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Understanding metaphors: Is the right hemisphere uniquely involved? ☆

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Abstract

Two divided visual field priming experiments examined cerebral asymmetries for understanding metaphors varying in sentence constraint. Experiment 1 investigated ambiguous words (e.g., SWEET and BRIGHT) with literal and metaphoric meanings in ambiguous and unambiguous sentence contexts, while Experiment 2 involved standard metaphors (e.g., *The drink you gave me was a meteor*) with sententially consistent and inconsistent targets (i.e., POTENT vs COMET). Similar literal and metaphor priming effects were found in both visual fields across most experimental conditions. However, RH processes also maintained activation of sententially inconsistent literal meanings following metaphoric expressions. These results do not strongly support the RH as the preferred substrate for metaphor comprehension (e.g., Anaki, Faust, & Kravetz, 1998; Bottini et al., 1994), and suggest that processes in both hemispheres can support metaphor comprehension, although not via identical mechanisms. The LH may utilize sentence constraint to select and integrate only contextually relevant literal and metaphoric meanings, whereas the RH may be less sensitive to sentence context and can maintain the activation of some alternative interpretations. This may be potentially useful in situations where an initial understanding must be revised.
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1. Introduction

A fundamental pursuit in cognitive science is the quest to get to the meaning of "meaning" by understanding language comprehension (i.e., how concepts are represented in our semantic memory, and how these representations are activated and retrieved when reading text or listening to discourse). Many valuable contributions to this quest have come from studies aimed toward understanding the neuropsychological basis of language processing (e.g., Burgess & Simpson, 1988; Caramazza & Hillis, 1990; Faust & Kravetz, 1998; Kutas & Hillyard, 1984; Zaidel, 1978). Although neuropsychological investigations use a variety of methods (e.g., visual half-field studies, neuroimaging and electrophysiological techniques, studying split-brain patients and other brain-injured populations), they generally aim to understand language processes in terms of the brain systems subserving those processes.

Divided visual field (DVF) research has been particularly useful for understanding language comprehension in terms of the functioning of the cerebral hemispheres. This research (see Beeman & Chiarello, 1998, for a review) has shown that although there is generally an overall advantage

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for linguistic stimuli presented to the RVF/LH, the RH is able to process and understand language to a certain extent. Moreover, it does so in a manner that is complementary, but qualitatively different to the LH. Processing in the LH tends to be fast, deep, and narrowly focused, whereas RH processes tend to be slower and broader in scope, such that several alternate meanings may remain active over longer durations (Atchley, Burgess, & Keeney, 1999; Burgess & Simpson, 1988; Chiarello, 2003). LH processing also appears more suited for comprehending sentences because it uses grammatical information and sentence constraint to integrate sentence meaning, while RH processes are less sensitive to syntactic structure, relying mainly on word-level semantic relations (Faust, 1998; Faust & Chiarello, 1998a, 1998b).

Most DVF investigations have focused on literal language, but the most intriguing challenge for theories of natural language comprehension involves the use of figurative expressions. In figurative language the intended meaning differs from the meaning of what is literally expressed, such that the concept of "meaning" itself is extended to its limits (Geiger & Ward, 1999; Hoffman, 1984). Several researchers (e.g., Bottini et al., 1994; Hoffman, 1984; Ortony, 1993) have noted that the use of figurative language is not restricted to poetic or literary devices, but occurs very frequently and is pervasive to all human communication and cognition. It has been estimated that figures of speech occur at the rate of about 4 per minute of speech (Abkarian, Jones, & West, 1992). Therefore, to be complete, neurocognitive theories must account for figurative aspects of language such as understanding metaphors.

Although the LH is generally considered the dominant neural substrate for linguistic processing, RH processes may be preferentially involved in the comprehension of metaphors and other figurative forms (e.g., Anaki et al., 1998; Bottini et al., 1994; Burgess & Chiarello, 1996; Sabbagh, 1999). This conclusion, however, is primarily based on research conducted with brain-injured individuals (e.g., Brownell, Potter, Bihrle, & Gardner, 1984, 1990; Kempler, Van Lancker, Marchman, & Bates, 1999; McIntyre, Pritchard, & Lombroso, 1976). It is thus unclear to what extent these results can be used to make inferences about the nature of processing in the "normal" (non-injured) RH and LH. Although some studies of normal participants support the RH as more involved in metaphor comprehension (e.g., Anaki et al., 1998; Bottini et al., 1994; Mashal, Faust, & Hendler, in press), results from other investigations are either equivocal (Faust & Weisper, 2000) or fail to show preferential RH metaphor processing (Coulson & Van Petten, 2000; Lee & Dapretto, 2003; Rapp, Leube, Erb, Grodd, & Kircher, 2004). Moreover, the evidence from several recent studies of brain-lesioned participants has either only weakly supported (e.g., Gagnon, Goulet, Giroux, & Joanette, 2003), or failed to support the RH metaphor hypothesis (e.g., Giora, Zaidel, Soroker, Batori, & Kasher, 2000; Tompkins, 1990). A summary of this research is presented in Table 1, which also illustrates the considerable variability in the materials and procedures used in prior studies. It is thus difficult to draw firm empirical conclusions about each hemisphere's ability to understand metaphoric language.

There are several theoretical reasons why RH processes may be better suited than LH processes for comprehending figurative language. Some researchers have proposed greater RH involvement in the various higher-level, top-down, and more complex sentence integration processes assumed to occur during metaphor comprehension (Bottini et al., 1994; Burgess & Chiarello, 1996; Martin & McDonald, 2003; Sabbagh, 1999). Examples of these processes include generating inferences (Bottini et al., 1994; Coulson & Matlock, 2001; Hoffman, 1984), analogical reasoning (Gentner, 1989; Gentner, Bowdle, Wolff, & Boronat, 2001), conceptual blending, mapping, and elaboration (Coulson & Van Petten, 2002; Gentner & Wolff, 2000; Kintsch, 2000), and social aspects of communication such as pragmatics (Sabbagh, 1999; Sadock, 1993). Considerable research has shown that the RH does indeed seem to be preferentially involved in such high-level processing (e.g., Happe, Brownell, & Winner, 1999; Luo et al., 2003; Mason & Just, 2004; Robertson et al., 2000; Sabbagh, Moulson, & Harkness, 2004).

In contrast, other accounts have focused on more basic bottom-up semantic activation processes (e.g., Anaki et al., 1998; Beeman, 1998; Burgess & Chiarello, 1996), with the RH claimed to activate a broad range of meaning including distantly related concepts and peripheral features, and to simultaneously maintain the activation of multiple meanings, even if they are inconsistent with a given context. LH processes, on the other hand, may only select and maintain the activation of the most closely related concepts and central aspects of meaning. Such proposals are based on demonstrations that contextually inconsistent or grammatically incongruous words are often primed in the RH but not in the LH (Arambel & Chiarello, 2006; Faust & Chiarello, 1998a), that only dominant and strongly associated meanings tend to be maintained in the LH (e.g., Anaki et al., 1998; Burgess & Simpson, 1988; Nakagawa, 1991), whereas both dominant and subordinate meanings (e.g., Atchley et al., 1999; Burgess & Simpson, 1988), non-associated category members (Collins, 1999; Koivisto, 1997), and metaphoric meanings (Anaki et al., 1998) all show RH activation, particularly at long SOAs.

These claims can be incorporated into Beeman's Fine-Coarse Coding theory (Beeman, 1993, 1998; Beeman et al., 1994), which postulates that RH functioning is such that it weakly activates "broad semantic fields," whereas the LH "finely codes" information, activating small semantic fields consisting of only the closest and most central aspects of meaning. The broader RH activation of semantic representations is assumed to result in the overlap of some semantic fields, allowing relations between those concepts to emerge, and result in the activation of concepts that "inferentially connect those distantly related words" (Beeman & Chiarello, 1998, p. 261). Understanding metaphors is assumed to

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