Physiological Data and fMRI

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Introduction

- FMRI= Functional Magnetic Resonance Imaging only focuses on hemodynamic changes in the brain and is used to identify certain conclusions about physiological properties of brain structures, as well as the structure and functional connectivity of brain networks.
- BOLD signals are changes in the ratio of oxygenated to deoxygenated blood in the brain, measured through functional magnetic resonance imaging (fMRI).
- Physiological data = breathing and heart rates measured in Hz (usually 1 Hz for cardiac signals and 0.3 Hz for respiration).
- Breathing and heart rate are one of three causes of motion in fMRI scans, which creates issues when claiming correlation between brain regions and networks.
- Physiological data can cause motion within the scan (increase in breath depth decreases blood flow and blood-oxygen-level-dependent (BOLD) signal).
- Changes in heart rate lead to fluctuations in signals throughout brain matter and tissue and while breathing; moving the chest wall and changes in cerebrospinal fluid flow also affects signals.
- All of this can affect functional connectivity, the strength of correlation or connection between different regions and areas of the brain.

Background

Past studies have found that there is a high correlation between respiration variation (RV), respiration volume per time (RVT) and the envelope of the waveform (ENV) which is derived from a respiration belt; RV and ENV are highly correlated, more so than with RVT (3). They also found that deeper breaths correlate to heart rate and signal changes, as well as motion. These deep breaths are also not sex-biased (2). The Power Lab examines more of the differences and similarities between sexes and physiological data.

Additionally, some evidence has been found that functional brain networks are driven by vascular physiology (1). This is particularly important because it could lead to breakthroughs in understanding more about functional brain networks as well as highlighting the importance of physiological data.

Gratton Lab

In the Gratton Lab, we focus on the organization of large-scale networks in people and over time, as well as specialization of these networks for goal-oriented behaviors. We work with fMRI, not jut MRI, which is used to identify certain conclusions about physiological properties of brain structures, as well as the overall structure and functional connectivity of brain networks. Overall, we work with brain networks and interconnectivity using resting state and task data.

Methods- Physiological Data: Measurement

Collection:

PPU098- Physiological Pulse Unit

PERU098- Physiological ECG/ Respiratory Unit

Data Processing:

- I obtained a code from CTI Neuro Imaging at NorthWestern University that was put into MatLab.
- MatLab is a programming language that the Gratton Lab uses to read/ extract and plot our data.

```
426
427   function [newminy, newmaxy] = plot_trace(trace, oldminy, oldmaxy, color, scale)
428   % plot trace and keep track of minimum and maximum values
429
430   miny = double(min(trace));
431   maxy = double(max(trace));
432   newminy = min(oldminy, miny);
433   newmaxy = max(oldmaxy, maxy);
434   if (scale && (miny ~= oldminy) || (maxy ~= oldmaxy))
435       trace = double(trace) .* ((newmaxy-newminy)/(maxy-miny));
436       trace = trace - min(trace) + newminy;
437   end
438   plot(trace,'Color',color);
439
```

Predicted Project

Testing for significant correlations between physiological data and sleep, caffeine, and anxiety.

Ideally, all three measures will be tackled and studied to find correlations with physiological data, in order to strengthen confidence in findings. If there are significant correlations, these measures can be screened for in order to get the best and clearest scans, before data cleaning. This might make the participant search harder, but it will ensure better data. I will start with sleep, as sleepiness is monitored and asked about as a self-reported value throughout the scan and rest runs.

Participant INET016

Good for identifying differences between physiological data and reported sleepiness, and how it may vary within one sample.

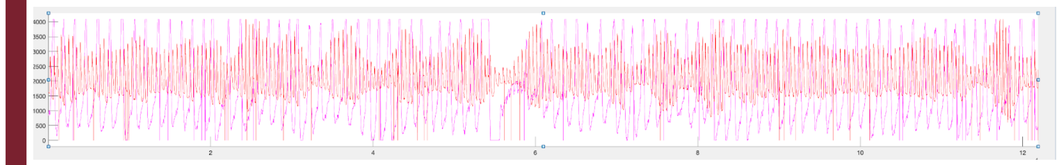
- Session 1
  - Run 1 & 2 = Sleepiness 4
- Session 2
  - Run 6 = Sleepiness 3
  - Run 7 = Sleepiness 2
- Session 3
  - Run 5 = Sleepiness 7
  - Run 8 = Sleepiness 2
- Session 4
  - Run 2 & 3= Sleepiness 7

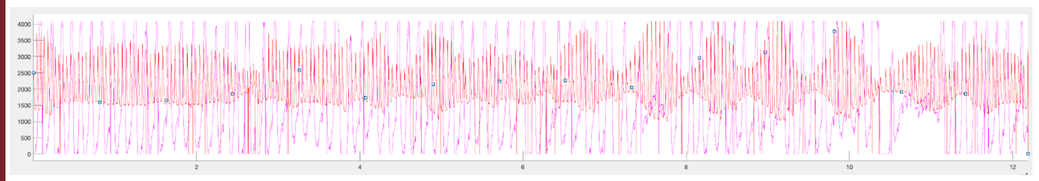
General Participants

Ages range between 18 and 65, but are highly concentrated between the ages of 18 and 22. The sample is currently predominantly female, and consists of FSU students.

Eventually, participants will come from naturally created group of different caffeine levels, sleep levels, and anxiety levels, defined later.

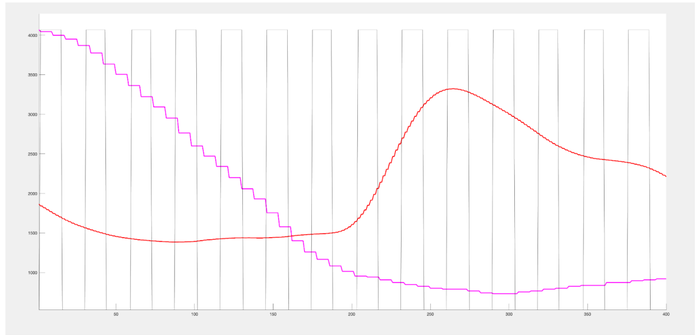
Results





The data shows two full DICOMs of Physiological Data, which comes out to about 10 minutes of scanning between the two. Some fluctuations are shown, such as around the center of the first DICOM, and the end of the second. This shows the variation that can create problems and confusion with functional connectivity and BOLD signals.

Results



The data above shows 400 ticks of 121900 ticks in a single DICOM of data. Each tick measures about 2.5 ms of data, so each DICOM is about 5.079 minutes of data. This is 1 second of typical physiological data from one of our participants (INET077).

Conclusion/Discussion

In the future:

- Find correlations between physiological data and the different measures.
- Use data to group participants by characteristics and further study.
- Apply to medical and psychological research in psychopathology.

Acknowledgements and References

Dr. Caterina Gratton
Ally Dworetsky
Nathan Labora

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2. Lynch CJ, Silver BM, Dubin MJ, Martin A, Voss HU, Jones RM, Power JD. Prevalent and sex-biased breathing patterns modify functional connectivity MRI in young adults. Nat Commun. 2020 Oct 20;11(1):5290. doi: 10.1038/s41467-020-18974-9.

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