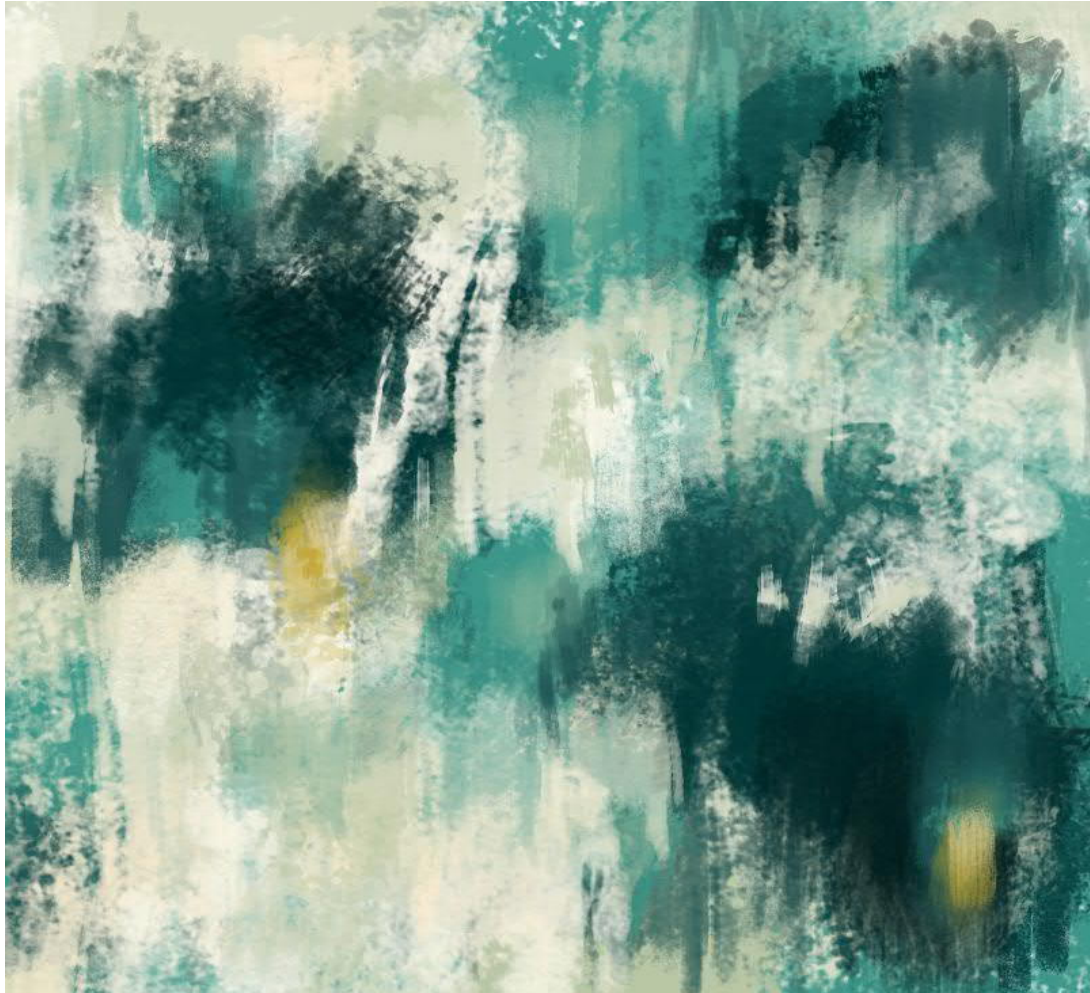


Binaural beats and music: using Theta and Alpha waves in music to induce relaxation and meditation



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Abstract

The current audio marketplace is full of products and services that promise a variety of benefits for their listeners' wellbeing and self-improvement. The binaural beat is a phenomenon that is frequently used in these audio applications. It is an illusionary auditory effect created in the human brain when two slightly different sound frequencies are presented simultaneously, one in the left and one in the right ear. Regardless of how it is used, past research results related to binaural beats' impact on humans are mixed and sometimes even contradictory. Moreover, some of the researchers acknowledge the further need for studies focusing on the practical applications of binaural beats in particular.

Motivated by this context, this thesis is an art-based exploration of the creation of binaural beats, their suggested effects on listeners and how they can be combined with music to induce relaxation and meditation. The emphasis is on two types of binaural beats, Theta and Alpha waves. Even though this thesis leans on the past research conducted in the field, it also features a practical, audio-based part that delves deeper into binaural beats and their use in practice. This practical project consists of an album named *Hidden*, which utilizes binaural beats and was created for a company called Havas, who will feature the album in their employees' recreational space.

This thesis found that in some of the previous research reports binaural beats were associated with having an impact on listeners' sleep, anxiety, memory, attention and visual perception, and, particularly in the case of Theta and Alpha waves, binaural beats were linked to relaxation and a meditative state of mind. *Hidden* integrated binaural beats with music by turning them into musical notes and chord structures, and the creation of its pieces was inspired by past research regarding relaxing sounds and music. As a result, *Hidden* has a relatively slow tempo and predictable rhythm, and it utilizes repetition and nature sound recordings. Synthesizers were particularly useful when creating the music and binaural beats.

This thesis responds to the recent demand for research regarding binaural beats, as it summarizes certain key effects they have been claimed to have while providing practical solutions on how to create and combine them with music in an attempt to elicit relaxation and meditation. Further research is needed to evaluate the effectiveness of *Hidden*.

Keywords binaural beat, Theta wave, Alpha wave, music, relaxation, meditation



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Työn nimi Binaural beats ja musiikki: Theta- ja Alpha-ääniaaltojen käyttäminen musiikissa rentoutumisen ja meditatiivisen mielentilan aikaansaamiseksi

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Nyky maailma on täynnä erilaisia äänituotteita ja -palveluita, jotka lupaavat käyttäjilleen moninaisia hyötyjä heidän terveytensä ja itsensä kehittämisen näkökulmasta. Binaural beat on ilmiö, jota usein käytetään näissä tuotteissa ja palveluissa. Se on ihmisaivoissa syntyvä ääni-illuusioefekti, joka saa alkunsa kahden toisistaan poikkeavan äänitaajuuden samanaikaisesta kuulemisesta siten, että yksi äänisignaali kohdentuu ihmisen oikeaan korvaan ja toinen äänisignaali vasempaan korvaan. Ilmiötä käsittelevä tutkimus tarjoaa vaihtelevia tutkimustuloksia, jotka ovat toisinaan jopa ristiriitaisia keskenään. Osa alan tutkijoista tiedostaa binaural beat -ilmiön kaipaavan lisätutkimusta erityisesti sen käytännön sovelluksiin liittyen.

Tämä konteksti inspiroi opinnäytetyötäni, joka on taidepohjainen tutkimus siitä, minkälaisia vaikutuksia binaural beatseillä on väitetty olevan ihmiselle ja kuinka niitä voi yhdistää musiikkiin, joka auttaa ihmisiä rentoutumaan tai meditoimaan. Tämä tutkimus keskittyy etenkin Theta- ja Alpha-ääniaaltoihin, jotka ovat erityisiä binaural beatsien muotoja. Opinnäytetyö hyödyntää materiaalina aiheesta tehtyä aiempaan tutkimusta, mutta se sisältää myös ääniteoksen, joka käsittelee ja analysoi ääni-ilmiötä ja sen käytännön sovelluksia *Hidden*-albumin kautta. Albumi tulee esille Havasnimisen yrityksen työntekijöille tarkoitettuun virkistys- ja taukotilaan.

Osa tutkijoista väittää, että binaural beat -ääniaallot voivat vaikuttaa kuulijan uneen, ahdistuneisuuteen, muistiin, tarkkaavaisuuteen ja visuaaliseen havaintokykyyn. Theta- ja Alpha-ääniaaltojen uskotaan liittyvän erityisesti kuulijan rentoutumiseen ja hänen kokemaansa meditatiiviseen mielentilaan. *Hidden* yhdistää binaural beatsejä musiikkiin muuttamalla äänisignaalit musiikillisiksi säveliksi ja sointurakenteiksi, ja albumin kappaleet myös hyödyntävät aiempaa tutkimusta rentouttavan äänen ja musiikin ominaispiirteisiin liittyen. Tästä johtuen albumin kappaleissa on suhteellisen hidas tempo ja tasainen rytmi, ja niissä korostuvat toisto ja moninaiset luontoäänitykset. Erilaiset syntetisaattorit ovat albumin keskeinen äänilähde niin musiikin kuin binaural beatsien luomista varten.

Opinnäytetyö vastaa binaural beats -ilmiötä koskevaan tutkimustarpeeseen. Se esittelee ääni-ilmiöstä yleisimmin johdettuja vaikutuksia kuulijalle, mutta työ myös tarjoaa käytännöllisiä tapoja luoda ja yhdistää binaural beatsejä musiikkiin, jonka tavoitteena on auttaa kuulijaa rentoutumaan tai meditoimaan. *Hidden*-albumin vaikuttavuuden arviointi kuulijan rentoutumiseen ja hänen kokemaansa meditatiiviseen mielentilaan liittyen tarvitsee lisätutkimusta.

Avainsanat binaural beat, Theta-ääniaalto, Alpha-ääniaalto, musiikki, rentoutuminen, meditaatio, rentoutumismusiikki, meditaatiomusiikki

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1 Introduction

While browsing the internet in a routinely search of some new music and sounds to listen to I came across a piece with the written description: “If you can't sleep tonight: 8 hours of a psychoacoustic thetawave modulated field recording of a North Sea coast forest meadow near my house.”, by the Dutch musician Legowelt (2019). Without giving the explanation too much thought, I proceeded to press play and started listening to the track, which was filled with different sounds - leaves rustling in the wind, distant airplanes passing by, flies occasionally hovering over the microphone, an ensemble of various bird songs, the light sounds of an approaching thunderstorm, later followed by the emergence of raindrops. Initially I could not hear anything abnormal about the field recording as I was using my laptop speakers, however when I switched to my headphones I began to experience a low frequency vibration inside my head despite not being able to identify a direct source. I managed to find more information about the piece via a YouTube link where Legowelt details the use of Theta wave frequencies of 4–7 Hz, and links them to wellbeing and relaxation (Nightwind Records 2019). After researching this further, I found the phenomenon behind my auditory experience: the binaural beat.

The audio marketplace appears to have a versatile range of different products and services that provide aid to wellbeing and self-improvement. For example, one can easily find tracks from music streaming services for studying, relaxing and yoga sessions. At the same time, lifestyle blogs and health information outlets, such as Healthline and Medical News Today, recommend various sound-based solutions to some of people's health disorders. Many of them mention binaural beats and their various benefits on human wellbeing, and there are even

companies who have focused solely on their effects within their commercial products and services. Elsewhere, binaural beats have made the way on the agenda of many scholars who have endeavoured to establish the exact mechanisms of how the binaural beats affect the human brain and thus affect human behaviour and feelings. Regardless of who is utilising or studying binaural beats, they are often mixed with music or other sounds, and in some instances these soundtracks have been turned into long, therapy-like programmes and courses.

Garcia-Argibay et al. (2019) have noted that the number of studies focusing on the practical applications of binaural beats is small and should be increased. Indeed, as binaural beats are present in many different forms in our practical life it is important to continue examining them. Past research and practical use of binaural beats have motivated me to explore the topic further in the form of art-based research. It consists of two parts: a written part, which this paper is a manifestation of, and an audio-based part in which I delve deeper into the subject by testing how binaural beats are created and utilised in practice. I produce the latter in the form of an album featuring binaural beats in its core, for a company called Havas where I also work. The album will be made available at a recreational space called The Wellness Lounge, where Havas' employees are encouraged to go during their workday if needed. As the purpose of The Wellness Lounge is to help its users unwind through techniques such as relaxation and meditation, I direct the focus of the album towards Theta and Alpha waves, which are specific types of binaural beats that have been associated in past research to the actions and sensations in question.

I start by briefly introducing the research topic in Chapter 1, in which I also outline the research questions that I attempt to answer subsequently in this thesis and through the audio project created for Havas. I begin Chapter 2 by making the reader familiar with some of the key terms related to the research inquiry, and I go through them individually. After this, I present the literary review regarding the research carried out in the field, however, it also includes examples of how binaural beats have been used in products and services in

practice. Chapter 2 forms the backbone for answering the first two of my research questions. In Chapter 3, I go through the implementation of the practical, audio-based part of this thesis. I introduce Havas and The Wellness Lounge in detail and I discuss my project design, workflow, research methods and the main tools that I have used to create the audio album. Chapter 4 is dedicated to the analysis of the research topic and questions based on the album produced, and I discuss my artistic process and aesthetic choices. This chapter has an emphasized role in answering the third research question in particular, however, it also elaborates on my first research question. Finally, in Chapter 5 I present the results of the research, after which I conclude with a brief reflection on essential topics for future research and highlight further development of the practical project.

1.1. The aims of the research and its limitations

This thesis is an art-based attempt to respond to the recent demand for research in the field of binaural beats (For example, Gao et al. 2014; Chaieb et al. 2015; Beauchene et al. 2017; Engelbregt et al. 2019; Garcia-Argibay et al. 2019). I endeavour to approach the topic comprehensively by focusing on past research conducted in the field, as well as by utilising the accumulation of practical knowledge available, and employ it to direct the steps I take to create the audio album for Havas.

However, my approach has some known limitations. In fact, I have designed the practical project with a method that only allows me to examine the way binaural beats can be created and mixed together with other sounds. Such an approach does not reveal the actual impact the binaural beats may have on the listeners, as this is out of the scope of this research inquiry. The same thing goes with the number of binaural beats that I have chosen under closer investigation in this thesis. I focus especially on Theta and Alpha waves, which limits the analysis of other binaural beats. Moreover, as my analysis revolves around both binaural

beats and the artistic practice of creating music, which are both subjective experiences, this research is not attempting to establish an undisputable, “single truth” about the topic or offer an exhaustive list of solutions that can inevitably be applied outside this thesis.

Regardless, the research questions are:

- 1) How can binaural beats be integrated into music?
- 2) What sort of an impact have binaural beats been claimed to have on listeners?
- 3) How can Theta and Alpha waves be combined with music and other sounds in order to induce relaxation and meditation amongst listeners?

2 Key terms and the research field

2.1 Key terms

2.1.1 Sound and human auditory system

Sound can have various different definitions, but for the purpose of this thesis paper we can define it to be “a wave physically propagating in a medium, usually air, and in most cases is caused by a vibrating mechanical object” (Pulkki and Karjalainen 2014, 15). Sound, whether propagated live or captured in a recording and reproduced later via suitable playback device, is perceived by humans through their auditory pathway, which carries it under their mental processing. The human auditory pathway comprises of outer and middle ears, cochlea, the auditory nerve, nuclei at every level of our brain stem, and multiple fields of the auditory cortex where the stimulus finally arrives after having travelled through the entire hearing system (Weinberger 1999). Sound, however, is merely vibrating waves until it reaches our eardrum, which transfers the waves into vibration in the middle ear that then causes our brain to detect a sensation (Farnell 2010). We sense these sounds as frequencies (Hertz, Hz) and can feel them starting from 1 Hz, however our ears only produce a sensation of sounds from 20 Hz up to 20000 Hz, although age can narrow this frequency band (ibid.).

2.1.2 Binaural beats

When two tones with constant but slightly different frequencies are presented simultaneously, one to the left ear and the other to the right ear, the human brain creates a third illusory tone, which has the frequency value equal to the difference between the two original frequencies. The phenomenon is called binaural beat, or binaural auditory beat (For example, Oster 1973; Brady and Stevens 2000, 55–56; Pratt et al. 2009; Ramdinmawii and Mittal 2017; Garcia-Argibay, Santed and Reales 2019, 357). For instance, if we direct a 330 Hz sound wave, or a carrier tone, to one ear and 340 Hz sound wave to the other, the third tone (binaural beat) occurs as a 10 Hz sound wave. We can perceive the beat distinctively when the frequency difference is around 30 Hz or below, however when it increases higher than this we hear the sound waves separately by our two ears (Turow and Lane 2011; Gao et al. 2015). The realization of binaural auditory beats dates back to 1839, when it was first reported by German experimenter H. W. Dove (Oster 1973; Chaieb et al. 2015). It has been argued that binaural beats can be effectively perceived only with carrier tones below 1000 Hz, and the effect is most apparent when the carrier frequency is around 400–440 Hz (Oster 1973; Licklider 1950). Stereophonic earphones are usually the best way to trigger binaural beats as they allow a good separation of the tones played to each ear (Oster 1973).

Binaural beats are not the only type of auditory beat stimulation. Indeed, isochronic tones and monaural beats also attempt to induce a frequency-followed brainwave response by using pulsating audio stimuli (Engelbregt et al. 2019). However, they differ in their means to create the effect. Monaural beats are experienced as an amplitude of modulated signals and are generated by directing two simultaneous sine wave signals with a small frequency difference to both ears (Oster 1973; Chaieb et al. 2015; Engelbregt et al. 2019). Disparately, isochronic tones are flickering signals with evenly spaced intervals, which result in a beat in the brain with a frequency that is dependent on the length of the intervals (Engelbregt et al. 2019). Both of them channel the same audio stimulus to each ear whereas the inception of binaural beats is somewhat more distinct, as it relies on audio signal separation between the left and right ear.

2.1.3 Relaxation and meditation

In this thesis, I discuss the general effects of binaural beats and sounds on humans with an emphasis on relaxation and meditation. I do not aim to create a clinical experiment to test how the audio may affect the audience, nor I merely seek to validate or nullify previous research done in this field, as this is outside the scope of this thesis. Rather, I use previous research and report findings from the field as a basis and inspiration for my practical project, which I later introduce in detail. My interpretation of relaxation in this thesis relies on the definition by the Oxford University Press (2019), which suggests that it is “the state of being free from tension and anxiety” and that it is a “recreation or rest, especially after a period of work”. This can mean different things for different people who may have various techniques to assist themselves to feel more relaxed. It is argued that meditation, the act of easily and passively focusing on a single or multiple simple stimuli whilst doing nothing else, classifies as one of these techniques (Smith 1999, 61; Smith 2005, 4). As I later explain in more detail, both of these states, relaxation and meditation, have been associated with listening to binaural beats, and in this thesis, I explore the idea behind this relationship.

2.2 Research field

2.2.1 Suggested effects of different binaural beats

Previous research suggests that binaural beats are generated originally in the superior olivary nuclei (Oster 1973; Draganova et al. 2008) and the brainstem (Wahbeh, Calabrese and Zwickey 2007), after which they move to the reticular formation (Garcia-Argibay, Santed and Reales 2019, 357) where they become measurable through electroencephalographic (EEG) tests in the cerebral cortex

in the form of a frequency following response, FFR (Padmanabhan, Hildreth and Laws 2005; Vernon, et al. 2014). Along with multiple other topics, research interest in the field of binaural beats has been directed towards their possibility to evoke an entrainment effect of neural oscillation in the brain. Consequently, this would create binaural beats that are similar to our brain state frequencies while we are doing other activities, such as meditating, sleeping, feeling relaxed or stressed, and so on (For example, Lavallee, Koren and Persinger 2011; Goodin et al. 2012; Solcá, Mottaz and Guggisberg 2015; Sung et al. 2017; Garcia-Argibay, Santed and Reales 2019). The purpose behind the research is often to see if binaural beats are capable of eliciting these different brain states amongst the test subjects and thus affecting how they feel. Despite small differences amongst researchers regarding the exact frequency values of human brain states, the categorization is typically close to the following five states or patterns: Delta waves (from 0.5 Hz to 4 Hz), Theta waves (from 4 Hz to 10 Hz), Alpha waves (from 8 Hz to 13 Hz), Beta waves (from 12 Hz to 30 Hz) and Gamma (from 30 Hz to 100 Hz) (Craig et al. 2012; Gao et al. 2014; Luo and Guan 2018; Buzsáki 2020).

The lowest binaural beats, Delta waves, have been argued to be present while we enter a non-REM (rapid eye movement) sleep (Buzsáki 2020), and inducing this brain wave state through binaural beats has shown some signals of assisting test subjects to fall asleep more quickly (Shumov et al. 2017). In the past studies, Delta waves have also been linked to anxiety reduction amongst subjects (Wahbeh, Calabrese and Zwickey 2007; Garcia-Argibay, Santed and Reales 2019, 367–368). Moving to a slightly higher frequency level, Theta waves have been called and described as “the hypnagogic state [...] and a kind of consciousness twilight that occurs between being deeply relaxed and sleeping” (Robbins 2014, 17). Theta beats have also appeared to reduce anxiety (Weiland et al. 2011; Garcia-Argibay, Santed and Reales 2019, 367), and it has been suggested that they could operate as a stimulus for generating a meditative state of mind (Jirakittayakorn and Wongsawat 2017). Based on these features, Theta waves may come across as a brain state pattern that could potentially affect people’s hypnotic susceptibility, however previous research has shown contradictory results for this (Brady and Stevens 2000; Stevens et al. 2003).

Alpha waves have been reported to be the first brain waves detected by German psychiatrist Hans Berger in the 1920s by using emerging technology of EEG monitoring, thus the Greek name “Alpha” (Buzsáki 2020). They have shown indications of playing a part in human memory and some of the previous research has suggested that exposure to binaural beats eliciting Alpha waves can positively affect one’s performance in memory tasks (Garcia-Argibay, Santed and Reales 2019, 367). Alpha waves have also been associated with meditation and feeling loosened up, hinting that binaural Alpha beats could potentially have an impact on how people relax (Robbins 2014; Ramdinmawii and Mittal 2017; Sung et al. 2017).

Moving on to more rapid brain activity, Beta waves typically occur while our brain is in a more awake state (Robbins 2014), and in the past they have been studied especially in relation to sensorimotor behaviour (Gola et al. 2013) as Beta patterns appear to be active in the brain’s motor system in the absence of movement (Buzsáki 2020). Beta waves also have shown links to our cognitive activity, such as attention (Gola et al. 2013) and visual perception (Hanslmayr et al. 2007), which to a certain extent suggests that binaural Beta waves could help tune our brain to a state of waking consciousness. Lastly, forming the highest brain state frequency level, Gamma waves dominate the brain’s electrical activity while it is in an alert and aroused state, yet they also seem to be present in most of the other brain structures and states (Buzsáki 2020). Binaural beat induced Gamma patterns have been argued to have a positive impact on test subjects performing memory tasks, and binaural beats within this frequency have shown positive effects on human attention in previous research reports (Garcia-Argibay, Santed and Reales 2019).

Overall however, the research results regarding binaural beats and their capability to increase brain’s rhythmic electrical activity, and thus affect human cognition and psychophysiological states, have been mixed and slightly controversial (Stevens et al. 2003; Turow and Lane 2011; López-Caballero and Escera 2017; Garcia-Argibay, Santed and Reales 2019). For example, researchers

have not found fully coherent evidence to support the effectiveness of binaural beats in aiding test subjects with attention tasks (Garcia-Argibay, Santed and Reales 2019), with their vigilance and anxiety (Chaieb et al. 2015), creativity (Reedjik, Bolders and Hommel 2013) or have an impact on emotional arousal when measured through changes in heart rate and skin conductance (López-Caballero and Escera 2017). What makes studying binaural beats and their suggested effects challenging is the fact that there appears to be no agreement on the specific brain mechanism(s) underlying binaural beats and how they transfer into changes in human EEG activity (Turow and Lane 2011; Garcia-Argibay, Santed and Reales 2019), which is why more research on binaural beats and their origin is needed. It is also important to bear in mind that many studies revolving around binaural beats have historically used modest sample sizes, which can weaken the validity of the results, as well as make them more difficult to be extrapolated (Garcia-Argibay, Santed and Reales 2019). As a result, it can be argued that consumers using binaural beat products and services that promise multiple wellbeing and self-improvement effects should take these with a grain of salt.

Oster (1973) argues that when the signals creating binaural beats are obscured by noise, which is just loud enough to mask them, the perception of binaural beats is enhanced. This statement has not been validated in more recent research reports, as they have not found that masking binaural beats with noise, such as pink noise or white noise, would lead to greater effects, rather, introducing music as a form of masking has appeared to be capable of reducing the effect of binaural beats (Garcia-Argibay, Santed and Reales 2019). From this perspective, it is somewhat surprising to observe that many audio products and audio services based on binaural beats utilise music, or some sort of musical elements, as one of their key features.

Previous research has shown signals indicating that multi-layered, complex-frequency binaural beats may create stronger effects than simple beats (Garcia-Argibay, Santed and Reales 2019). This means that instead of using just a single pair of tones to create the effect, one could utilise multiple pairs of them to create

complex binaural beats patterns (Turow and Lane 2011), which might be more impactful. Even though current research has suggested that an advisable duration for binaural-beat exposure is around 9–10 minutes (Garcia-Argibay, Santed and Reales 2019) study reports have also used other exposure times ranging from 3–5 minutes (Reedjik, Bolders and Hommel 2013; Gao et al. 2014) up to 1 hour (Wiwatwongwana et al. 2016). Therefore, it becomes difficult to define an optimal duration to listen to binaural beats in order to maximise their effect.

2.2.2 Other sounds, music and their impact on listeners

This thesis does not exclusively focus on binaural beats, as I intend to use them in conjunction with other sounds and music in the practical part of the research. Sine tones forming the binaural beats effect have not always been used on their own in the previous research either, and they have been often mixed with various other audio stimuli (For instance, Weiland et al. 2011; López-Caballero and Escera 2017), which I discuss further later in this chapter. Before I do so, however, I briefly examine the impact of music and nature sounds on humans, as they have a major role in the tracks that I create for my research project. I emphasize effects related to relaxation and meditation, as my thesis is inspired and motivated by these psycho-physiological states. The division of audio stimulus into binaural beats, nature sounds and music may seem slightly arbitrary since music can be defined as a form of art through which one can express emotions, created by combining sounds that have been produced in various ways (Carterette and Kendall 1999, 726). Given this wide definition, binaural beats and nature sounds could both be seen as music that I mix in my project with sounds created by traditional musical instruments. Regardless, I use the division between binaural beats, nature sounds and music for the sake of clarity as it allows me to effectively separate these different core elements of my tracks and explore their usage one at a time.

Music and its potential impact on our relaxation has intrigued researchers for a long time as they have attempted to find out whether it can operate as a relaxation technique (Tan et al. 2012). However, well before the western academic world started showing their interest in music's health benefits, it has been used by many ancient Asian cultures as a way to relax and meditate, where instruments such as singing bowls have been a vital part of their music tradition (Aarts, Ouweltjes and Bulut 2014; Landry 2014). Even though the research around music's influence on human wellbeing has appeared to show somewhat varying results (Thoma et al. 2013) previous reports have indicated that music can be capable of inducing positive emotions and reduce stress (Koelsch et al. 2011). We can all observe this in our everyday lives, for example when our favourite songs might make us feel happier, or when we listen to peaceful-sounding music to help us wind down. While the style of music that people choose to use for this is very subjective, it could be argued that there are a few musical genres in particular that seem to actively either promote these effects in different ways or have been studied in relation to them in the past research.

New age music is one of these genres, as a musical style designed to promote relaxation and human wellbeing through its repertoire. Yet, what does new age music actually mean? It has been suggested that it stems from the holistic and meditational fields and is influenced by the philosophies of new age movement, which support the ideas of physical healing and spirituality (Kemp and Lewis 2007; allmusic.com 2020). Despite having multiple different definitions and opinions on its roots and origins, the early 1970s have been typically identified as the period when the new age movement began (Kemp and Lewis 2007). Since then it has been stated to have shifted into the music industry in the early 1980s in the form of new instrumental music (Diliberto 1995). Moreover, it has also caught the interest of researchers as a potential way to enhance relaxation, although the results have been mixed (Smith and Joyce 2004; Pérez-Lloret et al. 2014).

Another genre that is relevant to the context of relaxation and meditation is ambient music. The term "ambient music" was coined by Brian Eno (b. 1948)

when he used it in his album *Ambient 1: Music for Airports* (1978) while describing his music as ambience, atmosphere or a surrounding influence that can be both ignorable and interesting to listen to, depending on the listener (Eno 1978; Field 2019; Watson 2020). Ambient music is meant to encourage calmness and a space to think (Eno 1978; Field 2019), so some of the key characteristics of relaxation and meditation are already factored in the definition of the genre. For example, ambient music artist Hiroshi Yoshimura (1940–2003) named the series of his 1993 album *Wet Land* to “Music for Your Mind – Relaxation Music Vol. 1” (Yoshimura 1993). Similar to new age music, ambient music’s effects on humans has also been researched and the results have indicated that ambient music could indeed operate as a tool to strengthen the feeling of relaxation (Becker-Blease 2004; González and Garces 2017).

Combined with new age and ambient music, classical music has also been on researchers’ agenda when studying the effects of music on humans. Classical music has been part of same experiments as binaural beats when exploring the effects of different audio stimuli on relaxation and meditation (Ramdinmawii and Mittal 2017) but is has also been tested against new age music to see which one test subjects find more relaxing (Smith and Joyce 2004). The results from these experiments have shown positive signals to suggest that especially pieces by Wolfgang Amadeus Mozart from the Classical period can assist in relaxation and achieving a meditative state of mind, however this could be due to certain characteristics of music that people generally find relaxing rather than the genre of music itself. Classical music is a wide genre and its repertoire is likely to have pieces of music that people find less relaxing or meditative. It is important to note that this is perhaps the case for new age, ambient and other genres of music as well.

Scholars have tried to identify and define some key properties of music that evoke relaxation within its listeners (Tan et al. 2012). For example, in the previous research it has been suggested that this “relaxation music” has improvised or loose melodic structure, moderate to slow tempo, repetitive or simple rhythmic structure and utilises instruments such as flute, piano, strings,

and synthesizers, but lacks vocalization and lyrics (ibid.). As music can consist of multiple elements and it has various characteristics to describe it by, it becomes challenging to map out all the possible aspects that may make music relaxing. Furthermore, music can be very subjective and all individuals have their personal preferences on what music they may use to assist them to relax or seek a meditative state of mind. For instance, some people might prefer listening to Mozart's *Eine kleine Nachtmusik* for this purpose, whereas someone else might find a modern pop song with recognizable lyrics more effective.

Before I steer the focus back on binaural beats I briefly discuss the potential effects that nature sounds could have on its listeners. By nature sounds, I mean any sound that originates from the natural world. Therefore, these sounds could be anything from wind, rain or water sounds to different animal sounds. In general, nature environments have been believed to support wellbeing and relaxation (Gould van Praag et al. 2017; Yu et al. 2018). Nature sounds have also been used in previous research along with binaural beats to study their impact on the listeners (Weiland et al. 2011). There are various potential reasons why people find nature sounds pleasant. Firstly, previous research has indicated that people might simply prefer natural sounds over mechanical or urban sounds (Yang and Kang 2005; Guastavino 2006), which can be a crucial factor for the wellbeing of people who live in cities with limited access to sources of nature sounds such as forests, parks or lakes. It has also been suggested that listening to nature sounds can channel us away from inward-focused attention, which may include worrying about different things (Gould van Praag et al. 2017; Yu et al. 2018). In addition, listening to nature sounds have been linked to an increase in our body's parasympathetic response that helps us relax, and this process is believed to be a consequence of human adaptation to natural sounds through our evolution (ibid.), as we have become more used to, and feel more familiar with, sounds of the nature.

2.2.3 Binaural beats based products and services

As binaural beats and their potential effects on us have gained more foothold in the research field, they have also turned into different kinds of audio products and services that have been made easily available to consumers. Some of these come with a price tag, such as specific meditation music packages mixed with binaural beats produced by specialist health companies, whereas the major content streaming services such as Spotify and YouTube are filled with a variety of artists who are offering binaural beats products free to anyone who might be interested in trying them out. Some providers simply label these as music that will help one concentrate, enhance memory and so on, according to the claimed health benefits that binaural beats seem to possess. Although not exclusively, in other cases, the phenomenon of binaural beats has been transformed into a form of “therapy” that claims to help people reduce stress and anxiety, amongst other things, through regular, binaural beats fused meditation practice. There are even binaural beats mobile phone and tablet applications that people can access wherever and whenever needed to.

Robert Monroe (1915–1995) was one of the key people who worked in the field of binaural beats and its clinical applications on humans (Turow and Lane 2011). In the early 1970s he founded Monroe Institute, “an educational and research organization” focusing on binaural beats and awakening human consciousness (monroeinstitute.org 2020). The institute has a main campus in Faber, Virginia USA, as well as programmes and services that are offered in eleven other countries around the world (ibid.). Their products and services vary from books, CDs, downloadable binaural beats music links and online programmes, to different workshops and retreats that people can physically attend in one of their campus locations to learn more about binaural beats stimulation and how it can be used for personal growth and health purposes (Turow and Lane 2011; monroeinstitute.org 2020). Robert Monroe developed and patented a binaural-beat technology called “Hemi-Sync auditory guidance system” which Monroe Institute uses in their services by mixing binaural audio stimulus with music, natural sounds and pink noise (Atwater 1999). The name of the technology originates from the two hemispheres of the brain, which Monroe Institute claims to operate coherently in sync while listening to binaural beats (Atwater 2014).

The Hemi-Sync process comprises of multiple elements in addition to the binaural-beat audio stimulation as it is coupled with various psycho-physiological inductive techniques such as controlled breathing exercises and restricted environmental stimulation, Monroe Institute's teaching practices and assisting social-psychological conditioning procedures (Atwater 1999; Atwater 2014). This is a rather multi-dimensional approach to binaural beats and their suggested health benefits, and Monroe Institute has built an extensive product and service range around it.

The ways binaural beats have been examined in research are diverse. Reports often detail a research setting where test subjects are exposed to binaural beats on their own, accompanied by pink or white noise, mixed with music or as a combination of all of these. For example, Padmanabhan, Hildreth and Laws (2005) used a commercially available binaural beats track Holosync Solution from a company called Centerpointe Research Institute, which has based their audio technology on the research carried out in the field by people such as Gerald Oster (centerpointe.com 2020). According to their website this audio technology is mixed inaudibly with environmental sounds and peaceful music, which claims to lead to new neural pathways and enhanced communication between the brain's two hemispheres, resulting in improved mental and emotional health (ibid.).

Instead of using ready-made binaural audio products, scholars can utilise self-controlled, free audio tool software such as Gnaural Binaural Beat Audio Generator 2.0 (For instance, Lavallee, Koren and Persinger 2011). These products typically allow users to set the ideal binaural beat frequency under investigation and control its playback duration according to the research inquiry. Gnaural Binaural Beat Audio Generator 2.0, for example, offers its user the options to create simple and simultaneous sine wave frequencies, place them freely on the track's timeline and, if the user desires to have multiple beats within the same track, choose the transition times and curves between different binaural beats (See Figure 1). The software also allows its user to add in other audio stimulus, such as external music files, rain or water drop sounds, pink

noise or isochronic tones, which assists in masking the sine tones and creating multi-layered audio tracks that can be very similar with some of the commercially available products. The main difference is that software such as Gnaural Binaural Beat Audio Generator 2.0 offer scholars the flexibility to choose and modify the binaural beat stimulus according to their research's needs, whereas with ready-made binaural beat products the audio stimulus is pre-determined and researchers will need to rely on their authors' descriptions of the tracks instead of creating them themselves. If the commercial tracks do not reveal much detail of the audio technology used it can become problematic and make it more difficult for scholars to fully understand how the binaural beats have been created and what is the purpose of the other sounds featured in the tracks, such as music, pink or white noise and nature sounds.

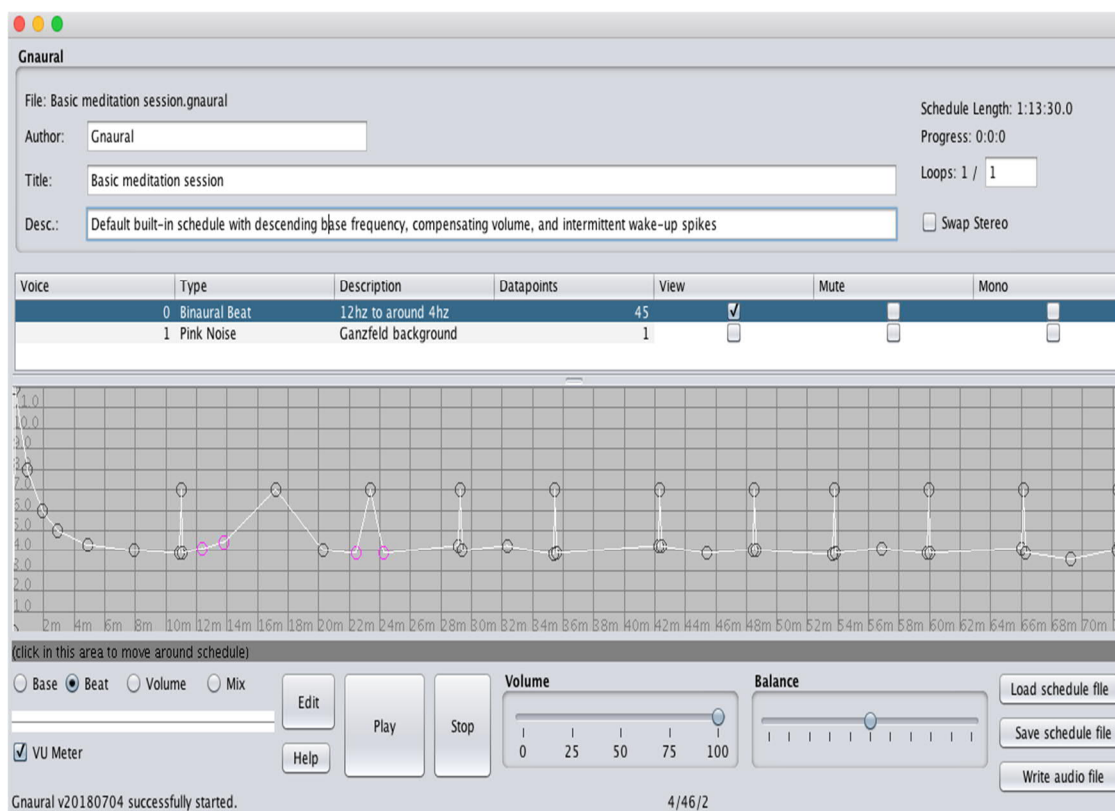


Figure 1. Editing transition times (horizontal axis) and curves between different binaural beat frequencies (vertical axis) on Gnaural Binaural Beat Audio Generator 2.0.

Regardless of the creator of the binaural beats stimulus, in research reports it is usually portrayed as a mean of intervention. The exposure can happen during a

single listening session (For example, López-Caballero and Escera 2017, Sung et al. 2017) and the research design can follow a traditional laboratory test setting where the impact of binaural beats is evaluated through a binaural auditory trial, which either generates measurable changes within the subjects or it does not. Sometimes, however, the intervention is more longitudinal in nature and the test subjects may listen to the binaural beats several times across multiple days (For example, Wahbeh, Calabrese and Zwickey 2007; Lavalley, Koren and Persinger 2011; Reedjik, Bolders and Hommel 2013; Zambi 2016). This allows the researcher to monitor whether the impact of binaural beats can be repeated consistently over time, and the interventions can form a structured listening programme or course. It could be argued that the latter research design is somewhat similar to the commercial binaural-beat services and products where the auditory interventions are used as a therapeutic tool.

2.2.4 Binaural beats and music production

As previously mentioned, a quick online search for binaural beats music fetches multiple sources to find different music tracks that embed binaural beats into their core. While listening to these tracks one can perceive and hear the binaural beats, nonetheless how the mixing with music has been done is not always explained to the listener. Delay and reverb plugins company ValhallaDSP by Sean Costello has offered a free device, ValhallaFreqEcho, which can transfer any audio source into a binaural beat pattern. On the company's website Costello walks through the steps on how to use it by separating the left and right channel and then changing their frequency difference to a desired binaural beat pattern (Costello 2010). Another audio product company, Light of Mind by brothers David and Steve Gordon, goes even further by stating that their "Binaural Beats Brainwave Music [...] is more effective and sounds better than any others they had heard before" as they partnered up with another sound specialist company, Songrest (Merrill 2020). In doing so, they created binaural beats music that relies on a music-brainwave algorithm, which aligns the pitch and tempo of the music used to the binaural beats tones to ensure that the foundation of the

binaural beat comes from both music and the additional tones directed to the left and right ear (ibid.). According to Light of Mind this mechanism results in more effective binaural beats since the music and tone frequencies are in harmony, and to maximise the impact of their tracks they also used tones from the music to create isochronic beats as an additional source of brainwave entrainment (ibid.).

Similarly, some scholars have demonstrated more clearly how they have created the binaural beats or mixed them together with music and other sounds. For instance, a study that investigated the effect of binaural beats and other sounds on how quickly test subjects fall asleep created their binaural beats by desynchronizing four simultaneous tones between the left and right ear, thus forming a chord (Shumov et al. 2017). The frequency difference between the tones varied between 0.5 and 4 Hz (ibid.). Another research report, studying the impact of binaural Theta pattern on hypnotic susceptibility, used Monroe Institute's specifically produced audio tapes, which consisted of carrier tones that changed periodically according to a chord progression of C major 7th, C major, G major, D minor and C major (Brady and Stevens 2000). Much alike the previous example, the binaural beat effect was accomplished by creating a 5.5–8.5 Hz left-right channel frequency difference while the carrier tones were played (ibid.).

Simpler solutions have also been used. A study examining the effects of different audio stimuli on emergency department patients' anxiety utilised two digital sine tone generators at 200 Hz and 210 Hz and then embedded this stimulus into the background of an audio field recording consisting of nature sounds (Weiland et al. 2011). The frequency difference between the tone generators changed during the soundtrack and it varied between 4 Hz and 10 Hz (ibid.). A similar approach was also used in a research that focused on evaluating how familiar music mixed with binaural beats would affect heart rate variability, blood pressure and depression level of subjects of an older age who also suffer from depressive symptoms (Sung et al. 2017). In this experimentation two audio signals, one at 350 Hz and the other at 360 Hz, were created with a software called Mind Station, and they were consequently used to generate an Alpha pattern at 10 Hz,

which was then embedded into pre-recorded songs that the test subjects were familiar with (ibid.).

3 Practical project

3.1 Havas Wellness Lounge

As a part of this thesis, I work on a practical project that focuses on the use of binaural beats within music. I approach this by creating an album of audio tracks that utilise Theta and Alpha waves with varying degrees, and I produce the album for a company called Havas who will use it in their London office's recreational space called The Wellness Lounge. Havas is a global media and public relations company that employs over two thousand office workers in their London sub-branch. They offer multiple services to their employees such as an in-house restaurant, a coffee shop, yoga classes, a hairdresser and sport facilities that allow its employees to play billiards, table tennis and foosball. Some of these services focus directly on wellbeing, and Havas hosts various talks ranging from a healthy work-life balance to nutrition and stress management, which are all free to attend. A large portion of the wellness related activities culminate on Wednesdays, which the company calls "Wellness Wednesdays". During these days, everyone in the office can attend thirty-minute guided meditation sessions that run throughout the day and take place in The Wellness Lounge.

Outside Wednesdays, The Wellness Lounge is open at any time to everyone in the building, and people can freely choose how long they want to spend there. As the Figure 2 shows The Wellness Lounge is a rectangle-shaped room that consists of multiple sofas and cushioned chairs that are typically placed next to a tablet device, which allows the visitor to listen to different music tracks, nature recordings or instructed meditation exercises through headphones. Of course, visitors do not necessarily have to listen to anything if they choose not to, and

they can stand or sit in silence if they prefer. The purpose of the room is to offer its users a space to relax and unwind during their workday, and the only rule is to avoid disturbing other visitors, which means that The Wellness Lounge is a quiet place where people are not allowed to speak aloud. It has large windows that can be covered with curtains in order to dim the lighting level, and physically the room has been placed far away from the spaces where people commonly do their daily work, which gives privacy to its users.



Figure 2. The Wellness Lounge.

The album I create will be uploaded on the tablets in The Wellness Lounge so that it will be available to all people working at Havas. It will be placed there on a permanent basis, and Havas will create a website for the project where people can comment and leave feedback regarding the tracks. I will also write a short information board on binaural beats and their use in my album, and this will be placed in The Wellness Lounge so that visitors get a general idea of the concept in case they have not heard about binaural beats before. The anonymous feedback received from the users will be directed to me in order to provide

another source of evaluation, which will also allow me to analyse the effects of the binaural beats music and to develop the concept further in the future. Yet, this is not the main objective of this thesis, as my exploration and analysis regarding my research questions are examined through the literary review in Chapter 2 and the analysis conducted in Chapter 4, which is based on the process of creating binaural beats and mixing them with music.

3.2 Project design and workflow

I create the project completely independently, which means that Havas does not take part in the design process itself. I have explained the concept of binaural beats to the company's human resource department and I have agreed with them that I will submit the tracks for their use as soon as the current coronavirus (COVID-19) outbreak subsides and Havas workers are allowed to return to the office. The purpose of the tracks for Havas is to reinforce and promote the mission of their recreational space by expanding the audio offering of its music and sound catalogue. Also, for the sake of transparency, I would like to clarify and confirm that all the tracks are produced as a part of this research project and my master's thesis, and therefore, they are not linked to my daily work at Havas to any extent.

I work on the practical project simultaneously while writing this thesis. I create new music and binaural beats during the process, though I also utilise my own personal field recordings in the tracks. I have made these audio recordings prior to the start of this research, and I have selected them carefully to match with the new audio material and the aims of this study. The finished practical project is an album consisting of four tracks that all have binaural beats embedded into them, and the creation of it for the most part follows a trial and error approach while I endeavour to create the Theta and Alpha binaural beats and mix them with the other audio material.

3.3 Research methods, tools and analysis

This thesis leans on art-based research, as the analysis in the following chapter for a great portion relies on my artistic experimentation in the context of binaural beats and music. Barone and Eisner (2012, 8) define art-based research as “the utilization of aesthetic judgement and the application of aesthetic criteria in making judgements about what the character of the intended outcome is to be”. In my case, this means that the generation of new information depends on the subjective choices that I make as a sound and music artist when I create binaural beats music for The Wellness Lounge. I use my personal judgement throughout the whole process, meaning that I constantly review the audio material I produce and edit it whenever I deem it necessary in order to reach the goals set for this research. However, these design choices and artistic judgement are not meant to be purely arbitrary, as I also utilise the previous research done in the field of binaural beats, which has an impact on the overall design process. This past research affects how I approach the creation of binaural beats and what type of music and other sounds I choose to combine with them. Furthermore, it influences the way I mix the binaural beats together with music and field recordings.

When evaluating it from a methodological point of view, it has been argued that art-based research is a branch of qualitative research (Barone and Eisner 2012, 11). A very simplistic categorization of research divides it into quantitative and qualitative tradition. Quantitative research seeks to generate accurate measurement and objective, new information that relies on numbers, statistical descriptions and testing hypotheses, while qualitative research is seen as something more interpretative and critical, and it usually places less emphasis on the generalization of the results beyond the research setting (Lapan, Quartaroli and Riemer 2011; Barone and Eisner 2012; Leavy 2017). In comparison, quantitative approach also often focuses more on investigating cause and effect within the studied phenomenon (Lapan, Quartaroli and Riemer

2011; Leavy 2017). Even though the distinction between quantitative and qualitative research has been contested (Lapan, Quartaroli and Riemer 2011; Barone and Eisner 2012), it is a workable way to describe my research, which, I would argue, resonates more with the common characteristics of qualitative tradition. In the practical part of my research I do not seek to invalidate or confirm any cause and effect relations related to the impact of binaural beats. Also, I do not attempt to gather a large amount of data in order to carry out statistical analysis that would assist me in answering to my research questions, and I do not endeavour to appear completely objective to the reader, as I make various subjective decisions and take actions based on them throughout the analysis.

In the creation of my audio album, *Hidden*, I use a variety of tools and software. Ableton Live (10 Suite version) is my digital audio workstation (DAW), however I also use other digital plugin software to complement and expand its audio production and editing capabilities. For the music creation, I use a MIDI (Musical Instrument Digital Interface) keyboard that allows me to play different digital instruments, and I utilise multiple audio field recordings that I have done with a Sony PCM-M10 digital recorder and Audio Technica AT2022 condenser microphone. These tools, together with the research orientation described earlier, form the basis for my analysis in the following chapter.

Hidden can be accessed here: <https://soundcloud.com/kalle-jurvanen/sets/hidden/s-bwGn7twpN60>

4 *Hidden* – analysing the creation of the album

4.1 Design process

In this chapter, I open up my artistic process behind the creation of the album *Hidden*, which I produced for Havas' Wellness Lounge. This operates as the main analysis of my research topic together with the actual process of creating the album, which I attempt to describe as clearly as possible. I also link my design and creation process back to the research field I presented in Chapter 2 in order to find links between theory and practice and to see how past research can be utilised in the creation of something new. As previously mentioned, I limited the scope of my practical exploration with binaural beats to Theta and Alpha waves, as they have been argued to be linked to relaxation and meditation, which constitute the core purpose of The Wellness Lounge. This also guided my process of creating the music and selecting and editing the field recordings used in *Hidden*.

4.2 Creating binaural beats

The entire process for the creation of all the tracks in *Hidden* started by finding ways to generate binaural beats in the form of Theta or Alpha waves. As I described earlier, in audio products focusing on binaural beats, as well as in previous research settings, these waves have been created in many different ways. For this reason I originally tested multiple software, such as Gnaural

Binaural Beat Audio Generator 2.0 and ValhallaFreqEcho, for the binaural effect generation, before I settled using Ableton Live's own instruments. Indeed, they offered me the most streamlined approach to link the binaural beats with other audio material, since I used Ableton Live as my main DAW through which I created the music and also edited the field recordings. I utilised Ableton Live's own software synthesizer instrument Operator, which allowed me to create a simple sine wave generator that I could duplicate and pan into left and right channels under Ableton's instrument rack (See Figure 3). By setting the frequency difference between left and right to a desired level, I was able to generate binaural beat tone of a chosen length, and change the frequency difference over time. This is very similar to Gnaural Binaural Beat Audio Generator 2.0, which allows the user to draw the frequency differences on a timeline and also flexibly adjust the transition periods between different binaural beats as described earlier in Chapter 2. However, since Java based Gnaural is not automatically synced with Ableton, I would have had to use an additional software, such as Soundflower, in order to route the audio between the software. Therefore, I ended up using Ableton's Operator synthesizers in all the tracks of *Hidden*.

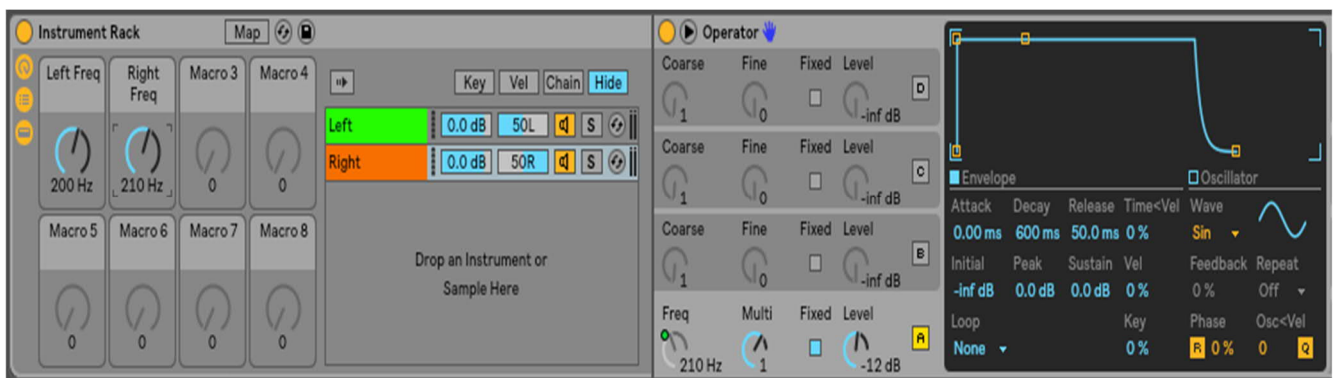


Figure 3. Splitting Ableton Operator synthesizer's sine wave into left and right channel and adjusting their frequency difference to create a 10 Hz binaural beat.

Out of the entirety of *Hidden*, *Endless Sunset* has the most simplistic way of utilising binaural beats as it has only one Theta wave track playing beside the music and field recording. It has a frequency of 4 Hz and it remains the same throughout the piece. It can be heard as a rather low frequency, as I have set the

left channel of the binaural beat track to 147 Hz, while the right has a value of 151 Hz. The reason why I wanted one of the pieces in *Hidden* to have a single, immutable binaural beat forming the third illusionary tone is because this approach has been utilised multiple times in past research (For example, Jirakittayakorn and Wongsawat 2017; Sung et al. 2017). *Endless Sunset* was the first piece I created and it operated as an opening to explore other ways for me to utilise binaural beats in music.

Rain by the Garden takes the idea of a single binaural beat source a step further. It consists of a field recording, which I combined with one binaural beat source that has a carrier frequency of 200 Hz. However, the frequency difference between left and right channel changes over time with a minimum value of 4 Hz and maximum value of 10 Hz, as I set left channel to 200 Hz and right channel to progress from 204 Hz to 210 Hz and then back to 204 Hz over the course of the piece. Thus, the binaural beats featured in *Rain by the Garden* are Theta and Alpha waves. This particular piece was influenced by a randomised controlled trial from Weiland et al. (2011) where their 20-minute audio recordings had the same frequency values within the binaural beat audio as described in Chapter 2. Yet, in an attempt to change the meditative state of the test subjects, they started with a 10 Hz frequency differential between their sine tone generators, which subsequently decreased to 4 Hz and then increased again to 10 Hz over the final part of the audio piece (ibid.). In *Rain by the Garden* the first twelve minutes or so have binaural beats at 4 Hz which then gradually increase to 10 Hz within the next two minutes, stay there around five minutes, then over the next two minutes decrease to 4 Hz where they remain until the end of the song. As Theta waves have been associated with a meditative state of mind and reduced anxiety levels, I wanted to start the piece with them and then move on to Alpha waves, which have been linked to relaxation. Finally, in order to keep the beginning and end consistent, I wanted to finish the song by bringing the binaural beat audio back to how it started, with a 4 Hz Theta beat.

Since previous research has suggested that multi-layered binaural beats could create stronger effect, I also wanted to explore the idea of having multiple

binaural beat sources in the same song. *Balm* begins with two 4 Hz Theta waves with carrier frequencies of 146 Hz and 196 Hz that were created with sine tones and that last throughout the entire piece. To complement this, I also used a software version of Moog's modular synthesizer to pair a G1 note (around 49 Hz) with an A1 note (around 55 Hz) that creates a sustained Theta tone of 6 Hz, which pulsates through the piece with regular intervals. I used audiology.org (2020) and Liutaio Mottola's lutherie information website (2020) in order to convert musical notes into frequencies whenever needed during the creation of *Hidden*. This assisted me when I was attempting to add musicality to the pieces, however I discuss this in more detail later in the chapter. For *Balm*, I also created additional 4 Hz binaural beats with Operator synthesizer's panned sine tone pairs, which emerge at 1:28, 2:24, 3:20 and 4:16 and last until the end of the piece. Their respective carrier frequencies are 247 Hz, 294 Hz, 370 Hz and 392 Hz. I designed this structure in an attempt to enhance the effect of Theta waves gradually during the song so that it would finish with seven simultaneous binaural beats.

Fade has perhaps the most multidimensional approach to creating binaural beats within *Hidden*, as I utilised three pairs of sine tone generators together with B major triads to create the effect. Two of the binaural beats play through the whole song and they are a Theta wave of 4 Hz, with a carrier frequency of 165 Hz, and an Alpha wave of 8 Hz, with a carrier frequency of 247 Hz. The third sine tone pair is another Theta wave with 4 Hz beat and a carrier frequency of 329 Hz, and it can be heard through regular and sustained binaural bursts that appear first between 1:30 and 2:15 and later from 3:27 till the end of the piece. The B major binaural beat chord, however, is slightly different. As the Figure 4 shows, these triads consist of three sine wave pairs that form the notes B, D# and F#. Their carrier tones are 247 Hz, 311 Hz and 370, and I created the binaural beat effect by adding 4 Hz to the right channel of each note, thus detuning the left-right frequency difference to the Theta range. Listener can observe these beats between 2:32 and 3:17 through four sustained B major triads. I was interested in exploring this approach as I saw the chord mechanism being utilised in some of the past research settings (Stevens et al. 2003; Shumov et al.

2017), and it assisted me in reinforcing the connection between the binaural beats and music.



Figure 4. A B major binaural beat chord, with each of its note featuring a 4 Hz left-right channel frequency difference similar to the highlighted B note.

4.3 Musical composition with binaural beats

Past research states that binaural beats are rarely used on their own in the clinical applications that rely on their illusory effect, as they often include music, verbal guidance or other sounds (Turow and Lane 2011). Moreover, while

browsing through The Wellness Lounge's audio catalogue, I noticed that music was especially well represented, and therefore I decided to explore the idea of having it in *Hidden*. Additionally, this allowed me to look into music's role within relaxation and meditation and its relationship with binaural beat patterns in my pieces. Stemming from this, all of the songs I created utilise music, yet the scope and means for this vary. For example, while some of the pieces feature obvious links to music through well-known instruments, other tracks may take a more inconspicuous path by first looking at music and its key principles more broadly and then applying this to the sounds used in the pieces.

As I described earlier, *Fade* uses binaural beat chords, however also *Balm* relies on this technique through simpler chord formation, as it features the Theta beat of 6 Hz, which was created by combining two lowest notes of Gsus2 chord (G and A) (Figure 5). Another way I utilised music theory in the design process was by basing nearly all of the carrier tones of the binaural beats to musical notes. For example, *Endless Sunset*'s binaural beat is built around D, while in *Balm* these come from D, G, B and F# and in *Fade* they are based in E and B. These all follow from the musical key that each piece is written in, as *Endless Sunset* is in B major, *Balm* is in G major and *Fade* is in E major. This approach is similar to the technique Light of Mind company I mentioned in Chapter 2 uses in their tracks, by relating the binaural tones mathematically to the music key and rooting them in the fundamental tones of their pieces (Merrill 2020). A research article by Tan et al. (2012) inspired me to write these pieces in major mode as it stated that vast majority of the music they defined as "relaxation music", and that was analysed in their experiment, was based on the major scale.



Figure 5. Playing G (around 49 Hz, left channel) and A (around 55 Hz, right channel) notes from Gsus2 chord to create a binaural beat effect.

Rain by the Garden is different from the other pieces since it only consists of a field recording and binaural beats that were created with a single pair of sine tones. If we were to define music as something that has been produced with traditional instruments this piece might not be considered music. In spite of this, I would argue that based on the definition of music I presented in Chapter 2 *Rain by the Garden* is indeed musical, as I pushed to produce something artistic and emotion provoking with the sounds I used in the piece. In a way, the rain sounds provide the track with its rhythmic structure by slowly increasing in intensity, while the frog sounds contribute to this by generating repetitive bursts throughout the piece and blending in to the rain sounds towards the end. Similar to the other songs in *Hidden*, the binaural beats in *Rain by the Garden* are related to the fundamental frequency of the piece. I used Ableton Live's Spectrum

analyser tool to locate the dominant frequency of the field recording and subsequently matched the carrier tone of the binaural beats with it, which in this case was around 200 Hz.

Since music, and art in general, are highly subjective matters and create personal experiences, it feels rather arbitrary to try and base one's design choices solely on previous research done in the field of relaxing and meditative music. Therefore, I was also relying on my own aesthetic judgement during the process as explained in Chapter 3. What this meant in practice is that while I was composing the music and deciding the instrumentation for each piece I listened carefully to the sounds that I was producing and evaluated them not only based on past research but also in relation to my own personal feeling regarding music that would assist me to relax or meditate. Arguably, as a result of this process, not everyone may find that the pieces featured in *Hidden* produce the same effects.

All of the songs in *Hidden* have a relatively slow tempo, which has been suggested to induce relaxation (Wolfe, O'Connell and Waldon 2002; Labbé et al. 2007; Tan et al. 2012; Pérez-Lloret et al. 2014). It felt appropriate to limit the pace of each piece to a level no higher than moderate in order to create a calming impression. Also, the rhythmic structure is somewhat repetitive and predictable across all the songs, as it has been argued to constitute a feature of relaxational music (Tan et al. 2012; Pérez-Lloret et al. 2014). I designed the rhythm to stay consistent in an attempt to direct the listener's attention away from it, and thus free up their cognitive capacity towards their own thoughts and other elements in the songs, such as the binaural beats. For example, in *Balm* my intention was to create a very predictable rhythmic structure while simultaneously and gradually increasing the number of binaural beats in order to steer listener's attention towards them.

While composing the music for *Hidden*, I found certain instruments more useful than others. As previously mentioned, I used Ableton's Operator synthesizer for the majority of the binaural beats, and synthesizers in general proved to be

convenient tools for the music creation due to their versatility. For instance, I used Moog's modular software synthesizer in *Balm* and *Fade*, as it allowed me to flexibly edit timbre, sustain, decay, release and various other elements of sound while composing, which assisted me in the whole song creating process. Even though they do not necessarily always brilliantly succeed, synthesizers can also be used to mimic sounds or characteristics of other instruments. I explored this in *Fade*, in which I utilised a software version of Oberheim Matrix 12 synthesizer and attempted to edit its sound towards wind instruments' features, yet still keeping it distinctively electronic-sounding. This synthesizer can be heard in the beginning of the piece between 0:27 and 1:30 and then from 4:22 until the end of the song. Another example of this attempt to emulate other instruments through sound synthesis is in *Endless Sunset*, where I used a granular synthesizer Granulator II throughout the entire piece to create sustained string-like sounds in the background. Both wind and string instruments have been suggested to be linked to relaxational music (Tan et al. 2012; de la Torre-Luque et al. 2017), and synthesizers offered me a practical way to try and add a hint of them into *Hidden*.

4.4 The use of field recordings and nature sounds

All of the songs I created for The Wellness Lounge utilise a different nature field recording as one of their key elements. In *Balm* it most dominantly comprises of sounds of multiple crickets chirping in a forest, whereas *Endless Sunset* features a variety of bird songs that have been recorded in close proximity to a lake, which occasionally can be heard during the piece due to fish swimming. As a distinguishable characteristic, *Endless Sunset* also includes a constant but gentle wind sound originating from the rustling leaves of close by trees. Both of these songs have the field recording playing throughout the whole piece, while the sound of waves in *Fade* only appear at the beginning of the song until 2:05 and then re-emerge again from 5:48 and last till the end of the piece. The field recording for *Rain by the Garden* was captured in the middle of a small rainstorm by placing the microphone outside, under a shelter. It features various water

sounds such as rainfall and water hitting the roof and the gutters of the shelter and dropping down on to a concrete floor, but also includes the croaking of frogs and chirping of birds, although the rain sounds are overall the loudest amongst all of them.

The reason why I decided to have nature recordings in the pieces is not limited to their suggested impact on listener's health and relaxation, as discussed in Chapter 2. When I was searching for examples of meditation, relaxation and binaural beat music on Spotify and YouTube I noticed that many of them include different nature sounds. In addition, various binaural beat mobile device applications appear to have an option to place nature sounds in the background, which myNoise and Atmosphere are examples of, not to mention some of the commercially available binaural beat tracks from companies such as Monroe Institute and Centerpointe Research Institute, which seem to rely on nature sounds as well. Ultimately, however, I based this design choice on my estimations of the typical visitors of The Wellness Lounge.

I considered what a usual workday for an office worker in London might look like and what some of the reasons for them to visit The Wellness Lounge might be. As I work at Havas, I recognize that workdays can often be somewhat hectic and people might not have time during their day to leave the building in order to go outdoors and experience the feeling of being close to nature. Furthermore, most of the windows at Havas cannot be opened, so people mainly listen to the soundscape of an office environment with its peeping phones and printer sounds, combined with multiple radio stations playing simultaneously. Deriving from this knowledge, I was keen for *Hidden* to feature various nature recordings that could potentially assist the listeners in experiencing a feeling of being somewhere else other than in the office.

While experimenting with different field recordings, binaural beats and musical composition, I was following some of the core principles of *musique concrète*, or *concrete music*, a movement originating from the thoughts and experiments of Pierre Schaeffer in the 1940s, to compose music with pre-recorded sounds

(Manning 2004; Hodgkinson 2009). These recorded sounds could consist of anything other than sounds created by traditional instruments, and they are edited to create different audio compositions (Hodgkinson 2009). Even though I also featured more traditional instruments in my compositions, the process of utilizing the field recordings was similar to musique concrète, as I manipulated the nature recordings in several ways, for example by cutting them to fit in with the other audio material I produced and by running them through equalizer effects. They were a crucial part of my whole composition process.

Not everyone prefers nature sounds, however. David Michael (2011) argues that nature sound recording has been long criticised and

panned as kitschy New Age, accused of pandering fantasy as ‘reality’ to a naive public, and worse, maintaining and perpetuating a picturesque, Romantic view of nature as something that is over there, separated from us, to be quasi-religiously revered. (206)

By manipulating the field recordings in different ways, or even by using certain microphones that ultimately affect the sound of the recordings, the sound recordist can be accused of producing certain hyper-realities that are not necessarily truthful to the original nature (López 1998). Indeed, a lot of relaxation and meditation music that features nature sounds appear to portray nature as untouched and soothing, almost as a sound-aided escape from reality. Within this context, *Hidden* could be subjected to the same criticism, as I ultimately produced seemingly peaceful and “composed” nature recordings, as I believed these would more feasibly allow me to achieve my goal of creating something that would assist people in the process of relaxation and meditation.

Despite the criticism, nature sounds provided me with something very useful while creating the binaural beats music. As discussed in Chapter 2, pink and white noises have often been used along with binaural beats in previous test settings (For instance, Stevens et al. 2003; Turow and Lane 2011; Shumov et al. 2017; Garcia-Argibay, Santed and Reales 2019). I did not originally plan to utilize

either of these as a distinctive feature in any of the tracks, however while I was producing the pieces I noticed that many of my nature recordings included sounds that seemed rather similar to pink and white noise. In all respects, Turow and Lane (2011) have argued that rushing water sounds bear resemblance to pink noise. This observation was especially prevalent within my recordings that included multiple sounds of water and wind, which is one of the reasons why I favoured them when creating the songs for The Wellness Lounge. Indeed, they operated as a tool for masking the sine tone signals that created the binaural beat effects, and were especially emphasized in *Endless Sunset*, *Fade* and *Rain by the Garden*, which all have relatively large amount of either water or wind sounds. The extreme example of this is found in the latter, which, coupled with binaural beats, relies heavily on various rain sounds that have also been suggested to emit a calming and soothing effect (Farnell 2010).

4.5 Mixing it all together

While I was composing *Hidden* and working with various sound materials, one of the key questions I had to consider regarded the ideal length of the pieces. Should they be short few-minute songs or would it be better to create pieces that last longer, even up to one hour? Given that Havas employees typically have a single one-hour lunch break, combined with a few shorter, ten to fifteen-minute breaks throughout their workday, I decided that it would be beneficial to produce song options with different lengths. In doing so, people can quickly drop by The Wellness Lounge and listen to a single, shorter track, or stay and listen to something longer, depending on their personal preferences and needs. I therefore created two shorter pieces, *Balm* (7:00) and *Fade* (8:00), and two longer ones, *Rain by the Garden* (27:43) and *Endless Sunset* (32:02). This decision also followed the examples of past research experiments related to binaural beats in the Theta and Alpha range, where various exposure times have been used. For example, while Ramdinmawii and Mittal (2017) utilised three-minute bursts of binaural beats, Beauchene et al.'s (2017) equivalent was five minutes

and Sung et al. (2017) used a 30-minute exposure time. I also aimed to give the longer pieces a slightly looser song structure with only a few instruments and by putting more emphasis on the nature sounds. This way The Wellness Lounge visitors would not feel forced to listen to these tracks until the end and could cut the listening experience short if needed.

As I mentioned in Chapter 2, previous research has not been able to fully confirm what happens to the effectiveness of binaural beats when the tones used to create them are masked with other sounds, and binaural beats have also been studied both as a sole audio stimulus and together with other audio stimuli. This has also been the case for commercially available binaural beat products. For instance, Turow and Lane (2011) state that Monroe Institute did not prefer generating binaural beats by using sine tones on their own, as they believed that they sounded dull and rather unpleasant. I felt the same while I was creating the binaural beats with Operator's sine waves and mixing them with my other sounds. I found them aesthetically challenging and in my opinion they generated a slightly irritating sound. As a result, I often lowered their volume if they were constant sine tones or alternatively synchronized them with louder music parts so that they could be barely heard. An example of the latter is the Operator-generated Theta beat in *Fade*, which I matched repeatedly together with musical notes played with Moog's modular software synthesizer, which had higher amplitude (See Figure 6).

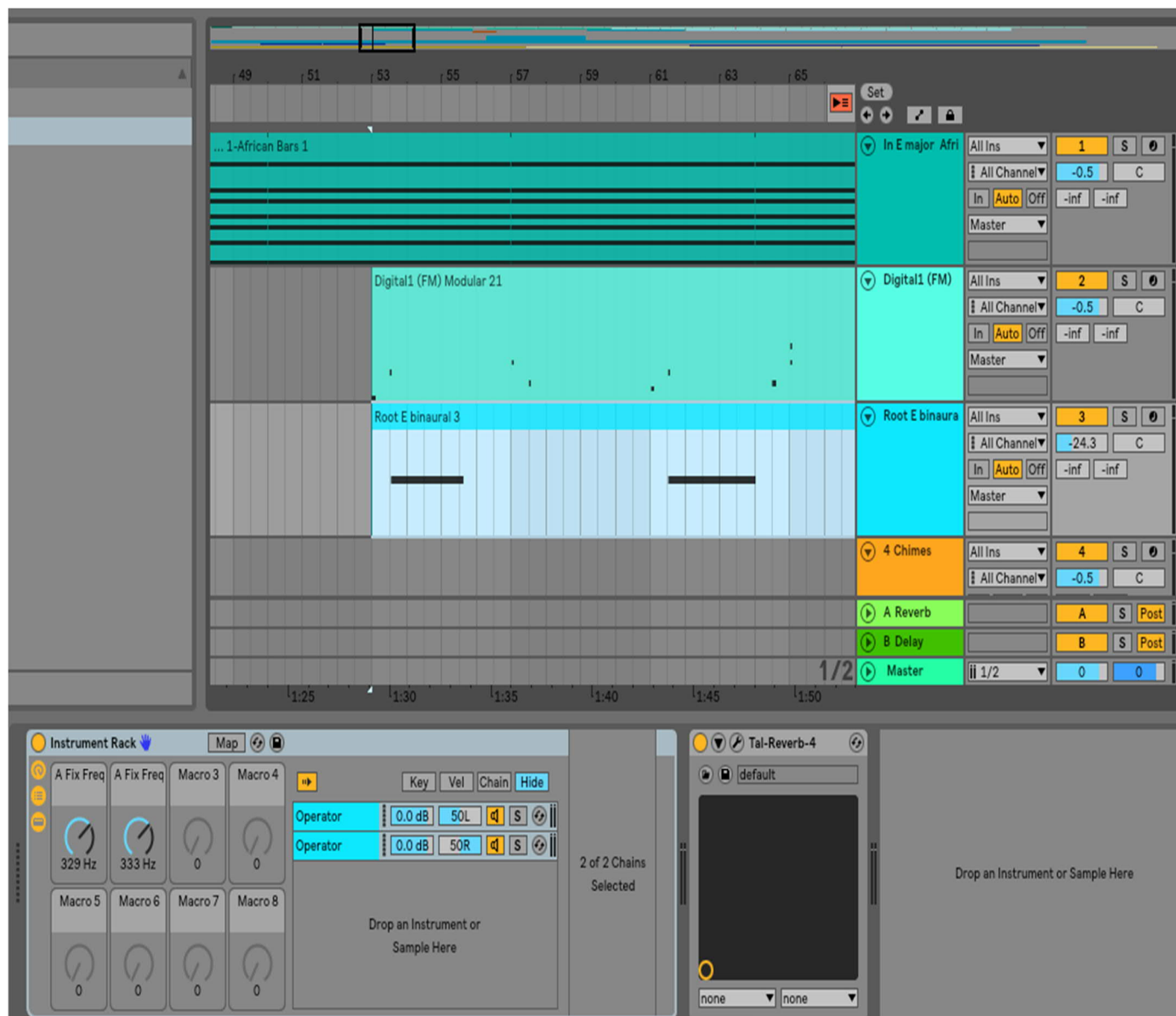


Figure 6. Masking binaural beat tones (turquoise) with notes from Moog's Modular synthesizer (aquamarine).

5 Discussion

5.1 Results and conclusions

In this thesis I have looked at the phenomenon of binaural beats in the context of music production. I have focused on what binaural beats are and how they can be created and used with music and other sounds. I have also considered their suggested effects on listeners through a review of past research, which has indicated that binaural beats could have an impact on test subjects' anxiety, sleep, attention, visual perception and memory. The emphasis of my study has been on two of the five binaural beat patterns, Theta and Alpha, which have been suggested to be associated with a meditative state of mind and feeling relaxed. Along with the written part, with this thesis I have also explored the research topic by creating binaural beats music to be featured at the recreational space, *The Wellness Lounge*, of a company called Havas. The Wellness Lounge is a free, physical space for Havas' employees, located in their London office and used for relaxation and meditation purposes during workdays. The binaural beats tracks created through my research form the audio album *Hidden*, which will be made available to listen to by Havas employees through tablet devices and headphones placed in the recreational space. The orientation of this study has been qualitative and I have followed the principles of art-based research via the use of my personal, aesthetic judgement and artistic criteria throughout the album's creation process, which has heavily influenced its outcome.

The binaural beat is an illusionary auditory effect created in the human brain when two slightly different sound frequencies are played simultaneously, one in the left and one in the right ear. The binaural beat has the frequency equal to the

mathematical difference of the two sound frequencies generating it. The beats under closer examination within this thesis, Theta and Alpha, range from 4 Hz to 10 Hz and from 8 Hz to 13 Hz, respectively. The research conducted in the field has been diverse and it has often focused on the effects binaural beats may have on the listeners. As previously discussed, the results from past research have been mixed and sometimes even contradictory (For example, Stevens et al. 2003). What makes analysing the impact of binaural beats even more complicated is the fact that researchers and scholars have not fully agreed on the specific mechanism in the human brain that causes the audio effect and transforms it into human EEG activity. Despite all of this, binaural beats have managed to seep into the consumer market through various commercial and non-commercial music products, therapies and other audio services that often promise their users certain health benefits. Some of the companies offering these services base them partly on the findings of academic journals, however, they also sometimes conduct their own research around binaural beats, which affects their products. This can become problematic especially when the consumers are not made fully aware of previous research and its test settings and limitations, as it may lead to offering a biased image of the effects and benefits of binaural beats.

By creating and designing *Hidden*, I have attempted to deepen my understanding of binaural beats and how they can be used alongside music and other sounds. In theory, any audio source is capable of generating binaural beats as long as its playback can be divided into left and right channels that have the required frequency difference. Throughout this thesis, I have found synthesizers to be particularly useful instruments in achieving the illusionary audio effect, and I have used them extensively by creating pure sine tone pairs and by generating other, modulated sound frequency combinations. In order to create and mix the binaural beats with other audio material used in *Hidden*, I leaned on some of the key principles of music theory. For example, I have mainly used frequencies that match, or are close to, musical notes, and when using multiple binaural beats within the same piece I have employed the musical key in which each piece was written in order to determine the frequencies for those binaural beats. In this, I

have favoured notes that are included in each piece's musical key and I have formed chords and parts of chords from these binaural beats. For *Rain by the Garden*, which does not have a clear musical key as it relies heavily on a field recording of nature sounds, I have used a frequency spectrum analyser tool to locate its dominant frequency, which I have subsequently used as a base to align the binaural beats' carrier tone frequency with. Moreover, in *Balm* I have also generated binaural beats by playing a suitable musical interval simultaneously, in this case a G-A major second.

I have endeavoured to compose binaural beats music that induces relaxation and a meditative state of mind amongst the visitors of Havas' Wellness Lounge, however, I have not relied solely on the effect of Theta and Alpha waves to achieve this aim. I have also composed the music and selected field recordings in a way that would assist me in achieving this goal. As a result, I have used relatively slow tempo and predictable rhythmic structures across all the tracks in *Hidden*, and I have largely utilised repetition. Regarding the instrument selection, I have relied heavily on different synthesizers that have also allowed me to experiment on their emulation capabilities of other instruments, such as wind and string instruments. I have also considered nature field recordings as a form of music and included them in all of the pieces as one of the key elements.

Nature sounds are often heard in music that promotes itself as relaxing or suitable for meditation, ranging from free binaural beat mobile applications and Spotify tracks to commercially available therapies and other audio products. This seems justifiable, especially as nature sounds have been argued to contribute positively to people's wellbeing and relaxation. I have used nature recordings in *Hidden* for this reason in particular, as my aim has been to offer the workers of Havas sounds that they may not hear otherwise during their workday in an office located in the middle of London. Nature recordings have also assisted me aesthetically by masking some of the sine tones creating the binaural beats. Moreover, water and wind sounds have also had another purpose. They can sound somewhat similar to the pink and white noise that have been used as an additional audio stimulus in the past binaural beat research, however, I had not

originally planned to include either of them before I started the composition process. This is mainly because their impact on the effectiveness of binaural beats has been contested in the research field. Regardless, I wanted to emphasize the role of water and wind sounds in *Hidden*, as I found them aesthetically pleasing and calming. I do not appear to be the only one feeling this. For instance, YouTube seems to be full of pink and white noise videos that claim to help listeners meditate, focus, relax and sleep amongst other things. Furthermore, previous research has also indicated that pink noise may be able to enhance sleep (Papalambros et al. 2017), which is why it might be capable of making people feel more relaxed on its own. Deriving from this, I have designed the nature sound generated pink noise to operate as an extra element, to assist The Wellness Lounge visitors in unwinding.

This thesis has several limitations. I have not designed my research in a way that would allow me to test any hypotheses nor verify or nullify any causal connections. This means, for example, that by creating *Hidden* I have not attempted to prove Theta and Alpha beats' effect on relaxation and meditation, nor have I yet asked The Wellness Lounge visitors about their sensations after listening to the pieces in the album. Rather, I have used previous research done in the field to spark my own artistic exploration of binaural beats and their use in music. In *Hidden* I have mixed multiple elements that either past research, other artists and producers, or I personally have felt would assist in achieving a meditative state of mind or a feeling of being relaxed, which makes investigating the impact of a single variable challenging due to the group effect. For instance, it would be difficult to define and compare the individual effects between nature sounds, musical notes and binaural beats as they are all often present at the same time within the pieces that I have created. It is also important to bear in mind that the concept of relaxing and meditation-inducing music can be a highly subjective matter, and people are likely to have their personal preferences on the music they use for this, if any. Therefore, my practical project has merely been a single, explorative attempt to create these effects through binaural beats music, which may not work in a similar way amongst all listeners.

In addition to the fact that previous research has not always succeeded in modulating the EEG power of test subjects via binaural beats (For example, Stevens et al. 2003; Goodin et al. 2012; Gao et al. 2014; López-Caballero and Escera 2017), it has also been argued that the contradictory results from past research is due to not factoring in the difference in the perception of binaural beats between genders (Garcia-Argibay, Santed and Reales 2019). Indeed, Oster (1973) has stated that the binaural beat spectrum may be different between males and females, and they may therefore perceive the auditory effect differently. From this point of view, some may see my research as limited, as I have created the audio pieces in *Hidden* for all workers rather than separating them by gender. In addition, all of the carrier frequencies I have used in the pieces to create the binaural beat illusions have been below the effective ideal of 400–440 Hz, due to aesthetic reasons such as matching these carrier frequencies with the musical key of the piece or being able to mask them efficiently with field recordings. Furthermore, I have used a carrier frequency of around 49 Hz (G1 note) in *Balm*, which has been argued to be below the level that generates easily observable binaural beats (ibid.). However, *Balm* includes several other carrier tones that are in the well-perceivable range. As I have detailed in this thesis, many of the past research experiments that have seen positive effects resulting from Theta and Alpha beats have reported using carrier frequencies below 400 Hz in their test settings (For instance, Weiland et al. 2011; Jirakittayakorn and Wongsawat 2017; Sung et al. 2017).

5.2 Future applications and research

Due to the volatility in the research results regarding binaural beats and their effects, there appears to be plenty of room for future research in the field. Firstly, in order to reach a consensus and a better understanding of the whole phenomenon, further research should focus on how binaural beats affect the human brain and potentially change its activity. This might make it easier for future research to study the effects binaural beats can have on humans. This

research would benefit from an approach that uses large sample sizes of test subjects and consistent study settings between different experiments, which might help to validate some of the results and generalize them (Garcia-Argibay, Santed and Reales 2019). Furthermore, since the research results regarding the impact of other audio stimuli on the effect of binaural beats appear to be contradictory, further studies on this topic would be useful and might assist in the creation of new practical applications that utilise binaural beats with music and other sounds.

Regarding Havas' Wellness Lounge and *Hidden*, I will monitor the feedback from visitors and take action accordingly. The idea is to gather general comments, suggestions and wishes from Havas' Wellness Lounge users and adjust the pieces based on this. I am especially hoping to receive feedback concerning the impact and effectiveness of the music as a whole and the experience from exposure to binaural beats, which will help me develop the project further in the future. Finally, it would be useful to organise a follow-up session at Havas where a fixed amount of people are chosen to listen to *Hidden* and subsequently asked to answer some key questions around the research topic.

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