Brain mapping using fMRI during Truth telling & Deception

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Abstract

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

Introduction

Among several techniques that are currently used and under development for detecting deception to date, polygraph is the most reliable (>90%) and widely used technique [(1)]. A polygraph examination can be performed using a variety of paradigms to elucidate deception. Irrespective of the questioning methodology used, polygraph has several drawbacks. These include failure of the polygraph examiner to properly prepare the examinee, a misreading of the physiological data on the polygraph charts, as well as areas of subjectivity involved in polygraph testing. Several recent 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 [(2-3)]. These studies failed to use standard polygraph techniques or innovations from that field of expertise. The techniques used in previous studies varied from digit memory testing, card sorting testing and neuropsychological evaluations. 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 polygraph task in an fMRI experiment and compared these results with standard computerized polygraph measurements.

Methods & Materials

The experiments were performed on 4 normal healthy volunteers using a standard 1.5T Siemens scanner. The physiological responses from the normal subjects were measured by using a four-channel polygraph machine. Three different types of physiological responses were measured. The rate and the depth of respiration were measured by two different pneumographs secured around the chest and the 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 subjects were instructed to lay still and close their eyes during the scanning. 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 four subjects, two were asked to tell the truth, that they were not involved in the relevant situation, and two 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. The data was then analyzed using SPM software and statistical parametric maps (SPM{t}) were generated to show visual representation of the areas in the brain wherein statistically significant differences between BOLD contrast during truth-telling and deception conditions are present.

Results & Discussion

The results show areas of frontal lobe (medial, inferior and superior frontal gyrus) [BA 9, 10, 47], temporal lobe [BA 37], and limbic lobe (anterior cingulate) to be significantly active ($p<0.001$) during the deception process. During truth telling, no significant activation regions were seen in the brain. However, at lower threshold levels ($p=0.05$) smaller areas of activation were seen in the temporal lobe and medial frontal gyrus. 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. These preliminary results are encouraging and warrant further investigation.

References (1). Nardini, W. Journal of Police Science and Administration 1987, 15:239-49. (2). Liu et al, Hum Brain Mapp 2002 (3):157-64., (3). Langleben D, et al, Neuroimage 2002 (3):727-32. (4) Mohamed FB et al, Proc. ISMRM, (P): 1920, 2003.