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Common and segregated neural substrates for automatic conceptual and affective priming as revealed by event-related functional magnetic resonance imaging

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ABSTRACT

The brain activity associated with automatic semantic priming has been extensively studied. Thus far there has been no prior study that directly contrasts the neural mechanisms of semantic and affective priming. The present study employed event-related fMRI to examine the common and distinct neural bases underlying conceptual and affective priming with a lexical decision task. A special type of emotional word, a dual-meaning word containing both conceptual meaning and affective meaning, was adopted as target. Short stimulus onset asynchrony (SOA) (50 ms) was used to emphasize automatic processing. Fifteen participants were scanned in the present study. We found that the left middle/superior temporal gyrus was the brain region involved in both automatic conceptual and affective priming effects, suggesting general lexical–semantic processing that share in the two types of priming. The left inferior frontal gyrus and right superior temporal gyrus were found to be the conceptual-specific areas in automatic priming effect, consistent with the role of these areas in more extensive within-category semantic processes. The results also revealed that the left fusiform gyrus and left insula were the affective-specific regions in automatic priming effect, demonstrating the involvement of the left fusiform gyrus in automatic affective priming effect, and clarifying the role of the insula in emotional processing rather than conceptual processing. Despite comparable behavioral effects of automatic conceptual priming and affective priming, the present study revealed a neural dissociation of the two types of priming, as well as the shared neural bases.

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1. Introduction

Semantic priming is a typical paradigm used to examine mental representations of word meanings and their relationships (Meyer & Schvaneveldt, 1971). The semantic priming effect refers to the increased speed and accuracy in recognizing a target preceded by a related prime word (e.g. sheep-cow), compared to an unrelated prime (e.g. table-cow). Semantic priming is thought to reflect the operation of different cognitive processes that make differential contributions depending on experimental conditions and on the semantic relationship between prime and target. For example, when the interval between prime and target (i.e., the stimulus onset asynchrony, SOA) is short, semantic priming is usually explained by an automatic spread of activation through semantic memory (Collins & Loftus, 1975; Neely, 1991).

The brain activity associated with semantic priming has been extensively studied in normal subjects (e.g., Copland et al., 2003; Gold et al., 2006; Kotz, Cappa, von Cramon, & Friederici, 2002; Mummery, Shallice, & Price, 1999; Rissman, Eliassen, & Blumstein, 2003; Rossell, Bullmore, Williams, & David, 2001; Rossell, Price, & Nobre, 2003; Tivarus, Ibinson, Hillier, Schmalbrock, & Beversdorf, 2006; for a review, see Henson (2003)) and individuals with lesions (e.g., Copland, 2003; Kensinger, Siri, Cappa, & Corkin, 2003; McDonald et al., 2005; Milberg, Blumstein, & Dworetzky, 1987; Milberg, Blumstein, Katz, Gershberg, & Brown, 1995). A large body of literature has implicated several brain regions in semantic priming, such as the left inferolateral frontal areas (Copland et al., 2003; Rossell et al., 2003), anterior cingulate gyrus (Mummery et al., 1999; Rossell et al., 2001), middle/superior temporal cortex (Copland et al., 2003; Gold et al., 2006; Kensinger et al., 2003; Rossell et al., 2001, 2003) and parietal cortex (Rossell et al., 2003).

In addition to semantic priming, another type of priming has been reported. This is the so-called "affective priming", during which a positive or negative prime stimulus (e.g., word or picture) is typically presented for less than 200 ms and followed by a positive or negative target stimulus after a short interstimulus interval. Results show that the time needed to evaluate the target stimuli as

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either "positive" or "negative" is significantly shorter when prime and target share the same valence (i.e., positive–positive or negative–negative; this is termed "affectively congruent") as compared to trials in which prime and target are of opposite valence (i.e., positive–negative or negative–positive, or "affectively incongruent") (Hermans, De Houwer, & Eelen, 2001). Thus far the phenomenon of affective priming has been investigated in a number of behavioral studies (e.g., De Houwer, Hermans, Rothermund, & Wentura, 2002; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Hermans, De Houwer, & Eelen, 1994; Hermans et al., 2001; for a review, see Klauer & Musch, 2003) and several neuroimaging studies (e.g. Fischer et al., 2003; Luo et al., 2004; Nomura et al., 2004; Wright et al., 2001). The affective priming effect – whereby primes facilitate the semantic encoding of affectively congruent targets – has been consistently observed at short SOAs (for a review, see De Houwer et al., 2002). Neuroimaging studies have found that the primary brain regions involved in subliminal and repetition affective priming were fusiform gyrus and amygdala (e.g., Luo et al., 2004; Nomura et al., 2004; Wright et al., 2001).

A handful of behavioral priming studies have adopted a comparative approach (e.g., De Houwer et al., 2002; Klauer & Musch, 2002; Klinger, Burton, & Pitts, 2000; Storbeck & Robinson, 2004) to compare the two types of priming effect. Significant semantic and affective priming effects have often been demonstrated in the same study. Though the two types of priming have similar reflexes at a behavioral level, whether or not the same underlying mechanisms were implicated in semantic and affective priming at the neural level remains unclear. To our knowledge, no single study has simultaneously investigated the neural basis of semantic priming and affective priming explicitly. Without direct comparison within a single study, the neural mechanisms underlying the two types of priming could be obscured by various other factors. For example, the stimuli used in semantic priming studies are usually neutrally valenced, while stimuli in affective priming studies are often emotionally salient. Moreover, affective priming studies typically adopt tasks that focus on emotional dimensions such as emotional categorization (e.g., judging whether a target is positive or negative). Thus, without an explicitly comparative approach, any conclusions about the common or different neural nature of the two types of priming are potentially problematic.

The present study aims to localize the neural networks – shared and distinct – that underlie both conceptual and affective priming, by using a combined semantic and affective priming paradigm. We employed a particular type of word, which we term "dual-meaning word", was used as target. A dual-meaning word contains two relevant dimensions of information: (i) a conceptual component that reflects an object or action (its "conceptual semantics"), and (ii) a certain attitude or emotive component (its "affective semantics") (Kövecses, 2003). For example, the word '暴君' (oppressor) contains both the concept of '君主' (emperor) and the emotion of '残酷' (cruel). Dual-meaning words are particularly useful for joint examination of semantic and affective priming effects. When a dual-meaning word was primed by a semantically related word, it resulted in a semantic priming pair. Likewise, when it was primed by an affective related word, an affective priming pair was obtained. In our paradigm, we used the same dual-meaning words as the target stimuli for both semantic and affective priming conditions. Additionally, we employed the same behavioral task across both conditions. Thus, any differences between semantic priming and affective priming could be directly assessed without the possibility of being confounded by different targets or tasks across conditions.

Note that affective priming is more of an automatic process (De Houwer et al., 2002; Hermans et al., 1994, 2001; Murphy & Zajone, 1993), and that reliable affective priming effects were only obtained with shorter SOAs (De Houwer et al., 2002; Fazio et al., 1986; Hermans et al., 1994, 2001; for a review, see Klauer & Musch, 2003). Because of these facts, the present study used a short SOA to ensure that affective priming effects would be reliably elicited.

In the priming literature, the lexical decision task (LDT) has been widely used (e.g., Copland et al., 2003; Gold et al., 2006; Kotz et al., 2002; Mummery et al., 1999; Rissman et al., 2003; Rossell et al., 2001, 2003). In this task, participants must decide whether the target item is a real word or not. Due to the lack of a specific task demand (e.g., to evaluate or categorize the target), the LDT does not explicitly favor either semantic or affective priming from a response competition perspective (De Houwer, 2003). Because of this, the LDT should be an appropriate task for measuring spreading activation related to semantic and affective factors (Neely, 1991; Storbeck & Robinson, 2004). Moreover, a rapid presentation event-related fMRI design (Dale & Buckner, 1997) was used, which has the advantage of being highly resistant to the subject's response habituation, expectation and strategy compared with blocked and fixed interval event-related fMRI designs, and at the same time it is able to distinguish blood oxygenation level-dependent (BOLD) responses despite signal overlaps (see also Luo et al., 2004).

The goal of this study was to explore the common and distinct neural networks underlying automatic semantic and affective priming. Towards this end, a special type of emotional word, dual-meaning words, were used as target stimuli, and a lexical decision task was adopted. In doing so, the two types of priming could be investigated simultaneously, and compared directly. Based on previous literature, we expected to examine common and specific activities for conceptual and affective priming in the inferior frontal gyrus (IFG), middle temporal gyrus (MTG), superior temporal gyrus (STG), fusiform gyrus (FG), and amygdala. We also wished to examine whether the insula would index semantic or affective priming, in order to gain insight on the debate on the role of the insula in semantic vs. affective processing. Some researchers have argued that the insula is a purely linguistic area used in conceptual processing (e.g., Rossell et al., 2001; Rumsey et al., 1997), while others have suggested that the insula is an area that is responsible for verbal motivation and verbal affect (e.g., Ardila, 1999; Ardila, Benson, & Flynn, 1997). By improving on the research design, we aimed to provide clearer evidence regarding the degree to which the neural networks involved in semantic and effective priming effects are shared, and the degree to which they are distinct.

2. Methods

2.1. Participants

Fifteen native Chinese speakers, eight males and seven females, aged from 18 to 25 years, participated in the experiment. They were all right-handed with normal or corrected to normal vision. None had any history of neurological or psychiatric disorders. They all gave informed consent before the experiment.

2.2. Design

The study used a typical priming paradigm while adopting a rapid presentation event-related fMRI design (see Fig. 1). The target word was either a dual-meaning word or a non-word. Dual-meaning words were preceded by a prime word that was either related or unrelated with either the target's conceptual or affective meaning. Note that the prime word was not a dual-meaning word, and was either neutrally or negatively valenced. The non-word was also preceded by a prime word. The prime was presented for 50 ms, the offset of which was followed by a target for 1150 ms.

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