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Cognition 87 (2003) 129–149
COGNITION
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Alphabetic and nonalphabetic L1 effects in English word identification: a comparison of Korean and Chinese English L2 learners

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Received 14 August 2002; received in revised form 4 November 2002; accepted 22 November 2002

Abstract

Different writing systems in the world select different units of spoken language for mapping. Do these writing system differences influence how first language (L1) literacy experiences affect cognitive processes in learning to read a second language (L2)? Two groups of college students who were learning to read English as a second language (ESL) were examined for their relative reliance on phonological and orthographic processing in English word identification: Korean students with an alphabetic L1 literacy background, and Chinese students with a nonalphabetic L1 literacy background. In a semantic category judgment task, Korean ESL learners made more false positive errors in judging stimuli that were homophones to category exemplars than they did in judging spelling controls. However, there were no significant differences in responses to stimuli in these two conditions for Chinese ESL learners. Chinese ESL learners, on the other hand, made more accurate responses to stimuli that were less similar in spelling to category exemplars than those that were more similar. Chinese ESL learners may rely less on phonological information and more on orthographic information in identifying English words than their Korean counterparts. Further evidence supporting this argument came from a phoneme deletion task in which Chinese subjects performed more poorly overall than their Korean counterparts and made more errors that were phonologically incorrect but orthographically acceptable. We suggest that cross-writing system differences in L1s and L1 reading skills transfer could be responsible for these ESL performance differences.

Keywords: Alphabetic and nonalphabetic L1 effects; English word identification; Korean and Chinese English L2 learners

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doi:10.1016/S0010-0277(02)00232-9

1. Introduction

Different writing systems in the world select different units of spoken language for mapping (DeFrancis, 1989; Perfetti, 1999). An alphabetic system selects phonemes, a syllabary system selects syllables, and a logographic system, traditionally considered, selects morphemes or words to represent spoken language. The effect of these systemic differences on the cognitive processes of reading has been the focus of research that focuses on the contrast between Chinese and English (Perfetti, Liu, & Tan, 2002). Chinese, usually considered a logographic writing system, maps a printed character to a corresponding monosyllabic morpheme. Because this mapping reflects a unit of pronunciation (the syllable) as well as a unit of meaning (the morpheme), Chinese can be characterized as a morpho-syllabic writing system (DeFrancis, 1989; Mattingly, 1992; Perfetti & Zhang, 1995). However, its contrast with an alphabetic system remains sharp. The Chinese writing system does not possess the segmental structure that is basic to alphabetic writing systems. The principle of phonological assembly that, in alphabetic systems, allows larger (syllable and word) units to be assembled from letter–phoneme mappings, e.g. /k/-/æ/-/t/ is assembled to make /kæt/, cannot apply in Chinese reading.

An additional interesting difference between Chinese and most alphabetic systems is the nonlinear spatial layout of the character. The Chinese character consists of interwoven strokes in a square-shape form in contrast to the linear arrangement of letters in most alphabetic orthographies. However, this alignment of mapping system with visual shape is not inevitable, as the case of Korean shows. The Korean alphabet, Hangul, maps letters onto phonemes just as English, Russian, and Italian do. However, Hangul is nonlinear. The composition of its symbols is shaped into a square-like block, in which the symbols are arranged left to right and top to bottom. Its overall shape makes Korean appear more similar to Chinese than to its fellow alphabetic orthographies. The distinction among Chinese, Korean and English writing systems is depicted in Table 1.

The present study aimed to examine the cognitive consequences of alphabetic versus nonalphabetic first language (L1) literacy experiences for learning to read an alphabetic second language (L2). We compared adult English second language (ESL) learners with

Table 1
Illustration of grapheme–phoneme mapping principles in Chinese, Korean, and English writing systems

	Chinese	Korean	English
Word	火	달	c a t
Pronunciation	/huo/3	/t/ /l/ /æ/	/k/ /æ/ /t/
Meaning	“fire”	“moon”	“cat”

contrasting L1 writing system backgrounds who were acquiring English L2 word identification skills. The two language groups of interest were Korean ESL learners with an alphabetic L1 background, and Chinese ESL learners with a nonalphabetic L1 background. While Korean (Hangul) and Chinese writing systems have contrasting mapping principles, they share a certain visual similarity in terms of spatial configuration of the graphic units. Therefore, they constitute a theoretically and methodologically sound comparison in testing the effects of different L1 writing systems on English L2 reading. This study becomes the first to demonstrate systematically how the fundamental difference in the mapping principles of different L1 writing systems impacts cognitive processes in English L2 literacy acquisition. In the present study, we focused on the relative reliance on phonological and orthographic information in meaning processing and phonological decoding of English words by the two language groups.

Reading research has consistently demonstrated that there are three underlying constituent processes in word identification across writing systems. The three lexical constituents are orthography (O), phonology (P), and semantics (S). The relationship between orthographic, phonological, and semantic constituents in lexical processing has been a central interest for reading researchers for the last two decades. Many researchers agree that in reading for meaning, both the direct route from orthography to semantics ($O \rightarrow S$) and the route from orthography to semantics via phonology ($O \rightarrow P \rightarrow S$) are possible in identifying a word. However, the controversy exists over whether the $O \rightarrow P \rightarrow S$ route is more important than the $O \rightarrow S$ route.

Several studies have suggested that phonological mediation (i.e. the $O \rightarrow P \rightarrow S$ route) is more important than the orthography–semantics ($O \rightarrow S$) route (e.g. Lesch & Pollatsek, 1993; Lukatela, Lukatela, & Turvey, 1993; Lukatela & Turvey, 1994a,b; Van Orden, 1987; Van Orden, Johnston, & Hale, 1988). One of the important sources of evidence for this position has come from semantic tasks, such as a category judgment task where subjects are required to process and retrieve the meaning of a word. In a seminal study by Van Orden (1987), subjects were asked to judge whether a presented target word (e.g. "rows") is a member of a given category (e.g. "a flower"). The critical trials were the categorization decisions for homophone foils (e.g. "rows"), where the correct answer is NO. Spelling control items (e.g. "robs") were visually similar to the category exemplars, and were selected to provide comparisons. The logic underlying this task is that if readers activate the phonological information of the target word "rows" while trying to retrieve its meaning information, then this phonological information should bring about the meaning of the unseen category exemplar "rose". Therefore, confusion is likely to occur where the subjects' decisions are interfered with by the activation of both meanings of the homophone pairs. Van Orden's results showed that subjects gave more false positive responses, and therefore, more errors on homophone foils than they did on spelling controls. He argued for an automatic and obligatory phonological involvement in reading for meaning. Phonology mediates semantic processing in English words.

The second important variable manipulated in Van Orden's experiment was the spelling similarity between the target words and the category exemplars. Two groups of homophone foils and spelling controls were chosen: similarly spelled foils (e.g. homophone foil "meet", spelling control "melt") and less similarly spelled foils (e.g. homophone foil "rows", spelling control "robs"). This spelling similarity effect was found to be significant;

in other words, subjects had significantly higher rates of false positives for similarly spelled homophone foils than for less similarly spelled controls. Taken together, these results support the idea that both orthography and phonology impact the process of visual word recognition. Van Orden's findings were challenged by other researchers; some researchers have argued that the homophone inference effect is conditional upon certain word properties, for example, frequency of the stimuli (Jared & Seidenberg, 1991; see Berent & Perfetti, 1995; Jared, Levy, & Rayner, 1999 for reviews). Taft and van Graan (1998) further argued that such a phonological effect observed in meaning judgment only occurs when the direct path from orthography to semantics does not provide a correct match. They suggested that phonological mediation may not be a "prerequisite" for meaning processing, and orthography to semantics may be a "primary" route in visual word identification. They argued that only when the orthography to semantics route fails does phonological mediation come into play.

The relationship between orthography to phonology, or print to sound is another controversial issue in the reading literature. Coltheart and his colleagues proposed a dual route model. This model claims that there exist two routes from printed words to sound (Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart & Rastle, 1994; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). One route is the direct route; it provides a direct linkage from visual input to word pronunciation. This route is sometimes referred to as the "addressed route". The other is the indirect route; it converts graphemes into phonemes, which in turn are used to access the word pronunciation. This route is sometimes referred to as the "assembled route". A number of studies have shown that "assembled" phonology or phonological recoding is an automatic and rapid process (e.g. Perfetti, Bell, & Delaney, 1988; Van Orden et al., 1988) and this process may occur prior to word identification – pre-lexically (e.g. Perfetti & Bell, 1991; Perfetti et al., 1988; Ziegler & Jacobs, 1995).

What is the role of phonological information in reading a logographic Chinese system? The issue of phonology in reading logographic Chinese characters, especially in the task of meaning processing, is a controversial one. A couple of studies found that phonology plays no role in accessing character meaning either in single character tasks (Chen, Flores d'Arcais, & Cheung, 1995) or in two-character word tasks (Zhou & Marslen-Wilson, 1996). For example, Chen et al. (1995) employed the semantic category judgment paradigm from Van Orden (1987) to tap into the phonological and graphic activation in reading characters for meaning. They found that subjects responded more slowly and made more errors in a graphically similar condition but not in a phonologically similar condition. Their findings suggest that reading Chinese for meaning, where phonology is less prevalent, is different from reading for meaning in English. The authors argue that visual/graphic information plays an important role in processing Chinese characters. Several other studies, however, reported a significant effect of homophone interference in meaning related tasks (Chua, 1999; Perfetti & Zhang, 1995; Xu, Pollatsek, & Potter, 1999). For example, Perfetti and Zhang (1995) designed a synonym judgment task in which the subjects were presented with two consecutive characters and asked to decide whether they were related in meaning. In one of the conditions, the succeeding characters had the same pronunciation as the preceding character. Stimulus onset asynchronies (SOAs) were varied. It was found that phonological interference occurred at all the SOAs, even at very early exposure of the character (SOA = 90 ms). These results suggest that phonological information is important in meaning processing of characters in Chinese.

Despite the controversy surrounding the issue of the role of phonology in reading Chinese, we believe that the important point here is not whether phonology is useful in reading Chinese, but rather at what level phonological information is activated in reading Chinese. As Perfetti and his colleagues argue, phonological information in reading Chinese characters is activated at the lexical level rather than the pre-lexical level (Perfetti & Tan, 1998; see Tan & Perfetti, 1998 for a review). Phonological processing in Chinese character recognition is at the "addressed" syllable–morpheme phonology level. This is the fundamental difference regarding the role of phonology between Chinese and alphabetic writing systems. The concept of "pre-lexical phonology" is misleading for Chinese character reading. However, in processing Hangul words, pre-lexical phonology is activated rapidly and automatically (e.g. Kim, 1999; Yoon, Bolger, & Perfetti, 1999). Reading Hangul words for meaning involves pre-lexical phonological information processing. Cho and Chen (1999) found that Korean readers demonstrated strong homophone interference effects for pseudohomophones in a category judgment task. Although the subjects also made more errors on visually similar foils than controls, the effect size for homophone interference was much stronger than that for visual similarity.

It is important to note that the Chinese character has a much more complex visual–orthographic structure compared to Hangul syllables, although the Hangul syllable blocks are roughly the same size as Chinese characters. Each Hangul syllable is built of two to four symbols that in various combinations represent each of 24 phonemes. Chinese characters, by contrast, are composed from 24 basic strokes, combined according to certain positional constraints to form more than 500 component radicals (Chinese Radical Position Frequency Dictionary, 1984). Radical components are combined according to certain positional constraints to form characters. The visual distinctiveness between any two characters thus varies widely, and the set of characters as a whole presents a challenge in visual discrimination. Furthermore, the correlation between visual form and pronunciation is weak, even at the whole character level. Two characters that share a pronunciation often share no visual resemblance. Existing Chinese reading models (e.g. Perfetti & Tan, 1999; Taft, Zhu, & Peng, 1999) emphasize the importance of a fully specified orthographic representation prior to the activation of phonological and meaning information in reading Chinese. Finally, it is worth noting that although Chinese characters are used in conjunction with Hangul in South Korea, their use is relatively sparse. According to Taylor and Taylor (1995), the proportions of Chinese characters in the body of the text of a daily Korean newspaper are about 10%. Chinese characters are not taught in primary schools.

To put this language and writing system analysis in the context of learning to read in a second language, we emphasize that the task of the learner is to acquire the form of the new orthography and its mapping to spoken language. Does it matter that the new orthography has fundamentally different mapping principles? The effects of cross-writing system differences in reading English by learners with a nonalphabetic L1 background have been demonstrated in a handful of studies (e.g. Akamatsu, 1999; Haynes & Carr, 1990; Holm & Dodd, 1996; Jackson, Lu, & Ju, 1994; Koda, 1999, 2000). Haynes and Carr (1990) compared Chinese and American undergraduates' visual efficiency skills in making visual same–different matching on orthographically irregular (i.e. illegal) four-letter strings, orthographically legal four-letter pseudowords, and real four-letter words. The orthographically illegal letter strings were found to be the most difficult to judge and real words were the easiest for both groups. In order to further examine whether the two groups contrasted in efficiency gains when the stimuli were more familiar, the authors computed "lexicality effect" (word efficiency–pseudoword efficiency) and "orthography effect" (pseudoword efficiency–letter string efficiency). The results revealed that the Chinese L2 readers benefited relatively little from orthography and relatively more from lexicality, compared to their American counterparts. Similar results were obtained by Koda (1989) for Japanese-speaking ESL adults. She found that Japanese ESL readers, literate in Kanji symbols (borrowed from Chinese), performed better in recalling strings of unpronounceable letters than in recalling strings of pronounceable letters. Koda maintains that phonological inaccessibility is less debilitating for logographic readers (e.g. Japanese) than for alphabetic readers. In a recent study, Wang and Geva (in press-b) found a similar pattern of performance in a spelling task even among young Chinese ESL readers whose logographic L1 experience was very limited. The difference between spelling performance on pronounceable and unpronounceable letter strings, controlling for visual similarity, was significantly smaller for Chinese ESL children than the difference for English-speaking children. These findings together seem to suggest that logographic readers rely less on phonological information from the graphemic form in order to access its lexical representation than do alphabetic readers. On the other hand, for alphabetic readers a direct analysis of phonological information from the graphemic form is necessary for encoding subsequent lexical representation. However, the interpretation of these studies is clouded by the lack of attention to the level of English proficiency in the L2 groups. It is important to separate whether differences arise from the L1 writing system background or from the level of skill attained in L2.

It is worth noting that different teaching approaches in reading Chinese have been shown to affect readers' phonological processing skills differently. Chinese readers who are experienced in using an alphabetic phonetic system known as Pinyin in learning to read are more successful in manipulating speech sounds than those who are literate only in Chinese characters (e.g. Read, Zhang, Nie, & Ding, 1986). Holm and Dodd (1996) found that ESL university students from Hong Kong did not differ from the other ESL groups with alphabetic L1 backgrounds in reading and spelling real English words. These ESL groups included Chinese Mandarin readers who were taught Chinese characters via Pinyin. Hong Kong ESL students were, however, significantly less competent than all other ESL readers on a set of phonological awareness tasks, as well as in reading and spelling pseudowords. In the present study, the Chinese subjects were experienced in either Pinyin or Zhu Yin Fu Hao, another phonetic system used to assist in learning to read Chinese characters in Taiwan, a fact that may reduce the difference they would otherwise confront in learning to read English.

In the present study, two experimental tasks were designed to investigate the cross-writing system transfer in learning to read an L2. The Van Orden (1987) semantic category judgment task was selected to test the involvement of orthography and phonology in reading for meaning. By varying the phonological and spelling similarity of the target words to the category exemplars, we can test the use of phonological and visual–orthographic information in L2 learners with a nonalphabetic L1 background. The second task was a phoneme deletion task developed by Hart and Perfetti (2000) and shown to correlate with reading skill for adult readers. This task requires the phoneme deletion on an English word followed by a spelling of the new word that results from the deletion. Phoneme deletion is a strong indicator of reading success (e.g. Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988) and is useful for assessing phonological processing skills at the phonemic level of English L2 learners. The main question for the present study is whether nonalphabetic L1 readers transfer their logographic reading skills into an alphabetic L2 reading. Specifically, we are interested in the following questions. (1) When Chinese L1 readers read English words for meaning, will they show less reliance on phonological information compared to the Korean control group whose L1 experience is of an alphabetic nature? Will the Chinese L1 readers show heavier reliance on orthographic (spelling) information than their Korean counterparts? (2) Will the two language groups differ in phonological decoding of the English words?

We hypothesize that alphabetic and nonalphabetic L1 reading experiences will have significant effects on learning to read English L2. (1) Because Korean L1 readers will transfer their reading skills of a shallow alphabetic orthography to reading English, we predict that the Korean ESL learners will demonstrate a stronger use of phonology in processing semantic information of English words compared to Chinese participants; therefore there will be stronger homophone interference in semantic processing for Korean than for Chinese ESL learners. Conversely, because Chinese ESL learners will transfer their logographic L1 reading skills, they will show a stronger reliance on orthographic information than Korean L1 subjects. (2) Based on L1 differences in the letter–phoneme level, we expect that in the English phoneme deletion task Chinese students would produce more phonologically and orthographically incorrect responses and more phonologically based errors than Korean students.

However, an alternative possibility must be considered: what is critical is that the two groups achieve the same level of skill in English. If what determines the use of the structure of L2 is the level of skill acquired in L2, then two L1 groups equal in L2 skill may not differ in their use of phonological structure in English. Thus, both groups would use phonological information in semantic processing of English words and both would show homophone confusions. Nor would the two ESL groups differ in manipulating individual phonemes in English words. This alternative outcome would be consistent with the assumption that level-of-skill in L2 and not L1 is the critical factor. It could also arise to the extent that Chinese ESL students' experience with Pinyin or Zhu Yin Fu Hao facilitates their use of English phonological information.

2. Method

2.1. Subjects

Two groups of adult ESL learners participated in the study: 20 native Chinese speakers and 21 native Korean speakers. Among the Chinese subjects, 12 were from Mainland China and eight were from Taiwan. The mean age of the Chinese subjects was 28 years and 11 months (SD = 4 years and 9 months). The mean age of the Korean subjects was 25 years and 1 month (SD = 4 years and 7 months). Seventy-five percent of the Chinese students and 60% of the Korean students had a college degree. The average number of years of studying English before coming to the US was 8.21 for Chinese students and 8.15 for Korean students. The average number of months living in the US was 10.73 for Chinese students and 8.25 for Korean students. The two groups of ESL learners did not significantly differ in education, length of studying English in their homeland, or residency in the US.

The majority of the subjects (75% of the Chinese participants and 76% of the Korean participants) were enrolled at the English Language Institute (ELI) of the University of Pittsburgh. The subjects were recruited from intermediate and advanced level classes. Eleven Chinese and ten Korean students were enrolled in the intermediate level classes, and four Chinese and six Korean students were in the advanced level classes. The ESL classes at ELI are designed to help students intensively practice listening, speaking, reading, writing and analyzing the grammar of English. One hour was allocated for each component per day, thus each full-time student received five hours of instruction per day in the program. The remaining subjects (five Chinese and five Korean) were recruited from first-year graduate students on the same campus.

The participants were also asked to self-rate their English proficiency level including grammar, listening comprehension, and vocabulary as well as reading ability according to a four-point scale (1 = poor, 2 = fair, 3 = good, 4 = very good). Table 2 shows the means and standard deviations of the ratings of each category for each language group. The ratings of the two groups did not differ significantly from each other on each aspect (all $F < 4$, $P > 0.05$). Overall, the subjects rated their grammar and reading ability higher than their listening and vocabulary skills. Scores on standardized English language proficiency tests, such as the Test of English as a Foreign Language (TOEFL) and the Michigan Test of English Language Proficiency administered by the ESL program, were matched for the two language groups as well (both $F < 1$, $P > 0.5$). Means and standard deviations of the TOEFL and Michigan Test scores are shown in Table 2.

2.2. Familiarity ratings of the test materials

Familiarity ratings were obtained from three experienced ESL instructors who were

Table 2
Means (and standard deviations) of self-rating and standard English proficiency tests scores[a]

	Self-rated English proficiency				Standard English proficiency tests	
	Grammar	Listening comprehension	Vocabulary	Reading ability	TOEFL	Michigan
Chinese ESL	2.35 (0.75)	2.05 (0.51)	1.95 (0.76)	2.05 (0.69)	560.31 (24.58)	62.13 (9.43)
Korean ESL	2.35 (0.81)	2 (0.65)	2.1 (0.85)	2.45 (0.76)	554.82 (38.02)	65.77 (8.02)

[a] The scores of self-rated proficiency were obtained from 20 Chinese and 21 Korean ESL students. The TOEFL scores were reported from the curriculum for 12 Chinese and 11 Korean subjects, and the Michigan scores were reported from the curriculum for eight Chinese and ten Korean subjects.

teaching the classes from which the subjects in this study were recruited. Instructors were provided with a list of the English words that were candidates for the experimental stimuli and asked to rate how familiar each word was to college-level ESL students. A five-point scale was employed. The five points were: 1 = known ("I think every ESL students knows this word and can use it productively"); 2 = very familiar ("I think most ESL students are familiar with this word"); 3 = familiar ("I think many ESL students are familiar with this word"); 4 = not likely familiar ("I think many ESL students are not familiar with this word"); 5 = not at all familiar ("I don't think most ESL students have seen this word before"). These familiarity ratings obtained from experienced ESL instructors may be more appropriate for our ESL sample than the frequency accounts commonly used for native English speakers such as Francis and Kucera's corpora. ESL students may have a very different distribution of reading materials compared to native English readers. These ratings were used to control for familiarity of the items used across the different experimental conditions. We controlled for average familiarity ratings across the conditions.

2.3. Experimental tasks

2.3.1. Semantic category judgment task

In the first task, subjects were shown a category name (e.g. "a flower") and then a word (e.g. "rows") on a computer screen, and they were asked to judge whether the word is a member of the category (e.g. whether "rows" is "a flower").

2.3.1.1. Materials and design The design of this experiment was similar to Van Orden (1987, Experiment 1). The two key variables in this experiment were phonological similarity and spelling similarity. The phonological similarity variable consisted of two types of stimuli: homophone foils and spelling controls. Spelling similarity was defined as in Van Orden (1987) based on graphic similarity between target words and category exemplars. The spelling similarity had two levels, similarly spelled and less similarly spelled foils, creating four experimental conditions: (1) similarly spelled homophone (e.g. "meet"); (2) similarly spelled control (e.g. "melt"); (3) less similarly spelled homophone (e.g. "rows"); (4) less similarly spelled control (e.g. "robs"). Comparing performance on homophone foils and spelling controls tests the effect of phonological interference on meaning judgment, whereas comparing performance on similarly and less similarly spelled foils tests the effect of orthographic interference on meaning judgment. Each subject viewed 86 trials in total, 17 of which (20%) were homophones. Nine of these were similarly spelled homophones, and eight were less similarly spelled homophones. Seventeen items were spelling controls: nine were similarly spelled controls, and eight were less similarly spelled controls. The stimuli used in this experiment are shown in Appendix A. There were 52 fillers including 43 "yes" trials and nine "no" trials. The purpose of the fillers was to ensure equal numbers of category exemplar targets and non-exemplar foils. This was to reduce response bias due to the unequal number of "yes" and "no" answers. The key trials in this experiment were those that contained either homophones or spelling controls. The dependent variables were reaction times (RT) and error rates (false positives) in judging whether a homophone or spelling control was an exemplar of the category. Thirty practice trials preceded the administration of the test items. There were no homophone foils in the practice session.

Highly familiar category exemplars (mean familiarity = 1.52 for the similarly spelled condition, and 1.55 for the less similarly spelled condition) were selected to ensure that the ESL learners had adequate knowledge of the words. Homophone and spelling controls were of moderate familiarity. The items of moderate familiarity were chosen for the homophone and controls to promote sub-lexical phonology, which may be easier to observe in this task than highly familiar words (Jared et al., 1999). The familiarity of the homophone foils and spelling controls for similarly spelled and less similarly spelled conditions was matched: mean = 3.01 and 2.56 for homophone foils and spelling controls in the similarly spelled condition, and 2.92 and 2.50, respectively, for the less similarly spelled condition. Paired sample *t*-tests indicated that the familiarity ratings of the category exemplars for the similarly spelled and less similarly spelled conditions did not differ significantly ($t(7) = -0.002$, $P > 0.5$), nor did those of the homophone foils and spelling controls for the similarly spelled and less similarly spelled conditions ($t(8) = 1.23$, $P > 0.05$ for the similarly spelled condition, $t(7) = 0.68$, $P > 0.5$ for the less similarly spelled condition). The familiarity matching is necessary to exclude any familiarity confound with the expected effects of spelling similarity or homophony.

Visual similarity (VS), using the procedure of Van Orden (1987), was scored on a scale of 0 to 1, where 1 means a perfect match of letters in the same positions. The VS was matched for the homophone and spelling control trials in both similarly spelled and less similarly spelled conditions. For high VS, the mean VSs for homophone foils and spelling controls in the similarly spelled condition were 0.74 and 0.69; for low VS, the means for homophone foils and spelling controls in the less similarly spelled condition were 0.55 and 0.52.

To ensure that the subjects in both groups understood the category names, we provided them with a list of the category names used in the experiment accompanied by their translations in the subjects' native language. The subjects were asked to read over the list before the experiment to make sure that they comprehended all the category names. The list was then removed when the experiment started.

2.3.1.2. Procedure The experimental trials were displayed on a computer screen controlled by E-Prime (Psychology Software Inc., Pittsburgh, PA). Each subject was seated approximately 70 cm from the computer screen. Stimuli were presented at the center of the screen in white lowercase letters against a black background. After a fixation sign (+) was shown for 500 ms, the subject was first shown a category name and instructed to read it silently. Each category name remained on the screen for 1500 ms, and was then replaced by a target word, which remained on the screen until the subject made a category response (see Fig. 1). The interval before the next trial was 500 ms. Subjects were instructed to press the left mouse button to indicate "Yes" and the right one to indicate "No" as quickly and accurately as possible. Feedback was given for practice items, but no feedback was given during the experiment session. RT were measured from the onset of the target word to the onset of the subject's response. Each subject received a new randomized order of trials.

If the subjects made more false positives for homophone trials than for spelling controls, this homophone interference effect would provide evidence for the active involvement of

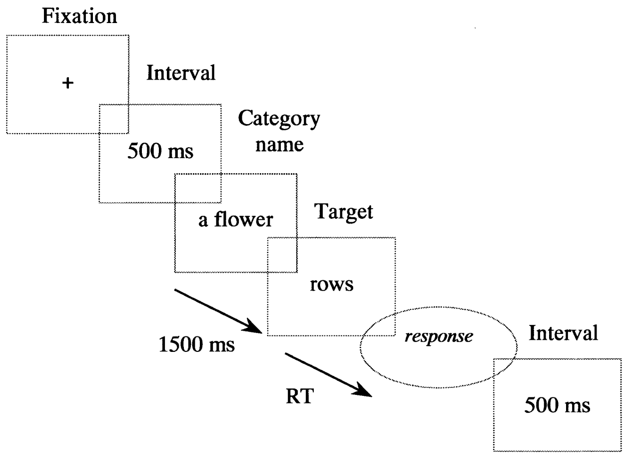

Fig. 1. The paradigm used in the category judgment task.

phonological information in processing meaning information. However, if the subject made more false positives for similarly spelled foils than less similarly spelled foils, we would argue for the effect of orthographic processing in word meaning processing.

2.3.2. Phoneme deletion task

A challenging phoneme deletion task examined the ability to manipulate sub-lexical phonological structure in English. Subjects were instructed to read aloud the word first, then remove a designated sound within the word, say aloud the resulting new word, and write it down on the answer sheet. Emphasis was placed on the new word being a real word. The target sound to be removed was indicated within a phonemic bracket / /. The uniqueness of this task is that the deletion of the required phoneme in the word leads to a new word with a different spelling form from the original one; for example, removing the /t/ sound from "might" created a word "my" which has a distinct spelling from "might". This feature requires the students not only to manipulate the individual phonemes in the word, but also to accurately access their spelling knowledge of the new word.

Thirteen items of moderate familiarity (mean familiarity rating = 2.67) were included in the task (see Appendix B). Care was also given to ensure that only phonemes that exist in both Korean and Chinese were included in the items. For four items the subjects were required to delete the initial single consonants of the words, for three items the subjects were required to delete the final single consonants, and for two items the subjects were required to delete the middle sounds of the words. For three items the subjects were required to delete the second consonant of an initial cluster. For one item they were required to delete a phoneme made of a consonant digraph represented by two consonants. Three practice items were given. Subjects were given eight minutes to complete the task.

The phoneme deletion task was coded into the following categories: (1) correct responses: subjects' written responses were both phonologically and orthographically correct (PH + OR +); (2) phonologically incorrect, but orthographically acceptable (PH − OR +); (3) phonologically correct, but orthographically unacceptable

(PH + OR −); and (4) both phonologically and orthographically incorrect (PH − OR −). For example, in the case of "might", when asked to remove the /t/ sound, the correct response is "my" (PH + OR +). If the subjects produced "me" or "may", these responses were coded as PH − OR + . If the subjects produced "migh" or "meye", these responses were coded as PH + OR − . Responses such as "moe" were coded as PH − OR − . Subjects' oral responses were also scored as correct or incorrect phonologically.

Interrater reliability for the coding system was established using Pearson correlations between two independent raters. The coding reliability for the written responses was 0.92, and for the oral responses 0.98.

3. Results

3.1. Semantic category judgment

3.1.1. Accuracy results

Our results exclude any subject whose accuracy in any of the four conditions was at chance or below chance level. After this adjustment, the results were based on 14 Chinese and 16 Korean ESL subjects.

Fig. 2 shows the accuracies of category judgment in the four experimental conditions by Chinese and Korean ESL groups. The differences among these means were assessed in a 2 (language group) × 2 (phonological similarity) × 2 (spelling similarity) mixed factorial ANOVA, which showed the two within-subjects main effects to be reliable by items and subjects: Phonological Similarity ($F_1(1,28) = 15.35$, $P < 0.01$, MSE = 0.016; $F_2(1,30) = 5.42$, $P < 0.05$, MSE = 0.022); Spelling Similarity ($F_1(1,28) = 26.28$, $P < 0.001$, MSE = 0.0079; $F_2(1,30) = 6.42$, $P < 0.05$, MSE = 0.022). More interesting were interactions of these effects with Language Group, reliable over both items and subjects for Spelling Similarity and subjects only for Phonological Similarity: Spelling

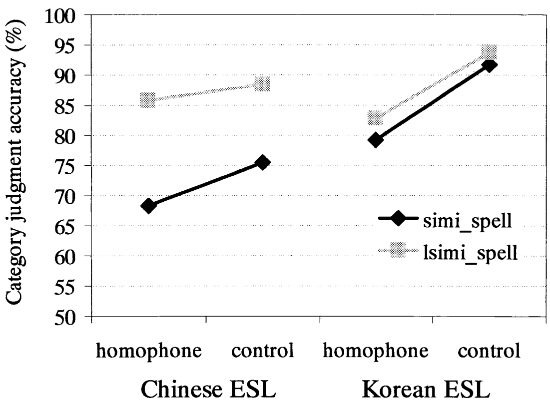

Fig. 2. Category judgment accuracies in the four experimental conditions by Chinese and Korean ESL groups (simi_spell = similarly spelled; lsimi_spell = less similarly spelled).

Similarity ($F_1(1,28) = 4.41$, $P < 0.05$; $F_2(1,30) = 7.16$, $P < 0.05$); Phonological Similarity ($F_1(1,28) = 7.17$, $P < 0.05$; but $F_2(1,30) = 2.18$, $P > 0.05$). According to post-hoc paired sample *t*-tests, accuracies on homophone foils and spelling controls differed significantly for the Korean ESL regardless of spelling similarity, as shown in the right panel of Fig. 2. The effect size of the homophone interference was 12.5% for the similarly spelled condition and 10.94% for the less similarly spelled condition ($t_1(15) = -3.44$, $P < 0.01$; $t_2(8) = -4.54$, $P < 0.01$ for the similarly spelled condition; $t_1(15) = -3.66$, $P < 0.01$; $t_2(7) = -4.25$, $P < 0.01$ for the less similarly spelled condition). For Chinese subjects, more homophone interference occurred in the similarly spelled condition than in the less similarly spelled condition, as shown in the left panel of Fig. 2. The effect size of the homophone interference was 7.15% for the similarly spelled condition and 2.68% for the less similarly spelled condition, although neither was reliable statistically ($t_1(13) = -1.61$, $P > 0.13$; $t_2(8) = -1.01$, $P > 0.3$ for the similarly spelled condition; $t_1(13) = -0.72$, $P > 0.4$; $t_2(7) = -0.67$, $P > 0.5$ for the less similarly spelled condition).

Accuracy depended on spelling similarity for Chinese ESL learners in both homophone and spelling control condition (all $t > 3$, $P < 0.01$), but not for Korean subjects (all $t < -1$, $P > 0.3$). For Chinese subjects, the effect size of spelling similarity was 17.46% for the homophone condition and 12.99% for the spelling controls. For Korean subjects, the non-significant difference between high similar and low similar spellings was 3.64% for the homophone condition and 2.08% for the spelling controls. Interactions between homophone and spelling similarity were not significant by the subjects and items, neither was the three-way interaction between the three independent variables (all $F < 1$).

Finally, the Language Group effect was significant by both subjects and items ($F_1(1,28) = 13.62$, $P < 0.01$, $MSE = 0.012$; $F_2(1,30) = 10.34$, $P < 0.01$, $MSE = 0.0089$). The two groups did not differ significantly in the less similarly spelled homophone and spelling control condition ($t(28) = 0.665$, $P > 0.5$; $t(28) = -1.60$, $P > 0.1$), but differed significantly in the similarly spelled homophone and spelling control condition ($t(28) = -2.62$, $P < 0.05$; $t(28) = -3.91$, $P < 0.01$). The Korean ESL subjects outperformed Chinese ESL subjects on the similarly spelled items.

3.1.2. Decision time results

The RT data for correct responses were trimmed by removing any RT two standard deviations below or above the cell mean, which resulted in removal of less than 3% of the responses. According to the ANOVA on these data, there was no main effect of either Phonological or Spelling Similarity (both subject and item $F < 1$). The Language Group effect was significant by both subjects and items ($F_1(1,28) = 9.79$, $P < 0.01$; $F_2(1,30) = 38.69$, $P < 0.001$), reflecting faster decision times for Korean than for Chinese subjects. Post-hoc independent sample *t*-test indicated that Korean subjects were faster in all of the experimental conditions than their Chinese counterparts (all $t > 2.10$, all $P < 0.05$). None of the interactions between phonological similarity and language group, spelling similarity and language group, phonological and spelling similarity and their three-way interaction were significant (all $F < 1.26$, all $P > 0.2$). It is often the case in L2 research that differences in reactions times are not a stable measure because of low L2 accuracy levels (Juffs, 2001).

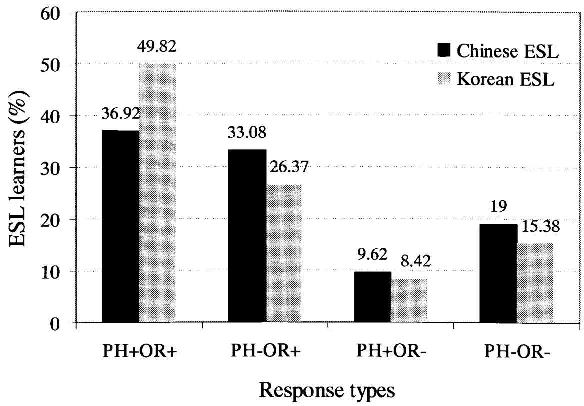

Fig. 3. Percent of Chinese and Korean ESL learners in the four response categories in the phoneme deletion task.

3.2. Phoneme deletion

3.2.1. Written responses

Results for the written responses to the phoneme deletion task are shown in Fig. 3. A series of nonparametric Wilcoxon signed ranks tests was performed to compare the percentage of subjects in each language group who fell into each category. Significantly more Korean participants produced correct words after deleting the designated phoneme (PH + OR +), and significantly more Chinese participants produced phonologically incorrect but orthographically plausible responses (PH − OR +) than Korean participants ($Z = -2.41$ and -2.34, respectively, both $P < 0.05$). The differences between the two language groups in the phonologically correct but orthographically implausible (PH + OR −) and both phonologically and orthographically incorrect responses (PH − OR −) were not significant (both $Z < -1$, both $P > 0.1$).

3.2.2. Oral responses

Oral responses were also analyzed in order to further examine phoneme manipulation skills at the oral level. A difference might exist between oral and written performance for ESL learners. The mean percentage of correct oral responses were 55.77 (SD = 18.66) for Chinese ESL and 69.23 (SD = 18.37) for Korean ESL students. Korean subjects were significantly better than Chinese subjects in deleting the designated phonemes orally in words ($t(39) = 2.33$, $P < 0.05$).

4. Discussion

The results provide support for the hypothesis that alphabetic and nonalphabetic L1 literacy experiences have cognitive consequences in learning to read an L2. Despite their experiences with Pinyin or Zhu Yin Fu Hao, native Chinese readers with a nonalphabetic L1 showed suggestive evidence of less pre-lexical phonological information in identifying

English words than native Korean readers with an alphabetic L1. On the other hand, Chinese L1 readers are more attentive to orthographic information than their Korean counterparts. Chinese and Korean Hangul are typologically different L1 writing systems and involve different demands on phonological and orthographic processes. Reading in Hangul relies heavily on phonological information, especially at the grapheme–phoneme–correspondence level. Reading in Chinese, on the other hand, does not entail direct letter–sound mapping, but rather draws upon detailed visual–orthographic analyses. Consequently, these L1 reading skills demanded by different L1 writing systems have an effect on English L2 literacy acquisition. The transfer of reading skills from a nonalphabetic L1 to an alphabetic L2 differs from the transfer between two alphabetic writing systems.

Korean subjects made more errors in judging homophone foils than spelling controls, whereas Chinese subjects did not show significant homophone interference. The Chinese subjects, on the other hand, demonstrated more sensitivity to the orthographic similarity than Korean ESL learners. They were more accurate in judging less similarly spelled words than similarly spelled words. Orthographic similarity created significantly more confusion for the Chinese ESL learners than their Korean peers. Chinese ESL learners were poorer than their Korean counterparts on the phoneme deletion task in which the subjects were required to manipulate the sounds in the words, and then use their orthographic knowledge to complete the new words. This task requires both phonemic manipulation and orthographic knowledge to access the correct answer. Chinese subjects made more orthographically acceptable but phonologically incorrect responses than Korean students. This result suggests that the Chinese subjects tend to rely on word based processes in analyzing the sub-lexical elements of the English words. Their difficulty in performing this task may not rest on the access to correct orthographic knowledge of the English words, but rather on the analysis and manipulation of the individual phonemic elements in the words. The result from the oral responses further confirms their poorer performance in manipulating sounds in English words than their Korean counterparts. Such Chinese ESL readers' reading performance resembles the "addressed" readers in the dual route reading model (e.g. Coltheart et al., 1993).

It is worth noting that, although not statistically significant, there was still more homophone confusion for Chinese ESL learners in the similarly spelled condition than the less similarly spelled condition.[1] This trend implies that regardless of L1 backgrounds the role of phonology exerts some influence in English word identification for L2 learners. Koda (1999) also found that both alphabetic and nonalphabetic ESL learners are sensitized, to a similar degree, to the internal structure of English words. Therefore, in learning to read an L2, it might be the case that it is the nature of the target writing system that also plays an important role. Various visual, phonological, orthographic and morphological features of the L2 writing system are the ultimate learning targets for L2 learners. In spite of the potential transfer of reading skills from L1 to L2, the L2 learners might also treat the L2 as a totally independent (unrelated to their L1), new target system. This might be especially true in the case of Chinese ESL learners, as the differences between their L1 and L2 are so

[1] Please note that this homophone confusion in the similarly spelled condition might have arisen from frequency difference between the homophones and spelling controls. Future research needs to control for this potential confound.

sharp and fundamental. It seems plausible that both the transfer from L1 to L2 and the nature of the L2 system may jointly contribute to L2 reading acquisition. This joint contribution reflects the interaction between L1 and L2. Moreover, the logographic L1 transfer effect on alphabetic L2 learning may occur only at the beginning stages of learning. With increasing proficiency in English, the effect of phonology on English word processing will eventually prevail in Chinese L2 readers' performance. The differences between the two language groups will decrease. Wang and Geva (in press-a) found evidence for a gradual diminution in the L1 transfer effect in the process of L2 learning. Their Chinese ESL children overcame difficulties in the spelling of novel English phonemes absent in their L1 phonology during their first 2 years of schooling.

The finding that the Chinese L1 readers were poorer overall than their Korean peers in the performance of the two experimental reading tasks, as well as slower in their responses in the category judgment task, was in accordance with the converging evidence that an alphabetic L1 facilitates word identification in an alphabetic L2, compared to a logographic L1. Muljani, Koda, and Moates (1998) studied Indonesian (an alphabetic system) students' and Chinese ESL students' word recognition skills. Indonesian subjects performed significantly more efficiently than Chinese subjects in an English lexical decision task. Their results along with ours suggest that ESL learners with an alphabetic L1 develop a better knowledge of English words when phonological decoding is necessary compared to Chinese ESL readers whose L1 is primarily of a logographic nature. However, it is worth noting that the Korean subjects were more accurate than Chinese subjects in judging English word meaning in the similarly spelled condition but not in the less similarly spelled condition. This result suggests that when the visual–orthographic patterns of the English words were similar the Chinese L1 readers had more difficulty than Korean L1 readers in meaning processing. The reason for this may be that the Chinese students relied heavily on the visual–orthographic information of the English words; therefore more confusion arose when the target words were more orthographically similar to the category exemplars. Moreover, phonological decoding of the English words does not provide as much support for this group of English learners with a nonalphabetic background. Alphabetic reading acquisition research has consistently documented the primary function of phonological skills in printed word learning (e.g. Share, 1995, 1999; Share & Stanovich, 1995). This prerequisite decoding skill, however, is not as well developed in Chinese ESL learners as in their Korean counterparts. Therefore, we suggest that the fact that Chinese students were more dependent on orthography is not to say that their orthographic skills were better than Korean students.

The experimental reading task used in the present study posed a particular challenge to these L2 learners, as only moderately familiar words were involved. As a result, the RT data were unreliable due to the low accuracies in judgment performance. Juffs (2001) pointed out that in L1 experiments accuracy data tend to be very high; therefore, after excluding the error data, the RT data should still be reliable. However, in L2 research, a relatively large number of errors may cause problems if one attempts to make any conclusion based on the correct-response data. So RT data cannot really provide reliable information. On the other hand, this pattern of results may also suggest that L2 learners shift their efforts towards accuracy more than speed in word processing, because they have limited resources to allocate in processing L2 materials. Accuracy might be their priority for attention. Informal interviews with the subjects after the experiments also revealed that many of them felt the need to sacrifice speed in order to process the stimuli more accurately.

English words with moderate familiarity ratings were chosen in an attempt to solicit the sub-lexical level of phonology in meaning judgment. It would be worthwhile in future research to further include high and low familiarity items so that the effect of word familiarity on phonological involvement can be examined. As we noted in the literature review, the frequency of the stimuli may affect the homophone interference effect in native English readers (e.g. Jared & Seidenberg, 1991). It would be interesting to see whether second language learners exhibit a similar effect. This would be an important way to demonstrate the influence of English L2 learning experience in word processing. Moreover, pseudoword items can also be constructed to solicit purer sub-lexical phonological processing in both the category decision and phoneme deletion task. Finally, language itself, apart from the writing system, is critical in both L1 and L2 reading. Chinese and Korean share many phonemes. However, Chinese syllable structure is simpler than Korean. Another important difference is that Chinese is a tonal language, but Korean is not. Future research needs to address the consequences of L1 linguistic differences in learning to read an L2. In addition, one or two oral English tasks can be included to control for non-orthographic skills between the two ESL groups.

One major conclusion can be drawn from the present study: different writing systems have an impact on cognitive processes in literacy acquisition. Chinese ESL learners may rely less on phonological information in word identification than their Korean ESL peers whose L1 experience is of an alphabetic nature. Instead, Chinese ESL learners heavily attend to orthographic information in words to access the lexical representation without necessarily having more orthographic knowledge. These findings can be explained by the cross-writing system differences in the L1s and the L1 reading skills transfer.

Acknowledgements

The research reported here was funded by a post-doctoral fellowship to the first author by the Social Sciences and Humanities Research Council of Canada and in part by National Science Foundation Grant SBR-9616519 to Charles A. Perfetti. We would like to thank Dorolyn Smith and Lionel Menasche for their assistance in recruiting subjects at the University of Pittsburgh, and Lacey Lankard for her assistance in data collection. Thanks also go to Ying Liu for his technical assistance in E-Prime programming. We are also grateful to the Editor and three anonymous reviewers for their helpful comments on previous drafts.

Appendix A. Semantic category judgment task

Category name	Exemplar	Homophone	Spelling control
		Similarly spelled foils	
A feature of an ocean shore	beach	beech	bench
Part of a sandwich	bread	bred	bead
A small stream	creek	creak	cheek
A body part	feet	feat	fees
Transportation in the sky	plane	plain	plans
Type of weather	rain	rein	ruin
Used to get up or down	stair	stare	stars
The end of your feet	toe	tow	toy
An alcoholic drink	wine	whine	wink
		Less similarly spelled foils	
An animal	bear	bare	beat
A breakfast food	cereal	serial	several
A part of a plant	flower	flour	flowed
Part of a person's face	nose	knows	snobs
A passage used by vehicles	road	rode	rods
A flower	rose	rows	robs
Part of a boat	sail	sale	salt
A sea animal	whale	wale	wheel

Appendix B. Phoneme deletion task

MIDDLE	remove the /d/ sound	________________
QUEEN	remove the /w/ sound	________________
HATCHED	remove the /ch/ sound	________________
MOTION	remove the /m/ sound	________________
WRAPPED	remove the /r/ sound	________________
CAUGHT	remove the /k/ sound	________________
PAGE	remove the /j/ sound	________________
LAUGHTER	remove the /l/ sound	________________
SKY	remove the /k/ sound	________________
ROD	remove the /d/ sound	________________
RACKS	remove the /r/ sound	________________
MIGHT	remove the /t/ sound	________________
SPOT	remove the /p/ sound	________________

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