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Short Communication

Semantic processing in native and second language: Evidence from hemispheric differences in fine and coarse semantic coding

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ABSTRACT

Previous studies suggest that whereas the left hemisphere (LH) is involved in fine semantic processing, the right hemisphere (RH) is uniquely engaged in coarse semantic coding including the comprehension of distinct types of language such as figurative language, lexical ambiguity and verbal humor (e.g., Chiarello, 2003; Faust, 2012). The present study examined the patterns of hemispheric involvement in fine/coarse semantic processing in native and non-native languages using a split visual field priming paradigm. Thirty native Hebrew speaking students made lexical decision judgments of Hebrew and English target words preceded by strongly, weakly, or unrelated primes. Results indicated that whereas for Hebrew pairs, priming effect for the weakly-related word pairs was obtained only for RH presented target words, for English pairs, no priming effect for the weakly-related pairs emerged for either LH or RH presented targets, suggesting that coarse semantic coding is much weaker for a non-native than native language.

1. Introduction

Much previous research suggests that the comprehension of figurative language, as well as other distinct types of language, such as lexical ambiguity and verbal humor, involves the unique semantic processing mechanisms of the right cerebral hemisphere (RH) (e.g., Beeman, 1998; Chiarello, 2003; Faust, 2012; Faust & Mashal, 2007; Federmeier, Wlotko, & Meyer, 2008; Jung-Beeman, 2005; Mashal, Faust, & Hendler, 2005). Thus, although traditionally the left cerebral hemisphere (LH) has been shown to be dominant for language processing, it has been suggested that the unique coarse semantic coding in the RH enables the processing of specific types of language that require the activation and/or maintenance of multiple meanings, including more distant and unusual meanings (e.g., Beeman, 1998; Jung-Beeman, 2005). However, the neural basis for fine and coarse semantic coding and, specifically, the unique ability of the RH to engage in coarse semantic coding was studied, to the best of our knowledge, only in native language speakers. Therefore, the aim of the present study was to directly examine LH and RH involvement in fine versus coarse semantic processing in non-native, second language, using native speakers of Hebrew who are also highly proficient in English, their second language. The findings could contribute to our understanding of the neural basis of bilingualism as well as of some of the differences in semantic processing between native and non-native language.

According to the Fine/Coarse semantic coding theory (FCT, Beeman, 1998; Jung-Beeman, 2005), semantic processing by the two cerebral hemispheres is qualitatively different (for reviews see e.g., Chiarello, 2003; Faust, 2012). Thus, the involvement of the RH in processing specific types of language, such as non-literal expressions, may not be particular to metaphors, idioms, etc., but rather may be one aspect of the unique semantic coding of this hemisphere, characterized by high sensitivity to distant semantic relations. The FCT postulates that immediately after encountering a word, the LH engages in relatively fine semantic coding, strongly activating closely related word meanings or semantic features, whereas the RH engages in coarse semantic coding, weakly and diffusely activating large semantic fields containing multiple alternative meanings and more distant associates. According to the FCT, coarse semantic coding by the RH facilitates the comprehension of specific types of language that may require activation and maintenance of distantly related meanings, such as metaphoric expressions, lexical ambiguity, verbal humor, insight problem solving and poetry. With regard to metaphoric language, for example, since the metaphorical meaning of a word is usually more semantically distant than its literal meaning, RH coarse semantic coding abilities will be needed for understanding metaphoric expressions.

Efficient language processing thus seems to depend on the ability to engage in both fine and coarse semantic coding, in line with the current linguistic, cognitive and social circumstances.

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According to the FCT, the two cerebral hemispheres of the intact brain constitute complementary semantic systems that enable successful coping with the full range of linguistic forms characterizing the human language, including non-literal language and lexical ambiguity (e.g., Atchley, Grimshaw, Schuster, & Gibson, 2011; Jung-Beeman, 2005; Burgess & Simpson, 1988; Chiarello, 2003). However, although the FCT is a central, highly influential model supported by much empirical evidence (e.g., Anaki, Faust, & Kravetz, 1998; Atchley, Burgess, & Keeney, 1999; Chiarello & Richards, 1992; Coulson & Williams, 2005; Faust, 2012; Faust, Ben-Artzi, & Harel, 2008; Gold, Faust, & Ben-Artzi, 2011; Schmidt, DeBuse, & Seger, 2007), previous research has focused on fine versus coarse semantic processing by the two cerebral hemispheres in native language, while to the best of our knowledge there are no data on differences in fine versus coarse semantic processing by the two cerebral hemispheres in a foreign, non-native language.

The cerebral basis of bilingualism has been drawing much interest in recent years. In our increasingly globalizing modern society, learning and mastering a second language has become a basic requirement, thus a large proportion of the world population is either bilingual or even multilingual. Since the pressure posed by modern society to master a foreign language is increasing tremendously, it is of great importance that foreign language learners achieve high levels of linguistic and communicative functioning in their second language. This in turn may depend on their ability to use the full range of semantic abilities including both fine and coarse semantic coding. Although bilingual persons may acquire full mastery of their non-native language, both everyday experience and research findings strongly suggest that the comprehension of specific types of language, such as non-literal language, tends to be much more difficult in a second, non-native language, even for persons with a high degree of proficiency in this language (e.g., Cacciari, 1993; Charteris-Black, 2002; Cieslicka & Heredia, 2011; Irujo, 1993; Moon, 1997; Zughoul, 1991). Given the abundance and high significance of metaphoric language, that permits the efficient expression of ideas that would otherwise be awkward to explain literally (Glucksberg, 2001), the difficulty in processing non-literal expressions in a non-native language could interfere with successful linguistic and communicative functioning in this language. Similarly, difficulties of non-native speakers in comprehending linguistic ambiguity and humor as well as other types of language that require some degree of coping with the multifaceted nature of word meaning, could become a major obstacle in fully mastering a second language.

The differences between native and second language in processing specific types of language, including non-literal language, may be just one manifestation of different semantic processing mechanisms in native and non-native languages. According to this claim, the neural basis for the specific difficulties in semantic processing experienced in a second language may be related to the different neural representations of the two languages (for a review see e.g., Dijkstra & van Heuven, 2012) and specifically to a reduced ability of the RH to engage in coarse semantic coding in a non-native language. Recent findings support this claim indicating hemispheric asymmetries in figurative language processing, such that whereas the LH manifests similar patterns of activation for both native and non-native languages, the RH shows only figurative facilitation in native languages and only literal facilitation in non-native languages (Cieslicka & Heredia, 2011).

Semantic processing by the two cerebral hemispheres has been studied mainly with an experimental paradigm combining split visual field presentation with central or lateral semantic priming. The semantic priming effect has been used to investigate how word meanings are accessed, comprehended and integrated within larger contexts and thus serves as a rich source of information about semantic processing. In semantic priming, a target word is responded to more quickly after presentation of a related prime word than after presentation of an unrelated prime. Two types of word pairs widely used in previous priming research as well as in the present study are semantically (e.g., sharing category membership) and associatively related pairs (for a review see Hutchison, 2003). It has generally been found that semantic priming occurs even without association and that strongly associated word pairs can lead to a "boost" of priming over and above the effect of semantic relationship alone (for review see Lucas, 2000). Thus, word pairs that are both semantically and associatively related lead to strong priming effects, although weaker priming effects have been also found for word pairs that are semantically, but not associatively, related.

The difference between these two types of priming has been used to study fine and coarse semantic coding by the two cerebral hemispheres. This research has shown that words presented to either hemisphere are primed by related primes, although not necessarily under the same conditions. Two major factors that differentially modulate priming effects obtained in the LH and RH are the nature of prime–target semantic relation and the time course of meaning activation (e.g., Chiarello, 2003). Thus, although the findings are not entirely consistent, strong priming for categorical associates was generally found in the LH across a range of prime–target intervals (SOAs). Priming for more weakly related words, such as non-associated category members, has been reported to diminish at longer intervals, particularly in the LH, and this may indicate the decay or suppression of more distant meanings in this hemisphere when there is no supportive context requiring their maintenance. However, RH priming for weakly related meanings has shown a delayed onset but was maintained across longer intervals during which the LH may no longer have access to distant meanings (e.g., Anaki et al., 1998; Chiarello, 2003; cf. Coney, 2002). The general picture emerging from the split visual field priming studies thus suggest much less robust hemispheric asymmetries when the words are strongly related and share many semantic features. In contrast, words with less semantic similarity appear to show a more distinctly asymmetrical pattern across hemispheres, and over time. Thus, whereas priming within the LH dissipates rapidly, RH priming is maintained across longer intervals. As mentioned above, this unique RH coarse semantic coding may support the processing of distinct types of languages, allowing access to the rich resources provided by native speakers' linguistic capacity.

In order to study fine and coarse semantic coding in a non-native language, we applied the same paradigm combining split visual field presentation with central priming using both native and second, non-native linguistic stimuli. We used categorical associate pairs for the strong, fine coding condition and non-associated category members for the relatively weak, coarse semantic coding condition, in addition to unrelated pairs. A relatively long time interval of 750 ms was used.

If the differential pattern of semantic coarse/fine processing by the LH and RH, respectively, reported in native language, is repeated in non-native language, this may support the notion of similar patterns of lateralization for semantic processing, at least in late bilinguals with high level of proficiency in their second language. If, however, the FCT does not generalize to semantic processing in a non-native language, then the findings may lend some support to the claim that hemispheric involvement in semantic processing is different for native and non-native languages. This difference may result in a different representation of word meanings in native as compared to non-native languages.

2. Results

For each participant, mean reaction times in milliseconds for correct responses and percent correct responses for target words