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Neural activities for negative priming with affective stimuli: An fMRI study

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Abstract

Negative priming refers to the slowing down in reaction time to a stimulus that is either the same as, or related to, a distracting stimulus that has been ignored by people in an immediately preceding trial. It can be used as an index to examine the extent to which people are able to disengage attention or even ignore a distracting stimulus. In this fMRI study, with healthy Mandarin-speaking Chinese participants, we replicated the basic negative priming effect with affectively neutral words. Negative priming was associated with increased activities in the anterior cingulate cortex and the insula, a result that supports the inhibition account of negative priming. We observed that the negative priming effect was attenuated by negative affective words, relative to neutral words, suggesting that subjects' inhibition of negative information was compromised. Such attenuation of negative priming by negative affective words was associated with increased activities in the ventrolateral and medial frontal regions, the hippocampus, and supplementary motor areas. These observations indicate that specific frontal and subcortical regions take part in attention orientation toward negative-affect information.

Keywords: Negative priming; Attention; Ventrolateral frontal region; Medical frontal region; fMRI

Negative priming refers to the slowing down in reaction time to a stimulus that is either the same as, or related to, a distracting stimulus that has been ignored by people in an immediately preceding trial [12,21,31]. It reflects the extent to which people are able to disengage attention from, or ignore, the distracting stimulus. In a pilot study using a negative priming paradigm, we observed that people's reaction time toward negative words that had been previously ignored was speeded up, rather than slowed down as in the case of neutral words [18]. Such attenuation of the negative priming effect on negative words seems to be consistent with the observation that people have difficulty ignoring negative information, or that they tend to pay more attention to negative information, including faces, scenes, and words, than to neutral information [14,15,27,34].

Brain imaging studies have tried to identify the neural correlates of the negative priming effect with affectively neutral stimuli [8,10,16,37]. However, it is still unclear if the negative priming effect involved inhibition of the internal representation of previously ignored information [31,32] so that regions associated with conflicts between previous inhibition and subsequent activation are involved; that is, the medial prefrontal cortex, in particular the anterior cingulate cortex. Alternatively, the effect might be primarily due to episodic memory retrieval of a "memory tag" attached to the ignored information [23] so that regions involving memory retrieval, such as the dorsolateral or ventrolateral prefrontal cortex, are involved, e.g. [10]. The

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neural substrates that are associated with the attenuation effect of negative valence on negative priming are also unknown. In general, the modification of attention priorities and direction by emotion has been thought to involve the interplay between the ventromedial and the dorsolateral prefrontal cortices [30]. In particular, as well as registering the valenced signals from the amygdala and limbic system, the ventromedial prefrontal cortex can reduce or inhibit the cognitive goal-related neural activity that has been coded in the dorsolateral prefrontal cortex. Despite this theoretical account, no studies have investigated whether the ventromedial prefrontal cortex is involved in the attention preference for negative information that is associated with the negative priming paradigm. This fMRI study investigated the neural correlates of negative priming effects with both neutral- and negative-affect stimuli. The goal was to acquire a better understanding of the neural mechanisms underlying the attention preference for negative information.

Eight healthy right-handed Mandarin-speaking Chinese female college students (mean age = 24.4 years, S.D. = 1.9 years, range = 22–28 years) participated in this study. Being screened through interviews with a checklist, none of them had any history of psychiatric or neurological diseases, including alcoholism or drug abuse.

One hundred and forty neutral and 60 negative two-character Chinese compound words were used as stimuli in the study. Following the paradigm described in Tipper [31], each trial consisted of two pairs of words that were matched on word frequency and were presented successively, one on a prime display and one on a probe display. On each display, the target word was in red, superimposed on the distractor word, which was in green. The relationship between the prime stimuli and the probe stimuli defined the experimental conditions of the trials. In the control condition, both the target and the distractor on the probe display were different from the target and the distractor on the prime display. In the ignored repetition condition, the probe target was the same as the prime distractor. The reaction time for the ignored repetition condition, relative to that of the control condition, was used to assess negative priming. To test for the valence effect, two new negative-word conditions were made by replacing the neutral words that defined the two conditions above with negative words (see Table 1) [4].

An event-related fMRI design was used. The experimental task consisted of a total of 120 trials in four scanner runs. The last two runs were duplicates of the first two runs, but the trials were presented in a different order. All trials were pseudo-randomized so that different conditions were equally represented in each of the two runs. As shown in Fig. 1, each trial started with a fixation cross shown at the center of the screen for 500 ms, followed by a prime display, another fixation cross shown for 500 ms, a probe display, then finally a fixation cross with a variable inter-trial interval (ITI) chosen for optimal statistical efficiency of the event-related fMRI design [6].

Table 1
Examples of the words used in the neutral-word and the depression-related-word conditions in the priming task

Word condition	Trial	Priming condition	
		Control	Ignored repetition
Neutral	Prime	直到 (Until)*	结论 (Conclusion)*
		高度 (Height)	情境 (Scenario)
	Probe	差别 (Difference)*	情境 (Scenario)*
		区委 (Councilor)	理由 (Reason)
Negative	Prime	欺遍 (Cheating)*	例如 (Example)*
		贫穷 (Poverty)	伤心 (Sad)
	Probe	伤害 (Hurt)*	伤心 (Sad)*
		气馁 (Dispirited)	书本 (Book)

Words with asterisks were the targets to which the participants were asked to attend.

The subject lay supine inside the scanner and wore earphones and goggles specially designed for the MR environment (Resonance Technology Company, Inc., Los Angeles). They were asked to read the red word on each display silently, and to press a response key immediately after they had finished reading. After the imaging session, the subjects filled in the Beck Depression Inventory—II for rating of depressed mood.

A 1.5 T Philips scanner with a standard head coil was used to acquire a total of 201 volumes. The pulse sequence was T2*-weighted gradient echo planar imaging with 18 slices covering the whole brain (slice thickness = 6 mm, no gap, interleaved, TR = 2 s, TE = 45 ms, flip angle = 90°, field of view = 230 mm, matrix size = 64 × 64). The orientation of the axial slices was parallel to the AC-PC line. The first three volumes were discarded to avoid saturation effects. Co-planar structural images were acquired for each subject using a T1-weighted spin echo pulse sequence (TR = 204 ms, TE = 14 ms, field of view = 203 mm, voxel size = 0.898 mm × 0.898 mm).

The preprocessing and statistical analyses were carried out with the Statistical Parametric Mapping software package SPM2 (Wellcome Department of Cognitive Neurology, London, UK) implemented in MATLAB Release 14 (Mathworks Inc., Natick, MA, USA). Preprocessing included slice timing correction,

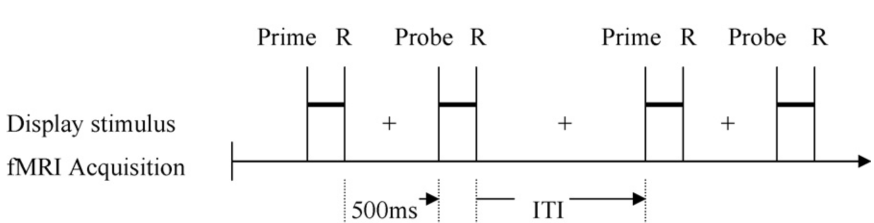

Fig. 1. Experimental time frame: immediately after the subject had made a response (R), the prime or the probe display was replaced with a fixation cross. The inter-trial interval (ITI) was variable for optimal statistical efficiency.