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EMOTION

Playing it safe or taking a risk: evoking the human amygdala

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The involvement of the human amygdala in emotionally charged behavior has been usually studied by classical conditioning or emotional judgement paradigms. Looking for differential brain responses to risky and safe choices, we have constructed a real life situation in which subjects played a video game against the experimenter while being scanned. Subjects were forced by the game's rules to make choices that might involve the risk of being "caught", and worsen their position in the game. Our results demonstrated differential BOLD fMRI signals in the amygdala complex following a risky choice (expecting to be penalized by the experimenter) versus a safe choice (not expecting to be penalized).

Introduction

Lesion studies in animals and humans have shown that the amygdala is involved in both acquisition and extinction processes of learned fear or emotional response (LeDoux1998). Recently, brain imaging methods were applied to demonstrate the role of the amygdala in facial expression recognition (Breiter 1996), implicit processing of emotionally charged stimuli (Whalen et al 1998) and conditioned emotional response (Buchel 1999, LaBar et al 1998).

In order to test whether amygdala complex is involved in natural human risk behavior, we have set out to simulate a "risk taking" real life situation during fMRI experiment, by using a computerized version of a modified domino game: In each game subjects were assigned 12 random chips which only they can see, and one master chip (shown face-up) (Fig.1A). At each step the subject selects one of his chips, and places it face-down besides the master chip. If the experimenter decides to continue by asking the subject to 'choose' the next chip, the face-down chip is disposed. However, if the experimenter asks the subject to 'show' the chosen chip and it is matched to the master chip, 2 additional chips are disposed randomly from the pile. If the chosen chip is non-matched, 2 additional chips are added to his pile as a penalty.

fMRI procedure

While in the magnet, 9 healthy subjects (age=18-46, m=5, f=4) were asked to play 3-6 games. Bold-fMRI contrast was acquired by gradient echo EPI sequence (TR=2500 TE=55 FA=90) on a 1.5T GE scanner. Functional slices of 5mm (gap 1mm) were superimposed on 4 -11 spin-echo T1 weighted anatomical images, along the temporal lobe and centered on the amygdala. The amygdala complex was seen clearly in 2-3 slices. In addition, 3D SPGR sequence was acquired on each subject, inorder to allow volume statistical analyses of signal changes during the game. BrainVoyager (BrainInovation Co.) fMRI analyses package and complementary in-house software were used for data analysis. Localization of individual functional clusters was determined relative to their distance from the amygdala borders. All clusters that were included in the analyses were within these borders. Differential BOLD-fMRI signal changes were obtained by event related statistical analyses. For that, discrete game intervals were defined in which the subjects were only expecting the consequences of their choice. These intervals start after the subject picked his choice and ended when the experimenter responded (either by Show or by Choose). Events of interest were analyzed for risky (non-match) and for safe (match) choices, averaged across games for each player, and across 14 subjects.

Results

Differential BOLD signals for safe and risky choices, were detected in the amygdala complex, while the subjects were expecting the exprimenter's response (Figure 1B). Greater relative change in signal was observed for a non-matched (risky) choice than for a matched (safe) choice (Figure 2). Analyzing the safe versus risky choices after a 'show' command did not reveal a significant difference. Thus, these data suggest differential response to risky vs safe choices in the amygdala complex, specifically related to expecting consequences rather then reponding to the feedback.

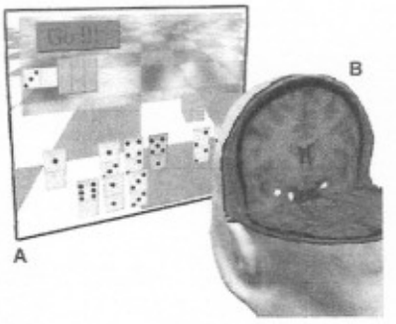

Figure 1. A. The screen as seen in the magnet during the game. In this game a matched choice should include either no dots or three dots. Any other selection will be a non-matched choice. B. A parametric map, superimposed on a 3D reconstruction of a single subject brain. Significant functional clusters ($p<0.001$) for risky vs safe choices in the amygdala complex.

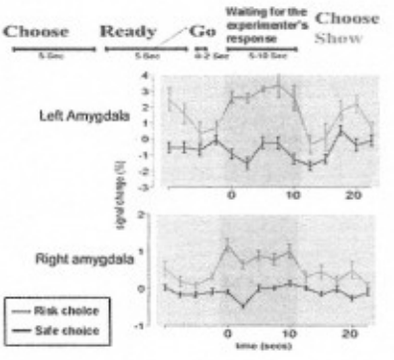

Figure 2. Time course of event related BOLD-fMRI for risk and safe choices while expecting the experimenter's response during the game.

Discussion

Our finding lending further support to the amygdala complex role in the mediation of emotionally charged behavior in humans. Unique experimental setup provided an opportunity to examine an almost real life situation during fMRI scan. Furthermore, we were able to demonstrate differential activation in the amygdala depending on the "risk-load" in the subject behavior. These findings shed new light on the well documented role of the amygdala in emotional regulation of human behavior.

References

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