Does the Modulation of the Insular Activity Affect Our Emotional Involvement? A Real-Time fMRI Study during Emotional Pictures Processing

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Introduction

Real-time functional MRI (rtfMRI) allows for on-line feedback and voluntary control of brain signals. Previous studies (deCharms et al., 2005; Weiskopf et al., 2004) have demonstrated that human subjects using rtfMRI training can learn self-regulation of localized brain regions. Importantly, one of these studies (deCharms et al., 2005) has shown evidence for behavioural modifications that accompany self-regulation training. This study reported that when subjects deliberately induced increases or decreases in rACC fMRI activation, there was a corresponding change in the perception of pain caused by an applied noxious thermal stimulus.

The aim of the present study was to evaluate the effects of increasing the insular activity on the emotional responsiveness of healthy adults. The activity of the insulae correlates with the subjective perception of emotional states (Craig, 2002, 2003). Studies on emotional perception showed that insula activity is correlating with the aversive valence of stimuli (Anders et al., 2004). A review of PET and fMRI studies investigating the neuroanatomy of emotion (Phan et al., 2002) revealed that the anterior cingulate and insula were recruited during induction by emotional recall/imagery and during emotional tasks with cognitive demand.

We expected that the enhancement of this region would affect responses during a following task that induced feeling states. We trained subjects to learn to control their own brain activity in the left anterior insula using real-time fMRI (3T Siemens Trio, TR 1.5s, TE 30ms, 16 slices, voxel size 3.3x3.3x5 mm^3). Emotional responsiveness was evaluated in terms of local brain activity, subjective valence and arousal during affective pictures presentation.

Methods

Ten healthy right-handed adults participated to our study. They were trained to voluntarily control the local BOLD signal of the left anterior insula using the rtfMRI. All subjects underwent a localizer session and a training of four feedback sessions. The sessions consisted of five alternated increase/decrease runs. Each run consisted of a 30s increase/decrease block followed by a 9s block, during which we presented a visual stimulus, that in turn was followed by a 12s evaluation block. During the increase/decrease blocks the subjects had to respectively increase or decrease the local brain activity in the target region of interest. During stimulus presentation blocks, one emotional picture from International Affective Picture Set (IAPS) was presented for 9s. During the evaluation blocks, coming immediately after the presentation of the pictures, the subjects were asked for ratings of the stimuli. Pictures were evaluated in terms of subjective emotional valence and arousal using the Self-Assessment Manikin (SAM, Bradley and Lang 94).

The feedback was the average BOLD signal of the left anterior insula displayed by means of thermometer bars. Online statistical analysis of the fMRI data was performed using Turbo Brain-Voyager and we used BrainVoyager QX for offline single subject ROI analysis. SPM2 offline analysis was also performed for group analysis.

Results and Discussion

Nine participants out of ten were able to successfully regulate BOLD–magnitude in the left anterior insular cortex. Training resulted in a significantly increased activation cluster in the anterior portion of the left insula across sessions. Subjects reported the use of both positive and negative mental imagery. Percent signal change calculated in the ROI as difference between increase and decrease blocks for each subject and then averaged across all the participants resulted in a clear monotonic increase across the sessions [repeated measures ANOVA, $F(3,8) = 4.46$, $P = 0.013$]. Evaluation of the pictures showed significant difference (Wilkoxon Signed Ranks test) of valence ratings for the aversive pictures presented after increase blocks respect to those presented after decrease blocks in the last session [$z = -2.13$, $P = 0.033$]. In the last session, when subjects were able to control left insula activation, aversive pictorial stimuli presented after subjects were increasing left insula activation were rated as significantly more negative than after subjects were decreasing left insula activation. No significant difference were found in arousal ratings. Valence and arousal ratings for the neutral pictures did not show significant differences comparing increase and decrease conditions across sessions. A correlation analysis examining the relation between the percent fMRI signal change in the left anterior insula and the resultant aversive pictures valence ratings reported a significant negative value [Spearman's rho = -1, $P = 0.01$, two-tailed].

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