Effects of Print Input on Morphological Awareness Among Chinese Heritage Language Learners

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This chapter explores how the quality and quantity of print input shape morphological awareness among school-age Chinese heritage language (CHL) learners. Morphological awareness pertains to the ability to analyze a word's morphological structure. The significance of this ability lies in its capacity for enabling learners to dissect, identify, and manipulate morphemes in printed words, and in so doing, assisting them in inferring the meaning of unfamiliar characters and accessing stored character information. Although a tacit grasp of morpheme structures and functions stems from oral language development, their explicit understanding necessitates considerable print exposure and experience. The primary goals of the chapter are three-fold: (a) to identify the major properties of the Chinese characters explicitly taught in a widely-used textbook series (Grade 1–6) specifically designed for CHL students; (b) to compare the character properties in the CHL textbooks with those introduced in a textbook series used in China (Shu, Chen, Anderson, Wu, & Xuan, 2003); and (c) to examine how the input properties available to CHL students relate to their morphological awareness. Our analysis suggests that input properties appear to have a powerful impact on the formation of morphological awareness.

Words are building blocks in any form of verbal communication, and as such, word knowledge is integral to language comprehension and production. Understanding how this knowledge develops, therefore, is anything but inconsequential. Previous research illuminates several important facts about this knowledge: (a) the knowledge is multi-dimensional; (b) its development entails multiple encounters with a word in its variety of uses in context; (c) recognizing new information about the word associated with a particular use in input is, in itself, an acquired competence; (d) the acquisition of this competence is greatly expedited by morphological awareness; and (e) both morphological awareness and word knowledge evolve through cumulative experience with print input. Consequently, systematic examinations of the two key factors—print input and morphological awareness—should shed substantial light on word-knowledge development.

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This chapter explores how the quality and quantity of print input affect morphological awareness among Chinese heritage language (CHL) students in the US. In this context, "CHL students" refers to school-age children who use Chinese (Mandarin and related dialects) as the primary means of communication at home, learn English as the language of instruction, and pursue additional literacy in Chinese as a heritage language. Typically, they attend a local elementary school during the week, and are enrolled in a weekend community school. Clearly, their heritage-language literacy is subservient to the school literacy in English, and occurs with substantially less expectation and heavily restricted print input. "Morphological awareness" is defined as the ability to analyze, identify, and manipulate morphemes in words. Although a tacit understanding of morpheme structures and functions emerges from the use of spoken language, their explicit grasp develops primarily through decoding and encoding morphological information in print (e.g., Bialystok, 2001; Carlisle, 2003; Kuo & Anderson, in press). Hence, systematic analysis of the print input available to CHL students serves as a critical first step in probing the nature of their morphological awareness.

Background

Roles of morphological awareness in word learning

Of late, interest in morphological awareness has risen sharply among reading researchers. Its facilitative benefits can be best understood through its capacity for enabling children to analyze a word's internal structure to identify its morphological constituents. Since morphemes provide grammatical, syntactic, and semantic information, this ability is essential in identifying a word's grammatical category, inferring the meaning of an unfamiliar word, and accessing stored lexical information (Carlisle, 2003; Koda, 2000s, 2005; Ku & Anderson, 2003). Although morphological awareness facilitates all modes of word learning, the nature of its contribution varies from one learning mode to another because each mode involves its own unique operations.

Intentional learning, for example, entails establishing linkages among three lexical elements—meaning, sound, and grapheme—in the words to be memorized. On the surface, such linkage building appears simple, involving only a single holistic bond connecting each element. In actuality, however, for "intentionally-learned" words to be serviceable, multiple features in a word's grapheme must be identified and linked, through multiple bonds, with their corresponding lexical and sub-lexical elements. To illustrate, when using an intentionally-learned word in context, children commonly fail to recognize its proper usage, because they tend to attend only to the core semantic information of the word, and disregard the syntactic cue available in the grapheme, such as "slow*ness*" and "slow*ly*" (McKeown, 1993; Scott & Nagy, 1997). Obviously, single holistic bonds are insufficient for efficient use of intentionally-learned words in context. As an enabler for intraword analysis, morphological awareness offers vital assistance in multiple bond building in intentional word learning.

In contrast, incidental learning occurs as a by-product of other activities, such as reading and studying, and lexical inference is integral to this mode of learning. Because lexical inference requires identifying known morphological elements in an unknown word, it relies critically on the ability to analyze the intraword morphological structure. According to Nagy and Anderson (1984), roughly 60% of the new words children encounter in printed school material is structurally transparent, multi-morphemic words, such as *unladylike*; their meanings can be easily constructed by dissecting the words into their morphological constituents. Thus, in principle, the meaning of more than half the new words children encounter in school could be deduced on the basis of morphological information. Here again, morphological awareness plays a crucial role in learning words in context.

Like word knowledge, morphological awareness is a multi-faceted construct, consisting of a number of component capabilities. As such, it develops gradually over time as its diverse facets mature at disparate rates according to their own timetables. In English, for example, children are sensitized to inflectional morphemes in structurally transparent words well before schooling (Berko, 1958; Carlisle, 2003), but the productive use of inflectional information does not occur until Grade 2 or 3 (Bear, Invernizzi, Templeton, & Johnston, 1996). Further, understanding of derivational morphemes develops over an even longer period of time—between Grade 4 and 8 (Ku & Anderson, 2003; Tyler & Nagy, 1989, 1990). Hence, as noted above, while a tacit grasp of morpheme structures and functions stems from oral language use, their explicit understanding necessitates considerable print exposure and experience. The section that follows explains precisely how this awareness evolves through experiential exposure to print input.

Role of input and experience

Recent psycholinguistic theories hold that linguistic knowledge and processing skills both emerge progressively through the continuous detection and abstraction of regularities implicit in input. Connectionist theory, as a case in point, offers plausible explanations of how co-occurring patterns are detected and identified as corresponding elements, and then internalized as linked units. Its main contention is that the internalization of the established relationships can occur through cumulative experience of mappings of the elements to be linked—that is, for example, mapping particular linguistic functions (e.g., plural marking) onto their corresponding forms (e.g., plural marker /s/ and /z/ in spoken words and "-s" in print). The more frequently particular patterns of mappings are experienced, the stronger the connection holding the linked elements together. The theory thus describes knowledge acquisition as a gradual transition from deliberate efforts to automatic execution, rather than as an all-or-nothing process. Accordingly, knowledge is seen as a dynamic, ever-changing, state, rather than a static entity.

In this view of learning, knowledge acquisition is predicated upon statistical probabilities wherein the elements to be linked co-occur. For example, when the letter "t" appears at the first position in a word, the letter most likely to be activated is "h," simply because the probability that "t" will be followed by "h" is 50 times higher than that for any other letter (Adams, 1990). Put simply, the connection linking the letters "t" and "h" at the word initial position is substantially stronger than any other letter combination. Eventually, it is this connection strength that explains efficiency in input processing in real-life communication. In the input-driven accounts, therefore, input characteristics (input frequency and regularity, in particular) and learner experience are the key determinants of learning outcomes. As Ellis (2002) puts it, "rules" of language, at all processing levels, are structural regularities evolving from learners' "lifetime analysis of the distributional characteristics of the language input" (p. 144).

In brief, the input-driven view of learning defines language learning as a process of detecting and abstracting structural regularities in input. It thus assigns the significant role to input and experience in explaining and predicting eventual learning outcomes. Logic suggests then that morphological awareness can be seen as a learning outcome, shaped through input processing experience in a particular language, and therefore, its eventual form can be identified through careful analysis of the morpheme properties of the language under consideration—Chinese, in this case.

Properties of Chinese morphemes

In Chinese, morphemes are graphically encoded at two levels: radicals and characters (e.g., Chen, Allport, & Marshall, 1996; Shu & Anderson, 1997). "Radicals" refers to the recurrent stroke patterns used in compound characters. Over 80% of the characters currently in use are compound

characters consisting of two functionally identifiable radicals: one providing semantic information and the other conveying phonological information (Zhang, 1994). The majority of radicals are single-unit characters, many of which are taught in early grades. Therefore, when these characters reappear as radicals in compound characters in a later grade, their information—either phonological or semantic—should be accessible in children's lexical memory. Character learning thus relies on the knowledge of the single-unit characters which turn to radicals because it provides the visual and functional bases for character segmentation, radical identification, and radical information extraction.

There are approximately 1,100 phonetic radicals. As noted above, many of them are single-unit characters, and therefore, their respective pronunciation is used as the reading of the compound characters containing them (Shu & Anderson, 1999). Hence, in theory, compound characters can be pronounced by extracting the phonological information from the phonetic radical. In contrast, semantic radicals, roughly 190 in use, provide a guide to the meaning of compound characters (Shu & Anderson). As an illustration, the meaning of characters containing the "water" radical relates to water in one way or another, as can be seen in the characters for 湖 "lake," 池"pond," 洋"ocean," 洪"flood," 泳"swim," all sharing this radical. Although semantic radicals are useful for categorizing semantically-related characters, their information is generally too broad, as evident in the "water" radical, to allow character meaning construction by itself. Semantic radical information is thus helpful only when other input sources, such as neighboring characters and surrounding sentences, provide sufficient semantic constraints on the meaning of the character to be inferred. Moreover, when single-unit characters serve as a semantic radical, only an aspect of their original meaning is captured. For instance, when the character for "gold" 金 is used as a semantic radical, it indicates that the characters containing this radical refer to something metallic, as in 链"chain," 铠"armor," 钢"steel," and 针"needle." It is important, therefore, for learners to understand that a subtle change in meaning occurs when single-unit characters are used as a semantic radical.

As noted above, Chinese morphemes are encoded at the two—lexical and sub-lexical—levels. Because of their meaning-bearing function, semantic radicals are often considered as equivalent to single morphemes (e.g., Nagy & Anderson, 1999; Packard, 2000; Shu & Anderson, 1997;). Since the meaning of characters—single-unit or compound—is also associated with their grapheme holistically, characters themselves are also treated as morphemes (e.g., Taft & Zhu, 1995). Because of the dual-level encoding, character recognition relies on semantic information extraction both at the character (lexical) and radical (sub-lexical) levels. Skilled readers are, in fact, capable of such parallel information extraction during character recognition (Taft & Zhu, 1995; Zhou & Marslen-Wilson, 1994). Although radical information is insufficient for character meaning construction, logographic readers tend to turn to semantic radicals when encountering unfamiliar characters in context. It has been reported that successful character meaning inference is achieved through the integration of character-internal (semantic radical) and character-external (adjacent characters and surrounding sentences) information (e.g., Ku & Anderson, 2003; Mori & Nagy, 1999; Shu, Anderson, & Zhang, 1995).

Based on these properties, we contend that morphological awareness in Chinese should entail an explicit understanding that (a) most characters can be decomposed into two or more graphic components; (b) one of the graphic components in a compound character provides partial information on the character's meaning; (c) the meaning of characters sharing the same graphic component may be related; (d) semantic radical information only captures an aspect of the original meaning of the character serving as the radical; and (e) many characters can be combined to form a new word. As in English, the varying facets of Chinese morphological awareness

develop at disparate rates during the school years (Ku & Anderson, 2003; Shu & Anderson 1999). Within the input-driven theory of learning, we argue that these facets are shaped through cumulative exposure to and experience with print input. It is imperative, therefore, that the nature of print input—through which morphological awareness is shaped in Chinese—be systematically analyzed.

Properties of school Chinese

Shu and colleagues (2003) examined the major properties of the characters explicitly taught in elementary schools in China based on an extensive analysis of a textbook series (grades 1 to 6) widely used in China. The features they analyzed include (a) types of characters (e.g., pictographic, ideographic, semantic-phonetic compound), (b) visual complexity (number of strokes), (c) spatial structure (placement of radicals in compound characters), (d) phonetic regularity (consistency between the phonetic radical and the character's pronunciation), (e) phonetic consistency (congruence of the phonological information provided by the same phonetic radical), (f) semantic transparency (degree of semantic radical's contribution to the character meaning), (g) independent and bound components (lexical status of radicals), and (h) phonetic and semantic families (number of characters sharing the same radical).

Their analysis revealed that (a) larger numbers of characters are taught in the first three grades; (b) that these "early" characters tend to be of high frequency and visually simple, but phonologically and semantically opaque; and (c) that characters introduced at the upper grades tend to be of low frequency and visually complex, but phonetically regular and semantically transparent. These results indicate that native Chinese speaking children (hereafter referred to as "Chinese" students) are initially taught structurally simple characters conveying familiar concepts, and then introduced to structurally more complex, and conceptually less familiar characters. Importantly, moreover, their analysis also showed that the majority of the radicals (90% of the phonetic radicals and 92% of the semantic radicals) are single-unit characters, many of which are taught as independent characters in the initial two grades. Clearly, these "basic" characters (a particular sub-set of characters which are used as radicals in compound characters) serve as building blocks in learning a large number of compound characters. The mastery of the "basic" characters in the early grades, therefore, is critical for character-knowledge development. Collectively, these and other findings suggest that the input available to Chinese children is logically organized, allowing them to first establish a solid functional base with the "basic" characters, and then learn the rules for assembling and dissembling those characters (serving as radicals) through a large number of structurally transparent compound characters. Hence, the input promotes systematic expansion of character knowledge through radical-based, componential, approaches to character learning.

Properties of school Chinese as a heritage language

Following the procedures used in the Shu et al. (2003) study, we analyzed the properties of the characters introduced in a textbook series (Grades 1 to 6) specifically designed for CHL students (*Zhong Wen*, 1997, hereafter referred to as "Heritage" textbooks), which has been widely used in weekend Chinese schools in the United States. The textbooks are distributed by the Embassy of China in the United States. Table 1 presents the major properties of the characters introduced in the Heritage textbooks and those in the Chinese textbooks (Shu et al., 2003). The most striking difference was found in the total numbers of characters introduced in the two textbook corpora: 940 and 2,570 in the Heritage and the Chinese textbooks, respectively. CHL students are thus exposed to only 36% of the characters taught to their native speaking counterparts. The numbers of semantic-phonetic compound characters are similarly contrasting: 514 (CHL) and 1,850 (Chinese) in the two corpora. Given that semantic-phonetic compounding is the most

dominant character formation type, and also that the school textbooks are virtually the only source of print input available to the vast majority of CHL students, these quantitative indices make it plain that CHL literacy learning indeed occurs with heavily restricted print input.

Table 1. Major properties of the characters introduced in the grade 1–6 "heritage" and "Chinese" textbooks

		grade 1	grade 2	grade 3	grade 4	grade 5	grade 6	total
total number of characters	heritage (US)	124	141	152	149	185	189	940
	Chinese (China)	436	709	541	358	323	203	2570
number of semantic-phonetic compounds	heritage (US)	28 (.23)	74 (.53)	98 (.64)	101 (.68)	104 (.56)	109 (.58)	514 (.55)
	Chinese (China)	196 (.45)	496 (.70)	411 (.76)	300 (.84)	278 (.86)	164 (.81)	1845 (.72)
number of single-unit characters	heritage (US)	82 (.66)	32 (.23)	24 (.16)	18 (.12)	31 (.17)	25 (.13)	212 (.23)
	Chinese (China)	113 (.26)	50 (.07)	27 (.05)	11 (.03)	10 (.03)	8 (.04)	219 (.09)
number of semantically transparent characters	heritage (US)	20 (.71)	62 (.84)	78 (80)	82 (.81)	95 (.91)	103 (.86)	440 (.86)
	Chinese (China)	159 (.81)	246 (.86)	370 (.90)	267 (.89)	256 (.92)	151 (.92)	1449 (.78)
number of phonologically consistent characters (%)	heritage (US)	12 (.42)	33 (.45)	58 (.59)	61 (.60)	69 (.66)	49 (.45)	282 (.55)
	Chinese (China)	112 (.57)	177 (.62)	284 (.69)	201 (.67)	189 (.68)	120 (.73)	1083 (.59)
visual complexity	heritage (US)	5.54	7.56	8.36	8.85	8.98	8.56	7.96
	Chinese (China)	7.37	9.22	9.80	10.29	10.57	10.56	9.635

As noted above, character learning largely depends on the mastery of the "basic" characters in the initial grades, because they reappear as radicals in compound characters introduced in later grades. Our analysis revealed that CHL and Chinese students are taught almost identical numbers of single-unit characters over the 6 years (216 and 219, respectively). Their distributions, however, are different between the two textbook corpora. While in the "Chinese" textbooks, nearly 75% (163/219) of the single-unit characters are taught in the first two grades, the single-unit characters introduced in these grades constitute a little over 50% (114/216) in the "Heritage" textbooks. According to Shu et al. (2003), moreover, roughly 60% of the single-unit characters introduced in Grades 1 and 2 are the "basic" characters. As shown in Table 2, however, of the 114 single-unit characters in the CHL Grade 1 and 2 textbooks, only 42 are the "basic" characters, which constitute meager 22% of the semantic radicals. This implies that the input available to CHL students, particularly in the early grades, is far from sufficient for establishing the critical functional base required for identifying and manipulating radicals in learning compound characters in the later grades.

Despite the quantitative differences, there are similarities between the two textbook corpora. For example, mirroring the real-life frequency distributions, semantic-phonetic compounds are by far the most dominant character type in both corpora. In specific, in the "Heritage" Grades 2–6 textbooks, the proportions of semantic-phonetic compounds range from 53% (Grade 2) to 68%

(Grade 4) with the mean proportion of 60%, and those in the "Chinese" textbooks vary from 70% (Grade 2) to 86% (Grade 5) with the mean proportion of 79%. Moreover, the majority of the semantic radicals in both "Chinese" and "Heritage" textbooks are semantically transparent (78% and 86%, respectively), conveying the information closely related to the whole-character meaning. These similarities indicate that despite the heavily restricted quantity, the input quality in the "Heritage" textbooks may provide CHL students a workable foundation sufficient for uncovering semantic radicals' basic properties—both structural and functional.

Table 2: Single-unit characters reappearing as radicals in compound characters in CHL textbooks

	grade 1	grade 2	grade 3	grade 4	grade 5	grade 6	total
# of single-unit charactersfuture semantic radicals	36	6	4	5	5	3	59
# of single-unit charactersfuture phonetic radicals	60	19	19	13	26	14	151

To sum up, our analysis demonstrates that the characters explicitly taught to CHL students are heavily limited in quantity. In particular, the total number of the "basic" characters introduced in the initial grades is severely restricted, making it difficult for CHL students to establish the functional base for using radical information in learning and processing compound characters. On the other hand, in both "Chinese" and "Heritage" corpora, semantic-phonetic compound characters are by far the most dominant character formation type, and the vast majority of them are structurally and functionally transparent. Such transparency presumably helps sensitize CHL students to the basic properties of radicals in compound characters. Beyond these, however, the restricted "sample" size, in all likelihood, prohibits CHL students from refining their rudimentary understanding of semantic radical (morpheme) forms and functions, and as a consequence, their morphological awareness is likely to remain "basic."

Predicting morphological awareness in Chinese as a heritage language

Based on the morpheme (characters/radicals) property analysis described above, we made several predictions regarding the morphological awareness among CHL students. Two assumptions underlie the predictions: one, for the majority of CHL students, the "Heritage" textbooks are the major source of print input; and therefore, two, the properties of the textbook characters are largely responsible for the formation of their morphological awareness. It is important to note that other variables, such as instructional methodology and teacher beliefs, also contribute to the formation of morphological awareness and character knowledge. The exclusion of these and other variables, by no means, indicates that they have been ruled out as factors. We are focusing on print input simply because our goal is to explore a possible causal connection between input properties and morphological awareness within the well-articulated, input-driven, theory of learning.

Based on the analysis above, we predicted morphological awareness in CHL students to have the following characteristics.

- Because they are exposed to a proportionally larger number of compound characters, they are sensitized to the segmental nature of characters.
- Because the majority of compound characters in their input are structurally regular, they develop a basic understanding of the structural constraints on radicals in compound character formation.

- Inasmuch as most radicals are functionally transparent, they also understand the primary function assigned to each radical in a compound character.
- They become aware of how semantic radical information relates to the whole-character meaning.

Beyond these, however, it is unlikely that CHL students can refine and adjust their morphological awareness to detailed properties of semantic radicals shared only a sub-set of characters. Hence, it is highly improbable that their morphological awareness will allow systematic expansion of character knowledge through radical analysis and manipulation.

Measuring morphological awareness in Chinese as a heritage language

We tested the predictions described above using the data collected in a related study (Koda et al., this volume). The study involved 59 Grade 3 to 5 CHL students (all speakers of Mandarin or a related dialect) attending a weekend Chinese school. Through paper-and-pencil, multiple-choice tests, diverse facets of morphological awareness were measured, including (a) sensitivity to the structural constraints on radicals in compound character formation (radical formation); (b) ability to identify the semantic radical in a semantic-phonetic compound character (radical form); (c) understanding of the functional relationship between the semantic radical and the whole character meaning (radical meaning); and (d) sensitivity to a subtle change in meaning when a "basic" character is used as an independent character and when it serves as a semantic radical (radical explanation).

The results are presented in Table 3. As evident, CHL students performed well above the chance level (25%) on all tasks, but one (radical explanation). The highest response accuracy was found in the radical formation task designed to measure CHL students' sensitivity to the structural constraints on radicals. As predicted, however, their performance declined considerably in the tasks requiring knowledge of the semantic content of radicals (radical form and radical meaning). These results clearly suggest that although a grasp of the structural properties of radicals can evolve with heavily restricted input, a clear understanding of their functional properties necessitates substantially more input than is currently available to CHL students. The lowest scores, moreover, occurred in the task assessing CHL students' sensitivity to a detailed property of semantic radicals (radical explanation). Obviously, the formation of such subtlety requires both knowledge of substantially more "basic" characters and increased exposure to a wider variety of compound characters. Presumably, the "Heritage" textbooks do not provide the input—in both quality and quantity—necessitated for the acquisition of this and other highly refined awareness facets.

Table 3: Means and standard deviations (in parentheses) of the morphological awareness sub-test scores (% correct) in the four-task test

morphological awareness facets					
task requirements	**tasks**	**overall (N=59)**	**grade 3 (N=23)**	**grade 4 (N=20)**	**grade 5 (N=16)**
structural violation detection	**radical formation**	.88 (.12)	.88 (.12)	.86 (.12)	.89 (.12)
semantic analysis	**radical meaning**	.46 (.21)	.52 (.16)	.44 (.20)	.43 (.26)
	radical form	.55 (.21)	.59 (.17)	.49 (.19)	.56 (.26)
detailed semantic analysis	**radical explanation**	.25 (.15)	.24 (.17)	.24 (.13)	.28 (.15)

Taken as a whole, these findings lend support to the hypothesized connection between print input and morphological awareness. As predicted, CHL students seem sensitized to the structural

properties of radicals in compound characters; but without sufficient knowledge of the "basic" characters, it appears that they are unable to build the functional foundation based on which they can fine-tune their awareness to accommodate detailed properties of semantic radicals.

Conclusions

This chapter explored the nature of print input available to CHL students, as well as its relation to their morphological awareness. The findings demonstrated that (a) the input available to CHL students is heavily limited in quantity, but similar in its distributional and other qualitative properties to that available to native Chinese-speaking children; (b) despite the quantitative restrictions, the input provides CHL students a sufficient foundation for forming sensitivity to the basic properties of semantic radicals; (c) the foundation, however, is far from sufficient for categorizing and abstracting detailed properties of semantic radicals; and as a result, (d) CHL students are unable to develop the skills to utilize radical information efficiently in learning and processing novel characters. Clearly, the quality and quantity of print input have a powerful and predictable impact on the formation of morphological awareness. Given the potential utility of these findings, further explorations are highly desirable. Future research, for example, should more directly examine the specific ways in which CHL students' underdeveloped morphological awareness affects the formation of diverse character learning competencies. Systematic probing of the dynamic interconnections among input, morphological awareness, and word knowledge development could yield significant new insights into the unique nature of literacy development among heritage language learners.

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