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Cross-language transfer of orthographic processing skills: a study of French children who learn English at school

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This study explores the nature of orthographic processing skills among French-speaking children in Grades 6 and 8 who are learning English at school as a second language (L2). Two aspects of orthographic processing skills are thought to form a convergent construct in monolingual beginning readers: word-specific knowledge (e.g. *rain-rane*) and sensitivity to sub-lexical regularities (e.g. *schoal-sckoal*). The present study examines these components in the first language (L1) reading of older children and charts the cross-language transfer of orthographic skills during the first 3 years of L2 learning. Word-specific orthographic knowledge in L2 correlates with L1 reading speed and results reveal direct cross-language transfer for this component of orthographic processing skill. However, no evidence is found for transfer of sensitivity to sub-lexical regularities. The concept of cross-language transfer in relation to these different components of orthographic processing is discussed with reference to L1 and L2 literacy skills in this school acquisition context.

Learning a second language (L2) at secondary school has become mandatory in most industrialised countries. This context of L2 learning has received far less attention than children who learn an L2 due to family (linguistic) background or who attend immersion programmes. Children learning English at French secondary schools receive from 3 to 4 hours of English teaching per week.[1] In this academic teaching context, exposure to the L2 spoken language is very limited and thus the importance of written language in determining exposure to L2 is probably greater than in any other learning context. Many

questions arise in this context of L2 learning, including how children come to construct effective procedures that constitute reading in L2, such as orthographic processing and how these relate to existing first language (L1) skills.

Two aspects of reading have received particular attention in monolingual research: (1) the procedures involved in reading such as a nonlexical phonological route based on orthography-to-phonology conversion and a lexical orthographic route involving the use of the orthographic form of a word to access the mental lexicon (e.g. Coltheart, Rastle, Perry, Langdon & Ziegler, 2001); and (2) the reading-related skills that contribute to reading progress (e.g. phonological awareness; for a review, see Goswami & Bryant, 1990).

Most of L2 research has focused on investigating whether variables commonly described as reading predictors in one language could contribute to reading achievement in another language. This approach, commonly referred to as *cross-language transfer*, has been motivated by the question of the language-general versus language-specific nature of the processes engaged in L2 literacy development (Durgunoğlu, 2002; Geva, 2000; see Lesaux, Koda, Siegel & Shanahan, 2006 for a review).

Our aim was to investigate those skills related to the lexical orthographic procedure of reading: orthographic processing skills or the 'ability to form, store and access orthographic representations' further termed as *lexical* orthographic processing (Stanovich & West, 1989, p. 414). Our approach was to examine whether this ability, developed in the L1, directly contributes to the same ability in an L2. Moreover, in an attempt to understand the processes that underlie orthographic processing, sensitivity to the orthographic regularities of a language, referred to here as *sub-lexical* orthographic processing for greater clarity, was examined as a potentially specific predictor of orthographic processing skills (Castles & Nation, 2006).

Thus, the present study will directly investigate the contribution from L1 to L2 of both measures of *lexical* and *sub-lexical* orthographic skills, and therefore test the language-general versus language-specific nature of these processes.

Transfer of reading and associated skills

In L2 research, two major hypotheses have been offered to describe the relationship between L1 and L2 skills. In the 'linguistic interdependence hypothesis' proposed by Cummins (1979), the general metalinguistic processes that underlie L1 literacy acquisition become available when learning an L2. Alternatively, the 'script-dependent hypothesis' proposes that the characteristics of the script may imply different processes underlying L1 and L2 literacy acquisition (Geva & Siegel, 2000; Gholamain & Geva, 1999; see Koda, 2007 for a review).

A substantial body of evidence from immersion studies shows transfer of reading skills across languages for English learners whose L1: (1) shares the same alphabet as in the case of Spanish (Durgunoğlu, Nagy & Hancin-Bhatt, 1993; Lindsey, Manis & Bailey, 2003), Italian (D'Angiulli, Siegel & Serra, 2001), French (Deacon, Wade-Woolley & Kirby, 2009), Dutch (Morfidi, Van der Leij, De Jong, Scheltinga & Bekebrede, 2007) and Portuguese (Da Fontoura & Siegel, 1995); (2) is also alphabetic but has different characters as in the case of Russian (Abu Rabia, 2001), Arabic (Abu Rabia & Siegel, 2002), Hebrew (Geva & Siegel, 2000; Geva, Wade-Woolley & Shany, 1997) and Korean (Wang, Park & Lee, 2006); or (3) is nonalphabetic and has a different script as in the case of Chinese (Gottardo, Yan, Siegel & Wade-Woolley, 2001; Wang, Perfetti & Liu, 2005).

In examining cross-language predictors of reading, phonological awareness, whose role in monolingual reading acquisition is well established (see Goswami & Bryant, 1990 for a review), has been shown to correlate across languages. L1 phonological processing skills have been reported to predict significant variance in L2 reading skills for both same-alphabet language pairings (Anthony et al., 2009; Cisero & Royer, 1995; Comeau, Cormier, Grandmaison & Lacroix, 1999; Da Fontoura & Siegel, 1995; Durgunoğlu et al., 1993) and different-alphabet pairings (Abu Rabia, 2001; Gottardo et al., 2001; Gottardo, Chiappe, Yan, Siegel & Gu, 2006; Xuereb, 2009). Thus, phonological processing skill has been identified as a language-general skill that can contribute to L1 as well as to L2 literacy acquisition.

The issue of cross-language transfer of orthographic processing skill to reading has been examined far less in the literature. Unlike phonological processing skills, orthographic processing has been thought to be language specific and not to transfer across languages, or at least not until a sufficient amount of experience with print has accumulated. Indeed, many studies have failed to find correlations between L1 and L2 orthographic processing skills (Abu Rabia, 2001; Arab-Moghaddam & Sénéchal, 2001; Gottardo et al., 2001; Wang et al., 2005, 2006).

However, all of these studies examined English L2 learners whose L1 either had a different script (Chinese) or a different alphabet (Persian, Russian, Persian, Korean or Arabic), raising the question of what happens when both L1 and L2 share the same alphabet. To our knowledge, this issue has been addressed in only one study by Deacon et al. (2009), who assessed Grade 2 English speakers attending French immersion classes. They investigated reading skills (isolated word reading) in both languages as well as reading-related variables such as phonological awareness, morphological awareness and lexical orthographic processing skills. The authors used the orthographic choice task to assess lexical orthographic skills, in which the participant must discriminate the correct spelling of a word from its pseudohomophone (e.g. *rain* vs *rane*). Significant correlations across languages were observed. Moreover, each of these variables correlated with both L1 and L2 reading. Regression analyses indicated that orthographic skills were a significant predictor of within-language reading over and above verbal and nonverbal ability and within-language phonological and morphological awareness. More importantly for our purposes, orthographic skills from one language predicted reading from the other language, after controlling for the variables described above and orthographic skills from this other language. Therefore, orthographic processing skills have been shown to contribute to reading both within and across languages and in a bidirectional manner from L1 to L2, as well as from L2 to L1.

Orthographic processing skills

Our goal was to examine orthographic processing per se as related to the lexical orthographic procedure involved in reading and to test whether this ability could directly transfer from L1 to L2. The orthographic choice task (e.g. *rain* vs *rane*) is regarded as a test of lexical orthographic processing because word-specific orthographic knowledge is necessary to distinguish between the homophonic foil and the target word (Olson, Wise, Conners, Rack & Fulker, 1989). One ability that has been suggested as a potential-specific predictor of lexical orthographic skills is the sensitivity to the orthographic regularities of a language (Castles & Nation, 2006), in other words, 'children's sensitivity

to graphotactic conventions' used in their language (Deacon, Conrad & Pacton, 2008, p. 120) or termed here *sub-lexical* orthographic processing. For example, participants might be asked which of two pseudowords is more word-like (e.g. *daik* or *dayk*). A number of studies of the development of sub-lexical orthographic processing have reported early sensitivity to regularities such as the position and identity of doublet consonants or vowels, and the onset/coda context surrounding vowels and consonants in French (Pacton, Fayol & Perruchet, 2002, 2005; Pacton, Perruchet, Fayol & Cleeremans, 2001) and in English (Cassar & Treiman, 1997; Hayes, Treiman & Kessler, 2006; Treiman & Kessler, 2006; see Deacon, Conrad & Pacton, 2008 for a review of both French and English findings).

Surprisingly, only a few studies have investigated the links between lexical and sub-lexical orthographic processing skills in L1 (Burt, 2006; Cunningham, Perry & Stanovich, 2001; Georgiou, Parrilla & Kirby, 2009; Pacton, Fayol & Lété, 2008). Similarly, there is a need for clarity about whether sub-lexical orthographic processing may be considered as a unitary skill or whether findings depend on the specific regularity under study. This question is directly related to the issue of its language-general versus language-specific nature. If orthographic sensitivity is driven by a mechanism that enables the encoding of abstract orthographic structures, this ability might be language-general, in other words, a (meta-)cognitive skill for deriving the regularities in any language, or at least in any same-alphabet language pairing. However, if this skill strongly depends on the specific L1 regularity under study, this would cast doubt on its generalisability and on the potential for transfer of this skill across languages. An alternative possibility is that some combination of these two positions might hold with the likelihood of transfer depending on the actual regularity under study and the overlap in structure between the two languages. We suggest that by manipulating the language typicality of the sub-lexical regularities under study it may be possible to gain a better understanding of the conditions for transfer, and hence, of the nature of the underlying skills.

The present study

Our study in the school learning context had two aims in investigating the cross-language transfer of orthographic processing skills: (1) to examine the direct contribution of lexical orthographic skills from L1 to L2; and (2) to explore the transfer between these languages of knowledge about sub-lexical orthographic regularities which vary in L1 and L2 typicality.

It has been usual in the literature to assess transfer by examining whether a given reading-related skill (such as phonological awareness) in one language predicts reading achievement in the other language after controlling for the reading-related skill in that language. As our first aim indicates, the present study focused instead on the transfer of the reading-related skill itself across languages, and in particular, on the transfer of lexical orthographic skills. Thus, we intended to examine whether the ability to store lexical orthographic forms that children have developed in L1 contributes to the same ability when learning an L2.

To fulfil our second aim, different categories of items were constructed for the L2 sub-lexical orthographic task in order to assess the following aspects of knowledge: (1) discrimination between L1 and L2 orthographic patterns; (2) discrimination between orthographically legal and illegal patterns in the L2; and (3) sensitivity to a deeper L2-specific regularity, namely consonant doubling.

Given the context of L2 acquisition of our study, proficiency and decoding were also considered. Indeed, achieving a certain level of L2 proficiency has been recognised as a key factor in considering literacy transfer as suggested by the concept of 'linguistic threshold' (Cummins, 2000). L2 proficiency might be expected to explain differences in orthographic processing as the more a word is encountered during reading, the more likely is its spelling to be known (Cunningham & Stanovich, 1990, 1991; see also Asfaha, Beckman, Kurvers & Kroon, 2009; Morfidi et al., 2007 for evidence in, respectively, Eritrean and Dutch children learning English). In addition, decoding skills have been shown to be relevant in predicting lexical orthographic skills in monolingual studies (Bowey & Miller, 2007; Cunningham, 2006; Cunningham, Perry, Stanovich & Share, 2002; De Jong & Share, 2007; Kyte & Johnson, 2006), and so were also examined.

Therefore, the present study will investigate both lexical and sub-lexical orthographic transfer in a manner that is sensitive to the L2 vocabulary and decoding levels of our participants who are Grades 6 and 8 French-speaking children learning English at secondary school.

Method

Participants

Our participants came from two age groups: 45 Grade 6 children (mean age: 11 years and 6 months, *SD*: 3 months) and 45 Grade 8 children (mean age: 13 years and 6 months, *SD*: 5 months). These participants were randomly recruited using informed parental/school consent procedures from three schools located in Paris, France. All had French as their native language. Although formal teaching of English did not begin until secondary Grade 6, many children had some introduction to English at elementary school that led to variation in length of L2 exposure in each group (sixth graders: 3–12 months; eighth graders: 27–36 months).

Materials and procedure

Testing took place between November and February. In the first testing session, the L1 and L2 orthographic processing tasks and the L2 decoding task were administered collectively during an English lesson. In the second session, the L1 reading and L2 vocabulary tasks were administered individually. Administration order was identical for all of the children and instructions were given in L1 French to ensure correct understanding.

L1 reading skills. L1 (French) reading skills were assessed using the standardised reading test, L'Alouette-R (Lefavrais, 1965), which yields indices of reading accuracy and speed. The accuracy index is calculated from the number of correctly read words in relation to the total number of words in the text (265). The reading speed index is based on multiplying the number of correctly read words by 180 (i.e. the 180 seconds allowed to read the text) and dividing by the actual time the participant took to read it. The higher the scores, the better the performances.

Lexical orthographic skills. The task was orthographic choice where participants must distinguish the correct spelling of a word from its pseudohomophone (an English example

would be: *rain – rane*). This task measures word-specific orthographic knowledge as the pseudohomophone foils make a phonological decoding strategy ineffective.

L1 (French) lexical task. There were 48 item pairs. Pseudohomophone foils were constructed by varying the transcription of the /ã/ sound (e.g. ***vengeance*** vs *vangeance*),[2] the /o/ sound (e.g. ***poteau*** vs *potau*), the /s/ sound (e.g. ***acide*** vs *asside*) or by manipulating single versus double consonants (e.g. ***apaiser*** vs *appaiser*). The Kuder–Richardson Formula 20 (KR-20) for the task was .71.

L2 (English) lexical task. There were 32 item pairs based on high-frequency English target words which were likely to have appeared in the children's English schoolbooks. Pseudohomophone foils were constructed according to English grapheme-to-phoneme correspondence rules (e.g. *boat – bowt*). The KR-20 of the task was .67.

Sub-lexical orthographic skills. Participants were asked to choose which of two pseudowords was most word-like (an English example would be *schoal* vs *sckoal*). This task is designed to measure sensitivity to the orthographic regularities. For the response to be based purely on orthographic sensitivity, the pseudowords should be homophonic according to the decoding rules of the language. However, this condition was not always respected in the English version of the task due to manipulation of L1/L2 typicality.

L1 (French) sub-lexical task. Initially, three kinds of regularities were included in the task, in line with the lexical orthographic choice task: (1) transcription of the /ã/ sound, (2) transcription of the /o/ sound and (3) context-dependence of single versus doublet consonants. The first two of these regularities had to be discarded due to floor effects, and so the analysis and discussion of this task will be based solely on the 21 pseudoword pairs that assessed the context-dependence of single versus doublet consonants. The target grapheme occurred either at the beginning or the end of the word and the probability for the consonant to be single or doubled was calculated according to the preceding and following vowel. For example, the consonant 'c' tends to be doubled when it follows the vowel 'o' and precedes the vowel 'a', leading to the construction of item pairs such as the target '*occaphile*' and the foil '*ocaphile*'. Targets were considered as being shared by more words compared with the foil, and these word 'neighbours' had a higher cumulative frequency (Lexique 3.55, New, Pallier, Ferrand & Matos, 2001). Children were instructed to select the string of letters that was most word-like in French. The KR-20 was .52.

L2 (English) sub-lexical task. Participants were asked to choose which of two pseudowords looked most word-like in English. There were 20 pairs of items where the target pseudoword differed by one letter from a real English word ('*coard*' vs '*coardt*', where '*coard*' is based on the real word '*board*'). In Condition 1, the foils were more French-like than the targets, containing French typical strings (e.g. *leck* vs *leque*). In Condition 2, the foils were neither French-like nor English-like but contained some 'foreign' strings that were illegal in both orthographic systems (e.g. *schoal* vs *sckoal*). The items in Condition 3 were taken from Hayes, Treiman and Kessler (2006) and examined the tendency for certain final consonants in English (L2) to be single when following double complex vowels (e.g. *joaf* vs *joaff*) and doubled or clustered with another consonant when following single vowels (e.g. *saff* vs *saf* or *meck* vs *mek*). The KR-20 for the test as a whole was .51.

In summary, Condition 1 tested whether children could distinguish between L1 and L2 orthographic patterns (L1/L2 discrimination); Condition 2 assessed the precision of 'knowledge' about typical L2 complex graphemes (L2 legality); and Condition 3 tapped a

deeper sensitivity to L2 orthographic patterns where the constituent graphemes were not illegal in L2 (L2 graphemic patterns).

L2 vocabulary (proficiency). Productive vocabulary was measured by asking participants to translate 50 French words into their English counterparts. The task was administered in a written format and approximate spellings were accepted as long as the experimenter could recognise the word. The KR-20 was .96.

L2 decoding skills. Participants had to decide whether two pseudowords would be pronounced the same according to English grapheme-to-phoneme correspondence rules. The 18 pairs of items for which the answer was 'yes' were taken from Perry, Ziegler and Coltheart (2002, e.g. *plaime* vs *plame*). An equal number of 'no' items were constructed by the authors (e.g. *rike* vs *reak*). All of the stimuli were checked by a native English speaker as well as by a native French-speaking lecturer in English linguistics. The KR-20 of the task was .53.

Results

Means and standard deviations for all measures are presented for each grade level in Table 1. There were 20 missing data points ($<3\%$) in the entire data set, which were completed with means for the grade group for that measure. The scores in each test were statistically better than chance except for the English (L2) decoding performance of the Grade 6 children, $t<1$. For each measure, t tests indicated that Grade 8 children had significantly higher scores than the Grade 6 children.

A mixed design analysis of variance was used to examine the different categories of knowledge about orthographic structure in the L2 sub-lexical task. Condition (L1/L2 discrimination, L2 legality, L2 graphemic patterns) was the within-subjects factor and grade level (Grades 6, 8) the between-subjects factor. There was a main effect of grade, $F(1, 88) = 22.14$, $p<.001$ and condition, $F(2, 176) = 75.36$, $p<.001$. Post hoc tests using Bonferroni corrections revealed that L1/L2 discrimination was significantly better than assessments of L2 legality ($p<.001$), which in turn was better than knowledge of L2 graphemic patterns ($p<.001$). A slight trend for an interaction between condition and grade level was also observed, $F(2, 176) = 2.46$, $p = .09$. This reflected slower improvement from Grade 6 to Grade 8 in knowledge of L2 graphemic patterns as compared with L1/L2 discrimination and the ability to assess L2 legality.

Pearson correlational analyses are presented in Table 2 for each grade level. The correlations will be described in the sections to follow and, where appropriate, hierarchical multiple regression analyses will be used to address our research questions.

Before running the regression analyses, multicollinearity was checked (all tolerance values $>.71$). Interaction between reading-related independent variables further entered in the regression analysis and grade effect was tested to ensure that both grades could be analysed together (Tabachnick & Fidell, 2007). Each interaction term was computed as the product of each variable and grade as a coded vector. Each interaction term was run in a standard regression analysis simultaneously with all the other predictor variables. None of the interaction terms contributed variance in explaining L2 lexical orthographic processing beyond the other predictors (β values ranged from $-.18$ to $-.32$, all $ts<1$, *ns*) except for the interaction between vocabulary and grade whose β value reached

Table 1. Means and standard deviations for accuracy and speed of French reading, and for percentage accuracy of French and English lexical orthographic processing, French sub-lexical orthographic processing, the overall plus individual scores for the three conditions of English sub-lexical orthographic processing, English vocabulary and English decoding.

Measures	Grade 6	Grade 8	$t(88)$	p
French (L1) reading accuracy				
M	97.42	97.95	1.88	*
SD	1.40	1.23		
French (L1) reading speed				
M	350	403	2.83	**
SD	80	98		
French (L1) lexical orthographic (%)				
M	72.70	84.10	4.21	***
SD	0.16	0.09		
English (L2) lexical orthographic (%)				
M	69.10	84.90	7.08	***
SD	0.13	0.08		
French (L1) sub-lexical orthographic (%)				
M	58.80	64.80	1.96	*
SD	0.14	0.15		
English (L2) sub-lexical orthographic (%)				
Total				
M	77.70	85.50	4.79	***
SD	0.12	0.08		
Condition 1 (L1/L2 discrimination)				
M	82.90	97.40	4.07	***
SD	0.21	0.06		
Condition 2 (L2 legality)				
M	74.50	89.30	4.84	***
SD	0.17	0.10		
Condition 3 (L2 graphemic patterns)				
M	63.80	71.80	1.98	*
SD	0.15	0.16		
English (L2) vocabulary (%)				
M	30.00	64.90	10.38	***
SD	0.13	0.19		
English (L2) decoding (%)				
M	49.00	56.30	3.54	***
SD	0.10	0.10		

*$p<.05$; **$p<.01$; ***$p<.001$.

significance (β value: $-.56$, $t = 2.46$, $p = .02$). Because of the existence of a significant interaction, all analyses were run separately for each grade.

Cross-language transfer of lexical orthographic processing skills

English (L2) lexical orthographic processing skills correlated significantly with French (L1) reading speed in both Grades 6 and 8. Interestingly, L1 and L2 lexical orthographic skills were also strongly correlated for both groups. Cross-language transfer of lexical orthographic processing skills was examined in depth using a hierarchical regression analysis (see Table 3) for each grade group. English (L2) lexical orthographic processing was used as the criterion variable. French (L1) reading speed was entered as the first step followed by English (L2) vocabulary as the second step (to control for the influence of

Table 2. Pearson correlation matrices for all the variables for Grade 6 (lower panel) and Grade 8 (upper panel) samples.

Variables		1	2	3	4	5	6	6a	6b	6c	7	8
French (L1) reading accuracy	1	–	.481**	.263	.141	−.047	.160	.239	−.089	.235	.104	.134
French (L1) reading speed	2	.482**	–	.437**	.433**	.134	.116	.111	−.152	.254	.282	.180
French (L1) lexical orthographic	3	.217	.313*	–	.554***	.236	.260	.269	−.052	.354*	.421**	.294*
English (L2) lexical orthographic	4	.240	.307*	.468**	–	.134	.219	.182	.145	.172	.636***	.270
French (L1) sub-lexical orthographic	5	.279	.262	.580***	.172	–	.175	.087	.115	.162	.002	.182
English (L2) sub-lexical orthographic	6	.129	.028	.270	.386**	.076	–	.694***	.665***	.855***	−.010	.202
Total												
Condition 1	6a	.195	.316*	.429**	.398**	.154	.713***	–	.248	.582***	.072	−.155
Condition 2	6b	.135	−.078	.187	.295*	−.036	.908***	.545**	–	.220	−.033	−.221
Condition 3	6c	−.033	−.111	.033	.219	.105	.687***	.165	.472**	–	−.024	−.098
English (L2) vocabulary	7	.299*	.324*	.450**	.608***	.204	.277	.258	.261	.111	–	.360*
English (L2) decoding	8	.184	.141	.137	.302*	.119	.265	.290	.220	.114	.273	–

Note: Lower panel: Grade 6; upper panel: Grade 8.
*$p < .05$; **$p < .01$; ***$p < .001$.

proficiency). The last variable to be entered was the French (L1) lexical orthographic processing measure.[3]

Each control variable made a significant contribution to the variance in English (L2) lexical orthographic processing at both Grades 6 and 8. Therefore, after controlling for French (L1) reading and English (L2) vocabulary, French (L1) lexical orthographic processing was found to make a unique and significant contribution to English (L2) lexical orthographic processing in the older group but this effect did not achieve significance for the younger group. Collectively, the three predictor variables accounted for a significant 53% of the variance in L2 lexical orthographic skills among the Grade 8 children and 42% of the variance among the Grade 6 children.

Cross-language transfer of sub-lexical orthographic skills

The correlational analysis showed significant associations between the three measures of English (L2) sub-lexical orthographic processing that varied slightly across grade levels. Before addressing the issue of cross-language transfer, the relationship between sub-lexical orthographic processing and other reading-related measures within the same language will be examined.

In L1 French, sub-lexical orthographic processing correlated significantly with lexical orthographic processing skills for Grade 6 children only. Interestingly, sub-lexical skills

Table 3. Hierarchical multiple regression analysis to investigate whether French (L1) lexical orthographic processing predicts English (L2) lexical orthographic processing in Grades 6 and 8 after controlling for French (L1) reading speed and English (L2) vocabulary.

Step	Predictor variable	Criterion variable: English (L2) lexical orthographic			
		Grade 6 children		Grade 8 children	
		β	ΔR^2	β	ΔR^2
1	French (L1) reading speed	.000	.094*	.000	.187**
2	English (L2) vocabulary	.495	.288***	.184	.287***
3	French (L1) lexical orthographic	.184	.040ℜ	.243	.055*

Note: Values reported are unstandardised β coefficients and changes in R^2 as they are entered into the model.
*$p < .05$; **$p < .01$; ***$p < .001$.
ℜ$p = .10$.

did not correlate significantly with reading for any group. In L2 English, lexical orthographic processing correlated significantly with the composite score for sub-lexical orthographic processing for the younger children only. Note that the correlations were stronger between lexical knowledge and the sub-lexical L1/L2 discrimination and L2 legality conditions than with the L2 graphemic patterns condition. Surprisingly, L2 lexical and sub-lexical orthographic skills did not correlate among the older children. Interestingly, L2 sub-lexical orthographic skills did not correlate with other L2 measures (vocabulary, decoding) for either group.

To turn to cross-language transfer, L1 French sub-lexical orthographic knowledge did not show any significant correlation with the composite score for L2 English sub-lexical skills, nor with any of the three individual sub-lexical conditions for either group. The only hint of a cross-language relationship came from the significant correlations between the L1/L2 discrimination condition of the L2 English sub-lexical task and both L1 French reading and lexical orthographic skills in Grade 6, and between the L2 graphemic patterns condition of the L2 English sub-lexical task and L1 French lexical orthographic skills in Grade 8.

Given the pattern of correlations in both grades, cross-language transfer was not expected to be observed. This was confirmed in a hierarchical regression analysis, the results of which can be obtained from the authors.

Discussion

The present study aimed to examine the transfer between orthographic processing skills when L2 is learned in a school context. It is worth re-emphasising that this makes the study relatively novel within the L2 acquisition literature, which focuses largely on immersion contexts in spite of the prevalence of L2 learning in later schooling. Typical features of L2 acquisition in this context are that children are exposed to the language for only a few hours per week, and that this involves more written and less oral exposure than is the case for children attending early immersion classes. Given the importance of written exposure, our study was focused on the orthographic processing skills involved in the lexical aspects of reading. More precisely, two different skills were examined: the ability to form, store and access word-specific representations, referred to as *lexical* orthographic skills, and sensitivity to orthographic regularities, referred to as *sub-lexical* orthographic skills. The study examined the direct transfer of those abilities, that is, the contribution of the L1 score to the L2 score after having controlled for L1 reading and L2 proficiency.

Lexical orthographic skills were assessed using the orthographic choice task (e.g. *rain* vs *rane*) which is thought to tap word-specific orthographic knowledge (Castles & Nation, 2008; Olson et al., 1989). To explore cross-language transfer, a regression analysis revealed that L1 reading, L2 vocabulary and L1 lexical orthographic skills together explained a significant and large proportion of the variance in L2 lexical orthographic skills (i.e. 42% and 53% for Grades 6 and 8, respectively). Interestingly, the two control predictors, L1 reading and L2 vocabulary, both made independent contributions to L2 lexical orthographic skills, confirming recent findings from Deacon et al. (2009) and Asfaha et al. (2009). With respect to L1–L2 skill transfer, French (L1) lexical orthographic skills in Grade 8 contributed unique and significant variance in explaining English (L2) lexical orthographic skills, over and above the control predictors. Note that this effect only achieved significance for Grade 8 children, which confirms the role of proficiency in transfer, especially in this context of L2 learning, as suggested by the concept of a 'linguistic threshold' (Bernhardt & Kamil, 1995; Cummins, 2000). Our study is consistent with previous findings of lexical transfer between same-alphabet orthographic systems (Deacon et al., 2009) and offers the first tentative evidence of more 'direct' transfer across languages of a reading-related skill, namely, lexical orthographic processing skills.

Sub-lexical orthographic skills were assessed by asking the participant to choose which of two pseudowords is more word-like in a given language. In the event, there was no correlation between L1 and L2 sub-lexical orthographic tasks for either grade. Thus, our results do not show any transfer between these skills.

Nevertheless, the results of the L2 sub-lexical orthographic task offer preliminary evidence for the existence of multiple components of this skill as different accuracy rates were observed for the three separate conditions, and the pattern of correlations varied slightly between each condition of the task and the other reading-related measures. More specifically, accuracy rates revealed that discrimination between French and English orthographic regularities (Condition 1) seemed to be an early acquired skill, as shown by the high accuracy scores after only 1 year of formal English (L2) teaching. Discrimination between orthographically legal and illegal English (L2) sub-lexical patterns (Condition 2) appeared more difficult, probably because this is likely to involve more precise and accurate English orthographic representations (i.e. knowledge of specific graphemes including the precise identity of the letters and their order). Sensitivity to regularities likely specific to the English orthographic system (Condition 3) seemed to be acquired most slowly of all.

Interestingly, it was only items that tested very fine-grained English L2 sub-lexical skills (Condition 3) that correlated with L1 lexical orthographic skills in Grade 8. There was a significant correlation between the L1/L2 discrimination Condition 1 of the L2 sub-lexical task and both French (L1) lexical orthographic skills and reading speed in Grade 6. In this condition, responses could have been driven by either rejecting the French patterns or by accepting the English patterns. So even though these cross-language correlations could be seen as evidence of transfer, they could also reflect the use of a 'French' response strategy.

Taken together, these results seem to support a distinction between language-general versus language-specific aspects of orthographic processing. However, it may seem surprising to observe transfer of the *lexical* orthographic skills that are thought to tap word-specific orthographic knowledge but no evidence for transfer of *sub-lexical* orthographic skills. The latter task is thought to assess sensitivity to the type of orthographic regularities considered to be supported by implicit learning (Pacton et al., 2001). It is worth noting that the pseudoword stimuli used to assess sub-lexical

knowledge do not benefit from the same network of orthography–semantics connections which support responses to the word stimuli in the lexical orthographic tasks.

The apparent paradox may enable us to shed some light on what actually drives transfer. Lexical orthographic transfer has recently been observed by Deacon et al. (2009) between same-alphabet languages, a finding that contrasts markedly with previous studies using different-script language pairings, which failed to find evidence of transfer. These findings imply a need for commonalities in the orthographic patterns between L1 and L2 in order for orthographic transfer to take place (Deacon et al., 2009). However, it is noticeable that the studies that assessed different-script language pairings (Abu Rabia, 2001; Gottardo et al., 2001; Wang et al., 2005, 2006) actually did not test for *lexical* orthographic transfer but used a sub-lexical orthographic task instead. In addition, the need for commonalities should be defined at a very general level, because English and French also have many language-specific orthographic patterns (e.g. ea, oa, ow, ck only in English; -aille, aine, eur only in French). Thus, the issue of whether cross-language transfer of lexical orthographic skills is dependent upon the specific orthographic patterns shared between L1 and L2 remains an unanswered but important question for further research.

In all, our results support the language-general nature of lexical orthographic skills (Deacon et al., 2009). This could potentially be explained by the relevance in literacy acquisition in both languages of the ability to make orthography–phonology–semantics links at similar, although not completely equivalent, grain-sizes (see Arab-Moghaddam & Sénéchal, 2001; Besse, Demont & Gombert, 2007; Koda, 2007; Wang, Koda & Perfetti, 2003 for studies on the influence of L1 background on L2 literacy and Ziegler & Goswami, 2005 for differences in monolingual literacy between same-alphabet languages).

Before considering the theoretical implications of our findings, it is important to draw attention on some possible limiting aspects of the tasks that were used to measure sub-lexical skills. In the L1 sub-lexical task, the regularities commonly assessed such as position of doublet consonant (e.g. febb vs ffeb) were unsuitable given the age of our participants and their greater mastery of the L1 orthography. Nevertheless, of the more fine-grained regularities that we included, two had to be removed due to floor effects. This left only one sub-lexical regularity in the L1 task (context-dependence of single vs doublet consonants), which limited the scope of our findings. In addition, it should be noted that the reliabilities of the sub-lexical tasks were generally lower than for the other tasks.

While it is important to acknowledge that these limitations may have prevented us from finding evidence of sub-lexical transfer, our data remain consistent with the view that sub-lexical orthographic skills are language specific. In order to understand why sub-lexical orthographic skills fail to show transfer, it is necessary to analyse more deeply what underlies these skills. A first question is whether sub-lexical task performance depends, at least partially, on a general ability to extract orthographic regularities from the visual input or, whether performance depends more strongly on the ability to 'learn' the specific regularity under examination. Although slight differences in the patterns of correlations between the three conditions of the L2 sub-lexical task were observed, our data seem to lend support to the first view that sub-lexical orthographic performance draws upon some shared skills. One could hypothesise on the basis of the 'linguistic threshold hypothesis'(Cummins, 2000) that participants may not have been proficient enough in the L2 for any cross-language connection in sub-lexical skills to have developed. Another promising direction for research relates to the issue of the precise nature of sub-lexical orthographic processing, especially its relationship with lexical orthographic processing (see Cunningham et al., 2001; Pacton et al., 2008 for preliminary findings). Although beyond the scope of this article, the divergent

pattern of correlations between lexical and sub-lexical orthographic skills according to grade calls for further studies of both bilingual *and* monolingual participants.

With regard to L2 decoding, a modest correlation with English (L2) lexical orthographic processing skills was observed. Although not the focus of this study, it appears that L2 decoding did not contribute to L2 lexical orthographic skills for either grade in the regression analysis. This may be explained by the very low accuracy rates on the L2 decoding task. Decoding and lexical orthographic processing skills in L1 are thought to be closely related according to Share's (1995) self-teaching theory of orthographic learning. However, as pointed out by Pacton et al. (2008), the relationship between decoding and orthographic skills tends to be weaker in more opaque orthographies such as English (Cunningham, 2006). Learning for only a few hours per week an L2 whose grapheme-to-phoneme correspondences differ from those of the L1 is likely to be a challenge for L2 learners, and an L2 such as English is likely to be perceived as highly opaque by French speakers. Therefore, the extent to which L2 decoding participates in the development of lexical orthographic skills merits further investigation in relation to the orthographic depth of the L2 being acquired in school contexts where oral exposure is lacking.

Other aspects of the present study reinforce the need for continuing research into these important questions. The lack of an intelligence measure may have concealed the role of some general factor in accounting for cross-language relationships. We attempted to compensate for this by taking into account the L1 reading and L2 vocabulary measures in our regression analysis as these two skills might be assumed to partially reflect ability differences among the participants. Another limitation is the lack of an English (L2) reading task, and although not central to our study, a measure of L2 reading could have been entered as a control variable in explaining L2 lexical orthographic knowledge. This was not an oversight but rather a concern about two factors. First, we know of no standardised reading test for L2 English learners. Second, the different phonemic categories in French and English, coupled with poor oral mastery in the young French children made it seem likely that uncertainty would arise in distinguishing between mispronunciations and word recognition errors in an L2 reading task. Returning finally to the lower reliabilities of the sub-lexical tasks, it seems that these may reflect the limited and varying number of test items. Therefore, one critical next step lies in the extension of the materials used to measure sub-lexical orthographic processing. Our own work will move towards examining the extent to which orthographic transfer depends on the orthographic commonalities shared between languages by investigating *lexical* orthographic transfer between different-alphabet language pairings, and by developing a contrast between the regularities shared by the L1 and L2 versus more language-specific orthographic patterns in both sub-lexical *and* lexical orthographic tasks.

To conclude, our motivation in this study was to stimulate research on cross-language orthographic transfer in the context of school L2 acquisition. Considering the poor exposure to the oral language in this context, understanding the ease with which different L2 reading-related skills develop and the extent to which L1 skills transfer should help orientate teaching methods and provide new interventions for children in difficulty. To our knowledge, this study is the first to attempt an investigation of L2 sensitivity to various types of sub-lexical orthographic regularities. Our results show evidence of orthographic transfer at the lexical level but raise questions about the transferability of more detailed knowledge about sub-lexical regularities. This highlights the need for further monolingual and bilingual studies to investigate the

mechanisms that underlie sub-lexical orthographic processing and how it relates to other linguistic skills.

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Notes

1. Information retrieved February 2010 from the website of the Ministère de l'Education nationale in France http://www.education.gouv.fr/cid80/horaires-par-cycle.html
2. The real French word is shown in bold in all examples of this task. Translations can be found in Appendix A.
3. Note that although English decoding skills were not entered in the regression analysis (due to limited number of participants), it was checked that the same pattern of results emerged when controlling for it.

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Appendix A: French lexical orthographic task

apaiser – appaiser (to calm); **devinette** – devinète (riddle); **liane** – lianne (creeper); **décolle** – décole (take off); **manchot** – menchot (one-harmed person); **logo** – logot (logo); **morale** – moralle (moral); **bergère** – bergerre (shepherdess); **anniversaire** – aniversaire (birthday); **tendu** – tandu (tense); **abandonne** – abandone (give up); **arrosoir** – aroisoir (watering can); **banquette** – benquette (wall seat); **marmite** – marmitte (cooking pot); **landau** – landeau (pram); **renvoyer** – ranvoyer (return); **osseux** – oceux (bony); **hôtesse** – hôtèce (hostess); **acide** – asside (bitter); **vengeance** – vangeance (revenge); **officier** – oficier (officer); **assiégé** – aciégé (besieged); **panthère** – penthère (panther); **ignore** – ignorre (to ignore); **accompagner** – acompagner (to accompany); **coutume** – coutumme (custom); **imiter** – immiter (imitate); **otage** – ottage (hostage); **randonnée** – rendonnée (hiking); **animer** – annimer (to liven up); **dentifrice** – dantrifrice (toothpaste); **opinion** – oppinion (opinion); **illuminer** – iluminer (to illuminate); **gigot** – gigo (leg of lamb); **paysanne** – paysane (women farmer); **opposer** – oposer (to fight); **pendule** – pandule (wall clock); **apparence** – aparence (appearance); **symbole** – symbolle (symbol); **discrète** – discrette (unassuming); **océanographique** – osséanographique (oceanographic); **poteau** – potau (pole); **lierre** – lière (ivy); **immigré** – imigré (immigrant); **nièce** – niesse (niece); **abattu** – abbattu (downed); **tantôt –** tentôt (sometimes); **monotone** – monotonne (monotonous).

Appendix B: English lexical orthographic task

boat – bowt; **proud** – prowd; **rain** – rane; **clean** – cleen; **low** – loe; **key** – kee; **dream** – dreem; **bottom** – bottum; **buy** – bie; **dry** – druy; **loud** – lowd; **wish** – wich; **smoke** – smoak; **allow** – allowe; **mountain** – mountane; **light** – lite; **break** – braik; **fear** – feer; **learn –** lurn; **safe –** saif; **begin** – begeen; **speech** – speach; **spell** – spale; **abroad** – abrowd; **build** – buildt; **shiny** – shinye; **moon** – moun; **catch** – catsh; **agree** – agrea; **ashamed** – ashaimed; **room** – rume.

Appendix C: French sub-lexical orthographic task

occaphile – ocaphile; **iderisme** – idderisme; **potrale** – potralle; **illucure** – ilucure; **bilane** – bilanne; **abatorne** – abbatorne; **gafronne** – gafrone; **offirion** – ofirion; **immofuge** – imofuge; **appagerne** – apagerne; **arudole** – arudolle; **oritomine** – orritomine; **oppomane** – opomane; **prolume** – prolumme; **arroguet** – aroguet; **doumette** – doumète; **affitage** – afitage; **blitore** – blitorre; **pralère** – pralerre; **abocerne** – abbocerne; **allupare** – alupare.

Appendix D: English sub-lexical orthographic task

Condition 1: **morest** – moreste; **leck** – leque; **feauty** – feautie; **allord –** allorde; **amost** – amauste; **ablow** – ableau; **abraid** – abraide.

Condition 2: **browd** – browdt; **whone** – wyone; **coard** – coardt; **mutcher** – mutscher; **nuggage** – nughgage; **mough** – mouph; **schoal** – sckoal; **maugh** – mauph; **veath** – veatht; **gark** – garkk; **lacket** – lachket; **tield** – tieldt; **dight** – digkt.

Condition 3: **vaff** – vaf; **neek** – neeck; **wook** – woock; **veck** – vek; **sool** – sooll; **joaf** – joaff; **yeel** – yeell; **saff** – saf; **meck** – mek; **fraif** – fraiff.

Appendix E: English decoding

Homophonic items: waint – weint; vord – voard; plaim – plame; choap – chope; plork – plawk; fent – feant; slare – slair; thark – tharc; noke – noak; durb – derb; groon – grune; droe – drow; draim – drame; spoab – spobe; proud – prould; bleem – bleam; murn – mearn; wesk – whesk.

Nonhomophonic items: queef – keef; maugg – maugh; lath – lathe; moth – moce; rike – reak; gouse – goose; agout – agoot; quole – cole; deat – dait; slaff – slafe; prowth – prowt; gake – gakk; afflaud – afflod; drowd – drud; thiel – thell; pight – pigt; droad – drod; sloader – slader.

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