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Hemispheric sensitivities to lexical and contextual information: Evidence from lexical ambiguity resolution

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Abstract

The present study examined the manner in which both hemispheres utilize prior semantic context and relative meaning frequency during the processing of homographs. Participants read sentences biased toward the dominant or the subordinate meaning of their final homograph, or unbiased neutral sentences, and performed a lexical decision task on lateralized targets presented 250 ms after the onset of the sentence-final ambiguous prime. Targets were either related to the dominant or the subordinate meaning of the preceding homograph, or unrelated to it. Performance asymmetry was found in the absence of a biasing context: dominant-related targets were exclusively facilitated in the RVF/LH, whereas both dominant- and subordinate-related targets were facilitated in the LVF/RH. Performance symmetry was found in the presence of a biasing context: dominant-related targets were exclusively activated in dominant-biasing contexts, whereas both dominant- and subordinate-related targets were facilitated in subordinate-biasing contexts. The implications of the results for both general and hemispheric models of word processing are discussed.

Keywords: Cerebral hemispheres; Lexical ambiguity; Word frequency; Sentence context; Priming; Visual field

1. Introduction

Understanding written words during sentence comprehension requires readers to rapidly access and integrate different sources of information from long-term memory, including lexical knowledge related to the word itself and contextual knowledge related to the sentential context in which the word is embedded. This process is complicated by the fact that many words have more then one distinct meaning and thus part of the comprehension process entails a selection of one of those meanings. Ample evidence from behavioral research (e.g., Duffy, Morris, & Rayner, 1988; Peleg, Giora, & Fein, 2001; Peleg, Giora, & Fein, 2004; Titone, 1998) indicates that this selection process is governed by lexical factors (for example, relative meaning frequency), and by contextual factors (for example, prior semantic information). However, despite decades of intensive research, effects on ambiguity resolution are still controversial and not fully fleshed out (for an overview, see Simpson, 1984; Simpson, 1994; Small, Cottrell, & Tanenhaus, 1988).

On the one hand, two-stage models argue that all meanings of an ambiguous word are initially activated regardless of either frequency or contextual bias. According to this view, contextually inappropriate meanings are discarded only at a later, post-lexical, selection stage (Onifer & Swinney, 1981; Swinney, 1979). On the other hand, direct-access models suggest that a strong biasing context can selectively activate the contextually appropriate meaning of an ambiguous word, regardless of relative meaning frequency (e.g., Martin, Vu, Kellas, & Metcalf, 1999; Vu, Kellas, & Paul, 1998). Between these two extremes, hybrid models such as "The Reordered Model" (Duffy et al., 1988) or "The Graded Salience Hypothesis" (Giora, 1997; Giora, 1999; Giora, 2003; Peleg et al., 2001, 2004) suggest that both contextual and lexical factors influence meaning activation immediately and independently of each other. According

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to these models, context can facilitate the activation of a contextually appropriate meaning, but it cannot inhibit dominant or salient inappropriate meanings. Thus, when context is biased toward the less salient, subordinate meaning of an ambiguous word, both meanings (the contextually appropriate subordinate meaning and the contextually inappropriate dominant meaning) are initially activated.

Importantly, recent neuropsychological studies have shown that lexical processing in general and ambiguity resolution in particular, require the intact functioning of *both* cerebral hemispheres (e.g., Grindrod & Baum, 2003). Moreover, converging data from split-brain (e.g., Iacoboni & Zaidel, 1996; Zaidel, 1987; Zaidel, 1990; Zaidel, 1998), focal lesion studies (e.g., Copland, Chenery, & Murdoch, 2002; Swaab, Brown, & Hagoort, 1998; Tompkins & Lehman, 1998), and neurologically intact subjects (e.g., Beeman & Chiarello, 1998; Beeman et al., 1994; Chiarello, 1988; Chiarello, 1998; Federmeier & Kutas, 1999) demonstrate that whereas both hemispheres participate in word processing, they do so in qualitatively different ways. Specifically, several studies have shown that the two hemispheres differ in the way in which lexical and contextual sources of information are applied to the processing of words (e.g., Burgess & Simpson, 1988; Coney & Evans, 2000; Faust & Chiarello, 1998; Faust & Gernsbacher, 1996; Titone, 1998). Thus, models of ambiguity resolution should be refined and extended so as to include these differential contributions of the two hemispheres.

A widespread experimental method for assessing hemispheric contributions to language comprehension in general and ambiguity resolution in particular is the divided visual-field (DVF) priming paradigm: this technique takes advantage of the fact that stimuli presented in the left side of the visual field are initially processed exclusively by the right hemisphere and vice versa. Although information presented in this manner can be later transmitted to both hemisphere, the interpretation of DVF paradigms rests on the assumption that responses to stimuli presented briefly to one visual field reflect mainly the processing of that stimulus by the contralateral hemisphere, so that responses to targets in the right visual field (RVF) reflect left hemisphere (LH) processes and responses to targets in the left visual field (LVF) reflect processes in the right hemisphere (RH) (for theoretical and electrophysiological support for this assumption, see Banich, 2003; Berardi & Fiorentini, 1997; Coulson, Federmeier, Van Petten, & Kutas, 2005).

Research using the DVF priming technique, has led to the conclusion that the hemispheres differ significantly in the way they deal with lexical factors such as relative meaning salience or frequency. Beeman (1993, 1998) proposed that during word processing, a different range of meanings or semantic associates is activated in each hemisphere: narrow, focused meanings are activated in the LH, while weak and diffuse activation occurs in the RH. This proposal, known as the ''Fine/Coarse Coding Model'', is based on evidence from studies showing that semantic priming effects of remotely related words are obtained in the RH but not in the LH (e.g., Beeman et al., 1994; Chiarello, Burgess, Richards, & Pollock, 1990). For example, in a study conducted by Beeman et al. (1994), two types of semantic priming were used: a prime word (*scissors*) closely related to the target (*cut*) and summation priming from three words (*cry–foot–glass*), each distantly related to the same target (*cut*). The results indicated that the direct primes were more effective for RVF/LH targets, while the summation primes were more effective for LVF/RH targets. The authors concluded that the LH strongly activates a small number of semantic fields of closely related meanings, whereas the RH weakly activates large loosely related semantic fields that also include distantly associated meanings.

Similarly, ambiguity resolution studies using the DVF paradigm, have shown that less salient, subordinate or figurative meanings are more likely to be maintained in the RH (e.g., Anaki, Faust, & Kravetz, 1998; Burgess & Simpson, 1988). For example, in a seminal study by Burgess and Simpson (1988), subjects read ambiguous word primes (e.g., *bank*) and performed lexical decision on target words that were either related to the dominant meaning (*money*) or the subordinate, less frequent meaning (*river*). The ambiguous primes were presented in central vision, followed by a target word projected to the left (LVF/RH) or right (RVF/LH) visual fields. Targets were presented either 35 or 750 ms after the onset of the prime (SOA). Results indicate that at the short delay, the LH activated immediately and exhaustively all of the meanings (both dominant and subordinate) of a semantically ambiguous word. However in longer SOAs (750 ms), only the dominant meaning was actively maintained. In contrast, the RH has access only to the more frequent interpretation in the immediate condition, and ''exhaustive'' availability of both meanings at the longer temporal delay. On the basis of these results, Burgess and Simpson suggested that the LH accesses all of the meanings of an ambiguous word very quickly and then suppresses the less frequent meaning. The RH, on the other hand, activates both meanings more slowly and maintains these meanings.

It is thus generally agreed that relative meaning frequency has differential implications for word processing in the hemispheres: the LH quickly focuses on a single dominant interpretation, whereas the RH activates and maintains a wider range of interpretations including distantly related, subordinate, figurative or nonconventional meanings (e.g., Anaki et al., 1998; Beeman et al., 1994; Chiarello et al., 1990). Indeed, consistent with this proposal, neurological studies have shown that subordinate, less salient, figurative, or connotative meanings are much less accessible when the RH is dysfunctional (e.g., Brownell, Simpson, Birhle, Potter, & Gardner, 1990; Schmitzer, Strauss, & DeMarco, 1997; Stemmer, Giroux, & Joanette, 1994; Weylman, Brownell, Roman, & Gardner, 1989).