

Reading The Brain

■ Goals

Interpret Neuroimaging Signals to Detect Cognitive State

■ *Psychiatric Disorders*

■ *BCI*

■ *Affect*

■ *Attention, etc...*

Provide Real-time Outputs and Neurofeedback

Use Existing Expert Knowledge

Create Interpretable ML Decision Layer

■ Methods

fMRI

EEG

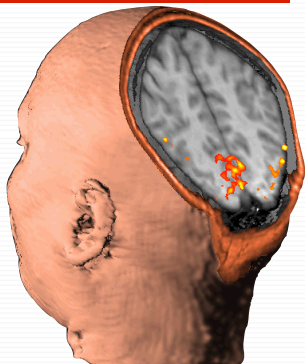
Machine Learning

www.brainmapping.org

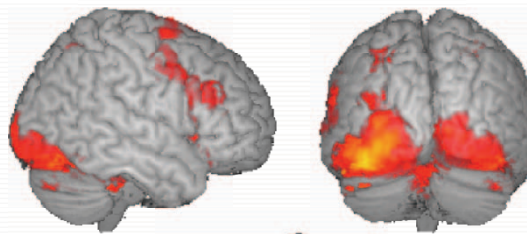
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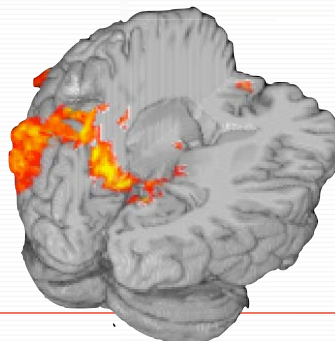
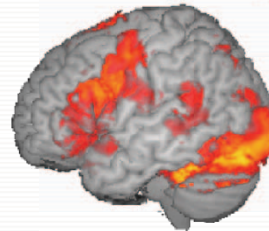
Individual Regions are Pluripotent



Visual stimulation



Language tasks



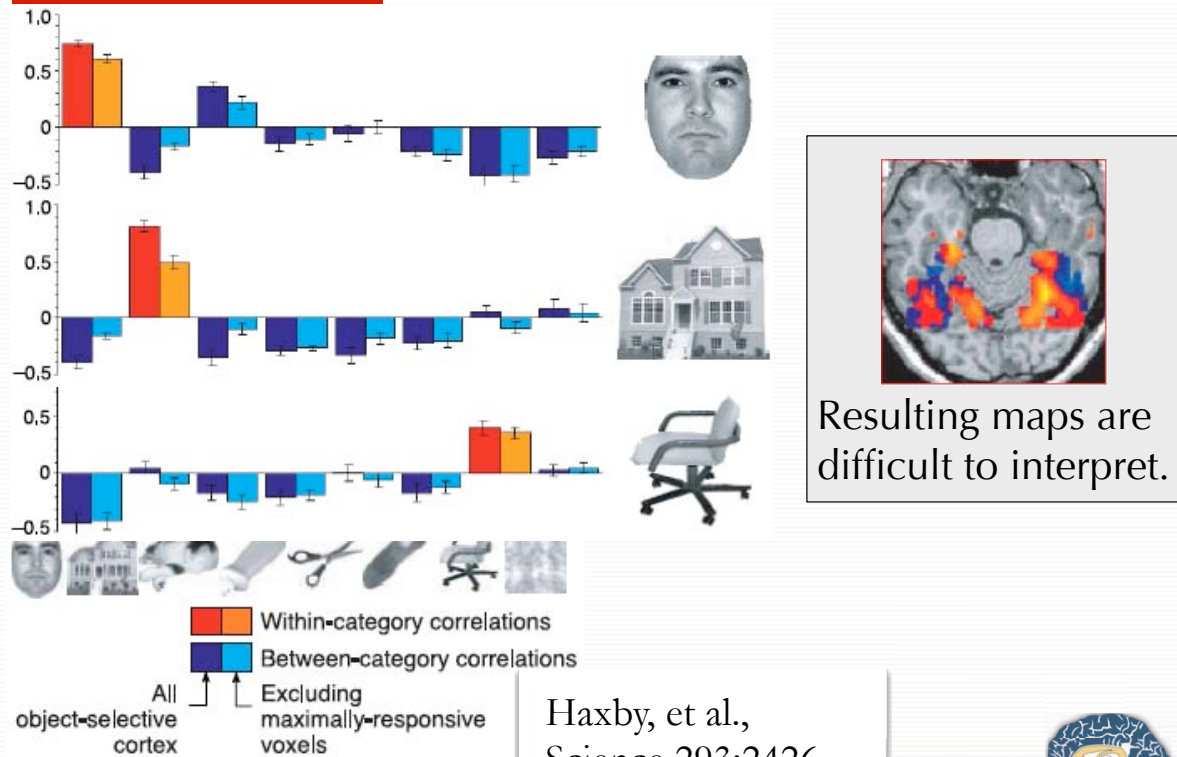
Mental imagery

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Machine Learning in fMRI



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Optimal Basis Selection

- Efficient Machine Learning Dimensions Are:
 - Independent Measures (*foot size + shoe size adds little*)
 - Sparse - Ideally the minimum number needed to categorize the data
 - Too Many Dimensions Results in Errors!
- For Scientific Applications Dimensions Ideally Reflect Real Sample Properties and are Explanatory
- What are the Right Dimensions for Neuroscience?

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A (perhaps naïve) Model of Cognition

- Multiple Networks are Concurrently Active
- Many Such Networks are Common Across People
- Current Cognitive State Reflects the Contributions of all Currently Active Networks
- *Perhaps:*
 - Current Cognitive State is the sum of Active Network Activity

$$CS = \alpha_1 N_1 + \alpha_2 N_2 + \alpha_3 N_3 + \dots + \alpha_j N_j.$$

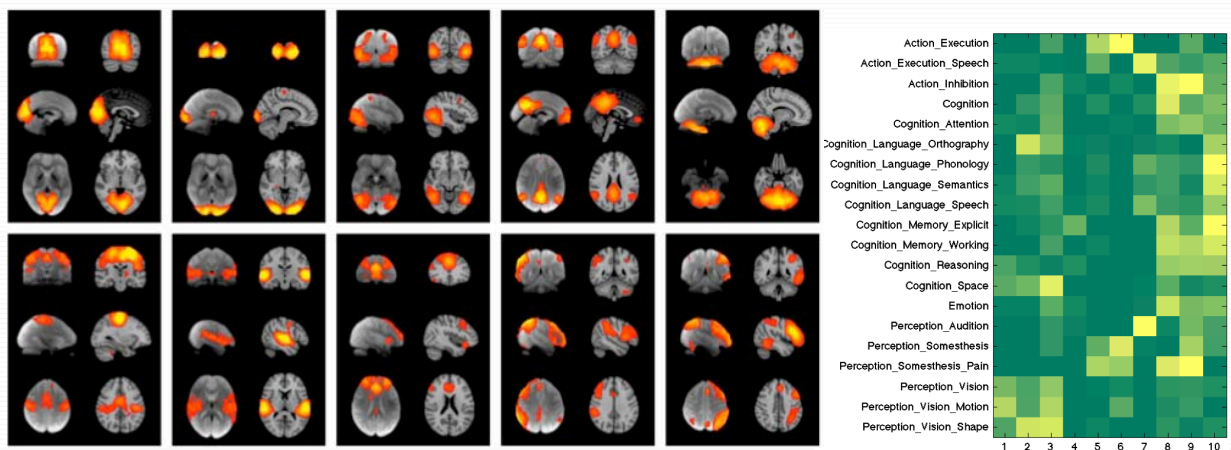
Where:

CS is the current cognitive state

N_k is one among many networks

α_k is the activity level of the corresponding network

ICA Exposes Functional Networks



The functional architecture of the human brain:
Correspondence between resting FMRI and task-activation studies

Stephen M. Smith¹ Peter T. Fox²
Karla L. Miller¹ David C. Glahn^{3,2} P. Mickle Fox² Clare E. Mackay¹
Nicola Filippini¹ Kate E. Watkins¹ Roberto Toro⁴
Angela R. Laird² Christian F. Beckmann^{5,1}

Operationalized Belief

- Autobiographical

You own a toaster oven.

Disbelieve Believe

- Ethical

It is good to help people in need.

Disbelieve Believe

- Factual

Sugar is sweet.

Disbelieve Believe

- Geographical

Nevada borders California.

Disbelieve Believe

- Mathematical

$(45/3) + 25 = 40$

Disbelieve Believe

- Religious

Jesus was actually born of a virgin.

Disbelieve Believe

- Semantic

“gigantic” means “huge”

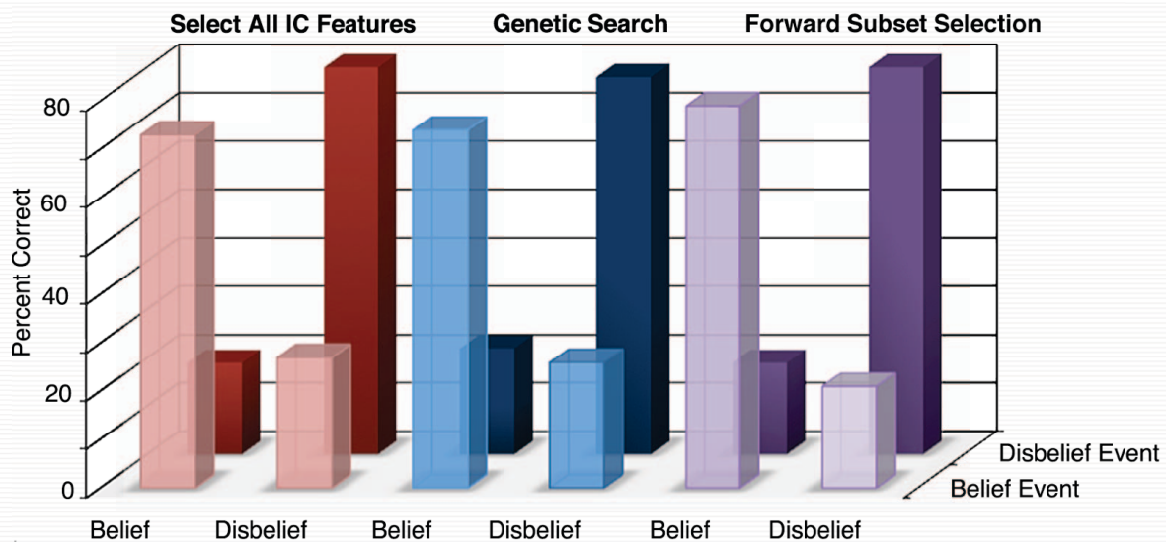
Disbelieve Believe

S Harris, SA Sheth and MS Cohen,
Annals of Neurology, 63(2): p. 141-147. 2008

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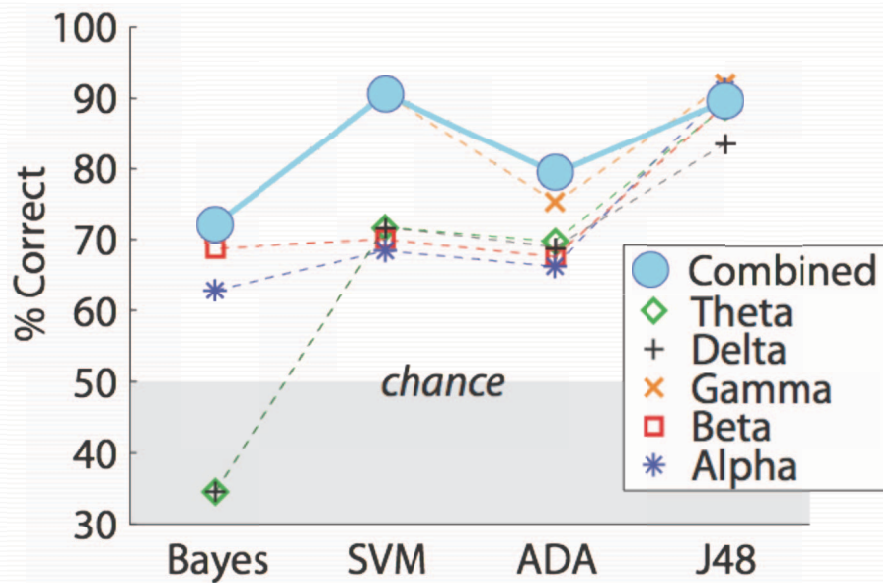
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A Special Word for Saying What you Don't Believe



Pamela Douglas, et al., Submitted

Classification by Frequency Band



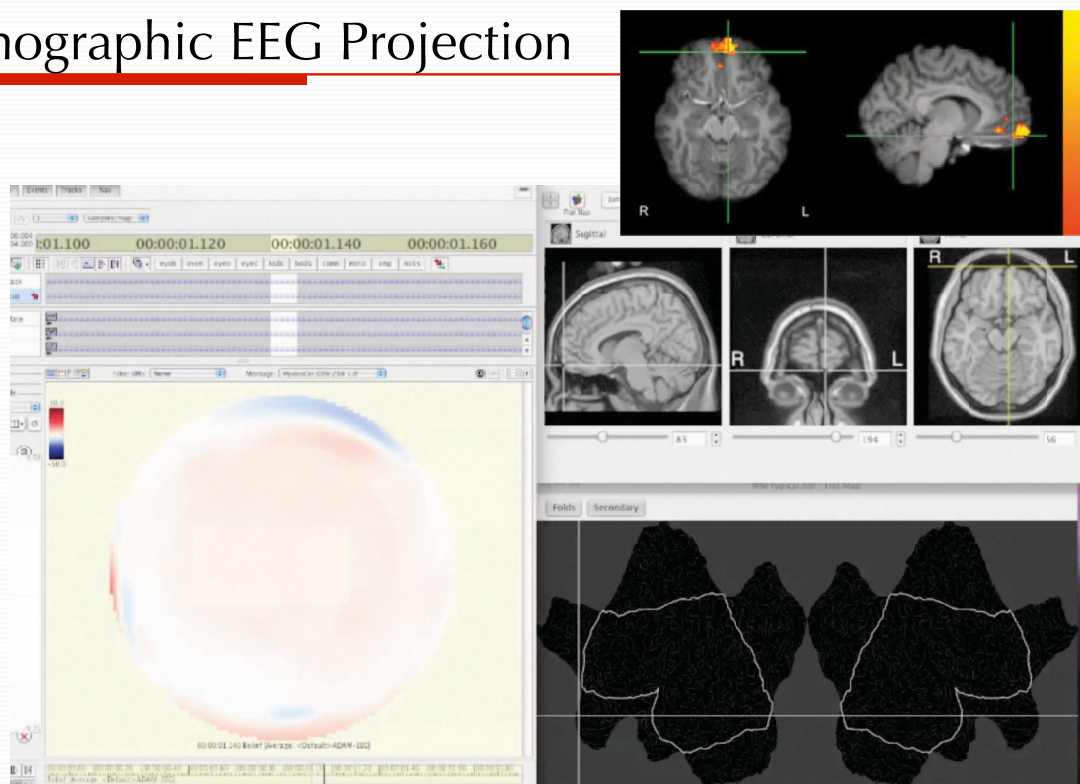
Pamela Douglas, Edward Lau
Agatha Lenartowicz, Wei Li

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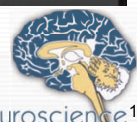
Tomographic EEG Projection



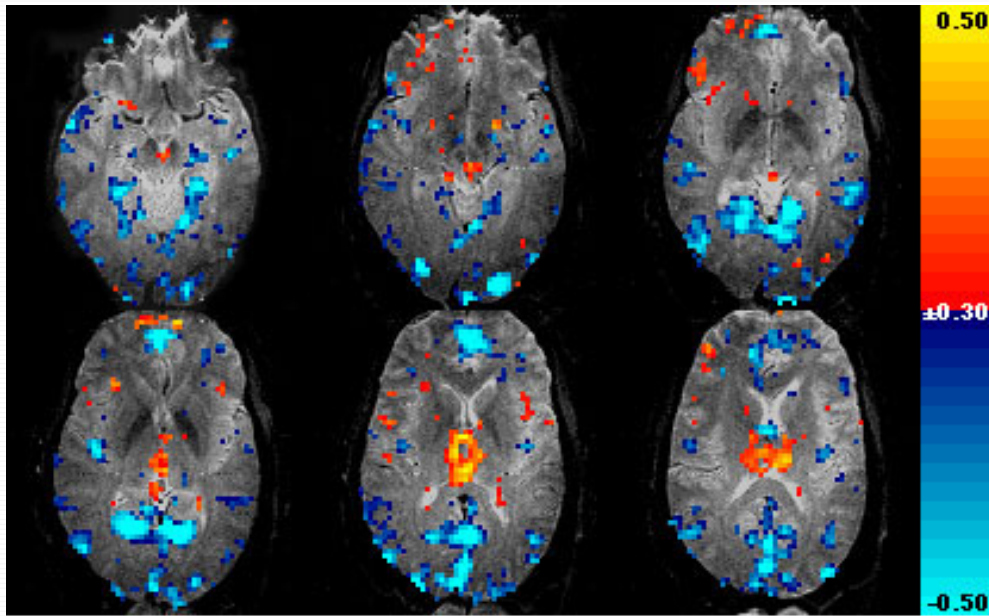
Wei Li, Edward Lau
Pamela Douglas, Agatha Lenartowicz,

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Alpha Tomograms



Goldman (2002) NeuroReport 13(18):2487

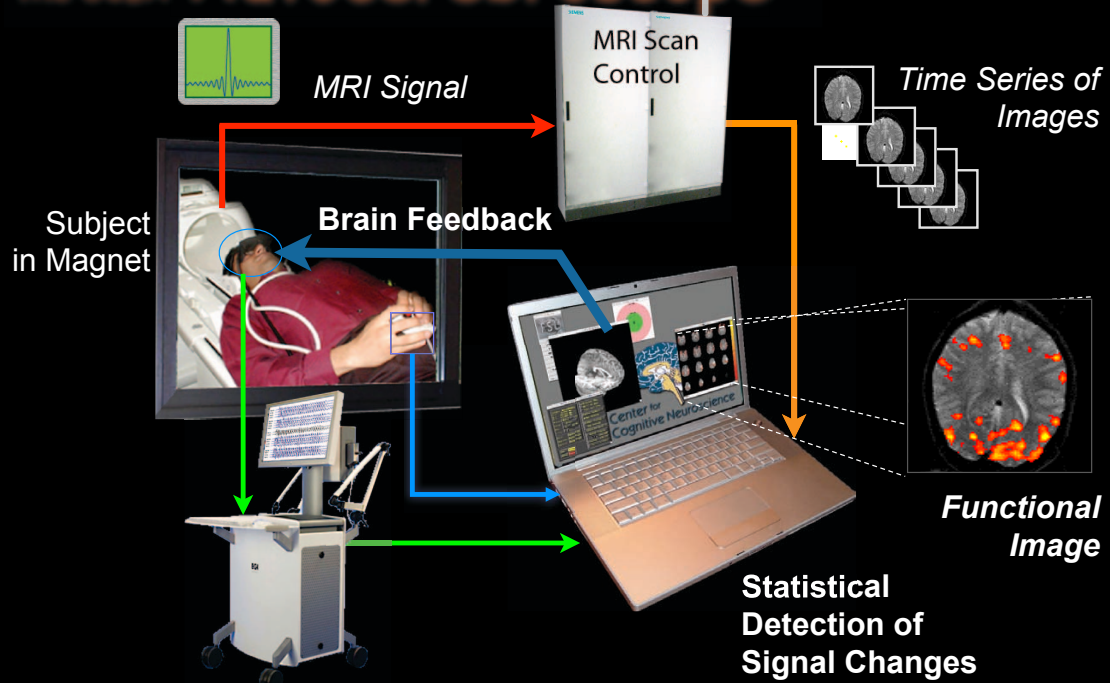
Patent no. 10/344,776

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the UCLA Autocerebroscope

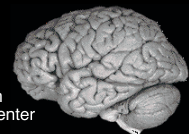


Cohen 10/25/07

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UCLA Brain
Mapping Center



CRT Projects

■ Best Feature Subspace

- Parametric Basis Functions*
- Neuroanatomical Knowledge Base*
- Compressive Sensing & Sparsity*
- Data*
- Internal Process (e.g., Markov)*

■ Multimodal Fusion

- fMRI, EEG, Behavior, Hypnosis, Physiological Markers*

■ Imaging Statistics

- Repeated Measures*
- Latent Information*