Music·Wave

Master Thesis

Companion Product for Orthopedic Surgery

Design for Interaction

Patients with AI-Generated Music

Ziyi Wang
Design the Soundscape Inside Operating Rooms During Surgery

Author
Ziyi Wang
Student Number: 5526639

Supervisor Team
Project Chair
Dr. Elif Özcan Vieira
Delft University of Technology

Project Mentor
Drs. Willem van der Maden
Delft University of Technology

Second Mentor
Dr. Monique van Velzen
Leiden University Medical Center

June 2023

Preface

Dear Reader

It is my great pleasure to share this exciting Master’s Graduation Project with you! I put a lot of effort into researching, designing, and reporting, and finally, here it is! Hope you could have fun reading it.

As Plato once put "Music gives a soul to the universe, wings to the mind, flight to the imagination, and life to everything." I have been playing violin for almost 14 years now, and every time I lift up the fantastic instrument, feeling the rubbing of strings and bow, a deep sense of inner peace would strike my heart. I think this is where the triggering part of making and enjoying music lies. When you listen to what you make, immersion would be enhanced and your mind will enter the flow state, where a totally different world is presented in front of your ears.

Every time I talk with people about why I want to study design, I would always say that I want to make the life of people around me better, by doing what I am good at and what I enjoy. Industrial design and interaction design really help me build up so many promising futures for people, and I quite enjoy the process of creating and making stuff. Growing up in a medical family, I was basically raised up in the hospital. So when I finally have the chance of designing something free and with my own will, I immediately think of designing for patients.

With the joined interest in music and healthcare, I reached out to Dr. Elif Özcan and started a research project with her about the noise inside orthopedic surgery rooms. Then the Graduation Project just naturally happens after data from the research project had been analyzed.

Soundscape is what we want to design for, and just like other physical products, designing sounds or music also requires an understanding of the properties, functions, and a clear mind of the redesign focus. The outcome might not be a specific product, but more like a recommendation for designing the soundscape inside this particular clinical context. I want the interaction and experience to provide patients with a personal zone or shelter when the surroundings seem to be out of control, and they will be able to have a place to hide and enjoy inner peace of mind.

Hope this thesis will give you a better look and understanding into the project! Enjoy and have fun, most importantly, start exploring music today!

Best,

May 2023
At Delft

Ziyi Wang
Summary

Background
Orthopedic surgeries are identified as one of the most noisy surgeries inside the OR (operation room). The highest noise sound level could reach up to around 130 dB, which is harmful to patients’ well-being and are likely to evoke negative feelings during surgery, in the previous study investigating the emotional experience of patients who receive spinal or general anesthesia in orthopedic surgeries, results showed that different kinds of sounds inside the OR could lead to fluctuating emotions for patients, such as nervousness, curiosity, and relaxation. Therefore, this project is mainly focusing on this user group and aims to improve their experience, especially regarding sounds inside the OR.

The background of the study and the previous research project will be presented in the report first, followed by the potential approach to deal with this noisy environment - by having music inside the OR for patients. Literature research about music therapy in clinical settings as well as the relationships between music and emotions was carried out. A convenient and creative way of generating music with emotional connotations that could be used to affect patients’ well-being by the AI model - “Riffusion”, was investigated and further developed.

Research & design procedure of the project
The research phase of the report includes two parts. The research in LUMC mapped out the patient journey, for instance, when, and how the design should intervene. Questionnaires for surgeons provided strong support for the rationale and effectiveness of musical interventions in this design project. Later on, the second part of the research, the one on AI music alignment proved that to some extent, AI generative model could understand the textual input with emotional descriptors, and output desired emotionally effective music that could influence the listeners’ perception. With this in mind, the design could refer to the circumplex model that Hevner and Schubert developed on music emotions to position the descriptors of specific musical emotions in two dimensions and achieve control of musical emotions in spatial terms.

The design concept mainly has two phases, the preference input phase, which allows patients to choose their favorite prompt list for the AI model to generate later on adding the emotional descriptors together as prompts; the music experience phase on the other hand, mainly happens during surgery when inside the OR, patients will be able to freely explore the music emotion variations during surgery with their favorite music styles (prompts). The design goal for the project would be to design a music companion product for orthopedic surgery patients who are undergoing spinal anesthesia. The product interaction aims to improve their emotional experience during the surgery period. The interaction should be distracting, desirable, and immersive for patients.

Final evaluation & recommendation
Once the general direction of the design concept is determined, the iteration phase began. The prompt input part is based on the brainstorming session and the co-creation session to develop an ideal interface for the experience. While for the music experience part, it had three concepts with different interacting ways for exploring the music emotions at first, and one of them will be chosen through the concept testing and evaluation procedure. The chosen concept will be further developed into the final concept - Music Wave. And finally, the design showcase of the interfaces and interactions will be presented, along with the last evaluation session of the working prototype.

In the future, I imagine that the OR would be an immersive sensing space for the patients as well, so adding visuals into the whole design would be another vision, that maybe will be further designed in later projects. This project, however, would only give a rough glance into what the whole experience could be like in the future, and how the surgery soundscape could be reframed.
01 Background

This chapter begins with the background of the graduation project. It is already tense enough for a patient to lie on an operation table without any idea what is going on with their body. Together with noise, it would only make things worse.

The project focuses on the experience of patients specifically in orthopedic surgeries, which are the loudest. The main scope of this project is to find a desired interaction intervention method and timing to reduce patients' negative emotions during different stages of surgery, as well as evoke neutral to positive emotions through AI-generated music.

1.1 Sounds in OR & Patient Experience
1.2 Patient Emotional Experience
1.3 Problem Definition
1.4 Project Scope

1.1 Sounds in OR & Patient Experience

Noise in OR had been widely discussed by many studies. In orthopedic surgeries, the equivalent sound pressure was found to be around 66.5 dBA. And medical staff had an average exposure to noise of 19-37 minutes (Kracht, et al. 2007).

Occasional high-spectrum sounds in surgeries such as TKR and THR performed an evident impact on medical staff and patients alike (Fritsch, et al. 2010), and therefore interfered with the surgery process. Typical sounds that can be found in the perioperative period include surgical instrument (tool) sounds; medical device sounds such as monitors, alarms, and suction apparatus; and sounds that come from humans, like talking sounds (Murthy, et al. 1995).

Surgical tool sounds could achieve high sound pressure levels when it comes to operating on bones, several instruments produce sounds that could reach a peak level of 120-140 dBA for more than 40% of the whole time (Ozcan et al. 2022). Anspach drill, for example, could reach 100-120 dBA on the bone at 80k rpm (revolutions per minute). While for a castcutter saw, sound pressure could be between 80-100 dBA on the bone (Fritsch, et al. 2010). Patient monitoring and support devices produce repetitive and constant sounds. Due to the demand for communication during surgeries, surgeons and nurses are likely to have a talking sound pressure of around 70-85 dBA (Kracht, et al. 2007).

Patients exposed to such complex soundscape will be likely to suffer from negative emotions (Fritsch, et al 2010). Especially with spinal anesthesia in TKR and THR (Turnbull, et al. 2017; Kehlet, et al 2015), when the awareness or responsiveness of the patient becomes higher (ASA, 2014). For patients who were under anesthesia, noise tended to be the most stimulating factor among all in the review by Bischoff, et al. in 2011. The complex soundscape inside OR was likely to cause hypertension (Burrow, et al. 2005). It may as well stress patients and increase annoyance or other negative feelings. In the research of Liu et al. 2000 (Liu, et al. 2000), one-third of the patients claimed that the surgery induction and recovery phases were noisy.

Figure 1.1 Sounds that could happen inside OR
Figure 1.2 Orthopedic Surgery Tools (Image from Google)
1.2 Patient Emotional Experience

To further study how patients feel in different stages of surgery, and whether their emotions will be influenced by multiple sounds that could happen inside the OR, a research project was conducted, with 51 orthopedic surgery patients who were under spinal anesthesia, and 13 orthopedic surgery patients under general anesthesia.

The research aimed to discover the relationship between sounds inside orthopedic OR and patients’ emotional experiences, find the possible impact of sounds on listeners, and provide further insights into sound-driven design inside OR. Therefore, the research had been carried out in two phases: a questionnaire survey and interviews. The survey focused on researching the sounds that patients heard during orthopedic surgery and how their emotions changed during this period. Questionnaires were handed out by medical staff to patients who had finished their surgeries.

Participants in this research were all recruited from China mainland, aged between 18 to 60 and above, with a gender ratio of 2:1 (Female: Male). The total number of the questionnaire collected was 69, with an effective questionnaire number of 64.

Spinal anesthesia patients were asked to write down their emotions at the three different stages of the surgery (See Figure 1.4). The three stages include the before surgery stage (When they were wheeled into the OR and waited for anesthesia), the surgery stage (After anesthesia and surgery procedure officially began), and after surgery stage (When the surgery was done and they were transferred out of the OR). They were given 10 emotions both positive, negative, and neutral to choose from and were able to choose up to 3 emotions at each stage.

In Figure 1.4, a line chart shows how many participants choose a certain emotion at one of the three stages, and how the number count is changing. Nervous, neutral, fearful, and anxious are the most chosen emotions before the surgery, whereas relaxed, neutral, relieved, and tiring are picked by more participants after surgery.

During the surgery, besides an obvious decrease in negative emotions like nervousness, we can see an increase in neutral, relaxed, and tiring. Curiosity went down a bit during the surgery and rapidly declined after surgery. Few people felt confused or depressed, compared to the rather steady amount of people who felt neutral the whole time.

Besides mapping out the emotional change of patients who receive spinal anesthesia, the participants were also asked to reflect on the sound they heard inside OR. Results suggest that certain sounds and surgery stage does have an effect on how patients feel. For example, patient monitoring and device sounds together with conversational sounds are likely to make one feel nervous before the surgery begins when in the OR, while surgical tool sounds are likely to cause curiosity in patients during surgery.

![Figure 1.3 Patient age & gender distribution. (Z. Wang & E. Ozcan, Forum Acusticum 2023)](image)

![Figure 1.4 Spinal anesthesia patients’ emotional change during three different stages of orthopedic surgery (Z. Wang & E. Ozcan, Forum Acusticum 2023)](image)
At the end of the survey, we purposed a possible solution of improving the sound environment inside the OR by playing music to them during surgery, and over half of the patients are positive to this proposal. In Figure 1.3, the types of music they would like to hear are put into a coordinate system for better analysis. In the diagram, most participants chose music that is more likely to be instrumental and abstract, words like sentimental, slow, and light music are often mentioned.

Interestingly, one of the surgeons who noticed this research had tried to play music for his patients already for several months. The surgeon would bring a little speaker to play the music after this. What was interesting was that the expert would choose the music they prefer to listen to rather than ask about the patient's preferences. "Since I am the one who will listen to this music the longest, why not?" As said in the interview. When asked about the feedback from the patients, it was said that they all enjoyed the songs played, no matter whether it was pop, classical, or light music. "The music won't influence me in the THR surgery, and I think the music is not as loud as the surgical tools." The surgeon also mentioned that they would give the patient some expectations about having music during the surgery before it began, so they would be delighted even before they are actually inside the room. Up until now, the act of playing music to patients seemed working well, and the interviewee was thinking of introducing Opera music in the future to the patients.

It is not difficult to see a future vision of having music as an intervention to improve patients' emotional experiences during surgery. Music often appears as a proxy for sound stimulation, as it can have a strong impact on psychological changes (Kim, et al, 2010).

In the research of Alvin & Andrews in 1975, music therapy was also found to be effective in dealing with depression and anxiety (Koelsch, 2009). Having music played during the surgery period would be an effective way of shifting patient emotions.

To conclude this research, there are several insights that could be taken into further studies.

1. Patients who received spinal anesthesia are likely to experience negative emotions during the surgery period, especially before and during the surgery while they are inside the OR.

2. Sounds inside OR do affect patients' emotional experience in various ways, and some of them might cause negative feelings which therefore affect patients' well-being.

3. The most preferred music genre by patients is music with instruments as dominant, which have fewer meanings and are ideally slow and soft, ambient or light music for example.

Music therapy was also found to be effective in dealing with depression and anxiety (Koelsch, 2009). Having music played during the surgery period would be an effective way of shifting patient emotions.

To conclude this research, there are several insights that could be taken into further studies.

1. Patients who received spinal anesthesia are likely to experience negative emotions during the surgery period, especially before and during the surgery while they are inside the OR.

2. Sounds inside OR do affect patients' emotional experience in various ways, and some of them might cause negative feelings which therefore affect patients' well-being.

3. The most preferred music genre by patients is music with instruments as dominant, which have fewer meanings and are ideally slow and soft, ambient or light music for example.

Music therapy was also found to be effective in dealing with depression and anxiety (Koelsch, 2009). Having music played during the surgery period would be an effective way of shifting patient emotions.

To conclude this research, there are several insights that could be taken into further studies.

1. Patients who received spinal anesthesia are likely to experience negative emotions during the surgery period, especially before and during the surgery while they are inside the OR.

2. Sounds inside OR do affect patients' emotional experience in various ways, and some of them might cause negative feelings which therefore affect patients' well-being.

3. The most preferred music genre by patients is music with instruments as dominant, which have fewer meanings and are ideally slow and soft, ambient or light music for example.

Table 1.1 The preferred music types by patients
Discussion: What kind of music inside OR is optimal?

While it is unlikely for designers to eliminate the sounds in OR, possible solutions for changing the soundscape for patients could be blocking sound propagation for patients or adding sounds that could mask the noise or distract patients’ attention from the acoustic environment. Considering the second option for a much better experience, music could be an answer for the “added sound” in OR. There have been many explorations of music as a therapy in healthcare fields, and many music excerpts used are either recorded or performed live by musicians, which is still a bit limited and rigid. When introducing music as an intervention method, different listeners could interpret certain types of music poles apart. Therefore, playing designed music excerpts is hard to suit personal needs and preferences.

Nowadays, AI-generated music has been a growing trend, and it provides us with new thoughts in making music interventions. With simple text input, the model will generate a short clip of music within 30 seconds. In this sense, the AI can generate personal and enjoyable music excerpts for patients that could improve their emotional experience as well as functionally change the soundscape inside the OR during surgery.

Taking insights from the previous results of the research project, it is obvious that to improve the emotional experience, we need to focus on reducing the negative feelings before, maintaining stable emotions during surgery, and reducing the feeling of tired afterward.

AI-generated music is mostly instrumental base and is good at producing vibes or ambiance. Therefore, with the right prompt input, we could be able to “design” a unique, personalized, and relaxing environment for patients who are going under surgery.

And as a future vision, a more personalized emotional experience for patients could be designed with various inputs such as the physiological parameters or eye movement that could create dynamic music which induces emotions.

1.3 Problem Definition

After having an understanding of the background of this project, which is in the context of orthopedic operating rooms, and with a user group of patients under spinal anesthesia, as well as a possible solution of having music intervention to improve patient experience. It is clear that the research and design process in this project aims to solve the following problems:

01 Design Timing

It is unclear now when and at which point should the music intervention come in for orthopedic surgery patients to ease their emotions. Either music is masking the undesired sounds or distracting patients’ attention inside the OR, it needs to perform at the right time.

02 Music Effect

The effect of preferable music on patients who are under spinal anesthesia during surgery is not specified enough. How much will it help reduce the negative feelings is still to be researched.

03 AI Alignment

For the AI model, the correct prompt input for desired music output is still to be defined through further testing. From our current understanding of the needs of patients, they can be fulfilled by different sonic ambiances, but it is unclear what the emotional connotations of those sonic ambient descriptors can be when using them as prompt input for the AI model. The AI model needs to be fed with the right frame of text prompt to be able to generate either emotionally or functionally well-performed music phrases that could improve the soundscape of the OR.

04 Interaction Pattern

An interactive and convenient way of inputting prompts for patients lying on the operating table should also be considered. Ergonomics need to be considered when testing with design comfort in mind. Also, the most desired interactions with patients should be tested as well. How the patients are going to interact with the product needs to be considered, as their heads are now being blocked by a sheet and they are unable to see their hands.
1.4 Project Scope

The project scope is illustrated on this page. There will be mainly three parts to this project:

1. Patients have got their self-chosen prompts as input for the AI music generator.

2. The AI model generates music according to prompts and basic ambient settings.

3. Music intervention is added to the complex soundscape with certain interaction patterns for the patients.

The research part of this project will mainly focus on the original scenario and intervention part, as well as the AI generation part. While the design part of the project will mainly focus on designing the desirable interaction pattern of each action taken place in this scope: prompts input, adding music intervention, and user interaction with music intervention.

Therefore, the project will be conducted in three paralleled processes, but each will be related to others in between. The insights gathered from background and early research will help develop a design concept. But to further detail it, the research on patients’ emotional change with music intervention and the research on AI music alignment is needed.
Conclusion

In this chapter, the research background of the project is shown, with several questions remaining to be detailed in further study. The research project provided insights about which direction the graduation project should aim at, as well as the problem focus - on music intervention and patient experience.

To define the problem, the background of what kind of sounds are there inside OR, what would be the possible influence of them on patients, how the patients’ emotions are changing at different stages of surgery, and the new technology of AI-generated music is illustrated in this chapter. This finally lead to four main aspects of the problem definition of this graduation project. In short words, they are when and where does the music intervention happen? How effective is the music intervention? How to phrase the prompts to let AI generate ideal music? How to naturally adapt this process in an interactive way inside the OR?

Finally, the project scope is mapped out, with three main parts to achieve throughout the project. This includes two research phases and one design phase. The three processes will go parallel but will be interconnected with each other. Further research will provide more insights into how to detail the design concept. The methodology for this will be discussed in the next chapter.
This chapter introduces the general approaches and the literature support behind them that will be implemented in this project. An overview of the project approach will be shown first, which will be aligned with the three parts mentioned in the previous chapter. This is the literature research for each part, from the effect of having music in clinical settings, to how music influences one’s emotions, and finally how AI-generated music is working.

Last, this chapter introduces the design approaches that can be used to reach the initial design goal. This part serves as the foundation of the whole project.

2.1 Music in Clinical Setting
2.2 Music & Emotion
2.3 AI Generated Music
2.4 Design Approach
2.1 Music in Clinical Setting

As mentioned before, patients inside the OR might suffer from various conditions, including anxiety, distress, and so on. While nowadays, music is more and more used in different stages of surgery to ease patients' emotional burdens (Spintge, 2012), we can see a lot of studies carried out inside the OR with music as an intervention.

Music that is used for medical applications is defined as “the scientifically based, medico-functional application of music to complement usual medical procedures in prevention, therapy, and rehabilitation” (Spintge and Droh, 1989; Spintge, 1996). And a more specific term “AAM (Anxiety Alleviating Music)” was developed by Spintge in 1983, and refined by using pre- and post-test patient questionnaires during the surgery period. So in this sense, the music that is planned to use in this graduation project can be also categorized as AAM.

A thorough overview of the studies that had been carried out inside OR and the AAM they used can be found in Table 1. Most of the AAM are classical, soft, and slow music, sometimes patients get to choose their preferred music. And some of them are performed lively by music therapists.

According to Spintge, responses to AAM from the researches mentioned tend to be promising. Not only does it have an impact on the patient’s physical well-being, such as decreasing the heart rate and blood pressure, but it also psychologically affects patients. For example, it could help patients better fall asleep during surgery, decrease postoperative confusion, improve preoperative mental functioning, and reduce restlessness.

When analyzing the method the researches used, most of them perform a compare-group study. With the music-intervention group and compare group. And the most commonly used device is headphones or speakers. For the study of McCaffrey in 2009, the setting is similar to this graduation project, which is also inside an orthopedic OR. And the participants were all elders with 11 in the music listening group and 11 in compare group. Data analysis methods are often ANOVA or general data analysis, such as comparison. The music list this research used had been listed on the left (McCaffrey, 2009), which could be a nice reference for choosing music intervention for this graduation project in research phase 2.

<table>
<thead>
<tr>
<th>AAM</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants' preferred music</td>
<td>Laopaibo, 2009</td>
</tr>
<tr>
<td>Nielsen Eye composed the</td>
<td>Nilsson, 2009</td>
</tr>
<tr>
<td>relaxation music</td>
<td>Schwartz, 2009</td>
</tr>
<tr>
<td>Music Channels (Light Piano)</td>
<td>Siedlecki, 2009</td>
</tr>
<tr>
<td>Channel</td>
<td>Fredriksen, 2009</td>
</tr>
<tr>
<td>Participants' preferred music</td>
<td>Kain, 2001</td>
</tr>
<tr>
<td>Instrumental music</td>
<td>Wang, 2002</td>
</tr>
<tr>
<td>Peaceful pan flute music</td>
<td>McCaffrey, 2009</td>
</tr>
<tr>
<td>Participants' preferred music</td>
<td>Ikonomidou, 2004</td>
</tr>
<tr>
<td>Lullabies and softy</td>
<td>Bins-Turner, 2008</td>
</tr>
<tr>
<td>Mozart music</td>
<td>Loewy, 2005</td>
</tr>
<tr>
<td>soft hits, classical, guitar,</td>
<td>Lubetzky, 2009</td>
</tr>
<tr>
<td>chamber music, folk music, and</td>
<td>Allen, 2001</td>
</tr>
<tr>
<td>popular singers from the</td>
<td>Krou, 2001</td>
</tr>
<tr>
<td>1940s and 1950s</td>
<td>Nilsson, 2005</td>
</tr>
<tr>
<td>Therapist</td>
<td>Leard, 2007</td>
</tr>
<tr>
<td>New-age synthesizer</td>
<td>Cunningham, 1997</td>
</tr>
<tr>
<td>Classical, country, pop or dance</td>
<td>Uvayola, 2006</td>
</tr>
<tr>
<td>music</td>
<td>Mozart piano sonatas</td>
</tr>
</tbody>
</table>

Table 2.1 AAM types in previous studies

Some of the Music Selection of McCaffrey (2009)
2.2 Music & Emotion

After understanding why we want to have music in a clinical context, and its potential benefits, the question naturally leads to what is the relationship between music and human perception, which eventually evokes strong emotions related to the music pieces. This part aims at finding out how emotions regarding music are described in the previous studies and also trying to find a rather validated model for further research to build on.

Before diving into the studies, a definition needs to be clarified. There are two ways to describe emotions while listening to music:

1. What is the music like? (Describe its emotional connotations)
2. How do you feel when listening to the music? (Describe your feelings)

These two types of questioning will lead to different results. And since the music we would like to use as an intervention must obtain certain emotional connotations that could be used to evoke neutral or positive emotions while listening, both aspects are important to the project. Therefore, while reviewing, the two are not strictly distinguished. And because some of the works are old, so the idea of mental model and perception is not yet fully developed, it is understandable for them to have certain limits.

When considering how to reflect on certain music pieces, there are mainly three ways of reporting emotions: free description, ratings, and continuous recording.

Free Description

Early in 1891, Gilman conducted research letting listeners freely report on their feelings about live performed piano and violin music. Most of the words that were used to describe music were rather emotionally related, but interestingly, when people fail to use certain abstract descriptors, they tend to use the existing object to describe the sounds they heard, like “storm” and “young girl”. Gundlach in 1935 tried to analyze whether structural factors in music would influence the perceptions of listeners. The study used the rank difference method to check the correlations and concluded the speed of music is by far the most important factor influencing the perception. Using free description can result in many unexpected answers, which might provide many insights, however, the answers may also be coherent with each listener when they listen to different pieces, and it can be hard to code (Rigg, 1937).

Ratings

Ratings of emotions usually appear in the form of questionnaires and scales and are therefore mostly dimensional. In 1969, a research conducted by Wedin using 20 pieces of music with 40 emotional descriptors to describe them had come to the result of putting music emotions into three general clusters: Tension - Energy, Gaiety - Gloom, and Solennity - Triviality. This was one of the earliest attempts at clustering music emotions and provided later research with a whole new angle. Later the clustering was developed into a two-dimensional quadrant, with two axes of "Tension - Relaxation" and "Negative - Positive" (Imberty, 1979). Whether it is Wedin or Imberty’s work, they could all be summarized into two dimensions in expressing music emotion (Gabrielson, A., & Lindström, E. 2001).

Valence: unpleasantness - pleasantness

Arousal: calm - excited

These two dimensions are rather important in this graduation project as it is going to be used as parameters to let listeners reflect on the music they listened to.

Continuous Recording

This method is specifically used to describe a long-lasting music piece, which could occur different emotions within the duration of it. And usually, tangible devices such as pressure sensors are used to let listeners reflect on how excited or tense they are while listening.

In 1937, Hevner developed an adjective list used for describing emotions that are evoked by different structured music phrases. The adjective list was adapted by Farnsworth in 1954, and finally appears as follows:

This Adjective List is also an important reference for defining the emotion model later in the research phase 2. And as a conclusion to this part, generally speaking, the perception of music fits the stereotype (Fast is happy, slow is tender ...), and the most important factors are the tempo and mode of the music piece (Gabrielson, A., & Lindström, E. 2001).

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awe-inspiring</td>
<td>Dark</td>
<td>Dreamy</td>
<td>Bright</td>
<td>Agitated</td>
<td>Delicate</td>
</tr>
<tr>
<td>Dignified</td>
<td>Depressing</td>
<td>Longing</td>
<td>Cheerful</td>
<td>Dramatic</td>
<td>Fanfoul</td>
</tr>
<tr>
<td>Lofty</td>
<td>Doleful</td>
<td>Lyrical</td>
<td>Gay</td>
<td>Exaging</td>
<td>Graceful</td>
</tr>
<tr>
<td>Sacred</td>
<td>Frustrated</td>
<td>Majestic</td>
<td>Happy</td>
<td>Exhilarated</td>
<td>Humorous</td>
</tr>
<tr>
<td>Serious</td>
<td>Frustrated</td>
<td>Martial</td>
<td>Joyous</td>
<td>Impetuous</td>
<td>Light</td>
</tr>
<tr>
<td>Sober</td>
<td>Doleful</td>
<td>Ponderous</td>
<td>Vigorous</td>
<td>Passionate</td>
<td>Playful</td>
</tr>
<tr>
<td>Solenn</td>
<td>Gloomy</td>
<td>Robust</td>
<td>Merry</td>
<td>Restless</td>
<td>Quaint</td>
</tr>
<tr>
<td>Spiritual</td>
<td>Mournful</td>
<td>Robust</td>
<td>Sprightly</td>
<td>Sensational</td>
<td>Sprightly</td>
</tr>
<tr>
<td></td>
<td>Mournful</td>
<td>Robust</td>
<td>Whimsical</td>
<td>Soothing</td>
<td></td>
</tr>
</tbody>
</table>

But the version of this Adjective List is a bit old, and may not adapt to the nowadays development of emotional adjectives for music. Therefore, we will be using the refined version of the Adjective List by Schuber in 2003 with updated terminology and with one more cluster of words.

Figure 2.1 Hevner Adjective List (Hevner, 1973)
2.3 AI Generated Music

Nowadays we are experiencing an era when AI generative model is developing so fast that they could basically generate anything you want, and all you need is to input something simple - "prompts". It can be words, phrases, long stories, images, and so on. Once decided on the prompts, you can use them to generate images, 3D models, paragraphs, and most amazingly, music.

There are many models that could generate music with a certain input, in this project specifically, the "Riffusion" AI generator is mainly used, as it can realize text-to-audio generation. You can simply put a random sentence like "cat DJ is dancing in the moon" into the portal, and a short clip of music will be generated within seconds. The mechanism of this model is that the developers, Seth Frosgren and Hayk Martiros, fine-tuned the text-to-image diffusion model into a model that could make spectrograms from the image, and eventually, the spectrogram could be converted into music clips by inverting the Short-time Fourier Transform (STFT). (https://www.riffusion.com/about)

![Spectrogram](image)

**Figure 2.2 Mechanism of Riffusion (Riff + Diffusion)**

This process could be easily understood as the deconstruction and reconstruction of the elements. Texts are firstly turned into noise, which will be denoised into an image, converted to a spectrogram, and finally music clip.

There are other models such as MusicLM, which allow direct conversion from text to audio. But since the model is not open source, this project will not use it as the music-generating tool.

**Why AI generated music?**

From the literature review of music and emotion, it is not hard to realize that although music perception has certain commonalities, it still can be very unlikely among individuals. As an old saying goes: "One man's meat is another man's poison", what appears to be calm is not necessarily calm to everyone. Someone would rather listen to heavy metal music at midnight to get better sleep. Playing recorded music always has certain limitations, and might have the opposite effect on patients.

AI-generated music, on the other hand, could be personalized, and you can even try the combination of "calming metal music". It allows listeners to create music that suits their appetites well. Another benefit of having AI generated music is that the effort in choosing music is low, all you have to do is to think about something you want, and a simple sentence could develop the music within minutes.

As a future vision of AI-generated music, we could see a lot of potential in using various forms of prompts. For example, if the patients lying on the bed is hard to type text, they could use their body movements, facial expressions, or even physiological parameters to create real-time music and improve the soundscape. No more performers or CDs, and even people with the lowest knowledge of music could enjoy the experience of creating something, and the feeling of self-autonomy.

Figure 2.3 Riffusion "APP" Interface (https://www.riffusion.com/?&prompt=bubblegum+eurodance)

- Run with Colab interface

![Coding of the AI Generative Model. Riffusion project by Seth Forsgren and Hayk Martiros, colab notebook by Jasper Gilley](image)
2.4 Design Approach

The whole process of the design approach is shown on the right. This project is not a linear design process, as the results in research phase one could already provide insights into design and prototyping. While a prototype could be helpful in research phase two, the results in the second phase could also provide design concepting with more detailed insights into the themes, functions, and interactions.

The prototyping and iterating processes are curriculum, and it allows the design to go back to the initial goal if the feedback is completely out of expectation in an undesired way.

The benefit of research and design acting in parallel is that one could always have design ideas developed and aim at more research details, rather than not having enough information when the research is done.
Conclusion

This chapter thoroughly introduced the literature reference of this project, as well as the methodology that is going to implement into the process. Literature about music in clinical use provides insights into what kinds of music should be played inside the OR. Emotion research gave a general look into how to measure and define music emotions, as well as what words are used as descriptors. The adjective list and the two-dimensional axes of music emotions will become a solid foundation for AI music alignment research. Finally, the AI technology was introduced, explaining the mechanism behind it, and how this project would benefit from the AI text-to-audio generative model. A future vision of why using AI generated music was illustrated in the end.

The last part showed a clear vision of how the process relates to each other during the project period. The project will be carried out in a non-linear way, with three procedures running parallel, but supporting one another in the meantime.

Next, the early study and research will be presented. As well as the setup of research phase two.
3.1 LUMC field research & patient journey

On March 10th, 2023, I visited LUMC and had meetings with Monique (who is also an anesthesiologist), Willem, and Rob (The head of the Orthopedic Department). This helped me better refine the user journey of orthopedic patients who need surgery. There are several things that I understood about the patients’ experience within LUMC.

Patient Routine

Normally, before the patients are admitted to the hospital, there will be two pre-meetings for them. One is hosted by the surgeons, to talk with the patients about their surgery details; The other one is with anesthesiologists, to talk with them about their anesthesia details and some things to keep in mind before admitting to the hospital, keep an empty stomach, for example.

Patients are usually admitted on the same day as their surgery or one day before. They will first be wheeled into the waiting area outside the OR, where they will wait for the surgery. In this area, patients will again have a session called “briefing”, to confirm their status, surgery details, etc. with the anesthesiologist team, the surgeon, and medical staff. After that, they will be wheeled into the OR, changed to the operating table, and receive anesthesia and surgery.

When inside OR, patients will receive their anesthesia. Spinal anesthesia usually requires patients to sit up and bend their back to receive the anesthesia, and it will take approximately 15-20 minutes for the anesthesia to work.

There will be a sheet blocking the patients’ view of their lower body, so they won’t be able to see anything but the view around their upper body.

After the surgery, patients will be pushed out of the OR and wait in the recovery area for the sedation or anesthesia to lose efficacy. They might be able to get out of the hospital in one or two days after surgery.
Figure 3.1 Patient journey for an orthopedic surgery.

**Patient Journey**

Present this patient journey with potential design intervention points.

**Design Intervention Timing**

From the journey map and the interview, it can be easy to notice that the best timing for the music intervention to be involved is on the day when the patient is admitted into the hospital. From Rob, we know that they are usually the most nervous when first come into the hospital.

Therefore, it would be better if we let them know that there might be a way to help reduce pressure - by providing them with music.

When patients are waiting in the holding area, they barely have anything else to do, so it would be another good time for us to introduce how the tangible interaction works, and deliver a brief introduction to the design. After they are more familiar with the product, they can be ready to go into the OR and operate the device on their own. In other words, patients design their sound experience inside the OR in advance.
Intervention Scenario

In the holding area/ward

Usually when patients are admitted to the hospital, they will reach the highest anxiety or other negative feelings, so it would be a good timing to introduce something that might be interesting and attractive to them, to make them distracted from the tense scenario.

What we now know is that patients would usually have to wait for a while and do nothing both in the ward and holding area before surgery. And at this moment, they can still see and hear, so it would be ideal to let them first get familiar with the interface and interaction.

Curiosity is expected to go up when exploring the music generated by AI. Also, it will give them a sense of promise for the upcoming sound environment inside the OR, to ease their mind.

To this degree, the product should be attractive, interactive, and desirable to use, and have a clear UI interface and user guidance.

Inside the OR

When patients are covered up by sheets, they are unable to see their hands, as well as what is happening with their lower body. This will again make them feel anxious. So it is important to let them know that the product they have in their hands will provide them protection and companionship.

In this sense, the design should be something that can keep them away from negative emotions like nervousness, anxiety, and boredom during surgery. And this requires the design to be relaxing, immersive, and distracting.

It should mainly focus on the sound interaction part, but it could also have a certain level of visual interaction, in case the patients want to turn the music off for a while, but still do not want to be bored.
3.2 Study of Orthopedic Surgeons

A survey of orthopedic surgeons was conducted to see if they are aware of the sound effects on patients, and whether they would prefer the idea of having music for patients during surgery. This is mainly to provide more evidence for the design project, as well as insights into the ideation phase.

A total of 18 surgeons participated in the questionnaire survey, and all of them are orthopedic surgeons or related medical staff who work in the Netherlands.

The questionnaire was made in English but thanks to my mentor Monique, who helped me translate it into Dutch. We handed them out in physical form, transcribed and translated the answers into English after collecting them.

Survey Content

We begin the survey by asking them whether they think surgeries on knees or hips, and surgeries on soft tissue are noisy or not. And the reason for it.

Then we ask them whether they have tried any intervention methods for the noise. Will they tell their patients that there might be noise during surgery? Also, have any patients receiving spinal anesthesia ever complained about the noise?

Last we asked them do they think noise will affect patients' well-being, and if they want to play music for patients during surgery.

The quantitative results are shown below. All of the 18 professionals think that surgeries on the knee or hip are noisy (because of sawing, inserting prosthesis, hammer, metal, etc.), and 2 claim that soft tissue surgeries are also noisy due to suction.

1/3 of the professionals have tried to use interventions against the noise, and most of them choose to use earplugs or headphones.

6 out of 18 professionals will tell their patients about the potential noise, and most of them do it before surgery. And when asking about whether patients reflect on the noise or not, only 6 claimed that they had such reflections, and most likely after surgery, when the patients would say things like "I heard you hammering" or "it looked like a workplace/craftsmen place". The professional who tells patients before and during the surgery that it might be noisy thinks that he or she did not receive negative feedback on noise because of this.

Most of the professionals think that the noise will affect patients' experience, because the sound can be impressive, making patients tense, unrest, fear, anxiety, and less deep sleep.

And when asked about whether they would like to play music for the patients, nearly all of them gave positive answers. Typical reasons are that it is comfortable, and patients prefer it. And surprisingly, many of them said that they already have music or radio on inside the OR, but sometimes for themselves as well. They would choose music that suits both patients' preferences and the medical staff's preferences alike.

Conclusion

The results of this study are promising in supporting the foundation of this graduation project: It is meaningful and helpful to have music inside OR during surgery. And most importantly, everyone likes it!
3.3 Case Study & Further Insights

A Case Study in China

As I have mentioned before, after the research project was released to the surgeons, one of them showed special interest in it and tried to play music for his patients through a speaker during knee or hip surgery, in the Second Hospital of Shanxi Medical University, China.

The temptation had been carried on for two months at the moment I interviewed him and his student who is responsible for this study. From the surgeon's perspective, playing music can be delightful for him and the patients, especially for himself, as he mentioned. He could have multiple choices of songs that he wanted to listen to, and after the surgery, most of the patients would remember the things they heard, instead of the surgery experience.

To my understanding, the action of playing music should be somehow dominant enough for the patients to pay attention to. Although many patients claim that they want to hear light music or somehow background music, this alone might not be enough for them to get over the negative feelings the environment creates. This is why sometimes the talk show or movie tape works better than music.

The surgeon used his speaker of Bose (as shown in the figure), due to the speaker of the whole surgery area might influence other ORs, and some surgeons enjoy quiet working space. This would raise another question of how should we define who is the main listener, the surgeon or the patients.

In this project, we would like to bring our attention more to the patient side, but of course, we would not want the music to be a bother for the surgeons, so we propose the idea of having headphones for patients, to create a rather private experience, and also enhance the sense of safety during the process.

Figure 3.4 Speaker used for playing music for patients inside the OR at the Second Hospital of Shanxi Medical University
03 Conclusion

The early research conducted in LUMC was introduced in this chapter. The patient journey was mapped out, with some new insights into when and where to implement the design intervention. From the survey of surgeons, positive feedback on using music inside OR truly provided the project discussion with an expert point of view, supporting the design concept. It is also really interesting that surgeons won’t think of mentioning the noise to patients before and during surgery, but almost all of them believe that noise has an impact on patients. This attempt in introducing music into orthopedic surgeries seems to be promising and has the potential to become something that could be enjoyed by both the patients and the medical staff as well.

The next chapter is going to talk about another research that is going parallel to this one but with the same importance of providing detailed insights to further designing.
Research AI Music Alignment

This chapter introduces the development of the AI alignment test in this graduation project. It begins with validating a solid circumplex model, and several pilot testing to find out the suitable prompts for Riffusion to generate high-quality music with enough variations. After the model and prompts are set, the testing procedure begins to organize, using the two-dimensional axes of music emotion as the parameters to reflect on music pieces generated with different word prompts.

The thorough procedure of the alignment test setup and data collection will be introduced, as well as the analysis. A few interesting results will be shown, along with further evidence for the design process.

Thanks Seth Forsgren and Hayk Martiros for developing the Riffusion Model.

4.1 Circumplex Model
4.2 Prompts Choice
4.3 Pilot Test
4.4 Public Test Setup
4.5 Data Analysis
4.6 Discussion & Insights

4.1 Circumplex Model

From the Hevner Adjective List (Hevner, K. 1937; Farnsworth, P. R. 1954), words that are used to describe music are clustered into eight categories. And if put into the two-dimensional quadrant of Valence and Arousal, we could get a circumplex model that can be used for rating. Therefore, with this thought in mind, I conducted the first round of testing with music I generated from Riffusion Playground.

This pilot test aims to find out in which way should I conduct the study, and how should I ask the participants questions regarding emotions evoked by music. As is shown in the figure, I first used a radar chart to let participants rate to which degree they feel each cluster of emotions expressed or felt while playing the AI-generated music.

The average time for the user to finish is 46-50 seconds for each 10 seconds music piece. But I found several important limits that are worth paying attention to:

1. The adjectives are too vague and sometimes hard to think of.

2. The music itself is a bit hard to evaluate because the participants were not sure of the standard scoring in their minds. In other words, they need more time to set their rating standards.

In the research of Berrios, R., Totterdell, P., & Kellett, S. (2015), they proposed a term called "Mixed Emotion". While emotions could be occurred fast and changed swiftly, mixed emotions on the other hand are more like a form of mood.

While thinking of the emotional experience of patients inside the OR, I could imagine that changing the soundscape with music intervention would have a more significant impact ideally on their moods. Therefore, it would be more about mixed emotions rather than single emotions.

As we know in the study of Scherer, K. R. (2005), there are mainly two ways of measuring emotions. One is a free expression with any words the participants would think of, the other one is a dimensional measurement. The reason why I choose dimensional measurement is that first, it is more structured and easy to conduct data analysis. Also, it would make participants more convenient since they are listening to a rather abstract music piece. Wilhelm Wundt in 1905 had developed a three-dimensional structure to categorize emotions. (Positive-Negative; Calm-Excited; Tense-Relaxed).

Figure 4.1 Representation of Hevner’s adjective clock (Hevner, 1973, with updated terminology from Schubert, 2003).

To be more specific about the emotion clusters, as well as fit with the current development of emotion adjectives, in this study, the updated version of the Adjective List is used as a reference. Also in the later design process, this model will serve as the ground foundation of the development of interface and interaction.

However, through the testing procedure, the nine properties are still quite a lot to the participants, and as rating one takes too much time, rating dozens of music pieces seems to be a too complicated task. So combining the two-dimensional quadrant of valence and arousal, and with the 9*9 Affect Grid (Russell et. al, 1989), a measurable circumplex model is developed. (See Figure on page 42)
4.2 Prompts for Music Generating

As we know, if we want to let AI generate music, we need to have text input for the generative model. In the previous section, we have got this circumplex model for music and emotions, and we would like to find out:

Can AI reliably generate effective music to stabilize the effect according to the label of the music?

So it would be ideal if we pick out two words from each of the 9 clusters, to become the labeling of the music pieces. But there comes another issue with the Riffusion Model, which is that if you have a longer prompt, the quality of the music might be better than if you only have several single words as input. So it would also be helpful if we could develop a structural prompt and leave the emotional descriptors blank to fill in later, for generating AI music.

To understand which words would be suitable for building up the prompts, I did a word cloud analysis with the word frequency of all the labels in the database of MusicCaps, which has 5518 pieces of music with over 14,000 different labels music. This database is also used for other generative models, so it might help choose the right word components used for Riffusion.

I decided that I would like to have words that represent music genre, instrument, and to some extent, context. Considering that music genre or style might also influence how participants are rating the two dimensions, I want to use two different styles of prompt structure, to find out if style would have an effect.

The way I choose music style is based on the following principle:
1. The two styles can be easily distinguished from each other.
2. The two styles need to have certain words with high frequency in the database.
3. The two styles should be somehow rather neutral when performing.

4.3 Pilot Tests

At first time, I choose two styles of guitar and string, but with 4 pre-tests, I found out that the ratings for those two styles were not varied a lot, people tend to choose more neutral ratings like 4 or 5, which means that these two style could not make the emotional descriptors explicit and distinguish with each other.

Therefore, I changed the style to electronic and melody, with these two words, the music generated by AI is more varied among the different emotional descriptor clusters.

Also, I first gave the participants each 24 music pieces for them to rate, but then I found out that it would take up too much time, and participants might find the music pieces somehow similar to each other the more they listen to them.

Task 01

Please listen to this music clip and answer the question below. 

Please rate the valence of this music according to yourself. 

Positive Valence 

Please rate the arousal of this music according to yourself.

Low Arousal 

So from the insights I get from the pilot tests, I would mainly improve the survey in the following aspects:

1. Change the prompts to one that could make more distinguishable music pieces with the AI model.
2. Reduce the number of questions that the participants need to answer by calculating the optimal sample size.
3. Make the questions of rating the two dimensions more intuitive. Also add one more rating about the quality of the music, in case it has a certain effect on how participants rate the valence scale.

Figure 4.2 Word cloud from database

Figure 4.3 Pilot Test Survey on Qualtrics.
4.4 Public Test Setup

After adapting the insights from the pilot tests, I changed the survey to make it more user-friendly and suitable for my research question.

The first thing I changed is how the "arousal" and "valence" is described to participants. According to a similar study of the bipolar scale conducted by Flynn in 2020, they used "calm, excited" and "unpleasant, pleasant" to represent arousal and valence from 1 to 9. This "Affective Slider" (Betella, A., & Verschure, P. F. 2016) also suggested that I should use the form of a slider instead of rating dots.

According to previous studies, the form of the slider, with two labels on the side and banded, shows lower bias and higher precision in the results (Söderholm, C., et al 2013). So that is why the form of the ratings is changed from the pilot test (Figure 4.4).

Participants

The participants of the public test are recruited from Prolific. Each of the participants will listen to 9 random music pieces and give their ratings accordingly. The randomization mechanism in Qualtrics ensures that each of the music pieces will get the same amount of rating results. I used G-power to do a calculation of what the optimal participant size would be, and want to achieve a power level of 0.8 with an effect size of 0.5 and an alpha level of 0.05. The results suggest that if we show each participant 9 questions instead of 36, we would need a total of 252/9 = 28 participants to collect 7 responses for each question. Participants were recruited from Prolific and with a gender ratio of 1:1. Participants' average age is 27, with a range from 21 to 43.

Test Flow

The testing procedure is shown on the right, and the study is ethically approved by the HREC of Delft University of Technology (2954-2023). As presented in the flow, the survey is mainly divided into four parts. Start with informed consent, and a reminder of putting on headphones, we want the participants to have the best environment to listen to the music. Then before heading into the formal tasks, we provide the participants with several guidelines on how the scale works and what the music piece will be like. On the one hand, they are expected to get familiar with the rating slider, on the other hand, they will be able to set up a standard in how to rate those music pieces in the later tasks.

The next part is the formal tasks, where they will have two pages of questions, one has five and the other has four music pieces on it. After finishing the rating, they were asked to reflect on the survey, about whether they had issues listening to music, and whether they listened, and rated truthfully.

Data

Test results are recorded in the Qualtrics, and for each of the music pieces, there will be ratings on “arousal”, “valence” and “quality”. The data will be analyzed firstly with each emotional cluster, to see the distribution of the answers in the quadrant, and how aligned it is. Then the mean of the answers will be used to analyze the overall distribution of all the music pieces, as well as the K-Means cluster, to see if the new cluster is somehow similar to the original circumplex model.

Test Flow Overview

![Test Flow Diagram](https://via.placeholder.com/150)

Figure 4.4 Modified rating sliders
Public Test Ongoing

On this page, the 9 clusters of the original circumplex model are analyzed individually, each with 4 pieces of music. Each dot in the 9x9 square represents one rating of "arousal" and "valence".

If compared with the original distribution of the circumplex model, certain trends could be seen just with the dots. In group A, cheerful and happy, the results are mostly in the arousal + dimension, and a bit to the valence +. In group D, dreamy and sentimental, the results are mostly in the arousal - and valence + dimension. And in group E, yearning is mostly in the valence - and arousal - area.

There are certain groups that the answers varied a lot. Like groups F and H, the answers are not concentrated, and for group G, the answer focus area is even opposite to the original model.

The results suggest that AI generative model could to some degree, understand the input of music emotions, and could produce music that could have the expected effect on listeners. While other prompts might not be aligned, but could also provide us with ideas of how they will influence the AI generative model in music generation.

Figure 4.5 The chosen words from the Adjective list

Figure 4.6 Distribution of the answers to each music piece (grouped by the emotional descriptor clusters in the circumplex model)
4.5 Data Analysis

As shown in this image, the means of the ratings were plotted in the quadrant, and we could find certain relationships between the new distribution and the original one.

The colors in this diagram show the results of K-means. The best cluster is 12 according to the K-means method (the value of the Silhouette Coefficient is 0.565), and therefore, there are 12 relocated groups shown in the picture. Note that I have carried out two K-means separately on SPSS and Orange, and the results might be slightly different from each other, but all with 12 clusters, and the distribution is the same. The picture shown on this page is the results in Orange.

It is not difficult to see that the result range of valence is not as wide as arousal, and it might be because many results are rather neutral, around 4 or 5 when participants are unable to set a standard for a certain piece of music.

There are clusters in the first, third, and fourth quadrants, but not the second one, probably because people still feel a bit conflicted about choosing some music that is arousal but negative. And there is a new cluster that represents a neutral feeling towards music that pop out in the diagram.

Figure 4.7 Results of the K-means cluster in the arousal and valence axes.
To be more precise about the clustering and where each piece of music with certain labels is located, I did another K-Means in SPSS, with also 12 clusters, and similar results as what is shown in the previous pages. On the right, the table shows the final cluster center and which music is inside this cluster. (_m is the music style of melody, and _e is the music style of electronic).

Here we could also see that there is no valence - and arousal + group, and instead, there are two neutral groups.

Both emotional descriptors and styles would influence the ratings. Most melody-style music tends to be of low arousal, and electronic to be of higher arousal. But there is also the combination of dreamy and yearning with electronic, which ends up in the third quadrant.

As far as we know, the labels that are working as we expected with AI generative model are: "Cheerful_e" from group A; "Relaxed_m" from group C; "Yearning_e" and "Yearning_m" from group E; and "Tense_e" from group I.

Again this result shows that to a certain degree, the AI generative model could understand the input prompt, and deliver desired output music to people. The research question is answered by this. And there are some interesting connections between the prompt descriptors and the out effect to be further investigated.

![Final Cluster Centers](image)

**Figure 4.8 Results of the cluster center of the 12 new clusters after K-means**
Furthermore, I also calculated the coordinate value differences of each prompt compared to their original location on the circumplex model. Table 4.1 has the specific data for each prompt, as well as the means of the ratings on the quality of the music. After conducting a two-sided correlation analysis, I found out that the original position of the valence and arousal is statistically significantly correlated to the distance difference in the coordinate values of the rating results. For valence, the Pearson Correlation value is \(-0.954\), with \(p<0.01\). For arousal, the Pearson Correlation value is \(-0.894\), with \(p<0.01\). This indicates that participants are more precise on the perception of music generated with prompts that has emotional descriptors with higher valence and arousal value. In other words, emotional clusters A, B, C and maybe H are interpreted more precisely by the AI model.

Table 4.1 The original position of the music according to circumplex model (Valence,0 & Arousal,0) and the distance difference of the values (Valence, D & Arousal, D), as well as the quality of each music pieces according to the participants.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Distance</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>apnoa</td>
<td>0</td>
<td>1.14</td>
</tr>
<tr>
<td>apnea</td>
<td>0</td>
<td>0.79</td>
</tr>
<tr>
<td>annea</td>
<td>0</td>
<td>-0.08</td>
</tr>
<tr>
<td>great_e</td>
<td>5</td>
<td>-1.31</td>
</tr>
<tr>
<td>great_m</td>
<td>5</td>
<td>-1.31</td>
</tr>
<tr>
<td>sect_e</td>
<td>1</td>
<td>5.39</td>
</tr>
<tr>
<td>sect_m</td>
<td>1</td>
<td>6.39</td>
</tr>
<tr>
<td>Stress_e</td>
<td>5</td>
<td>-2.14</td>
</tr>
<tr>
<td>Stress_m</td>
<td>5</td>
<td>5.37</td>
</tr>
<tr>
<td>Monica</td>
<td>5</td>
<td>-6.06</td>
</tr>
<tr>
<td>Monica</td>
<td>5</td>
<td>5.36</td>
</tr>
<tr>
<td>Monica</td>
<td>2</td>
<td>5.38</td>
</tr>
<tr>
<td>Monica</td>
<td>2</td>
<td>5.38</td>
</tr>
<tr>
<td>Monica</td>
<td>2</td>
<td>-0.28</td>
</tr>
<tr>
<td>Light_e</td>
<td>9</td>
<td>-6.96</td>
</tr>
<tr>
<td>Light_m</td>
<td>9</td>
<td>-6.96</td>
</tr>
<tr>
<td>Relaxation</td>
<td>10</td>
<td>6.50</td>
</tr>
<tr>
<td>Relaxation</td>
<td>10</td>
<td>6.50</td>
</tr>
<tr>
<td>Relax_a</td>
<td>5</td>
<td>-2.13</td>
</tr>
<tr>
<td>Relax_a</td>
<td>5</td>
<td>-2.13</td>
</tr>
<tr>
<td>Relax_e</td>
<td>5</td>
<td>5.38</td>
</tr>
<tr>
<td>Relax_m</td>
<td>5</td>
<td>5.38</td>
</tr>
<tr>
<td>Seda</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_e</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_m</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_m</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_e</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_m</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_m</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_e</td>
<td>1</td>
<td>5.29</td>
</tr>
<tr>
<td>Sed_m</td>
<td>1</td>
<td>5.29</td>
</tr>
</tbody>
</table>

4.6 Discussion & Insights

The study of AI music alignment on the one hand proved that we could use the circumplex model as a reference for developing certain interactions that could be used as prompt input for participants to choose their ideal music emotions. On the other hand, it gives us some insights on how should we let users choose the input and how they should receive the music.

The prompts we used in this study is made by certain structure - the music style and the music emotion. Therefore, it would be important for users to first determine this and then try to explore the music generated by AI. Knowing this would make us realize that in the later design phase, the design should be divided into two procedures, one is the prompt input, or the preset of the AI generative model, so that it could generate music within the user’s preference. The second procedure is the user should explore the music emotion changing by using the circumplex model while inside the OR. The two phases together will adapt the AI generative model into the final design outcome and therefore improve the patients’ emotional experience during the surgery time and even in the period when they are inside the hospital.

04 Conclusion

This AI music alignment test was built on the literature research on music and emotion, especially the circumplex model and two-dimensional emotional description of valence and arousal. This chapter talked about how the specific circumplex model in this research is developed, and by using it, how the prompts were generated.

Several pretests had been performed to make sure that the survey and music quality is on track. Generally speaking, the more diverse the prompts are, the better the music quality is. So the final prompt template used is quite complex. The two training tasks ensure that participants get familiar with the expressions and how the rating slider works. To reduce fatigue for participants, the participants will only have to complete 9 questions in total.

The results of the study are interesting and can provide us with some foundation on the design interactions, as well as help us understand how the AI generative model would deliver desired music output to users. As suggested, we could trust AI on some music generations, and use the circumplex model as a reference for developing interfaces for interactions. In the next chapter, the design conception and ideation process will be thoroughly introduced.
5.1 Design Goal

Design Goal

I want to design a music companion product for orthopedic surgery patients who are undergoing spinal anesthesia. The product interaction aims to improve their emotional experience during the surgery period. The interaction should be attractive, desirable, comfortable and fun for patients.

Interaction Vision

The interaction should be like

“Fluctuating the surface of water full of bubbles with your hand.”

With this interaction vision, the metaphor I imagined the design should be like is that if we take the soundscape inside OR as a visualized surface, the noise that occurred would be the bubble or mist on the top of the surface, and what the user want to do is to fluctuate the bubble, or wipe the mist out, to see a clear surface, without noise, or to create a changing environment to make them distracted from the context.

Sensory Space

In sensory design, designers create a sensory space and design this space in different sensory dimensions to meet the specific needs of the user. If imagining a soundscape is a huge interior design, what would people feel, how would they perceive it depending on the sound properties, just like the structure of the building? Adding music into the already noisy OR would be like giving patients autonomy to create an imaginary space in their mind that help them meet their initial needs.

“Running finger across the car window which is full of water mist.”
5.2 Design Criteria

Distraction from the noisy environment
The design should be able to drag users' attention from the OR context and make them feel distracted by the noise. Therefore, it should be attractive enough, and in the meantime, able to distract auditory attention.

Patients are desired to use it
The design should be desirable enough for the users to use. This criterion should be reached in the following ways:
• Users feel desired by the outcome of the music.
• Users feel comfortable using the functions provided.

The music experience is immersive
The design should in the end reach a flow state for the user, which let them immersively experience the music exploration. This criterion should be reached in the following ways:
• Users feel devoted while experiencing the interaction.
• Users feel relaxed and have fun while experiencing the interaction.

The design is able to use in a clear way
The design should reach the basic usability standard, it should provide clear instructions and be functionally satisfied by the users.

5.3 Mind Map

On the right is the mind map I made for developing the concept. As shown in the user journey in Chapter 3, we want to design the experience in two phases. The first phase is for patients to choose their preferred prompts, feed the AI and generate music accordingly. The second phase is where the interaction design lies, when the patients are inside the OR, how should they interact and enjoy the music experience with the product?

Preference Input
In this phase, I want to mainly design how the patients choose their preferred theme of words or prompts, the input timing, as well as the way of choosing the prompts. So the traditional way of doing this would be letting patients enter whatever they like as prompts, but considering the time limitation inside the holding area, they might not have enough time to enter several prompts for their favorite styles.

Therefore, a more convenient way of inputting the prompt and setting up the desired soundscape is required. There are two ways of input, a more proactive way like using text or audio, or even visual interactions to self-input, or a more passive way, like using modular choosing blocks or quadrant exploration to choose the preferred prompts.

Music Interaction
The music interaction experience inside the OR is considered to be the most important part of the design concept, so I used the "How-to" method to focus on the part I want to aim for.

• How do patients interact comfortably with the concept? How to let them interact smoothly while lying down?
One of the patients' hands is often occupied during the surgery, so they will be able to do limited interactions only. When designing the interaction, this aspect should be taken into consideration.

• How to make the interaction attractive and immersive?
The interaction should serve the purpose of dragging patients' attention away from the noise and tense environment.

• How to make the product part of healthcare?
The product ideally could become part of the healthcare circle, during the perianesthesia period. Like music therapy, it could also become part of the medical practice in the future.
Scenario of Usage

There are mainly two using scenarios of the design, or in other words, the design contains two parts of user experience.

On the day or one day before the patients are admitted to the hospital, they will be able to interact with the system which would let them input their preference on music, or simply anything they enjoy that would make them feel pleasant. This input will then help the AI generative model to create a frame of prompt which will be used later during surgery. Interactions in this phase might include tangible products or digital interfaces.

The second scenario is when patients are inside the operation zone. They will first be given the device of music playing and interacting in the holding area before entering the OR. This is to get them familiar with the interaction. And when inside the OR, patients will enter an immersive soundscape space that they create by themselves and will be able to realize several kinds of interaction to ad music into the sound environment during surgery. In this sense, it would be like letting them make a "safe" sound zone for themselves to either cover noise or distract attention. Furthermore, the music played will be transformed by AI in real-time, in case the user wants more "motivating" or "pleasing" music based on the current music style.

The storyboard shows the concept of the two phases, and this will serve as the guidance of the ideation phase.

5.4 Design Ideation

I used the intention of waves to represent sound waves. If there is a physical interaction, I hope it can be like a booth-like device where the user can adjust the preference of the type of music in the middle. If not physical, I would imagine that the whole interaction takes place on the smartphone.

Patients get to choose music in two dimensions, music style, and music emotion. The former is decided when setting up what to feed to the AI, while the latter is explored when inside the OR. I proposed how the layout should look, as well as three possible interactions that could happen with the product, to control the music's emotion.

The idea of interaction vision is aligned with the motion of hands, and reflected on the influence of the soundscape patients create together with the product.

In the future, I would hope the prompt input is like automatically reading the memories on certain objects and then generating text prompts accordingly. The controlling product inside the OR could be a digital screen as well, an add-on with visuals representing the whole soundscape in front of the patient's eyes.
Existing Product Analysis

To better define the form of the concepts, I decided to look up the existing music product on the market. The product analysis will aim for the following purposes:

- What is the product like, and what is its main function?
- What are the main interactions, and how do they require the hands to move?
- What could the limitations be when using the product?

The reason why I mainly analyze the physical product is that no matter what the form of design would look like, it would always rely on hardware interactions to achieve the ideal effect. The difference would only be that if using an interface, the hardware would be the smartphone, and others would be smart devices.

Therefore I have chosen four typical music-related products to analyze the interactions they obtain. Sony headphone mainly allows users to slide up and down to control volumes, while JBL uses clickable interaction buttons. The HomePod Siri will only be activated when long pressing, but for ORBA, you only need to slide around to use all the functions on the surface.

Each of the interactions has its pros and cons, and all have something to do with the control of music playing. I will rearrange those interactions with the circumplex model and the concept, to develop the first three possible controlling pads for the music experience part. The interactions will mostly be the three following functions:

- Changing prompts (music style)
- Exploring music emotions (circumplex model)
- Volume up and down

### Product

![Sony wh-1000xm4](image)

- **Main Function**
  - Play / pause Music
  - Tuning up / down the volume
  - Change the play mode of the headphone

- **Interactions**
  - Slide up and down to turn up / down the volume

- **Limitation**
  - The original round shape is a bit limited to the interaction mode, which only allows up and down sliding.

![HomePod Mini](image)

- **Main Function**
  - Activate Siri
  - Turning up / down the volume

- **Interactions**
  - Long press to activate Siri

- **Limitation**
  - The volume buttons need pressing, and the long press with talking is not flexible enough.

### ORBA

- **Main Function**
  - Tuning the music
  - Adding beats
  - Generating sounds

- **Interactions**
  - Circular rotate to control the pad

- **Limitation**
  - The flexibility of this kind of interaction is too large, thus making the product hard to control.

### JBL Flip6

- **Main Function**
  - Play / pause
  - Party mode
  - Bluetooth

- **Interactions**
  - Click to use function buttons

- **Limitation**
  - Requires two times to activate and deactivate a certain function.
5.5 Concepts

There are mainly three concepts that I choose to evaluate based on the design goal and criteria, as well as the insights I got from the product analysis. The interaction layouts are built on TouchOSC, and then connect to the program on the laptop through TouchDesigner, so that it could control the music playing by the interactions on the phone to simulate the music experience.

The functions are as what the last section discussed: Choosing music style, choosing music emotion, and changing volume.

To include all the interactions that are common now on other products, I mainly make variations on the part where the users could explore the music’s emotions. In this function part, there will be three different interactions, which allow the finger to touch and move in diverse ways.

For the music style choosing function, I applied two ways of interacting, one requires a long press, and the other with a toggle button only needs a one-time press. The volume-changing function is built with the fader, and all three were the same interaction, but with different layout proportions.

For the concept prototype, because it is just for the demonstration of the concept, so I only put four different styles, and in each style, four different pieces of music represent distinct emotions.

Concept “Radio”

1. Four push buttons
   This is used to change the music styles, I put classical, k-pop, popular, and rock into the database, and users needs to long press and hold it, to listen to music.

2. The radio disc
   The two disc shape is to change the music emotions in a certain direction, users would have to change them one at a time or together to shift to another emotion by dragging.

3. Volume fader
   This is the middle slim fader among all to change volume.

Concept “Quadrant”

1. Four push buttons
   This is used to change the music styles, I put classical, k-pop, popular, and rock into the database, and users needs to long press and hold it, to listen to music.

2. The quadrant
   This layout is basically the form of the quadrant of the emotional circumplex model, and users could move the point to wherever they want by dragging it to change music emotions.

3. Volume fader
   This is the most slim fader among all to change volume.

Concept “Slider”

1. Four toggle buttons
   This is used to change the music styles, I put classical, k-pop, popular, and rock into the database, and users only have to press once to change the style.

2. The sliders
   The two slider is to change the music emotions in certain directions in the circumplex model, and users could slide them together or separately.

3. Volume fader
   This is the most thick fader among all to change volume.
Concept Demonstration

This shows how the concepts are working. Basically as explained before, the concepts will be demonstrated through TouchOSC and TouchDesigner. By using the phone as hardware input, and the laptop as music output, it could simulate the music experience inside OR.

Note that to make the participants of the tests aware of the movements of the music emotion exploration, I put a visual representing the position of their fingers in the quadrant, or the circumplex model. This will also be tested later once they finished the music experience interactions testing.

Figure 5.1 The iteration evaluation setup
Conclusion

This chapter shows the development of the design concept of this first phase. From a very fuzzy front end, insights are gathered and developed into a design goal. And as the design product, user, context, and criteria are all set, the interaction vision is developed to better explain the ideation and provide guidance for further sketching and designing.

The technology used for prototyping is thoroughly explained and with much potential in it. By analyzing the existing products, several interactions are chosen to realize the intended concept and three concepts are developed for further evaluation.

The concepts are founded based on the similarity of waves and sound waves. Imagining a soundscape as a water surface with ripples, putting music into it would be like throwing a rock into the water, or using a stick to stir the water. Interactions are therefore developed based on this analogy or metaphor.

In the next phase, how the interactions will contribute to the design goal, whether they meet the design criteria, and how they fit with the condition of patients will be tested and evaluated out, and finally developed into a final concept.
Design Iteration

After having the three concepts, some evaluations of the concepts will be carried out. The purpose of the evaluation is to first find out which one is the best to achieve the design goal, and then for this specific concept, how the interaction and experience should be improved according to the users. Because the evaluation could not be carried out with real patients, the main goal would be proof of concept in this stage with a healthy population. Three concepts will be evaluated, and the final one chosen will be iterated further into a better concept with the results and insights gathered.

6.1 Iteration Plan

The iteration will be carried out in three stages. First I am going to choose one concept out of three concepts, with the working concept testing, and collect both qualitative and quantitative data as a reference. I am going to use methods like “Harris Profile” to evaluate each concept. Moreover, I am going to conduct a co-creation session with different users to gather insights for developing the interface as well as the interaction details about music exploration.

Then after choosing one concept, I am going to make the second iteration on this specific concept with the insights from the co-creation sessions, and the semi-structural interview with the participants after testing.

The concept will be developed into the final concept and the evaluation plan will be set for the final proof of concept. Also, the storyboard and user journey of the final concept will be illustrated in the end.
6.2 Co-Creation Session

Setup

The Co-Creation Session is prepared with sensitizing material - a booklet of four pages, a pack of markers pens, a few labels representing prompts, and A4 papers. The participants were asked to bring their smartphones with music Apps on them. The session is arranged for 15 - 30 minutes and takes place inside the IO faculty. Participants were recruited from the students and employees from the faculty.

Goal

The ultimate goal of the co-creation session is to find out the desired layout of the music exploration according to different users.

The secondary goal of this session is to make users more dive into the music experience and might be able to understand better the next session of working prototype testing.

Procedure

1. Participants were asked to write down their names and date, as well as imagine what they were like when listening to music. This is to make them understand the whole theme of the project is about the music experience.

2. The favorite music of participants was asked, and what do they feel when listening to the music. Also whether they would like to listen to something different, and why. This step prepares for the next music exploration phase.

3. Participants were asked to open one music App on their phone and try to find one music piece that they have never listened to before and draw the important steps they took for exploring. This will provide insights into how people used to explore music, and what they value the most.

4. Participants were asked to draw out one layout with two dimensions of music labels - music genre and musical emotions. They were asked to imagine what the labels would be like, and how would they choose to explore music through the labels.

General Insights

During the seven sessions I carried out with the participants, I found that most of the participants would use the recommended tags for music exploration, and they choose to listen to music by the context they are currently in. For example, if they are walking alone, they would like to listen to music that is more soothing or relaxing. If they are working, they would want to listen to something more motivating.

I also found that most people think that certain music genres would create specific emotional vibes, such as hip-pop to be more passionate, and blues to be more sentimental.

When comes to drawing the layout, many participants said that they would choose the music styles first, and then the music emotion, or sometimes even not the emotions, because they are too vague for them to choose. They would prefer to choose the two dimensions separately or with some recommendations among the tags, which is aligned with the concepts I developed in the previous chapter.

Besides all these, I found out that when trying to describe how they feel when listening to their favorite music, they tend to use color as a supporting method to bring up the memory of listening to a certain piece of music or to better choose a word for emotional description. This also explains why some of the participants tend to explore the wanted music style by the cover and the visual information, instead of the name or lyric of the music.
6.3 Concept Evaluation

After the co-creation session, participants were invited to test out the three concepts. They will be first introduced to the orthopedic surgery context, and to dive more into the context, they were asked to watch a surgery video about hip replacement with a loud noise. Then they will be asked to use the three concepts after some instructions on the functions. Here are the procedures for the test:

1. Participants will be introduced to the background of the project, including why designing for patients and why using an AI generative model produces music.

2. Participants will watch a video clip about orthopedic surgery for 1 minute.

3. Participants will be introduced to the first concept, and put on the Sony noise-canceling headphones, then interact with it until they find one piece of music that they would like to listen to as patients lying inside the OR. They are required to look at the interface as less as possible.

4. Participants will be asked to rate the interaction qualities and design criteria.

5. Participants will be asked to experience the second and third concepts as well, and then rate the qualities and criteria.

6. Participants will be asked to rate the overall feeling of the concepts.

7. A semi-structural interview will be carried out with the participants about their favorite concept and their ideas for improving the interactions.

8. The visual will be shown to participants, and they will be asked about their opinion on the visual interaction if there is any.

Data will be analyzed both in coding for the interview and the general description of the results from scales as well. The scales were developed based on the design criteria, and the form is based on the PSSUQ (Post-Study System Usability Questionnaire) and SUS (System Usability Scale) (Lewis, 2002; Zhou & Chan, 2017).

6.4 Results Analysis

Which concept do you like the most and why?

When asked which concept they liked the most, all seven participants said that concept “Quadrant” was the best. And here are why they choose concept one over the other two.

- **Freedom**
- **Interactive**
- **Easy-Positioning**
- **Intuitive**

Do you feel there is a better way of improving your music experience?

I asked the participants whether they feel there is a better way to improve their music experience, and some of them mentioned that they would like to have a “like” list, while others would like to have certain visuals in front of their eyes. Many of them also mentioned of having more music choices would make the experience better.

When using the prototype, do you feel uncomfortable?

Three of the participants mentioned that when pressing the button to start the music, they feel a bit uncomfortable since one of their fingers could not move.

Would you want to control some visuals as well during the time?

Almost all the participants answered yes to this question, and many proposed their idea on changing the visual, such as giving colors, making more diverse moves, or changing according to the music spectrogram.

Overall, I am satisfied with the functions and interactions.

Participants are generally satisfied with the experience they had with the concepts (mean = 5.8), but certain concepts might lower the rating, the concept “Slider” for example, is not that popular among participants. They think the concepts are fun and free enough for them to “DIY” their own music experience. Some participants suggest to give out more instructions on the interface, and also the color of the concepts to be lighter. Negative comments could be for example, the music is not adequate to explore.

I am able to focus on experiencing the music while using the prototype

The focus level of the prototypes is generally high (mean = 5.1). The headphone provides a nice support for the focus feeling. But some said that the music is still a bit like background sounds, and not as stimulating as for example, talk shows.

I am able to choose one music that I want to listen to throughout this experience

This question receives the lowest score among the three ratings (mean = 4.9), which is mainly because participants are all focusing on exploring the music, and could not settle down to a certain piece by using the product.
The interaction quality and design criteria questions are analyzed with the means of the ratings of each concept. Based on the design goal, I set a priority of the criteria: Tire one is attractive, comfortable, and desirable; Tire two is flexible, relaxing, and fun.

**Overall, I am attracted to the interaction and experience**

Participants generally rate higher scores for the concept "Quadrant", due to the reason that it is the most flexible, interactive, and feels like there are many possibilities when moving around the area. Due to the shape of the quadrant, it made some participants think of touchpads. When increased to two radio discs or two sliders, participants feel confused and therefore not so attracted to the interaction.

**Overall, I feel comfortable with the interaction and experience**

For this question, the most complained function is the push button in concept "Quadrant" and "Radio". The toggle button, on the other hand, captured some positive feelings of participants. They are more used to using one hand to control the interface instead of holding it like a gamepad.

**Overall, I feel this way of listening to music is desirable if I need some distractions**

Participants’ feedback on this quality is a bit different than others, the degree of distraction might also be influenced by how complicated the interaction is. Therefore, the concept "Radio" got the highest score.

**I feel the process of exploring and listening to music is flexible.**

Some participants rate this on the freedom of their hands, so they would prefer the concept "Quadrant" more. Others might evaluate this on the music choice range, and they feel the music is too less to choose from and could add more to the prototype.

**I feel the process of exploring and listening to music is relaxing.**

From the feedback of the participants, this quality has little to do with the interaction. The music style and whether they have got their preferred music to listen to is what matters the most when rating it. But the concept "Quadrant" makes them feel like a DJ, and can explore the music's emotion without restriction, so they feel more relaxed.

**I feel the process of exploring and listening to music is fun.**

This is another winning concept "Quadrant". The other two concepts, especially the 'Slider' is recognized as "boring" by some users, because it has four sliders on it, which makes the interaction too similar to each other for different functions. On the other hand, the exploration area of "Quadrant" is what the participants would want to have.

**Harris Profile**

I choose to use Harris Profile to do the concept evaluation so that I could see which concept best fits the design goal and criteria.

No matter from the perspective of interactive qualities, or the alignment with the circumplex model, concept one seems to be the best choice, for now, to further develop. But there are also some qualities of the other two concepts that are worth discussing. For example, concept "Radio" has clear dividing lines, so the users would know the exact emotional boundaries, instead of cluelessly moving their fingers around. "Slider" has an area that is perfect for putting some guidance or visuals onto. All these together could contribute to the next iteration stage.
Observation

During the whole testing process, there are several interesting points that I found during the observation of user action.

The usage of the interface

Some participants would assume that the slider or the disk is for press only, instead of dragging them, they would prefer to click on them and see what is changing. Some participants would think that the quadrant needs to keep dragging and therefore was afraid to put away their fingers.

• “To some extend, I like the second or third one a bit more than the ‘Quadrant’ because I could just choose which section I want to stay in and release my hands.”

Interestingly, if not instructed clearly and only hand the phone to the participants, some of them would use the interface vertically, instead of horizontally, especially when they have to control it with one hand.

• “I don’t see any explanation of the function areas on the interface, so I can only rely on your instructions.”

The choice of genre & emotion

When using the concepts, I found out that participants don’t explicitly follow what they mentioned as their “music exploration routines”. For example, one might say that he or she likes to choose style first and then emotion, would firstly explore what kind of emotions are there, and then change the tags later. This is caused by the freedom of the concepts, as well as the sense of curiosity that occurred by the limited information given out on the interface.

About the visual

When asked about the visual on the laptop screen, all of them showed great interest and said different words about the stuff they see.

• “I like the jellyfish thing, and also the shadow traces it creates.”

Mix the music

I found out that several users would like to quickly change the genres and emotions, to reach an effect of remixing sounds together.

• “I like the fact that you could have several prompts turned on at the same time, and maybe in the future you could make remixes through the buttons”

The duration of the “interesting” time

During testing, many participants mentioned that they might be bored after 20 minutes of using this interface, and therefore they would like to have something that could stimulate their senses.

• “I would be exploring for some time, but I don’t think it could cover the whole 2 or 3 hours of surgery.”

When mentioning what would become the stimulus, participants said that the range of exploring music is the most influential factor.

Recommendation & Like List

Some participants also mentioned having a recommendation or like function for the concept, but that is mainly when they were looking at the screen and proposed such a suggestion. When using the interface without specially looking at it, they would enjoy the process of exploration more.

The volume function

Participants seldom use the changing volume function, even though it is just on their right hand, and with the increase of the proportion, they still ignore the slider. One possible reason could be that they are too busy with changing the music, instead of controlling the volume.

• “I would prefer a more tangible button to change the volume, like on the side of the smartphone.”
6.5 Insights & Chosen Concept

The concept is attractive enough
Participants are satisfied with the concepts because of the freedom of exploration and the unexpected feeling of running into some music pieces that suit their taste. They are more willing to keep interacting with it and explore more possibilities.

The less rigid, the better for focusing
Participants would pay more attention to the interface and interaction when the concept has some “unclearness”, for example, the emotional changing boundary is blurred, such as in the concept “Slider”, the changing point is not at the middle of the bar, but rather at three quarters.

The need for basic instructions
Participants need to explore on their own, and sometimes they would ask what the section does on the interface. Although it might not influence the actual music listening process, having some texts on the interface is better for a starter to use.

The interface orientation
I found out that if giving the interface was horizontal to the participants, they would tend to use both their hands, but in reality, they would not want to be occupied by these many movements at the same time. So maybe changing to a vertical layout is a better idea. Also for the patients lying on the surgery table, they could only use one hand possibly during the period. A vertical layout would be better for the real users in the future.

Consideration of the finger interaction
A long time of finger rubbing the screen might be uncomfortable for the users, therefore it should let the finger away for some time. In this sense, push buttons are no longer suitable for the concepts.

6.6 Second Iteration

After choosing the concept “Quadrant” as the final iteration concept, there are several aspects of iterating the concept to better suit the design goal and reflect the feedback from the participants.

The orientation of the layout
The layout now is horizontal, but since patients could only use one hand to operate the product, it is better layout vertically, also release the other hand, and make users less stressed about holding the device.

Text Information
There should be some textual information on the interface briefly introducing the functions.

Rearrange the functions
The volume function is no longer necessary on the layout, and the music genre or the prompt-choosing section needs more variations.

Visual interaction
The visual could represent the whole soundscape inside the OR, with the idea of music wave, and add with the interaction vision, the movement of the fingers inside the quadrant area could be visualized as well.
Also, different emotion areas could be presented with colors, to let users know where to explore.

Music listening
The music transition can be more smooth and a bit mixed, which would provide a better experience when exploring.

The whole experience
Besides this particular working interface, I should think of the whole experience, and what the possible interfaces could be to fill in the user journey.
**Interface Iteration**

To make users control the interface more conveniently, I put all the necessary functions in the middle, and with little distance, so that they could easily reach the area with one single finger.

They could choose one prompt to begin with, and change emotions on the top section, or could also sweep around the prompt area to explore new combinations.

To make the interface more clear to a new user, I put the textual information on top of each function area. And in the future, I hope the prompt section could also have pop-outs or other things that could remind the users what the prompts are.

Because the general theme is waves and lines, so I want to mainly use a line grid feeling for the look of the interface, with white lines and black background, to fit with the dim environment (for the visual interaction).

To adapt more music variations, and also fit with the theme that textual input could be of a single word or a longer phrase, I made the whole prompt section look like a keyboard, and users could sweep to change the keywords aligned on the current screen.
Conclusion

This chapter mainly shows how the concepts from Chapter 5 are evaluated and selected. The three interaction concepts went through the process of prototype testing, and with the results of the design criteria scale and semi-structural interview, the concept “Quadrant” was chosen because of its flexibility, fun, and immersive experience compared to other concepts. The results of “Harris Profile” also suggest that this concept is the one that best suits the design goal and interaction qualities of the design criteria.

To better iterate on the chosen concept, I collected the results from the co-creation session, as well as the other qualitative data I got from the interview, and used them as a reference for developing the interface and interaction. From horizontal to vertical layout, and from a grid visual to visualization with colors and representation of the soundscape, all the changes are meant to bring a more immersive experience for the patients.

In the next chapter, the final concept will be shown, as well as the details of the interactions. A showcase will be presented, along with the storyboard. The technology used for developing the workable prototype will be introduced as well.
Final Design - Music • Wave

With the sketches and further iteration of the concepts, the final concept - Music • Wave is better developed and optimized. This chapter will introduce the design details, how the interface is aligned, and what functions this product has. The flow of use will be presented, with the interaction state displayed in various cases. The technology used for developing the prototype will be illustrated and analyzed. Finally, the design showcase will bring you a better look into the product and how it will work.

7.1 User Scenario
7.2 Design Details
7.3 Technology
7.4 Design Showcase
Introduction of Music - Wave

In this section, I will introduce you to the product I designed for orthopedic surgery patients, with AI generated music as a way to improve the soundscape inside the OR during surgery.

Firstly there is an overview of the functions that this product achieves.

While they are inside the OR, they will be able to operate on the interface as well. And they could either slide all over the prompts they have just chosen, and explore the different variations of the prompts, or they could swipe the prompt section, to bring in some new prompts recommended by the system, in case they are bored with the current styles or genres.

Besides the main part of the interface, I also add the visualization according to the user feedback, but note that to better define how it should look and how to interact, it requires more research. The visual here is only to make the project a more complete design. The visualization is changing according to three factors:

- The waves represent the current soundscape, and if there are noises, the waves will fluctuate more dramatically.
- The waves could be changed by the finger movement in the emotional exploration section - the quadrant. Patients could experience a sense of control over their sound environment through this interaction and can remain more focused and unaffected by noise.
- The color of the visualization is changed slowly according to the different emotional sections, to keep patients attracted and be more clear about the ideal emotion they are aiming for.

Function

The functions are divided into two sections, aligned with the two phases of the design.

For the preference selection part, the patients need to feed AI with some prompts, whether input by themselves or generated by the App automatically. So I will let patients first have some preset prompts, to begin listening to, and then they could either choose to change according to the prompts or just swipe and change another prompt set. They will hear 10-second AI-generated music pieces for a tryout, and then decide whether to add this prompt to their playlist or not.

After they have chosen the prompt lists they would like to hear inside the OR, they will begin with the music emotion exploration.

Visual Style

The choice of visual style is all under the theme of using waveform changes to visualize sound changes. Because the product is about music, so I used the imagery of a vinyl record as a representation of the AI-generated music. Every time the prompts are changed, the recording disk will change its cover to fit with the vibe of this certain text information.

The style of the visualization in the OR is also designed according to the participants’ feedback in the last iteration cycle. Making it more like a net, and also add with sound waves onto it. Now the representation of the finger movement is a sphere shape, but in the future, it could be more nimbly.
7.2 Design Details

This section thoroughly shows how the design fits with the whole process of patients within the surgery period. All process suits the design goal and interaction vision - to let patients feel attracted, to let them have desired interactions, and provide them with an immersive experience.

From the start of the interface, when patients are lying on the bed in the holding area, they could start to choose their prompt list for the latter experience inside the OR during surgery. This feels much like whenever you are going to fly for over 2 hours, you pre-download some films on your phone or iPad and then watch them onboard to kill time.

They could choose to either try out the music or they could just choose them by entering their phrases, or randomly choose from the database. There will be a cover for the disc for each prompt, to bring more ideas to the patients about how the music would feel like.

By swiping the prompt section, they can change another set of prompts. The ones that are chosen and added to the list will remain green and stay in the same place, while others will be swapped. When patients feel like it is enough, or their time is up for the surgery, they could confirm the list and enter the next page of the interface.

After initialization of the AI generative model, emotional descriptors are added to the prompts, and then aligned according to the circumplex model in quadrants. Patients lying on the surgery table could move around and explore the different emotions, and settle with one that best suits them for now, or could keep changing to keep themselves distracted from the rather tense surroundings.

They could also refer to the visualization they see in front of their eyes, either for the idea of the distribution of emotions, or the change of the soundscape inside OR. To make them more focused, they could see their fingers interacting with the sound waves, and control the music they hear.
7.3 Technology

In this section, I'm going to briefly introduce the coding and the visual that I developed for this project. How it can change music emotions, and how the prototype is detecting the surrounding music.

With TouchOSC, I can develop a workable prototype, which could connect my phone to the laptop under the same WiFi internet. The coding I made is built on the software of Touch Designer. This software is based on Python and could receive the signal from OSC Apps, and turn the signal into certain variables, which could be used to control the other parameters that in the end, are used for the variables that control statements and functions in programming.

The music emotion control section is based on the parameter of xy position information, and this can be used to detect the state of the finger movement and the quadrant in which it finally lands to determine the specific emotion of the music according to the circumplex model.

The toggle buttons built for the prompt section is sending a 0 or 1 signal to the "OSC in" in Touch Designer, which could be used to control the music players inside the program.

The soundscape spectrum is collected with the "Audio Device in". With some lines of changing the range, smoothing its changes, and adapting it to the grid, it could visualize the changes in the environment. The finger movement's parameters are referred to as the meta ball in the program, which could create a force and change the shape of the grids around it, so it could be used to represent the movement of the patients towards the visualization of the soundscape.

On the right, there are some key lines and blocks that are used for coding the prototype.
Choose one style to tryout

Creating the playlist

7.4 Design Showcase

This section shows what the interface and the visualization would be like in the future OR regarding sound design and music therapy.

Ideally, the light environment inside the OR could be dimmer for the patients with the help of the shell in the concept sketch and therefore create this zone for their own to hide. Hopefully, the product could help the patients fall asleep soon after listening to a few music pieces, but in case they did not, they can still interact with the visual to kill time.
Music · Wave
Explore & Build Your Own Soundscape
Escape From the Surgery

Feel free to use it when you are experiencing stress in a medical environment regarding noisy sounds. Create a “music space” that is only for your auditory perception. Leave only nice memories about the surgery.
Conclusion

This chapter explains and shows the product design in detail. From the overall function of the product to each important interface during interactions, readers could have a first clear vision of the design. Then from the user flow of the product, how the design is adapted to the user journey inside the hospital is presented.

The technology of product prototyping is also introduced. Adding on with the visual inside the OR, patients would have an immersive experience during surgery, and forget about the tense situation. The design display images create the future scenario of the design use scenario for the readers.

In the next chapter, we will enter the final stage of the design, which is the evaluation and recommendation of the concept. In this project, we will test the concept with healthy populations, and in future studies, the actual patients could be tested in a real context.
## 8.1 Evaluation Plan

### Evaluation Objectives

The main goal of the evaluation is to prove the concept. This process evaluates the product in terms of the achievement of the design goal and the interaction qualities of the design. Here are the key objectives that are aimed for:

- Whether the product does affect improving the emotional experience of participants exposed to surgery sounds.
- Whether the product and interactions are perceived in the desired way by the participants.

### Method

This evaluation process will be carried out in a room that simulates the surgery room vibe, and participants will be using the product and rate on the criteria after experiencing it.

### Main Outcome

The primary outcome of the evaluation is to which degree, the final designed product has reached the design goal. This will be represented by delta anxiety response based on a shortened version of STAI (Marteau TM, Bekker H. 1992). This scale is from 1-4 (1: Not at all, 2: Somewhat, 3: Moderately So, 4: Very Much So), and will help define participants’ emotional experience as well as their attitudes towards sounds they hear.

There will also be rating results from AttrakDiff (Hassenzahl, M. 2006), for assessing the product and interaction. The ratings on how the design is and how the participants perceive the music are also the expected outcome. These results will provide insights on how to better develop the design in the future. As well as how to adapt the product in a more suitable form.

### Procedure and Outcome

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Status</td>
<td>STAI 0 - 1-4 STAI Scale</td>
</tr>
<tr>
<td>Sensitizing the Context</td>
<td>No Sounds</td>
</tr>
<tr>
<td>Surgery sounds</td>
<td>STAI 1 - 1-4 STAI Scale</td>
</tr>
<tr>
<td>Introduction of the Product</td>
<td>Surgery Sounds</td>
</tr>
<tr>
<td>AttrakDiff</td>
<td>Music</td>
</tr>
<tr>
<td>Portfolio Presentation</td>
<td>Sensory Experience</td>
</tr>
<tr>
<td>Description of Words</td>
<td>Surgery Sounds + Music</td>
</tr>
<tr>
<td>Using the product</td>
<td></td>
</tr>
<tr>
<td>STAI 2 - 1-4 STAI Scale</td>
<td></td>
</tr>
<tr>
<td>Questions</td>
<td></td>
</tr>
<tr>
<td>Semi-Structural Interview</td>
<td></td>
</tr>
</tbody>
</table>
8.2 Evaluation Process

Setup

The setup of the test is mostly inside the faculty of Industrial design engineering at TU Delft. I have individual rooms booked for testing from the 20th of June to the 27th of June. This is to ensure that there are no other disruptions while testing a sound design product. Participants were required to lie down flat, therefore the room has to have a certain place which length can allow an adult to lie comfortably.

Surgery sounds are the soundtrack of the Youtube video: “Watch the Full Hour-Long Knee Replacement Surgery with Nurse Holly” (https://youtu.be/3TzNfpawN90).

Surgery sounds were put into the MP3 player and played through JBL Go3.

The prototype was built with Figma for the “music preference choosing” part, and with TouchOSC and TouchDesigner for the “surgery music experience” part.

STAI questionnaire was made with Google questionnaire, while the AttrakDiff questions were carried out through the platform: https://esurvey.uid.com/

Music for Prototype

AI-Generated Music

To achieve a more realistic experience, I pre-generated 25 music pieces by using Riffusion for the participants to choose from in the “music preference choosing” phase. With the same prompt, I also generated different covers for the music, as a visual representation of the style characteristic.

The words that make up the prompts were selected from the MusicCaps database. The generation of the music and images was done through this model on Hugging Face: https://huggingface.co/spaces/DSpitzer/TXT-2-IMG-2-MUSIC-2-VIDEO-w-RIFFUSION.

The model is made by DSpitzer.

The music pieces were all 10 seconds long and were played through the laptop while using the interface. On the right, there are covers generated by AI with different prompts same as the ones used for music generation.

Music for the Surgery Experience

To achieve a better experience with the music in the working prototype in the “surgery music experience” part, I selected 100 songs from the MusicCaps database. These songs were filtered by keywords of both music genres and emotions. The four sections in the quadrant represent different emotion directionality: Happy, Passionate, Sentimental, and Relaxed. Therefore, the selection was carried out by searching for music with tags of a certain genre and each genre with four variations of the emotional descriptors.

The pieces of music were aligned in the quadrant according to the distribution of the emotional circumplex model. When participants are changing the position of the sliding block, they are controlling the volume of the four music pieces under this specific style, to realize a feeling of smooth transition between different emotions. Therefore, when the block is in the middle of the quadrant area, the music has the lowest volume, and when on the corners, it has the highest volume.
A Recap of the Design Goal

I want to design a music companion product for orthopedic surgery patients who are undergoing spinal anesthesia. The product interaction aims to improve their emotional experience during the surgery period. The interaction should be attractive, desirable, comfortable, and fun for patients.

Methodology
Participants
Due to the accessibility of orthopedic patients during surgery, the evaluation of the product was carried out with healthy populations. Therefore, the goal of the design can only be proved partially with the emotional experience. The interaction qualities, on the other hand, won't be affected that much. I conducted the tests with 15 participants in total, and most of them aged between 20-40 (a standard age range on the eSurvey platform of AttrakDiff).

Procedure
Participants were invited to look at the images of the holding area and OR, and then fill out the shortened STAI questionnaire via Google form.

Participants were asked to lie down and close their eyes to listen to the surgery sounds for 5 minutes, and then get up and fill out the STAI questionnaire again.

Participants were introduced to the product, and the basic functions, and they can experience it freely. They were also asked to fill out the assessment for the product through the eSurvey platform by AttrakDiff.

Participants were asked to lie down again and use the product to listen to music while the surgery sounds were played through the speaker for 5 minutes, and then fill out the STAI questionnaire again.

Some questions regarding the experience will be asked after the tests through a semi-structural interview.

8.3 Results & Analysis

i. Results on Emotional Experience

The graphs shown below are the STAI scores and distributions of the STAI-6 tool. I first show how the six different terms were rated by participants, and there is a clear trend of positive emotions’ rating scores going down and up, while the changes of the negative emotions are in the opposite way.

The first evaluation objective is “Whether the product does affect improving the emotional experience of participants exposed to surgery sounds”.

The emotions are measured with shortened version STAI questionnaire three times: Before the test starts, after listening to the surgery sounds for 5 minutes, and after using the product in the OR soundscape for 5 minutes.

The six terms of the emotions were the validated descriptors that could reflect how anxious one is at the moment. To be more precise about the emotions regarding sounds, I asked in the questionnaire “What I heard made me feel...” both after hearing the surgery sounds only and after hearing both surgery sounds and music from the product.

In the table on the right, the calculated STAI score is shown. The score is calculated by summing the six scores together, but positive emotions (calm, relaxed, content) should be assigned in reverse, for example, 4 is 1 and 3 is 2. The summed values reflect the current anxiety level of the person filling out the questionnaire at the moment. STAI scores are commonly classified as “No or low anxiety” (20-37), “Moderate anxiety” (38-44), and "High anxiety" (45-80).

When using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean scores for STAI in different soundscape were statistically significantly different (p<0.01). The results could also be seen in the bar chart. There is a significant rise in STAI score when there is surgery sounds alone, and the score dropped back to near the start status when adding music to the surgery sounds.

Results suggest that having the product and music experience together with surgery sounds is likely to reduce anxiety compared to solely having surgery sounds.
A Recap of the Design Goal

I want to design a music companion product for orthopedic surgery patients who are undergoing spinal anesthesia. The product interaction aims to improve their emotional experience during the surgery period. The interaction should be attractive, desirable, comfortable and fun for patients.

ii. Results of product assessment

To assess whether the product I designed has obtained the initial interaction qualities that I wish to achieve in my design goal, I used the AttrakDiff questionnaire to give the product named "Music Wave" a thorough assessment. (Hassenzahl, M. 2006)

The same 15 participants were asked to rate the word pairs after experiencing the two phases of the product:

In the "music preference choosing" phase, they used the interface that patients would use inside the holding area and tried to create their music list.

In the "surgery music experience" phase, they tried out the workable prototype to get familiar with the interactions and the music player that patients would use inside OR.

The results of the rating were categorized into four parts: pragmatic quality, hedonic quality in identity and stimulation, and attractiveness. The interaction qualities of attractive and desirable lie in the "Attractiveness (ATT)" part, while comfortable lies in the "Pragmatic Quality (PQ)" part, and fun in the "Hedonic Quality (HQ)" part.

Generally speaking, all four parts were shown positively by the average values, meaning that the product was perceived as positive by the users. When looking at the specific parts, ATT has all the pairs positive, HQ with only two pairs negative, and PQ with 4 pairs negative. This indicates that the product is overall very attractive to the users. It is fun and creative, but at the same time, it could be a bit confusing and technical to use.

When put into the two-dimensional quadrant of PQ and HQ, the product is somewhere in between the "Neutral" and "Self-oriented" zone. To become more desired, it lacks some instructions. But on the flip side, some negative words might not be necessarily a bad thing for the product. Take "separates me from people = brings me closer to people" for example, the product could create a shield for the listeners, and therefore make them feel safe and protected.
User Experience & Observation

During the tests I conducted, I also tried to analyze the user experience through semi-structural interviews as well as observation during the tests. This section will be about the ideal and undesirable product experiences.

Ideal Experience

The dynamic balance between sounds

When it comes to asking how participants feel about the whole experience when using the product with the OR sounds being played through the speaker, many of them mentioned a critical point that could be one of the most important properties that separate this product from other music player Apps: it can allow users tune the music as much as they want, and therefore reach a dynamic balance between the sounds of surgery and the music sounds.

• "When it is noisy, I want to move it more to the upper right part, especially when there is the drill sound"
• "Trying to find an optimal point, where I can hear both音乐 and surgery sounds"

Through observation, I also found that participants tend to move faster when noise occurs, and would be more willing to stick to a certain piece while the surgery sounds are rather quiet.

The process of exploration

By moving around the quadrant, and clicking the boxes to search for liked music styles, participants are highly engaged in the experience and would pay more attention to the music exploration, rather than the noisy environment.

• "80% of the time I am trying out the different styles and emotions, to find one music that can cover the noise"
• "The process is fun, and I can explore many songs, although I can imagine that people would stick to one song for a while"

The novelty of the interaction

When using the product, participants would unconsciously compare it with the music Apps they have used before. The process of choosing music, and tuning it, is quite new to most of the participants, so they would like to play it more. One participant specifically fell asleep after moving the sliding cube to the lower right part (calm section), and a few participants were seen to move their bodies a bit to follow the rhythm of the music when in the upper sections (passionate and happy).

• "Feels like I am a DJ, this looks like the pads"
• "I heard a certain type of music, and got excited"

Undesirable Experience

The low controllability

The overall controllability of the product is low, which might result in several consequences that could risk the experience. For example, the surgery sounds sometimes rise suddenly without warning, and participants don’t have time to react to it, they still have to search for some music that could help them get through this "emergency", which often takes a while, and they would feel bad due to this sudden interruption.

• "When shifting the music style, and suddenly the sound is noisy out there, it could be a bit nervous"

Also, some participants mentioned the different volumes of the music pieces, which is another factor that might affect the listening experience while shifting the music styles.

The need for an anchor point

Many participants mention having little hints about the styles of the boxes. The idea of a blind box is fully appreciated by only half of the participants.

• "I want to have some hints of what I am choosing or just colors"
• "I would like to have more visuals to support the whole process"

Some of them also said things like keywords, or icons would make the process much more intuitive. Although they would very much enjoy the process of free exploration, they want to be able to quickly go back to their favorite ones when needed.

The choice of the music styles

There is a conflict between whether to have more or fewer styles for them to choose. But either way, the current amount of styles is a bit overloaded, especially when aligned in this square pattern.

• "You can reduce the amount of the prompts, too many boxes now, and hard for me to explore."

The duration of the music experience

During the test, there is something interesting that I found out. Some of the participants only want to listen to the music for one to two minutes, and they would ask me whether the test is over or not already. When asked about the reason to stop, they would say.

• "I stopped because the song is over, shall I change to another one? Or keep listening to this one?"

It is important to define whether the music should be played in a loop, or it could be changed over time by the AI to give more sense of aural refreshment.
Discussion of the Results

Back to the design goal

After analyzing all the data I got from the evaluation, it is time to discuss the original design goal. Besides the part that the aimed users are not able to reach out to, and are replaced with a healthy population to achieve a rather similar effect, the function and interaction qualities of the product can be fully evaluated.

We notice that when playing surgery sounds to the participants, they tend to be more anxious, and after having the product with them, surgery sounds seem to be less attention-catching, and their anxiety score drops to the level same as the anxiety level when they start the test. We could say that having this product would to some extent, help listeners reduce their negative feelings, and improve the emotional experience regarding the surgery soundscape.

As for the interaction qualities, the primary quality of attractiveness and desiring all came with positive results from the assessment of the participants. Comfortableness needs to be improved due to some confusion on the interface, and the sense of uncertainty. Fun, on the other hand, was received by most of the participants, and can be clearly expressed in practice.

Sound interactions

As mentioned before, participants seem to be acting similarly when the soundscape of surgery changes: They would turn to loud and passionate music when the sounds are noisy, and would be more willing to listen to calm music when there are fewer sounds.

More explorations were conducted when the soundscape is changing rapidly and unpredictably. When the surrounding acoustic environment is stable, participants would also listen to a certain piece for a longer duration.

These interesting interaction patterns could be further analyzed and developed as an important attribute to distinguish this product from other music products.

Less self-oriented

During tests, I found out that many participants were a bit confused about what to do in the first place when choosing the music, or to operate the interacting interface. Maybe it is a better idea to have a preset music style already played when clicking on the page, and users would know that it is used for listening and playing music.

Some participants would just want to have background music during the whole process. They either turn to the calm section of the quadrant or would rather turn off the music. Maybe there could be a function that allows the playing mode for the music experience to be changed automatically to the current soundscape. Whether it is aiming for covering up noise or just distract attention, it could real-time monitor the ambient sound levels and then switch modes.

Now the level of self-orientation is too high, and I found out that participants would be more willing to accept some assistance from the system. Whether it is automatically adjusting the music, or pre-selection of the playlist, it could somehow reduce the mental workloads for the patients, to provide a better user experience.

Limitations

The limitations of the evaluation itself are as follows:

1. The location of the evaluation could be more real, simulating the setup of the OR for example.

2. The participants were healthy populations, so the anxious feeling of going to a real surgery will not be simulated through this evaluation.

3. The music that is used for the workable prototype is not AI-generated, due to the real-time generation limitation.

4. The App interface itself could benefit from advanced coding.
8.4 Expert Interview

Objective of Expert Interview

After the evaluation of the product with users, I also conducted several expert interviews regarding the design and interaction. The evaluation could benefit a lot from the experts’ point of view since they could be potential stakeholders in the whole service related to the product.

To get more comprehensive expert feedback, experts in both AI generative model fields and the healthcare system are required. The former could provide useful advice on how to make the interaction of AI generative models more fluid and user-friendly. The latter could validate the possibility of using the product for patients and suggest some improvements in practical use accordingly.

Experts

Prof. Dr. Liu Yingjie

Dr. Liu is the Associate Chief Surgeon of the Orthopedic Department at Luo Yang Central Hospital. He mainly performs hip and knee replacements, arthroscopic procedures, etc. With over 20 years of surgery experience, he is an expert in conducting such orthopedic surgeries.

Prof. Dr. Dave Murray-Rust

Dr. Murray-Rust is the Associate Professor in Human-Algorithm Interaction Design at the Faculty of Industrial Design Engineering, at Delft University of Technology. He obtains a strong knowledge of the relationship between AI and humans. He researches how artificial intelligence can make sense of human behavior to support design insights and have a special interest in AI generative models.

Li Ya

Li Ya is the Nurse-in-charge of Orthopedic surgeries and neurosurgery at the Second Affiliated Hospital of Xi’an Jiaotong University. Her role is the circulating nurse inside the surgery area and OR. With more than 10 years of experience, she is quite familiar with patients undergoing surgery.

Wang Ting

Wang Ting is a Nurse-in-Charge of Orthopedic surgery, and she acts as both a circulating nurse and instrument nurse in the surgery area. She also has plenty of experience in using the new integrated OR in the Second Affiliated Hospital of Xi’an Jiaotong University.

Methodology

The expert interviews were conducted either in person or online. They were reached out by email and chatting Apps. The interview was one on one, and all experts were given the prototype and shown all the functions the design could realize. If applicable, they were also invited to experience the interactions. The initial design goal was also introduced to them.

Each interview session lasted about 20 to 40 minutes, and notes were taken by the researcher for the key points they mentioned. The interview was semi-structured, and due to the different professions of the interviewees, questions were also designed accordingly.

Results & Discussion

The interview results were organized into both positive feedback and weakness about the product. Therefore, in the following section, the strengths and weaknesses of the product will be discussed with some quotes from the experts.

The abbreviation of the expert names used in the quote:
• Prof. Dr. Liu Yingjie: YJ
• Prof. Dr. Dave Murray-Rust: DM
• Li Ya: LY
• Wang Ting: WT

General feedback of the product

During the interviews, almost all the experts expressed their interest in this product interaction and praised it. The interfaces for choosing the preferred music were said to be futuristic sci-fi and very mysterious. As for the music tuning interaction inside the OR, the experts gave out positive feedback on the action of letting patients have something to do while lying there and helping them become distracted from the noisy environment. There is, however, some specific feedback on the appearance and the AI-generated music that might result in undesirable experiences. The main concern is whether the AI-generated music could be understood by patients, and if they are capable of choosing the preferred music style through entering prompts and free exploration. The product is seemingly too restrained from their perspective, and cannot fully replace the actual music that real humans nowadays produce.

Strengths

• “I think this design is very nice, (...) because I also want to calm the patients down, especially when in the holding area, but I don’t have time for it.” (LY)
• “I think the idea of letting them use it already in the holding area is nice, because there would be many sounds happening there, (...) many people walking around, (...) and they need to stay there for 30 minutes to an hour sometimes.” (WT)

Weakness

• “I personally don’t like the generated music that much, (...) lack a sense of real human feeling.” (DM)
• “Some patients might like the idea of listening to music, but others would just want to quietly lay down.” (WT)

Degree of controllability

I have discussed whether they feel this form of interaction would be helpful or not for the patients both in the holding area and in the surgery room. The answer was mostly positive, and they mentioned that patients would lack a sense of security and something to rely on when entering the surgery area, and this product could be a nice substitute under these circumstances. But in the meanwhile, providing too much freedom and choice might be a problem as well. Some mentioned that the choice of music is too random and unexpected, and patients might not want to explore that much. Regarding AI-generated music, while a prompt can be anything, it creates confusion for users on some levels.

Strengths

• “When patients are inside the surgery area, they don’t bring anything with them, not only the aged but also the young patients, they will lose the sense of security. So it is good to have something that they can rely on, such as a phone or other tangible stuff.” (WT)

Weakness

• “I think the choice of music could be less. If it is too much, patients can have selection difficulties. It could be easier to understand, especially for the elder patients.” (YJ)

Recommendations

• “You could have recommended styles regarding patients’ age, occupation, and education level. (...) When preparing for the surgery, we medical staff could help them preset the APP, and then hand it to them for choosing the music playlist.” (YJ)
• “You can add another layer of using ChatGPT to convert everyday language into the professional descriptive language of music genres, so on both sides, it is intuitive for the users and the AI model to understand the preference.” (DM)
Comparing to past practices

Through the talk, I found out that the hospitals do have music played through speakers, both in the holding area or inside the OR through phones a long time ago. But the reason they stopped was mostly because of the poor quality of the music, and the tastes in music vary from person to person. When they notice my design, they would compare it to the previous practices that they have conducted before, and provide me with more suggestions. The good thing about MusicWave is that it is highly personalized, and can be controlled by the patients. But at the same time, it should have a certain filter for the music played to the patients, to avoid possible medical consequences such as a rise in blood pressure when hearing too enthusiastic music.

Strengths

- "There will be many patients inside one room(...) and they would influence each other. (...) Many of them are anxious before surgery." (LY)
- "In 2009, our holding area tried to play music for patients in the morning shifting, 7:30 am, (...) The music was broadcast through the radio and to all the 24 patients inside the holding area. (...) But we stopped because the tastes are different for people." (LY)

Weakness

- "There used to be sounds inside the surgery rooms, but after a while, it was canceled. Partially because the sounds were disturbing to some medical staff, and also because the music is not good for external playback." (WT)

Recommendations

- "Blood pressure should not fluctuate too much either, so the music could be somehow calming and relaxing, to let the blood pressure be stable." (YJ)

Patient practicability during surgery

One thing that I am concerned about is whether patients can use the interface the way I wish them to during surgery while on the surgery table. So I specifically asked them if patients were able to use the product. The answers I got are positive, but it depends on the status of the patients during surgery, as well as the type of surgery. In surgeries like knee replacement and knee arthroscopy, patients could lie down flat and use both their hands. But for hip replacement, for example, they have to lie down on one side, and the arms should be put above the head in the other direction.

Strengths

- "Patients can do the interactions on the interface with different positions during surgery. Some of them are lying on the side, some are lying on the stomach, and some of them are lying flat." (LY)

Weakness

- "We worry about patients’ hands moving during the surgery. Touching the medical devices, or influencing the surgery procedure. When the hip replacement, patients are lying on the side, and one hand must be put to the other direction rather than beside their hip." (YJ)

The future immersive experience

Besides the sound experience, I also proposed the future visual design which might be part of the surgery experience as well for patients. The experts were very much attracted by the idea of having visuals, and Ting who worked inside the integrated OR also said that they are already trying to implement this kind of experience. The OR itself has Dolby Surround Sound, as well as a amazing ceiling that patients could stare at during surgery. This information again provided me with the direction of developing this project further for a more futuristic and immersive experience.

Strengths

- "The feeling of a screensaver is nice to me, the visual." (WT)
- "I like the visual idea of somehow hypnosis patients." (YJ)

Recommendations

- "Now we have four integrated Operating Rooms, which have better speakers and an amazing ceiling. (...) It is similar to your visual idea." (WT)
- "The ceiling of the integrated OR has a blue sky, and patients could look at that during surgery, but you need to investigate more about the optimal height of the visual, to their eyes, for staring at for 2-3 hours." (WT)

Figure 8.1 The integrated OR at the Second Affiliated Hospital of Xi’an Jiaotong University
Conclusion

This chapter provides a detailed evaluation of various aspects of the current design. The user evaluation part was carried out with 15 participants, and the results suggested that the goal of "improving emotional experience" is achieved under the testing context. Participants have seen a significant drop in anxiety levels after using the product in the surgery soundscape. To have a more scientific result, real patients need to be involved in the OR context.

As for the assessment of the properties of the product, the interaction qualities of "attractive", "desiring", "comfortable" and "fun" are mostly achieved through the results of AttrakDiff. The product is overall neutral to the participants and is partially biased towards self-oriented. To let the assessment move to a desired zone, the product needs to have more guidance on the interface and through the usage.

Expert interviews provide strong support for the rationality and practicability of the design. The degree of controllability, patient usability, and fluency in communication with the AI model needs to be further investigated and considered.

The next chapter will be about the reflection of the whole graduation project as well as the further steps that could be taken to further develop it.
Next Steps

**Music · Wave** has gone through several iterations and has passed the evaluation under the test context and has received adequate feedback to be further developed. This chapter will show the reflections I had on this graduation project, what is good, and what needs to be watched out for the next time. Also, the recommendations for this project will be given based on the results and insights. A whole new future vision of the surgery experience will be presented as part of the conclusion of this project. In the end, some final words about the project will be given to the readers.

9.1 Conclusions
9.2 Recommendations
9.3 Future Design Vision
9.4 Reflections
9.1 Conclusion

Recap of design goal & interaction vision

The design goal is:

I want to design a music companion product for orthopedic surgery patients who are undergoing spinal anesthesia. The product interaction aims to improve their emotional experience during the surgery period. The interaction should be attractive, desirable, comfortable and fun for patients.

The interaction should be like:

"Fluctuating the surface of water full of bubbles with your hand," or "Running finger across the car window which is full of water mist."

The proposed design solution to the design goal provides a first step into the field of design for surgery sound experience for patients.

With the use of an AI generative model to produce music pieces from texts, we could get music without restrictions on the style or instruments. This unfettered tool allows us to further develop music that could be designed with targetting characteristics.

To put this technology into better use, we noticed the healthcare domain. Patients are often suffering from negative emotions regarding the soundscapes inside the OR during surgery, and when it comes to improving their emotional experience, traditional ways like music therapy would assist medical workers to stabilize patients' emotions. But this kind of practice is often limited to the various individual taste in music and the limitation of the need of having a therapist.

In this sense, AI-generated music gives us a solution. With the prompts containing emotional descriptors that could be understood by the AI generative model, the model is able to produce music with functionality that could somehow influence listeners' current emotional state.

With the circumplex model of music and emotions developed by Hevner and Schubert, we could use the two quadrants of valence and arousal to locate a certain emotional descriptor in the two-dimensional quadrant. This gives us the inspiration of designing similar interactions to allow users to move freely inside a quadrant for the emotional transition of a certain music style. Based on this, several interaction styles were tested and further developed to better fit with the AI tuning action. This prototype will allow patients to adjust the music in real-time during surgery, to fit their needs at the moment. AI generative music also allows the transition between emotions within the range of a certain preferred style, so that the music patients are listening to is always personalized.

After several iterations and evaluations, MusicWave is born. This product allows patients to first choose their favorite music styles through prompts while they are in the holding area, waiting for the surgery to happen. As soon as they are pushed into the OR, they could use the interface to tune the music to either cover the noise or to distract their attention from the complex acoustic environment.

The evaluation results of the product are promising. User evolution shows that the design goal of improving listeners' emotional experience is achieved, although it is only with healthy populations. The results from AttrakDiff show that the interaction qualities perceived by participants are somehow aligned with the ideally designed properties. Further evaluation with the experts from AI and the healthcare field provides positive feedback on the product itself and the future possibility of the project. Several limitations and recommendations are also proposed according to the evaluation, the controllability and the usability of the product for example, as well as the visualization of the design.

To conclude, this thesis demonstrates a complete process from problem definition in the OR context regarding noisy sounds, to user research of patients, surgeons, and healthy populations, and then design iteration and evaluation. Methods used in the thesis could be replicated and further studied. The thesis provides a guideline for dealing with similar design situations in the future. Moreover, it discussed the possible design directions for sound interaction design in the healthcare domain.

Limitations of this thesis would be firstly the user research could be conducted in a more thorough way, and with real patients, for the final evaluation. The design could be improved as well, not only the coding part involving AI generative music but also the visual style of the interface could be further developed.

This attempt of using AI-generated music as part of the healthcare system is a starting point for how to implement the rapidly developing AI models into our daily life usage. The connection between humans and AI has just begun to deepen, and we as designers should help AI and humans on both sides to position the optimal communication patterns of this newly developed technology.

Regarding the soundscapes inside the OR, I believe in the future, the surgery experience will be improved with the development of integrated operating rooms. Nowadays we have seen OR having premium speakers, simulated ceilings, and robotic arms. Perhaps in the future, we can create an acoustic environment that simultaneously conveys a sense of trustworthiness to the patient and is rich in generative music that could be tuned accordingly.

This field of Medisign focusing on medical sounds requires more research and study, and maybe letting AI do the important but mentally draining things like calming the patients and acting as a companion in a rather tense context would benefit the medical procedure as well.
9.2 Recommendations

In this section, a discussion of the graduation project will be illustrated in the form of several themes. Research, technology, and user experience are the three themes of this section. Each theme will be discussed with its recommendations and limitations.

Research

Limitations

• It would be better to test during the surgery on this concept, but the real condition is hard to achieve, if allowed, this kind of experiment would be very helpful.
• The connection with actual patients would benefit the design evaluation more. Using a healthy population would only test out the interaction part and proof of concept.
• The AI alignment test music could be generated with better generative models such as MusicLM if allowed. Now the music is indeed of a rather low quality, which might influence the results.
• The evaluation of the prototype could be done in a more real context, and the setup can create an authentic sense of actually being inside the OR.

Recommendations

• The study of AI music alignment could be carried out with more participants to see if there is any further effect.
• The corporation with the hospital should be taken more carefully by both sides, early contact with medical students specifically would benefit the projects of Medisign.

Technology

Limitations

• The AI model could be improved, with MusicLM instead of Diffusion. Now the music quality is not as good as it should have been. Also, the generated music is only 10 seconds, which is not enough for testing.
• The music preference selection part is not yet fully developed, and is still tested with “Wizard of Oz”.

Recommendations

• The AI model generation is not real-time, therefore instant change is hard to realize. Further development on this part could either put the generated music into a loop or could use a better GPU with mass storage to realize longer generations.
• The prompt input part could be developed further on how to do it through app and text input, which requires another project to design for.

User Experience

Limitations

• The music remix function and music fade-away effect could be fine-tuned further. Now the transition of the music between different emotions is not yet smooth enough.
• The prompt chosen for the prototype music is only based on one dataset: the “MusicCaps” and might not apply to every generative model.

Recommendations

• The visual experience is mentioned multiple times by the participants. Future projects could focus on how to provide a more immersive experience for patients inside OR.
• The visual could also represent the changing soundscape but requires also another study.

9.3 Future Design Vision

Interface or tangible interactions?

Whether using an interface or the tangible counselor to control the music experience inside the OR is yet to be defined. This thesis only gives out one possible solution with the interface, but with similar interaction patterns, future design projects could also apply it to the tangible product. By having an actual product that could be touched or squeezed, patients are likely to be more comforted by the experience. On the other hand, interface would also be a promising direction, since VR and XR are a growing trend in the design field, and patients could find an optimal way of using this virtual interface to interact.

Future OR

The sketch shows how the future OR would look after adapting the design concept. Ideally, there will be a space created for the patients when lying on the operating table. They could reach the interface with their free hands. There will be a curved screen covering them, and in the meanwhile, show the visuals according to the soundscape inside the OR.

The last version of the visualization only presents where the finger is, and does not give out any information about the area, and the soundscape. So in the iterated visual concept, I first gave it a mesh-like structure to reflect the changes in sound waves. Then, on top of that, the background color is added to reflect the information that different areas represent different emotional tendencies.

When users are moving around and exploring the music, they can see the interaction they made with the surrounding soundscape. The colors will change slowly with time, as well as the prompts, thus making the whole experience more unpredictable and keep garnering the attention of patients.

When patients have something in their hands, that they can control, instead of doing nothing and lying on the operating table, they would feel a sense of autonomy, and therefore more confident about the environmental changes.

The form of the visualization has not been decided yet, but according to the OR nowadays, it would be hard for them to have this equipment for patients. So I would prefer to refer to this as a future vision. But since many participants in the previous round of iteration mentioned the willingness of looking at something, I think it is logical to add the visual interaction for now to make the concept more complete.

The screen in the future could be replaced with AR or VR sets so that it won't affect surgeons. And the surface on the outside could have the patient's information on it so that the device screens could be saved by merging them all together here. Anesthesiologists could easily see the patients' conditions through the screen, and refer to the data beside patients' bodies.
Figure 9.1 The pattern variations of the visual style.
9.4 Reflections

This thesis has finally come to an end. Besides the reflections on the design itself and the project management, I would want to think back on these 21 weeks of graduation time and focus more on myself.

I have always been the kind of student who cannot relax, and if I have to finish something, I would want to do it as perfectly as I could. Sometimes when I think about the planning and schedule, I would wish everything to be exactly on time. A silent disturbance would drive me crazy. I could not say that after these 21 weeks, I have improved the stability of my inner mind, but I have indeed learned how to become a better self. People should always focus on what they could control, rather than what they could not foresee. In my case, things have changed a lot after midterm, the cancellation of LUMC research really threw a bomb at my graduation project. Everything seemed to be uncertain again, and I have to adjust to a new plan to evaluate my design. But this is real life, not everything will go as you expected, and I have been trying to accept it.

Sometimes you have to admit that as a student, there is so little you can do, and even as a designer, you a merely one of the employees in a firm. The graduation project is not the perfect work you should ever have done, because it is the actual start of my design career. When realizing all these, I began to really try to enjoy the process of doing my work.

There are many people that I am grateful for. During the whole process, I am so lucky to have my parents and my friends who listen and care about me. I have met and received so much kindness from the professional perspectives, and the life aspects. Every time I went to Delft church square, and the Saturday market, I would be amazed by the chill life pace and felt as if university never existed.

I know from a young age that drawing and doing design is what I want to do, and also what I can do best in. I want to help people with my design, and I want to feel the joy that my design brings, to those who are in need. I am not sure how much this design helps the patients and the healthcare system, but from the feedback I got, I have indeed felt the enthusiasm the expert and patients have toward having music inside the OR.

Growing up in the hospital, I know very clearly how helpless and scared someone who has to go through surgery is. Every time when the family members came to my father for help, I was there sitting quietly and listening to them. They have a smile on their face, but that is a fake smile, only for the others and for the patients. I notice their inner sadness and fear, not to say the patients themselves.

We would always assume that the hospital is a very serious place, but seldom have we thought about how dynamic it could be. The blue sky roof in the OR could even make me surprised, while live LED sky in the shopping mall would just be an ordinary scene. We as designers should think about this more often in the future. How do we care about patients, how do we stand in their position and look at the world from their perspective?

It is always a dilemma for us to balance the rationality of the design and the creativity of the design. Sometimes designs are just irrational, and you cannot even tell the logic behind the “God feelings”. But most of the time, we should be able to tell the reasons behind our decision to convince the audience. But we should make sure who is the audience, are they the client that we have to convince, or they are the professionals that we have to study from? But in either way, I would hope to find a balance between the two sides of the design, and still enjoy the amazing procedure of creating stuff.

Ziyi Wang
At Delft
2023.06.30
References

A


B


C


E


Fernell, J. (2002). Listening to music during ambulatory ophthalmic surgery reduced blood pressure, heart rate, and perceived stress. Evidence Based Nursing, 1(5), 16-26. 10.1136/ebn.5.1.16


Krou, R.E. (2001). The effects of single-session music therapy interventions on the observed and self-reported levels of pain control, physical comfort, and relaxation of hospice patients. American Journal of Hospice and Palliative Medicine, 18(6), 383–90. 10.1177/104990910101800607


O
Appendix 0

Project Brief
### Personal Project Brief - IDE Master Graduation

**Title:** Companion for Orthopedic Surgery Patients with AI-Generated Music

<table>
<thead>
<tr>
<th>Start date</th>
<th>17 - 02 - 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>End date</td>
<td>14 - 07 - 2023</td>
</tr>
</tbody>
</table>

**INTRODUCTION**

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title concise and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Surgery has always been a significant part of healthcare. While plenty of researchers have studied how to improve the surgery process and benefit the patients physically, it can be easy for us to ignore the emotional experience of them while lying on the operating table and experiencing something unfamiliar and stressful. If not receiving general anesthesia, there are plenty of reasons why it could trigger negative emotions in patients, such as the high intensity, the cold scalpel touch, or the inevitable surgical sounds inside the OR operating room. While focusing on the soundscape of the OR, take orthopedic surgery as an example, the average sound level of a Total Hip Arthroplasty could be around 80 dB, with the peak reaching 134 dB (Ozcan, E., et al, 2002). Physiologically, noise in surgery was likely to cause hypertension (Burrow, et al, 2005), which caused the blood to start to flow faster (Pfander, 2004) and over the vision of orthopedic surgeons. It may as well stress patients and increase annoyance or other negative feelings. In the research of Liu et al, 2006, one-third of the patients claimed that the surgery induction and recovery phases were noisy. When considering the anesthetics in nowadays' surgical practice, more studies have proved that spinal anesthetics is better for patients both physically and mentally. But with lighter anesthetics, the awareness or responsiveness of the patients becomes higher (ASA, 2019). For patients under anesthesia, noise tends to be the most stimulating factor among all in the review by Bischoff, et al, 2011. Therefore, the impact of sound on patients under anesthesia during surgery is worth discussing. A rising need to improve the soundscape of OR for patients can be seen so far.

While it is unlikely for designers to eliminate the sounds in OR, possible solutions for changing soundscape for patients could be blocking sound propagation for patients or adding sounds that could mask the noise or distract patients' attention from the acoustic environment. Considering the second option for a much more experience, music could be an answer for the “added sound” in OR. There have been many explorations of music as a therapy in healthcare fields, and many music excerpts used are either recorded or performed live by musicians, which is still a bit limited and rigid. When introducing music as an intervention method, different literatures could interpret certain types of music poles apart. Therefore, playing designed music excerpts is hard to suit personal needs and preferences. Nowadays, AI-generated music has been a growing trend, and it provides us with new thoughts on making music interventions. With simple text input, the model will generate a short clip of music within 30 seconds. In this sense, it is possible for the AI to generate personalized and enjoyable music excerpts for patients that could improve their emotional experience as well as functionally change the soundscape inside the OR during surgery.

Following my research project in Critical Assets Lab, I discovered that Nervousness, Fear, and Anxiety are the most likely evoked emotions before surgery, so it would be nice to reduce those kinds of negative emotions. Emotion like Curious reduces as surgery goes on, while Neutral is seen to increase. And after surgery; Relief and Tiredness are taking the leading role in how patients are feeling. It is obvious that to improve the emotional experience, we need to focus on reducing the negative feelings before, maintaining stable emotions during surgery, and reducing the feeling of tired after. This project will be the very first attempt of adopting AI-generated music in the OR context, and with these kinds of interventions to regulate patients’ emotions, the amount of anesthesia used for calming effects can be reduced appropriately. Better surgery experience would benefit patients’ recovery, and as much as possible avoid psychological trauma after the operation. With the results and findings of the project, a more personalized emotional experience for patients could be designed in the future with various inputs such as the psychological parameters or eye movements that could create dynamic music which induces emotions. The limitations are that it is still unclear for us to know the right prompts for desired output of music which could induce certain emotions, and the results of the project may be limited to only a few emotea.

<table>
<thead>
<tr>
<th>Digital signing date</th>
<th>02 - 07 - 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital signature</td>
<td>Robin van Boeber</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initials &amp; Name</th>
<th>Z. W. Wang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student number</td>
<td>55266019</td>
</tr>
</tbody>
</table>

**IDE TU Delft - E&S Department // Graduation project brief & study overview // 2018 01 01**

**Title of Project:** Companion for Orthopedic Surgery Patients with AI-Generated Music

---

**Procedural Checks - IDE Master Graduation**

**APPROVAL PROJECT BRIEF**

To be filled in by the chair of the supervisory team.

**CHECK STUDY PROGRESS**

To be filled in by the IDE & E&S (Shared Service Center - Education & Student Affairs) after approval of the project brief by the chair. The progress will be checked for a 2nd time just before the gold light meeting.

**FORMAL APPROVAL GRADUATION PROJECT**

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the MSc programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
  - **APPROVED**
  - **NOT APPROVED**

- Is the level of the project challenging enough for a MSc IDE graduating student?
  - **APPROVED**
  - **NOT APPROVED**

- Is the project expected to be double within 100 working days/20 weeks?
  - **APPROVED**
  - **NOT APPROVED**

- Does the composition of the supervisory team comply with the regulations and fit the assignment?
  - **APPROVED**
  - **NOT APPROVED**

<table>
<thead>
<tr>
<th>Chair</th>
<th>Elif Ozcan</th>
<th>date: 01 - 07 - 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital signing date</td>
<td>02 - 07 - 2023</td>
<td></td>
</tr>
<tr>
<td>Digital signature</td>
<td>Robin van Boeber</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature</th>
<th>Robin van Boeber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initials &amp; Name</td>
<td>Z. W. Wang</td>
</tr>
<tr>
<td>Student number</td>
<td>55266019</td>
</tr>
</tbody>
</table>
The main focus of this project is to find a desired interaction intervention method and timing to reduce patients' negative emotions during different stages of surgery, as well as evoke neutral to positive emotions through AI-generated music.

1. It is unclear now when and at which point should the music intervention come in for orthopedic surgery patients to ease their emotions. Either music is masking the undesired sound or distracting patients' attention inside the OR; it needs to perform at the right time.

2. The AI music to generate personalized output, information pre-collection is required, which is not yet determined when and how to happen for the patients.

3. For the AI model, the correct prompt input for desired music output is still to be defined through further testing. From our current understanding of the needs of patients, they can be fulfilled by different sonic ambiances, but it is unclear what the emotional connotations of those sonic ambient descriptors can be when using them as prompt input for the AI model. The AI model needs to be fed with the right frame of test prompt to be able to generate either emotionally or functionally well-performed music phrases that could improve the soundscape of the OR.

4. An interactive and convenient way of inputting prompts for patients lying on the operating table should also be considered. Ergonomics need to be considered when testing with design comfort in mind. Also, the most desired interactions with patients should be tested as well. How the patients are going to interact with the product needs to be considered, as their heads are now being blocked by a sheet and they are unable to see their hands.

I want to design a music companion product for orthopedic surgery patients who are undergoing a spinal anesthesia. The product aims to improve their emotional experience during different stages of surgery. The project will focus on discovering the suitable method and timing for personalized music intervention to come in for the patients during surgery inside the OR.

The design project will mainly contribute to the surgery experience of orthopedic patients in several ways:

1. The product design will improve the patient's experience in the operating room regarding the sound environment. Through tangible interactions and AI-generated music, patients are expected to be less anxious, fear, or nervous before surgery, and emotions like curious or neutral are preferable to be evoke during surgery. They are expected to be more relaxed and relieved after surgery. Besides the emotional effect of the music excerpt, the design will also look into the functional side of the music, whether it could mask the noisy sounds inside the OR, or cause a distraction for the patients.

2. AI-generated music has the advantage of being unique and personalized especially when aiming at fulfilling the need of patients, where fixed music playlist could not please, motivate or comfort everyone.

2. It will provide insights for future sound and interaction designs in the operating room settings from the research and analysis results of the AI music alignment study as well as the contextual testing in LUMC. And with a future vision, more diverse input could be applied through this design to provide patients with a more personalized and caring soundscape during surgery.
PLANNING AND APPROACH **

Include a Sanat Chart (if you have one) - more examples can be found in Module 2 that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given time of 1200-2000 hours of work time and your planning model includes a kick-off meeting, week planning meetings, green light meeting and graduation ceremony. Illustrate your Sanat Chart by, for instance, explaining your approach, and please indicate periods of part time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or part-time activities.

start-date: 17.2.2023
end date: 14.7.2023

The whole design process will follow the general principle of “Human-centered Design Approach for Healthcare.” And as a DFI student, I would focus more on the user experience and interaction design within the project. Below are approaches that will be implemented to deal with the defined problems:

1. **Field research in LUMC** will be required to understand the whole context of design, as well as develop proper user journeys and touchpoints. Considering the soundscape inside OR as a product to improve, I will do a product understanding through observation, literature review, or focus group discussions to make a context map.

2. **Technology-wise**, I would use either Diffusion or Moodkit to generate music from text prompts. To define the right input frame for a desired output, an alignment test is required with quantitative questionnaires to find out the emotional connotation of the sonic ambient descriptors with different word inputs. Data will be analyzed by factor analysis to find out the matched in-out.

3. **The ideation** will start with many insights gathered from previous studies, brainstorming sessions, and co-creation sessions could be involved. The whole process of prototyping and testing is nonlinear, meaning that prototyping will be quick and fast and tested by users immediately with low fidelity. And then, higher-fidelity prototypes will be developed. The prototype will be tested without the patients first, and then bring to the hospital for a usability test in the end with real patients in between groups. Testing of patients in LUMC would be in the form of between-group testing. Data will be collected through questionnaires or interactive coding. In order to analyze the correlations, I will use a rating or scale as the main form of the questions. This phase would prove the usability of the design, as well as the effect of the AI-generated music on improving the soundscape inside OR.

**MOTIVATION AND PERSONAL AMBITIONS**

I set up this project mainly because I have passion in sound design, as well as the implementation of sound design in the hospital settings. I have done a research project with Dr. Elif Ozcan on the emotional experience of orthopedic patients regarding the sound environment inside the operating rooms, and from the results and insights I gathered, I see the potential in designing for better surgery experience. I always like to seek for the possibility between AI and user experience, since we can improve AI as a bridge to help articulate what we can’t ‘human’ cannot have done in a short time. Therefore, I gradually developed this idea of having AI-generated music as a more interactive and novel way to improve the patients’ emotional experience. I have discussed with Dr. Monique van Wezen about having music as a way of reducing negative emotions, so that to reduce the amount of calming drugs would benefit the patients. This again let me see the potential in this project.

Dr. Willem van der Maden and I have discussed about the possibility of having AI involved, and we both agreed that AI could generate more personalized music in shorter times, which is a huge advantage of these models. With this technology, music could be used in a more convenient way as “medicine”.

In this project, I would also like to make the design more tangible and interactive, and I would like the demonstration of the design to be more immersive. Also, I would like to practice my design research skills in this project, as well as data analysis methods, make solid foundations for my future careers.

---

**Final Comments**

In case your project brief needs final comments, please add any information you think is relevant.
Geluidsoverlast voor patiënten op OK?

De afdelingen Anesthesiologie en Orthopedie van het LUMC en het Soundlab van de faculteit Industrieel Ontwerp van de TU Delft starten een onderzoek naar geluid en overlast van geluid op en in de operatiekamers. Graag vragen wij enkele minuten van uw tijd voor de volgende vragen. De vragenlijst is volledig anoniem. Bedankt voor uw tijd!

1. Bent u orthopedisch chirurg of bent u werkzaam in een operatiekamer waar orthopedische ingrepen plaatsvinden?
   - JA
   - NEE

2. Vindt u ingrepen waarbij knie- of heupprotheses worden geplaatst luid of lawaaiige ingrepen?
   - JA wanneer?
   - NEE

3. Vindt u ingrepen aan weke delen luid of lawaaiige ingrepen?
   - JA wanneer?
   - NEE

4. Neemt u maatregelen om geluid of geluidsoverlast tijdens een ingreep te beïnvloeden?
   - JA => hoe?
   - NEE

5. Vertelt u aan uw patiënt die een spinaal / locoregionaal krijgt dat er harde geluiden op OK kunnen zijn? Zo ja, wat vertelt u?
   - JA, voor de ingreep
   - JA, tijdens de ingreep
   - NEE

6. Hebben patiënten die een spinaal / locoregionaal kregen wel eens geluksd of feedback gegeven over de harde geluiden die zij tijdens de ingreep hebben ervaren? Wat was de feedback?
   - JA, tijdens de ingreep
   - NEE

- Eventuele toelichting:

7. Denkt u dat geluid tijdens de ingreep invloed heeft op de ervaring van de patiënt met een spinaal?
   - JA
   - NEE

- Ik denk het niet, want:

8. Heeft u wel eens overwogen muziek in de OK te draaien voor uw patiënt met een spinaal?
   - JA
   - NEE

- Zo ja, waarom en welk soort muziek? Zo nee, waarom niet?

9. Heeft u nog op- of aanmerkingen naar aanleiding van deze vragen?
   - NEE
   - JA =>

Hartelijk dank voor uw tijd en uw antwoorden! Als u meer informatie wil over dit project, neem dan contact op met dhr. Z.WANG-69@student.tudelft.nl
You are being invited to participate in a research study titled *Music Alignment Test*. This study is being done by Ziyi Wang from the TU Delft. The purpose of this research study is to research the evoked emotion of AI generated music, and will take you approximately 5-10 minutes to complete. The data will be used for the Masters graduation thesis publication. We will be asking you to rate on how you feel about each audio clip you hear in the questionnaire. As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by keeping all the answers anonymous completely. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. The data will only be used and kept during the research period. If you have any questions, please contact Ziyi Wang at Z.Wang.69@student.tudelft.nl By clicking next to this question, means that you agree with the data usage above, and willing to participate into this study. Thanks for your time and enjoy your music journey!

**Appendix 2**

**AI Alignment Test**

Welcome to this music journey! Through this survey, you are going to hear about 9 audio clips each with 10 seconds duration. After hearing each piece, you will be asked to rate the audio according to your own opinion. There are no right or wrong answers, just follow your heart and intuition!

*If you have headphones, please put them on.*

You are going to do finish a training task first on next page to get you prepared.

- [ ] I am listening through headphones
- [ ] I am listening through another wearable device
- [ ] I am listening on my laptop/computer speakers
In this study, we will present you a number of audio clips. Your task is to evaluate how pleasant and arousing the clip is, as well as the quality of the audio clip. Evaluate the pleasantness of the audio clip on a scale of 1-9 where 1 = very unpleasant, 5 = neutral, 9 = very pleasant. Evaluate the arousal of the audio clip on a scale of 1-9 where 1 = very calming, 5 = neutral, 9 = very exciting. And, lastly, evaluate the audio quality of the clip on scale of 1-9 where 1 = very low quality, 5 = neutral, 9 = very high quality.

Training Task 1
Please evaluate the experience of the audio clip
► 0:00 / 0:11

Unpleasant - Pleasant
1 9
Calm - Excited
1 9
Low - High Quality
1 9

Training Task 2
Please evaluate the experience of the audio clip
► 0:00 / 0:11

Unpleasant - Pleasant
1 9
Calm - Excited
1 9
Low - High Quality
1 9

* I have fully understand the task and am ready to begin.

Yes
Ethics Approval Application: Al Generated Music Alignment Test
Applicant: WANG, Ziyi

Dear Ziyi WANG,

It is a pleasure to inform you that your application mentioned above has been approved.

Thanks very much for your submission to the HREC which has been conditionally approved. Please note that this approval is subject to you ensuring that the following condition/s is/are fulfilled: no IP data is collected and data is anonymous.

In addition to any specific conditions or notes, the HREC provides the following standard advice to all applicants:

• In light of recent tax changes, we advise that you confirm any proposed remuneration of research subjects with your faculty contract manager before going ahead.
• Please make sure when you carry out your research that you confirm contemporary covid protocols with your faculty HSE advisor, and that ongoing covid risks and precautions are flagged in the informed consent - with particular attention to this where there are physically vulnerable (eg: elderly or with underlying conditions) participants involved.
• Our default advice is not to publish transcripts or transcript summaries, but to retain these privately for specific purposes/checking; and if they are to be made public then only if fully anonymised and the transcript/summary itself approved by participants for specific purpose.
• Where there are collaborating (including funding) partners, appropriate formal agreements including clarity on responsibilities, including data ownership, responsibilities and access, should be in place and that relevant aspects of such agreements (such as access to raw or other data) are clear in the Informed Consent.

Good luck with your research!

Sincerely,

Dr. Cath Cotton
Policy Advisor
Academic Integrity

Date: 31-Mar-2023

Contact person: Dr. Cath Cotton, Policy Advisor
E-mail: c.m.cotton@tudelft.nl

Human Research Ethics Committee TU Delft
(http://hrec.tudelft.nl)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Dr. Ir. U. Pesch
Chair HREC
Faculty of Technology, Policy and Management
Appendix 3

Co-Creation Session

- The results of the co-creation sessions (Note: This is in both English and Chinese):
## Appendix 4

### Iteration Evaluation

<table>
<thead>
<tr>
<th>Evaluation Results</th>
<th>Attracted</th>
<th>Comfortable</th>
<th>Distraction</th>
<th>Flexible</th>
<th>Relaxing</th>
<th>Fun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concept 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave</td>
<td>5.1</td>
<td>4.9</td>
<td>5.6</td>
<td>5.0</td>
<td>5.0</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Evaluation Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concept 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave</td>
<td>4.9</td>
<td>4.2</td>
<td>5.8</td>
<td>4.2</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Evaluation Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concept 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave</td>
<td>3.9</td>
<td>3.8</td>
<td>5.1</td>
<td>3.8</td>
<td>4.1</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Evaluation Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave</td>
<td>5.8</td>
<td>5.1</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
25 Prompts Chosen for Prototype Phase
"Preference Choosing"

Electronic music house vibe
Guitar tempo
Crowed DJ in the room
Metal bass groovy feeling
Red rock with cat dance
Water dropping harmony
Funky monkey space sounds
Old movie in 1990s
Orchestra church god
Wooden mellow folk song
Windmill blowing up petals
Colorful cloths in summer
Classical rapping
Tropical moombahton
Lo-fi holidays bell
Home cozy air
e-guitar beats
Love story in Paris
People surrounding
Soulful chords
Blue hair reggae
Beer in the ocean
Youthful rainbow scene
Trumpet forest
Background slow moving

100 Keywords Combination Chosen for Prototype Phase "Surgery Music Experience"

• The string in the table is the Youtube video number, for example:
  https://www.youtube.com/watch?v=8My0cI-IZcl

<table>
<thead>
<tr>
<th>Styles</th>
<th>Happy</th>
<th>Relaxed</th>
<th>Sentimental</th>
<th>Passionate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>-</td>
<td>0.3512</td>
<td>0.3688</td>
<td>0.4133</td>
</tr>
<tr>
<td>Dance</td>
<td>-</td>
<td>0.3688</td>
<td>0.3601</td>
<td>0.4133</td>
</tr>
<tr>
<td>Electronic</td>
<td>0.3095</td>
<td>0.4503</td>
<td>0.3737</td>
<td>0.4133</td>
</tr>
<tr>
<td>Jazz</td>
<td>-</td>
<td>0.3737</td>
<td>0.3688</td>
<td>0.4133</td>
</tr>
<tr>
<td>Nature</td>
<td>-</td>
<td>0.3688</td>
<td>0.3601</td>
<td>0.4133</td>
</tr>
<tr>
<td>Pop</td>
<td>0.3095</td>
<td>0.4503</td>
<td>0.3737</td>
<td>0.4133</td>
</tr>
<tr>
<td>Rock</td>
<td>-</td>
<td>0.3737</td>
<td>0.3688</td>
<td>0.4133</td>
</tr>
</tbody>
</table>

• The database of MusicCaps:
### STAI - 6 Results

#### Before Test

<table>
<thead>
<tr>
<th></th>
<th>I feel calm</th>
<th>I am tense</th>
<th>I feel upset</th>
<th>I am relaxed</th>
<th>I feel content</th>
<th>I am worried</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>03</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>04</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>06</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>07</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>08</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>09</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Surgery Sounds

<table>
<thead>
<tr>
<th></th>
<th>I feel calm</th>
<th>I am tense</th>
<th>I feel upset</th>
<th>I am relaxed</th>
<th>I feel content</th>
<th>I am worried</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>03</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>04</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>05</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>06</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>07</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>08</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>09</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Surgery Sounds + Music

<table>
<thead>
<tr>
<th></th>
<th>I feel calm</th>
<th>I am tense</th>
<th>I feel upset</th>
<th>I am relaxed</th>
<th>I feel content</th>
<th>I am worried</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>03</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>04</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>05</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>06</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>07</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>08</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>09</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

### Appendix 6

Final Evaluation - Results

AttrakDiff Evaluation Results: [Link to Google Sheets](https://docs.google.com/spreadsheets/d/1NTcKLXyYxscbFf6Dj-nW6jiPrtA8O5/edit?usp=sharing&ouid=11253070849693699585&rtpof=true&sd=true)
Appendix 7

Final Evaluation Interview
• Diffusion could not do that much, and the music it generated is a bit homogeneous.
• You also need to consider the affordability in using AI generated music for patients, and also to let them understand how to choose the prompts.
• I personally don’t like the generated music that much, lack a sense of real human feeling.
• If you want to reach a sense of control, to let them be attracted, it is indeed very interesting, and you have to offer the ability, and affect our planning sometimes.
• You can add another layer of ChatGPT to convert everyday language into professional descriptive language of music genres, so in both sides, it is intuitive for the users and the AI model to understand the preference.
• David Berezan, makes music for running, instead of the traditional playlist while doing sports.
• You could have the 10 seconds music loop 3 times and then change to the next piece for real-time generation. Although the surgery and AI generated music seems to me like a nightmare, but it is an interesting combination, and the prototype itself is quite interesting as well.

• Acting as circulating nurse in Orthopedic surgery, neurosurgery. There are circulating nurses and instrument nurses, the former one is in charge of the patients in OR, the latter one is more for the medical instruments to corporate with the surgeons.
• I would check with the patients inside the holding area, there are five sections for orthopedic surgery, and I would find the one for the next surgery. Then I would work, position the patients.
• While inside the holding area, the patients have many time for choosing the music, cuz some of them would be pushed in the holding area much earlier than needed, 20 minutes at least, and some are even longer, if the former surgery is delayed.
• There will be many patients inside one room, and they would influence each other. Many of them are anxious before surgery.
• Now many patients receive general anesthesia, but spinal is possible for knee or hip replacement.
• Patients are able to do the interactions on the interface with different positions during surgery. Some of them are lying on the side, some are lying on the stomach, and some of them are lying flat.
• Patients who are not that aged, and the ones with minor underlying diseases, no need for real-time monitoring of vital signs, can operate on the interface without any issues.
• In 2009, our holding area have tried to play music for patients in the morning shift, 7:30am, when the nurses are having morning meetings. The music were broadcaster through the radio, and for all the 24 patients inside the holding area. Mostly are light music. In the afternoon, 2:00pm, there will also be music for medical workers to relax themselves. But we stopped because the tastes are different for people.
• I think this design is very nice, because I also want to calm the patients down, especially when in the holding area, but I don’t have time for it.
• If the OR is 21 – 25 degrees, and due to coldness, unknown surgery and the sounds, they can be really scared during surgery.
• I would go for more soft colors, to reduce the anxiety.

• Most of the patients are awake in our hospital during these types of surgery when receiving spinal anesthesia.
• When doing Knee Arthroscopy, I will communicate with some of the patients. Maybe they want to see the screen, but many of them would rather just be asleep and don’t want to know they are under surgery.
• Patients many times don’t want to consider how successful the surgery is, but only care about how they feel. Especially the elder patients, they would describe the noise and pain just around them.
• After the major part is completed, the nurses will sometimes say things like 'where is the gauze', and patients would be confused by these sentences, and become too worried.
• There were background music in our OR before, mainly light music, but not much songs, and sometimes we play through our phones.
• I think as long as the patients’ blood pressure don’t spike, like when they are in the holding area, 130-140, but to the OR, many of them would reach 170,180 and even 200. This might cause severe consequences to the surgery.
• Blood pressure should not fluctuate too much either, so the music could be somehow calming and relaxing, to let the blood pressure be stable.
• I think the choice of the music could be less. If there are too much, patients can have selection difficulties. It could be more easy to understand, especially for the elder patients.
• We worry about patients’ hands moving during the surgery. Touching the medical devices, or influence the surgery procedure. When the hip replacement, patients are lying on the side, and on hand must be put to the other direction rather than besides their hip.
• I like the visual idea of somehow hypnosis patients.
• You could have recommended styles regarding patients age, occupation, education level. When preparing the surgery, we medical staff could help them preset the App, and then hand it to them for their to choose the music play list.

• Both act as circulating nurse and instrument nurse, will be in touch with the patients for 2.3 hours.
• Some of the patients will receive more sedation after the surgery starts, even they had spinal anesthesia. This is to let them become more calm.
• Some patients might like the idea of listening to music, but others would just want to quietly lay down.
• With the actual sounds of the surgery, they might feel more safe during the surgery. They would trust surgeons and nurses with these sounds.
• There used to be sounds inside the surgery rooms, but after a while, it was canceled. Partially because the sounds were disturbing to some medical staff, and also because the the music is not good for external playback.
• Now we have four integrated Operating Room, which have better speakers.
• I think the idea of letting them use it already in the holding area is nice, because there would be many sounds happening there, many people walking around, and they need to stay there for 30 minutes to an hour sometimes.
• They are more nervous when suddenly enter the holding area, so it is nice.
• There will be 20 minutes or so for the anesthesia procedure.
• Some of the bad feelings are caused by the sense of tools touching their body, not because of the feeling of pain. Whenever the patients say that they are painful, our anesthesiologist will give them more sedation if needed.
• The ceiling of the integrated OR has a blue sky, and patients could look at that during surgery, but you need to investigate more about the optimal height of the visual, to their eyes, for staring at for 2-3 hours.
• Patients might not want to listen to what we are talking about. When they have the music while entering the OR, they will not resist the sounds that much.
• The feeling of a screensaver is nice to me, the visual.
• When patients are inside the surgery area, they don’t bring anything with them, not only the aged, but also the young patients, they will lose the sense of security. So it is good to have something that they can rely on to, such as a phone or other tangible stuff.
Appendix

STAI-6 Questionnaire & AttrakDiff

Please rate before the test

A number of statements which people have used to describe themselves are given below.
Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment.
There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

I feel calm *

1 2 3 4
Not at all □ □ □ □ Very much so

I am tense *

1 2 3 4
Not at all □ □ □ □ Very much so

I feel upset *

1 2 3 4
Not at all □ □ □ □ Very much so

I am relaxed *

1 2 3 4
Not at all □ □ □ □ Very much so

I feel content *

1 2 3 4
Not at all □ □ □ □ Very much so

I am worried *

1 2 3 4
Not at all □ □ □ □ Very much so

AttrakDiff

Please provide your impressions of the product you have tested by checking marking your impression on the scale between the terms offered in each line.

human □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ ^