RECORDING FAST OPTICAL DATA

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Prior to Data Collection...

Design an Experiment

- Determine what brain regions you need to sample
- Design a montage (placement of sources and detectors)
- Check source/detector distances for cross-talk
- Implement the experiment with software that can send out a trigger and/or marker to synchronize stimuli with Boxy recording
- Set Boxy to record continuously for the length of 1 block (and set all other Boxy parameters)
- Check the timing consistency between behavioral expt and Boxy recording
Time Division Multiplexing of Sources (aka Muxing)

• Not all sources are on at the same time, instead they come on in series
• We call each slice of time that a source is on a “mux channel” or “mux slot”
• The PMT (detector) cannot differentiate sources, it will collect all light available during any given time
• Therefore, you must take care when placing sources that share a mux slot (i.e., 2 sources that turn on at the same time)
Switch Settings on Imagent
Switch 16 mode

Maximum of 2 sources on at a given time (per Imagent)
Maximum of 16 MUX channels

Detector A
Detector B
Detector C
Detector D

Main Power
Modulation

830 nm
690 nm
Switch Settings on Imagent
Switch 8 mode

Maximum of 4 sources on at a given time (per Imagent)
Maximum of 8 MUX channels
EROS Montages

Back of helmet
Considerations for Montage Design

- The more crossing/overlap of channels, the better the S/N and the better the localization.
- The more varied the src-det distances, the better coverage across cortical depths.
- **To avoid cross-talk:** when 2 or more diodes are turning on during the same MUX slot, only 1 can be within 6 cm of a given detector
  - This distance will be smaller with certain populations (older adults, infants) due to increased transparency.
- Optimize design such that most src-det pairs have a distance of 2-5 cm (most at 2.5 - 3 cm)
  - Too short, not hitting cortex
  - Too long, lose too many photons
Example:

Dual wavelengths (2 sources in each hole)
Three patches (bilateral frontal and occipital)
Example:
• One wavelength (1 source in each hole)
• Almost full cortical coverage
  • 24 Detectors
  • 60 Sources (mux 16)

All 830 nm
Why do we use layouts based on rows?

- Maximizes the spatial sampling across depths
- Maximizes the overlap of channels

• For large montages, we have scripts to help automate the process of assigning mux channels while avoiding cross-talk (see Kyle Mathewson and Ed Maclin)
• Under development: using multi-objective optimization theory to design montage configurations automatically using a genetic algorithm to search the space of possible montage configurations and return solutions achieving localized sampling and cross-talk minimization objectives (see David Steines and Pauline Baniqued)
Syncing stimulus presentation with data collection

- Boxy receives a trigger to start recording data
  - Via BNC connection
- Boxy can also record a digital code that can mark the timing and type of specific events in the data stream
  - Via a 9 pin D-connector
  - These codes appear in the data file under the column labeled digital auxiliary (on mux 1 only)
- We cross check this timing with the output of our experiment presentation software
BOXY: Imagent data collection software
This will usually be set to 1 because we will re-trigger Boxy with every block.

This will be determined by the timing of a single block.

“File fill time” should be a little longer than the time it take to complete 1 experimental block.

Ex. Optical sampling rate = 62.5 Hz; Block duration = 3.3 min
Sampling period = 1000/62.5 = 16 ms
12600 pts * 16 = 201,600 ms = 201.6 sec = 3.36 min
→ optical will collect data continuously for 3.36 minutes
"Waveform" refers to 1 cycle of the CCF.

Number of samples/cycle of the CCF
Will change ADC Sample Rate, Divisor, and DMA rates.

Data Update Rate = final sampling rate

The final sampling rate is determined by:
1. The number of sources (mux channels)
2. The cross-correlation frequency
3. The number of waveforms to skip
4. The number of waveforms to average
5. The number of cycles to average per data update cycle
File format settings in Boxy
--For compatibility with p_pod
Tips for recording that we’ve learned over the years...

- Support the fibers from above
  - Less weight on subject
  - Added support near the receiving end of the fiber
  - Less tangling/breakage of fibers
  - Adds clearance to the back of the head

- Don’t keep graphs or text monitors open while recording data
  - Because it increases the risk of timing errors (i.e., missed packets)

- Limit the length of one block to less than 5 minutes, ideally less than 3
  - This greatly reduces movement artifacts because it gives the subject a chance to squirm a little between blocks

- The subject monitor refresh rate CAN appear as an aliased frequency in the AC intensity (and produce artificially low phase variability)
  - Minimize by using black/dark backgrounds instead of white
  - Cover regions of helmet/patch that might allow stray light in
  - Inspect the frequency spectrum of your channels as a quality control measure

- The subject chair is an important piece of equipment
  - Comfortable!
  - No swivel, recline, or wheels
Checking signal quality just prior to data collection

- Adjust gain (bias) of each detector such that DC values are near 16000 (limited by the shortest distance channels)
  - This will minimize the risk of over-voltaging
    - The sum of AC, DC, and PH has to be less than the A-to-D conversion range (32K)
- Good channels should have:
  - AC values above 100
  - PH standard deviations below 5
    - Your shortest channels should ideally have stdev less than 1.
    - The lower the stdev, the better your signal-to-noise
- If you don’t have very many channels in your montage, you can also plot each channel as a time course (AC intensity) to check that a pulse is visible.
  - You may want to use some of Boxy’s calculation features to filter the plotted data to isolate the pulse signal
Boxy output file - header

• Important header information (appears at the top of the file)

BOXY.EXE: ISS Oximeter R&D Program Version 0.40
Ascii Record File

#ACQ INFORMATION
8 Detector Channels
10 External MUX Channels
0 Auxiliary Channels
6250 Waveform (CCF) Frequency (Hz)
2 Waveforms Skipped
8 Waveforms Averaged
1 Cycles Averaged
8 Acquisitions per Waveform
62.5000 Update Rate (Hz)

#FILE INFORMATION
FALSE -- External MUX Channel results are NOT parsed.
TRUE -- AC DC and Phase are GROUPED.
TRUE -- Companion Program Settings File CREATED.
FALSE -- AC data not excluded
FALSE -- DC data not excluded
FALSE -- Phase data not excluded
TRUE -- Auxiliary Chn. data excluded
Tab delimiters

• After this info, there will be more header info, but this is for use when collecting absolute oxy/deoxy concentrations (i.e., multi-distance method with dual wavelengths)
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Hardware Maintenance

- Routine testing of fibers, diodes, and PMTs is recommended.
  - Frequency of checks dependent on use
- Using a phantom to acquire sample data (keeping gain constant):
  - Test each fiber in a standard diode
  - Test each detector bundle in a standard PMT
  - Using a “good” fiber (one reserved only for testing), test each diode
  - Using a “good” detector bundle, test each PMT