Korean–English Biliteracy Acquisition: Cross-Language Phonological and Orthographic Transfer

Min Wang, Yoonjung Park, and Kyoung Rang Lee
University of Maryland

Cross-language phonological and orthographic relationship in the biliteracy acquisition of children learning to read Korean and English was investigated in this study. Forty-five Korean–English bilingual children were tested in first-language (L1; Korean) and second-language (L2; English) reading skills focusing on 2 reading processes—phonological and orthographic processing. The authors found that phonological skills in L1 and L2 were strongly correlated, and Korean phonological skills explained a unique amount of variance in English pseudoword reading beyond English phonological and orthographic skills. However, there was limited orthographic skill transfer between the 2 systems. Results are discussed within the framework of universal phonological processes in learning to read. The authors conclude that bilingual reading acquisition may be a joint function of general phonological processes and orthographic-specific skills.

Keywords: Korean, English, biliteracy, cross-language transfer

Recent research on biliteracy development has yielded consistent results for a strong facilitation between first-language (L1) reading skills and second-language (L2) reading skills. However, these studies have only focused on children learning to read English whose L1 is another Roman alphabetic system, such as Spanish, French, or Italian (e.g., Comeau, Cormier, Grandmaison, & Lacroix, 1999; D’Angiulli, Siegel, & Serra, 2001; Durgunoglu, Nagy, & Hancin-Bhatt, 1993). The present study seeks to investigate such biliteracy development for children learning to read English whose L1 is a non-Roman alphabetic system, that is, Korean. Korean and English share a fundamental alphabetic principle; graphemes in both languages correspond to phonemes. However, Korean Hangul has a unique visual and spatial configuration compared with other orthographic systems. Korean has a nonlinear spatial layout, just like Chinese. Korean–English biliteracy acquisition provides an excellent opportunity to study cross-language and orthography transfer in two alphabetic systems that share a mapping principle but not a visual form. In this study, we focused on two basic reading components: phonological processing and orthographic processing. These two variables have been shown in the literature to be critical for learning to read in all languages, whether alphabetic or nonalphabetic. We were interested in addressing the issue of how cognitive processes of phonology and orthography contribute differentially to L1 and L2.

The Roles of Phonological and Orthographic Processing in Learning to Read Alphabetic Languages

For alphabetic languages, a large volume of research has revealed that early phonological processing skills in general predict later reading success (e.g., Goswami & Bryant, 1990; Lundberg, Olofsson, & Wall, 1980; Mann & Liberman, 1984; Rack, Snowling, & Olson, 1992; Shankweiler, 1999; Torgesen, 1999). Phonological processing skills generally refer to the ability to analyze and manipulate sound units of spoken language. According to Treiman and her colleagues’ linguistic structure hypothesis (e.g., Bruck, Treiman, & Caravolas, 1995; Treiman, 1995; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995), the syllable is at the top of the hierarchical structure—it is the largest and most accessible unit. The phoneme is at the bottom of the hierarchical structure—it is the smallest unit and is a later developing one for children. Between syllables and phonemes lie intermediate onset and rime units. Studies demonstrate the importance of processing both large and small phonological units for reading skills. For example, processing of relatively large phonological units in tasks such as rhyme and alliteration has been shown to be important for promoting young children’s learning to read (e.g., Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Goswami & Bryant, 1990; see also Bryant, 2002, for a review). It has been suggested in other studies that children’s skills at processing the smallest phonological units—phonemes—are powerful predictors of individual differences in learning to read and that

Min Wang and Yoonjung Park, Department of Human Development, University of Maryland; Kyoung Rang Lee, Department of Curriculum and Instruction, University of Maryland.

The research reported here was supported by a National Academy of Education/Spencer Fellowship and a Summer Research Award from the General Research Board of the University of Maryland awarded to Min Wang. Preparation of this article was supported by a National Institutes of Health/National Institute of Child Health and Human Development Grant 1R01HD048438-01 awarded to Min Wang. We thank all the teachers and parents in the Korean Language School in Ellicott City, Maryland for their warm support and the children for their active participation. We also thank Kirsten VanMeenen, Alec Chen, and Stella Chen for their assistance with collecting and scoring the data. Thanks also go to Charles A. Perfetti, Catherine McBride-Chang, Che Ken Leong, Jennifer Cromley, and Donald J. Bolger for their valuable comments on an earlier version of this article.

Correspondence concerning this article should be addressed to Min Wang, Department of Human Development, 3304P Benjamin Building, University of Maryland, College Park, MD 20742. E-mail: minwang@umd.edu
training children in phonemic-level skills can benefit their later reading progress (e.g., Byrne & Fielding-Barnsley, 1995; Hulme et al., 2002; Lundberg, Frost, & Petersen, 1988; Muter, Hulme, Snowling, & Taylor, 1998).

Orthographic knowledge has also been shown to facilitate children’s reading acquisition. Orthographic knowledge generally refers to “children’s understanding of the conventions used in the writing system of their language” (Treiman & Cassar, 1997). One important orthographic processing skill is children’s ability to detect acceptable and unacceptable letter sequences and their relation to letter positions in words (Cassar & Treiman, 1997; Treiman, 1993). For example, Cassar and Treiman (1997) found that by late kindergarten, children have acquired some knowledge of the acceptable form and position of consonant doublets. These young children preferred spellings with final doublets (e.g., buff) to those with beginning doublets (e.g., bbad).

These young children also preferred spellings with acceptable doublets (e.g., yill) to those with unacceptable ones (e.g., yihh). Some researchers have argued that phonological and orthographic knowledge mutually facilitate each other and that grapheme-phoneme knowledge provides young readers with a powerful tool to bind the spelling patterns of individual and multiple letters with their pronunciations in words (e.g., Ehri, 1991, 1998). Recent empirical research suggests that this orthographic knowledge may contribute significantly to word recognition skill in children over and above phonological factors (e.g., Cunningham, Perry, & Stanovich, 2001; Cunningham & Stanovich, 1990).

It has been well documented that the transparency of grapheme-phoneme mappings, or orthographic depth (Frost, 1994; Katz & Frost, 1992), affects children’s progress in learning to read (e.g., Cossu, Shankweiler, Liberman, Tola, & Katz, 1988; Durguunoglu & Oney, 1999; Frith, Wimmer, & Landerl, 1998; Geva & Siegel, 2000; Goswami, Gombert, & Barrera, 1998; Shimron, 1999). These differences have been observed in various languages—English versus German, Spanish, and Italian. For example, readers of a shallow orthography (e.g., Italian) demonstrate an advantage in phonological awareness over readers of English, a less transparent orthography (Cossu et al., 1988). In Italian, there are direct letter-sound correspondences, whereas in English, the letter-sound correspondences are not one-to-one. For example, the letter a in English words can be pronounced in many different ways, as in about, fall, cake, says, and so forth. Furthermore, Goswami and colleagues found that children who learn to read English benefit more from processing large orthographic units, such as rimes, than children who learn to read Spanish, a highly transparent orthography. Frith and colleagues reported a similar result when comparing English with German learners. Neuroimaging studies of adult reading suggest that not only can reading strategies be affected by the orthography but also that these strategy differences become manifest in the brain structures that are activated during word reading (Paulseu et al., 2000).

In the present study, we examined phonological and orthographic skills in a group of Korean–English bilingual children and analyzed their contribution to basic reading skills in both L1 and L2. We did this by designing parallel experiments that tap phonological and orthographic skills in the two languages. In the following section, we provide brief descriptions of the Korean language and orthography in order to facilitate understanding of the Korean tasks.

Korean Language and Hangul Orthography

The Korean language has 14 basic consonants (e.g., /p, b, t, d, k, n, t, l/) and 10 basic vowels (e.g., /a, e, i, o, u, o, jo/). Some Korean phonemes are the same as English phonemes (e.g., /m/ and /n/). However, Korean does not have the two English “th” sounds, as in this and think; there is also no /fl/ or /vl/ sound. Just like Chinese and Japanese speakers, Koreans have difficulty distinguishing /fl/ and /vl/ sounds in English. The syllable is an important unit in Korean, but its syllable structure is simpler compared with English. Korean syllables can be in the form of CV (e.g., /γγ/ga/), CVC (e.g., /γγ/muk/), and CVCC (e.g., /γγ/dak/) structures. Please note that the first consonant in a final consonant cluster in Korean CVCC words is usually not pronounced. There are no initial consonant clusters in Korean syllables; final consonant clusters are limited. This simpler syllable structure may pose less of a phonemic-level phonological processing challenge for learning to read Korean in comparison to learning to read English.

The nature of the Korean writing system, Hangul, is alphabetic; it maps letters onto phonemes just as English, Russian, and Italian do. One important feature of Hangul is that it is nonlinear: The composition of letters is shaped into a squarelike syllable block. The symbols are arranged from left to right and from top to bottom. Each Hangul syllable is built of 2–4 symbols that in various combinations represent each of the 24 phonemes. Its overall shape makes Korean appear more similar to Chinese than to its fellow alphabetic orthographies. Each Hangul letter contains between one and eight strokes, compared with English letters that contain between one and four strokes. The simplest syllable block contains two strokes (e.g., /γγ/), and the most complex block has 13 strokes (e.g., /γγ/bbal/). Taylor and Taylor (1995) pointed out that the uneven visual complexity of Hangul syllable blocks should help recognition because the more varied the visual shapes of graphs, the more easily they are distinguished from one another.

There are some letter position constraints for Hangul syllables (Simpson & Kang, 2004). A horizontal vowel is always placed under an initial consonant (e.g., ğ, /bol, “cow”). A vertical vowel is always placed to the immediate right of the initial consonant (e.g., ğ, /mal, l/). A written syllable always starts with a consonant (or a null consonant that does not have a pronunciation). There are also constraints on final consonant clusters and simple vowel combinations; certain combinations of two consonants will lead to illegal final clusters. Likewise, certain combinations of two simple vowels will lead to illegal Hangul syllables.

Because the Hangul syllable blocks are separated, there is a clear syllable boundary for a Hangul word (e.g., /γγ/ /γγ/ /γγ/, /γγ/ /γγ/ /γγ/ /γγ/, “ka/ /ka/, hello”). As a result, Korean Hangul is sometimes more accurately called an alphabetic syllabary. It is noteworthy that the syllabary aspect of Hangul is different from Japanese Kana, which is a true syllabary system. The Japanese Kana syllables cannot be further segmented into consonants and vowels; therefore, memorization of the existing Kana syllables is necessary for beginning learners. Hangul learners, however, do not need to memorize the syllable blocks; instead, they need to learn the alphabetic symbols and then the simple and reliable rules to package them. Hence, Hangul is a shallow orthography. Finally, although Chinese characters are used in conjunction with Hangul in South Korea, their use is relatively rare because they are not taught in primary schools.
Phonology is important in reading Korean Hangul, just like other alphabetic languages. Research has shown that reading Hangul words involves prelexical information processing and that prelexical phonology is activated rapidly and automatically even in semantic processing of Korean words (e.g., Kim, 1999; Yoon, Bolger, & Perfetti, 2002). Cho and Chen (1999) found that Korean readers demonstrated strong homophone interference effects for pseudohomophones in a category judgment task. That is, phonological similarity of the stimuli (e.g., suite for the category “an article of clothing”) caused greater confusion for Hangul readers when making meaning judgments compared with control items (e.g., blane for the same category). Although the subjects also made more errors on visually similar trials than on controls, the effect size for homophone interference was much stronger than that for visual similarity. In another study suggesting the importance of phonology in reading Hangul, Kim and Davis (2004) found that Korean poor readers performed poorly on Korean phonological awareness measures when compared with good readers. In contrast to studies on phonological processing, little research has been conducted regarding the role of orthographic processing skills in learning to read Korean Hangul. In this study, we examined the contribution of both phonological and orthographic skills to learning to read Korean and their relationship to learning to read English among a group of bilingual children. The unique feature of the Korean Hangul orthographic system forms an excellent comparison with other Roman alphabetic systems in studying bilingual literacy acquisition.

**Bilingual and Biliteracy Acquisition Within Alphabetic Languages**

Cummins (1979, 1986, 1991) proposed the linguistic interdependence hypothesis. This hypothesis suggests that the child develops reading skills in L1, he or she is able to transfer those skills to L2. Recent research on biliteracy acquisition across two alphabetic languages and orthographic systems, such as Spanish–English and French–English, has yielded two major findings. First, there is clearly a close phonological relationship between two alphabetic languages. Phonological skills in one language are highly correlated with phonological skills in the other language. Second, phonological skills in one language contribute to word-reading skills in the other language. For example, first-grade Spanish-speaking children who were enrolled in a transitional bilingual education program on both Spanish and English reading skills were tested in a study by Durungulu et al. (1993). Their results demonstrated that children who could perform well on Spanish phonological awareness tasks were more likely to be able to read English words and pseudowords than were children who performed poorly on these tasks. The phonological awareness tasks included different linguistic units (onset–rime and phoneme) in Spanish words. Moreover, phonological awareness was a significant predictor of performance on word recognition tests both within and across languages. Cisero and Royer (1995) used longitudinal data to demonstrate this cross-language phonological transfer in Spanish–English bilingual children. Their results showed that phoneme detection in Spanish at Time 1 contributed to phoneme detection in English at Time 2. Ganschow and Sparks (1995) further showed that explicit, direct training in Spanish phonology resulted in significant gains in English phonological processing, word reading, and spelling in a group of Spanish–English bilingual children, many of whom had English reading difficulties. More recently, this strong facilitation from L1 to L2 phonology was shown in research in Canada on English-speaking children learning to read French (e.g., Comeau et al., 1999), Italian (e.g., D’Angiulli et al., 2001), and Hebrew (Geva & Siegel, 2000). For example, D’Angiulli and colleagues found strong correlations in skills on various reading and spelling tasks between English and Italian. The authors argued that exposure to a shallow orthography, such as Italian, which involves relatively direct letter-sound correspondences, may promote phonological skills in learning to read English. However, it is not certain whether a similar pattern of cross-language relationship exists across two different orthographic systems when they share similar mapping principles but differ in visual forms.

The aforementioned studies mainly focused on cross-language transfer at the phonological level. These studies have successfully demonstrated a robust and universal cross-language phonological transfer phenomenon for various alphabetic systems. However, little is known about any possible transfer at the orthographic level, in particular, for those orthographic systems that differ in visual forms. Because of the alphabetic nature of the Korean Hangul system, we hypothesize that there will be a close relationship between Korean and English phonological processing. We predict that phoneme, rhyme, and phonemic processing will be highly correlated in the two languages and that phonological processing skills will predict word-reading skills in both languages. We also hypothesize that phonological skills in Korean L1 will contribute a significant amount of unique variance to English word identification even after English phonological and orthographic skills are taken into consideration. With respect to orthographic processing skills in the two languages, there may be two possible results. One is that orthographic skills may not contribute a unique amount of variance to reading in each of the two languages over and above phonological skills, given the fundamental phonological skills required to read alphabetic languages. The other possibility is that orthographic skills are also a critical factor in acquiring alphabetic languages and that orthographic skills will explain a unique amount of variance in reading both Korean Hangul and English after taking into account phonological skills in the two languages. However, because of the nature of the nonlinear orthography of the Korean Hangul system, in contrast to the linear orthographic system of English, orthographic skills in the two systems may not be significantly related to each other. We also predict limited orthographic transfer in reading across these two languages. For within-language phonological skills, we hypothesize that the performance difference between onset rhyme and phonemic-level tasks will be greater for learning English compared with learning Korean. This is because of the simpler syllabic structure of the Korean language compared with English.

**Method**

**Participants**

Forty-five Korean-speaking children were recruited from one Korean language school in the Washington, DC area. Most of the parents were first-generation Korean immigrants and spoke Korean at home. There were 24 boys and 21 girls. They simultaneously attended first-grade (n = 16, mean age = 6.71 years), second-grade (n = 14, mean age = 7.84), and
English Tasks

Experimental phonological tasks. Experimental tasks were designed for testing English phonological skills. These included onset detection, rhyme detection, and a phoneme manipulation task (i.e., phoneme deletion).

Onset-rhyme detection. This detection task was designed to tap into children’s ability to manipulate and differentiate between phonological units in spoken English words. One-syllable nonwords were used in this task, ranging from 3 to 5 letters in length. Nonwords were used to exclude any potential confound resulting from influence of lexical access of the items; 15 items were included for each condition. Materials were similar to those used by Bradley and Bryant (1983); Stanovich, Cunningham, and Cramer (1984); and Gottardo (2002). In the onset-detection condition, onsets for all of the items were single consonants. In the rhyme-detection condition, 4 of 15 items had consonant clusters as onsets. Native English speakers recorded the materials via a digital voice recorder; the digital audio files were then saved as audio files on a CD.

Children were tested individually in a quiet room equipped with a CD player on a desk. The child was asked to listen carefully through a pair of earphones connected to the CD player. The child heard three spoken words, for example, bap, bap, and gonk, with a time interval of 5 s between the three words, and an interval of 15 s between each item. This time interval was sufficient to allow children to respond. In order to reduce the memory demands, the child was shown three number signs on the desk; the first word corresponded to the “1” sign on the desk, the second word corresponded to the “2” sign, and the third word corresponded to the “3” sign. The child’s task was to choose which of these three words (a) did not start with the same sound as the other two words in the onset-detection condition or (b) did not end with the same sound as the other words in the rhyme-detection condition. The child was instructed to point to one of the numbers on the desk to represent the one word that was different from the other words. Three practice items were given for each condition. Accuracy data were recorded. Using Cronbach’s alpha, the internal consistency reliability of the onset and rhyme tests was .72 and .80, respectively.

Phoneme deletion task. Of the commonly used phonological processing tasks (e.g., blending, segmenting, rhyming, oddity), phoneme deletion has been found to be the most difficult for young children (e.g., Stanovich et al., 1984). Nonwords were used in this task to control for the effect of lexicality on children’s performance. Children were encouraged to play a word game with the experimenter. A female native English speaker recorded the audio stimuli, which were presented via a CD player. The child heard a word first and was asked to repeat the word. Then the child was asked to remove a sound in the word. For example, the child was instructed as follows: “Say muh. Now say it again, but don’t say /b/.” Twenty items were included in this task, similar to those used by Wade-Woolley (1999) and Gottardo, Yan, Siegel, and Wade-Woolley (2001). The position of the phoneme to be deleted from the word was varied in order to test the difficulty level associated with phoneme positions. There were two items each for beginning and ending consonants. There were four items each for the first phoneme of a beginning consonant cluster, the second phoneme of a beginning consonant cluster, the first phoneme of a final consonant cluster, and the second phoneme of a final consonant cluster. Children’s responses were recorded via a digital voice recorder. Children’s responses were scored as correct if the target phoneme was deleted accurately. Cronbach’s alpha internal consistency reliability was .77 for this task.

Orthographic choice task. The child was presented with a pair of nonwords on a card at a time. The child was instructed to point to the one that looked more like a real word. The stimuli set included 28 items, similar to those used by Treiman (1993) and Siegel, Share, and Geva (1995). Pseudowords were used. The task tapped into children’s sensitivity to various orthographic patterns in English. For example, there is a legal position of certain double consonants (e.g., ff does not occur at the beginning of a word). Five examples were given and accuracy data were recorded. Cronbach’s alpha internal consistency reliability for this task was .77.

Real-word naming. The child was shown one word at a time on a card and was instructed to say the word aloud as best as he or she could. The materials contained 35 words from the Word Recognition subtest of the Wide Range Achievement Test—Revised (WRAT-R; Jastak & Jastak, 1984). Five examples were given. Children’s naming responses were recorded via a digital voice recorder. Children’s responses were scored as correct or incorrect, and only fully accurate pronunciations were accepted as correct.

Pseudoword naming. The child was shown two items at a time on a card and was instructed to sound out the letter string aloud as best as he or she could. Forty items from the Word Attack subtest of the Woodcock Reading Mastery Test—Revised (Woodcock, 1987) were administered. Five examples were given. Children’s naming responses were recorded via a digital voice recorder. Children’s responses were scored as correct or incorrect, and only fully accurate pronunciations were accepted as correct.

Korean Tasks

Onset-rhyme detection task. Parallel to the English onset-rhyme detection task, two sets of 15 Korean pseudowords were created for the Korean onset and rhyme detection tasks, respectively. For example, in the rhyme detection task, the child was asked to choose one of the three words that did not have the same rhyme as the other two words, .Safe, /g/ & /b/, //g/. The procedure was the same as that for the English tasks. Cronbach’s alpha internal consistency reliability was .78 for both measures.

Phoneme deletion task. Parallel to the English phoneme deletion task, a set of 20 Korean pseudowords was created to assess children’s skill in manipulating phonemes in different word positions. However, because Korean syllables do not contain beginning consonant clusters, there were only items for deleting single beginning consonants. Also, because one of the two final consonants in Korean is normally silent, only single final consonants were used for the Korean phoneme deletion task. Furthermore, because the final consonants in Korean are all voiceless, it is difficult to single out the final consonant in a word and pronounce it. We decided that instead of pronouncing the final sound in the word, we would label it as the final sound. For example, the child was asked to say /sub/ and then say
it again without pronouncing the final sound /ɹ/. The correct answer would be /li:su/). There were 10 such items, each targeting the beginning or final sound of a Korean syllable. The internal consistency reliability (Cronbach’s alpha) for this task was .85. Because of the simpler syllable structure of Korean, children were expected to show less difficulty with this task in relation to onset and rhyme tasks compared with English.

**Orthographic choice task.** There were 28 items in total, targeting four types of constraints in the Hangul orthographic system. First, Korean Hangul is a nonlinear orthographic system, and there are some constraints on placing vowels in a square-shape form. As described earlier, a horizontal vowel always should be placed under the initial consonant, whereas a vertical vowel always should be placed to the immediate right of the initial consonant. Six items were designed to measure children’s sensitivity to the legality of the vowel position, for example, /ʌ/ (illegal) versus /θ/ (legal), and /ɛ/ (illegal) versus /ɛ/ (legal). Second, six items were presented to see whether children could identify the legality of the combination of simple vowels, for example, /iː/ (illegal) versus /θ/ (legal). Third, three items were designed to test children’s knowledge about the required initial consonants in Hangul syllables, for example, /θ/ (illegal) versus /θ/ (legal). Finally, 13 items were designed to measure children’s ability to detect the legality of final consonant clusters, for example, /θθ/ (illegal) versus /θθ/ (legal). There were four practice items at the beginning of the testing. The internal consistency reliability for this task was .66 (Cronbach’s alpha).

**Real-word and pseudoword reading.** There were 36 items each for the real-word and pseudoword reading tasks. Each reading task consisted of 12 one-syllable, 12 two-syllable, and 12 three-syllable words. We selected the real-word items from the Korean language school curriculum. There were three levels of familiarity in the real-word naming task: high, medium, and low. Level of familiarity was rated by the language school teachers. Three teachers together discussed and reached agreement for each item’s level of familiarity. All of the items in the pseudoword reading task were pronounceable Hangul nonwords by replacing phonemes in real words that were not used in the real-word naming task. Of the 12 two-syllable and 12 three-syllable nonwords, half of the items in each subset contained 1 pronounceable non-Hangul syllable, and the remaining half contained 2 non-Hangul syllables. There were five practice items for each naming task. Internal consistency reliability (Cronbach’s alpha) was .96 and .97 for the real-word and pseudoword tests, respectively.

**Nonverbal ability test.** The Pattern Completion subtest of the Matrix Analogy Test (MAT-expanded form; Naglieri, 1985) was used to test children’s nonverbal ability. This measure includes 14 abstract designs of the standard progressive matrix type. The child was shown a picture with a missing piece in it and asked to choose one from five options to complete the pattern. The items require the child to detect the shapes and directions in an abstract diagram to decide what option fits the pattern. The child was allowed either to point or to say aloud the number of his or her answer.

**Procedure**

Children were tested in two sessions. One session was devoted to English tasks, which were administered by a trained graduate student, a native English speaker. The other session was devoted to Korean tasks, which were administered by a trained graduate assistant, a native Korean speaker. The order of the two sessions was randomized among the children. The order of the tasks within the sessions was also randomized for each child. Each session took about 30 min, and children were given a break in the middle of each testing session. Children were given school-related gifts for participation at the end of each testing session.

**Results**

Means and standard deviations for the English and Korean tasks by grade are shown in Table 1. Overall, English language and reading skills were significantly improved from Grade 1 to Grade 3, for all of the tasks \( F(2, 42) = 9.37, 3.30, p < .001 \) and \( p < .05 \), respectively. Children’s performance on the other Korean tasks still showed improvement across age; however, the changes did not reach significance. To increase the number of participants, we pooled data from the three grades together and focused on the cross-language transfer in the subsequent correlation and regression analyses.

**Correlations Among All the Variables**

Correlations among all of the Korean and English tasks, after partialing out children’s age, are shown in Table 2. Several important observations were obtained: English rhyme detection, English phoneme deletion, and English orthographic skills were strongly correlated with English real-word and pseudoword reading \((all \, r > .4, p < .01)\). English onset detection, rhyme detection,
and phoneme deletion skills were closely correlated with Korean onset detection, rhyme detection, and phoneme deletion skills \((r = .60, .74, \text{ and } .43, \text{ respectively; all } ps < .05)\). Korean onset detection, rhyme detection, and phoneme deletion were highly correlated with English real-word and pseudoword reading (all \(r > .41\), \(ps < .05\)). Korean phoneme deletion and orthographic skills were strongly correlated with Korean real-word and pseudoword reading (all \(r > .37, p < .05\)). Real-word and pseudoword reading were significantly correlated with each other in both orthographies \((r = .80 \text{ and } .90, \text{ respectively; both } ps < .01)\). Korean orthographic and English orthographic processing skill were not significantly correlated \((r = .28, p > .05)\). We also found that the English onset and rhyme detection tasks tended to be more highly correlated with Korean Hangul reading than did Korean onset and rhyme detection tasks. For example, the correlation between English onset detection and Hangul pseudoword reading was .38, whereas the correlation between Korean onset detection and Hangul pseudoword reading was .18.

**Cross-Language Phonology and Orthography Prediction**

In this section, we focused our analyses on cross-language and orthography prediction from Korean to English reading and from English to Korean reading. We were interested in whether phonological and orthographic skills could be transferred from one language to the other. Using a set of hierarchical regression analyses, we first examined the variables that predict English word reading using both English and Korean tasks. Our goal was to determine whether Korean tasks explained a significant amount of variance in English word reading after English tasks were taken into consideration. Second, we examined variables that predict Korean word reading using both English and Korean tasks. Similar to our analyses of English word reading, we aimed to examine the unique variance in Korean word reading accounted for by English language and orthographic skills. In both sets of analyses, age was always entered first to control for its effect when considering cross-language and orthography prediction. Nonverbal (MAT) skill was also entered when English-reading measures were the dependent variables; however, it was not entered in predicting Korean-reading skills because of the nonsignificant correlations shown between these variables.

For predicting English word reading, the order of entry was age, MAT, English phonological processing, English orthographic processing, Korean phonological processing, and Korean orthographic processing. Korean tasks were entered after the English tasks to examine the unique variance explained by Korean language and orthographic tasks over and above the English tasks. Orthographic tasks were entered after phonological tasks in order to explore the unique variance explained by orthographic tasks after considering phonological tasks. In order to reduce the number of predictors in the regressions, we created English and Korean phonological composite scores using principal-component scores for the English and Korean phonological measures. For the English phonological composite, the first principal component had an eigenvalue of 2.15 and explained 71.77% of the variance in the three phonological variables. Loadings on the first principal component were large (onset: .86; rime: .86; phoneme: .82). Principal-component scores were then calculated from these loadings. These principal-component scores were then used in the regression analyses. For the Korean phonological composite, the first principal component had an eigenvalue of 2.15 and explained 71.77% of the variance in the three phonological variables. Loadings on the first principal component were large (onset: .85; rime: .86; phoneme: .82). Principal-component scores were then calculated from these loadings. These principal-component scores were then used in the regression analyses. For predicting Korean word reading, the order of entry was age, Korean phonological processing, Korean orthographic processing, English phonological processing, and English orthographic processing.

Results of the hierarchical regressions on English reading are shown in Table 3, and those for Korean reading are in Table 4. Age clearly contributed a significant amount of variance to learning to read both English and Korean when entered first. The size of this effect was larger for learning to read English than for reading
greater than (8/ ratio, the sample size for each predictor should be equal to or that in order to achieve an adequate case-to-independent variable sizes, taking into account the effect sizes. Green (1991) suggested mentioned regression analyses, we calculated appropriate sample and orthographic skills were taken into account. word reading from English tasks once the Korean phonological phonological transfer did not occur for reading real English words. This cross-language phono- graphic skills were taken into account. This cross-language pho- phonological structure in Korean. Recall that the phono- neme deletion task included five types of phonemes to be deleted. Phonological processing skills. Phonemic-level processing is more fine-grained than onset- and rime-level processing. In order to get a glimpse of bilingual children's performance at the different levels of phonological processing, we compared their performance on the onset and rhyme tasks with the phoneme deletion task in each language. We found that children were significantly poorer at English phoneme deletion than at English onset and rhyme detec- tion, \( t(44) = 11.01, 13.97, \) respectively, both \( p < .001. \) This difference was much smaller for Korean, \( t(44) = 0.84, p > .1, \) for the difference between Korean onset detection and phoneme de- letion and, \( t(44) = 3.21, p < .01, \) for the difference between Korean rhyme detection and phoneme deletion. This was because of the simpler syllabic structure in Korean. We further analyzed children’s accuracy on the different phoneme positions. The pooled Grade 1–Grade 3 means and standard deviations for the different levels of phonological processing are as follows, each with a maximum total score of four: (a) the begin- ning and ending sound deletion combined (\( M = 2.28, SD = 1.28; \) (b) the first sound deletion in the beginning consonant cluster (\( M = 1.37, SD = 1.31; \)) (c) the second sound deletion in the beginning consonant cluster (\( M = 1.84, SD = 1.36; \)) (d) the first

Korean Hangul. Phonological skills in Korean predicted a significant amount of unique variance for Korean word reading. This was true for both real words and pseudowords. Phonological skills in English also predicted a significant amount of unique variance for English word reading, including real words and pseudowords. Orthographic processing skill in both English and Hangul orthog- raphy contributed a significant amount of unique variance to reading both real and pseudowords in the same language.

More important, the Korean phonological skills further contrib- uted a significant amount of unique variance to English pseudoword reading even after English phonological and ortho- graphic skills were taken into account. This cross-language phono- logical transfer did not occur for reading real English words. There was no additional cross-language contribution for Korean word reading from English tasks once the Korean phonological and orthographic skills were taken into account.

To examine whether we had adequate participants for the afore- mentioned regression analyses, we calculated appropriate sample sizes, taking into account the effect sizes. Green (1991) suggested that in order to achieve an adequate case-to-independent variable ratio, the sample size for each predictor should be equal to or greater than \( (8/ R^2) + (I - 1), \) where \( R^2 = R^2/(1 - R^2), \) \( R^2 \) is the total multiple \( R^2 \) in each regression, and \( I \) is the number of predictors. The needed sample size for predicting English real- word reading, English pseudoword reading, Korean real-word reading, and Korean pseudoword reading was 46, 37, 54, and 61, respectively. Therefore, the present sample size of 45 was appropriate for predicting English reading skills but relatively small for predicting Korean reading skills.

### Table 3

**Hierarchical Regression Analyses Predicting English Word Reading Using English and Korean Tasks**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mult. ( R )</th>
<th>Mult. ( R^2 )</th>
<th>( \Delta R^2 )</th>
<th>( \Delta F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicting English real-word reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 Age</td>
<td>.62</td>
<td>.38</td>
<td>.38</td>
<td>19.86***</td>
</tr>
<tr>
<td>Step 2 MAT</td>
<td>.68</td>
<td>.47</td>
<td>.08</td>
<td>4.89*</td>
</tr>
<tr>
<td>Step 3 English phonological processing</td>
<td>.75</td>
<td>.56</td>
<td>.10</td>
<td>6.69*</td>
</tr>
<tr>
<td>Step 4 English orthographic processing</td>
<td>.85</td>
<td>.73</td>
<td>.16</td>
<td>17.54***</td>
</tr>
<tr>
<td>Step 5 Korean phonological processing</td>
<td>.87</td>
<td>.75</td>
<td>.02</td>
<td>2.62</td>
</tr>
<tr>
<td>Step 6 Korean orthographic processing</td>
<td>.87</td>
<td>.75</td>
<td>.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Predicting English pseudoword reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 Age</td>
<td>.71</td>
<td>.50</td>
<td>.50</td>
<td>32.02***</td>
</tr>
<tr>
<td>Step 2 MAT</td>
<td>.76</td>
<td>.58</td>
<td>.08</td>
<td>5.57*</td>
</tr>
<tr>
<td>Step 3 English phonological processing</td>
<td>.84</td>
<td>.71</td>
<td>.13</td>
<td>13.50**</td>
</tr>
<tr>
<td>Step 4 English orthographic processing</td>
<td>.90</td>
<td>.81</td>
<td>.10</td>
<td>14.37**</td>
</tr>
<tr>
<td>Step 5 Korean phonological processing</td>
<td>.93</td>
<td>.87</td>
<td>.06</td>
<td>12.94**</td>
</tr>
<tr>
<td>Step 6 Korean orthographic processing</td>
<td>.93</td>
<td>.87</td>
<td>.00</td>
<td>0.81</td>
</tr>
</tbody>
</table>

**Note.** Mult. = Multiple; MAT = Matrix Analogy Test.

* \( p < .05. \) ** \( p < .01. \) *** \( p < .001. \)

### Table 4

**Hierarchical Regression Analyses Predicting Korean Word Reading Using English and Korean Tasks**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mult. ( R )</th>
<th>Mult. ( R^2 )</th>
<th>( \Delta R^2 )</th>
<th>( \Delta F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicting Korean real-word reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 Age</td>
<td>.36</td>
<td>.13</td>
<td>.13</td>
<td>5.71*</td>
</tr>
<tr>
<td>Step 2 Korean phonological processing</td>
<td>.60</td>
<td>.36</td>
<td>.23</td>
<td>13.46**</td>
</tr>
<tr>
<td>Step 3 Korean orthographic processing</td>
<td>.73</td>
<td>.53</td>
<td>.18</td>
<td>14.08**</td>
</tr>
<tr>
<td>Step 4 English phonological processing</td>
<td>.73</td>
<td>.53</td>
<td>.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Step 5 English orthographic processing</td>
<td>.73</td>
<td>.54</td>
<td>.00</td>
<td>0.20</td>
</tr>
<tr>
<td>Predicting Korean pseudoword reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 Age</td>
<td>.44</td>
<td>.20</td>
<td>.20</td>
<td>9.72**</td>
</tr>
<tr>
<td>Step 2 Korean phonological processing</td>
<td>.60</td>
<td>.36</td>
<td>.16</td>
<td>9.77**</td>
</tr>
<tr>
<td>Step 3 Korean orthographic processing</td>
<td>.68</td>
<td>.47</td>
<td>.10</td>
<td>7.06*</td>
</tr>
<tr>
<td>Step 4 English phonological processing</td>
<td>.70</td>
<td>.49</td>
<td>.02</td>
<td>1.41</td>
</tr>
<tr>
<td>Step 5 English orthographic processing</td>
<td>.70</td>
<td>.49</td>
<td>.00</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**Note.** Mult. = Multiple.

* \( p < .05. \) ** \( p < .01. \)
sound deletion in the ending consonant cluster ($M = 1.02, SD = 0.94$); and (e) the second sound deletion in the ending consonant cluster ($M = 1.56, SD = 1.16$). Paired sample $t$-tests revealed that children performed best on deleting word initial and final sounds compared with all other positions (all $ps < .05$). Children had the most difficulty with the first sound of the ending consonant cluster, compared with all other positions (all $ps < .05$), except the first sound of the beginning cluster.

Korean phoneme deletion items were further grouped into two categories: first consonant and final consonant deletion. The mean accuracies (and standard deviation) were 6.04 (2.91) and 5.96 (3.89), each with a maximum total score of 10. There was no significant difference between students’ performance at deleting these two consonant types.

**Discussion**

Our results add to those from other studies on bilingual and biliteracy acquisition to support cross-language phonological transfer across various alphabetic languages. Korean Hangul and English orthographic systems share a fundamental alphabetic principle. Learning to read Hangul and English both involve mapping graphemes to phonemes. Our study successfully demonstrated that for two alphabetic languages, phonological skills are highly correlated with each other, and this finding suggests that better phonological skills in one language will lead to better phonological skills in another language. Korean onset detection, rhyme detection, and phoneme deletion are highly correlated with English onset detection, rhyme detection, and phoneme deletion. Korean phonological skills, including onset detection, rhyme detection, and phoneme deletion, were also significantly correlated with English real-word and pseudoword reading.

More important, Korean phonological skills explained a unique amount of variance in English pseudoword reading even after English phonological and orthographic skills were taken into account. This result suggests that L1 phonological skills facilitate L2 pseudoword reading. This is not surprising because reading English pseudowords requires true alphabetic knowledge, in other words, strong letter-sound correspondence skills, and phonological processing skills are essential for processing these nonwords. Real words, however, can be read either via letter-phoneme mapping, an assembly route, or a whole-word access lexical route, as was described in a well-known dual-route reading model (e.g., Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Therefore, real-word reading may not be as sensitive to the phonological processing skills as is pseudoword reading. Our finding that L1 phonological skills contribute to L2 word reading complements and reinforces previous findings for bilingual groups of children such as Spanish–English (e.g., Durgunoglu et al., 1993), French–English (e.g., Comeau et al., 1999), Italian–English (e.g., D’Angiuoli et al., 2001), and Portuguese–English children (e.g., DaFontoura & Siegel, 1995) in which both languages are of a Roman alphabetic nature. In the present study, we demonstrated cross-language phonological transfer across two different alphabetic orthographies that differ in visual forms as well as orthographic transparency. Phonological processing is an important general process in learning to read different alphabetic orthographies. Two recent studies on bilingual reading across different writing systems such as Chinese–English, in which Chinese is a nonalphabetic writing system, suggest that there are common phonological processes even in reading two different writing systems (Gottardo et al., 2001; Wang, Perfetti, & Liu, 2005). For example, Wang and colleagues found that the Chinese contrastive phonological property, tone, explained a modest but significant amount of unique variance in English pseudoword reading even after taking English phonological tasks into consideration. Taken together, we can make a strong claim that bilingual reading builds on general phonological processes of the two spoken languages.

It is also worth noting that this cross-language phonological transfer was weak in the direction of English to Korean. It appears that the influence from L2 to L1 was not as strong as that from L1 to L2. We believe this is because learners can draw upon a well-established L1 phonological system in learning to read L2. However, weak L2 oral language proficiency limits such reliance for learners. Some bilingual researchers have also found this asymmetric link between L1 and L2 meaning representation. For example, Kroll and Stewart (1994) found that there is shared conceptual understanding of L1 and L2 vocabularies; however, the connection from L1 to the shared concept is much stronger than that from L2 to a shared concept.

We found limited orthographic transfer in learning to read two different orthographies. Korean and English orthographic skills were not significantly correlated with each other. Korean orthographic skill did not predict English word reading over and above English phonological and orthographic skills. We suggest that this reflects the differences in visual forms and possibly the orthographic transparency between the two languages. English is a linear orthographic system, whereas Korean is nonlinear. The visual-spatial configuration of Korean Hangul is in contrast with English. Wang et al. (2005) found among a group of Chinese–English bilingual children that Chinese orthographic skills did not correlate significantly with English orthographic skills and did not predict English word reading. Korean and Chinese characters share a nonlinear and squarelike structure. Recent neuroimaging work on Chinese–English bilingual adults (e.g., Liu & Perfetti, 2003; Tan et al., 2001, 2003) has shown that reading Chinese resulted in more activation in some brain areas that are responsible for coordinating and integrating visual-spatial analyses of logographic Chinese characters compared with reading English. We expect that reading Korean Hangul words would involve similar activation in those brain areas relating to visual-spatial analyses of nonlinear Hangul words. Another explanation for this nonsignificant orthographic transfer is that the Hangul system is a shallow orthography, in which single letters directly map onto individual phonemes, and one letter stands for only one sound. However, English is a deep orthography; the relation between letters and sounds is opaque, and in many cases one letter can be pronounced as more than one sound. Therefore, not much help would be expected from a shallow orthographic experience for learning a deep orthography.

Both phonological and orthographic processing skills are important for learning to read English and Korean Hangul systems. These findings are consistent with the literature on roles of phonology and orthography in learning to read alphabetic languages (e.g., Cunningham et al., 2001; Ehri, 1991, 1998; Goswami & Bryant, 1990; Hulme et al., 2002; Lundberg et al., 1980). In the present study, we found that orthographic skills in both Korean and English not only explained unique variance in reading both real
and pseudowords in the two orthographies but also predicted far more variance than did phonological skills for English real-word reading. This finding indicates that orthographic learning plays an important role for this group of bilingual children. The strong prediction from English orthographic skill to English real-word reading is not surprising. This echoes the claim made by some researchers that basic reading skill is highly related to building orthographic knowledge. That is, one of the critical factors in word identification skill is the development of strong orthographic representations of lexical items (e.g., Perfetti, 1992; Share, 1995). A recent extended version of the orthographic depth hypothesis suggests that reading in a shallow orthography, such as Italian and German, may rely primarily on a single phonological processes, whereas a deep orthography, such as English or Dutch, entails both phonological and visual-orthographic processes (e.g., Seymour, Aro, & Erskine, 2003; Share, 2004). Our results for learning to read English from a group of bilingual children supported the aforementioned hypothesis about deep orthography. Nevertheless, our result on learning to read the Korean Hangul system challenged the hypothesis on the shallow orthography part. Share (2004) suggested that children who learn to read Hebrew, a shallow alphabetic orthography, were not sensitive to word-specific orthographic detail until Grade 3 despite their high levels of decoding accuracies. Korean Hangul is a perfectly shallow orthography; however, Hangul orthographic processing skill contributed a significant unique amount of variance to Hangul word reading over and above phonological processing skill for a group of Grade 1–Grade 3 children. We speculate that the unique visual form of the Hangul system may be responsible for the difference in the role of orthographic skill between reading the Korean Hangul alphabetic system and other Roman alphabetic systems. We further suggest that it is necessary to take into account the visual form of the alphabetic system when considering the degree of orthographic transparency among languages in the world.

The poorer performance in processing English phonemic information compared with English onset and rhyme information is in line with the findings in reading literature. The ability to attend to phonemes develops later than the ability to attend to larger phonological units such as onset-rhyme divisions of the syllable (e.g., Goswami, 1993; Goswami & Bryant, 1990; Perfetti, Beck, Bell, & Hughes, 1987). The English phoneme deletion task is an especially challenging task. It requires that children isolate a given sound in the word, hold the resulting sound in memory, and then blend sounds together; therefore, phoneme deletion is sometimes called a compound phonemic awareness task (e.g., Yopp, 1988). The children had the most difficulty with the first consonant in the final consonant cluster; they were also poor in processing the first consonant in the beginning consonant cluster. This is not surprising because consonant clusters impose a higher demand when children have to manipulate phonemes in words (e.g., Bruck & Treiman, 1990; Treiman, 1985; Treiman & Weatherston, 1992). According to Treiman and her colleagues, children tend to treat the consonant cluster as a whole unit; therefore, segmentation of the two sounds appears to be a daunting task even for children in the primary school grades.

A recent study on Korean children learning to read Hangul at kindergarten and Grade 2 found that both syllabic- and subsyllabic-level skills uniquely predicted Hangul word recognition (Cho & McBride-Chang, 2005). This finding suggests that the Korean Hangul system requires children to be sensitive to both syllabic and subsyllabic linguistic units. Their results are consistent with our study on the prediction of subsyllabic processing skills in reading Hangul. However, their results also point to the importance of syllable-level skills for successful Hangul reading. Cho and McBride-Chang argued that the high salience of syllables in Korean language as well as in Korean script relative to other languages, such as English, is responsible for such a strong prediction of Korean syllable-level skills for learning to read Hangul. Future research in studying Korean–English biliteracy acquisition could include both syllable-level and subsyllable-level tasks so that a comparison can be made directly as to the contribution of syllable-level skills in learning to read Hangul versus English in a group of bilingual children. One more limitation of our study is that a measure of oral language proficiency in either Korean or English was not included. Previous research suggested that English language proficiency could influence word-reading performance in English as a second language (e.g., Geva, Yaghoub-Zadeh, & Schuster, 2000). Thus, care should be taken in future research to control for this factor. Various measures tapping the oral language proficiency, such as vocabulary, grammatical knowledge, and discourse-related knowledge, can be used in cross-language transfer studies.

Finally, findings from our study have important educational implications. Classroom teachers need to pay attention to bilingual children’s strong L1 language skills and be aware that these strong first L1 language skills can be transferred to L2 learning. Furthermore, teachers can make use of the children’s language skills in their L1 as a “facilitator” or “springboard” to develop their L2 language and literacy skills (see Durgunoglu, 2002, for this suggestion, p. 192).

In the case of bilingual children whose L1 and L2 are both alphabetic languages, phonological processing skills transfer from L1 to L2 could be fully used in the classroom. Durgunoglu (2002) also proposed a way to use cross-language transfer as a screening tool for L2 children’s reading disabilities. There are two possible sources of difficulties associated with L2 reading difficulties: One is children’s low levels of linguistic proficiency in L2, and the other is more general cognitive and learning difficulties. For children who have good L1 language and literacy skills, we should expect transfer to their L2 literacy. Presumably, if children have strong L1 language and literacy skills but still have not acquired strong L2 literacy skills, then it is possible that they need more time and exposure to L2 for improving their L2 language proficiency. Their reading difficulty is not because of a true cognitive/learning disability. This way we can distinguish a true L2 reading disability and a delayed L2 learning because of limited L2 language proficiency.

To conclude, the findings from our study suggest that bilingual reading acquisition may be a joint function of general phonological processes and orthographic-specific skills. Phonological skills in L1 contributed to phonological skills and reading in L2. However, in the case of two orthographic systems that share the alphabetic principles but differ in visual forms, there is limited facilitation of orthographic skills from one to the other. Both phonological and orthographic skills are important predictors for reading in two different alphabetic orthographies.
References


Kim, J. (1999). Investigating phonological processing in visual word recognition: The use of Korean Hangul (alphabetic) and Hanja (logo-
graphic) scripts. Dissertation Abstracts International: Section B: The Physical Sciences and Engineering, 59(11-B), 6093.


Received September 23, 2004
Revision received July 11, 2005
 Accepted July 13, 2005