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Cross-linguistic perspectives on second language reading☆

Ludo Verhoeven[a,*], Charles Perfetti[b], Kenneth Pugh[c]

[a] Behavior Science Institute, Radboud University, Netherlands
[b] University of Pittsburgh, USA
[c] Haskins Laboratories, USA

A B S T R A C T

Throughout the world, many people learn to read in a second language (L2) which can be considered a challenging task given that a script needs to be learned in a language that is not fully acquired yet. The neurocognitive processes of learning to read in an L2 are just beginning to be understood. Across different languages, L2 reading can be seen as a learned sensitivity to the systematic relationships among the surface representations of words and their meanings, and their unification into sentences and text in the target language. It can be assumed that the brain regions that are involved in L2 reading to a large extent converge with first language (L1) reading (intralingual hypothesis). However, different perceptual, linguistic, and computation demands of L2 reading may also require additional supporting brain regions during learning (interlingual hypothesis). To what extent L2 reading processes can be considered intralingual or interlingual may also be dependent on the onset of learning and on the first and second languages that are involved. In this issue of JNL, the universals and particulars of L1 and L2 reading processes will be examined while taking a cross-linguistic perspective with differential studies originating from psycholinguistic, cognitive and neural perspectives research.

When it comes to learning to read in a multilingual context, second language (L2) reading may refer to becoming literate in a language other than the language spoken at home, or to the reading of an L2 after literacy in the L1 has already been acquired, i.e., in foreign language learning. The language situation of children immersed in an L2 environment can generally be characterized as emergent bilingualism. Their first language is acquired and strengthened in preschool years thanks to the input in L1-speaking homes while L2 comes into play through playmates and school. Previous research has shown that becoming literate in an L2 can be a challenging task (Chen, Dronjic, & Helms-Park, 2016; Verhoeven, 2017). In many places throughout the world, children are totally immersed in an L2 reading curriculum with minimal attention to their native language literacy and to their L2 spoken language level. These children are thus confronted with the task of learning to read in a language that they have yet to master. We see different situations for the learner when L2 is learned later in life as a result of migration and when a foreign language is learned in school (cf. Ellis, 2013).

Whatever the context of learning, L2 reading reflects a learned sensitivity to the systematic relationships among the surface representations of words and their meanings, and their unification into sentences and text in the target language. Although shared brain regions appear to be involved in first language (L1) and second language (L2) reading (convergence hypothesis), there is also evidence that different perceptual, linguistic, and computation demands of the second language involve additional supporting brain regions during learning. The extent to which such differences are involved may depend on the similarity of the two languages (MacWhinney, 2005) and their writing systems (Perfetti et al., 2007) as well as the age of L2 acquisition and the degree of L2 exposure. (For an overview see Verhoeven, 2010, 2017). This issue of JNL aims to shed more light specifically on L2 reading processes by taking a cross-linguistic lens that draws on research from psycholinguistic, cognitive and neural perspectives and

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* Corresponding author.
E-mail address: l.verhoeven@pwo.ru.nl (L. Verhoeven).

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examines the universals and particulars of L1-L2 processes of reading and learning to read.

1. Second language reading

Research on L1 reading has clearly demonstrated the importance of lexical representations as a major source of individual differences in reading tasks (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Plaut, McClelland, Seidenberg, & Patterson, 1996). The lexical quality hypothesis (Perfetti & Hart, 2001) expresses the basic idea that reading skill among children and adults is supported by their knowledge of words, including the precision of the reader's representation of orthography, phonology, morphology and meaning, as well as the sheer number of known words. Cross-linguistic studies on the development of reading have provided strong evidence for this claim (Carreiras, Armstrong, Perea, & Frost, 2014; Frost, 2012; Pugh, 2006; Verhoeven & Perfetti, 2017).

It can be argued that processes of learning to read in a second language can be considered highly intralingual, i.e. to a large extent controlled by L2 processes with only little L1 involvement. On this view, L2 learners are just less efficient than L1 readers in building up visual lexical representations in the target language (cf. French & Jacquet, 2004). Indeed, comparative studies, have shown that many children experience serious difficulties in learning to read in L2 and that the individual variation in achievement or rate of learning to read tends to be much larger among non-native learners than native learners (e.g., Chen, Ramirez, Luo, Geva, & Ku, 2012; Droop &Verhoeven, 2003; Durgunoglu and Goldenberg, 2011). In the early stage of reading acquisition, L2 learners may have difficulties in their use of L2 phonology to support word identification, which may hamper the assignment of a full range of correct pronunciations to (sub)lexical units (cf. Russak & Saiegh-Haddad, 2011). Furthermore, a later age of acquisition or less exposure to the L2, may impede children's L2 reading comprehension development (Verhoeven, 2000; Chen et al., 2012). In addition, listening comprehension is an important predictor of reading comprehension as formalized in the simple view of reading that expresses reading comprehension as the product of word decoding and listening comprehension (see Catts, 2018). Previous studies consistently show the role of decoding in the explanation of reading comprehension to be large for beginning readers and the role of listening comprehension to become more prominent for more proficient readers in both L1 and L2 (Verhoeven & Van Leeuwe, 2012).

Although it can be assumed that advanced L2 readers will perform like native speakers on many tasks, they often show residual asymmetries, suggesting that L2 is still partially parasitic on L1 (cf. Geva & Genesee, 2006). The Competition Model (MacWhinney, 2005) predicts the level of interaction to be dependent on the proficiency level in the two languages in line with the dynamics of competition between emergent linguistic modules. Transfer may occur if complex lexical mappings required in a second language have already been grounded in the first language (Ellis, 2013; Janssen, Segers, McQueen &Verhoeven, 2015). Most researchers currently accept the notion of at least a partially overlapping organization of bilingual memory for spoken and written lexical entries (Cheng, Wang, & Perfetti, 2011; Tan et al., 2003), while favouring non-selective access, i.e., access to words in both languages simultaneously (Dijkstra & Van Heuven, 2002).

2. A neurocognitive perspective

According to neurocognitive models underlying second language reading, even though reading involves many common areas, distinct control mechanisms can be distinguished in bilingual interactive activation, operating on inputs to and outputs from the bilingual neural network system (Abutalebi, 2008; Lallier, Carreiras, Tainturier, Savill, & Thierry, 2013). Driven by stimulus input, an automatic (‘bottom-up’) process is assumed to influence the level of activation in the bilingual lexico-semantic system, whereas an intentional (’top-down’) process is supposed to respond to signals coming from the same system without necessarily modifying its activation levels (see Grant, Legault, & Li, 2018). This regulation of the bilingual neural network provides an explanation of both intralingual (language-specific) and interlingual (language-transfer) types of lexical processes in the bilingual. The key question for research progress is to determine how neurocognitive processes of learning to read in L2 are guided by intralingual processes related to the target language and/or interlingual processes related to the source language.

Another critical question in this field of research is how neurolinguistic processes of second language reading relate to children's cognitive development. In metalinguistic tasks that are highly relevant for reading, bilingual learners may use top-down processes such as selective attention and control to partially inhibit the activation of one language while activating a coordinated resonance in the other language (Abutalebi, 2008). Such processes enable the learner to make linguistic and conceptual representations more explicit and structured, and to make predictions about L2 on the basis of stored representations in L1. Indeed, overlap of L2 with L1 at the level of orthography (Geva & Siegel, 2000), phonology (Lopez & Greenfield, 2004; Verhoeven, 2007), morphology (de Zeeuw, Verhoeven & Schreuder, 2013), and lexico-semantics (Tytus & Rundblad, 2017) may help the second language learner to build L2 skills. This leads to another key question: to what extent and under which conditions transfer takes place and how the organization of bilingual memory affects the course of learning to read in L2. The roles of both general cognitive processes and language specific transfer are major research foci and these are represented in the current issue.

3. The present issue

Cognitive and linguistic research has provided a broad variety of theoretical models for processes of second language reading and its acquisition. However, because the bulk of research has been conducted on the English language, the generalization of theoretical models of L2 reading and L2 reading acquisition to other contrastive languages can be questioned. In recent years, the research base has broadened, as research around the world has provided new information on different contexts of L2 learning. The time is right to

bring together observations across languages and writing systems within cross-linguistic and cross-writing system perspectives. These perspectives allow a focus on those aspects of the reading process that might be relatively specific to (or at least modified by) specific language properties and those aspects that are common to all languages and orthographies, theoretical claims about L2 reading processes can be challenged.

In the present issue, experts have been brought together with various multidisciplinary backgrounds (including cognitive neuroscience, cognitive psychology, developmental cognitive science, psycholinguistics, education). The authors address the processes that are involved in L2 reading across a broad variety of writing systems, orthographies and scripts with the goal of establishing a clear and meaningful cross-linguistic perspective on universals and particulars in L2 reading acquisition. Our central claim is that L2 reading involves the learning of systematic relationships among the surface forms of words and their meanings in the target language which highly conforms to L1 reading. However, because writing systems vary in how they represent the languages they encode and languages substantially differ in phonological, syntactic and morphological structures, a broad variety of particular effects of linguistic transfer across writing systems and orthographies from L1 to L2 can also be predicted. To address the role of cross-linguistic differences in learning to read in L2, reading researchers who represent a broad sampling of written languages have contributed by providing evidence from a specific orthographic background or by taking a cross-linguistic perspective in discussing cognitive, neurobiological or developmental issues related to the study of L2 reading. We preview the issues and findings of the authors in the remainder of the introduction.

Brice, Mencl, Frost, Bick, Rueckl, Pugh and Frost present a bi-directional cross-linguistic study focusing on neurobiological aspects of Hebrew vs English L2 reading. While performing a semantic judgement task on spoken and written words and pseudowords in both their L1 and L2, English-Hebrew and Hebrew-English participants received an fMRI scan in addition to a series of L1 and L2 behavioral measures. For both groups, the imaging data evidenced a similar network of activation for reading across the two languages with similar print and speech processing across a network of left-hemisphere regions in both L1 and L2. Convergence was greater for L1 in occipito-temporal regions tied to automatic skilled reading processes including the visual word-form area, but greater for L2 in frontal regions of the reading network, tied to more effortful, active processing. Similarly, the main groupwise brain activation was greater for L2 than L1 across frontal, temporal and parietal regions, but greater L1 than L2 activation in parieto-occipital. These results provide evidence for the shifting of the reading networks towards more automatic processing as reading proficiency increases and the mappings and statistics of the new orthography are learned and incorporated into the reading system.

Saiegh-Haddad examines the role of phonological awareness in Arabic and Hebrew second language reading. Although phonological awareness is considered a primarily metalinguistic skill not affected by the individual's L2 language proficiency, or by L1-L2 linguistic distance, L2 phonological awareness may be affected by L2 language-specific factors, and these factor can be just as important in phonological awareness in L2 as the fundamental metalinguistic insight that words are decomposable into smaller phonological units. Saiegh-Haddad reports significant differences between phonological awareness in L1 and L2, along with a significant correlation between L2 oral language proficiency and phonological awareness in L2 and finds that L2 phonological awareness depends on the phonological differences between L1 and L2. The conclusion is that phonological awareness in L2 should be regarded a two-dimensional construct encompassing a component that is metalinguistic in nature and language-independent, on the one hand, and a linguistic component reflecting language-specific phonological representations in L2, on the other hand.

Verhoeven, Voeten and Vermeer highlight the impact of lexical quality in learning to read Dutch as a second language. Starting from the SVR claim that reading comprehension is the product of word decoding and listening comprehension, they examined the additional role of early lexical quality in the prediction of reading comprehension, either directly or indirectly via word decoding or listening comprehension. Following a longitudinal design, children learning to read Dutch as L1 and children learning to read Dutch as L2 in the Netherlands were tested on indicators lexical quality (LQ) in kindergarten (speech decoding, morphological knowledge and vocabulary); word decoding and listening comprehension in first grade; and then reading comprehension in second grade. The results showed L2 learners to consistently lag behind L1 readers on all measures except for word decoding. Both word decoding and listening comprehension predicted later reading comprehension for not only L1 but also L2 learners. However, later reading comprehension was also directly predicted by the children's early morphological and vocabulary knowledge, indirectly by speech decoding and morphological knowledge via word decoding and indirectly by morphological and vocabulary knowledge via listening comprehension. These results show the beginning reading achievement of both L1 and L2 learners to be largely predicted by the quality of their early lexicons.

Prins, Dijkstra and Koeneman investigate the neural correlates of morphological decomposition in native Dutch speakers and Turkish-Dutch early bilinguals. They focused on temporal differences combined with electroencephalography recordings in the processing of regularly and irregularly inflected and productively and non-productively derived words in a lexical decision task. Similar negative brain responses for regularly and irregularly inflected words and for productively and non-productively derived words were found in the 200–350 ms time window for both participant groups. These are interpreted as a reflection of early, form-based processing of complex words. For the irregularly inflected verbs, most negative brain responses were observed in the 350–500 ms time window. The authors argue that this processing is affected by a discrepancy between orthography and morphology. Different results for the Dutch and Turkish-Dutch speakers in the nonword contexts seem to indicate that decomposition is more automatized in the bilingual speakers given their experience with Turkish which is considered to be an agglutinative language.

Yu, Chen, Cherodath, Tzeng and Wu provide neuroimaging evidence for sensitivity to orthography-to phonology conversion in both native readers and foreign learners of Chinese. They examined the neural correlates of Chinese reading in the two groups of learners in relation to neurocognitive factors. In an in fMRI study, participants were exposed to pronunciation and color verification tasks using Chinese pseudo-phonograms. Participants IQ, working memory and sensitivity to extracting systematic regularity in nonverbal materials as a proxy of visual statistical learning were also measured. The native participants activated a left lateralized

reading network associated with orthography-to-phonology conversion of Chinese, whereas a more extended network that included right hemispheric regions was evidenced for the L2 learners. Left inferior frontal sites were found to be related to the mapping of Chinese pseudo characters to potential sounds, particularly in the L2 learners. Furthermore, the visual statistical learning scores in both native Chinese and Chinese learners were negatively correlated with the brain activities in left inferior parietal and left inferior frontal regions, respectively. The authors suggest that statistical learning supports the acquisition of Chinese reading in L1 and L2 through modulating computation demands on the brain regions associated with universal orthography-to-phonology conversion processing.

Takashima and Verhoeven examine radical repetition effects in beginning learners of Chinese as a foreign language reading. Their aim was to examine whether repetition of radicals during training of Chinese characters would lead to better word acquisition performance in beginning learners of Chinese as a foreign language. Thirty Dutch university students were trained on a series of Chinese one-character words for their pronunciations and meanings. They were also exposed to the specifics of both the phonetic and semantic radicals in their association with character pronunciation and meaning. They found that repeated exposure to phonetic and semantic radicals through character pronunciation and meaning trainings indeed induced better understanding of those radicals that were shared among different characters. Repetition of phonetic radicals lead to better pronunciations whereas repetition of semantic radicals hindered the learning of exact meanings in that students confused the meanings of characters that shared the semantic radical. The authors suggest that in learning to read Chinese, the identification of individual characters requires specific training on top of the learning of radical interpretations.

Hye Pae, Kim, Mano and Wang examined predictors of L2 in Korean-English and English-Korean learners. While evidence shows that consonants play a primary role over vowels in reading Roman scripts, it remains unclear whether this primacy extends to reading other non-Roman alphabetic scripts, such as Korean. This study investigated the role of vowels in L2 English word reading among native Korean readers. Korean- and English-speaking adults read words in a naming task with four different types of letter strings lowercase words, uppercase words, letter strings with no vowels (e.g., cmmn for common), and letter strings with randomly missing letters (e.g., corct for correct). Overall, the vowel deletion manipulation gave rise to higher accuracy and faster reading than the random omission for the two groups. When the baseline was controlled, L1 group and type of letter string jointly affected accuracy, but the two variables made independent contributions to naming latency. Korean students were also found to be more error-prone than English readers in naming letter strings that selectively lacked vowels. Given the unique characteristics of Korean, the findings suggest that L1 effects of native Korean readers are observable in L2 English word reading.

Li and Clariana argue for an integrative approach to reading comprehension in L1 and L2, based on both cognitive and neuroimaging evidence. They propose research directions that will address how brain mechanisms that support reading in the native language apply to reading comprehension in a second language. The first is that significant individual differences in reading performance are related to the reader's cognitive capacity. For example, for L2 readers, their language processing network will continually interact with the cognitive control network, because they must devote additional resources for the work of comprehension, e.g., keeping track of relationships between lexical items and making inferences across sentences. The second proposal is that cognitive support for reading, especially cognitive control, will interact with the level of the reader's L2 proficiency: Low-proficiency learners evoke the cognitive control network more strongly during reading, whereas higher-proficiency learners use their more developed L2 semantic network more efficiently for lexical access and retrieval. This is indicative of a shift from paying attention to more effortful, non-linguistic processing to more automatic linguistic processing. Finally, it is assumed that high-proficiency L2 readers may approximate the brain network patterns of the L1 readers.

Raudzus, Segers and Verhoeven show that situation model building ability uniquely predicts first and second language reading comprehension of children in fourth grade. They examined the unique role of textbase memory and situation model building ability in first (L1) and second (L2) language reading comprehension. The authors used a pathfinder network to assess textbase memory and situation model building ability while also assessing readers' working memory, nonverbal reasoning, decoding, vocabulary, and grammar as cognitive and linguistic predictors of reading comprehension. Reading comprehension was assessed by a standardized test unrelated to the textbase and situation modeling task. The results showed no difference between L1 and L2 readers in textbase memory and situation modeling, nonverbal reasoning, and working memory. L2 readers were more efficient decoders than L1 readers, but lagged behind on vocabulary, grammar, and reading comprehension. Situation model building ability was found to predict reading comprehension over and above the other cognitive and linguistic predictors to the same extent in both groups.

Martin, Hirshorn, Durisko, Moore, Schwartz, Zheng and Fiez examine to what extent adults use their native English reading network in acquiring a second, artificial orthography for reading English. Two different artificial orthographies were used. One, *HouseFont* is alphabetic system in which house images represent English phonemes; the second, Faceabary, is an alphasyllabic system in which face images represent English syllables. Sustained improvements in reading in the new orthographies over 6 weeks of training showed that adults have considerable capacity to learn a second orthography for their native language, even when it involves perceptually atypical graphs. This learning involves assimilation into the same reading network that supports reading English in its normal Latin alphabet. Furthermore, learning patterns varied across the two orthographies with *Faceabary* inducing more bilateral learning effects in the mid-fusiform gyrus and greater engagement of regions associated with semantic processing. It is hypothesized that the large graph inventories of non-alphabetic systems may create visual-perceptual challenges that increase reliance on (sub) lexical reading procedures and associated neural substrates.

Ben-Yehudah, Hirshorn, Simcox, Perfetti and Fiez explore to what extent Chinese-English (CE) and Korean-English (KE) bilinguals transfer their differing L1 lexical reading procures to L2 English. Because their L1 writing system is a morphosyllabary, Chinese-English (CE) bilinguals may approach L2 English using the more lexically-based orthographic coding that is functional in Chinese; in contrast, because their L1 system is alphabetic, Korean-English (KE) bilinguals may transfer the sublexical reading procedures and

analytic orthographic coding that are functional in Korean. To test this hypothesis, CE and KE groups matched on English language experience named English words that varied in frequency and orthographic consistency, and also pronounceable English nonwords. The words were presented in either normal upright or inverted forms. CE bilinguals exhibited slower naming latencies, especially for inverted stimuli. Furthermore, the effects of inversion appeared to interact differently with frequency and consistency across the two groups, with CE bilinguals more sensitive to frequency and KE bilinguals more sensitive to consistency. Group differences in naming accuracy were also observed, even when differences in reading skill were taken into account. It appears that stimulus inversion is a procedure that can unmask differences in L2 reading procedures that are transferred from the L1 writing system.

Finally, Chung, Chen and Geva provide a review on deconstructing and reconstructing processes of cross-language transfer in bilingual reading. They review studies of cross-language transfer in word reading, spelling, reading comprehension, and writing to clarify both universal and particular aspects of transfer of literacy skills across languages. The authors conclude that cross-language transfer is interactive in nature and influenced by cognitive and linguistic factors, including whether the targeted construct is relatively language general or language specific, the L1-L2 distance, L1-L2 proficiency and language complexity. At the same time, cross-language transfer is constrained by sociolinguistic and social-cultural factors such as age of acquisition, immigration experience, educational settings, and extent of exposure to the L1 and L2. The complexity of the mechanisms involved, in combination with the heterogeneity of the bilingual population, makes it difficult to predict the direction (from the L1 to L2 or the other way around) and extent of transfer for any given construct. Finally, it is concluded that the validity and generalizability of the results depend on the scientific rigor of the research design.

4. Conclusions and outlook

The collection of studies in this special issue used a broad range of methods, ranging from online and offline cognitive and neural assessment of L2 reading processes. The range of reading processes also had a broad focus—orthography to phonology conversion, lexical processing, morpho-syntactic binding and/or text integration—with theoretical perspectives related to the intralinguistic and interlinguistic nature of these processes. The studies also addressed individual variation in L2 reading and their development over time by relating L2 reading processes to underlying linguistic and cognitive precursor measures.

Overall, the studies would appear to suggest considerable overlap between reading processes in L1 and L2, particularly in more advanced stages. Studies show networks of brain activation that are similar across a reader's two languages in linking print and speech processes and in supporting phonological awareness, grapheme-phoneme mapping, morphological decomposition, syntactic binding and text and situation modeling with support of uniform control networks. It is interesting to note that convergence of processes in L1 and L2 reading was evidenced across languages and writing systems. The importance of sensitivity to orthography-to-phonology conversion and visual statistical learning applied to both opaque (English) and transparent (e.g., Dutch, Turkish, Hebrew) alphabetic orthographies as well as the morpheme-based Chinese writing system, and was also evidenced in the learning of artificial alphabetic vs syllabic orthographies.

Nevertheless, the question of same vs different networks is not a simple one. Although similar brain areas are involved at high levels of L2 reading skill, differential computational demands may apply to learning an L2 that likely involves specific brain reorganization of language, reading and control networks. Especially interesting for interpreting bilingual brain networks is a finding that when late Chinese-English bilinguals respond phonologically to printed English words, they show activation patterns very similar to Chinese speakers responding to Chinese and different from English speakers responding to English (Cao, Tao, Liu, Perfetti, & Booth, 2013). Further, even at high levels of proficiency, there is evidence within this special issue that procedures that serve a non-alphabetic L1 (Chinese) may be transferred non-optimally to an alphabetic L2.

Another general finding across the studies is that L2 reading efficiency is initially less proficient and well-organized than for L1 reading due to limited L2 linguistic proficiency on the part of the learner. It is clear that L2 reading requires additional neural resources associated with prefrontal control among other things. It is unsurprising of course that greater control is needed in the case of late acquisition of L2 and more so for low L2 proficiency learners. Whereas the activation of reading networks in L1 was generally found to be greater in occipital-temporal brain areas associated in many studies with a high degree of word reading fluency, in L2 activation was relatively greater for frontal areas associated with more effortful active processing. It seems from all this that the development of L2 reading processes towards fluency and automaticity can be interpreted as a shift in activation from frontal to occipital-temporal areas in the brain. The studies in aggregate also show that processes of L2 learning depend on such factors as the age of acquisition, the distance between L1 and L2 orthographies, scripts and writing systems, and the cognitive capacity of the learner.

Finally, the present collection of articles shows specific evidence for critical linguistic transfer from L1 to L2. Linguistic transfer was most salient in phonological awareness, orthography-to-phonology conversion and word decoding. We can suggest that L2 reading development requires a continuous reorganization of neural networks that adapts to the interaction of bottom-up processes triggered by the linguistic input and top-down processes guided by L1 knowledge and knowledge of the world.

To conclude, the focus on shared and unshared neural pathways and brain-behavior models of L2 reading in a broad variety of settings of bilingual development can be seen as a promising beginning in arriving at a better understanding of the cross-linguistic dimensions of L2 reading, and the papers here which used varied methodologies across highly contrastive languages help to frame further needed research. With an eye on future studies, we suggest an emphasis on the detection of neural pathways in experimental offline and online studies that are related to the reorganization of the brain in L2 reading development across different languages and writing systems and ultimately the development of theories that can seamlessly account for both cross language differences and individual differences within any set of languages.

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