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Research Report

A special role for the right hemisphere in metaphor comprehension? ERP evidence from hemifield presentation

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ABSTRACT

It has been suggested that the right hemisphere (RH) has a privileged role in the processing of figurative language, including metaphors, idioms, and verbal humor. Previous experiments using hemifield visual presentation combined with human electrophysiology support the idea that the RH plays a special role in joke comprehension. The current study examines metaphoric language. Event-related potentials (ERPs) were recorded as healthy adults read English sentences that ended predictably (High-cloze Literals), or with a plausible but unexpected word (Low-cloze Literals and Low-cloze Metaphoricals). Sentence final words were presented in either the left or the right visual hemifield. Relative to High-cloze Literals, Low-cloze Literals elicited a larger N400 component after presentation to both the left and the right hemifield. Low-cloze Literals also elicited a larger frontal positivity following the N400, but only with presentation to the right hemifield (left hemisphere). These data suggest both cerebral hemispheres can benefit from supportive sentence context, but may suggest an important role for anterior regions of the left hemisphere in the selection of semantic information in the face of competing alternatives. Relative to Low-cloze Literals, Low-cloze Metaphoricals elicited more negative ERPs during the timeframe of the N400 and afterwards. However, ERP metaphoricity effects were very similar across hemifields, suggesting that the integration of metaphoric meanings was similarly taxing for the two hemispheres, contrary to the predictions of the right hemisphere theory of metaphor.

1. Introduction

Metaphoric language involves reference to one domain, known as the *target* or *tenor*, with vocabulary commonly used to refer to another domain, known as the *source* or *vehicle* (Coulson and Oakley, 2005). For example, "winter" in the opening lines of Shakespeare's Richard III ("Now is the winter of our discontent") is used to evoke the concept of finality. Understanding this metaphor involves recruitment of an analogy between the source domain of the seasons of the year and the target domain of a period of discontent in Richard's life. In this analogy, spring maps onto a beginning, and winter maps onto an ending. Thus if Richard is in the winter of his discontent, bad times are soon to be a thing of the

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past. The underlying processes of metaphor comprehension are relevant for an understanding of the neural basis of verbal creativity.

Although metaphor is most obvious in literary venues, linguists have also shown that it is pervasive in everyday language. Average speakers use metaphors to talk about a wide range of subjects, including emotions such as anger and love, abstract concepts such as time and progress, and taboo topics such as sex and death (Lakoff and Johnson, 1980; Turner, 1987). Metaphor is a basic means of extending existing word meanings, and is a major factor affecting the way that languages change over time (Sweetser, 1990). For example, since the late 1990s the word "spider" is used to refer to a computer program (also known as a "webcrawler") that searches the web for new sites and links them to search engines. Over time, metaphoric uses can become so entrenched that speakers no longer recognize them as metaphoric (e.g. "leg" in "table leg"). One study of the frequency of metaphor in spoken language found that, on average, speakers utter 4.08 of these "frozen" metaphors, and 1.80 novel metaphors per minute of discourse (Pollio et al., 1977).

1.1. *Right hemisphere metaphor theory*

Most neuropsychologists consider metaphor comprehension to be somewhat distinct from other language abilities and, consequently, have hypothesized that it recruits distinct brain regions, stressing an important role for the right hemisphere (RH). For example, metaphor comprehension dissociates from other language skills in patient populations such as schizophrenia, Asperger's syndrome, and Alzheimer's disease, consistent with its characterization as an "extra-linguistic" skill (DeBonis et al., 1997; Dennis et al., 2001; Papagno, 2001; Rapp et al., 2004). In keeping with the idea that the RH plays an important role in this process, these cases of impaired metaphor comprehension have been linked to irregular lateralization patterns often observed with pathologies such as schizophrenia.

More important for the motivation of the right hemisphere metaphor theory are a number of patient studies which suggest that focal lesions in the left and right hemisphere have different effects on a patient's ability to comprehend metaphorical language. Some left hemisphere-damaged (LHD) patients have shown preserved appreciation for metaphoric meanings of adjectives (e.g. cold), while right hemisphere-damaged (RHD) patients preferred the literal meanings for the same terms (Brownell, 1984, 1988). Unlike their LHD aphasic counterparts, basic language production and comprehension skills are intact in most RHD patients, yet their interpretation of idioms is often characterized as being overly literal (Van Lancker and Kempler, 1987; Winner and Gardner, 1977).

The contrast between the detrimental impact of LHD on core language skills such as naming, word-finding, parsing, and sentence comprehension, and the relatively subtle communicative deficits experienced by patients with RHD has led to the suggestion that the left hemisphere mediates basic language skills, while the right hemisphere is implicated in *pragmatics*, or aspects of meaning that depend on an understanding of the physical, social, or cultural context of an utterance. Indeed, RHD patients have been shown to exhibit deficits in a variety of pragmatic abilities, including joke comprehension (Bihrle et al., 1986; Brownell et al., 1983; Shammi and Stuss, 1999), the production and interpretation of indirect requests (Brownell and Stringfellow, 1999; Foldi, 1987; Stemmer et al., 1994), and the recognition of sarcastic utterances (Kaplan et al., 1990).

The right hemisphere theory of metaphor comprehension is appealing because of the way that it fits into this larger picture of the division of labor in the brain, with the LH specializing in strictly linguistic aspects of meaning, while the RH is assigned to non-literal meaning that presumably includes metaphor. The importance of the RH has been bolstered by an influential positron emission tomography (PET) study that revealed increased RH blood flow in prefrontal cortex, the middle temporal gyrus, the precuneus, and the posterior cingulate in the comprehension of metaphoric sentences relative to literal sentences with the same structure (Bottini et al., 1994). We describe the hemodynamic literature on metaphor comprehension more extensively in Discussion.

1.2. *Hemifield priming and hemispheric differences in semantic activation*

A technique that has been used to investigate the role of the right hemisphere in neurologically intact individuals is the visual hemifield priming paradigm. By presenting stimuli outside the fovea, it is possible to selectively stimulate visual cortex in the left or right hemisphere. In normal individuals the information is rapidly transmitted to other brain regions, including those in the other hemisphere. Nonetheless, differences in the initial stages of processing can indicate hemisphere-specific computations (Banich, 2002; Chiarello, 1991). Although lexical decision latencies are typically shorter when stimuli are presented to the right visual field (RVF/LH), priming effects, that is, greater accuracy rates and shorter response times for words preceded by related compared to unrelated material, are sometimes greater with presentation to the left visual field (LVF/RH) (Chiarello, 1988).

The hemifield priming literature points to hemispheric differences in the specificity of semantic activations, in that those in the right hemisphere are less specific than those in the left. For example, in a task of generating a semantic associate for a laterally presented word, Rodel and colleagues observed closely related responses for LVF cues, but more distant associates (according to normative association data from central presentation) after RVF cues (Rodel et al., 1989). In word-pair priming studies, most investigators using hemifield presentation report equivalent priming for strongly associated word pairs ("dog–cat") with LVF and RVF presentation, but greater priming effects with presentation to the LVF (RH) for nonassociated category members ("dog–goat") (Chiarello et al., 1990). When ambiguous words serve as the primes, only LVF (RH) presentation yields priming effects for the subordinate and contextually irrelevant senses of ambiguous words, especially when relatively long stimulus onset asynchronies (greater than 200 ms) are obtained between the prime and the target (Burgess and Simpson, 1988; Faust and Chiarello, 1998; Titone, 1998). Finally, people benefit more from so-called summation primes (three words weakly related to a target) when naming target words presented to the LVF (RH) than the RVF (LH) (Beeman et al., 1994).