Flexibility in young second-language learners: examining the language specificity of orthographic processing

S. Hélène Deacon
Dalhousie University, Canada

Lesly Wade-Woolley
Queen's University, Canada

John R. Kirby
Queen's University, Canada

This study examines whether orthographic processing transfers across languages to reading when the writing systems under acquisition are sufficiently related. We conducted a study with 76 7-year-old English-first-language children in French immersion. Measures of English and French orthographic processing (orthographic choice tasks) and standardised measures of English and French word reading (Woodcock and FIAT) were taken, in addition to verbal and nonverbal ability, and phonological and morphological awareness. Analyses reveal significant contributions of orthographic processing to reading both within and across the two languages, despite the inclusion of control variables. Findings of the transfer of orthographic processing skills to reading across languages suggest that orthographic processing may not be as language specific as previously hypothesised. We discuss the several similarities between English and French, such as a shared alphabet and cognates, that may drive transfer across languages in the context of current theories of second-language reading development.

Bilinguals are now in the majority worldwide (UNESCO, 2003), and many of these individuals learn to read and write in two languages. The existence of general cognitive mechanisms that operate across the boundaries between languages enables bilingual children to move quickly towards the goal of biliteracy. Phonological awareness, or the understanding of the sound structure of words, has been widely advocated as one such language-general skill that can facilitate reading across languages. And yet not all reading-related skills are ubiquitous in their impacts; some skills may need to be acquired separately for each of the scripts that bilingual children master. Orthographic processing, or the ‘ability to form, store and access orthographic representations’ (Stanovich & West, 1989, p. 404), has been nominated as one such ‘language-specific’ skill (Abu-Rabia,
2001, p. 451) in that it does not appear to transfer to reading across languages. The question of which skills are language specific and which are language general is a critical one as it delineates the challenges that young learners of two orthographies are likely to face and the ways in which these hurdles might be overcome.

The direct evidence that phonological awareness is a language-general skill comes from findings that it is related to reading across languages. This finding has been termed ‘cross-linguistic transfer’, and it has been revealed in studies of bilingual children learning to read pairs of languages sharing the same alphabet, such as Spanish and English (e.g. Durgunoglu, Nagy & Hancin-Bhatt, 1993) and French and English (e.g. Comeau, Cormier, Grandmaison & Lacroix, 1999), as well as language duos that are represented with different alphabets, such as Korean and English (e.g. Cho & McBride-Chang, 2005). The greatest degree of abstraction is demonstrated in the evidence of transfer when children are learning to read languages that use entirely different orthographic systems, as is the case for children biliterate in logographic Chinese and alphabetic English (Gottardo, Yan, Siegel & Wade-Woolley, 2001). The relationship seems to work in both directions; in Comeau et al., there was a contribution of phonological awareness to reading from the first language to the second and vice versa in young English learners of French. These findings of a bidirectional relationship lead to the conclusion that ‘phonological awareness is a general (not language-specific) cognitive mechanism’ (Comeau et al., 1999, p. 39).

In contrast, orthographic processing is widely advocated as language specific (e.g. Abu-Rabia, 2001). Orthographic processing tasks have traditionally tapped individual word-specific representations (e.g. choosing between rain and rane; Barker, Torgesen & Wagner, 1992; Cunningham & Stanovich, 1990; Cunningham, Perry & Stanovich, 2001) or letter patterns that occur across many words (e.g. filk vs filv or yb vs ib; Cassar & Treiman, 1997; Siegel, Share & Geva, 1995; see Castles & Nation, 2006; Burt, 2006 for a description and critique of these tasks). Research with monolingual learners has shown that orthographic processing is related to reading outcomes (e.g. Cunningham et al., 2001; Martinet, Valdois & Fayol, 2004; Roman, Kirby, Parrila, Wade-Woolley & Deacon, 2009; Stanovich, West & Cunningham, 1991; Wagner & Barker, 1994). A growing body of research with bilingual children has found that orthographic skills predict reading in the language in which they are measured, but not across languages. These findings of language specificity have emerged in studies of bilingual learners of languages with entirely different bases, such as logographic Chinese and alphabetic English (Gottardo et al., 2001; Leong, Hau, Cheng & Tan, 2005). They have also appeared in studies of learners of languages that are both represented with alphabets, albeit different ones. This is the case for studies of learners of English with first languages of Korean (Wang, Park & Lee, 2006), Russian (Abu-Rabia, 2001), Persian (Arab-Moghaddam & Sénéchal, 2001) and Hebrew (Abu-Rabia, 1997). The consistent pattern of within- but not across-language relationships between orthographic processing and reading has led to the prevailing conclusion that children need extensive experience with a specific orthography to work out how that specific language is represented on the page (e.g. Abu-Rabia, 2001). There is an intuitive appeal to the argument of language specificity; it seems logical that children learning to read both alphabetic and logographic scripts might have to work out how letters can be combined separately from the ways in which the radicals within characters are put together.

And yet there is a critical piece of support for the language specificity of orthographic processing in reading development that is missing currently. The language generality of
phonological awareness has been demonstrated at three levels of relationship between the script pairings under acquisition: those that share the same alphabet and share many similar words (e.g. English and French), those that both use alphabets but not the same one (e.g. English is represented with the Latin alphabet and Russian with the Cyrillic alphabet) and those with entirely different orthographic bases (e.g. English and Chinese with their alphabetic and logographic scripts, respectively). The studies that have demonstrated the language specificity of orthographic processing have examined the latter two of these three pairings. None of the studies, to our knowledge, has examined developing learners of language duos that share the same alphabet. This is the key piece of evidence that would be required to demonstrate that orthographic processing is, in fact, language specific.

The possibility that orthographic processing might transfer when two languages share the same alphabet requires serious consideration. In their discussion of the language-general cognitive mechanism of phonological awareness, Comeau et al. (1999) suggested that this language-general skill might ‘develop as a result of one being exposed to auditory input and analyzing the phonological properties of this input’ (p. 39). A relatively abstract orthographic skill might accrue in a similar fashion. Children likely develop orthographic processing skills through exposure to print input and analysis of the orthographic properties of the input. Such a possibility was suggested by Ehri (1994) in her discussion of the development of orthographic knowledge through the amalgamation of letter–sound patterns that occur again and again in the words that children decode. There are at least two plausible conceptualisations of orthographic processing that would permit development in a relatively generalisable manner when the languages are sufficiently related. The first is based on the general abilities that young readers develop and the second lies in the specific knowledge that they acquire.

At the most general level, orthographic competence may be a relatively stable cognitive ability (like phonological awareness; Comeau et al., 1999); its incorporation into the individual differences approach to reading suggests that this is plausible (e.g. Stanovich & West, 1989; Olson, Forsberg, Wise & Rack, 1994). Here we are considering orthographic processing as a process underpinning reading achievement. Those with greater ability might recognise or amalgamate orthographic regularities (such as which and where consonants double) more quickly, and this, in turn, might support orthographic representations that could be accessed more quickly and reliably. Such a learning process might occur through repeated phonological recoding (see e.g. Ehri, 1994) or through statistical learning (see e.g. Deacon, Conrad & Pacton, 2008; Perruchet & Pacton, 2006, for reviews). Given the results reviewed above (e.g. Gottardo et al., 2001), it may be that transfer at this most general level is unlikely across very different scripts (e.g. English and Chinese) because the units upon which the processing occurs are dissimilar. Transfer may become more likely as the distance between scripts decreases (e.g. each with different alphabets, both with the same alphabet and both with the same alphabet with similar letter sequences) because of the increasing similarity in the units from which information is being extracted (e.g. Latin letters for English and French).

At the other end of generality, orthographic competence may transfer at the level of specific knowledge that is accrued over the course of orthographic learning, such as sensitivity to the frequency and location of particular letter sequences (see e.g. Pacton, Perruchet, Fayol & Cleeremans, 2001). This cannot happen across different writing systems or even across different alphabets because the very units of representation are different. The use of the same alphabet to represent two different languages means that it is possible that there are similar letter patterns. And for languages sharing an alphabet,
transfer would become increasingly likely as the letter sequences in the two languages become more similar. This is an issue worth considering, given that even scripts as different as Finnish and English or Czech and English have some letter sequences in common (e.g. *nn* in Finnish and English).

There is no reason for the process and knowledge explanations to be mutually exclusive; both may operate. These explanations give cause to reconsider the idea that orthographic skills are language specific. Orthographic processing might not be so constrained in its operation should one test the possibility of transfer with learners of languages that share the same alphabet and many similar letter sequences, such as English and French. Both English and French are represented with the Latin alphabet, and they use the same letters, with the exception of the diacritical marks (e.g. the grave accent in French, but not in English). These letters are combined in similar ways (such as consonant doublets occurring most frequently in the middle, rather than at the beginning of words), although there are, of course, some differences (such as the legality of consonant doublets at the ends of words in English, but not in French; see e.g. Cassar & Treiman, 1997; Pacton et al., 2001). Further, these two languages contain many of the same sounds; this is especially the case for consonants, and even many vowel sounds are shared. There are even many shared words (e.g. *table*) and many historical links between words (e.g. *mansion* and *maison*). These many levels of similarities between the representation of these two distinctive languages make them an intriguing pairing between which to examine the language specificity of orthographic processing. This is the goal of the analyses presented here.

All studies attempting to demonstrate the relationship between any factor and reading must limit the possibility that any uncovered link is due to some spurious third variable. Given that discussions of language-general skills are at the heart of the matter here, verbal and nonverbal abilities are vital controls because they are likely to be language general to some extent. They serve to limit the possibility that any relationships uncovered are due to some general ‘g’ factor. Secondly, the evidence of the language generality of phonological awareness nominates it as a further critical control variable. Another, perhaps less well-known, variable lies in morphological awareness, or the ability to manipulate the smallest units of meaning in words, which has been linked to reading outcomes in both monolingual (e.g. Carlisle, 2000; Casalis & Louis-Alexandre, 2000; Ku & Anderson, 2003) and bilingual children (Deacon, Wade-Woolley & Kirby, 2007). Finally, the most stringent tests of cross-linguistic transfer need to include controls for within-language abilities; for example, English orthographic processing must be controlled in assessing the impact of French orthographic processing on reading in English (based on studies of phonological awareness, e.g. Comeau et al., 1999). This statistical control was added to the cross-linguistic examinations, in addition to controls for verbal and nonverbal ability, and phonological and morphological awareness.

The analyses reported here examine the language specificity of orthographic processing (e.g. Abu-Rabia, 1997). We conducted this study with children with English as a first language undertaking their early elementary school learning entirely in French. The data were collected as part of a larger study on reading-related skills in French immersion children. This study included additional measures designed to permit us to conduct a preliminary investigation of the possibility of transfer of orthographic processing to reading between English and French as a test of the language-specificity hypothesis.

We tested the children’s reading and reading-related skills at Grade 2, a point at which phonological awareness, orthographic processing and morphological awareness should
influence reading development. We included the control measures of phonological and morphological awareness and verbal and nonverbal intelligence in the analyses. The measures of verbal and nonverbal ability come from an earlier testing point, and these data were included in the present analyses in an effort to control for general ‘g’ factor explanations of any uncovered relationships between variables. Given the extensive evidence of the transfer of phonological awareness across languages in prior studies (e.g. Comeau et al., 1999), we limited its measurement to English in the current study. The morphological awareness measure focused on past-tense manipulations in each language, which are similar in meaning, but different in form between the two languages. Past-tense analogy tasks have been successful in predicting reading and spelling outcomes in monolingual and bilingual children (e.g. Deacon & Kirby, 2004; Deacon et al., 2007; Nunes, Bryant & Bindman, 1997). Similarly, orthographic processing was assessed with a classic task with established construct validity (Cunningham et al., 2001): the identification of correct irregular word spellings in each language (Olson et al., 1994). Finally, to ensure that cross-linguistic effects are independent of within-language factors, we control for key within-language variables in all analyses. The inclusion of this wide range of control variables helps to eliminate several alternative explanations for any relationships uncovered.

Method

Participants and procedure

We tested 76 native English-speaking typically developing children enrolled in a French immersion programme who participated as part of a longitudinal study of reading development. These children came from a variety of economic and social backgrounds and all lived in English-speaking communities. The majority of the children were learning to speak and read entirely in French during school hours from Kindergarten to the end of Grade 2 (a few began French only in Grade 1). Vocabulary and nonverbal reasoning were assessed in the fall of Grade 1, when the children were a mean age of 6 years and 5 months (standard deviations [SDs] of 3.3 months). This provides a measure of verbal and nonverbal ability at school entry in the child’s first language. All other measures were administered in the spring of Grade 2, when the children were an average age of 7 years and 10 months. The tests were given in the same order in each language, as is the standard in studies examining individual differences. The order was chosen with an eye to maintaining children’s interest by varying the types of tasks presented. The English and French batteries were given in separate sessions on different days. The experimenters spoke the language of the tests during administration of the test items.

Measures

Orthographic processing. Participants chose between alternative spellings for a word (e.g. brain and brane in English and livre and lyvre in French). This task was based on the classic work by Olson et al. (1994), and the 20 items for the English task were chosen from the original task. The 20 French items were selected after consultation with French immersion teachers as to which words were likely to be in the reading vocabulary of early elementary school French immersion children. Reliability for the task was reasonable at .71 for the English and surprisingly low for the French task at .19. Reduction to the most
reliable 12 items increased reliability to .48. These more reliable scores were used in all correlational and regression analyses.

**Reading.** English isolated word reading was assessed using the Woodcock Word Identification Test (Woodcock, 1987), which tested reading of single isolated words aloud in English (e.g. *is, beautiful*). The French Immersion Achievement Test assessed French reading. It is standardised for French immersion students (e.g. *vite, demandait*; Wormeli & Ardanaz, 1987). Each of these tests has reliability coefficients above .9 at Grade 2, and each has a stop rule after six errors.

**Vocabulary.** The Peabody Picture Vocabulary Test – Third Edition (Dunn & Dunn, 1997) measures English receptive vocabulary and it has a test–retest reliability above .9. Children are told a word and they are asked to choose which one of four pictures best depicts that word.

**Nonverbal reasoning.** The Matrix Analogies Test – Short Form (Naglieri, 1985) involves 36 coloured plates of design elements from which a portion is removed. Children choose the best option from a set of possible completions for the pattern. Testing was stopped after three mistakes within five responses. Grade 1 reliability of this task is reported at .82 (α).

**Phonological awareness.** Given the extensive evidence of cross-linguistic transfer of phonological awareness (e.g. Comeau et al., 1999), we assessed phonological awareness only in English. We used a phoneme deletion task with 10 items (e.g. ‘Say *cat* without saying */k*/’). This task has good reliability (α = .75).

**Morphological awareness.** Based on the sentence analogy task developed by Nunes et al. (1997), participants were given a pair of example sentences that reflected a tense change, such as ‘Peter walks to school’ to ‘Peter walked to school’. Children were asked to make the same kind of change to another sentence, such as ‘Sylvie jumps around,’ for which the correct manipulation is ‘Sylvie jumped around’. There were eight items in each language that all involved past-tense manipulations. Reliability for the task was reasonable at .71 for the English and .64 for the French items.

### Results

The means and SDs for all of the measures are presented in Table 1. Examination of scores from this table suggests that the children were typically developing. Their reading vocabulary and matrix analogy scores hovered around 100 in standard scores, as did their English and French reading. Scores for the orthographic choice task are statistically better than chance for both the English and the French versions, *t*(75) = 9.46 and 22.21, *p* < .001, respectively.

The data were prepared for analysis through investigation of normality and completeness. Scores for each task were examined for skew. Positive skew on the scores for the matrix analogies task was corrected with square root transformations, as recommended by Tabachnik and Fidell (2001). The remaining analyses were conducted with the transformed scores. There were four missing data points (<1%) in the entire data set; these were completed with means for the entire group for that measure. The results for the data set with completed means are reported here. The same pattern of results emerges when the data are analysed without the completed means. Further,
as reported earlier, the French orthographic processing task had low reliability. All correlational and linear regression analyses reported were conducted with the more reliable version of the French orthographic processing task and with the transformed matrix analogies score. Analyses with the non-adjusted values result in the same pattern of significant findings.

The correlations reported in Table 2 reveal significant cross-linguistic relationships between the measures of orthographic processing in the two languages, as well as between the reading measures in the two languages. Further, there are correlations between all measures of orthographic processing and reading, including that of French orthographic processing. This supports the validity of this measure, despite low reliability. All the variables are related to the English reading outcomes and all, with the exception of English vocabulary, are related to the French reading measures.

We turn now to the linear regression analyses designed to examine the language specificity of the contribution of orthographic processing to reading. The analyses that we present here are relatively conservative, in that they include controls for verbal and non-verbal ability as well as several reading-related variables. Perhaps most notably, the cross-linguistic analyses include within-language controls for the variable in question (e.g. controlling for English orthographic processing in assessing the contribution of French orthographic processing to English reading), reflecting an extremely conservative approach to analyses that removes any joint variance shared by the two scores.

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Table 1. Mean number correct (and standard deviations) for raw scores of English phonological awareness, English and French orthographic processing, morphological awareness, and mean standard scores (SS) for the verbal and nonverbal intelligence and word reading measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>English</th>
<th>French</th>
</tr>
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<tbody>
<tr>
<td>Matrix analogies</td>
<td>94.42 (11.57)</td>
<td>_</td>
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<tr>
<td>Peabody picture vocabulary</td>
<td>110.34 (6.83)</td>
<td>101.55 (22.81)</td>
</tr>
<tr>
<td>Word identification</td>
<td>105.84 (17.50)</td>
<td>_</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>7.06 (2.18)</td>
<td>2.16 (1.77)</td>
</tr>
<tr>
<td>Morphological awareness</td>
<td>4.67 (2.14)</td>
<td>14.10 (1.61)</td>
</tr>
<tr>
<td>Orthographic processing</td>
<td>13.56 (3.28)</td>
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</tbody>
</table>

*Scores for the more reliable version of the French orthographic task (with 12 items) were an average of 9.13 and standard deviation of 1.84.

Table 2. Correlations between all measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>1.</th>
<th>2.</th>
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<th>6.</th>
<th>7.</th>
<th>8.</th>
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<tbody>
<tr>
<td>1. Vocabulary</td>
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<tr>
<td>2. Matrix Analogies</td>
<td>.367**</td>
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<td>3. English PA</td>
<td>.268*</td>
<td>.216</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. English MA</td>
<td>.211</td>
<td>.302*</td>
<td>.320*</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>5. French MA</td>
<td>.114</td>
<td>.196</td>
<td>.091</td>
<td>.182</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6. English OP</td>
<td>.229*</td>
<td>.345*</td>
<td>.363**</td>
<td>.369**</td>
<td>.293*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. French OP</td>
<td>.172</td>
<td>.189</td>
<td>.382**</td>
<td>.238*</td>
<td>.250*</td>
<td>.248*</td>
<td></td>
<td></td>
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<tr>
<td>8. English Reading</td>
<td>.345*</td>
<td>.436**</td>
<td>.456**</td>
<td>.515**</td>
<td>.421**</td>
<td>.729**</td>
<td>.550**</td>
<td></td>
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<tr>
<td>9. French Reading</td>
<td>.126</td>
<td>.299*</td>
<td>.409**</td>
<td>.435**</td>
<td>.419**</td>
<td>.529**</td>
<td>.536**</td>
<td>.751**</td>
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</table>

*Note: PA = phonological awareness; MA = morphological awareness; OP = orthographic processing. *p < .05; **p < .001.
The first linear regression analyses examined the contribution of orthographic processing to English reading (Table 3). The within-language control variables of phonological and morphological awareness, as well as verbal and nonverbal ability control variables accounted for approximately 44% of the variance. The within-language contribution of English orthographic processing to English reading was quantified at 21% (Step 4). This serves to confirm the importance of orthographic processing to reading within a single language.

The next step in the equation serves as the critical test of the language specificity of orthographic processing. French orthographic processing was entered as the fifth step in the equation, accounting for an additional 9% of variance in English reading. The inclusion of the within-language control of orthographic processing nominates any additional variance as specifically cross-linguistic, thereby, at least to some extent, nominating orthographic processing as language general.

Similar analyses were conducted with French orthographic processing (Table 4), in which we entered verbal and nonverbal ability, phonological awareness and then French morphological awareness. The significance of these control variables at each of Steps 1 through 3 attest to the importance of their inclusion (accounting for ~ 34% of variance). Further, the finding that the measure of English phonological awareness accounted for 13% of the variance in French reading validates the inclusion of a single language measure of this variable. French orthographic processing explained 10% of the variance in reading ability within that language.
English orthographic processing entered as the critical fifth step tests the cross-linguistic transfer of orthographic processing. At this point, it accounted for 8% of variance in reading cross-linguistically, even after the within-language control for French orthographic processing, and several other reading-related variables. A summary of these results is presented in Figure 1.

Discussion

This research shows the first evidence of cross-language transfer of orthographic processing to reading of which we are aware. Orthographic processing measured in English made a significant contribution to reading in French, and French orthographic processing made a significant contribution to reading in English. This finding of bidirectional contributions of orthographic processing to reading is similar to that uncovered by Comeau et al. (1999) for phonological awareness. The relationships between orthographic processing and cross-language reading withstood controls for several reading-related variables, including within-language orthographic processing. These findings offer the first tentative support that orthographic processing transfers across languages, at least when the languages share several features, including the same alphabetic basis. These findings provide the first evidence that orthographic processing might not be as language specific as may have been previously thought.

We clearly need to consider why we have uncovered transfer in the present study, particularly in light of the substantial body of evidence of language specificity of orthographic processing (e.g. Abu-Rabia, 2001). Perhaps the most important variable to consider lies in the nature of the languages under investigation. Unlike all other language pairings that have been investigated to date, English and French share the same alphabet. We think that this is one critical dimension that must be in common to drive transfer across languages. And yet English and French also share other features, such as similarities in sounds, letter patterns, specific cognate words and some historically related words. As a preliminary step in examining which features might be critical in driving transfer, we re-analysed our own data by excluding the few cognate words in each of the orthographic processing tasks. The same pattern of results emerged, suggesting that the present results are not due to the presence of cognate forms within the tasks analysed. New studies could include tasks designed to isolate each of the orthographic features that are shared between target languages to define the features required for transfer to appear. Given the findings here of transfer between closely related languages, it would also be useful for such studies to examine intermediate language contrasts, such as English and
Such combinations might be especially helpful in isolating the features that drive transfer; as an example, English and Finnish share some letter patterns, but not word forms. Regardless of the specific features required to drive transfer, the findings reported here lead us to reconsider the conclusion that orthographic processing is language specific. It might, at the very least, be alphabet specific or, at an even more fine-grained level, be specific to language pairs with shared alphabets that share specific features.

We need to consider another feature of English and French scripts that is likely a critical factor in determining whether children will use orthographic processing in reading these orthographies. Both are considered to be deep orthographies in that they are relatively opaque in the ways in which they represent sound in print (Seymour, Aro & Erskine, 2003). This may explain why we see use of orthographic processing within each of these scripts, in that English orthographic processing contributes to English reading and the same pattern is found for French (as in studies of monolingual learners of these two orthographies; e.g. Stanovich et al., 1991; Martinet et al., 2004). The examination of learners of two relatively transparent scripts that are represented with the same alphabet (such as Italian and Spanish) is less likely to result in transfer of orthographic processing to reading across languages, as orthographic processing is typically not drawn on by readers of purely transparent scripts (see e.g. Mumtaz & Humphreys, 2001). We would add some degree of opacity of the script to the sharing of the same alphabet as one of the features required for the transfer of orthographic processing.

Clearly, these findings of transfer leave us wondering as to how children build up orthographic processing that is abstracted, at least to some degree, from a specific script. As we suggested in the introduction, there are at least two ways in which orthographic processing might develop in a relatively generalisable manner. The first relied on children’s general ability to extract regularities, whether this is through a process such as phonological recoding (e.g. Ehri, 1994) or statistical learning (e.g. Perruchet & Pacton, 2006). Specifically, there might be some commonality in the mechanism by which grapheme patterns are extracted across different scripts when the scripts use the same units of representation. This similar basis in the underlying process is less likely to occur when the scripts do not rely on the same graphemic units for representation, as occurs when they use different alphabets. The second was based on commonality in the specific knowledge accrued, with a greater likelihood of transfer when the languages share letter patterns. In both these (non-mutually exclusive) cases, the likelihood of transfer increases as the distance between the written representation of the languages decreases. Clearly, further research is required to examine which features are likely to drive transfer and how such transfer occurs. This research could benefit, for example, from the work on differing visual skills used in reading scripts with different bases (e.g. Ho & Bryant, 1999). Such visual skills might serve as one component of an orthographic processing ability that might transfer to reading languages that share several features, including the same alphabet.

All work on orthographic processing benefits from careful attention to recent discussions of the validity of the orthographic processing framework. Perhaps the most powerful criticism lies in the observation that orthographic processing tasks, particularly those requiring the identification of correct spellings of words, are similar to single word reading tasks. Researchers such as Burt (2006) and Castles and Nation (2006) argue that this creates a circular relationship between dependent and independent variables in the evaluation of variables contributing to reading outcomes. It is noteworthy that Stanovich et al. (1991) foresaw this concern some time ago. In response, they demonstrated that orthographic processing (measured with an orthographic choice task) predicts word
reading after controlling for phonological awareness and, most importantly, print exposure. Stanovich et al.’s inclusion of print exposure as a control measure goes a long way towards allaying concerns that orthographic processing is redundant with experience in word reading.

In our own work, we were motivated by queries from a reviewer to include reading skill in the other language in analyses, given that, for example, French orthographic processing might be considered to be a measure of French word reading. In these analyses, French orthographic processing still made a significant contribution (in the range of 3%) to English word reading, when entered after the controls of verbal and nonverbal ability, English phonological and morphological awareness, English orthographic processing and French word reading. Parallel analyses were conducted for the contributions of English orthographic processing to French reading, but these did not reveal significant contributions. The sustained contribution of French orthographic processing to English reading after controls for French reading is remarkable, given the number of controls in the equation, and it suggests some dissociation between orthographic processing and word reading. And yet we are wary of drawing too heavily on these results. Firstly, they are not replicated in the English to French analyses, and, perhaps more importantly, it is debatable as to whether such controls are warranted. The inclusion of reading as a control variable in the regression equation is not possible in monolingual research where it is a standard outcome variable. Such analyses also suffer from multicollinearity concerns, given the high correlations between reading in each language. In our view, the most important control in dual language research lies in the inclusion of within-language measures of orthographic processing (following on Comeau et al., 1999), accounting for the correlation between these two variables. New research with both monolingual and bilingual samples could address this issue perhaps most fruitfully by including broader measures of orthographic processing and by examining orthographic learning (e.g. Castles & Nation, 2006).

We need to remain wary of the possibility that the transfer of orthographic processing to reading across languages simply reflects general relationships between abilities; a general ‘g’ factor could account for similarities in performance across the linguistic tasks. This interpretation seems unlikely for several reasons. First, the relationships remained after the initial control variables of verbal and nonverbal ability. Of course, such tests can never account for the entire construct of intelligence, but the inclusion of measures of both verbal and nonverbal ability goes some way towards this end. Secondly, the cross-linguistic relationships between orthographic processing and reading observed in the present study are in sharp contrast to the earlier studies in which no such relationship was observed (e.g. Abu-Rabia, 2001). It would seem unlikely that a general ‘g’ factor could account for the results in the present study, and not drive such findings in the numerous prior investigations. Certainly, this raises the question of how one should demonstrate transfer. Within the literature on reading development, the model advocated by Comeau et al. (1999) of bidirectional transfer within a correlational study with the requisite control variables is taken as a stringent test of cross-linguistic relationships. It is a standard that the present results have achieved. Of course, it would be important to provide other demonstrations of transfer, perhaps using experimental designs. The results of the present study suggest that orthographic processing is not as language specific as has been previously thought.

These results have clear implications for theories of second-language reading development, which have focused primarily on the skills used within reading each of the bilingual learners’ languages. The script-dependent hypothesis advocates that the
nature of the scripts under acquisition by bilinguals is a vital piece of information in determining which skills will be used (Geva, Wade-Woolley & Shany, 1997). This explains the relationship between orthographic processing and reading uncovered within languages for English and French; these are opaque scripts that are likely to draw at least in part on individuals’ abilities in extracting letter patterns. This model also suggested that more advanced skills would be used in first- than in second-language reading because the first language should progress more quickly through the phases of reading development (e.g. Ehri, 1999). The relatively greater contribution of orthographic processing to the first language than to the second (e.g. ~ 21% within English and 12% within French) is accounted for well within this prediction. Alternatively, it is possible that this pattern reflects the relatively greater number of irregularities in English than in French (see Ziegler, Jacobs & Stone, 1996; Ziegler, Stone & Jacobs, 1996).

And yet the findings presented here move us beyond the initial parameters of this model in that they force us to consider the skills that might operate across languages. In this line of thinking, we need to consider the nature of the scripts (as advocated by Geva et al., 1997 for within-language relationships). The nature of the scripts under acquisition might be a more important consideration for orthographic processing (as we uncovered here) than for other reading-related skills, such as phonological awareness.

Although not the primary focus of the analyses reported here, this research also adds to the large body of evidence demonstrating a relationship between both phonological and morphological awareness and reading ability across languages (e.g. Comeau et al., 1999; Deacon et al., 2007). Phonological awareness made a significant within-language contribution to reading in English and across languages to reading in French, as did morphological awareness. This research confirms phonological awareness’ status as a language-general skill in reading development, and it supports the decision here to include a measure in one language alone. The substantial amount of variance in reading taken up by verbal and nonverbal abilities in English (between 9% and 23%) and by morphological awareness within each language (between 9% and 12%) also speaks to the importance of the inclusion of these control variables.

There are several key steps for future research, reflecting in part the limitations of the present study. One lies in longitudinal evaluations to establish developmental origins and end points. The contributions of orthographic processing across languages may be dependent on some degree of written and/or oral language proficiency (as suggested by, e.g. Deacon et al., 2007 for morphological awareness). The individual differences approach adopted here could also be linked to the cognitive research on the adult bilingual lexicon (e.g. Kroll & Dijkstra, 2002), permitting an investigation of the varying outcomes of development. A second issue lies in examining the range of orthographic skills needed in reading, investigating, for example, how it is that children work out both the commonalities and the differences between scripts. Certainly, the correlations between the orthographic processing measures in the two languages suggest parallels in the development of orthographic processing in the two orthographies. Nevertheless, the finding of independent cross-linguistic contributions further nominates orthographic processing as an abstract skill that can be used in reading across languages in certain situations. A third limitation lies in the reliability of the French orthographic processing measure, which was just below standard limits for reasonable reliability. The low reliability reflects, at least in part, the challenge of developing measures appropriate for testing second-language learning samples. This is especially difficult when the children have differing levels and types of exposure to print in the two languages, as is the case
with French immersion children who are learning French formally at school, but who are
exposed informally to massive amounts of English print media. It is important to
remember that low reliabilities only serve to lower the possibility of finding relationships
between variables, acting against the hypothesis under investigation. Further, and perhaps
most convincing, the results for the lower-reliability French measure paralleled those for
the English measure for which reliability was within standard limits. Nevertheless, the
conclusions for analyses with the French orthographic task need to be considered
tentative. New studies clearly need to establish new measures for working with highly
diverse second-language learning populations such as the one under investigation here.

The results of the study reported here suggest that developing bilingual readers appear to
be remarkably adaptive in their use of information regarding the orthographic structure of
the script that they encounter. These findings challenge us to reconceptualise orthographic
processing; it does not appear to be as language specific as previously hypothesised in that
it operates across languages when these share features, including a common alphabet.
Critical next steps lie in working out which features need to be shared for transfer to be
uncovered; such investigations will inform us about how children build up flexible
processing abilities that permit them to access the meaning that is represented on the page.

Note

1. The past tense in English involves the addition of a /t/ or /d/ sound at the end of verbs (as in the addition of
   -ed at the end of the regular past tense verb studied). In French, it requires an auxiliary avoir or être and the
   word-final é added, as in a étudié. Recent research indicates that 4–6-year-old monolingual English and
   French children have similar abilities in the generation of regular and irregular past-tense forms (Nicoladis,
   Pulmar & Marentette, 2007).

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