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Syntactic processing in two languages by native and bilingual adult readers: An ERP study

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Abstract

The present study examined differences in brain activity, specifically in event-related potential (ERP) amplitudes and latencies in bilingual (English/Hebrew and Hebrew/English) readers when processing the grammatical functions of words during reading of sentences in two languages. Twenty-six bilingual university students (later bilinguals) participated in the study: 10 native English speakers and 16 native speakers of Hebrew. Two points were investigated: (1) differences between syntactic processing strategies in English and Hebrew as first and second languages, and (2) differences in activation patterns in sentence processing between the two groups of participants in the two languages. Results indicate significant differences in reading-related measures (e.g., decoding) between Hebrew speakers reading in English and vice versa, but not in the reading itself in both languages (i.e., rate, accuracy, and reading comprehension). In both groups of participants, P100, P200, P300, N400, and P600 ERP waves were identified for three grammatical functions (subject, predicate, and direct object) in each sentence, in all reading items, and in both languages. Analysis of the results showed that participants used the same mixed strategy to identify the grammatical role of words in both languages. This strategy included elements of both word-order and verb-oriented (morphologically based) patterns of processing. The article suggests that the reason for using this strategy is suggested lies in the properties of the experimental paradigm and in the characteristics of participants (age and level of experience in the two languages). The most important outcome of the study was revealing the significant differences in patterns of brain activation between native speakers of Hebrew and English and between patterns of brain activation when both groups process words in the two languages.

Keywords: Bilingualism; ERP; Syntactic processing; English; Hebrew

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People who come to be bilingual after puberty constitute a substantial proportion of the population in countries with high immigration rates. In Israel, the language situation is especially complicated and involves the coexistence of three dominant languages, Hebrew, Arabic, and English, as well as the native languages of large groups of immigrants. English is widely used in many contexts, and especially in the academic field. The investigation of differences in reading processing between various native languages and between reading in first (L1) and second/third (L2) languages is of great interest from the theoretical point of view and important for understanding difficulties in learning L2 reading.

Reading processing in bilingual populations has been studied intensively in the past decades (Garcia, 2000; Tartter, 1998), but these studies dealt mostly with relatively young readers and focused more on phonological/orthographic and lexical-semantic properties than on the morphological and syntactic aspects of L2 reading. Sentence comprehension is a complex task that involves several cognitive processes (e.g., Ferstl & Flores d'Arcais, 1999). In addition to phonological and orthographic operations, sentence processing involves such language factors as morphological and syntactic knowledge. The morpho-syntactic characteristics of sentence processing in later bilinguals have been studied far less, especially from the neurological and neurophysiological point of view (Clahsen & Felser, 2006; Hahne & Friederici, 2001; Wade-Woolley & Geva, 1999).

Learning a second language and using it efficiently becomes more difficult with increasing age. Many behavioral studies indicate that, in contrast to lexical-semantic aspects, syntactic and phonological aspects of L2 are particularly difficult to master during late acquisition (De Groot & Kroll, 1997; Ellis, 2002). Although less numerous, neurophysiological studies provide additional evidence that the age at the time of L2-acquisition is critical for the mastery of that language and for the functional specialization of language in the brain (Weber-Fox & Neville, 1996). Liu and Perfetti (2003) hypothesized that different brain mechanisms may be involved in syntactic processing by late language learners than by native speakers. Recent brain imaging studies investigating sentence processing seem to indicate that this is indeed the case (Friederici, Hahne, & Saddy, 2002; Perani et al., 1998). In particular, it was reported that brain activation for L1 and L2 use shows only little overlap in late bilinguals (Perani et al., 1998). In addition, syntactic abilities in L2 seem to depend not only on the age of acquisition but also on the characteristics of bilinguals' native language (Liu & Perfetti, 2003; McDonald, 2000).

Several studies, mostly neuropsychological, have suggested distinct non-overlapping cortical representations of the two languages in bilinguals (Fabbro, 2001; Paradis & Goldblum, 1989), and different ERP patterns have been observed in first language processing of bilinguals and monolinguals (Donald, Meuter, & Ardal, 1986). Other studies, however, found evidence of overlapping cortical representations in bilinguals (e.g., Sarfarazi & Sedgwick, 1996). Empirical findings of locations of activation for the two languages using fMRI have also been contradictory (Illes et al., 1999). Behavioral studies of bilingual language processing have also yielded mixed results: some have suggested separate activation of L1 and L2 (Gerard & Scarborough, 1989) and others (e.g., Dijkstra, 2001) simultaneous activation of the two languages.

These controversies have been explained by differences in methodologies or subject populations (e.g., Grosjean, 1998). It has also been suggested to distinguish between different bilingual processing styles for phonetic and syntactic information, on the one hand, and for lexical-semantic information, on the other (e.g., Marian, Spivey, & Hirsch, 2003). Two additional factors may account for the controversies mentioned above: