Unraveling Rodent Brain Signals During Euthanasia with Eigensystem Realization Algorithm (ERA)

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1 Abstract

Our study reconstructs the Local Field Potential **LFP** time series of anesthetized and awake rats before and during CO_2 euthanasia **[1]**. We use the Eigensystem Realization Algorithm **ERA** to identify a linear dynamical system capable of generating the observed data.

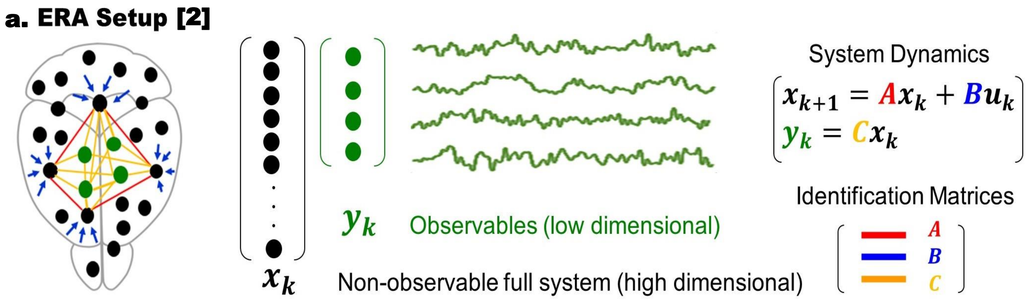
Our results show that the complexity level, ***number of stacks (NS)***, of anesthetized brains is higher than that of the awake brains before CO_2 administration. However, euthanasia causes significant changes in the complexity or last-fight response profile of awake brains, indicating a state of heightened neuronal activity. In contrast, anesthetized brains enter a more subdued state early on.

2 Objectives

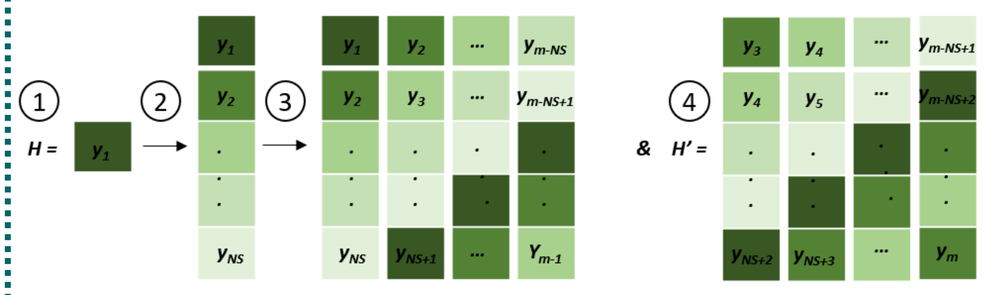
Our research identifies equations explaining brain activity in rats during euthanasia, demonstrating our ability to accurately reconstruct complex **LFP** time series.

3 Method

a. ERA Setup [2]

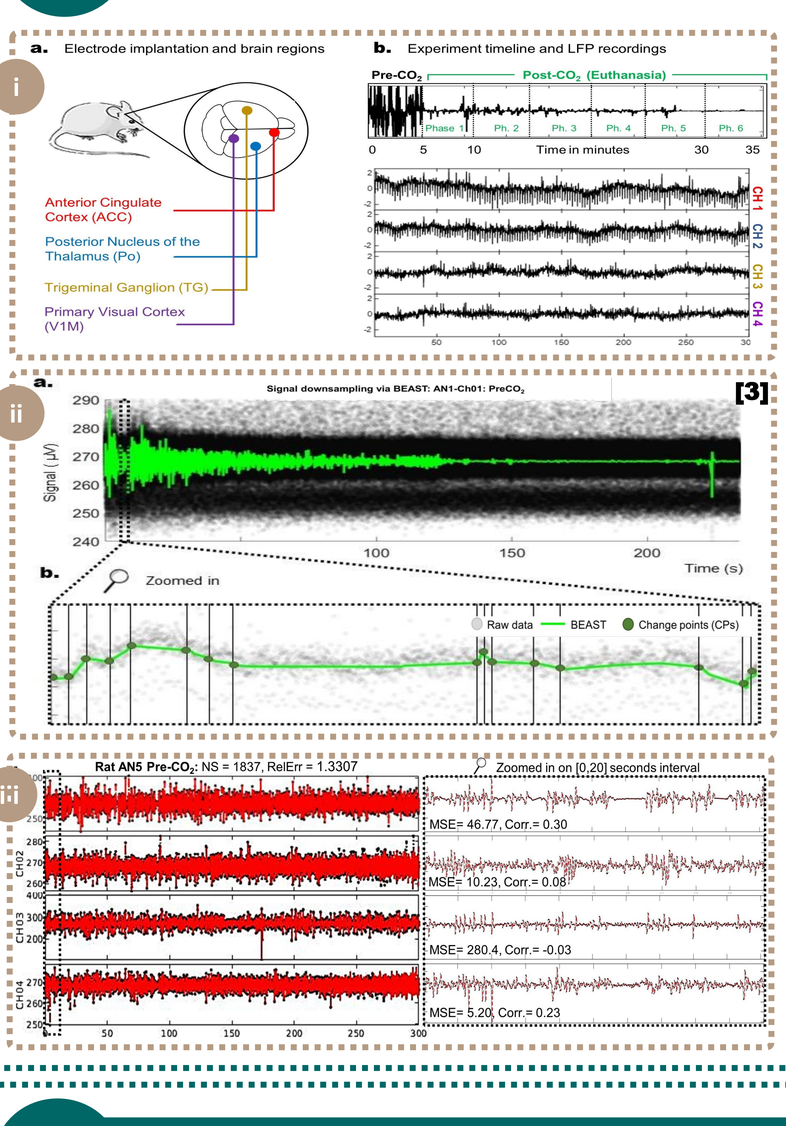


b. Number of Stacks (NS) and Brain complexity



1. Assuming the first Data Matrix ***H*** is given by a single mode y_1
2. Stacking the current state y_1 with ***NS*** copies of ***y*** at future times.
3. Extending the process to include ***NS*** time-shifted states to get **Hankel Matrix (*H*)** with ***NS*** stacks.
4. time-shifted **Hankel Matrix (*H'*)** with ***NS*** stacks.

4 Results



5 Conclusion

1. Anesthetized brain signals are more complex than awake brain signals before CO_2 administration.
2. During euthanization with CO_2, awake brain signals became more complex.
3. After CO_2 exposure, the awake group has higher ***NS*** values, indicating a last fight or sudden surge in brain signal complexity.
4. These results highlight the effectiveness of **ERA** in analyzing **LFP** signals and provide insights into the effects of anesthesia on brain activity.
5. **ERA** in ICU monitors brain activity in real-time, allowing early detection of near-death experiences, memory issues, and mortality in humans.

6 Future Work

We plan to use the **ERA** reconstruction method to validate its applicability across rodent datasets, including the Allen electrophysiology recordings. **ERA** reveals data complexity, emphasizing the need for more research. Furthermore, the "**last fight**" phase in rodents requires further investigation to understand its mechanisms better.

In humans, research shows that heightened brain activity may indicate memory replay after cardiac arrest. **ERA** allows real-time monitoring of brain activity in ICUs, providing early warning signals. This research offers insight into near-death experiences, memory, and human mortality.

7 References

[1] Wang Z, Peng YB. Multi-region local field potential signatures in response to the formalin-induced inflammatory stimulus in male rats.

[2] Kutz, N., Brunton, B., Brunton, S., Proctor, J. Dynamic Mode Decomposition: Data-Driven Modeling of Complex Systems.

[3] J. Li and a. N. Y. Zhao-Liang Li and, Hua Wu, “A trend, seasonality, & abrupt change detection method for land surface temperature time-series analysis: Evaluation & improvement.”

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