fMRI

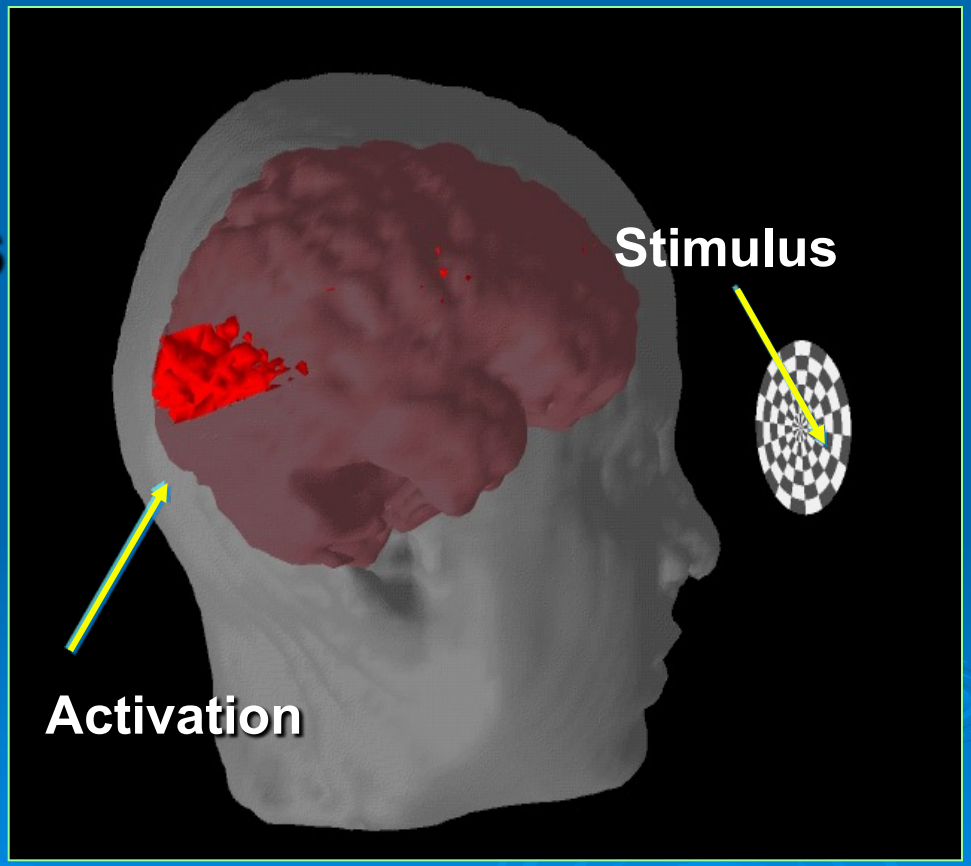
The essential steps

- to acquire images over time in order to describe a time series
- to make the MRI signal intensity depend on neural activity
  - BOLD contrast
  - Other contrast mechanisms
    - Water diffusion (discussed later)

fMRI

Images are acquired multiple times while the subject performs tasks to systematically vary the neuronal activity

- time series
- type of task: cognitive, sensory, motor, etc



Types of Experimental Designs

- **Categorical**

comparing the effect of one task to the effect of another task (or rest)

- **Parametric**

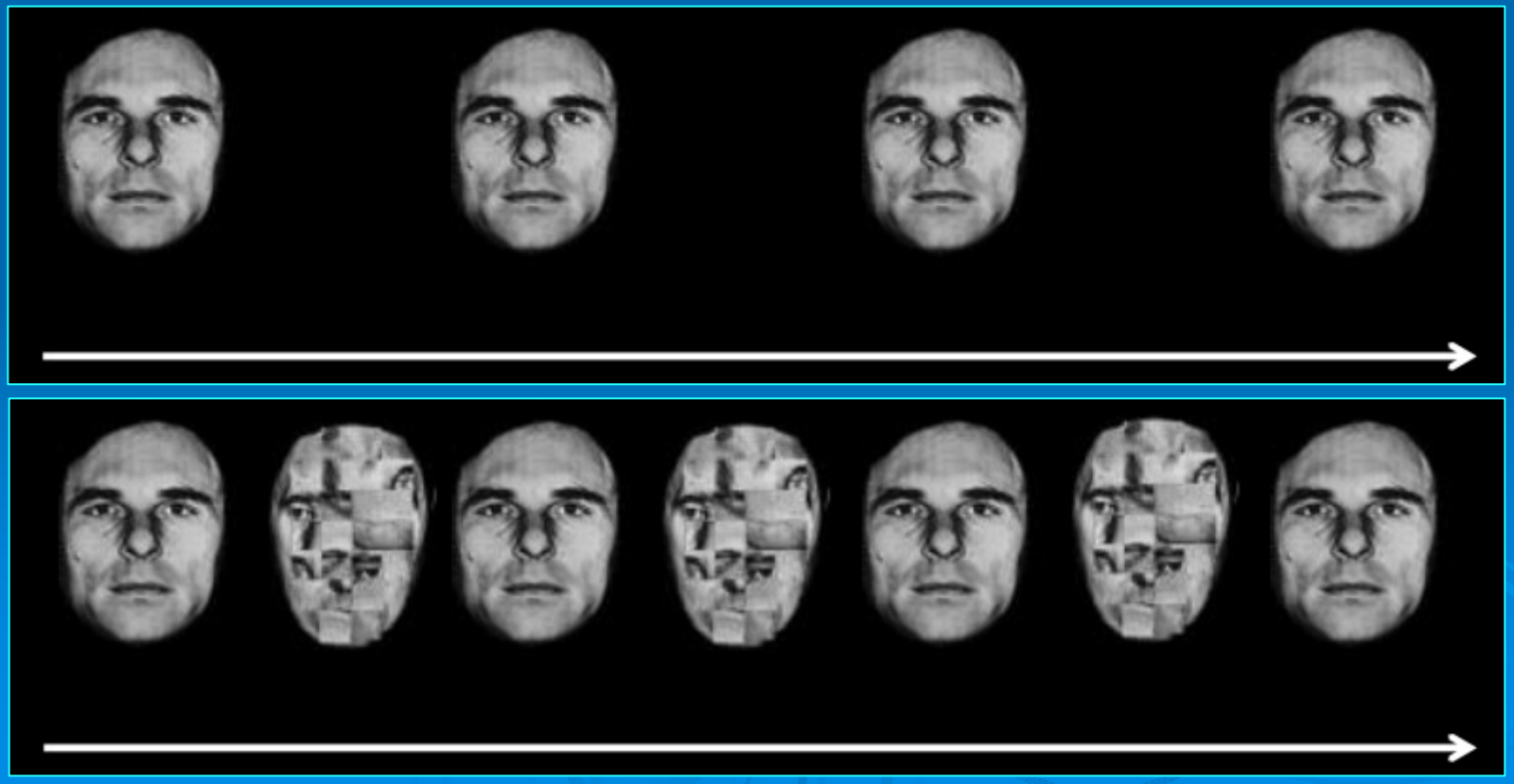
varying ‘doses’ of task

- **Factorial**

combining two or more factors within a task and looking at the effect of one factor on the response to other factor(s)

Categorical design

The design of the reference or baseline state is as important as the design of the stimulus



Petra Schweinhardt 2013

Parametric Design

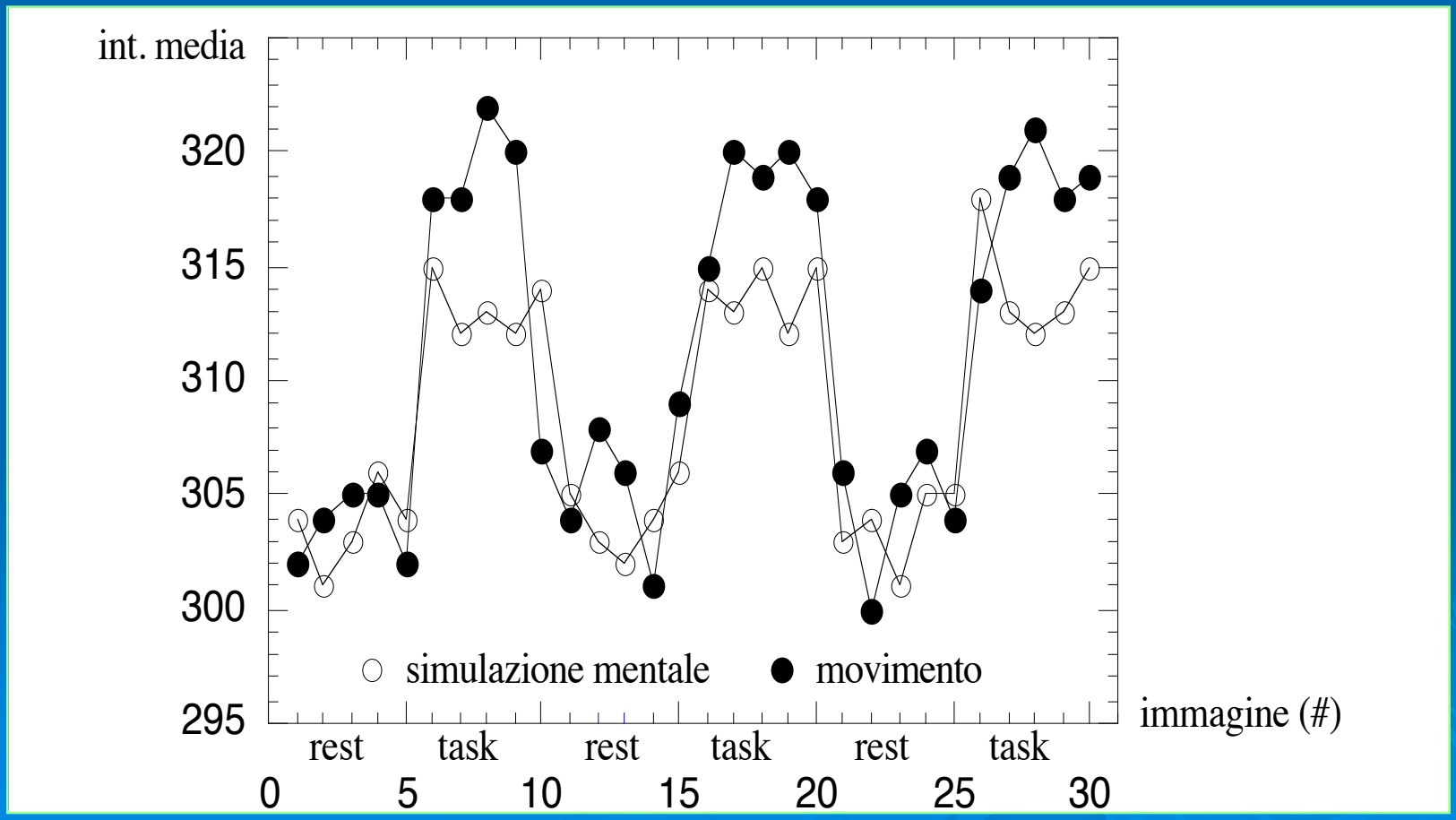
- Exploring systematic changes in the brain responses according to intesity of task
  - difficulty levels, increasing sensory input

- Hypothesis

as task dose changes, BOLD response changes

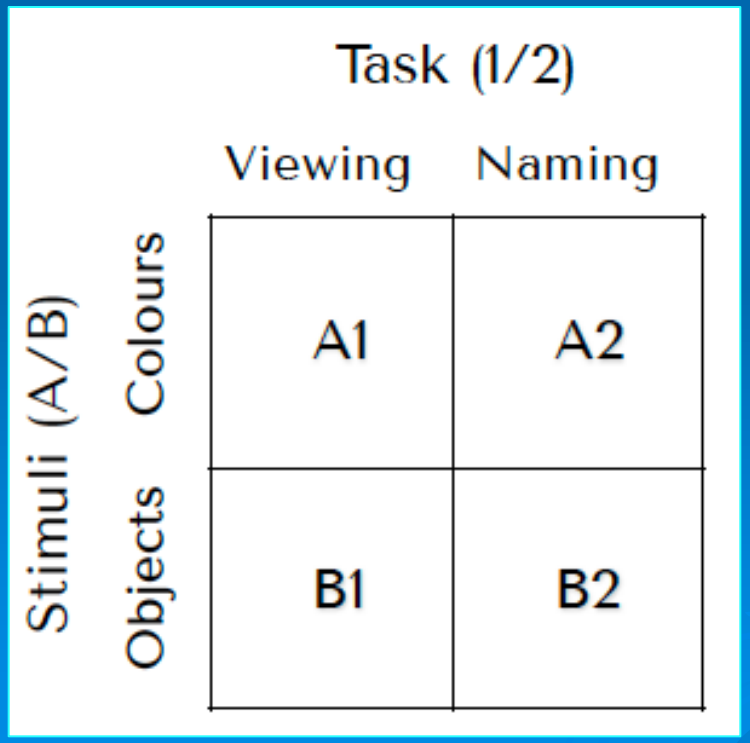
  - Linear
  - Nonlinear
  - Model-based (e.g. predictions from learning models)

Task vs. imaginary task (finger tapping)



Factorial design

Combining two or more factors within a task and looking at the effect of one factor upon the other(s)

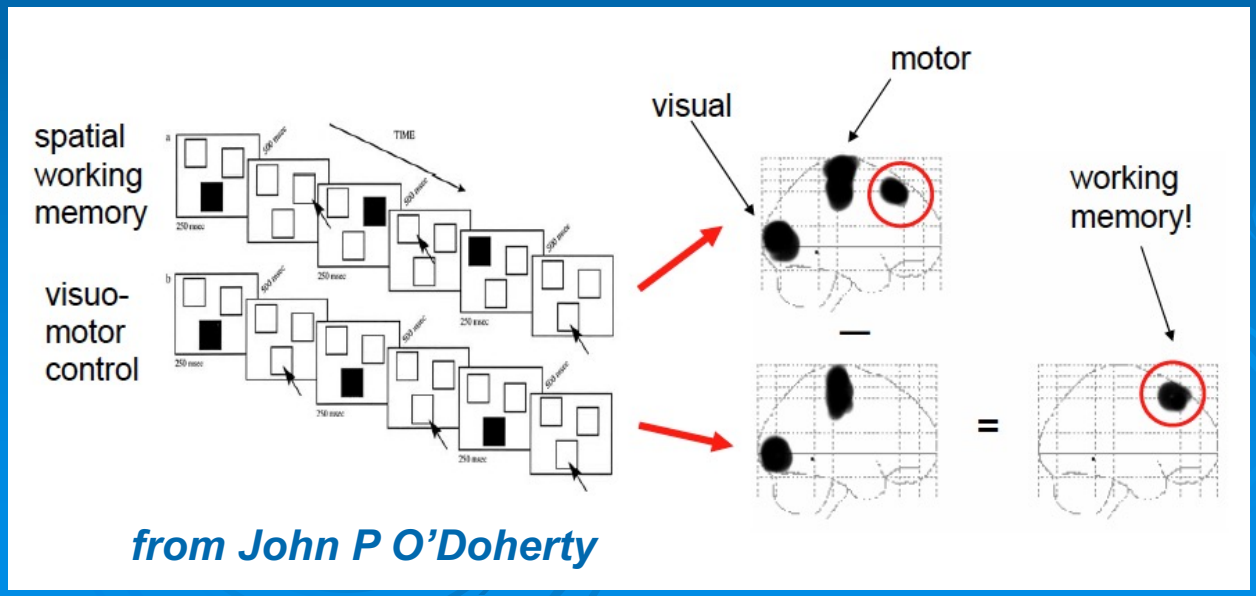


- Main effect of task: $(A1 + B1) - (A2 + B2)$
- Main effect of stimuli: $(A1 + A2) - (B1 + B2)$

Interaction of task and stimuli:
$(A1 - B1) - (A2 - B2)$

Criticisms of Subtraction Paradigm

- ✓ We assume that adding components to the task does not affect other processes
  - i.e. assumption of pure insertion
- ✓ We design tasks that differ along one significant detail
  - change the task or the stimuli but not both!



from John P O'Doherty

fMRI data processing

A challenge for fMRI is to separate image changes due to

- neural function
- physiological motion
- movement of the person being studied
- random noise
- subtle changes in the MRI system itself
  - such as due to heating, vibration, electrical power supply fluctuations, etc.

https://www.imaios.com/en/e-Courses/e-MRI/Functional-MRI/analysis-functional-mri-data

fMRI data processing

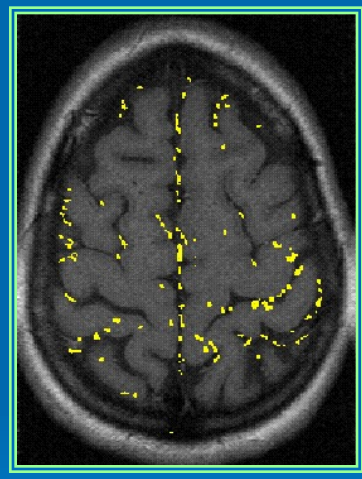
A challenge for fMRI is to separate image changes due to

- neural function
- physiological motion
  - cardiac cycle
  - breathing
- movement of the person being studied
- random noise
- subtle changes in the MRI system itself
  - such as due to heating, vibration, electrical power supply fluctuations, etc.

fMRI data processing

A challenge for fMRI is to separate image changes due to

- neural function
- physiological motion
- movement of the person being studied
  - Head motion artifact discussed previously
- random noise
- subtle changes in the MRI system itself
  - such as due to heating, vibration, electrical power supply fluctuations, etc.



https://www.imaios.com/en/e-Courses/e-MRI/Functional-MRI/analysis-functional-mri-data

fMRI data processing

A challenge for fMRI is to separate image changes due to

- neural function
- physiological motion
- movement of the person being studied
- random noise
  - Higher the magnet field higher the SNR
- subtle changes in the MRI system itself
  - such as due to heating, vibration, electrical power supply fluctuations, etc.

https://www.imaios.com/en/e-Courses/e-MRI/Functional-MRI/analysis-functional-mri-data

fMRI data processing

A challenge for fMRI is to separate image changes due to

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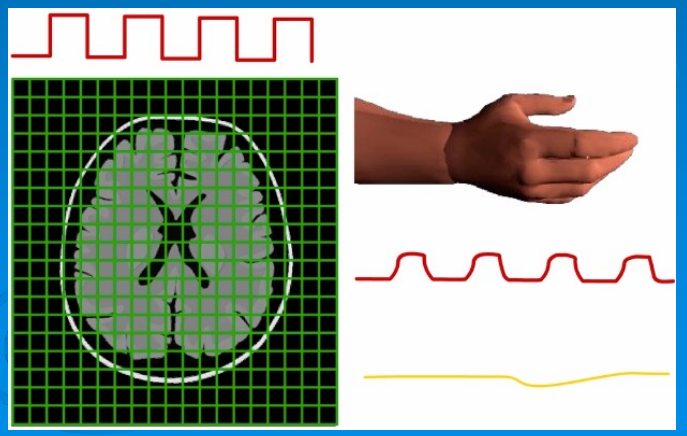


https://www.imaios.com/en/e-Courses/e-MRI/Functional-MRI/analysis-functional-mri-data

Study design

- ✓ What we want to study
  - requested spatial and temporal resolution
- ✓What region of the brain
  - ✓Are there problems of artifacts in that area?
- ✓Are there simpler or cheaper techniques?
- ✓What do you hope to see and what is the null hypothesis?
  - condition of rest ?
  - uniquely defined ?
  - which statistical analysis ?

Optimal spatial resolution

Theoretical: 1.5 mm cubic voxel

- **Approximate size of the smallest vascular unit**
  - **The extent of the smallest region that is supplied by a single arteriole**

practicals

Each group will acquire

- 2 fMRI exams
- 1 DWI and 1 DTI data set

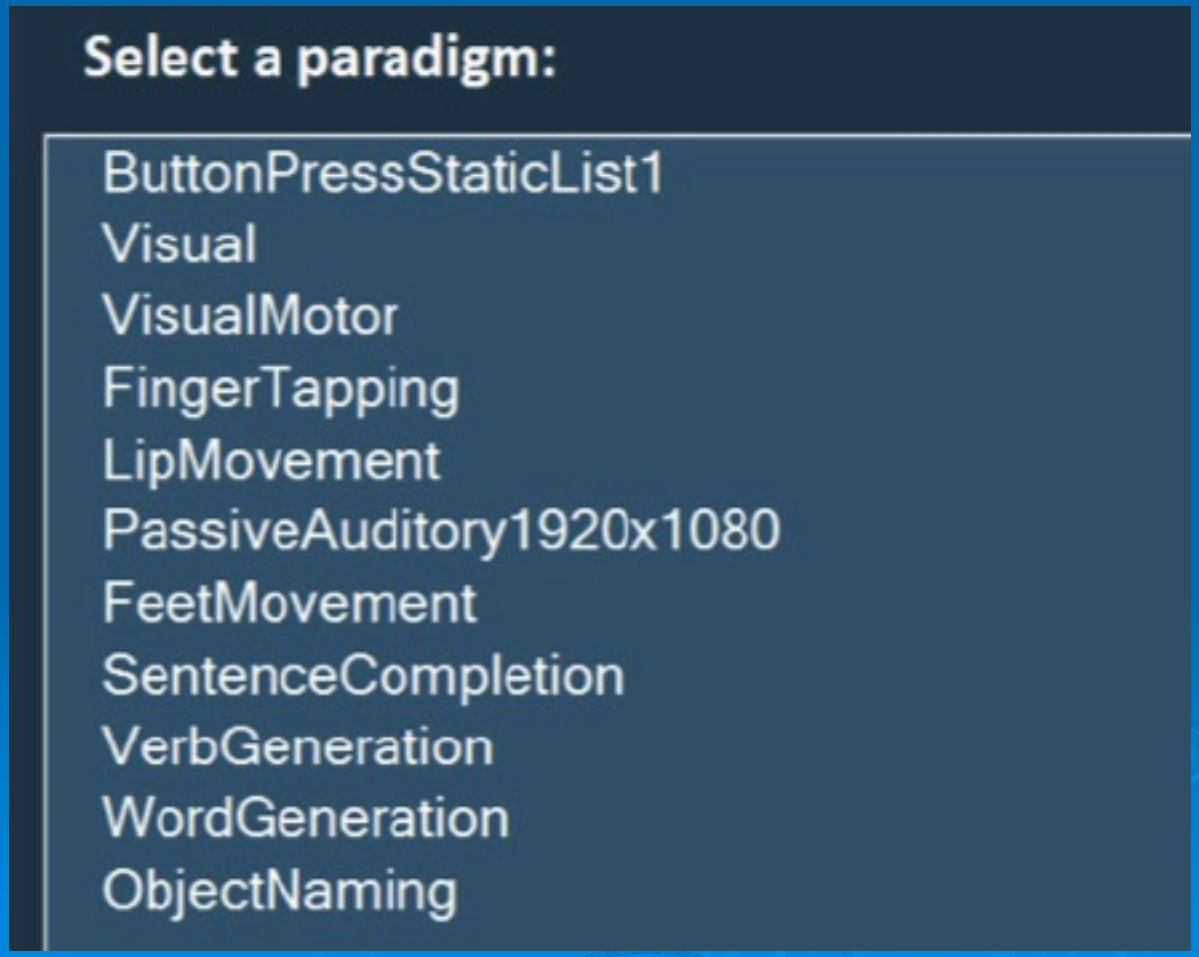
Data processing

- fiber tracking from DTI data set
- fMRI data processing

Available fMRI protocol

Clinically validated fMRI paradigms

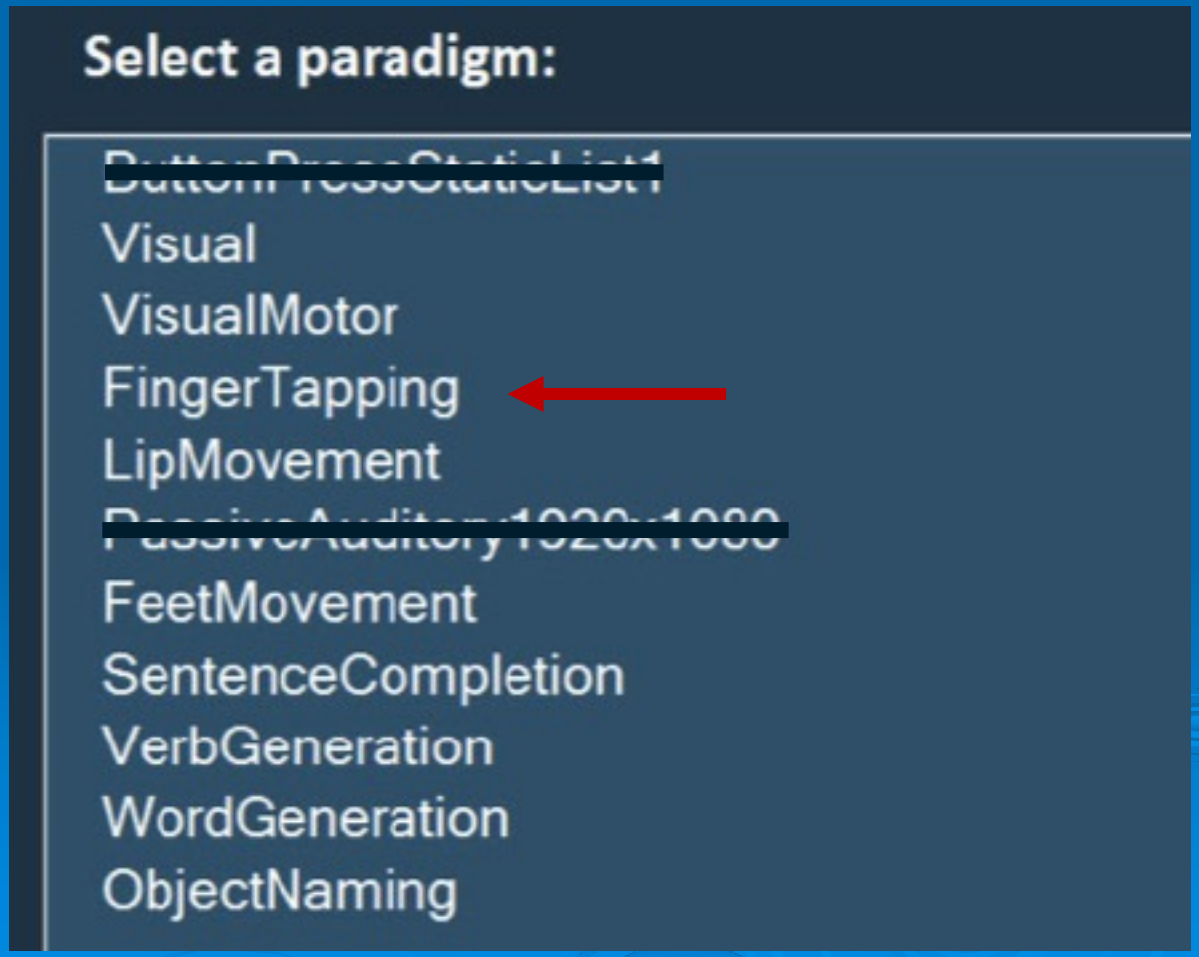
- **pre-loaded with the system**
- **synchronized with the MRI scanning protocol**



Available fMRI protocol

Each group acquires

- finger tapping
- Another paradigm of its choice
  - May be 2 if make sense in term of science



Available fMRI protocol

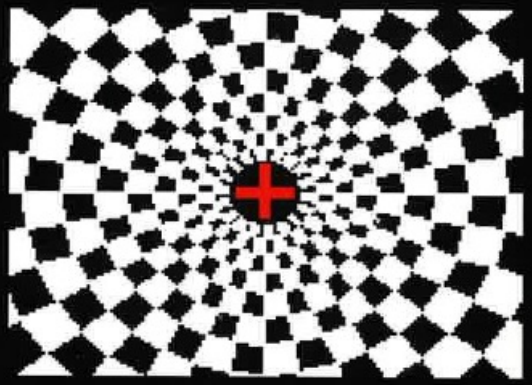
Available fMRI protocol

Visual Task

Always look at the small '+'.

The `+' may be the only item on the screen.

Sometimes the `+' will be on top of flashing checkerboards.



Keep looking at the '+' the whole time.

Available fMRI protocol

Visual Motor Task

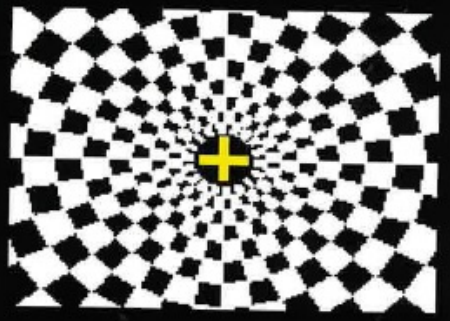
There are 2 tasks:

– **Motor:**

- Tap your fingers while you see the picture of a hand.
- DO NOT move any other part of your body.

– **Visual Flashes:**

- After a while, the hand disappears and it is replaced by flashing checkerboards.
- Keep your eyes open and focus on the "+"

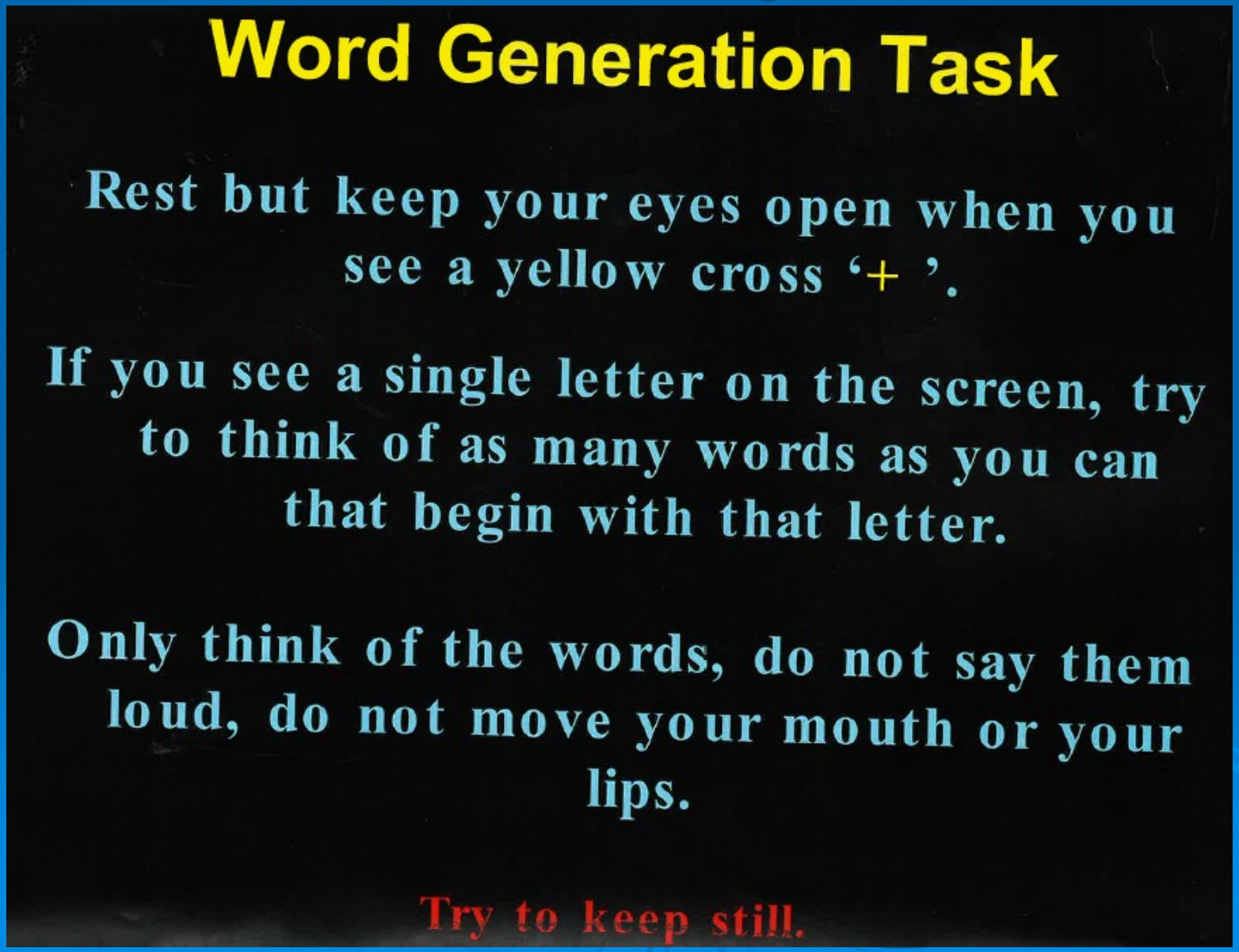


Try to keep your head still all the time.

Available fMRI protocol

Available fMRI protocol
Feet movement

Available fMRI protocol



Available fMRI protocol

Sentence Completion Task

- Rest but keep your eyes open when you see a series of nonsense letters.

Example: Fkoniwe kasd iepaw akd ____dfe.

In Italian ….

- If you see an English sentence, read it to yourself and thin of a word that fits into the blank.

Example: Young cats are called _____.

- Don't speak out loud, don't move your mouth or lips.

Try to keep still.

Available fMRI protocol

Object Naming Task

Rest and relax when you see: ⊕

Try to relax and do nothing. Do not say to yourself the name of the object on the screen.

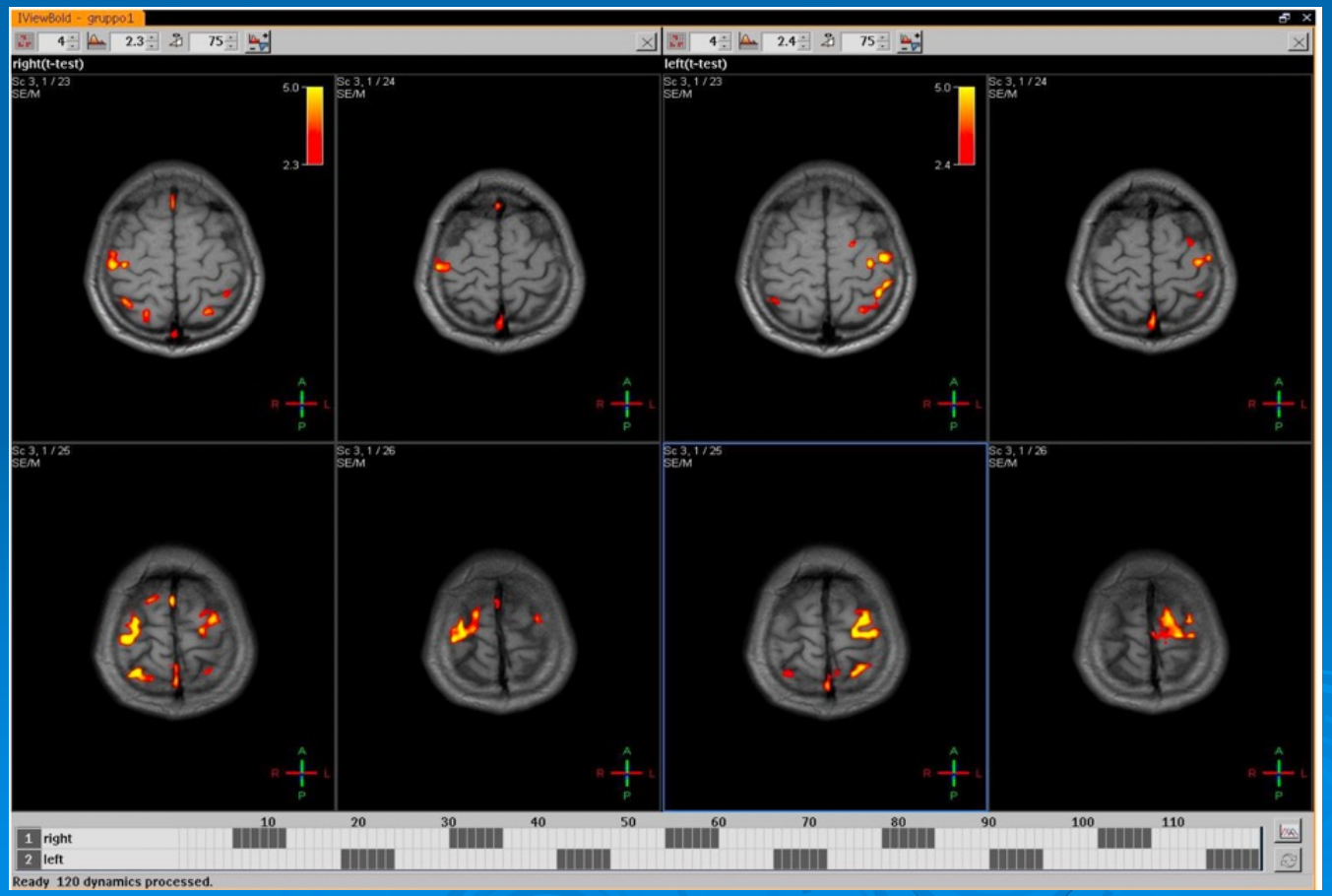
When you see the picture of an object like:

Think at the name of the object

Try to keep still.

Available fMRI experiments

Finger tapping protocol can be applied 2 times to investigate lateralization



Before practicals

- Select a volunteer
  - MRI compatible !!!
- Select your paradigms
  - What are the expected activated areas?
  - What can we learn comparing the results of different paradigm?

During practicals

Collect information for the report

- Data acquisition
- Data analyses
- Fiber tracking of various tracts
- Comparison between DWI and FA map
- Time course of the BOLD signal during the fMRI experiment

Safety

- No ionizing radiation
- The magnetic field is 10000 times higher than our Earth field !

Safety

- Static magnetic field strengths greater than 1.5 T may induce mild sensory effects when a person moves within the field
- Time-varied gradient field strength may cause peripheral nerve stimulation
  - Gradients are measured in gauss per centimeter per second
- The RF pulses have the potential to heat tissue
  - Due to the conductivity of the tissues
  - Pay attention tattoo !!!

Safety

- ferromagnetic objects: the static magnetic field may torque the object and exert a translational force

- Prior to MR imaging examinations, technologists and clinicians should carefully question patients about whether they have ferromagnetic implants
  - surgical clips, coils, stents, and pacemakers
  - tatoo

https://educationalgames.nobelprize.org/educational/medicine/mri/game/index.html

Safety

- Fatal accidents in MR imaging were caused by the failure to identify subjects with a cardiac pacemaker
  - New cardiac pacemakers are MRI compatible
- The FDA recently received several reports of serious injury in patients with neurologic stimulators
  - including coma and permanent neurologic impairment

Safety

Projectile effect

- **Magnetic objects are attracted at high speed to the scanner**
- **Severe or fatal injury to the patient is possible**

QUESTIONARIO PRELIMINARE ALL'ESECUZIONE DI RISONANZA MAGNETICA

Soffre di claustrofobia ?	Si		No	
Ha mai lavorato (o lavora) come saldatore, tornitore, carrozziere	Si		No	
Ha mai subito incidenti stradali o di caccia?	Si		No	
E' stato vittima di traumi da esplosioni?	Si		No	

Ha mai subito interventi chirurgici? Si | | No | |

(se **SI** specificare tipo d'intervento, Strutture ed anno presso le quali sono stati eseguiti)

	TIPO	STRUTTURA/OSPEDALE	ANNO
Testa-collo			
Torace			
Addome			
estremità-altro			

Ha già eseguito Risonanze Magnetiche dopo gli interventi chirurgici subiti? Si | | No | |

QUESTIONARIO PRELIMINARE ALL'ESECUZIONE DI RISONANZA MAGNETICA

E' portatore di :

Pace-maker cardiaco o altro tipo di cateteri cardiaci?	Si		No	
Punti chirurgici metallici in sede vascolare (aorta, cervello) o dispositivi endovascolari ferromagnetici (filtri, stent da meno di 6 settimane). Testa ☐ Addome ☐ Collo ☐ Torace ☐ Altro ☐ Data impianto:	Si		No	
Valvole cardiache? Data impianto:	Si		No	
Distrattori (protesi) della colonna vertebrale?	Si		No	
Pompa di infusione per insulina o altri farmaci?	Si		No	
Corpi metallici nelle orecchie o impianti per udito? Data Impianto:	Si		No	
Neurostimolatori, elettrodi impiantati nel cervello o subdurali?	Si		No	
Catetere spinale o ventricolare (in pazienti affetti da idrocefalo), catetere di Schwan-Ganz?	Si		No	
Protesi metalliche (per pregresse fratture, interventi articolari correttivi, ecc) viti,chiodi,fili ecc… Eventuale localizzazione:	Si		No	
Protesi dentarie fisse?	Si		No	
Protesi dentarie mobili?	Si		No	
Protesi al cristallino o impianti oculari?	Si		No	
Schegge o frammenti metallici?	Si		No	

FIRMA PAZIENTE **FIRMA DEL MEDICO RADIOLOGO RESPONSABILE DELL'ESAME RM** --

_____ _____

QUESTIONARIO PRELIMINARE ALL'ESECUZIONE DI RISONANZA MAGNETICA

Questionario preliminare all'esecuzione di un esame di Risonanza Magnetica

E' affetto da anemia falciforme (anemia mediterranea) con ematocrito elevato?	Si		No	
E' sottoposto a dialisi?	Si		No	
E' affetto da insufficienza renale grave? Se **SI**, quale è il valore della Creatininemia?	Si		No	
E' portatore di piercing, cerotti medicati?	Si		No	
E' portatore di tatuaggi ?	Si		No	
E' portatore di qualche allergia? Se **SI** specificare il tipo:	Si		No	

Per le donne:

E' in stato di gravidanza ?	**Si**		**No**	
Data delle ultime mestruazioni				
E' portatrice di spirale endouterina (IUD)?	**Si**		**No**	
E' in allattamento?	**Si**		**No**	

Prima di eseguire l'esame di Risonanza Magnetica accertarsi di non indossare lenti a contatto, apparecchi per l'udito o protesi dentarie mobili, occhiali, fermacapelli, indumenti di materiale sintetico, oggetti metallici o schede magnetiche.
Indispensabile inoltre asportare cosmetici dal volto.
Il giorno dell'esame si ricorda di portare la documentazione relativa all'indagine in oggetto.

FIRMA DEL MEDICO RADIOLOGO RESPONSABILE DELL'ESAME RM

Practicals
Cattinara Hospital

Meeting at the entrance of the MRI units ground floor, radiology area

Thursday 9 November	14-16.30	group A
Thursday 9 November	16.30-19	group B
Thursday 23 November	14-16.30	group C
Thursday 23 November	16.30-19	group D
Thursday 30 November	14-16.30	group E
Thursday 30 November	16.30-19	group F