

Broca's area BA 45 mediates the cognitive and emotional interference resolution in healthy adolescents

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Abstract

Despite the remarkable progress in uncovering the neural basis of cognitive control, it is not known to what extent the cerebral mechanisms implementing it in an emotional and non-emotional context, are similar. We used variants of counting Stroop task and fMRI, to compare the activation patterns during cognitive and negative emotional interference, and to identify the areas specifically engaged in processing selection (i.e. showing activation in task versus various baseline conditions - fixation, motor control, and neutral words). Cognitive interference elicited activation in a bilateral fronto-parietal circuit; emotional interference engaged a mainly left lateralized fronto-temporo-occipital network. Broca's area, BA 45 has been found to be specifically involved in both types of interference.

Introduction

Everyday life often requires focusing on tasks, and ignoring distracting (emotional, or non-emotional) concurrent information. Although a lot of work has been devoted to uncover the neural mechanisms underlying cognitive and emotional interference processing, highlighting the prominent involvement of prefrontal regions, it is not known to what degree the resolution of cognitive and emotional interference involves similar neural mechanisms. This is especially important during adolescence, a time of emotional maturation. Here we employed functional MRI and variants of counting Stroop task to investigate comparatively the neural substrates of cognitive and negative emotional interference in a cohort of adolescents 16-17 years of age.

Methods

Thirty five healthy adolescents (18 boys), participated in a block design 3T fMRI experiment. One to four words – incongruent number (e.g. “four” written two times), neutral (e.g. table, chair), and negative emotional (e.g. sad, worry) were displayed to the subjects, which had to indicate as fast and as accurate as possible the number of words seen, using a button box. Each run consisted of eight repetitions of three 14 seconds conditions: fixation, motor control (words were replaced by rows of X) and Stroop task. Since the regions specifically involved in interference processing are posited to show increased activity regardless of the baseline condition [1], we first investigated the activation patterns from Stroop task (number, or emotional) versus each of the corresponding control conditions (fixation, motor control, neutral words). Next, conjunction analyses [2] were employed to search for regions showing common activation in the contrasts pertaining to either cognitive, or emotional interference, and finally, to investigate the common neural substrate mediating both types of interference.

Results

Only thirty subjects provided complete datasets and were included in the analysis. A significant behavioral interference was observed in the counting Stroop (mean RT, $t=8.16$, $p<0.0001$; Acc, $t=-3.53$, $p<0.001$ versus neutral words task), but not in emotional compared to neutral words ($t=-0.18$, $p<0.85$ for mean RT, and $t=-0.88$, $p<0.38$ for Acc). Number words and cognitive interference processing (Stroop vs. motor control) elicited activation in a bilateral fronto-parietal circuit, comprising the middle, inferior and dorsal frontal gyri (L BA 9/46/45, R BA 9/44/45, and R/L BA 8) and the inferior parietal lobules (R/L BA 40). Negative valence words and interference elicited activation in a predominantly left-lateralized fronto-temporo-occipital network (L BA 44/45/47, L BA 22 and cuneus BA 18/19). Both, cognitive and emotional interference resolution specifically engaged left Broca's area BA 45-pars triangularis, see Figure 1.

Discussion

Our results show that cognitive interference activate regions belonging to the dorsal-, whereas emotional interference recruits areas assimilated to the ventral attentional system [3], and that L BA 45 represents a bridge of interaction between the two systems. Although no robust behavioral emotional interference was observed, the activation of the L BA 45, associated with inhibitory functions [4], suggests the presence of an attentional bias, but also of a mechanism of overriding it [5]. No activation was observed in the anterior cingulate gyrus (ACC) in the task vs. control (motor, or neutral words), suggesting that ACC is not specifically involved in interference resolution.

References

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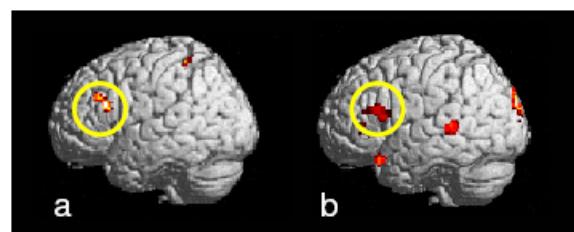


Figure 1. Specific regions involved in cognitive (a) and in emotional (b) interference processing. Yellow circle indicates Broca's area BA 45.