12/7/2023

Bio ca1

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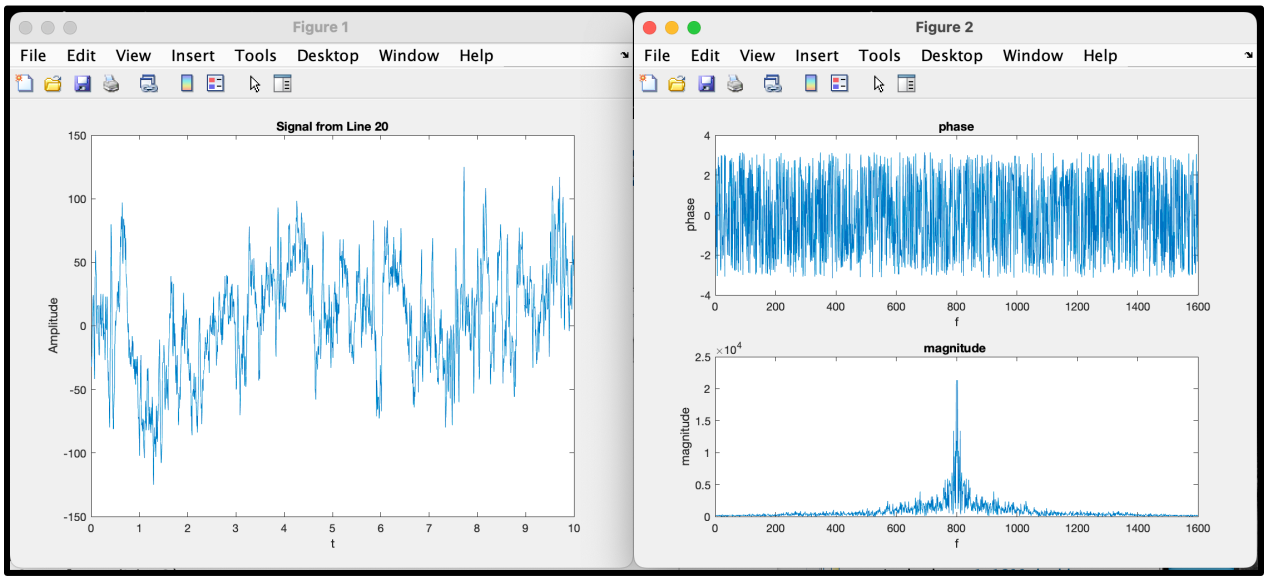
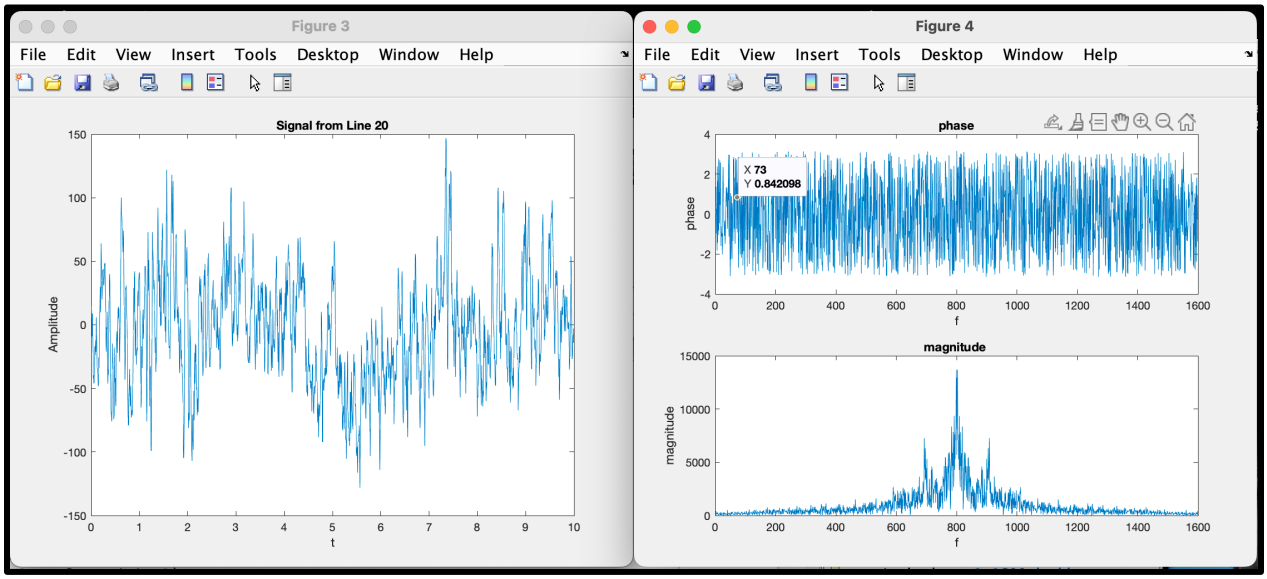
Part One:

Time and Frequency Domain Plotting:

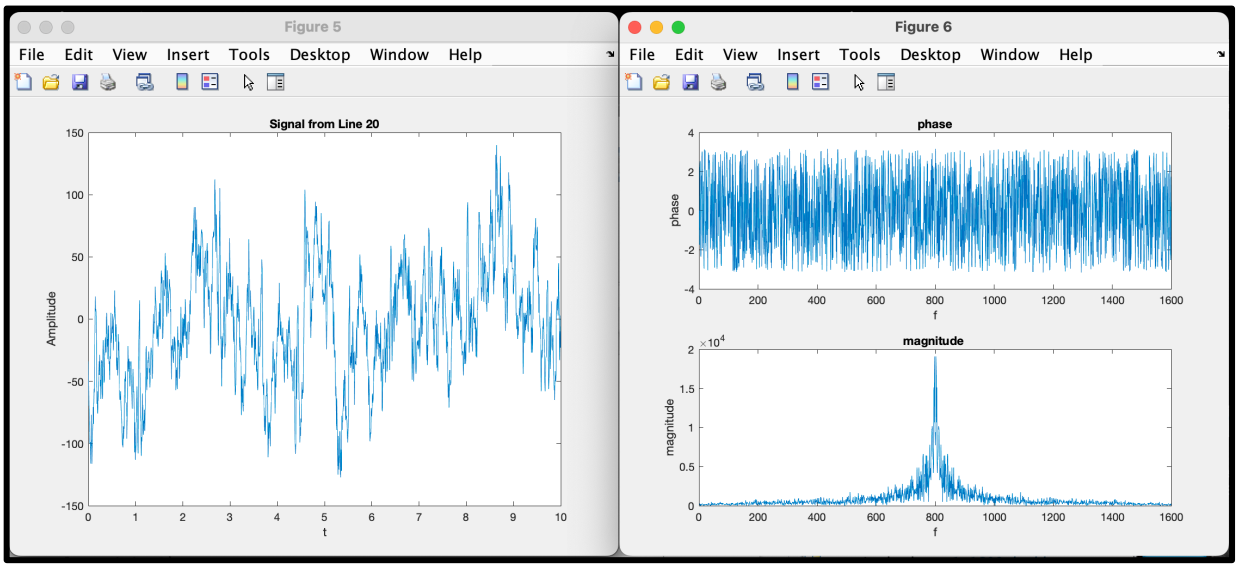
Plotting the v1 graph:



Plotting the v2 graph:

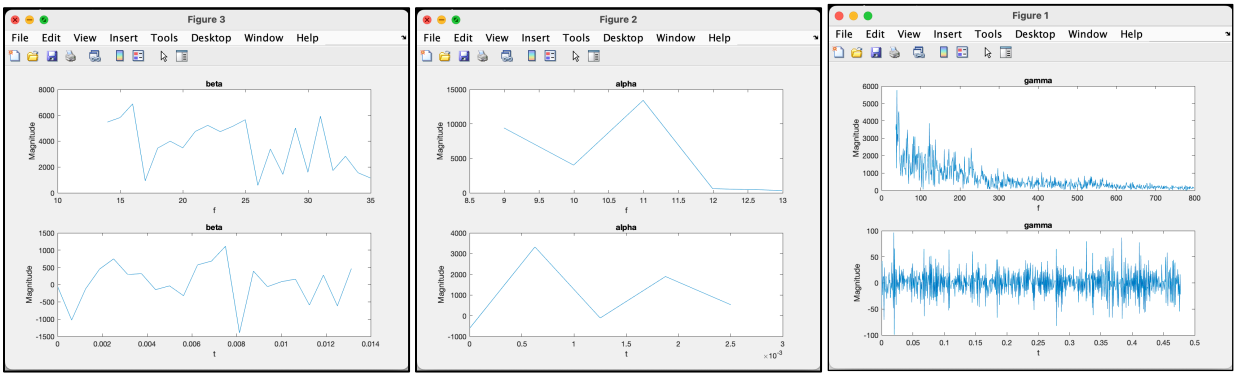


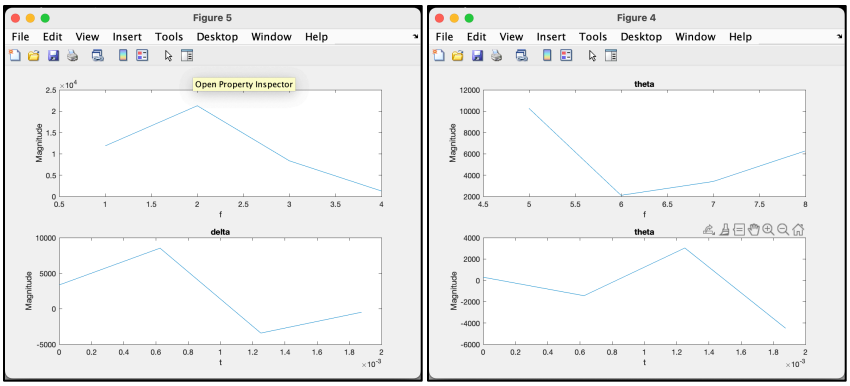
Plotting the v3 graph:



As can be seen, it is difficult to establish a connection between time and frequency, and generally, the brain signal in the time domain appears more like noise. This is why brain signals are often transformed into the frequency domain and further divided into different components to study brain activity at various frequencies. In the next section, we will plot the different frequency bands corresponding to various brain states (gamma, alpha, beta, theta, delta).

Different Waves for the v1 Graph:





After dividing the signal into different components, we need to determine in which frequency band the brain has the most activity. This can be understood by observing the amplitude of the graph in that region. As is evident, the amplitude in the delta band is much higher, indicating that the brain is primarily active in this region. (We could have used the ylim function to standardize the display range of the amplitude for all graphs, which would make analysis easier. However, in that case, except for the delta graph, the other graphs would nearly approach zero. For this reason, I conducted the analysis based on the amplitude values next to the graph.)

Part Two:

The human body passes through two phases of sleep during the night: 1) Rapid Eye Movement (REM) and 2) Non-Rapid Eye Movement (NREM) sleep, which is further divided into three stages, N1 to N3. Each phase and stage of sleep involves changes in muscle tension, brain wave patterns, and eye movements. The body goes through these stages about 4 to 6 times during the night, with each cycle lasting around 90 minutes.

The quality of sleep and the time spent in each sleep stage can be influenced by factors such as depression, aging, brain injuries from trauma, medications, and more.

The sleep cycle is regulated by the circadian rhythm, which is controlled by the suprachiasmatic nucleus (SCN) of the hypothalamus. Sleep-promoting inhibitory nuclei using GABA are found in the brainstem, lateral hypothalamus, and preoptic area.

Transitions between sleep and wake states are coordinated by several brain structures, including:

- **Hypothalamus**: Controls the initiation of sleep
- **Hippocampus**: Memory region that is active during dreaming
- **Amygdala**: Emotion center that is active during dreaming
- **Thalamus**: Prevents sensory signals from reaching the cerebral cortex
- **Reticular formation**: Regulates the transition from sleep to wakefulness
- **Pons**: Helps initiate REM sleep. The rapid eye movements that occur during REM are linked to the activity of the PPRF (Paramedian Pontine Reticular Formation/Center for Conjugate Gaze)

As mentioned earlier, the sleep cycle is regulated by the circadian rhythm, which is governed by the Suprachiasmatic Nucleus (SCN). The circadian rhythm also controls the nightly release of hormones such as Adrenocorticotropic Hormone (ACTH), Prolactin, Melatonin, and Norepinephrine (NE).

Although it seems clear that humans need sleep, our current understanding of exactly why sleep is such a vital part of life remains uncertain. We can imagine that the main value of sleep lies in restoring the natural balance between neural centers, which is essential for overall health. However, the specific physiological functions of sleep remain a mystery and are the subject of extensive research. Current hypotheses about the functions of sleep include:

- Neural development
- Facilitation of learning or memory
- Purposeful synaptic pruning to "forget" unimportant information that may disrupt the neural network
- Cognition
- Removal of metabolic waste products generated by neural activity in the awake brain
- Conservation of metabolic energy

Conclusion:

Human sleep occurs in five main stages:

1. **Wakefulness**: This is the most active stage of sleep, characterized by beta waves in the EEG. During this stage, the brain is active, and you are alert.
2. **N1 Stage 1 - Light Sleep**: This is the shortest stage of sleep, characterized by theta waves in the EEG. During this stage, you can be easily awakened and may feel dizzy or unsteady.
3. **N2 Stage 2 - Deeper Sleep**: This is the longest stage of non-REM sleep, characterized by sleep spindles and K-complexes in the EEG. In this stage, your breathing slows, and you are less responsive to external stimuli.
4. **N3 Stage 3 - Deepest Non-REM Sleep**: This is the deepest stage of non-REM sleep, characterized by delta waves in the EEG. At this stage, it is difficult to wake up, and you may feel very groggy. This stage is essential for body restoration.
5. **REM (Dreaming Stage)**: This stage is marked by rapid eye movements and active brain activity. During this stage, you dream and may experience involuntary movements, like talking or eye movements.

Average time spent in each stage of sleep:

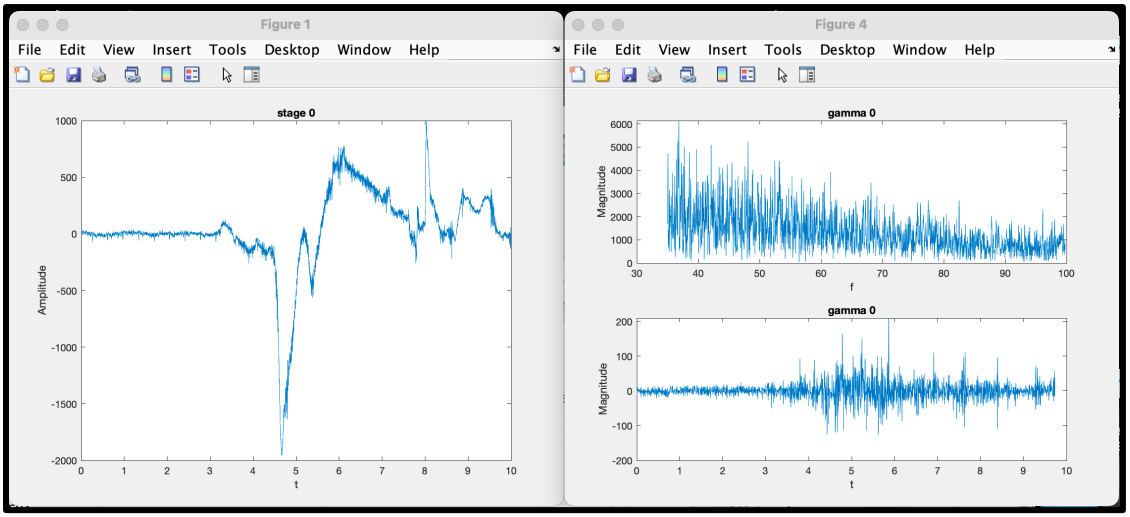
1. **Wakefulness**: 20%
2. **N1 (Stage 1)**: 5%
3. **N2 (Stage 2)**: 45%
4. **N3 (Stage 3)**: 25%
5. **REM (Dreaming Stage)**: 25%

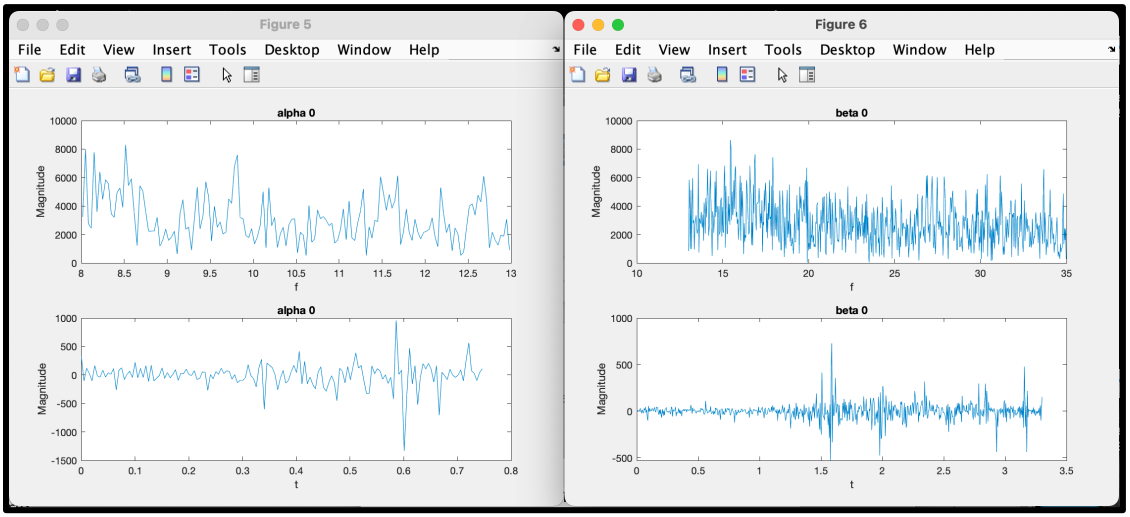
Important Note: Each complete sleep cycle lasts about 90 to 110 minutes and repeats several times throughout the night. As the night progresses, the duration of REM sleep increases, while the duration of N3 sleep decreases.

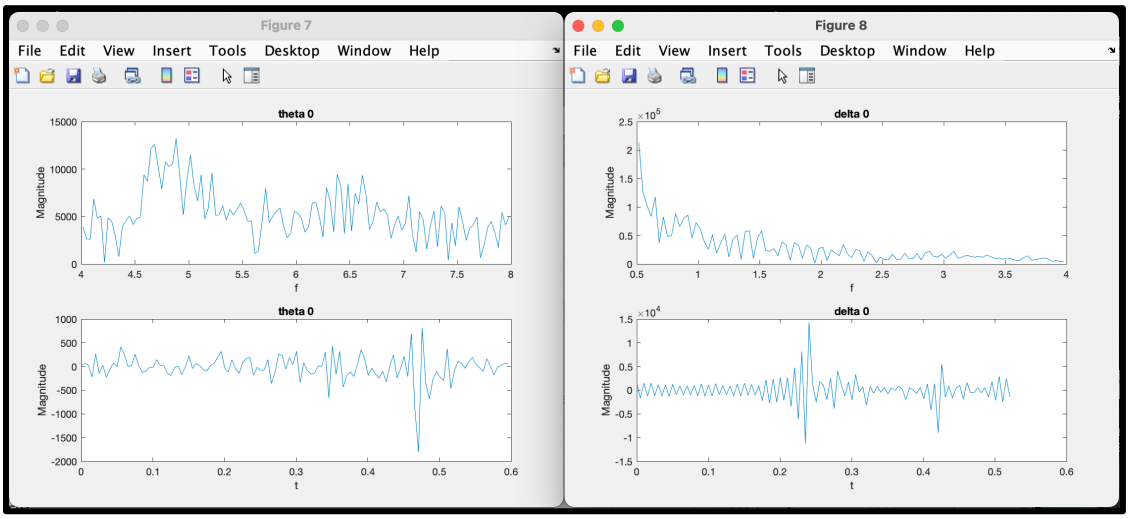
Source:

Physiology, Sleep Stages
Aakash K. Patel; Vamsi Reddy; Karlie R. Shumway; John F. Araujo.
Year: September 7, 2022

Data Related to Stage 0:







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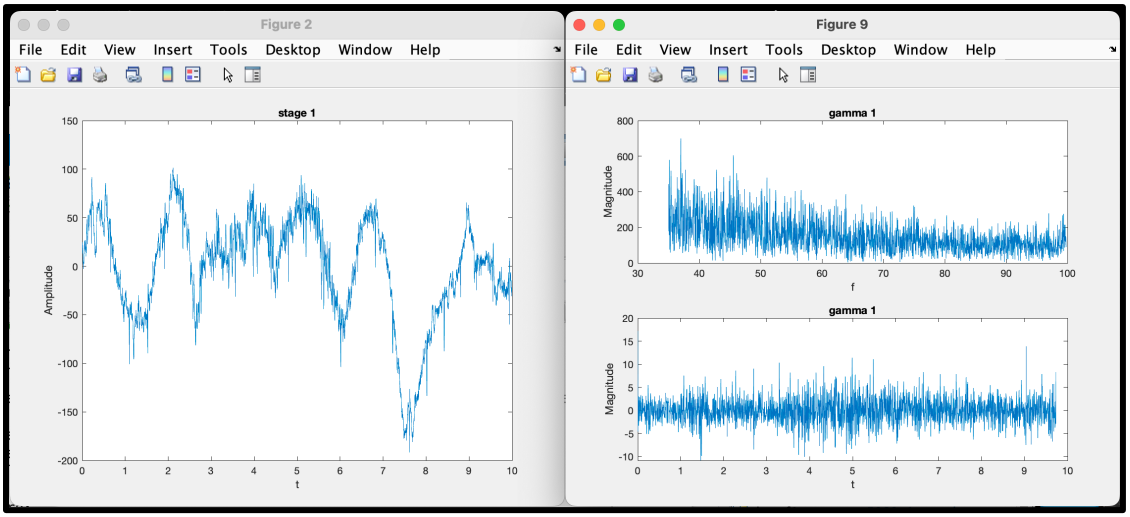

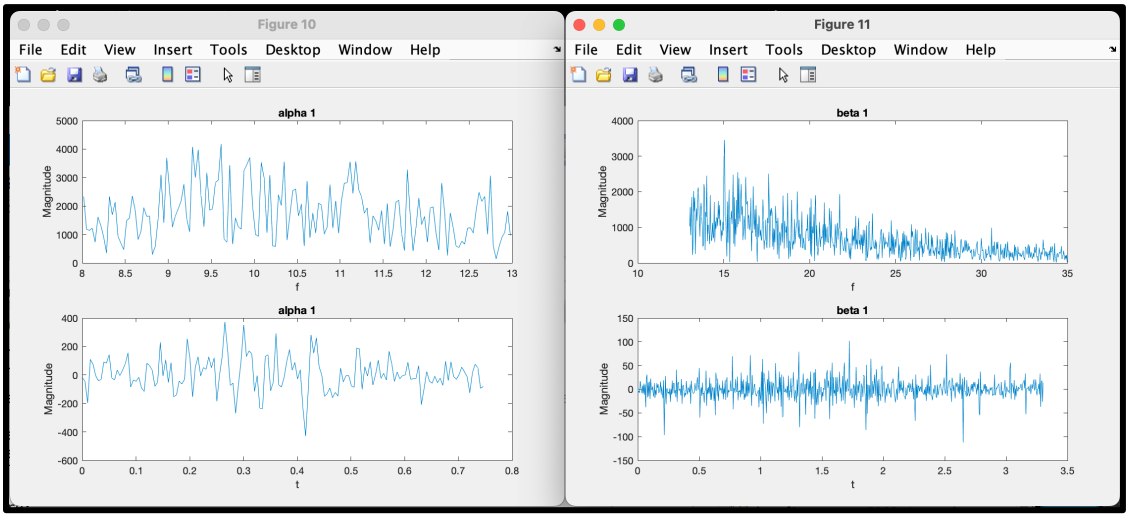

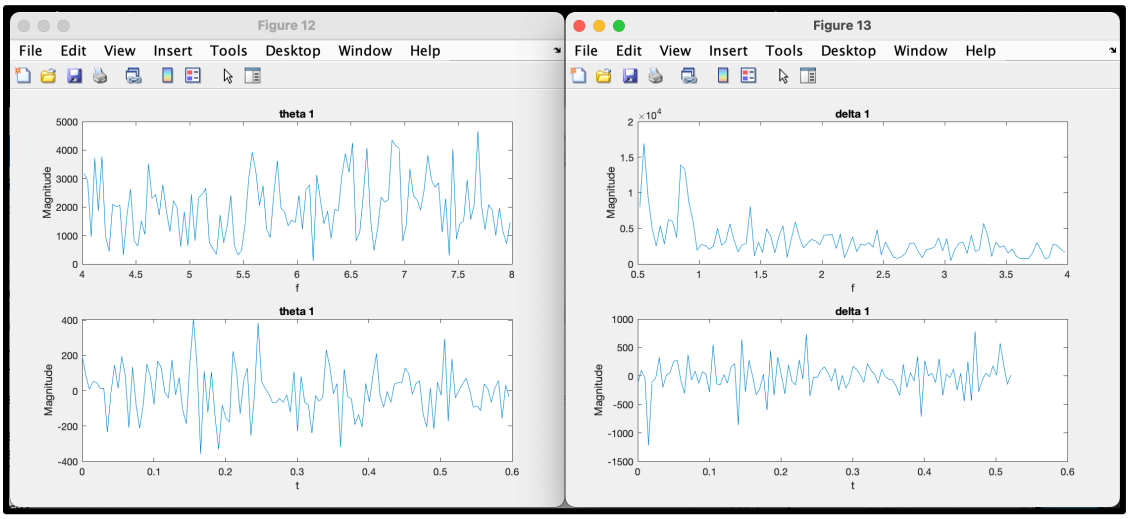

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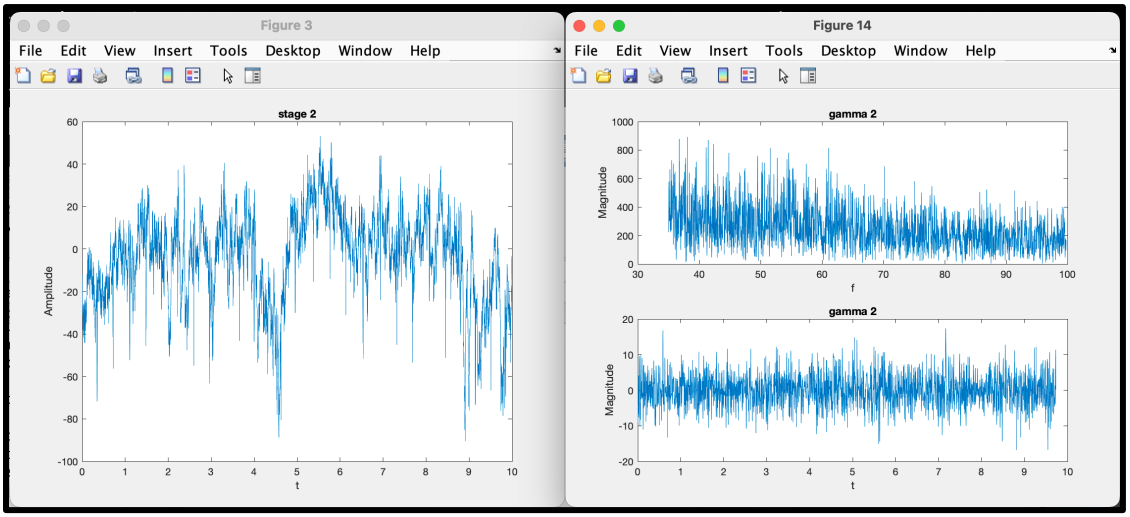
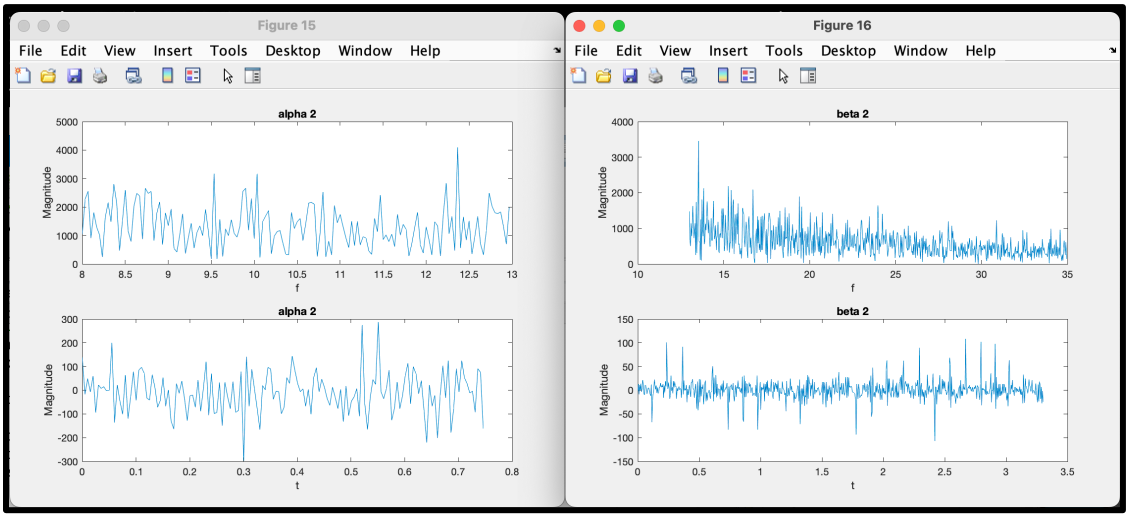
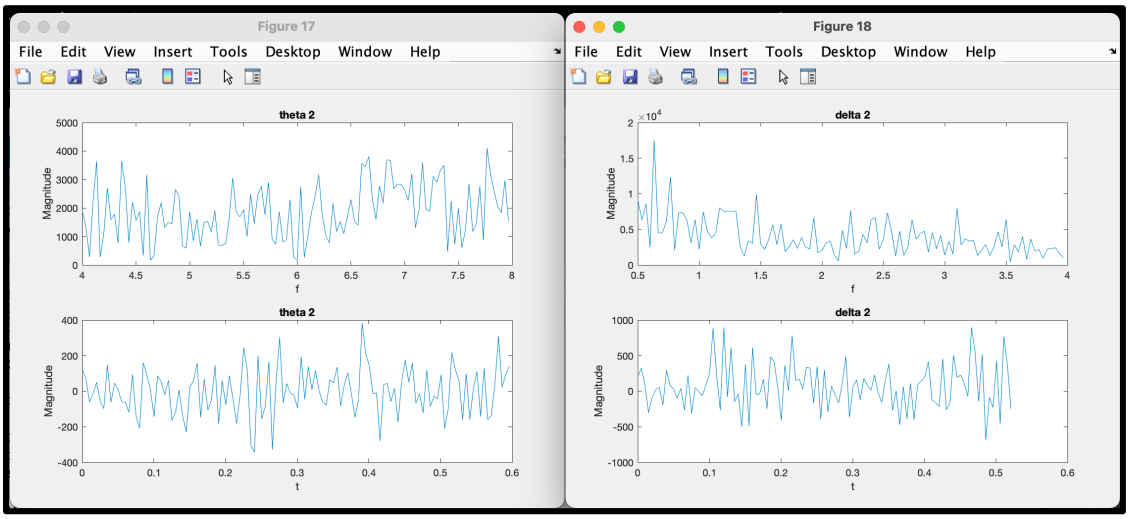
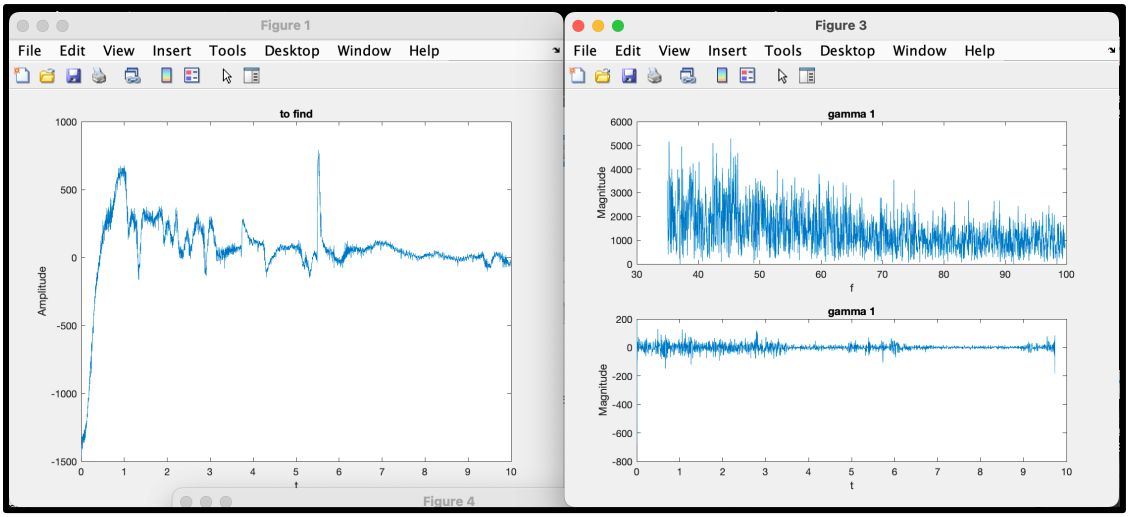
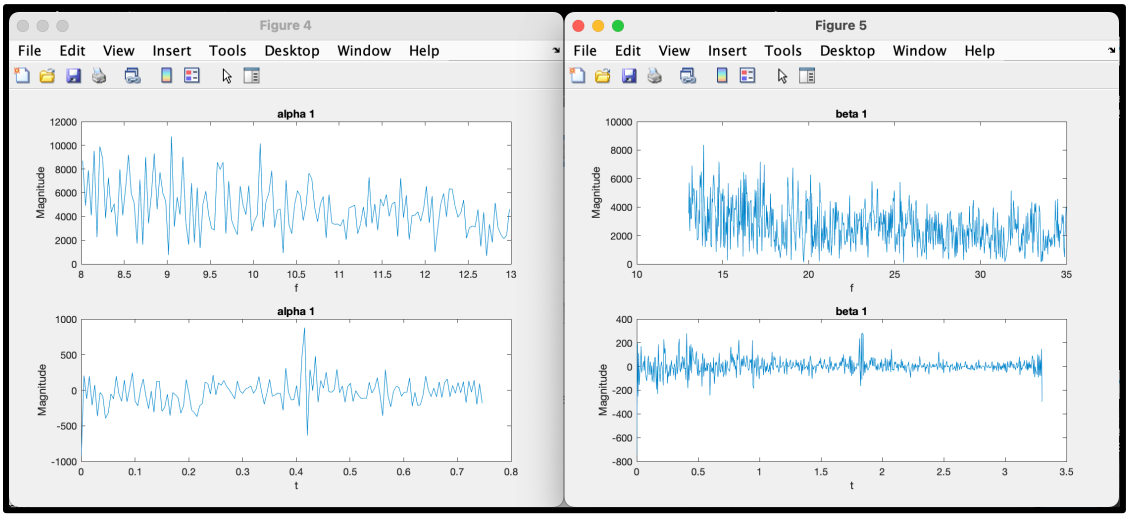


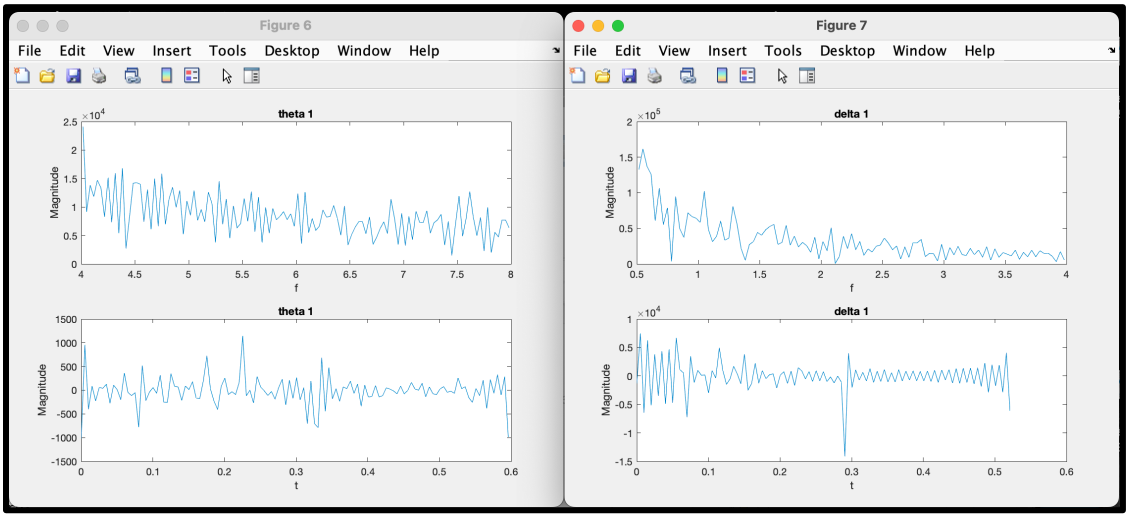




Data Related to To Find 1:







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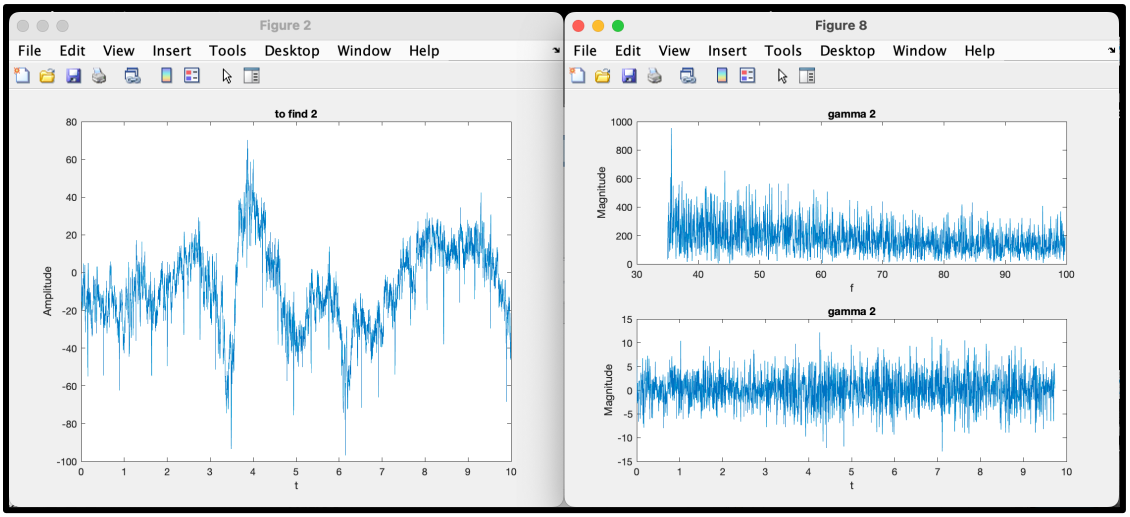
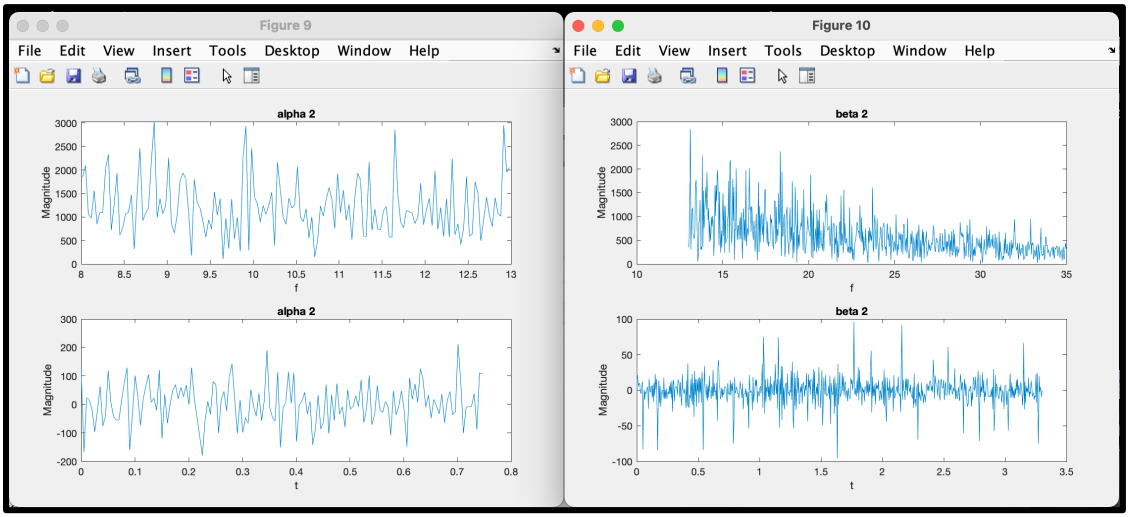
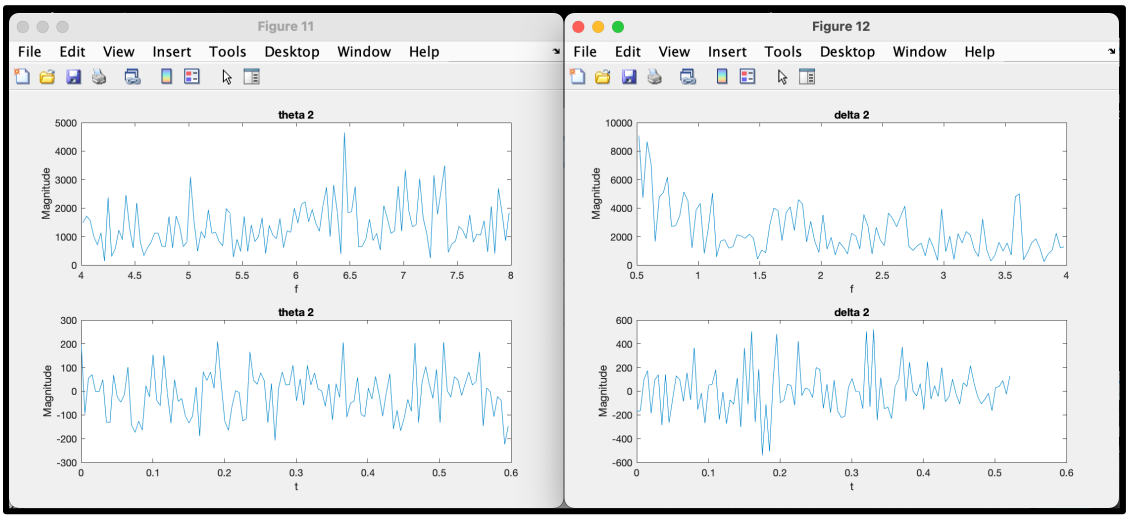
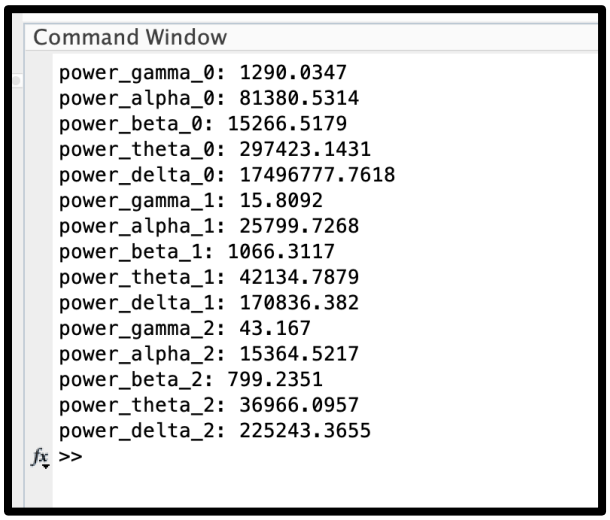




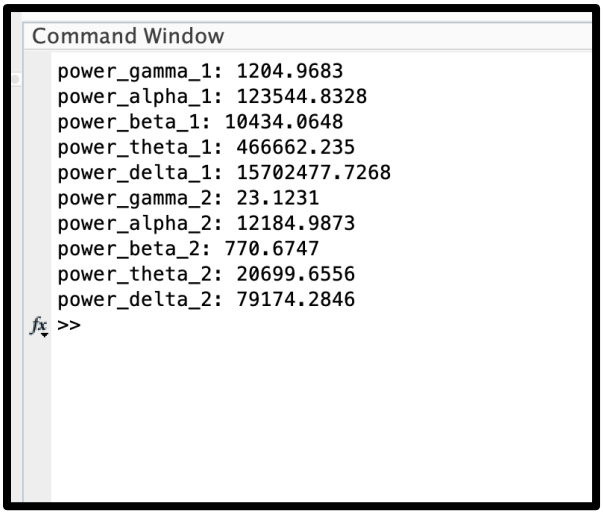


As mentioned, the signals were plotted, and for each of them, different waves (gamma, alpha, beta, theta, delta) were displayed. For the power section as well:

Power of the Stages:



Power of the To Finds:



We know that to calculate power, we need to use the power formula and take the integral, which is as follows:

$$P = \frac{1}{T} \int_{t1}^{t2} |x(t)|^2 \, dt$$

Now, assuming that the stage data are the reference, we need to determine which stage each of the "to find" data corresponds to. As we can see, the power and amplitude of the "to find 1" data are closest to the "stage 0" data, indicating that it is in this sleep stage. Similarly, for "to find 2," the power and amplitude are closer to the "stage 2" data.