

# What's Next for fMRI?

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&

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Lecture Number	Day	Date	Time	Location	Topic Please Click on link to view Video	Lecturer
1	Friday	6/2/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Introduction to Course &amp; A history of fMRI and Neuroimaging</a>	Peter Bandettini
2	Monday	6/5/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">fMRI Limits, Paradigms, and Processing</a>	Peter Bandettini
3	Wednesday	6/7/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">fMRI methods and applications at high field and high resolution</a>	Renzo Huber
4	Friday	6/9/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">fMRI and MRI at the NIH</a>	Sean Marrett
5	Monday	6/12/17	12:00 PM	Bldg 35, Rm 610	<a href="#">Basics of MRI</a>	Vinai Roopchansingh
6	Wednesday	6/14/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Advanced MRI and fMRI Acquisition Methods</a>	Andy Debyshire
7	Monday	6/19/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Minimizing noise during fMRI acquisition</a>	Dan Handwerker
8	Monday	6/19/17	4:00 PM	Bldg 49, Rm 1A51/9	<a href="#">What's neuronal and what's not in fMRI</a>	Dan Handwerker
9	Wednesday	6/21/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Magnetoencephalography (MEG)</a>	Richard Coppola
10	Friday	6/23/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Approaches to functional activity mapping during natural viewing</a>	Brian Russ
11	Wednesday	6/28/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Studying CNS diseases with advanced MRI</a>	Pascal Sati
12	Friday	6/30/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Human Spectroscopy Introduction and Glutamate Spectroscopy at 7T</a>	Li An
13	Monday	7/5/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">AFNI plus SUMA: analyzing your data</a>	Bob Cox
14	Wednesday	7/5/17	3:00 PM	Bldg 49, Rm 1A51/9	<a href="#">The AFNI - based Functional and Anatomical Connectivity Platform</a>	Paul Taylor
15	Friday	7/7/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">fMRI Data Sharing</a>	Adam Thomas
16	Monday	7/10/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">T1 Contrast, MPRAGE and MT</a>	Peter van Gelderen
17	Wednesday	7/12/17	10:00 AM	Bldg 40, Rm 1201/3	<a href="#">Resting State fMRI</a>	Catie Chang
18	Friday	7/14/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Reliability vs Validity in Resting State fMRI</a>	Steve Gotts
19	Monday	7/17/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">MRI Brain Segmentation Algorithms</a>	Dzung Pham
20	Wednesday	7/19/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Positron Emission Tomography (PET)</a>	Bob Innis
21	Friday	7/21/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Perfusion Imaging</a>	Lalith Talagala
22	Monday	7/24/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Neuromodulation methods</a>	Bruce Luber
23	Wednesday	7/26/17	10:00 AM	Bldg 40, Rm 1201/3	<a href="#">EEG/fMRI and Pharmacologic fMRI</a>	Jen Evans
24	Friday	7/28/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">EEG/fMRI and the study of Language</a>	Peter Molfese
25	Monday	7/31/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">EEG/fMRI and Neurofeedback</a>	Silvina Horovitz
26	Wednesday	8/2/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Quantitative MRI</a>	Govind Bhagavatheeshwaran
27	Friday	8/4/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">The physics of neuromodulation</a>	Zhi Deng and Tom Radman
28	Monday	8/7/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Multi-echo EPI for task-based and resting-state fMRI</a>	Javier Gonzalez-Castillo
29	Wednesday	8/9/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Dynamic Resting State fMRI</a>	Javier Gonzalez-Castillo
30	Friday	8/11/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Machine Learning and fMRI</a>	Javier Gonzalez-Castillo
31	Monday	8/14/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Depression and Multimodal Neuroimaging</a>	Allison Nugent
32	Tuesday	8/15/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Statistics of fMRI</a>	Gang Chen
33	Wednesday	8/16/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Multivariate pattern analysis and brain decoding</a>	Martin Hebart
34	Friday	8/18/17	2:00 PM	Bldg 49, Rm 1A51/9	<a href="#">Imaging Changes in Brain Anatomy</a>	Cibu Thomas
35	Monday	8/21/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Anatomical and Functional Neuroimaging in Animal Models</a>	Cecil Yen
36	Wednesday	8/23/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Genetics and Neuroimaging: How to analyze imaging data and SNPs</a>	Yin Yao
37	Friday	8/25/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Imaging Stroke and Traumatic Brain Injury</a>	Lawrence Latour
38	Monday	8/28/17	2:00 PM	WebX	<a href="#">Neuromodulation applications</a>	Sarah Hollingsworth Lisanby
39	Wednesday	8/30/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">Diffusion MRI</a>	Joelle Sarlls
40	Wednesday	8/30/17	3:00 PM	Bldg 40, Rm 1201/3	<a href="#">What you can and cannot do with diffusion MRI</a>	Carlo Pierpaoli
41	Friday	9/1/17	2:00 PM	Bldg 40, Rm 1201/3	<a href="#">The future of fMRI &amp; Course Conclusion</a>	Peter Bandettini

# Where are we now after 26 years?

## *What has improved...*

- **Technology is more sophisticated, powerful, and stable**
- **Image quality and temporal stability have improved**
- **fMRI is generally easier to implement**
- **More standardization in acquisition, processing, and display**
- **Multivariate decoding, encoding, pattern effect mapping, machine learning, cross subject correlation, and dynamic resting state connectivity analyses have opened up new insights and directions.**
- **Artifacts are more easily identified and removed**
- **Underlying neuronal correlates of fMRI are better established**
- **Number of groups working with fMRI have increased**
- **Research applications have increased**
- **Resting state fMRI has exploded**
- **Large pooled datasets have catalyzed meta-analysis, transparency, new methods, and biomarker discovery**
- **Individual assessment in fMRI is growing**
- **Highest resolution and fastest speed (per volume) have increased**
- **Standard resolution used has increased**
- **More high field scanners**
- **More multimodal integration**

# Where are we now after 26 years?

## *What has not improved...*

- **Still struggling with subject motion and breathing**
- **Temporal SNR still limited by physiologic fluctuations**
- **Still struggling with HRF: spatially variable BOLD latency & magnitude**
- **Spatial resolution of fMRI has reached a theoretical limit due to hemodynamics.**
- **fMRI is still not used clinically**
- **Vendors still have not put many resources into fMRI**
- **Scanners are still loud and confining**
- **MRI is still extremely expensive**
- **Still using 2.5 mm<sup>3</sup> voxels for most studies**
- **We don't understand "connectivity" as inferred by correlation**
- **We don't understand source of resting state or biologic purpose that resting state serves**
- **Shimming is still an issue**
- **Db/dt limit is still an issue**

# Where are we going?

- **Increased clinical impact as we equate fMRI measures with individual behavior and physiology**
- **Increased vendor attention and cutting edge products.**
- **More detail and potentially a qualitative jump as column, layer, and pattern effect mapping grow: connectivity and activation mapping**
- **Improved noise characterization and removal**
- **Computational models will have an increased role**
- **Insights into fMRI mechanisms through animal models and multimodal assessment**
- **Standardized Parcellation for single subject comparisons**
- **Increase in well curated naturalistic task data. Naturalistic task database?**
- **Growth in real time fMRI and neurofeedback**
- **Reintroduction in local gradient coils.**
- **Increased embedded contrast (fingerprinting) sequences**
- **Explosion of deep learning on all things MRI and fMRI**
- **Growth in neuromodulation studies**
- **Increased longitudinal databases for predictive biomarkers discovery**
- **RF coils: more elements, smaller, embedded?**
- **Re-analysis of old data**
- **New MRI technology will permeate fMRI: compressed sensing, fingerprinting, etc..**

# Ultimate fMRI limits?

- **Sub – mm functional resolution for whole brain**
- **Simultaneous flow, BOLD, volume with multi-echo - will be standard**
- **Hemodynamic latency spread issue will have effective calibration**
- **Motion and breathing is solvable**
- **Cross vendor, scanner, upgrade calibration is solvable**
- **Layer specific cross subject registration – better layer analysis pipeline**
- **Detailed cross subject functional registration will be more common**
- **Shimming is solvable**
- **Quantitative baseline fMRI- based metabolic rate mapping**
- **Individual subject fMRI-based “stress-test” will be standard in clinic**
- **Standardized processing pipelines for clinical use and for large databases**
- **Real time fMRI for therapy**
- **Silent fMRI sequences – or better noise cancellation**
- **Cryogen-free scanners up to 7T**
- **Massive cross disease, cross modality databases**
- **Longitudinal databases**
- **Studies using naturalistic paradigms will rapidly grow**
- **There will grow a tension between deep learning approaches and standard processing.**
- **Other contrasts? Neuronal current, CMRO<sub>2</sub>, elastography, pH, diffusion**
- **Basis and purpose of resting state signal will be solved.**
- **Time series will contain only fMRI signal and thermal noise – physiologic fluctuations will be solved.**
- **Correlation as it relates to connectivity will be determined to be a bigger issue than currently thought**

# What could change everything?

- **Room temperature superconductors**
- **New robust direct neuronal contrast mechanism is discovered**
- **One powerful and unique clinical application of fMRI**
- **Any proof that MRI is either therapeutic or dangerous**
- **Proof that layer dependent fMRI can discern causality**
- **Breakthrough in function-specific contrast agents (labelled agents or nano-particles)**

# Technology

**Magnet**  
**RF Coils**  
**Gradients**  
**Pulse Sequences**

# Methodology

**Paradigm Design**  
**Pre and Post Processing**  
**Subject Interface**  
**Data Display and Comparison**

**Increases**  
**Decreases**  
**Dynamics**  
**Locations**  
**Fluctuations**

**Neuroscience**  
**Physiology**  
**Genetics**  
**Clinical (diagnosis, prediction, therapy)**  
**Lie Detection**  
**Military**  
**Marketing**  
**Entertainment**

# Interpretation

# Applications



# Thank you!

- **Attendees**
- **Speakers**
- **Roark Maccado & Dorian Van Tassell**

**We welcome any suggestions for next year....**

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*The End*

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