

Functional MRI Study for Eye Blinking and Finger Tapping

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ABSTRACT : In recent years there has been explosive growth in the number of neuroimaging studies performed using functional Magnetic Resonance Imaging (fMRI). The field that has grown around the acquisition and analysis of fMRI data is intrinsically interdisciplinary in nature and involves contributions from researchers in neuroscience, psychology, physics and statistics, among others. Brain-mapping techniques have proven to be vital in understanding the molecular, cellular, and functional mechanisms of the brain. Normal anatomical imaging can provide structural information on certain abnormalities in the brain. However there are many neurological disorders for which only structure studies are not sufficient. In such cases it is required to investigate the functional organization of the brain. Further it is necessary to study the brain functions under normal as well as diseased conditions. In this paper we discuss the analysis of fMRI data, from the initial acquisition of the raw data to its use in locating brain activity for finger tapping and eye blinking making inference about brain connectivity and predictions about psychological or disease states.

Keywords - Eye Blinking, Functional MRI (fMRI), Mapping, Finger Tapping.

I. INTRODUCTION

Modern imaging has transformed practice in the clinical neurosciences by providing information about structural abnormalities in the brain non invasively. However many chronic neurological or psychiatric complaints confronted in the clinic (for example pain, movement, disorders, depression and psychosis) are not associated with structural abnormalities that can be detected in an individual patient with current clinical technologies. There are many approaches to measurement of functional changes in brain. While some method directly monitor electrical events in neurons, others by secondary effects of increased neuronal firing rates. Metabolic demand and the requisite changes in blood delivery are useful for localizing the sites and magnitude of brain activity. Several functional brain mapping techniques have been developed over the 3 decades which have revolutionized our ability to map activity in the living brain. [1, 3]

II. BRAIN MAP

The brain has many parts including the cerebral cortex, brain stem and cerebellum. The brain is a very complex organ, it regulates every aspect of human behavior. Everything about ourselves and the environment is experienced through the brain. It has been described as a three pound universe. It is thought to house the seat of the self, the place where the sense of self resides. Damage to the hippocampus interferes with the ability to store new memories. Likewise, the ability to use language recognize familiar faces, to count, read and many other higher functions are dependent on intact memory functions. Impairments in such basic functions are fundamental to personal identity. [4]

The following represents primary brain functions and some of the common problems that result from brain injury. The brain functions as an interrelated whole, however injury may disrupt a portion of an activity that occurs in a specific part of the brain. Brain function map is shown in figure 1.

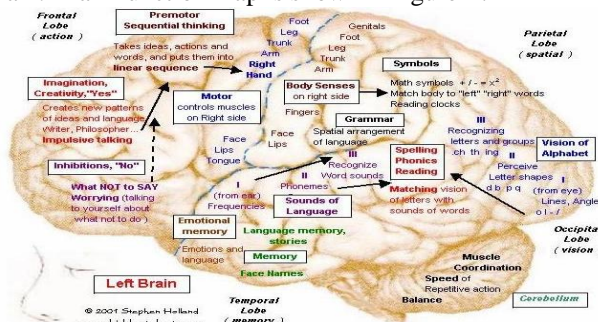


Fig 1: Brain function MAP

2.1 Frontal Lobes

<p>Functions: Located, right under the forehead (anterior) the frontal lobes are involved in tracking and sense of self. Additionally, they're involved in arousal and initiations well as consciousness of environment reaction to self and environment, Executive functioning and judgments Emotional response and stability Language usage Personality Word associations and meaning Memory for habits motor activity [13]</p>	<p>Impairments caused by head injury: Sequencing - difficulties planning and completing complex tasks in correct order, such as making coffee. Perseveration - repeating same actions and comments over without conscious awareness of having done so. Loss of spontaneity in interacting with others. Loss of flexibility in thinking, (<i>mental rigidity</i>). Distractibility - easily distracted Attention - difficulty focusing on tasks Concentration difficulties Mood swings - (<i>emotional lability</i>) Changes in personality and social behavior Diminished abstract reasoning - imagination Difficulty with problem solving Expressive difficulties - language usage and word finding (<i>Broca's Aphasia</i>) Loss of simple movement of various body parts (paralysis)</p>
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2.2 Parietal Lobes

<p>Functions: located near the back and top of the head the Parietal lobe is involved in: Visual perception Tactile or touch perception Object manipulation Integration of sensory information that allow for understanding of a single concept Goal-directed voluntary movements[13]</p>	<p>Impairments caused by head injury: Difficulties naming objects (<i>Anomia</i>) Difficulties writing words (<i>Agraphia</i>) Inability to attend to more than one object at a time Inability to focus visual attention Problems with reading (<i>Alexia</i>) Poor hand-eye coordination Confusing left-right orientation Difficulty performing math calculations (<i>Dyscalculia</i>) Difficulty drawing Poor visual perception Lack of awareness of certain body parts and/or surrounding space (<i>Apraxia</i>) that leads to difficulties in self-care.</p>
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2.3 Temporal Lobes

<p>Functions: Located on the Side of the head above ears The temporal Lobes have to do with Intellect Auditory perception (hearing) Long-term memory Some visual perception Object categorization [13]</p>	<p>Impairments caused by head injury: Difficulty remembering names and faces (<i>Prosopagnosia</i>) Difficulty understanding spoken words (<i>Wernicke's Aphasia</i>) Difficulty with identification of, and verbalization about objects. Difficulty with concentration Short-term memory loss Interference with long-term memory Aggressive behavior Change in sexual interest Persistent talking (damage to right lobe) Difficulty locating objects in environment. Inability to categorize objects (<i>Categorization</i>) Religiosity Seizure disorders, auras and strange reveries</p>
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2.4 Occipital Lobes

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<p>Functions: Located at the back of the head (<i>Posterior</i>) Visual perception</p>	<p>Limitations: Visual defects (<i>Visual Field Cuts</i>) Difficulty recognizing colors (<i>Color Agnosia</i>) Hallucinations Visual illusions - inaccurately seeing objects. Word blindness - inability to recognize words Difficulty recognizing drawn objects Difficulty perceiving movement (<i>Movement Agnosia</i>) Loss of academic skills (reading, writing) [13]</p>
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III. FMRI FOR BRAIN MAPPING

fMRI is becoming the diagnostic method of choice for learning how a normal, diseased or injured brain is working, as well as for assessing the potential risks of surgery or other invasive treatments of the brain.[1] Physicians perform fMRI to:

Examine the anatomy of the brain. Determine precisely which part of the brain is handling critical functions such as thought, speech, movement and sensation, which is called **brain mapping**. Help assess the effects of stroke, trauma or degenerative disease (such as Alzheimer's) on brain function. Monitor the growth and function of brain tumors. [9]Guide the planning of surgery, **radiation therapy**, or other surgical treatments for the brain. Intense brain activity ~ increase in oxygen demand: Oxygen provided in blood flow, Measure Blood MR Signal, Repeat every 1-4 sec. Detect tiny metabolic changes, Blood Oxygenation Level Dependent (BOLD) Figure 2 shows the BOLD signal and Figure 3 shows the signal flow of fMRI response. [5]

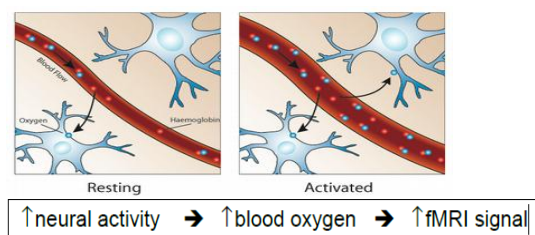


Fig 2: BOLD signal

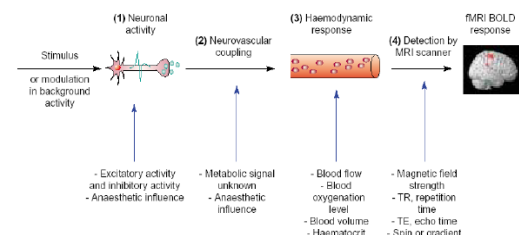


Fig 3: Signal flow of fMRI response

IV. FMRI FOR EYE BLINKING ACTIVITY

Eye blinking involves the action of two muscles: levator palpebrae superioris and orbicularis oculi. Inhibition of the levator and the simultaneous contraction of the orbicularis muscles produce the eye closure in a blink cycle, then the reverse process opens the eye. Mapping of brain areas for blinking has recently been done with PET [10] although indirect evidence has long implied the presence of such controls from studies on the dry eye and the video display terminal (VDT) syndrome[12]. Dry eye is a major cause of ocular fatigue, irritation, and discomfort. It is often accompanied by an increasing blink rate in response to desiccation of the ocular surface [12]; however, in the case of VDT syndrome, the blink rate is actually reduced

During task performance thereby worsening the condition [9]. Thus it appears that eye blinking is not a simple reflex but a more complicated process associated with vision related functions. To examine this possibility, fMRI (functional MRI) was employed to map cortical response to controlled blinking.

Image Analysis: The brain response to the blinking scheme was plotted as signal intensity vs. time. The image intensity of areas with the highest activation was measured with a standard region-of-interest program. Alternatively, statistical comparison was made between the control and the experimental images and the *P*-values computed. The *P*-maps were then superimposed onto T1-weighted anatomical images. Localization of the activated areas was based on anatomy. From graphic prescription serial images shown in figure 4 and 5. Two of which are of particular interest, i.e., the orbitofrontal cortex and the visual cortex. [11]



Fig 4: Anterior portion of the visual cortex

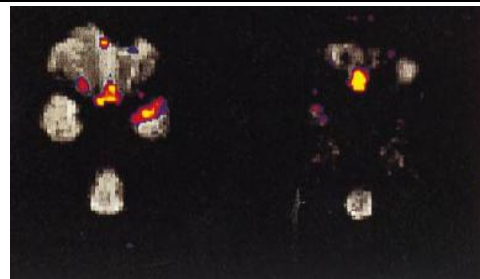


Fig 5: Orbitofrontal cortex

V. FMRI FOR FINGER TAPPING

The fMRI experiment was carried out on the GE sigma 1.5-T scanner. The subject was asked to perform the finger-tapping task with both hands and the EPI images were recorded. The data set consists of four slices each of size 64x64 pixels, cutting through the motor cortex. For each of the slices a time series of 128 images was recorded. This generated a data set of dimensions $4 \times 64 \times 64 \times 128$.

Gradient echo sequence was used with time interval between successive scans (TR) of 3000 msec, and echo time of 60msec. To compensate for the delay in the haemodynamic response we neglected the first images at the beginning of each block in the ON-OFF pattern and finally it reduced to a $4 \times 64 \times 64 \times 122$ matrix of data. Our analysis needs the length of time series equal to some multiple of the stimulus period, in this case 20. Therefore in the actual analysis, we considered the first 120 images out of 122 again resulting into a data set of dimensions $4 \times 64 \times 64 \times 120$. [7]

Image Analysis: The periodicity transform was applied to the time series data belonging to the intracranial region. The Mbest algorithm calculates the periodicity within the time series. The output parameters are the normalized norm after each periodicity, the number of periodicities detected along with the periodicity values. Those pixel time series, which exhibit a strong periodic component at the stimulus period, are marked as activated. If the periodicity extracted matched with 20 then the power of the extracted signal was tested. The threshold was entered in an interactive manner manually in the range between 0 to 1. The code was written in MATLAB. activation pattern superimposed on the Anatomic Image shown in figure 6.

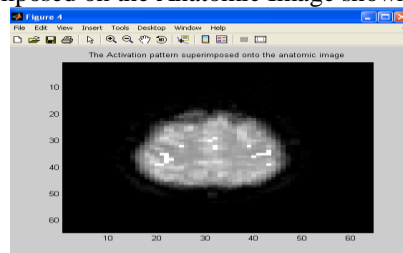


Fig 6: Activation pattern superimposed on the Anatomic Image

The results for the main effects analysis across all finger-tapping tasks exhibited clusters of concordance in regions commonly associated with the performance of motor tasks, including the primary sensorimotor cortex (SM1), supplementary motor area (SMA), basal ganglia (BG), and cerebellum. The primary sensorimotor cortex has traditionally been considered the main executive locus for simple voluntary movements.

VI. CONCLUSION

fMRI is a non invasive method for investigating the structure and function of the brain. The activation sites in fMRI maps represent areas with significantly higher hemodynamic changes than the control, for example, in the blinking scheme: eyes closed followed by normal blinking shows activation in the orbitofrontal cortex and the visual cortex. In the finger tapping scheme shows activation in the primary sensorimotor cortex (SM1), supplementary motor area (SMA), basal ganglia (BG), and cerebellum.

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