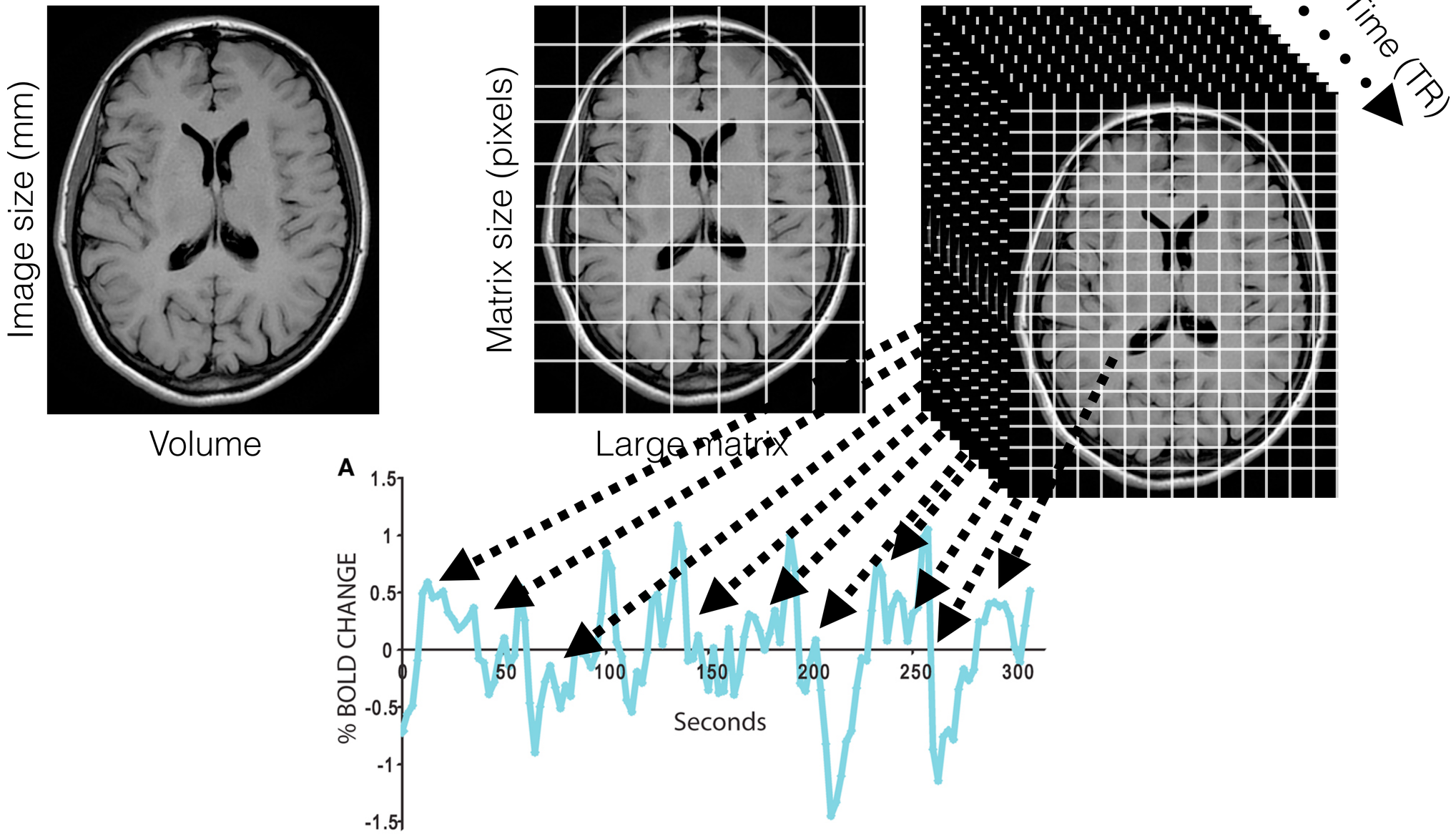
Module 16: Functional Connectivity MRI Studies

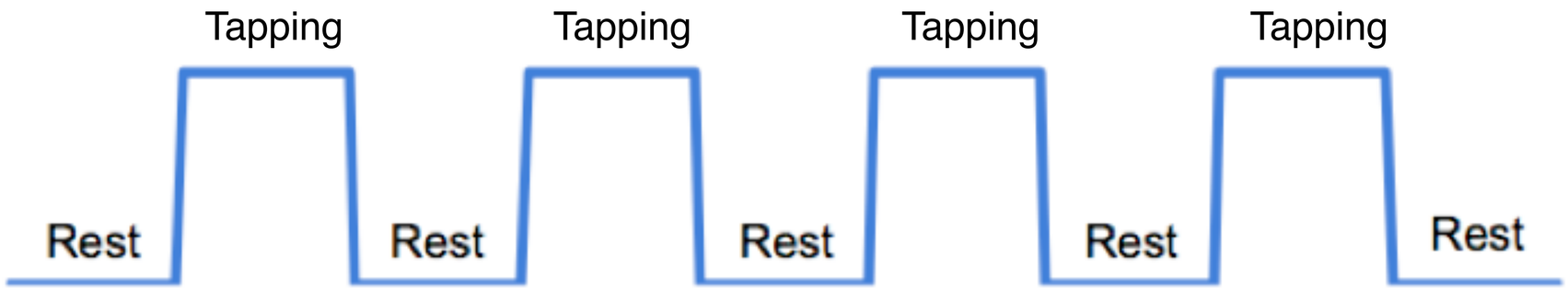
Arnold Bakker
Department of Psychiatry and Behavioral Sciences
Division of Psychiatric Neuroimaging
Johns Hopkins University School of Medicine

fMRI Experiment



fMRI Experiment

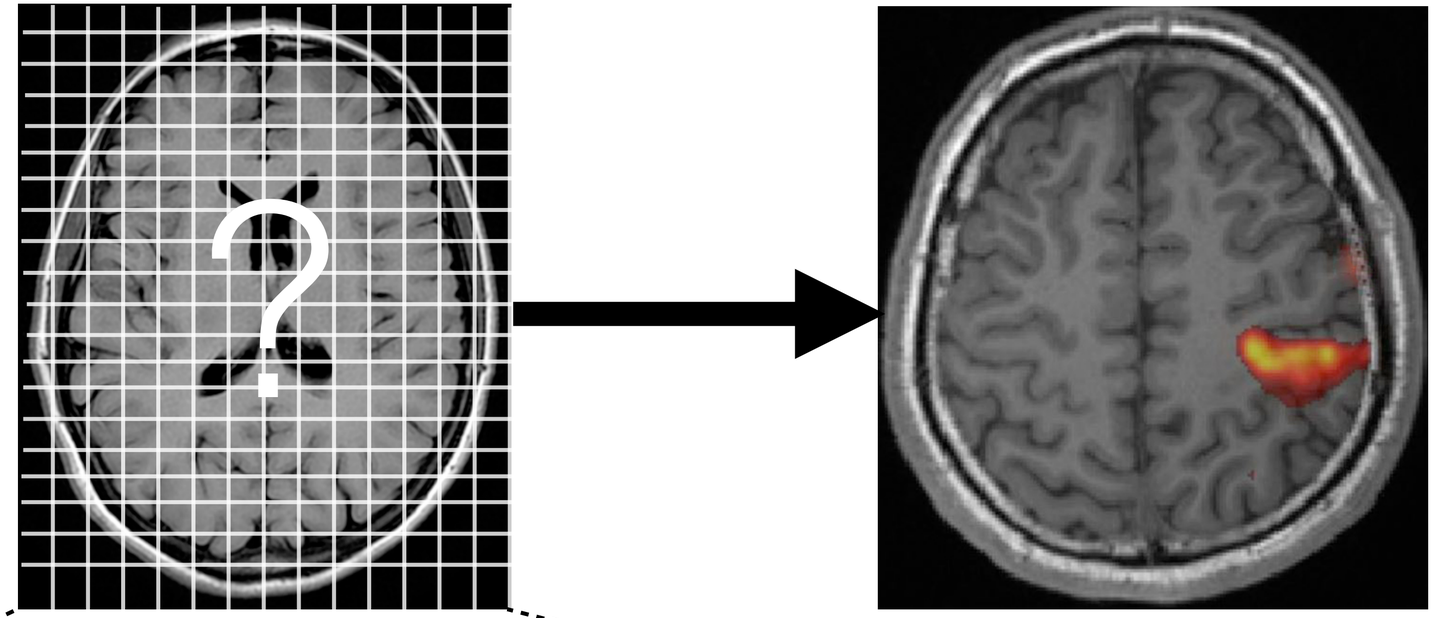
Finger tapping Experiment



BOLD Response in a Voxel

fMRI Experiment

Finger tapping
Experiment

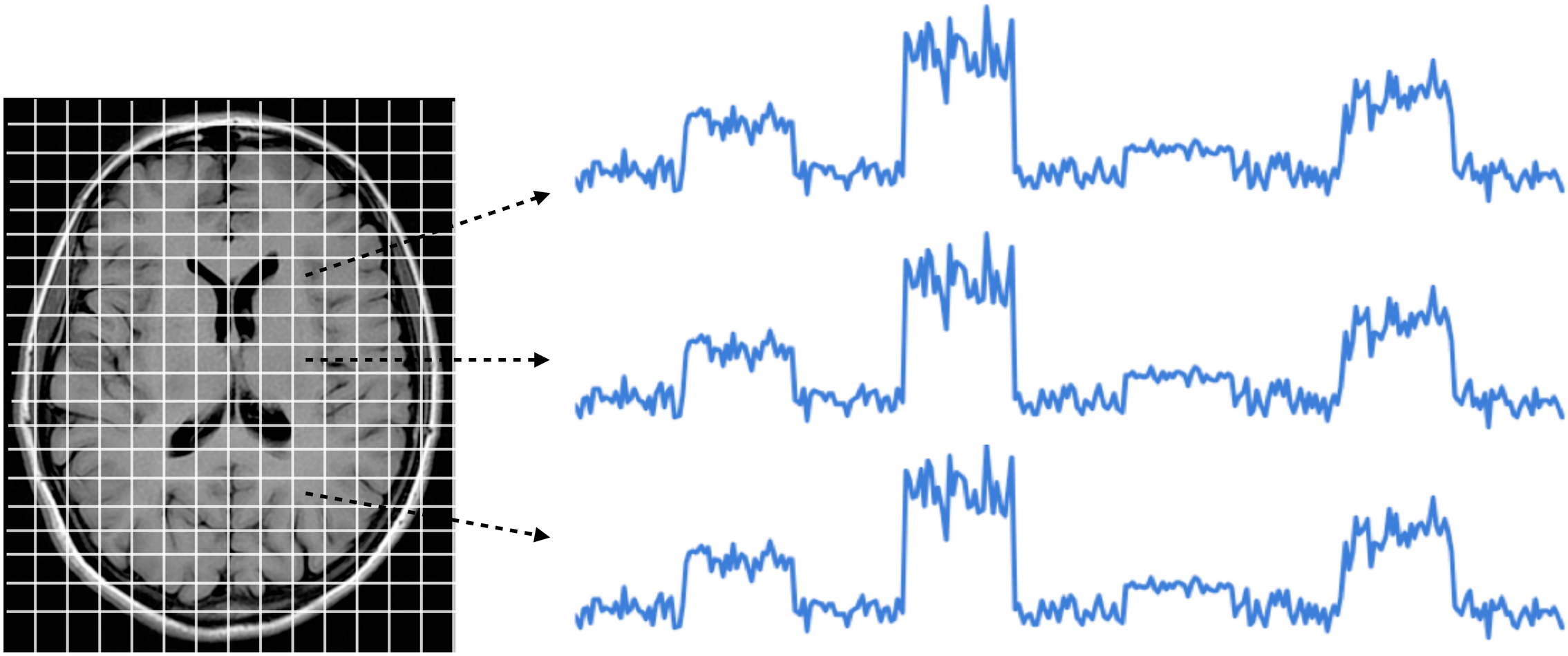


BOLD Response in a Voxel

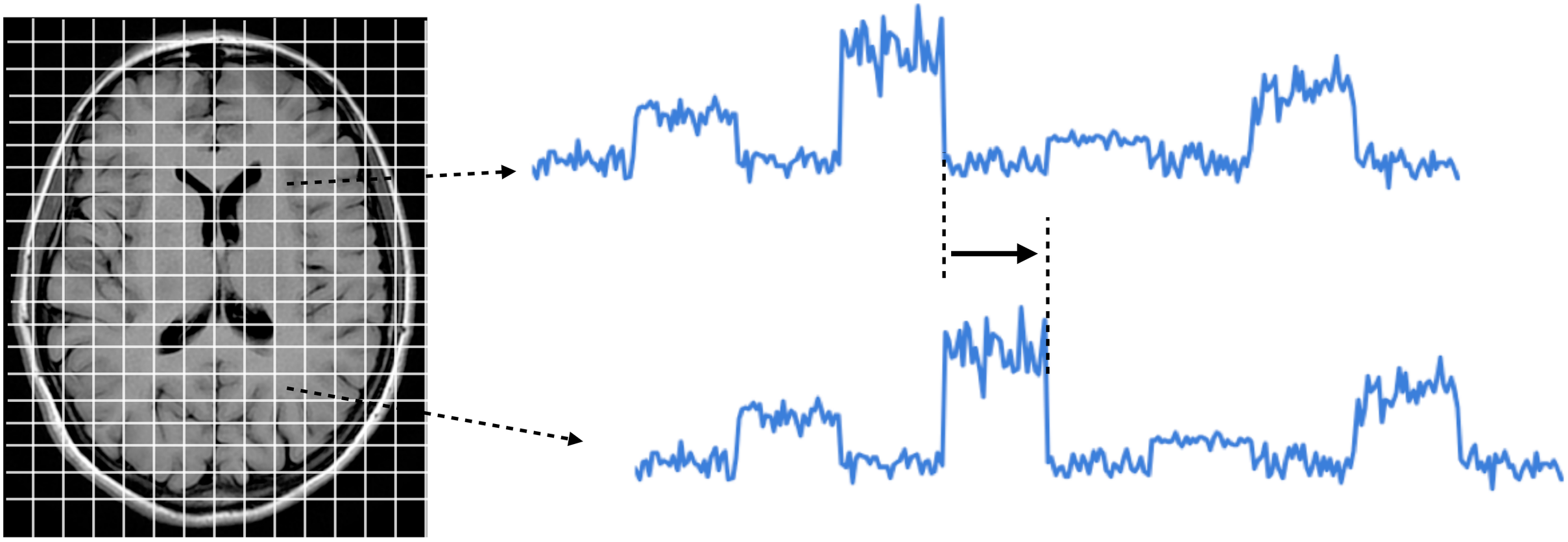
Functional Connectivity MRI

- Functional Connectivity MRI (fcMRI) is a variant of fMRI
- Brain activity is observed in the absence of external tasks demands or stimuli
- Examining brain activity during rest explores the functional organization of the brain
- Hebbian principle: Cells that fire together, wire together

Functional Connectivity MRI



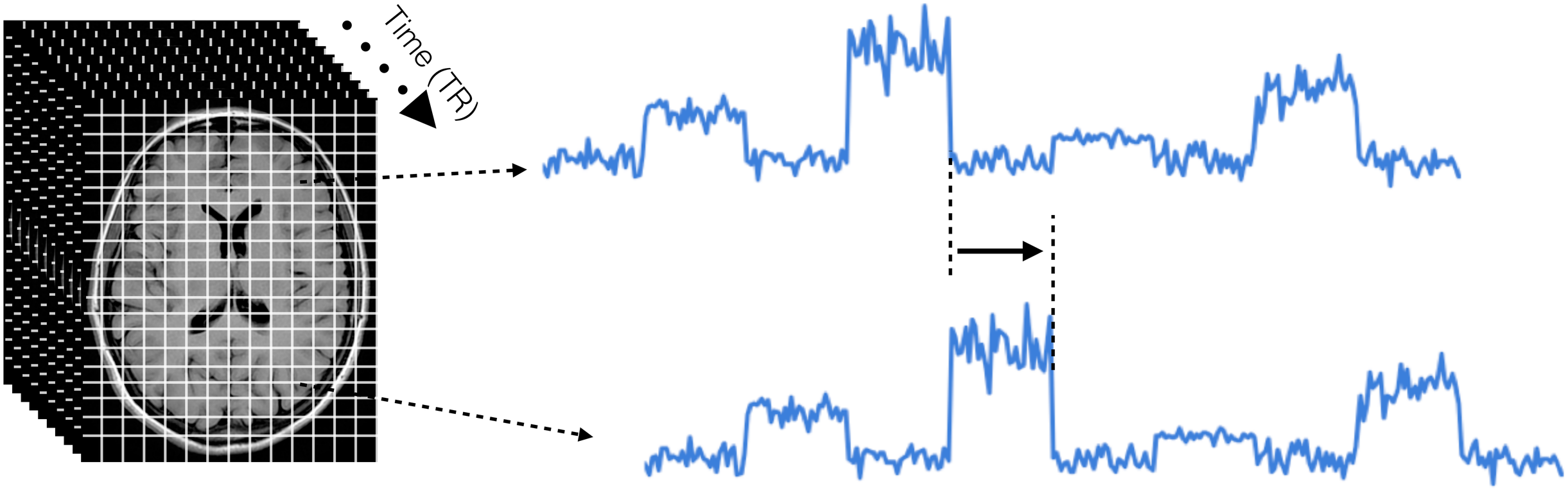
Functional Connectivity MRI



Spatial correlation

Temporal correlation

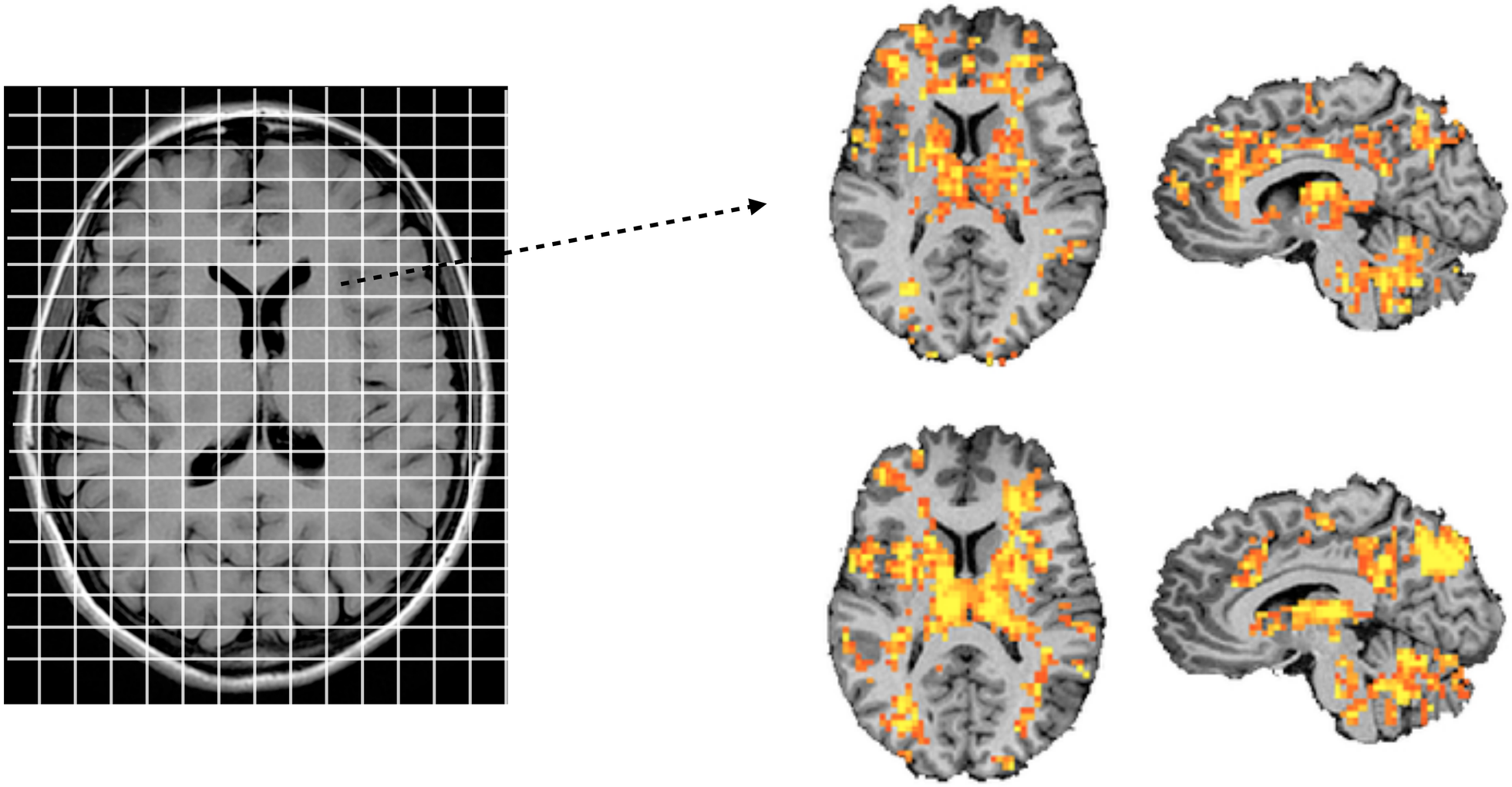
Functional Connectivity MRI



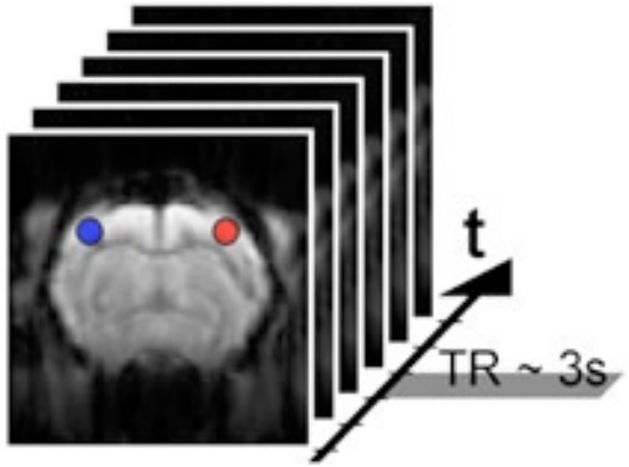
Spatial correlation

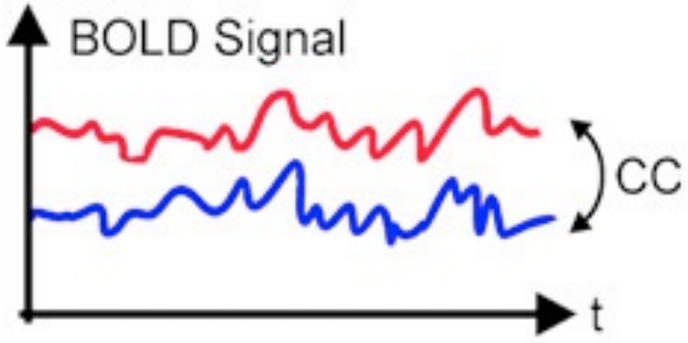
Temporal correlation

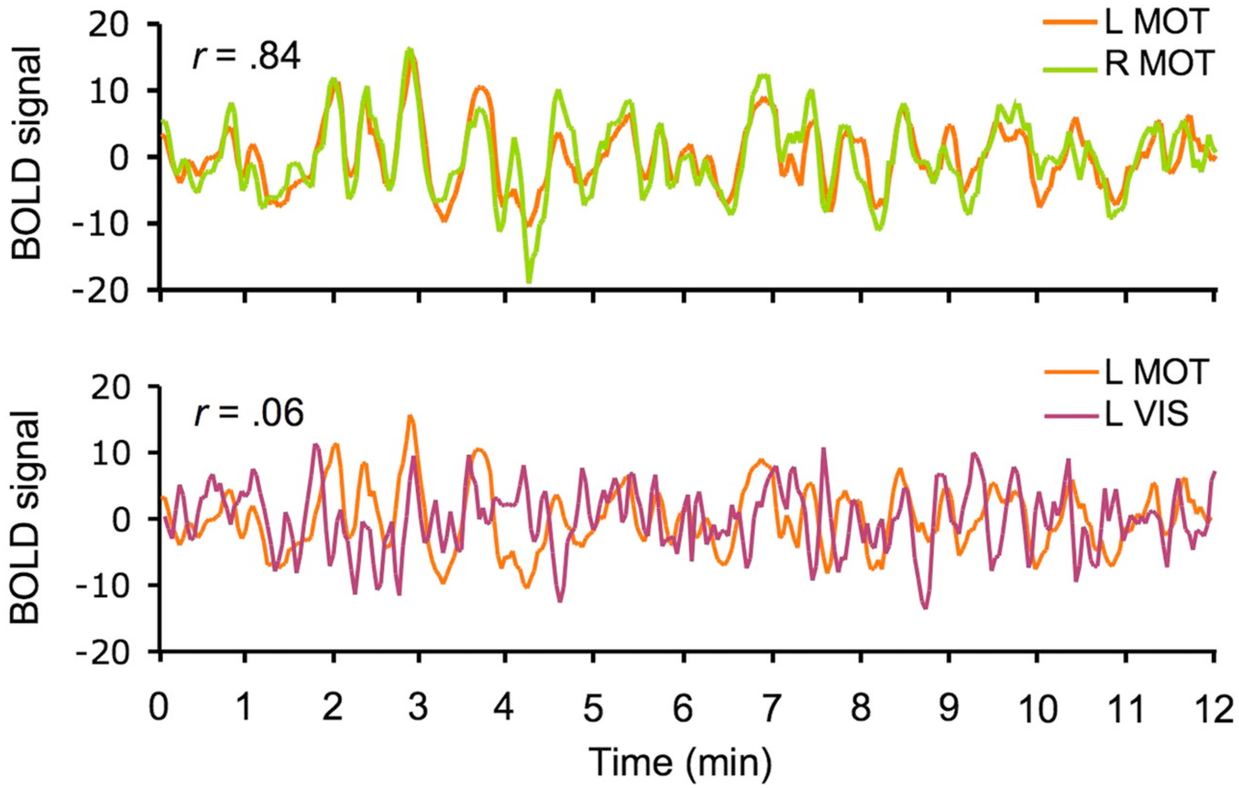
Voxel to voxel connectivity



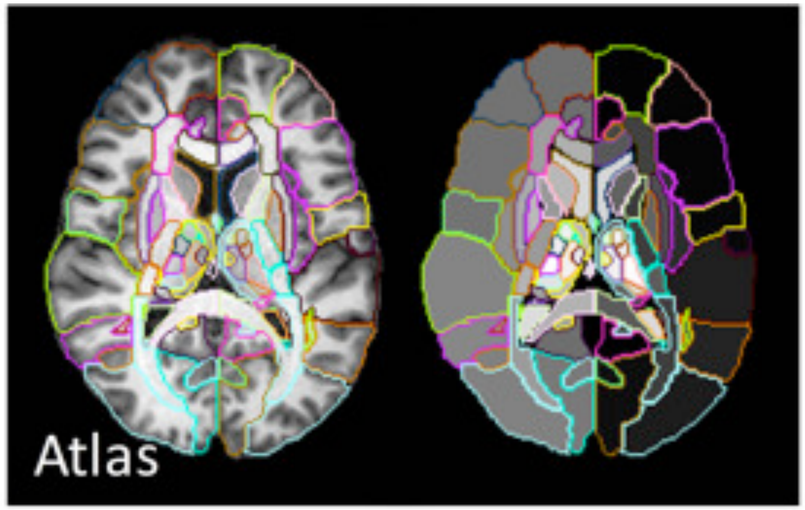
Seed based connectivity

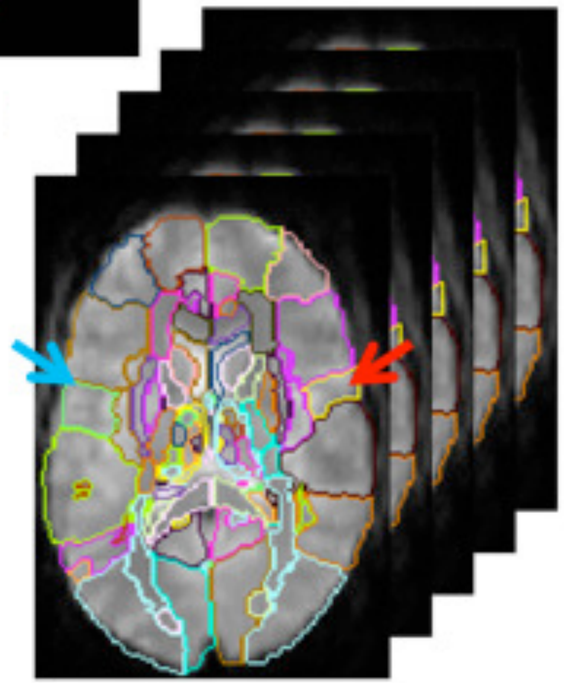


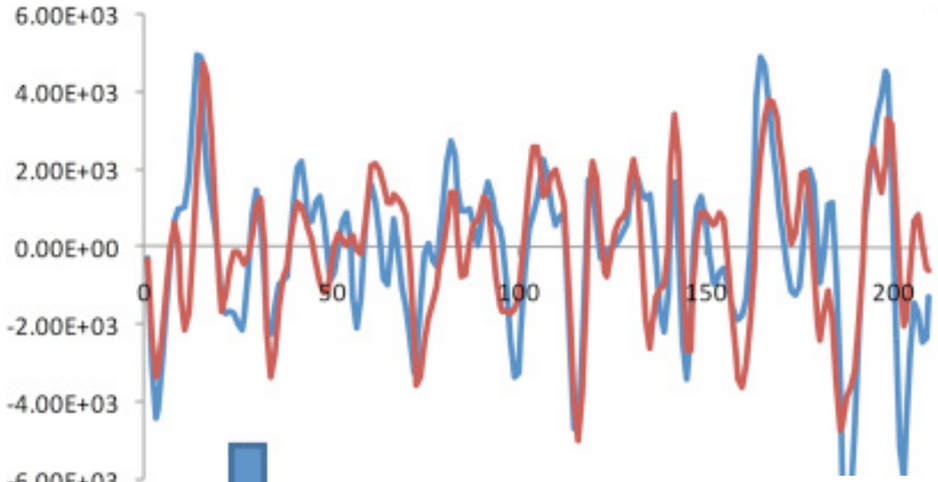


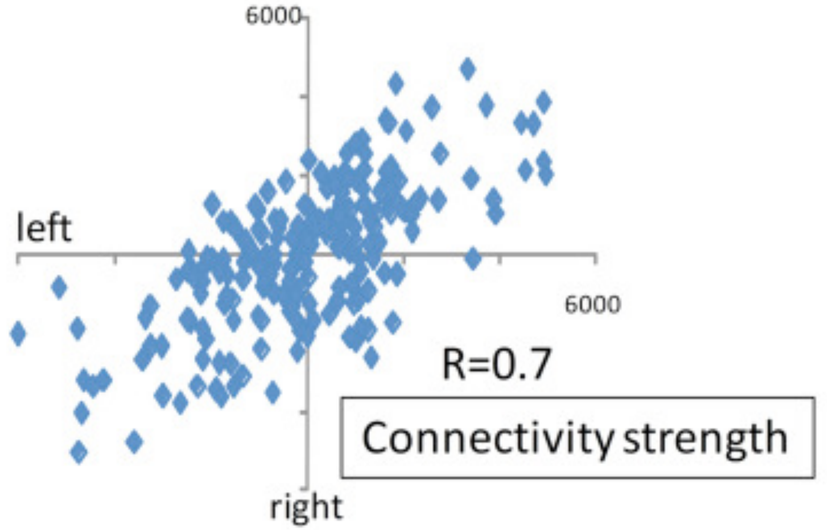


Functional Connectivity MRI

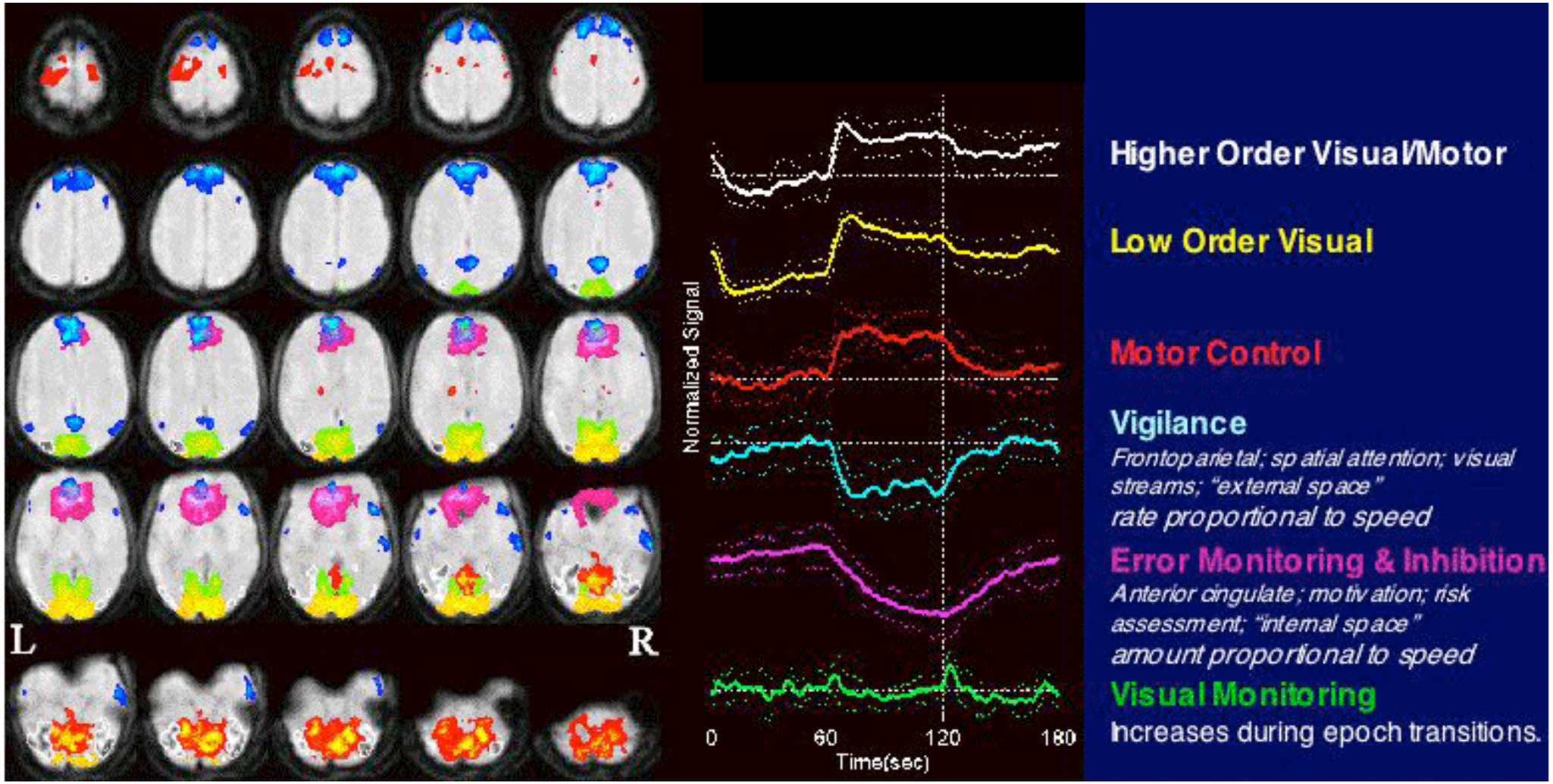








Functional Connectivity MRI



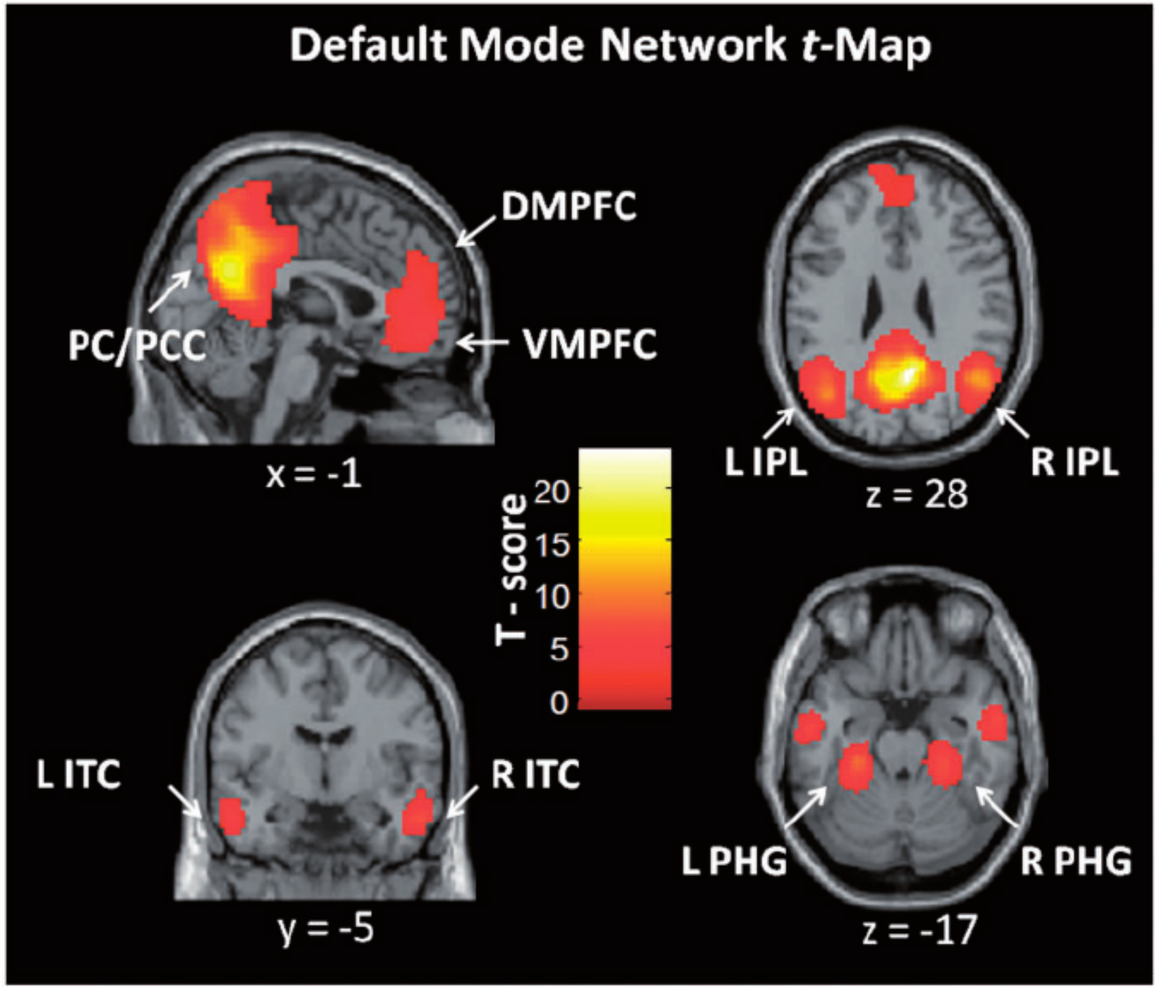
Independent component analysis

Calhoun et al., HBM 2002

Default Mode Network

Default mode network (DMN):

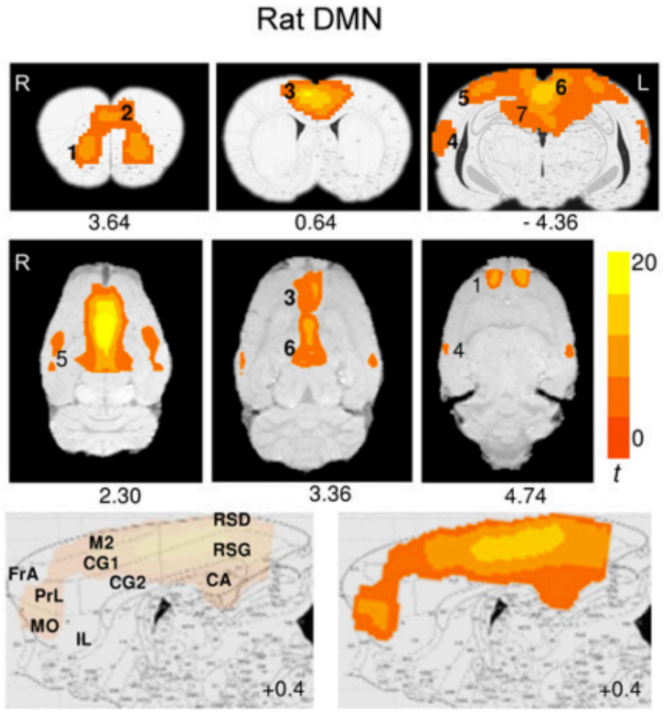
- Network of brain regions with highly correlated activity during wakeful rest
- Tends to be less active during the performance of an external task

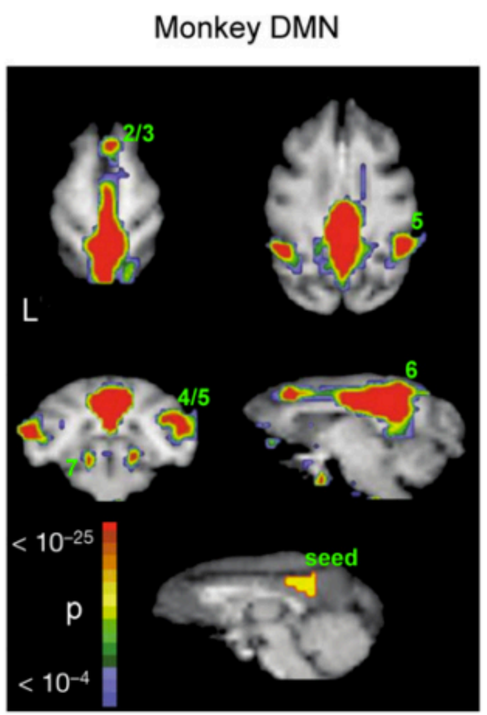


Default Mode Network

Default mode network (DMN):

- Developmentally established
- Great similarity between rodent and primate brain





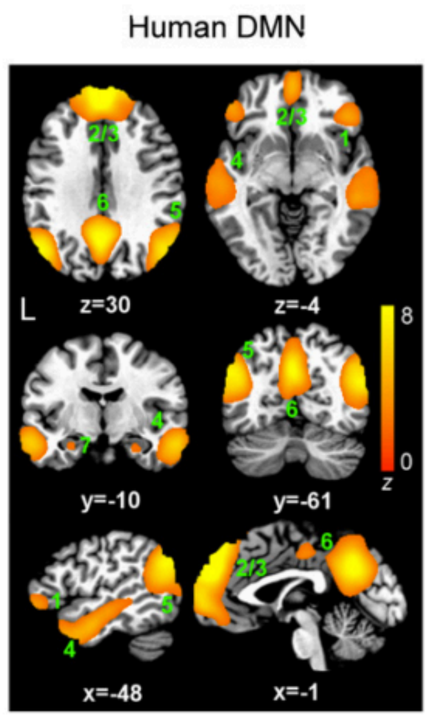


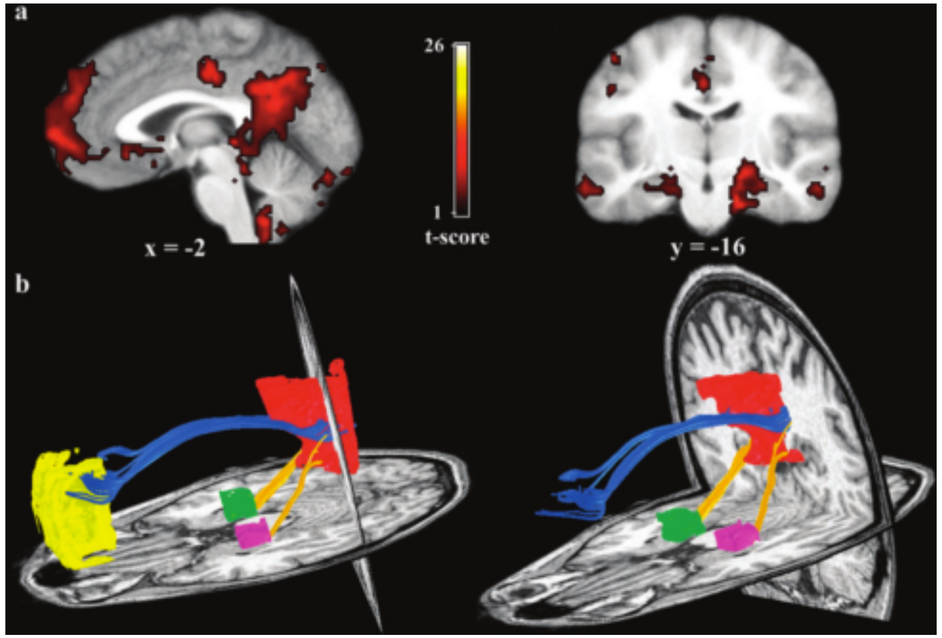
Table 1. List of the coordinates of the DMN components in rat and human

Rat DMN				Human DMN			
	Paxino's atlas				Talairach space		
Region	M-L	D-V	A-P	Region	X	Y	Z
Orbital ctx (VO, LO, rMO)	±1.8	5.2	3.64	Orbital frontal ctx (BA 47)	46	31	−1
					−46	37	−3
Prelimbic ctx (CG1/CG2)	±0.6	3.0	3.64	mPFC/ACC (BA 9/10/11/24/32)	1	52	33
	±0.4	2.0	0.64				
Auditory/temporal association ctx	−7.0	5.8	−4.68	Infer temporal gyrus (BA 20/21)	56	−11	−16
	7.4	5.4	−4.68		−55	−5	−18
Post parietal ctx (PtPR, PtPD, V2M)	3.2	1.0	−4.36	Infer parietal ctx (BA 7/39/40)	50	−61	21
	−4.4	1.4	−4.36		−47	−65	29
Retro splenial ctx (RSD/RSG)	±0.4	2.3	−3.36	Post cingulate ctx (BA 23/31)	−2	−58	30
Dorsal hipp	±1.0	4.0	−4.36	Parahipp gyrus/hipp (BA 27/28/35/36)	25	−10	−19
					−25	−11	−18

Default Mode Network

Default mode network (DMN):

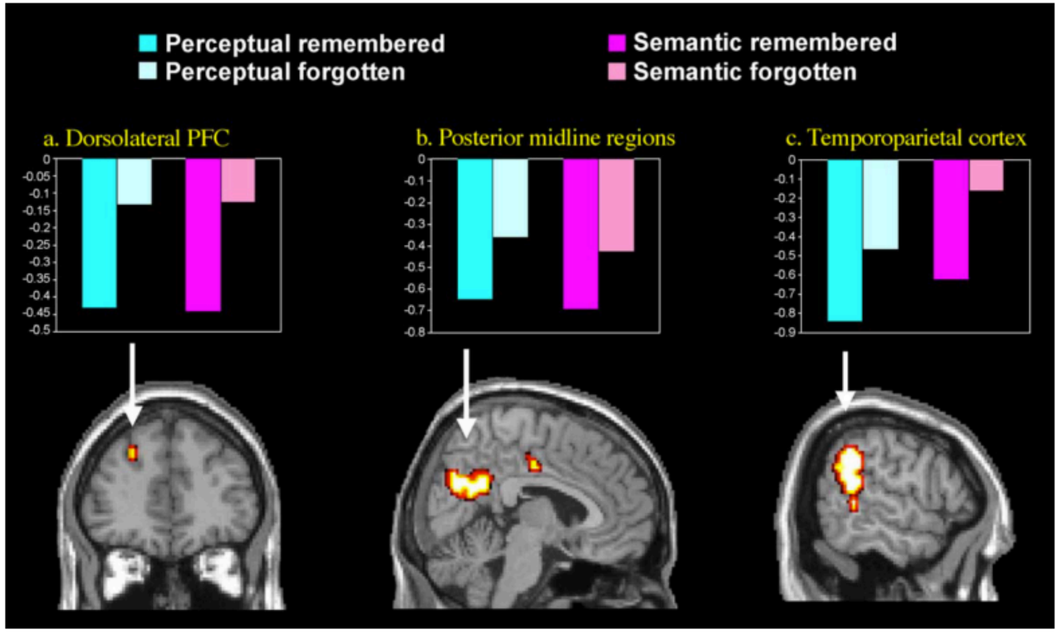
- Great overlap with structural connectivity
- Thought to support comprehension, learning and memory
- Thought to support the neurological basis of the self, self-reference, autobiographical information etc.
- Thought to support ability thinking about past and future
- Thought to support theory of mind, social cognition and emotion



Default Mode Network

Default mode network (DMN):

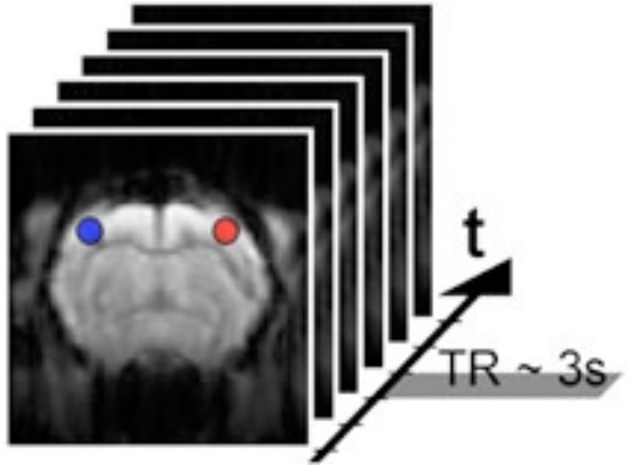
- Deactivation of the DMN correlated with successful memory encoding
- Deactivation of the DMN correlated with task difficulty
- Activation of DMN after learning improves retention

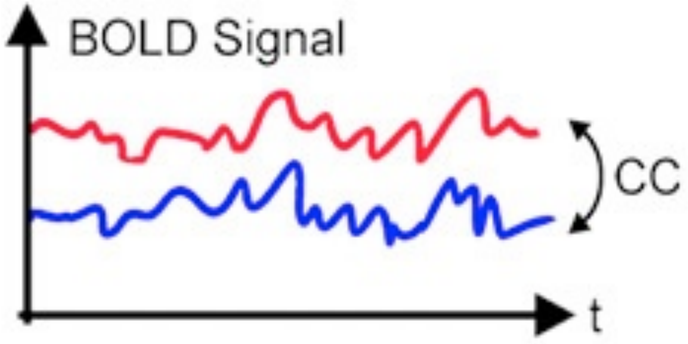


Connectivity Studies

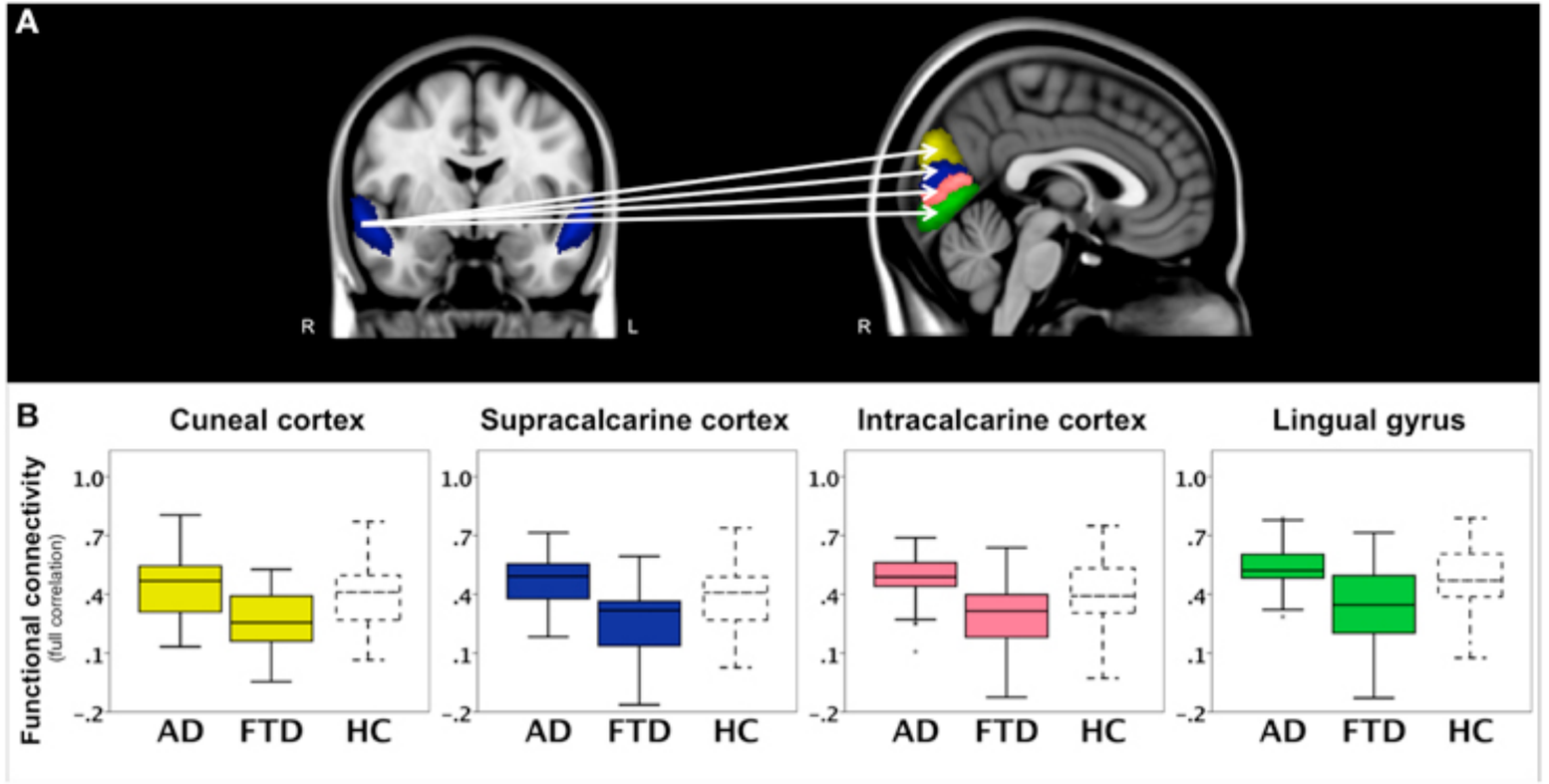
Collect functional MRI data during rest

- Assess connectivity related to brain structure or brain region
- Assess connectivity related to task performance
- Compare connectivity between participant groups





Connectivity Studies

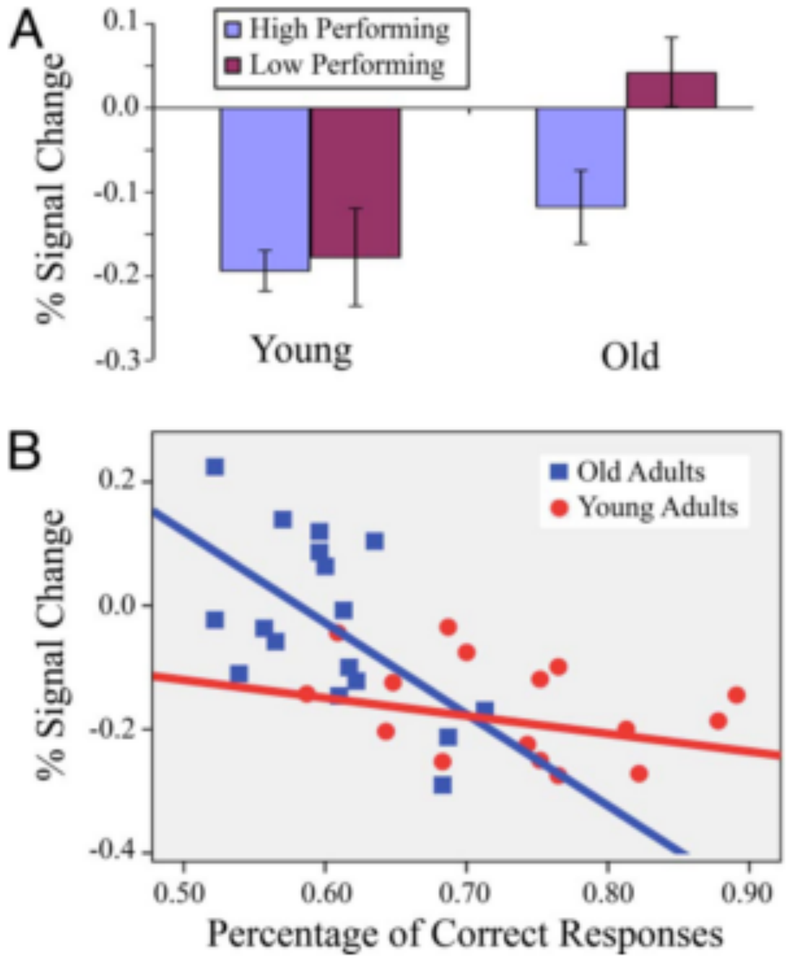


Connectivity difference between control subjects (HC), patients with frontotemporal dementia (FTD) and Alzheimer's disease (AD)

Hafkemeijer et al., 2015

Connectivity Studies

Differences in default mode network deactivation is associated with task performance in young and older adults



Miller et al., 2007

Connectivity Studies

Connectivity and default mode network changes observed in:

- Alzheimer's disease
- Autism
- Depression
- Schizophrenia
- Aging
- Epilepsy
- Parkinson's disease
- Obsessive compulsive disorder
- Anorexia nervosa
- Individual differences