Bridging BOLD & electrophysiological signals

Gamma oscillations → major role in visual
But we don't see them in motor or other areas

BOLD correlates well with ECoG broadband
but doesn't with ECoG Gamma

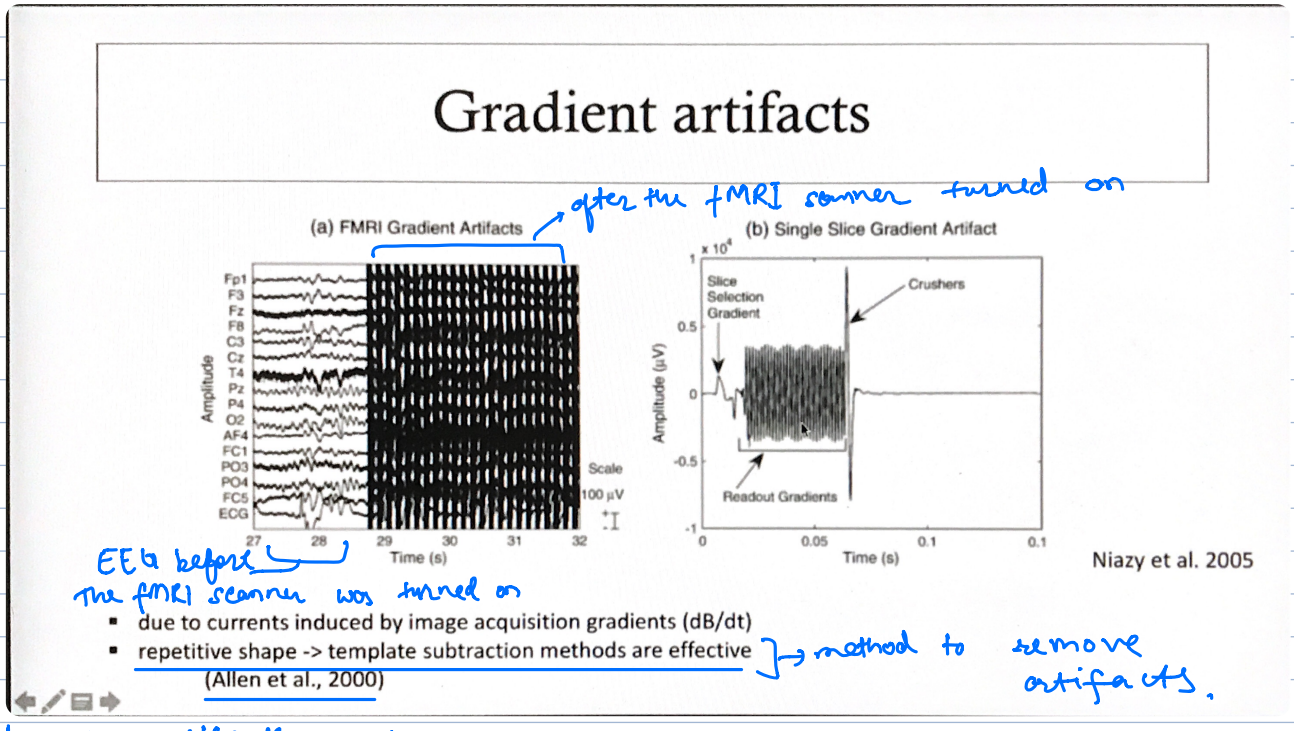
ECoG is sensitive to synchrony, fMRI isn't → obviously

(Lecture too much specific in research. Didn't watch everything.)

Simultaneous EEG-fMRI to study brain function

	EEG	fMRI
spatial resolution	low	High
temporal resolution	High	low

→ Drawbacks: data quality ↓, setup time ↑, need for MRI compat. equipment
post processing ↑



To decrease artifacts we:
- BCG Ref. layer
- carbon wire loops

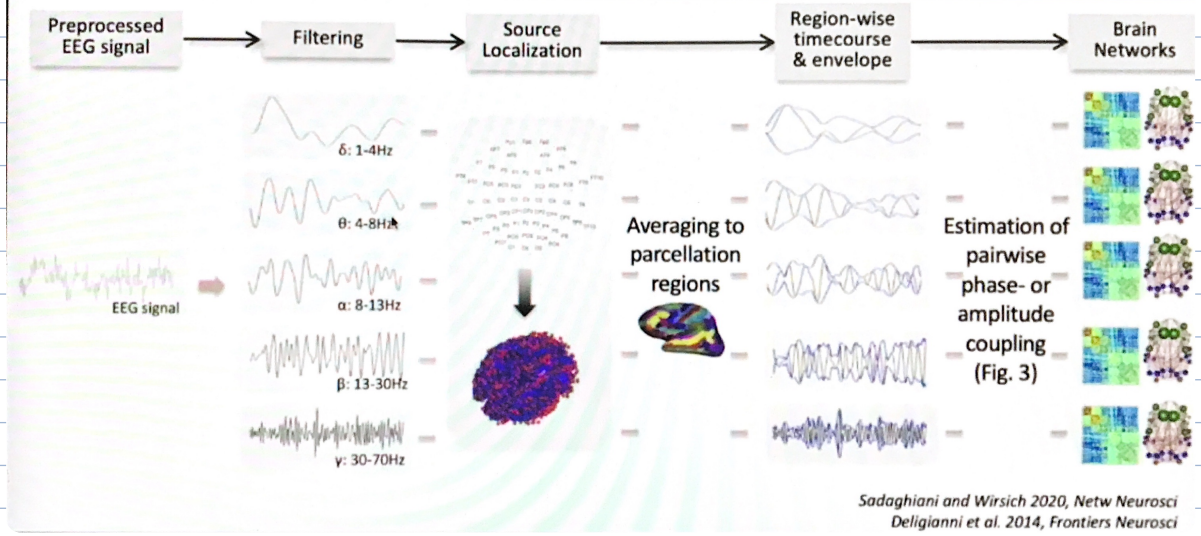
Artifacts in fMRI from EEG

- Signal dropout due to EEG cables (copper wire → RF shielding)
- Susceptibility dropout from electrodes

Intrinsic connectivity across modalities: integrating information from EEG-fMRI & ECOG

→ going from EEG to functional connectivity

Whole-brain connectomes in EEG/MEG



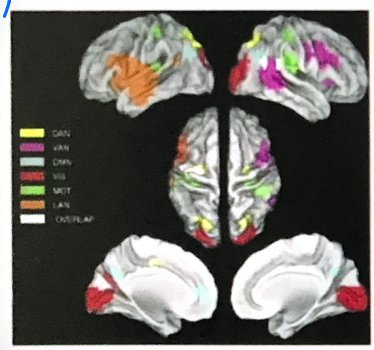
Sadaghiani and Wirsich 2020, Netw Neurosci
Deligianni et al. 2014, Frontiers Neurosci

Space

(Static connectivity)

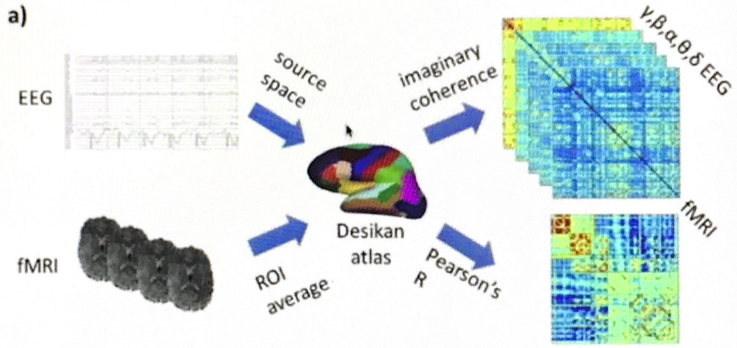
Stability of intrinsic connectivity across timescales

Intrinsic connectivity networks exist in MEG



de Pasquale et al. 2012
Amplitude coupling (broad-band)

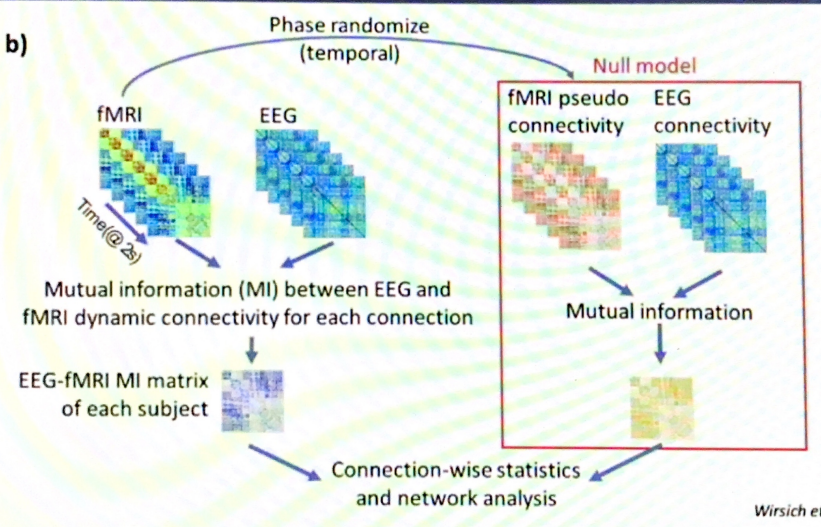
NICE



Time

(time-varying connectivity)

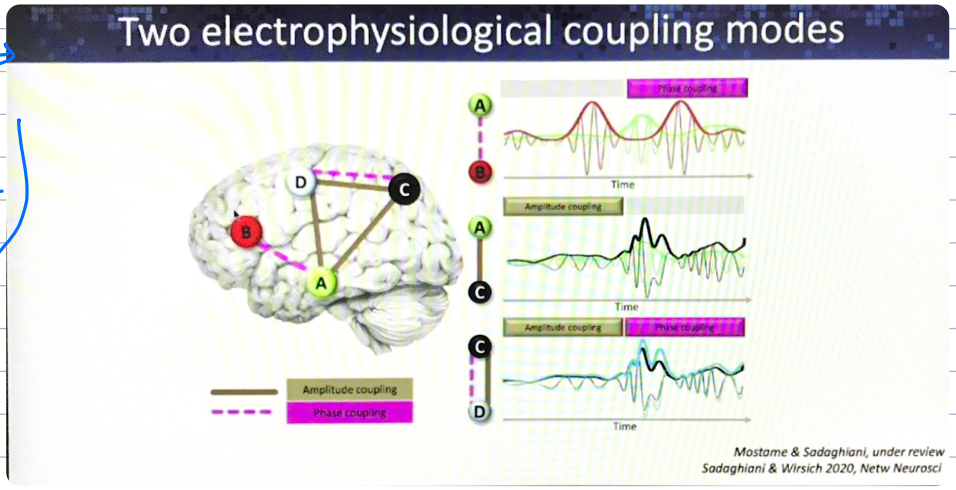
Intrinsic connectivity across timescales: dynamics



Wirsich et al., NeuroImage 2020

phase vs amplitude coupling →

(look Miller, 2019, nature human behaviour for the data link)



Nice review paper → Intrinsic connectome organization across temporal scales: new insights from cross modal approaches (MIT press journal)

Bridging electrophysiology and neuroimaging to understand brain dynamics

Catie Chang, Ph.D. Co Organizer
Vanderbilt University
Nashville, TN
United States

Laura Lewis Organizer
Boston University
Boston, MA
United States

Functional MRI and electrophysiological (EEG, ECoG) signals provide complementary information about brain dynamics, and a rapidly growing research area seeks to integrate these modalities to advance our understanding of human brain function. Nonetheless, there are a number of challenges involved in gathering high quality multimodal data, and in fusing these different types of signals to maximize their joint information.
This workshop will introduce fundamental concepts and techniques in bridging fMRI and electrophysiological signals (focusing on simultaneous EEG-fMRI, as well as ECoG, MEG, and fMRI data acquired separately), and highlight recent technical developments, applications, and future directions.
Attendees will learn about the biological basis of fMRI and electrophysiological signals, practical aspects of acquiring and analyzing these signals, and the benefits and tradeoffs of different multimodal techniques. They will also learn advanced analysis techniques and how to select the imaging modality or technique appropriate to specific questions, including discussion of applications in resting state connectivity, neural decoding, and cognition and perception.
By covering neurobiology and introductory and advanced approaches for bridging imaging and electrophysiology, and their applications in cognitive neuroscience, this session will be an ideal fit for a broad range of neuroimagers. Scientists who use a single modality will learn how to integrate or interpret other modalities into their research, while scientists performing multimodal studies already will learn advanced techniques for designing, analyzing, and interpreting these studies.
We have assembled a list of expert speakers across multiple career stages and nationalities, who can provide discussion of both introductory and cutting-edge topics in multimodal imaging.

Objective

- Understand the biological origins and complementary information provided by electrophysiological and neural signals.
- Learn the potential challenges and limitations in acquiring and analyzing imaging and electrophysiology data, and

how to interpret studies in this field.
- Learn analysis techniques that can be used to provide new kinds of information about neural dynamics when integrating multiple types of multimodal data (whether simultaneously acquired or not), such as fMRI, MEG, EEG, or ECoG.

Target Audience

Our primary target audience will be scientists currently engaged in at least one modality (either EEG, MEG, ECoG, or fMRI) who would like to learn about how these signals can be interpreted in the context of other measures of neural activity, to better understand brain dynamics. Our target audience will also include people who are planning to begin or are already engaged in multimodal imaging studies, as our session will address both introductory and advanced concepts underlying multimodal imaging.

Presentations

The bridge between BOLD and electrophysiological signals.

The session will open with a talk discussing the biological links between electrophysiological and neuroimaging signals. These signals have complex origins, and measure different aspects of neural activity. The speaker will provide an overview of the origins of these two signals; discuss the role of mean activity and synchrony in each signal type, and discuss how they are related vs. distinct. This talk will address the origins and interpretation of these disparate signals, and how they can provide complementary information to neuroscientists.

Presenter

Dora Hermes, UMC Utrecht and Mayo Clinic Utrecht, n/a
Netherlands

Using simultaneous EEG-fMRI to study brain function and physiology.

Simultaneous EEG-fMRI is a growing technique that can provide rich information about multiple aspects of brain dynamics. This presentation will provide an overview of simultaneous EEG-fMRI, presenting a tutorial on experimental design, and acquisition. It will discuss the basics of analyzing EEG-fMRI data, and how these studies can be used in neuroscience applications of EEG-fMRI to advance understanding of brain function and physiology.

Presenter

Catie Chang, Ph.D., Vanderbilt University Nashville, TN
United States

Detecting new aspects of neural dynamics through multimodal brain imaging at high spatiotemporal resolution.

Recent increases in the spatiotemporal resolution of fMRI offer new opportunities for imaging brain dynamics at fast timescales and at mesoscale. This talk will cover how advanced fMRI techniques, such as accelerated (TR<400 ms) or ultra-high field (7 Tesla) imaging, can be integrated with simultaneous EEG. It will discuss how studies integrating EEG with fast fMRI or high spatial resolution fMRI can yield new types of information about neural dynamics, will discuss recent state-of-the-art and future prospects for how EEG can be integrated with other advanced imaging modalities, and will discuss advanced analytical methods for joint inference across these diverse data types.

Presenter

Laura Lewis, Boston University Boston, MA
United States

New technologies for advancing applications of multimodal imaging.

Engineering advances are changing the landscape of what technologies are available for measuring electrophysiology and imaging signals. This lecture will discuss recent advances and future prospects for novel technologies for multimodal imaging. The lecture will present an overview of new hardware for EEG-fMRI with improved image and signal quality; new intracranial electrode designs that allow for concurrent MRI; discuss safety considerations for novel multimodal imaging hardware; and outline future possibilities for what is ahead for these techniques. This talk will also discuss the contraints involved in integrating technologies with fMRI scanning, to take into account when designing new studies using multimodal imaging techniques.

Presenter

Giorgio Bonmassar, Ph.D., Massachusetts General Hospital, Harvard Medical School Boston, MA
United States

Intrinsic connectivity across modalities: Integrating information from EEG-fMRI and ECoG to understand intrinsic connectivity.

The study and interpretation of network connectivity is an exciting application area for multimodal imaging, which can reveal new properties of brain connectivity. The origins of connectivity signals are complex, but these patterns can be detected with some homology across modalities such as fMRI and ECoG data. However, the analyses leading to connectivity metrics in each modality are often quite different. Integrating information from multiple data types can provide new insight into the functional origins and cognitive implications of resting state connectivity. This lecture will discuss the nature of intrinsic networks and connectivity metrics across modalities, and how multimodal data (such as EEG-fMRI and ECoG-fMRI) can yield new insights into these networks.

Presenter

Sepideh Sadaghiani, University of Illinois at Urbana-Champaign Urbana, IL
United States

Fusing non-simultaneous multimodal data to understand neural dynamics across timescales.

This lecture will discuss approaches to uniting MEG and fMRI signals acquired in separate (non-simultaneous) studies, to understand the dynamics of cognitive and perceptual processes across multiple timescales. Topics will include classification and representational similarity approaches for linking neural computations across modalities, fusion of non-simultaneously acquired MEG and fMRI data, and showcasing applications in cognitive neuroscience.

Presenter

Santani Teng, Massachusetts Institute of Technology Cambridge, MA
United States