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The concurrent development of reading and spelling in English and Persian were examined in a sample of bilingual children. The objective was to compare how phonological and orthographic processing skills contribute to reading and spelling for two alphabetic languages that differ drastically. English orthography is characterised by both polyphony (i.e., a grapheme representing more than one phoneme) and polygraphy (i.e., a phoneme represented by more than one grapheme) which results in a complex script to read and write. In contrast, vowelised-Persian orthography is characterised by polygraphy only, which results in a simple script to read but more complex to write. Fifty-five Iranian children in grades 2 and 3, who had lived in English-speaking Canada for an average of 4 years, were tested on word reading and spelling in English and Persian. We found that the predictors of reading performance were similar across languages: Phonological and orthographic processing skills each predicted unique variance in word reading in English and in Persian once we had controlled for grade level, vocabulary, and reading experience. As expected, the predictors of spelling performance differed across language: Spelling in English was predicted similarly by phonological and orthographic processing skills, whereas spelling in Persian was predicted by orthographic processing skills only. It is possible that the nature of the Persian orthography encourages children to adopt different strategies when reading and spelling words. Spelling Persian words might be particularly conducive to using an analytic strategy which, in turn, promotes the development of and reliance on orthographic skills.

Introduction

In many places around the world, children learn to read and write in alphabetic languages other than English. Although much progress has been made in our understanding of how English-speaking children become literate, our understanding of how other children become literate is less advanced. Cross-linguistic comparisons are necessary to assess whether the models of literacy acquisition developed for English generalise to other languages (Caravolas, 1993). Research has been conducted to contrast literacy acquisition in alphabetic versus syllabic or ideographic scripts (e.g., French, 1976; Jackson, Lu, & Ju, 1994) and to assess variation among alphabetic scripts (e.g., Bruck, Genesee, & Caravolas, 1997; Caravolas & Bruck, 1993; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Wimmer & Goswami, 1994). In most of the latter studies, the alphabetic scripts being compared were similar (e.g., English, French, or Spanish), but much less work has been done regarding learning to read and write in two languages for which the alphabetic scripts differ drastically (e.g., Geva, Wade-Woolley, & Shany, 1993; Gholomian, 1992). The present study examined the development of word reading and spelling when bilingual children learn concurrently in English and Persian, two languages that differ in orthographic complexity (i.e., the extent to which the orthography of a language maps onto the phonology of that language).

The role of phonological and orthographic processing skills

The development of reading and writing in young children is influenced primarily by word-level skills such as word identification and spelling (for a review, see Adams, 1990). In addition, it is assumed that word identification and spelling depend on similar skills, namely, phonological and orthographic processing skills (e.g., Gough, Juel, & Griffith, 1992; Gough & Tumner, 1986; Juel, Griffith, & Gough, 1986). Phonological processing skills represent the child's procedural knowledge about grapheme-to-phoneme correspondence rules. They enable readers to translate the letters into their corresponding sounds and then combine the sounds to read words. Furthermore, phonological skills are used to spell words. Phonological skills enable spellers to segment the sounds in words and try to represent the sounds with corresponding letters. A child may segment the phonemes in 'pat' as /p/, /ae/, and /t/ and represent each with the corresponding graphemes, p, a, t (Varnhagan, 1995). There is now much evidence indicating the necessity of phonological

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skills in learning to read and spell in English (reviewed by Adams, 1990).

Orthographic processing skills represent the "ability to form, store, and access the orthographic representations" of words or meaningful parts of words (Stanovich & West, 1989, p. 404). These skills involve one's knowledge of the letters in words and their sequence. Orthographic skills allow the reading of words by sight and the spelling of words from memory. These skills are presumably acquired through reading experience as children develop extensive spelling-to-sound knowledge (Stanovich, 1992). However, individual differences in orthographic skills are not completely explained by reading experience (Barker, Torgesen, & Wagner, 1992). Frith (1985) argued that differences in orthographic skills might also result from differences in the degree to which children adopt a reading strategy whereby they analyse or process all the letters in words (see also, Share, 1995).

Stage-like models of the development of reading (Frith, 1985) and spelling (Ehri, 1987, 1989) suggest that children initially rely on phonological skills, but come to rely on both phonological and orthographic processing skills after sufficient exposure to print. Consider the second and third stage of Frith's three-stage model. In the second stage, children learn to use phonological information to read words. They pay attention to the individual letters within words. As a consequence of using their growing phonological skills, children in the third stage use their accumulated knowledge about letters in words and their order (i.e., their orthographic skills) to identify words. The link between phonological and orthographic skills is supported by the strong correlation between the two skills in beginning readers of English (Juel et al., 1986). In addition, orthographic skills make a contribution to reading performance that is independent of that attributed to phonological skills. This is the case for skilled readers (Stanovich & West, 1989), children in grade 3 (Barker et al, 1992; Cunningham & Stanovich, 1991) as well as beginning readers and spellers (Juel et al., 1986). Moreover, longitudinal studies show that the unique contribution of orthographic skills increases over time (Juel et al., 1986).

The effect of orthographic complexity

Cross-linguistic comparisons are necessary to assess whether the models describing the use of phonological and orthographic skills developed for anglophone children apply to other alphabetic scripts (e.g., French or German). Alphabetic scripts, however, are not all alike. They differ, among other things, in the consistency with which the letters map on to the phonology of the language. Consider the case of Spanish versus that of English. In Spanish, the correspondences between phonemes and their graphemic representations are simple and consistent. A grapheme consistently represents the same phoneme (i.e., a letter consistently represents the same sound) and a phoneme is consistently represented by the same grapheme (i.e., a sound is consistently represented by the same letter). Such orthographies are labelled as *shallow* or *transparent*. In contrast, English is characterised by complex and inconsistent correspondences between phonemes and their graphemic representations. The English orthography is polyphonic and polygraphic. English is polyphonic because its orthography includes graphemes that can represent more than one phoneme (e.g., *i* in m*i*nt vs. p*i*nt; *ea* in h*ea*l vs. h*ea*lth), and it is polygraphic because it includes some phonemes that can be represented by different graphemes (e.g., /f/ in *f*arm vs. *ph*armacy; /c/ in *c*ake vs. *k*ite). Orthographies such as English are labelled as *deep* or *opaque*. The issue then becomes whether variation in the complexity of the grapheme-to-phoneme mappings has any influence on children's reliance on phonological and orthographic skills to read and spell. Research on cross-linguistic differences is growing. Researchers have addressed the issue of complexity differences with regards to skilled reading performance (e.g., Persian: Baluch, 1996; Baluch & Besner, 1991; Serbo-Croatian: Katz & Frost, 1992; Turkish: Oney, Peter, & Katz, 1997), as well as beginning reading (e.g., Persian: Baluch & Shahidi, 1991; Turkish: Oney et al., 1997). In addition, some researchers have included measures of spelling performance (Dutch: Coenen, van Bon, & Schreuder, 1997; Italian: Cossu, Gugliotta, & Marshall, 1995; Hebrew: Geva et al., 1993; German: Wimmer & Hummer, 1990).

It is worthwhile to evaluate whether the complexity levels of orthographic scripts remain the same for reading and spelling. Consider the reading and writing of vowelised Hebrew in which all vowel sounds are represented with letters (Geva et al., 1993; Geva & Willows, 1994). Vowelised Hebrew, used with beginning readers, is relatively transparent for readers because each grapheme corresponds to a single phoneme. However, the Hebrew orthography is more complex for spellers because more than one grapheme can correspond to the same phoneme (for a complete description, see Geva et al., 1993). This discrepancy between the level of complexity for reading compared to spelling raises the possibility that children may rely on different skills when they read and write in Hebrew. The use of phonological skills for reading in vowelised Hebrew may result in successful reading. In contrast, reliance on phonological skills may not always result in correct spellings, instead spelling in that specific language may require a greater reliance on orthographic skills.

The effect of orthographic complexity on the role of phonological and orthographic skills in children's word reading as well as spelling was investigated in a longitudinal study by Geva et al. (1993). They followed a group of 45 kindergarten children until grade 2 to examine the concurrent development of reading and spelling in English, an opaque orthography, and in vowelised Hebrew, a transparent orthography in terms of reading but opaque in terms of spelling. The results indicated that although phonological and orthographic skills played roles in the emergence of reading and spelling in English, orthographic skills quickly dominate in such a deep orthography. In contrast, phonological skills rather than orthographic skills predicted reading and spelling in Hebrew. The results for spelling performance in Hebrew were somewhat surprising given the argument that reliance on phonological skills to spell in Hebrew would produce phonologically correct but othographically incorrect spellings. The children in the Geva et al. study were learning Hebrew as a second language, the issue then remains as to whether children who speak Hebrew as a first language would show the same reliance on phonological skills to read and spell.

The present study was conducted to examine whether children rely on similar skills when reading and writing in languages that differ in orthographic complexity. In the present study, the children were native speakers of Persian living in English-speaking Canada while their parents attended Canadian universities. As such, the children were learning to read and spell concurrently in English and in Persian, two very

distinct orthographies. English has an opaque script to read and spell whereas vowelised Persian, which has similar characteristics to vowelised Hebrew, has a transparent orthography for reading but opaque for spelling. A brief description of Persian follows.

Persian has an alphabetic script that consists of thirty-two alphabetic letters. The Persian alphabet is a modified version of the Arabic script and is written from right to left (Khanlari, 1979). Hence, the Persian script bears no visual similarities with the Roman alphabetic writing systems (Baluch, 1996). The language has six spoken vowels, three long vowels /i/, /u/, and /a/ each represented by a letter, and three short vowels, /e/, /o/, and /ae/ typically not represented by letters. In vowelised Persian, used for beginning readers, the three short vowels are represented by diacritics added to a consonant letter. A lack of diacritics for short vowels does not cause problems for skilled readers; they read and interpret these words by using alternative sources of knowledge, such as letter sequences and contexts (for a full description see Baluch & Besner, 1991; but for a description of facilitative effects of vowelised arabic script in skilled readers, see Abu-Rabia, 1997). Persian has very regular grapheme-to-phoneme correspondence rules because each grapheme has a single pronunciation (i.e., Persian is not polyphonic). The Persian script, however, is polygraphic because some phonemes are represented by more than one grapheme. For example, the phoneme /s/ can be represented by three different graphemes; and the phoneme /z/ can be represented by four graphemes. The polygraphy of Persian should not have any consequences for reading because any given letter consistently has the same pronunciation. In contrast, the polygraphy of Persian should affect the spelling of words because the speller has to select from an array of possible candidates, the letter that accurately spells a given word.

The purpose of the present study was to assess children's reliance on phonological and orthographic skills when reading two very different orthographies. We tested word reading and spelling skills among children (grades 2 and 3) learning to read and spell concurrently in English as a second language (L2) and in Persian as a first language (L1). We decided to use a sample of bilingual children because we did not have access to Persian-speaking children who were not bilingual. This sample selection had two advantages. A within-subject design allowed us to control for cognitive factors related to reading such as intelligence and working memory. Moreover, examining bilingual children's performance in English allowed us to extend current findings obtained with native speakers of English—a strategy that has been used with other languages (Portuguese: Da Fontoura & Siegel, 1995; Punjabi: Chiappe & Siegel, 1999; Greek: Chitiri & Willows, 1997). Finally, the children in the present study were learning to read concurrently in two languages, whereas most research on bilingualism has focused on the successive acquisition of reading in two languages (Koda, 1994). We attempted to match children's reading skills in the two languages by selecting children who were at the same grade level in the two languages.

Contrasting children's performance in English (complex script to read and write) and Persian (transparent script to read but complex to write) allowed a test of the notion that differences in the level of complexity of an orthographic system for reading and spelling may affect the links between children's reading and spelling and the underlying phonological and orthographic skills. Because English maintains a similar level of orthographic complexity for reading and spelling, we predicted that the relative importance of phonological and orthographic skills would be similar across tasks. Because Persian does not maintain a similar level of orthographic complexity for reading (less complex) and spelling (more complex), it is possible that the relative contribution of phonological and orthographic skills might show different patterns across tasks. As with other scripts that are regular and consistent, the Persian script should facilitate the application of grapheme-to-phoneme conversion rules for beginning readers. Efficient phonological skills, in turn, should facilitate the acquisition of sight vocabulary (Frith, 1985; Gough et al., 1992). Hence, the use of both orthographic and phonological skills should characterise good readers of Persian. This may not be the case for good spellers, however. The application of grapheme-to-phoneme correspondence rules may not be successful for spellers because reliance on a phonological strategy may lead to writing words that have correct pronunciations but that have incorrect spellings. It follows that reliance on orthographic skills may be a key factor in becoming a good speller of the Persian script.

Method

Participants

The sample consisted of 65 Iranian children who spoke Persian (L1) as a first language and English as a second language (L2). The parents were students attending Canadian universities and they all reported that Persian was the language spoken at home. On average, the families had lived in Canada for four years. The children attended Canadian public schools and also attended private Persian schools (for an average of six hours per week) in the province of Ontario, Canada. Reading and spelling in English was taught with a combination of whole language and phonics whereas reading and spelling in Persian was taught with a phonics method.

Children were in grades 2 and 3 and were selected if they were in the same grades in Persian as in their English classes to ensure sufficient exposure to literacy instruction in both languages. For example, a child in grade 2 in a Persian school was also in grade 2 in an English school. Of the 65 children tested, ten were not included in the final analyses because five children could not perform the English tasks due to lack of reading and spelling fluency in English, three children decided not to complete all the tasks, and two children were judged to be outliers after preliminary analyses of the data. Therefore, the data from 55 children (32 girls and 23 boys) were analysed. The children were, on average, 8;2 years of age.

Materials

Word reading. To assess children's ability to read words in English, words were selected from the Woodcock Reading Mastery Test (Woodcock, 1973) and Woodcock-Johnson Letter-Word Identification Task (Woodcock & Johnson, 1989). The words introduced in the two standard tests (almost 200 words) begin with highly familiar words, then proceed to less frequent and orthographically more complex words. Thirty-eight words were selected based on level of difficulty and number of syllables. Twenty easy words were selected from words introduced in grades 1 and 2 and

consisted of 10 one-syllable and 10 two-syllable words. Eighteen difficult words were selected from words used in grades 3, 4, and 5 and consisted of 6 one-syllable, 6 two-syllable, and 6 three- or more-syllable words. The words averaged 5.5 letters in length.

To assess children's ability to read words in Persian, a test was developed based on the Persian vocabulary introduced in Iranian schoolbooks at different grades. This approach is often used in cross-linguistic research when no standardised reading tests exist (e.g., Baluch & Shahidi, 1991; Bruck et al., 1997). The structure of the test is identical to that of the English task. The list consisted of 38 words for which the short vowels were represented by diacritics. The design of the test was identical to that of the English test. The 20 easy words (10 one-syllable and 10 two-syllable) were selected from the reading vocabulary introduced in schoolbooks in grade 1 and the first part of grade 2. The 18 difficult words were selected from the reading vocabulary taught in grades 4 and 5 and consisted of 6 one-syllable, 6 two-syllable, and 6 three- or more-syllable words. Half of the words in both the easy and difficult categories were words for which each letter corresponded to a single phoneme and the other half were words for which different letters might represent the same phoneme. The Persian words had a mean length of 5.2 letters including vowels. Because short vowels in Persian are specified with a diacritic instead of a letter, it seems that the average number of the letters per word was smaller than in English. However, the number of phonemes per word was similar in the two languages.

The procedure and scoring were similar to that of Woodcock-Johnson (1989). The children read aloud the words at their own pace and skipped any word they could not read. When a child paused for too long on a particular item, he/she was encouraged to skip that item and to continue reading. Testing was stopped when the child made six consecutive errors. The responses were tape recorded for later verification of correct pronunciation because the experimenter spoke English as a second language. One point was given for each correct word. English word reading was scored twice: once by a native English speaker for verification of correct pronunciation and once by a native speaker of Persian to verify whether we were not penalising children unduly for their Persian accents. The correlation between the two scores was strong ($r = .92$) and both scores yielded identical results in the analyses below, therefore only the scoring by the native speaker of Persian was reported. The inter-item reliabilities for the English and Persian word reading tasks were .94 and .81, respectively.

Spelling. To provide an equivalent measurement of reading and spelling, the same 38 items that were used for reading were used for the spelling task. For each word they were asked to spell, children listened to an audiotape of a native speaker saying the word, then saying the word in a sentence, then repeating the word. Spelling accuracy was measured by counting the total number of words spelled correctly. The inter-item reliabilities for the English and Persian word spelling tasks were .93 and .83, respectively.

Phonological processing skills. A pseudoword reading task can be a valid indicator of children's use of phonological skills because it measures children's ability to decode nonsense words for which they presumably have no lexical knowledge (Stanovich & Siegel, 1994; Wimmer & Hummer, 1990). Pseudowords are pronounceable letter strings that do not correspond to real words but can be read by using grapheme-to-phoneme correspondence rules. There is no help from orthographic skills for pronouncing pseudowords as the child has not seen these words previously (Olson, Frosberg, Wise, & Rack, 1994). Generally, pseudowords may be generated by modifying real words, replacing two or three letters with others (e.g., cap to hap; Katz & Feldman, 1983).

Thirty English pseudowords were selected from the Word Attack subtests of the Woodcock Reading Mastery Tests (Woodcock, 1973) and Woodcock-Johnson Letter-Word Identification Task (Woodcock-Johnson, 1989). There were 10 one-syllable, 10 two-syllable, and 10 three- or more-syllable pseudowords; they averaged 5.8 letters in length. A Persian version of a pseudoword reading task was developed by modifying words selected from Persian schoolbooks. Thirty pronounceable pseudowords were constructed by changing either the initial, medial, or final consonant of real words or by changing the long vowels. There were of 10 one-, 10 two-syllable, and 10 three- or more-syllable pseudowords; they averaged 5.6 letters in length.

The children were told that the words were not real words. They were asked to read the pseudowords aloud, and if they did not respond, they were encouraged to do so. If the child still did not respond, they were encouraged to continue reading. Testing was stopped when the child made six consecutive errors (Woodcock, 1973). Scoring was based on the number of words read correctly. Because the experimenter was not a native English speaker, the children's responses were audiotaped for later verification of correct pronunciation. English pseudoword reading was scored by both a native Persian speaker and a native English speaker. The correlation between the two scores was strong ($r = .83$) and the two scores yielded identical results in the analyses (see later). We reported the scoring by the native Persian speaker. The inter-item reliabilities for the English and Persian phonological tasks were .84 and .76, respectively.

Orthographic processing skills. A spelling recognition task developed by Olson, Kliegl, Davidson, and Foltz (1985) was used to measure children's orthographic processing skills. The measure is a forced-choice discrimination task in which children are presented with a word and a pseudohomophone of that word (e.g., cake and caik) and they are asked to select the real word. Olson et al. (1985) claimed that phonological skills could not be used to make a correct decision between the two words because both words sound the same. Instead, a correct decision had to be based on the word's orthographic characteristics. Therefore, "the task should to some extent reflect the accessibility and quality of orthographic entries in the lexicon" (Stanovich & Siegel, 1994, p. 33).

The task consisted of eight practice and 40 experimental word pairs, each including a real word and a pseudohomophone of that word. These English words were common words and were selected from grade 2 reading vocabularies. The words averaged 4.5 letters in length. The Persian version of the task consisted of Persian words selected from the reading vocabulary introduced in grade 1 school books and the first part of grade 2 school books. The Persian words averaged 4.6 letters in length. Children were asked to identify which of the items in each stimulus pair was spelled correctly. Scoring was based on the number of words correctly identified. The inter-item reliabilities for the English and Persian orthographic tasks were .85 and .76, respectively.

Vocabulary knowledge. We included a measure of vocabulary in each language to ensure that the expected differences across languages were not confounded with differences in oral language proficiency. A short version of the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981) was used. In this task, the experimenter said a word and children were asked to select from an array of four pictures the one that represents the named word. A short version of the PPVT-R was successfully used by Cunningham and Stanovich (1991) as a reliable measure of vocabulary. For the purpose of the present study, four practice items and 24 test items were selected for each language. The 24 test items were selected among items 7 to 109 because they represented a range of words from easy to hard (i.e., ranging from ages 3 to 15). Form L of the PPVT-R was used for the English test and Form M for the Persian test. The inter-item reliabilities for the English and Persian vocabulary tasks were .78 and .70, respectively.

Reading experience. Parents were asked to indicate how frequently during a typical week they observed their child read English and Persian books, other than school books. Data for this measure is missing for one child due to experimenter error. We replaced the two missing data points with the mean for the appropriate group in the regression analyses (Tabachnick & Fidell, 1989).

Procedure

Most children were tested individually in their homes, but a group of children were tested at their Persian school and were administered the spelling and visual recognition tasks in class. The order of presentation of the English and Persian tasks was counterbalanced across children. Within each language, the order of presentation of the six tasks was random with the constraint that half the children received the spelling tasks first and half received the reading tasks first. This constraint was necessary because children were required to read and spell the same words within each language. Children were told that they could rest whenever they felt tired and a ten minute pause occurred after the completion of five tasks. Finally, children were familiarised with the procedure for each task by the presentation of a series of practice items. The children were not given any feedback on the accuracy of their responses during the experiment.

Results and discussion

Preliminary analyses revealed that individual or group administrations of spelling and orthographic processing tasks had no significant effects in either Persian and English, all ts < 1.32, and ps range from .20 to .90, and that the order of presentation for reading and spelling in each grade had no significant effect in either languages, all ts < 1.06, and ps range from .31 to .92. It was important to show that asking children to read or spell the words first had no statistically significant effect on their performance because children were asked to read and spell the same words within each language.

The descriptive statistics for the Persian and English measures are displayed in Table 1. Children's performance in grade 3 was superior to that of children in grade 2, Wilks' λs $(5, 49) = .80$ and .49, ps $< .001$ and .05, for the English and Persian measures, respectively. As a consequence, grade level was entered in all subsequent analyses. Comparisons of children's performance across languages showed that children were more proficient in Persian (L1) than in English (L2) on all tasks, ts $(54) = 4.16$, 12.17, 7.25, 4.34, and 2.88, ps $< .007$, for reading, spelling, phonological skills, orthographic skills, and vocabulary, respectively. This is consistent with the findings that second language learning lags behind first language learning (reviewed by Koda, 1994). In addition, children could read more words correctly than they could spell correctly, ts $(54) = 20.62$ and 10.76, ps $< .001$, for the English and Persian measures, respectively. This is consistent with findings showing that spelling words is a more cognitively demanding task than reading in both transparent (Italian: Cossu et al., 1995; Turkish: Oney & Durgunoglu. 1997; German: Wimmer & Hummer, 1990) and more complex orthographies (English: Juel et al., 1986; Shankweiler & Lundquist, 1992). Finally, parents reported that their children

Table 1
Means (and standard deviations) for the English and Persian measures for each grade and the entire sample

Variable (max score)	*Grade 2* (N = 27)		*Grade 3* (N = 28)		*Overall*	
	Mean	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
English measures						
Word Reading (38)	26.74	(9.28)	30.89	(6.77)	28.85	(8.29)
Spelling (38)	14.44	(8.08)	19.25	(6.70)	16.89	(7.73)
Phonological skills (30)	18.26	(7.38)	20.11	(6.95)	19.20	(7.16)
Orthographic skills (30)	24.11	(5.60)	27.29	(4.36)	25.73	(5.21)
Vocabulary (24)	16.37	(4.44)	17.71	(3.84)	17.05	(4.16)
Reading experience[a]	3.42	(1.04)	3.14	(1.01)	3.28	(1.03)
Persian measures						
Word Reading (38)	31.33	(3.74)	35.79	(2.86)	33.60	(3.98)
Spelling (38)	26.67	(4.81)	31.43	(2.83)	29.09	(4.58)
Phonological skills (30)	24.07	(4.52)	27.43	(2.23)	25.78	(3.90)
Orthographic skills (30)	27.56	(2.94)	29.25	(1.17)	28.42	(2.36)
Vocabulary (24)	17.07	(2.45)	20.82	(1.66)	18.98	(2.80)
Reading experience[a]	1.32	(1.29)	1.71	(1.21)	1.52	(1.26)

[a] Parent reports of the number of times per week their child reads books other than school books.

read more often in English than they did in Persian, $t(53) = 8.1$, $p < .001$. This finding may reflect the greater availability in Canada of books in English as compared to books in Persian.

Examination of the correlation coefficients presented in Table 2 revealed that, within each language, all tasks were positively intercorrelated. These findings replicate those of Geva et al. (1993) and others (e.g., Gholomian, 1992) showing that the emergence of reading and spelling are interrelated in both L1 and L2. However, the correlation coefficients were much lower when we compared the same variables across the two languages. Consider the low correlation between reading in English and in Persian. This pattern of low correlations suggest that the concurrent acquisition of literacy skills in two language that bear no visual resemblance to each other might occur fairly independently for the two languages. As such, this pattern is different from the strong pattern of correlations obtained when children acquire literacy skills in two languages successively (Koda, 1994).

A closer examination of the pattern of correlations revealed differences across languages. As expected, we found that phonological and orthographic skills held very similar relations with both reading and spelling in English. This was also the case for reading in Persian. In contrast, we found that orthographic skills ($r = .75$) were more strongly correlated to spelling in Persian than were phonological skills ($r = .55$). The difference between these two correlation coefficients, corrected for attenuation (i.e., adjusted for differences in the reliability of the measures), was statistically significant ($z = 2.19$, $p < .05$; Steiger, 1980). Further examination of the correlation table revealed an unexpected finding: The relation between phonological and orthographic processing skills differed across the two languages. We assumed that children's orthographic skills build upon efficient phonological skills, and, thus, had predicted a strong relation between these skills (Frith, 1985). As expected, the relation between phonological and orthographic skills in English was strong, but unexpectedly, that relation was significantly weaker for Persian (rs = .83 and .63 for English and Persian, respectively; $z = 3.87$, $p < .05$ using correlations corrected for attenuation; Steiger, 1980). This pattern of differences across languages raised the possibility that the development of orthographic skills in Persian may not be as closely linked to efficient phonological skills.

To examine the effects of orthographic complexity further, we conducted fixed-order hierarchical regression analyses. After controlling for grade level, vocabulary, and reading experience, we alternatively entered phonological and orthographic skills to determine whether each variable made an independent contribution to reading and spelling. First, we analysed the results of reading and spelling in English (see Table 3). For English reading, both phonological and orthographic skills accounted for unique variance as indicated in Models 1 and 2. We found that for children learning English as a second language, their orthographic skills (8%) explained more than twice as much variance in their reading performance than did their phonological skills (3%). These results were consistent with the findings of Juel's et al. (1986) for native speakers of English. The results for spelling in English revealed that both phonological skills (4%) and orthographic skills (5%) predicted similar amounts of unique variance. This latter finding did not replicate the results of Juel et al. showing that grade 2 children who are native speakers of English also rely more heavily on orthographic skills to spell words. A reasonable interpretation might be that because spelling is more difficult than reading (Shankweiler & Lundquist, 1992), the shift from greater reliance on phonological skills to greater reliance on orthographic skills is delayed somewhat for non-native speakers of English.

Persian reading and spelling were analysed with parallel regression analyses to those for English (see Table 4). The results for Persian reading were very similar to those for English. Both phonological and orthographic skills accounted for statistically significant unique variance, with orthographic skills predicting more than twice (9%) as much unique variance than did phonological skills (4%). These results extend the findings obtained for reading in English to reading in Persian. The results are also consistent with results obtained with skilled readers of Persian (Baluch & Besner, 1991).

The analyses for Persian spelling revealed a different pattern of results. Phonological skills did not account for any unique

Table 2

Zero-order correlations among the variables above the diagonal and partial correlations controlling for grade below the diagonal

	English measures						*Persian measures*					
	Rdg	*Sp*	*Ph*	*Ort*	*Voc*	*Exp*	*Rdg*	*Sp*	*Ph*	*Ort*	*Voc*	*Exp*
English measures												
Reading (Rdg)	–	.86	.87	.90	.49	.43	.20	.27	.32	.48	.03	−.06
Spelling (Sp)	.85	–	.82	.84	.46	.33	.21	.36	.35	.52	.09	−.04
Phonological (Ph)	.87	.83	–	.83	.47	.31	.25	.29	.38	.50	.01	−.03
Orthographic (Ort)	.89	.82	.84	–	.41	.23	.20	.32	.31	.47	.09	−.06
Vocabulary (Voc)	.47	.44	.46	.39	–	.31	−.13	−.19	.01	−.06	.02	−.16
Reading experience (Exp)	.49	.39	.33	.28	.34	–	−.08	.01	−.06	.17	.25	.05
Persian measures												
Reading (Rdg)	.07	.05	.21	.04	−.27	−.00	–	.74	.74	.74	.61	.39
Spelling (Sp)	.17	.25	.27	.19	−.33	−.10	.64	–	.55	.75	.47	.31
Phonological (Ph)	.24	.25	.36	.21	−.07	.00	.67	.42	–	.63	.49	.24
Orthographic (Ort)	.43	.46	.49	.41	−.13	.23	.70	.71	.56	–	.31	.41
Vocabulary (Voc)	−.19	−.17	−.11	−.17	−.12	−.22	.38	.19	.30	.09	–	.28
Reading experience (Exp)	−.10	−.09	−.06	−.12	−.19	.07	.37	.27	.19	.39	.24	–

Note: rs $\geq .27, .35, .43$, ps $< .05, .01, .001$, respectively.

Table 3
Hierarchical regression analyses for English reading and English spelling

Criterion: / *Predictor*	R^2	R^2 *change*	*F*
English word reading			
Model 1			
1. Grade	.06	.06	3.61
2. E-Vocabulary	.27	.21	15.00***
3. E-Reading experience	.39	.11	9.33**
4. E-Phonological skills	.82	.43	12.14***
5. E-Orthographic skills	.90	.08	36.60***
Model 2			
4. E-Orthographic skills	.87	.48	181.86***
5. E-Phonological skills	.90	.03	13.82***
English spelling			
Model 1			
1. Grade	.10	.10	5.78*
2. E-Vocabulary	.27	.17	12.46***
3. E-Reading experience	.33	.06	4.55*
4. E-Phonological skills	.73	.40	74.89***
5. E-Orthographic skills	.79	.05	1.97***
Model 2			
4. E-Orthographic skills	.74	.41	79.05***
5. E-Phonological skills	.78	.04	9.04**

Note: E = English language. * $p = .05$; ** $p = .01$; *** $p = .001$.

Table 4
Hierarchical regression analyses for Persian reading and Persian spelling

Criterion: / *Predictor*	R^2	R^2 *change*	*F*
Persian reading			
Model 1			
1. Grade	.32	.32	24.70***
2. P-Vocabulary	.41	.10	8.62**
3. P-Reading experience	.47	.06	5.55*
4. P-Phonological skills	.68	.20	31.47***
5. P-Orthographic skills	.77	.09	18.56***
Model 2			
4. P-Orthographic skills	.72	.25	44.62***
5. P-Phonological skills	.77	.04	9.17**
Persian spelling			
Model 1			
1. Grade	.28	.28	20.17***
2. P-Vocabulary	.30	.03	1.97
3. P-Reading experience	.34	.04	3.13
4. P-Phonological skills	.43	.09	7.75**
5. P-Orthographic skills	.65	.22	30.71***
Model 2			
4. P-Orthographic skills	.65	.31	44.76***
5. P-Phonological skills	.65	.00	< 1

Note: P = Persian language. * $p = .05$; ** $p = .01$; *** $p = .001$.

variance in spelling (see Model 2) whereas orthographic skills accounted for 22% of unique variance in spelling (see Model 1). We further analysed children's spelling to assess whether the reliance on orthographic skills was due to the inclusion of polygraphic words in the stimulus set. The results of separate analyses for the 19 non-polygraphic words and for the 19 polygraphic words were identical to those described in Table 4: Persian-speaking children relied on orthographic skills to spell words in Persian. How can these results be explained? It is plausible that the polygraphic nature of the Persian script encourages children to adopt a different strategy when reading and spelling words. Persian spelling might encourage children to adopt an analytic strategy whereby they pay particular attention to all the letters in words and their sequence. This analytic strategy might be particularly conducive to the development of and reliance on orthographic skills (Frith, 1985).

Conclusion

According to Gough and his colleagues, efficient word reading and spelling rely on similar skills, namely, phonological and orthographic processing skills (e.g., Gough et al., 1992; Gough & Tumner, 1986; Juel et al., 1986). Furthermore, it is assumed that orthographic skills result from efficient phonological skills (Ehri, 1992; Frith, 1985). The results of the present study extend this view to Persian-speaking children who are learning to read and spell in English as a second language. We found that English phonological and orthographic skills were highly correlated, and that both phonological and orthographic skills made independent contributions to reading and spelling. This general pattern of findings replicates that obtained with native speakers of English (Cunningham & Stanovich, 1991; Juel et al., 1986).

The children in the present study were also learning to read and spell in Persian, their native language. We found that Persian phonological and orthographic skills were more weakly related than in English, and that reading and spelling were predicted by different skills. Young readers of (vowelised) Persian relied more heavily on orthographic skills but also used their phonological skills. This finding extends English models of reading acquisition (e.g., Frith, 1985) to reading in Persian. In contrast, young spellers of Persian relied on their orthographic skills only. These results raised the possibility that the nature of the Persian orthography encourages children to adopt different strategies when reading and spelling words. Spelling Persian words might be particularly conducive to using an analytic strategy which, in turn, promotes the development of and reliance on orthographic skills.

Further research conducted with Persian children is needed to examine this possibility more fully. A longitudinal study in which the gradual development of phonological and orthographic skills is tracked would be particularly useful. Such a study would allow a stronger test of whether Frith's (1985) developmental model, whereby children proceed from using their phonological skills to using orthographic skills, applies to Persian reading and spelling. Such a study would also allow one to document more fully the effects of the instruction methods used to teach reading and spelling in Persian. For example, informal discussions with parents and teachers of Persian revealed that children are encouraged to memorise the spelling of words from the outset of instruction. Finally, such a

design would allow a stronger conclusion as to whether beginning users of alphabetic scripts for which the orthographic complexity differs for reading (less complex) and spelling (more complex) rely on different strategies to read and spell successfully.

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