Analysis of High Gamma Waves in the Hippocampus During Fixation and Go Phases

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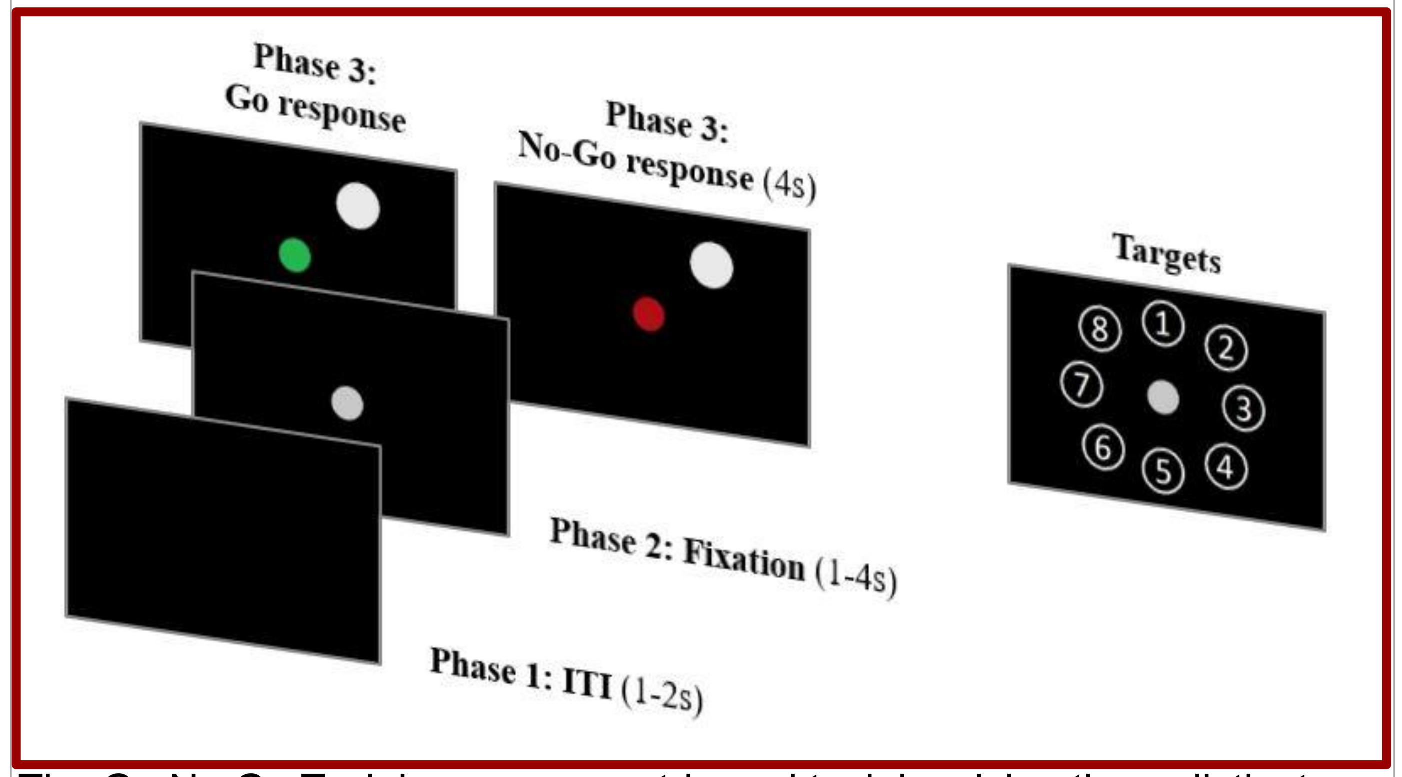
Abstract

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 high gamma frequency band (80-150 Hz) during voluntary movement remains unclear. In this study, we analyzed anonymous data from epilepsy patients using stereotactic electroencephalography (SEEG) during a reaching task. The investigation of the high gamma frequency band's role in movement is of significant importance in understanding and addressing epilepsy. We processed and plotted the collected data using MATLAB, a data analysis program. Employing spectral density analysis through the Chronux toolbox, we observed a spike in power within the high gamma frequency band during movement planning and execution.

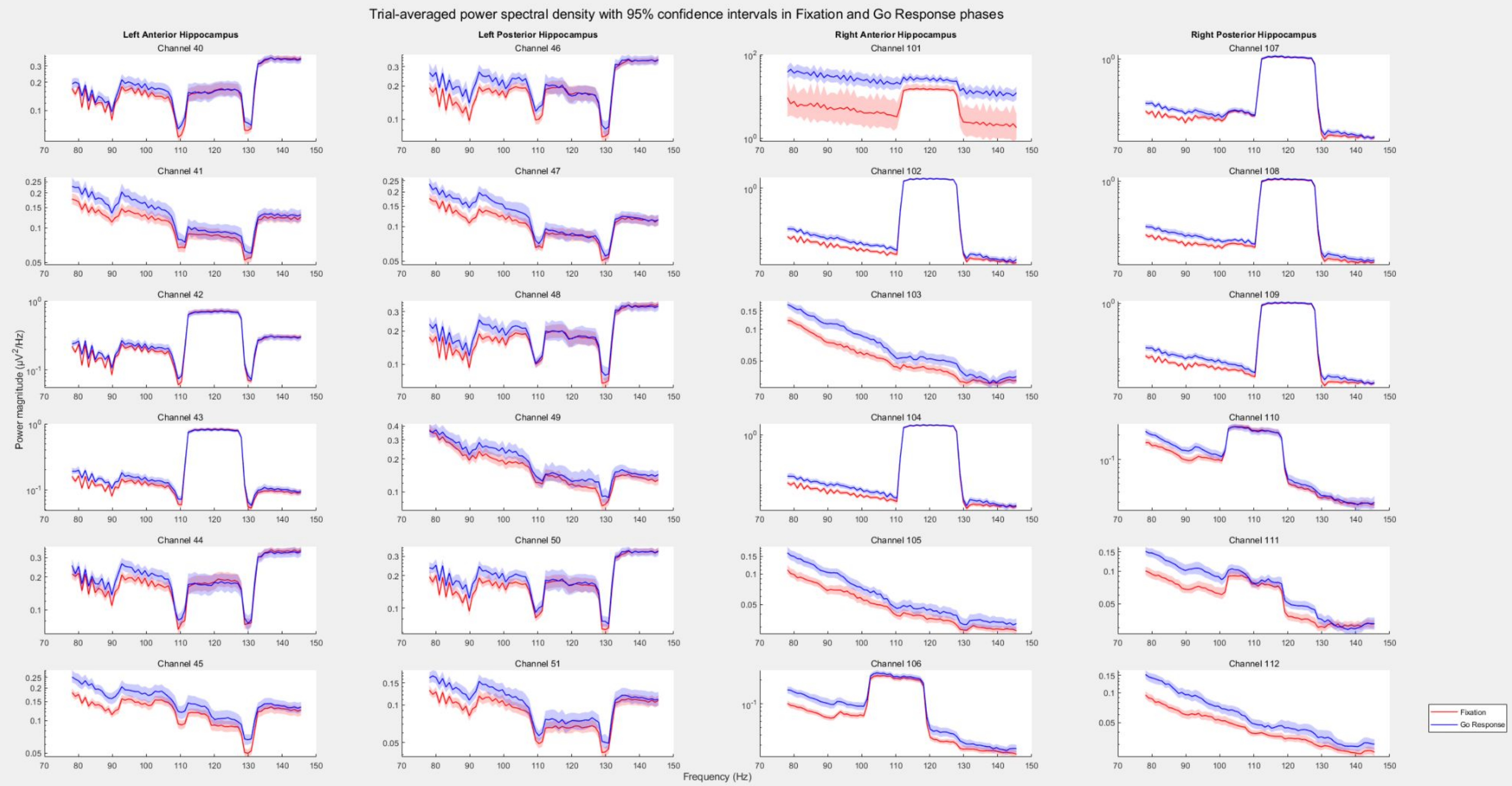
Objective

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



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).

High Gamma Band



Findings

- The involvement of the hippocampus in the high gamma band is evidenced by the differences in power during both the Go and Fixation phases.
- The majority of channels during Fixation and Go phases mirror each other, with the power magnitude being slightly less during the Fixation phase.
- The humps in the signals are likely due to noise from electromagnetic interference.
- Some of the channels on the right hippocampus were not affected by interference, but all of the channels on the left were.
- There is a more consistent separation of the signal between the Fixation and Go Response phases, with the power magnitude typically lower for Fixation than for the Go Response.
- The confidence intervals for the right hippocampus channels have more separation instead of overlap, which indicates that the right hemisphere of the hippocampus is much more involved in the anticipation and action of movement.

Summary

One of the primary functions of the hippocampus involves spatial navigation, a critical aspect in the direct go-no-go task. Upon analyzing and graphing the data, it is evident that the high gamma band exhibits minimal variation between Fixation and Go Response. However, there is separation present in the lower part of the high gamma band between the Fixation and Go Response, possibly indicating the anticipation of movement. Although the remaining graphs generally display lower magnitudes for fixation compared to the go response, the slight disparity between the magnitudes of both signals is insufficient to establish a definitive distinction. This can be helpful to predict movement, but not to control it. Based on these neural signals, it becomes plausible to develop algorithms utilizing specific channels and frequencies in the hippocampus for controlling prosthetics.

References

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