Combine ASL Perfusion and BOLD fMRI for Imaging Risk in The Human Brain

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Introduction Risk is a ubiquitous component of the natural world. Considerable effort has been devoted to understanding how people make risky decisions, and the results have consistently demonstrated the importance of emotion in risky decision-making (1-4). However, not all risks are predicated on our decisions. Some risky situations we can voluntarily choose while others we are forced to accept. This dichotomy suggests that risk may be dissociable from decision. However, previous studies confounded risk and decision making, and the neural bases mediating risk taking with and without decision making are still unclear. By combining ASL perfusion and BOLD fMRI, the present study measured both the tonic and the transient neural activation patterns associated with these two types of risk taking.

Methods The modified Balloon Analog Risk Task (BART) (5) was used as the risky stimuli for fMRI scanning. Subjects were required to sequentially inflate a virtual balloon that can either grow larger or explode. Larger balloons were associated with increasingly larger monetary rewards (from 0.05$ to 6$) as well as increasingly larger risk of explosion (from 0 to 90%). We administered this task both in an active mode where participants have the choice to decide whether to add air or collect the money, and in a passive "Russian Roulette" mode where participants merely added air at each turn while the computer determined the loss or gain outcomes. Except for the choice to voluntarily stop inflating, the two tasks were same in all other experimental parameters. Fourteen subjects (8 male, age 21-35 years) were scanned on a Siemens 3.0 T Trio scanner. The BOLD data was acquired with a standard EPI sequence (TR=1500, TE=30 ms, 25 axial slices), while the perfusion data was acquired with a pseudo-continuous ASL sequence (6). For each task, each participant completed two 8 minutes functional runs, one for BOLD and another for perfusion. The imaging data were analyzed by SPM2, using an event-related model for BOLD and a box-car model for perfusion. The transient activities associated with risk were isolated by parametric analysis of BOLD data, while the tonic activities associated with risk were revealed by block comparisons between risky tasks with resting baselines.

Results The BOLD results showed that both kinds of risk induced robust transient activation in perception related regions in occipital, fusiform and parietal cortex, while active risk induced additional transient activation in anterior cingulate cortex (ACC), striatum, and insula (Fig1a, b). The perfusion results showed that both tasks activated bilateral parietal, ACC, and right middle frontal cortex, while active risk task additionally activated right insula and right dorsal lateral prefrontal cortex (Fig1c, d). The ROI results confirmed the significant difference between the two kinds of risk tasks for the transient ACC activation, but no difference for the tonic ACC activation (Fig2).

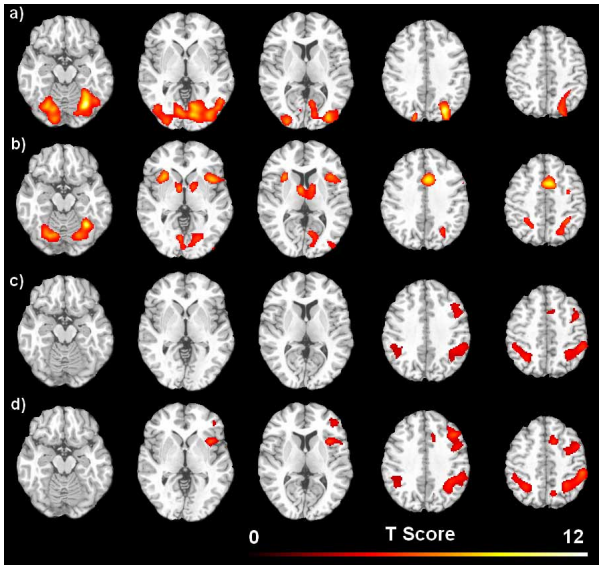

Fig1. BOLD (a, b) and perfusion results (c, d) of risk taking without choice (a, c) and risk taking with choice (b, d).

Conclusions From the analyses of BOLD data, only voluntary risk taking induced robust activation in the striatum for reward processing and the insula for aversive processing. This result suggests that the combination of risk and decision making, rather than risk or decision making alone, engages the positive and negative emotional system in human brain. During the passive risk task, perfusion imaging analyses revealed significant activation in ACC that was not observed by BOLD. This result suggests that the free choice condition may change the transient but not tonic activation associated with risk.

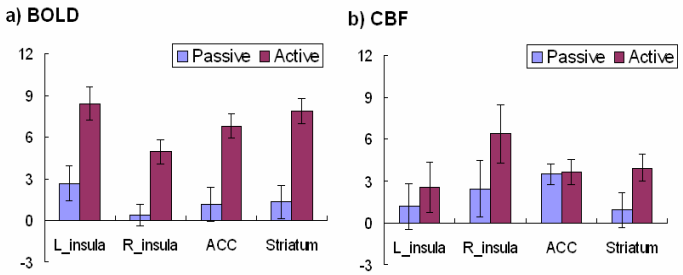

Fig2. a) BOLD and b) CBF results from ROI analysis.

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