EXPERIMENTAL DESIGN, ETC.

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9/7/2017

TODAY

* Finish up intro from Tuesday

* Experimental design & natural stimuli

* Marr & understanding

NEUROPHYSIOLOGY

* Individual neurons can be characterized as having **receptive fields**

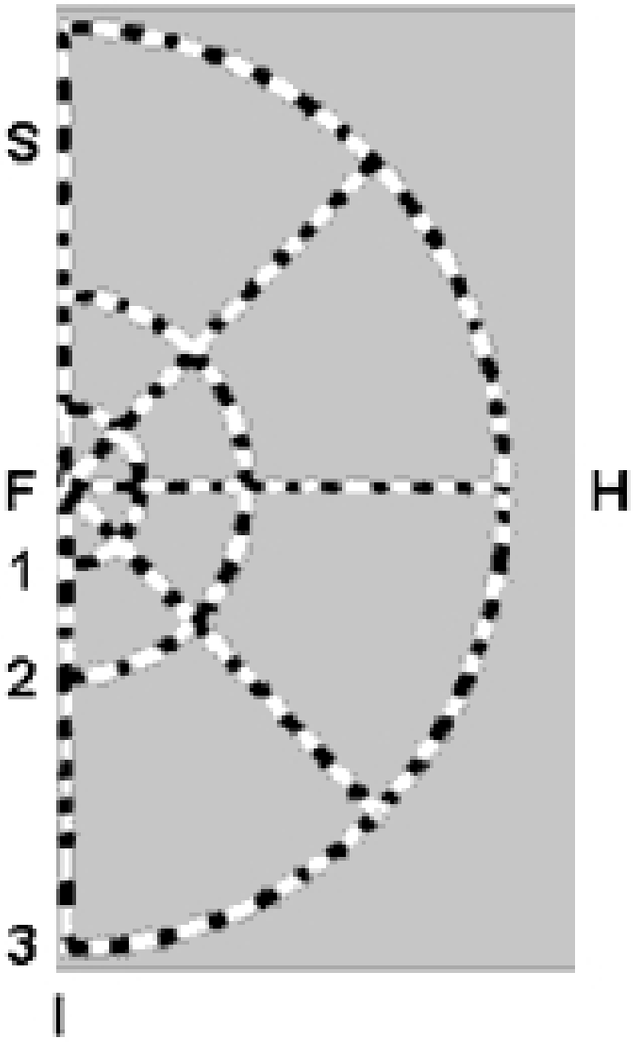
* A receptive field is the **stimulus subspace** that **elicits activity** in a neuron

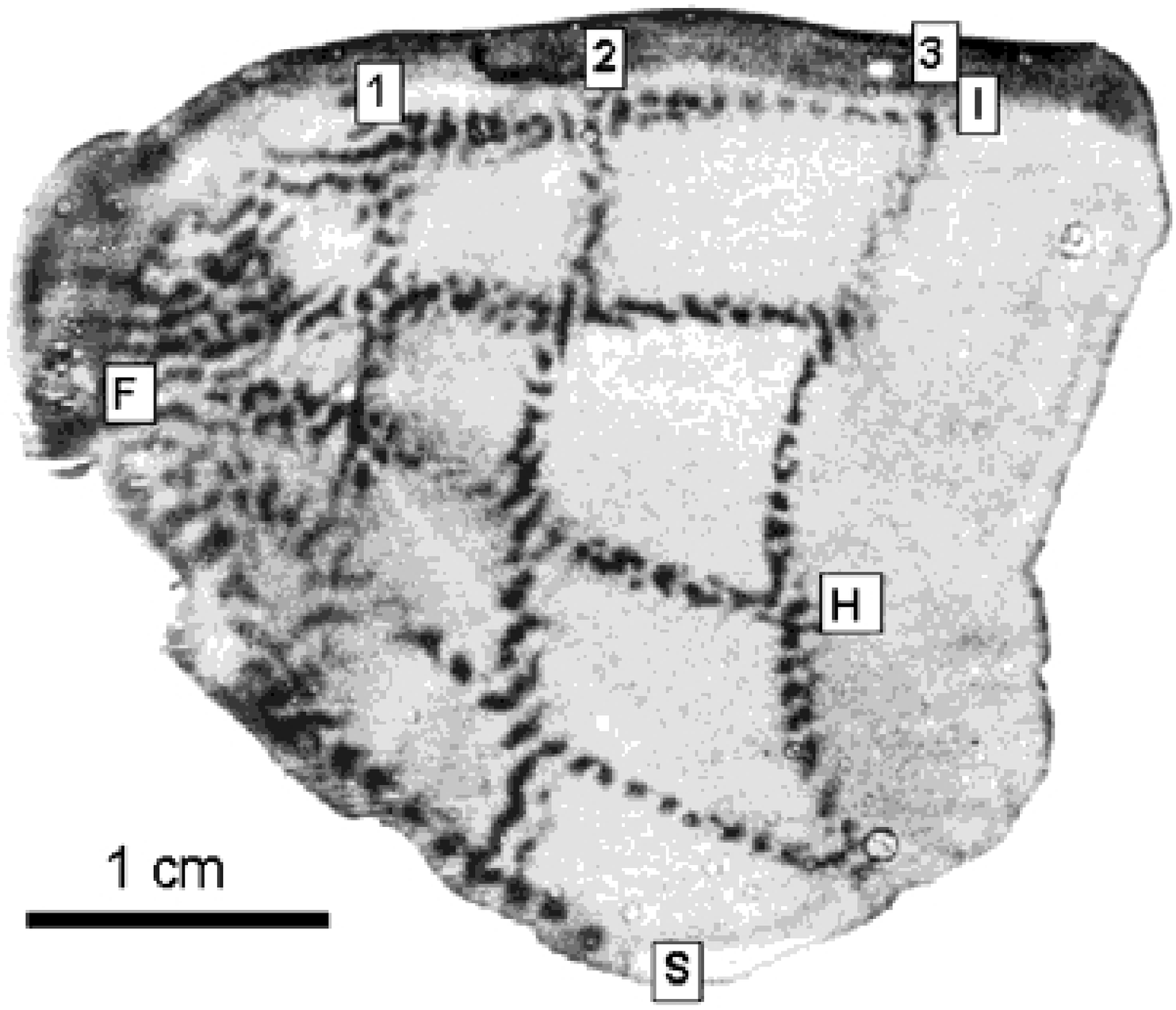
NEUROPHYSIOLOGY

* In cortex, many neurons are organized into **maps**

* *Nearby* neurons have *similar* receptive fields

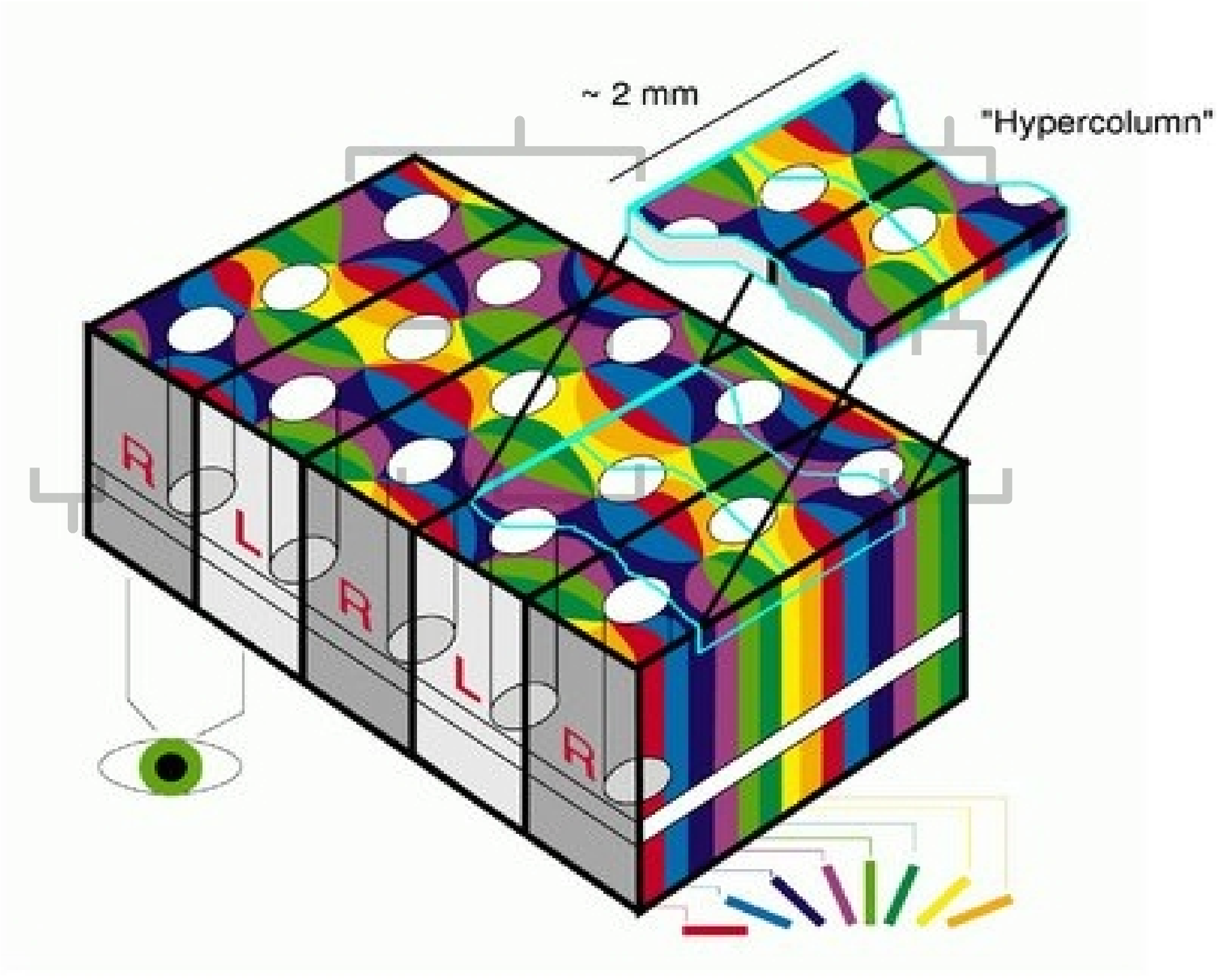
Retinotopic map in primary visual cortex



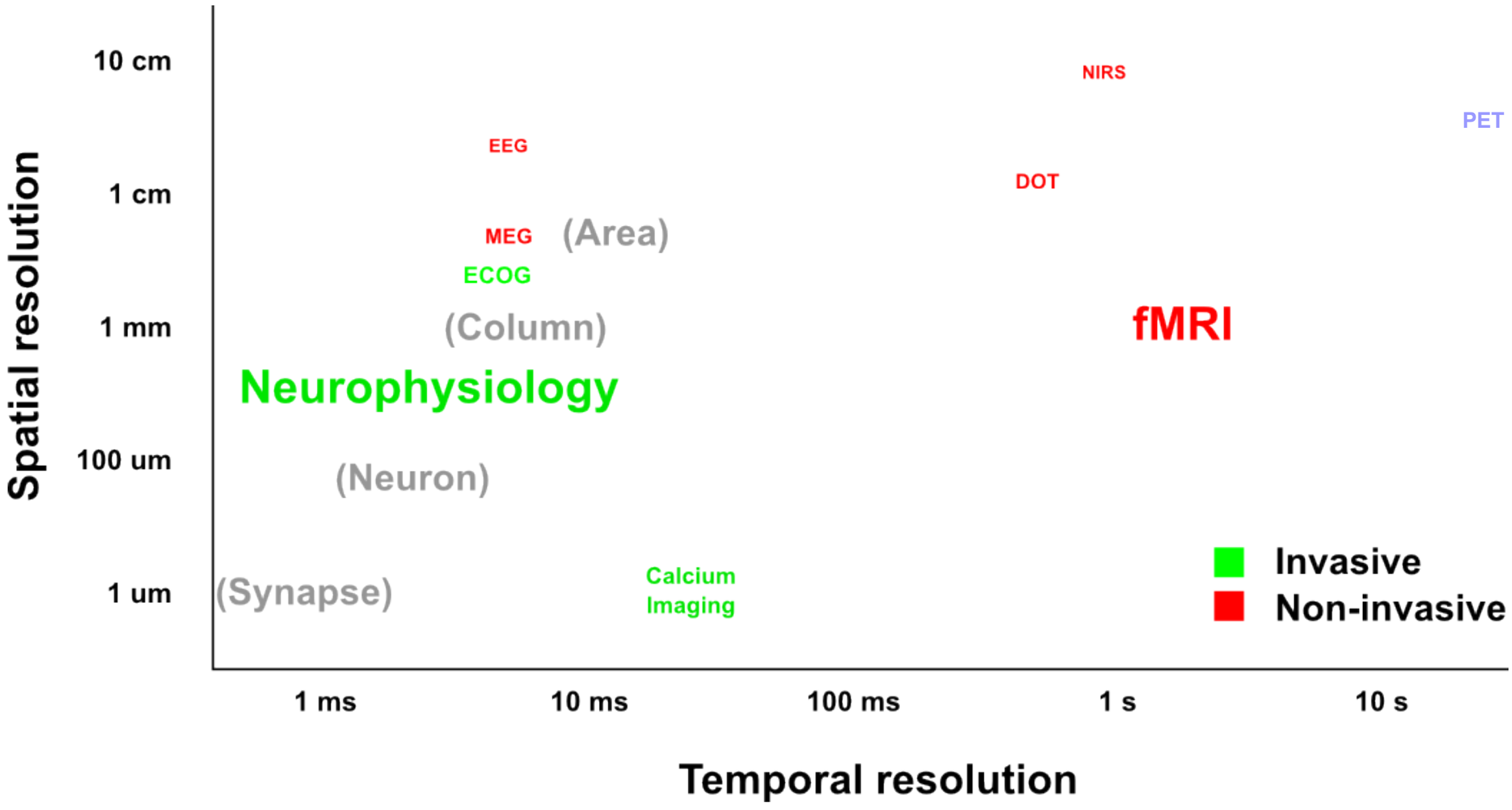


Tootell, Silverman, Switkes & DeValois, 1982

Many dimensions are coded at each position



Methods for recording brain activity



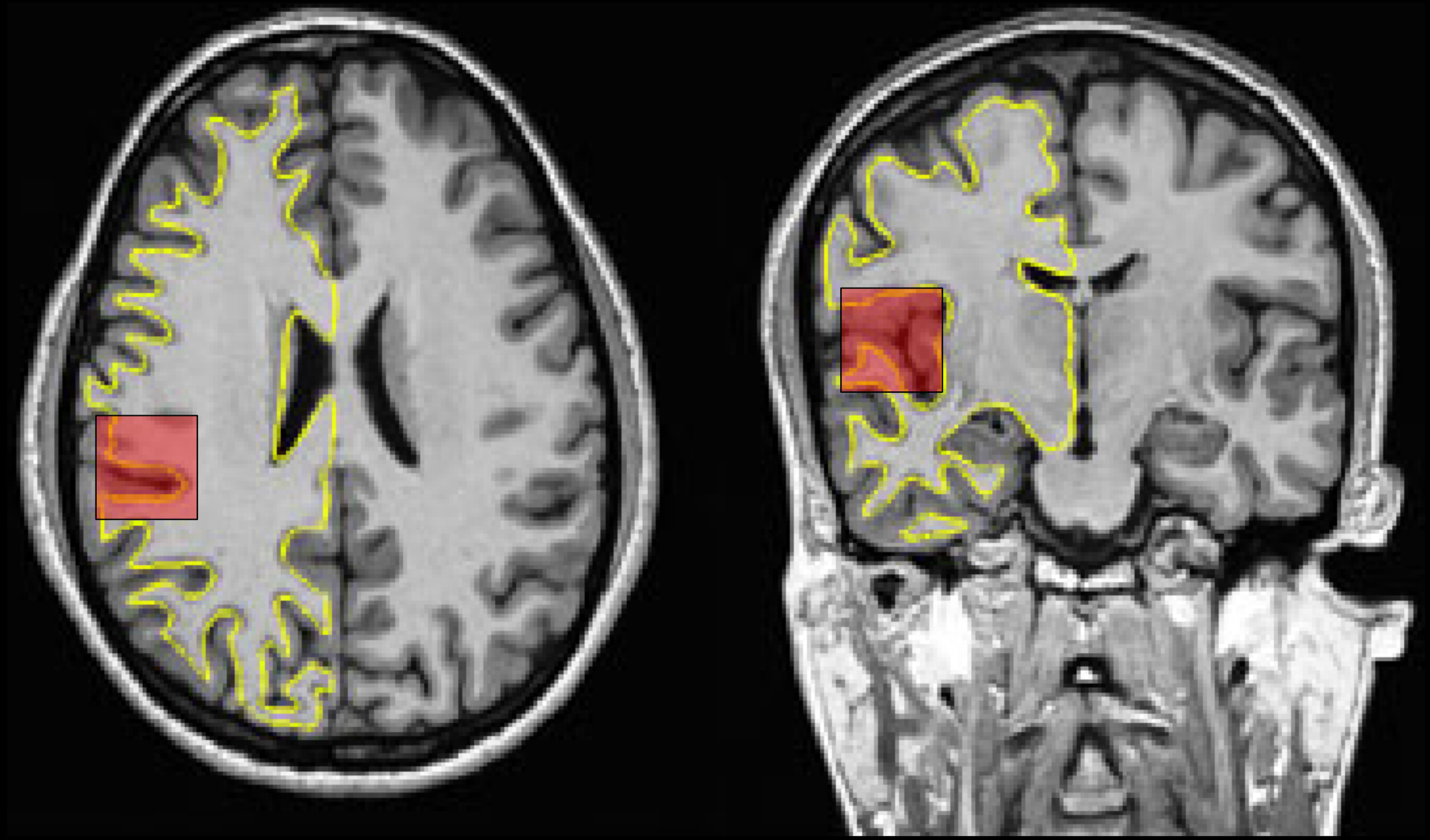
EEG: Electroencephalography

Tangemann et al. 2010

Cichocki et al. 2009

Advantages	Disadvantages
Relatively simple and cheap	Poor signal quality
Good temporal resolution	Poor spatial resolution (> 1 cm)
Measures neural activity	Neural activity measure is biased
Inherently 2D	

EEG has poor spatial resolution

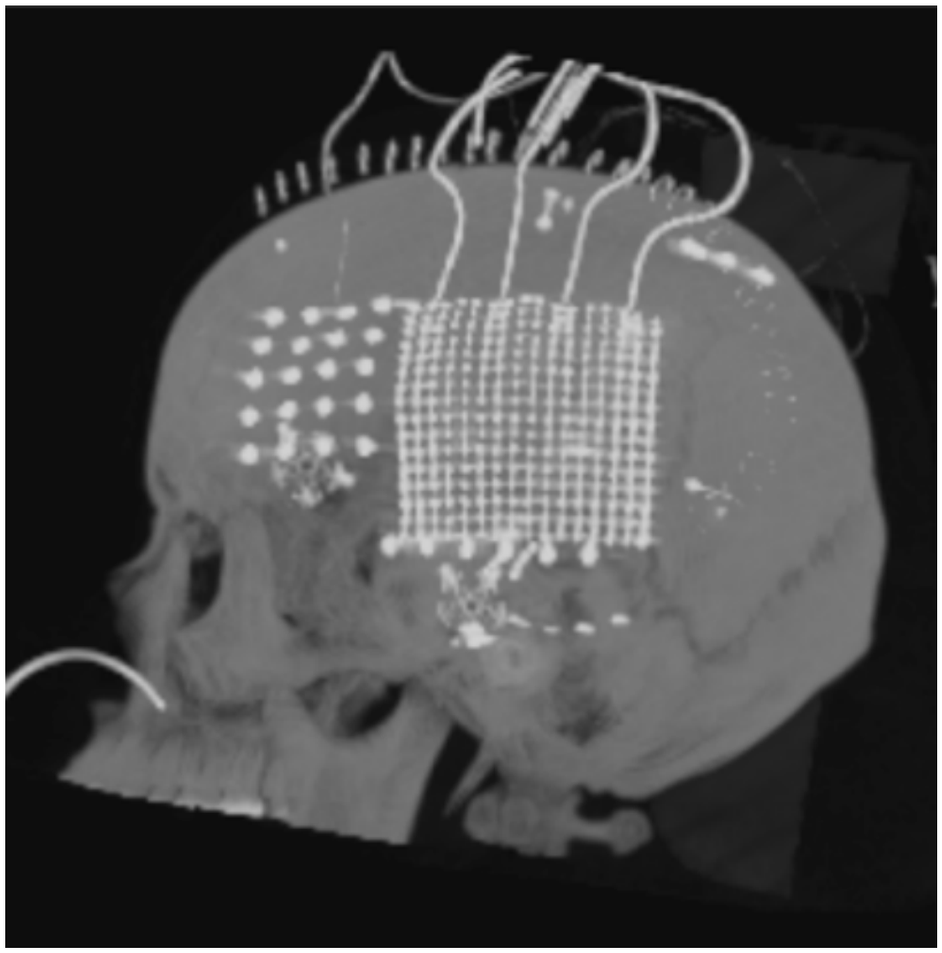


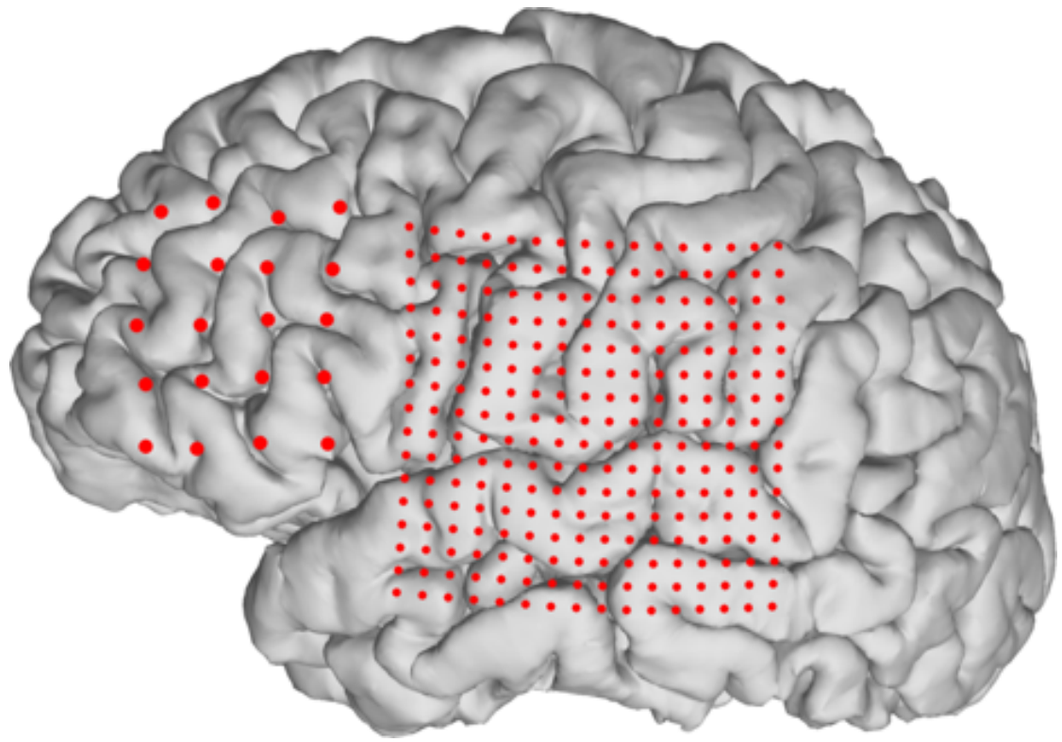
MEG: Magnetoencephalography

Roberts et al., 2008

Advantages	Disadvantages
Better signal quality than EEG	Expensive, requires gnomes
Good temporal resolution	Poor spatial resolution (~ 8 mm?)
Measures neural activity	Neural activity measure is biased
Inherently 2D	

ECoG: Electrocorticography

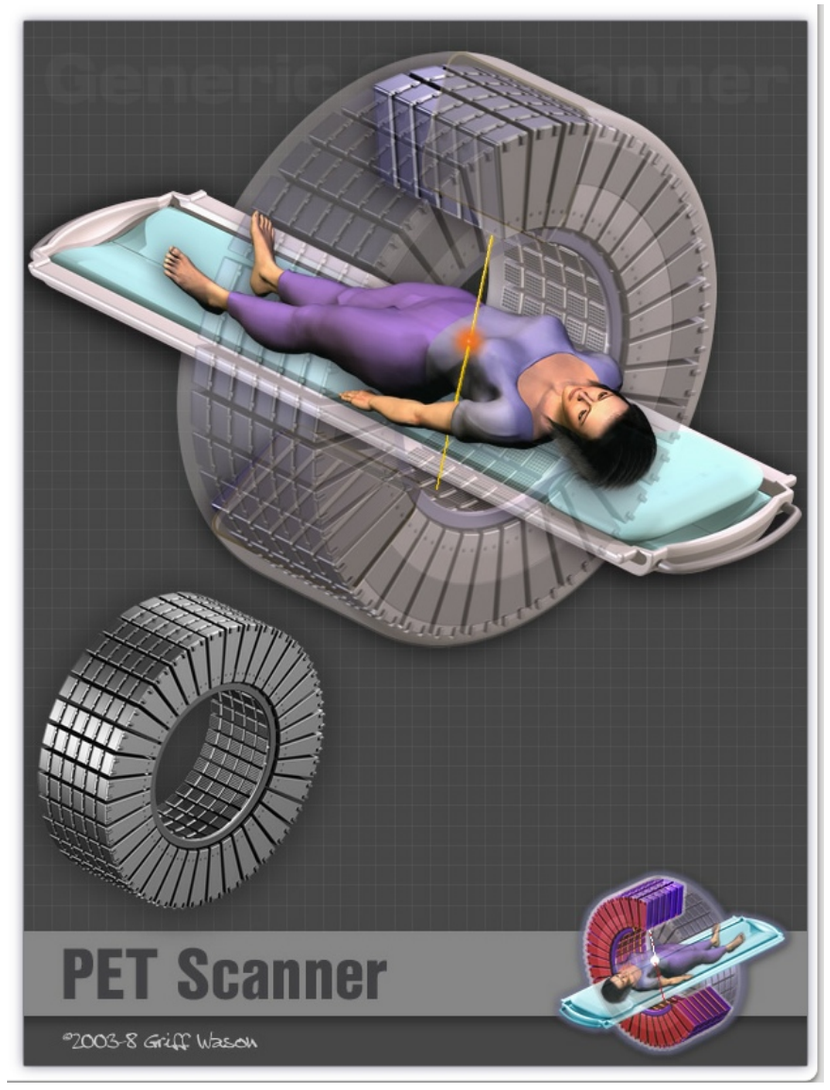




images c/o Liberty Hamilton, Chang Lab UCSF 2016

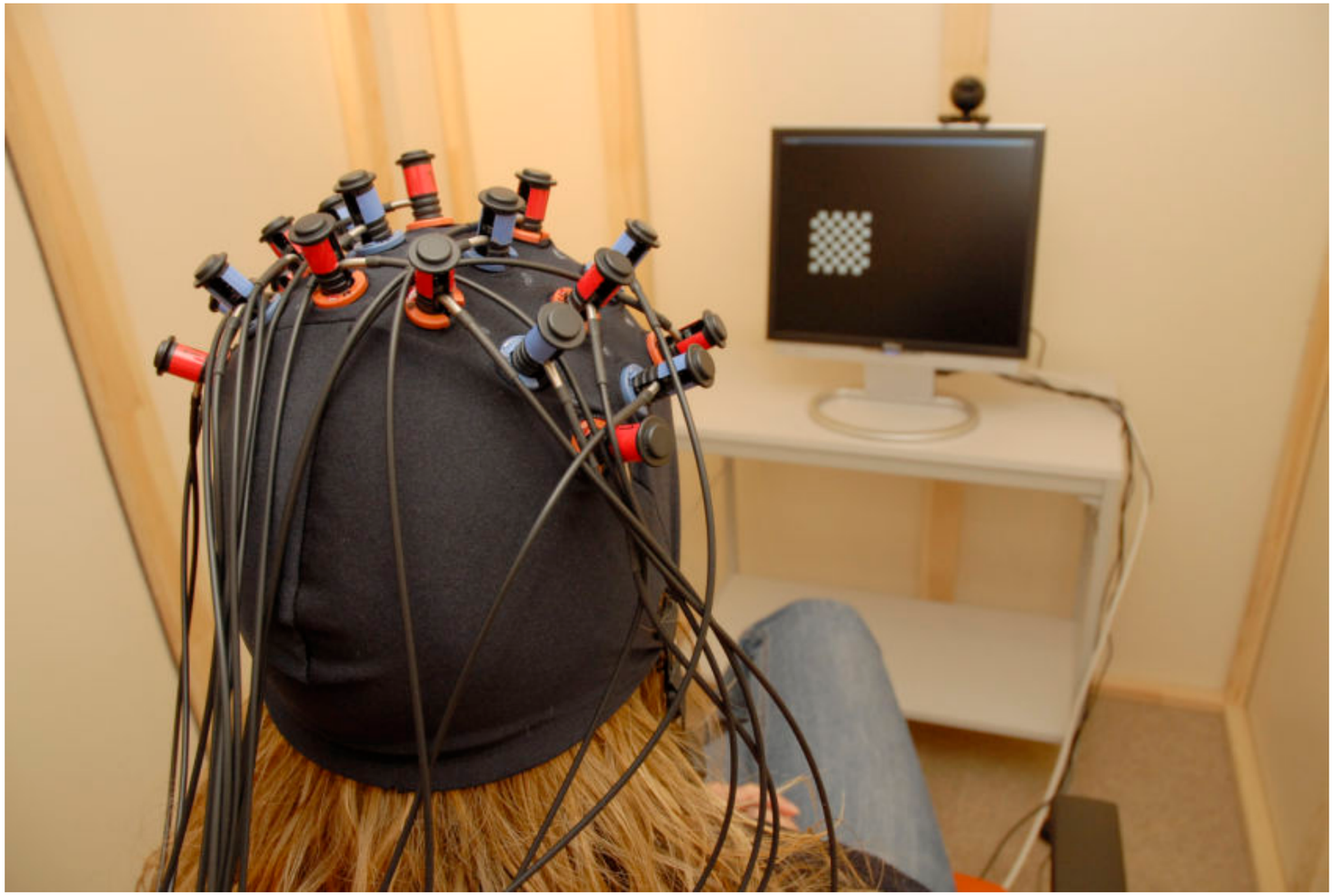
Advantages	Disadvantages
Relatively good signal quality	Invasive, requires craniotomy
Good temporal resolution	Poor spatial resolution (~ 8 mm)
Measures neural activity	Neural activity measure is biased
Inherently 2D	

PET: Positron emission tomography



Advantages	Disadvantages
Relatively simple and cheap	Poor signal quality
Good temporal resolution	Poor spatial resolution (> 1 cm)
Tomographic (2D slice)	Probably really bad for you

NIRS: Near-infrared spectroscopy



Neuper & Pfurtscheller, 2010

Advantages	Disadvantages
Relatively simple and cheap	Poor signal quality
Inherently 2D	Bad spatial resolution (> 3 cm)
	Doesn't measure neural activity

FMRI: Functional Magnetic Resonance Imaging

Advantages	Disadvantages
Good spatial resolution (~ 3 mm)	Very expensive & complicated
Inherently 3D	Poor temporal resolution (> 1 s)
	Does not measure neural activity

There are no great methods for measuring maps in the human brain.

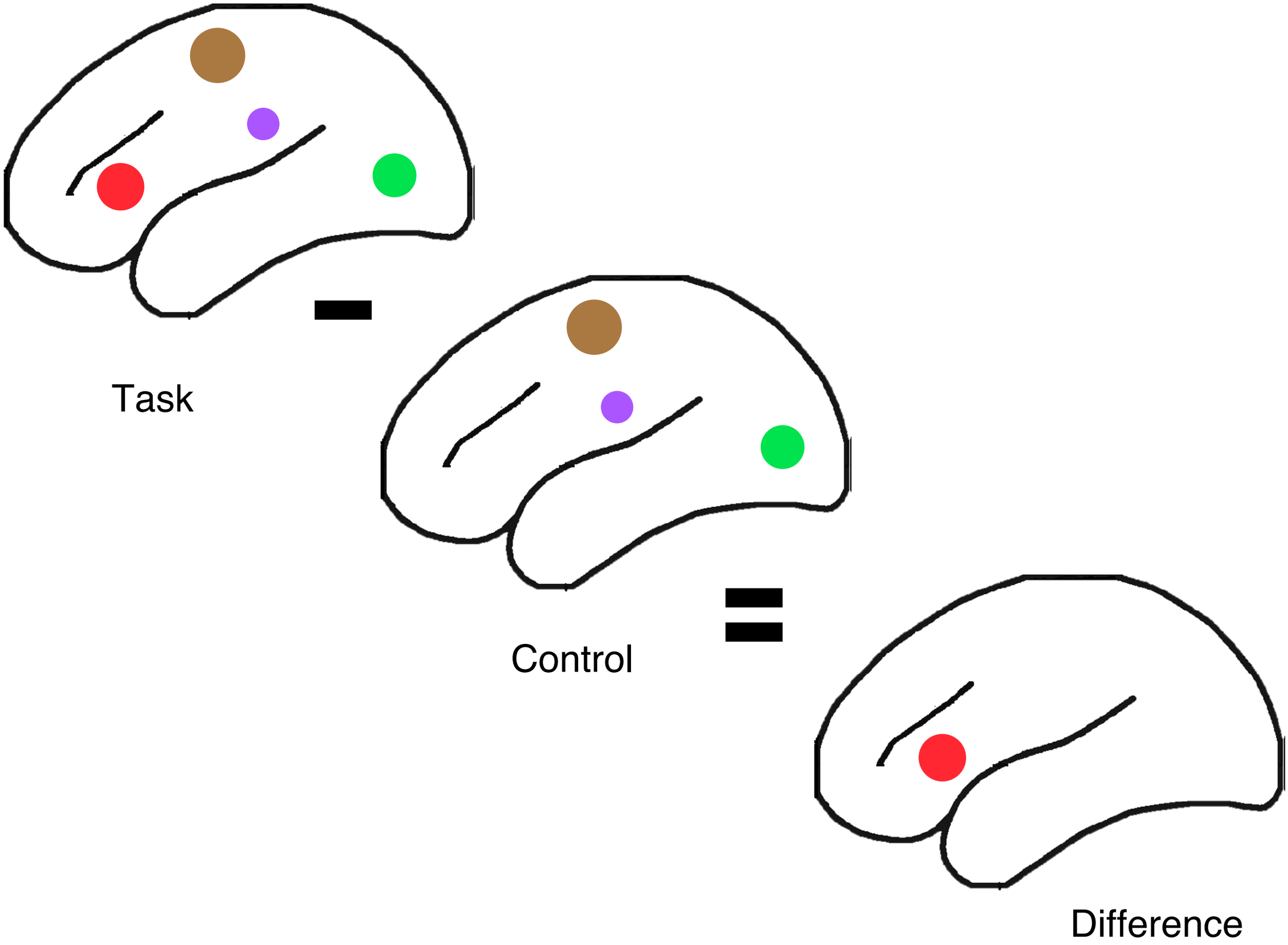
EXPERIMENTAL DESIGN

DEDUCTIVE APPROACH

* the **“contrast method”**
  aka **“localizer method”**
  aka **“subtraction method”**

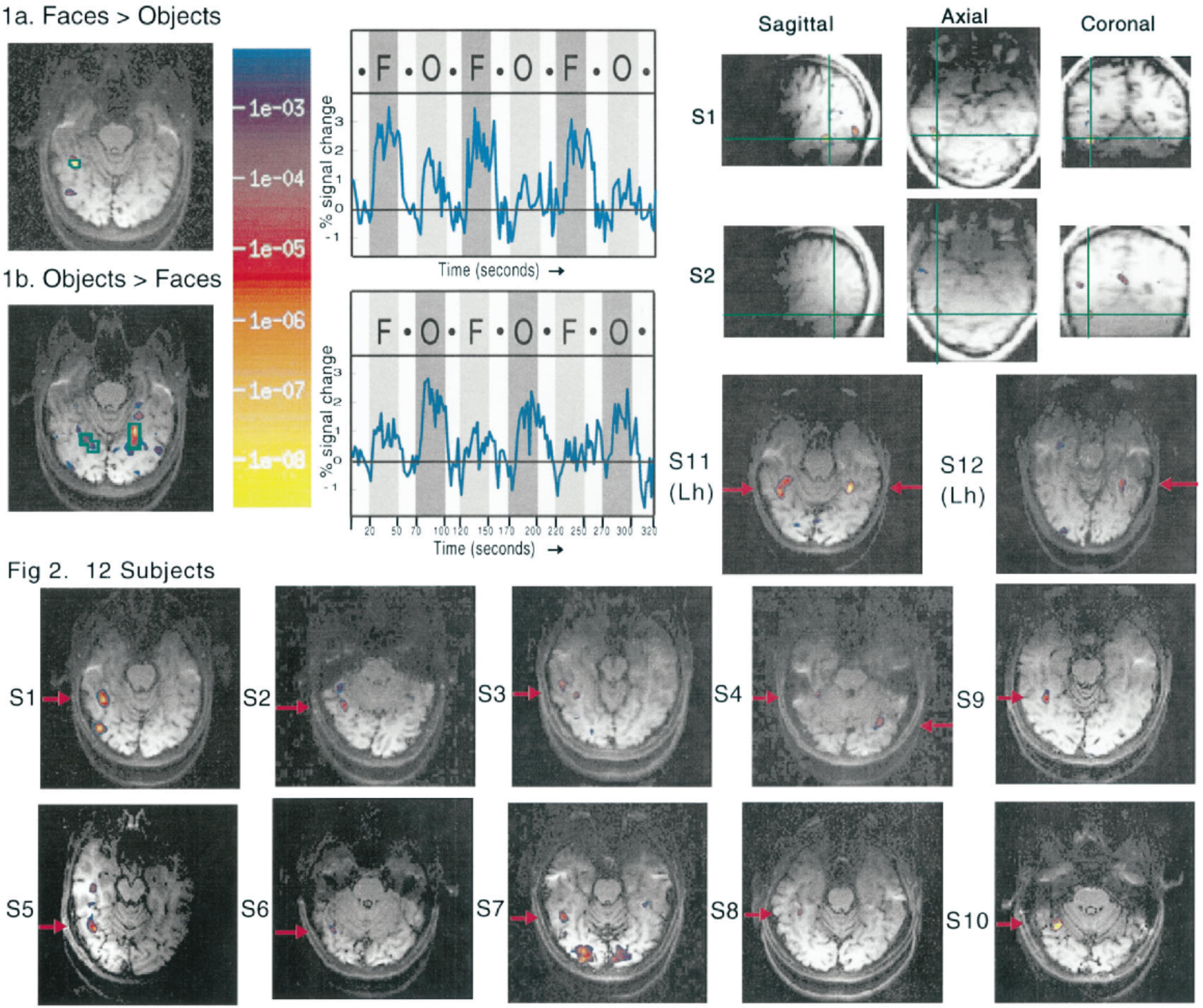
* Subtract fMRI signal in one condition from fMRI signal in other condition

* Use some statistic to determine whether difference between conditions is significant


Task
Control
Difference

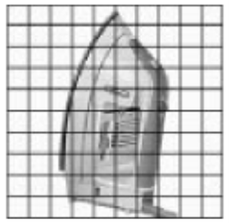
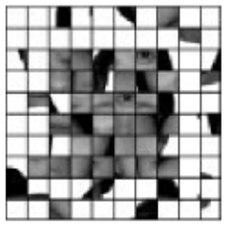
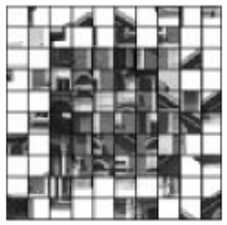
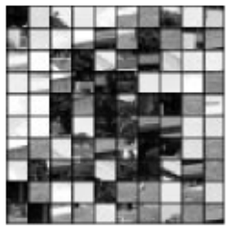
DEDUCTIVE APPROACH

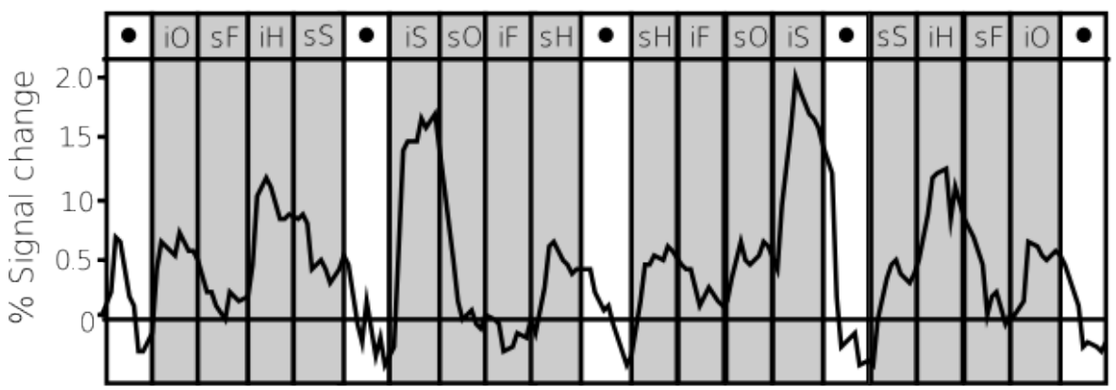
Functional localizer for the fusiform face area

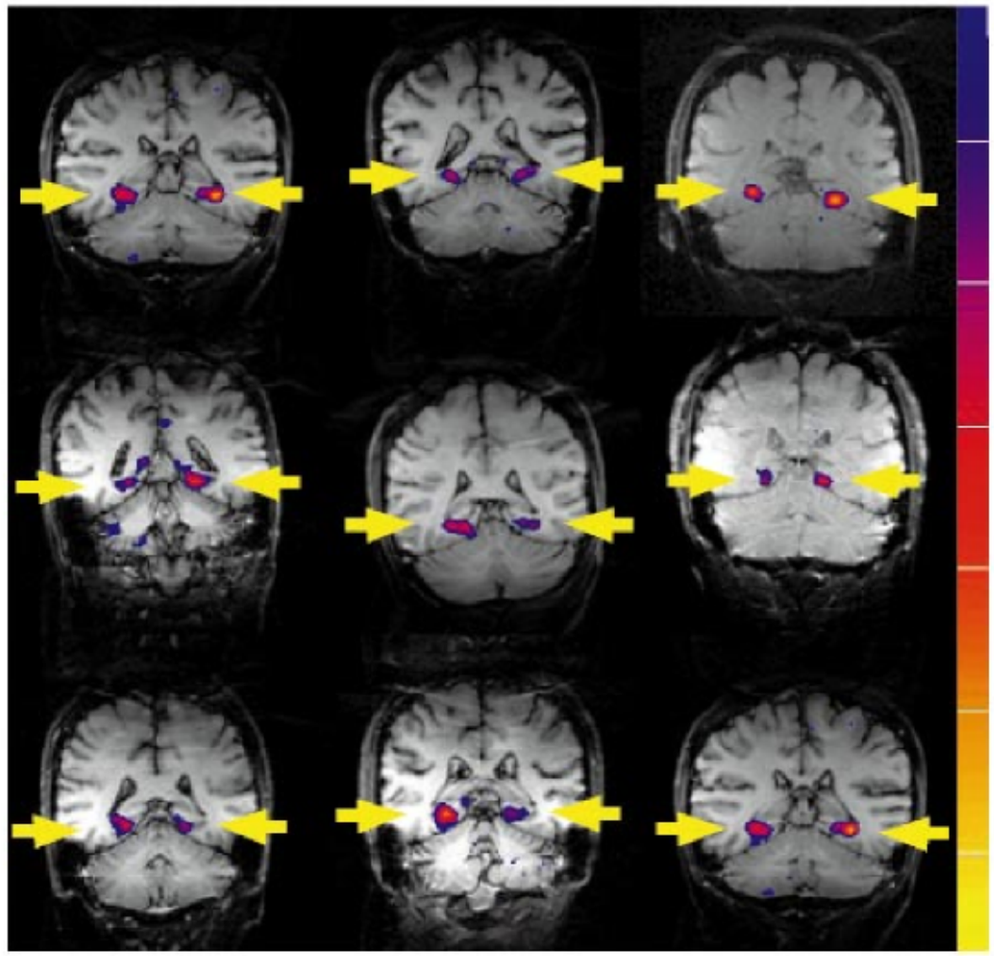


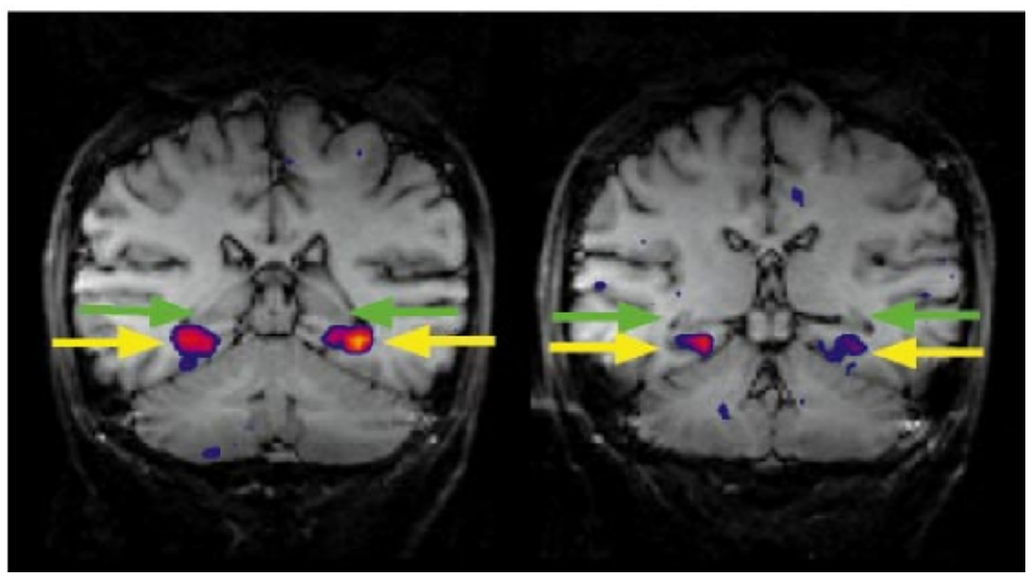
Kanwisher et al. 1997

FL for the parahippocampal place area

Stimuli		Faces	Objects	Houses	Scenes
	Intact				
	Scrambled				
Results	Int	0.12	0.56	0.95	159
	Scr	0.20	0.34	0.51	0.51
	I-S	-0.08	0.22	0.44	108





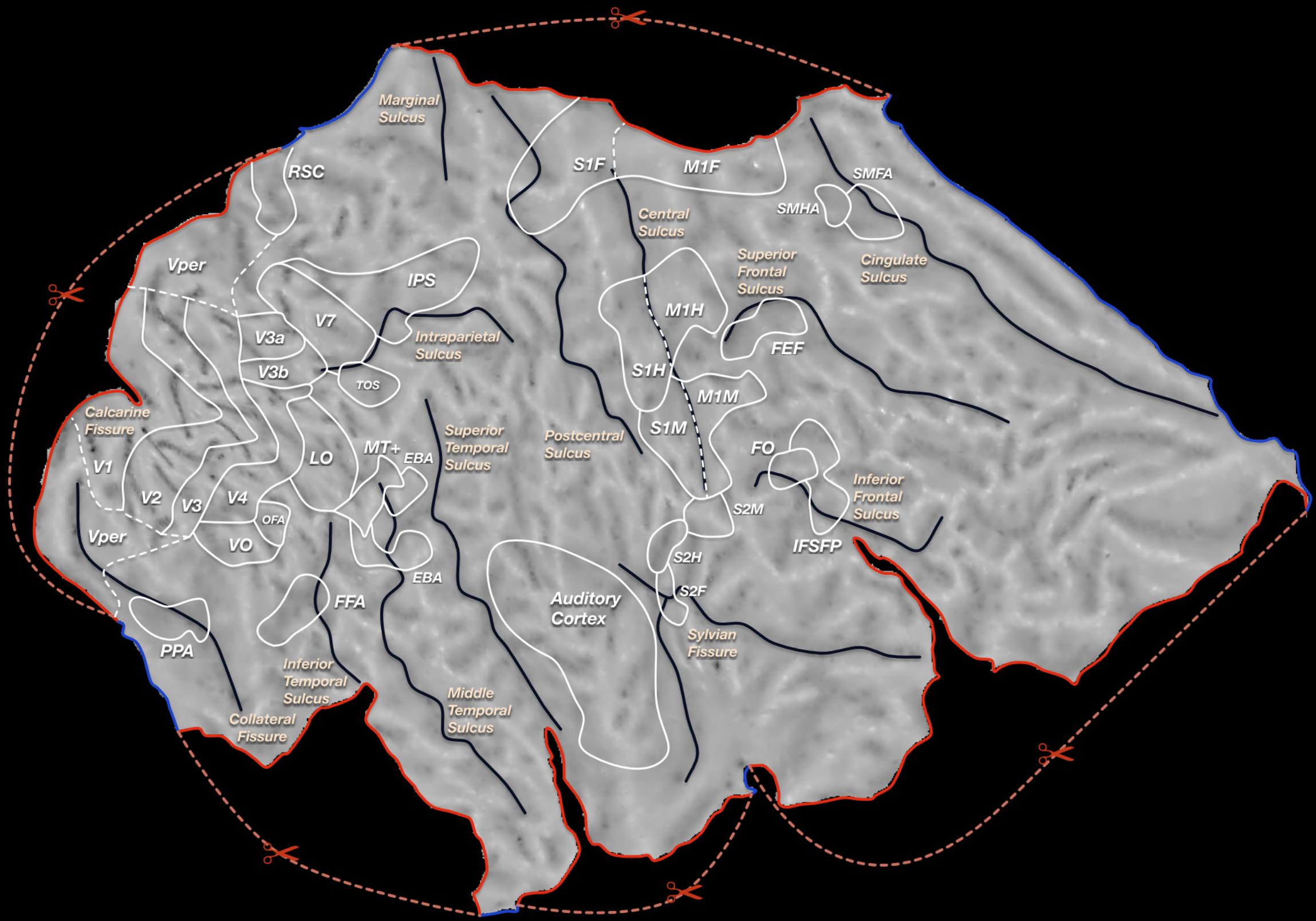


Epstein & Kanwisher 1998

Functional localizers for vision

Name	Location	Contrast	References
FFA (fusiform face area)	Posterior fusiform gyrus	Faces – Objects	Kanwisher et al, 1997 McCarthy et al, 1997
OFA (occipital face area)	Just anterior to V4v/VO	Faces – Objects	Kanwisher et al, 1997 Halgren et al, 1999
IFSFP (inferior frontal sulcus face patch)	IFS anterior to precentral sulcus	Faces – Objects	Avidan et al, 2005 Tsao et al, 2008
ATFP (anterior temporal face patch)	Temporal pole	Faces – Objects	Rajimehr et al, 2009
STSFP (superior temporal sulcus face patch)	Posterior superior temporal sulcus	Faces – Objects	Clark et al, 1996 Kanwisher et al, 1997
EBA (extrastriate body area)	Anterior to MT+ on the medial temporal gyrus	Bodies – Objects	Downing et al, 2001
FBA (fusiform body area)	Fusiform sulcus/gyrus anterior to FFA	Bodies - Objects	Peelen & Downing, 2005 Schwarzlose et al, 2005
PPA (parahippocampal place area)	Collateral fissure	Scenes – Objects	Epstein & Kanwisher, 1998
TOS (transverse occipital sulcus)	Just inferior to V7	Scenes – Objects	Nakamura et al, 2000 Hasson et al, 2003
RSC (retrosplenial cortex)	Medial wall just superior to PPA	Scenes – Objects	Aguirre et al, 1996
FEF (frontal eye field)	Precentral sulcus adjoining superior frontal sulcus	Saccades – Fixation	Luna et al, 1998
iFEF/FO (inferior frontal eye field)	Inferior portion of precentral sulcus	Saccades – Fixation	Berman et al, 1999 Corbetta et al, 1998

Visual areas identified by functional localizers



Inductive vs deductive approaches

Induction

Use complex (natural) stimuli

Low power everywhere

Focus on predictions

Works best when we know little

Generalizes well

Deduction

Use simple parametric stimuli

Maximum power in subspace

Focus on significance

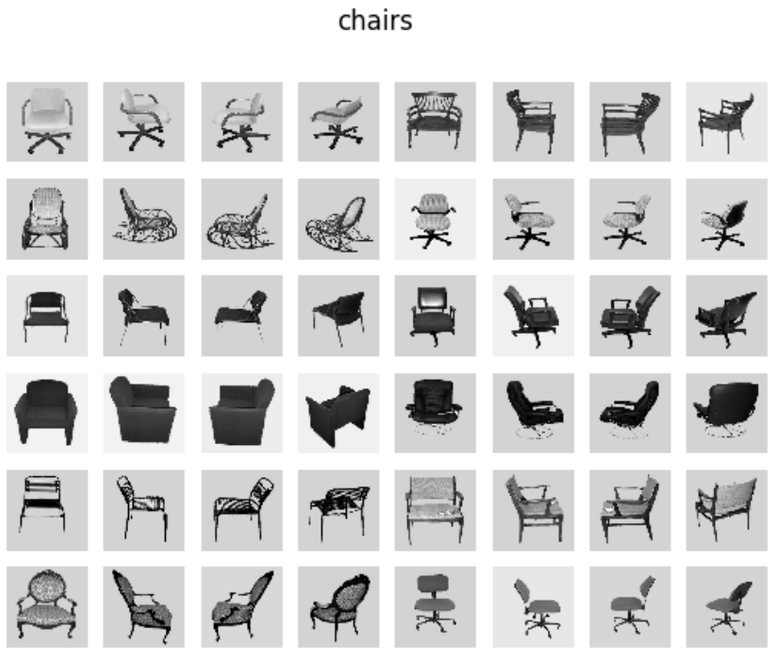
Works best when we know a lot

May not generalize well

NATURAL STIMULI: WHAT?

THIS:

NOT THIS:



SYSTEM IDENTIFICATION

$$Y = f(X)$$

* What kind of a function is f?

* Can we learn f?

MARR

* What does it mean to understand a neural system?

MARR

* Is the kind of understanding gained different for inductive and deductive approaches?

MARR

* What does success look like?

NEXT TIME

* Natural stimuli!

* Linear regression for system identification!