The sequential involvement of distinct portion of anterior cingulated cortex in different stages of decision making using Iowa Gambling Task

J-J. Lee[1], H-J. Song[1], J-A. Park[1], J-H. Kim[1], S-T. Woo[1], H-K. Kim[1], H-J. Lee[2], and Y. Chang[1,2]

[1]Department of medical & Biological Engineering, Kyungpook National University, Daegu, Jung-Gu, Korea, Republic of, [2]Department of Diagnostic Radiology, Kyungpook National University, Daegu, Jung-Gu, Korea, Republic of

Introduction

Decision making is a complex process of forming preferences, selecting and executing actions, and evaluating outcomes. In some situations, the decision must be made without knowledge of the possible outcomes or the probabilities for reward and punishment. These types of decision are called "decisions under ambiguity", that is, the outcome is not described by some probability distribution. In other situations, the possible outcomes are also uncertain, but at least they are described by some probability of each one occurring. This type of decisions has been termed "decisions under risk", that is, there is knowledge of what the probability of the outcome might be. Therefore, decisions involving ambiguity are distinct from decisions involving risk. The aim of this study is to investigate the differences in activated neural substrates between the early trials and latter ones of the Iowa gambling Test (IGT). In addition, it is also aimed to investigate the possible role of distinct portions of the IGT. In addition, it is also aimed to investigate the possible role of distinct portions of anterior cingulated cortex (ACC) in different blocks of the IGT using functional magnetic resonance imaging (fMRI).

Material and Methods

Subjects: Thirteen normal subjects (10 men and 3women) participated in this study. Age range was from 23 to 42 years (mean 28.15 yrs). All subjects were right-handed. They had no history of any psychiatric or neurological disorders, or serious physical illnesses and had no within second-degree relatives with a history of major psychiatric disorders.

Task: Participants performed the control task and risk taking task (active task). This IGT is a computerized gambling card game that tests the ability to choose between high gains with a risk for even higher losses, and low gain with a risk for smaller losses. Compared with the active task, the four decks used for the control task were equal in gains and losses. Participants were commanded to picked cards from the decks sequentially in the fixed order of A-B-C-D-A-B-C-D-etc (Fig. 1). For Iowa gambling risk task, the subjects were instructed to try to gain as much money as possible by drawing 100 selections from a choice of four decks. Two of decks are more risky and disadvantageous, producing immediate large rewards but these are accompanied by significant money loss due to extreme punishments. The other two decks are advantageous; reward is modest but more consistent and punishment is low. This tasks was repeated We developed a computerized version of the IGT according to the original version ; play money was converted form dollars to Korea won.

fMRI: fMRI experiment were achieved on a 3T whole body scanner equipped with a 8ch head coil (Signa Exite HD,GE,USA). fMRI parameters were as follows; echo plannar image, repetition time (TR) = 5s, echo time = 40ms, field of view (FOV) = 240mm, matrix = 64×64,31 slice with 4mm slice thickness and no slice gap. Anatomic T1weigted image were as follows; 3D SPGR, TE = 3.9ms, FOV = 240 mm, matrix = 256×256,120 slice with 1.3 slice thickness. The raw fMRI data over the IGT were analyzed in two different ways. First, the data were divided into two phases (50 trials each) and the activations were analyzed for each phase by testing the BOLD signal differences between the active and the control Task (Analysis type A). Second method consists of five separate blocks of trials (20 trials each) and the activations for each block were analyzed by testing the BOLD differences between the active and the control task (Analysis typeB). fMRI data analysis was performed using statistical parametric mapping (SPM2, http://fil.ion.ucl.ac.uk/spm).

Results and Discussion

The results of analysis type A showed the activity in right dorsolateral prefrontal cortex (DLPFC) and the right medial superior frontal cortex during ambiguous decision-making (the first half of 100 trials in the IGT). Risky decision making (the second half of 100 trials in the IGT) on the other hand was more associated with activity in right orbitofrontal cortex (OFC), ventromedial ACC, and cerebellum (Fig.2). Since subjects do not known about contingencies of reward and punishment during early phase of the IGT, they had to concentrate the probability and magnitude of reward and punishment in each deck. Therefore, decisions under ambiguity involve working memory which was related to the DLPFC[1], whereas preference based on prior experiences that was associated with the OFC was involved in decisions under risk. The results of analysis type B showed the brain activities for each blocks consisting of 20 trials. From the first block to the last block, the main finding of analysis of type B was that the activity in mPFC moves gradually from dorsal portion to ventral ACC over the course of the IGT (Fig.3).

Reference

[1] MacDonald III AW, Cohen JD, Stenger VA, Carter CS (2000): Science 288:1835–1838

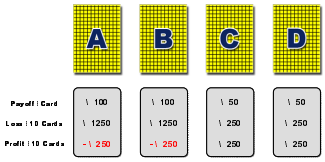

Fig.1. Iowa Gambling Task

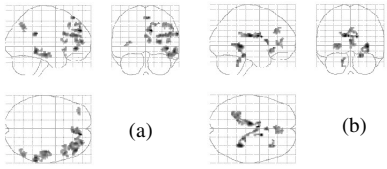

Fig.2. fMRI map were shown (a) ambiguous decision-making (first50 trials) and (b) risky decision-making (latter 50trials). Right side is right. P-value is 0.01

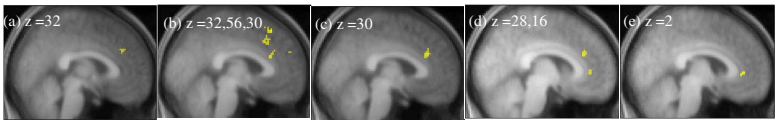

Fig.3. fMRI map were shown (a)1~20 trials (b) 21~40 trials (c) 41~60 trials (d) 61~80trials (e) 81~100 trials map. Right side is right. P-value is 0.05