Lie Detection using Functional MRI

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Introduction

The Digit Memory Test (DMT) of a forced choice format has been previously documented to improve the accuracy of deception detection (1,2). Recently, it was demonstrated that simulated malingerers were clearly distinguishable from normal controls using this method (3). In this study, we implemented DMT in a functional MRI (fMRI) experiment to examine the brain activation during simulated malingering. It is clearly evident that intentional lying requires accurate verbal recall followed by conscious manipulation of the recalled information and hence intimately involves neural substrates responsible for such behavior. Most recently, other investigators have showed that prefrontal cortices were strongly activated during information manipulation and integration, programming strategies, and the control of executive functions (4, 5). Therefore, we hypothesized that lying would place a heavier demand on the prefrontal regions than simple recall. FMRI was utilized to test this hypothesis by measuring brain activation during both correct recall and intentional lying.

Methods

To investigate neural changes underlying deception, the cerebral activity of 5 male volunteers was monitored using fMRI both during accurate verbal recall and when they faked a memory problem. All participants (age range: 31.6 - 37.2 years) had academic qualifications upto the level of postgraduation. The attention span of the subjects during the experiment was controlled at the 7 +/- 1 digit's level as measured by the Digit Span test. In order to encourage skillful lying, two other conditions, namely, answering incorrectly and answering randomly were added to the design. Following the DMT of a forced choice format, we performed this blocked design fMRI study using 3-digit numbers. Each block was initiated by the control condition (14 sec), instruction (4 sec), and then followed by one of the four experimental conditions (28 sec). The control condition involved the viewing of a 3-digit number without the component of recall. The four experimental conditions included answering correctly, faking badly, answering incorrectly, and answering randomly. Two trials were included in the control state, and four in the task state. During each trial, each number was exposed for 0.75 followed by visual fixation on a cross hair for 2.25 sec. Upon completion of this, a new number was again presented for 0.75 sec followed by a cross hair for 3.25 sec. For the task state, subjects were requested to respond, during the 3.25 sec visual fixation, according to the specific instructions set aside for each experimental condition. Three blocks were repeated for each of the four conditions. The duration of each block was 46 seconds. Care was taken to ensure that the order of the experimental conditions was balanced among the 12 blocks of scanning. After scanning was completed, all participants were asked about the strategies they had adopted for faking badly during the experiment. Experiments were performed on a 1.9 T GE/Elscint Prestige MRI scanner. A T2*-weighted gradient-echo EPI sequence was used for fMRI scans, with the slice thickness = 6 mm, in-plane resolution = 2.9 mm x 2.9 mm, and TR/TE/FA= 2000 ms/45 ms/900. Twenty axial slices were acquired to cover the whole brain. For each slice, 276 images were acquired with a total scan time of 552 s. For the anatomical detail, a T1-weighted image was obtained with the resolution of 1 mm3. Activation maps were calculated by comparing images acquired during each task state with those acquired during the control, and specially, during the faking badly with the answering correctly task states, using a t-test. Images were spatially normalized to the Talairach space using a Convex Hull algorithm (6). The averaged activation maps across subjects with a t value threshold corresponding to $p < 0.01$ were then overlaid on the corresponding T1 images. For each comparison, Talairach coordinates of the center-of-mass and volume of the activation clusters were determined based on the averaged activation maps.

Results

In the comparison between the faking badly and the answering correctly task states, we observed a strong activation in the prefrontal regions bilaterally that was accompanied by significant activation involving both the fronto-polar prefrontal areas (BA 10)(Fig. 1a-1c). Significant activation was also seen bilaterally in the following areas of the brain: anugular (BA 39) and supramarginal (BA 40) gyri of the parietal lobe, and the cingulate and caudate locations of subcortical regions. The activation of BA 39 & 40 was not unexpected because all participants reported that they had made calculated responses. It was also evident that the most popular strategy adopted in feigning a memory problem was to calculate the proportion of right and wrong answers. These findings are in excellent conformity and consistency with previous knowledge that suggests the involvement of the fronto-parietal network in the comparison and computation of digits. The involvement of the subcortical region in this group of subjects was most likely due to self-monitoring of random errors. We repeated the experiment again but used instead autobiographic questions of a forced choice format. Similar loci were activated even in the repeat experiment (Fig. 1d-1f).

Discussion

Our findings provide conclusive evidence of the existence and involvement of a fronto-parietal-subcortical circuit in feigning a memory problem. Extensive examination of lying and deception detection in both normal and clinical populations using behavioral and functional imaging paradigms will provide further theoretical refinement of these findings. Validations of our data will also definitely help in establishing a platform for cross validation of functional imaging and behavioral paradigms in the detection of deception. Potentially significant applications of this work include future investigations aimed at distinguishing different types of liars and different types of lying with or without metacognitive calculations.

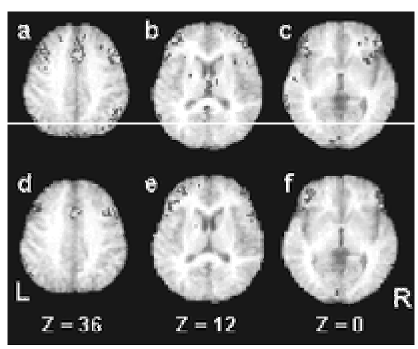

Figure 1. Averaged functional maps ($p < 0.01$) overlaid on the T1 images, in faking badly vs. answering correctly states using DMT (a-c) and autobiographic test (d-f). Three normalized planes are z = 36, 12 and 0 mm, relative to the bicommissural line.

References

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