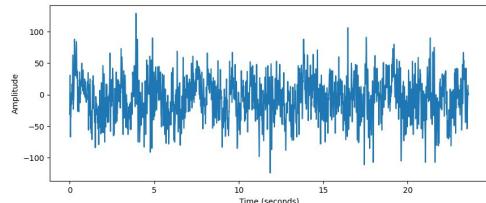


# EEG Data Analysis

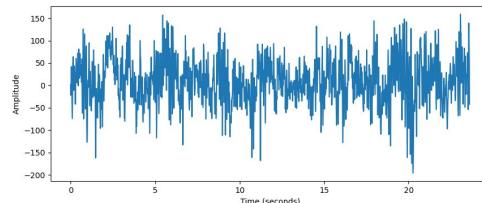
Jyotiraj Nath

(MSc Dissertation at Center for Quantum Science and Technology)

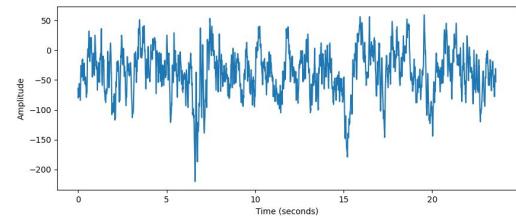
# Original Signals of all 5 datasets (Channel: 8)



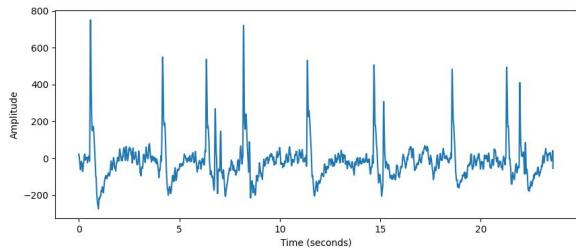
Healthy eyes open



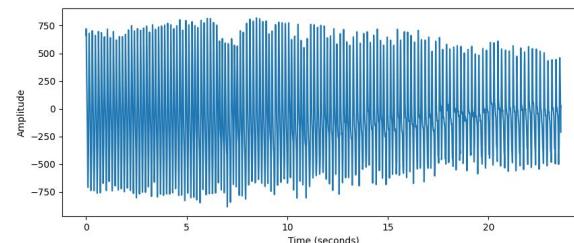
Healthy eyes closed



Epileptic patient  
(Hippocampal)

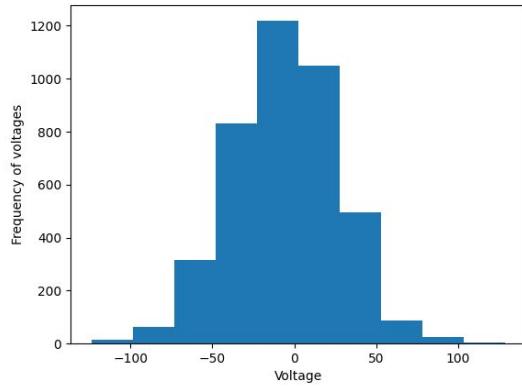


Epileptic patient  
(Epi. Zone)



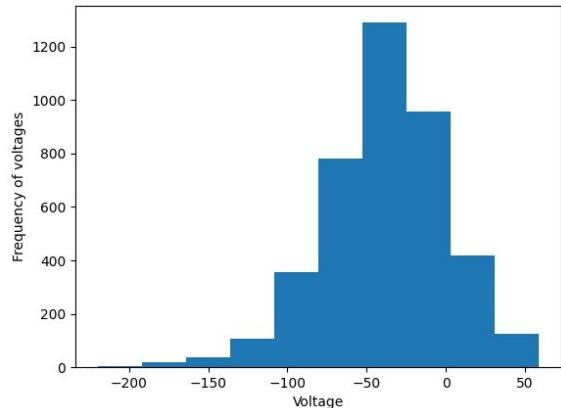
During Epilepsy

# Histogram of all 5 (channel 8)

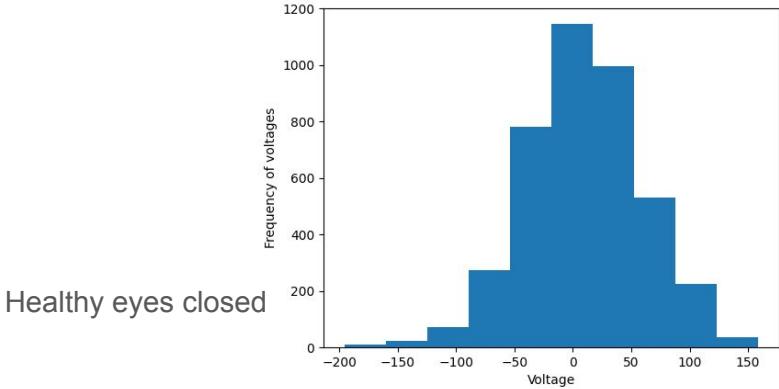


Epileptic patient  
(Hippocampal)

Healthy eyes open

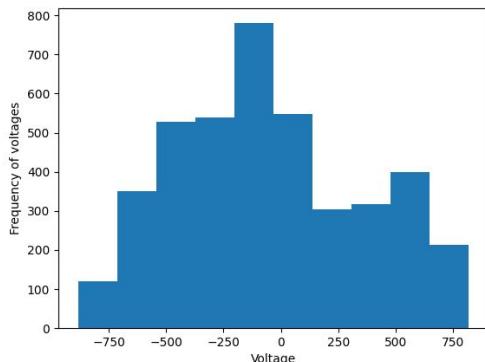
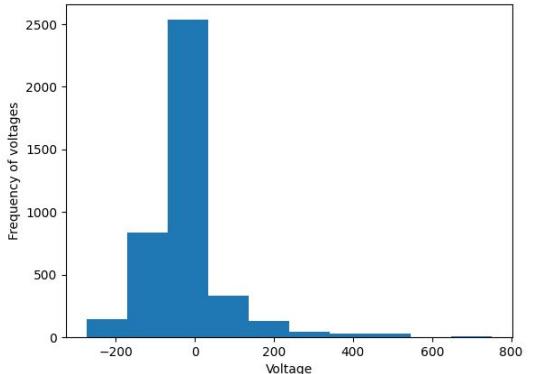


Epileptic patient  
(Eppi. Zone)

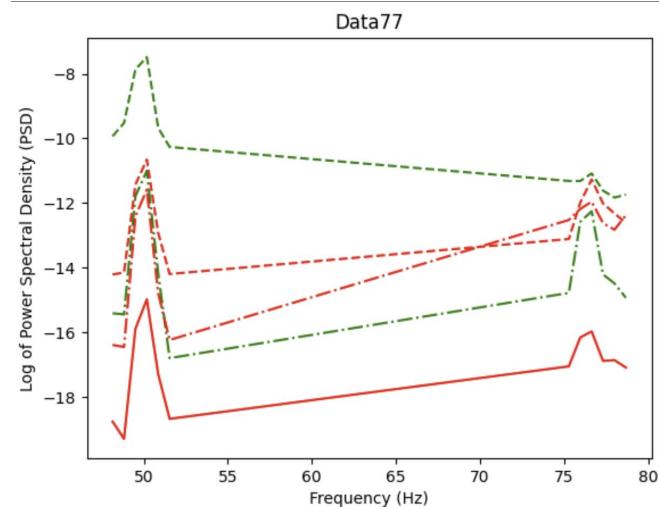
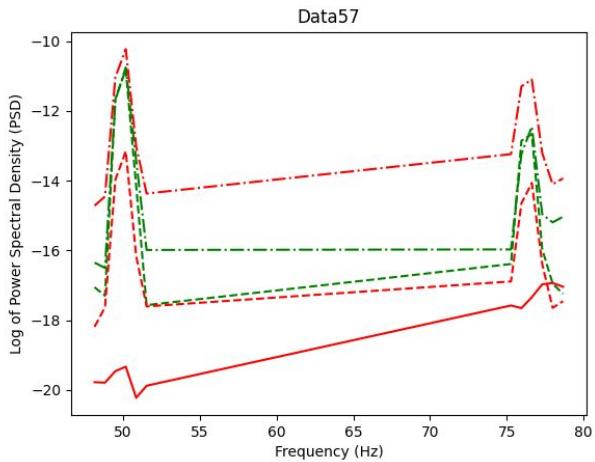
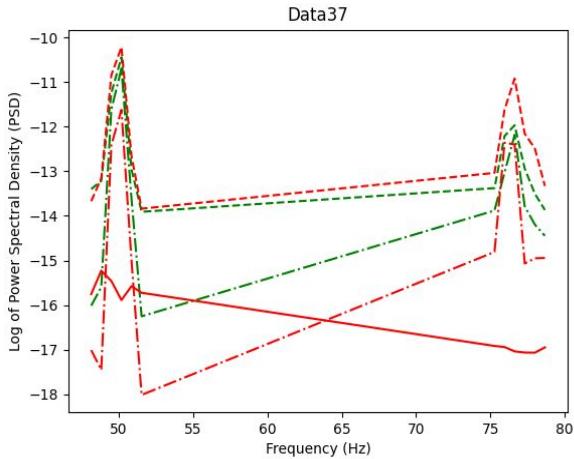
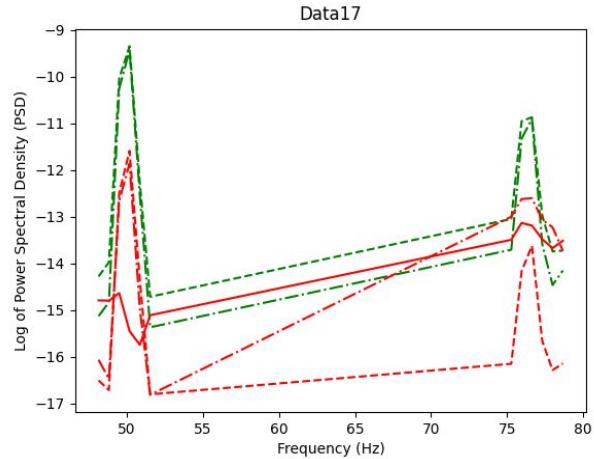


Healthy eyes closed

During Epilepsy

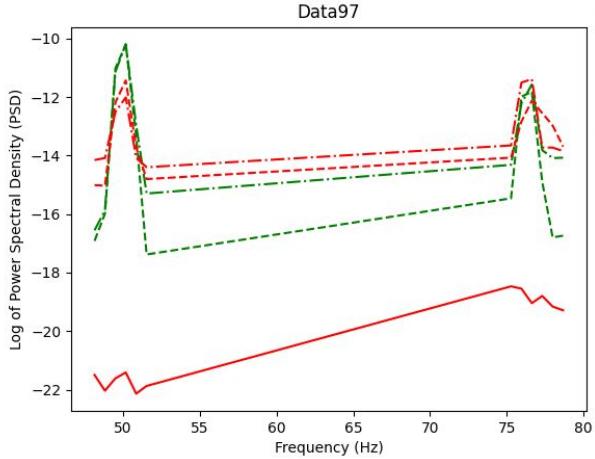


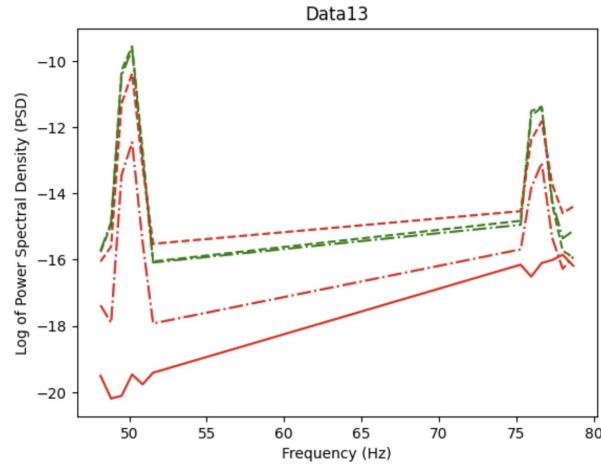
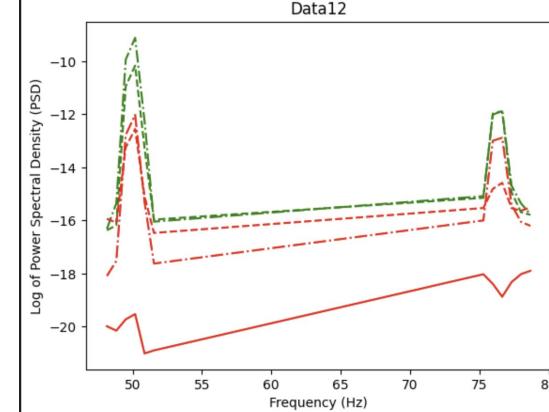
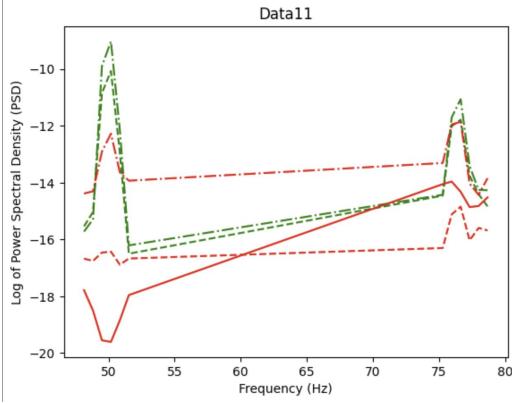
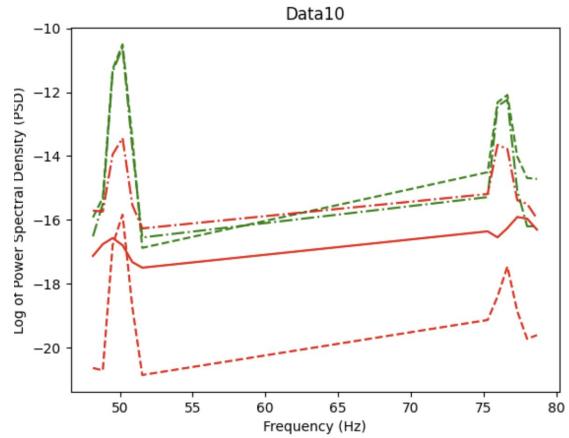
# AVERAGE STATISTICS



- Healthy\_eyes\_open
- Healthy\_eyes\_closed
- Epileptic\_hippocampus
- Epileptic\_epilepsy region
- Epileptic\_during\_seizure

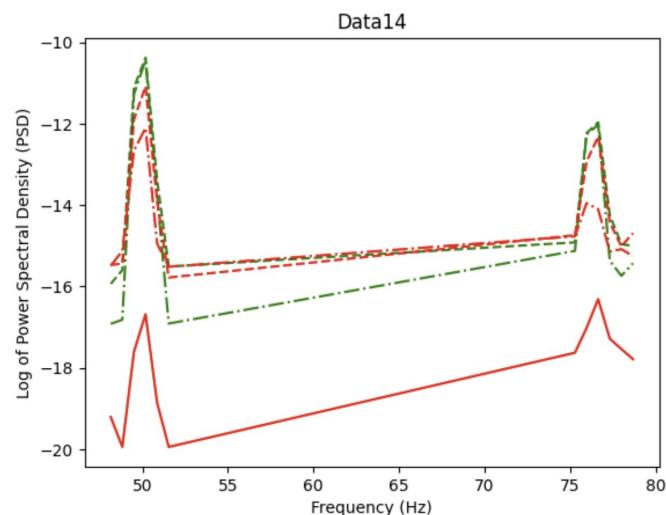
Smoothen DATA with  
25 bins DATA, peak  
range: peak1-> 48,  
52; peak2= 69, 73

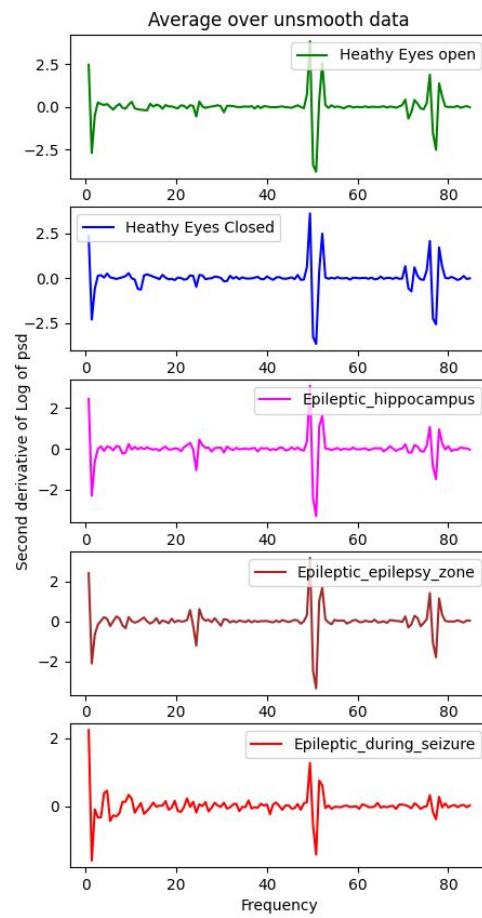
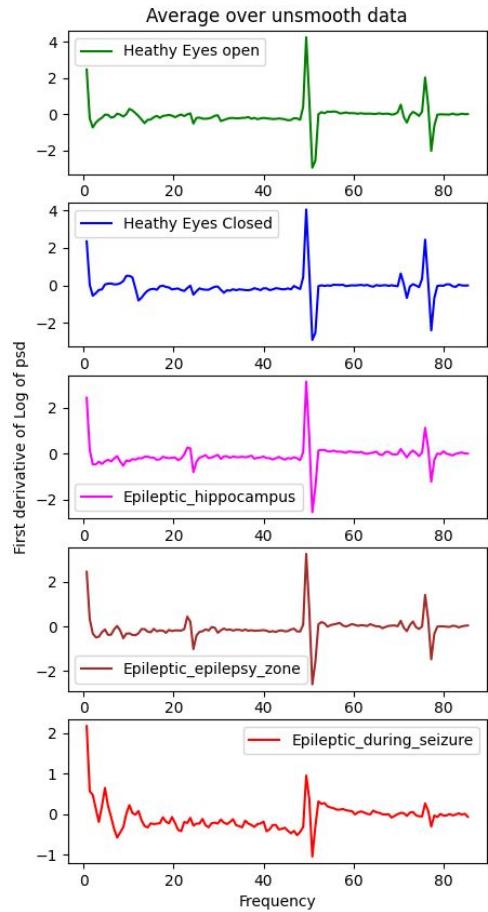
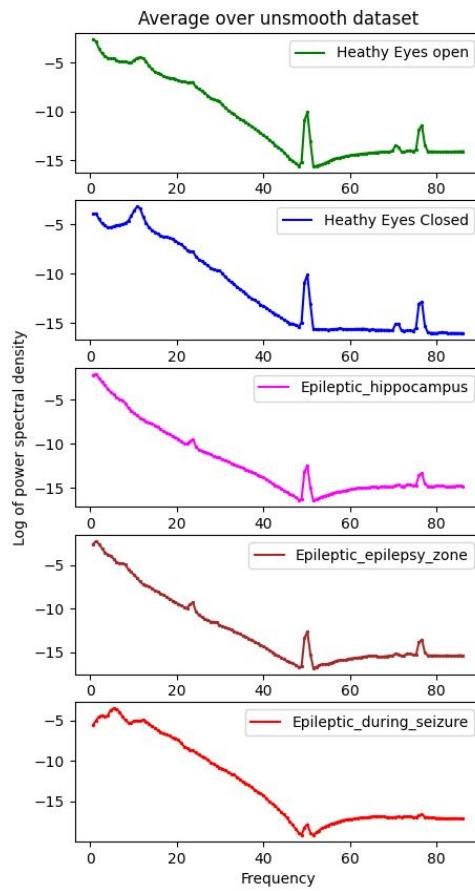


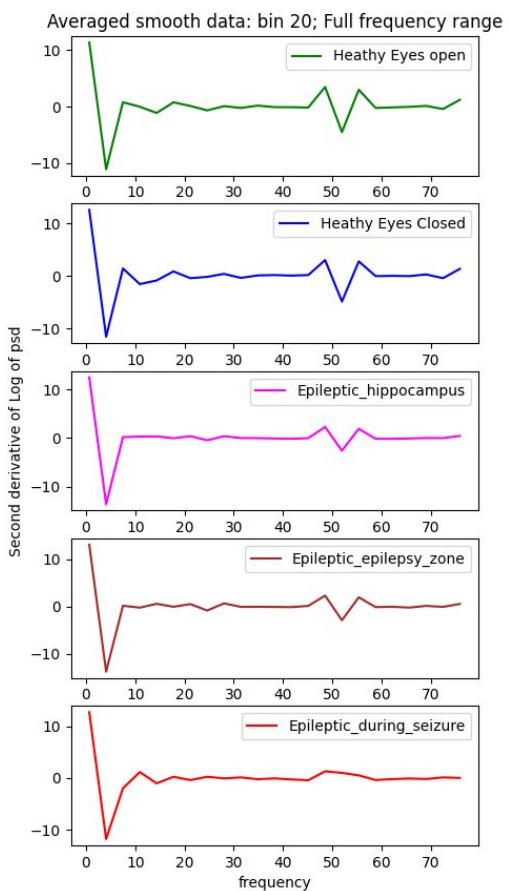
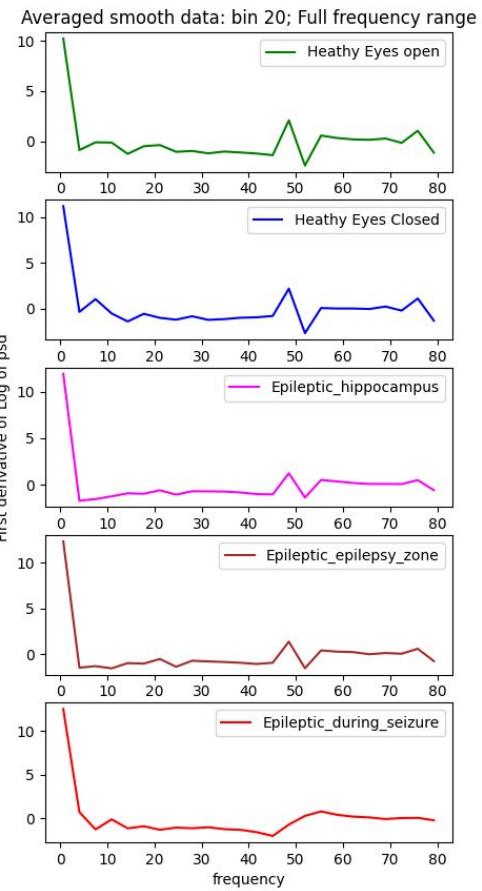
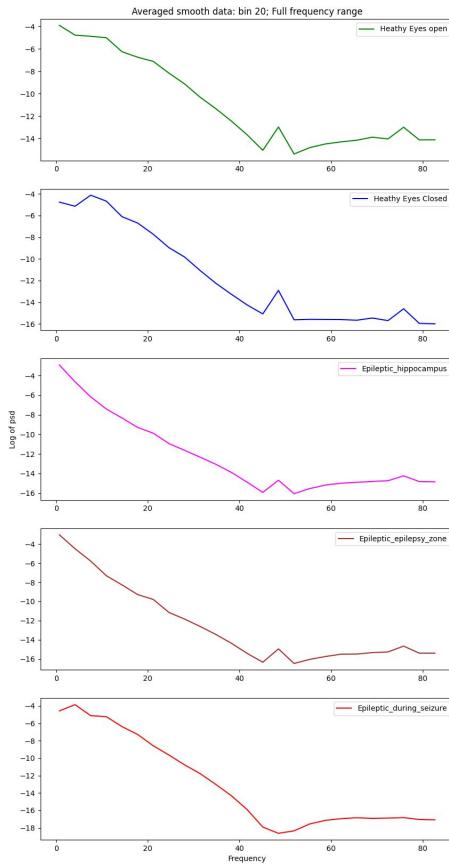


- Healthy\_eyes\_open
- - Healthy\_eyes\_closed
- . - Epileptic\_hippocampus
- . . - Epileptic\_epilepsy region
- Epileptic\_during\_seizure

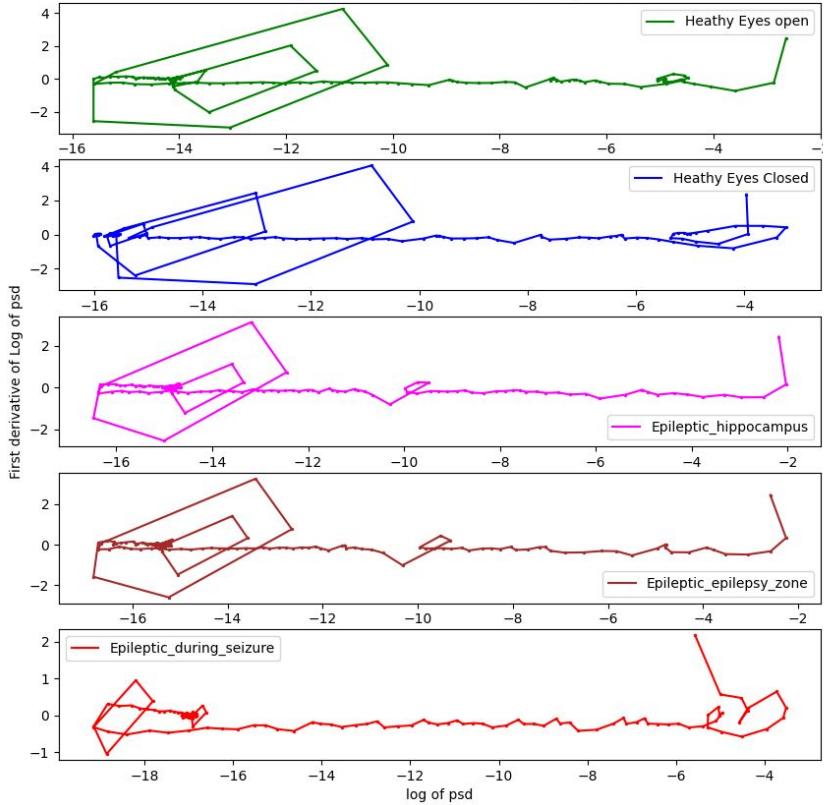
Smoothen DATA with  
25 bins DATA, peak  
range: peak1> 48,  
52; peak2= 69, 73



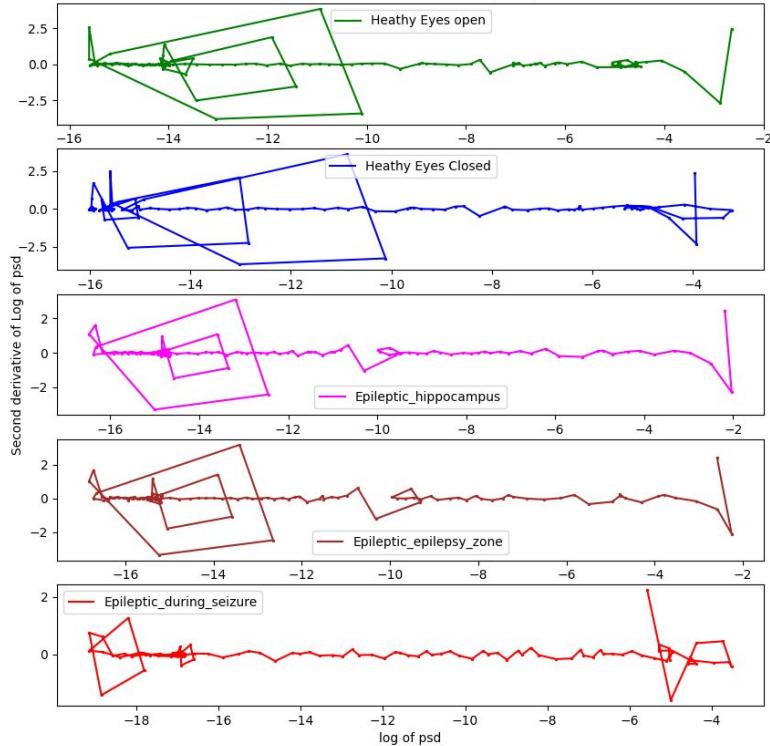


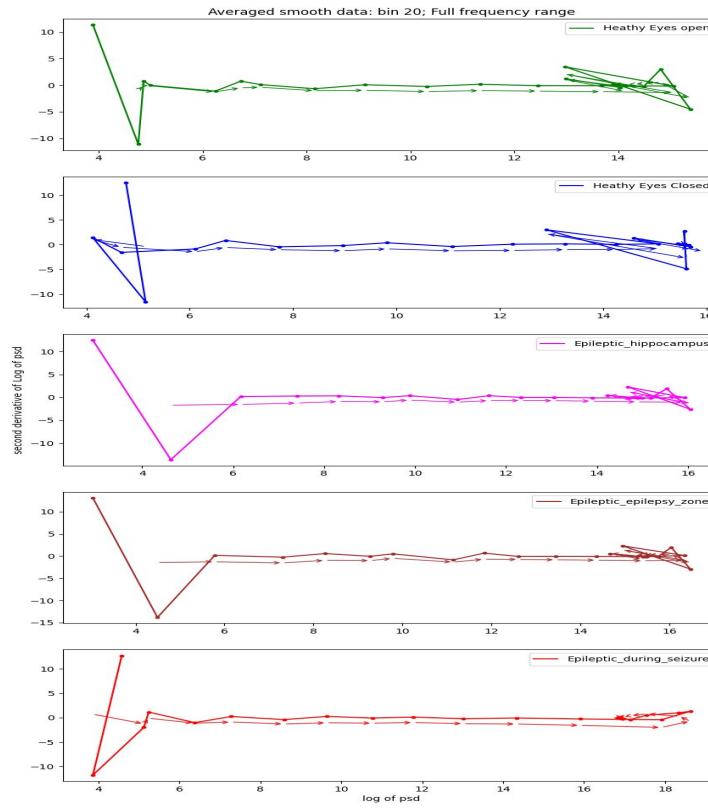
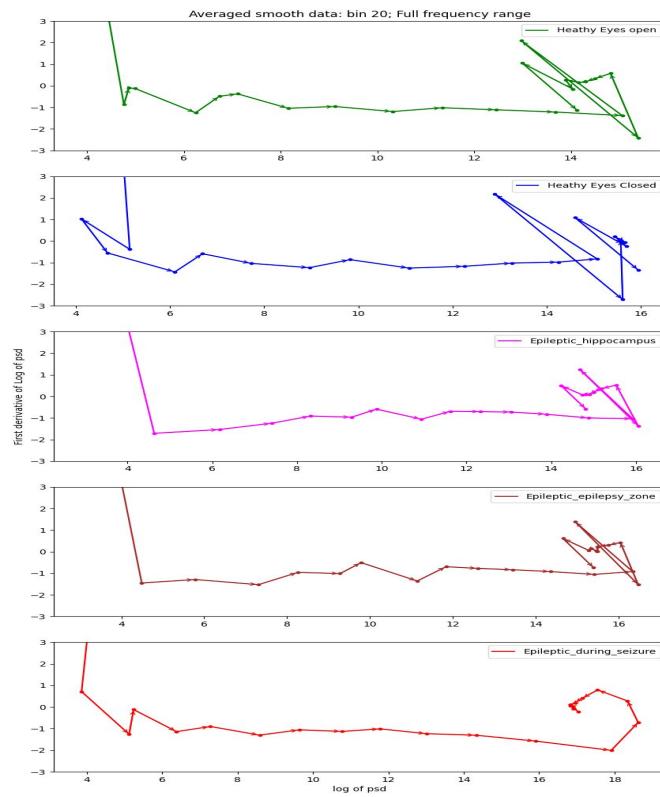


Averaged unsmooth data: Full frequency range

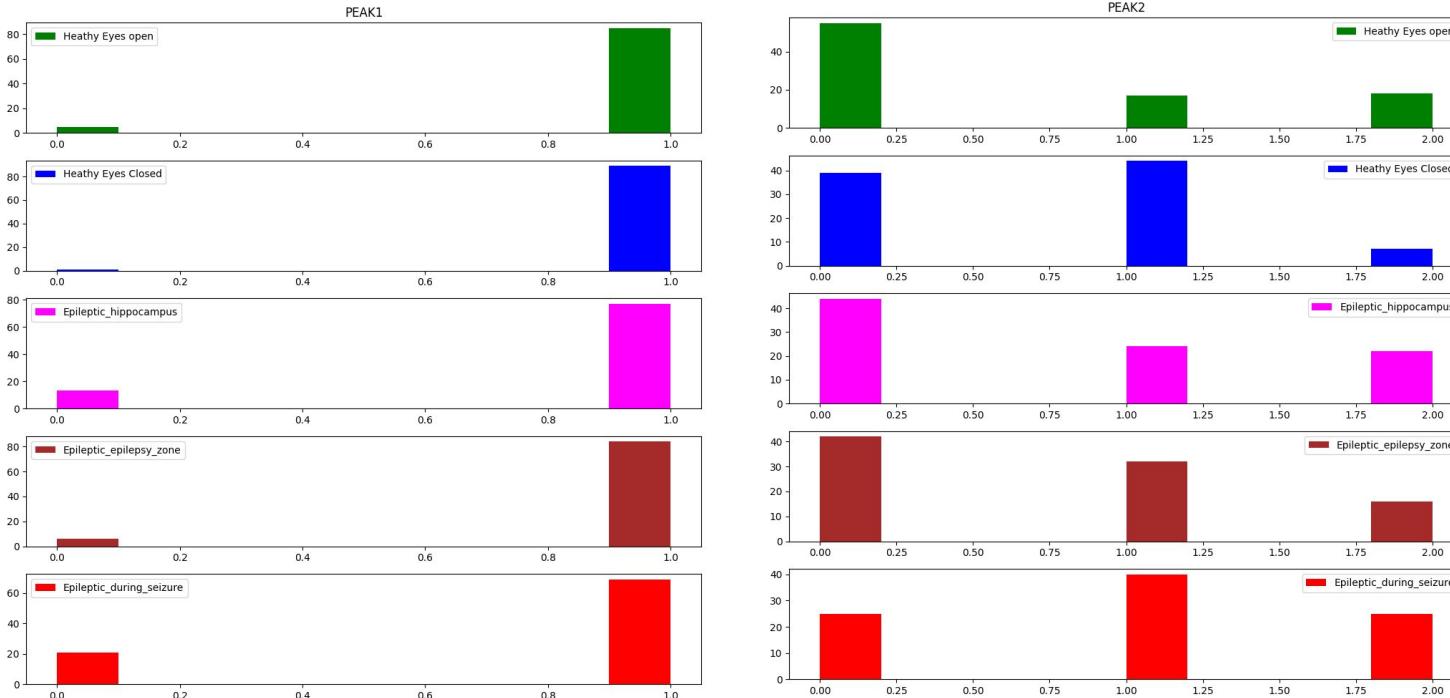


Averaged unsmooth data: Full frequency range





# Histogram for derivative of log of power spectral density crossing zero at frequency range 45-55 (peak1) and 67-77 (peak2)

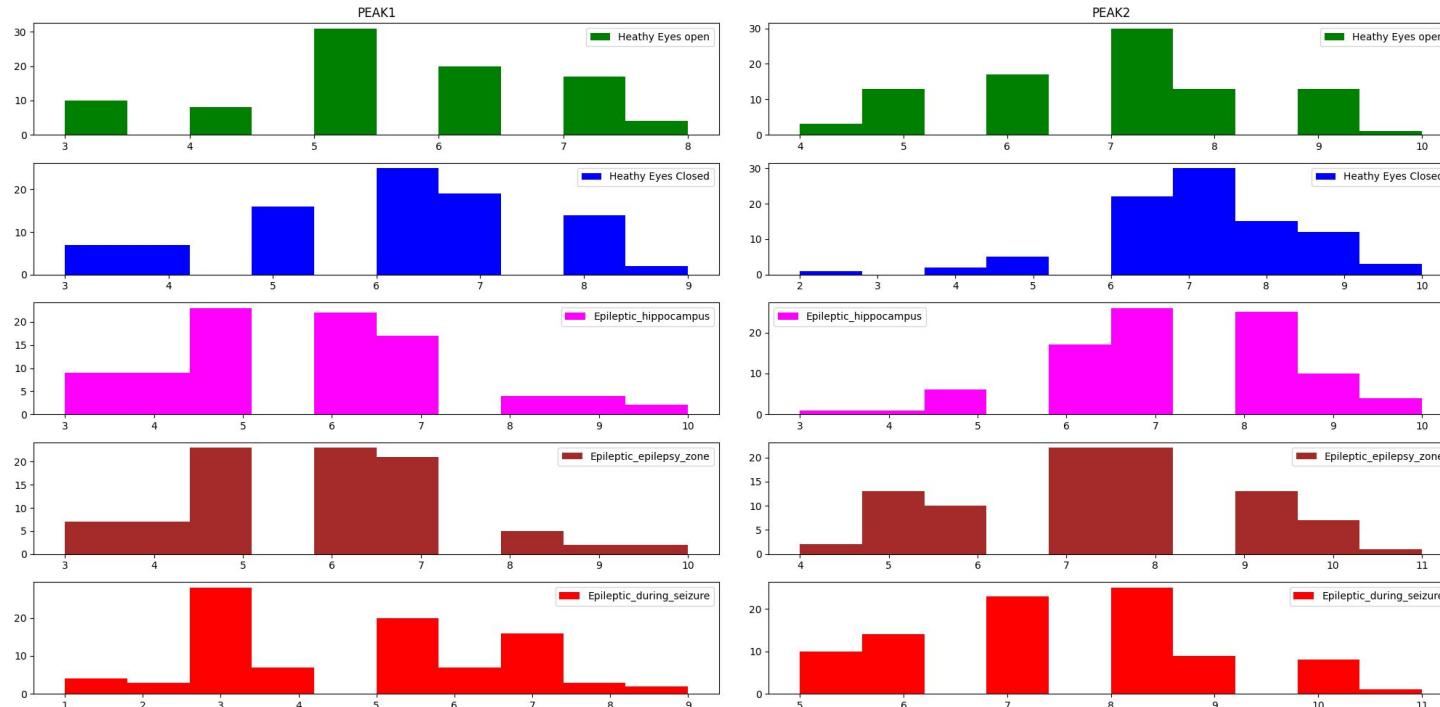


**X axis:**  
No of times derivative of *log of psd of eeg* crosses zero; i.e., how many peaks

**Y axis:**  
No of data that crosses zero; i.e., out of 100 data of each category how many has *x* peaks.

Smoothen DATA with 20 bins DATA, peak range: peak1-> 48, 52; peak2= 69, 73

## Histogram for derivative of log of power spectral density crossing zero at frequency range 45-55 (peak1) and 67-77 (peak2)

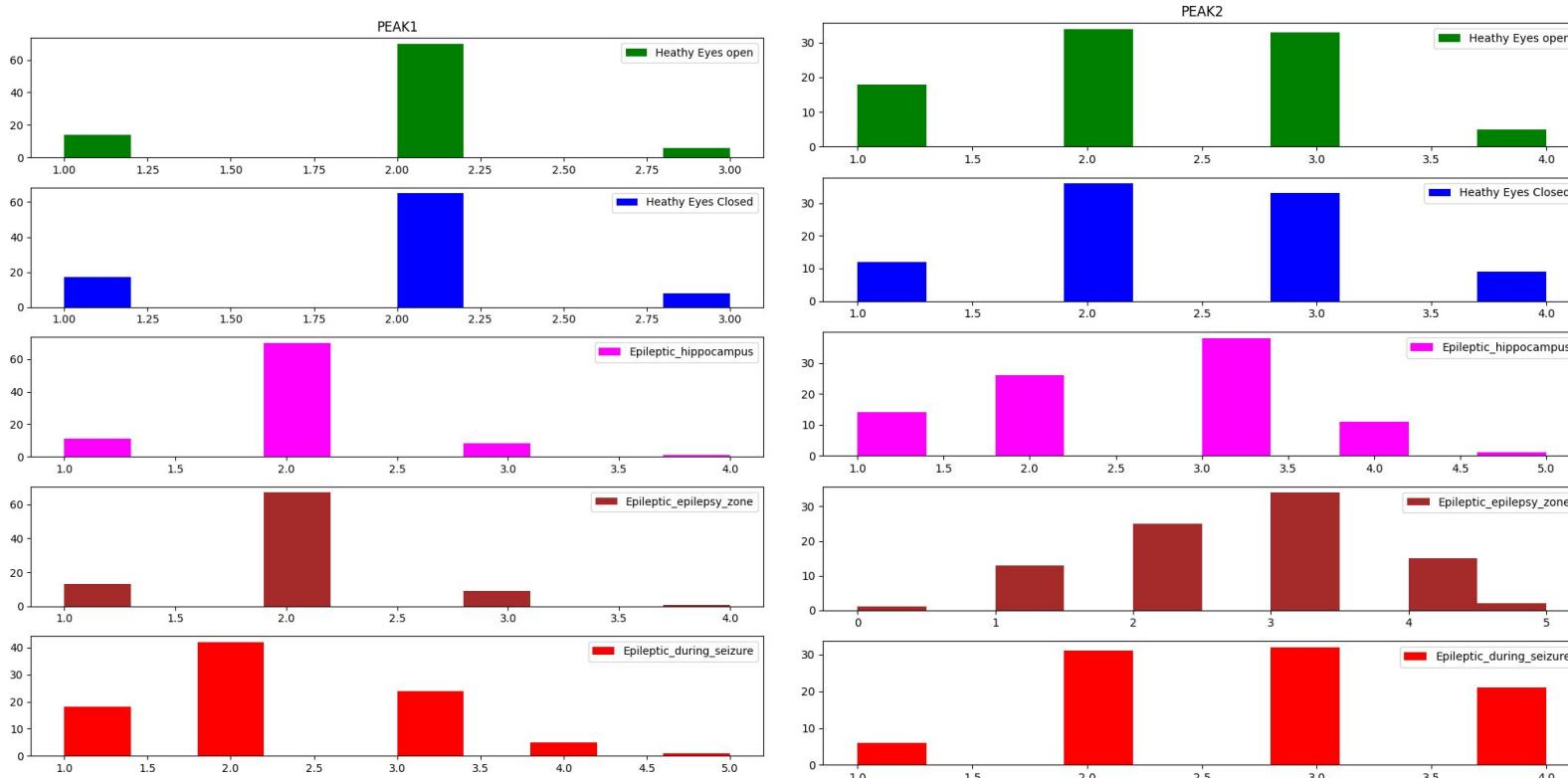


**X axis:**  
No of times derivative of *log of psd of eeg* crosses zero; i.e., how many peaks

**Y axis:**  
No of data that crosses zero; i.e., out of 100 data of each category how many has *x* peaks.

Smoothen DATA with 20 bins DATA, frequency range: peak1-> 45, 55; peak2= 67, 77

Histogram for derivative of log of power spectral density crossing zero at frequency range 45-55 (peak1) and 67-77 (peak2)

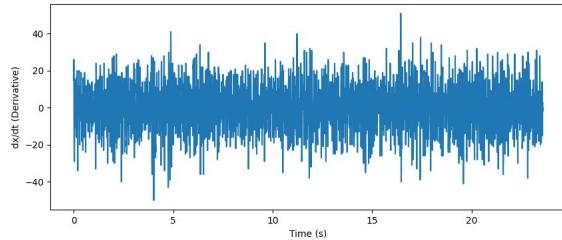


**X axis:**  
No of times  
derivative of  
*log of psd of*  
*eeg* crosses  
zero; i.e., how  
many peaks

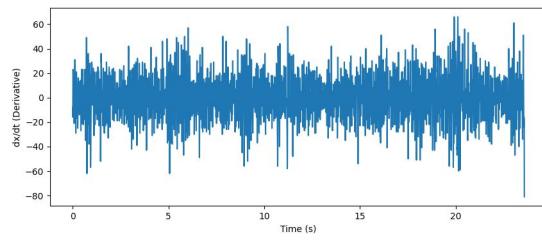
**Y axis:**  
No of data that  
crosses zero;  
i.e., out of 100  
data of each  
category how  
many has *x*  
peaks.

Unsmooth DATA, frequency range: peak1-> 48, 52; peak2-> 69, 73

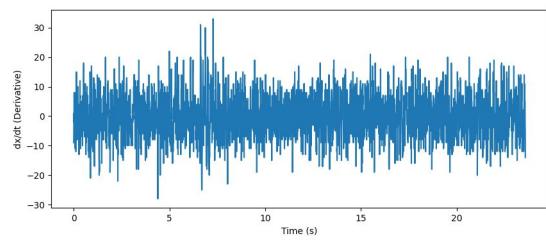
# Original signal t v/s $dx/dt$ (Channel: 8)



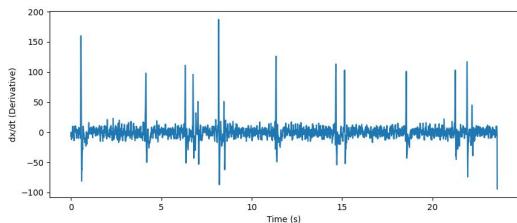
Healthy eyes open



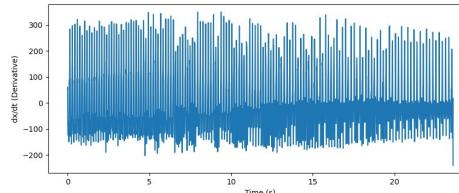
Healthy eyes closed



Epileptic patient  
(Hippocampal)

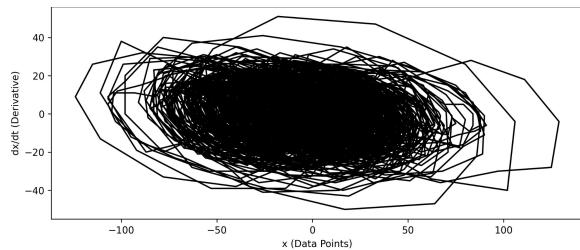


Epileptic patient  
(Epileptic Zone)

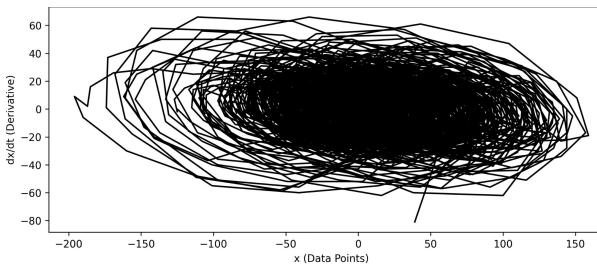


During Seizure

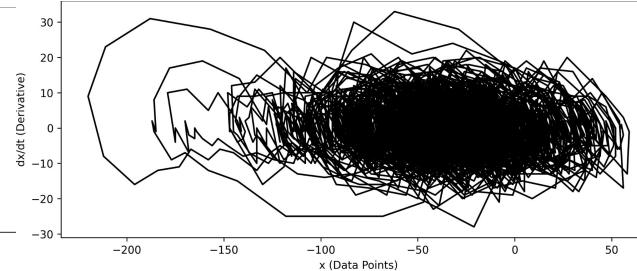
# Original Signal phase plots [Full range] (x vs dx/dt) (Channel: 8)



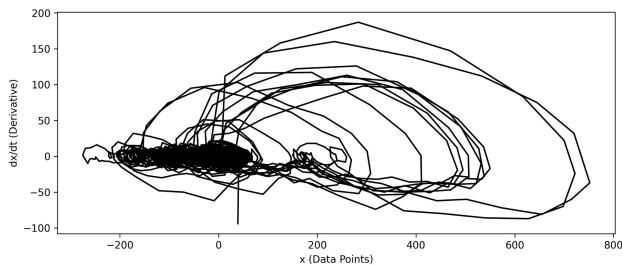
Healthy eyes open



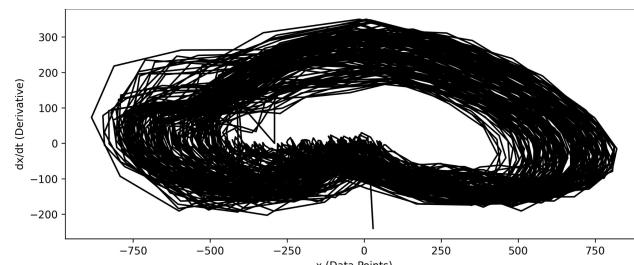
Healthy eyes closed



Epileptic patient  
(Hippocampal)

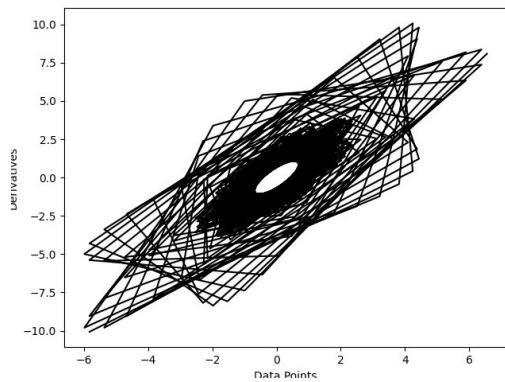


Epileptic patient  
(Epilepsy Zone)

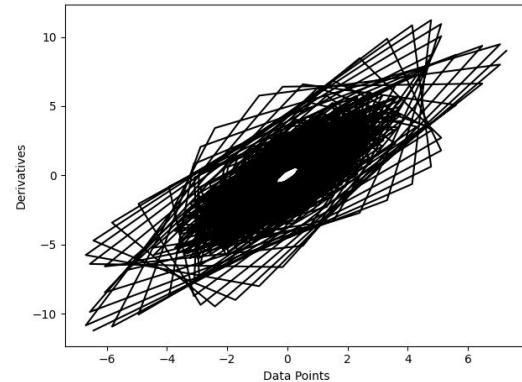


During Seizure

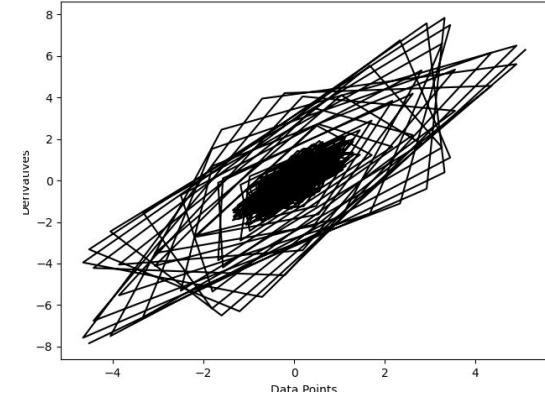
# Original Signal phase plots [Peak 1: 48-52 Hz] (x vs dx/dt) (Channel: 8)



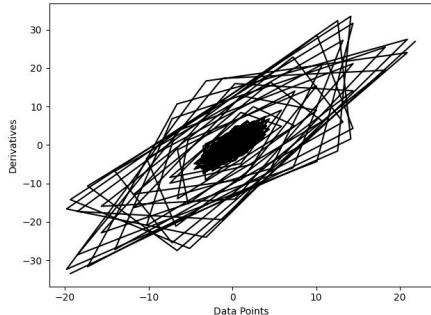
Healthy eyes open



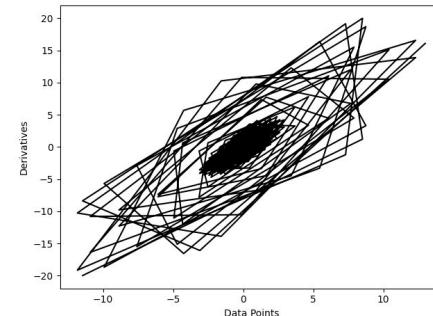
Healthy eyes closed



Epileptic patient  
(Hippocampal)

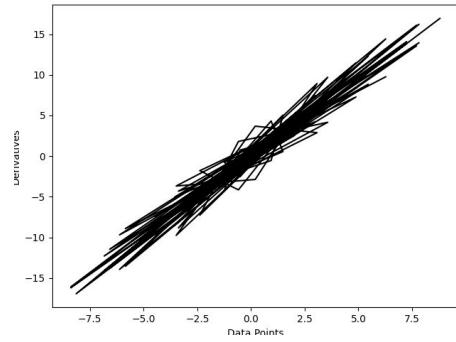


Epileptic patient  
(Epilepsy Zone)

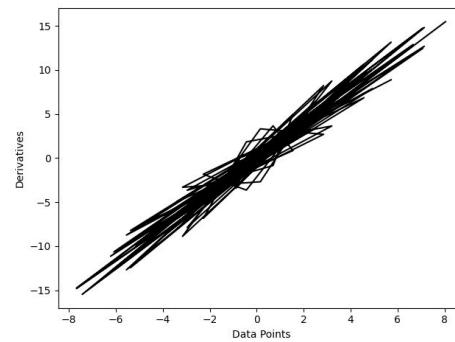


During Seizure

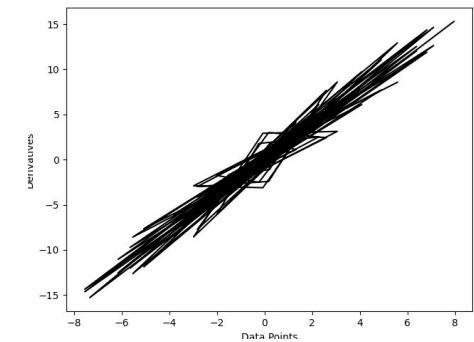
# Original Signal phase plots [Peak 2] (x vs dx/dt) (Channel: 8)



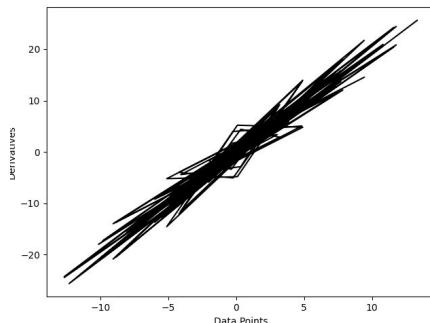
Healthy eyes open



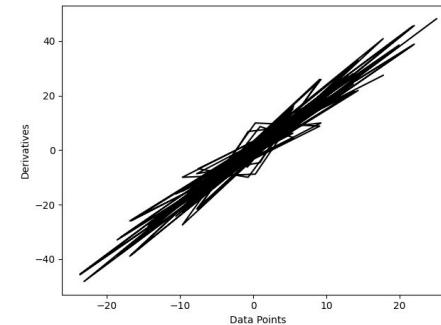
Healthy eyes closed



Epileptic patient  
(Hippocampal)

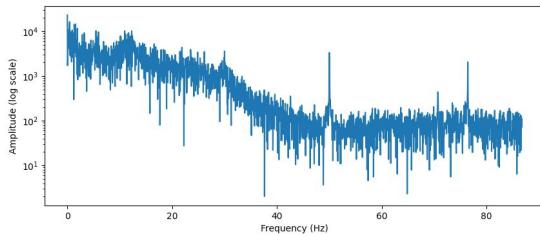


Epileptic patient  
(Epilepsy Zone)

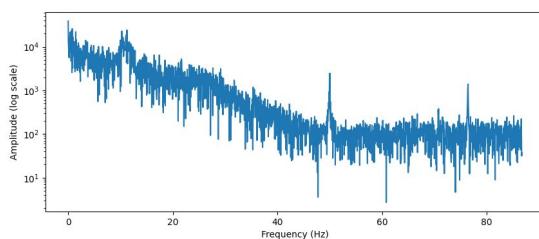


During Seizure

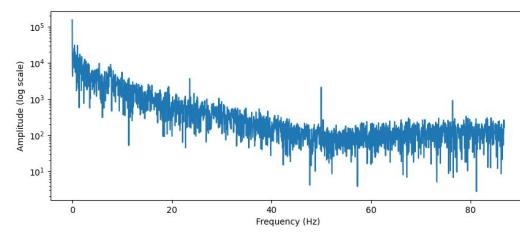
# Normal FFT of original signal (Semilogy)



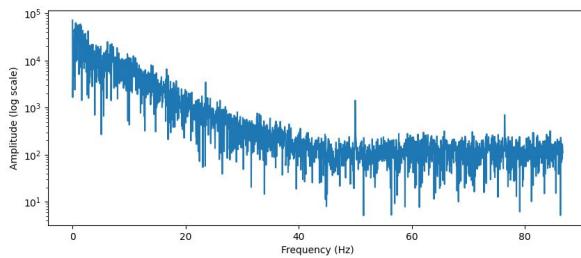
Healthy eyes open



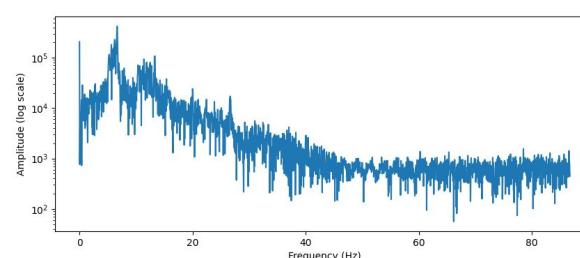
Healthy eyes closed



Epileptic patient  
(Hippocampal)

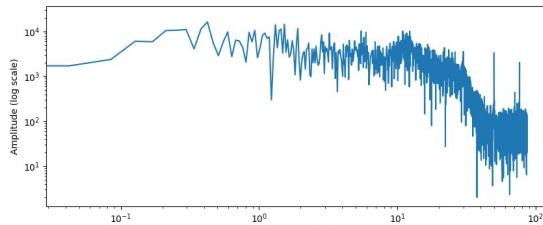


Epileptic patient  
(Epilepsy Zone)

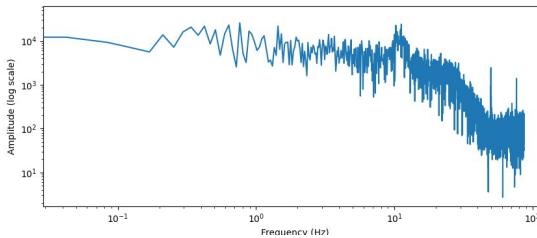


During seizure

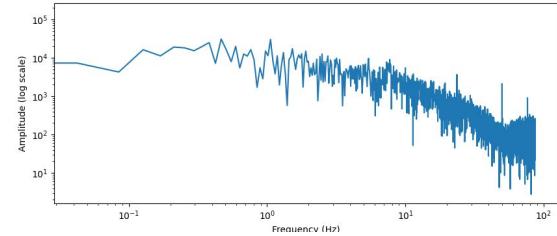
# Normal FFT of original signal (log-log plot) (channel: 8)



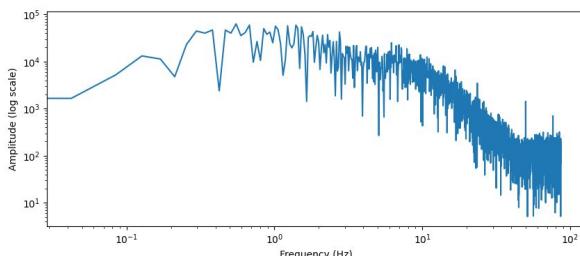
Healthy eyes open



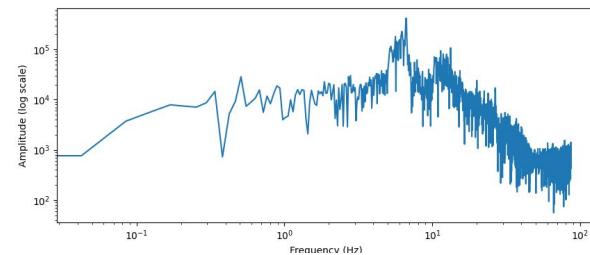
Healthy eyes closed



Epileptic patient  
(Hippocampal)

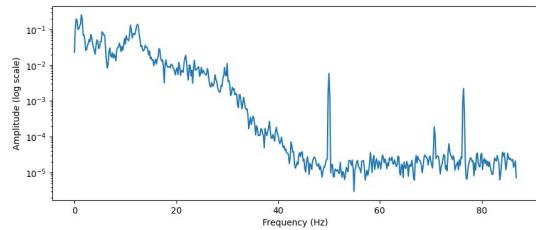


Epileptic patient  
(Epilepsy Zone)

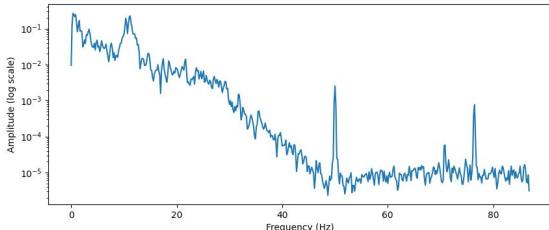


During seizure

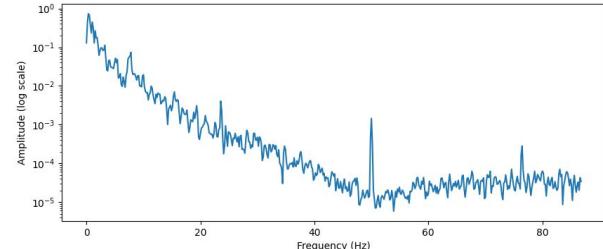
# Welch FFT of the original signal (Semilogy) (Channel: 8)



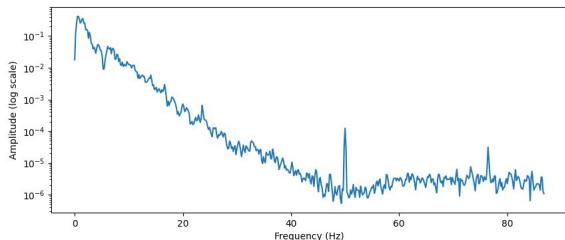
Healthy eyes open



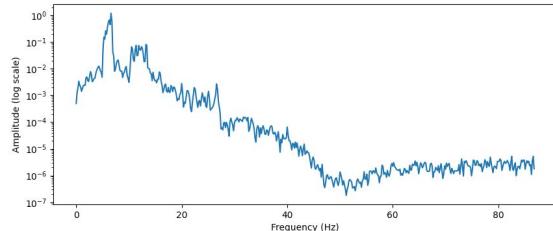
Healthy eyes closed



Epileptic patient  
(Hippocampal)

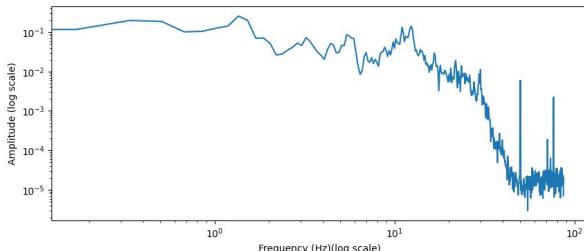


Epileptic patient  
(Epilepsy Zone)

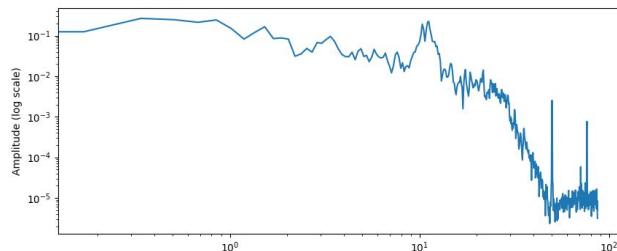


During seizure

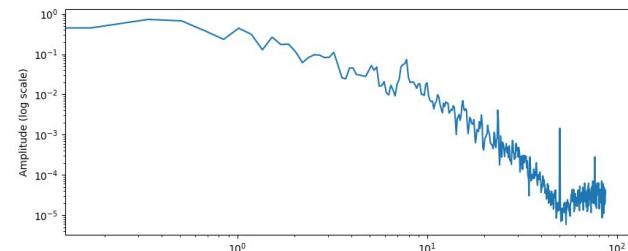
# Welch FFT of the original signal (log-log) (Channel: 8)



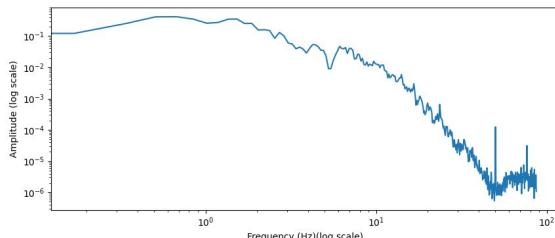
Healthy eyes open



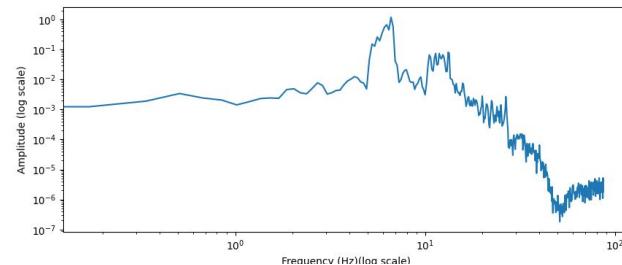
Healthy eyes closed



Epileptic patient  
(Hippocampal)

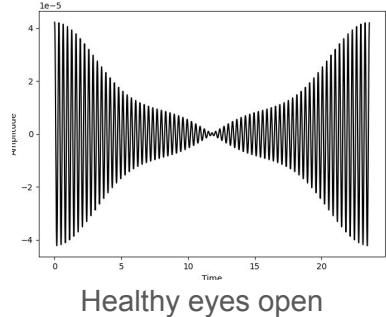


Epileptic patient  
(Epilepsy Zone)

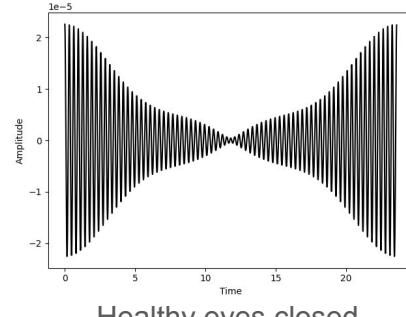


During seizure

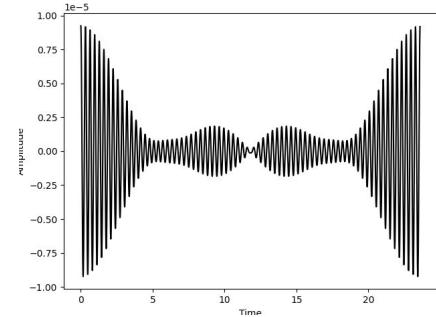
# Reconstructed signal (Channel: 8) (Peak-1)



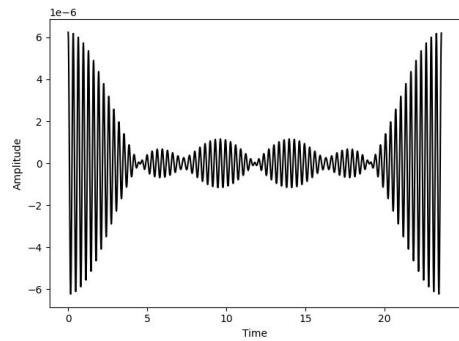
Healthy eyes open



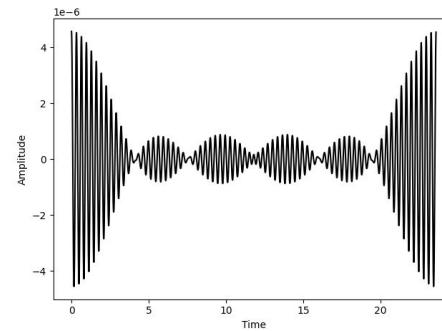
Healthy eyes closed



Epileptic patient  
(Hippocampal)

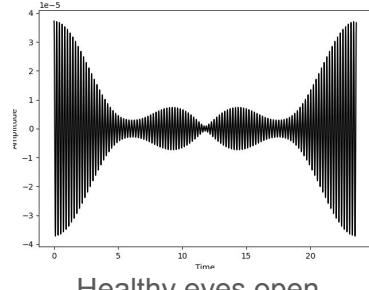


Epileptic patient  
(Epilepsy Zone)

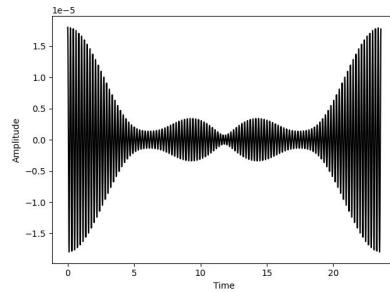


During seizure

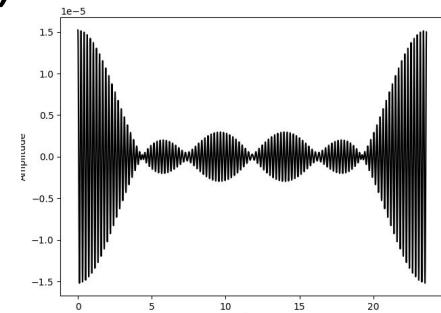
# Reconstructed signal (Channel: 8) (Peak-2)



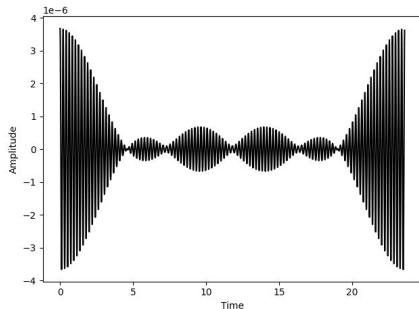
Healthy eyes open



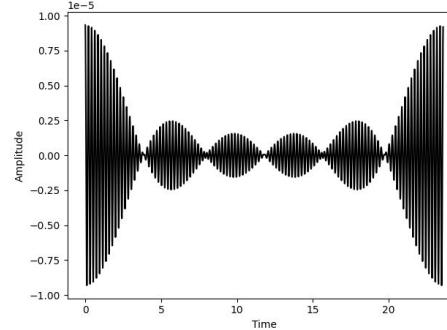
Healthy eyes closed



Epileptic patient  
(Hippocampal)

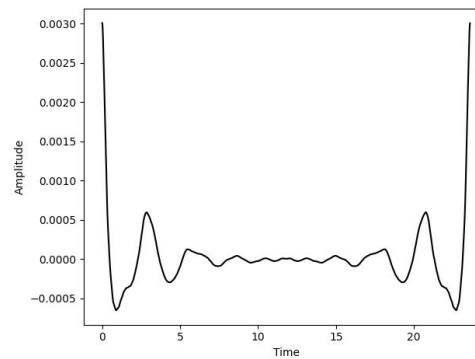
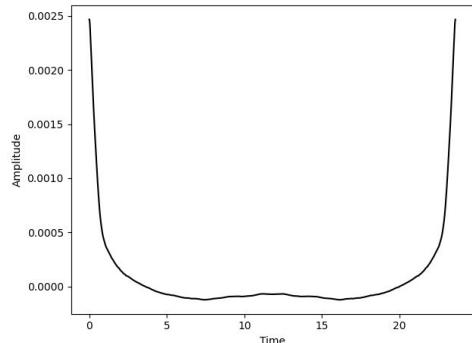
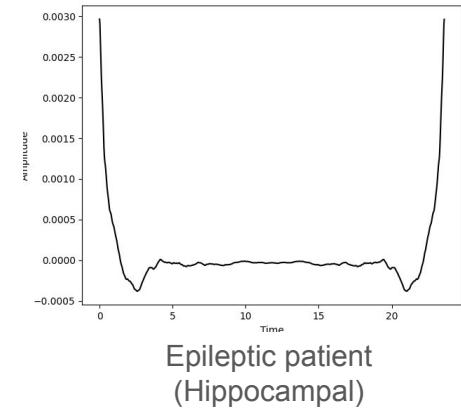
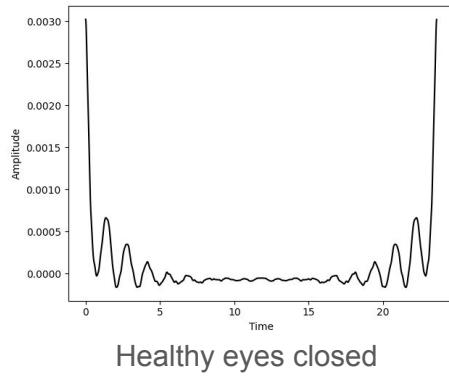
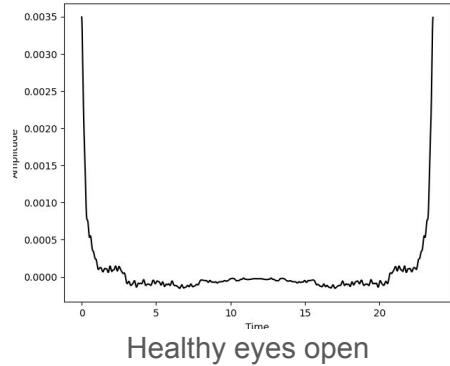


Epileptic patient  
(Epilepsy Zone)

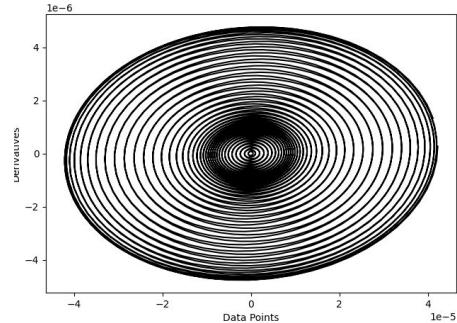


During seizure

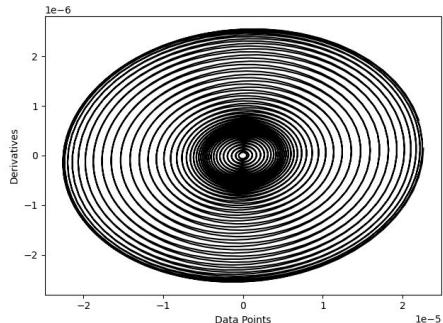
# Reconstructed signal (Channel: 8) (Full time range)



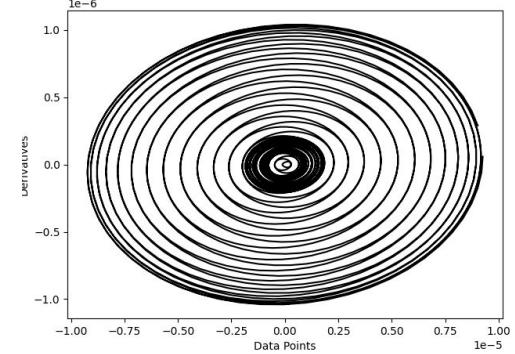
# Phase plots (using welch method) (channel - 8)(Peak - 1)



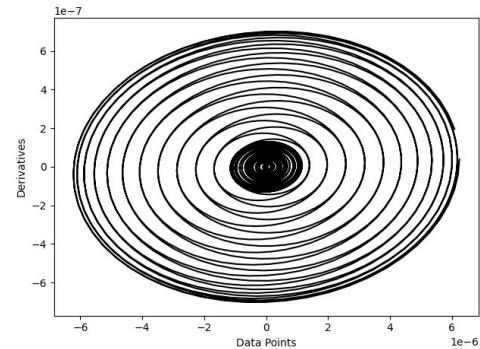
Healthy eyes open



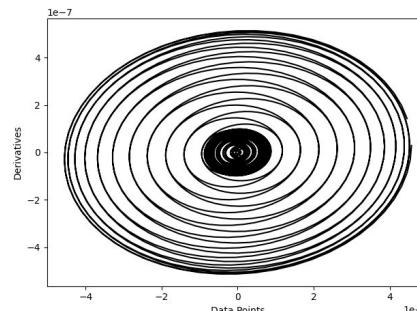
Healthy eyes closed



Epileptic patient  
(Hippocampal)

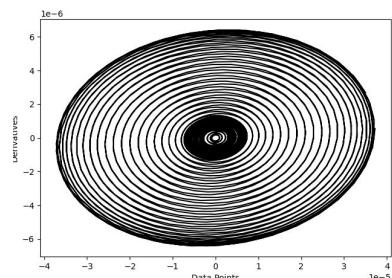


Epileptic patient  
(Epilepsy Zonal)

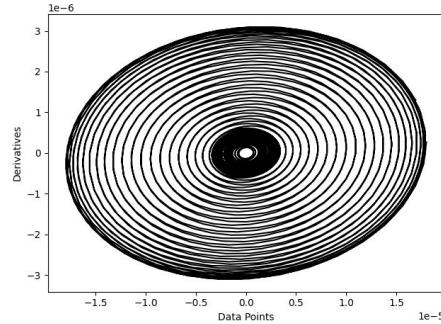


During seizure

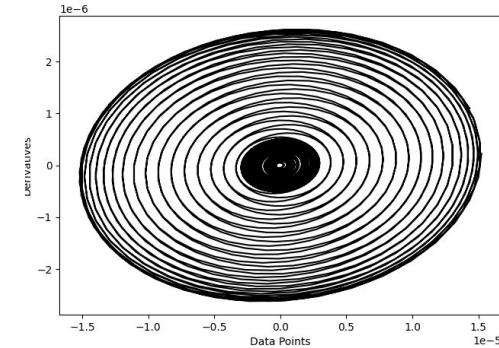
# Phase plots (using welch method) (channel - 8)(Peak - 2)



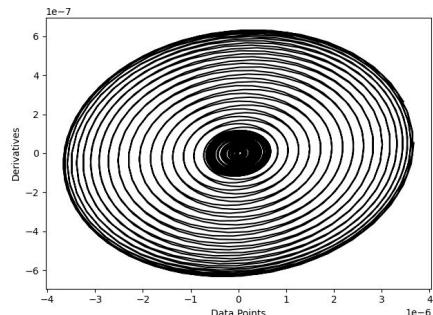
Healthy eyes open



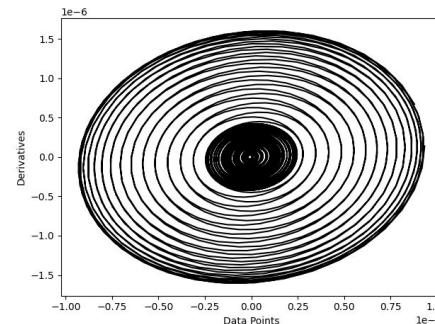
Healthy eyes closed



Epileptic patient  
(Hippocampal)

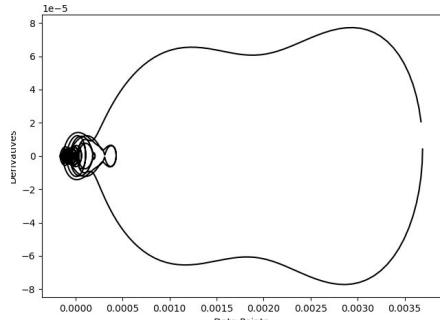


Epileptic patient  
(Epilepsy Zone)

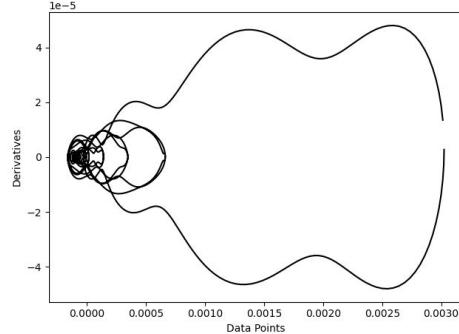


During seizure

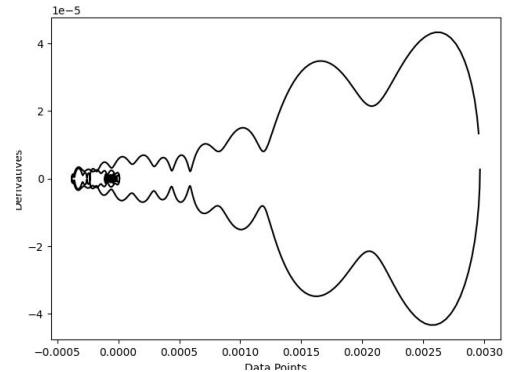
# Phase plots (using welch method) (channel - 8)(Full range)



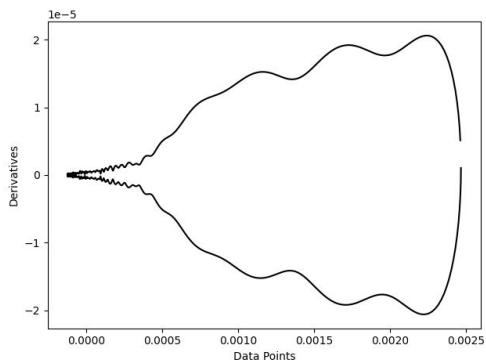
Healthy eyes open



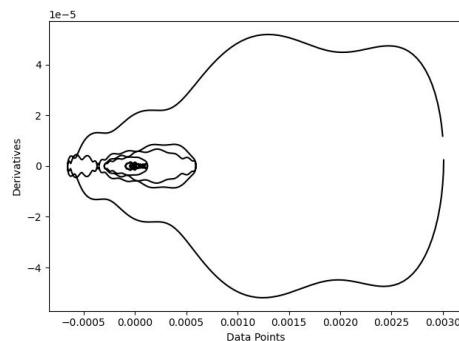
Healthy eyes closed



Epileptic patient  
(Hippocampal)

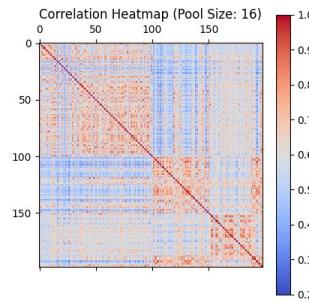


Epileptic patient  
(Epilepsy Zonel)

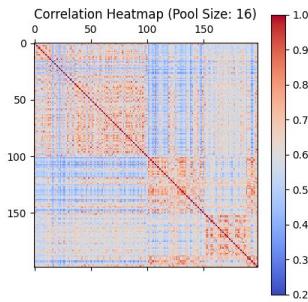


During seizure

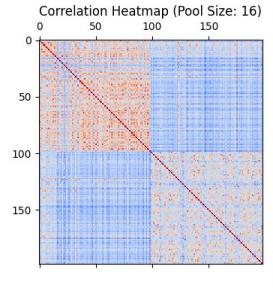
# Phase correlations (welch)(Full range) (Pool size: (16,16))



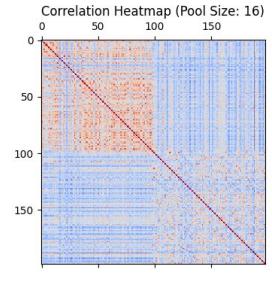
Healthy eyes open-closed



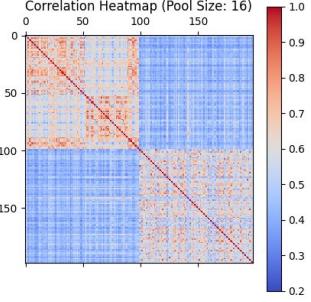
Healthy eyes open & Epileptic Hippocampal



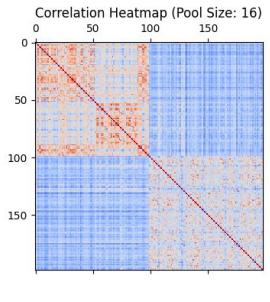
Healthy eyes open & Epileptic Epilepsy range



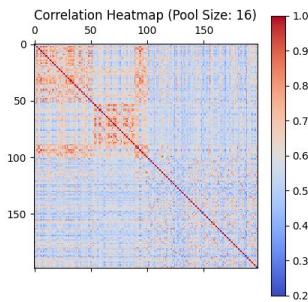
Healthy eyes open & Seizure



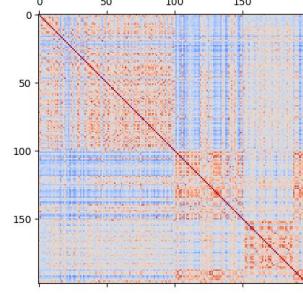
Healthy eyes closed & Epileptic



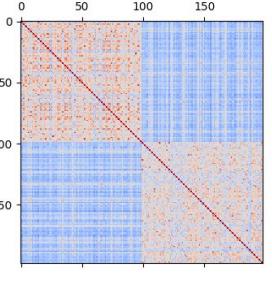
Healthy eyes closed & Epileptic Epilepsy zone



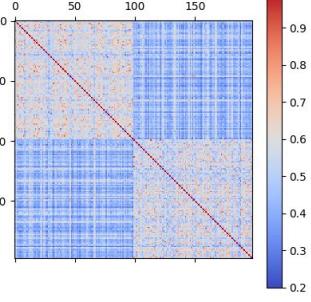
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range

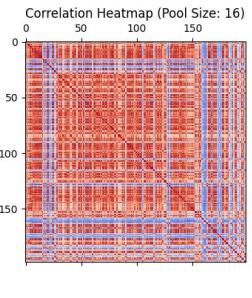


Healthy Epileptic Hippocampal range & Seizure

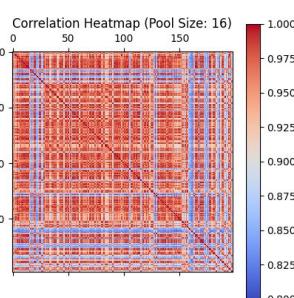


Epileptic Epilepsy range & seizure

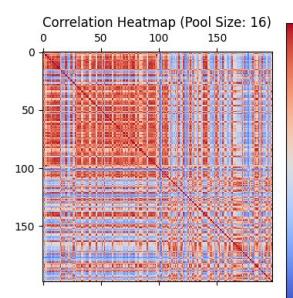
# Phase correlations (welch)(Peak 1) (Pool size: (16,16))



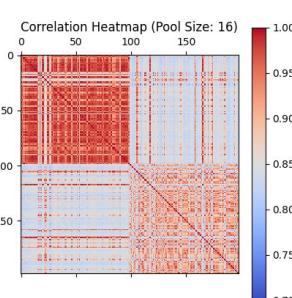
Healthy eyes open-closed



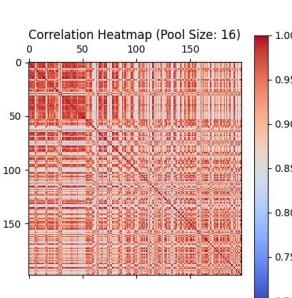
Healthy eyes open & Epileptic Hippocampal



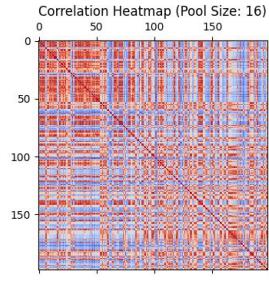
Healthy eyes open & Epileptic Epilepsy range



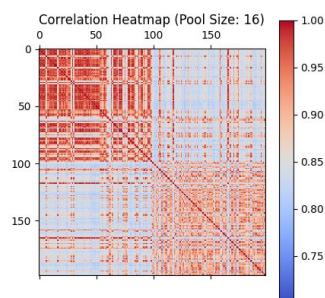
Healthy eyes open & Seizure



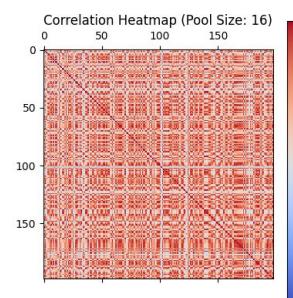
Healthy eyes closed & Epileptic Hippocampal



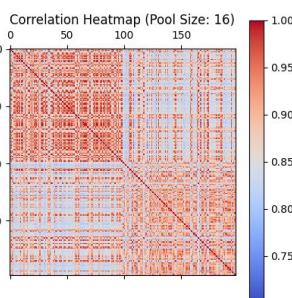
Healthy eyes closed & Epileptic Epilepsy zone



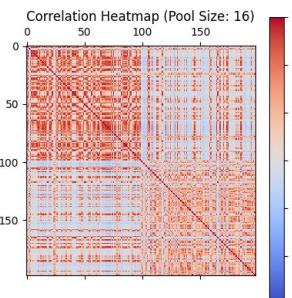
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range

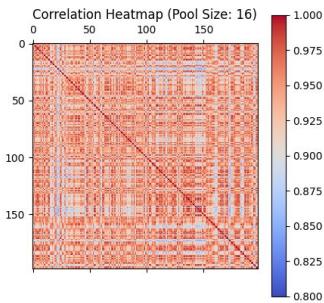


Healthy Epileptic Hippocampal range & Seizure

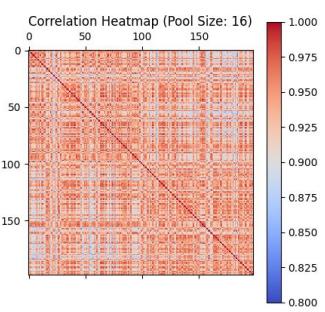


Epileptic Epilepsy range & seizure

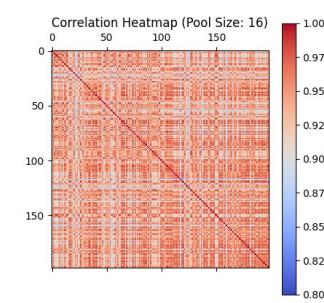
# Phase correlations (welch)(Peak 2) (Pool size: (16,16))



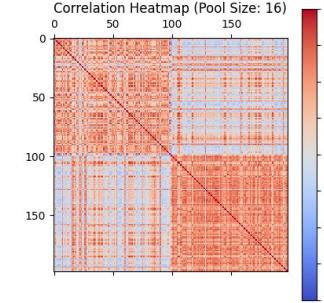
Healthy eyes open-closed



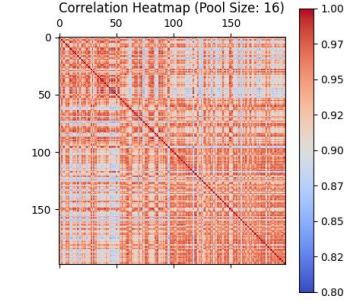
Healthy eyes open & Epileptic Hippocampal



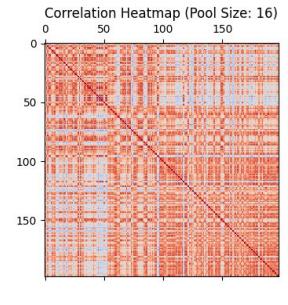
Healthy eyes open & Epileptic Epilepsy range



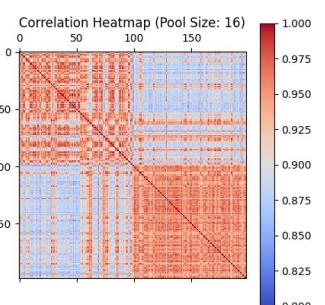
Healthy eyes open & Seizure



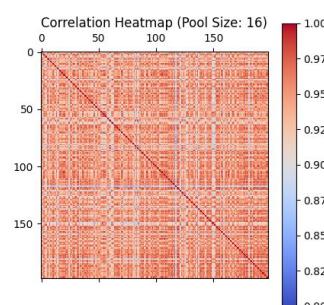
Healthy eyes closed & Epileptic Hippocampal



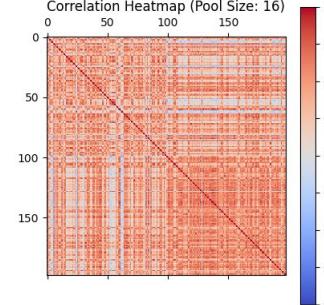
Healthy eyes closed & Epileptic Epilepsy zone



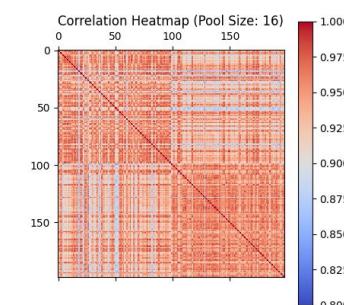
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range

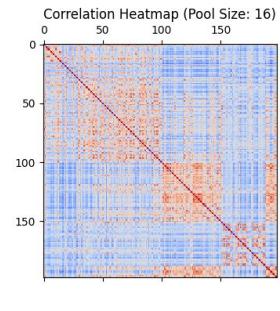


Healthy Epileptic Hippocampal range & Seizure

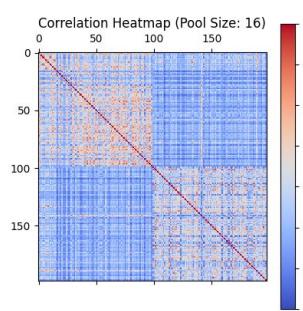


Epileptic Epilepsy range & seizure

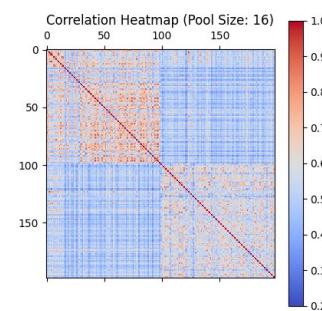
# Phase correlations (original)(full) (Pool size: (16,16))



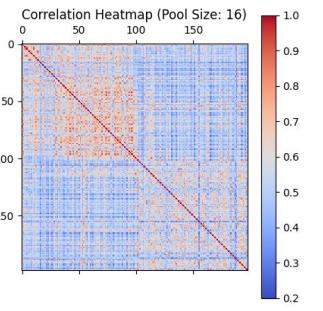
Healthy eyes open-closed



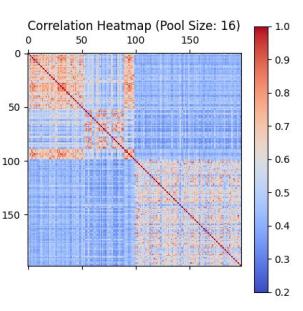
Healthy eyes open & Epileptic Hippocampal



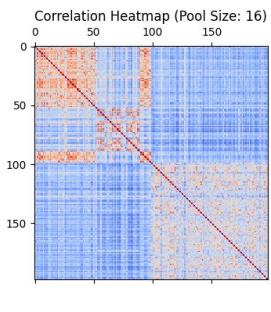
Healthy eyes open & Epileptic



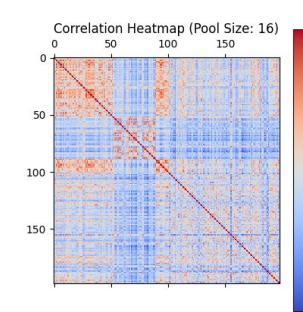
Healthy eyes open & Seizure



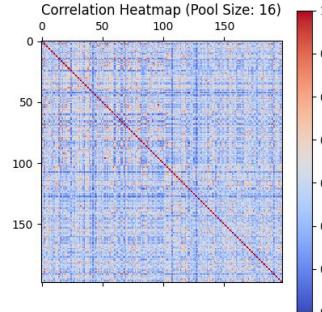
Healthy eyes closed & Epileptic Hippocampal



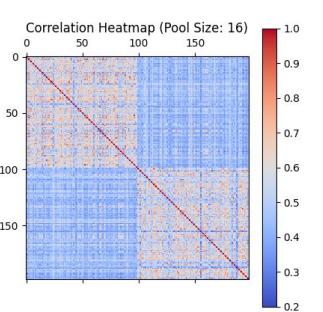
Healthy eyes closed & Epileptic Epilepsy zone



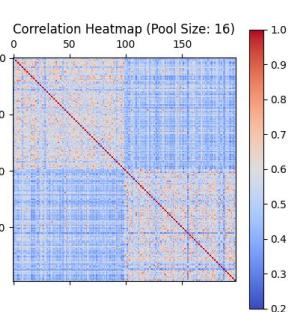
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range

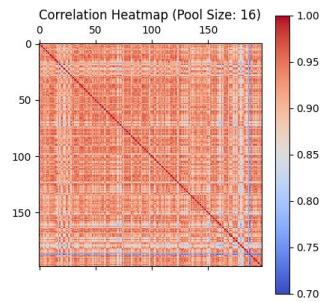


Healthy Epileptic Hippocampal range & Seizure

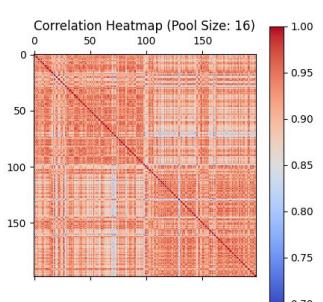


Epileptic Epilepsy range & seizure

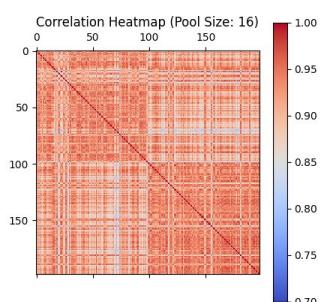
# Phase correlations (original)(peak1) (Pool size: (16,16))



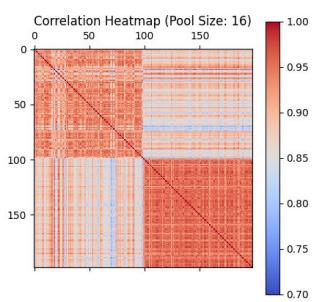
Healthy eyes open-closed



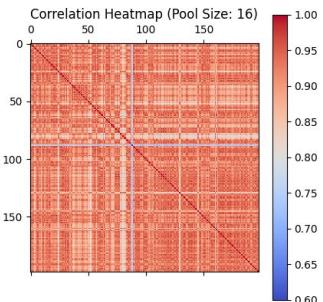
Healthy eyes open & Epileptic Hippocampal



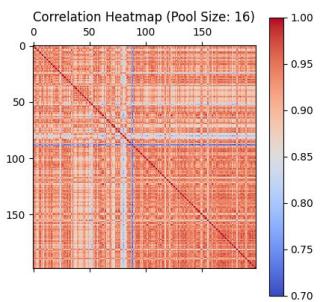
Healthy eyes open & Epileptic Epilepsy range



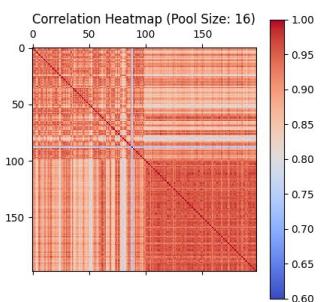
Healthy eyes open & Seizure



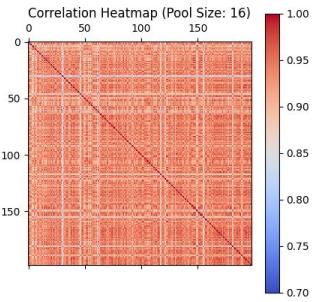
Healthy eyes closed & Epileptic Hippocampal



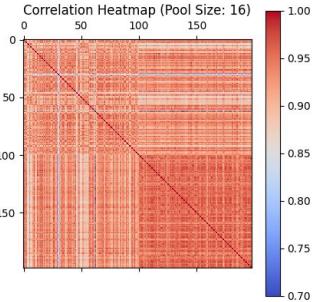
Healthy eyes closed & Epileptic Epilepsy zone



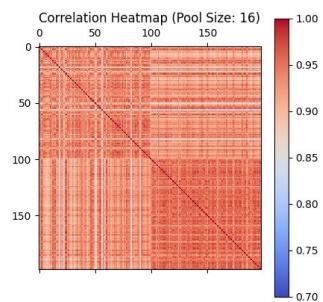
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range

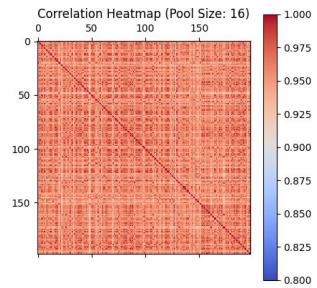


Healthy Epileptic Hippocampal range & Seizure

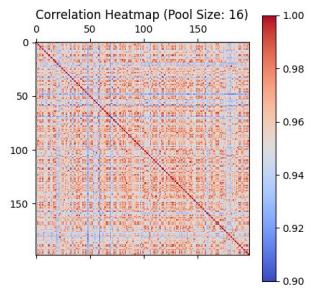


Epileptic Epilepsy range & seizure

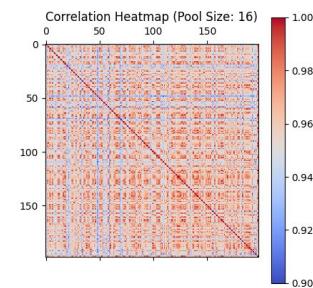
# Phase correlations (original)(peak2) (Pool size: (16,16))



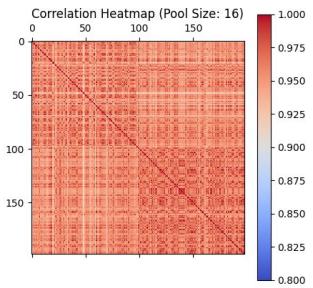
Healthy eyes open-closed



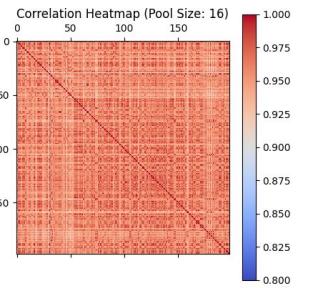
Healthy eyes open & Epileptic Hippocampal



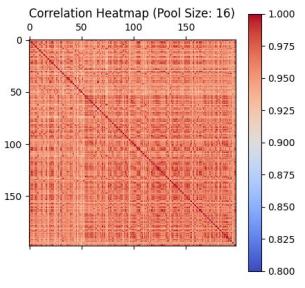
Healthy eyes open & Epileptic Epilepsy range



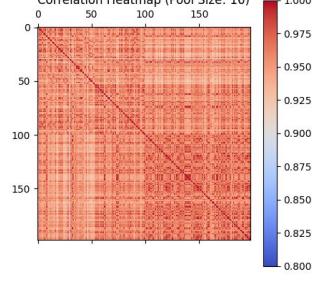
Healthy eyes open & Seizure



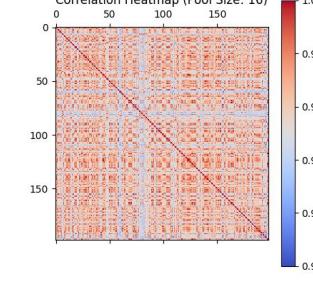
Healthy eyes closed & Epileptic Hippocampal



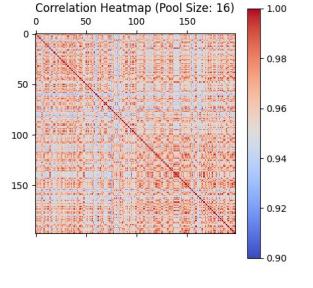
Healthy eyes closed & Epileptic Epilepsy zone



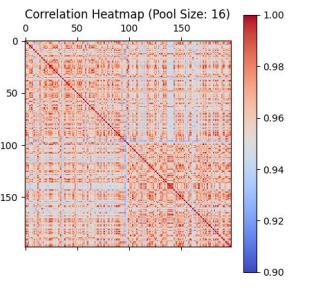
Healthy eyes closed & Seizure



Healthy Epileptic Hippocampal range & Epileptic Epilepsy range



Healthy Epileptic Hippocampal range & Seizure



Epileptic Epilepsy range & seizure

# Confusion matrices

	Full range original				Full range Welch				Peak 1 original				Peak 1 Welch				Peak 2 Original				Peak 2 Welch			
	Linear Regression		SVM		Linear Regression		SVM		Linear Regression		SVM		Linear Regression		SVM		Linear Regression		SVM		Linear Regression		SVM	
	Train	Test	Train	SVM	Train	Test	Train	SVM	Train	Test	Train	SVM	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test
AB	1	0.875	0.99	0.875	1	0.82	0.98	0.85	0.76	0.55	0.76	0.57	0.51	0.52	0.67	0.62	0.51	0.52	0.65	0.65	0.55	0.55	0.52	0.72
ac	1	0.975	0.98	0.975	1	0.82	0.98	0.85	0.97	0.77	0.83	0.9	0.51	0.52	0.67	0.62	0.66	0.67	0.68	0.6	0.67	0.57	0.82	0.72
aD	1	1	0.99	1	1	1	0.99	1	0.97	0.8	0.86	0.77	0.53	0.52	0.76	0.72	0.64	0.62	0.71	0.57	0.71	0.6	0.72	0.65
AE	1	<b>0.92</b>	<b>0.99</b>	<b>0.95</b>	1	<b>0.925</b>	<b>1</b>	<b>0.95</b>	<b>1</b>	<b>0.92</b>	<b>0.99</b>	<b>0.95</b>	<b>0.93</b>	<b>0.85</b>	<b>0.94</b>	<b>0.9</b>	<b>0.95</b>	<b>0.92</b>	<b>0.92</b>	<b>0.87</b>	<b>0.96</b>	<b>0.87</b>	<b>0.93</b>	<b>0.95</b>
BC	1	0.97	1	0.97	1	0.97	1	0.97	0.51	0.47	0.8	0.8	0.79	0.7	0.83	0.72	0.79	0.77	0.82	0.67	0.83	0.7		
BD	1	0.95	1	0.975	1	0.97	1	0.975	0.85	0.65	0.82	0.75	0.57	0.62	0.77	0.57	0.67	0.65	0.77	0.675	0.82	0.67	0.83	0.7
BE	1	<b>0.85</b>	<b>0.99</b>	<b>0.85</b>	1	<b>0.85</b>	<b>0.99</b>	<b>0.92</b>	<b>1</b>	<b>0.87</b>	<b>0.96</b>	<b>0.9</b>	<b>0.85</b>	<b>0.72</b>	<b>0.91</b>	<b>0.77</b>	<b>0.95</b>	<b>0.85</b>	<b>0.93</b>	<b>0.9</b>	<b>0.96</b>	<b>0.82</b>	<b>0.93</b>	<b>0.82</b>
CD	1	0.72	0.95	0.67	1	0.65	0.94	0.67	0.6	0.57	0.67	0.6	0.51	0.55	0.7	0.65	0.55	0.52	0.59	0.55	0.63	0.6	0.77	0.625
CE	1	0.975	1	0.975	1	1	1	1	0.96	0.82	0.88	0.82	0.75	0.75	0.84	0.8	0.72	0.75	0.75	0.745	0.8	0.72	0.62	0.8
DE	1	0.92	1	0.975	1	0.95	0.99	0.975	1	0.85	0.92	0.825	0.89	0.8	0.84	0.8	0.85	0.85	0.8	0.7	0.88	0.82	0.86	0.8
	1	0.9155	0.989	0.9215	1	0.8955	0.987	0.916	<b>0.862</b>	<b>0.727</b>	<b>0.849</b>	<b>0.7885</b>	<b>0.684</b>	<b>0.655</b>	<b>0.79</b>	<b>0.715</b>	<b>0.733</b>	<b>0.697</b>	<b>0.7586</b>	<b>0.6985</b>	<b>0.769</b>	<b>0.674</b>	<b>0.821</b>	<b>0.7405</b>