Neurocognitive mapping of visuospatial judgment in healthy subjects and chronic alcoholics – an fMRI study

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Introduction: Interaction of spatial environments and cognitive agents occur through integration of spatial representations. The parietal cortex has been proposed as part of the neural network for guiding spatial processing [1-2]. Alcoholism is a chronic disease, which progresses over time and results in significant impairment of motor coordination, loss of good spatial judgment and tact, serious loss of balance, blurred vision, poor reaction time, ineffective short-term memory, lack of attention and concentration, inability to comprehend and impaired hearing [3]. The visual system exploits symmetry to facilitate object recognition. Impairment in the parietal cortex could greatly inhibit a person's ability to judge symmetry [4]. We have mapped the cognitive areas responsible for visuospatial symmetry judgment task in healthy subjects and chronic alcoholics.

Materials & Methods: Twelve healthy subjects and three chronic alcoholics (35-55 years) were chosen for the study. The baseline phase involved sustained attention, while the activation phase involved attention-shifting tasks. The paradigm was chosen to eliminate the areas responsible for short-term memory and to focus on visuospatial tasks. It consisted of 255 questions in the baseline and 210 in the active phase and was supposed to invoke 16 responses (correct answers) in each phase. The subject's response was monitored with the help of a feedback response device built in-house.

FMRI was carried out using 1.5 Tesla whole-body MRI system (Magnetom Vision, Siemens, Germany) with a circularly polarized head coil. 33 oblique slices covering entire brain were acquired using gradient echo based interleaved EPI sequence with TR = 1.68ms, TE = 64ms and field of view = 230 x 230mm^2. Block paradigm (BABABABA….) with alternating phases of activation (A) and baseline (B) was chosen. 65 sequential image volumes (belonging to six cycles + one baseline for eliminating T_1 saturation effects and acclimatization of the patient to the gradient noise) were taken with an optimized inter-scan interval of 7.2 seconds. Pre-processing and post-processing were performed using SPM99 software. The voxel threshold was 6.96 with extent threshold value 'k' = 5 voxels. One-sample 't' test for group analysis within task (uncorrected $p \leq 0.001$, extent threshold 'k' = 5 voxels) was performed.

Results & Discussion: The response of the controls was 65% and 98% 'correct hit' and less than 2% and 0% 'false alarm' in the active and baseline phases respectively. The response of the alcoholics was 40% and 85% 'correct hit' and 30% and 2% 'false alarm' during active and baseline respectively, which indicates that they performed the task at chance levels (greater number of 'false alarms' while responding to the questions). Significant BOLD activations ($p \leq 0.001$) were found in the superior and inferior parietal lobules (SPL/IPL), peristriate (Brodmann Area 19) region of the occipital lobe, cuneus and precuneus, medial, middle and superior frontal gyrus and the middle occipital gyrus in controls (Figure 1). Activations in superior and inferior parietal lobules are attributed to spatial orientation processing and spatial encoding respectively. The peristriate region is associated with visuospatial processing and visual perception. Activations in cuneus and precuneus are attributed to the retrieval of the visual images and they play an important role in recall and judgment. The activations in the frontal lobe, particularly the middle, medial and superior frontal gyrus are related to shift in attention (active phase) compared to fixation (baseline) and decision making. Additional activations observed in the middle occipital gyrus can be attributed to the higher order processing of information.

Reduced activation was observed in the three alcohol users in prefrontal, parietal and occipital lobes (Figure 2, Table 1). The diminished responsiveness of prefrontal and subcortical areas in alcohol users could account for their difficulties in task performance and their inability to switch their attention to implement an attentionally more demanding action [5]. The posterior half of the parietal cortex (Brodmann Area 5) is significantly activated in controls and hardly activated in alcoholics (Figure 3). Hence, we infer that the initial cortical processing of tactile and proprioceptive information during the performance of visuospatial decision making tasks is impaired in alcoholics.

Conclusion: The study suggests parietal-occipital interactions in tasks involving visuospatial judgment. This interaction is impaired in alcoholics as compared to healthy subjects.

References:

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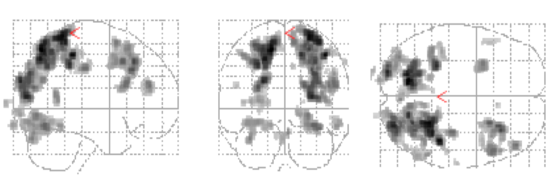

Figure 1: Shows the significantly activated areas for visuospatial judgment in healthy subjects

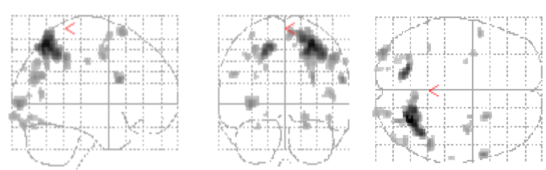

Figure 2: Shows the significant reduction in activation for visuospatial judgment tasks in alcoholic subjects.

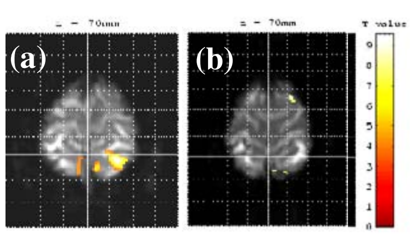

Figure 3: Shows the activation pattern in the posterior half of the parietal cortex in (a) healthy subjects and (b) alcoholics.

Table 1: Average cluster summary in controls and alcoholics during visuospatial judgment task.

	Controls	Alcoholics
SPL/IPL	1892	656
Brodmann Area 19	992	172
Precuneus	529	285
Cuneus	41	26
Frontal	490	185
Brodmann Area 5	28	0