Methods Lunch: Introduction and demo for the fNIRS system

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What is fNIRS?

- fNIRS = Functional Near-InfraRed Spectroscopy
- Uses low levels of red to near-infrared light (650-950nm)
- Measures changes in the optical absorption of tissue due to oxy-, deoxy- or total hemoglobin
- Light propagates up to several cm, deep enough to reach cerebral cortex
The Hemodynamic Response

Neural activation
  ↓
Increased metabolic demand
  ↓
Increased food flow
  ↓
Increase in oxy-hemoglobin
  ↑
Wash-out of deoxy-hemoglobin

fMRI
Blood-oxygen dependent (BOLD)
fMRI measures functional changes in deoxy hemoglobin, as well as the head’s (brain, skull, etc) structure

fNIRS
fNIRS measure relative changes in oxy, deoxy, and total hemoglobin, but does not measure structural characteristics
Measuring the hemodynamic response with fNIRS

- The “standard” 3 cm channel measures both event-evoked and non-evoked responses (neural and systematic) from both cerebral and extra cerebral tissues.

- Shorter channels (<1 cm) are used to measure only extra cerebral responses.

- The shorter-channel measurements are regressed out, leaving the event-evoked responses.
Non-evoked responses (or noise) include:

- Arousal changes
  - Excitement, boredom
- Emotional state changes
  - Stress, frustration, anger, sadness, etc.
- Other non-evoked neural responses:
  - Respiration
  - Mayer Waves
  - Scalp blood flow
  - CSF, skull thickness
  - Skin/hair pigment

Measuring the hemodynamic response with fNIRS
Practical considerations

Light penetration depends greatly on:

- Thickness of scalp, skull, and CSF
  - The forehead and temporal cortices are easiest to measure
- Density and colour of hair
  - Darker and thicker is more difficult
  - The roots of the hair can be problematic (denser or spikier hair)
  - Red-dyed hair can be problematic (due to the light absorption properties of red colour molecules)

It is important to be aware of the challenges to obtain a good signal quality!
Gendered variability in skull and CSF thickness (in children)

Correlation of scalp-to-brain depth with (a) head circumference and (b) age (in children)

Greater depth of cortex means that fNIRS will be less sensitive to changes in brain activation

females < males
larger heads < smaller

Benefits over fMRI

- Portable and low-cost
- Can be performed in a naturalistic environment without sedation or restraint
- Ability to record from paediatric or other special populations for whom MRI is difficult or contraindicated
- Noiseless (beneficial for auditory paradigms)
- Quick set-up
- Hyperscanning capabilities
More benefits to fNIRS

• NIRS is optical, does not cause or receive interference

• Compatible with:
  • EEG
  • MEG
  • fMRI
  • TMS

• Relatively stable signal despite movement-related noise
Limitations of fNIRS

- Cannot measure hemodynamic responses involving “deep” brain regions (e.g., basal ganglia, amygdala)
  
- fNIRS measurements are restricted to outer cortex

- Precise identification of brain areas is improved, but not perfected, with 3D MRI
  
  - Exact position of source/detector, optical properties of localized tissue

- But, being able to measure most of the brain surface greatly improves our interpretation of NIRS results
What’s “hot” in the world of fNIRS:
Skimming some of the most-cited fNIRS papers


Interested in doing an fNIRS study?

Interested in being added to the fNIRS mailing list?

Contact me (Nicolette): nnoonan3@uwo.ca
Questions?