# Auditory Attention Using EEG

Saurabh Kataria, Sandeep Reddy Kothinti
MLSP project presentation

# Introduction

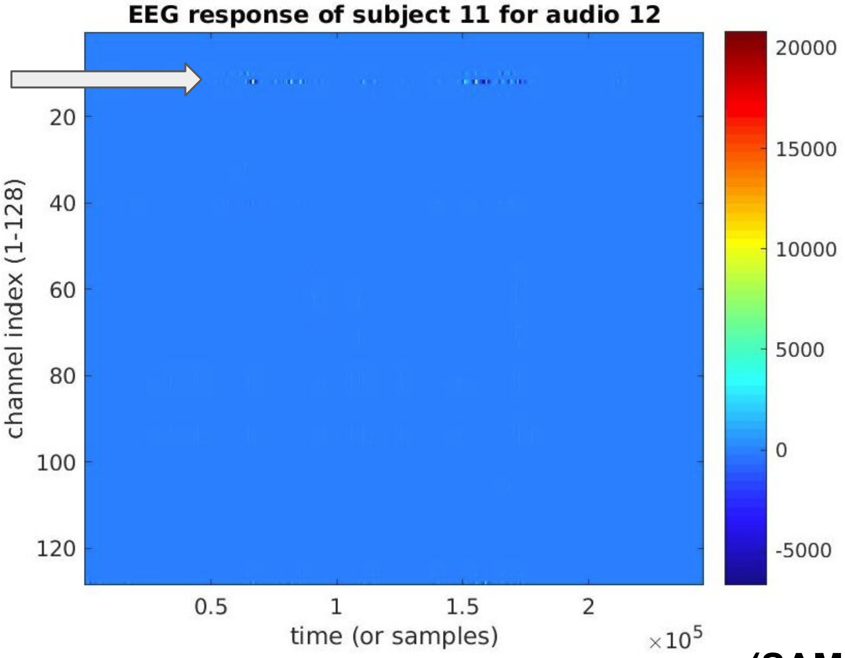
- Attention (Cocktail Party Problem)
  - How your brain processes complex acoustic scenes
  - Can identify and ***attend*** to one or few of the input stimuli
- Bottom-up vs Top-down
  - Top-down attention studies deal with goal-driven or task-driven attention. For example, listen to a specific source in multiple streams.
  - Bottom-up attention is concerned with involuntary attention. For example, how we notice a cell phone ringing in the middle of a class.
- EEG for attention
  - Bottom-up experiments without top-down factors are difficult to design
  - EEG enables ‘free-view’ parallel for auditory attention

# Experimental Setup for Data

- Data collected by LCAP@JHU
- Subjects listen to stimuli where a periodic tone is overlaid with **natural stimuli**
- Different from other datasets in stimulus space
- Targeted for studying Bottom-up attention
- Subjects listen to audio stimulus, and corresp. 128-D EEG response is recorded.

# Electroencephalography (EEG)

Refers to recording of electrical potential from scalp at multiple points (channels).



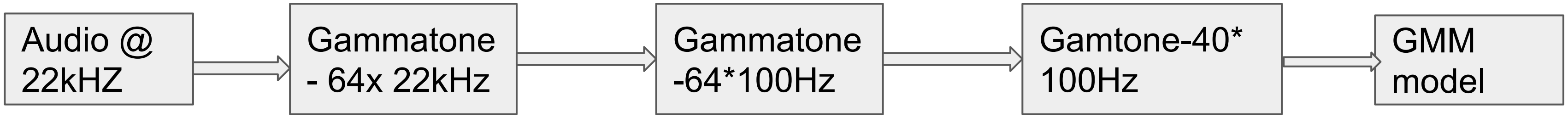

**(SAMPLE EEG RESPONSE)**

# Methodology

1. Salient event detection from audio (stimuli)
2. Salient event detection from EEG (response)
3. Analyze correlation between the results

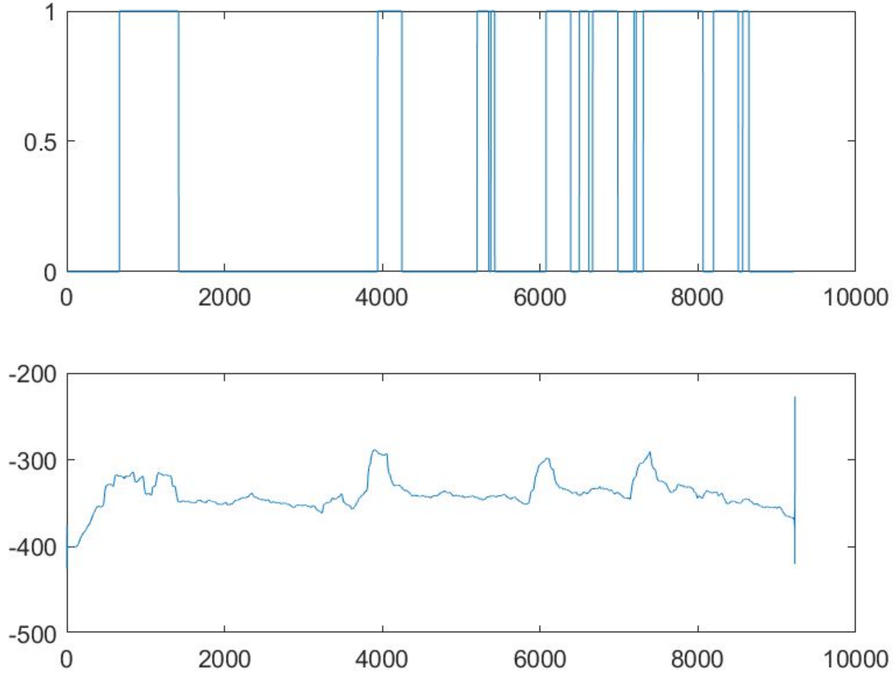
# Saliency from Stimulus

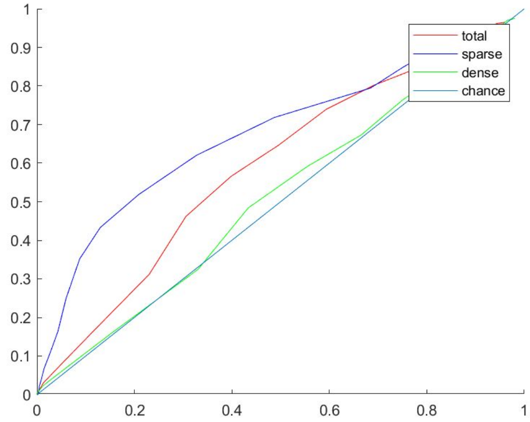
- We use the following pipeline for feature processing as proposed by [4]




- We compute PCA for the final stage by stacking 7 filter bands across 9 frames and sliding 3 bands at a time.
- PCA transformation is computed using 3Hrs data from BBC-sounds
- We use negative log-likelihood as a measure of saliency

# Saliency from Audio Stimulus




ROC for different stimulus

# EEG Pre-processing steps

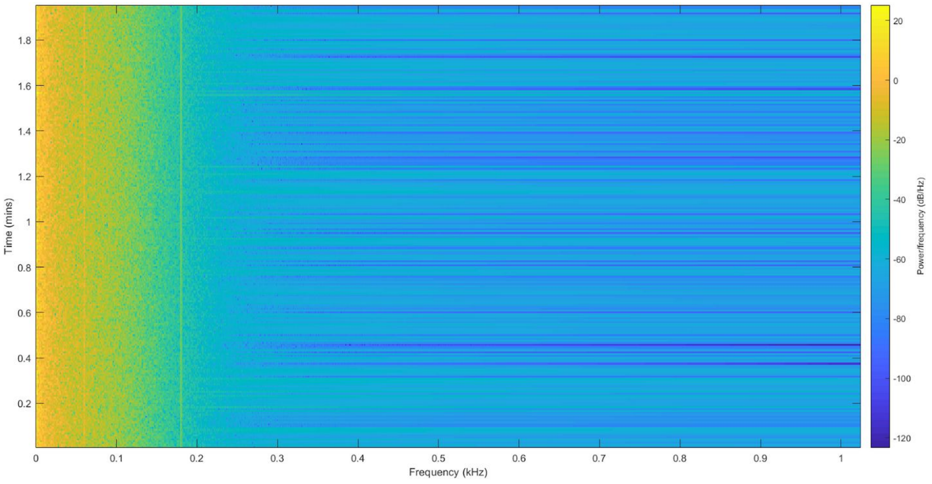
1. High-pass filtering @ 0.5 Hz (because of the presence of underlying highly non-stationary ‘drift’) [1]
   - also recommended if using ICA-based artifact removal later
2. Low-pass filtering @ <120 Hz ; because wave patterns recorded by EEG are low-frequency. [3]
3. Downsampling from sampling rate of 2048 to 300
4. Removal of noise due to power line
5. Removal of artifacts such as eye movement, heart sounds.

# Preprocessing - Line Noise removal

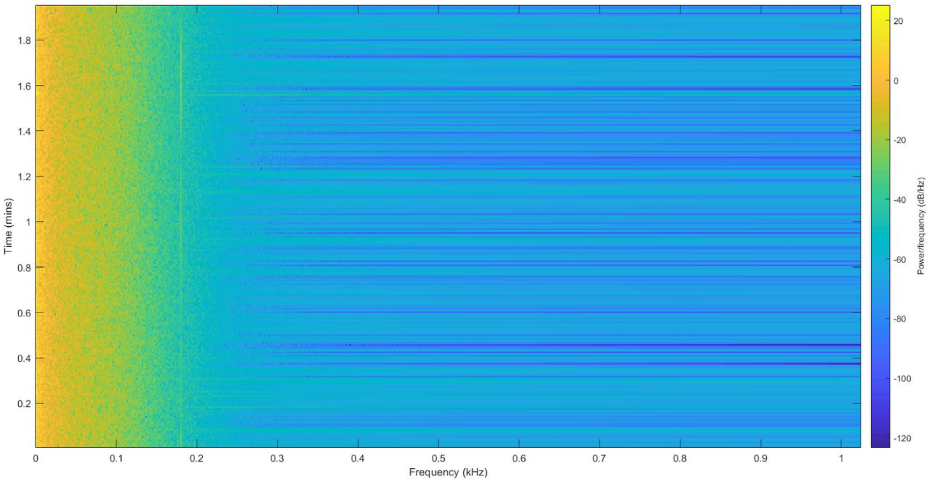
Due to electrical line, high noise is present at 60 Hz (& its harmonics at 120, 180).

Band-stop/notch filter is used to remove noise at those frequency values.

(before)




(after; not perfect)



# Preprocessing- muscle artifact removal

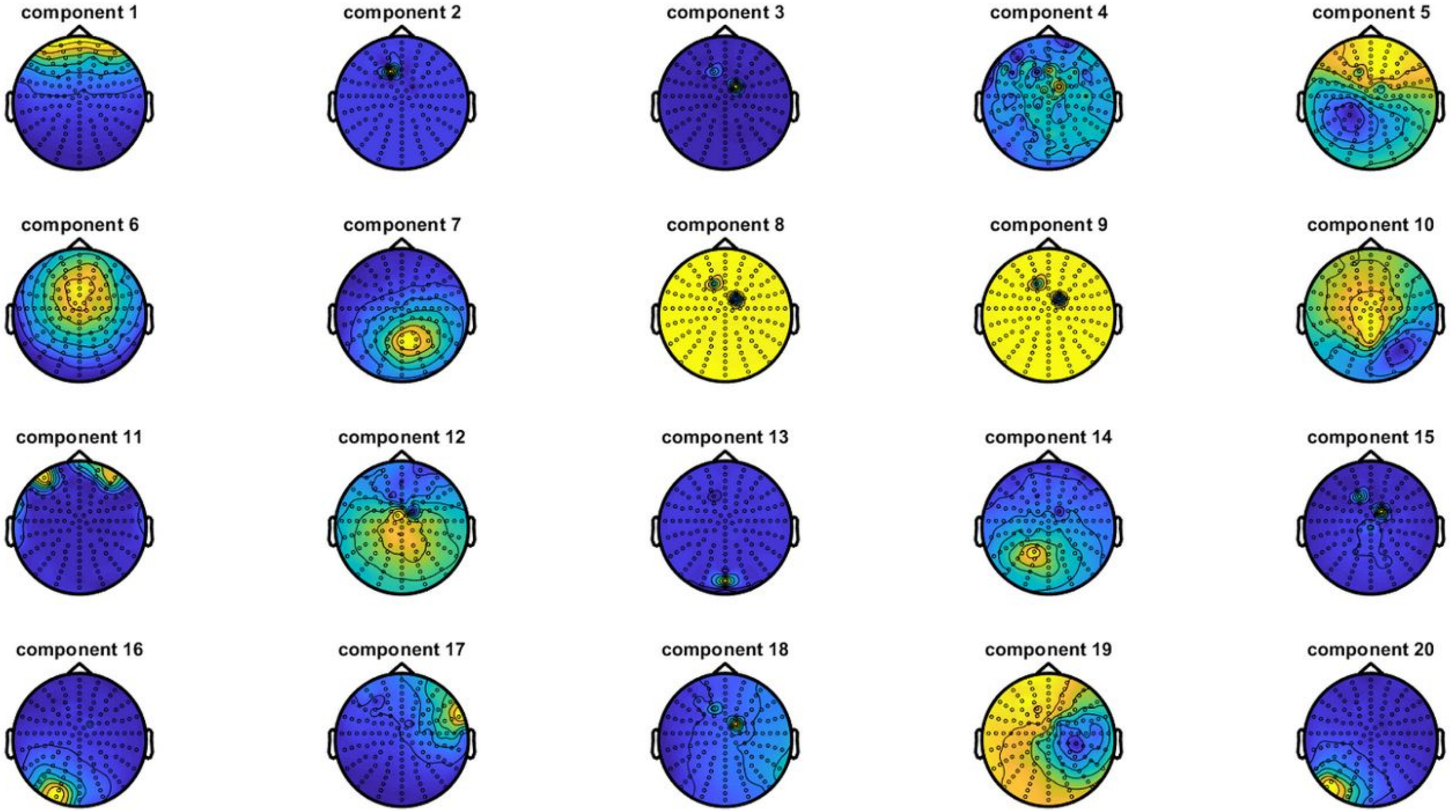
Approach: Independent Component Analysis (ICA) [6]

Hypothesis: Some components of ICA contains the effect due to artifacts such as eye muscle movement, facial movement, heart sounds, etc.

Challenge: How many components? and how to identify that component?

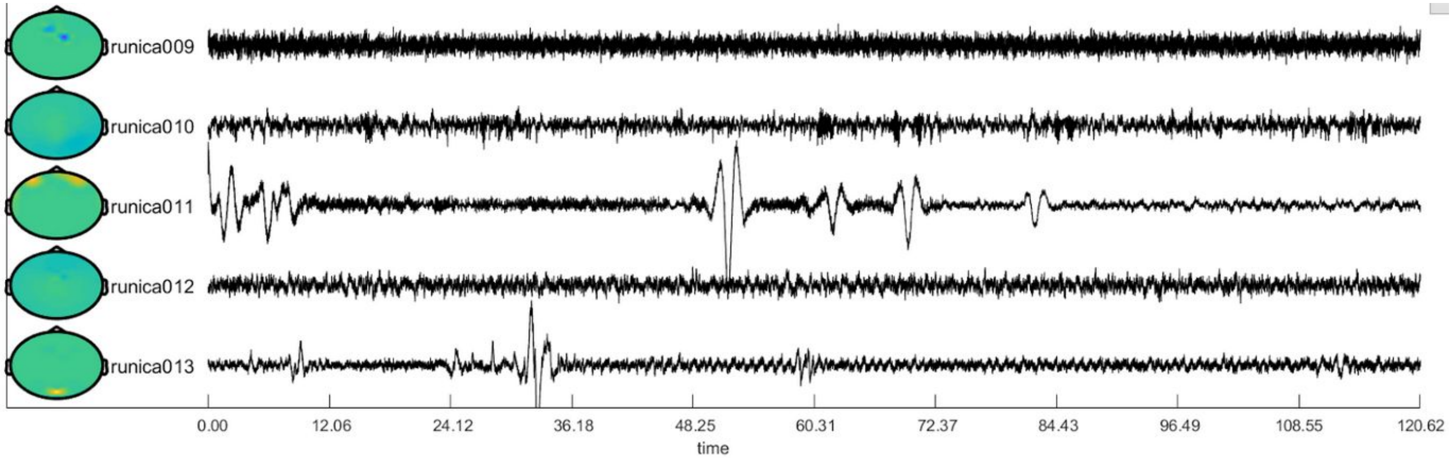
Solution: 1) Data will have significant variance along those components, 2) Identification by inspection of such components

# Preprocessing- muscle artifact removal (Illustration)



# Preprocessing- muscle artifact removal (Illustration)

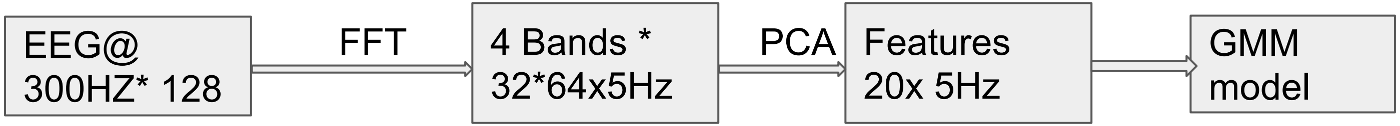
Channel 11 captures eye blink movement




Challenge: The component ID is different for different subjects. Hence, manual inspection is done for rejecting components.

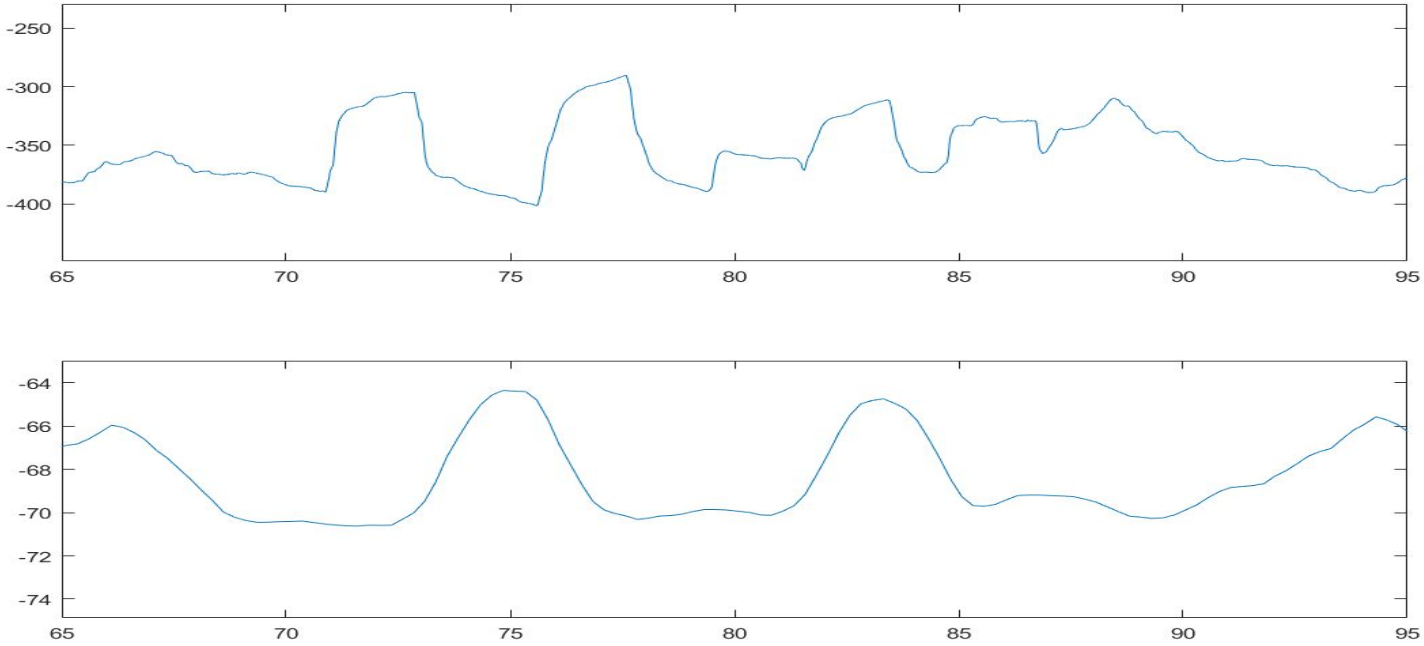
# EEG analysis- Event detection

- We follow similar principle to that we used for Stimulus

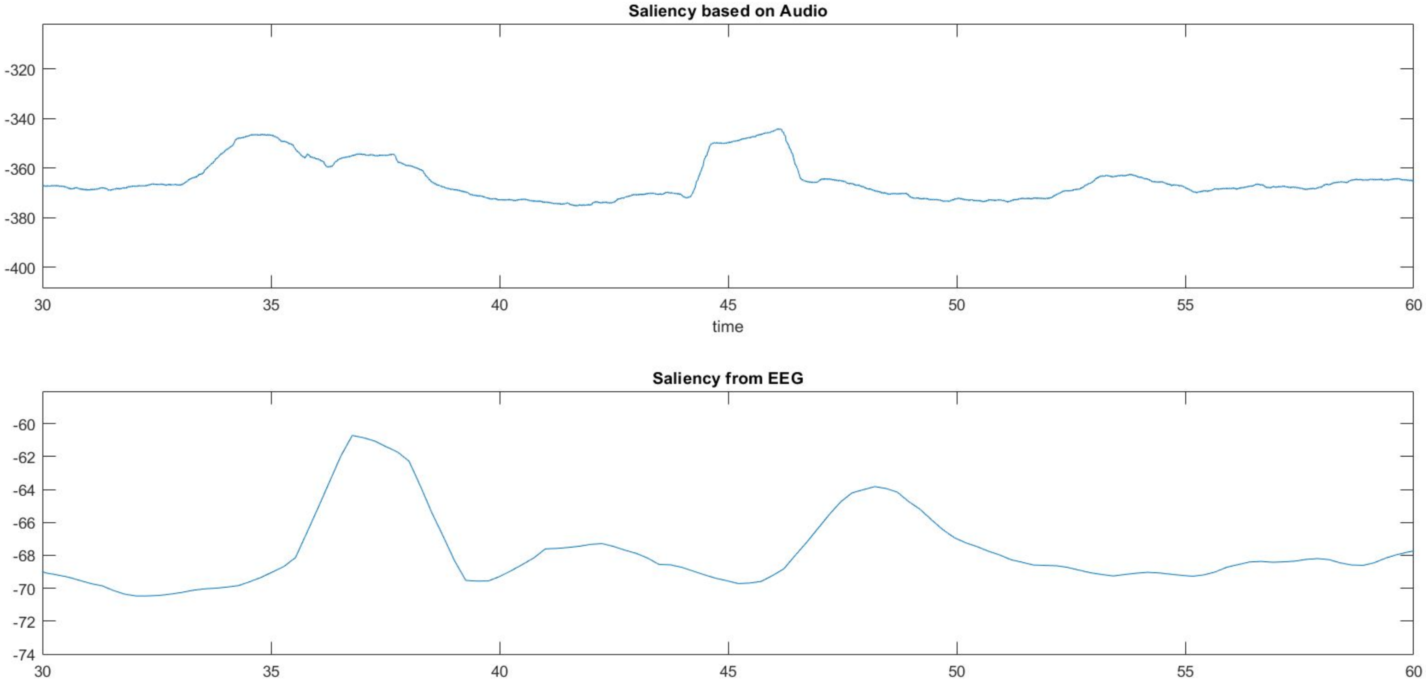



- We use all of a subject’s data to compute PCA and use that data to compute GMM parameters
- We use negative log likelihood to get saliency map

# EEG-Stimulus saliency comparison



# EEG-Stimulus saliency comparison



# Conclusion

This project presents an attempt to establish correlation between saliency curves from audio stimuli and EEG response.

For stimuli (audio), the model shows good results for sparse data.

In some trials, perceptually, the saliency curves of stimuli and EEG response does show correlation with some delay.

# Thank you

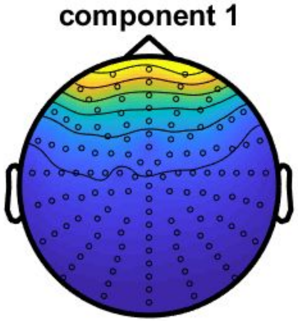
# References

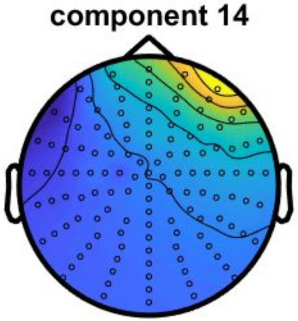

1. Winkler, Irene, et al. "On the influence of high-pass filtering on ICA-based artifact reduction in EEG-ERP." Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE. IEEE, 2015.
2. Joyce, Carrie A., Irina F. Gorodnitsky, and Marta Kutas. "Automatic removal of eye movement and blink artifacts from EEG data using blind component separation." Psychophysiology 41.2 (2004): 313-325.
3. https://www.wikiwand.com/en/Electroencephalography#/Normal_activity
4. Tsuchida, Tomoki, and Garrison Cottrell. "Auditory saliency using natural statistics." Proceedings of the Cognitive Science Society. Vol. 34. No. 34. 2012.
5. Oostenveld, Robert, et al. "FieldTrip: open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data." Computational intelligence and neuroscience 2011 (2011): 1.
6. Makeig, Scott, et al. "Independent component analysis of electroencephalographic data." Advances in neural information processing systems. 1996.
7.

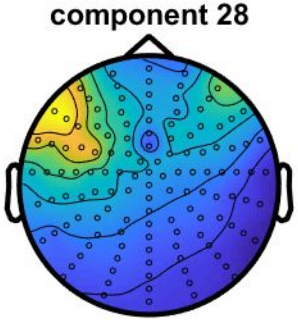
# Extra slide: rhythmic frequency range from Wikipedia [3]

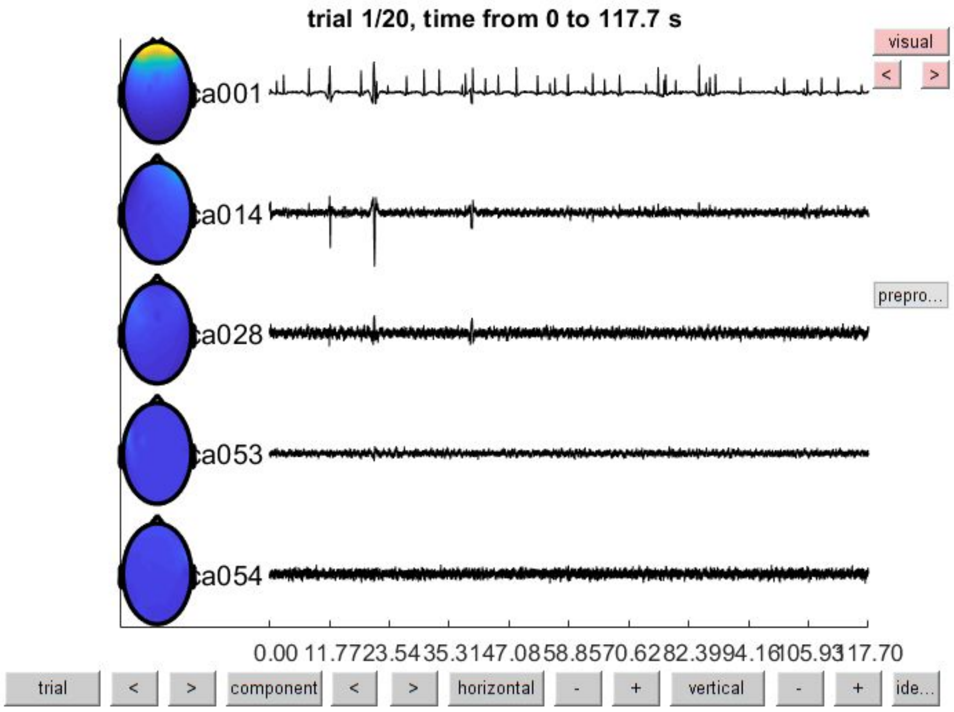
- Frequency based
  - Delta: < 3.5 Hz
  - Theta: 3.5-7.5 Hz
  - Alpha: 7.5-13 Hz
  - Beta: > 13 Hz
  - Rhythmic, arrhythmic, disrhythmic

# Extra plots showing ICA pre-processing




Subjective opinion: Comp 1 corresp to heart beatbeat, comp 14, 18 corresp to eyeblink movement

# Extra slide: layout of EEG electrodes for our setup