Analysing Sound Design Principles to Create an Application that Alleviates the Symptoms of People with Anxiety

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MSc dissertation check list

Milestones	Date of completion	Target deadline
Proposal	05/06	Week 3
Initial report	26/06	Week 6
Full draft of the dissertation	10/08	2 weeks before final deadline

Learning outcome	The markers will assess	Pages[1]	Hours spent
Learning outcome 1 Conduct a literature search using an appropriate range of information sources and produce a critical review of the findings.	* Range of materials; list of references * The literature review/exposition/background information chapter	* 87-94 * 17-33	100 hours
Learning outcome 2 Demonstrate professional competence by sound project management and (a) by applying appropriate theoretical and practical computing concepts and techniques to a non-trivial problem, or (b) by undertaking an approved project of equivalent standard.	* Evidence of project management (Gantt chart, diary, etc.) * Depending on the topic: chapters on design, implementation, methods, experiments, results, etc.	* (Appendix 1) 100 * 34-46, 47-57, 58-77	350 hours
Learning outcome 3 Show a capacity for self-appraisal by analysing the strengths and weakness of the project outcomes with reference to the initial objectives, and to the work of others.	* Chapter on evaluation (assessing your outcomes against the project aims and objectives) * Discussion of your project's output compared to the work of others.	* 78-81 * 82-83	50 hours
Learning outcome 4 Provide evidence of the meeting learning outcomes 1-3 in the form of a dissertation which complies with the requirements of the School of Computing both in style and content.	* Is the dissertation well-written (academic writing style, grammatical), spell-checked, free of typos, neatly formatted. * Does the dissertation contain all relevant chapters, appendices, title and contents pages, etc. * Style and content of the dissertation.		100 hours
Learning outcome 5 Defend the work orally at a viva voce examination.	* Performance * Confirm authorship		1 hour

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[1] Please note the page numbers where evidence of meeting the learning outcome can be found in your dissertation.

Authorship Declaration

I, Kirsty Bryce, confirm that this dissertation and the work presented in it are my own achievement.

Where I have consulted the published work of others this is always clearly attributed;

Where I have quoted from the work of others the source is always given. With the exception of such quotations this dissertation is entirely my own work;

I have acknowledged all main sources of help;

If my research follows on from previous work or is part of a larger collaborative research project I have made clear exactly what was done by others and what I have contributed myself;

I have read and understand the penalties associated with Academic Misconduct.

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Abstract

In this dissertation, the sound design principles associated with alleviating the symptoms of people with anxiety were analysed with the purpose of creating a relaxation application. Conventional treatments for anxiety include cognitive behavioural therapy and anti-depressants, but these can be ineffective in some instances. This can lead to people seeking alternative methods of alleviating anxiety such as sound therapy, which have been shown to have a positive impact on reducing stress. An example of sounds that can be used to reduce stress levels is nature and ASMR (Autonomous Sensory Meridian Response) sounds. By using these sounds in the setting of an application, it may be possible to reduce a user's stress levels. In addition to the sound principles implemented in the application, physiological and environmental data can be used to create an intuitive system for the user. To determine which type of sounds is the most effective in reducing stress levels of people with anxiety, ten nature and ASMR sounds were produced and implemented into an application that participants were asked to listen to and provide feedback on. An online survey and a listening study were conducted, and the results of the research suggested that nature-based sounds were the most effective in relaxing participants. The results also showed that participants had a mostly positive impression of the application and would use it again, which suggested that the diffusion of relaxing sounds through an application may be an effective method of reducing stress levels. Future research and developments into a smart sound therapy system could include a wider range of sounds for reducing anxiety levels as well as the integration of more types of sensors that could be used to measure stress levels.

Key words: Sound Therapy, Anxiety, Psychoacoustics, Application, ASMR, Nature Sounds

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1 Introduction

In this chapter, the topic of using sound to alleviate anxiety will be clearly defined, and its background established. The reasons for pursuing the research will be explained in context of the current trends in the field of psychological support applications. The aims of the project and its objectives will be stated to further explain what the project will consist of. The dissertation structure will be defined, and each chapter will be summarised to establish an overview of the project.

1.1 Background

This project will be an analysis of sound design principles that can be used to help reduce the stress levels of people experiencing anxiety. Research will be conducted into the different types of sounds that are considered to effectively relax people and how they can be implemented into an application. A prototype of an application will be created and tested with the aim of reducing people's anxiety levels. There will be a look into possible future implementations of the research and using smartwatch and smartphone technologies to gather user data.

It is worth looking at this project as there has been a growing number of applications and trends offering alternative ways to manage stress and anxiety. Conventional treatments for anxiety disorders include cognitive behavioural therapy and selective serotonin-reuptake inhibitors, but these may not work for everyone which can lead to people seeking alternative treatments to help manage their stress levels (Craske & Stein, 2016). Popular relaxation applications like Headspace and Calm offer guided meditation, as well as soothing sounds and music (Wallop, 2019). The interest in alternative methods of reducing stress levels to conventional treatments for anxiety disorders is an important factor in the development of this project. The reason for pursuing this topic is that the diffusion of an easily accessible and intuitive system that produces sounds for reducing the effects of anxiety could be useful and could potentially be beneficial to many different types of people.

1.2 Aims

- Conduct a literature review into the effects of sound on people with anxiety and psychoacoustic principles, and psychological support systems.
- Gather requirements about how to use data from a user's surroundings and their physiological data, as well as audio design principles to effectively produce relaxing sounds for them.
- Conduct a survey and listening study aiming to measure the effectiveness of an application that produces sounds to reduce the stress levels of people with anxiety.
- Evaluate the findings of the survey and listening study aiming to measure the effectiveness of an application that produces sounds to reduce stress levels of people with anxiety and the project as a whole.

1.3 Objectives

Through an in-depth literature review, a clearly defined background on the topic of using sound to help people with anxiety can be established. Anxiety disorders will be clearly defined as well as the conventional treatments currently available. The field of sound and its psychological affects will be looked at in a broad sense, and then specific sound principles that have been shown to effectively reduce the stress levels of people with anxiety will be analysed. Psychological support applications will be researched and evaluated.

The sound design principles that will be used in the application will be defined based on the research from the literature review. Once these principles have been clearly defined and explained, the methodology of how they will be implemented into the application will be researched. There will be an analysis of the use of technologies such as smartphone and smartwatch sensors and microphones to gather data about a user's state and surroundings. Once these principles have been researched and evaluated, sounds will be produced, and an application prototype will be created.

There will be an experiment through remote listener testing (ensuring social distancing rules) to test the effectiveness of the application's sounds in reducing anxiety. The user will be asked to listen to the sounds from the application and provide feedback about the effectiveness of the system in reducing their stress levels. A survey will also be

distributed online which will gather information about people's use of relaxation applications and media, and it will allow people to use the prototype online and provide feedback about the application and its sounds.

The effectiveness of the application in reducing people's stress levels will be evaluated based on the results from the remote listener test and the online survey. The overall project will be looked at to determine the effectiveness of using sound and music to help people with anxiety and suggestions will be given for possible future research and implementations of the project.

1.4 Dissertation structure

In the introduction, the topic of the dissertation is established and clearly defined along with the aims, objectives and structure of the project. The background is defined to further contextualise the research topic and relate it to the literature review which will explore the background in more detail. The objectives explain the aims in more detail and show how they relate to each other.

The literature review serves as the foundation of the dissertation, exploring the existing research in the fields related to the project topic. There will be in-depth research on anxiety disorders and conventional treatments for them. The psychological effects of sound will then be investigated, and its use in order to reduce stress levels will also be researched. Existing psychological support systems that use sound to reduce stress levels will be researched and evaluated. The use of sensors and technologies such as smartphones and smartwatches in applications to gather data to provide a personalised user experience will also be looked at, as well as their possible use in a psychological support system. The literature serves as an in-depth background of the research topic and a way to establish the previous research that has been undertaken in the fields related to the dissertation.

The requirements for the application will be analysed and defined to gain a better understanding of what is needed to develop the system. Based on the research conducted on the current sounds that are used for relaxation in the literature review, there will be an analysis of a set of sounds. The sounds will be analysed using an

acoustic spectrum analysis tool (Audacity) to determine their frequency content. Along with an analysis of sounds, there will be an interface analysis of the relaxation applications Calm and Headspace. Visual design concepts and user interface functionality will be looked at to determine which elements could be used in the application. Once the user interface elements of the app have been defined, an overview of the system can be created with unified modelling language (UML) diagrams.

The sound design principles that will be used to produce the application will be defined based on the research conducted in the literature review and the requirements analysis. Once these principles have been laid out, the sounds for the application will be produced using digital audio workstation software (Logic Pro X). The production process will be documented in detail as well as the principles behind the sounds that validate the stress reducing effects they may have. The prototype for the application will be created using prototyping software (Axure) and the sounds will be implemented into the system. The process of creating the application will be documented and the design (user interface and sound) elements will be clearly defined and the reasons for their choice explained.

Once the prototype of the application has been created it will be evaluated through a listener study and a survey. The listener study and survey will be conducted online. The creation of the study and survey will be documented, and the methodology of the research will be laid out. Once the study has been conducted, the results of the study and survey will be explained in detail. The results will then be analysed and discussed to determine the effectiveness of the application in reducing people's stress levels.

In the conclusion, the dissertation will be summarised and critically analysed to determine if it was successful or not. Considerations for future research on the topic will be recommended based on the results of the study. Suggestions will be proposed for how the application could be improved in the future.

1.5 Summary

To summarise, the dissertation will be an analysis of sound design principles associated with reducing people's stress levels, and research will be conducted into the effectiveness of those sounds to help people with anxiety in the context of an application. The background of the topic is grounded in sound design, psychoacoustics, and how they relate to anxiety disorders. Through the research that will be conducted in sounds that can help reduce anxiety, a set of sound design principles will be defined and used to produce a prototype of an application. The aims of the dissertation are a literature review of the research fields that form the background of the topic, research into the use of physiological data and relaxing sounds to reduce stress levels, and conduct a listening study and survey and analyse the results to determine the effectiveness of the application in reducing anxiety.

2 Literature review

This literature review investigated the research that has been conducted in the fields of anxiety, sound and its psychological affect. In this chapter, anxiety disorders were looked at as a whole and generalised anxiety disorder was defined along with its treatments. Psychological, pharmacological, and e-interventions were looked at and analysed as treatments of generalised anxiety disorder. This chapter defined sound therapy and the effects of sound on psychology. Phenomena such as autonomous sensory meridian response were looked at in the context of sound to reduce stress levels. Finally, relaxation and e-intervention applications were researched and evaluated to determine their effectiveness and what that means for the application that will be created for this dissertation. These applications were evaluated based on the current research that has been conducted in this field to determine their efficacy in reducing stress levels. The research conducted in this chapter showed that sound has the ability to be relaxing for people with anxiety, and with the popularity of relaxation applications this may be an effective method for diffusing sound with the purpose of reducing stress.

2.1 Anxiety

Mental health disorders are common among the general population, and conditions such as depression and anxiety are estimated to account for 14% of diseases worldwide (Phillips et al., 2011). Anxiety disorders are considered the most common mental health condition, with one in nine people affected worldwide as of 2013 (Craske & Stein, 2016). Despite their prevalence, anxiety disorders are often undetected and undertreated (McGrandles & Duffy, 2012).

There is a normal level of anxiety that can be useful and likely to be experienced by most people. The purpose of short-term anxiety is that it can heighten a person's awareness in situations where they may need to protect themselves. This is what is commonly referred to as 'fight or flight' which is a survival mechanism involving physiological arousal. A heightened level of anxiety can be beneficial for some people to enhance performance in certain situations such as during an exam or interview. This short-term anxiety can also cause paralysing fear for some people which can cause inaction. For most people their arousal level returns to normal once the anxiety-causing

event has passed, but for others the symptoms persist and can develop into a mental disorder. Anxiety can also develop through living with long-term stress (McGrandles & Duffy, 2012).

Anxiety disorders are a group of conditions that mostly begin in childhood, adolescence, and early adulthood and can continue throughout a person's life. Some of these disorders are separation anxiety disorder, selective mutism, specific phobias, social anxiety disorder, panic disorder, agoraphobia, and generalised anxiety disorder. They are defined by common characteristics such as persistent and marked anxiety that is out of proportion to the perceived threat and that has an impact on an individual's daily functioning (Craske & Stein, 2016). Anxiety can also cause physical side effects such as palpitations. The symptoms of anxiety and responses to treatments are varied, and if left untreated, these disorders can cause long-term disability and premature mortality (McGrandles & Duffy, 2012). If no treatment is given to patients, anxiety disorders tend to be chronic (Craske & Stein, 2016). The cause of depression and anxiety is not fully understood, but it's suggested that chronic stress can have an impact on the development of these disorders (Phillips et al., 2011).

Generalised anxiety disorder (GAD) is a condition that causes marked worry most days and that is hard to control (Craske & Stein, 2016). The side effects and severity of the anxiety varies for different people but the difficulty to control it is common and persistent (McGrandles & Duffy, 2012). Some symptoms include restlessness, fatigue, lack of concentration, irritability, muscle tension, and issues with sleep (Craske & Stein, 2016). GAD has overlapping symptoms with depression such as difficulty concentrating and sleeping, and in severe cases suicidal ideation (McGrandles & Duffy, 2012). There is an estimated three to five percent lifetime prevalence for the condition (Craske & Stein, 2016). At some point in their lives, one in five people will have GAD and less than half will have a full remission after five years. GAD may be linked to genetics but may also be caused by previous trauma in a person's life. The goal of intervention in GAD is to reduce the symptoms of anxiety and improve quality of life (Gale & Millichamp, 2011).

A range of psychological and pharmacological treatments are available for GAD, but more research is necessary to provide greater access to and more personalised

treatments (Craske & Stein, 2016). Psychological treatments include cognitive behavioural therapy (CBT) which has been shown to improve anxiety, through exposure, relaxation, and/or cognitive restructuring (Gale & Millichamp, 2011). In terms of pharmacological treatments, anti-depressants are used for most anxiety disorders and the most used are selective serotonin-reuptake inhibitors (SSRIs) and serotonin–noradrenaline-reuptake inhibitors (SNRIs) (Craske & Stein, 2016). Antidepressants have been shown to be effective in reducing anxiety in patients, but they may cause unwanted negative side-effects. Antipsychotic medications may be used if other treatments have been unsuccessful and have shown to reduce symptoms of anxiety but may also cause adverse reactions (Gale & Millichamp, 2011).

Most e-interventions are a form of CBT and are considered effective at reducing anxiety compared to no treatment. There is some controversy around e-interventions as further research is required to determine the overall efficacy, acceptability and safety of the treatment, as there is no therapist present to ensure the person's symptoms don't worsen (Craske & Stein, 2016). Self-help is also a possible aid to reducing anxiety, as patients can access resources through the internet, books, or CDs to learn relaxation techniques that may alleviate their symptoms (McGrandles & Duffy, 2012). Another treatment that may be used is sound therapy, as it may be effective in reducing symptoms of people with anxiety (Flores Gutiérrez, Andrés & Camarena, 2015).

2.2 Sound and Psychological Affect

Sound therapy is a field of healthcare that uses sound and music to assist people experiencing a wide range of physical, emotional, cognitive, and social disorders. The effects of sound therapy have been shown to be useful in improving the quality of life, managing stress and alleviating the pain of patients with a wide range of conditions (Duerksen, 2013). There are many different methods of sound therapy that require varying levels of interaction from the person receiving the therapy. The British Academy of Sound Therapy (BAST) method of sound therapy includes the use of specialist instruments such as singing bowls, gongs and tuning forks (Cooper, 2014). The specificities of the term sound therapy differ depending on sources. Any clinical use of sound can be defined as sound therapy which can lead to confusion. Some definitions of sound therapy include the use of masking therapy, while others exclude

it. In this dissertation, masking therapy will be considered a part of sound therapy (Hoare, Searchfield, El Refaie & Henry, 2014).

The reasons for the effectiveness of sound therapy may be linked to our inherent appreciation for patterns and organisation, and this can be observed in human responses to music. By using this appreciation, music can be used to create an enhanced auditory environment (Duerksen, 2013). One of the areas where sound therapy can be used is in the treatment of tinnitus, where sound masking can be used to distract a sufferer from the noises produced by their condition and as a result lower their stress levels. By using sounds such as white noise to mask the effects of the tinnitus, it can distract and bring relief to the patient (Hobson, Chisholm & El Refaie, 2012). Another area when sound therapy has shown to be effective is in alleviating the symptoms of people with anxiety (Flores Gutiérrez et al., 2015).

Music therapy is a form of sound therapy that includes two fundamental methods: receptive and active. Receptive music therapy is a listening-based method where the person receiving the treatment listens to music in a controlled setting. Active music therapy is a method where the person receiving the treatment plays a musical instrument (Guétin et al., 2009). Music therapy has been used as an effective non-pharmacological therapy for various psychiatric disorders such as depression (Pavlov et al., 2017). It may also be effective in reducing the effects of anxiety through strategies such as listening to music, composing music, and playing instruments. Music therapy has also been used to build emotional competence and facilitate self-expression. This makes it a powerful tool in changing the mood and emotions of people and relieve feelings of distress (Kwok, 2019).

Listening to relaxing music has been shown to reduce anxiety and pain and increasing comfort and relaxation in cancer patients, making it a useful and effective tool in the healthcare sector (Li et al., 2011). A form of relaxing music is nature sound music which is characterised by its slow tempo, low tones and no lyrics, and has been shown to be effective in reducing stress (Laska et al., 2018). Listening to music creates changes in brain wave status which affects the cardiovascular system and respiration. The right frontal lobe is activated when listening to music which decreases cortisol levels, thus reducing stress (Laska, Suryono, Widyawati, Suwondo & Kusworowulan, 2018).

Exposing people to nature sounds can reduce stress levels and help people recover from stress quicker compared to exposing them to unpleasant non-nature sounds (Alvarsson, Wiens & Nilsson, 2010). One example of sound therapy is Nature-Based Sounds listening which is used in care settings where high noise levels and other stress-inducing factors can cause tension for patients. It is inexpensive and non-invasive which makes it an intervention which is easy to apply and can increase patient well-being (Aghaie et al., 2014). Music can be used to create a comforting and familiar environment for patients. Patient-directed music (PDM) intervention is used to reduce anxiety and sedative medication exposure, thus creating an inexpensive way to empower patients to manage their own anxiety (NewsRx, 2013). The presence of music has increased a lot over the years and people are surrounding themselves with music throughout everyday tasks (Joshi, Kiran & Sah, 2017). The wide-spread use of technology in society creates higher noise levels which can be overwhelming for some people. The negative effects of high noise levels can be reduced by using noise-blocking headphones and music to distract people (Johnson, Raymond & Goss, 2012).

Other than nature sounds, another type of audio that can be used to reduce stress is binaural beats. Brainwave entertainment is a binaural beat phenomenon where two different frequencies are played in each ear which can induce a different cognitive state and create a relaxation effect (Baracskai & Finn, 2013). Monochord sounds have also been shown to be effective in pain alleviation and relaxation. Monochord sounds come from a 30-string instrument that is tuned to one base tone and produces many overtones, which created sounds that merge into one continuous sound. These sounds are considered calming and listeners experience positive physical and psychological feelings (Lee, Bhattacharya, Sohn & Verres, 2012). Music that has 60 to 80 beats per minute (close to human heartbeats), a slow tempo, middle to low pitch, low volume, and simple rhythmical melody has been shown to be effective at reducing anxiety (Liu, Chang & Chen, 2009).

There are some sounds that can trigger anxiety for a number of people such as screaming, thunder, and roars due to their perceived threat level. Individuals that have anxiety are likely to have difficult attentional disengagement from negative auditory information, meaning that when they are fixated on negative sounds, they find it difficult

to withdraw from it (Wang, Xiao, Luo & Yang, 2019). This is an indication that sound masking and distraction may be useful for alleviating the symptoms of people experiencing anxiety.

There are many strategies for managing stress such as counselling, meditation, getting a good amount of sleep, spending time with others, and listening to music. Music may be used to convey our emotions which can make it an effective tool in reducing stress. It has a relaxing effect on our mind and can be used as a distraction tool (Joshi et al., 2017). Conventional treatments for anxiety may be effective, but they may not work for everyone or they may have adverse side-effects that can lead to a patient seeking alternate treatments (Wallop, 2019).

Relaxation applications, such as Headspace and Calm, have become popular in recent years and suggest many benefits, such as reduced stress levels and increased overall happiness. These applications often feature guided meditations, relaxation sounds, and music (Wallop, 2019). The interest in using sounds for relaxation has been growing outside of mobile applications, as seen with the trend of auditory autonomous sensory meridian response (ASMR) videos on YouTube. People are finding that the therapeutic effects of calming sounds are helping them with various conditions such as anxiety, stress, and insomnia (Poerio, Blakey, Hostler & Veltri, 2018). In some cases, ASMR can help reduce the symptoms of chronic pain and improve mood, similar to the effects of mindfulness-based stress reduction therapy and yoga (Cash, Heisick & Papesh, 2018). The phenomenon of ASMR can be described as a tingling sensation at the crown of the head that is triggered by sounds such as whispering and tapping and visuals (Poerio et al., 2018). The name ASMR comes from the sensations that come with the phenomenon: the feeling is autonomous as the user has no control over it, it is a sensory experience and it happens along the centre of the body (Cash et al., 2018).

The acoustic features of the auditory stimuli have an impact on the experience of ASMR, and low-pitched sounds with dark timbre tend to trigger it. Binaural listening was found to extend the length of the ASMR experience compared to diotic listening. Sounds that were ‘moving’ around the listener’s head also enhanced the experience compared to static sounds (Koumura, Nakatani, Liao & Kondo, 2020). These effects generally create a sense of calm and a positive affect for the user. The side-effects of

ASMR are like those of mindfulness. Both ASMR and mindfulness can lead to an increase in relaxation and wellbeing (Fredborg, Clark & Smith, 2018). The most effective and popular auditory triggers are whispering and crisp sounds. When users were asked why they consume ASMR media, 98% of respondents said they use it for relaxation purposes, 82% said they use it to help them fall asleep, and 70% use it to reduce stress (Barratt & Davis, 2015).

2.3 Applications for Psychological Support

In recent years, smartphones and wearables have been integrated into everyday activities in a seamless way which has enabled more advancements and research in the field of pervasive computing (Dobbins & Fairclough, 2017). It is important to consider the impact that this technology has had on the medical sector, such as the introduction of wearables for health purposes (Baracskai & Finn, 2013). In the context of this dissertation, the influence that technology has had on measuring anxiety levels will be looked at and analysed.

The Internet-of-Things (IoT) is a computational platform that involves the use of devices that have digital-based capabilities and can connect to the internet. The healthcare sector has become more complex and makes use of IoT devices and sensors. The use of these technologies has led to the term SmartHealth being used to describe the support of health practices by smart devices, such as smartphones and patient monitoring devices. This has allowed the healthcare sector to transform from a clinic-centred practice to a patient-centred one, where people's health statuses can be constantly monitored which reduces discrepancies in access to high quality medical care. There are, however, some issues linked to SmartHealth which need to be addressed such as security, privacy, ensuring the quality of the care, and ethical considerations (Wahaishi, Samani & Ghenniwa, 2015). The use of wearables and medical IoT is growing rapidly and it is estimated that as of 2019, 87% of health organisation will have adopted IoT technologies (Hudson & Clark, 2018).

Smartphones have over 14 types of sensors that can measure things like motion, environment, position, and localisation. Wearable sensors are growing in popularity and are useful for gathering physiological data (Dobbins & Fairclough, 2017). Table

2.1. shows sensors that are common to most smartphones and that are supported by the Android platform (Google LLC, 2019).

Table 2.1: List of Smartphone Sensors Supported by the Android Platform

Sensor	Type	Description
Accelerometer	Hardware	Used for motion detection and measures the acceleration force on the three physical axes (x, y, and z) including the force of gravity.
Temperature		User for monitoring air temperatures.
Gyroscope		Used for detecting rotations and measures the rate of rotation around the three physical axes (x, y, and z).
Light		Used for measuring the ambient light level.
Magnetic Field		Used for creating a compass and measures the geomagnetic field of the three physical axes (x, y, and z).
Pressure		Used for monitoring air pressure changes and measures the ambient air pressure.
Proximity		Used for measuring the position of the phone during a call and if it's held to the user's ear.
Relative Humidity		Used for measuring the relative ambient humidity levels.
Orientation	Software	Used for determining the position of the device and measures the degrees of rotation around the three axes (x, y, and z).
Rotation vector	Software or Hardware	Used for motion and rotation detection by measuring the orientation of the device.
Gravity		Used for motion detection and measures the acceleration force on the three physical axes (x, y, and z).
Acceleration		Used for monitoring acceleration and measures the acceleration force on the three physical axes (x, y, and z) excluding the force of gravity.

Consumer wearables can also be used for health purposes such as Fitbit wristbands and Apple watches, the latter of which can measure heart rate, balance, sleep pattern, gait, activity level, speech impairment and hearing. Biosensors in wearables may introduce new standards in measuring diseases and analysing their progression and severity in individuals. It is worth noting that wearables are at risk of being hacked which can cause a security concern if the user's data is not encrypted (Mombers, Legako & Gilchrist, 2016).

Biosensors and wearables can be used to measure stress levels in people with anxiety. Measuring people's stress levels can help them develop self-awareness and coping skills that are important for reducing stress. By using the data of the stress levels measured from biosensors in a mobile platform, the user can gain an insight into their behaviour, emotions, and possible stress triggers (Dobbins & Fairclough, 2017). Some of the effects of stress that can be measured are changes in heart rate, blood pressure, breathing pattern, galvanic skin response, emotion, and voice intonation. Figure 2.1 shows the techniques for measuring these effects, which include

electroencephalography (EEG), blood volume pulse (BVP), electrocardiogram (ECG), galvanic skin response (GSR), and electromyography (EMG). EEG is used to measure electronic signals produced by neural activity in the brain and can show stress and relaxation levels more effectively than blood pressure and heart rate measurements. ECG (superior measurement to heart rate variability [HRV]) measures heartbeats by detecting electrical activity produced by the cardiac muscles. Galvanic skin response (GSR) is a measurement of skin conductance by analysing the flow of electricity through a person's skin (Sharma & Gedeon, 2012).

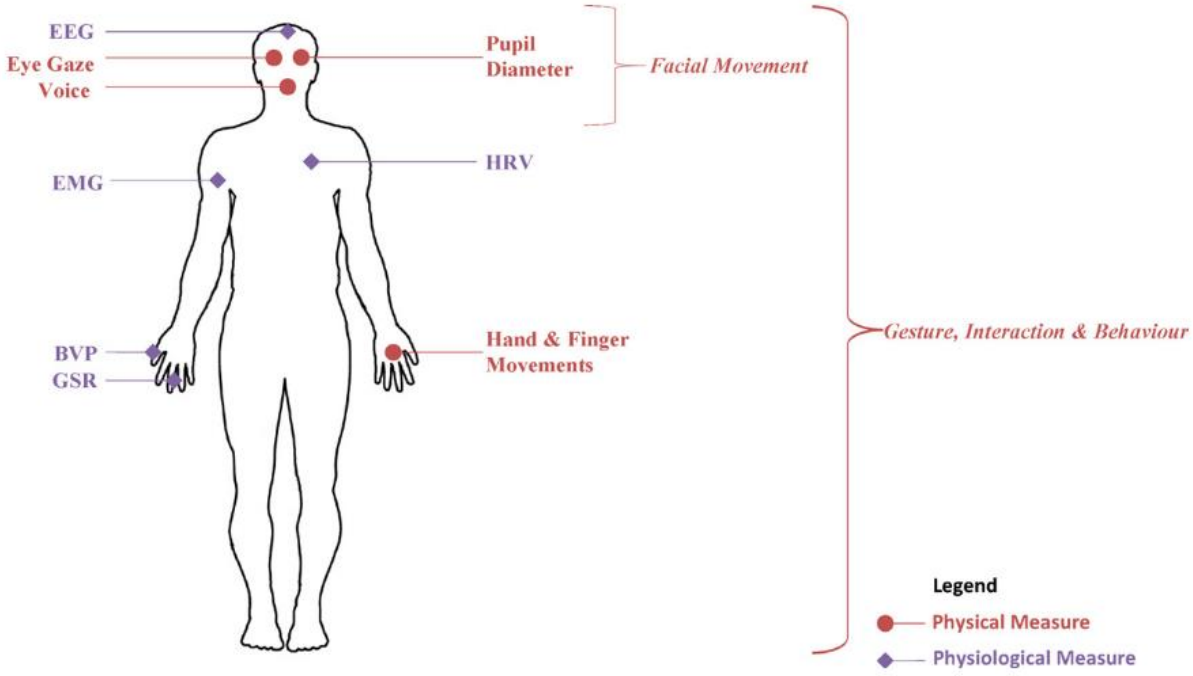


Figure 2.1: Physical and Physiological measurements for stress (Sharma & Gedeon, 2012, p. 1289).

Some of the physical signs of emotional states include changes in facial expressions, vocal sounds, gestures, and postures (Baimbetov, Khalil, Steinbauer & Anderst-Kotsis, 2015). It's possible to measure stress through a person's voice, and it can be detected by looking at changes in fundamental frequency and more high frequency components with high energy. The variable that will be analysed to detect stress in a person's voice is loudness, fundamental frequency, zero-crossing rate, jitter, and energy frequency ratios (Sharma & Gedeon, 2012). A smartphone is an ideal tool for detecting a user's stress levels and emotional state due to its audio detection capabilities. It is important for computers to be able to identify a person's emotions. Acoustic emotion recognition

can be applied in cross-language systems as acoustic information can be extracted from a voice regardless of the language it's in (Baimbetov et al., 2015).

One of the difficulties in measuring anxiety with sensors is determining if the physiological arousal is caused by anxiety or by an unrelated state such as that caused by physical activity. One of the physical side effects of anxiety is a raised heart rate and this may be mistaken for physical activity. A possible solution for this is to use a motion sensor to detect when the user is doing physical activity to reduce the likelihood of false positives in anxiety detection. In order to accurately detect anxiety, it is important to identify a user's baseline physiological characteristics and then detect changes from this that indicate the user is under stress (Puli & Kushki, 2020).

There is a global burden of mental health disorders and many remain untreated, so web-based and mobile interventions are a potential option for helping people manage their symptoms, although more research is needed to assess their effectiveness. (Mani, Kavanagh, Hides & Stoyanov, 2015). Some examples of web-based interventions are MoodGym (e-hub Health Pty Ltd, 2020), Mind Over Mood (Padesky, 2020), and Be Mindful (Wellmind Health, 2020), the latter of which is a CBT course that is designed to help people manage the symptoms of stress, anxiety, and depression. While web-based interventions are important for providing information to patients, they were shown to be most effective when used along with professional guidance and support (McGrandles & Duffy, 2012).

Mindfulness has become popular in recent years as an effective self-help technique that reduces stress and promotes well-being. Mindfulness can be defined as a way of thinking that focuses on the present moment in a non-judgemental way and allowing experiences to happen. It is a skill that is developed over time and with practice, and the benefits of mindfulness are enhanced awareness, more self-regulation, acceptance of experiences, and more perspectives on information. Some of the exercises that aid in the development of mindfulness are meditation, breathing exercises, and other relaxation techniques. Mindfulness has been shown to be an effective tool in reducing psychological distress, however, finding an effective method of delivering this treatment to a wide audience is still a challenge (Mani et al., 2015).

As of 2015, out of the 1.4 million apps on the Apple Store, 35 thousand were health related. The growing number of health-related apps has also included mental health support apps, including mindfulness-based ones (Mani et al., 2015). As of 2019, there was found to be 560 mindfulness apps in the Apple and Google app stores that are available in English. Of those apps, the most popular in the Apple Store were Calm, Aura, and Headspace. In the Google Play Store, the most popular mindfulness apps were Headspace, Calm, and Deep Calm (Huberty et al., 2019). For a mindfulness app to be effective it needs to explain the concepts of the practice and the philosophy behind it. It should encourage regular practice as mindfulness is a mind-training skill that requires sustained effort for it to have a positive outcome. The user is more likely to be engaged if the app is designed well visually and practically (Mani et al., 2015). A study has shown that mindfulness applications (Headspace) can be effective at improving the mental health symptoms of participants if they used the app regularly. Mindfulness apps are useful as they allow more people to experience high quality guided meditation than face-to-face courses would, which helps to lower the geographical, financial, and social barriers that prevent people from having access to this kind of treatment usually. However, more research is needed to ensure the quality and effectiveness of these apps. There is also a high-turnover rate of apps in general which makes it challenging to examine the effectiveness of the apps. One study that looked at the mindfulness app Headspace found that users reported less symptoms of depression, anxiety and stress and these outcomes were mostly maintained forty days after the beginning of the experiment. This shows that mobile mindfulness could be a promising tool in relieving the symptoms of anxiety in people and enhance well-being if practiced regularly (Flett, Hayne, Riordan, Thompson & Conner, 2019).

2.4 Effective Application Design

When designing an application, it is important to consider all of the aspects that can affect the quality of the app and what the user will find enjoyable to use. Personalised and adaptive user interfaces can increase user satisfaction. One of the most important aspects of interactive systems is the user interface (UI) which is the main point of contact of the user and the functionalities of the application. Poorly designed UI can stop the user from exploring all of the functionalities of an app. There are many issues that UI designers face when creating systems due to the fact that the app will be

distributed to many different end users across different platforms and devices. Different users have different wants and needs when it comes to applications, and this multiplicity of end users can make it difficult to design an app with user satisfaction in mind. Adaptive UI is a way to overcome these difficulties by creating a personalised user interfaces for each user, as opposed to a singular design for all users. There is no way to consider the variability of user wants with a one-size-fits-all design approach (Hussain et al., 2018).

Adaptive user interface research focuses on the different variables that can influence the UI such as a user's culture, characteristics, disabilities, and cognition. An example of the impact of culture in UI design is that some specific colours may be associated with certain meanings in some cultures and not in others. Disability is also important to consider when designing an adaptive system, as font can be enlarged for visually impaired users or audio level increased for hearing impaired users. Personalisation of the UI, such as hiding and showing certain elements, is also important to consider in adaptive UI. More research is required to build a framework around adaptive UI (Hussain et al., 2018).

Adaptive UI can increase user satisfaction by monitoring user experiences and feedback. Data gathered from user experience monitoring such as user sensory information (user sight, hearing, touch sensitivity), user mobility (hand or finger precision), and user positive and negative emotions can give an insight into how the user feels about a system and how it can be improved. Figure 2.2 demonstrated how an application can be adapted based on current situations thanks to the context model that uses information about a user's surroundings such as light, noise level, and any other events that are occurring. There are two types of contextual information that can be stored about a user's surroundings: physical context, and time and location context. The physical context encompasses information about light, noise level, temperature and weather that is gathered through sensors. The time and location context can be used for purposes such as to determine where a user is currently or was in the past (Hussain et al., 2018).

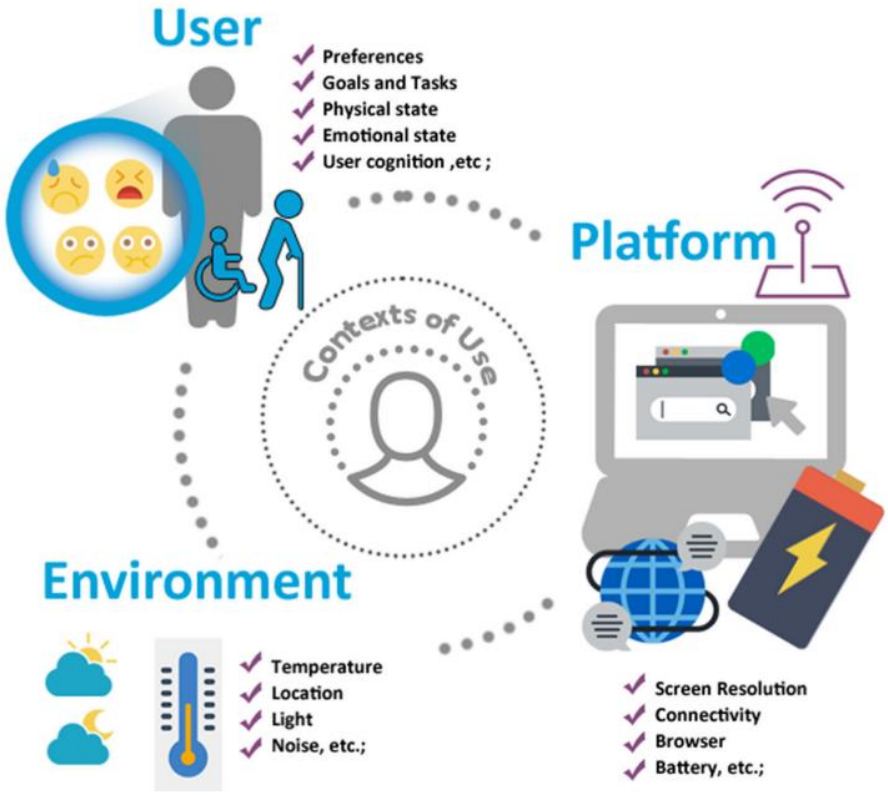


Figure 2.2: Contexts of Use of an Adaptive UI (Hussain et al., 2018, p. 6).

Multimodal user interfaces (MMUI) lets users interact with systems using speech and gestures which reduced the cognitive load and arousal level of the user. This can help to reduce the stress levels of users while performing complex tasks. By detecting a user's cognitive load in real-time using sensors such as GSR, the system can be adapted depending on their experiences (Shi et al., 2007).

2.5 Evaluating Psychological Support Software

Usability testing is an important step in developing health apps to encourage user engagement and ensure the app is designed well before effectiveness testing. A study that involved the testing of a prevention and intervention app for youth anxiety found that the app was mostly positively rated (83% positive rating from participants). The app may have received high satisfaction ratings due to the fact that participants found the app easy to learn and use, and the messages generated by the app were helpful (Stoll, Pina, Gary & Amresh, 2017). This suggests during the development of a health app it may be useful to consider that learnability and efficiency are important factors in ensuring user satisfaction. It is also important to consider how adaptive user interfaces

have an impact on learnability and efficiency. Adaptive UI has been shown to increase user efficiency and the adaptive accuracy has an impact on user performance. Although, it is worth considering that adaptive UI can disturb user learnability rate if there are frequent adaptation that cause changes in the UI (Hussain et al., 2018).

Treatments delivered through applications for mental health have become popular but there is still a lack of research on their effectiveness (Bostock, Crosswell, Prather & Steptoe, 2019). Despite the popularity and availability of mindfulness apps there have not been a lot of studies evaluating the efficacy of them in reducing anxiety levels. Mindfulness-based interventions (MBI) have not been studied a lot either compared to conventional mental health treatments. In one study, an eight-week MBI was compared to an eight-week behavioural activation program which were both delivered through mobile apps for participants with major depressive disorder. The MBI app had guided mindfulness practices and psychoeducation. The outcome of the study showed that both interventions had similar results in reducing the effects of depression which lasted for six months minimum (Van Emmerik, Berings & Lancee, 2017). Meta-analyses on the efficacy of mindfulness-based psychological interventions found that they are effective in reducing stress levels for healthy people, and they are effective in helping people with anxiety and depression in terms of psychosocial outcomes (Bostock et al., 2019).

Another study looked at the mindfulness app Headspace, and in particular its Take 10 program which features daily ten-minute meditations over ten days. The results showed that the app was effective in reducing the effects of depression but had no positive effect on general life satisfaction and social-psychological prosperity. These studies show that there are positive prospects for these apps in providing support for people suffering from mental health conditions such as depression, but more research is needed to confirm their efficacy and their long-term effects (Van Emmerik et al., 2017). Mindfulness apps were shown to be equally as effective as traditional intervention methods in increasing wellbeing and compassion and reducing depressive symptoms according to three studies conducted (Bostock et al., 2019).

It is suggested that mindfulness interventions may be a more suitable option for mobile apps due to their simplicity as opposed to multicomponent treatment packages. There

is a need for self-help treatments for patients that don't have alternative options, so mindfulness delivered through an app may be ideal treatments for them (Hoa et al., 2014). Mindfulness apps have also been shown to be effective in helping people suffering from insomnia (Low, Meaklim, Conduit & Jackson, 2018). When comparing traditionally delivered mindfulness (TDM) to a smartphone delivered mindfulness (SDM) intervention (Headspace), the participants who followed the SDM intervention were more satisfied, compassionate and experienced less burnout compared to the participants who followed the TDM intervention (Morrison Wylde, Mahrer, Meyer & Gold, 2017).

Some common features amongst high quality mindfulness apps are that they all contain both guided meditations and mindfulness education. Some of the meditations offered are breathing, body scan, sitting meditation, and thoughts and emotions meditation. Body scan and breathing meditations were found in almost every mindfulness app (Mani et al., 2015).

2.6 Summary

Research shows that sound can be an effective tool in reducing the symptoms of people with anxiety. Relaxation applications have become an increasingly popular method of diffusion of mindfulness techniques to reduce stress. This suggests that the diffusion of sound through a relaxation app could be an effective method to reduce anxiety levels.

Anxiety is a disorder that affects a lot of people and is considered one of the most common mental health conditions. If left untreated, anxiety can cause various health problems and long-term disability. Some anxiety disorders include separation anxiety, social anxiety, panic disorder, agoraphobia, and generalised anxiety disorder. They have common characteristics such as persistent anxiety and worry that is out of proportion to the perceived threat. There are both psychological and pharmacological treatments available for anxiety, but they may have negative side effects or not be effective for everyone. There are some alternative treatments for anxiety such as sound therapy.

Sound therapy is a field of healthcare that uses music and sound to help people with various disorders including anxiety. It is effective in reducing anxiety through techniques such as listening to music, composing music, and playing instruments. Some of the sounds that have been shown to be effective in reducing people's stress levels are nature sounds, binaural beats, and monochord sounds. Other types of sound that are effective in reducing stress are sounds produced in Autonomous Sensory Meridian Response (ASMR) media such as tapping and whispering sounds. ASMR is a phenomenon where certain sounds are used to trigger a tingling sensation at the crown of the head.

The popularity of smartphones and smartwatches has allowed people to use these devices to measure and log information about their health. This is useful for monitoring anxiety as the biosensors in wearables and smartphones can be used to detect if someone is experiencing stress. Some of the sensors that are useful for measuring stress levels are the electrocardiogram (ECG), blood volume pulse (BVP), and galvanic skin response (GSR). Along with the easier way of monitoring anxiety, technology has allowed people to have more access to mobile interventions for anxiety than ever before. Relaxation and mindfulness apps, such as Headspace, can be useful and effective at reducing stress levels, although there needs to be more research to determine how they compare to conventional treatments for anxiety disorders. When evaluating psychological support applications, it was found that both e-interventions and relaxation apps have been shown to be effective in some studies, but more research in this field is needed.

The research conducted in this chapter will be used to develop a prototype of a relaxation application that will generate sounds to reduce the user's stress levels. This prototype will be evaluated by creating an online survey and listening test. The survey will ask people to test the prototype on their own and give feedback of their experiences using it and if they found that it helped them relax. The listening test will be conducted online and participants will be asked to try the prototype and listen to certain sounds to determine if they are effective in reducing stress levels, and the participants will be interviewed after the test where they can give their feedback on the prototype and the sounds. The results of both the survey and the listening test will then be analysed to determine if the sounds were effective in reducing stress levels.

Each stage of the dissertation will be evaluated, such as the creation of the sounds for the application, the creation of the prototype, and the results of the study. The evaluation of each stage will be done in comparison with the current research that has been conducted in this field and how the findings of this dissertation compare to it. At the end of the dissertation, there will be a reflection on the research conducted and the impact it potentially has on the industry as well as suggestions for future study. The strengths and weaknesses of the project will be analysed as well as determining if the project's aims that were laid out at the start of the process were successfully attained.

3 Requirements Analysis

In this chapter, the requirements for the application were defined based on research into sounds for relaxation purposes and an interface analysis of relaxation applications. Gathering requirements for the application is useful to determine what elements are necessary to implement when developing the system. The sounds that could be used for the application are defined based on the research conducted in the literature review on sounds that are shown to be effective in reducing anxiety. The frequency content and the temporal variation of these sounds were analysed, as well as the RMS, the peak, and the crest levels. It was found that sounds with frequency content mostly below five kHz with some peaks up to 15 kHz may be effective in reducing stress levels. The design and functionality of the system was defined based on an interface analysis of relaxation applications such as Calm and Headspace. The interface analysis looked at the visual elements, overall aesthetics and layout of the applications to define concepts that can be used in the development of the relaxation system. Once the design of the application was defined, unified modelling language (UML) diagrams were used to demonstrate the overview of the system and how it will interact with the user. Based on the interface analysis that was conducted in this chapter, it was found that minimalistic and modern designs seem to be common amongst popular relaxation applications. These applications tend to have soft colours and visual elements such as nature imagery, and the information provided is presented in a non-cluttered way.

3.1 Analysing Sounds for Relaxation Purposes

The sounds that were analysed in this section were chosen based on the sound design principles that were found to be effective in reducing stress levels in Section 2.2. The types of sounds that were found to be stress reducing are ASMR, monochord, nature, and binaural beat (brainwave entertainment) sounds. A total of eight sounds were chosen as an example of these sound design principles. These sounds were analysed in the digital audio workstations Audacity and Logic Pro X by importing the audio files and using three spectrogram tools to view the spectrum of frequencies of the sounds (See Appendix 2). The sounds that were analysed are detailed in Table 3.1.

Table 3.1: List of Sounds Analysed

Type	Name	Description	Author	Source
ASMR	*ASMR Brain Tingling Triggers For INSTANT Sleep (Plucking, Scratching, Rubbing)*	Whispering, scratching, tapping, water/slimes, and stroking fabric sounds	DennisASMR	YouTube
ASMR	*Be Calm & Sleepy ASMR for Anxiety*	Soft talking, whispering, soft breathing, tapping, scratching, and stroking fabric sounds	WhispersRed ASMR	
Nature	*4K Sunset Relaxing Video for Sleep and Relax Nature Music Screensaver Birds and crickets*	Insects such as crickets and bird sounds	Relax by Red Conifer	
Nature	*Calm River Mountain, Nature Sounds, Meditation, short relaxation*	Water, wind/tree, birds, insect sounds	YouTherapeutic	
Brainwave Entertainment	*Brainwave Entertainment*	Droning music, beating frequencies	Symphonic Distribution	
Monochord	*Soundbed*	String plucking, droning music in the same frequency	juskiddink	Freesound
Monochord	*Soundbox*	String plucking, droning music in the same frequency	juskiddink	
Monochord	*Julia-Monochord-Klangreise*	Droning music in the same frequency	stefan_machu	

Table 3.2 shows the results of the analysis of the relaxation sounds. When looking at the frequency content of the two ASMR tracks, most of the audio content is below five kHz which can be attributed to sounds like soft talking and breathing, and there were peaks in amplitude at 160, 200, and 250 Hz which can be caused by tapping sounds and strong whispering. The monochord sounds consisted mostly of frequencies below six kHz and peaks up to 1.2 kHz were also present. The nature sounds from the “4K Sunset Relaxing Video for Sleep and Relax Nature Music Screensaver Birds and crickets” video had most of its audio content in the two to six kHz frequency range, with some peaks at 2.5, 3.1, and four kHz (Relax by Red Conifer, 2019). The sounds from the “Calm River Mountain, Nature Sounds, Meditation, short relaxation” video had a lot more frequencies below five kHz and also some peaks at 200 and 250 Hz as shown in Figure 3.1 (YouTherapeutic, 2020).

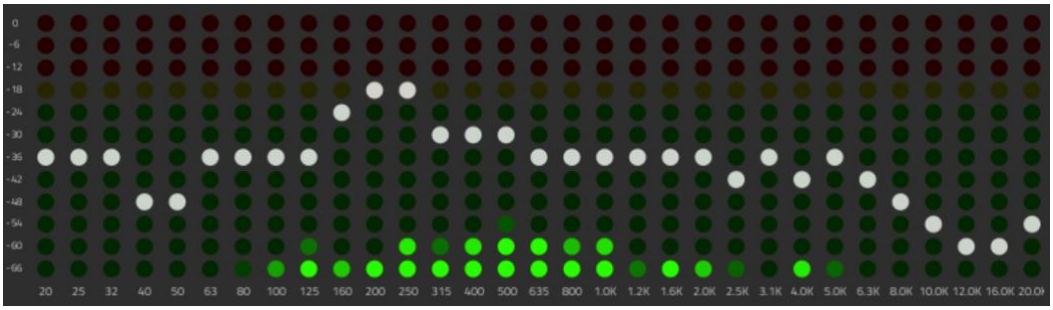


Figure 3.1: Spectral Analysis of "Calm River Mountain, Nature Sounds, Meditation, short relaxation" Sound Using HoRNet ThirtyOne in Audacity (Audacity, 2020).

The brainwave entertainment sounds consisted mostly of frequencies below 800 Hz with peaks at 160, 200, 250, and 315 Hz. Looking at the analysis of these sounds, there seems to be a commonality that sounds with frequency content mostly below six kHz and with some peaks at 160, 200, and 250 kHz are effective in lowering stress levels. Further research needs to be conducted to determine which other audio characteristics play a part in reducing stress levels.

Table 3.2: Results of the Analysis of Relaxation Sounds

Sound	Sound level (in dBFS)			Frequency content (in Hz)		Temporal Variation
	RMS Value	True Peak Value	Max Crest Factor	Consistent level of sound	Peaks	
ASMR Brain Tingling Triggers For INSTANT Sleep (Plucking, Scratching, Rubbing)	- 27.6	1.8	24.2	At around -24 dB from 25 to 3.1k	160, 200, and 250	Intermittent
Be Calm & Sleepy ASMR for Anxiety	- 44.1	- 9.3	21.3	At around -36 dB from 20 to 5k	160, 200, and 250	
4K Sunset Relaxing Video for Sleep and Relax Nature Music Screensaver Birds and crickets	- 44.8	- 22.9	13.8	At around -42 dB from 2k to 6.3k	2.5k, 3.1k, 4k	
Soundbed	- 16.5	- 1.1	9.6	At around -18 dB from 40 to 800	125 and 160	Continuous
Soundbox	- 23.8	- 4.3	14.7	At around -30 dB from 100 to 6.3k	500, 635, 800, 1k, and 1.2k	
Julia-Monochord-Klangreise	- 23.3	- 6.5	9.5	At around -24 dB from 100 to 635	315	
Calm River Mountain, Nature Sounds, Meditation, short relaxation	- 49.9	- 29.6	11.5	At around -36 dB from 20 to 5k	200 and 250	
Brainwave Entertainment	- 25.2	- 9.4	11.2	At around -30 dB from 40 to 800	160, 200, 250, and 315	

Along with the frequency content analysis that was conducted using Audacity, the sounds were additionally analysed using the spectrum analysis plugins Voxengo SPAN and Blue Cat FreqAnalyst in Logic Pro X, and HoRNet ThirtyOne in Audacity. The FreqAnalyst and ThirtyOne plugins were used to further analyse the frequency content of the sounds. The Root-Mean-Square (RMS) value, the true peak value, and the maximum crest value were determined with the SPAN plugin, and the temporal variation of the sounds was determined by visually analysing the waveforms. The RMS value is a way of measuring the energy contained in an audio signal (Brixen, 2012). It is an average of the instantaneous sound pressures of an audio signal (Kinsler, Frey, & Mayer, 1963). The peak value is the instantaneous maximum amplitude value within an audio signal over a specific period of time. The crest factor is used to measure the difference between the RMS and peak values and corresponds to the peak value divided by the RMS value (Brixen, 2012).

The temporal variation is used to determine the type of sound. By looking at the temporal variations in sound pressure level, it is possible to classify the sound as continuous, intermittent, or impulsive. The difference in temporal variation is visible in the sound's waveform as seen in Figure 3.2. Continuous sound has very little fluctuations in sound pressure level. A sound can be described as intermittent when the level lowers several times to the background noise. Impulsive sound has one or more bursts of energy that are short in duration (Kinsler et al., 1963).

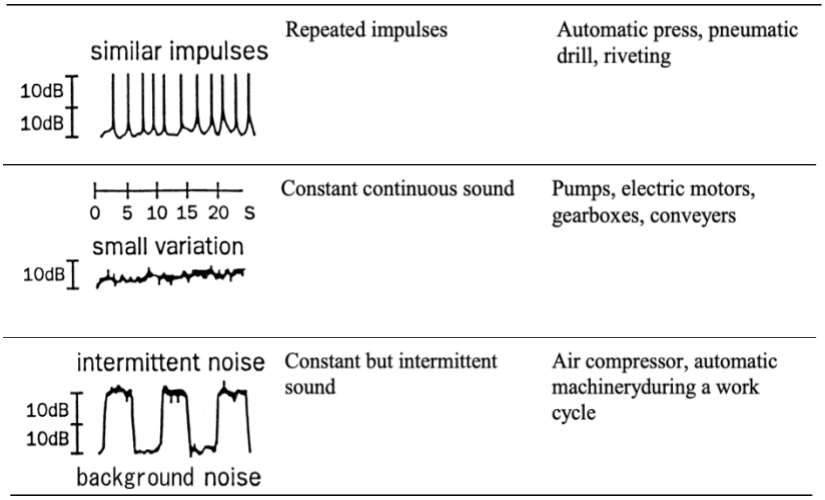


Figure 3.2: Types of Temporal Variation in Sound (Kinsler et al., 1963, p. 46).

The temporal variations of the sounds were determined by looking at the RMS levels at various points in the sound. If there was more than a 40 dB change in RMS level within 0.5 s, then the sound was determined to be impulsive. If the RMS level was constant within around 5 dB for 0.5 s, then the sound was determined to be continuous. If the sound was neither constant nor impulsive then it was determined to be intermittent. The sound “Calm River Mountain, Nature Sounds, Meditation, short relaxation” was determined to be a continuous sound as the RMS level at 1 min 7 s is -50.2, and at 1 min 7.5 s it is -49.7 which means that there is a difference of less than five decibels, as shown in Figure 3.3 (YouTherapeutic, 2020).

Figure 3.3: RMS Level of “Calm River Mountain, Nature Sounds, Meditation, short relaxation” Sound at 1 min 7 s (Top) and at 1 min 7.5 s (Bottom) (Apple Inc., 2020).

When looking at the temporal variation of the sounds in Table 3.2, five of them are continuous and three are intermittent. The intermittent sounds are two ASMR tracks which feature sounds like tapping and whispering, and one nature track that features sounds like crickets and birds. Non-steady sounds like tapping and animal sounds could explain the intermittent nature of the tracks. The continuous sounds are three monochord tracks and one nature track that features river sounds. The monochord and brainwave entertainment tracks have little amplitude and frequency dynamics which produces a droning and steady type of sound, and the river sounds in the nature track are steady and remain the same throughout the length of the sound. These characteristics could explain the continuous nature of the sounds.

3.2 Interface Analysis of Relaxation Apps

The requirements analysis for a relaxation application can be conducted by performing an interface analysis of other similar systems. The apps that will be analysed are Headspace, Calm, Companion, Nature Sounds, Meditopia, and Sanvello. In particular, Headspace and Calm are interesting to look at as both applications have shown

positive results in helping users decrease their stress levels. Both applications start with three steps: sign up for the app (through Facebook or email), set up user preferences through a short quiz (see Appendix 3.1), and accepting the privacy policy notice. When setting up the preferences, some common questions from both apps are the reasons for using that app and the user's experience level with meditation (see Figure 3.4 and 3.5).

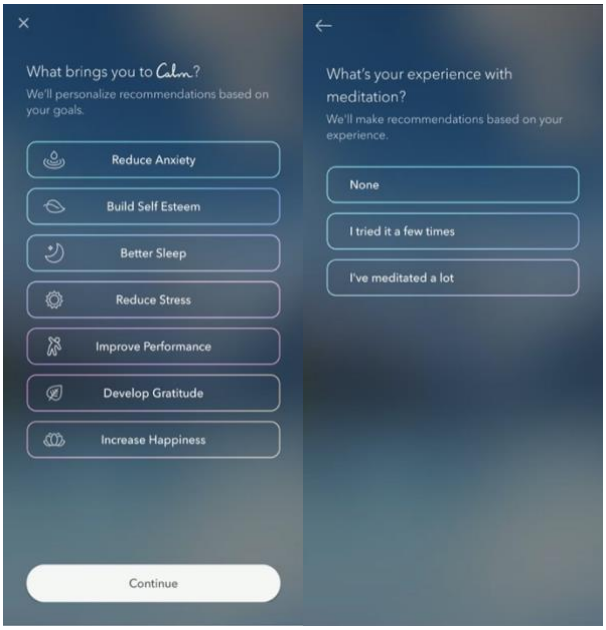


Figure 3.4: Questions from Calm's User Preference Quiz (Calm.com, Inc., 2020a).

By setting up the user preferences, the app is personalised to the user and a recommended relaxation plan can be offered (see Appendix 3.2). Both applications have various types of relaxation content such as guided meditations, music, sounds, and mindfulness knowledge. Each application has a clear design aesthetic that makes it uniquely distinguishable.

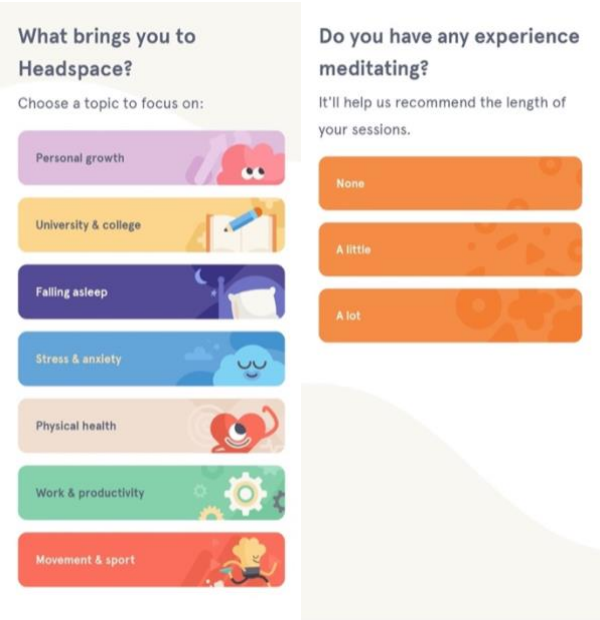


Figure 3.5: Questions from Headspace's User Preference Quiz (Headspace, Inc., 2020a).

Calm has soft blue tones and occasional splashes of colour, but overall it is very clean, modern and minimalistic. The app has nature imagery in the background, which is used to create a calming, serene experience as shown in Figure 3.6. Headspace has a bright colour palette with pale oranges, yellows, whites, and greys. Similar to Calm, it has a simplistic, clean design aesthetic. The app has visual elements such as drawings which help to contextualise the content of the app and give it life and character as shown in Figure 3.7.

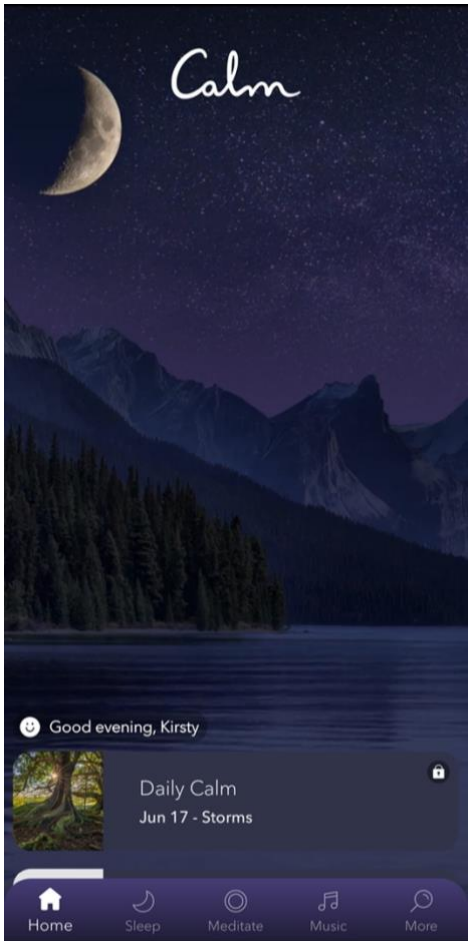


Figure 3.6: Calm's User Interface (Calm.com, Inc., 2020a).

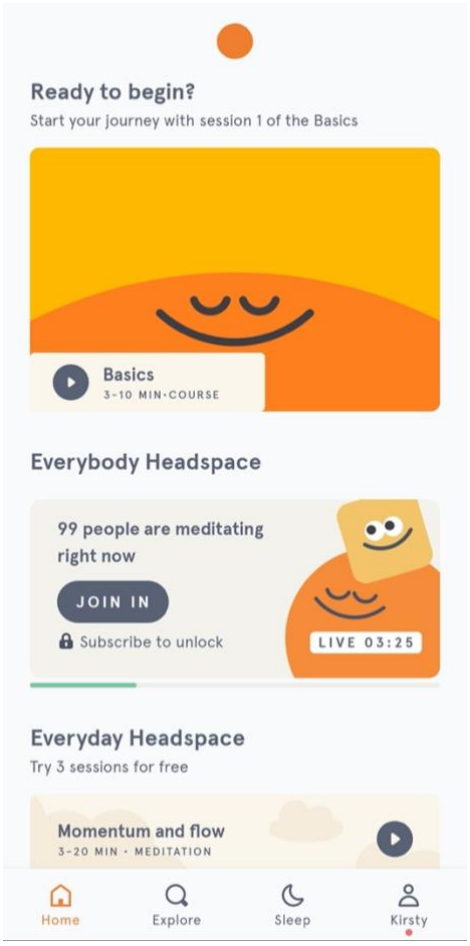


Figure 3.7: Headspace's User Interface (Headspace, Inc., 2020a).

The clean and simple design choices for the app can be understood as a way to not overwhelm the user with too much information and visual stimulation which could make the user feel stressed. Instead the information in the applications is spread out and given in a step-by-step format so as to not give the user too many things to focus on at once.

Based on the interface analysis, the visual design elements that can be considered for the relaxation application are minimalistic, modern and clean design with a cohesive colour palette that isn't too striking, and calming visuals such as nature or drawings. Along with the design aesthetics, it would be useful to have the information of the application spread out and not congregated in one place so as to not clutter the app and overwhelm the user.

Table 3.3: Comparison of Relaxation Applications

Meditation Apps	Setup Process	Design Aspects	Colours	Visual elements	Content Offered
Headspace	1) Sign up 2) Choose preferences: reasons for using the app, level of experience with meditation, and set meditation reminder	Clean, modern, energetic	Orange, yellow, beige, grey	Drawings	Meditations, workouts, mindfulness skills, relaxing music, and sleepcasts (sleep podcasts)
Calm	1) Accept privacy policy 2) Choose preferences: reasons for using the app, frequency of feeling anxious. biggest source of anxiety, and way of experiencing anxiety 3) Sign up 4) Additional user preferences questions: type of content to explore and level of experience with meditation	Clean, minimal, modern, relaxing	Blue, grey, white	Nature imagery	Guided meditations, breathing exercises, relaxing music, sleep stories, soundscapes
Companion	1) Sign up	Clean, minimal, modern, simple	Blue, teal, green, white	No distinct elements	Breathing exercises, audio relaxation guides, thought reframing, written guides
Nature sounds	1) Accept privacy policy	Colourful, modern	Blue, purple, green, grey	Nature imagery	Nature sounds
Meditopia	1) Sign up 2) Choose preference: Set 3 goals for using the app	Clean, modern, relaxing	Blue, purple, white	Nature imagery	Mindfulness skills, music, meditation, sleep stories
Sanvello	1) Choose preferences: Choose theme, set 3 goals for using the app, set reminder 2) Accept privacy policy 3) Sign up	Colourful, modern, energetic	Blue, black, grey, green	Nature imagery	Mindfulness skills, meditation, music playlist, health tools (sleep, exercise), thought journal, guided journeys

As well as Headspace and Calm, the relaxation applications Companion, Nature sounds, Meditopia, and Sanvello were analysed as shown in Table 3.3 (see Appendix 3). Headspace, Calm, Meditopia, and Sanvello all feature user preferences questions during the setup process of the application. The one question in common with all four application was the goals or reasons for using the application. Looking at the design elements and colour scheme of all the relaxation apps, most of them have some form of nature imagery and tend to have a blue colour palette. The applications have modern

and clean user interfaces. The content that is common in most of the applications is mindfulness skills, meditations, and relaxing music and sounds.

3.3 Defining the Elements of the Application

The application will use sensors to determine when the user is feeling stressed and when the system needs to generate relaxing sounds to calm them down. The sensors that would be useful to use for the application can be found in most smartphones and smartwatches and are listed in Table 3.4. Other than connecting sensors to the application, it is useful to consider the possibility of connecting the app to a smart speaker. Both Headspace and Calm allow their users to connect the app to a smart speaker such as Google Home or Amazon Echo (Google LLC, 2020a; Amazon.com, Inc., 2020). Headspace allow its users to connect the app to a Google Home or Amazon Alexa assistant (Headspace, Inc., 2020b). Once connected the user can say commands such as "Hey Google, tell Headspace I'm ready to meditate" to listen to the app's content through their smart speaker (Headspace, Inc., 2020c). The Calm app can be connected to Google Home, Apple HomePod, and Sonos smart speakers (Calm.com, Inc., 2020b). When it is connected to a Google Home speaker, the user can listen to app content such as guided meditations, body scans, and sleep stories through the speaker (Calm.com, Inc., 2020c). The relaxation app will be developed by looking at the design elements that were defined during the interface analysis of the apps Calm and Headspace.

Table 3.4: List of Sensors That Can Be Used for the Relaxation Application

Sensor Type	Device it's used on	Use for the application
Light sensor	Smartphone	Determine the light level in a room if the user is about to go to sleep and needs relaxing sounds to fall asleep.
Microphone		Determine if the user is in a stressful environment, monitor the stress in a person's voice, and detect voice commands.
GPS sensor		Determine if the user is at home or not, or if they are in a stressful location and they may need relaxing sounds to calm them down.
Heart rate (HRV and ECG)	Smartwatch	Determine when the user is feeling anxious.
Accelerometer		The motion sensor can be used to disregard any increase in heart rate if it's due to physical activity and can reduce false positive detections of stress.

As well as monitoring the user's stress levels, the app will track the user's moods and feelings by asking them how they are feeling. This can be set up and disabled in the user preferences, and the user can determine how often the app will prompt them to input how they are feeling. This can be found in existing relaxation applications such as Sanvello, which checks in with the user and asks them to log their moods, as shown in Figure 3.8 (Sanvello Health Inc., 2020).

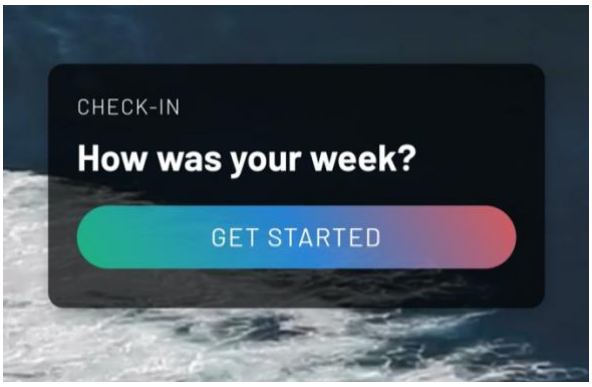


Figure 3.8: Mood Log Prompt from the Relaxation Application Sanvello (Sanvello Health Inc., 2020).

Along with logging the user's mood, the app will ask the user how they are feeling when listening to sounds for the first time, and if the user has a negative reaction to the sound then it will be registered as not usable for that user and similar sounds will also be removed for them. If the user has a positive response to a sound, then the app will register that those types of sounds are effective in relaxing the user and will continue to play similar sounds. Possible future developments of this application can use this principle to create a smart sound environment for the user that will automatically respond to what their preferences are.

The Nature Sounds application allows the user to control the sounds they are listening to by giving them an option to layer different types of sounds to create a unique sound and experience for then, as shown in Figure 3.9 (Relaxio s.r.o., 2020). In a study that asked participants to create a mix based on nine various relaxation sounds and then listen to it to relax, it was found that the monotonous task of mixing the sounds was perhaps stress-relieving in itself. The ideal relaxation mix varies depending on each person so allowing the user to personalise the sounds they listen to is helpful in achieving an optimal stimulus (Baracskai & Finn, 2013). This suggests that

implementing an element of control of the sound for the user may be useful for the relaxation application. The user will be able to control the volume of the sound, as well as the sounds available to them and layer them together.

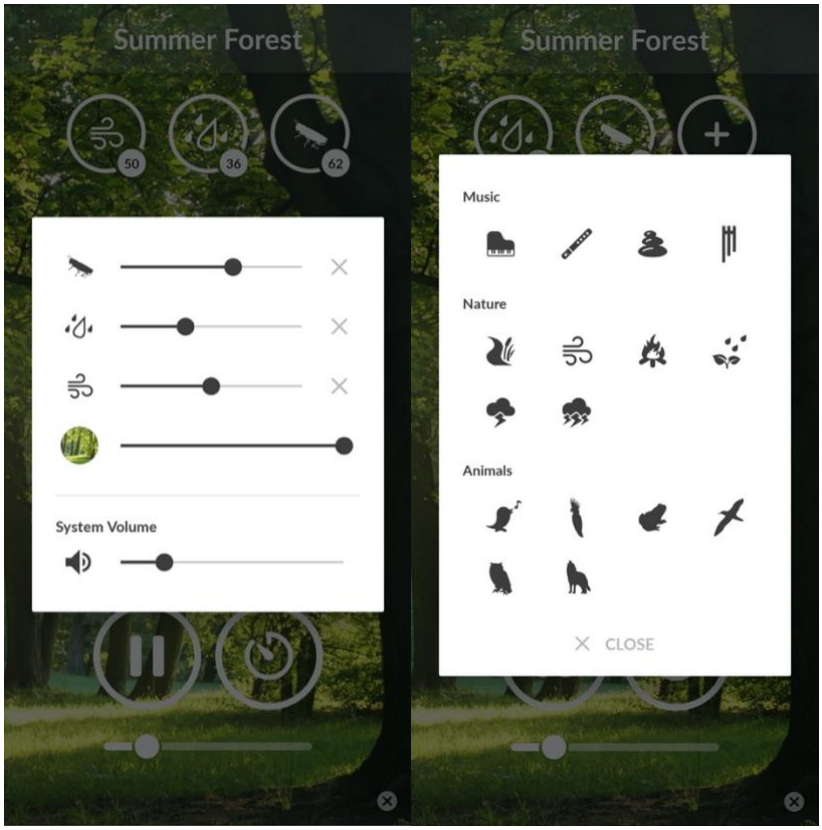


Figure 3.9: Interface for Choosing Sounds in the Application Nature Sounds (Relaxio s.r.o., 2020).

3.4 Summary

By analysing the sounds that can be used to reduce anxiety it is possible to derive design concepts that can be used in the production of sounds for the application. The eight sounds that were chosen were based on the research conducted in the literature review on sounds for relaxation purposes, and they are ASMR, nature, monochord, and brainwave entertainment sounds. The analysis of these sounds based on their frequency content shows that sounds below five kHz with some peaks up to 15 kHz seem to be effective in lowering stress levels.

The interface analysis of the relaxation applications was conducted to provide a set of design elements that can be used in the development of a relaxation system. Aesthetical designs such as colour palettes and other visual element, as well as the

functionality and layout of the applications were analysed. The applications were observed to make use of a minimalistic and modern design for the interface with soft colours, and visual elements such as nature imagery and drawings. In terms of the layout of the applications, the information is not overwhelming to the user and is presented in a spread out and non-cluttered way.

The sensors that can be used for a relaxation system to measure the stress levels of a user were explained. The smartphones sensors that can be used are light sensors, microphones, and GPS sensors, and the wearable sensors that can be used are heart rate sensors (HRV and ECG) and accelerometers. By defining the design elements and sensors that will be used, and the sounds that will be integrated into the system, it is possible to create an overview of the application. Creating an overview of the system helps to define how it will be developed and how a user could interact with it.

4 Application development

In this chapter, the application development method was defined based on the research conducted in the previous chapter. The method for developing the application focuses on the visual design elements, the sound design principles, and the functional aspects. The sound design principles that were used to develop the sounds for the app were further defined based on the research conducted in the literature review and the analysis of sounds in the previous chapter. The sounds for the application were produced once the design principles were defined and the process of creating them was described. Five nature and five ASMR sounds were produced, and they include waves, birds, insects, wind, stream, water, paper, tapping, scratching fabric, and whispering sounds. The prototype of the application was created after the sounds were produced, and it implemented all of the design and functional elements that were previously defined. The application, named ZenSounds, was produced and deployed based on the requirements that were laid out, and it featured visual elements such as nature imagery and a simple user interface that was easy to navigate.

4.1 Application Development Method

The method for developing the application was inspired by the interface analysis conducted in the previous chapter. Based on the analysis of the relaxation applications in Section 3.2, design aspects that will be used for the app were defined and are listed in Table 4.1.

Table 4.1: Design Aspects That Can Be Used in the Relaxation Application:

Design Aspect	Description
Colour	Single, soft, less vibrant, non-aggressive colour across the app, part of the branding
Navigation	Simple, minimal text and information, easy to set up and access the app
Visuals	Calming visuals such as nature imagery
Sounds	Nature and ASMR sounds that can be controlled by the user.

The functional elements of the app were based on the research from Section 2.4 that demonstrates that multimodal user interfaces can be less stress inducing for users. The user will be able to control the app through their phone or wearable touch screen, and through voice commands either to their phone or to their wearable device. Another main functional element of the app will be that when setting up the app the user will

take a preference quiz which will determine the best sounds to use and propose a relaxation plan for them, along with gathering user information that could be used to create an adaptable user interface. The user also has the choice to use the sensors in their phone or to connect wearable devices to the app. The prototype for the app that will be created in this dissertation will be a simplified version of this application. The main aspect of the prototype is to give the user an example of an experience they could have with the fully developed app. The prototype will allow users to navigate the app and chose different sounds to listen to.

Figure 4.1 shows the overview of the system as a UML (Unified Modelling Language) use case diagram and how it will function for the user. The first action the user will take when they use the app will be to sign up and set the user preferences. The user will be able to set up the permissions by choosing what the app has access to in the phone and the sensors it can use. The user can change these regularly so they will be asked to choose how often they want to be reminded to change the permissions (once a month, every six months, etc.) or the user can choose to accept once. The user can switch off app monitoring whenever they like, and this can be set up in the user preferences. When the user preferences have been set up, they then have the option to connect their wearable technologies for an advanced stress measuring ability and app experience. They can also begin logging their data which includes environmental, physiological, and psychological data. Once they have successfully set up the app, they can get access to the content of the app and their personalized relaxation plan. After they have used the app for the first time, they will gain access to their health log where they can see the information gathered from their phone and wearable readings.

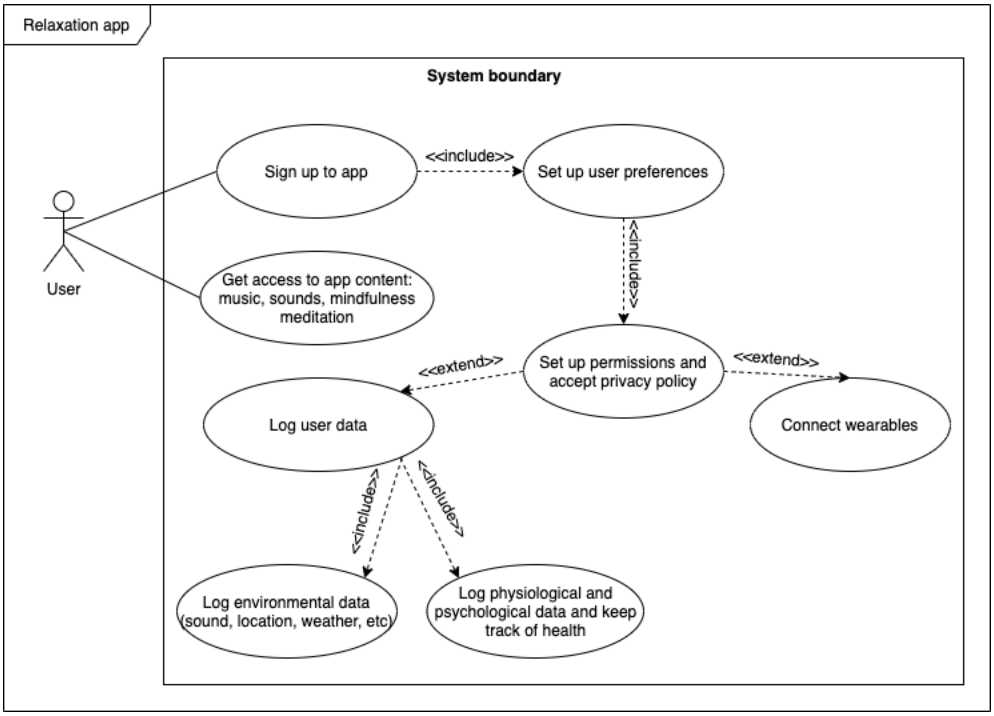


Figure 4.1: UML Use Case Diagram for Relaxation App

Figure 4.2 shows a more detailed overview of the system as a UML activity diagram. When the user signs up for the app and is successful, they can begin setting up their preferences, otherwise they will be brought back to the start of the app. Once they have signed up, the user will set up the preferences by agreeing to the privacy policy and setting a reminder for when they want to renew the agreement. After the user has set up their preferences, they will be able to choose between setting up sensors for the app or accessing the content of the app without monitoring the user. If the user wants to connect sensors, then they can set up environmental and physiological sensors, as well as connecting other devices such as smart speakers. Once the user has decided on their sensor setup, they can calibrate the sensors and measure their physiological base level. Once the sensors have been fully set up, they can gain access to the content of the app and their own personalised relaxation plan. After they have used the app, the user will be able to get access to their health data in a log.

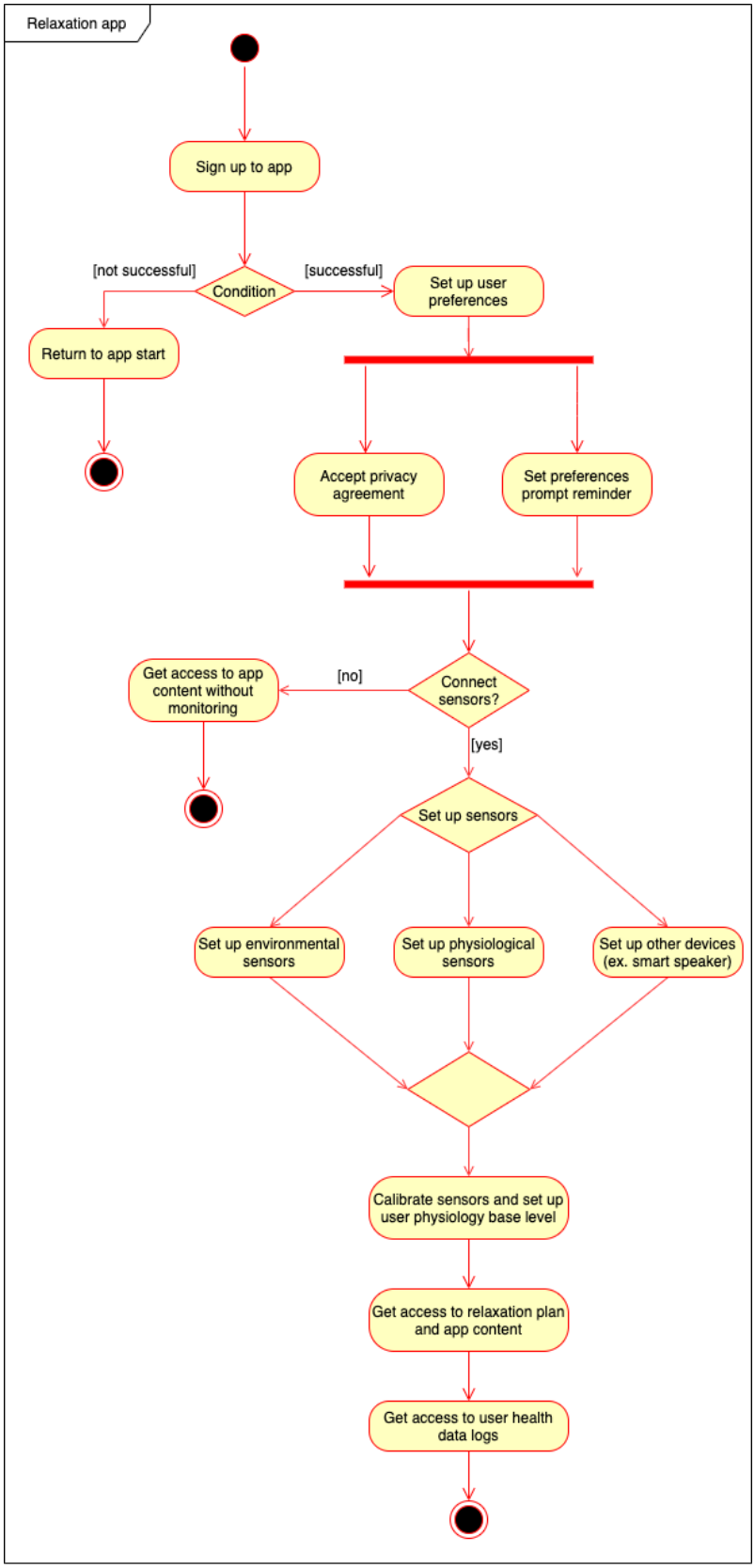


Figure 4.2: UML Activity Diagram for Relaxation App

4.2 Defining the Sound Design Principles

The sounds that will be used in the application will be non-music based. Thus, the sound design principles for producing the sounds for the application are focused on ASMR and nature sounds, as both monochord and brainwave entertainment sounds have musical qualities. Based on the research conducted in Section 3.1, the sound design principles for ASMR and nature sound are shown in Table 4.2.

Table 4.2: Sound Design Principles for Relaxation Sounds

Type of sound	Frequency content (in Hz)	RMS level (in dB)	Peak level (in dB)	Max Crest Factor (in dB)	Temporal variation	Examples of sounds
ASMR	Mostly <5k with peaks at 160, 200 and 250	-44 to -27	-9.3	21.3 to 24.2	Intermittent	Tapping sounds, whispering, and crisp sounds
Nature	Mostly <6k with peaks at 200, 250, and 2-4k.	-49.9 to -44.8	-29.6 to -22.9	11.5 to 13.8	Intermittent or continuous	Animal sounds (birds, crickets), river sounds, rain sounds, and tree sounds.

Each sound will be one minute in length and a total of ten sounds will be produced, five ASMR and five nature sounds. When deciding which types of nature sounds to produce, it is important to look at the possible positive or negative associations related to the sounds.

Nature sounds such as wind, water, and birds have been shown to have a relaxing effect (Ratcliffe, Gatersleben & Sowden, 2016). Bird sounds have been found to be an important aspect of nature sounds and have an association with imagined environments. Bird sounds can have positive or negative associations. The sounds that were considered positive were associated with green spaces and the seasons of spring and summer and are commonly found in familiar places for people such as in gardens. The negatively associated sounds were linked with exotic and marine environments and with negative bird behaviour. In general, bird sounds are found to have positive associations for people, but this can vary based on different types of bird species. Amongst the bird sounds that have been shown to have positive associations for people, the birdsongs of dunnocks, greenfinches, blackbirds, silvereyes, and brown thornbills were found to be the most effective in relaxing people. An example of bird sounds that can have negative associations are screeching or owl hooting sounds as they may be frightening for some people. Songbirds are more likely to have positive

associations than non-songbirds as the latter may be linked to aggressive or threatening attributes (Ratcliffe et al., 2016).

The nature sounds that will be produced will use bird sounds that are found to have positive associations. Table 4.3 shows the details of the sounds that will be produced.

Table 4.3: Description of the Sounds That Will Be Produced

Type of sound	Description
ASMR	Sounds of soft fabric being scratched and stroked
	Whispering and soft-spoken sounds
	Solid objects tapping sounds
	Underwater sounds
	Paper and writing sounds
Nature	Insects (evening)
	Wind in trees
	Waves
	Gentle stream
	Birds (morning)

4.3 Producing the Application Sounds

Five ASMR and five nature-based sounds each around one minute in length were produced for the application. As shown in Table 4.4, most of the sounds for the application were sourced from the online sound library Freesound, other than the scratching, paper and writing, and tapping sounds that were all recorded (2020, Freesound). The sound of fabric being scratched and stroked was produced by recording the sounds from various objects such as a plush toy, a satin cushion, and a cotton cushion. The tapping sounds were produced by recording objects such as a cardboard box and glass jar being tapped with fingernails. The paper and writing sound was produced by recording the pages of a book being turned and paper being written on with a pencil and a marker. The whispering and soft-spoken sound features a recording of two people quietly talking with minimal ambient noise in the background. The underwater sound was created by layering three different recordings that were done underwater with a hydrophone. For the insects sound, it was decided that sounds of evening insects would be ideal so recordings of cicadas, crickets and distant frogs were used. The wind in trees, waves, and gentle stream sounds all use multiple recordings of their respective sounds to create a fuller and more dynamic sound. The birds sound uses a recording of blackbirds in the morning which complements the

insects sound which is in the evening. Blackbirds were chosen as they were found to be one of the most effective birdsongs in relaxing listeners (Ratcliffe et al., 2016).

Table 4.4: Description of Sounds Produced for the Application

Type	Description	Name	Author	Source
ASMR	Sounds of soft fabric being scratched and stroked	*Fabric*	Kirsty Bryce	Recording
	Paper and writing sounds	*Paper*		
	Solid objects tapping sounds	*Tapping*		
	Underwater sounds	*underwater5 06-09-2012*	wescwave	Freesound
		underwater	monica137142	
		underwater ambience	akemov	
	Whispering and soft-spoken sounds	*Whisper Ambience*	Piggimon	
Nature	Insects (evening)	*Frogs and Cicadas at Night in Tennessee*	heyheymaimai	
		Crickets At Night - Clean sound	Defelozedd94	
		Cicadas chirping at night (choir)	CaganCelik	
	Wind in trees	*Wind Rustling Trees*	FunWithSound	
		Tree Rustle 3	le_abbaye_Noirlac	
	Waves	*Waves*	juskiddink	
		Ambience, Seaside Waves, Close, A	InspectorJ	
	Birds (morning)	*Dawn_chorus_5AM*	strangely_gnarled	
	Gentle stream	*Relaxing, Mountains, Rivers, Streams, Running Water*	INNORECORDS	
		Stream Wyre forest 8.1.14	turbostream	

The sounds that were produced for the application were analysed, as shown in Table 4.5. All of the ASMR sounds are intermittent, and all of the nature sounds are intermittent other than the insects sound which is continuous. The frequency content of the ASMR sounds is mostly below 5 kHz, other than the whispering and paper sounds which have frequency content below 12 kHz. The frequency content of the nature sounds is below 12 kHz.

Table 4.5: Analysis of the Sounds Produced for the Application

Sound	Type of sound	Sound level (in dBFS)			Consistent level of sound (in Hz)	Temporal Variation
		RMS Value	True Peak Value	Max Crest Factor		
Sounds of soft fabric being scratched and stroked	ASMR	- 54.3	- 22.2	9.6	At around - 42 dB from 20 to 1.0k, and peaks at 50-100	Intermittent
Paper and writing sounds		- 51.4	- 22.2	18.4	At around - 42 dB from 1.2k to 12.0k	
Solid objects tapping sounds		- 49.5	-13.7	20.5	At around - 36 dB from 20 to 315	
Underwater sounds		- 40.8	- 21.7	16.2	At around - 42 dB from 20 to 2.0k	
Whispering and soft-spoken sounds		- 53.9	- 17.7	14.0	At around - 48 dB from 20 to 10.0k, and peaks at 160 and 200	
Insects (evening)	Nature	- 43.7	- 29.1	10.9	At around - 48 dB from 25 to 250, and peaks at 2.5k-5.0k	Continuous
Wind in trees		- 48.4	- 31.4	19.6	At around - 48 dB from 63 to 12.0k	Intermittent
Waves		- 42.6	- 21.4	10.1	At around - 42 dB from 20 to 12.0k	
Birds (morning)		- 47.7	- 27.5	20.8	At around - 48 dB from 315 to 4.0k	
Gentle stream		- 45.9	- 24.7	16.1	At around - 42 dB from 1.6k to 8.0k	

4.4 Developing the Application Prototype

The development of the application was done using the prototyping software Axure. A basic version of the application described in Section 4.1. was developed where the user isn't required to sign in to use the app, they are first greeted with a start screen asking them to continue. In future developments of the application, the start screen will include a log in and sign up process before continuing to the rest of the app. In the prototype, once the user has pressed the "continue" button, they then see the sounds page where they can choose from ten nature and ASMR sounds (five of each). When the user clicks on a sound, they are then taken to the page of that sound where the sound plays once the user presses the "play" button. The sound loops until the user presses the "pause" button or changes the sound. The audio control buttons on the pages for each sound are fully functional. When the user presses play, the "play" button is replaced with the "pause" button and vice versa. The "previous" button restarts the sound when pressed once and goes to the previous sound if pressed twice, or back to

the sounds page if it's the first sound on the list. The "next" button takes the user to the next sound or back to the sounds page if it's the last sound on the list.

The name that was chosen for the application is ZenSounds as the purpose of the app is to relax people by listening to sounds. Most of the application was developed in Axure without the need to manually code, but the software does not support the use of audio in prototypes. After the development of the initial design of the app and all of the functionality other than the implementation of the sounds and audio controls, the code from Axure was exported and the application was further developed in Visual Studio Code. Once the HTML, CSS, and JavaScript code was exported, the sound was added to the application using JavaScript. The functionality of the audio control buttons was also added with JavaScript, as shown in Appendix 4. When all of the functionality of the application had been finalised with JavaScript, the app had to be deployed using GitKraken and hosted on Github, as the prototype could no longer be hosted using Axure's cloud hosting services as they do not support audio.

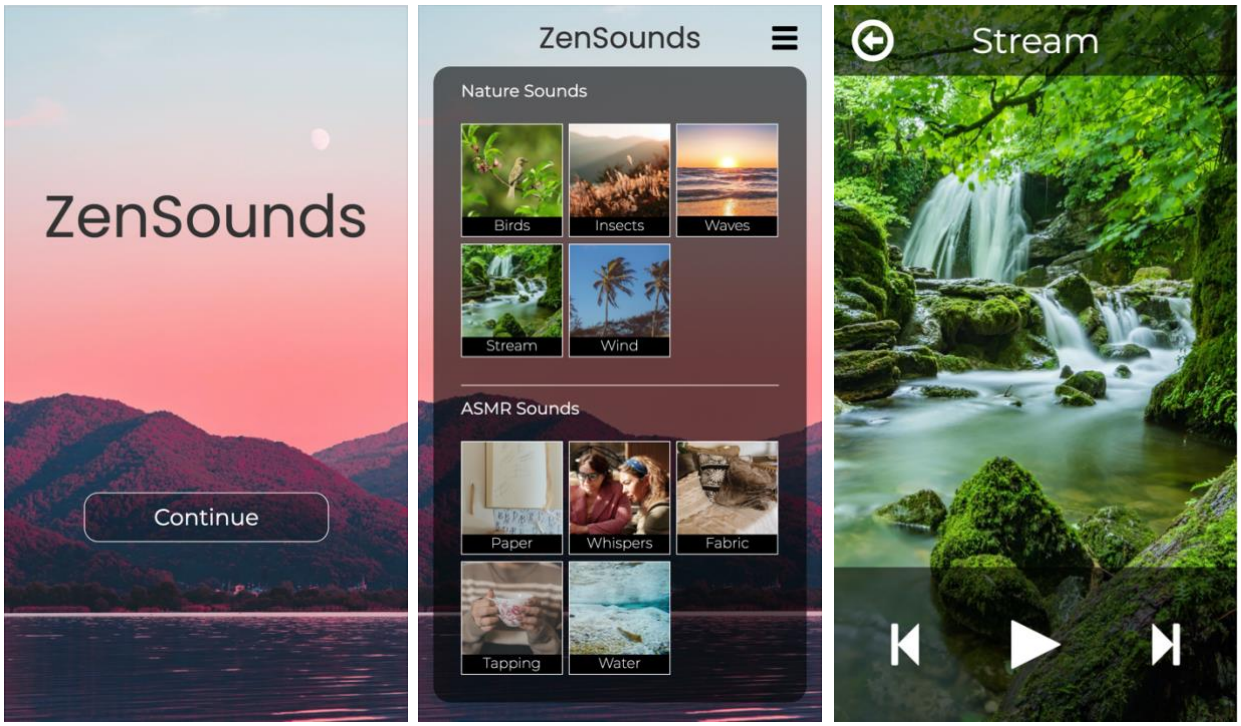


Figure 4.3: Screenshots of the ZenSounds app (Bryce, 2020)

The design of the app was developed based on the design aspects that were laid out in Section 4.1. The navigation of the application was kept simple without too much information and text to not overwhelm or confuse the user. The visual aspects of the app are nature pictures, as shown in Figure 4.3. Each sound has an accompanying image to contextualise the sound and help the user to feel like they are experiencing the sound in real life.

The quality control of the application was conducted by verifying and validating that the system meets the user's needs. The verification of the application can be done by making sure that the requirements of the system are met and being implemented correctly. The requirements of the simplified version of the system that is being developed for the prototype is to create an interface where the sounds of the application are displayed, there is nature imagery, and the sounds can be accessed and listened to. These requirements were met as there is a successful implementation of the design elements such as nature imagery and functionality such as access to nature and ASMR sounds. The validation of the system can be conducted by analysing whether the needs of the users were met. The needs of the user are to access the application, be able to see the different sounds available for them to listen to, click on them and listen to the sounds, control the sounds by playing, pausing, restarting, and skipping them. These requirements were met in the development of the prototype as the ten sounds were successfully implemented and the users have full control over the sounds they listen to. The functionality and UI of the application was purposefully designed to be easy to use which aims to help the user access and listen to the sounds with little difficulty and confusion. The testing of the system will determine if there is anything that will need to be changed or added to future versions of the application.

4.5 Summary

Based on the guidelines laid out in the requirements analysis for the application in Chapter 3, the functionality and design of the app was defined. The design aspects of the app that were defined were the colour scheme, the navigation, the visuals, and the sounds. The prototype was defined as being a simplified version of the application that was described in the requirements analysis. The prototype allows the user to navigate the app and choose different sounds to listen to. UML diagrams were created to show

a more detailed overview of the system and how it could function in future developments.

The sounds of the app were defined based on the analysis of ASMR and nature sounds in Chapter 3, and the individual sounds of the app were described. Based on the analysis of ASMR and nature sounds, a guideline for the measurements of the sounds was defined including the frequency content, RMS level, true peak level, maximum crest factor, and the temporal variation. The nature sounds for the application include waves, birds, insects, wind, and stream sounds. The ASMR sounds for the application include water, paper, tapping, scratching fabric, and whispering sounds.

After the sounds for the application were defined, they could start being produced. Other than three sounds that were recorded, all of the sounds were sourced from the sound library Freesound.org. The three sounds that were recorded were the fabric scratching, tapping, and paper sounds. Other than birds and whispering, the sounds that were produced from the sound library used two or more sounds that were layered to create a more unique and in-depth soundscape. Once the sounds were produced, they were analysed to verify that they met the guidelines for the sounds defined in Section 4.2.

The prototype of the application was created using Axure and was based on the application development methodology defined in Section 4.1. Most of the prototype was created with Axure, with the addition of some JavaScript coding for the addition of audio and the functionality of the audio controls. The prototype was deployed using GitKraken and is hosted on GitHub. The application was named ZenSounds and was designed with nature visuals and simple navigation so that it is easy to use.

5 Application evaluation

In this chapter, the application was evaluated by conducting a survey and listener test, and the results were then analysed and discussed. The background of the study was defined with the purpose of contextualising and describing the process of the research. The information that needed to be gathered, the reasons for gathering it, and the expected outcomes of the study were detailed. Once the background had been explained, the method of the study was defined to further develop the process that was laid out in Section 5.1. The method outlined the type of participants that were asked to take part in the survey and listener test, what they did during the study, how the research was designed and conducted, and how the collected data was analysed. Once the method had been delineated, the results of the dissertation were extracted and explained. The results were then analysed and discussed, and the research questions were answered. The application was mostly positively perceived and evaluated by participants in terms of navigation and visual elements. In terms of the application sounds, nature sounds were found to be more positively perceived by participants than ASMR sounds and may be more effective in relaxing people with anxiety.

5.1 Background

Anxiety disorders are a common mental health condition that as of 2013, one in nine people were affected by. If left untreated, anxiety disorders tend to be chronic (Craske & Stein, 2016). There are many psychological and pharmacological treatments for anxiety disorders, but they may have negative side effects or may not be effective for some people (Gale & Millichamp, 2011). Less intrusive treatments for anxiety exist such as e-interventions but there is a lack of research determining their effectiveness (Craske & Stein, 2016). Sound therapy is another treatment that may be effective in reducing the stress levels of people with anxiety (Flores Gutiérrez et al., 2015).

Sound therapy uses sound and music to help people with a wide range of physical and psychological conditions (Duerksen, 2013). Sounds such as nature sounds have shown to be effective in reducing people's stress levels (Alvarsson et al., 2010). Another type of sound that may be used to help relax people is ASMR (autonomous sensory meridian response) which is a phenomenon where some people feel a tingling

sensation at the top of their head in response to certain audio triggers such as whispering and tapping (Poerio et al., 2018). ASMR has shown to have a relaxation effect for some people and improve mood (Cash, Heisick & Papesh, 2018).

The research that was conducted explores the effectiveness of nature and ASMR (autonomous sensory meridian response) sounds in reducing the stress levels of people with anxiety. An online survey and listening study were conducted where participants were asked to test an application that features five nature and five ASMR sounds, and they were asked to give feedback on whether or not they found the sounds relaxing (see Appendix 5).

To appropriately evaluate the application the information that was collected from participants will be analysed and discussed. The data that was gathered can be split into two categories: information about the participant and information about the effectiveness of the application. The data that was gathered about the participants includes information about whether they have been diagnosed with anxiety or not, how often they feel stressed and how they manage it, if they have used relaxation apps and whether they found them effective in reducing their stress levels or not. The data that was gathered about the effectiveness of the application includes information about whether or not the participants found each sound pleasant and/or relaxing, if they found the user interface easy to navigate and pleasant to look at, and if they would use the app again.

The purpose of the research was to determine if listening to nature and ASMR sounds is an effective way to reduce the stress levels of people with anxiety and help them to manage their anxiety better. Through this research it was possible to define a set of guidelines that may be useful for future developments of an application for reducing stress with sound. The data from the research may be used to define which sounds are most effective in reducing stress levels, and this information may be useful for future research in the field. It was expected that the data would provide an insight into people’s perceptions and positive or negative associations with nature and ASMR sounds, which can be used to determine which sounds have the most relaxing properties. It was also expected that there may be conflicting results for some sounds,

as associations related to sounds are very personal and can vary from person to person.

5.2 Method

The participants of the research were between the ages of 18 and 70 and were required to have been diagnosed with anxiety as this is the main demographic that the application is aimed towards. The goal of the research was to find methods of lowering the stress levels of people with anxiety, so in order to take part in the study the participants must have anxiety. The number of respondents that took part in the survey was 11, and the number of participants for the listener study was three. The first part of the survey and listener study gathers the necessary demographic information about the participants. Information about the age, gender, and country of residence of the participants was gathered. The average age of the respondents is 31, and there is an age range of 37 with the youngest participant being 22 years old and the oldest 59 years old. When looking at the gender data, it can be observed that 12 female and two male participants took part in the study. Most of the respondents were located in the United Kingdom, with 11 people listing it as their country of residence. As for the rest of the respondents, one person is located in Spain and two in Belgium. Once the basic demographic data of the participants had been collected, information about their anxiety was gathered.

The research consisted of a survey that was conducted online using Novi, and a listener study that took place via Skype to determine the efficiency of the application. The materials that the participants had access to are the application itself that was shared through a web URL that was included in the survey or sent directly to the participant before the listener study. Through the application, they had access to the ten sounds that they were asked to listen to for the study.

The survey and listener study that was conducted was non-experimental quantitative and qualitative research. The research was designed so that during the survey and the listener study the participants were asked the same set of questions, but the main difference between the two is that during the listener study the participants were asked more in-depth questions about their experience listening to the sounds. During the survey the participants were asked to rate if the sounds are relaxing and pleasant on

a scale of one to five, whereas during the listener study the participants were asked to give detailed answers about why they did or didn't find the sound relaxing or pleasant. The survey and listener study first asked the participants to read and agree to the consent and privacy forms (see Appendix 6.1-6.3), and then to answer questions about themselves and their experiences with anxiety and relaxation apps, followed by questions about the application and the sounds, and finally the participants were asked to consent to taking part once more before submitting the results. If the participant didn't agree to the consent and privacy forms, or if they failed to meet the requirements for participation (must be between the ages of 18 and 70 and be diagnosed with anxiety) then they were taken to the end of the survey and could no longer proceed.

The procedure of gathering the research data consisted of asking people on various social media websites to participate in the survey or listener study. The results of the survey were exported in the format of an Excel spreadsheet, and the results of the listener study consisted of a transcription of each participant's interview in the format of a Word document. Once the data from the survey and the listener study had been gathered, it was exported and coded using NVivo (QSR International, LLC, 2019). The data was split into different nodes in NVivo that represent relevant groups of results which could then be used to extrapolate conclusions about the results. The data was visualised by using Excel to create graphs for some of the results, and it was also used to calculate information about the quantitative data such as mean, median, mode, and standard deviation. In the next chapter, the results will be shown and explained based on the analysis that was conducted.

5.3 Results

All of the participants have been diagnosed with anxiety, so it is useful to further explore how they experience and manage stress to better understand how the condition affects them. They were first asked how often they feel stressed and most of the participants answered multiple times a week, with multiple times a day being the second most common answer as shown in Figure 5.1.

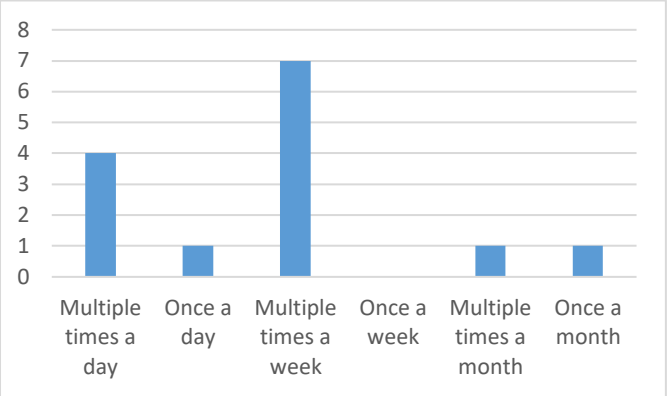


Figure 5.1: Frequency of Feeling Stressed of the Survey and Listening Study Participants

Once it was determined how often the participants experience stress, they were then asked which methods they use to calm down when feeling stressed or overwhelmed. As shown in Figure 5.2, the five most common methods are breathing exercises and listening to music with nine respondents each, exercise with seven respondents, spending time or talking with loved ones with six respondents, and listening to relaxing sounds with four respondents.

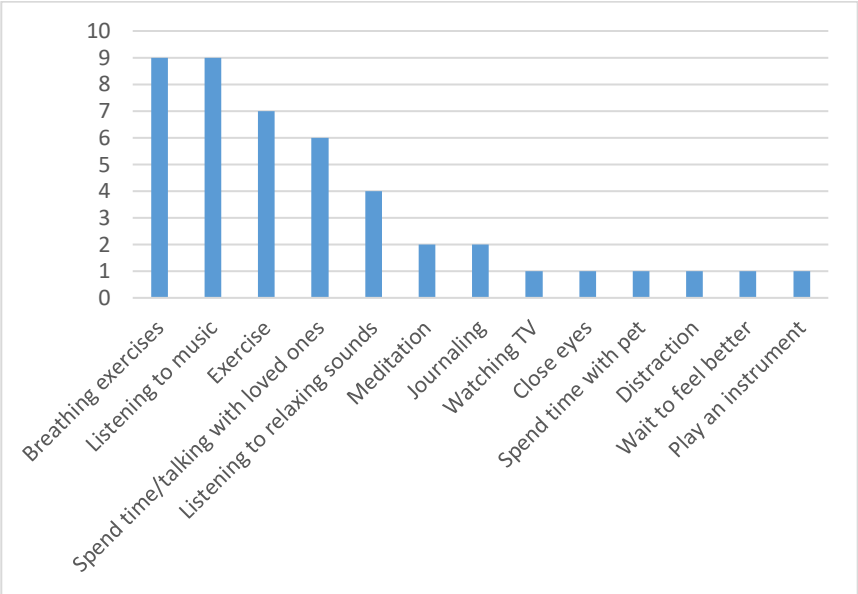


Figure 5.2: Methods of Calming Down Used by the Survey and Listening Study Participants

When asked if they had previously used relaxation apps, ten of the participants responded that they had and four that they hadn't. Among the ten people that had used relaxation apps, the most popular one that was used was Calm with nine respondents, followed by Headspace with six respondents, as shown in Figure 5.3 (Calm.com, Inc., 2020a; Headspace, Inc., 2020a). The other applications that were used by participants

were Clear Fear, Feeling Good, YouTube, and Sattva (stem4, 2019; NHS, 2020; Google LLC, 2020b; Sattva, 2020).

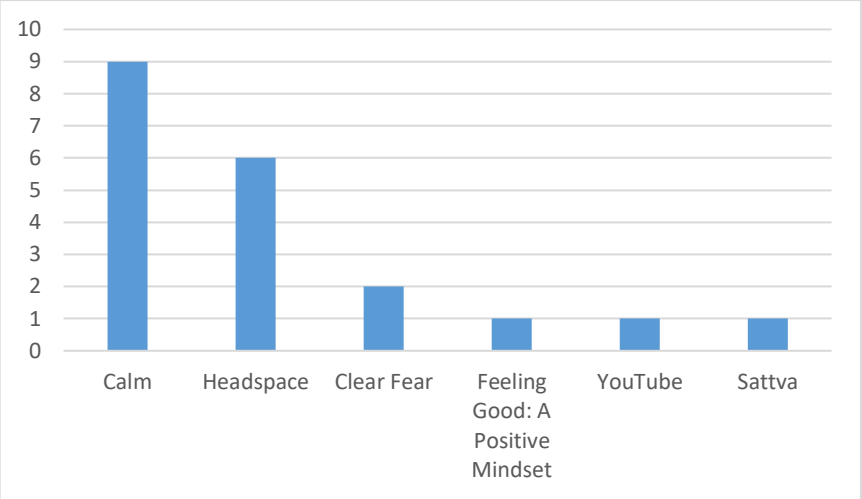


Figure 5.3: Relaxation Apps Used by Participants of the Survey and Listening Study

When asked about the effectiveness of the apps, two participants found that they did not help them relax, two had neutral opinions about the apps, and three found that they had a positive impact and helped them relax. Among the negative opinions about the apps, one of the reasons given was that the application felt too forced in trying to calm the user down which made them feel more stressed. Looking at the neutral opinions, respondents said that the effectiveness of the app depended on factors such as the level of interaction the user can have in the relaxation process, and the voice of the person guiding the meditation. Among the positive opinions of respondents, some of the reasons given for the effectiveness of the app were that it helped them change their train of thought and relax them, it helped them to calm down, and that it allowed them to choose which parts of the app they liked and that was effective in relaxing them.

Once the effectiveness of relaxation apps was determined, the participants were then asked to test the ZenSounds app and provide feedback on their experience. The participants of the survey were first asked to listen to the ten sounds provided by the app and for each sound give a one to five score on how pleasant and how relaxing the sound was. The results are shown in Figure 5.4 as the average score of the pleasantness and level of relaxation of each sound. The nature sounds of the app are birds, insects, waves, stream, and wind. The ASMR sounds of the app are paper,

whispers, fabric, tapping, and water. The five most highly rated sounds are birds, waves, and stream that are rated at four, along with wind and water that are rated at three.

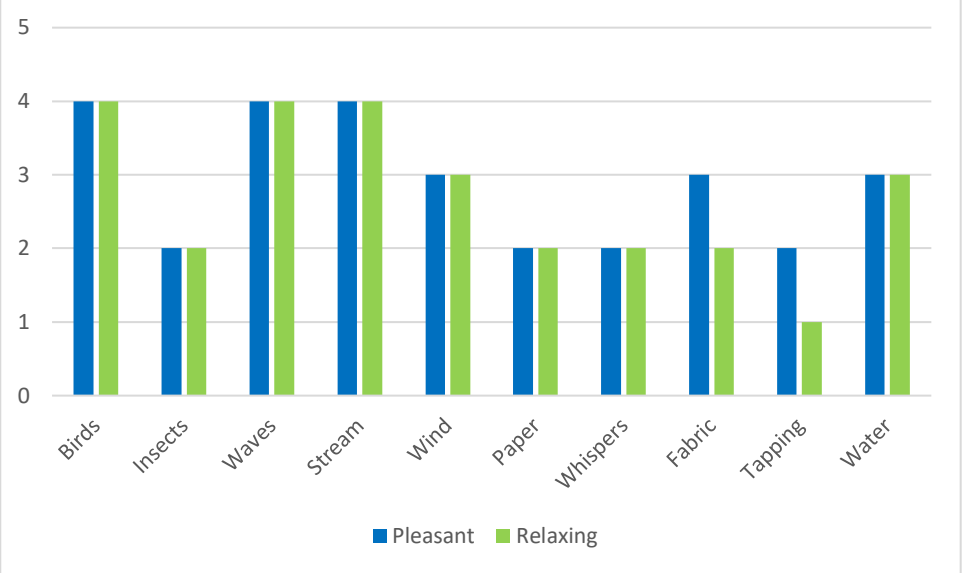


Figure 5.4: Average Level of Pleasantness and Relaxation of ZenSounds App Sounds According to Survey

The participants of the listener study were asked to provide more detailed feedback on the sounds and the results are shown in Table 5.1. Three people took part in the study and will henceforth be referred to as Participant A, B, and C.

Table 5.1: Feedback on the Level of Relaxation and Pleasantness of ZenSounds App Sounds from Listener Study

	Participant A		Participant B		Participant C	
Sounds	**Pleasant**	**Relaxing**	**Pleasant**	**Relaxing**	**Pleasant**	**Relaxing**
Birds	Yes	Yes	Yes	Yes	Yes	Yes
Insects	Yes	Yes	Yes	Yes	Yes	Yes
Waves	Yes	Yes	Yes	Yes	Neutral	A little
Stream	Yes	Yes	Neutral	A little	Yes	Yes
Wind	Yes	No	No	No	No	No
Paper	Neutral	No	Yes	Yes	Yes	Yes
Whispers	No	No	Yes	Yes	No	No
Fabric	No	No	Yes	Yes	A little	No
Tapping	No	No	Neutral	Neutral	Neutral	Neutral
Water	Yes	Yes	Yes	Yes	Yes	Yes

Looking at the feedback of the Birds sound, all of the participants found the sound pleasant and relaxing to listen to. Participant A said that “all together it was […] just like memories because I go to the forest a lot and I like the nature” (P. A, 2020). Participant B stated that they found the sound relaxing, stating: “it just brings back memories of my childhood. Like hearing a lot of birds when I was younger takes me

back to the good times. I think just the fact that it like brought back memories" (P. B, 2020). Participant C found the sound gentle, not aggressive, and melodic, and stated that "because it's a nature sound, when you close your eyes you can feel like you're away from everything" (P. C, 2020).

The Insects sound was also pleasant and relaxing to listen to for all of the participants. Participant B specified that the "fact the sound was quite repetitive was quite relaxing" and that like the Birds sound, it brought back memories of holidays" (P. B, 2020). Participant C stated that the insects reminded them of summer and that "the tone is very repetitive, there's little variation which is good for anxiety because it helps to ground me" (P. C, 2020). The participant also stated that the fact that it's a nature sound makes them feel like they're outdoors and "away from everything" (P. C, 2020).

The Waves sound received mostly positive feedback from the participants. Participant A found the sound pleasant for the most part, but the more they listened to it they found it less pleasant and more annoying due to the changes of loudness of the sound, as there were some parts that were quieter than others (P. A, 2020). The participant also stated that they found the sound more relaxing during the louder parts more than the quieter parts and that the parts "where the waves felt a little closer to you [were more relaxing] than the ones farther away, because it was just like, more present. […] So it was easier to concentrate on it" (P. A, 2020). Participant B stated that they found the sound pleasant as it was repetitive like the Insects sound, and there weren't any unexpected sounds (P. B, 2020). The participant found the sound relaxing as it was "a nice sound to listen to" (P. B, 2020). Participant C stated that they didn't find the sound unpleasant, but it was "not as pleasant as the birds and insects. Not as calming. Too much variation in loudness, almost aggressive" (P. C, 2020). The participant found the sound a little relaxing but not as much as the Birds and Insects sounds, and they like sea sounds but not this sound as it made them a little anxious, stating: "I felt like I was in the water as opposed to sitting on the coast. Also, I think if I was having anxiety and I played that sound I would find it overwhelming" (P. C, 2020).

The Stream sound was mostly positively perceived by the participants. Participant A found the sound pleasant but not for long as they stated that they would feel overwhelmed if they listened to it for longer (P. A, 2020). The participant also found the

sound less relaxing than the waves as “the waves were a little smoother. This was more forcing” (P. A, 2020). Participant B found the sound “somewhat pleasant, but it was a little unsettling” (P. B, 2020). The participant found the sound a little relaxing at first but then felt less relaxed as they had associated the sound of water running with a leak stating the following: “I got a slight sense of anxiety thinking like, where is the noise coming from? Is that a leak or something?” (P. B, 2020). Participant C stated that the sound was pleasant as it was a gentle and soothing sound and it made them feel like they were in nature and away from day to day life (P. C, 2020). They found the sound relaxing as it was “a very repetitive sound and constant, you could drift off with it” (P. C, 2020).

The Wind sound received mostly negative feedback from the participants. Participant A found the sound pleasant but not relaxing, as they found it a little busy so they wouldn’t use it to calm down if they were feeling stressed (P. A, 2020). Participant B didn’t find the sound pleasant or relaxing as they have a negative association with the sound of wind, stating the following: “I think it's just like when I hear the wind it’s like never a good thing” (P. B, 2020). Participant C found the sound abrasive as it’s in a low pitch, and a dominant sound that demanded their attention and not soothing to listen to in the background to calm down (P. C, 2020). They had a negative association with the sound of strong winds as it reminded them of a storm building up which made them uncomfortable (P. C, 2020). The participant found the sound unpleasant and not relaxing, stating that:

> It was too strong of a sound, not a delicate sound that you could use to help you control your breathing or your mind. I felt like it made my heart rate go up, quite an alerting sound that made me feel like something bad is going to happen. (P. C, 2020)

The Paper sound was perceived positively by most of the participants. Participant A found the sound pleasant in some parts and unpleasant in others (P. A, 2020). They specified that the sound of the paper moving was unpleasant and this made the sounds unrelaxing, but that the sound of the pencil on the paper was pleasant (P. A, 2020). Participant B found it pleasant and relaxing and said that it is a nice sound (P. B, 2020). Participant C found it pleasant, stating the following: “It triggers a memory, I’m not sure of what, but it was a really satisfying and soothing sound. Even though it’s lower pitched

it was a delicate sound, and I love paper and stationery" (P. C, 2020). The participant also found the sound relaxing due to the feeling of nostalgia which gave them a comforting and nice feeling, and which made the sound enjoyable to listen to (P. C, 2020).

The Whispers sound was mostly negatively perceived by the participants. Participant A found the sound unpleasant and unrelaxing, specifying that they didn't like that the whispers were distinguishable and that hearing what the people were saying was annoying (P. A, 2020). They stated the following:

> [I would like it] if I wouldn't be able to recognize what they say. I think it was the fact that I could hear what they were saying that made it so unpleasant and unrelaxing. But I don't think that like pure whispering would be relaxing to me, either. (P. A, 2020)

Participant B found the sound pleasant but unsettling at first not knowing what was being said, but subsequently found the sound relaxing later on (P. B, 2020). They specified that they liked being able to understand what they were saying, and it was interesting listening to the people talk (P. B, 2020). The participant also stated that they prefer it when they can see a video of the person whispering like in ASMR videos, rather than the audio alone (P. B, 2020). Participant C disliked the sound and found it both unpleasant and unrelaxing (P. C, 2020). They specified that they hate the sound of whispering and that the accent of the speaker bothered them and was annoying (P. C, 2020). The participant also stated that they didn't like the fact that they could understand what the speaker was saying, stating the following: "it was distracting, I think if it was indistinguishable whispers it would maybe be more soothing. I was too focused on what they were saying" (P. C, 2020).

The Fabric sound was considered negative by most of the participants. Participant A found the sound okay in the beginning but after a while found it annoying, unpleasant and too busy (P. A, 2020). They felt unrelaxed and more stressed while listening to the sound, due to the amount of movement in the sound:

> I think the like changing rhythm of like, touching the fabric, like I felt like at times it was just like very smooth and then it was very rapid and then it was very slow and that just made me dizzy. (P. A, 2020)

Participant B found the sound pleasant and relaxing, stating that they found it relaxing as it sounded like a cat purring (P. B, 2020). Participant C found the sound a little pleasant as it sounded like white noise (P. C, 2020). However, they found that it sounded as if the fabric was being ripped at some points which is a sound they don't like, and this made them feel on edge and unrelaxed (P. C, 2020).

The Tapping sound received mostly neutral and negative feedback from participants. Participant A found the sound unpleasant and unrelaxing as it was too busy like the Fabric sound, and stated the following: "it made me feel like if I would close my eyes and try to relax, this sound would actually want me to wake up and check out what's going on. Like, it made me actually feel a little anxious" (P. A, 2020). Participant B found some of the tapping sounds pleasant (P. B, 2020). They found the first sound was nice to listen to and was relaxing but they didn't like the other sounds (P. B, 2020). They stated the following:

> But when they're changing from one sound to another sound, I'm not sure I like that. I think I would have preferred it if it was just one sound that sounds really similar. I wasn't sure about like, one sound changing into another sound, but I didn't expect it. (P. B, 2020)

Participant C found the first sound pleasant but not the other two (P. C, 2020). They found the first sound pleasant as it was a "dull sound, almost like the surface was soft so it absorbed the forcefulness of the sound. The second and third were quite loud and harsh sounding" (P. C, 2020). The participant found the first sound relaxing as it was a dull and muted sound but found the rest unrelaxing and too abrupt (P. C, 2020).

The Water Sound received mostly positive feedback from all participants. Participant A found the sound pleasant and relaxing in some parts more than others (P. A, 2020). The participant found the sound of the water itself at the beginning more pleasant and relaxing than the sound of the bubbles that appears later on (P. A, 2020). They stated the following:

> […] the combination of the two was a little weird and I didn't like it so much, but like the first bit which was the dominant part of the sound that was quite relaxing for the same reasons as with the waves sound. […] The beginning bit that was basically there constantly but some noises changed but the background part that was the relaxing part. (P. A, 2020)

Participant B also found the sound relaxing and pleasant and specified that the sound of the bubbles was nice, and it made them feel like they were swimming through the water (P. B, 2020). They also stated the following: “It sounded as if whatever was in the water was moving forward. And I'm not sure why I found that quite relaxing the way it was going in one direction rather than like all over the place” (P. B, 2020). Participant C found the sound relaxing and pleasant, stating that the sound was soft and smooth (P. C, 2020). The participant stated the following:

> The water element made me feel like either I was in a bath with my head underwater or in a pool or the beach, and I associate that with relaxing and being on holiday. I associate that sound with my head being submerged in water so I don’t hear any other sounds, like you’re muting out the world and your anxiety. (P. C, 2020)

Once the participants of the survey and the listening study provided feedback on the sounds of the app, they were asked to provide further feedback on the visual and functional elements of the app. The participants were first asked to give feedback on their experience of using the app in terms of the difficulty of navigating it, and the results are shown in Figure 5.5. Most of the participants found the app easy to navigate with six respondents stating it was “very easy” and two stating it was “easy”. The rest of the respondents (four) were neutral on the difficulty of navigating the app.

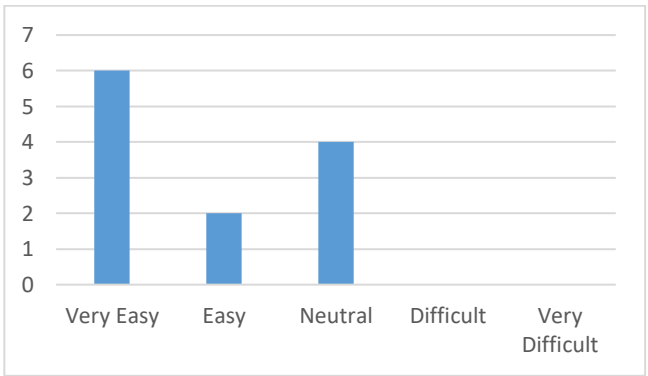


Figure 5.5: Feedback on the Level of Difficulty of Navigating the ZenSounds App by Participants of the Survey and Listening Study

The Participants were then asked to share their opinion on the pleasantness of the visual elements of the app and the results are shown in Figure 5.6. Most of the participants stated that they found the visual elements pleasant as six respondents

said they were “very pleasant” and four people said that they were “pleasant”. Three people were neutral on the pleasantness of the visuals and one person found them “unpleasant”.

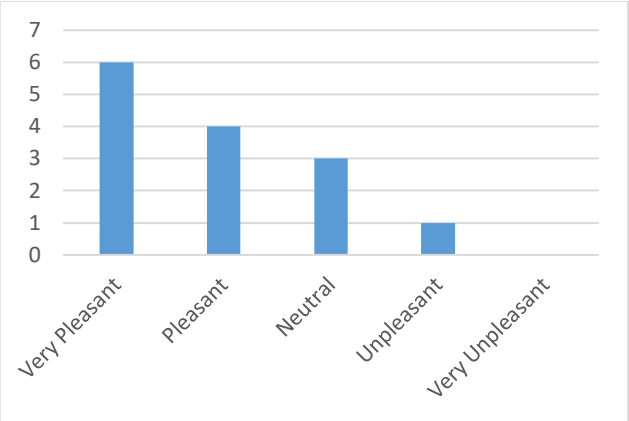


Figure 5.6: Feedback on the Pleasantness of the Visual Elements of the ZenSounds App by Participants of the Survey and Listening Study

The participants provided suggestions for sounds that they would like to be included in the ZenSounds app, as shown in Figure 5.7. The most frequently suggested sounds were animal sounds such as dolphins, the sound of a cat purring, and more bird sounds, and music such as instrumental guitar, piano and lo-fi hip-hop, and they were each suggested by three respondents. Two respondents suggested to add the sound of sand to the app, and two also suggested more nature sounds such as forest and rain. Some of the other suggestions were mechanical sounds such as that of a train or an appliance fan, the sound of meditation bells and Tibetan bowls, and binaural sounds.

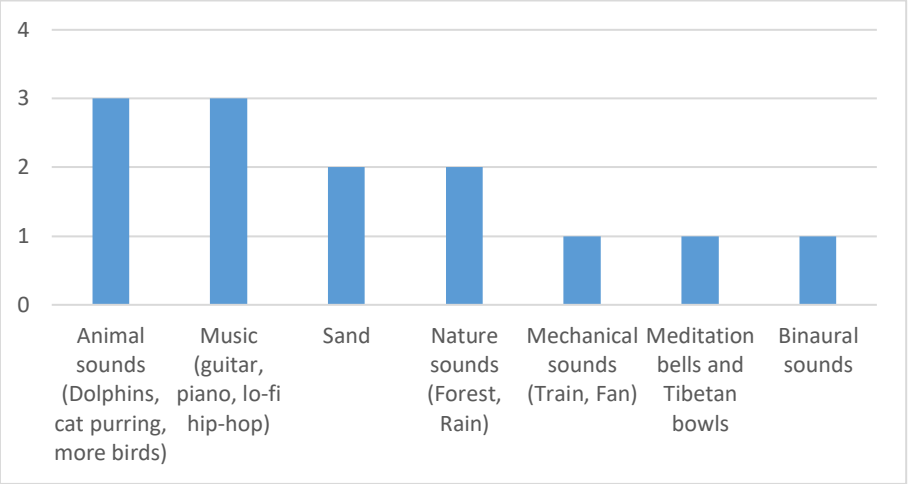


Figure 5.7: Suggestions on Sounds to Add to ZenSounds App from Participants of the Survey and Listening Study

When asked which elements of the application they would add or remove, one participant said to remove the Whispers sound and to provide more detailed information about what ASMR is. Another participant stated that they would like the ability to choose how long they would listen to the sound and that it could continue for that length of time without fading out. They also said they would like some video visuals to accompany the sounds such as for the Whispers sound to see the person's lips moving while whispering. One participant said they would also like the ability to choose how long the sound plays for, as well as the ability to see what sound is coming up next, and have playlists of different sounds on the app for specific moment such as when you're feeling stressed or when you want to unwind.

When asked if they would consider using the ZenSounds app again in the future, 11 participants said yes and three said no. The participants were also asked if they would consider connecting wearables such as smartwatches to the app to measure their stress levels and automatically play relaxing sounds when they feel stressed. Out of the survey and listener study participants, eight people said that they would use wearables with the app and five said that they wouldn't. During the listener study, participants were asked to explain their answers. One participant that said no explained that they wouldn't use the feature as they don't use wearables or smart devices. Another participant said that they would use the feature as it "would be really cool" but that they would also be worried if the app started playing sounds in public places such as at work or at university, so they would only like to use the feature when they are at home.

5.4 Discussion

The majority of respondents said that they experience stress multiple times a week and multiple times a day. This suggests that people that have anxiety experience stress relatively frequently, and that an effective relaxation application may be useful for people with anxiety. This aligns with the research that was conducted in the literature review that showed that anxiety disorders such as generalised anxiety disorder can cause marked worry most days that is difficult to control (Craske & Stein, 2016). The most popular methods for calming down of the participants were breathing exercises, listening to music and relaxing sounds, and exercising. This suggests that incorporating these methods into a relaxation application may be helpful and useful in reducing the stress levels of people with anxiety. The breathing exercises could be incorporated into the application in the form of guided meditations for example, and exercise videos such as yoga may be useful to add as well.

Calm and Headspace were stated as being the most popular relaxation apps used by participants, although opinions on the effectiveness of the apps were mixed. Research conducted in the literature review showed that Calm and Headspace were both some of the most popular mindfulness applications on the Apple and Google Play stores (Huberty et al., 2019). Research also showed that due to the high turnover rate of apps, it is difficult to determine the effectiveness of mindfulness apps, and therefore more investigation is needed to ensure their quality (Flett et al., 2019). Some of the reasons given by participants on why the apps were effective are that the app helped to change their train of thought, and that there was a level of interaction where the user can choose how they want to relax using the app. The reasons given by some participants on why the applications are ineffective were that the app felt too forced in trying to relax the user, that the user had a limited amount of interaction with the app and the method of relaxation, and that they didn't like the voice of the person doing the guided meditation. This suggests that to create an effective relaxation application, there must be a high amount of interaction that the user can have with the app in terms of how they want to be relaxed and it can't be forced onto them. It would be useful to include methods for how to change the user's train of thought in the app, for example by having mindfulness techniques and knowledge. It would also be interesting to have guided meditations with multiple different types of speakers so that if a user doesn't like a particular type of voice, they can find another one that they like. For this it may be

interesting to have speakers of different genders and with different accents to cover a wide range of voice styles.

Looking at the results of the feedback of the ZenSounds app sounds, it appears that nature sounds may have been perceived to be more relaxing and pleasant than ASMR sounds according to participants. The results of the survey suggest that nature sounds were more relaxing and pleasant than ASMR sounds, and that the Birds, Waves, Stream, Wind, and Water sounds were the most popular sounds among participants. The results of the listener study also suggest that nature sounds were more relaxing and pleasant than ASMR sounds, and that Birds, Insects, Waves, Stream, and Water were the most popular sounds among participants. The sounds that were consistently well rated amongst the survey and listener study participants were the Birds, Waves, Stream, and Water sounds. This suggests that these sounds may be interesting to focus on when developing a relaxation app as they may be the most effective in relaxing the user. It was shown in the literature review that nature sounds such as wind, water, and birds are shown to have a relaxing effect on people, and this aligns with the results of the study that suggests that these types sounds are the most effective in reducing stress (Ratcliffe et al., 2016). Research in the literature review showed that ASMR sounds was effective in reducing stress and that the most popular triggers are whispering and crisp sounds (Barratt & Davis, 2015). However, the results of the study show that ASMR sounds were not as well received as nature sounds, and whispers and crisp sounds such as paper were amongst the lowest rated sounds in the survey. During the listener study, the participants were asked to provide feedback on each sound and explain their reasons for the positive or negative perception of the sound. Common elements appeared across the feedback of the participants on why certain sounds were relaxing and pleasant and others weren't, as shown in Table 5.2. It would be useful to consider the common elements of the positively rated sounds when producing sounds for a relaxation application. The positive elements may be used as a set of guidelines for producing relaxing and pleasant sounds for users. According to the common elements, smooth and soft sounds that are repetitive and have little variation in loudness may be the most effective in reducing stress levels. Positive associations to sounds such as bringing back memories and sounds that make the listener feel like they are escaping real life such as being in nature may also be effective for relaxing users. These results align with the research conducted in the literature

review that shows that nature sounds such as birds that have positive associations for people are found to be linked with imagined environments such as green spaces and seasons of spring and summer (Ratcliffe et al., 2016). Some sounds that may be added to a future relaxation application based on feedback from participants are more animal sounds such as birds and dolphins, instrumental music such as guitar and lo-fi hip-hop, and more nature sounds such as sand and rain.

Table 5.2: Common Element of Positively and Negatively Rated Sounds From the Listener Study Participants

Elements of Positively Rated Sounds	Elements of Negatively Rated Sounds
Positive associations to sound such as bringing back old memories	A lot of variation in sound and loudness
Gentle, non-aggressive, soft sound	Aggressive, abrasive, strong sound
Gives feeling of being away from day-to-day life such as being in nature	Overwhelming sound
Repetitive, rhythmic, and little variation in sound and loudness	Negative associations to sound such as danger and alarm to the Wind sound
Smooth sound	Too busy, too much movement in sound
Dull and muted sound	Too distracting such as understanding what people were saying in the Whispers sound

The results also show that there are conflicting results when it comes to the perceptions of some sounds which suggests that determining whether a sound is relaxing or not is very personal and depends on the listener's associations and experiences related to that sound. An example of this is the Whispers sound that was mostly negatively rated by participants. Among the negative feedback for that sound, one of the reasons that was given by two participants was that they didn't like that they could understand what the person was whispering. This is directly conflicted with a positive feedback of the sound from a participant that stated that they like the sound because they could understand what was being said. Another example of this is with the Paper sound, that was mostly positively perceived by participants of the listener study but that was relatively negatively rated by the respondents of the survey as it received an average score of two. One participant found the sound unpleasant and unrelaxing because they didn't like the sound of the paper moving, while another participant like the sound as it brought back positive memories. This suggests that while it may be possible to determine a set of guidelines for how to develop effectively relaxing sounds, there may be exceptions to the rule, and it is important to remember that what people find relaxing can vary from person to person and that it may depend on personal experiences. It may be useful to consider adding a wide range of sounds to the application to increase the likelihood of the user finding a sound that they find relaxing.

The navigation of the application was mostly found to be easy by participants and the visuals were generally perceived to be pleasant. This suggests that the navigation and visual design of the application was adequate for the purpose of a relaxation app and may be used as the basis for a future application. In terms of additions to the application, based on the feedback from participants it may be useful to add more information about ASMR, visual elements such as videos for each sound, the ability to choose how long the user wants to listen to a sound, and playlists of sounds for different moods or situations.

Most participants said that they would use the app again which suggests that the application is a good basis for a relaxation app. When asked if they would connect wearables to the app to measure their stress levels, most participants said that they would, which suggests that this is an interesting feature to add to the app. It may be useful to allow users to set up the feature so that the app only measures the user's stress levels and plays sounds when they are at home, as feedback from participants suggests that there is concern over the prospect of sounds automatically playing in public spaces. Overall the results indicate that the app may be useful if fully developed and may help relax people and reduce their stress levels.

5.5 Summary

The background of the research includes an online survey and listening study conducted via Skype with the purpose of determining the effectiveness of listening to nature and ASMR sounds to reduce stress levels. The goal of the research was to define a set of guidelines for developing an application that uses sound to reduce stress. The research provided an insight into people's positive and negative perceptions of nature and ASMR sounds. This information may be useful for future research in using sound to reduce stress levels.

The participants of the research were between the ages of 22 and 59 and have all been diagnosed with anxiety. There were 14 participants in total, 11 took part in the survey and three took part in the listener study. The research that was conducted was non-experimental and gathered quantitative and qualitative information. The

participants were asked the same set of questions in the survey and the listener study, but the participants of the listening study were asked to provide detailed feedback on the sounds of the application. The data was processed and analysed using NVivo and Excel.

The research that was conducted aimed to provide an insight into how people with anxiety experience and manage stress. The results suggest that the participants experience relatively high levels of stress with most people stating that they feel stressed multiple times a week or day. The participants' most common methods for relaxing include breathing exercises, listening to music and relaxing sounds, exercising, and spending time or talking with loved ones. These results may be useful for developing a relaxation application as they suggest that people with anxiety experience high levels of stress and may find an app that helps them to relax useful. The results are also useful for gaining an insight into what kind of content could be included in a relaxation application such as relaxing music and sounds, breathing exercises and guided meditation, and exercise videos such as yoga.

When asked about their experience of using relaxation apps, most participants said that they had used them before, and the apps Calm and Headspace were the most used amongst them. The feedback on the effectiveness of the applications was mixed, as some participants found that they helped them relax and change their train of thought, while others found them too forced in trying to relax them, and that there was a lack of interaction in terms of the relaxation methods offered by the app. Based on the feedback of relaxation apps, it may be useful to consider offering a high amount of interaction to the user when choosing a relaxation method, as well as mindfulness knowledge and techniques to help change the user's train of thought. The navigation and visual elements of the app were mostly positively perceived by participants which suggests that the design of the ZenSounds app is adequate enough for the purpose of reducing a user's stress levels, and may be considered as the basis for a future relaxation app.

The participants were asked to provide feedback on the ZenSounds app sounds during the research, and the sounds that were consistently well rated were the Birds, Waves, Stream, and Water sounds. Nature sounds seemed to be more pleasant and relaxing

for participants than ASMR sounds. The common positive elements of sounds based on the feedback received during the listener study was used to create a set of guidelines for producing relaxing and pleasant sounds. Some of the common elements include gentle and soft sounds that are repetitive and have little variation in loudness, and that may have positive associations for the users such as bringing back good memories. It is worth noting that perceptions of sounds may vary from person to person, so these guidelines are not definitive. It was expected that there may be conflicting results for some sounds, and this was found to be true for the Whispers and Paper sounds. To create an effective application for reducing stress levels it may be useful to consider including a wide range of sounds to increase the likelihood of relaxing the user. Some of the suggestions from participants on sounds to add to the app include more animal sounds such as birds and dolphins, instrumental music such as guitar and lo-fi hip-hop, and more nature sounds such as sand and rain.

6 Conclusions

In this chapter, the outcomes of the dissertation were analysed and discussed. A summary of the findings was described, including the main conclusions from the literature review and the results of the survey and listener study. The research aims and objectives were discussed, and it was determined if they were met and why. The main findings from the dissertation were summarised at the end of Section 6.1. Recommendations for future work were discussed, and the main points to be considered for future developers and researchers were explained. The contributions to the field of sound therapy were mentioned, as well as the reasons why the research conducted in this dissertation is unique. The work of the dissertation was reflected upon and its strengths and weaknesses were highlighted. The steps that can be taken in future developments of the ZenSounds application were also discussed in detail.

6.1 Research Aims and Objectives

Looking at the research aims and objectives, it can be concluded that they were all met. The first aim consisted of conducting a literature review into the effects of sound on people with anxiety and psychoacoustic principles, and psychological support systems. Sections 2.1, 2.2, and 2.3 gave an in-depth look into the field of sound therapy, the psychological effects of sound and music, and how sound can be used to reduce the stress levels of people with anxiety. Conventional treatments for anxiety were discussed as well as alternative treatments such as e-interventions and relaxation applications.

The second aim was to gather requirements about how to use data from a user's surroundings and their physiological data, as well as audio design principles to effectively produce relaxing sounds for them. In Section 2.4, the physiological data that could be gathered from smartphone and smartwatch sensors was discussed, and the sensors that can be used to measure stress levels were explained. In Section 2.2 sounds that can be used for relaxation purposes were researched, and in Section 3.1 some of these sounds were analysed. Based on the analysis of relaxing sounds that was conducted, a set of sound design principles were defined in Section 4.2. Sounds for the ZenSounds app were produced and documented in Section 4.3, and Section 4.4 discusses the process of developing the prototype of the relaxation app.

The third aim consisted of conducting a survey and listening study aiming to measure the effectiveness of an application that produces sounds to reduce the stress levels of people with anxiety. An online survey and listener study were conducted with the purpose of determining the effectiveness of the relaxation application and the sounds that were produced for it. The background and process of the research is outlined in Sections 5.1 and 5.2. The last aim was to evaluate the findings of the survey and listening study aiming to measure the effectiveness of an application that produces sounds to reduce stress levels of people with anxiety and the project as a whole. Sections 5.3 and 5.4 explain and evaluate the findings of the research in the context of the whole project. The application was found to be positively received overall, and the nature sounds were found to be the most effective in relaxing the participants.

Anxiety is one of the most common mental health conditions that includes disorder such as social anxiety disorder, panic disorder, and generalised anxiety disorder. Some of the common characteristics of anxiety disorders are persistent and marked worry that has an impact on the sufferer's daily functioning. If patients don't receive any treatment, anxiety disorders tend to be chronic (Craske & Stein, 2016). Although anxiety disorders are common, they are often undetected and undertreated (McGrandles & Duffy, 2012). Various psychological and pharmacological treatments exist for anxiety. Psychological treatments include cognitive behavioural therapy (CBT) and pharmacological treatments include anti-depressants. Conventional treatments are shown to reduce anxiety, although they may have negative side-effects and may not be effective for all people (Gale & Millichamp, 2011). Less intrusive treatments for anxiety exist, such as e-interventions, although further research is needed to determine the efficacy of them (Craske & Stein, 2016).

Sound therapy can also be used to treat anxiety as it may be effective in reducing stress levels (Flores Gutiérrez et al., 2015). Sound therapy is a field of healthcare that helps people with various physical and psychological conditions using sound and music. It has shown to be effective in improving people's quality of life and managing pain and stress (Duerksen, 2013). Listening to music has shown to decrease cortisol levels and thus stress levels (Laska et al., 2018). Music that has shown to be effective in reducing anxiety has 60 to 80 beats per minute, a slow tempo, middle to low pitch,

low volume, and a simple rhythmic melody (Liu et al., 2009). Nature-based sounds may be used in some types of sound therapy as they are shown to be effective in reducing stress levels (Alvarsson et al., 2010). Autonomous Sensory Meridian Response (ASMR) is a type of phenomenon where some people may experience a tingling sensation at the crown of the head in response to certain audio triggers such as whispering and tapping (Poerio et al., 2018). In some cases, ASMR has shown to be an effective method of reducing stress, pain, and improving mood (Cash, 2018).

Relaxation applications have become popular in recent years and suggest benefits such as stress reduction and increased happiness. They usually feature element such as guided meditation, and relaxation sounds and music (Wallop, 2019). In 2019, some of the most popular relaxation applications on the Apple and Google Play stores were Calm and Headspace (Huberty et al., 2019). Although these apps may be popular, more research is needed to determine their efficacy in reducing stress (Flett et al., 2019). In recent years, the use of technologies such as wearables has become more widespread in the medical industry (Hudson & Clark, 2018). Wearable technologies are becoming more popular and can be used to gather physiological data (Dobbins & Fairclough, 2017). Consumer wearables such as Fitbit and Apple Watch can be used for health purposes by measuring people's physiological data such as heart rate, sleep pattern, and activity level. These wearables may be used to measure diseases and analyse their progression and severity (Mombers et al., 2016). Wearables can also be used to measure the stress levels of people with anxiety which can help sufferers develop self-awareness and coping skills. Linking the data gathered by wearables to a mobile platform, users may be able to gain an insight into their behaviour, emotions, and possible stress triggers (Dobbins & Fairclough, 2017). It is possible to determine if a person is feeling stressed by monitoring changes in heart rate, blood pressure, breathing pattern, galvanic skin response, emotion, and voice intonation. These changes can be measured by using sensors such as electroencephalography (EEG), blood volume pulse (BVP), electrocardiogram (ECG), galvanic skin response (GSR), and electromyography (EMG) (Sharma & Gedeon, 2012).

The results of the research conducted in the online survey and listening study show that participants experienced stress relatively often. The most popular methods of relaxation among the participants are breathing exercises, listening to music and

relaxing sounds, exercising, and spending time or talking with loved ones. Most of the participants had used relaxation apps before, with Calm and Headspace being the most popular, but the feedback on the effectiveness of the apps was mixed. Among the positive feedback of relaxation apps, some participants stated that they found that they helped them relax and change their train of thought. Participants that had negative feedback of relaxation apps stated that they found them too forced in trying to relax them, and that there was a lack of interaction in terms of the relaxation methods offered by the app.

When asked to evaluate the sounds of the ZenSounds app, most of the participants of the online survey and listening study found the nature sounds more relaxing and pleasant than the ASMR sounds. It was found that the most popular sounds were Birds, Waves, Stream, and Water sounds. Based on the feedback from participants, some of the common elements of positively rated sounds were gentle and soft sounds that are repetitive and have little variation in loudness, and that may have positive associations for the users such as bringing back good memories. The results of the research also showed that there are sometimes conflicting results for some sounds which suggests that the perception of sounds is a personal experience that can vary depending on each person.

The research showed that most participants would use the ZenSounds app again, and that they found the visual elements pleasant to look at and the navigation of the app easy. Most participants said that they would connect wearables to the app to measure their stress levels. Feedback from participants suggests it may be useful to allow users to set up the feature so that the app only measures the user's stress levels and plays sounds when they are at home as there may be concern over the prospect of sounds automatically playing in public spaces.

To conclude, it was found that anxiety disorders are prevalent and that there are many treatments that exist for them including sound therapy. It was found that sound and music can have a relaxing effect on people with anxiety. Certain sounds may be more effective than others in reducing stress levels, such as nature sounds. Relaxation applications are popular and suggest benefits such as reducing stress levels, but more

research is needed to determine their efficacy. Additional research is also needed to find which sounds are the most effective in relaxing people.

6.2 Recommendations

The results of the research conducted in the dissertation are useful for future developers of relaxation application and sound therapy researchers, as shown in Table 6.1. The results show that people with anxiety experience high levels of stress and may find an app that helps them to relax useful. The research may also provide some insight into what people like and dislike about relaxation applications, and which elements may be useful to consider when developing an app. It may be useful for future developers to consider offering a high amount of interaction to the user when choosing a relaxation method, as well as mindfulness knowledge and techniques to help change the user's train of thought. In terms of sounds for relaxation purposes, the research conducted suggests that nature sounds such as birds, waves, stream, and water may be the most effective in relaxing users. Some of the elements of positively rated sounds are gentle and soft sounds that are repetitive and have little variation in loudness, and that may have positive associations for the users such as bringing back good memories. This information may be useful for developers of relaxation apps who want to include sounds that reduce stress levels in the app, or people who may want to play relaxing sounds in other settings such as in patient waiting rooms or hospitals.

Future research may look into developing more detailed sound design principles for producing relaxing sounds. There may also be a deeper analysis and evaluation of nature and ASMR sounds to find out which types of sounds are consistently effective in relaxing a larger number of people. It would also be interesting to look at a larger range and number of sounds, not just nature and ASMR sounds, to see which ones may be the most relaxing. Future research and developments may also look at including the use of sensors in relaxation applications to measure the stress levels of users and create a smart sound therapy system.

Table 6.1: Recommendations for Future Relaxation Application Developers and Sound Therapy Researchers

Recommendations for relaxation app developers	Recommendations for sound therapy researchers
Offer a high amount of interaction to the user	Look into developing more detailed sound design principles for producing relaxing sounds
Include mindfulness knowledge and techniques	Conduct a more in-depth analysis and evaluation of nature and ASMR sounds
Include nature sounds and gentle and continuous sounds that have positive associations	Look at a larger range and number of sounds to see which ones may be the most relaxing
Look at the use of sensors to determine stress levels	

6.3 Contributions to the Field

Based on the research conducted in the literature review, it seems that while there has been research on nature and ASMR sounds separately, this dissertation may be the first research that looks at both types of sounds at the same time and in the context of a relaxation application. This dissertation has contributed to the field of sound therapy by analysing the effectiveness of certain sounds in relaxing people with anxiety and proposing a set of guidelines for developing relaxing sounds based on the common elements of the positively rated sounds, as shown in Table 6.2. These guidelines could be used in the field of sound therapy to produce relaxing sounds for people with anxiety and implemented into e-intervention systems, or in medical spaces that are used to treat anxiety such as hospitals or psychology practices. Relaxing sounds could be played in the waiting rooms of hospitals or practices to help calm down patients who may be experiencing anxiety. The guidelines can also be used by developers of relaxation applications to produce soothing sounds to help calm their users. The research conducted in this dissertation has also contributed to the analysis of relaxation applications, as the effectiveness of certain apps such as Calm and Headspace was evaluated based on feedback from the online survey and listening study. This information is useful for developers who want to create a relaxation application that is effective in reducing people's stress levels and that is pleasant to use.

Table 6.2: Proposed Set of Guidelines for Developing Relaxing Sounds

Type of Sound	Nature (such as birds, waves, stream, and water)
Sound Characteristics	Gentle, smooth, repetitive, little variation in loudness
Temporal Variation	Intermittent
RMS Value	-47 to -40 dBFS
True Peak Value	-27 to -21 dBFS
Max Crest Factor	10 to 20 dBFS
Frequency Content	20 to 12k Hz

6.4 Self-Reflection

Overall, the aims of the project were met and the study that was conducted successfully provided an insight into the kinds of sounds that people find relaxing. The results of the study could have been more insightful if there were more participants. The lack of participants is the biggest weakness of the research, as there were not enough people to form any statistical conclusions based on the data. Due to the lack of time, the ASMR sounds that were recorded (fabric, paper, and tapping) were of relatively low production which may have contributed to them being rated lower by participants. In future research, it may be more interesting to have a professional ASMR producer to make the sounds or to find pre-recorded ASMR sounds that are copyright free and can be used in a study. The prototype of the application was one of the most successful parts of the dissertation, as it was produced well without any bugs and seemed to be positively received by participants. The strengths of the project are that it provided an insight to a lot of different areas in one study, such as how people manage their anxiety, the use and effectiveness of relaxation applications, which sounds can be used for relaxation purposes, and the use of wearable technologies. The literature review successfully covered a wide range of research fields in detail such as anxiety, sound therapy, and applications for psychological support. This dissertation successfully covered many topics related to the research aims while adequately exploring and delving into the details of each topic, something that was challenging due to the lack of time.

6.5 Future Work

Most of the participants of the online survey and listening study found the ZenSounds application pleasant to look at and easy to navigate, and they stated that they would use the application again. This suggests that the application is a good basis for a relaxation application and can potentially be developed further. In terms of future developments of ZenSounds, the research conducted in this dissertation provided an insight into what elements may be beneficial to add to a relaxation application, as shown in Figure 6.3. Based on the results of the methods that participants use to relax, it may be useful to add content such as relaxing music, breathing exercises and guided meditation, and exercise videos such as yoga to the application. Some of the sounds

that could be added are more animal sounds such as birds and dolphins, and more nature sounds such as sand and rain, and instrumental music such as piano, guitar and lo-fi hip-hop. It may be useful to also add more information about ASMR, and some videos to accompany the sounds. It may also be important to include a wide range of sounds in the application to increase the likelihood of the user finding a sound that they find relaxing. Participants also expressed the want to be able to control the length of the sounds so this may be a useful addition to the app. Specially curated playlists of sounds for different situations or moods may be beneficial to add to the app, as well as personalised playlists for each user depending on their most played sounds.

Once a basic version of the ZenSounds application has been created, it may be possible to develop it further by adding the possibility of connecting wearables such as smartwatches to the app that can be used to measure the user's stress levels and automatically play sounds to relax them. Based on the research conducted in the survey and listener study, most of the participants said that they would use wearables with the application. This smart relaxation system would be able to relax the user when they begin feeling stressed, so they don't have to play the sounds themselves. The system will also know which sounds are the most effective at reducing the stress levels of the user and only play those types of sounds to increase the likelihood of relaxing them. The application could also play sounds adapted to each user based on their current auditory environment, their location, and their heart rate. It would be useful to include a feature that only allows the app to play sounds when the user is at home, as some participants stated concern over the prospect of audio automatically playing in public spaces. The creation of an automated audio relaxation system will remove the user's need to search for a solution to their stress when it is currently happening as the system will be ready to help them whenever needed.

Table 6.3: Content and Functionality That May Be Added to the ZenSounds App

Content to Add	Functionality to Add
Relaxing instrumental music such as piano, guitar and lo-fi hip-hop	Control for the length of the sounds
Relaxing sounds such as animal sounds (birds and dolphins), and nature sounds (sand and rain)	Ability to create personalised playlists for each user depending on their most played sounds
Breathing exercises and guided meditation	Connect wearables such as smartwatches to app to measure user's stress levels
Exercise videos such as yoga	Play sounds adapted to each user based on current auditory environment, location, and heart rate
Specially curated playlists of sounds for different situations or moods	Feature that only allows the app to play sounds when the user is at home
Mindfulness knowledge and techniques	
Videos to accompany the sounds	
Information about ASMR	

6.6 Summary

The aims and the objectives of the dissertation were successfully met. The first aim involved conducting a literature review into the effects sound has on people with anxiety. Anxiety disorders were found to be common and many conventional treatments exist. Sound therapy has been shown to be effective in reducing stress levels and may be used to treat anxiety. Sound and music can be used to help people relax, and some sounds are more effective than others at doing so. The second aim consisted of gathering requirements about how to use data from a user to produce relaxing sounds for them. It was found that certain sensors can be used to determine a person's stress levels and this can be used in a relaxation application to automatically play soothing sounds to calm them down when they feel stressed. The third and fourth aims involved conducting and evaluating the findings of the survey and listener study aiming to measure the effectiveness of an application that produces sounds to reduce the stress levels of people with anxiety. The application was mostly positively perceived by the participants and the nature sounds were found to be the most relaxing and pleasant to listen to. Additional research is needed to determine which sounds are the most effective in relaxing people.

The recommendations for future developments in relaxation applications are to offer a high level of interaction to the user in terms of choosing a method of relaxing, as well as mindfulness knowledge. It is also recommended to add nature sounds such as birds, waves, stream, and water to the relaxation app. Developers can also look at implementing wearables in their applications to detect and monitor the user's stress

levels. Recommendations for future research include the development of more detailed sound design principles for producing relaxing sounds and a deeper analysis into which types of sounds are effective in reducing stress. Future research can also look at a larger range of sounds outside of nature and ASMR sounds.

The contributions to the field of sound therapy include analysing the effectiveness of nature and ASMR sounds on reducing the stress levels of people with anxiety. The research also contributed to the analysis of relaxation applications as the effectiveness of apps such as Headspace and Calm was analysed. When reflecting on the dissertation, it was found that the aims of the project were met. The strengths of the dissertation were that the prototype of the ZenSounds app was successfully developed, and that the literature review and study provided an insight into a lot of different areas such as anxiety, sound therapy, and relaxation applications. The weaknesses of the dissertation were that there was a lack of participants for the survey and listener study, and that some of the ASMR sound were poorly produced due to time constraints.

In terms of future work, the ZenSounds application may be further developed to include some of the features requested by participants during the study. Most of the participants stated that they would use the app again and that they found it visually appealing and easy to navigate. This suggests that the prototype is a good basis for a relaxation application. Some of the features that may be added include more animal and nature sounds, instrumental music, breathing exercises and guided meditation, exercise videos, visuals to accompany the sounds, and user control over the length of sounds. It may also be interesting to add the possibility of connecting wearables to the app to measure the user’s stress levels and to automatically play relaxing sounds. Overall, this dissertation successfully met its research aims by covering the topics of anxiety and sound therapy in detail and analysing the efficiency of nature and ASMR sounds in the context of a relaxation application.

References

Aghaie, B., Rejeh, N., Heravi-Karimooi, M., Ebadi, A., Tayeb Moradian, S., Vaismoradi, M., & Jasper, M. (2014). Effect of nature-based sound therapy on agitation and anxiety in coronary artery bypass graft patients during the weaning of mechanical ventilation: A randomised clinical trial. *International Journal of Nursing Studies*, 51, 526–538. https://doi.org/10.1016/j.ijnurstu.2013.08.003

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health*, *7*(3), 1036–1046. https://doi.org/10.3390/ijerph7031036

Amazon.com, Inc. (2020) Echo (2nd Generation) - Smart speaker with Alexa and Dolby processing. Retrieved 9 July 2020, from https://www.amazon.com/all-new-amazon-echo-speaker-with-wifi-alexa-dark-charcoal/dp/B06XCM9LJ4.

Apple Inc. (2020). Logic Pro X (10.5.1) [Computer software]. Retrieved from https://apps.apple.com/be/app/logic-pro-x/id634148309?l=nl&mt=12.

Audacity. (2020). Audacity (2.4.1) [Computer software]. Retrieved from https://www.audacityteam.org/.

Audacity Team. (2020) Spectrogram View. Retrieved 18 June 2020, from https://manual.audacityteam.org/man/spectrogram_view.html.

Baimbetov, Y., Khalil, I., Steinbauer(B), M., & Anderst-Kotsis, G. (2015). Using Big Data for Emotionally Intelligent Mobile Services Through Multi-modal Emotion Recognition. In A. Geissbühler, J. Demongeot, M. Mokhtari, B. Abdulrazak, & H. Aloulou (Eds.), *Inclusive Smart Cities and e-Health* (pp. 127–138). Geneva, Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-19312-0

Baracskai, Z., & Finn, S. (2013). Relaxation effects of binaural phenomena. *Proceedings of the AES International Conference*, 139–143.

Barratt, E. L., & Davis, N. J. (2015) Autonomous Sensory Meridian Response (ASMR): a flow-like mental state. https://doi.org/10.7717/peerj.851

Bostock, S., Crosswell, A. D., Prather, A. A., & Steptoe, A. (2019). Mindfulness on-the-go: Effects of a mindfulness meditation app on work stress and well-being. *Journal of Occupational Health Psychology*, *24*(1), 127–138. https://doi.org/10.1037/ocp0000118

Brainwave Entertainment. (2020). [Video]. Retrieved 19 June 2020, from https://www.youtube.com/watch?v=ZA7odDXBn1c.

Brixen, E. (2012). *Audio Metering, 2nd Edition* (2nd ed.). Routledge. https://learning.oreilly.com/library/view/audio-metering-2nd/9780240814674/

Bryce, K. (2020). ZenSounds [Web app]. Retrieved 29 July 2020, from https://kirstybryce.github.io/ZenSounds/.

Calm.com, Inc. (2020a). Calm - Meditate, Sleep, Relax (4.28) [Mobile app]. Retrieved 9 July 2020, from https://www.calm.com/.

Calm.com, Inc. (2020b). *Is Calm available on Google Home, Apple HomePod, Sonos, Alexa, or Amazon Echo? Calm Help Center.* Retrieved 27 June 2020, from https://support.calm.com/hc/en-us/articles/115004233614-Is-Calm-available-on-Google-Home-Apple-HomePod-Sonos-Alexa-or-Amazon-Echo-

Calm.com, Inc. (2020c). *Calm for Google Home — Calm Blog.* Retrieved 27 June 2020, from https://blog.calm.com/blog/calm-for-google-home.

Cash, D. K., Heisick, L. L., & Papesh, M. H. (2018). Expectancy effects in the Autonomous Sensory Meridian Response. https://doi.org/10.7717/peerj.5229

Companion Apps Limited. (2020). Stress & Anxiety Companion (2.0) [Mobile app]. Google Play Store. https://play.google.com/store/apps/details?id=com.companionapps.anxietycompanion.

Cooper, L. (2014). What Is Sound Therapy? [online] The British Academy of Sound Therapy. Retrieved 14 August 2020, from https://www.britishacademyofsoundtherapy.com/what-is-sound-therapy/.

Craske, M., & Stein, M. (2016). Anxiety. The Lancet, 388(10063), 3048-3059. doi: 10.1016/s0140-6736(16)30381-6

DennisASMR. (2020). *ASMR Brain Tingling Triggers For INSTANT Sleep (Plucking, Scratching, Rubbing)*. [Video]. Retrieved 19 June 2020, from https://www.youtube.com/watch?v=CUWuWUzIg4o.

Dobbins, C., & Fairclough, S. (2017). A mobile lifelogging platform to measure anxiety and anger during real-life driving. In *2017 IEEE International Conference on Pervasive Computing and Communications Workshops, PerCom Workshops 2017* (pp. 327–332). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/PERCOMW.2017.7917583

Duerksen, G. L. (2013). Music therapy. https://doi.org/10.1093/gmo/9781561592630.article.A2257019

e-hub Health Pty Ltd. (2020) moodgym. Retrieved 20 June 2020, from https://www.moodgym.com.au/.

Flett, J. A. M., Hayne, H., Riordan, B. C., Thompson, L. M., & Conner, T. S. (2019). Mobile Mindfulness Meditation: a Randomised Controlled Trial of the Effect of Two Popular Apps on Mental Health. *Mindfulness*, *10*(5), 863–876. https://doi.org/10.1007/s12671-018-1050-9

Flores Gutiérrez, E. O., Andrés, V., & Camarena, T. (2015). The Arts in Psychotherapy Music therapy in generalized anxiety disorder. *The Arts in Psychotherapy*, *44*, 19–24. https://doi.org/10.1016/j.aip.2015.02.003

Fredborg, B. K., Clark, J. M., & Smith, S. D. (2018). Mindfulness and autonomous sensory meridian response (ASMR). *https://doi.org/10.7717/peerj.5414*

Freesound. (2020). Freesound. Retrieved 19 June 2020, from https://freesound.org/.

Google LLC. (2020a). Google Home. Retrieved 9 July 2020, from https://store.google.com/us/product/google_home_speaker?hl=en-US.

Google LLC. (2020b). YouTube. Retrieved 14 August 2020, from https://www.youtube.com/.

Google LLC. (2019). Sensors Overview. Retrieved 23 June 2020, from https://developer.android.com/guide/topics/sensors/sensors_overview.

Guétin, S., Portet, F., Picot, M. C., Pommié, C., Messaoudi, M., Djabelkir, L., Olsen, A. L., Cano, M. M., Lecourt, E., & Touchon, J. (2009). Effect of music therapy on anxiety and depression in patients with Alzheimer's type dementia: Randomised, controlled study. Dementia and Geriatric Cognitive Disorders, 28(1), 36–46. https://doi.org/10.1159/000229024

Headspace, Inc. (2020a). Headspace: Meditation & Sleep (3.57.0) [Mobile app]. Retrieved 9 July 2020, from https://www.headspace.com/.

Headspace, Inc. (2020b). *Using Headspace – Help Center*. Retrieved 27 June 2020, from https://help.headspace.com/hc/en-us/categories/202463367-Using-Headspace.

Headspace, Inc. (2020c). *How do I set up Headspace on my Google Home? Headspace Help Center*. Retrieved 27 June 2020, from https://help.headspace.com/hc/en-us/articles/360005858293-How-do-I-set-up-Headspace-on-my-Google-Home-.

Hoa Ly, K., Trüschel, A., Jarl, L., Magnusson, S., Windahl, T., Johansson, R., Carlbring, P., & Andersson, G. (2014). Behavioural activation versus mindfulness-based guided self-help treatment administered through a smartphone application: a randomised controlled trial. *BMJ Open*, *4*, 3440. https://doi.org/10.1136/bmjopen-2013

Hoare, D. J., Searchfield, G. D., El Refaie, A., & Henry, J. A. (2014). Sound therapy for tinnitus management: Practicable options. *Journal of the American Academy of Audiology*, *25*(1), 62–75. https://doi.org/10.3766/jaaa.25.1.5

Hobson, J., Chisholm, E., & El Refaie, A. (2012). Sound therapy (masking) in the management of tinnitus in adults. *Cochrane Database of Systematic Reviews*, (11). https://doi.org/10.1002/14651858.CD006371.pub3

Hudson, F., & Clark, C. (2018). *Wearables and Medical Interoperability: The Evolving Frontier*. Retrieved from http://bit.ly/cliniotblkngrp.

Hussain, J., Ul Hassan, A., Muhammad Bilal, H. S., Ali, R., Afzal, M., Hussain, S., Bang, J., Banos, O., Lee, S. (2018). Model-based adaptive user interface based on context and user experience evaluation. *Journal on Multimodal User Interfaces*, *12*(1). https://doi.org/10.1007/s12193-018-0258-2

Johnson, B., Raymond, S., & Goss, J. (2012). Perioperative Music or Headsets to Decrease Anxiety. https://doi.org/10.1016/j.jopan.2012.03.001

Joshi, A., Kiran, R., & Sah, A. N. (2017). An experimental analysis to monitor and manage stress among engineering students using Galvanic Skin Response meter. *Work*, *56*(3), 409–420. https://doi.org/10.3233/WOR-172507

Kinsler, L. E., Frey, A. R., & Mayer, W. G. (1963). Fundamentals of Acoustics. *Physics Today*, *16*(8), 56–57. https://doi.org/10.1063/1.3051072

Koumura, T., Nakatani, M., Liao, H.-I., & Kondo, H. M. (2020). D\eep, soft, and dark sounds induce autonomous sensory meridian response. *Cold Spring Harbor*.

Kwok, S. Y. C. L. (2019). Integrating Positive Psychology and Elements of Music Therapy to Alleviate Adolescent Anxiety. *Research on Social Work Practice*, *29*(6), 663–676. https://doi.org/10.1177/1049731518773423

Laska, Y., Suryono, Widyawati, M. N., Suwondo, A., & Kusworowulan, S. (2018). Effect of nature sound therapy on the level of cortisol in postpartum primipara. *Belitung Nursing Journal*, 4(1),26-30.

Lee, E. J., Bhattacharya, J., Sohn, C., & Verres, R. (2012). Monochord sounds and progressive muscle relaxation reduce anxiety and improve relaxation during

chemotherapy: A pilot EEG study. *Complementary Therapies in Medicine*, *20*(6), 409–416. https://doi.org/10.1016/j.ctim.2012.07.002

Li X.-M., Zhou K.-N, Yan H., Wang D.-l. & Zhang Y.-P. (2011). Effects of music therapy on anxiety of patients with breast cancer after radical mastectomy: a randomized clinical trial. *The Authors Journal of Advanced Nursing 68*(5), 1145–1155. https://doi.org/10.1111/j.1365-2648.2011.05824.x

Liu, Y.-H., Chang, M.-Y., & Chen, C.-H. (2009). Effects of music therapy on labour pain and anxiety in Taiwanese first-time mothers. https://doi.org/10.1111/j.1365-2702.2009.03028.x

Low, T., Meaklim, H., Conduit, R., & Jackson, M. (2018). Treating subclinical and clinical symptoms of insomnia with a mindfulness-based smartphone application: A pilot study. *Journal of Sleep Research*, *27*, e67_12766. https://doi.org/10.1111/jsr.67_12766

Mani, M., Kavanagh, D. J., Hides, L., & Stoyanov, S. R. (2015). Review and Evaluation of Mindfulness-Based iPhone Apps. *JMIR MHealth and UHealth*, *3*(3), e82. https://doi.org/10.2196/mhealth.4328

McGrandles, A., & Duffy, T. (2012). Assessment and treatment of patients with anxiety. *Nursing Standard*, *26*(35), 48–56.

Meditopia. (2020). Meditopia: Anxiety, Breathing (3.11.0) [Mobile app]. Google Play Store. https://play.google.com/store/apps/details?id=app.meditasyon&hl=en.

Mombers, C., Legako, K., & Gilchrist, A. (2016). Identifying medical wearables and sensor technologies that deliver data on clinical endpoints. *British Journal of Clinical Pharmacology*. Blackwell Publishing Ltd. https://doi.org/10.1111/bcp.12818

Morrison Wylde, C., Mahrer, N. E., Meyer, R. M. L., & Gold, J. I. (2017). Mindfulness for Novice Pediatric Nurses: Smartphone Application Versus Traditional Intervention. https://doi.org/10.1016/j.pedn.2017.06.008

NewsRx. (2013). Analgesics; Music therapy reduces anxiety, use of sedatives for patients receiving ventilator support. *Biotech Week; Atlanta*, 346. https://doi.org/10.1001/jama.2013.5670

NHS. (2020). Feeling Good: positive mindset [Mobile app]. Retrieved 14 August 2020, from https://www.nhs.uk/apps-library/feeling-good-positive-mindset/.

Padesky, C. (2020). *Mind Over Mood*. Retrieved 20 June 2020, from https://www.mindovermood.com/.

Pavlov, A., Kameg, K., Cline, T. W., Chiapetta, L., Stark, Ann, S., & Mitchell, M. M. (2017). Music Therapy as a Nonpharmacological Intervention for Anxiety in Patients with a Thought Disorder. *Issues in Mental Health Nursing*, *38*(3), 285–288. https://doi.org/10.1080/01612840.2016.1264516

Phillips, A. C., David Batty, G., Gale, C. R., Lord, J. M., Arlt, W., & Carroll, D. (2011). Major depressive disorder, generalised anxiety disorder, and their comorbidity: Associations with cortisol in the Vietnam Experience Study. *Psychoneuroendocrinology*, *36*, 682–690. https://doi.org/10.1016/j.psyneuen.2010.09.011

Poerio, G., Blakey, E., Hostler, T., & Veltri, T. (2018). More than a feeling: Autonomous sensory meridian response (ASMR) is characterized by reliable changes in affect and physiology. *PLOS ONE*, *13*(6), e0196645. doi: 10.1371/journal.pone.0196645

Puli, A., & Kushki, A. (2020). Toward Automatic Anxiety Detection in Autism: A Real-Time Algorithm for Detecting Physiological Arousal in the Presence of Motion. *IEEE Transactions on Biomedical Engineering*, *67*(3), 646–657. https://doi.org/10.1109/TBME.2019.2919273

QSR International, LLC. (2019). NVivo 12 (12.6.0) [Computer software]. Retrieved from https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home.

Ratcliffe, E., Gatersleben, B., & Sowden, P. T. (2016). Associations with bird sounds: How do they relate to perceived restorative potential? *Journal of Environmental Psychology*, *47*, 136–144. https://doi.org/10.1016/j.jenvp.2016.05.009

Relax by Red Conifer. (2019). *4K Sunset Relaxing Video for Sleep and Relax Nature Music Screensaver Birds and crickets.* [Video]. Retrieved 19 June 2020, from https://www.youtube.com/watch?v=mYcsTPt0CCQ.

Relaxio s.r.o. (2020). Nature Sounds (3.4.0) [Mobile app]. http://www.relaxio.net/.

Sanvello Health Inc. (2020). Sanvello for Anxiety, Depression & Stress (8.8.1) [Mobile app]. Google Play Store. https://play.google.com/store/apps/details?id=com.pacificalabs.pacifica&hl=en.

Sattva. (2020). Sattva [Mobile app]. Retrieved 14 August 2020, from https://www.sattva.life/.

Sharma, N., & Gedeon, T. (2012). Objective measures, sensors and computational techniques for stress recognition and classification: A survey. *Computer Methods and Programs in Biomedicine*, *108*(3), 1287–1301. https://doi.org/10.1016/j.cmpb.2012.07.003

Shi, Y., Ruiz, N., Taib, R., Choi, E., & Chen, F. (2007). Galvanic skin response (GSR) as an index of cognitive load. In *Conference on Human Factors in Computing Systems - Proceedings* (pp. 2651–2656). Association for Computing Machinery. https://doi.org/10.1145/1240866.1241057

Stem4. (2019). Clear Fear [Mobile app]. Retrieved 14 August 2020, from https://www.clearfear.co.uk/.

Stoll, R. D., Pina, A. A., Gary, K., & Amresh, A. (2017). *Usability of a Smartphone Application to Support the Prevention and Early Intervention of Anxiety in Youth*. www.elsevier.com/locate/cabp

Van Emmerik, A. A. P., Berings, F., & Lancee, J. (2017). Efficacy of a Mindfulness-Based Mobile Application: a Randomized Waiting-List Controlled Trial. https://doi.org/10.1007/s12671-017-0761-7

Wahaishi, A. M., Samani, A., & Ghenniwa, H. (2015). SmartHealth and Internet of Things. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 9102, pp. 373–378). Geneva, Switzerland: Springer Verlag. https://doi.org/10.1007/978-3-319-19312-0_38

Wallop, H. (2019). McMindful Inc: the rise and rise of meditation apps Calm and Headspace.Retrieved 28 May 2020, from https://www.thetimes.co.uk/article/mcmindful-inc-the-rise-and-rise-of-meditation-apps-calm-and-headspace-dzthb0vgr

Wang, Y., Xiao, R., Luo, C., & Yang, L. (2019). Attentional disengagement from negative natural sounds for high-anxious individuals. *Anxiety, Stress and Coping*, *32*(3), 298–311. https://doi.org/10.1080/10615806.2019.1583539

Wellmind Health. (2020). *Be Mindful*. Retrieved 20 June 2020, from https://www.bemindfulonline.com/.

WhispersRed ASMR. (2019). *Be Calm & Sleepy ASMR for Anxiety*. [Video]. Retrieved 19 June 2020, from https://www.youtube.com/watch?v=X9pPv1Bh_ak.

YouTherapeutic. (2020). *Calm River Mountain, Nature Sounds, Meditation, short relaxation.* [Video]. Retrieved 19 June 2020, from https://www.youtube.com/watch?v=UVdyyqRDzzE.

Appendix 1. Research Proposal

1) MSc RESEARCH PROPOSAL

1. **Student details**

First name	Kirsty
Last (family) name	Bryce
Edinburgh Napier matriculation number	40451875

2. **Details of your programme of study**

MSc Programme title	Computing
Year that you started your diploma modules	2019

3. **Project outline details**

Please suggest a title for your proposed project. If you have worked with a supervisor on this proposal, please provide the name. You are strongly advised to work with a member of staff when putting your proposal together.

Title of the proposed project	Analysing the Sound Design Principles Necessary to Create an Application that Produces Sound to Alleviate the Symptoms of People with Generalised Anxiety Disorder
Is your project appropriate to your programme of study?	Yes
Name of supervisor	Dr. Iain McGregor

4. **Brief description of the research area - background**

The project will involve the analysis of sound design principles that can be used in an application that produces sound to help people experiencing anxiety. Research will be conducted in looking at using smartwatch and smartphone technologies to gather user data such as heartrate, breathing pattern, and noise levels to create a personalised audio environment to reduce the user's stress levels.

The American Music Therapy Association (AMTA) defines Music Therapy as a field of healthcare that makes use of music to assist people experiencing a wide range of physical, emotional, cognitive, and social disorders. The use of music therapy can be helpful in improving the quality of life, managing stress, and alleviating the pain of patients. It can be said that as a species we are more likely to appreciate patterns and organisation, and this can be seen in human responses to music. Through this inherent appreciation, music can be used to create an enhanced auditory environment (Duerksen, 2013). Sound therapy, like music therapy, can be used to help people with a wide range of conditions. One area where sound therapy has been used is in the treatment of tinnitus, where sound masking can be used to distract a sufferer from the noises produced by their condition and as a result lower their stress levels (Hobson, Chisholm & El Refaie, 2012).

Music therapy has been shown to be affective in alleviating the symptoms of people experiencing anxiety (Flores Gutiérrez, Andrés & Camarena, 2015). Anxiety disorders are debilitating conditions that include social anxiety disorder, panic disorder, agoraphobia, and generalized anxiety disorder, amongst others. Treatments for anxiety disorders, such as cognitive behavioural therapy and selective serotonin-reuptake inhibitors, can be effective especially when used together (Craske & Stein, 2016). However, they may not work for everyone, which can leave people looking for alternatives to conventional treatments for anxiety. Relaxation applications, such as Headspace and Calm, have become popular in recent years and boast many benefits, such as reduced stress levels and increased overall happiness. These applications often feature guided meditations, relaxation sounds, and music (Wallop, 2019).

The interest in using sounds for relaxation has been growing outside of mobile applications, as seen with the trend of autonomous sensory meridian response (ASMR) videos on YouTube. People are finding that the therapeutic effects of calming sounds are helping them with various conditions such as anxiety, stress, and insomnia. The phenomena of ASMR can be described as a tingling sensation at the crown of the head that is triggered by sounds such as whispering and tapping, and visuals such as hand movements (Poerio, Blakey, Hostler & Veltri, 2018). The most effective and popular audio triggers are whispering and crisp sounds. When users were asked why they consume ASMR media, 98% of respondents said they use it for relaxation purposes, 82% said they use it to help them fall asleep, and 70% use it to reduce stress (Barratt & Davis, 2015).

An example of sounds that can be used to reduce stress levels is nature sounds. Studies have shown that exposing people to nature sounds after being under psychological stress helps them recover quicker compared to listening to less pleasant non-nature sounds (Alvarsson, Wiens & Nilsson, 2010). Brainwave entertainment is a binaural beat phenomenon where two different frequencies are played in a person's ears which can induce a different cognitive state and create a relaxation

effect (Baracskai & Finn, 2013). These stress-reducing sounds are examples of sound design principles that can be implemented in the application. With the addition of smartwatch and smartphone user data, it is possible to create an automated system that can adapt the sounds produced to the user based on their current audio environment, location, and physiological data.

5. **Project outline for the work that you propose to complete**

The idea for this research arose from:

My reason for pursuing this topic is a rather personal one, as I am someone who deals with anxiety and who knows many people who are also affected by it. I feel that the diffusion of an easily accessible and intuitive system that produces sounds for reducing the effects of anxiety could be useful and could potentially be beneficial to many different types of people, including myself. The topic also fits well with my academic background, as I have studied in the areas of both sound and computing.

The aims of the project are as follows:

- Conduct a literature review into the effects of music and sound therapy on people with generalised anxiety disorder.
- Gather requirements about how to use data from a user's surroundings (location and noise level) and their physiological data (heart rate and breathing) to effectively produce relaxing sounds for them in the context of a sound therapy application.
- Conduct a listening study aiming to measure the effectiveness of an application that produces sounds to reduce stress levels of people with generalised anxiety disorder.
- Evaluate the findings of a listening study aiming to measure the effectiveness of an application that produces sounds to reduce stress levels of people with generalised anxiety disorder and the project as a whole.

The main research questions that this work will address include:

- Which sound design principles could be used to create an application that produces sounds to effectively reduce the stress levels of people with generalised anxiety disorder?
- What are the possible technological limitations that may arise and how can they be overcome?

The software development/design work/other deliverable of the project will be:

- Sound design guidelines for producing sounds that can help reduce anxiety.
- A prototype of an application that produces sounds to help people that are experiencing anxiety, created with Axure.

The project deliverable will be evaluated as follows:

- Experimentation through remote listener testing (ensuring social distancing rules) to test the effectiveness of the application's sounds in reducing anxiety.

- An online questionnaire gathering user feedback on the prototype of an application to reduce stress levels through sounds.

The project will involve the following research/field work/experimentation/evaluation:

- An in-depth analysis of the field of sound therapy and its relation to anxiety disorders.
- Develop a method for implementing sound into a mobile application environment with the intention of reducing stress levels of people with anxiety.
- Inquire about the usability and effectiveness of the mobile application by interviewing potential users.

This work will require the use of specialist software:

- Logic Pro X, Ableton, Axure.

This work will require the use of specialist hardware:

NA

The project is being undertaken in collaboration with:

NA

6. **References**

Abedikoupaei, M., Poushaneh, K., Mohammadi, A. Z., & Siampour, N. (2013). Sound Therapy: an Experimental Study with Autistic Children. *Procedia-Social and Behavioral Sciences*, *84*, 626–630. https://doi.org/10.1016/j.sbspro.2013.06.615

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health*, *7*(3), 1036–1046. https://doi.org/10.3390/ijerph7031036

Baracskai, Z., & Finn, S. (2013). Relaxation effects of binaural phenomena. *Proceedings of the AES International Conference*, 139–143.

Barratt, E. L., & Davis, N. J. (2015) Autonomous Sensory Meridian Response (ASMR): a flow-like mental state. https://doi.org/10.7717/peerj.851

Craske, M., & Stein, M. (2016). Anxiety. *The Lancet*, *388*(10063), 3048-3059. doi: 10.1016/s0140-6736(16)30381-6

Duerksen, G. L. (2013). Music therapy. https://doi.org/10.1093/gmo/9781561592630.article.A2257019

Flores Gutiérrez, E. O., Andrés, V., & Camarena, T. (2015). The Arts in Psychotherapy Music therapy in generalized anxiety disorder. *The Arts in Psychotherapy*, *44*, 19–24. https://doi.org/10.1016/j.aip.2015.02.003

Hobson, J., Chisholm, E., & El Refaie, A. (2012). Sound therapy (masking) in the management of tinnitus in adults. *Cochrane Database of Systematic Reviews*, (11). https://doi.org/10.1002/14651858.CD006371.pub3

Poerio, G., Blakey, E., Hostler, T., & Veltri, T. (2018). More than a feeling: Autonomous sensory meridian response (ASMR) is characterized by reliable changes in affect and physiology. *PLOS ONE*, *13*(6), e0196645. doi: 10.1371/journal.pone.0196645

Wallop, H. (2019). McMindful Inc: the rise and rise of meditation apps Calm and Headspace. Retrieved 28 May 2020, from https://www.thetimes.co.uk/article/mcmindful-inc-the-rise-and-rise-of-meditation-apps-calm-and-headspace-dzthb0vgr

7. **Ethics**

If your research involves other people, privacy or controversial research there may be ethical issues to consider (please see the information on the module website). If the answer below is YES then you need to complete a research Ethics and Governance Approval form, available on the website: http://www.ethics.napier.ac.uk .

Does this project have any ethical or governance issues related to working with, studying or observing other people? (YES/NO)	Yes

8. **Confidentiality**

If your research is being done in conjunction with an outside firm or organisation, there may be issues of confidentiality or intellectual property.

Does this project have any issues of confidentiality or intellectual property? (YES/NO)	No

10. **Submitting your proposal**

1. Please save this file using your surname, e.g. macdonald_proposal.docx, and e-mail it to your supervisor, who will discuss it with you and suggest possible improvements.
2. When your supervisor is content with your proposal, submit it to the Research Proposal Upload link on Moodle, and email your internal examiner to notify them that you have submitted. They will leave feedback for you on Moodle.
3. Discuss your feedback from the internal examiner with your supervisor and if necessary make final changes to your proposal.
4. When you produce your dissertation, add your finalised proposal as an appendix.

2) Gantt Chart

Tasks	Deadline	W 1 25/05	W 2 01/06	W 3 08/06	W 4 15/6	W 5 22/6	W 6 29/6	W 7 6/7	W 8 13/7	W 9 20/7	W 10 27/7	W 11 03/08	W 12 10/08	W 13 17/8
Write proposal	***05/06/2020***													
Write proposal	01/06/2020	✓												
Submit proposal	05/06/2020		✓											
Write chapter 1	***08/06/2020***													
Write abstract	01/06/2020	✓												
Write chapter 1	04/06/2020		✓											
Revise chapter 1	06/06/2020		✓											
Write chapter 2	***22/06/2020***													
Write 2.1: Anxiety	07/06/2020		✓											
Write 2.2: Sound and Psychological Support	12/06/2020		✓	✓										
Write 2.3: Applications for Psychological Support	12/06/2020			✓										
Write 2.4: Effective Application Design	19/06/2020				✓									
Write 2.5: Evaluating Psychological Support Software	13/6/2020			✓										
Write chapter 2.6: Summary	13/6/2020			✓										
Revise chapter 2	22/06/2020				✓									
Write initial report	***26/06/2020***													
Write initial report	23/06/2020				✓									
Revise initial report	24/6/2020					✓								
Submit initial report	25/6/2020					✓								
Write chapter 3	***23/06/2020***													
Research and analyse sound design principles	18/06/2020				✓									
Write 3.1: Analysing Sounds for Relaxation Purposes	19/06/2020				✓	✓	✓							
Look at functionality & design of relaxation apps	20/06/2020				✓									
Write 3.2: Interface Analysis of Relaxation Apps	20/06/2020				✓									
Choosing design elements for app (UI & sound)	20/06/2020				✓									
Write 3.3: Defining the Elements of the Application	20/06/2020				✓									
Write 3.4: Summary	22/06/2020				✓									
Revise chapter 3	23/06/2020				✓									
Write chapter 4	***27/07/2020***													
Write 4.1: Application Development Method	19/06/2020						✓							
Write 4.2: Define sound design principles	30/06/2020						✓							
Choosing the sounds for the app	15/6/2020						✓							
Mixing/editing sounds with Logic Pro X	06/07/2020							✓						
Write 4.3: Producing sounds for the app	06/07/2020							✓						
Create the application	06/07/2020								✓					
Write 4.4: Creating the application prototype	27/07/2020									✓				
Write 4.5: Summary	27/07/2020									✓				
Revise chapter 4	27/07/2020									✓				
Write chapter 5	***10/08/2020***													
Write 5.1: Background	03/07/2020										✓			
Write 5.2: Method	03/07/2020										✓			
Ethics and GDPR approval	20/07/2020								✓					
Prepare study and survey	20/07/2020								✓					
Conduct study and survey	03/08/2020									✓	✓			
Extract data from study	03/08/2020											✓		
Write 5.3: Results	10/08/2020											✓		
Write 5.4: Discussion	10/08/2020											✓		
Write 5.5: Summary	10/08/2020											✓		
Revise chapter 5	10/08/2020											✓		
Finish first draft of dissertation	***15/08/2020***													
Write 6	15/08/2020												✓	
Finish first draft of dissertation	15/08/2020												✓	
Submit dissertation	***17/8/2020***													
Revise dissertation	16/8/2020													
Submit dissertation	17/8/2020													

Appendix 2. Sound Analysis

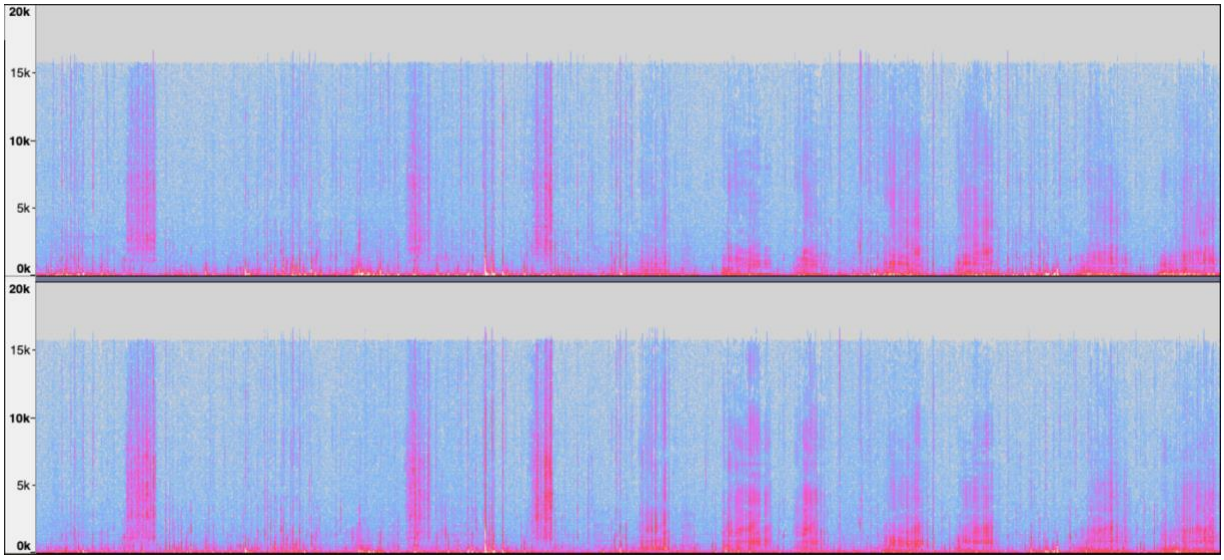
Each sound was analysed using four spectrogram tools: spectrogram view in Audacity, Voxengo SPAN, Blue Cat FreqAnalyst, and HoRNet ThirtyOne.

The spectrogram images that were created with Audacity have a colour to represent each level of sound. With the default settings of Gain = 20 dB and Range = 80 dB, the colours correspond to the following levels:

- anything above -20 dB is indistinguishably white
- levels from -40 dB to -20 dB transition from red to white
- levels from -60 dB to -40 dB transition from magenta to red
- levels from -80 dB to -60 dB transition from dark blue to magenta
- levels from -100 dB to -80 dB transition from light blue to dark blue
- anything below -100 dB is grey (Audacity Team, 2020).

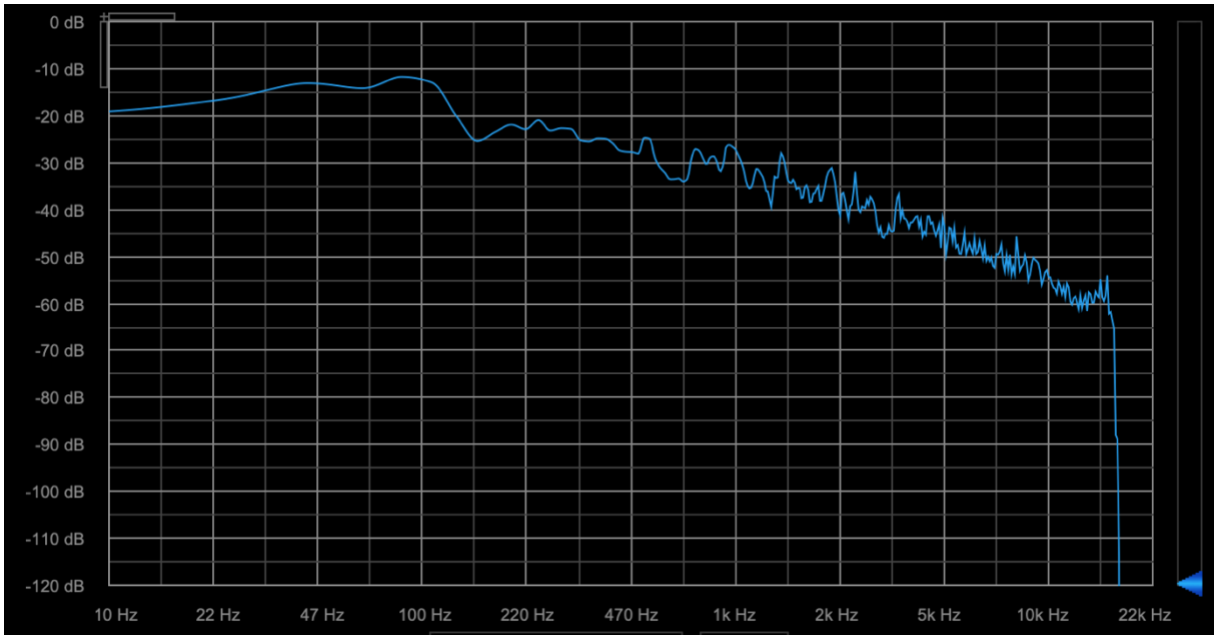
- ASMR sounds:
    - Sound from the YouTube video “ASMR Brain Tingling Triggers For INSTANT Sleep (Plucking, Scratching, Rubbing)” (DennisASMR, 2020).

Spectrogram view in Audacity (Audacity, 2020):

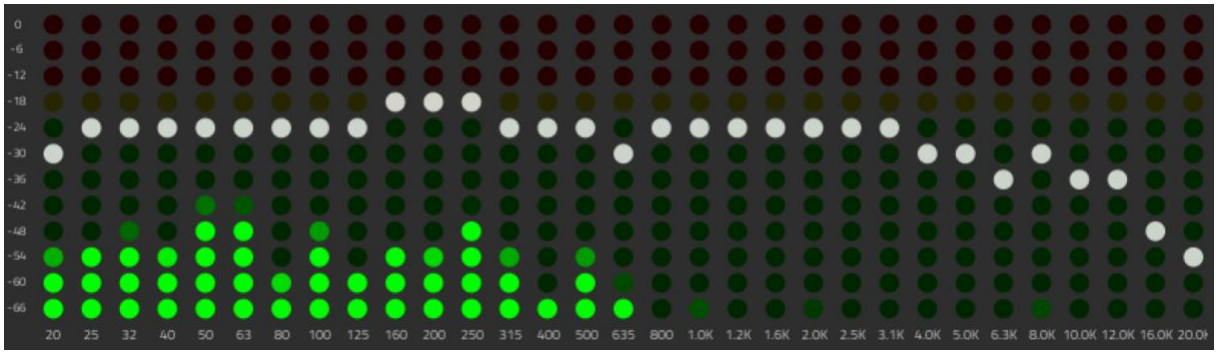


Voxengo SPAN (Apple Inc., 2020):

Blue Cat FreqAnalyst (Apple Inc., 2020):

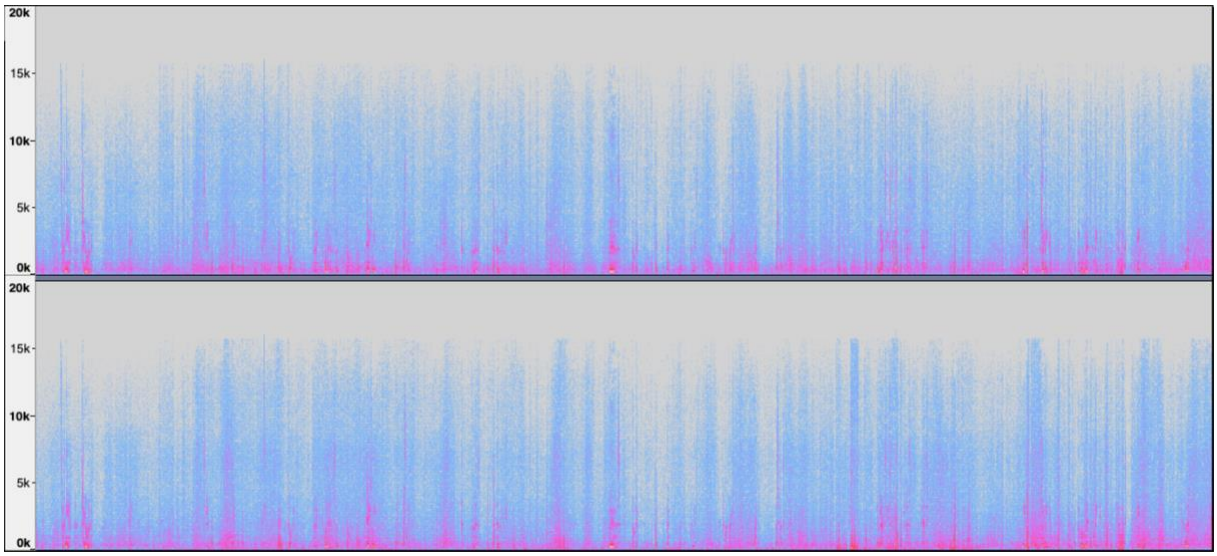


HoRNet ThirtyOne (Audacity, 2020):

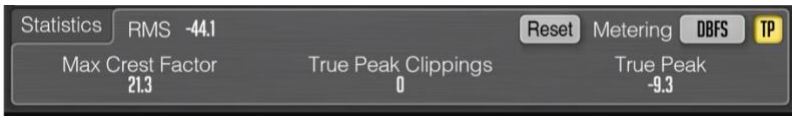


- Sound from the YouTube video “Be Calm & Sleepy ASMR for Anxiety” (WhispersRed ASMR, 2019).

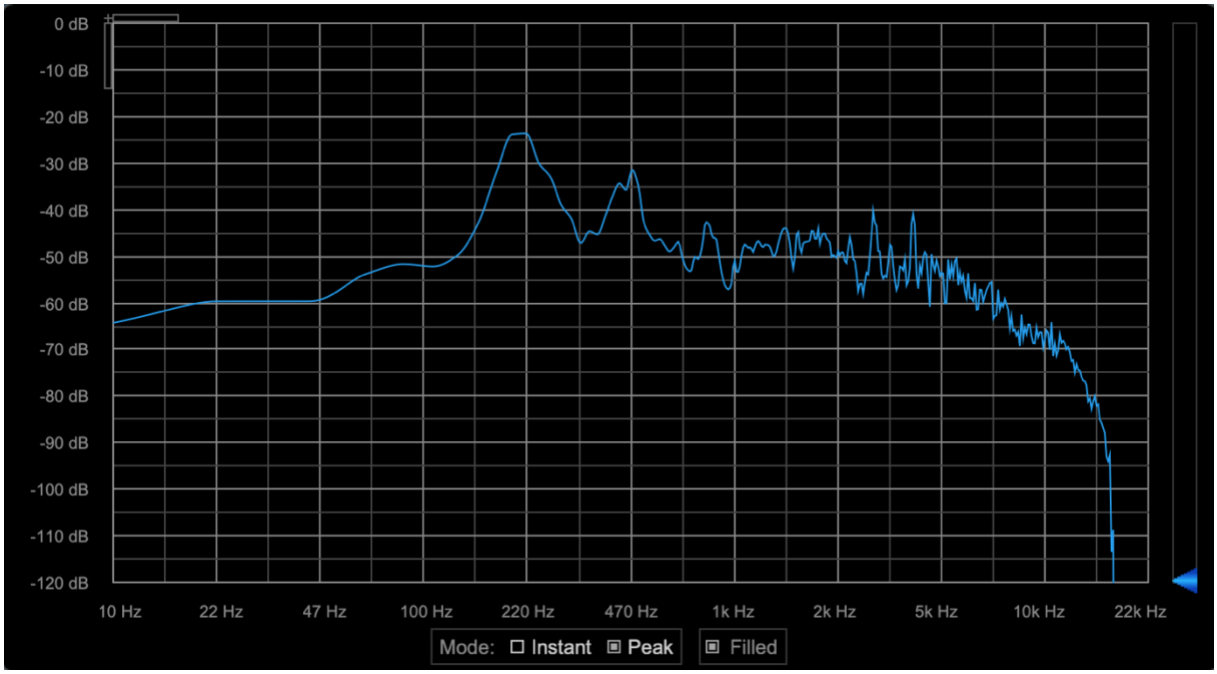
Spectrogram view in Audacity (Audacity, 2020):



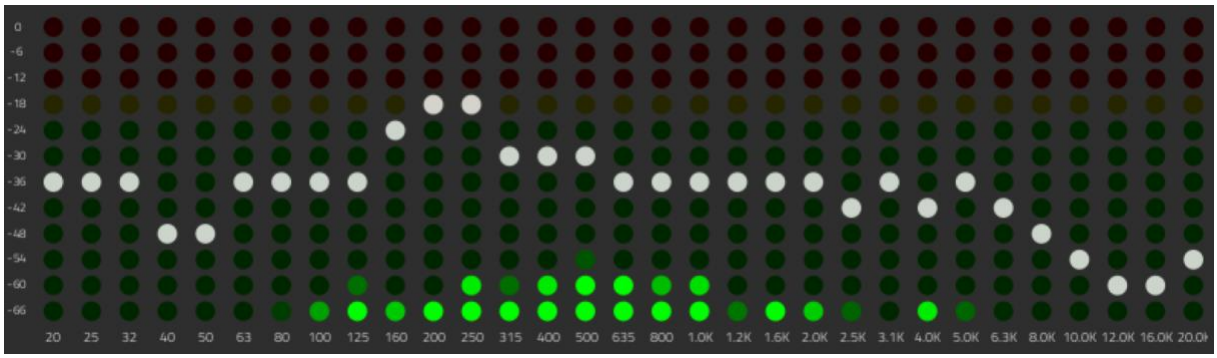
Voxengo SPAN (Apple Inc., 2020):



Blue Cat FreqAnalyst (Apple Inc., 2020):

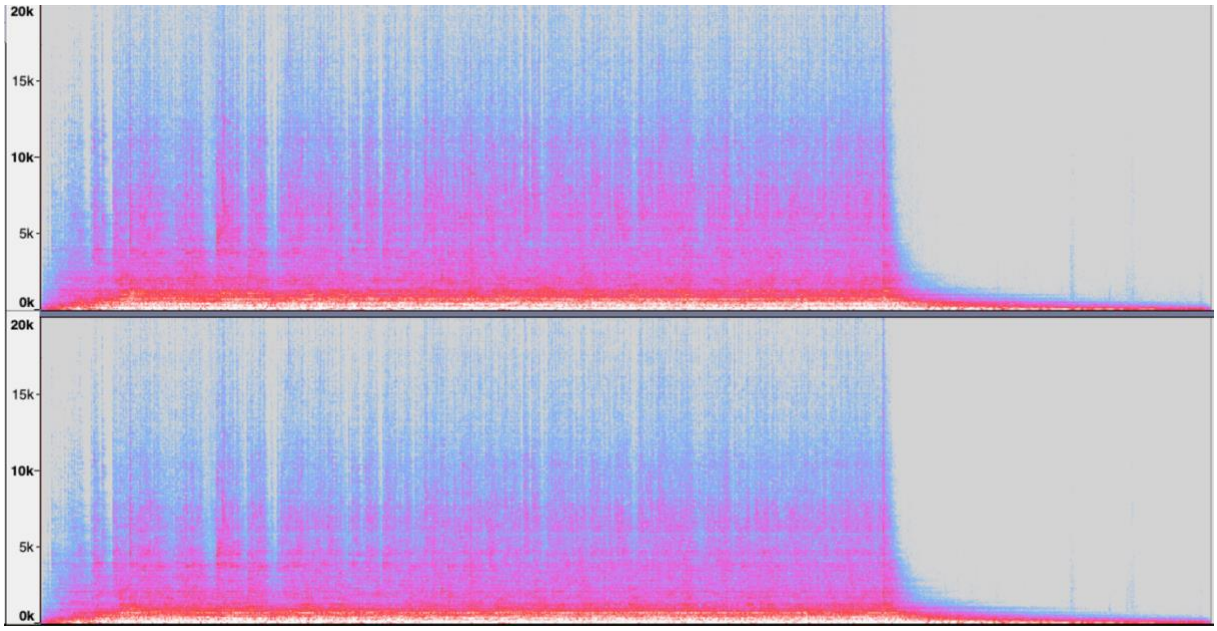


HoRNet ThirtyOne (Audacity, 2020):



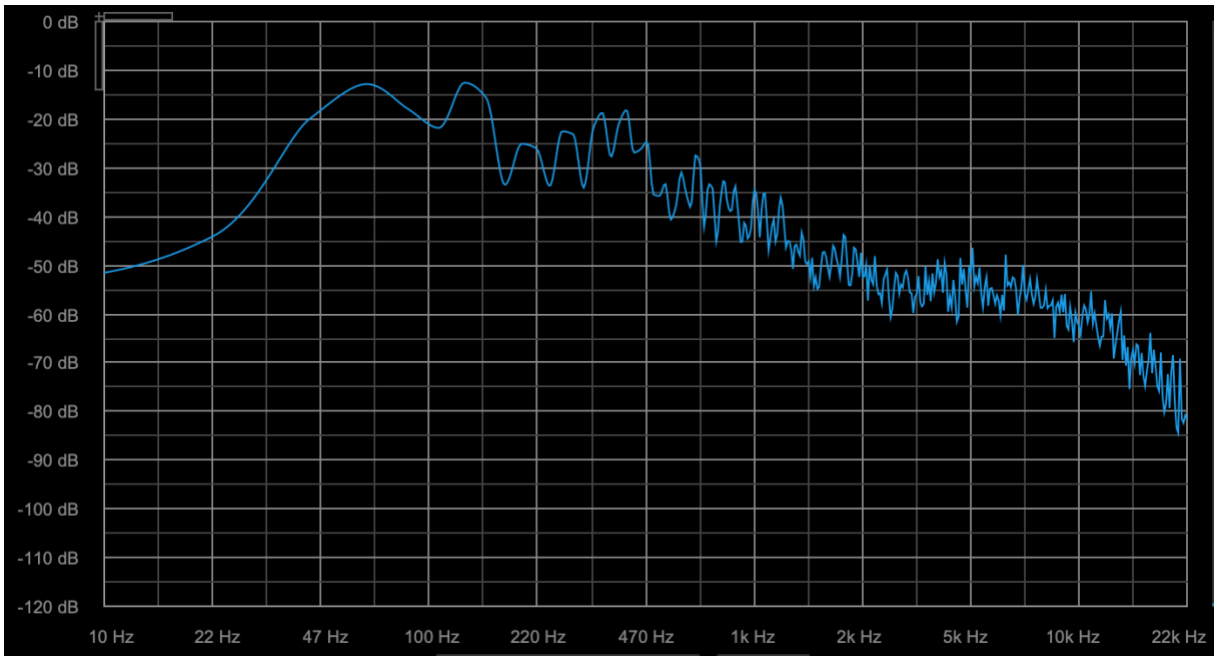
- Monochord sounds:
    - Sound from Freesound “Soundbed” by juskiddink.

Spectrogram view in Audacity (Audacity, 2020):

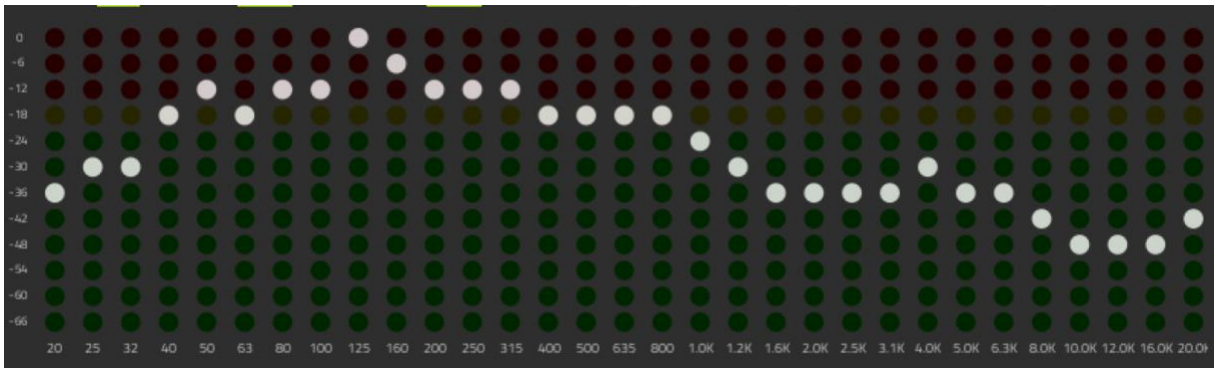


Voxengo SPAN (Apple Inc., 2020):

Blue Cat FreqAnalyst (Apple Inc., 2020):

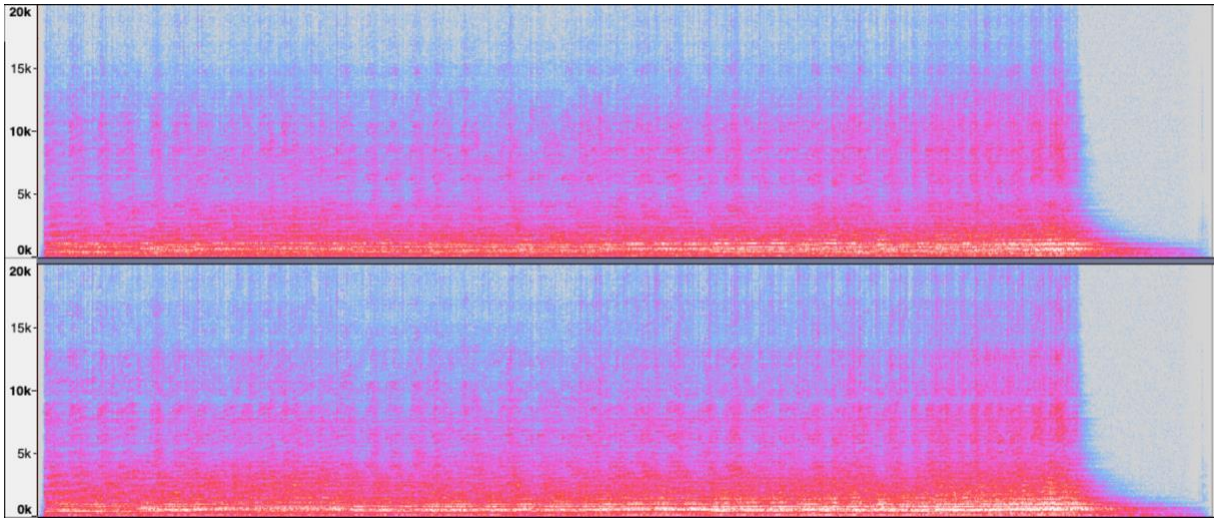


HoRNet ThirtyOne (Audacity, 2020):

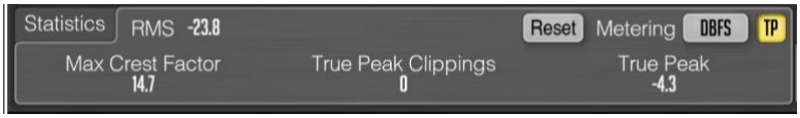


- Sound from Freesound “Soundbox” by juskiddink.

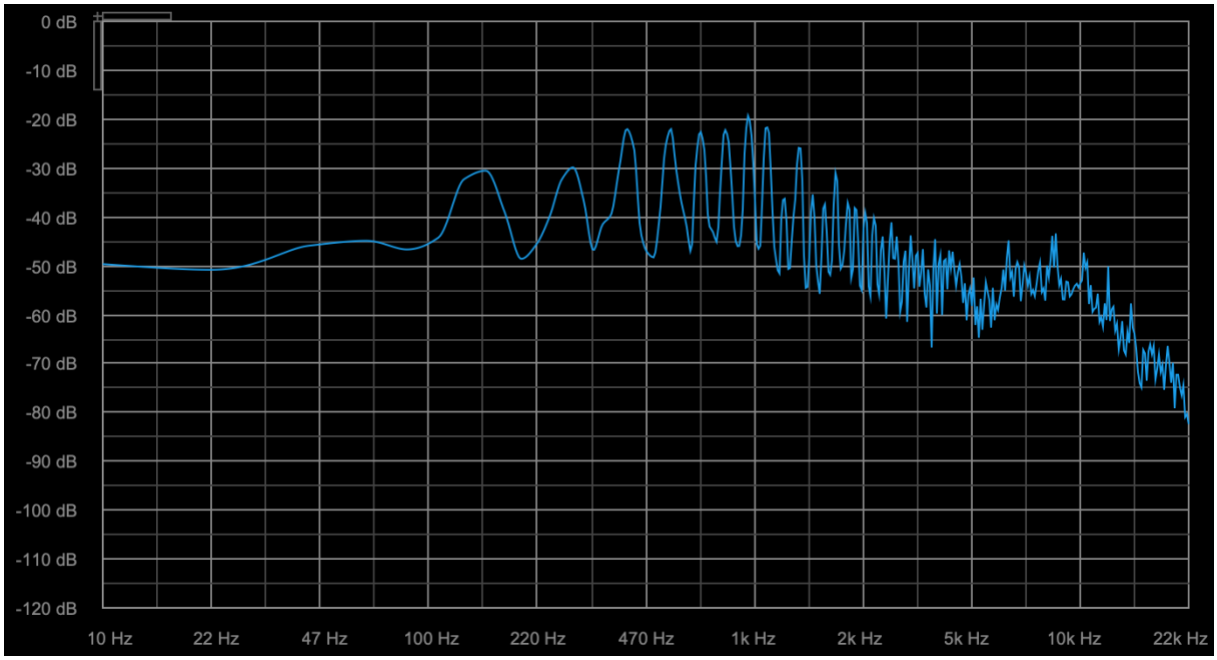
Spectrogram view in Audacity (Audacity, 2020):



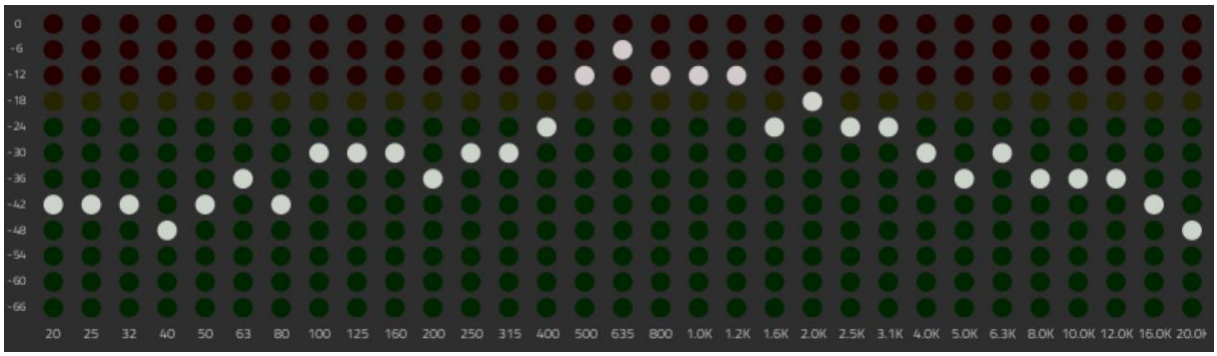
Voxengo SPAN (Apple Inc., 2020):



Blue Cat FreqAnalyst (Apple Inc., 2020):

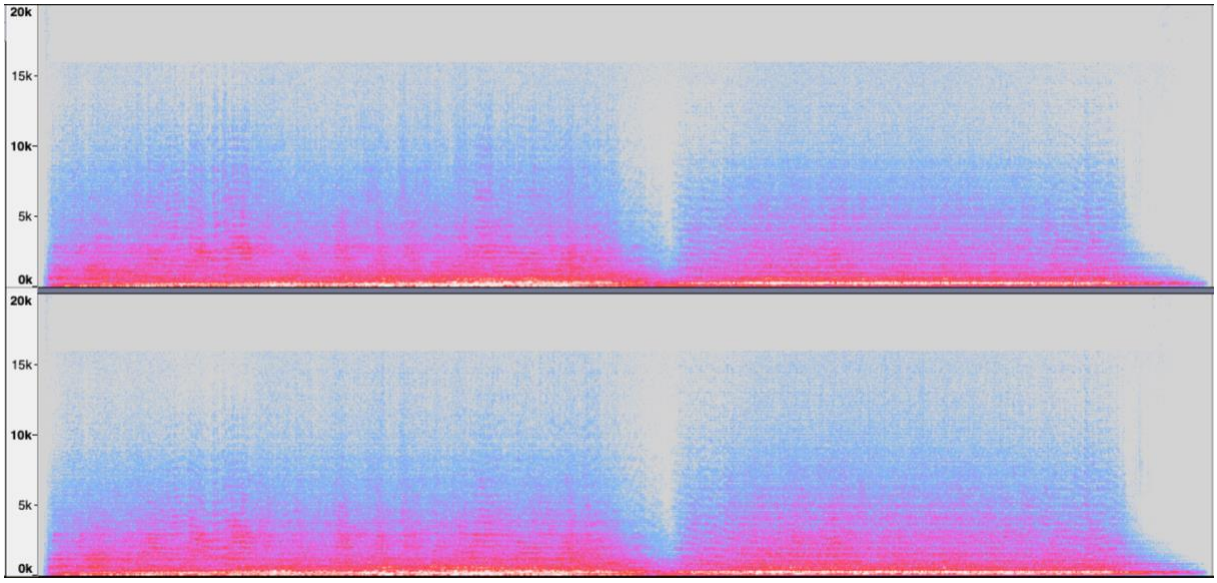


HoRNet ThirtyOne (Audacity, 2020):

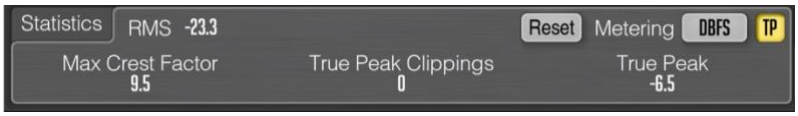


- Sound from Freesound “Julia-Monochord-Klangreise” by stefan_machu.

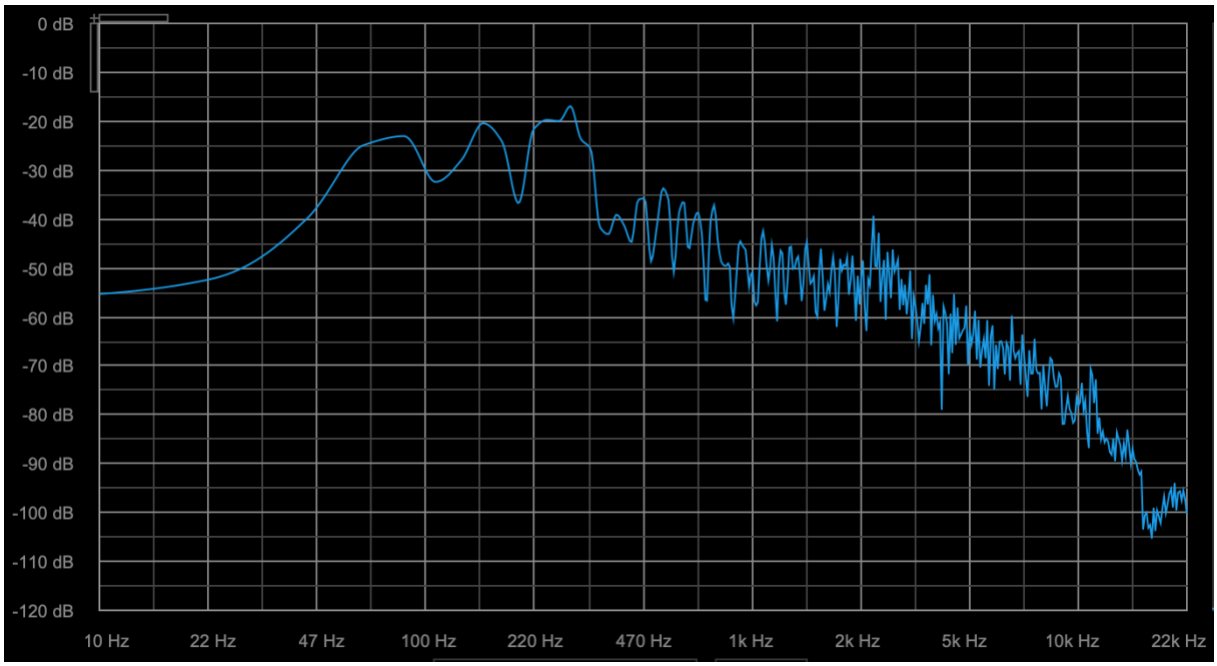
Spectrogram view in Audacity (Audacity, 2020):



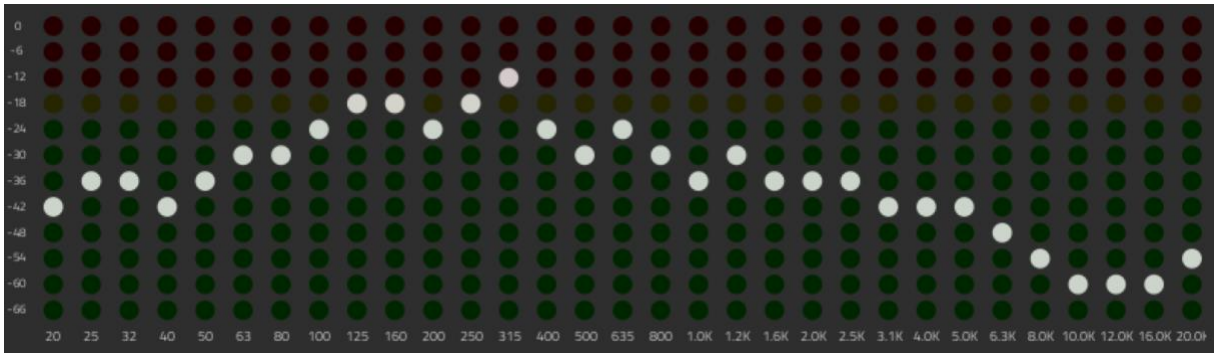
Voxengo SPAN (Apple Inc., 2020):



Blue Cat FreqAnalyst (Apple Inc., 2020):

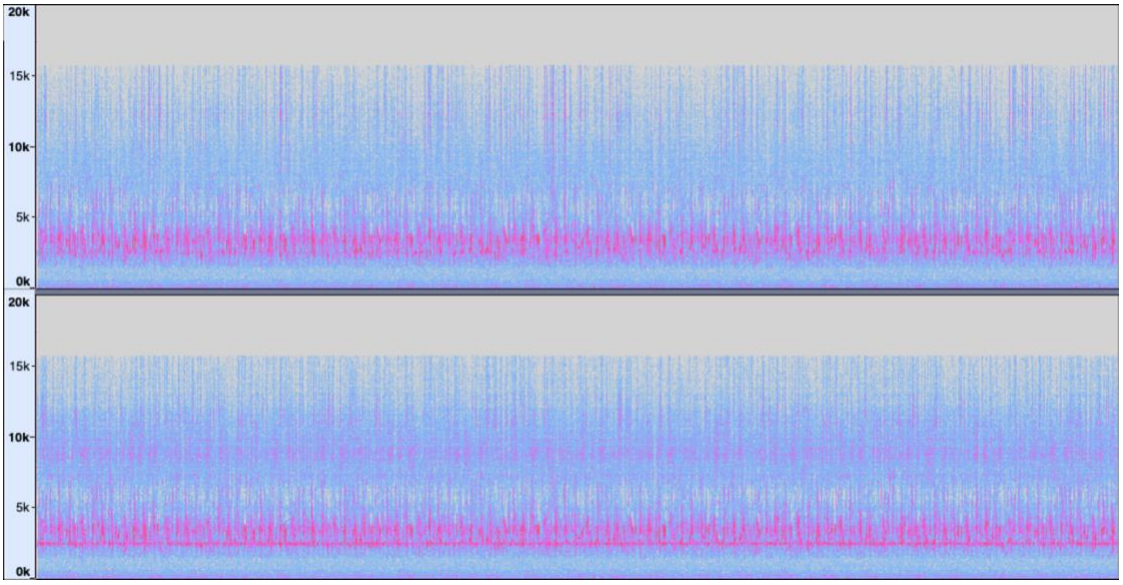


HoRNet ThirtyOne (Audacity, 2020):



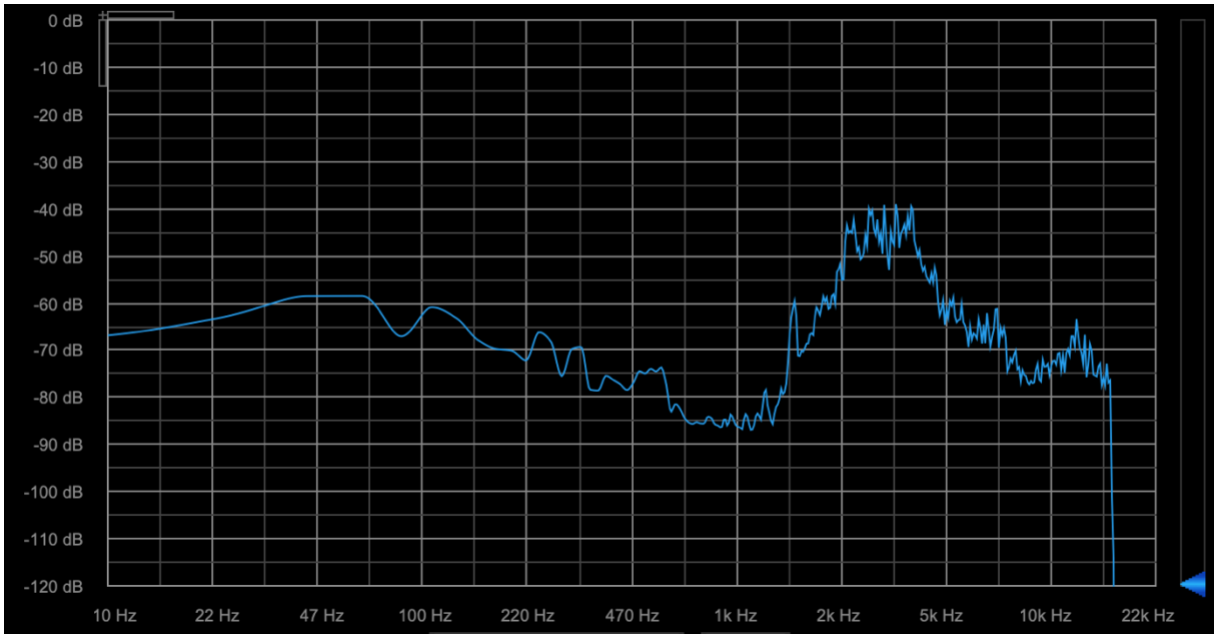
- Nature sounds:
    - Sound from the YouTube video “4K Sunset Relaxing Video for Sleep and Relax Nature Music Screensaver Birds and crickets” (Relax by Red Conifer, 2019).

Spectrogram view in Audacity (Audacity, 2020):

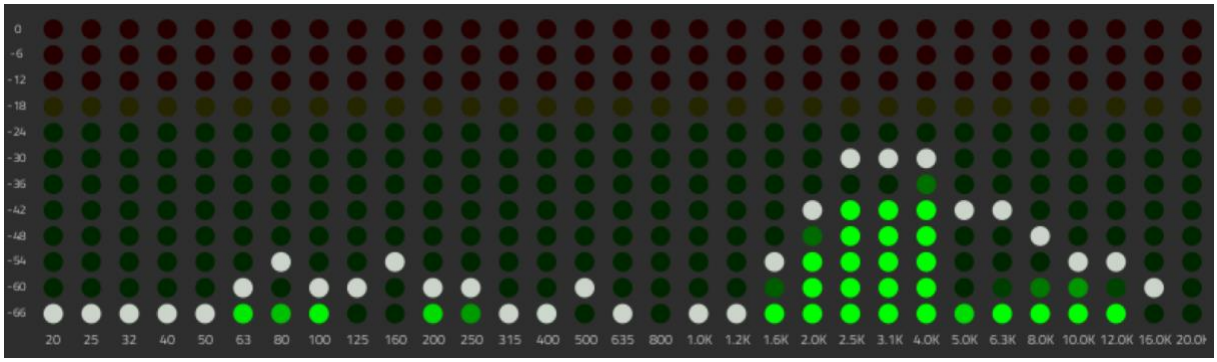


Voxengo SPAN (Apple Inc., 2020):

Blue Cat FreqAnalyst (Apple Inc., 2020):

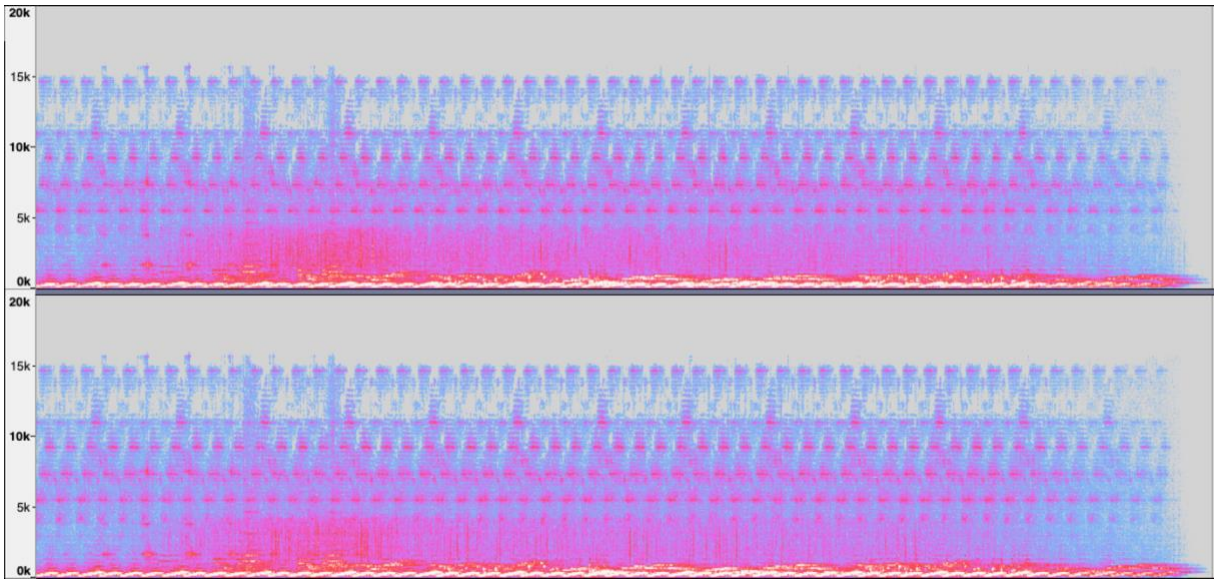


HoRNet ThirtyOne (Audacity, 2020):



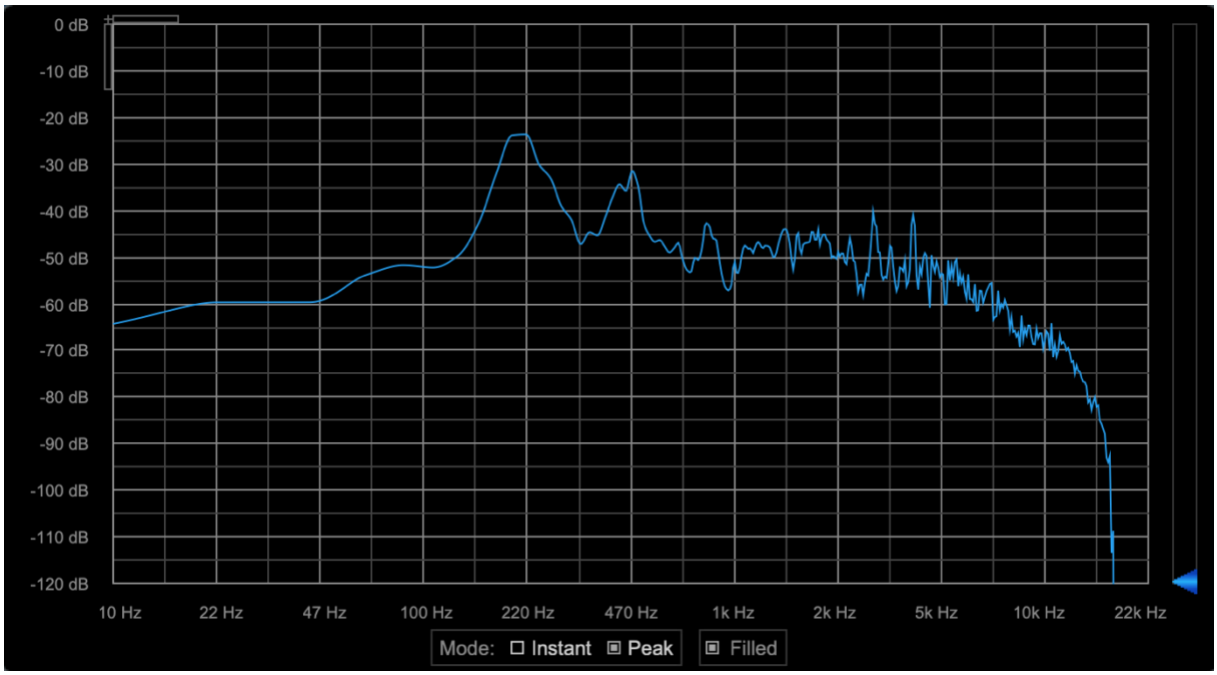
- Sound from the YouTube video “Calm River Mountain, Nature Sounds, Meditation, short relaxation” (YouTherapeutic, 2020).

Spectrogram view in Audacity (Audacity, 2020):



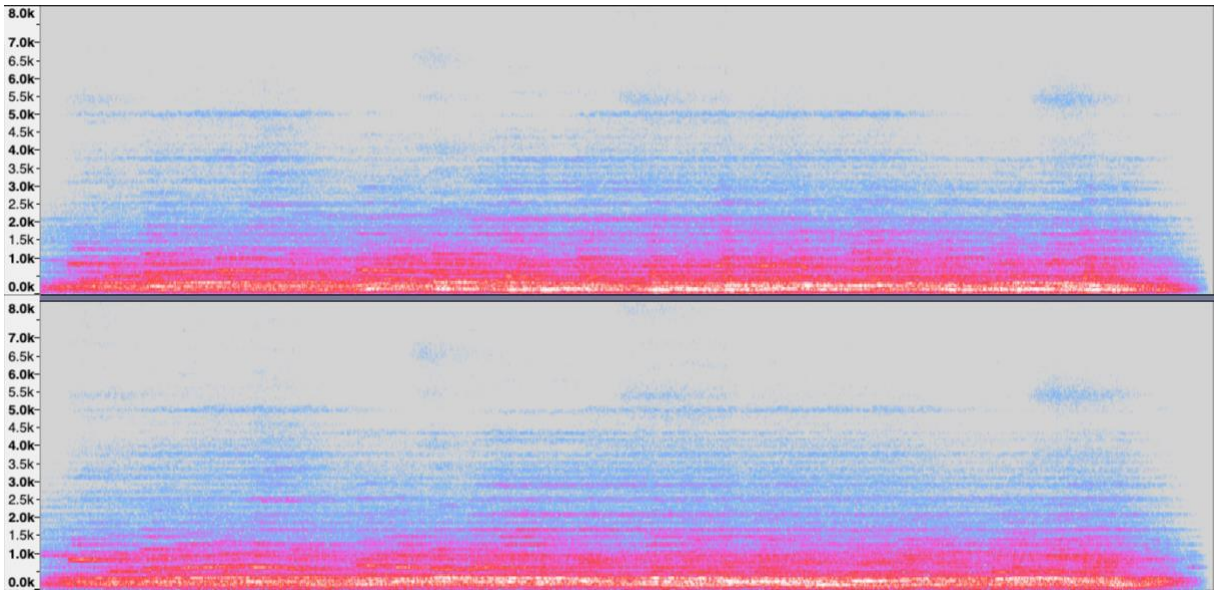
Voxengo SPAN (Apple Inc., 2020):

Blue Cat FreqAnalyst (Apple Inc., 2020):

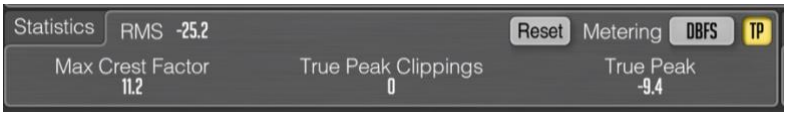


- Brainwave entertainment:
    - Sound from the YouTube video “Brainwave Entertainment” by Symphonic Distribution.

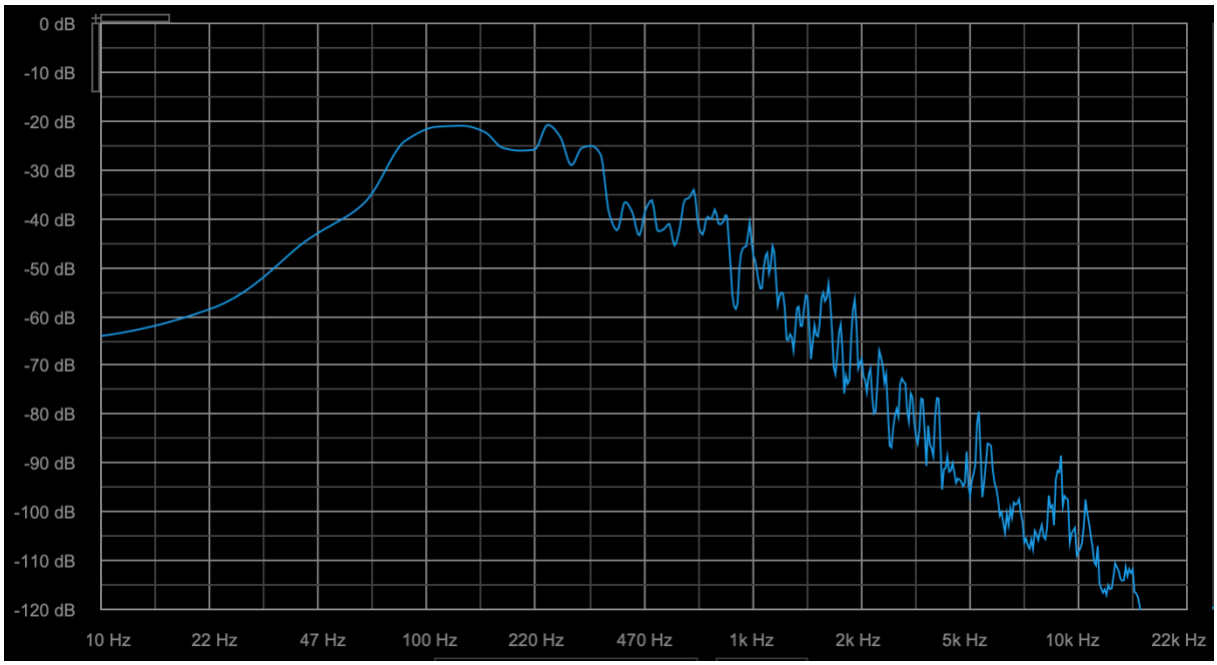
Spectrogram view in Audacity (Audacity, 2020):



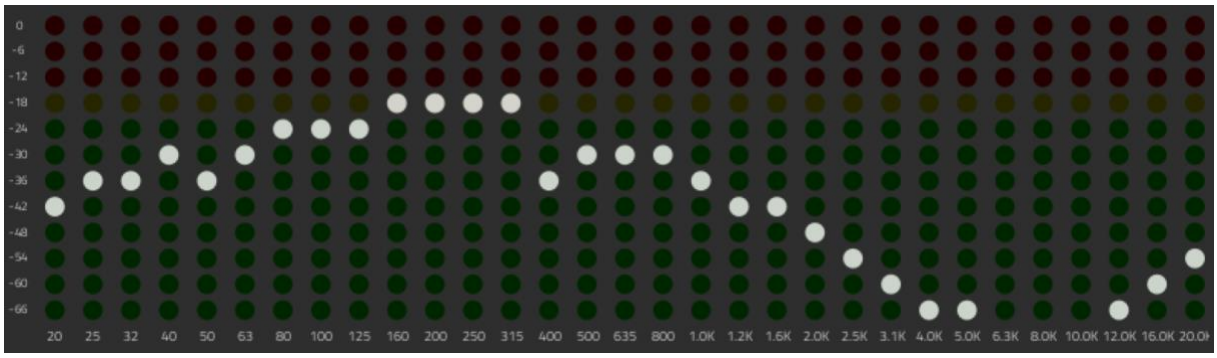
Voxengo SPAN (Apple Inc., 2020):



Blue Cat FreqAnalyst (Apple Inc., 2020):



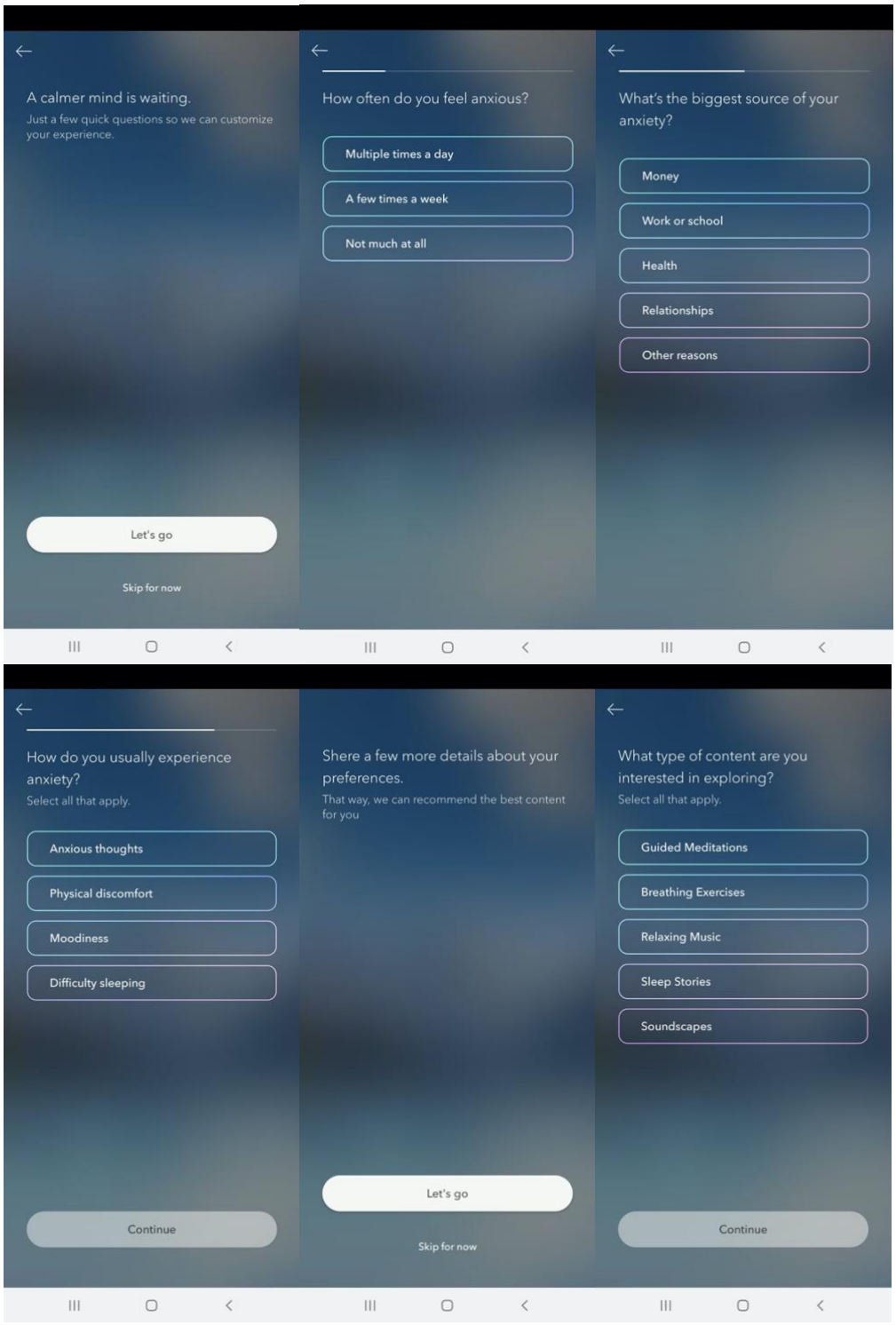
HoRNet ThirtyOne (Audacity, 2020):



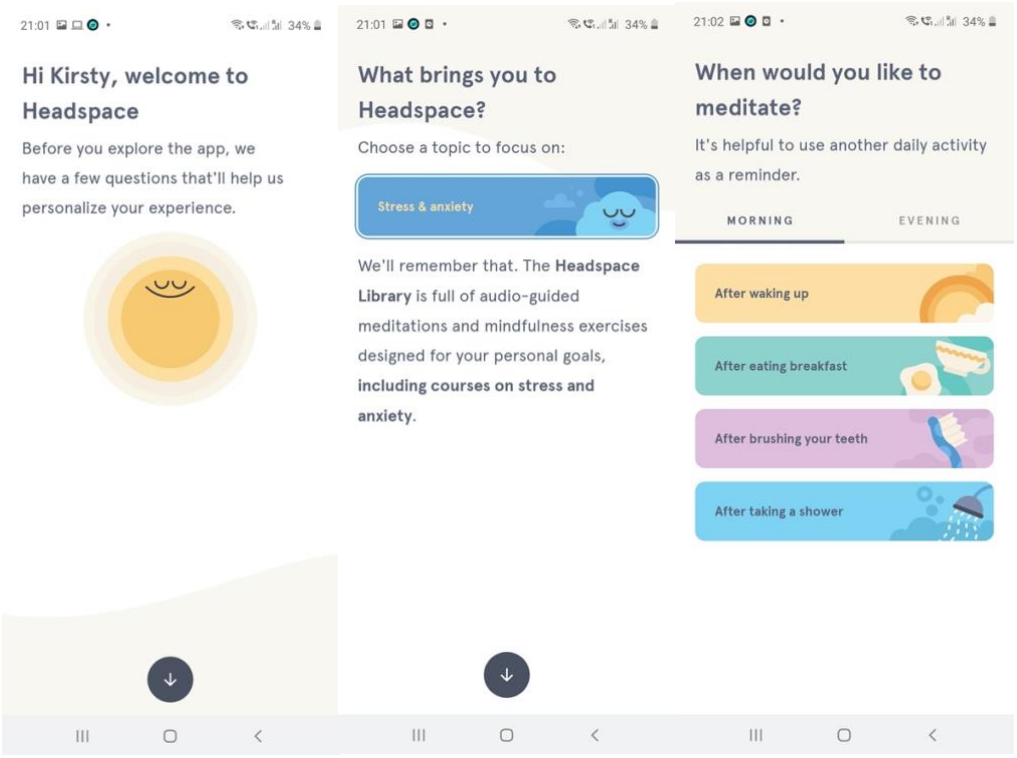
Appendix 3. Relaxation Applications Analysis

1) Screenshots of the user preferences quizzes from Calm and Headspace

a. Calm (Calm.com, Inc., 2020a).

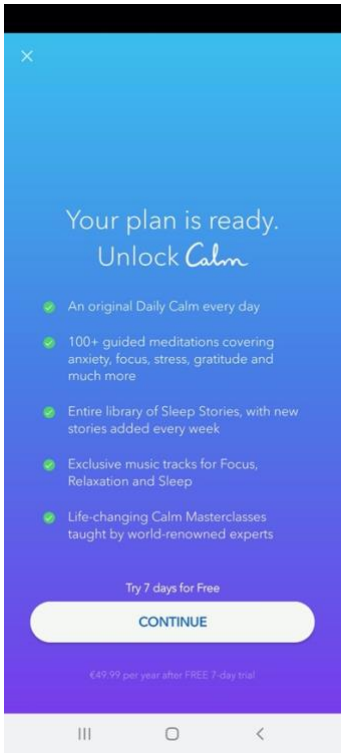


b. Headspace (Headspace, Inc., 2020a).

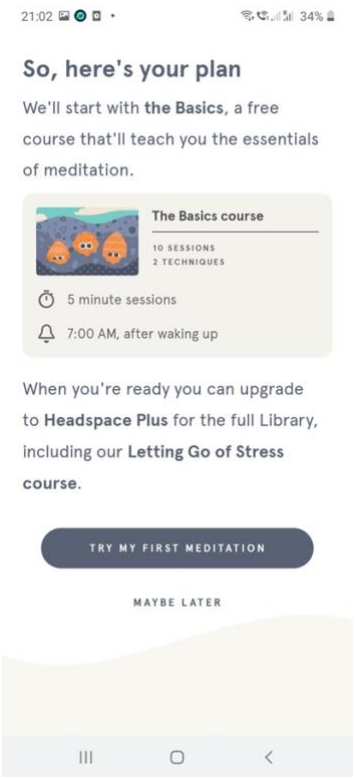


2) Screenshots of the relaxation plans from Calm and Headspace

a. Calm (Calm.com, Inc., 2020a).

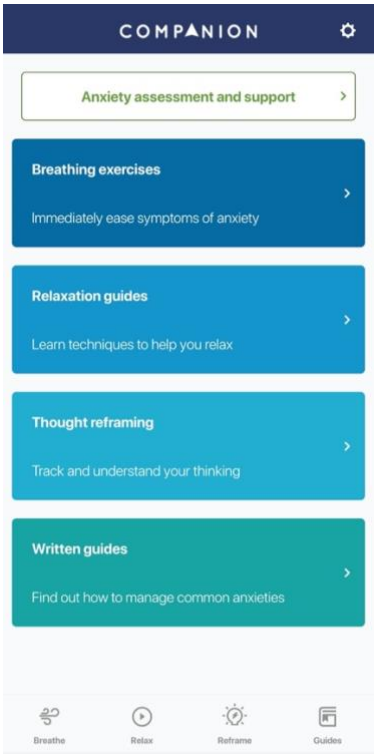


b. Headspace (Headspace, Inc., 2020a).

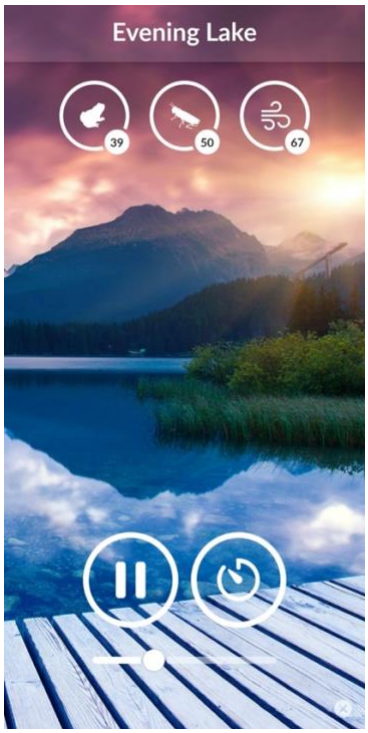


3) Screenshots of relaxation applications

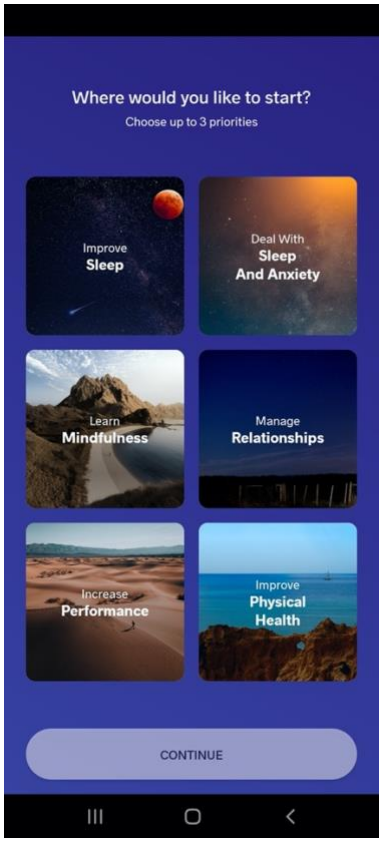
a. Companion (Companion Apps Limited, 2020)



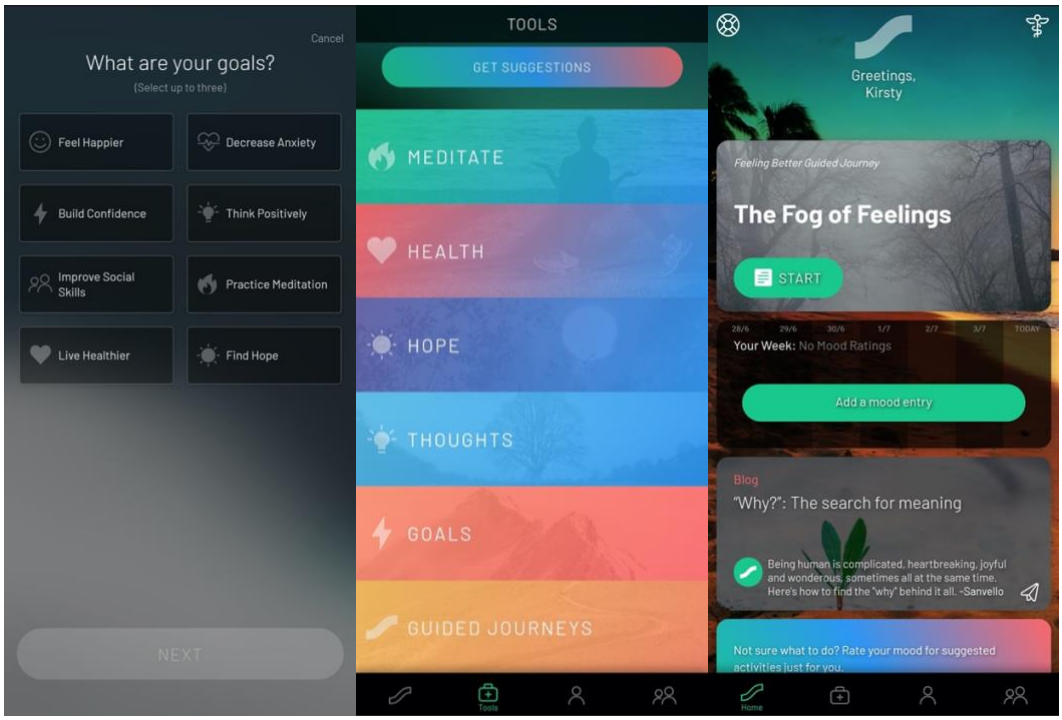
b. Nature Sounds (Relaxio s.r.o., 2020)



c. Meditopia (Meditopia, 2020)



d. Sanvello (Sanvello Health Inc., 2020)



Appendix 4. ZenSounds Application Code

Excerpt from the ZenSounds application code for the Birds page of the prototype, showing the JavaScript code that was added for the functionality of the audio controls.

```
<!DOCTYPE html>
<html>
 <body>
    <!—Excerpt of HTML code showing only previous, pause and play buttons-->

    <!-- previous_btn (Shape) -->
    <div id="u59" class="ax_default icon" data-label="previous_btn">
     <img id="u59_img" class="img " src="images/birds/previous_btn_u59.svg" onclick="restartAudio()"/>
     <div id="u59_text" class="text " style="display:none; visibility: hidden">
      <p></p>
     </div>
    </div>

    <!-- pause_btn (Shape) -->
    <div id="u61" class="ax_default icon" data-label="pause_btn">
     <img id="u61_img" class="img " src="images/birds/pause_btn_u61.svg" onclick="pauseAudio()"/>
     <div id="u61_text" class="text " style="display:none; visibility: hidden">
      <p></p>
     </div>
    </div>

    <!-- play_btn (Shape) -->
    <div id="u63" class="ax_default icon" data-label="play_btn">
     <img id="u63_img" class="img " src="images/birds/play_btn_u63.svg"   onclick="playAudio()"/>
     <div id="u63_text" class="text " style="display:none; visibility: hidden">
      <p></p>
     </div>
    </div>

  </div>
  <script src="resources/scripts/axure/ios.js"></script>
 </body>
</html>
```

```
<!-- add audio -->
<audio id="myAudio">
  <source src="audio/Nature - Birds.wav" type="audio/wav">
</audio>




<!-- add JavaScript -->
<script>
  // hide pause btn
  setTimeout(function() {
    var imgPause = document.getElementById('u61');
    imgPause.style.visibility = "hidden";
    imgPause.style.display = "none;"
  }, 10);

  var x = document.getElementById("myAudio");

  function playAudio() {
    x.play();
    //hide play btn
    var y = document.getElementById("u63");
    if (y.style.visibility === "hidden") {
      y.style.visibility = "visible";
    } else {
      y.style.visibility = "hidden";
    }

    if (y.style.display === "none") {
      y.style.display = "block";
    } else {
      y.style.display = "none";
    }

    // hide pause btn
    var imgPause = document.getElementById('u61');
    imgPause.style.visibility = 'visible';
    imgPause.style.display = 'block';
```

```
}

function pauseAudio() {
  console.log("pause");
  x.pause();
  // hide pause btn
  var z = document.getElementById("u61");
  if (z.style.visibility === "hidden") {
    z.style.visibility = "visible";
  } else {
    z.style.visibility = "hidden";
  }

  if (z.style.display === "none") {
    z.style.display = "block";
  } else {
    z.style.display = "none";
  }




  //show play btn
  var imgPlay = document.getElementById('u63');
    imgPlay.style.visibility = 'visible';
    imgPlay.style.display = 'block';

  // hide pause btn
  var imgPause = document.getElementById('u61');
    imgPlay.style.visibility = 'hidden';

  // show play btn
  var imgPlay = document.getElementById('u63');
    imgPlay.style.visibility = 'visible';
}

// restart audio
function restartAudio(){
x.currentTime = 0
}
```

```
// loop audio
x.addEventListener('ended', function() {
  this.currentTime = 0;
  this.play();
}, false);
</script>
```

Appendix 5. Survey Questions

Section 1:

1. How old are you?

2. What is your gender?

3. Which country do you normally reside in?

4. Do you think you have a normal hearing range for your age?
( ) Yes
( ) No

5. Have you been formally diagnosed with an anxiety disorder?
( ) Yes
( ) No

Section 2:

1. How often do you find yourself feeling stressed or overwhelmed?
( ) Multiple times a day
( ) Once a day
( ) Multiple times a week
( ) Once a week
( ) Multiple times a month
( ) Once a month
( ) Other

2. When you feel stressed which methods do you usually use to calm down?
[ ] Breathing exercises
[ ] Meditation
[ ] Exercise
[ ] Journaling
[ ] Spend time with loved ones
[ ] Listening to relaxing sounds
[ ] Listening to music
[ ] Other

3. Have you tried relaxation apps (such as Calm or Headspace) before?
( ) Yes
( ) No

4. If yes, which ones have you tried?
[ ] Headspace
[ ] Calm
[ ] Companion
[ ] Meditopia
[ ] Sanvello
[ ] InnerHour
[ ] Wysa
[ ] Sattva
[ ] Other

5. How effective did you find the app(s) in reducing stress?
( ) 1 - Very ineffective
( ) 2 - Ineffective
( ) 3 - Neutral
( ) 4 - Effective
( ) 5 - Very effective

6. Please explain your experience of using the app(s) (optional):

Section 3:

Test ZenSounds App:
Please click on the link below (on desktop) and listen to all 10 sounds (approx. 1 min each):
https://kirstybryce.github.io/ZenSounds/

1. Did you find the sounds pleasant to listen to?

	Unpleasant		Neutral		Pleasant
	1	2	3	4	5
Birds					
Insects					
Waves					
Stream					
Wind					
Paper					
Whispers					
Fabric					
Tapping					
Water					

2. Did the sounds make you feel relaxed?

	Unrelaxing		Neutral		Relaxing
	1	2	3	4	5
Birds					
Insects					
Waves					
Stream					
Wind					
Paper					
Whispers					
Fabric					
Tapping					
Water					

3. Did you find the app easy to navigate?
( ) 1 - Very difficult
( ) 2 - Difficult
( ) 3 - Neutral
( ) 4 - Easy
( ) 5 - Very easy

4. Did you find the visual aspects of the app pleasant to look at?
( ) 1 - Very unpleasant
( ) 2 - Unpleasant
( ) 3 - Neutral
( ) 4 - Pleasant
( ) 5 - Very pleasant

5. Are there any other types of sounds that you would like to be included in the app?

6. Are there any aspects that you would like to add or remove from the app?

7. Would you use the app again?
( ) Yes
( ) No
( ) Other

8. If you could connect wearables (such as smartwatches) to the app to measure your stress levels and automatically play relaxing sounds when you're stress, is this something you would be interested in using?
( ) Yes
( ) No
( ) Other

Appendix 6. Research Forms

1) Edinburgh Napier University Research Consent Form

Listener test/survey for Zensounds application

Edinburgh Napier University requires that all persons who participate in research studies give their written consent to do so. Please read the following and sign it if you agree with what it says.

1. I freely and voluntarily consent to be a participant in the research project on the topic of analysing the effectiveness of sounds in the reduction of anxiety to be conducted by Kirsty Bryce, who is a postgraduate student at Edinburgh Napier University.
2. The broad goal of this research study is to explore the effectiveness of certain sounds in reducing a participant's stress levels. Specifically, I have been asked to listen to a set of sounds and provide feedback on the experience, which should take approximately 45 minutes to complete.
3. I have been told that my responses will be anonymised. My name will not be linked with the research materials, and I will not be identified or identifiable in any report subsequently produced by the researcher.
4. I also understand that if at any time during the listening test and interview I feel unable or unwilling to continue, I am free to leave. That is, my participation in this study is completely voluntary, and I may withdraw from it without negative consequences. However, after data has been anonymised or after publication of results it will not be possible for my data to be removed as it would be untraceable at this point.
5. In addition, should I not wish to answer any particular question or questions, I am free to decline.
6. I have been given the opportunity to ask questions regarding the listening test and interview and my questions have been answered to my satisfaction.
7. I have read and understand the above and consent to participate in this study. My signature is not a waiver of any legal rights. Furthermore, I understand that I will be able to keep a copy of the informed consent form for my records.

Participant's Signature Date:

I have explained and defined in detail the research procedure in which the respondent has consented to participate. Furthermore, I will retain one copy of the informed consent form for my records.

Researcher's Signature Date:

2) Participant information

Listener test/survey for Zensounds application

Thank you for your time in taking part in this study. The research being conducted is on the effectiveness of sounds in reducing the stress levels of people with anxiety and is part of the researcher's dissertation for the Computing MSc course at Edinburgh Napier University. The aims of the research are to determine if certain sounds are relaxing for people and if so, then which type of sounds are the most effective at reducing stress levels.

Participation in the study is entirely done online and should take around 45 minutes to complete. Participants should be between the ages of 18 and 70 as well as having been formally diagnosed with an anxiety disorder. Taking part in this study will ask the participants to share some personal information about themselves (age, gender, country of residence and anxiety diagnosis) and provide their honest feedback after using the application. Participation is anonymous, voluntary, and the participant can choose to leave the study at any point.

A set of ten sounds were produced for the study, based on current research in the field of sound therapy for relaxation purposes, and they include five nature-based and five ASMR (autonomous sensory meridian response) sounds. A web app was created to diffuse the sounds, and this study will be used to ask participants to provide feedback on the sounds and the functionality and design of the app itself. Participants should be aware that while listening to the sounds of the app, there may be a risk of negative reactions or discomfort to the sounds, and if this is the case then the participant can stop listening to that sound and skip it, or stop the study entirely, if they feel necessary.

All answers from participants will be recorded using the P01, P02… convention to ensure full anonymity. The data collected from this survey will be securely stored on the Edinburgh Napier University's OneDrive and will destroyed upon successful completion of the dissertation (expected 02/10/2020). If participants are taking part in the listener study, the audio from the Skype call will be recorded for transcription purposes, and once transcribed will be destroyed. The survey will be conducted with Novi and will not be used to collect any participant identifiers such as names or IP addresses. The anonymised results of the survey and the listener study could be published in the future, but this is not yet confirmed.

If you have any further questions or concerns, or if you're interested in taking part in the listener study via Skype please contact Kirsty Bryce on +32492849653 or via 40451875@live.napier.ac.uk.

Thank you for your time and participation.

3) Privacy notice

Name of Research Project: Analysing Sound Design Principles to Create an Application that Alleviates the Symptoms of People with Generalised Anxiety Disorder

Description of Project: This dissertation looks at the possible relaxation effects of sound to help reduce the stress levels of people with anxiety disorders. An application and ten sounds were produced and will be used in a study to determine their effectiveness in reducing stress levels. The study consists of an online survey and a listener test.

Data Controller	Edinburgh Napier University
Purposes for collection/processing	The aims of the project and study are to determine the effectiveness in certain sounds in reducing stress levels.
Legal basis	Art 6(1)(e), performance of a task in the public interest/exercise of official duty vested in the Controller by Statutory Instrument No. 557 (S76) of 1993 as amended, e.g. for education and research purposes. Where sensitive personal data is being processed the additional bases from Article 9 is: Art 9(2)(j) for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes. The study will collect data from people between the age of 18 and 70 that have been diagnosed with anxiety as this is the population that the application is designed for. Rights and interests of the participants are protected by ensuring they are entirely anonymous, and that their data will be stored securely and deleted after successful completion of the dissertation (expected 02/10/2020).
Whose information is being collected	Students and anonymous social media participants. Participants have to be between the ages of 18 and 70 and have been diagnosed with an anxiety disorder.
What type/classes/fields of information are collected	Sensitive personal data such as age, gender, country of residence, diagnosis, and frequency of symptoms.
Who is the information being collected from	From the data subject (directly)
How is the information being collected	In person by the researcher, online form (survey), and online recorded interview
Is personal data shared with externally	No

How secure is the information	For services provided locally by Information Services, information is stored on servers located in secure University datacentres. These datacentres are resilient and feature access controls, environmental monitoring, backup power supplies and redundant hardware. Information on these servers is backed up regularly. The University has various data protection and information security policies and procedures to ensure that appropriate organisational and technical measures are in place to protect the privacy or your personal data. The University makes use of a number of third party, including "cloud", services for information storage and processing. Through procurement and contract management procedures the University ensures that these services have appropriate organisational and technical measures to comply with data protection legislation. The University is Cyber Essentials Plus accredited.
Who keeps the information updated	N/A
How long is the information kept for	Until successful completion of the Master's dissertation (Expected 02/10/2020).
Will the data be used for any automated decision making	No
Is information transferred to a third country? Outside the EEA and not included in the adequate countries list.	No
You can access all the University's privacy notices using the following link: https://staff.napier.ac.uk/services/governance-compliance/governance/DataProtection/Pages/statement.aspx You have a number of rights available to you with regards to what personal data of yours is held by the University and how it is processed – to find out more about your rights, how to make a request and who to contact if you have any further queries about Data Protection please see the information online using the following URL: https://staff.napier.ac.uk/services/governance-compliance/governance/DataProtection/Pages/default.aspx	

4) Oath of confidentiality

EDINBURGH NAPIER UNIVERSITY

OATH OF CONFIDENTIALITY – RESEARCH STUDENT
(General Data Protection Regulation and Data Protection Act 2018)

Full name	Kirsty Bryce	**Matriculation No.**	40451875
Course	Computing MSc	**School**	School of Computing

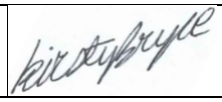
I acknowledge that for the purposes of my dissertation/research project at the University, I will have access to the personal information of living identifiable individuals. I recognise that I have a duty of confidentiality in relation to this information and am bound by the provisions of the Data Protection legislation and the University's obligations under the legislation.

As a University research student, I undertake to:

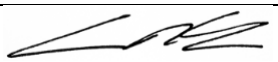
- only ever access and process personal information in order to carry out my research
- never use any such data for any purpose other than to perform my research
- never disclose the data to any other person at the University except where appropriate to my research supervisor and/or other authorised person
- never disclose any data to any individual or organisation external to the University (other than an external examiner/supervisor as required) in accordance with the legislation
- securely retain the data in both electronic and manual format at all times. Manual/paper records/data to be kept in a locked container and electronic data to be stored only on the University's ICT network/systems as per guidance provided online at: https://staff.napier.ac.uk/services/governance-compliance/governance/DataProtection/Pages/ProcessingDataforResearch.aspx .
- securely dispose of the data in accordance with relevant retention requirements and University policy
- adhere to the obligations set out above and below during my period of research and after it has ended

I understand that:

- disclosure or processing of personal information outside these terms will only take place in consultation with my research supervisor and/or Governance and Compliance Services
- where relevant, I am bound by the University's Information Security, Manual Data Security policies and Data protection Policy and CoP to which I have been directed (see link above)
- I may be subject to disciplinary proceedings for failing to observe these obligations

Signed		**Date**	18/07/2020

Witness (staff member)

Name	Dr Iain McGregor		
School	Computing	**Post held**	Lecturer
Signed		**Date**	20th of July 2020

5) Researchers' checklist for complying with data protection legislation

Name of researcher: Kirsty Bryce
Name of research project: Analysing Sound Design Principles to Create an Application that Alleviates the Symptoms of People with Generalised Anxiety Disorder

Guidance for completing the checklist:
All statements in the second column must have a corresponding Y, N or N/A in the third column. Y = Yes, I agree that the statement (in the 2nd column) is correct in relation to my research project, and N = No, the statement is not correct in relation to my research project. N/A = Statement is not applicable to the project/study.
Please provide comments/further details on the 4th column where required.

#	Requirements of the legislation	Y, N or N/A	Comment
A	**Consider if the project is covered by the provisions of the legislation with regard to processing for archiving purposes in the public interest, scientific or historical research purposes.**		
i	This information is being used *exclusively* for research purposes	Y	The information collected will solely be used for the purpose of the dissertation and will be destroyed upon successful completion of it.
ii	The information is not to support measures or decisions relating to any identifiable living individual	Y	The information collected is used only to support the possible effectiveness of sounds in reducing stress levels.
iii	The data is not being used in a way that will cause, or is likely to cause, damage or distress to any data subject or result in a risk to their rights and freedoms	Y	The rights and freedoms of the participants will be protected by ensuring all data is anonymous, securely stored, and destroyed upon successful completion of the dissertation. All participants can choose to leave the study at any point and can request for their data to be removed from the study and destroyed after taking part.
iv	The result/s of the research, or any resulting statistics, will not be available / published in any form that identifies the research participants	Y	All participants and their information will be anonymous.
B	**Principle 1 – Lawfulness, fairness and transparency**		
i	The legal basis for processing is Art 6(1)(e), performance of a task in the public interest/exercise of official duty vested in the Controller by Statutory Instrument No. 557 (S76) of 1993 as amended, e.g. for education and research purposes.	Y	Data will be collected in adherence to the University's guidance, and will securely processed, stored, and destroyed upon successful completion of the dissertation.

ii	Where special category (sensitive) personal data is being processed the additional bases from Article 9 is: Art 9(2)(j) for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes.	Y	The data that will be collected will involve the anxiety diagnosis of participants as this is relevant to the aim of the study and only people with a diagnosed anxiety disorder can take part in the study. The aim of the study is to determine the effectiveness of certain sounds in reducing the stress levels of people with anxiety. All participants can choose to leave the study at any point and can request for their data to be removed from the study and destroyed after taking part.
iii	You have put additional safeguards in place where processing the personal data of children and vulnerable persons	N/A	N/A
iv	You have made provision for providing privacy notices e.g. in/with participant information sheets, in public places, etc. as appropriate	Y	The participants will be provided with participant information, an informed consent form, and a privacy notice at the beginning of the study, and another consent form at the end of the study.
C	**Principle 2 – Purpose limitation. Collected for specified, explicit and legitimate purposes**		
i	You have set out the purposes for processing in the Privacy Notice	Y	Specified that the purpose of this dissertation is to research the possible relaxing effects of certain sounds on people with anxiety, and that the data is required to report the population who took part in the evaluation.
D	**Principle 3 – Data minimisation. Personal data collected must be adequate, relevant and limited to only that which is necessary to fulfil the purposes for which the data was collected.**		
i	You have designed your project to only collect the personal data absolutely necessary to meet the aims and objectives of the project (the minimum necessary)	Y	The information collected is relevant to the aims of the study which are to determine the effectiveness of certain sounds in reducing stress levels of people with anxiety disorders.
E	**Principle 4 - Accuracy**		
i	You will take reasonable measures to ensure that the data you collect is accurate	Y	The data will be collected directly from participants.
ii	Where appropriate and necessary you will put measures in place to keep the data up-to-date	N/A	N/A
F	**Principle 5 – Storage limitation**		
i	You have agreed retention periods for the data with your Supervisor and have included this information in your data management plan and privacy notice	Y	Until successful completion of the Master's dissertation (expected 02/10/2020).
G	**Principle 6 – Integrity and confidentiality**		
	You have appropriate organisational and technical measures in place, including assessing the security of your work environment and the electronic and manual systems you use, to protect and secure personal data during:		

i	Collection	Y	The data will be collected via a survey hosted with Novi and the listening study will collect data via Skype.
ii	Storage	Y	The research data will be securely stored on the researcher's University OneDrive.
iii	Sharing/transfer	N/A	N/A
iv	Use and re-use	N/A	N/A
v	Deletion/Archiving	Y	Secure deletion of OneDrive files upon completion of the Master's dissertation.
vi	Are you sharing any personal data with 3rd parties external to the University?	N	N/A
vii	If the answer to G)vi above is Y, do you have data sharing/processing agreements in place	N/A	N/A
viii	If the answer to G)vi above is Y, have security checks been completed to ensure those 3rd party/ies comply with Principle 6	N/A	N/A
H	**Principle 7 – Demonstrating compliance**		
i	You have records documenting the decisions taken with regards to the processing of personal data which may include a data management plan, data collection form, privacy notice, etc.	Y	- Participant information - Participant consent form - Privacy notice
J	**Personal data not to be transferred to 3rd countries/ territory (outwith the EEA and not on the ICO's 'adequate' list) without appropriate and adequate protection – GDPR Chapter V refers**		
i	You are transferring personal data to a third country or territory outwith the EEA and not on the 'adequate' list.	N	N/A
ii	If the answer to J i above is Y - you have a contract or data sharing agreement in place with the recipient of the data which ensures appropriate safeguards are in place and enforceable data subject rights and effective legal remedies for data subjects are available	N/A	N/A
iii	You have completely anonymised the data	N/A	N/A
K	**Data subjects are able to exercise their rights**		
	You have made arrangements to comply with the individuals' rights – in particular:		
i	You have provided privacy notices to provide individuals with details of the processing (Articles 12-14 – right to receive information)	Y	- Provide participants the contact details of the researcher - Privacy notice and consent form
ii	You will be able to provide an individual with a copy of their personal data being processed, if requested (Article 15 – subject access)*	Y	

iii	You will rectify, erase, restrict or stop processing of, or destroy data securely, if necessary (Articles 16, 17 & 19, 18 & 19, 21 – Rectification*, Erasure*, Restrict processing* and Object to*/stop processing respectively)	Y	
iv	You will be able to provide a copy of personal data provided to you, in a machine readable format, if required and provided for by the legal basis for processing (Article 20 – Portability)	Y	
v	You will ensure that no decision which significantly affects an individual is based solely on automated processing or profiling of their data (Articles 4(4) & 22 – Restrict automated decision making with significant effects)	Y	
vi	You will stop using data if it is likely to cause unwarranted substantial damage or distress to any data subject or result in a risk to their rights and freedoms	Y	

L	Breach notification		
i	You will immediately report any personal data breach or other breach of the legislation to your research supervisor and they will follow University procedures. Definition: 'personal data breach' means a breach of security leading to the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to, personal data transmitted, stored or otherwise processed.	Y	See section 7.10 online

Note for research supervisors:

- All checklist answers should be Y, apart from J)i & G)vi which should be N
- If J)i & G)vi are marked Y further detail must be given – refer to Governance Services
- N/A answers would only be possible for B)ii & iii, J)ii & iii & G)vii
- If students/researchers have already provided detail in the project Privacy Notice they can point to that in the details/notes column rather than duplicating the wording.

6) Application for Cross-University Ethical Approval

1. Research Details

Name:	Kirsty Bryce
School or Professional service department:	School of Computing
Email:	40451875@live.napier.ac.uk
Contact number:	+32492849653
Project Title:	Analysing Sound Design Principles to Create an Application that Alleviates the Symptoms of People with Generalised Anxiety Disorder
Start Date:	25/05
Duration of Project:	12 weeks
Type of Research:	Masters

2. Screening Questions

Please answer the following questions to identify the level of risk in the proposed project:
If you answer 'No' to all questions, please complete Section 3a only.
If you have answered 'Yes' to any of the questions 5-14 please complete Section 3a and 3b.
If you have answered 'Yes to any of the questions 1-4, complete all of Section 3.

	You Must Answer All Questions	**Yes**	**No**
1.	Is the research clinical in nature?	☐	☒
2.	Is the research investigating socially or culturally 'controversial' topics (for example pornography, extremist politics, or illegal activities)?	☐	☒
3.	Will any covert research method be used?	☐	☒
4.	Will the research involve deliberately misleading participants (deception) in any way?	☐	☒
5.	Does the Research involve staff or students within the University?	☒	☐
6.	Does the Research involve vulnerable people? (For example, people under 18 or over 70 years of age, disabled (either physically or mentally), those with learning difficulties, people in custody, migrants etc).	☐	☒
7.	Is the information gathered from participants of a sensitive or personal nature?	☒	☐
8.	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?	☒	☐
9.	Have you identified any potential risks to the researcher in carrying out the research? (for example, physical/emotional/social/economic risks?)	☐	☒
10.	Are there implications from a current or previous professional relationship i.e. staff/student/line manager/managerial position that would affect the voluntary nature of the participation?	☐	☒
11.	Will the research require the use of assumed consent rather than informed consent? (For example, when it may be impossible to obtain informed consent due to the setting for the research – e.g. observational studies/videoing/photography within a public space)	☐	☒
12.	Is there any risk to respondents' anonymity in any report/thesis/publication from the research, even if real names are not used?	☒	☐

13.	Will any payment or reward be made to participants, beyond reimbursement or out-of-pocket expenses?	☐	☒
14.	Does the research require external ethics clearance? (For example, from the NHS or another institution)	☐	☒
15.	Does the research involve the use of secondary data?	☐	☒

3A. Details of Project

In this section please provide details of your project and outline data collection methods, how participant consent will be given as well as details of storage and dissemination.

Please give a 300 word overview of the research project	
The purpose of this study is to determine the effectiveness of sounds such as nature based and ASMR (autonomous sensory meridian response) in reducing the stress levels of people with anxiety. Mental health disorders are common among the general popular, and conditions such as depression and anxiety are estimated to account for 14% of diseases worldwide[2]. Despite their prevalence, anxiety disorders are often undetected and undertreated[3]. The interest in alternative methods of reducing stress levels to conventional treatments for anxiety disorders is an important factor in the development of this project. Conventional treatments for anxiety disorders include cognitive behavioural therapy and selective serotonin-reuptake inhibitors, but these may not work for everyone which can lead to people seeking alternative treatments to help manage their stress levels[4]. The effects of sound therapy have been shown to be useful in improving the quality of life, managing stress and alleviating the pain of patients with a wide range of conditions[5]. Popular relaxation applications like Headspace and Calm offer guided meditation, as well as soothing sounds and music[6]. Exposing people to nature sounds can reduce stress levels and help people recover from stress quicker compared to exposing them to unpleasant non-nature sounds[7]. The interest in using sounds for relaxation purposes can be observed in the trend of autonomous sensory meridian response (ASMR) videos on YouTube. The phenomena of ASMR can be described as a tingling sensation at the crown of the head that is triggered by sounds such as whispering and tapping. People are finding that the therapeutic effects of calming sounds are helping them with various conditions such as anxiety, stress, and insomnia[8].	
Data Collection	
1.	**Who will be the participants in the research?**
	Friends and family of the researcher, anonymous participants from social media (Facebook).
2.	**How will you collect and analyse the research data? (please outline all methods e.g. questionnaires/focus groups/internet searches/literature searches/interviews/observation)**
	Through a survey shared on social media (Facebook) including in anxiety support groups, and online listening tests (via Skype).
3.	**Where will the data will be gathered (e.g. in the classroom/on the street/telephone/on-line)**

[2] Phillips, A. C., David Batty, G., Gale, C. R., Lord, J. M., Arlt, W., & Carroll, D. (2011). Major depressive disorder, generalised anxiety disorder, and their comorbidity: Associations with cortisol in the Vietnam Experience Study. *Psychoneuroendocrinology*, *36*, 682–690. https://doi.org/10.1016/j.psyneuen.2010.09.011

[3] McGrandles, A., & Duffy, T. (2012). Assessment and treatment of patients with anxiety. *Nursing Standard*, *26*(35), 48–56.

[4] Craske, M., & Stein, M. (2016). Anxiety. The Lancet, 388(10063), 3048-3059. doi: 10.1016/s0140-6736(16)30381-6

[5] Duerksen, G. L. (2013). Music therapy. https://doi.org/10.1093/gmo/9781561592630.article.A2257019

[6] Wallop, H. (2019). McMindful Inc: the rise and rise of meditation apps Calm and Headspace. Retrieved 28 May 2020, from https://www.thetimes.co.uk/article/mcmindful-inc-the-rise-and-rise-of-meditation-apps-calm-and-headspace-dzthb0vgr

[7] Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health*, *7*(3), 1036–1046. https://doi.org/10.3390/ijerph7031036

[8] Poerio, G., Blakey, E., Hostler, T., & Veltri, T. (2018). More than a feeling: Autonomous sensory meridian response (ASMR) is characterized by reliable changes in affect and physiology. *PLOS ONE*, *13*(6), e0196645. doi: 10.1371/journal.pone.0196645

	Online.
4.	**Please describe your selection criteria for inclusion of participants in the study**
	Between the ages of 18 and 70 with a diagnosed anxiety disorder.
5.	**If your research is based on secondary data, please outline the source, validity and reliability of the data set**
	N/A
Consent and Participant Information	
7.	**How will you invite research participants to take part in the study? (e.g. letter/email/asked in lecture)**
	Contact friends and family directly and share the survey online in anxiety support groups on Facebook.
8.	**How will you explain the nature and purpose of the research to participants?**
	Participant Information sheet
9.	**How will you record obtaining informed consent from your participants?**
	Signed informed consent form for interviews, or double confirmation of consent at start and end of Novi survey.
Data storage and Dissemination	
10.	**How and in what format will data be stored? And what steps will be taken to ensure data is stored securely?**
	The data will be stored in the format of an Excel Spreadsheet on the researcher's university OneDrive.
11.	**Who will have access to the data?**
	Only the researcher.
12.	**Will the data be anonymised so that files contain no information that could be linked to any participant?**
	Yes.
13.	**How long will the data be kept?**
	Until successful completion of the Master's dissertation (Expected 02/10/2020).
14.	**What will be done with the data at the end of the project?**
	Data will be destroyed from the OneDrive upon successful completion of the Master's dissertation (Expected 02/10/2020).
15.	**How will the findings be disseminated?**
	As part of the Master's dissertation (SOC11101).
16.	**Will any individual be identifiable in the findings?**
	No.

3B. Identification and Mitigation of Potential risks

This section is designed to identify any realistic risks to the participants and how you propose to deal with it.

1. **Does this research project involve working with potentially vulnerable individuals?**

Group	Yes	NO	Details (for example programme student enrolled on, or details of children's age/care situation, disability)
Students at Napier	☒	☐	Students on the Computing MSc course
Staff at ENU	☐	☒	

Children under 18	☐	☒	
Elderly (over 70)	☐	☒	
Disabled	☐	☒	
Migrant workers	☐	☒	
Prisoners / people in custody	☐	☒	
Learning difficulties	☐	☒	

2. If you are recruiting children (under 18 years) or people who are otherwise unable to give informed consent, please give full details of how you will obtain consent from parents, guardians, carers etc.

N/A

3. Please describe any identified risks to participants or the researcher as a result of this research being carried out

The risks to the study being carried out are the following:
- Risk of hearing damage/loss while listening to sounds
- Ensuring the anonymity of participants

4. Please describe what steps have been taken to reduce these identified risks? (for example providing contact details for appropriate support services (e.g. University Counselling, Samaritans), reminding participants of their right to withdraw and/or not answering questions, or providing a full debriefing to participants)

The measures that have been put in place to reduce the identified risks are the following:
- The sounds are of a relatively low level with a maximum RMS level of - 40.8 dBFS with the highest peak at -13.7 dBFS (an example for comparison: YouTube video at - 27.6 dBFS with a peak of 1.8 dBFS).
- The anonymity of participants will be ensured by recording all answers using the P01, P02… convention.

5. If you plan to use assumed consent rather than informed consent, please outline why this is necessary

N/A

6. If payment or reward will be made to participants please justify that the amount and type are appropriate (for example the amount should not be so high that participants would be financially coerced into taking part, or that the type of reward is appropriate to the research topic).

N/A

3C. Justification of High Risk Projects

If you answered 'Yes' to the screening questions 1-4 this section asks for justification on the choice of research topic and methodology.

1. If you have answered yes to question 1 please give a full description of all medical procedures to be used within the research and provide evidence that the project has obtained NHS ethical approval.

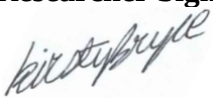
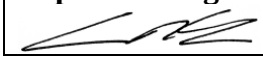
N/A

2. **If you have answered yes to questions 2 (research into a controversial topic) please provide a justification for your choice of research topic and describe how you would deal with any potential issues arising from researching that topic.**

N/A

3. **If you have answered yes to questions 3 or 4 (use of deception or covert research methods) please provide a justification for your choice of methodology, and state how you will mitigate the risks associated with these approaches**.

N/A

Declaration		
☒	I consider that this project has no significant ethical implications to be brought to the attention of Research Integrity Committee	
☐	I consider that this project may have significant ethical implications to be brought to the attention of the Research Integrity Committee	
Researcher Signature: 		**Date: 21/07/2020**
Supervisor Signature: 		**Date: 22nd of July 2020**

Checklist

All applications require the following to be submitted with the application form

Participant Information Sheet	☒
Informed Consent Form	☒
Interview/Survey Questions	☒