Spectral Analysis of Low Gamma Frequency Band During Arm Reaching Movement

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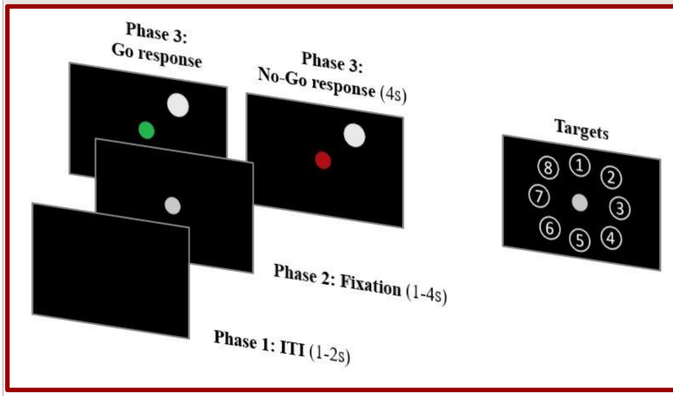
Abstract

The hippocampus, a brain structure situated in the temporal lobe of each cerebral cortex, plays a vital role in long-term memory and memory recall. However, its involvement in the low gamma frequency band (30-80 Hz) during voluntary movement remains unclear. In this study, we used de-identified and anonymized data recorded from epilepsy patients using stereotactic electroencephalography (SEEG) during a reaching task[1]. The investigation of the low gamma frequency band's role in movement is of significant importance in understanding and addressing epilepsy. We processed and graphed the collected data using MATLAB, a data analysis program. Employing spectral density analysis and graphing, we observed a spike in power within the low gamma frequency band during movement planning and execution.

Objectives

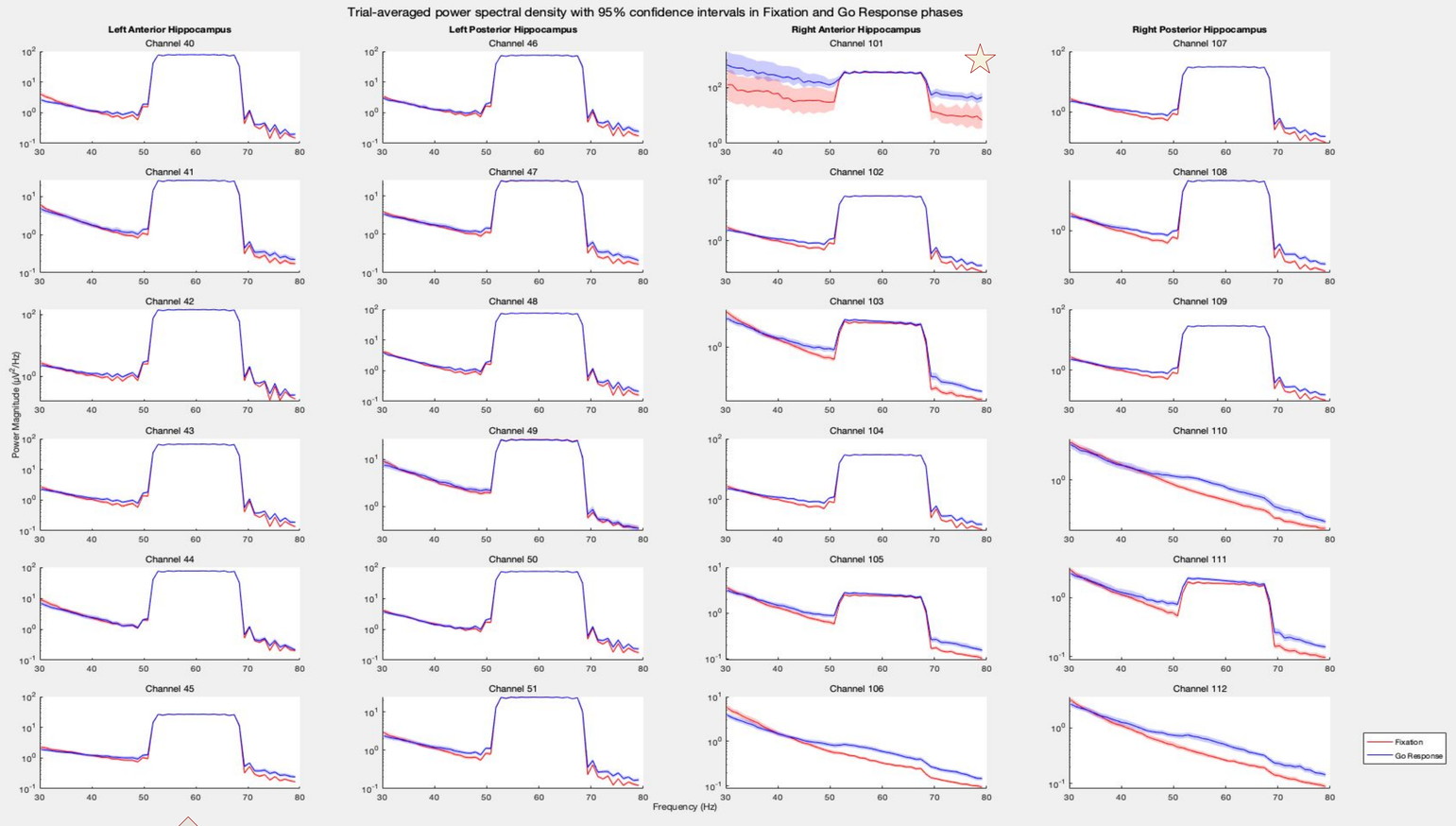
Distinguish the role of the Low Gamma Frequency Band in the hippocampus during voluntary movement.

Go No Go Task



The Go No Go Task is a movement-based task involving three distinct phases. The initial phase, known as the Inter-Trial Interval (ITI), is characterized by the absence of visual stimuli. Participants are instructed to keep their right arm raised and positioned 2 inches away from the screen. They maintain this position while waiting for a fixation dot to appear, which marks the beginning of the Fixation phase. In the Fixation phase, a gray dot with a radius of 9.53 mm appears at the center of the screen. Participants are directed to gaze at the dot without touching the screen. This phase serves as a baseline period during data analysis, as it does not involve any movement. The final phase is the Response phase, where a white target circle with a radius of 15.88 mm appears at one of eight target locations displayed above and to the right of the screen. The target locations are presented in a pseudorandom order, with 8 trials per target. Participants are instructed to quickly reach for the target and perform a double tap on it as soon as it appears. The time elapsed between the target's appearance and the participant's response is defined as the response time. All trials are conducted consecutively without any interruption. The task is programmed using MATLAB and displayed on a 21.5-inch LED-backlit screen with a resolution of 1920 × 1080 pixels and a luminance of 250 cd/m2 (S2240Tb, Dell Inc., Round Rock, TX, USA). MATLAB is a program designed for analysis and design systems.

Trial Averaged Spectral Density in Fixation and Go Phases in the Hippocampus



The humps in channels 40-105, 107-109, and 111 are most likely line noise artifacts. does not suggest any spike in power as there is no significant separation between Fixation and Go.

Channels 106, 110, and 112 have the most significant spikes in power suggesting that the low gamma frequency band in parts of the right hippocampus are involved in movement.

Overall, the power spikes in the right side hippocampus were more severe than those in the right side hippocampus, proposing that the low gamma frequency band in the right side hippocampus is more involved in fixation and movement than the right side hippocampus.

☆ Channel 101 is an EKG artifact.

Summary

One of the main roles of the hippocampus is related to spatial navigation, which is crucial in the direct go-no-go task. After analyzing and plotting the data, it becomes apparent that there is variation in the low gamma frequency band between Fixation and Go. Interestingly, a noticeable spike in the low gamma band is observed more in the right side of the hippocampus. The magnitudes of both the go response and fixation were found to be different. These neural signal differences could be used to develop algorithms that utilize specific channels in the hippocampus for controlling prosthetics.

References

[1]Del Campo-Vera RM, Tang AM, Gogia AS, Chen KH, Sebastian R, Gilbert ZD, Nune G, Liu CY, Kellis S, Lee B. Neuromodulation in Beta-Band Power Between Movement Execution and Inhibition in the Human Hippocampus. Neuromodulation. 2022 Feb;25(2):232-244. doi: 10.1111/ner.13486. PMID: 35125142; PMCID: PMC8727636.

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