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USING RADICALS IN TEACHING CHINESE CHARACTERS TO SECOND LANGUAGE LEARNERS

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A study was carried out to determine whether knowledge of the internal radical structure of a Chinese character helps a naïve learner to memorize that character. Four groups of Australian subjects who knew nothing about Chinese were asked to learn 24 character/meaning pairs (e.g., 咀–CHEW). Each character was composed of two radicals taken from a set of 16. Every subject was presented with the set of character-meaning pairs three times and then were given each character alone and asked to recall the meaning associated with it. Before seeing any characters, one group (*Radicals Before*) told about radicals and had 15 minutes to learn the set of 16 radicals thoroughly. Another (*Radicals Early*) was told about radicals at the first presentation of the stimuli, but were simply asked, as each character was presented, to point out on a chart its component radicals. A third group (*Radicals Late*) did the same thing, but at the third presentation of the stimuli; while a final group (*No Radicals*) were told nothing about radicals at all. It was found that memory for the character-meaning pairings was best for the Radicals Early group, suggesting that it is important to highlight the radicals when a character is first presented to the learner.

Key words: Chinese characters, radicals, teaching orthography, second language learning

Chinese characters are composed of strokes combined in such a way as to form structures that can be called "radicals". By the definition to be used here, many characters contain more than one radical (e.g., 咀 is composed of the radical 口 on the left and the radical 且 on the right). When teaching new Chinese characters to second language learners, it is sometimes the case that explicit emphasis is placed on this radical structure (e.g., Huang & Chen, 1988), but often that it is not (e.g., DeFrancis, 1965; Lee, 1993). In the latter case, characters are learnt by rote, supported by practice in writing the character stroke by stroke. Certainly, stroke order tends to follow radical structure in the sense that the strokes that compose a radical are typically written consecutively, but the discrete point where one radical finishes and the next radical begins is not made explicit in the teaching process. Occasionally, it is noted that several characters share certain sub-units, but there is little systematic teaching of the radical building blocks. The question being addressed in this article is whether character learning is facilitated when radical structure is given prominence rather being disregarded, as it so often is.

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Even when characters are taught to Chinese children, there is not necessarily a systematic introduction to radical structure (Shu & Anderson, 1997). However, simple characters that act as radicals in complex characters tend to be taught early and can thus be used as building blocks for those complex characters, even if this is not explicitly highlighted by the teacher. The order of presentation of characters in texts designed for second language learners, however, tends to be based more on the order in which the words are introduced in the course rather than on any structural features of the character.

There is growing evidence that radicals do play an important role in the recognition of Chinese characters by adult native readers (e.g., Feldman & Siok, 1997; Flores D'Arcais, Saito, & Kawakami, 1995; Taft & Zhu, 1997). For example, Taft and Zhu (1997) and Feldman and Siok (1997) both demonstrated that the time taken to recognize a character is influenced by the frequency of occurrence of its component radicals (though the two studies differ in their conclusions about which type of radical is of most importance). If expert Chinese readers make use of radical structure when reading, it seems sensible to suggest that learning would be facilitated if this structure were explicitly highlighted when teaching characters to novices.

One way to consider the role of the radical in character recognition is within a multilevel interactive-activation framework whereby each level of structure is represented hierarchically as units of activation. Such a framework is depicted in Fig. 1 (see Taft & Zhu, 1995; 1997). As can be seen from the figure, when a character is presented for recognition, units at the feature (and/or stroke) level are activated and these, in turn, send activation to orthographic units representing radicals. Once a radical unit is activated it sends activation to those character-level units that are linked to it. Semantic units (which would actually be comprised of a constellation of semantic features) are associated with each character, as are phonological units. Whether semantic and phonological units are also associated with radical level units is a moot point (see Taft, Liu, & Zhu, 1999).

In recognizing a Chinese character, an expert Chinese reader would activate the radical representations in the process of activating the representation of the character. Thus, having a level of representation for radicals is important for expert character recognition. It would make sense, then, for the teaching of Chinese characters to novices, if one were to begin by establishing representations at the radical level in order for the character level to be built upon these. If characters are taught either before radicals are taught, or in the absence of any information at all about radicals, it is possible that development of an expert-like lexical processing system may be retarded. Without the existence of a radical level, the lexical processing system would have to be entered directly at the character level. Radicals might eventually be extracted out by a reader when they are found to recur in several different characters, but this would be a very unsystematic development of the hierarchical activation system. It would be similar to teaching words written in an alphabetic script without giving any information about the letters that make up those words. Thus, it seems logical that the learning of Chinese characters would be expedited by the prior

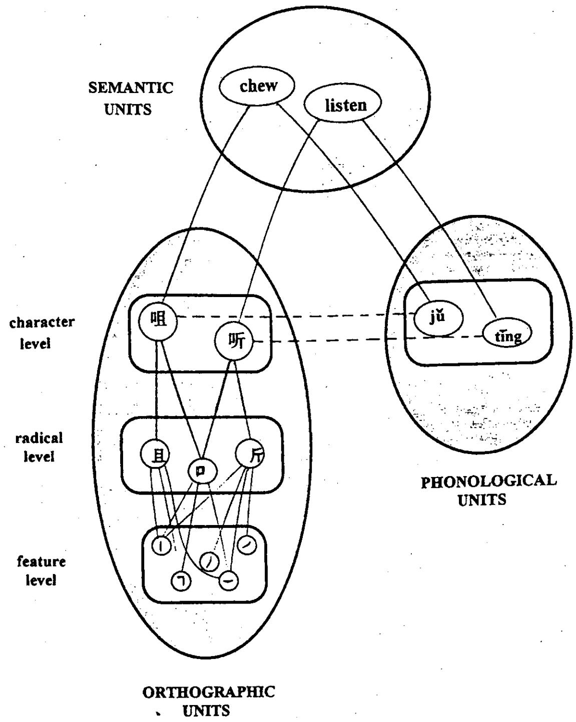

Fig. 1. A multilevel interactive-activation framework for considering Chinese character recognition.

learning of the building blocks that make up those characters, namely, the radicals. Yet, as pointed out above, this is often not done in any systematic fashion.

The Present Study

The study to be reported here looked at the learning of Chinese characters by novices either when they were exposed to the radicals that made up those characters or when they were not. For this first attempt at looking at this issue, radicals were treated purely in terms of their form and not in terms of their function. That is, learners were told nothing about the semantic and phonological cues that are potentially provided by radicals. These are factors that would be introduced in later research depending on the outcome of the present study whose aim was simply to establish at the most basic level whether knowledge of the building-blocks of characters facilitate learning.

Method

Participants: All participants were presented three times with a set of 24 Chinese characters. Each character was presented singly, together with its meaning (e.g., 析-DIVIDE) on each of the three occasions. After the three exposure periods (with the items presented in a different random order each time), the participants were presented with all of the characters again, but this time without their meaning. The task was then to write down the appropriate meaning for each character. That is, the task was to learn 24 character-meaning pairings after three presentations, and subsequently to recall the meaning associated with each character. This cued recall task was administered twice: Immediately after the third exposure period and again one week later.

Materials and Procedure: The 24 characters all consisted of two radicals structured horizontally (e.g., 析-DIVIDE, 听-LISTEN, 叶-LEAF, 诅-SWEAR). Only 16 radicals were used to generate the entire set of characters, such that every radical occurred in three different characters. Each radical occurred in the same position in all three characters in which it occurred (e.g., 听, 叶, and 咀 all have the radical 口 on the left, while 析, 听, and 折 all have the radical 斤 on the right). The meanings of the three characters sharing a radical were as unrelated as was practicable so that the learners would not be inclined to generate a link between a radical and a meaning. The characters were never pronounced during the experiment.

There were four methods by which the characters were taught, thus requiring four groups of participants. Each group contained 10 individuals who were all students at the University of New South Wales and were all ignorant about the structure of Chinese.

The four teaching methods were the following:

1) *Radicals Before*. Before being exposed to the 24 characters, participants were told about radicals being the building blocks of Chinese characters and were then given a chart that contained the 16 radicals that would make up the characters that they were supposed to learn. They were then given 15 minutes to try to learn those radicals thoroughly and were encouraged to copy each one several times as a means of achieving this. After the learning period, the participants in this group were exposed three times to the character-meaning pairs as described above.

2) *Radicals Early*. Just before their first exposure to the character-meaning pairs, participants were told about radicals. As each character was then presented, they were asked to point to the two radicals that comprised that character on a chart of the 16 radicals. This was done only during the first exposure to the character-meaning pairs.

3) *Radicals Late*. Participants followed exactly the same procedure as the "Radicals Early" group, except that they were not told about radicals until just before the third presentation of the character-meaning pairs. Thus, participants knew nothing about radicals during the first two periods of exposure to the characters and were only asked to point to the radicals on the chart during the final period of exposure.

4) *No Radicals*. Participants performed the learning task without any knowledge of radicals.

It was expected that learning the radicals thoroughly prior to learning the characters that contained them would facilitate memory for those characters. By setting up a radical level of representation, it is being suggested that one can build a character level of representation upon that. Thus, memory performance should be best in the Radicals Before group. The Radicals Early group might provide the next best memory performance because the learning conditions also give three opportunities to associate the characters with a radical-level unit, but a unit that has not been established as thoroughly as in the Radicals Before condition. Whether or not performance of the Radicals Late group is better than that of the No Radicals group depends on whether the late introduction of the notion of radicals does not actually disrupt the learning that has already taken place during the first two learning phases. Note that it is the Radicals Late condition that probably most simulates the teaching conditions in the classroom or textbook where emphasis is placed on the rote learning of characters, with the similarity of characters in terms of their radical structure only being mentioned as an afterthought, if at all.

Results

The memory performance of the four groups is illustrated in Fig. 2.

It can be seen that the best condition under which to learn the characters was when the radicals were introduced at the same time as the first presentation of the character. This Radicals Early group was significantly better than both Radicals Late and No Radicals (collapsing over delay), $F(1, 19)=5.97$, $p<.05$ and $F(1, 19)=14.44$, $p<.01$ respectively. Radicals Before differed significantly from No Radicals, $F(1, 19)=5.62$, $p<.05$, but fell in between Radicals Early and Radicals Late without significantly differing from either, with F values of 2.03 and 1.04, respectively. Finally, the Radicals Late group was no different to the No Radicals

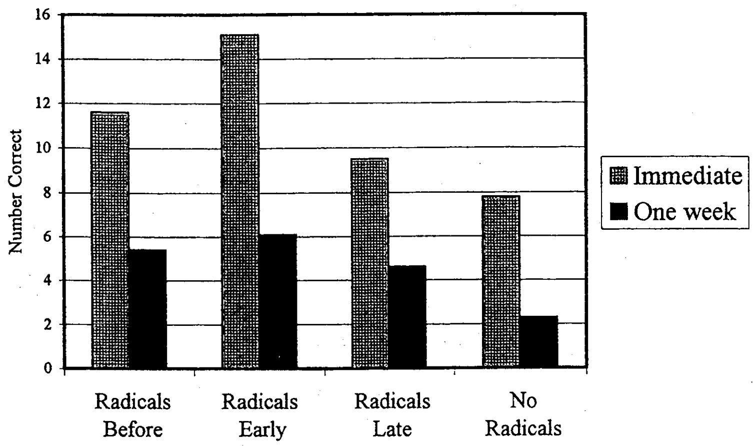

Fig. 2. Mean number of correct meanings given in response to the set of 24 characters for each group.

group, $F(1, 19)=1.85, p>.1$.

This pattern of significance was exactly the same as that obtained when looking at immediate recall independently of delayed recall, with the Radicals Early being significantly different to Radicals Late, $F(1, 19)=8.07, p<.02$, and to No Radicals, $F(1, 19)=12.67, p<.01$, as well as Radicals Before being significantly different to No Radicals, $F(1, 19)=10.11, p<.01$. While the pattern of data was the same for delayed recall as for immediate recall, the effects were very much diminished. Presumably, this was because the maximal level of performance was so reduced after a week's delay that the sensitivity of the different learning conditions was lost to a floor effect. Nonetheless, the Radicals Early and Radicals Before groups still showed better memory performance than the No Radicals group, $F(1, 19)=4.88, p<.05$ and $F(1, 19)=8.88, p<.01$, respectively, and there was also a strong tendency for the Radicals Late group to be better than the No Radicals group, $F(1, 19)=4.04, p<.1$.

Discussion

It is clear that awareness of radicals facilitates the learning of Chinese characters. Even after only a fairly brief exposure to radical structure, as in this experiment, characters are remembered better over a period of a week than when no reference is made to radicals at all. Note that during the three exposures to the set of characters in the No Radical condition, it is apparent that the learners did not abstract out the units that repeatedly occurred in different characters (i.e., the radicals). Merely exposing a person to a systematically varying set of materials, does not allow them to extract out that systematic variation (i.e., they do not extract out the fact that the characters can be broken down into a smaller subset of units). Of course, it can be argued that three exposures is insufficient for the systematic variation to be discovered; but even if more exposures would allow this to happen, what has been shown is that explicit instruction on this systematic variation (i.e., radical structure) enhances the learning process at an early stage.

To explain why knowledge of radicals might enhance learning, reference can be made to the "levels of processing" idea originally put forward by Craik and Lockhart (1972) whereby the deeper (or more elaborate) the processing of the stimulus during the learning phase, the better the recall. Thus, analyzing a character in terms of its radicals potentially involves deeper processing than that undertaken by the No Radical group. A levels of processing account, however, merely describes a situation and does not detail the theoretical basis for why deeper processing might aid memory. A lexical processing model is adopted here in an attempt to specify how radical knowledge (i.e., "deeper processing") might contribute to the retention of Chinese characters.

This theoretical framework is the multilevel interactive-activation approach depicted in Fig. 1. The suggestion is that if characters are taught without reference to their radicals, then the character level of representation must be built directly upon the feature level which is less constraining than if there were an intervening radical level. That is, many of the characters to be learnt include the features ㇕, ｜, and –, but fewer (only three in the present experiment) include the radical 且. Thus, fewer competing character-level units would be activated via a radical unit (e.g., 且) than would be activated via feature units (e.g., ㇕, ｜, and –). This is really just a computational way of saying that it is easier to memorize an item when one has knowledge of the subunits that make up that item, and the larger those subunits are the easier it becomes.

In relation to the multilevel interactive-activation framework, it was expected that setting up the radical level first would allow the character-level units to be readily added and hence better remembered. In the event, however, it was found that exposure to radicals *at the same time* as the characters (Radicals Early) was, if anything, better than learning the radicals before learning the characters (Radicals Before). This implies that character-level units and radical-level units should be set up at the same time in order for an association to be most effectively drawn between them. It seems that even though learners might have set up radical-level units in the Radicals Before condition, many did not spontaneously link these to character-level units. In other words, after being told that characters are composed of radicals, and even after establishing what those radicals are, many learners did not apply that knowledge when required to memorize the characters.

Finding out about radicals at a late stage of learning characters appears to be unhelpful in memorizing those characters. That is, the Radicals Late group were no better than the No Radicals group. However, it must be noted that the Radicals Late group did appear to be more like the Radicals Early and Radicals Before groups after a week's delay, possibly suggesting that exposure to radicals at a late stage may not have an immediate impact, but does help to retain the character information over a longer period. The level of long-term retention for all groups, however, was very low and, therefore, it may be that the failure to continually reinforce the knowledge attained during the initial learning stage may have masked a long-term advantage of learning radicals at the same time as the characters that contained them (i.e., Radicals

Early) compared to learning them subsequently (i.e. Radicals Late).

Further Issues

In this study, radicals were taught purely as structural units. Their contribution to the meaning and/or pronunciation of the character was ignored. What has been shown is that even without considering these potential functional roles, knowledge of the radical structure of a character facilitates memory for that character. The question then is whether teaching the meaning of a "semantic" radical and/or the pronunciation of a "phonetic" radical would aid retention to an even greater degree.

It is quite possible that teaching the meaning of a semantic radical would be helpful. Knowing that the semantic radical 氵 refers to *water* might well be helpful in remembering characters like 海 (*sea*), 流 (*flow*), 泳 (*swim*), 汽 (*steam*), and, 港 (*harbor*), and maybe even 清 (*clear*), 油 (*oil*), and 酒 (*alcohol*), because it provides an extra cue to remembering both a part of the character (i.e., the left part) and the meaning-character association. That is, it may be easier to link a character representation into the system when it shares semantic features with many of the other characters that share a radical with it. Indeed, the research of Shu and Anderson (1997) with Chinese school children indicates that the ability to use such semantic information is characteristic of good native readers.

There are many cases, however, where the semantic cuing function of the radical is very weak indeed (e.g., 汉 meaning *Chinese people*, 法 meaning *law*, and 没 meaning *not*). In these cases, it is debateable whether knowledge of the radical structure would be helpful, but it is quite possible that it would. In much the same way that forming bizarre images can help in learning word pairs (e.g., Andreoff & Yarmey, 1976), it may be possible to form an unusual association between the character and its radical. For example, one can remember that 汉 refers to the Chinese people if one supposes that the Chinese race developed around a major water source. How such an idea might be captured within a computational framework, however, is not immediately obvious.

As for teaching the pronunciations of phonetic radicals, perhaps the same expectations hold as for teaching the meaning of semantic radicals. If the learner has already learnt a pronunciation-meaning association (e.g., that the word *clear* is pronounced *qīng* in Chinese), then forming an association between the character 清 and *qīng* will be helpful in remembering that 清 means *clear*. It may then be an advantage to know that the phonetic radical 青 is also pronounced *qīng* (when used as a separate character) because it will provide an extra cue for remembering at least the right part of the character for *clear* and also in remembering the character-pronunciation association.

However, the relationship between the pronunciation of a phonetic radical and the pronunciation of the character that contains it is far from reliable. In fact, it is estimated that they are identical in only about 26% of cases (Fan, Gao, & Ao, 1984). For example, 请 (*ask*) is pronounced *qǐng* with a different tone to 青, and 咀 (*chew*) is pronounced *jǔ* while 且 is pronounced *qiě*. Such variability in the phonological relationship between radical and character would seem to have a different impact on learning than would the variability in the semantic relationship between radical and character. For example, it is possible to construct a semantic link, no matter how bizarre, between the *water* radical 氵 and the character 汉 (*Chinese people*) or with 法 (*law*), but it makes no sense to try to form a link between *jǔ* (the pronunciation of 咀) and *qiě* (the pronunciation of its radical 且). Thus, knowing the pronunciation of the phonetic radical is likely to be more of a distraction than an advantage in learning the character that contains it. That is, if one is trying to remember that 咀 is the word *jǔ* (i.e. *chew*), it is hard to see how the knowledge that is phonetic radical is pronounced *qiě* will help in this.

Finally, the question can be raised as to whether knowledge of radicals will continue to be helpful once a large number of characters containing those radicals are learnt. Will there be confusion between characters that share a radical? For example, if one knows many characters that contain the radical 口 and the radical 几, will it be difficult to learn the character 叽 because so many competing character-level units will be activated by each of the two radical-level units? It would appear that expert Chinese readers do not encounter such a difficulty, since commonly occurring radicals are associated with fast recognition times to the characters that contain them (Feldman & Siok, 1997; Taft & Zhu, 1997). While fast recognition responses do not necessarily mean that it was easy to acquire the character representation in the first place, it seems likely that there would be a correlation between ease of acquisition and subsequent ease of recognition.

Conclusion

The research reported here provides an indication that knowledge about radicals is something that facilitates the learning of characters that contain those radicals. It is suggested that this is because representations of the characters are activated in the Chinese lexical processing system within a hierarchy of levels via units representing their radicals. It seems that the most effective method of setting up such a system is to emphasize the radical structure of a character at the time that that character is first encountered, such that the links between character and radicals can be readily constructed. The common practice of getting students to learn complex characters as whole entities, without a systematic emphasis on their radical structure, is not the most effective method of teaching characters.

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Appendix

Below are the items (character-meaning pairs) that were taught to the four groups in the study.

折	BREAK	拉	PULL	扛	LIFT
咀	CHEW	听	LISTEN	叶	LEAF
汁	JUICE	泣	CRY	江	RIVER
村	VILLAGE	析	DIVIDE	机	MACHINE
仿	IMITATE	什	VARIOUS	位	PLACE
肘	ELBOW	肪	FAT	肌	MUSCLE
组	GROUP	纺	WEAVE	红	RED
诅	SWEAR	讨	DISCUSS	讥	MOCK