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Neurocognitive determinants of performance variability among world-language users

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Although the notion of world language has been variously defined, most accounts acknowledge inter-user performance variability as a key aspect of the construct. The sociocultural aspects of such a phenomenon have been extensively treated in the literature. However, comparatively little attention has been paid to its neurocognitive underpinnings. This paper addresses the biopsychological bases of performance variability among word-language users, focusing on bilingual speakers of English. Available evidence reveals four neurocognitive determinants of variability, namely manner of appropriation, age of acquisition, level of proficiency, and degree of formal similarity between the native and the non-native language. In its concluding section, the paper highlights the benefits of incorporating neurocognitive evidence into the study and conceptualization of world languages.

Keywords: world languages; performance; variability; neurocognition; interdiscipline

1. Introduction

In contemporary neurolinguistics jargon, the term "bilingual" denotes any person who uses two languages or dialects in daily life (Grosjean 1994; Fabbro 2001a) and who can willingly communicate in one or the other according to the circumstances (Paradis 1984), at any level of proficiency (LoP; Meinzer et al. 2007). Thus defined, bilinguals are estimated to represent one half (Grosjean 1994), to two thirds (Walraff 2000), to three fourths (Azarpazhooh et al. 2010; Porch and de Berkeley-Wykes 1985) of the world's population. The global expansion of bilingualism, in general, and of a selected group of languages, in particular, has sparked scholarly interest in the so-called world languages – i.e., languages spoken by a significant proportion of individuals the world over, which play a dominant role in international media, institutional, and diplomatic communications (Baker and Prys Jones 1998).

The boundaries between world languages and non-world languages are fuzzy. The former can be conceived as occupying one end of a linguistic continuum, indicating maximal inter-user variability in geographical distribution (Baker and Prys Jones 1998), manners of appropriation, and levels of proficiency (Paradis 2009) (see Figure 1). Non-world languages, placed towards the other end of the continuum, would tend to be more similar in terms of those variables.

Inter-user performance variability in world languages (in particular, English) has been studied from various perspectives, including political (Mair 2003; Crystal 2003),

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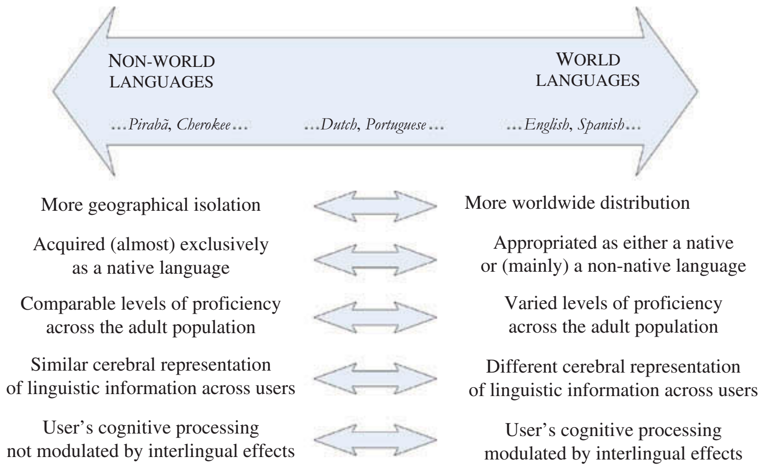

Figure 1. The neurocognitive world-language continuum.

grammatical (Wahid 2013), phonological (Fatemi et al. 2012), sociodialectal (Chan 2013), curricular (Doan 2012), pedagogical (Gilsdorf 2002), and otherwise theoretical (Kilickaya 2009) approaches. However, there is a dearth of studies examining the neurocognitive basis of the phenomenon. To bridge such a gap in the literature, this paper reviews evidence on the neurocognitive determinants of performance variability among users of world languages, with an emphasis on English. Relevant data are gleaned from neurolinguistic and psycholinguistic studies of bilingualism. Specifically, the view will be posited that observable variability in linguistic behavior among users of world languages, in general, and English, in particular, is determined by differences in the neuropsychological representation of linguistic information. This claim is schematically illustrated in Figure 1.

Idiolectal differences aside, performance variability across users of a given language is largely determined by neurocognitive factors (Paradis 2009). The closer a language is to the left end of the continuum, the more similar its users' neurocognitive processing systems and linguistic performance. On the other hand, the closer a language is to the right end, the greater the variability among its users' language processing and behavior. As shown in the following sections, the key cerebral and cognitive factors responsible for performance variability among users of a world language – especially, English – are manner of appropriation (as a native or as a non-native language), age of acquisition (AoA), LoP, and degree of formal similarity between the first language (L1) and the foreign language (L2). More succinctly, this paper seeks to demonstrate that a specific world language can be represented and processed in very different ways, depending on a number of interrelated but dissociable neurocognitive factors.

2. Neurocognitive determinants of variability in world-language use

Paradis (2004, 2009) distinguishes two manners of appropriation of linguistic information. On the one hand, learning consists in the conscious appropriation of the stimuli's sensible properties. Its outcome is explicit knowledge, which can be used willingly in a controlled fashion. Thus, learning is a function of declarative memory. On the other hand, acquisition refers to the incidental appropriation of the abstract patterns underlying the stimuli's physical forms. Its result is implicit competence, which is used automatically. Incidental acquisition of linguistic information, then, constitutes a function of procedural memory. In the following sections, the terms "appropriation", "learning", and "acquisition" will be used in the technical senses presently defined.

2.1 World languages as native languages

While all individuals have different, unique neurocognitive systems, all native speakers (of Western languages) feature the same neurofunctional organization and neuroanatomical distribution of their linguistic subsystems. First of all, phonological, lexical, and grammatical information is lateralized to the left hemisphere (LH) in roughly 97% of the population (Obler and Gjerlow 1999; Springer et al. 1999). Within the LH, there are functionally autonomous systems responsible for phonological production as well as morphological and syntactic processing, on the one hand, and lexico-semantic information, on the other. In the case of native languages, the former functions are acquired incidentally, used automatically – that is, with negligible variability (Paradis 2009) – and critically subserved by frontobasal areas implicated in procedural memory (e.g., aspects of Broca's area, basal ganglia). On the other hand, lexico-semantic information is explicitly learned, used under conscious control, and represented in temporal and temporo-parietal regions related to declarative memory (e.g., Wernicke's area, medial temporal lobe, hippocampal region). These dissociations have been captured in the declarative/procedural model (Paradis 1994, 2004, 2009; Ullman 2001; 2004, 2008).

According to Eichenbaum and Cohen (2001), the declarative memory system specializes in learning and representing episodic and semantic knowledge. This system subserves fast incorporation of arbitrarily related information, with little exposure to relevant stimuli. Such information is mostly accessible to consciousness and can be explicitly retrieved. On the other hand, procedural memory subserves the acquisition and representation of sensorimotor and cognitive skills and habits. Abstract patterns in this system are built gradually, requiring sustained exposure to relevant stimuli. Information processed by this system is implicit in nature, which renders it opaque to consciousness. Procedural memory is implicated in the representation of serial abstract sequences, which are used automatically, or non-deliberately (see also Packard and Knowlton [2002]).

The evidence compiled by Ullman (2001, 2004, 2008), involving mostly monolingual English speakers, shows that neurological diseases compromising declarative memory while sparing procedural memory (e.g., fluent aphasia, Alzheimer's disease, amnesia) result in lexico-semantic, but not in grammatical, deficits (Alexander 1997; Bozeat et al. 2000; Dronkers et al. 2000; Graham et al. 1999). On the contrary, lesions affecting the substrates of procedural memory without damaging those of declarative memory (e.g., those causing non-fluent aphasia, Parkinson's disease, specific language impairment) impair syntactic and morphological processing while sparing lexico-semantic functions (Alexander 1997; Clahsen et al. 1997; Dewey and Wall 1997; Dronkers et al. 2000; Dubois et al. 1991; Ellis Weismer and Hesketh 1996). Such a dissociation is further supported by neuroimaging evidence (e.g., Damasio et al. 1996; Friederici 2002). It is of note that while declarative memory processes result in widely different linguistic output across and within users, language processes sustained by procedural memory present virtually no variability within and between subjects (Paradis 2009).

In sum, a world language that is appropriated as a native language features negligible inter-user variability in grammatical performance, since syntax and morphology, in all cases, are processed automatically by procedural memory. However, declarative functions, such as lexical and semantic processing, are less homogeneous because they are subject to conscious, controlled processes, varying greatly within and across individuals. Still, the more noticeable sources of performance variability among world-language users are related to bilingualism, as seen in the following sections.

2.2 World languages as non-native languages

A distinguishing trait of some world languages is that they are spoken by more non-native that native users. Bilingualism itself modulates cognitive processing overall. Relative to monolinguals, bilinguals have been consistently shown to possess enhanced skills across several domains, including selective attention, problem-solving, metalinguistic awareness, inhibitory control, and executive processing at large (for reviews, see Bialystok [2001], [2011] and Bialystok et al. [2009]). However, bilingualism (especially in children) proves detrimental to certain aspects of language processing, as it increases the frequency of tip-of-the-tongue states (Gollan and Acenas 2004) while reducing word-retrieval speed, lexical fluency, and vocabulary in each language (Bialystok et al. 2009). These findings imply that both native and non-native bilingual users of a world language tend to have a poorer lexical performance than monolingual users of the same language.

Another reason why bilingualism brings about performance variability in world-language use is that the sociocognitive conditions of language appropriation are much more varied for foreign than native languages. In particular, the neurocognitive underpinnings of language processing are less consistent across individuals for L2s than for L1s. Dehaene et al. (1997) conducted a functional magnetic resonance imaging (fMRI) experiment with late French-English bilinguals, and asked them to listen to fragments of stories in L1, L2, and a third language played backwards. Activations for the L1 condition were very similar across participants, engaging regions in and around Wernicke's area. However, activated areas in the L2 condition were varied and inconsistent between participants, engaging both frontal and posterior regions in both hemispheres. Also, several evoked-response potential (ERP) studies have revealed that, relative to monolinguals, bilinguals exhibit delayed latencies in the semantic-sensitive N400 component (for a review, see Moreno et al. [2008]). The greater variability in the neurocognitive representation of an L2 relative to an L1 is likely related to the multiple learning styles and strategies framing L2 appropriation and use, as opposed to the relative uniformity of the processes sustaining L1 acquisition.

In the case of late language learners, several intersubjective differences relate to their increased reliance on declarative memory, which may be used to process not just lexico-semantic, but also grammatical, information. According to Paradis (2009, 189):

> [t]he use of declarative memory to learn a second language leads to interindividual variability in ultimate attainment, resulting from differences in working memory capacity, level of education, IQ, motivation, and other factors that do not affect first language acquisition.

However, certain aspects of a foreign language can be automatized and processed implicitly, through the use of procedural memory. Given a sufficient amount of exposure and practice:

> [s]ome implicit linguistic competence in L2 can probably be acquired in certain aspects of linguistic structure (syntax, morphology, phonology, in that order of probability) though not

> completely at any level. This is one reason why there is great variability in individual success at learning a second language (Paradis 2009, 118).

Specifically, performance differences among non-native users of a world language are related to a number of interrelated, though independent, neurocognitive variables, as explained below. Most of the studies cited involve English as a particular language under scrutiny.

2.2.1 The age of appropriation factor

A world language may be appropriated as an L2 at varying ages, ranging from early childhood to adulthood. The ability to incidentally acquire linguistic information is bound to optimal periods, which renders AoA another key factor underlying inter-user variability. By age five, approximately, procedural memory circuits begin to lose plasticity (Paradis 2009), which progressively undermines the brain's ability to acquire new implicit, automatic routines. Studies with humans and rodents confirm that the acquisition of procedural information, via the basal ganglia, is subject to short-lived critical periods (Fredriksson et al. 2000; Schlaug 2001). At the same time, declarative memory performance steadily improves throughout childhood (DiGiulio et al. 1994), and then decays during adulthood (Kirasic et al. 1996). One reason behind these changes would be the increase of estrogen levels during childhood and adolescence, as this substance seems to inhibit the procedural system while promoting activation in the declarative system (Ullman 2004).

Birdsong (1999) showed that, in languages appropriated after late childhood (i.e., around age seven), grammatical skills are poorer than lexical abilities. Möhring (2001) tested early bilinguals and found that gender agreement rules were easily acquired before age three, but became progressively more difficult at later ages. Moreover, the review offered by Birdsong (2006) shows that most of the tasks in which bilinguals' L2 performance is comparable to their performance in L1 are offline in nature – meaning that they allow for conscious control via declarative and executive processes.

These data warrant the postulation that the critical AoA to distinguish between early and late L2 learners lies between ages five and seven. This critical period is determined by maturational brain processes rendering individuals above age seven better prepared to learn – rather than acquire – linguistic information. Thus, whereas early learners may promptly achieve native-like levels of performance in processing implicit abstract routines, late learners only rarely manage to do so. Indeed, the neural representation of an early learned L2 is much more similar to that of a native language than is a lately learned L2. In reference to the declarative/procedural model of bilingualism, Fabbro (2001b, 219) states that:

> [. . .] the acquisition or learning modality seems to determine a different participation of procedural memory systems vs. declarative memory systems. If L1 and L2 are acquired in informal contexts and both are at a high level of proficiency, their phonologic and morphosyntactic aspects are stored in procedural memory systems. On the other hand, traditional learning of L2 after the age of 7, along with limited proficiency in production, seems to involve the declarative memory systems to a greater extent.

Indeed, early bilinguals tend to represent the grammar and the lexico-semantics of their L2s in the same broad neuroanatomical regions as their L1s – i.e., grammar is represented in procedural memory (frontobasal regions), and lexical information is processed by declarative memory (temporal/temporo-parietal areas). On the contrary, late bilinguals tend to represent both the grammatical and the lexical information of their L2 in declarative memory. Aphasiological evidence supports this claim. Ku et al. (1996) report the case of a late Mandarin-English bilingual with a lesion focused on the left temporal lobe, which compromised his syntactic abilities more markedly in L2 than in L1. Aladdin et al. (2008) discuss two Ukranian-English bilingual epileptics whose seizures originated in left temporal regions. In both cases, for roughly 20 minutes post-seizure, the patients would find themselves unable to speak in L2 while their L1 remained virtually unaffected (comprehension abilities, however, remained fully functional in both languages).

However, when late bilinguals sustain lesions to frontobasal areas, their grammatical competence in L1 is selectively compromised. Evidence for this dissociation is offered by Fabbro and Paradis (1995), who review four cases of bilingual aphasia subsequent to basal ganglia damage. All four patients (late learners of their respective L2s) were more significantly impaired in their native than in their non-native languages (e.g., they omitted more functors in obligatory contexts in L1 than in L2). A similar pattern was observed by Garcia-Caballero et al. (2007) in their case study of a late bilingual suffering from crossed aphasia.

Converging evidence has been found through neuroimaging studies with non-pathological subjects. Single-word tasks consistently show that lexico-semantic processing in L1 and L2, regardless of AoA, engages the same macroanatomical regions, especially within the temporal lobe (Illes et al. 1999; Paradis 2004; Ullman 2005; Mondt et al. 2009). However, tasks involving syntactic processing (parsing or stripping) indicate a marked AoA effect.

For example, in the Chee Michael et al. (1999) experiment, early Chinese-English bilinguals were asked to decide whether sentences presented in one or the other language were true or false. Stronger activations were detected in the middle and inferior prefrontal cortices, the left temporal region, the left angular gyrus, the supplementary motor cortex, and bilateral occipital and parietal areas. What is remarkable is that all these areas were equally activated in both languages, which supports the view that syntactic processes in early bilinguals engage the same neurocognitive mechanisms for both languages. For their own part, in a positron emission tomography (PET) experiment, Perani et al. (1996) asked late Italian-English bilinguals to listen to stories in L1, L2, and a third language unknown to them. In L1, differential activations were observed in the inferior frontal gyrus, the medial and superior temporal gyri, the temporal pole, the angular gyrus, and the right cerebellum. However, L2 yielded significant activations only in bilateral middle and superior temporal areas and parahippocampal regions. These data are consistent with the claim that, in late bilinguals, L2 syntactic processing relies more heavily on posterior regions implicated in declarative memory.

Other studies provide direct comparisons between early and late bilinguals. Hirsch et al. (1997), in an fMRI experiment, compared the activation patterns of early and late bilinguals during a silent sentence-generation task. Both L1 and L2 yielded overlapping activations in Broca's area in the "early" group, but they engaged separate frontal regions in the "late" group. No differences between groups were observed in Wernicke's area. In a more recent fMRI study, Waldron and Hernandez (2013) compared brain activation patterns in early and late Spanish-English bilinguals with similar proficiency in both languages. Participants were asked to covertly generate the past tense form of visually presented L2 verbs. The "early" group demonstrated greater activations throughout frontal-temporal regions associated with automatic processes, whereas the "late" group presented differential activations in posterior and prefrontal areas associated to controlled processes.

There is also behavioral evidence demonstrating the role of AoA in L2 processing. For example, Marinis and Chondrogianni (2011) showed that the development of comprehension of pronouns and reflexives is similar between early bilingual children's L2 and monolinguals' native language, but not between the former group and late L2 learners. To the extent that such word classes involve grammatical processing, these results are also consistent with the claim that grammar is subserved by different cognitive mechanisms for early and late bilinguals.

In sum, the evidence indicates that AoA has an impact on how non-native languages are neurocognitively represented and processed (but see Frenck-Mestre et al. 2005). If these are appropriated at an early age, they will tend to resemble native languages both in the anatomical distribution of their subsystems and in the type of cognitive mechanism responsible for the latter's processing. Hence, inter-user performance variability in typically procedural (e.g., grammatical) functions will not be as marked as variability in declarative (e.g., lexical) functions. On the contrary, if a language is learned at a late age, all of its subsystems will tend to be processed declaratively, via conscious, controlled mechanisms – including executive processes (Waldron and Hernandez 2013), leading to greater interindividual variability in performance.

2.2.2 The level of proficiency factor

Another factor underlying performance variability in world languages is LoP. LoP and AoA effects are often confounded in experimental designs, since early bilinguals tend to have higher LoPs than late bilinguals. However, each variable contributes independently to performance variability among users.

There is abundant behavioral evidence demonstrating that LoP modulates processing in a non-native language. For instance, translation asymmetries, asymmetrical switching costs, and differences in conceptual involvement between L1 and L2 tasks are greater in low-proficiency than in high-proficiency bilinguals (for reviews, see French and Jacquet [2004], Brysbaert and Duyck [2010], and Kroll et al. [2010]).[1] Moreover, LoP has an impact on the neurological representation of languages. In this sense, a leading proposal is the so-called convergence hypothesis:

> According to this hypothesis, as proficiency in L2 increases, the representation of L2 and its processing profile (i.e., ERP and neuroimaging data) converge with those of native speakers of that language. That is, any qualitative differences between native speakers of a language, and L2 speakers of that language, disappear as proficiency increases [...] Notice the convergence hypothesis is a claim about neural representation and processing profiles and not a claim about whether or not an L2 speaker of a language can simulate or pass off as a native speaker of that language (Green 2004, 5).

Support for this view has been found in varied studies. For example, Ibrahim (2009) reports the case of M.H., an aphasic bilingual patient who suffered an intracraneal hemorrhage compromising his left temporal lobe (declarative memory) but sparing frontobasal regions (procedural memory). A native speaker of Arabic, M.H. learned Hebrew metalinguistically, through formal instruction, since the fourth grade. Although he was a late bilingual, he had achieved a high LoP in Hebrew (not only did he use it daily in academic, professional, and private contexts, but he graduated from a Hebrew university). Subsequent to his lesion, M.H. presented with similar deficits in both languages, in fluency, comprehension, and repetition. Moreover, after three months of therapy, grammatical deficits were not observed in either language, although vocabulary deficits remained. This case suggests that even the grammar of a lately learned L2 may eventually be processed through the more automatic mechanisms of procedural memory, provided the user has developed a sufficiently high LoP.

More evidence has been offered in neuroimaging experiments. Using the PET technique, Perani et al. (1998) formed two groups which differed in AoA but possessed similar LoPs, and asked them to listen to stories in L1, L2, and a third language unknown to them. The "early" group comprised native speakers of Italian who spoke either Spanish or Catalan as L2. The "late" group was composed of Italian-English bilinguals. The latter group showed left temporal and hippocampal activations for both languages, without significant differences between them. For its own part, the "early" group presented bilateral hippocampal and left-lateralized temporal and parietal activations. Left temporal activations, however, were less pronounced in this group. This study shows that differences in L2 neural representation between age groups may be attenuated with increased LoPs by late learners – i.e., extensive practice and exposure lead to greater macroanatomical convergence between corresponding L1 and L2 subsystems.

In an fMRI study, Videsott et al. (2010) administered a picture naming task to a sample of native Ladin[2] speakers with a high LoP in Italian and an intermediate LoP in English. While word production in all three languages engaged common brain areas, the two fluently spoken languages involved enhanced right prefrontal activity relative to English. Given the well-documented role of the right prefrontal cortex in cognitive control, the authors suggest that such a structure may support language proficiency by supervising effective word retrieval.

LoP also modulates brain potentials associated with lexical processing. Moreno and Kutas (2005) examined N400 deflections in two groups of Spanish-English bilinguals during a semantic decision task. One group was composed of early bilinguals with high vocabulary proficiency in English, whereas the other comprised late learners with lower English vocabulary proficiency. In both subgroups, the N400 effect peaked with a significant delay in the non-dominant than in the dominant language. Among other results, it was found that both AoA and LoP independently accounted for a statistically significant amount of the variance in N400 latency. The authors further suggested that early AoA does not necessarily guarantee a fast response to semantic incongruity. Moreover, a language dominance effect was found which resembled abstractness/concreteness effects observed at a similar time range within a single language (i.e., relative to abstract words, concrete words yielded a larger anterior negativity). This led the authors to conjecture that LoP may influence a language's overall processing style, making it more literal or metaphorical. For further evidence that L2 LoP is systematically associated with ERP responses, see Hahne (2001), Elston-Güttler et al. (2005), and Kotz and Elston-Güttler (2007).

All in all, LoP-related evidence seems largely consistent with the convergence hypothesis. A non-native world language spoken at a low LoP is processed via conscious, declarative mechanisms, and its grammar is represented in posterior brain areas that are separate from those subserving native-language grammar. However, as LoP increases, both its processing and gross neural representation tend to converge with those of native languages (i.e., processing depends on frontobasal regions, becoming more automatic and implicit). Moreover, LoP differences account for performance variability even in strictly declarative functions, such as vocabulary processing: a greater LoP reduces word activation latencies and executive involvement.

2.2.3 The interlinguistic influence factor

Unlike monolingual users of a world language, bilinguals represent information about (at least) two languages, each of which may influence processing in the other. Thus, performance in a world language that is represented as either a native or a non-native language may also vary depending on specific properties of the other language.

As a rule, native speakers of European languages tend to develop greater proficiency in English as an L2 than do Chinese learners. When matched for AoA, years of L2 instruction, and years spent in the United States, European bilinguals outperform Asian bilinguals in listening and reading tasks. Such differences in L2 attainment are likely related to the fact that, unlike Chinese, most European languages use alphabetic scripts, which would facilitate processing in other alphabetic-script languages, such as English (Bialystok and Miller 1999; Birdsong and Molis 2001; Jia et al. 2002; Jia 2006).

Moreover, the formal properties of a native language may influence the neurocognitive representation of a lately learned L2. Yang et al. (2011) examined whether the neural representation of lexical categories in a non-native language is influenced by that of a given native language. Strategically, the authors relied on fMRI to explore the neural distribution of nouns and verbs in late Chinese-English bilinguals. This language pair is well-suited to answer such a question. In monolingual speakers of English, nouns and verbs are differentially represented in left frontal/prefrontal regions and left middle/posterior temporal areas, respectively (Damasio and Tranel 1993; Martin et al. 2000; Shapiro et al. 2006). The neural dissociation between nouns and verbs also holds in non-native speakers of English whose native language also presents a morphological distinction between both classes (Hernández et al. 2007; Willms et al. 2011). However, no such dissociation occurs in Chinese monolinguals (Li et al. 2004), arguably because Chinese features no inflections signaling a formal distinction between such lexical classes (Kao 1990). A previous fMRI study with *early* Chinese-English bilinguals raised in Hong Kong found that each language presented the same profile observed in monolingual speakers (Chan et al. 2008). However, in their study with *late* bilinguals, Yang et al. (2011) found that nouns and verbs, in both Chinese (L1) and English (L2), were subserved by largely overlapping regions, although the network for English was more widely distributed than that involved in Chinese – which likely reflects more effortful processing in the former. The key finding was that, unlike what occurs in native English speakers and western learners of English as an L2, these subjects showed no neural dissociation between nouns and verbs. The authors suggest that “the lack of grammatical morphology and the high degree of noun-verb ambiguity in Chinese might lead to the speaker’s insensitivity to noun-verb differences”, so that late bilinguals “may be applying the neural mechanism for Chinese (L1) to the processing of English (L2) and hence also show no neural sensitivity to nouns versus verbs in English” (Yang et al. 2011, 680).

Basnight-Brown et al. (2007) offer further evidence that the level of formal similarity between a non-native world language and a native language influences processing in the former. Using a cross-modal priming paradigm, the authors compared magnitudes of facilitation between Serbian-English and Chinese-English bilinguals. The study focused on different types of English verbs: irregular nested-stem verbs (*drawn-draw*), irregular change-stem verbs (*ran-run*), and regular past tense/present tense verbs (*guided-guide*). While both groups showed significant facilitation for regular verbs and no facilitation for change-stem irregulars, only the Serbian group exhibited facilitation effects for nested irregulars. In light of these results, Basnight-Brown et al. (2007, 76–77) posit that “due to familiarity with a highly inflected language and with a written language that captures inflectional variation, L1 speakers of Serbian appear to be analytic with respect to form in their L2," thus being "better able to transfer their sensitivity to word structure from the L1 to the L2 so as to exploit orthographic and phonological similarities between various inflected forms." On the contrary, the authors claim, "the Chinese speakers tend to be less attuned to morphological relatedness overall and more rigid in their criterion for similarity so that it includes only those pairs that entail affixation of -ed." More generally, these findings suggest that speakers of logographic languages are less consistent than speakers of alphabetic languages in their reliance on formal information during English (L2) processing.

Formal similarities between a native language and a non-native world language also influence lexical processing in the latter. This is particularly evident in the so-called cognate effect, that is, the empirical finding that cognates (i.e., words which are phonologically/orthographically similar to their translation equivalents) are processed faster than noncognates (de Groot and Nas 1991; Sáchez-Casas et al. 1992; Gollan et al. 1997; Kiran and Lebel 2007; Schwartz et al. 2007; Dimitropoulou et al. 2011).

Notably, this effect is sensitive to the *degree of formal similarity* between equivalents. In an English lexical decision task with Dutch-English bilinguals, Dijkstra et al. (2010) observed that cognate facilitation effects were proportional to the degree of orthographic overlap between equivalents. Reaction times decreased as formal similarity increased across counterparts (e.g., *lamp-lamp* < *flood-vloed* < *song-lied*). Even word pairs with only partial formal overlap (e.g., *guide-gids*, *rhythm-ritme*) elicited facilitation effects. However, the cognate effect was modulated by task demands, as results were completely opposite in Dutch-English language decision. In this task, Dijkstra et al. (2010) observed a cognate inhibition effect, whose size depended on the degree of orthographic overlap between equivalents (identical cognates were processed more slowly than non-identical cognates). It follows from these findings that the greater the degree of formal overlap between the English and the native-language lexicons, the greater facilitatory and inhibitory effects will tend to be in the former during specific language processes. Typologically related languages, then, are particularly susceptible to these crosslinguistic effects – as well as others, such as the effect of first language polysemy on L2 semantic processing (Elston-Güttler et al. 2005; Elston-Guttler and Williams 2008).

Although the cognate facilitation effect is generally larger in L2s than in L1s (Kroll et al. 1999), it also affects L1 processing. Direct evidence for this was obtained by García et al. (in preparation), who administered identical single-word translation tasks to three groups of Spanish-English bilinguals, and two groups of English-Spanish bilinguals. The cognate effect emerged in both translation conditions (backward translation, forward translation), irrespective of the participants' LoP and language pair. This shows that lexical processing in English is modulated by the degree of formal similarity with another language, regardless of whether the former is a non-native or a native language.

Interlinguistic effects may even modulate brain activity in the absence of significant behavioral correlates. Thierry and Wu (2007) tested Chinese-English bilinguals via an implicit priming paradigm. Participants were asked to read and listen to pairs of English words so as to decide whether they were semantically related. Critically, the Chinese equivalents of some of the English pairs had a repeated character (e.g., the words *train* and *ham* are not semantically related, but their Chinese counterparts, *Huo Che* and *Huo Tui*, have a character in common). Since the tasks were performed entirely in English, the participants were unaware of this manipulation. Although this hidden factor did not affect behavioral performance, it did significantly modulate brain potentials by reducing the amplitude of the N400 component (an effect that was also observed in monolingual Chinese controls). Since this component is associated with unconscious semantic and repetition priming, the results demonstrate that the native language is unconsciously activated during second-language comprehension. They further indicate that implicit neurocognitive processing of a non-native world language is sensitive to covert, L1-specific structural features.

In conclusion, cognitive processing of, and behavioral performance in, a non-native world language is modulated by its level of formal similarity with a specific native language. Similarly, the appropriation of a second or foreign language may modulate both processing and performance in a native language. Hence, part of the performance variability among users of English as a world language depends on the idiosyncratic properties of the other language(s) they have appropriated, either as L1 or as L2. Remarkably, some of these effects may operate below the threshold of conscious awareness.

3. Discussion

As seen throughout this paper, performance variability among world-language users can be (partially) explained by reference to varied neurocognitive factors. Whereas native speakers rely on procedural memory to process grammar automatically, this function depends on conscious, declarative mechanisms in non-native users. Moreover, as compared to monolinguals, bilingual users of a world language tend to possess poorer lexical skills but better executive functions – some of which play a role in verbal communication. In addition, relative to native speakers, non-native speakers represent world-language information in more widely distributed neural networks, which suggests the use of additional cognitive resources during processing.

Another set of factors account for the differences *among* non-native world-language users. Whereas early and/or highly proficient bilinguals tend to represent syntactic and morphological routines in procedural memory, late and/or low-proficiency bilinguals rely on declarative memory to process such functions. On the other hand, lexical representations are sustained by declarative memory regardless of AoA. This does not mean that word processing is similar for all non-native users of a world language. In fact, L2 lexical access is faster for high-proficiency non-native users than low-proficiency ones, especially if their L1 and L2 share formal features. If both languages are formally dissimilar, late learners will tend to process L2 information using L1-related neural mechanisms, even if these differ from the ones typically used by native speakers.

The factors surveyed in this paper are but a sample of the multiple neurocognitive determinants of performance variability among world-language users. More precise accounts could be offered by considering the functional, neurophysiological, and even molecular implications of variables such as sex, level of education, and context of use, to name but a few. Be that as it may, those heretofore unexplored aspects are probably interwoven with the ones presently addressed.

The construct of world language has rarely been studied from an internalist perspective. Most scholarly investigations on the topic have focused on the institutional, educational, political, social, and dialectal aspects of the phenomenon. However, there is a paucity of attempts to offer cognitive and neurological insights into it. While admittedly atypical, studies offering a neurocognitive perspective on aspects of world languages (e.g., inter-user variability) may prove valuable for epistemological, methodological, and practical reasons.

First, epistemologically, world languages are multi-level phenomena. The notion of world language certainly involves a political, a sociolinguistic, a pragmatic, and a dialectological dimension, among others. While this observation stands undisputed, it is no less true that world languages also imply a neurocognitive dimension. At the level of the individual, all linguistic information physically exists in, and is physiologically processed by, the brain. If world languages are characterized by wide variability among users' performance, it is because the multiple political, institutional, pragmatic, and otherwise social contexts in which they are appropriated and used result in equally varied modes of neurocognitive representation – which, in turn, support widely varying processes and forms of output.

Notice that accepting this view does not imply relinquishing other perspectives in favor of a neurocognitive approach. Neither does it mean that an externalist conception of language must be validated with neurocognitive data. On the contrary, every relevant perspective, in its own right, has much to offer to the elucidation of this complex phenomenon; but an integrative understanding of world languages requires the interaction of *all* pertinent perspectives, not just some of them (see Figure 2). Moreover, knowledge about any given dimension of a multi-level phenomenon may enrich our conception of another dimension. By gaining insight into the neurocognitive aspects of world-language use, we may better understand its pragmatic, sociolinguistic, and dialectal properties, and vice versa.

Second, from a methodological viewpoint, neurocognitive findings may provide scholars studying other dimensions of world languages with insights for research design and data interpretation. Neurological and cognitive aspects of language are not divorced from the social and educational contexts in which verbal communication occurs. Awareness of the impact of factors such as memory-system involvement in appropriation, AoA, LoP, and interlinguistic effects can result in more valid and reliable externalist experimental designs, as well as in more solid data analysis, even if the focus of research is not the neurocognitive underpinnings of language use themselves.

For example, a study examining proficiency test performance in a multicultural classroom may reveal different patterns of error between Chinese and Latin American learners of English. As seen in Section 2.2.3, neurocognitive evidence shows that verbs

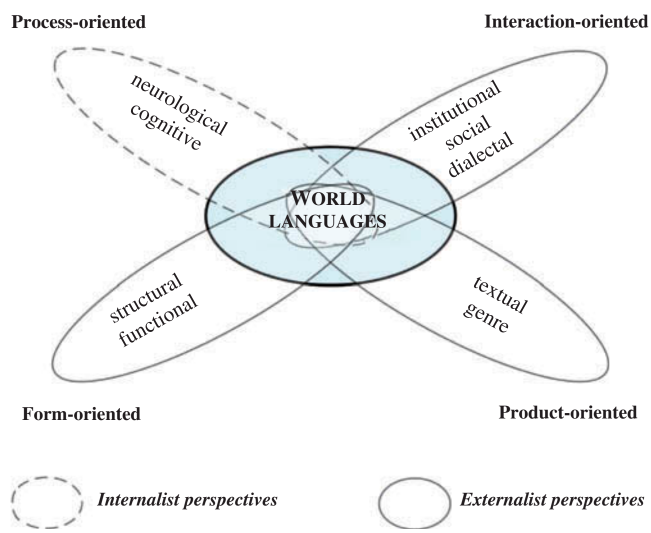

Figure 2. Multiple perspectives converging in an integrative view of world languages.

and nouns in a lately learned L2 tend to be processed by the same brain mechanisms subserving such classes in L1 (Yang et al. 2011). If only Chinese learners fail to make proper use of inflectional morphology in these lexical classes, an explanation that emphasizes attention deficits, lack of interest, homesickness, or merely structural differences between languages may be misguided or incomplete, unless it also incorporates relevant neurocognitive data. (Of course, neurocognitive studies of world languages may also profit from the findings of externalist approaches.)

Finally, including neurocognitive evidence in the study of world languages may also have practical benefits. Consider, for example, studies aimed at developing and improving world-language teaching resources. Both pedagogical and didactic tools can be informed by neurocognitive evidence, in the pursuit of more ecologically valid materials. By knowing the neurocognitive profiles of students, teachers should be able to design activities aimed at exploiting the cognitive mechanisms used by students, depending on their AoA, LoP, and mother tongue.

Lamendella (1979) offers an early example of such interdisciplinary endeavor by using aphasiological evidence to specify the benefits and limitations of drilling exercises. More recent illustrations can be found in the incipient field of neuroeducation. For instance, Netten and Germain (2012) draw on cognitive neuroscience to develop a new approach to foreign-language teaching, rooted in five neurolinguistic principles. In a similar vein, García (2013) turns to neurolinguistic evidence to expose the theoretical contradictions of English-as-a-foreign-language (EFL) curricula in the Buenos Aires high-school education system. For an overall appraisal of the advantages and limitations of using neuroscientific findings to develop educational tools, see Tokuhama-Espinosa (2010).

4. Conclusion

Internalist and externalist approaches can complement one another to provide an integrative account of world-language-related phenomena. The present paper demonstrates that inter-user performance variability among users of a world language depends not only on institutional, pragmatic, and sociolinguistic variables, but also on a number of interrelated neurocognitive factors. Specifically, performance variability is largely determined by the users' mode of appropriation, AoA, LoP, and degree of formal similarity between L1 and L2. The study of world languages can profit from the findings of neurocognitive science as much as from those of any other relevant discipline. A world language is a multi-level phenomenon; as such, its full conceptualization is only attainable through a non-exclusionary interdisciplinary approach.

Notes

1. However, greater executive control may allow non-native speakers to compensate for weaker language proficiency relative to native speakers (Bialystok and Feng 2009).
2. Ladin is a language spoken in southern Italy.

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References

Aladdin, Y., T. J. Snyder, and S. N. Ahmed. 2008. "Pearls & Oy-sters: Selective Postictal Aphasia: Cerebral Language Organization in Bilingual Patients." *Neurology* 71: e14–e17. doi:10.1212/01.wnl.0000325017.42998.d1

Alexander, M. P. 1997. "Aphasia: Clinical and Anatomic Aspects." In *Behavioral Neurology and Neuropsychology*, edited by T. E. Feinberg and M. J. Farah, 133–150. New York: McGraw-Hill.

Azarpazhooh, M. R., N. Jahangiri, and M. Ghaleh. 2010. "Subcortical Organization of Languages in Bilingual Brain." *Journal of Neurolinguistics* 23: 531–539. doi:10.1016/j.jneuroling.2010.03.007

Baker, C., and S. P. Jones. 1998. *Encyclopedia of Bilingualism and Bilingual Education*. Avon, UK: Multilingual Matters.

Basnight-Brown, D. M., L. Chen, S. Hua, A. Kostić, and L. B. Feldman. 2007. "Monolingual and Bilingual Recognition of Regular and Irregular English Verbs: Sensitivity to Form Similarity Varies with First Language Experience." *Journal of Memory and Language* 57: 65–80. doi:10.1016/j.jml.2007.03.001

Bialystok, E. 2001. *Bilingualism in Development: Language, Literacy and Cognition*. Cambridge: Cambridge University Press.

Bialystok, E. 2011. "Reshaping the Mind: The Benefits of Bilingualism." *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale* 65 (4): 229–235. doi:10.1037/a0025406

Bialystok, E., and B. Miller. 1999. "The Problem of Age in Second Language Acquisition: Influences from Language, Structure, and Task." *Bilingualism: Language and Cognition* 2: 127–145. doi:10.1017/S1366728999000231

Bialystok, E., and X. Feng. 2009. "Language Proficiency and Executive Control in Proactive Interference: Evidence from Monolingual and Bilingual Children and Adults." *Brain & Language* 109: 93–100. doi:10.1016/j.bandl.2008.09.001

Birdsong, D. ed. 1999. *Second Language Acquisition and the Critical Period Hypothesis*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bialystok, E., F. I. M. Craik, D. W. Green, and T. H. Gollan. 2009. "Bilingual Minds." *Psychological Science in the Public Interest* 10 (3): 89–129. doi:10.1177/1529100610387084

Birdsong, D. 2006. "Age and Second Language Acquisition and Processing: A Selective Overview." In *The Cognitive Neuroscience of Second Language Acquisition*, edited by M. Gullberg and P. Indefrey,9–49. Oxford: Blackwell.

Birdsong, D., and M. Molis. 2001. "On the Evidence for Maturational Constraints in Second Language Acquisition." *Journal of Memory and Language* 44: 235–249. doi:10.1006/jmla.2000.2750

Bozeat, S., M. A. Lambon Ralph, K. Patterson, P. Garrard, and J. R. Hodges. 2000. "Non-Verbal Impairment in Semantic Dementia." *Neuropsychologia* 38: 1207–1214. doi:10.1016/S0028-3932(00)00034-8

Brysbaert, M., and W. Duyck. 2010. "Is it Time to Leave Behind the Revised Hierarchical Model of Bilingual Language Processing after Fifteen Years of Service?." *Bilingualism: Language and Cognition* 13 (3): 359–371. doi:10.1017/S1366728909990344

Chan, A. H. D., K.-K. Luke, P. Li, V. Yip, G. Li, B. Weekes, and Li. Hai Tan. 2008. "Neural Correlates of Nouns and Verbs in Early Bilinguals." *Annals of the New York Academy of Sciences* 1145: 30–40. doi:10.1196/annals.1416.000

Chan, J. Y. H. 2013. "Contextual Variation and Hong Kong English." *World Englishes* 32: 54–74. doi:10.1111/weng.12004

Chee, M.W.L., D. Caplan, C.S. Soon, N. Sriram, E.W. Tan, T. Thiel, and B. Weekes. 1999. "Processing of Visually Presented Sentences in Mandarin and English Studied with fMRI." *Neuron* 23: 127–137. doi:10.1016/S0896-6273(00)80759-X

Clahsen, H., S. Bartke, and S. Göllner. 1997. “Formal Features in Impaired Grammars: A Comparison of English and German SLI Children.” *Essex Research Reports in Linguistics* 14: 42–75.

Crystal, D. 2003. *English as a Global Language*. 2nd ed., Cambridge: Cambridge University Press.

Damasio, A. R., and D. Tranel. 1993. “Nouns and Verbs Are Retrieved with Differently Distributed Neural Systems.” *Proceedings of the National Academy of Sciences* 90 (11): 4957–4960. doi:10.1073/pnas.90.11.4957

Damasio, H., T. J. Grabowski, D. Tranel, R. Hichwa, and A. R. Damasio. 1996. “A Neural Basis for Lexical Retrieval.” *Nature* 380: 499–505. doi:10.1038/380499a0

de Groot, A. M. B., and G. L. J. Nas. 1991. “Lexical Representation of Cognates and Noncognates in Compound Bilinguals.” *Journal of Memory and Language* 30: 90–123. doi:10.1016/0749-596X(91)90012-9

Dehaene, S., E. Dupoux, J. Mehler, L. Cohen, E. Paulesu, D. Perani, P.-F. van de Moortele, S. Lehéricy, and D. Le Bihan. 1997. “Anatomical Variability in the Cortical Representation of First and Second Language.” *NeuroReport* 8: 3809–3815. doi:10.1097/00001756-199712010-00030

Dewey, D., and K. Wall. 1997. “Praxis and Memory Deficits in Language-Impaired Children.” *Developmental Neuropsychology* 13 (4): 507–512. doi:10.1080/87565649709540692

DiGiulio, D. V., M. Seidenberg, D. S. Oleary, and N. Raz. 1994. “Procedural and Declarative Memory: A Developmental Study.” *Brain and Cognition* 25 (1): 79–91. doi:10.1006/brcg.1994.1024

Dijkstra, T., K. Miwa, B. Brummelhuis, M. Sappelli, and H. Baayen. 2010. “How Cross-Language Similarity and Task Demands Affect Cognate Recognition.” *Journal of Memory and Language* 62: 284–301. doi:10.1016/j.jml.2009.12.003

Dimitropoulou, M., J. A. Duñabeitia, and M. Carreiras. 2011. “Masked Translation Priming Effects with Low Proficient Bilinguals.” *Memory and Cognition* 39: 260–275. doi:10.3758/s13421-010-0004-9

Doan, Ba. N. 2012. “Contrasting Representations of English as an International Language (EIL) in Two EIL Undergraduate Programs.” *English as an International Language Journal* 7 (1): 1–21.

Dronkers, N. F., B. B. Redfern, and R. T. Knight. 2000. “The Neural Architecture of Language Disorders.” In *The New Cognitive Neurosciences*, edited by M. S. Gazzaniga, 949–958. Cambridge, MA: MIT Press.

Dubois, B., F. Boller, B. Pillon, and Y. Agid. 1991. “Cognitive Deficits in Parkinson’s Disease.” In *Handbook of Neuropsychology*, edited by F. Boller and J. Grafman, 195–240. Amsterdam: Elsevier.

Eichenbaum, H., and N. J. Cohen. 2001. *From Conditioning to Conscious Recollection: Memory Systems of the Brain*. New York: Oxford University Press.

Ellis Weismer, S., and L. J. Hesketh. 1996. “Lexical Learning by Children with Specific Language Impairment: Effects of Linguistic Input Presented at Varying Speaking Rates.” *Journal of Speech and Hearing Research* 39: 177–190.

Elston-Guttler, K. E., and J. N. Williams. 2008. “First Language Polysemy Affects Second Language Meaning Interpretation: Evidence for Activation of First Language Concepts During Second Language Reading.” *Second Language Research* 24: 167–187. doi:10.1177/0267658307086300

Elston-Güttler, K. E., S. Paulmann, and S. A. Kotz. 2005. “Who’s in Control? Proficiency and L1 Influence on L2 Processing.” *Journal of Cognitive Neuroscience* 17 (10): 1593–1610. doi:10.1162/089892905774597245

Fabbro, F. 2001a. “The Bilingual Brain: Bilingual Aphasia.” *Brain and Language* 79: 201–210. doi:10.1006/brln.2001.2480

Fabbro, F. 2001b. “The Bilingual Brain: Cerebral Representation of Languages.” *Brain and Language* 79: 211–222. doi:10.1006/brln.2001.2481

Fabbro, F., and M. Paradis. 1995. “Differential Impairments in Four Multilingual Patients with Subcortical Lesions.” In *Aspects of Bilingual Aphasia*, edited by M. Paradis, 139–176. Oxford: Pergamon.

Fatemi, M. A., A. Sobhani, and H. Abolhassani. 2012. “Difficulties of Persian Learners of English in Pronouncing Some English Consonant Clusters.” *World Journal Of English Language* 2 (4): 69–75.

Fredriksson, A., N. Schröder, P. Eriksson, I. Izquierdo, and T. Archer. 2000. “Maze Learning and Motor Activity Deficits in Adult Mice Induced by Iron Exposure During a Critical Postnatal Period.” *Developmental Brain Research* 119 (1): 65–74. doi:10.1016/S0165-3806(99)00160-1

French, R., and M. Jacquet. 2004. "Understanding Bilingual Memory: Models and Data." *Trends in Cognitive Sciences* 8 (2): 87–93. doi:10.1016/j.tics.2003.12.011

Frenck-Mestre, C., J. L. Anton, M. Roth, J. Vaid, and F. Viallet. 2005. "Articulation in Early and Late Bilinguals' Two Languages: Evidence from Functional Magnetic Resonance Imaging." *NeuroReport* 16 (7): 761–765. doi:10.1097/00001756-200505120-00021

Friederici, A. D. 2002. "Towards a Neural Basis of Auditory Sentence Processing." *Trends in Cognitive Sciences* 6 (2): 78–84. doi:10.1016/S1364-6613(00)01839-8

García, A. M. (2013). Bilingüismo, neuroeducación y Diseños Curriculares: Una mirada neurolingüística sobre la enseñanza de la gramática en la clase de inglés como lengua extranjera. Poster presented at the Segundo Congreso Internacional de Neuroeducación. Buenos Aires University, School of Medicine. September 22–23, 2013.

García, A. M., A. Ibáñez, D. Huepe, S. G. Chaves, A. L. Houck, C. G. Lezama, S. Chadha, and Á. Rivera-Rei (in preparation). "Directionality effects in single-word translation: The role of translation expertise in a cross-(bi)linguistic comparison."

Garcia-Caballero, A., I. Garcia-Lado, J. Gonzalez-Hermida, R. Area, M. José Recimil, O. Juncos Rabadan, S. Lamas, G. Ozaita, and F. J. Jorge. 2007. "Paradoxical Recovery in a Bilingual Patient with Aphasia after Right Capsuloputaminal Infarction." *Journal of Neurology, Neurosurgery & Psychiatry* 78: 89–91. doi:10.1136/jnnp.2006.095406

Gilsdorf, J. 2002. "Standard Englishes and World Englishes: Living with a Polymorph Business Language." *The Journal of Business Communication* 39 (3): 364–378. doi:10.1177/002194360203900305

Gollan, T. H., and L.-A. Acenas. 2004. "What is a TOT? Cognate and Translation Effects on Tip-of-the-Tongue States in Spanish-English and Tagalog-English Bilinguals." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 30: 246–269.

Gollan, T. H., K. I. Forster, and R. Frost. 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 (5): 1122–1139.

Graham, K. S., K. Patterson, and J. R. Hodges. 1999. "Episodic Memory: New Insights from the Study of Semantic Dementia." *Current Opinion in Neurobiology* 9: 245–250. doi:10.1016/S0959-4388(99)80035-X

Green, D. 2004. "The Neurocognition of Recovery Patterns in Bilingual Aphasics." In *Handbook of Bilingualism: Psycholinguistic Approaches*, edited by J. F. Kroll and A. M. B. De Groot. New York: Oxford University Press.

Grosjean, F. 1994. "Individual Bilingualism." In *The Encyclopaedia of Language and Linguistics*, edited by R. E. Asher, 1656–1660. Oxford: Pergamon Press.

Hahne, A. 2001. "What's Different in Second-Language Processing? Evidence from Event-Related Brain Potentials." *Journal of Psycholinguistic Research* 30 (3): 251–266. doi:10.1023/A:1010490917575

Hernández, M., A. Costa, N. Sebastián-Gallés, M. Juncadella, and R. Reñé. 2007. "The Organisation of Nouns and Verbs in Bilingual Speakers: A Case of Bilingual Grammatical Category-Specific Deficit." *Journal of Neurolinguistics* 20: 285–305. doi:10.1016/j.jneuroling.2006.10.002

Kim K.H.S., N.R. Relkin, K.M. Lee, and J. Hirsch, 1997. "Distinct Cortical Areas Associated with Native and Second Languages." *Nature* 388: 171–174. doi:10.1038/40623

Ibrahim, R. (2009). Selective deficit of second language: A case study of a brain-damaged Arabic-Hebrew bilingual patient. Behavioral and Brain Functions, 5(17). Accessed May 12, 2012. http://www.behavioralandbrainfunctions.com/content/5/1/17

Illes, J., W. S. Francis, J. E. Desmond, J. D. E. Gabriel, G. H. Glover, R. Poldrack, C. J. Lee, and A. D. Wagne. 1999. "Convergent Cortical Representation of Semantic Processing in Bilinguals." *Brain and Language* 70: 347–363. doi:10.1006/brln.1999.2186

Jia, G. 2006. "Second Language Acquisition by Native Chinese Speakers." In *Handbook of East Asian Psycholinguistics*, edited by P. Li, Li. Hai Tan, E. Bates, and O. J. L. Tzeng, 61–69. Cambridge: Cambridge University Press.

Jia, G., D. Aaronson, and Y. Wu. 2002. "Long Term Language Attainment of Bilingual Immigrants: Predictive Variables and Language Group Differences." *Applied Psycholinguistics* 23: 599–621. doi:10.1017/S0142716402004058

Kao, M. K. 1990. "Guanyu hanyu de cilei fenbei [On the Differentiation of Lexical Classes in Chinese]." In *Kao MK yuyanxue lunwenji [Linguistic Essays of Kao Ming Kai]*, edited by M. Kai Kao, 262–272. Beijing: Commercial Press.

Kilickaya, F. 2009. "World Englishes, English as an International Language and Applied Linguistics." *English Language Teaching* 2 (3): 35–38.
Kiran, S., and K. R. Lebel. 2007. "Crosslinguistic Semantic and Translation Priming in Normal Bilingual Individuals and Bilingual Aphasia." *Clinical Linguistics & Phonetics* 21 (4): 277–303. doi:10.1080/02699200701243873
Kirasic, K. C., G. L. Allen, S. H. Dobson, and K. S. Binder. 1996. "Aging, Cognitive Resources, and Declarative Learning." *Psychology and Aging* 11 (4): 658–670. doi:10.1037/0882-7974.11.4.658
Kotz, S. A., and K. E. Elston-Güttler. 2007. "Bilingual Semantic Memory Revisited – ERP and fMRI Evidence." In *Neural Basis of Semantic Memory*, edited by J. Hart Jr. and M. A. Kraut, 105–132. Cambridge: Cambridge University Press.
Kroll, J. F., J. G. van Hell, N. Tokowicz, and D. W. Green. 2010. "The Revised Hierarchical Model: A Critical Review and Assessment." *Bilingualism: Language and Cognition* 13: 373–381. doi:10.1017/S136672891000009X
Kroll, J. F., T. Dijkstra, N. Janssen, and H. J. Schriefers. 1999. "Cross-Language Lexical Activity During Production: Evidence from Cued Picture Naming." In *Proceedings of the 11th Congress of the European Society for Cognitive Psychology*, edited by A. Vandierendonck, M. Brysbaert, and K. van der Goten, 92. Gent: ESCOP/Academic Press.
Ku, A., E. A. Lachmann, and W. Nagler. 1996. "Selective Language Aphasia from Herpes Simplex Encephalitis." *Pediatric Neurology* 15: 169–171. doi:10.1016/0887-8994(96)00154-3
Lamendella, J. T. 1979. "The Neurofunctional Basis of Pattern Practice." *TESOL Quarterly* 13 (1): 5–19. doi:10.2307/3585971
Li, P., Z. Jin, and Li. Hai Tan. 2004. "Neural Representations of Nouns and Verbs in Chinese: An fMRI Study." *NeuroImage* 21: 1533–1541. doi:10.1016/j.neuroimage.2003.10.044
Mair, C., ed. 2003. *The Politics of English as a World Language: New Horizons in Postcolonial Cultural Studies*. Amsterdam: Rodopi.
Marinis, T., and V. Chondrogianni. 2011. "Comprehension of Reflexives and Pronouns in Sequential Bilingual Children: Do They Pattern Similarly to L1 Children, L2 Adults, or Children with Specific Language Impairment?" *Journal of Neurolinguistics* 24: 202–212. doi:10.1016/j.jneuroling.2010.02.009
Martin, A., L. G. Ungerleider, and J. V. Haxby. 2000. "Category Specificity and the Brain: The Sensory/motor Model of Semantic Representations of Objects." In *The Cognitive Neurosciences*, edited by M. S. Gazzaniga, 1023–1036. Cambridge, MA: MIT Press.
Meinzer, M., J. Obleser, T. Flaisch, C. Eulitz, and B. Rockstroh. 2007. "Recovery from Aphasia as a Function of Language Therapy in an Early Bilingual Patient Demonstrated by fMRI." *Neuropsychologia* 45: 1247–1256. doi:10.1016/j.neuropsychologia.2006.10.003
Möhring, A. 2001. "The Acquisition of French by German Pre-School Children: An Empirical Investigation of Gender Assignment and Gender Agreement." In *EUROSLA Yearbook*, edited by S. H. Foster-Cohen and A. Nizegorodcew, 171–193. Amsterdam: John Benjamins.
Mondt, K., D. Baleriaux, T. Metens, P. Paquier, P. Van de Craen, M. Van den Noort, and V. Denolin. 2009. "An fMRI Study of Level of Proficiency as a Predictor of Neurocognitive Convergence for L1/L2 During a Lexicosemantic Task in a Paediatric Population." *Second Language Research* 25 (1): 107–134. doi:10.1177/0267658308098998
Moreno, E., A. Rodríguez-Fornells, and M. Laine. 2008. "Event-Related Potentials (ERPs) in the Study of Bilingual Language Processing." *Journal of Neurolinguistics* 21: 477–508. doi:10.1016/j.jneuroling.2008.01.003
Moreno, E., and M. Kutas. 2005. "Processing Semantic Anomalies in Two Languages: An Electrophysiological Exploration in Both Languages of Spanish-English Bilinguals." Brain Research. *Cognitive Brain Research* 22 (2): 205–220. doi:10.1016/j.cogbrainres.2004.08.010
Netten, J., and C. Germain. 2012. "A New Paradigm for the Learning of a Second or Foreign Language: The Neurolinguistic Approach." *Neuroeducation* 1 (1): 85–114.
Obler, L. K., and K. Gjerlow. 1999. *Language and the Brain*. Cambridge: Cambridge University Press.
Packard, M., and B. Knowlton. 2002. "Learning and Memory Functions of the Basal Ganglia." *Annual Review of Neuroscience* 25: 563–593. doi:10.1146/annurev.neuro.25.112701.142937
Paradis, M. 1984. "Aphasie et traduction." *Meta: Journal des Traducteurs/Meta: International Translator's Journal* 29: 57–67. doi:10.7202/003781ar
Paradis, M. 1994. "Neurolinguistic Aspects of Implicit and Explicit Memory: Implications for Bilingualism." In *Implicit and Explicit Learning of Second Languages*, edited by N. Ellis, 393–419. London: Academic Press.

Paradis, M. 2004. *A Neurolinguistic Theory of Bilingualism*. Amsterdam: John Benjamins.
Paradis, M. 2009. *Declarative and Procedural Determinants of Second Languages*. Amsterdam: John Benjamins.
Perani, D., E. Paulesu, N. S. Galles, E. Dupoux, S. Dehaene, V. Bettinardi, S. F. Cappa, F. Fazio, and J. Mehler. 1998. "The Bilingual Brain. Proficiency and Age of Acquisition of the Second Language." *Brain* 121: 1841–1852. doi:10.1093/brain/121.10.1841
Perani, D., S. Dehaene, F. Grassi, L. Cohen, S. F. Cappa, E. Dupoux, F. Fazio, and J. Mehler. 1996. "Brain Processing of Native and Foreign Languages." *NeuroReport* 7: 2439–2444. doi:10.1097/00001756-199611040-00007
Porch, B. E., and J. de Berkeley-Wykes. 1985. "Bilingual Aphasia and Its Implications for Cerebral Organization and Recovery." *Clinical Aphasiology Conference*. Vol. 15, 107–112. Rockville: BRK.
Sánchez-Casas, R. M., J.E. García-Albea, and C.W. Davis. 1992. "Bilingual Lexical Processing: Exploring the Cognate/Non-Cognate Distinction." *European Journal of Cognitive Psychology* 4: 293–310. doi:10.1080/09541449208406189
Schlaug, G. 2001. "The Brain of Musicians: A Model for Functional and Structural Adaptation." *Annals of the New York Academy of Sciences* 930 (1): 281–299. doi:10.1111/j.1749-6632.2001.tb05739.x
Schwartz, A. I., J. F. Kroll, and M. Diaz. 2007. "Reading Words in Spanish and English: Mapping Orthography to Phonology in two Languages." *Language and Cognitive Processes* 22: 106–129. doi:10.1080/01690960500463920
Shapiro, K. M., L. R. Moo, and A. Caramazza. 2006. "Cortical Signatures of Noun and Verb Production." *Proceedings of the National Academy of Sciences USA* 103: 1644–1649. doi:10.1073/pnas.0504142103
Springer, J. A., J. R. Binder, T. A. Hammeke, S. J. Swanson, J. A. Frost, P. S. F. Bellgowan, C. C. Brewer, H. M. Perry, G. L. Morris, and W. M. Mueller. 1999. "Language Dominance in Neurologically Normal and Epilepsy Subjects: A Functional MRI Study." *Brain* 122: 2033–2046. doi:10.1093/brain/122.11.2033
Thierry, G., and Y. J. Wu. 2007. "Brain Potentials Reveal Unconscious Translation During Foreign-Language Comprehension." *Proceedings of the National Academy of Sciences* 104 (30): 12530–12535. doi:10.1073/pnas.0609927104
Tokuhama-Espinosa, T. 2010. *Mind, Brain, and Education Science: The New Brain-Based Learning*. New York: Norton.
Ullman, M. T. 2001. "The Declarative/Procedural Model of Lexicon and Grammar." *Journal of Psycholinguistic Research* 30 (1): 37–69. doi:10.1023/A:1005204207369
Ullman, M. T. 2004. "Contributions of Memory Circuits to Language: The Declarative/procedural Model." *Cognition* 92: 231–270. doi:10.1016/j.cognition.2003.10.008
Ullman, M. T. 2005. "A Cognitive Neuroscience Perspective on Second Language Acquisition: The Declarative/procedural Model." In *Mind and Context In Adult Second Language Acquisition: Methods, Theory, and Practice*, edited by C. Sanz, 141–178. Washington, DC: Georgetown University Press.
Ullman, M. T. 2008. "The Role of Memory Systems in Disorders of Language." In *Handbook of the Neuroscience of Language*, edited by B. Stemmer and H. A. Whitaker, 189–198. London: Elsevier.
Videsott, G., B. Herrnberger, K. Hoenig, E. Schilly, Jo. Grothe, W. Wiater, M. Spitzer, and M. Kiefer. 2010. "Speaking in Multiple Languages: Neural Correlates of Language Proficiency in Multilingual Word Production." *Brain & Language* 113: 103–112. doi:10.1016/j.bandl.2010.01.006
Wahid, R. 2013. "Definite Article Usage Across Varieties of English." *World Englishes* 32: 23–41. doi:10.1111/weng.12002
Waldron, E. J., and A. E. Hernandez. 2013. "The Role of Age of Acquisition on Past Tense Generation in Spanish–English Bilinguals: An fMRI Study." *Brain & Language* 125: 28–37. doi:10.1016/j.bandl.2013.01.002
Walraff, B. 2000. "What Global Language?" *Atlantic Monthly* 286: 52–63.
Willms, J. L., K. A. Shapiro, M. V. Peelen, P. E. Pajtas, A. Costa, L. R. Moo, and A. Caramazza. 2011. "Language-Invariant Verb Processing Regions in Spanish-English Bilinguals." *NeuroImage* 57: 251–261. doi:10.1016/j.neuroimage.2011.04.021
Yang, J., Li. H. Tan, and P. Li. 2011. "Lexical Representation of Nouns and Verbs in the Late Bilingual Brain." *Journal of Neurolinguistics* 24: 674–682. doi:10.1016/j.jneuroling.2011.07.002