Neuro-Hackathon

March 10-12

SURGE sandbox

LSC Oceanography Rm. 2660

Hands-on with EEG & brain-computer interfaces (BCI)

No previous experience necessary!

Prizes in 3 categories:
applications · machine learning · hardware

SURGE
Science Unleashed

DALHOUSIE UNIVERSITY

surgeinnovation.ca
/events

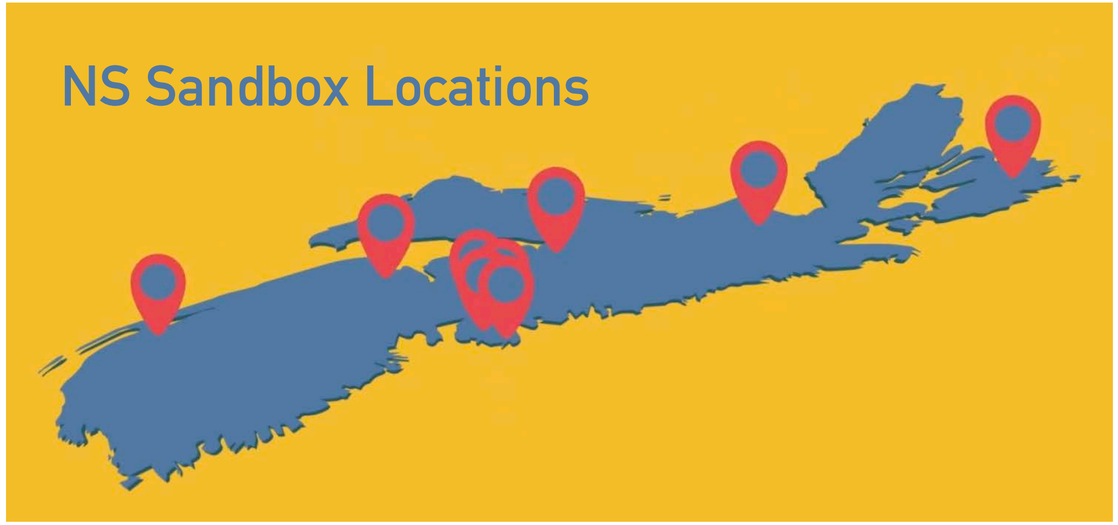
SURGE

Science Unleashed

surgeinnovation.ca
@surgeinnovation
SURGE@dal.ca

What is SURGE?

- One of 10 NS **innovation sandboxes**
- 5 at Dalhousie (Sci, Eng, CS, Ag, Health)
- Experiential learning in:
  - Applying science to real world problems
  - Creativity, innovation, design thinking
  - Entrepreneurship and the startup ecosystem
  - Leadership, 21st century skills



What We Teach

Problem Definition
Needs finding
Customer discovery
Business models

Finding a Solution
Human-centered design
Ideation
Brainstorming

Entrepreneurship
Customer Discovery
Product-Market Fit
Commercial & Non-Commercial

21st Century Skills
Working in teams
Networking
Professionalism

Technical Understanding
Scientific & technical knowledge
Intellectual property
Technology readiness assessment

Personal Development
Leadership
Self-driven learning
Pitching an idea

Why?

- The most digitally-intensive roles also place the highest emphasis on non-digital skills — notably, **teamwork**, **communication**, **judgment**, and **problem-solving** skills…
- Cognitive and social skill requirements in job advertisements **predict occupational wage differences** across labour markets, even when controlling for education and experience requirements.

Brookfield Institute (2019)

What we do

- Hackathons
- Science Innovation course: **SCIE 4701 / 4702**
- Internships @SURGE
- Residency program (student-led startups)
- Discover Coding
- FIGS
- Dalbox collab

SURGE

Science Unleashed

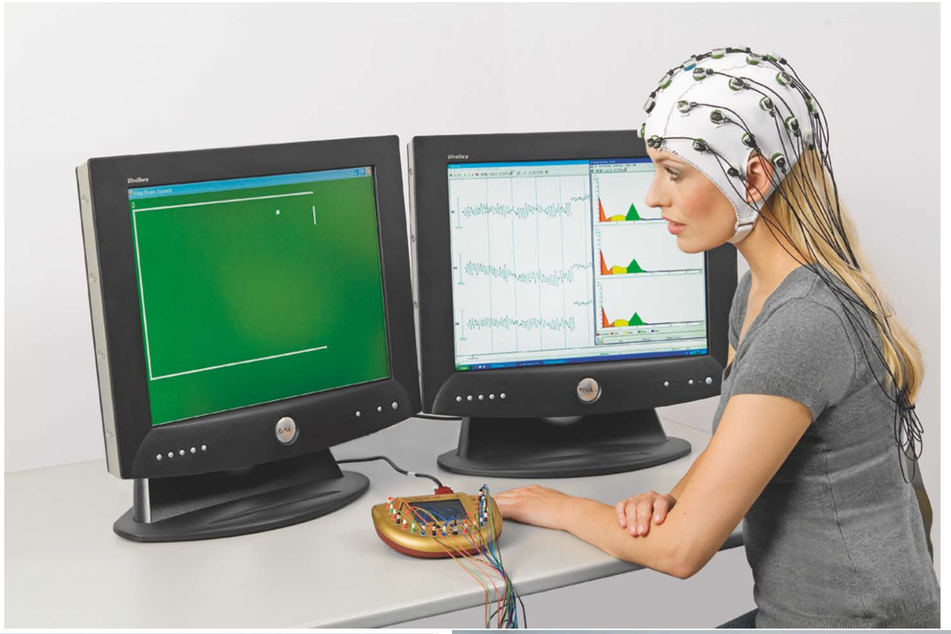
Brain-Computer Interface Neuro-Hackathon

March 10-12, 2023

Brain-Computer Interface (BCI)

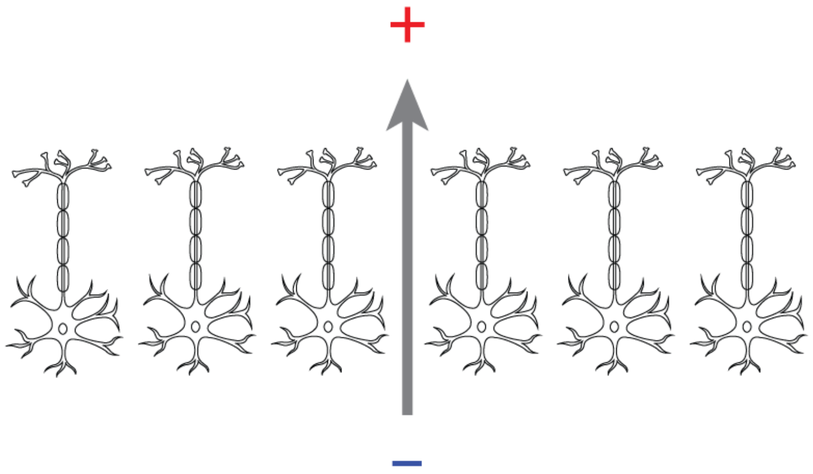
- Interaction between brain and machine
- Applications:
  - Assistive technology
  - Diagnostics
  - Therapeutics
  - Biometrics
  - Human enhancement
  - Entertainment

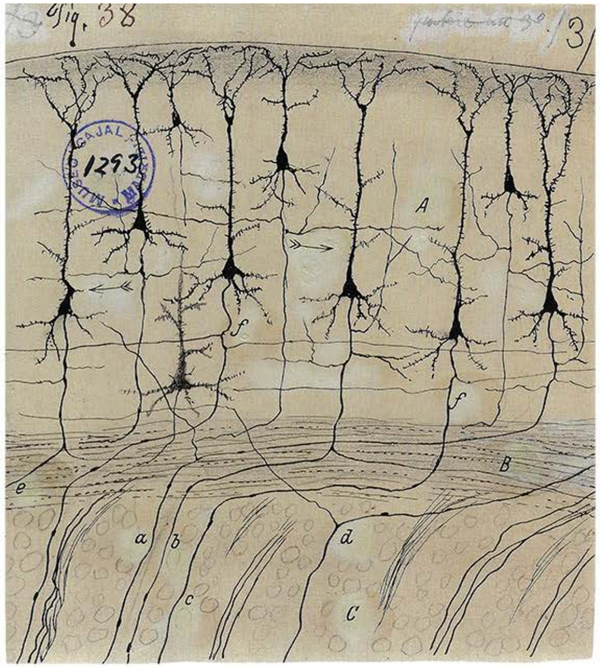
Neuroimaging Methods

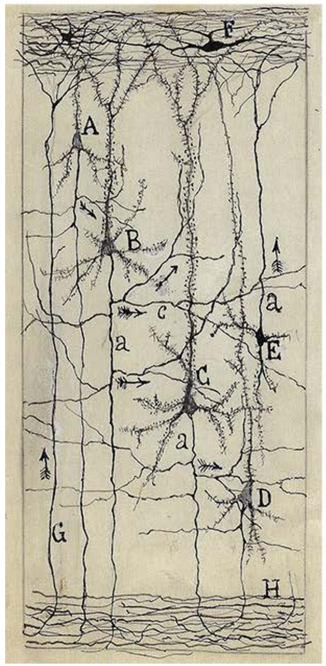


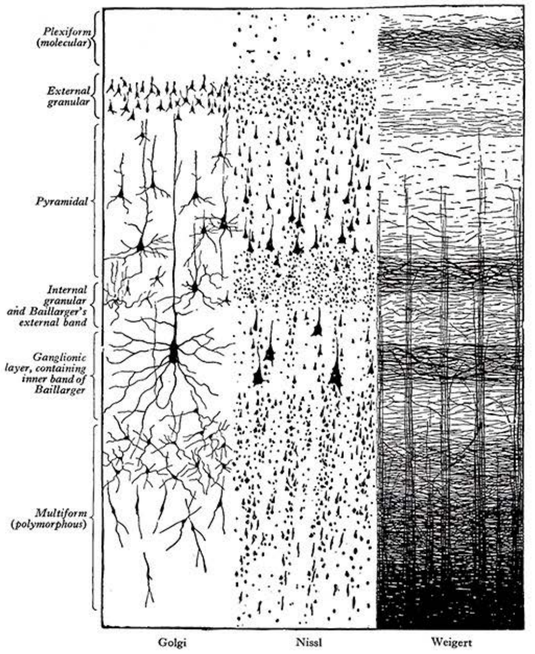
What does EEG measure?

- Pyramidal neurons
- **Open fields**
  - Thousands of neurons whose electrical potentials fluctuate synchronously



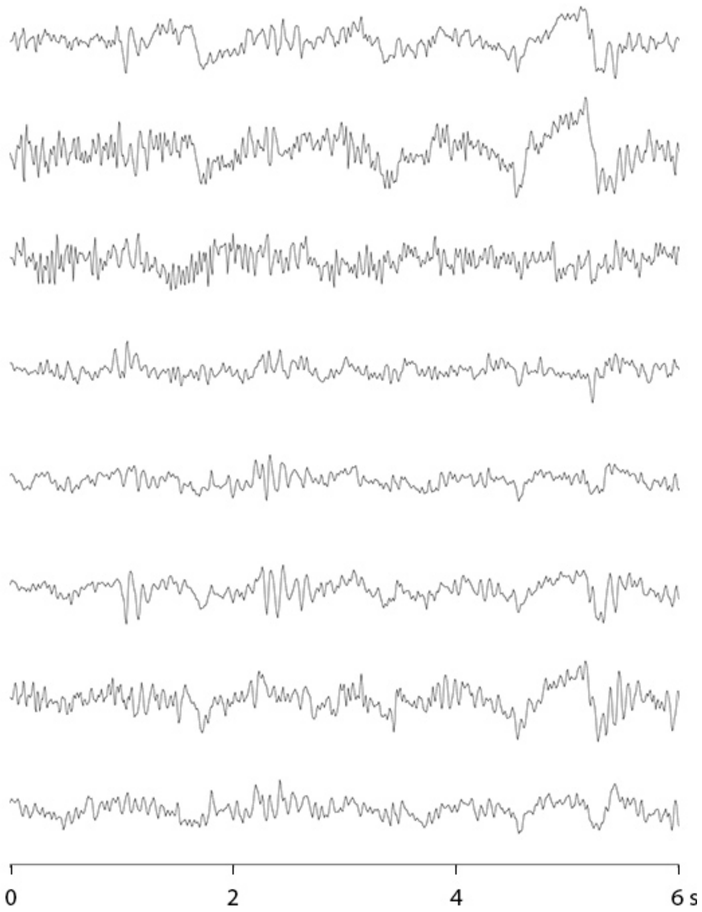




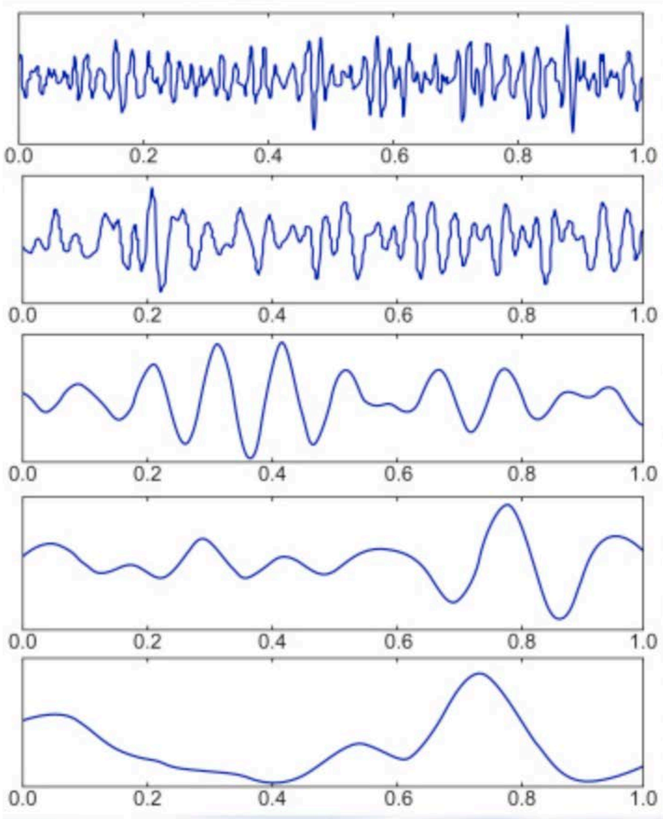


Two Domains

Time Domain



Frequency Domain



Gamma
>35 Hz

Beta
15–35 Hz

Alpha
8–14 Hz

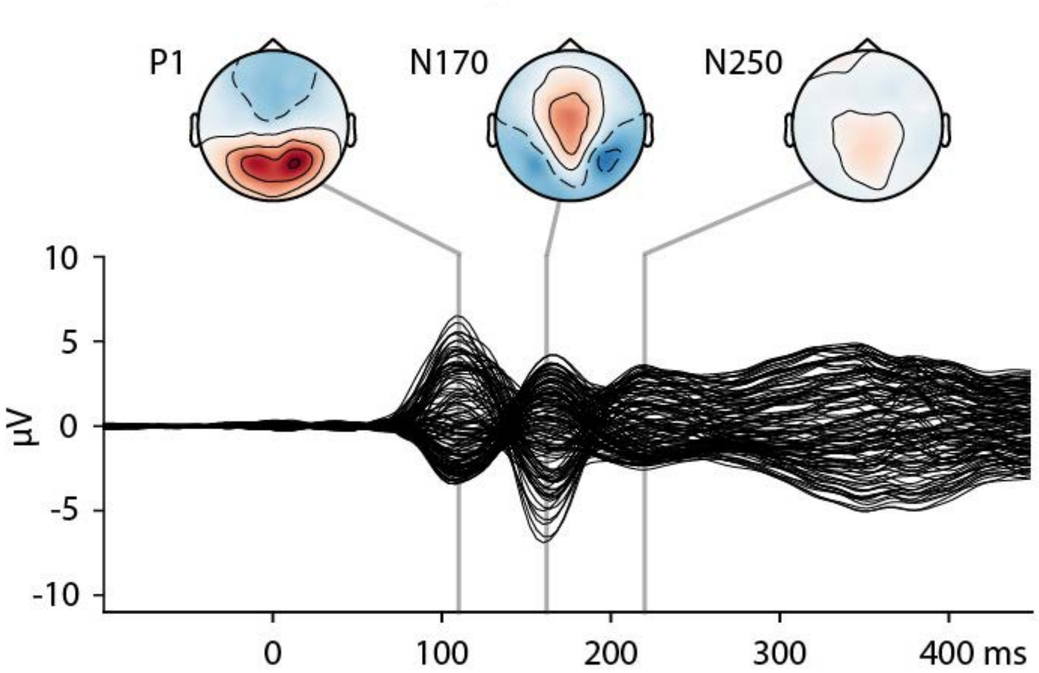
Theta
4–7 Hz

Delta
0.5–4 Hz

Time Domain

Event-Related Potentials (ERPs)

- ERP **Components**
  - Defined by:
    - Latency
    - Polarity
    - Scalp distribution
    - Eliciting conditions

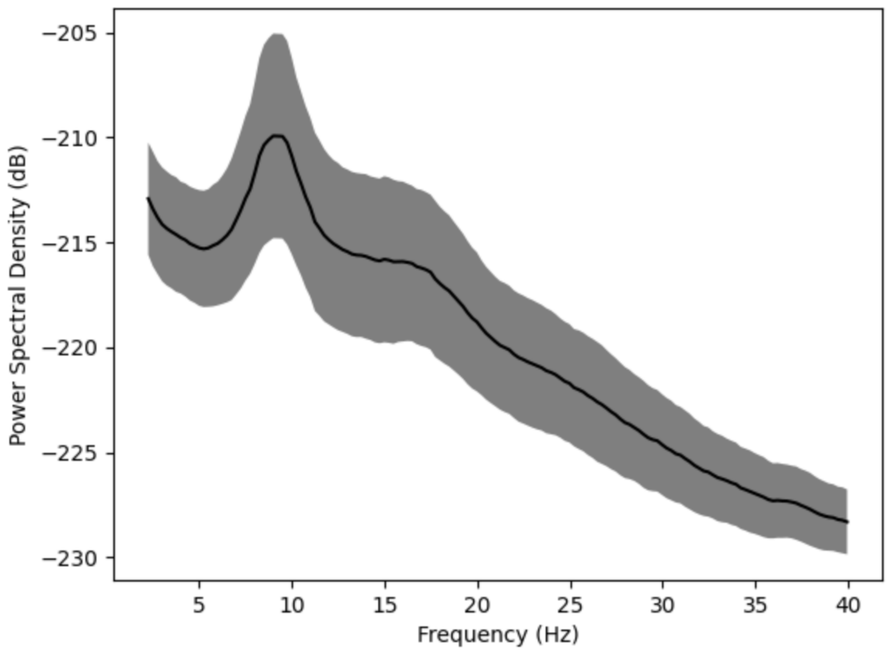


Example ERP Components

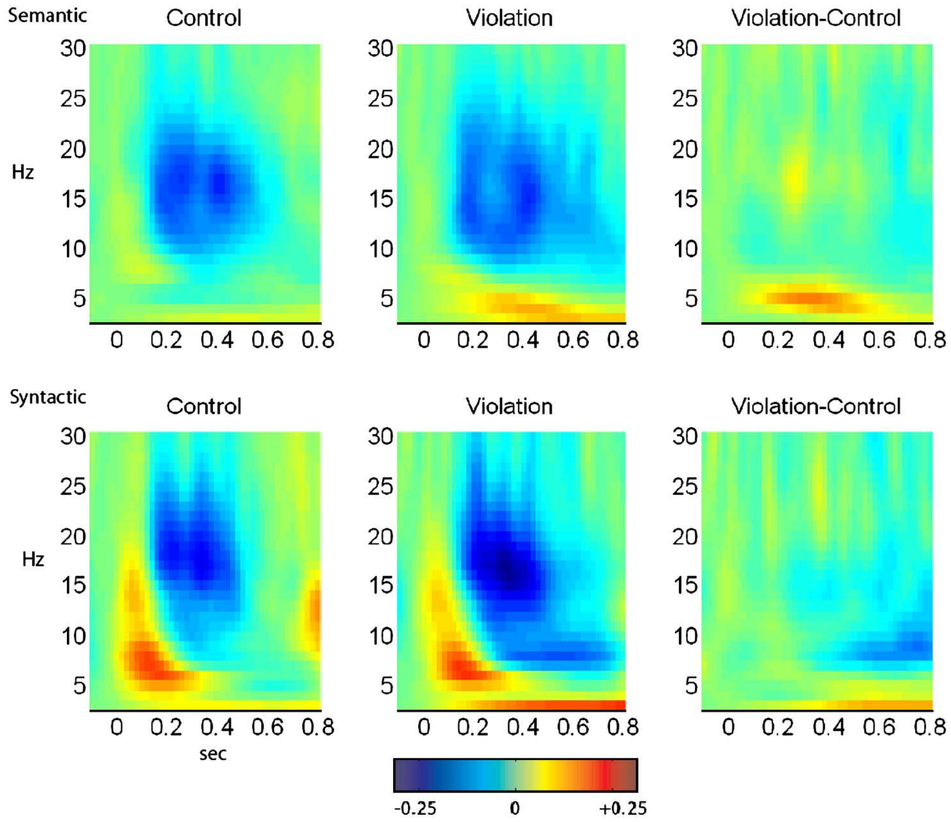
- P1–N1-P2 complex (sensory, attention)
- N170 (faces, objects, printed words)
- P3 (attention)
- N400 (meaning)
- LPC (emotional valence/arousal)
- FRN (feedback/learning signal)
- ...and many more!

Frequency Domain

Spectral Power Bands

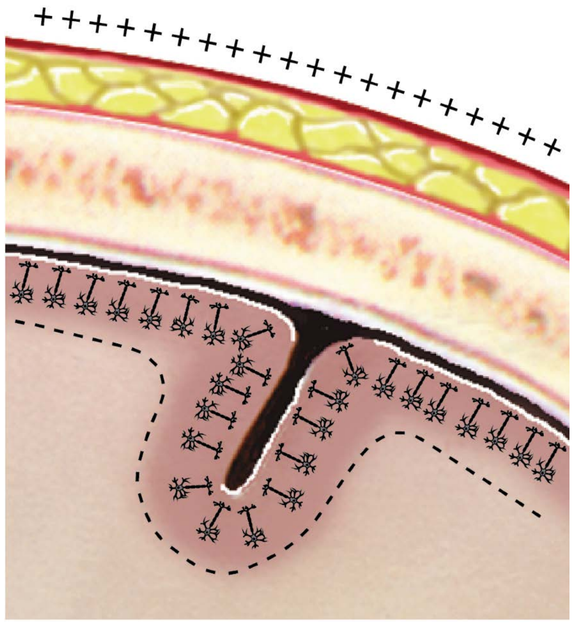


Time-Frequency Analysis



Challenges of EEG

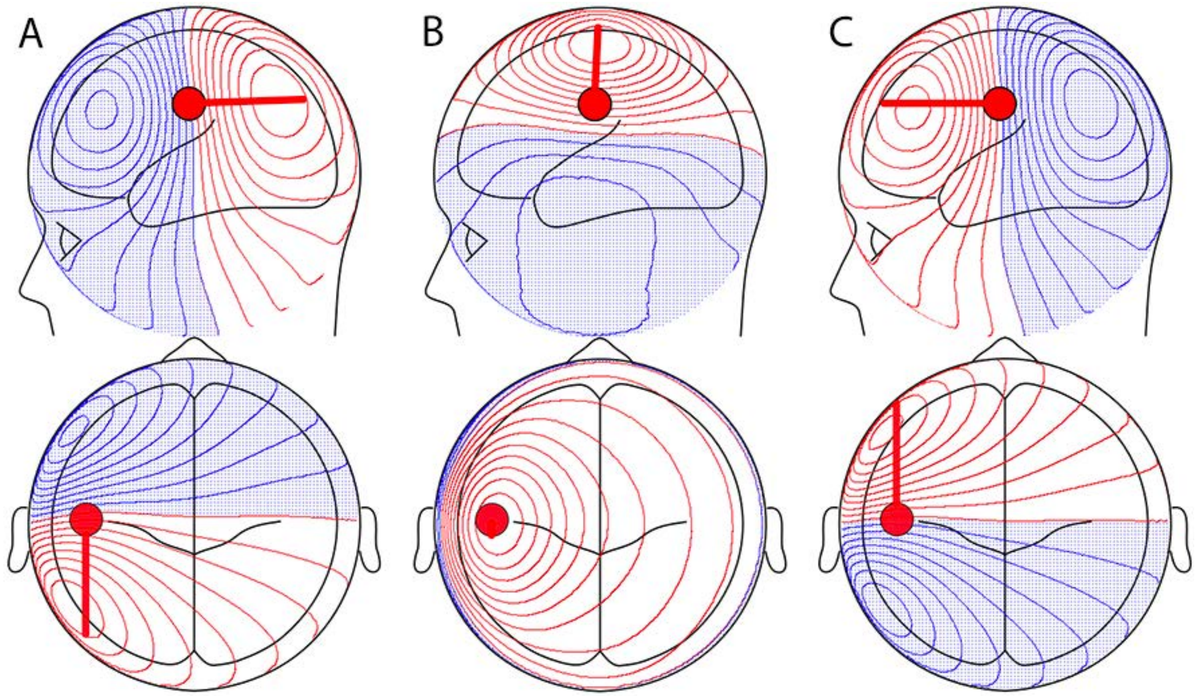
- Environmental noise
- Physiological noise
- Skull
- Cortical folding patterns



Dipoles & Volume Conduction

- Electrical signals volume-conducted throughout the head
- In reality, many areas generating signals at any time
- Scalp potential reflect sum of many (but not all) active brain areas

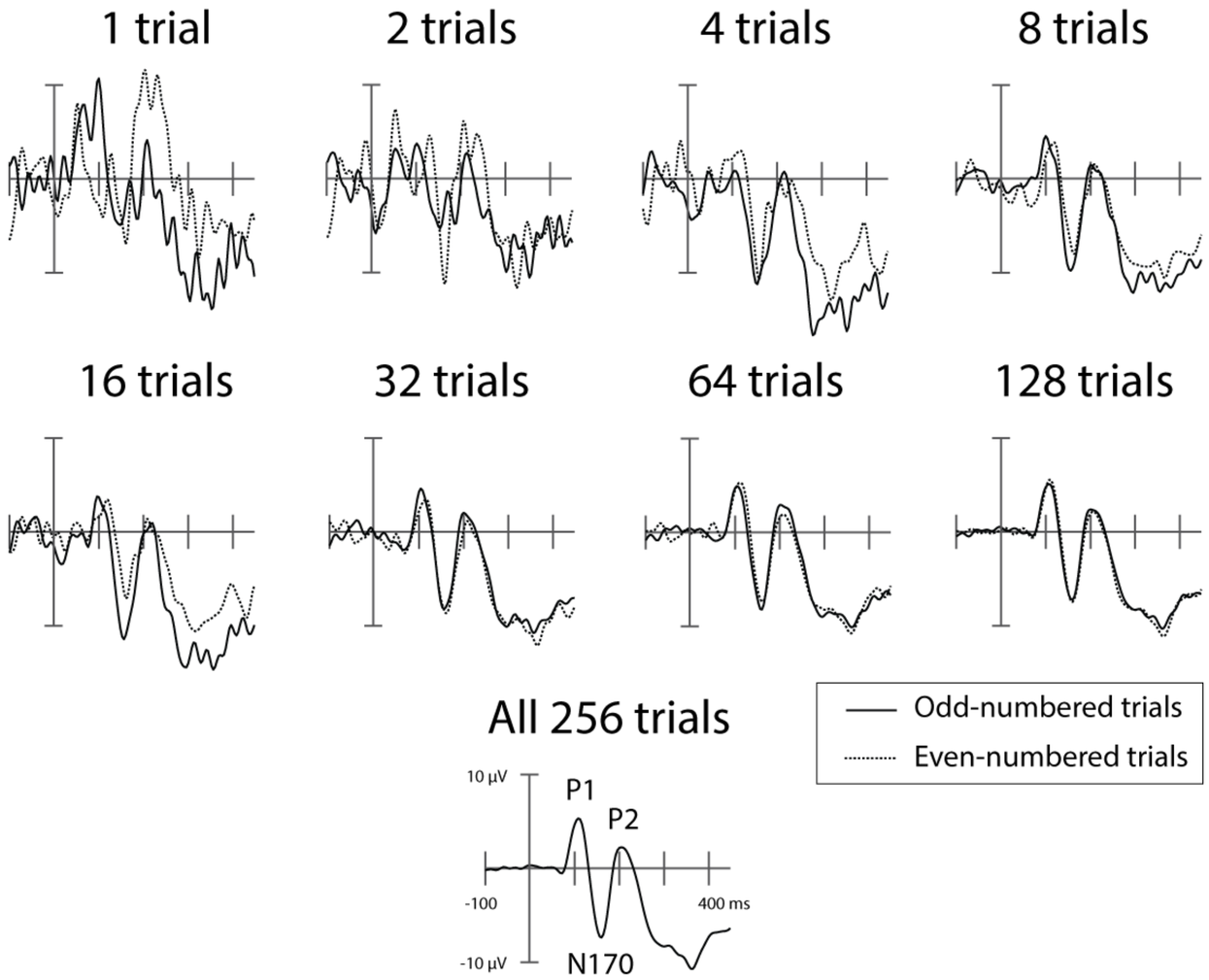
→ Focus on measurable effects, not where in the brain they're coming from



(Partial) Solutions

- Reduce environmental noise
- Filter noise
- Identify/remove artifacts
- Task design
- More data / trial averaging

Signal Averaging



BCI

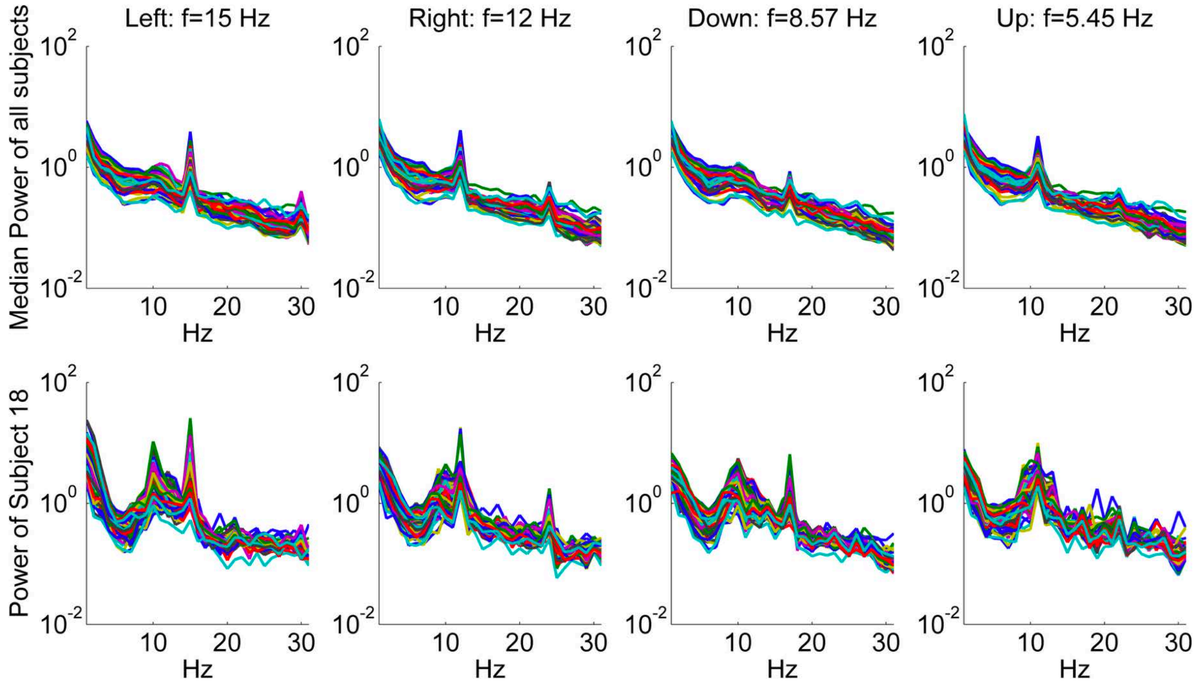
Speller

- P3 ERP component:
  - Infrequent, task-related stimulus
- P3 elicited for letter attention is focused on in a grid, relative to other letters

SSVEP

Steady-State Visual Evoked Potentials

- Visual cortex will oscillate in synchrony with flickering visual stimuli
- Target selection: different locations on screen flicker at different rates
- Largest in alpha range (8-14 Hz), but higher frequencies also work



Motor Imagery

- Motor cortex oscillatory signals change during real and imagined movements
  - Beta range (18-25 Hz)
  - Mu range (8-12 Hz)
- (Imagined) movement causes **desynchronization** (reduced power) over motor cortex **contralateral** to target hand (left hand – right motor cortex)

EEG Recording

- Choose electrode locations
- Apply electrodes
- Reduce imedance
- Go

BCI Workflow

- Build stimulus paradigm
- **Offline (training) phase:** Run paradigm — collect data
- Train ML classifier
- **Online (deployment) phase**: use trained classifier to operate BCI