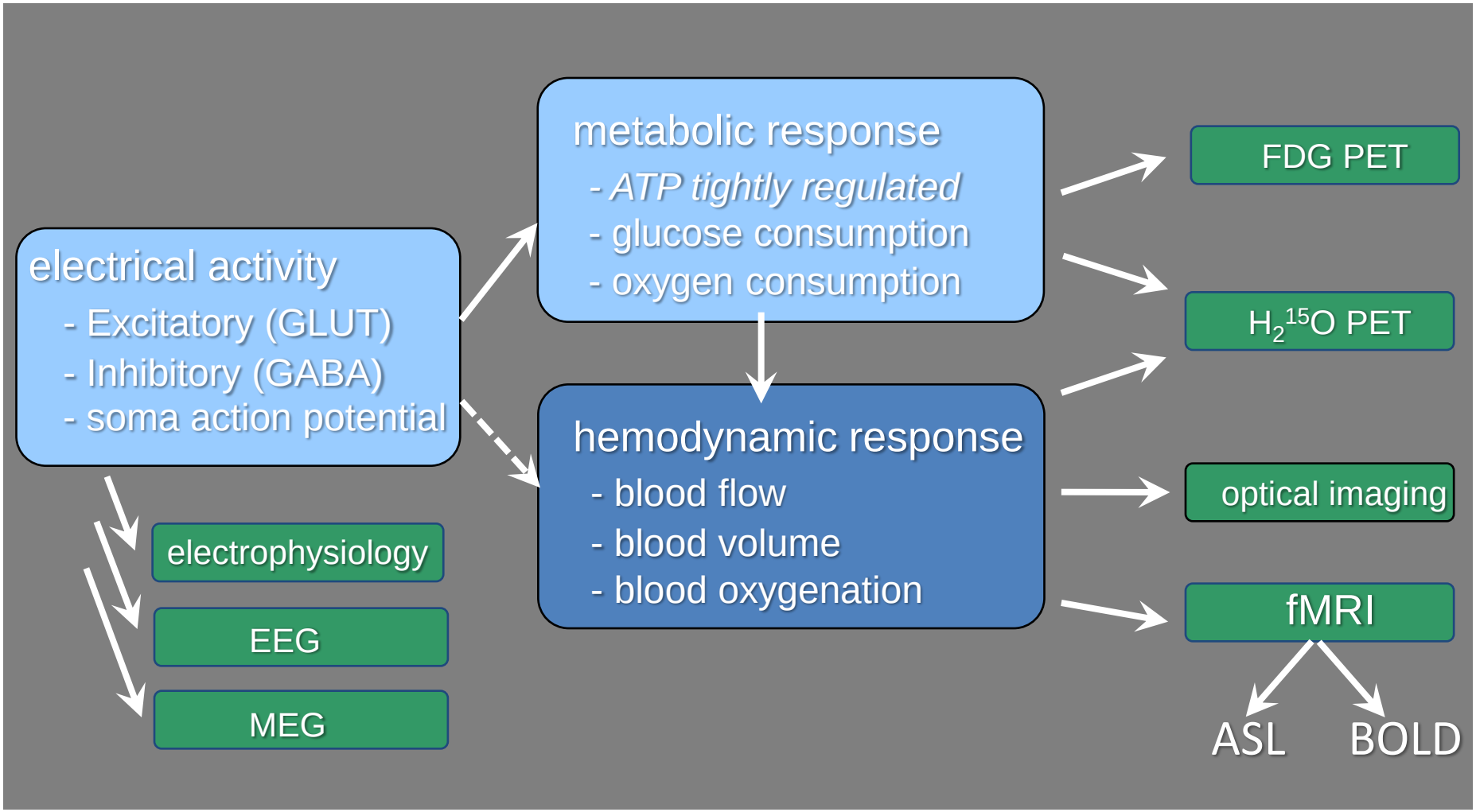
Imaging Physiological Correlates of Neural Function



Cerebral Blood Flow

- Brain is a highly perfused organ
  - Receives 15-20% of cardiac output
  - CBF varies with age, gender, phenotype, genotype
- CBF is closely coupled to neural activity
  - Mechanism of coupling remains uncertain
- Provides a versatile biomarker for regional brain function
  - Not clear whether this is a model of current propagation ….

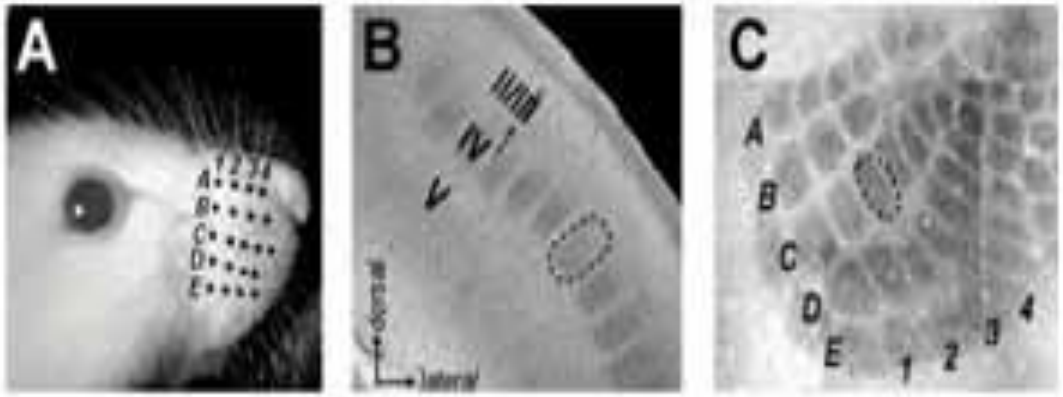
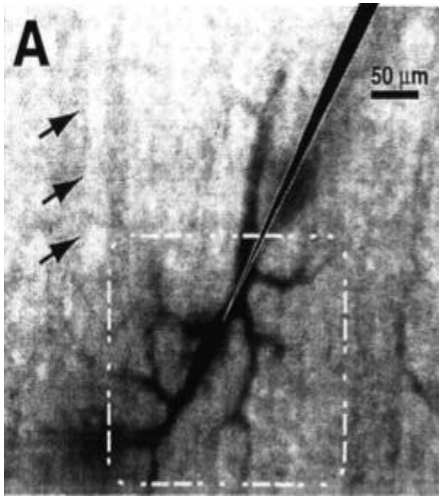
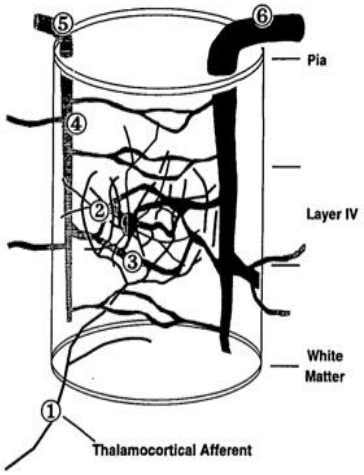


Figure 2. The topography of the barrel cortex replicates the topography of the whisker pad.

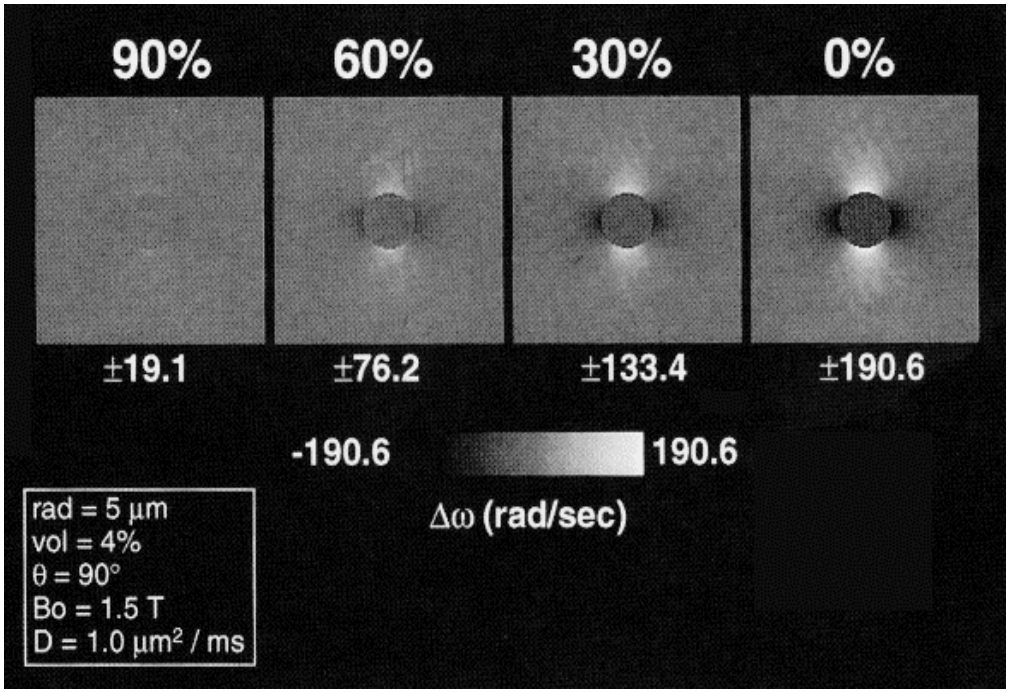




Woolsey, Cerebral Cortex 19

Blood Oxygenation Level Dependent (BOLD) Contrast Susceptibility (T2*) Weighted Imaging (Gradient Echo)

Ogawa, Magn. Reson. Med. 1990

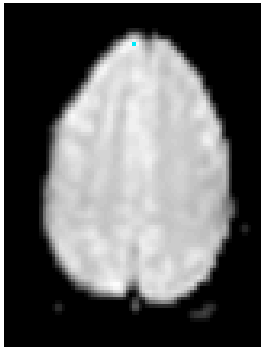


Bandettini and Wong. *Int. J. Imaging Systems & Technology* 1995

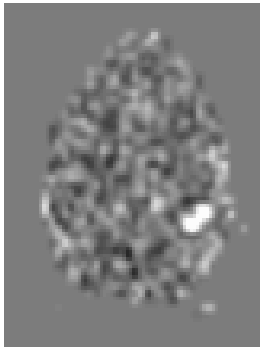
Hypoxia

Brain Activation Analysis

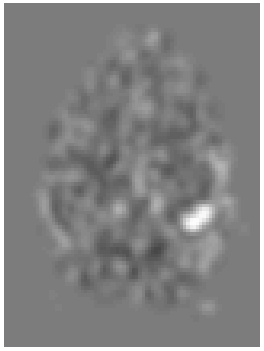
T2*-weighted Snapshot Image



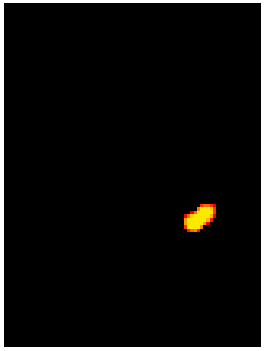
Average Difference Image



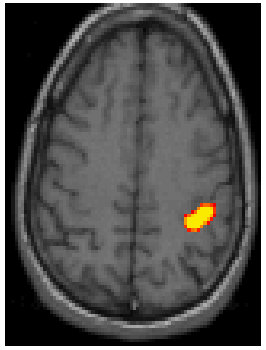
Statistical Significance Image



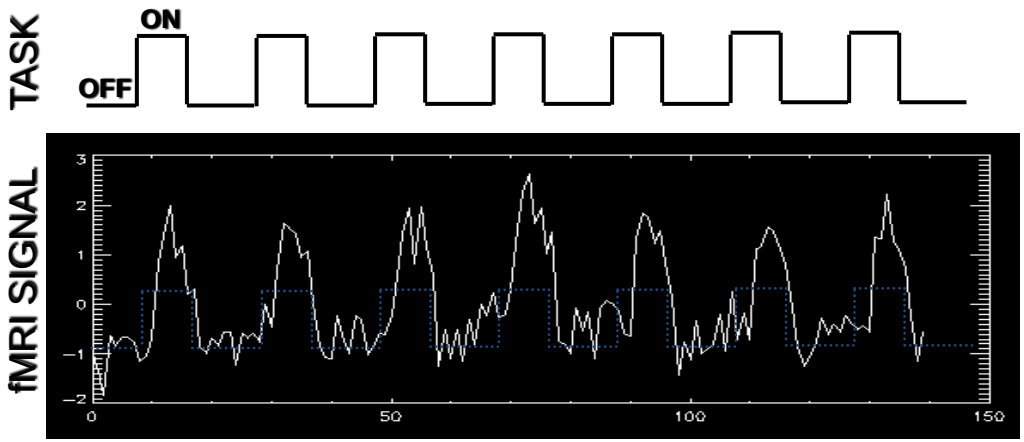
Thresholded Statistical Image



Overlay on T1 Anatomic Image

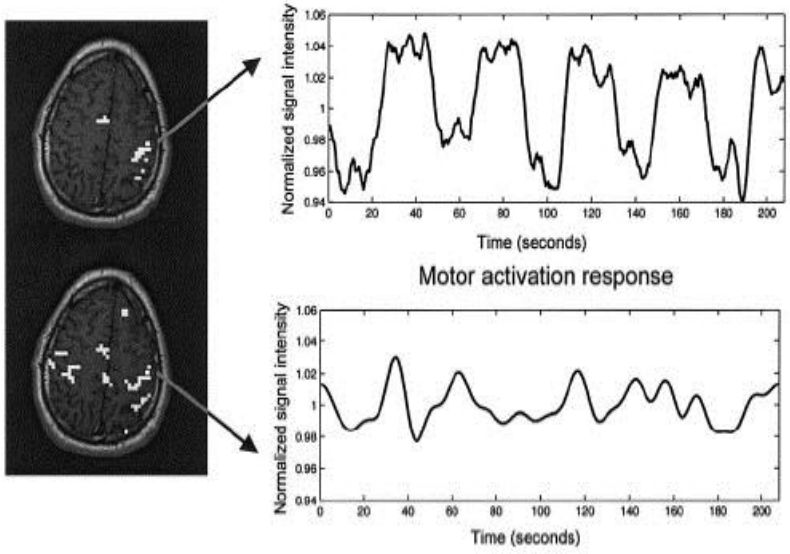


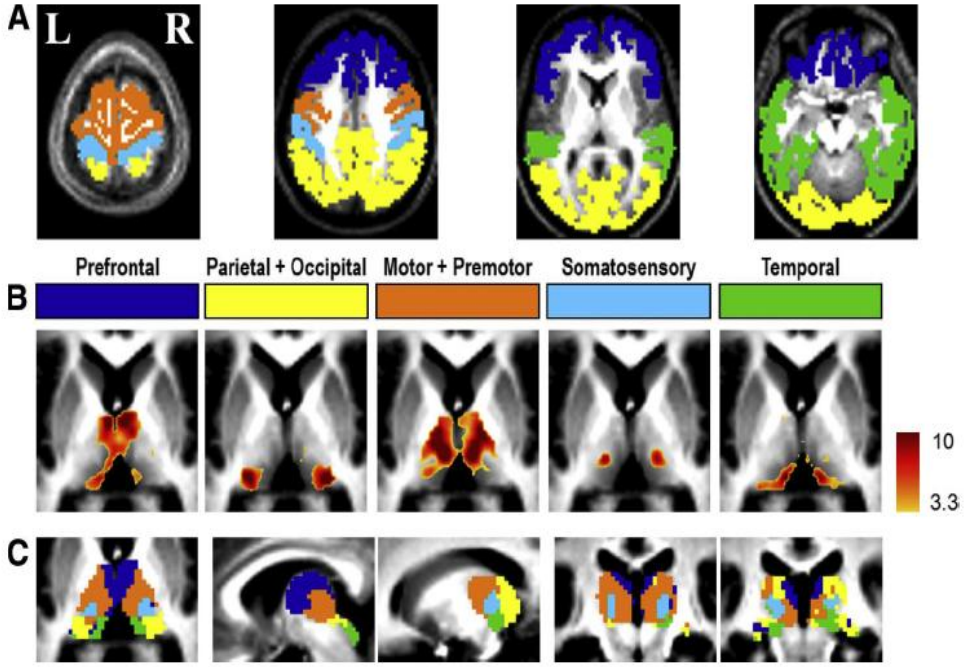
TIME SERIES



Intrinsic Connectivity in BOLD fMRI
Biswal et al., MRM 1995 and ff

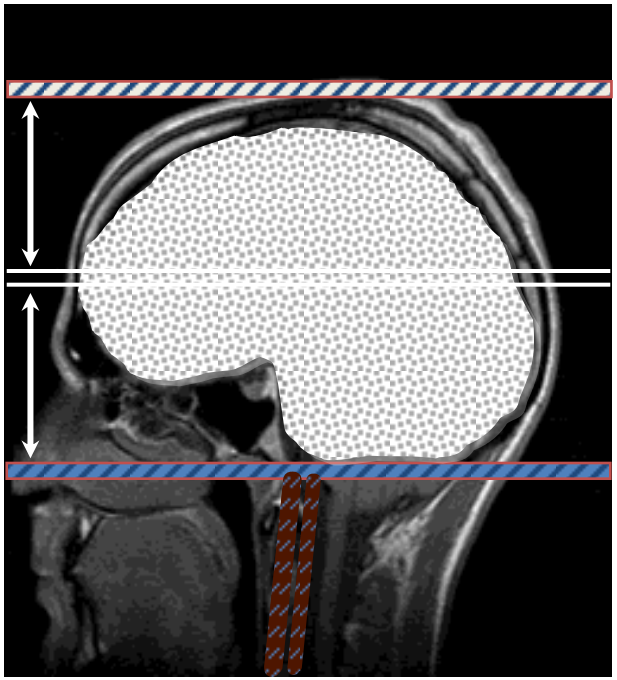
- Significant correlations within functionally distinct networks in very low-frequency BOLD data (<0. 1 Hz)
  - Physiological basis uncertain, but appears to depend on neuronal connection
- Does not require task activity
  - Present during sleep
- Altered with disease





Perfusion MRI with Arterial Spin Labeling

Schematic



Control Inversion Plane

Imaging Slice

Arterial Tagging Plane

Continuous Adiabatic Inversion Geometry

Control - Label

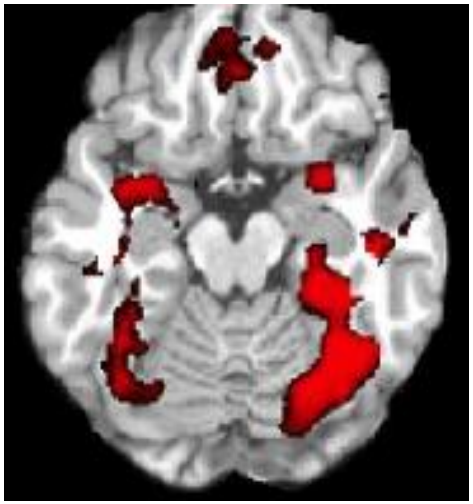
Single Slice Perfusion Image about 1% effect

CBF in "classical" units of ml/100g/min

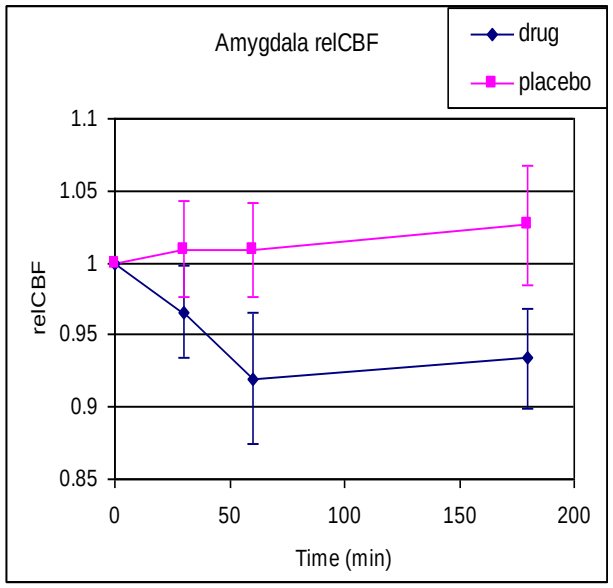
One of the only MRI contrasts whose biological basis is

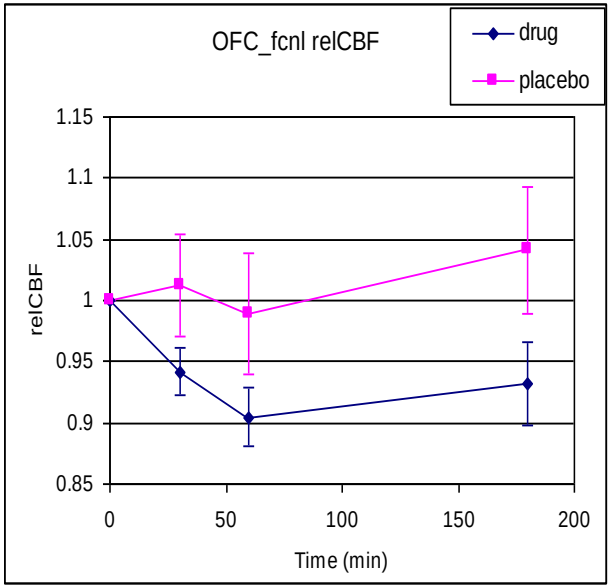
ASL: Effect of Single Dose Oral Citalopram
Chen et al., Clin Pharmacol Ther 2010

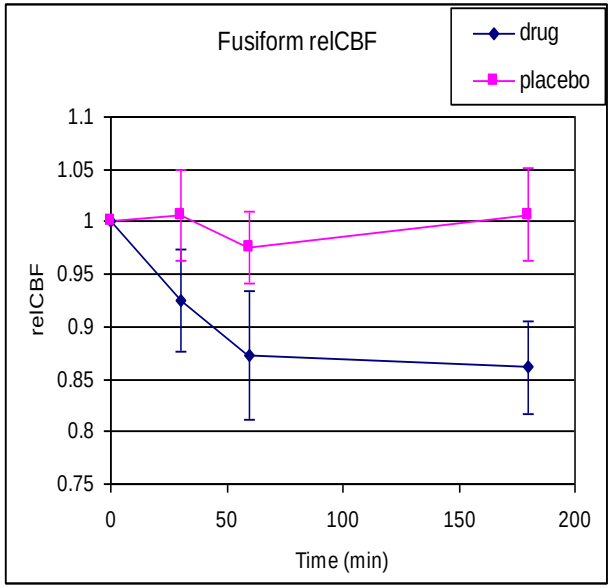
- N=12 healthy volunteers
- 20 mg Citalopram vs. Placebo (single dose)
- Randomized sessions one week apart
- CBF at baseline and 30, 60, and 180 min
- Analysis of relative CBF (vs. baseline)



SVM

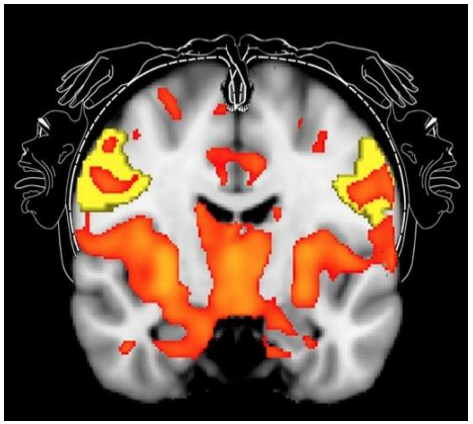




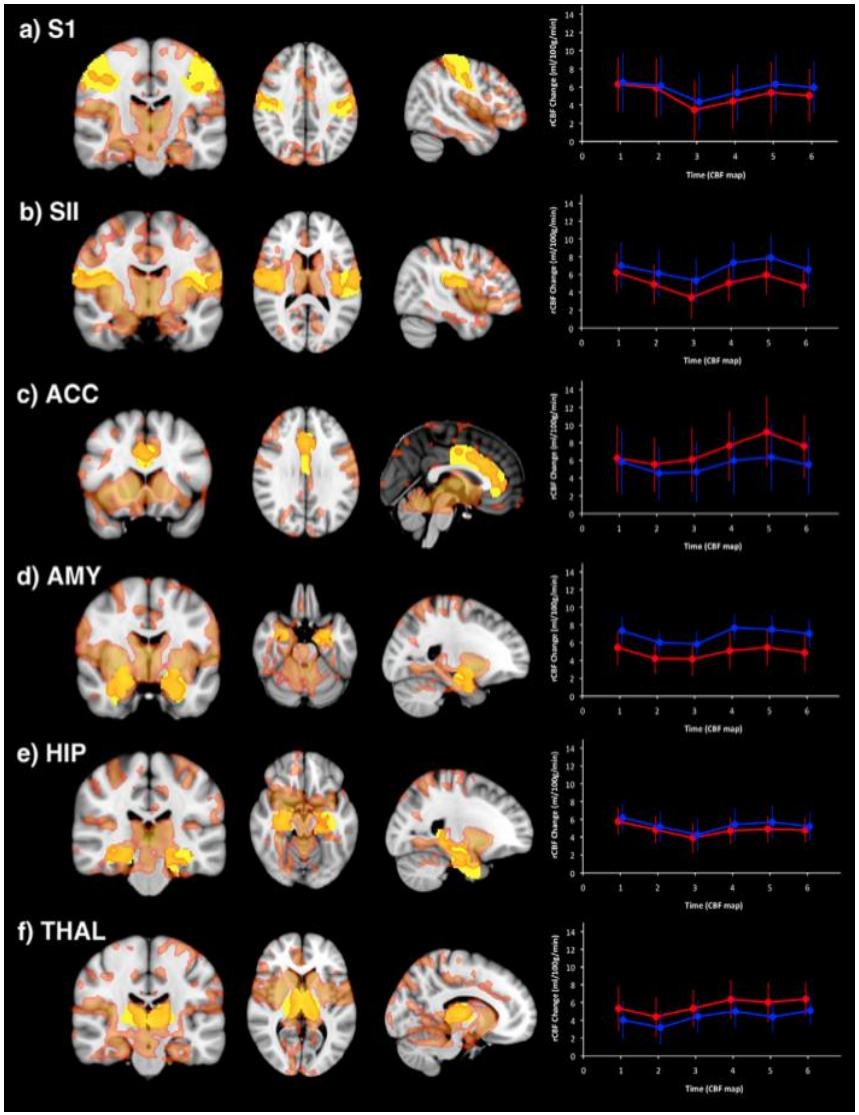


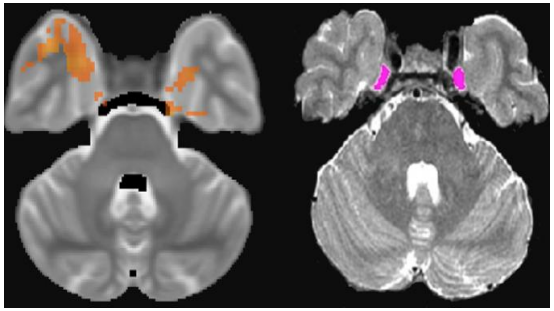
Perfusion fMRI of Pain

Howard et al., PloS ONE 2011



- N=16 bilateral molar extractions
- 3T pCASL MRI before and after each extraction
  - Off pain medication during scanning

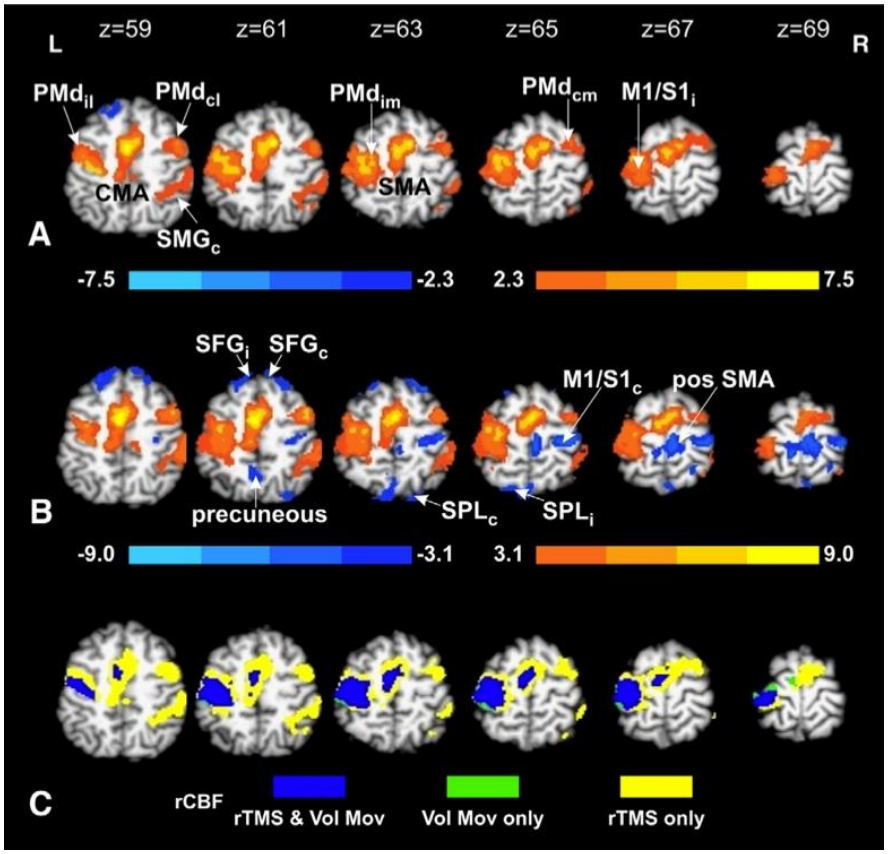


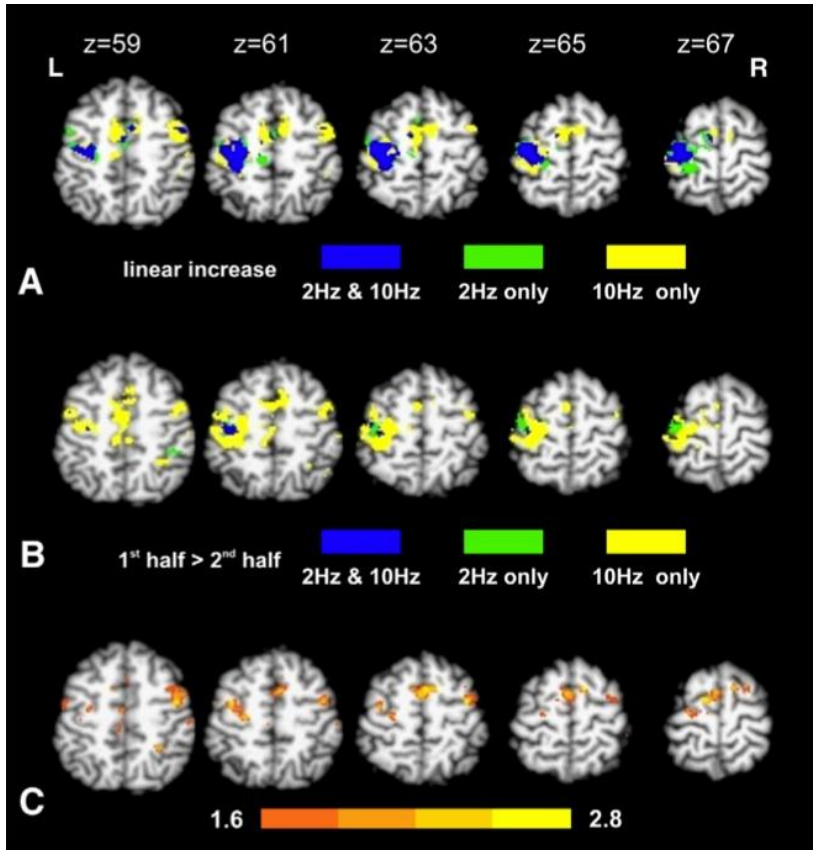


- **Reproducible CBF changes of 5-10% in ROI's involved in somatosensory and affective function**
  - **Even in trigeminal ganglion!**

fMRI of TMS, ASL and BOLD

Moisa et al, NeuroImage 2010





Case Report: Halco Neuroimage 11 (BIDMC)

Rehab+tDCS for hemianopia

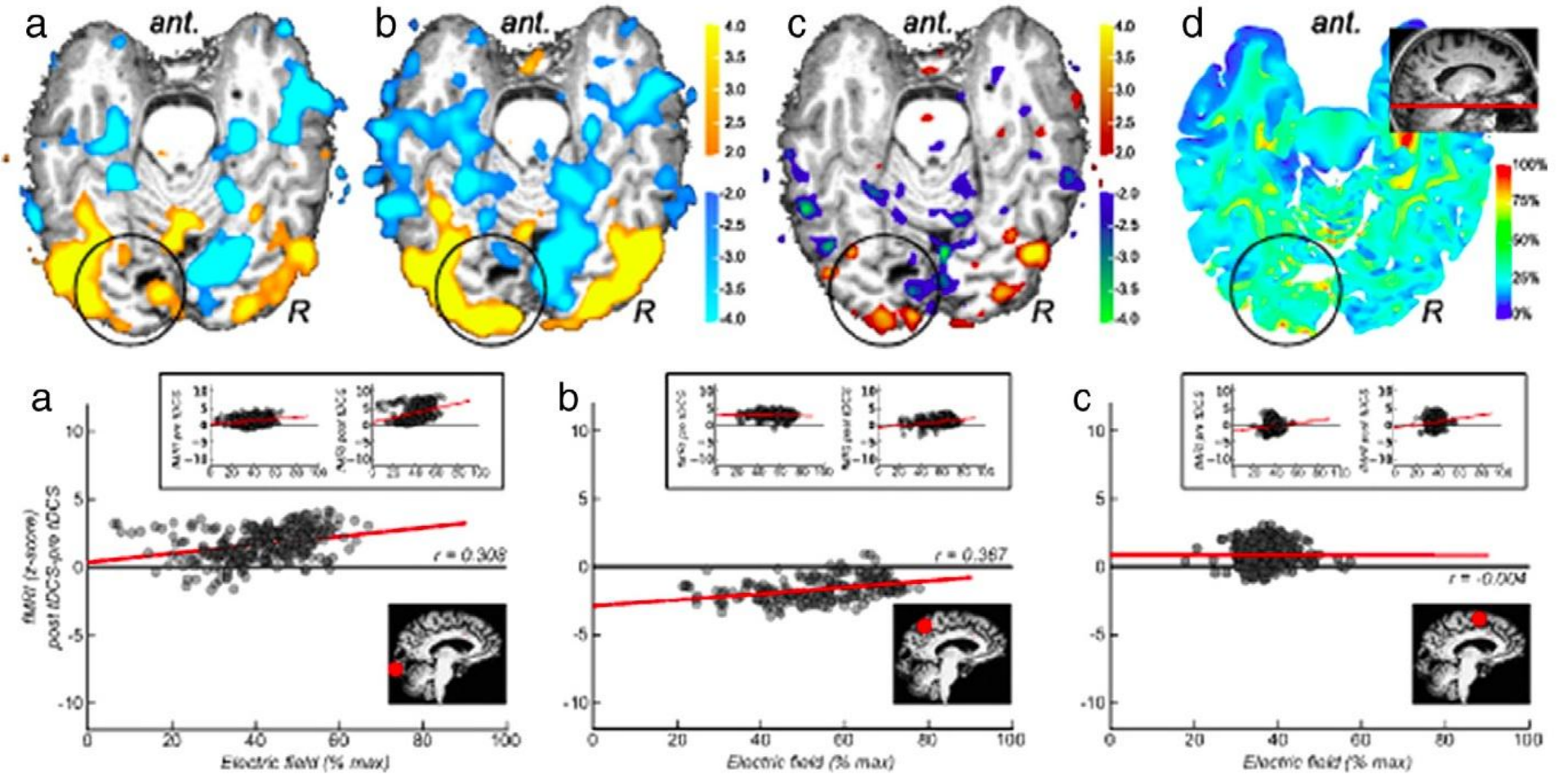
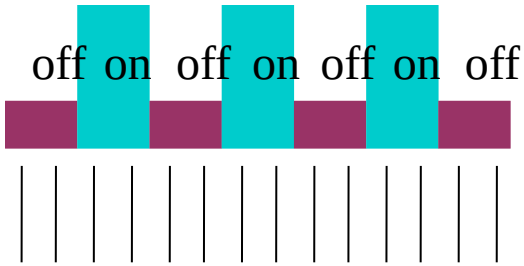
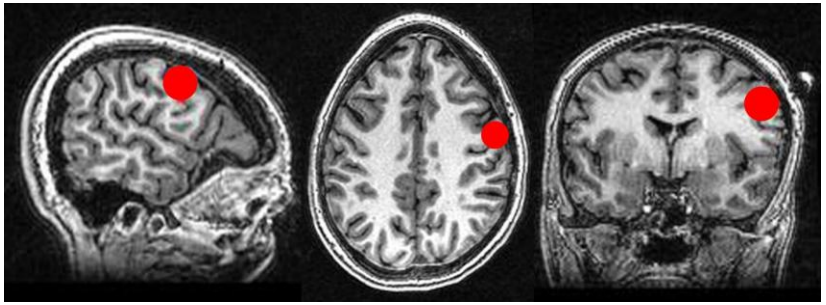
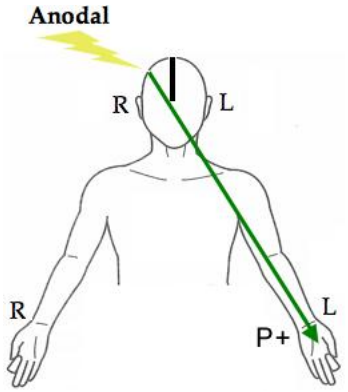


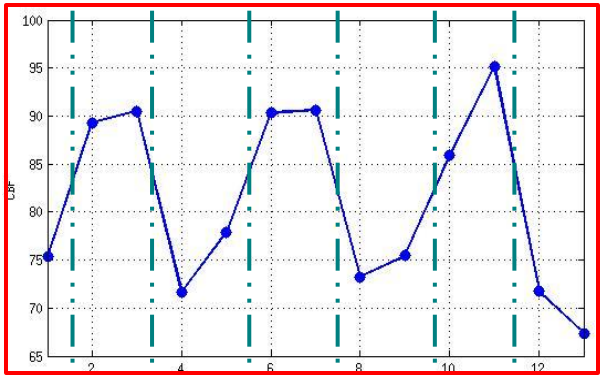
Fig. 3. Regional correlations between electrical field and change in fMRI activity. (a) Correlation of individual voxel electrical field and fMRI change in signal for gray matter underneath the anode at the ipsilesional occipital pole. Inset left: correlation between baseline fMRI activation and electrical field; inset right: correlation between post-treatment fMRI activation and electrical field. (b) Correlations of voxels in ipsilesional parietal cortex. Inset left, correlation between baseline fMRI activation and electrical field; Inset right, correlation between post-treatment fMRI activation and electrical field. (c) Correlations of voxels at ipsilesional vertex. Inset left, correlation between baseline fMRI activation and electrical field; Inset right, correlation between post-treatment fMRI activation and electrical field.

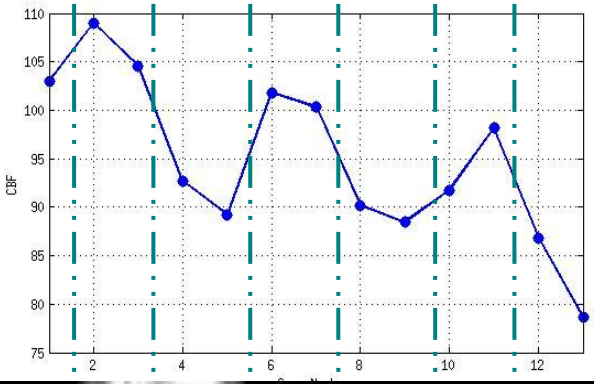
ASL of tDCS: Zheng, Schlaug, Alsop BIDMC

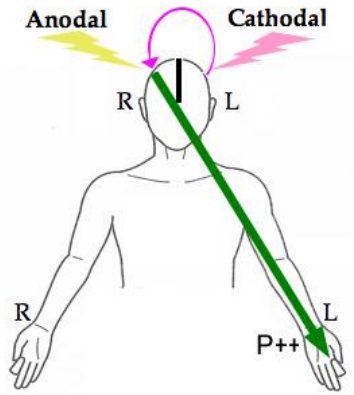


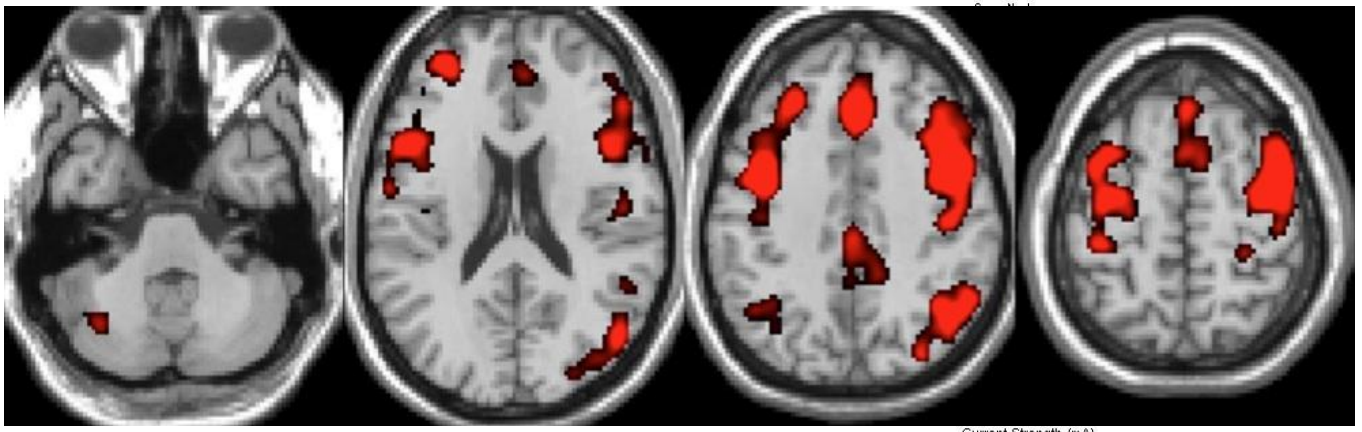




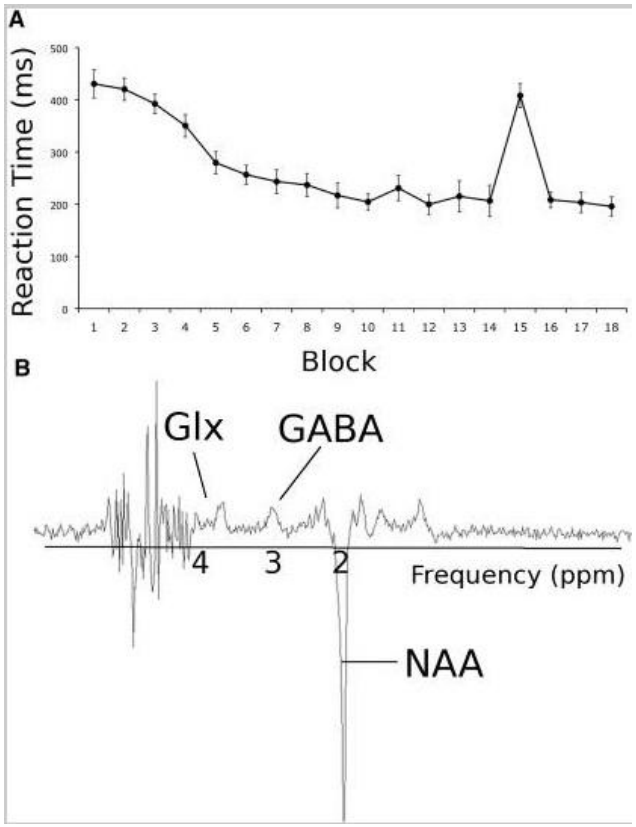






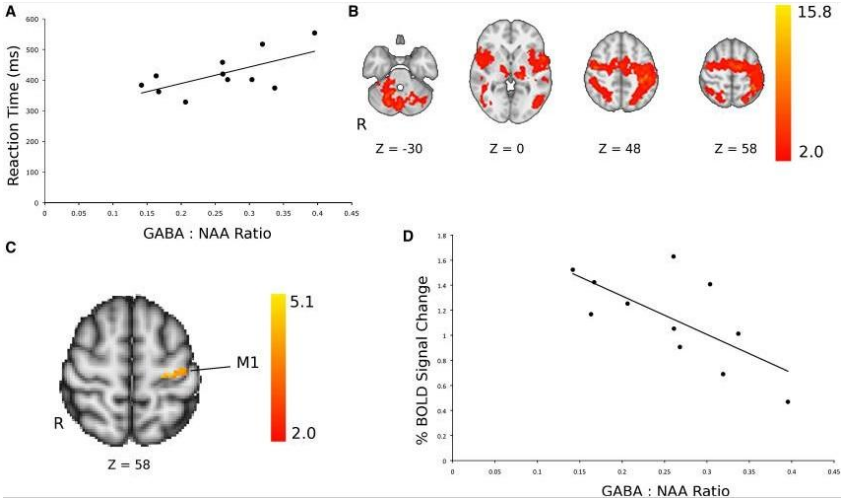


GABA and Motor Learning: Stagg Curr Biol 2011

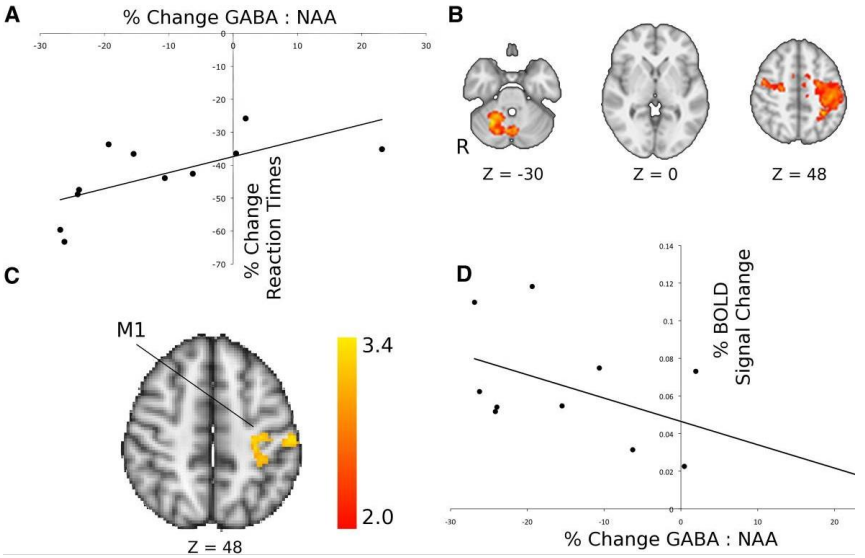


tDCS

BASELINE

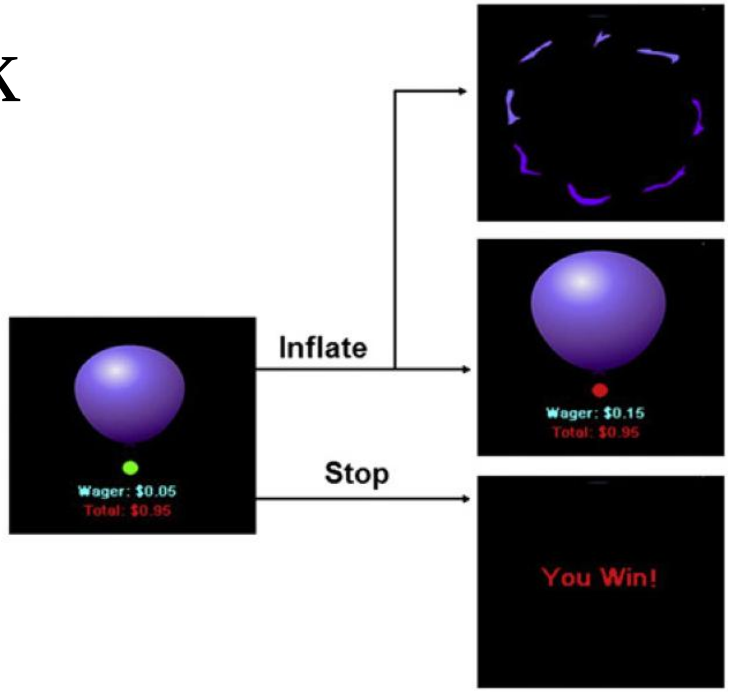


After tDCS

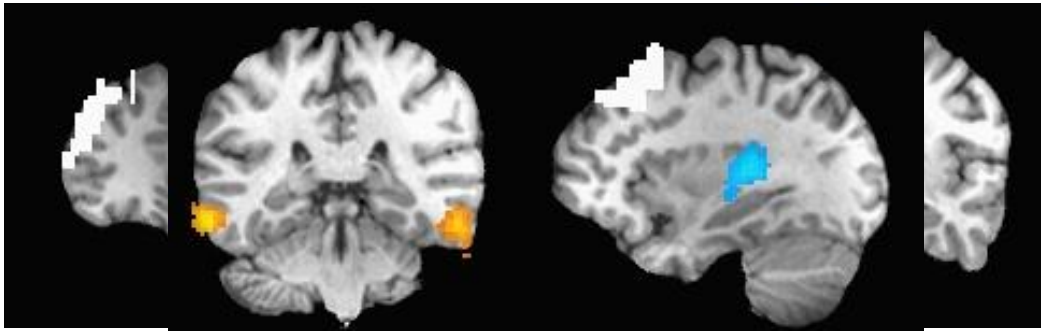


Balloon Analog Risk Task

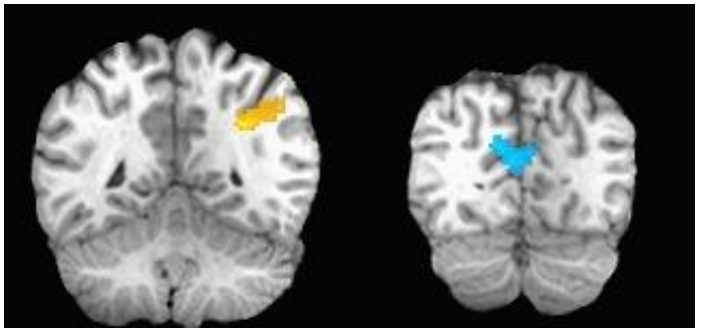
On each trial, subjects are confronted with a balloon. The more they pump the balloon, the more money they win, but the more likely the balloon is to pop. If the balloon pops, they lose the money they would have won.



- Activates dorsolateral PFC (Rao et al., 2008).
- Risk aversion increased by tDCS to dorsolateral PFC (Fecteau et al., 2007)
- Our experiment examines resting CBF (ASL) and BART fMRI activation.

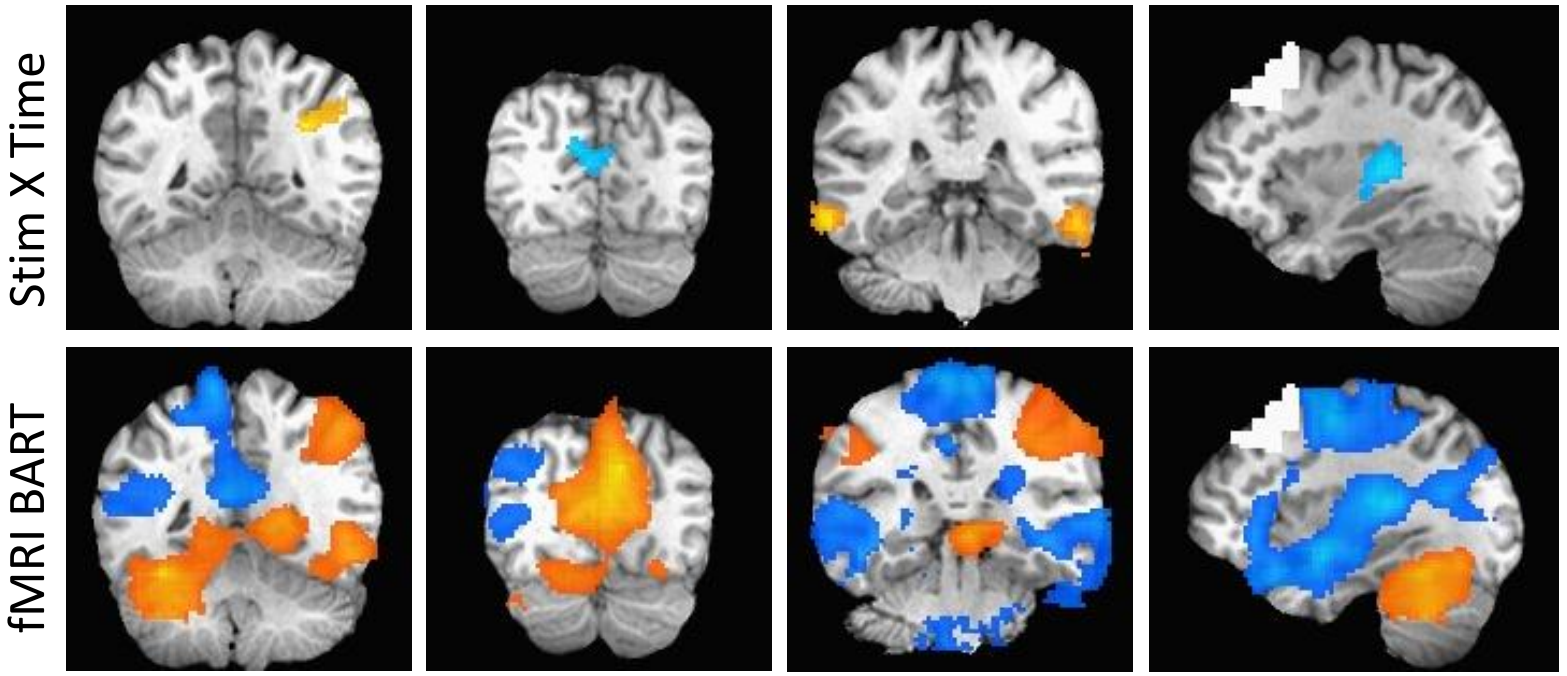


RESTING CONNECTIVITY
ASL STIM-BASELINE



LOSSES: STIM X TIME INTERACTION

Regions with Stimulus X Time interaction pattern are involved in the BART network, which we replicate from Rao et al. (2008):



Right IPL is active during wins

Cuneus is active during wins and losses

MTG is deactivated during wins

Left posterior insula is deactivated during wins and losses