Impact of L2 Reading Proficiency on L1 Transfer in Visual Word Recognition

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1. Introduction

Reading, in any language, is a complex process. Reading in a second language is even more complicated because of the cross-linguistic influences that come from the reader's two (or more) languages. In particular, cross-linguistic influences have been shown to affect word recognition processes. Much research has shown that properties of a reader's first language, especially the writing system, can greatly affect how a reader recognizes words in a second language. However, there are also more universal effects that influence second language word recognition. The comparative influence of reading universal and script-dependent factors has been of particular interest in recent years.

Cross-linguistic studies of word recognition have shown that orthographic features of a reader's first language affect second language word recognition in three main ways: the type of information that readers predominantly rely on during word recognition, the degree to which readers are sensitive to intra-word information, and the efficiency with which readers process the components of words (Akamatsu, 2003). However, these influences have largely been seen in the previous research as static influences that affect readers throughout the language learning process. Thus, the goal of the present study is to investigate whether these cross-orthographic influences on L2 word recognition change as readers become more proficient in reading a second language.

2. Literature Review

A universal step in learning to read is that the reader must understand how the writing system of a language encodes the spoken form (Perfetti, 2003). In order to read, one must first understand what unit is mapped by the writing system of a language: phonemes, syllables, or morphemes. In an alphabetic language, which maps phonemes, a reader must understand that each grapheme represents a sound, that words are made up of separate graphemes, and the amalgamation of the sounds of these graphemes produces the spoken form of the word. For readers of a morphosyllabic language such as Chinese, however, such serial assembly of sounds is not possible. Instead, readers must realize that the graphemes of the writing system map larger units, namely syllables and morphemes (see Figure 1).

Although readers in any language must understand how the written form maps the spoken form of the language, language-specific differences in mapping systematically result in differences in how words are recognized. The Orthographic Depth Hypothesis (Frost, 1994; Frost, Katz, & Bentin, 1987) proposes that the process used to recognize words is dependent upon the extent to which the written form of a language corresponds with the phonological form. When a language's written form provides a one-to-one relationship between the graphemes and phonemes (i.e., grapheme-phoneme correspondence) in a word, then the language is considered to be orthographically shallow. On the

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Figure 1. Orthographic and Phonological Representations in Chinese and English

other hand, when the relationship between the graphemes in a word and the phonological representation is not as direct, as in Chinese, a language is considered to be orthographically deep. The ODH proposes that the more orthographically shallow a language is, the greater extent individual letters will be processed and phonology will be activated during word recognition; on the other hand, more orthographically deep languages will involve less activation of phonology during word recognition and more holistic word recognition of the orthographic form.

Katz and Feldman (1983) investigated this phenomenon in L1 speakers of three languages which, although they are all alphabetic, vary in their degree of orthographic depth: Serbo-Croatian, English, and unvoweled Hebrew. These languages were chosen because they provide a range from orthographically shallow to orthographically deep. It was found that word naming depended more on phonology in Serbo-Croatian (an orthographically very shallow language) than in English (orthographically deeper than Serbo-Croatian), and word naming depended more on phonology in English than in Hebrew (orthographically deeper than English). In addition, effects of orthography consistent with the ODH have been demonstrated in a number of other L1s (Welsh: Ellis & Hooper, 2001; Hebrew: Frost, 1994; English, French, and Spanish: Goswami, Gombert, & De Barrera, 1998; Turkish: Öney & Durgunoglu, 1997).

Although the ODH makes predictions of differences between languages, grapheme-phoneme correspondence has also been shown to have an effect within languages as well. Spelling regularity (i.e., reliability of grapheme-phoneme correspondence) has been shown in English to affect word recognition (Seidenberg, 1985). For example, in words with exceptional spelling, such as *colonel*, grapheme-phoneme correspondence is fairly low, and thus there is less serial, letter-by-letter processing than in words with more regular spelling, such as *cat*. In addition, spelling regularity has been shown to interact with word frequency in that spelling regularity has a greater effect on low-frequency words (Seidenberg, 1985).

Reading skills acquired from learning to read a first language have been shown to transfer to reading in a second language as well. In particular, orthographic depth of a reader's L1 has been shown to affect the way that they recognize words in their L2. Research has shown that L2 learners recognize words in their L2 in a similar way that they recognize words in their L1. Koda (1988, 1990), applying the ODH to L2 word recognition by investigating L1 Japanese, Spanish, and Arabic learners of English, found that the L1 Japanese (a deep orthography) readers relied more on orthographic information during L2 English word recognition. On the other hand, the L1 Spanish and Arabic readers (both of which are more shallow than English) relied more on phonological information than orthographic. These results suggest that the learners were applying the word recognition strategies from their first language to word recognition in their second language as well.

In another study that investigated transfer of orthographic processing strategies, Wang, Koda, and Perfetti (2003) explored the role of L1 Chinese (deep) and L1 Korean (shallow) L1 background on L2 English word recognition. Using a semantic category judgment task, it was found that L1 Chinese readers were affected more by orthographic interference than phonological, while L1 Korean participants were affected more by phonological than orthographic interference. In a separate task, participants' phoneme deletion skills were measured; L1 Chinese readers showed more difficulty manipulating phonemes than the proficiency-matched L1 Korean participants. Both of these results seem to show that L2 readers transferred the orthographic processing strategies of their L1 to word

recognition in their L2, as alphabetic L1 Korean readers would rely more on phonology because their L1 is shallow, and L1 Chinese would rely more on orthographic features because their L1 is deep.

Similarly, Chikamatsu (1996) found an effect of L1 orthography on L2 reading, this time in a study of L1 English and L1 Chinese learners of Japanese. Among these languages, English is the most shallow, whereas Chinese and Japanese are both orthographically deep. Through use of a lexical decision task involving script manipulation to remove visual familiarity of Japanese words, Chikamatsu found that L1 Chinese learners of Japanese were more dependent upon orthographic information, whereas L1 English learners of Japanese were more dependent upon phonological information than orthographic, findings that are consistent with transfer of L1 skills that are predicted by the ODH.

In another study involving script manipulation, Akamatsu (1999) also found results that show L1 orthographic influence on L2 word recognition. In this study, Akamatsu included L1 Chinese, L1 Japanese, and L1 Persian readers, and measured word recognition via a naming task of English words written in alternating case (e.g., aLtErNaTiNg cAsE). He found that the L2 English learners who had experience with an alphabetic L1 (Persian) were affected less by loss of visual information than those whose L1 was morphographic (Chinese and Japanese), again showing that L1 orthographic processing is transferred to L2 word recognition.

Collectively, these cross-linguistic studies have shown that features of L1 orthography affect L2 word recognition, and that L2 word recognition systematically varies according to learners' L1 orthography. While these findings demonstrate the nature of the influence of L1 orthography, it is still not clearly understood *to what extent* L1 orthography affects L2 word recognition. To this effect, Wang et al. (2003) note that a "logographic L1 transfer effect on alphabetic L2 learning may occur only at the beginning stages of learning" (p.144) and that previous investigations of L1 orthographic effects on L2 word recognition are "clouded by the lack of attention to the level of English proficiency in the L2 groups" (p.134). Wang et al. (2003), however, did not manipulate L2 English reading proficiency, and instead opted to control it between groups. Nonetheless, the authors take the position that "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" (p. 144).

Some empirical studies have indeed suggested that with increased L2 reading proficiency, L1 orthographic effects may diminish. Chikamatsu (2006) investigated word recognition processes of L1 English learners of Japanese, again using script-manipulation in a lexical decision task to remove visual familiarity, forcing readers to process words grapheme by grapheme. The processing of the constituent graphemes of words has been shown in previous research (e.g, Brown & Haynes, 1985) to be greatly affected by L1 orthographic transfer. Chikamatsu (2006) included two levels of L2 Japanese proficiency, second semester and fourth semester learners. Chikamatsu found that higher L2 proficiency readers showed less L1 transfer, and read decontextualized words more similarly to how L1 Japanese readers would be expected, based on the ODH, to read words, and concluded that "diminishing L1 negative effects… and switching to a more efficient L2 strategy can possibly be viewed as developmental restructuring in L2 word recognition" (p.71).

Similarly, Sun (1991, cited in Chitiri et al., 1992) examined word recognition by L1 English learners of Chinese at two different reading proficiency levels. In a word matching task, the lower-proficiency group could not discriminate among the minor visual differences between characters, thus indicating that the less proficient readers had not yet adapted to the visual information processing that is crucial for Chinese word processing. Chitiri et al. (1992) state that these results may indicate that L1 transfer effects are lessened at higher levels of L2 reading proficiency. Similar findings were found by Haynes and Carr (1990), who studied L2 English word recognition by L1 Chinese speakers from Taiwan. In this study, Haynes and Carr included two levels of L2 English proficiency, and, through a word matching task, found that there were significant differences between the L2 proficiency groups, with the higher L2 proficiency group performing more similarly to the L1 English group than the lower L2 proficiency group. These results again show that the degree of L2 proficiency may have an

effect on the extent to which L1 orthographic effects are realized, and that with more L2 experience, L1 orthographic transfer effects may be diminished.

However, not all investigations have found changes in the degree of L1 transfer in L2 word recognition along with increased L2 reading proficiency. Akamatsu (2005) investigated L2 English word recognition by L1 Japanese readers who were either graduate students in Canada, or undergraduate students in Japan. The group in Canada had significantly higher TOEFL reading scores. Participants completed a task in English that, similar to Chikamatsu (2006), implemented script manipulation (this time, words in alternating case) in order to remove visual familiarity and force participants to process words letter by letter. However, instead of a lexical decision task, Akamatsu (2005) implemented a verbal production task. The results showed that the two L2 reading proficiency groups did not differ significantly in their speed or accuracy in producing alternating case words versus words in all lower case; both groups were impaired similarly by removing visual familiarity, and being forced to process the constituent letters of words. From these results, Akamatsu concluded that "L1 orthography affects L2 word-recognition processes so deeply that L2 reading proficiency could not influence L1 orthographic effects" (p.253). However, both groups showed similar effects of word frequency and spelling regularity.

In addition, the effect of L2 reading proficiency may depend on the context in which words are read (i.e., decontextualized or within a context). Chikamatsu (2006), while finding an effect of L2 reading proficiency on the extent to which L1 orthographic properties affect L2 word recognition of single words, did not find such an effect on reading sentences that contained similarly manipulated words. Chikamatsu states that this may be a result of different degrees of phonological coding between context-free (i.e., single word) reading and contextual reading (i.e., in sentential context). Similarly, Segalowitz and Hébert (1990) found that French-English bilinguals used different degrees of phonological reliance depending on whether words were context-free or in sentential context. However, because Chikamatsu's (2006) sentential context reading was measured as time to read entire sentences, and without word-level reading times, the effect of the orthographically manipulated words remains unclear.

In summary, previous research has shown that L1 orthographic properties systematically affect L2 word recognition. More specifically, research has shown that L1 word recognition is transferred to L2 word recognition. However, some research has suggested that the extent of this L1 orthographic effect may be lessened at higher levels of L2 reading proficiency, although some research has not found such results. In addition, it has also been suggested that the context in which words appear (i.e., without context or within sentential context) may moderate the degree of L1 orthographic effect, and also that more universal factors of spelling regularity and word frequency may also play important roles.

3. The present study

This study investigates the effect of L2 reading proficiency on the extent to which L1 orthography affects L2 word recognition of context-free words as well as words in sentential context. In this study, L1 orthographic transfer was operationalized as L1 Chinese readers' ability to process the constituent letters of words, as such processing has been shown to greatly affect readers whose L1 is morphograhic (Brown & Haynes, 1985). Similar to other studies (e.g., Akamatsu, 1999, 2002, 2005; Chikamatsu, 1996, 2006), this study implemented script manipulation to remove visual familiarity and force readers to process the constituent graphemes of words. To investigate the effect of context, two experiments were conducted, the first using context-free words and the second using words in sentential context. In both experiments, possible moderating effects of word frequency and spelling regularity were also investigated.

3.1. Research Questions

Based on the previously reviewed literature, the present study sought to answer two research questions:

1) Does L2 reading proficiency affect L2 readers' processing of the constituent letters of single words? If so, is this dependent upon either word frequency or spelling regularity?

2) Does L2 reading proficiency affect L2 readers' processing of the constituent letters of words in sentential context? If so, is this dependent upon either word frequency or spelling regularity?

4. Experiment 1

4.1. Participants

All participants were students at a large Midwestern university; for the purpose of creating a contrast in L2 reading proficiency, participants were recruited from a graduate program in second language acquisition, and from intermediate levels of an intensive English program. All participants were native speakers of Chinese from either mainland China or Taiwan. English reading proficiency was measured using the reading subsection of the Michigan Test of English Language Proficiency (MTELP), administered at the time of the study. In total, 30 participants completed all parts of the study; however, because this study sought to investigate the effect of L2 reading proficiency differences, it was imperative that reading proficiency differences between the two groups be maximized. For this reason, it was decided to implement an extreme groups approach (EGA). The 30 participants were divided into thirds based on L2 reading proficiency score. The 10 participants with the highest total MTELP scores became the higher L2 reading proficiency group and the 10 with the lowest scores became the lower L2 reading proficiency group. Only the highest third and lowest third were included in the analysis. Although the use of EGA is controversial because it can produce artificially inflated effect size estimates, it is beneficial when the exact relationship between the variables involved is unknown, and the goal of the research is to determine whether an interaction exists, regardless of the magnitude (Preacher, Rucker, MacCallum, & Nicewander, 2005); it is for this reason that it was felt that EGA was justified in the context of the current study.

In addition to MTELP scores, as a part of the background questionnaire, all participants rated their own abilities in both Chinese and English (Table 1). Self-evaluations have also been collected in other psycholinguistic studies (e.g. Jiang, 2007; Midgley, Holcomb, & Grainger, 2008), and can often provide insight into or corroboration of tested measures. While all participants rated themselves similarly as native speakers of Chinese, the higher L2 reading proficiency group's self-ratings of L2 English reading proficiency were significantly higher than the self-ratings of the lower L2 reading proficiency group.

The groups did not differ significantly in age, although the higher L2 reading proficiency group did have significantly longer length of residence in English-speaking places.

Table 1
L2 Reading Proficiency Scores

	L2 Reading Proficiency Group			
Measure	Higher	Lower	*t*	*p*
MTELP Reading	16.00 (1.16)	6.80 (2.20)	11.70	<.0001
Reading Self-evaluation	3.95 (.60)	2.40 (.84)	4.75	<.001

Note: The Michigan Test of English Language Proficiency (MTELP) reading subsection score is on a 20-point scale, where 20 is highest. Reading self-evaluation is on a 5-point scale, where 5 is highest.

4.2. Materials

Participants completed a lexical decision task that contained 80 target words and an equal number of pseudo-word distractors. Half of the target words were in lower case, and half were in mixed

(alternating) case. In addition, half of the words were low frequency words, and half were high frequency words, determined using Kucera and Francis (1967). Half of the words had regular spellings, and half of the words had exception spellings, determined using Berndt, Reggia, and Mitchum's (1987) study of grapheme-phoneme correspondence probability as a guide. There were 10 words in each combination of the word variables (frequency, spelling regularity, and case). Half of the stimulus words were borrowed, with permission, from Akamatsu (2005). See Table 2 for examples and stimulus conditions.

Table 2
Word conditions and examples of stimuli

Frequency	Spelling Regularity	Case	Number	Example
High	Regular	Lower	10	tell
High	Regular	Mixed	10	hElP
High	Exception	Lower	10	young
High	Exception	Mixed	10	wOrK
Low	Regular	Lower	10	fluid
Low	Regular	Mixed	10	pItCh
Low	Exception	Lower	10	aisle
Low	Exception	Mixed	10	nAiVe

Two word lists were used in this experiment; each list contained the same words, but words that were in lower case in one list were in mixed case in the other list, and vice versa. Half of the participants in each group saw List 1 and half of the participants saw List 2. This was to avoid any effect of the words used; that is, if only one list were used, it is possible that the list of lower case words and the list of mixed case words may have had inherent differences. By using two word lists containing the same words but in different cases, the possibility of inherent differences is removed because the lower case words for one group and the mixed case words in the other group have exactly the same attributes, except for the case in which they are presented. In addition, words in each condition were matched for length (number of letters).

4.3. Procedure

The lexical decision task was conducted using the DMDX software package (Forster & Forster, 2003) on Windows XP-based computers. Participants were seated approximately 50cm from the monitors, with blinder walls on either side of the participant. Stimuli were presented in 14-point font in black text on a white background. Presentation of items was randomized for each participant. Before each stimulus item, participants were presented with a fixation mask for 500ms. Participants made a decision as to whether they thought the presented word was a real word in English or not[1]. Participants responded using their left and right index fingers. In order to familiarize participants with the task so that they knew which hand to use for which response, each participant completed ten practice items before beginning the task, of which five were presented in lower case and five were presented in mixed case, and five were real words and five were non-word distractors. Both response time and accuracy were recorded for each word.

[1] Although having only two options (yes and no) increases the chance level, it was felt that having more than two options would increase the complexity of the task and possible confusion, thus impacting both reaction times and error rates.

4.4. Results

The analysis utilized a 2x2x2x2 (L2 reading proficiency, word frequency, spelling regularity, and word case) repeated measures ANOVA. In order to preserve data, responses greater than two standard deviations from the mean of each participant were trimmed; this affected 2.34% of the data. Only correct responses were analyzed. Means for reaction times and error rates are presented in Table 3.

4.4.1. Reaction Times

Overall, there was a main effect of proficiency group, $F(1, 18) = 11.30$, $p < .01$, $\eta^2 = .386$; on the whole, the more proficient readers recognized words faster ($M = 873.21$, $SD = 177.7$) than the less proficient readers ($M = 1054.45$, $SD = 294.84$). In addition, there was a main effect of case, with participants recognizing lower case words ($M = 847.86$, $SD = 107.9$) significantly faster than mixed case words ($M = 1083.80$, $SD = 216.1$), $F(1, 18) = 59.72$, $p < .001$, $\eta^2 = .768$. There was also a main effect of word frequency; high frequency words ($M = 852.01$, $SD = 120.9$) were recognized more quickly than low frequency words ($M = 1079.65$, $SD = 198.8$), $F(1, 18) = 99.40$, $p < .001$, $\eta^2 = .847$. The main effect of spelling regularity was not significant.

There was a significant interaction between frequency and L2 reading proficiency, $F(1, 18) = 8.59$, $p < .01$, $\eta^2 = .323$, showing that word frequency had more of an impact on the lower proficiency group (high frequency: $M = 911.18$, $SD = 192.5$; low frequency: $M = 1205.73$, $SD = 307.5$) than it did on the higher proficiency group (high frequency: $M = 792.85$, $SD = 141.6$; low frequency: $M = 953.58$, $SD = 175.1$), $t(18) = 3.68$, $p < .005$.

Most important to the present study, however, was the interaction between L2 reading proficiency and case. The results did reveal a significant interaction between case and proficiency group, $F(1, 18) = 5.47$, $p < .05$, $\eta^2 = .233$, showing that the higher L2 reading proficiency readers were affected to a significantly lesser degree by the mixed case text (lower case: $M = 790.93$, $SD = 126.6$; mixed case: $M = 955.50$, $SD = 184.5$) than the lower L2 reading proficiency readers (lower case: $M = 904.80$, $SD = 172.4$; mixed case: $M = 1212.10$, $SD = 313.0$), $t(18) = 3.21$, $p < .01$. None of the three-way interactions between L2 reading proficiency, case, and either word frequency or spelling regularity were significant.

Table 3
Reaction Times and Error Rates for Experiment 1

	Reaction Times		Error Rates	
Condition	Higher L2	Lower L2	Higher L2	Lower L2
High Freq., Reg. Lower	755.70 (113.4)	769.20 (117.2)	0.62 (2.5)	0.00 (0.0)
High Freq., Reg., Mixed	889.90 (165.8)	1082.60 (171.9)	5.00 (6.3)	3.12 (4.8)
High Freq., Exc., Lower	699.20 (80.2)	807.50 (120.9)	0.00 (0.0)	1.88 (5.4)
High Freq. Exc., Mixed	826.60 (130.7)	985.40 (171.9)	1.88 (5.4)	4.64 (5.5)
Low Freq., Reg., Lower	879.10 (104.3)	980.00 (125.8)	10.38 (10.7)	21.25 (16.3)
Low Freq., Reg., Mixed	1078.20 (161.7)	1421.50 (410.0)	10.07 (10.6)	32.63 (21.2)
Low Freq., Exc., Lower	829.70 (135.0)	1062.50 (141.0)	9.38 (16.5)	28.53 (12.6)
Low Freq., Exc., Mixed	1027.30 (176.4)	1358.90 (221.0)	5.07 (6.4)	35.07 (17.5)

Note: Standard deviations are given in parentheses. Reaction times are in milliseconds and error rates are in percent. Reg. and Exc. refer to regular and exception spelling, respectively, while Lower and Mixed refer to lower case and mixed case, respectively.

4.4.2. Error Rates

Similar to the reaction time results, there was a main effect of L2 reading proficiency, $F(1, 18) = 63.63$, $p < .001$, $\eta^2 = .780$; the higher L2 reading proficiency group was more accurate ($M = 4.75\%$, SD

= 8.3) than the lower L2 reading proficiency group (M = 17.40%, SD = 19.4). In addition, there was a main effect of case, $F(1, 18) = 10.45$, $p < .01$, $\eta^2 = .367$, showing that participants read lower-case words more accurately (M = 9.03%, SD = 6.5) than mixed case words (M = 13.12%, SD = 9.2). The main effect of frequency was also significant, $F(1, 18) = 93.89$, $p < .001$, $\eta^2 = .839$, with participants being more accurate on high frequency words (M = 2.18%, SD = 2.1) than low frequency words (M = 20.00%, SD = 14.2).

The interaction between frequency and proficiency group was also significant, $F(1, 18) = 37.82$, $p < .001$, $\eta^2 = .678$. The lower L2 reading proficiency group showed a greater frequency effect (high frequency: M = 2.86%, SD = 5.26; low frequency: M = 31.94%, SD = 17.42) than the high L2 reading proficiency group (high frequency: M = 1.50%, SD = 4.27; low frequency: M = 8.00%, SD = 9.92), $t(18) = 5.32$, $p < .001$.

The interaction between proficiency group and spelling regularity was also found to be significant, $F(1, 18) = 4.84$, $p < .05$, $\eta^2 = .212$. The higher proficiency readers' error rate for regular spelling words (M = 7.50%, SD = 10.1) was significantly greater than that for exception spelling words (M = 2.00%, SD = 4.7), $t(18) = 3.50$, $p < .01$. This difference was not significant in the case of the lower L2 reading proficiency group, M = 16.16%, SD = 20.4 for regular words, M = 18.6%, SD = 18.6 for exception words, $t(18) = .756$, $p > .4$.

Most important to the present study was the interaction between L2 reading proficiency and case. Although this interaction was not significant, it did trend toward significance, $F(1, 18) = 4.20$, $p = .055$, $\eta^2 = .189$. In addition, none of the three-way or four-way interactions were significant, all $F(1, 18) < 1.38$, $p > .2$.

4.5. Discussion

In Experiment 1, a lexical decision task was used to measure differences between higher and lower L2 reading proficiency readers' ability to process the constituent letters of words (i.e., in response to Research Question 1). The processing of individual letters in words is a process that does not exist in the native language of the participants, Chinese, but does in their L2, English. In addition, the processing of constituent letters in words can be seen as a measure of assembled phonology, which is theorized to be the primary way that words are recognized in English (Lesch & Pollatsek, 1998). Therefore, this experiment sought to determine whether, for L1 Chinese readers, the processing of constituent letters and assembled phonology while reading L2 English changes with L2 reading proficiency.

Overall, the results of this experiment suggest that the higher L2 reading proficiency readers did show lessened L1 orthographic transfer effects. The results suggest that mixed case text had a significantly greater effect on the lower proficiency readers than on the higher proficiency readers. That is, the higher proficiency readers showed less interference from loss of visual word shape information and were better able to process the individual letters of words, an aspect of reading that is especially affected by L1 orthographic transfer.

This result is similar to those found by Chikamatsu (2006), Haynes and Carr (1990), and Sun (1991), but different from Akamatsu (2005). An interesting difference between these studies, however, is that while all of these studies make claims about word recognition, Chikamatsu (2006) and Sun (1991) both used receptive word recognition tasks, whereas Akamatsu (2005) used a word production task. It could be that this difference between reception and production tasks may have an effect on results; the present study, also implementing a reception task, found similar results to other studies that used reception tasks.

The absence of a three-way interaction between proficiency, case, and word frequency or spelling regularity shows that the effect of proficiency on reading constituent letters of words did not depend on the frequency or spelling regularity of words.

Although Experiment 1 showed that L2 reading proficiency did have an effect on L1 Chinese readers' ability to process constituent letters of words, previous research (e.g., Chikamatsu, 2006;

Segalowitz & Hébert, 1990) has suggested that the context in which words appear may have an effect on intra-word processing. For this reason, Experiment 2 was conducted.

5. Experiment 2

5.1. Participants

The participants in Experiment 2 were the same as those in Experiment 1.

5.2. Materials

In Experiment 2, participants completed a word-by-word self-paced reading task (Just, Carpenter, & Woolley, 1982) in which they read 80 sentences, each of which contained a critical word. The critical words embedded in sentences in Experiment 2 were similar to the target words in Experiment 1, including length (number of letters) and word class distribution. As in Experiment 1, there were 10 words in each combination of the three word-based variables (high/low frequency, regular/exception spelling, lower/mixed case). Again, half of the stimulus words were borrowed, with permission, from Akamatsu (2005), and given sentential context; these were not the same words that were used in Experiment 1. The order of presentation of Experiment 1 and Experiment 2 was counterbalanced.

Sentences ranged in length from 5 to 13 words, and the location of the critical word ranged from the fourth to the tenth word. Sentences were grammatically simple, and did not contain any relative clauses.

5.3. Procedure

Stimuli were presented via the Linger software package (Rohde, 2003) on Windows XP computers. Participants were seated approximately 50cm from the computer screen. Stimuli were presented in 14-point black text on a white background. Stimulus sentences initially appeared as a series of dashes in place of each word, and participants pressed the space bar to reveal each word sequentially. When the participant pressed the space bar again, the next word in the sentence appeared and the previous word reverted to dashes. The time between button presses to reveal each word was taken as the reading time for each word. Sentence order was randomized by the presentation software.

Each sentence was followed by a yes/no comprehension question to encourage participants to read each word in the sentences carefully. For example, for the sentence *He put the sTaMp on the envelope,* the question was *Did he put the stamp on the envelope?* The number of yes and no comprehension questions was counterbalanced. No participants showed extremely high error rates on the comprehension questions. The words preceding the critical word did not offer a general context, and was not specific enough to easily infer the critical word; the comprehension questions did not require any information outside of the stimulus sentence.

5.4. Results

The analysis was similar to that of Experiment 1, involving a 2x2x2x2 repeated measures design. A repeated measures ANOVA was performed on the reading time of the critical word and of the word following the critical word in each sentence (to test for any spillover effects). In addition, the word before the critical word in each sentence was also analyzed to make sure that sentences were comparable.

In the analysis of the word directly preceding the critical word in each sentence, only the main effect of L2 reading proficiency was significant, $F(1, 18) = 6.63$, $p < .05$, $\eta^2 = .269$. This shows that, other than the higher L2 reading proficiency group ($M = 400.83$, $SD = 123.5$) reading faster than the lower L2 reading proficiency group ($M = 506.54$, $SD = 114.4$), at the point immediately before the critical word, the two groups were reading the sentences similarly.

At the point of the critical word, there were significant main effects of word frequency (high frequency: M = 536.83, SD = 174.5.; low frequency: M = 685.96, SD = 398.1), $F(1, 18) = 20.89$, $p < .001$, $\eta^2 = .537$; case (lower case: M = 515.06, SD = 193.8; mixed case: M = 707.73, SD = 379.3), $F(1, 18) = 33.59$, $p < .001$, $\eta^2 = .651$, and L2 reading proficiency (high: M = 458.67, SD = 170.2; low: M = 764.13, SD = 352.15), $F(1, 18) = 14.19$, $p < .005$, $\eta^2 = .441$. Also at the critical word, there was a significant interaction between word frequency and L2 reading proficiency, $F(1, 18) = 16.20$, $p < .005$, $\eta^2 = .474$; word frequency had a greater effect on the lower L2 reading proficiency group (high frequency: M = 623.89, SD =167.5; low frequency: M = 904.36, SD = 427.6) than the higher L2 reading proficiency group (high frequency: M = 449.76, SD = 134.43; low frequency: M = 467.57, SD = 201.0), t (18) = 3.09, $p < .01$. Most relevant for the present study, however, was the interaction between L2 reading proficiency group and case, which, at the point of the critical word, was significant, $F(1, 18) = 10.40$, $p < .005$, $\eta^2 = .366$, ; the higher L2 reading proficiency group seemed to be affected by mixed case text (lower case: M = 415.95, SD = 131.8; mixed case: M = 501.39, SD = 193.7) to a significantly lesser degree than the lower L2 reading proficiency group (lower case: M = 614.17, SD = 196.3; mixed case: M = 914.08, SD = 408.1), t (18) = 3.07, $p < .01$ There were no significant three or four-way interactions.

Looking at the word after the critical word, there were still significant main effects of word frequency (high frequency: M = 470.70, SD = 95.4; low frequency: M = 570.57, SD = 121.0), $F(1, 18) = 66.03$, $p < .001$, $\eta^2 = .786$; case (lower: M = 500.65, SD = 118.3; mixed: M = 540.61, SD = 118.3), $F(1, 18) = 7.51$, $p < .05$, $\eta^2 = .294$, and L2 reading proficiency (higher: M = 483.50, SD = 127.50; lower: M = 557.77, SD = 98.7), $F(1, 18) = 4.7$, $p < .05$, $\eta^2 = .207$. In addition, there was a significant interaction between L2 reading proficiency and case, $F(1, 18) = 12.09$, $p < .005$, $\eta^2 = .402$; however, the direction of the interaction was opposite of that found at the critical word. Instead of there being more of an effect of mixed case for the lower L2 reading proficiency group, there was a larger effect for the higher L2 proficiency group (lower case: M = 438.17, SD = 91.39; mixed case: M = 528.84, SD = 142.7) than for the lower L2 proficiency group (lower case: M = 563.14, SD = 109.41; mixed case: M = 552.4, SD = 87.8), t (18) = 5.76, $p < .001$. This suggests that whereas the lower L2 reading proficiency group showed a greater effect of the mixed-case words at the point of the critical word, the higher L2 reading proficiency readers showed a greater effect at the point of the word immediately following the critical word (i.e., a spillover effect). There were no significant three or four-way interactions.

Because of the inconsistent results found at the critical word and the word after the critical word, an additional analysis was performed incorporating the reaction times at both the critical word and the following word in order to create a critical region. This analysis was performed in order to include both immediate and spillover effects. This analysis found no significant interaction between L2 reading proficiency group and case, $F(1, 18) = 3.239$, $p = .089$, $\eta^2 = .153$. This finding suggests that there was no general difference in the effect of mixed case between the two L2 reading proficiency groups. That is, both groups were affected similarly by the need to process the constituent letters of the critical words.

5.5. Discussion

Overall, the results of Experiment 2 seem to suggest that L2 reading proficiency did not have an effect on readers' ability to process the constituent letters of words, as evidenced by the lack of a significant interaction between L2 proficiency group and case in the critical region analysis combining the reading times of both the critical word and the word immediately following the critical word. This result suggests that both L2 reading proficiency groups were affected similarly by the mixed-case words. This result is similar to the results of both Chikamatsu (2006) and Segalowitz and Hébert (1990), in which there were differences between the ways that L2 readers processed decontextualized words and words in a context. Chikamatsu (2006), which also found a significant interaction between script manipulation and L2 proficiency in decontextualized words but not when words were contextualized, suggests that this may occur because readers tend to recognize words more rapidly

when they appear in a semantically-congruent context. Looking at the reaction times of both groups for both experiments, it does appear that both groups read the manipulated words more quickly in Experiment 2 than in Experiment 1, even though the words were matched in terms of length, word class, frequency, and spelling regularity. Furthermore, Chikamatsu (2006) suggests that such a context facilitation effect may be greater for less-skilled readers because more skilled readers do not need to depend as much on contextual information as less-skilled readers do (Borowsky & Besner, 1993, 2000, cited in Chikamatsu, 2006). Thus, deficits that lower-proficiency readers might experience, as compared with higher-proficiency readers, when reading decontextualized words might be reduced when words appear in a supportive context.

6. General Discussion

The present study sought to investigate differences in word recognition processes that arise from differences in L2 reading proficiency. Experiment 1 used script manipulation within a lexical decision task in order to investigate participants' ability to process the constituent letters of decontextualized words. In this experiment, higher L2 proficiency readers showed faster intra-word processing of constituent letters of words than did lower L2 English proficiency readers. Furthermore, a trend of higher accuracy rates in processing these words was observed in the higher L2 proficiency readers. In addition, these results did not depend on word frequency or spelling regularity.

In order to investigate the effect of contextualization, Experiment 2 was conducted, in which critical words that were similar to those in Experiment 1 in terms of word frequency, spelling regularity, word class, and word length, and also incorporating similar script manipulation, were presented within a sentential context. Results of Experiment 2 suggest that effects of L2 reading proficiency on the ability to process constituent letters of words may not occur when words appear in context. That is, when words appear contextualized, differences between high and low L2 proficiency readers may disappear.

The results of the present study have two main findings. First, in decontextualized words, L2 reading proficiency may have an effect on L1 Chinese readers' ability to process constituent letters of English words, which previous research has found to be an L1 orthographic transfer effect. This may provide an extension to previous research regarding intra-word processing of decontextualized words (e.g., Brown & Haynes, 1985; Holm & Dodd, 1995; Koda, 1999; Wang, Koda, & Perfetti, 2003) to show that intra-word processing may develop together with L2 reading proficiency. In addition, assuming that the processing of the constituent letters of a word does lead to assembled phonology during word recognition as theorized, these findings may also demonstrate that, for L1 Chinese readers, the degree of phonological activation during visual word recognition of L2 English may be developmental. These results may also be relevant to the application of the orthographic depth hypothesis to L2 reading. The ODH hypothesizes degrees of phonological reliance due to orthography, and previous cross-orthographic word recognition research has applied it in this way, without regard to other factors that may affect word recognition, such as L2 reading proficiency. The results of the present study, however, suggest that the degree to which L1 orthography affects L2 reading may depend on L2 reading proficiency. Therefore, future studies of L2 word recognition, especially those investigating L1 orthographic effects, should pay closer attention to L2 proficiency as a potential source of variation among learners.

The second finding of the present study is that there may be important differences between the processing of decontextualized and contextualized words. Much of the extant literature on L2 word recognition has investigated only decontextualized words. However, the results of the present study suggest that in addition to decontextualized words, research on L2 word recognition should also include contextualization, as the recognition process may be significantly impacted by incorporation of surrounding contextual information, resulting in findings that are quite different from those of studies of decontextualized words. Thus, future research on word recognition should also take context into account, and investigate not only decontextualized words, but also words in context.

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