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Second Language Proficiency and Cross-Language Lexical Activation

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Although research has consistently shown that a bilingual's two languages interact on multiple levels, it is also well-established that bilinguals can vary considerably in their proficiency in the second language (L2). In this paper we review empirical studies that have examined how differences in L2 proficiency modulate cross-language co-activation and interaction during bilingual lexical processing. We review studies investigating cognate and homograph processing in visual word perception and word production, auditory word perception using the visual world paradigm, and cross-language priming, focusing specifically on how differences in proficiency modulate co-activation during lexical access. We further discuss differences in L2 proficiency in relation to immersion and age of L2 acquisition, how differences in L2 proficiency relate to neurocognitive aspects of cognitive control, and how changes in L2 proficiency relative to L1 proficiency may affect lexical processing.

Introduction

The majority of the world's speakers regularly use more than one language, and many of them have learned their second language (L2) at school during childhood. It is well-attested that L2 learners differ substantially in the success with which they learn the novel language, and only few L2 learners achieve native-like proficiency in their L2. The question we address in this paper is how

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differences in L2 proficiency affect the perception and production of the basic building blocks of a language, words.

A central question in research on bilingual lexical processing is how bilinguals access words in their two languages. The language-selective view holds that bilinguals activate only word candidates from the language that corresponds with the language of the incoming information (in comprehension) or with the language that is currently in use (in production). The nonselective view, on the other hand, claims that words from both languages are activated. More than a decade of research has found ubiquitous evidence that lexical activation in bilingual memory operates in a parallel, language nonselective way, even when the social and linguistic context calls for only one language (Kroll & De Groot, 2005). The bilingual memory system is fundamentally permeable across language boundaries, not only for bilinguals who speak two languages with the same script (for a review, see, e.g., Schwartz & Van Hell, 2012), but also for bilinguals whose two languages have different scripts (e.g., Gollan, Forster, & Frost, 1997; Hoshino & Kroll, 2008; Kim & Davis, 2003; Thierry & Wu, 2004; 2007), different gesture systems (Brown & Gullberg, 2010), or are even from two different modalities, as in sign-speech bilinguals (e.g., Morford, Wilkinson, Villwock, Piñar, & Kroll, 2011; Van Beijsterveldt & Van Hell, 2009, 2012). The majority of these studies have investigated highly proficient adult second language speakers. To what extent is the co-activation of languages modulated by differences in proficiency in the second language?

The large majority of theoretical models on the bilingual mental lexicon describe adult highly proficient bilinguals. The Revised Hierarchical Model (Kroll & Stewart, 1994; see also Kroll, Van Hell, Tokowicz, & Green, 2010) is among the few developmental models in the bilingual mental lexicon literature that incorporates a model for less proficient L2 speakers and a transition to higher levels of proficiency. Specifically, the model postulates that in the early stages of learning an L2, the connections between the L2 word form and its meaning are weak. With increased proficiency, the L2 word-form to concept mappings become stronger. The Revised Hierarchical Model does not make an explicit distinction between orthography and phonology, but also the strength of the link between these codes in the L2 will increase with increased proficiency. An implication for lexical access and retrieval is that because of the relatively weak connections between phonological, orthographic, and semantic information in the less proficient speakers' L2 lexical system, the activation of the different codes will be delayed, which will lead to slower processing of the L2 in less proficient L2 speakers as compared to more proficient L2 speakers.

This slower processing in the L2 can lead to two opposing patterns of parallel co-activation of the two languages. The overall slower processing in L2 could entail a greater decay rate of activation over time of lexical information in the nontarget language L1. By the time the L2 learner is ready to make a response (e.g., push the button in a lexical decision task or say out loud the name of a picture), activation of the nontarget L1 has decayed which may lead to reduced (or even no longer detectable) patterns of co-activation of the target and nontarget languages in less proficient L2 speakers. Alternatively, slower language processing in the L2 may entail a longer time window for co-activation of the nontarget L1, and may thus boost patterns of co-activation in less proficient L2 speakers as compared to more proficient L2 speakers. By the same token, the slower processing in target language L2 will entail a longer window of co-activation with the L1 than the fast processing in target language L1 offers the co-activated nontarget language L2.

In this paper, we will review empirical studies that examined how differences in L2 proficiency, or differences in relative proficiency in a bilingual's L1 and L2, affect the extent of parallel activation of the two languages. We specifically focus on three paradigms that have been used relatively frequently to address the role of L2 proficiency in lexical activation: cognate and homograph processing in visual word perception and word production, auditory word perception using the visual world paradigm, and cross-language priming (other tasks that have been used to study the role of L2 proficiency are, for example, language switching (e.g., Costa, Santesteban, & Ivanova, 2006) and code-switching (Kootstra, Van Hell, & Dijkstra, in press), word translation (e.g., De Groot & Poot, 1997; Kroll, Michael, Tokowicz, & Dufour, 2002), or morphosyntactic processing (for a review, see Van Hell & Tokowicz, 2010).

The large majority of empirical studies in this domain has adopted a group approach, and compared two groups of bilinguals with low versus high proficiency levels in the L2 (or occasionally, compared L1 and L2 speakers). Typically, L2 proficiency is used as a between-subject grouping variable with two levels (e.g., median split or extreme groups) in an analysis of variance (ANOVA) design. However, language proficiency is a continuous variable, and can be described as a multidimensional construct, characterized by continua along which individuals can progress as language experience changes a bilingual's lexical, morphological, or syntactic knowledge in the two languages. One way of investigating how individual differences in language proficiency impact cross-language lexical activation would be to use the continuous nature of proficiency in modeling experimental outcomes. For example, experimental designs might include proficiency measures in both L1 and L2 as covariates in regression models, such that L1 and L2 proficiency could be either controlled for as fixed covariates or used as interactive factors to model any potential modulating influences on cross-language activation. Although the regression-based approach has the ability to most closely approximate the continuous nature of proficiency effects, the existing research on cross-language lexical activation that has addressed L2 language proficiency has not used this method. Our literature review is therefore based on studies that have taken a group approach, but the outcomes will be informative for a genuine individual differences approach using regression-based statistical models.

Moreover, a large majority of studies has examined bilinguals' processing in only one language, which implies that any conclusion regarding the role of L2 proficiency necessitates a comparison across different studies. Conclusions from such cross-study comparisons have only limited generalizability because of confounds in both the stimulus materials and methods used, as well as the resulting lack of control over learners' language learning backgrounds or profiles of use of the bilinguals' two languages. Only a few studies have focused systematically on the role of L2 proficiency by using appropriate experimental designs that warrant strong conclusions on how differences in L2 proficiency may modulate cross-language interaction, and the extent to which the co-activation of the nontarget language is related to proficiency in that language. Such designs include within-participant designs in which, for example, the same bilingual is tested in L1 and in L2 or between-participant designs that, for example, compare bilingual speakers with the same L1 but with different levels of L2 proficiency or that use the same stimulus materials in one language (e.g., English) and present this to bilingual speakers of the same language combinations but with different L1s (e.g., French-English and English-French). In this paper, we will specifically focus on studies whose design allows for viable conclusions on the influence of L2 proficiency differences.

Variations in Cross-Language Orthographic, Phonological, and Semantic Overlap

Studies on lexical activation in bilingual memory often manipulate the orthographic, phonological, or semantic similarity of words across languages to trace at which linguistic level(s) the bilinguals' two languages interact. A frequently used comparison is that between cognates (i.e., words with a similar or identical orthography, phonology, and semantics across languages, for example the English-Spanish translations "piano-piano" or "palace-palacio") and noncognate control words that only share meaning across languages (e.g., "apple-manzana"), interlingual homographs (e.g., Spanish word "pan" meaning "bread" in English) and control words, or interlingual homophones (e.g., French word "sous" pronounced as "sue" in English) and control words. If cognates, homographs, or homophones are processed differently from noncognates (e.g, faster and more accurately), one inference is that the representations of cognates, homographs or homophones in the two languages were co-activated at some point during lexical activation (at the level of orthography, phonology, or meaning), which altered the time-course or ease of activation (assuming that the cognates, homographs or homophones were matched with noncognate controls on lexical factors including frequency, length, and orthographic neighbors). The typical finding is that cognates are processed faster than noncognates when presented in the weaker language, both in perception and in production. The direction of homograph and homophone effects is more mixed, with some studies finding that, for example, homophones are processed faster (e.g., Haigh & Jared, 2007) or slower (e.g., Dijkstra, Grainger, & Van Heuven, 1999) than control words. In what follows, we will discuss studies that either examined bilinguals with different levels of L2 proficiency, or compared processing in L2 versus L1, to study how differences in proficiency affect the co-activation of the bilinguals' two languages in both production and perception.

In one of the first studies that explicitly examined the role of differences in L1 versus L2 proficiency on lexical access in production, Costa, Caramazza, and Sebastián-Gallés (2000) asked highly proficient Catalan-Spanish and Spanish-Catalan bilinguals to name pictures whose names are cognates or noncognates. All bilinguals named these pictures in Spanish, which was the dominant language of the Spanish-Catalan bilinguals and the nondominant language of the Catalan-Spanish bilinguals. Cognate pictures were named faster than noncognate pictures in both the nondominant L2 and in the dominant L1, although the cognate facilitation effect was larger when naming in the nondominant L2 than in the dominant L1.

These findings were paralleled in a recent study by Poarch and Van Hell (2012) who examined cognate effects in picture naming in five groups of native German speakers: child beginning learners of L2 English, child German-English bilinguals with high proficiency in L2 English, child trilinguals who were proficient in German and a third language and moderately proficient in English, child German monolinguals (control), and adult proficient German-English bilinguals. The four groups of children were similar in age (mean age ranged from 6.6 to 7.5 years), parental educational level, and proficiency in L1 German (as measured with the TROG-German). Proficiency in L2 English (as measured with the TROG-English) was lowest for the low-proficiency L2 learners (and nonexistent in monolingual controls), higher for the trilingual children, and native-like for the bilingual children. In all groups (except the monolingual children), a cognate facilitation effect was observed in picture naming in L2. The bilingual children and adults and the trilingual children, but not the low proficient L2 learners, also showed a cognate facilitation effect in L1 picture naming, though this effect was smaller than in L2 picture naming. The Costa et al. (2000) and Poarch and Van Hell (2012) studies thus indicate that adult as well as child bilingual and multilingual speakers can demonstrate bidirectional cognate effects in L1 and L2, provided that proficiency in the L2 is sufficiently high. Moreover, cognate facilitation effects are typically smaller in L1 than in L2 processing, which indicates that the co-activation of target and nontarget language codes is related to differences in relative language proficiency in L1 and L2.

A study by Van Hell and Dijkstra (2002) found that differences in proficiency in the nontarget language also modulates the cognate facilitation effect in L1 processing, by manipulating relative proficiency in the nontarget languages within-subjects. Van Hell and Dijkstra (2002) tested two groups of Dutch-English-French trilinguals, who all spoke Dutch as their native language, English as their second and French as their third language. As confirmed in online proficiency tests in the three languages, the proficiency in French of one group of trilinguals was lower than in the second group of trilinguals (proficiency in L1 Dutch and L2 English was similar). In a lexical decision task, both groups of trilinguals were presented words in their L1 Dutch that were either cognates with L2 English, cognates with L3 French, or noncognates. Both groups of trilinguals processed L1 words that were cognates with L2 faster than noncognates, but only the trilinguals with high proficiency in L3 French also showed a cognate facilitation effect in the L1 words that were cognates with L3 French. This study thus suggests that processing words in the L1 co-activates the nontarget L2 and L3, but a minimal level of nontarget language proficiency is needed for cognate facilitation effects to emerge.

A recent study confirmed that differences in L2 proficiency affect the magnitude of cognate effects in word recognition, but also observed that cognate facilitation is less robust in less proficient L2 speakers, and more vulnerable to contextual factors as stimulus list composition. In a lexical decision study, Brenders, Van Hell, and Dijkstra (2011) presented cognates and noncognates in L1 and L2 to native Dutch speaking children who were beginning classroom learners of L2 English (5th and 6th graders) or more advanced classroom learners of L2 English (7th and 9th graders). All four groups of participants recognized cognates faster than noncognates in L2, but not in L1, corroborating earlier evidence that cognate effects only emerge when proficiency in the nontarget language is sufficiently high. A second experiment suggested, however, that also in L2 processing the cognate effect is not very robust in the beginning stages of L2 learning. In this experiment homographs and homophones (i.e., false friends) were added to the list of cognates and noncognates, and presented to child beginning L2 learners (5th graders) at 6, 10, and 20 months of L2 instruction (for about one hour a week), and to more advanced L2 learners (7th and 9th graders). Remarkably, at all three measurement times, the beginning L2 learners now recognized cognates *slower* than noncognate controls, and false friends were also recognized slower than noncognate controls. A similar cognate inhibition effect was obtained in the moderately proficient 7th and 9th graders. The mixing of cognates and false friends thus resulted in an inhibitory effect in the low and moderately proficient bilinguals, even though in highly proficient adult Dutch-English bilinguals robust cognate facilitation effects had been observed both in conditions where cognates were mixed with false friends or were not mixed (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Dijkstra et al., 1999). This indicates that the cognate effect in low and moderately proficient L2 speakers is sensitive to the composition of the list the critical words are embedded in. A possible explanation is related to the link between L2 word forms and their meaning, which is assumed to be stronger in proficient bilinguals than in less proficient bilinguals, as advanced by the RHM. In proficient bilinguals, presentation of an L2 cognate will activate its orthographic, phonological, and semantic codes in the L2 and L1. The convergence of the three codes will speed up responses of cognates as compared to noncognates. For false friends, however, the co-activation of the semantic codes will slow down responses, because the two different meanings of false friends compete. In proficient bilinguals, the link between L2 word-form and meaning is strong, and they will use the semantic co-activation of cognates to facilitate their lexical decision, even when false friends are embedded in the stimulus list. In low-proficiency bilinguals, however, the link between L2 word-form and meaning is weaker. In processing cognates, low-proficiency bilinguals, unlike high-proficiency bilinguals, thus cannot rely on strong L2 word-form to concept mappings to resolve the lexical ambiguity created by the addition of false friends to the cognate and noncognate list. In low-proficiency bilinguals, cognate processing can thus be slowed down in situations of lexical ambiguity and enhanced lexical competition, whereas proficient bilinguals demonstrate robust cognate effects also in case of lexical ambiguity.

How differences in L2 proficiency affect cross-language activation has not only been examined by using cognates and false friends. Jared and Kroll (2001) studied whether word naming in one language is influenced by word body neighbors in a second language. They asked French-English bilinguals and English-French bilinguals to name English words (e.g., "bait") that had conflicting word body neighbors in French (-ait is pronounced differently in French "lait" and "fait") or English words with no French word body neighbor (e.g., "bump"). On the basis of a median-split, the participants in each bilingual group were divided into less or more fluent L2 speakers. The French-English bilinguals (of both L2 English proficiency levels) demonstrated a weak influence of conflicting L1 French neighbors on naming L2 English words, but the English-French bilinguals (of both L2 French proficiency levels) did not show an effect of L2 French neighbors on naming L1 English words. Only when they had just named a block of French filler words did the English-French bilinguals (of both L2 French proficiency levels) show an effect of conflicting French neighbors. Similar effects were found in a study using interlingual homographs (Jared & Szucs, 2002). These studies provide further evidence of a proficiency-related asymmetry in the co-activation of phonological representations during reading. Interestingly, they also demonstrate that when the bilinguals have just used the nontarget language, phonological representations can affect reading in both L1 and L2. The recent use of the nontarget language thus "overruled" proficiency-related asymmetrical co-activation.

In a word recognition study comparing interlingual homophones and controls, Haigh and Jared (2007) examined whether phonological representations in the bilinguals' two languages are activated during reading in one language. In a lexical decision study, they presented English-French bilinguals (who were proficient or highly proficient in French) and French-English bilinguals (who were proficient or highly proficient in English) with interlingual homophones and controls in English. The English-French bilinguals, who performed the lexical decision task in their L1, showed no consistent homophone effect; a weak facilitatory homophone effect was only found in the error data of the highly proficient, balanced bilinguals or when the activation of French was boosted by making the bilinguals aware that their knowledge of French was important, by having them read French words prior to the L1 English lexical decision task (as also observed in Jared & Kroll, 2001; Jared & Szucs, 2002) or by increasing the amount of French distractors by replacing the pseudowords (requiring a "no"-response in a lexical decision task) with French words. In contrast, the French-English bilinguals, who performed the lexical decision task in their L2, showed an interlingual homophone facilitation effect. The observation of a facilitatory effect is in line with a homophone facilitation effect observed in Dutch-English bilinguals by Lemhöfer, Dijkstra, and Michel (2004), but stands in marked contrast to the inhibitory interlingual homophone effect observed in a similar group of Dutch-English bilinguals by Dijkstra et al. (1999). Irrespective of the direction of the effect, the studies provide evidence that bilinguals activate phonological representations from their first language when reading silently in their second language, but in the reverse direction this is the case only under certain conditions that are related to variations in L2 proficiency.

Overall, these studies using lexical decision, picture naming, or word naming show robust cross-language effects across multiple linguistic codes (semantic, phonological, and orthographic), especially when performing in the L2. The presence of cross-language activation when performing in the L1 seems to depend crucially on variations in proficiency, where effects surface only in bilinguals with high L2 proficiency, or when participants are made aware of the relevance of their L2 when performing in the L1.

Auditory Word Recognition in the Visual World Paradigm

A paradigm that has been used to examine how differences in L2 proficiency affect cross-language interaction in spoken word recognition is the visual world paradigm. In a first application of this paradigm to lexical access and the co-activation of two languages in bilinguals, Spivey and Marian (1999; see also Marian & Spivey, 2003a, 2003b) had Russian-English bilinguals listen to sentences such as "Poloji marku nije krestika" ("Put the stamp below the cross"), and presented four objects on the computer screen: the stamp ("marka" in Russian), a marker (an English word that shares initial phonemes with the target "marka"; "flomaster" in Russian), and two objects whose names were phonologically unrelated to the target. Recordings of the participants' eye-movements showed that upon hearing the Russian word "marku" the bilinguals looked more frequently at the picture of the between-language competitor word "marker" than at the distractor objects. This between-language competition effect was stronger in the L1 Russian sentences than in the L2 English sentences.[1] The finding that the L2 competitor has a stronger influence on L1 auditory word recognition than vice versa is remarkable, as it implies that the weaker L2 has a stronger effect on L1 than the stronger L1 has on the weaker L2. A possible explanation is that the Russian-English bilinguals lived in the US and were thus immersed in an English-speaking environment. However, in a follow-up experiment with a similar sample of Russian-English bilinguals tested in L1 Russian and L2 English, the opposite pattern was obtained: bilinguals again made more eye-movements to the cross-language competitor than to the unrelated distractors, but now the cross-language competition effect was larger when tested in L2 English than in L1 Russian (Marian & Spivey, 2003a). According to the authors, the bilinguals in Marian and Spivey (2003a) were in a stronger monolingual mode (e.g., Grosjean, 2001) than the bilinguals in Spivey and Marian (1999), although one could argue that a monolingual mode should reduce the amount of cross-language competition in Spivey and Marian (1999), but not yield an opposite pattern.

Using a similar task as Marian and Spivey, Weber and Cutler (2004) tested Dutch-English bilinguals, who were not immersed in their L2 English, in both their L2 and L1. In addition, they compared phonemic contrasts that are known to be difficult to comprehend for Dutch speakers of English (e.g., the vowel contrast /æ/ and /ε/ as in "panda"-"pencil") with phonemic contrasts that are easier for Dutch-English bilinguals (e.g., the vowel contrast /ɑ/ and /i/ as in "bottle"-"beetle"). Indeed, the Dutch-English bilinguals fixated longer on distractor pictures that contained English vowels that are difficult for Dutch speakers to discriminate ("panda"-"pencil") as compared to distractor pictures with English vowels that are easier to discriminate ("bottle"-"beetle"). However, in contrast to Spivey and Marian (1999) and Marian and Spivey (2003a), Weber and Cutler observed that cross-language competitors affected recognition in L2, but not in L1. These differential results cannot be attributed to immersion experience per se, as the results of Weber and Cutler (2004) with nonimmersed bilinguals are paralleled by similar findings reported by Ju and Luce (2004) with Spanish-English bilinguals who lived in the United States and were thus immersed in an L2 environment. Ju and Luce (2004) observed that Spanish-English bilinguals who listened to L1 Spanish target words (e.g., "playa") only co-activated L2 English competitors (e.g., "pliers") when the word-initial voice onset time of the initial phoneme (here: /p/) of the Spanish target was manipulated such that it resembled English voice onset times.

Blumenfeld and Marian (2007) explicitly tested the role of variation in L2 proficiency by comparing German-English (German L1) and English-German (English L1) bilinguals who heard object names in English (e.g., "coral," "click on the coral") and identified them from a display with four pictures that included the target, a similar-sounding German competitor (here: Korb [basket], and two unrelated distractors. To examine whether variations in cross-language phonological overlap would affect cross-language competition, the onset similarity between English target words and German competitors was either low (e.g., English target "ball" and German competitor "Birne" [pear]), medium (target "coral" and competitor "Korb" [basket]), or high (e.g., target "mop" and competitor "Mops" [pug dog]). A higher onset similarity will increase the ambiguity between targets and competitors, which should lead to stronger competition. Furthermore, the cognate status of the English targets was manipulated: in half the trials the targets were English-German cognates, and half were noncognates. It appeared that, in case of the English-German cognate targets, both the German-English and the English-German bilinguals looked more frequently at the German cross-language competitor than at the unrelated distractors. However, only German-English bilinguals (L1 German), and not English-German bilinguals, co-activated the German distractors when processing noncognate English targets. So, L1 German speakers consistently co-activated German during English auditory word recognition, whereas less proficient L2 German speakers co-activated German only during the recognition of cognate targets. Cognate status thus boosted parallel language activation in the less proficient L2 German speakers. Furthermore, an analysis of the time-course of eye movements showed that in the cognate targets, but not in the noncognate targets, higher phonological overlap between the German competitor and English target (as in "mop" and "Mops") increased the co-activation of German competitors. This co-activation lasted longer in English-German bilinguals than in German-English bilinguals, suggesting that L1 German bilinguals had resolved the cross-language competition of the German distractor at an earlier point than the English-German bilinguals who were less proficient in L2 German.

In sum, the Blumenfeld and Marian (2007) study thus confirms that differences in language proficiency influence the extent of co-activation of two languages in this auditory word recognition paradigm, which parallels the findings of Marian and Spivey (2003a), Ju and Luce (2004), and Weber and Cutler (2004). Moreover, L2 competitors seem to influence L1 word processing only under specific conditions, for example, when the target is a cognate (Blumenfeld & Marian, 2007), or when the voice onset time of the initial phoneme of the target resembled English-specific voice onset times (Ju & Luce, 2004). Second, Blumenfeld and Marian (2007) found that the German-English (German L1) bilinguals solved the cross-language competition of the German distractor at an earlier point than English-German (German L2) bilinguals, suggesting that highly proficient bilinguals may be faster (and better) in resolving language ambiguity and competition, which may be related to higher levels of automaticity and cognitive control mechanisms. We will come back to this issue later.

Phonological, Semantic, and Translation Priming

Several studies have investigated the degree of co-activation and interaction between languages in bilinguals using priming techniques, though only very recently have these studies begun to focus directly how differences in L2 proficiency may modulate the degree of co-activation. These studies show that variation in L2 proficiency differentially affects cross-language interactions at different levels of the linguistic code (e.g., phonological or lexico-semantic). For example, cross-language masked phonological priming has been shown to be unaffected by differences in L2 proficiency. Duyck, Diependaele, Drieghe, and Brysbaert (2004) tested balanced (highly proficient) simultaneous Dutch-French bilinguals as well as unbalanced (moderately-proficient) Dutch-French bilinguals who had learned their L2 in school. Both groups were more likely to identify a briefly presented French target word when it was preceded by a masked Dutch prime that shared a phonological representation across both languages (e.g., *kraan-CRANE*, meaning "tap-SKULL") than when the target was preceded by a graphemically related (e.g., *graan*, meaning "grain") or unrelated (e.g., *stoom*, meaning "steam") Dutch control word. Importantly, the size of this priming effect was consistent across both levels of L2 proficiency. Zhou, Chen, Yang and Dunlap (2010) showed a similar result in lower- and higher-proficiency Chinese-English bilinguals for both word naming and lexical decision in the L1 and L2. Masked primes facilitated access to phonologically-related targets in both the L1 and L2, and this effect did not interact significantly with L2 proficiency level. It should be noted that even the lower proficiency bilinguals in these two studies had already reached at least an intermediate level in the L2, so it is unclear if similar priming effects would be found in beginning L2 learners. However, given that the primes in both of these studies were masked such that participants had no conscious awareness of them, these results suggest that there is relatively automatic co-activation of phonological information in a bilingual's two languages, even when there is a significant imbalance in the bilinguals' relative language proficiency. Moreover, this co-activation is minimally affected by increasing proficiency in the L2.

In contrast, several studies have documented that differences in proficiency affect semantic processing and cross-language semantic and translation priming. If cross-language semantic and translation priming are largely conceptually mediated, then a prerequisite for cross-language effects is the establishment of L2 word form-to-concept links (in line with the Revised Hierarchical Model), as well as links between semantically related words within the L2. One possibility is that as a bilingual's proficiency in the L2 increases and becomes more balanced with his or her L1 proficiency, cross-language priming patterns will become more symmetrical as access to the L2 lexicon becomes more automatized as L2 word form-to-concept mappings become stronger. Frenck and Pynte (1987) studied cross-language semantic priming in English-French bilinguals who had been immersed in an L2 environment for differing lengths of time. Bi-directional priming was found for both less- and more-skilled bilinguals. In line with the prediction of more balanced priming associated with increased L2 proficiency, the less-proficient bilinguals showed an asymmetry with greater L1–L2 than L2–L1 priming, while priming was more symmetrical for the more proficient bilinguals. However, Frenck and Pynte used a relatively long SOA (500ms), so that their priming effects could have resulted from strategic, controlled processes on the part of the participants instead of automatic cross-language activation (see, e.g., Altarriba & Basnight-Brown, 2007; Hutchison, Neely, & Johnson, 2001).

Event-related potentials (ERPs) index more implicit aspects of language processing by recording brain activity that co-occurs with specific processing events. McLaughlin, Osterhout, and Kim (2004) used ERPs in an unmasked word-pair priming paradigm to study acquisition of L2 lexical knowledge during the first year of classroom L2 French instruction longitudinally. Results showed that, while learners' brain responses distinguished between real French words and pseudowords after only a few hours of French instruction, semantic priming effects did not emerge until learners had experienced several months of instruction, and had become more proficient in French. Overall this suggests that learners initially become sensitive to L2 word forms, but gradually establish conceptual links between those words with increasing proficiency. Kotz and Elston-Güttler (2004) showed further that, in addition to L2 proficiency level, the type of semantic relationship between words is important in determining the strength of priming effects within the L2. The authors cross-sectionally investigated semantic priming in L1 German learners of L2 English at two levels of L2 proficiency for both associatively (e.g., *boy-girl*) and categorically (e.g., *boy-junior)* associated words in a word list priming paradigm. Both reaction time and ERP measures showed associative priming for participants at both high and low L2 proficiency, but category priming only neared significance in the ERPs for only the high proficiency bilinguals. Kotz and Elston-Güttler argued that associative priming shows that low proficiency learners have established links between L2 words, while the lack of category priming shows that even high proficiency bilinguals have not established complete links between words and their underlying concepts.

Automatic aspects of lexical co-activation have also been studied using masked semantic and translation priming (for a review of behavioral and ERP studies, see Van Hell & Kroll, 2012). While the considerable methodological discrepancies can make it difficult to directly compare results across studies, some broad generalization can be made. The basic pattern of results from most studies on unbalanced bilinguals shows a strong asymmetry in priming direction: L1 words show strong priming of L2, while L2 words show either no priming of L1 targets or significantly less priming than the L1-L2 direction (e.g., Dimitropoulou, Duñabeitia, & Carreiras, 2011a; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Keatley, Spinks, & De Gelder, 1994; Midgley, Holcomb, & Grainger, 2009; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; but see Duyck & Warlop, 2009). In contrast, research focusing on more balanced, highly proficient bilinguals has shown fully symmetrical L1–L2 and L2–L1 priming patterns when the L1 and L2 were acquired simultaneously (e.g., Duñabeitia, Dimitropoulou, Uribe-Etxebarria, Laka, & Carreiras, 2010; Perea, Duñabeitia, & Carreiras, 2008) or sequentially in early childhood (Basnight-Brown & Altarriba, 2007; Perea et al., 2008).

Two recent studies of masked translation priming have directly investigated how differences in proficiency affect cross-language interaction.[2] Dimitropoulou, Duñabeitia, and Carreiras (2011b) studied masked translation priming in L1 Greek learners of L2 English in Greece at three proficiency levels. Their results showed significant bidirectional, but asymmetric, cross-language priming for all three proficiency groups. Importantly, the asymmetry was constant across the range of L2 proficiencies tested. This lack of a proficiency effect led the authors to suggest that age of learning may be the primary determinant of cross-language interactions in lexical processing. Previous reports of symmetrical priming studied bilinguals who were either simultaneous acquirers or who had learned their L2 early in childhood, while Dimitropoulou and colleagues' participants were all late L2 learners. The authors suggest that L1 and L2 lexical items that are acquired simultaneously or in close temporal proximity are more likely to share strong semantic links than items which are acquired years apart, such that weaker links lead to decreased L2–L1 priming. Contrasting with this are the findings of Zhao, Li, Liu, Fang, and Shu (2011) who studied cross-language priming in Chinese-English bilinguals in China who had either low or high L2 English proficiency, as well as Chinese-English bilinguals who were immersed in an L2 English environment. Results showed L1–L2 translation priming for all three groups, but L2–L1 translation priming only reached significance for bilinguals with both high L2 proficiency and immersion experience.

L2 Proficiency, Immersion, and Age of Acquisition

The apparent differences between the Dimitropoulou et al. (2011b) and Zhao et al. (2011) studies point to a possible role of immersion experience in addition to L2 proficiency in shaping cross-language translation priming effects. Dimitropoulou et al.'s participants, who differed in L2 English proficiency but showed similar asymmetrical priming effects, had only lived in Greece (nonimmersed). In contrast, the only bilinguals in the Zhao et al. study that showed a trend toward increasing priming symmetry were the bilinguals immersed in an L2 environment. Likewise, participants in the studies showing symmetrical L1–L2 and L2–L1 priming effects using a lexical decision task were immersed in an L2-speaking environment, or were living in a richly bilingual environment (Basnight-Brown & Altarriba, 2007; Duñabeitia et al., 2010; Perea et al., 2008; cf. Midgley, Holcomb, & Grainger, 2011). Immersion experience may allow both for faster lexical access and for the development of richer L2 word-to-concept mappings, which would lead to an increase in priming symmetry.

However, different immersion experiences did not seem to demarcate findings in studies on cross-language activation using manipulations of cross-language orthographic, phonological, and semantic overlap. For example, cognate facilitation effects in picture naming have been observed in bilinguals who were immersed in their L2 (e.g., Costa et al., 2000) as well as in bilinguals who were not immersed in their L2 (e.g., Poarch & Van Hell, 2012). Likewise, homophone facilitation effects were observed in both immersed (Haigh & Jared, 2007) and nonimmersed bilinguals (Lemhöfer et al., 2004).

The effects of immersion in studies on auditory word recognition using the visual world paradigm are less conclusive. More specifically, distractor competition effects have been found in the L2 but not in the L1 in both nonimmersed Dutch-English (Weber & Cutler, 2004) and immersed Spanish-English (Ju & Luce, 2004) bilinguals, but in a different group of immersed bilinguals, Russian-English bilinguals, distractor effects have been found in both L1 and L2 (Marian & Spivey, 2003a).

Second, in many studies on variations in L2 proficiency and cross-language interaction, including the studies reviewed in this paper, differences in L2 proficiency are often confounded with differences in age of L2 acquisition. This raises the question whether patterns in bilinguals' lexical access and lexical-semantic processing are driven by variations in L2 proficiency or by differences in the age of L2 acquisition. Current behavioral and neurocognitive evidence seems to converge on the notion that L2 proficiency is the more decisive factor in lexical access and lexical-semantic processing, whereas age of acquisition is a more important determinant of grammatical processing in the L2 (for a review, see Hernandez & Li, 2007; but see Dimitropoulou et al., 2011b). For example, the cross-sectional study by Wartenburger et al. (2003) indicated that the level of L2 proficiency influenced the neuronal correlates of lexical-semantic processing, whereas age of acquisition influenced the neural substrates of grammatical processing.

Increased L2 Proficiency: Impact on Cognitive Control and L1 Proficiency

The above review of studies employing three selected paradigms suggests that differences in L2 affect the co-activation of languages in bilinguals, such that the stronger language (typically L1) has a more profound effect on the weaker language (typically L2) than vice versa, and processing in the L1 is only affected by the nontarget L2 in bilinguals with relatively high levels of L2 proficiency.

These effects are typically explained in terms of variations in the strength of connections between orthographic, phonological, and semantic codes in the bilinguals' two languages, along the lines of the Revised Hierarchical Model (Kroll & Stewart, 1994) or the recent developmental variant of the Bilingual Interactive Activation model (Grainger, Midgley, & Holcomb, 2010). Variations in the strength of lexical-semantic connections may describe the modulating effects of L2 proficiency on lexical access and retrieval, but it may not fully capture the changes in the cognitive system that co-occur with increased L2 proficiency. A true understanding of the impact of increased L2 proficiency may require a broader conceptualization of its consequences for cognitive processing.

Increased proficiency in the L2, and the more frequent use of L2 and switching between L1 and L2, may lead to changes in the cognitive mechanisms that control the activation and inhibition of the bilinguals' two language systems. More specifically, increased L2 proficiency co-occurs with increased attentional control (e.g., Segalowitz & Hulstijn, 2005) and cognitive control (e.g., Abutalebi & Green, 2007; Bialystok & Craik, 2010; Elston-Güttler, Paulmann, & Kotz, 2005), the ability to filter out irrelevant information (interference suppression) and to inhibit inappropriate but prepotent response tendencies (response inhibition). Segalowitz and Frenkiel-Fishman (2005), for example, had English-French bilinguals at different levels of L2 French proficiency perform a linguistic version of the alternating runs task-switching paradigm, requiring the participants to switch to the alternate task and to repeat a given task on every second trial, following a consistent and predictable switching pattern. Attentional control was measured as the switch cost (i.e., the cost in response time to switch from one task to another relative to repeating a task). Regression analyses indicated that attentional control was an important factor underlying variation in L2 proficiency based on efficiency of lexical access. Future longitudinal studies may shed more light on the causal relation between variation in L2 proficiency and attentional control. Does an increased efficiency of automaticity in lexical access in the L2 improve attentional control, or does the bilinguals' improvement of L2-related cognitive control skills further enhance the efficiency of L2 lexical access?

Building on Petrides's (1998) two-level hypothesis on active-controlled (strategic) retrieval and automatic retrieval, Abutalebi and Green (2007) propose that lexical retrieval in low L2 proficiency bilinguals may rely more on strategic, nonautomatic control processes and engage the inferior prefrontal cortex, whereas lexical retrieval in high L2 proficiency bilinguals is more automatic and would not recruit the prefrontal cortex. An increase in L2 proficiency is thus accompanied by a shift from controlled to automatic processing, and this will co-occur with a reduction in prefrontal activity. Empirical support for this suggestion is provided by an fMRI study by Chee, Hon, Lee, and Soon (2001), who asked low and highly proficient Mandarin-English bilinguals to perform a semantic judgment task on words and characters. Highly proficient bilinguals were faster and more accurate than low proficient bilinguals, and the neuroimaging data indicated reduced brain activity particularly in the left prefrontal areas in high proficient bilinguals as compared to low proficient bilinguals (see Tatsuno & Sakai, 2005, for similar findings with low and high proficient Japanese-English bilinguals).

A recent longitudinal study tracking L2 learners over a longer period of time provided important insights into how increased L2 proficiency incurs changes in neural structures involved in cognitive control, in particular the prefrontal cortex. Stein et al. (2009) tested native English-speaking exchange students learning German at the beginning of their stay and about five months later, and measured their neural activity while reading words in English (L1), German (L2), and Romansh (an unknown language). Activation in the prefrontal cortex (i.e., right inferior frontal gyrus, left inferior frontal gyrus, and inferior frontal sulcus) when reading L2 words decreased significantly from the first to the second measurement. Behavioral tests verified that L2 proficiency had increased at the second measurement. No detectable changes in neural activation occurred during processing the unknown Romansh words. This longitudinal study thus suggests that lexical processing in low proficient L2 speakers co-occurs with high activation levels in the frontal areas associated with cognitive control. This frontal activity decreases with increased proficiency in the L2.

Increased L2 Proficiency: Incurs a Cost in L1 Processing?

An additional issue we would like to discuss is that, contrary to many traditional assumptions, individual differences exist in L1 proficiency, and these differences correlate with differences in L1 processing profiles (Pakulak & Neville, 2010). Moreover, an increase in proficiency in the L2, often resulting from an increased exposure to L2, may co-occur with a decrease in proficiency in L1, particularly when the bilinguals become immersed in a second-language environment (e.g., Dussias & Sagarra, 2007; Linck, Kroll, & Sunderman, 2009). Recent studies even suggest that a recent and intensive exposure to L2 items in the short time-scale of an experiment incurs a global inhibition of the L1, and an observable impairment in the subsequent processing of L1 items (Guo, Liu, Misra, & Kroll, 2011; Levy, McVeigh, Marful, & Anderson, 2007). Becoming more proficient in the L2 (or intensive exposure to L2) may thus incur a cost in L1 processing, and may affect the efficiency of lexical retrieval in the L1 or may dampen the activation of L1. This potentially influences observable effects of cross-language interaction, interference, and priming. In other words, a change in the magnitude of cross-language interaction effects as a function of changes in L2 proficiency (as discussed in this paper) may be related to a change in the relative proficiency in L1 and L2, which can be driven by an increase in L2 proficiency (as is typically assumed), but may also be caused by a decrease in L1 proficiency. The typical procedure in experiments testing bilinguals is that proficiency in the L2 is measured, but very few studies also test proficiency in the L1. Future studies may seek to gain more insight into the extent to which increased L2 proficiency incurs a cost on L1 processing, to fully capture the dynamics of becoming a more proficient bilingual.

Studying L2 Proficiency: Group Design and Individual Differences Approaches

As noted prior to reviewing the empirical work on differences in L2 proficiency and cross-language interaction, the large majority of studies in this field adopted a multiple-groups design, and compared groups of bilinguals that differed in L2 proficiency. At a methodological level, providing a clearer picture of the relationship between cross-language activation effects and individual differences in L2 proficiency requires a move away from group designs and toward designs that allow for more robust statistical modeling of the interaction between individual-level characteristics (e.g., language proficiency) and stimulus-level characteristics (e.g., word cognate status). As previously mentioned, regression-based approaches can model the continuous nature of individual-level variables, like language proficiency. Hierarchical linear models, also known as mixed models, are one such regression-based method that have shown an enormous gain in popularity in recent years, and they are ideal for modeling data with repeated measures such as those typically elicited in psycholinguistic experiments (i.e., they recognize that trial-level data within subjects are not independent and can appropriately partition variance into multiple levels (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999; see also Baayen, Davidson, & Bates, 2008, for discussion of linear mixed models with fully-crossed subject and item random effects structures). Mixed models also offer a number of other advantages over traditional ANOVA-based designs, including the fact that they easily handle unequal group sizes, unequal variances, and missing data. With regard to the study of individual differences, they do not require arbitrary grouping of participants in order to treat subject-level variables as categorical. Mixed models can thus more accurately model the continuous nature of individual differences in language proficiency profiles (see Blozis & Traxler, 2007; Kootstra et al., in press; Linck, Schwieter, & Sunderman, 2012, for examples). We suggest that future research investigating proficiency effects in cross-language activation may wish to take this regression-based approach, so that individual differences can provide a starting point for research questions rather than motivate a post-hoc grouping variable.

Notes

1 In a later replication using Russian-English bilinguals similar to those tested in Spivey and Marian (1999), Marian and Spivey (2003b) observed between-competition from both languages, affecting performance in both languages.

2 Davis et al. (2010) also investigated priming in bilinguals at different proficiency levels, but failed to show any priming for noncognates. However, they did show the typical asymmetry for cognate priming at low proficiency levels, which became symmetrical at higher levels.

References

Abutalebi, J., & Green, D. (2007). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics*, *20*, 242–275.

Altarriba, J., & Basnight-Brown, D.M. (2007). Methodological considerations in performing semantic and translation-priming experiments across languages. *Behavior Research Methods*, *39*, 1–18.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390–412.

Basnight-Brown, D. M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory & Cognition*, *35*, 953–965.

Bialystok, E., & Craik, F. I. M. (2010). Cognitive and linguistic processing in the bilingual mind. *Current Directions in Psychological Science*, *19*, 19–23.

Blozis, S. A., & Traxler, M. J. (2007). Analyzing individual differences in sentence processing performance using multilevel models. *Behavior Research Methods*, *39*, 31–38.

Blumenfeld, H. K., & Marian, V. (2007). Constraints on parallel activation in bilingual spoken language processing: Effects of proficiency and lexical status using eye-tracking. *Language and Cognitive Processes*, *22*, 633–660.

Brenders, P., Van Hell, J. G., & Dijkstra, A. (2011). Word recognition in child second language learners: Evidence from cognates and false friends. *Journal of Experimental Child Psychology*, *109*, 383–396.

Brown, A., & Gullberg, M. (2008). Bidirectional cross-linguistic influence of L1-L2 encoding of manner in speech and gesture. *Studies in Second Language Acquisition*, *30*, 225–251.

Chee, M. W. L., Hon, N., Lee, H. L., & Soon, C. S. (2001). Relative language proficiency modulated bold signal changes when bilinguals perform semantic judgments. *Neuroimage*, *13*, 1155–1163.

Costa, A., Caramazza, A., & Sebastián-Gallés, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 1283–1296.

Costa, A., Santesteban, M., & Ivanova, I. (2006). How do highly-proficient bilinguals control their lexicalization process? Inhibitory and language-specific selection mechanisms are both functional. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*, 1057–1074.

De Groot, A. M. B., & Poot, R. (1997). Word translation at three levels of proficiency in the second language: The ubiquitous involvement of conceptual memory. *Language Learning*, *47*, 215–264.

Davis, C., Sanchez-Casas, R., Garcia-Albea, J. E., Guasch, M., Molero, M., & Ferre, P. (2010). Masked translation priming: Varying language experience and word type with Spanish-English bilinguals. *Bilingualism: Language and Cognition*, *13*, 137–155.

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

Dimitropoulou, M., Duñabeitia, J. A., & Carreiras, M. (2011a). Masked translation priming effects with low proficient bilinguals. *Memory & Cognition*, *39*, 260–275.

Dimitropoulou, M., Duñabeitia, J. A., & Carreiras, M. (2011b). Two words, one meaning: Evidence for automatic co-activation of translation equivalents. *Frontiers in Psychology*, *2*, 1–20.

Duñabeitia, J. A., Dimitropoulou, M., Uribe-Etxebarria, O., Laka, I., & Carreiras, M. (2010). Electrophysiological correlates of the masked translation priming effect with highly proficient simultaneous bilinguals. *Brain Research*, *1359*, 142–154.

Dussias, P. E., & Sagarra, N. (2009). The effect of exposure on syntactic parsing in Spanish-English bilinguals. *Bilingualism: Language and Cognition*, *10*, 101–116.

Duyck, W., Diependaele, K., Drieghe, D., & Brysbaert, M. (2004). The size of the cross-lingual masked phonological priming effect does not depend on second language proficiency. *Experimental Psychology*, *51*, 1–9.

Duyck, W., & Warlop, N. (2009). Translation priming between the native language and a second language: New evidence from Dutch-English bilinguals. *Experimental Psychology*, *56*, 173–179.

Elston-Güttler, K. E., Paulmann, S., & Kotz, S. (2005). Who's in control? Proficiency and L1 influence on L2 processing. *Journal of Cognitive Neuroscience*, *17*, 1593–1610.

Frenck, C. & Pynte, J. (1997). Syntactic ambiguity resolution while reading in second and native languages. *Quarterly Journal of Experimental Psychology*, *50*, 119–148.

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

Grainger, J., Midgley, K., & Holcomb, P. J. (2010). Re-thinking the bilingual interactive-activation model from a developmental perspective (BIA-d). In M. Kail & M. Hickmann (Eds.), *Language acquisition across linguistic and cognitive systems* (pp. 267–284). New York: John Benjamins.

Grosjean, F. (2001). The bilingual's language modes. In J. L. Nicol (Ed.), *One mind, two languages: Bilingual language processing* (pp. 1–22). Oxford, UK: Blackwell.

Guo, T., Liu, H., Misra, M., & Kroll, J. F. (2011). Local and global inhibition in bilingual word production: fMRI evidence from Chinese-English bilinguals. *NeuroImage*, *56*, 2300–2309.

Haigh, C. A., & Jared, D. (2007). The activation of phonological representations by bilinguals while reading silently: Evidence from interlingual homophones. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*, 623–644.

Hernandez, A. E., & Li, P. (2007). Age of acquisition: Its neural and computational mechanisms. *Psychological Bulletin*, *133*, 638–650.

Hoshino, N., & Kroll, J. F. (2008). Cognate effects in picture naming: Does cross-language activation survive a change of script? *Cognition*, *106*, 501–511.

Hutchison, K. A., Neely, J. H., & Johnson, J. D. (2001). With great expectations can two "wrong"s prime a "right"? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*, 1451–1463.

Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, *44*, 2–31.

Jared, D., & Szucs, C. (2002). Phonological activation in bilinguals: Evidence from interlingual homograph naming. *Bilingualism: Language and Cognition*, *5*, 225–239.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition*, *2*, 59–75.

Jiang, N., & Forster, K. I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language*, *44*, 32–51.

Ju, M., & Luce, P. A. (2004). Falling on sensitive ears: Constraints on bilingual lexical activation. *Psychological Science*, *15*, 314–318.

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

Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language*, *49*, 484–499.

Kootstra, G. J., Van Hell, J. G., & Dijkstra, T. (in press). Code-switching in sentences: The role of lexical repetition, cognates, and language proficiency. *Bilingualism: Language and Cognition*.

Kotz, S. A., & Elston-Güttler, K. E. (2004). The role of proficiency on processing categorical and associative information in the L2 as revealed by reaction times and event-related brain potentials. *Journal of Neurolinguistics*, *17*, 215–235.

Kroll, J. F., & De Groot, A. M. B. (Eds.). (2005). *Handbook of bilingualism: Psycholinguistic approaches.* New York: Oxford University Press.

Kroll, J. F., Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research*, *18*, 137–171.

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., Van Hell, J. G., Tokowicz, N., & Green, D. W. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, *13*, 373–381.

Lemhöfer, K., Dijkstra, T., & Michel, M. C. (2004). Three languages, one ECHO: Cognate effects in trilingual word recognition. *Language and Cognitive Processes*, *19*, 585–611.

Levy, B. J., McVeigh, N. D., Marful, A., & Anderson, J. C. (2007). Inhibiting your native language: The role of retrieval-induced forgetting during second-language acquisition. *Psychological Science*, *19*, 29–34.

Linck, J. A., Kroll, J. F., & Sunderman, G. (2009). Losing access to the native language while immerse in a second language. *Psychological Science*, *20*, 1507–1515.

Linck, J. A., Schwieter, J. W., & Sunderman, G. (2012). Inhibitory control predicts language switching performance in trilingual speech production. *Bilingualism: Language and Cognition*, *15*, 651–662.

Marian, V., & Spivey, M. (2003a). Competing activation in bilingual language processing: Within- and between-language competition. *Bilingualism: Language and Cognition*, *6*, 97–115.

Marian, V., & Spivey, M. (2003b). Bilingual and monolingual processing of competing lexical items. *Applied Psycholinguistics*, *24*, 173–193.

McLaughlin, J., Osterhout, L., & Kim, A. (2004). Neural correlates of second-language word learning: Minimal instruction produces rapid change. *Nature Neuroscience*, *7*, 703–704.

Midgley, K., Holcomb, P., & Grainger, J. (2009). Masked repetition and translation priming in second language learners: A window on the time-course of form and meaning activation using ERPs. *Psychophysiology*, *46*, 551–565.

Midgley, K., Holcomb, P. J., & Grainger, J. (2011). Effects of cognate status on word comprehension in second language learners: An ERP investigation. *Journal of Cognitive Neuroscience*, *23*, 1634–1647.

Morford, J. P., Wilkinson, E., Villwock, A., Piñar, P., & Kroll, J. F. (2011). When deaf signers read English: Do written words activate their sign translations? *Cognition*, *118*, 286–292.

Pakulak, E., & Neville, H. (2010). Proficiency differences in syntactic processing of monolingual native speakers indexed by event-related potentials. *Journal of Cognitive Neuroscience*, *22*, 2729–2744.

Perea, M., Duñabeitia, J. A., & Carreiras, M. (2008). Masked associative/semantic priming effects across language with highly proficient bilinguals. *Journal of Memory and Language*, *58*, 916–930.

Petrides, M. (1998). Specialized systems for the processing of mnemonic information within the primate frontal cortex. In A. C. Roberts, T. W. Robbins, & L. Weiskrantz (Eds.), *The prefrontal cortex—executive and cognitive functions* (pp. 103–116). Oxford, UK: Oxford University Press.

Poarch, G. J., & Van Hell, J. G. (2012). Cross-language activation in children's speech production: Evidence from second language learners, bilinguals, and trilinguals. *Journal of Experimental Child Psychology*, *111*, 419–438.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Segalowitz, N., & Hulstijn, J. (2005). Automaticity in bilingualism and second language learning. In J. F. Kroll & A. M. B. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 371–388). Oxford, UK: Oxford University Press.

Segalowitz, N., & Frenkiel-Fishman, S. (2005). Attention control and ability level in a complex cognitive skill: Attention-shifting and second language proficiency. *Memory & Cognition*, *33*, 644–653.

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, A. I., & Van Hell, J. G. (2012). Bilingual visual word recognition in sentence context. In J. Adelman (Ed.), *Visual word recognition* (pp. 129–148). London, UK: Psychology Press.

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Thousand Oaks, CA: Sage.

Spivey, M. J., & 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., et al. (2009). Reduced frontal activation with increasing 2^{nd} language proficiency. *Neuropsychologia*, *47*, 2712–2720.

Tatsuno, Y., & Sakai, K. L. (2005). Language related activation in the left prefrontal regions are differentially moderated by age, proficiency, and task demands. *Journal of Neuroscience*, *16*, 1637–1644.

Thierry, G., & Wu, Y. J. (2004). Electrophysiological evidence for language interference in late bilinguals. *NeuroReport*, *15*, 1555–1558.

Thierry, G., & Wu, Y. J. (2007). Brain potential reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences*, *104*, 12530–12535.

Van Beijsterveldt, L.M., & Van Hell, J. G. (2009). Structural priming of adjective-noun structures in hearing and deaf children. *Journal of Experimental Child Psychology*, *104*, 179–196.

Van Beijsterveldt, L. M., & Van Hell, J. G. (2012). The development of deaf writers' tense marking in narrative and expository text: A bimodal bilingual perspective. *Bilingualism: Language and Cognition*, *15*, 128–144.

Van Hell, J. G., & Dijkstra, A. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin & Review*, *9*, 780–789.

Van Hell, J. G., & Kroll, J. F. (2012). Using electrophysiological measures to track the mapping of words to concepts in the bilingual brain: A focus on translation. In J. Altarriba & L. Isurin (Eds.), *Memory, language, and bilingualism: Theoretical and applied approaches* (pp. 126–160). New York: Cambridge University Press.

Van Hell, J. G., & Tokowicz, N. (2010). Event-related brain potentials and second language learning: Syntactic processing in late L2 learners at different L2 proficiency levels. *Second Language Research*, *26*, 43–74.

Wartenburger, I., Heekeren, H. R., Abutalebi, J., Cappa, S. F., Villringer, A., & Perani, D. (2003). Early settings of grammatical processing in the bilingual brain. *Neuron*, *37*, 159–170.

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language*, *50*, 1–25.

Zhou, H., Chen, B., Yang, M., & Dunlap, S. (2010). Language nonselective access to phonological representations: Evidence from Chinese-English bilinguals. *Quarterly Journal of Experimental Psychology*, *63*, 2051–2056.

Zhao, X., Li, P., Liu, Y., Fang, X., & Shu, H. (2011). Cross-language priming in Chinese-English bilinguals with different second language proficiency levels. In L. Carlson, C. Hölscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.