Music Meditation in the Digital Age: How Music Could be Used to Help Improve Sleep Quality

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20th April 2015

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Abstract

Poor sleep is a common problem in modern society and has been proven to cause many motoring and work related accidents each year in addition to general poor mental performance. Accordingly, the purpose of this research is to discover whether music that incorporates brainwave entrainment (BWE) methods could be used to alleviate troubles in getting to sleep. Previous studies in BWE were analysed and empirical evidence gathered to discover whether poor sleep is still prevalent. The study concluded although no valid research has been conducted into BWE's effects on sleep; strong evidence exists to support the use of BWE for the alleviation of headaches, back-pain, PMS whilst also increasing cognitive functioning, specifically for special reasoning tasks. It also found that some BWE methods to be more effective than others, specifically confirming that binaural beats BWE is ineffective. Further experimental study is needed to fully assess the effect that specifically composed BWE music could have on improving sleep quality.

Introduction

The evidence of music as a means of reaching an altered state is evident across history, from the 1995 discovery of a Neanderthal bear-bone flute dating back 43,000 years, on which was possible to play modern diatonic and pentatonic scales (Boyle, 2013), to the clubs in modern towns and cities; humans' empathy to music both physically and emotionally is undeniable. In Aristotle's, Poetics of 335BC, an early literary work partly in critical response to Plato's view of the moral negativity of art aired in his work Republic, Aristotle discusses the merits of poetry in positive morals and good health, and uses the term psychagogia, which is taken from the literal Latin translation, soul-leading and was contextually applied to the audience, who's state is described as entranced and transported when captured by the emotional nature of a play (Aristotle, 335BC), an early documented example of how melody and rhythm can be applied to create an altered state.

On a more basic level, many of today's attention holding and hypnotic past-times and activities all share a common factor, the soothing repetition of sight or sound. Television's entrancing affect has long been passively observed, as has the mesmerising flicker of a fire and the cyclic rushing of waves crashing on sand or shingle, just to name a few. Although non-BWE relaxation music is widely available and found in varying qualities; can the use of brainwave entrainment (BWE) methods buried in music and soundscapes offer improved sleep for somnipathy sufferers and a form of meditation for the digital age?

Aims and Objectives

The fundamental aim of this work is to discover if music that incorporates brainwave entrainment (BWE) technique can be effective in helping improve sleep quality in poor sleepers and further support whether poor sleep is a valid problem that would benefit from further exploration. This will hopefully lead to further more extensive research and data collection through bias controlled tests. There has been previous research in the areas of brainwave entrainment, sleep disorders and sleep music, but there is a lack of investigation to how music and BWE can be used together to provide a brainwave entrainment laden musical alternative or addition to existing sleep aids.

Rationale/Context

This work straddles many areas of existing research in the fields of music, psychology, psychoacoustics and neuroscience, necessitated by the breadth of areas for investigation to discover whether music with BWE can be used as an aid to sleep.

Somnipathy, or abnormal sleep and sleep disorders such as insomnia, affect around 30% of the adult UK population on a regular basis (Sleep Matters, 2011) and recent studies such as the Sleep Matters study by the Mental Health Foundation in 2011 have shown that poor sleepers are more prone to poor physical health. The notion of the dangers of sleep deprivation and tiredness has permeated culture in several different

guises; tiredness and fatigue is often cited, and previously televised Government campaigns attribute these to being a contributing factor in many road traffic accidents. The UK's Department for Transport's, Fatigue and Road Safety: A Critical Analysis of Recent Evidence, probes and analyses patterns in statistical evidence from 2000 to 2010 to determine the extent in which tiredness contributes to road accidents. In summary, it indicated that the implications of tiredness on driver safety does not just result in momentary lapses in concentration and micro-sleep that has previously been contributed to causing accidents, but also the detrimental effect of tiredness on reaction time and alertness (Jackson et al., 2011). Vas supports this concept further in her 2004 book Meditation, by discussing the means in which observable improvements can be seen in working productivity; reporting of the experiment conducted by a R.W. Montgomery, a chemical factory owner in Detroit asked his employees to meditate for 20 minutes in the morning before work and 20 minutes during the day, 52 of 70 workers agreed and over the course of the next three years sick days taken fell by nearly half, productivity more than doubled and it was reported that profits increased over 500% (Vas, p.52). Could brainwave entrainment music be used as the meditative medium to improve sleep and its related detrimental effects?

The evidence to suggest the contributing factors of tiredness and fatigue in road accidents and poor work productivity is unequivocal, supporting the validity and potential importance of further research in methods of improving sleep. The potential scope for BWE music as a meditative and sleep aid is large.

The title of this paper, 'Music Meditation in the Digital Age: How Music Could be Used to Help Improve Sleep Quality', portrays the topics investigated and frames the study in a way that will be accessible to any future researcher. The use of a colon allows the title to be explanatory enough to be targeted and relevant whilst also being succinct in length.

Questions

There are three questions that an answer is being sought through investigative methods in this body of research:

1) Can music with BWE methods such as isochronic tones, monaural beats and binaural beats help improve the amount and quality of sleep experienced by poor-sleepers? This is the key question, for the reasons set out above.

2) What is the reach of this research: how many people suffer from poor sleep at the time of investigation? This is important to qualify the body of research and to ensure that the investigation is a worthwhile academic endeavour and relevant to potential poor sleepers.

2) Could an embryotic listening environment be used to further augment the musical experience? This is considering the potential for an embryotic listening environment that may augment the effectiveness of brainwave entrainment and the perceived enjoyment of the BWE session and therefore ultimate improving the desire to use BWE. This question is being investigated to understand more about the possible practical application of BWE.

Exclusions

It is important to note a few exclusions that this work deliberately does not consider. The extent of this study is limited by resources to conduct thorough primary empirical research and accordingly record extended responses from a large sample of people, equipment such an electroencephalogram (EEG) was not available to investigate a wider range of physiological responses such as brainwave pattern, respitory rate and skin conductance, which are all indicators of levels of anxiety and consciousness. This paper is not intended to be used in a purely medical context, although much of the research is based in the field of psychology, somnipathy and physiological response,

the BWE music enquired and created is not intended to be a cure for serious sleep problems, but as an aid to reach a state of natural sleep, especially when the symptoms are caused mainly by the inability to 'switch off', environmental distractions and other controllable variables.

Methodology

Original empirical data will be collected to validate the necessity of this research. The type of empirical data collection will be enable the analysis of a range of sleeping behaviour and sleep hygiene across an unrestricted demographic of volunteers. Analysis of music and published texts; journals, literature, studies and scholarly articles will be undertaken to assess the potential suitability to use BWE music to aid falling sleep and quantative data from studies will be cross-examined for transferability from previously researched areas of BWE, to the area of music and sleep, to which to be investigated. Additionally, the music that is suggested to accompany BWE tone is to be discussed and recommendations and example audio examples of musical compositions and constituent auditory BWE techniques are to be provided in the accompanying discography.

Survey research will be used to record behaviour in sleep hygiene and will either support or deny previous research indicated prior and further allow for further extrapolation of information about the range and extent of the problem in sleeping in the survey participants. This type of survey designed was a descriptive type (Lincoln, 2003) to record existing behaviours, which can be further quantified and analysed.

The survey is open to all, apart from a minimum age of 16, which allows for the analysis of sleep across wide range demographic and obtains a cross-section of the population. The importance of random sampling extends to the distribution of the survey and takes form in a variety of methods, as wide as possible, such as social media, direct contact with potential participants through email. The survey is totally

anonymous which is paramount to reduce the effects of privacy bias on the part of the volunteer, which should also lead to the improvement of the reliability of the data collected.

The questions that have been set in the survey were a function of the information that aimed to be gathered, the fundamental drivers of the survey used when creating questions; to discover what proportion of people report poor sleep, to find out more about the sleep conventions used and to what they currently use, if anything, to help to get to sleep. These 10 questions aim to be fully accountable to the original aims and hypothesis of the study, for example question 4 (shown in appendix 2), asks how much sleep the respondent gets on average a night, this is a prequel to the more specific questions about sleeping patterns during the working week and weekend, the choices are banded into groups to allow for easier statistical analysis and a higher survey completion rate, due to the increased ease of response. This question also asks the respondent whether they think that this is enough sleep for them, allowing for the naturally occurring differences in the required amount of sleep between individuals for normal functioning. This particular question does however rely on the participant to be able to self-diagnose whether they get the required amount of sleep for normal functioning, although this should be fairly easily discerned as the accumulative effect of insufficient sleep can be quite debilitating.

The more sensitive independent variable such as age, sex and occupation were all delivered, as openly as possible and for these questions a response was not required before proceeding to the next page, allowing the subjects choose not to provide a response. Questioning the ethnicity of the respondent was not deemed to be important for gathering of the data related to the aims of the study. If further, more detailed research were to be conducted this may be important in determining whether there is a link between ethnicity and sleeping habits, this could be further augmented by enquiring of the country of residence of the respondent, which could give clues to

the way that different cultures experience sleep problems and to what extent this may occur, if at all.

The initial study proposal outlined the intent to gather a group of participants to test whether a musical composition that used BWE methods and a non-BWE music track, would elicit different physiological responses. However, due to the lack of access to appropriate testing equipment such as an EEG and heart-rate monitor, that would be of sufficient accuracy to offer valid results, it was decided to postpone this area research for a future study, which would also allow the conclusions and findings from this study to be applied. In the proposed study the 2 musical pieces would be in a controlled, safe and pre-determined location, the data will be collected by means of EEG, heart rate monitor and participant questionnaire that would allow for objective measuring of physiological response, in addition to the subjects' perception, both of which are important in the process of sleep and to discover whether poor sleepers can benefit from using BWE music.

Brainwave Entrainment

Brainwave entrainment is the process of using an external stimulus or stimuli to control the frequency of the brain's overarching electrical impulse by creating synchronicity between the stimulus frequency and the brain's frequency (brainwave). This is thought to be directly linked to the states of consciousness experienced by human beings, ranging from the different stages of sleep to hyper-activity.

The three main stimulus methods that have previously been employed to deliver these synchrony-seeking frequencies are auditory, visual and both auditory and visual coincidentally. The first documented case of employing brainwave entrainment was by French Psychologist Pierre Janet, who in 1889 reported that hospital patients experienced "reductions in hysteria and increased relaxation when exposed to flickering lights" (Budzynski, ND). Berger confirmed the physiological effect of external

visual stimuli on the brain in 1929, when he demonstrated that the brain emits an electrical impulse in response to the input stimulus. Adrian and Matthews further built upon this in 1934, when they simultaneously used visual and auditory stimuli at the same frequency to demonstrate that the power of the physiological response to the input stimulus grew largely with the combination of impulse sources (Goodin et al., 2011)

More organically occurring examples of this can also seen throughout history, is it a coincidence that the victims of the tragic slave trade used chant and song and unwittingly created a new genre of music, the blues; when they were being subjected to the exhausting hardship and drudgery of their existence through racial persecution? Certainly it could be argued that the repetitive nature of the vocal melodies could have contributed to attaining an altered state, even if just to a minor extent.

The brain's ability to respond to a sensory input with a sympathetic electrical impulse is the main operation process that allows BWE to function. This has been proven by a number of studies, extensively by Kinney, McKay et al. study 'Visual evoked responses elicited by rapid stimulation 'in 1973 coining the term 'cortical evoked response', published in the 34th Journal of Electroencephalography and Clinical Neurophysiology. It also drew a poignant and note-worthy analogy between the brain's electrical response to visual/auditory stimulus to sympathetic resonance of solid objects and instruments from mechanical air pressure.

The selection of specific frequencies to achieve a desired affect through BWE is well documented and throughout this research a clear pattern has emerged to the specific frequency (Hz) bands and their associated different states of brain activity, they name taken from the Greek alphabet. The below table is complied from experimental studies researched.

Fig 1. Brainwave Frequencies

Hz	Name	Effect	Research
25-100Hz	**Gamma**	"Important role in higher cognitive functions, by binding the necessary spatial and temporal information in different cortical areas to build a coherent perception"	Bhattacharya et al, *Long-Range Synchrony in the Gamma Band: Role in Music Perception*. The Journal of Neuroscience, August 15, 2001
12-25Hz	**Beta**	Natural waking-state waves BWE at beta frequencies appeared to improve the cognitive functioning of ADDH sufferers. (18-21Hz)" Can reduce Random Alpha waves in conscious thought. Dramatic increases in EEG amplitude at the vertex (18.5Hz)	1991 - Harold Russell, (Clinical Guide to Light & Sound) Frederick, J., Lubar, J., Rasey, H., Brim, S., & Blackburn, J. (1999) Effects of 18.5 Hz audiovisual stimulation on EEG amplitude at the vertex. Journal of Neurotherapy, 3
8-12Hz	**Alpha**	"Improvement of Learning Efficiency (10.5Hz)" Increased Relaxation	2009 - A Study of Brainwave Entrainment Based on EEG Brain Dynamics M Hutchinson, 1999, *The Technicolor Symphony: Orchestrating Your Brain with Light and Sound*
4-8Hz	**Theta**	The Twilight State Observed during the first 2 stages of sleep	T Budzynski, ND, *The Clinical Guide to Sound and Light,* Stanford University. Stages of Sleep, N.D
0-4Hz	**Delta**	Experienced during deep sleep (Stage 3 NREM & REM)	Stages of Sleep, N.D

What is particularly interesting is that the 3 slowest frequency waves align respectively with the four different stages of sleep, which is discussed further into this document.

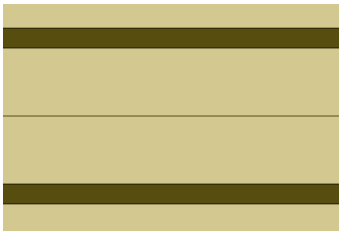
Shattacharya et al. also proved during the experiment evaluating the effectiveness of gamma band (25-100Hz) stimuli, that when musicians were exposed, they had a stronger synchronicity between stimuli and brain frequency than non-musicians.

In current auditory BWE research practice, there are three methods of practical delivery of the auditory brain training frequency discussed above; binaural beats, monaural beats and isochronic tones (an audio example of each method can be heard in the accompanying discography).

Binaural beats use a method of neural-occurring phase subtraction to achieve the

desired programming frequency. This must be delivered through headphones to function as the left and right ear. For example, a sine wave of 400Hz through the left channel and 407Hz through the right will result in the brain 'hearing' a resultant sine frequency of 7Hz, also due to the neural phase modification that fundamentally allows for the phenomenon to occur, the combined frequency of 7Hz will appear to modulate in amplitude by +/- 3dB.

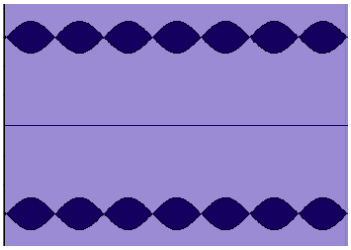
Fig 2. Binaural Beat Waveform View



As can be seen from fig.2 the beating that creates that training pulse cannot be observed, as the phenomenon is purely exists in the brain. 3

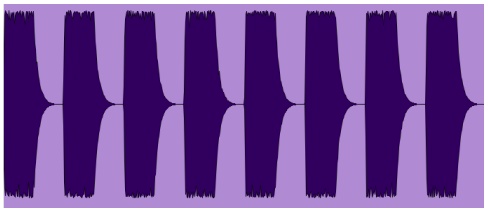
Monaural beats are the monophonic equivalent of binaural beats. Whereas, in binaural beats the phase subtraction takes place inside the listener's brain, in monaural beats use two sine waves which are again combined, but playback occurs through a single audio channel and therefore the phase interaction that generates the programming frequency is created in the audio recording. A well-exhibited but often overlooked example of monaural beats is in a phenomenon often experienced during the tuning of a stringed instrument such as a guitar; when 2 pitches are very nearly identical, but vary slightly different and creates a beating-like effect as the fundamentals and harmonics interact in the air and through the mass of the instrument. This is the fundamental operating method of this type of auditory BWE.

Fig 3. Monaural Beat Waveform View



The most recently explored type of BWE method is isochronic tones. In this method, phase interactions are not used, but the repetitive pulsing of a single sound at the desired frequency is used instead, this can be thought in a similar manner to strobe light that emits on/off signal (it is important to note that no research encountered suggests that pulsating sounds have an effect on epilepsy sufferers). When the audio example is observed, it is clear to see why an alternative method is sought to deliver BWE in a user friendly way.

Fig 4. 8Hz Isochronic Tone Waveform View



Products in this area of BWE training do exist, but they are limited in their application in the sense that many are computer-based relaxation software; which obviously limits the users' ability to find a comfortable environment, however more modern solutions such as mobile phone and tablet apps do exist and offer a potential platform for the delivery of BWE to aid sleep.

Literary Review

Research exists that investigates the effectiveness of different BWE methods, in both light and sound, although there are no current studies that aim to understand the role that auditory BWE could play in increasing the ability to reach the state of sleep.

Recent clinical studies have concluded that BWE is effective in reducing the effects of pain suffered from headaches migraines, PMS and long term stress. Huang and Charyton evaluated the results from 20 studies that dealt with the physiological effects of BWE. The studies analysed used a range of different methods for stimulation, some used only visual light stimulus while others just auditory, and some used a combination of both of these. Also the frequency of the visual/auditory training pulse varied widely, as did the length of sessions, some only 1 20-minute session where other studies focussed on eliciting responses only from long-term studies, all of the research conducted employed isochronic tones due to the large impact that isochronic tones have over monaural beats (Huang Charyton, 2008). The longer-term studies that included multiple sessions proved to be more effective. The results are varied in relation to the range of ailments that were being targeted, migraines had mixed outcomes from different studies and can only be concluded that further long-term studies would be needed. However, nearly all of the 20 studies investigated shows a positive response to BWE in the reduction of the pain and improved cognitive functioning, much in support of Janet and Berger's findings, in 1889 and 1929 respectively. Ideally, further evaluation of Huang and Charyton's hypothesis from their findings of their evaluative study to discover whether long-term treatment with BWE could help improve sleep in somnipathy sufferers.

None of these studies sought to incorporate the use of music in delivering the aural BWE methods such as binaural, monaural or isochronic form. The studies that analysed mood showed no impact on the test subjects' mood at all, one of these conducted extensively; 60-minute sessions over 60 days, and still found no changes or improvement in mood, with in fact a 0% improvement. It did suggest that the use of a progressively decreasing frequency until the desired frequency was met increased the effectiveness of the BWE sessions that used the technique.

The actual environmental conditions during the practical application of BWE offer far

less research to which to draw upon. However, Restricted Environmental Stimulation: Theoretical and Empirical Developments in Flotation Rest is a well-controlled study of the physiological effects of flotation rest and concluded that shares much of the same neural output as shown when test subjects in a twilight state are observed. It is shown how the experience of rest is quite functionally similar to a twilight state (Budzynski, 1990). The development of this type of environment would allow for the testing of increased physiological response that would be expected, due to the compounding nature of auditory and visual BWE, in addition to discovering if an encapsulating environment can play a key role in the delivery of effective BWE music.

Several studies have offered evidence to suggest that music can help improve the sleep of students and older adults, most notably Lai and Good's 2005 study, concluding that use of soothing music did help those sufferers of minor sleep problems. Specifically, the participants experienced "…significantly better components of sleep quality" which were defined as "…better perceived sleep quality, longer sleep duration, greater sleep efficiency, shorter sleep latency, less sleep disturbance and less daytime dysfunction" in older adults (Lai, Good, 2005). The similarly titled Music Improves Sleep in Students, in 2008 showed a "…statistical significant improve in sleep…" (Harmat et al., 2008).

With the additional use of BWE tones incorporated into the effective soothing music, the fundamental sound-bed to which employ the chosen BWE method could be formed. Certainly, it could be argued that if non-BWE music has been proven to help, why does an alternative BWE method need be sought, but the answer is explained when considering the original sleep survey results, in which is was reported that this has not been an effective sleep aid for everyone, although only 37.5% of participants stated they currently use music to try and help sleep, over half of these respondents said they still suffered from sleeping problems.

The types of music that have been in previous studies investigated are quite limited in breadth stylistically and all upbeat music has been previously avoided, attributed to avoiding auditory over-stimulation. Classical music was popular and used in several of the studies, including Lai and Good's study. Harmat et al.'s study was also very narrow in its approach to music choice, as this was clearly not the aim of the survey; the music cited as being used was from, 'Baroque to Romantic-The Most Relaxing Classical (2 CD, Edited by Virgin 1999)' and no more specific information was given to the specific musical pieces used and no data was generated to give an insight to how the actual musical components affect the listener's physiological response.

Literature in popular culture such as the widely acclaimed and best selling, Your Brain on Music by D Levitin, covers a wide range of scientific topics to enlighten the way that music is processed in the brain. It includes findings about music & memory, musical perception and reasons behind our love of music. It does not reference sleep directly but does discuss the positive mental impact that music does have and the potential to increase focus and learning ability (Levitin, 2006).

Discussion

The type of BWE method that is used has an impact on the strength of the sympathetic physiological response and therefore, must have effect the effectiveness of the treatment. Binaural beats are discriminatory against those with the use of only 1 ear, although this may be a very minor proportion of the potential users. However this is subsidiary to the fact that at least 7 studies have conclusively proven that the use of binaural beats are ineffective in achieving brainwave entrainment (Oyster, 1973. Lane et al., 1998. Le Scouarnec, 2001. Stevens et al., 2003. Kennerly, 2004. Ulam, 2006. Wahbeh et al., 2007. Goodin et al., 2012). This is important for a number of reasons, no synchronicity will occur and therefore no BWE will occur either. The research indicates that there is very little change in the output EEG of the test subject from the control sound of white noise and therefore "…[it was] insufficient to generate

entrainment" (Goodin et al., 2012), and resultantly would not be suitable for further investigation in this scenario, notwithstanding, that there are still occasionally uses in clinical neurological functioning tests (Entraining Tones and Binaural Beats, N.D).

Further examples of the effectiveness of BWE can be seen in Thomas and Siever's 'The Effect of Repetitive Audio/Visual Stimulation in Skeletomotor and Vasomotor Activity' which used 30 participants, split into 2 groups of 15. The groups were asked to sit and relax, one experiencing auditory and visual BWE in the alpha frequency (8-12Hz) and the other not, the under-skin temperature and muscle tension were measured and the results concluded that the control group with no BWE stimulation actually showed more physiological indicators to suggest an increase in tension levels, whereas the BWE group had a significant drop in their muscle tension and a raise of body temperature, associated with increased relaxation (Hutchinson, 1999). This specific study is important as it indicates that BWE can increase restfulness and relaxation, which is physiologically similar to first stage of sleep, stage 1 NREM (non-random eye movement) (Stages of Sleep, N.D).

During a waking state, the brain's overarching frequency is in the Beta range (see fig. 1); this is a relatively high frequency and allows the brain to perform the complex neural tasks that are associated with wakeful activity. This then reduces to a slower Alpha wave as sleep approaches and as stage 1 NREM sleep is encountered, Theta frequency brainwaves are prevalent, continuing into stage 2 NREM sleep, finally being eclipsed by the slowest and higher amplitude brainwaves, Delta, which are experienced during the stage 3 NREM sleep, which is where deep sleep occurs (Stages of Sleep, N.D) and into dreaming state sleep, REM sleep. Thomas and Siever studied only the effects of Alpha waves and therefore cannot offer a full justification to the power of BWE, further studies into the effects of different BWE frequencies, especially in relation to sleep. The study however was able to offer further strong evidence that BWE elicits a positive psychological response.

Relaxation and ambient music that is often used as an aid for sleeping and to help the body achieve more of a rest state may not be effective for all users, mainly for the reason that they can be overly influenced stylistically and therefore it is likely that many people would be deterred from using this type of music in the quest to improve sleep and reducing anxiety if they are not fans of this genre of music. Ambient artist Brian Eno again highlights the fact that the dislike of the styles can act as a barrier to using non-BWE music; "I find that it come[s] from a rather un-peaceful sort of place. I think an element of danger and a kind of unsettled quality. Unresolved issues. I don't find it meditative at all, just the opposite. If that were meditation, I for one would give up immediately" (Holmes, 2008).

The uprising of technology and media sharing sites such as YouTube have given a new delivery format to connect with new audiences, a search shows there are many channels that specifically cater for monaural and binaural compositions, with many of these tracks with well over 300,000 views (April 2015), which certainly shows that there are users searching and consuming this type of music and a potential audience for any compositions created.

Musical Discussion

Music research has shown that music can be a behaviour modifier, antiquity has also suggested this previously, demonstrated in the well-known Mozart experiment, where Mozart sonatas were found to temporarily improve the special-reasoning ability of test subjects, compared to those who were in silence (Ball, 2011). Additionally, research has shown that employing background music in mathematics classes at a special educational needs school can significantly improvement behaviour and mathematical performance (Hallam, Price, 1998).

The use of specific music genres for different functional and emotional applications is widely known, if only through passive cultural programming by most of the world. A

common example of this is the music that is used for visual media such as TV commercials and films, where the music is composed to specifically evoke an emotional response, whether soft romantic piano, driving up-beat electronic rhythms or staccato strings to punctuate a car chase scene.

In 1982 Gorn studied the power of music in influencing advertising choices, which for a while was widely influential in supporting that music was a modifier of buying behaviours, however, his hypothesis and findings were proved to be inaccurate, mainly attributed to the bias and flawed design of the experiment by 3 independent studies, Allan and Madden in 1985, Park and Young in 1986 and more recently by Kellaris and Fox in 2001 (Kellaris et al., 2001). The latter, conducting 3 experiments which recreated Gorn's original study but with modifications to the experiment's delivery to reduce bias imparted by Gorn's initial study and ultimately found no correlations between background music and brand choice, only trivially finding that Mozart's music was far more popular than Milhaud's compositions. However, a study that only investigates the influence of Mozart and Milhaud's music upon the selection of a colour of a branded pen from a box will never be able to fully assess whether music and/or genre can influence any buying decisions, however elaborate.

Composing Isochronic Music

A supporting musical composition that incorporates isochronic tones has been composed to support this research and offer a control composition for any other researchers that may not have the facilities to create isochronic BWE music. Isochronic tone BWE was utilised to evoke potentially the strongest physiological response as it has a high impact in amplitude (Oyster, 1973), the visual differences can be seen by comparing fig.1, fig.2 and fig.3.

The concept of emotional specific composition was used alongside BWE methods in the musical composition. Initially, the focus was on the sound that would be the isochronic

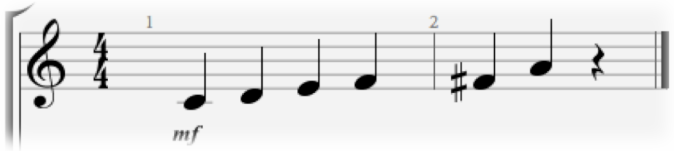
rhythm of this brainwave entrainment track; this holds critical importance as it must be clearly audible and have a sharp attack and a percussive nature to allow for the brain to clearly follow the meter but no so much that the listener would become annoyed by the repetition. It has been shown that the use of sine wave (pure tones) that have only fundamental harmonics, to be the most effective due to the acceptability of the tones (Huang, Charyton, 2008). It was deemed important to try and keep the track as genre-free as possible, to allow for a greater potential audience. Different instruments that are common from a variety of genres were used, a synthesiser, piano and orchestral instruments woven together through a journey of organic sound effects and atmospheres.

The track was composed with the isochronic tone at 8Hz, falling within the Theta range, which is low in frequency and therefore potentially offers a low frequency sympathetic neurological response, much like the Theta brainwaves that occur during the 1st two stages of sleep. It offers a higher chance of reduced mental stimulation of wakening brainwaves (mainly Beta) than using a higher 10.5Hz Alpha range brainwave stimulus frequency such as the one used in 'The Study of Brainwave Entrainment Based on EEG Brain Dynamics', which elicited a higher rate of cognitive functioning on test subjects, and would therefore not be suitable for the intended reduction in consciousness desired from this composition. Accordingly, the BPM of the host DAW set at 60bpm to give a tone every 75milliseconds (8Hz) if the isochronic tone sounds on each crotchet. For this example, a certain amount of free-form abstract structure was permitted but whilst also keeping the loose introductory 5/4 time signature for the initial 1minute 30seconds, allowing the natural flow of the ambient nature of the harmonic and melodic sounds in an almost homophonic fashion. This modulates to common time (4/4) when the first melody appears and continues throughout to create an hopefully enjoyable pulse. The composition also modulates key from the initial 1minute 30second introduction, giving an uplifting experience as all the instruments and sounds resolve and continues to the tonal plateau for the remainder of the composition.

The sound effects were chosen for their own individual quality to shape the aural soundscape and can be experience as a linear journey, as different 'scenes', from a playground, walking through a tunnel and out into the open forest, on to a waterfall, the open shoreline etc. This was done to increase the accessibility to users with lower interest levels, as some potential users may not want to sit and listen to a single pulse tone for extended periods of time, in addition to providing further organic stimuli that is intended to help revert back to a primary state and induce sleep.

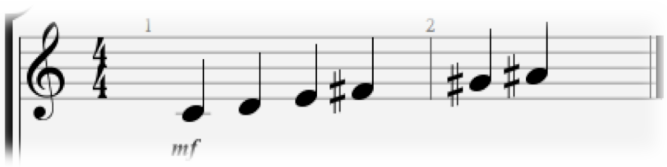
Tonally, the diatonic major mode of Lydian was initially considered due to its overtly positive tonality, owed to the raised 4th interval in comparison to the root major (Ionian) scale. Musicians requiring a very bright sound, notably contemporary guitarists Joe Satriani and Steve Vai, both who have demonstrated its ability to sounds very exotic and with a slight dream-like quality, have used this mode extensively. Vai's 'K'm Pee Du Wee', exploit melodies that offer the sharpened 4th as the tonal resolve. Ultimately its use was discarded due to its close sonic relationship with the common major scale and slightly jarring quality.

Fig 5. C Lydian Scale



Also considered for the tonal grounding of the composition was the whole tone scale which uses only whole-tone interval, in the case of C the notes would be C, D, E, F#, G#, A#.

Fig 6. C Whole Tone Scale



The whole tone scale is a very exotic sounding scale and due to the dreamlike quality of the intervallic formula, it was considered to feature in the composition, however, it was felt that staying away from too many unusual scales, that although effective, could detract from the BWE and give the listener's brain too much stimulus. It has also been used in western art music composition from the end of the 19th century, as composers such as Liszt and Borodin made use of more chromatic harmony and drew closer to the tonal experimentation in the proceeding century. More strongly chromatic compositions that are based around the whole tone scale include the short form piece for solo piano, The Night Winds composed by American impressionist Charles Griffes between 1910-1915, a decade before the rise of serialism. The whole-tone scale has also been used in many TV shows and films and can be heard fairly commonly to imply a dreamy-feel. An A specific example is the opening music to the 2001's children's TV show entitled 'Ultimate Book of Spells', the composition starts with glimmering ascending and descending swells of the whole-tone scale arranged for harp and encapsulates the identity of the TV show very well, according to IMDB (Internet Movie Database) the composers are W Anderson and J West (IMDB, 2015).

It was concluded that a simple tonal progression, was to be employed as not to distract from the experience, the composition featured a root D and a C, with accompanying melodic lines scattered throughout. The length of the composition was chosen to allow for the user to be able to be taken by the experience (18m: 39s). More experimentation is needed to define the best length and deployment of the composition.

Percussive instruments were exclusively avoided due to the strong likeliness that they would interfere with the brainwave programming pulse provided by the isochronic tone. All melodic instruments had a high-pass filter applied with a cut-off frequency of at least 500Hz, ensuring that no frequency masking of the isochronic tone occurred. Recurring themes in both sound effect and musical components were used to further create a sense of resolve and 'returning home' to further aid the feeling of comfort and

familiarity, but differences in perspective both in terms of sound field and depth, employed by the use of panning and different reverberation levels and shapes.

Empirical Findings

From the survey conducted, there were 20 total responses, 19 (95%) of which were genuine, 16 (80%) participants completed the whole set of twelve questions, the remaining can be potentially accounted for by the respondents loosing interest with the survey, this tried to be addressed in creating mainly multiple-choice questions, although a balance had to be found where enough useful information could be extrapolated from which to draw conclusion.

Within the responses that were gathered, it was clear that many people did suffer from poor sleep and that this had a negative effect on their waking lives, even just through feeling 'constantly tired' and that provided it was affordable, would be willing to try alternative sleep aids. The question 'On the nights you can't sleep, what do you think is the problem?' 81% of respondents From the respondents who agreed that they had trouble sleeping, the majority attributed the cause to thoughts running through their heads, "work related stresses", "…brain doesn't shut off", "overthinking" and similar problems (The full range of responses can be seen in Appendix 3). This type of poor sleep has the potential to be addressed by use of BWE, due to the relatively minor nature of the somnipathy suffered, supporting evidence that music is effective in helping sleep for some people. Further evaluation revealed that poor sleep is certainly still a problem in 2015, this is only likely to increase with ever heightening use of smartphones, laptops, iPads and other devices that emit light and potentially interrupt the natural circadian rhythm that modifies sleep patterns and behaviour. BWE music could offer an ideal focus for the potential user that finds it hard to put away distractions. From 17 respondents 8 agreed that they feel asleep watching the TV in the evening and 8 claimed they did not, this is important in suggesting that a 'focused distraction' such as BWE music could be effective in helping sufferers get to sleep.

Fig 7. Respondents who fell asleep whilst watching TV

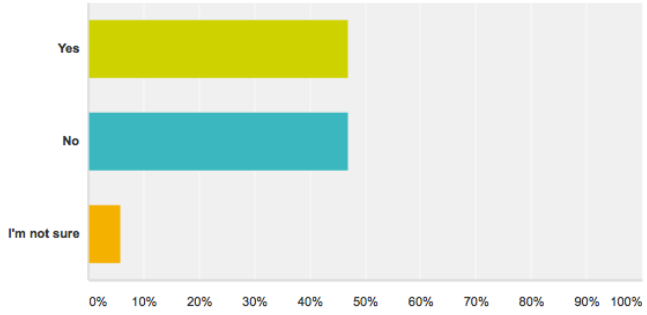


Table taken from SurveyMonkey.com

There was 1 false response to the survey, defined in this instance as a set of answers that were given which were clearly entered by someone as a form of self-entertainment and racism, as one of the comments would not be ethical to repeat. This is likely to be down to the delivery method of the survey, through channels such as e-mail to friends and shared on social networking sites, this would certainly be avoided in any future surveys; a likely future delivery method would be through paid distribution channels such as Survey Monkey and Qualtrics for reasons also discussed previously.

If similar future tests were conducted, changes would certainly be made, foremost to collect a higher number of responses allowing a more reliable set of answers. Survey services that distribute the survey to a pre-selected audience could be used. This would allow for the survey to be to a much wider demographic and could importantly reduce the amount of false responses that were gathered, especially if the respondent were being paid for their participation.

Although the data gathered from the set of responses clearly shows that over half of the sampled population aged 16-66 do suffer from problems getting to sleep, it is clear from the empirical data gathered that it would be inaccurate to draw final conclusions to the full extent of sleep problems and considering the counter-argument that the empirical data set gathered is too insignificant in magnitude to give a full and accurate account (Full data can be found in appendix 3).

Conclusion

There is a wide range of evidence that suggests that music has far reaching implications that are beyond its current perceived value as purely entertainment. There certainly seems to be a growing market for meditative therapies, popular media outlets often run articles that discuss the scientifically supported benefits of meditation. Moreover, the amount of popular figures in modern society that claim to have learn and regularly use Maharishi Yogi's Transcendental Meditation technique is surprising (including Jennifer Aniston, Russell Brand, Sheryl Crow and Clint Eastwood).

An embryotic listening environment utilising both light and auditory stimuli is proposed to create the strongest effect for further study, as research shows a compounding effect for the use of both auditory and visual BWE together and that a state of rest can be similar to the Theta wave emitting early stages of sleep. In engaging future users, this also has the potential to be used as a new platform in which to enjoy existing visual/aural media in a fresh and exciting way and could prove to be popular with the increasing amount of poor sleepers in the hectic technology-laden 21st Century, although, this would be another study entirely.

Although the survey results were limited quantitively, the results collected were effective in discovering whether poor sleep was experienced by many of the population, which has been proven to be true and validate that there is a potential problem that exists and the potential importance of further exploration of the subject. It was also clear that there is a potential audience for further developments in BWE music, as well as many existing sufferers of poor sleep that appears to be often caused by distractions and random thoughts while trying to sleep. It also appeared that a large proportion of the poor sleepers studied accredited difficulty in getting to sleep on the use of devices and other distractions, which could be potentially alleviated by the user engaging with the enjoyable BWE music instead.

It has been shown that short-term BWE sessions are effective at reducing the negative effects of a range of different ailments such as headaches and PMS, as well as improving cognitive functioning, to the extent that short-term improvements in special-reasoning, mathematical calculus and memory have all been identified. Music has been proven with enough extent to conclude that music can help improve sleep functions in a range of different sufferers. It has also been shown that BWE binaural beats are not effective in creating synchronicity between the brain and training BWE frequency and isochronic tones have proven to be the most extensively used BWE stimulus in experimental studies.

A wide range of BWE research studies have been encountered, varying widely from its effect on toxicomania, intelligence, relaxation, stress disorders, complexity of self-projected visual-imagery etc. but very surprisingly there appears to be no research into BWE's potential in improving sleep functions. Cross-examining the different uses of BWE in the treatment if the range of problems encountered would certainly show that there is a strong positive response in many psychological areas to BWE methods, particularly auditory and visual employed in unison and would support further investigation. This would clearly support that BWE is a powerful tool that may be able to be developed into the area of sleep.

In final conclusion, research such as Harmat et al.'s study, many of its contemporaries studied and this research gathered show there is a clear gap for further experiential testing to determine the full extent, if any, to which BWE music can be used as a way of easing the transition to entering the sleep state.

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Discography

(Available at https://www.dropbox.com/sh/qz4v7jr3owoaykj/AAAR1xkOIuSlolO3C6lkM3ZSa?dl=0)

Chris Stanley – 'Forests of Sound' `(2015, Creative Commons License, 18:35)

Binaural Example (Chris Stanley, 2015. Creative Commons License, 1:00)

Monaural Example (Chris Stanley, 2015. Creative Commons License, 1:00)

Isochronic Example (Chris Stanley, 2015. Creative Commons License, 1:00)

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Glossary of Terms

Binaural Beats: A type of aural BWE method that delivers a different sine wave to each ear, with the difference of the sine wave's frequencies creating the entrainment frequency (i.e. 450Hz–455Hz= 5Hz). Only effective when employed with headphones.

BWE: Brainwave Entrainment. The process of using auditory and visual stimuli to influence the pattern of the brain's naturally occurring electro-impulses.

EEG: Electroencephalogram. A device that records the electrical impulses that carried and synchronised across the brain.

Isochronic: A type of aural BWE method that uses an auditory pulse as the training rhythm.

Monaural Beats: A type of auditory BWE delivery method. Use 2 sine waves.

NREM: Non-Rapid Eye Movement. Refers to the all non-REM sleep patterns from P1 to P4.

PMS: Premenstrual Stress. Abdominal pain experienced by some women during the menstruation cycle.

REM: Rapid Eye Movement. A stage of sleep that occurs at the end of the sleep phase, commonly associated with the time that dreams occur and named after the way that eyelids twitch during this state.

Somnipathy: A term used to define abnormal sleep.

Appendix

Appendix 1 – Proposed Schedule

<table>
<tr><th colspan="6">Proposed Schedule</th></tr>
<tr><td>November</td><td>December</td><td>January</td><td>February</td><td>March</td><td>April</td></tr>
<tr><td>Research: Sleep and Music</td><td>Research: New Technologies</td><td></td><td colspan="2">Sensory Environments Testing</td><td>Conclusions</td></tr>
<tr><td></td><td></td><td colspan="3">Sonic Design</td><td></td></tr>
<tr><td colspan="2">Product Market</td><td>Product Potential</td><td colspan="3">Product Design</td></tr>
</table>

Appendix 2 – Survey Questions

1. What is your age range?
2. What gender are you?
3. What is your employment sector/profession?
4. On average, many hours' sleep do you get a night?
5. Do you feel this is enough?
6. What time do you go to bed & awaken on a typical workday?
7. What time do you go to bed & awaken on a typical weekend/day off work?
8. Tell me a little about your sleeping habits (e.g. You like to sleep with the light on/off, you wake up frequently, any bedtime rituals etc.)
9. On the nights that you can't sleep, what do you attribute the problem to?
10. Do you 'accidentally' fall asleep when you are watching TV in the evening?
11. Do you use ever use music to help you get to sleep?
12. Would you purchase a product that would help aid sleep?

Appendix 3 – Survey Result Data Tables

1. What is your age range?

Answer Choices (If Applicable)	Responses	Percentage	Comments
14 - 25	6	30%	
26 - 37	7	35%	
38 - 49	2	10%	
50 - 65	3	15%	
66+	2	10%	
Total	20	100%	
Non-Responses	0	0%	
False Responses	0	0%	

2. What gender are you?

Male	9	45%	
Female	11	55%	
Total	20	100%	
Non-Responses	0	0%	
False Responses	0	0%	

3. What is your employment sector/profession?

Accountancy, Banking & Finance	3	15.79%	
Business, Consultancy & Management	0	0%	
Charity/Voluntary Work	0	0%	
Creative Arts/Design	1	5.26%	
Energy/Utilities	0	0%	
Engineering/Manufacture	1	5.26%	
Environment/Agriculture	0	0%	
Healthcare	2	10.53	
Hospitality	0	0%	
Information Technology (Computing)	1	5.26%	
Law	0	0%	
Law Enforcement/Security	0	0%	
Leisure, Sports & Tourism	0	0%	
Marketing, Advertising & PR	0	0%	
Media/Internet	1	5.26%	
Property Construction	0	0%	
Public Services/Administration	1	5.26%	
Recruitment/HR	0	0%	
Retail	1	5.26%	
Sales	0	0%	
Science/Pharmaceuticals	0	0%	
Student (Full-Time)	3	15.79	
Social Care	1	5.26%	
Teaching/Education	4	21.05	
Transport/Logistics	0	0%	
Other			
Total	19	95%	
Non-Reponses	1	5%	
False Responses	0	0%	

4. On average, many hours' sleep do you get a night?

Less than 4 hours	0	0%	
4-5 hours	1	5.26%	
5-6 hours	5	27.78%	
6-7 hours	4	22.22%	
7-8 hours	6	33.33%	
More than 8 hours	2	11.11%	
Total	18	90%	Could be more
Non-Responses	2	5%	Most of the time
False Responses	0	5%	Usually

5. Do you feel this is enough?

Yes	7	35%	
No	6	30%	
Total			
Non-Responses	6	30%	
False Responses	1	5%	

6. What time do you go to bed & awaken on a typical workday?

Responses	It's usually around midnight and then wake up at 7am		
	go to bed at ten and wake up hat half six		
	go to bed at 12(midnight) or 1-2am and wake up at 7:30am		
	12 : 00 or 12:00 wake up at 7 30		
	12:00 7:00		
	1-2am / 8am		
	1 am, 5:30 am		
	Bed 10, wake up 6		
	Go to bed 11.30 up at 5.30		
	Go to bed at 11, wake and 6.45am		
	10-11pm to 6.15am-7.15am		
	22:00 6:00		
	11pm 9am		
	10 wake at 6.15		
	10pm - 6am		
	11.00 pm 06.10 am		
	Midnight and 7am		
Total	18	90%	
Non-Responses	1	5%	
False Responses	1	5%	

7. What time do you go to bed & awaken on a typical weekend/day off work?

Responses	I can sleep from early hours in the morning to maybe 1 or 2pm		
	asleep 12 ten awake		
	go to bed at like 2-3am wake up at 10:30am		
	10 or 11 am		
	12:00 8:00		
	1-2 - 8am		
	2 am, 9:30 am		
	10-12 bed, wake up 6-8		
	go to bed 11.30 up at 5.30		
	Go to bed around midnight, wake up around 10am		
	Varies. 11pm-1am to 8am-10.30am		
	23:00 9:00		
	1am 10am		
	10 7		
	11pm - 8.30 am		
	11.00 pm 07.00 am		
	Midnight to 8:30am		
Total	18	90%	
Non-Responses	1	5%	
False Responses	1	5%	

8. Tell me a little about your sleeping habits (e.g. You like to sleep with the light on/off, you wake up frequently, any bedtime rituals etc.)

Responses	in the dark naked.		
	I'm kinda scared of the dark so we have our hallway light on until we're all going to bed but that's it		
	sleep with lights of and just fall asleep and dont wake up till alarm		
	tv on wake upn during the night sometimes		
	Light off, quite regularly wake up, prefer a cooler room so often have window open, no real rituals except I'll usually knock one out before bed for relaxation purposes.		
	Lights off, sleep strait through, no rituals or light on		
	mobile:playing, texting, reading news, TV, audio book, sleep timer is a must, lights off - use snooze alarm (like hell), feel exhausted		
	Light off, wake up occasionally, fall to sleep reading.		
	Need complete darkness and silence. Wake 2 - 3 times a night		
	Usually watch tv in bed before going to sleep		
	Light in hallway		
	Watch Tele in bed approx 1hour and then sleep. Wake up around 5 and then snooze		
	Window open or ajar, turn pillow over so it's cold light off		
	Sleep with lights off, frequently toss and turn and struggle to sleep through the night.		
	Lights off..no tv. Restless sleeper		
	I often find it hard to sleep when there is complete silence and darkness, as all I am left with is my own thoughts and anxieties.		
Total	17	85%	
Non-Responses	2	10%	
False Responses	1	5%	

9. On the nights that you can’t sleep, what do you attribute the problem to?

Responses	My brain doesn't shut off and i'm up thinking about things all night		
	if i drink pop too late at night or close to when i want to go to sleep.		
	stress with course work and work in general		
	i dont know to streesd or other		
	over excited brain can't switch off		
	Thoughts (!!!), media, headache, NO comfortable position		
	Stress and overthinking		
	brain wont switch off		
	Cant switch off, thinking about things too much		
	Work related stress and noisy environment (Cat)		
	When I'm thinking too much or have had a hard day at work		
	My eye lids won't shut		
	Random trivial thoughts pop into my mind and I struggle to switch off thinking about them.		
	Never have nights that I can't sleep		
	Thoughts running through my head is the main reason		
	My brain doesn't shut off and up thinking about things all night		
	if i drink pop too late at night or close to when i want to sleep.		
Total	16	80%	
Non-Responses	3	10%	
False Responses	1	5%	

10. Do you ‘accidentally’ fall asleep when you are watching TV in the evening?

Yes	8	47.06%	
No	8	47.06%	
Not Sure	1	5.88%	
Total	17	85%	
Non-Responses	3	15%	
False Responses	0		

11. Do you use ever use music to help you get to sleep?

Yes	6	37.50%	
No	10	62.50%	
Total	16		
Non-Responses	4		
False Responses	0		

12. Would you purchase a product that would help aid sleep?

Yes	6	66.66%	
No	3	33.33%	
Total	10	50%	
Non-Responses	9	45%	
False Responses	1	5%	