fMRI analysis of functional brain connectivity in three language tasks in schizophrenia

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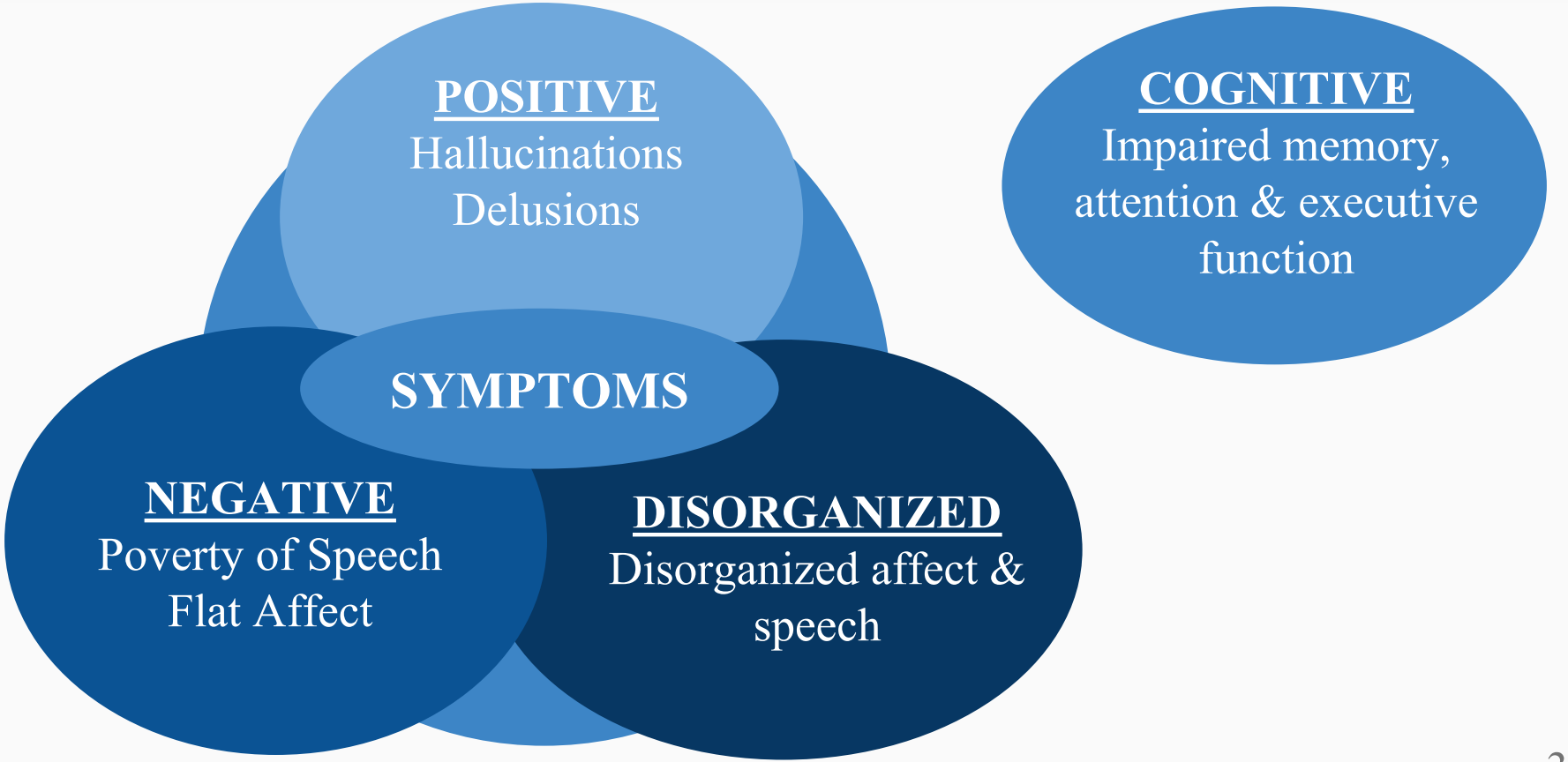
Acknowledgements:

OUTLINE

1. Motivation
2. Theory
3. Experiment Details
4. Resources
5. Summary

1.1 Overview of schizophrenia and current treatment options



1.1 Overview of schizophrenia and current treatment options

- Treatment Options
  - Pharmaceuticals
    - *Typical & Atypical Antipsychotics*
    - Side effects, moderate efficacy & resistance

https://www.psycom.net/clozaril-clozapine

1.1 Overview of schizophrenia and current treatment options

- Treatment Options
  - Cognitive Therapy
    - *Cognitive Behavioural Therapy (CBT)*
    - *Metacognitive Training (MCT)*
    - Moderate efficacy

1.1 Overview of schizophrenia and current treatment options

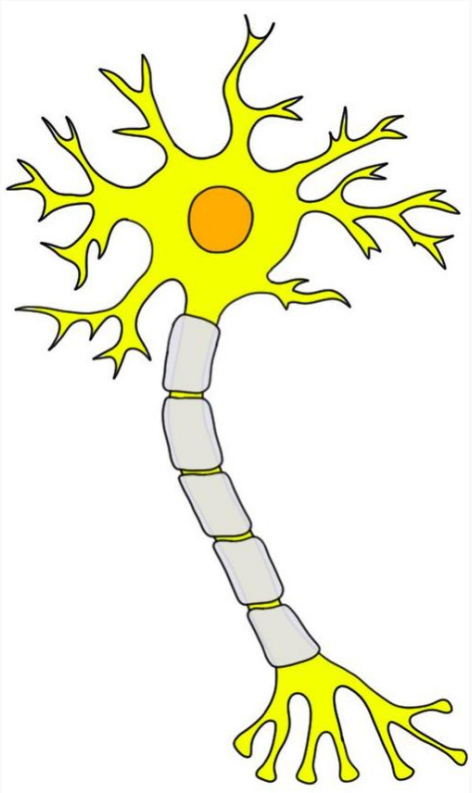
- Side effects
- Limited efficacy
- Resistance

- Limited efficacy

- Ex. Neuromodulation

1.2 Neuromodulation

- Neurons & Brain Networks
  - Neurons = nervous system cells
  - Communicate by releasing neurotransmitters upon electrical impulses

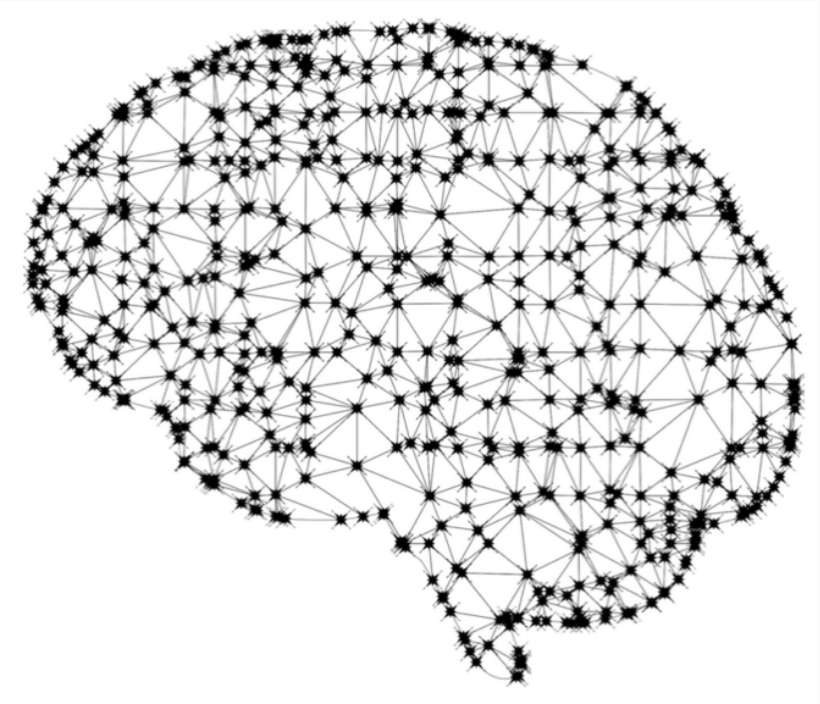


Neuron

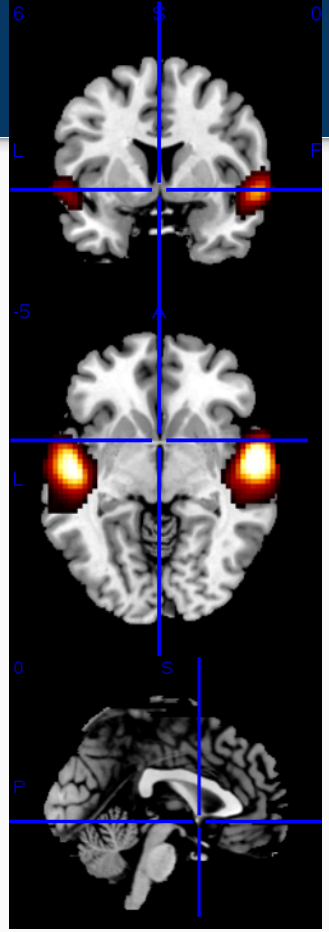
https://www.neuroscientificallychallenged.com/glossary/neuron/

1.2 Neuromodulation

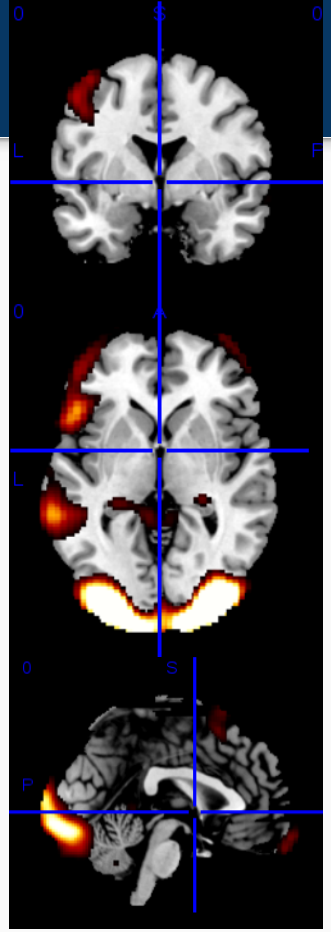
- Neurons & Brain Networks
  - Found in networks throughout brain
  - Brain network activity can change



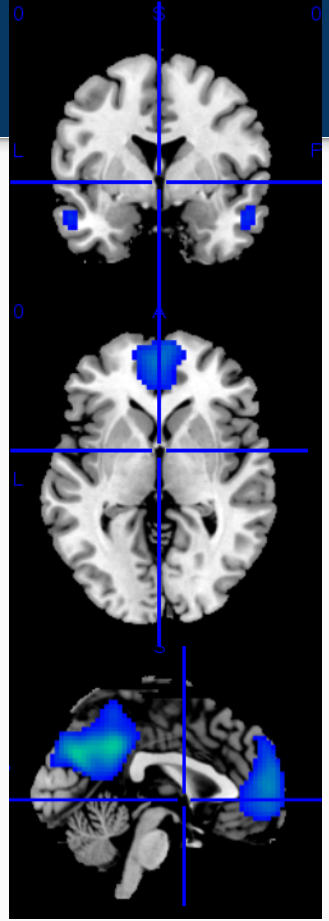
https://www.studzine.com/brain-artificial-intelligence-neural-networks/



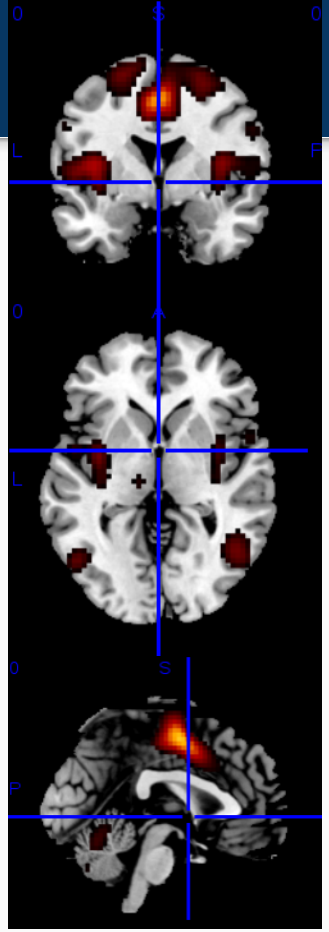
Auditory



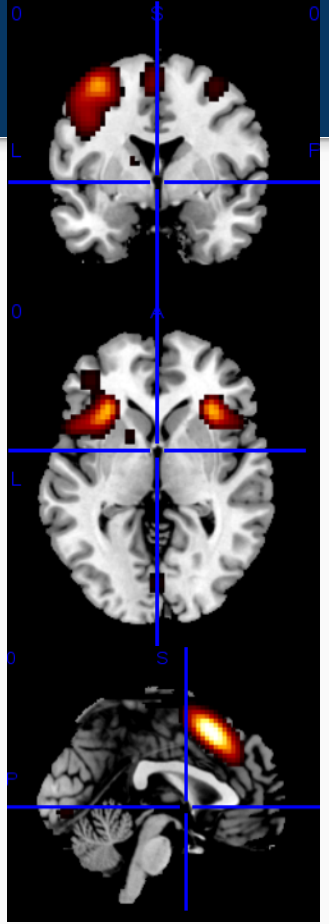
Language



Default Mode



Response



Internal Attention

1.2 Neuromodulation

- Neuromodulation
  - Modify neural oscillatory electrical signals to increase or decrease the likelihood of neuron activation
  - Transcranial Alternating Current Stimulation

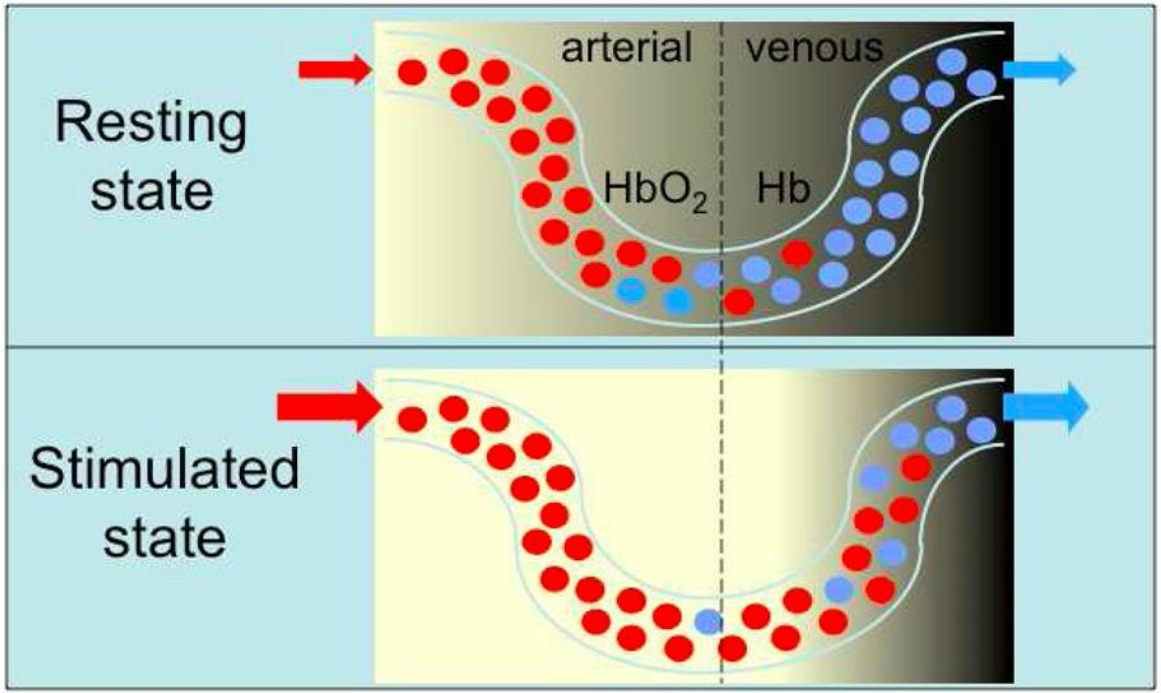
http://www.medicalexpo.com/prod/electrical-geodesics/product-68326-544197.html

1.3 Contribution of fMRI

- Neuromodulation
  - Requires spatial and temporal resolution

		fMRI	EEG
1	SPATIAL	3-5 mm	cm
2	TEMPORAL	1-3 s	ms
3	USEFUL TO MEASURE	BOLD signal	Neuron firing patterns

BOLD Signal = Blood Oxygenation Level Dependent Signal



Glover, G. H. (2011). Overview of Functional Magnetic Resonance Imaging

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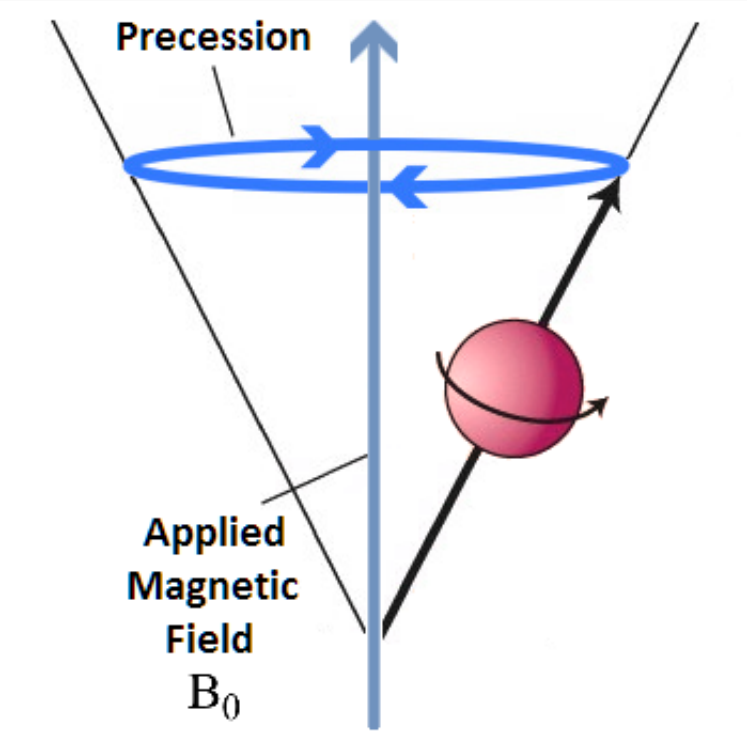
THEORY

2. Theory
    1. Functional Magnetic Resonance Imaging (fMRI)
    2. BOLD Signal
    3. fMRI-Constrained Principal Component Analysis (fMRI-CPCA)

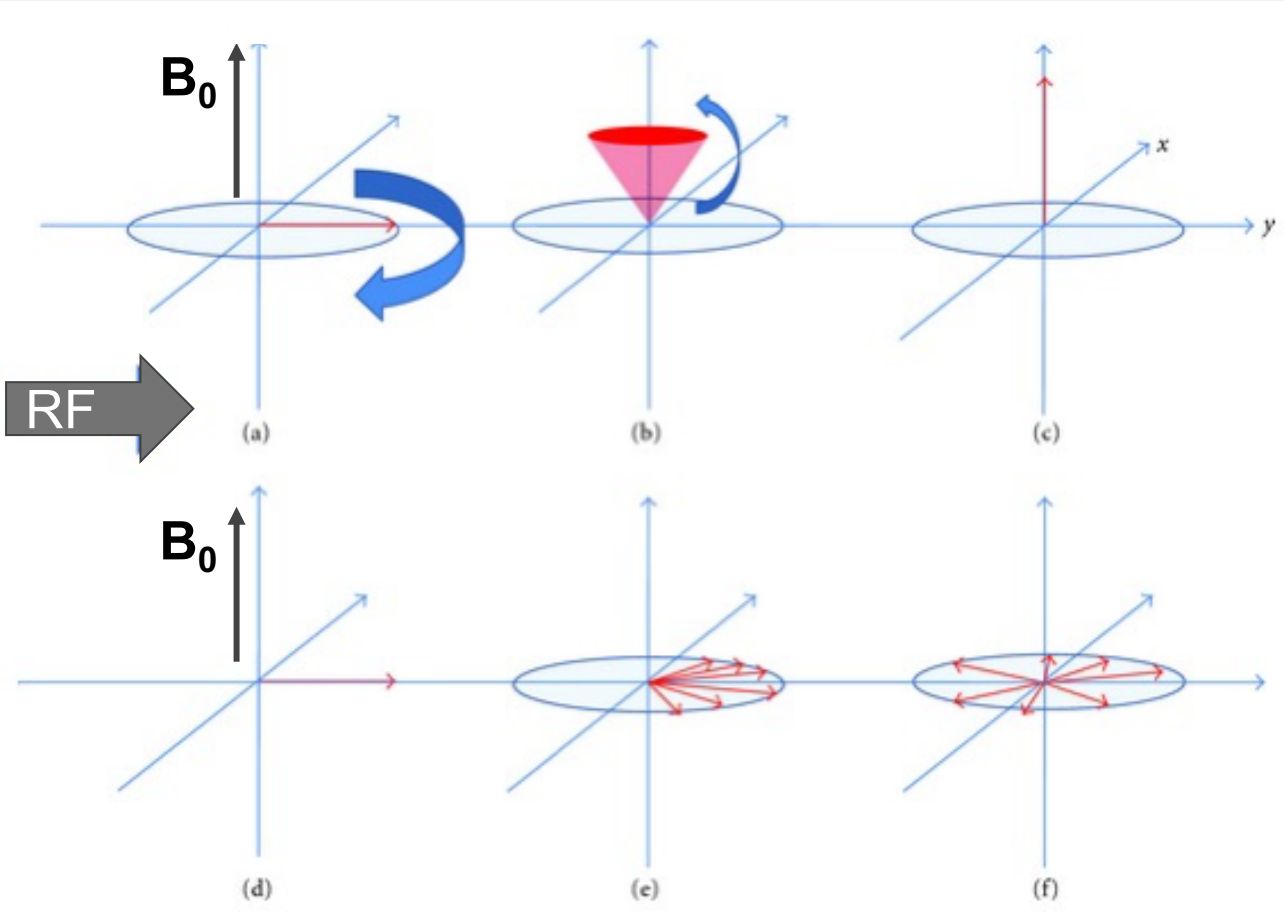
2.1 fMRI

- Nuclear Magnetic Resonance
  - Magnetic moment of protons from H nuclei in water
  - Tip away from B_0
  - Precession frequency: $\boldsymbol{\omega} = \boldsymbol{\gamma} B_0$



https://my-ms.org/mri_physics.htm

2.1 fMRI



T_1: Longitudinal component recovery

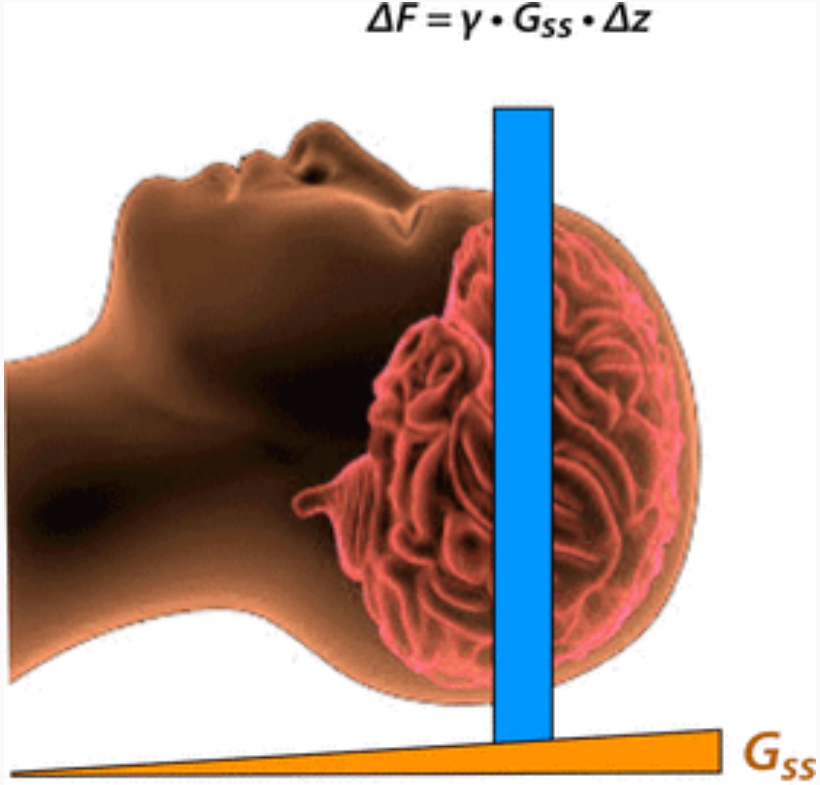
T_2: Transverse component dephasing

T_2*: Reversible dephasing due to field inhomogeneities

https://www.researchgate.net/figure/Schematic-of-T1-and-T2-relaxation-MRI-utilises-the-behaviour-of-protons-within-varying_fig2_227712215

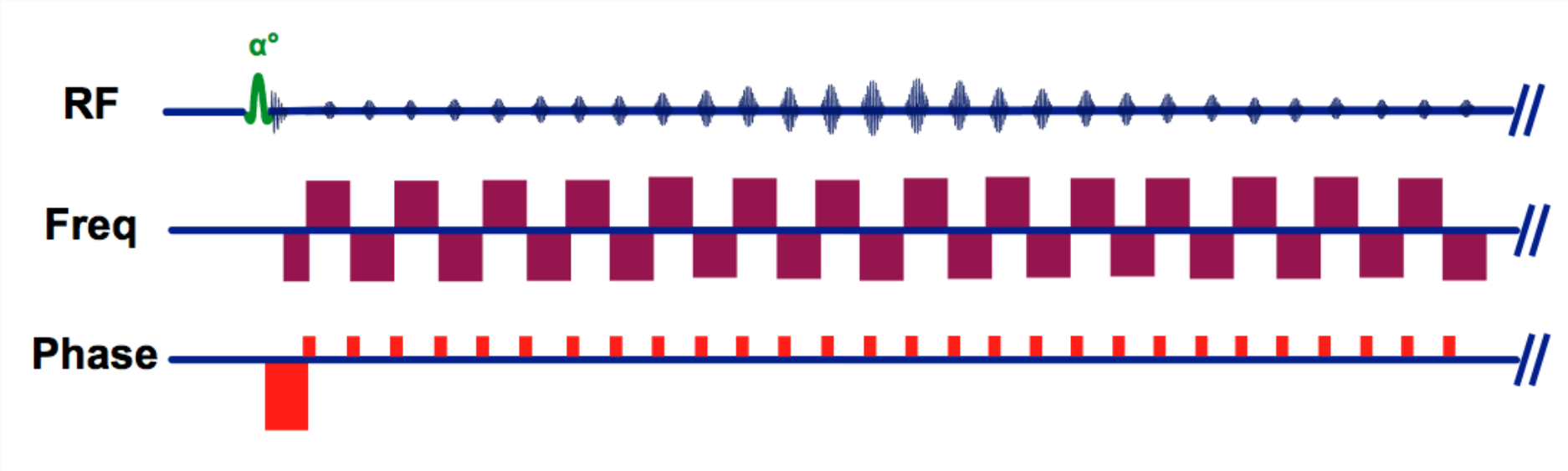
2.1 fMRI

- Signal Localization
  - RF pulse selects slice
  - Frequency & Phase encoding gradients localize within slice



http://mriquestions.com/slice-selective-excitation.html

- Echo Planar Imaging



http://mriquestions.com/echo-planar-imaging.html

2.2 BOLD Signal

Oxyhemoglobin = Diamagnetic

↓ magnetic susceptibility

↑ T_2*

↑ Intensity

Deoxyhemoglobin = Paramagnetic

↑ magnetic susceptibility

↓ T_2*

↓ Intensity

2.3 fMRI-CPCA

- fMRI-CPCA
  - Determine functional brain networks
  - Estimate post-stimulus BOLD signal changes
  - Test effects of experimental manipulations

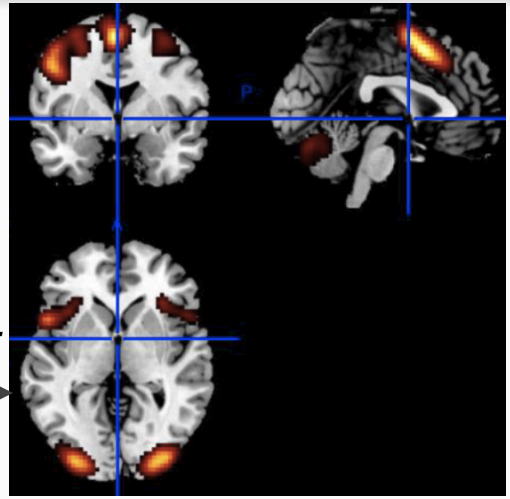
2.3 fMRI-CPCA

Z Input Data = **GC** Constrained Variance + **E** Residual Variance

Principal Component Analysis

U Component Scores | **D** Singular Values | **V'** Right Singular Vectors

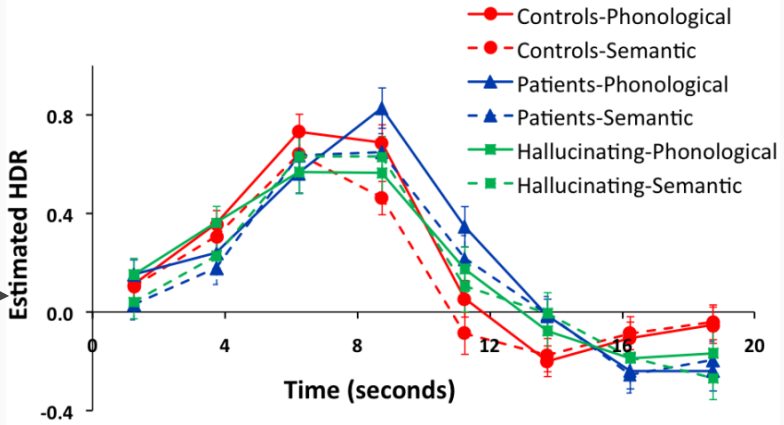
Component Loadings: **VD/√(m-1)**



Regression

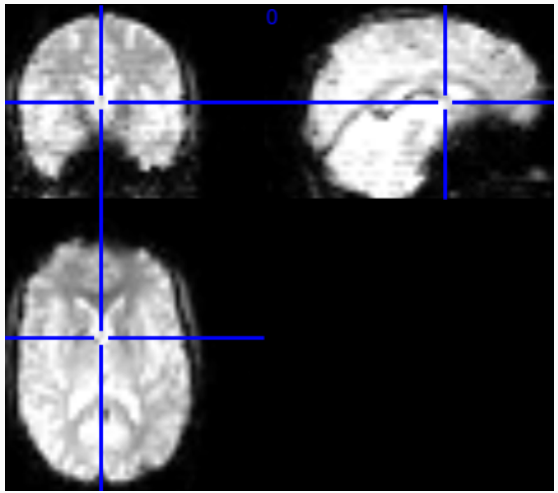
G Design Matrix | **P** Predictor Weights

Plot against time

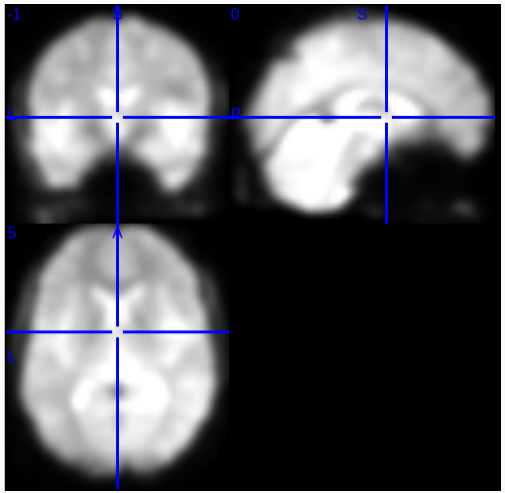


2.3 fMRI-CPCA

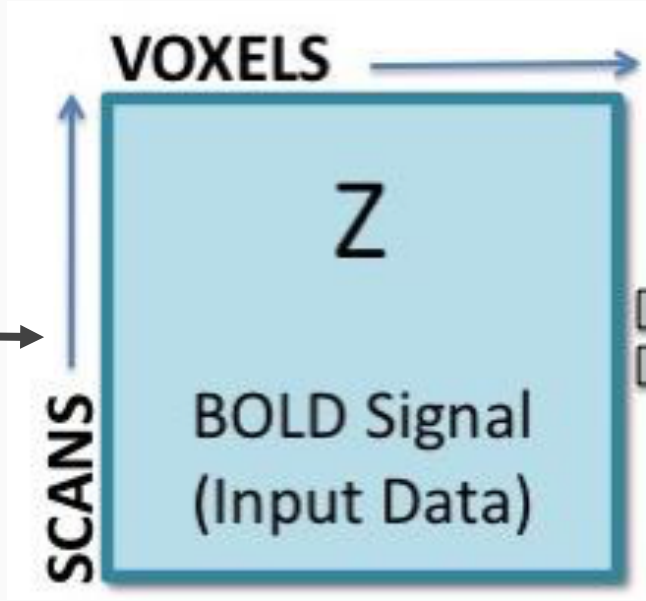
- Z Activation Matrix



Raw



Preprocessed

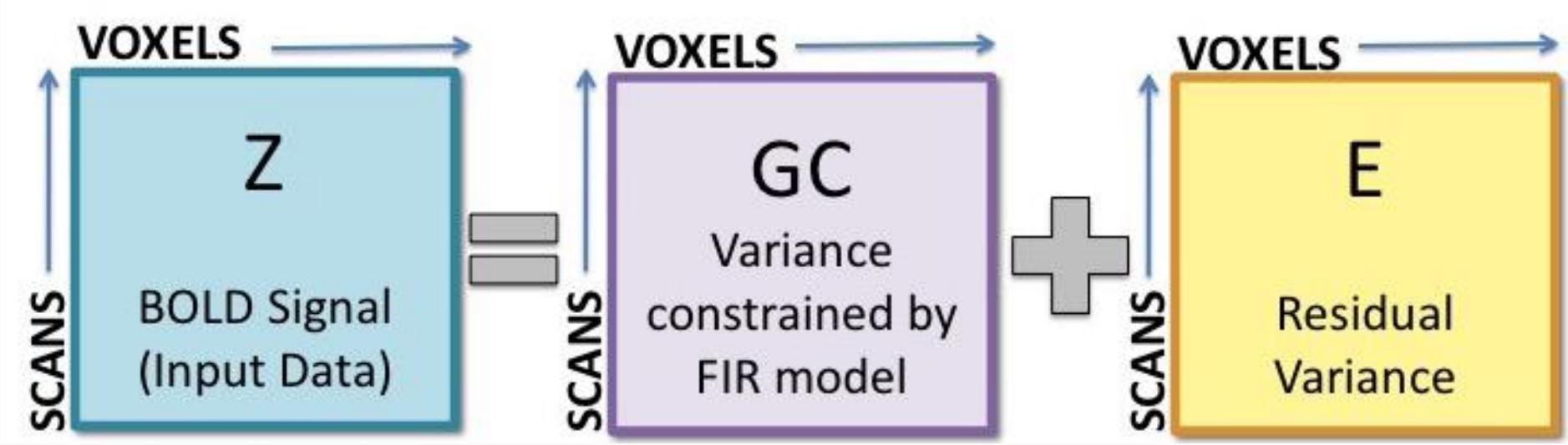


2.3 fMRI-CPCA

- G Design Matrix
  - Encodes task timing
  - Scans X Conditions at post-stimulus time
  - Finite Impulse Response model
  - Expected signal: 1
  - Otherwise: 0

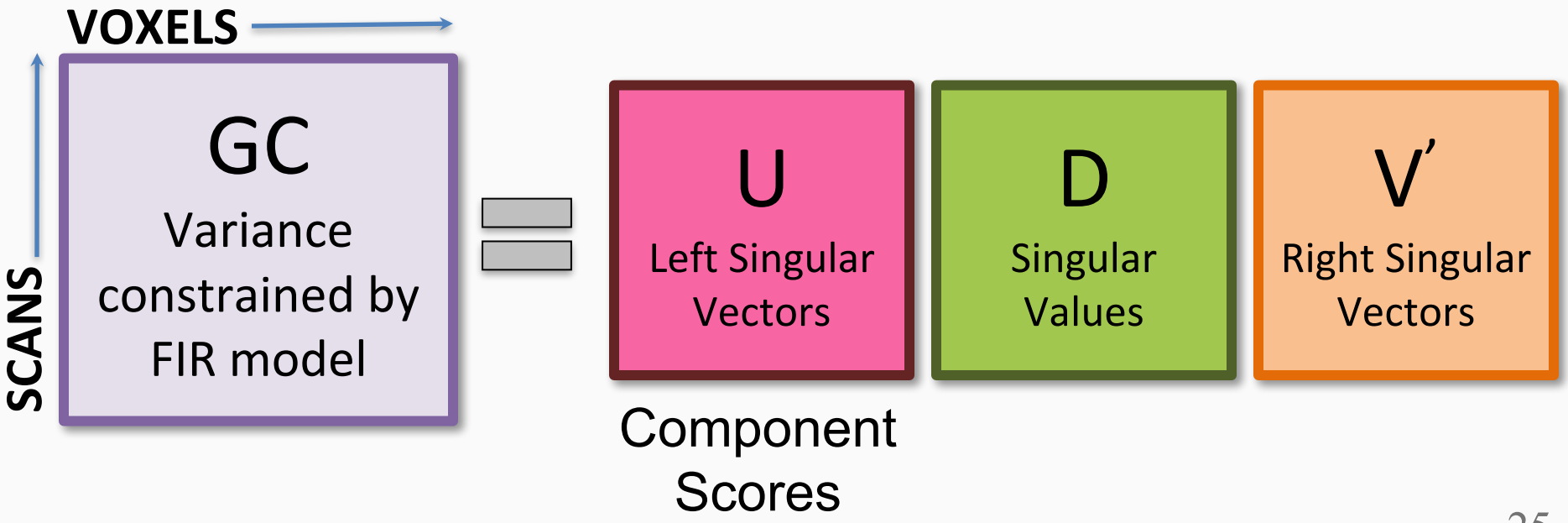
2.3 fMRI-CPCA

- Z matrix regressed onto G matrix with multivariate least-squares linear regression



$$C = (G'G)^{-1}G'Z$$

- Principal Component Analysis extracts components from GC



2.3 fMRI-CPCA

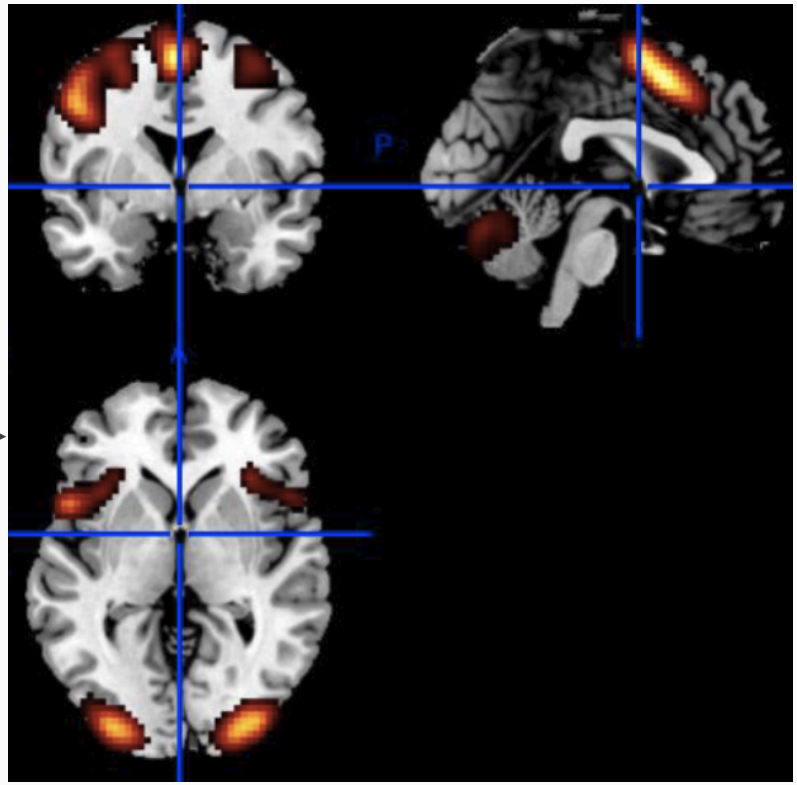
- Columns represent component loadings, or anatomical correlates of each brain network

Component Loadings

V
Right Singular Vectors

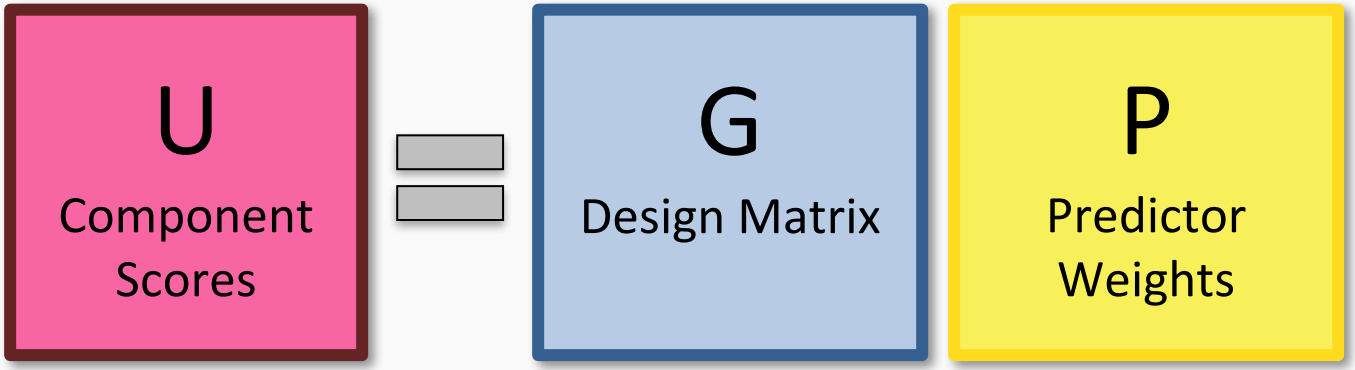
D
Singular Values

$\frac{}{\sqrt{(m-1)}}$



2.3 fMRI-CPCA

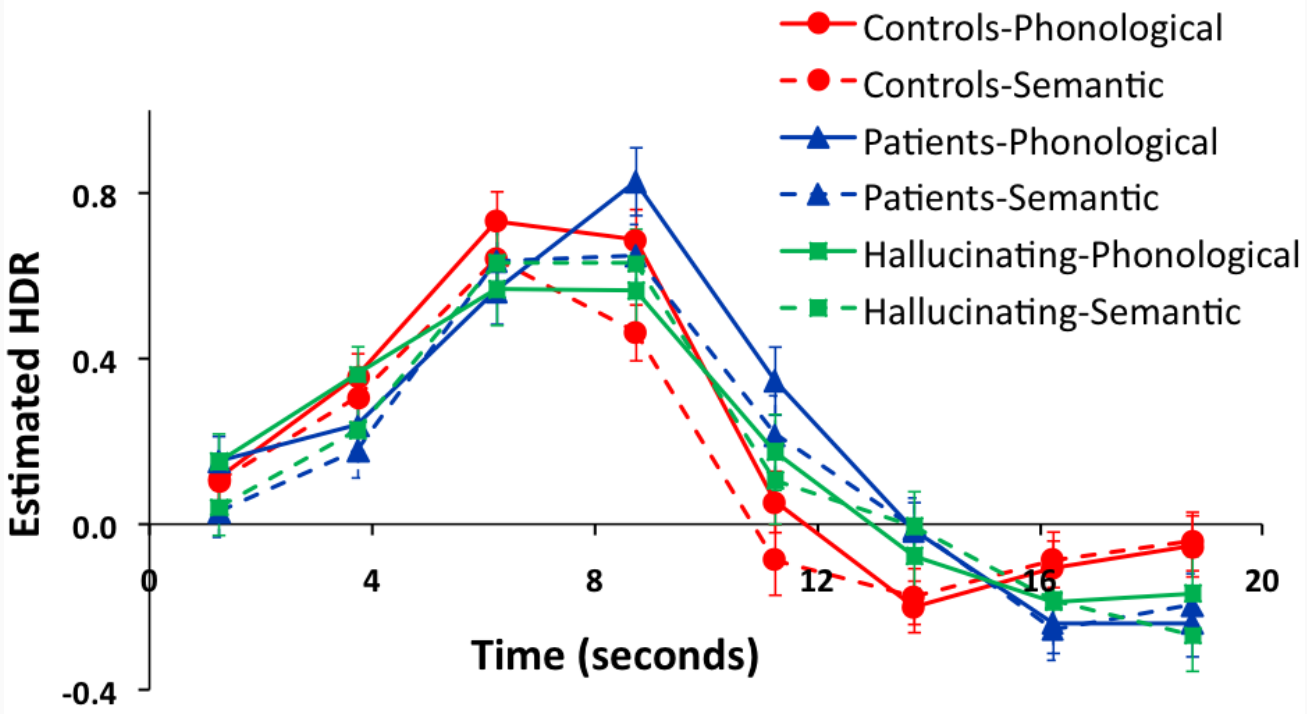
- Predictor weights indicate importance of each column in G for a given component



2.3 fMRI-CPCA

- Predictor weights plotted against time give the hemodynamic response (HDR) for the component

P
Predictor Weights



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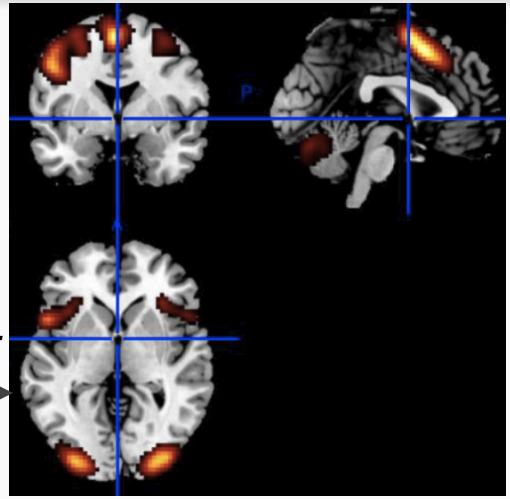
Component Loadings:

VD/√(m-1)



Regression

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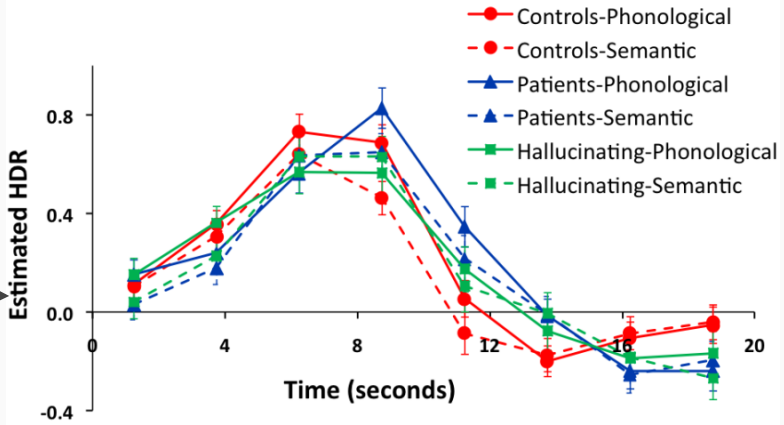
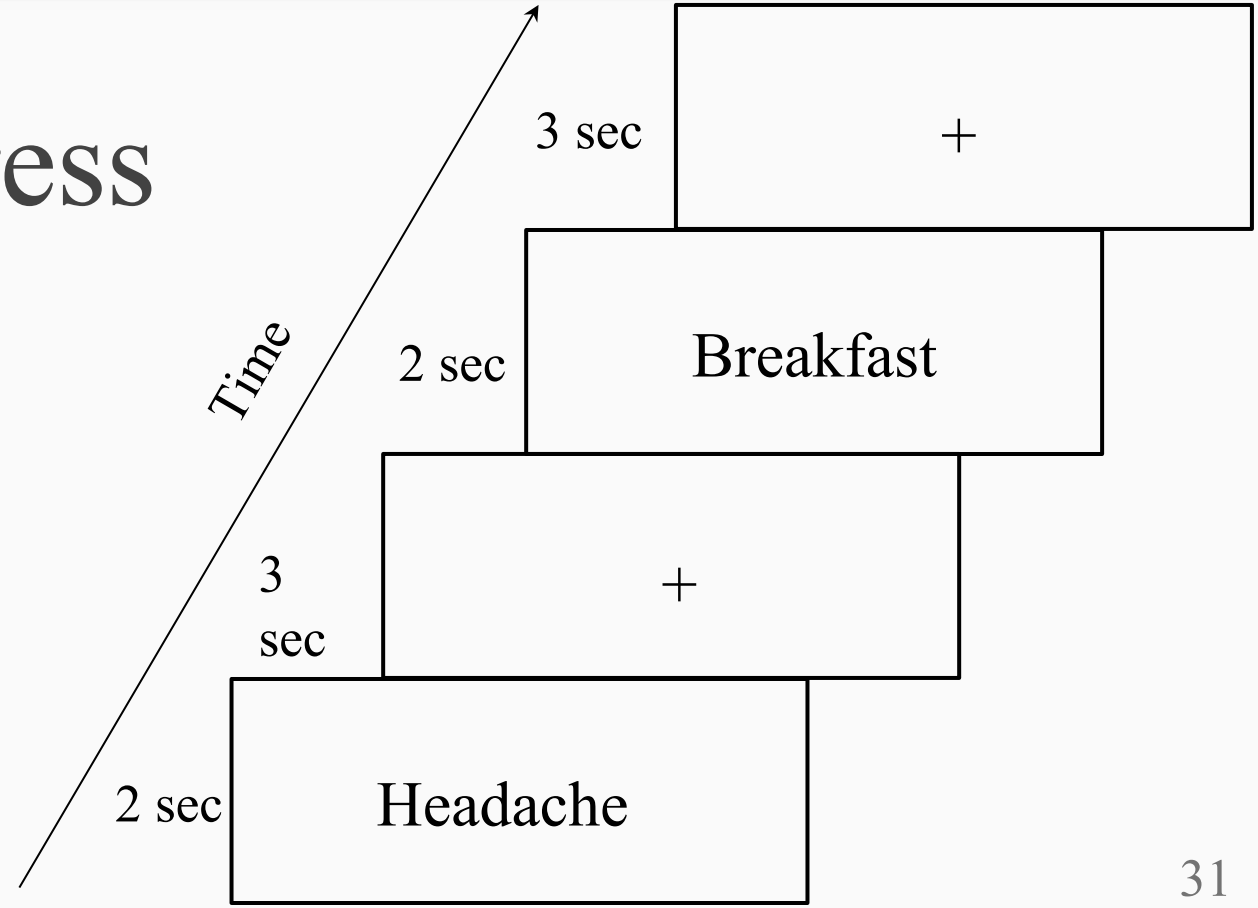


Experiment Details

3. Experiment Details
    1. Language Tasks
    2. Functional Brain Networks
    3. Procedure

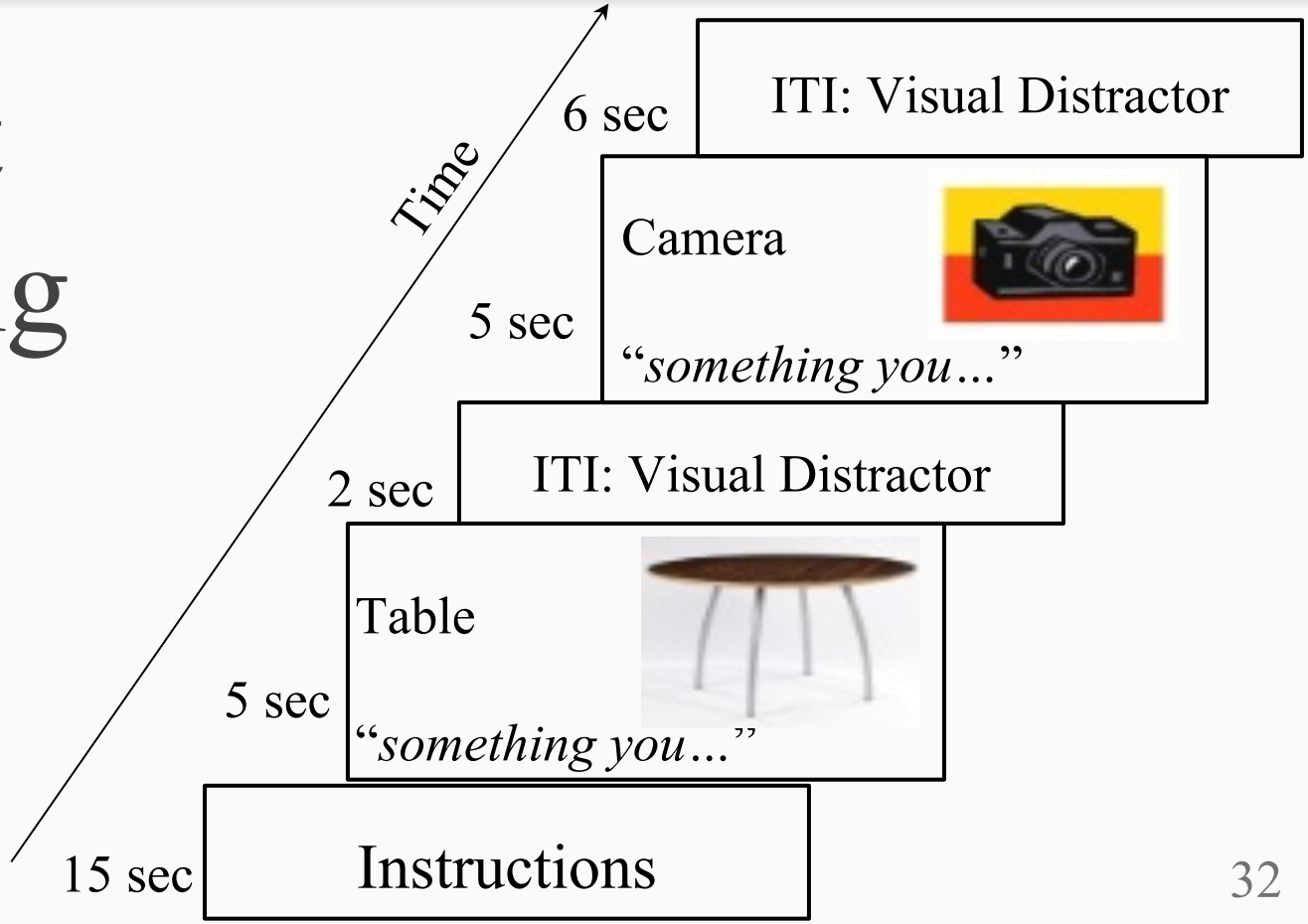
Metrical Stress

(MS)



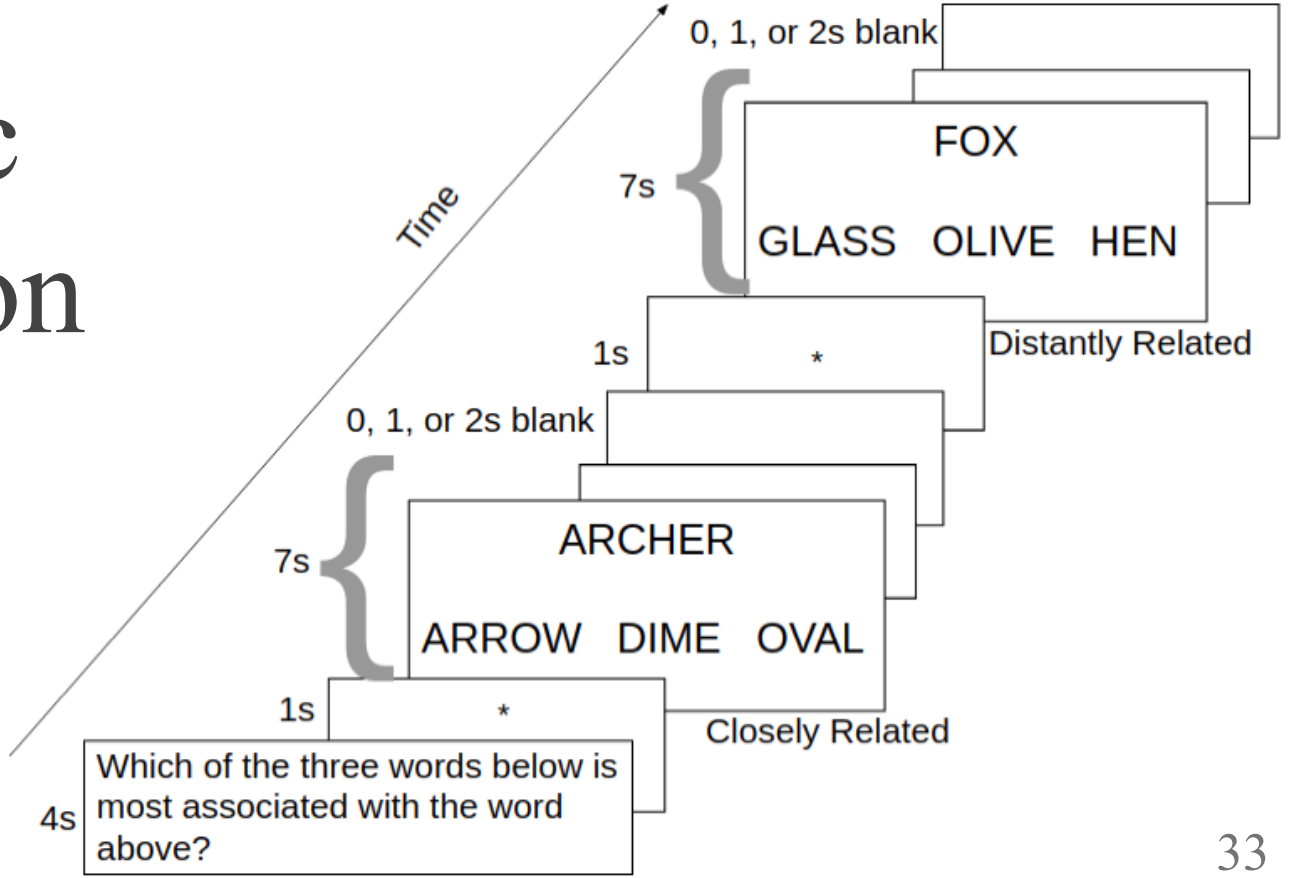
Thought Generating Task

(TGT)



Semantic Association

(SA)



3.3 Procedure

1. **fMRI Scan Preprocessing**
   - SPM8
2. **Networks & HDR**
   - fMRI-CPCA
3. **Statistical Analysis**
   - SPSS
   - Repeated measures ANOVAs
4. **Network Classification**
   - Templates
   - HDR

4. Resources

- Access to MS, TGT and SA datasets
- SPM 8 Software
- fMRI-CPCA Software
- SPSS Software
- Computer time

5. Summary

- fMRI may be used to examine BOLD signal
- Determine functional networks from three language tasks in both healthy controls and schizophrenia patients with fMRI-CPCA
- Increase understanding of spatial localization of brain networks and influence potential neuromodulation methods for schizophrenia patients