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Research Report

Hemispheric contributions to semantic activation: A divided visual field and event-related potential investigation of time-course

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ARTICLE INFO

Article history:
Accepted 23 May 2009
Available online 2 June 2009

Keywords:
Semantic priming
Event-Related potential
Hemispheric contribution
Divided visual field
Controlled processing

ABSTRACT

Hemispheric contributions to lexical-semantic processing were investigated using event-related potentials and a divided visual field semantic priming paradigm. Hemispheric activation for pairs related via semantic category membership and association (CA) or via semantic category membership only (CO) was examined over two stimulus onset asynchronies (SOAs). Experiment 1 employed a SOA of 250 ms, and Experiment 2 employed a SOA of 750 ms. Controlled semantic priming was targeted in both experiments via a high relatedness proportion. Behavioral accuracy data revealed significant bilateral priming for both CA and CO conditions at 250 ms SOA. At 750 ms SOA hemispheric differences were observed within the behavioral data, with significant priming of the CO condition and priming for the CA condition approaching significance in the left hemisphere, and significant priming of the CA condition only in the right hemisphere. At 250 ms SOA, ERP analysis revealed bilateral CA activation in the N400 and LPC time windows. The second experiment (750 ms SOA) revealed bilateral CA priming during the N400 time window, with no significant LPC effects. The CO condition did not elicit significant ERP priming within either time window at either SOA. The results indicate no hemispheric differences for the ERP measures, with bilateral hemispheric N400 priming observed for associated category members irrespective of SOA, and a bilateral LPC effect at 250 ms SOA only, under controlled semantic priming conditions.

1. Introduction

Divided visual field (DVF) semantic priming studies (e.g., Burgess and Simpson, 1988; Chiarello et al., 1990; Koivisto and Laine, 2000) and investigations of people with unilateral hemispheric lesions (e.g., Ansaldo and Arguin, 2003; Copland et al., 2002) suggest that both cerebral hemispheres participate in lexical-semantic processing. DVF priming studies enable the examination of lexical-semantic activation in the targeted hemisphere, via the manipulation of visual stimuli presentation to separate visual fields. In DVF investigations primes can be presented either laterally in a single visual field or centrally to both visual fields, while targets are presented to each hemisphere individually. Current evidence suggests that hemispheric differences in semantic processing can be found for stimuli that vary in semantic distance or strength

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doi:10.1016/j.brainres.2009.05.053

(e.g., Burgess and Simpson, 1988; Koivisto and Laine, 2000). For instance, hemispheric differences are found for priming of associated and nonassociated category member stimuli (e.g., Chiarello et al., 2003; Koivisto, 1997). However, DVF investigations continue to produce variable findings regarding the nature of each hemisphere's role in semantic processing.

One current proposal suggests that hemispheric differences primarily reflect an interaction between the strength of a semantic relationship and the time-course allowed for the activation of different processing mechanisms (e.g., Koivisto and Laine, 2000). Explanations from DVF investigations that employ central primes suggest that the LH is more sensitive than the RH to the underlying semantic strength distinction, especially under strategic processing conditions (Fassbinder and Tompkins, 2006). Despite the suggestions that different semantic processing mechanisms influence hemispheric semantic activation over time, there are few specific investigations of the time-course of strategic processing (Audet et al., 1998; Collins, 1999) (excepting some focus on right hemisphere (RH) postlexical processes (e.g., Koivisto, 1998). Given its excellent temporal resolution, event-related potential (ERP)[1] methodology, in combination with DVF semantic priming, has more recently provided an avenue for investigating the timing of semantic activation in the hemispheres (e.g., Bouaffre and Faita-Ainseba, 2007). Therefore, the current investigation aims to specifically examine the time-course of strategic lexical-semantic processing in each hemisphere, for associated and nonassociated category members, using the ERP and DVF methodologies.

1.1. *Semantic priming mechanisms*

The semantic priming effect occurs when a word is processed more quickly when it is preceded by a related word (e.g., dog–cat), than when preceded by an unrelated word (e.g., wood–cat) (Meyer and Schvaneveldt, 1971), as indexed by faster and/or more accurate word recognition. There are three mechanisms proposed to underlie different aspects of the semantic priming effect. Automatic spreading activation refers to an unconscious spread of activation from the prime word to other related items (Collins and Loftus, 1975; Neely, 1977). This activation occurs quickly and decays with time and is therefore suggested to be prominent at short stimulus onset asynchronies (SOAs) between prime and target (Collins and Loftus, 1975; Posner and Snyder, 1975) (but see Deacon et al., 1999). The pre-activation of related items results in faster subsequent processing of those related items, and therefore demonstrates a priming effect.

Expectancy-based priming is a form of controlled or strategic processing that is slow acting and involves the facilitation of expected items and the inhibition of unrelated items (Posner and Snyder, 1975). Upon seeing the prime word, the participant creates an expectancy set. Targets included in the expected set are facilitated and subsequently processed more quickly than other targets (Neely, 1991; Posner and Snyder, 1975). It takes time for expectancies to be generated, and therefore expectancy-based activation is not thought to occur at SOAs of 250 ms or less (de Groot, 1984; den Heyer et al., 1983). Other experimental findings have suggested that expectancy-based activation begins between 300 ms SOA (Hutchinson et al., 2001) and 500 ms SOA (e.g., de Groot, 1984; Neely, 1991).

The third mechanism is postlexical semantic matching. This controlled processing mechanism is suggested to occur following lexical access of both the prime and target, but before a lexical decision is made (Neely, 1991; Neely and Keefe, 1989). Postlexical semantic matching uses information about the relatedness between prime and target to shorten response time. If the prime and target are related, then the target is assumed to be a word, thereby speeding up the lexical decision (Neely and Keefe, 1989).

As suggested previously, priming mechanisms can be influenced by SOA. Automatic spreading activation is expected at short SOAs and expectancy-based activation is expected at longer SOAs (thought to start between 300 ms and 500 ms) when other conditions are neutral (Neely, 1991). Postlexical matching appears to occur with little sensitivity to SOA length (de Groot, 1984; Hill et al., 2002), and has been found to be efficient from at least 240 ms SOA (de Groot, 1984). Specific priming mechanisms can also be targeted via the manipulation of the relatedness proportion (the ratio of related target words to unrelated target words). Low relatedness proportions encourage automatic spreading activation, and high relatedness proportions target controlled processing. Postlexical matching can be specifically encouraged via a high nonword target ratio (Neely, 1991).

1.2. *Associated and nonassociated semantic relationships*

Hemispheric differences in semantic processing have been regularly observed in investigations of semantic or associative relationships. In particular, DVF semantic priming studies have found evidence of hemispheric differences for stimuli pairs that are related by (a) association and category membership (e.g., dog–cat) (Audet et al., 1998; Chiarello et al., 2003), (b) nonassociated category membership (e.g., rabbit–goat) (Abernethy and Coney, 1996; Collins, 1999; Koivisto, 1997), and (c) associated non-category membership (e.g., bee–honey) (Abernethy and Coney, 1993).

Traditional priming investigations (not DVF) that incorporate associated and/or nonassociated category members have attempted to separate the differential impact of these relationship types. Priming differences between semantic (category) and lexical associative stimuli speak to the organization and access of the semantic system during automatic spreading activation (e.g., Hines et al., 1986; Meyer and Schvaneveldt, 1976). The use of these stimuli in DVF studies enables further investigation of semantic system organization and activation via the inclusion of hemispheric factors.

The organization of semantic system activation has been described in terms of spreading activation via nodes representing words (activation spread via associative/lexical relationships) (Collins and Loftus, 1975), and the distributed network model of activation, where activation spreads via shared semantic features (e.g., Masson, 1995; McRae et al., 2005). Behavioral priming investigations suggest that both

[1] ERP is a time locked average of neuronal activity, picked up by an electroencephalogram, which is linked to an external event or stimulus.