Sleep Enhancement

Recovery, memory and performance

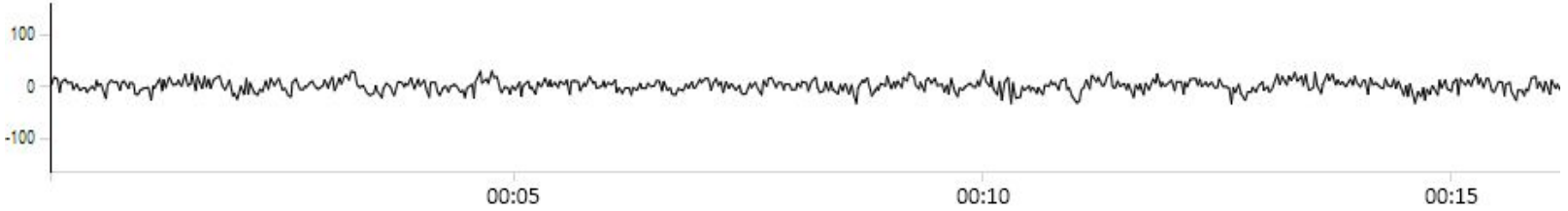
Evoked Response & Sleep Enhancement

Summary

Evoked Response developed audio sleep stimulation that increases neural activity called Slow Oscillations (SO), as well as time spent in Slow-Wave Sleep (SWS), which are both crucial for memory consolidation, neural plasticity, bodily recovery, metabolism, mood and general health.

What are Slow Oscillations (SO)?

Wakeful activity



Slow Oscillations

Images taken from Evoked Response EEG recordings

Slow-Oscillations In Sleep Stages

Stage 2 (Light Sleep)

Slow-Oscillations are used to regulate memory consolidation. When an SO is present in this stage, it usually precedes a “sleep spindle” which indicates one of the day’s events going into long term memory.

Stage 3 (Deeper Sleep)

Slow-Oscillations start to appear more frequently in this stage. Memories are still being created, but slow-oscillations are also involved in the body’s ability to repair itself, and a healthy immune system.

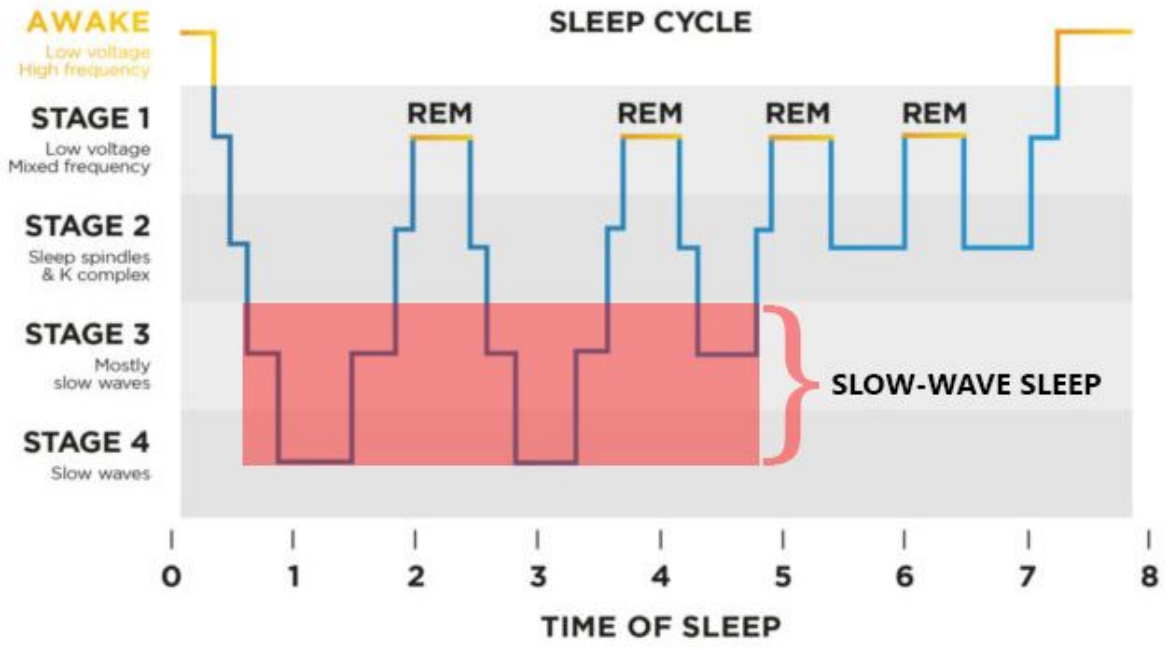
Stage 4 (Deepest Sleep)

Slow-Oscillations dominate this stage, where they are critical for hormone release, metabolism, and flushing adenosine or beta-amyloids from the brain (toxins left over after the day). If you do not have sufficient SO activity, you can wake up feeling groggy even if you sleep 8 hours.

Slow-Oscillations Throughout The night

Slow Oscillations (SO) dominate ~30% of Stage 3 and ~50% of Stage 4 sleep, which is why they have become known collectively as Slow-Wave Sleep (SWS).

However, SO are also used to regulate memory consolidation in Stage 2 (light sleep) and slightly faster versions are even found in REM.



What's so great about Slow Oscillations?

Slow-Oscillations (SO) are the most important neural signals in sleep. Period.

- They are found in every non-REM stage of sleep.
- They regulate the consolidation of long-term memory.
- They regulate bodily repair, recovery, neural plasticity, the release of growth hormone, immune system regulation, metabolism, clearing the brain of beta-amyloids, adenosine and other toxins built up during the day, and more.
- Every mammal tested exhibits SO. It is crucial to cellular health.

Read more here and here.

The Business Of Slow Oscillations

There is a *rapidly growing business* surrounding SO.

Example: the DREEM band's primary business is the stimulation of slow waves using audio (awaiting FDA approval).

Audio stimulation has already been proven to enhance memory, immune function, slow Alzheimer's and more using a closed-loop EEG system.

There is already published research showing the effectiveness of auditory stimulation *without* an EEG loop.

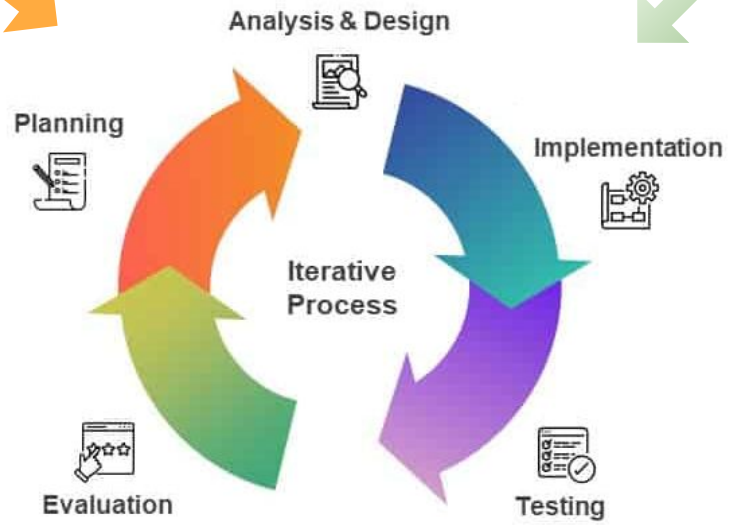
Evoked Response stays ahead of the game using extensive testing and rapid iteration on processes to achieve results above what is seen in academia (yet).

There is a *large business opportunity* here. To be the first, and the best. Calm and Headspace do sleep music, but do not have this technology.

Sleep Enhancement Approach

GOALS

1. More slow-oscillations
2. Increase time spent in slow-wave sleep
3. Higher amplitude, or power, of slow oscillations



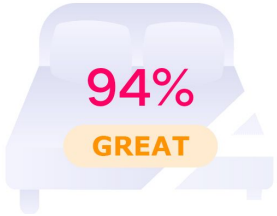
FACTS

1. During sleep, the brain monitors audio, making it the perfect vector for stimulation.
2. Audio stimulation can create Slow Oscillations in the brain

14 Day Sleep Study (Averages)

- **Stimulation**
- **Control (Silence)**

Sleep Efficiency



Scored by DREEM Sleep Coach App
10-30% over control

REM SLEEP

49min (13%)
1h14 (17%)

LIGHT SLEEP

4h14 (75%)
5h09 (78%)

DEEP SLEEP (SWS)

50min (15%)
25min (6%)

WAKE

19min (6%)
50min (13%)

SLEEP ONSET DURATION

19min
34min

AWAKENINGS

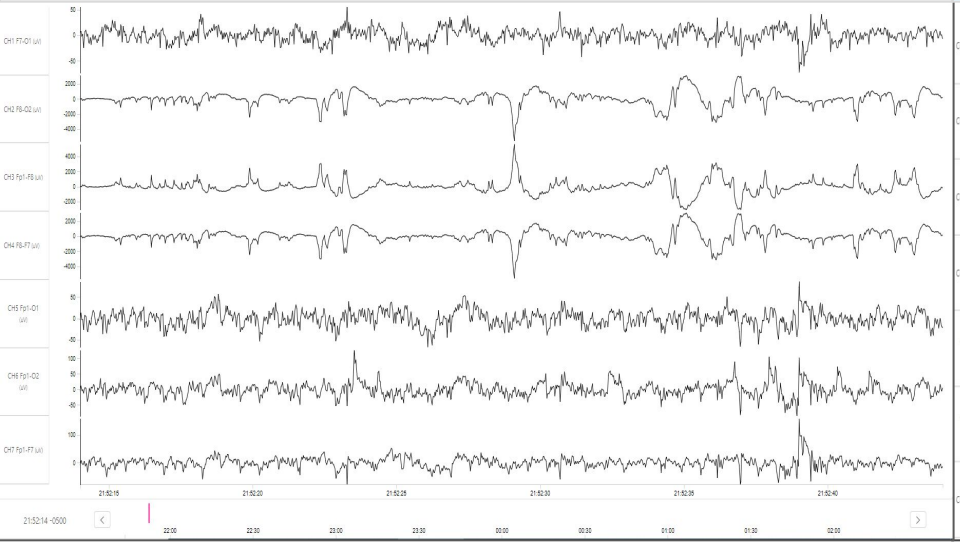
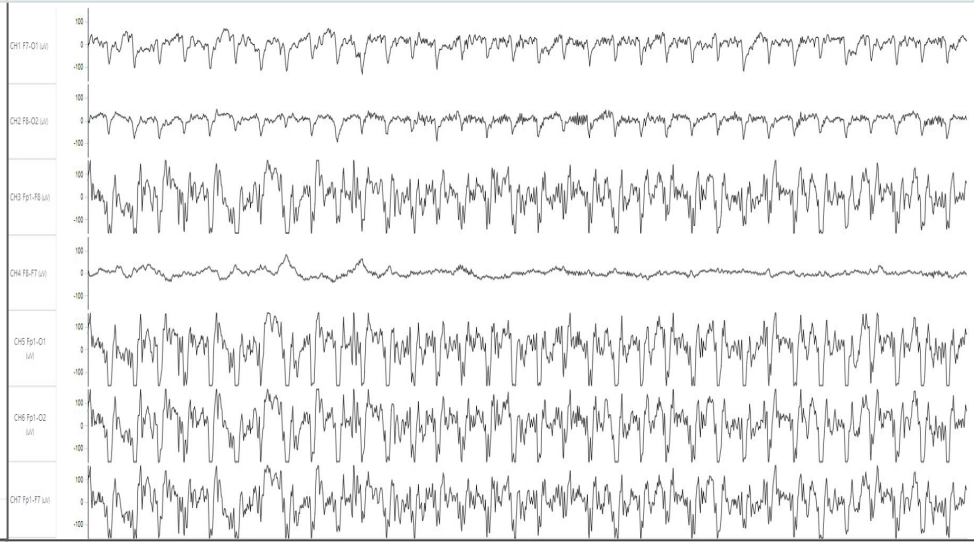
1
3.3

POSITION CHANGES

9
15

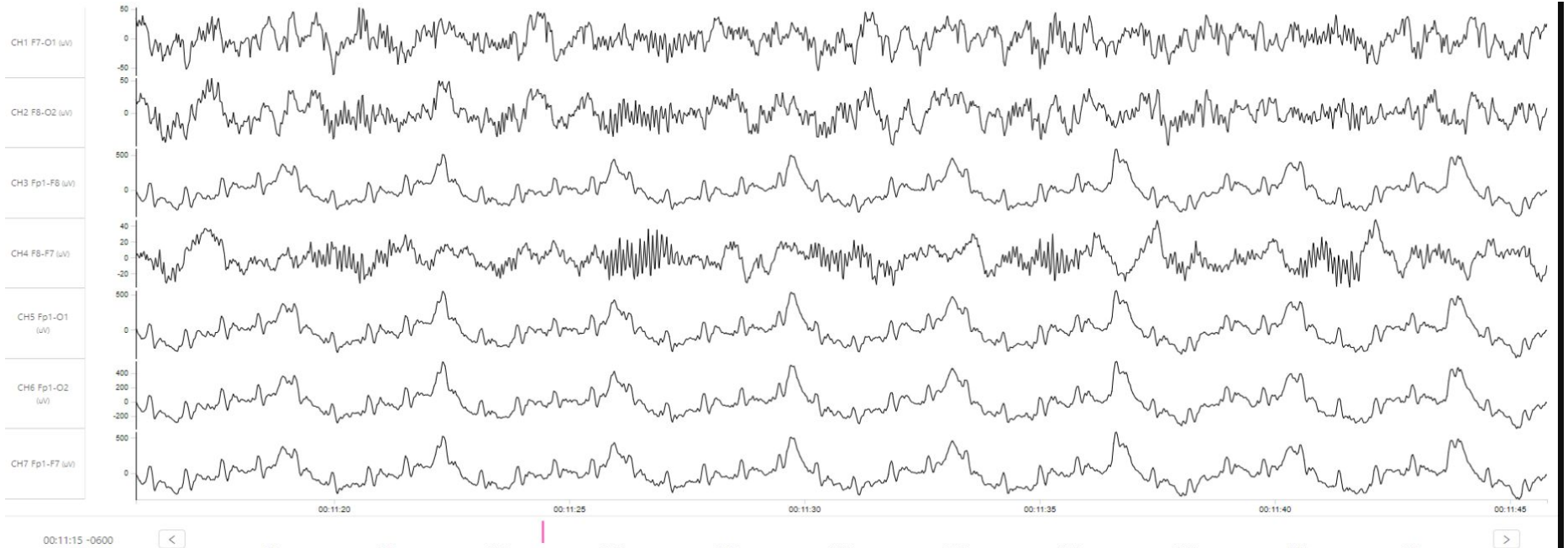
Sleep Stimulation In Action

Stimulation creates consistent regularity in EEG readouts. The brain becomes more coordinated, facilitating rhythmic communication across the entire cortex.

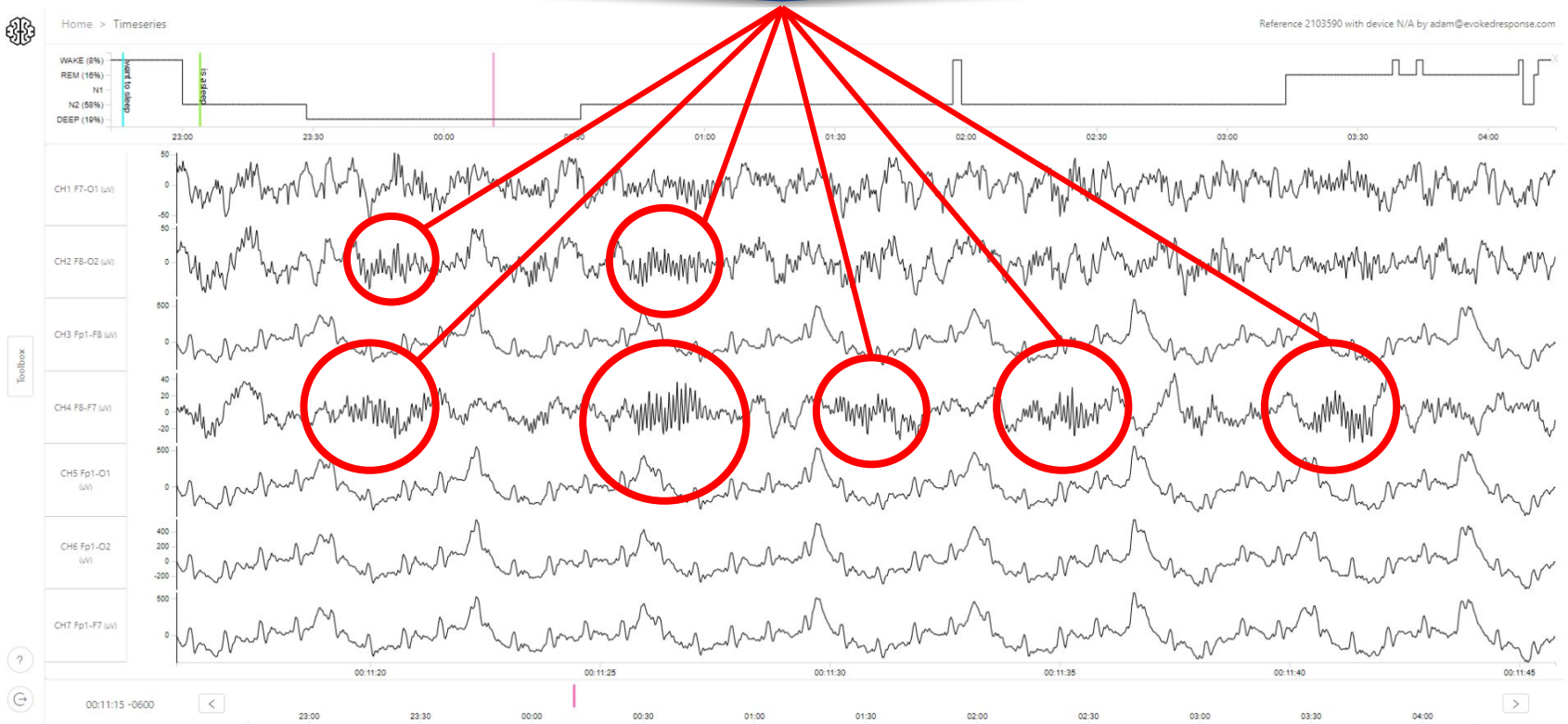
Control (Silence)	Sleep Music
	

Memory Consolidation

“Sleep spindles” can be clearly seen throughout every recording, indicating an *experience from the day being consolidated to long term memory.*

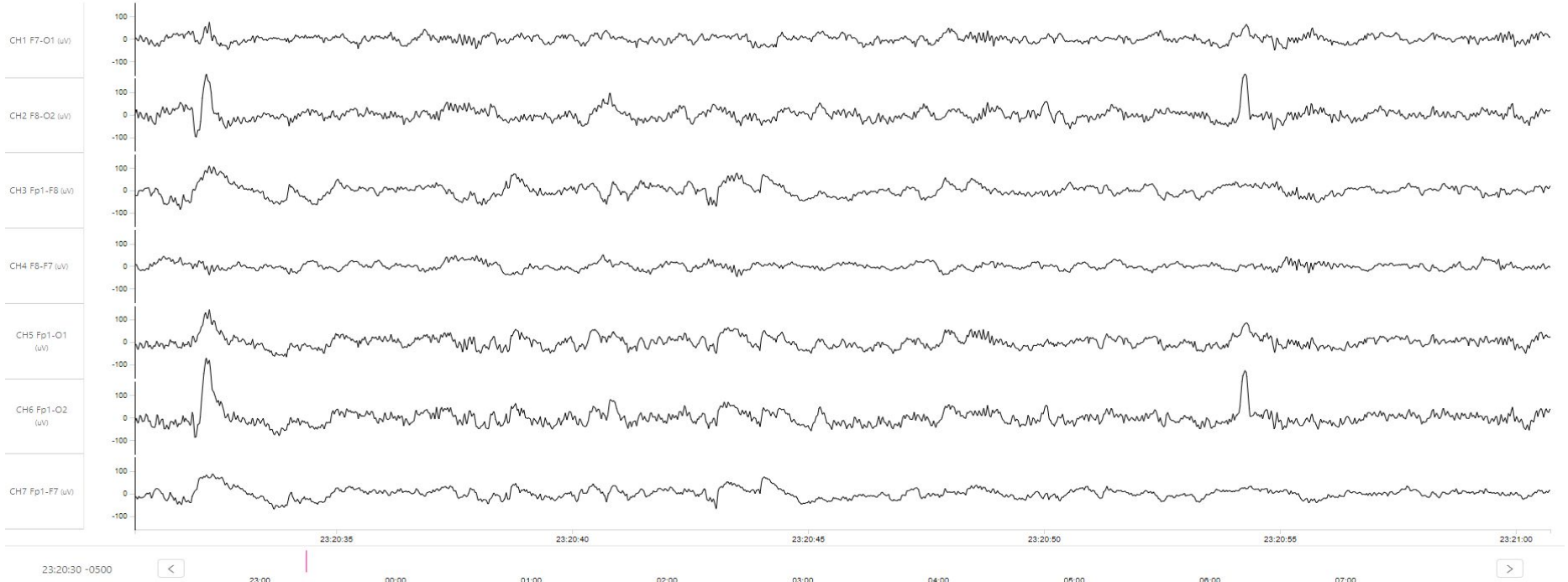


Sleep Spindles



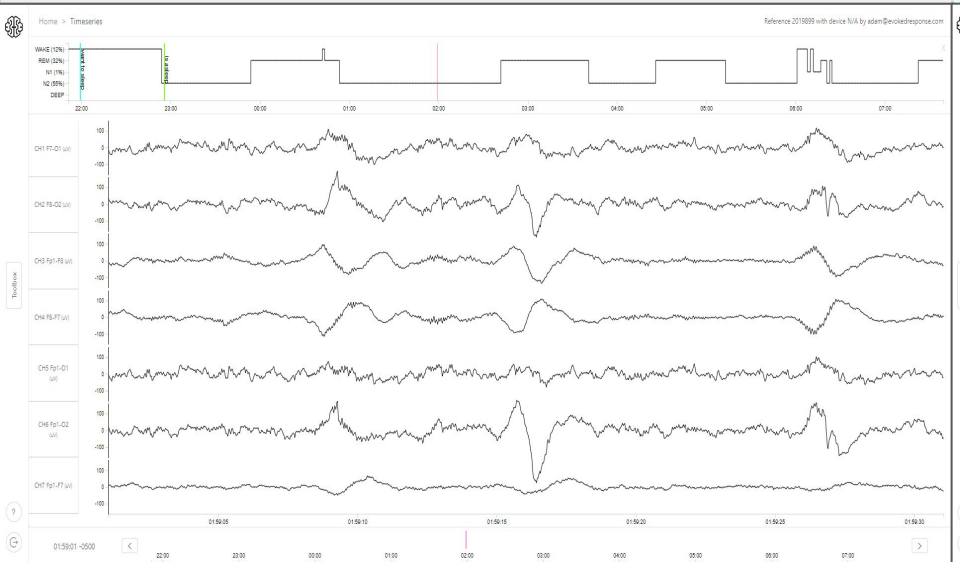
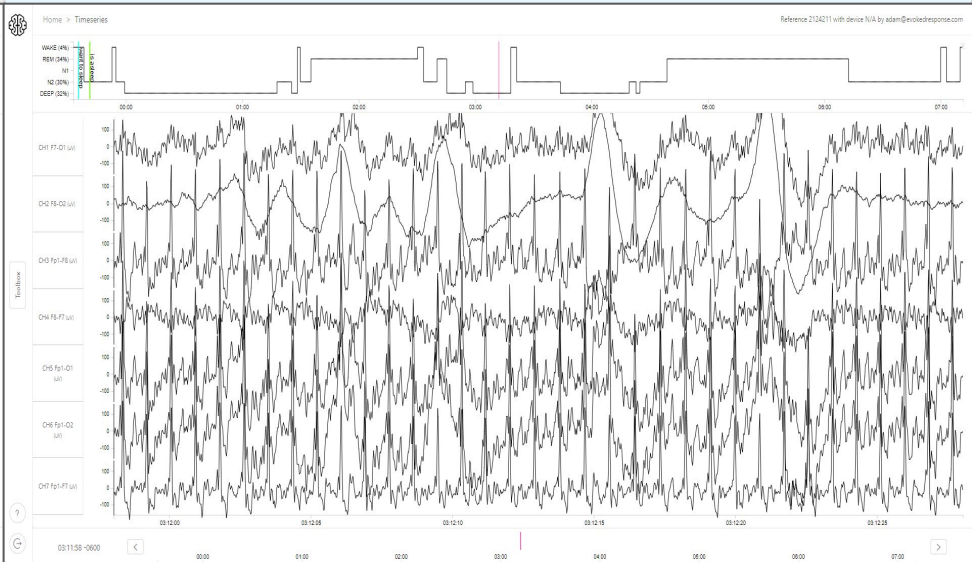
Control Spindle Activity

Control group exhibited significantly fewer slow waves, and correspondingly less spindle activity - a strong indicator that stimulation improves memory consolidation. More analysis to come.



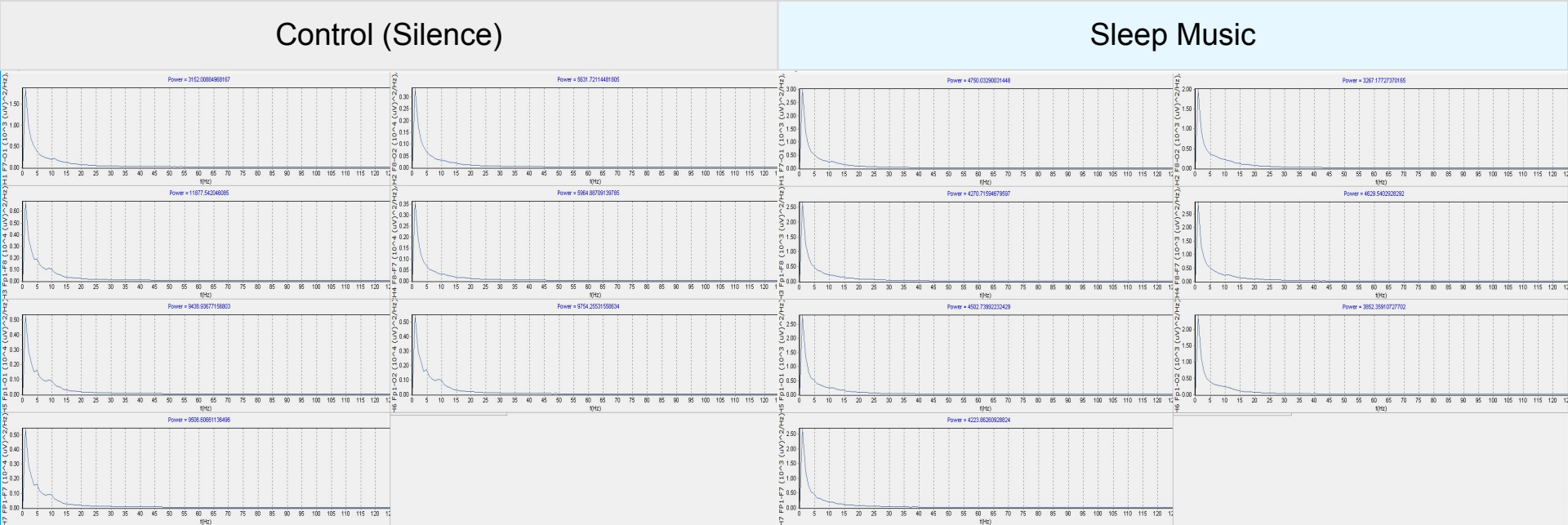
Amplitude Differences

Amplitude of slow-oscillations is highly correlated to memory improvements and increased spindle activity. The amplitude during the sleep music condition was larger than the condition in all cases.

Control (Silence)	Sleep Music
	

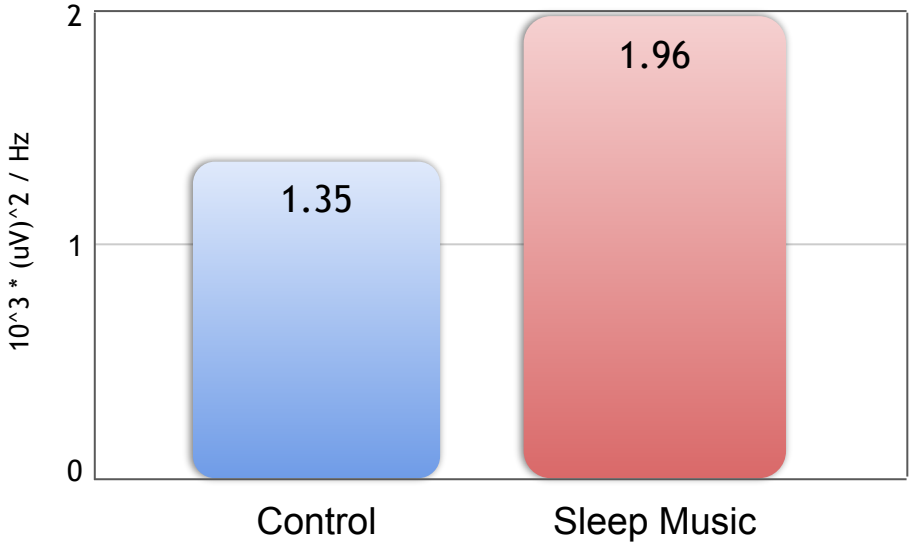
Amplitude Analysis

Over 6 full nights, amplitude was analyzed and averaged across all EEG channels.



Amplitude Analysis Results

Frequency analysis comparison, average over 6 nights. The “up-state” of the slow-oscillations strongly correlated with increased spindle activity. This indicates that sleep music can increase the memory consolidation benefit.



Sleep Music Benefits

- ➔ Healthier sleep pattern: get to sleep faster, stay asleep longer
- ➔ Facilitating long-term *memory consolidation*
- ➔ Facilitating neuronal plasticity
- ➔ Enhancing *bodily recovery and growth*
- ➔ Clearing of beta-amyloids, adenosine, other toxins
- ➔ Preventing weight gain due to poor SWS, *enhancing weight loss efforts*
- ➔ Waking up feeling refreshed, not groggy
- ➔ Increasing alertness, *daytime performance and memory*