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Model for Disconnectivity Analysis in Schizophrenics for Sternberg Item Recognition Paradigm

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***Abstract*— Functional magnetic resonance imaging(fMRI) has currently gained popularity as a method in the decision making process of neuroscience due to its excellent spatial resolution and non-invasive nature . It's key feature lies in the ability to precisely localize the brain areas activated when subjects perform various tasks. Statistical Parametric Mapping (SPM) is an tool in medical imaging to assist fMRI study. It allows one to compare images or regions of images for differences. It helps one to make inferences on a group of subjects. Using MATLAB and the SPM software, the authors have done connectivity analysis on three memory cycles commonly established in healthy controls during working memory task and absent in schizophrenics.The authors have employed SIRP(Sternberg Item recognition paradigm) working memory and used data from Fbirn site for carrying out the said fMRI study . In this study the subject is asked to recognize numerical digits between 0-9 in steps of increasing load by first identifying a single digit then three and subsequently five. The effect of increasing memory load is analyzed first using classical analysis in SPM.It is inferred that as memory load is increased there is substantial decrease in activations in schizophrenic controls as compared to healthy controls.The disconnectivity analysis is tested for a connectivity cycle commonly established during working memory tasks and alterations in the connectivity are inferred.**

***Keywords*- fMRI,SPM,classical,effective connectivity**

I. Introduction

Mapping of human tasks to brain areas is accomplished by engaging subjects into specific tasks and observing their corresponding brain activations. Cognitive overload, utility, and emotions are measures that are arguably difficult to reliably measure with self reports, but they are possible to be reliably captured with fMRI. fMRI data is captured when subjects observe a stimulus, thereby measuring brain activity[1] The individuals are not capable to evaluate his surroundings and to interact with other peoples in their surroundings [2] Schizophrenia is a mental disorder which causes impairment in person's thought processes, impairments in insight and judgment [3] fMRI data for the healthy control and for schizophrenic patients are used to characterize and find abnormalities. The definition of working memory according to Allan Baddeley is a short term temporary storage and retrieval of information to carry out a specific task like learning ,reasoning etc. Intermediate results are kept temporarily in this place in order to accomplish the task successfully.Working memory plays an important role in cognition. Brain activity changes when induced with a working memory task.The four primary components of working memory are :-Central executive component which is responsible for controlling attention.There are two temporary storage systems responsible for holding speech and visual information .The last one is the episodic buffer.The main component hence is the central executive.[4]

II. Related Work

Functional MRI (fMRI) data-processing methods based on changes in the time domain involve, among other things, correlation analysis and use of the general linear model with statistical parametric mapping (SPM).[5] fMRI can be used to produce activation maps showing which parts of the brain are involved in a particular mental process. There are three stages to the analysis of the data from any fMRI experiment. Firstly there are the pre-processing steps, which can be applied to the data to improve the detection of activation events. These include registering the images, to correct for subject movement during the experiment, and smoothing the data to improve the signal to noise ratio. Next, the statistical analysis, which detects the pixels in the image which show a response to the stimulus, is carried out. Finally the activation images must be displayed, and probability values, which give the statistical confidence that can be placed in the result, quoted. statistical map is combined with the map of the original difference in brain activity (or, more generally speaking, with the original contrast) and color codes are attributed to the latter. The atlas-driven region-based selection relied on averaged weights of the active voxels obtained from the AAL (automated anatomical labelling) and BA(Brodmann's area) maps and these were used as elements of feature vector. In event related designs we have the ability to detect transient variations in hemodynamic responses and also allows for analysis of individual responses to trials.

III. Sirp Task

In the fMRI study subjects were asked to memorize a set of target digits. They were then presented with probes (single digits) and respond by indicating whether the probe is a target (a member of the memorized set) or a foil (not a member of the memorized set). The number of targets can be varied to provide a range of working memory load conditions. The version of the SIRP task in the research consists of three working memory loads, where subjects are shown a memory set of 1, 3 or 5 target digits as shown in fig 1. For each run, two memory sets for each of the three load conditions, were presented. Each condition has three portions: learn, encode, and probe epochs.The 6 s encode epoch is followed by a 2.7 s delay and a 37.8s probe epoch. During the probe epoch, subjects are shown 14 individual WM probes. Within each WM condition, half of the probes are targets, half are foils, and each member of the target set is presented at least once. Probe digits are random integers between 0 and 9, and are not repeated within a single memory set; no more then 3 consecutive digits are targets within a memory set. Following an initial 1s fixed delay before the first probe digit, probes are displayed for a duration of 1.1 s with a random interval between probes varying between 0.6 - 2.486 s. Thus, on average, a probe digit occurs approximately once every 2.7 seconds as shown in fig 2. Each subject underwent three sessions on different days.

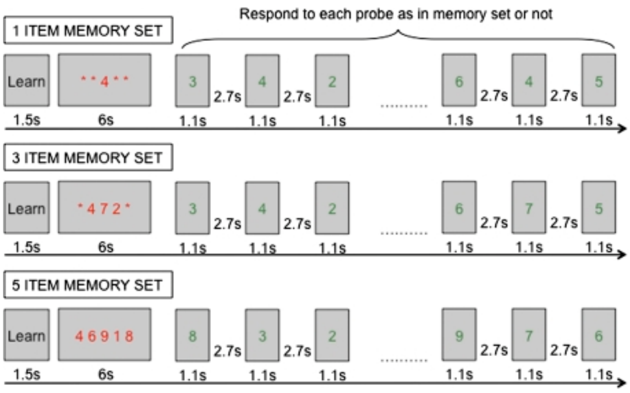

Fig 1:SIRP Task Description

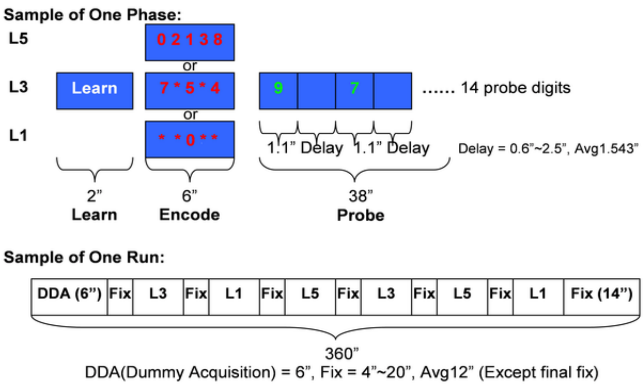

Fig 2:Timing Diagram for one phase

III. PROPOSED WORKING MEMORY CYCLE

The Proposed model for testing performance of schizophrenics with increasing memory load is shown in fig 3.

Model : (dorsolateral circuit)-dorsolateral- caudate nucleus ,globus pallidus –thalamus circuit that loops back.The loop is responsible for the memory, learning and retrieving function with dorsolateral prefrontal cortex in the role of cebtral executive component of working memory.[6]

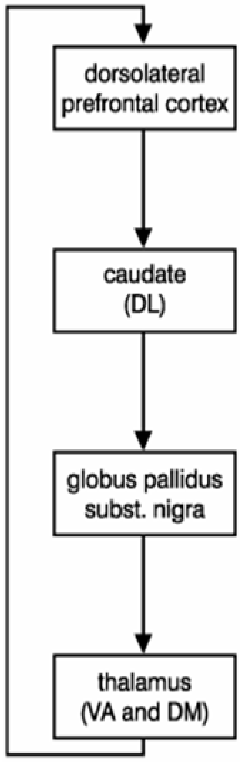

Fig 3. Proposed Model of Working memory cycle

IV. PREPROCESSING

For Preprocessing the authors have employed Spatial Pre-processing

1) Realignment: In this step the data gets realigned to eliminate any movement related error.

2) Slice-timing correction: The data were corrected for slice-timing using the fact that there are “24 axial slices acquired continuously with a TR=2s” and TA=1.92, where “TR is the time between the onset of the first slice of one volume and the first slice of next volume”, and “TA is the time between the onset of the first and last slice of one volume”. [1]

3) Coregistration: Coregistration is performed to maximize the mutual information between the structural and functional images.

4) Segmentation: The images are segmented as grey matter, white-matter and cerebrospinal fluid.

5) Normalization: The functional images are spatially normalized

6) Smoothing: The images are smoothed using a FWHM of 8mm x 8mm x 8mm (the SPM default). (These images are used only for classical analysis).

V. STATISTICAL DESIGN

FMRI data sets typically consist of time series associated with the voxels of the brain. For each voxel, the significance of the response to the stimulus is assessed by statistically analyzing the associated fMRI time series. In this way, brain activation maps, or statistical parametric maps (SPMs), can be constructed.In fMRI implementations of the general linear model (GLM), a matrix is needed to define the experimental design and the nature of the hypothesis testing to be implemented. This matrix is called design matrix, and it is an essential algorithm. The design matrix must be created by the researcher who should select and organize the images acquired in each run and group them as a function of the condition in which they were taken. Creating a correct design matrix is one of the most important aspects of fMRI data analysis. The design matrix contains the indicator variables (parametric covariates) that encode the experimental tasks. Specifically, each column of the design matrix corresponds to an effect that is built into the fMRI protocol to prevent confounds. These are referred to as explanatory variables (or covariates or regressors). Their effects on the response variable is modeled in terms of functions of the presence of these conditions (i.e. events smoothed with a hemodynamic response function), and they constitute the first columns of the design matrix. Then, there is a series of terms that must be designed to remove or model low frequency variations in signal due to artifacts, such as aliased biorhythms and other drift terms. The final column is whole brain activity.The rows of the design matrix corresponds to each of the scans as shown in fig. 4. In SPM8 all conditions are specified in terms of their i) onsets and ii) durations.

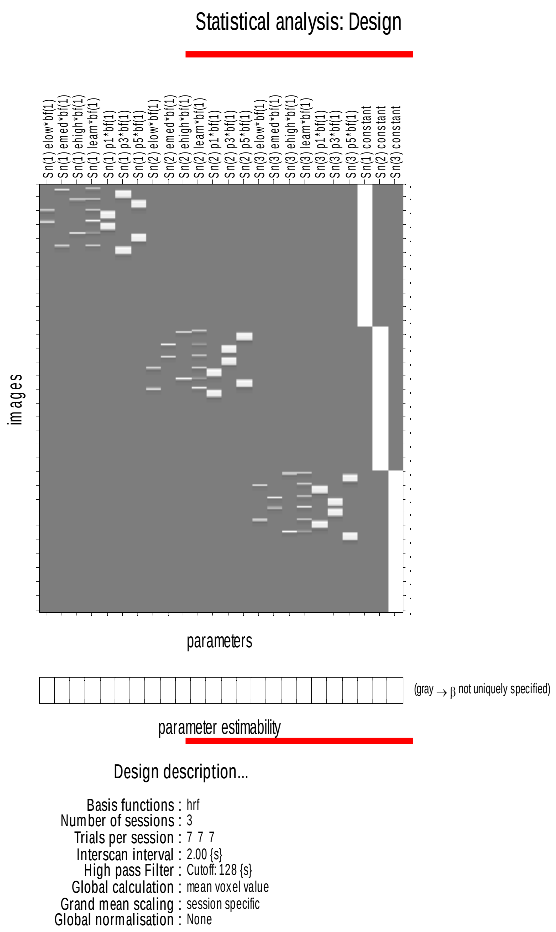

Fig 4. Design Matrix

VI. Results And Discussions

fMRI results are displayed in the form of figures that graphically show the activated brain areas using a thresholded color-coded statistical map that specifies the intensity of brain activations and illustrates the number of activated voxels. It includes the view of the anatomical image (e.g., axial, coronal, saggital) .The thresholded color-coded images are statistical maps that imply a direct statistical comparison that brain activation is present in one area and absent from another.By using an corrected threshold of 0.05 SPM maps are generated. There is a statistically significant difference observed between two contrasts i.e healthy Vs Control, in brain activations. There was significantly greater blood oxygen level dependent (BOLD) activity in healthy controls compared with schizophrenics with increasing memory load [6] as illustrated in figures 5-6

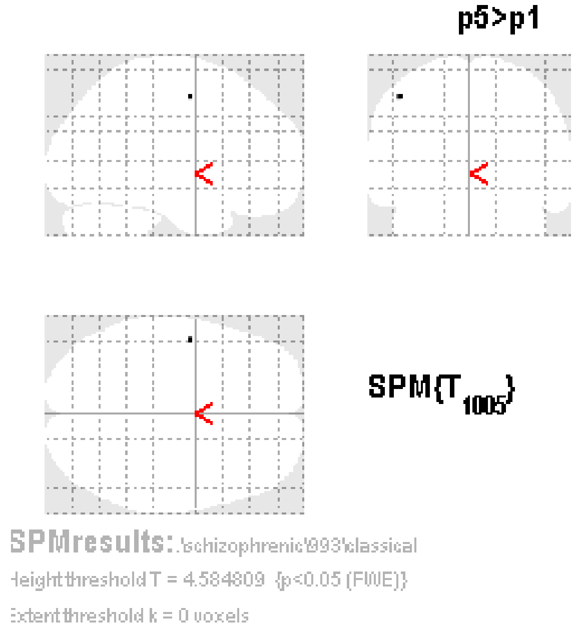

Fig 5.SPM in schizophenics for five digit recognition

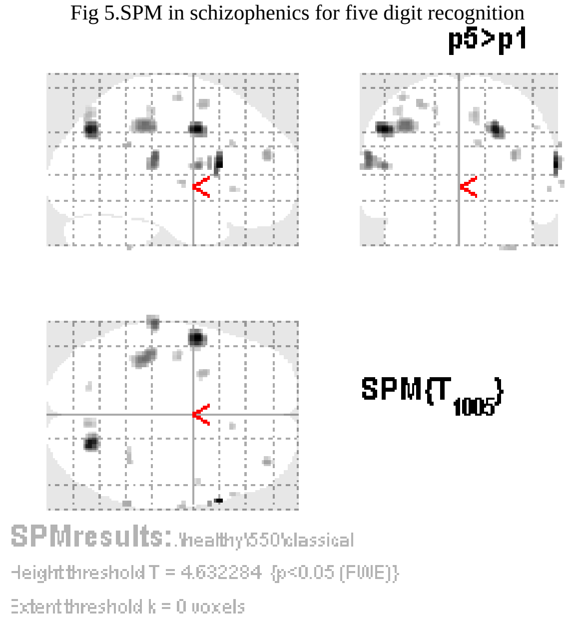

Fig 6.SPM in Healthy controls for five digit recognition

The neuroimaging findings provide insights into interaction between brain regions.[7]The functional connectivity found between dorsolateral prefrontal cortex(DLPFC) and caudate nucleus(DL)-impaired(reduced activity) is consistent with previous studies that claims that caudate nucleus contributes towards making the appropriate response that is necessary to achieve or complete the task.[8] The caudate nucleus ,globus pallidus in conjunction with thalamus has been implicated with memory,learning etc further suggesting that the volume of white matter was reduced in schizophrenics which may imply deficits in attentional shifts(action-outcome).

VII. CONCLUSIONS

Working memory is one of the most important mental faculties and it is critical for cognitive abilities such as reasoning ,problem solving etc**.** The proposed model design in the paper is for establishing effective disconnectivity in schizophrenic during working memeory task. fMRI can be used to understand how a given individual's brain functions and perhaps, in the future, making psychiatric diagnoses and treatment recommendations. Differences in activity may also be represented as a 'glass brain', a representation of three outline views of the brain as if it were transparent. Only the patches of activation are visible as areas of shading. This work will facilitate the medical practioners in better understanding and analyzing the complexity and functionality of brain network. Hence this has got a potential for further exploration and experimentation.

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