Characteristic Frequencies in Monkey ECoG

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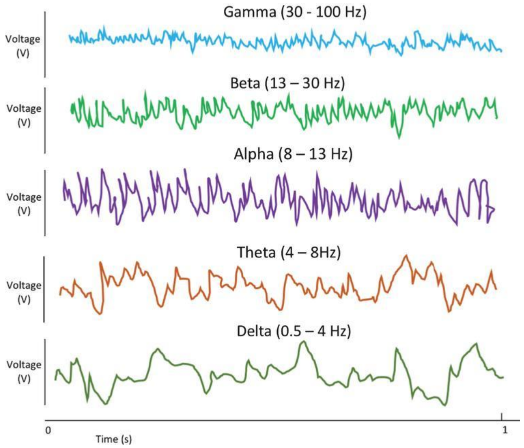
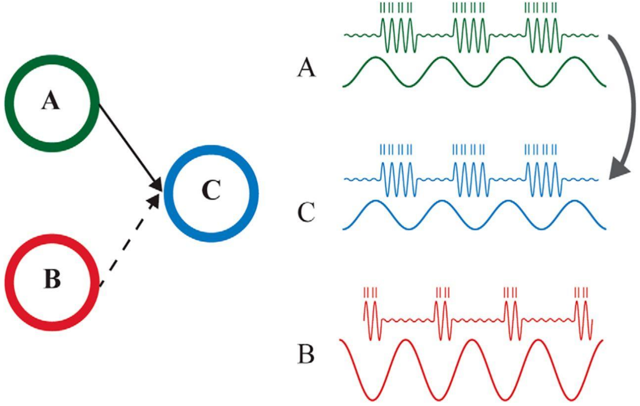
Research Question

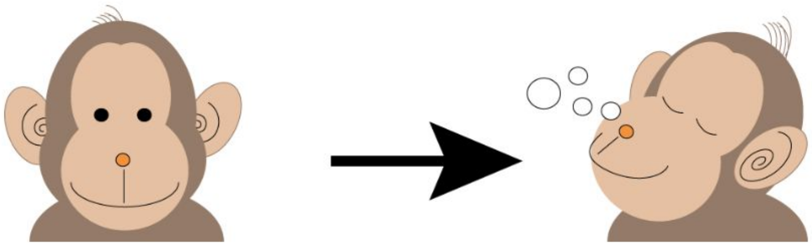
What are the characteristic frequencies associated with different stages in the occipital lobe: awake eyes open, awake eyes closed, and anesthetized? Could there be different characteristic frequencies in the different areas of the brain or are they all about the same for each state? In other words, does this characteristic frequency in the occipital lobe carry over to other brain regions or is it region-specific?

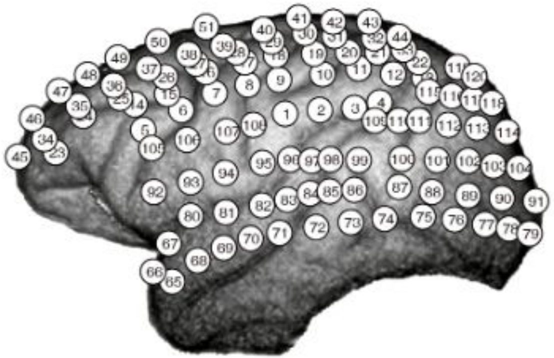




Hypothesis

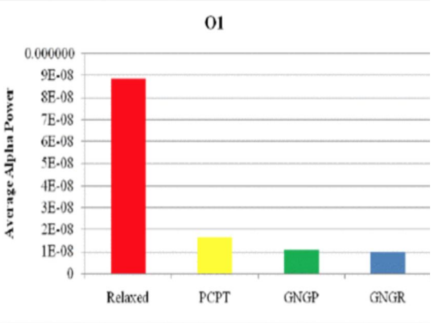
After reviewing the literature, we believe we will find a dominant alpha frequency in the awake eyes open stage, a stronger alpha frequency in the awake eyes closed stage, and delta or theta frequency in the anesthetized stage in the occipital lobe. We also predict we will find different characteristic frequencies across the different brain regions for the awake eyes open and awake eyes-closed state but the similar characteristic frequencies across brain regions for the anesthetized state due to neural synchrony.

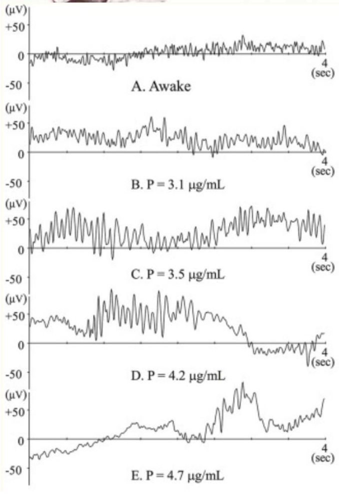


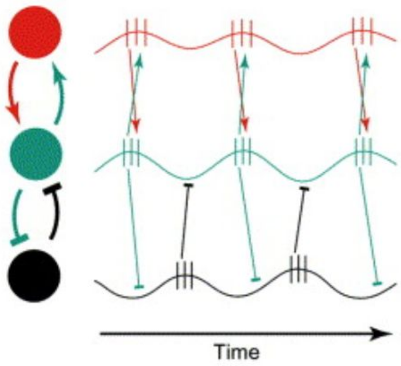


Existing Research

- Alpha frequency one of the first recorded by Hans Berger in 1920s
    - Observed an increase in alpha activity during eyes closed
- Alpha also observed in a relaxed state
- Low concentrations of anesthetics result in an increase of alpha activity but higher concentrations result in an increase of theta and delta activity
- Increase in neural synchrony after the induction of anesthetics







Methods and Parameter Decisions

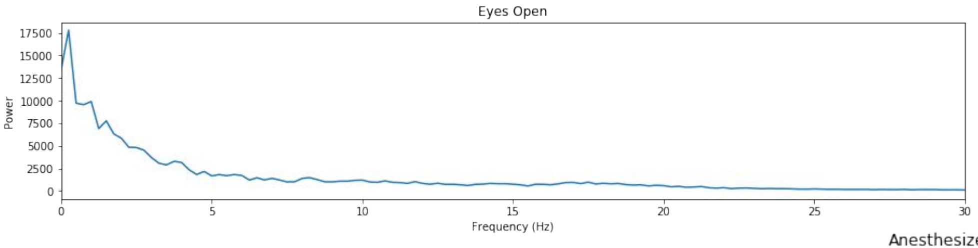
- Short-Time Fourier Transform
- Spectrograms and Power Spectrum
- Filtering and Correlation
- Hilbert
- Cross Correlation

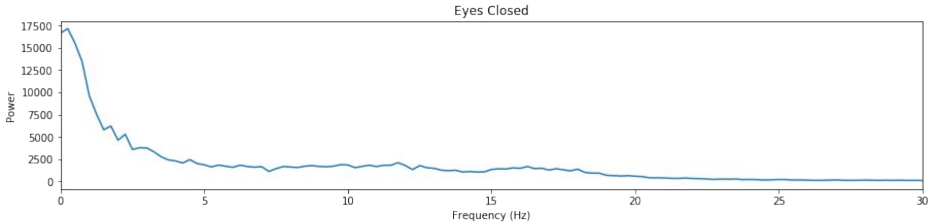
STFT, Spectrogram, and Power Spectrum

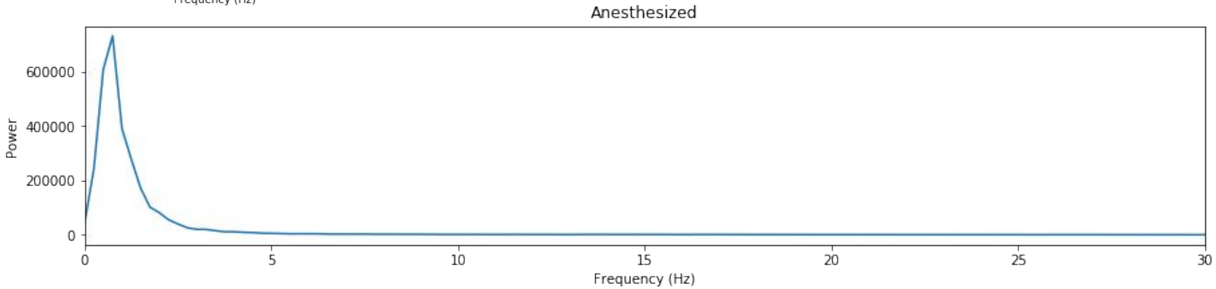
- We used a short-time fourier transform for every state in the occipital lobe.
- The goal of the STFT was to find the sinusoidal frequency and phase content as it changes over time.
- Once we performed the STFT for every state in the occipital lobe, we created a spectrogram using signal.spectrogram.
- We picked a window size of 4, because we found some low frequency in our first pass so we wanted to ensure we capture all frequencies.
- After getting the spectrogram, we used it to get the power spectrum of the signal.

Filtering and Correlation

- We filtered as a way to isolate the dominant frequencies in each state.
- We used a low- pass filter because the range of most dominant frequencies for all three stages start around 0.
- We set the cut off at 3 Hz for the anesthetized, and 5 Hz as a cut-off for the other stages.







Filtering and Correlation Cont.

- Compared the Filter and Raw Signal
- To represent the “importance” of the frequencies we picked, we calculated the correlations between the filtered signals and the original signals.
- We looked at the correlation of the three states to see if filtering out the non-dominant frequencies drastically changed the signal.

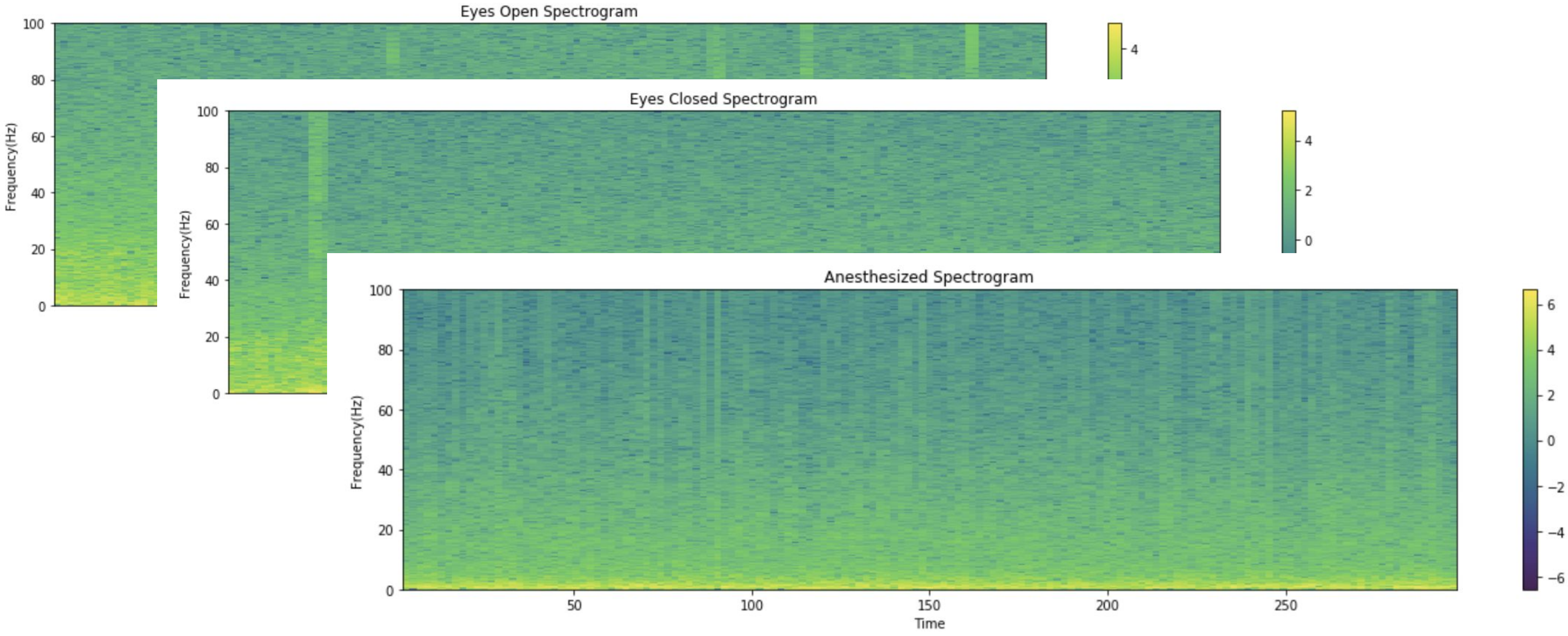
Hilbert

- We used Hilbert transform to calculate the analytical signal, so we could get better time and frequency resolutions.
- We used Hilbert transform to bandpass filter signature frequencies and compare them among the different brain states

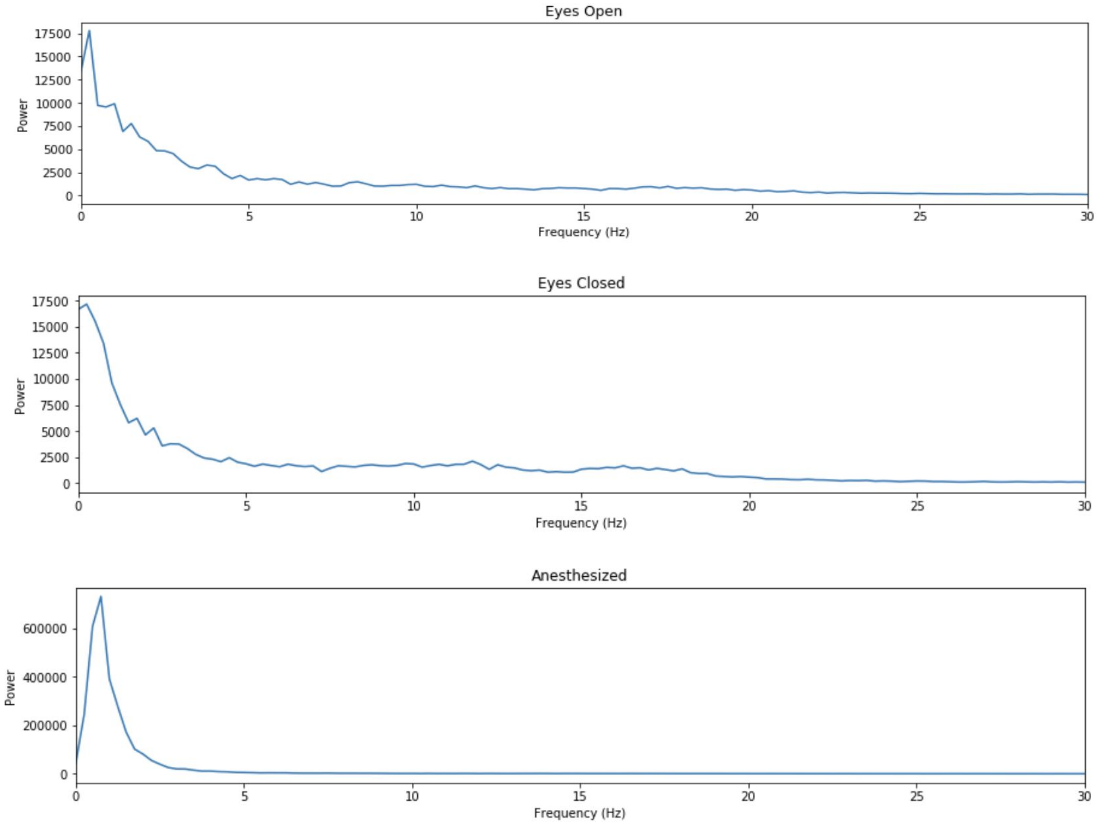
Cross- Correlation

- After getting nine different Hilbert transforms for each brain state in all three brain areas, we computed a cross correlation.
- We used this in our analysis to test for temporal correlation between the same state among the different regions and computed cross-correlation to find any time delays.

Analysis - Power Spectrograms



Analysis - Power Spectra



Analysis - Filters and correlations

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Anesthesized: 0.9701158134237569
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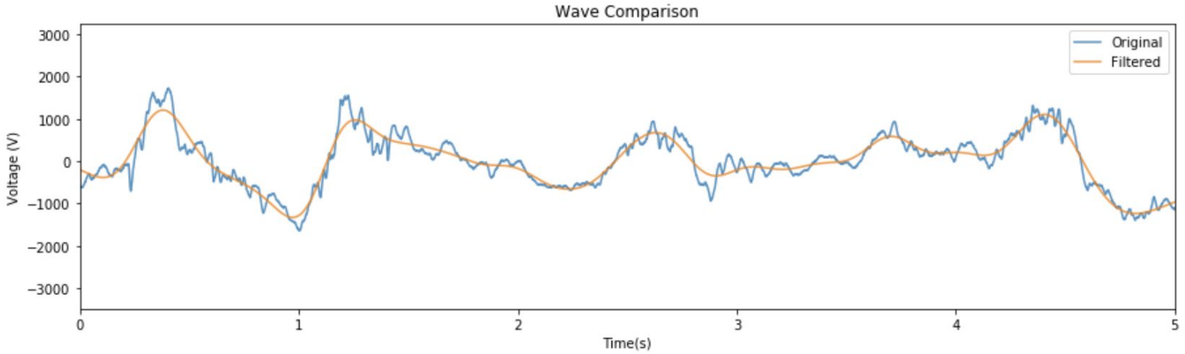
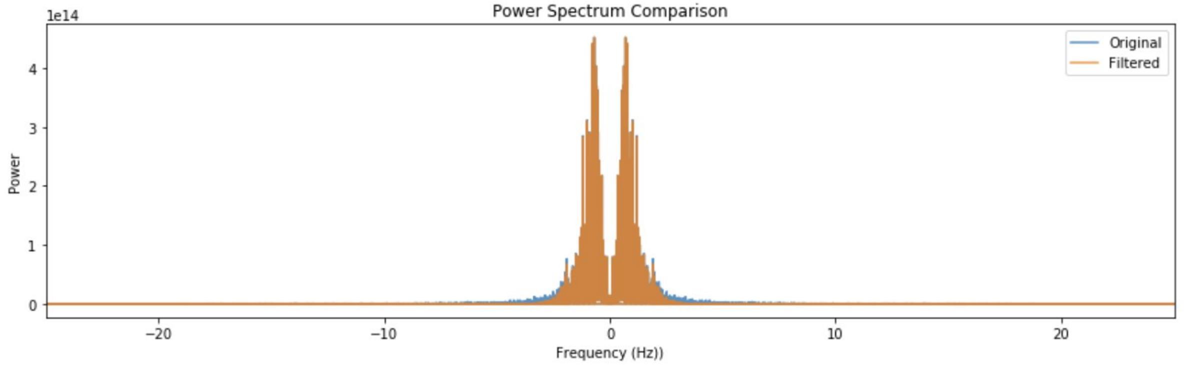




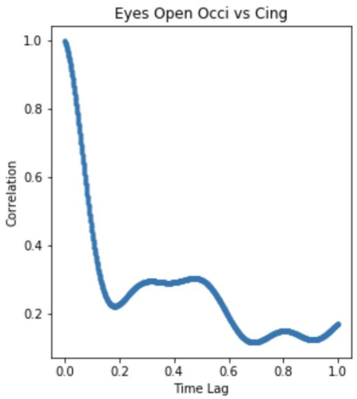
Eyes open:
Correlation = 0.7994

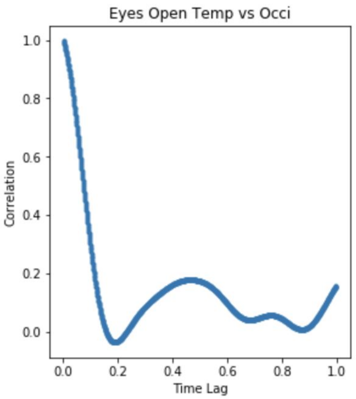
Eyes closed:
Correlation = 0.7612

Anesthetized:
Correlation = 0.9701

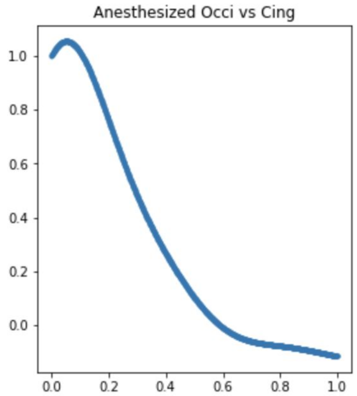
Analysis - Cross Correlation

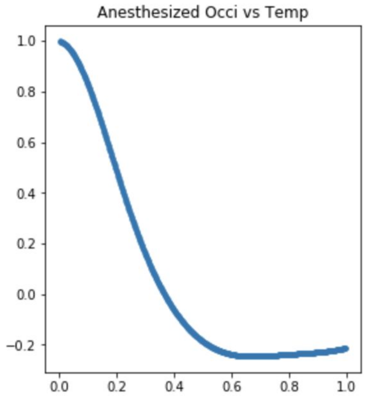
	Eyes Open	Eyes Closed	Anesthe-tized
Occipital vs Temporal	0.12	0.24	0.47
Occipital vs Cingulate	0.38	0.51	0.21



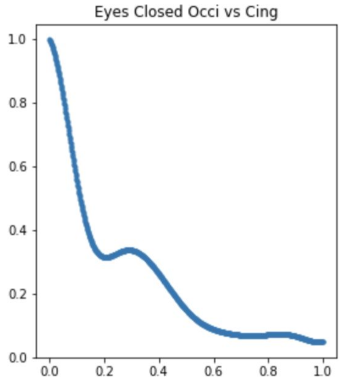


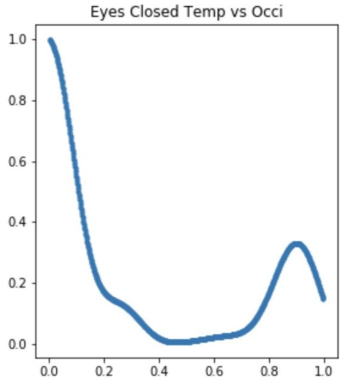
Eyes open





Anesthetized





Eyes closed

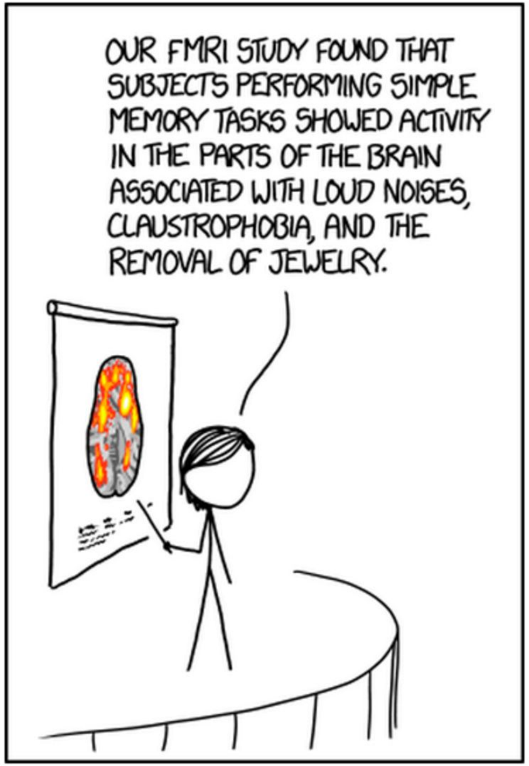
Results

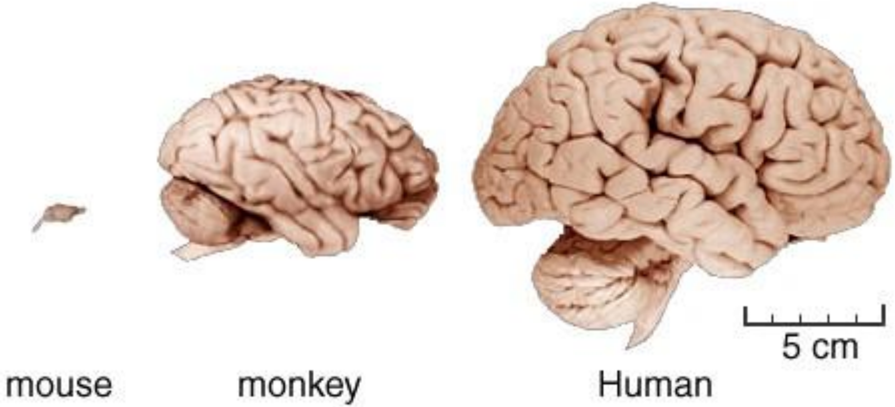
- Anesthetized occipital lobe had overall lower frequency distribution compared to eyes open and closed.
- No significant difference in characteristic frequencies between eyes open and eyes closed in the occipital lobe .
- Correlation between occipital and other lobes was lower with eyes open.
- Higher power in anesthetized versus eyes open or closed.

Conclusion

- Our hypothesis of delta waves in the anesthetized state was correct, but we did not find a dominant alpha wave in the awake open eyes and eyes closed.
- The higher overall power in anesthetized state was due to frequency distribution.
- Visual input from eyes open could be the factor behind lower correlations.

Limitations





- Data itself
- Parameters
- Bias
- Research