Unmixing of Absence Epileptic Seizures in GAERS

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1. Research Objectives

- Understanding the dynamics of absence epileptic seizures.
- Estimate onset layers in somatosensory cortex.
- ➢ **Signal processing challenges:** designing new methods for localizing and extracting time varying sources and events.

2. Data

- Depth recording from **GAERS**[1]
- Original data set from **GIN**[2]: cortical depth recordings.

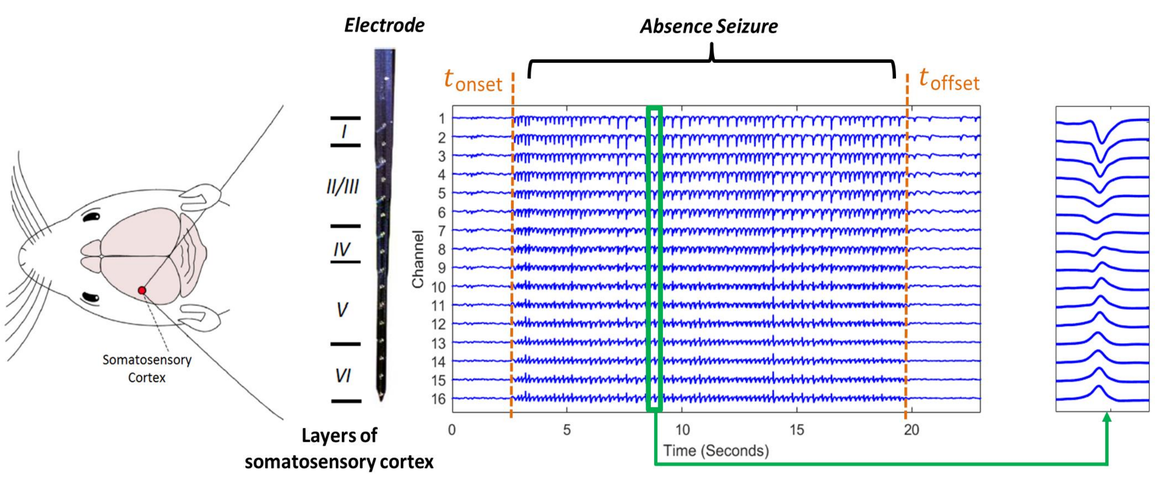

Fig 1. Implementation scheme, the recording electrode, and an absence seizure.

3. A Spatio-Temporal Model for an Absence Seizure

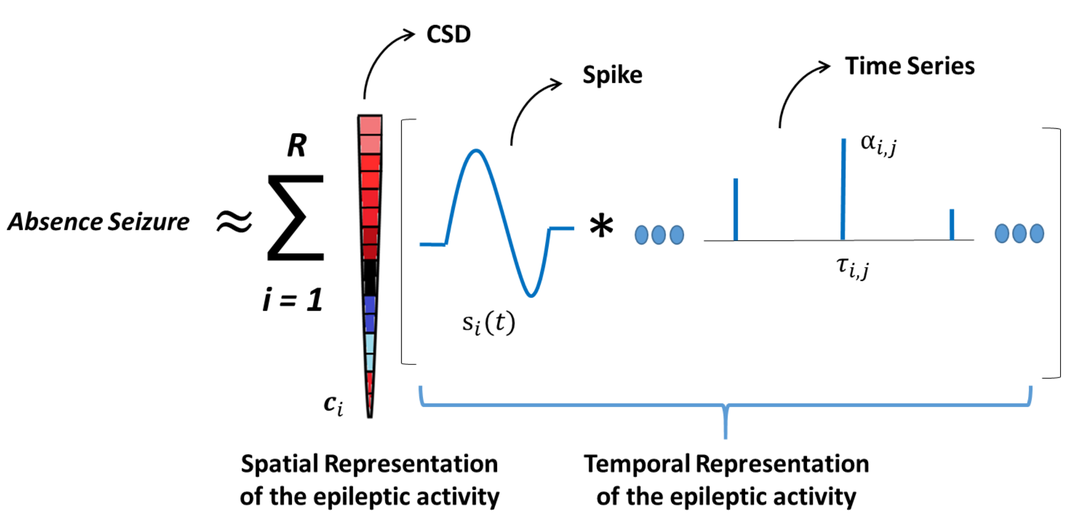

Fig 2. An absence seizure is modeled by a linear combination of R epileptic activities which have spatio-temporal representations.

Epileptic Activity → CSD + Spike + Time Series

4. Problem Formulation

✓ **Target:** Estimating θ from a recorded absence seizure.

$$\mathbf{x}(t) = \sum_{i=1}^{R} \mathbf{c}_i \sum_{j=1}^{L_i} \alpha_{i,j} s_i(t - \tau_{i,j}) + \mathbf{n}(t)$$

$$\Theta = \left\{ R, L, \bigcup_{i=1}^{R} \{\mathbf{c}_i, \mathbf{s}_i, \bigcup_{j=1}^{L} \{\alpha_{i,j}\}\}, \bigcup_{j=1}^{L} \{\tau_j\} \right\}$$

✓ **Main Assumptions:**

- The times series are sparse signals.
- The epileptic activities are synchronized.

✓ **Objective Function:**.

$$f(\Theta) = \|\hat{\mathbf{X}} - \mathbf{C}(\hat{\mathbf{S}} \odot \hat{\mathbf{A}})\|_F^2 \quad \text{------>} \quad \textbf{Alternation Minimization}$$

[1] Genetic Absence Epilepsy Rat from Strasbourg.

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5. Model Parameters Estimation

The best bio physiological interpretation will determine R.

I. CSD

$$\mathbf{C}_{opt} = \underset{\mathbf{C}}{argmin} \|\hat{\mathbf{X}} - \mathbf{C}(\hat{\mathbf{S}} \odot \hat{\mathbf{A}})\|_F^2$$
$$s.t. \quad diag(\mathbf{C}^T\mathbf{C}) = \mathbf{I}$$

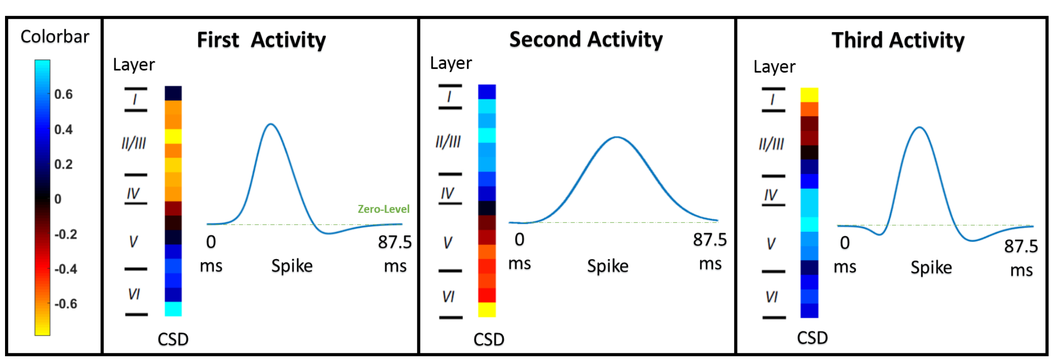
II. Spike

$$\hat{\mathbf{S}}_{opt} = \underset{\hat{\mathbf{S}}}{argmin} \|\hat{\mathbf{X}} - \mathbf{C}(\hat{\mathbf{S}} \odot \hat{\mathbf{A}})\|_F^2$$
$$s.t. \quad diag(\hat{\mathbf{S}}^H\hat{\mathbf{S}}) = \mathbf{I}, \quad \hat{s}_i(-f) = \hat{s}_i^*(f), \quad i = 1, 2, ..., R$$

III. Time Series

$$\hat{\mathbf{A}}_{opt} = \underset{\hat{\mathbf{A}}}{argmin} \|\hat{\mathbf{X}} - \mathbf{C}(\hat{\mathbf{S}} \odot \hat{\mathbf{A}})\|_F^2$$
$$s.t. \quad L \leq L_{max}, \quad \alpha_{i,j} > 0, \quad i = 1, 2, ..., R, \quad j = 1, 2, ..., L$$

6. Results



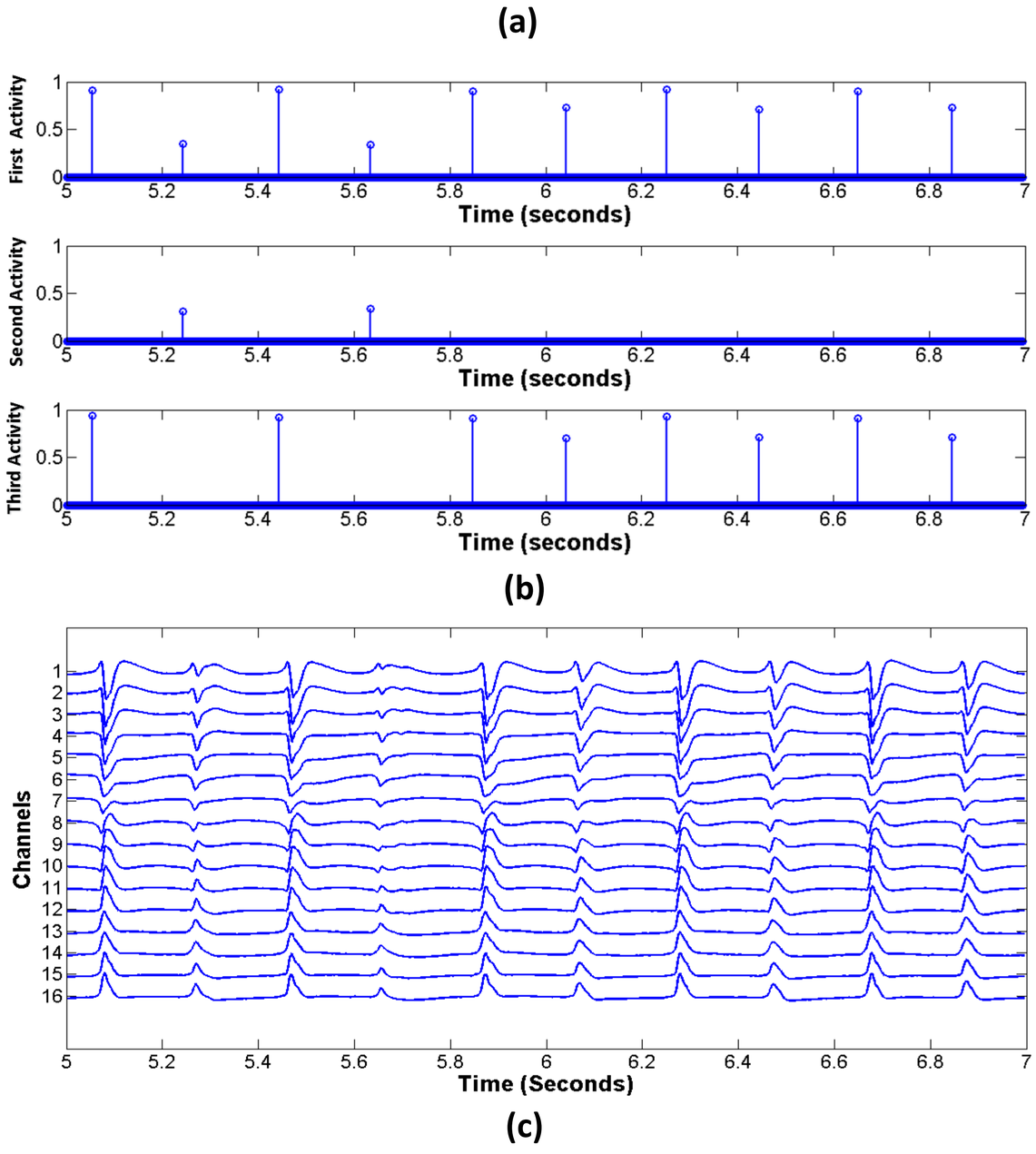


Fig 3. (**a**) The CSDs and the spikes of the epileptic activities generating the absence seizure. (**b**) Two seconds of the time series of the epileptic activities, and (**c**) the corresponding absence seizure.

7. Conclusion

- ✓ There are three epileptic activities during the absence seizures.
- ✓ One of the epileptic activities is dominant, and the other epileptic activities randomly activate with the dominant epileptic activity.
- ✓ The origins of the epileptic activities are located in the top and the bottom layers of somatosensory cortex.