Neuroscience Statistics Research Laboratory

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Course Presentation: Neuroscience of Learning, Memory, Cognition
Sharif University of Technology

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Overview

Introduction

Neuroscience Statistics Research Laboratory

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Emery N. Brown

- Computational neuroscientist and anesthesiologist
- Professor of Anesthesia at Harvard Medical School
- Professor of Medical Engineering and Computational Neuroscience at MIT
- Practices anesthesiology at Massachusetts General Hospital

Emery N. Brown

Research Areas of NeuroStat Lab

1. Neural Signal Processing Algorithms
   - how hippocampal neurons represent spatial information in their ensemble firing patterns
   - analyze formation of spatial receptive fields in the hippocampus during learning of novel environments
   - relate changes in hippocampal neural activity to changes in performance during procedural learning
   - improve signal extraction from fMR imaging time-series
   - construct algorithms for neural prosthetic control the spiking properties of neurons in primary motor cortex
   - localize dynamically sources of neural activity in the brain from EEG and MEG recordings
   - measure the period of the circadian pacemaker (human biological clock) and its sensitivity to light
   - characterize the dynamics of human heart beats in physiological and pathological states

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Research Areas of NeuroStat Lab

2. Understanding General Anesthesia
   - track brain states under general anesthesia

> *...still, the mechanism by which an anesthetic drug induces general anesthesia remains a medical mystery...*

a systems neuroscience approach to study how the state of general anesthesia is induced and maintained

- EEG
- fMRI
- neurophysiological recordings
- mathematical modeling

Anesthesia

Anesthesia and the dynamics of the unconscious mind

Emery Brown

TEDMED2014

Emery Brown, anesthesiologist, Professor of Computational Neuroscience at MIT, and Co-Director of the Harvard-MIT Division of Health Sciences and Technology, unveils the surprising truth about exactly what happens to your brain under anesthesia and what it suggests for understanding the brain and improving treatment.

> "[With respect to anesthesia] sleep is not the state you're going in, nor would it be the state in which someone could perform an operation on you."
> — Emery Brown

https://www.tedmed.com/talks/show?id=293009

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"...it was kind of like Moneyball. If you think about what happend in Moneyball, Billy Beane is the manager of the Oakland A's. Baseball had been around for years, statistics had been around for years, and he decided to use statistics to get to actually build a good baseball team. ***Anesthesia has been around for years, neuroscience has been around for years, but the two really hadn't been put togethe, and that to me, seemed like the answer****..."*
- Emery Brown

`https://www.tedmed.com/talks/show?id=293009`

A Note on Baseball Statistics

Baseball statistics (Sabermetrics) main purposes:

1. To compare key performances among certain specific players under realistic data conditions
2. To provide prediction of future performance of a given player or a team
3. To provide a useful function of the player's contributions to his team

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Anesthesia - NSRL findings

Anesthesia and the dynamics of the unconscious mind

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TEDMED2014

- hyper-synchronous oscillations
- waves running back and forth between the thalamus and the cortex
- cortex: thinking and reasoning
- thalamus: the major way station through which information travels

...if these two areas are tied up, it's going to be very very difficult to be conscious...

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Publications

1. **A transient cortical state with sleep-like sensory responses precedes emergence from general anesthesia in humans**
   Brown EN et al. (2018), eLIFE.
   - During awake consciousness, the brain intrinsically maintains a dynamical state
   - How the brain reaches this state spontaneously is not known
   - General anesthesia; a unique opportunity to examine how the human brain recovers its functional capabilities after profound unconsciousness
   - identification of a distinct transient brain state that occurs immediately prior to recovery of behavioral responsiveness
   - A state characterized by large, spatially distributed, slow sensory-evoked potentials resembling the stage two of sleep
   - But the dynamics in this transitional state differ from sleep

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2. **Design, implementation, and evaluation of a physiological closed-loop control device for medically-induced coma**
   Brown EN et al. (2017), Conf Proc IEEE Eng Med Biol Soc.
   - Design, implementation, and evaluation of a PCLC device for delivering medically-induced coma
   - automatically adjusting the infusion rate of propofol - a general anesthetic - in response to an EEG pattern called burst suppression
   - a computational patient model which interfaces with hardware and produces realistic EEG signals in response to propofol infusion
   - Finally, testing the performance of the PCLC device in rodents

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3. **Neural oscillations demonstrate that general anesthesia and sedative states are neurophysiologically distinct from sleep**
   Akeju O, Brown EN. (2017), Current opinion in neurobiology
   - General anesthesia; a man-made neurophysiological state comprised of unconsciousness, amnesia, analgesia, and immobility along with maintenance of physiological stability
   - Anesthetic-induced neural oscillations; a primary mechanism of anesthetic action
   - Each anesthetic drug class produces distinct oscillatory dynamics that can be related to the circuit mechanisms of drug action
   - This review; a discussion on the differences between anesthesia- and sleep-induced altered states from the perspective of neural oscillations

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