THE CONCURRENT AND LONGITUDINAL RELATIONSHIPS BETWEEN
ORTHOGRAPHIC PROCESSING AND SPELLING IN FRENCH IMMERSION
CHILDREN

by

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Abstract

We examined the relationship between orthographic processing and spelling in French immersion children. Study 1 included 148 first graders and they were assessed on orthographic processing and spelling in English and French. In Study 2, we followed 69 second graders for two years. Orthographic processing and spelling in English and French were administered in second and third grade. In Study 3, we analyzed the spelling errors made by the third graders in Study 2.

In Study 1, we found a within-language relationship in English and French between orthographic processing and spelling. Cross-language transfer from French orthographic processing to English spelling was also observed. In Study 2, Grade 2 English spelling predicted gains in Grade 3 English and French orthographic processing. Study 3 showed that children made transfer errors when spelling in English and French. Overall, the current research highlights the importance of orthographic processing and spelling in French immersion children.
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Chapter 1: Introduction

In 1965, the first French immersion program was introduced in St. Lambert, Quebec. The goals of this program were to provide English-speaking children residing in Quebec with enhanced and extended opportunities to become bilingual in English and French within the context of public schooling (Lambert & Tucker, 1972; Genesee, 1987). Children in the original program received total instruction in French beginning in kindergarten until the end of Grade 2. With the introduction of the Official Languages Act in 1969, French immersion programs have proliferated across Canada. Enrolment in French immersion nationally was 45,000 in 1977; by the 2010-2011 academic year, it had increased to over 350,000 students (Canadian Parents for French, 2011).

One of the critical issues in understanding bilingualism research is how the literacy skills are related to each other among children who are acquiring two or more languages simultaneously. Two of the key literacy skills that have received less attention in bilingualism research is orthographic processing and spelling, especially pertaining to children who are in French immersion programs. The current research had two goals. The first was to examine the concurrent within- and cross-language role of orthographic processing in spelling in French immersion children. The second was to identify the direction of the relationship longitudinally between orthographic processing and spelling, both within and across languages. By understanding the mechanism in which key literacy skills develop and interact with each other, the current study elucidates whether and how transferable skills in English and French contribute to young children’s biliteracy success.
This thesis is composed of three studies. In Study 1, we recruited two consecutive cohorts of Grade 1 bilingual children enrolled in an early total French immersion program and examined their orthographic processing skill in English and French. We also investigated the concurrent relationship between orthographic processing and spelling, both within English and French and across the two languages. In Study 2, we followed another group of cohort for two years from the same French immersion school from Grade 2 to 3 and explored the concurrent and longitudinal relationship between orthographic processing and spelling, both within English and French and across the two languages. In Study 3, we analyzed the spelling errors made by the participants in Grade 3 in Study 2.

There are seven chapters in the present work. The first chapter outlines background information on French immersion programs in Canada. Chapter 2 provides a review of the relevant theoretical frameworks and empirical studies that are related to the present research. An overview of the three studies comprising this thesis and research questions are laid out in chapter 3. The three studies are then presented in chapters 4, 5, and 6, respectively. Finally, chapter 7 presents a general discussion of the three studies and directions for future research.

Background of French Immersion in Canada

French immersion is a form of optional bilingual education in which the students receive at least half of their instruction in French. French is thus the primary medium and not the object of instruction (Turnbull, Lapkin, Hart, & Swain, 1998). Numerous studies have demonstrated the academic, cognitive, and linguistic benefits of French immersion programs (see Lazaruk, 2007, for a review). The initial program was created in part due
to the advocacy of English-speaking parents residing in Quebec who were dissatisfied with the traditional core French programs (Turnbull et al., 1998). It is designed for non-native speakers of French; students enter with similar (and limited) levels of French language proficiency (Lyster, 2008). Immersion programs emphasize developing fluency in an initially unknown language through content-based teaching in the second language (L2), at no expense to the first language (L1) of the students; in other words, one language is not replaced with another (Swain & Lapkin, 2005).

In Canada, the Canadian Charter of Rights and Freedoms guarantees the right of minority language education. Further, the Official Languages Act (originally adopted in 1969) guarantees that services are provided in both English and in French, as well as the opportunity to learn in both languages. While education in Canada is under provincial jurisdiction, these two federal Acts entitle students to be educated in either English or French. Currently, French immersion programs are offered in all Canadian provinces and territories, with the exception of Nunavut.

Since the inception of the first French immersion program, alternative forms of immersion have been developed and were modified to include alternative entry points and different proportions of English and French language instruction (Rebuffot, 1993). Generally, French immersion programs are classified according to the proportion of instruction through English relative to instruction through French, as well as the grade level at which the program begins (Genessee & Jared, 2008; Lyster, 2008). In total French immersion, 100% of the curriculum is taught in French at the start of senior kindergarten or Grade 1. In Grade 3 or 4, English is introduced with one period each school day and the amount of English instruction gradually increases over time. By
Grade 7 or 8, both English and French are equally used in the curriculum. In partial French immersion, a minimum of 50% of the curriculum is taught in French for one or more years (Genesee, 2004).

With respect to entry points, immersion programs tend to be classified according to three types. Early French immersion starts at kindergarten or Grade 1, in which the teaching of literacy skills are introduced first in French, followed by the introduction of English literacy instruction in Grades 3 or 4. Middle French immersion starts at Grade 4 or 5 and late French immersion begins at Grades 6 and up (Lyster, 2008). The current study focuses on children in Grades 1 to 3 enrolled in an early total French immersion program in a school where English language arts are first introduced as a subject in Grade 4. Thus, all early literacy instruction is offered in an L2 for children who are in the early French immersion program.
Chapter 2: Literature Review

In this section, the definition and assessment of orthographic processing are first discussed. Theoretical frameworks on the development of orthographic processing and cross-language transfer are then presented. Finally, literature on the relationship between orthographic processing and both reading and spelling is considered.

What is Orthographic Processing?

Orthographic processing skill, or the understanding of how words are spelled and of the orthographic conventions used in a writing system (Cunningham & Stanovich, 1990), is a multi-dimensional construct, consisting of both word specific (lexical) and general (sublexical) spelling knowledge. For example, orthographic processing at the lexical level illustrates knowledge of the spellings of real words (e.g., knowing that dream is correct and dreem is not), whereas orthographic processing at the sublexical level demonstrates knowledge of regularities of letter patterns (e.g., knowing that the letter combination ff is legal in the medial and final position in an English word, as in puffer and puff, but illegal in the initial position).

Generally, orthographic processing is measured at two levels: lexical and sublexical. At the lexical level (also referred to as word-specific orthographic knowledge), participants are asked to choose between two phonologically plausible alternatives (e.g., turtle and tertle; Olson, Forseberg, Wise, & Rack, 1994). At the sublexical level (also referred to as general orthographic knowledge), participants are asked to select the most plausible spelling for a made-up word (e.g., feep and fiip; Cassar & Treiman, 1997). Recently, reviews on studies of orthographic processing and its relationship to word reading have posed concerns about the tasks used to assess
Development of Orthographic Processing

Orthographic processing skill is of interest in part because it is considered to play an important role in children’s reading and spelling success (Conrad, Harris, & Williams, 2012; Cunninghan, Perry, & Stanovich, 2001). Skilled readers and spellers have good orthographic processing skills to remember word spellings and understand the variety of ways in which letter patterns are positioned in a word (i.e., initial, medial, or final position). It is widely held that children develop orthographic processing skills based on their experiences with the printed language. Stage models of reading and spelling development (Ehri, 1986, 2005; Frith, 1985) maintain that children’s orthographic knowledge starts to influence a child’s reading and spelling when the child has acquired a considerable number of words that are recognized by sight. As such, orthographic processing is viewed as a late-developing skill compared to other literacy-related skills.

Some studies have used a judgment task to explore children’s sensitivity to orthographic patterns. For instance, an experimental study by Cassar and Treiman (1997)
showed that young monolingual English-speaking children in kindergarten and Grade 1 were more likely to choose pseudowords as word-like if they contained legal doubled vowels (e.g., choosing *geed* over *gaad*) or legal doubled consonants (e.g., choosing *pess* over *ppes*). Similar results emerged with even younger children in pre-school (Ouellette & Sénéchal, 2008; Pollo, Kessler, & Treiman, 2009), French-speaking children (Martinet, Valdois, & Fayol, 2004; Pacton & Fayol, 2004) and Finnish-speaking children (Lehtonen & Bryant, 2005).

In Deacon et al’s (2013) study, they showed that Grade 1 French immersion children have developed lexical and sublexical orthographic processing skills in both English and French. Given that the children in the study had only began to receive formal instruction in French at the beginning of Grade 1, it is remarkable that they demonstrated orthographic processing skill in French, at lexical and sublexical levels. It was also observed that the children showed greater skill with letter patterns that occur in both English and French (e.g., *-ame* is legal in both languages) compared to letter patterns that are unique to one of these languages (e.g., *-eille* is unique to French).

Taken together, evidence suggests that monolingual and bilingual children have at least some level of orthographic knowledge in their language(s) early in their literacy development.

**Theoretical Framework**

According to the Orthographic Depth Hypothesis (Katz & Frost, 1992), there are systematic differences between how spelling and pronunciations are mapped across different alphabetic orthographies. In consistent or shallow orthographies (e.g., Spanish and Italian), there is a simple correspondence between letters and sounds. To illustrate, in
Spanish, the sound /f/ corresponds to the letter f (feliz [happy]). Conversely, in inconsistent or deep orthographies (e.g., English and French), a more complex and indirect correspondence occurs between letters and sounds. For instance, in English, the sound /f/ can be spelled in many different ways, including f (friend), ff (cuff), ph (phone) and gh (enough). Given this, Ziegler and Goswami (2005) suggested that it is easier to read and spell in a transparent orthography because there are fewer sound-letter correspondences need to be learned than in a deep orthography, where it is more difficult to read and spell due to the unpredictable nature of the orthography.

Indeed, past studies have shown that it is more likely for children who are learning less consistent writing systems to rely on orthographic processing skills when reading and spelling than children who are learning more consistent orthographies. For instance, Goswami, Gombert, and de Barrera (1998) compared school-aged native English-, French-, and Spanish-speaking children on their reading speed of pseudowords that shared rhyme with real words (e.g., dake [cake]) with those that did not (e.g., daik). The three languages differ in the degree of orthographic consistency, with English being the most unpredictable language in spelling-sound relationships, followed by French, then Spanish. The results showed that pseudowords that shared rhyme with real words (e.g., dake) were easier to read than pseudowords that did not. Additionally, the Spanish-speaking children decoded the pseudowords that do not share rhyme with real words (e.g., daik) extremely accurately, followed by the French-speaking, then English-speaking children. The authors concluded that orthographic consistency and familiarity of the orthographic representation might influence decoding skills.
Orthographic complexity also seemed to influence reading and spelling skills in bilingual children. Arab-Moghaddam and Sénéchal (2001) investigated predictors of reading and spelling abilities in school-aged English-Persian bilingual children in Canada. The orthographic processing skill was measured with a lexical choice task (e.g., cake-caik); parallel measures in Persian were also developed. Both phonological and orthographic processing skills explained a unique variance in English and Persian reading, after controlling for grade level, vocabulary, and reading experience. However, there were differences in the predictors of spelling performance between English and Persian. Both phonological and orthographic processing skills predicted English spelling, whereas only orthographic processing predicted Persian spelling. The authors suggested that this finding was due to the differences in orthographic consistency in reading and spelling in both languages. English orthography is characterized by inconsistencies in both grapheme-phoneme (feedforward) and phoneme-grapheme (feedback) correspondences. In contrast, Persian orthography is characterized by feedback inconsistency only, which results in a simple script to read but more complex to spell. The authors concluded that the nature of the Persian script encourages children to employ different skills when reading and spelling words.

Put together, the results from cross-linguistic studies provide evidence that the extent to which orthographic processing plays a role in reading and spelling may be determined, at least in part, by the orthographic consistency of a language.

Orthographic Processing and Reading among Monolingual Children

Despite the measurement concerns in assessing orthographic processing skills, existing studies have shown that the relationship between orthographic processing and
reading is established in monolingual children. Evidence of this finding emerges from studies that have used lexical or sublexical measures of orthographic processing or a combination of both types of measures. To illustrate, Cunningham and Stanovich (1990) administered a battery of phonological and lexical orthographic processing tasks to children in Grades 3 and 4. The lexical orthographic processing tasks were composed of two sub-tests, orthographic choice (e.g., room-rume) and homophone choice task (e.g., “Which is a fruit? Pair-pear?”). In addition, the study also used a Title Recognition Test (TRT) as a proxy measure of children’s print exposure. Findings revealed that orthographic processing accounted for unique variance in word recognition, independent of phonological processing ability and that orthographic processing was linked to print exposure differences.

Subsequent studies have also yielded similar results. Cunningham and Stanovich (1993) investigated monolingual English children in Grade 1 on their phonological and orthographic processing in relation to word recognition. The study used a sublexical task to measure orthographic processing, in which the participants were asked to choose the pseudoword that looks more like a real word (e.g., beff-ffeb). Results revealed that orthographic processing contributed a unique variance to word recognition, independent of phonological processing skills. Similarly, when several different reading tasks were used to measure both accuracy and speed, Barker, Torgesen, and Wagner (1992) showed that lexical orthographic processing made a unique contribution to reading, after controlling for both intelligence and phonological awareness in Grade 3 children. There is also some evidence from concurrent studies that the relationship between orthographic
processing and word reading is evident in children who are native speakers of a language other than English, such as Persian (Rahbari, Sénéchal, & Arab-Moghaddam, 2007).

Unlike cross-sectional studies that examined the relationships between orthographic processing and reading at a single time point, longitudinal studies can reveal the direction of the relationship over time between the two constructs. Cross-lag analysis incorporates multiple controls for spurious third variables, thereby clarifying the direction of the relationship between a predictor and an outcome variable (e.g., Perfetti, Beck, Bell, & Hughes, 1987). In longitudinal studies, it is very critical to account for the effect of an autoregressor, which is the outcome variable measured at an earlier time point. The predicting power of other predictors in a longitudinal analysis can be artificially inflated if the autoregressor is not included (Kenny, 1975).

Limited number of longitudinal studies have examined whether orthographic processing determines word reading. Wagner and Barker (1994) showed that Grade 1 orthographic processing was associated with gains in Grade 2 word reading skills, beyond the controls for verbal ability, phonological awareness, and the autoregressive effects of word reading in Grade 1. However, the orthographic processing measure included children’s letter-name knowledge, which is considered as a separate construct from orthographic processing (e.g., McBride-Chang & Ho, 2005). Hence, the results may not have accurately reflected the longitudinal relationship between orthographic processing and word reading.

In Cunningham, Perry, and Stanovich’s (2001) study, they followed native-English speaking students from Grade 1 to 3. They used a more comprehensive battery of tasks that included lexical and sublexical tasks to test children’s orthographic processing
skill. After taking phonological awareness and earlier measure of pseudoword reading into account, the composite score of orthographic processing in Grade 2 predicted unique variance in word reading in Grade 3. However, the autoregressive effects of pseudoword reading, not real word reading, was included in the regression analyses. As with Wagner and Barker’s (1994) study, it is not clear whether orthographic processing skill predicts gains in word reading skill over time.

Despite the considerable evidence of a relationship between orthographic processing and word reading in monolingual children, the direction of the relationship remains unclear. Deacon, Benere, and Castles (2012) pointed out that it is possible that children might learn orthographic processing through their reading. Past longitudinal studies have not conducted analyses to examine the relationship in the reverse direction, from word reading predicting orthographic processing (e.g., Barker & Wagner, 1994; Cunningham et al., 2001). In order to determine the direction of the relationship between orthographic processing skill and word reading, Deacon et al. (2012) followed Grade 1 monolingual English children for three years until Grade 3 and used both lexical and sublexical measures of orthographic processing. Unlike Cunningham et al. (2001) who treated lexical and sublexical orthographic processing as one holistic construct, this study examined the individual contribution of lexical and sublexical processing to word reading and vice versa. After partialling out orthographic processing in Grade 1 as the autoregressor and a series of other control measures, it was observed that word reading in Grade 1 predicted unique variance in lexical and sublexical orthographic processing in Grades 2 and 3. Critically, the results also showed that neither lexical nor sublexical orthographic processing in Grade 1 were longitudinal predictors of word reading in
Grades 2 and 3, after controlling for word reading in Grade 1 as the autoregressor. The findings from this study supported the conclusion that reading predicts growth in orthographic processing skills, at the lexical and sublexical levels, during children’s first years of formal schooling. The orthographic processing measures seem to assess the outcome of reading acquisition, rather than the predictor of reading development.

Put together, converging evidence from a variety of concurrent studies indicates that monolingual children’s orthographic processing skills contribute to reading success, independent of phonological awareness and other cognitive control measures. There are conflicting findings among the existing longitudinal studies by Barker & Wagner (1994) and Cunningham et al. (2001), which found some evidence of early orthographic processing predicting later word reading, and Deacon et al. (2012), which found the reverse relationship. The lack of longitudinal studies that have systematically examined the temporal relationship between orthographic processing skill and reading limits our understanding of how these skills are related to each other over time. It is evident that more research is needed in establishing the direction of the relationship between orthographic processing and word reading.

Cross-Language Transfer

Of particular interest in bilingualism research is the notion of cross-language transfer, in which skills developed in one language contribute to the literacy development in the other language (Genesee, 2004). The study of cross-language transfer has been fundamental in L2 education because it informs researchers and educators the mechanisms in which key literacy skills develop and interact with each other to enhance L2 learning. In the context of the current thesis, the concept of transfer can be explained
within two significant theoretical frameworks: the Contrastive Analysis Hypothesis (Lado, 1957) and the Linguistic Interdependence Hypothesis (Cummins, 1981).

A key assumption of the Contrastive Analysis Hypothesis (Lado, 1957)\(^1\) is that the characteristics of one’s L1 can determine the difficulty or ease of which L2 learning occurs. Depending on the similarities and differences in the linguistic structures between the L1 and L2, the contrastive framework maintains that transfer can be characterized as positive or negative. In positive transfer, skill in one language may be seen as facilitating the development of a skill in another language (Durgunoğlu, 2002). For example, positive transfer could be evidenced by the recognition of grapheme-phoneme correspondences (or letter-sound knowledge), in French by English-speaking children due to the sharing of the same alphabet in both languages. Alternatively, negative transfer can occur when certain linguistic structures are different between the L1 and L2. For example, negative transfer could be evidenced by the difficulties faced by Chinese (Cantonese) students learning English when spelling specific phonemes, such as /ʃ/ and /θ/, that are absent in Cantonese phonology (Wang & Geva, 2003). The Contrastive Analysis Hypothesis focuses on the structural similarities and differences between the L1 and L2 and this focus may help to identify what is (and is not) transferred and what processes are involved during L2 literacy development. This theory, however, does not account for cross-language transfer that takes place beyond structural boundaries.

Another prominent theoretical framework is the Linguistic Interdependence Hypothesis (Cummins, 1979, 1981) which proposes that L2 competence is dependent upon the level of first language (L1) competence. Unlike the Contrastive Analysis

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\(^{1}\) The Contrastive Analysis Hypothesis subsequently evolved into the Script Dependent Hypothesis (Geva & Siegel, 2000) which predicts that children learning opaque orthographies will encounter more difficulties in acquiring fundamental literacy skills than children learning transparent orthographies.
Hypothesis that focuses on specific linguistic features, the Linguistic Interdependence Hypothesis stresses the underlying cognitive and academic skills that are shared across languages, regardless of whether the languages are typologically similar or dissimilar. This common underlying skills allows for the transfer of cognitive, academic, and literacy-related skills from one language to another. For instance, in the context of French immersion programs, when a student receives total instruction in French at school, the student is not neglecting the L1 (e.g., English); instead, while gaining L2 proficiency, the student is also contributing to linguistic proficiency in the L1. Thus, students with strong L1 skills, particularly those related to literacy, are expected to have an advantage when learning an L2.

Evidence supporting the Linguistic Interdependence Hypothesis comes from studies that examined the relationship between phonological awareness and reading in bilingual children. Phonological awareness refers to the understanding of sound structure of the language (McBride-Chang, 1995). Cross-language studies have found that phonological awareness transfers to reading in bilingual children learning relatively similar languages, such as Spanish and English (Durgunoğlu, Nagy, & Hancin-Bhatt, 1993) as well as languages that are distinctly different, such as Chinese and English (Gottardo, Yan, Siegel, & Wade-Woolley, 2001). As such, it is widely held that phonological awareness is a language-general skill that facilitates children’s literacy development across languages. In contrast, classic view on orthographic processing is that it is a language-specific skill that is built upon each of the languages under acquisition (Abu-Rabia, 2001). However, as we will see in the following sections,
orthographic processing may not be entirely language-specific under certain circumstances.

Orthographic Processing and Reading among Bilingual Children

When the nature of the languages under acquisition are substantially different, research shows that orthographic processing predicts reading in the language in which they are measured, but not across languages. Such findings have emerged from cross-sectional studies of bilingual learners of languages with entirely different writing systems, such as logographic Chinese and alphabetic English (Gottardo et al., 2001; Leong, Hau, Cheng & Tan, 2005) and learners of languages that are represented with different alphabets, such as Persian and English (Arab-Moghaddam & Sénéchal, 2001), Russian and English (Abu-Rabia, 2001), Korean and English (Wang, Park & Lee, 2006) and Hebrew and English (Abu-Rabia, 1997). The absence of findings of a cross-language relationship between orthographic processing and reading in bilingual children has led to the conclusion that orthographic processing skills need to be learned separately for each language under acquisition, and accordingly, orthographic processing has been regarded as a language-specific skill.

On the other hand, more recent studies have found that orthographic processing transfers to reading in the other language when the languages under acquisition share the same alphabet, as in the case with English and French (Deacon, Wade-Woolley, & Kirby, 2009; Deacon, Commissaire, Chen, & Pasquarella, 2013; Pasquarella, Deacon, Chen, Commissaire, & Au-Yeung, in press) and English and Spanish (Deacon, Chen, Luo, & Ramirez, 2011; Sun-Alperin & Wang, 2010). Evidence supporting this claim comes from studies that used lexical and sublexical measures of orthographic processing.
Deacon et al. (2009) found that for Grade 2 children in French immersion, both English and French lexical orthographic processing significantly accounted for within- and cross-language word reading, after controlling for verbal and nonverbal abilities, phonological awareness, and morphological awareness. Similar results also emerged in Deacon et al’s (2013) study involving Grade 1 French immersion children. In this study, both lexical and sublexical measures of orthographic processing in English and French were used. The sublexical task included a language-specific condition, in which the target orthographic patterns were legal only in the target language of the task (e.g., gook-gook, where the target orthographic pattern –ook is legal in English only), and a language-shared condition, in which the target orthographic patterns occurred in both English and French (e.g., plame-plahme, where –ame is legal in both languages). The study showed that both lexical and sublexical orthographic processing in English and French was related to reading outcomes in that language. Further, there was a unique contribution of English language-shared sublexical orthographic processing in French word reading, after partialling out controls that include French language-shared sublexical orthographic processing. However, there were no such relationships between French sublexical orthographic processing and English word reading. Deacon and her colleagues proposed that the transfer of English language-shared sublexical orthographic processing to French word reading might be driven by shared script and orthographic patterns in the two languages.

There was also some evidence of cross-language transfer in bilingual children learning two languages that substantially differ in orthographic depth, such as English and Spanish (Deacon et al., 2011; Sun-Alperin & Wang, 2011). Both English and
Spanish scripts are alphabetic in nature and use Roman letters. However, the Spanish language is much more consistent in letter-sound correspondences than English (Seymour, Aro, & Erskine, 2003). Sun-Alperin and Wang (2011) studied native Spanish-speaking children learning English in Grades 2 and 3 and showed that lexical orthographic processing skills in Spanish predicted English real word and pseudoword reading, and these relationships survived controls for English phonological and orthographic processing and Spanish phonological processing. Sun-Alperin and Wang argued that, despite the differences in orthographic transparency between English and Spanish, the similarities between the two languages (i.e., both languages use the Roman alphabet and are based on a linear system) supported Spanish-speaking children’s performance on English real word and pseudoword reading.

A study by Deacon et al. (2011) involved a group of older Spanish-English students in Grades 4 and 7. They observed relationships between sublexical orthographic processing and reading within each language of Spanish and English. The within-language finding for Spanish was particularly interesting because it demonstrated that orthographic processing relates to reading even in a transparent orthography. With respect to cross-language relationships, sublexical orthographic processing in Spanish contributed unique variance to English word reading; however, English orthographic processing did not transfer to Spanish word reading. In interpreting their findings, the authors suggested that since English is the more opaque orthography, it is likely to draw more heavily on orthographic processing skills, both within and across languages. The finding that orthographic processing transfers across languages give further support for
the notion that orthographic processing might not be purely language-specific when the languages under acquisition share the same alphabet.

Much like the analyses conducted with monolingual children, all of the studies discussed previously are cross-sectional or concurrent in nature, and as such, the direction of the relationship between orthographic processing and word reading in bilingual children remains unclear. In order to tease apart the direction of the relationship in bilingual children, Pasquarella et al. (in press) conducted a two-year longitudinal study on Grade 1 French immersion children. They found that word reading in Grade 1 significantly predicted lexical orthographic processing in Grade 2 within each of English and French, after controlling for the autoregressor of orthographic processing in Grade 1, and non-verbal ability, vocabulary, phonological awareness, and rapid automatized digit naming. The finding of word reading predicting lexical orthographic processing longitudinally extends Deacon et al.’s (2012) study on monolingual English children.

With respect to cross-language transfer, French word reading in Grade 1 significantly predicted English lexical orthographic processing in Grade 2, after accounting for the autoregressor of English lexical orthographic processing in Grade 1, the same set of cognitive control variables, and English word reading in Grade 1. The researchers proposed that French immersion children can build up a store of English orthographic representations from their reading experience in French, their L2. The cross-language finding provides further evidence that orthographic processing is not purely language-specific.

Taken together, these studies suggest that the transfer of orthographic processing takes place when the languages share a common alphabet (and in some cases, similarities
in orthographic depth). The direction of the transfer, however, requires further examination in order to clarify the temporal relationship between orthographic processing and word reading in bilingual children.

Orthographic Processing and Spelling among Monolingual and Bilingual Children

While there have been several studies that have acknowledged that children’s spellings reflect knowledge of orthographic consistencies and conventions (e.g., Caravolas, Kessler, Hulme, & Snowling, 2005; Lehtonen & Bryant, 2005; Pacton & Fayol, 2004; Pacton, Perruchet, Fayol, & Cleeremans, 2001), there are far fewer studies that specifically examined the contribution of children’s orthographic processing skills to spelling outcomes. Existing evidence suggests that children’s orthographic processing relates to their early spelling development. For example, Ouellette and Sénéchal (2008) examined orthographic knowledge and its relationship to spelling in 115 English-speaking kindergarteners who have limited skill in reading. Orthographic knowledge was assessed by two separate sublexical tasks: recognition of legal characters (e.g., glide-g8i3e) and recognition of permissible sequences within words (e.g., ppon-ponn). Regression analyses revealed that both recognition of legal characters and permissible sequences explained a unique variance in invented spelling, over and above the contribution of phonemic awareness. This study provides empirical support of the role of orthographic knowledge in spelling in the very early stages of children’s literacy development.

Conrad et al. (2012) observed similar results involving native-English speaking children between 7 and 9 years of age. The study used both lexical and sublexical measures of orthographic processing. The findings revealed that lexical and sublexical
orthographic processing individually contributed to reading and spelling, after controlling for age and phonological awareness. However, the relatively small sample size ($n = 41$) and the inclusion of few control variables may have affected the interpretation of the results.

Pertaining to research on bilingual children, we are aware of only two studies that have examined the role of orthographic processing in spelling. In analyzing the relationship between orthographic processing and spelling in second and third grade native Spanish-speaking children learning English, Sun-Alperin and Wang (2011) found a within-language relationship in which English lexical orthographic processing skill predicted a significant amount of unique variance in English spelling, beyond the controls of age, vocabulary, and English phonological awareness. The study, however, did not include a Spanish spelling task and as such, it is not known whether a within-language finding would also emerge with Spanish orthographic processing and spelling.

In terms of the cross-language analysis, Spanish orthographic processing was not a significant predictor of English spelling. As discussed previously, the study found that Spanish orthographic processing was related to English reading, but not English spelling. The authors suggested that since reading requires less orthographic knowledge than spelling in English, orthographic processing skills in Spanish, a transparent orthography, may be able to predict English reading, but not English spelling, given the nature of its inconsistent relationship between letters and sounds. The authors concluded that orthographic processing may be language-specific as it relates to spelling performance among Spanish-English children.
Additionally, Arab-Moghaddam and Sénéchal (2001) studied Persian-English bilingual children in Grades 2 and 3. The results revealed that lexical orthographic processing uniquely predicted reading and spelling in the languages in which they were measured. English lexical orthographic processing skills contributed a significant variance to English spelling, after controlling for grade, English vocabulary, reading experience in English, and English phonological awareness. Similarly, Persian orthographic processing skills accounted for a unique variance in Persian spelling, beyond the controls of grade, Persian vocabulary, reading experience in Persian, and Persian phonological awareness. The study did not report cross-language analyses and thus, it is not certain as to whether orthographic processing in one language transfers to spelling in the other language when children are learning Persian and English.

Taken together, although there is some evidence that suggests that monolingual and bilingual children’s orthographic processing contributes to spelling abilities, the direction of the relationship between the two constructs remains unclear, especially pertaining to bilingual children attending a French immersion program. As discussed earlier with studies concerning monolingual children and the relationship between orthographic processing and reading, cross-sectional and concurrent studies do not inform us about the direction of the relationship. It is evident that much more research is necessary to understand the relationship between orthographic processing and spelling in bilingual children.
Chapter 3: The Present Research

This chapter provides a brief summary of the current state in orthographic processing research, followed by an overview of the three studies included in the present research. The specific research questions of this thesis are then presented.

Statement of the Problem

For children attending an early total French immersion program, the instructional language is different from their native or societal language. As such, these children are faced with the additional challenge of mastering fundamental language and literacy skills in a language that they have not fully acquired. One critical skill that they must master is spelling. Learning to spell accurately and automatically is an important part of literacy development, and brings with it valuable experience in analyzing the sounds of language. While a number of studies have identified key predictors of spelling, such as phonological awareness, vocabulary knowledge, and letter-sound knowledge (e.g., San Francisco, Mo, Carlo, August, & Snow 2006; Vandervelden & Siegel, 1995; Wade-Woolley & Siegel, 1997), it is possible that another skill is also involved.

Research on children’s reading and spelling have informed us that orthographic processing may be a potential source of unique variance in children’s literacy development (e.g., Cunningham et al., 2001; Conrad et al., 2013). However, the extent to which findings of orthographic processing skill are consistent across languages in bilingual children’s spelling remains unclear. In order to understand the literacy development of bilingual children in French immersion, it is imperative that well-designed, concurrent and longitudinal studies are conducted.
Based on the current state of research concerning bilingual children, it is apparent that several issues need to be addressed. First, orthographic processing and spelling measures need to be included in both languages that are being studied. By doing so, more systematic cross-language analyses can be conducted to determine the relationship between orthographic processing and spelling, both within each of the languages under acquisition and across the languages. Second, existing studies that have investigated the role of orthographic processing in spelling among bilingual children involved learners of languages that substantially differ in orthographic depth (e.g., Sun-Alperin & Wang, 2011) or scripts (e.g., Arab-Moghaddam & Sénéchal, 2001). Comparing learners of languages that are similar in orthographic depth and use the same script may offer a greater chance of observing cross-language transfer, as suggested by Deacon et al. (2009). Finally, a longitudinal design can reveal the temporal order of the relationship between orthographic processing and spelling (e.g., Deacon et al., 2012; Pasquarella et al., in press). The cross-sectional nature of previous empirical studies on bilingual children do not tell us the developmental trajectory of these skills. While it is possible that orthographic processing plays an independent role in the development of spelling, it is equally possible that children acquire orthographic processing through their spelling, according to the stage models of reading and spelling acquisition (Ehri, 1986, 2005; Frith, 1985). This possibility warrants further examination.

The Present Research

The present research consists of three studies. The main objective of Study 1 was to investigate the relationship between orthographic processing skills and spelling within and across languages in Grade 1 bilingual children attending an early total French
immersion school. As a starting point, we were interested in whether Grade 1 bilingual children demonstrate English and French orthographic processing skills. In addition, we were interested in the within and cross-language contribution of orthographic processing to spelling. We tested participants from two consecutive cohorts in Grade 1 from the same French immersion school and assessed their orthographic processing and spelling abilities in both English and French at the end of Grade 1. We performed a series of hierarchical linear regressions to examine the relationship between orthographic processing and spelling within and across languages and included controls for age, non-verbal ability, and phonological awareness.

In Study 2, we examined the concurrent and longitudinal relationships between orthographic processing and spelling both within English and French and across the two languages in bilingual children enrolled in an early total French immersion program. Using a two-year longitudinal design, we followed one cohort of Grade 2 bilingual children attending the same early total French immersion school as Study 1. The longitudinal relationships between orthographic processing and spelling within and across languages were tested using a cross-lagged design with autoregressive controls.

Finally, in Study 3, we developed a coding scheme to analyze the children’s spelling errors to determine whether children used their knowledge of orthographic patterns in one language to spell in the other language. The analyses were conducted on the Grade 3 children from Study 2.

Research Questions

The research questions addressed in the three studies in this thesis were as follows:
Study 1. (a) Do Grade 1 French immersion children demonstrate orthographic processing skills in English and French?; and (b) What is the unique contribution of orthographic processing to spelling within English and French and across the two languages in Grade 1 children in early total French immersion?

Study 2. (a) What is the concurrent relationship between orthographic processing and spelling within English and French and across the two languages among Grade 2 and Grade 3 children in an early total French immersion program?; (b) What is the longitudinal relationship between orthographic processing and spelling within English and French and across the two languages from Grade 2 to Grade 3 among bilingual children attending an early total French immersion school?

Study 3. (a) Do Grade 3 children use orthographic patterns that are unique in one language to spell in the other?
Chapter 4: Study 1

The objective of Study 1 was to investigate the concurrent role of orthographic processing in spelling, both within English and French and across the two languages in Grade 1 French immersion children. We first present the methodologies used for the study, followed by the results and a discussion of the results.

Method

Participants

Two Grade 1 cohorts from two consecutive years were recruited from the same early French immersion public school in a large Canadian metropolitan area. The participants were recruited using informed parental and school procedures. There were 148 children in total who participated in Study 1. Cohort 1 consisted of 78 children (including 52% males), with a mean age of 82.27 months ($SD = 3.59$) at Time 1. Cohort 2 consisted of 70 children (including 56% males), with a mean age of 82.25 months ($SD = 3.60$). There was no significant difference in mean age between Cohort 1 and Cohort 2 children, $t(146) = .035, n.s$. At this particular French immersion school, children receive French-only instruction when they enter Grade 1 and they only begin to partially receive English instruction at the start of Grade 4. As such, all of the participants’ formal literacy experience was in French.

Parents of the children completed a consent form and a questionnaire to collect basic demographic information and background on children’s home language environment. The majority of children spoke English most often at home. Of the 148 children, 90 spoke English at home more than 50% of the time. The remaining 58
children\(^2\) spoke the following languages most often: Russian \((n = 27)\), Chinese \((n = 9)\), Hebrew \((n = 5)\), Farsi \((n = 3)\), Korean \((n = 3)\), Serbian \((n = 2)\), Romanian \((n = 2)\), French \((n = 1)\), Spanish \((n = 1)\) and Amharic \((n = 1)\). All children had at least 10 English books at home, with the majority of children \((82\%)\) having at least 50 books. The majority of parents \((72\%)\) reported that they read with their child almost every day. The frequency distribution of maternal education for both cohorts is reported in Table 1. Maternal education was used as a proxy for socio-economic status (Gottfried et al., 2003). For Cohort 1, approximately 85\% of mothers completed at least college or university. For Cohort 2, approximately 95\% of mothers completed at least college or university. An independent samples \(t\)-test found no significant difference between Cohort 1 and Cohort 2 on maternal education, \(t(146) = 0.61, p > .05\).

Table 1.

*Frequency Distribution of Maternal Education for Cohort 1 and Cohort 2.*

<table>
<thead>
<tr>
<th></th>
<th>Cohort 1 ((n = 78))</th>
<th>Cohort 2 ((n = 70))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent (%)</td>
</tr>
<tr>
<td>Some High School</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Completed High School</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Some College/University</td>
<td>11</td>
<td>14.1</td>
</tr>
<tr>
<td>Completed College/University</td>
<td>25</td>
<td>32.1</td>
</tr>
<tr>
<td>Professional Degree/Certificate</td>
<td>30</td>
<td>38.4</td>
</tr>
<tr>
<td>Post-graduate Degree (Master’s, Doctorate, Law)</td>
<td>11</td>
<td>14.1</td>
</tr>
</tbody>
</table>

*Measures*

Children were tested at two time points. Time 1 took place in the fall semester of Grade 1 and Time 2 took place in the following spring semester. Instructions were given in the appropriate language of the tasks by trained research assistants.

\(^2\) Four participants did not respond to this question.
Measures of Orthographic Processing

Lexical orthographic processing test. The lexical orthographic processing test was adapted from Olson et al. (1994) to examine children’s word-specific orthographic knowledge. The participants were asked to choose between alternative spellings for a target word in their response booklets (e.g., dream-dreem in English; jaune-jeaune in French). The alternative spellings were homophonic with the target word and adhered to the graphotactic constraints of the appropriate language. Since the two options sound the same when decoded, differences in phonological decoding ability cannot be the sole cause of performance differences on this task. While children might still use phonological decoding to determine their response to some extent, this task requires children’s accessibility and quality of the orthographic entries in the lexicon (Cunningham et al., 2001).

The experimenter told the children that each pair of words contained one word that was spelled correctly and one that was spelled incorrectly. The children were instructed to circle the correctly spelled word in their response booklets. Two practice pairs in each language were done as a class to ensure that the children understood the task. The number of each pair of items was called out by a research assistant to avoid skipped responses. There were 42 test items in both languages. Reliability coefficients for this task were .89 in English and .84 in French.

Spelling. Items for the English spelling task were adapted from the green subtest of the Wide Range Achievement Test-Revised (WRAT-R; Jastak & Jastak, 1984) and items for the French spelling task were adapted from the Canadian French Individual

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3 Please see Deacon et al. (2013) and Commissaire, Pasquarella, Chen, & Deacon (in press) for more details on the orthographic processing measures.
Achievement Test (FIAT; Wormeli & Ardanaz, 1987). Students were given a pre-numbered lined sheet of paper and were asked to clearly print the target word on it. A research assistant read the target word aloud in the appropriate language. To provide context, a sentence was read with the target word and the target word was repeated again. There were 20 items in both the English and French spelling tests, with increasing difficulty with items that varied in length from 2 to 9 letters (e.g., go, shout, and institute in English; sa, jupe, and armoire in French). Students’ responses were scored as either correct or incorrect according to conventional spelling rules in the appropriate language. Reliability coefficients for this task were .87 in English and .82 in French.

Control Measures

Non-verbal Reasoning. The Matrix Analogies Test (Naglieri, 1985) consisted of 64 pictures from 4 different subtests of 16 items each. All participants attempted each of the 4 subtests. For each item within a subtest, the children were shown a picture with one portion missing. The participants were asked to complete a visual-spatial matrix by choosing which of the 6 options correctly completes the picture. The task was stopped within a subtest when children answered four consecutive items incorrectly. Cronbach’s alpha reliability rating was .96.

Phonological Awareness. Children’s English phonological awareness was assessed using the elision subtest of the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999). Children were asked to delete individual sounds from words and to give the remaining part as their response (e.g., “Say cat. Now say cat without saying /k/”). There were six practice items with feedback, with a total of 20 test items. The test items were presented in order of increasing difficulty. The items begin
with the deletion of syllables, then to initial and middle phonemes from words. The test was discontinued if the child made three consecutive errors. The raw score was used for the measure. Cronbach’s alpha reliability rating was .93.

**Parental demographic questionnaire.** Children’s parents completed a questionnaire about language, demographic, and educational information. The parents were asked which language(s) the child spoke at home and the approximate percentage of each language spoken by the child on a 5-point Likert scale (never (0%), rarely (0-24%), sometimes (25-49%), frequently (50-74%), always (75-100%)). Parents also specified whether they spoke English, French, or another language to the child and how often they spoke the language(s) (most often, occasionally, and least often). We collected information on maternal education by asking the parents to indicate the highest level of education received on a 6-point scale (some high school, completed high school, some college/university, completed college/university, professional degree/certificate, and post-graduate degree).

**Procedure**

This study involved both group and individual testing that took place at the school site during school hours. In both testing settings, trained research assistants who were native or near-native speakers of the respective languages administered the measures. At Time 1, only non-verbal reasoning was administered to the children individually in a quiet room at the school. Parents of participating children also filled out the Parental Demographic Questionnaire at this time. At Time 2, phonological awareness and English and French measures of orthographic processing and spelling were administered. The phonological awareness was administered to the children individually.
Measures of orthographic processing and spelling were administered to a whole class at once and took approximately 45 minutes. The orthographic processing measures were administered before the spelling tasks and the English tasks were administered before the French tasks. During the group testing, there were three to four research assistants present in the room to ensure smooth administration of the tasks.

Results

The data was examined for univariate and multivariate outliers. There were no univariate outliers in the sample. With the use of a \( p < .001 \) criterion for Mahalanobis distance (Tabachnick & Fidell, 2013), four children were identified as multivariate outliers when the following relations were considered: English and French orthographic processing; French orthographic processing and English spelling; and English orthographic processing and English spelling. These children were excluded in all correllational and linear regression analyses.

Table 2 displays the means and standard deviations of each measure administered. There was no significant difference between Cohort 1 and Cohort 2 with respect to age \( t(146) = -0.29 \), non-verbal ability \( t(146) = -0.119 \), and phonological awareness \( t(146) = -1.49 \), all \( p \)’s > .05. Likewise, there was no significant difference between Cohort 1 and Cohort 2 on measures of orthographic processing in English \( t(146) = -1.82 \), and in French \( t(146) = -1.25 \), and on spelling in English \( t(146) = -1.50 \), and in French \( t(146) = -0.71 \), all \( p \)’s > .05.
Table 2.

**Descriptive Statistics of Measures for Cohort 1 and Cohort 2.**

<table>
<thead>
<tr>
<th></th>
<th>Cohort 1 (n = 78)</th>
<th>Cohort 2 (n = 70)</th>
<th>Combined (n = 148)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age (in months)</td>
<td>82.27</td>
<td>3.59</td>
<td>82.25</td>
</tr>
<tr>
<td>Non-verbal ability</td>
<td>22.21</td>
<td>11.64</td>
<td>21.76</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>11.69</td>
<td>5.23</td>
<td>13.01</td>
</tr>
<tr>
<td>English OP</td>
<td>26.72</td>
<td>8.04</td>
<td>29.25</td>
</tr>
<tr>
<td>French OP</td>
<td>27.31</td>
<td>6.84</td>
<td>28.99</td>
</tr>
<tr>
<td>English spelling</td>
<td>7.11</td>
<td>3.98</td>
<td>8.14</td>
</tr>
<tr>
<td>French spelling</td>
<td>6.08</td>
<td>3.78</td>
<td>6.62</td>
</tr>
</tbody>
</table>

*Note.* OP = orthographic processing

The data was examined for normality for each predictor and outcome variable by inspecting skewness and kurtosis. Scores on the French orthographic processing measure were significantly negatively skewed. Following Tabachnick and Fidell (2013), a sequence of reflection, square root transformation, and re-reflection was conducted on the variable to remove the skew. After the transformation was performed, the skew fell within reasonable limits. All other variables were normally distributed. The correlational and linear regression analyses were conducted with the transformed score. Analyses with nonadjusted values generated the same pattern of significant findings.

**Levels of Orthographic Processing and Spelling Skills**

We conducted a one-sample *t* test to determine whether the Grade 1 participants in our study demonstrated orthographic processing in English and French by determining whether their scores were above chance. Scores for the English and French orthographic processing were significantly better than chance, *t*(146) = 10.68, *d* = 0.82 and *t*(146) = 12.79 *d* = 1.21, all *p*'s < .001, respectively. These results suggest that the children in our study possessed at least some orthographic processing skill in both languages in Grade 1.
Scores on the English and French orthographic processing did not differ significantly, $t(146) = -0.68$, $p > .05$.

The participants in our study performed poorly in both English and French spelling tests. Given that the English spelling subtest, Wide Range Achievement Test-Revised (WRAT-R; Jastak & Jastak, 1984) was standardized with a sample of students who predominately received school instructions in English and that the French spelling subtest, Canadian French Individual Achievement Test (FIAT; Wormeli & Ardanaz, 1987) was standardized with Grade 2 French immersion students and not Grade 1, it was not surprising that the children performed poorly on these measures.

*The Relationship between Orthographic Processing and Spelling in English and French*

Bivariate correlations among all measures used in the analyses are presented in Table 3 for the combined sample of Cohort 1 and Cohort 2 children. Among Grade 1 bilingual children in early French immersion, non-verbal ability and phonological awareness scores were significantly correlated with orthographic processing and spelling measures in both English and French. English spelling moderately correlated with performance on French spelling, English and French orthographic processing (all $r$’s > .41, $p < .01$). Similarly, there was a moderate correlation between French spelling and English orthographic processing ($r = .54$, $p < .01$) and a high correlation between French spelling and French orthographic processing ($r = .66$, $p < .01$). English orthographic processing was highly correlated with French orthographic processing ($r = .62$, $p < .01$).
Table 3.

Correlations among all Measures for Cohort 1 and Cohort 2.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Non-verbal ability</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Phonological awareness</td>
<td>.28**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. English OP</td>
<td>.36**</td>
<td>.49**</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. French OP</td>
<td>.31**</td>
<td>.45**</td>
<td>.71**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>5. English spelling</td>
<td>.31**</td>
<td>.57**</td>
<td>.75**</td>
<td>.71**</td>
<td>--</td>
</tr>
<tr>
<td>6. French spelling</td>
<td>.23**</td>
<td>.52**</td>
<td>.54**</td>
<td>.66**</td>
<td>.68**</td>
</tr>
</tbody>
</table>

*Note. OP = orthographic processing.*

**p < .01

The Role of Orthographic Processing in Spelling

In order to determine whether orthographic processing skills are related to spelling both within and across languages, we conducted a series of hierarchical linear regression analyses. We included the participants in both cohorts in the same regression analyses. For each of the analyses, age and non-verbal ability were entered in the first step and phonological awareness was entered in the second step in order to control for the possible effects of spurious third variables. Orthographic processing measures were entered after phonological awareness task to examine the unique variance explained by orthographic processing after taking phonological awareness into account. The cross-language analyses included within-language controls for the outcome variable in question (following on Deacon et al., 2009).

The first hierarchical regression equation modelled the unique contribution of English and French orthographic processing to English spelling (left side of Table 4). Beyond the 37% of variance taken up by the control variables, English orthographic processing explained an additional 25% (p < .001) of the variance in English spelling, illustrating the within-language contribution. French orthographic processing contributed
an additional significant 5% ($p < .001$) of the variance to English spelling. Altogether, all variables entered in the regression model explained about 66.5% of the variance in English spelling.

The second hierarchical regression equation modelled the unique contribution of French and English orthographic processing to French spelling (right side of Table 4). Beyond the 29% of variance taken up by the control variables, French orthographic processing significantly contributed over 21% ($p < .001$) of the variance to French spelling, representing the within-language contribution. Entered at the fourth step, English orthographic processing made no independent contribution to French spelling. As such, we did not observe a cross-language relationship between English orthographic processing and French spelling. Together, the variables considered in the model accounted for approximately 50% of the variance in French spelling.
Table 4.

*Hierarchical Linear Regression Predicting English and French Spelling in Grade 1.*

<table>
<thead>
<tr>
<th>Step and predictors</th>
<th>Outcome: English spelling</th>
<th></th>
<th>Outcome: French spelling</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General model summary</td>
<td>Coefficients</td>
<td>General model summary</td>
<td>Coefficients</td>
</tr>
<tr>
<td></td>
<td>ΔR²</td>
<td>β</td>
<td>ΔR²</td>
<td>β</td>
</tr>
<tr>
<td>1. Age (in months)</td>
<td>.107***</td>
<td>.064</td>
<td>.062**</td>
<td>.041</td>
</tr>
<tr>
<td>Non-verbal ability</td>
<td></td>
<td>- .011</td>
<td></td>
<td>-.027</td>
</tr>
<tr>
<td>2. Phonological awareness</td>
<td>.265***</td>
<td>.231***</td>
<td>.224***</td>
<td>.258***</td>
</tr>
<tr>
<td>3. English OP</td>
<td>.247***</td>
<td>.403***</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4. French OP</td>
<td>.046***</td>
<td>.311***</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3. French OP</td>
<td>--</td>
<td>--</td>
<td>.211***</td>
<td>.462***</td>
</tr>
<tr>
<td>4. English OP</td>
<td>--</td>
<td>--</td>
<td>.006</td>
<td>.113</td>
</tr>
</tbody>
</table>

Note. OP = orthographic processing.

**p < .01, ***p < .001
Discussion

Study 1 examined early orthographic processing and its relationship to spelling in Grade 1 bilingual children attending an early total French immersion school. Our participants demonstrated orthographic processing skill in both English and French by the end of Grade 1, which is earlier than expected in existing theories of reading and spelling development (Ehri, 1989, 1995; Gentry, 1982). We observed a within-language relationship in English and French between orthographic processing and spelling. There was also some evidence of cross-language transfer of orthographic processing to spelling across languages. The results highlight the important role that orthographic processing plays in bilingual children’s spelling abilities.

_Orthographic Processing Skill in English and French_

We observed orthographic processing skill in both English and French with our young bilingual participants, which parallel Deacon and colleagues’ work (2009, 2013) that also examined young school-aged children in French immersion. Given their above chance performance on the lexical orthographic processing tasks in English and French, our results strongly suggest that bilingual learners have developed at least some knowledge about the orthographic patterns in the languages under acquisition, like their native-speaking English and French monolingual peers (Cassar & Treiman, 1997; Pacton et al., 2001). Within our study, the bilingual children demonstrated orthographic knowledge earlier than they are given credit for in the existing theories of reading and spelling development (Ehri, 1989, 1995; Gentry, 1982). This also fits in nicely with Share (1995) who suggested that children need relatively few exposures to acquire orthographic representations.
Relationship between Orthographic Processing and Spelling within Languages

We explored the relationship between orthographic processing skills and spelling abilities within English and French in Grade 1 French immersion children. We showed that orthographic processing skill measured in English and French is related to spelling within each language. English orthographic processing accounted for a significant amount of unique variance in English spelling, just as French orthographic processing accounted for a significant amount of unique variance in French spelling. These results emerged in analyses that controlled for age, non-verbal ability, and phonological awareness. Our results extend previous studies demonstrating a relationship between orthographic processing and reading in monolingual and bilingual children (e.g., Deacon et al., 2009, 2012; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009) and between orthographic processing and spelling in monolingual children (e.g., Conrad et al., 2012).

These findings can be contextualised within the script-dependent hypothesis (Geva, Wade-Woolley, & Shany, 1997). According to this hypothesis, bilinguals are likely to engage in skills determined by the nature of the scripts under acquisition. This explains the relationship between orthographic processing and spelling within English and French. Both English and French are considered deep orthographies (Seymour et al., 2003). In particular, spelling in English and French is considered highly irregular and unpredictable in the phoneme-to-grapheme direction (Ziegler, Jacobs, & Stone, 1996; Ziegler, Stone, & Jacobs, 1997). For instance, depending on neighbouring letters and its position in a word, the phoneme /f/ is represented by many graphemes, such as f (friend), ff (cuff), ph (phone), and gh (enough) in English; similarly, in French, the same phoneme /f/ is represented by the graphemes f (froid [cold]), ff (chauffeur [driver]), and ph (photo).
In order to spell correctly in these languages, spellers need to rely on orthographic processing skills, in addition to other literacy-related factors, to produce each individual letters in the correct sequence (Caravolas, 2004).

**Relationship between Orthographic Processing and Spelling across Languages**

A key finding established by this study is that there was some evidence of cross-language transfer from orthographic processing to spelling. French orthographic processing was related to English spelling, following controls for age, non-verbal reasoning, phonological awareness, and English orthographic processing. Intriguingly, we did not find a bidirectional cross-language relationship; that is, English orthographic processing was not significantly related to French spelling after substantive controls. Our finding of cross-language transfer of orthographic processing to spelling, at least from French orthographic processing to English spelling, supports the language-general nature of orthographic processing when the languages under acquisition share the same alphabet.

Classic view on orthographic processing is that orthographic processing is a language-specific skill that is developed separately for each language under acquisition (Abu-Rabia, 1997, 2001). Support for this view comes from studies in which cross-language transfer of orthographic processing to word reading or spelling was not observed in bilingual children learning languages that differed substantially in the nature of the writing systems, such as Chinese and English (Gottardo et al., 2001), Persian and English (Arab-Moghaddam & Sénéchal, 2001), Korean and English (Wang et al., 2006), and Hebrew and English (Abu-Rabia, 1997). Recently, however, there has been increasing evidence that orthographic processing transfers across languages to word reading when the languages under acquisition share the same script; notably, the Roman
alphabet. Studies of bilingual children learning to read and spell languages that share the same alphabet, such as English and Spanish (Deacon et al., 2013; Sun-Alperin & Wang, 2010) and English and French (Commissaire et al., 2013; Deacon et al., 2009, 2012; Pasquarella et al., in press), have found evidence of cross-language transfer of orthographic processing to reading.

According to Koda (2000), cross-language transfer may occur at the knowledge and/or skill levels. The knowledge level refers to the learning of structural features common between the two languages under acquisition. In addition to the sharing of the same alphabet, both English and French share common letter patterns and their positions within words. For instance, the orthographic pattern \( st^- \) is legal at the beginning of a word in English and French, but \( stt^- \) is illegal in both languages. The skill level reflects the analysis of the letter patterns and their positions within words in print in both English and French. It is likely that the Grade 1 participants in our study relied on a deeper level of processing of their orthographic knowledge in both English and French in order to meet the demands of the highly inconsistent nature of English spelling.

We did not, however, find bidirectional transfer of orthographic processing to spelling; that is, English orthographic processing did not contribute a significant amount of variance in French spelling. This is not unusual; past studies that have examined children learning two languages that share the same alphabet have also observed a unidirectional relationship. Deacon et al. (2011) found that Spanish sub-lexical orthographic processing was significantly related to English word reading, but there were no such relationships from English orthographic processing to Spanish word reading in Spanish-English bilingual children. They explained this unidirectional finding by
suggesting that since English is more orthographically opaque than Spanish, it is likely that the participants relied more heavily on orthographic processing skills both within and across languages. Similarly, Sun-Alperin and Wang (2011) found that Spanish lexical orthographic processing significantly contributed to English reading, but not to English spelling. In interpreting their findings, they suggested that reading requires less orthographic processing than spelling, and as such, orthographic processing skills in Spanish may be able to account for English reading, but not English spelling, due to the inconsistent nature of phoneme-grapheme correspondence. Like Deacon et al. (2011) and Sun-Alperin and Wang (2011), we think that a possible reason as to why we observed a unidirectional transfer is that English is a highly inconsistent orthography. According to Seymour et al. (2003), English is a more opaque orthography than French. As such, it is likely that English spelling requires children to draw more heavily on orthographic processing skills in both within and across languages. The more consistent nature of French orthography may require drawing from orthographic processing skills in within language only, and not necessarily across languages.

Another potential explanation for our unidirectional finding is that the children in our sample had more variability in their exposure to English than to French. We conducted our study in a French immersion school located in a linguistically and culturally diverse area of a large metropolitan city in Canada. According to the parental demographic questionnaire, approximately 40% of the participants speak a language other than English at home most of the time. All of the participants, however, had relatively consistent exposure to French since the start of Grade 1. This context is different from Deacon et al.’s (2009) study that included only native-speaking English
children, leading to more uniform exposure levels to each of English and French, and potentially, to their findings of bidirectional transfer of orthographic processing and reading in their study.

In contextualizing our results to past studies that have examined the concurrent relationship between orthographic processing and reading in bilingual French immersion children (e.g., Deacon et al., 2009, 2012), we suggest that the contribution of orthographic processing may be different for reading and spelling. Spelling is perceived as a more difficult task than reading in both English and French (Bosman & Van Orden, 1997). During reading, it is not necessary to process each individual letter in order to recognize a word, whereas during spelling, each letter needs to be produced in the correct order. Spelling, especially in an opaque orthography, may require greater orthographic processing skill than reading. However, given that the measures we used to assess spelling was difficult (as evidenced by our Grade 1 participants’ low performance in both English and French spelling), in addition to the construct itself as a difficult skill to acquire in the early stages of literacy development, it is possible that there was a limited predictive power of orthographic processing on spelling across languages.
Figure 1. Summary of significant findings in Study 1.

Lines illustrate a significant relationship ($p < .05$) between orthographic processing (OP) and spelling. All analyses control for age, non-verbal ability, and phonological awareness in Grade 1. The cross-language relationships have the additional control of within-language OP.
Chapter 5: Study 2

The purpose of Study 2 was to investigate the concurrent and longitudinal relationships between orthographic processing and spelling within each of English and French and across the two languages in children in French immersion. In this chapter, the methodologies of the study are first described, followed by a report of the results. Finally, a discussion of the results is presented.

Method

Participants

Seventy-five children (52% males) with a mean age of 91.08 months ($SD = 3.70$) participated in Study 2 in the spring semester of Grade 2 (Time 1) and again in the spring semester of Grade 3 (Time 2). Six children who participated in Grade 2 did not participate in Grade 3. Attrition was due to children moving to different schools. The data from these six participants are included in the analyses at Time 1. Study 2 included a different cohort of children than Study 1. The participating children in Study 2 are referred to as Cohort 3. All participating children in both studies attended the same early total French immersion school and their first formal schooling experience was in French since Grade 1.

According to the Parental Demographic Questionnaire, 91% of the participating children were born in Canada. Sixty-two out of 75 children in the sample spoke English at home more than 50% of the time. Of the remaining 13 children who spoke English less than 50% of the time at home, only three children spoke English at home less than 25% of the time. For the 13 students, they spoke the following languages at home more than
50% of the time: Russian (n = 5), Chinese (n = 3), Hebrew (n = 2), Hungarian (n = 1), Korean (n = 1), and Azerbaijani (n = 1).

Exposure to English print began early for all participating children. All students whose parents completed our questionnaire (96% of the sample) had at least 10 English books at home, with the majority having more than 50 books. Approximately 83% of parents reported starting to read with their children in English before 2 years of age, with the rest reporting starting to read in English with their children between 3 and 5 years of age. All parents read with their children at least once or twice a week, with the majority (84% of the sample) doing so almost every day. Similar to Study 1, the mothers of children in Study 2 were well-educated, approximately 94% of mothers had completed at least college or university.

Table 5.

*Frequency Distribution of Maternal Education for Cohort 3.*

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some High School</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Completed High School</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Some College/University</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Completed College/University</td>
<td>29</td>
<td>42.0</td>
</tr>
<tr>
<td>Professional Degree/Certificate</td>
<td>24</td>
<td>34.8</td>
</tr>
<tr>
<td>Post-graduate Degree</td>
<td>14</td>
<td>20.3</td>
</tr>
<tr>
<td>(Master’s, Doctorate, Law)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Measures and Procedure*

All children in Study 2 received the same battery of measures in English and French as the children in Study 1. For the participants in Study 2, measures of phonological awareness and the English and French versions of orthographic processing
and spelling were administered in the spring semester of Grade 2 (Time 1) and Grade 3 (Time 2). The orthographic processing measures\textsuperscript{4} in Grade 3 contained 10 additional items in both languages than the measures in Grade 2. The spelling measures in Grade 2 and Grade 3 contained 10 additional items than the measures in Study 1. Nonverbal reasoning was administered when the participants were in Grade 1, as part of a larger study (e.g., Deacon et al., 2013; Pasquarella et al., in press). A demographic questionnaire was also given to the parents of participating children in Grade 1. The procedure is the same as in Study 1.

Results

Following Tabachnick and Fidell (2013), we screened for univariate and multivariate outliers in the sample. For univariate outliers, we examined the z scores of all the measures used in the analysis. For multivariate outliers, we used a $p < .001$ criterion for Mahalanobis distance. No univariate and multivariate outliers were found. Table 6 presents the mean scores, standard deviations and Cronbach’s alpha reliability for all administered measures.

\textsuperscript{4} Please see Deacon et al. (2013) and Commissaire et al. (in press) for more details on the orthographic processing measures.
Table 6.

Desciptive Statistics of all Measures for Cohort 3.

<table>
<thead>
<tr>
<th></th>
<th>Grade 2 (n = 75)</th>
<th>Grade 3 (n = 69)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age (in months)</td>
<td>91.08</td>
<td>3.70</td>
</tr>
<tr>
<td>Non-verbal ability</td>
<td>18.88</td>
<td>11.53</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>14.19</td>
<td>4.67</td>
</tr>
<tr>
<td>English OP (52 items)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>English OP (42 items)</td>
<td>30.84</td>
<td>7.55</td>
</tr>
<tr>
<td>French OP (52 items)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>French OP (42 items)</td>
<td>32.57</td>
<td>5.33</td>
</tr>
<tr>
<td>English spelling</td>
<td>9.03</td>
<td>5.16</td>
</tr>
<tr>
<td>French spelling</td>
<td>12.85</td>
<td>5.27</td>
</tr>
</tbody>
</table>

Note. OP = orthographic processing.

a Non-verbal ability was administered in Grade 1 only.
b The mean raw scores and standard deviations for the 52 items in the extended task administered in Grade 3.
c The mean raw scores and standard deviations for the 42 common items in the task administered in Grade 3.
d Indicates a Cronbach’s alpha (α) reliability coefficient.

Violations in normality were found for four variables. Following the recommendations by Tabachnick and Fidell (2013), a sequence of reflection, square root transformation, and re-reflection was performed on three moderately negatively skewed variables: French orthographic processing in Grade 2 and English and French orthographic processing in Grade 3. Phonological awareness in Grade 3 was also found to be significantly negatively skewed. A series of reflection, logarithm transformation, and re-reflection was conducted on this variable. After the transformations were performed, the skews were within reasonable limits. All other variables were normally distributed. The analyses were conducted with the transformed score in all correlational and linear regressions.
**Development of Orthographic Processing Skill**

The first set of analyses looked at whether the participants in our sample demonstrated orthographic processing skill in English and French at each grade level by determining whether their scores on the orthographic processing measure were above chance. The children’s scores on the orthographic processing task were statistically better than chance in Grade 2 for both the English and French versions, \( t(74) = 11.46, p < .001, d = 1.29 \) and \( t(74) = 19.31, p < .001, d = 0.29 \), respectively. Given that there were 10 additional items in the Grade 3 English and French orthographic processing tasks, only total scores calculated for the 42 test items common in both Grade 2 and Grade 3 versions were used against the chance analysis. In Grade 3, the children’s performance on the orthographic processing task were statistically better than chance for both English and French versions, \( t(68) = 20.78, p < .001, d = 2.38 \) and \( t(68) = 20.87, p < .001, d = 2.39 \), respectively. All subsequent analyses were conducted with scores on the 52 items on the Grade 3 orthographic processing task. These findings suggest that the children in our study demonstrated orthographic processing skills in both English and French.

We then conducted a series of paired-samples \( t \)-test contrasting performance on each orthographic processing measure to examine children’s development of orthographic processing over time. Similar to the previous analyses, only total scores calculated for the 42 test items common in both Grade 2 and Grade 3 versions were used in the paired-samples \( t \)-test. As expected, the children performed significantly better in Grade 3 English orthographic processing than in Grade 2 English orthographic processing \( t(68) = -6.94, p < .001 \). Similarly, scores were significantly higher on the
French orthographic processing in Grade 3 than in Grade 2, $t(68) = -2.34, p < .05$. These results suggest that over time, the children improved in their performance on both English and French orthographic processing tasks.

Development of Spelling Skills

In order to examine children’s spelling skills over time, a series of paired samples $t$-test were performed on each of the spelling measure administered to the children in Grade 2 and Grade 3. Contrary to expectations\(^5\), the children’s scores on the English spelling task in Grade 3 ($M = 8.30, SD = 5.33$) was statistically lower than in Grade 2 ($M = 9.03, SD = 5.16$), $t(68) = 2.06, p < .05, d = 0.14$. With respect to the children’s performance on the French spelling task, the scores in Grade 3 were significantly greater than the scores in Grade 2, $t(68) = -8.89, p < .001, d = 0.62$. These findings indicate that our participants improved significantly on French spelling from Grade 2 to Grade 3, but decreased in performance on English spelling over time.

The Relationship between Orthographic Processing and Spelling in English and French

Pearson correlations among all variables and across all grades are shown in Table 7. Both non-verbal ability and phonological awareness in Grade 2 were significantly positively correlated with all orthographic processing and spelling measures concurrently and longitudinally. In Grade 2, significant positive correlations were found between orthographic processing in English and French and between spelling in English and French. Additionally, English and French orthographic processing in Grade 2 significantly correlated with the two spelling measures in Grade 2, as well as the orthographic processing and spelling measures in both languages in Grade 3. English and

\(^5\) We excluded the six students who did not participate in Grade 3 and re-ran the analysis. The English spelling task in Grade 3 ($M = 8.34, SD = 5.28$) was still significantly lower than the English spelling task in Grade 2 ($M = 9.15, SD = 4.99$), $t(68) = 2.33, p < .05$. 
French spelling in Grade 2 were also shown to have moderate to high correlations with the two orthographic processing and spelling measures in Grade 3 (all $r$'s >.53, $p$’s < .01).

In Grade 3, phonological awareness significantly correlated with the two orthographic processing and spelling measures ($r$’s range from .27 to .53). As expected, strong correlations were observed between the two orthographic processing measures and between the two spelling measures in Grade 3 ($r = .69$ and .75, respectively, all $p$’s < .01).

English orthographic processing in Grade 3 moderately correlated with English and French spelling in Grade 3 ($r = .67$ and .64, respectively, all $p$’s < .01). Likewise, in Grade 3, moderate correlations were found between French orthographic processing and English and French spelling ($r = .62$ and .57, respectively, all $p$’s < .01).
Table 7.

Correlations among all Measures for Cohort 3.

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
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<th>7</th>
<th>8</th>
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<th>10</th>
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</thead>
<tbody>
<tr>
<td>1. Non-verbal ability</td>
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<tr>
<td>2. Gr. 2 Phonological awareness</td>
<td>.43**</td>
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<td></td>
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<tr>
<td>3. Gr. 2 English OP</td>
<td>.47**</td>
<td>.27*</td>
<td>--</td>
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<td></td>
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<tr>
<td>4. Gr. 2 French OP</td>
<td>.30*</td>
<td>.26*</td>
<td>.64**</td>
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<tr>
<td>5. Gr. 2 English spelling</td>
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<td>.51**</td>
<td>.71**</td>
<td>.62**</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>6. Gr. 2 French spelling</td>
<td>.25*</td>
<td>.47**</td>
<td>.62**</td>
<td>.65**</td>
<td>.81**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Measures in Grade 3</td>
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<td>7. Gr. 3 Phonological awareness</td>
<td>.27*</td>
<td>.65**</td>
<td>.28*</td>
<td>.41**</td>
<td>.50**</td>
<td>.57**</td>
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<td></td>
<td></td>
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<tr>
<td>8. Gr. 3 English OP</td>
<td>.37**</td>
<td>.28*</td>
<td>.81**</td>
<td>.65**</td>
<td>.78**</td>
<td>.70**</td>
<td>.40**</td>
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<td>9. Gr. 3 French OP</td>
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<td>.66*</td>
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<td>.53**</td>
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<td>.69**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>10. Gr. 3 English spelling</td>
<td>.34**</td>
<td>.47**</td>
<td>.59**</td>
<td>.53**</td>
<td>.85**</td>
<td>.79**</td>
<td>.52**</td>
<td>.67**</td>
<td>.62**</td>
<td>--</td>
</tr>
<tr>
<td>11. Gr. 3 French spelling</td>
<td>.31*</td>
<td>.48**</td>
<td>.57**</td>
<td>.59**</td>
<td>.72**</td>
<td>.83**</td>
<td>.53**</td>
<td>.64**</td>
<td>.57**</td>
<td>.75**</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01

Notes. OP = orthographic processing. Non-verbal ability was the only measure administered in Grade 1.
The Concurrent Role of Orthographic Processing in Spelling

We carried out a series of hierarchical regression analyses to determine the concurrent within and cross-language effects of orthographic processing on spelling in Grade 2 and Grade 3. Table 8 presents the change in $R^2$ and standardized beta coefficients ($\beta$), for each analyses. All analyses included age and non-verbal ability entered at Step 1 and phonological awareness entered at Step 2. Orthographic processing measures were entered after phonological awareness to examine the independent contribution of orthographic processing to spelling after partialling out phonological awareness. The cross-language analyses accounted within-language controls for the outcome variable in question (e.g., Deacon et al., 2009). We first discuss the analyses of the within and across language predictors of Grade 2 English spelling and French spelling (upper left and right side of Table 8, respectively), followed by Grade 3 English and French spelling (lower left and right side of Table 8, respectively).

The first linear regression analyses examined whether orthographic processing skills are related to English spelling both within and across languages in Grade 2. The upper left portion of Table 8 reports the predictors of English spelling in Grade 2. Beyond the 32% of the variance taken up by the control variables, English orthographic processing in Grade 2 contributed an additional 31.4% ($p < .001$) of the unique variance to English spelling, indicating a within-language relationship. A cross-language contribution was also observed with French orthographic processing explaining an additional 2.9% ($p < .05$) of unique variance in English spelling, above and beyond all previously controlled variables. Altogether, the factors examined in this model accounted for 66.5% of the variance in Grade 2 English spelling.
We then examined the within and across language contribution of orthographic processing to French spelling in Grade 2 (upper right side of Table 8). Beyond the 27% of the variance taken up by the control variables, French orthographic processing in Grade 2 explained about 30% of the variance in French spelling in Grade 2, illustrating the within-language relationship. When entered in the final step, English orthographic processing in Grade 2 made an independent contribution to French orthographic processing. At 3.9%, this contribution survived controls for French orthographic processing, in addition to age, non-verbal reasoning, and phonological awareness. Collectively, the variables considered in the regression model explained over 61% of the variance in Grade 2 French spelling.

The next set of analyses examined the concurrent contribution of orthographic processing to English spelling in Grade 3 (lower left side of Table 8). As before, we first explored the within-language contributions. Beyond the 33% of the variance explained by the control variables, English orthographic processing in Grade 3 accounted for a statistically significant portion of unique variance (16%) in English spelling, representing the within-language contribution of English orthographic processing to English spelling in Grade 3. Finally, entered fourth into the regression equation was French orthographic processing in Grade 3 and this variable made a cross-language contribution to English spelling in Grade 3, by accounting for an additional 8%, even after the variance in English orthographic processing, age, non-verbal ability, and phonological awareness have been removed. All variables entered in the model explained about 56% of the variance in children’s English spelling in Grade 3.
The final analyses explored the question of whether unique variance in Grade 3 French spelling is predicted by Grade 3 English and French orthographic processing (lower right side of Table 8). Beyond the 36% of the variance taken up by the control variables, French orthographic processing in Grade 3 predicted a substantial amount of variance in French spelling (18.5%) at Step 3. Entered at Step 4, English orthographic processing accounted for an additional significant 2.4% to French spelling in Grade 3, representing the cross-language relationship. Jointly, all variables entered in the model accounted for about 57% of the variance in Grade 3 French spelling.
Table 8.

*Hierarchical Linear Regressions Predicting Concurrent English and French Spelling in Grades 2 and 3.*

<table>
<thead>
<tr>
<th>Step and predictors</th>
<th>Outcome: Gr. 2 English spelling</th>
<th>Outcome: Gr. 2 French spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General model summary</td>
<td>Coefficients</td>
</tr>
<tr>
<td></td>
<td>$\Delta R^2$</td>
<td>$\beta$</td>
</tr>
<tr>
<td>1. Age (in months)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-verbal ability</td>
<td>.156**</td>
<td>.030</td>
</tr>
<tr>
<td>2. Gr. 2 Phonological awareness</td>
<td>.166***</td>
<td>.319***</td>
</tr>
<tr>
<td>3. Gr. 2 English OP</td>
<td>.314***</td>
<td>.482***</td>
</tr>
<tr>
<td>4. Gr. 2 French OP</td>
<td>.029*</td>
<td>.236*</td>
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<td>3. Gr. 2 French OP</td>
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<td></td>
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<tr>
<td>4. Gr. 2 English OP</td>
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<td></td>
</tr>
</tbody>
</table>

|                              | Outcome: Gr. 3 English spelling | Outcome: Gr. 3 French spelling |
|                              | General model summary           | Coefficients                  | General model summary           | Coefficients                  |
|                              | $\Delta R^2$                    | $\beta$                       | $\Delta R^2$                    | $\beta$                       |
| 1. Age (in months)           |                                 |                               |                               |                               |
| Non-verbal ability           | .091*                           | -.042                         | .134**                         | .062                          |
| 2. Gr. 3 Phonological awareness | .241***                    | .346***                       | .223***                       | .335***                       |
| 3. Gr. 3 English OP          | .160***                         | .227                          | --                            | --                            |
| 4. Gr. 3 French OP           | .076***                         | .369***                       | --                            | --                            |
| 3. Gr. 3 French OP           |                                 |                               | .185***                       | .340**                         |
| 4. Gr. 3 English OP          |                                 |                               | .024*                         | .221                          |

*Note.* OP = orthographic processing

*p < .05, **p < .01, ***p < .001
The Longitudinal Role of Orthographic Processing to Spelling from Grade 2 to 3

A series of cross-lag hierarchical regression analyses with auto-regressive controls were conducted to evaluate the role of orthographic processing to spelling from Grade 2 to Grade 3 both within and across languages. As in the concurrent analyses, age and non-verbal ability were entered in Step 1 and phonological awareness in Grade 2 was entered in Step 2. At Step 3, we included the auto-regressive control of the outcome variable measured at an earlier time point (e.g., Deacon et al., 2012). The orthographic processing measure in the same language of the predicted spelling measure was included in Step 4 as the within-language variable. Finally, at Step 5, the orthographic processing measure in the other language of the predicted spelling measure was entered as the cross-language variable. The inclusion of these variables allows us to take a conservative approach in investigating within and cross-language relationships over time. We first discuss the analyses of the within and cross-language predictors of English spelling in Grade 3 (left side of Table 9), followed by the within and cross-language predictors of French spelling in Grade 3 (right side of Table 9).

The left portion of Table 9 presents the predictors of English spelling in Grade 3. English spelling in Grade 2 was entered as the auto-regressive control at Step 3. Beyond the 73% of the variance taken up by the control variables, neither within and cross-language relationships were not found. All variables included in the model accounted for about 74% of the variance in English spelling in Grade 3.

We then investigated the within and cross-language contribution of orthographic processing to French spelling in Grade 3 (right side of Table 9). The auto-regressive control of English spelling in Grade 2 was entered at Step 3. Beyond the 69.5% of the
variance taken up by the control variables, neither within and cross-language relationships emerged. Collectively, the factors considered in this model accounted for over 75% of the variance in French spelling in Grade 3.
Table 9.

**Hierarchical Linear Regressions Predicting English and French Spelling from Grade 2 to 3.**

<table>
<thead>
<tr>
<th>Step and predictors</th>
<th>Outcome: Gr. 3 English spelling</th>
<th>Outcome: Gr. 3 French spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General model summary</td>
<td>Coefficients</td>
</tr>
<tr>
<td></td>
<td>ΔR²</td>
<td>β</td>
</tr>
<tr>
<td>1. Age (in months)</td>
<td>.091*</td>
<td>-.029</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.134**</td>
</tr>
<tr>
<td></td>
<td>Non-verbal ability</td>
<td>-.014</td>
</tr>
<tr>
<td>2. Gr. 2 Phonological awareness</td>
<td>.170***</td>
<td>.057</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.165***</td>
</tr>
<tr>
<td>3. Gr. 2 English spelling</td>
<td>.467***</td>
<td>.949***</td>
</tr>
<tr>
<td>4. Gr. 2 English OP</td>
<td>.010</td>
<td>-.139</td>
</tr>
<tr>
<td>5. Gr. 2 French OP</td>
<td>.000</td>
<td>-.030</td>
</tr>
<tr>
<td>3. Gr. 2 French spelling</td>
<td></td>
<td>.396***</td>
</tr>
<tr>
<td>4. Gr. 2 French OP</td>
<td></td>
<td>.005</td>
</tr>
<tr>
<td>5. Gr. 2 English OP</td>
<td></td>
<td>.001</td>
</tr>
</tbody>
</table>

*Note. OP = orthographic processing
*p < .05, **p < .01, ***p < .001
The Longitudinal Role of Spelling to Orthographic Processing from Grade 2 to 3

We evaluated the within and cross-language contribution of spelling in Grade 2 to orthographic processing in Grade 3. The relationships were tested using a cross-lagged design with autoregressive controls. For each of the analyses, age and non-verbal ability were entered together at Step 1, followed by phonological awareness at Step 2. Grade 2 orthographic processing in the same language as the outcome variable was entered at Step 3 as the auto-regressive control (e.g., Deacon et al., 2012). Grade 2 spelling in the same language as the outcome variable was entered at Step 4. We then included Grade 2 spelling in the other language as the outcome variable at Step 5 to explore the cross-language relationship.

The left side of Table 10 reports on the predictors of English orthographic processing in Grade 3. English orthographic processing in Grade 2 was entered at Step 3 as the autoregressor. Beyond the 66% of the variance taken up by the control variables, English spelling in Grade 2 explained an additional significant 3% of the variance and this demonstrates within-language relationship from spelling to orthographic processing over time. We did not find cross-language relationship from French spelling in Grade 2 to English orthographic processing in Grade 3, after substantive controls. Altogether, the variables taken into account in this model explained over 70% of the variance in English orthographic processing in Grade 3.

The final set of analyses examined the unique contribution of spelling in Grade 2 to French orthographic processing in Grade 3, both within and across languages (right side of Table 10). The auto-regressive control of French orthographic processing in Grade 2 was entered at Step 3. Beyond the 42% of the variance taken up by the control
variables, French spelling in Grade 2 did not survive controls of French orthographic processing in Grade 2. As such, we did not observe a within-language contribution of French spelling in Grade 2 to gains in French orthographic processing between Grades 2 and 3. Finally, at Step 5, we found a cross-language relationship of English spelling in Grade 2 to French orthographic processing in Grade 3. English spelling in Grade 2 made a significant contribution of 7% of the variance, over and above age, non-verbal ability, phonological awareness, French orthographic processing in Grade 2, and French spelling in Grade 2. Together, all the variables considered in the regression models explained over 51% of the variance in French orthographic processing in Grade 3.
Table 10.

*Hierarchical Linear Regressions Predicting English and French Orthographic Processing from Grade 2 to 3.*

<table>
<thead>
<tr>
<th>Step and predictors</th>
<th>Outcome: Gr. 3 English OP</th>
<th>Outcome: Gr. 3 French OP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General model summary</td>
<td>Coefficients</td>
</tr>
<tr>
<td></td>
<td>ΔR²</td>
<td>β</td>
</tr>
<tr>
<td>1. Age (in months)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-verbal ability</td>
<td>.004</td>
</tr>
<tr>
<td>2. Gr. 2 Phonological awareness</td>
<td>.053*</td>
<td>.027</td>
</tr>
<tr>
<td>3. Gr. 2 English OP</td>
<td>.454***</td>
<td>.651***</td>
</tr>
<tr>
<td>4. Gr. 2 English spelling</td>
<td>.033**</td>
<td>.200</td>
</tr>
<tr>
<td>5. Gr. 2 French spelling</td>
<td>.001</td>
<td>066</td>
</tr>
<tr>
<td>3. Gr. 2 French OP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gr. 2 French spelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Gr. 2 English spelling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* OP = orthographic processing  
*p < .05, **p < .01, ***p < .001*
Discussion

Study 2 investigated the relationship between orthographic processing and spelling within each of English and French and across the two languages in young French immersion children. We examined these relationships both concurrently and longitudinally by following one cohort of children in Grade 2 to the end of Grade 3. In Grades 2 and 3, we observed a within-language relationship between orthographic processing and spelling in both English and French, following controls for age, nonverbal ability, and phonological awareness. Across languages, English and French orthographic processing also explained unique variance in spelling in the other language in both grades, beyond the same set of substantive controls, in addition to within-language orthographic processing. Longitudinally, we found that only English spelling in Grade 2 was associated with gains in English and French orthographic processing in Grade 3.

The Concurrent Relationship between Orthographic Processing and Spelling in Grades 2 and 3

In terms of the within-language analyses, our results indicated that in both English and French, orthographic processing explained a unique variance in spelling in Grade 2 and 3, after substantive controls. With respect to the cross-language analyses, we found a bidirectional relationship in both grades; that is, in Grades 2 and 3, English orthographic processing was significantly accounted for a unique proportion of variance in English spelling and French orthographic processing significantly contributed to French spelling, after controlling for the same set of variables.

The evidence of within-language contribution of orthographic processing to spelling is not surprising, given that past studies involving monolingual children have
also observed the contribution of orthographic processing in reading and spelling in opaque orthographies (e.g., Barker et al., 1992; Conrad et al., 2012). Opaque orthographies, such as English and French, may require learners to rely on orthographic processing during spelling to meet the demands of the inconsistent nature of its phoneme-to-grapheme correspondence. Orthographic processing allows spellers to know how letters can and cannot be combined depending on positional constraints. To illustrate, in order to accurately spell the English word *cat*, the speller has to know that the initial /k/ corresponds to *c*, and not *ck* because even though *ck* represents the phoneme /k/, it does not appear at the beginning of a word in English. Thus, it is possible that the children’s understanding of letter combinations and their sequence in words allowed them to spell accurately in both English and French. Furthermore, past studies have observed a within-language relationship between orthographic processing and word reading in bilingual children (e.g., Deacon et al., 2009, 2013; Arab-Moghaddam & Sénéchal, 2001). Our study is unique in that we observed a within-language relationship between orthographic processing and spelling in French immersion children.

Turning to cross-language relationships, the bidirectional contributions of orthographic processing in one language to spelling in the other language in Grade 2 and Grade 3 provide evidence that orthographic processing is not entirely language-specific when the languages under acquisition share the same Roman script. Our results build on past studies by Deacon and colleagues (2009, 2013) that found cross-language transfer of orthographic processing in one language to word reading in another language, as measured with a lexical task. Our study gives further support of orthographic processing
as a transferable skill as it relates to spelling in children learning languages that share the same alphabet.

These findings lead us to examine the ways in which orthographic processing functions across languages that are written with the same script. According to Koda (2000), transfer can occur at the knowledge and skill levels. With respect to orthographic processing, the knowledge level indicates the learning of individual features that are common between languages. In English and French, there are similarities in terms of orthographic strings and their positions in words (e.g., st- is legal at the beginning of words in both languages, whereas stt- is illegal). The similar patterns of orthographic structure shared in both English and French may explain our cross-language transfer results. The skill level reflects children’s analysis of orthographic patterns in text in both English and French. Both English and French spelling may require children to adopt an analytic skill in which they draw their attention to the orthographic structure of their languages. Analyzing the letter combination in words and their sequence may be particularly helpful in using orthographic processing to spell in highly inconsistent orthographies (e.g., Arab-Moghaddam & Sénéchal, 2001).

The Longitudinal Relationship between Orthographic Processing and Spelling from Grade 2 to 3

While past empirical studies have shown that there is a relationship between orthographic processing and word reading and spelling (e.g., Conrad et al., 2012; Deacon et al., 2009, 2011, 2013; Rahbari, et al., 2007; Sun-Alperin & Wang, 2010), the nature of cross-sectional studies makes it difficult to determine the temporal relationship between orthographic processing and spelling. It is possible that orthographic processing
determines success in spelling; however, it is also equally possible that the relationship can run in the reverse direction. To examine this possibility, we conducted a two-year longitudinal study of Grade 2 children in early total French immersion in Study 2. Using cross-lag analyses, we performed bidirectional analyses from orthographic processing to spelling and from spelling to orthographic processing, both within English and French, as well as across the two languages.

With respect to within-language relationships, we found that English spelling predicted growth in English orthographic processing between Grade 2 and 3, after controlling for the autoregressor of English orthographic processing in Grade 2 and age, non-verbal reasoning, and phonological awareness. There were no relationships in the other direction. Our finding echoes the results of longitudinal studies by Deacon et al. (2012) with English-speaking children and Pasquarella et al. (in press) with young bilingual children in early French immersion, in which orthographic processing was the outcome and not the predictor of earlier word reading. These studies, including the current one, are consistent with prominent theories of reading and spelling development (Ehri, 1989, 2005; Frith, 1985) as well as the statistical learning approach (Pacton et al., 2001). The existing theories of reading and spelling development suggest that children rely on phonological skills, but eventually rely on both phonological and orthographic processing skills after sufficient exposure to print. To illustrate, consider Ehri’s (1989) stage model of spelling development. During the phonetic stage, children spell words such that most sounds correspond to a letter or letters in the spelling (e.g., spelling doctor as doktdr). Children’s spellings consist of many violations in the orthographic patterns and its position in words; however, the spellings are phonetically plausible. Subsequently,
as children gain more experience in the complex orthographic patterns of the language and move to the transitional stage, children tend to rely on the orthographic skills (in addition to phonological skills) to spell words correctly or in an orthographically plausible manner (e.g., *dockter*). Similarly, the statistical learning approach holds that experience with print, through reading and spelling, increases children’s orthographic knowledge, such as being able to discriminate between legal and illegal position of consonant doublets (Pacton et al., 2001). Our findings provide empirical support of these hypotheses for children learning two languages. For bilingual children attending an early total French immersion program, experience with English spelling supports growth in English orthographic processing.

We did not observe a longitudinal relationship from early orthographic processing to later spelling in French. This is surprising because from a theoretical perspective, the increase in children’s exposure to and acquisition of text in academic learning should, in part, explain the role of early French spelling to later French orthographic processing (e.g., Ehri, 1989, 2005; Frith, 1985). Further, there has been evidence of a relationship between early word reading and later orthographic processing in French in French immersion bilingual children (Pasquarella et al., in press). Nevertheless, the relationship between French orthographic processing in Grade 2 and French spelling in Grade 3, as well as between French spelling in Grade 2 and French orthographic processing in Grade 3 were significantly correlated, indicating that there is an emerging relation between the two skills over time.

A significant finding demonstrated in this study is that spelling predicted gains in orthographic processing across languages. In particular, we found that English spelling in
Grade 2 was associated with gains in French orthographic processing in Grade 3, after controlling for age, non-verbal ability, phonological awareness, French orthographic processing in Grade 2 as the autoregressor, and French spelling in Grade 2. These findings are remarkable given the extremely conservative estimates provided in longitudinal regression models with autoregressor (Kenny, 1975). Based on our findings, it seems possible that English spelling supports growth in French orthographic processing in part because of common orthographic patterns in the two languages that share the same script. While past studies have not observed the transfer of orthographic processing in children learning languages represented by different scripts, such as Chinese and English (Gottardo et al., 2001) and Korean and English (Wang et al., 2006), transfer has been observed in children learning languages that are represented with the same Roman script, such as French-English and Spanish-English bilinguals (Deacon et al., 2009, 2013; Pasquarella et al., in press; Sun-Alperin & Wang, 2011). Thus, our study gives support for the view that orthographic processing is not purely language-specific, as suggested by Abu-Rabia (2001). This also fits well within the predictions of the Contrastive Analysis Hypothesis which maintains that cross-language transfer takes place when languages share the same linguistic feature (Lado, 1957). Within our study, the children were learning English and French, two languages that share the same alphabet, and this might be a key factor in driving transfer across languages.

However, we did not find a cross-language relationship between French spelling to gains in English orthographic processing between grades 2 and 3. Our unidirectional transfer finding suggests that the development of orthographic processing skill might be contingent on the nature of the orthographic opacity. For example, English is a more
opaque orthography than French (Seymour et al., 2003; Ziegler et al., 2010). When spelling in English, children need to learn to spell many words with inconsistent orthographic patterns for which accurate spelling cannot be achieved on the basis of phonological analysis alone. Accordingly, the highly inconsistent nature of English may require a deeper level of processing of letter combination and their sequence during spelling which encourages the development of orthographic processing skills both in English and French.

The finding of unidirectional transfer has also been observed in previous cross-sectional studies that examined lexical and sublexical orthographic processing and word reading in bilingual children learning two languages that share the same alphabet. For example, in Deacon et al.’s (2011) study, Spanish sublexical orthographic processing explained a unique variance in English word reading in Spanish-English bilingual children, beyond the controls for age, maternal education, non-verbal ability, Spanish vocabulary, phonological awareness, rapid automatized naming, and English orthographic processing. They suggested that because English is the more orthographically opaque of the two languages, it is likely that the bilingual children drew more heavily on orthographic processing skills during reading. Similar unidirectional transfer finding was also observed in Sun-Alperin and Wang’s (2011) study from Spanish lexical orthographic processing to English word reading. They, too, proposed that the nature of the English language likely requires orthographic processing skills in Spanish. Unlike these studies, however, the current research was unique in that we tested the relationship between orthographic processing and spelling in bilingual children using a cross-lagged design with autoregressive controls.
Figure 2. Summary of significant findings in Study 2.

Lines illustrate a significant relationship ($p < .05$) between orthographic processing (OP) and spelling in concurrent and longitudinal analyses. All analyses control for age, non-verbal ability, and phonological awareness. All longitudinal analyses control for the outcome variable measured at an earlier time point. The cross-language analyses have the additional control of the appropriate within-language OP or spelling.
Chapter 6: Study 3

In Study 3, we extended the concurrent findings in Study 2 through qualitative means in order to explore the nature of spelling errors made by the children in Grade 3. In particular, we examined whether there was evidence of transfer in their English and French spelling in Grade 3. In this chapter, the methodologies used for the study is first described, followed by a report of the results. Finally, a discussion of the results is presented.

Method

Participants

The participants for Study 3 were the 69 Grade 3 students in Study 2. Their demographics were described in that study. No additional tasks were administered in Study 3; only in-depth error analyses were conducted on the spelling responses for the English and French spelling tasks.

Coding Scheme

We carried out a qualitative analysis of English and French spellings of our Grade 3 participants to examine their transfer errors. Analyses were conducted on the Grade 3 data only to ensure that the children had sufficient experience with print in both languages. We define transfer error as orthographic rules specific to one language are used to spell a word in the other language.

In our coding scheme, each word in a student’s response was scored as correct, transfer error, or other error (Appendices D and E). A response was scored as correct if all the letters are spelled correctly. For instance, for the target English word kitchen, the response kitchen was scored as correct. A response was coded as transfer error if the
response contains letter combination that corresponds to a phoneme in the target language, but the letter combination is unique in the non-target language. To illustrate, the phoneme /ʃ/ exists in both English and French but the spelling of this phoneme is different in both languages. In English, /ʃ/ is spelled with the graphemes sh, whereas in French, it is spelled ch. Thus, if a child spelled the English target word shout as chout or other variations where ch was used in the initial position, then this response was categorized as transfer error. Finally, a response was scored as other error based on the error categorization typically found in literature (e.g., Treiman, 1993). For example, spelling cat as kat was scored as other error because it is considered as a homophone confusion error. Because other error includes all non-transfer spelling errors, the majority of children’s spelling errors fell into this category. After we obtained a frequency count for each of the categories (i.e., correct, other error, or transfer error), we calculated the children’s transfer errors in proportion to the total number of errors (i.e., other error and transfer error). A second research assistant coded 20% of the sample and the interrater reliability was .62.

Results

Table 11 displays the descriptive statistics for the proportion of transfer errors, total number of other errors and total number of overall errors in English and French spelling.
Table 11.

Descriptive Statistics of Grade 3 Children’s Transfer Errors, Other Errors, and Total Errors.

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of transfer errors in English spelling</td>
<td>0</td>
<td>37</td>
<td>0.6</td>
<td>0.08</td>
</tr>
<tr>
<td>Proportion of transfer errors in French spelling</td>
<td>0</td>
<td>33</td>
<td>0.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Total number of other errors made in English spelling</td>
<td>0</td>
<td>30</td>
<td>16.5</td>
<td>8.43</td>
</tr>
<tr>
<td>Total number of other errors made in French spelling</td>
<td>0</td>
<td>24</td>
<td>10.61</td>
<td>5.51</td>
</tr>
<tr>
<td>Total number of errors(^a) made in English spelling</td>
<td>8</td>
<td>30</td>
<td>21.64</td>
<td>5.42</td>
</tr>
<tr>
<td>Total number of errors(^a) made in French spelling</td>
<td>3</td>
<td>27</td>
<td>13.74</td>
<td>5.55</td>
</tr>
</tbody>
</table>

Notes. Min = Minimum, Max = Maximum, SD = Standard Deviation.
\(^a\) Total number of errors includes the total number of transfer errors and other errors combined.

We conducted two paired-samples *t*-test to determine whether there is a significant difference in the proportion of transfer errors in both languages and in the total number of errors made in both languages. The results revealed that there was a significant difference in the proportion of transfer errors in English and French spelling, *t*(68) = 2.98, *p* < .01. These results suggest that Grade 3 bilingual children in French immersion made greater proportion of transfer errors when spelling in French than English. Further, the results showed that there was a significant difference in the total number of other errors in English and French spelling, *t*(68) = 1.99, *p* < .001. The results also showed that there was a significant difference in the total number of errors made in English and French spelling, *t*(68) = 1.99, *p* < .001, indicating that there were more total number of errors made in English than French spelling.

The Relationship between Transfer Errors and Spelling in English and French

Pearson correlations between transfer errors and spelling in English and French are displayed in Table 12. Significant negative correlations were found between Grade 3 English spelling and proportion of transfer errors in both English and French spelling (*r*’s
range from -.36 to -.24). There was a strong positive correlation with total number of other errors in French spelling and English spelling. Strong negative correlation was observed with total number of other errors in English spelling and Grade 3 French spelling, as well as between total number of other errors in French spelling with Grade 3 English spelling.

Table 12.

*Correlations among Proportion of Transfer Errors, Other Errors, and Spelling Measures in English and French.*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proportion of transfer errors in English spelling</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Proportion of transfer errors in French spelling</td>
<td>-.19</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Total number of other errors in English spelling</td>
<td>.37**</td>
<td>.22</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Total number of other errors in French spelling</td>
<td>.22</td>
<td>.21</td>
<td>.79**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>5. Gr. 3 English spelling</td>
<td>-.36**</td>
<td>-.24*</td>
<td>-.99**</td>
<td>-.76**</td>
<td>--</td>
</tr>
<tr>
<td>6. Gr. 3 French spelling</td>
<td>-.22</td>
<td>-.22</td>
<td>-.79**</td>
<td>-.99**</td>
<td>.77**</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01

*Note. OP = orthographic processing.*

Discussion

Study 3 was designed to determine whether there was evidence of transfer in the Grade 3 English and French spelling of children attending an early total French immersion program.

The error analysis revealed three critical points about the nature of bilingual children’s English and French spellings. First, while the Grade 3 children in our study made more transfer errors in French than English spelling, they made significantly more overall errors in their English than French spelling. One possible explanation for this finding is that the formal and systematic instruction in French reading and spelling may be particularly important in understanding the orthographic structure of a language. The
children in our study had received all school instruction in French at the beginning of Grade 1 and no instruction in English in the early grades. As such, the children may have greater understanding that the French orthographic patterns and their sequence are specific to that language. Consequently, it is likely that the children tend to use less of French-specific orthographic patterns to spell in English, compared to using English-specific orthographic patterns to spell in French. To the best of our knowledge, we are not aware of studies that have looked at transfer patterns in both of the languages under acquisition. Further, the total number of errors (both transfer and other errors) made in English spelling explains the relatively low performance in Grade 3 English spelling. In Study 2, we showed that our participants actually decreased in English spelling from Grade 2 to 3. Thus, while children might have used less transfer errors in Grade 3 English spelling, they made significantly more total errors that resulted in the decreased performance from Grade 2 to 3. Both Cummins and Swain (1986) and Lambert and Tucker (1972) have also reported that French immersion children typically do poorly on English spelling in Grade 3, when compared to a control group of students in a regular English program. It appears that as children gain more literacy-related instruction in French at school in the early primary grades, their English spelling skills do not increase in performance.

Second, significant negative correlations were found between English spelling in Grade 3 and both the proportion of transfer errors made in English and French spelling. This suggests that children who make more transfer errors in both English and French spelling tend to do more poorly in English spelling. These findings are similar to a cross-sectional study by Zutell and Allen (1988) which involved Spanish-English children in
Grades 2, 3, and 4. The error analysis revealed that those who performed poorly on the English spelling test (scored between 0 to 50%) made more Spanish-influenced errors (e.g., spelling horse as jors) than those who did well. Additionally, it was found that the more successful spellers tend to demonstrate more language-specific spelling errors (e.g., spelling cream as creem) than the less successful spellers. Cummins and Swain (1986) explained that young bilingual spellers experience challenges due to the interfering and competing linguistic structures in both languages. Among many things, the speller has to monitor how phonemes are represented in print in both languages and make decisions about the application of graphemes in the appropriate language. Our study illustrates some evidence to suggest that there is a link between transfer errors and English spelling; however, the descriptive and correlational nature of our analysis limits our understanding of the causal nature of these factors.

Finally, it is worthwhile to note the similarities and differences in the findings between Study 2 and Study 3. Certainly, as the evidence from the descriptive statistics indicate, children use English orthographic patterns in French spelling and likewise, French orthographic patterns in English spelling. This finding gives support to the concurrent analyses conducted in Study 2 where we also found bidirectional cross-language transfer from orthographic processing to spelling in Grade 3. Specifically, orthographic processing in one language explained a unique variance in spelling in the other language. And yet, when the cross-language relationship was examined through qualitative means, the results revealed a different picture. The pattern of negative correlations suggests that children in our study do not necessarily benefit from transferring their knowledge of the French orthographic patterns to spell in English.
Caution should be employed in interpreting the results. Both the English and French spelling tasks were standardized instruments and as such, they were not designed to examine transfer errors. Many of the items on these tests contained phonemes that were unique to one language and thus, they did not correspond to a grapheme or graphemes in the other language. For instance, in the English word *grown* /groʊn/, the medial diphthong /oʊ/ is unique to English and thus, it does not have a corresponding orthographic pattern in French. To observe a transfer error according to our definition, a phoneme in a word has to exist in both English and French but differ in their orthographic pattern in representing that specific phoneme. Accordingly, the choice of measures to assess spelling may have resulted in the decreased likelihood of observing transfer error in our sample. It is also worth mentioning that our coding scheme may have not captured all forms of transfer errors. We stipulated that a specific phoneme has to exist in both languages, but the grapheme(s) to represent this phoneme has to be different in English and French. However, it is possible that children use certain combination of graphemes that does not correspond to a phoneme. For example, the letter pattern *ay* is unique to English and in one instance, a child wrote the French word *odeur* (odour) as *oday*, in which the *ay* does not correspond to any phonemes in *odeur*. Because we did not code for these instances, it is likely that the proportion of errors is greater than described. The low interrater reliability also indicates that a more refined coding scheme should be developed. Furthermore, it seems that our participants found the spelling tasks to be challenging. In Study 2, the descriptive statistics showed that the performance on English spelling actually decreased over time from Grade 2 to Grade 3. Future studies might benefit from experimental spelling measures (e.g., real word or pseudoword spelling) that
are designed to target specific phonemes and orthographic patterns, in addition to taking into account the level of difficulty of words. Moreover, it is imperative to note that we did not include a control group of native-English children with which to compare the spelling results and to confirm that the transfer errors were indeed a result of the differences in the spelling systems between the two languages.
Chapter 7: Conclusion

General Discussion

While the importance of orthographic processing skill in word reading has been well established, little research has been conducted to investigate the relationship between orthographic processing and spelling in bilingual children. To address this dearth of research, the present thesis examined the concurrent and longitudinal relationships between orthographic processing and spelling among English-French bilingual children enrolled at an early total French immersion program. The research had two general purposes. The first was to examine the concurrent within- and cross-language role of orthographic processing in spelling in French immersion children. The second was to identify the direction of the relationship longitudinally between orthographic processing and spelling, both within and across languages. These questions were examined in three interrelated studies and several insights were gained in relation to the issues investigated.

Results from Study 1 showed that Grade 1 French immersion children demonstrated orthographic processing skill in both English and French, as measured with a lexical task. It is interesting that orthographic processing is evident in French, the language in which the children have been receiving formal instruction for less than seven months at the time of testing, as well as in English, the language they have been learning informally. Deacon et al.’s (2013) study also yielded similar results in which Grade 1 French immersion children demonstrated orthographic processing in both English and French, as measured with a lexical and sublexical task. Also in Study 1, there was a relationship between orthographic processing and spelling within each of English and
French in Grade 1 French immersion children. The within-language relationships remained robust after partialling out age, non-verbal ability, and phonological awareness. These results extend past studies that involved school-aged native English-speaking children (e.g., Conrad et al., 2012), as well as bilingual children learning pairs of languages that share the same alphabet, such as English and Spanish (e.g., Deacon et al., 2011) and English and French (e.g., Deacon et al., 2009) when the relationship between orthographic processing and reading were examined. There was also evidence of cross-language transfer between French orthographic processing and English spelling, after controlling for age, non-verbal ability, phonological awareness, and English orthographic processing. This finding provides support for the notion that orthographic processing may not be entirely language-specific when the languages share the same Roman letter. This is contrary to past studies that have found that orthographic processing did not transfer across languages when the languages under acquisition are markedly different, such as English and Chinese (Gottardo et al., 2001), English and Korean (Wang et al., 2006), and English and Russian (Abu-Rabia, 2001).

The evidence of a cross-language relationship in our study, at least from French to English, raises two critical points. First, our unidirectional finding suggests that the highly inconsistent nature of English requires children to draw more heavily on orthographic processing skills in both within and across languages. This also explains the finding that the more consistent nature of French orthography may require drawing from orthographic processing skills in within language only, and not necessarily across languages. Second, while past concurrent studies have found a bidirectional cross-language transfer between lexical orthographic processing and word reading in Grade 1
and 2 French immersion (e.g., Deacon et al., 2009, 2013), the finding of a unidirectional cross-language transfer in our study suggests that orthographic processing might be different for spelling. To illustrate, learning to read and learning to spell are related (Holmes & Castles, 2001). Ehri (1997) explains that reading involves one response, that of retrieving and pronouncing the words, whereas spelling requires multiple responses that of writing several letters strung together in the correct sequence. Accordingly, spelling is perceived as a more difficult skill to acquire than reading in both English and French, where there are more irregularities in spelling than in reading (Ziegler, Jacobs, & Stone, 1996). The more difficult skill of spelling, in addition to the French spelling test (FIAT) that was standardized with Grade 2 French immersion students, may have resulted in the limited predictive power of English orthographic processing on French spelling.

In Study 2, we followed one cohort of Grade 2 French immersion for two years. We found that there was a relationship between orthographic processing and spelling within each of English and French when the participants were in Grade 2 and again in Grade 3, over and above the contribution of age, non-verbal ability, and phonological awareness. This general pattern of results replicates that obtained with monolingual English children (Conrad et al., 2012; Cunningham & Stanovich, 1991) as well as English-Persian (Arab-Moghaddam & Sénéchal, 2001), English-French (Deacon et al., 2009; 2013), and English-Spanish children (Deacon et al., 2011). Orthographic processing may be particularly helpful in opaque orthographies where accurate spelling cannot be achieved on the basis of phonological analysis alone. When spelling in English and French, children need to learn to spell many words that contain inconsistent
orthographic patterns (e.g., knowing that the word *enough* contains the graphemes *gh* which correspond to /f/ in this particular case). According to Ehri (1989, 2005), lexical orthographic processing supports reading and spelling of familiar words directly from word specific representations stored in memory, as well as reading and spelling unfamiliar words through analogy to words already stored in memory.

Furthermore, there was a bidirectional cross-language relationship between orthographic processing and spelling in Grade 2 and Grade 3, after controlling for the effects of age, non-verbal ability, phonological awareness, and within-language orthographic processing. This finding further supports the notion that orthographic processing is not purely language-specific as suggested by Abu-Rabia (2001). It is possible that orthographic processing operates across languages that share similar structural features, such as a common alphabet, as predicted by the Contrastive Analysis Hypothesis (Lado, 1957). Further, it is interesting to compare the cross-language transfer in Study 1 to that of Study 2. In Study 1, French orthographic processing explained a unique variance in English spelling in Grade 1 French immersion children, whereas in Study 2, both English and French orthographic processing were significantly related to spelling in the other language in Grade 2 and Grade 3. These differences in the cross-language transfer of orthographic processing to spelling indicate that children’s increased exposure to English in Grade 2 and 3, and subsequently, increased understanding about the English orthographic patterns, support in the transfer of this skill to French spelling. Additionally, it is also critical to note the differences in the amount of students who speak a language other than English at home in the two studies. In Study 1, approximately 40% of the participants speak a language other than English at home most
of the time, whereas in Study 2, it was approximately 17% of the participants. It is possible that the smaller percentage of children who speak a language other than English at home most of the time in Study 2 might have resulted in less variability in English orthographic processing, leading to the findings of a bidirectional cross-language transfer in Study 2 and not in Study 1.

A particularly interesting aspect of Study 2 was that we assessed the temporal relationship between orthographic processing and spelling with a longitudinal design. While many past cross-sectional studies have shown that individual differences in orthographic processing contribute to reading and spelling in monolingual and bilingual children (e.g., Arab-Moghaddam & Sénéchal, 2001; Conrad et al., 2012; Deacon et al., 2009, 2011, 2013; Sun-Alperin & Wang, 2011), the correlational nature of these studies do not tell us about the direction of the relationship.

Following on Deacon et al. (2012) and Pasquarella et al. (in press), we used a cross-lagged design with autoregressive controls to investigate the longitudinal relationship between orthographic processing and spelling in both English and French. The results showed that English spelling in Grade 2 predicted progress in acquiring English orthographic processing in Grade 3, after controlling for the autoregressor of English orthographic processing in Grade 2, and age, non-verbal ability, and phonological awareness. We also found that English spelling in Grade 2 was associated with gains in French orthographic processing in Grade 3, after accounting for the autoregressor, French spelling in Grade 2 (as the within-language control), and the same set of substantive controls. Orthographic processing in Grade 2 did not determine growth in spelling in either English or French. The finding that orthographic processing was the
outcome, and not the predictor of spelling extends the results of Deacon et al. (2012) and Pasquarella et al. (in press) who investigated the relationship between orthographic processing and word reading. Our results are consistent with prominent theories on reading and spelling development (Ehri, 1989, 2005; Frith, 1985) which hold that children develop orthographic representations of individual words through experience with print. It is imperative to note that because the children in Study 2 decreased in English spelling performance from Grade 2 to 3, it was not surprising that orthographic processing in either English or French did not predict growth in English spelling between Grade 2 and 3. Additionally, the cross-language transfer from English spelling to French orthographic processing suggests that the opaque nature of English encourages the learners to adopt a deeper level of processing of letter combination and their sequence during spelling, which in turn, encourages the development of orthographic processing skills both within and across languages. The lack of a relationship between early French spelling and later English orthographic processing implies that the more consistent nature of French orthography may require less processing of orthographic patterns and their position within words, resulting in the limited predictive power of French spelling to orthographic processing within and across languages.

In Study 3, we conducted an in-depth error analysis of the English and French spelling of the Grade 3 children in Study 2. While there was evidence that children used their knowledge of the orthographic patterns in one language to spell in the other language, we observed negative correlations between English spelling in Grade 3 and both the proportion of transfer errors in English and French, which do not align with the
findings in Study 2. Our results suggest that it may be difficult to know which orthographic patterns are unique to English and French during spelling.

Taken together, the current research contributes to the existing literature in three ways. First, the orthographic processing skill in young bilingual children attending an early total French immersion supported their spelling within each of English and French in Grades 1, 2, and 3. Second, the finding of a cross-language relationship between orthographic processing and spelling provides support for the idea that orthographic processing is not purely language-specific when the languages under acquisition share the same alphabet. Lastly, this study illustrated novel evidence of the longitudinal role of spelling in orthographic processing.

And yet, we remain wary of drawing too heavily on our findings in part due to the dynamic construct of orthographic processing. While we referred orthographic processing skills as the understanding of how words are spelled and of the orthographic conventions used in a writing system (Cunningham & Stanovich, 1990), there is substantial inconsistency with which orthographic processing has been defined. Within in the literature, some researchers focus on the ability to store information about orthographic patterns. To illustrate, it has been defined as “the ability to represent the unique array of letters that defines a printed word, as well as general aspects of the writing system, such as sequential dependencies, structural redundancies, letter position frequencies, and so forth” (Vellutino, Scanlon and Tanzman, 2004, p. 314), and “legal symbols and patterns within words” (Mather & Goldstein, 2008, p. 369). Others view orthographic processing skill as access to word-specific representations. For example, Szeszulski and Manis (1990) suggested that orthographic processing “allows direct
access to a mental lexicon for familiar words based on their unique orthography” (p. 182) and Frith (1985) defined it as the skill to “[analyze] words into orthographic units without phonological conversion” (p. 306). The tasks used to assess orthographic processing reflect these various definitions, including lexical (e.g., *dream*-*dreem*) and sublexical (e.g., *feep*-*fiip*) orthographic choice, exception word reading (e.g., yacht, eye), lexical decision, and spelling production tasks. Within our own work, we have illustrated a small portion of the multidimensional component of orthographic processing and as such, this may have precluded us from gaining a more in-depth examination of the relationships between orthographic processing and spelling skills.

**Educational Implications**

There are several educational implications that emerge from our study. First, it is imperative for French immersion teachers to know that their students possess skills that can be transferred to support the development of orthographic processing and spelling. Educators can teach the students about the orthographic structures in English and French orthographies during reading and spelling instruction. Second, the evidence of cross-language relationships in children learning two languages with the same Roman letter suggests that it might be easier to acquire orthographic processing and spelling skills for children learning languages that are represented with the same script than those whose languages do not. Finally, teachers and parents would benefit from recognizing that young French immersion children make transfer errors in their spelling as a result of applying orthographic rules that are specific to either English or French. Rather than classifying these transfer errors as incorrect, it may be helpful to draw attention to the similarities and differences in orthographic patterns in English and French.
Limitations and Future Directions

There are several limitations that need to be considered in future research. To start, there is some controversy involved with the tasks used to assess orthographic processing. Burt (2006) and Castles and Nation (2006) argued that the lexical orthographic processing task which requires children to choose between alternative spellings for a target word (e.g., *dream*- *dreen*) actually measures reading achievement and not orthographic processing. To address this issue, the regression analyses can include controls for word reading when examining the relationship between orthographic processing and spelling. Additionally, it has been proposed that a more accurate assessment of orthographic processing skill is the use of sublexical measures, which require children to choose between alternative spellings for a pseudoword (e.g., *feep*- *fiip*; Cassar & Treiman, 1997). Also in line with this suggestion, a pseudoword spelling task may be a better indicator of orthographic processing skills than real word spelling. When spelling real words, children can rely on memorization to spell the words correctly. On the other hand, the pseudoword spelling task requires the spellers to use targeted letter combinations in the appropriate position to spell the words. By incorporating this task, it may be more apparent to observe children’s understanding of the orthographic patterns and rules. The issues with the measures might also explain, at least to some extent, the lack of a longitudinal relationship between French spelling and French orthographic processing in Study 2.

Second, a large majority of the children in our study have come from middle or high SES families; over 90% of the mothers have completed at least a university degree. While French immersion students tend to come from higher SES backgrounds (Allen,
the SES backgrounds of our sample of students may be particularly too high for
the results to generalize to the French immersion population as a whole. Future studies
should recruit children from a broader range of SES backgrounds. Another limitation is
that Study 2 (and Study 3) involved a relatively small sample. While our sample size was
adequate for the linear regression analyses that we conducted, a larger sample size should
be used to replicate and confirm the relationships uncovered in the current study.

Finally, our sample consisted of a considerable amount of multicultural children
who speak a language that is neither English nor French at home. Although our study is
consistent with the increasing diversity of immersion student population in Canada (e.g.,
Swain & Lapkin, 2005), the inclusion of multicultural children may have resulted in
more variability in the English skills in the sample. A more homogeneous sample of
children might provide a clearer picture of the nature of the relationship between
orthographic processing and spelling in English and French.

Conclusion

Overall, the research presented in this thesis demonstrated the concurrent and
longitudinal relationships between orthographic processing and spelling in young
bilingual children attending an early total French immersion program. Concurrently, both
Study 1 and Study 2 were consistent in the significant within-language relationships
between orthographic processing and spelling in English and French. In Study 1 and
Study 2, we also found evidence that orthographic processing may not be entirely
language-specific. The cross-language transfer of orthographic processing to spelling was
observed from French to English in Study 1 with Grade 1 children, whereas in Study 2, it
was from French to English and from English to French with Grade 2 and 3 children.
Longitudinally, English spelling in Grade 2 predicted gains in English and French orthographic processing in Grade 3. In Study 3, an in-depth examination of the spelling errors showed that Grade 3 French immersion children made transfer errors when spelling in English and French. Taken together, the current research enhances our understanding of the nature of the relationships between orthographic processing and spelling in young French immersion children.
Appendix A

Lexical Orthographic Processing Task

Practice Items

Circle the correct spelling

A bowl-boal
B. wroat-wrote

Encercle le mot qui est épelé correctement

A. lyvre-livre
B. genou-jenou

Note that * represents those items added to the task in Grade 3 (Study 2 only)

English task


French task

Appendix B

English Spelling Task (with contextual sentence)

Note that * represents those items added to the task in Study 2 (Grade 2 and Grade 3)

1. Go The children want to go home.
2. Cat A cat has fur.
3. Boy The boy likes to swim
4. Run Jean can run fast.
5. Will They will wait for you.
6. Cut My mother cut the cake.
7. Arm His arm hurts.
8. Dress The dress fits well.
9. Shout If you shout, she will hear you.
10. Train The train was on time.
11. Grown Potatoes are grown in many countries.
12. Watch My watch is fast.
13. Explain He tried to explain his problem.
14. Kitchen Our kitchen is very small.
15. Result Your success is the result of hard work.
16. Mountain The mountain road is sleep.
17. Educate Schools serve to educate people.
18. Purchase She did not purchase the car.
19. Institute The art institute held an exhibit.
20. Equipment The office manager bought some new equipment.
21. Museum* We spent the afternoon at the museum.
22. Suggestion* They followed my suggestion.
23. Occupy* That hobby will occupy all of your time.
24. Yield* The employer refused to yield to the worker’s demands.
25. Familiar* We are very familiar with that neighbourhood.
26. Illogical* His thinking was illogical.
27. Physician* She became a physician to heal the sick.
28. Appropriation* The school district received an appropriation for new textbooks.
29. Prejudice* Prejudice among people is an attitude that society will not tolerate.
30. Commission* The commission reported to the mayor.
Appendix C

**French Spelling Task** (with contextual sentence)

Note that * represents those items added to the task in Study 2 (Grade 2 and Grade 3)

1. **Lave**  
   Pierre se **lave** les mains.
2. **Malade**  
   Hier, elle était **malade**.
3. **Sa**  
   Sa robe est très longue.
4. **Banane**  
   Je mange une **banane**.
5. **Lui**  
   Le joueur **lui** lance la balle.
6. **Carte**  
   Cette **carte** routière n’a pas de ligne.
7. **Bas**  
   J’ai un trou dans mon **bas**.
8. **Blanche**  
   La belle neige **blanche** tombe ce matin.
9. **Jupe**  
   Elle aime sa **jupe** rose.
10. **Chanteur**  
    Le **chanteur** apprend une mouvelle chanson.
11. **Chaleur**  
    Le soleil donne de la **chaleur**.
12. **Semaine**  
    Il y a sept jours dans une **semaine**.
13. **Armoire**  
    Le papier est dans l’**armoire**.
14. **Jolie**  
    La femme est très **jolie**.
15. **Métal**  
    Les contenants sont faits en **métal**.
16. **Source**  
    Le pétrole est une **source** d’énergie.
17. **Saluer**  
    Le soldat a oublié de **saluer** son capitaine.
18. **Organiser**  
    Il faut **organiser** la fête de Marie un peu mieux.
19. **Bruit**  
    La roué du camion fait du **bruit**.
20. **Album**  
    Les timbres sont dans l’**album**.
21. **Jardinier***  
    Le **jardinier** plante ses fleurs.
22. **Exploitation***  
    L’**exploitation** des forêts apporte une richesse à notre pays.
23. **Confédération***  
    Le Canada est une **confédération**.
24. **Odeur***  
    Cette **odeur** me fait touser.
25. **Surveiller***  
    Le professeur doit **surveiller** ses élèves.
26. **Frapper***  
    Il faut **frapper** avec le marteau.
27. **Chasse***  
    Le **chasseur** chasse le lièvre.
28. **Épinette***  
    Le fermier plante une **épinette** jaune.
29. **Puissant***  
    Le moteur est très **puissant**.
30. **Fructueuse***  
    La vente de poissons est **fructueuse**.
### Appendix D

#### Transfer Error Coding Scheme\(^6\) – English Spelling

<table>
<thead>
<tr>
<th>English Spelling</th>
<th>Transfer Error</th>
<th>Other error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Applies to all:</td>
<td>(Treiman, 1993)</td>
</tr>
<tr>
<td></td>
<td>*Final letter ending in –s (excluding #8 and 18)</td>
<td>- <strong>Primitive errors:</strong></td>
</tr>
<tr>
<td></td>
<td>*Final letter ending in –d (excluding #24)</td>
<td>- Visual letter confusion (b/d, q/p)</td>
</tr>
<tr>
<td>1. Go /gou/</td>
<td>- /ɔl/: eau, eaux, aux, ð, os, ot</td>
<td>- Random letters</td>
</tr>
<tr>
<td>2. Cat /kæt/</td>
<td>- Final /-l/: -tte, -ttes, -ttent, -the</td>
<td>- <strong>Consonant errors:</strong></td>
</tr>
<tr>
<td>3. Boy /bɔi/</td>
<td>- Not possible</td>
<td>- Silent consonant omitted (wach = watch)</td>
</tr>
<tr>
<td>4. Run /rən/</td>
<td>- Final /-n/: -nne, -nnes, -nnent</td>
<td>- Silent consonant attempted (educait = educate)</td>
</tr>
<tr>
<td>5. Will /wɪl/</td>
<td>- Final /-l/: -lle, -lles (e.g., wille)</td>
<td>- <strong>Vowel error:</strong></td>
</tr>
<tr>
<td>6. Cut /küt/</td>
<td>- Final /-l/: -tte, -ttes, -ttent, -the</td>
<td>- Silent part of vowel omitted (educait = educate)</td>
</tr>
<tr>
<td>7. Arm /arm/</td>
<td>- Initial /a/ : h- (silent ‘h’, e.g., harme)</td>
<td>- Vowel omission (trn = train)</td>
</tr>
<tr>
<td>8. Dress /drɛs/</td>
<td>- Final /-s/: -sse, -sses (e.g., dresse), -ssent</td>
<td>- Related vowel substitution (wel = will)</td>
</tr>
<tr>
<td>9. Shout /ʃaʊt/</td>
<td>- Initial /ʃ-/: ch- (e.g., chout)</td>
<td>- <strong>Other:</strong></td>
</tr>
<tr>
<td>10. Train /trɛn/</td>
<td>- Final /-l/: -tte, -ttes, -ttent, -the</td>
<td>- Intrusions (camt = cat)</td>
</tr>
<tr>
<td>11. Grown /grʊn/</td>
<td>- /ɔl/: eau, eaux, aux, ð, os, ot</td>
<td>- Reversal of phonemes in words (byo = boy)</td>
</tr>
<tr>
<td>12. Watch /wɔtʃ/</td>
<td>- Final /-n/: -nne, -nnes, -nnent</td>
<td>- Over-pronunciation (arme = arm)</td>
</tr>
<tr>
<td>13. Explain /ɪkˈsplɛn/</td>
<td>- /ɔ/ : è, ez</td>
<td>- Same language homophone (groan = grown)</td>
</tr>
<tr>
<td>14. Kitchen /ˈkɪtʃən/</td>
<td>- Final /-n/: -nne, -nnes, -nnent</td>
<td></td>
</tr>
<tr>
<td>15. Result /rɪˈzʌlt/</td>
<td>- /ɔz/ : ss</td>
<td></td>
</tr>
<tr>
<td>16. Mountain /ˈmaʊntn/</td>
<td>- Final /-n/: -nne, -nnes, -nnent</td>
<td></td>
</tr>
<tr>
<td>17. Educate /ˈɛdʒət/</td>
<td>- Initial /ɛ/: ë, ë (e.g., ëgukêt)</td>
<td></td>
</tr>
<tr>
<td>18. Purchase /ˈpɜːtʃəs/</td>
<td>- Final /-s/: -sse, -sses (e.g., purchesse), -ssent</td>
<td></td>
</tr>
<tr>
<td>19. Institute /ˈɪnstɪtʃʊt/</td>
<td>- Final /-l/: -tte, -ttes, -ttent, -the</td>
<td></td>
</tr>
<tr>
<td>20. Equipment /ˈkwɪpment/</td>
<td>- /ɔl/: -ou</td>
<td></td>
</tr>
<tr>
<td>21. Museum /ˈmjuːziəm/</td>
<td>- Final /-l/: -mne, -mmes, -mment</td>
<td></td>
</tr>
<tr>
<td>22. Suggestion /ˈsæɡˈdʒestʃən/</td>
<td>- Final /-l/: -mne, -mmes, -mment</td>
<td></td>
</tr>
</tbody>
</table>

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\(^6\) The following sources were used to determine the transfer errors in English spelling: Ewert (1933), Hall (1961), Hill and Ure (1962), Loiseau (1980), and Valdman (1976).
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **23. Occupy**  
/ˈɒkɪə.pau/ | -  
/kəː: quə |   |
| **24. Yield**  
/yild/ | -  
Final /-dəl/: -des, -dent |   |
| **25. Familiar**  
/faˈmɪlɪər/ | -  
Not possible |   |
| **26. Illogical**  
/iˈlɒdʒɪkəl/ | -  
/kəː: quə |   |
| **27. Physician**  
/ˈfɪzɪʃən/ | -  
/ch (e.g., fasichin)  
Final /-nəl/: -nne, -nnes, -nnent |   |
| **28. Appropriation**  
/ə.prəˈproprɪ.eʃən/ | -  
/ch (e.g., apropiatchan)  
Final /-nəl/: -nne, -nnes, -nnent |   |
| **29. Prejudice**  
/prɛdʒədɪs/ | -  
Final /-səl/: -sse, -sses, -ses (e.g., prejitesse), -sent, -ssent,  
/ɛl/: ẽ, ê |   |
| **30. Commission**  
/ˈkərɪməʃən/ | -  
/ch (e.g., comichan)  
Final /-nəl/: -nne, -nnes, -nnent |   |
### Appendix E

Transfer Error Coding Scheme\(^7\) – French Spelling

<table>
<thead>
<tr>
<th>French Spelling</th>
<th>Transfer Error</th>
<th>Other Errors (Treiman, 1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lave /lav/</td>
<td>- Not possible</td>
<td>- <strong>Primitive errors:</strong></td>
</tr>
<tr>
<td>2. Malade /malad/</td>
<td>- Final /-d/: no ‘e’ (e.g., malad)</td>
<td>- Visual letter confusion (b/d, q/p)</td>
</tr>
<tr>
<td>3. Sa /sa/</td>
<td>- Not possible</td>
<td>- Random letters</td>
</tr>
<tr>
<td>4. Banane /banan/</td>
<td>- Final /-n/: n (e.g., banan)</td>
<td>- <strong>Consonant errors:</strong></td>
</tr>
<tr>
<td>5. Lui /lui/</td>
<td>- Final /-i/: ends in e, ea, ee (e.g., lue, oea)</td>
<td>- Silent consonant attempted (bas = bac)</td>
</tr>
<tr>
<td></td>
<td>* -ie ending is NOT a transfer (e.g., louie)</td>
<td>- Silent consonant omitted (bas = ba)</td>
</tr>
<tr>
<td>6. Carte /kart/</td>
<td>- Final /-t/: ends in –t (e.g., cart, kart)</td>
<td>- Consonant omission (jue = jupe)</td>
</tr>
<tr>
<td>7. Bas /ba/</td>
<td>- Not possible</td>
<td>- Phonetic letter confusion (l/f, v/d)</td>
</tr>
<tr>
<td>8. Blanche /blâʃ/</td>
<td>- /ʃ/: spelled sh (e.g., blansh, blanshe)</td>
<td>- <strong>Vowel error:</strong></td>
</tr>
<tr>
<td>9. Jupe /ʒyp/</td>
<td>- Final /-p/: ends in –p (e.g., jup, joup)</td>
<td>- Vowel omission (crte = carte)</td>
</tr>
<tr>
<td>10. Chanteur /ʃɑtœʁ/</td>
<td>- Initial /ʃ/-: spelled sh (e.g., shanter, shtr)</td>
<td>- Related vowel substitution (jarden)</td>
</tr>
<tr>
<td>11. Chaleur /ʃalœʁ/</td>
<td>- Initial /ʃ/-: spelled sh (e.g., shadler)</td>
<td>- Reversal of phonemes in words (joi = joli)</td>
</tr>
<tr>
<td>12. Semaine /s(ə)men/</td>
<td>- Final /-n/: spelled n (e.g., semain, cemen)</td>
<td>- Over-pronunciation (albume = album)</td>
</tr>
<tr>
<td>13. Armoire /armwar/</td>
<td>- /w/: w</td>
<td>- Same language homophone (ça = sa)</td>
</tr>
<tr>
<td>14. Joli /ʒoli/</td>
<td>- Final /-i/: ends in e, ea, e (e.g., jolea, jolle, jolee)</td>
<td></td>
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<tr>
<td></td>
<td>/li/: ends in ly (e.g., joly)</td>
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<tr>
<td>15. Métal /metal/</td>
<td>- Final /-l/: ends in ll (e.g., metal)</td>
<td></td>
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<tr>
<td>16. Source /sœrs/</td>
<td>- /u/: oo</td>
<td></td>
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<tr>
<td></td>
<td>- Final /-s/: ends in s, ss, (e.g., sour, sors)</td>
<td></td>
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<tr>
<td>17. Saluer /sâluʁ/</td>
<td>- Final /-el/: ay, eigh</td>
<td></td>
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<tr>
<td>18. Organiser /ɔrganizer/</td>
<td>- /i/: ee, ea, e (e.g., organeesey)</td>
<td></td>
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<tr>
<td></td>
<td>- Final /-el/: ay, eigh</td>
<td></td>
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<tr>
<td>19. Bruit /bruʁ/</td>
<td>- Final /-i/: ends in –ee, ea, e (e.g., bre, briele)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>* -ie ending is NOT transfer (e.g., brue)</td>
<td>-</td>
</tr>
<tr>
<td>20. Album /albom/</td>
<td>- Not possible</td>
<td>-</td>
</tr>
<tr>
<td>21. Jardinier /ʒaʁdineʁ/</td>
<td>- /i/: -ee, ea, e (e.g., jardin)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Final /-el/: ay</td>
<td>-</td>
</tr>
<tr>
<td>22. Exploitation</td>
<td>- /w/: w</td>
<td></td>
</tr>
</tbody>
</table>

\(^7\) The following sources were used to determine the transfer errors in English spelling: Ewert (1933), Hall (1961), Hill and Ure (1962), Loiseau (1980), and Valdman (1976).
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>23. Confédération /kɔfederəsjo/</td>
<td>Not possible</td>
</tr>
<tr>
<td>24. Odeur /ɔdœr/</td>
<td>Not possible</td>
</tr>
<tr>
<td>25. Surveiller /syrveje/</td>
<td>Not possible</td>
</tr>
<tr>
<td>26. Frapper /frape/</td>
<td>Final /-e/ : ay, eigh</td>
</tr>
<tr>
<td>27. Chasse /fas/</td>
<td>Initial /f/- : sh (e.g., shase)</td>
</tr>
<tr>
<td></td>
<td>Final /-s/- : -s, -ss, -se (e.g., chase)</td>
</tr>
<tr>
<td>28. Épinette /epinet/</td>
<td>Final /-t/ : -t (e.g., epinet)</td>
</tr>
<tr>
<td></td>
<td>/ɪ/ : ee, ea, e</td>
</tr>
<tr>
<td>29. Puissant /pɥisɑ̃/</td>
<td>Not possible</td>
</tr>
<tr>
<td>30. Fructueuse /fɾyktɥøz/</td>
<td>Final /-z/ : -s (e.g., frktueus)</td>
</tr>
</tbody>
</table>
References


