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Evidence for dissociable neural mechanisms underlying inference generation in familiar and less-familiar scenarios ☆

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Abstract

In this study, we investigated whether the left and right hemispheres are differentially involved in causal inference generation. Participants read short inference-promoting texts that described either familiar or less-familiar scenarios. After each text, they performed a lexical decision on a letter string (which sometimes constituted an inference-related word) presented directly to the left or right hemisphere. Response-time results indicated that hemisphere of direct presentation interacted with type of inference scenario. When test stimuli were presented directly to the left hemisphere, lexical decisions were facilitated following familiar but not following less-familiar inference scenarios, whereas when test stimuli were presented directly to the right hemisphere, facilitation was observed in both familiar and less-familiar conditions. Thus, inferences may be generated in different ways depending on which of two dissociable neural subsystems underlies the activation of background information.

Keywords: Inferences; Familiarity; Hemisphere asymmetries; Text comprehension; Background knowledge; Semantic associations

1. Introduction

Inferences we generate during reading are influenced by our familiarity, i.e., background knowledge, with the topics described in the text. However, little is known about the number or neural implementation of inference-generation processes. In the research presented here, we investigated the extent to which inference-generation processes differ depending on the amount of background knowledge the reader has of the scenario depicted in the text and, in particular, whether the left and right hemispheres may be differentially involved in inference generation for familiar and less-familiar scenarios.

A major initial component of inference generation is the activation of information during comprehension that is not explicitly described in the text. To maintain coherence during comprehension, a reader must be able to connect incoming information in the text with information currently active in working memory (Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983). If the immediately preceding text or information in working memory does not provide a causal explanation for the current event, the comprehender will activate inference concepts based on background knowledge that successfully bridge the coherence gap (Fletcher & Bloom, 1988; Graesser, Bertus, & Magliano, 1995; Graesser, Haberlandt, & Koizumi, 1987; McKoon & Ratcliff, 1986, 1989; Meyers, Shinjo, & Duffy, 1987; Potts, Keenan, &

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Golding, 1988; van den Broek, 1990, 1994; van den Broek & Lorch, 1993). For instance, after encountering the sentences, "*Laurie left early for the birthday party. She spent an hour shopping at the mall.*" readers will be compelled to explain why Laurie shopped at the mall. When a sufficient explanation for the focal event has not been explicitly provided in the text, readers often maintain coherence by constructing an inference supported by background knowledge (in the example, the inference that Laurie went to buy a birthday present).

A comprehender's familiarity with relevant background information can affect the context in which individual words and combinations of words are interpreted, thereby facilitating specific inferences. For instance, inferences about the meaning of words in ambiguous passages are influenced by a reader's familiarity with the topics in those passages. Weight lifters interpreted an ambiguous passage containing the words "held," "lock," "strong," and "break" as a wrestling match whereas musicians interpreted the passage as a prison scenario (Anderson, Reynolds, Schallert, & Goetz, 1976). Similarly, baseball experts were faster and more accurate than baseball novices in judging inferences relevant to baseball in a discourse, but not to elements that were not part of the game (Spilich, Vesonder, Chiesi, & Voss, 1979). Findings such as these indicate that individual or group differences in background knowledge help predict the inferences generated by different comprehenders.

It is unknown, however, whether such effects stem from a single, unified process or from multiple, distinct processes. In the current study, we examined whether the familiarity of a causal inference scenario (familiar vs. less-familiar) would have different effects in two hypothesized neural subsystems contributing to inference generation. One possibility is that a single neural system underlies the processes involved in generating inferences both from familiar background knowledge and also from less-familiar background knowledge (i.e., knowledge that has been less experienced by the reader). Another possibility is that inferences constructed from less-familiar inference scenarios are generated by a process that differs from another process that can generate inferences from familiar scenarios. The latter theory stems from interesting findings of hemispheric asymmetries in inference making. Both cerebral hemispheres appear to contribute to the generation of inferences, but subsystems in the left hemisphere (LH) and subsystems in the right hemisphere (RH) may contribute in different ways to different kinds of inferential processing depending on the type of background knowledge that is needed to generate a particular inference.

There is some evidence that semantic processing in the RH is either responsible for or heavily involved with the inference making process in readers (for a review see Lehman & Tompkins, 2000). For example, Beeman (1993) measured facilitation of inference-related concepts with a lexical decision task during story comprehension in patients with RH damage and control subjects. Although readers without RH damage exhibited a facilitation effect in the form of faster lexical decisions for inference-related probes than for unrelated probes, no such facilitation was observed for RH-damaged patients. This suggests that semantic activation that contributes to inference facilitation normally takes place in a RH subsystem. A similar conclusion was drawn by Beeman, Bowden, and Gernsbacher (2000). Furthermore, processing in the RH can contribute to the generation of inferences from relatively unfamiliar background knowledge. In support of this, RH-damaged patients had difficulty generating the alternate, less-preferred (i.e., less-familiar) inference from a sentence after reading a second sentence that reinforced the alternate interpretation (Brownell, Potter, Bihrle, & Gardner, 1986). Similarly, RH-damaged patients also tend to choose more literal interpretations of idiomatic expressions rather than correct metaphorical interpretations (Meyers & Linebaugh, 1981) and have difficulty understanding metaphoric meanings of ambiguous words (Brownell, Simpson, Bihrle, Potter, & Gardner, 1990). Also, at least some of the scenarios used by Beeman (1993) seem to have probed inferences generated from relatively unfamiliar background information (e.g., priming "overflow" from cleaning a mess after a bathtub faucet was left running). Therefore the effects observed by Beeman (1993) may be consistent with the notion that a RH semantic subsystem is capable of generating inferences from less-familiar knowledge.

There also is evidence that semantic processing in the LH contributes to inference generation. For example, readers with an intact LH but a damaged RH did not demonstrate an inference deficit as compared with normal controls for inferences dependent on familiar world knowledge (Purdy, Belanger, & Liles, 1992). Similarly, RH-damaged patients generated inferences as well as readers without brain damage when an ambiguous sentence elicited a dominant (i.e., familiar) inference (Brownell et al., 1986). Also, in classification experiments with a split-brain patient, the LH was less capable than the RH at deciding that previously unseen information was in fact new information if those items were in the same category as previously presented (i.e., familiar) information. One interpretation is that the LH stores less veridical memories than the RH, indicating that the LH is more effective than the RH at making generalizations and inferences (Metcalfe, Funnell, & Gazzaniga, 1995). Such findings suggest that an undamaged LH is capable of making inferences, contributing to the processing of inferences generated from familiar background knowledge. In addition, highly familiar and organized background knowledge such as