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## **Music, sleep, and depression**

### *An interview study*

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## **Music, sleep and depression: an interview study**

### **Abstract:**

Music has been suggested as a potential sleep aid option in the treatment of depression related insomnia, however, research is needed to fully understand the possible benefits. In this study the objective was to examine experiences of music listening at bedtime for adult psychiatric outpatients with depression related insomnia. The study design implied a qualitative thematic analysis using phenomenological methods applied as microanalysis of interview data. Participants were recruited from an Outpatient unit for depression in psychiatry, Aalborg University Hospital, Denmark. Four adults with depression and sleep disturbances took part in a semi-structured interview after completing a four-week music intervention as part of a clinical trial. The participants evaluated a music listening intervention for sleep improvement. Six themes were highlighted: Sleep and relaxation, Distraction, Mood, Habits, Preference and Technology. Three participants reported intervention effective in improving sleep and relaxation. Interactions with technology and music preferences were important. The findings highlight influences of music on relaxation and sleep in depression related insomnia with examples; Music distracts from inner stimuli, affects mood, arousal and supports healthy habits potentially improving sleep hygiene. In conclusion, this study improves our understanding of the multiple effects of music in depression insomnia including limitations and directions for future research.

### **Introduction**

This qualitative study explores the effects of music listening on depression related insomnia. Increased attention to the importance of sleep as a key component to the recovery from depression as well as essential to achieving treatment benefit across diagnosis in psychiatric settings has resulted in a search for non-pharmacological interventions to improve sleep quality in psychiatric populations. Sleep disturbances in depression are common and the comorbid presentation of depression and insomnia is described in psychiatric research articles (Fava, 2004; Jindal & Thase, 2004) Sleep loss may lead to aggravation of symptoms and consequently relapse of depression due to poor sleep (Fava, 2004; Herman, 2010; Jindal & Thase, 2004). A recent literature review investigating music on prescription for treating sleeping problems reports a higher effect of music than audiobooks and suggests an improved quality of sleep with increased exposure. The authors conclude that the effect of music is unexplainable “there are some peculiarly mysterious effects of music that science has yet to address” (Dickson et al, 2020).

Treatment options usually involve medication and the first line nonpharmacological treatment is cognitive behavioral therapy, in short CBT (The National Institute for Health and Care Excellence, 2009). This treatment is time consuming and requires a trained CBT-therapist, which may explain under-utilization (K. V. Jespersen et al., 2019). In addition to existing non-pharmacological interventions, music is a potential tool in the treatment of depression insomnia, having few side effects (K. Jespersen et al., 2015; K. V. Jespersen et al., 2019). In this context, music interventions also termed music medicine represents the therapeutic use of music without the presence of a music therapist (Gold et al., 2011).

Meta reviews have pointed to an effect of music interventions in improving depression symptoms (Chan et al., 2011; Chanda & Levitin, 2013; Leubner & Hinterberger, 2017). In addition, there is an increasing body of evidence indicating music as an efficient tool in improving sleep quality and related day time impairments in insomnia disorders (Chang et al., 2012; Dickson & Schubert, 2019; Harmat et al., 2008; K. Jespersen et al., 2015). The effect of music on sleep quality in depression has been reported in only one published study investigating music interventions in the treatment of depression related insomnia (Deshmukh et al., 2009).

A pilot study investigating the feasibility of a trial of music intervention in the treatment of depression insomnia was reported with satisfactory results (Lund & Pedersen, 2016). Hence, a single-center randomized controlled trial (RCT) in a two-arm parallel group design was initiated in May 2018 (Lund et al., 2020) in which data collection is ongoing. The RCT and the qualitative interview study are included in an explanatory mixed methods study design.

Therefore, we aimed to investigate music and depression related insomnia through an in-depth investigation of subjective experiences and the usefulness of the MusicStar app in the context of sleep disturbance in the present qualitative study.

## **Rationale for an interview study**

The complex mechanisms of the music-body-mind interaction, which may facilitate sleep considering the symptoms of depression, are under investigated and includes many subjective components. Therefore, a qualitative interview study, which facilitates the emergence of participants' views, allowing for more detail than in a large sample questionnaire approach, may be beneficial and further give explanations to future findings from the randomized controlled trial. The interview analysis provides insights into the phenomenological music listening experience and the psychological and physiological mechanisms which take place (Braun & Clarke, 2006; Crowe et al., 2015). As reported in a systematic review, insights into factors influencing the association between music, wellbeing, depression and quality of sleep are in demand (Jespersen et al., 2015).

## **Method**

### RCT

This interview study is a part of a bigger RCT study taking place in an outpatient unit in psychiatry at Aalborg University Hospital in Denmark. Inclusion criteria allowed one hundred and twelve patients aged 18-65 in treatment for depression with sleep disturbances identified in HAM-D17 and in stabilized medical treatment to participate. The participants were eligible when following standard treatment for depression according to national Danish guidelines. Patients with organic sleep disorders, sleep apnea, and psychotic symptoms were excluded. Patients with a sentence to treatment by law or substance abuse were excluded as well. In addition, patients with hearing loss and a dislike of music were excluded.

### **Ethics**

The study was approved by the North Denmark Region Committee on health Research Ethics September the 5th 2017; N-2017555. Written informed consent was obtained from the participants and kept in a locked place. The data was anonymized.

### Music intervention

Participants were instructed to listen to music using a sound pillow and The Music Star app (see fig. 1.) including 16 color-coded playlists for a minimum of 30 minutes at bedtime every night for four weeks. The study protocol was published (Lund et al, 2020). The description of the music and sound equipment below is in accordance with the guidelines for reporting of music intervention studies (Robb et al., 2011).

The sound pillow is a pillow with in-built stereo speakers connected to a music player (phone or tablet). For this study, an iPad mini 4 with the Music Star app installed in locked screen function, was used. The Music Star is an intuitive app with color coded playlists of calm music selected by music therapists. The design is the shape of a star and the music is organized according to the degree of stimuli (Lund et al., 2016) influenced by a taxonomy of music (Warja & Bonde, 2014). Music choice is a simple one touch process which is a crucial feature of the intervention since users may have cognitive deficits and are required to access the intervention unaided.

**(Fig 1 here)**

### *Fig 1. The MusicStar app*

The design of The MusicStar has been guided by user needs identified in clinical practice in a psychiatric hospital setting and supported by music intervention studies (Gebauer & Vuust, 2014; Hannibal et al., 2005; Lin et al., 2011; Short & Ahern, 2009; Tan et al., 2012). Fifteen playlists are available as well as one extended soundtrack providing a total of 16 playlists with a duration of 30 or 60 minutes each. The curated options include music characterized as ambient, new age, classical, folk, pop, rock, film soundtracks and specially composed music. Aiming at avoiding possible negative expectations towards genres the playlists are organized by color graduating musical stimuli from blue (least stimuli) increasing to red (most stimuli). While the blue, green and red playlists are sub-categories of supportive music with increasing stimuli inspired by the taxonomy of music by Wärje and Bonde, the grey triangles contain playlists for specific purposes. For this project, two sleep playlists of 30 minutes were included in the grey triangles. The playlists contain mostly instrumental music with a few vocal playlists allowing users to select known music and/or unknown music. Combining expert selected music with the option to choose music according to preference has been a guiding feature in the app design.

### Selection of interview participants

In the fall of 2019 patients volunteered for a post intervention individual semi-structured interview. The aim was to include participants representing variation in age and sex. Inclusion criteria: 1) completion of the music intervention period regardless of outcome 2) ability to communicate personal experience in an interview format. Four interviews were included for thematic analysis. In this period, more women than men were recruited for the trial resulting in only one male participant.

Participants (3 females, 1 male) aged 23 to 62 who, at time of study, were patients receiving treatment for unipolar depression in an outpatient unit in the department of psychiatry at Aalborg University Hospital. The participants had moderate or severe sleep disturbances including difficulties falling asleep or maintaining sleep. The Hamilton Depression Rating Scale (HAM-D17) identified the sleeping problems by a score of at least 2 in one item, or at least 3 in total for the three items (sleep items 4-6).

The names of the participants are anonymized, and they are presented in figure 2.

### ***(Fig. 2. Here)***

*Fig. 2. Name, age, work/health status and habitual use of music for sleep.*

Except for Mona, the participants suffered from prolonged sleep initiation. In addition, Mona, Alice and Louis had symptoms of nightly awakenings. At baseline, all participants reported early morning awakenings.

### Procedure

Interviews were carried out within one month after the music intervention period and conducted face to face by an independent researcher (second author) at the hospital. The mean length of the interview was 42 minutes. In order to help participants recall the playlists and play extracts, the interviewer was provided with a tablet with The MusicStar App. Interviews were conducted in Danish and audio recorded. The analysis of the interviews followed the systematic procedure of Phenomenological Microanalysis as reported by McFerran and Grocke (Wosch & Wigram, 2007).

## Analysis

In the first step, interviews were fully verbatim transcribed and checked for accuracy by the first author. In the second step, *Identifying Key Statements*, the first author and the last author read the transcripts independently and noted key statements for the research questions (Appendix 1). Statements answering directly to the research questions were included as well as statements on how music listening with a sound pillow and The MusicStar App had had an effect during the four-week period. Comments on future improvement of music listening and audio equipment were included, but statements including the effect of other music or sound during the four-week period were excluded. Expressions of other themes than indicated in the research questions were excluded as well as statements of the future use of other means than music (other audio).

Inclusion of two researchers selecting key statements aimed at reducing potential researcher bias. The interrater agreement was 93%. Disagreements were resolved via discussions between raters and researchers. In the third step, *Creating Structural Meaning Units*, the key statements were categorized using headings guided by statements on the effects of the music intervention during the four-week period. For example; "Sleeping problems related to loneliness" was removed because it represented an individual theme. "Selecting music for the brain" was subsumed into the category "Selection of music (structural musical features)" and "Change of habits – no screen" was subsumed into the category "Change of habits and behaviour". The fourth step, *Creating Experienced Meaning Units*, involved a revision of categories and titles. The third and fourth step were merged in the working process. The fifth step, *Developing the individual distilled essence*, implied writing a narrative summarizing the essence of the participant experience. An example of the first part of the individual distilled essence (Mona) would be:

*Mona reported that the music intervention had a positive effect. Music listening made her calm down resulting in improved sleep quality. She explained that music listening at night changed her behavior, so she did not lie in bed with the cell phone. In addition, she turned the television off in the evening. She put the music on at bedtime and when she woke up at night, she would turn it on again to find a sense of calmness supporting her to fall asleep again. Music listening promoted relaxation".*

In step 6, *Identifying Collective Themes*, commonalities were gathered, and global themes were created including contributions from all participants. The previously identified themes were categorized into common, significant and individual themes. Sixteen collective themes were included. In the final step, six overarching themes emerged, and the global distilled essence summarized the conclusions from each theme.

### **Results: Themes emerging from the qualitative interviews.**

The main overarching themes are: Sleep and relaxation, Distraction, Mood, Habits, Preference and Technology. The themes reflect the dominant topics of discussion as the participants evaluated their experiences and they are presented in figure 3.

Three participants found the music intervention effective in improving sleep and relaxation, enhancing acceleration of sleep initiation and reducing nightly awakenings . Positive effects were both psychological and physiological. Music enhanced relaxation by distracting from thinking and physical restlessness. The structural musical features of the selected music were also highlighted as beneficial. In addition, music was reported to distract from tinnitus.

Two participants experienced a positive change of mood as well as positive effects of changing bedtime routines including turning off screens, stopping activities and preparing for bed earlier. Duration and frequency of music listening during the night varied and calm and predictable music, played at low volume, was reported to enhance relaxation and sleep.

Three participants evaluated the available playlists positively and reported favourites. Music choices were made with varying rationale and the wish for familiarity and non-familiarity was equally emphasized. The quality of the sound equipment was discussed with suggestions for improvement.

**(Fig. 3 here)**

*Fig 3. The illustration shows the subjects arising in chronological order within the interviews.*

Each theme with associated subthemes is presented with illustrative quotes. Quotes have been translated from Danish by the first author.

#### **Sleep and relaxation**

Music was reported as a relaxing stimulus promoting sleep. The statements were characterized by not separating relaxation from sleep, suggesting a crucial relationship between relaxation and sleep. Participants defined sleep quality in relation to sleep disturbances in depression, characterized by problems concerning sleep initiation, nightly awakenings and early morning awakenings. Evaluation of sleep quality:

*“Yes, during the time I used the app, I slept better than I did before”. (Mona)*

*“I fall asleep fast enough, it’s just the thing that I wake up often. Here I didn’t wake up so often”. (Mona)*

*“The result wasn’t that I slept for 8 hours straight on, but I felt differently rested in another way in a shorter time, than I did previously”. (Alice)*

*“A few times I have slept for four and six hours. I haven’t done that for a whole year”.*  
(Alice)

Mona and Alice experienced improved relaxation and sleep quality characterized by longer periods of continuous sleep, improved daytime restedness, and less frequent awakenings at night. Alice reported fewer nightmares. Alice and Louis reported acceleration of sleep initiation.

*“The music gives you something else to think about, well, it helps you fall asleep, like you are falling away from your own thoughts and just turning quiet”.* (Louis)

There were individual differences concerning when participants engaged with the intervention. Mona and Alice used the music intervention continuously during the night, while Louis used the music at bedtime and in the following hours. Alice and Louis experienced improved sleep initiation when listening to relaxing music in bed.

Louis reported positive physical and mental effects of the music intervention but no improvement in overall sleep quality, as the music intervention did not affect nightly awakenings. Mona emphasized the positive physical effects of the music, including physical sensations and improved wellness while Alice emphasized the positive effect on the brain and the mind comparing music listening to meditation.

*“The music has helped me calm down at night. You just get such a bodily calmness”.*  
(Mona)

*“I feel a sense of calmness, when I wake up. Even if I wake up after an hour or two, then I feel another calmness. It is a calmness in my head but also, like, peace of mind”.* (Alice)

*“When I heard the music, there was another kind of calmness in my head, meaning that when I slept, I really slept”.* (Alice)

Tina listened to music while waiting for her sleep medication to have effect and reported no beneficial effects. She normally listened to an audiobook at bedtime and this was helpful.

*“The music had no effect even if it played every night and often played until the end of the playlist”.* (Tina)

*“My own music is actually an audiobook and it has music in the background. The reader has a nice voice, it is like music. There is a little bit of music in the background and it suits me fine. I don’t focus on what he (the reader) reads, or on the music. I can simply fall asleep to it”.* (Tina)

The impact of music included a broad spectrum of individual responses and the exposure to music extended 30 min. at bedtime to continuous use during the night.

Distraction



Distraction played a significant role and was discussed in depth in three interviews. Alice and Louis consciously directed the attention to the music and found this helpful for relaxation and sleep initiation. Mona reported distraction from physical restlessness. Alice was distracted from painful emotions. Music facilitated a peaceful inner space locking out fear of death, unwanted emotions and thoughts.

*“If you start to focus on what’s happening in the music, that is, you try to figure it out. Then you remove many running thoughts. It is extremely calming”. (Louis)*

*“I get medication for anxiety as well, and that of course is a combination of being so tormented by COPD (Chronic Obstructive Pulmonary Disease) at times, right, so it’s a kind of fear of death that you have. Emotionally I do get a lid on (when listening to music). It’s such an inner calmness. I imagine, it’s like, if you meditate, you can somehow lock something out. It is comfortable, it is a relief and it’s something I have experienced only a few times this year. (Alice)*

Alice was diagnosed with Chronic Obstructive Pulmonary Disease. In addition to depression, she suffered from physical pain of the lungs, shortness of breath and anxiety. Music enabled distancing to feelings of pain and fear of death, her use of a lid as a symbol illustrated how music provided a safe and peaceful inner space, the lid blocking out anxiety and pain.

## Mood

One well researched feature of music is positive impacts on mood (MacDonald et al 2012). Depression and negative mood are closely related. Improvement of mood was discussed by Mona and Alice experiencing mood changes towards a more positive mood as well as pleasure of music listening. In addition, Alice experienced rare feelings of happiness. Tina experienced that music listening caused frustration resulting in a negative mood.

*“Yes, (music listening) has probably improved my mood a little”. (Mona)*

*“It can give you a complete sense of happiness.... It has really been good, not the first week, right, you must get used to it and finding out what kind of music to listen to. But then, I was really looking forward to listening to the music, because I knew I would get that peace, so yes, it has really been nice”. (Alice)*

Improving mood may help alleviate the depression symptoms and increase wellbeing. This was particularly relevant for Alice who reported improved mood and wellness combined with improved sleep and relaxation.

## Habits

Bedtime habits play a role in sleep hygiene (Dickson et al, 2020). The role of habits in relation to sleep was investigated as music listening may influence and become a part of bedtime routine. Mona and Alice reported changed habits and positive effects. Mona turned off the television and cell phone while Alice stopped crossword activity and prepared for bed actively at an earlier time.

*“It (music listening) has changed my behavior so I don’t lie down with my cell phone anymore, which I consider a good thing”. (Mona)*

*“Yes, I have changed bedtime routines a little. Even if I am tired, I am still not going to bed. I do get more ready (for bed) while I had the music, because I can fall asleep. I even looked forward to listening to that music, because I knew it would give me peace of mind”. (Alice)*

Music at bedtime implied attention to (bad) habits at bedtime with the aim of improving sleep hygiene. However bedtime, habits did not change during the four-weeks for the participants who were used to music listening at bed time.

### Preference

When speaking of preferences, the participants searched for music with a relaxing and calming effect. They described the effect of music they wanted to obtain and the specific musical features which would enhance relaxation and sleep. In addition, they discussed their favorite playlists and commented on the sound of rain as this was the only non-musical playlist. Tina selected music, which she considered helpful to improve relaxation and sleep.

*“I listened to the dark blue playlist because it was the one, I felt made me relax without it being stressful”. (Tina)*

Music was selected considering psychological and physical effects. While Alice selected music according to a psychological effect (peace of mind), Mona chose music primarily considering a physical effect (bodily wellness ).

*“I chose music according to physical sensations. Some of the playlists were better some days than other days, and it may have something to do with bodily restlessness”. (Mona)*

Alice found that the purpose of listening in order to sleep changed her listening mode.

*“ I intend to teach my brain, that when I listen to this calm music, then you can turn of the thoughts. And then it calms down now. I didn’t use to listen that way. I used to listen to music because I listen to it. (Alice)*

This is a good example of how participants used the intervention for very specific goals with individual rationale. The interaction with music took multiple forms, from a static one-way receptive process to a dynamic interactive process adjusting music stimuli to physical state ad hoc. Alice interacted by adding a cognitive behavioral element introducing a supportive regulating thought “Turn off the brain when this music plays”.

## Playlists

Participants tested playlists and discussed the process of selection and rejection. Alice and Louis selected music with a high level of predictability. Mona reported selecting music according to her preference for the specific feature of a calm human voice humming. Alice associated the chosen music style specifically with the purpose of sleep, selecting music differing in genre from her usual preferred music. Louis liked the sound of rain and the pleasure of listening to this sound was reported as a selection criterion. Musical features including music with unpredictable elements and too much activity explained exclusion of music as well as the missing ability to identify with the music.

*“The red playlists are much too jazzy for me, oh, it’s really not my thing”. (Tina)*

*“Well, singing and those red ones (playlists), that’s not me”. (Alice)*

MusicStar playlists, which were rejected, were described having negative effects. The reactions were stress and irritation, and the music was characterized as disturbing, interrupting, annoying and noisy.

## Favorites

Preferred music obtained status as favorites for some participants. The participants discussed their sleep music favorites which varied from one to four playlists. Two participants chose a light blue playlist as a favorite, Zen Spaces by Kristian Thorsager (recorded for the MusicStar).

### Favorite playlists:

Tina: Resting Place (mixed classical). By Fabrizio Paterlini, Steve Dobrogosz, Eric Satie and Vivaldi among others.

Mona: Zen Spaces (modern acoustic new age) by Kristian Thorsager and Easy Going (mixed pop) by Jack Johnson.

Louis: Zen Spaces (modern acoustic new age) by Kristian Thorsager and Summer Rain (acoustic soundtrack) by Lars Rye Bertelsen and Helle Nystrup Lund.

Alice: Quiet Please (ambient/electronic new age) by Jacob Gurevitch, Musicure (acoustic new age) by Niels Eje, Simplicity (electronic new age) by Gurevitch, and Light Moods (mixed folk/classical).

A common feature in the favorites of the participants were playlists from the blue segment. The blue playlists are characterized by having the least stimuli, slow tempo, predictable sound with little harmonic and melodic change, simple orchestration and mostly instrumental.

## Nature sounds

A playlist of the natural sound of summer rain was included as the only non-musical playlist. The soundtrack of summer rain was not a common favorite. Tina, Mona and Alice responded negatively to this soundtrack for different reasons. Tina found the sound of rain lacked musical elements. Mona disliked the soundtrack and described it as an unpleasant artificial sound. Alice

could not identify with the sound of rain and had unpleasant associations. Louis had a positive evaluation of the soundtrack without further explanation. He chose the sound of rain as a favorite.

*“I listened to this one, it’s good, I always listened to this one called ‘Summer Rain’.  
(Louis)*

The varying favorites and perceptions of the “Summer Rain” soundtrack support the argument that a given music intervention should offer a varied music (and sound) selection with enough choices to meet individual preferences.

## Technology

Technological aspects including frequency, duration and volume were discussed as they had an impact on the listening experience. Options to adjust frequency, duration and volume of music were evaluated positively and the importance of adjusting the volume to an individual low level was emphasized.

*“If I was very tired, I turned the volume down. If I wasn’t so tired, I would turn it up”.  
(Mona)*

*“I thought it should be a lot louder for me, than it should, actually. It must be like floating passing my ear, calmly, quietly. I can hear it, but it’s not in a way that it’s so loud that you, like, now you get what’s happening here”. (Alice)*

The option to change music according to needs was appreciated. Mona and Louis expressed satisfaction with limited options of playlists, since too much choice could cause doubt and confusion. Mona and Alice reported that their normal (daytime) preferred music would be ineffective for sleep, since it would be inappropriate, disturbing and too dominant. Alice noted that she specifically associated the ‘new’ music in The MusicStar with sleep.

*“If I had been listening to the music that I regularly listen to, when I am driving and things like that, yes, then I probably wouldn’t have fallen asleep, I don’t think so. I think too much is happening and, maybe I would have fallen asleep, but it would perhaps have taken a little longer. Besides, I don’t think I would have found the same bodily calmness”. (Mona)*

*“I simply wouldn’t be able to use my own music in the same way. It’s another style. And it has been stuff like ‘let’s party’, and I simply associate this with something else”. (Alice)*

Mona and Louis found their normal preferred nighttime music was similar or identical to the music they selected in The MusicStar app.

## The MusicStar app and the color codes

Three participants evaluated the app and the color codes positively. Louis evaluated the grouping of similar playlists in subgroups of four, positively. Categorization in color groups visualized options and promoted decision-making. He had positive comments on the visual design with a suggestion to enlarge the app to ensure correct use (precision when selecting) at nighttime. Mona, Alice and Louis were satisfied with the music selection. Tina missed music of her personal preference.

*“I hoped that I might find something a little bit more (appealing to) me.” (Tina)*

## The Sound Pillow

Evaluation of the sound pillow was mixed. Tina, Alice and Louis reported user satisfaction and rated the pillow of good quality. Mona reported that the local sound distribution enabled her to listen to music at nighttime without disturbing her partner. Alice found the sound provided a sensation of a protective bonnet around her head creating distance to exterior sounds.

*“It is like a bonnet around your head. You don’t have to take it all in, what’s coming from around you, so you’re like protected around here”. (Alice)*

Tina and Louis gave a detailed evaluation of the sound equipment listing (dis)advantages and gave suggestions for improvement. The evaluation of sound quality ranged from low to good.

In conclusion, themes and subthemes are presented in a visual theme map (see Fig. 4.). The subthemes highlight the complexity of mechanisms related to music listening.

**(Fig. 4 here)**

*Fig. 4. Flow chart of themes and subthemes.*

## Discussion

As this study includes a small number of participants the findings cannot in any way be generalized. However, we think the systematic qualitative analysis of the interview verbatim has provided important findings concerning an understanding of complex mechanisms of music and depression insomnia.

### Effect of music on sleep

The findings in this study highlight a positive effect of music listening on sleep and sleep hygiene which aligns with research in music and sleep in the general public (Trahan et al., 2018). The study by Trahan et al. reported a thematic classification of responses from 651 participants which showed four key areas where music was beneficial: The properties of music stimulate sleep (Provide), music becomes part of a bedtime routine (Habit), music induces a physical and/or mental state enabling sleep (State) and music blocks internal or external stimuli preventing sleep

(Distract). This study provides examples of the function of music in these four categories. Habitual music at bedtime did not only get integrated as a reinforcing element in sleep hygiene, but showed potential to 'overrule' unhealthy habits, for example lying in bed with the cell phone. The distracting effect of music seemed particularly beneficial regarding distraction from internal stimuli regarding depression symptoms.

#### Arousal regulation

The findings in this study illustrate that music intervention in some cases can improve sleep and relaxation and our ability to regulate our affective state using music. Regulation takes place when individuals select music to achieve a psychological goal and this use of music for change is a common everyday occurrence (Baltazar & Saarikallio, 2016, 2019; MacDonald et al., 2012a; Randall et al., 2014; Saarikallio et al., 2017). The potential counterproductive use of emotion regulation strategies in depression was investigated in a study on emotion regulation with music in depressed and non-depressed individuals finding no significant differences between groups regarding regulation mechanisms, goals and strategies (Sakka & Juslin, 2018). Saarikallio et al., (2017) reported positive effects in adolescents who used music to lower arousal levels highlighting how music listening can be employed to actively enhance psychological and physiological wellbeing. We suggest that mechanisms of lowering arousal for sleep in depressive insomniacs are similar to the arousal regulating effects of music in adolescents.

#### Familiarity and preference

When investigating sleep inducing music, the relationship between the influence of structural components (tempo, rhythm, instrument etc.) and the impact of preference is paramount. The impact of preference and familiarity has been investigated in several studies (Dickson & Schubert, 2020; Groarke et al., 2020; K. Jespersen et al., 2015; Loewy, 2020a; MacDonald et al., 2012b; Saarikallio et al., 2017; Tan et al., 2012; Trahan et al., 2018)

Trahan et al argue that varying music may apply to varying aims i.e. different music is required for distraction as to arousal regulation. Therefore, a combination of intended therapeutic use and preference may optimize beneficial effects of music listening. This theory can be further unfolded. We argue that musical preference as self-medication has a value not limited to selecting preferred music. Adjusting duration (dosage) and volume possibly optimizes a beneficial effect as well and the options to adjust the intervention according to needs empowers the individual, and feeling of control may enhance the regulatory effects (Groarke et al., 2020). The effect is also influenced by the utilised technology. Selecting preferred playlists from a limited music selection was reported satisfactory. Navigating playlists of lullabies, relaxing music and 'sleep music' generated by algorithms available on streaming services requires cognitive skill and energy. Participants in this study reported that too much choice may cause doubt and confusion and offering unlimited choice may hence be counterproductive.

In previous studies familiarity has shown to correlate with perceived relaxation (Tan et al., 2012;). This study contributes with one example of preference in favour of non-familiarity. Alice was able to associate sleep with music that was unknown to her. Labelling specific music as sleep-music was beneficial, and positive anticipation of sleep was reinforced by the signal value (the sound indicating time to sleep), since this music served only this purpose. The association of particular

songs with sleep is an important psychological mechanism. Participants to some extent cognitively condition themselves to prepare for sleep when hearing particular songs.

#### Self-assessment

In daily life, music is used to purposely modify our mood and influence our immediate environment (MacDonald et al., 2012a). Music evoking positive emotions and stimulating the production of dopamine, is not beneficial when aiming at lowering arousal. Assessing music for relaxation and sleep requires a mindset adapted to the psychological state (depression). The beneficial music is likely to differ from previously experienced beneficial music due to the changed psychological state in depression. The ability to interact with music in a dynamic interactive process allowing ad hoc self-assessment to guide the self-prescription of music, adjusting the dose and forming musical habits, may be key to the positive effect of music on sleep. **The argument that flexible and context-appropriate regulation strategies are paramount for positive outcome in depressed listeners is supported by Gross and Thompson (Gross, 2007).**

#### Musical features

An increasing body of evidence supports the use of music as a sleep aid in clinical populations exhibiting depression (Chan et al., 2011; Chanda & Levitin, 2013; Kamioka et al., 2014). The components of sleep-inducing musical features include; slow tempo, recognizable musical structures and sparse instrumentation, few harmonic changes and shorter melodic lines with predictable beginning and end (Grocke & Wigram, 2007). These characteristics define most of the music in the MusicStar app. The term *music medicine* is used to indicate that music serves as medication. However, music listening differs from taking sleep medication and the participants' statements describe complex experiences beyond simple cause-effect relationships. An example: disliked music causes negative effects as it is being perceived as disturbing and noisy despite psychophysiological properties of relaxing music.

#### Diverse symptoms – diverse use of music

The sleeping problems of participants were diverse and this was reflected in a varied use of music. Music listening at bedtime supported and accelerated sleep initiation and music listening during the night supported a continuous sleep. Improved wellness caused by music listening when awake at night is valuable although not reflected directly in improved sleep quality. Based on the findings in this study, we suggest wellbeing at night as a relevant measure in future studies. The stress associated with not being able to sleep may be reduced and lead to improved wellness and relaxation. The pleasure of music listening may also influence mood and relaxation positively.

#### Expert selected music or individual preferences

The debate on whether expert selected or individual preferred music has the most beneficial effect is ongoing (Groarke et al., 2020; Loewy, 2020b; Trahan et al., 2018) and a Cochrane review concluded that a similar positive effect of music was found in studies with individual selected music and expert selected music (Cepeda et al, 2006). Discussions should consider applied technical solutions providing easy access to a large music library on mobile phones and tablets and

modern solutions tailored to support therapeutic aims. In this study we have aimed to bridge this polarized either-or dichotomy by allowing choice and preference including options of familiarity and non-familiarity offering a selection of playlists curated by music therapists. The technology is of vital importance to this study allowing sophisticated solutions and incorporating user needs. This technology allows for both the expertise of the therapist and the personal preferences of the user to produce a more nuanced music selection process that goes beyond experimenter selected versus participant selected approaches.

#### Future Research

The nature of the sleep disturbances and other individual factors with a potential impact on sleep were not investigated. Future studies should address these concerns unfolding the interplay of sleep and music, investigating the etiology of the sleep disturbance as a confounder of the effects of music. This may help identify the population most likely to benefit from music on prescription.

#### Conclusion

The testimonials have unfolded influences of music on relaxation and sleep in depression related insomnia. Music has shown to distract from inner stimuli, affect mood, arousal and support healthy habits potentially improving sleep hygiene. Music was reported valuable as a sleep aid in three of four cases while it is unknown how representative the sample of four is for the population.

This study suggests that music provided by The MusicStar may be beneficial in improving sleep in depression for several reasons: The music is in accordance with basic musical properties of sedative music. Simplicity in the music search process makes the intervention easily accessible for individuals with cognitive deficits. An explicit aim at arousal regulation has guided the app design from user interface to selection of music. When creating individual playlists of music for sleep The MusicStar may be influential. The MusicStar as an accessible, noninvasive and low-cost intervention sleep aid option in the treatment of depression related insomnia has shown promising potential with this small sample and further investigation is recommended

This study has reported experiences of music listening at bedtime. Multiple mechanisms have been discussed shedding light on the complex interplay between music and sleep, relaxation and wellbeing.

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Appendix 1. Questionnaire for semi-structured interview.

**Theme:** The quality of sleep of the participant, the experience of the music, the sound pillow and of the MusicStar.

1. Has music listening had an influence on you and your sleep? If yes, how and when? (Did the music make a difference when falling asleep, in the middle of the night, in the early morning hours?)
2. Has music listening made a difference regarding bedtime routines and have you changed any behaviours when listening to music at bedtime?
3. Has music listening influenced you in other ways than in relation to sleep? If yes, how? (Has music listening had an influence on your mood, your energy or made you relax?)
4. Has music listening affected negative or running thoughts, or restlessness? If yes, describe how.
5. Additional remarks or comments concerning the music and the effect.
6. Describe which music in the MusicStar that seemed to work best. What seemed to work, when and how?
7. What do you think about the music selection and the colour codes in The Music Star?
8. Do you think there was enough music to choose from? If yes, why? If no, what did you miss?
9. How will you describe the music in the MusicStar in comparison with the music you listen to usually?

10. Would it have made a difference for the effect of the music listening if you had been listening to your own music, instead of the MusicStar? If yes, describe in detail the difference you think it would make.
11. How long should the music play before there was an effect?
12. What is your opinion on the sound pillow (comfort, sound quality and sound experience)?
13. Further comments concerning the sound equipment? Satisfaction/Dissatisfaction.
14. Supplementary comments regarding your participation in the research project.