Identifying Neural Waveforms From Vagus Nerve Recordings

- METHOD TO EXTRACT NEURAL EVENTS FROM RAW RECORDINGS (MATLAB).

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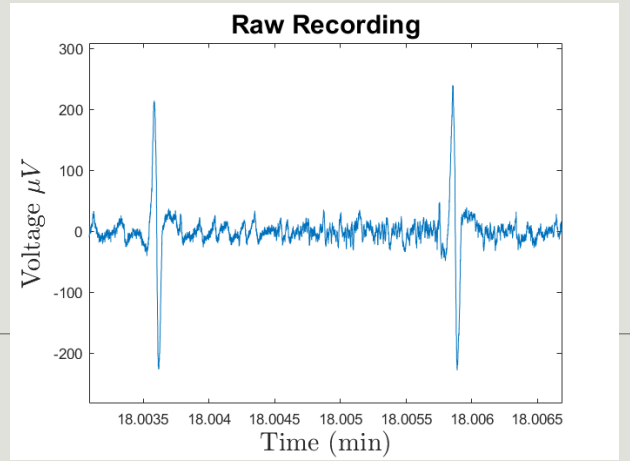
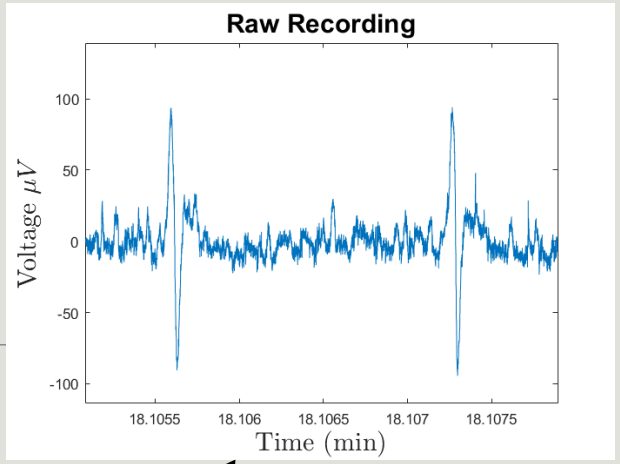
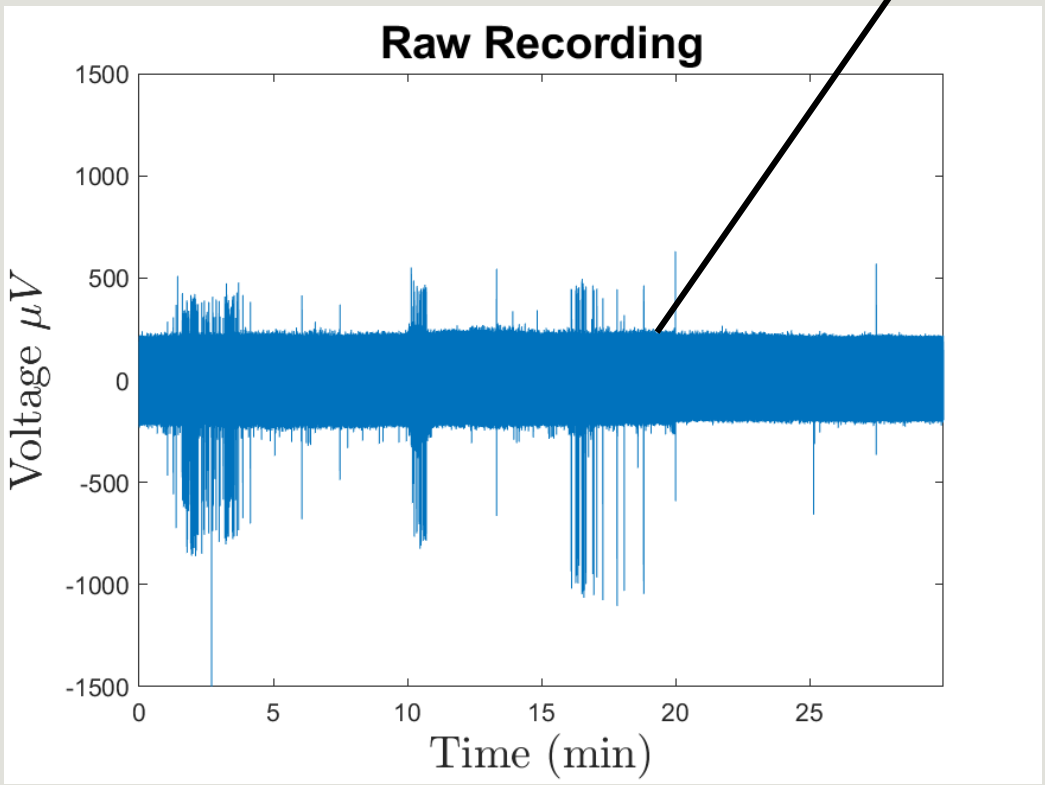
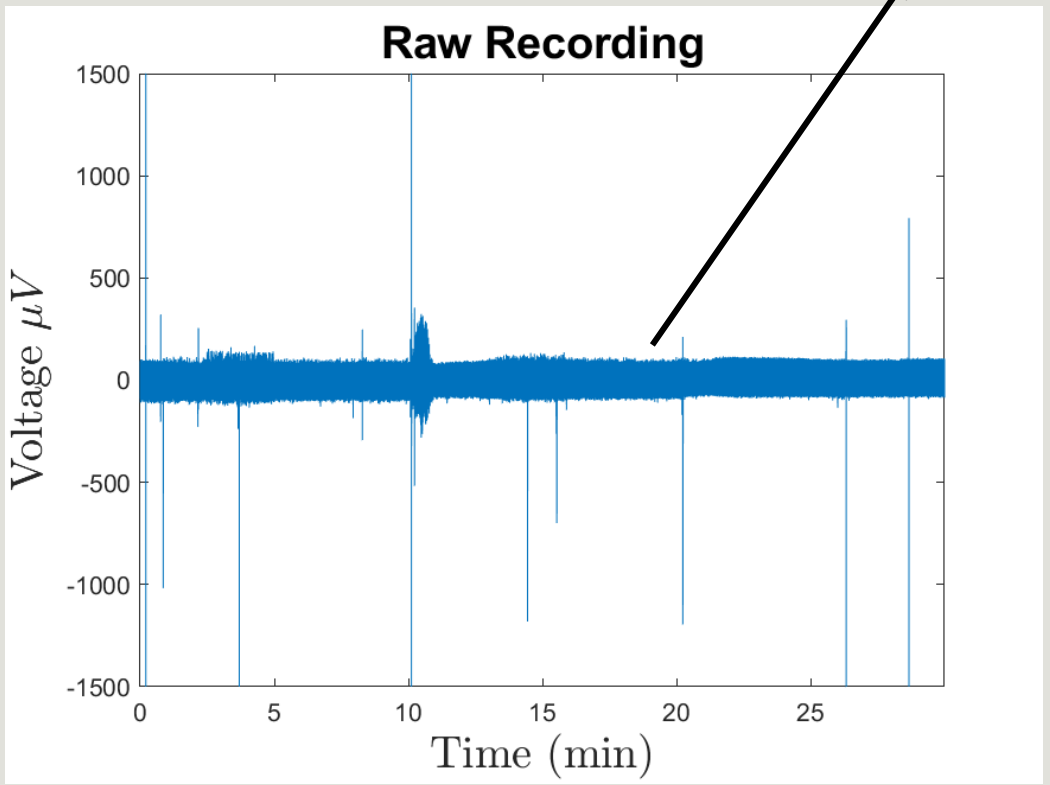
Pre-processing

Raw Signal









Main Steps in Pre-processing

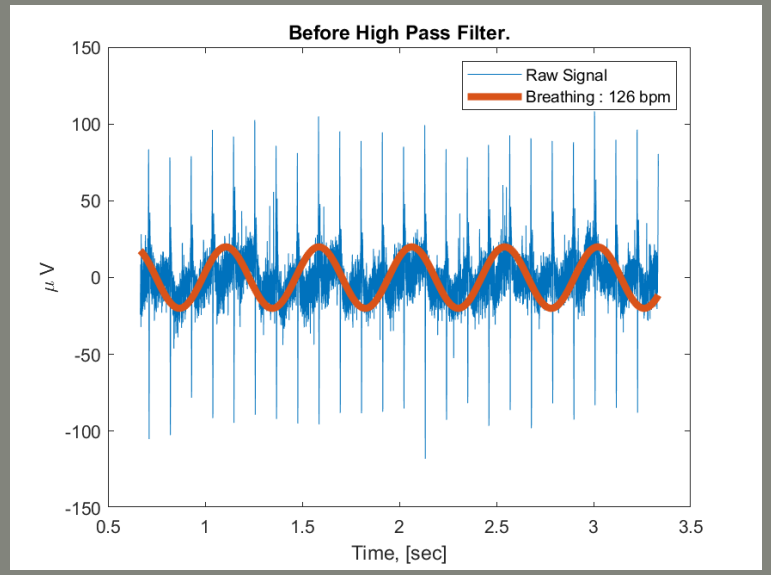
Aim to find all Compound Action Potentials (CAPs) from raw recording.

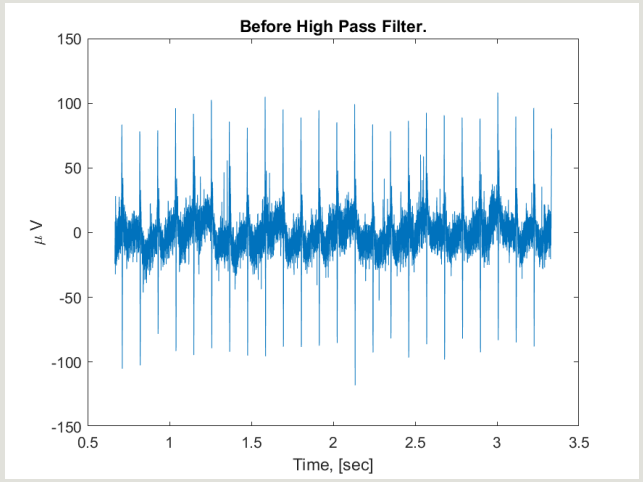
- High pass filter – Removes low frequencies from raw signal
- (Downsample – Solve memory issues and speed up computations.)
- **Adaptive Threshold** – Extracting the Neural Event from noise and other sources of interference. (e.g. cardiac events)

Pre-processing

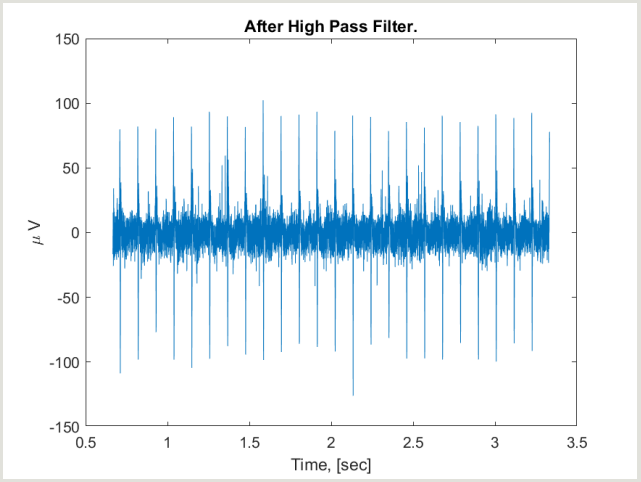
1. High Pass Filter (hpf)

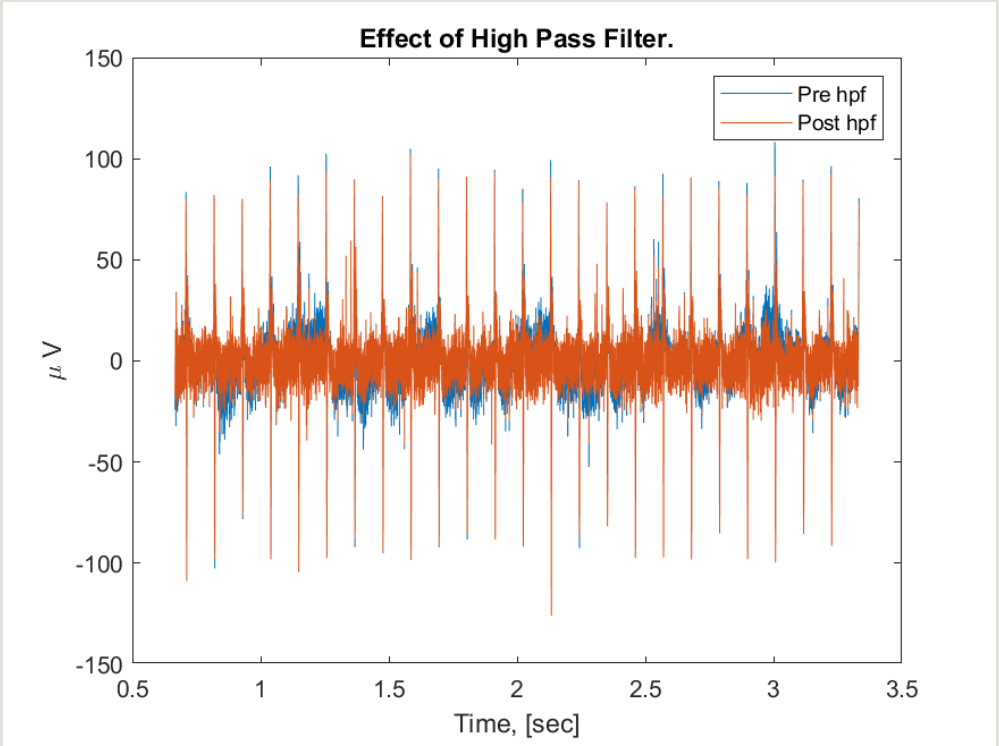
- Remove frequencies in signal below 10Hz.
- Assumes that this remove noise sources related, e.g. to micromovements of electrode caused by respiratory movements
- Respiratory rate in mice 80-230 bpm. (1.3 – 3.8 Hz)





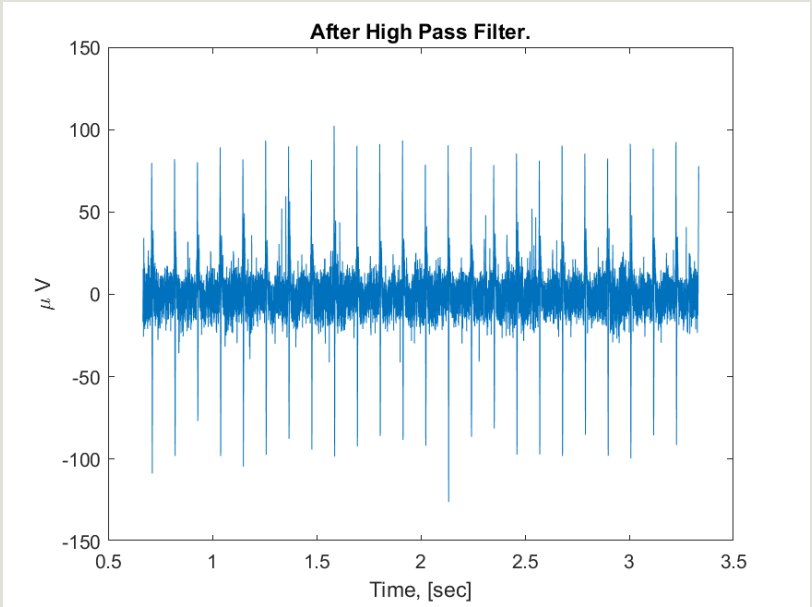
hpf

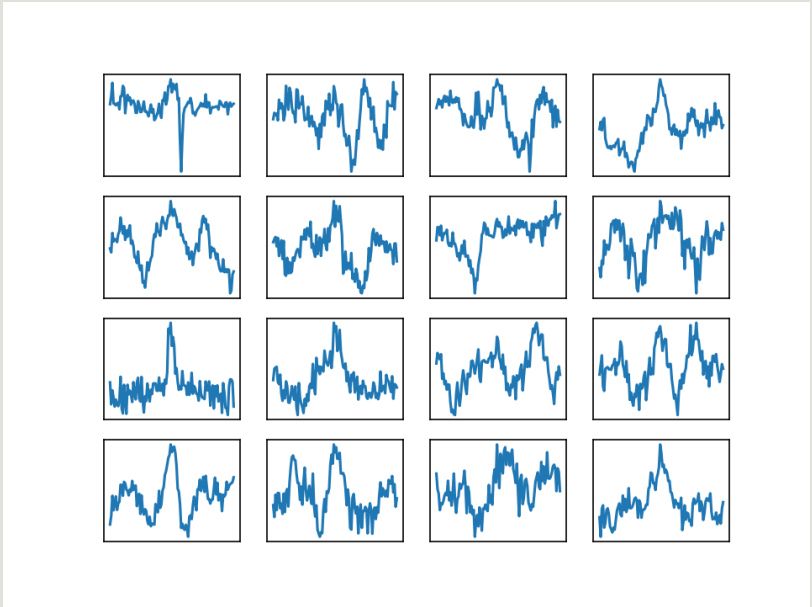




Pre-processing
2. Adaptive - Threshold

Overview -- Extracting signal (CAPs) from noise and other sources of interference:

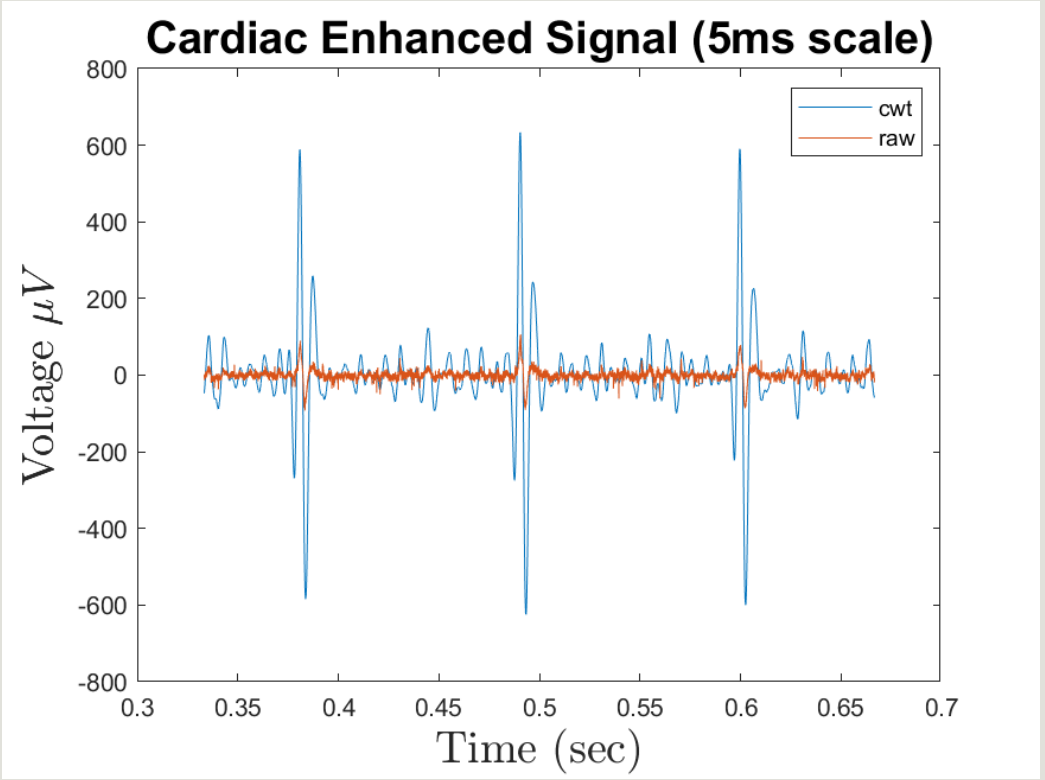




Pre-processing
2. Adaptive - Threshold

Includes:

- Get signal where cardiac events are emphasized -- event of the 5ms scale. (Wavelet transform)



Pre-processing
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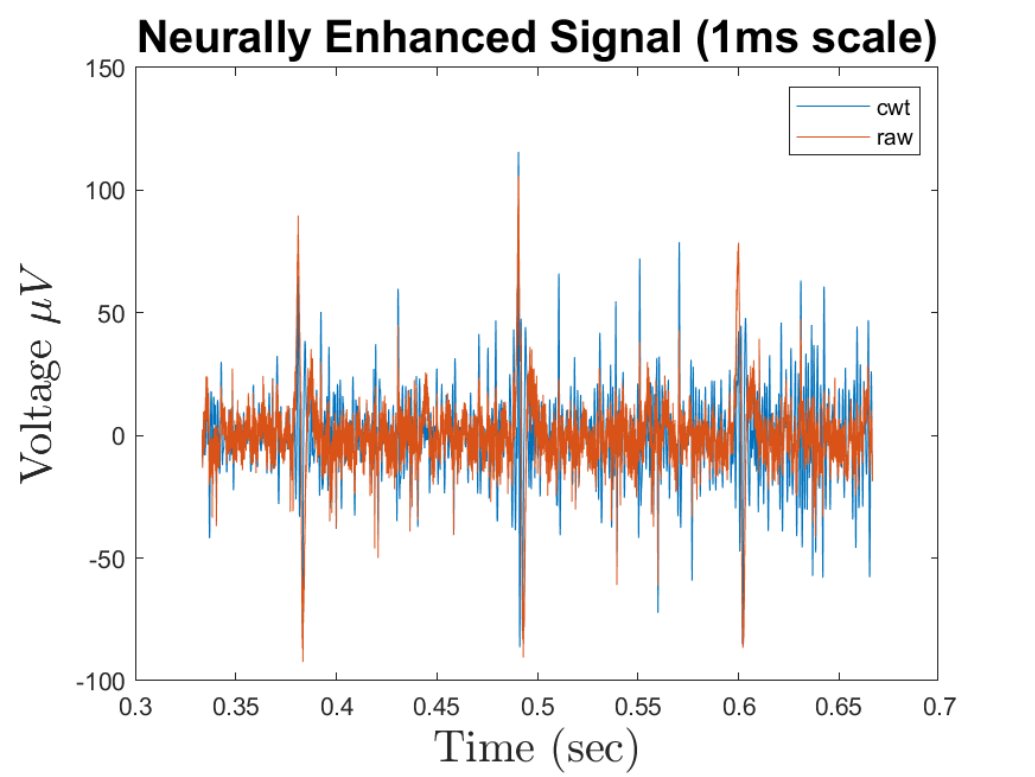
Includes:

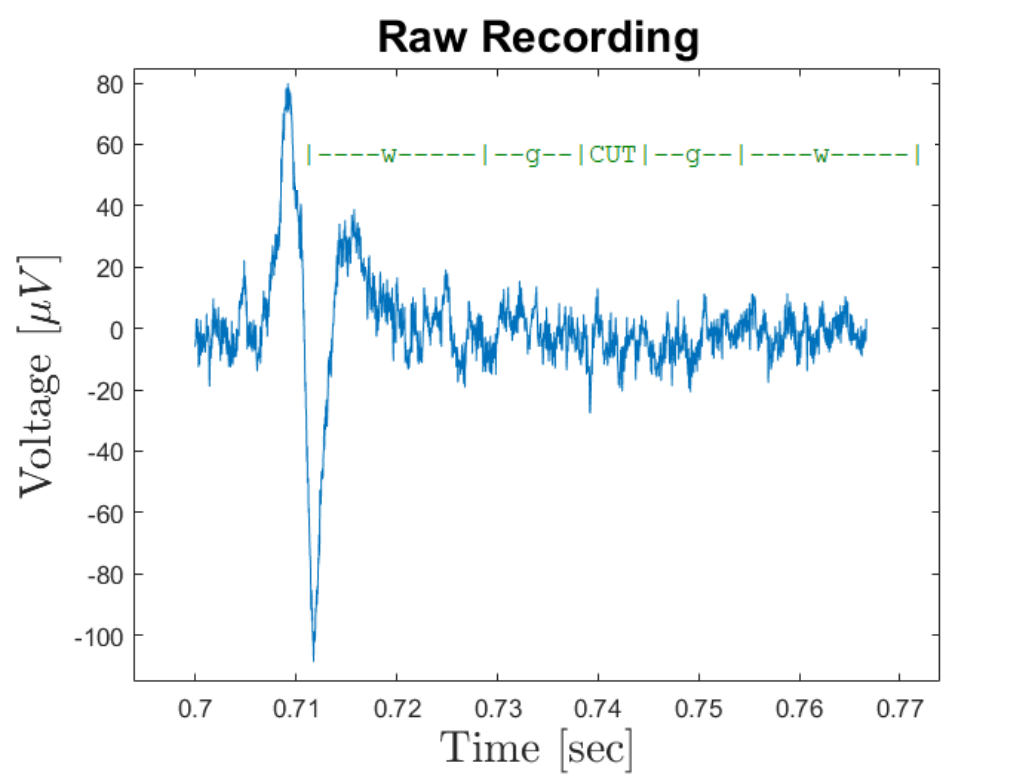
- Get signal where cardiac events are emphasized -- event of the 5ms scale. (Wavelet transform)
- Get signal where neural events are emphasized -- event of the 1ms scale. (Wavelet transform)



Pre-processing
2. Adaptive - Threshold

Includes:

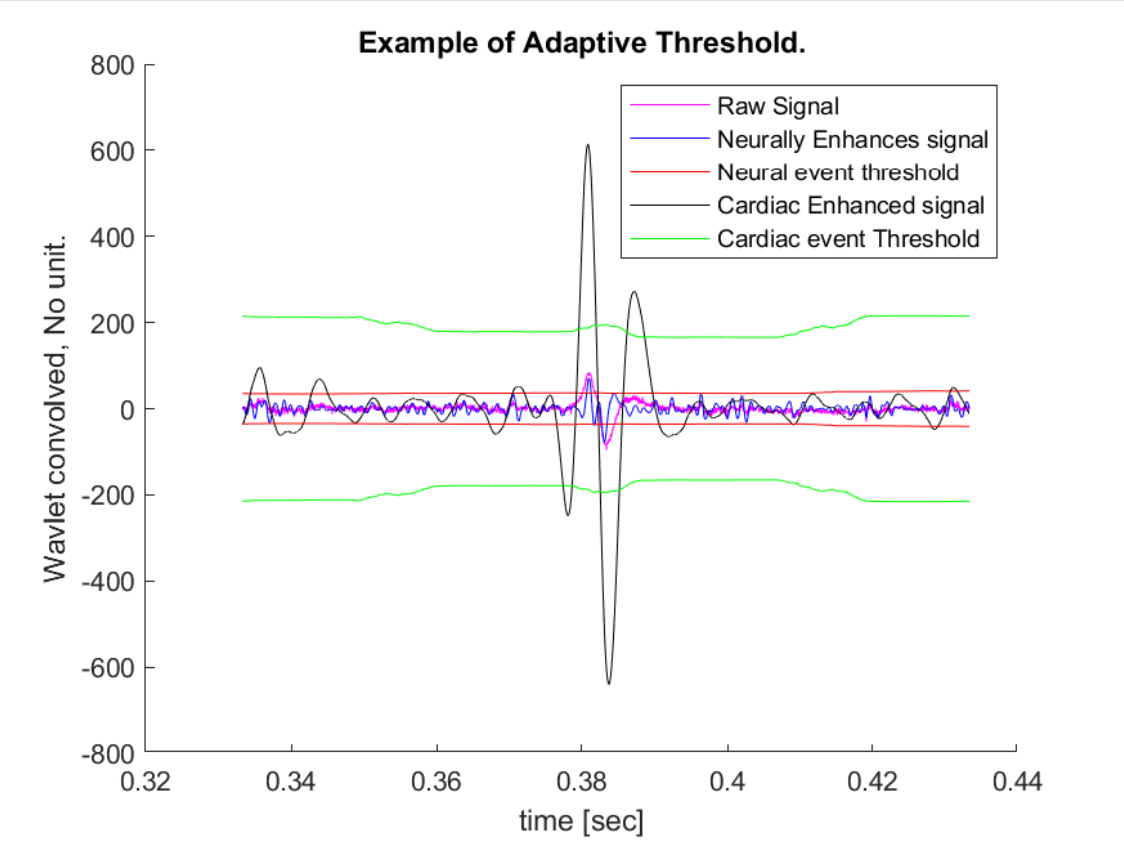
- Get signal where cardiac events are emphasized -- event of the 5ms scale. (Wavelet transform)
- Get signal where neural events are emphasized -- event of the 1ms scale. (Wavelet transform)
- Use a sliding window, calculating the local-in-time noise-level for the two signals. (background statistics)
  - "CUT" : "Cell Under Test".
  - w : windows where the standard deviation is estimated
    - w = 188ms
  - g : "guard" regions – a possible signal in the "CUT" should not corrupt the SD-estimate.
    - g = 13 ms



Pre-processing
2. Adaptive - Threshold

Includes:

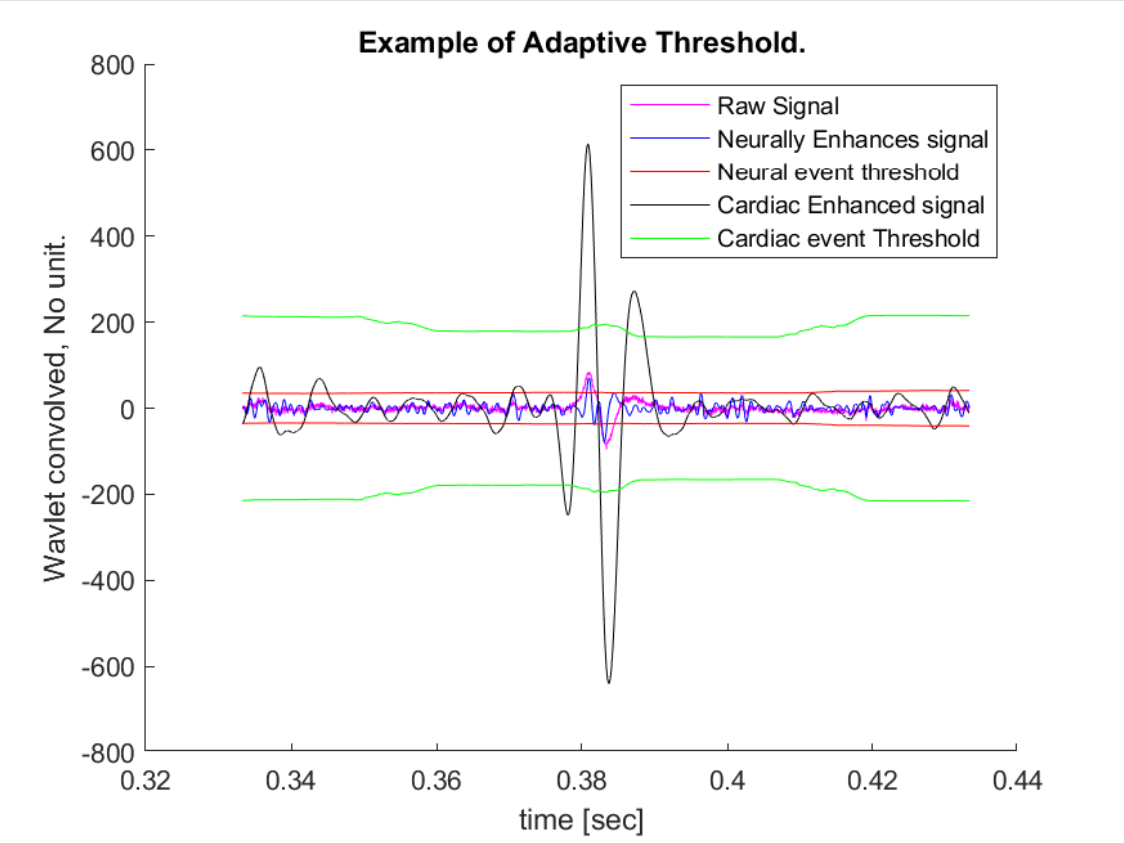
- Get signal where cardiac events are emphasized -- event of the 5ms scale. (Wavelet transform)
- Get signal where neural events are emphasized -- event of the 1ms scale. (Wavelet transform)
- Use a sliding window, calculating the local-in-time noise-level for the two signals. (background statistics)
- Extract cardiac- and neural events that deviated more than 3 SD from mean for both signals.



Pre-processing
2. Adaptive - Threshold

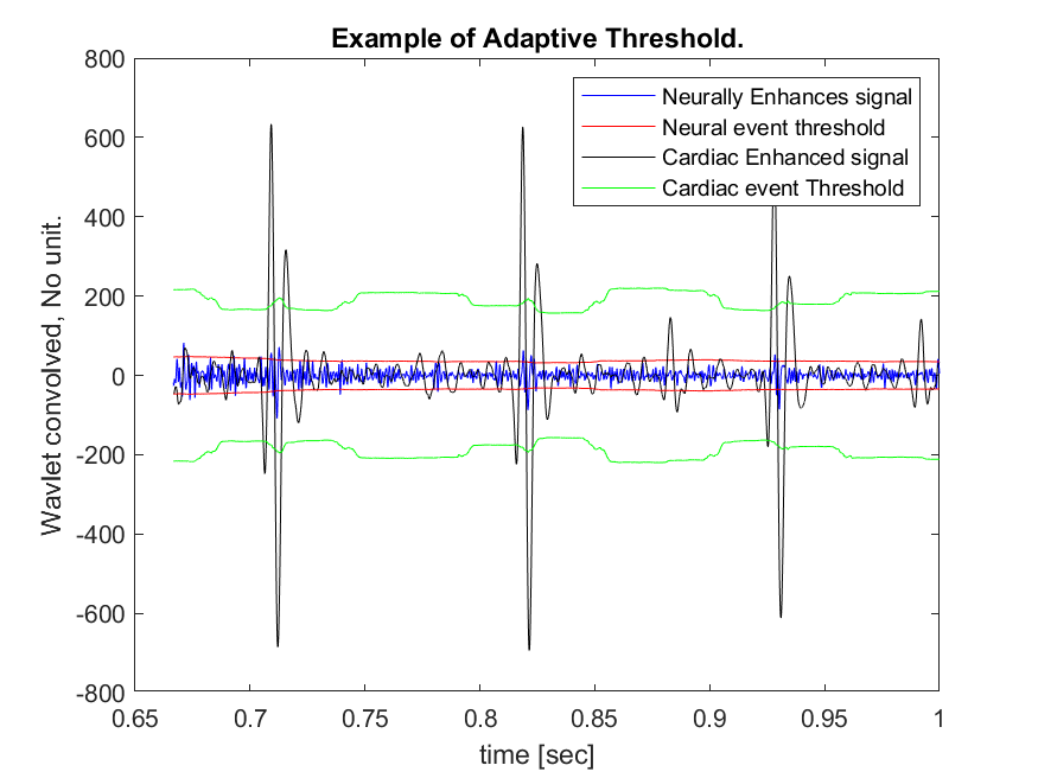
Includes:

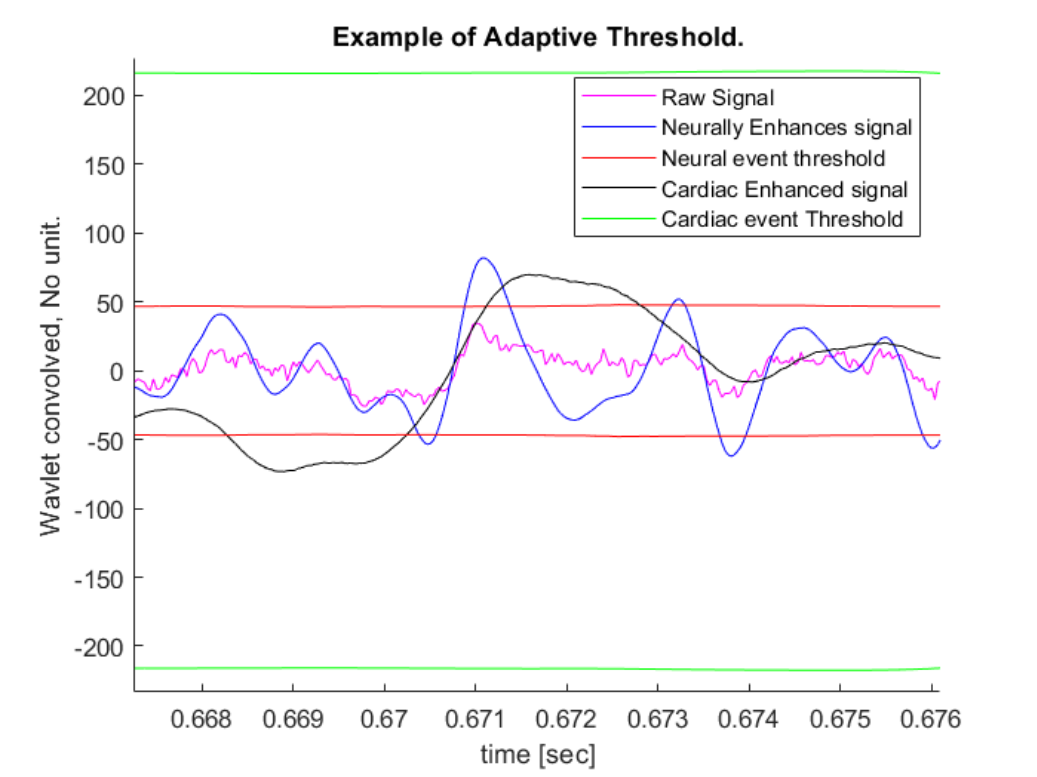
- Get signal where cardiac events are emphasized -- event of the 5ms scale. (Wavelet transform)
- Get signal where neural events are emphasized -- event of the 1ms scale. (Wavelet transform)
- Use a sliding window, calculating the local-in-time noise-level for the two signals. (background statistics)
- Extract cardiac- and neural events that deviated more than 3 SD from mean for both signals.
- Discard neural events that cooccur with cardiac events.



Pre-processing

2. Adaptive - Threshold

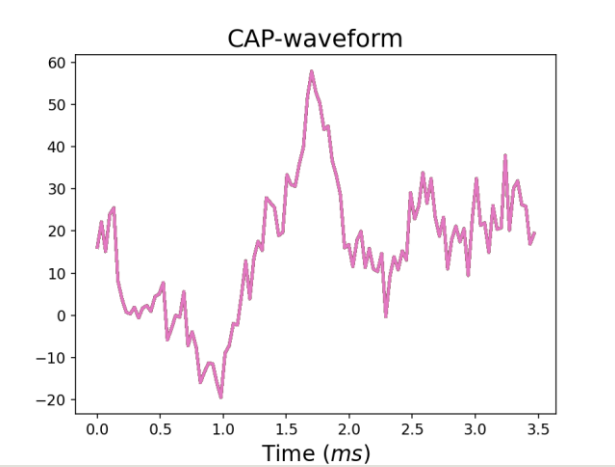


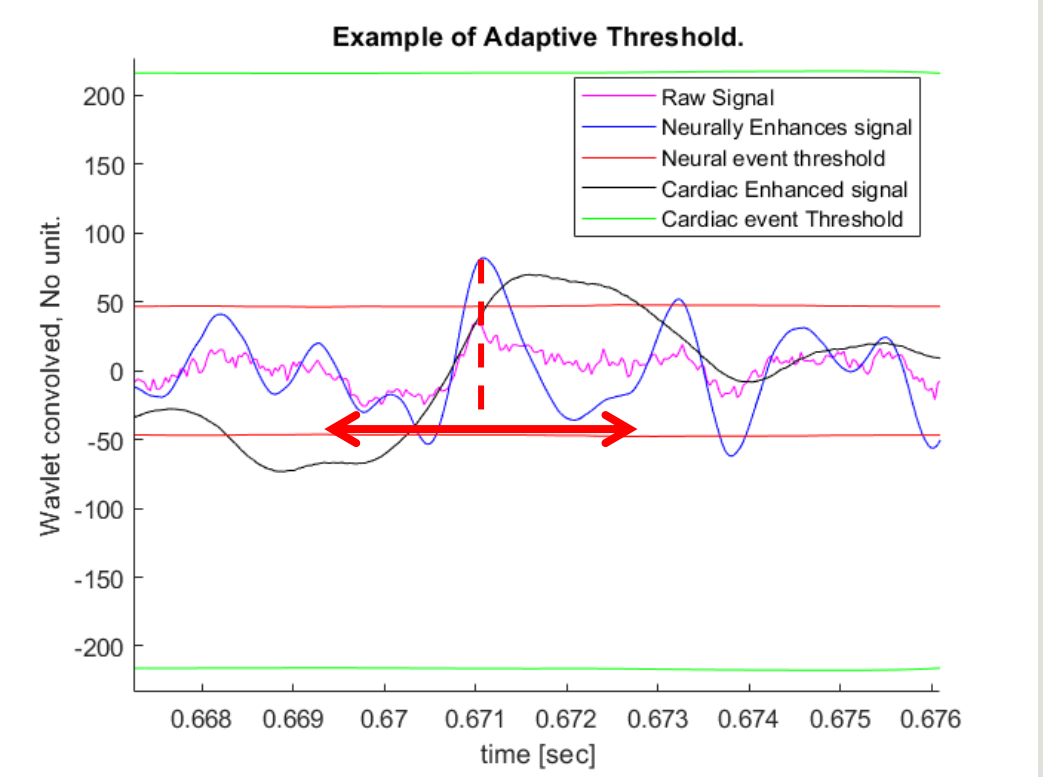


Pre-processing
2. Adaptive - Threshold

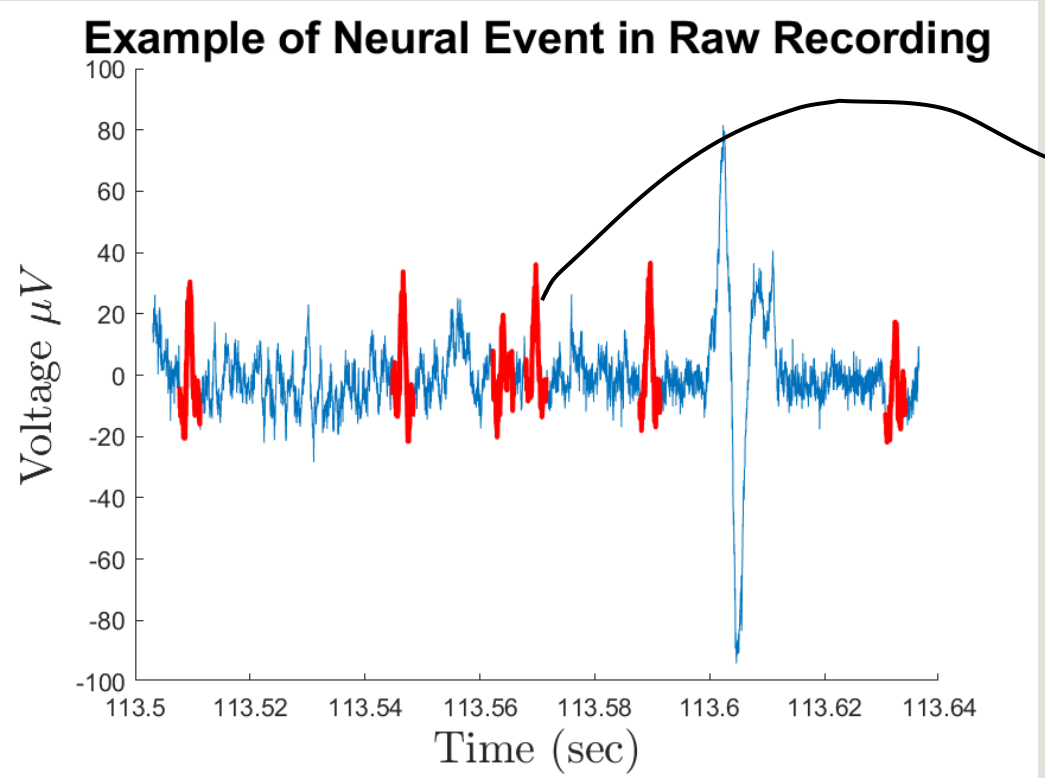
The extracted CAPs / waveforms are:

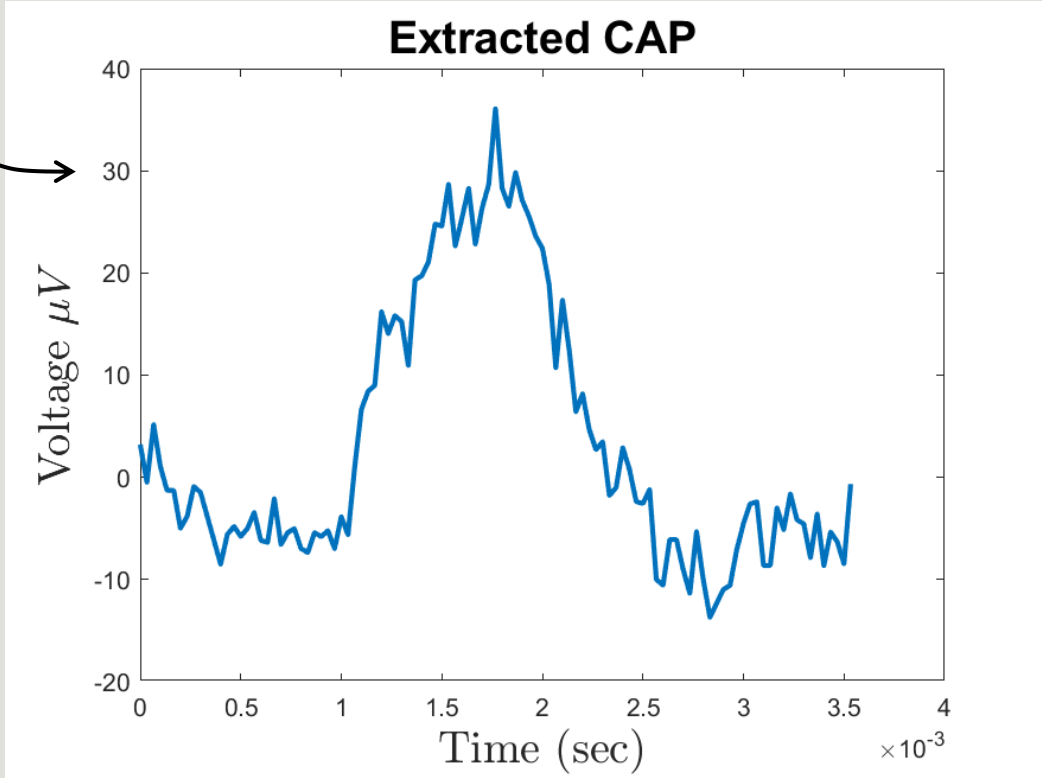
- Assumed to be 3.5 ms in duration
- ”max-centered” – the max peak is placed at the 1.75 ms mark.
- Example: (Not corresponding to right figure ->)





Example of Extracted Waveforms

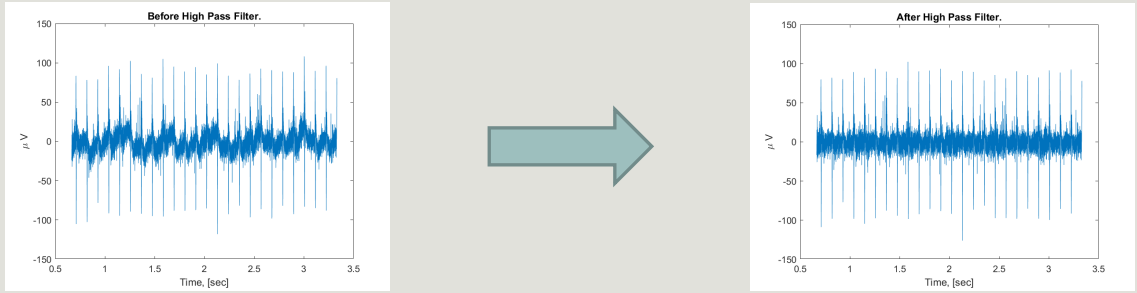




Summary – Identifying CAPs

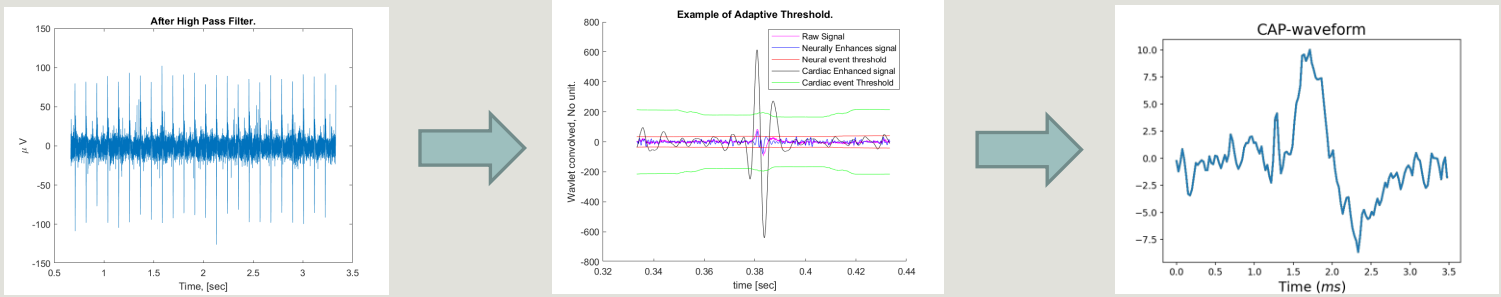
High Pass Filter

- Remove low frequencies



Adaptive Threshold

- Emphasize Neural/Cardiac events
- Apply threshold
- Disregard CAPs that cooccur with cardiac events.



Amplitude threshold (Python)

- Waveforms with a max-amplitude larger than a specific value are discarded.