Physiologic fMRI signals: friend or foe? How and why to measure, model, and account for physiology.

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Educational Course - Half Day (4 hours)
SEC Armadillo
Room: Forth

The brain does not exist in isolation, and the field of neuroscience is increasingly interested in the intricate relationships between brain function and diverse concurrent physiological processes throughout the body. For fMRI researchers, this is not a new concern - strategies for removing cardiac and respiratory artifacts from fMRI data have been explored for decades. However, there is now a resurgence of interest in such physiological signals, as improved fMRI sensitivity and specificity enable new means of “denoising” our BOLD-weighted timeseries. Improvements in data quality also facilitate the isolation and quantification of these physiological signals, resulting in promising new biomarkers for brain health that can complement and inform our understanding of neural activity patterns. This course introduces the types of physiological signals that influence typical fMRI datasets, and presents methods for recording the most common physiological processes during scanning and modeling the associated signal variance, to either study or remove these effects. Alternative, data-driven methods for achieving similar outcomes will also be presented, which can bring new insight into existing data resources that do not include physiological recordings, and guide more individualized exploration of physiological effects in fMRI. Finally, in addition to the primary didactic course content, we will provide practical guidance for how to get started with making physiological recordings during imaging experiments, incorporating these data into fMRI analyses, and what existing data and software resources are available to support researchers interested in this important and growing area of neuroscience.

Objective

- Learn how to set up physiological data collection in an MRI setting.
- Learn how to study brain physiology using functional MRIneuroimaging data.
- Learn how to remove and model physiological fluctuations from BOLD fMRI timeseries, with or without

physiological recordings.

Target Audience

Researchers working with BOLD fMRI, from cognitive to clinical research, interested in knowing how to improve data denoising, to add physiological-related data and exploration to their research, and to explore the use of BOLD fMRI to investigate cerebrovascular health.

Presentations

That brain you are scanning is inside a living, breathing human, and it shows

Although fMRI is a powerful tool for studying neural activity, the signals we measure reflect a diverse range of physiologic processes that intrinsically couple the brain to the body. We do not scan a brain in isolation from the human being that hosts it, and it is nearly impossible to “turn off” a beating heart or breathing lungs when we probe brain function. In this educational session, I will discuss the physics and physiology of how cardiac and respiratory factors influence the fMRI timeseries, and demonstrate best practices for recording and interpreting physiologic signals during an fMRI scan. I will also introduce less well-established physiologic signals that can also be explored in fMRI, to better understand arousal, blood pressure, gut-brain interactions, hormonal fluctuations, and how all these aspects of human physiology may interact with our understanding of brain function when using neuroimaging.

Presenter

Molly Bright, D.Phil., Northwestern University Chicago, IL
United States

Methods for mitigating “physiological noise” in fMRI time series

As an indirect measure of neural activity, fMRI is inevitably sensitive to blood flow and oxygenation changes regulated by the autonomic nervous system, including both faster-scale oscillations time-locked to the respiratory/cardiac cycles and slower-scale variations (< 0.1 Hz) that overlap with the spectrum of intrinsic brain activity. Isolating local functional dynamics from these confounding physiological factors is key to improving the sensitivity and neuronal specificity of fMRI for broad cognitive and clinical applications. In this educational talk, I will provide an overview of existing approaches that remove various physiological artifacts from fMRI time series. I will also discuss potential challenges in de-noising fMRI data when autonomic regulation tracks global neuronal changes in specific populations and brain states.

Presenter

Jingyuan Chen, Massachusetts General Hospital Cambridge, MA
United States

Data-driven methods for modelling and removing physiologically-driven signals without complementary recordings

Accounting for physiological fluctuations in functional MRI experiments is often thought to require concurrent recording of physiological signals. However, physiological signals are not routinely acquired in the majority of fMRI studies due to the lack of equipment, extra effort during acquisition and analysis. Even if they are collected, their quality could be corrupted by artefacts, signal losses, etc, making them unusable. In this educational talk, I will describe how to model and estimate physiological signals in the absence of recordings, from established data-driven approaches to cutting-edge machine and deep learning approaches, that operate directly on the fMRI signal to extract such information. I will also discuss potential challenges in the use and adoption of these algorithms in order to convey that accounting for physiological factors in fMRI studies does not necessarily require simultaneous recordings.

Presenter

César Caballero-Gaudes, Basque Center on Cognition, Brain and Language Donostia - San Sebastián, Gipuzkoa Spain

Cerebrovascular health measures – combining fMRI and physiological signals to investigate cerebrovascular processes

In this educational talk, I will discuss the use of fMRI and simultaneously acquired physiological signals (related to cardiac and respiratory processes) to probe cerebrovascular health. I will outline the physiological basis of fMRI signals and their relationship to systemic physiology, explaining how they can be used to measure cerebrovascular function. Practicalities of measuring physiological signals in the MR environment and common difficulties will be discussed. I will summarise the advantages of measuring cerebrovascular function to complement other functional imaging measures.

Presenter

Kevin Murphy, Cardiff University Brain Research Imaging Centre Cardiff, Wales
United Kingdom

Can we get something for nothing? -- Physiological information encapsulated in resting-state fMRI

Resting-state fMRI (rs-fMRI) is widely applied in various study designs and populations, generating a vast amount of data. However, with the increasing awareness of the physiological contributors, comes mounting concerns over the neuronal interpretation. What if we turned the question around, and used rs-fMRI for physiological mapping? And what if we do not have comprehensive physiological recordings? This talk focuses on recent developments relevant to these questions. Guiding questions include:

1. How to gather information related to pulsatile flow in the cerebrospinal fluid using rs-fMRI?
2. How to relate rs-fMRI fluctuations to dynamic blood pressure?
3. How to estimate end-tidal CO2 contributions to rs-fMRI without end-tidal CO2 recordings?

4. How to extract metrics related to cerebrovascular reactivity from rs-fMRI?

Presenter

Jean Chen, Rotman Research Institute, Baycrest Health Centre Toronto, ON Canada

Let’s get the physiological party started: software and communities to start your journey in physiological data analysis

Having explored the reasons to collect physiological signals, as well as the different reasons they can be useful, it is the moment to think about how to do so. In this talk, I will introduce the communities of researchers that can help with collecting and analysing data, and through which it is possible to keep up with the latest advances in physiological imaging and denoising. Moreover, this talk will feature short presentations of various software tools that can be adopted to prepare physiological data for data storage, data sharing, denoising, and physiological imaging, in order for all participants to become familiar with different aspects of working with physiological data. Finally, we will also initiate a Q&A on social media with various software developers, to be held asynchronously throughout the conference period, in order to engage researchers in an open and inclusive discussion.

Presenter

Stefano Moia, Basque Center on Cognition, Brain and Language Donostia - San Sebastián, Gipuzkoa Spain