Assessing the acute effects of transcranial magnetic stimulation (TMS) on spatial learning and memory in rats performing the Barnes Maze task

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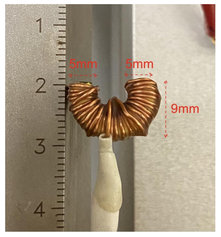
Abstract

Transcranial Magnetic Stimulation (TMS) is a non-invasive technique that is used or investigated for research and therapeutic applications. This includes the study of normal and pathological brain function and the treatment of neurological and psychiatric disorders. TMS uses brief, strong magnetic pulses to produce an electrical field that modulates neural activity. Additionally, the Barnes Maze task was used along with TMS to see if TMS can improve the spatial memory and learning ability of rats. This project aims to evaluate and analyze the effects of TMS on the learning and memory performance of rats via the Barnes Maze task. The ultimate goal is to shed light on how spatial memory and cognitive ability are modulated by TMS in these animals and potentially provide insights applicable to the treatment or neuropsychiatric disorders.

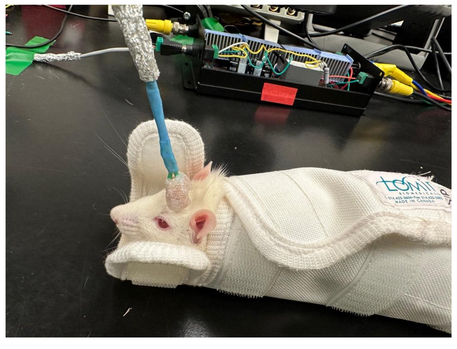
Method

I. Miniaturized TMS Coil for Rodents & Modified Barnes Maze



II. Protocol

1. Set up maze and computer
   - Mount escape box
   - Test speaker
   - Open timer and recording software
2. Set up TMS Treatment
   - Prepare waveform generator
   - Prepare DC voltage source
3. Apply TMS/sham treatment to 2 rats for 5 minutes



Testing Schedule

1. Baseline Training (Day 1)
   - Acquisition Phase:
     - Train rats to find escape box at first location (H13)
     - First session consists of 12 trials instead of 8 to let rats acclimate themselves to the environment
   - Reversal Learning Phase:
     - Train rats to find new escape box (H5)
2. Alternative TMS/sham (Day 2&4)
   - TMS for H13 and H5
   - Sham for H13 and H5
3. Alternative sham/TMS (Day 3&5)
   - Sham for H13 and H5
   - TMS for H13 and H5

Day 1	H13	→	H5	→	H13	→	H5
Day 2	rTMS H13	→	rTMS H5	→	Sham H13	→	Sham H5
Day 3	Sham H13	→	Sham H5	→	rTMS H13	→	rTMS H5
Day 4	rTMS H13	→	rTMS H5	→	Sham H13	→	Sham H5
Day 5	Sham H13	→	Sham H5	→	rTMS H13	→	rTMS H5

Results

I. Overall Performance of 2 Rats

TMS = **Black,** Control = Gray

1. Overall Performance Around H13

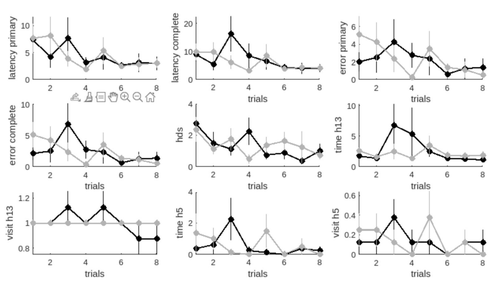


Fig 1) **TMS** vs control of both rats' complete and primary latency, errors, hole visits, and time around target holes over 8 trials at H13

2. Overall Performance Around H5

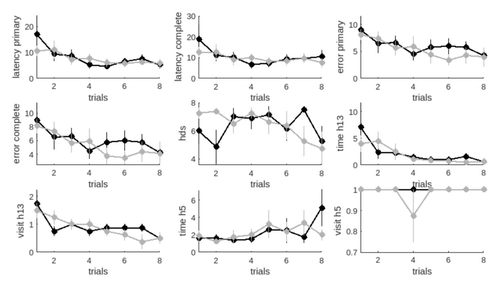


Fig 2) **TMS** vs control of both rat' complete and primary latency, errors, hole visits, and time around target holes over 8 trials at H5

II. Brain Activity After TMS Treatment

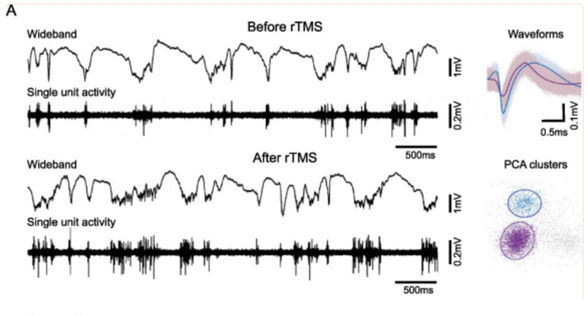


Fig 3) Wideband and high-pass filtered neural signals demonstrating changes after TMS treatment (Jiang et al. 2022)

III. Firing Rate of Neurons in the Brain

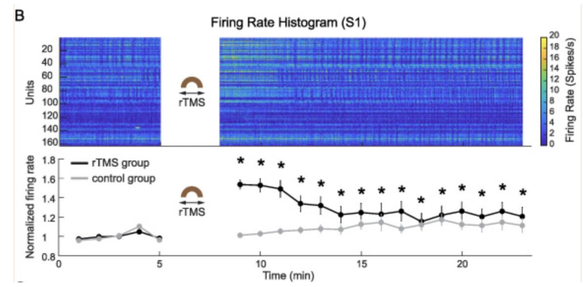


Fig 4) Firing pattern of the rat's somatosensory cortex (S1) neurons before and after TMS (Jiang et al. 2022)

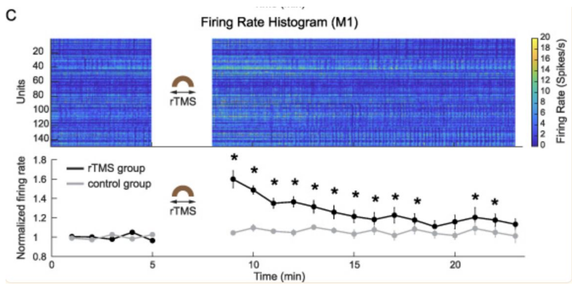


Fig 5) Firing pattern of the rat's primary motor cortex (M1) neurons before and after TMS (Jiang et al. 2022)

Conclusion & Summary

- TMS seemed to have no significant improvements on the rat's spatial memory and learning.
- This suggests that the effects of TMS treatment takes time to occur so there were no immediate changes in the rat's behavior. It may also be because neuroplastic changes in the brain require an extensive amount of time as well.
- Further experimentation is needed to help develop a deeper understanding of TMS on spatial memory and cognitive abilities. This may include incorporating electrophysiology to see the difference

References

[1] Jiang, W., Isenhart, R., Liu, C. Y., & Song, D. (2023). A C-shaped miniaturized coil for transcranial magnetic stimulation in rodents. *Journal of neural engineering*, *20*(2), 026022. https://doi.org/10.1088/1741-2552/acc097

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