

NBML, Webinars, Second Meeting

Resting State fMRI: From Basics to Advance Applications in



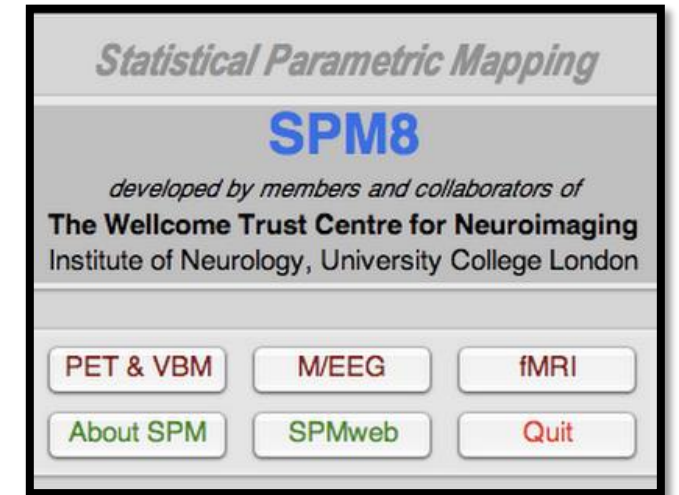
Hamed Ekhtiari, MD, PhD,
National Brain Mapping Laboratory (NBML)

Multimodal population brain imaging in the UK Biobank prospective epidemiological study

Karla L Miller¹, Fidel Alfaro-Almagro¹, Neal K Bangerter², David L Thomas³, Essa Yacoub⁴, Junqian Xu⁵, Andreas J Bartsch⁶, Saad Jbabdi¹, Stamatios N Sotiropoulos¹, Jesper L R Andersson¹, Ludovica Griffanti¹, Gwenaëlle Douaud¹, Thomas W Okeell¹, Peter Weale⁷, Iulius Dragonu⁷, Steve Garratt⁸, Sarah Hudson⁸, Rory Collins^{8,9}, Mark Jenkinson¹, Paul M Matthews¹⁰ & Stephen M Smith¹



Main Functional Neuroimaging Softwares



BrainVoyager 

Multimodal population brain imaging in the UK Biobank prospective epidemiological study

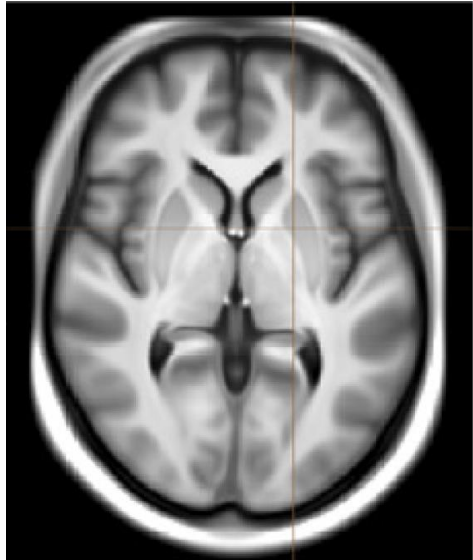
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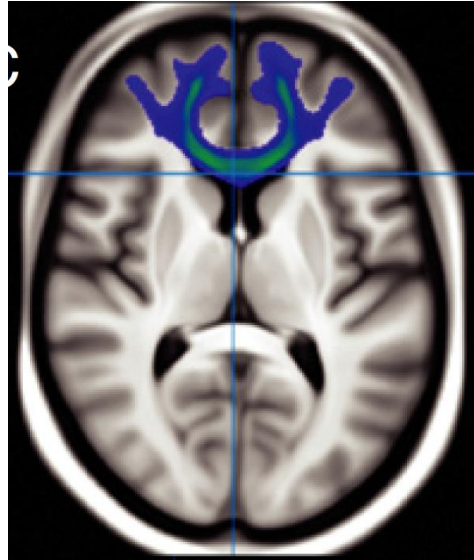
biobank^{uk}

biobank^{uk}

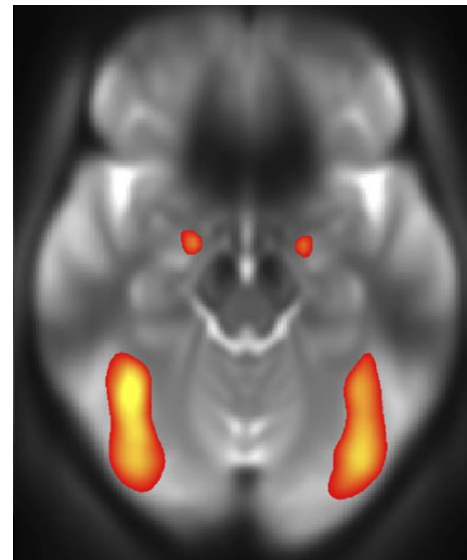
Imaging study



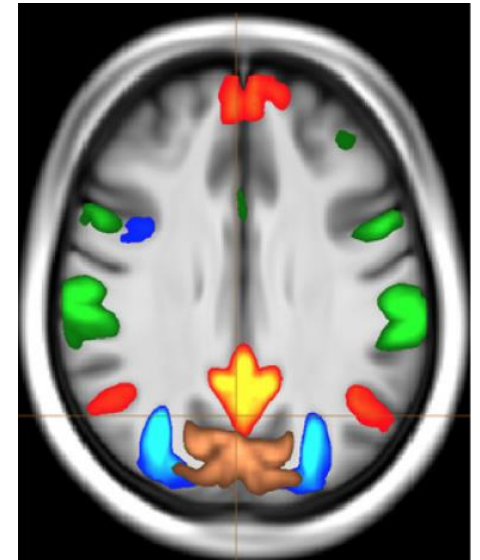
sMRI



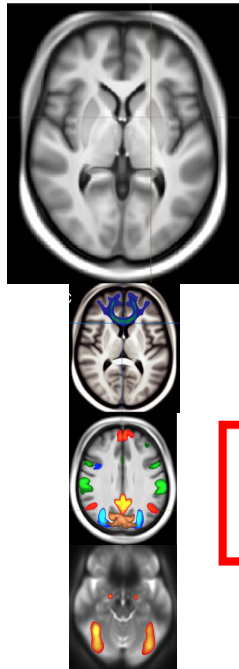
dMRI



tfMRI

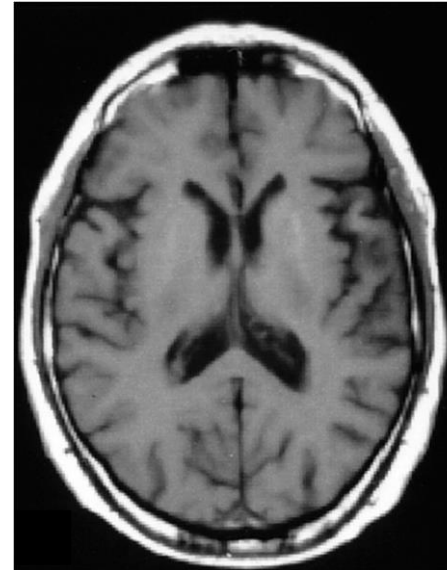
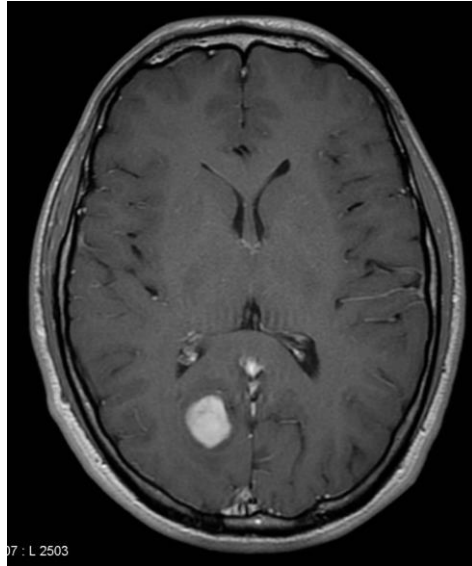


rfMRI



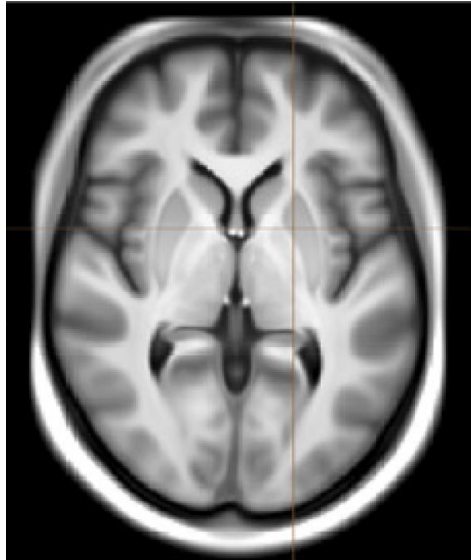
Modality	Duration	Voxel, Matrix	Key Parameters
T1	4:54	1.0x1.0x1.0 mm 208x256x256	3D MPRAGE, sagittal, R=2, TI/TR=880/2000 ms
T2 FLAIR	5:52	1.05x1.0x1.0 mm 192x256x256	FLAIR, 3D SPACE, sagittal, R=2, PF 7/8, fat sat, TI/TR=1800/5000 ms, elliptical
swMRI	2:34	0.8x0.8x3.0 mm 256x288x48	3D GRE, axial, R=2, PF 7/8 TE1/TE2/TR=9.4/20/27 ms,
dMRI	7:08	2.0x2.0x2.0 mm 104x104x72	MB=3, R=1, fat sat, b=0(5x + 3x phase-encoding-reversed), 1000(50x), 2000(50x)
rfMRI	6:10	2.4x2.4x2.4 mm 88x88x64	TE/TR=39/735 ms, MB=8, R=1, flip angle 52°, fat sat
tfMRI	4:13	2.4x2.4x2.4 mm 88x88x64	Acquisition same as rfMRI. Task is faces/shapes "emotion" task.

Clinically Meaningful Image-Derived Phenotypes (IDPs)

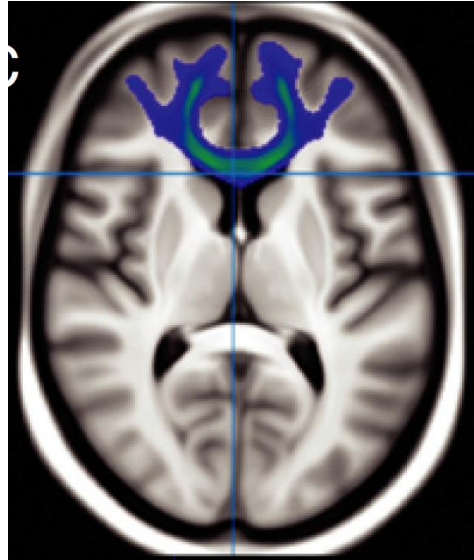


Automated Clinically Meaningful Image-Derived Phenotypes (IDPs)

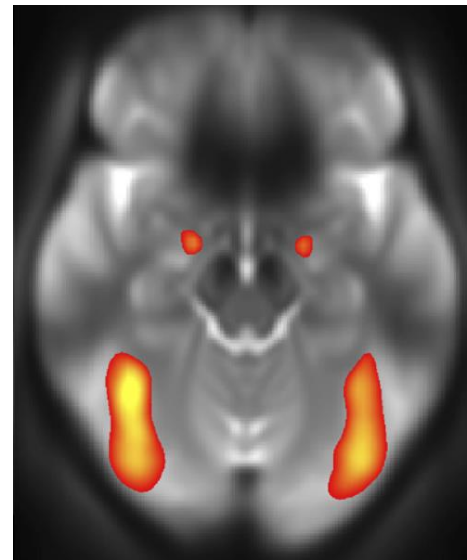
Automated Clinically Meaningful Image-Derived Phenotypes (IDPs)



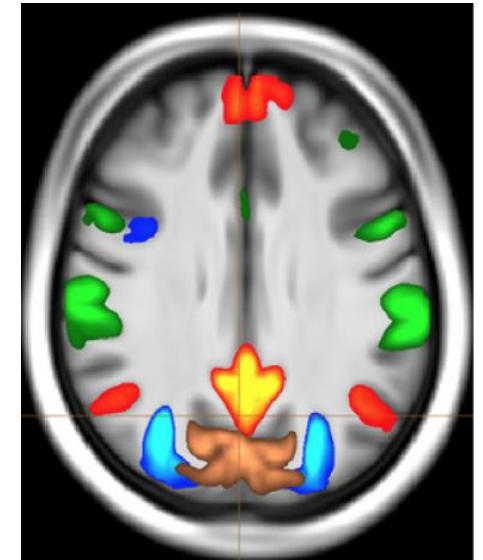
sMRI



dMRI

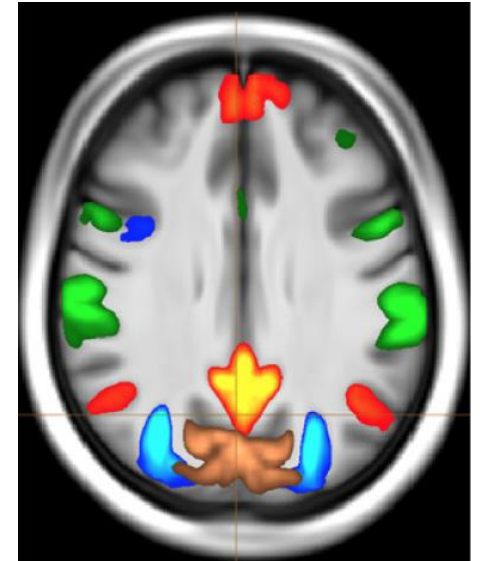


tfMRI



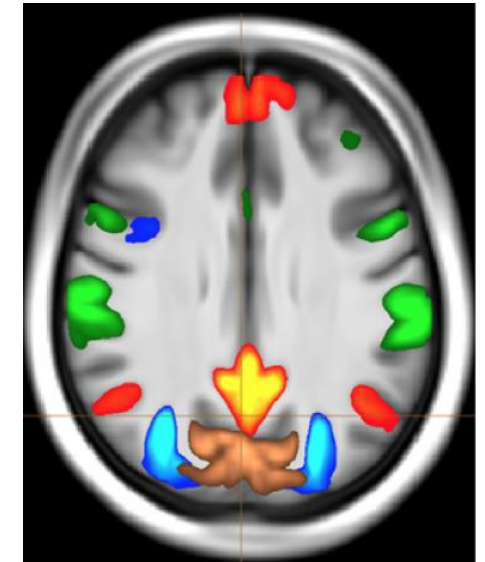
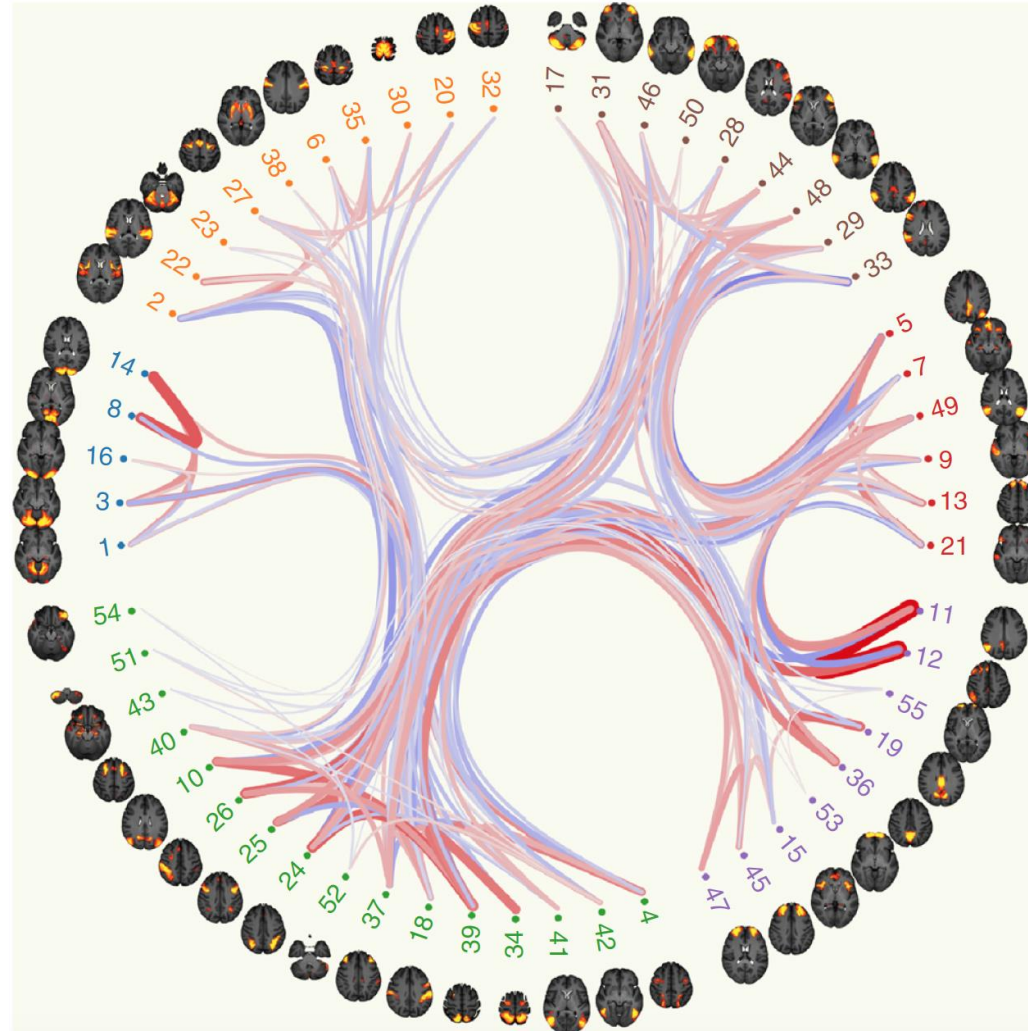
rfMRI

Automated Clinically Meaningful Image-Derived Phenotypes (IDPs)



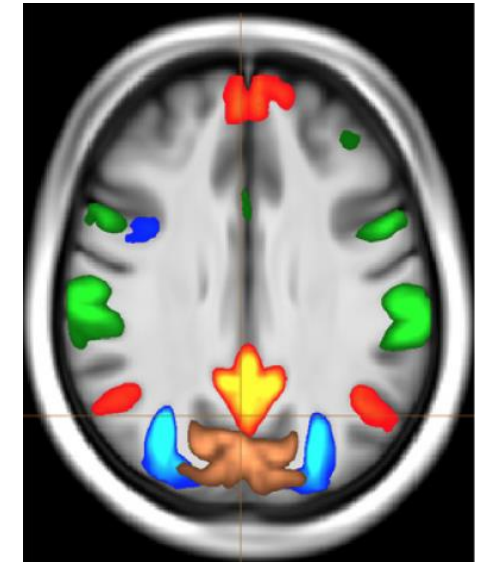
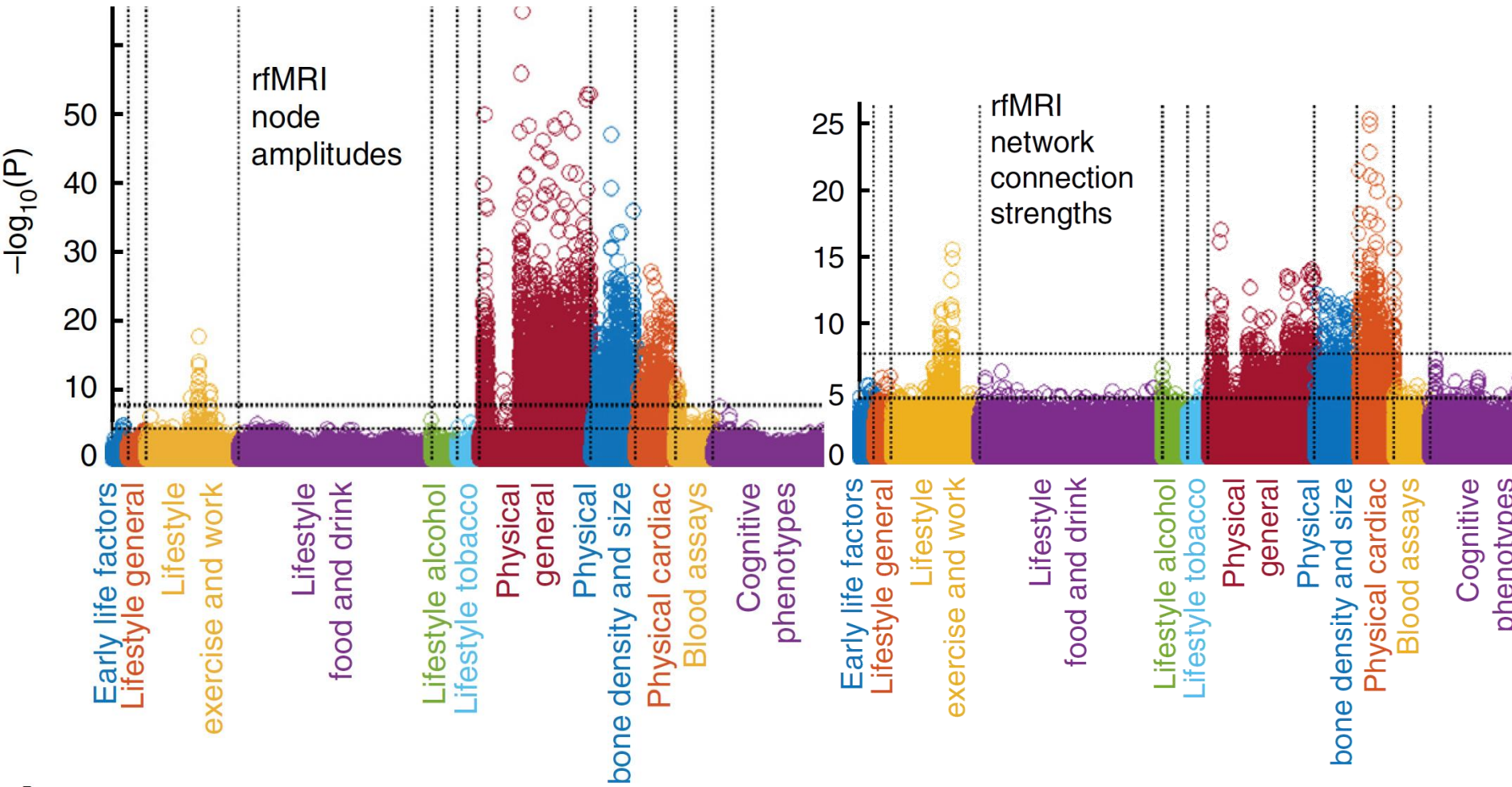
rfMRI

1771 Automated Image-Derived Phenotypes (IDPs)



rfMRI

? Clinically Meaningful Automated Image-Derived Phenotypes (IDPs)



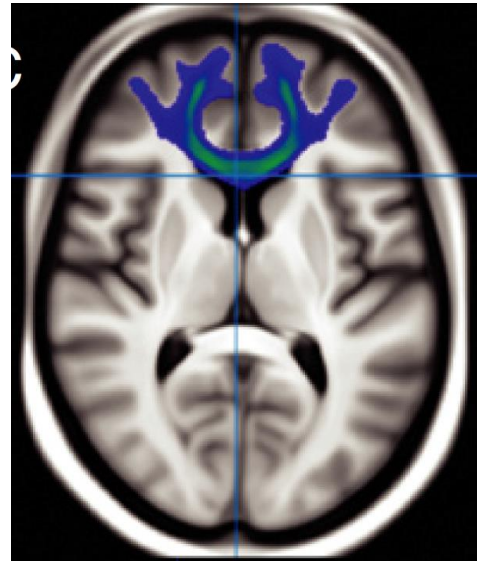
rfMRI

Automated Clinically Meaningful Image-Derived Phenotypes (IDPs)



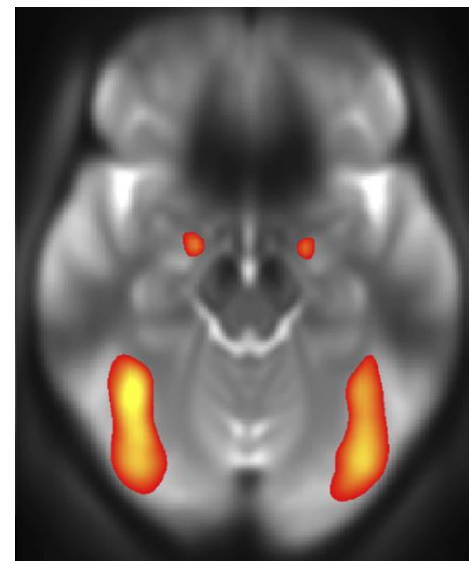
sMRI

39



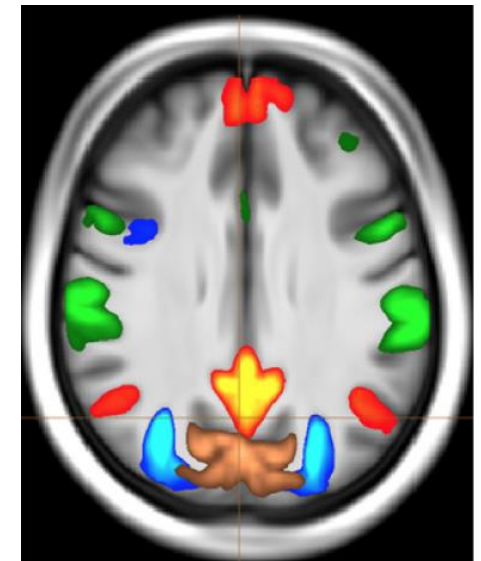
dMRI

675



tfMRI

16



rfMRI

1771

1100 Health Related Factors (11 Cat)

2501 IDPs (6 Cat)

Early life factors
Lifestyle general
Lifestyle
exercise and work

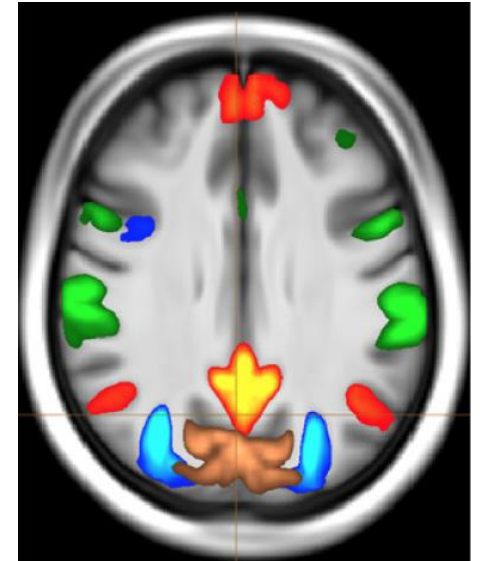
Lifestyle
food and drink

Lifestyle alcohol
Lifestyle tobacco
Physical
general
Physical
bone density and size
Physical cardiac
Blood assays

Cognitive
phenotypes

○ T1
○ swMRI
○ tfMRI
○ dMRI
○ rfMRI amplitudes
○ rfMRI netmats

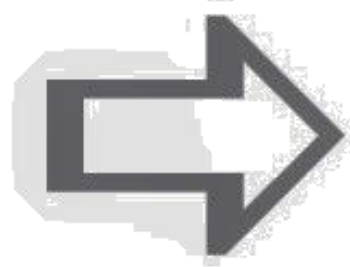
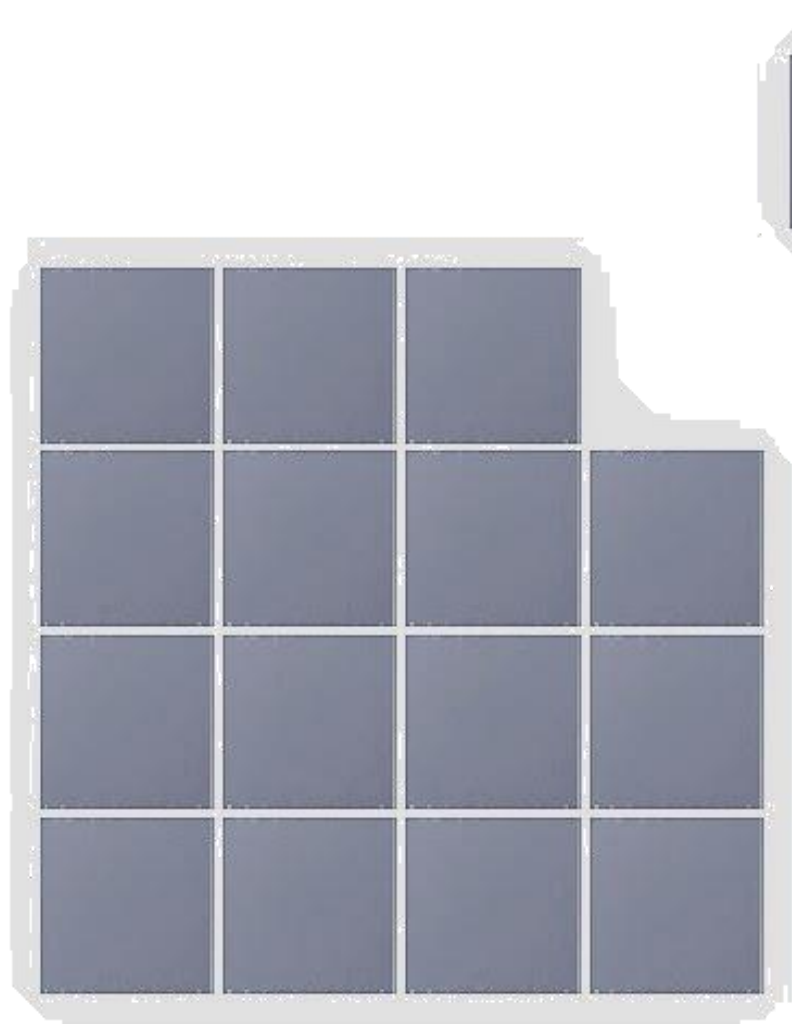
What is Resting Functional MRI?



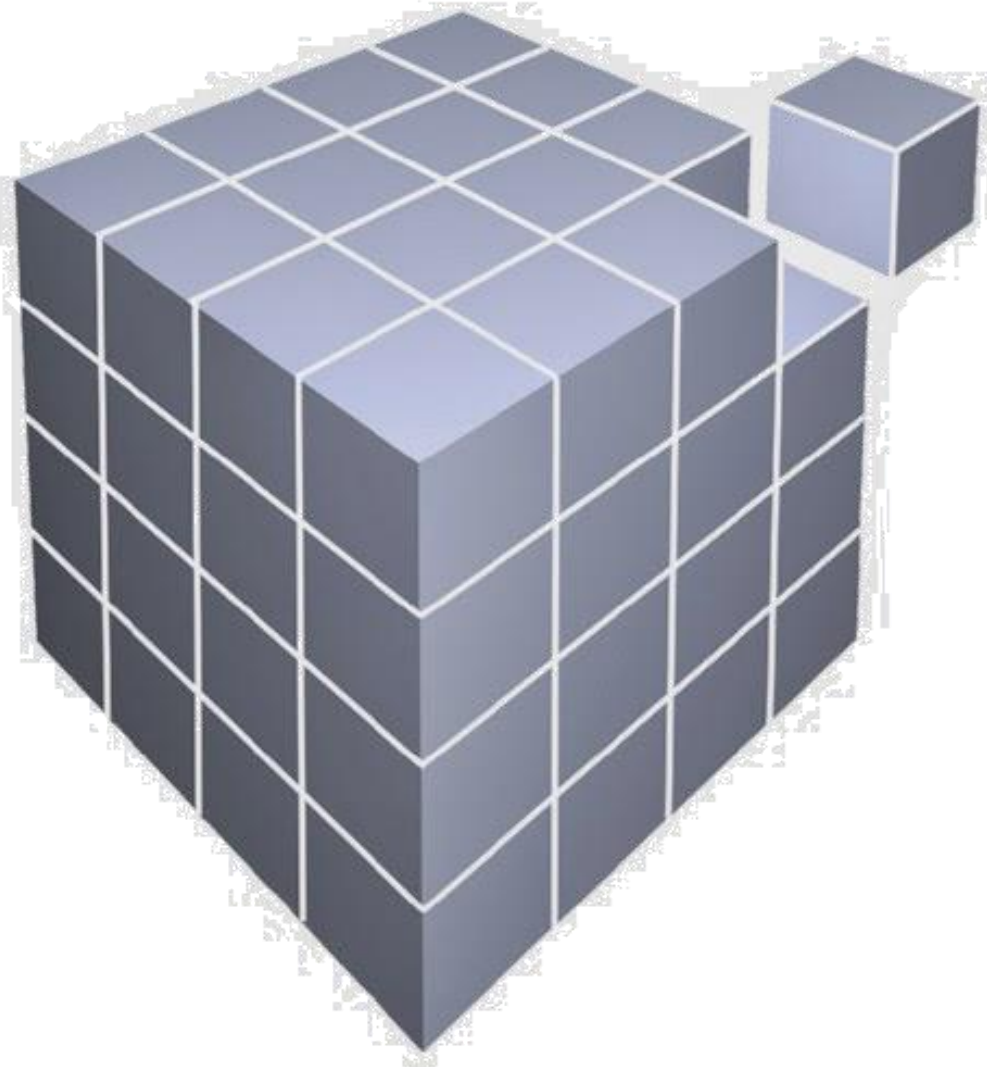
rfMRI

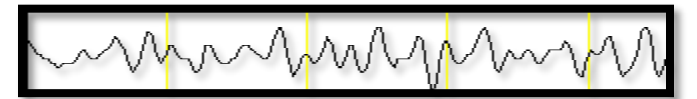
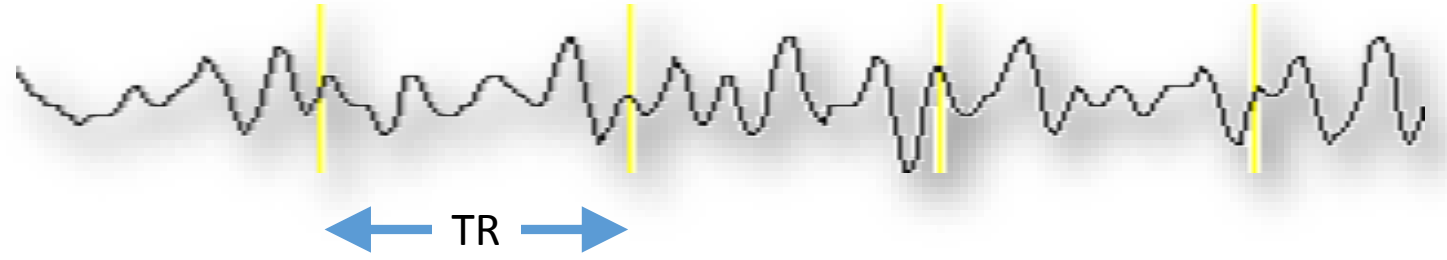
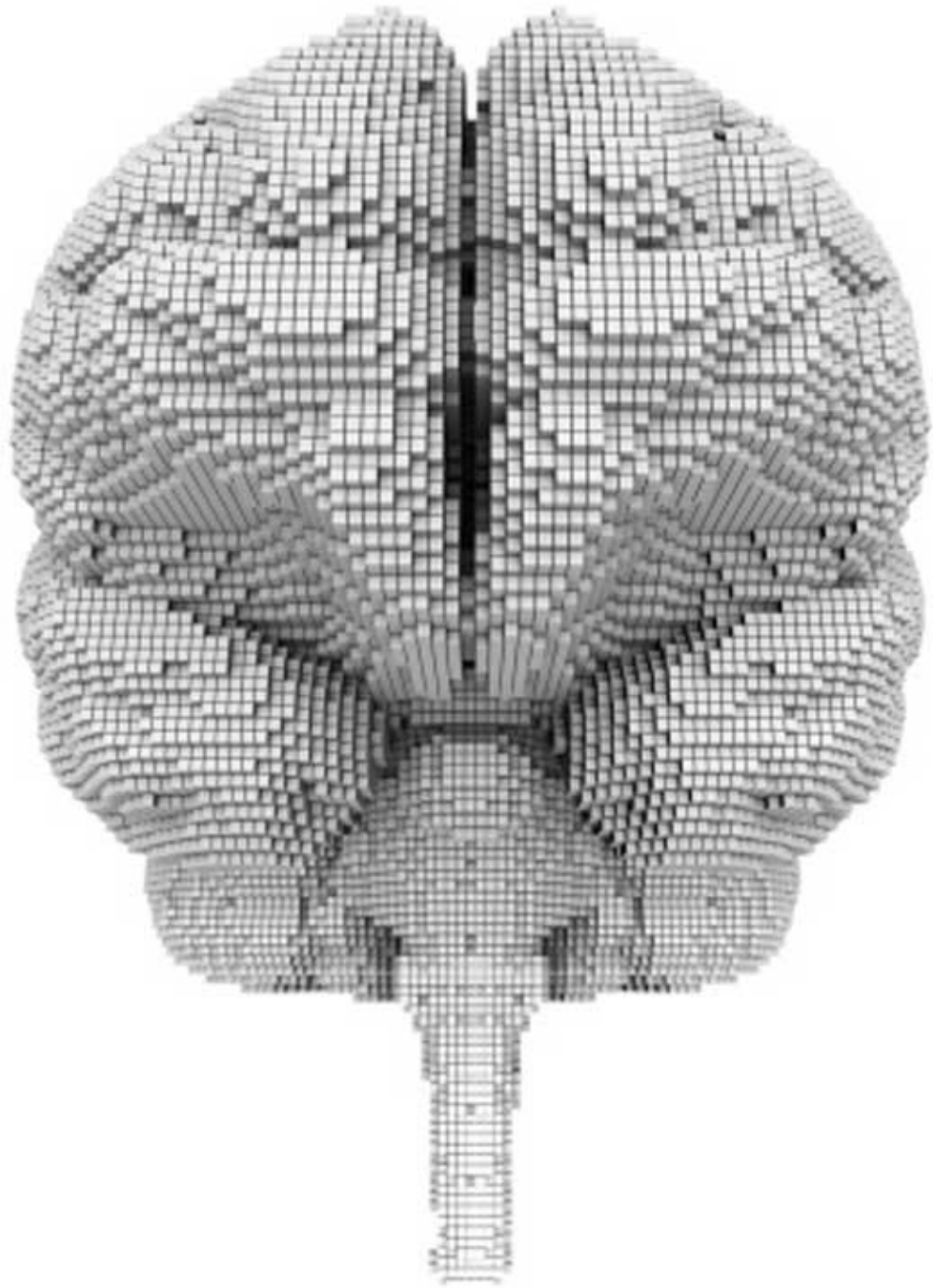
1771

Pixel

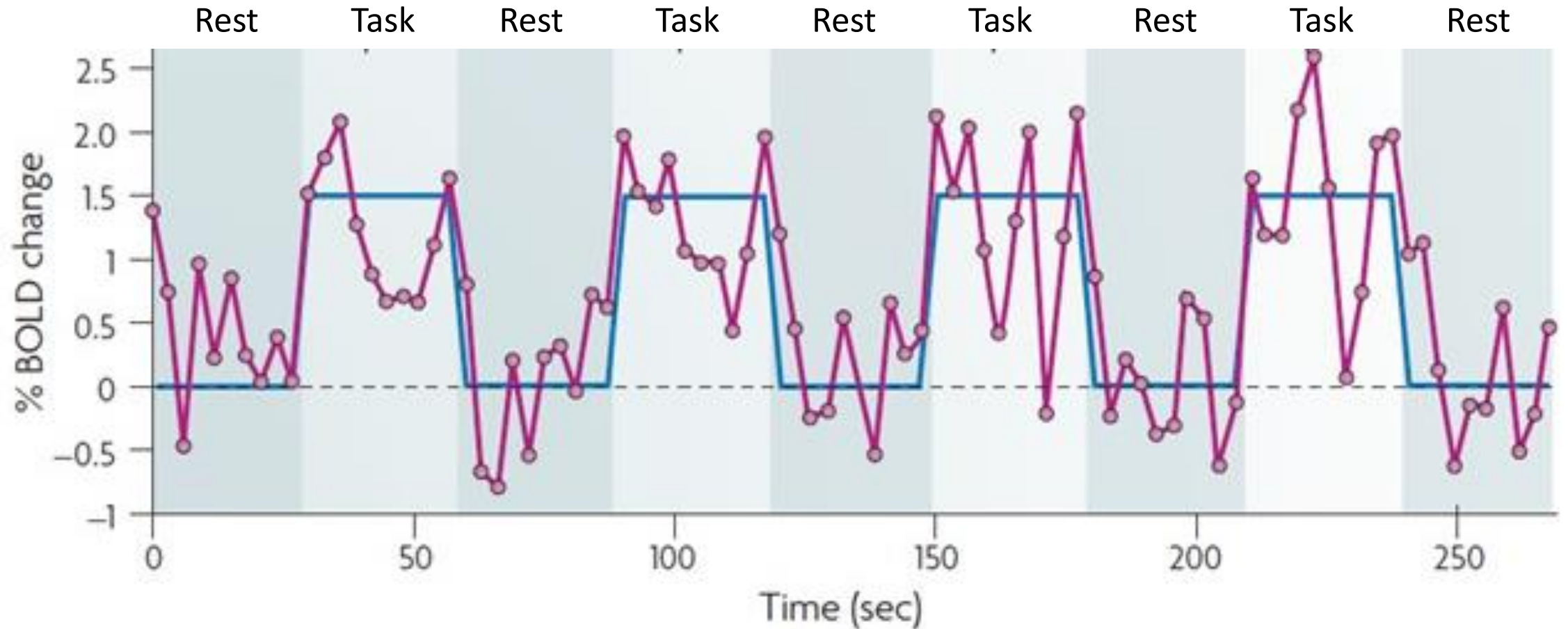


Voxel

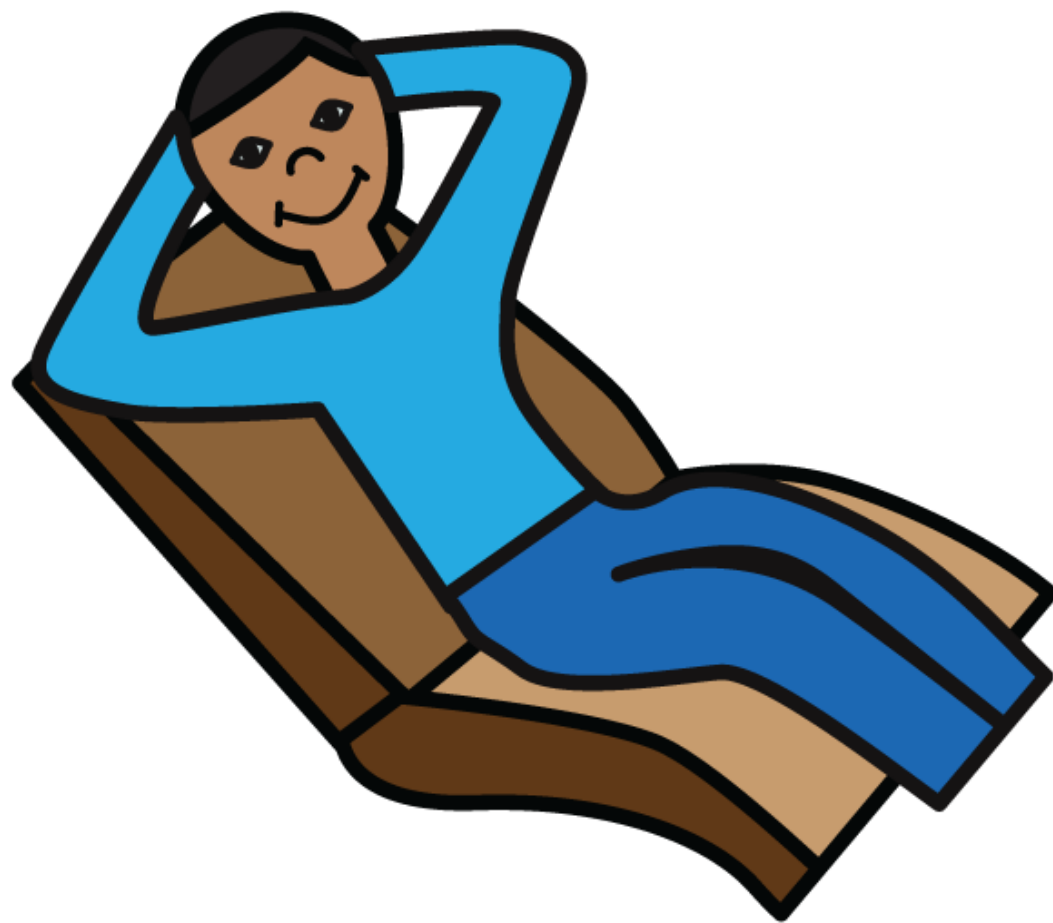




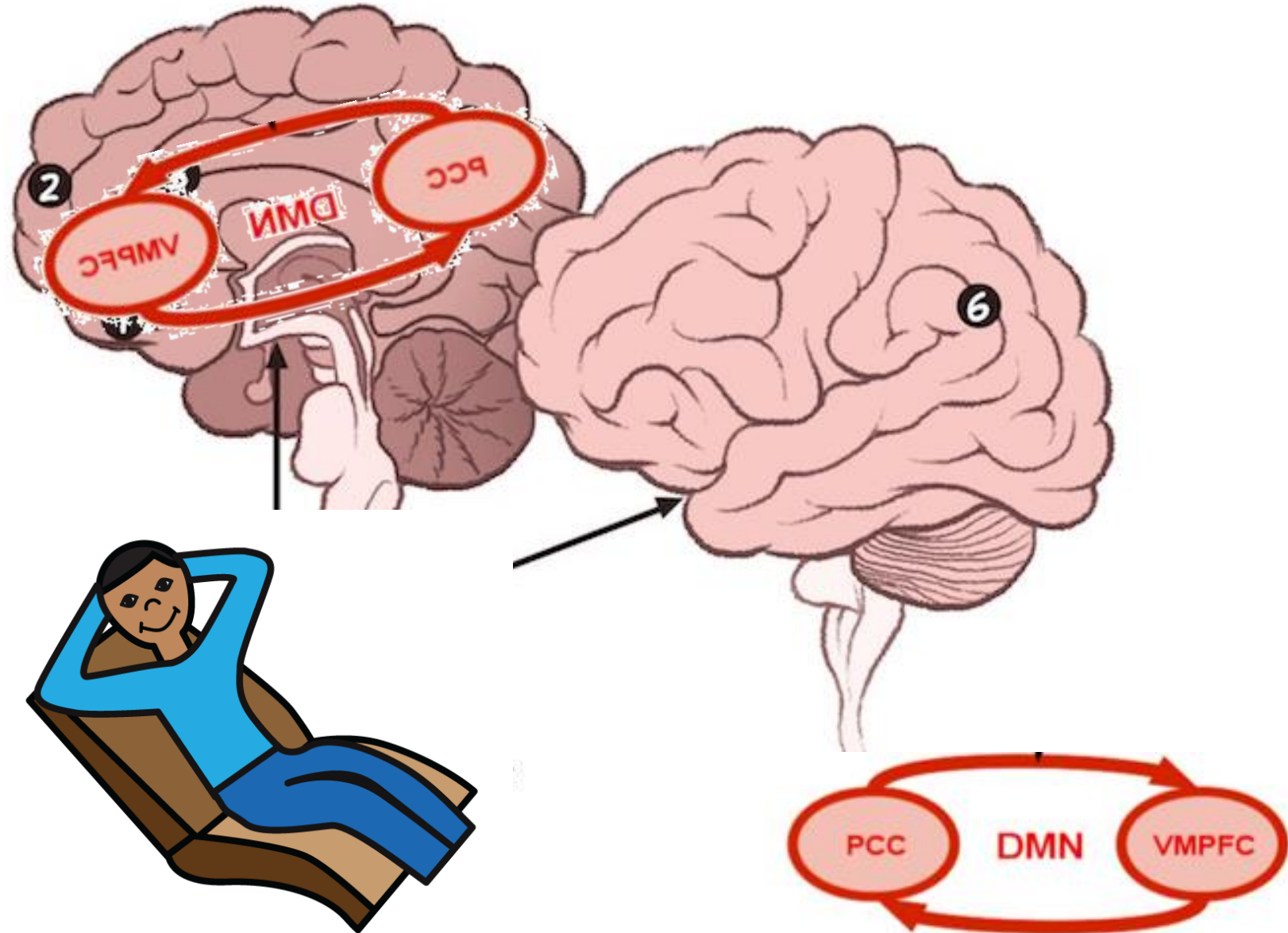
Task-based fMRI (Task>Rest)



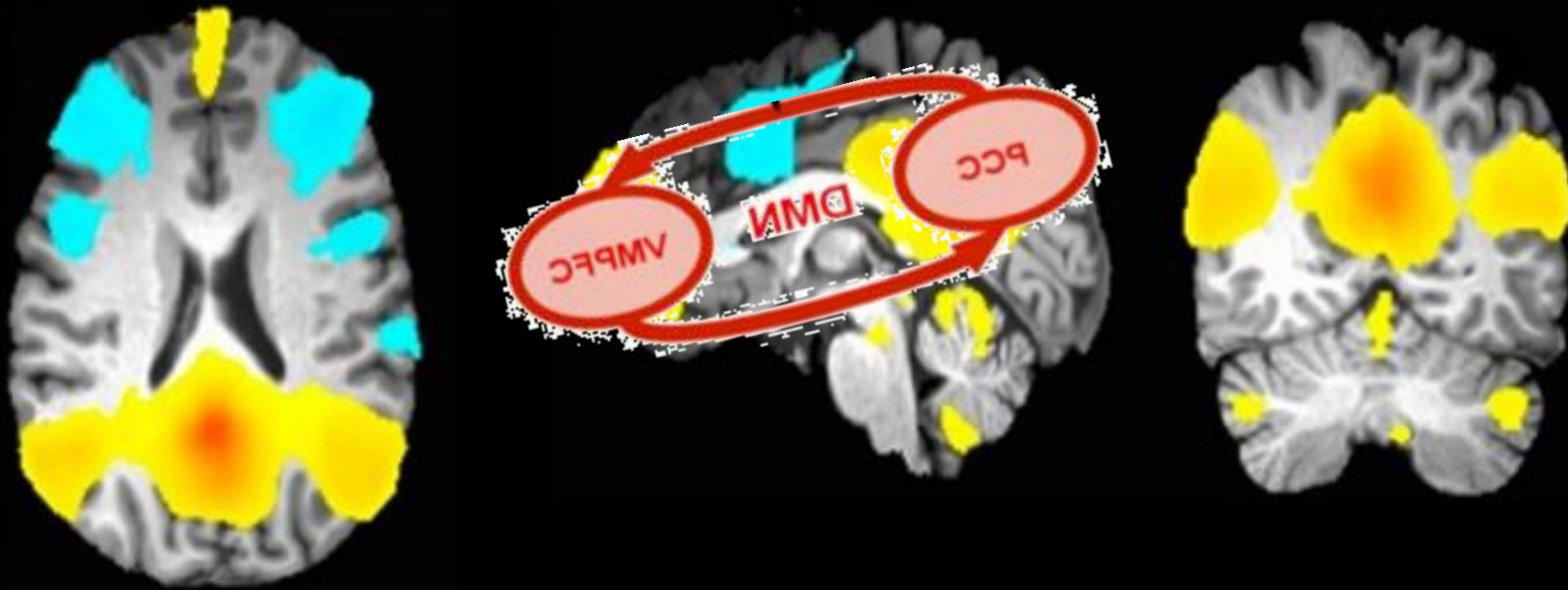
What happens during REST? (Rest>Task)



Default Mode Network (DMN)



baseline Default Mode Network (DMN)



Lets do some calculations!

$$13 * 12 = ?$$

156

$$15 * 16 = ?$$

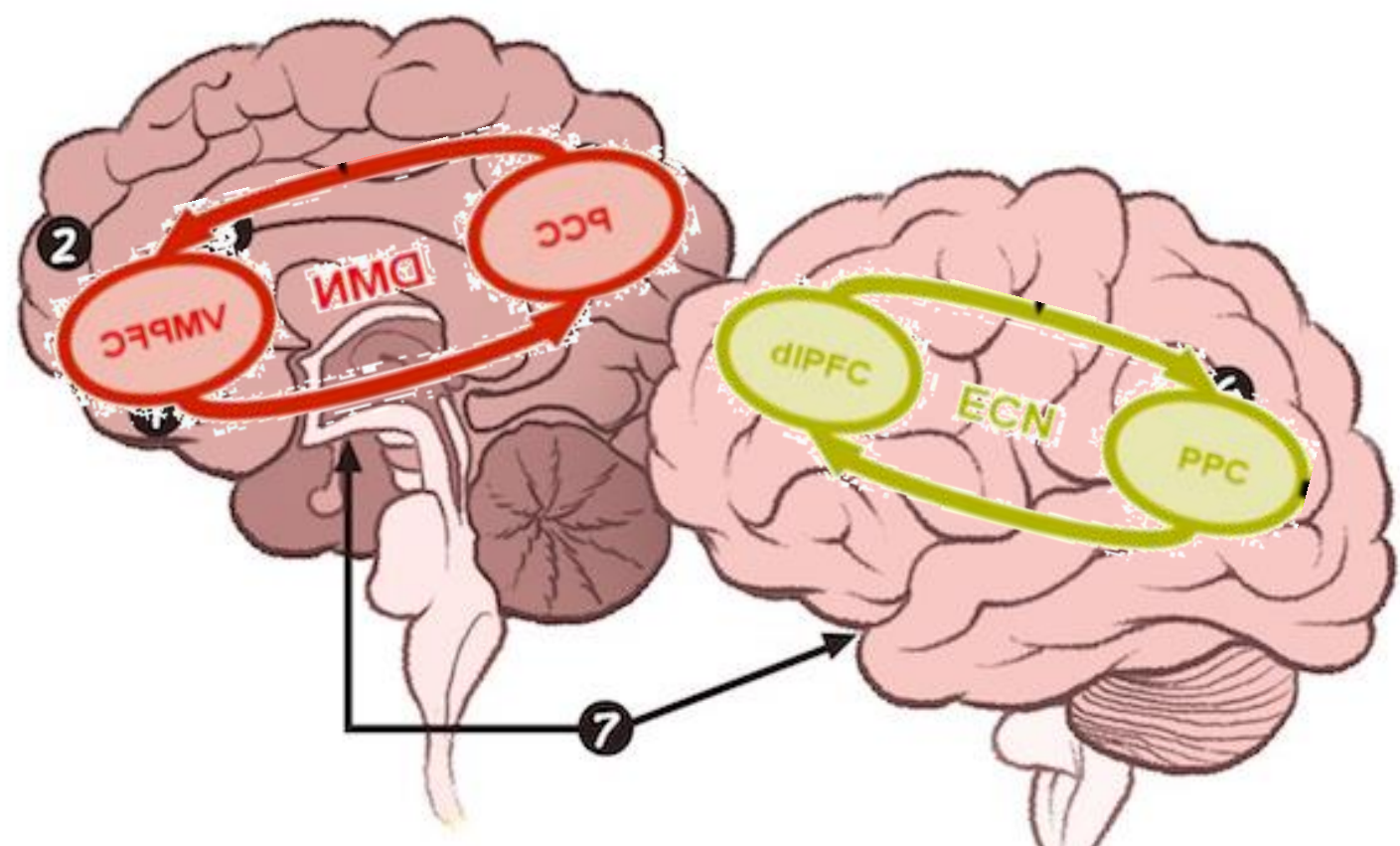
240

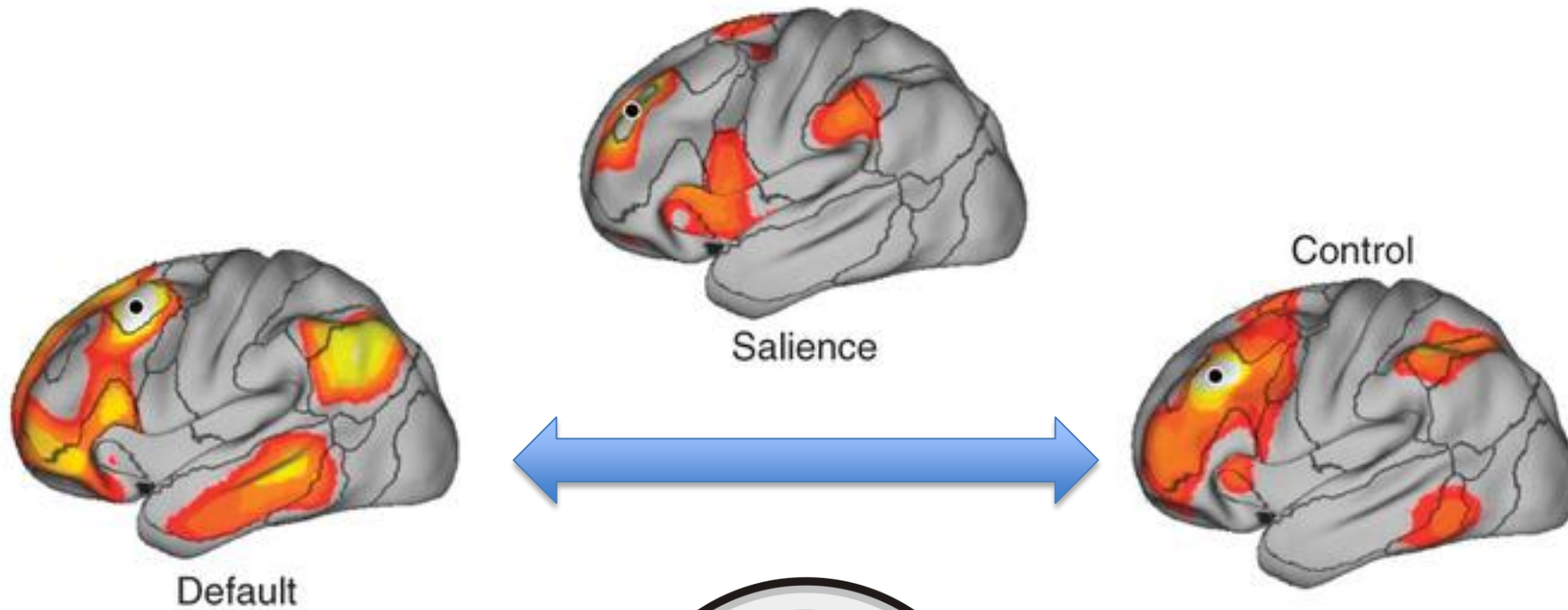
$$23 * 21 = ?$$

483

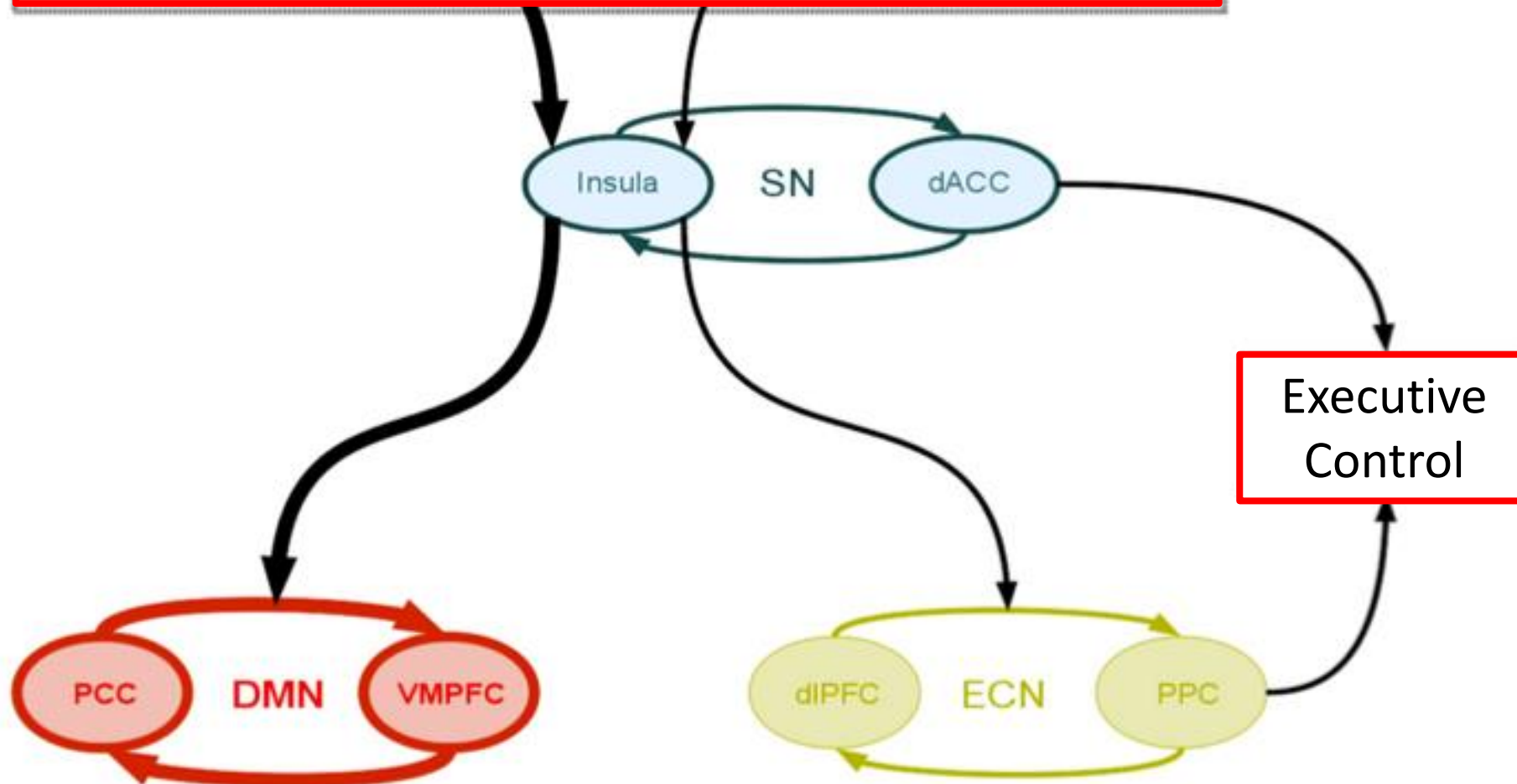
$$24 * 15 = ?$$

360

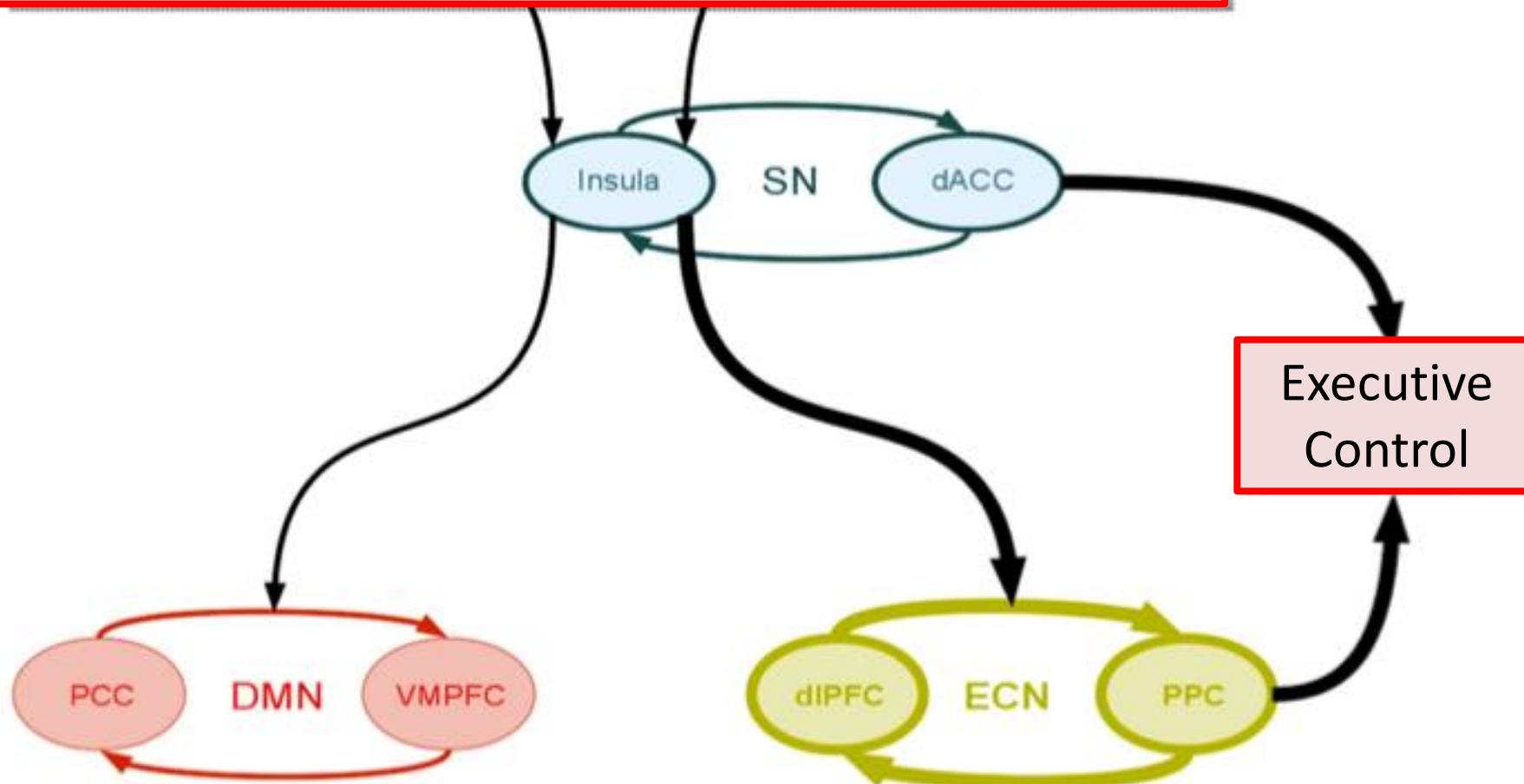




Environmental Cues

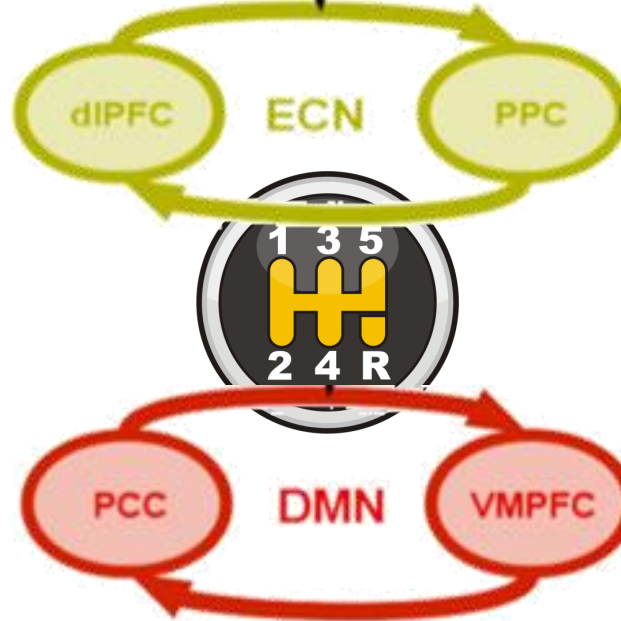


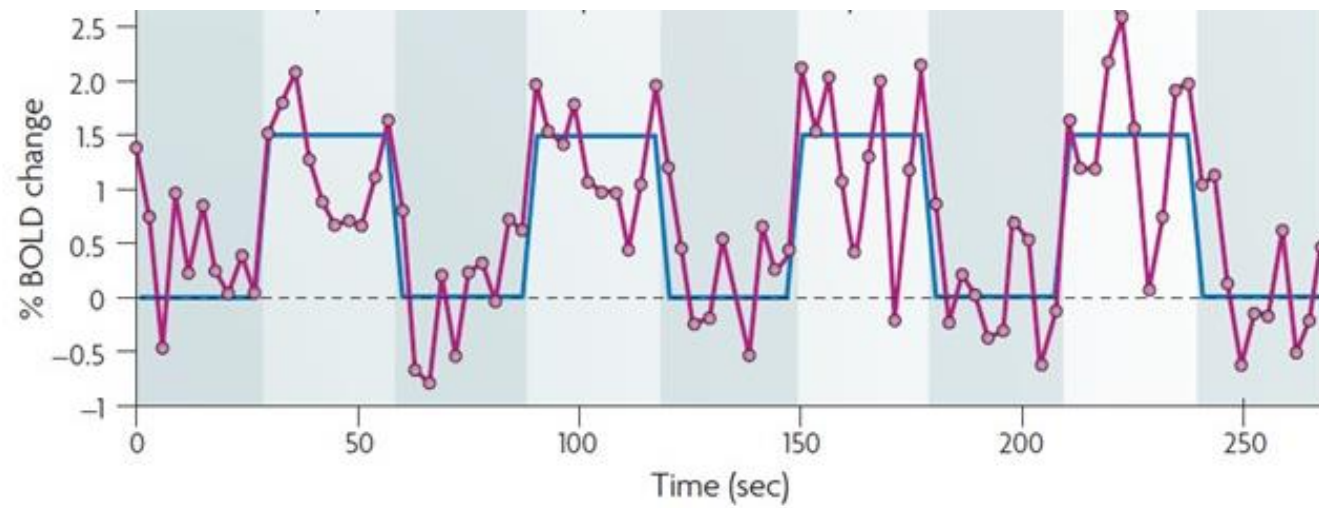
Environmental Cues



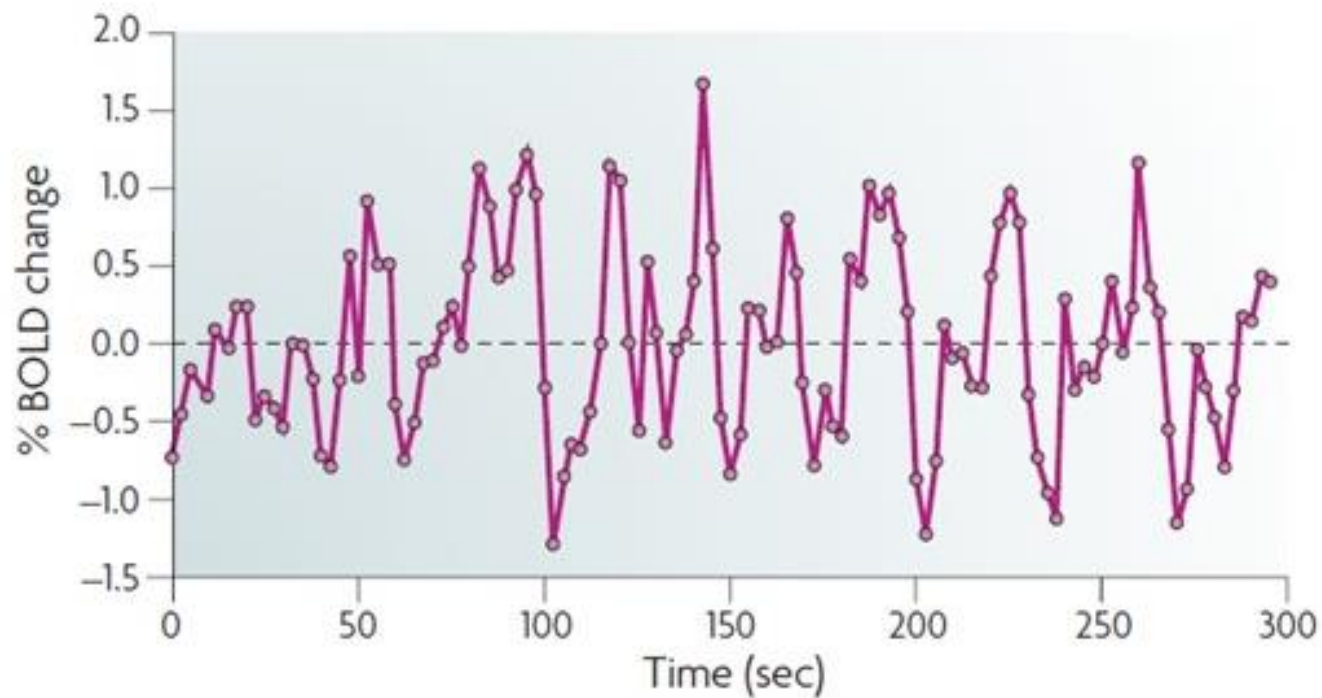




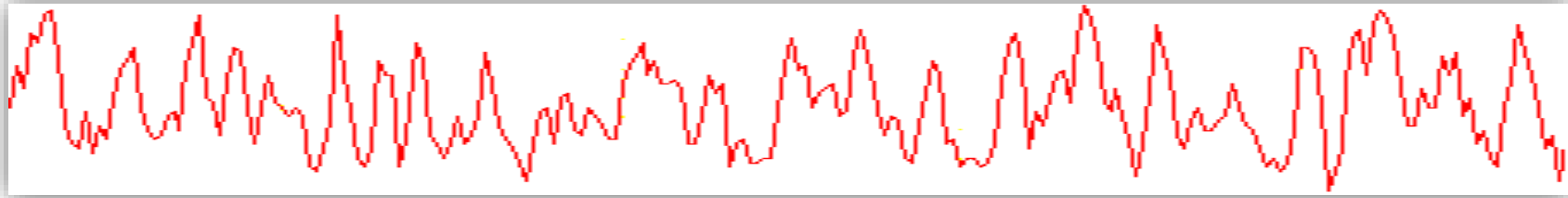


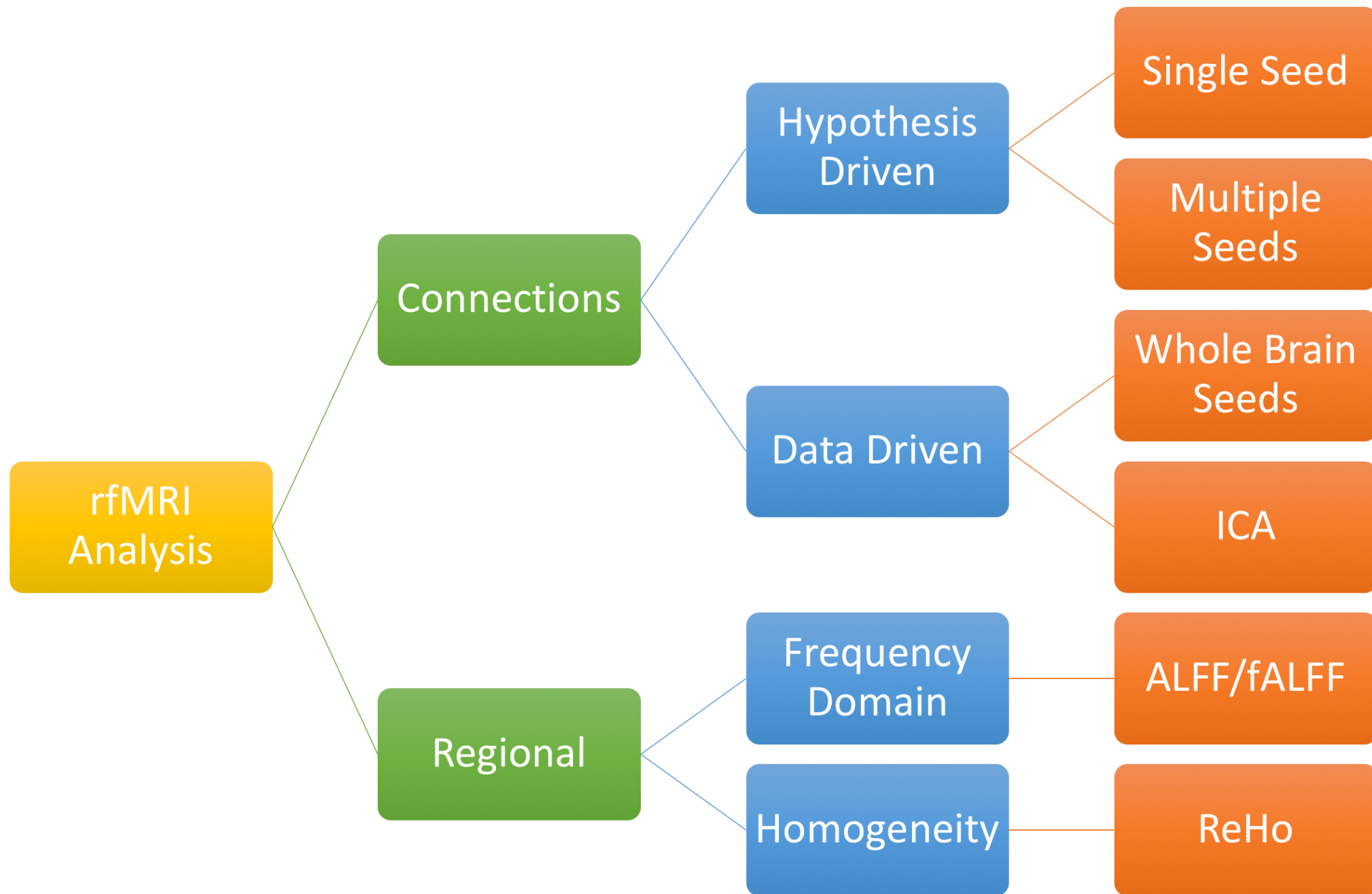


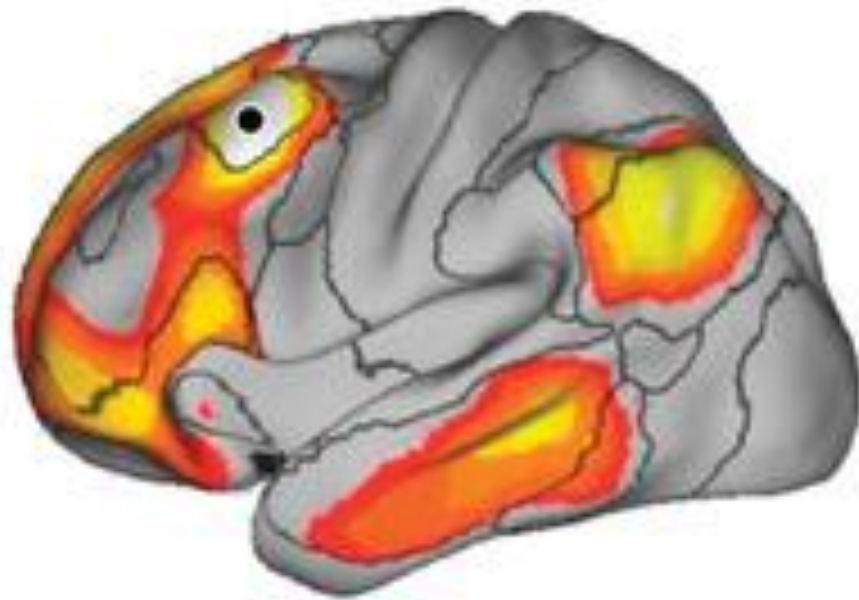
Spontaneous Low Frequency Fluctuations during Rest Have Meaningful Signals



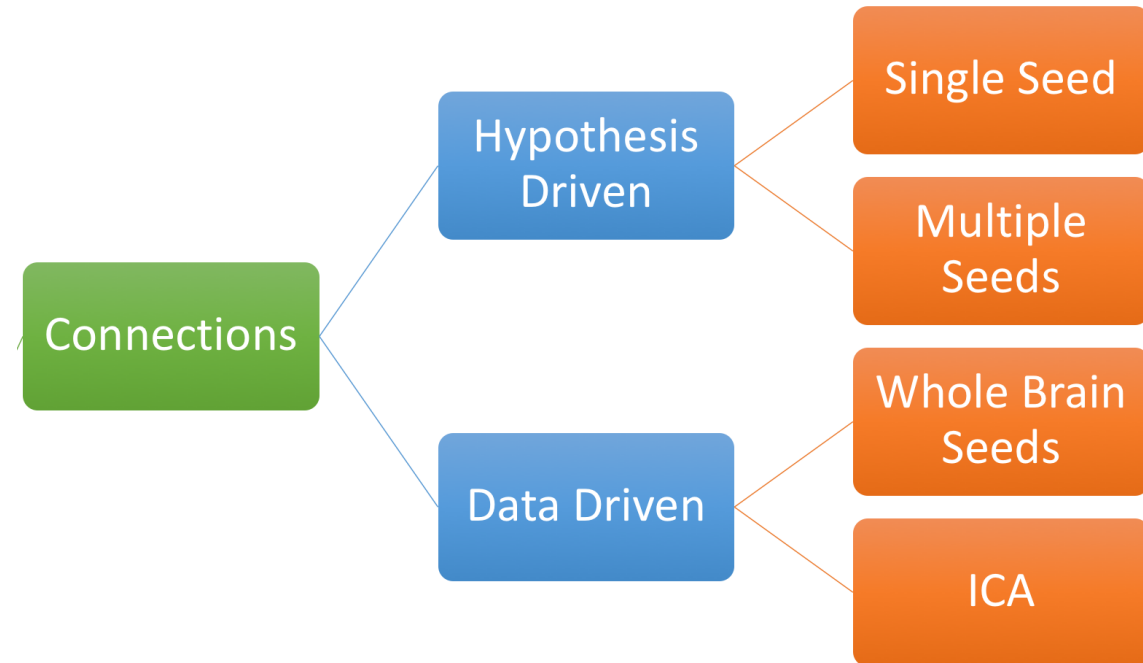
How to Analyze These Time Series of Data (rfMRI)?





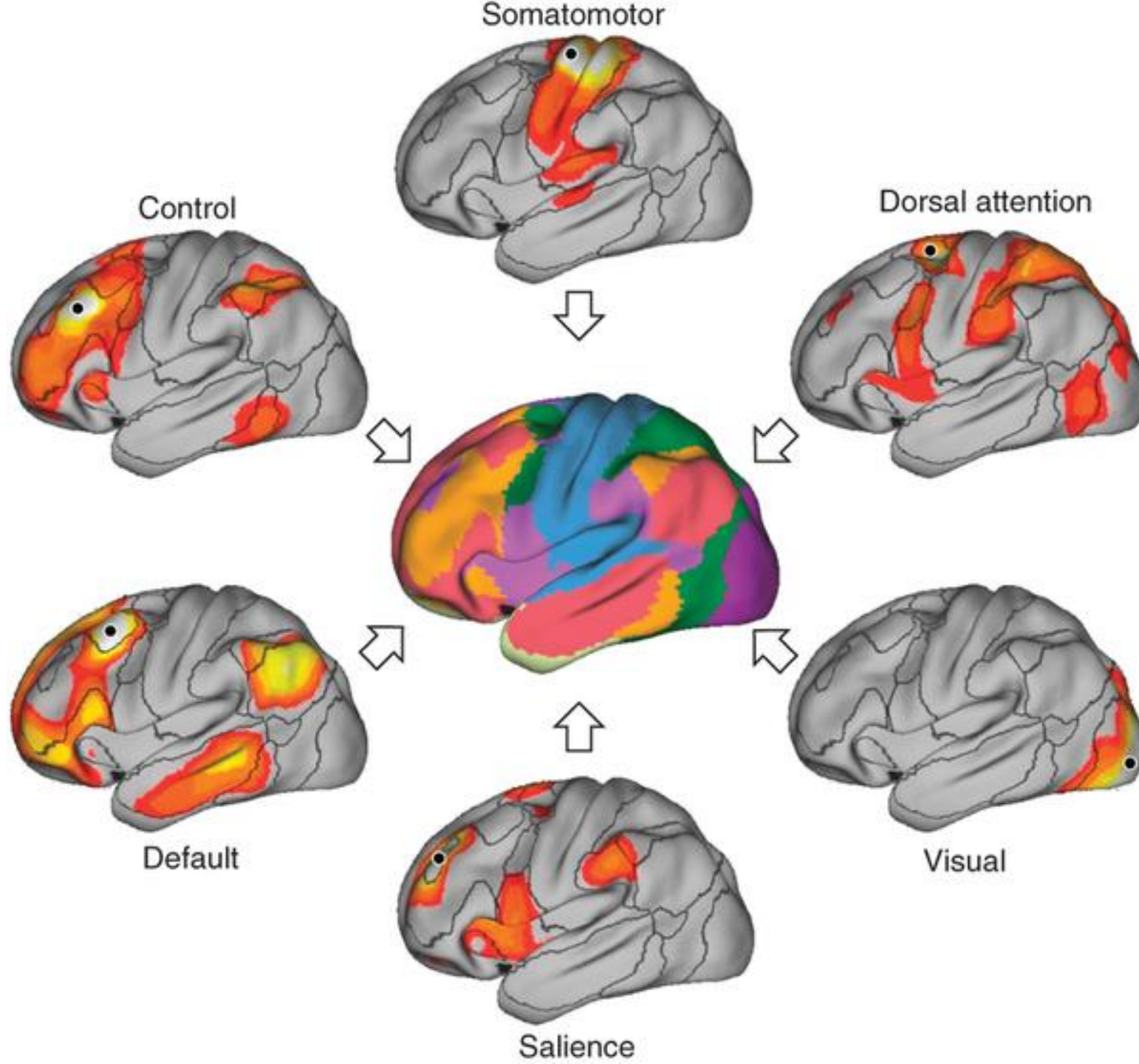


Default

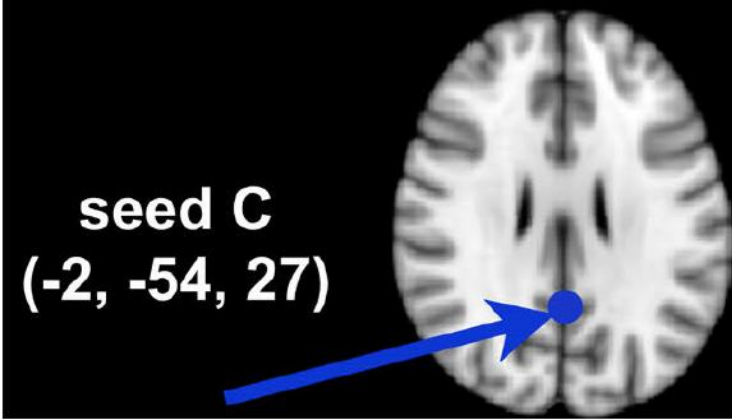


Single Seed

Hypothesis
Driven



Default Mode Network with Seeds in PCC



Default Mode Network with Seeds in PCC

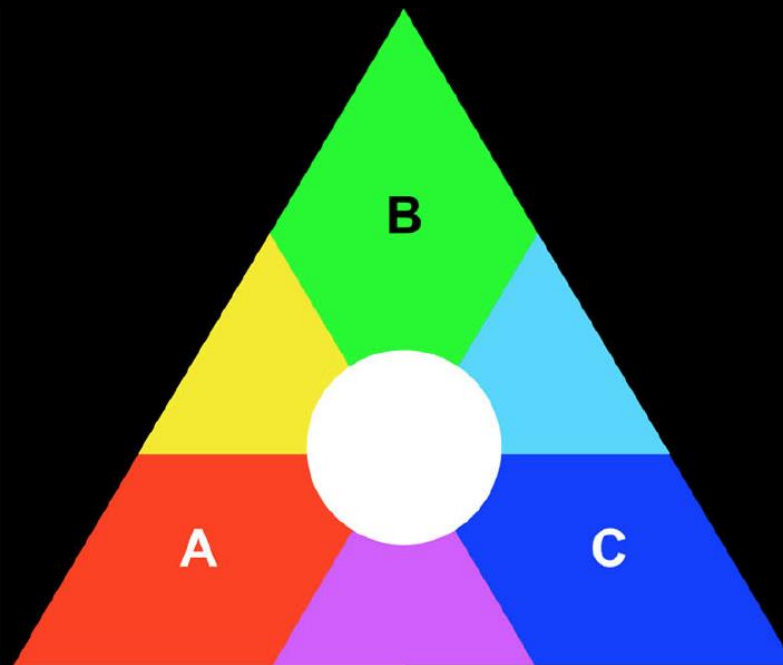
seed A
(-2, -39, 38)



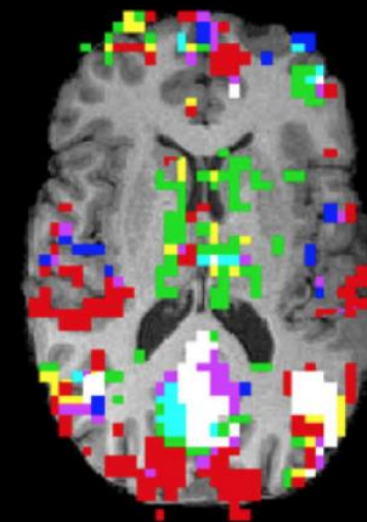
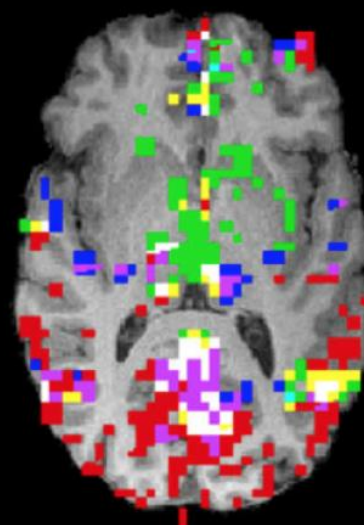
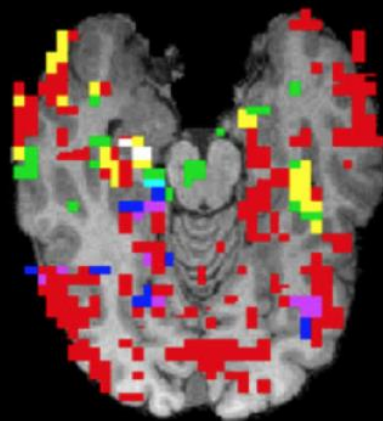
seed B
(2, -60, 36)



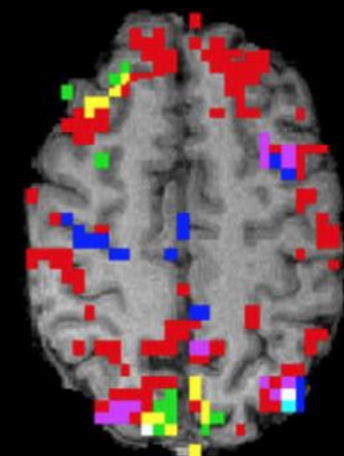
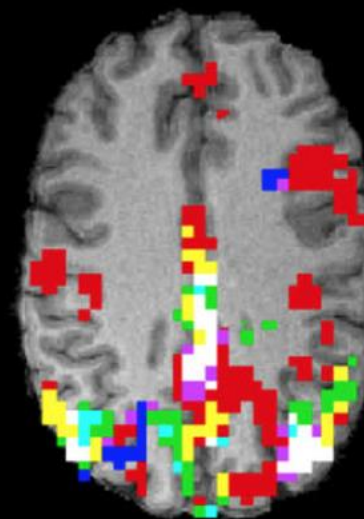
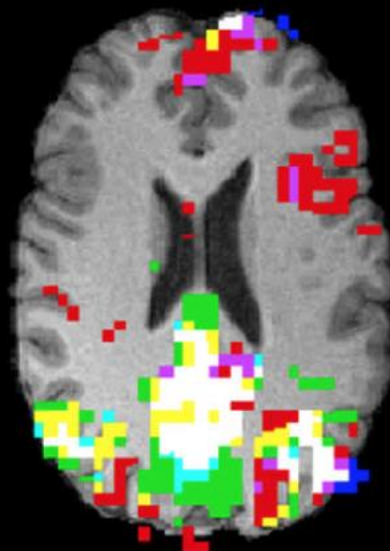
seed C
(-2, -54, 27)



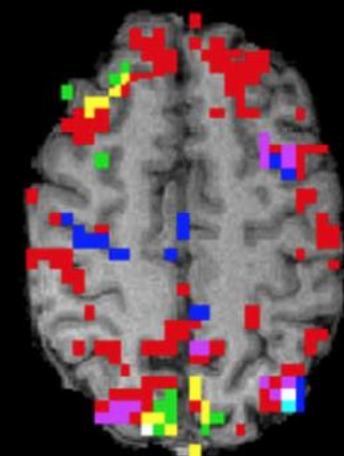
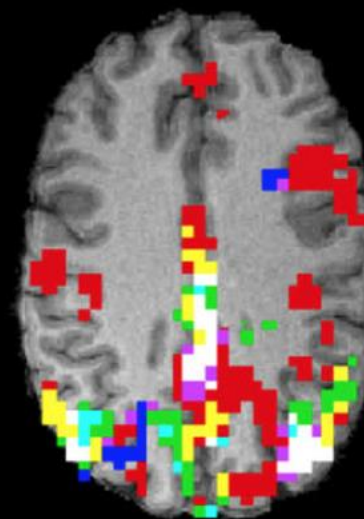
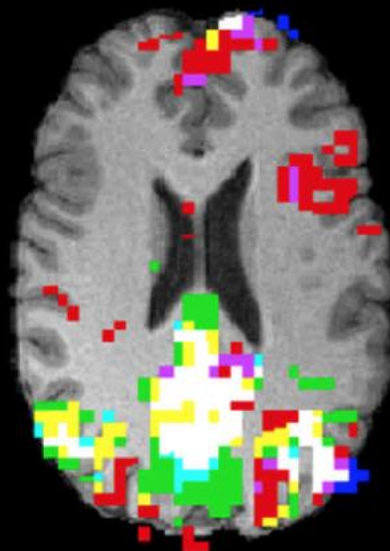
seed A
(-2, -39, 38)



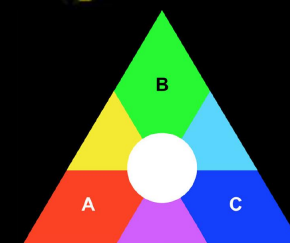
seed B
(2, -60, 36)



seed C
(-2, -54, 27)



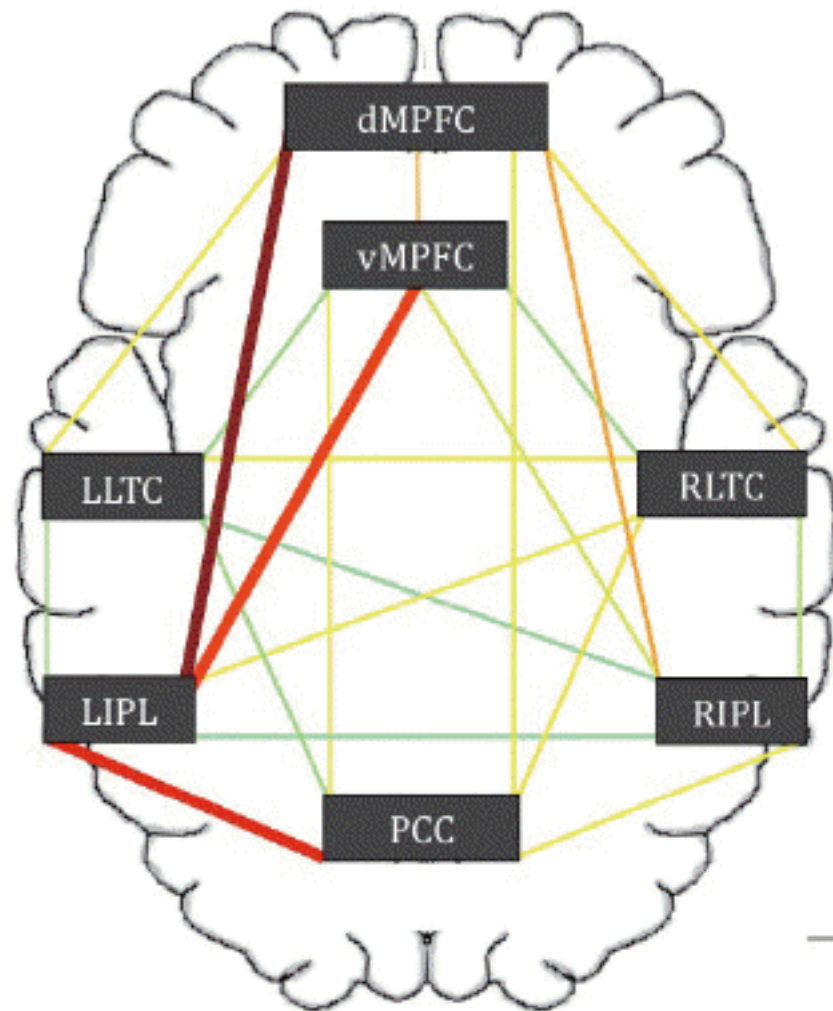
(Cole, et al., 2010)

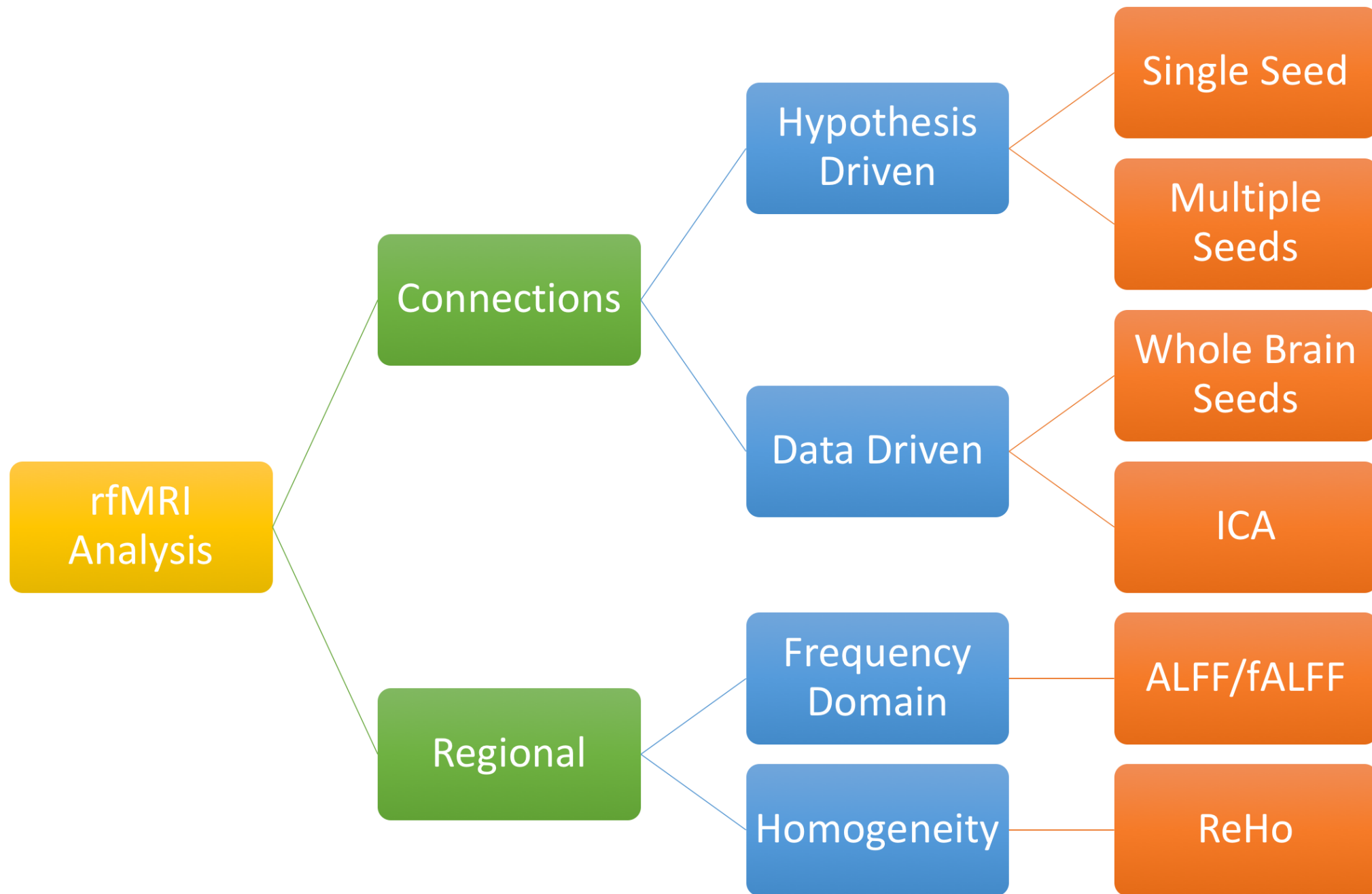


Hypothesis
Driven

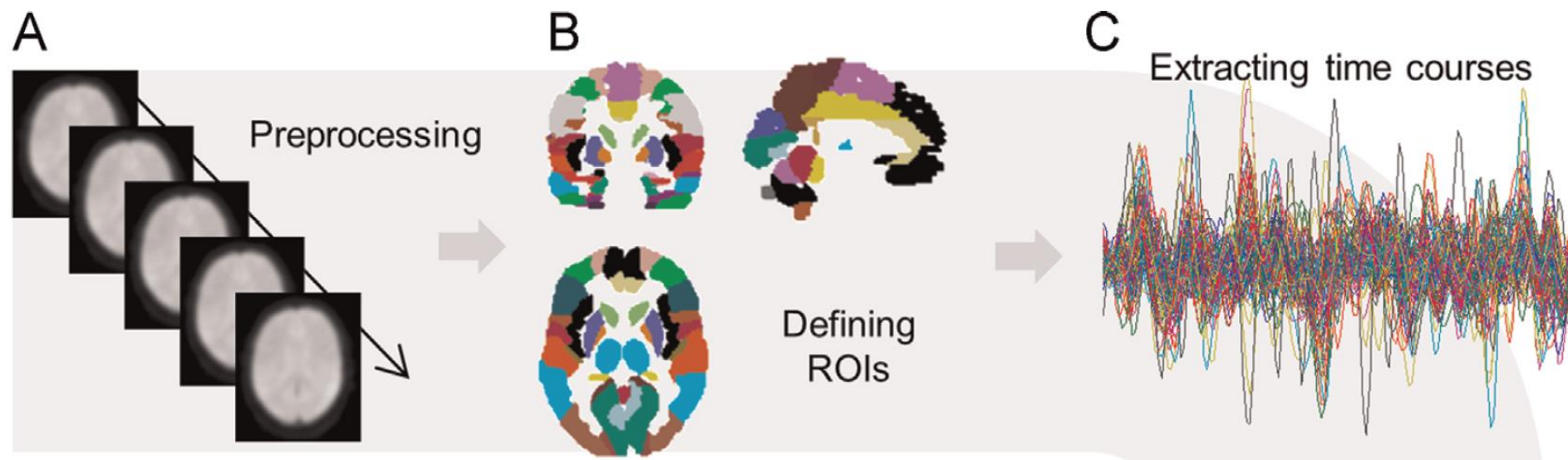
Single Seed

Multiple
Seeds

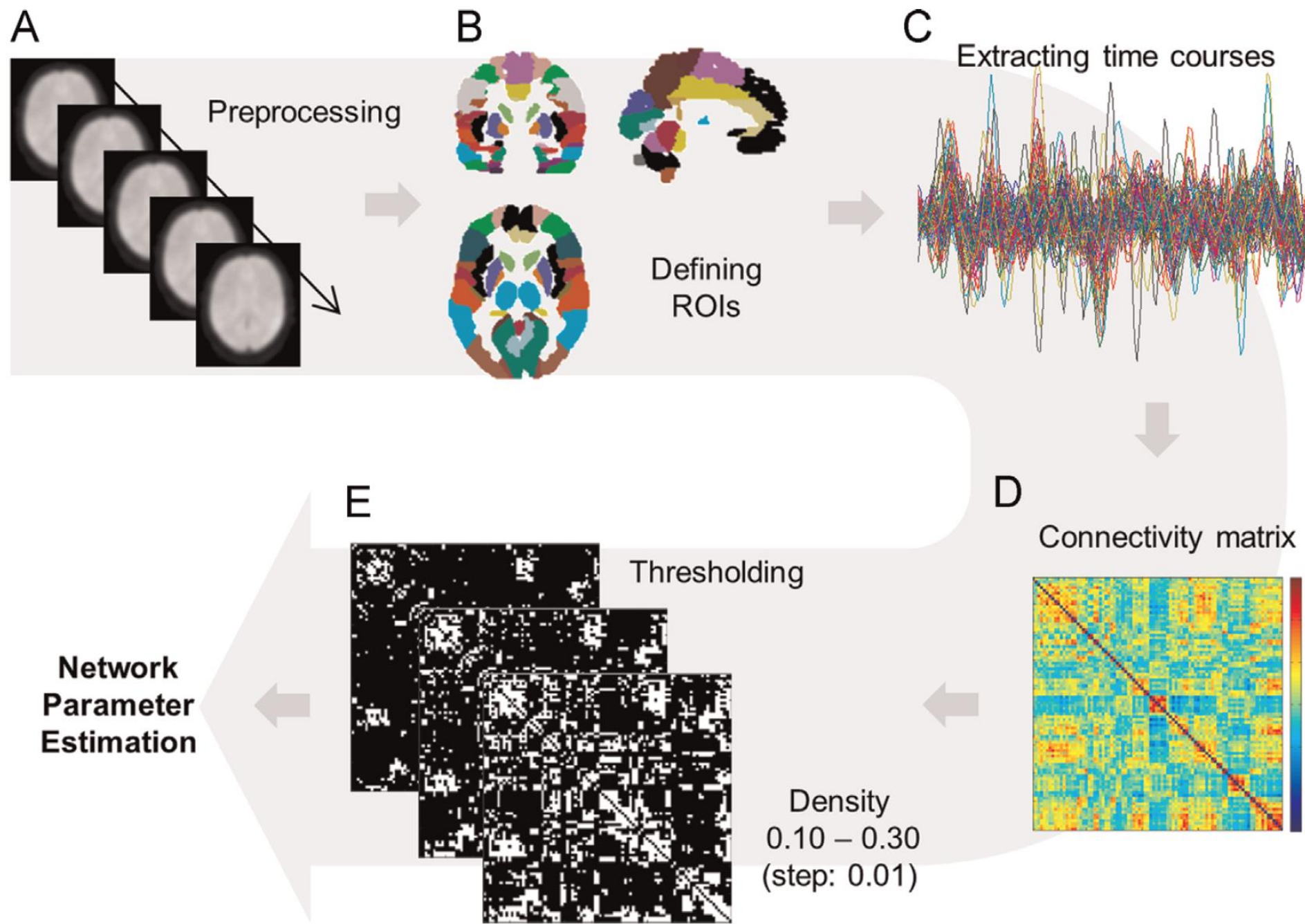


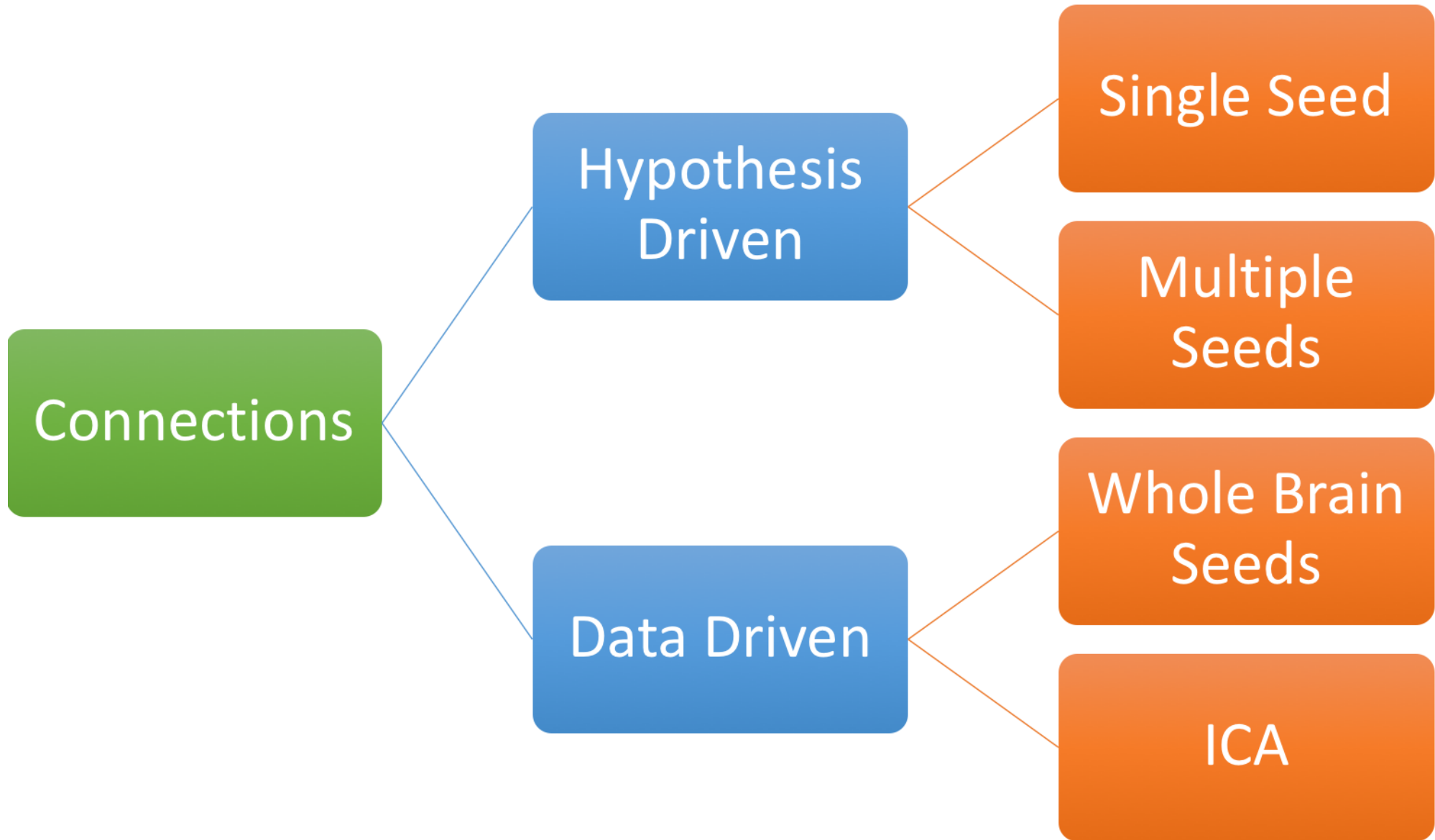


Whole Brain Seeds

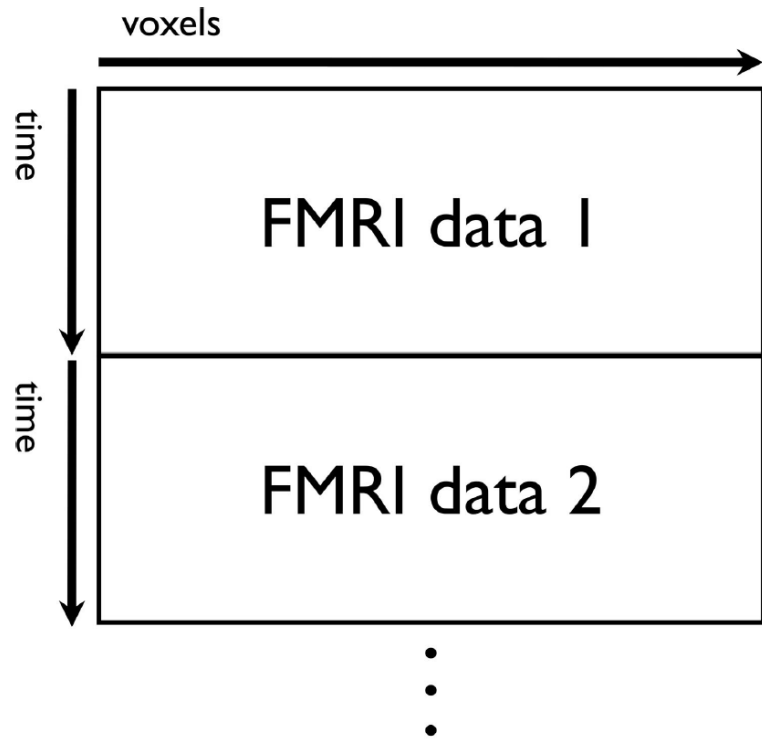


Whole Brain Seeds

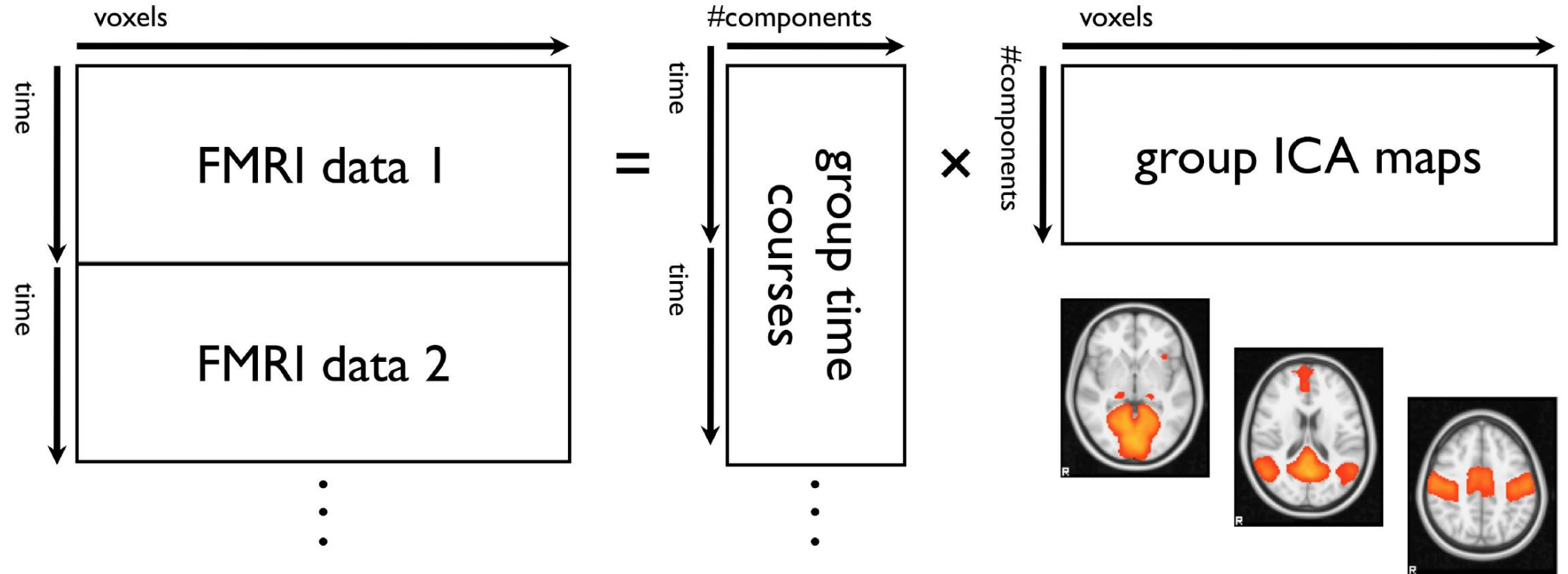




Temporal Concatenation

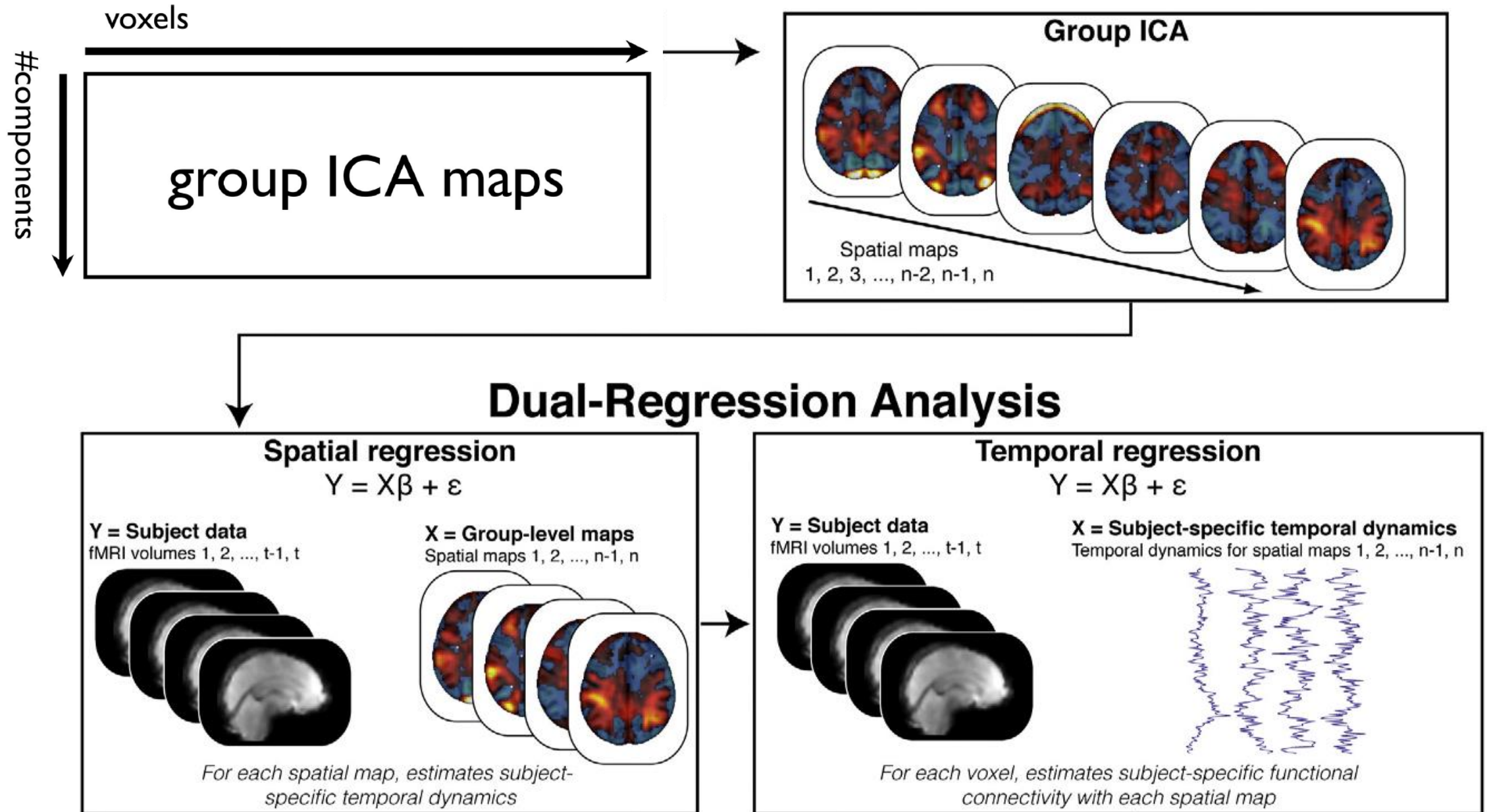


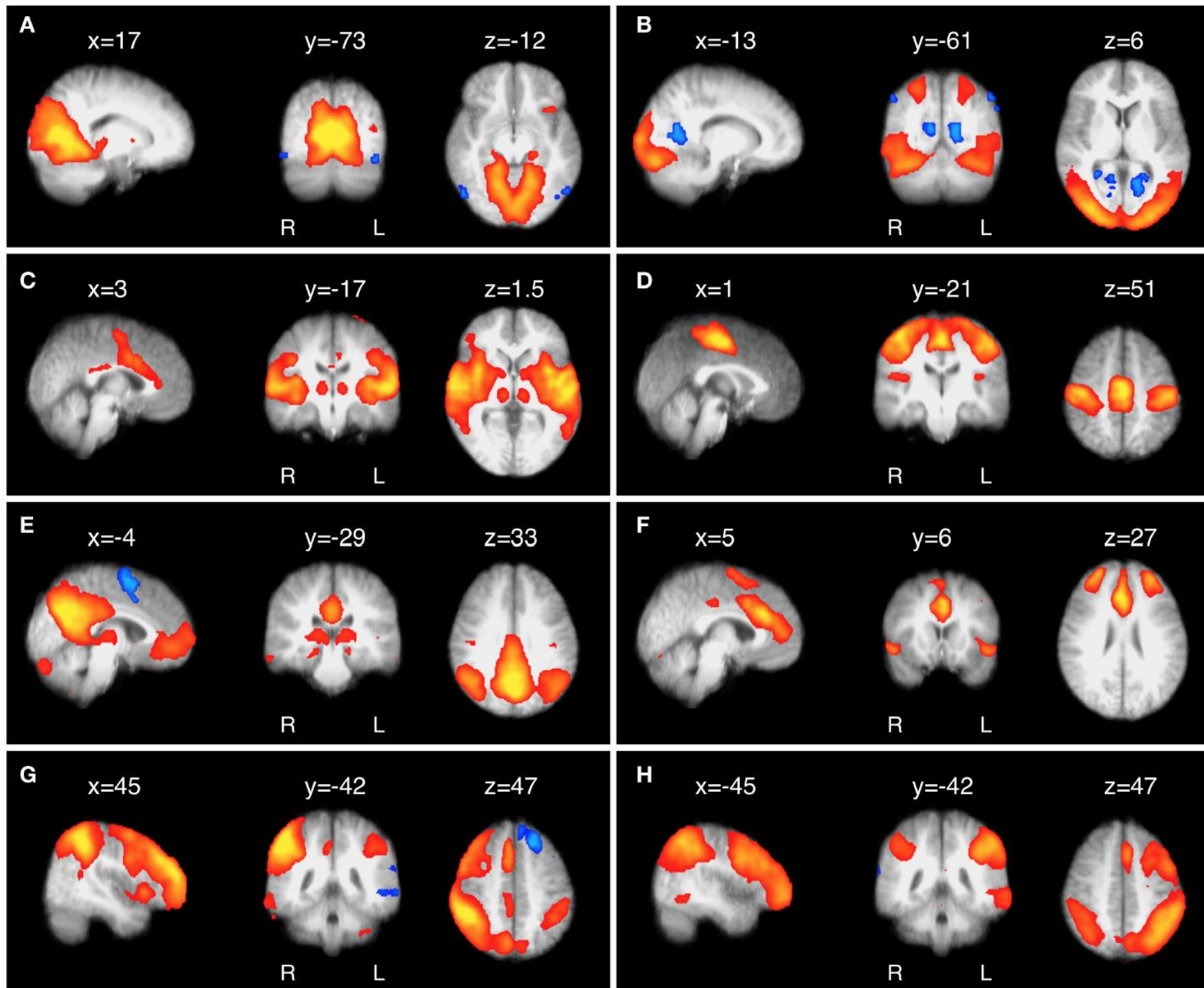
Temporal Concatenation



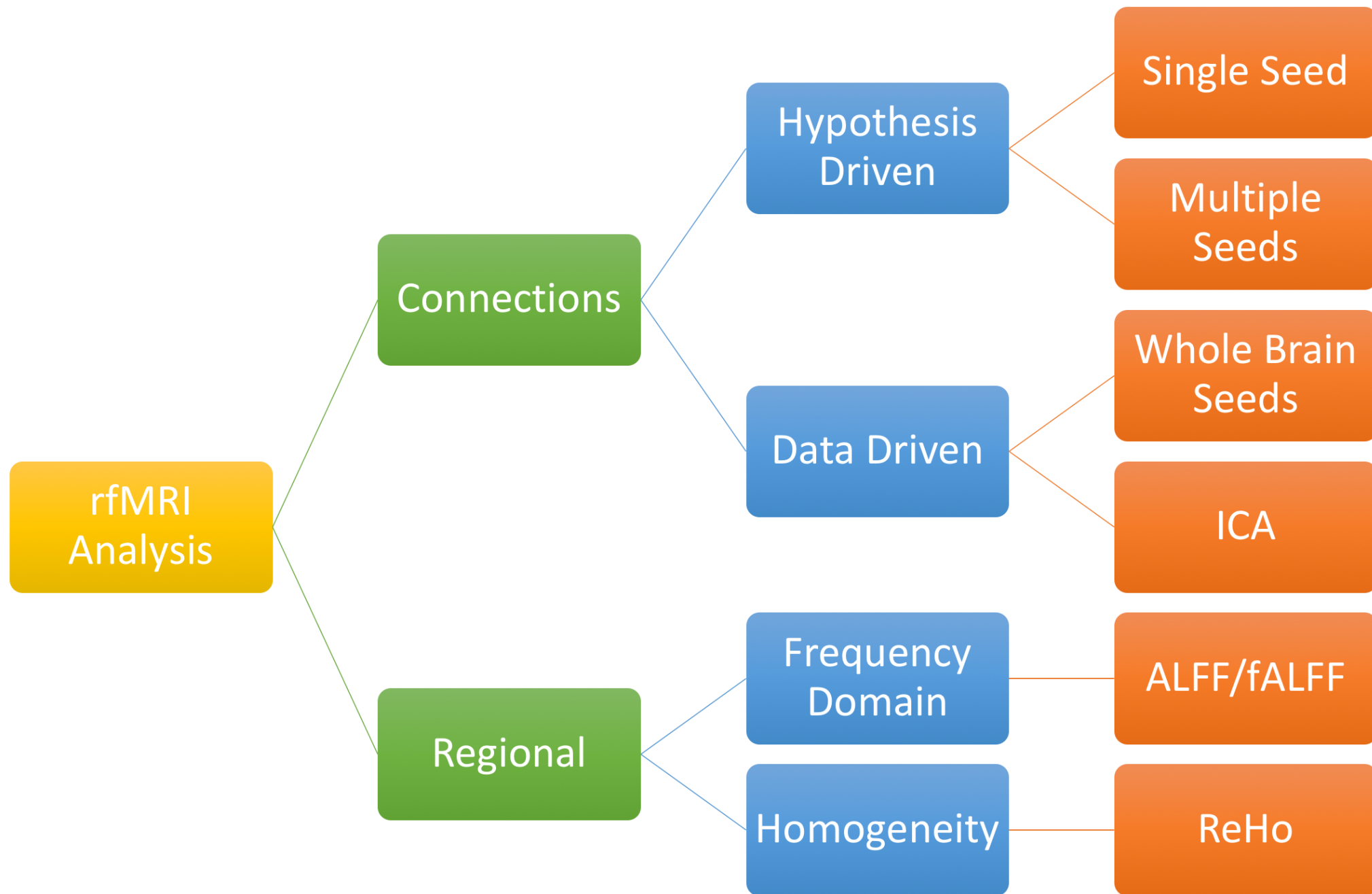
From Group ICA to Individual Maps

ICA

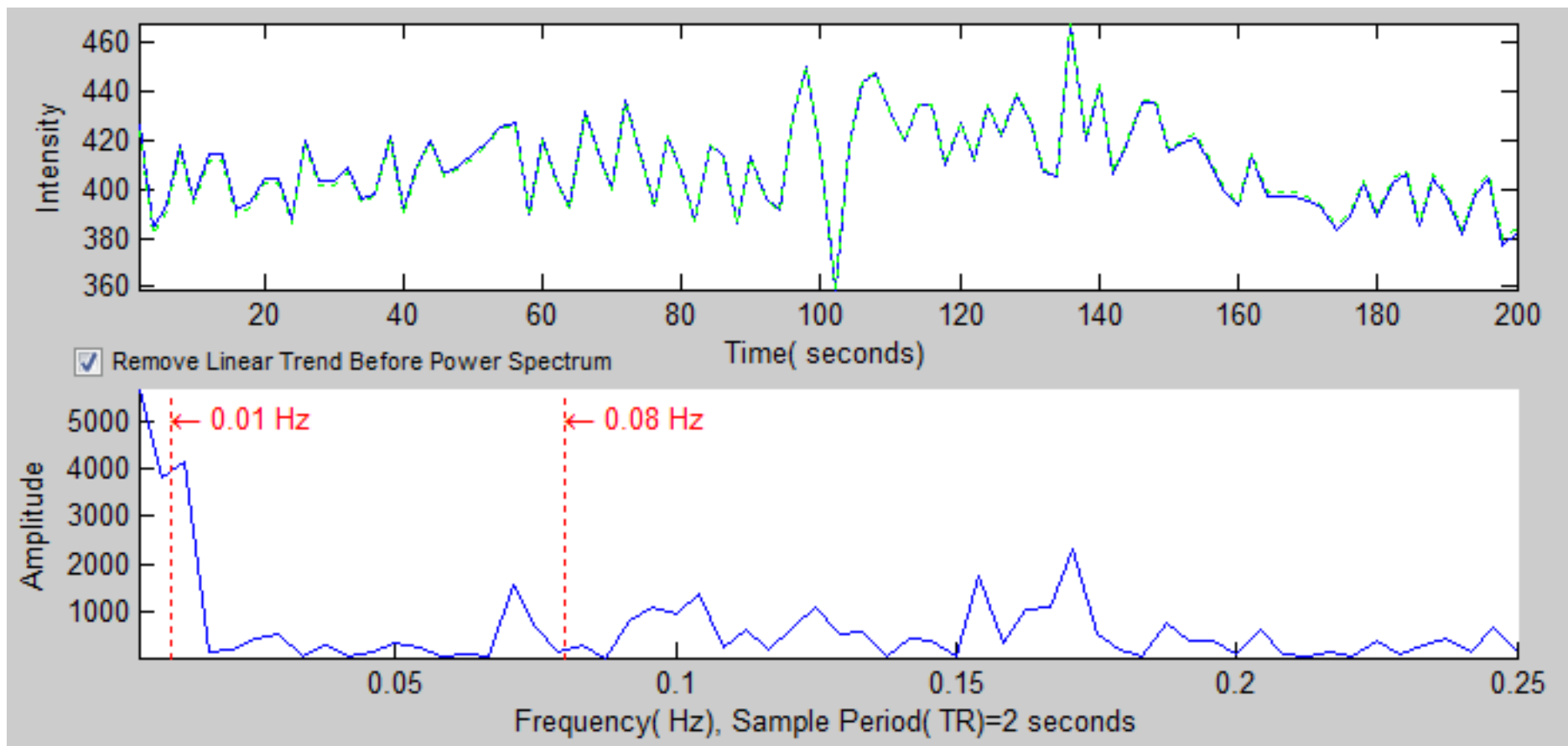




ICA



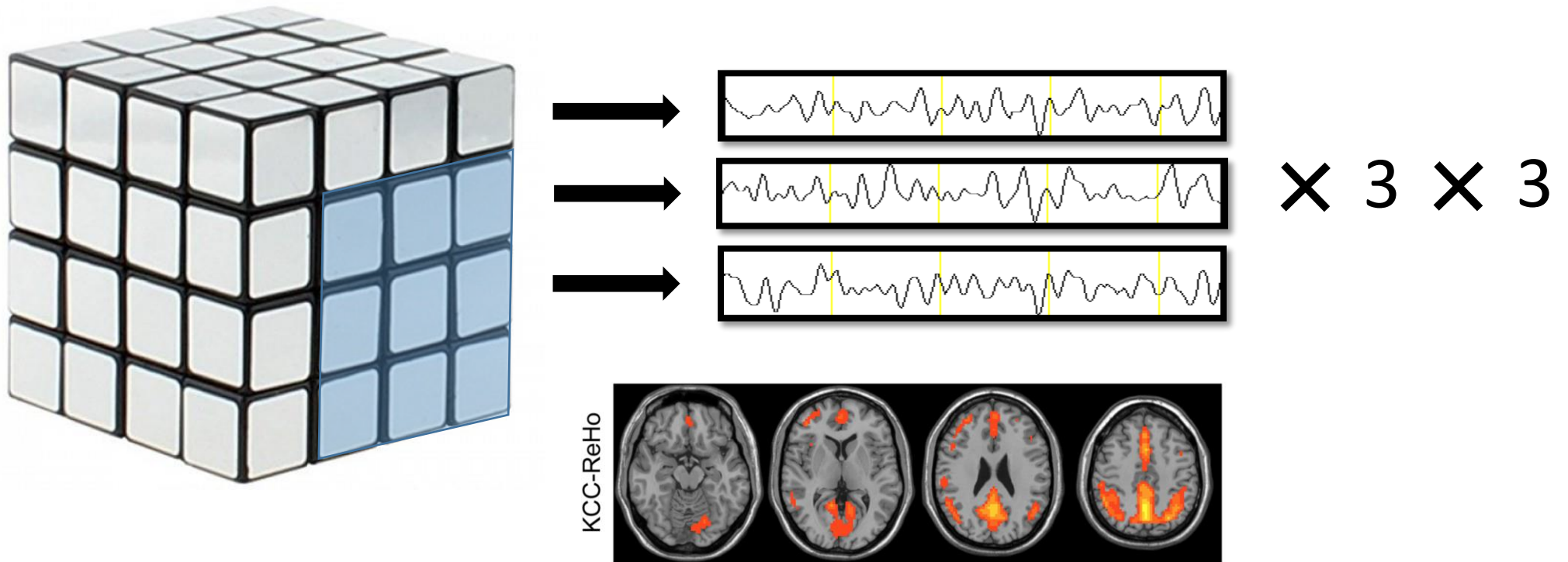
Amplitude of Low Frequency Fluctuation (ALFF)

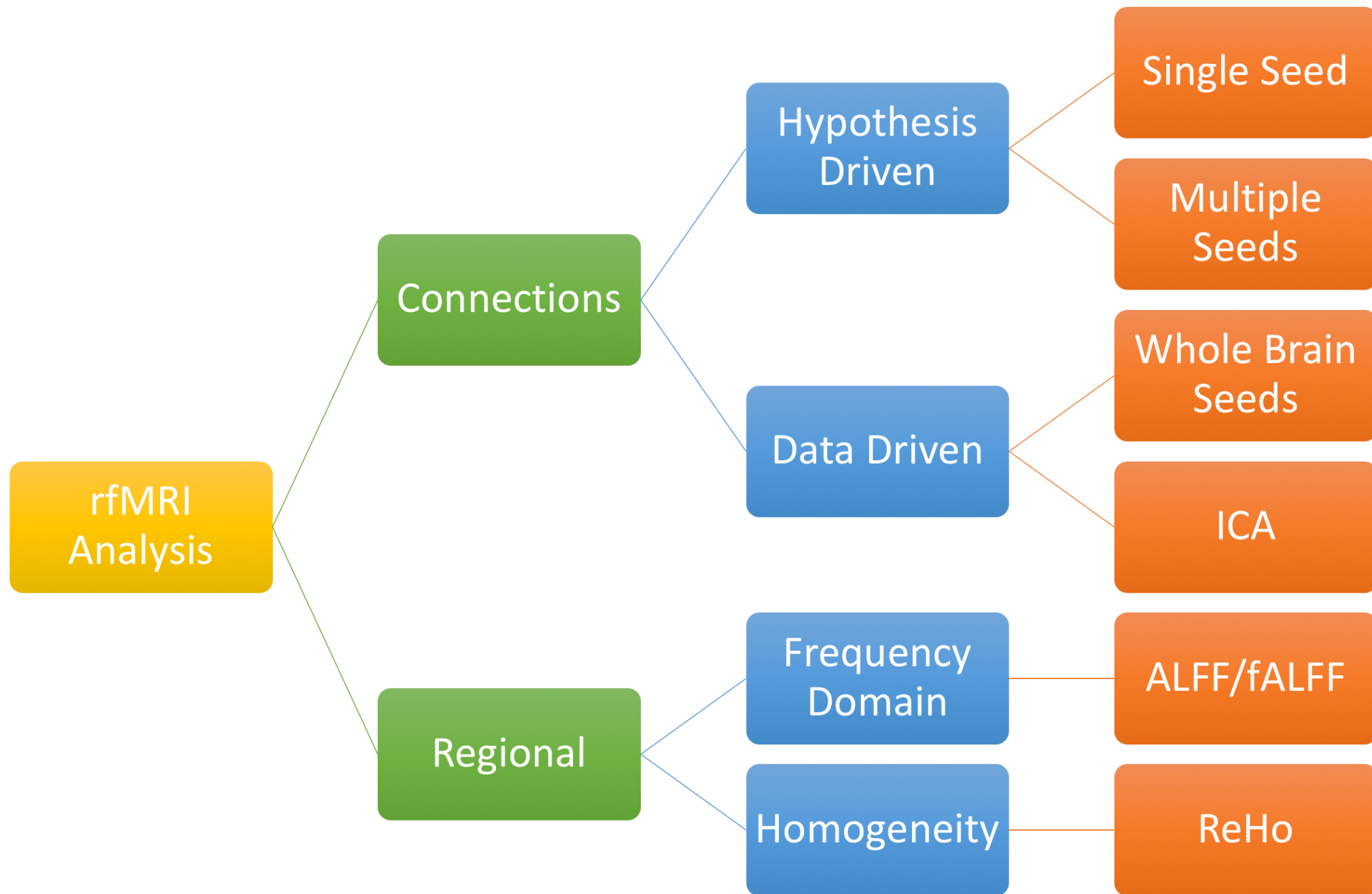


(Zang et al., 2007, 2008)

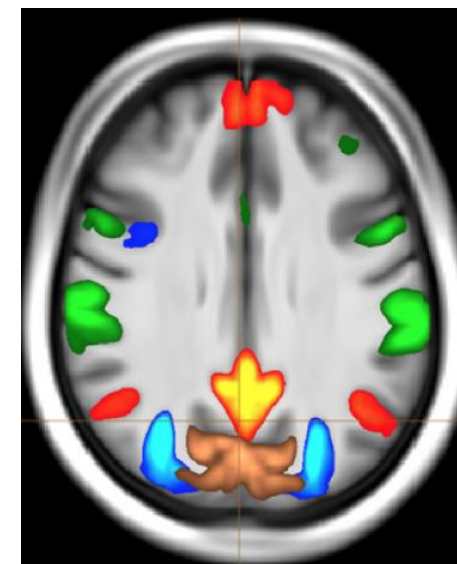
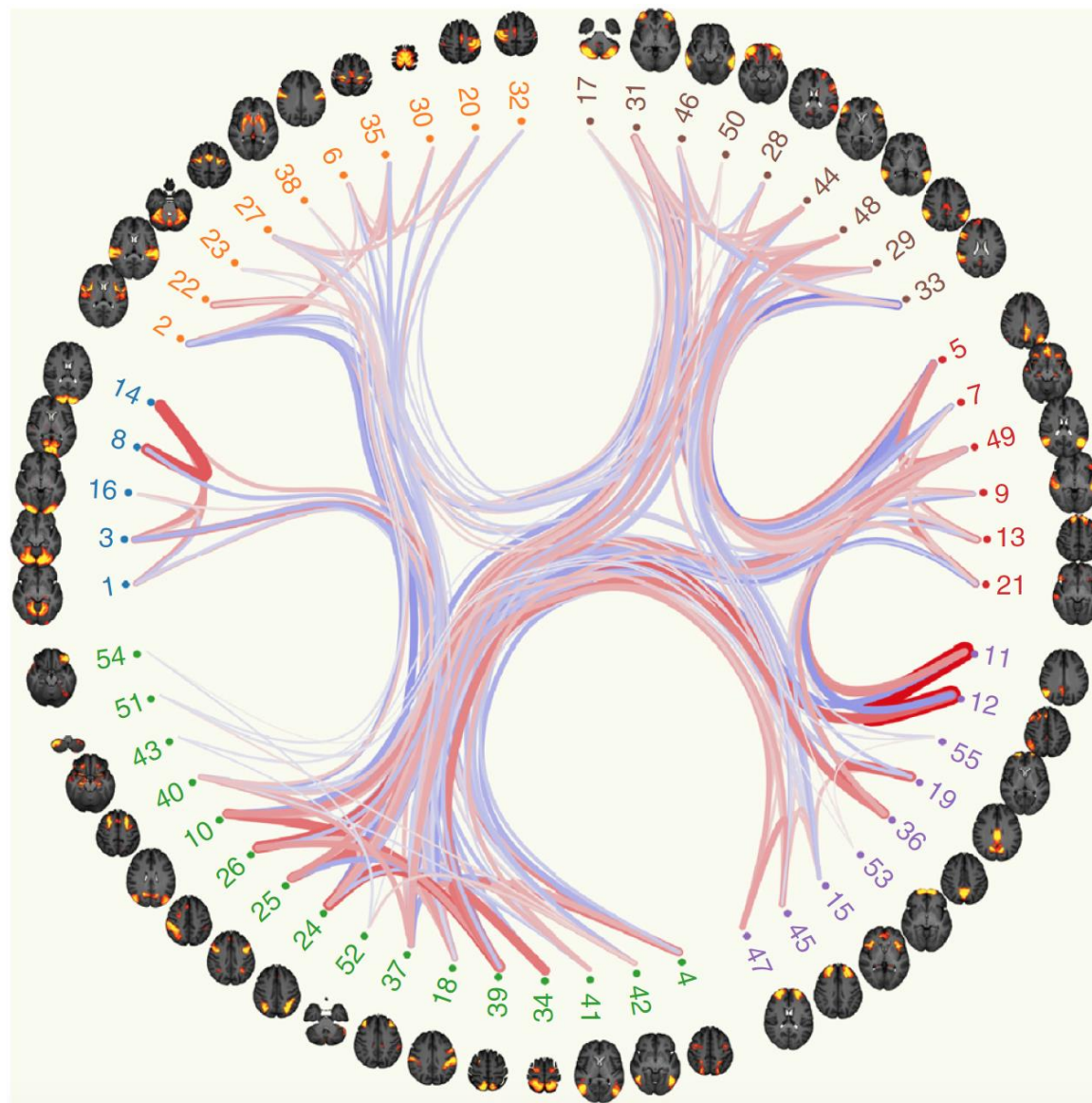
Regional Homogeneity (ReHo)

- Similarity of the time courses within usually 27 neighboring voxels
- Measured with Kendall Coefficient of Concordance (KCC) (0-1)
- Recorded as a value for the central voxel
- Results in a voxel wise KCC values in the individualized maps

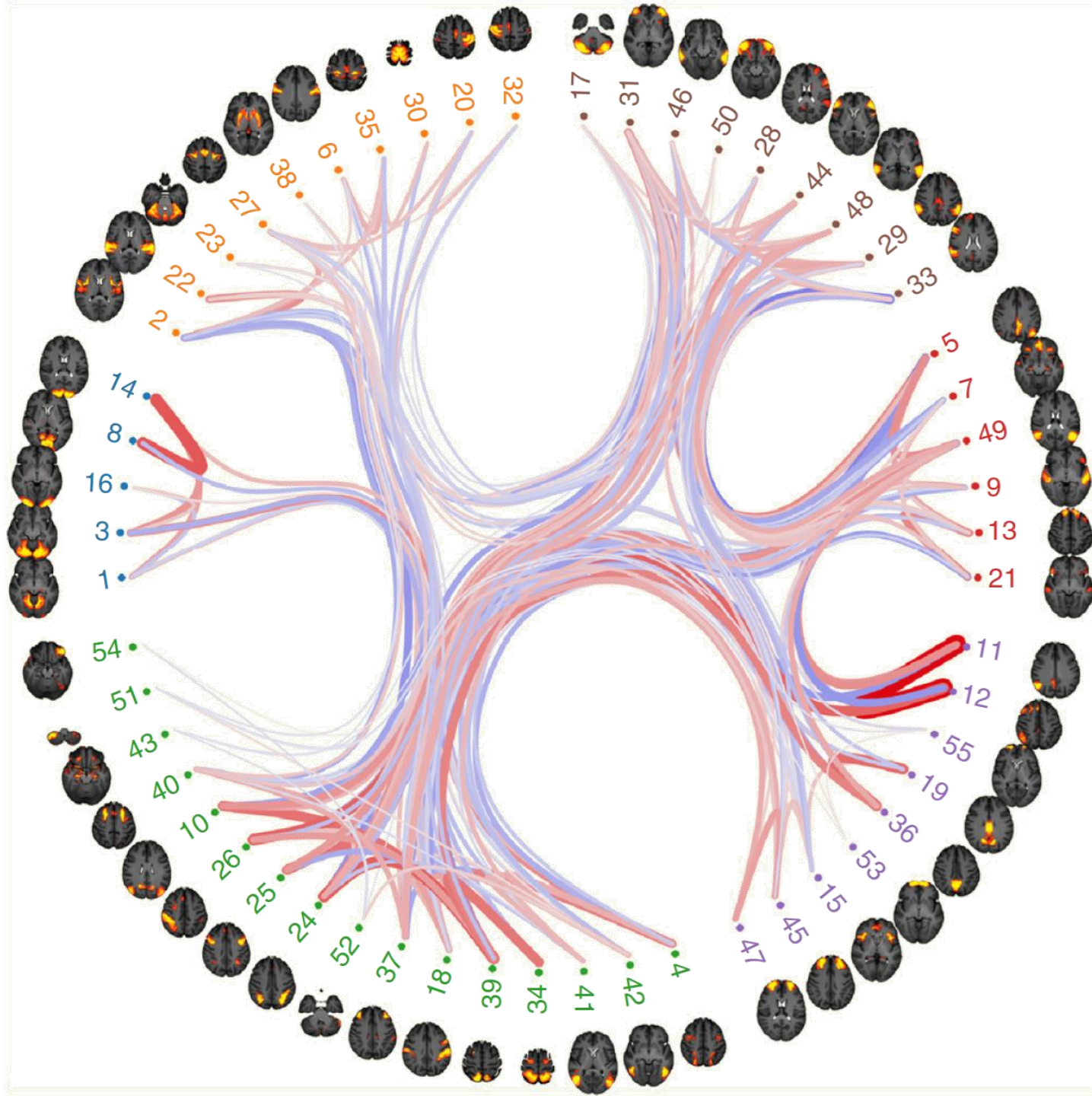




Now, What is this?

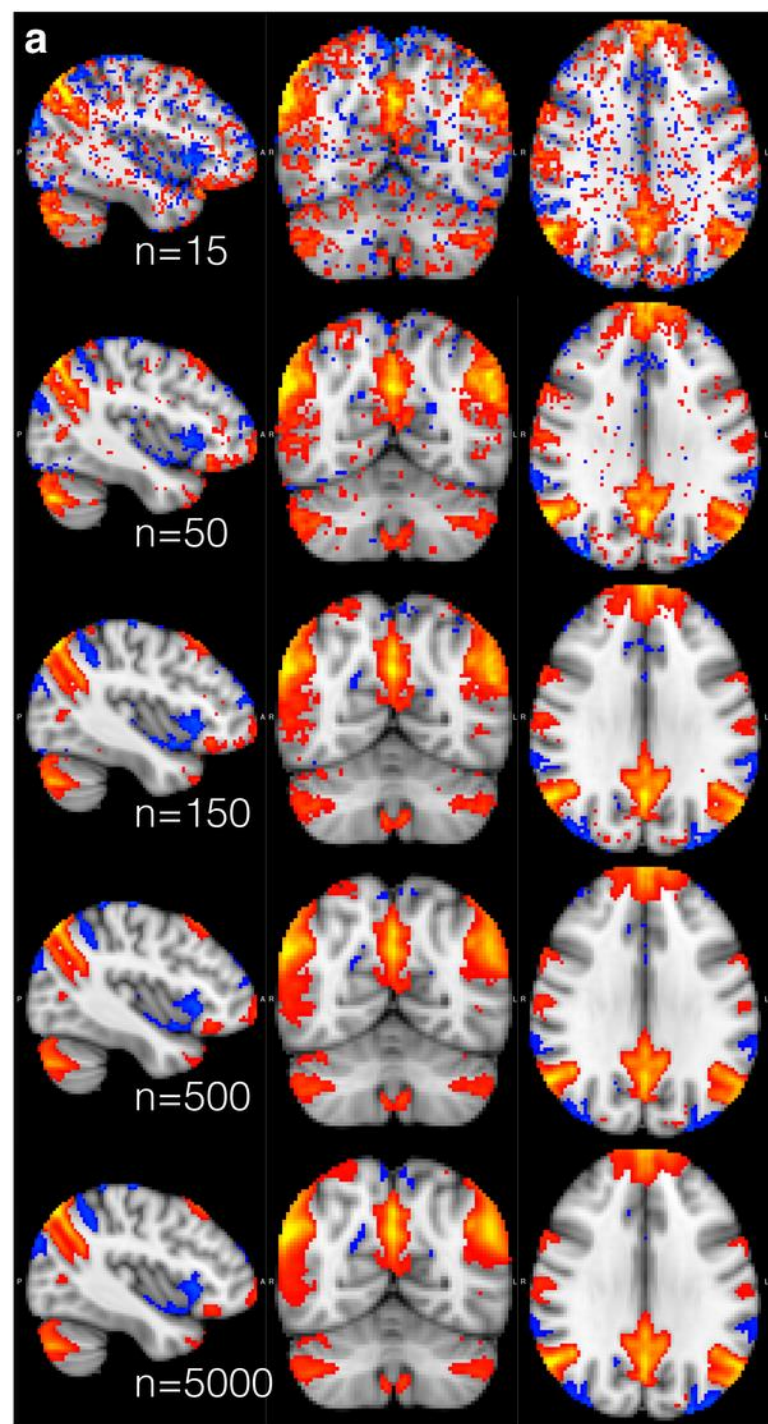


rfMRI



IDPs: 55 (out of 100) Nodes
(Regional ALFF) and 1695
Edges (Connectivity)!

Number Matters?



What do you do with this database?

nature
neuroscience

1100 Health Related Factors &

2501 Image-Derived Phenotypes (IDPs)

Early life factors
Lifestyle general
Lifestyle
exercise and work

Lifestyle
food and drink

Lifestyle alcohol
Lifestyle tobacco

Physical
general

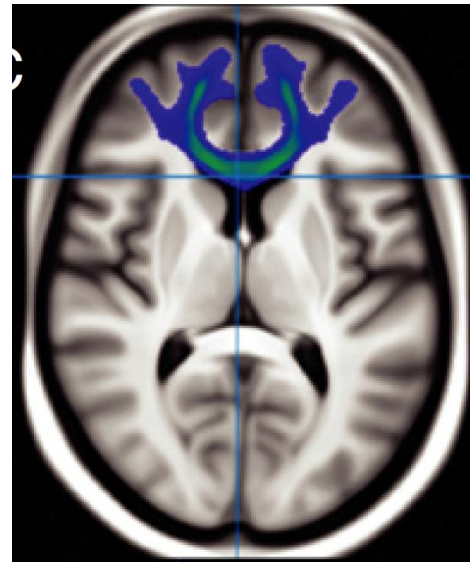
Physical
bone density and size

Physical cardiac
Blood assays

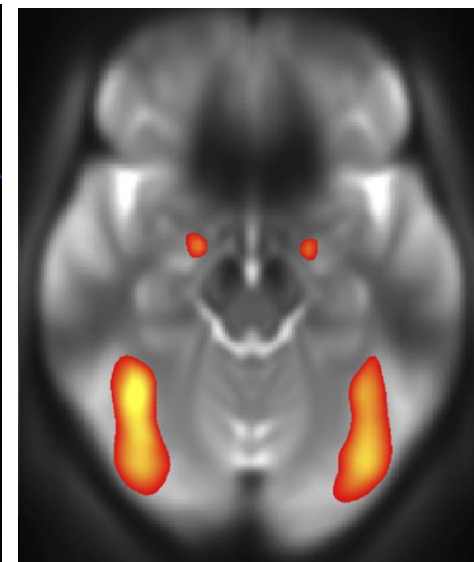
Cognitive
phenotypes



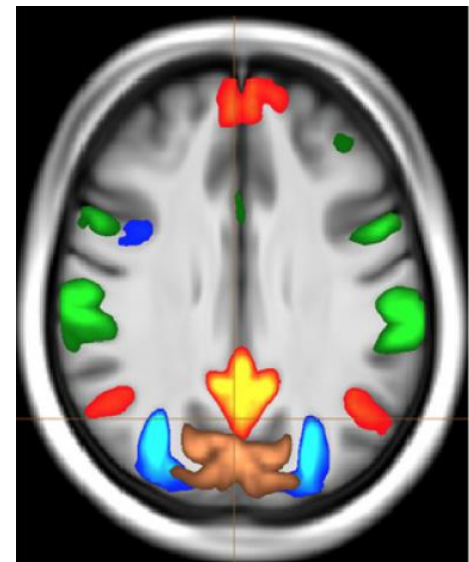
sMRI
39



dMRI
675



tfMRI
16



rfMRI
1771

What do you do with this database?

nature
neuroscience

1100 Health Related Factors &
2501 Image-Derived Phenotypes (IDPs)

Levels of Data Analysis

1. Univariate Correlations (one by one)
2. Covariates of No Interest or Confounders (Age, Gender, and etc)
3. Data Driven Multivariate Analysis
4. Hypothesis Driven Analysis

1. Univariate Correlations (one by one)

2.8 million testing

FDR ($P = 3.8 \cdot 10^{-5}$) and Bonf ($P = 1.8 \cdot 10^{-8}$)

Early life factors
Lifestyle general
Lifestyle
exercise and work

Lifestyle
food and drink

Lifestyle alcohol
Lifestyle tobacco

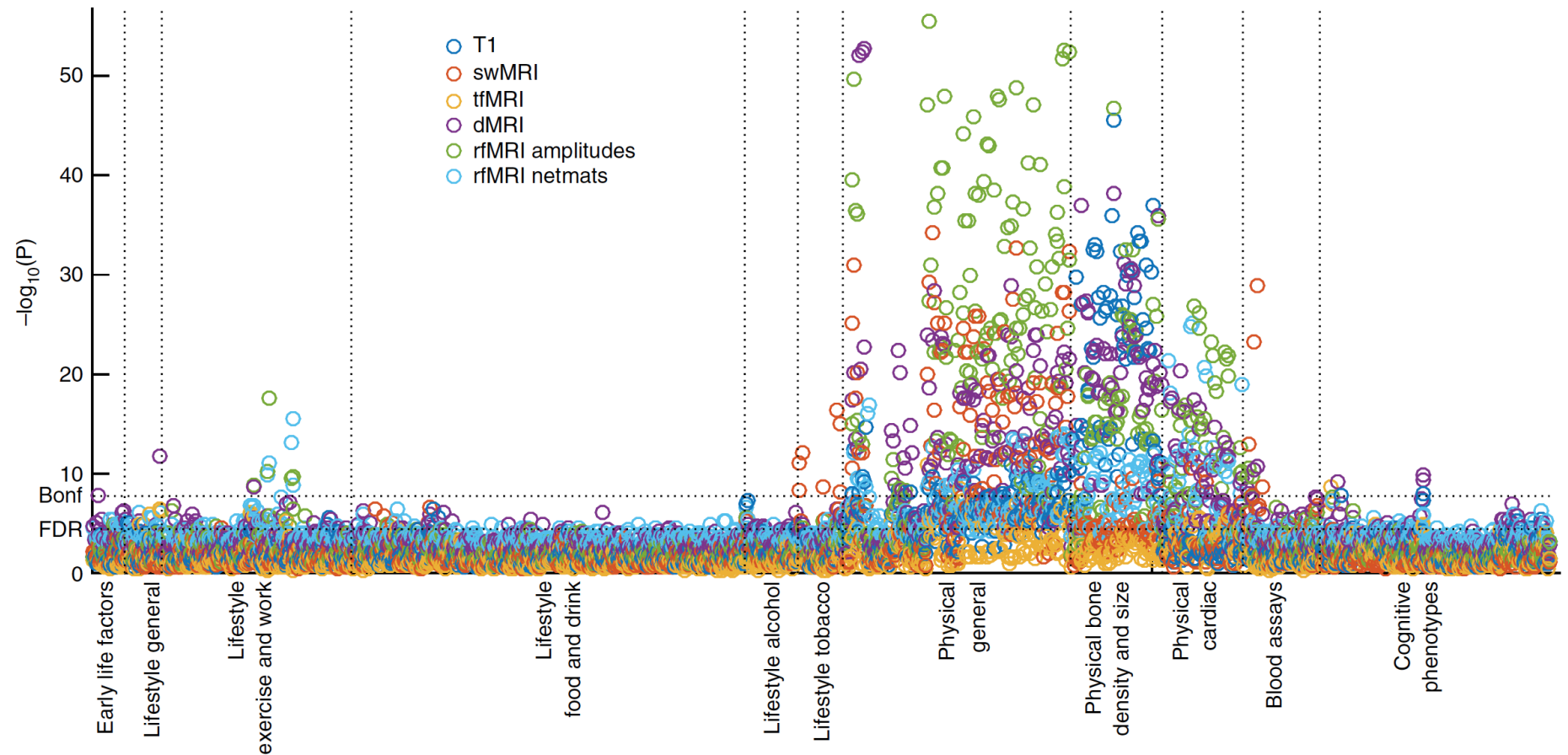
Physical
general

Physical
bone density and size

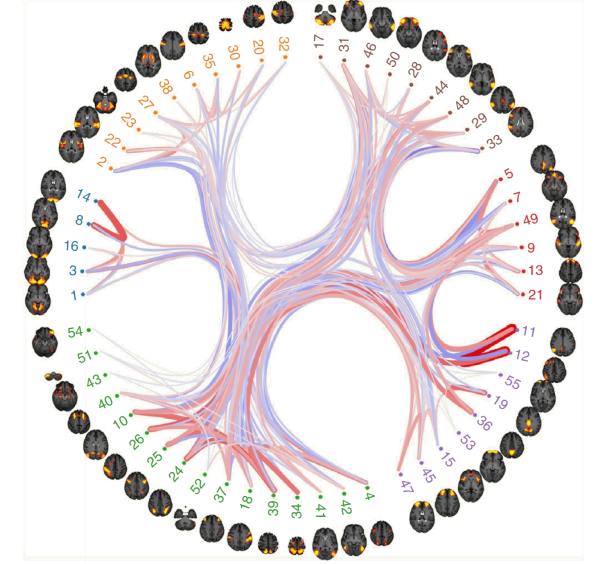
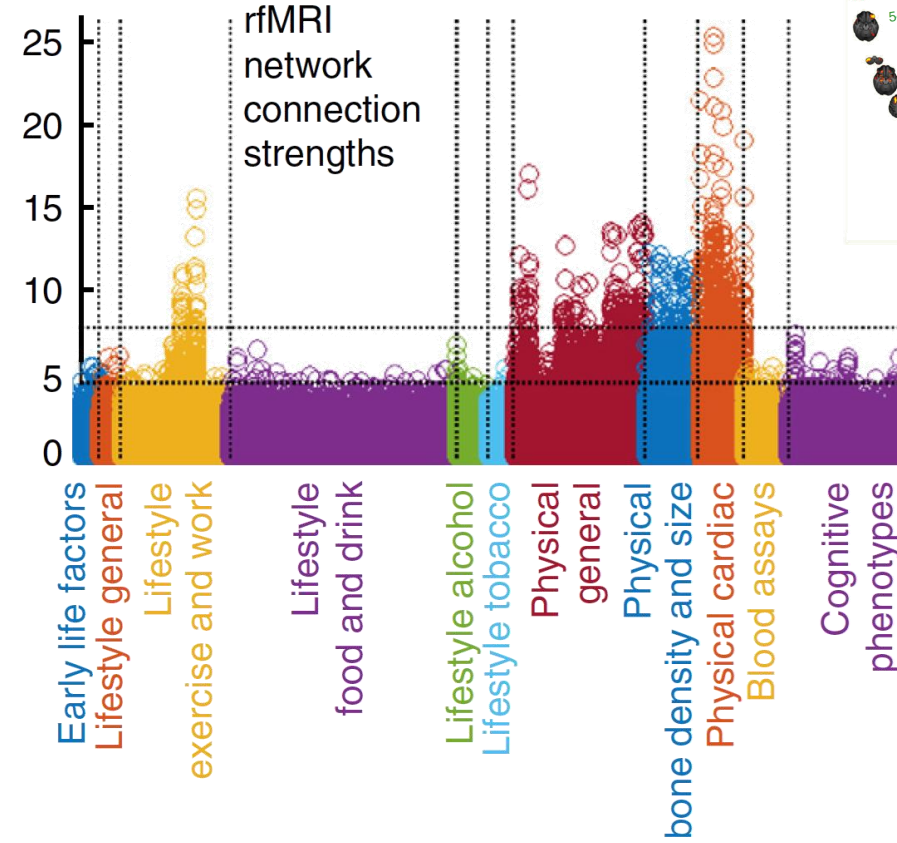
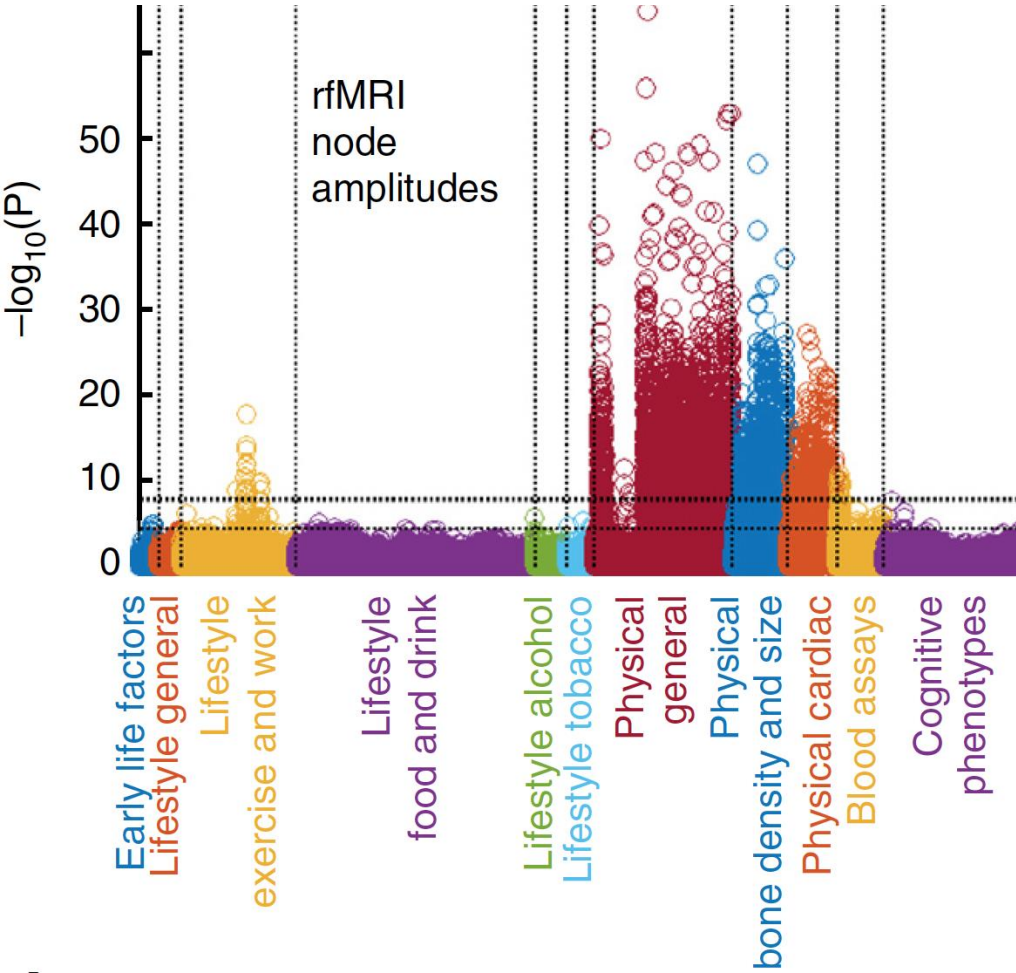
Physical cardiac

Blood assays

Cognitive
phenotypes



1. Univariate Correlations





Multimodal population brain imaging in the UK Biobank prospective epidemiological study

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