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Hemispheric asymmetries in semantic processing: Evidence from false memories for ambiguous words

Miriam Faust [a,*], Elisheva Ben-Artzi [a,b], Itay Harel [a]

[a] *Department of Psychology, Bar-Ilan University, 52900 Ramat-Gan, Israel*
[b] *Kinneret College, Tzemach, Israel*

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Abstract

Previous research suggests that the left hemisphere (LH) focuses on strongly related word meanings; the right hemisphere (RH) may contribute uniquely to the processing of lexical ambiguity by activating and maintaining a wide range of meanings, including subordinate meanings. The present study used the word-lists false memory paradigm [Roediger, H. L. III., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 803–814.] to examine whether these differences between the two cerebral hemispheres in semantic processing also affect memory representations for different meanings of ambiguous words. Specifically, we tested the differences between the LH and RH in recollecting unpresented, semantically related, ambiguous words following the presentation of lists of words all related to either the dominant or the subordinate meanings of these ambiguous words. Findings showed that for the unpresented ambiguous words, the LH made more false alarms than the RH for the dominant lists, whereas the opposite pattern emerged for subordinate lists. Moreover, *d'* analyses showed that, whereas the LH was more sensitive to subordinate than dominant meanings, the RH showed no differences in sensitivity for the two types of word–lists. Taken as a whole, these results support the RH coarse semantic coding theory [Beeman, M. (1998). Coarse semantic coding and discourse comprehension. In Beeman & M., Chiarello, C. (Eds.), *Right hemisphere language comprehension: Perspectives from cognitive neuroscience* (pp. 255–284). Mahwah, NJ: Erlbaum; Jung-Beeman, M. (2005). Bilateral brain processes for comprehending natural language. *Trends in Cognitive Sciences, 9,* 512–518.] indicating that during word recognition, the RH activates and maintains a broader and less differentiated range of related meanings than the LH, including both dominant and subordinate meanings of ambiguous words. Furthermore, the findings suggest that hemispheric differences in ambiguity resolution during language processing extend also to verbal memory.

Keywords: Visual fields; Hemispheres; False memory; Semantic processing; Lexical ambiguity

1. Introduction

The accumulated evidence from neurologically intact, split-brain and brain-injured participants indicates that, although both cerebral hemispheres have access to word meanings, comprehension of semantic relations differs in the left (LH) and right (RH) hemispheres (for reviews, see e.g., Chiarello, 2003; Jung-Beeman, 2005). Much research indicates that when a word is recognized by the LH, only the most strongly related meanings are activated, whereas in the RH a much broader set of meanings, including distant, unusual, non-salient, subordinate and figurative meanings becomes available (e.g., Beeman, 1998; Chiarello, 1991, 1998, 2003; Faust & Lavidor, 2003; Jung-Beeman, 2005). One aspect of the qualitative differences between the hemispheres in semantic processing, which has been studied extensively in word recognition and comprehension, is the unique RH involvement in processing alternate meanings of ambiguous words (e.g., Burgess & Simpson, 1988; Coney & Evans, 2000; Faust & Chiarello, 1998; Faust & Lavidor, 2003). The aim of the

* Corresponding author. Fax: +972 3 5350267.
E-mail address: faustm@mail.biu.ac.il (M. Faust).

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present study was to examine whether hemispheric differences in the ability to activate and maintain multiple meanings of ambiguous words, including subordinate, weakly related meanings holds also for verbal memory. Specifically, we used a modified word-lists false memory paradigm (e.g., Gallo, 2006; Howe, 2006; Roediger & McDermott, 1995) to investigate the susceptibility of the LH and RH to unstudied lexically ambiguous words following the presentation of lists of words all related to either the dominant or subordinate meanings of these ambiguous words.

1.1. Hemispheric differences in semantic processing: The fine–coarse coding theory (FCT)

An explanation of the role of the RH in lexical semantic processing has been provided by the fine–coarse semantic coding theory (FCT) developed by Beeman (e.g., Beeman, 1998; Jung-Beeman, 2005). According to the FCT, immediately after encountering a word, the LH engages in relatively fine semantic coding, strongly and quickly focusing semantic activation on features related to the dominant, literally or contextually relevant meanings, while inhibiting features related to the subordinate or contextually irrelevant meanings. However, the RH engages in coarse semantic coding, weakly and diffusely activating large semantic fields containing multiple alternative meanings and more distant associates, including subordinate meanings of ambiguous words. Jung-Beeman (2005) has suggested that, while the strong categorical semantic activation in the LH is conducive to most language comprehension tasks, the biggest advantage conveyed by RH coarse semantic coding arises when people process multiple distantly related words. This is because given multiple input words, large semantic fields are more likely to overlap than smaller, more focused semantic fields. The findings of a multiple priming study (Beeman et al., 1994) supported this claim by showing that when people are presented with three-word primes (*food*, *glass*, *pain*) where each word is distantly related to the target word (*cut*), weak semantic activation from the three prime words summates in the RH, yielding stronger priming for the left visual field (LVF)/RH than for right visual field (RVF)/LH presented target words. However, a single, strongly related prime word (*scissors*) yielded stronger priming for RVF/LH than for LVF/RH presented target words. Thus, in response to multiple words, the RH's large semantic fields are more likely to overlap than the LH's small semantic fields. As a result, the RH is more likely to activate a concept that inferentially connects distantly related words (Jung-Beeman, 2005).

The notion that the LH and RH activate and maintain different word meanings has to be understood within the context of processing systems in which the availability of different types of information change over time (Chiarello, 2003). Previous priming research (e.g., Anaki, Faust, & Kravetz, 1998; Burgess & Simpson, 1988) generally indicates that the LH may initially activate a wide set of word meanings, but that this early stage is followed by a selection process in which the strongly related, dominant meanings are selectively maintained, while other weakly related meanings are discarded and not maintained for later processing. In contrast, the RH may be slower in meaning activation, but continues to maintain more distant meanings, including subordinate meanings, during time periods when these meanings are no longer available within the LH (for reviews see Beeman, 1998; Chiarello, 2003).

Hemispheric differences in the availability of alternate word meanings during different stages of language processing were examined in several priming studies by varying the interval (SOA) between the presentation of the prime and target word. Burgess and Simpson (1988) examined priming for both the dominant and subordinate meanings of ambiguous words (*bank*). At a short SOA of 35 ms, the less frequent subordinate meanings (*river*) were primed only within the RVF/LH, whereas at a 750-ms interval they remained accessible only within the LVF/RH. Thus, in the LH, only the more frequent dominant meanings were still active after relatively long intervals. In another study, Anaki et al. (1998) examined priming for laterally presented target words related to either the metaphorical weakly related (*insult*) or literal, strongly related (*mosquito*) meanings of centrally presented prime words that had both a literal and a metaphorical meaning (*stinging*). Bilateral priming of the metaphorical meanings was obtained at the short SOA (200 ms), but at a longer interval (800 ms) the metaphorical, more distantly related meanings were available only within the LVF/RH, whereas the literal, strongly related meanings were maintained only in the LH. The findings of both studies, as well as those of additional research (for review, see Chiarello, 2003), strongly suggest that the LH suspends rather rapidly processing of distantly related words, maintaining only the strongly related meanings for relatively long periods, while the RH functions to maintain a wide range of meanings for relatively long periods of time.

1.2. Hemispheric differences in true and false memories

The differences between the LH and RH in the time course of meaning activation and maintenance suggest that the hemispheres may also fundamentally diverge in their memory representations of the alternate meanings of words. However, hemispheric differences in memory tasks remain understudied, particularly in non-clinical populations (Federmeier & Benjamin, 2005). A few studies have examined hemispheric differences in semantic memory using the word-lists false memory paradigm (Fabiani, Stadler, & Wessels, 2000; Ito, 2001; Westerberg & Marsolek, 2003). This paradigm, originally developed by Deese (1959) and later revived by Roediger and McDermott (1995), is currently referred to as the DRM (Deese/Roediger–McDermott) paradigm. In a typical experiment, participants are presented with 12-word–lists of thematically related words (e.g., *blanket*, *bed*, *night*) all associated with