ECE1778 Final Report

CalmMind

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Word Count: 2385

1. Introduction

What:

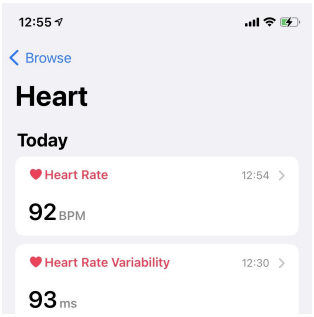
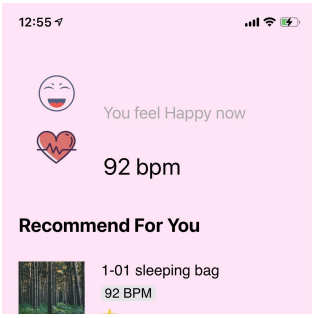
The goal of CalmMind is to help people who are stressed out or suffering from sleep issues by playing calm music. The idea is to find and play a piece of music that matches the user's mood and heart rate, then reduces the playback speed as the user's heart rate decreases. The music library contains a list of calm music chosen by our specialist, each classified by its speed and appropriate mood.

Why:

During the COVID-19 pandemic, the global pooled prevalence rate of sleep issues among all populations was 35.7% according to research (Krishnamoorthy et al., 2020). Therefore, we hope to create a tool to help individuals cope with this problem. The CalmMind app is designed based on the iso-principle, which is playing music that matches someone's mood and then gradually altered to bring them to their desired emotional state. However, the technique isn't limited to just one's mood; it also has physiological benefits known to respond to heart rate positively (Heiderscheit et al., 2015). For instance, if a client's heartbeat is 120 beats per minute (BPM), a therapist would play a song at 120 BPM to match the client's physiological state. The therapist then gradually decreases the music's tempo until the client reaches the desired heart rate.

2. Screen Shots & Functionalities

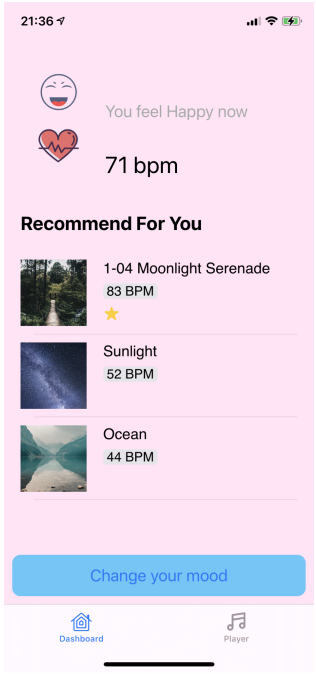
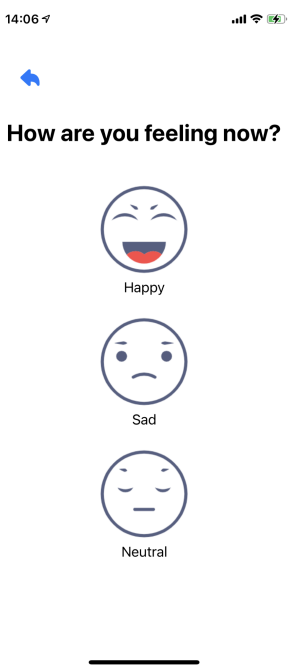
Heart Rate Parsing:

Figure 1.1	Figure 1.2	Figure 1.3
		

The user's heart rate can be measured using an Apple Watch (figure 1.1) and synchronized to the iPhone's Health app (figure 1.2) after some delays. The CalmMind app will constantly parse heart rate data from the Health app and display it on the dashboard page (figure 1.3).

Ideally, we would like heart rate parsing to happen in the background and also in real-time, but Apple Watch would only passively measure the user's heart rate every 10 minutes if the user is not moving. Furthermore, whenever the latest heart rate is recorded on the watch, that data will not be synchronized to the iPhone immediately unless the Health app is manually opened. This issue will be further discussed in the reflection section of this report.

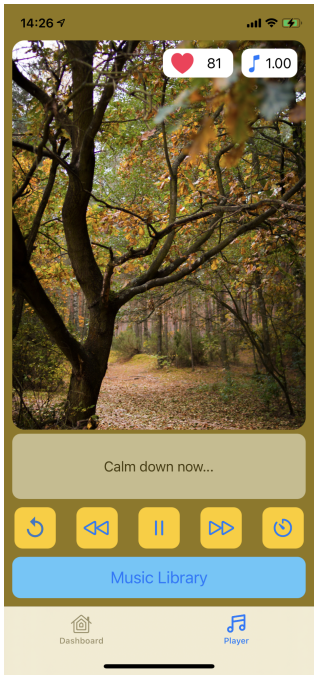
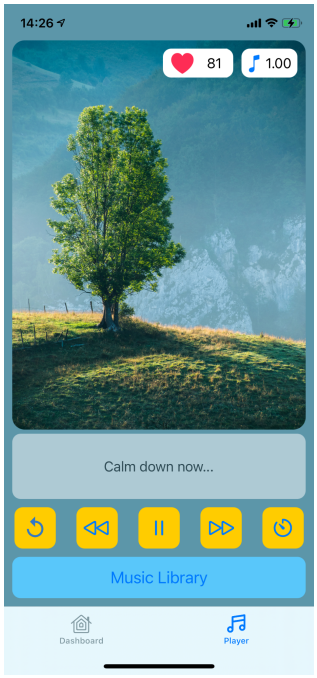
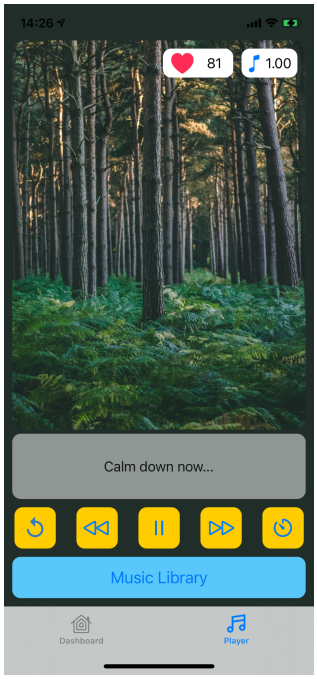
Mood Selection & Music Recommendation:

Figure 2.1	Figure 2.2	Figure 2.3
		

When the CalmMind app is opened, the user needs to select his/her current mood on the mood selection page (figure 2.1). The dashboard page displays the user's mood as well as a list of recommended music generated based on the user's mood and heart rate, where the best matching track is labelled by a star symbol (figure 2.2). Since each music track in the music library is classified by its speed and appropriate mood, the recommended music list is generated by selecting music tracks from the corresponding mood playlist that have a similar tempo to the user's heart rate.

The user can also change his/her current mood by tapping on the "Change your mood" button on the dashboard page (figure 2.2), and the app will prompt the user to select a new mood (figure 2.3).

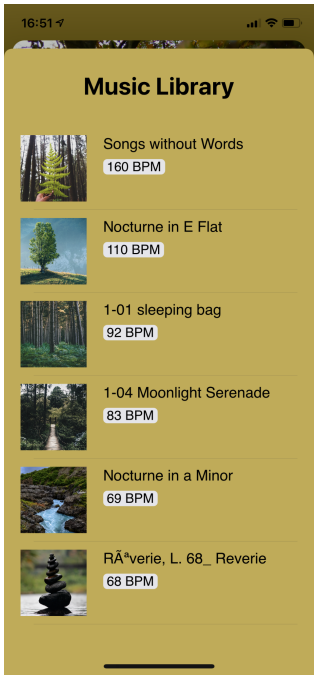
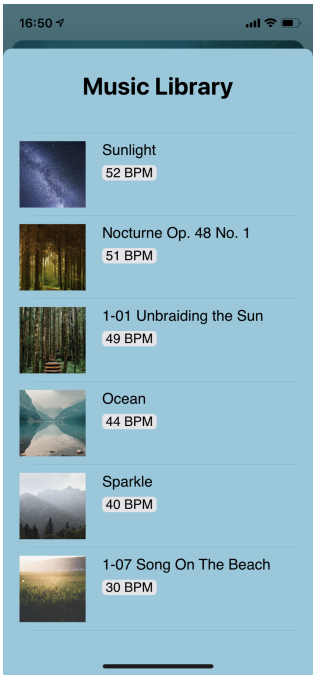
Music Player:

Figure 3.1	Figure 3.2	Figure 3.3
		

Tapping on a recommended music track or the “Player” tab on the tab bar (figure 2.2) will direct the user to the music player page (figure 3.1). Each music track has its corresponding background image as well as theme colour (figure 3.1, figure 3.2, and figure 3.3).

There are two labels on the top right corner, which display the user’s current heart rate and the current playback speed of the music. Besides, the five yellow buttons allow the user to replay the selected track, switch to the previous track, pause/resume the selected track, switch to the next track, and set a timer.

Music Library:

Figure 4.1	Figure 4.2
	

The app's music library can be accessed by tapping on the "Music Library" button on the music player page (figure 3.1), and it contains the complete list of all music tracks (figure 4.1 and figure 4.2). Moreover, Each track is labelled by a BPM label to indicate its speed. The background colour of this page also adapts to the theme colour of the music player page.

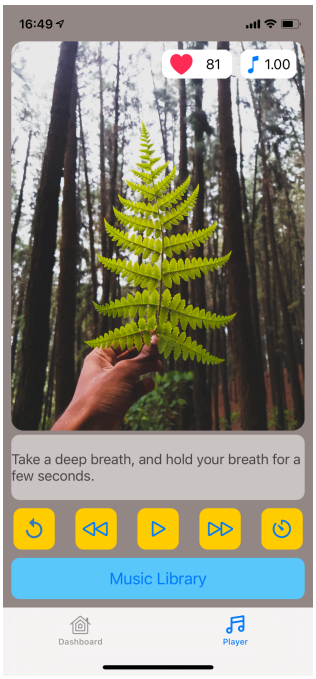
Currently, the speed and mood classification of each music track is done manually by our specialist. In the future, the app should be able to measure the tempo of a music track and classify its appropriate mood. This is also mentioned in the future work section of this report.

Automatic Playback Speed Adjustment:

Figure 5.1	Figure 5.2	Figure 5.3
		
Figure 5.4	Figure 5.5	Figure 5.6
		

The playback speed of the selected track is reduced by 5% every time the user's recorded heart rate decreases by 10%. Suppose the heart rate label in figure 5.1 shows the user's initial heart rate. The playback speed remains unchanged when the user's heart rate increases relative to the initial heart rate (figure 5.2), and decreases as the user's heart rate decreases (figure 5.3 and figure 5.4). Moreover, the playback speed adjustment is lower bounded by 40 BPM, and the app will stop doing any further adjustments that would exceed the limit (figure 5.5 and figure 5.6).

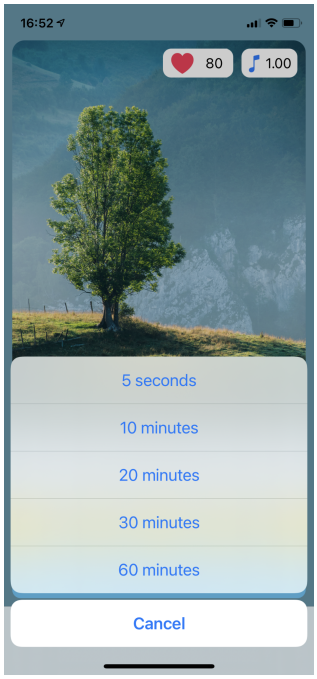
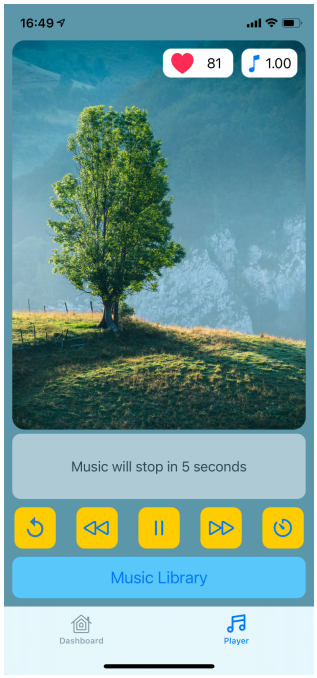
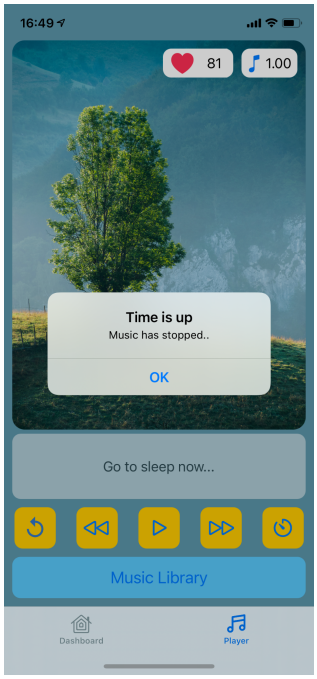
Audible Relaxation Script:

Figure 6.1	Figure 6.2	Figure 6.3
		

The user can follow the app's relaxation script to calm down or relax. If the user taps on the textbox below the background image that says "Calm down now..." (figure 5.4), the textbox will start displaying lines of the relaxation script (figure 6.1, figure 6.2, and figure 6.3), and the audio for each line will be read out at the same time.

We are currently using a built-in voice package in Swift (AVSpeechUtterance) to read out the relaxation script. However, the voice does not sound natural or relaxing, which defeats the purpose of having a relaxation script. In the future, it should be substituted with a better voice package (if there is one), or a pre-recorded audio of the script.

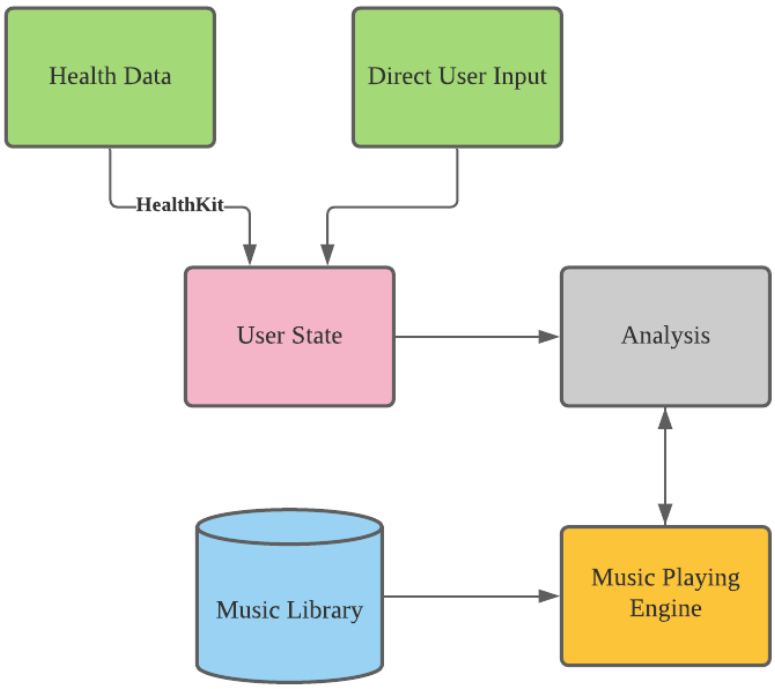
Timer:

Figure 7.1	Figure 7.2	Figure 7.3
		

The user can set a timer to stop the playing music by clicking on the timer button, and a list of options will be available for the user to choose from (Figure 7.1). Once the timer is set, the textbox for displaying the relaxation script will be changed to display a countdown (Figure 7.2). The user will be notified when the timer expires (Figure 7.3).

Additionally, music will keep playing in the background when the app is minimized or the screen is locked, so if the user wants to use the app before going to bed, he/she can play a track, set a timer, and then lock the phone.

3. Overall Design



Health Data:

Heart rate data measured using an external device (e.g., Apple Watch). Our app will extract this data from iPhone via HealthKit.

Direct User Input:

Information provided by the user. In our case, the user can set or change his/her mood.

User State:

Keeps track of the user's mood and the latest recorded heart rate.

Analysis:

Performs analysis for finding the best matching music tracks from the music library based on the user's mood and latest recorded heart rate. It also performs analysis for reducing the playback speed of the playing track, if the user's heart rate decreases.

Music Playing Engine:

Provides basic functionalities for playing a music track (pause/resume, select a track from the music library, adjust the playback speed, etc.).

Music Library:

Stores a list of calm music chosen by our specialist, each classified by its appropriate mood and speed.

General Flow:

The user state takes a direct user input for the user's mood. The user's heart rate is measured using an external device and uploaded to the user state via HealthKit. These information are then used for the analysis block to perform analysis. Based on the analysis result, the music playing engine will get a music track from the music library and periodically query the analysis block to adjust the playback speed.

4. Reflection

If we could start the project again, we would start by conducting user surveys to get a better understanding of what users want in such an app and prioritize implementing those features. On the technical side, we envisioned our app to retrieve real-time heart rate data measured by the user's Apple Watch, but the long data synchronization delay between Apple Watch and iPhone makes it difficult. As a result, it was hard for us to test the heart rate parsing feature at the early stage of our development. If we could start again, we would use a more responsive approach for getting the heart rate data, such as using the iPhone's camera and flashlight (there will be almost no delay since the heart rate is measured by the iPhone itself).

As a group, we learned how to communicate and collaborate in a productive way to generate ideas for our app, even though we are all coming from a different field of study. More importantly, we learned how to iteratively improve our app based on presentation feedback, and also learned how to properly demonstrate an application under a time constraint.

5. Contribution

All members made an equal amount of contribution to this project, more specifically:

Jun (Programmer):

App features implemented:

- Constantly parsing and displaying the user's heart rate from the iPhone's Health app.
- Mood selection and displaying mood on the dashboard page.
- Generating a list of recommended music tracks on the dashboard page based on the user's mood and heart rate, where one of them is the best matching track.
- Audible relaxation script on the music player page.
- An adjustable timer to stop the music.
- UI design of the mood selection page and the dashboard page.

Kyle (Programmer):

App features implemented:

- Automatic playback speed adjustment based on user's heart rate.
- Functionalities of the music library (selecting and playing a music track, etc.).
- Functionalities of the music player (pause/resume, next track, etc.).
- Background music playing when the app is minimized or the screen is locked.
- A demonstration switch for adjusting the heart rate manually (for presentations only, removed in the final app).
- Transition logic and data model shared between pages.
- UI design of the music player page and the music library.

Annie (Specialist):

- Select music tracks from music and sleep quality research supplemental files.
- Measure the music tempo in BPM.
- Construct and organize a music library based on the mood and tempo.
- Modulate and provide a Progressive Muscle Relaxation (PMR) script.
- Description of features and the rationale of the app idea.
- Coordinate and organize project meetings.

6. Specialist Context (Music Therapy)

The CalmMind app differs from other wellness apps, as it integrates clinically proven music and music therapy techniques to help with mindfulness and relaxation and help people who are suffering from sleep issues. Some people who suffer from stress, depression, sleep deprivation, low self-confidence, and low self-esteem can find it challenging to act on their feelings, and verbal communication may be difficult. This is where music comes in; as a universal language, it transcends linguistic and verbal barriers, making it a powerful tool for people to communicate with one another and with themselves. According to research, deep listening to particular types of music seems to have fundamentally positive effects on our bodies, minds, and spirits.

Some research has supported the view that certain slow-tempo music has the power to calm the muscle tone, heart rate, and respiratory system and reduce both serotonin and cortisol (Thaut & Hodges, 2018). Moreover, the parasympathetic nervous system is in charge of "rest-and-digest." In the most recent study of parasympathetic nervous system and music, Bretherton, Deuchars, and Windsor (2019) observed that a significant increase in measures of parasympathetic nervous system activity was observed for the decrease in the tempo of 60 BPM. That is, listening to relaxing-decreasing tempo music activates the parasympathetic nervous system, leading to lower heart rate and respiratory rate.

All in all, the CalmMind app integrates clinically proven music therapy techniques to help with relaxation. By matching the user's heart rate and emotional state and reducing the playback speed as the user's heart rate decreases, the app gradually alters to bring users to their desired emotional and physiological (heartbeat) state. Additionally, CalmMind may allow clients to continue practicing their goals outside music therapy sessions. For instance, clients may carry out a daily home program with the CalmMind app based on the exercises (i.e., progressive muscle relaxation) addressed in the weekly sessions. Finally, with further refinement, CalmMind may function as a research tool. Since there is not much empirical research related to music and sleep, the CalmMind may allow a better research method to help increase validity and reliability for future music and relaxation research studies in music and health sciences. We are hopeful that future iterations of CalmMind could be used in a research study to examine the feasibility and effectiveness in enhancing sleep quality for persons with insomnia in a clinical sample.

7. Future work

The ClamMind app is still a prototype at its current stage. In the future, we would like to implement the following features. First of all, users should be able to upload music tracks according to their preferences, and the app will classify each uploaded track with its appropriate mood and speed. After that, a mechanism is needed for the app to detect mood changes and switch music tracks accordingly. Additionally, we would like to develop a mechanism for evaluating the user's sleep quality. With further refinements, the CalmMind app can function as a research tool to gather user data for future research and generalization. Most of the music and sleep quality research were conducted in a laboratory where participants were asked to nap in a laboratory. Thus, collecting user data through the app might be helpful as an objective measurement and parameter of the time spent in bed at home for a research study.

8. Consent Form

	Kyle	Jun	Annie
Video of Final Presentation	Yes	Yes	Yes
Report	Yes	Yes	Yes
Source Code	Yes	Yes	Yes

References:

Bretherton, B., Deuchars, J., & Windsor, W. L. (2019). The effects of controlled tempo manipulations on cardiovascular autonomic function. *Music & Science*, *2*, 2059204319858281.

Heiderscheit, Annie & Madson, Amy. (2015). Use of the Iso Principle as a Central Method in Mood Management: A Music Psychotherapy Clinical Case Study. Music Therapy Perspectives. 33. 45-52. 10.1093/mtp/miu042.

Krishnamoorthy, Y., Nagarajan, R., Saya, G., & Menon, V. (2020). Prevalence of psychological morbidities among general population, healthcare workers and COVID-19 patients amidst the COVID-19 pandemic: A systematic review and meta-analysis. *Psychiatry Research*, *293*, 113382–113382. https://doi.org/10.1016/j.psychres.2020.113382

Thaut, M., & Hodges, D. (2018). *The Oxford handbook of music and the brain.* Oxford University Press.