Rugg, M. D., & Nagy, M. E. (1987). Lexical contribution to nonword-repetition effects: Evidence from event related potentials. *Memory and Cognition, 15*, 473–481.

Santesso, D. L., & Segalowitz, S. J. (2009). The error-related negativity is related to risk-taking and empathy in young men. *Psychophysiology, 46*, 143–152.

Scheffers, M. K., & Coles, M. G. H. (2000). Performance monitoring in a confusing world: Error-related brain activity, judgments of response accuracy, and types of errors. *Journal of Experimental Psychology: Human Perception and Performances, 26*, 141–151.

Sebastian-Galles, N., Rodriguez-Fornells, A., Diego-Balaguer, R., & Diaz, B. (2006). First-and second-language phonological representations in the mental lexicon. *Journal of Cognitive Neuroscience, 18*, 1277–1291.

Segalowitz, S. J., & Dywan, J. (2009). Individual differences and developmental changes in the ERN response: Implications for models of ACC function. *Psychological Research, 73*, 857–870.

Share, D. L. (2004). Orthographic learning at a glance: On the time course and developmental onset of self- teaching. *Journal of Experimental Child Psychology, 87*, 267–298.

Shiran, A. (2009). *The effect of working memory training on recall range and speed of information processing in working memory among dyslexics as compared to regular readers*. Unpublished M.A thesis. The Faculty of Education, University of Haifa, Israel.

Smith-Spark, J. H., Fisk, J. E., Fawcett, A. J., & Nicolson, R. I. (2003). Central executive impairments in adult dyslexics: Evidence from visuospatial working memory performance. *European Journal of Cognitive Psychology, 15*, 567–587.

Snowling, M. J., & Nation, K. A. (1997). Language, phonology, and learning to read. In C. Hulme & M. Snowling (Eds.), *Dyslexia: Biology, cognition and intervention* (pp. 153–166). London: Whurr Publishers, Ltd.

Sternberg, S. (1966). High speed scanning in human memory. *Science, 153*, 652–654.

Stiles, J. (2000). Neural plasticity and cognitive development. *Developmental Neuropsychology, 18*, 237–272.

Thomson, M. (1978). A psycholinguistic analysis of reading errors made by dyslexics and normal readers. *Journal of Research in Reading, 1*, 7–20.

Van De Voorde, S., Roeyers, H., Verté, S., & Wiersema, R. (2010a). Working memory, response inhibition, and within-subject variability in children with attention-deficit/hyperactivity disorder or reading disorder. *Journal of Clinical Neuropsychology, 32*, 366–379.

Van De Voorde, S., Roeyers, H., Verté, S., & Wiersema, R. (2010b). Error monitoring in children with ADHD or reading disorder: An event-related potential study. *Biological Psychology, 84*, 176–85.

Van Meel, C. S., Heslenfeld, D. J., Oosterlaan, J., & Sergeant, J. A. (2007). Adaptive control deficits in attention-deficit/hyperactivity disorder (ADHD): The role of error processing. *Psychiatry Research, 51*, 211–220.

Vidal, F., Burle, B., Bonnet, M., Grapperon, J., & Hasbrouccq, T. (2003). Error negativity on correct trials: A reexamination of available data. *Biological Psychology, 64*, 265–282.

Walczyk, J. J. (1990). Relation among error detection, sentence verification, and low-level reading skills of fourth graders. *Journal of Educational Psychology, 82*, 491–497.

Wiersema, J. R., van der Meere, J. J., & Roeyers, H. (2005). ERP correlates of impaired error monitoring in children with ADHD. *Journal of Neural Transmission, 112*, 1417–1430.

Yeung, N., Cohen, J. D., & Botvinick, M. M. (2004). The neural basis of error detection: Conflict monitoring and the error related negativity. *Psychological Review, 111*, 931–959.

Reading in More Than One Language: Behavior and Brain Perspectives

Anat Prior, Ph.D.

A majority of people in the world today speak more than one language (Edwards 2004), though the contexts of bilingualism vary greatly. Some individuals are raised in bilingual environments or societies, others are faced with the need to learn the language of a new environment following immigration, and still others study a foreign or additional language in a school setting. Bilingual individuals differ in various dimensions including their proficiency in each of the languages and the age at which they were acquired, the degree to which they use each language for educational, recreational and economic purposes, and of most relevance for the present discussion, the level and trajectory of literacy development and attainment in each of the languages. Literacy development is a complex process even under the simplest circumstances of a monolingual individual learning to read in her native language. Various factors contribute to literacy acquisition and shape its outcomes. As will be described below, almost all the contributors to first language (L1) literacy are also involved in second language (L2) literacy, but L2 literacy is uniquely influenced by aspects of first language literacy and by transfer across languages. Further, there is much greater variation in the language proficiency and exposure patterns of individuals acquiring literacy in the L2 than is normally the case for L1 literacy acquisition. Thus, reaching a full description and understanding L2 literacy is a challenging enterprise.

A recurring theme throughout this chapter will be the interplay of commonalities and differences in first and second language reading. Some commonalities can be attributed to universal theories of reading (e.g. Perfetti 2003), because in all languages writing is mapped to spoken language, and the goal of reading is always extracting phonology and meaning from print. Other commonalities are most likely the result of cases where there are specific similarities between the pair of languages examined in a given study, for example, two alphabetic languages of similar transparency (e.g. Italian and German, Wartenburger et al. 2004).

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Divergences between first and second language reading can also be a result of different circumstances. In some cases, these differences will be a manifestation of inherent differences between the writing systems examined, exemplified by findings of similar differences between L1 readers of the two languages. However, in other cases differences will be a true manifestation of the added complexity of mastering two writing systems, and the unique two-way influence of orthographies on each other. Additionally, the specific attributes of L2 reading, such as limited proficiency in the spoken language, may also come into play.

In the first section of the chapter I will briefly describe bilingual language representation, focusing on the degree to which the two languages of bilinguals rely on common or distinct cognitive and neural substrates, at different levels of processing. I chose to include this section in the current review because it is important to remember that literacy constitutes only one facet of the complex skill of language knowledge and proficiency. Indeed, the acquisition of literacy presupposes some level of proficiency in the spoken language. As the goals of reading are the extraction of phonological and semantic information from print, we should consider how the phonological and semantic representations in the L2 map onto those of the L1, and the possible interactions between the two systems. Further, some of those interested in literacy development in speakers of two languages are less familiar with the body of research focusing on language representation more generally in bilinguals. I believe that this literature can have a positive contribution to research and theorizing about literacy development, and can inform work in this domain.

In Sect. 2, I will then present cross-linguistic research on reading, investigating how different orthographies are acquired and processed by native speakers of the respective languages. I will then rely on these two bodies of knowledge in Sect. 3 to consider how literacy is acquired in two languages, either simultaneously or consecutively, and how skilled reading is influenced by the presence of more than one orthography. Finally, after presenting the current state of knowledge, in Sect. 4 I will offer suggestions as to how differences in orthographic features might play out in literacy in various L1-L2 pairings.

1 Language Representation and Processing in Bilinguals

Research on how two linguistic systems are organized within the brain and cognitive systems of bilinguals has focused on three main issues. First, the question of representation, and the independence of each language or to what degree languages rely on shared resources at different levels – phonetic, lexical, semantic and grammatical. The second issue relates to language activation and whether the cognitive system can effectively "switch off" a language that is not task-relevant at any given moment, in order to allow for uninterrupted use of the other language. Finally, there is growing interest in the cognitive and brain mechanisms that control language selection and activation in bilinguals and second language learners – whether these are domain general or specific dedicated functions within the language system, a topic that will receive only brief attention in this chapter.

1.1 Semantic Representation

Most current models of bilingual language representation distinguish between lexical and semantic representation, claiming separate mental lexicons for the two languages, but a shared semantic network (Francis 2005; Van Hell and DeGroot 1998). The Revised Hierarchical Model proposed by Kroll and Stewart (1994; for a recent reassessment see Kroll et al. 2010) describes the development of the bilingual lexicon in second language learners. According to this model, at first words from the L2 activate their meaning only via words from the first language. However, with growing proficiency, words in the second language can activate their meaning directly, without first language mediation. Eventually, words in both languages have direct conceptual links to semantic representations that are mostly but not completely shared.

Evidence for shared semantics comes from findings of semantic priming effects from one of a bilingual's languages to the other (Basnight-Brown and Altarriba 2008; Keatley et al. 1994; Schoonbaert et al. 2009). Additionally, conceptual representations of words in the L2 seem to be shaped by L1 semantics (Jiang 2000) and recently is has also been demonstrated that a second language learned later in life can influence conceptual representations even when they are activated through the L1 (Degani et al. 2011). However, the degree of overlap in meaning between words in the two languages of bilingual speakers can be modulated by different factors, including word type (Van Hell and DeGroot 1998) and ambiguity in translation (Prior et al. 2007; Tokowicz and Kroll 2007).

1.2 Lexical Activation

As for activation, there is abundant evidence that, perhaps counter-intuitively, both languages of proficient bilingual speakers are constantly active. Thus, it seems that the intention to speak in one language is not sufficient to suppress all activation of the other language (for a recent review see Costa 2005). This might be especially true in non-balanced bilinguals speaking in the second language (Kroll et al. 2006), but is not limited to this population. Similarly, lexical candidates become activated in both languages, even in a monolingual setting, both for auditory (Spivey and Marian 1999) and, of greater interest in the present context, for visual word recognition (for a recent review see Dijkstra 2005).

I will first present research on cross-language activation in bilingual visual word recognition that has been conducted on populations that read two languages that share the Roman alphabet, most notably the work of Dijkstra and colleagues on Dutch-English bilinguals. Findings from several different paradigms have demonstrated convincingly that under these conditions word recognition and lexical access are language nonselective, meaning that word candidates in all the languages that the reader knows become active following exposure to the letter string.

To illustrate, Van Hell and Dijkstra (2002) asked participants to perform a lexical decision task in Dutch, their native language, and examined the effect of cognate status – cognates are words the have similar phonology and meaning across languages (*bakker* in Dutch and *baker* in English). All participants were highly proficient speakers of English, their L2. Participants in one group were also advanced learners of French, whereas the other group had only limited knowledge of French. Some of the Dutch words in the experiment had cognates in English and others had cognates in French, but never in both languages. Importantly, participants were recruited without any reference to their foreign language knowledge, and at no point during the experiment did they receive information that knowledge of languages other than Dutch was relevant for task performance.

Results showed significant cognate facilitation, expressed by shorter reaction times, for Dutch-English cognates by all participants, and for Dutch-French cognates by the high-proficiency French trilinguals. This means that although participants were performing a lexical decision task in their native and strongest language, the stimuli activated lexical information in a task-irrelevant weaker language. These findings constitute a strong demonstration of nonselective lexical access in visual word recognition, though a threshold level of proficiency in a language has to be met before information is automatically activated.

Effects of non-selective lexical access have also been demonstrated for interlingual homographs, words that share orthography but not meaning (and often differ in phonology as well) across languages. Thus, the word *room* in Dutch means cream. Several studies have found that interlingual homographs are processed differently than words that unambiguously belong to one of the languages (e.g. Beauvillain and Grainger 1987; Dijkstra et al. 1999). The direction of the effect (facilitation or inhibition) depends on the specific task parameters introduced in each study, but its presence is evidence that such stimuli activate representations in both languages. Finally, cross-language effects have also been demonstrated in experiments examining orthographic neighborhood (e.g. Van Heuven et al. 1998) and word frequency effects (Dijkstra et al. 1998).

There are only a few studies that have examined cross language activation in languages that do not share a script. Generally, semantic facilitation effects are found for languages that don't share a script (e.g. Chen and Ng 1989). An interesting study by Gollan et al. (1997) showed cross linguistic masked translation priming in a lexical decision task, for Hebrew and English, languages that differ not only in script but in reading direction as well (Hebrew is written from right to left). Primes in the L1 facilitated the processing of their translations in the L2, for both Hebrew dominant and English dominant bilinguals. The priming effect was stronger for cognates than for non-cognates. The authors ascribe this pattern of results to links between translation equivalents at the lexical level, and claim that the phonological form similarity of cognates results in stronger links for these items, when compared with non-cognates. They further suggest that distinct orthographies provide a salient cue for language membership of visual words forms, which can allow for more efficient lexical access, possibly limited to the relevant lexicon.

1.3 Neural Representation

Studies of brain function and language localization in bilinguals mostly give rise to results converging with the behavioral studies presented above. Generally speaking, first and second language processing are overall supported by the same brain areas, with extensive overlap with language areas identified for monolinguals. Nonetheless, brain activation patterns in L2 are modulated both by the proficiency in the language and in some circumstances by age of acquisition as well.

Studies examining bilingual language production in highly proficient bilinguals, regardless if they acquired the L2 at an early age or later in life, have found very similar patterns of activation for both languages. However, bilinguals with lower proficiency in the L2 recruited more brain tissue when producing words in the second language, and activation went beyond the classical language areas (Abutalebi et al. 2005). A study examining multilinguals who spoke four languages each, found that producing words in less proficient languages lead to wider left hemisphere activation, especially in prefrontal areas (Briellmann et al. 2004).

Studies of written and spoken language comprehension reveal similar patterns, at least as far as semantics are concerned – wider and more variable activation for less proficient languages (e.g. Dehaene et al. 1997), with minimal influence of age of acquisition. For example, a recent longitudinal study focusing specifically on single word processing examined native English speaking exchange students shortly after arriving in Germany and 5 months later, and compared the activation patterns for reading words in English and in German. Initially, words in German, the foreign and less proficient language, evoked greater frontal activations than words in English, the native language. However, several months later these differences were significantly reduced, due to the participants growing proficiency and experience in reading German. Thus, lexical-semantic processing of first and second languages converges onto similar networks when differences in proficiency diminish, and when both languages are alphabetic (Stein et al. 2009).

However, a different pattern emerges for syntactic processing. Wartenburger and colleagues (2004) tested three groups of Italian-German bilinguals: one group of highly proficient bilinguals who had learned both languages at an early age, and two groups of late learners – one of highly proficient speakers of German and the other of less proficient speakers. Participants read sentences in both languages, and performed two tasks in different experimental blocks. Results showed that when participants performed a semantic judgment task, answering the question "does this sentence make sense?", activation patterns were highly similar for L1 and L2 for both high proficiency groups, but low proficiency participants activated wider areas when processing the L2 than when processing the L1, corroborating previous findings. However, when participants performed a grammaticality judgment, answering the question "is this sentence grammatically correct?," a different pattern emerged. In this case, the early high-proficiency bilinguals activated highly overlapping brain areas for grammatical processing in the two languages, but both of the late learner groups showed significantly larger activations when processing grammar in the L2, in Broca's area and in subcortical structures. This last finding is especially striking, since in terms of their accuracy on the task, the high proficiency late learners were indistinguishable from the early learners. This study demonstrates that different aspects of language processing are variably sensitive to factors such as proficiency and age of acquisition.

1.4 Bilingual Language Representation – Conclusions

To summarize, behavioral studies show largely parallel and nonselective activation of the two languages of high-proficiency bilinguals. Thus, for bilinguals whose two languages share an orthography, it seems that words in any language activate both lexicons in a search for appropriate candidates. Further, visual word recognition is influenced by properties of the word in all the languages a person knows, at least beyond a minimal level of proficiency. For languages that do not share a script, it seems that lexical and semantic links again provide the means for cross language activation. Imaging studies demonstrate that L1 and L2 of highly proficient bilinguals are mostly supported by the same neural tissue. For less proficient users, processing in the second language recruits additional neural resources that often extend beyond classical language areas.

The large degree of overlap in language representation and processing for bilinguals might lead to the prediction that literacy related skills and abilities acquired in the L1 would be available for reading in the L2 as well, leading to strong positive transfer effects and commonalities in performance across languages. At the same time, the language non-selective access demonstrated for bilinguals could imply strong cross-linguistic interference in reading. Such effects might be expressed in transfer of non-appropriate strategies and schemas, and could necessitate bilingual readers to recruit control mechanisms that are not usually recruited by monolingual readers. A better understanding of how these issues might play out requires first a consideration of the degree of similarity of reading in different orthographies, and the possible differences arising from the unique properties of various writing systems. This issue will be presented in the next section.

2 Reading in Different Orthographies

Reading is a complex skill that relies on several linguistic and cognitive subcomponents (Vellutino et al. 2007). In acquiring literacy individuals must first learn to map orthography to phonology, a task that requires visual identification of letters, the ability to isolate spoken speech sounds or phonological awareness, and the working memory capacity allowing linking up one to the other. With time and practice readers acquire fluency in word decoding, allowing them to automatically map orthography to phonology and allocate attentional resources to the task of high level text comprehension. At this stage, extracting meaning from print also relies on syntactic and lexical knowledge of the spoken language, and on general cognitive, memory and inference skills. The specific roles played by the various subcomponents can change along the trajectory of literacy acquisition, and are also influenced by the characteristics of different writing systems. Most of the research reviewed in this section focuses on the earlier stages of reading, namely decoding and lexical access, whereas less time is devoted to reading comprehension.

Orthographies can differ in the basic mapping principles of graphemes to phonemes, and a main distinction is between logographic orthographies which represent phonology at the whole word or morphemic level, and alphabetic orthographies which are used in the majority of modern languages, and that represent smaller phonological units directly with letters or letter combinations. However, even alphabetic languages differ in the complexity of the system or orthographic depth (Katz and Frost 1992). Thus, certain orthographies, such as Spanish or German, are very consistent in the way that graphemes represent phonemes, whereas in other orthographies, such as Danish or unpointed Hebrew, the mapping between letters and sounds is less straight forward. Alphabetic scripts also differ in the level at which they are consistent, or the grain size of the correspondence between the orthographic and the phonological information (Ziegler and Goswami 2005). In this section I will review the implications that the differences outlined above between scripts have for literacy acquisition and skilled reading on the behavioral level, and for the neural basis of reading.

2.1 Literacy Acquisition

Several studies have compared the progress of literacy acquisition in different orthographies (e.g. Caravolas et al. 2003; Ellis and Hooper 2001; Seymour et al. 2003). Seymour and colleagues conducted a large-scale study of first grade children in 14 European countries, learning to read in as many different orthographies. Children learning to read consistent shallow orthographies made rapid progress in literacy acquisition. For example, children learning to read Finnish, Greek and German, which all have shallow and consistent orthographies, reached ceiling levels in accurately decoding both words and non words by the end of the first year of instruction. On the other hand, children learning to read more complex and less consistent orthographies, such as French or Danish, displayed relatively high error rates at a parallel point of instruction. Further, children learning to read in English were significantly delayed when compared to children acquiring literacy in other languages, and had error rates of over 50% even after a full year of instruction. The extreme difficulty encountered by children learning to read in English can be attributed to the great depth and opacity of the system, as noted by Share (2008).

It is difficult to directly compare reading acquisition in logographic orthographies, such as Chinese, to reading in alphabetic languages because of the inherent differences and the challenge of constructing parallel tests. However, children learning to read Chinese first receive instruction in Pinyin, an alphabetic script in which letters from the Roman alphabet represent phonemes in Chinese, in a highly transparent and consistent manner. Children learn this script rapidly, and become highly competent in decoding it (Hanley 2005), and continue to use it throughout elementary school at least, to allow them to pronounce novel characters independently. These findings can be seen as another example of rapid and successful acquisition of a shallow and consistent orthography. As for the development of competence in reading Chinese characters, children in mainland China are expected to master approximately 2,400 characters by the end of elementary school.

Besides learning rates and trajectories, the question arises whether literacy acquisition in different orthographies relies on the same underlying cognitive skills, a question that will receive more attention in Sect. 3, discussing the transfer of literacy skills between the languages of bilingual readers. Most research has addressed the role of phonological awareness in literacy acquisition, and the bidirectional influences between phonological awareness and learning to read. Thus, initial phonological awareness allows children to begin isolating phonemes and correctly establishing the mappings between them and the newly acquired graphemes. At the same time, increasing practice with letters and sounds leads to greater sensitivity to individual phonemes and an improved ability to manipulate them. Phonological skills, at least at the phonemic level, seem to have lower predictive value for literacy acquisition in Chinese, for example, than in alphabetic orthographies (Hanley 2005). Further, Ziegler and Goswami (2006) argue convincingly that the exact nature of the phonemic representations most important for effective reading acquisition varies across languages, as a function of their orthographic properties.

A recent cross-linguistic study investigated the role of phonological awareness, memory, vocabulary, rapid naming and nonverbal intelligence in predicting the reading performance of second graders across five orthographies, varying in their depth from transparent (Finnish) to relatively opaque (French) (Ziegler et al. 2010). Results demonstrated that phonological awareness was the strongest predictor of decoding and word reading in all the orthographies examined, followed by rapid naming that predicted speed of performance in most orthographies, and phonological memory and vocabulary that were weaker predictors of performance in some of the languages. Nonverbal IQ was not related to reading as measured in this study in any of the participating countries. More interestingly, however, the strength of the relation between phonological awareness and single word reading and non-word decoding was modulated by orthographic depth. Thus, phonological awareness was

a weaker predictor of performance in transparent than in opaque orthographies. The conclusion is that the predictors of literacy acquisition and decoding in alphabetic languages are relatively universal, though the specific weights may differ depending on the characteristics of specific scripts.

2.2 Skilled Reading

In addition to literacy acquisition, skilled reading also differs across orthographies. The orthographic depth hypothesis (Frost et al. 1987) and the psychological grain size theory (Ziegler and Goswami 2005, 2006) both claim that reading in different orthographies is not identical and that the depth of an orthography, as well as the structure of a language, can influence skilled reading (Frost 2005). Specifically, it is argued that readers of shallow orthographies rely mainly on assembled phonology, namely recovering the phonological representation of the word from print, because in shallow orthographies this process is relatively easy and simple. Conversely, readers in deep orthographies rely more on larger phonological units, and/or use an impoverished and only partly-specified phonological representation to access the lexicon and retrieve lexical information that in turn guides the composition of a fully specific phonology and ultimately lexical access (Coltheart et al. 2001; Frost 2005).

A study demonstrating the influence of orthography on skilled reading was conducted by Ziegler et al. (2001), who compared adult readers of German, a shallow orthography, and English, a deep orthography, naming the exact same words and non-words. The English readers exhibited strong effects of body and rhymes, which are relatively large units. Conversely, the German readers' naming performance was affected by the number of letters, or overall length, of both words and non-words. The authors interpret these results as demonstrating that skilled readers of different orthographies rely on variously sized units that have proven themselves effective throughout the reader's experience with the orthography. Thus, readers of deep orthographies rely on large-sized units, whereas readers of shallow orthographies rely on the smallest possible units, namely single phonemes.

Frost (2009) has further argued that lexical access in languages that differ in morphological structure is qualitatively different, due to different organizing principles of the lexicon. In a detailed comparison of Hebrew and English, two alphabetic orthographies that are very different in morphological structure, he demonstrates striking differences in performance. There are strong effects of orthographic information facilitating word recognition in English and other European languages, both in masked priming (e.g. Davis and Lupker 2006) and in parafoveal facilitation (Rayner 1998). However, the effects of morphological information are not as consistent in these languages in both research methodologies. In Hebrew, on the other hand, the opposite pattern of effects is observed – robust facilitation from morphological information in masked priming (Frost et al. 2005) and parafoveal preview (Deutsch et al. 2000), but no influence of orthographic information (Frost et al. 2005).

Finally, orthographic features also influence eye-movements in reading, and specifically the size and nature of the perceptual span, the space of characters from which information can be extracted during a specific fixation (Rayner 1998). For readers of English and other European languages, the perceptual span is asymmetrical, extending only 3–4 characters to the left of the fixated word, but 14–15 characters to the right. In orthographies written from right to left, such as Hebrew, this asymmetry is reversed. Thus, the perceptual span extends further towards the direction of reading. Additionally, the perceptual span is significantly smaller for readers of logographic languages such as Japanese kanji and Chinese, extending 1–3 characters to the left of the fixated character, and 3–6 characters to the right. This is most likely because these orthographies are densely packed visually, so that each character carries more information.

2.3 *Imaging Studies*

Additional evidence for the claim that orthographies with different characteristics are not processed identically comes from studies examining brain activation during reading. A PET study comparing readers of English and Italian (a deep and a shallow orthography, respectively) showed that overall similar brain areas are involved in reading. But, readers of Italian showed greater activation of the left planum temporale, which is involved in sublexical phonology, whereas English readers had greater activation in the visual word form area when reading non-words, probably due to heavier reliance on a strategy of analogy to existing words than Italian readers, who most likely relied more on phonological assembly (Paulesu et al. 2000). These differences in brain function are driven by the differences between the orthographies of the two languages which lead skilled readers to adopt different strategies.

A second study comparing reading in English with reading in Spanish using fMRI reports similar findings (Meschyan and Hernandez 2006). Namely, when reading words in Spanish, a highly transparent orthography, the superior temporal gyrus which is implicated in phonological processing was more highly activated than when participants read words in English. Reading words in English, on the other hand, lead to stronger activations in visual processing and word recoding areas, at the occipito-parietal border. However, these findings must be interpreted with caution, because the participants in the study were more proficient in English than in Spanish, a fact that might have influenced the findings.

Finally, a recent meta-analysis compared brain activity in individuals reading different scripts, by including fMRI studies of single word reading in alphabetic European languages, in the two scripts of Japanese (Kanji and Kana) and in Chinese characters (Bolger et al. 2005). It is important to stress that all studies included in the meta-analysis recruited native speakers/readers of the relevant language. The results reveal convergence across these vastly different writing systems, and identify a network of three brain areas in the left hemisphere that support reading. These include the superior posterior temporal gyrus (BA22), the inferior frontal gyrus (BA6) and the occipitotemporal region, with foci both in the posterior fusiform and in the mid-fusiform gyrus, identified as the visual word form area. At the same time, there were also areas of divergence across the scripts examined. The exact localization of peak activation within the broad areas was different for logographic scripts (Chinese and Kanji) on the one hand and the alphabetic scripts (European languages and Kana) on the other. Without going into too much detail, the logographic scripts tended to activate areas more consistent with larger phonological units, and those that support the synchronous processing of phonological and semantic information. Reading in Chinese lead to activations in right inferior occipital and posterior fusiform regions, in addition to the activation of these areas in the left hemisphere that was observed for alphabetic scripts (see also Tan et al. 2005). The authors postulate that these activations reflect the need of Chinese readers to process the complex spatial information of Chinese characters.

2.4 *Reading in Different Orthographies – Summary*

To summarize this section, there is behavioral and neural evidence supporting the claim that there are aspects of literacy and reading that are universal. However, the specific characteristics of different orthographies have also been shown to influence the rate and predictors of literacy acquisition, the performance of skilled readers and the neural substrates involved in reading.

As far as the performance of bilinguals reading in two languages, the universal aspect of these findings can lead us to expect behavioral and neural commonalities, and transfer or sharing of literacy related skills across languages. However, the extent of such commonalities will probably depend on the degree of similarity between any two orthographies examined. For example, children acquiring literacy simultaneously in two orthographies that differ markedly in consistency might display different learning rates. Additionally, the utility and effectiveness of transferring literacy strategies from an L1 to an L2 will again be modulated by the degree to which the orthographies in question rely on similar mapping principles. The next section will describe studies examining such questions, and suggest a framework for conceptualizing reading in more than one language.

3 Bilingual Reading

3.1 *Literacy Acquisition in More Than One Language*

There is a moderately sized body of research examining children acquiring literacy in more than one language. In many cases, children are native speakers of one language, and learning to speak and read the second language. Whereas children acquiring literacy in their L1 learn to read words and syntactic structures that are already part of their oral repertoire, learners of a foreign language need to learn the new alphabet, the meaning of new words and syntactic rules simultaneously as they learn to accurately recognize the written form of these features (Geva et al. 1997). In other cases, children are proficient bilingual speakers of two languages, and are acquiring literacy concurrently in both.

Oral language skills relevant for acquiring orthographic decoding abilities and fluent word reading, including phonological working memory (e.g. Gholamain and Geva 1999) and phonological awareness (e.g. Gottardo et al. 2001), are mostly found to correlate across the two languages of children learning to read in an L2. Further, a review of the literature reports robust correlations across first and second language for word and for pseudoword reading (Dressler and Kamil 2006). Interestingly, correlations are of a similar magnitude for languages that share an alphabet (e.g. Spanish and English, Durgunoglu et al. 1993) and languages that do not (e.g. Persian and English, Gholamain and Geva 1999). Another recent large scale review (Lesaux and Geva 2006) also reported that children acquiring literacy in English as a less proficient L2 did not differ significantly from native English speaking children acquiring literacy in their L1 on measures of word reading accuracy and spelling ability. Additionally, similar factors, including phonological processing skills, phonological memory and rapid naming predicted reading performance for all children. However, the specific properties of different orthographies have been found to influence the amount of exposure necessary for accurate and efficient decoding.

To illustrate this point, I will describe several studies focusing on word reading in Hebrew and English, languages that differ in script and in orthographic transparency – pointed Hebrew (which includes vowel information) is considered a shallow orthography while English is a relatively deep orthography. Geva et al. (1997) recruited native English speaking children in the first and second grade, who were acquiring literacy simultaneously in English, their L1 and in Hebrew, their less proficient L2. The authors report robust correlations across the two languages in measures of accuracy and speed in single word reading. At the same time, the morphosyntactic density of Hebrew influenced the development of reading skill, and hindered the children's ability to reach high efficiency in reading texts in Hebrew. A second study testing a similar population, but extending up to fifth grade (Geva and Siegel 2000), found that memory skills predicted word reading in both languages, but that children read more accurately in Hebrew, a shallow orthography, than in English, a deep orthography (see also Gholamain and Geva 1999). Further, the decoding errors committed in the two orthographies were qualitatively different, due to their different nature. Schiff and Calif (2007), on the other hand, examined Hebrew speakers in the initial stages of learning English as a foreign language, and found a strong correlation between L1 and L2 word reading only when there was a deficiency in Hebrew orthographic-phonological or morphological awareness. Thus, they concluded that high scores on Hebrew orthographic-phonological

and morphological awareness tasks do not necessarily ensure successful English word reading, possibly because of the fundamental differences between the two orthographies.

All three studies, therefore, point to some overlap in basic reading skills across Hebrew and English, but these are limited by the orthographic differences between the two writing systems, and by the linguistic differences, specifically at the morphological level. Additional support for this conclusion comes from another relevant study that focused on readers of English and Arabic, a Semitic language with many similarities to Hebrew. Again, participants were children who were native speakers of English studying Arabic as a second language (Saiegh-Haddad and Geva 2008). Results showed a significant correlation between phonological awareness in English and pointed transparent Arabic, but morphological awareness in the two languages was not correlated

The studies reviewed so far in this section focused on lower level processes in reading, specifically decoding and fluent word reading, and found mostly similarities across the two languages of young readers, though these might be limited by the degree of typological similarity across language and orthographies. However, when investigating higher level literacy skills, most notably reading comprehension, somewhat different patterns of results emerge. On the one hand, in a review of the literature, Dressler and Kamil (2006) report significant transfer of reading comprehension skills across the languages of biliterate children. Similarly, Gelderen et al. (2007) demonstrated a relationship between L1 (Dutch) and L2 (English) reading comprehension in adolescents, and a strong effect of metacognitive knowledge on L2 reading comprehension. At the same time, they found that language specific knowledge in the L2 significantly influenced reading comprehension outcomes.

However, in a comparison of reading comprehension achievement of L2 compared with L1 readers, larger gaps are evident than is the case for lower level reading skills such as single word decoding. Thus, in the same review by Lesaux and Geva (2006) that found comparable decoding performance for native English speakers and learners of English as a second language the latter group exhibited significantly poorer reading comprehension, most likely because of decreased oral language proficiency and limited vocabulary knowledge.

There is no doubt that a main building block of reading comprehension is the proficiency level of the language, whether it is a first language or an additional language. Various facets of proficiency have been identified in this regard, including vocabulary knowledge, syntactic awareness (Lesaux et al. 2006) and morphological awareness (Koda 2007) for both L1 (Vellutino et al. 2007) and L2 (Durgunoğlu 2002; Lesaux and Kieffer 2010). Gottardo and Mueller (2009) expanded the Simple View of Reading model (Gough and Tunmer 1986), which was initially proposed in the context of L1 reading, to encompass reading comprehension in the second language, and tested Spanish speaking first and second graders learning English as a second language. Results demonstrated that listening comprehension, vocabulary, syntactic knowledge and decoding in L2 were good predictors of English reading comprehension. Lesaux and Kieffer (2010) found a higher rate of poor comprehenders amongst sixth grade English language learners than among their native speaking classmates, but all poor comprehenders, regardless of language background had poor vocabulary skills in English. A study of 4th grade children comparing native speakers and children learning English as a second language (Lesaux et al. 2006), again confirmed similar profiles for good and poor comprehenders, regardless of their language group.

Before moving on to describe research dealing with biliteracy in adult readers, I would like to raise the intriguing possibility that simultaneous, or sequential, acquisition of literacy in two languages might confer advantages and lead to faster or more efficient learning. Schwartz and colleagues (Schwartz et al. 2005, 2008) examined the literacy development of Hebrew in the first grade among Russian-Hebrew bilinguals and Hebrew monolinguals. Importantly, half of the bilinguals had started acquiring literacy in Russian before beginning schooling in Hebrew, and were thus biliterate, whereas the others were bilingual speakers of both language, but were monoliterate in Hebrew. Results showed a clear advantage for the biliterates over monolingual and bilingual monoliterates in measures of reading fluency and phonological awareness. The authors ascribe this advantage to their early exposure to the fully fledged Russian orthography, which enhanced their ability to distinguish consonants from vowels, a skill that was then transferred to Hebrew.

Bialystok et al. (2005) addressed a similar question, by comparing four groups of first grade children in Canada acquiring literacy in English: English monolinguals, and three bilingual groups: Spanish-English, Hebrew-English and Cantonese-English. All bilingual groups were highly proficient in their oral use of the two languages, and were concurrently learning to read in English and in their other language. The Spanish-English and the Hebrew-English bilingual children outperformed the Cantonese-English bilinguals and the monolinguals on a phoneme counting task, exhibiting stronger phonological awareness skills. These advantages are most likely due to their exposure to two alphabetic languages, which enhanced the development of phonological awareness because of its critical role in decoding alphabetic scripts. Further, even after controlling for differences in phonological awareness, the Spanish-English and the Hebrew-English bilinguals outperformed the monolinguals in a decoding task in English, and the Cantonese-English bilinguals were at an intermediate level. Again, what is important here is that the similarity between the two orthographies being acquired modulates the degree of transfer of skills. Learning two alphabetic languages, even if they do not share the same script (Hebrew and English), enhanced literacy development and allowed children to generalize their emerging skills to a greater degree than learning a logographic and an alphabetic script (Cantonese-English). Further support for this conclusion can be found in the fact that reading in the two languages was highly correlated for the Spanish-English and the Hebrew-English bilinguals, who were reading two alphabetic languages, but was not related at all for the Cantonese-English bilinguals (for similar findings of divergence between reading skill in English and logographic languages see Gottardo et al. 2001).

3.2 Second Language Reading in Skilled Adult Readers of an L1

In comparison with research on literacy acquisition in children, less is known about the development and stabilization of reading skills in adult second language learners or bilinguals. Still, in this section I will present studies concerned with visual and phonological processing of L1 and L2 in this population.

Green and Meara (1987) found significant differences in visual search for shapes and orthographic symbols (Roman and Arab letters and Chinese characters) among readers of the different languages. Readers of Arabic and Chinese were compared with readers of English and Spanish, and were found to process symbol strings differently. Most importantly, even when searching strings of Roman letters, the Arabic and Chinese native speakers maintained the same search pattern that they had displayed in their native language, despite being intermediate to advanced readers of English as a second language. The authors conclude that word reading strategies established for reading in the native language are transferred to the second language, and seemingly do not change to accommodate the orthographic specificities of the new script.

Several additional studies provide consistent evidence that features of L1 orthography influence the reliance on different mechanisms and strategies in L2 reading. Koda (1988, 1990) found that L2 learners of English who had an alphabetic L1 (Arabic, Spanish) showed superior grapheme to phoneme conversion in English than did L2 learners who were L1 readers of Japanese, a non-alphabetic language. The alphabetic L1 readers were also more significantly impaired when confronted with unpronounceable words in an English text than were the Japanese L1 readers. Further, Akamatsu (2003) found that readers with a non-alphabetic L1 background (Chinese and Japanese) were delayed to a greater extent when reading an L2 English text that had been visually modified by using case alternation than readers with an alphabetic L1 background (Persian). Finally, Wang et al. (2003) compared college aged native readers of Korean (an alphabetic script) and Chinese learning English as a second language, and found that the former group relied more strongly on phonological processing, whereas the latter relied less on phonology and more on orthographic information when reading single words in English. Taken together, these findings demonstrate that mechanisms and strategies shaped by features of the L1 orthography are transferred to L2 reading, and continue to exert their influence even in fairly advanced readers. Specifically, readers with a non-alphabetic L1 background continue to rely on visual information even when processing an alphabetic L2, which leads to less efficient word processing.

A recent study by Ehrich and Meuter (2009) found similar effects, but in the reverse direction. Native speakers of Chinese and English were compared on their ability to learn an artificial logographic orthography. Chinese speakers outperformed the English speakers in a lexical decision task on the newly acquired symbols, an advantage that stems from experience with a logographic script. This finding demonstrates transfer of L1 logographic processing that is parallel to the previously described transfer of alphabetic processing from an alphabetic L1 to an alphabetic L2.

Wade-Woolley (1999) compared the decoding ability of L1 readers of Russian and Japanese in their L2, English. The Japanese readers were impaired relative to the Russian readers on a phoneme deletion task, but outperformed them in tasks of orthographic sensitivity. The two groups did not differ in their English decoding ability, but seemed to reach these comparable levels of performance in different manners. The L1 Russian readers relied more extensively on phonological processing, but the L1 Japanese readers recruited their strength in orthographic processing. These findings provide further support to the notion of transfer from L1 to the L2, and demonstrate that different linguistic backgrounds can allow for the transfer of different linguistic component skills, leading to qualitatively different outcomes despite an overall matched level of performance.

Fewer studies have examined reading comprehension in adult populations, but the extant evidence again supports the notion of cross-linguistic transfer and the influence of both L1 and L2 skills on L2 reading comprehension. Koda (1992) investigated native English speaking college students learning Japanese as a foreign language, and found that lower level skills, such as letter identification and word recognition in Japanese significantly predicted reading comprehension. Similarly, Nassaji and Geva (1999) tested adult native speakers of Farsi, who were advanced learners of English as an L2. They found that phonological and orthographic processing contributed significantly to reading comprehension and reading rate, but only orthographic processing remained a significant predictor after accounting for effects of syntactic and semantic knowledge of English.

Meschyan and Hernandez (2002) investigated native English speaking college students, in the first semester of acquiring Spanish as a second language. Decoding skills in English were found to correlate highly with decoding skills in Spanish. Further, Spanish decoding skill was found to mediate the ability of English decoding skill to predict vocabulary acquisition and final course grade in Spanish. These findings attest to significant transfer of phonological-orthographic ability from the native language to the second language among college-age adults, albeit across two alphabetic scripts using the same Roman alphabet. The results further demonstrate the importance of lower level skills in the L2 for language learning in general.

Several studies focusing on fairly advanced bilingual readers of Hebrew and English give rise to interesting findings. In one study of college-age readers, measures of word and pseudoword reading in the two languages were correlated (Oren and Breznitz 2005), and participants were equally efficient in reading the two orthographies, despite their differences. A second study again found significant correlations across the two languages, this time in measures of sentence comprehension (Breznitz et al. 2004), but in this case significant advantages emerged for processing Hebrew, the native language, over English, the L2. Shimron and Sivan (1994) reported that balanced bilinguals read English texts faster and showed better comprehension over text presented in unvoweled Hebrew. However, no differences were found between reading in English and reading in voweled Hebrew. The authors ascribe these findings to the specific challenge of reading in unvoweled Hebrew which is characterized by a paucity of phonological information, as well as the overall morphological density of written Hebrew, in both forms.

Finally, Velan and Frost (2007) tested the hypothesis that the structural differences between Hebrew and English, especially in morphological richness, would lead to different effects in reading the two languages. Balanced Hebrew-English bilinguals were tested with a letter transposition paradigm. Previous research in European languages has demonstrated that priming can occur from words with letter transpositions, such as *gadren* priming *garden*, and that reading text including transposed words does not cause great difficulty for readers in these languages. Hebrew morphology is based on three-letter consonantal roots, and many roots share the same consonants but in different order, which might lead to increased sensitivity to letter position when reading Hebrew. In the study, participants were rapidly presented with sentences in English and in Hebrew, half of which included a word whose letters had been transposed. When reading in English, participants' ability to repeat the sentence was not impeded by the presence of a transposed word, and they were at chance level when requested to report whether a sentence had indeed included such a transposition. Strikingly, when reading sentences in Hebrew these same participants suffered a 20% decrease in accuracy in sentence repetition, and were highly accurate in detecting transpositions ($d' = 2.51$).

The correlations found across performance in the two languages of bilingual readers show that there are common underlying mechanisms that support reading generally. The importance of low level skills for reading in the L2, even in adults, has also been stressed. Finally, the research reviewed in this section demonstrates that the mechanisms of reading orthographies with different features and languages of different structure can vary even within the same individual. In some cases, patterns established through the L1 are carried over when processing the L2, whereas under different circumstances bilingual readers exhibit differential processing across their two languages. This last point will also become apparent in the next section, discussing the neural substrates for reading in the two languages of bilinguals.

3.3 *Neural Substrates of Reading in More Than One Language*

Several studies have examined the neural substrates involved in reading different languages, and have focused specifically on bilinguals. In this section I will focus on research examining the brain networks recruited by bilingual readers when reading alphabetic as opposed to logographic language. Because of the fundamental difference between these two types of scripts, and previous findings (discussed in Sect. 2.3) demonstrating that there are indeed differences between native readers of orthographies of these types, this bilingual population provides a powerful test case of the degree to which L2 reading relies on patterns established in the L1.

Nakada et al. (2001) examined bilingual and monolingual readers of English and Japanese, half with English as L1 and half with Japanese as L1. As might be expected, activation patterns for native readers in Japanese were different from those observed for native readers in English. Both groups showed activation of the left fusiform gyrus, but Japanese readers additionally showed activation of the left inferior temporal sulcus that was lacking from the English readers, whereas the English readers had significant activation in the lingual gyrus bilaterally, that was mostly absent from Japanese readers. More importantly, when reading in the L2 the bilingual participants, who were highly literate in both languages, showed activation patterns that were virtually identical to those displayed when they read in the L1. Thus, English natives reading in Japanese showed activation patterns similar to the ones they exhibited when reading in English, and the same was true for Japanese natives – their activation patterns were indistinguishable whether they were reading in L1 Japanese or L2 English. These findings are reminiscent of the behavioral findings presented in the previous section, regarding transfer of visual (Green and Meara 1987) and decoding mechanisms (Wade-Woolley 1999) from L1 to L2 reading.

A second study examining reading in Japanese English bilinguals (Buchweitz et al. 2009) made use of the fact that Japanese can be written using two distinct writing systems – Kana (syllabic) and Kanji (logographic). Kanji showed more activation than Kana in right-hemisphere occipito-temporal areas associated with visuospatial processing, because of the increased visual complexity of the logographic script. Reading sentences in Kana lead to greater activation in areas of the brain associated with phonological processing. When participants read sentences in English, an alphabetic language and their less-proficient L2, greater activation was found in the inferior frontal gyrus, medial frontal gyrus, and angular gyrus as compared to reading in Japanese. This additional activation is most likely associated with increased phonological processing of an alphabetic script and greater demands on verbal working memory, due to reduced proficiency in the language.

Perfetti and colleagues have studied different groups of readers of Chinese and English. Using event related potentials and source localization, Liu and Perfetti (2003) studied Chinese English bilinguals in a delayed naming task for Chinese characters and English words. Early components peaked earlier for Chinese, the more proficient language, than for English, the second language, and word frequency effects extended for a longer time window in English than in Chinese. Bilateral occipital areas were involved in processing Chinese characters, whereas the processing of high-frequency English words was limited to left occipital cortex. Chinese character reading also lead to strong right prefrontal activations, but English words activated more medial frontal areas.

In a training study, native English speakers with no knowledge of Chinese were taught 60 Chinese characters (Liu et al. 2007). Following training, passive viewing of the studied characters showed activation in the bilateral middle frontal area, and right occipital and fusiform cortex. These regions partially overlap with regions found in studies of skilled reading of Chinese but not of alphabetic languages (Bolger et al. 2005). A further study compared the brain activation of reading Chinese and English in two groups of participants: native English speakers studying Chinese in college, and proficient Chinese-English bilinguals (Nelson et al. 2009). Replicating the previous findings, native English readers displayed different patterns of activation when reading Chinese and English, and specifically recruited right fusiform areas for Chinese but not for English. Thus, their activation patterns for Chinese were similar to those exhibited by native readers of the language. The proficient Chinese-English bilinguals displayed a different pattern of results – these readers activated fusiform areas bilaterally regardless of whether they were reading English or Chinese.

The native English speakers in both studies displayed accommodation of the brain's reading network to the specific features of the acquired writing system, in this case the visual complexity of Chinese characters. However, the native Chinese readers in the second study show assimilation, because they were reading their L2 using the same network that had developed for reading their L1 (see also Nakada et al. 2001). Nelson and colleagues (2009) suggest that this pattern of assimilation is due to the fact that the reading network established for L1 Chinese includes procedures sufficient for the graphic demands of L2 English without major change.

Recently, Tan et al. (2011), using fMRI, examined reading in L1 Chinese and L2 English in 10 year old children, who had been studying English for approximately 4 years. The results show overall similarities in brain activation patterns when children performed lexical decision in the two languages, including bilateral activations in fusiform areas, the inferior frontal gyrus and occipital areas. Activation patterns were also correlated with reading performance in both languages measured immediately before the scanning session and again 1 year later. Activation rates in the left fusiform gyrus during performance of the lexical decision task in English were significantly correlated with concurrent reading performance and significantly predicted gains in reading a year later. Moderate and non-significant correlations between fusiform activity and Chinese concurrent and future reading were also found. Most interestingly, however, left caudate nucleus activation was highly correlated with reading and reading gains in English, the L2, but not in Chinese, the L1. This last finding is related to the role of the caudate nucleus in inhibiting interference from the non-relevant language in bilinguals. This underlines the fact that skilled performance in the L2 necessitates successfully overcoming parallel activation of competing L1 forms, as discussed in Sect. 1.

The studies reviewed in this section reveal a complex pattern. The brain networks recruited for reading in first and second language clearly overlap and again reveal certain universals. However, the degree of accommodation necessary for reading a newly acquired L2 orthography that differs markedly from that of the L1 is determined by the specific properties of the two orthographies. Further, there are cases where readers of an L2 rely on brain networks that are distinct from those used by native readers of the same orthography, by virtue of the brain's reading network being shaped by the specific properties of the L1 orthography.

4 Summary and Conclusions

In this chapter, I reviewed research demonstrating that semantic representations are mostly shared across the two languages of bilinguals, that lexical access is language non-selective, at least when the two languages share the same script, and that the neural representation of first and second language is influenced by proficiency and age of acquisition. I have discussed how the trajectory and predictors of acquiring literacy in different languages are influenced by features of the language and the orthography, such as orthographic depth, morphological complexity and visual density of the script. Further, these same features have been shown to influence the performance of skilled readers of various orthographies, and to be expressed in the areas of the brain supporting reading. Finally, a review of the research of individuals who are literate in more than one language reveals a complex interaction between the nature of the scripts involved and the characteristics of the individual. Due to these complexities and as yet only partial coverage of research for different language pairings and different bilingual populations, there are certain inconsistencies in results that at this point in time still hinder our ability to reach a complete understanding of this multifaceted phenomenon. Most importantly, we have not yet reached a full picture of the reciprocal influences existing between first and second language reading, nor of the specific conditions under which native language reading strategies and mechanisms are transferred to L2 reading as opposed to conditions more conducive to the development of more independent L2 reading mechanisms.

Although further research focusing on specific L1-L2 pairings that vary in the degree of overlap in orthographic principles and features is called for, nonetheless the extant literature allows me to suggest several guiding principles. For pairs of languages that share the same character set, such as European languages using the Roman alphabet, the initial stages of L2 reading are facilitated (e.g. Kempe and MacWhinney 1996). However, skilled readers of such language pairs might suffer increased interference from the two lexicons, due to the lack of orthographic cues that might assist in limiting activation to the currently-relevant language.

More generally, from the reviewed research I wish to identify three relevant dimensions along which a given pair of orthographies can be judged as similar or more distinct: (1) Writing system, i.e. alphabetic or logographic; (2) Orthographic depth, or grain size; (3) Linguistic or typological similarity of the oral languages.

I hypothesize that greater similarity across these dimensions will result in greater transfer of literacy skills across languages in bilingual readers. Thus, a native reader of an alphabetic and orthographically shallow script can quite easily utilize decoding processes developed in the context of the L1 when attaining literacy and then reading fluently in a similarly shallow alphabetic orthography of the L2. However, increasing dissimilarity between the L1 and the L2 along these dimensions might lead to transfer of L1 literacy skills being less than optimal for L2 reading, or at the minimum will lead to differences in processing for L2 readers of varying L1 backgrounds, as reviewed above.

A central question in this regard is how much flexibility and plasticity exists in the cognitive and neural systems for developing L2 specific reading mechanisms. As is the case for second language in general, the answer to this question most likely depends both on the degree of oral and written proficiency in the L2 and on the reader's age and the entrenchment of L1 reading mechanisms (MacWhinney 2005). From the literature reviewed above, a likely possibility is that as in spoken

language, beyond a certain point in development, L1 literacy is bound to leave an "accent" on L2 reading (Koda 2007). In this regard it is important to stress Cook's (2003) multi-competence framework, claiming that native speaker performance should not be the yardstick against which bilingual performance is measured. In this regard, acquiring literacy in more than one language often broadens a person's horizons and is a worthy goal, even if the L2 is processed in a manner that is qualitatively different, both cognitively and neurologically, from that common in L1 readers of the same language.

References

Abutalebi, J., Cappa, S. E., & Perani, D. (2005). What can functional neuroimaging tell us about the bilingual brain? In J. F. Kroll & A. M. B. DeGroot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 497–515). New York: Oxford University Press.

Akamatsu, N. (2003). The effect of first language orthographic features on second language reading in text. *Language Learning, 53*, 207–231.

Basnight-Brown, D. M., & Altarriba, J. (2008). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory and Cognition, 35*, 953–965.

Beauvillain, C., & Grainger, J. (1987). Accessing interlingual homographs: Some limitations of language-selective access. *Journal of Memory and Language, 26*, 658–672.

Bialystok, E., Luk, G., & Kwan, E. (2005). Bilingualism, biliteracy, and learning to read: Interactions among languages and writing systems. *Scientific Studies of Reading, 9*, 43–61.

Bolger, D. J., Perfetti, C. A., & Schneider, W. (2005). A cross-cultural effect on the brain revisited. *Human Brain Mapping, 25*, 92–104.

Breznitz, Z., Oren, R., & Shaul, S. (2004). Brain activity of regular and dyslexic readers while reading Hebrew as compared to English sentences. *Reading and Writing, 17*, 707–737.

Briellmann, R. S., Saling, M. M., Connell, A. B., Waites, A. B., Abbott, D. F., & Jackson, G. D. (2004). A high-field functional MRI study of quadri-lingual subjects. *Brain and Language, 89*, 531–542.

Buchweitz, A., Mason, R. A., Hasegawa, M., & Just, M. (2009). Japanese and English sentence reading comprehension and writing systems: An fMRI study of first and second language effects on brain activation. *Bilingualism: Language and Cognition, 12*, 141–151.

Caravolas, M., Bruchk, M., & Genesee, F. (2003). Similarities and differences between English- and French-speaking poor spellers. In N. Goulandris (Ed.), *Dyslexia in different languages: Cross-linguistic comparisons* (pp. 157–180). London: Whurr.

Chen, H. C., & Ng, M. L. (1989). Semantic facilitation and translation priming effects in Chinese-English bilinguals. *Memory and Cognition, 17*, 454–462.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual-route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*, 204–256.

Cook, V. J. (Ed.). (2003). *Effects of the second language on the first*. Clevedon: Multilingual Matters.

Costa, A. (2005). Lexical access in bilingual production. In J. F. Kroll & A. M. B. DeGroot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 308–325). New York: Oxford University Press.

Davis, C., & Lupker, S. J. (2006). Masked inhibitory priming in English: Evidence for lexical inhibition. *Journal of Experimental Psychology. Human Perception and Performance, 32*, 668–687.

Degani, T., Prior, A., & Tokowicz, N. (2011). Bidirectional transfer: The effect of sharing a translation. *Journal of Cognitive Psychology, 23*(1), 18–28.

Dehaene, S., Dupoux, E., Mehler, J., Cohen, L., Paulesu, E., Perani, D., Van de Moortele, P. F., Lehéricy, S., & Le Bihan, D. (1997). Anatomical variability in the cortical representation of first and second language. *NeuroReport, 8*, 3809–3815.

Deutsch, A., Frost, R., Pollatsek, A., & Rayner, K. (2000). Early morphological effects in word recognition in Hebrew: Evidence from parafoveal preview benefit. *Language & Cognitive Processes, 15*, 487–506.

Dijkstra, T. (2005). Bilingual word activation and lexical access. In J. F. Kroll & A. M. B. DeGroot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 179–201). New York: Oxford University Press.

Dijkstra, A., Van Jaarsveld, H., & Ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition, 1*, 51–66.

Dijkstra, A., Grainger, J., & Van Heuven, W. J. B. (1999). Recognizing cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language, 41*, 496–518.

Dressler, C., & Kamil, M. (2006). First and second language literacy. In D. L. August & T. Shanahan (Eds.), *Developing literacy in a second language: Report of the national literacy panel on language minority children and youth* (pp. 197–238). Mahwah: Lawrence Erlbaum Associates.

Durgunoğlu, A. (2002). Cross-linguistic transfer in literacy development and implications for language learners. *Annals of Dyslexia, 52*, 189–204.

Durgunoglu, A. Y., Nagy, W. E., & Hancin-Bhatt, B. J. (1993). Cross-language transfer of phonological awareness. *Journal of Educational Psychology, 85*, 453–465.

Edwards, J. V. (2004). Foundations of bilingualism. In T. K. Bhatia & W. C. Ritchie (Eds.), *The handbook of bilingualism* (pp. 7–31). Malden: Blackwell.

Ehrich, J. F., & Meuter, R. F. I. (2009). Acquiring and artificial logographic orthography: The beneficial effects of a logographic L1 background and bilinguality. *Journal of Cross-Cultural Psychology, 40*, 711–745.

Ellis, N. C., & Hooper, M. (2001). Why learning to read is easier in Welsh that in English: Orthographic transparency effect evinced with frequency-matched tests. *Applied PsychoLinguistics, 22*, 571–599.

Francis, W. S. (2005). Bilingual semantic and conceptual representation. In J. F. Kroll & A. M. B. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 251–267). New York: Oxford University Press.

Frost, R. (2005). Orthographic systems and skilled word recognition processes in reading. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 272–295). Oxford: Blackwell Publishing.

Frost, R. (2009). Reading in Hebrew vs. reading in English: Is there a qualitative difference? In K. Pugh & P. McCradle (Eds.), *How children learn to read: Current issues and new directions in the integration of cognition, neurobiology and genetics of reading and dyslexia research and practice* (pp. 235–254). New York: Psychology Press.

Frost, R., Katz, L., & Bentin, S. (1987). Strategies for visual word recognition and orthographical depth: A multilingual comparison. *Journal of Experimental Psychology. Human Perception and Performance, 13*, 104–115.

Frost, R., Kugler, T., Deutsch, A., & Forster, K. I. (2005). Orthographic structure versus morphological structure: Principles of lexical organization in a given language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1293–1326.

Gelderen, A. V., Shoonn, R. D., de Gloper, K., & Hulstijn, J. (2007). Development of adolescent reading comprehension in L1 and L2: A longitudinal analysis of constituent components. *Journal of Educational Psychology, 99*, 477–491.

Geva, E., & Siegel, L. S. (2000). Orthographic and cognitive factors in the concurrent development of basic reading skills in two languages. *Reading and Writing, 12*, 1–30.

Geva, E., Wade-Woolley, L., & Shany, M. (1997). Development of efficient reading in first and second language. *Scientific Studies of Reading, 1*, 119–144.

Gholamain, M., & Geva, E. (1999). Orthographic and cognitive factors in the concurrent development of basic reading skills in English and Persian. *Language Learning, 49*, 183–217.

Gollan, T., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates an noncognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1122–1139.

Gottardo, A., & Mueller, J. (2009). Are first- and second-language factors related in predicting second-language reading comprehension? A study of Spanish-speaking children acquiring English as a second language from first to second grade. *Journal of Educational Psychology, 101*, 330–344.

Gottardo, A., Yan, B., Siegel, L. S., & Wade-Woolley, L. (2001). Factors related to English reading performance in children with Chinese as a first language: More evidence of cross-language transfer of phonological processing. *Journal of Educational Psychology, 93*, 530–542.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*, 6–10.

Green, D. W., & Meara, P. (1987). The effects of script on visual search. *Second Language Research, 3*, 102–117.

Hanley, J. F. (2005). Learning to read in Chinese. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 316–335). Malden: Blackwell Publishing.

Jiang, N. (2000). Lexical representation and development in a second language. *Applied Linguistics, 21*, 47–77.

Katz, L., & Frost, R. (1992). Reading in different orthographies: The orthographic depth hypothesis. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning* (pp. 67–84). Holland: Elsevier.

Keatley, C., Spinks, J., & De Gelder, B. (1994). Asymmetrical semantic facilitation between languages. *Memory and Cognition, 22*, 70–84.

Kempe, V., & MacWhinney, B. (1996). The crosslinguistic assessment of foreign language vocabulary learning. *Applied PsychoLinguistics, 17*, 149–183.

Koda, K. (1988). Cognitive process in second language reading: Transfer of L1 reading skills and strategies. *Second Language Research, 4*, 133–156.

Koda, K. (1990). The use of L1 reading strategies in L2 reading: Effect of L1 orthographic structures on L2 phonological recording strategies. *Studies in Second Language Acquisition, 12*, 393–410.

Koda, K. (1992). The effects of lower-level processing skills on FL reading performance: Implications for instruction. *The Modern Language Journal, 76*, 502–512.

Koda, K. (2007). Reading and language learning: Crosslinguistic constraints on second language reading development. *Language Learning, 57*, 1–44.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language, 33*, 149–174.

Kroll, J. F., Bobb, C., & Wodniecka, Z. (2006). Language selectivity is the exception not the rule: Arguments against a fixed locus of language selection in bilingual speech. *Bilingualism: Language and Cognition, 9*, 111–135.

Kroll, J. F. K., Van Hell, J., Tokowicz, N., & Green, D. (2010). The revised hierarchical model: A critical review and assessment. *Bilingualism: Language and Cognition, 13*, 373–381.

Lesaux, N., & Geva, E. (2006). Synthesis: Development of literacy in language minority students. In D. L. August & T. Shanahan (Eds.), *Developing literacy in a second language: Report of the national literacy panel on language minority children and youth* (pp. 53–74). Mahwah: Lawrence Erlbaum Associates.

Lesaux, N. K., & Kieffer, M. J. (2010). Exploring sources of reading comprehension difficulties among language minority learners and their classmates in early adolescence. *American Educational Research Journal, 47*, 596–632.

Lesaux, N. K., Lipka, O., & Siegel, L. S. (2006). Investigating cognitive and linguistic abilities that influence the reading comprehension skills of children from diverse linguistic backgrounds. *Reading and Writing, 19*, 99–131.
Liu, Y., & Perfetti, C. A. (2003). The time course of brain activity in reading English and Chinese: An ERP study of Chinese bilinguals. *Journal of Human Brain Mapping, 18*, 167–175.
Liu, Y., Dunlap, S., Fiez, J., & Perfetti, C. A. (2007). Evidence for neural accommodation to a writing system following learning. *Human Brain Mapping, 28*, 1223–1234.
MacWhinney, B. (2005). A unified model of language acquisition. In J. Kroll & A. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 49–67). New York: Oxford University Press.
Meschyan, G., & Hernandez, A. (2002). Is native-language decoding skill related to second language learning? *Journal of Educational Psychology, 94*, 14–22.
Meschyan, G., & Hernandez, A. (2006). Impact of language proficiency and orthographic transparency on bilingual word reading: An fMRI investigation. *NeuroImage, 29*, 1135–1140.
Nakada, T., Fujii, Y., & Kwee, I. L. (2001). Brain strategies for reading in the second language are determined by the first language. *Neuroscience Research, 40*, 351–358.
Nassaji, H., & Geva, E. (1999). The contribution of phonological and orthographic processing skills to adult ESL reading: Evidence from native speakers of Farsi. *Applied PsychoLinguistics, 20*, 241–267.
Nelson, J. R., Liu, Y., Fiez, J., & Perfetti, C. A. (2009). Assimilation and accommodation patters in ventral occipitotemporal cortex in learning a second writing system. *Human Brain Mapping, 30*, 810–820.
Oren, R., & Breznitz, Z. (2005). Reading processes in L1 and L2 among dyslexic as compared to regular bilingual readers: Behavioral and electrophysiological evidence. *Journal of Neurolinguistics, 18*, 127–151.
Paulesu, E., McCrory, E., Fazio, F., Menoncello, L., Bruswich, N., Cappa, S., Cotelli, M., Cossu, G., Corte, G., Larusso, M., Pesenti, F., Gallagher, A., Perani, D., Price, C., Frith, C., & Frith, U. (2000). A cultural effect on brain function. *Nature Neuroscience, 3*, 91–96.
Perfetti, C. A. (2003). The universal grammar of reading. *Scientific Studies of Reading, 7*, 3–24.
Prior, A., Kroll, J. F., & MacWhinney, B. (2007). *The impact of translation ambiguity and word class on bilingual performance*. Paper presented at the 6th International Symposium on Bilingualism, University of Hamburg, Hamburg.
Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*, 372–422.
Saiegh-Haddad, E., & Geva, E. (2008). Morphological awareness, phonological awareness, and reading in English-Arabic bilingual children. *Reading and Writing, 21*, 481–504.
Schiff, R., & Calif, C. (2007). Role of phonological and morphological awareness in L2 oral word reading. *Language Learning, 57*, 271–298.
Schoonbaert, S., Duyck, W., Brysbaert, M., & Hartsuiker, R. J. (2009). Semantic and translation priming from a first language to a second and back: Making sense of the findings. *Memory and Cognition, 37*, 569–586.
Schwartz, M., Leikin, M., & Share, D. L. (2005). Bi-literate bilingualism versus mono-literate bilingualism: A longitudinal study of reading acquisition in Hebrew (L2) among Russian-speaking (L1) children. *Written Language and Literacy, 8*, 179–207.
Schwartz, M., Share, D. L., Leikin, M., & Kozminsky, E. (2008). On the benefits of bi-literacy: Just a head start in reading or specific orthographic insights? *Reading and Writing, 21*, 907–927.
Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*, 143–174.
Share, D. (2008). On the anglocentricities of current reading research and practice: The perils of overreliance on an "outlier" orthography. *Psychological Bulletin, 134*, 584–615.
Shimron, J., & Sivan, T. (1994). Reading proficiency and orthography: Evidence from Hebrew and English. *Language Learning, 44*, 5–27.

Spivey, M., & Marian, V. (1999). Cross talk between native and second languages: Partial activation of an irrelevant lexicon. *Psychological Science, 10*, 281–284.
Stein, M., Federspiel, A., Koenig, T., Wirth, M., Lehman, C., Wiest, R., Strik, W., Brandeis, D., & Dierks, T. (2009). Reduced frontal activation with increasing 2nd language proficiency. *Neuropsychologia, 47*, 2712–2720.
Tan, L. H., Laird, A. R., Li, K., & Fox, P. T. (2005). Neuroanatomical correlates of phonological processing of Chinese characters and alphabetic words: A meta-analysis. *Human Brain Mapping, 25*, 83–91.
Tan, L. H., Chen, L., Yip, V., Chan, A. H. D., Yang, J., Gao, J. H., & Siok, W. T. (2011, January). Activity levels in the left hemisphere caudate-fusiform circuit predict how well a second language will be learned. *Proceedings of the National Academy of Sciences of the United States of America*. doi:doi 10.1073/pnas.0909623108 [published online].
Tokowicz, N., & Kroll, J. F. (2007). Number of meanings and concreteness: Consequences of ambiguity within and across languages. *Language & Cognitive Processes, 22*, 727–779.
Van Hell, J. G., & DeGroot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition, 1*(3), 193–211.
Van Hell, J. G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin and Review, 9*, 780–789.
Van Heuven, W. J. B., Dijkstra, A., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language, 39*, 458–483.
Velan, H., & Frost, R. (2007). Cambridge University vs. Hebrew University: The impact of letter transposition on reading English and Hebrew. *Psychonomic Bulletin and Review, 14*, 913–918.
Vellutino, F. R., Tunmer, W. E., Jaccard, J. J., & Chen, R. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. *Scientific Studies of Reading, 11*, 3–32.
Wade-Woolley, L. (1999). First language influences on second language word reading: All roads lead to Rome. *Language Learning, 49*, 447–471.
Wang, M., Koda, K., & Perfetti, C. A. (2003). Alphabetic and nonalphabetic L1 effects in English word identification: A comparison of Korean and Chinese English L2 learners. *Cognition, 87*, 129–149.
Wartenburger, I., Heekeren, H. R., Abutalebi, J., Cappa, S. F., Villringer, A., & Perani, D. (2004). Early setting of grammatical processing in the bilingual brain. *Neuron, 9*, 159–170.
Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin, 131*, 3–29.
Ziegler, J. C., & Goswami, U. (2006). Becoming literate in different languages: Similar problems, different solutions. *Developmental Science, 9*, 429–436.
Ziegler, J. C., Perry, C., Jacobs, A. M., & Braun, M. (2001). Identical words are read differently in different languages. *Psychological Science, 12*, 379–384.
Ziegler, J. C., Bertrand, D., Toth, D., Csepe, V., Reis, A., Faisca, L., Saine, N., Lyytinen, H., Vaessen, A., & Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science, 21*, 551–559.