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Hemispheric asymmetries in discourse processing: Evidence from false memories for lists and texts

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ABSTRACT

Previous research suggests that the right hemisphere (RH) may contribute uniquely to discourse and text processing by activating and maintaining a wide range of meanings, including more distantly related 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 the hypothesis that difference between the two cerebral hemispheres in discourse processing may be due, at least partly, to memory representations for implicit text-related semantic information. Specifically, we tested the susceptibility of the left hemisphere (LH) and RH to unpresented target words following the presentation of semantically related words appearing in either word lists or short texts. Findings showed that the RH produced more false alarms than the LH for unpresented target words following either word lists or texts. These findings reveal hemispheric differences in memory for semantically related information and suggest that RH advantage in long-term maintenance of a wide range of text-related word meanings may be one aspect of its unique contribution to the construction of a discourse model. The results support the RH coarse semantic coding theory [Beeman, M. (1998). Coarse semantic coding and discourse comprehension. In M. Beeman & C. Chiarello (Eds.), *Right hemisphere language comprehension: Perspectives from cognitive neuroscience* (pp. 255–284). Mahwah, NJ: Erlbaum.] and suggest that hemispheric differences in semantic processing during language comprehension extend also to verbal memory.

Previous research suggests that, while the left cerebral hemisphere (LH) is dominant for language processing, the right hemisphere (RH) might play a unique role in the comprehension of natural language, i.e. in processing language in contexts that extend beyond the meanings of individual words or sentences such as stories, conversations, or texts (for a review, see Jung-Beeman, 2005). For example, several studies have shown that injury to the RH can disrupt discourse and narrative comprehension, i.e. the ability to understand a group of sentences that describe a sequence of events, as in a story or conversation (e.g. Brownell & Martino, 1998; Chiarello, 2003; Tompkins, Baumgaertner, Lehman & Fassbinder, 2000). Furthermore, results of behavioral split visual fields (e.g. Chiarello, 2003; Jung-Beeman, Bowden, & Gernbacher, 2000; Long & Baynes, 2002) as well as of neuroimaging studies (e.g. Ferstl, Rinck, & Von Cramon, 2005; St. George, Kutas, Martinez, & Sereno, 1999; for reviews, see Demonet, Thierry, & Cardebat, 2005; Xu, Kemeny, Park, Frattali, & Braun, 2005) that examined hemispheric differences in the intact brain also indicate that the RH is involved in discourse processing. For example, Xu et al. (2005) reported that, when the brain's responses to random words, unconnected sentences, and narratives were compared, the RH was increasingly active as contextual complexity increased and was maximal at the narrative level. Furthermore, whereas LH activity was more prominent at the onset of the story, the RH was more activated when the story unfolded and when a coherent representation of it was built. The authors concluded that RH activation during discourse processing reflects an attempt to construct a unitary coherent model of discourse. It should be noted, however, that several studies did not find unique RH involvement in discourse comprehension (e.g. Ferstl & von Cramon, 2001; Zaidel, Kasher, Soroker, & Baroti, 2002; for a review, see Prat, Long, & Baynes, 2007).

Although previous research shows some variability in RH involvement in text and discourse comprehension, overall, the findings seem to suggest that the RH contributes to discourse-level language processing. The goal of the present study was to test a potential explanation for the putative role played by RH during discourse comprehension. According to this explanation,

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in order to achieve coherence and to make inferences, discourse comprehension necessarily involves the retrieval of background information, including relevant world knowledge (e.g. Ferstl et al., 2005). The unique ability of the RH to maintain and retrieve a wide range of semantic information (e.g. Beeman, 1998; Jung-Beeman, 2005) may be one aspect of this hemisphere's contribution to the integrative processes needed to achieve global coherence during discourse processing. Thus, a wide range of text-related meanings may be activated and maintained in the RH even if they do not appear in the text. These additional meanings may be integrated with explicit text information (Faust, Barak, & Chiarello, 2006). Moreover, since the processing of discourse may require the maintenance of widespread semantic activation for an extended period of time, the RH advantage in semantic processing that arises mainly when people process complex language input (e.g. Burgess and Simpson, 1988; Chiarello, 1991; 2003; Faust & Lavidor, 2003; Faust et al., 2006), may reflect hemispheric differences in verbal memory (e.g. Ito, 2001).

Although hemispheric differences in basic memory tasks remain relatively unstudied, several previous studies have recently used the word-lists false memory paradigm to explore hemispheric differences in the range of activation and maintenance of lexical semantic associations (e.g. Bellamy & Shillcock, 2007; Ito, 2001; Westerberg & Marsolek, 2003). The word-lists paradigm involves the presentation of word lists followed by the presentation of semantically related, unstudied target words (e.g. Howe, 2006; Roediger & McDermott, 1995). Participants typically demonstrate a surprisingly high rate of false recall and false recognition for the semantically related unstudied target words, reflecting the sustained activation of these words in memory. The present study used this paradigm to further understand the underlying RH mechanisms involved in discourse processing. Specifically, it investigated the susceptibility of the LH and RH to unstudied semantically related words following the presentation of either word lists or short texts that contained the same words. The unstudied target words were semantically related to the relevant general world knowledge and thus represented implicit background information needed for text comprehension. Hence, higher rates of false memories for text-related unpresented target words in the RH would suggest that this hemisphere's contribution to discourse and text comprehension may stem, at least partly, from the ability to maintain a wide range of text-related, including implicit information for relatively long periods of time.

As mentioned above, the findings of several studies indicate that the RH is involved, at least to some extent, in the construction of a discourse model that represents the context or situation to which the context refers (e.g. Faust et al., 2006; Kintsch, 1998; Long & Baynes, 2002; Long, Baynes, & Prat, 2003, 2005). Long and colleagues investigated how the propositional representation and the discourse model are distributed across the two hemispheres in a series of studies using a lateralized item-priming-in-recognition paradigm (Long & Baynes, 2002; Long et al., 2003, 2005). The general picture emerging from their findings was that whereas the LH is more sensitive to propositional relations, the RH is relatively more involved in the processing of textual information based on discourse model relations. Since the construction of discourse model during text comprehension seems to depend, at least partly, on the ability to retrieve stored information, the contribution of the RH to the processing of discourse may also involve memory for a wide range of semantically related, both presented and unpresented information.

The ability to maintain activation of widespread related meanings for an extended period of time during text comprehension may involve the activation and maintenance of a wide range of word meanings, both strongly and weakly related, including information that is not explicitly mentioned. The RH role in processing global and discourse semantics may thus be one aspect of the unique coarse lexical semantic coding of the RH. 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 (Beeman, 1998; Beeman et al., 1994; Jung-Beeman, 2005). According to the FCT, immediately after encountering a word, the LH engages in relatively fine semantic coding, strongly focusing on a few 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. Although LH fine semantic coding is involved in most language comprehension tasks, RH coarse semantic coding may have significant advantages for discourse and text comprehension that may reflect this hemisphere's unique ability to maintain for relatively long periods a broader set of script-related semantic associations (Faust et al., 2006; Jung-Beeman, 2005). The findings of several fMRI studies also seem to support the idea that RH activates and maintains a wide range of text-related associations and that this information may be used to achieve global coherence during text processing (Ferstl et al., 2005; St. George et al., 1999).

When considering the relevance of RH coarse semantic coding to discourse and text comprehension, it should be emphasized that the semantic field activated in each hemisphere is differentially modulated not only by context, but also by time course (Jung-Beeman, 2005). Previous findings indicate that the RH activates weakly related semantic information more slowly and maintains it longer than the LH, making a wide range of word meanings available for longer time periods (e.g. Anaki, Faust, & Kravetz, 1998; Burgess & Simpson, 1988; Faust & Kahana, 2002). Such findings suggest that the two hemispheres may also differ in semantic memory. Thus, as a result of the different time course of meaning availability, semantic information that has been already suppressed in the LH might still be activated in the RH (for a review, see Chiarello, 2003). Furthermore, a recent study (Faust et al., 2006) combined priming by short texts containing two different world knowledge domains, presented in the form of two different script contexts appearing sequentially with laterally presented script-related target words. The findings supported the claim that the broad and long-lasting script priming effects shown in the RH could be crucial in order to achieve global coherence during text processing. Specifically, these findings showed RH advantage in sustaining for relatively long periods simultaneous activation of word meanings related to two different scripts appearing sequentially in a coherent narrative text. Those words were not explicitly mentioned in the text, but, nevertheless, were semantically related to the general situation or theme described in the preceding texts.

The differences between the LH and the RH in the time course of meaning activation and maintenance suggest that the hemispheres may also fundamentally diverge in their memory representations of language that extend beyond single words and sentences. However, as mentioned above, hemispheric differences in basic memory tasks remain understudied, particularly in non-clinical populations (Federmeier & Benjamin, 2005). An experimental paradigm that has been used to examine hemispheric differences in semantic memory is the word-list false memory paradigm (Bellamy & Shillcock, 2007; 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 related to one non-presented critical lure (*SLEEP*). Subsequently, participants demonstrate a surprisingly high rate of false recall and