ECT-Induced Memory Disruption: Insights from Local Field Potential Recordings in Rats

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Introduction

Electroconvulsive therapy (ECT) is a procedure used to treat severe mental health conditions when prior treatments have failed. While ECT remains the most effective treatment, studies have found that the use of ECT has lead to memory impairments. The **purpose** of this study is to understand the neuro-mechanisms of pain-processing in the brain through the use of ECT and local field potentials (LFPs). We **hypothesize** that (1) a formalin injection given in the left hind paw will induce an increase of LFP activity; (2) ECT will disrupt pain memory activity in the brain. The **aim** of this study is to determine the effects of ECT in four brain areas: ACC, R-CeA, CA1, and CA3.

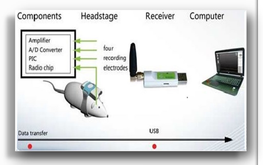
Methods

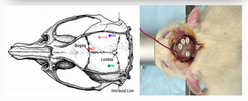
Animals

Nine adult Sprague Dawley rats (N = 9, n_1 = 6, n_2 = 3), with an average weight of 427.6±41.1g and a range of 357g-503g were utilized in this study. All procedures were approved by the Institutional Animal Care and Use Committee (IACUC) at the University of Texas at Arlington. All animals were euthanized after the completion of each experiment.

Electrode Implantation

The rat was placed on the stereotaxic frame under 3% isoflurane inhaled anesthesia. Four 0.010 inch electrodes were intracranially implanted into four regions of the brain: (1) right ACC at 0 mm posterior to bregma, 0.70 mm lateral to the right, 3.20 mm deep; (2) right central amygdala at 2.04 mm posterior to bregma, 4.00 mm lateral to the right, 8.00 mm deep; (3) right CA3 at 5.60 mm posterior to bregma, 4.50 mm lateral to the right, 6.10 mm deep; (4) left CA1 at 5.60 mm posterior to bregma, 3.70 mm lateral to the left, 3.20 mm deep (Paxinos & Watson 2007). Two screws were fastened to the skull, one on the upper right region, and the other on the upper left region of the skull, connecting to a cable for grounding and reference purposes. Dental cement was used to anchor the four electrodes and screws.





Module Setup and Recording

The four electrodes and reference cable were connected to the wireless recording module (designed by SiChuan NeoSource BioTektronics limited (*http://neoscbio.com*)) to receive the local field potential (LFP) from the brain. A USB dongle paired with the module was inserted into the computer to transmit the signal from the module to the recording software.

Formalin Model

LFP was recorded under 1.5% isoflurane anesthesia for 10-minutes as a baseline for all rats. 50ul of 3% formalin was injected in the left hind paw of all animals after the 10-minute baseline.

ECT Stimulation

Ugo Basile ECT Unit 57800 was used for the stimulation

Group one: Formalin Only

In the first experimental condition (n=6), following a 10-minute baseline, 50ul of 3% formalin was injected into the left hind paw of the animal, followed by a 65-minute LFP recording.

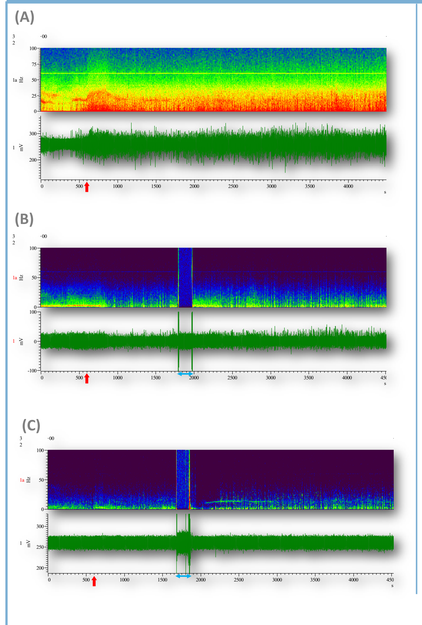
Group two: Post-formalin ECT

In the second experimental condition (n=3), following a 10-minute baseline, 50ul of 3% formalin was injected into the left hind paw of the animal, followed by a 20-minute LFP recording. After the 20-minute recording, ECT parameters with a 50pulse/ s, 0.7ms, 2s at 50mA, delivered 3 times, 12-15 seconds apart was administered.

Data Analysis

The raw data of LFP recorded from the module was processed by power spectrum analysis with the custom program of MATLAB. The power was calculated in MATLAB every 10-seconds, we then averaged the power intensity depending on the duration. Finally, the power of each frequency band was normalized by baseline average power. Next, the raw data was imported into Spike2 to analyze the data in power spectrogram and waveform graphs. A mixed-design analysis of variance (ANOVA) was utilized in SPSS to determine statistical significance.

Results



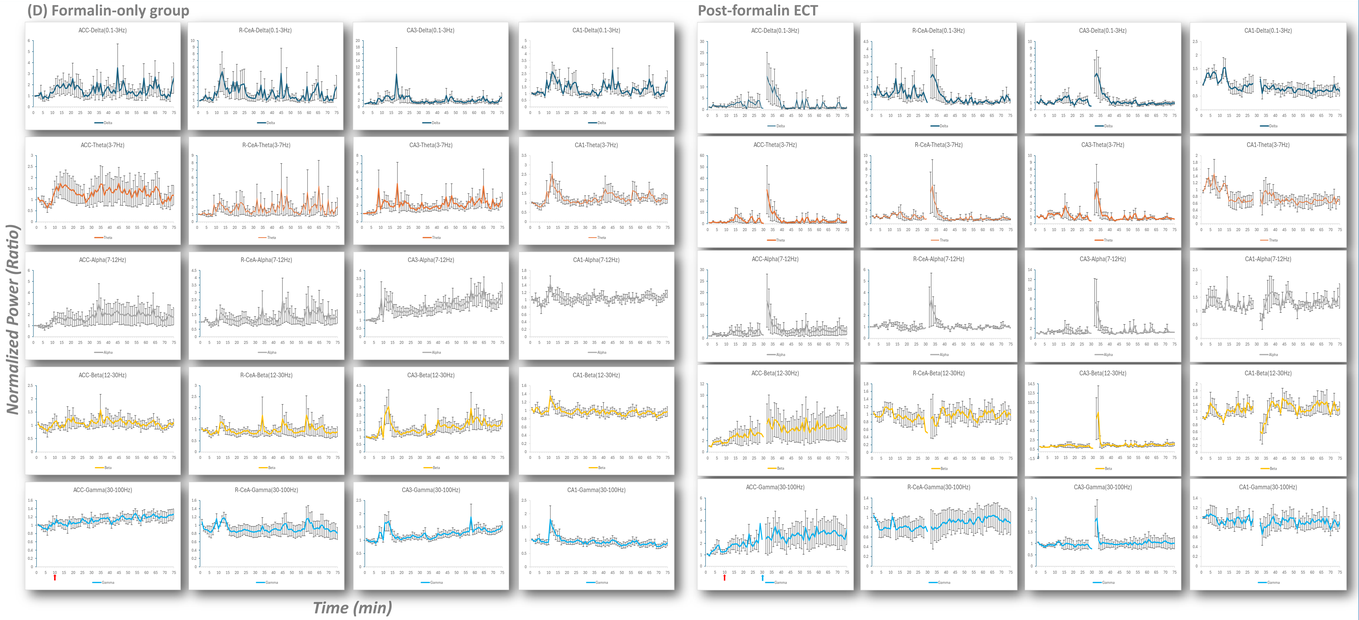


Figure 1. (A) Power spectrogram of CA3 region for representative animal in formalin-only group. (B) Power spectrogram of CA3 region for representative animal in post-formalin ECT group (facilitation). (C) Power spectrogram of CA3 region for representative animal in post-formalin (inhibition) ECT group. (D) Power spectrum analysis every 1-minute for formalin-only, and post-formalin ECT groups. Note: **red** arrow indicates formalin injection, whereas **blue** arrow represents ECT administration.

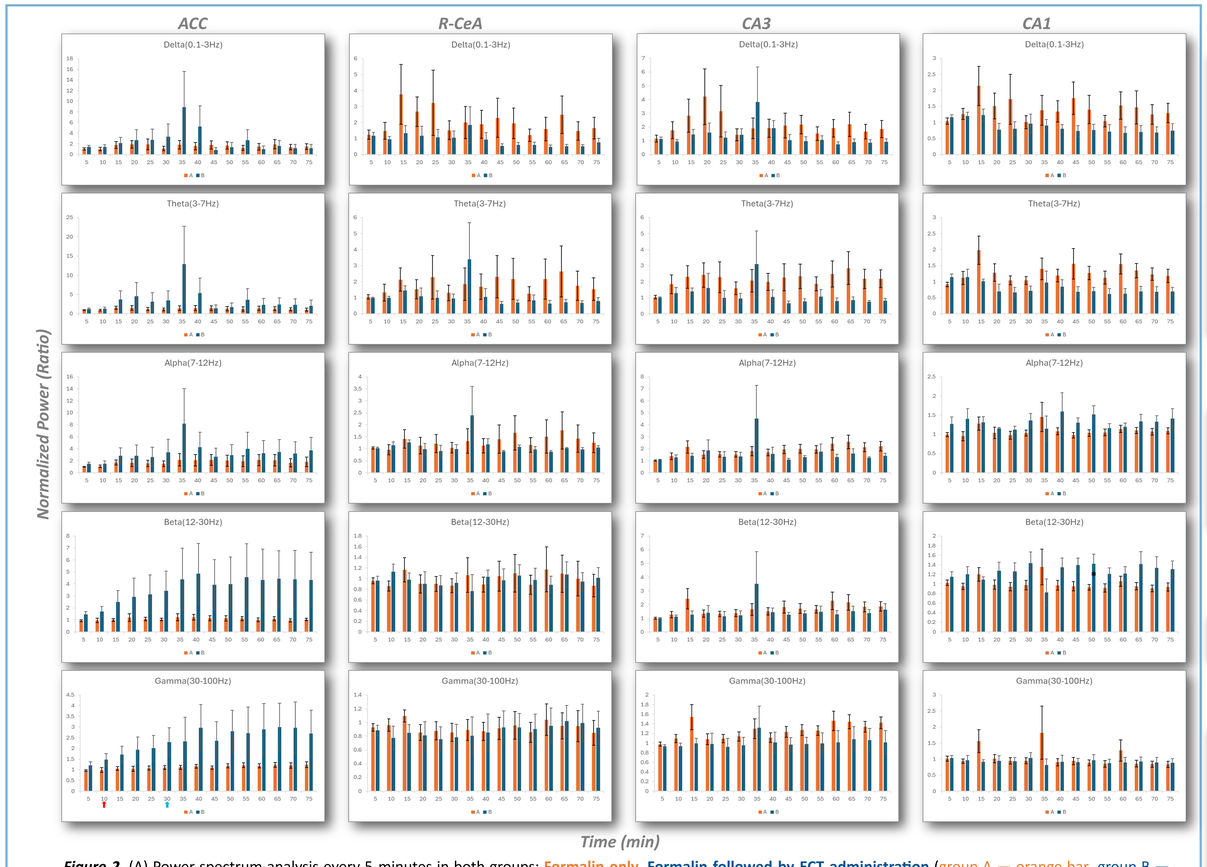


Figure 2. (A) Power spectrum analysis every 5-minutes in both groups: **Formalin-only**, **Formalin followed by ECT administration** (group A — orange bar, group B — blue bar) in the ACC (n=6, group A; n=3 group B), right CeA (n=6, group A; n=3, group B), CA3 (n=6, group A; n=3, group B), and CA1 (n=6, group A; n=3, group B). Note: **red** arrow indicates formalin injection, whereas **blue** arrow represents ECT administration. '*' indicates significant difference between groups A and B. '*' indicates $p < 0.05$.

Discussion

- In the Formalin Only group, there is an obvious increase of power across all five frequency bands at the 10-minute mark when a formalin injection is administered.
- In the Post-formalin ECT group, there is a mild increase in power across all five frequency bands at the 10-minute mark when a formalin injection is administered.
- The Post-formalin ECT group displays mixed results, with an inhibition or facilitation across all five frequency bands.
- Statistical significance was only observed in the beta frequency band in the CA1 brain region at 50 minutes (***Figure 2***).

Conclusion

- For the current data, we observed an increase of frequency power in all five frequency bands in the Formalin only group. We also observed mixed results in the Post-formalin ECT group.
- Further research is needed in unanesthetized animals.

Acknowledgement

- This research is supported by the Department of Psychology.

References

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