# Exploring profiling and personalisation in sleep music design
## Towards conceptualising musical sleep aids for hospital use

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**DOI**
10.1145/3561212.3561245

**Publication date**
2022

**Document Version**
Final published version

**Published in**
Proceedings of the 17th International Audio Mostly Conference

# Exploring profiling and personalisation in sleep music design: towards conceptualising musical sleep aids for hospital use

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## ABSTRACT

Music as a low-cost sleep aid is a promising way to improve the sleep quality of people. However, most available sleep music playlists are limited to generic, soothing songs, which do not take in account personalisation. In collaboration with the Neurology Department of the Reinier de Graaf hospital (Delft, The Netherlands), we explored a profile-based personalisation approach to deliver music that fits with people' sleep and music preferences. Through generative research, we collected people's preference data and proposed four, evocative sleep music profiles: the Explorer, the Diver, the Hunter, and the Observer. The results of the profiling evaluation suggest that the profile experience is credible, intuitive, and easy to use. Four profiles can reflect people's preferences, but may not be stable.

## CCS CONCEPTS

• **General and reference → Design**; • **Human-centered computing → Empirical studies in interaction design**.

## KEYWORDS

Profiling, personalisation, sleep music, sound-driven design

**ACM Reference Format:**
Stefano Delle Monache, Doudou Jia, Daan Kamphuis, and Elif Özcan. 2022. Exploring profiling and personalisation in sleep music design: towards conceptualising musical sleep aids for hospital use. In *AudioMostly 2022 (AM '22), September 6–9, 2022, St. Pölten, Austria.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3561212.3561245

## 1 INTRODUCTION

Sleep disorders represent serious health problems. The recommended sleep duration by the National Sleep Foundation[1] is 7 – 9 hours per night for adults between 18 and 64 years old. 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 apnoea. Falling as sleep in the hospital environment is even more difficult and the total sleep time is significantly shorter than the usual sleep at home [27]. Noise is one of the many sleep-disturbing factors in the hospital, which is typically tackled by providing earplugs, raising noise awareness, and changing nurses' behaviours.

From a complementary angle, delivering interventions that can positively influence patients' sleep experience represents a feasible direction for dealing with sleep issues [2]. Music is considered a promising intervention for delivering positive and direct effects on patients' sleep [19]. Nonetheless, most of the sleep studies make use of generic sleep music playlists which do not take into account the listeners' personal preferences [22].

Sleep habits and music preferences can influence the effects of music on sleep promotion and the inclination to listen to music for sleep. Therefore, the research question tackles the understanding of personal preferences, as a means to inform the design of music-based interventions.

We present a profile-based personalisation approach to design and deliver music that fits with the people's sleep and music preferences. The study was carried out in the scope of the "Sleep Better" project led by the Neurology Department of the Reinier de Graaf hospital of Delft (The Netherlands), with the aim of designing and evaluating a profile-based system for the delivery of personalised sleep music. The study, which originally included the organisation of in-presence workshops with the specialists and the patients of the Neurology ward, underwent several rearrangements due to the COVID-19 pandemics. A major caveat is especially the missed interaction with the patients which led to reduced opportunities to perform thorough iterations. Therefore, to assess the effectiveness of the profiling logic and tool, we reconfigured our study as pilot by involving non-patients in the design process.

The paper is organised as follows: in Section 2 we provide the context of our research, by discussing the sleep quality and uses of music as sleep aid in the well-being and consumer market; in Section 3 we introduce the profile-based personalisation approach, we discuss the information collection and profiles initialisation in Sections 4 and 5 respectively. The integration and evaluation of the profiling logic is discussed in Section 6. We conclude with implications for future design iterations.

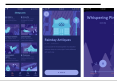
[1] Data by the National Sleep Foundation, https://www.thensf.org/sleep-facts-and-statistics/.



*AM '22, September 6–9, 2022, St. Pölten, Austria*

ACM ISBN 978-1-4503-9701-8/22/09.
https://doi.org/10.1145/3561212.3561245

**Table 1: Sleep-promoting products with sound intervention, available on the market (product names are active link).**

| Sleep aid | Aim | Sound intervention / rationale | Personalisation |
|---|---|---|---|
| Somnox  | To promote immersive, controlled breathing exercises to facilitate sleep. | White noise and natural soundscapes to facilitate relaxation. | Selection of favourite playlists from audio streaming services. |
| HeadSpace  | To facilitate falling asleep with bedtime stories. To create distraction and habit. | Audio-guided wind-down exercises, sleep casts and storytelling to lower blood pressure and reduce stress | None, selection of available sleepcasts. |
| SleepCycle  | Sleep tracker to facilitate relaxation and healthy sleep habits. | Sound library with soft music and meditation sounds to evoke relaxation response | None, selection of available playlists |
| Dreampad  | Bone conduction transducer to trigger calming effects. | Sound library and one's own preferred music to facilitate distraction and relaxation. | Possibility to create collections and playlists or to play audio streaming services. |
| SoundSleep  | Sound system with a collection of noises to facilitate falling and staying asleep. | White, pink, brown, and environmental noises produce masking effects that positively affect sleep quality. | None, selection of available embedded sound stimuli. |
| MusicCare  | Music treatment protocol to reduce anxiety and stress in clinical situations. | Algorithmic composition and musical parameters modulation to facilitate relaxation, promote sleep onset, gradual awakening. Music library of commissioned compositions. | The specific treatment is administered by clinicians, according to a protocol. The overall music genre can be set by the patient when possible. |

## 2 SLEEP AND MUSIC

### 2.1 Sleep quality

Sleep quality encompasses the satisfaction with the sleep experience, including sleep initiation, sleep maintenance, sleep quantity, and refreshment upon awakening [16]. Sleep quality can be measured by means of objective methods (e.g., polysomnography, actigraphy) or subjective methods (e.g., questionnaires, sleep diaries), with different degree of sensitivity and specificity [13]. Subjective methods can provide detailed information about which part of sleep is affected, and can access the person's perception of sleep. The Pittsburgh Quality Sleep Index (PSQI) is a validated and accessible questionnaire-based method for assessing various aspects of sleep quality and sleep-related behaviours, including sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daily routine disturbances [3]. In this respect, music-based interventions can be tailored to specific aspects of the sleep experience, for instance by supporting the pacing of the daily routines [26].

### 2.2 Music as a sleep aid

The literature on the use of music as sleep aid is not conclusive on the effect of sleep music. A meta-analysis about the effects of music intervention on the sleep quality of older adults showed that music interventions can reduce sleep latency, while improving sleep duration and efficiency [25]. Music-assisted relaxation was shown to have a moderate effect on the sleep quality of adults and elders with sleep complaints [6]. The positive effect of sedative music on young adults with long sleep latency problems (i.e., >= 10 minutes) was assessed by means of polysomnography, vital signs monitoring and standardised questionnaires, and the results showed shorter quiet sleep and prolonged deep sleep stages [4]. Similarly, it was shown that that listening to music before a nap improved the participants' subjective and objective sleep parameters [5].

On the contrary, it was found that sporadic music delivery (e.g., for one night only) has no positive impact on sleep quality [17], whereby extended usage might increase the possibility of improving sleep quality [8]. Fourteen different music genres were found as a result of an online survey on musicality and sleep habits, with 651 participating respondents [24]. Finally, music can support sleep by facilitating relaxation, distraction, entrainment, masking, and enjoyment [7, 26].

To summarise, music can play a positive role in promoting sleep when there is a rationale behind the music selection and delivery. Individual differences in sleep habits and music experiences may explain the contradictory findings in studies that make use of generic music playlists. The impact of music largely depends on who is using the music, where it is used, and whether the music selection fits with people's needs [18]. Therefore, when designing music-based interventions, it is crucial to consider the desired effects, the use context, and the listeners.

### 2.3 Sleep music in the consumer market

Table 1 reports a variety of sound-based solutions available on the market, together with the type of sound intervention strategies,

overall aim, and degree of personalisation. Except for `Music Care`, which makes use of specific music-based protocols tailored for clinical use, and the `DreamPad` sound transducer, the other products utilise sound and music as secondary features to complement various sleep tracking functionalities and wind-down activities. They are conceived for home usage and are equipped with a variety of features to meet the different preferences and needs of consumers. In this respect, the music intervention is not the main focus. Furthermore, the degree of sleep music personalisation is in general split between selecting available ready-made playlists and creating or importing personal collections in the sleep music app.

## 3 A PROFILE-BASED APPROACH TO SLEEP MUSIC PERSONALISATION

There are several challenges in personalising sleep music, including the understanding of people's preferences and sleep-related behaviours. Consequently, a further challenge is how to provide relevant content, based on personal information.

Profiling for personalisation can be used to describe groups of people based on known facts or data. Personalisation allows a system to identify a user as a specific type and deliver appropriate content. The main design challenge is finding a balance for a generic, yet personalised music-based intervention.

### 3.1 Personalisation and profiling

Personalisation is the "the process of providing relevant content based on individual user preferences or behaviours" [12, p.4]. User profiling usually includes demographic data such as gender, age groups, or behavioural characteristics [15]. A profiling approach can support researchers in categorising users into different segments through a user-centred approach. Designers can tailor design solutions to the different needs and preferences of the target groups. There are no specifications about what kind of data should be used for profiling. The information included in the user profile is highly dependent on the application and the purpose of the system. Personalisation based on general characteristics can sometimes be more successful than creating more detailed and nuanced profiles.

Figure 1 shows a comprehensive and iterative profiling process for personalisation, in four stages of information collection of user data, initialisation of the profiles, their integration and update [10]. The first stage for building a profile is the **information collection**

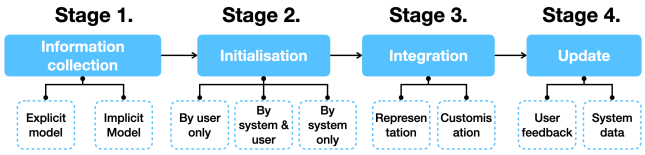



**Figure 1: The four stages of the profile-based personalisation process (adapted after [10]).**

on the user and her context, including demographics, personal, professional and behavioural data depending on the purpose at hand. User data can be collected by means of explicit or implicit models. The explicit model relies on the user's input and motivation to collect information. In the implicit model, the information is collected in a "silent" manner, that is the system collects data in the backend without disturbing users.

The second stage is the **initialisation** of the profiles, which can be thought as containers seeded with the information analysed in the first stage. Profiles can be seeded in three different ways depending on who is involved, whether the users and/or the system. When the initialisation process involves the users only (e.g., questionnaires and surveys) the system uses the resulting information without further processing. On the contrary, the system creates users' profiles from a set of stored data, if it is "by the system only". When the user and the system are combined, the designers uses the user's input to inform the system processing.

The third stage of **integration**, the profile is integrated into the personalisation system, before the final stage of iterative profile **update**, based on both the user's and the system's data collection and feedback.

Since the collection process can produce a large amount of data, it is essential to plan and constrain the types of data and the number of dimensions that are most suitable to conceptualise the information into straightforward and representative profiles. In the scope of this work, we made use of a mixed-methods approach to understand how the user's preferences and characteristics can contribute to the understanding of the needs and expectations regarding music-based interactive systems in healthcare [11, 15].

By following the stages of this profiling process, we sketched the profiling system logic for the delivery of personalised sleep music. We focused our design activities on the first three stages, that is collecting users data on their sleep and music routines and preferences in context (i.e., information collection), extracting meaningful thematic dimensions to represent knowledge about sleepers-listeners (i.e., profiles initialisation), integrating the resulting profiles in a personalised sleep music app with the aim of assessing the effectiveness of our exploratory approach to music profiling. For this purpose, we deliberately discarded the update stage as we are interested in understanding first the representativeness of sleep music profiles. In the following sections, we discuss the design activities carried out in the information collection, profile initialisation and integration stages.

## 4 STAGE 1: INFORMATION COLLECTION

By facilitating immersion and reflection, a generative design approach can sensitise people to express their needs and preferences, thus providing access to their tacit and latent knowledge [23]. We made use of a diary toolkit and spread the participants' daily tasks over five days, to collect information regarding their sleep and music preferences. A semi-structured interview with participants followed up on the diaries' completion. The resulting qualitative data were instrumental to initialise the profiles.

The diary included incremental topics, that is sleep behaviour and rituals (days one and two), sound and sleep (days three and four), and music persona (day five). Figures 2 shows two examples of activities proposed in the diary (available at the following link: https://bit.ly/3E2Qhkf). The diary's design was aimed at 1) as a sensitising material to prepare the participants for the interviews and 2) as a prototype tool to understand people's sleep and music preferences.

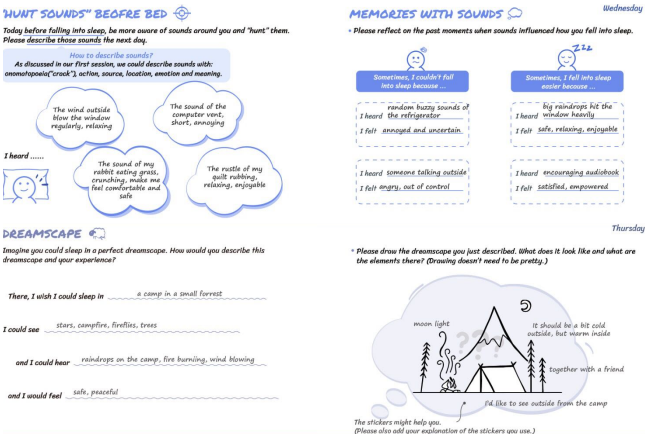



**Figure 2: Two examples of daily tasks proposed in the diary. Up, recalling positive and negative associations between sound and sleep; down, imagining an ideal, personal dreamscape in an evocative way.**

## 4.1 Method

Fourteen subjects took part in the diary-based study, split in two groups. Group A included six professionals from the Reinier de Graaf Hospital, that is one nurse, two managers, and three sleep specialists (N(Female) = 5). Due to the COVID19 pandemics, it was not possible to involve patients in the study, therefore in Group B we recruited eight lay participants (Mean age = 27.75, SD = 8.2, N(Female) = 5). Only Group B participated in the post-diary interview. Two online workshops introduced the participants to ear training and sensitising activities on sound. The participants of both groups A and B were provided with personal copies of the diary, and received reminders of the activity of the day via WhatsApp, with filled examples as inspiration. Participants in group B took part in a 30-minutes semi-structured interview with the researcher (second author D.J.), after the completion of the booklet.

## 4.2 Emerging sleep and music preferences

We analysed the information collected with the diaries and the interviews, by separately coding the data and then converging to high-level themes representing the personal preferences to music and sleep. The resulting preferences themes were instrumental to initialise the profiling, and coupling the profile's content with its purpose, that is devising a personalisation system for sleep music delivery. Consequently, we set the following requirements for the profile creation:

- The profiles should favour abstraction rather than detailing, in order to group people according to their preferences;
- Since both music and sleep preferences are not stable attributes, the profiles should present some stable aspects to improve their reliability;
- The resulting profiles should be implementable in a personalisation system.

The thematic analysis resulted in six themes for sleep preferences and three themes for music preferences.

### 4.2.1 *Six sleep preferences.*

The sleep preferences themes include:

(1) **Sleep concerns:** The sleep problems that sleepers want to solve with music. These include removing negative thoughts, masking environmental noises, and feeling relaxed;
(2) **External variable support:** Healthy sleepers need little support, whereby poor sleepers may even need sleep aids;
(3) **Level of relatedness:** Some sleepers may prefer silence and feel alone. Others may prefer to be accompanied by familiar voices, that make them feel safe when they sleep;
(4) **Sleep engagement:** People's sleep preferences differ in the level of engagement in before-bed activities, e.g. from straight sleeping to reading books, watching videos, or playing games;
(5) **Established sleep routine:** People's sleep preferences also differ in whether they have an established sleep routine or not. Some sleeper already have sleep playlists, use earplugs or meditate before going to bed. They have tricks and develop them into a habit. Others only occasionally use music or meditation as tools. The preference towards establishing a sleep routine can affect the acceptance of using music;
(6) **Mood:** Sleepers prefer either a relaxed, safe, or positive mood.

### 4.2.2 *Three music preferences.*

The music preferences themes include:

(1) **Relationship with music:** Sleepers have different affinity with music, from low to high. The relationship with music affects the acceptance and affection towards using music as a sleep aid;
(2) **Instruments:** Four participants showed a clear preference towards specific musical instruments. There is no clear pattern found in the music instrument preference and this should better be conceived as an optional customisation function;
(3) **Music openness:** People have varying degrees of openness to music and genres. Some participants are open and interested in discovering new music, while others limit their choices to a few music genres. For example, one participant with low music openness reported that "I update my music playlist very carefully. I add one or two new songs every year, and I have been listening to the same music I like for more than ten years".

According to the afore-mentioned profile creation rationale, the profiles should favour abstraction over detailing. For this purpose, sleep engagement and music openness are the candidate dimensions to represent the sleep music profiles. Sleep engagement represents the way people want to fall asleep. Music openness indicates the music delivery strategy combined with the users' sleep preference.

We are aware that two themes only may not fully represent the richness of sleep and music preferences found both in the literature and user research. However, this design choice allowed us to conceptualise the sleep music profiles at the highest level of abstraction, while retaining the possibility to include the other found preferences in the development and update stages. In other words, sleep engagement and music openness can simplify the sleeper's preferences while representing profiles for personalisation. At the same time, these two themes are not too abstract to lose the individual differences in sleep and music preferences.

**Table 2: Characteristics of the Sleep Engagement dimension.**

| Sleep Engagement | Low ⟷ | High |
|---|---|---|
| Attention / cognitive effort on before-bed activities | low | moderate |
| Sleep aid by | relaxation | distraction |
| Emotional arousal | low | moderate |

**Table 3: The facets of low / high openness to experience [14].**

| Low openness | High openness |
|---|---|
| Predictable | Curious |
| Not very imaginative | Imaginative |
| Dislike change | Creative |
| Prefer routine | Open to try new things |
| Traditional | Unconventional |

**Table 4: Characteristics of the Music Openness dimension.**

| Music Opennes | Low ⟷ | High |
|---|---|---|
| Attitude towards the music experience | conservative | open |
| Favourite music / genres | limited to few<br>familiar, predictable | many<br>novel, engaging |

# 5 STAGE 2: INITIALISING THE SLEEP MUSIC PROFILES

We built the sleep music profiles in the sleep engagement and music openness dimensions. In the following we describe the two dimensions, and how they inform the emergence of the four profiles in the four quadrants of a Cartesian space.

## 5.1 Sleep engagement

Engagement is "a multidimensional construct comprising behavioural, cognitive and affective components" [15, p.10], that is it reflects the users' behavioural pattern, including the attention facets, the involvement and enjoyment. The specifications of the components vary in different domains. In the sleep music profiles, sleep engagement refers to the individual's inclination in being involved in an activity to aid their sleep, including the attention facets, the purpose, and the emotional arousal, as summarised in Table 2.

How people want to fall into sleep is reflected in their sleep routine and sleep aids. These before-bed activities can be low or highly engaging depending on the required cognitive effort. People's level of sleep engagement could influence how they would like to be immersed in the listening experience. We define **low sleep engagement** as the tendency to spend low amount of attention and cognitive efforts on before-bed activities, including for example activities such as listening to soft music, listening to white noise, just doing nothing before falling asleep, reading monotonous books: The information is received rather passively, with low emotional arousal. These activities assist people in relaxation rather than distraction. We define **high sleep engagement** as the tendency to spend a moderate amount of attention and cognitive efforts on before-bed activities, e.g., in watching streaming videos, reading detective books, reading articles, playing simple games. These activities assist people by distraction rather than relaxation, demand a higher level of attention, and a medium level of cognitive effort and emotional arousal.

## 5.2 Music openness

In psychology, the Openness to experience is one of the items included in the Big Five personality traits model, together with Agreeableness, Neuroticism, Consciousness, and Extraversion [20]. The facets of low and high openness are reported in Table 3: People who score low on openness are considered to be reluctant to experience. They prefer routines and are more pragmatic. They generally have a narrower range of interests. People who score high on openness are more imaginative and creative. They enjoy being spontaneous instead of having a traditional routine [14]. Accordingly, we interpret music openness as how open an individual is towards novel music experiences. Similar to sleep engagement, there is no clear definition of music openness yet in the literature, although individual preferences towards different types of music correlate with personalities [21]: For example, openness to experience was related to "reflective and complex", "intense and rebellious" music preference. A recent study also suggested the value of personality in music preferences: Machine learning algorithms, trained with musical preferences and habitual listening behaviours data, could predict the Big Five personality traits with moderate to high accuracy [1]. For instance, users scoring high on openness were more receptive to exploring various music genres.

Our interpretation of music openness is therefore similar to the definition of openness in personality traits, but it is defined in the music listening context, as summarised in Table 4. Individuals with low music openness have a conservative attitude towards new music preferences. **Low music openness** implies a narrow preference and acceptance of new or imposed music: Listeners prefer only one or two genres of music, and prefer listening to familiar music. In contrast, **high music openness** involves a general preference towards different kinds of musical experiences. People with a high music openness enjoy listening to and exploring new and novel music, which can keep them engaged. Listening to the same playlist over and over again can easily make them feel bored.

On an abstract level, sleep engagement is stable when sleep habits are regular. On the contrary, people with irregular sleep habits, due to several external factors from environmental noise to sleep problems, may want to alternate relaxation and distraction. The music openness dimension is instead relatively stable, since it is based on the openness in personality traits. Although it takes on different forms at different times, the personality is relatively stable throughout people's lives, causing a relatively stable music openness over a more extended period than sleep preferences. Openness is higher in younger than older people [9], suggesting that music openness might change along a more extended period as well.

After the data collection, the initialisation stage resulted in four sleep music profiles in the sleep engagement and music openness dimensions. We characterised the four profiles as the Diver, the Hunter, the Explorer, and the Observer.

## 5.3 The Diver, the Hunter, the Explorer, and the Observer

Figure 3 shows the four sleep music profiles as a function of sleep engagement and music openness. In this section, the aspects of each profile are described in more detail with their specific features, an evocative illustration, an overview of the sleep and music preferences, and the general recommended sleep music characteristics. These profiles are labelled metaphorically (e.g., Diver, Explorer, Observer and Hunter) to engage in the imagination of the user for a quick grasp of the function of each profile.

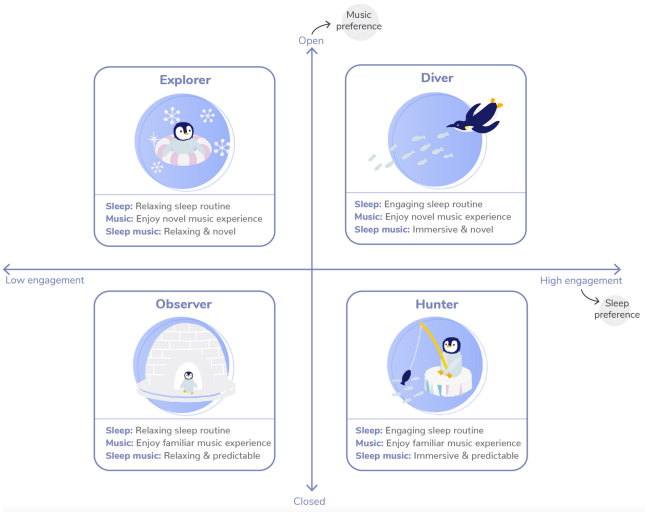



**Figure 3: The four sleep music profiles as a function of sleep engagement and music openness and their specific traits.**

*5.3.1 The Diver: High sleep engagement + high music openness.* The Diver likes to focus on some external support before going to sleep, to divert their attention. As an example, the participants reported diverse activities, including but not limited to watching streaming videos, reading detective books and articles, playing simple games. Divers enjoy more engaging and immersive activities compared to Observers. These activities support Divers to distract from ruminating or feeling less annoyed before sleep, for example:

> "On TickTock or Weibo, I can watch all kinds of random videos recommended by the system. I might first watch a very boring video, but finding the next one is funny. I enjoy receiving various types of random information."

Divers also have an open and curious inclination to new music experiences, which can arouse their interest. They also 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 are reluctant to repeated listening to familiar music. Sleep music for Divers should meet the preference towards novel music, in order to facilitate attention shifting and engagement. Novel and immersive sleep music is suitable for Divers.

*5.3.2 The Hunter: High sleep engagement + low music openness.* The Hunter prefers to do activities that attract their attention. The combination of high sleep engagement and low music openness brings about a slightly different music inclination than the Diver and the Explorer. The Hunter likes to listen to familiar music:

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

The music delivery aims at capturing the Hunters' attention and immersion. Music plays a role similar to the activities preferred by Divers. Therefore, immersive and predictable music is assumed to be suitable for Hunters' sleep music preferences.

*5.3.3 The Explorer: Low sleep engagement + high music openness.* In general, the Explorer wants a very relaxing sleep routine. Before going to bed, they prefer relaxing activities that require little attention and thinking. Low engagement might come from listening to soft music, white noise, doing nothing before sleep and less attractive readings:

> "I enjoy listening to calming sounds or only silence at night so that I can be with myself and fall asleep easily. Reading interesting novels before bed, makes me 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 dancing and rhythmic."

Relaxing yet novel music is assumed to be suitable for Explorers' sleep music preference.

*5.3.4 The Observer: 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. They don't attract my attention and after 10 minutes I feel sleepy already."

Concerning music, Observers are rather conservative. They prefer to listen to familiar music, and to a narrow choice of genres:

> "Usually, I only listen to meditation music, healing music, which is very calm and without lyrics. Some melodies from old songs are also nice, but I don't tolerate those with lyrics. They sound annoying."

The music content should be predictable and familiar, as the Observer's preference for music is very narrow, with a conservative attitude. In summary, sleep music for Observers should be calming and use music structures familiar to the listener. Relaxing and predictable sleep music is considered suitable for Observers.

# 6 STAGE 3: INTEGRATING AND EVALUATING THE PROFILING LOGIC

Stage 1 and 2 informed the design decisions for the sleep music profiles. In the Integration stage, we conceived DREAMe[2], a mobile-based demonstrator for the purpose of assessing the logic and the effectiveness of the emerging profiles. The demonstrator delivers a personalised sleep music experience by implementing the profiling logic and integrating the profiles in a personalised music player. The sleep music profile settings characterise the user and assign the corresponding profile. Figure 4 depicts the profile generation

[2]A video of the DREAMe concept is available at the following link: https://youtu.be/jsWk-1UmLzM.

logic, implemented as screens in DREAMe, which in turn informs the music personalisation system.

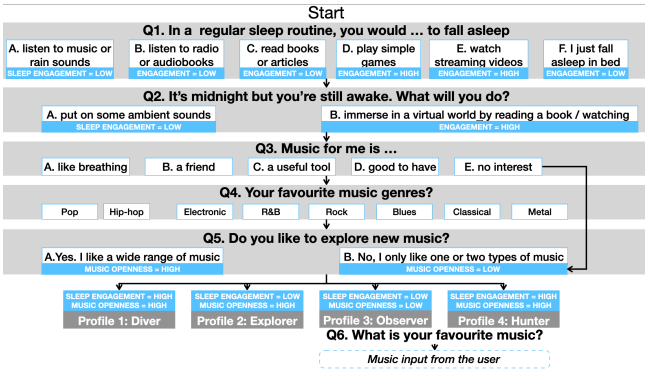



**Figure 4: The flow chart of the profile generation logic.**

We closely worked with a professional sound designer for the design and composition of a small set of soundtracks conceived around a general 3-stage structure of *attraction* → *immersion* → *entrainment*, to fit with the particular sleep and music preferences of the four profiles. In the *attraction* part, familiar or unfamiliar instrumental music is introduced, in the *immersion* stage environmental sounds are introduced, and finally in the *entrainment* stage the tempo and density of the overall soundscape progressively slow down and fade away. The overall soundtracks duration was set to 10 minutes equally divided between the three parts, although we plan to introduce a procedural approach in future iterations. In this respect, the music personalisation system was sketched for the purpose of complementing the profile creation. However, the design and evaluation of the soundtracks are beyond the scope of this paper, and will not be discussed further. We focus instead on the evaluation of the profiling logic and its effectiveness in representing the sleepers.

## 6.1 Method and procedure

We wanted to assess how credible and intuitive is the profile creation logic. Ten participants (mean age = 29.1 years, SD = 9.7, N(Female) = 6) took part in an individual evaluation, online session on Zoom, of approximately one hour each. The researcher (second author D.J.) first introduced DREAMe, the sleep music concept realised in the Adobe XD[3] environment, with the storyboard depicting the main user flows and usage context. Then, the participant was invited in a talk-aloud exploration of the profile settings and creation of the sleep music profile. The participant's screen sharing was enabled in order to observe and take track of the user interaction. Before receiving the system-generated sleep music profile, the researcher asked the participant to indicate the most plausible profile, so to prevent the passive acceptance of the profile resulting from the configuration process. Each participant was asked to fill in a 7-point Likert scale questionnaire on the profile creation and user experience, reported in Table 5. Finally comments and feedbacks by each participant were also collected.

[3] https://www.adobe.com/products/xd.html.

**Table 5: Evaluation questionnaire on profile creation and user experience**

| | |
|---|---|
| **Profile creation experience** | Q1: I well understood the questions and options in the profile configuration. |
| **Profile credibility** | Q2: I could easily choose one of the four profiles that fits with my person. |
| | Q3: The system-generated profile represents my preferences. |
| **User experience** | Q4: Using the app is intuitive. |
| **Desirability of use** | Q5: If I were an hospitalised patient, I would use this product to help me falling asleep. |

## 6.2 Results

The results of the participants' answers to the 5-items questionnaire are summarised in the boxplot in Figure 5. Despite the small

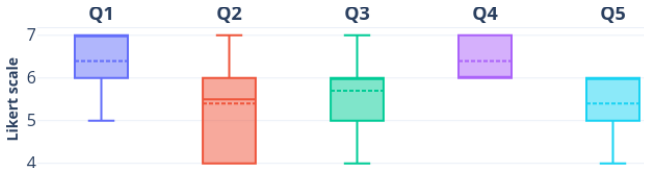



**Figure 5: Boxplot with whiskers (min. max. values) and mean value (dotted line) of the participants' answers. Q1: Profile creation experience; Q2, Q3: Profile credibility; Q4: User experience; Q5: Desirability of use (1 = totally disagree, 7 = totally agree).**

sample size, the overall profiling logic seems to be promising in capturing the sleep and music preferences of the participants, returning a credible sleep music characterisation, and more in general in segmenting user groups (Q2, Q3):

> "The four categories have quite a clear difference. I could easily pick out that I am an Explorer."

Moreover, during the talk-aloud observations, the participants could understand the characterisation of the four profiles, and choose the most representative one by comparing the description with their personal sleep and music preferences. Each profile was indeed selected by at least two participants, thus suggesting that the four profiles are representative of some parts of the individual differences in music and sleep preferences. The sleep music profiles, however, are not fixed, since the users' preferences are not static:

> "When I imagine myself at the hospital, I might become a Diver and want to be distracted from the negative thoughts."

In this respect, we argue that the participants were concerned that their sleep preferences might change. Sleep preferences can change between low and high engagement depending on the environment, mood and other sleep-related factors.

In Q3, the participants rated the credibility of the system-generated profile. Here, the distribution of the answers suggests that the system's logic is reasonably effective in characterising the users' preferences through profiling. One participant criticised the oversimplification of the profile's content:

> "I'm not too sure [about the profile] because only a few preferences of mine are represented."

It is reasonable that the profile information is not rich enough, especially if compared with the information provided by personality tests. However, our design choice was to show only the information related to the sleep engagement, the music openness, and the sleep music recommendation. The rationale is to maximise the transparency of the personalisation system. Finally, the scores in Q5 suggest that the sleep music personalisation feature can drive the desirability of usage, although we acknowledge that the long-term use is inevitably dependent on the efficacy of the sleep music itself:

> "I have used a few of these sleep apps before. None of them is personalised, so this is very good. It makes me feel like this sleep music is just for me."
> "I'll certainly try it out, but how long I use it depends on the music effects. Letting me know the science behind the music would help me stick with it for a longer time".

## 7 CONCLUSIONS AND IMPLICATIONS FOR DESIGN

Understanding and conceptualising the users' sleep and music preferences represent the main challenge in the design of music-based intervention. A profile-based personalisation process was used as main research approach. We proposed four sleep music profiles as a function of sleep engagement and music openness. A demonstrator was realised as means to evaluate the typicality of the profiles. Our exploration represents a first step in the design of sonic profiling, in order to set a methodological understanding of the listeners' preferences in context. We conclude that the profile generation logic is reasonable and that the four profiles could represent people's sleep and music preferences, although we acknowledge not only the need to include more participants in future evaluations, but also to carefully consider the hospitalisation context as soon as patients will be involved.

In the scope of this paper, we focused on the information collection, profiles initialisation and integration stages, yet the next iterations can include the update stage in the profile-based personalisation. Data for the system update can come from both the system and the users. For instance, users can report their subjective sleep experiences after one night listening. Sleep trackers can be coupled with the DREAMe application to collect and measure physiological data. In this way, the whole chain can be iterated to accommodate the people's sleep needs. In this respect, customisation is considered a further important step. In the information collection stage, seven secondary themes were derived, including "sleep concerns", "external support", "relatedness", "established sleep routine", "mood", "relationship with music", and "instruments". These themes can inform the design and development of customisation features, by representing further the nuances of the profiles. In this way, the user's feedback and the system data can contribute to shape more accurate and dynamic portraits of the sleeper-listener.

## ACKNOWLEDGMENTS

The paper is based in part on author D.J.'s master project thesis. Author S.D.M. performed his work as part of the project PaDS, funded by the EU Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 893622.

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