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Towards the development of music as an intervention for Insomnia treatment: A research synthesis

Richter, Miriam

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TOWARDS THE DEVELOPMENT OF MUSIC AS AN INTERVENTION FOR INSOMNIA TREATMENT: A RESEARCH SYNTHESIS

By

MIRIAM RICHTER

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AUTHOR'S DECLARATION

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

At no time during the registration for the degree of Research Masters has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

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Abstract

Name:
Miriam Hannah Daliah Richter

Title:
Towards the development of music as an intervention for insomnia treatment: a research synthesis

Though research has been conducted with regards to music and sleep over the last two decades, there is still a significant uncertainty to its effectiveness due to the lack of scientific validation through objective testing and data analysis (Jespersen et al 2015). It has been proven that music can help in the management of physical pain and psychological conditions such as depression and anxiety, hence, music is already being implemented in medical treatments in the form of music therapy (Jespersen et al 2015). The literature review commences with a brief consideration of conventional treatment methods including pharmaceutical and talking therapy-based methods. It then investigates various research trials using music as the main intervention and contributes to the field by introducing and exploring certain sleep-music products which are available on the open market. The thesis aims to compare research regarding the psychology of music and sleep, sleep sciences, music as an intervention for insomnia, music-assisted relaxation (PMR) for Insomnia, Cognitive Behavioural Therapy for Insomnia (CBTi), and Sleep Medication. From these two main areas of interest comparisons and contrasts can be drawn up which highlight specific areas which may need more attention. From the research certain gaps can be acknowledged and suggestions can be made for the continuation of sleep-music research including the need for familiarity and preference in surroundings and music choice, but also highlights the confusion on the open market with regard to binaural beats technology for example. It is suggested in this thesis that more time is required for the evidence in support of sleep-music to build, but also that care must be given as certain online sleep-music products may restrict or obscure genuine research-driven outputs.

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Introduction

Though research has been conducted with regards to music and sleep over the last two decades, there is still a significant uncertainty to its effectiveness due to the lack of scientific validation through objective testing and data analysis (Jespersen et al 2015). There is a larger issue that requires attention. It has been proven that music can help in the management of physical pain and psychological conditions such as depression and anxiety, hence, music is already being implemented in medical treatments in the form of music therapy (Jespersen et al 2015).

This extensive research has already suggested the possible effectiveness of music in healthcare. The idea that music interventions could be expanded as a treatment for Insomnia has become very popular and is receiving increasing amounts of academic acknowledgement and study. This interest also attracts organisations selling products which have not been validated, for example the growing online availability of binaural beats-based sleep-music, which has the potential negative effect of reducing, or slowing down genuine research development. It can also cause confusion for the potential customer, as it becomes difficult to differentiate between genuine research-driven and non-research-based products.

Though literature reviews have already been published in the field of sleep music (Jespersen et al 2015), there has so far not been a literature review that also incorporates the open market. It is vital to acknowledge the products available to establish a detailed route for future research. There is a type of

stalemate situation between academic research and products on the open market which may cause a lack of trust or belief in the product. As the products available are broad and vast in quantity, but expensive and untested, actual health authorities currently refuse to acknowledge them and more importantly, to incorporate them in medical treatments offered by the NHS for example. As this review will take these "real world" organisations into account, the review will aim to be comprehensive and helpful for ongoing research.

The literature review investigates companies such as Rythm, Sleepio, Brain.fm and Sleepstation, in comparison to research conducted into the psychology of music and sleep, sleep sciences, music as an intervention for insomnia, music-assisted relaxation (PMR) for Insomnia, Cognitive Behavioural Therapy for Insomnia (CBTi), and Sleep Medication.

The review will also consider the recurring issues with regards to measuring sleep quality, for example, the sole use of the PSQI scale often does not give objective test results but offers more of a subjective opinion which is not quantifiable. (Alongside the main strand of enquiry which is sleep-music research, the NHS Choices website was also studied alongside the self-help products in the form of books available on Amazon.co.uk, these can be read in the appendices A and B at the end of the main text).

This thesis has been categorised into two main areas of interest, Non-music-based interventions for insomnia and music-based interventions. The initial section concerns itself with areas of research including pharmaceutical and therapy (CBT) based approaches to gain an overall understanding of this line of

research that can then be used to inform and compare the music-based interventions to.

The music-based section considers a variety of research outputs with music listening being the core treatment method. From these two main areas of interest comparisons and contrasts can be drawn up which highlight specific areas which may need more attention.

The music-based section will continue in chapter 3 introducing a larger issue that requires consideration; as extensive research has already suggested the possible effectiveness of music in healthcare, the idea that music could be expanded as a treatment for Insomnia has become very popular and is receiving increasing amounts of academic acknowledgement and study, but also attracts organisations selling products which have not been validated, which has the potential negative effect of reducing, or slowing down genuine research development.

It must be mentioned here that certain trials, including Oxtoby et al 2013 and Jespersen et al 2015 have been mentioned in more than one section of the thesis, this is because the broad contents of their studies lent themselves to various sections including sleep music reviews and music assisted progressive muscle relaxation. It will also be stated here that this thesis predominantly deals with pharmaceutical, CBTi, digital CBTi and a selection of music related areas of research, but also acknowledges that there are numerous other music-related interventions available (including Vibrotactile music amongst others) which are not featured in this thesis.

Overview of structure

The review will commence with an overview of non-music-based methods which have been deemed successful including talking therapy (CBTi) and Medication (NHS prescription medications and effects). This section will also include an overview of online organisations including Sleepstation and Sleepio which offer alternative treatment methods online using CBTi as a fundamental driver.

The review is broken down into two distinct sections over 3 chapters. Chapter 1 will investigate non-music-based research outputs including published materials in the form of recent literature reviews and trials in various related areas of research. Chapter 2 will focus on music-based interventions in the form of research trials, associated music psychology and current sleep music products available on the open market in chapter 3. The thesis will conclude with a discussion of these materials with the aim to realise certain gaps in research which may contribute to further research practices in the future.

It is noted here, that there are certain differences in the chronology of the contents. The survey includes certain research outputs that were deemed interesting and associated to the entire research as this project did not explicitly specify time-restraints. Within each section, a certain chronology in the dates of publication has been established. For contextualisation reasons, explanations have been offered where older research has been included.

Insomnia

Insomnia is a sleeping disorder identified by the difficulty to fall asleep in a patient, and/or problems in staying asleep. It is classified as one of the more prevalent of the sleeping disorders. It has been found that Insomnia, in general can be classified as being in a constant state of 'hyperarousal', which is evident in the patient's inability to fall asleep or stay asleep (Avidan and Zee 2005).

Insomnia, alongside other related sleeping disorders has been on the increase in the UK. To gain an understanding of the overall context and the rising importance of sleep disturbances in society, Insomnia has been mentioned in the general news over the years. For example, in 2011 Tracy McVeigh wrote for The Guardian: *"(…) the nation's health is suffering as a result of Insomnia*". In the same article, it was proclaimed by Professor Colin Espie of Glasgow University and co-founder of sleep organisation Sleepio (which will be considered in more detail later) that Insomnia is "(…) *a real medical issue that should be taken seriously*." (McVeigh 2011). According to the BBC (2017), at least one third of the UK population suffers from some kind of Sleeping Disorder.

Insomnia counts as one of the most common sleeping disturbances as it can present itself in various forms. The most common symptoms of Insomnia are, the inability to fall asleep and/or displaying prolonged periods of sleeplessness at night. Other symptoms can also be, waking up too early in the morning, as well as not feeling like one has had enough or good quality sleep. Insomnia can have a variety of causing factors, which can include: Lifestyle choices, mental health conditions, beliefs, disabilities and physical environments amongst

others. The effects of these symptoms can have a variety of consequences, including:

- Feeling tired, exhausted during the day
- Unable to concentrate on simple tasks
- Easily agitated or distressed
- Loss of memory, inability to think clearly (Sleepstation 2017)

It is evident that Insomnia is a complex condition that can manifest itself through various causes and can express itself through various symptoms with varying consequences. It is this that makes this a very common complaint, with the BBC reporting cases of Insomnia in at least one third of the UK population, it is interesting to establish why treatments are varied, with varying amounts of success.

These next sections will consider a selection of approaches in order to explore what is currently happening in research. It is vital to have a good understanding of what is currently available in order to realise possible routes for future research.

Chapter 1: Non-music-based interventions

Pharmaceutical Interventions

There are two main variants of medication which are still being prescribed for the treatment of Insomnia, including Benzodiazepines (BZDs) and so-called Z-drugs. Z-drugs are separately classified from Benzodiazepines but work in similar ways (Knott 2017). BZDs were first introduced in the 1960s and are commonly referred to as CNS depressants (Central Nervous System depressants) as they impact the bodies muscle systems (Buffett-Jerrott et al 2002, Griffin et al 2013).

BZDs are rarely prescribed as a treatment as they can present various types of psychological and physiological side effects including; hypotension, nausea, feeling dizzy, decreased attention ability, appetite changes, nightmares and aggression, as well as a risk of dependence and growth in bodily tolerance levels reducing function (Buffett-Jerrott et al 2002, Cordant Health Solutions 2016).

However, in bouts of severe Insomnia and anxiety related episodes, BZDs are still prescribed before, during or after other methods of treatments, including talking therapy and CBT (Knott 2017). The table below briefly illustrates some of the common Insomnia treatment drugs and their related effects.

Name	Classification and use	Half-life (hour)

Diazepam	Benzodiazepine- Management of anxiety and epilepsy related symptoms	20-80
Flurazepam	Benzodiazepine derivative- short term treatment of Insomnia	2.3
Lorazepam	Benzodiazepine- treatment of anxiety disorders	10-20
Loprazolam	Imidazole-benzodiazepine derivative- helps in the short-term treatment of Insomnia	7-8
Nitrazepam	Benzodiazepine- treatment for anxiety disorders and Insomnia	29-40
Temazepam	Benzodiazepine- for the short-term treatment of Insomnia	8-15
Triazolam	Benzodiazepine- for the short-term treatment of Insomnia	1.5-5.5
Zopiclone	Z-drug/ Cyclopyrrolone- nonbenzodiazepine- for the short-term treatment of Insomnia	5
Zolpidem	Z-drug/ Similar to Benzodiazepine-for the short-term treatment of insomnia	1.4-4.5

Table 1: Table of pharmaceutical interventions. Modified from:
Griffin et al (2013) *Benzodiazepine Pharmacology and Central Nervous System–Mediated Effects*. (Online). Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3684331/, Ochsner J. 2013 Summer; 13(2): 214–223.
Cordant Forensic Solutions (2016) *Urine Drug Test Information Sheet-Benzodiazepines.* (Online). Available at: http://2tlwk93pj6ddba08a1egtidy.wpengine.netdna-cdn.com/wp-content/uploads/2017/09/final_info_benzodiazepines_sheet_ext_001.01_07262016_mmedits.pdf
Smith et al (2002) *Comparative Meta-Analysis of Pharmacotherapy and Behavior Therapy for Persistent Insomnia.* (Online). Available at: https://www.ncbi.nlm.nih.gov/pubmed/11772681 Am J Psychiatry. 2002 Jan;159(1):5-11.

2013 review of benzodiazepine (BZDs) interaction with the Central Nervous System

To gain a perspective of how BZDs function in contrast to CBT, Griffin et al considered the various effects of BZDs on the central nervous system by examining a selection of BZDs including Clonazepam, Lorazepam, Midazolam and Diazepam. BZDs affect the GABA neurotransmitter which is located in the nervous system, specifically within the cortex and lower internal limbic areas which are associated with memory, thought and motor functions (Buffett-Jerrott and Stewart 2002, Griffin et al 2013, Knott 2017). BZDs have a sedative effect on these areas by binding with the GABA transmitters, creating an inhibitive effect (sedation). The review continues to discuss details with regards to pharmacokinetics (how the body reacts to drugs, and vice versa- how drugs react to the body).

Interesting details are discussed regarding the various forms of administration of BZD drugs, and the importance of considering the best interest of the patient. Various BZDs have different strengths, or relative potencies (low, medium or high), which have different affective working times (half-life stages) (Stoelting 2012). High potency drugs became preferred methods of treatment due to the faster and stronger effectiveness, which in turn also displayed increased amounts of negative side effects on patients (Griffin et al 2013).

This is a crucial element of the review, as it clearly states that low potency BZDs are effective for treating Insomnia, especially sleep onset time, night time wakefulness on a short-term basis (considering the majority of low potency drugs display a half-life of around 1-12 hours), meaning there is a reduced chance of over dosage or excessive side effects. Medium and high potency BZDs can take12-40 and 40-250 hours to reach half-life, meaning there is a

high risk of severe side effects and dependency. Side effects can include a variety of symptoms including drowsiness and fatigue. In worse cases motor functions and cognitive ability can be impaired, with possible long-term memory loss (Buffett-Jerrott and Stewart 2002, Griffin et al 2013).

This review described the effect BZDs have on the central nervous system with a synthetic sedating effect on the body which assist in the short-term treatment of Insomnia. Due to the nature of the drugs, long-term treatments cannot be considered for these drugs as risks of side effects appear to increase with drug potency over time. The next review will examine a comparative review of drug interventions verses behavioural therapy treatments.

Pharmaceutical versus CBT treatments

2002 Pharmacotherapy verses behavioural therapies study

In 2002 Smith et al conducted a meta-analysis to analyse the comparative effects of sleep medication in contrast to behavioural therapy. Though this research is not up to date, it does however offer insight into the research that triggered the prominent prescription of therapy rather than sleep medication.

The review initially considered the outcome of 194 studies, after exclusions caused by criteria restrictions, 21 studies from the years 1979 to 1999 were actually used with an average trial length of two weeks. Sleep Medication considered in this review included a variation of medication: Flurazepam, Zolpiderm, Zopiclone, Quazepam, Lorazepam, Triazolam, Temazepam. Overall, the results were interesting considering the pre and post treatment mean scores. Sleep latency was reduced by 30% using sleep medication (-14.49),

behavioural therapy scored a 43% decrease (-23.31). Sleep onset time in minutes was reduced by 46% with sleeping tablets (25.60), and 56% through behavioural therapy (-38.38). Sleep time improved by 12% with sleep medication (40.51 mins) in contrast to only 6% using behavioural therapy (19.61 mins). Sleep quality outcomes were similar in both methods, 20% improvement from medication (0.63d) and a 28% improvement from therapy (0.96d) (calculated using the Cohen's d index) (Smith et al 2002).

This review discusses that behavioural therapy interventions may be more effective than sleep medication. Smith et al continue to examine the issue with regards to sleep diary utilisation for gaining evidence and data for quantitative assessment. It was argued that participants often misjudge personal sleep times including sleep latency and wake time after sleep onset. These miscalculations often cause irregular results with subjective and bias implication on data quality.

Though this review was conducted in 2002, the same issues are still being discussed in contemporary reviews and trials with regards to subjective data gained from sleep diaries and PSQI scales, for example, the review conducted by Feng et al in 2017 stated similar issues in the discussions). Another interesting issue this review considers is the element of cost effectiveness.

Though the paper dates back to 2002 and is USA based (currency) it discusses the price differences between sleep medication and behavioural therapy, with the latter being a more expensive route, that requires the consideration of various elements, including paying professionals, scheduling and logistics

including travel. It was suggested however, that in the long term, it would be advisable to prescribe behavioural therapy over sleep medication due to the long-term effects in contrast to sleep medicine, which has been suggested to only be useable in the short-term (Buffett-Jerrott and Stewart 2002, Smith et al 2002, Jespersen et al 2015, Feng et al 2017).

Conclusion

Overall it can be concluded that research has suggested a superiority of CBT versus pharmacotherapy interventions (Buffett-Jerrott and Stewart 2002, Smith et al 2002, Jespersen et al 2015, Feng et al 2017). BZDs and Z-drugs are designed to affect the central nervous system, by bonding with the GABA neurotransmitter with an inhibiting effect to induce sleepiness and muscle relaxation. Sleep medication is still prescribed as a means to treating severe bouts of Insomnia despite the possible side effects. Side effects are dependent on the potency of the drugs which can be low, medium or high in effect.

The half-life and routes of administration of drugs also needs to be considered for the best interest of the patient. Drugs with higher half-life ratios increase the risk of dependency and side effects due to the increased risk of overdosing, which can be caused if a medication is used nightly to treat insomnia repeatedly, building up residual in the body, decreasing effectiveness over time, hence why sleep medication is only prescribed on a short-term basis and cannot be considered a as a long-term treatment method.

CBTi

One of the successful methods used in the treatment of Insomnia is CBTi (Cognitive Behavioural Therapy for Insomnia, Similar to CBT with specific focus on sleep), research has indicated that CBT is effective and offers a longer lasting effect than sleep medication (Ritterband et al 2009), rendering the treatment an essential element in this research. Cognitive Behavioural Therapy is a talking therapy treatment that is commonly prescribed for the treatment for common mental health related complaints, including stress, depression and anxiety related symptoms. As this form of treatment is deemed successful, a special variant has been developed that is designed to treat Insomnia known as Cognitive Behavioural Therapy for Insomnia (CBTi). This treatment involves the patient to liaise with a therapist to pro-actively target the specific triggers experienced known to cause the Insomnia by keeping diaries and harnessing mental skills to control triggers. These triggers can be related to personal stressful events, lifestyle choices including activity levels and diet, and mental states including heightened levels of anxiety or OCD. Using CBTi the patient can learn to harness and negotiate the trigger to reduce the onset of the symptoms in the future.

This method is available through various means, including the NHS. In response to high demand, logistical and geographical issues revolving around local CBT treatments, digital variants are available via Sleepstation and Sleepio.

Online CBT Research

CBT treatment has certain limitations, it is not available in certain geographical locations, it can be expensive, and is also limited by the amount of health professionals trained in the field. Research has also indicated the increasing prevalence of Insomnia in the UK, Espie et al stated in 2012, that there were significant scaling issues with regards to providing face-to-face treatments for all individuals affected by the condition. The internet could now be construed as a norm in the household in the shape of personal computers, laptops, tablets and mobile phones.

The internet is already being utilised for general medical advice and is now also being used to promote the importance of quality sleep and offers online based CBT-I treatments which are easily accessible, and in some cases, affordable. There are various organisations offering CBTi online. This review will consider the claims of three of these; SHUTi, Sleepio and Sleepstation, with a critical comparison and engagement with related online CBT research.

Online Cognitive Behavioural Therapy for Chronic Insomnia

Espie et al conducted a crucial placebo-controlled trial in 2012 to ascertain the risk of placebo responses when engaging with self-help online-based help which may increase vulnerability from lone-treatment and unregulated self-assessments. The trial was conducted in the UK using three specific strands: CBT, control (TAU) and the placebo group: imagery relief therapy (IRT). 164 adults participated in the trials, chosen from individuals who had participated in the Great British Sleep Survey (an ongoing study conducted by Sleepio) and received 6 weekly online support sessions through the Sleepio website.

Assessments were evaluated using sleep diaries and clinical status calculations of participants pre and post online assessment, as well as at the 8-week follow up. The outcomes of the trials displayed an overall improvement in sleep efficiency of 20%, in contrast to the IRT (7%), and a 9% increase in TAU. In general, the test outcomes displayed an advantage to CBT over the Placebo. It was discussed in the trial that the outcomes were similar to the results reached by Ritterband et al in a similar 2009 study (SHUTi).

An interesting point to be made here is that the Ritterband et al trial as well as Espie et al, both suffered less drop-outs (Ritterband et al (4%), Espie et al (12-20%), which is lower than other trials which saw attrition rates up to 33% pre and 49% post trial assessments, causing low sample sizes (Ritterband et al 2009 and Espie et al 2012). It was proposed by Espie et al that the lower attrition rates may be caused by higher amounts of enthusiasm and interest in self-help treatments.

Online CBT Organisations

Sleepio

Sleepio is a stem of Big Health, a self-proclaimed online “digital medicine” provider working in partnership with Oxford University, Boston Medical Centre, Boots. Ltd and UK Mental Health Foundation (Espie et al 2012). Sleepio develop automated behavioural programmes designed to function around individual needs to improve cognitive ability. It was stated by Sleepio that 68% of NHS patients suffering from cognitive behavioural impairments including depression and anxiety were referred to Sleepio for Treatment as research

indicated links between insomnia and depression related symptoms (Luik et al 2016).

Sleepio's method is to gain custom through sleep awareness campaigns, including the Great British Sleep Survey which in turn calculates personalised sleep quality feedback and a personalised treatment proposal which can be accessed instantly (Sleepio 2018). The patient is assigned an artificial online therapist, alongside courses and self-help guides in the shape of documents and videos designed to engage with the therapy in an immersive multi-format way to increase satisfaction and the sense of support (Ritterband et al 2009). In a 2012 randomised controlled trial it was suggested that Sleepio helped 76% of people with sleep disturbances (Espie et al 2012).

Sleepstation

Sleepstation is a UK based organisation which offers CBTi treatment over the course of about 6 weeks. Sleepstation also work with the NHS where some eligible patients can gain treatment with Sleepstation if directed by the GP. Sleepstation offers treatment for a weekly fee, starting from £25 for week one, £150 for weeks 2-4 and £100 for weeks 5-6. The total cost of their treatment is about £275. The patient gains tips that may improve sleep, advice on how to make positive lifestyle changes that may influence their sleep quality and access to the Sleepstation team for guidance and advice. The method proposed by Sleepstation is not that dissimilar to the service offered by the NHS, the only main difference is that a patient has to pay for what Sleepstation offer.

The GoodNight Study

A large-scale trial was conducted in 2016 by Christensen et al with regards to testing the potential relationships between insomnia and depression. Christensen et al proposed that online-CBTi treatment may also offer effective treatments for patients with depression and anxiety related symptoms. The study, which was conducted between 2013 and 2014 involved 1149 participants which were either assigned to the SHUTi programme (n=574) or the placebo group HealthWatch (n=575). 51% of all participants completed the initial 6-week trials and 44% completed the follow-up assessments.

An interesting outcome of the study included the diagnosis of severe depression disorders in 4% of total participants within the 6 weeks. Results of the trials indicated that the implementation of SHUTi significantly affected the level of PHQ-9 symptoms in participants. Christensen et al discussed the positive effect online-based CBTi interventions could have in the treatment effectiveness of insomnia and depression, which are both occurring on an increasing basis (Christensen et al 2016).

Digital Cognitive Behavioural Therapy (dCBT) and Insomnia related symptoms

Research conducted by Christensen et al 2016 found links between Insomnia related symptoms, depression and anxiety. Trials were conducted where participants from an NHS community-based provider in 2015 diagnosed with associated symptoms received weekly CBTi treatment from Sleepio.com as well as telephone-based NHS IAPT support calls from treatment coordinators.

Discussions concluded the effectiveness of internet-based therapy interventions with promising test results: 120 total participants (down to 98 after initial assessments, and 72 totals at finish of trial- 73% of start total). According to the IAPT target recovery rate index the mean anxiety reduced from 7.8 to 3.7 points, depression (PHQ-9) responses also reduced from 10.1 to 4.4 points. Interestingly, insomnia related issues also reduced from 18.3 to 6.6 points with strong links between PHQ-9 and Insomnia related symptom behaviour (Laik et al 2016). Something to be pointed out about the 2008 IAPT (The Improving Access to Psychological Therapies) e-therapy service, is that the e-therapy coordinator does not hold treatment qualifications or gained any form of formal psychological training, which may require further consideration due to the nature of the field of research.

Effectiveness comparison

To gain an indicative comparison between pharmaceutical and CBTi treatments, and to contribute towards this review, the mean improvement percentage was calculated from two studies looking at the effectiveness of pharmaceutical verses CBTi treatments (Smith et al 2002 and Ritterband et al 2009).

The graph below demonstrates the outcomes of this comparison, though it has to be taken into consideration that the Smith et al study involved a study of 470 participants, Ritterband et al had 22 which indicates the difficulty in gaining reliable and useable data to due discrepancies and anomalies. These two studies were selected as they were two of the only studies included in this

review to consider all four main test categories including Sleep Efficiency, Sleep Duration, Sleep Onset Latency and Sleep Quality.

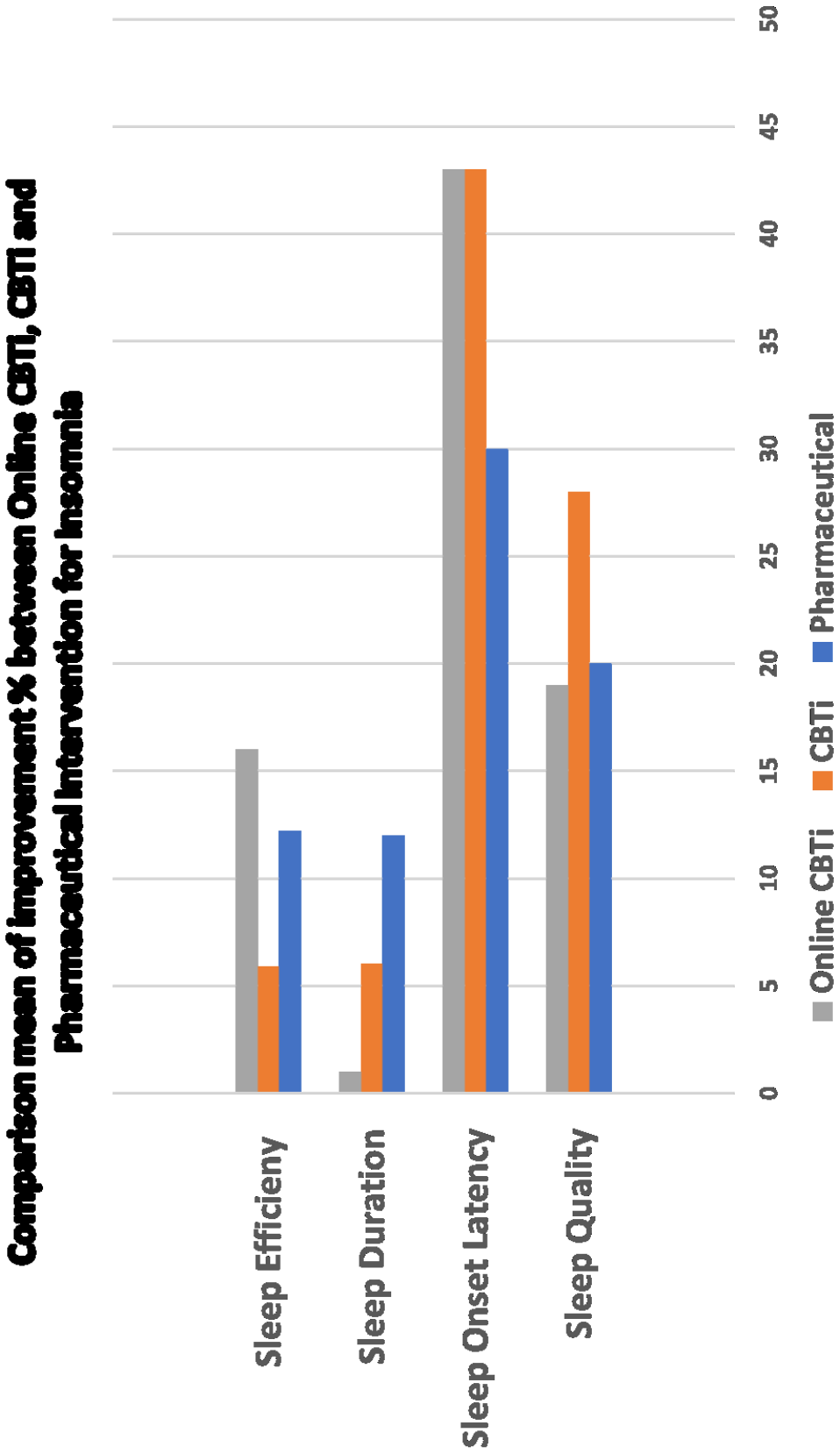

Figure 1: Comparison mean improvement % between Online CBTi, CBTi and pharmaceutical interventions for insomnia

From the Graph above it can be seen that Online CBTi provided by companies such as Sleepstation and Sleepio offers the greatest overall improvement in sleep categories, specifically in Sleep Efficiency and Sleep Onset Latency. It can also be seen that Pharmaceutical interventions have the greatest impact on sleep duration in hours. Standard CBTi scored the highest in Sleep Quality and also gained an equal score in Sleep Onset Latency.

Overall these findings are indicative that neither of the current treatment routes are more effective overall in all main categories. From the review, it is made evident that there are positive and negative attributes to the different treatment modes, and though there are positive test results gained from this comparison, it is not indicated that Online-CBTi or standard CBTi routes are much greater in overall effectiveness in contrast to pharmaceutical interventions.

CBT, Insomnia and Personality traits

Personality traits and preference are strongly associated with the effect of music and relaxation which is evident from extensive research (Schramm et al 1995, Tan et al 2012, Oxtoby et al 2013). To gain a better understanding of the history of this line of research, older research was considered to ascertain a comparative position between older and contemporary research findings. There is a definitive link in the research over the last two decades, proving substance and continuity in the field but also common issues with varying and inconclusive outcomes, and it has been suggested that more research must be conducted to gain better understandings (Schramm et al 1995 and Laar et al 2010). There are however a few definitive suggestions.

In 1995 Schramm et al conducted a study of 66 patients (taken from a total sample) which were diagnosed with Insomnia using the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R). The research found 50% of participants suffered from some kind of underlying mental health condition or showed signs of prominent personality traits. The predominant personalities found within this study showed signs of high levels of anxiety and depression, with a lack of willingness to communicate clearly with health practitioners with regards to various troubles including sleep disturbances. The overall conclusion stated a strong connection between mental health conditions and insomnia (Schramm et al 1995).

In 2002 Smith et al suggested the logistical issues around a holistic CBT treatment for insomnia, due to the high demand of the treatments, geographical restrictions and financial limitations which can affect certain patients (paying for treatments) and organisations (investing in training). Since 2002 more research has been conducted in this area, but certain issues are still being deliberated, especially those of logistic and geographical limitations, which require constant engagement. Cognitive behavioural therapy is now available over the internet, with various organisations such as Sleepio and Sleepstation offering CBTi treatments in response to the issues mentioned.

It was also suggested by Laar et al in 2010 that there is a link between personality traits and Insomnia development. The report stated that Insomniacs tend towards neuroticism, anxious and depressive episodes as the well as a lack of willingness or ability to share thoughts and concerns. A comparison

between participants to the Minnesota Multiphasic Personality Inventory (MMPI scale) also suggested that certain personality traits may lend themselves more or less to CBT interventions (Laar et al 2010) considering task-avoidance measures and participation willingness, which may develop certain issues for the treatment of insomnia using this method for some types of individuals.

Further research conducted in 2012 added a study of 84 adults suffering from Insomnia, with the addition of a drug dependence. It was concluded in this study that the majority of insomnia prevalent candidates were categorised as Cluster C disorders (anxiety, fear, avoidant etc.) with the highest quantity (n=39/ 50% overall) showing symptoms of Obsessive-Compulsive Disorders (OCD). A major suggestion made in this paper added that individuals with OCD showed a certain trend in over or underestimating sleep scales including night time waking via sleep diaries and study interviews (Ruiter et al 2012). This adds to the issue of subjective data collection using sleep diary methods and PSQI which has been discussed in various research strands in relations to insomnia. In 2017 a network analysis by Dekker et al involving 2089 participants suggested that Insomnia sufferers can be associated with neuroticism traits including anxiety, fear, anger, frustration and depression etc.).

Conclusion

Though these studies all point towards an association between certain neurotic traits and insomnia, more research is required to ascertain which traits show stronger links to insomnia related symptoms. It can however be concluded that personality and a certain willingness to adhere to ideas, to accept new ideas and the willingness to engage with personal issues has a strong connection to Insomnia severity and CBT as a successful treatment method, which can be

taken forward in this research. As mentioned previously, research has indicated that the connection between Insomnia and music as a possible treatment is prevalent and must be at least considered in the development of a new sleep music strategy.

Chapter 2: Music-Based Interventions

Various research has already been conducted in the non-pharmaceutical methods for treating Insomnia. For this review a selection of outputs have been examined in relation to music as a possible treatment. The review is broken into specific sections including various music therapy reviews, the consideration of personal preference in music, and music in conjunction with progressive muscle relaxation (PMR) techniques.

The majority of research has been dependant on scholarly and test-validation. To broaden the field, it was important to consider sleep-music organisations and products currently on the market to ascertain how the research relates to what these organisations are producing. Brain.fm and Rythm (the developers of the newly launched Dreem Headband) which will contribute towards a wider understanding of the sleep-music industry.

The previous section of this literature review looked at pharmaceutical and behavioural therapy (CBT) methods. It is evident that there are major concerns with regards to the long-term use of sleep medication due to the high risk of side-effects. CBTi is currently the forerunner for insomnia treatments. The methods used in CBTi treatments revolve around the patient's ability to control and navigate personal problems which may impact their sleep, including excess worrying, fear, OCD and other possibly neurotic-related tendencies (Schramm et al 1995 and Laar et al 2010). These findings show a correlation between character traits and sleep quality. These traits have already been discussed in

conjunction with effective CBTi treatments and may also be useful when considering musical preference and sleep music.

From these findings it is evident that the utilisation of music as a treatment method is logical, but due to its very nature presents certain difficulties in producing concrete results. For example, in 2011 Alfredo Raglio from the Sospiro Foundation made an interesting statement about music as therapy in the journal for Psychiatric and Clinical Neurosciences. There Raglio stated, that in order for music to become a concrete therapy the concept and system behind the treatment must be clear through the use of exact conditions and quantifiable data, only then can music have a function as a therapy (Raglio 2011).

There is a certain divide between actual clinical research and music as an alternative therapy. This divide is an increasing issue within the field, as alternative medicines often lack any kind of clinical trials or results become obscured (Pan 2017) alongside the increasing number of products available which lack scientific validation. This has resulted in a sleep music industry that appears to lack coordination and structure. Health authorities such as the NHS are yet to acknowledge the field of sleep music research as a strong and valid funding possibility which is something that can only be rectified through a systematic and data-rich approach.

All therapy strands must be considered with a certain amount of caution, as the majority of results and discussions relate to the same kind of issues, either the sample pool was too narrow or too small to gain significant results, or there were other issues concerning methodologies or attrition rates etc. (Chang et al

2012, Jespersen et al 2015, Feng et al 2017, Pan 2017). There are various research outputs which feature these kind of trial errors, resulting in an increasing variety of contributions to the field, but with a lack of concrete and useable results. However, certain results gained point towards a positive and probable effectiveness of using music as a treatment.

Trial comparison

Before moving to more specific studies regarding musical traits and music preference, this section will now present a qualitative comparison of four music-based intervention studies. To gain a comparative value to the comparison completed between pharmaceutical, CBTi and Online CBTi interventions, the same test categories have been considered, including sleep Efficiency, Total sleep time, Sleep onset latency and Overall sleep quality. The following trials gained qualitative data using the PSQI scale, the outcomes indicate the overall mean percentage improvement.

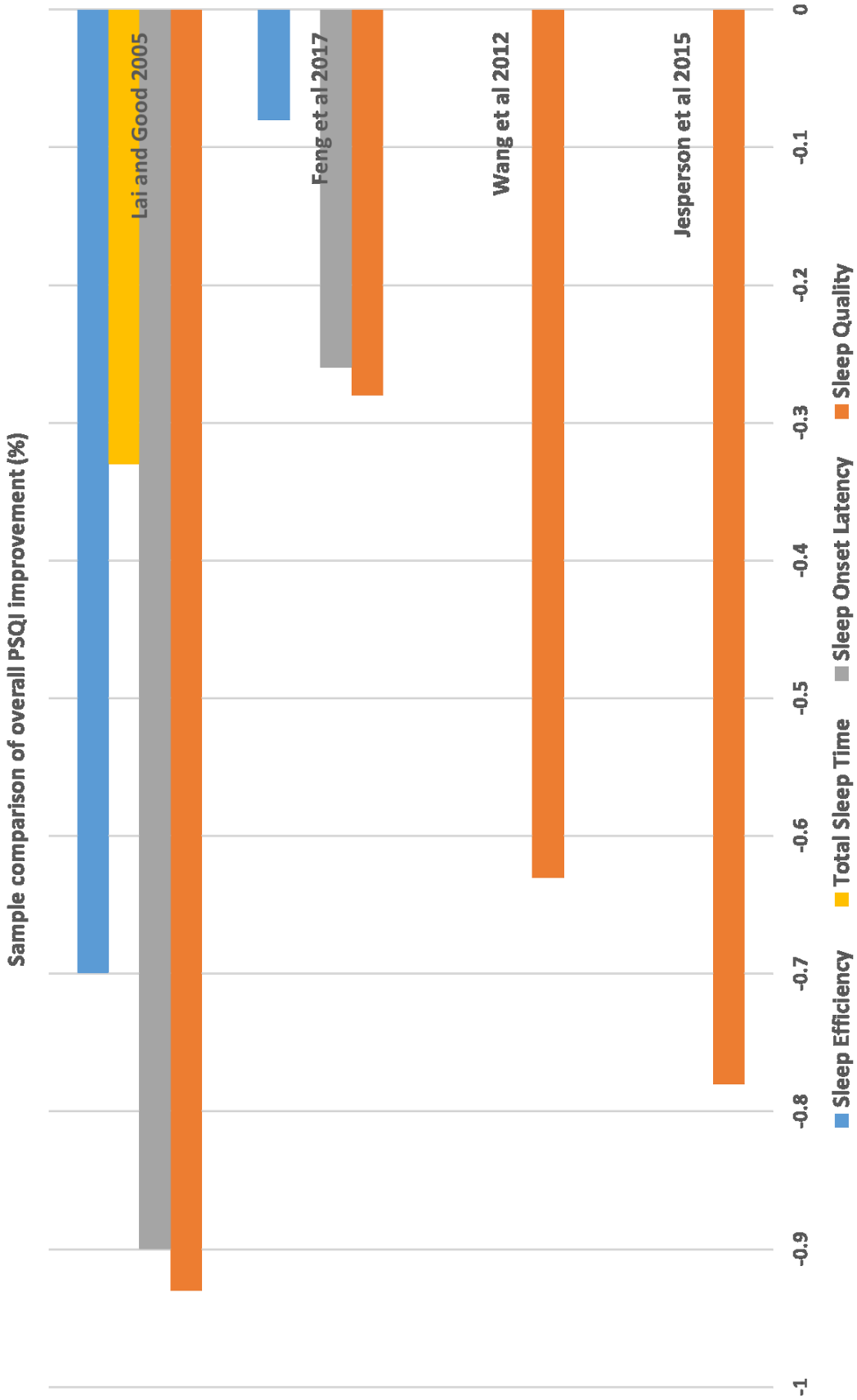

Figure 2: Sample comparison of overall PSQI improvement (%)

It is evident from the results that Sleep Quality showed the most improvement across all categories, but there are also very clear discrepancies. Although all tests considered the use of music listening for the treatment of insomnia it can be added that Wang et al 2012 and Jespersen et al 2015 had no data for sleep efficiency, total sleep time or sleep onset latency and Feng et al 2017 did not include a result for total sleep time. This could be because the PSQI scale does not offer quantitative data, which requires PSG and EEG data. As these trials gained data using PSQI, there is a discrepancy, rendering this entire comparison incomplete and unusable in the attempt of figuring a quantifiable and concrete treatment intervention using music.

These findings indicate quite strongly that more research is required in this field of research, in contrast to the conventional modes of treatment including pharmaceutical and CBTi routes examined in the previous section. Overall, it can be concluded that there can be optimism, especially considering the overall mean improvement within the sleep quality category.

Musical traits in interventions for Insomnia

2004 report on music effect on Insomnia in older adults

Lai and Good conducted an RCT in 2004 with specific interest in older adults aged 60-83 years in Taiwan. The purpose of the trial was to investigate the effect of listening to slow/ calming music before bedtime on sleep disruptions over a 3-week testing phase. 60 participants were chosen (30 test group/ 30 control), using the PSQI and ESS as assessment criteria.

In contrast to the 2015 Cochrane review conducted by Jespersen et al, the participants for this 2004 study were allowed to choose from six pieces of relaxing music from western classical and eastern traditions. Participants PSQI and ESS were measured before the trial and after three weeks after the completion of the trial. Interestingly, for this study the actual music choice was also considered. An assessment conducted on music preference was conducted that concluded that 63% of participants preferred listening to western music over Chinese (27%). It was also concluded that the preferred musical instruments were piano and harp. The trial asked participants to listen to their selected piece of music before bedtime. After the three weeks, it was found that the music listening group substantially decreased in PSQI mean score from 11 pre-tests to 7 at week 3.

In contrast the control group showed no improvements with PSQI scores remaining at just above 10 for the entirety of the trial. Though the means PSQI score reduced in the music-listening group, it does however have to be noted that this trial was only inclusive of individuals between the ages of 60 and 83 years with no other common health conditions such as depression, use of

medication or caffeine, making this trial interesting but lacking in realistic measurements. This trial also relied on PSQI and ESS assessments. Though these are industry standard measuring tools, they are subjective and often do not accurately reflect data that would be gained from an objective test. It was suggested by Lai and Good that further research would require longer testing times (beyond 3 weeks) and to utilise PSG (Polysomnography) results for accurate and quantifiable data.

2012 report using PSG and self-assessment to determine effect of music on sleep quality in Insomnia

This 2012 report by Chang et al contributed to the field of sleep music research by attempting to formulate an objective measurement. It was suggested in the paper that it was already known that certain, calming music can assist in increasing sleep quality, but so far little objective data was available to show exactly what the effect is and now it could be analysed in a scientific and numerical way. 50 participants for the experiment were chosen who fit certain criteria, including a PSQI scale lower than 5, and were between the ages of 20 and 60. To obtain an even balance of scores, the test excluded participants with any kind of neurological or psychiatrist problem (Chang et al 2012). For this trial participants were requested to bring their own bed-time music to listen to. For the participants who did not have this kind of music, the researchers provided a small selection of pieces. The pieces were chosen using the following inclusion criteria:

- Tempi between 80 and 85 Bpm
- Minor in tonality
- Smooth, simple melodic structures
- No sudden or intense changes in movement throughout the music including rhythm and volume.

The trials took place in a three-bedroom sleep laboratory using PSG (Polysomnography) and morning self-assessments over three days. The participants were also requested to complete a music evaluation, where the music pieces were evaluated using a VAS (Visual analogue scale) depending on the following criteria: Likeability, relaxation and sleepiness. The results of the study indicated that music does affect sleep quality. The trial found that the resting-state of the participants who listened to music increased in contrast to the control group. It was also found that the NREM stage 2 sleep was shorter, but REM sleep increased, which indicates that PSG sleep quality improves with listening to music.

The self-assessments completed by the participants also suggested similar results. This trial also contributes towards testing methods by discussing trial lengths. It was discussed by Chang et al that the trial was three days in length, but it was also discussed that other interventions required longer periods (two weeks) to gain useable results (Levin 1998).

2013 article considering the impact of relaxing-music on Insomnia related behaviour

Oxtoby et al performed a randomised control trial in 2013 using Harvey's cognitive model of insomnia maintenance, or Harvey's cognitive model in short. This theory suggests that individuals who suffer from Insomnia experience states of negative cognition. These negative cognitive states, or thoughts occur during day and night times and can substantially affect the various sleep processes as the individual proceeds through various stages of anxiety and distress caused by the cyclic negative thoughts, impacting sleep quality.

Oxtoby et al continue to discuss the research that has already been done with regards to music traits. They suggest, as the 2012 report by Chang et al suggested, that the music should have specific traits including:

- Slow tempi
- Low volume
- Simple melodic lines including heavy repetition
- Repetitive and basic use of rhythms

The article also contributes to the argument that participants should be given the opportunity to choose their own music as personal preference increases the relaxing effect of music due notions of familiarity, security and comfort. Oxtoby et al discuss the requirement for more varied testing scales. It is argued that many interventions using music rely heavily on the PSQI, though it is an industry standard scale, it does issue subjective results and do not help in explain why or how music can assist in sleep improvement.

The trial tested 56 participants across the control and music groups. The intervention lasted two weeks and asked the music group participants to listen to the test music for at least 20 minutes before bedtime, either before or as they were going to bed. The test music consisted of pieces of music the participant could choose from, including classical piano/ guitar and ambient which all lasted about 58 minutes in total length. The trial showed that the classical music was the most chosen (52.7%) over ambient (27.7%) and a mixture of the two styles (19.4%) (Oxtoby et al 2013).

To gain a varied set of data, various scales were used to measure the outcomes. These included the *Dysfunctional Beliefs and Attitudes about Sleep scale, PSQI, Glasgow centre of thoughts inventory, Sleep Association Monitoring Index, Sleep-Related Behaviour Questionnaire, Depression Anxiety Stress Scales* and *Pre-Sleep Arousal Scale.* According to the sleep quality questionnaires completed at the follow-up stage of the trial, it was found that the majority of participants improved their sleep quality. It was however concluded that the actual sleep quality (PSQI) did not significantly change.

It was discussed by Oxtoby et al that this finding was unprecedented, and that stronger results in favour of the music intervention were expected. This trial was designed to test the Harvey's cognitive model to ascertain how music could be used to alter cognitive states to improve sleep quality. In this trial there was a lack of supporting evidence, but as with many randomised controlled trials, there were various limitations with regards to inclusion, exclusion and method which may have influenced the end data.

Trial lengths discussion with regards to Music Therapy as a treatment of Insomnia - a ten study meta-analysis

Considering the debate with regards to trial lengths, a meta-analysis looking at music as an intervention for chronic sleep disorders, completed by Wang et al in 2013 considered ten studies with 557 participants. Though this trial did not exclusively look at Insomnia, it did come to similar conclusions that music does have the ability to impact sleep behaviours. More interestingly, the review identified that trials require an average length of three-weeks to determine the effect music has on sleep. This was suggested as the majority of trials analysed

showed a heterogeneity between subjective and objective results over a minimum three-week follow-up period.

These results became negative with regards to music as a possible intervention as it was suggested in previous research that new sleep interventions require more than three-weeks to show ultimate effect. It was suggested by Wang et al, that previous trial outcomes may not represent the actual ability of music as an intervention because many trials were shorter than three weeks.

2015 Cochrane review of Music for Insomnia in adults

Jespersen et al conducted a literature review in 2015, including six studies and 314 (n=314) participants. The purpose of this review was to investigate the effect of listening to music as well as other factors which may impact results. For this review, trials were selected where researchers pre-selected recorded music for clinical and- or home trialling, with no detail on why or how the music was selected as the intervention.

On some occasion, it was stated that participants were given a choice from a small selection of pre-selected music, and some of the music was chosen for certain musical attributes which have been linked to improving sleep (Bonde and Wigram 2002). Overall the review consisted off RCT and qRCT trials and considered the following sleep measurements using the PSQI and PSG scales alongside morning questionnaires: Sleep quality, sleep onset latency, total sleep time, sleep interruptions and sleep efficiency.

The review also considered other outcomes such as psychological and physical impacts on the participants. It was stated by Jespersen et al that the overall quality of the data was low-moderate due to the low numbers of test subjects, or the inability to gain access to test data for analysis. Though the test data was assessed as low to moderate in quality, it was however found that five of the six studies considered sleep quality (n=264) with a significant favour towards the music intervention as treatment against the control group. The review found no evidence of improvement to sleep onset latency, total sleep time, improvements to sleep interruptions or sleep efficiency. From the secondary outcomes including psychological and physical effects (quality of life), it was found that listening to music significantly improved the outcomes against the control group, but it was also stated that these results were at high risk of bias and may not offer quality data for further analysis. Overall this review has highlighted that music has the potential to influence sleep quality but found little to no evidence for any other sleep measurement.

Music Preference and Sleep

This section will consider the area of research involving music preference and its relation to music as a successful intervention for insomnia. To begin with, this section will introduce some music psychology aspects which are crucial to include as this area of music study demonstrates the effect music can have on cognitive function and behaviour.

Humans begin hearing sounds and music pre-natal, and the interest and understanding of certain music is shaped through life experiences and memories which can influence what music a person enjoys. It has been proven

that music can impact decision making and thought processes as well as influence how society behave in given situations, indicating that music has the potential to have a powerful effect on varying lifestyle factors (Hargreaves and North 1997, Juslin and Sloboda 2001, Hallam 2016).

Though music is an increasingly present aspect of modern living, there are specific elements and traits music can have which lends it to certain characters. The following section will look at these key music traits as presented by theorist Leonard Meyer in his 1956 study *Emotion and Meaning in Music*. These traits can then be used to ascertain how music has been developed by sleep music organisations such as Brain.FM. This can also be used to gain an understanding as to why certain participants may choose one genre of music over others for the specific task of calming down and falling asleep.

Associated Music Psychology

The human aesthetic response, which is the cognitive reaction to music, can be manipulated through various compositional means; for example, sudden changes in musical flow create a sense of obstruction and frustration, which are areas of research considered by music theorists such as Leonard Meyer in 1956 and David Huron in 2006 (Meyer 1956, Huron 2006). If the brain is confronted with a set of ideas in which it takes too long to identify well-ordered points of familiarity, the information will be distorted to make it coherent (able to be memorised) or, if this cannot be achieved the data will be forgotten.

To achieve a familiar, and soothing cognitive state using music, it is important for the music to have simple but effective integrity with logical continuation (movement from one idea to the next) and return. This means a well organised melodic motif or harmonic structure is more likely to be remembered than an obscured or obstructed set of ideas (Meyer 1956). Meyer and Huron explained the following:

Prägnanz and Gestalt: The process the brain undertakes of finding form and organisation within music in order to compute it in a clear and stable manner

Pitch Proximity: It is suggested that humans find it easier to respond to and remember smaller intervals in music rather than larger ones.

Step Inertia: In 2006 theorist David Huron considered Step Inertia as a directional strategy in music, where a phrase will either rise or fall in in a step by step manner and will continue in that direction.

These three music analysis processes can be utilised to consider previous sleep music developments, and also contribute towards the wider area of sleep music research. It could be concluded, that music must have specific features to have certain cognitive impacts, which for sleep music may be notions of calmness. Considering Prägnanz and Gestalt, this would require the music to be repetitive and slow to enable the brain to find shape and logic within the music.

These processes would also suggest that the music must not include large or sudden jumps in pitch or dynamics and must also create a sense a comfort by

keeping the flow of the music simple by not changing direction in pitch in a sporadic or sudden manner. The following section will consider how music familiarity and preference has been measured with regards to sleep music as these could be suggested to be significant feature when using music as an intervention for Insomnia, considering the associated music psychology.

2003 Study of the effects of familiar music and sleep

Iwaki, Tanaka and Hori conducted an experiment in 2003, contributing to the understanding of how music may affect sleep, with a focus on whether familiar music affected sleep onset latency. There were two main groups, including natural sleep (the participant could sleep when they wanted to), and attempted sleep (to fall asleep as quickly as possible), these included control and test groups.

The participants (n=20) were asked to listen to their own choice of music to fall asleep to, in contrast to the control group in a laboratory setting. Data was gathered via PSG (Polysomnography) to measure brain activity. The experiment considered three subjective criteria including Sleepiness, Pleasantness and subjective estimate of sleep onset.

The data gathered in the trials indicated that participants in the test group experienced a more pleasant sleep experience to the control group. It was also gathered that the sleep onset latency was reduced in the music listening group in comparison to the control group. Overall, it was found that music improved sleep onset latency to stage 2 sleep overall in the natural sleep group, but actually negatively impacted the attempted sleep group by indicating similar

results in the test and control group, where it was found, that even the familiar music lengthened the time it took the participants to fall asleep.

2012 Selection studies regarding Preference and familiarity in relaxing music

In 2012 Tan et al conducted a series of studies with regards to music therapy. The studies were interested in defining relaxing properties in music within the context of music therapy. The study asked a selection of fourteen professional music therapists active in the USA to analyse and consider 30 pieces of relaxing music. The studies were broken down into three distinct areas:

- Study 1: music therapists recommended 30 specific relaxing music samples
- Study 2: the music selection is validated by nine music therapists
- Study 3: The selected music was tested

The chosen pieces were then trialled on adult participants (n=80), asking the participants to rate the familiarity of the pieces, and to choose a set of preferences. A table of musical characteristics was identified as part of the project, which lists the various traits of relaxing music. The following musical traits were considered in the research.

TABLE 1
Summary of Findings of Psychophysical Properties in Relaxation Music

Property	Description	Sources
Tempo	Moderate to slow	Knight & Rickard, 2001; Labbe, Schmidt, & Babin, 2007; Lorch et al., 1994; Radocy & Boyle, 2003; Sehhati-Chafai & Kau, 1985; Taylor, 1973; Thaut & Davis, 1993
	Repetitive or constant	Hadsell, 1989; Labbe et al., 2007
	At or below 72 beats per minute	Robb et al., 1995
	Between 60 to 80 beats per minute	Voss et al., 2004
Dynamics	Soft and quiet	Gaston, 1951; Iwanaga et al., 1996; Lorch et al., 1994; Radocy & Boyle, 2003; Taylor, 1973
	Restrained	Thaut & Davis, 1993
	Predictable or constant	Sehhati-Chafai & Kau, 1985; Labbe et al., 2007; Robb et al., 1995
Beat	Lacked steady and pulsating beat	Borling, 1981
Melodic structure	Improvised or loosely structured	Thaut & Davis, 1993
	Small step-wise intervals	Robb et al., 1995; Sehhati-Chafai & Kau, 1985
Rhythmic structure	Repetitive	Gaston, 1951; Hadsell, 1989
	Simple	Gaston, 1951
	Nonsyncopated	Knight & Rickard, 2001; Sehhati-Chafai & Kau, 1985
	Predictable	Robb et al., 1995
	Lack of strong rhythms	Voss et al., 2004
Melodic line/ contour	Fluent	Borling, 1981
	Sustained	Gaston, 1951
	Melodic	Iwanaga et al., 1996; Thaut & Davis, 1993
	Legato style with fluidity	Radocy & Boyle, 2003; Robb et al., 1995
	Gentle contours	Knight & Rickard, 2001
	Homogeneous ascending and descending lines	Sehhati-Chafai & Kau, 1985
Timbre	Soft non-percussive	Gaston, 1951; Radocy & Boyle, 2003; Sehhati-Chafai & Kau, 1985; Voss et al., 2004
	String instruments, flute, piano	Knight & Rickard, 2001; Labbe et al., 2007; Robb et al., 1995
	Absence of vocalization and lyrics	Lorch et al., 1994 Voss et al., 2004

Table 2: Summary of Findings of Psychophysical Properties in Relaxing Music. Taken from: Tan et al (2012) The interplay of Preference, Familiarity and Psychophysical Properties in Defining Relaxing Music. Page 153. Journal of Music Therapy, 49(2), 150-179. The American Music Therapy Association.

The 30 pieces of relaxing music that were identified by the music therapists also included the following traits, rendering them to be relaxing in nature:

- Tempo at about 60 Bpm
- Pitch range around C5/ mid-high range on standard keyboard
- Small changes in dynamic variation, changing in a step-by-step manner
- Minimum of 65% repetition in melodies, and 80% repetition in rhythm
- Tonal harmonies in a major key
- Basic instrumentation, including chamber music with no vocals
- The best timbre was indicated as synthesised or stringed instrument sounds

These findings correlate with the research conducted by Oxtoby et al in 2013 and the associated music psychology, which was considered at the beginning of this section, which also indicated slow tempi and repetition to be vital components. It is evident there is a strong link between relaxing music used in music therapy and music as an intervention for Insomnia, meaning these findings are crucial for the understanding of how music impacts the ability to sleep.

2013 Study considering Classical, ambient and mixed music preference

Oxtoby et al performed a randomised control trial in 2013 using Harvey's cognitive model of insomnia maintenance, or Harvey's cognitive model in short. This theory suggests that individuals who suffer from Insomnia experience states of negative cognition. The model suggests that insomnia related symptoms may be caused by negative thought processes during the day and

night which impacts the ability to fall asleep and stay asleep. This inability is triggered from the anxiety caused by the negative thoughts. It is also suggested by this model that a person suffering from these symptoms becomes more aware of their condition, increasing the possibility of these negative though process to happen (Oxtoby et al 2013).

The study invited a variety of participants (total at end of trial n=56), the test group (n= 36) were asked to complete an initial online survey, which included different scales used to measure the varying elements of the model, and to download the specifically chosen test music (3 hours in total). The test group was asked to listen to music for at least 20 minutes before bedtime each night and the control group (n= 29) were asked to maintain their normal evening routines. At the end of the trial the test group was asked to complete another online survey.

The test music was chosen in response to research conducted before the trials, and consisted of three main genres, including classical (piano and guitar), ambient music and a mixture of the two genres excluding vocal music. It was stated that 57.7% of participants chose the classical music route, 27.7% ambient, and 19.4% mixture (Oxtoby et al 2013). The outcome of the trials indicated that the test group improved on various aspects of the various model scales, but interestingly it was also found that overall sleep quality did not improve.

This outcome corresponds with the other trials considered in this review, specifically that there is scope for music to influence sleep, but that more

research is required in this area. The study, however contributed that the majority of participants chose classical and ambient music for listening from the choices, which lends itself to the importance of music preference and participant choices. Considering the music psychology that was discussed at the beginning of this section, it is evident that the classical and ambient music, which consisted of piano and guitar music realised the music traits required by the participants to be able to calm down and fall asleep.

It must also be added, that the music was predetermined by the research group, and the participants were given the choice of music from three options. The outcome indicating no overall improvement in sleep quality could also be associated to the fact that the music was familiar but not necessarily the preference of some of the participants, considering that even within classical and ambient music there is vast scope of variation, rendering a music likable or not which can also heavily influence the functionality of the music in that context.

The next part of this section will deliver an overview of an analysis of sleep music produced by the company Brain.fm. As part of this project, it was indicated in the introduction the importance of considering not only research outputs, but also to investigate the market. Brain.FM is an online organisation offering music-based Insomnia solutions.

The sleep music produced by Brain.fm can be hired directly from their website and listened to for a maximum of an 8-hour sleep cycle. The analysis considered the actual sleep music and compared it to the associated music

psychology outlined earlier in this dissertation. Considering the online presence of Brain.FM and the growing online market for sleep music products, it is important to consider exactly how the music is structured to gain a better understanding of how organisations meet the requirements of the user.

A music psychology review of sleep music by organisation Brain.fm

This section of the thesis is a reduced and rewritten version of research conducted by the same author titled "*Sleep Music Psychology: Music as a concrete and universal treatment for Insomnia*" (Richter 2018). Brain.fm is an online organisation specialising in delivering a music-based Insomnia intervention using auditory and sleep neuroscience. Although Brain.fm have not officially announced a scientific verification to their approach, a white paper written by research advisor Benjamin Morillon in 2017 outlining the algorithm was published on their website.

This white paper was designed to offer an insight and explanation to the theory behind Brain.fm. It was stated by Morillon (2017) that the neural oscillations within the brain can be manipulated using external sources such as sound. Morillon continues to discuss the correlation between certain neuronal oscillations and associated cognitive states such as sleep and attention. Brain.fm utilises brainwave entrainment methods through music to stimulate the neuronal oscillations to evoke other mind-sets i.e to induce sleep. Furthermore, it was suggested that the sleep music must feature certain traits to function appropriately:

- Midrange frequencies (cut below 45Hz and cut above 5KHz)
- Subtle melodic and harmonic changes that do not distract or cause sudden arousal
- Regular and repetitive rhythms

It is evident that there are links between the theory suggested by Morillon in 2017 and outcomes of the trials by Tan et al in 2012 and Oxtoby et al 2013 as well as the music psychology introduced at the beginning of this section. The same music psychology elements including Prägnanz, pitch proximity and phrasing, timbre, dynamics and tempo were considered in the analysis of Brain.fm music.

The music available on the website (www.brain.fm) comes as eight separate pieces of music, lasting about one hour each. For the analysis, samples were taken in the format of one complete piece of music (60 minutes) and nine 60 second samples to capture aspects of the entire collection. The analysis was broken down into two main sections, where section one dealt with the above-mentioned elements using a 60-minute sample (1.60), and section two considered the melodic and harmonic structure using nine one-minute samples (9x1) using spectrographic analysis which offered a detailed view of the structure of the sounds.

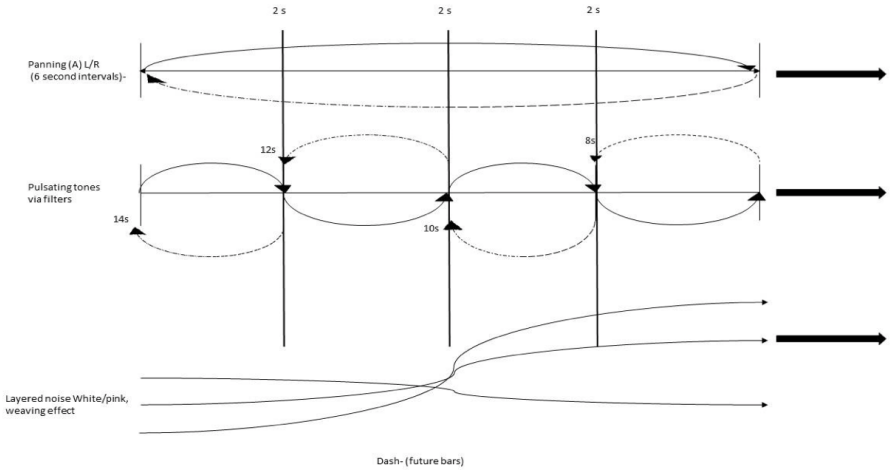

Figure 3: General Prägnanz structure over an 8 second sample, indicating the repetitive nature of the music.

The table below outlines the outcome of analysis 1.

Prägnanz	Three distinct musical ideas were identified. The first was a dense, synthesised sound that panned gradually from left to right in a continuous motion throughout the sample. Each complete cycle took about 12 seconds. The second set of sounds was a combination of notes playing a low A (220hz). These notes were pulsating at 2s, also panned left to right on a 6s basis. The final sound noted was a collection of noises including white and pink in a less coherent structure, these noises were background sounds in a weaving style.
Pitch proximity and phrasing	Overall there was no immediate pitch changes to be heard. The sounds were neither high or low. The changes concentrated on the layering of dense sounds around the fundamental 220Hz. The pitches changed gradually using the interference from the noise and

	panning to soften any sudden changes. It could be suggested that the music changes horizontally (panning), rather than vertically (interval, pitch gaps).
Timbre	There was a specific selection of 4-5 perceived Timbres. The general sound was synthesised, imitating that of choral and natural sounds such as wind and rushing. There were minor differences in the timbre. Filters and EQ were implemented to alter similar sounds on a slight basis. This created a thick but non-intrusive sonic environment.
Dynamics	There were no clear dynamic changes in the music. The initial 20 seconds saw the introduction of the sounds, but even there, dynamics were controlled by sound density rather than actual volume. Dynamical change in the music appears to be controlled via the horizontal panning which gives the feeling of space without getting quieter or louder.
Tempo	The tempo was measured using a standard metronome and was given the mark 40bpm, which is also commonly known as extremely slow or larghissimo. Though the actual tempo was measured extremely slow, the music had a certain circular motion to it. This can be linked back to the research, Morillon stated that the music

	attempts to affect with the brain wave oscillations to induce certain cognitive states

Table 3: Table outlining analysis results for Prägnanz, pitch proximity and phrasing, timbre, dynamics and tempo

Analysis 2 considered the harmonic and melodic contents taken from 9x1 minute samples. The spectrograph below illustrates one 60 second sample.

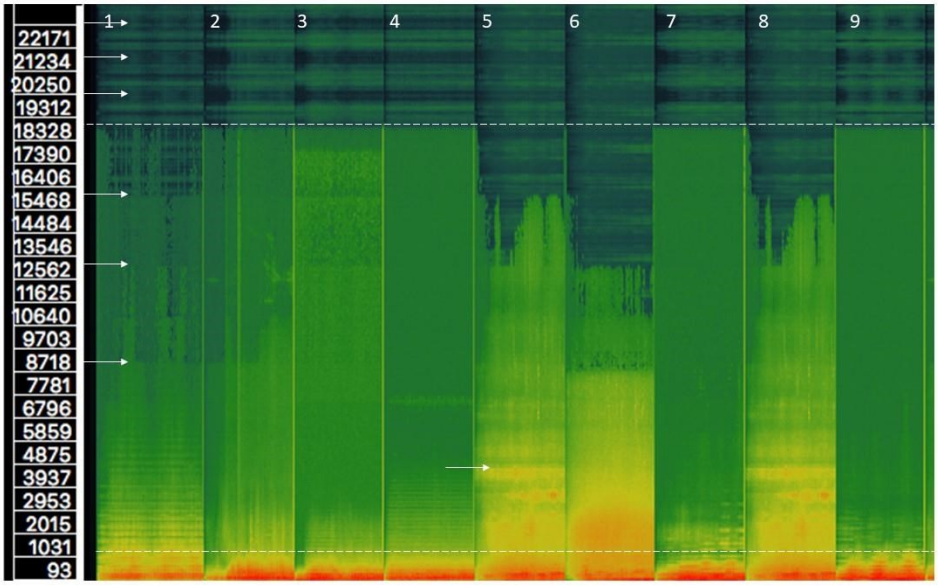

Figure 4: Spectrograph showing 60 second samples of the Brain.FM music collection. Sonic Visualizer was used to create the spectrographs

The findings from the harmonic and melodic analysis were put together into a diagram outlining the behaviour and relationship of the pieces.

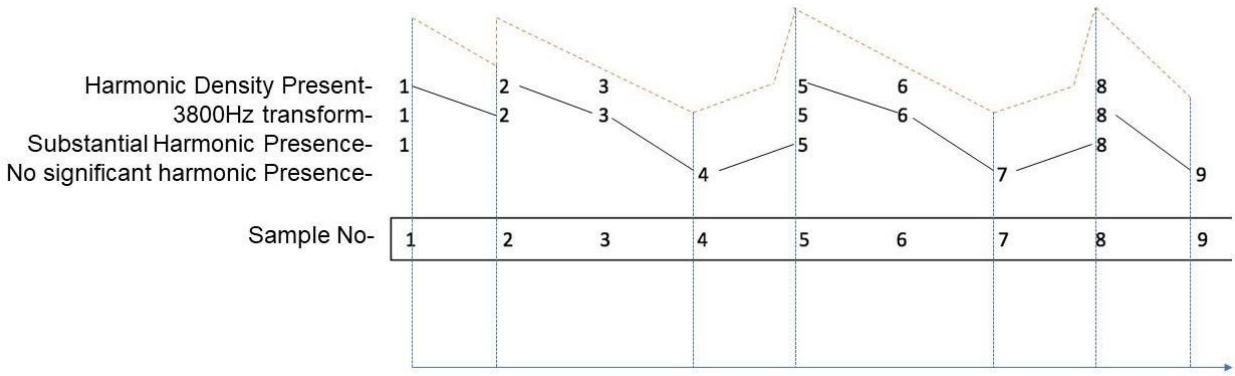

Figure 5: Diagram showing the connection and interrelationship between the eight pieces taken from the 60 second samples. Note the increased harmonic activity in samples one and two, five and eight.

The following assumptions were made following the analysis of the sound samples:

- There is an overall downward shape to the order of pieces
- A piece that has little to no harmonic overtone presence, will be followed by a piece that offers a rich harmonic texture
- The music changes in a wave like shape, starting with high intensity, to medium and to low, then returning to high

Furthermore, the spectrograph was considered in more detail, offering the following findings:

- There is a strong notion of fundament, with most of the consistency not reaching beyond 1.3Khz
- There is a cut off at around 19000Hz in each sample.

- The pieces follow a certain routine, starting with high harmonic content, transforming through another and ending with a low intensity piece before returning to high intensity. This creates a cyclic and imitating musical structure that lends itself to sleep music.

From the first analysis conducted it is evident that the music developed by Brain.fm is specifically designed to serve a purpose. The music fulfils the requirements set out by the music psychology for it to have a calming and relaxing effects with the aim to induce sleep. The study also considered the melodic contents by considering pitch proximity between intervals and chord densities. The score below illustrates the findings of an analysis of the highest and lowest frequencies present within each sample. It is evident from the score, that interval sizes, or pitch proximity is monitored and limited to avoid cognitive over stimulation from sudden melodic changes in the music.

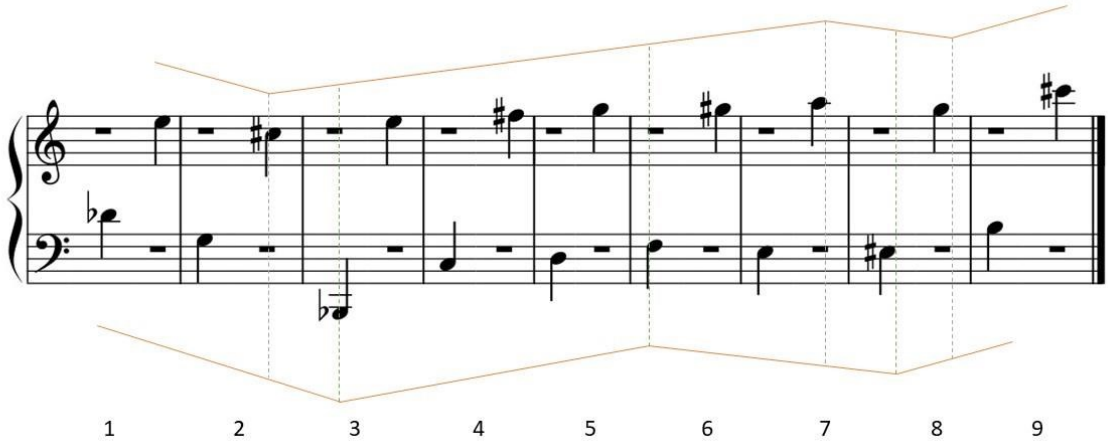

Figure 6: Score outlining the minimum and maximum pitch proximity of the eight samples taken.

From this score, the following points were made:

- The intervals move up or down in unison
- The top and bottom line have direction changes
- The lines move generally in the same direction

The spectrograph below also indicates the strongest frequencies present in the various samples. From this it can be seen that the music is specifically composed in the mid-range of frequencies, with little activity below 45Hz and no strong musical activity above 500Hz as specified by Morillon in the theoretical paper of 2017 in response to the findings of this study, a compositional sketch was created, envisaging the textures and timescales of musical content for sleep music.

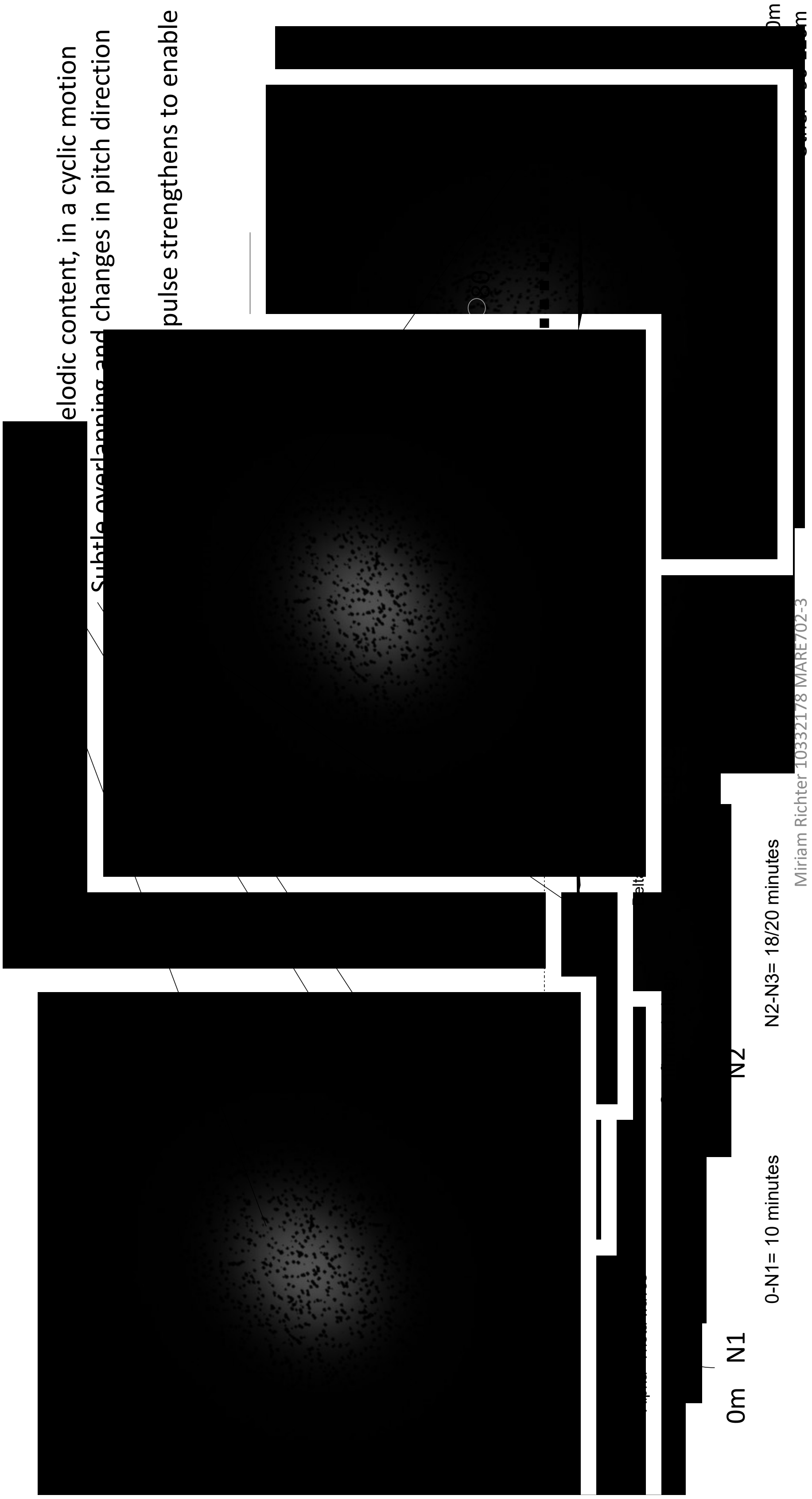

Figure 7: Compositional sketch: Outlining ideas in response to research

Overall, this study was designed to investigate how the sleep music by Brain.fm worked by analysing it against associated music psychology. It is evident that

this music functions in correlation to findings from other research by Tan et al 2012 and Oxtoby et al 2013. Although this sleep-music organisation has not been scientifically validated, it is evident that the music fulfils the criteria and requirements for it to have calming and possibly sleep-inducing qualities.

Conclusion

The section was designed to engage with associated music psychology which needs to be considered to gain a broader understanding of how music can influence cognition with regards to sleep quality. From the research that was considered, it can be concluded that there are strong correlations between the music psychology and findings from the studies, including the necessity for music to have very specific traits including:

- Specific tempos around 60 Bpm
- Certain harmonic and melodic simplicities and plenty repetitions
- Agreeable timbres, including synthesised and string-based music

These findings contribute to a fundamental understanding of how sleep music works and how these traits can impact cognition. Now that these fundaments in music have been acquired, further investigations can be added to contribute to the research. The next section will consider Music-assisted progressive muscle relaxation, which is a form of music therapy, which has been proven to be an effective treatment for Insomnia.

Music-assisted Progressive Muscle Relaxation (M-PMR)

Progressive Muscle Relaxation (PMR) is a non-pharmaceutical therapy variant, designed to help with aspects of pain relief, anxiety and stress, and also sports therapy (Borkorvec et al 1975, Robb 2000, Alexandru et al 2009 and Feng et al 2017). PMR is a technique that usually required instruction and focusses on the tensing and releasing of specific muscle groups associated with poor sleep quality. This includes helping the patient concentrate their mind on positive and calming thought processes, which can be linked to contemporary CBT treatments which also involves a therapist being present. The therapist for PMR also instructs the patient in the tensing and releasing of certain muscle groups associated with the patient's individual psychological arousal levels, causing the Insomnia related symptoms. It is evident from this, that PMR is a strategy that may require the supervision and presence of an expert, making this a less accessible and easy-to-use option for treating Insomnia.

Various forms of PMR exist including Music assisted PMR, or M-PMR which will be considered in more depth in this section. Research is increasing with regards to its effectiveness in comparison to other treatments for Insomnia, for example in 2017 Feng et al conducted a systematic review of various treatments, including pharmaceutical, acupuncture, exercise and music-assisted relaxation as well as music listening alone. This section aims to analyse specific trials and reviews considering the effectiveness of muscle-relaxation techniques in conjunction with music listening.

2000 comparison of relaxation techniques including M+ PMR, PMR and music listening

In 2000 Robb conducted a comparative review of music and progressive muscle relaxation (M+ PMR), progressive muscle relaxation (PMR) and music listening towards the better understanding of relaxation therapies for the specific treatment for stress and anxiety. Though this study was not specifically aimed at Insomnia treatments, certain links can be made from the results. Insomnia related symptoms are heavily associated with negative cognition, stress, anxiety and some traits associated with OCD. It could be ascertained that these conditions are linked, and that the participant suffering from anxiety and stress may also display symptoms of Insomnia.

The trial was categorised into four main groups (1.PMR n=15 2.M + PMR n=15 3. Music n=15 and 4. Silence n=15) and were tested against the Spielberger State Anxiety Inventory (STAI) and Visual Analogue Scale (VAS), which is a graphic line-rating scale used before and after the trial. Group one was asked to follow a PMR video recording for 15 minutes. Group two also engaged with the PMR video recording, but with the addition of music listening. Group three were assigned listening to relaxing music whilst in a relaxing position and group four were asked to relax in silence for the same 15-minute cycle.

From the results it was evident that M + PMR caused the greatest change between the pre and post-trial testing. Further analysis revealed that the M+PMR group paid 25% (75%) less attention to the feel of the music in contrast to the music listening group which achieved 100% respectively, but despite the 25% attention reduction, the music listening group only achieved +2% (40%) in the positive thoughts category, in comparison to the M+PMR group which

achieved 38%. This 2% difference shows the influence music can have on cognitive and physiological activity. Although the M+PMR group also followed a PMR video, the concentration on the music was only 2% less than the music listening only group. From these results, it could be ascertained that, although M+PMR achieved the greatest change in STAI and VAS results, a substantial amount of effectiveness may come down to the presence of the music.

2009 comparative study: PMR, sleep hygiene and binaural beats

Alexandru, Robert, Viorel and Vasile conducted a comparative study of three specific self-help approaches for Insomnia, including progressive muscle relaxation (PMR), sleep hygiene therapy and binaural beats. Sleep hygiene predominantly focuses on educating the patient about poor sleep hygiene, and how to prevent these behaviours from happening. Binaural beats music is an auditory response which occurs in the midbrain and brainstem region and is triggered by certain frequencies (1000 to 1500Hz) with a small interval of no more than 30Hz (Alexandru et al 2009). As the brain finds it difficult to differentiate between the interval tones due to the small interval size, the brain initiates the perception of a third sound called the binaural beat.

The experiment involved three groups (n=57) in a trial lasting over 50 days, with the initial 10 days categorised as the base-line stage, and the last 10 days categorised as the follow-up stage. In the treatment phase, the participants were asked to follow the set procedure in the presence of a sleep therapist and to keep a sleep diary. The sleep hygiene participant was instructed on improving lifestyle choices and restricting day-time sleep as well as gaining cognitive therapeutic pointers. The PMR participant was assigned a PMR video of about 30 minutes and a psychologist to assist the participant in learning and

actively engaging with the techniques. The binaural beats group listened to binaural beats music before going to bed which was also 30 minutes in length to match that of the PMR group. This group also received instruction on the psychology and function of binaural beats music to better understand the concept. It was ascertained at the end of trial that binaural beats showed the least efficiency in contrast to PMR and sleep hygiene. It can be suggested from these findings that CBT, which was an element of the PMR and sleep hygiene group, is more effective than binaural beats.

Alexandru et al do continue to discuss the probability of error in the discussion with regards to collecting data for binaural beats testing, it is evident that binaural beats as an intervention for insomnia requires more consideration and testing to be considered as a competitive method for treatment alongside CBT and pharmaceutical interventions.

2017 systematic review of music as an intervention for Insomnia in comparison to PMR

In 2017 Feng et al conducted a systematic review and meta-analysis of various research conducted with regards to music and Insomnia. This was a large review including 20 trials, involving 1339 participants. The study considered a variety of interventions that utilised music as a primary treatment, including; listening to music verses usual care, music-assisted relaxation techniques, music verses pharmacotherapy, music with exercise and acupuncture.

From these studies the PSQI was measured as well as the overall sleep quality and sleep onset latency. From the meta-analysis it was found that pharmaceutical interventions had the lowest PSQI rating alongside acupuncture

offering the least improvements. Listening to music gained the highest results against the control group, closely followed by music-assisted relaxation techniques. For overall sleep quality, music-assisted relaxation techniques gained the highest scores for sleep quality.

It was stated by Feng et al that music-assisted relaxation showed the highest scores in comparisons to all other music interventions that were considered in the review. Overall, it was found in this review that listening to music and music-assisted relaxation gained the best improvements on the PSQI scale and overall sleep quality assessments.

Conclusion

The purpose of this section was to introduce research that considered progressive muscle relaxation in conjunction with music listening. It can be ascertained from the results that PMR, which is regularly categorised under the CBT umbrella, is a highly effective treatment method for stress and anxiety, as well showing effectiveness in the treatment for Insomnia related symptoms. Considering the outcome of the Feng et al review from 2017, and outcomes of Robb 2000, it is evident that music assisted relaxation techniques are effective, especially considering the interesting outcome of the Robb 2000 trial, which showed the minor difference of only 2% between the M+PMR and music listening group in responding to music.

This section has also introduced research involving binaural beats. Binaural beats therapy is a system that has gained an increased amount of attention with regards to music therapy in general but is also increasingly present in sleep music products. This will be considered in more detail in the next section.

Binaural Beats in Insomnia treatments

The previous section introduced the sonic phenomena known as binaural beats. This phenomenon happens when the human brain is subjected to two different frequencies (between the right and left ear). The interval between these frequencies is specifically narrow, as this causes a third placebo frequency to occur in the hearing called the binaural beat. The brain will negotiate the mean difference between the two played frequencies, for example, if the right ear hears a frequency of 205Hz, and the left ear hears a frequency of 200Hz, the binaural beat will be 202.5Hz.

The type of resulting frequency can be categorised as one of the following waves found within the human body regarding sleep:

Delta	Theta	Alpha	Beta	Gamma
0.5-3Hz	4-7Hz	8-13Hz	14-30Hz	30-100Hz
Deep sleep	Early sleep stages	Drowsy or relaxed state	awake	Highly attentive state of mind

Table 4: list of various brainwaves and corresponding sleep activity

It is discussed that different frequencies evoked by binaural beats stimulate certain brainwaves in conjunction to certain emotions and cognitive responses (Hooper 2001 and Filimon 2011). There are various products available that utilise binaural beats technology as a treatment for insomnia as well as other conditions such as anxiety, stress and addiction therapies including alcoholism and drug abuse (Filimon 2011). There are various online organisations offering binaural beats music for

Figure 8: The Reson-8 binaural beat generator. available to purchase online for $99. available at: http://www.megabrainpower.com /resonate.htm

insomnia including Binaural Beats Meditation, Sound Healing and Free Binaural Beats. There are also devices on the market designed to emit binaural beats including the Reson-8 binaural beat generator. A link between cognitive states and Insomnia was established earlier in this review, where it was ascertained that a link existed between individuals suffering from Insomnia and conditions such as stress, anxiety and obsessive-compulsive disorder symptoms (Ruiter et al 2012). The following research presents an investigation regarding the possible impact binaural beats may have on human performance and mood, which may be used to ascertain how binaural beats may be implemented as a treatment for Insomnia.

1998 Human performance and mood study using binaural beats

Although this is an older research output, it was included in this study as it presented interesting links between human emotional states and the impact Binaural Beats may have on the affective response system. The age of this research also indicates the vast timescale of outputs in the field with regards to binaural Beats research.

In 1998 Lane et al conducted a study designed to investigate how binaural beats may impact human behaviour, specifically cognitive performance and mood through specific performance tests and questionnaires. The trial invited 29 participants to listen to three different audio files comprising of pink noise over 30 minutes whilst performing a set task. The three categories of tapes used in the experiment were defined by

a) delta/theta waves using 100Hz tones using 1.5Hz binaural beats and 200 and 250Hz tones presenting 4Hz binaural beats

b) beta waves testing consisted of 200Hz tones with 16Hz binaural beats and 300Hz with 24Hz binaural beats. 100Hz and 250Hz tones were absent of any binaural beats

The participants were unaware of the presence of the binaural beats. For the testing a performance vigilance task was set using a computer where participants had to respond to certain stimulus on the computer screen using the keyboard where the response time was measured for both the delta/theta and beta testing conditions. The task performance was measured out of 180 tasks, considering correct and false attempts.

The outcome of the trial suggested that a larger number of participants responded correctly to the challenges presented via the beta (mean= 153.5/180) test in contrast to the delta/theta frequencies (mean= 147/180). Participants reported more incorrect responses to the testing using the delta/theta waves (mean=8.7). Although it was suggested that the presence of the binaural beats affected the performance of the participants, the scores were not significant enough to make a certain decision.

To gain more data, another trial was conducted during the performance tasks that measured the subjective mood of the participants when listening to the test tapes whilst completing the tasks. The POMS score was utilised to measure mood. The POMS score was used to measure the following criteria:

a) confusion and bewilderment
b) fatigue and inertia
c) depression and rejection

d) Vigour and activity

From these trials and questionnaires, it was evident that the binaural beats affected the participants ability to complete the tasks in certain ways. It could be concluded that the presence of the delta/theta waves induced a sense of fatigue and exhaustion in the participants. From this it was also suggested in the discussion part of the study that this outcome regarding the delta/theta waves may be used in the treatment of Insomnia due to the decreased levels of cognitive arousal in the participants which may aid to initiate sleep (Lane et al 1998).

2017 Comparative analysis of binaural beats verses monaural sounds and their effects on falling asleep

In 2017 Shumov et al conducted a comparative analysis of the effects of binaural beats on falling asleep in comparison to other similar sound outputs without binaural beats being present by measuring the sleep onset time of test and control participants. The test music was broken down into three different kinds of sound outputs including; music consisting of pink noise and binaural beats, comparable sounds without binaural beats and related sounds without any beats.

The outcome of the study suggested that the presence of binaural beats reduced the sleep onset time but that more research was required to gain more concrete and useable data.

Another interesting point made by this investigation was the unbalanced relationship between sleep music including binaural beats and other formats on the open market and the steady success of these, and the lack of evidence provided by research to support this market.

Conclusion

The purpose of this section was to consider the effects of binaural beats on Insomnia. Binaural beats are a phenomenon that occurs in the brain when two frequencies are played, and the brain produces a third frequency as a product of the mean average between the two frequencies (Lane 1998, Hooper 2001, Filimon 2011 and Shumov 2017). It is discussed that binaural beats can have certain psychological effects on the brain, inducing certain mind-sets including relaxation and focus, and hence lending itself to the promotion of sleep.

Although the research that has been considered here, contributes to the idea that binaural beats can affect Insomnia, more research is required to provide objective data for this. As discussed by Shumov (2017), there is a certain discrepancy between the success of the online sleep music market and the supporting research-based evidence. The next section will consider the market in more detail by introducing and analysing how the market promotes the sale and use of sleep music products.

Chapter 3: Sleep-music market

There is an increasing market for sleep music via the internet. As discussed previously by Shumov in 2017, there appears to be a discrepancy between the products on the market and the research backing the science. This section will consider a selection of specific sleep music products, including Dreem by Rythm and Brain.fm. The purpose of this investigation is to ascertain how and why these products are successful by considering the marketing strategies in relation to the underlying research that has so far been considered in this thesis.

As mentioned in the introduction, this extensive study is designed to challenge the market and to propose a strategy aiming to re-consider sleep- music as a viable and realistic option for Insomnia, backed by appropriate research. By linking the products to actual research as a comparison criterion, a link can be established as to how effective the products are which may contribute to the understanding of why sleep music is thus far considered an alternative treatment method for Insomnia, rather than a prescribed and scientific method.

Dreem by Rythm

The Dreem headband was initially launched in 2016 by Rythm and is now available through the Dreem headband website, found at: https://dreem.com/en/. The device is worn on the head throughout the night and is designed to monitor brainwave activity continuously through EEG sensors. Other aspects are also monitors including heartrate, breathing and movement. The device measures the brave wave oscillations and emits pink noise (suggested by Dreem to have hypnotic qualities) or brown noise (popular for relaxing qualities) depending on the brain activity. The purpose of this is to stabilise the brain activity by encouraging regular and rhythmic oscillations, where the opposite can cause sleep disturbances. The device is for sale at $499.

Figure 9: The Dreem headband, demonstrated by model. Picture taken from Dreem.com

The headband went through two stages of testing in 2016 before official launch in the shape of a sleep-lab trial and a community-based test. The initial trial invited 20 participants to use the device, EEG data was collected for comparison over 60 nights.

The second part of the testing invited 90 participants to use the device from home. From the lab-based tests it was suggested that the Dreem headband had similar acquisition abilities to a PSG in a sleep-lab. The community-based tests revealed that participants did not get used to the sounds repeatedly, which would have a lessened effectiveness of the device, and it was also claimed that the emitted noise synchronised with the brainwave oscillations. From these

findings in 2016 the Dreem headband was considered promising as a method for treating sleep disturbances (Debellemaniere et al 2017).

To further support the product, Dreem conducted further clinical trial-based research in 2017 as part of their campaign. An observational study conducted on 500 Dreem headband users was carried out considering the efficiency of deep sleep stimulation, other features such as the Smart alarm and user feedback. It was concluded in various peer-reviewed texts (Chambon et al 2018, Debellemaniere et al 2018 and Kanbi et al 2018) that the technology was effective in relieving insomnia symptoms and helping to maintain a healthier sleep pattern when using the headband by comparing the PSG outputs of the device in comparison to sleep laboratory results. This research is being continued by Dreem through further clinical research (Dreem 2018).

It is evident that Dreem have managed to produce a product that can be backed by scientific research. Although it is interesting to note the transformation since 2016. When this research was initialised, Dreem only made available an online blog with certain details and data available (mainly the introductory trials carried out in 2016). Since then the company have established better and more convincing evidence that this sleep-music device works and has a scientific fundament.

This is a promising transformation as it is realised that there is a greater need for scientific validation with regard to Sleep-music technology. The next section will consider another online Sleep-music product known as Brain.fm, which is also available for purchase similar to the Dreem headband.

Brain.fm

Previously in this thesis, as part of the psychology of sleep music, the music output by Brain.fm was considered in a study comparing the music against associated music psychology. It was realised that the function of this Sleep-music was specific and composed to serve a purpose. This section will look more closely at the research conducted by Brain.fm. This will then be used to compare the effectiveness of Brain.fm to the Dreem headband which was previously considered as well as the associated Binaural Beats research.

Brain.fm is advertised as a music software designed to stimulate certain cognitive states through neuronal oscillation manipulation using sound, as suggested in the company's white paper *"Behind Brain.fm: Theory & Algorithms"* (Morillon 2017). Brain.fm suggest that certain cognitive states can be achieved by altering the oscillation of neurons in the brain by synchronising the rhythm of the neuronal oscillations to music patterns as suggested by Jones et al in 2002 (n=21) and Lakatos et al in 2008 (n=24). As examined in the previous section for the psychology of sleep music, a study of the sleep music by Brain.fm was conducted to compare the behaviour of the music to music psychology with specific interest in creating notions of calm and comfort in the listener.

As discussed, the music by Brain.fm has been specifically composed to meet the listeners requirements using specific techniques, including a stable rhythm and speed at 120bpm to encourage synchronisation. The requirements are also met by filtering out strong bass and low frequencies (below 45Hz) and above 5kHz to prevent over-stimulation in the listener. Melody and harmony are

repetitive and simple to encourage a feeling of comfort and familiarity (Huron 2006).

Brain.fm and Dreem headband comparison

Brain.fm designed their music to be listened to through standard headphones, with no extra requirement of additional tools or equipment which considering the ergonomics, may be more effective than the Dreem headband which is designed to be worn on the head throughout the night which may deem it less attractive to certain groups on the market including individuals with certain mental or physical impairments or age-related illnesses. In contrast, personal headphones are a technology that may be easier to use and more comfortable for some.

Both technologies pride a sense of individuality by not suggesting any certain genre in their respective music. Dreem developed an audio output designed around noise, pink noise specifically for Insomnia related treatment, and Brain.fm have also exempt themselves from a specific type of music, making them appear more scientific and reliable than some other open sources available through music streaming applications including Spotify, Amazon Music and iTunes.

The Dreem headband is a device which can be purchased for $499, which is increasingly gaining scientific backup for its approach which centres around the function of noises, specifically pink and brown noise to induce certain emotional states. Considering the cost of the device and the certain ergonomic issues mentioned earlier, this may not be a feasible route which could potentially be prescribed via a health authority for the treatment of insomnia. In contrast to the

scientific sleep music trials considered earlier in this thesis, it appears more research is required to fully backup this method, as the previous research considered as part of this investigation appears to be in the fundamental stages of how music could be utilised for sleep specifically. In contrast, Dreem appear to be ahead in research.

Brain.fm are an online organisation which stream music which was composed using certain algorithms based on neuronal oscillation research. As suggested by Lakatos et al in 2008, the brain has the ability to detect rhythms which promote certain neuronal stimulations. These stimulations can be manipulated using specific compositional tools, such as frequency and tempo to induce different emotional states, including sleepiness. Jones et al 2002 also stated that the brain familiarises itself to repetitive rhythms more easily which is a central focus of the Brain.fm music. This theory was also discussed earlier in the sleep-music psychology section, where the importance of familiarity through repetition and simplicity was analysed through the work of Meyer 1956 and Huron 2006.

Brain.fm is available via the Apple App store and the Google Play Store, as well as their website making it a very accessible source (over 2000 downloads from the Google Play store alone). Another interesting point to be made here, is the route of listening, as mentioned before, Brain.fm promotes flexibility as the listener can use standard headphones, promoting familiarity and simplicity. In contrast, the Dreem device has to be worn on the head throughout the sleep cycle, meaning it may cause ergonomic issues for certain users.

A study considered earlier by Feng et al in 2017 considered various sleep-inducing methods in comparison to music by considering their respective PSQI scales from trials. It was ascertained that treatments including acupuncture scored the lowest improvement in the trials for promoting sleep, but the same trial also suggested the music-assisted relaxation techniques (M+PMR) was effective. This gives evidence to the slightly confusing state sleep-music is in with regards to the overall market and research.

Discussion

The purpose of this thesis was to contribute to the overall field of music as an intervention for insomnia. The layout was designed to highlight and compare main strands of research in sleep-music research through the two main categories (non-music-based interventions and music-based interventions). The initial section, although not specifically about how music was used as a treatment, outlined the research that has happened so far with regards to overall insomnia treatments including pharmaceutical and therapy (CBT) based routes.

Sleep research is moving away from medication-based approaches due to the vast variety of side effects which can potentially impact a patient's wellbeing. For example, physiological and psychological implications could include nausea, blood-pressure problems and decreased attention ability which can have major implications on general quality of life (Buffett-Jerrott 2002).

Other issues regarding medication that must be considered are that of dependence and tolerance build up which can be caused by the continuous use of benzodiazepine-based (BZD) medications. Although these medications are rarely prescribed, they are still commonly used in cycles of severe insomnia in patients (Knott 2017).

The other main area considered in this first section of the thesis is Cognitive Behavioural Therapy (CBT) and the insomnia specific counterpart (CBTi). As

research has proven that pharmaceutical interventions are not suitable for long-term use, and also do not help to treat the main cause of insomnia, CBTi was developed as an alternative method. A study by Smith et al in 2002 found that CBTi was more effective in treating insomnia than pharmaceutical interventions. It was then stated by Ritterband et al in 2009 than CBTi provided a long-lasting and effective treatment for insomnia. Further research within this thesis also included the consideration of online-based CBTi organisations such as Sleepio and Sleepstation. A comparison of sleep efficiency, sleep duration, sleep onset latency and sleep quality (%) between online CBTi, general CBTi and pharmaceutical interventions found that online CBTi showed the most improvement in sleep efficiency and sleep onset time.

Moving forward in the thesis, the second section concerned itself with music as an intervention, with research including a variety of strands such as, music for insomnia reviews, music-assisted progressive muscle relaxation techniques, music listening, music preference and music traits in sleep-music, music psychology and genres, binaural beats and products on the open market including Dreem and Brain.FM.

It is clear from the various research that music has the ability to impact sleep habits considering how music affects the cognitive states as suggested by Meyer in 1956 and Huron in 2006. These music psychology theories, alongside others have been utilised to great extent to develop music that can impact the brain to induce states of sleep.

The main issue regarding music as a treatment, is the way in which the music becomes a science and becomes scientifically validated. As suggested by Raglio in 2011, there is a divide between clinical research (which is still revolving around pharmaceutical and CBT based interventions) and that of music as a treatment.

Objective and comparable data is required to give music the necessary evidence to become a main contender alongside prescription methods from health authorities rather than an alternative remedy. Pan discussed in 2017, that the ever-increasing sleep-music market may be confusing and obscuring the realistic potential. Although this study considered a variety of clinical sleep-music trials, various issues regarding sample sizes and test criteria (Jespersen et al 2015) and mostly being based on rather subjective PSQI scales, it is difficult to pinpoint the scientific validation behind the trials, although the majority discussed the dominant effectiveness of music over other treatment methods (Chang et al 2012, Jespersen et al 2015, Feng et al 2017 and Pan 2017).

Considering the outputs of the non-music-based interventions, it could be suggested here that more attention is required to develop a universal comparison criteria for trials that not only rely on PSQI or ISI scales, but that also create empirical data including thorough PSG data which can be reconsidered and analysed in comparison to other trials which may promote a healthy incline in structured data for sleep-music.

Another interesting part of sleep-music that was considered in this thesis was that of binaural beats. This aural phenomenon has received an increased amount of attention and publicity on the internet with regards to sleep with companies such as Binaural beats meditation, and Free binaural beats offering online sleep-music streaming based on this phenomenon.

Two main trials were considered to ascertain how effective binaural beats were with mixed results. In 1998 Lane et al considered human performance benchmarks using binaural beats. Although the results pointed towards the effect binaural beats have on the human brain in contrast to monaural sounds, there was an evident lack in significance in the scores for the research to have a profound effect on the supporting evidence.

The second research output was a recent comparative analysis conducted by Shumov et al in 2017 with similar mixed results. The data collected in this study suggested that binaural beats showed greater improvement on sleep onset time, but that there was a lack of data to support other areas of sleep including efficiency, sleep time and overall sleep quality (Shumov 2017). This research contradicts certain products available on the market, for example the Reson-8 binaural beat generator which is for sale at $99.

It is evident that there is a confusion on the market with regards to the effectiveness of binaural beats as a specific treatment for insomnia. To add to the overall understanding of the internet market the technology by Dreem and Brain.fm were also analysed. As discussed by Shumov in 2017, there is a discrepancy between the scientific research that underpins products.

The Dreem headband was launched in 2016 by company Rythm. Initial research that was conducted for this thesis commenced in the autumn of 2017 with the only supporting scientific statements available in the form of online blogs developed by Dreem. In these blogs initial laboratory tests and home-based tests were acknowledged but lacked the specifics to value this device apart from the other products and as a realistic treatment method (at $499).

In 2018 Dreem supplied various peer-reviewed publications supporting their research which increased the evidence for the scientific justification the technology required to stand-out from other products. Although there was now published research to support the noise-based head device, there were other concerns including ergonomic and economic factors which would need to be considered.

This device may not be suitable for users with certain physical or mental impairments due to the constrictive and slightly imposing nature. Also, the cost of the device would result in a difficulty to promote and prescribe this device via a health organisation or insurance. The company offer a payment plan, but this may also not be an attractive method of acquiring this device.

To gain a comparison to the Dreem headband, Brain.fm offer an online-based music streaming service which can be purchased. In contrast to the Dreem headband, the only supporting evidence for the theory behind Brain.fm is the white paper available to download from their website. From this white paper, the

bibliography could be consulted for further evidence to support their scientific approach.

Two of the main areas of research that were considered was the research by Lakatos et al in 2008 and Jones et al in 2002 which suggested from the data that the theory does have a firm backing. The sleep-music psychology section of this thesis also conducted a successful analysis of how the music by Brain.fm behaved in comparison to related music psychology indicating that this sleep-music is effective.

This supports the claim made by Raglio in 2011 and Pan in 2017 that for music to find a certain place in sleep research, there must be a concrete and objective method behind the testing and collecting of supporting data. There is evidently a vast market for sleep-music products, with mixed types of outputs including streaming websites to physical devices which can be ordered. The main point suggesting there is not enough emphasis on supporting research.

Companies such as Dreem and Brain.fm have made contributions, with the reality that there is a certain place for music as an intervention for insomnia, but the over-crowded and confusing market is causing a grey-area between the genuine research and non-validated products based on ideas and minimal data, such as that of binaural beats.

This thesis was designed to highlight the areas of research closely connected to Insomnia. By considering the two main categories (non-music-based interventions and music-based interventions) it was possible to gain an overall

understanding of the sleep-music market, which can be taken forward to suggest new strategies for better and more supportive research.

From this review, a selection of suggestions can be made using evidence from the various trial outcomes towards the continuing development of sleep-music research:

- As suggested by Oxtoby et al in 2013, more varied measurement scaling should be implemented in trials to gather more objective data
- Trial lengths were often mentioned in discussions as certain concerns, it was stated by Wang et al in 2012 that trial lengths should have a minimum period of 3 weeks
- As suggested by Ritterband et al in 2009 and Espie et al in 2012 personal music preference in candidates are a vital component
- It was also recommended by Ritterband et al in 2009 that self-assessment and self-treatment routes are gaining increasing amount of interest and hence should receive more research
- Regarding music, familiarity and preference have shown to increase sleep effectiveness and sleep onset latency (Iwaki et al 2003), which are difficult measurements to ascertain without objective measurements (PSG). More research is required in the effectiveness of music familiarity in sleep-music specifically
- Iwaki et al 2003 also found that trials produced most promising results in natural test settings i.e at home
- Sleep-music should include certain traits as found by Tan et al in 2012
- Technology such as binaural beats have been proven to require more research to back up the vast online availability of this technology

(Alexandru et al 2009). It was found in the same study that progressive muscle relaxation and CBT are more effective treatment methods, hence this review suggests a requirement for more research involving familiar music and muscle relaxation technologies.

It is evident more is being done to promote sleep-music, with trial-based experiments being completed on a regular basis, building towards a stronger fundament for this intervention, but care must be taken to acknowledge the power of the internet and possible negative implications of non-validated products which may slow-down or confuse the progress in research.

Appendices

Appendix A- Amazon Self-help guides

This section will consider what types of Insomnia treating self-help materials are available on the open market, specifically from the highly successful online mega market Amazon.co.uk. The outcome, or results will be roughly represented through feedback gained for products within certain related categories. Though this is a rather simple method of gaining data, it gives a good indication on how popular products are, and considering qualitative, or subjective responses, give a good indication if that method of treatment is successful. Due to the vast amounts of material available on Amazon.co.uk, This paper will only outline data collected within specific related categories

As this research is mainly interested in UK based research, a survey was conducted in 2017 of what the UK branch of Amazon has to offer for the treatment of Insomnia. 993 books across four sub-categories were considered under the search term “Sleeping Disorders”, (it was conducted in this way to imitate the easiest way an individual may looking for a self-help guide online). The subcategories that were considered the most appropriate for the research were:

- Health, Family & Lifestyle
- Neurological and Clinical Neuropsychology
- Mind, Body, Spirit
- Psychology & Psychiatry

These were chosen because evidence suggests that there is a strong link between personal attributes, beliefs, daily actions, mental and/or physical disabilities, and relationships which can have an impact on sleep quality. The four categories above outline the broad majority of what these attributes or qualities could fall into. For example, personal beliefs or lifestyles could fall into the Health, Family & Lifestyle category, the treatment for an individual displaying mental health problems or a mental disability looking for a self-help treatment may search within the Neurological and Clinical Neuropsychology category and so on.

Amazon has a unified approach to receiving feedback on all their products using a star system. The customer can leave between 1 and 5 stars (1 being the very poor to 5, being excellent). They can also leave a statement giving detail on their personal experience of a product, but this will not be considered in this short survey as it would get very complicated due to the very subjective and uncontrolled nature of that kind of feedback. The star system that is analysed here, gives a very rough but yet interesting overview of how well books are received.

Going back to the survey outcomes, from the 993 books across the four sub-categories, the below table gives the outcomes of how printed texts (books) were received on the open market in the domain of sleeping disorder self-help treatment:

Category	Health, Family & Lifestyle	Neurological & Clinical Neuropsychology	Mind, Body, Spirit	Psychology & Psychiatry
TOTAL	393	354	164	82
Feedback (1-5 stars)				
1	112	100	46	22
2	108	97	44	22
3	97	88	40	21
4	76	69	34	17
5	0	0	0	0

Table 5: Table showing results from short survey conducted from analysing feedback from www.amazon.co.uk (Accessed: 20/10/2017). Evidence suggests that the majority of feedback given categorised the available materials as poor to very-poor

None of the materials gained 5 stars. Only 19.7% gained 4 stars, 24.7% gained 3 stars, 27.6% gained 2 stars and the majority of 28.0% gave 1 star. Though this evidence high highly subjective and unmonitored, it does however show that the general feedback is poor for this kind of self-help treatment method, from the vast difference between 1 and 5-star reviews across the categories. It is also interesting to see in which categories the majority of purchases occurred. From the 993 totals, 393 were made from the Health, Family & Lifestyle category. The reasoning for this may have several factors involved, but considering the audience of these texts, it appears that the category of Health, Family & Lifestyle is the most approachable and open to the non-expert buyer, in comparison to the other, more specialist, categories which may attract more

of an expert/researcher audience, but this is a pure speculation which could be researched further for more exact answers.

For now, this short survey of materials available on the open market, prove that this method of treatment has little impact and does not work universally.

The self-help book as a means to treating any kind of disorder, in this instance Insomnia, has some issues which can immediately be addresses here. Taking the advice offered across the board for the treatment of Insomnia involved a selection of techniques, or abilities that are deemed necessary in the patient in order for them to work. For example, the task of reading and understanding alone, is a complex method. It involves the management and development of knowledge which could prove stress inducing and confusing in its own right. Patients with learning disabilities or other impairments would find it difficult or even impossible to consider these texts without guidance or support.

The evidence above proves that books have the potential to be useful, but more often they are not. The techniques offered in these books are of varying kinds, are often untested and non-universal, meaning they are not accessible to all who suffer from the complaint. This is shown in the very mixed feedback. It is evident that this method may not provide a substantial enough way of treating Insomnia successfully.

Appendix B- NHS Choices for Insomnia

NHS Choices is now marketed as the NHS go-to place for help and guidance on various illnesses, disorders and other complaints before seeking medical attention, the results once again are mixed. The general advice the NHS provides to patients via the NHS Choices website with regards to Insomnia is as follows:

- Regulate bed times
- Relax before going to bed
- Keep the bedroom dark and cold
- Avoid drinking or eating before bed, including anything containing caffeine or alcohol. They also suggest avoiding nicotine.
- Do not watch TV or use any electrical equipment such as mobile phones, tablets or laptops before bed.
- Do not sleep during the day
- Keep a diary of thoughts which may hinder good sleep, for example, stressful situations encountered on the day or worries. (Sleepstation 2017)

Feedback (1-5 stars)	Amount
1	386
2	173
3	266
4	489
5	525

Table 6: Feedback ratings for self-help guides

The website offers a similar feedback system as Amazon.co.uk. Upon reading the guides, a patient can leave a feedback using the star system again. For the purpose of this review, there were two guides that were used:

- 10 tips to beat Insomnia (1076 reviews)
- How to get to sleep (757 reviews)

Between the two online guides there were 1,833 reviews left, with an average of 3/5 stars. Breaking this down further: Similar to the amazon reviews, the feedback is mixed, but there is a striking difference in that the majority of review left were 5 stars. This provides a strong, and possibly confusing contrast to the feedback left on Amazon.co.uk, which presented zero 5-star reviews for the products available. This, once again, could have a variety of contributing factors including availability, ease of access and cost. It has to be taken into consideration that the guides available through the NHS Choices website are free to view, in comparison to the materials available on Amazon.co.uk, it may be that individuals were less critical of the free materials, but again this would need further research to prove correct. But it may show that treatment requires

the cost to be appropriate, but this will be considered later. It is interesting to see though, that there were more 1-star reviews than 2 or 3, hence why the average was 3/5 altogether. This shows once again that, as with the materials on Amazon these methods as treatment as not particularly reliable. It appears that they work for some, but not for others, and the same issues that were pointed out in the previous section could also be appropriate to mention here. The NHS Guides also require the patient to have certain abilities already in place in order for this type of treatment to work. Once again, this would not work for anyone and everyone with sleeping disorders.

Considering the tips, the NHS provide (here restated through the Sleepstation website), there are a few issues which arise with the different ideas. Going through each is possible to see as to why these tips may be difficult to follow:

- **Keep regulate bed times**- This may be difficult to achieve, for example, for individuals who work various early/late shifts, have carer duties such as childcare.
- **Relax before going to bed**- For an individual who is sleep deprived due to stress and/or anxiety, it would be difficult for them to just relax without assistance.
- **Avoid drinking or eating before bed, including anything containing caffeine or alcohol. They also suggest avoiding nicotine.** It may be easier for someone to avoid caffeine before bed, but for a smoker, avoiding nicotine may be more stress inducing which may also hinder the ability to sleep.

- **Do not watch TV or use any electrical equipment such as mobile phones, tablets or laptops before bed-** This is not a practical approach, considering the popularity of social media. It would require a complete lifestyle change in order to make this work and may have negative implications.

- **Keep a diary of thoughts which may hinder good sleep, for example, stressful situations encountered on the day or worries**- These are CBTi techniques which have been proven successful, but again it is not in everyone's nature to write down their feelings. For some this may be quite alienating, or even difficult due to learning disabilities or other hindering conditions.

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