Infra-slow brain dynamics as a marker for cognitive function and decline

Shagun Ajmera, Shreya Rajagopal, Razi Ur Rehman,

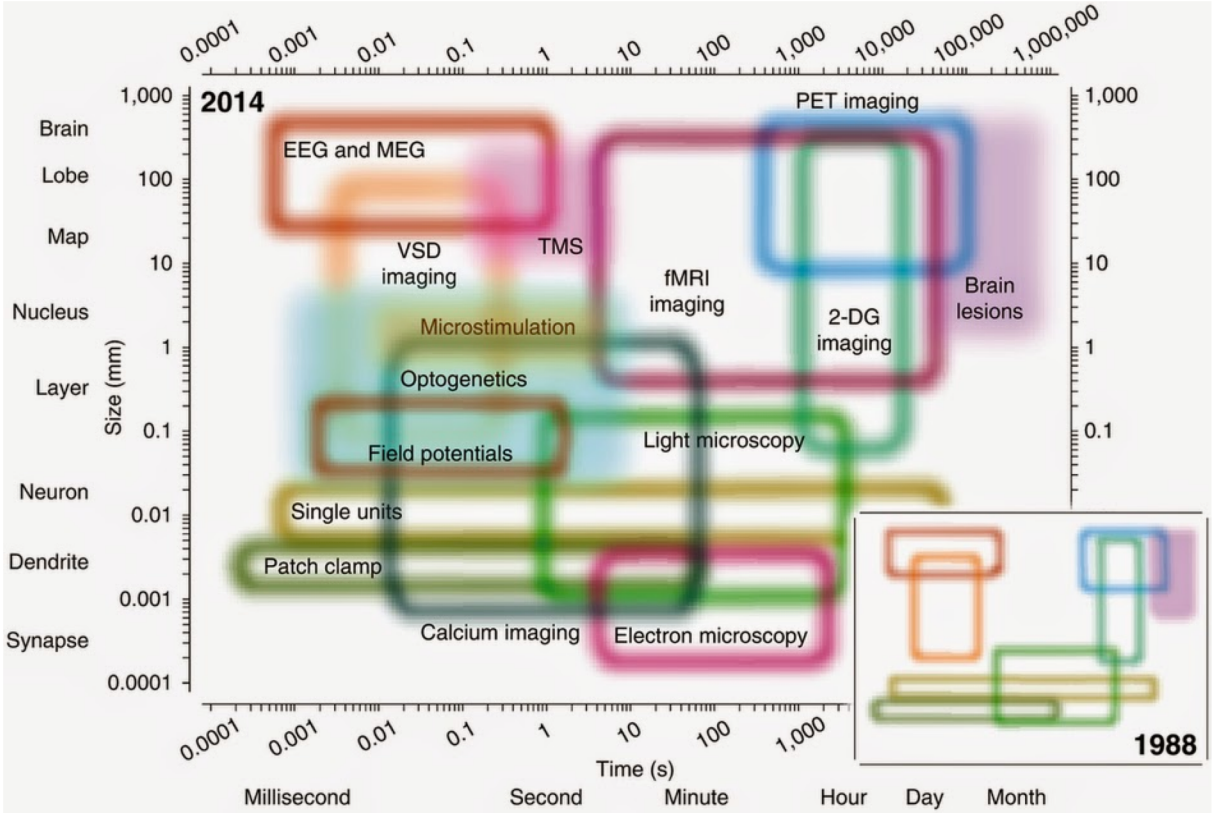
Devarajan Sridharan

Indian Institute of Science, Bangalore

sridhar@iisc.ac.in

(NeurIPS 2019 - Poster **#191**)

Brain activity: Many scales



Sejnowski, Churchland and Movshson, 2014, Nature Neuroscience

How relevant are slow (<1 Hz) and infra-slow (<0.1 Hz) fMRI brain dynamics for human cognition and behavior?

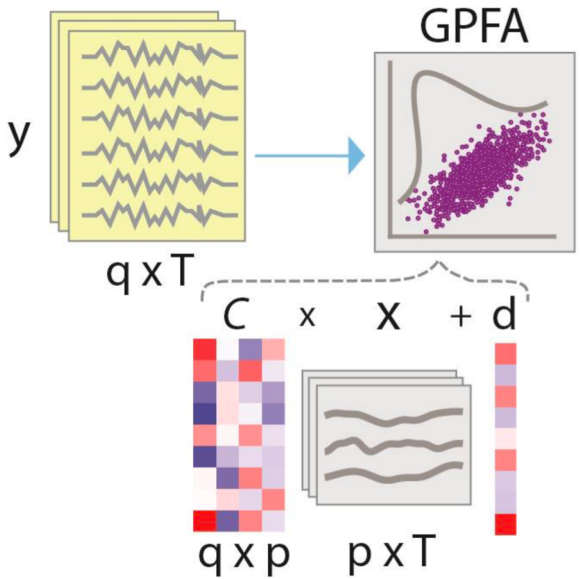
Gaussian Process Factor Analysis (GPFA)

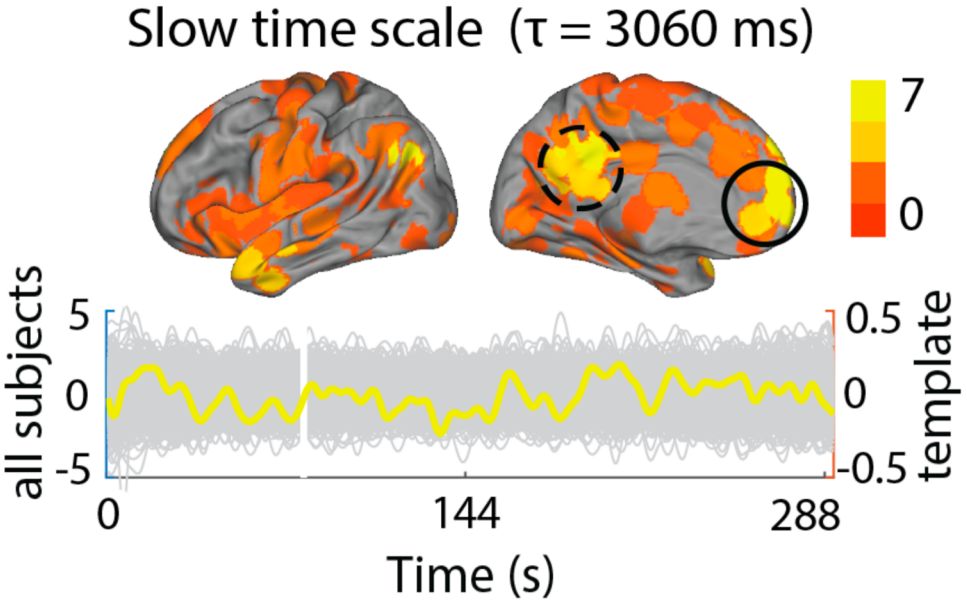
Technique for simultaneously denoising and extracting smooth, low-dimensional dynamics at characteristic timescales

*Yu et al, **NeurIPS**, 2009*

$\boldsymbol{y}_{:,t} \in \mathbb{R}^{qx1}$	high-dimensional fMRI data
$\boldsymbol{x}_{:,t} \in \mathbb{R}^{px1}$	low-dimensional GPFA latent components $(p < q)$
$\boldsymbol{y}_{:,t} \mid \boldsymbol{x}_{:,t} \sim \mathcal{N}(\boldsymbol{C}\boldsymbol{x}_{:,t} + \boldsymbol{d}, \boldsymbol{R})$	linear-Gaussian relationship
where $\boldsymbol{C}$	weight matrix
$\boldsymbol{d} \in \mathbb{R}^{qx1}$,	mean of each fMRI series
and $\boldsymbol{R} \in \mathbb{R}^{qxq}$	independent variances
$\boldsymbol{x}_{i,:} \sim \mathcal{N}(0, \boldsymbol{K}_i)$	GPFA latent dimensions, with
$\boldsymbol{K}_i \in \mathbb{R}^{TxT}$	temporal covariance being
$\boldsymbol{K}_i(t_1, t_2) \propto \exp(-\frac{(t_1-t_2)^2}{2\tau_i^2})$	a squared exponential function
$\theta = \{\boldsymbol{C}, \boldsymbol{d}, \boldsymbol{R}, \tau_1, \ldots, \tau_p\}$	GPFA parameters learnt via Expectation Maximization [4]

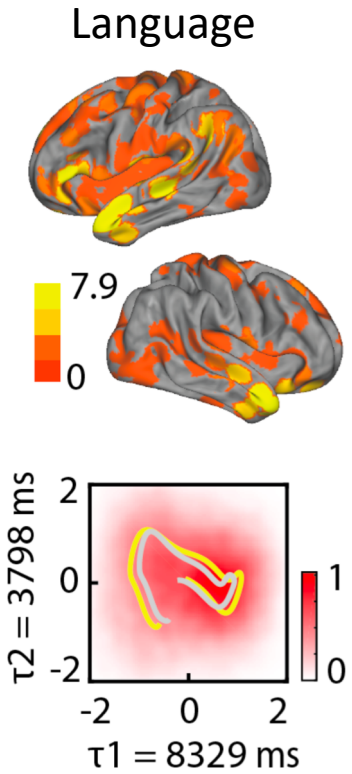
GPFA Latents: Slow dynamics and Spatial modes

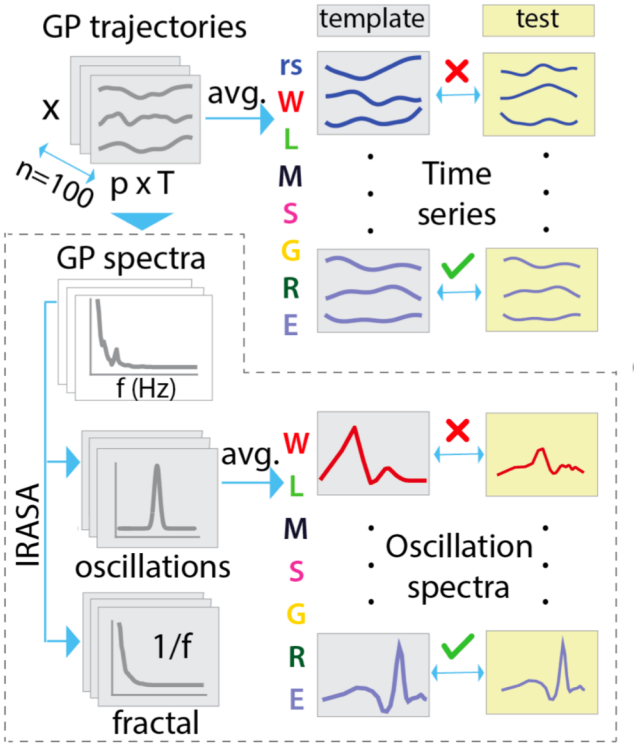


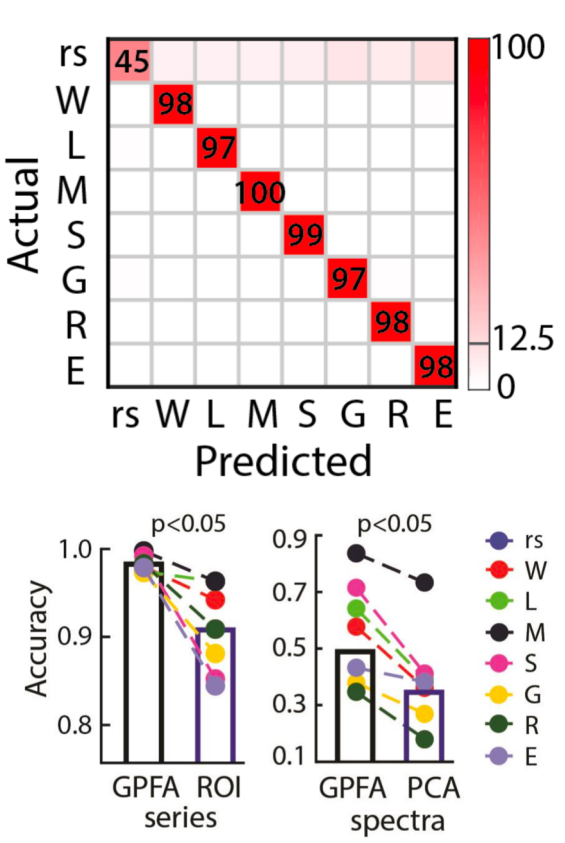


N=8000 fMRI scans from HCP database

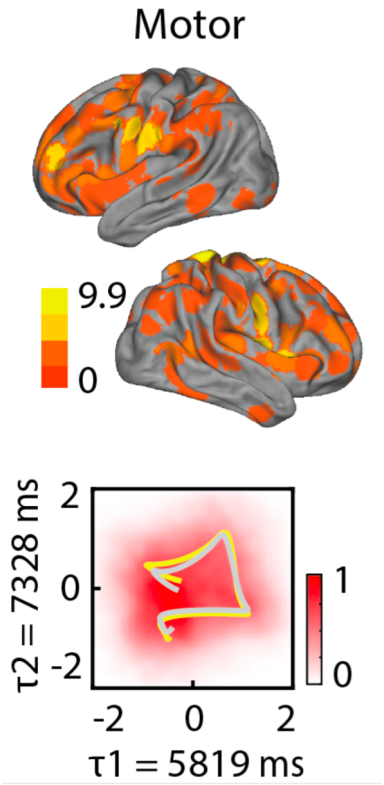
Slow trajectories characterize cognitive states

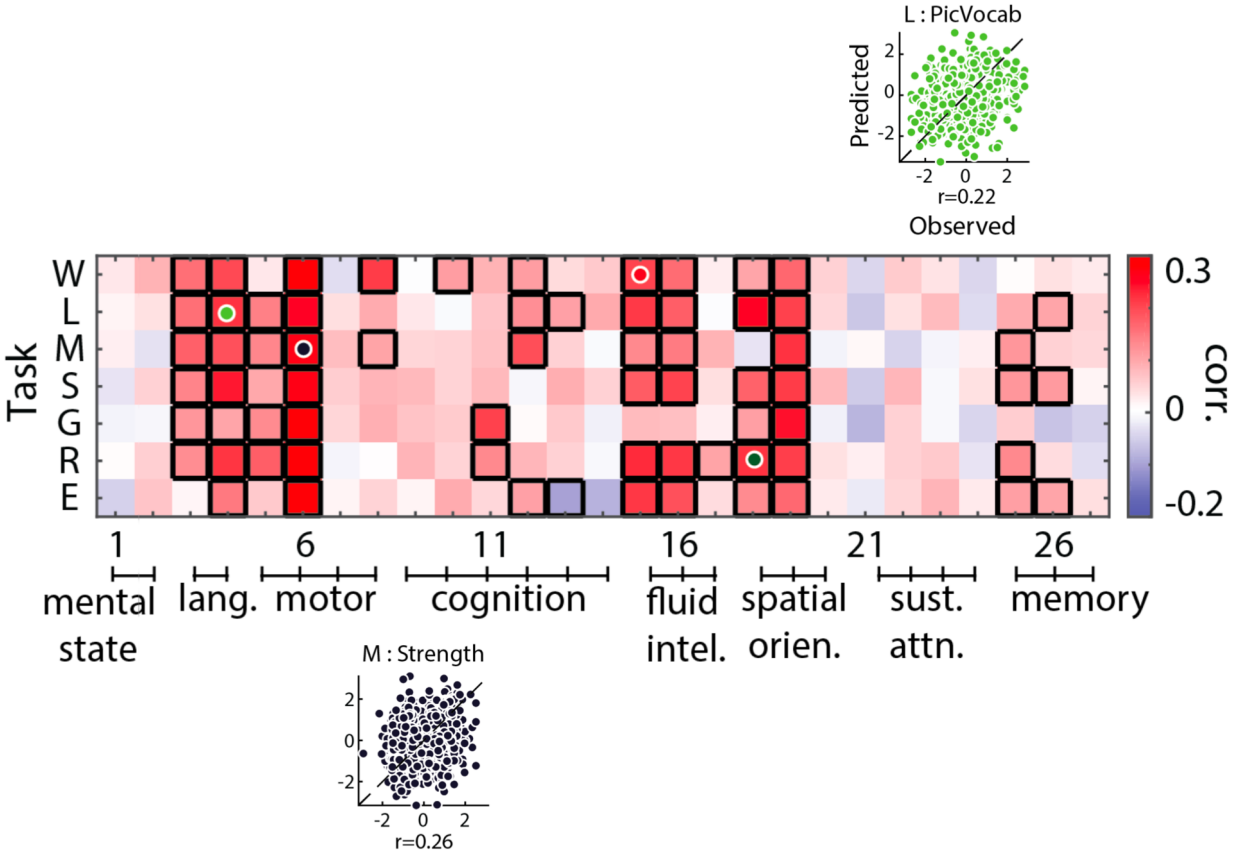




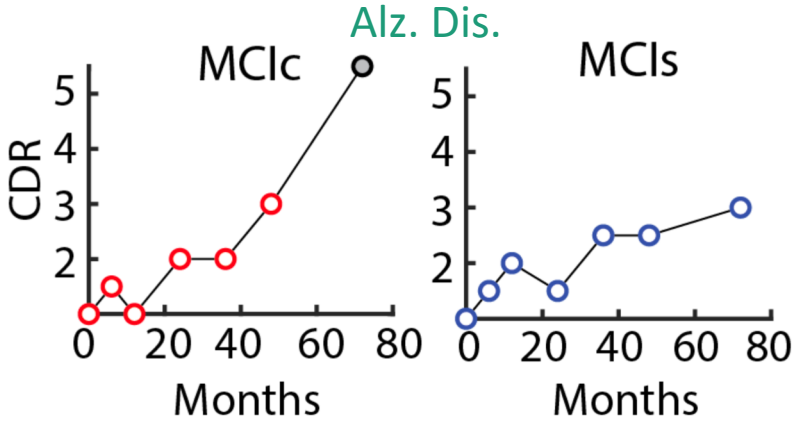


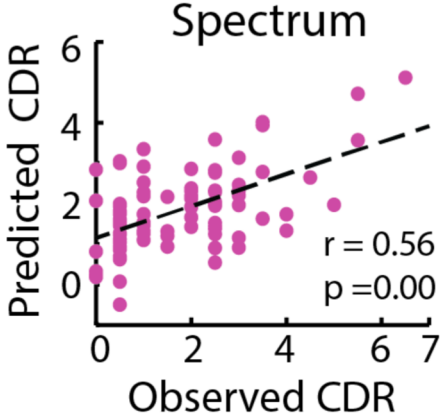
Slow latents predict cognitive score variations

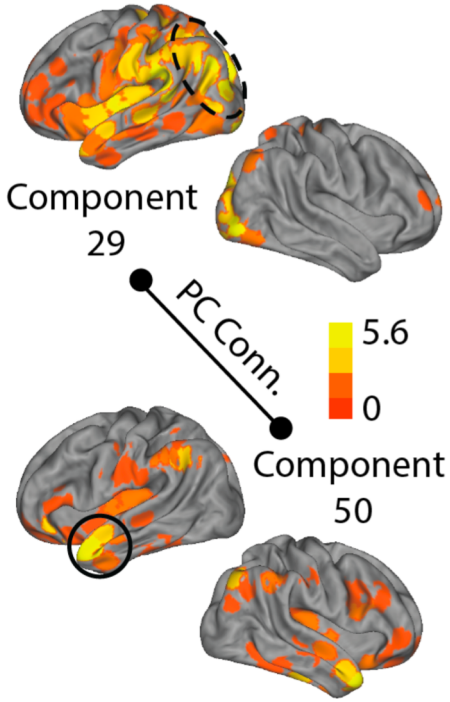


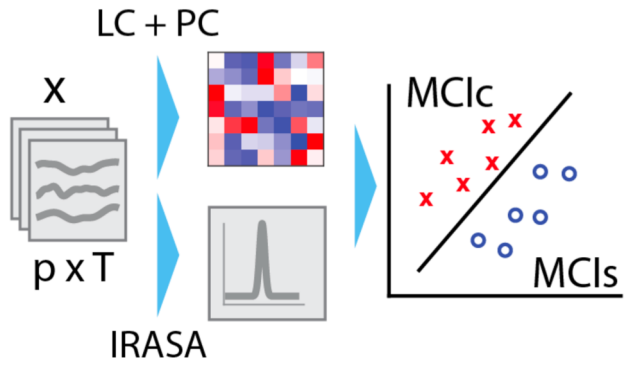


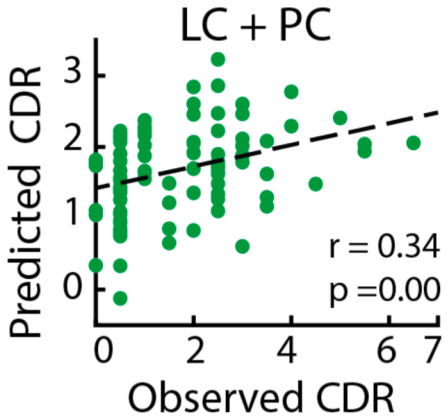
Slow latents mark cognitive decline











Data source: ADNI

Acknowledgments

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