When the Right ('Wrong') Hemisphere Kicks in: Re-Reading Words in The Context of a Memory Task Activates the Non-Dominant Inferior Frontal Gyrus

Dr. Galia Tsarfaty, Neuroradiology Unit
Dr. Abigail Livny-Ezer, Researcher, Radiology Unit
David Matias, 3rd year Medical student, TAU

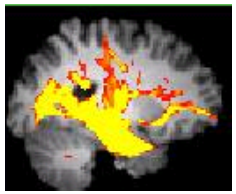
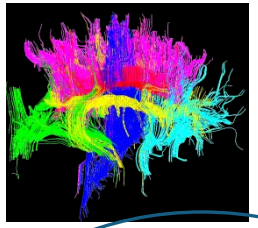
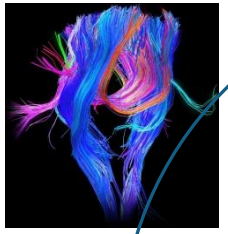
Outline

- Introduction: MRI, fMRI and BOLD Response
- Study:
  - Hypothesis
  - Methodology: Study Design, fMRI Analysis
  - Results
  - Conclusions
- Summary

MRI

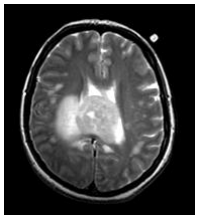
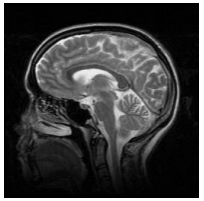
White Matter Tracts &connectivity

1994- Diffusion Tensor Imaging (DTI)

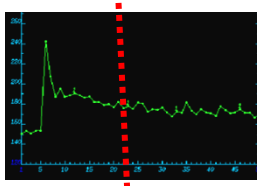
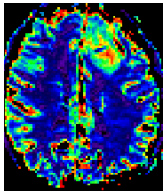
Structure

Conventional MRI contrasts & advanced methods

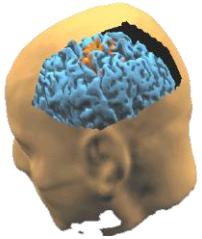
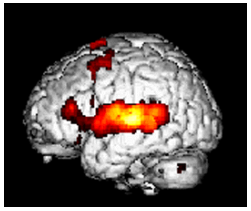
PD,T1W, T2W, T2*W, T1W+Gd

Vascular techniques: Perfusion, MRA/MRV

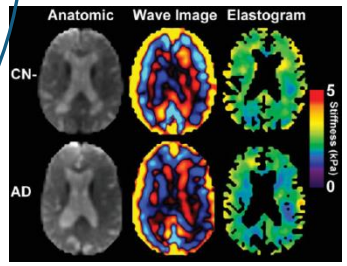
Brain Function

1990 – BOLD Functional Imaging (fMRI)

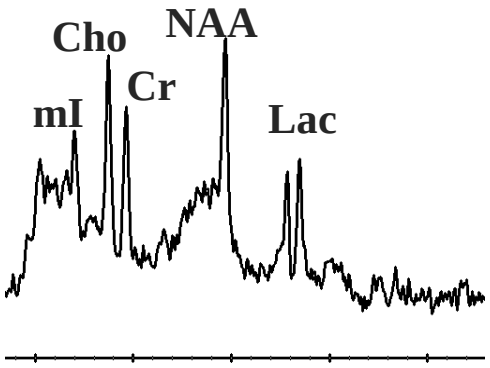
Mechanical Properties

Elastography



Metabolites

Spectroscopy

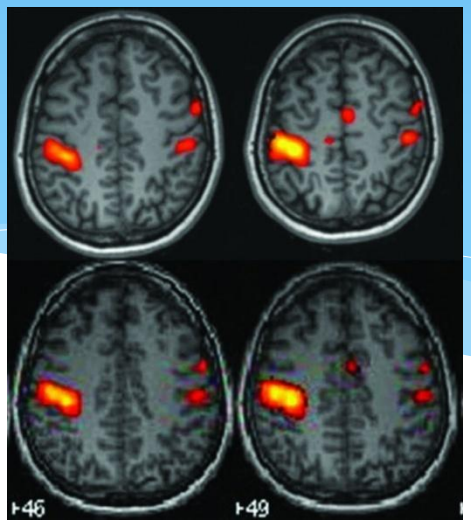


fMRI – Functional Magnetic Resonance Imaging

- Measures Brain <u>Function</u>

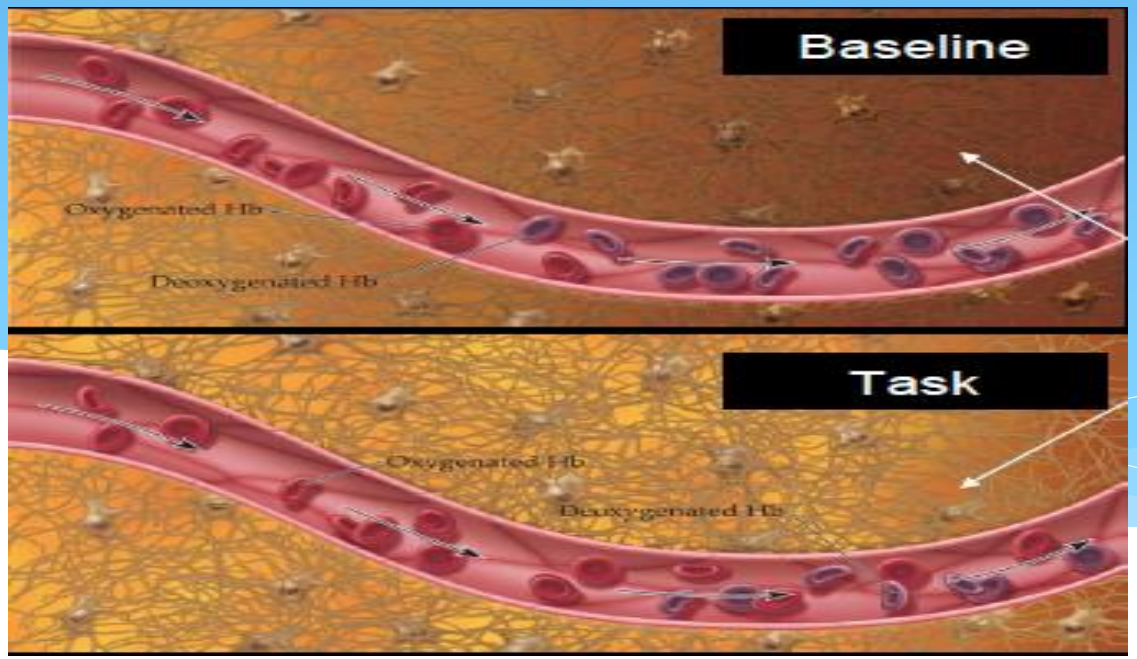
- Examination of brain regions while those regions are functionally engaged in a specific cognitive, affective or motor task

- Indirect Measurement of neural activity



BOLD – Blood Oxygen Level Dependent Response

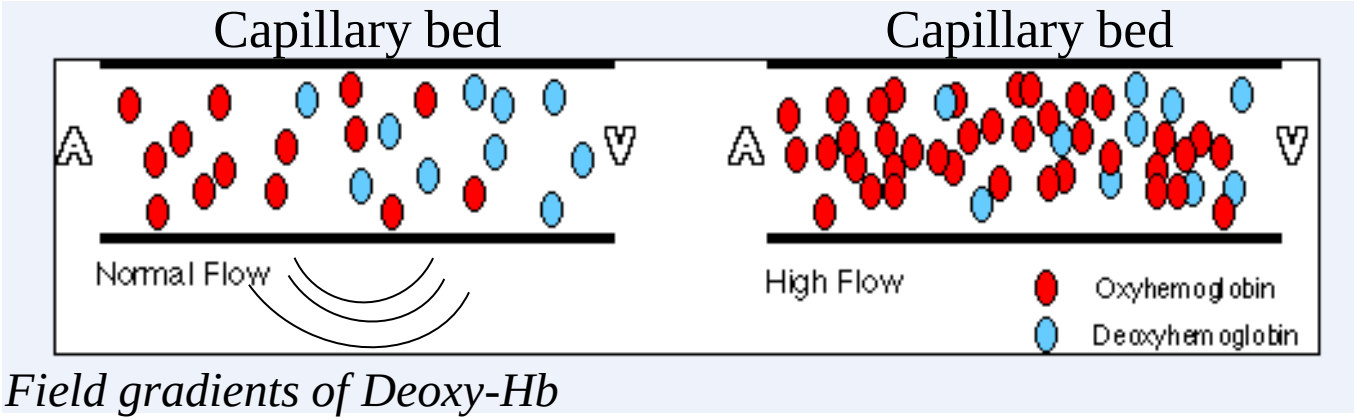
- ↑ neuronal activity ↑ O_2 = ↑ Blood Oxygen Level Dependent (BOLD) Response.
- ↑ Oxygenated/deoxygenated hemoglobin ratio



BOLD – Blood Oxygen Level Dependent Response

Baseline state

Activated state



Field gradients of Deoxy-Hb

Normal Flow
Baseline Hb
Baseline CBV
Normal MRI signal

Increased CBV
Increase HbO_2, less deoxy-Hb
Increased MRI signal

Block Design

Stimuli of the same condition presented in groups

Visual

Language

فكر في عمل يدل على الكلمة

Auditory

Motor

Memory

Words, faces, letters

fMRI Tasks – Verb Generation

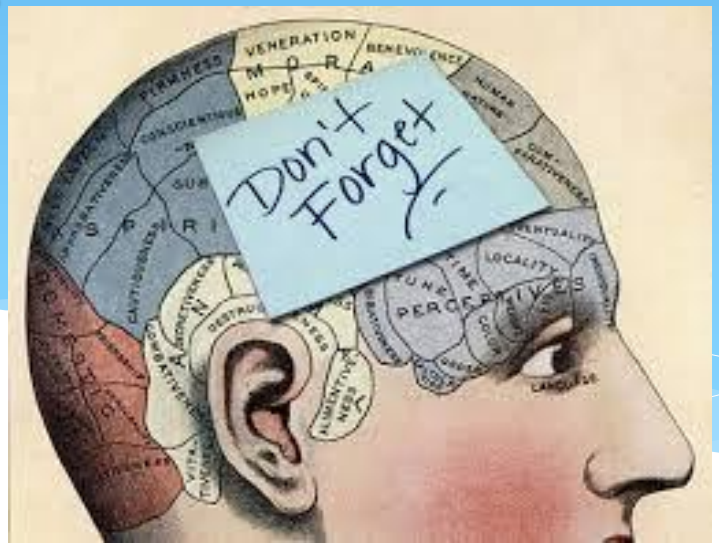
- A series of nouns is presented on screen, and the subject thinks of a verb that is associated with it.
-For instance: cup ⟶ drink, wash, hold, etc.
- Measures the anterior language areas

fMRI Tasks – Semantic Decision

- A series of sentences is displayed on the screen, and the subject thinks (speaking is not needed) whether the sentence is logic
- Logical Sentence: The child ate the apple
- Illogical Sentence: The child ate the washing machine

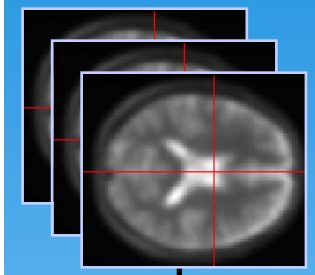
fMRI Tasks – Verbal Memory

- A series of sentences\nouns from the previous tasks is displayed on screen, mixed with blocks of new words, and the subject has to decide whether or not he has seen them before.

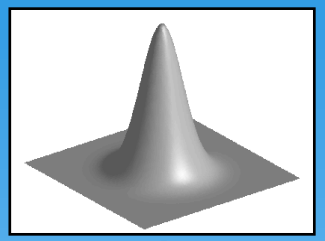


Basic Framework of fMRI Analysis

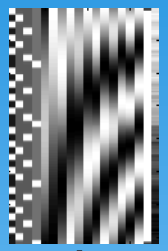
fMRI time-series



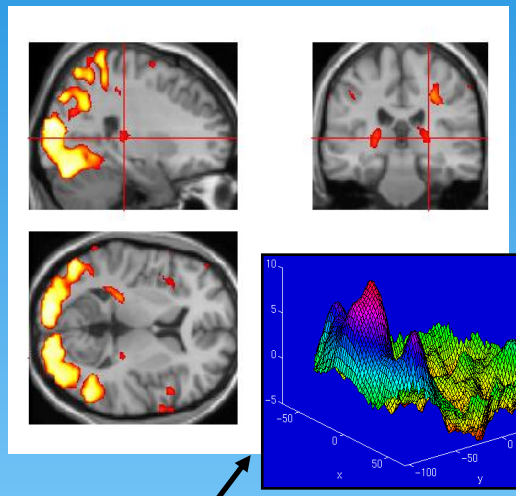
kernel



Design matrix



Statistical Parametric Map

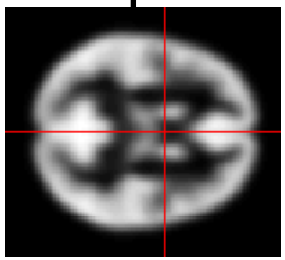


Motion correction

Smoothing

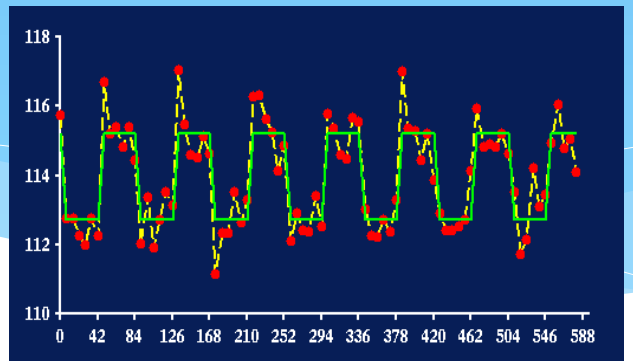
General Linear Model

Spatial normalisation



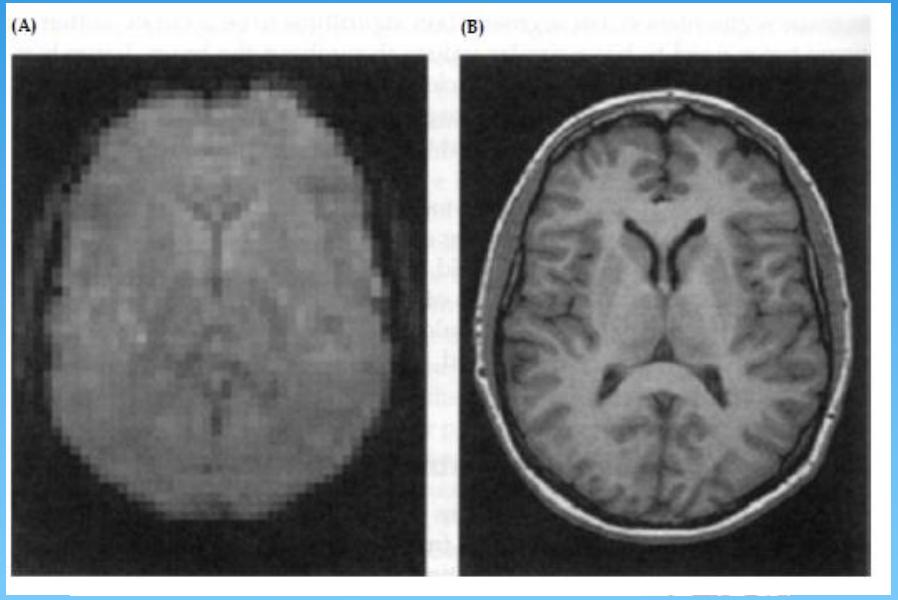
Standard template

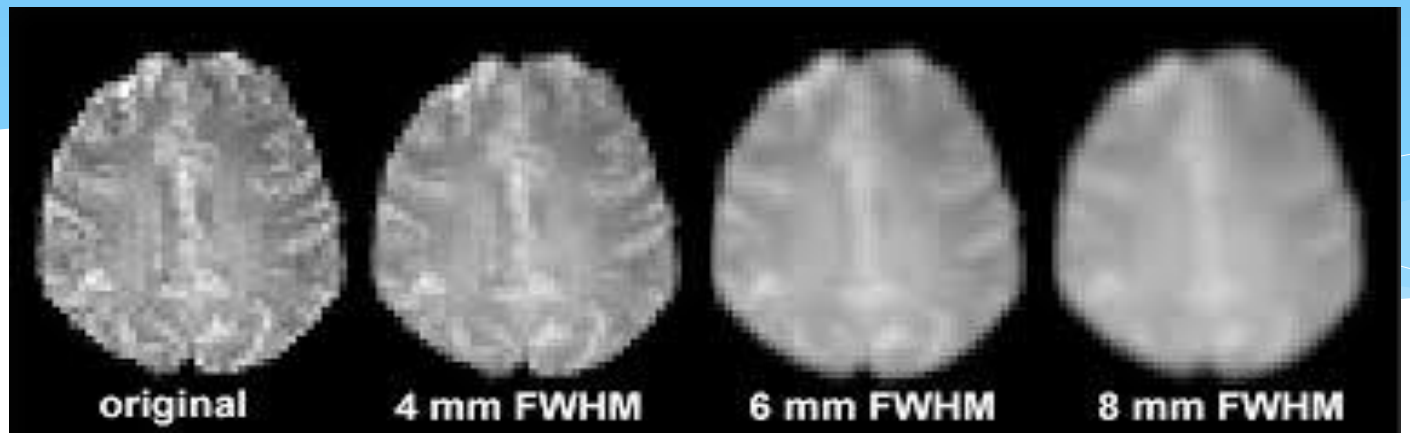
Parameter Estimates



fMRI Analysis - Spatial PreProcessing

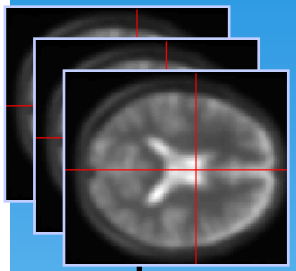
1. Realignment
2. Segmentation
3. Coregistration
4. Normalization
5. Smoothing



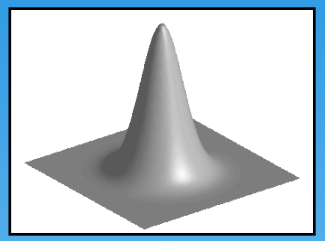


Basic Framework of fMRI Analysis

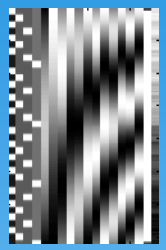
fMRI time-series



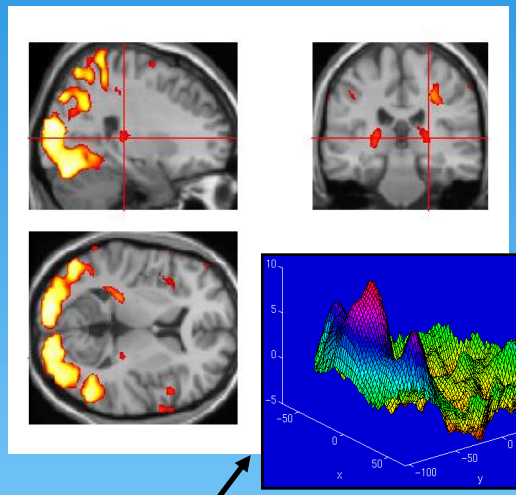
kernel



Design matrix



Statistical Parametric Map

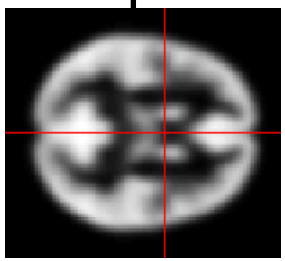


Motion correction

Smoothing

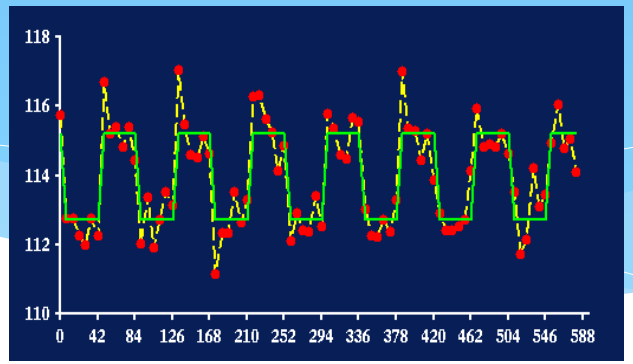
General Linear Model

Spatial normalisation

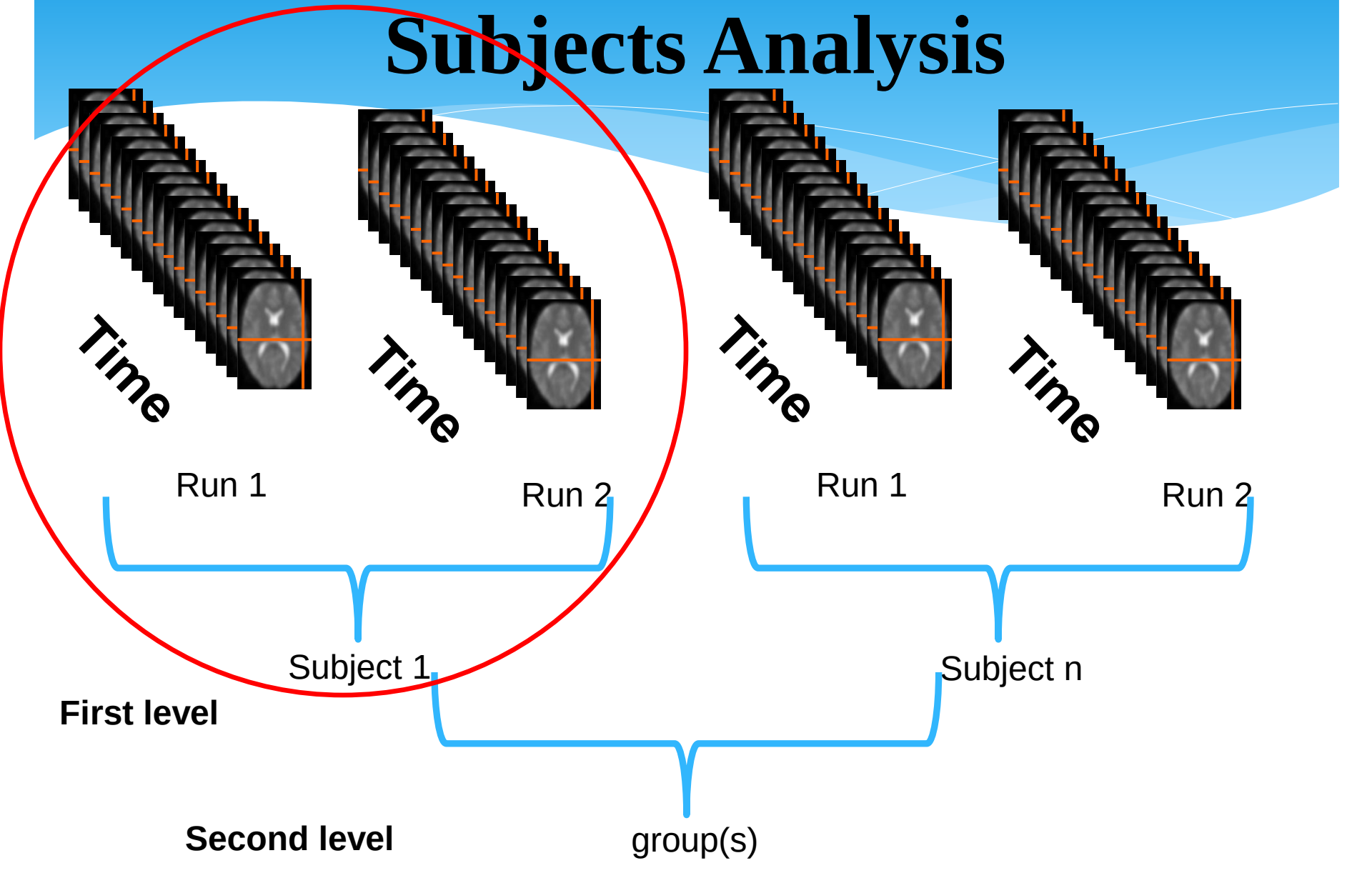


Standard template

Parameter Estimates



1st level Analysis - Within Subjects Analysis

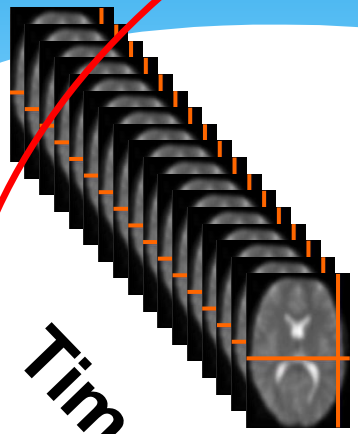


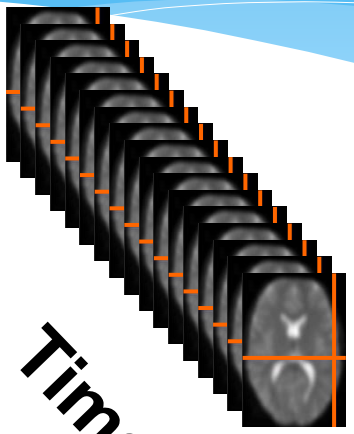
fMRI Analysis – 1st Level

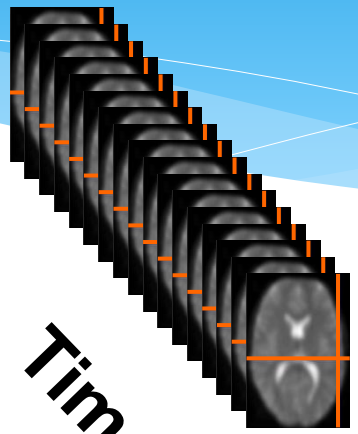
-Measuring within each subject which areas are activated during activity in comparison with a resting state

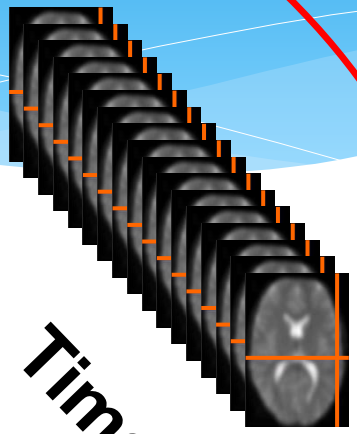
- Based on the General Linear Model

2nd Level Analysis - Between Subjects Analysis









Run 1

Run 2

Run 1

Run 2

Subject 1

Subject n

First level

Second level

group(s)

fMRI Analysis – 2nd Level

-Measuring between subjects which areas are activated during activity in comparison with a resting state

- After acquiring the statistical map for each subject, we use them to determine what's similar between them (1-sample t-test) or compare between populations (2-sample t-test).

Study Objective

- To compare the lateralization of anterior language and memory areas in a Verb Generation (VG) task and a subsequent Memory Word Recollection (MWR) task using a similar word list

Study Methods – General

- 22 healthy participants underwent an fMRI examination using a 3T MRI.
- Participants were males+females, right handers, between the ages 20-40
- Not all participants underwent all 3 tasks.
- fMRI acquisition: T2* weighted, GRE sequence TR/TE 4000/35, FOV 22cm, matrix 64X64, 3.4mm^3 resolution.

Study Methods – Data Analysis

- Following preprocessing, contrasts of interest were produced for each subject and task, using GLM.
- Data was analyzed using SPM8 software.

Study Methods – Data Analysis

- **Laterlization Index:**

$$LI = \frac{L - R}{L + R}$$

- **2*2 ANOVA analysis of Broca's+Hippocampus**

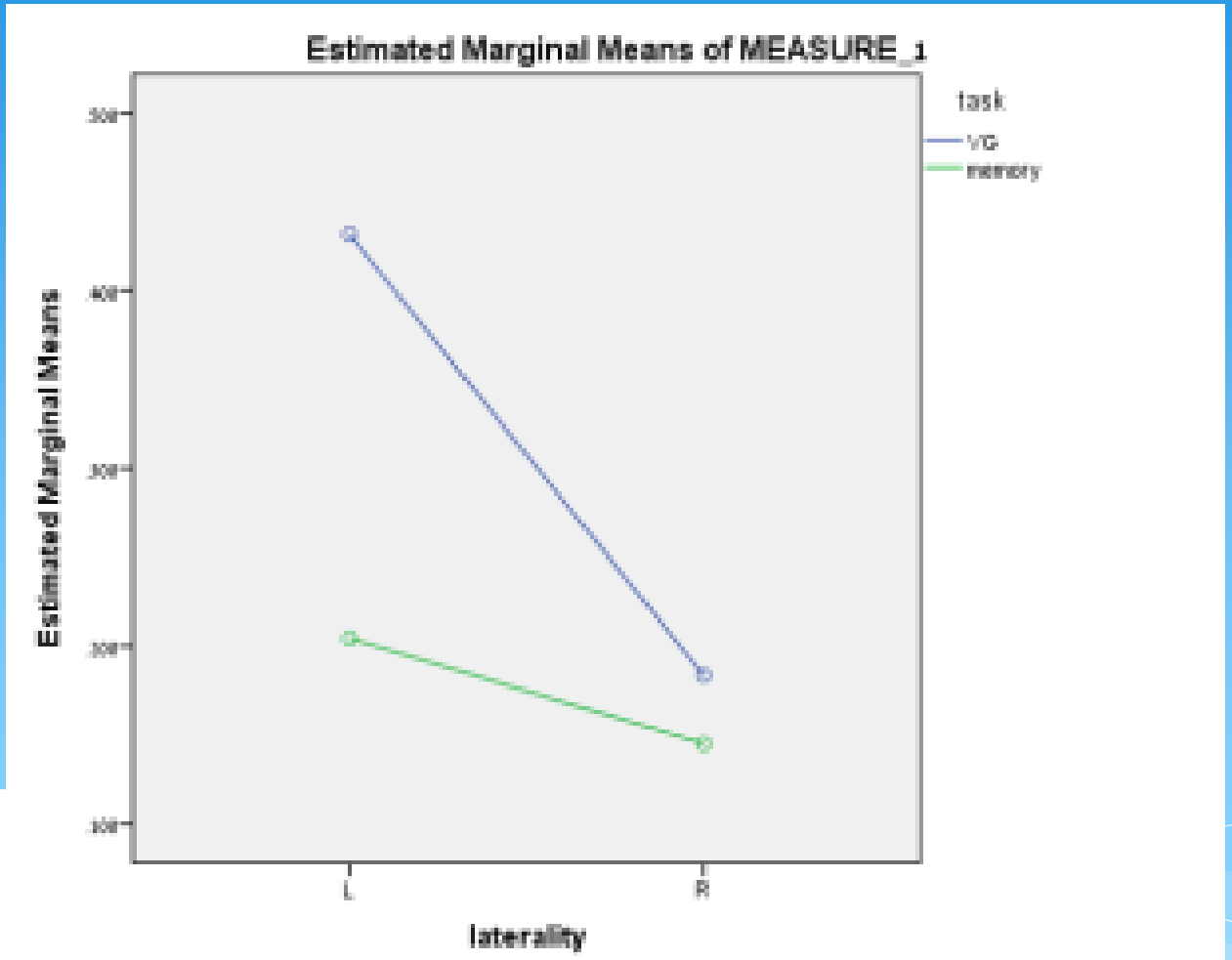
Study Results - Lateralization

- VG task's brain activation was significantly ($p<0.05$) left lateralized ($M = 0.41$, $SE = 0.30$), compared to that of the MWR task's ($M = 0.00$, $SE = 0.32$).

Study Results – Broca's Area

- Task: The two-factor analysis of variance for Broca's area showed no main effect for task, $F(1,21)=3.63$, $p>0.05$;
- Laterality: main effect for laterality, $F(1,21)=29.5$, $p<0.01$
- Interaction: interaction between task and laterality, $F(1,21)=21.27$, $p<0.01$

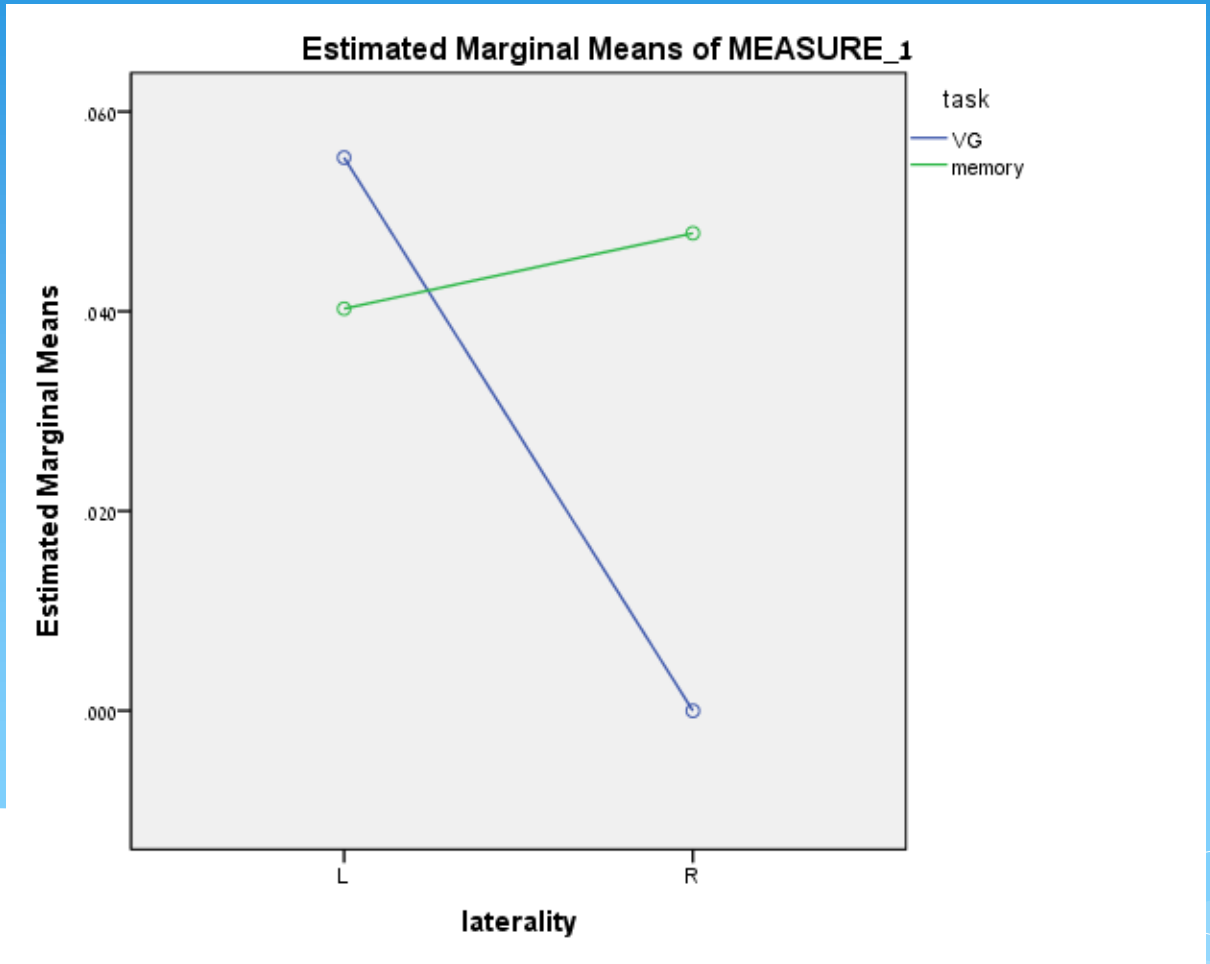
Study Results – Broca's Area



Study Results - Hippocampus

- **Task: The two-factor analysis of variance for the hippocampus showed no main effect for task, $F(1,21)=0.13$, $p>0.05$;**
- **Latearlity: main effect $F(1,21)=4.63$, $p<0.05$**
- **Interaction: A significant interaction between task and laterality, $F(1,21) = 22.46$, $p<0.01$**

Study Results - Hippocampus



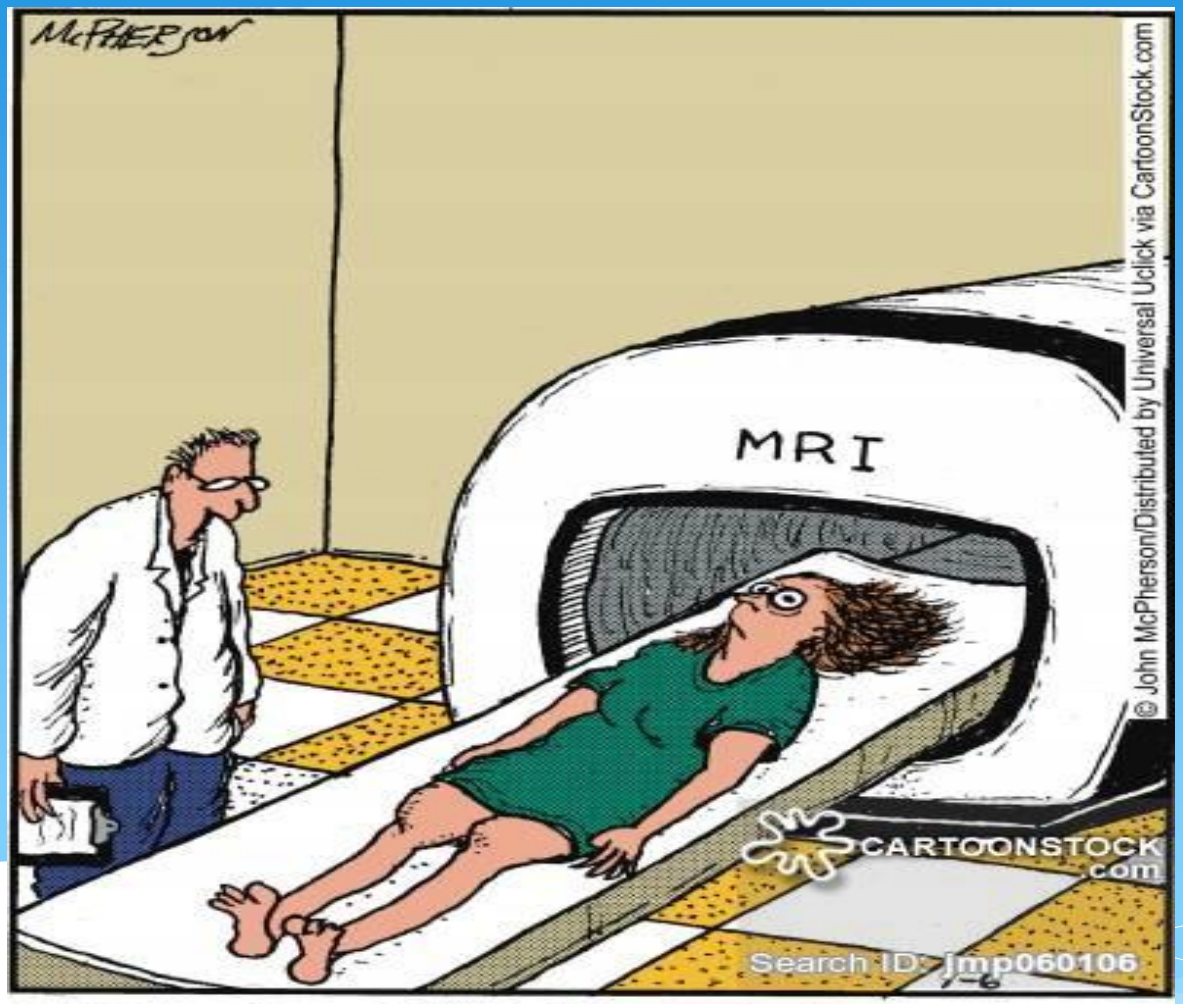
Study Conclusion

- When switching from a VG to MWR task, the engagement of left Broca and the Hippocampus was reduced and the right contralateral areas kicked in, suggesting that the lateralization of language representation may be task-dependent.

What's Next?

- Doing the same analyses for the semantic decision task and finding out whether this task bears similar/different results
- The final results may help us better understand the connectivity and mechanism of human speech, help patients who are suffering from speech-related problems and assist surgeons in carrying out operations.

Thank You!



"OK, Mrs. Dunn. We'll slide you in there, scan your brain, and see if we can find out why you've been having these spells of claustrophobia."