Regional differences in brain activation during deception and truth using fMRI

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Abstract

The purpose of this study was to investigate the regions of brain activation using a modified positive control question technique (PQT) during deception or truth by functional MRI using blood oxygenation level dependent (BOLD) contrast and compare the results with those of a standard polygraph examination.

Introduction

Polygraph examination, the most reliable (>90%) and widely used technique [1] that is currently used for detecting deception, can be performed using a variety of paradigms to elucidate deception. Some of drawbacks of polygraph include misreading of the physiological data on the polygraph charts, as well as areas of subjectivity involved in polygraph testing. Recently imaging studies have shown the involvement of prefrontal cortices, parietal lobes and anterior cingulate to be strongly activated during judgment, manipulation of information and planning of response including inhibition [2-4]. These studies however failed to use standard polygraph techniques or innovations from that field of expertise. The techniques used in previous studies varied from guilty knowledge, digit memory, card sorting and neuropsychological evaluations. In our previous fMRI study using control question technique (CQT), one of the most acceptable polygraph methods used, resulted in a poor correlation between the fMRI and polygraph tests, presumably due to insufficient BOLD signal arising from the CQT task [4]. In the current study, we implemented a unique and cognitively challenging modified PQT in an fMRI experiment and compared the group results with standard computerized polygraph measurements.

Methods & Materials

The experiments were performed on 11 normal healthy volunteers using a standard 1.5T Siemens scanner (5 females & 6 males). All subjects gave written informed consent and the local Institutional Review Board approved the study. Three physiological responses from the normal subjects were measured by using a four-channel polygraph machine. The rate and the depth of respiration were measured by two different pneumographs secured around the chest and abdomen. A blood pressure cuff (sphygmanometer) placed around the bicep of the volunteer was used to measure cardiovascular activity. The galvanic skin conductance (GSC), a measure of electrical conductivity related to perspiration, was measured with electrodes attached to two of the fingers of the volunteers. All the polygraph signals were digitally recorded and the responses were displayed on a moving chart in a laptop using the software provided by the Lafayette Instrument Company, Indiana. The functional MRI experiment used a box-car type block design for collecting images. The order of the fMRI and polygraph procedure was randomized across subjects. The auditory stimulus was controlled from outside the scanner using neuropsychological software (NeuroBehavioral Systems) and delivered through the headphones. The subjects' responses were measured using a MR compatible response box. Initially a high-resolution (256*256) T1-weighted spin echo sequence was used to acquire anatomical images. Contiguous axial images were positioned and aligned parallel to the AC-PC line covering the entire brain. Functional images were then acquired with echo planar (EPI-FID) sequence in the same plane as the structural images. The imaging parameters were: matrix=128*128; FoV=22 cm; st=5mm; TR=4s; TE=54 ms; & NEX=1.

A relevant situation was created prior to the fMRI scanning and polygraph testing. Of the eleven subjects, five were asked to tell the truth, that they were not involved in the relevant situation (shooting a toy gun), and six were asked to deliberately lie and deny their involvement in the relevant situation. The subjects were presented with 5 separate blocks of control (irrelevant) and relevant questions alternating with rest period blocks. During each block (24 sec long), 6 volumes of EPI images were acquired, yielding a total of 120 EPI volumes. It was expected that the subjects denying their involvement in the relevant situation would produce a greater autonomic response to the relevant question than to control (irrelevant) questions. Continuous scanning was performed until all the 20 blocks were completed. Two separate fMRI experiments were carried out. The first trial named "Lie Only Condition" was carried out to compare the brain activity during "known lie" to control (irrelevant) questions and subjective lie to relevant questions. This was followed by another trial named "Truth Only Condition", where the brain activity during "known truth" to control (irrelevant) questions and subjective truth to relevant questions were compared. The questions were randomized and repeated between different blocks. Subject-level statistical analyses were performed using the general linear model in SPM2 and group-level random effects analyses for main effects were accomplished by entering whole brain contrasts into one-sample t-tests.

Results & Discussion

The results show areas of frontal lobe (medial inferior and precentral) [BA 9, 10, 6], temporal lobe (hippocampus, middle temporal [BA 19], and limbic lobe (anterior and posterior cingulate) to be significantly active ($p<0.005$, cluster threshold>10)) during the deception process. During truth telling, activation regions were seen in the inferior and middle frontal [BA 46, 10], inferior temporal [BA20] and cingulate gyrus. Overall there were regional differences in activation between lying and truth conditions. Furthermore, there were more areas of the brain activated during the lying process compared to the truth telling condition. These results suggest that there may be unique area(s) in the brain involved in the truth-telling or deception process that can be measured using fMRI. The polygraph results correlated well with both the lying and truth telling subjects except in one case where the polygraph results were inconclusive. These preliminary results are encouraging and warrant further investigation.

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