Affective State Change

via Procedurally Generated Haptics

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What the goal of our project?

"The goal of the project is to develop a proof of concept that **utilizes procedurally generated long-form audio and haptics to induce affect state changes** such as relaxation and/or flow, thus enhancing user's emotional well-being during study or work sessions."

State of the art technology

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AudioCraft

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AudioCraft lets you easily generate high-quality audio and music from text.

Supercollider

supercollider.github.io

index

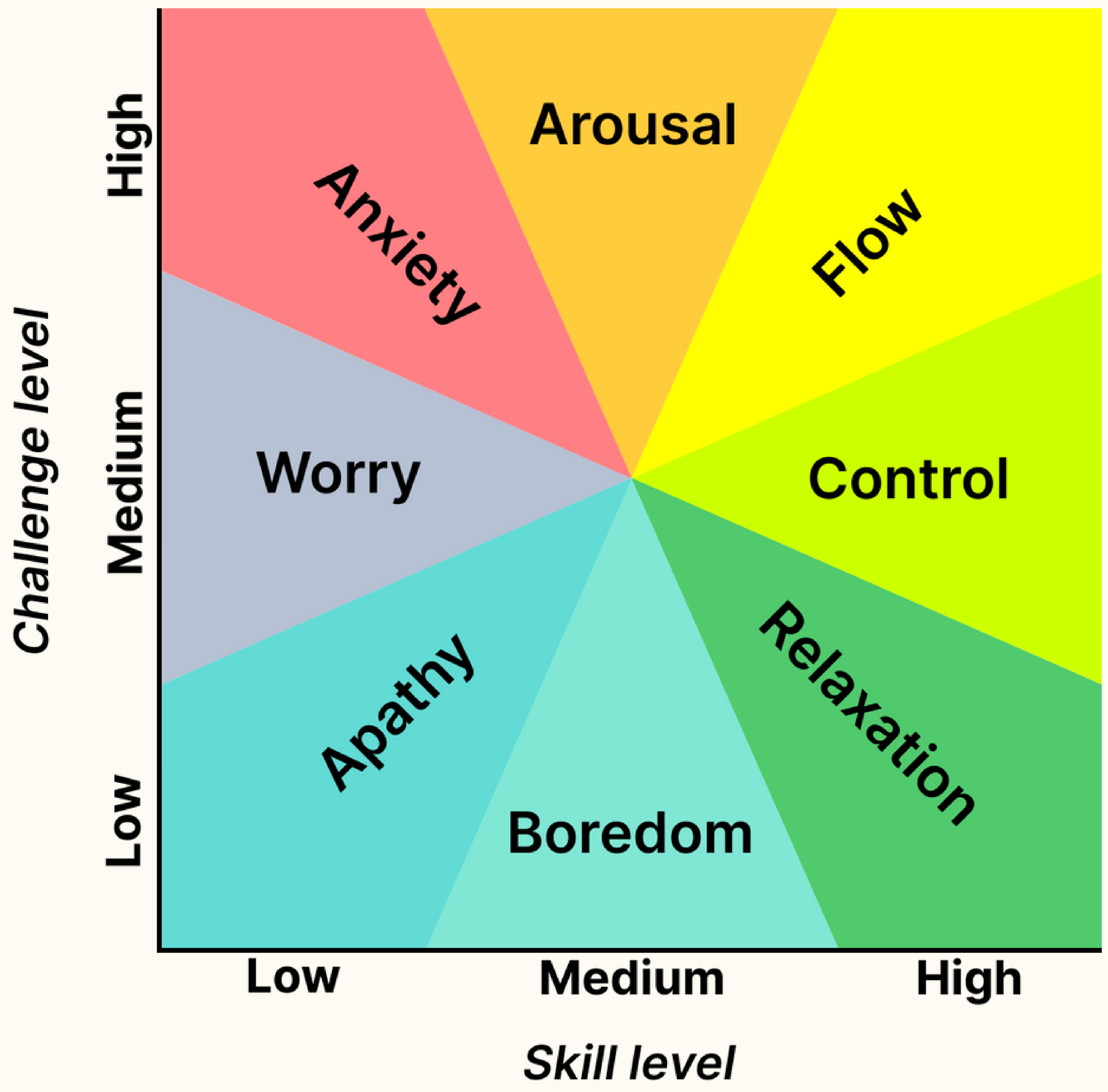
A platform for audio synthesis and algorithmic composition, used by musicians, artists and researchers working with sound.

Review of Related Literature (1)

Go with the flow: A neuroscientific view on being fully engaged

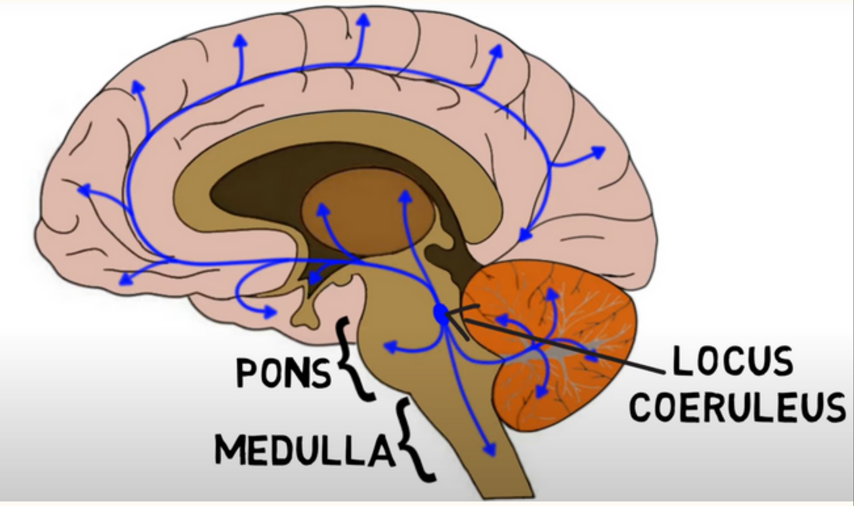
- “[..]in order to experience flow, a key dimension is the **match between a person’s skill and the tasks challenges**.”
- “People who experienced flow often [..] **having a clear sense of direction** (i.e., clear goals)”

Van der Linden et al. 2021



Review of Related Literature for Flow (2)

Stimulating the pons might result in more effective relaxation/ guide into flow states



The Locus Coeruleus Norepinephrine System

- The LC-NE system **influences our choice to engage or disengage** with tasks.
- It controls this through varying norepinephrine release patterns.

Source: van der Linden et al., 2021

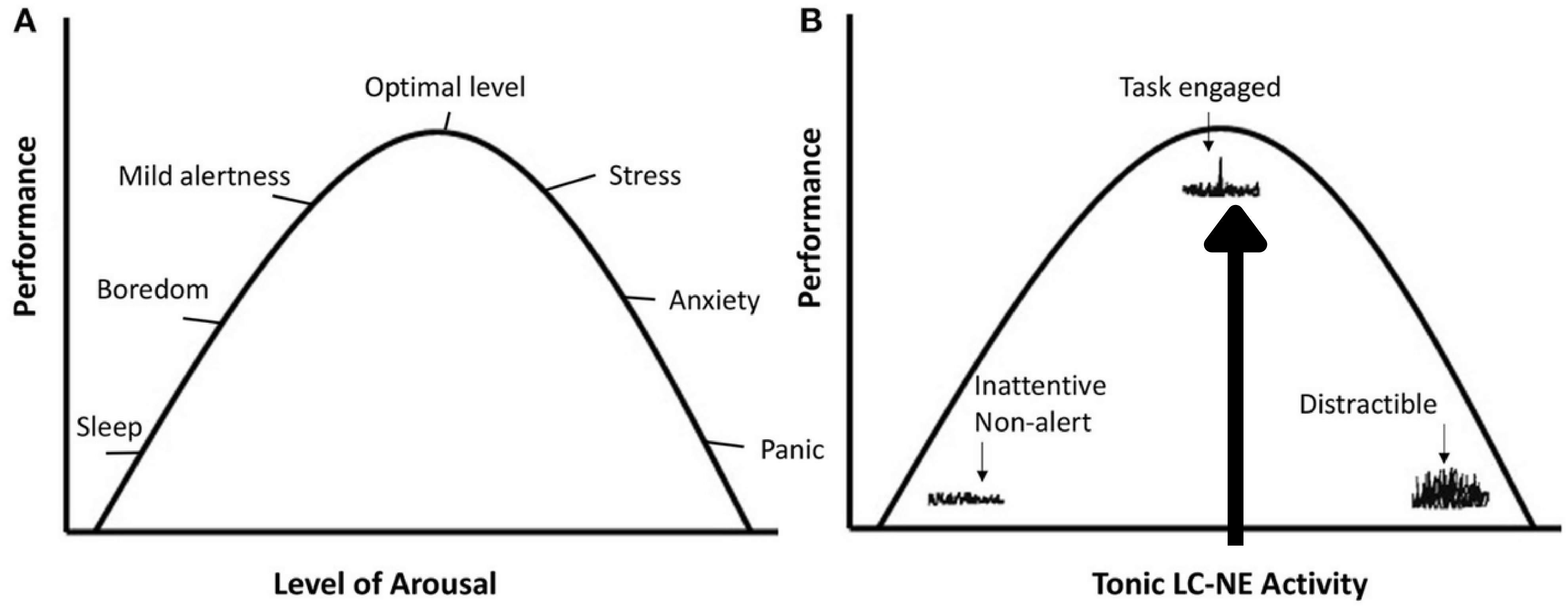
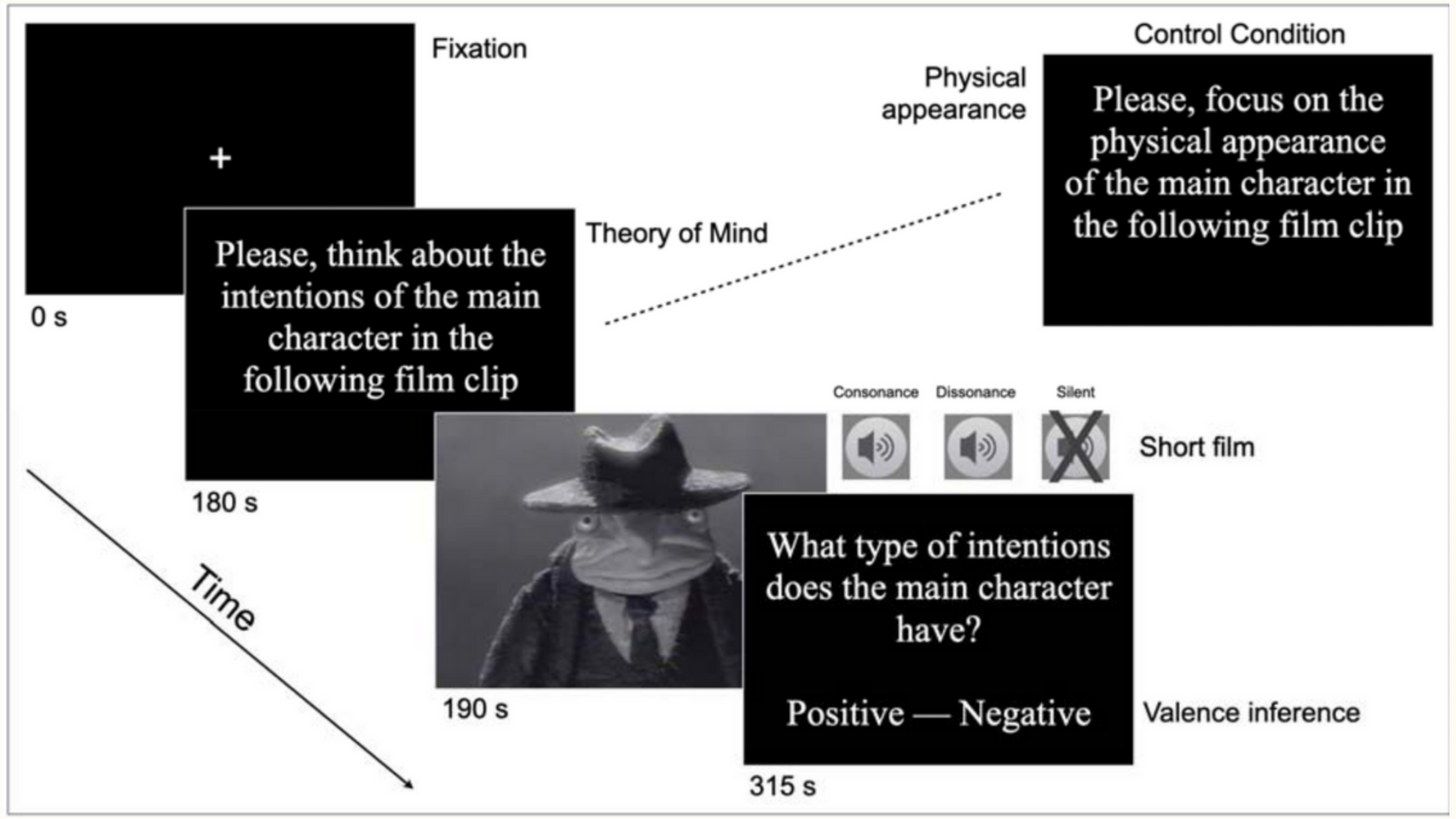


FIGURE 1 | (A) Reflects the mood states and performance as a function of the level of arousal. **(B)** Plots performance as a function of tonic and phasic LC-NE activity in line with the theory of Aston-Jones and Cohen (2005). On the left side, tonic LC-NE is low and so are phasic responses to stimuli. This has been referred to as the disengagement mode (Hopstaken et al., 2015). With intermediate tonic LC-NE activity, phasic LC-NE responses are strong to task-relevant stimuli. This is the exploitation mode, associated with optimal engagement and performance. On the right side, tonic LC-NE is high, and phasic LC-NE responses are undifferentiated. This is the exploration mode.

Review of Related Literature (3)



Good environmental influences might positively alter the perception of the user and ease the way into comfort

We see what we hear: dissonant music engages early visual processing

- Highlights the **cross-modal impact of auditory stimuli,** suggesting our **soundscapes** must be carefully curated to **avoid cognitive dissonance that could disrupt flow**

Source: Bravo et al., 2023

Valence ratings for consonant and dissonant variations

Musical variation	Mean	Std. deviation	95% CI (adjusted)
Consonant			
C1	4.25	1.295	
C2	4.14	1.580	
C3	4.11	1.663	
C4	4.32	1.786	
Composite-rating Cons.	4.205	1.018	[3.870, 4.534]
Dissonant			
D1	6.07	2.071	
D2	6.36	1.638	
D3	6.21	1.475	
D4	5.86	1.580	
Composite-rating Diss.	6.125	1.139	[5.712, 6.532]

Review of Related Literature (4)

Modeling The Effect of Background Sounds on Human Focus Using Brain Decoding Technology

"For example, it has been found that listening to music with lyrics while reading or working can decrease concentration or cognitive performance (H. Liu et al., 2021; Shih et al., 2012), while several studies have shown oppositely that natural-occurring sounds such as white noise, as well as classical music, can be beneficial for increasing focus and can improve learning outcomes (Angwin et al., 2017; Chou, 2010; Davies, 2000; Gao et al., 2020)."

Source: Haruvi et al., 2021

Review of Related Literature (5)

By Daniels definition of waves : Do musically **pleasing frequencies translate also into positive haptic experiences**?

Source: Haruvi et al., 2021

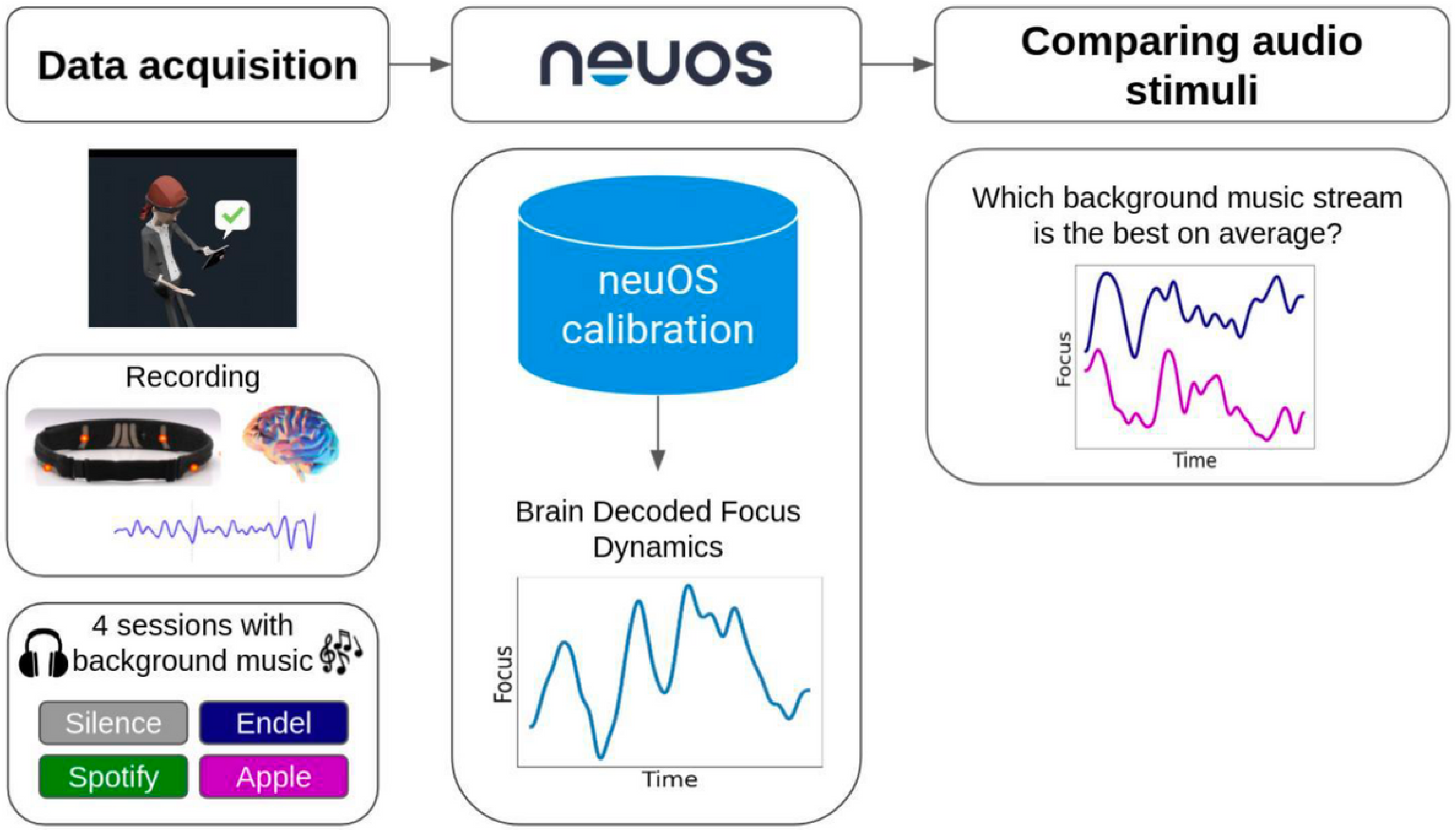


Figure 2. **Schematic illustration of the data processing pipeline.** Data acquisition included at-home recordings of four sessions, each with a different background sound type. Arctop's neuOS brain decoding technology was used to predict the focus dynamics at a rate of 5Hz. Obtaining the brain decoded focus dynamics synchronously with the sound content enables comparison of focus levels correlated with different physical properties of sound.

Our Approach

"Developing a tool to transition users from relaxation to flow states, setting clear goals to reduce anxiety and increase motivation, thereby fostering more effective flow experiences."

Our Framework

Relaxation

"Reduce stress/anxiety and give motivation by setting feasible goals."

- **from 12 – 20 BrPM (breaths per minute)**
- **to 6 – 8 BrPM**
- **for 5 – 10 mins**

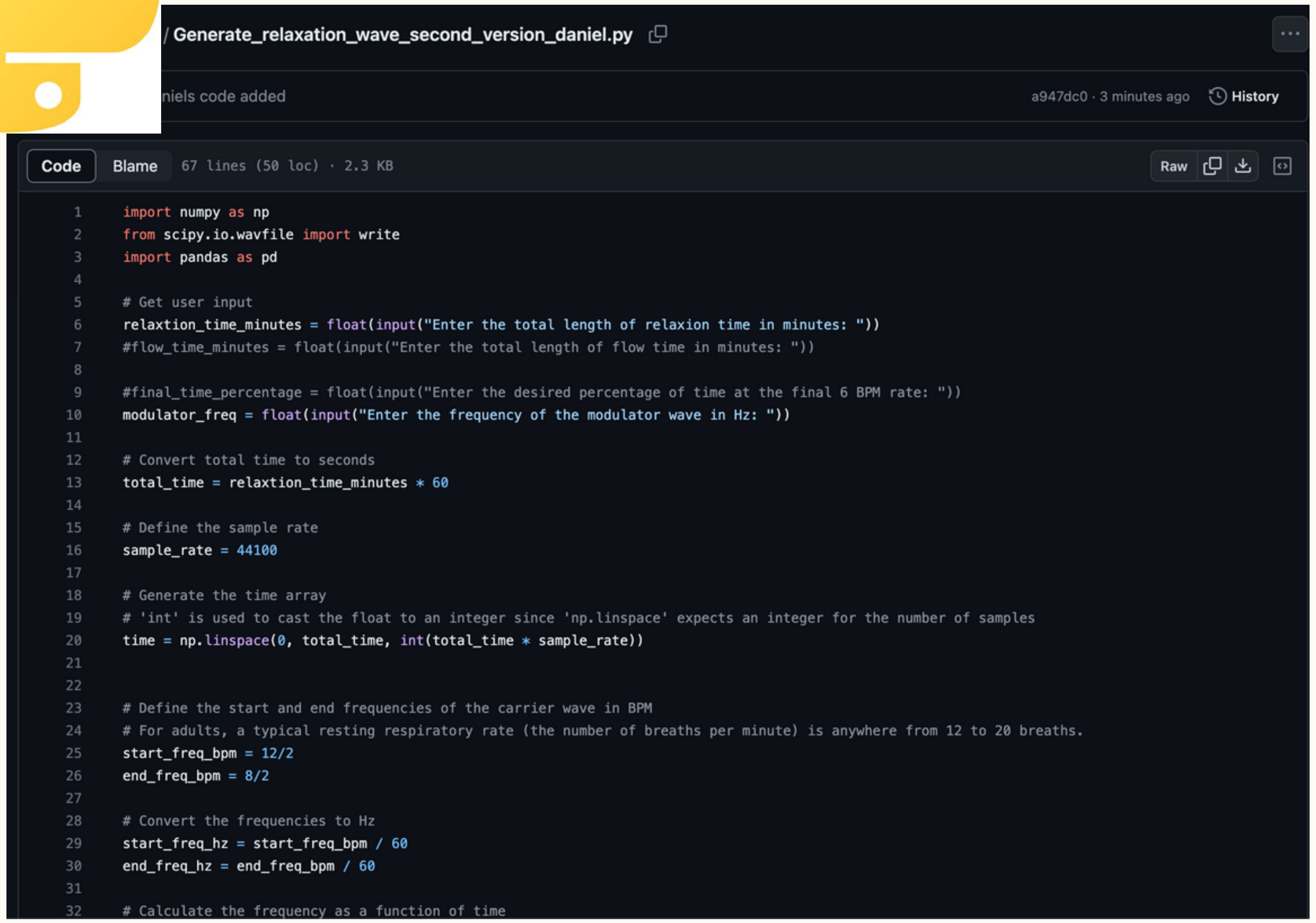
Flow

"Gradually ease into flow and keeping focused for longer"

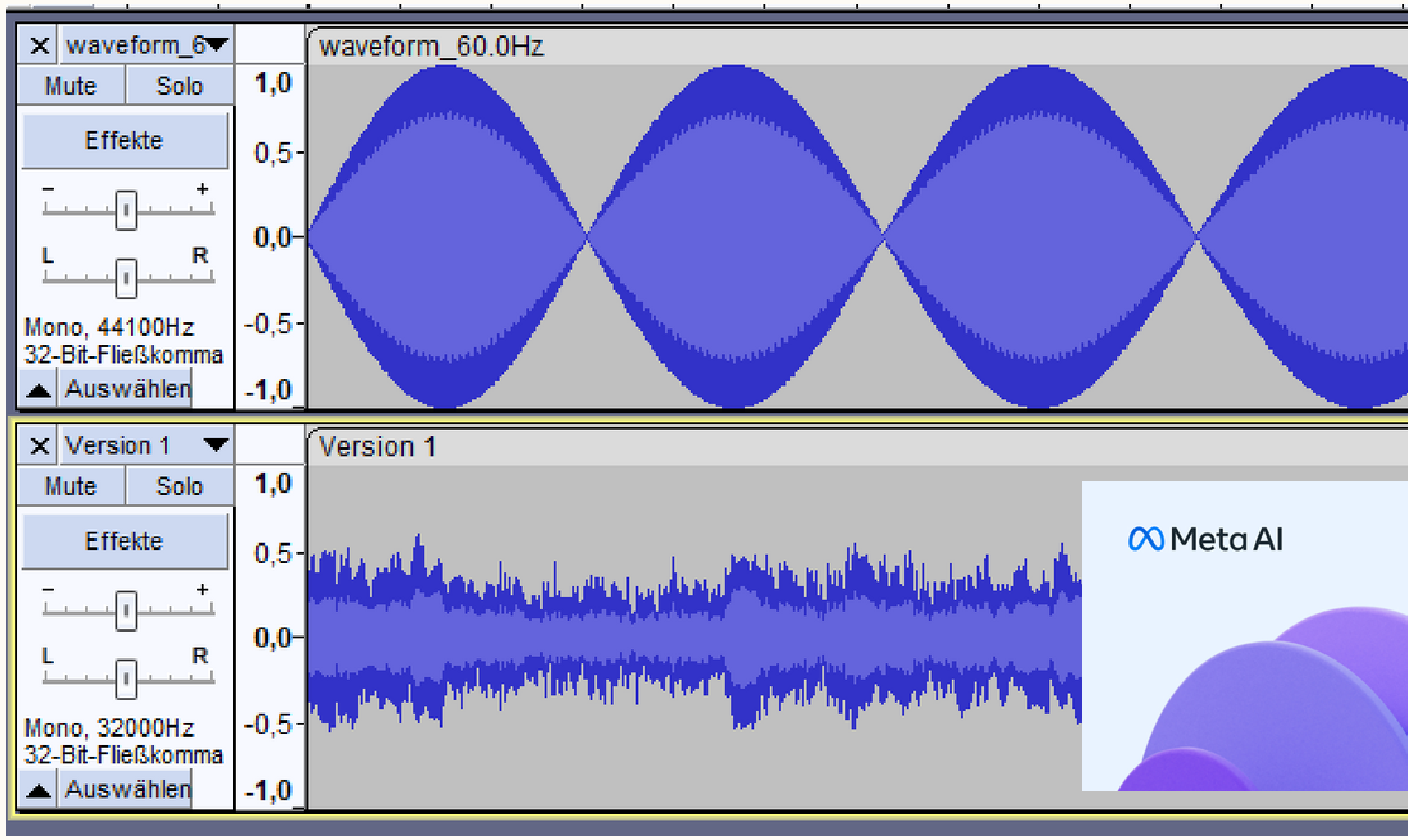
- **having around 60 – 88 BPM (beats per minute)**
- **for a minimum of 15 minutes**

- **Relaxation Mode:** Create a baseline for the user's emotional state.
- **Flow Mode:** Slowly raise BPM to the preferred speed and complexity and create a rhythm pattern

Technical Implementation




```python
import numpy as np
from scipy.io.wavfile import write
import pandas as pd

# Get user input
relaxtion_time_minutes = float(input("Enter the total length of relaxion time in minutes: "))
#flow_time_minutes = float(input("Enter the total length of flow time in minutes: "))

#final_time_percentage = float(input("Enter the desired percentage of time at the final 6 BPM rate: "))
modulator_freq = float(input("Enter the frequency of the modulator wave in Hz: "))

# Convert total time to seconds
total_time = relaxtion_time_minutes * 60

# Define the sample rate
sample_rate = 44100

# Generate the time array
# 'int' is used to cast the float to an integer since 'np.linspace' expects an integer for the number of samples
time = np.linspace(0, total_time, int(total_time * sample_rate))


# Define the start and end frequencies of the carrier wave in BPM
# For adults, a typical resting respiratory rate (the number of breaths per minute) is anywhere from 12 to 20 breaths.
start_freq_bpm = 12/2
end_freq_bpm = 8/2

# Convert the frequencies to Hz
start_freq_hz = start_freq_bpm / 60
end_freq_hz = end_freq_bpm / 60

# Calculate the frequency as a function of time
```



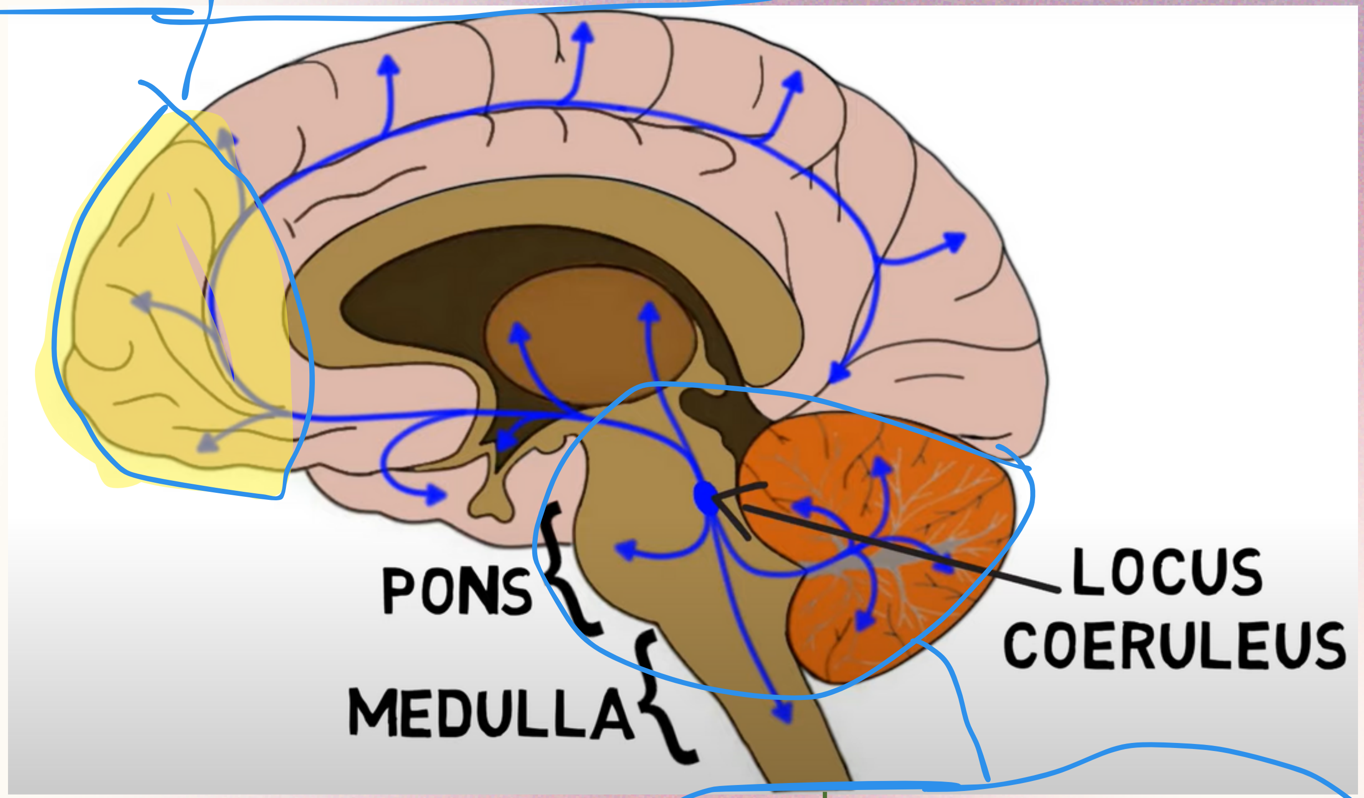
Affective Waveforms (Baseline) – Rhythmic – Sinewave

Dynamic – Melodic – “fun sparks”

Prototype Ideas

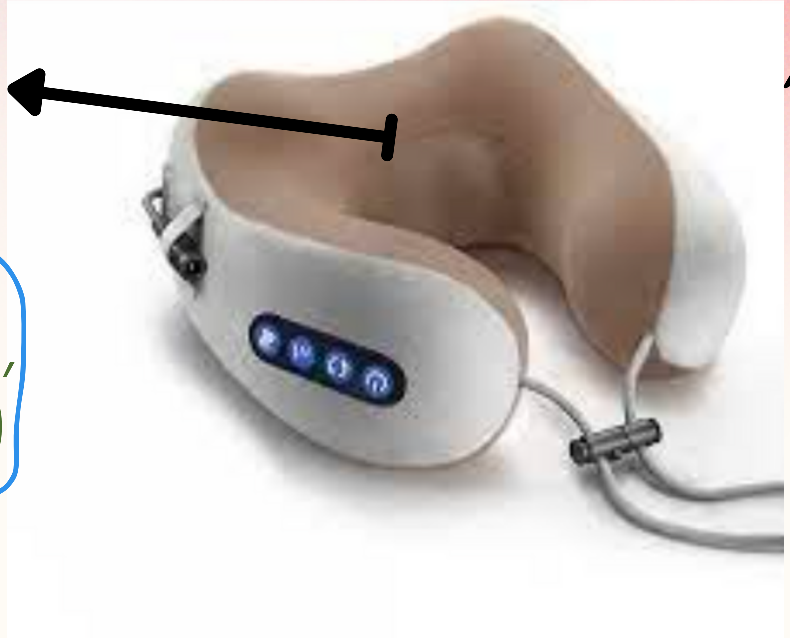
Stimulating neck area might result in more effective relaxation/ guide into flow states?

Lower prefrontal cortex activity (Loss of self, self-awareness and perception(time))



Higher LCNS activity (arrousal, optimism & hope, positive mood, motivation)

Musical frequencies translate also into similar haptic experiences?



Individualized frequencies positively influence ease into comfort?

Project Plan

1. Generate Custom Waveforms	• Develop a script for **procedurally generating waveforms** as a baseline
	• Explore AI-generated audio to create a dynamic melody layered on-top
2. Design a Physical Prototype	• Design a **physical haptic prototype** to deliver the customised waveforms
	• Explore how this can be achieved in non-obtrusive ways for long periods
3. Develop a Mobile App	• Build a mobile app that connects both **waveform and haptic prototype**
4. Evaluation	• (Conduct a user study to determine the effectiveness of the prototype)