspond to meaningful morphemes when standing alone — 葡萄, for example, is the word for *grape*, but neither 葡 nor 萄 taken alone carries a meaningful reference to speakers of Chinese. For the most part, however, it is safe to say that most Chinese compound words can be parsed into characters that are also able to function as morphemes independently — take, for example, 电话 (*telephone*), composed of 电 (*electric*) and 话 (*speech/words*); or 牛油 (*butter*), composed of 牛 (*cow/ox*) and 油 (*oil*). In this way, Chinese is understood to be a logographic system, with its individual written units, or characters, representative of whole words.

Defining radical awareness

Before embarking on a synthesis of studies on the topic of radical awareness, it is necessary to define what is meant by this term. One definition of radical awareness that I found useful was offered by Shen and Ke (2007), who referred to it as a functional understanding of the role of radicals in forming Chinese characters, and the ability to use this knowledge consciously in learning characters. Another helpful understanding of the concept was offered by Tong et al. (2017), who described radical awareness as the ability to access the orthographic, phonological, and semantic information of radicals for character recognition. Essentially, each of the ten studies understood radical awareness to be an aspect of an individual reader's functional knowledge of Chinese, including their knowledge of the existence of radicals as well as their ability to actively utilize this knowledge in interpreting characters while reading. One thing that researchers and scholars debate, however, is whether radical awareness should be characterized as representative of a person's morphological knowledge, or orthographic knowledge (Shu & Anderson, 1997). Within alphabetic orthographies, morphemes are typically units of meaning that are pronounceable, and morphological awareness is conceptualized as one's knowledge of possible combinations of morphemes within a given language, as well as the word-building rules that dictate when and how morphemes can be manipulated. In such a framework, morpheme-level manipulations are identifiable in a written and spoken language such as English because of a change, such as an addition or modified pronunciation, to word structure (McBride, 2016). But semantic radicals, however, are not pronounced within characters, begging the question of if they can be considered morphemic if they can be manipulated only in print and not in speech. What seems to be at issue in the debate on how to characterize radical awareness is not something having to do with radicals themselves, in fact, but with the accepted underlying definition of morphology.

Because morphological knowledge was conceptualized based on definitions from orthographies that do not have semantic radicals (McBride, 2016), our resultant understanding of what constitutes a morpheme is decidedly lacking the necessary conceptual framework for dealing with the Chinese logographic system. In the sense that radicals are crucial constituents to the writing of characters in Chinese, radical awareness could easily be classified as orthographic knowledge. But at the same time, the fact that semantic radicals play a role not only in configuration but also in cueing understanding of meaning for a majority of characters, and in this sense serve as a productive tool for learning to read, semantic radicals could be understood as theoretically very close to morphemes (McBride, 2016). Thus, one could potentially argue that radical knowledge constitutes an aspect of both orthographic and morphological awareness for readers of Chinese.

Gaps in existing literature

The subject of the Chinese written language has been given a great deal of attention and scholarly investigation. Less so, however, has been the subject of Chinese character constituents, namely, radicals, and their properties and functional uses for speakers and learners of Chinese. And even when this subject is explicitly taught, discussions on the constituents or make-up of Chinese characters will often emphasize the characters that are pictographs, with the shape or appearance of the character itself indicative of its meaning. But truly pictographic characters are rare (as stated, logographic is a more accurate characterization of the Chinese orthography) and focusing a discussion of character constituents on a few simple characters such as 日, 山, and 木 is necessarily oversimplistic and, in most cases, unrepresentative of Chinese derivational morphology. Of course, scholarly literature tends to treat the subject more accurately, but even as the topics of radicals and radical awareness have been given increased exposure over recent years, there still exists a scarcity of information on the subject, particularly in the treatment of Chinese

as an L2, as opposed to first language. The most evident gap in existing research seems to be in this area, of Chinese as an L2 and of the development of radical awareness among learners of Chinese. A great deal of existing studies focus on children who are heritage speakers of Chinese, and examine radical awareness in the context of children's early development of their L1 reading skills. A sizable subgroup of this literature concentrates on subjects with documented reading difficulty or learning differences like dyslexia and operationalizes radical knowledge as an element of their L1 reading ability in attempting to separate and distinguish various subskills for these young readers. In contrast, studies on morphological or orthographic awareness largely concentrate on expert, or adult heritage speakers of Chinese, rather than subjects for whom Chinese is an L2. Thus, while I have incorporated a small number of studies that focus on heritage-speaker children to serve as a baseline for comparison, I draw mostly on research that specifically studies the radical awareness of non-heritage learners of Chinese. In addition, another gap or scarcity in radical awareness research lies specifically in the topic of Chinese phonetic radicals: many of the studies I found exclusively investigated semantic radicals or treated semantic radicals as the only relevant subject of analysis. Research specifically devoted to the role of phonetic radical awareness among Chinese speakers is either scarce or nonexistent, for I came across no studies that chose to research solely phonetic radicals and neglected semantic radicals. This makes sense, given the demonstrated usefulness and productivity of semantic radical knowledge, as well as their necessary co-occurrence with phonetic radicals in compound characters; I would not anticipate it being either useful or possible for researchers to attempt to isolate phonetic radicals in order to examine them exclusively. I do, however, think that the discussion of a semantic radical preference among Chinese speakers' merits attention, and thus I have purposefully selected a few studies that

intentionally make this distinction between semantic and phonetic radicals to illustrate this so-called “semantic bias”.

Present Study

Synthesis questions

A basic assumption of this research process was the fact that radical awareness itself exists, for both heritage speakers and learners at a certain stage, even if comprehensive understanding of their regularities and functions is lacking. In undertaking this research, I wanted to address features of radical awareness in both heritage speakers of Chinese and in non-heritage learners. The research questions that guided this synthesis, then, are as follows:

- 1) When does radical awareness begin to manifest in children?
- 2) Is radical awareness acquired abruptly or does it develop in stages, for both heritage speakers and learners?
- 3) What is the effect of radical awareness on components of Chinese literacy acquisition, such as character recognition and word reading, for both heritage speakers and learners?
- 4) What is the relationship of radical awareness to overall reading ability, for both heritage speakers and learners?
- 5) Is there a preference that favors either semantic radicals or phonetic radicals in helping readers decipher characters, for both heritage speakers and learners?

Methodology and coding scheme

- The databases that comprised the sources for my research were: JSTOR, LLBA, PsycINFO, and Google Scholar.

- The keywords searched in the above four databases were: “radical awareness,” or alternatively “radical sensitivity,” or “radical knowledge,”; “character reading,” or alternatively “character recognition,” “character acquisition,” “word acquisition,” or “word reading,”; and “ability.”
- The first two steps generated upwards of 100 studies across the four databases, but closer examination revealed many of these studies to be only very loosely relevant to my topic, or overly general or overly narrow in scope. Eventually, ten primary studies (marked with * in References list) were selected as components of the synthesis by referring to the following inclusion and exclusion criteria: studies on radical awareness in Chinese and published in English were included (regardless of whether research site was Hong Kong, mainland China, or elsewhere), and studies with a focus on participants with diagnosed learning differences, as well as overly broad studies on general principles of Chinese morphology, were excluded.
- Guided by the above five synthesis questions, I have coded the ten studies with reference to the synthesis questions they relate to, as well as some helpful demographic information such as what kind of participants each study deals with and where the research site was located. A table with the coded studies is presented as Table 1.

Table 1.
Summary of studies on Chinese-language radical awareness

Study	Related Synthesis Question #	Subject Language Backgrounds	Average Age of Subjects	Grade Level of Subjects	Research Site	Avg. Length of Chinese Study
Shu and Anderson (1997)	1, 2, 3, 4	heritage Chinese	not given	1, 3, and 5	Beijing, China	
Tong, Tong, and McBride (2017)	1, 2, 3, 5	heritage Chinese	5.89, 8.09, and 11.06	kindergarten, 2, and 5	Hong Kong	
Ho, Ng, and Ng (2003)	1, 2, 3, 5	heritage Chinese	7, 9, and 11	1, 3, and 5	Hong Kong	
Zhang, Li, Dong, Xu, and Sholar (2015)	3, 5	non-Chinese	13.2	7 and 8	southern U.S.	4 months

Study	Related Synthesis Question #	Subject Language Backgrounds	Average Age of Subjects	Grade Level of Subjects	Research Site	Avg. Length of Chinese Study
Wong (2017)	2, 3	non-Chinese	11.24	senior-primary	Hong Kong	4.35 years
Tong and Yip (2014)	3, 5	non-Chinese	22.86	undergrad and graduate	Hong Kong	3.45 years
Nguyen, Zhang, Li, Wu, and Cheng (2017)	3, 4, 5	non-Chinese	19.63	undergrad	Hanoi, Vietnam	1 year
Su and Kim (2014)	2, 3, 5	non-Chinese	20.59	undergrad and graduate	southeastern U.S.	more than one semester
Shen and Ke (2007)	2, 3	non-Chinese	18-26	undergrad	several U.S. universities	1-4 years
Williams and Bever (2010)	3, 5	heritage Chinese	not given	undergrad and graduate	University of Arizona	

Results

Radical awareness among children

Evidence gathered from numerous experiments performed in Chinese elementary schools corroborates the theory that radical awareness among Evidence gathered from numerous experiments performed in Chinese elementary schools corroborates the theory that radical awareness among L1 Chinese-speaking children is positively correlated to their character and word reading abilities. The three studies focusing on children examined here, by Shu and Anderson (1997), Tong et al. (2017), and Ho et al. (2003) each looked at variance with age level and recorded findings not only on radical awareness specifically, but also on how morphological and orthographic knowledge seems to be acquired by children gradually, in stages.

Shu and Anderson (1997) performed two experiments at a Beijing elementary school, with a total of 292 first, third, and fifth-grade students as participants. The first experiment, consisting of a multiple-choice test, presented children with a series of replacement tasks in which a two-character word was given, with one of the two appearing in Pinyin (the Shu and Anderson (1997) performed two experiments at a Beijing elementary school, with a total of 292 first, third, and fifth-

grade students as participants. The first experiment, consisting of a multiple-choice test, presented children with a series of replacement tasks in which a two-character word was given, with one of the two appearing in Pinyin (the ‘target’ character), that instructed children to select one of the four given character options to replace the Pinyin. Characters were classified as either familiar, recently learned, or unfamiliar for each grade level, and target characters were classified as morphologically transparent, morphologically opaque, or unanalyzable, meaning that the character consisted of just one part and could not be further broken down.

The results of this first experiment showed that in general, children performed better on morphologically transparent characters than either opaque or unanalyzable characters, both when the characters were recently learned and especially when the characters were unfamiliar. This performance, particularly on less familiar characters, indicates the presence of morphological-level processing in the participants. To attain these higher scores on morphologically transparent characters, especially unfamiliar ones, the children must have been able to identify the various radicals and make inferences about the relationship between the radical and word meaning as a whole.

This experiment also revealed a difference in performance among students rated by their teachers as high-level readers and the performance of those rated as average or low-level readers. As character familiarity decreased, better readers got statistically-significantly higher scores than did poorer readers, both on recently learned characters and unfamiliar characters. This trend also supports the theory that better readers have greater awareness of the morphological constituents of characters, in this case, the semantic radicals, and that this radical knowledge is useful to them in decomposing novel characters.

Analyzing the results as a function of grade level, however, revealed that the ability to productively use radical information was largely limited to the third and fifth-grade participants; this finding is nearly exactly replicated by Ho et al. (2003). First-grade students had some structural knowledge but did not yet demonstrate the ability to recognize and use the semantic information contained in radicals — this ability did not begin to manifest until third grade. This suggests at the very least a developmental progression in radical-level processing ability, a finding similarly reflected in the research of both Tong et al. (2017) and Ho et al. (2003).

The study by Tong et al. (2017), which examined 535 kindergarten, second, and fifth-grade students across six kindergartens and five elementary schools in Hong Kong, found that awareness of the positional, phonological, and semantic cues of radicals is developmental in nature, and even that sensitivity to each of these types of cues varies as a function of age.

Using a picture-character mapping task, which presented pictures of objects or specific concepts and then asked students to select the most plausible out of four “character” options, all of which were nonexistent characters but contained real Chinese character components (radicals), the researchers found that children’s chosen radical strategies differed according to grade: younger students tended to rely on the phonetic cue in character learning, whereas older students were more inclined to rely on semantic and positional information of the embedded radicals. The overall trend revealed by regression analyses was that with increased age, children’s sensitivity to positional constraints and semantic cues increased, while sensitivity to phonetic radicals, or sound-based cues, decreased. The suggestion here is that early character learning emphasizes sound-form mapping — thus causing the kindergarteners to rely more on phonetic radicals in coding novel characters — while more advanced learners, with more years of schooling and more exposure to characters, have become more sensitive to the semantic and positional aspects.

The study by Ho et al. (2003) also chose to distinguish semantic from phonetic radical awareness, conducting two experiments in order to isolate each type of radical knowledge and measure their correlation, if any, to Chinese word reading and sentence comprehension. This study examined a total of 60 first, third, and fifth-grade children from a primary school in Hong Kong. Unlike the previous two, the researchers in this study administered an IQ test and a reading-aloud test in addition to various radical judgment tasks, including a sentence-completion task and tasks relating to radical position and semantic relatedness. As with the study by Shu and Anderson (1997), Ho et al. (2003) found that children as young as first grade had acquired some knowledge of character structure, but it was not until third grade that students became aware that semantic radicals served semantic cuing functions. The first experiment found that semantic radical knowledge correlated significantly to both Chinese word reading and sentence comprehension. Likewise, the second experiment found that phonetic radical knowledge correlated significantly with Chinese word reading.

A striking overlap between this study and the study conducted by Tong et al. (2017) relates to the theory of staged radical awareness development. The findings of both Ho et al. (2003) and Tong et al. (2017) support a staged model in which children first acquire structural, or positional, knowledge before functional knowledge (e.g., semantic function of semantic radicals). The research design employed by Ho et al. (2003) and the wide variety of radical judgment-related tasks they administered was especially useful in clarifying this phenomenon: in general, it seems that children acquire positional radical awareness before becoming attuned to the functional regularities of radicals.

Given this conclusion about the developmental stages of radical-level processing, which was also reflected in the findings of the first experiment by Shu and Anderson (1997), a second

experiment by these researchers focused only on their third and fifth-grade participants, leaving out the first-grade group included in their first round. It utilized the same testing procedure, but this time with all unfamiliar characters, and for the target characters, the researchers varied whether they contained familiar or unfamiliar radicals.

The results of this second experiment found that children's performance on transparent characters with familiar radicals was considerably better than on transparent characters with unfamiliar radicals or on opaque characters. This confirmed the findings from their first experiment, which indicated that students were capable of using information in radicals to decode characters. An especially noteworthy finding from this experiment, however, came from children's performance on the set of transparent characters containing unfamiliar radicals. Their poor performance on this set supports the conclusion that it is an awareness of radicals, rather than something else, being used by participants for the purposes of successfully interpreting novel characters.

Additionally, the interaction of reading level with these results was revelatory as well — for students of the three different reading levels, there was no difference in performance on opaque characters, and no statistically significant difference on morphologically transparent characters with unfamiliar radicals. But on morphologically transparent characters with familiar radicals, readers of different strengths performed quite differently, with high-level readers far outperforming the average and low-level groups. This is a significant finding, for if the high scores of the better readers were attributable to a greater knowledge of certain characters in general, they would have outperformed the other groups on *all* character types — transparent, opaque, and unanalyzable. But they scored better *only* on characters with transparent morphology, implying

that the advantage of the stronger readers has to do with their ability to make use of radical awareness.

Overall, these three studies on radical awareness among students acquiring Chinese as an L1 demonstrate that not only are children aware of radicals and their functional properties and can make use of them to interpret novel characters, but also that radical-level awareness is acquired in progressive stages. Notably, the fact that both Shu and Anderson (1997) and Ho et al. (2003) found that first-graders seemed to be unaware of semantic information in radicals, while Tong et al. (2017) found that kindergarteners were sensitive only to phonetic radical cues, offers further evidence for this developmental theory — that children acquire a sensitivity to phonological elements first, and the ability to utilize semantic cues later. In addition, these studies demonstrate that orthographically, structural knowledge precedes functional knowledge for young children learning to read Chinese. Another important finding was a correlation between radical awareness and reading comprehension, with stronger readers demonstrating a reliance on radical knowledge to interpret characters, while poorer readers either did not or could not make use of radical knowledge for this purpose.

Radical awareness among adolescent learners of Chinese

To expand upon the findings gathered from research on young L1 speakers of Chinese, I now turn to studies that focus on learners of Chinese as a foreign language (CFL). The two studies examined in this section focus on adolescent-age CFL learners.

Zhang et al. (2015) examined 34 American students in seventh and eighth grade. Each of the students were beginning-level learners, with an average of four months' Chinese language experience. Participants were administered a paired associate character learning task and completed three measures: word reading, semantic radical knowledge, and phonetic radical

knowledge. Like the test administered by Tong et al. (2017), the character learning task made use of non-real pseudo characters, allowing for the semantic transparency and phonetic regularity of their constituent radicals to be easily manipulated and controlled. The major finding of this study was the fact that these beginning learners of Chinese were able to use transparent semantic radicals to decode meanings of novel characters but were consistently less able to use regular phonetic radicals to learn to produce character pronunciations. This is consistent with the conclusions of Ho et al. (2003) and Tong et al. (2017) in their studies of L1 Chinese-speaking children, which found a predominant reliance on semantic strategy as an aid to word reading for students who had reached a certain age. Likewise, the American students examined in this study demonstrated a preference for using the semantic properties over the phonological properties of radicals in character learning. The researchers posit that this can be explained as a result of the fact that semantic radicals are more visually distinct and more reliable as cues than phonetic radicals (Zhang et al., 2015; Shen & Ke, 2007). They also point out that semantic radicals are typically high transparency, high frequency, and have a large family size (Zhang et al., 2015). Thus, it seems that non-heritage Chinese learners exhibit many of the same spontaneous habits and preferences in radical-level processing as do heritage speakers of Chinese with at least a third-grade education. It is necessary to note, however, that this study examined exclusively beginning-level students of Chinese, and thus offers rather tentative conclusions as to learners' radical awareness overall. To further investigate how learners' radical awareness relates to character reading development over time, I turn to a study by Wong (2017).

The study by Wong (2017) is unique among the ones discussed here for its longitudinal approach, enabling it to provide insight as to how radical knowledge and character reading ability interact over time. It is also unique in its effort to distinguish simple, or one-radical, characters

from multi-radical compound characters, and investigate them separately from each other. The participants in this study, as in the research of Zhang et al. (2015), were adolescent learners of Chinese as a foreign language. Unlike in the previous study, these participants were not Americans but rather non-Chinese senior-primary students at a school in Hong Kong, with backgrounds from countries including Nepal, Pakistan, and India. Students had a variety of L1s, and also generally had English proficiency too. In total, 142 students were assessed at the end of their primary-four term (Time 1) with tests of Chinese character reading and radical awareness, and then reassessed at the end of their primary-five term (Time 2) for character reading again. The findings from this study demonstrated, firstly, a statistically significant correlation between simple character reading and radical awareness. It also showed that radical awareness accounted for compound character reading variance over the course of a year when the effect of simple character reading was controlled. A facilitative effect of radical awareness for Chinese character reading and its development was found, but it is important to note that the independent effect of radical awareness was most pronounced at the emergent-literary stage, very early in the learners' Chinese instructional experience. The effect of radical awareness actually diminished as learners in this study acquired more compound characters, with no direct effect by either radical awareness or simple character reading on the compound character reading tested at Time 2. Overall, the suggestion by this study is that radical awareness may actually be more prominent among novice learners of Chinese. This conclusion is potentially discrepant with findings from the other studies addressed here, which for the most part suggest a consistent reliance on radical-level processing at many stages of Chinese learning, including for both heritage speakers and non-heritage learners, but because this is the only truly longitudinal study of those compiled here, it is perhaps worth considering as a caveat or possible exception to findings from the other research.

Radical awareness among adult learners of Chinese

The following studies address adult, rather than adolescent, features of radical awareness and how it relates to aspects of learners' literacy acquisition. Findings overwhelmingly indicate the influence of a semantic radical bias for learners in attempting to decipher novel characters, as well as corroborate earlier conclusions from studies on L1 Chinese-speaking children that found that radical awareness does indeed appear to grow over preliminary stages of learning, as a function of increased exposure to characters with increased schooling experience in Chinese.

Tong and Yip (2014) approached the topic from a broad, fundamental perspective much like Tong et al. (2017) in first asking the basic question of whether participants were aware of the information contained in radicals, and if this radical awareness was predictive of their Chinese word reading ability. Participants were 93 learners of Chinese, from a variety of L1 language backgrounds, with an average of 3.45 years of Chinese instructional experience. Like the study conducted by Tong et al. (2017), their research employed a picture-character mapping task involving non-real Chinese characters to gauge learners' sensitivity to positional, phonological, and semantic information. The invention of characters in this method was useful in that semantic and phonetic radicals appeared in both correct and incorrect positions, and the manipulation of their presentation enabled researchers to evaluate learners' preferences for different types of radical information when all were equally visibly accessible. Test items, consisting of a picture accompanied by five choices of logograph that students would select to best represent the picture, were presented in three different conditions: no cue, semantic cue condition, and phonetic cue condition. Results of the test indicated that adult learners of Chinese, just like heritage-speaker children, are indeed aware of the positional, phonological, and semantic information of radicals, and make use of this information in character reading. Learners also demonstrated a semantic

radical bias, by choosing pseudo characters composed of correct semantic radicals in proper positions *over* the ones composed of correct phonetic radicals in proper positions, under both the no-cue and semantic cue conditions. Interestingly, Tong and Yip (2014) found that both semantic radical awareness and phonetic radical awareness were predictive of Chinese learners' word reading abilities, although semantic radicals evidently played a greater role. The findings of Nguyen et al. (2017), on the utility of teaching semantic radicals to Chinese language learners, corroborates the usefulness of semantic radicals as an interpretative tool for reading by staging an instructional intervention and tracking the results.

Nguyen et al. (2017) investigated the assumption that teaching semantic radicals to Chinese learners could facilitate inferring novel character meanings. Participants were 54 Vietnamese undergraduates at a university in Hanoi, Vietnam. They each had one year of Chinese instructional experience, and none had studied Chinese prior to entering the university. To examine whether explicit teachings on semantic radicals would help learners apply radical knowledge to infer character meanings in sentence reading, a sentence-completion task asking students to select one of four given character options to appropriately finish the sentence was administered before and after an instructional intervention. Although this study could not be called longitudinal, there was a pre-test and post-test involved. Two experimental groups and one control group completed the procedures. The findings of Nguyen et al. (2017) indicated an even greater productive potential for semantic radical teaching than was anticipated: post-test scores showed significant improvement for both experimental groups and not for the control group, but more importantly, the experimental groups also demonstrated the ability to transfer their newly-learned semantic radical strategies to infer the meanings of characters with radicals that were *not* taught to them. These results indicate that semantic radical awareness among these participants went beyond

explicit instruction and contributed to lexical inferencing ability in sentence reading for non-heritage speakers. Further investigation of semantic radical knowledge specifically, and in particular its interaction with various proficiency levels, is explored in the following study by Su and Kim (2014).

The study by Su and Kim (2014) examined the relationship of semantic radical awareness to adult learners' Chinese language proficiency and word reading ability. Participants were 97 students at a public university in the southeastern U.S., drawn from 10 Chinese classes at this university. A latent variable for language proficiency of the participants was constructed based on number of semesters of Chinese courses taken and a self-rating questionnaire. Notably, this study focused exclusively on semantic radicals and neglected to address phonetic radicals, much like Shu and Anderson (1997). Four dimensions of semantic radical knowledge — receptive and productive knowledge of position, and receptive and productive knowledge of semantic function — were assessed using three tasks. Results of the study found that students of higher language proficiency performed significantly better on all the measures of semantic radical knowledge and word recognition. Moreover, both receptive and productive knowledge of semantic radical position, as well as productive knowledge of semantic radical function, were positively correlated to word reading ability after controlling for proficiency level. In general, the finding that higher-level learners had higher levels of semantic radical knowledge represents an extension to findings from previous studies on radical awareness, because this study investigated proficiency in addition to age and heritage status. It is important to note, however, that the finding here about a positive relationship between proficiency and radical knowledge is not quite comparable to studies on the positive relationship between older age and radical knowledge for L1 learners of Chinese — as those studies were researching L1 acquisition, L1 readers from different grade levels not only

represent different ages but also different levels of cognitive maturity. Thus, the variance in cognitive maturity among participants in such L1 studies negates comparison to participants in such a study as this one, who vary in proficiency, not stage of cognitive development. The findings of the present study by Su and Kim (2014) provide evidence for the theory that learners of Chinese are initially inclined to learn characters as independent wholes, rather than decomposing them into radicals, but as their proficiency grows, they increasingly treat characters as separable configurations comprised of constituent radicals. The final study addressed in this section expands upon the scope of the previous three to address the question of exactly how learners' radical knowledge is related to their radical knowledge application skills, and in turn, how the development of radical knowledge application skills is associated with Chinese word acquisition.

The research of Shen and Ke (2007) focused not on the features of radical awareness but instead on the developmental trends of acquiring radical knowledge, radical knowledge application skills, and how the development of these skills relates to Chinese word acquisition. Beginning from the assumption that the development of radical awareness is a gradual process for learners — as exhibited in the research of Su and Kim (2014) and Wong (2017) — Shen and Ke (2007) focused on adult learners of Chinese and aimed to inspect possible trends in the respective developments of these three components of radical awareness, from beginning to advanced proficiency levels. Participants were 140 adult learners of Chinese at nine U.S. universities, with 35 students per proficiency level. Four tests were designed for data collection purposes: a radical perception test, radical knowledge test, radical knowledge application test, and a vocabulary test. Findings from this study revealed that the development of skills related to decomposing compound characters into radicals emerged at the very earliest stages of learning, after only a few weeks' exposure to characters, and progressed rapidly during the learners' first year of study. This early

and rapid development of visual decomposition ability is explained by Shen and Ke (2007) as a potential result of the adult learners' cognitive maturity, a topic that is also addressed by Su and Kim (2014). Subsequent findings illustrated interesting disparities in how the three developmental trends compared: although students' radical knowledge showed a significant increase at each proficiency level, their radical knowledge application skills did not proceed synchronously. Rather, increases from year to year in application skill were startlingly negligible, with a significant increase in radical knowledge application skill not being observed until the end of learners' third year of study — an unexpected “plateau” phenomenon that the researchers tentatively attribute to what they call “cognitive restructuring,” or the process by which learners acquiring a new language must revise their existing cognitive representations to assimilate newer, more complex cognitive representations and increase their control of more complicated linguistic tasks (Shen & Ke, 2007). Even accounting for this temporary plateau, however, an overall linear trend was observed between the development of radical knowledge and the application of this knowledge for adult learners. In turn, the relationship of radical knowledge application skills to Chinese word acquisition showed a moderate positive association. The overarching results of this study, which found that radical knowledge does not develop synchronously with its application skills or with word acquisition but rather that each displays a unique developmental pattern, offers an interesting framework by which to understand the results of the previous studies. The evidence here of a developmental continuum for the acquisition of radical knowledge and its corresponding skills carries useful implications for both the field of Chinese language instruction and for further studies investigating developmental and psychological trends in language acquisition.

Evidence from adult L1 radical awareness

The final study addressed here presents a brief corollary to findings already revealed and discussed, but this time with a new subject of study, the L1 Chinese-speaking adult. Radical awareness among heritage-speaker children, among adolescent learners of Chinese, and among adult learners of Chinese have all been investigated, and this study by Williams and Bever (2010) on the radical awareness of heritage-speaker adults corroborates many of the same patterns that manifested among other types of participants. In this study, the general effects of semantic and phonetic radicals on Chinese character decoding were examined. The 36 participants were all heritage Chinese speakers from the People's Republic of China, studying at the University of Arizona at the time of the experiment. In the first experiment, a semantic categorization task, participants were administered a test comprised of 35 different semantic categories (e.g., animal, water, etc.) that each contained four single-character test words. Participants were shown a semantic category and presented with four characters one at a time, then asked to quickly determine whether or not each character fit within the given semantic category (reaction time was measured). In the second experiment, a homonym recognition task, participants were shown pairs of characters and asked if the two were homonyms (pronunciation differences in non-homonymic pairs were not solely tonal; they could vary in onset, rhyme, or both). In the third experiment, a lexical decision task, participants were shown 98 total characters (48 pseudo characters and 50 true characters) with either the semantic radical or the phonetic radical slightly blurred and asked to determine if the shown character was an existent character in Chinese.

Results of the three experiments found that both semantic and phonetic radicals were accessible to participants in character decoding, but that in a more neutral lexical recognition task, the semantic radical proved consistently more informative. In particular, semantic radicals that

accurately related to character meaning facilitated faster reaction time for participants in the semantic categorization experiment. In contrast, radicals with no effectual relationship to character meaning displayed a strong inhibitory effect. In the same pattern, phonetic radicals that accurately indicated character pronunciation facilitated the homonym recognition task, while phonetic radicals with different pronunciations from their characters inhibited participants' ability to recognize homonyms. Finally, in the lexical decision task, characters appearing with a blurred semantic radical prompted significantly higher error rates and longer response times among participants, indicating that they tended to rely more on the semantic radical than the phonetic radical. These findings are particularly illustrative because of the fact that they are based not on children or on learners of Chinese, but on 'expert,' or L1 adult speakers of Chinese. The findings suggest that even for cognitively mature heritage speakers, there exists a predisposition to semantic decoding strategies, rather than the balance of activation strategies that one might expect. In discussing these results, Williams and Bever (2010) bring the discussion back to the fact that the Chinese orthography differs significantly from alphabetic scripts in the relative unreliability of its phonological cues, as well as the fact that semantic information is visually available in characters — two factors that render semantic pathways to character decoding a much more viable process in logographic Chinese than in many other languages.

Significance and Pedagogical Implications

The significance and practical implications of these findings form a strong case for the development and inclusion of explicit classroom instruction on radicals in the Chinese language, for both children beginning to learn to read in an L1 and for learners of Chinese as a foreign language. In research conducted by Nguyen et al. (2017), an instructional intervention that provided two experimental groups with explicit teaching on semantic radicals conferred clear

benefits for those groups' ability to decode characters as compared to before, while the control group showed no such improvement. In addition, their post-instruction improvement even extended to the level of knowledge transfer, enabling them to transfer the semantic radical strategies they had learned to make inferences about novel characters not containing explicitly taught radicals. The productive benefits of heightened radical awareness were evident in nearly all of the above studies, such as in the study by Su and Kim (2014) which showed that knowledge of semantic radical position and function were positively correlated to word reading ability, even after controlling for participants' proficiency level. Another profound implication of these studies is the fact that morphology-level processing ability, specifically an awareness of radicals and their functions, is likely related to reading comprehension, particularly for children in the process of learning to read. In the study by Shu and Anderson (1997), children who were better readers demonstrated consistently greater radical awareness and use of radical awareness strategies in interpreting novel characters, while poorer readers either did not or could not put radical awareness strategies to use. The pedagogical implication that such findings carry is the potential benefit of explicit Chinese morphological instruction in elementary school classrooms, and instruction on how to use radical strategies for meaning decoding. At the very least, a practical implication of these findings is that lessons on semantic radicals and their functions could be useful tools for children in the early stages of learning to read characters. Especially given the correlation found between radical knowledge and reading ability (Shu & Anderson, 1997), the development of instructional methods aimed at building students' radical awareness could have transformative benefits for both the efficacy of Chinese pedagogical methods and in the reading confidence of students themselves.

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