DREAME

Sleep in your personalized sonic dreamscape

A profile-based modular music system for personalized sleep experiences in general wards

Master thesis
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MSc Design for Interaction

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A profile-based modular music system for personalized sleep experiences in general wards

Master Thesis in Design for Interaction

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Abstract

Hospitalized patients were found to sleep significantly worse in the hospital than at home. The lack of quality sleep can cause serious health problems and affect patients' health recovery. Music as a low-cost sleep aid is a promising way to improve patients' sleep. However, most available sleep music playlists are limited to generic, soothing songs. People's personal preferences in relation to the effects of music are not well-considered and under-researched. Therefore, this project aims to explore how to design and deliver music that fits with patients' sleep and music preferences with a profile-based personalization approach.

Literature research was first carried out to understand sleep knowledge, how and why music aid sleep, practices in music therapy and profile-based personalization. Through generative research, people's preference data was collected and lead to four sleep music profiles: explorer, diver, hunter, observer. A design direction was proposed based on insights from the research activities. In the design phase, two brainstorming sessions were carried out and resulted in a feasible system concept. After two iterations, the final design DREAMe was proposed. DREAMe is personalized music modular system, including profile generation and music delivery. The profile generation logic allows the system to predict which profile users are based on a list of questions. Each profile comes with a sleep music module. To evaluate the music effects, sleep music samples were made under a summarized music design guideline. The music melodies of users' favourite music come from instrumental covers of the songs participants provided. The resources downloaded online were used fairly and only for this evaluation purpose.

In project evaluation, results suggest that the product and profile experience are logical, intuitive, and easy to use. The four profiles can reflect people's preferences, but they may not be stable. An eight-day evaluation was conducted to test the music effects on sleep. DREAMe music was found to reduce sleep onset latency and improve sleep quality. People could fall asleep more easily and feel more relaxed after two days' music listening. The music design delivers a relaxing, enjoyable and immersive music experience.

Acknowledgement

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CHAPTER OVERVIEW

1.1. Problem definition

The sleep problem is a serious health problem. In the Netherlands, 22% of people over 12 suffer from sleep disorders (Kerkhof, G. A., 2017). The recommended sleep duration of the National Sleep Foundation is seven to nine hours per night for adults between 18 and 64 years. However, more than one-third of adults do not get the recommended amount of sleep. 10 to 30% of adults struggle with insomnia. 2 to 9% of adults are affected by obstructive sleep apnea ("Sleep by the Numbers | National Sleep Foundation," 2021).

For hospitalized patients, sleep is even more important to maintain a healthy state for recovery. However, hospitalized patients struggle with the problem of lack of quality sleep. It was found that **the total sleep time in the hospital was 83 minutes shorter than the usual sleep at home, and patients found it more difficult to fall asleep in the hospital** (Wesselius et al., 2018).

This problem also occured in the context of Reinier de Graaf Hospital. Patients at Reinier de Graaf Hospital were found to have shorter sleep duration, lower sleep quality, and lower sleep efficiency than at home (Yiling, 2020).

Many existing sleep-promoting approaches aim to tackle sleep-disturbing factors like noise by providing earplugs, raising noise awareness, and changing nurses' behaviours. Many of these approaches attempt to manage the adverse effects caused by sleep-disrupting factors. It is undeniable that patients' sleep quality could be improved if the negative effects were eliminated. From another perspective, delivering interventions that can positively influence patients' sleep experience is also a feasible direction for dealing with sleep issues.

Music is considered a feasible and promising intervention for delivering positive and direct effects on patients' sleep. In music research, many studies were conducted to explore the effects of music on sleep. Music has been shown to have positive effects on patients sleep in different age groups. On the other hand, the music used in the sleep studies is mostly generic sleep music playlists without considering personal preferences. **No one sleep music is suitable for everyone. People have different sleep habits and different tastes in music.** These personal factors can influence the effects of music on sleep promotion and the desirability of listening to it.

Moreover, music therapy for sleep induction has high credibility and validated effects in solving sleep problems among the available music interventions. Music therapy delivers sleep music to each patient's specific sleep needs, and the music elements are selected under serious consideration. However, music therapy has not been widely used to promote sleep because it depends much on the therapist's credibility and is not flexible enough to satisfy the needs of a larger number of patients' groups.

In conclusion, research and design that can accommodate both sleep and music preference are still underexplored. The main challenges remain: what are these personal preferences, and how to take individual preferences into account while designing music.

1.2. Project scope

The project scope is illustrated in figure 1, and the key components include:

Project goal
This project's overarching objective is to improve the sleep experiences for patients at Reinier de Graaf hospital. The desired final effect is that patients fall asleep easier, with an improvement in sleep onset latency.

Target user and context:
Patients at Reinier de Graaf hospital are the target users. Patients' sleep conditions and sleep routines at the hospital are taken into consideration.

Sleep promoting approaches
There are many approaches in promoting sleep, in which music and sound interventions are considered the main design interventions within the project scope.

Personalization design approach
The personalization design approach is used as the primary design approach to deliver specific music to patients toward their sleep and music preferences.

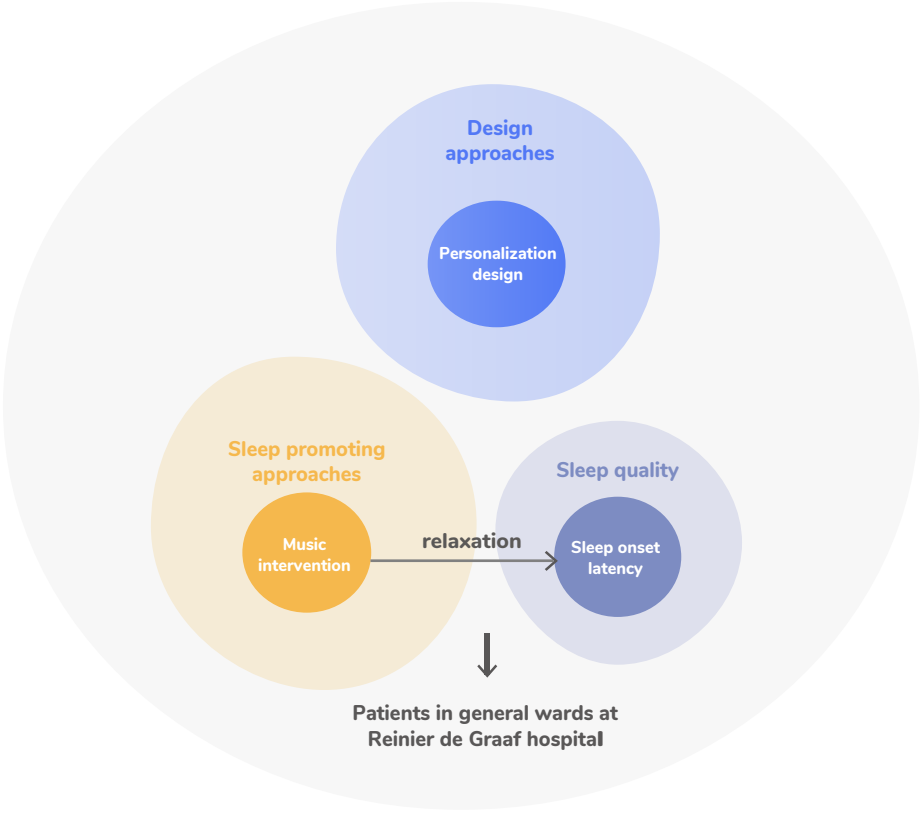


Figure 1. Project scope visualization

1.3. Project approach

Figure 2 shows an overview of the project journey. Literature research was conducted to gain basic knowledge in the areas that fall within the design scope, sleep, music and personalization. The rest of the project followed the profile-based personalization approach, including preference data collection, sleep music profile creation, and integration of profiles into the personalization system.

The generative research method was used to understand and collect personalized data contributing to four profiles and a design direction. Following the design direction, a modular music delivery system was delivered based on profiles. After two design iterations, the final design was proposed. Finally, two iteration tests provided both qualitative and quantitative insights into product and music listening experiences.

Approach	Goal	Activities
Literature research	• Understand sleep knowledge, sleep measurement methods and patients' sleep • Discover the opportunity of music as a sleep aid and learn from current practices • Personalization and profiling approaches	• Literature study in the fields of sleep science, patients' sleep at the hospital, music for sleep, and personalization approach • Desk research about the existing consumer products
Context research	• Understand the context of intervention and target groups	• A field study during the night shift at the hospital
Generative research	• Collect qualitative data about users' sleep and music preference • Profiling users' sleep and music preferences	• Explorative interviews as a pilot test • Generative research through a physical diary • Generative research results analysis • Creating sleep music profiles based on a qualitative approach
Ideation	• Come up with a concrete design direction	• Set the design goal and interaction vision • Carry out two brainstorming sessions
Iterative design process	• Prototype and iterative on the system in two parts: profile creation and music design	• Design and iterate on the profile logic • Design and iterate on the soundscape design • Collaborate with a sound designer for better music design quality
Final evaluation	• Evaluate final design outcome: a profile-based music personalization system	• Conduct the two final evaluation evaluations: product and profile experience evaluation, and music experience evaluation

Figure 2. An overview of the project approaches

Chapter 2
Sleep and music

CHAPTER OVERVIEW

2.1. Basic sleep knowledge

In this section, basic sleep knowledge will be introduced. Understanding properties of sleep, individual differences, and how to determine a good night's sleep is important for conducting the following design and research activities.

Scientific knowledge about sleep provides a foundation for developing a research-based sleep-enhancing design solution. It is helpful for user research to determine the scope of the research, such as whether sleep routines should be considered. Scientific knowledge about sleep will also support approaches to sleep quality assessment in the final phase of this project, in terms of what aspects of sleep should be assessed and what metrics determine good or poor sleep.

Good sleep is vital

People spend a third of their lives sleeping. Most of us know the self-evident importance of a good night's sleep. While sleep, diet and exercise all contribute to overall health, sleep is considered much more important than diet and exercise (Phillips, 2020).

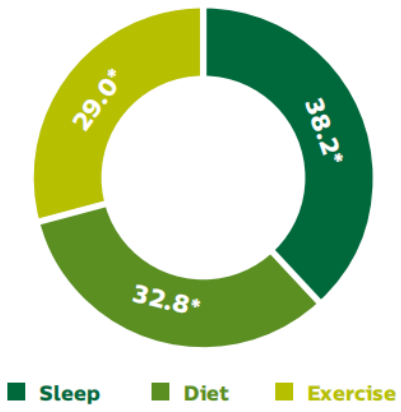


Figure 3. A bar chart about how people perceive the importance of sleep, diet, and exercise (Phillips, 2020)

Adequate good sleep plays a crucial role in a person's physical and mental health. A good night's sleep helps us improve our cognitive thinking skills, such as decision making, problem-solving, and learning new things. On the other hand, lack of efficient sleep can cause many chronic health problems, impair the performance, or even affect brain function and emotional well-being ("Sleep Deprivation and Deficiency | NHLBI, NIH," 2021).

What influence our sleep quality?

Many people do not get proper rest at night. According to Phillips Global Sleep Health Survey, 2020, half of the population is dissatisfied with their sleep (Phillips, 2020). Among all the factors that affect sleep, anxiety and stress are identified as the factor that most limits a good night's rest. Thirty-three percent of people in this study said worry and stress have a bad effect on them.

In the 2021 survey results, nearly half (48%) people said the epidemic COVID -19 had greatly affected their stress. 37% believed the epidemic had negatively impacted their ability to sleep soundly.

On a positive note, the adoption of techniques to improve sleep had increased since 2020. More and more people are turning to internet services and telemedicine for sleep problems. Strategies people are using to address their sleep problems include watching TV, reading, listening to soothing music, reducing coffee consumption, and using natural or organic sleep aids.

Sleep characteristics

The definition of the main sleep parameters and their relationship to sleep quality are summarised as follows.

Sleep quality and sleep health

Sleep quality means how well people sleep. Kline defined sleep quality as the satisfaction with the sleep experience, which includes aspects of sleep initiation, sleep maintenance, sleep quantity, and refreshment upon awakening (Kline C., 2013). Later, the concept of sleep health was defined by Buysse (see figure 4). Sleep health has six aspects: regularity, satisfaction, alertness, timing efficiency, and duration. Sleep health is very similar to sleep quality but take the sleep routine like regularity into consideration (Buysse, 2014).

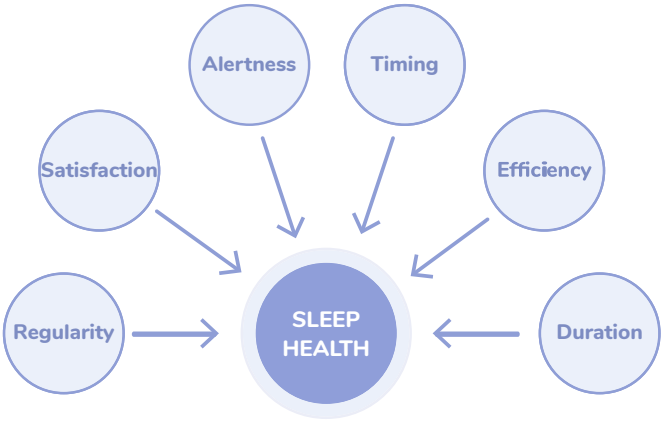


Figure 4. Sleep health includes six aspects: regularity, satisfaction, alertness, timing, efficiency, and duration (Buysse, 2014)

The definition of sleep quality and sleep health indicates that sleep is influenced by factors in different sleep phases, including pre-sleep, during-sleep, and post-sleep performance. Overall positive performance on all of these aspects indicates quality sleep.

Sleep cycles

While humans sleep, the body goes through four phases called sleep cycles. Over the course of a night, the body goes through a new stage of sleep approximately every 90 minutes. Healthy sleep consists of a total of 4-5 complete sleep cycles. Each stage is different and serves different purposes ("What are the Sleep Stages? | National Sleep Foundation", 2021).

Sleep duration

Sleep duration refers to total sleep time in 24 hours. Sleep duration is different for everyone, and there is no one number that is optimal for everyone. It is recommended that most people should stick to the recommended sleep duration depending on their age (Chaput et al., 2018)). For adults, 7-9 hours of sleep is good enough. Sleeping too short or too long is strongly associated with health problems (Cappuccio et al., 2010).

Sleep latency

Sleep latency is defined as the time it takes people to fall asleep. A sleep latency of 15 minutes indicates good quality sleep. 16 to 30 minutes is close to good quality. A sleep latency of 45-60 minutes indicates poor sleep quality in all age groups except the elderly, and more than 60 minutes indicates poor sleep quality in all age groups (Ohayon et al., 2017).

Sleep efficiency

Sleep efficiency is the percentage of time spent in bed that is spent falling asleep. It is calculated by dividing the time spent in sleep by the total time spent in bed. It indicates how long people stay in bed trying to fall asleep. Across all age groups, a sleep efficiency of ≥85% was judged as an appropriate indicator of good sleep quality (Ohayon et al., 2017).

Sleep quality measurement

In order to evaluate sleep quality, it is necessary to understand the advantages and disadvantages of sleep measurement methods.

Sleep measurement methods can be divided into objective methods (polysomnography, actigraphs) or subjective methods (questionnaires, sleep diaries). All methods have their advantages and disadvantages.

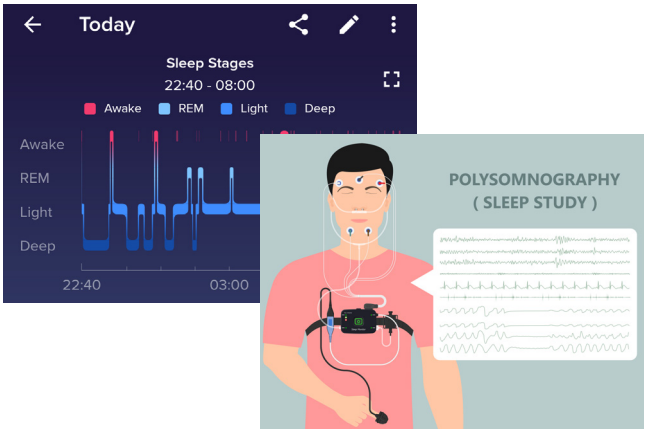


Figure 5. Objective sleep measurement examples

Objective methods have a very high sensitivity, over 90%, but a low specificity. (Ibáñez, Silva & Cauli, 2018). Now many apps have the sleep measurement functions embedded. These sleep measurement apps can measure sleep quality with actigraphy. However, many commercial software apps have not yet been validated for clinical use. Among these hardware and software products, Fitbit, the app watch, and the sleep cycle app have better accuracy than others (College of Arizona Health Sciences, 2021). Objective methods are not used in this project due to the constraints in devices and participants requirements. The use of objective methods requires that all participants wear the same devices. Due to the Covid situation, it is not possible to remotely recruit all participants wearing the same sleep monitoring devices.

Instead, subjective measurements are used in this project. Subjective methods have lower sensitivity (73%-97.7%) than objective methods, but higher specificity (50%-96%) (Ibáñez, Silva & Cauli, 2018). This means that subjective methods can provide detailed information about which part of sleep is going wrong. Subjective methods also have the advantage of knowing the patient's perception of sleep based on the qualitative responses in the diary, questionnaire or interview. This advantage is very important for a design research project such as this one. The results of detailed sleep patterns and scores alone cannot show which part of the design actually plays a role in influencing the sleep experience and how the design can be subsequently developed.

Among these subjective methods, the Pittsburgh Quality Sleep Index (PSQI) is a validated and accessible questionnaire-based method for assessing sleep quality from various aspects. The PSQI questionnaire consists of a series of questions about sleep-related behaviours. It includes seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daily routine disturbances. The sum of the items can assess sleepers' sleep quality (Buysse, Reynolds, Monk, Berman & Kupfer, 1989). The questions are divided into different aspects, and researchers can also use only a part of them for sleep research without causing bias. Due to the project focus, questions in subjective sleep quality, sleep latency and sleep duration part is used.

2.2. Patients' sleep at the hospital

Various studies have shown that the sleep quality of patients in hospitals is worse than sleep at home. Both external and internal sleep-disturbing factors have been discovered.

In hospitalized Canadian General Internal Medicine patients, sleep quality is significantly worse than at home. Noise (59%), nursing interruptions (30%), uncomfortable mattresses (18%), bright lights (16%), new settings (14%), and discomfort were the most commonly cited causes of poor sleep (9%) (Dobing et al., 2016).

A study in the Netherlands involving 39 hospitals and a total of 220 patients demonstrated a low sleep quality of patients in hospitals than at home (Wesselius, 2018). It was found that patients' total sleep time in the hospital was 83 minutes shorter than normal sleep at home, and patients found it harder to fall asleep in the hospital. The sleep quality and duration of hospital patients are negatively affected by some hospital-related factors. Among all factors, environmental noise and pain are the most influential factors.

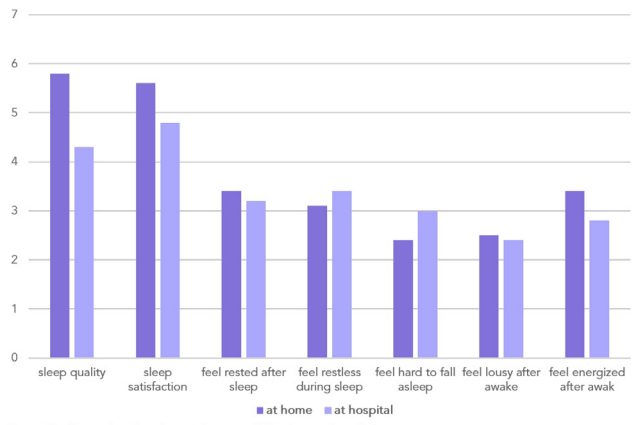


Figure 11: Comparing the sleep at home and the sleep at hospital.

Figure 6. A comparation of sleep at home and sleep at Renier de Graaf hospital (Yiling, 2020)

Similar results were found at Reiner de Graaf Hospital. A survey was conducted with 13 patients in the neurology department to measure the sleep quality of the patients (Yiling, 2020). The results show that patients also experience shorter sleep duration, poorer sleep quality, and lower sleep efficiency in the hospital than at home (figure 6). Noise was found to be the most threatening factor affecting patients' sleep in the hospital.

A qualitative study of patients' sleep experiences found that both physical and psychological experiences affect patients' sleep (Gellerstedt et al., 2014). Psychological factors such as nurses' bedside manner, integrity, and commitment were reported to positively or negatively influence patients' sleep. The physical factors found are similar to sleep-disturbing factors such as environmental noise, light, pain, the influence of medication and treatment, etc.

From the study results, we can see that the **sleeping conditions in the hospital with many external and unpredictable disturbing factors makes it difficult for patients to have a good night's rest.** The good thing is that many of these factors are modifiable, and introducing design interventions can positively influence patients' sleep quality.

2.3. Music as a sleep aid

Music effects for sleep

Music has been proved to have positive effects on people's sleep, in support of subjective and objective-based sleep music studies.

The improvement measured by self-report questionnaires is established with healthy participants and patients from infants to the elderly. For example, a meta-analysis about the effects of music intervention on sleep quality of older adults showed that music interventions benefitted especially sleep latency, sleep duration, sleep efficiency, and sleep of daytime dysfunction (Wang et al., 2021). Another meta-analysis evaluates the efficacy of music-assisted relaxation for sleep quality in adults and elders with sleep complaints and found out that music-assisted relaxation had a moderate effect on patients' sleep quality (de Niet, Tiemens, Lendemeijer & Hutschemaekers, 2009).

The objective effects of sleep quality have been considered more and more important in recent years as well. Chen et al. measured the effects of music on objective sleep quality. One hour of listening to music after subjects went to bed significantly decreased the amount of stage N2 sleep and increased deep SWS in a subgroup of participants with long sleep latencies. Another study shows that participants' subjective and objective sleep parameters were improved when listening to music before a nap (Cordi, Ackermann & Rasch, 2019).

However, not all sleep music study has positive effects. Lazic and Ogilvie (2007) found that delivering music for only one night has no positive impact on sleep quality. An extended usage might also increase the possibility of improving sleep quality (Dickson & Schubert, 2020). As summarized in a literature review: "music, in and of itself, may or may not improve sleep. If skillfully selected, and when music can be part of a protocol informed by music therapists, the likelihood of its contributing to sleep health will increase"(Loewy, J., 2020). This indicates that music can play a better role in promoting sleep when there is a rationale behind the music selection and delivery.

The effects of music might be improved when the patients' needs are better considered when delivering the music.

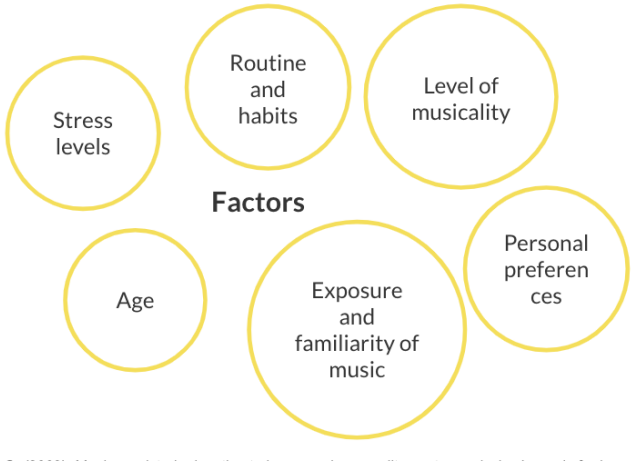


Figure 7. Identified factors that might influence the effects of music on sleep

Figure 7 summarises factors that might influence how music affects sleep quality, such as level of musicality, personal preferences, exposure and familiarity with music, age, stress level, sleep routine, and habits (Loewy, J., 2020). Some of these factors, such as routine and habits, are stable, but stress levels can be unstable. **Great variety can be observed in personal preferences regarding sleep and music, in contrast to the most commonly used soothing playlists for sleep.** Individual differences in sleep habits and music experiences may explain why generic music playlists in sleep music studies do not always work for everyone.

Music for sleep promotion in everydat life

A study conducted by Tabitha shows how people use sleep music in their daily lives (Tabitha, 2018). First, listening to music to aid sleep is a fairly common sleep-inducing strategy for people of all ages. From the survey results, 62% of the 651 respondents have listened to music at least once to help them fall asleep. However, not many people listen to music every day. About 1 in 3 people use music at least once a week, with only 4.22% of respondents listening to music every day. This might indicate that listening to music is not a daily sleep routine for most people. It was also found out that music users were younger, more stressed, and had poorer sleep quality and efficiency than those who did not listen to music. It is also believed that sleep quality deteriorates when the age of stress increases, but no music is used.

Genre	Proportion
Classical	31.96%
Rock	10.82%
Pop	7.47%
Acoustic	6.70%
Jazz	6.19%
Soundtracks (film/theatre)	5.93%
Ambient	5.93%
Folk	5.15%
Instrumental	4.90%
Indie	4.12%
Meditation	4.12%
Metal	3.35%
Electronic	2.58%
House	0.77%

Figure 8. Music genres people think effective as sleep music (Tabitha, 2018)

As can be seen in figure 8, the music that is considered effective for sleep includes 14 musical genres and 545 artists. This wide range of music selection suggests that **generic playlists for falling asleep without considering people's personal preferences may not be enough.** Sleep music need not be limited to certain types of slow classical music, which is often selected by researchers in sleep music studies. **A wide variety of music can be used as effective sleep music.**

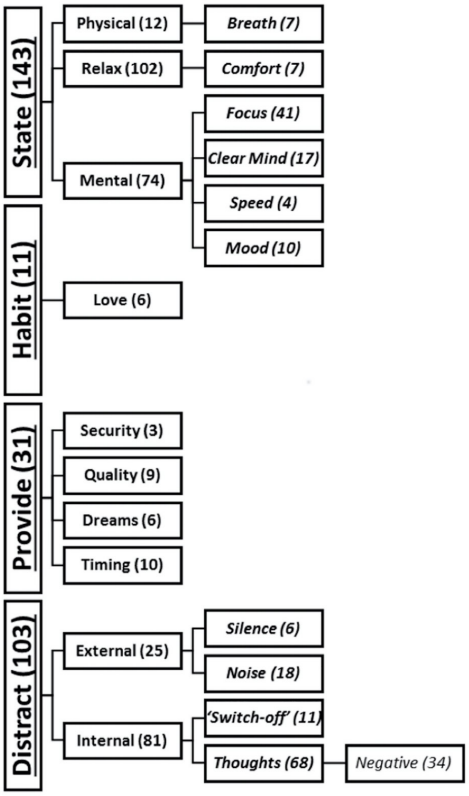


Figure 9. Themes from the survey about how people think music can aid their sleep (Tabitha, 2018)

As shown in figure 9, four themes about how people think music can help them fall asleep were defined in this study.

Provide: stimulate a secondary experience that facilitates sleep
Habit: listen to music as a habit or love to enjoy music before sleep
State: change to a sleep state
Distract: block sounds or a state of mind

The variety of responses reflects that music can play different roles to support people's different and changing sleep needs and concerns. There is no one particular way in which music can achieve the best effects. The impact of music largely depends on who is using the music, where they are using it, and whether the intention of music selection fits with people's needs.

How music aids sleep?

In order to use music effectively, it is important to understand the functional role of music in promoting sleep. As shown in figure 10, music supports sleep in several ways: relaxation, distraction, entrainment, masking, and enjoyment. (Dickson & Schubert, 2019).

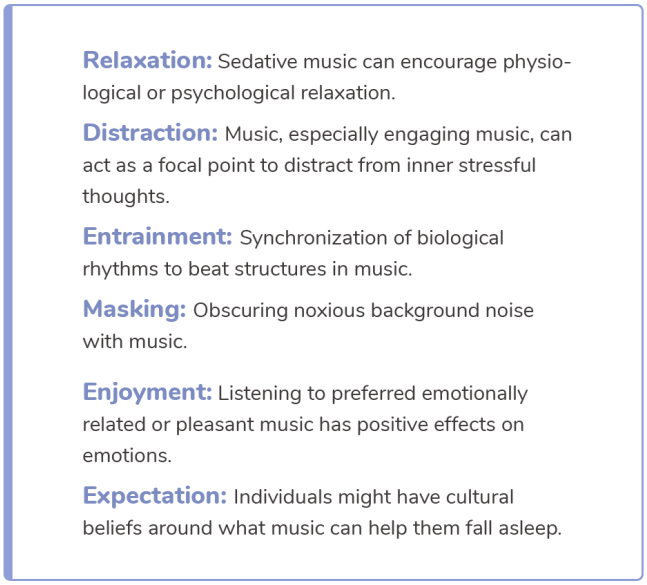


Figure 10. Music can aid sleep in six different ways (Dickson & Schubert, 2019)

The effects of music are not completely independent of each other. It is suggested that relaxation may be a mediator for the other effects. The relaxation effect can be achieved through enjoyment or distraction. Compared to the other effects, the masking effect is somewhat different because it depends on the user's environment. If the environment is quiet, the masking effect may not have the desired effect. The way music supports sleep shows how music can play different roles in the design solutions in order to achieve certain effects. It is a reasonable assumption that the different effects may be achieved by a different type of music.

Relaxing sleep music features

Literature research about the general characteristics of music that can prompt sleep was conducted.

According to College of Cumbria psychologist Dave Elliot, the most calming music had these qualities, "90 beats per minute, a 4/4 time signature, piano and strings, and narrow note sequences where notes move from low to high" ("This Music Is Designed to Help You Relax and Sleep," 2021). Tan et al. (2012) suggest that music for falling asleep should have the following characteristics: a tempo of about 60 beats per minute (bpm), pitches around C5, a tonal centre, small dynamic changes in the music, and simple rhythms. Wei-Chun Wang study of college students' preference for sleep music found that perceived levels of relaxation and calm increased as tempo, dynamics, and rhythmic complexity decreased. However, the mode effect (major vs minor) was not significant for students' perceptions of pleasantness (Wang, W. C., 2014). Dickson and Schubert examined the characteristics of music reported by 161 students as successfully promoting sleep. The features included "(a)their main frequency register was in the middle frequency range; (b)their tempo was medium; (c)their articulation was legato; (d) they were in the major mode; and (e)lyrics were present."(Dickson & Schubert, 2020).

It can be concluded that **relaxing music is usually related to features like, slow tempo, simple rhythm, and medium frequency level.**

On the other hand, a recent study by Hernandez-Ruiz suggests that a single change in musical elements does not produce a significant difference in psychophysiological measures of relaxation but may work if all elements together have a "relaxing" effect. "Musical features on their own seem insufficient to alter psychophysiological responses in a predictable way." (Hernandez-Ruiz, 2020).

This result suggests that **sleep music should be designed and evaluated as a whole, with consideration of relaxing music elements.**

2.4. Music therapy: achieve individual health goals

What is music therapy?

Music therapy is a health profession that uses music and its many elements to help patients achieve and maintain optimal health. Music therapy has been shown to improve patients' cognitive, motor, emotional, and social development and quality of life. Interacting with music in a therapeutic way helps patients achieve their health goals.

Music therapy is used in various context, like medical and cancer clinics, schools, drug and alcohol rehabilitation centers, psychiatric hospitals and prisons. Music therapy can also be used for all ages and different types of illnesses ("Physical Medicine & Rehabilitation, Chang Gung Memorial Hospital, Taipei.", 2021).

Figure 11. A music therapy session at the hospital

Music therapy is a clinical and evidence approach for delivering music. It is necessary that music therapy is used with a clear intention for achieving specific healthcare goals. Also, a professional music therapist is crucial for delivering the right music to satisfy the patients' needs. They are usually trained with specific music educational programs.

Music therapy approaches

In literature, there are several approaches to use music as a therapeutic tool to promote health, including environment music therapy (EMT), a music characterization system, and music-based sleep protocol.

EMT environment music therapy

Environment music therapy (EMT) is a music intervention approach that takes patients, caregivers, and staff's mental and physical needs into consideration (Canga et al., 2012). It has a positive effect on reducing the stress level and the noise perception of patients and caregivers. EMT usually takes place in real places in hospital waiting rooms. Music therapists deliver live music, and they will gradually change the music according to an observation of people's reactions.

Music characterization system

This music characterization music assists a music prescription process proposed by Rossetti (Rossetti, 2014), aiming to understand and deliver music programs by understanding patients' musical preferences. They choose "prescribed music" to show a selection of music in line with the "prescribe" definition. The music elements need to be carefully consideration and selected after examinations.

An assessment of the patient is a starting point of the prescription process. The therapist will first get to know the patients' psychological state, sleep history, preference of music, and cultural aspects. After this, patients' preferred music elements will be analysis. Fiannly, music intervention is delivered.

The music characterization system includes 12 musical elements and 4 non-musical elements (see figure 12). Values can be given to each element to gain an overview of the characteristics of the given music piece. In the music delivery phases, music therapists will deliver the music

according to the state of the patient. Patients are expected to change to the desired state while interacting with the delivered music.

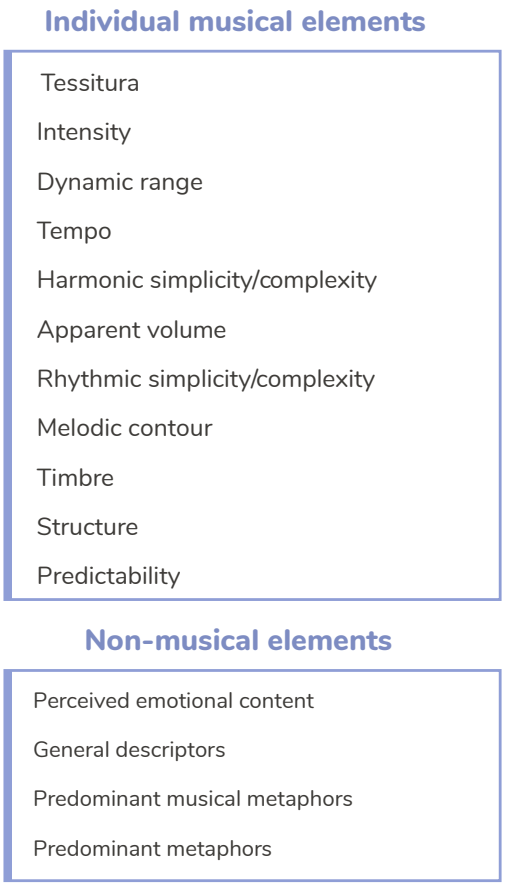


Figure 12. musical elements and 4 non-musical elements in the music characterization system (Rossetti, 2014))

The sleep problem, as one of the music influencial health problems can also be targeted using music therapy. Music therapy for solving sleep problems with an evidence approach offers a feasible direction for how recorded music can be designed and selected for better effect.

Music based sleep protocal

In a literautre review of music as an intervention to promote sleep, a music-based sleep protocol is proposed (Loewy, 2020). This protocol provides guidance on how to better use music as a sleep aid.

The first step is an analysis of patients' sleep. The sleep analysis includes an understanding of the following information:

- Previous sleep history
- Anxiety level to influence the ability to relax
- The duration of the music intervention must take into account the time for the sleep cycle, the depth and quality of sleep before and after the intervention

Then, the therapist can select the music according to the sleep analysis results. In terms of sleep music selection, it is suggested that the patient's music can be programmed to change speed, rhythm and intensity in response to the patient's presentation. By changing the basic components of the music, the sequence of the music can be designed to achieve progressive deactivation.

A music therapist is recommended to be invovled in the process to make better decisions in music selection as clinical input.

Learning points

It is noted that these approaches have common requirements for designing, selecting and delivering music. **First, the general characteristics of the music and personal preferences must be considered. Second, the musical elements can be modified according to the patient's situation.**

Music therapy has a great advantage as a personalized approach. However, it is less flexible and not efficient in meeting the sleep needs of a larger number of patients. A qualified music therapist needs to be trained to understand the sleep needs of patients and then play music at the patient's bedside to support sleep. We can still learn from these approaches and requirements to achieve validated effects and address the needs of each individual patient.

The limitation of music therapy is undeniable, especially for patients who want to improve their sleep rather than solve the servers' sleep problems. The lack of flexibility is also why music therapy is not used with every patient in the hospital.

2.5. Existing sleep music products

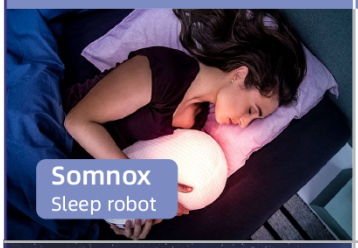
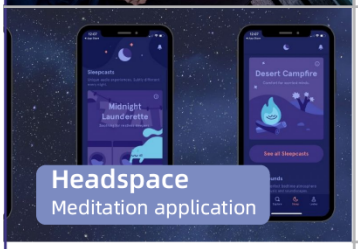
Sleep aid products	Sound related inter-ventions	The research behind sound interventions	Sources
 Somnox Sleep robot	Selected white nosie and natural music	Whitenoise and natural music can help people feel relaxed.	What are Sleepcasts?. (2021). Retrieved 25 August 2021, from https://www.head-space.com/sleep/sleepcasts
 Headspace Meditation application	A sound library with audio-guided wind down exercises, sleep casts	Classical music has been shown to lower blood pressure and reduce stress. Mindful meditation can reduce stress. Being absorbed in a story can reduce stress by 68%.	Sleep Sounds and Music: Helpful Resources and Tips | Sleep Cycle. (2021). Retrieved 25 August 2021, from https://www.sleepcy-cle.com/sleep-sounds-mu-sic/
 Sleep Cycle Sleep tracker, monitor	A sound library with soft music and meditation sounds	Meditation can evoke a relaxation response in the body and balance the nervous system.	Joel Lundberg, Sleep Aid Music Composer | Sleep Cycle. (2021). Retrieved 25 August 2021, from https://www.sleepcy-cle.com/sleep-sounds-mu-sic/joel-lundberg-composer/
 Dreampad Medium Support Pillow	A vibrational sound system Featured 10 sleep songs The function of playing user-selected music	Whitenoise and natural music can help people feel relaxed. The product has been tested in several studies and has positive effects on sleep.	Sound+Sleep – Sound of Sleep. (2021). Retrieved 25 August 2021, from https://www.-soundofsleep.com/soundsleep/
 Sound+Sleep Sleep Sound Machine	Provides natural and white, pink and brown noise. Sound customization functions A built-in microphone to dynamically adjust the volume based on ambient noise levels.	White, pink, and brown noise is found to improve the sleep quality for some people.	Sound+Sleep MINI – Sound of Sleep. (2021). Retrieved 25 August 2021, from https://www.sound-ofsleep.com/product/-soundsleep/

Figure 13. Desk research about existing sleep-promoting products with sound interventions

There are many sound-based sleep solutions on the consumer market in the form of an app, pillow, soundbox, headband, or even a mask. A desk review of existing sleep-promoting products was conducted (see figures 13&14). Figure 13 illustrates the sound-related intervention included in these products and the research-based reasons behind the design of these sound interventions. All information was obtained from the products' websites.

From the table, we can conclude that these popular **sleep-promoting products usually put music intervention as a secondary focus.** Music is generally considered an extended function compared to sleep measurement functions, or combined as a secondary function with vibration, meditation sounds, or physical relaxation. All of these approaches are put together to help people relieve stress and fall asleep more easily. Compared to other products, the Sound+sleep Soundbox is the only one that uses sounds as the primary intervention. It offers various white noises and natural sounds for people to choose from. It is also discovered that although the personalized approach is widely used on popular streaming services such as YouTube, Netflix, and Spotify, **personalized sleep music developed based on scientific research has not been applied to these sleep products.**

Another interesting fact is that **almost all products have invited musicians to compose music and sounds.** Both Headspace and Sleep Cycle promote their sleep music with the help of their composers. This shows that sound designers are important for developing high-quality sleep music applications. However, it might be difficult for users and researchers to evaluate music effects. Different composers' skills and personal preferences could also influence the music effects.

None of these products is intended for patients. They are usually used at home. Therefore, these applications are equipped with a variety of features to meet the different needs of consumers. **In this project, when developing products for the hospital, it is important to remember that patients should not be disturbed with too many functions that might require too many cognitive effects at night.**

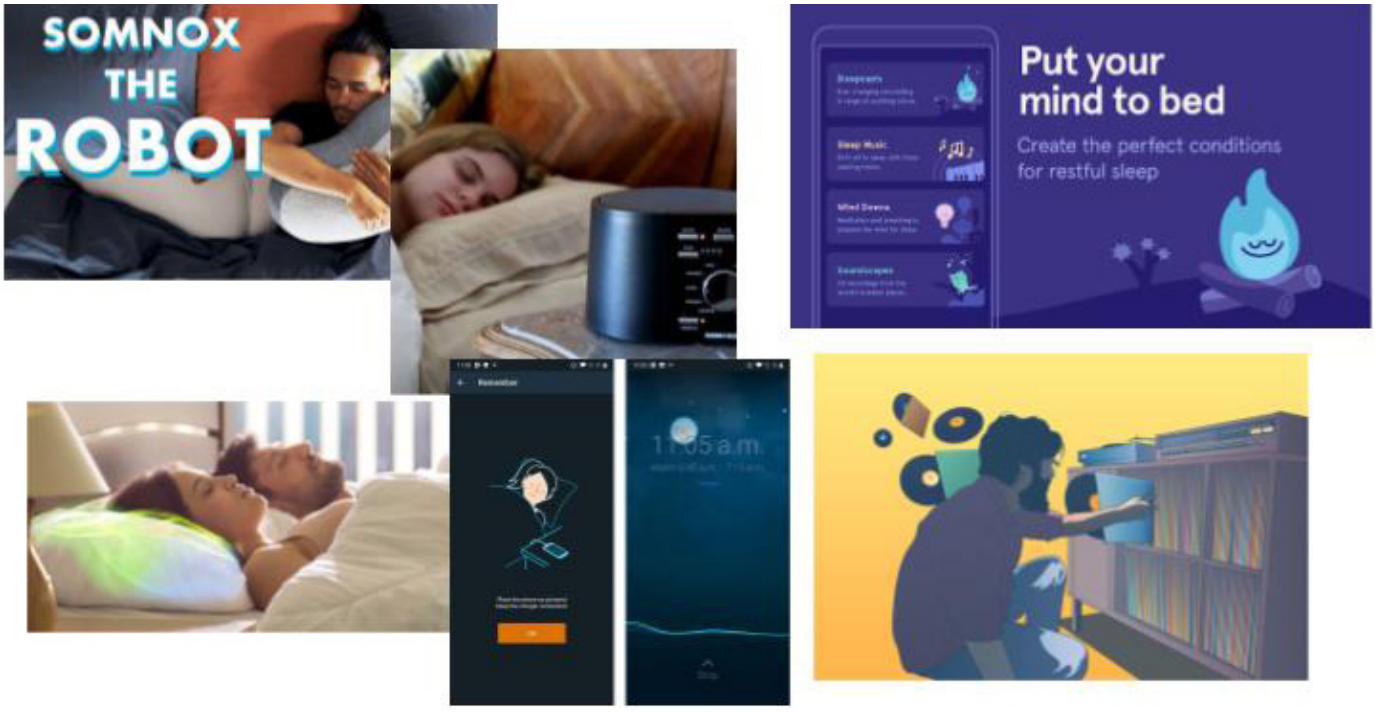


Figure 14. An overview of the researched sleep-promoting products on the consumer market

2.6. Personalization and profiling

As mentioned earlier, generic soothing sleep music playlists are not enough, leading to the need for more personalized music. There are several challenges in personalizing sleep music. The first one is to understand people's preferences and sleep-related behaviours. The other is how to provide relevant content based on personal information. To solve these challenges, profiling for personalization is a feasible approach. A user profile can be used to describe groups of people based on known facts or data. Personalization allows a system to identify a user as a specific type and deliver appropriate content and functionality

Personalization

There are at least 22 different definitions of personalization. They indicate different research methods and implementations (Fan & Poole, 2006). In this project context, **"the process of providing relevant content based on individual user preferences or behaviours"** is an applicable definition of personalization. More specifically, the personalization of sleep music can provide relevant music content based on individual user preferences or behaviours.

Customization is a concept very similar to personalization. The main difference is how much freedom is given to the user. Personalization is passive: users are given content, experiences, and features by developers that fit with the predication of user preference profile. In contrast, customization allows users to create their own experiences to meet their specific needs. The personalization approach is chosen because relying too much on the customization approach will impose high interaction costs on users, which does not match the capabilities of the target audience ("Customization vs. Personalization in the User Experience", 2021).

User profile and persona

Profile and persona are similar terms that both try to explain similar characteristics of a group of people. However, they differ in many aspects, such as the creation process, usage, and utility. Persona is a methodology proposed by Cooper for design processes (Cooper, A., 1999). He defined personas as "an accurate description of our users and what they want to achieve." Personas represent a group of people with common characteristics. Personas are used in the design process to help designers make better assumptions about target users, communicate better at work, and focus on specific audiences (Friess, E., 2012).

User profiling is more numerical than personas. It usually includes demographic data such as gender, age groups, or behavioural characteristics such as the type of interaction (Kelders, S. M., & Kip, H., 2019). The profiling approach is more relevant to personalization in this context, as it can help researchers categorize users into different segments through a user-centred approach. Moreover, designers can tailor design solutions to the different needs and concerns of the target groups (Schrauwen, 2021).

There are no specifications about what kind of data should be used for profiling. The only thing is that the information included in the user profile is highly dependent on the application and the purpose of the system. **Personalization based on general characteristics can sometimes be more successful than creating more detailed and nuanced profiles** (Customization vs. Personalization in the User Experience, 2016).

Profile-based personalization

Profiling users is a way to understand users' preferences in a simplified way. There are different approaches for profiling depending on which type of data is collected and the final goal. Figure 15 presents a comprehensive and iterative profiling process for personalization (El Allioui, Y., & El Beqqali, O., 2012).

The first stage for building a profile is data collection. There are two defined ways to collect user data: through explicit or implicit models. The explicit model relies on users to input information, and motivation is required to get them to do this manual process. In the implicit model, information is collected in a "silent" manner. The system collects data in the backend without disturbing users.

The second stage is called initialization. In this stage, profiles are initialized in three different manners depending on who is involved: the users and the system. The initialization process only involves users are like letting users filling a questionnaire about themselves, and the system will use that information without processing it at all. In contrast, the system creates users' profiles from a set of stored data if it is "by system only". For a combination of the two, designers will extract useful content from users' input for the system to create a profile.

In the third stage, the profile will be integrated into the personalization system. User profiles are primarily integrated into personalization systems by providing them with visual components and guiding them through the customizing process.

Update of the profile iteratively is the final stage. Both human feedback and the system can aid in collecting the data for the update.

Regarding the project's scope, the main focus should be on the information collection, initialization, and integration stages.

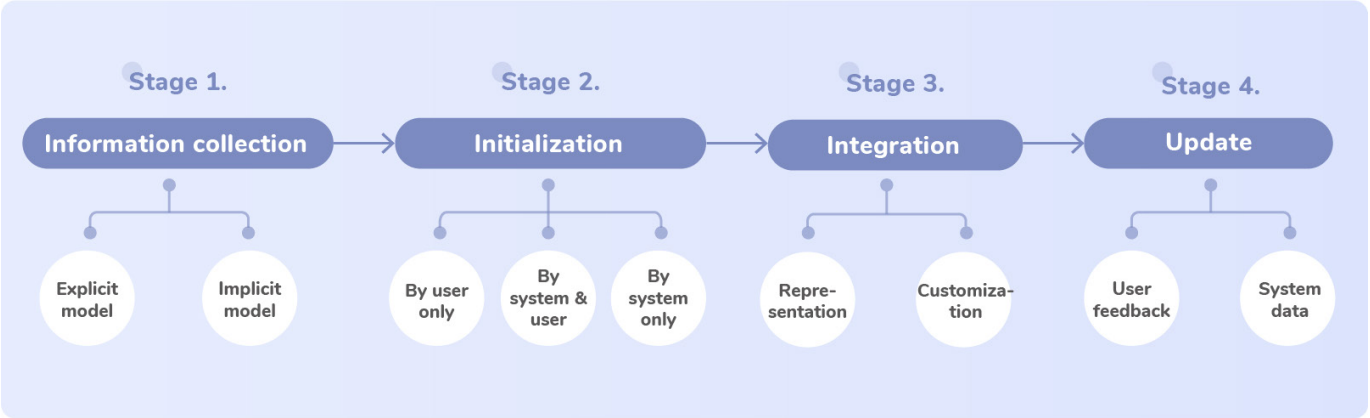


Figure 15. An overview of the profile-based personalization process (El Allioui, Y., & El Beqqali, O., 2012).

Learning from various approaches

Desk research about the existing profiling approach from literature and projects were conducted. The insights from these examples will support the profile creation process in chapters 3 and 4.

1. Creating profiles with a small amount of qualitative data

The first example comes from a study that looks at how users' personalities and characteristics affect their needs and interactions with the music information retrieval system (Kelders, van Zyl & Ludden, 2020). Although the researcher stated this process as creating "personas", these "personas" are seen as profiles under the profile definition of this research project. The data is collected from user interviews and observation of user sessions. Researchers record 77 user behaviours and use the card sorting method to organize and name similar behaviours to the group. Then, two dimensions are identified to express the differences among the user groups organized by their common behaviours: "companionship (willingness to engage in social aspects of music recommendation and listening: social neutral-private) and investment (willingness to invest time/effort to interact with the system: positive-neutral-none). In total, seven representative personas with special traits and users' attitudes are created. Since the results come from a relatively small sample, more data collection is still needed to validate the profiles.

Key points:
Based on qualitative data
Data tag: Individual music listening habits
Two dimensions: companionship + investment
Collecting small sample qualitative data from interviews
Analysis method: card sorting method

2. Profiling with quantitative data

The second example shows how qualitative data is used for profiling. The study focuses on capturing users' attitudes towards healthcare services and then segmenting subgroups by analyzing people's quotes (Jasper, 2021). The profiling aims to tailor suitable solutions towards specific target groups.

The grounded theory analysis translates users' quotes to codes, concepts, categories and theories for profile creation. In each category, three attitude profiles are created (see figure 16). Since data come from a qualitative approach, each attitude profile includes descriptions, quotes, and traits. Designers and researchers can also see the proportion of each user type to target their design solutions more effectively.

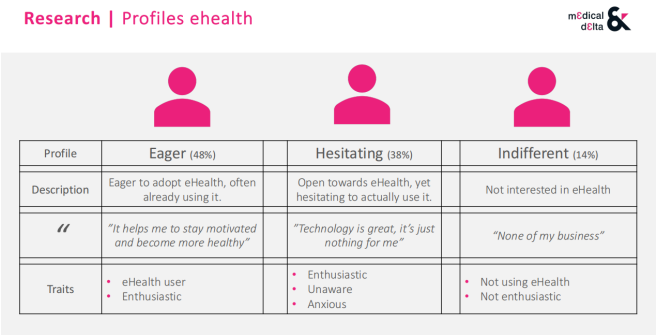


Figure 16. Three user profiles which describes people's different attitudes towards e-health (Jasper, 2021)

Key points:
Based on qualitative data
Data tag: Attitude towards e-health
Gathering data through a large number of interviews
Analysis method: the ground theory analysis

3. Profiling with quantitative data

The third example is a research project about profiling patients' behaviours for e-health products (Schrauwen, 2021). A top-down approach is used for creating in-depth profiles. The purpose of profiling is to study and change certain users' product usage behaviours. Therefore, the project starts with collecting product usage data. Four profiles are created based on the usage frequency and adherent level (see figure 17).

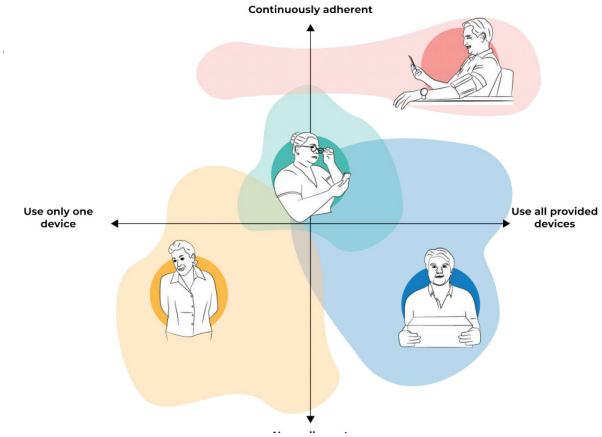


Figure 17. Four profiles are created from quantitive usage data of 261 users (Schrauwen, 2021)

Data is collected over several months. Due to this large amount of data, only a selection of data is used for building the profile model. Information for each profile includes the demographics like age, gender and health data from patients documented by the product (see figure 18).

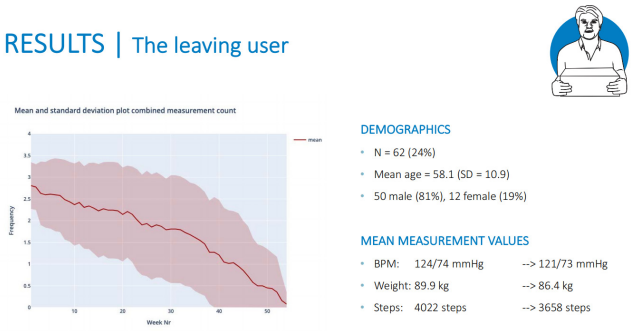


Figure 18. Detailed information in each profile, including demographic details and mean measurement values (Schrauwen, 2021)

From profile results, designers and researchers can get lots of insights into each segmented user group's typical behaviour patterns. Even though the profiles are created on quantitative data, qualitative information by further interviewing is still important for designers to understand the reason behind the behaviour patterns.

Key points:

Based on quantitative data
Data come from an extensive database collected by an e-health product
Data tag: A usage behaviour pattern
Two dimensions: usage frequency & adherent level.

Learning points from the above examples:

- Depending on the research purpose and duration, there are different ways to collect data, from semi-structured interviews to observations to technology-based data collection.
- Researchers need to select the data type that is most suitable for profiling because the data collection process usually ends up with a large amount of relevant data.
- Profiling, especially the first profiling step, usually focuses on one or two dimensions of the same type of data. Otherwise, it is too difficult to conceptualize the data into straightforward and representative profiles.

I will use these insights in the profile creation phase in the project to support the selection of relevant preference data and the steps of the profile creation process.

Chapter 3
Generative research on sleep & music preferences

CHAPTER OVERVIEW

3.1. Context research at Reinier de Graaf

Context research was conducted with the help of a nurse and under the permission of the hospital managers. A project brief was designed for recruiting nurses (see appendix B). The context research was a three-hour context observation during a night shift at Reinier de Graaf Hospital. The aim is to understand patients' sleep environment, general sleep routines, and patient interactions in general wards. A basic understanding of the context and target users help to keep the contextual factors in mind and develop empathy with users. Insights from context research will help to understand the environmental requirements and constraints for the music design interventions.

During the nighttime, patients can be more vulnerable than usual, so the field research should have as little influence on patients' as possible. Therefore, during the night shift, the researcher walked together with a nurse while she was working as usual. The nurse first introduced the project information to the patients with Dutch and then worked as usual. A nurses' uniform is also worn to prevent patients from feeling unsafe when seeing unfamiliar people. After the field research, visual documentation (see figure 19) is made to record the context and patients sleep conditions.

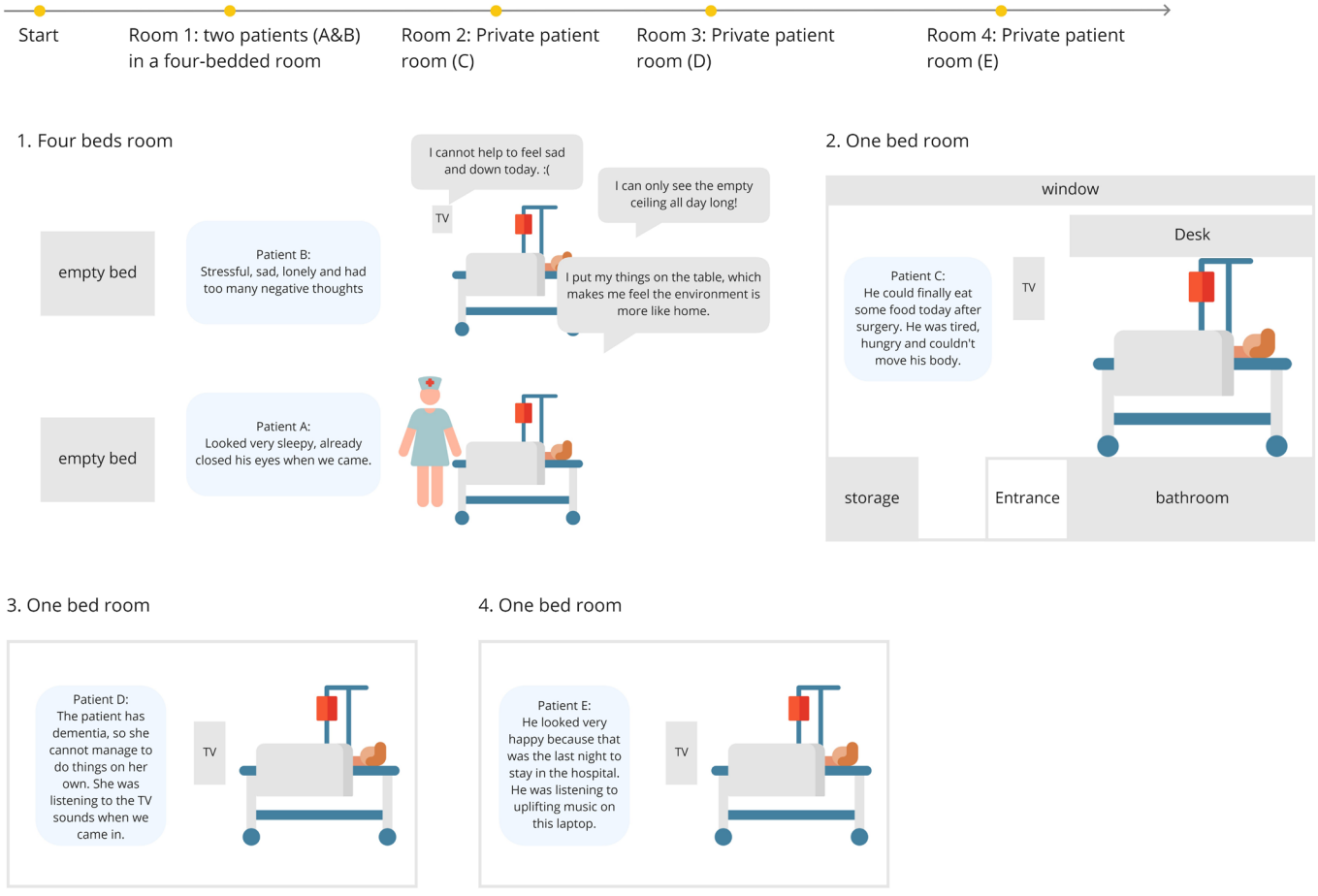


Figure 19. Visual documentation of the context observation during a typical night shift at Reinier de Graaf Hospital

Patients' sleep environment

There are two types of rooms for patients in Reinier de Graaf hospital. The first and most common one is the four-bedded room, where four patients share one room (see figure 20). There is a curtain next to each bed to separate patients from others. Another type is private rooms (see figure 21). Patients use a private space, equipped with a bathroom, a desk, a storage place and a TV. Patients in private rooms usually have more severe health problems than patients in shared rooms, and they need nurses' support for daily life activities. Television with headphones is equipped for each patient on the top of their beds. They can watch TV hearing sounds by wearing headphones without disturbing each other. The TV is quite far from the bed and is controlled by a console near the patient's bed. While the sound from TV is unlikely to be a sleep-disturbing factor, the light of it might influence other patients when the light goes off after 10 o'clock. However, patients in four bedrooms who are next to each other can also listen to the sounds from each other clearly.

Figure 20. A picture of the four-bedded room at Reinier de Graaf hospital

Figure 21. A picture of the private room at Reinier de Graaf hospital

Nurses' night shift routine

These are the activities included in a nurse night shift routine, around 8 pm to 10 pm each night before the lights on the corridor go off. A nurse is usually responsible for 6-8 patients. For patients who don't need a health check or taking medicine at night, this is the time when they say goodnight to nurses.

1. The nurses will first check the patient's health status and ask how the patient is feeling today. At the same time, they enter patients' health data into the computer.

2. Nurses usually have small talks with the patient during and after the health check.

3. Nurses need to help some patients to take to insert medications.

4. Nurses will bring patients with necessities (food, water) from the food storage place.

5. Nurse help the patient with cleaning if the patient cannot manage to do it independently.

6. Patients and nurses say good night to each other. Nurses will help with closing the TV or the door after asking patients.

Patients' before bed activities

Through observation of six patients, different before-bed activities were found. These activities include: watching phones or laptops, listening to uplifting music from a laptop, closing eyes and almost falling asleep, watching tv or doing nothing. During the observation, only one patient watched TV, but the nurse said watching tv and looking at the phone were the most common before bed activities for patients. It is also quite common for the elderly to watching videos on the phone before bed.

No direct interaction between patients is observed in the four-bedded room. The main reason is that there are only two patients in that room, and one of them seems to be very sleepy at that time. .

Even though I didn't enter any other four-bedded room, laughter and talkings from another four-bedded room were noticed when passing by. According to what the nurse said, there is more interaction among patients in the four-bedded room during the day. Patients talk to each other friendly and often motivate each other. There are fewer talkings during the nighttime because patients don't want to disturb others who sleep earlier.

Patients' needs

As shown in the visual documentation (figure 19), patients have different health conditions, mental states and the capability of interactions.

Patient B wanted to distract herself from her negative thoughts because she felt sad, lonely, and unsafe without her family's company at night. The desired experience for her might be to engage in an activity that she finds enjoyable before bed. An active and engaging interaction can help her forget about the negative thoughts.

Patient C had just had surgery during the day and wanted to feel relaxed and relieved his pain. Due to his health state, he had low capability and motivation for interaction.

Patient D couldn't handle the daily life issues and need support from nurses. No intervention or a gentle intervention might be delivered based on an observation of her sleep performance.

It can be seen that patients have very different sleep needs due to their health conditions and mental states. To satisfy these various needs, the design of music intervention should be flexible and easy to use. Patients' cognitive and physical abilities also vary widely, which should be taken into consideration while designing.

The role of caregivers (nurses)

The role of caregivers is found to be important in the patients' sleep routines. Nurses play an essential role in providing emotional and practical support during the night. Nurses understand the needs of the patients well by talking to them on a regular basis. They might also play a role in delivering music in general wards. For example, nurses might suggest to patients that they can listen to our music before going to bed.

However, what cannot be overlooked is that nurses are very busy taking care of the patient on a night shift. They need to walk around, check patients health and provide necessities for them whenever they need. If the design intervention involves nurses as one part of the experiences, it should not burden nurses' regular workload.

3.2. Ask about sleep & music preference

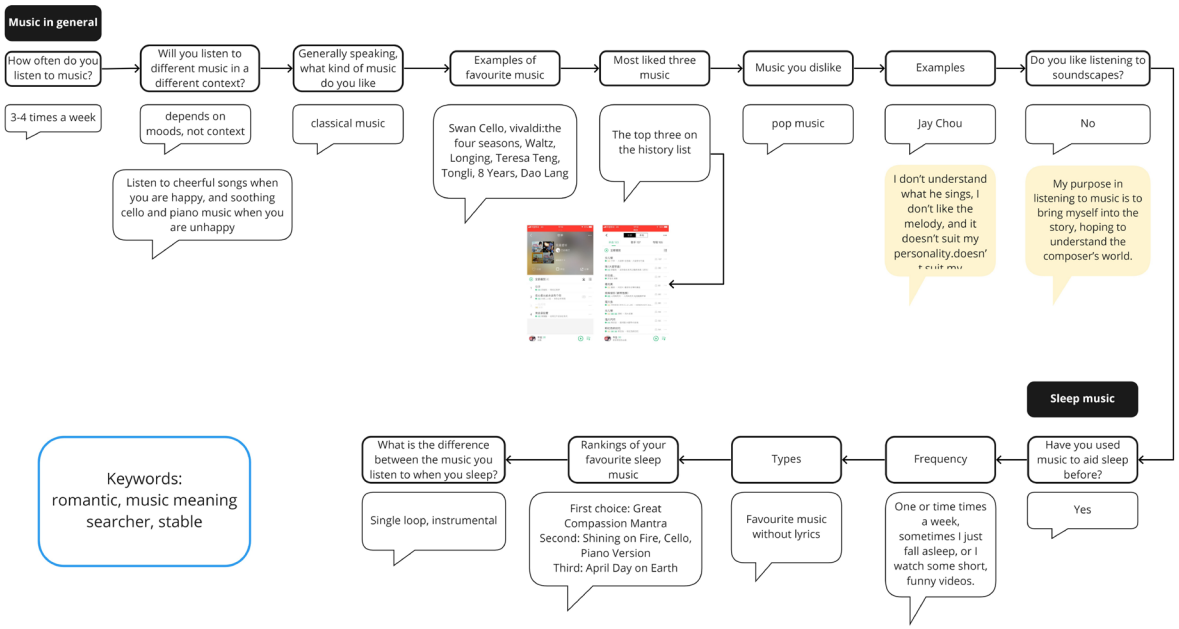


Figure 22. The flow chart that documents the questions and answers of one explorative interview

The exploratory interview aims to understand **what questions we should ask to get an intimate image of a people's sleep music preference.** This is an exploration activity as a pilot for generative research. Three participants were interviewed. The feedback and insights about these questions will be input in generative research. The interview question list includes a wide range of questions about the relationship with music, music usage for relaxation, favourite music, sound in everyday life and sleep-related behaviours (see appendix C).

Main insights are concluded as follows:
To understand people's music preferences, we should **ask specific questions instead of generic ones.** For example, "In general, what types of music do you like" will lead to the same general answers like "relaxing music". In contrast, if participants are suggested to talk about their three favourite and least favourite music and describe the reason behind. Participants' responses to these specific questions tend to be rich, informative, leading to a better understanding of individuals' intimate preferences.

Providing people with a music listening context is evocative. Encourage people to talk about music by asking, "What do you usually listen to at different moments of your day" is a good starting point. This question is closely related to people's daily music listening experiences. They can easily recall their recent memories about music listening and talk with researchers in a storytelling way.

The sequence of the questions also matters. Some questions that need time for reflection (e.g., the relationship with music) should be put after the easy and intuitive questions (e.g., the music listening frequency).

Finally, **the importance of understanding the relationship between sleep and music preferencess should not be overlooked.** The figure above (figure 22) shows an interview we mainly talked about music. Without building a link between music listening and sleep preferences, it can be difficult to see how we can use music as a sleep aid.

3.3. Generative research through a preference diary

Objective

The main research objective is to understand participants' sleep and music preferences in an evocative way and later extract valid qualitative data as profile input.

Method

The generative design research method is used for this activity. The knowledge, like people's intimate preference, needs time for immersion and reflection. Some people are less aware of their preferences. A generative design approach can sensitise people and evoke them to express their needs and preferences (Sanders & Stappers, 2013). As shown in figure 23, compared with interviewing or observation, the advantage of this method is that it provides tacit and latent knowledge through what people make.

A toolkit is usually needed for this type of research. Among all toolkit types, a dairy toolkit is decided to be used. A toolkit in the form of a diary can spread activities or tasks over several days. People can have enough time to immerse themselves. Enough information can be gained without burdening participants with too much workload. A semi-structured interview is followed after participants finish the diaries.

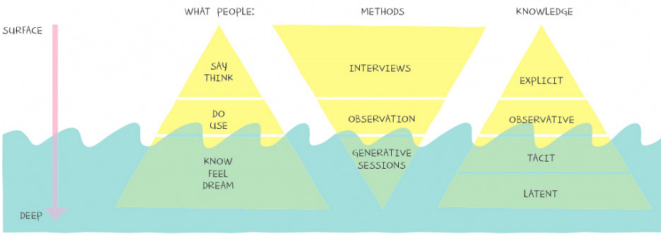


Figure 23: Different methods helps designers to understand the knowledge about people in different layers. A generative session can reveal what people know, how they feel and what their dreams are (Sanders & Stappers, 2013)

Participants

Considering non-patients also have sleep and music preferences and the project's time constraints, only healthy people were recruited. There are 14 participants in total in two separate groups. Group 1 has six participants who are nurses, managers and specialists from Reinier de Graaf Hospital. Group 2 has eight laypeople as participants. Participants' demographic details are shown in figures 24 and 25. Due to the availability of healthcare professionals, only laypeople were interviewed after finishing the diaries.

Participant (group 1)	1	2	3	4	5	6
Gender	Female	Female	Female	Male	Male	Male
Profession	Health professional	Health professional	Health professional	Health professional	Health professional	Health professional
Nationality	Dutch	Dutch	Dutch	Dutch	Dutch	Dutch

Figure 24: Demographics details of recruited participants in group 1 for generative research

Participant (group 2)	1	2	3	4	5	6	7	8
Gender	Female	Female	Female	Male	Female	Male	Male	Female
Age	23	27	28	24	24	23	24	49
Profession	Student	Student	Student	Student	Student	Student	Student	Teacher
Nationality	Chinese	Korean	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese

Figure 25: Demographics details of recruited participants in group 2 for generative research

Material design

Diary as both prototype and sensitizing material is designed (see figure 26). As a prototype, the goal is to evaluate whether the questions and answers in the diary can be used to understand patients' sleep and music preferences for profiling. As a sensitizing material for interviews, it lets people immerse themselves in past sleep and sound experiences.

Based on the question list from the exploratory interviews, a new list of questions is designed. The questions are selected and reframed according to the feedback from the design students (see appendix D). These questions are used to create the first version of the diary (see appendix E). Later on, an iteration was conducted based on four pilot tests with students and researchers. They confirmed the content and form to ensure no misconceptions and everything was as simple as possible. Finally, the physical diaries were printed and delivered to the participants (Figure 26). Since not all the participants can receive the physical diary, a digital one was created in Miroboard, which had the same content.

Procedure

Group 1 procedure:

1. The way to introduce the toolkit is as important as the design of it (Sanders & Stappers, 2013). The first step was to introduce the tasks and purpose of the research activities in an online zoom session to health professionals who were not familiar with creative design sessions. Figure 27 shows two of the presentation slides on the zoom session.
2. Physical books were delivered to participants with daily reminders via WhatsApp around 8:00 am with filled examples as inspiration. The filled examples can be seen in appendix G.
3. Diaries results were collected via WhatsApp messages

Group 2 procedure:

1. Participants chose a digital or a physical diary.
2. Participants were asked to complete the diary in five days and were introduced to the tasks.
3. After they finished it, they contacted the researcher for a 30-minute interview.
4. The 30-minute semi-structured interview was conducted with a list of questions. The goal is to evoke participants to talk about their needs for sleep and music.

Figure 26. Printed booklets with stickers and envelopes

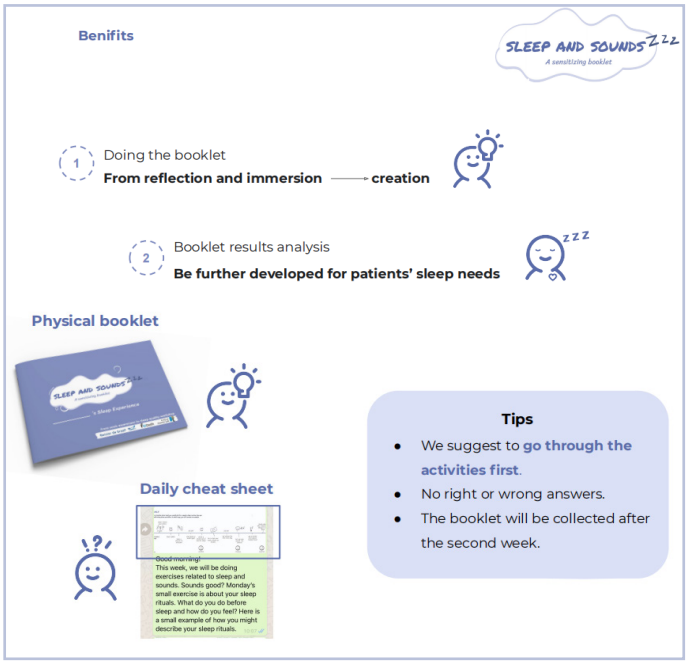


Figure 27. Two of the slides for introducing the diary booklet to participants online

Sounds & sleep diary content

Sounds and sleep are very personal experiences. We have different perceptions of similar sounds and different strategies for better sleep. Combining personal preferences of sounds with sleep habits, we may identify opportunities for sounds in sleep.

The diary is divided into three parts: “sleep behaviour and rituals”, “sounds and sleep,” and “music persona” (see figure 28). The diary will move from sleep preference questions to music preference questions. Based on the explorative interview insights, questions that are easy to answer are put in the beginning part and questions that need time to reflect on are put afterwards.

Topic 1: Sleep behaviours and rituals

Topic 1 on day 1&2 is about sleep routines. Sleep preferences and sleep habits are the foundation for music implementation. It allows designers and researchers to know how music can aid them to fall asleep in their desired way.

On day 1, participants make a timeline to describe their activities before sleep and their feelings and thoughts towards those activities (see figure 29). This part aims to reveal people’s sleep habits. The storyline is used to evoke people’s memories (Sanders & Stappers, 2013). The sentence on the left corner suggests participants use provided stickers to express feelings. Stickers with emojis are used because it can be difficult for some participants to describe feelings. It also makes the exercise more engaging and interactive. Since there might be some cultural differences towards the meanings of emojis, participants write down the feelings in words next to emojis.

Figure 28: The diary covers three topics from sleep to music throughout five day

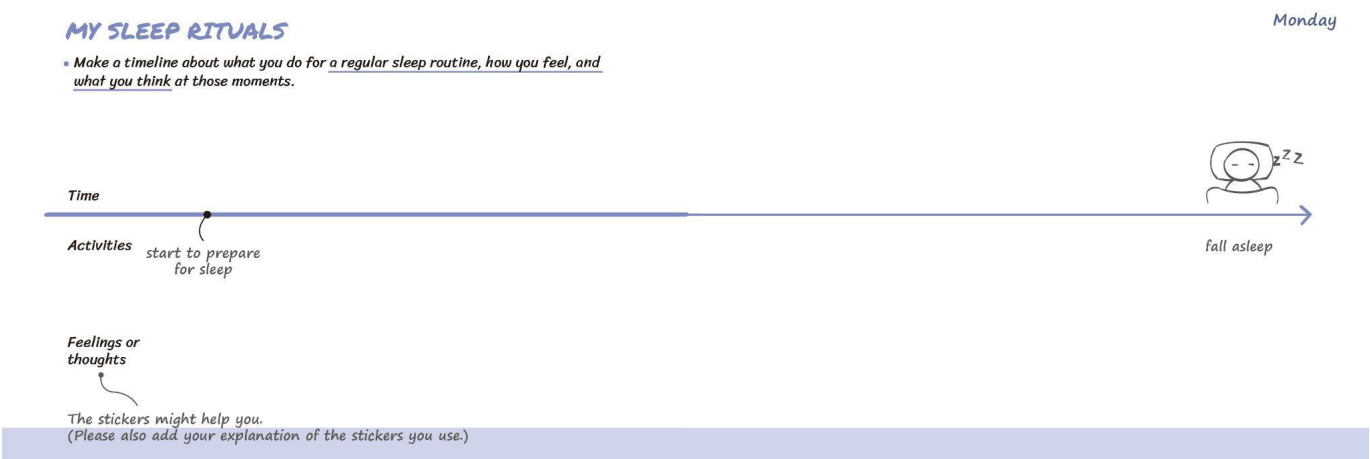


Figure 29. The activity on day one is describing sleep rituals in a timeline

On day 2, the activity is about naming specific tricks and threats for better sleep and the underlying reasons (see figure 30). Listening to music before bed as a habit or aid is not a sleep routine for most people. To look for music and sounds design opportunities, the first step is to know people's current sleep aids that reflect their sleep preferences. The sounds and music could be a better and healthier substitute for these aids. Similarly, examining personal threats to sleep helps us understand what we should avoid for better, more personalized sleep.

Topic 2: Sounds and sleep

Topic 2 aims to understand the relationship between sounds and personal sleep experiences.

On day 3, participants are asked to pay more attention to sounds before bed (see figure 31). As this activity can evoke positive or negative memories, the second part is about recalling sound memories. This exercise is based on the assumption that people have different preferences (positive and negative) for sounds during sleep. A sound that is helpful to one person may be disturbing to another. Recognizing that people perceive sounds differently may help to provide appropriate music. This activity could also assist participants in developing a greater awareness of sounds and learning more sound vocabulary, which will be helpful for the activities later on. It is known from the pilot tests that it can be difficult for people with no musical experience to describe sounds, so a speech bubble is added to stimulate expression.

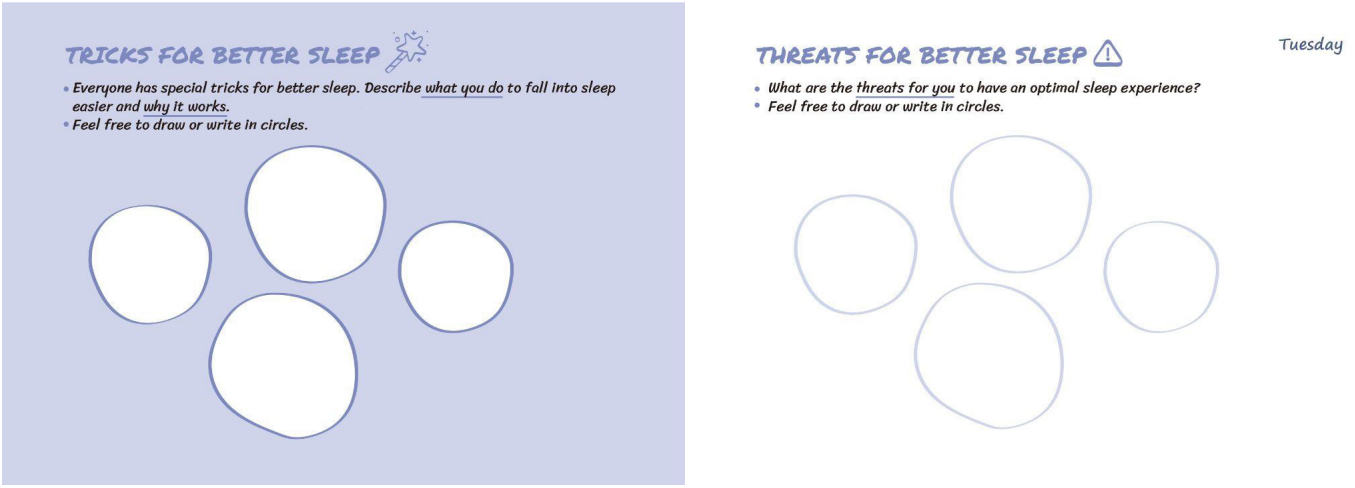


Figure 30. The activity on day two is providing tricks and threats for better sleep

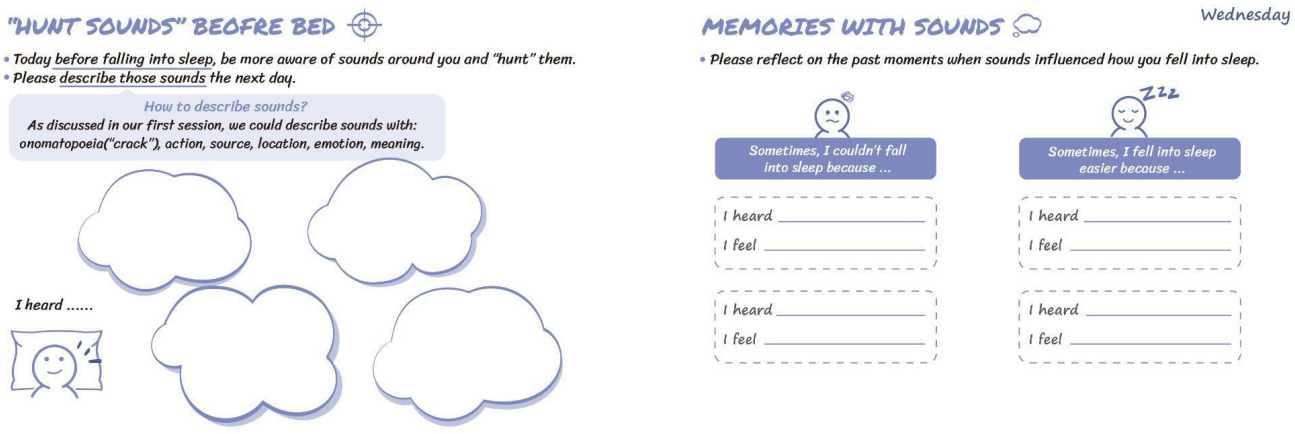


Figure 31. The activity on day three is to listen to sounds before bed and recall memories with good and bad sounds

On day 4, participants are asked to imagine a dreamscape perfect for them and draw a holistic picture of this environment (figure 32). In this way, a visible relationship between sleep preference and sounds will be established. One assumption is that music may help people fall asleep because it creates the desired sleep environment with sounds. Having users draw or stick emojis makes the activity interactive and increases the likelihood that they will express themselves personally. Richer information about personal preferences can be discovered. The “see, hear, feel” questions are asked first to stimulates the imagination.

Topic 3: Music persona

The final topic on **day 5** is sound persona: what kind of music or soundscape they like or dislike (see figure 33). The definition of sound persona here is a personal preference for certain musical elements. Participants are asked to write down two of their favourite and least favourite music, with an explanation of what music aspects affect their choices. The preference towards musical elements (both liked and disliked) brings a closer understanding of individual differences in music preferences.

Figure 32. The activity on day four describes the perfect personal dreamscape.

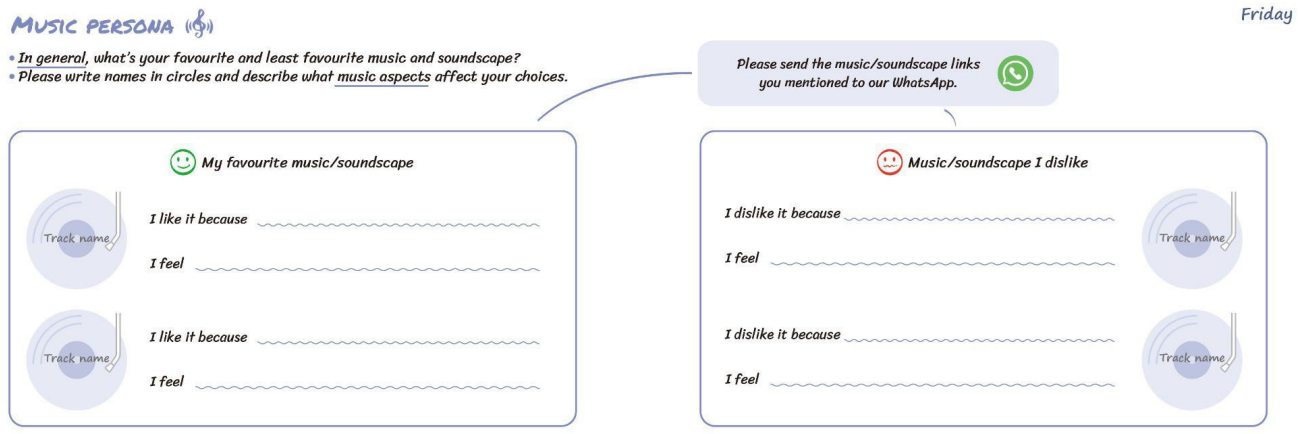


Figure 33. The activity on day five is introducing the two favourite and least favourite music.

3.4. Generative research results

In this part, the results of the qualitative research from diaries and interviews will be presented as a whole.

Sounds for sleep

Based on the input of the diary “Sounds as aids and threats” and interview scripts, people’s preferences towards sounds for sleep were identified (see figure 34). The findings will be used as inspiration and requirements for sound design.

Sound as aids

As shown in figure 34, sounds that people perceive as sleep aids include nature sounds, animal sounds, sedative music, and silence. Because the feelings and types of sounds vary widely, we can assume that this also reflects people’s individual needs for how music can aid their sleep.

These sounds can evoke safe, relaxed, and positive feelings. It seems that these feelings are all associated with a low emotional arousal state. Some people prefer silence because it makes them feel safe. Others enjoy listening to music and enjoy being in a place where they feel content and calm.

The research involves a relatively small number of people, so the sound clusters can not cover all possible sounds as sleep aids. However, the results are valuable as sources of inspiration for the sound design part of the design phase. In addition, the final design should evoke similar feelings.

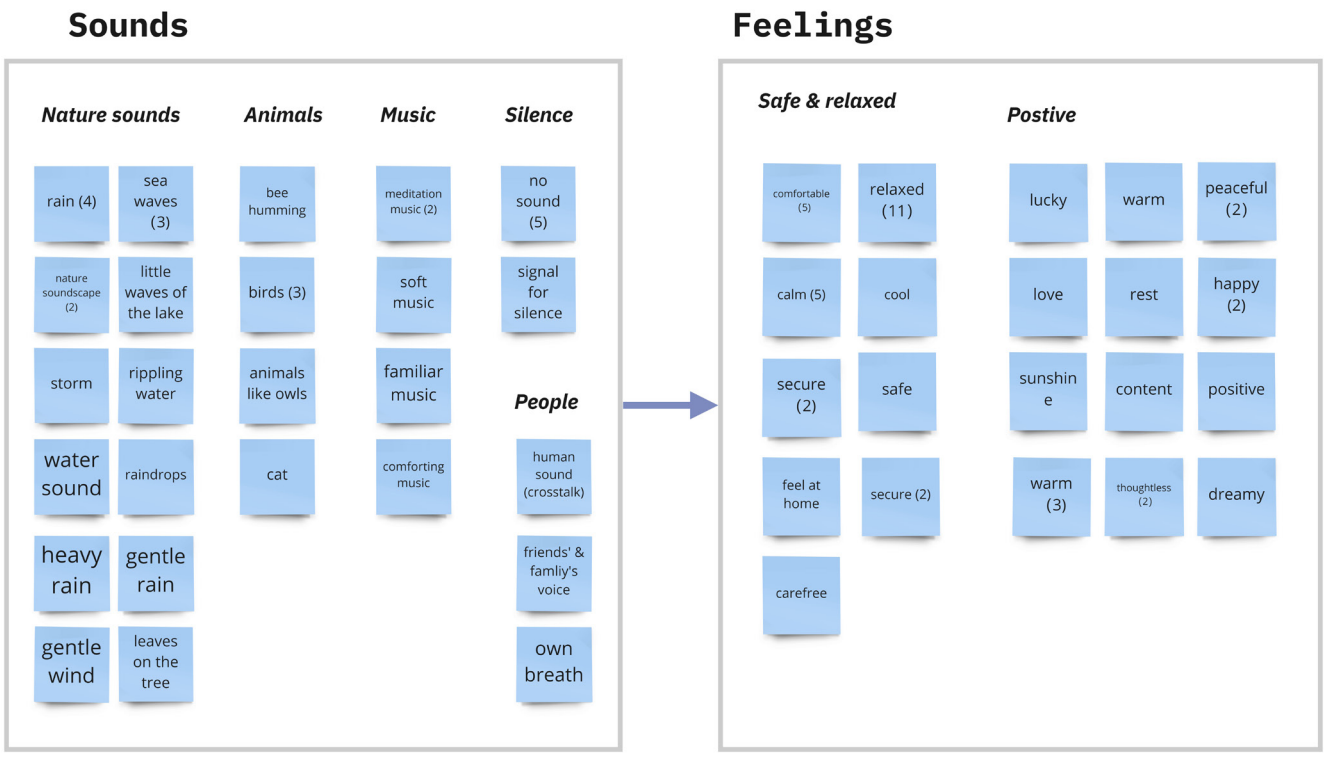


Figure 34. The sounds that people believe can help them fall asleep and the feeling evoked by these sounds

Sounds as threats

Sounds that people perceive as sleep include: sounds from people around, inappropriate music and object noise(see figure 35). These sounds can cause negative feelings such as anger and agitation. The similar characteristics of these sounds are unpleasant and unpredictable. Most of these sounds can be perceived as noise and are not pleasant to listen to. The angry feeling could be evoked when listeners cannot control the sounds themselves. People also feel alarmed and alert by the sounds which they perceive as warnings. The results suggest that appropriate sounds for sleep should be pleasant to listen to, bring listeners a sense of autonomy and avoid sounds that resemble alarm sounds.

General requirements of sounds as a sleep aid

According to the results of the interview analysis, the general requirements for sleep-promoting sounds are both predictable and flexible.

Predictable

Sounds should be predictable and controllable for the listener. The predictability of sounds is important to avoid evoking negative emotions and giving the listener the feeling of autonomy.

- *"I prefer a quiet environment because I feel like I am in control."*
- *"If I know when the noise is going to stop, I feel less anxious."*

Flexible

Sounds should also be flexible enough to accommodate people's sleep conditions and sleep needs. For example, different sleep conditions may require different sounds. People usually prefer silence when the environment is too noisy. When it is too quiet, people tend to prefer subtle sounds. Preferred sounds may also be different for the same person under different situations. Some participants said they used music to help them fall asleep when they were awake till late, but when they felt tired, they preferred silence.

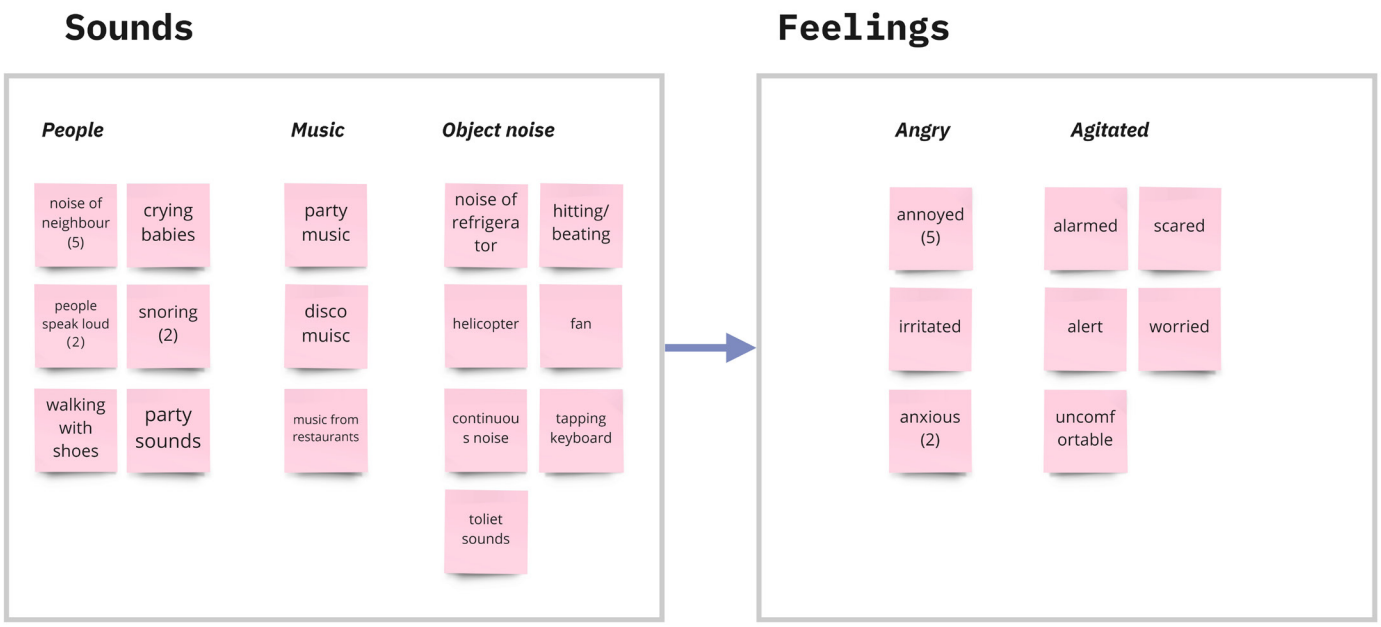


Figure 35. The sounds that people perceive as threats for sleep and the feelings evoked by these sounds

Desired dreamscape

All participants were asked to draw their dreamscape in the diary and describe where they are, what they see and hear, and how they feel (see figure 36). The results about the dreamscape were analysed by clustering keywords. Through the analysis process, patterns are found. This part presents results about "view" and "location" because the "hear" and "feel" parts have very similar results as the "sound as aids" (see figure 37).

Figure 36. Participants' various dreamscapes

Locations in the desired dreamscape

The types of dreamscapes do not vary much. Dreamscapes are mainly holiday places like "beach", "forest" and "lake" as well as "home". It can be seen that familiarity increases from fantasy places to holiday places to home.

Views in the desired dreamscape

What people want to "see" in their dreamscape are beautiful natural landscapes with a little dynamism. The dynamism comes from the fact that the dreamscape is usually not a still image but a dynamic environment for the participants. For example, one participant described her dreamscape as follows:

> *"I could see the moon over the water and some deer in the meadow near the edge of a forest." Similarly, another participant described, I could see the sun going down, people celebrating summer on the beach around a fire and enjoying a cocktail."*

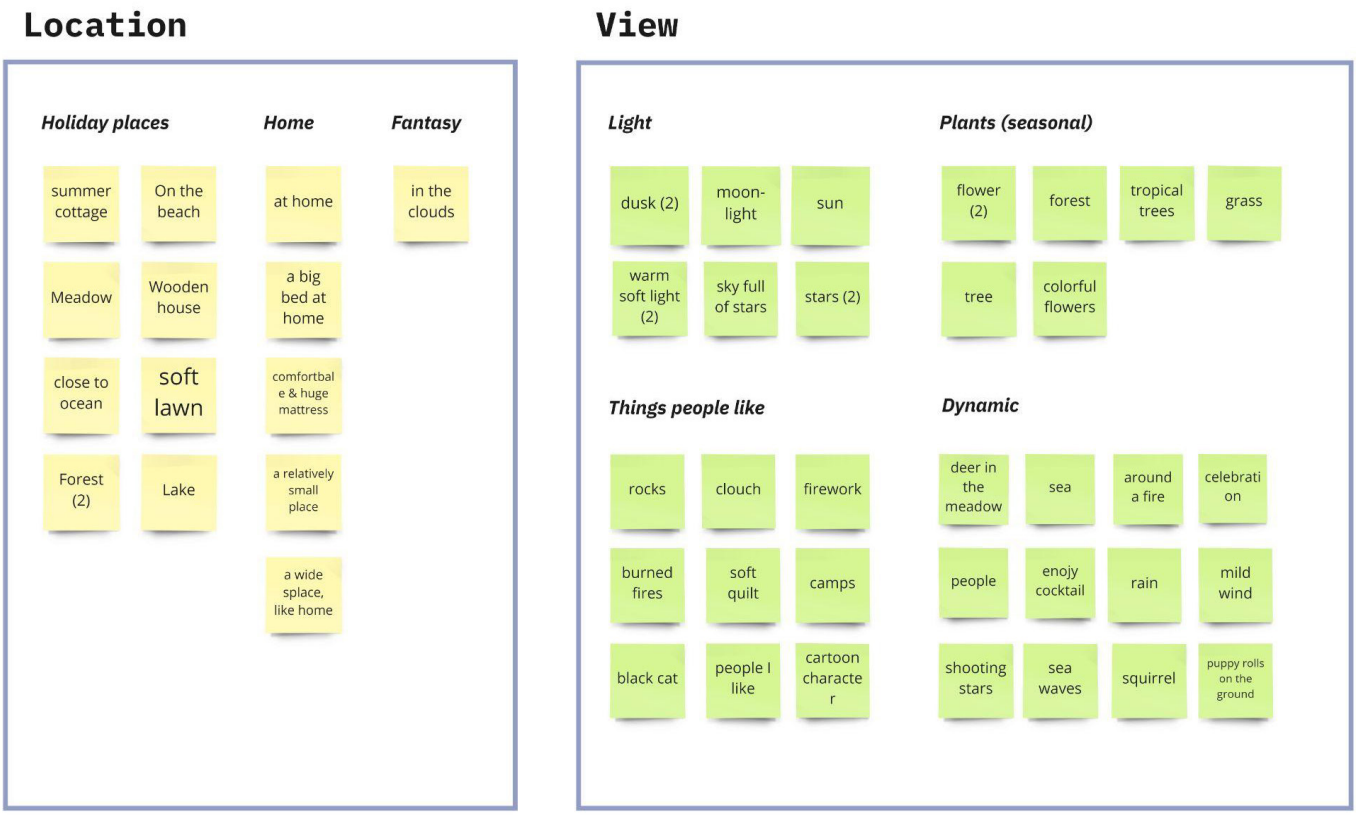


Figure 37. Clustering the keywords mentioned in participants' dreamscape

Three sleep needs

Based on the results of the interview, ease, enjoyment, and away from reality are identified as the three most essential sleep needs (see figure 38). They can be solved by the functional role of music, which includes distraction, entertainment, relaxation, enjoyment and masking (see chapter 2)..

Ease

The need for ease means that people have no worries on their minds and are in a low emotional state of arousal. It covers both physical comfort and mental ease. Physical comfort can be achieved through the entertainment function of music. Mental ease can be achieved through the distraction or enjoyment function of music.

"I just want to empty my mind and avoid negative thoughts."

Enjoyment

People seek enjoyment before sleep by engaging in simple physical or cognitive activities such as "breathing exercises," "reading books," "listening to music/radio," and "playing Sudoku." Some participants enjoy recalling good memories from the past to feel satisfied and pleasant.

"I want my dreamscape to be near the seaside, so I can hear ocean sounds…"

Away from reality

Being away from reality means being away from daily life problems and forgetting about their daily life concerns. People want to prepare their minds for sleep by having a clear mind.

"Reading books helps empty my brain and thoughts … I forget the world, and my mind is well-prepared for sleep."

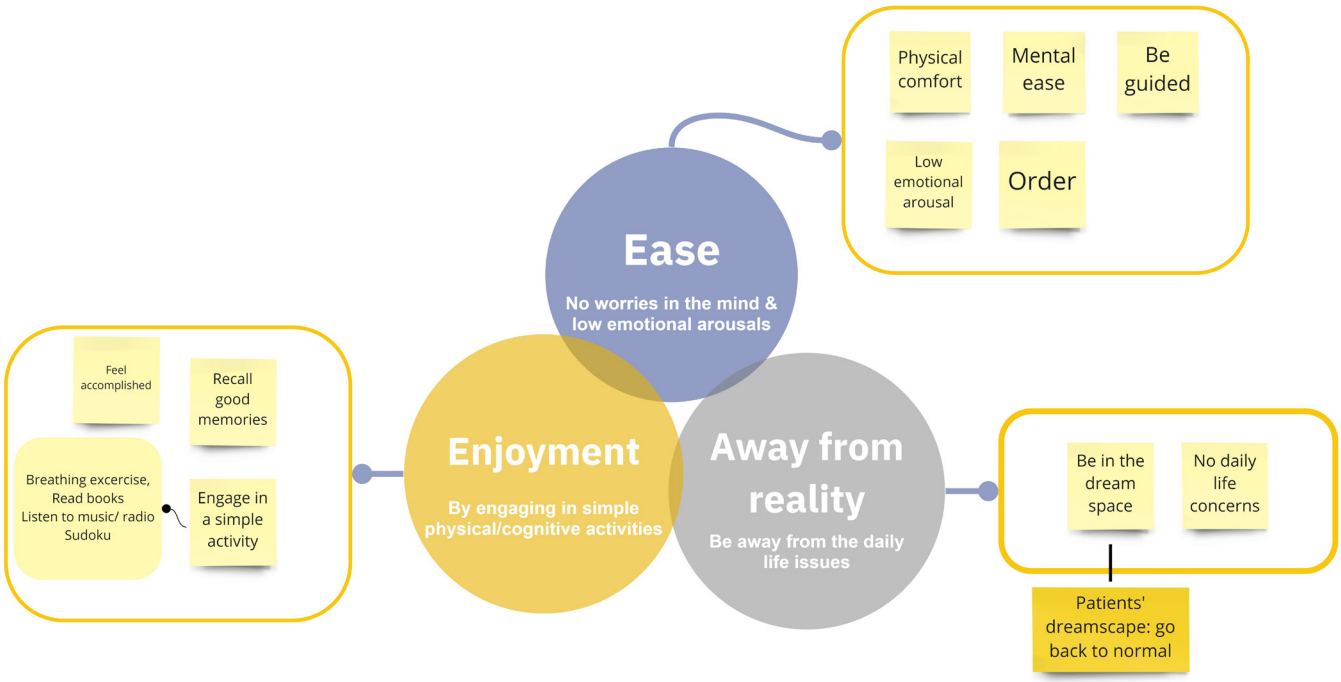


Figure 38. The three most important sleep needs: ease, enjoyment and away from reality

Sleep needs of patients

These three needs are further confirmed through an interview with the nurse working at Reinier de Graaf Hospital. Patients have similar sleep needs but might be due to different reasons.

Ease

Patients usually have many worries due to their health conditions and uncertainties towards the future. Some of them also suffer from pain. When they get rid of fears and feel physically relaxed, they are more likely to fall asleep better.

Enjoyment

Patients' before bed activities reflect their need in seeking enjoyment. Many patients take their laptops or watch TV in the hospital to entertain themselves and feel more enjoyable.

Away from reality

Patients also feel the need to be away from reality. However, it is more likely for patients that everything is back to normal in their dreamscape, and they are at home with their family instead of escaping daily life issues.

Music preference

By letting people describe what aspects they like or dislike about their self-selected music (in diary day 5), insights about music preference are discovered.

Preference for sound features

The sound characteristics of music are part of the reasons why people like or dislike certain music. As one participant said,

- *"I like music with a relatively slow tempo, low pitch and low frequency."*

Tone, tempo, rhythm, dynamics, complexity, and pitch were all the musical characteristics mentioned by participants. This indicates individual preferences for the sound itself and may explain or even predict people's favourite music.

A functional role in life

Although music is liked by most people, it is not an important part of daily life for everyone. Some participants likeed certain music because music could help them achieve goals. The functional role of music can benefit people and also create positive feelings.

- *"I like yoga music because it calms me down and makes me feel relaxed."*
- *"With this classical music, I can concentrate better."*
- *"It's very relaxing, and I can feel the vibrations going through me. I feel uplifted, fulfilled."*

Being in a place you like

Music can have many positive effects on people. Apart from the direct effects on the physiological level, music can create a desired virtual environment for people. Seven participants explained the reason for their preference along these lines. One participant said that he likes natural soundscapes for sleeping because it makes him feel like he is outside in the mountains where he feels comfortable and can sleep peacefully.

- *"It makes me feel at home, or somewhere I lived before. I feel very safe."*
- *"I feel like it takes me to a place that is far away and empty."*
- *"It makes me feel like I am walking in a meadow. I feel open and free."*
- *"Meditation music makes me feel like I am in a peaceful and calm environment."*
- *"I like rock because it has a good atmosphere."*

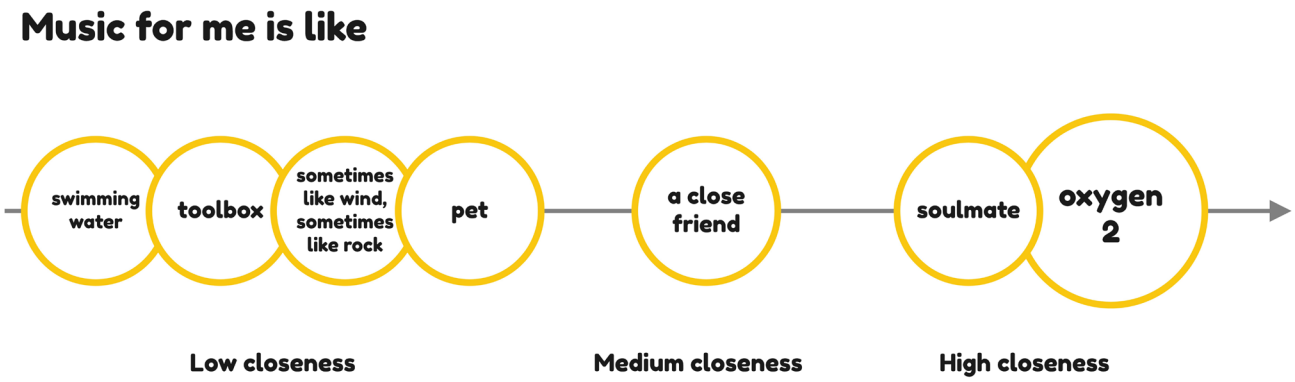


Figure 39. People's relationship with music from low to high closeness

Relationship with music

There are different degrees of closeness in people's relationship with music. As shown in figure 39, the relationship can be clustered into three levels of closeness.

(1) High closeness

People with high closeness see music as an essential part of their lives and listen to music almost every day.

> *"Music is an essential part of my life. I can't live without music."*

(2) Medium closeness

People with medium closeness usually regard music as their close friend. They listen to music quite often. Music can provide them with functional support.

> *"Music is like a friend of mine who can help me out when I'm in trouble."*

(3) Low closeness

People with low closeness see music only as a tool. They don't listen to music regularly.

> *"It's nice to listen to some music, but it's okay if there is no music."*

3.5. Conclusion

The user research was conducted with the generative research method. A sleep and music preference diary was designed as a generative research material and a prototype. The main results and findings include:

Based on diary results, "sounds as sleep aids" and "sounds as sleep threats" were summarised. The general characteristics of sounds are concluded based on interviews. Three general sleep needs: ease, enjoyment and away from reality, were identified through the clustering method. These needs are further confirmed to be applicable for patients after an interview with a nurse working in Reinier de Graaf hospital

4. By letting participants describe what aspects they like or dislike about their top 2 favourite and least 2 favourite music, different elements were found in music preferences like musical features, the functional role of music, what kind of environment the music can create and the relationship with music.

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Chapter 4

Creating sleep music profiles

CHAPTER OVERVIEW

4.1. Profile creation process overview

Based on the learning points in profiling approaches research in chapter 2.6, the following profile creation process is defined (see figure 40). It includes three steps: highlighting and organizing meaningful quotes from user research, creating preference tags representing personal preference, and finally defining two dimensions from the tags to create final profiles.

Before creating the profiles, it isn't easy to foresee what content should the profile include precisely. There are no specifications and guidelines for profiles creation as well. However, as mentioned in the literature review, **the profile's content should be highly related to the purpose.** Therefore guidelines are designed first to direct the profile creation process based on the objective of personalization. The tags that can create a profile fit with the guidelines should be chosen.

The created profiles should meet the following requirements:

- Rather than focusing on presenting detailed elements of people's preferences, the profile should be at an appropriate abstract level. In this way, the profile can divide people into different groups based on their preferences.
- Since both music and sleep preferences are not stable attributes, the profile can present at least some stable aspects, which can improve the reliability of the profile.
- The profile as a basis should be possible to be implemented in a personalization system.

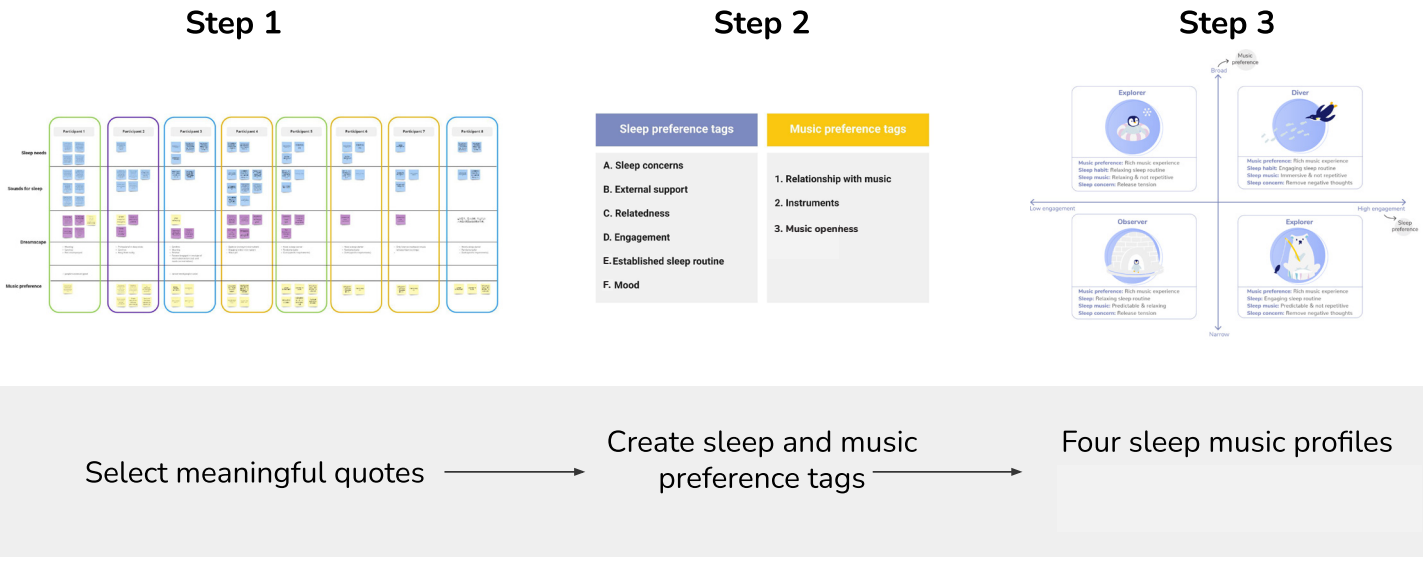


Figure 40. An overview of the profile creation process in three steps

4.2. Create preference tags

Select meaningful quotes

Meaningful quotes that reflect personal preferences were selected from the diary and interview results. Individual differences were highlighted for comparison. For example, some differences are clear conflicts. One participant wants to feel fulfilled before going to bed. The other wants to explore without a goal. Some differences involve different expressions of an attribute. For example, it is important to do activities that require low cognitive effort before sleep, but some participants enjoy doing activities that require more mental effort.

From the results, it was found that individual preferences differ in many aspects. Therefore, all sleep and music preferences differences were collected and listed as tags (see figures 41&42).

Sleep preference

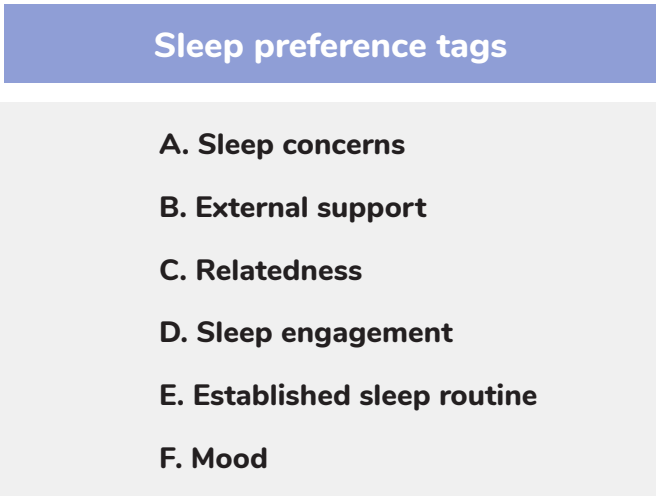


Figure 41. An overview of sleep preferences tags

A. Sleep concerns
Sleep concerns refer to what kind of sleep problems people want to solve with music. These include removing negative thoughts, masking noise, and feeling relaxed.

B. External support
People also need different amounts of external support, from people with no sleep problem, who need little support, to a need for sleep improvement or sleep aids.

C. Relatedness
The prefered sounds reflect the level of relatedness that people need. Some participants prefer silence because they want to feel alone. Others want to be accompanied by the voice of their family because it makes them feel safe when they sleep.

D. Sleep engagement
There is a wide range of activities that people engage in before sleep, such as going straight to sleep to reading books, watching videos, or playing Sudoku. People's sleep preferences differ in the level of engagement need for the activity they like to do before sleep.

E. Established sleep routine
People's sleep preferences also differ in terms of whether they have an established sleep routine. Some participants already have sleep playlists, have gotten into using earplugs or meditating before bed. They have tricks and develop them into a habit. The others only occasionally use music or meditation as a tool. This preference could affect their acceptance of using music.

F. Mood
According to the clusters of feelings in the diary results section, people prefer either a relaxed, safe, or positive mood.

Music preference

Music preference tags

1. Relationship with music

2. Instruments

3. Music openness

Figure 42. An overview of music preferences tags

1. Relationship with music
As mentioned before, people have different closeness with music, from low, medium to high. The relationship with music affects the acceptance and affection towards using music as a sleep aid.

2. Instruments
Some participants have a clear preference for certain instruments such as trumpet, piano and violin, but some people have no instrumental preference. There is no clear pattern found in the instrumental preferences. The prefered instrument sounds should better be designed as optional choices for users as a customization function.

3. Music openness
People have varying degrees of openness to music. Some participants are open to all types of music genres and are interested in discovering new music, while the others limit their choices to several music genres. For example, one participant with low music openness said,

> *"I update my music playlist very carefully. I add one or two new songs every year, and some music I like I have been listening to for more than ten years."*

Selection of tags

To conclude, many tags can reflect people's sleep or music preferences in different aspects. According to the guidelines described in the beginning part of this chapter, sleep engagement in sleep preferences and music openness in music preferences are selected.

Sleep engagement represents the way people want to fall asleep. Music openness indicates what kind of music should be delivered to users combined with their sleep preference.

With only two tags, the richness of sleep and music preference found both in literature and user research cannot be fully represented. However, by building a profile foundation with the two tags at the most suitable abstract level, other preference tags can be included easily in the further development and update process. Sleep engagement and music openness can represent and simplify people's preferences to better develop profiles for personalization. At the same time, these two tags are not too abstract that lose the individual differences in sleep and music preferences.

4.3. Define two profile dimensions

As described in the last section, two dimensions for profile creation are chosen: sleep engagement and music openness. In this section, the definition of these two dimensions, the characteristics of the four profiles " explorer". "observer", "hunter" and "diver" created from the two dimensions will be explained in detail.

Define sleep engagement

There is no shared understanding of engagement definition in different domains. Therefore, it is important to know how engagement is defined in a broader perspective before defining sleep engagement. The current definition of engagement is context-specific. The descriptive words indicate the given context, like patient engagement, work engagement, customer engagement, and health engagement. Engagement can be seen as a process (engage in) or a state (be engaged). It involves not only people but also their interaction with the outside environment. According to a recent literature review (Kelders, van Zyl & Ludden, 2020), despite the disputes, engagement in different fields can be seen as "a multidimensional construct comprising behavioural, cognitive and affective components." It means that engagement reflects the users' behavioural pattern, for example, their adherence to usage, which is usually how e-health interventions define engagement. It also includes how much attention is paid, how involved and enjoyable people feel. However, the specifications of the components vary in different domains, so it's important to clarify what these components mean in the given content. This multidimensional attribute with a specified definition of each component is used for defining sleep engagement.

In sleep music profiles, sleep engagement refers to the extent towards which an individual wants to be involved in an activity to aid their sleep.

Figure 43 demonstrates how sleep engagement is defined, reflected on before-bed activities, and the differences between low and high sleep engagement.

How people want to fall into sleep is reflected in their sleep routine and sleep aids. What kind of sleep aid can help them fall asleep and why? From the diary research insights, we can see all sorts of sleep activities, from reading, meditation, playing games, and watching videos. When people cannot fall asleep, they also have different approaches to aid their sleep. These before-bed activities can be divided into low and high engagement dimensions depending on the required efforts. Still, people should be in a low emotional arousal state and be at ease before sleep, which means they shouldn't spend too much cognitive effort. However, there is a difference in the amount of effort they would like to spend. People's level of sleep engagement could influence how they would like to be immersed in the listening experience.

Low sleep engagement is defined as the tendency of spending low amounts of attention and cognitive efforts on before-bed activities. Low engagement activity includes:

- Listen to soft music
- Listen to white noise
- Do nothing before falling asleep.
- Read less interesting books

These activities have the characteristics of requiring people to spend less attention on them. Users usually receive information passively, which causes less cognitive effort and low emotional arousals. Therefore these activities also assist people in relaxation more than distraction.

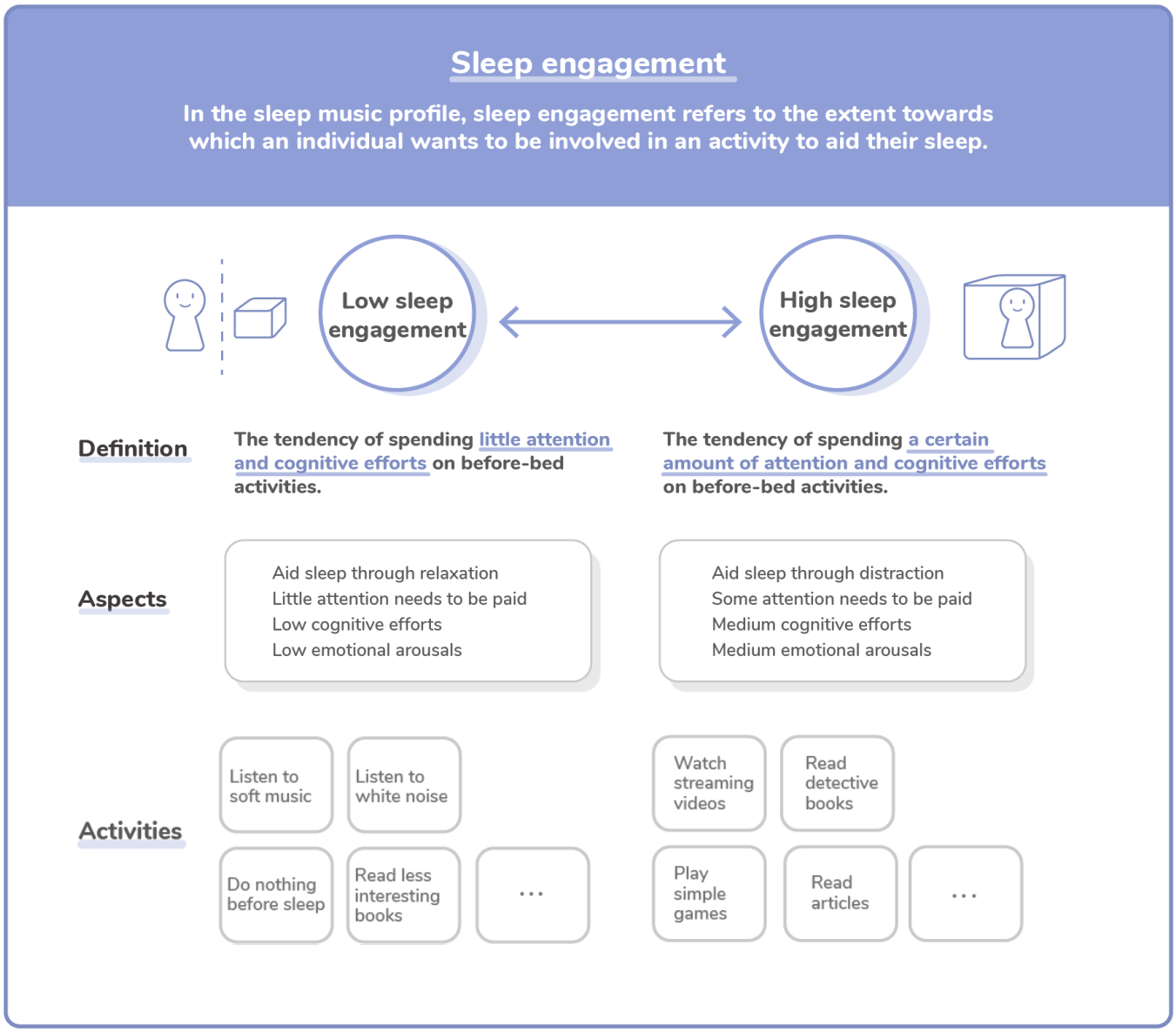


Figure 43. Sleep engagement dimension definition

High sleep engagement is defined as the tendency of spending a certain amount of attention and cognitive efforts on before-bed activities. High engagement sleep activities found in the research include:

- Watch streaming videos.
- Read detective books.
- Read articles
- Play simple games.

These activities aid people's sleep through distraction. They have the characteristics that need people to pay more attention. A medium level of cognitive efforts and emotional arousals are required for doing these activities. Due to these characteristics, these activities assist people to distract more than relax.

Define music openness

According to user research regarding music preference, individuals' music preference includes the relationship with music, type of instruments sounds, and how open they are towards new music experiences. In the music dimension, openness is chosen to be the one that describes individual preferences.

Before defining music openness, definitions of openness and some discussions related to music openness will be introduced first.

In psychology, openness is one of the personality traits in the Five-Factor Model of the big five theory (see figure 44). Big five theory defines the five factors that can reveal people's personalities: extraversion, agreeableness, openness to experience, conscientiousness, and neuroticism (McCrae, R. R., & John, O. P., 1992).

These factors are related to specific qualities to describe individual differences in all aspects. Openness, one of the five personality traits, is still a broad construct and involves six facets: active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, intellectual curiosity, and challenging authority. Each of them is significantly correlated with the other.

Figure 45 presents the facets of low and high openness in the big five theory. People who score low on openness are considered to be closed to experience. They prefer routines and are more practical. They generally have a narrower range of interests. Facets of low openness include: "predictable," "not very imaginative," "dislikes change," "prefer routine," and "traditional." People who score high on openness are more imaginative and creative. They enjoy being spontaneous instead of having a traditional routine. Facets of openness include: "curious," "imaginative," "creative", "open to trying new things", and "Unconventional" (John, O. P., & Srivastava, S., 1999).

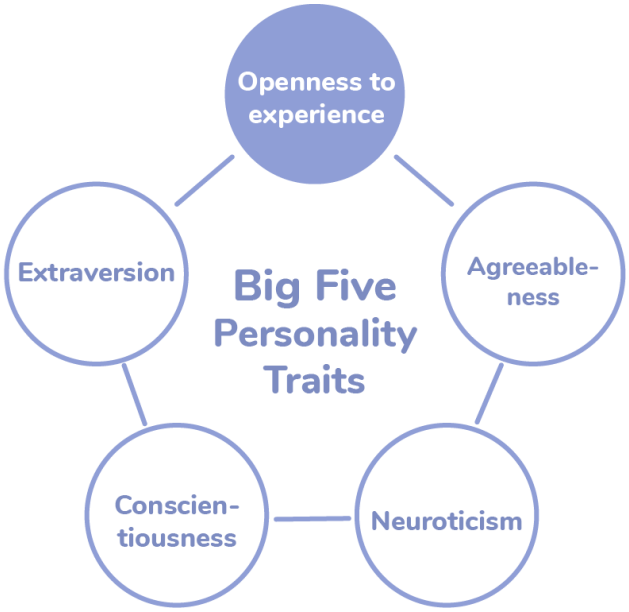


Figure 44. Five personality traits from the big five theory in psychology (McCrae, R. R., & John, O. P., 1992)

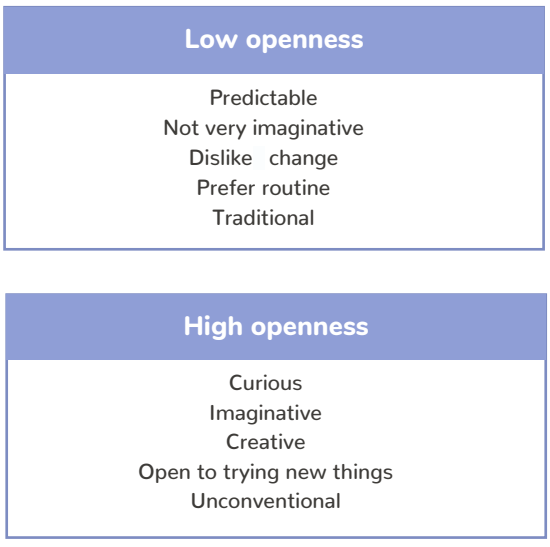


Figure 45. The facets of the low and high openness (John, O. P., & Srivastava, S., 1999)

Similar to sleep engagement, there is no clear definition of music openness yet. However, the relationship between personality traits and musical preference has been studied over the past decade.

The research from Rentfrow & Gosling examined individual differences in music preference, which lays a foundation for the relationship between music preference and personality. From the music preference of 3500 undergraduates, they found four music-preference dimensions: “reflective and complete”, “intense and rebellious”, “upbeat and conventional”, and “energetic and rhythmic”. The main finding is that preference towards these music dimensions correlates with the personality dimensions. For example, openness to experience is related to “reflective and complex”, “intense and rebellious” music preference. It was also found that chronic emotional states don’t have a strong effect on music preference. One possibility assumed by the researchers is that the existing personality dimension influences the general music preference. Emotional state influences what music individuals choose to listen to according in a shorter period.

A recent study from Spotify also suggested the value of personality in music preferences. The relationship between personality traits and music listening behaviour is investigated to assist with machine learning (Anderson et al., 2020). Their work shows contrast with the previous meta-analysis based on self-reports that suggested personality traits don’t have a big influence on musical preference. With the advantage in collecting streaming

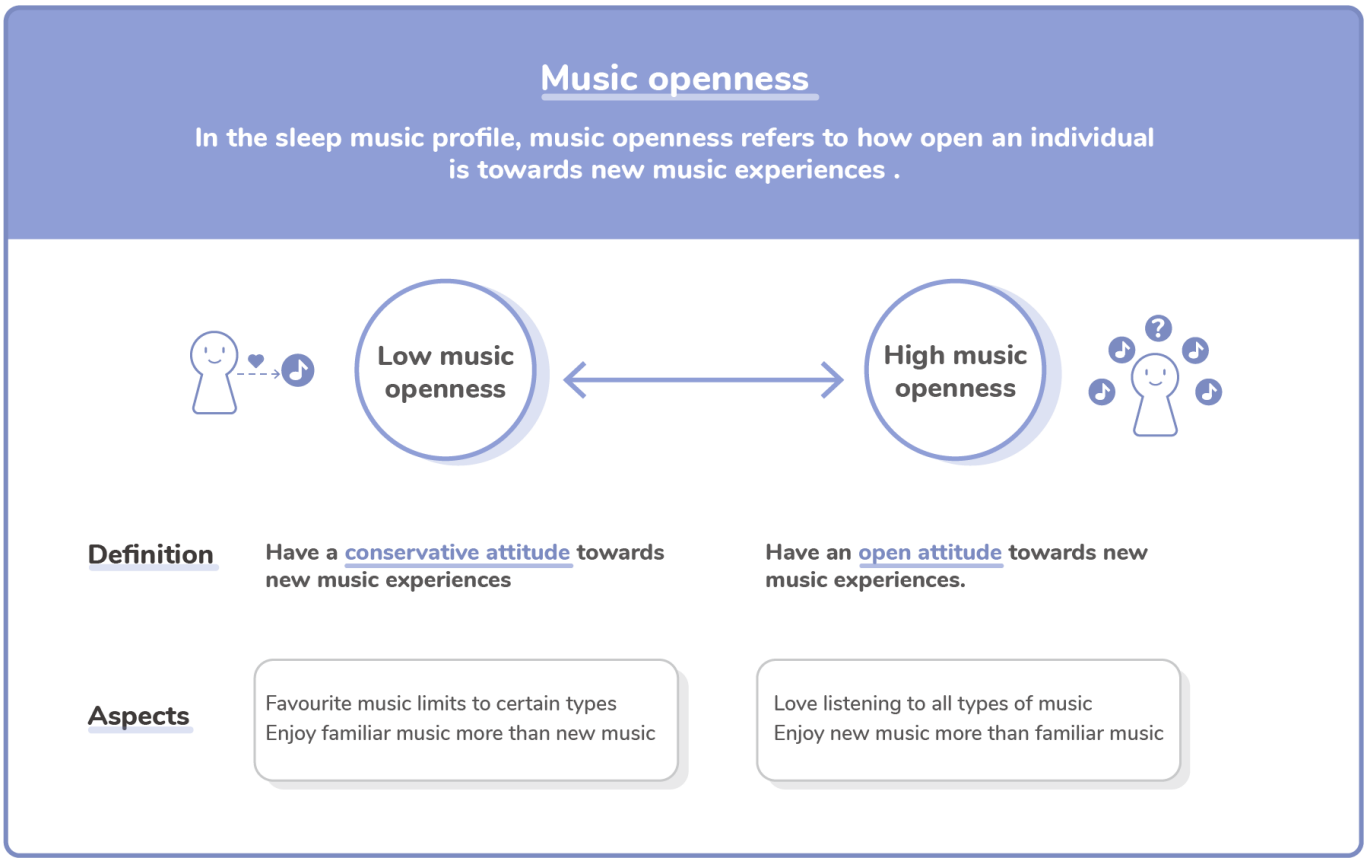


Figure 46. Music openness dimension definition

music listening data, 5808 Spotify users participated in the 3-month study by listening to 17.6 million songs. The findings from machine learning demonstrated that musical preferences and habitual listening behaviours could predict the big five personality traits with moderate to high accuracy. More specifically, Openness correlated positively with “all-time track discovery rate” and “genre entropy”. This finding means that **users scoring high on openness are more receptive to exploring various music genres.**

Music openness in the sleep music profile (see figure 46) refers to **how open an individual is towards new music experiences.** The definition of music openness is very similar to the definition of openness in personality traits, but it is defined in the music listening context.

Individuals with **low music openness** have a conservative attitude towards new music preferences. Low music openness has two main aspects: one is a narrow preference in music types: they prefer only one or two kinds of music, another is they prefer listening to familiar music.

In contrast, **high music openness** involves a general preference in different kinds of musical experiences. For example, people with high music openness usually like to listen to different music genres and will not limit themselves to classical music. People with a high music openness enjoy listening to and exploring new music. They are open to new and novel music, which can keep them engaged. Listening to the same playlist over and over again can easily make them feel bored.

Stability of the two dimensions

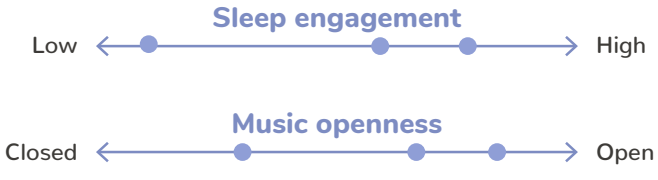


Figure 47. Both sleep engagement and music openness is not stable and are on a contintious spectruam

On an abstract level, the sleep engagement dimension tends to be unstable because sleep habits, routines, and habits are inevitably influenced by many external factors, including noise, mood, the presence of sleep problems, etc. More specifically, bedtime engagement is also unstable. That’s why there is a need first to categorize people’s sleep preferences abstractly while also taking a dynamic view, which will give us a more realistic and integrated understanding of users’ sleep preferences. Engagement is relatively stable for people with regular sleep habits; for people with irregular sleep habits, the level of engagement is less stable. One night people may want to feel relaxed, and the next night they may want to be distracted.

Another dimension, the openness of music, is relatively stable. The main reason is that music openness is based on the definition of openness in personality traits. Although it takes on different forms at different times, personality is relatively stable throughout people’s lives, causing relatively stable music openness over a more extended period than sleep preferences. From a more macro perspective, openness was found to be higher in younger people than in older people. This suggests that openness might change in a more extended period as well.

In addition, a simple distinction between high and low in both dimensions has been made for building profiles for further personalization. In an actual situation, both dimensions would be a spectrum (see figure 47).

4.4. Four sleep music profiles

Four sleep music profiles were designed and visualized by combining the two dimensions: **explorer, diver, observer, and hunter.** In figure 48, these four typical profiles are located in each of the four quadrants of the axis. For each profile, the information marked out includes the naming of the profile's characteristics, the corresponding illustration, and an overview of their sleep preferences, music preferences, and recommended sleep music characteristics. In this section, the aspects of each profile will be described in detail in turn.

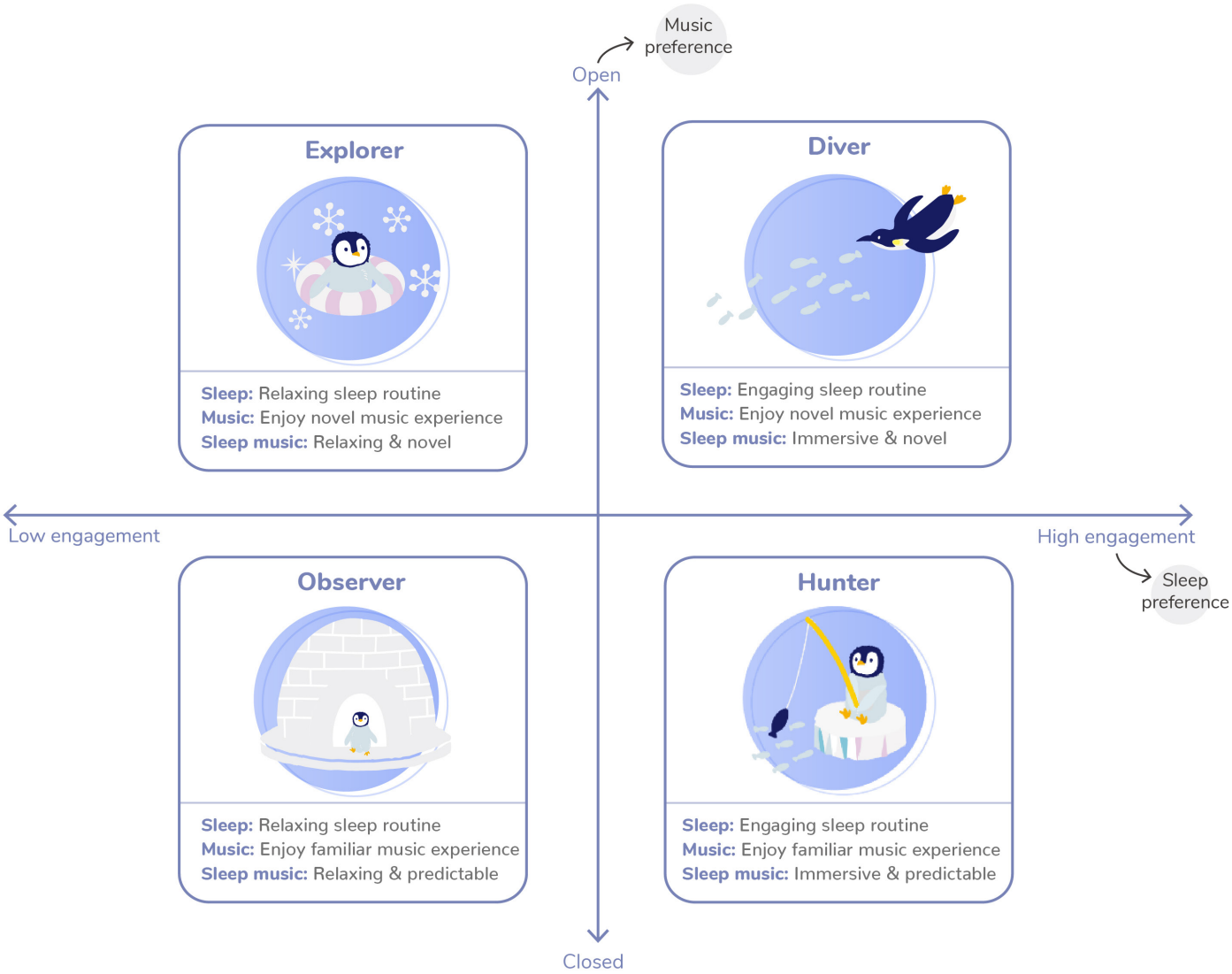


Figure 48. Four sleep music profiles and their traits

Diver profile

High sleep engagement + high music openness

As we can see from figure 48, the diver profile is in the first quadrant. Divers like to focus on some external support before going to sleep. This often requires a certain amount of attention and cognitive efforts, which can help them to shift their attention. As stated in the explanation of high sleep engagement, these activities include but are not limited to: watching streaming videos, reading detective books, reading articles, playing simple games, etc. Divers enjoy doing activities that are less boring and more immersive than activities observers love. These activities can act as a way to help divers to distract their negative thoughts, so they can fall into sleep with more mental ease. It can also be just a habit for divers to feel less bored before sleep.

"On ticktock orWeibo, it has everything and is quite random. I first watched a very boring one, but the next one might be very funny. I enjoy gaining this variety of information."

Divers also have a different attitude towards new music experiences. They are very open and curious to listen to new music that they haven't listened to before, which can arouse their interest and make them feel novel. This also means that they like a wide range of music types.

"It's actually very difficult to find my favourite songs because I think I listen to everything."

Conversely, they get bored relatively quickly with music that they find familiar and are therefore reluctant to listen to it repeatedly.

Sleep music for divers should, firstly, meet the need to listen to new music. Secondly, it should also have an attractive feature to help them shift attention and be engaged.
It is assumed that novel and immersive sleep music is suitable for divers.

Explorer profile

Low sleep engagement + high music openness

In general, the explorer wants to have a very relaxing sleep routine. Before going to bed, they prefer activities that help them relax and require little attention and thinking. Low engagement might come from listening to soft music, white noise, doing nothing before sleep and reading less attractive books.

"I enjoy listening to calming sounds or only silence at night so that I can be with myself and fall asleep easily. If I read interesting novels before bed, I will be too excited."

Explorers, as the name suggests, like to explore different types of music.

" My favourite music changes quite often. In general, I enjoy listening to pop songs which are dancy and rhythmic."

Relaxing and novel music is assumed to be suitable for explorers' sleep music preference.

Observer profile

Low sleep engagement + low music openness

The observer is located in the third quadrant. They also enjoy having a very relaxing sleep routine as explorers do.

"I like reading nonfiction books because it is quite boring. After 10 mins, I'll feel sleepy already because it doesn't attract my attention at all."

Concerning music, observers are more reserved in their attitude towards new musical experiences. They prefer to listen to music they are familiar with, and their favourite genres are single and narrow. For example, they only accept one or two genres of music, and they can have negative feelings when they hear other types of music.

- *"Usually, I only listen to meditation music, healing music, which is very calm and without lyrics. Some melodies from the old songs are also nice, but I cannot accept most songs with lyrics. They sound annoying."*

The sleep music should be designed to aid the observer in relaxation before going to sleep subtly. The content of the music should be familiar, as the observer's preference for music is very narrow, with a conservative attitude towards new music. In this regard, it is reasonable to assume that using familiar music in sleep music for observers would open up and increase the possibility that the delivered sleep music fits with observers' preferences.

In summary, sleep music for observers should be calming and relaxing and use a musical melody familiar to the user to increase predictability.
Relaxing and predictable sleep music is considered suitable for observers.

Hunter profile

High sleep engagement + low music openness

The hunter is in the fourth quadrant of the chart, with high sleep engagement and low music openness. They prefer to do activities that attract their attention and are interesting for them.

The combination of high sleep engagement and low music openness brings about a slightly different musical aspiration than the two above. Hunter wants to hear familiar music.

- *"I like pure instrumental music like piano and cello music. The pitch of the sound should also be in the middle, so not too high or too low."*

Delivered music needs to capture hunters' attention and help them become deeply immersed in the music. Music will play similar effects as the preferred activities described by divers.

- *"Reading helps me fall asleep because it takes some space from my brain.Your mind has to process something. At the same time, my brain isn't too active."*

Therefore, immersive and predictable music is assumed to be suitable for hunters' sleep music preference.

4.5. Conclusion

This chapter introduces how the four profiles were created based on the qualitative data from diary research. Two dimensions: sleep engagement and music openness, were chosen from the personal preferences tags first. Then clear definitions for both dimensions were introduced with support with literature. Finally, four sleep music profiles are designed: diver, explorer, observer, and hunter. The four profiles can represent people's sleep and music preferences. Assumptions about what types of music are suitable for each profile were made based on the profile traits. These profiles will be the foundation for the design of a personalized music experience.

According to previous market research, there are no products that offer personalized music design based on a profile of sleep and music preferences, so the design of music based on the profiles are important for validating the profiles. Combining music and profiles will allow for more accurate verification of these assumptions.

Chapter 5
From research to design

5.1. Design direction

The project goal is to improve the sleep experiences for patients at Reinier de Graaf hospital using music as the primary way of intervention. The desired effects (relaxation before sleep) and the main approach (personalization) are included. Based on the generative research and context research insights, a design direction is defined with design goal, interaction quality and design guidelines.

Design goal

The design goal is to provide patients with **personalized nighttime sonic environments** based on their profiles and help them **immerse in their dreamscape** to feel more relaxed before sleep.

Interaction vision

The interaction with the design should feel like a child **having their favourite story read to them** by their parents.

Figure 49. A picture that represents the desired effects of the final design interaction

In this interaction, children are delighted because they know that this story is their favourite one. They feel guided when their parents help them choose and read the stories to them. With the familiar voices of their parents, they feel safe enough and immerse themselves in the imaginative world of stories. Finally, they fall asleep feeling happy and ease.

Interaction quality

Relaxing: The tailored music listening experience is relaxing.

Enjoyable: Users feel enjoyable while listening the music.

Immersive: Users feel they are away from reality and be immersed in the personalized sonic environment.

Design guidelines

The design guidelines are defined based on all previous research activities from user research, contextual research, literature review and design directions. The design guidelines will be used to select the ideas in the ideation phase and will be included in the final design evaluation plan. Different priorities are defined as follows:

Must (First priority)

1. The delivered sonic environment must be personalized and immersive.

Should (Second priority)

The project usage experience and profile creation process should be easy and intuitive.

Could (Third priority)

Enable customizable functions: The tailored experience is customizable and controllable for users.

Inclusiveness: cater for different patients' capability

5.2. Ideation process

The set design goal, vision, and design guidelines bring the following **design questions**:

1. How can patients create their profiles in an easy and intuitive way?
2. How to design music and sound elements for an immersive experience?
3. How to create personalized music based on patients' profiles?

After two brainstorming sessions using the "how-to" and "crazy eight" method ("Share and engage with the Design Sprint Community", 2021), I came up with as many ideas as I could to answer the design questions (see figure 50). Multiple ideas that can answer these design questions and fit with the design specifications were selected and combined into an initial concept, which will be introduced in the next part.

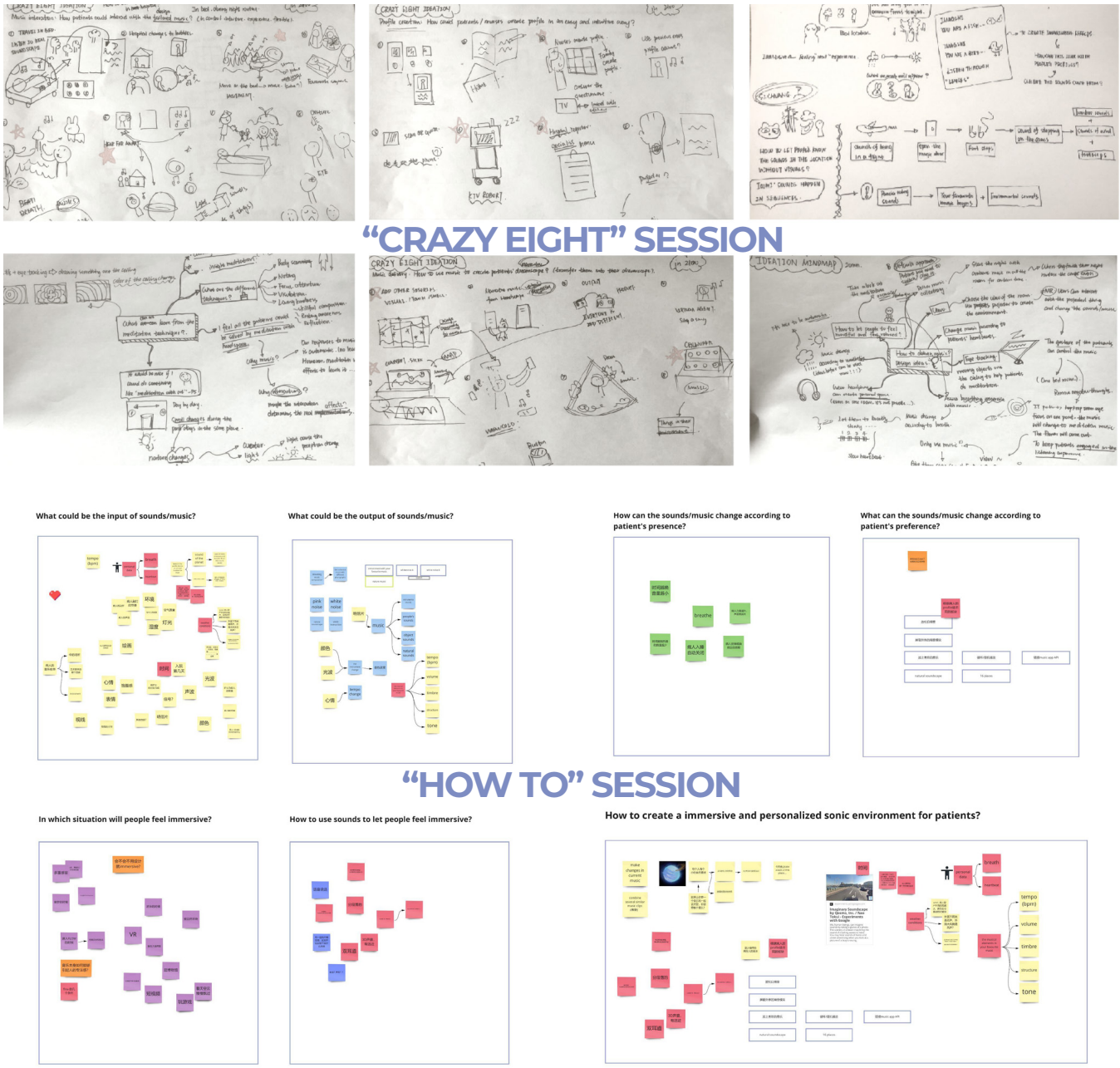


Figure 50. An overview of the two brainstorming sessions

5.3. Personalized modular music system

System outline

The outline of a personalized modular sleep music system is visualized in figure 51. The procedure starts with profile creation as user input. Then, the system maps users' data based on an algorithm to deliver a personalized sound experience.

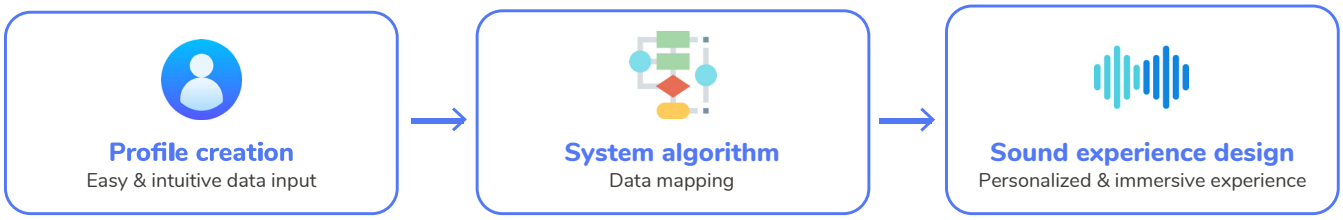


Figure 51. The system outline from data input to data mapping and sound as data output

Profile creation process

Design question 1: *How can patients create their profiles in an easy and intuitive way?*

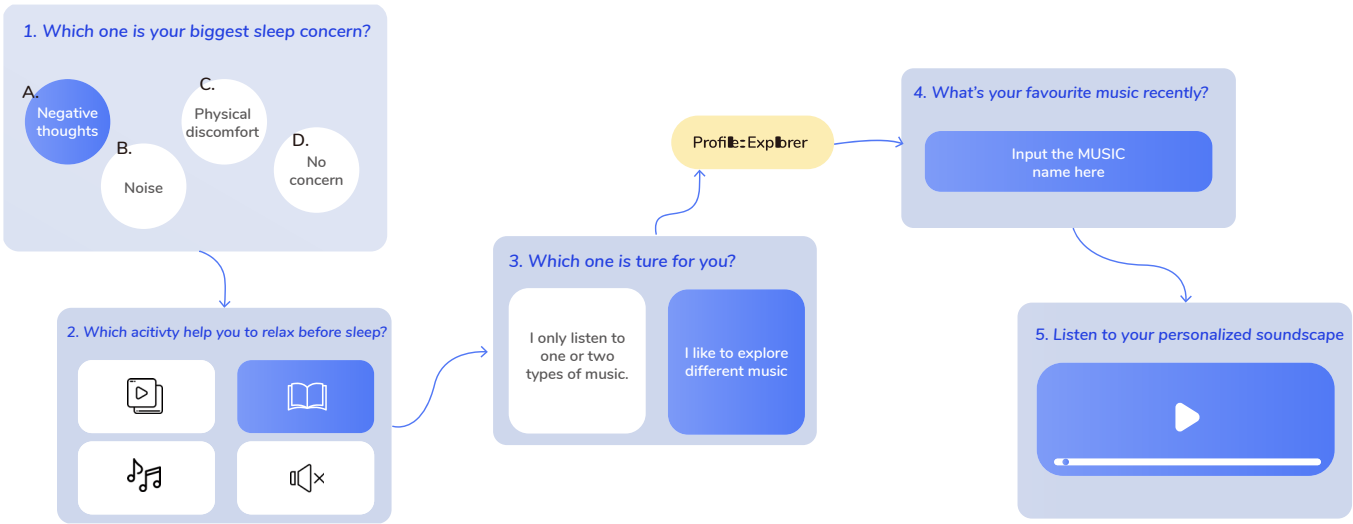


Figure 52. The initial concept about how patients can create their profile in an easy and intuitive way

An initial visualization of how patients can create their profiles is shown in figure 52. Users begin by answering questions to help the system understand who they are. There are questions about sleeping and music preferences, and different profiles are generated based on their answers.

Music experience design structure

Design question 2: *How to design music and sound elements for an immersive experience?*

In the brainstorm session, different ideas about how to create an immersive sound experience came up. The idea of designing the music in a **three-phase structure** was finally chosen, **using the power of music to take participants to their dreamscape step by step.**

The sound experience design idea is first inspired by the play phases: exploration, functional play, variation and integration (Gielen, M., 2020). It is an interaction design theory to help people be engaged and interact with the design. Since listening to music can also be seen as an interaction with an external 'object'. The main difference is that we use another sense to interact. That's why this theory is also considered to be applicable in the sound design context. Similar to the play phases, the phases in the music structure design involve the attraction phase, immersion phase, and entrainment phase. Then the following design question popped up is how to achieve these interaction effects using music.

As mentioned before, music has different functions in aiding people's sleep: entrainment, relaxation, distraction, enjoyment, and masking. These functional roles of music fit well with the effects that I want to achieve in the three phases. Therefore I came up with the idea of **applying the different functional roles of music for these three interaction phases to achieve desired music effects.** Based on these thoughts, the initial sound experience design idea is visualized in figure 53.

In the first phase, immersion, the user's favourite music is played to grab their attention and keep them engaged.

Different kinds of environmental sounds are put together to create a sonic environment in the second phase, the immersion phase. It aims to help people to be immersed in this sonic environment and be away from reality.

Finally, in the entrainment phase, the music tempo will slow down to help people feel more relaxed and slow their heartbeats through the music entertainment effect.

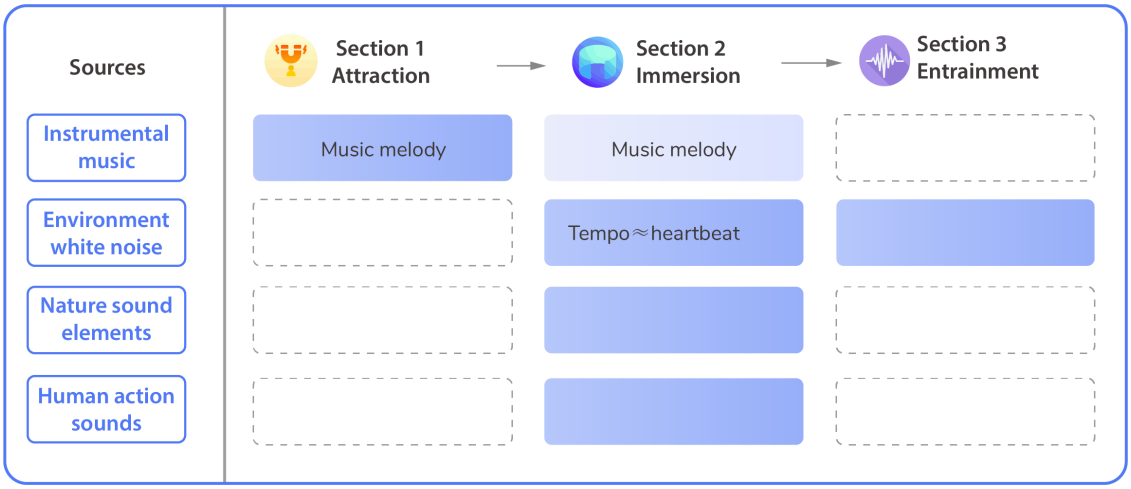


Figure 53. The initial concept of music experience design in three phases, using different functional roles of music

Modular music system logic

Design question 3: *How to create personalized music based on patients' profiles?*

Diver

Sleep: Engaging sleep routine
Music: Enjoy novel music experience
Sleep music: Immersive & novel

Sources \ Phases	Phase 1 Attraction	→ Phase 2 Immersion	→ Phase 3 Entrainment
Instrumental music	Freestyle music	Freestyle music	
Environmental white noise		Tempo=heartbeat	Slower the tempo
Natural sound elements		Random	
Human action sounds		Rhythmic	

Explorer

Sleep: Relaxing sleep routine
Music: Enjoy novel music experience
Sleep music: Relaxing & novel

Sources \ Phases	Phase 1 Attraction	→ Phase 2 Immersion	→ Phase 3 Entrainment
Instrumental music	Freestyle music	Freestyle music	
Environmental white noise		Tempo=heartbeat	Slower the tempo
Natural sound elements		Random	

Observer

Music: Enjoy simple music experience
Sleep: Relaxing sleep routine
Sleep music: Predictable & relaxing

Sources \ Stages	Phase 1 Attraction	→ Phase 2 Immersion	→ Phase 3 Entrainment
Instrumental music	Favourite music	Favourite music	
Environmental white noise		Tempo=heartbeat	Slower the tempo
Natural sound elements		Random	

Hunter

Sleep: Engaging sleep routine
Music: Enjoy familiar music experience
Sleep music: Immersive & predictable

Sources \ Stages	Phase 1 Attraction	→ Phase 2 Immersion	→ Phase 3 Entrainment
Instrumental music	Favourite music	Favourite music	
Environmental white noise		Tempo=heartbeat	Slower the tempo
Natural sound elements		Random	
Human action sounds		Rhythmic	

Figure 54. Four music modules with different sound layers following the same structure are designed to satisfy different needs of each profile

Music modules design

In the profile creation phase, I defined four profiles: diver, explorer, observer, and hunter. Each profile has different sleep music features that fit with their sleep and music preferences. Based on the sound experience design structure, the main question is how to deliver personalized sounds that fit the profile's sleep and music preferences (engagement and openness) and are suitable for sleep.

Different ideas from changing the sound content, the whole music structure, processing the music with different parameters came up. The idea chosen was to change the content of the sounds layers under the same music structure. Figure 54 presents the link between the differentiated music modules and users' profiles.

In the attraction phases, freestyle music is offered for high openness profiles like divers and explorers to satisfy their music needs for exploring and listening to novel and less familiar music. In contrast, favourite music is delivered for creating a familiar feeling for low openness profiles. When coming into the second phase, the volume of the music becomes lower. The combination of music melody and environmental sounds will gradually bring participants to their dreamscape.

In the immersion phase, high engagement profiles listen to immersive environmental sounds, including a human action sound layer, like the footsteps on the beach, which is considered to have the feeling of immersion. Low-engagement profiles will listen to less immersive sounds without the human action sounds layer.

The sound experience design structure and the modular music system will be tested through prototyping and an iterative test in the next section.

Chapter 6
Detailing the profile logic and music modules

CHAPTER OVERVIEW

6.1. Detailing profile generation logic

In chapter 5, the basic profile generation structure was defined. The main goal of the detailing phase is to develop this structure into a profile test. This involves the selection of profile questions, answers and the design of logic pathways towards four profiles.

Due to the project time limitation, it is not realistic to design a well-validated questionnaire like the personality test questionnaire. However, using generative research results as the primary questionnaire input and iterate on the questions with a small sample test can improve the reliability of questions within the given limit.

The profile creation process should be implementable and straightforward, so multiple-choice questions were used instead of open questions (like in the diary). Since four profiles were created based on sleep engagement and music openness dimensions, a logical way of designing pathways of profile logic is to use a list of questions to define these two dimensions separately. The following questions and answers were chosen:

Sleep engagement: What activities do people do as a sleep routine and a sleep aid?

Q1: In a regular sleep routine, you will. . . to fall into sleep better.

Q2. It's midnight, but you are still awake. Which one aids you sleep better?

Sleep engagement is defined as how much cognitive effects people want to spend on the before bed activity. "Watch streaming videos, read detective books, read articles, play simple games" are high engagement ones. "Listen to soft music, listen to white noise, do nothing before sleep, read less interesting books" are low engagement ones. However, it is considered that reading books and listening to audible books can be both high or low engagement depending on the people's understanding. Therefore, the second question as validation is added. People who want to listen to ambient sound instead of being immersed in another world are labelled as low engagement, vice versa.

Music openness: How open are people towards new music experiences?

Q3. Music for me is.

This question is asked to understand people's acceptance of music, not influencing the profile results. The reason for having this question is because some participants might have no interest in music. With the option of knowing people's relationship with music, we could understand their acceptance of sleep music, which can be used as extra information for delivering personalized music.

Q4. Do you like to explore new music?

Q5. Please select the music genres you are interested in.

The openness towards music is more obvious than sleep engagement. Q4 and Q5 are designed to understand users' music openness by asking directly and letting them choose the music genres they like. The answers to these two questions will determine whether the users have a high or low sleep engagement.

The profile generation logic is presented in a flow chart (see figure 55). Colour codings are used to indicate how these answers are mapped into different profile tags.

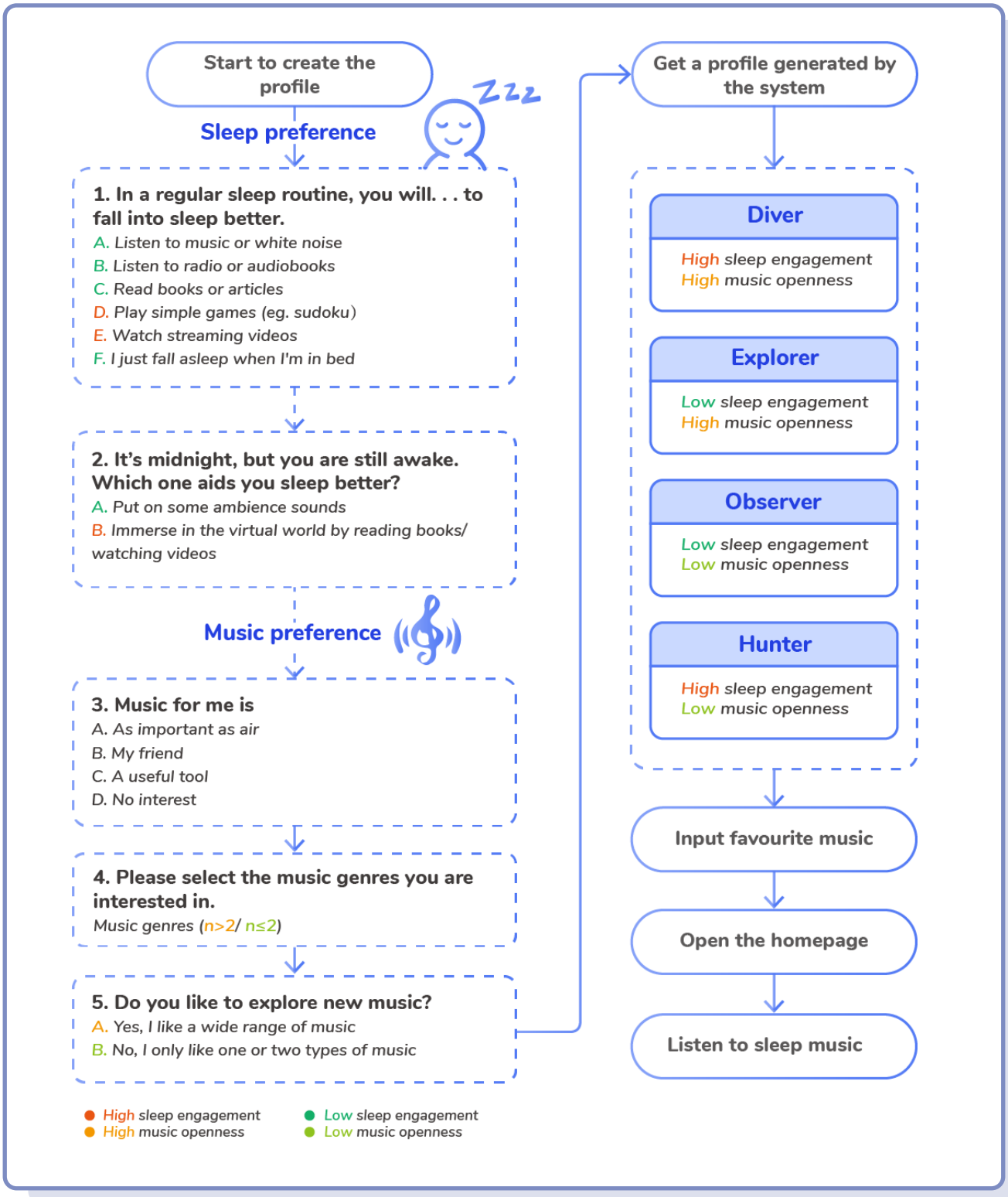


Figure 55. The flow chart of the profile generation logic

6.2. Iterating profile generation logic

Test setup

Research objective

After the creation of profile logic, a small sample iteration test was conducted. The main research objective is to test the profile creation logic and experiences to explore profile iteration opportunities.

The research questions include:
1. How do participants experience the process of creating the profile by answers the questions?
2. Does the generated profiles fit with their preferences?

Figure 56. An overview of interfaces used in the profile generation iterative test

Test method and procedure

An online iteration test was conducted with a google form. Profile creation interfaces were first designed based on the previously designed profile creation logic (see figure 56). Then, these interfaces pictures were embedded in a google form (see figure 58). A full version can be seen in appendix J. Google forms were used to collect responses and still present the interfaces to test the profile experience.

Participants did the test remotely by answering the profile questions in the google form. After participants filled the form, they received their profile through a message and described how they thought about the profile creation experience and how they thought the profile fit with their preferences. If participants generally think the provided profile fits their preference, the profile logic was considered reliable.

Participants

In total, five participants were invited remotely for this iterative test. Their demographic details are shown in figure 57.

Participant	1	2	3	4	5
Gender	Female	Female	Female	Female	Male
Age	24	24	23	25	20
Profession	Student	Student	Student	Student	Student
Nationality	Chinese	Chinese	Chinese	Chinese	Chinese

Figure 57. Demographic details of participants in the profile iteration test

Figure 58. A screenshot of the google form that participants use in the profile iterative test

Easy and meaningful experience

If participants agreed that the profile fit with their sleep music preferences well and was convincing. The complexity level of the profile test was relatively low because profile questions were easy to understand, and the number of questions was suitable. Participants thought the profile creation experience was meaningful because the information would be used in further music personalization. Supported by the system design, users' choices in the profile creation process have a direct influence on the music they will receive.

> *"I've done a test about music preference before, but they just give me random results, and no recommendation of music is provided as well."*

Test platform

The google form was used because it is efficient to document participants' responses and show the app interfaces. However, it was found that participants had different expectations of experiences on different platforms. Intuitiveness, ease of use, and aesthetics are important for a profile test on an app. However, they prefer an efficient experience (e.g., only short text without visuals) when taking the profile test on a google form. In the current design, while visuals and aesthetics have been well considered, it does not meet the expectations of participants when filling out a google form. The interaction would be more intuitive and more realistic if the design is presented in an app.

> *"It will be more intuitive if it's in a real app setting."*

Therefore, creating an interactive app prototype for facilitating a better user experience is an important next step.

Provide feedback

Give feedback about which profile the participant belongs to immediately after data input is necessary. Google form logic can not support the proposed profile generation logic, so the profiles were sent to participants a manual analysis of their responses in google forms. For participants, this experience was not intuitive and motivating enough. Participants would prefer to receive instant feedback after doing the test within the same program. Revealing the generated profiles right after users answer the questions can bring them a sense of accomplishment and make personalization more transparent.

Questions and answers design

Different from designing the physical diary, the questions and answers in the digital profile creation need to be as simple and direct as possible. Whether the questions are evocative is not the priority. For example, the last question, "if you could only take one piece of music with you to outer space, which one will you choose", was asked to evoke people to think about their favourite music in an interesting way. However, one participant provided space music instead of the music he liked most. This suggests that the profile questions and answers need to be direct and using language that is understandable for people with different backgrounds.

Apart from this, the answers should be designed to cover more possibilities. One participant thought her relationship with music was in between "no interest" and "a tool", so there was no option suitable for her.

6.3. Detailing sleep music modules

Chapter 5 proposes the modular logic of music design for each profile. However, these modules are still somewhat abstract for designing and composing music. In order to regulate the music modules and facilitate their integration into the music system, the detailed settings for each module need to be specified in advance. In the literature section, we have talked about the research on the functions of relaxation music that has been conducted by many researchers. These findings from the literature are used to regulate the music modules. Figure 59 shows more detailed music modules with specific music functions ready for prototyping music.

Time setting

As for the duration, the feasible solution is to design each small section for 3 minutes since the average duration of songs is about 3 minutes. Due to the convenience of the modular design of music, each module can be looped for a longer duration if needed. To simplify the module at this stage, we first design the modules without considering looping.

Phase 1: Attraction phase 3min

Through self-experimentation, I have found that the attraction effects can be achieved quite easily, and there is no need to keep letting listeners be attracted for a long time. On the other hand, the entrainment effects take time. Therefore, I decided to use the structure “3 minutes of attraction duration + 3 minutes of immersion + 3*X minutes of entertainment”. Based upon the research insights, following requirments and setting are used for music modules: Tempo ≈ 107BPM, main frequency register ≈ 1822 (Dickson, G. T., & Schubert, E., 2020)

Phase 2: Immersion phase 3min

Melody + environmental white noise + nature sounds + human movement sounds.

It is decided to use environmental sounds and music melody to create an immersive feeling. There

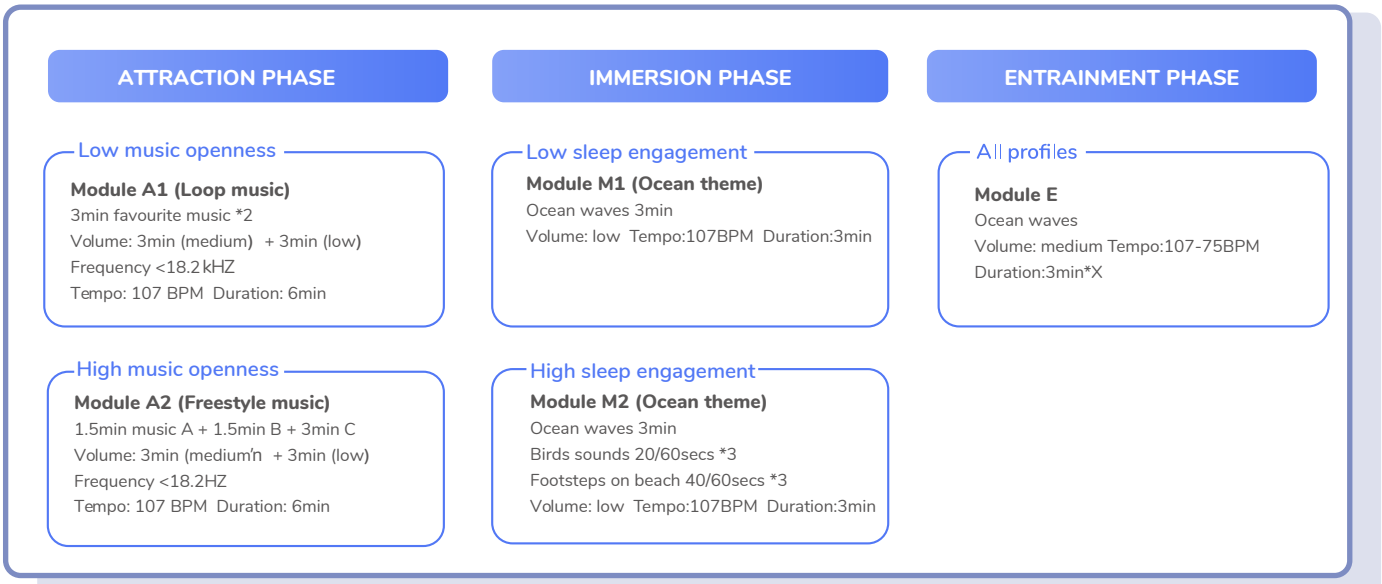


Figure 59. Detailed sleep music modules with specific sound content , duration, tempo, volumn, and frequency

are two types of environmental sounds modules.

Module M1 is intended for profiles with low engagement. This module contains only one type of environmental sound, such as rain sounds, wind sounds, and ocean waves. Module M2 is for a high engagement profile. This module is more complicated and aims to create a higher level of immersion. First, it also contains continuous white noise. It can serve as a basis for creating the acoustic environment. Another component is more dynamic sounds, such as bird sounds, which contribute to a more vivid sonic environment. The sounds of human actions are the third layer to make the participants feel that they are in that place.

We know from user research that users have a personal preference for their dreamscape. Inspired by this insight, I added a customization feature to the sound modules: participants first get the default environment sounds, but they can switch to a theme they like. Since all elements are modular, only the environmental sounds layer need to be changed.

Phase 3: Entrainment phase 3min*N

In this phase, the music melody slowly disappears. The whole soundscape's tempo gradually slows down so that participants tend to slow down their breathing and heartbeat. The volume will also decrease progressively to create a relaxing and not disturbing ending.

6.4. Prototyping and iterating sleep music modules

Prototype tool selection

Ableton Live was chosen to be the prototyping tool. It is an audio station that provides lots of possibilities to change the sound parameter, like changing pith, applying filters to remove frequency, fading sounds in and out, etc. Ableton Live also have some embedded instrumental sounds that are available for usage. It can also be connected with Max/MSP to build the sounds modular system.

Procedure

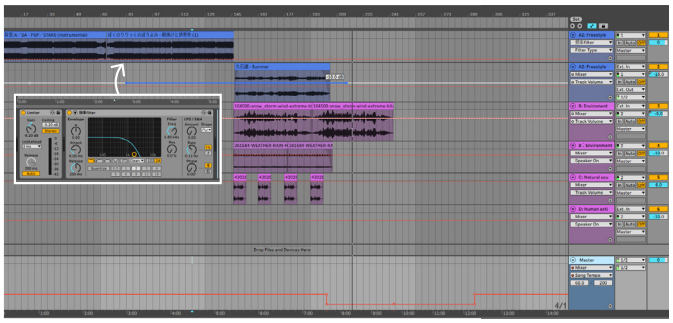
The music prototyping process includes the following steps.

1. Define user profile
2. Search for favourite music (instrumental)
3. Define the sound environment theme and download relevant environmental and action sounds
4. Set all the sound clips tempo = 107BPM
5. Adjust the volume of different phases
6. Add frequency filter to music clips (frequency <18.2Khz)
8. Time: set each phase as 3 mins

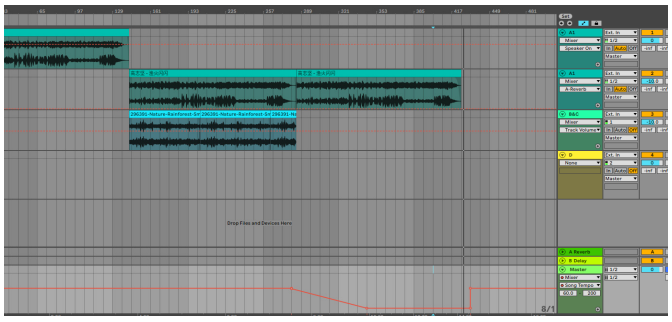
The four initial soundtracks for each profile can be seen in figure 60.

An informal iterative test was conducted to get quick feedback on how to improve music further, a. Three participants were invited for listening to it for one night. The main goal is to see what musical aspect works and what doesn't work. Some other insights and problems are discovered from prototyping, and self-experimenting are included as well.

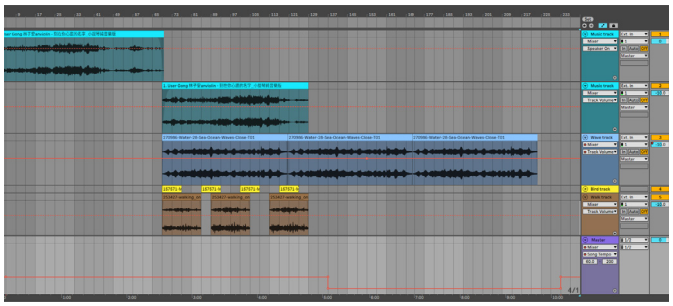
Explorer soundscape



Hunter soundscape



Diver soundscape



Observer soundscap e

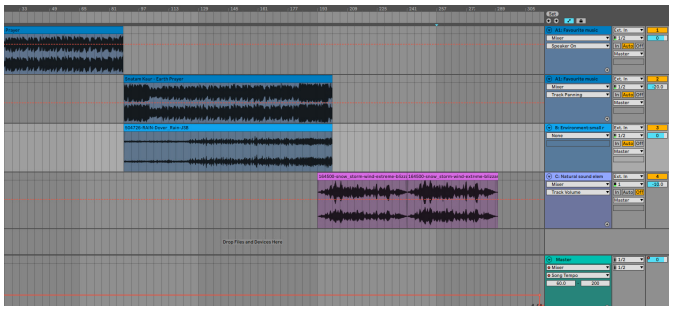


Figure 60. Four sleep music soundscape design in Abolten Live

What works

Overall, the sound design modules work in an intended way. In the first stage, participants were awared and felt enjoyable listening to their favourite music. In the second stage, an immersive feeling was evoked by the environmental sounds. Finally, accompanied by music, participants felt they gradually become more relaxed. However, many musical aspects related to music composition and module settings need to be improved for better music quality.

★ What needs to be improved

The music duration is a bit short.

The provided music duration should take people's sleep onset latency into account. People would like to listen to music till they fall asleep. However, the current music duration is around 9min, shorter than the average sleep onset latency (15-20min) for healthy adults. Everyone's sleep onset latency varies, so the duration is very important as a customization function.

Music source quality is not high enough.

Some sound such as the sound of the waves has a low sound quality and can be a little annoying to the user. A good selection of sound sources is important. Participants' might not notice the quality during the daytime. However, during night time when people's only listen to music, details in the music can be noticed. If sound sources for composition are not of high quality, negative emotions could be evoked.

Unnatural transitions

The transition from the attraction phase to the immersion phase is not natural because the music and the environmental sounds are not mixed very well.

Sound content

By removing the human action sounds, the user is more immersed in the environmental sounds. The main reason is that these sounds are too directive and can draw too much attention, leaving the user less room to relax.

Overly regular dynamic sounds

Sound elements are perceived too regular. For example, the birds chirping appear once every few seconds. Too regular sounds may feel very unnatural to people. Natural music can be immersive because it allows for some irregularity in the overall predictability of sounds.

Process of favourite music

When working on a prototype, it was found that the processing of the sound has limited effects. If the user uploads very upbeat rock music, it isn't easy to achieve a relaxing, soothing and quiet effect with the sound editor. If the tempo is reduced too much, it becomes challenging to maintain the melody of the music.

Evoke positive associations

Participants might have some negative associations with the music if there are no cues. Their emotions and environment will direct how they imagine the sounds. Therefore, instead of providing too much freedom in imagination, visual cues might help evoke positive associations.

I will improve these design shortcomings in the final design. A music designer is also invited for a short collaboration to improve and enhance the music. Being supported by sound expertise helps solve the technical problems associated with the music composition and can create quality sleep music to meet the user's needs.

Chapter 7
Final design: DREAMe

CHAPTER OVERVIEW

7.1. What is DREAMe

DREAMe function overview

DREAMe delivers a personalized sleep music experience based on profile generation and a music personalization system. The info-structure map (see figure 61) presents an overview of all functions in DREAMe. All features are designed based on previous research results, directed by design goal and vision. There are two essential features: a sleep music profile test and a personalized music listening player. Customization functions are secondary features.

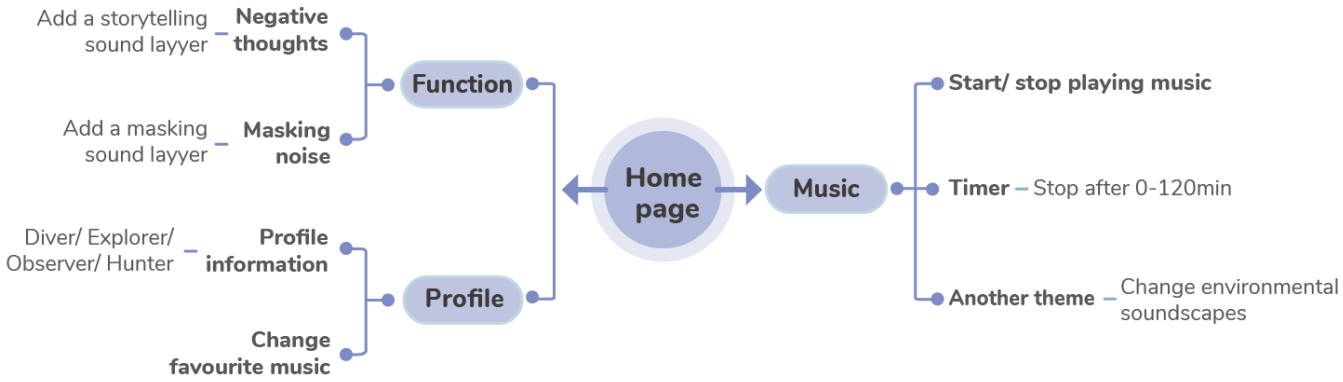


Figure 61. An overview of all functions in an info-structured map

Interaction flow

Figure 62 presents a storyboard about how DREAMe aids patients' sleep, from getting a sleep music profile, customizing music settings, to listening to sleep music.

Set up a profile

When opening the application, patients are first suggested to create a profile in few steps. This is a mandatory step for using the app. The profile setup process follows a profile generation logic, which will be introduced later. Patients will answer five questions in total about personal sleep and music preference as profile input. Then patients will get their profile as a starting point of using DREAMe. The last step before moving to the app homepage is the input of favourite music. This music (after processing) will be used as a source for generating personalized sleep music.

Customizing music settings

Patients can customize sleep music settings either before or after listening. They could set a timer for how long they prefer to listen to, so they could fall asleep at night accompanied with music, without being worried about shutting down the music. Based on generative research results, people have different preferences for their "dreamscape". It reflects a personal preference in what kind of imagery association is evoked by the sleep music. If the default environmental sounds don't fit their expectations, they can change to another theme with different environmental sounds. The sleeping condition in the hospital is less predictable than at home. In some conditions, when patients have negative thoughts or find too much noise in their sleep environment, advanced options for adding another sound layer are suggested to deal with these occasionally occurring sleep problems.

Listening to sleep music

Patients will first listen to a piece of music, either familiar or novel to them, depending on their profiles. At the end of the first phase, the music tempo will slow down to help people feel relaxed.

Then, patients listen to a combination of the environmental soundscape and music melody and are immersed in the sonic environment. Finally, the whole music piece slows down, and the sound level gradually trails off. Participants will fall into sleep with ease and calmness accompanied by music.

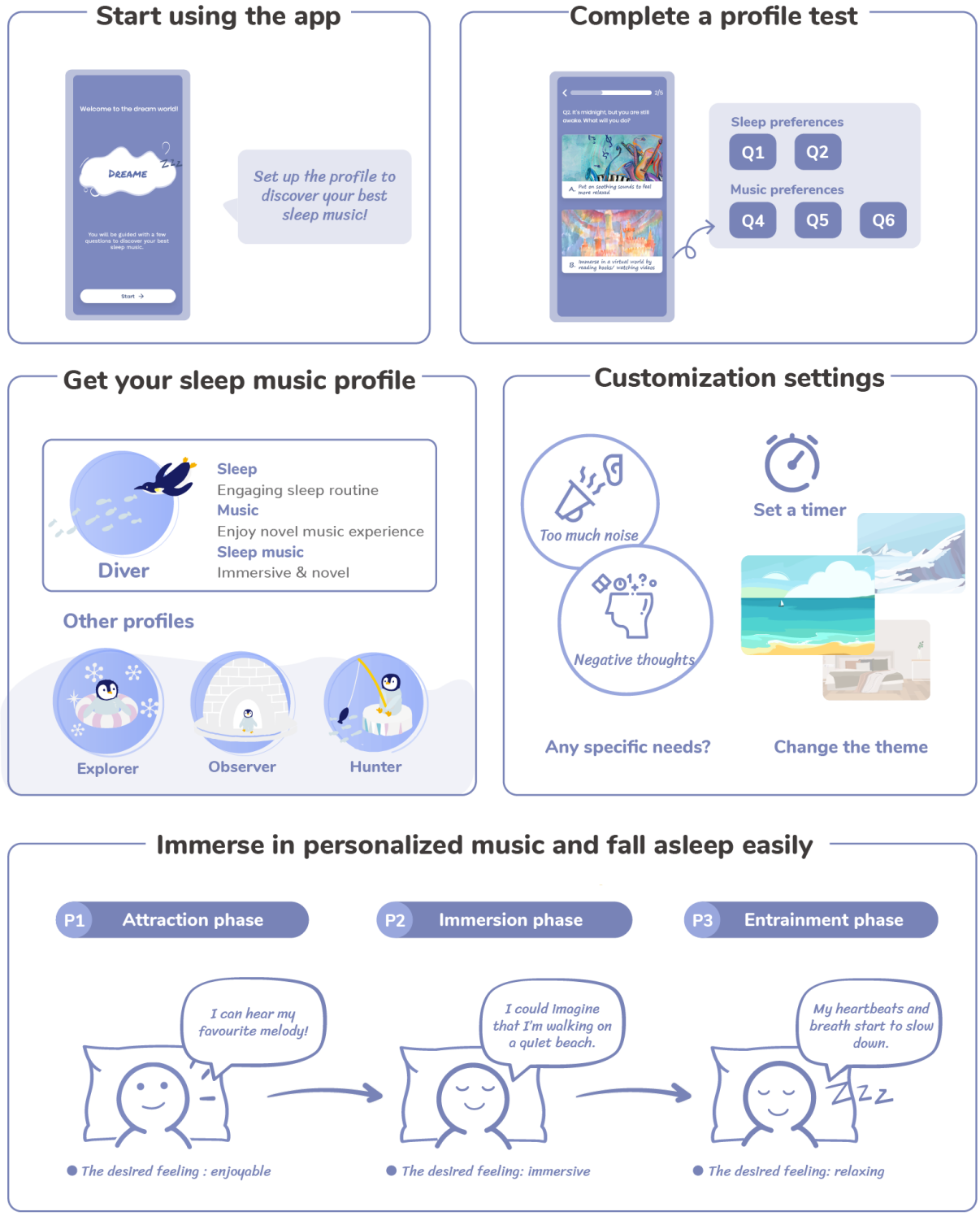


Figure 62. A storyboard of how patients can use DREAMe to aid their sleep

7.2. Test a profile in DREAMe

Profile creation process

An easy and intuitive profile test for personalization

Profile test provides the foundation for music personalization. Figure 63 presents all interfaces designed in the profile test. After users make their choices, they will see one of the four sleep music profiles. The music input interface shows how users can input their favourite music. People's sleep and music preferences are known with simple and intuitive input. It simplifies the sleep music selection process for patients with a profile-based approach.

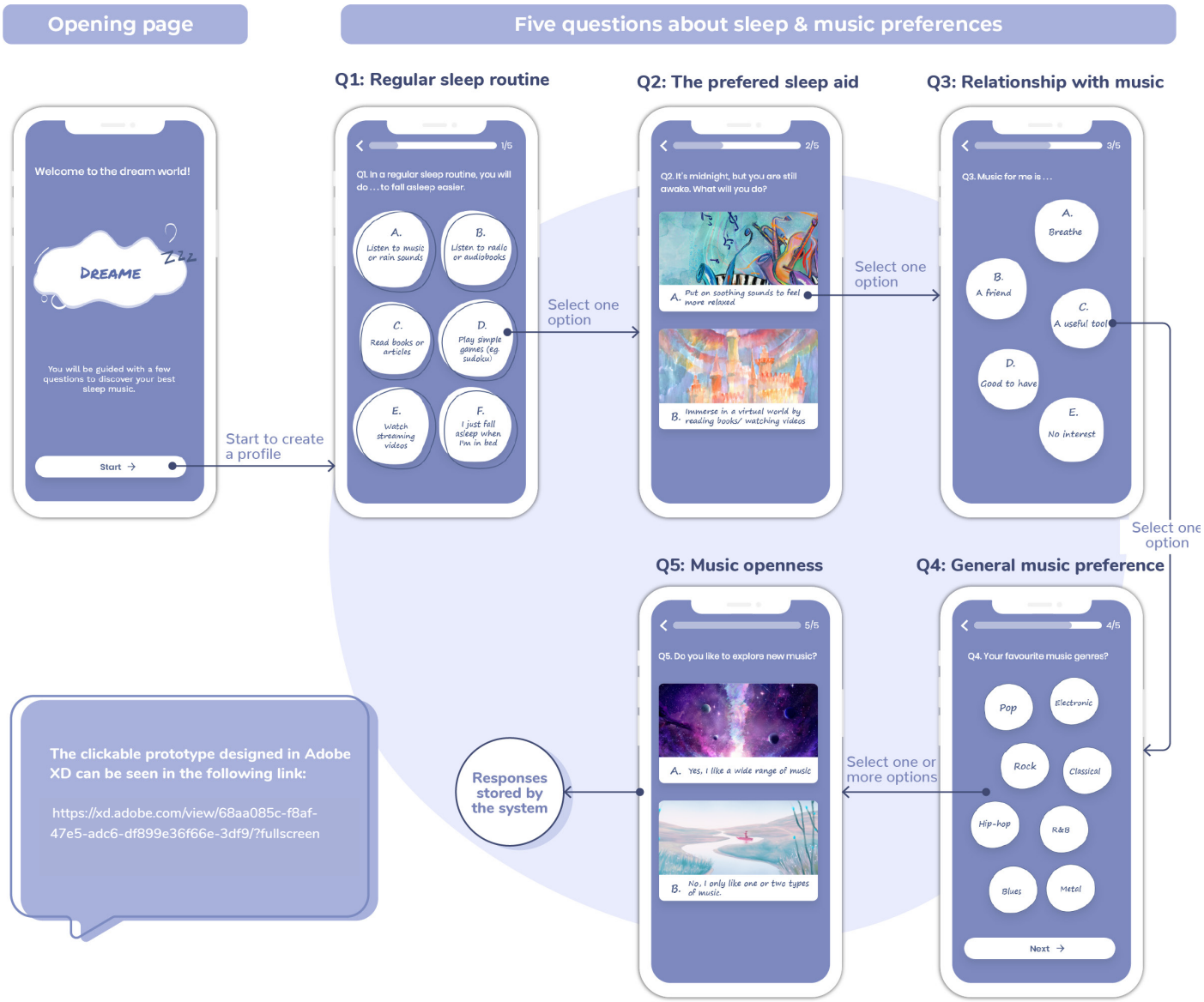


Figure 63. An overview of profile creation interfaces

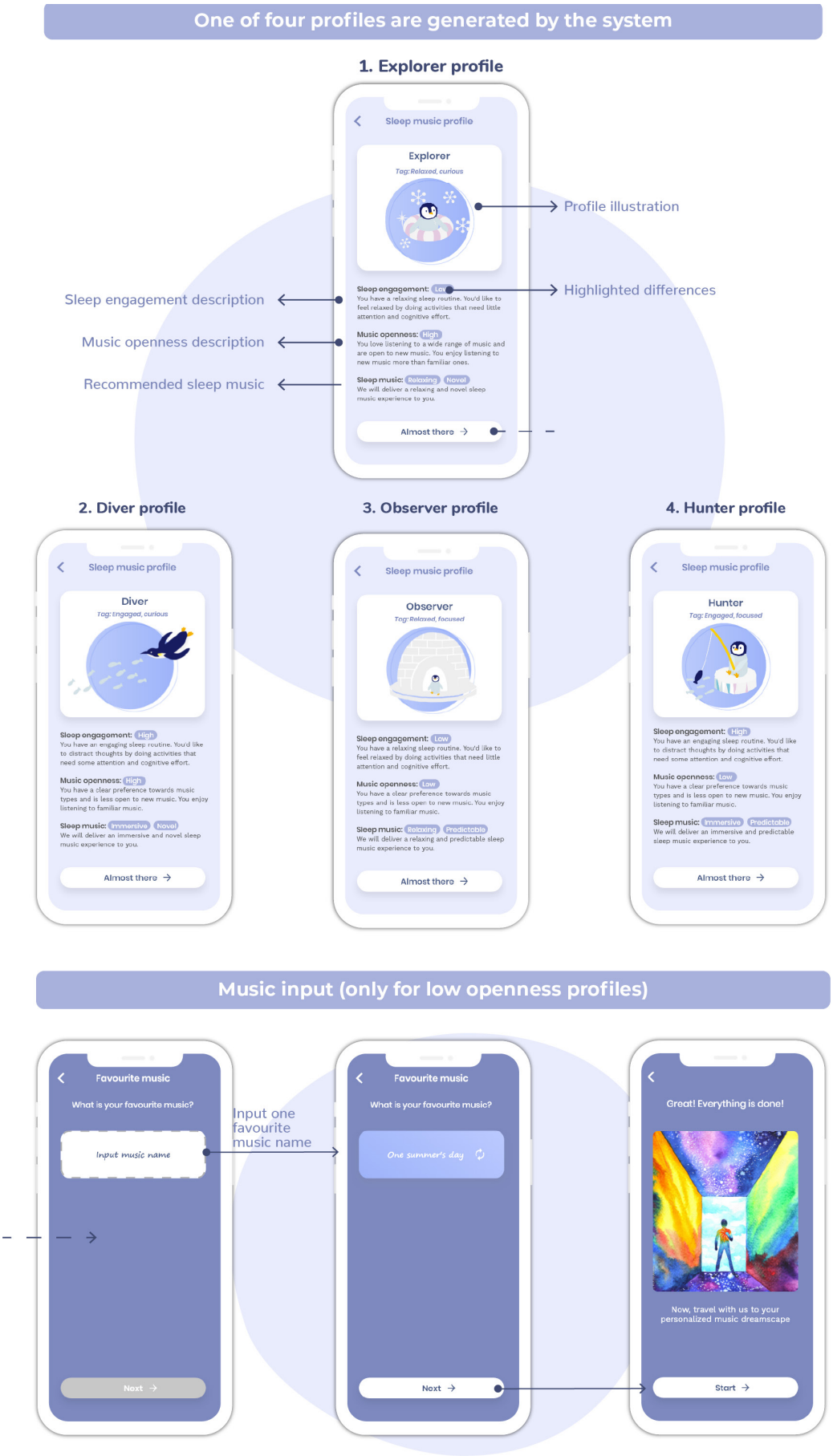


Figure 64. An overview of profile creation interfaces

Understand the logic behind

Research-based profile generation logic

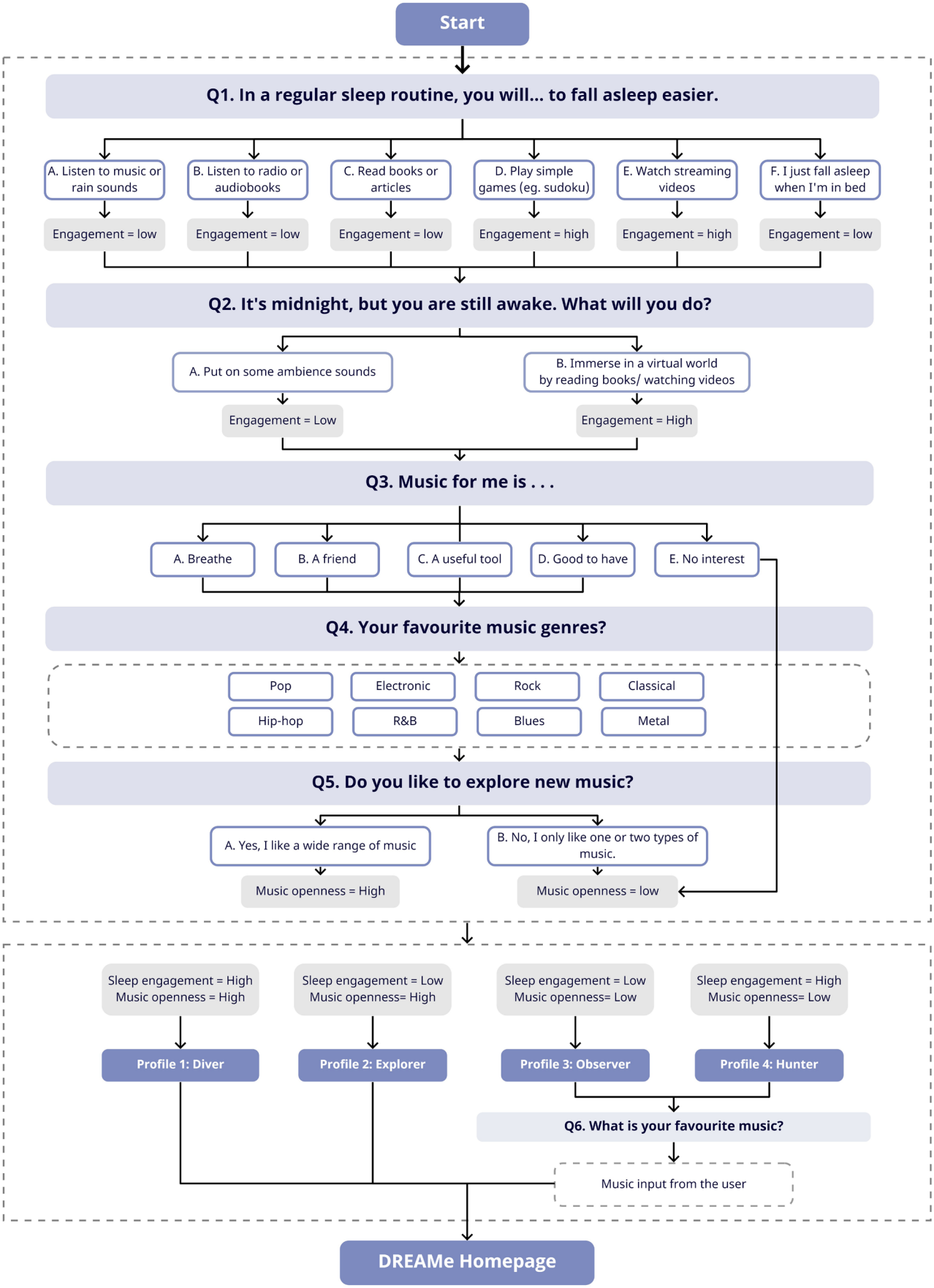


Figure 65. The profile generation logic chart

7.3. Enjoy sleep music in DREAMe

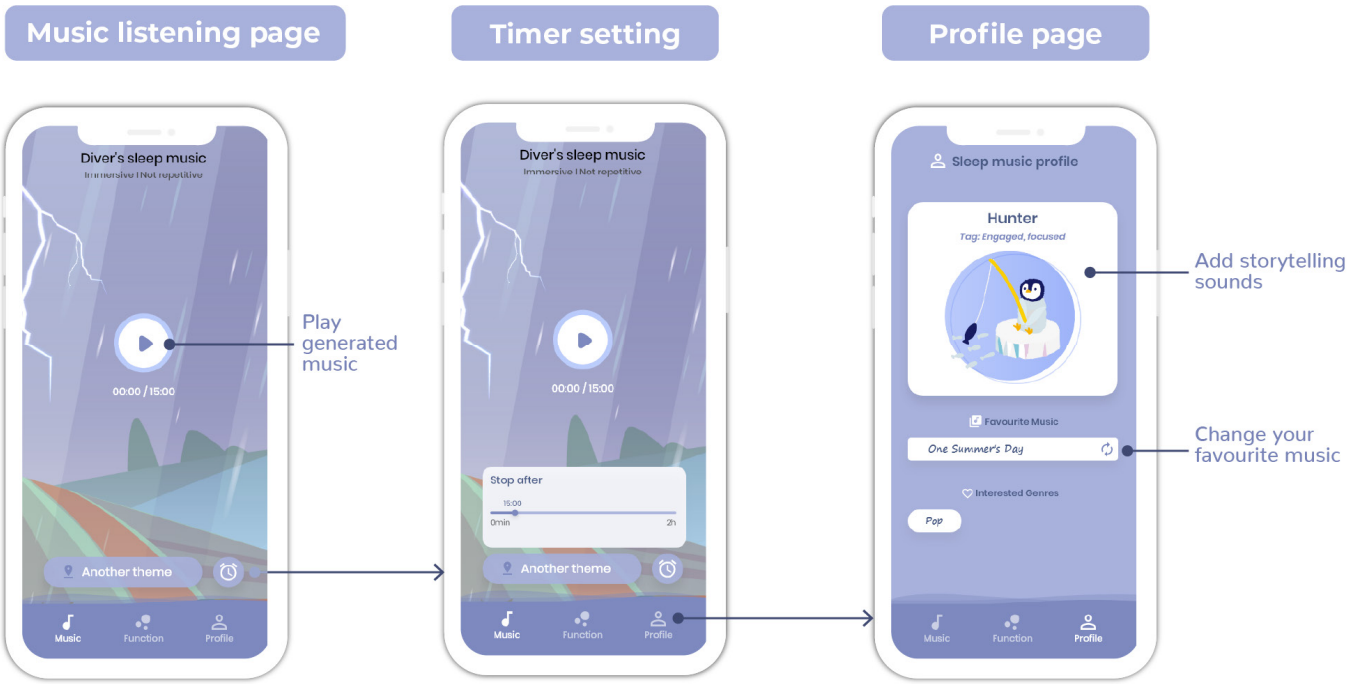


Figure 66. App interfaces for music listening, timer setting, and profile pages

Playing personal sleep music

An immersive and personalized music experience that bring patients to their dreamscape

The immersive and personalized experience of music is delivered based on a modular music system. Both personal and general sleep music features are reflected in intimate and unique music experiences. The music listening page follows a minimum design, and illustrations are used to evoke positive association.

Sleep music duration setting

Catering individual differences in sleep latency

Allowing the user to choose the listening duration is a necessary feature for music applications and adds value in this context. Patients' have different latency to fall asleep, which means they will have their preferred listening duration. Therefore the timer is a simple but fundamental feature that directly influences the effects of music on sleep.

Figure 67. App interfaces for theme selection and special functions page

Sound theme selection

Select your prefered sound “dreamscape”

The possibility of selecting different environmental sound themes can provide a more flexible listening experience. This flexibility brings a nice balance between the user in control and the product in control, increasing the likelihood of an optimal music listening experience.

Particular function for sleep concerns

Functional roles of music for particular sleep needs

Having a good sleep at a hospital, surrounded by different noises, can be a big challenge for patients. Being disturbed by too much noise or experiences too many negative emotions can occur at any time. That's why a particular function is designed to add new sound layers to the essential sleep music.

7.4. DREAMe music design guidelines

Based on previous generative research results, attempts on the prototype of music, the collaboration and discussion with sound designer Willem, the following guidelines are concluded:

On the one hand, the guidelines support the design of the sound from a theoretical and practical point of view, increasing the possibility of sleep music to help the user fall asleep. On the other hand, it serves as a source of inspiration and guidance for the sound designer to synthesize and produce sleep music. These guidelines act as a starting point for designing personalized sleep music, which is recommended to be iterated by collecting more user feedbacks.

A progressive structure

Sleep music uses an overall three-stage musical structure: attraction - immersion - entrainment.

In the first stage, familiar or unfamiliar music is used to attract the user's attention and create an enjoyable feeling through music.

In the second stage, relaxing environmental and sounds and instrumental music are used, which are combined to create a sonic environment. The sonic environment helps the user to relax and immerse themselves in their dreamscape.

In the final stage, the sound is gradually slowed down, and the volume is reduced as the user slowly falls asleep with the help of the low-frequency sounds, lowering their heart rate and slowing their breathing.

Sleep aid sound elements

User research results (sound as sleep aids) provide inspiration for sound designers to make environmental sounds.

In choosing sound elements, **it is advisable to choose environmental sounds that people perceive as sleep aids.** For example, these sounds were discovered during the user research phase:

- Nature sounds like rain sound, sea waves, rippling water
- Animal sounds like bird sounds
- Music like meditation music, familiar music, soft and comforting music
- Silence, or familiar voices

These sounds can make people feel safe, relaxed and evoke many other positive feelings like a peaceful, happy, and dreamy, etc.

Inspired by sound designer Willem, binaural sounds can be used to give the whole piece more unity and help with entrainment when listeners choose to wear headphones.

The sounds we should avoid are people's noise, party music, hitting or beating sounds. These sounds can evoke negative feelings like feeling annoyed, anxious, alarmed, etc.

Relaxing musical features

The music features should meet the characteristics of relaxing music as much as possible, but given the entire music as the priority.

Tempo: 70-107BPM on average at first. From the beginning to the end of the song, the tempo gradually slows down to a level close to and below the user's heart rate (40-70BPM), thus helping the listener to relax.

Frequency: avoid using too many high-frequency sounds in the music.

Time: Each music phase should be around 3-5 minutes, with a loop entrainment phase when the

user wants to listen for a longer period of time, as the three-part structure of the music is linear and leads the user to relax slowly. If the user is already relaxed after looping a whole section of music, they will get excited again when they hear the first part of the music, which will have a negative effect on sleep.

Differentiate profile modules

The main difference between DREAMe music and other music on the market is that the music can be personalized to meet the user's musical needs. Thus, it's important to deliver specific music modules for each profile to meet each profile's needs for sleep music. As previously mentioned, four profiles are created based on the sleep engagement and music openness dimensions. Assumptions are also made about the type of music required by the four profiles. Explorer and observer profiles are provided with a piece of relatively gentle and less immersive music: creek music.

The other is the use of music that is familiar or unfamiliar to the user to meet the user's high or low musical openness dimension. For those with low musical openness, such as observer and hunter, the first part of the module uses familiar music provided by the user, while for those with high musical openness, the first part of the module is based on music that is not familiar to the user in the music library. The design and visualisation of each music module will be presented in more detail in the next section.

Process familiar music

The instrumental version of users' favourite music needs to be remixed into the first phase of the music for low engagement profiles. During the prototype phase, an exploration was made into the processing of familiar music melodies. It turns out that a good way to do this is to **look for the instrumental cover of the uploaded music and slow it down and decrease its frequency.**

However, it is important to note that the music uploaded by users can be very fast-paced. It might be uneasy to maintain a relaxing speed while still being able to hear the familiar melody. Therefore there is no guarantee that all songs will be as slow as those in the music library. How much the tempo is reduced is determined by the music harmony and evoked feelings.

Embrace creativity & iteration

Embrace the creativity of the music designer in the music design process is important. There is no need to give up some of the musical ideas to meet all suggestions. For example, if the sound of birds singing blends well with the overall music and is relaxing, it's acceptable that the frequency is slightly higher than recommended. The frequency can be reduced appropriately, rather than making the birds sound like other animals to make the frequency meet the requirements and thus make people feel scared.

The music designer's expertise can improve the overall quality of the music and avoid a lack of harmony in the music, which can lead to negative feelings towards the music. This is even more important for the design of sleep music. The quality of sleep music itself needs to be better than the music listened to during the day. It is easy for the participants to focus on the music at night and to hear every part of it. A small dissonance can make the user feel uncomfortable and thus unable to sleep well. This is particularly true for patients in hospital rooms, where the environment, physical condition, and sleep quality can make them more sensitive and vulnerable than at home at night.

It is suggested to focus on overall music quality, and feelings music brings, rather than using these suggestions as a set framework to follow for every sleep music piece. It is also stated in the previously mentioned paper (Hernandez-Ruiz, 2020) that the relaxing feeling of the music is brought about as a whole, not by the change of a single element.

7.5. Four sleep music modules in DREAMe

This section will show the sound library and the four sound modules. The sound library contains a number of sounds to provide support for music generation. The library sources come from different places. The environmental sounds are recorded and remixed by the sound designer. System music is from the web resources. Another input is the melody of the user's favourite music. The melody comes from an instrumental cover of certain music.

Figure 68 shows what sounds are available in a basic sound library and their classification. Figure 69 to figure 72 illustrates the four music modules for four profiles. These music modules all meet the guidelines described in the previous section.

Diver: immersive & novel sleep music
Immersive: immersive environmental soundscape
Heavy rain & thunder sounds are used
Novel: use new music from the system library

Explorer: relaxing & novel sleep music
Relaxing: gentle environmental soundscape
Creek & birds sounds are used
Novel: use new music from the system library

Observer: relaxing & novel sleep music
Relaxing: gentle environmental soundscape
Creek & birds sounds are used
Familiar: use users' favourite music melody

Hunter: immersive & familiar sleep music
Relaxing: immersive environmental soundscape
Heavy rain & thunder sounds are used
Familiar: use users' favourite music melody

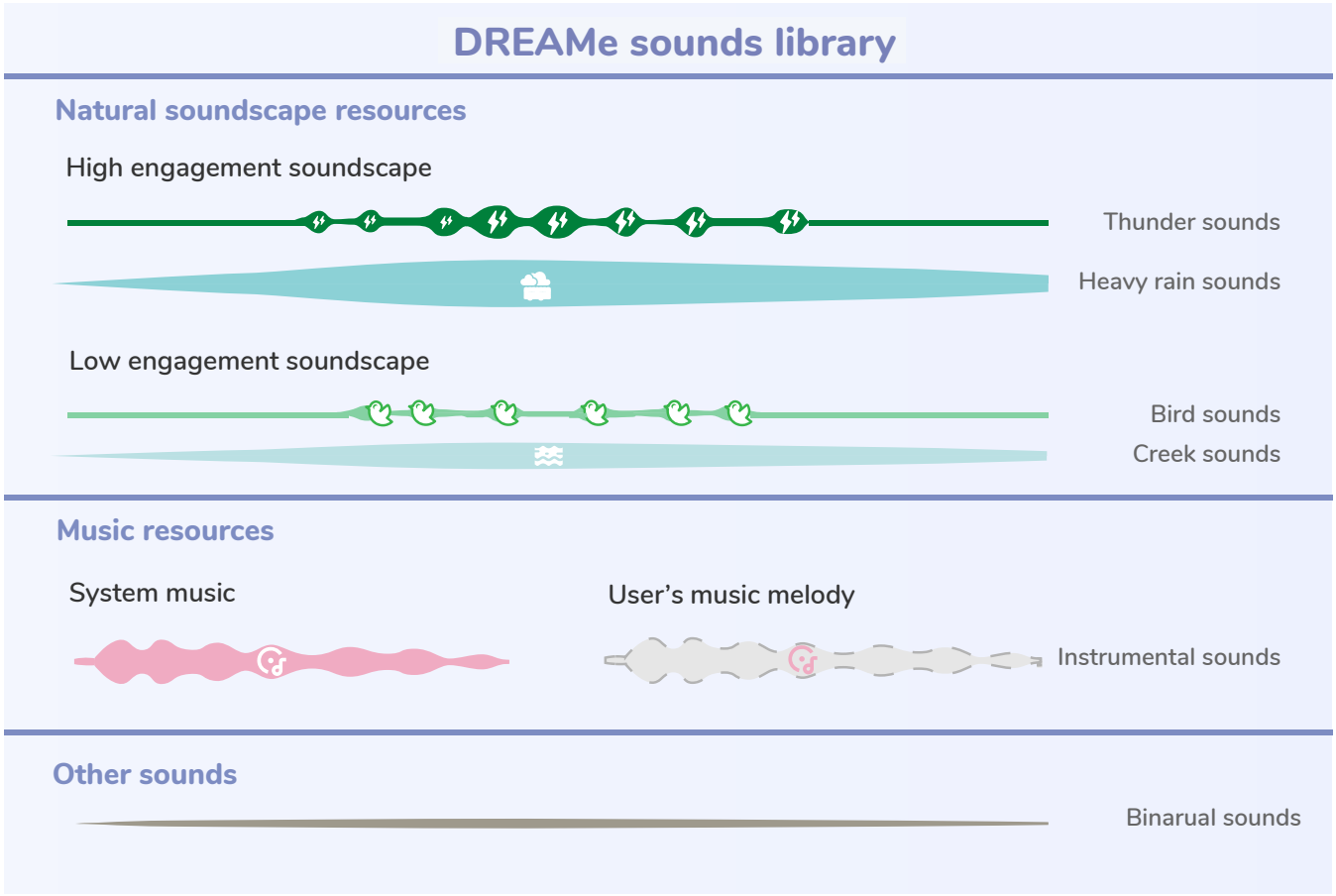


Figure 68. DREAMe sounds library

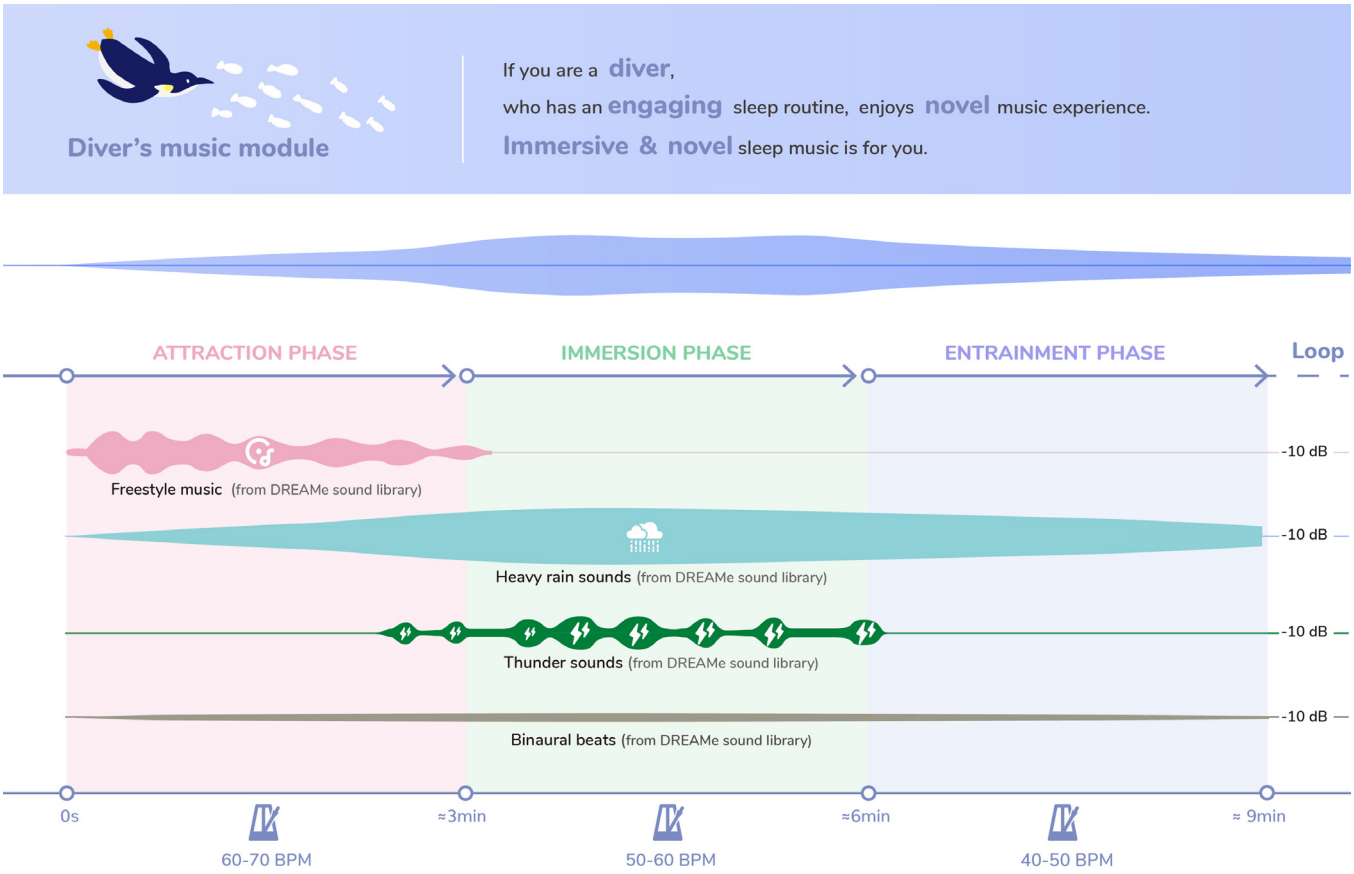


Figure 69. Diver's sleep music module for programming the final music

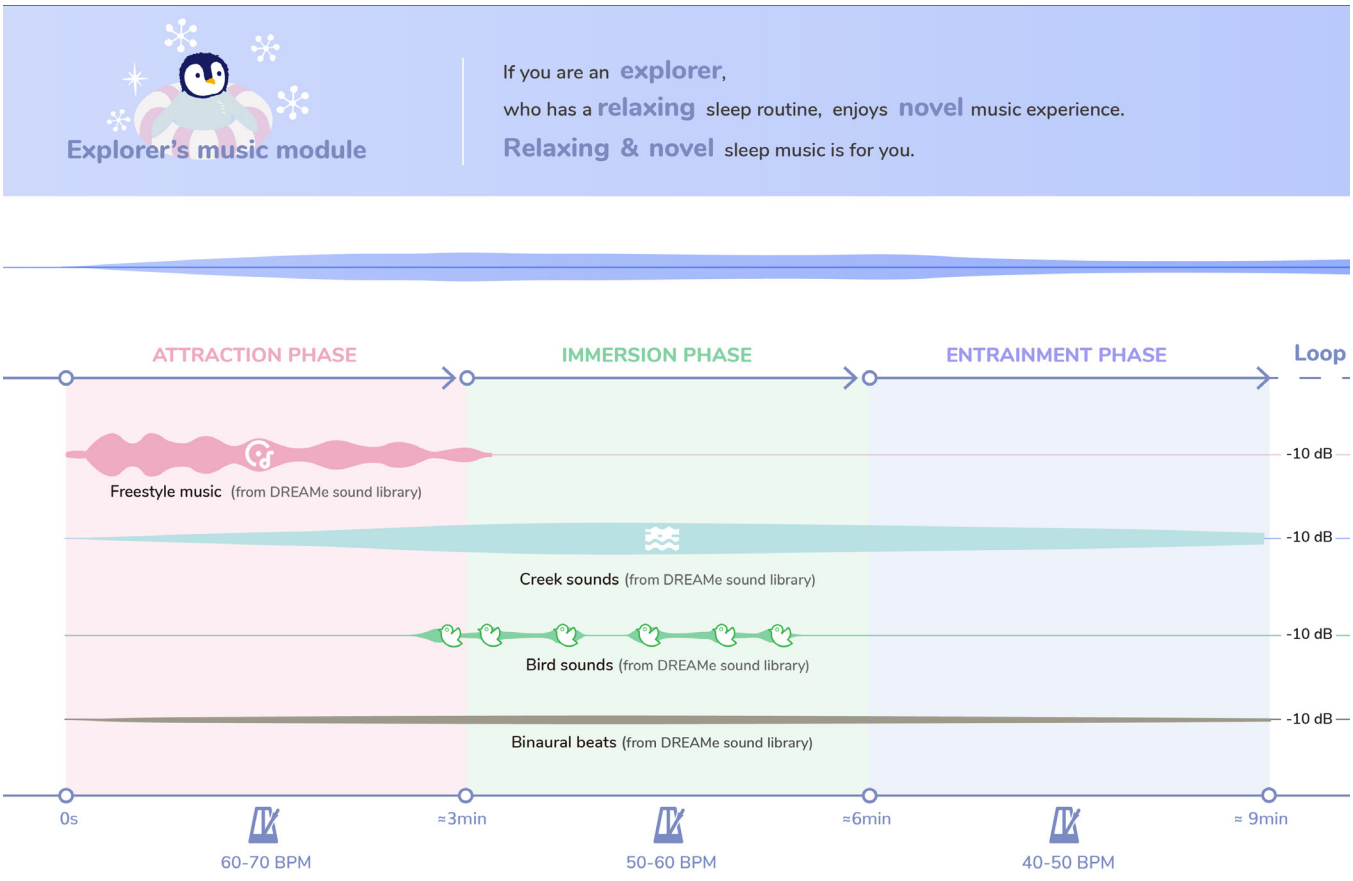


Figure 70. Explorer's sleep music module for programming the final music

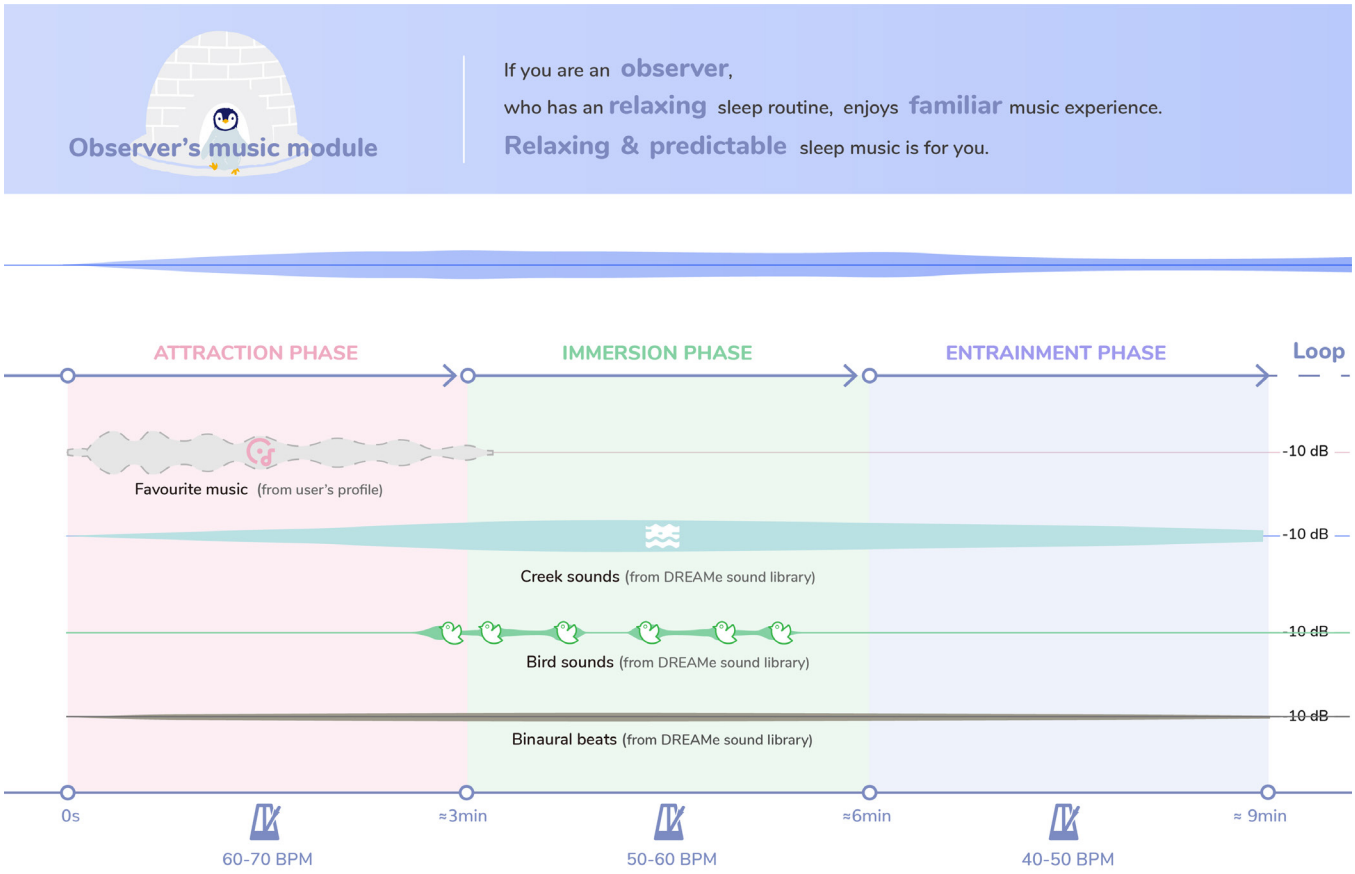


Figure 71. Observer's sleep music module for programming the final music

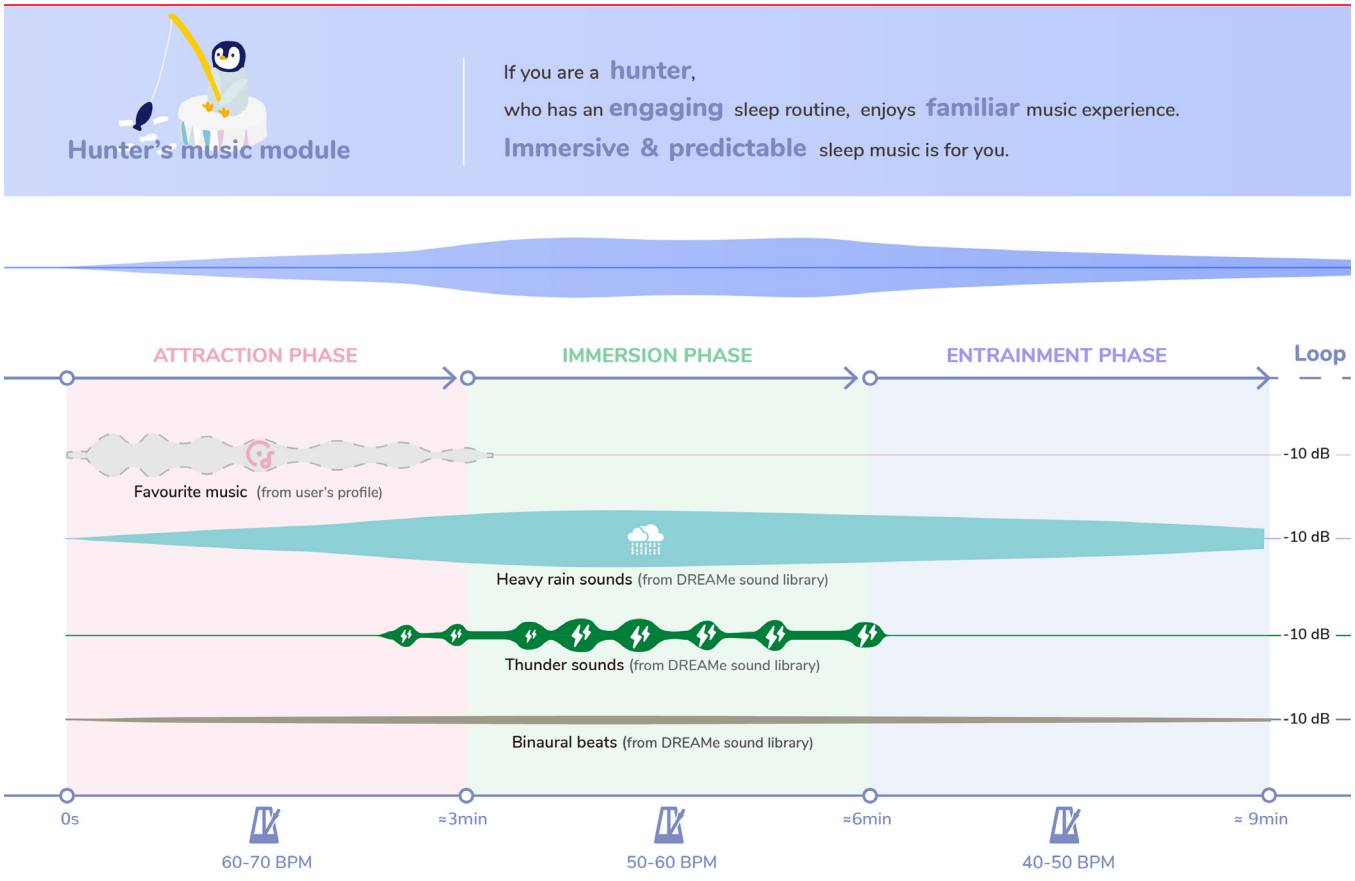


Figure 72. Hunter's sleep music module for programming the final music

Chapter 8
Evaluation 1: Product experience evaluation

CHAPTER OVERVIEW

8.1. Product evaluation setup

Research objective

This evaluation aims to evaluate the profile logic as the main focus and take the profile creation experience and overall app interface usage experience into account. The results of the evaluation should be able to answer the following research questions:

1. How credible is the profile logic design?
Sub research questions:
2. How intuitive is the profile creation process?
3. How do people experience the product?

Research method

The test will be conducted online via zoom. The participants will be invited to experience the profile creation process and the main feature in DREAMe with a clickable prototype.

Material preparation

Profile creation prototype

A clickable high-fidelity prototype is designed in Adobe XD (see figure 73). Participants can click on the prototype to choose answers for the profile questions. Their choices lead to four different profiles. Participants could also experience features like changing themes or setting the music duration.

Product and profile experience evaluation questionnaire

The profile creation and product experience is a secondary focus of this test. A questionnaire including five questions with a Likert scale is used (appendix K). The questions were designed based on the design requirements.

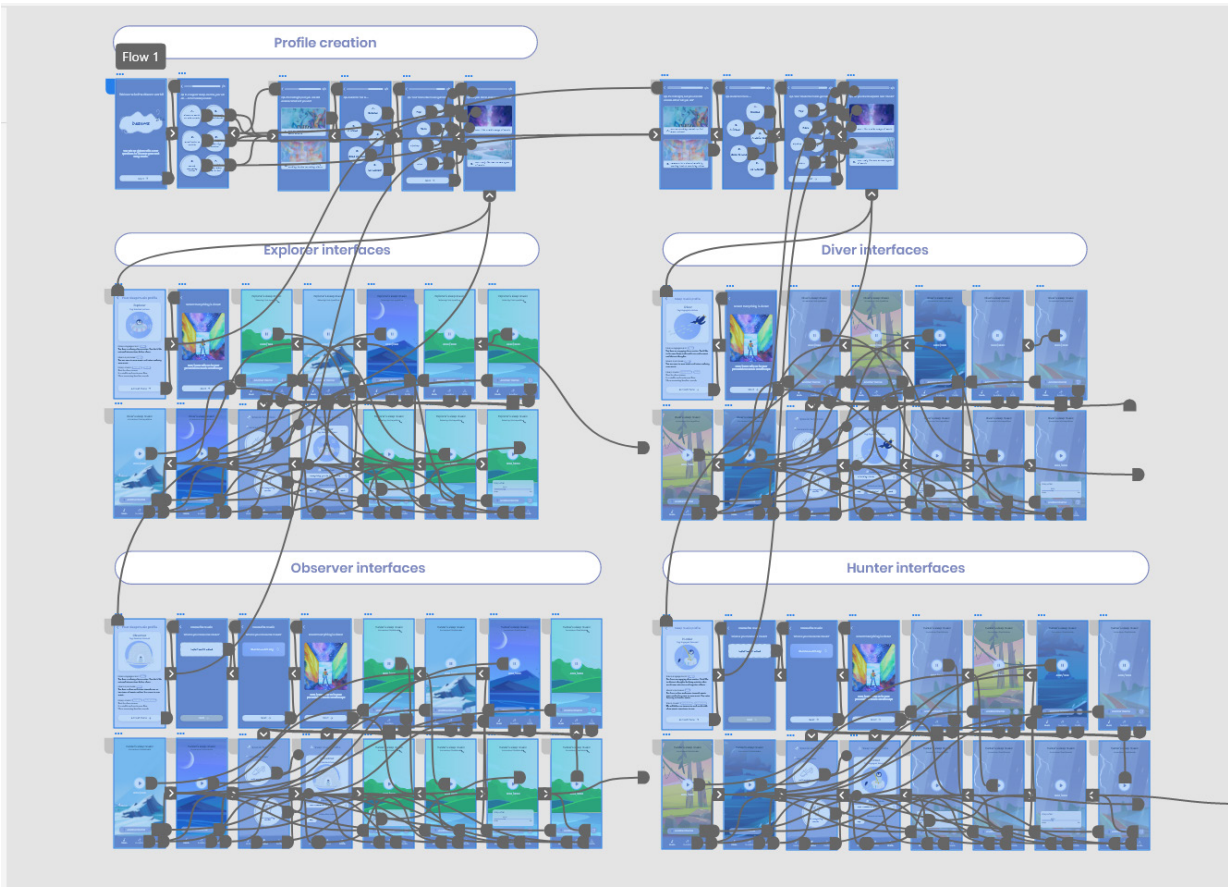


Figure 73. The interactive prototype which enables the profile creation process

Participants

Ten participants are invited for a test session through online recruitment. Their demographic details can be seen in figure 74.

Procedure

Screenshots in figure 75 present the test procedure.

Product introduction: Participants were first presented with a storyboard including main user flows and usage context (see figure 75). This could help participants to understand why they use the app and in which context. The storyboard can also facilitate participants to imagine how they might interact with the design, which is especially helpful for online concept evaluation.

Answer profile questions: After having a basic idea of the concept as a whole, participants were invited to experience the prototype. In the meantime, they were asked to screen sharing their usage and talking aloud. It can help researchers to identify the reason behind each interaction and choices towards profile options.

Select the best fit profile: In an actual use case, users will get their profile results after answering the questions. However, in a pilot test, it was found out that if participants only see their profile, they tend to accept it and see this profile fit with their preference. This cognitive bias might hinder the discovery of the actual profile credibility. Therefore, participants were asked to select the profile that fits them before receiving a system-provided profile.

Experience the app: Finally, participants explore the main functions in the app homepage with the same prototype. Since evaluation 2 is about music, participants were asked to focus on experience the interfaces instead of music.

Rate on a questionnaire: Participants answered the Likert scale questionnaire (appendix L) about the profile creation and product usage experience in the final step.

Participant	1	2	3	4	5	6	7	8	9	10
Gender	Female	Female	Male	Male	Female	Female	Male	Female	Female	Male
Age	24	24	25	24	49	25	25	24	23	48
Profession	Student	Student	Student	Student	Teacher	Student	Student	Student	Student	Engineer
Nationality	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese

Figure 74: Demographics details of recruited participants for product and profile experience evaluation test

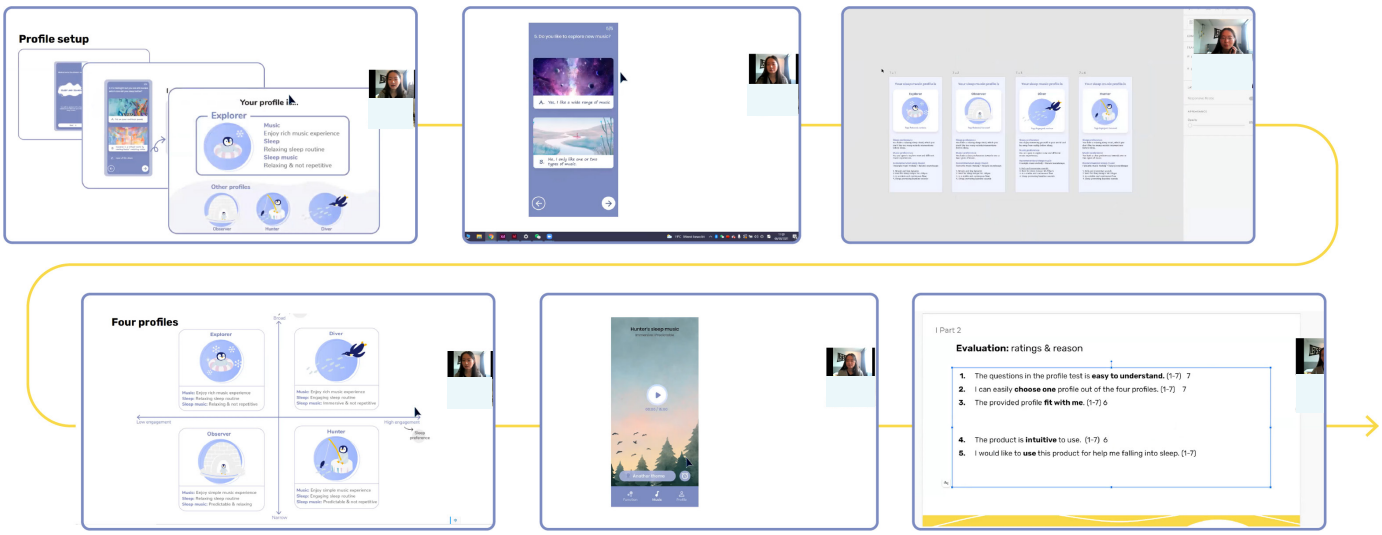


Figure 75: Screenshots in one of the evaluation tests with participants to show the test process

8.2. Product evaluation results

Both qualitative and quantitative data are again from the profile evaluation test, including 10 participants' Likert scale ratings for five questions and their explanation of why they give specific ratings during a follow-up interview. The data from questionnaires are presented in two types of tables. Figure 84 demonstrates an overview of the score range of all five questions in the questionnaire. Figure 85 to 89 shows how many people give certain scores for each question. The test research questions will be answered and discussed by combining the data from both types of tables and participants' quotes.

Profile credibility

As shown in figure 76, two statements in the questionnaire is related to the profile credibility: Ratings of these two questions range from 4-7, with an average score of 5.4 and 5.7.

The distinction of four profiles

As we can see from figure 77, there are no scores below 4. This means that no participant found it difficult to choose one of the four profiles. Secondly, seven participants chose a score of five, six and seven. It means that they can select one profile that suits their preferences quite easily.

> *"The 4 categories have a quite clear difference. I can easily pick out that I am a diver."*

It was observed in the session that participants could understand the differences between the four profiles. They chose one of the four by comparing their sleep and music preferences to the descriptions. Moreover, all four different profiles were selected by at least two of the participants. It suggests that **the four music profiles are representative of some parts of the individual differences in music and sleep preferences. It is possible to use these profiles to segment users groups.**

In addition, three users chose a score of 4. It means they are not sure if they could choose a profile from the 4 profiles that fit them very well.

> *"I think I could either be a diver or an explorer, depending on my mood. Sometimes I would like to be very immersed in another world, but sometimes I want to lay on the bed."*

> *"When I imagine myself at the hospital, I might*

Goal	Questions	Lowest score	Highest score	Average score
Profile creation experience	Q1: Questions and options in the profile test are easy to understand.	**5**	**7**	**6.4**
Profile credibility	Q2: I can easily choose one profile that fits with me out of the four profiles.	**4**	**7**	**5.4**
	Q3: The provided profile fits with my preference.	**4**	**7**	**5.7**
Product usage experience	Q4: The app is intuitive to use.	**6**	**7**	**6.4**
Desirability of usage	Q5: I would like to use this product to help me fall asleep at the hospital.	**4**	**6**	**5.4**

Figure 76. The score range of profile and product experience evaluation

become a diver and want to be distracted by the negative thoughts. "

The quotes indicate that participants are not sure whether they can choose one profile because their sleep preferences might change. This confirms the previous assumption about the stability of profiles: users' preferences are not static. **Sleep preferences can change between low and high engagement depending on the environment, mood and other sleep-related factors.**

This score might also correlate with how well participants know themselves. People who know their sleep and music preferences better tend to choose without much thought. Users who are less aware of preferences need some time to think and recall their behaviours.

The profile logic

Participants were also provided with a system-generated profile and rate how the profile fits with their preference. (The preferences here refer to the ones described in the profile: "sleep preference", "music preference", and "sleep music preference". The results from figure 78 suggest that most participants agree that the generated profiles based on their answers are in line with their preferences.

"*The description of this profile fit with me very well. This is definitely me.* "

The generated profiles match participants' expectations of preferences indirectly shows that the system's logic is reasonable: the system with the designed logic can predict users' preferences through profiles. One participant who scores 4 thinks the profile's content and presentation is convincing, but the content in the profile is a bit simple.

"*I'm not sure because there are only several sentences about my preferences.* "

It is reasonable that participants think the profile information is not rich enough, especially when comparing it with the information presented by some personality tests. Only information related to the music output is presented on the profile, including music openness, sleep engagement and sleep music recommendation. The main consideration of not adding information that is not directly related to the outcome is to ensure the transparency of the personalization system, which is found to be valuable in the iterative test.

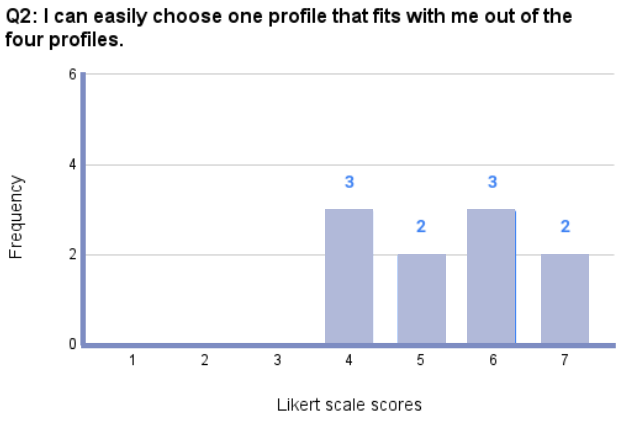


Figure 77. Profile evaluation Q2 distribution map (1=totally disagree, 7=totally agree)

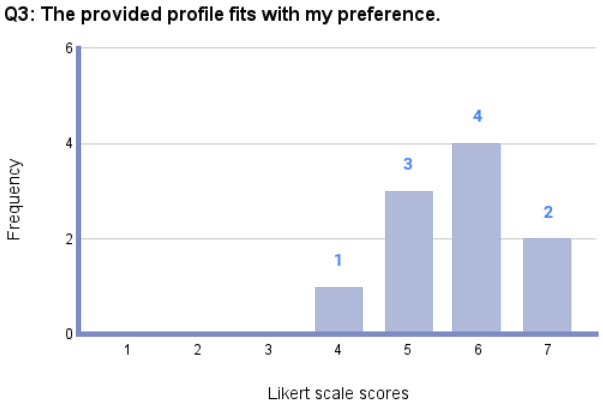


Figure 78. Profile evaluation Q3 distribution map (1=totally disagree, 7=totally agree)

Profile creation experience

As shown in figure 76, the score for question 1 ranges from 4 to 7, with a high average score of 6.4. Six out of ten participants agree questions and options in the profile test are easy to understand (see figure 79). During the observation in the zoom session, it was found that most participants finished the profile test around 2 minutes. Participants' facial expressions while testing the profile also indicate that little thinking is needed. This can lead to the conclusion that the profile creation experience is easy and intuitive.

The number of questions also does not overwhelm the participants. In contrast, one participant thought that the questions were fewer than expected. It is unlikely that the quantity of answers influences the perception of the quality and credibility of the test.

> *"There are not many questions, but I feel all the questions are asked in a quite detailed way, which I think can show people's differences."*

Since there is no indication of whether participants can redo the test again, some of them were hesitant for making a choice.

> *"I'm a bit hesitant because I don't know whether I can still change my selection."*

Therefore, it is believed that being able to edit the profiles or change the choices after patients have received the profile can reduce the cognitive impact of taking the test and make the experience easier and more intuitive.

Product usage experience

Question 4 is intended to reflect the general experience with the product. Participants gave a high average score of 6.4, ranging from 6-7 (see figure 76). Six participants gave a score of 6, and four give 7 (see figure 80).

The results mean that participants strongly agree that the product is easy and intuitive to use. Participants who are comfortable with digital applications can use DREAMe with ease and intuitiveness. Even for first time usage, a small learning curve is needed.

> *"The main function is pretty clear. I have no trouble finding a function I need.*

Interacting with DREAMe also gives participants a sense of familiarity. This suggests that people who already have experience listening to music can use this feature in DREAMe.

> *"I feel familiar when I interact with this app. I just know how to play music, change the theme, or set a timer.*

This further confirms the success in designing DREAMe with a minimalist approach. It creates a familiar and straightforward interaction with

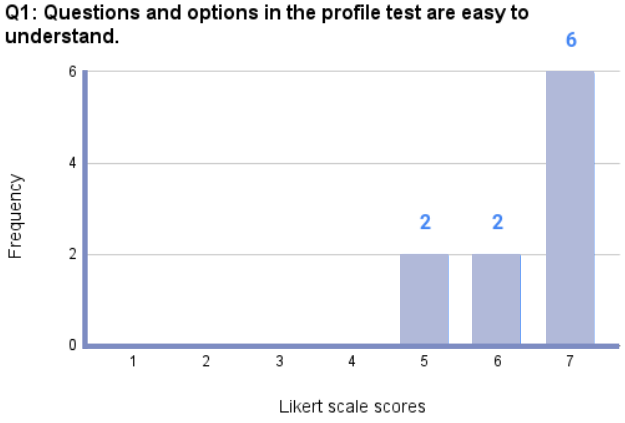


Figure 79. Profile evaluation Q1 distrbution map (1=totally disagree, 7=totally agree)

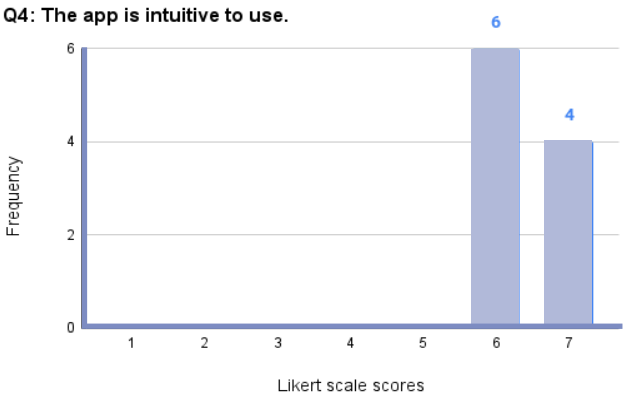


Figure 80. Profile evaluation Q4 distrbution map (1=totally disagree, 7=totally agree)

a clear focus on listening to music. The music is always put first. This simple interaction not only leads to a better user experience but also enhances the usability of the app. Users require little cognitive effort or skill to use DREAMe.

The simplicity of the design is also a great advantage in implementing DREAMe in hospitals to meet the sleep needs of patients in different age groups.

Desirability

Personalization leads to the intention to use

The last question targets whether participants have the desire to use DREAMe as a sleep aid in the hospital. As shown in figure 76, the statement "I would like to use this product as a sleep aid in the hospital" received an average score of 5.4, ranging from the lowest 4 to the highest 6. Figure 81 shows that more than half of the participants gave a score of 6. The rest gave scores of 4 and 5, indicating that most participants are willing to use the app to listen to music in the hospital. DREAMe product could evoke an intention to potentially use it even before the participants have had an actual experience. The desirability of usage is important, especially when people are overwhelmed with too many application options today.

Whether people have the intention to use or buy a product is determined by a need gap (Solomon, M. R., 2013). In this context, it means that if the product can show people that they can sleep better with this product, or if people feel that they need to solve their sleep problems, these two situations can lead to a desire for the product. Considering the flexibility in design, **DREAMe can serve both as a tool to solve sleep problems and as a means to create a better sleep experience for long-term sleep health.**

Figure 81. Profile evaluation Q5 distrbution map (1=totally disagree, 7=totally agree)

Personalization increase involvement

Participants also indicated that they were interested in using this product for multiple nights because of the personalization feature.

> *"I have used a few of these sleep softwares before. None of them is personalized, so this is very good. It makes me feel like this sleep music is just for me."*

It shows that personalization can increase user involvement in product use, leading to a longer usage time. Apart from the effects of personalization, users are encouraged to gradually make small efforts in profiling, motivated by the profile results as positive feedback. People are more likely to use the product because it becomes representative of their sleep music preference, and they build an emotional attachment to DREAMe. The literature also states that people's affection for a product increases when they participate in the creation process (Norton, Mochon & Ariely, 2012).

Long-term use

Although personalization features may increase the possibility of prolonged use of the product, the functional effects of sleep music are inevitably important. DREAMe should provide users with long-term motivation to use it, such as building a habit of listening to sleep music.

> *"I'll certainly try it out, but how long I use it depending on the music effects. Letting me know the science behind the music would help me stick with it for a longer time."*

8.3. Product evaluation conclusion

Limitation

Due to time constraints, the sample size of the evaluation is relatively small. Only ten participants were recruited for the profile and product evaluation test. The sample size is sufficient to answer the research questions with both qualitative and quantitative data. However, it's not enough to draw accurate quantitative conclusions from these results.

In addition, although the participants are in different age groups from 23 to 49 years old, they are all Chinese, 8 of them are students, and none of them is patients. The limitation of the target groups might affect the generalizability of the test. In order to validate the conclusions and obtain more accurate quantitative results, it is recommended to include more patients in the future evaluation test.

Conclusion

In this chapter, the evaluation process was presented. Regarding the obtained results, research questions were answered using questionnaires and interview data. The final design can meet the design requirements well.

People are able to create a credible and representative profile through a simple and intuitive profiling process. The results show that the sleep music profiles reflect the personal preferences of the users. Users are able to easily select one of their sleep music profiles.

The logic of profile creation is also found to be credible. The system can create a profile that matches users' preferences based on the answers to five questions. For some users, the content of the profiles could be richer to meet their need for variety.

Overall, profile creation and product usage are simple and intuitive. People can also interact with the app with little cognitive effort and a small learning curve. For desirability of usage, the profile-based personalization approach can get people to use the app and engage with it for a longer time.

Chapter 9
Evaluation 2: Sleep music experience evaluation

CHAPTER OVERVIEW

9.1. DREAMe music evaluation setup

Research objective

In evaluation test 1, the product usage and profile creation were tested. However, the ultimate goal of DREAMe is to help users sleep better with personalized music. Therefore the second evaluation aims to test whether the music delivery experience meets the project design goal, interaction qualities and how.

Design goal: *Provide patients with personalized nighttime sonic environments based on their profiles, and help them immerse in their dreamscape to feel more relaxed before sleep.*

Interaction qualities:
Relaxed, Enjoyable, Immersive,

Research method

An eight-day control test was conducted to evaluate the music effects by comparing the sleep quality before and after design intervention. The purpose of doing a control test is to see the effect of the music interventions on the user's basic sleep quality. It can reduce the influences of other personal factors on the results. Likert scale questionnaires are used to verify whether the final design meets the design goal and vision. After the control test was finished, an interview was conducted to understand how music plays a role in the effects and how personalized music fits individuals' preferences. Randomized control was used for the delivery of music.

Participants

Six participants were recruited for the second evaluation test. Their demographic details are presented in figure 82. They are non-patients between the ages of 20 and 50. None of the participants had any obvious health or sleep problems in the last one month. During the eight-day test, all participants slept alone at home.

Material preparation

Evaluation test materials for each participant were put into a table (see appendix N). The material links prepared for each participant were listed to make the material distribution and collection process more efficient. The randomized control influences the order of the music playlists, profile presentation and profile selection questions in questionnaires.

Questionnaires

Sleep music evaluation questionnaires 1&2 were designed for the test and can be seen in appendixes L and M. Both questionnaires can be completed within 3 minutes.

Sleep music evaluation questionnaire 1

The first questionnaire was used for the first four days without intervention (appendix L). Questions were adapted from the PSQI questionnaire to

Participant	1	2	3	4	5	6
Gender	Female	Female	Female	Female	Female	Male
Age	29	24	23	23	49	48
Profession	Student	Student	Student	Student	Teacher	Computer engineer
Location	Netherlands	Netherlands	China	China	China	China
Nationality	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese

Figure 82: Demographics details of participants for the music experience evaluation test

measure the overall subjective sleep quality and sleep onset latency.

Sleep music evaluation questionnaire 2
Participants answered the second questionnaire in the last four days with the design intervention (appendix N). Compared with questionnaire 1, a music experience section was added to evaluate how people experience the delivered music

Profile links
Four profiles were put in the Adobe XD link so that participants can decide on which profile they were every day. The sequence of profiles is randomized. The initial idea was to add one music sample for each participant to help them be more aware of their choices. However, this function from Adobe XD can only work on a computer or for android users. Finally, the music sample function was replaced by letting people try out the music by themselves while looking at the profiles.

Figure 83 presents the four profile descriptions to one participant. Each profile is placed on one screen, and participants can click arrows beneath to switch among four profiles. For each profile, the sleep engagement, music preference and sleep music are explained with text. To help participants understand the differences among the four profiles, the keywords of each profile are highlighted. The design here only serves for the final evaluation. In the actual product, each user will only see their own profiles.

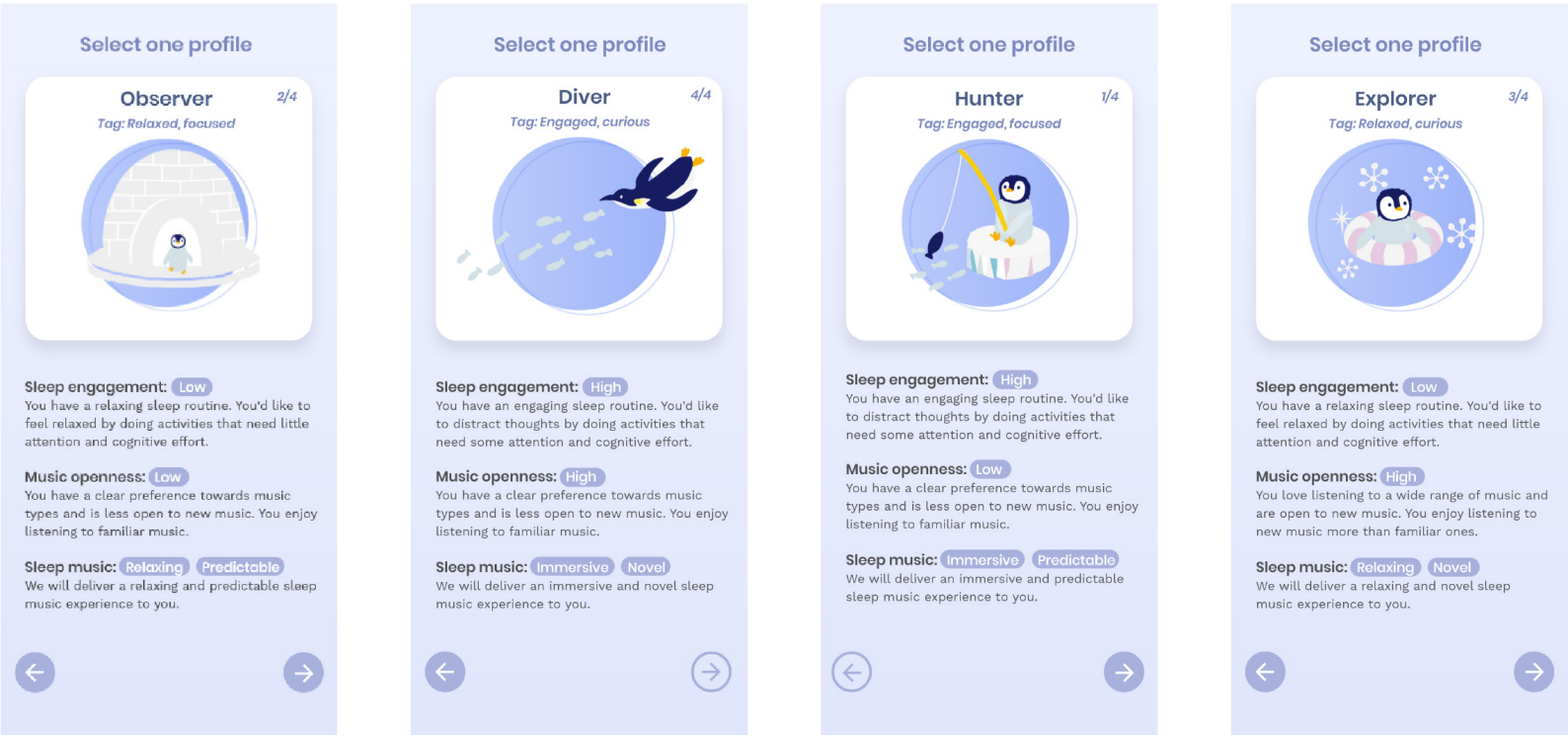


Figure 83: Four profiles presented to one participant through an Adobe XD link

Music preparation

Figure 84 to 87 shows how the 14 pieces of music were prepared for 6 participants.

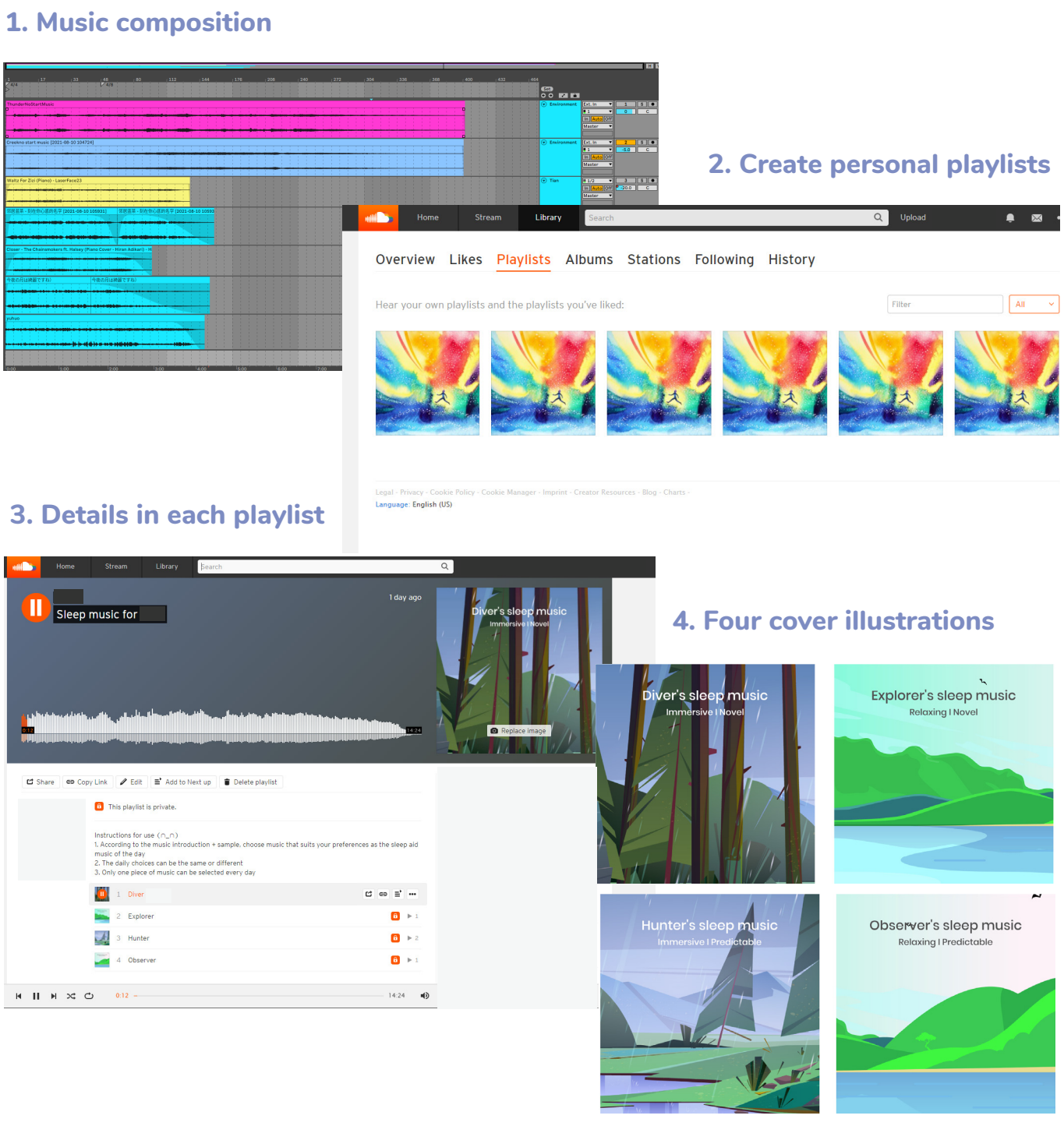


FIgure 84: Remixing the soundscape with users' favourite music melody
FIgure 85: Six prepared albums for participants to listen from
Figure 86. The music listening list for each participant with a randomized sequence, an instruction and labels
Figure 87. Four different illustrations as music covers to help participants distinguish music from each other easily.

The first step of music preparation was to collect the favourite music from participants. All the participants were asked to send the name of their favourite music to the researcher. Music was stored for making personalized sleep music. The environmental soundscape and the low openness profile music (diver & explorer) samples were made by sound designer Willem. According to the sleep music logic described in the design part, the melody of users' favourite music was put into the first part of the soundscape, with a change in the loudness, frequency range and tempo. The sources of the users' music melody came from online instrumental covers. All the music sources were under fair use and only for the evaluation purpose.

Music sharing

Prepared music pieces were uploaded as a private playlist to Soundcloud. In total, six shareable and labelled playlists were created (see figure 85). Each playlist includes the test instructions in the description section, so participants can be reminded when they start to listen. Four different illustrations with a profile name were set as music covers to help participants recognize and distinguish pieces. The covers also help to indicate the sounds elements, like forest or creek sounds. Finally, each music was labelled with the profile names: explorer music, diver music, hunter music, and observer music.

Procedure

Introduction

Participants were introduced to the testing procedure via Zoom or in person prior to the start of the test. Participants received daily reminders and test materials through an online communication tool (Wechat, similar to WhatsApp but more available to Chinese participants).

Day 1-4: Measure sleep without intervention

Participants received the sleep music questionnaire 1 before the test began. They were asked to go through the questions to be aware of their sleep during the night. The next day, they received a reminder to complete the questionnaire by reflecting on the previous day's sleep. The questionnaire takes only 3 minutes to complete.

Day 5-8: Measure sleep with intervention

On day 4, all participants received the materials for the next four days, including tasks instructions, profiles, personal music playlists, and sleep music questionnaire 2. Before bedtime, participants went through four profiles and listened to the associated music for 10-20 seconds. They then selected one profile music to aid their sleep. They could choose only one music for a day.

9.2. DREAMe music evaluation results

The project's goal is to help people fall asleep better, focusing on improving the before sleep experiences through personalized music. Therefore, in the evaluation results section, I'll introduce and discuss the effects of music from these three aspects: the overall sleep quality, sleep onset latency and sleep music listening experiences. The results come from the sleep music evaluation questionnaires 1&2 (see appendixes M&N).

Subjective sleep quality

The results about subjective sleep quality are shown in figures 88 and 89. Mean and median scores are in light and blue colours. Comparing the scores with and without design intervention shows a slight increase in subjective sleep quality. Subjective sleep quality with the design intervention is 0.2 (mean score) and 0.4 (median score) higher than those without intervention.

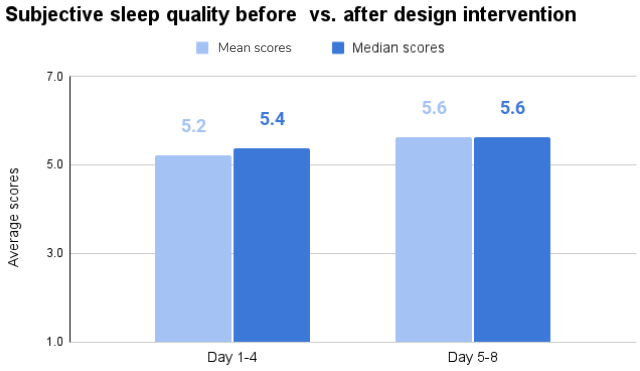


Figure 88. Mean and median scores of subjective sleep quality before and after design intervention (1=totally disagree, 7=totally agree)

As shown in figure 88, participants agree that they sleep better with music intervention, which means **listening to DREAMe sleep music before bedtime is likely to help participants have a better sleep quality.**

Figure 89 shows an overview of how six participants rate the subjective sleep quality over eight days. Looking at the change in scores, the mean and median fluctuate slightly one or two times over eight days. The trend of mean and median scores performed differently in the last four days with the designed intervention. The mean score tends to increase, but the median first increases and then decrease.

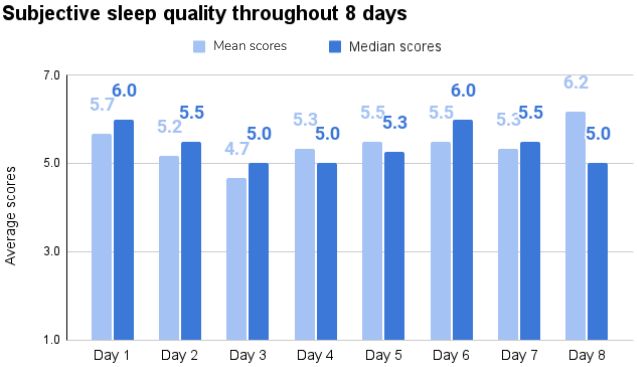


Figure 89. The mean and median scores of subjective sleep quality throughout 8 days (1=totally disagree, 7=totally agree)

The results from figures 88 and 89 suggest that **personalized music can moderately enhance participants' subjective sleep quality. The positive effect of music is not fully stabilized in a four days' intervention**.

Sleep duration

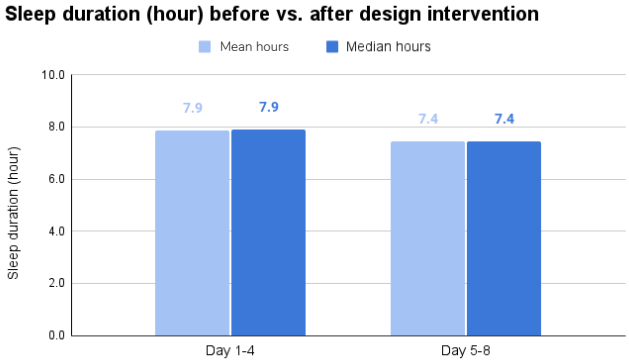


Figure 90. Mean and median scores of sleep duration before and after design intervention

The next two charts show that the mean and median scores of sleep duration. Figure 90 shows that participants sleep duration decreased by an average of 0.5 hours after listening to DREAMe music after sleep, from 7.9 hours to 7.5 hours. Both the sleep duration before (7.9 hours) and after music intervention(7.5) is within the healthy sleep duration for adults, between 7-9 hours (Chaput et al., 2018). The results suggest that **participants' sleep duration decreases by half an hour after the music intervention in a healthy sleep duration range.**

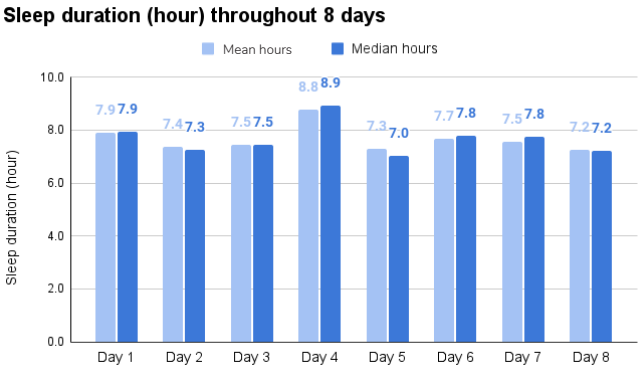


Figure 91. The mean and median scores of sleep duration (hour) throughout 8 days

There is an increase in sleep duration from day 3 to day 4 (figure 91). Participants' sleep time tends to be more stable after the music intervention. The results suggest that **participants tend to have a more regular sleep duration after listening to music**.

Sleep latency

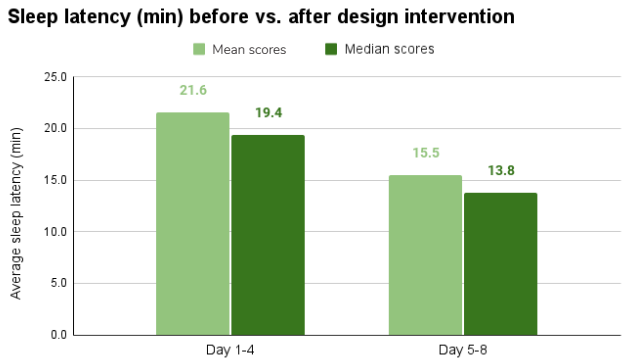


Figure 92. Mean and median sleep latency (min) before and after design intervention

Figures 92 to 93 show data on sleep latency. In figure 92, it can be seen that the mean sleep latency decreased by 6.1 minutes from 21.6 to 15.5 minutes and the median decreased by 5.6 minutes from 19.4 to 13.8 minutes after the DREAMe music intervention. These results show a significant reduction in the time it takes participants to fall asleep. **With the DREAMe music intervention, participants are able to fall asleep approximately 6 minutes faster than with a normal home sleep routine.**

Figure 93 provides an overview of how much time it takes participants to fall asleep over 8 days. The average score decreases over the last two days, and the average score has a decreasing trend over the days with music intervention.

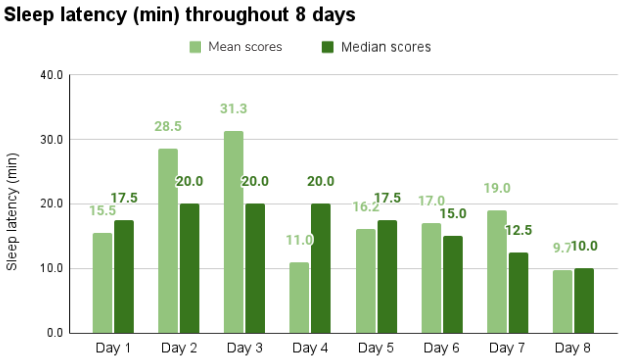


Figure 93. Mean and median sleep latency(min) throughout 8 days

The decreasing trend in sleep latency in the last four days indicates that **the longer duration of the music intervention might potentially put the user to sleep more quickly.**

How relaxed participants feel before falling asleep

Figures 94 and 95 show the effects of music on how relaxed participants feel before falling asleep. In figure 94, it can be seen that the mean and median of the level of relaxation during a normal sleep routine is rated as 5. This means that with a normal sleep routine, participants feel relatively relaxed before falling asleep. With the music intervention, the mean score of participants' relaxedness decreased from 5.0 to 4.8, but the median score increased from 5.0 to 5.1. The mean and median scores perform differently, and the changes in both scores are small.

Listening to DREAMe music before bed does not seem to change the participants' level of relaxation before falling asleep during the test period.

Looking specifically at the values on each day, as shown in figure 95, we can see that the level of relaxation before going to sleep is constantly changing. On the second and sixth days, there are the lowest values. The highest values appear on the seventh day. Participants score low on the first two days of the intervention, around 5 and 4 respectively, with an increase on the second two days, between 5 and 6.

The decrease in relaxation level before falling asleep on the first two days of the music intervention might relate to the fact that users are less familiar with the music. **Participants' relaxation levels increased after being exposed to the DREAMe music intervention for two days.**

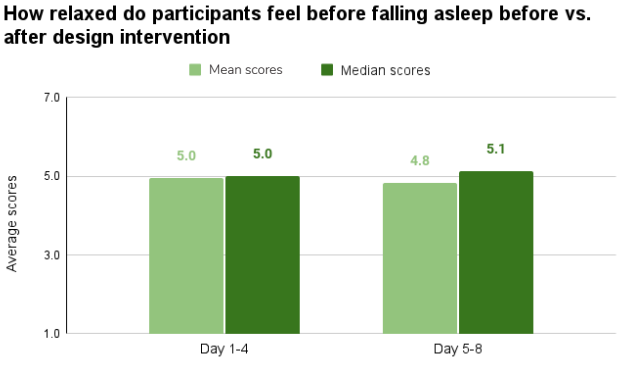


Figure 94. Mean and median score about how relaxed do participants feel before falling asleep before and after design intervention (1=totally disagree, 7=totally agree)

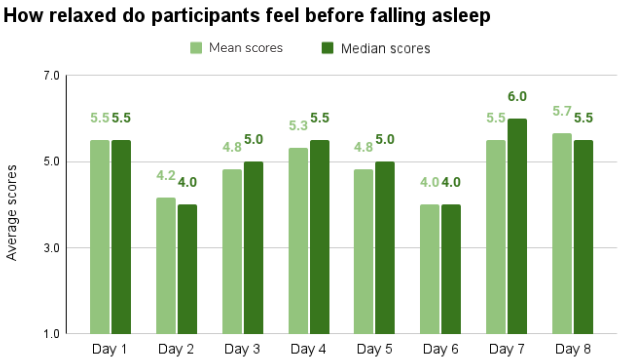


Figure 95. Mean and median score about how relaxed do participants feel before falling asleep throughout 8 days (1=totally disagree, 7=totally agree)

How easy it is to fall asleep

Figures 96 and 97 about how easy it is to fall asleep seem similar to the previous two (figure 94 & figure 95). The results in figure 104 show that the mean and median score of how easy it is to fall asleep with design intervention is 0.2 points lower than the scores without any intervention. The small drop in both scores shows that **participants find it slightly less easy to fall asleep with DREAMe music intervention.**

Figure 97 illustrates how easy it is to fall asleep on eight days. It can be seen that the lowest mean and median values are 4 and 4.2, respectively. The overall values for the degree of ease are also above 5 (see figure 96). Combining these two results, we know that participants generally agree it's pretty easy to fall asleep before and after the intervention. **It is unlikely that listening to DREAMe music will lead to difficulty in falling asleep.**

Figure 97 also shows that the ease of falling asleep varies greatly over the eight days. Similar to relaxation level, participants found it least easy to fall asleep on days 2 and 6. On the last day with music, participants found it easiest to fall asleep. The mean reached a high of 6.5 and the median a high of 7.

On day 5, the first day with the music intervention, users found it more difficult to fall asleep than the previous day. Both the mean and median scores continued to decrease. However, from day 7 to 8, both scores increase. Participants found it easiest to fall asleep on the last day with the music intervention.

Similar speculations can be derived from these changes as from the previous ones. Although the ease of falling asleep decreases at the beginning of the music intervention, **the effect of DREAMe music in helping people fall asleep appears with increasing duration of music exposure.**

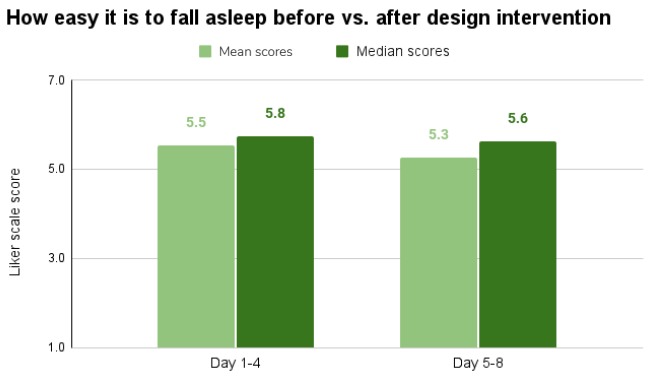


Figure 96. Mean and median scores about how easy it is to fall asleep before and after design intervention (1=totally disagree, 7=totally agree)

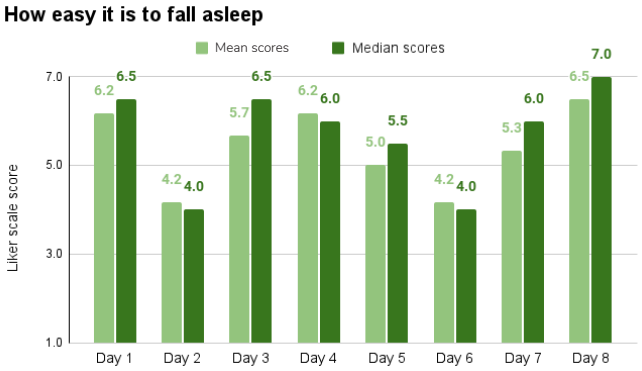


Figure 97. Mean and median scores about how easy it is to fall asleep throughout 8 days (1=totally disagree, 7=totally agree)

Music listening experience

This section focuses on the effects of personalised sleep music and how music leads to certain effects. The data collected on the experience of sleep music is presented in figure 98.

Interaction quality: **relaxed**

As shown in figure 98, the highest scores on days 5, 7 and 8 all reach a maximum of 7, while the lowest score on day 5 is two. The lowest score falls below 4 only once, indicating that most participants felt relaxed on the first day they listened to the sleep music, while some did not.

Mean and median scores are above 5 every day and steadily increase throughout the four days. On the last day, the music has the highest relaxation effect on the participants. This suggests that **DREAMe music can provide an overall relaxing listening experience. Although it may be perceived as less relaxing by some participants at first, they start to feel relaxed after two days' music listening.**

According to the interview session, the relaxed feelings are related to:

The overall relaxing qualities of music, such as slow tempo, soft timbres and natural sounds , make people feel relaxed.

> *"Slow tempo of the music, soft piano sounds, and natural sounds make me feel relaxed."*

The predictability of natural sounds also leads to a relaxing feeling.

> *"The creek sound as a whole is short, thin, and continuously predictable..."*

Finally, the gradual slowing down of music also has a relaxing effect.

> *"I feel most relaxed when I feel the pace of my favourite music gradually slows down."*

	Date	Min scores	Max scores	Mean scores	Median scores
When I listen to it, I feel relaxed.	**Day 5**	2.0	7.0	5.3	5.5
	Day 6	4.0	6.0	5.2	5.0
	Day 7	5.0	7.0	6.2	6.0
	Day 8	5.0	7.0	6.5	7.0

	Date	Min scores	Max scores	Mean scores	Median scores
When I listen to it, I feel enjoyable.	**Day 5**	2.0	6.0	5.2	6.0
	Day 6	3.0	7.0	5.3	5.5
	Day 7	4.0	7.0	5.7	5.5
	Day 8	5.0	7.0	6.0	6.0

	Date	Min scores	Max scores	Mean scores	Median scores
When I listen to it, I forget the outside world.	**Day 5**	2.0	7.0	5.0	5.5
	Day 6	5.0	5.0	5.0	5.0
	Day 7	3.0	7.0	5.0	5.5
	Day 8	6.0	7.0	6.2	6.0

Figure 98. Score ranges for the three qualities in design vision in the last four days (1=totally disagree, 7=totally agree)

Interaction quality: **enjoyable**

Figure 98 shows that the highest score from the first to the fifth day is 7. The lowest scores on the first two days are below four, at 2 and 3 respectively.

The results mean that listening to music is always enjoyable for some participants. However, some of the others do not find it enjoyable at the beginning.

In the last two days, all participants agree that the DREAMe music gives them a pleasant listening experience. The increase in scores indicates that the enjoyment provided by the music also increases over time.

Enjoyable feelings come from:

Participants tend to feel enjoyable when they hear their familiar melody.

- *"I felt happy when I heard a familiar melody."*

Positive associations are evoked with environmental sounds.

- *"Listening to sounds of the creek brings back many positive memories for me.*

There are no distracting sounds in the music.

- *"I did not hear any distracting sounds."*

Interaction quality: **immersive**

The lowest score for immersive feeling is a score of 2 on day 5 （see figure 98). Except for day 6, the highest score on each day is 7. With all mean and median scores above 4.5, participants find listening to DREAM music immersive. The gap between the lowest and highest scores slowly decreases, indicating that the immersive feeling that music evokes increases over time.

Initially, participants had varying opinions on how immersive they felt. Over time, participants agreed that the music made them feel very immersive.

Immersive feelings are created by

Familiarity with the music provides immersion.

- *Listening to the music itself is immersive…"*

The mixture of music and environmental sounds can immerse participants in the dreamscape.

- *"It's not just music or ambient sounds. It's a combination of both. It's better than only have one of them because it feels full, and it can create a space for me.*

- *"… the natural sounds help create an environment."*

The gradual slowing down of the melody leads to an immersive experience.

- *"The tempo slows down and can help me sink into it…"*

Unfamiliar parts of the music can also grab the listener's attention and brings a sense of immersion.

- *"The unfamiliar parts in the music makes me forget the outside world."*

Personalization and music effects

Participants	P1	P2	P3	P4	P5	P6
Profile	**Hunter**	**Diver**	**Observer**	**Explorer**	**Observer**	**Hunter**
Day 5 music selection	Explorer music	Diver music	Observer music	Explorer music	Diver music	Hunter music
Day 6 music selection	Explorer music	Obsever music	Observer music	Observer music	Observer music	Hunter music
Day 7 music selection	Explorer music	Observer music	Observer music	Diver music	Hunter music	Hunter music
Day 8 music selection	Hunter music	Observer music	Observer music	Exploer music	Observer music	Hunter music
Most effective music	Explorer music	Observer music	Observer music	Explorer music	Observer music	Hunter music

Figure 99. Participants' everyday music selections from day 5 to day 8

Figure 99 shows the results of each user's daily music choices. Participants five and six chose to listen to the same profile music every day. The rest of the participants also listened to other music.

The question "which music suits you best?" was asked in the follow-up interviews to better understand the relationship between the user's music and their profile.

Four participants felt that their profile music was best for sleeping. This suggests that there may be a positive relationship between profile-based selection and music effectiveness.

Although the profile reflects preferences for sleep music, this does not mean that the system can recommend optimal sleep music that all aspects of it are preferred by the participant. The main reason is that **profile-based music focuses on general openness to music and engagement in sleep rather than detailed preferences for musical elements.**

For example, participant 1 considered explorer music was more effective than her profile hunter music. Her preference was consistent with the main characteristics of hunter music: she wanted to have an immersive music experience and preferred to listen to familiar music. The main reason for choosing a different piece of music was that she didn't like piano music. Listening to piano music would make her uncomfortable, and if she had a choice, she would prefer violin music.

The sleep music profiles reflect what kind of sleep music people like and could be related to the effectiveness of music in supporting sleep.

This suggests a need to enriching the sleep music profiles with customization functions. Considering a combination of sleep music profiles and preferences for musical elements might better predict what music people find most effective for sleep.

9.3. DREAMe music evaluation discussion

In this section, an overview of the findings is summarized. Based on these findings, the design goal and design vision are addressed. Then, some other findings from the evaluation test and the limitations of the test are discussed.

Addressing the design goal

The design goal is to help patients sleep better before they fall asleep. **The evaluation results suggest that DREAMe music is likely to help people fall asleep faster and fall asleep more easily and relaxed after two days of exposure.**

Shorter sleep latency

In terms of sleep latency, listening to DREAMe music helps participants fall asleep 6 minutes faster than a regular sleep routine. Their overall sleep latency decreases from over 20 minutes to 15-20 minutes, indicating healthier sleep. The more days the participants are exposed to the music, the more pronounced the effect.

An increasing trend in relaxation and ease level

On the other hand, the DREAMe music intervention improves the level of relaxation before sleep after two day's exposure to music.

Some people find it slightly uneasy to fall asleep with music initially. However, it is also found that the effect of DREAMe music in helping people to fall asleep increases as the duration of music exposure increases. Then the participants' level of relaxation increases, and they find it easier to fall asleep.

Influential factors

Some factors might be related to these results, like the familiarity with music listening, sleep aid urgency, and the way of listening.

Familiarity with music listening

The gradual increase in the relaxation effects of music may come from a sense of familiarity, that participants become familiar with music listening behaviour. Music listening is not commonly used as an everyday sleep routine, and only 4.22% of people in one survey reported that they listen to music every day (Tabitha, 2018). Therefore it is reasonable that people need to accept this new behaviour, especially those who use music as a sleep aid for the first time.

> *"On the first day, I didn't adapt to listening to music. It was something new, and I could always feel it was present. Then after slowly becoming familiar with listening to music, the presence of music was weaker and more able to help one fall asleep."*

Participant was not used to listening to music and felt unnatural at first. When she got used to it, she could enjoy the music better.

This result is consistent with the conclusion from a music study that also suggests that the effect of music on sleep increases over time (Dickson & Schubert, 2020). However, since not all participants listened to the same piece of music for four days, the increasing effect of music may be caused by the change of music content.

Sleep aid urgency

The relaxation effects of music might be related to how much people need for relaxation. One explanation for the limited effects of DREAMe on relaxation is that recruited participants don't have an urgent need for aiding sleep. All

participants are healthy and claim they don't have any problems falling asleep. One participant explained why she doesn't feel music help a lot: "It was quite relaxing to listen to, but I didn't need music to help me relax."

Different ways of listening

People's relationship with music might influence how they listen to music. Whether people actively listen to the music might impact the effects of music. Participants were found to listen to music in different situations, which might influence how music plays a role.

> *" Usually, I get to bed until I'm exhausted and fall asleep easily every day, with little motivation for external support."*

> *"I use my phone all the time before I go to bed and turn on music when it's time."*

Improvement in sleep quality

Increased sleep quality and shorter duration

Music intervention increases the quality of sleep and shortens the time to fall asleep. Participants' subjective sleep quality was moderately improved after listening to DREAMe sleep music. However, the beneficial effect on sleep quality is not entirely stabilized during a four-day intervention. Participants' sleep duration decreases by half an hour to a healthier sleep duration range. Their sleep time tends to be more consistent as well.

After listening to sleep music, a shorter sleep duration with an increase in subjective sleep quality implies that participants' sleep needs can be satisfied with a lower amount of sleep. This is consistent with the finding in one study that less sleep duration is associated with better sleep quality in young adults (Takeuchi et al., 2018). It is assumed that listening to music may help people develop better sleep habits and sleep more regularly, thus achieve better sleep efficiency.

High expectation for sleep music effects

Participants seem to have high expectations for the effects of music on sleep. They expect the music can help them fall asleep very easily, like sleep pills.

However, the effects of music are not instant, so that it might lead to some disappointments. The high expectation tends to happen on participants who use sleep music for the first time.

> *" I don't feel the music have a huge effect on me to help me suddenly fall into sleep very easily."*

The participant, who usually uses music before bed, tends to have a lower expectation for sleep music, and she knew what she wanted from the sleep music.

> *"The sleep music I need is to help me feel calm. I expect the sleep music to be repetitive and predictable."*

This indicates that it's important to inform participants well about how the effects of music can establish after several weeks. Otherwise, even if music can improve people's sleep quality, people would drop out before the music plays an effect.

Sleep music listening experience

Addressing design vision

DREAMe music achieves the design vision regarding the evaluation results by providing an overall relaxing, enjoyable, and immersive listening experience. Participants seem to enjoy the music more when listening to it after two to three days.

The function of sleep music

Designed music elements can bring participants positive feelings in different ways. The relaxing feelings while listening comes from the relaxing features of music (tempo, frequency and timbre), natural sound elements, and the gradual slowing down of the music.

The combination of music and environmental sounds has an excellent effect on helping participants feel immersive by creating a sonic environment. Apart from that, the gradual slow down of melody also has the effect of helping people be immersive.

Personalization and music effects

Participants tend to think their profile music is more effective, indicating that personalized music can better fit people's sleep and music preferences. However, participants preferences towards specific music elements are not included in the evaluation. These preferences can be very different for each individual. There is a need to combine the customization approach with the profile-based personalization system for achieving a more comprehensive system.

Limitations

It takes at least a day to prepare music materials for one participant, and there is a time limit for this project. Therefore only six non-patients were invited for the evaluation. It is recommended to conduct a test with more participants and include patients as well.

The final music evaluation was conducted throughout eight days, including four days without intervention and four days with music intervention. Ideally, an evaluation for several weeks would give more accurate and reliable results. Therefore, a long-term experiment on music effects is recommended afterwards.

Chapter 10
Next steps

CHAPTER OVERVIEW

10.1. Project conclusion

The project objective is to use music intervention to help patients fall asleep better in a relaxing way. A profile-based music personalization system was designed to assist patients' sleep at Reinier de Graaf hospital.

The main challenges involve:
1. How to get an intimate image of patients' sleep and music preferences?
2. How to create profiles that are representative of patients' preferences?
3. How can music be delivered based on profiles?

Research

Literature research was conducted to understand sleep knowledge, music as a sleep aid, and personalization approaches. The generative user research acted as a data collection process with the following outcome:

- Sleep & music diary as a preference data collection tool
- Sounds that are perceived positively/ negatively related to sleep
- Three sleep needs "ease, enjoyment and away from reality" applicable to patients
- Eleven sleep and music preference tags

Sleep engagement (low-high) and music openness (closed-open) were selected as two dimensions for creating profiles from the preference tags. After several iterations, four profiles were proposed: **diver, explorer, observer and hunter**, representing personal sleep and music preference.

Design direction

Design goal: Provide patients with personalized nighttime sonic environments based on their profiles, and help them immerse in their dreamscape to feel more relaxed before sleep.

Interaction quality: Relaxing, Enjoyable, Immersive

Personalization system design

After the brainstorm session, a system design was outlined, from profile creation to system algorithm and sound experience. In the concept detailing phase, the system was designed to be more concrete. The profile initialization process involves how users can input information and generate profiles. Sleep music modules were regulated in preparation for music prototyping. After two separate iterative tests, insights were concluded for the final design.

The final design, DREAMe, is an application based on a personalized sleep music system. The core functions are **a sleep music profile test and a personalized music player**. An interactive prototype was designed to demonstrate the app interfaces and interactions. Through a collaboration with a sound designer, personalized music modules were visualized and composed.

The final evaluation includes two tests, the profile and the music experience test. **Profile & product experience evaluation conclusions:**

- The overall product experience is easy and intuitive.
- People are desried to use DREAMe.
- Profiles generation logic is reasonable.
- Four profiles could represent people's preferences, but sleep preferences might change over time.

Music experience evaluation conclusions:

- DREAMe sleep music can help people fall asleep quicker and have a better sleep quality.
- The relaxation effects of DREAMe music increase over time and tend to provide a more relaxing feeling after 2-3 days' intervention.
- DREAMe music delivers a relaxing, enjoyable and immersive experience for people. An increasing music exposure time leads to more obvious positive effects.

10.1. Recommendations

Based on the final evaluation insights, DREAMe can be further developed in the following aspects.

System design

Develop a generative music system

In this project, final music samples were composed based on the modular music system. Composing music is still manual, but it can be a valid step for prototyping the system. One highly recommended next step for this project is collaborating with sound designers to prototype the proposed music modular system in Max/MSP. In Max/MSP program, it is possible to sequence different music samples based on the predefined structure and replace music modules based on user input. Therefore, building the generative music system only needs one step forward, transferring the manual process into the coding language in Max/MSP.

Having a simple generative music system can bring lots of benefits. For designers and researchers, the iteration and improvement of music will be more convenient because it can automate the music composition process and generate many pieces of music in a short time. Designers and researchers can prototype different music versions by simply adjusting settings and iterate quickly. Users can listen to their personalized music in real-time and customize it instead of waiting for the composed and not customizable music. Changing theme music or music duration will become testable functions if this system is ready to use.

Include a feedback loop

From the literature research, we know that the profile-based personalization process includes four steps: information collection, initialization, integration and update.

This project aims to build a basic system focusing on the previous three steps. Future designs can include the update stage in the system as well. Data for the system update can both come from the system and patients. From patients, we can gain subjective data, like sleep quality, listening experience and emotions. Patients can report their subjective sleep experiences and how they think about the music after one night's listening. We can gain objective data from the system like sleep characteristics, including sleep latency, duration, efficiency, and sleep patterns. Sleep trackers like Fitbit can be combined with the application to measure data. Based on a reasonable interpretation of data feedback, the system can be iterated and developed for better catering to people's sleep needs.

Behavioural design

Build a sleep music listening habit

There is a design opportunity for building long-term sleep music listening habits. People are desired to try out the product, and whether they will continue to listen is largely affected by first-hand experiences. People who have not tried music before tend to have a quite high expectation of the music effects. However, the music effects in aiding sleep might not be instant. A longer time of music listening might be necessary for people to experience the real effects of music on sleep quality. Hence, there is a need to use design to control patients' expectations and motivate them to listen to music regularly to achieve better effects. Patients who will stay for a shorter period at the hospital can start listening to the music even before being hospitalized. Some behavioural models like the Fogg model (Fogg, 2009) can be applied for supporting the design.

Guidance for the way of listening

The design can be designed to guide patients to listen to the music in an intended way. The illustrations in DREAMe app is designed to evoke pos-

itive associations. However, illustrations can only guide the imagination about the environment. Indications about how people may pay attention to some parts of the music are needed. For example, one participant thought that the slowing down of the music was not as effective as the guided meditation. One reason could be that participants are constantly guided by the verbal instructions in mediation, while there is no guidance in music listening. Therefore, it is suggested that text or audio guidance of the music can be given before the music starts as a variation.

On the other hand, delivering freedom in listening might bring a sense of autonomy to patients. In the future, a test between how people listen to the music can affect the sleep music effects might help decide whether guidance in music is needed.

Customization design

Customization in musical elements

Customization is considered an important next step. From the final evaluation, it is found that even though people in specific profiles tend to enjoy certain types of sleep music, the musical elements also impact how people like the music. Take the preference of musical instrument sounds as an example. Some people who do not like piano sounds might not like the piano part of the sleep music, although the sleep music fits their other preferences well. In the research phase, nine tags other than sleep engagement and music openness were derived, including: “sleep concerns”, “external support”, “relatedness”, “established sleep routine”, “mood”, “relationship with music, instruments”. These tags cannot represent a broad aspect of preference compared with sleep engagement and music openness, but they are suitable for building customized features. Designers can further develop the customization features based on the defined preference tags.

Explore variations in user input music

In the final design of DREAMe, users were asked to provide their favourite music, and they were free to choose what type of music they wanted to use. However, favourite music is also context related. The music features of the uploaded music can influence the generated music and influence how people feel when listening to it. A user who usually listens to dancy and dynamic music might upload one rock music. Even if the extracted melody of the music is slow and easy, it may still evoke exciting feelings and emotions.

In the future, designers can explore what kind of indications or restrictions can be provided. For example, start by asking the user to select what kind of feeling they would like to feel when listening to sleep music. Then, they can provide one or several pieces of music that can evoke desired feelings. The indications can ensure that music brings the desired emotions.

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All sound recources are under fair use for the evaluation purpose:

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Yoko Kanno, composer. “Waltz For Zizi.” Cowboy Bebop, covered by LaserFace23, SoundCloud, 2016.

Appendix A. Project brief

DESIGN FOR our future

4995

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Jia
initials: _____ given name: Doudou
student number: 5034272
street & no.: F _____
zipcode & city: 2 _____
country: N _____
phone: 3 _____
email: D l

Your master programme (only select the options that apply to you):
IDE master(s): ( ) IPD (★) DfI ( ) SPD
2nd non-IDE master: _____
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign ( ) Tech. in Sustainable Design ( ) Entrepeneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Elif Özcan Vieira dept. / section: HCD – DA
** mentor: Stefano Delle Monache dept. / section: HCD – DA
2nd mentor: Daan Kamphuis
organisation: Reinier de Graaf ziekenhuis
city: Delft country: the Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

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

chair Elif Özcan Vieira date 29 - 03 - 2021 signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 27 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 27 EC

List of electives obtained before the third semester without approval of the BoE

[X] YES all 1st year master courses passed

[ ] NO missing 1st year master courses are:

name C. van der Bunt date 27 - 05 - 2021 signature

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)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: [V] APPROVED [ ] NOT APPROVED

Procedure: [V] APPROVED [ ] NOT APPROVED

- the projectbrief has been submitted late (explanation already received)
- the planning seems 3 weeks too long
(this student does not meet the Medisign conditions, therefore not ticked)

comments

name Monique von Morgen date 8/6/2021 signature MvM

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

Personal Project Brief - IDE Master Graduation

TU Delft

Music for better sleep experience in the hospital — project title

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

start date 17 - 03 - 2021 — 31 - 08 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

The sleep problem is a serious healthcare issue. Sleep is perceived as important as exercise and diet for a healthy life. High-quality sleep can also promote physical and mental wellbeing. Even though, many people cannot have a good rest during the night. According to Phillips global sleep health survey in 2020, half of the population are not satisfied with their sleep experience (Phillips, 2020). In the Netherlands, 22% of people aged older than 12 experience sleep disorders (Kerkhof, G. A., 2017). For hospitalized patients, sleep is more crucial to maintain a good physical and psychological state for recovery. However, the total sleep time in the hospital was 83 min shorter compared with habitual sleep at home and patients feel more difficult to fall asleep (Wesselius et al., 2018). Different approaches have been practiced to promote sleep hygiene in hospitals, from raising awareness of the noises, providing earplugs, controlling lights to reducing external noise. It remains a challenging issue because there are still many sleep-disturbing factors that need to be addressed. Among them, pain and anxiety are two of the most significant symptom-related factors perceived by patients (Grossman, 2017).

Utilizing sound and music as an intervention to promote sleep is a promising direction. On the one hand, there is scientific evidence for the positive effects of music on sleep. For example, physical and psychological responses to music are effective in reducing physical pain perception (Lee, J. H., 2016). Listening to music can also contribute to relaxation (Su et al., 2013). On the other hand, the flexibility of sound design together with human's natural emotional responses to music open up interaction design possibilities. Deisgning with sound amusic involves specifying, acquiring, or creating auditory elements using audio production tools. Recently, sound design has been widely applied in various human-computer interfaces. With music programming tools (e.g. MAX/Msp), designers could design interactive music for different intentions.

This project aims to design sleep-promoting music experiences for patients. The context is within the general wards in Reinier de Graaf hospital. Reinier de Graaf hospital and TU Delft Critical Alarms Lab are main stakeholders.

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space available for images / figures on next page

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

In the consumer market, there are lots of sound-based sleep products, but music is usually a secondary focus. The functional role of music for sleep is not clearly defined as well. In hospitals, music therapy has been used to address sleep issues and other patients' needs. However, there is usually a lack of flexibility for patients and depends a lot on the credibility of therapists. Hence, there is a need for designing a more flexible and effective sound-based digital application. This project will focus on reducing pain and anxiety perception of patients through relaxation with music.

This design aims to tackle these three main challenges: The first and the most crucial one is to figure out a way to deliver suitable and effective music for different individuals. No one music works for everyone. Effects of music are influenced by different personal factors, like stress levels, routine and habits, level of musicality, age, personal preferences, exposure, and familiarity with music (Loewy, 2020).

The second is the music listening experience. Interactive music should help patients to relax with some changes in musical elements like tempo, volume, timbre, etc. Music entertainment is considered a feasible way to support the relaxation effect, but how to trigger the effect with design interactions is an important issue.

Finally, the design should consider patients' current night routine. By designing a better user experience that fits with their current habits, patients are more likely to trust and be engaged with the music application.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

In this project, a music application will be designed to provide personalized music experience to patients in general wards to reduce their pain and anxiety perception through relaxation with interactive music, to reduce their sleep onset latency.

Design research will focus on how to create patients' music profiles. This is a foundation for music selection and ultimate effects. The music profile includes personal data that is helpful for suitable music generation, for example, musical preferences, patient health information, and context. According to the completed profile, the system could provide patients with relevant music to select from. In this way, personalized music will be tailored towards the patient before sleep time.

While patients listen to the music, musical elements could change according to patients' vitals to entrain patients' toward relaxation. The pre-recorded music would be used as the original ones and changes could be made through music production tools. In terms of music output devices, headphones provided by the hospital for each bed would be the main consideration.

This is a Medesign graduation project, so designers will work together with stakeholders in Reinier de Graaf hospital and implement healthcare design tools and knowledge into the design process.

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

Personal Project Brief - IDE Master Graduation

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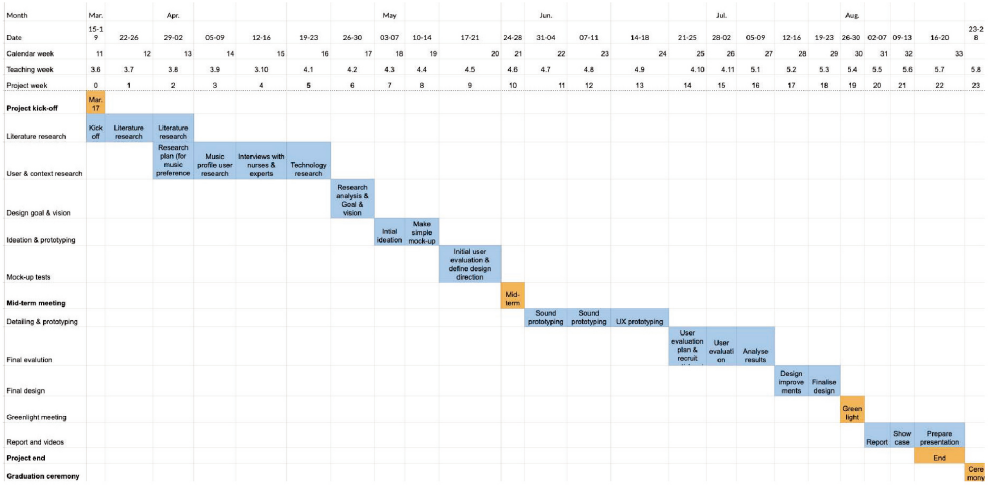
PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 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 net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt 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 parallel activities.

start date 17 - 3 - 2021 31 - 8 - 2021 end date



The project contains three main phases: research, design iteration, and evaluation phase.

The research will be started with a literature review, to understand music entertainment effects for relaxation, and current approaches to helping people fall asleep with sound. A generative session will be set up to investigate the general preferences for sleep music and how music profiles could be created. With the help of Reiner de Graaf hospital, there will be interviews with nurses and experts. Interviews with nurses could help to gain information about the context (e.g. facilities, infrastructure) and the sleep routine of patients. Interviews with experts as a supportive approach help with gaining more theoretical knowledge. Technology research aims to understand the feasibility of future design ideas. At the end of the research phase, results will be synthesized and the design vision will be created.

The interactive design process follows after the research phase. At first, a co-creation session with design students will be conducted first to come up with ideas. By doing simple mock-up tests with music, those ideas will be evaluated and one converging concept will be defined to be iterated on. After detailing this converging concept by prototyping music interaction and user interface, the evaluation plan will be designed Finally, the concept will be prototyped and evaluated in a simulated environment with recruited participants. The final design will be developed further based on the evaluation results.

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I set up this graduation project because it is a combination of my personal and career interest. I'm interested in music and psychology, so I've done design and research projects related to emotion design, gamification design, and design for wellbeing. As a Medesign student, I would like to further pursue my design career in the healthcare industry after graduation. I see the graduation project as a valuable opportunity to apply design knowledge into the healthcare field and develop competencies along the process.

Competences learned from previous experiences
1. User research
Context mapping for context research (C&C, EI courses)
2. User tests
User experience and usability test for design evaluation (UXAD course)
3. Prototyping
MAX/msp, Arduino, UX design (ITD course)
4. Design theory and methodology
Theories and models of health psychology (Health psychology elective), gamification design methods (E-health elective), research emotional needs with different techniques(Design for emotion elective)

Ambitions
1. Design for healthcare
By collaborating with stakeholders and experts in the healthcare industry I could have a further understanding of design methods in the medical field, and broaden the skill set of design research for healthcare.

2. Prototyping
Through prototyping the product, I expect to practice using sound prototyping tools and develop basic programming skills for that.

3. Sound interaction design
I would like to gain more knowledge about sound interaction design. For example, how to design and evaluate the expected sound effects, and how to design the interactions by making using of musical elements.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

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introduction (continued): space for images

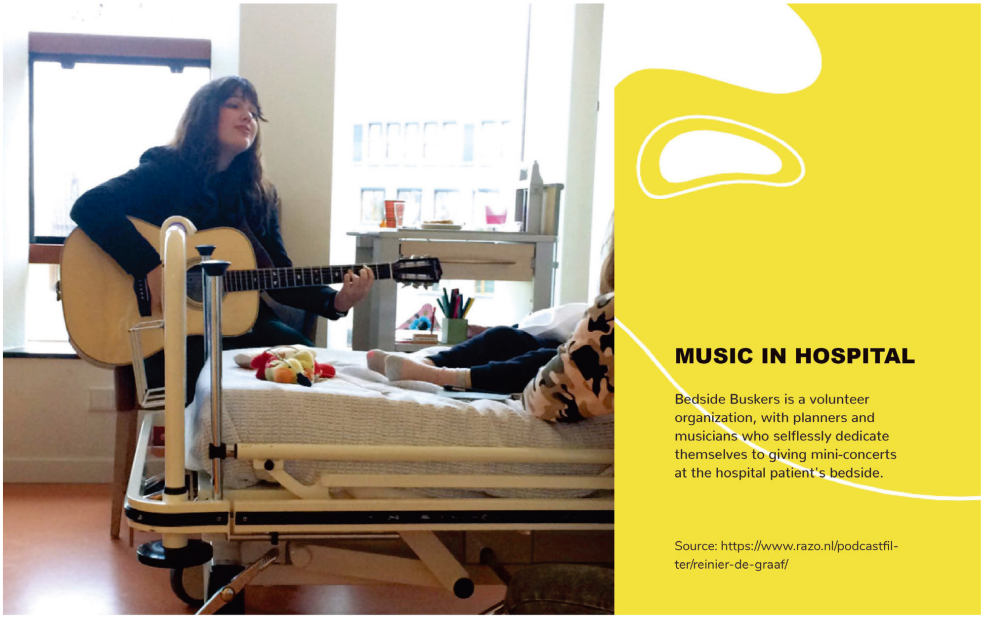


image / figure 1: Music in Reiner de Graaf hospital

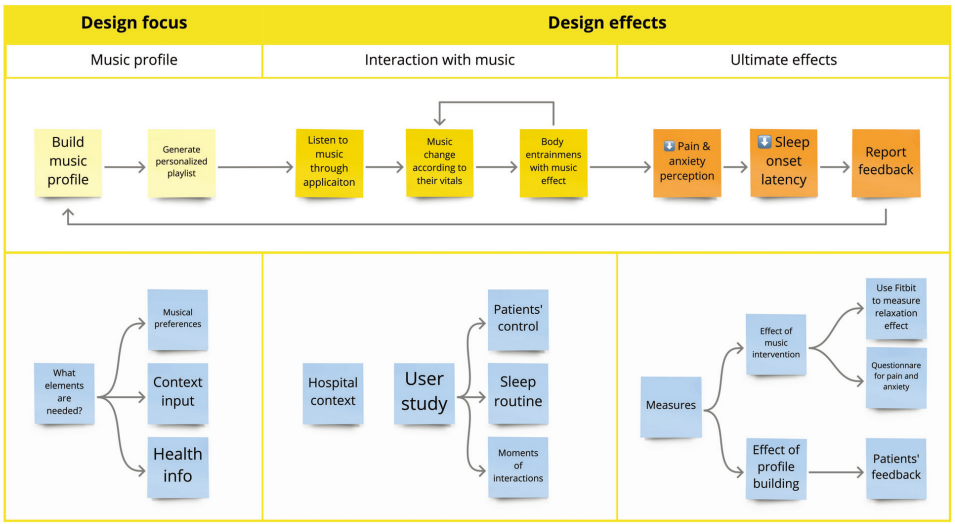


image / figure 2: Design and research scope

Initials & Name Jia Student number 5034272

Title of Project Music for better sleep experience in the hospital

Appendix B. Project proposal

Music for better sleep in general wards

Recruiting nurses to work together

HELLO!

My name is Doudou Jia and I come from China. I'm currently a graduate design student at Delft university of technology. I'm looking for nurses who are interested in working with me on this project.

PROJECT DESCRIPTION

I started my graduation project as a member of the Critical Alarm lab in TU Delft with a collaboration of Reinier de Graaf hospital. This project aims to design sleep-promoting music experiences for patients in general wards in Reinier de Graaf hospital. At the end of this project, a music application for patients will be designed to provide personalized music in general wards to reduce their sleep onset latency through relaxation.

NURSES AS PARTICIPANTS

I'm looking for a nurse who is willing to participate in this project and help me with:

1. An interview with you to understand patients' sleep routines, sleep context (e.g. facilities, infrastructure)
2. Recruit participants in general wards for the final design evaluation

Your help would be invaluable because you work most closely with patients in the wards and understand their needs best, which is crucial for the promising design outcome.

INTERESTED?

Don't hesitate to contact me through this address **D.Jia-1@student.tudelft.nl**

PROJECT TEAM

Daan Kamphuis
Elif Özcan Vieira
Stefano Delle Monache

Reinier de Graaf

Critical Alarms Lab

TU Delft

Appendix C. Explorative interview questions

Music

The relationship with music, attitude, and musicality

- *How would you describe your relationship with music?*
- *Imagine what kind of object it is or what kind of person it is?*

Liked music features and elements

- *Special features make you like these two songs/ soundscape?*
- *Type of instrumental sounds do you like?*

Ask questions that are found to be helpful in the previous explorative interviews.

- *How often do you listen to music?*
- *Will you listen to different music in different contexts?*
- *Have you listened to soundscapes before (like the background music)? How do you feel about those soundscapes? Do you like them?*

- *Have you used music to aid sleep before?*
- *How often do you listen to music before sleep?*
- *What types of music would you listen to before sleep?*
- *If you remember, could you maybe give one example? Like the track name?*

- *Do you think there are many differences between the music you listen to during the day and the night?*
- *If not, why don't you listen to your music before sleep?*

Sleep

Sleep routine

- *What are the essential things to do before sleep for you?*
- *How do you think those behaviors influence your sleep? (good/bad)*

Understand why these activities influence people's sleep

- *One most important trick? Why can it help you fall asleep?*
- *Most threatful? Why?*

Sleep and sounds

Sleep sounds preference

- *Do you think there are certain features of sounds that influence your sleep?*

Ideal sleep environment

- *Could you explain why you draw the dreamscape?*
- *Imagine they are sleeping in the hospital. What are the changes you will add to the dream space?*

Finally

- *General suggestions/feedback for the booklet?*
- *Do you experience some confusion while you are doing this booklet?*

Appendix D. The dairy question list

Booklet outline

What to do with this booklet?

- We would like you to spend some time a day to look back at some of you favourite music.
- Complete on page in the booklet for one day
- If you like, you could scan this QR code to enjoy some music while filling the booklet.

1.Recall memoreis with music

Have you learned any instrument before?
I'm / I'm not a music lover, becasue _____
I listen to music ___ times a month
When I listen to muisc, I feel ___(emotions to select)_____.

What kinds music do you listened to in different moments of your day?

- timeline
- context/activity
- emotion
- assoications

2.General music preferences

Could you choose three of your favourite songs from your music history list and explain why you like them?

THREE MUSIC THE WOULD

Could you use words and images to describe the features of the SOUND you like & dislike?

- simple college (word clouds & images for instruments, descriptors, context, feelings)

3.Music for relaxation

I have/haven't listened to music for relaxation before.
I listened to_____ , when I was at/in_____ I feel___

Could you give me an example of one relaxing music you like?
Why you like this music?
What aspects of this music make you feel relaxed?

4.Music for sleep

Have you tried to sleep with music? How do you feel and which music did you use for that? If not, would you like to try it and why?

What type of music you would like to listen to before sleep?

5.Feedback for the booklet

The feedback for the booklet will be used for further design iteration

- How much do you think the content in the booklet represent your personal music preference?
- What do you think are missing here? Feel free to add

Booklet visual and layout

This booklet is expected to be inspiring and motivating to fill in. So some generative materials will be used to spart participants' imagination and creativity.

Appendix E. Diary version 1

I am..

Me AND my music

Music for me is.....

Memories with music

I'm/ I'm not a music lover.
I've learned _____ (no) music intruments before

I listen to music __ times a month

When I listen to muisc, I feel _____

Mark the moments when you listen to music on a regular day

Activities

Music morning afternoon evening

Emotions

example here

Music I like

Could you choose three of your favourite songs from your music history list and explain why you like them?

1 _____

2 _____

3 _____

Could you use words and images to describe the features of the music you like & dislike?

- simple college (word clouds & images for instruments, descriptors, context, feelings)

Relaxing music

I have/haven't listened to music for relaxation before.

I listened to_____, when I was at/in_____I feel__

One relaxing music I like is _____

What aspects of this music makes it relaxing for you?

Why you like it?

Sleep music

Have you tried to sleep with music? How do you feel and which music did you use for that? If not, would you like to try it and why?

What type of music you would like to listen to before sleep?

Feedback

The feedback for the booklet will be used for further design iteration

How much do you think the content in the booklet represent your personal music preference?

What do you think are missing here? Feel free to add

Appendix F. Diary version 2

SLEEP AND SOUNDS ZZZ

_____ 's Sleep Experience

From sonic awareness to sleep quality workshop

Reinier de Graaf | TU Delft | Critical Alarms Lab

WELCOME!

This booklet is meant to get you in the mood for the session in May and it will also be iterated further for patients.

WHAT TO DO ?

- *Spend 5 mins a day to complete a spread page.*
- *Go through all the small activities when you receive the booklet.*
- *You will receive a "cheat sheet" via What'sApp every day.*
- *Think freely. There are no right or wrong answers.*

Critical Alarms Lab

THANK YOU SO MUCH!

This is the end of the booklet! Hope you have some fun! If you have any questions about the booklet, please contact us via WhatsApp.
Our next exciting session will be on May 27!
Looking forward to seeing you soon!

Critical Alarms Lab

From sonic awareness to sleep quality workshop

MY SLEEP RITUALS

Monday

- *Make a timeline about what you do for a regular sleep routine, how you feel, and what you think at those moments.*

Time →

Activities — start to prepare for sleep

fall asleep

Feelings or thoughts

The stickers might help you.
(Please also add your explanation of the stickers you use.)

MUSIC PERSONA

Friday

- *In general, what's your favourite and least favourite music and soundscape?*
- *Please write names in circles and describe what music aspects affect your choices.*

Please send the music/soundscape links you mentioned to our WhatsApp.

My favourite music/soundscape

Track name

I like it because _____

I feel _____

Track name

I like it because _____

I feel _____

Music/soundscape I dislike

I dislike it because _____

I feel _____

Track name

I dislike it because _____

I feel _____

Track name

TRICKS FOR BETTER SLEEP

- Everyone has special tricks for better sleep. Describe what you do to fall into sleep easier and why it works.
- Feel free to draw or write in circles.

THREATS FOR BETTER SLEEP

Tuesday

- What are the threats for you to have an optimal sleep experience?
- Feel free to draw or write in circles.

DREAM SPACE

- Imagine you could sleep in a perfect space. Where would you like to sleep? (It could be both realistic or fictional places)

There, I wish I could sleep in _____

I could see _____

and I could hear _____

and I would feel _____

Thursday

- Please draw the dream sleep space you described. The drawings don't need to be pretty, but please include important elements of that space.

The stickers might help you.
(Please also add your explanation of the stickers you use.)

"HUNT SOUNDS" BEOFRE BED

- Today before falling into sleep, be more aware of sounds around you and "hunt" them.
- Please describe those sounds the next day.

How to describe sounds?
As discussed in our first session, we could describe sounds with: onomatopoeia("crack"), action, source, location, emotion, meaning.

I heard .....

MEMORIES WITH SOUNDS

Wednesday

- Please reflect on the past moments when sounds influenced how you fell into sleep.

Sometimes, I couldn't fall into sleep because ...

I heard _____
I feel _____

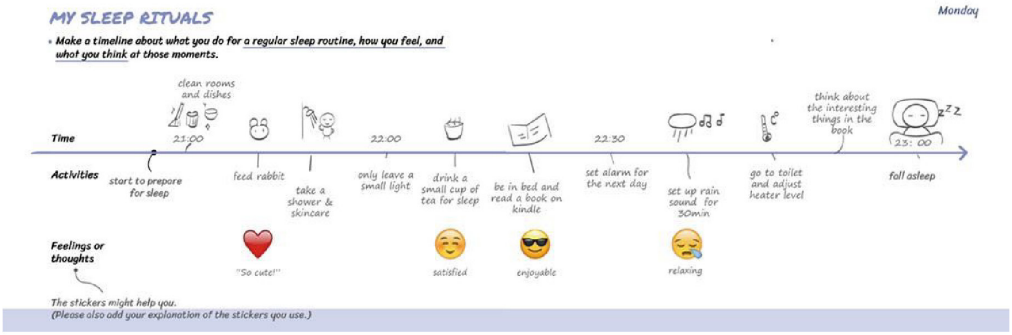
I heard _____
I feel _____

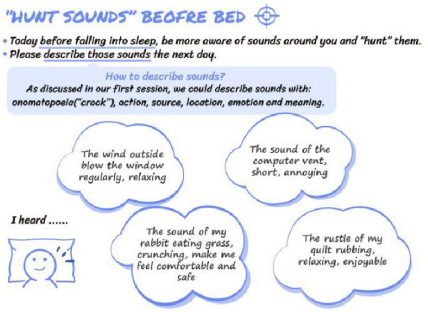
Sometimes, I fell into sleep easier because ...

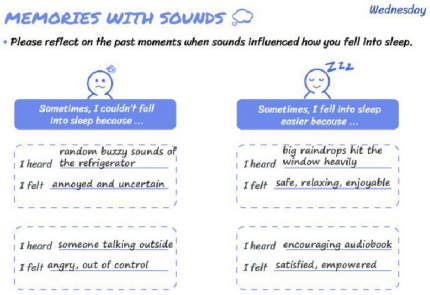
I heard _____
I feel _____

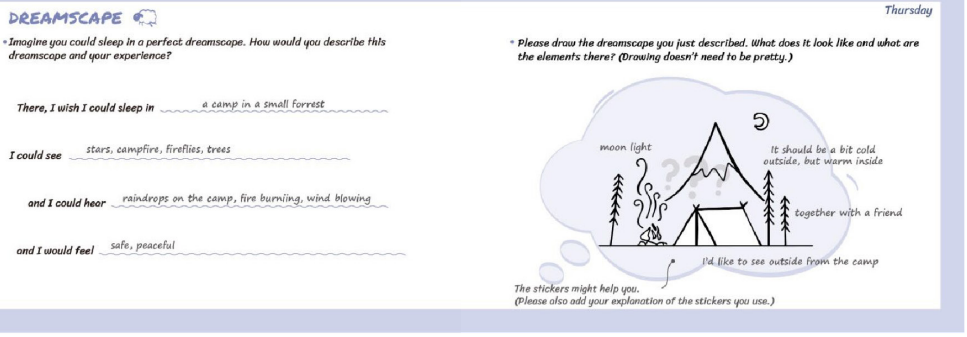
I heard _____
I feel _____

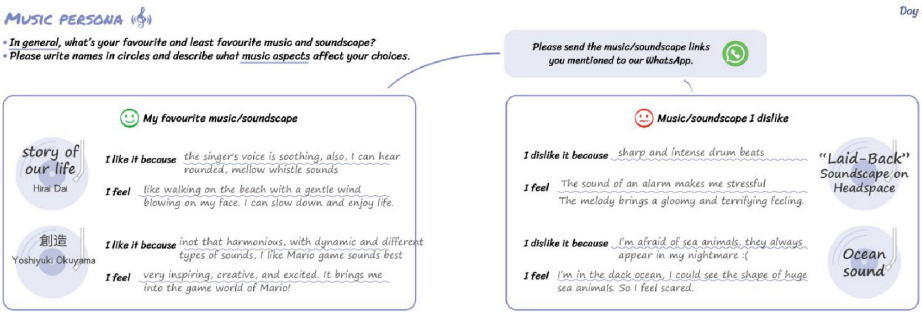
Appendix G. The diary example





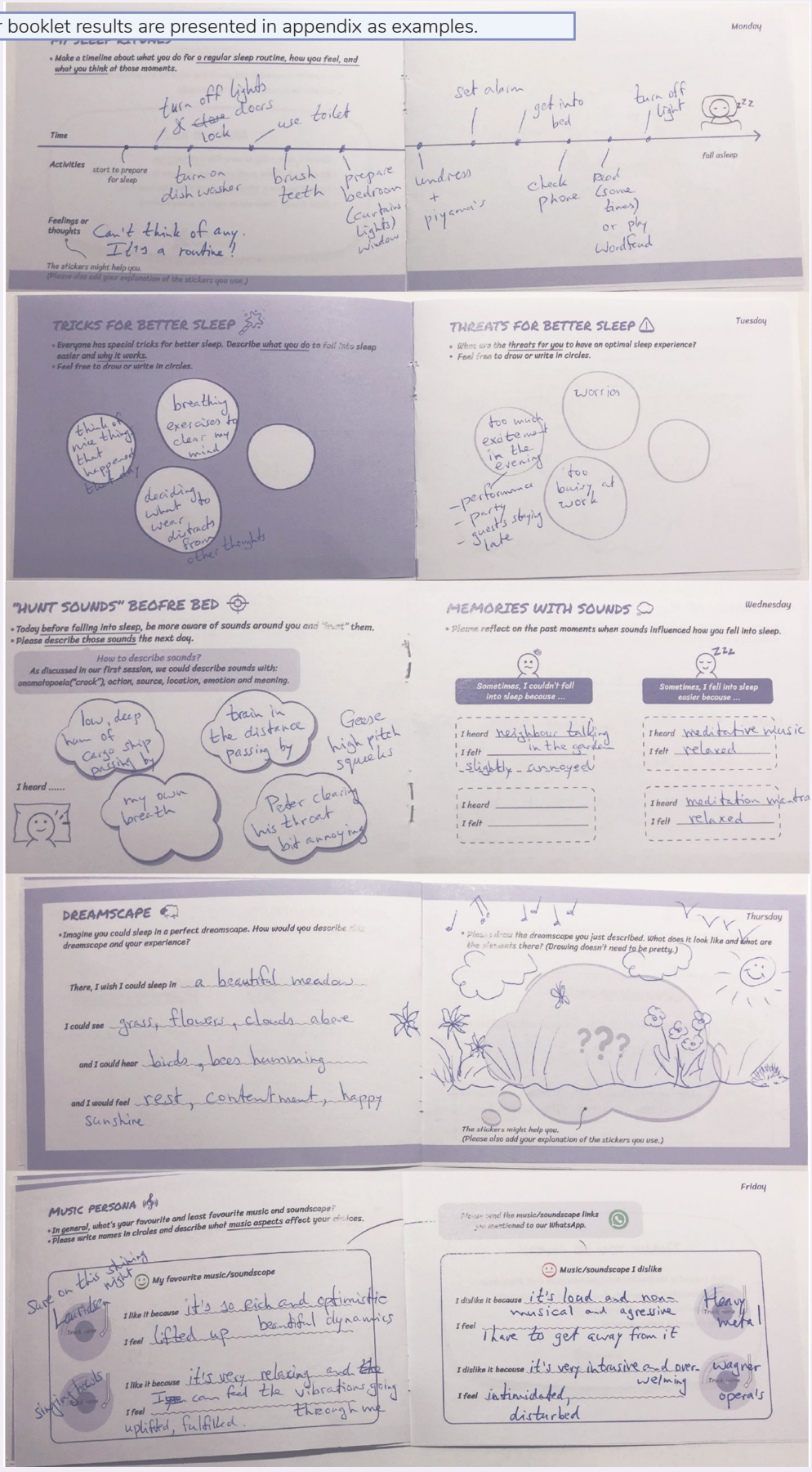




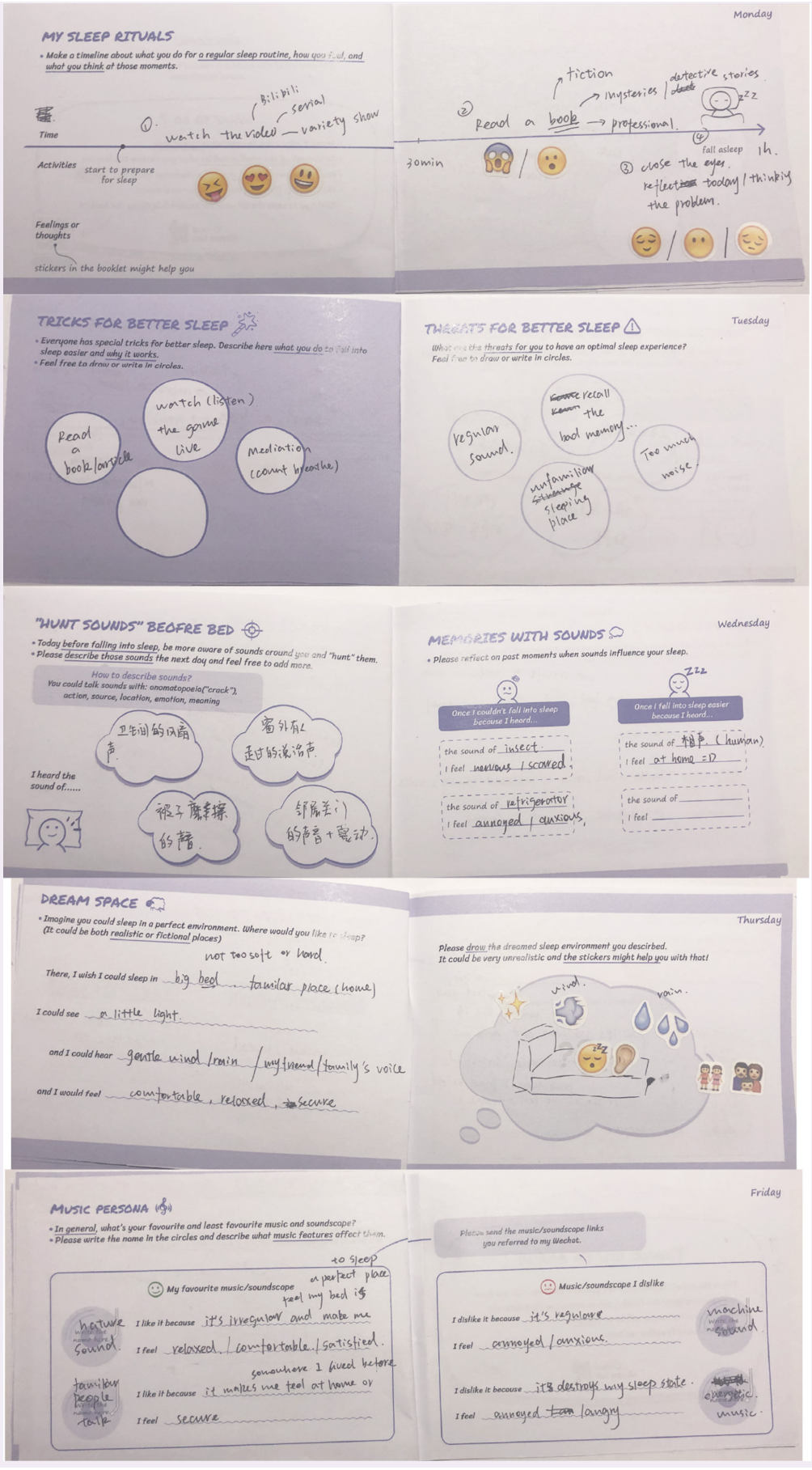


Appendix H. Diary results -1

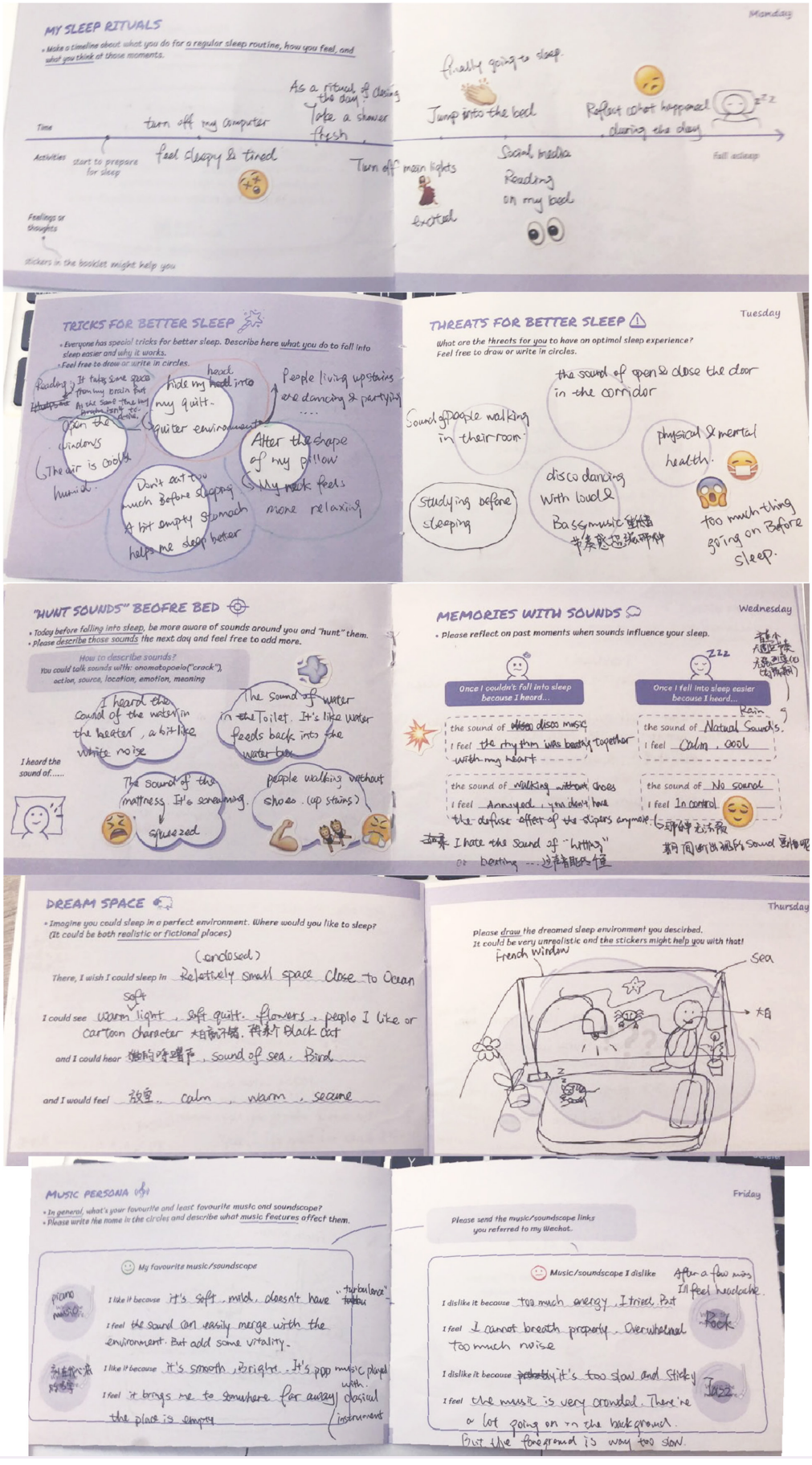
Four booklet results are presented in appendix as examples.



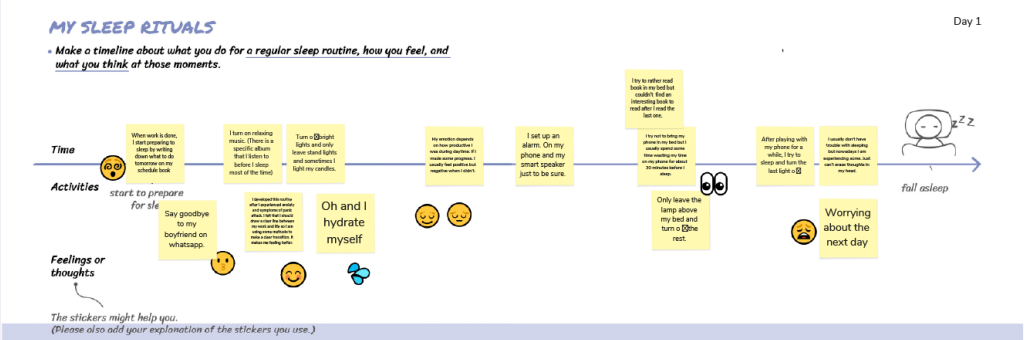
Diary results -2

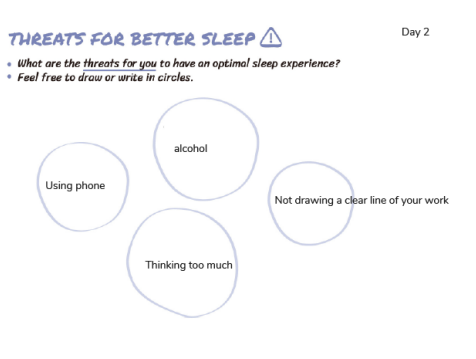


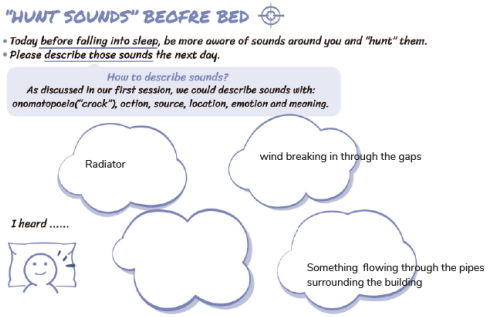
Diary results - 3

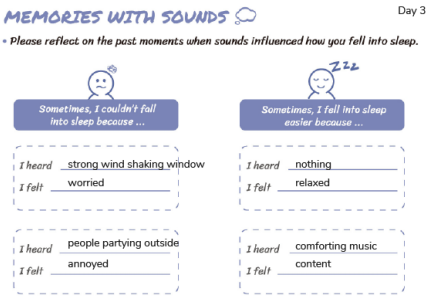


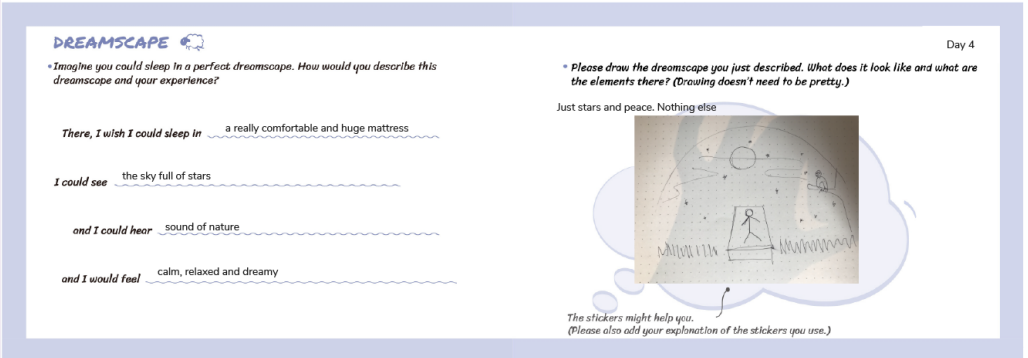
Diary results - 4 one digital version

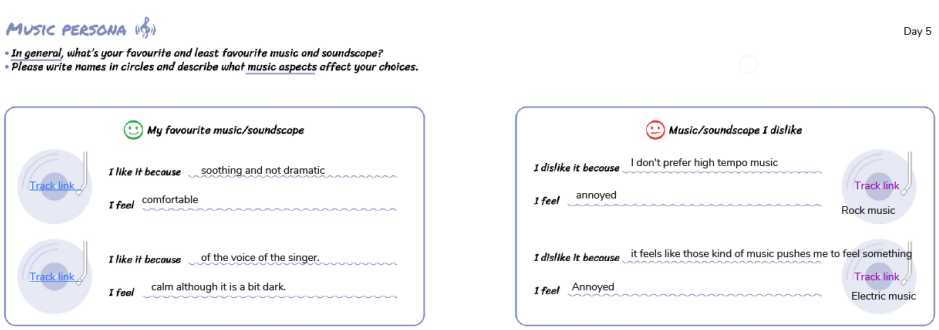




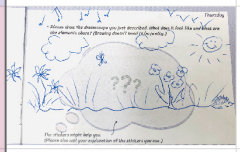








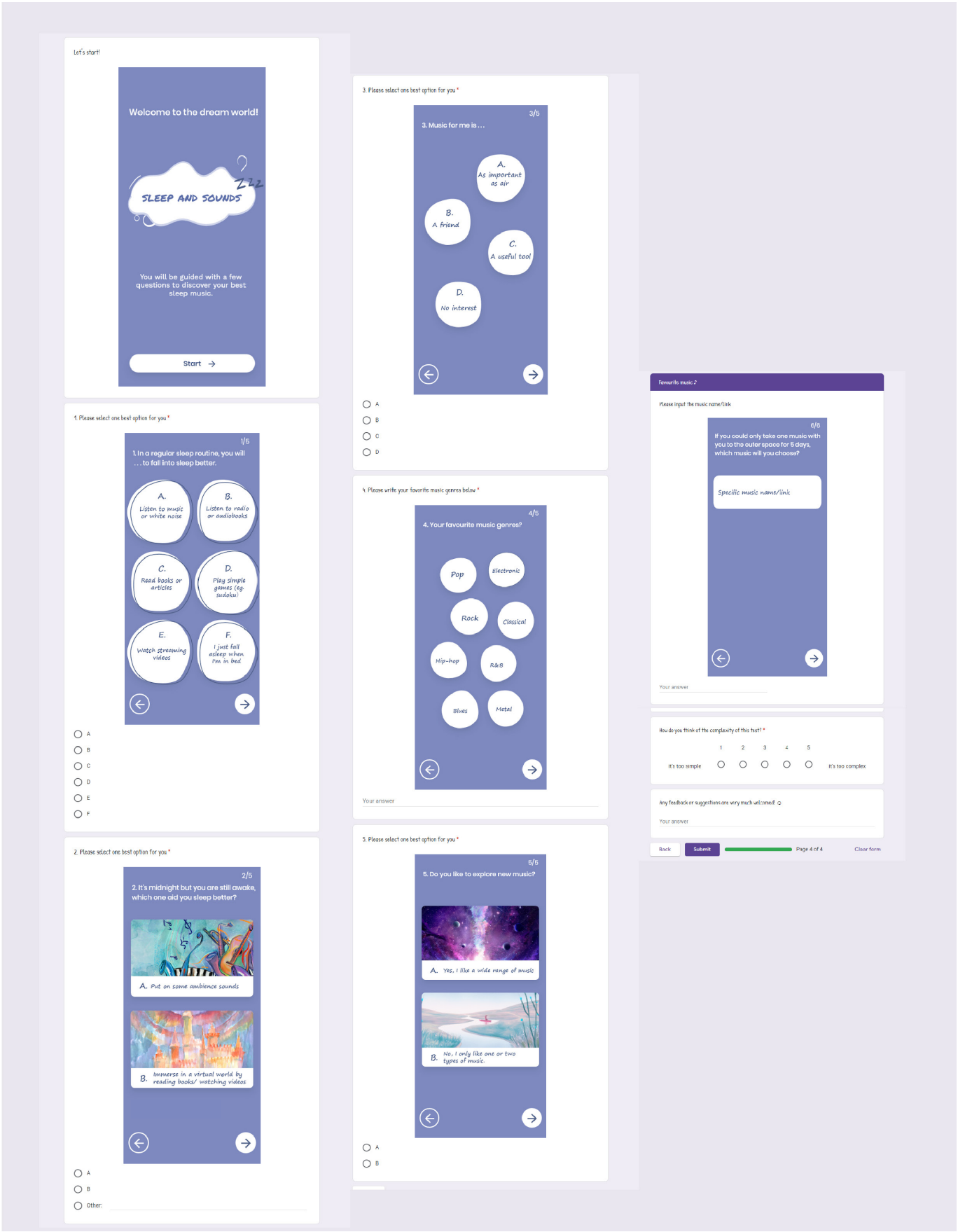
Appendix I. Diary and interview results table

t_1	Sleep ritual	1. Turn off lights & lock doors 2. Turn on dish washer 3. Use toilet 4. Brush teeth 5. Prepare bedroom (curtain, lights, window) 6. Undress + pjyamis 7. Get into bed 8. Check phone 9. Read (sometimes) or play wordfeud 10. Turn off light (can't think of anything, because it's a routine People play simple but a bit challenging game before sleep.	1. Completion of work: Surprised that the day has changed 2. Prepare supplies for the next day: Powerful to start a new day 3. Take a shower: Enjoying the warmth of the shower 4. Listen to the radio with the wake-up light on: While listening I feel that I am going to fall asleep 5. Fall asleep: I love to sleep Be prepared for the next day before sleep makes people feel powerful to embrace the new day.	20:30 bring children to bed and read a chapter from children book 21:00 clean the kitchen and made fire in heater 21:30 drink coffee with oldest daughter and wife and played game yahtzee with daugfhter 22:30 prepared a small job for next day 23:00 went to bed 23:05 felll a sleep 06:45 woken up to free a small bird which entered from outside the childrens bedroom - People live with their family will enjoy the moments before sleep to interact with family members. - People want to make sure the things at home are in order before sleep. - People want to be ready for the next day's work.	1. read, watch tv or iPad try to relax 2. I feel tired and a bit sleepy. 3. fill up the dishwasher and things like that 4. shouldn't have opent my calender for tomorrow and not start that film 5. Brush my teeth, clean my face 6. In bed, trying to sleep with waterfall or fireplace sound 7. fall asleep after about half an hour, sometimes (much) later		10:30 pm: sanitar 23:00 pm: read a l worried? 23:30 fall asleep
	Tricks	- Think of nice things that happened that day - Breathing excercise to clear my mind - Deciding what to wear, distract from other thoughts People want to be distracted and recall postive moments before sleep.	- Take a shower - Listen to music - Lie on my stomach - No screens Listen to music is already one part of the participant's sleep routine and help to fall into sleep.		- Drink hot tea like rooibos or ginger to feel comfortable and relax - Open the window because I like the room cool - Listen to soft sounds of rain or the talking on a tv show it stops my mind from thinking - Wearing warm slippers for warm feet - People want to feel phsycial and mentally at ease.	- Book - Sudoku - Some talking - Music	- Read a detective - Listen to radio af first wake up
t_2	Threats	- Worries - Too much excitement in the evening (performance, party, guests staying late) - Too busy at work People want to stay in a low emotional arousal state in order to better fall into sleep.	- Crying babies - Snoring partner - Cold - To pee		- Having a discussion before going to bed - Loud or unfamiliar sounds and angry voices - Work late because my mind won't stop - Starting an exciting video late because go to bed later than I should Both the interal and external threats are important for falling into sleep better.	- Dripping water - Mosquito - Noise outside	
	Hunt sounds	- Low, deep ham of cargo ship passing by - Train in the distance passing by - My own breath - Peter clearing his threat, bit annoying - Geoge high pitch squeeks The soundscape people listen to includes both sounds nearby and far way.	- Running neighbors - Partner's phone - Crying babies - Rain	Yesterday evening in bed I listened if there was something to be heard: while lying in bed I concluded it was completely stil. In the middle of the forest in sweden every bird was sleeping, no tractors/machines and the rest of the Family was also sleeping making no sound. The only sound to be heard was from the owl. This felt very relaxing.	- Some ducks quacking feels relaxed like home - Breathing sounds - The wind in the tree by the window is making a soft nice sound Familiar and natural sounds help people to feel relaxed.	- Fell asleep right away	- Cars in the stree
t_3	Sounds as pills	- Meditation music: relaxed - Meditation mantra: relaxed	- Rain: comfortable - Music: relax	Sometimes fall easier in sleep because of hearing nothing This silence made me feel lucky. Knowing that our surrounding here is not spoiled with sounds from cars on a highway etc.	- soft music: relaxed and secure - rain and storm: warm and safe in bed Music can help people to feel relaxed, secure and peaceful. The sounds of bad weather evoke positve responses like feeling safe and warm.	- Rain on the roof: peaceful - Soft music: relaxed	
	Sounds as threats	- Neighbour talking in the garden - Slightly annoyed	- Running neighbours: irritated - Crying babies: irritated Different noises from people within the same or nearby sleep environment are obvious and easily noticeable threats.	- Sometimes I could not fall easily into sleep, hearing music coming from the beachrestaurants due to the wind which causes the sound from hard music from the beach brought to close to the beach and dunes house. - Or I could sometimes fall not easily into sleep on a warm hot summer night people returning from a party or so spoke loud on the street. - Listen to music that one don't like very much played by unkown people, or from other places (even far away) could be threats for sleep. - When people feel the music the not the best for them, they should have control over it and be able to close or shift it. - Listening to people you don't know about and stay in a different emotional state than you, talking loud makes people feel difficult to fall into sleep.	- a helicopter: alarmed. reminds me of an accident - snoring of my partner: alert like waiting for it to get louder Sounds from people around and sounds from unnormal resources make people alert and assicoate with bad things.	- Party music in the neighbourhood - Annoyed	
t_4	Dreamscape						
	Description	- Sleep in a beautiful meadow - See grass, flower, clouch above - Hear birds, bee humming - Rest, contentment, happy, sunshine - People want to be at ease and feel both physcially and mentally comfortable (ease). - Aesthetic enjoyment is important (stimulation).	- Sleep in a big bed - See the sea - Hear the rippling water - Relax - Physcial comfort (sleep in a big bed) - The dreamscape looks like the place you stay during the holiday. People might need to be away from work, home and be in the space they don't need to think about real life issues.		- a small wooden house by a forest with a lake - the moon over the water and some deer in the meadow near the edge of a forest - the little waves of the lake and the sounds of the animals nearby like owls - the warmth of the fireplace and a cool blanket Sounds from people around and sounds from unnormal resources make people alert and assicoate with bad things.	- I could sleep in beachbed in the caribbean - I could see sea, tropical trees, sun, rocks - I could hear birds, soft music, tinclms? of ice in the beachbar - I would feel totally relaxing, warm, throughtless Away from dailylife and be in the holiday place They enjoy the nature dreamscape might because now people are not able to be on holidays, so the dreamscape might reflect some needs that are not fufilled. The rich imagery informaiton might related to the sitimultaiton needs, less boring.	- All night thtough - Hear nothing
t_5	Most favourite music/soundscape 1	Sure on this shining night - Lauridsen	Rock		David Bowie - Heroes (Live Aid, 1985) - Bing video	Latin bachata bolero	- BWV 915 FUGA
	Reason	- It's so rich and optimistic, beautiful dynamics - I feel lifted up	- It has a good atmosphere - I feel happy		I love the voice and its great memories Happy and young	the rhythm Relaxing, on holding	- It's nice and inte - I feel good
	Most favourite music/soundsc	Singing bowls	World music		Rainstorm		Birdsong
	Reason	- It's very relaxing and I can feel the vibrations going through me. - I feel uplifted, fulfilled.	- You can move well on it - Feel loose		Because it is soothing, regular but not boring Safe and relax	The soft tones Relaxed, sleepy	It's nature
	Least favourite music/soundsc	Heavy metal	Classic		SUICIDE SILENCE - You Only Live Once (OFFICIAL VIDEO) - Bing video		House music
	Reason	- It's loud and non-musical and agressive. - I feel I have to get away from it.	- I cannot relax with this - I feel nervous		it is loud and not harmonious uncomfortable		It sounds terrible

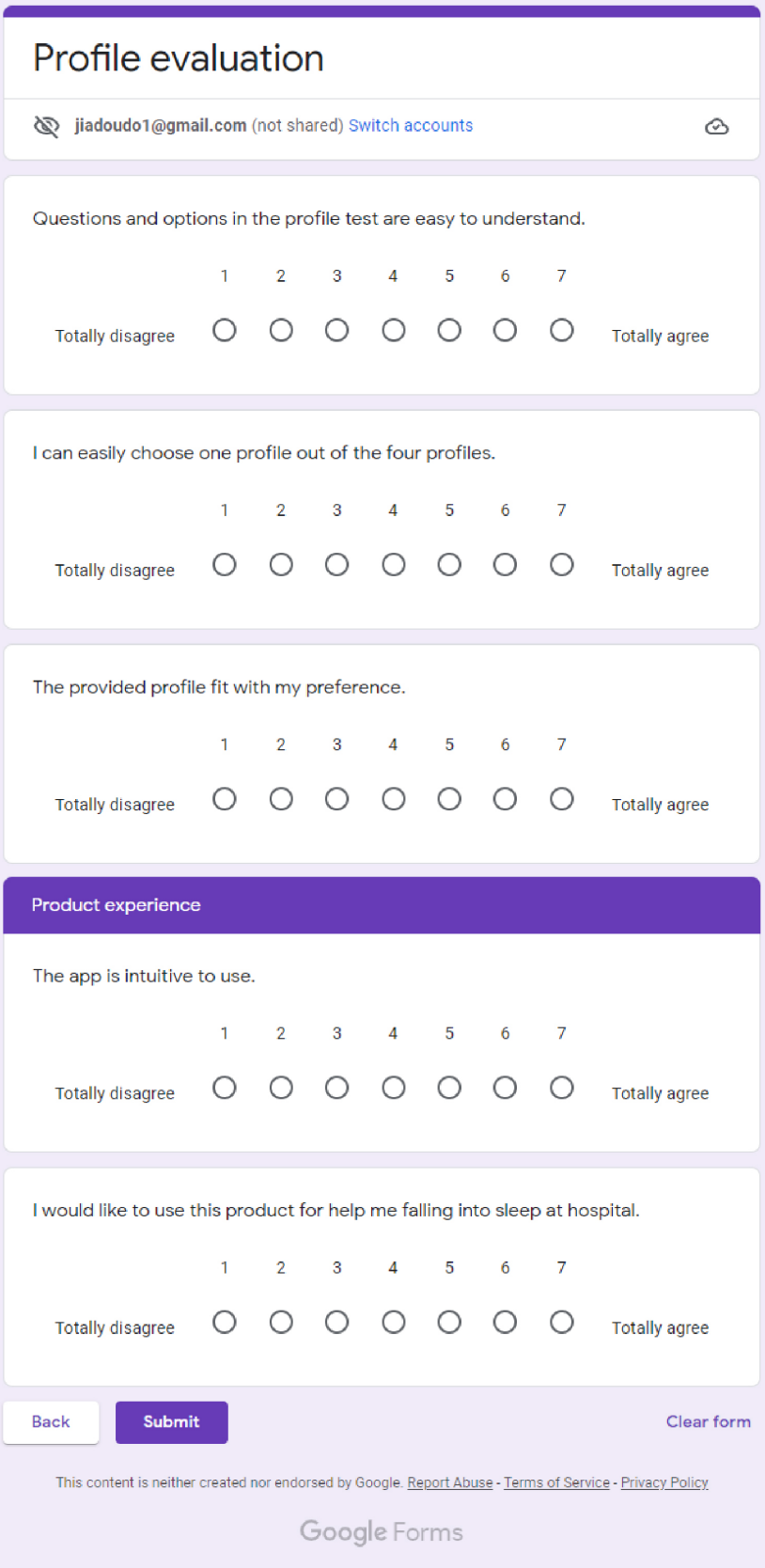
	1. Watch the video (bilibili, serial, variety show): happy, excited 2. Read a book (fiction/mysteries/detective stories/professional): nervious, scared *"Usually I would read books interesting but without much cognitive effects. However, if I already watch TV for two hours, I'll read non fiction books to gain knowledge and feel less guilty about myself."* Too much hedonic happiness might cause the guilty feeling , so the participant learn new things before sleep to feel better about herself. 3. Close the eyes/reflect today/thinking the problem content, worried *"When I was happy, I would not recall how happy I was today. I would just lie in bed and fall asleep when I felt very happy. However, it's easy for you to overthink when you are unhappy."* When people are alone with no distractions, they tend to overthinking before sleep. The participant think and reflect on negative things and worried about tomorrow instead of looking back at happy moments. *"If I will hang out with friends in the next at, I fall into sleep slower because I get more and more excited when I think about it."* Anticipation and too much excitement leads to emotional arousals and make it difficult for people to fall into sleep.	Developed a sleep routine 1. Writing down what to do tomorrow on my schedule book 2. Say goodbye to my boyfriend on whatsapp. 3. I turn on relaxing music. (There is a specific album that I listen to before I sleep most of the time) 4. Turn off bright lights and only leave stand lights and sometimes I light my candles. 5. I set up an alarm. On my phone and my smart speaker just to be sure. 6. I try to rather read book in my bed but couldn't find an interesting book to read after I read the last one. 7. I try not to bring my phone in my bed but I usually spend some time wasting my time on my phone for about 30 minutes before I sleep. 8. Only leave the lamp above my bed and turn off the rest. 9. After playing with my phone for a while, I try to sleep and turn the last light off. 10. I usually don't have trouble with sleeping but nowadays I am experiencing some. Just can't erase thoughts in my head. *"Reading books/write a diary/meditation to empty my brain and thoughts* *I think just emptying my, my brain and thoughts, like, just you know, forgetting about the word. Yeah, in that way, I think it will help. But I'm, I think I, I just mostly read books, or just write a diary before I sleep so that I can. My mind can't be prepared to fall asleep"* People want to preare their mind for sleep (empty their brain and thoughts) and forget about the world.	1. Turn off my computer - sleepy and tired 2. Take a shower to close the day - refreshed 3. Turn off main lights - excited 4. Social media, reading on my bed - focused The cognitive effort of watching social media is relatively small, and it feels like memorizir It's not helping me sleep, it's just a habit. It doesn't matter what you see, as long as the effo 5. Reflect on what happended during the day - worried In the evening, I can think of details that I didn't think about during the day, and then regre generally I think bad things are rarely good.
	- Read a book/article - Watch (listen) the game live - Meditation I like reading nonfiction books because it is quite boring. After 10 mins, I'll feel sleepy already because it doesn't attract my attention at all. Prefer reading instead of listening to audible book because don't want to fall asleep without finish listening to one part/chapter.	- Control the brightness before get sleep - Meditation - Soothing music and candle - Reading book	- Reading: Reading helps me fall asleep becasue it takes some space from my brain. At the isn't too active. Your mind have to process something. I will watch 10-20 minutes and read shorter articles. Books are relatively long, and they a you go to bed before going to bed, you may forget the piece when you see it, and you won' back and forth. But you can basically read the entire article of an article, and then you feel finished. Sometimes I was very sleepy, I had already fallen asleep once, and then I still wan (This may be related to personal behavior habits) - Open the windows: air is cool and humid - Hide my head into quilt - Don't eat too much before sleep - Alter the shape of my pillow to make my neck feels more relaxing There is a passive feeling in reading, that is, you have to process this thing. If your mind is but I think it is easier to fall asleep. It's similar to a familiar music, but there is no need to p clothes are not selected, but its sound is there again, you have to understand it a little bit.
	- Regular sounds - Recall the bad memory - Too much noise - Unfamiliar sleeping place When I sleep in a new environment, for exmaple in a hoetal, I tend to have a less good sleep. I feel the bed is different and the sounds in the space will seems louder than usual. Sleeping in a new environment makes the participant play closer attention to the unfamiliar sounds (noise), which influence the sleep quality.	- Using phone - Alcohol - Not drawing a clear line of your work - Thinking too musch	- Sound of people walking in their room - The sound of open & close the door in the corridor - Physcial and mental health - Too much things going on before sleep - Disco dancing with loud & busy music, high tempo and low beat - Study before sleep Writing articles and studying are not good, because the brain will be very active and can't
hreats	- Insect: nervous/scared - Sound of human (crosstalk): feel at home When there are mosquitoes in my ears, I can imagine how many legs the mosquitoes are particularly annoying. People don't like the sound if they associate this sounds with something they don't like, or afraid of. If you can clearly know that the insect is outside, but I don't like the sound if it's nearby your ear. The distance of the same sounds will effect how people perceive it. I always think whether there is something wrong with this thing, or whether it is broken. The main reason is that the source of the sound is inexplicable and worried. People don't like to hear the noise from an unknown source, because it act as a signal that something might goes wrong.		- Disco music: feel the rthythm was beating together with my heart - Walking without shoes: not predictable - Hate the sound of hitting or beating I hate those with bass. I'm afraid it's quiet around, and then I make a sound, I'll listen to it with concentration, and asleep.
ills	- Crosstalk/ human voice: feel at home *Human voices or noisy voices can give me a sense of security or familiarity.* Listen to the environment sounds like people used to bring them the sense security and familiarity before sleep.	Nothing - feel relaxed Comforting music - content	- Natural sounds (rain), low volumn, irregular tempo, no high dynamic (predictable): feel c - No sound : feel in control not totally silent I don't like the sound of raining too fast or too fast Even with the same sound of rain, different people have different preferences for light rai rain/frequency. The kind of raw that burns in the fireplace It also has something to do with your environment Fireplace
e			
	- Sleep in a big bed, not too soft or hard, familar place (home) - See a little light I am afraid that I can't see anything when I open my eyes, and I feel blind. It can be moonlight or this kind of floor lamp. - Hear gentle wind/rain/my friends/family's vocie The worse the weather outside, the more comfortable I feel. The bigger the wind, the better, and then the snow will be more beautiful. It will make me feel that my sleep is environment is treasurable, like sandstorms is also good. or example, the weather outside is like it is cloudy these days. When the weather outside is particularly cloudy, I really want to go to bed at noon, and I want to sleep a little longer, but if the sun is outside, I don't even want to take a nap. I like the sound of the climate, such as the sound of wind and rain or the rustle of grass blowing, or the sound of ocean waves. Environmental or climate soudns are both good. Animals sounds but no cat sounds are also nice. If someone familiar with me talks next to me, I will fall asleep more easily, which may bring me a sense of psychological security, make me feel that this place is safe and I can fall asleep safely, or someone makes me relax. I also fall asleep	- Sleep in a really comfortable and huge mattress - See sky full of stars - Hear sound of nature - Feel calm, relaxed and dreamy I just like to be in nature. So I would like to feel that I'm lying down outside. There shouldn't be strong wind or something. It has to be very. It is kind of a fantasy that I would like to have. So yeah, just seeing the sky, and stars. And just, sometimes I just listen to cricket sounds like those sounds that you can do. In summer. just not seeing buildings and stuff.	- Sleep in relatively small space, close to ocean (enclosed) - See warm soft light, soft quilt, flowers, people I like or cartoon character, black cat, Bayrr It should be to make this house look warmer and more secure. - Hear sound of cat, sea, birds - Feel zoom out, calm, warm, secure I drew a house by the sea, and then I prefer to have enclosed spaces, but I prefer to be abl and then it is a sea. If I want to sleep, I will still close the curtains. I prefer to have the sens the beach. Then I hope to have a cat, and I feel warm and secure when listening to the sno
u are the /hat are s you will e?	-I don't like the regular sound of that kind of machine -Especially if the environment like a hospital is very quiet, it is difficult for me to sleep because I feel very insecure. -I always want to find something more familiar. For example, I prefer to live in a homestay rather than a hotel, because the homestay will make me more familiar with the TV, coffee table, snacks, etc., and give me a feeling more like a place to live. The hotel feels like a box, and the hospital feels a bit similar. This kind of talk among patients, such as talking about their illnesses themselves, may aggravate my anxiety. But if the discussion is about how much these dishes are, I think it's pretty good. It's best to be some daily lighthearted.	I think my dreamscape will still be valid even at the hospital. I think the interior design of the hospital is often depressing and the equipment and machines frighten me. So I would rather appreciate seeing nature than a white ward in a hospital and remove all the beeping sound of the machines.	Each of the beds is in the middle, and then both sides are empty, and then the bottom is al makes me feel like I'm on an island.
rite dscape 1	Nature sound	F.S.Blumm-Tag Eins Tag Zwei https://open.spotify.com/playlist/2HOZ0NYMaDv1IJV0I8kKnI?si=27c2174348ea4590	Piano https://youtu.be/pR-9nLAUabc https://www.youtube.com/watch?v=e3-mUqBqKKM
	- It's irregular and make me feel my bed is a perfect place to sleep. - Feel relaxed/comfortable/satisfied.	- Soothing and not dramatic - Comfortable	- It's soft, mild, doesn't have "turbulence". slow songs - I feel the sound can easily merge with the environment, but add some vitality. I like pure instrumental music like piano and cello music. The pitch of the sound shound al not too high or too low.
rite dscape 2	Familar people talk	Portishead - Roseland NYC Live https://open.spotify.com/playlist/45s9rE7IxomKiRJTZhVna0?si=409b6e50a9494912&nd=1	Voillin pop (Pop music played by classical instrument) https://youtu.be/9XTEyEDMohU https://youtu.be/LTn3gkC5kkk
	- It makes me feel at home or somewhere I lived before. - I feel secure.	- The voice of the singer. - Calm although it is a bit dark.	- It's smooth, bright. - I feel it brings me to somewhere far away. The place is empty.
rite dscape 1	Rap	Rock music	Rock5min https://youtu.be/6CTQtL4tZOk I don't like the kind of running and jumping feelings, with an exciting atmosphere. I don't li that are a bit sad.
	Cannot breath	- I don't prefer high tempo music - I feel annoyed	- Too much energy. I feel headache after a few mins. - I feel I cannot breath properly. Overwhelmed, too much noise.
rite dscape 2	Classical music	Electric music that you can hear when you go to a bar	Jazz https://www.youtube.com/watch?v=jRBj2tNFm4U&feature=youtu.be
	Make me feel sleepy, and boring. The participant feel annoyed about classical music, especially those with different paragraphs and different	- It feels like those kind of music pushes me to feel something - I feel annoyed	- It's too slow and sticky - I feel the music is crowded. There are a lot going on in the background. But the foregrou The background sounds are loud, the sand is blowing, the foreground sounds are drowning

- comfortable e (animal crossing, relaxing games) have any tasks, you just do everything for yourself. For example, today I want to cut I want to plant flowers. It's very casual, there are no tasks, the world is your own. ound, bgm is too hypnotic, they are all very soothing. Change the theme of bgm every dal of 24 songs, and then the background music is different for each period. The fun , on the grass, on the muddy ground, and walking on the ground of the museum board, fferent, and the shoes you wear are also different. If you walk on the beach, the bgm ecome low and there will be loud waves. I like that game because everything is very . py deos, weibo, tiktoc, bilibili (various short vidoes in different catergories) bo, it has everything and is quite random. I first watch a very boring one, but the next unny. I enjoy tp gain this variety of information. nny, suprised, sleepy need to use your brain, you are comfortable, others tell you stories, transmit	1. Take a shower: let my brain know it's time for sleep 2. Play familar music to calm me down Those music I might listen to them about 10 times. Most of them are slow tempo rock music. 3. Open humidifier: water makes me feel calm 4. Social media posts 5. Read novels 6. Listen to the humidifier sound and fall asleep	1. Wash face 2. Foot bath while watching news, posts, reply messages, drink warm milk 3. Brush teeth 4. Watch phone/read books: relaxing 5. If I cannot fall asleep at the relugar moment, I'll play music.	1. Push-ups: phsycially comfortable and mentally content 2. Cleaning 3. Watch streaming videos: expand my knowledge, reduce stress to help fall into sleep Learning something or gaining some information can help me to reduce stress.	Reading books can help me fall asleep f Meditation can help me fall asleep with
l meaningless short videos like vidoes on tiktok s no noise before sleep th lyrics (feel someone next to you talking) I don't listen to music at night, I only listen to music when I go to bed at noon ut cognitive efforts	- Play familar music or listen to the humidifier sound - Close lights, as dark as possible - Don't think negative things	- Feel very tired during the day - White noise, empty my mind - Warm milk	- Watch animal worlds to make me feel relaxed - Push-ups to make me feel tired - Count sheeps to feel boring - Eat snacks: feel full to fall into sleep	- Meditation - Reading books - Deep breathe I don't want to read books or watching sleep. I need some very calm sounds or that I could be with myself and fall into
ators, sounds from neighbours, corridor nds) nd again the things i experience during the day d then you always think about the cause and effect, and then you will think about a lot eel that your head is not relaxed. ats, open windows for more air	- Party sounds - Sounds of excercising from neighbours I cannot sleep with any light. I found that the sleep quality in the dormitory is different from that at home. If I don't feel at home, I might be uncomfortable and I don't think I fall asleep very quickly.	- Too much coffee - Continuous noise - Excited	- Worried about tomorrow's things - Alcohol - Sad about injustice - Looking at friends' circles	- Stress - Reading novels - Overthinking the work
rs: annoyed or: annoyed ator is making noise, I hope to know when it will start, and try to fall asleep before it		- Someone talking very loud: annoyed - Continuous noise: annoyed	- Rommates tapping the keyboard: annoyed - Sounds from the toilet: higth db and continue for a long time - Roommates talking with each other murmurously: annoyed	- Snoring: uncomfortable - Fan: might have a cold
ful APP every day. Occasionally, I lie in bed. If I am not asleep after quite a long time, I will ound, I might fall asleep again when I lie down. I feel it is a melatonin to me. e the main bgm feels like that kind of fairy tale. It feels like in a certain animated movie, g in a certain place. ng is the sense of being in another place. I can even imagine where I am. peaceful y which is better, but I usually sleep with earplugs.		- Rain sound: feel comfortable - Sound of eating stuff: empty my mind	- Roommates washing sound : signal that the dorm wiil be slient from now on	- Meditation sounds: comfortable - Seawaves: calm
				
t fires, camps ops falling on the camps, fire is burning, bugs are singing, wind sound nfortable scene that is unfamiliar and in my ideal place. Then there are natural and detailed h as the sound of the wind, the crackling of the firewood of the bonfire, and sometimes of rain falling on the tent, it feels very natural. be the junction of spring and summer or the junction of summer and autumn.	- Sleep in a wide space, similar as home environment - See many plants, lay down I can see stars - Hear no noise - Secure, calm There is a big window there, you can see the stars outside, it is more peaceful, you can turn your attention, similar to the kind of sheep who can't sleep. I think looking at the stars is also a way to divert attention. When I was young, my mother posted a lot of luminous stars on the wall. Then, because I like plants very much, I painted a lot of things like nature on the right, and I found that I like nature very much. Because I like cats so much, I think if he might raise a cat in the future, his voice may be more familiar, and he might also make me sleep more quickly.	- Sleep in the clouds and will not fall down - See mild wind, shooting stars, rain, sunset glow, sea wave, fireworks - Hear raindrops hitting the window, windwave pat the beach regularly, soft and low whistle - Happiness, relaxing, secure, entirely free from worry	- Sleep on soft lawn - See the squirrel on the tree, the puppy is rolling on the ground, there are many colorful flowers blooming around - Heat the birds are singing, the stream hits the rocks with a crisp sound, and the wind makes the rustle of leaves. - Feel the air is humid, sun is warm but not too bright	- Own home, clean, empty - Myself, free, reabxed, calm - Breath - I can have a good sleep
ng with lyrics that I often listen to, it loops every three minutes, will be very annoying. I e to choose. In case I want to listen to the same as yesterday, or just listen to ight. It has something to do with my own preferences and current state. If I'm very vant to listen to something new. If I think I slept very well last night, I might listen to the ther night.	I think it's good to listen to others because you can share your feelings after listening. It's boring in the hospital anyway. This feeling may also be regarded as a kind of help in relieving your condition, I guess. Because it is a hospital after all, and maybe if I live in a house, can I add some familiar music to it, for example, if he lives with others, I hope that everyone's voice will not be too loud, just to influence each other..			
sic types because it's difficult to find only three I like most. For example, it might change ent place. EDM and pop are good during exercise. Then RMB is better if you have dy. My own playlist is a mix of everything. I don't want to listen to only one type of ight be boring as I told you, just smash it a little bit more. Every time before listening to nly set up a playlist like this, and sometimes I will also set up some fixed playlists. It's lt for you to find my favorite songs because I think I listen to everything. These are just 've listened to recently.	春风十里－李宇春	风带着我的身体冲入海底 - Canvas Town	稻香 - Jay Chou	Meditation music : calm Usually, I only listen to meditation musi which is very calm and without lyrics. S the old songs are also nice to listen to.
ill e	- I'm familiar with her voice - I feel warm and calm	- Rhythm, when listening to the scene is very like - Free and happy	- The lyrics is meaningful and educational - Release and reduce stress,	- Immersive & peaceful
ll - Finneas	Obstacles - SYd Matters	Classical symphony	琵琶语 - 林海	Yoga sounds
good, unique, a bit jazz.	- It makes me feel I'm walking on the grassland. - I feel open/board.	- You can concentrate better	- Tune is beautiful - Feel the subtle beauty in eastern culture	- Sound is slow and from away, feel rela
disliked music. Might be some of the rap.	卡路里-火箭少女 But it has nothing to do with rhythm. If it's a more cheerful melody, he probably used a few notes at the time, it's a bit of a guitar sound, a kind of song with a single melody, it's still good, but noisy melody.	Divine Comedy of Native Tasty "Skateboard Shoes" Kind	No	Pop songs
	- Too many people's voice, noisy rhythm - Be interrupted	- Weird, fretful, pointless	No	High pitch, high tempo
	3055-Olafur Arnalds	No	No	Uncomfortable
	- Calm and sad - Feel uncomfortable	No	No	

Appendix J. Profile iteration questionnaire



Appendix K.
Product and profile experience questionnaire



Profile evaluation

jiadoudo1@gmail.com (not shared) Switch accounts

Questions and options in the profile test are easy to understand.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

I can easily choose one profile out of the four profiles.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

The provided profile fit with my preference.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

Product experience

The app is intuitive to use.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

I would like to use this product for help me falling into sleep at hospital.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

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Appendix L.
Sleep music evaluation questionnaire - 1

Sleep music evaluation 1

Please recall your last night's sleep experience and answer the questions.

jiadoudo1@gmail.com (not shared) Switch accounts

*Required

Please rate your last night's overal sleep quality *

	1	2	3	4	5	6	7	
Very bad	○	○	○	○	○	○	○	Very good

When did you fall asleep last night? *

Time

__ : __

When did you get up today? *

Time

__ : __

How long did it take you to fall asleep? *

Your answer

I fell asleep easily.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

I feel relaxed before falling asleep. *

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

Many thanks! Wish you enojy a brand new day! O(∩_∩)O~~

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Appendix M.
Sleep music evaluation questionnaire -2

Sleep music evaluation 2

Please recall your last night's sleep experience and answer the questions.

jiadoudo1@gmail.com (not shared) Switch accounts

*Required

Please rate your last night's overal sleep quality

	1	2	3	4	5	6	7	
Very bad	○	○	○	○	○	○	○	Very good

When did you fall asleep last night? *

Time

:

When did you get up today? *

Time

:

How long did it take you to fall asleep?

Your answer

I fell asleep easily.

	1	2	3	4	5	6	7	
Totally disagree (完全不同意)	○	○	○	○	○	○	○	Totally agree (完全同意)

I feel relaxed before falling asleep.

1	2	3	4	5	6	7
○	○	○	○	○	○	○

Music experience

Please recall your last night's sleep & music experience and answer the questions.

I chose *

- ○ Diver music
- ○ Explorer music
- ○ Hunter music
- ○ Observer music

How long did you listen? *

Your answer

When I listen to it, I feel relaxed.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

When I listen to it, I feel enjoyable.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

When I listen to it, I forget the outside world.

	1	2	3	4	5	6	7	
Totally disagree	○	○	○	○	○	○	○	Totally agree

Many thanks! Wish you enojy a brand new day! O(∩_∩)O~~

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Appendix N. Sleep music evaluation materials

Test 1		Test 2			
Participants	Questionnaire 1	Sequence	Profile link	Music playlist	Questionnaire 2
P1	https://forms.gle/HvUFZYVThNcdRbMu8	ODHE *Obsever, Diver, Hunter, Explorer	https://xd.adobe.com/view/45f61171-cb0b-4831-8084-5aa2b5792565-10a5/	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-1/s-dx2iNkw9yPS	https://forms.gle/sxe7a7FSqoamjbBQ7
P2	https://forms.gle/Bt2LfEbzdVK1sHLf6	DEHO	https://xd.adobe.com/view/cd122761-9924-49dc-bd50-7a88a6923a10-9841/?fullscreen&hints=offf	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-2/s-z8s57BZObT1	https://forms.gle/w3c4irRRYJ3aLQLb7
P3	https://forms.gle/UDbcw97VkS1i1PkH8	HOED	https://xd.adobe.com/view/22cec40a-0b2d-4259-b0ca-5ff921930c33-779d/	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-3/s-jHBrpdILAPw	https://forms.gle/faExB7XSDT6FwtCN6
P4	https://forms.gle/HTKxF7cmqq6nyk7H7	EDOH	https://xd.adobe.com/view/34619297-aad3-49b9-9248-acdf8cd49cda-6132/	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-p4/s-w6lAXvBvLTN	https://forms.gle/rbPwcaDnDhZqe2Bz9
P5	https://www.wenjuan.com/s/UZBZJvPcLQ6/ *This participants cannot access google from.	OEHD	https://xd.adobe.com/view/9f061270-b7bf-4ec6-95bf-5fdbf6f36389-ca55/	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-du-2/s-z6aea1Jb9ZH	https://www.wenjuan.com/s/Jv2QZjQ
P6	https://forms.gle/QNr1vKzTXfAg4Hsf8	DHEO	https://xd.adobe.com/view/960832f7-2d88-4326-b045-937f06287198-c35b/	https://soundcloud.com/dd-ee-197392689/sets/sleep-music-for-6/s-itzTEKKsAq4	https://forms.gle/wjRKWDRejVN7C1Uj8

Appendix O. Final evaluation data table - 1

	Before design intervention					
	Please rate your last night's overal sleep quality	☒ When did you fall asleep last night?	☒ When did you get up today?	How long did it take you to fall asleep?	I fell asleep easily.	I feel relaxed before falling asleep.
P1	6	01:30:00	07:45:00	3min	7	5
	6	01:17:00	07:35:00	1min	7	5
	5	00:40:00	07:40:00	1min	7	4
	5	11:40:00	07:30:00	1min	7	3
P2	6	23:30:00	07:40:00	20min	5	3
	5	23:30:00	08:30:00	1h	2	4
	3	01:00:00	08:20:00	2h	1	3
	5	00:30:00	09:30:00	20min	5	4
P3	3	01:15:00	08:50:00	maybe 15 minutes	6	6
	6	02:00:00	09:00:00	20min	6	4
	3	01:20:00	10:10:00	25min	7	6
	5	01:40:00	10:00:00	20min	6	7
P4	5	00:30:00	08:10:00	30min	5	5
	4	01:00:00	08:30:00	60min	3	5
	5	00:45:00	08:20:00	20min	6	5
	6	23:00:00	08:00:00	5min	7	7
P5	7	09:50	06:03	5min	7	7
	6	10:46	05:10	10min	2	3
	6	23:20	05:10	2min	7	5
	5	11:30	09:10	5min	6	5
P6	7	21:50:00	07:00:00	20min	7	7
	4	23:00:00	07:00:00	20min	5	4
	6	22:00:00	06:10:00	20min	6	6
	6	22:00:00	06:50:00	15min	6	6

	Before design intervention										
	Please rate your last night's overal sleep quality	When did you fall asleep last night?	When did you get up today?	How long did it take you to fall asleep?	I fell asleep easily.	I feel relaxed before falling asleep.	I chose	How long did you listen?	When I listen to it, I feel relaxed.	When I listen to it, I feel enjoyable.	When I listen to it, I forget the outside world.
P1	5	00:40:00	07:26:00	15 min	5	2	Explorer music	5min	5	6	5
	6	01:30:00	07:11:00	2 min	6	4	Explorer music	5min	5	6	5
	5	12:40:00	06:55:00	7min	6	5	Explorer music	7min	6	7	5
	6	01:30:00	07:30:00	5min	7	4	Hunter music	5min	7	7	6
P2	6	11:30:00	08:00:00	20min	7	7	Diver music	20min	7	6	7
	5	00:00:00	07:50:00	10min	4	3	Observer music	10min	6	7	5
	5	00:30:00	08:00:00	1h	1	3	Observer music	15min	7	5	3
	5	00:00:00	07:30:00	10min	7	5	Observer music	7min	7	6	6
P3	6	02:00:00	09:00:00	1 hour	2	3	Observer music	11 minutes	5	6	4
	6	01:00:00	08:50:00	30 minutes	4	6	Observer music	11 minutes	6	7	5
	5	00:40:00	08:40:00	20minutes	6	7	Observer music	11 minutes	7	7	6
	7	01:00:00	09:30:00	20 minutes	6	7	Observer music	11 minutes	7	7	6
P4	6	00:40:00	08:13:00	20min	6	7	Explorer music	25min	7	5	6
	5	01:00:00	08:45:00	30min	4	4	Observer music	25min	4	4	5
	6	00:40:00	08:30:00	10min	7	6	Diver music	10min	6	5	7
	6	00:45:00	08:00:00	10min	7	6	Explorer music	10min	6	5	6
P5	6	00:50	07:40	1min	7	7	Diver music	1-3min	6	6	6
	5	10:00	05:43	10min	5	5	Observer music	5min	5	5	5
	6	10:45	06:30	2	6	6	Hunter music	5min	6	6	5
	7	10:20	05:30	3min	7	7	Observer music	3min	7	6	6
P6	4	22:10:00	05:15:00	40min	3	3	Hunter music	30min	2	2	2
	6	22:00:00	07:10:00	20min	2	2	Hunter music	2min	5	3	5
	5	22:00:00	04:00:00	15min	6	6	Hunter music	10min	5	4	3
	6	22:00:00	05:00	10min	5	5	Hunter music	10min	5	5	6