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Awareness of Orthographic Structure in Children's Learning of Chinese Characters

Ho-Cheong Lam* Bike-May Amy Tsui**

Abstract

Most of the previous developmental studies on children's learning of Chinese characters focus on age difference in their awareness of the functions of components in providing a clue to the meanings of characters. The present study takes a step further to investigate children's awareness of the orthographic structures of characters and the implications of their development. This study used pseudo-characters formed by different combinations of components. There was the same component located in different positions in the orthographic structures of these pseudo-characters. 425 children in Grade 1 to 4 from 3 primary schools in Hong Kong were invited to a test to analyze these pseudo-characters. The results show that these junior children did not fully understand that a component only provides a clue to the meaning of a character when it is located in a certain position in the specific orthographic structure of the character and that the orthographic structure cannot be interpreted arbitrarily. Meanwhile, this study also found that children's awareness of the orthographic structures, regarding the function of components in providing a clue to the meanings, improved across grade levels. A developmental progression was observed with statistical significance. The awareness of the orthographic structures of characters is essential for children to fully make sense of how these characters are structured to denote their meanings and therefore, further investigation is worth more attention.

* Ho-Cheong Lam, Assistant Professor, Department of Early Childhood Education, The Hong Kong Institute of Education
E-mail: hclam@hkucs.org (Corresponding Author)
** Bike-May Amy Tsui, Pro-Vice-Chancellor and Vice-President (Teaching and Learning), The University of Hong Kong
E-mail: bmtsui@hkucc.hku.hk
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學童對於漢字結構的覺識能力

林浩昌 * 徐碧美 **

摘 要

先前探討學童學習漢字的發展研究，一般只注意到學童對於「部件具有提示字義功能」的覺識能力之年齡差異，本研究則進一步探討學童對於「漢字結構」的覺識能力，並且探討其所具有的發展意義。本研究以同一部件、但因位置不同、組合方式不同所形成的不同結構之假造漢字，請 425 名來自三所香港小學一至四年級的學童進行辨識，結果發現這些初小學童尚無法完全正確掌握「漢字當中，只有特定位置的部件及組合方式，才具有提示字義的功能，而不能隨意準用」之要領。同時，本研究還發現，學童這種「覺識到部件的位置及組合方式，與其所具提示字義的功能有所關聯」之能力，有隨著年齡增長而提升的趨勢，而且此一趨勢達到統計上的顯著水準。這種對於漢字結構的覺識能力，是學童能夠掌握漢字部件組合的原理、進而正確理解字義的基礎，值得繼續深入研究。

關鍵詞：漢字結構、漢字學習、形旁表義覺識、認讀漢字

* 林浩昌，香港教育學院幼兒教育學系助理教授（通訊作者）
電子郵件：hclam@hkucs.org
** 徐碧美，香港大學副校長（教學）
電子郵件：bmtsui@hkucc.hku.hk
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Introduction

What Components Signify

According to statistics on the Chinese characters used in primary school textbooks, the vast majority of 72%[1] of the characters fall into the category of semantic-phonetic characters形聲字 (Shu, Chen, Anderson, Wu, & Xuan, 2003). This means that each of these characters is made up of one semantic radical and one phonetic radical, which respectively give a clue to the meaning and the sound of the character[2]. For example, the character 榕 /jung4/ (banyan) is composed of the semantic radical木 (tree) on the left and the phonetic radical容 /jung4/ on the right, which respectively give the indication that the character has a meaning associated with "tree" and a sound similar to /jung4/. (Note that, when not specified, the sounds of characters in this paper are in Cantonese, which is widely spoken by 90% of people in Hong Kong.)[3]

Based on this linguistic feature, most studies on learning Chinese characters take the form of studying children's understanding of the relation

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1 In congruent with this, another report by 李孝定（1986：41）, based on a more ancient script of Chinese characters (i.e., zhuanshu 篆書), indicates that semantic-phonetic characters account for as much as 90% of all characters. However, many of the most frequently used characters are not semantic-phonetic characters. As 高景成（1988）points out, in the top 50 most frequently used characters, only 9 of them are semantic-phonetic characters, that is, of only 18%. But if we take into account all characters, the vast majority of the characters are semantic-phonetic characters.

2 In this paper, this kind of characters is called semantic-phonetic characters. But there is as yet no consistent terminology to describe these linguistic units of Chinese characters in English. Other researchers may call these characters picto-phonetic characters, phonetic compounds, phonograms, phono-semantic compounds, and others. Some researchers also refer semantic radicals to as semantic components, morphological components, or simply radicals while phonetic radicals are referred to as phonetic components or in short phonetics.

3 The sounds are transcribed using the Cantonese romanization developed by 香港語言學學會（2002）, for example, 芬 /fan1/ (fragrant), 粉 /fan2/ (powder), 訓 /fan3/ (to teach), 焚 /fan4/ (to burn), 憤 /fan5/ (anger), and 份 /fan6/ (portion). Details can be found in http://humanum.arts.cuhk.edu.hk/Lexis/lexi-can/. Besides, Hanyu Pinyin will only be used in this paper when we mention studies that were conducted in Putonghua.

between components in characters and what the components signify, that is, they measure how well children are aware of the functions of the semantic and the phonetic radicals in characters. For instance, Shu and Anderson (1997) presented to children in Beijing words such as "tong2 孔 " (in Putonghua) and asked the children to select one from a list of characters such as 瞳 /tong2/ (pupil), 撞 /zhuang4/ (to bump), 僮 /tong2/ (boy servant), and 潼 /tong2/ (the name of a place) to replace the pinyin tong2[4]. It was found that the children performed better in reading morphologically transparent characters, for example, 銅 /tung4/ (copper), which was clearly related to the semantic radical 金 (metal), than morphologically opaque, for example, 錯 /co3/ (error)[5], or un-analyzable characters. This demonstrated the children's awareness of the functions of semantic radicals. Beside this, studies that investigated children's awareness of the functions of phonetic radicals are reported in Ho and Bryant (1997a, 1997b) and Shu, Anderson, and Wu (2000).

Another linguistic feature of Chinese characters is that certain components can only serve as semantic radicals at their specific f*unctioning positions* in the characters. For example, when 木 (tree) is used as a semantic radical, it should be located either on the left of those characters with a left-right configuration, such as the 木 (tree) in 榕 /jung4/ (banyan), or at the bottom of a top-bottom configured character, namely, the 木 (tree) in 梨 /lei4/ (pear)（邱德修，1995；梁東漢，1959）. When the component 木 appears on the right of a character, namely, 沐 /muk6/ (to bathe), that is, not in its functioning position, it does not serve as a semantic radical. In this example, the 木 /muk6/ functions as a phonetic radical.

Based on this linguistic feature, several studies were conducted to investigate children's understanding of the functioning positions of components in characters. Chan and Nunes (1998) presented children with semantic and phonetic radicals printed on transparencies and asked them to use the semantic and the phonetic radicals to form invented characters for representing novel objects. It was found that, from about age 6, the children

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4 The correct answer is 瞳 .

5 The original meaning of the character 錯 /co3/ (error) is "the crossing on the surface of metal" as in 交錯 (interlocked). This explains why the character has the 金 (metal) as its semantic radical. But, due to historical reasons, the character is now more commonly used to refer to the meaning of "error."

began to place the semantic and the phonetic radicals according to their functioning positions. (See Ho, Yau, & Au, 2003 for a similar study).

How Characters Are Composed

What is common to the above studies is the idea to identify components that serve particular functions in characters (e.g., serving as a semantic radical) and test to what extent children are aware of such functions. But here, we think a more fundamental question has been left unexplored, which is why the children at first place are able to recognize which of the components in the characters serve such functions (i.e., which components in a character serve as semantic radicals and which ones do not).

Consider the situation that children encounter an unfamiliar character. The first thing that they have to do is to analyze the character as a whole and determine the function of each of the components in the character. Not until then, no knowledge of what the individual component signifies can be applied. As such, in order to appropriately analyze the character, the children at first need to understand the correct way to interpret how the character is formed from its components, that is, how the character is structured to denote what it means. For example, in the character 媽 /maa1/ (mother), the children have to recognize that the 女 (female) provides a clue to the meaning, while the 馬 /maa5/ provides a clue to the sound. This is what we refer to as the awareness of the orthographic structure of a character.

Failure to recognize the orthographic structure of a character will almost certainly result in an incorrect interpretation of the character. For example, when children analyze the character 媽 /maa1/ (mother), if unknown to them, they may reckon that the character refers to a kind of horse when they erroneously consider the 馬 (horse) as serving as a semantic radical; or they may be mistaken that the character sounds like /neoi5/ when the 女 /neoi5/ is incorrectly determined as serving as a phonetic radical. Even worse, children may interpret the character 媽 as referring to a kind of "female horse" when they incorrectly take both of the components 女 (female) and 馬 (horse) as providing clues to the meaning of the character. Such incorrect interpretation of characters are not something that will never happen, and were indeed the response of some of the children in Lam (2008)

study, where the children from Grades 1 to 3 were asked to articulate how they made guesses in deriving the meanings of unknown characters.

Even more complicated is that, in characters of three or more components, some components may function as *sub-components* in the orthographic structures of the characters. This happens when the phonetic radicals of the characters are themselves characters that consist of two or even more components（高明，1996）. For example, the character 努 /nou5/ (effort) has the phonetic radical 奴 /nou4/, which on its own, as the character 奴 /nou4/ (slave), consists of the two components 女 (female) and 又 (again). Thus, in the character 努 /nou5/ (effort), the 女 and the 又 are only part of the 奴 /nou4/ and do not provide any clue to the meaning or the sound of the whole character 努 (i.e., they serve as sub-components).

In this sense, each of these characters can be analyzed into a hierarchy (as shown in Figure 1), which is in fact in congruent with the historical development of the character from their components（王寧，2002；王寧、鄒曉麗，1999）.[6] Components at different levels in the hierarchy take on completely different functions with regard to their constituency to the character. In the example of 努 /nou5/ (effort), the 力 (power), and 奴 /nou4/ constitute the meaning and the sound respectively of the character (i.e., they serve as constituent components), while in contrast, the女 (female) and the又 (again) do not. Detailed explanation about the notions of constituent component and sub-component can be found in Lam (2012).[7]

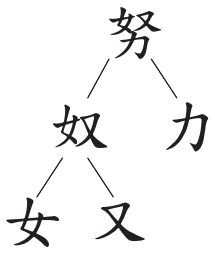

Figure 1　Hierarchical decomposition of the character 努 /nou5/ (effort)

[6] In this paper, the historical analysis of characters is based on the dictionaries of 谷衍奎（2003）and 高景成（2004）.

[7] 蘇培成（2001）also adopts a hierarchical analysis of characters, which however does not follow the constituency of the components in the characters and instead is for the purpose of breaking down the characters into the smallest reusable units.

One may wonder how important it is for children to be aware of the functions of sub-components in characters. For experienced readers, they apparently do not need to bother to break down the characters to the sub-component level in order to recognize the characters. However, it is exactly because the experienced readers are aware of the orthographic structures that they are able not to bother about the sub-components. Otherwise, they may incorrectly interpret the sub-components as one of the constituent components that provide a clue to the meanings of the whole characters. In the earlier example, the character努 , if unknown, may be incorrectly interpreted as referring to "a female person" because of the sub-component 女 (female). Such erroneous interpretation of sub-components in characters was also what was found in Lam (2008). Thus, in the learning of characters, children's awareness of the orthographic structures, and in particular the functions of the sub-components, is important and makes it possible for the children to fully make sense of how the characters, especially those with three or more components, are composed.

The notion of orthographic structure in this paper may indirectly echo the results from cognitive studies of adult readers on the lexical processing of the components in characters. For instance, Taft and Zhu (1997) manipulated the frequency of occurrence of components in different positions of characters and showed that the response times of the adult readers in a character decision task were different. They proposed that there were different mental representations for a component in its different positions in the characters. For example, in our mind, there are separately a left-hand 木 as in the character榕 and a different right-hand木 as in the character 沐 (See also Ding, Peng, & Taft, 2004; Feldman & Siok, 1997; Taft, Zhu, & Peng, 1999). This is in line with what is argued in this paper about children's awareness of the position of a component in the orthographic structure. However, it should be noted that these studies were conducted with adult experienced readers rather than children who are just learning characters, as in this study.

In this paper, we would like to argue for greater importance of the awareness of orthographic structure for children to fully make sense of why characters are composed of their components. Our concern here is how children's awareness of orthographic structure develops over the junior

grade levels. In what follows, we will report on the results of a developmental study, which is based on part of the Ph.D. study of the first author (Lam, 2006). In this developmental study, we investigated how children made use of a component located at different positions in the orthographic structure of a character to make inferences about the meaning of the character. The study tried to answer the following specific questions:

1. How aware are primary school children of the way to infer meaning from a component in a character?
2. How aware are they of the functioning position of a component in a character?
3. How aware are they of whether a component functions as a sub-component in the orthographic structure of a character?
4. How does the children's awareness of the orthographic structures of characters change across grade levels?

Method

Based on the above linguistic concepts, we have designed and conducted the following study, which is of a 4 (grade level) × 8 (character position) mixed design. The character position factor is manipulated within participants.

Participants

A total of 425 children (215 boys and 210 girls with age from 6 to 11) from Grades 1 to 4 from three primary schools in Hong Kong were tested at the beginning of their school year in 2005-06. The students were mostly from working class families and were native speakers of Cantonese, which were the medium of instruction in the schools.

Teaching Chinese Characters in Schools

Children in Hong Kong begin to learn Chinese characters in kindergartens through reading story books, engaging in learning activities,

and writing tasks. According to a preschool survey, children have on average learned 63.9, 133.6, and 204.2 characters at K1, K2, and K3 levels respectively.[8] Thus, children already have a few years of experience with characters when they enter primary schools, where the characters are formally taught in lessons.

In our study, the three primary schools, which were chosen by convenient sampling, were typical primary schools in Hong Kong. During the time of this study, no innovative approach to teaching characters, as advocated in recent educational reform, had been tried out. Chinese characters were basically taught in a traditional manner. The teachers closely followed the textbooks in their instruction, and the children learned characters in model texts. An analysis of the textbooks used by one of the three schools reveals that the children were taught to use approximately 200 new words in one of the two terms in a school year. See Table 1.[9]

The children were mainly expected to learn the characters from the model texts. Only on a few occasions, would the teachers analyze the characters into components in a lesson. Bu-shou (i.e., 部首), which were common components useful for looking up characters in Chinese dictionaries, were taught to the children (Schools B and C in Grade 3, School A in Grade 1[10]). Besides, the topic of one of the model texts was about the six-principles for constructing Chinese characters (i.e., 六書). During the lessons on this model text, the children might gain a brief understanding of how a few characters were constructed from their components. Moreover, School A has mentioned that their children were required to write characters in boxes such as □□, which were for the practice of writing left-right configured characters. This might give the children an indication that the components on the left and on the right served different

[8] The survey was conducted by Centre for Advancement of Chinese Language Education and Research, Faculty of Education, The University of Hong Kong. The powerpoint about the survey is downloadable from: http://web.edu.hku.hk/press/20120402/assets/20120402_Powerpoint_Prof_SK_TSE.pdf.

[9] List of characters that are expected to be introduced to children in each grade level can be found in 香港課程發展議會（1990）and 課程發展處（2007）.

[10] Although School A taught Bu-shou earlier in Grade 1, their children's performance in our study does not differ remarkably from the other two schools. See Table 4.

Table 1 Number of New Words Introduced in the Textbooks used by one School

	Grade 1		Grade 2		Grade 3		Grade 4	
	Term		Term		Term		Term	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
No. of wordsa for recognition only[b]	112	93	108	112	157	165	172	192
No. of words for use[c]	211	192	208	227	205	215	232	233
No. of model texts	20	20	20	20	20	20	18	18

[a] The word is used as the unit for instruction since children are expected to learn the characters in their usage in words. Lists of new words are available in the textbooks. In these lists, the number of characters in a word ranges from 1 to 4. The majority are two-character words.
[b] Children are expected to be able only to recognize these words after instruction.
[c] Children are expected to be able to use these words after instruction.

functions. However, the purpose was mainly to teach them to write in a legible manner rather than to understand the constituency of the components to characters. Apart from the above occasions, where the orthographic structures of characters were explicitly taught, there was also the possibility that some children came to recognize by themselves the orthographic structures through learning the characters, that is, implicit learning. At any rate, the children in the schools were essentially taught characters in model texts with a look-and-say method. Thus during the instruction of characters, the teachers would have only given limited attention to the orthographic structures of characters.

Task

In this study, we investigated the children's awareness of orthographic structure by looking into how they made inferences about the meanings of unknown characters. We asked them to choose whether or not a stimulus character belonged to a certain meaning category. For example, was桿 related to木 (tree)？(i.e.,「桿」與「樹木」是否有關？) The children were told that there was no penalty for any incorrect answer. This should encourage them to make guesses when the characters were unknown to them. Figure 2 shows a sample item of what was actually presented to the children during

the study. The stimulus characters were printed in point size 36.

Figure 2 A sample item in the study

[a] The meanings of the words 樹木 (tree), 有關 (related), and 無關 (not related) were all orally explained to the children during the study. Thus their knowledge of these words should not affect their understanding about how this task should be done.

Materials

The stimulus characters were fabricated, that is, not real characters (or called pseudo-characters). The reason of using pseudo-characters was that if real characters had been used, the children's knowledge about the actual meanings of the characters would have affected their decision on the answers to the questions. For example, the children might interpret the stimulus character 橙 /caang4/ (orange) as related to 木 (tree) because they knew the actual meaning of the character "orange," rather than they recognized the component 木 as serving as a semantic radical in the character.

Eight types of items (the A to the H items) of 10 pseudo-characters each (i.e., 80 in total; see appendix) were constructed. Sample items from the eight types are provided in Table 2 Except the A items, each of the items contain a common component (called the target component) that may or may not function as a semantic radical, depending on its location in the orthographic structure of the item. For example, among the B to the H items below, the target component is 木 , which is located in one of the seven different positions.[11]

[11] The effect of certain locations of the target component, such as the top right position in the same configuration as F, has not been measured because such case rarely exists in real characters. To illustrate why, we take the target component (water) as an example. Since can only appear on the left of a two-component character such as 波 /bo1/ (wave) and 湯 /tong1/ (soup), in a three-component character can be found at the top left or bottom left positions such as 婆 /po4/ (grandma), 燙 /tong3/ (to scald

Table 2 Pseudo-characters Used in the Test

	Type of items							
	A	B	C	D	E	F	G	H
Pseudo-characters	伕	杣	休	桱	偞	荃	椒	術
Target component	木	木	木	木	木	木	木	木
Configuration [a]								
Expected answer	No	Yes	No	Yes	No	No	Yes	No
No. of components	2	2	2	3	3	3	3	3

[a] The darkened part in the configuration indicates the location in which the component should actually provide a clue to the meaning of the character.

The A and the B items were designed to measure whether or not children could make use of the target components to infer the meanings of the characters. If so, they should interpret the meanings of the B items as "related," while those of the A items as "not related." The B items contain the target components, while the A items do not.

The B and the C items were used to determine whether or not children could recognize the functioning positions of the target components. If so, they should regard the B items as "related," while the C items as "not related." Both the B and the C items contain the target components but the target components appear in their functioning positions in the B items, while they appear in other positions in the C items.

The D, the E, the F, the G, and the H items were designed to measure whether or not children could recognize that the target components function only as sub-components in the orthographic structures. If so, they should interpret the D and the G items as "related," while the E, the F, and

and cause a burn), 薄 /bok6/ (thin), and 茫 /mong4/ (boundless). However, in order to have a at the top right of a character in the same configuration as F, the component at the top of the character must be on its own a two-component character with the on the right, which is not possible. Therefore, there is no character with a at the top right position. For this reason, we did not take into consideration such locations of the target components in the study.

the H items as "not related." All five types of items are made up of three components and contain the target components. But the target components function as constituent components in the D and the G items, while they function as sub-components in the E, the F, and the H items.

The items were formed by merging the components of several real characters together. This was to avoid the violation of any unnoticed construction rules for the creation of the characters. For example, the item 佷 was made by crossing together the two real characters 根 /gan1/ (root) and 信 /seon3/ (trustworthy). In so doing, all components in the resulting items would remain in the same position as in the real characters before, thus, ensuring the preservation of the legal positions of the components, for example, the component would not be made to appear on the right of an item.

The target components used in the items were of high frequency of use in other real characters, for example, 木 (tree), 女 (girl), 氵(water), 扌(hand), and 目 (eyes). In this way, if the children did not know what meanings the target components signified in the items, it would probably not be because they had never seen the target components before.

The total numbers of strokes of the items were controlled to 8 ± 2 and 12 ± 2 for those items having two and three components respectively.

Besides the pseudo-character items, another 80 items of simple real characters were added as fillers to equalize the total number of plausible "yes" and "no" answers. This also made the test apparently easier to the children because if the items in the test were all unknown, the children would probably find the test too difficult and might eventually give up. The real characters were all taken from the textbooks in mostly junior Grade 1 and 2 levels and as such were familiar to the children. Among the 80 filler items, 50 items have the target components in question clearly function as semantic radicals in the characters and provide a clue to the meanings of the characters (i.e., the "related" filler items). For example, in the character 妹 /mui6/ (younger sister), the meaning of the component 女 (female) is clearly related to the meaning of the character as "female younger sibling." The other 30 items do not have the components that provide the clues to the meaning categories in question (i.e., the "not related" filler items). For example, 球 /kau4/ (ball) does not contain the component 女 and is obviously

not related to the meaning of "female." The children were not expected to have any difficulty in answering these filler items.

Procedure

All items (160 in total) were presented in the form of a paper-and-pencil test administered in the classroom. The test began with a few of the easiest questions on the filler items so as to familiarize the children with the test. The order of the rest of the items was randomized.

Results

A total of 425 children participated in the test. After the test, the data of 11 children who left out more than 10% of the items were dropped from the analysis. In the remaining data, missing values, which were mostly careless omission, were replaced with the mean of the type of items of that child. Further to this, the data of another 25 children whose performance on either the "related" or the "not related" filler items fell below 50% were screened out as these children probably did not understand the procedure of the test.[12]

Internal Reliability

Inter-item correlation was conducted to determine the internal consistency for each type of items using the Cronbach's Alpha model. As shown in Table 3, the correlation estimates are satisfactory, mostly having reached an acceptable level of higher than .800 with only one exception, which is that of the A items of only .650.

[12] These screened-out participants tended to be younger children. All of them are in age from 6 to 9. Their teachers slightly tended to regard them as low in reading ability level on the basis of their performance in the Chinese language subject in schools. 10, 9, and 17 of them were regarded as of high, medium, and low reading abilities respectively.

Table 3 Internal Reliability of the Eight Types of Items

	Type of items							
	A	B	C	D	E	F	G	H
Internal reliability	650	832	893	841	833	877	837	874

Comparison among the Three Schools

To check if the performance of any of the three schools differs remarkably from the others, we have calculated the mean correct percentages of the three schools, which are shown in Table 4 Using one-way ANOVA, no statistically significant main effect was observed among the three schools on most types of items. The only exception are the H items with F (2, 386) = 4.163, p = .016. Post hoc comparisons were performed using Scheffe method, which reveals that only the performances of School B and School C differ considerably on this type of items with p = .018.

Table 4 Mean Percentage of Correct Response on the Eight Types of Items as a Function of School

	Type of items							
	A	B	C	D	E	F	G	H
School A n = 152	91.5	79.6	55.3	77.8	77.1	49.3	76.6	62.4
School B n = 121	91.9	78.4	54.7	78.8	73.2	49.4	77.8	58.3
School C n = 116	91.6	77.7	63.9	77.1	79.3	52.9	75.2	70.2

In what follows, we will discuss the main results from the analysis of the data. Table 5 tabulates the mean correct percentages of the children on the eight types of items. The obtained mean percentages have been checked against the 50% chance level.

Overall Trend

As can be seen from Table 5, the children's overall performance

Table 5 Mean Percentage (and Standard Deviation) of Correct Response on the Eight Types of Items as a Function of Grade Level

	Type of items							
	A	B	C	D	E	F	G	H
Grade	㑹	杷	休	桱	偞	荃	楸	術
Grade 1 *n* = 66	87.9 (20.3) .000** [a]	73.28 (25.5) .000**	45.0 (35.0) .251	70.7 (28.0) .000**	68.8 (29.9) .000**	43.6 (32.4) .110	69.3 (27.9) .000**	56.1 (30.2) .107
Grade 2 *n* = 102	91.9 (12.7) .000**	73.9 (29.3) .000**	55.6 (36.1) .120	73.9 (29.5) .000**	76.0 (23.0) .000**	47.3 (32.3) .408	73.3 (29.7) .000**	59.0 (31.9) .005**
Grade 3 *n* = 112	92.9 (12.5) .000**	83.0 (23.0) .000**	59.4 (36.6) .008**	84.1 (21.4) .000**	75.9 (28.7) .000**	49.3 (35.6) .841	80.6 (24.0) .000**	62.9 (36.3) .000**
Grade 4 *n* = 109	92.3 (12.4) .000**	81.7 (23.4) .000**	65.4 (30.5) .000**	79.6 (25.7) .000**	82.4 (24.5) .000**	58.4 (34.3) .012*	79.8 (25.6) .000**	72.7 (28.5) .000**

[a] *p*-value from checking the mean percentage against the 50% chance level.

** $p < .01$, * $p < .05$

from Grades 1 to 4 confirms a developmental progression. Using one-way ANOVA, statistically significant main effects of grade were found on all of the B, the C, the D, the E, the F, the G, and the H items with F (3, 385) = 3.622, p = .013; F = 4.985, p = .002; F = 4.730, p = .003; F = 3.762, p = .011; F = 3.262, p = .022; F = 3.548, p = .015; and F = 4.835, p = .003 respectively.

Semantic Radical

The children, as young as in Grade 1, were able to infer meanings of the items from the target components. For example, they recognized that the女 (female) in the character媽 /maa1/ (mother) signified a meaning of "female." As indicated in Table 5, the first graders correctly interpreted 73.8% of the B items, which contain the target components, as related to the meanings suggested by the target components. Their performance levels off to Grade 2 at 73.9%, goes up to 83.0% in Grade 3, and levels off again to Grade 4 at 81.7%. Their mean percentages are all significantly higher than the 50% chance level. In comparison to this, the children correctly interpreted the A items, which do not contain the target components, as not related to the meanings of the target components. Their performance on the A items remains roughly at 90%. See Figure 3 The results show that the children, even in Grade 1, had little problem with recognizing the functions of the target components in providing clues to the meanings of the characters (i.e., about what components signify).

Component not at Functioning Position

However, the children, especially before having reached Grade 3, encountered much difficulty in recognizing that the target components not in their functioning positions did not provide clues to the meanings of the characters. For example, they still regarded the meaning of the character汝 /jyu5/ (you) as related to "female" even though the component女 (female) in the character was actually not in its functioning position. As shown in Table 5, the first and the second graders only correctly responded to 45.0% and 55.6% of the C items, in which the target components were not located in their functioning positions. The mean percentages of the children in these two

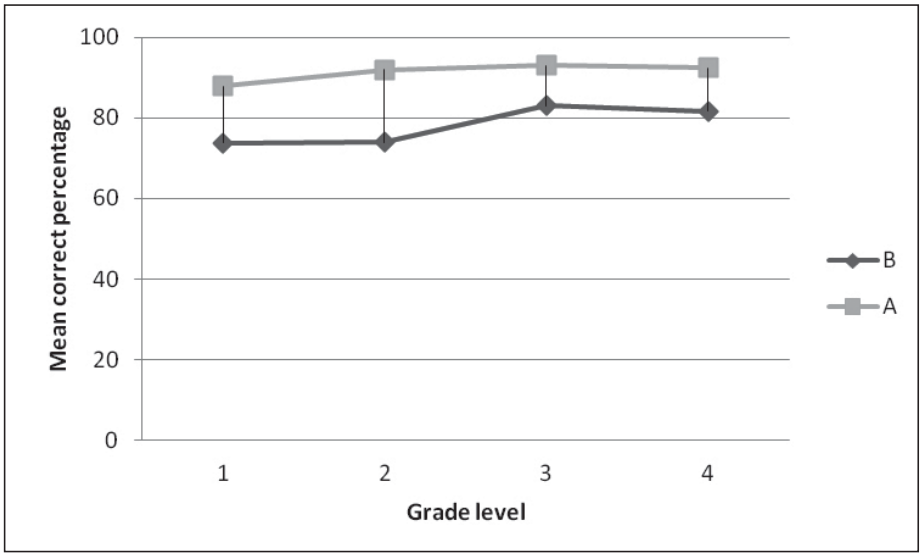

Figure 3 Mean correct percentages for the A and the B items as a function of grade level

grade levels do not differ significantly from the 50% chance level. In Grades 3 and 4, the performance goes up to 59.4% and 65.4% respectively, both having reached a significant difference from chance. However, even up to Grade 4, the children still interpreted 34.6% of the C items as incorrectly related to the meanings suggested by the target components. As a basis for comparison, the children's performance on the B items is higher than 70% as reported earlier. This means that the children did not simply regard all items as "not related" because they had never seen the items before. Otherwise, they would have also regarded the B items as "not related." The results show that the children, especially second graders and below, had difficulty in recognizing that when the target components were not located in their functioning positions, they did not provide clues to the meanings of the characters. See Figure 4.

Sub-component

Another major difficulty of the children was that they erroneously interpreted the target components that functioned as sub-components in the orthographic structures as providing clues to the meanings of the characters. For example, they had difficulty in recognizing that the sub-component 女

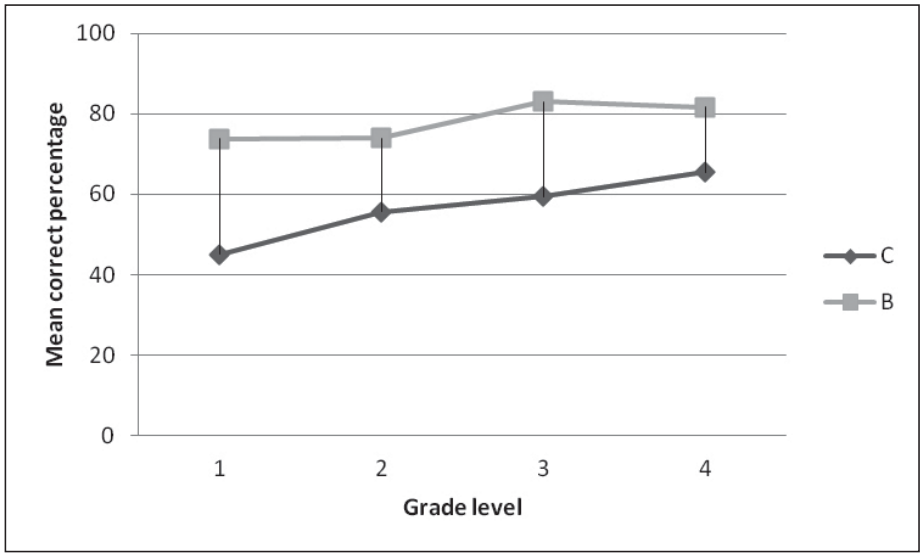

Figure 4 Mean correct percentages for the B and the C items as a function of grade level

(female) in the character努 /nou5/ (effort) was only part of the constituent component奴 /nou4/ and thus had nothing to do with the meaning of the whole character努 . As can be seen in Table 5, the children's awareness of the functions of sub-components seems to vary depending on the different configurations of the items. The target components in the E, the F, and the H items all served as sub-components in the items. But the children had least difficulty with the E items, in which the target components were located at the bottom right of the items. The children's mean percentages increase from 68.8% in Grade 1 to 82.4% in Grade 4, which all significantly differs from the 50% chance level. The next less difficult items to the children were the H items, in which the target components were located in the middle of the three components arranged horizontally in the items. The mean percentages increase from 56.1% in Grade 1 to 72.7% in Grade 4, and begin to be significantly higher than the 50% chance level in Grade 2. The most difficult items were the F items, in which the target components were located at the top left of the items. The mean percentages of the children go up from 43.6% in Grade 1 to 58.4% in Grade 4. Only the mean percentage in Grade 4 differs significantly at the level of .05 from chance. But it is noteworthy that the fourth graders actually still incorrectly interpreted a large portion of 41.6% of the F items as "related." See Figure 5. For comparison, the children's

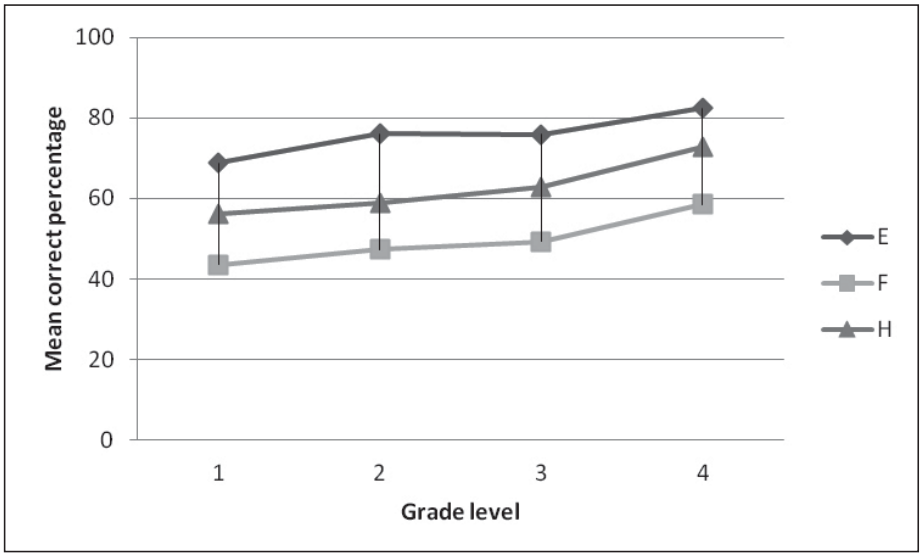

Figure 5 Mean correct percentages for the E, the F, and the G items as a function of grade level

mean percentages for the D and the G items, in which the target components function as constituent components rather than sub-components, are roughly higher than 70% in all grade levels. This means that the children did not simply regard all unseen items as "not related." Above all, the children incorrectly interpreted quite a substantial portion of those items in which the target components functioned as sub-components in the orthographic structures, as related to the meanings suggested by the target components. This is especially the case for those items with the configuration of the F items. This aspect of the children's awareness of orthographic structure, regarding the functions of sub-components, was less well developed (i.e., about how characters are composed).

Discussion

This study provides evidence that, to children in junior grade levels, determining what a component signifies in a character does not seem to be a major problem. This converges with the earlier results of Shu and Anderson (1997) that children are aware of the functions of semantic radicals in characters. Going beyond this, this study shows that children have trouble

with taking into account the position of a component in the orthographic structure of a character for determining whether or not the component provides a clue to the meaning of the whole character. In particular, the children in our study incorrectly interpreted the F items, in which the target components served only as sub-components (e.g. 女 in the character 努 /nou5/ [effort]), as having meanings associated with those of the target components. Even the fourth graders were only correct on 58.4% of such items, which is just above chance level. This means that children take no notice of the fact that sub-components in characters are only part of the constituent components and thus have nothing to do with the meanings of the whole characters.

Perhaps the difficulty of the children in analyzing characters with the 凵 configuration, as revealed in the poor performance on the F items in our study, has to do with the infrequent occurrence of such characters in textbooks. We have counted the number of such characters in the characters listed in the curriculum in Hong Kong（香港課程發展議會，1990）, on which the contents of the textbooks were based. It was found that such characters cover only on average 4.4% of the total number of characters for children from Grades 1 to 4. See Table 6. Because of the low frequency of use of characters with such configuration, children may have little experience with these characters, thus having difficulty in figuring out the orthographic structures of these characters.

Another explanation for the poor performance on the F items in our study may be that the children were more familiar with the target components than the other components in the items so that they chose the target components as the semantic radicals of the items. Since the target components used in this study such as the木 (tree) and the女 (female) were of high frequency of use, while the other components in the items such as the壬 (the ninth of the Heavenly Stems天干) and疋 (a roll of clothing

Table 6 Number of Characters Listed in Curriculum with Configuration 凵

	Grade 1	Grade 2	Grade 3	Grade 4	Total
No. of characters with configuration 凵 (percentage)	9 (1.9)	22 (4.4)	34 (6.4)	27 (4.5)	92 (4.4)
Total number of characters	460	500	530	590	2,080

material) were not. Thus it was possible that the children did not even know the meanings of the other components (i.e. they could not even recognize these components) so that the only things left for their consideration were the target components.

To further complicate the issue, we would like to add that children might actually not just pick one of the components in a character as the only semantic radical in the character. It was possible for them to regard more than one component as providing clues to the meaning of the character. In other words, our assumption is that whether a component in a character served as a semantic radical was not necessarily dependent on those of the other components in the same character. Our study just looked into the effect of one component, which was of high frequency of use, while the effect of the interaction of several components can be investigated in the future.

Although linguistically the interpretation that all of the components in a character provide clues to the meaning of the character is not correct in the case of semantic-phonetic characters, it is the correct way to interpret another category of logical-aggregate characters會意字 . The meanings of these characters came from the combinations of the meanings of all of their components. For example, the logical-aggregate character信 /seon3/ (trustworthy) is composed of the components 人 (people) and言 (to say), which should be explained as "what people say is trustworthy." Another example is the character解 /gaai2/ (take off), which is composed of the three components角 (horns of animals), 刀 (knife), and 牛 (cattle) and the meaning of the character should be explained as "to take off a horn from a cattle." Since these characters make up a total of 22% of the characters that children encounter in the textbooks in Grade 1 (Shu et al., 2003), there is the possibility that in our study the children erroneously applied what they had learned from the orthographic structures of the logical-aggregate characters to the items in our test.

Chinese linguists also add further complication to this issue. In certain semantic-phonetic characters, the phonetic radicals actually signify not only the sounds but also the meanings of the characters. This occurs when the characters historically evolved from characters that now serve as their phonetic radicals. For example, those characters with the phonetic radical 青 /cing1/ not only have sounds similar to /cing1/ but also refer to meanings

related to "to see through and shiny," for example, 清 /cing1/ (clear), 精 /zing1/ (rice so clear that light can pass through), 晴 /cing4/ (sunny), and 睛 /zing1/ (bright eyes)（邱德修，1995； 高明，1996； 王寧、 鄒曉麗，1999；龍宇純，2001）.

Thus to correctly analyze the orthographic structures of characters linguistically may not be as simple as one expects. The development of the awareness of the orthographic structures of characters may be difficult to children. Even though they have learned the characters, they may not have fully developed meaningful understandings of the orthographic structures of the characters, that is, to recognize how the characters as a whole are composed from their components to denote their meanings. The importance of such awareness of orthographic structure is what we have been arguing for throughout this paper.

One pedagogical implication from the above results is that teachers can try to teach children in what situation a component provides a clue to the meaning of a character and when it does not. To do this, one can show children simultaneously contrast pairs of characters such as榕 (banyan) and 想 (to think), in which the same component木 (tree) is located at different locations in the orthographic structures of the two characters (i.e. on the left and at the top left respectively). As such, one of the two characters (i.e. 榕) is related to the meaning of the component木 , while the other (i.e. 想) is not. We in fact have empirically tested the effectiveness of such method of using contrast pairs of characters, and found that the method is effective in enhancing children's awareness of the orthographic structures of characters (Lam & Tsui, 2013). However, as a final word of caution, the teaching of the orthographic structures of characters to children should not involve a lot of mechanical drill and practice such that it turns out to become another heavy burden for them, who may probably benefit more from extensive reading of enjoyable and fun stories.

Conclusion and Further Research

The study reported in this paper is an attempt to investigate how well children are aware of the orthographic structures of Chinese characters.

To do this, in the study we adopted the approach of investigating how the children made inferences about the meanings of unknown characters. This approach is however not enough. For instance, this study has only specifically dealt with components, such as the木 (tree) in榕 /jung4/ (banyan), which are themselves simple characters made up of only one component. But how is it about those components which are compound characters, namely, the波 /bo1/ in菠 /bo1/ (spinach)? Do children incorrectly interpret the characters菠 /bo1/ (spinach) and椒 /ziu1/ (pepper) as related to the meanings of波 (wave) and叔 (uncle) respectively? Being the phonetic radicals, these components however do not provide a clue to the meanings of the characters.

This study has also only examined those components with functioning positions on the left, such as the女 (female) in媽 /maa1/ (mother). Do children recognize the functions of those components that are located on the right as semantic radicals, for example, the 刂 (knife) in the character刻 /hak1/ (crave) and the鳥 (bird) in鴨 /aap3/ (duck)? Does children's awareness of the functions of these components on the right develop later than that of the more familiar components on the left? Or does it simply depend on the frequency of occurrence of the components in functioning as semantic radicals regardless of their functioning positions in the characters? It is in fact interesting to find out how children will actually analyze an unknown character like鳩 /gau1/ (turtledove). Do they recognize the鳥 on the right as a semantic radical and arrive at the conclusion that鳩 is a kind of "bird"? Or, do they attempt to pronounce the character鳩 as /niu5/ since the鳥 /niu5/ is on the right, where phonetic radicals are usually located? Answers to all these questions can more solidly substantiate the results of the present study and give us a more complete picture of children's awareness of the orthographic structures of Chinese characters.

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Appendix

Full List of the Eight Types of Items used in the Study