The Synchronization of Physiological Oscillations in the Brain and Heart During Slow-Wave Sleep

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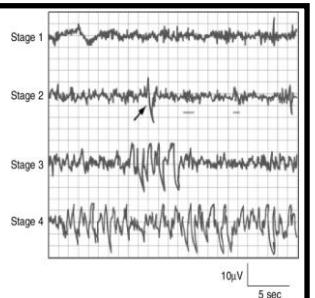
Introduction

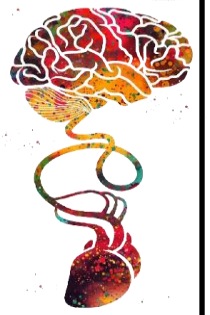
What is Slow-Wave Sleep?

- Occurs during stages 3 and 4 of non-REM sleep
- Characterized by high amplitude slow waves called delta waves
- Frequency rate of 0.1-4 Hz
- Heartbeat and breathing at slowest



The Brain and Heart are not Independent Systems

- There exists increased interactions between brain and heart during sleep [1]
- Phase-locking between brain waves during slow wave sleep and oscillations that were driven by heartbeat [2]



CAP Sequences

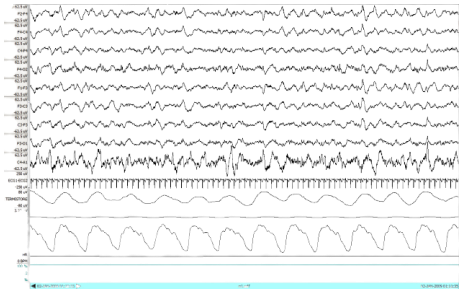
- 2 Phase Physiological Phenomenon during non-REM sleep [3][4]
- Heightened occurrences in those with sleep conditions

Our Goal:

- Study the synchronization of oscillations between EKG and EEG data during slow wave sleep in different populations

Results

- Data collection unable to be automated due to size of data files, data type, and differences within collected data
- Most collected EEG data included frontal lobe, parietal lobe, central area, and occipital lobe
- Python script was successful in searching through sleep scoring text file
- Able to collect time series data for pure Stage 3 or Stage 4 sleep lasting 60 seconds without interruptions from CAP events or different sleep cycles
- Polyman was able to successfully view and clip the data files



Data was successfully collected from:

- 14/16 Controls
- 7/9 Insomnia patients
- 19/22 REM Behavior Disorder patients
- 37/40 Nocturnal Frontal Lobe Epilepsy patients
- Over 1400 clippings of data = Over 23 hours of data

The data was significantly reduced from its original size

- Now possible to conduct data analysis

With this collected data, it is now possible to begin running the time series analysis in MATLAB.

Methods and Materials

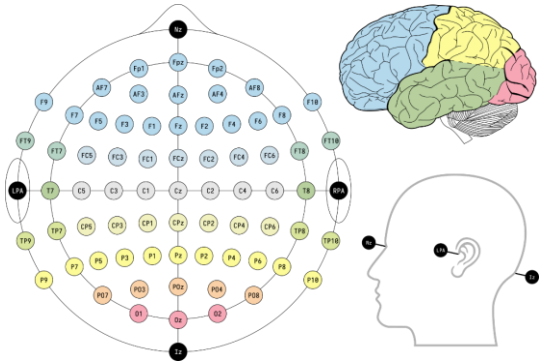
The data comes from an open access dataset of participants in Parma, Italy. [3][4]

Dataset Includes:

- Polysomnography data
  - Includes: EEG, EKG, EMG, oxygen levels
- Expertly recorded sleep scorings

We selected data from 87 participants:

- healthy controls (16)
- participants who have been diagnosed with:
  - insomnia (9)
  - nocturnal frontal lobe epilepsy (40)
  - REM behavior disorder (22)
- Approximately 700 hours of data



Use Python to sift through sleep scorings

Use Polyman Software to collect the data clippings of the sleep data

Discussion

- It is difficult to access sleep datasets containing EEG and EKG data of participants with diagnosed sleep disorders
- Including CAP Sleep Sequences could alter results of time series analysis

Next steps include:

- Using a Hilbert transform to obtain the phase of the waves and sine time series behavior of the phase
- Calculating the phase-locking index between EEG and EKG data
- Applying a First Return Map to learn the fine temporal structure of synchronization between EEG and EKG data

References and Acknowledgements

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[3] MG Terzano, et al. (2001). Atlas, rules, and recording techniques for the scoring of cyclic alternating pattern (CAP) in human sleep. Sleep Medicine 2: 537-553.
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