Contemporary Educational Psychology 39 (2014) 287–300

Contents lists available at ScienceDirect

Contemporary Educational Psychology

journal homepage: www.elsevier.com/locate/cedpsych

Theoretical Analysis

Acquisition of Chinese characters: the effects of character properties and individual differences among learners

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ARTICLE INFO

Article history:
Available online 21 July 2014

Keywords:
Acquisition
Chinese
Literacy
Metalinguistic awareness

ABSTRACT

Drawing upon research on the visual complexity effect and Dual Coding Theory, this study investigated a) the effects of character properties on, and b) the contribution of individual learner differences to Chinese character acquisition. Participants included 325 Chinese-speaking children in grades 1 through 3 in China. Using a novel character acquisition task, the study extended the scope of previous research by investigating the process of acquiring the *meaning* of new characters. Results showed that for all three grade-groups, a) characters with radicals and with less visual complexity were easier to acquire than characters without radicals and with greater visual complexity; and b) the effect of radical presence was more pronounced with characters with greater visual complexity. Visual analogical skill made a significant contribution to the acquisition of characters varying in properties, regardless of age. The contribution of radical awareness, however, varied with character properties and age.

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1. Introduction

Central to the entire discipline of literacy development is the acquisition of written vocabulary, that is, the association between the written form of a word and its meaning (Kuo & Anderson, 2006). While various theories have been proposed to account for such acquisition processes (for reviews, see Alvermann, Unrau, & Ruddell, 2013; Kuo & Anderson, 2008; Sadoski, 2005), few studies have taken into consideration both the properties of the acquired vocabulary and the individual differences of the learners. The present study addresses this gap in the literature by examining the acquisition of Chinese characters among Chinese-speaking children.

Research on Chinese literacy acquisition has drawn unprecedented attention over the past two decades (e.g., Nagy et al., 2002; Packard et al., 2006; Shu & Anderson, 1997; Wu et al., 2009; for a review, see Perfetti, Cao, & Booth, 2013). The Chinese writing system differs significantly from more widely-studied alphabetic languages in its visual configuration as well as in the way sounds and meanings are mapped onto graphemes. These contrasts afford a unique opportunity for educational psychologists to gain a more comprehensive understanding of the cognitive processes involved in reading from a broader cross-linguistic perspective (Perfetti et al., 2013).

Earlier research on reading in Chinese focused more on the processing and the acquisition of characters varying in visual complexity *or* radical presence (e.g., Feldman & Siok, 1999; Perfetti & Tan, 1998; Shu & Anderson, 1997; Zhou, Marslen-Wilson, Taft, & Shu, 1999). More recently, research has emphasized how individual differences in visual skills (e.g., Ho & Bryant, 1997; Luo, Chen, Deacon, Zhang, & Yin, 2013; McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005; Tong, Chang, Shu, & Wong, 2009) or radical awareness (e.g., Ho, Ng, & Ng, 2003; Wu et al., 2009) contribute to reading achievement. Drawing upon research on the visual complexity effect (Su & Samuels, 2010) and Dual Coding Theory (Sadoski & Paivio, 2013), the present study extends the scope of previous research in two directions. First, it examines the *joint* effects of two major character properties, visual complexity and radical presence, on character acquisition including meaning. Second, the study investigates the contribution of individual learner differences in visual skills and radical awareness to the acquisition of characters varying in visual complexity and radical presence. By concurrently examining character properties as well as individual differences, we aim to build a more comprehensive research base for literacy development, in general, as well as for Chinese character acquisition.

In the following sections, we first provide an overview of the characteristics of the Chinese writing system with a focus on how it is contrasted with the more widely studied alphabetic languages. Next, we present theories of visual complexity and dual coding in the context of Chinese character processing and review the importance of character properties and individual learning differences in relation to character acquisition.

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http://dx.doi.org/10.1016/j.cedpsych.2014.07.001
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1.1. The Chinese writing system

The Chinese written language is a logographic system in which each lexical morpheme is represented by a unique symbol called a *character* (Shu & Anderson, 1997; Whitney, 1998). Each character maps to one morpheme rather than to an individual phonemic unit of the spoken language (Feldman & Siok, 1999), which posits several critical contrasts with the dominant letter-recognition-based models for word recognition derived from research on alphabetic-phonemic languages (Williams & Bever, 2010). In alphabetic-phonemic languages, the relationship between the orthographic unit and the semantic information it conveys is largely arbitrary. Contrastively, a large number of Chinese characters embed semantic information within each individual character (Williams & Bever, 2010). More than 80% of the characters in modern Chinese are *compound characters*, which are composed of two components: a *semantic radical* that gives a clue to the meaning of a character and a *phonetic component* that offers a clue to the pronunciation of a character (Chen, Allport, & Marshall, 1996; Hoosain, 1991).

Some radicals can stand individually as independent characters while others serve as a stroke pattern that can only occur within characters. For instance, the radical –女– *(female)* in the character –妈– *(mother)* is itself a character, whereas the radical –忄– *(heart)* in the character –怕– *(fear)* is not a free-standing character. Radicals in characters generally follow certain *positional regularities*. Most of the radicals are located in the left or top positions. While there are a few exceptions, the same radicals are generally restricted to the same location in a character. A significant number of Chinese compound characters share the same radicals, and those that share the same semantic radicals generally belong to the same semantic category and are related in meaning (Tong et al., 2009). For instance, the characters 妈 (mother), 姐 (sister), 姨 (aunt) and 媳 (daughter-in-law) share the same radical 女 (female), which is a core semantic feature of the characters that contain the radical representing *female*. The aforementioned characters with the female radical are called *radical-transparent* characters because the shared semantic feature is fairly obvious. It should be noted, however, that there are also small groups of *radical-opaque* characters (Flores d'Arcais, 1992; T'sou, 1981), which are compound characters that share the same radical but are not semantically related. Despite the exceptions, it has been estimated that more than 70% of the characters Chinese children learn in elementary school are radical-transparent characters (Shu, Meng, & Lai, 2003), and therefore, radicals serve as a reliable indicator of a character's general semantic category in early Chinese literacy development.

In addition to the way semantic information is encoded in the writing system, Chinese also presents a sharp contrast with the alphabetic languages in a) the relationship between semantic information and phonetic units and b) the way phonetic units are mapped onto graphemes. Chinese characters are monosyllabic, which means each character corresponds to one syllable. Chinese is also a tonal language in which changing the pitch of a vowel sound in a character can alter the meaning. For instance, the meaning of the Chinese character 鸡 *(jī, chicken)*, which is in a flat tone, is changed to *worried (jí,* 急*)* in a rising tone, *crowd (jǐ,* 挤*)* in an inflected tone, and *send (jì,* 寄*)* in a falling tone. While there are tens of thousands of potential English syllables, it has been estimated that Chinese uses only about 400 possible syllables (Shu & Anderson, 1997). What further complicates the interface among phonology, semantics and orthography in Chinese is that the same syllable with the same tone can be represented in different characters with different meanings. For example, all the following characters share the same syllable with the same tone, *jì:* 寄 *(send),* 記 *(memory),* 季 *(season),* 濟 *(help),* 計 *(plan),* 忌 *(taboo),* 技 *(skill)*. In other words, Chinese contains a large number of *homophones*, words that share the same sound but differ in meaning. Contrastively, English only contains a limited number of homophones, such as *to, too* and *two*, and *for* and *four*. In Chinese, while thousands of morphemes are used on a daily basis, they are represented in only 1200 syllables after differentiation by tone (Anderson & Li, 2005; Wu et al., 2009). It has been estimated that in Mandarin Chinese, each syllable possesses an average of five homophones (McBride-Chang & Zhong, 2003). Given that the prevalence of homophones makes vocabulary acquisition a more complicated and challenging process in Chinese, the visual representations of the characters, in particular the radicals, play an even more critical role in literacy development as they provide a primary clue to disambiguate the meanings of the homophonic characters.

1.2. Dual Coding Theory, radical presence, and character processing

According to the Dual Coding Theory (Paivio, 1971, 1986, 2007; Sadoski & Paivio, 2013), all mental representations occur in two separate mental systems or codes: the *verbal* code, which is specialized for representing and processing language, and the *nonverbal* code, which serves for processing non-linguistic world knowledge. The theory has been extended to account for reading processes (Sadoski & Paivio, 1994, 2001, 2004, 2013; Sadoski, Paivio, & Goetz, 1991). The theory postulates that three distinct dimensions of processing are involved in reading: a) representational processing, b) associative processing and c) referential processing. Representational processing refers to the initial activation of mental representations, such as recognition of a word or part of a word as familiar, but the process does not necessarily result in meaningful comprehension. Associative processing involves spreading the initial activation *within* a code, which is typically associated with meaningful comprehension. For example, the word *mother* may activate verbal associations such as *female, baby, children*, and *cooking*. Referential processing involves spreading activation *between* codes that is typically associated with meaningful comprehension. For example, the word *mother* may activate mental images (i.e., the non-verbal code) of females, babies, children, and cooking. These activated mental images may then spread their activation referentially to other words in the verbal system, providing a rich verbal–nonverbal network of semantic associations.

Dual Coding Theory has significant implications for explaining Chinese character acquisition because that acquisition involves both verbal and nonverbal processing at all three levels. At the representational level, acquiring a Chinese character involves the visual recognition and discrimination of written stroke forms including radicals (i.e., verbal processing) and detection of their positional regularities in two-dimensional spatial arrays (i.e., nonverbal processing). These distinctions will be explained in detail later. At the associative level, words can activate verbal semantic associates such as the association of *mother* with *female, baby*, and *children* as described earlier. At the referential level, the word *mother* may evoke nonverbal mental images of females, babies, and children as described earlier. In addition to the properties of the written words and the mental images activated by the written words, the theory also argues that individual differences in verbal and nonverbal skills may contribute to representational, associative, and referential processing (Sadoski & Paivio, 2013).

Consistent with the central role of radicals in the configuration of the majority of Chinese characters and predictions made by Dual Coding Theory, research has shown that readers of Chinese are automatically processing the radicals within the characters. Two major aspects of radical information are being processed during reading: semantics and positional regularity. With regard to semantics, research with Chinese-speaking adults (Chen et al., 1996; Feldman & Siok, 1999; Miao & Sang, 1991; Taft & Zhu, 1994, 1997; Taft, Zhu, & Peng, 1999; Zhang, Zhang, & Peng, 1990) and young children (Ho,

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