

FUNCTIONAL MRI FOR LOCALIZATION OF LANGUAGE AND MOTOR AREAS IN RESECTABLE BRAIN TUMORS

Essay

*Submitted for Partial Fulfillment of Master Degree in
Radiodiagnosis*

By

David Tharwat Tawfik

M B, B Ch

Faculty of Medicine
Ain Shams University

Supervised By

Prof. Dr Saad Aly Abd-Rabou

Professor of Radiodiagnosis
Faculty of Medicine
Ain Shams University

Prof. Dr Zenat Ahmad Al-Sabbagh

Assistant Professor of Radiodiagnosis
Faculty of Medicine
Ain Shams University



Faculty of Medicine
Ain-Shams University
2009

Acknowledgments

First of all, I thank **God** for without His help, I couldn't have finished this work.

I would like to express my thanks and gratitude to ***Dr. Saad Ali Abd-Rabou***, Professor of Radio-diagnosis, Faculty of Medicine, Ain Shams University for his continuous encouragement, help and valuable comments.

I would also like to express my thanks and deep appreciation to ***Dr. Zenat Ahmad Al-Sabbagh***, Assistant Professor of Radio-diagnosis, Faculty of Medicine, Ain Shams University, for her helpful advice, guidance and thoughtful remarks.

Finally, I would like to thank my family for their continuous support, care, love and devoted help through the hardest time of my life last year.

Dedication

In everyman's life there is a light that shines through and enlightens his path. This light is a gift from GOD to show us the way in the hard battle of life.

I have been gifted by a man who is my guiding light, like a candle whose light has showed me my way since I opened my eyes to this world. He has always been there for me through all my steps, through every hardship of my life he was the wall I leant on to keep me standing tall and always gave me the love and faith to work and excel.

I would like to dedicate this work to my great teacher, professor and more like a father to me, to my uncle **Dr. Mahrous Aziz Samak**, *Consultant of Orthopedic Surgery, Southend University Hospital, England* for his continuous support and encouragement was my biggest motive.

List of Abbreviations

AC	Auditory Cortex
ADP	Adenosine diphosphate
AG	Angular gyrus
ATP	Adenosine triphosphate
BA	Brodmann area
BOLD	Blood Oxygen Level Dependant
CBF	Cerebral blood flow
CBV	Cerebral blood volume
CPC	Choroid plexus carcinoma
CPP	Choroid plexus papilloma
CPT	choroid plexus tumor
CNS	Central nervous system
CS	Central sulcus
CSF	Cerebrospinal fluid
D	Digit
Deoxy-Hb	Deoxygenated hemoglobin
DES	Direct electrical stimulation
EEG	Electroencephalography
EM	Executed movement
EMF	Executed movement of foot
EMH	Executed movement of hand
EMT	Executed movement of tongue
fMRI	Functional Magnetic Resonance Imaging
GE-EPI	Gradient echo- Echo planar imaging
h	Hour
hrf	Hemodynamic reference factor

IAP	Intrarterial amobarbital injection
ICA	Internal carotid artery
ICP	Intracranial pressure
IFG	Inferior frontal gyrus
IFS	Inferior frontal sulcus
IPL	Inferior parietal lobule
IPS	Inferior parietal sulcus
IOG	Inferior occipital gyrus
IOS	Intraoccipital sulcus
IPL	Inferior parietal lobule
IPS	Inferior parietal sulcus
ITG	Inferior temporal gyrus
ITS	Inferior temporal sulcus
LI	Lateralization index
M1	Primary motor area
mA	Milliampere
MEG	Magnetoencephalography
nVxL	Number of activated voxels in the left hemisphere
nVxR	Number of activated voxels in the right hemisphere
Oxy-Hb	Oxygenated hemoglobin
OS	Occipital sulcus
paraCL	Paracentral lobule
PET	Positron emission tomography
postCG	Postcentral gyrus
preCG	Precentral gyrus
preCS	Precentral sulcus
rCBF	Regional cerebral blood flow

rCBV	Regional cerebral blood volume
s	Second
SFG	Superior frontal gyrus
SFS	Superior frontal sulcus
SG	Sentence generation
SmI	Primary somatosensory area
SmII	Secondary somatosensory area
SMA	Supplementary motor area
SOG	Superior occipital gyrus
SOS	Superior occipital sulcus
SPL	Superior parietal lobule
STG	Superior temporal gyrus
STS	Superior temporal sulcus
subCG	Subcentral gyrus
T	Tesla
T1WI	T1 weighted images
T2WI	T2 weighted images
TE	Time to echo
TR	Time to repeat
V1	Primary visual area (Visual one)
V2	Secondary visual area
V3	Association visual area
WG	Word generation

List of Tables

Table	Title	Page
1	Functional arrangements of the four lobes of the cerebral hemispheres.	27
2	Set of Visual Stimuli and the defined sentences for Sentence Generation paradigms.	112
3	Set of Visual Stimuli and the defined words for Word Generation paradigms.	112

List of figures

Figure	Title	Page
1	Diagram representing the superolateral surface of the cerebral hemisphere.	9
2	Lateral aspect of the left hemisphere.	10
3	Superior aspect of the left and right hemispheres.	11
4	Medial aspect of the right cerebral hemisphere.	14
5	Inferior aspect of the brain with cerebellum and brainstem removed.	16
6	A diagram representing a cross section through the brain and the motor homunculus.	21
7	Diagram of human brain showing surface gyri and the primary auditory cortex.	24
8	Diagram representing Brodmann areas numbered; Superolateral & medial surface.	28
9	Diagram representing Microscopic structure of the neuron.	23
10	Diagram representing an overview of the aerobic metabolism of glucose to ATP following the Krebs's cycle.	38
11	Diagram representing the blood supply of the nerve cells.	27

12	Diagram representing the percent of benign and malignant brain tumors in brain tumors patient.	40
13	Gross specimen of a low-grade astrocytoma.	50
14	Low-grade fibrillary astrocytoma.	51
15	Low power view of a cellular tumor.	55
16	Microscopic picture of ependymoma.	38
17	Low power photomicrograph of a high grade large cell lymphoma of the brain.	62
18	Metastatic carcinoma to brain.	63
19	Idealized time course of the hemodynamic response following a long stimulation event.	75
20	Diagram representing relation between neural activity and BOLD MRI responses.	77
21	Diagram representing schematic illustration of different paradigms.	80
22	Diagram representing Scheme of a typical fMRI setup.	82
23	Diagram representing typical equipment for visual stimulation.	83
24	Fully automated pneumatically driven tactile stimulation.	84
25	A task-induced signal change for a sensory task	87

	involving tactile stimulation (touching) the left hand.	
26	Overlay of 2D-fMRI activation maps on anatomical 3D data sets results in 3D-fMRI activation maps that are typically used for diagnostic presurgical fMRI.	91
27	Dynamic thresholding: Evaluation routine for individual clinical fMRI data.	94
28	Measuring BOLD-signals under defined conditions to distinguish between “true” activation and “artifacts”.	95
29	Diagrams representing recommended self-paced movements to investigate sensorimotor somatotopy in clinical fMRI.	101
30	Clinical standard protocol for motor paradigms .	102
31	Presurgical fMRI somatotopic mapping of the motor cortex.	103
32	Schematic drawing of language areas in the left hemisphere according to the classical language model.	106
33	Diagram representing Nonmagnetic mirror glasses with slide-in module for optical correction lenses that were fitted before functional MR imaging.	110
34	Examples of visually presented triggers for SG & WG paradigms.	111

35	Presurgical fMRI language localization and lateralization in a right handed patient with a malignant glioma of the left superior temporal gyrus – critical to Wernicke’s area by anatomical consideration.	115
36	Presurgical fMRI localization of Broca’s area using the word generation paradigm (WG) in a patient with a left inferior frontal astrocytoma as reflected by the typical activation of the inferior frontal gyrus, pars opercularis.	116
37	A 71-year-old woman with metastatic brain tumor located inside the right-sided premotor area.	121
38	Activation maps and mean percent signal change of the hemodynamic response function, following a visual flash and a consequent finger tap, before and after drinking three cups of coffee.	123
39	A graph representing the mean signal change in the visual and motor cortex before and after drinking three glasses of beer as a result of the visual flash stimulation with single finger tap.	124
40	Example of a pulsation artifact.	125
41	Diagram representing Simulation of the effect of head motion between different states of activation on the observed activation in a subtraction map.	128
42	Diagram showing a custom build bite-bar system used to minimize patient motion during the fMRI experiment.	129

43	Effect of subject motion on the resulting fMRI activation map of a patient.	130
44	The effect of the correction of motion artifacts on the observed real and false motion induced activation in the calculated fMRI map.	131
45	Intraoperative view of a patient showing bipolar stimulation using a probe.	134
46	Correspondence between fMRI and intraoperative cortical stimulation.	136
47	Validation of preoperative functional MR imaging language localization with intraoperative DES.	137
48	Validation of preoperative functional MR imaging language lateralization by using selective Wada test in 23-year-old woman with left temporal cavernoma.	141
49	fMRI images taken during alternating rest and stimulation periods.	148
50	fMRI motor cortex somatotopy.	149
51	fMR images, in the transverse plane, show areas of cortical activation during hand movement.	150
52	Typical cortical activation pattern of complex finger opposition.	151
53	Variation of paradigms to localize the motor hand area results in different activation patterns.	152

54	fMR images showing sagittal views of cortical activation in the left hemisphere during verb generation tasks with the single-task block-design protocol and with the multitask paradigm.	153
55	Functional localization of Broca' s and Wernicke' s areas using the word generation (WG) and sentence generation (SG) paradigms.	154
56	Sagittal axial, and coronal. fMR images in patients performing word-generation tasks.	155
57	Presurgical fMRI images showing mapping of the upper motor cortex in a patient with left postcentral high grade glioma.	158
58	Presurgical fMRI mapping of the lower motor cortex in a patient with left parietal cavernoma.	159
59	Presurgical fMRI localization of the motor hand area in a patient with metastasis visualized at the motor hand area.	160
60	Presurgical fMRI somatotopic mapping of the motor cortex in a hemiparetic patient with a recurrent left rolandic astrocytoma prior to repeated surgery.	161
61	fMRI images in a 33-year-old man with a biopsy-proved recurrent high grade right parietal astrocytoma.(Case 1).	164
62	fMRI images in a 23 years old female patient with right parietal lobe anaplastic oligodendroglioma.(Case 2).	166

63	fMRI images in a 32-year-old female with a space-occupying lesion within the right frontal lobe. (Case 3).	168
64	fMRI images in 77-year-old man suffering from left temporal lobe metastatic adenocarcinoma.(Case 4).	170
65	fMRI images in a 37-year-old right handed woman suffers from recurrent left parietal lobe anaplastic astrocytoma.(Case 5).	172
66	fMRI images in a 23-year-old woman with left intraventricular central neurocytoma.(Case 6).	174
67	fMRI images in a 30-year-old man with medial left frontal lobe well-differentiated astrocytoma.(Case 7).	176
68	fMRI images in a 20 years old female patient with left posterior temporooccipital region pleomorphic xanthoastrocytoma.(Case 8).	178

CONTENTS

1. Introduction and aim of work.
 2. Anatomical and physiological considerations.
 3. Pathophysiology and clinical aspects.
 4. Physical principles and technique of functional MRI localization of motor and language areas.
 5. Normal functional MRI appearances.
 6. Functional MRI findings and illustrative cases.
 7. Summary and Conclusion.
 8. References.
 9. Arabic Summary.
-
-