

Classification of Sleep Spindles
and Epilepsy Seizures in EEG
after Traumatic Brain Injury
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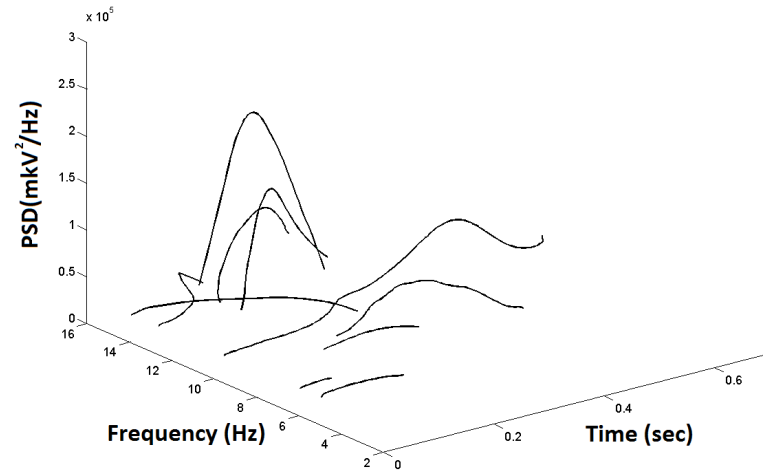
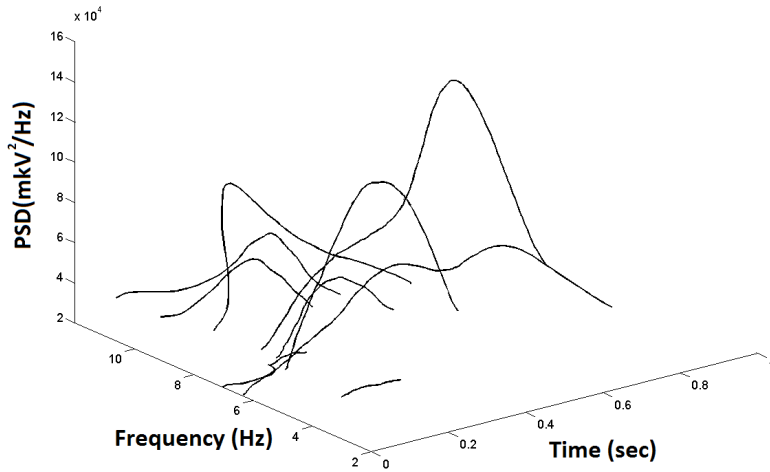
Problem Statement

- Development of **Post Traumatic Epilepsy (PTE)** after **Traumatic Brain Injury (TBI)**
- Diagnostics of PTE on the early stage based on **brain activity** factors
- Problem of **recognition** and **classification** of Sleep Spindles and Epilepsy Seizures in EEG

Experiment Design

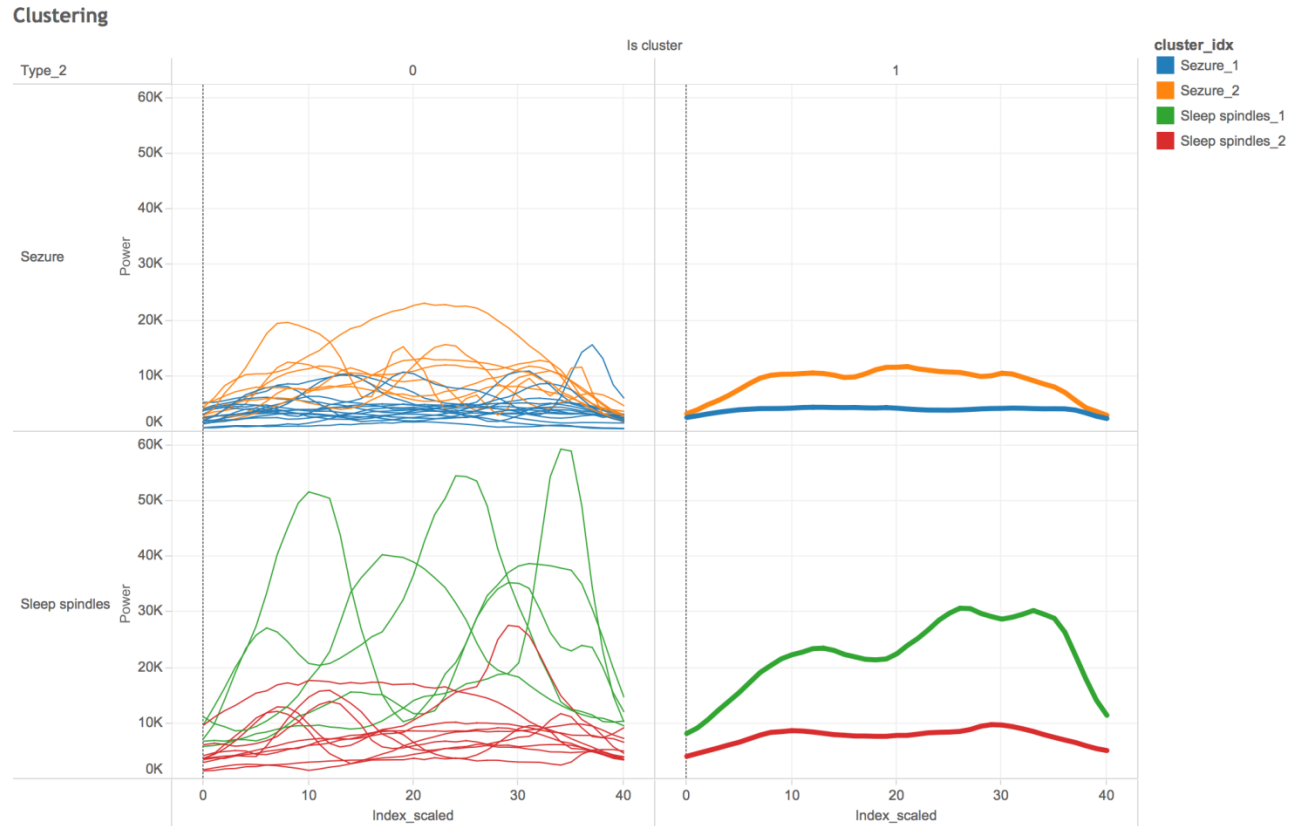
- EEG was measured on rats for **7 days before** and **7 days after** traumatic brain injury (water hammer)
- **Experts** created a **markup** of signals as “Sleep Spindles” and “Epilepsy Seizures”
- **3-10 seconds** EEG records were used for the event **detection**

Event Detection in EEG



Event detection was done based on the **connectivity** of EEG wavelet spectrogram **extrema** in time – power space

Clustering of EEG signals



K-means clustering in 40-dimensional space of PSD and Frequency.
Reverse transform of centroid into time-dependent signal was done.

Quantitative evaluation of EEG signals

$$sm = \frac{sd(F)}{mean(F)}$$

Before TBI:

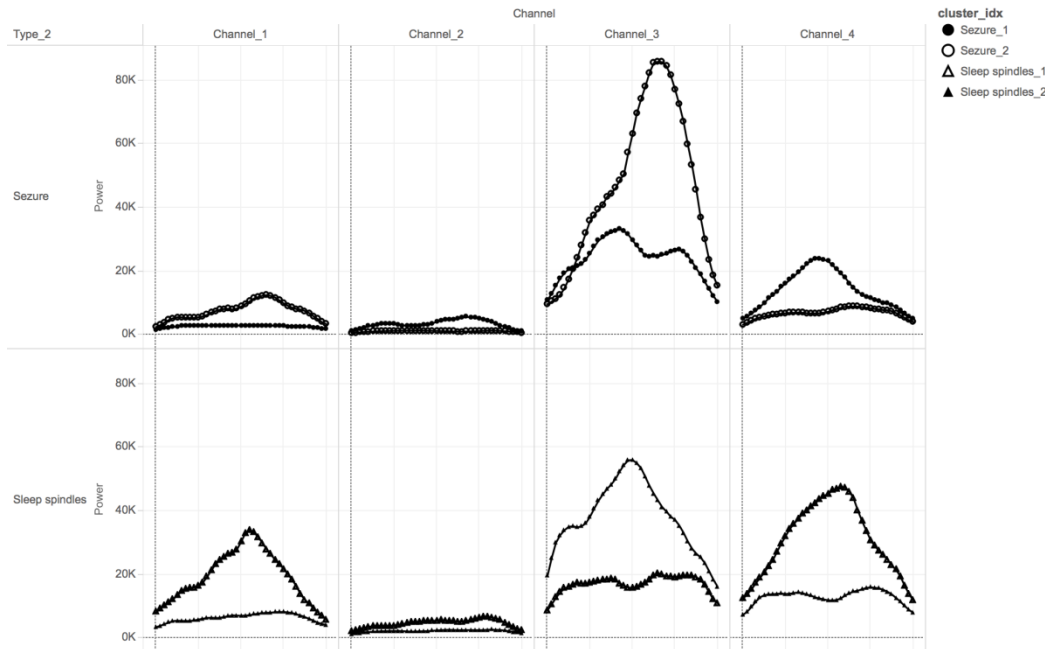
Type_2	Channel			
	Channel_1	Channel_2	Channel_3	Channel_4
Sezure	23% +- 12,08% (42 Files)	19% +- 10,21% (41 Files)	17% +- 7,74% (50 Files)	18% +- 7,56% (54 Files)
Sleep spindles	20% +- 11,05% (47 Files)	22% +- 9,94% (45 Files)	22% +- 9,31% (47 Files)	21% +- 11,02% (51 Files)

After TBI:

Type_2	Channel			
	Channel_1	Channel_2	Channel_3	Channel_4
Sezure	27% +- 20,40% (21 Files)	20% +- 8,09% (15 Files)	13% +- 5,87% (19 Files)	16% +- 9,70% (23 Files)
Sleep spindles	26% +- 9,59% (10 Files)	23% +- 10,49% (12 Files)	22% +- 10,47% (14 Files)	26% +- 11,61% (15 Files)

Distributions of *sm* between spindles and seizures differ after Traumatic Brain Injury

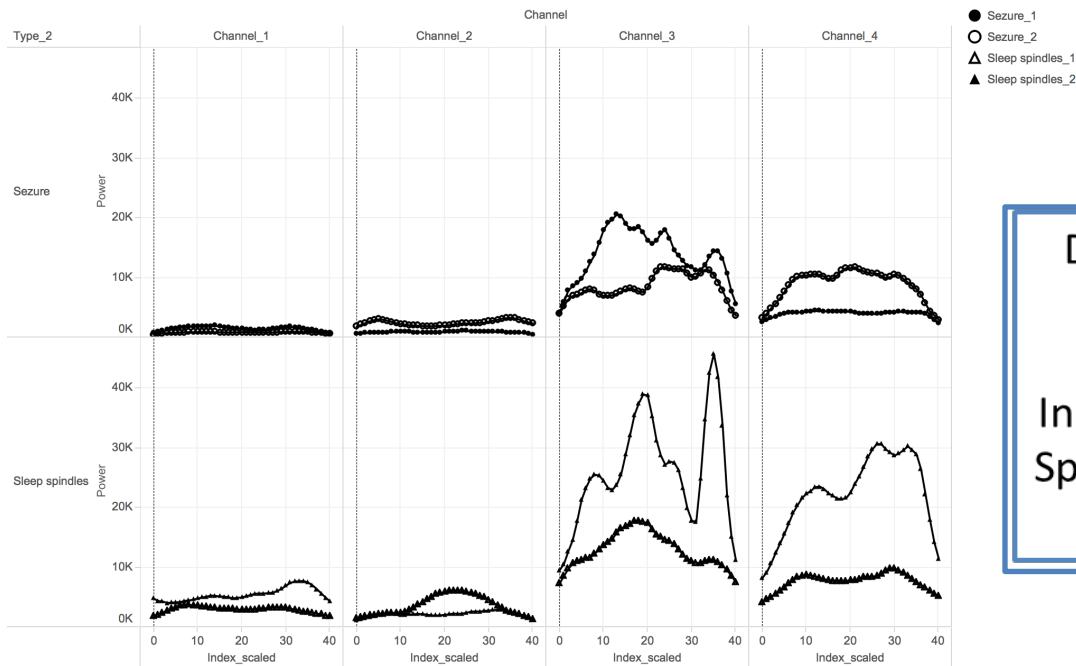
Quantitative evaluation after clustering, before TBI



There is no significant difference in cluster curves before TBI

Type_2	cluster_idx	Channel_1	Channel_2	Channel_3	Channel_4
Seizure	Seizure_1	24% +- 12,36% (36 Files)	30% +- 15,86% (4 Files)	18% +- 7,93% (41 Files)	18% +- 6,38% (20 Files)
	Seizure_2	17% +- 8,40% (6 Files)	18% +- 9,00% (37 Files)	14% +- 6,39% (9 Files)	18% +- 8,25% (34 Files)
Sleep spindles	Sleep spindles_1	14% +- 4,99% (8 Files)	24% +- 12,56% (14 Files)	22% +- 9,02% (29 Files)	18% +- 9,58% (9 Files)
	Sleep spindles_2	21% +- 11,55% (39 Files)	21% +- 8,59% (31 Files)	22% +- 10,01% (18 Files)	21% +- 11,36% (42 Files)

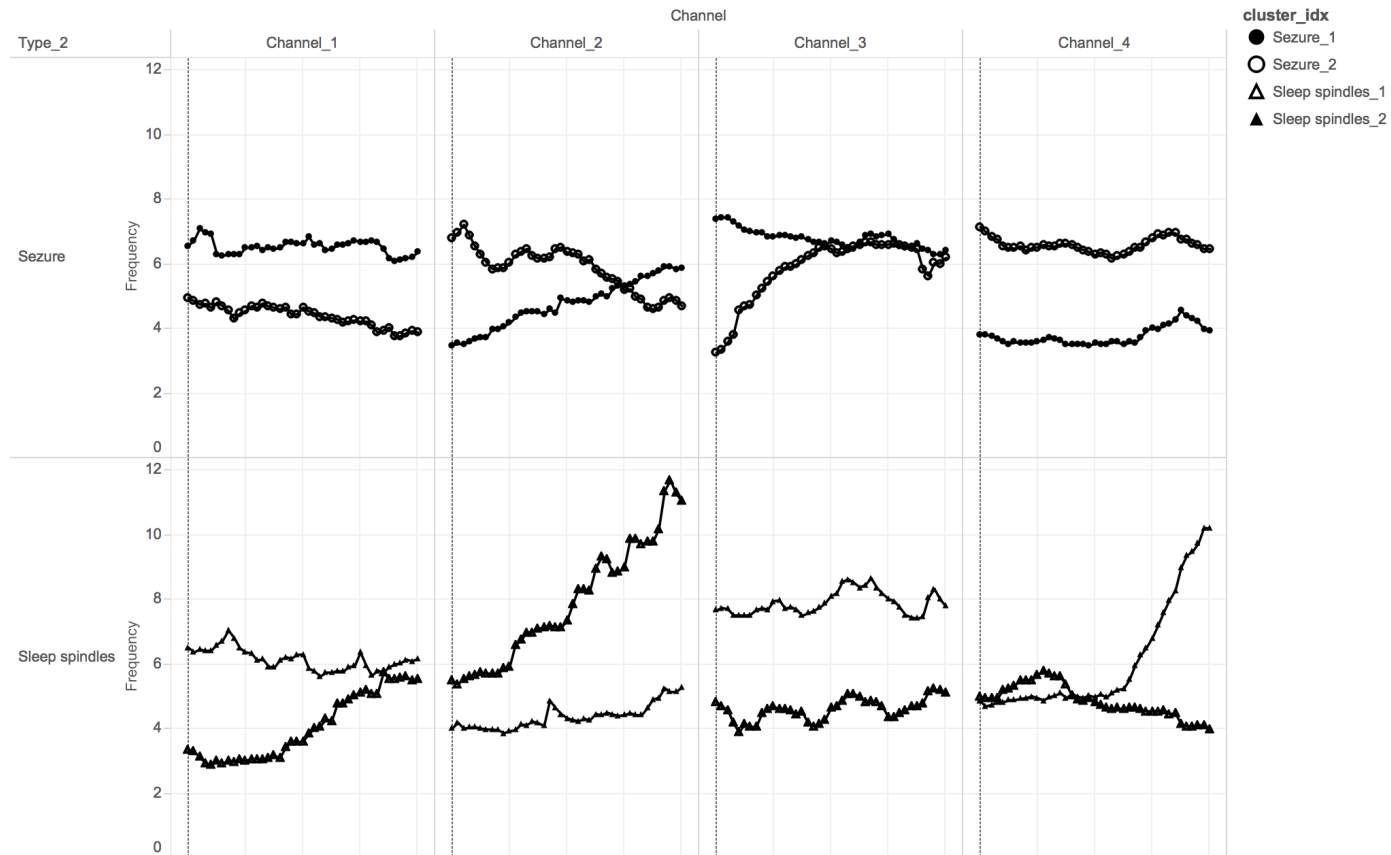
Quantitative evaluation after clustering, after TBI



Distributions of *sm* do not overlap between spindles and seizures in Channel 3 and 4. In the identified clusters, *sm* of Sleep Spindles is higher than *sm* of Epilepsy Seizures.

Type_2	cluster_idx	Channel_1	Channel_2	Channel_3	Channel_4
Seizure	Seizure_1	22% +- 11,19% (7 Files)	20% +- 7,81% (13 Files)	13% +- 5,16% (8 Files)	19% +- 10,51% (15 Files)
	Seizure_2	30% +- 23,63% (14 Files)	19% +- 13,51% (2 Files)	13% +- 6,58% (11 Files)	10% +- 3,12% (8 Files)
Sleep spindles	Sleep spindles_1	23% +- 10,56% (6 Files)	17% +- 5,15% (4 Files)	20% +- 10,90% (12 Files)	25% +- 10,74% (10 Files)
	Sleep spindles_2	32% +- 5,09% (4 Files)	26% +- 11,60% (8 Files)	29% +- 0,02% (2 Files)	29% +- 14,19% (5 Files)

Clustering in Frequency space



Clusters of Sleep Spindles show higher Frequency deviation than Epilepsy Seizures

Summary

- There is **no** significant **difference** in shape nor frequency between Sleep Spindles and Epilepsy Seizures **before TBI**
- Average value of **relative frequency deviation differs** between Sleep Spindles and Epilepsy Seizures **after TBI**. However, **distributions overlap** in 3rd and 4th channels.

Thank you for your attention!