Comparison of stochastic and variational solutions to ASL fMRI data analysis

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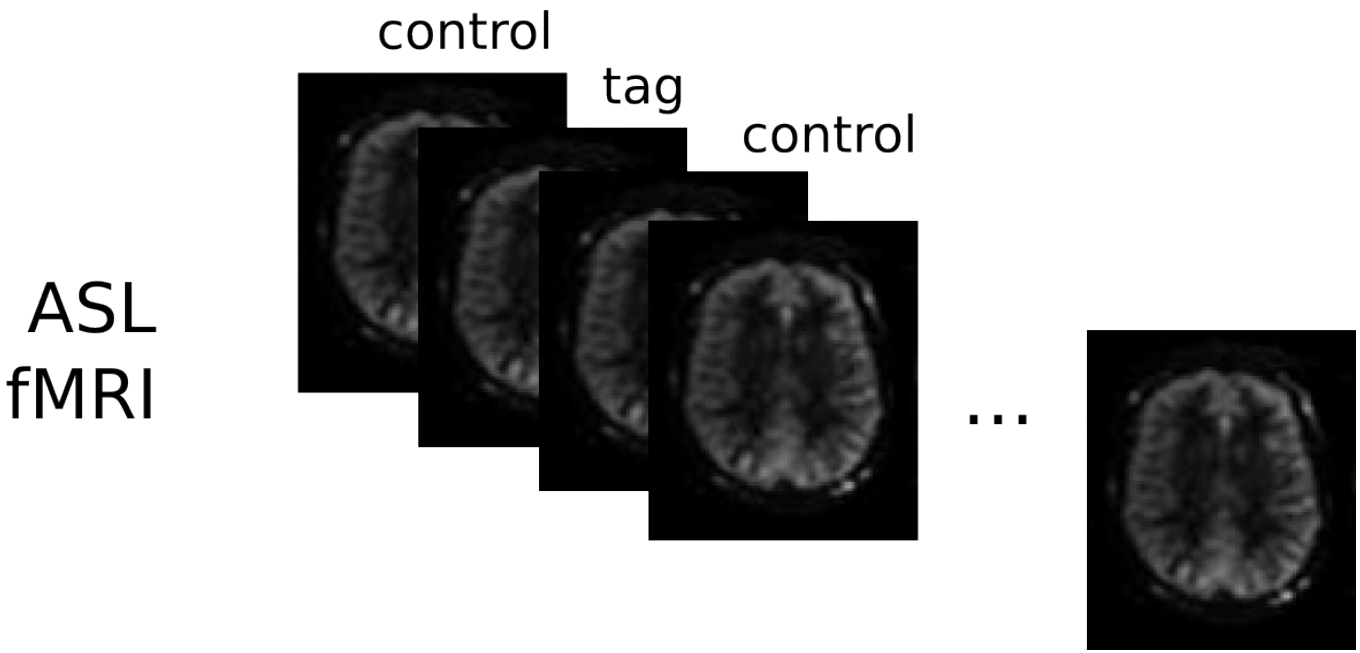
September, 2015

Arterial Spin Labeling (ASL): Quantitatively imaging cerebral perfusion

- ASL: can provide a direct quantitative measure of cerebral blood flow **(in ml/100g tissue/min) but low SNR**

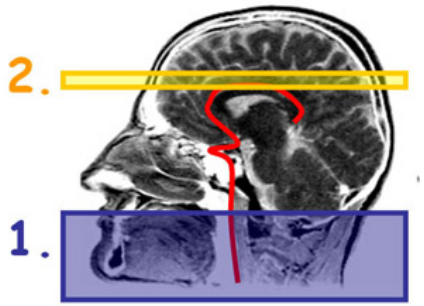
in contrast to

- BOLD: complicated mix of parameters **(blood flow, blood volume, oxygen consumption) but high SNR ($\gg$ ASL)**



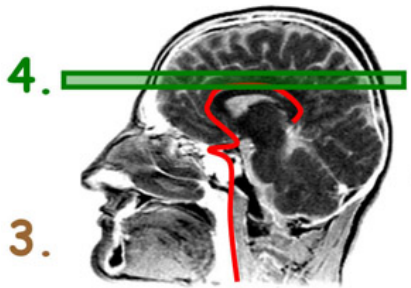
Arterial Spin Labeling data acquisition

- Acquire Tag Image: Tag inflowing arterial blood by magnetic inversion



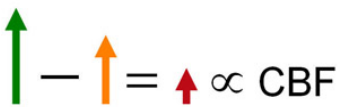
Time delay between 1 and 2: Labeled water reaches capillary bed and is exchanged with water molecules in the tissue $\longrightarrow$ signal change

- Acquire Control Image: Repeat experiment without labeling inflowing blood



- Subtract: Control Image (4) - Tag Image (2)

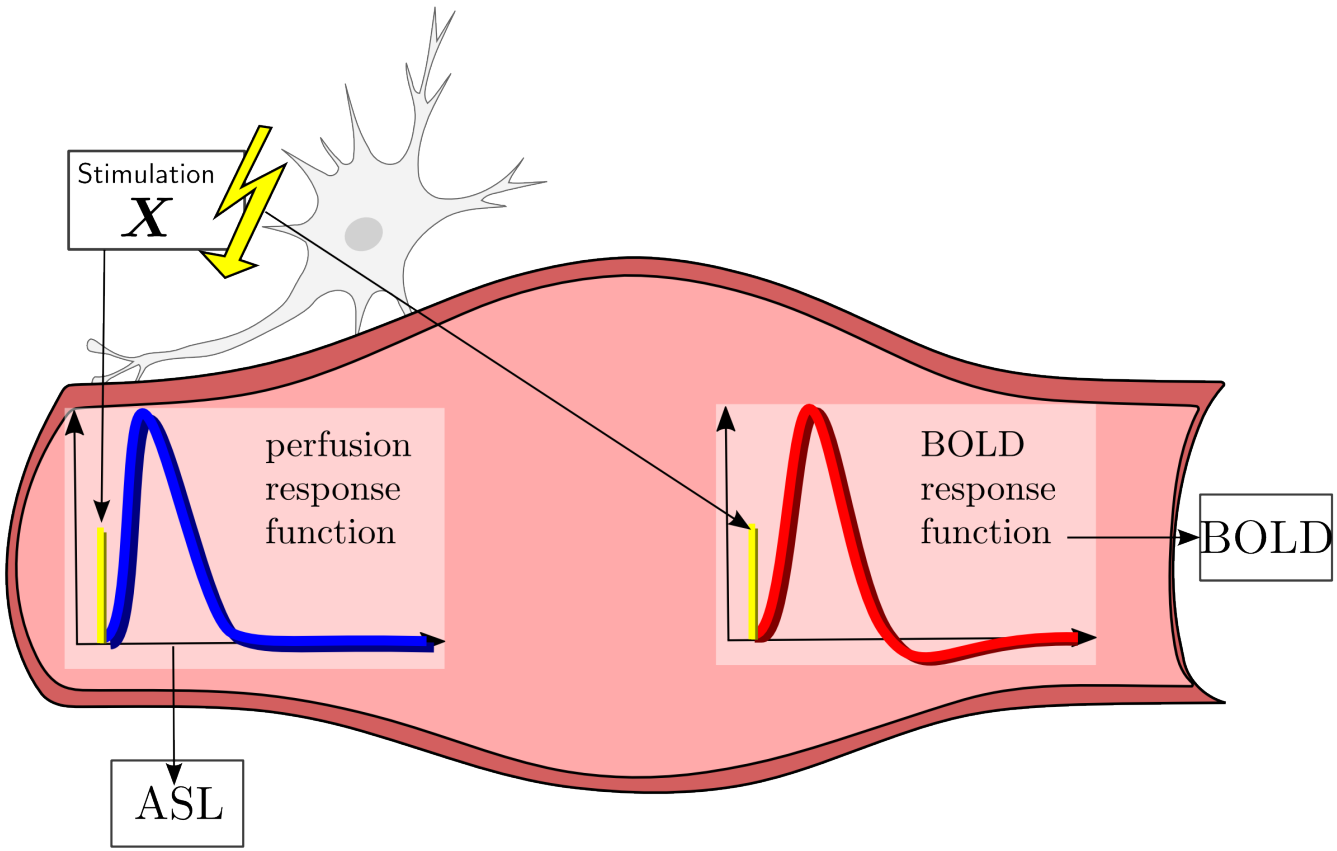
The Difference in magnetization is proportional to regional cerebral blood flow



Ref: http://fmri.research.umich.edu/research/main_topics/asl.php

Statistical analysis of ASL fMRI data

ASL data contain both hemodynamic & perfusion components

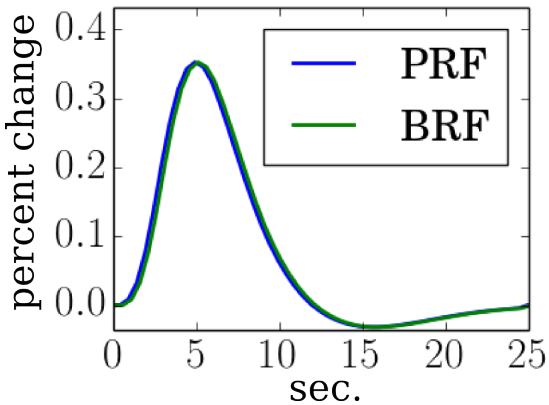


Statistical analysis of ASL fMRI data

- GLM

  Unique fixed canonical hemodynamic response function (HRF)
  [Hernandez-Garcia et al, 10, Mumford et al, 06]

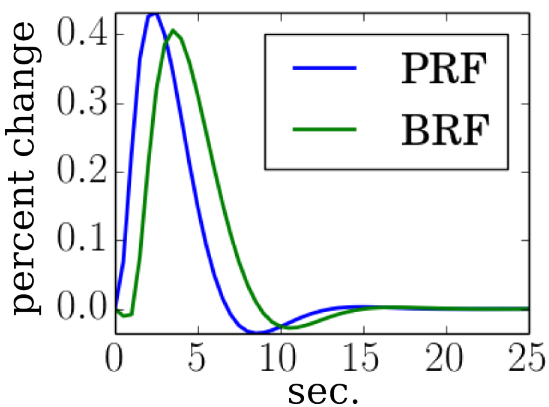
  Inaccurate PRF shapes



- Joint Detection-Estimation (JDE)

  Separate estimation of 2 response functions (HRF & PRF)
  Use of MCMC methods
  [Vincent et al, 13, Frau-Pascual et al, 14]

  Computationally very expensive



GOAL

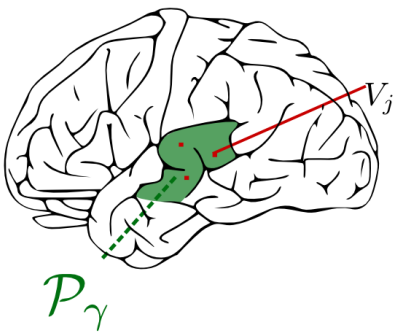
Providing an efficient solution to hemodynamic and perfusion response estimation from ASL fMRI data with acceptable computational times **compared to the stochastic solution**

Based on:

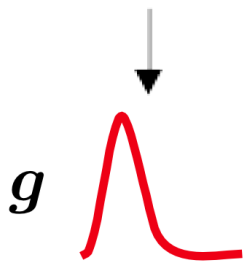
- Variational Expectation-Maximization [Chaari et al, 12]
- Physiological prior information

ASL signal model

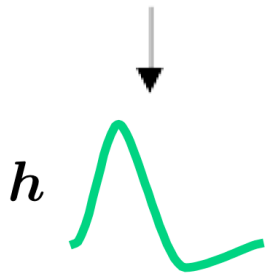
ASL signal = perfusion baseline + task-related perfusion + task-related BOLD + drift term + noise term



For every voxel in a parcel, ASL signal can be decomposed in different terms. We estimate the parameters of this model.

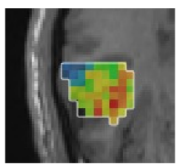


perfusion response function (PRF)

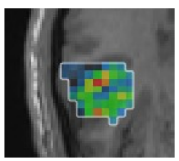


hemodynamic response function (HRF)

parcel-wise



perfusion response levels (PRLs)



hemodynamic response levels (BRLs)

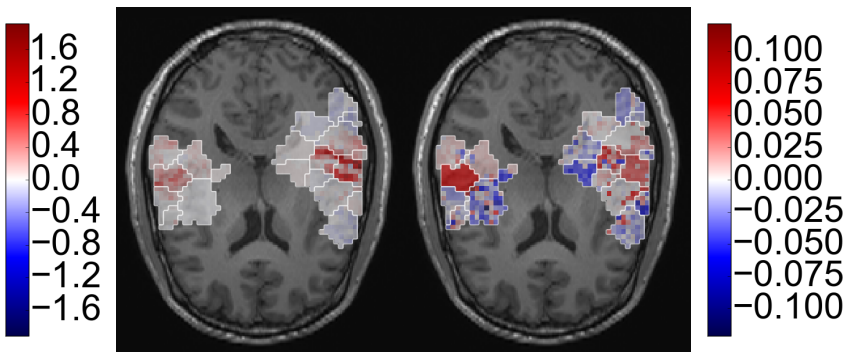
voxel-wise

Variational vs stochastic solutions

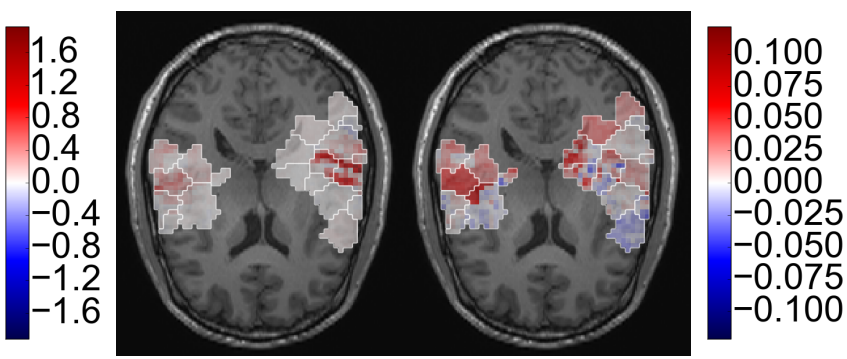
Real data analysis for an auditory task

Response levels

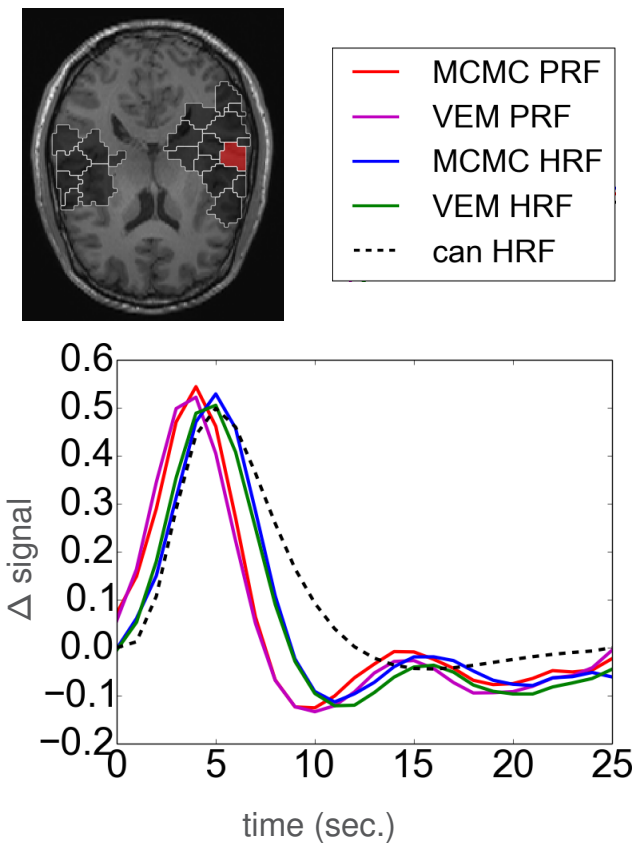
MCMC



VEM



Response function



Coming soon...