The effects of music and alpha-theta-wave frequencies on meditation

An explorative study

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Abstract

Meditation and music are usually performed together. In many cases music is the background of meditation. Thus, the question arises whether music has a positive effect on meditation. This master thesis deals with the assumptions that 1) *music* and 2) *alpha-theta wave frequencies* have an effect on meditation.

It is hypothesized that 1) relaxing music has a positive effect on meditation compared to arousing music or no music, 2) arousing music has a negative effect on meditation compared to relaxing music or no music, and 3) alpha-theta wave frequencies have a positive effect on meditation/ relaxation compared to no music. Fast theta- and slow alpha- waves (6-10Hz) are representative for a meditative and relaxed state. As a consequence, it was tested whether these frequencies played via headphones are triggering a meditative or relaxed state. The assumption is that frequencies in the range of alpha and theta waves are able to provoke or intensify the production of these brain waves via superposition of waves or resonance phenomena and therefore a meditative and relaxed state can be achieved.

A pretest evaluated the best music pieces for the conditions "relaxing music" and "arousing music" and tested the ability of the headphones to produce infrasounds at a certain sound pressure level without any audible by-products.

In the main study GSR-measurements, standardized questionnaires (STAI-X, STOMP-R, and d2-R) and rating scales have been used to obtain valid data.

The major findings are: arousing music has a significant negative effect on meditation. Relaxing music showed no significant differences with the lack of music, which might be due to background-noise on the audio-files. Alpha-theta-wave frequencies led to conflicting results. It is possible that these conflicts are due to two different states of relaxation, not separated in this study. Based on the results it is assumed that alpha- theta wave frequencies have a positive effect on a tired relaxed state and can trigger tiredness, whereas at the same time they have a negative effect on a meditatively relaxed state. Several explanations for this observation are discussed.

Therefore, it it reasonable to argue that alpha- theta wave frequencies could be used against sleeping disorders as they appear to increase tiredness. However, further studies are needed, evaluating the proper effects of these frequencies on humans and testing the effects of relaxing music without background noises.

Keywords: meditation, music, alpha- theta waves, GSR, CDA.SCR

Kurzzusammenfassung

Meditation und Musik werden oft zusammen ausgeübt. In vielen Fällen fungiert Musik dabei als Hintergrund. Daher stellt sich die Frage, ob Musik einen positiven Effekt auf Meditation hat. Die zugrundeliegende Masterarbeit beschäftigt sich mit den Annahmen, dass 1) *Musik* und 2) *Alpha- Thetawellen Frequenzen* einen Einfluss auf Musik haben. Die folgenden Thesen wurden daher formuliert: 1) Entspannende Musik hat einen positiven Effekt auf Meditation im Vergleich zu aufreibender Musik oder keiner Musik, 2) Aufreibende Musik hat einen negativen Effekt auf Meditation im Vergleich zu entspannender Musik oder keiner Musik, und 3) Alpha- Theta Wellen Frequenzen haben einen positiven Effekt auf Meditation oder Entspannung im Vergleich zu keiner Musik. Schnelle Theta- und langsame Alphawellen (6-10Hz) sind repräsentativ für einen meditativen und entspannten Zustand. Daher wurde getestet, ob derartige Frequenzen, wenn diese über Kopfhörer abgespielt werden, einen meditativen oder entspannten Zustand hervorrufen können. Die Annahme ist dabei, dass Frequenzen im Bereich von Alpha- und Thetawellen die Produktion gleichlautender Gehirnwellen anregen oder verstärken können und so ein meditativer oder entspannter Zustand erreicht werden kann. Dies geschieht dabei entweder durch Überlagerung von Wellen oder durch Resonanzphänomene.

Ein Pretest diente zur Evaluation der besten Musikstücke für die Konditionen "entspannende Musik" und "aufreibende Musik" und testete darüber hinaus die Fähigkeit der verwendeten Kopfhörer, Infrasounds bei einem bestimmten Schalldruckpegel wiederzugeben, ohne dabei hörbare Artefakte/ Nebenprodukte zu produzieren.

Um valide Daten zu erfassen wurden in der Hauptstudie Hautleitwertmessungen, standardisierte Fragebögen (STAI-X, STOMP-R und d2-R) sowie Ratingskalen herangezogen. Es zeigte sich, dass aufreibende Musik einen signifikant negativen Effekt auf Meditation hat. Entspannende Musik hingegen zeigte keine signifikanten Differenzen zu keiner Musik, was möglicherweise auf Hintergrundgeräusche der Audiodatei zurückzuführen ist. Alpha- Thetawellen zeigten indes widersprüchliche Ergebnisse. Es wird angenommen, dass diese Ergebnisse auf zwei verschiedene Zustände von Entspannung zurückzuführen sind, die in dieser Studie nicht getrennt erhoben wurden. Weiters ist davon auszugehen, dass Alpha-Thetawellen Frequenzen einen positiven Effekt auf einen müde-entspannten Zustand haben und Müdigkeit anregen können, während diese gleichzeitig einen negativen Effekt auf einen meditativ-entspannten Zustand haben.

Es erscheint möglich, dass Alpha- Thetawellen gegen Schlafprobleme eingesetzt werden könnten. Um den Effekt dieser Frequenzen auf Menschen genauer zu untersuchen und um die Effekte entspannender Musik ohne Hintergrundgeräusche zu studieren, werden weiterführende Studien benötigt.

Keywords: Meditation, Musik, Alpha- Thetawellen, Hautleitwert, CDA.SCR

List of abbreviations

Abbreviation	Meaning
GSR	Galvanic Skin Response
STAI-X	State Trait Anxiety Inventory -original form X
STOMP-R	Short Test Of Music Preferences - Revision
d2-R	Concentration ability test
CDA.SCR	Average phasic driver within a given response window - concerning GSR
IHC	Inner Hair Cells
OHC	Outer Hair Cells
HRV	Heart Rate Variability
nuLF	normalized units of Low Frequency
nuHF	normalized units of High Frequency
LF/HF	Estimate of the LF/HF ratio
EEG	Electroencephalogram
ANOVA	Analysis of Variance

1. Introduction

Meditation and music are usually performed together. In many cases music is the background of meditation. Both, meditation and music can lead to an altered state of consciousness, which is said to be healing and relaxing. In combination, they should lead to an easier access and a more intense altered state of consciousness. Proofing this assumption is one part of this thesis.

Sometimes when we are longer engaged in different activities we reach and of course experience an altered state of consciousness. This feeling is very common for activities such as meditation or constantly repeated music. Most of the time it is very difficult to explain or express such an experience. The following citation of Kjaer and his co-authors (2002) explains the feeling of an altered state of consciousness in relation to meditation in a good way:

> *There are two main, complementary aspects of consciousness: consciousness of our sensory world and the equally important consciousness of action. Yoga Nidra is a relaxed meditative state in the meditation tradition where these aspects are subjectively dissociated: the mind withdraws from wishing to act. This state is not associated with a change in emotional state of willpower. The mediator becomes a neutral observer. He experiences loss of conscious control of his actions and experiences an enhancement of sensory stimulations or imagination.*
>
> *(Kjaer et al., 2002, p. 255)*

There is a long tradition of using music and meditation together. When we look back in history, we realize that for example around 850 years ago our ancestors already used music to reach altered states of consciousness. In the Notre-Dame-age for example modalrhythmics were used to reach states of trance (Mittwede, 2002). When we further look at different cultures and religions, it becomes also evident that one goal of reaching such an altered state of consciousness is to get closer to god or devine entities. One very interesting example is *John of God,* who practices spiritual healing ceremonies in Brasilia. People who go there in order to be healed have to meditate, because meditation helps them to reach a higher level of being, which in turn gives entities the possibility to heal them (RavenWing, 2002). It is interesting that also in this case music is used as background.

As we can see, experiencing an altered state of consciousness has a very long-lasting important meaning for mankind. But why is music and meditation such a preferred tool to reach such a state? Often music acts as background for meditation. Does this have a deeper sense? Have music and meditation something in common, what we never thought of before? Possible answers to these questions will be discussed in this thesis on *the effects* of *music and alpha-theta-wave frequencies on meditation*.

Different disciplines like ethnology, psychology, neuropsychology, ethnomusicology and systematic musicology deal with parts of this topic. While psychology and neuropsychology try to find ways to describe altered states of consciousness in the brain, ethnology, systematic musicology or ethnomusicology try to find explanations why reaching such a state is of benefit.

Before going into detail and starting to argue, it is important to explain the most important terms of this masters thesis.

Meditation means the act of going deeply into ones inner self, and which should lead to an altered state of consciousness. According to Lazar and his coworkers (2000) meditation is a form of mental exercise which leads to relaxation. In the following also the term meditative state will be used. This is just another word for an altered state of consciousness reached through meditation.

Another term to be defined is *consciousness*. Consciousness is a complex system which changes itself frequently. In general it is differentiated into awake state and sleeping state. According to Ludwig (1966) the characteristics of an altered state of consciousness is the change/alteration of thinking, of the sense of time, of control, of emotionality, of the body image and of the perception of meaning and importance. As mentioned in the previous citation it refers further to the loss of conscious control of action and an enhancement of sensory stimulation and imagination (Kjaer et al., 2002, p. 255). The most common deviations from a normal conscious state in relation to music are trance and ecsctasy (Fachner, 2009). Rouget (1985) divides trance into three different forms, which are the emotional, collective and shamanic forms of trance. According to Rouget (1985) trance is associated with a bigger or smaller amount of sensory over-stimulation in relation to noises, music, smells or arousal. Furthermore Fachner (2006) points out that there is a lot of different definitions of trance which are in some cases even contradictory.

The next frequently occurring term is *music*. Music here is meant both in the active and the passive sense. Active music means that someone plays a piece of music with his or her instrument or sings. In contrast, passive music means listening to music. Therefore, when the term music is not further differentiated into active or passive it means both

Since the topic of meditation is difficult to deal with, because of it's "esoterique" nature, it is important to look at it from different positions. Thus this thesis tries to find answers from current research in enthnomusicological, anthropological, musicpsychological and biological perspectives. Furthermore, the empirical study designed for this thesis should strengthen the different hypotheses.

2. Current state of Research

2.1 Music and altered states of consciousness

As written above meditation leads to an altered state of consciousness. If music is able to facilitate meditation and reaching a meditative state, music should be also related to changed states of consciousness. A lot of literature can be found concerning the relation of music and altered states of consciousness. They reach from ethnological to neurological perspectives and differ a lot in their points of view. Thus it is important to summarize the most important findings in this chapter and to see whether music can lead to changed states of consciousness and if yes, what the reasons could be.

2.1.1 Musicethnological point of view

Sundar (2007) reports about Indian traditional systems of health and healing. She (Sundar, 2007) explains the important role of music in different treatments. For the Fire-Walk, which has a long-lasting tradition, music and sounds are used to reach an altered state of consciousness, which in turn reduces the perception of pain. Such a state of consciousness is reached through loud beats of drums and loud religious shouts and religious songs. (Sundar, 2007)

Furthermore the Vedic tradition, which reaches back around 5000 years, used music to heal and for up-liftment. The music is characterized by a lot of sounds and rhythmns, and the present Indian music therapy uses some of the Vedic verses (with single, two and three notes) „to enhance focused attention [...], to improve concentration and to help get into meditative and relaxed states. (Sundar, 2007, p. 399) As demonstrated by these two examples the use of music to enter an altered state of consiousness has a long tradition. Thus it seems to be likely that music is able to induce altered states of consciousnes. Also eyecatching is the fact that in the Fire-Walk and the Vedic tradition the music to enter a changed state of consciuosness is characterized by a repetitive rhythmn and a high loudness.

According to Rouget (1985) there is no universal property of music in inducing trance, because every trance music varies from culture to culture. This counts for the melody, for the chants for different ghosts or spirits and for the rhythmn.

Rouget (1985) further argues that music has no direct effect on trance and that music is just one of many components necessary to produce a state of trance. As an example he mentions that in one society soft music can favor trance, whereas in another society loud sounds lead to this altered state of consciousness. This is also the same with fast versus slow rhythmns (Pilch, 2006). These arguments are contradictory to the before mentioned, because here it seems that the loudness of music must not be high to induce trance. But they do not negotiate repetitive rhythmns in inducing trance. Therefore the possible trance inducing effect of music could be due to a repetitive rhythmn, equally if fast or slow and loud or calm.
According to Kartomi (1973) music must have a mesmeric effect to induce trance. Music is best to provoke trance, if it is made of regular pulsation and repetitive tonal patterns based on a restricted number of pitch levels (Kartomi 1973). At the same time music should not be boring. This finding also supports the assumption that repetitive rhythmns are important for music to induce changed states of consciousness. But Pilch (2006) believes that every kind of music can have a trance-inducing effect. According to him (Pilch, 2006) it just depends on the subjective interpretation of music. In relation to this opinion Meyer (1967, p. 126) writes, "What we know and believe has a profound effect upon what we perceive and how we respond." This point of view strongly relates to constructivism. It is possible that constructivist theories are best in explaining the effect of music in inducing altered states of consciousness. But if we really believed in constructivism, we would not have to explain anything anymore. Thus constructivism will not be taken into account in this thesis.
Rouget (1985) discusses the possibility that music has a universal characteristic in inducing trance. But his arguments are sometimes misleading. He states for example that music cannot be universal in inducing a state of trance, because in Ghana people were found who just fall into trance without music. Clearly no one ever thougt that music is universal in inducing altered states of consciousness. Of course there are a lot of other things which can lead to a changed state of consciousness (e.g. drugs, sports, being tired). This argument does not counterargue the possibility that music can induce an altered state of

consciousness or has at least one characteristic in it, which is universal in its trance-inducing effect. Therefore, Rougets (1985) argumentation cannot be considered to precisely enough address the issue.

According to the discussed literature the following important characteristics of music in inducing an altered state of consciousness can be summarized (see *table 1*).

Table 1: Important characteristics of music in inducing altered states of consciousness

Characteristic of music	References
High loudness	(Sundar, 2007)
Repetitive rhythmn	(Sundar, 2007),(Kartomi, 1973)

2.1.2 Neurological point of view

Neher (1962) tries to find a neurological explanation for the trance-inducing effect of music. He thinks that rhythmn is the most important element for such an induction. Equal to photo-driving, a mechanism where rhythmical flashing light stimulates the brain, Neher (1962) believes that there also exists an auditory-driving effect. Rhythmical stimulation via photo-driving in laboratory situations is further able to provoke an altered state of consciousness. For the reason that rhythmical sounds, according to Neher (1962) are most important in ceremonies to induce trance, he draws a parallel between the well known and empirically reviewed photo-driving and the suggested auditory-driving. Through the rhythmical stimulation of the brain with light (photo-driving), the brain oscillations move to the new frequency of the light. In comparing different ethnological studies Neher (1962) further found out that trance-inducing music often uses rhythmns which are similar to the frequencies of alpha waves in the brain. Such rhythmns are found to be used in the music from Haiti and in different parts of Africa (Neher, 1962). Since not every culture uses these rhythmns to induce trance with music, it is not clear whether this argumentation is acceptable. Moreover many scientists (i.e. Rouget) critisize Nehers studies, especially because his already cited study does not show his methods nor the exact results for the so-called auditory-driving. Fachner (2006) further argues that the possible frequencies of the drums played are rather located in the frequency range of theta-waves than of alpha-waves. This is because such fast rhythmns in the range of 8Hz to 12Hz cannot be realized with drums.

In relation to Nehers study another study of Hutson (2000) concerning raves has to be mentioned.

According to Hutson (2000) changed states of consciousness while being on a rave-party are due to an interaction of light, music and dance. The dynamic light-effects, especially the flashlight can lead to photo-driving, whereas the fast bass rhythmns can lead to an auditory-driving, thus evoking a trance-state. Moreover long rhythmic dancing leads to exhaustion which can end up in trance.

2.1.3 Musictherapeutical point of view

Hutson (2000) was able to show that the altered states of consciousness induced through rave have therapeuthical effects. According to Hutson (2000) these effects are a raise of self-esteem, the healing of fears and anxiety disorders, the feeling of inner peace and an improved consciousness for other things. All these effects can also be found with meditation. Thus this is another argument for music in inducing a meditative state, and also that frequencies are important for such an induction, as it is the case at rave-parties.

Music is most often used in music therapy to induce changed states of consciousness to gain positive effects with the clients. Referring to Haerlin (1998) sound- and pulsation-instruments, especially for rattles, are one of the oldest tools to enter a healing changed state of consciousness.

The pulsations of the drums affect electrical activities of the brain which are usually not affected (Haerlin, 1998). Hereby Haerlin (1998) refers amongst others to Arrien (1996) who mentions:

> *direkte Beziehung zwischen dem Trommelrhythmus ausgedrückt in Schlägen pro Sekunde und den daraus resultierenden, vorübergehenden Veränderungen der Gehirnwellenfrequenz (Zyklen pro Sekunde) und/oder subjektiven Erfahrungen [...] vorausgesetzt, derselbe Trommelrhythmus wurde mindestens 13-15 Minuten lang beibehalten (Arrien, 1996 S.233f).*

Moreovere according to Haerlin (1998), 45 minutes of being in trance can give clients the feeling of eight hours of restorative sleep.

As discussed, there are frequencies which can have an effect on the activity of the brain. Furthermore it was found that these frequencies (especially rhythmic flashing light) are able to affect the frequenices (brain waves) of the brain.
For the main topic of music and its effects on meditation it is important to clarify whether these two actions have something in common. It is clear that one of their common factors is relaxation. It is also well known, that both, music and meditation lead to relaxation. Relaxation is thus also one important factor for the possible effect of music on meditation, as it helps to relaxe. Furthermore, as previously discussed, music is connected to altered states of consciousness. Thus music may facilitate getting into a changed state of consciousness with meditation, as both, music and mediation, are used to enter such a mental state. To argue for a profound connection of music and meditation it is necessary to see whether they also activate the brain in a similar way or whether they activate similar brain areas. The following chapter will focus on this point.

2.2 Activation of brain areas through music and mediation

To make this chapter clear for everyone it is important to explain some terms, which will occur in the following pages. *Imagination* is one aspect of a changed state of consciousness. Here imagination is differentiated into uncontrolled or controlled imagination. *Uncontrolled imagination* would be watching yourself from above or seeing things which come spontaneousely into your mind. *Controlled imagination* is consciously i.e. visualizing love in form of a light or something similiar to it.

The main question of this chapter is: Do music and meditation activate similiar brain areas? If yes, it can be further argued that the altered states of consciousness produced by music or meditation are similar, and thus music may help to meditate because it helps activating important brain areas for meditation. To answer the previously stated question this chapter is divided into two subtopics, which are music, meditation and active brain areas, and music, meditation and longterm-effects on particular brain areas. Provided that both topics lead to similiar results for music and meditation, it is pretty possible that altered states of consciousness, which are produced by music or meditation, are similar. This could shed first light to the question, whether music could have an effect on meditation.

What else could be relavant concerning this topic? In case the same brain areas are active while practicing music and while meditating, it would not only provide evidence that music and meditation could induce the same altered states of consciousness. Moreover it would indicate which brain areas are generally the key to an altered state of consciousness. If same brain areas are active while being in an altered state of consciousness reached by different ways (music and meditation), there must be important and relevant brain areas for reaching such a state. Once we identify them, we can also identify ways to enable an easier access to such a state. Changed states of consciousness are often related to healing, enhancing power or relaxing (Lazar et al., 2000). Thus such a finding could be used to help people in many ways.

The first part of the main section tries to argue that music and meditation activate the same brain areas.

2.2.1 Music, meditation and active brain areas

First some terms have to be defined. The first important term occurring in this chapter is the midbrain.

The *midbrain* is shown in *Fig. 1* with the red arrow and the green circle around it. It is a part of the central nervous system.

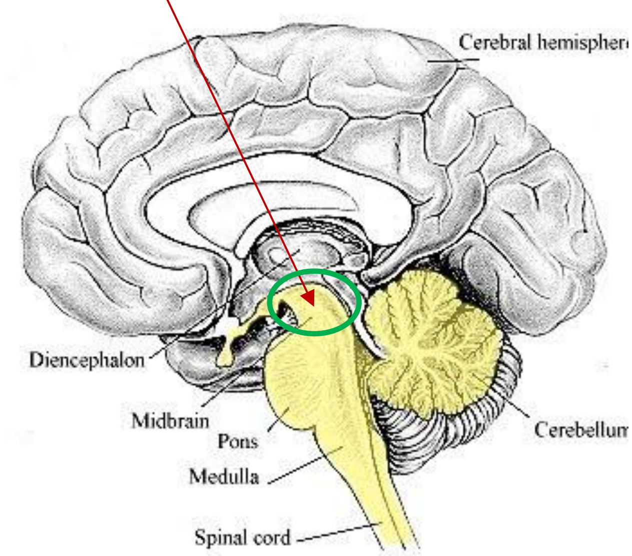

Fig. 1: Sagittal section of the human brain (URL: http://streetanatomy.com/2009/01/30/anatomic-fashion-friday-bird-brain/) abgerufen am 28.3.2012

Another term is the *anterior cingulate cortex*. *Anterior* explains the position in the cingulate cortex. Its location is shown in Fig. 2 in the yellow area.

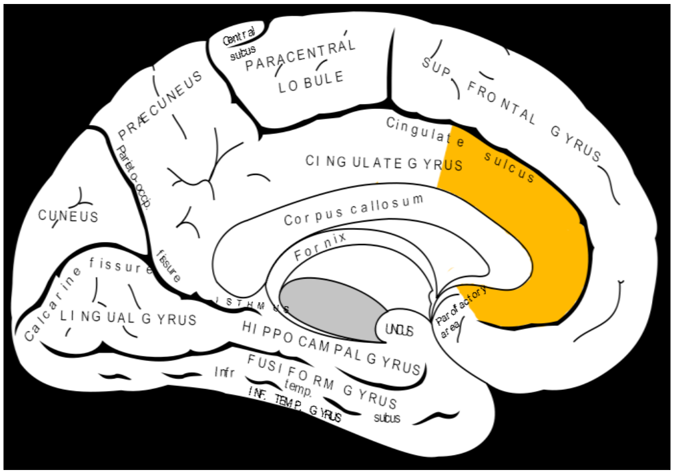

Fig. 2: Sagittal section of the human brain with the different gyri (URL: http://en.wikipedia.org/wiki/File:Gray727_anterior_cingulate_cortex.png) abgerufen am 9.3.2012

Moreover the *hippocampus* is another important brain area mentioned in this chapter. The location of the hippocampus in the human brain is shown in *Fig. 3* with the red arrow.

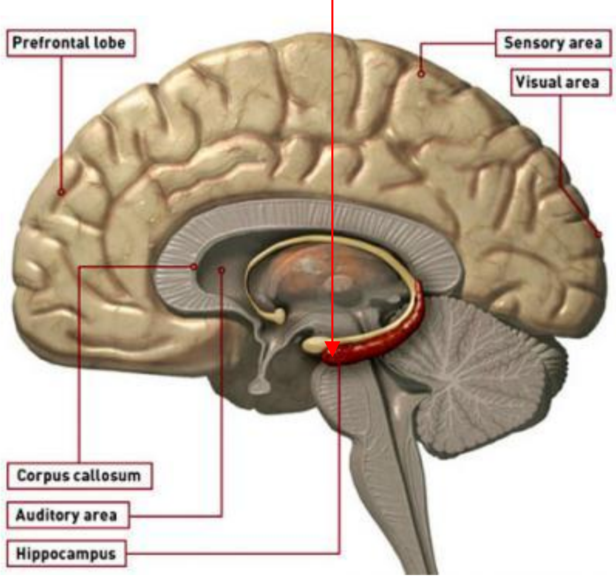

Fig. 3: Sagittal section of the human brain (URL: http://www.shockmd.com/wp-content/berger_embed_brain.jpg) abgerufen am 25.3.2012

The last term to be explained is the *precentral gyrus*. Gyrus is the name for a winding in the brain. The location of the precentral gyrus in the brain is shown in *Fig. 4* with the red arrow and the red area.

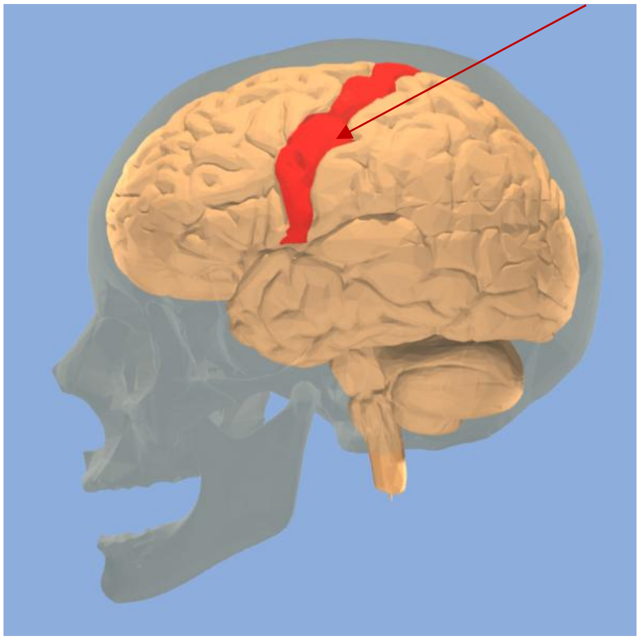

Fig. 4: Outside view of the human brain (URL: http://upload.wikimedia.org/wikipedia/commons/9/96/Precentral_gyrus_3d.png) abgerufen am 25.3.2012

The question to this topic is: Are the same brain areas active while listening to music and while meditating, and are they related to a changed state of consciousness?

The possible answers are:

Listening to music and meditation does not activate the same brain areas.

Listening to music and meditation does not activate the same brain areas and is not related to an altered state of consciousness.

Listening to music and meditation activates the same brain areas, but is not related to a similarly altered state of consciousness.

Listening to music and meditation activates the same brain areas and is related to a similarly altered state of consciousness.

To come to a conclusion on the most likely answer the relevant literature is discussed. In this chapter the results concerning brain areas activated during listening to music and while meditating were compared to see whether there are similarities in brain activation.

The following table presents the findings of this exploration.

Table 2: Active brain areas while listening to music compared with active brain areas while meditating

Active brain areas	
listening to music	**meditation**
Left inferior frontal gyrus (Platel et al., 1997)	
Left superior temporal gyrus (Platel et al., 1997)	
Right superior temporal gyrus (Platel et al., 1997)	
Left middle occipital gyrus (Platel et al., 1997)	
Left anterior cingulate gyrus (Platel et al., 1997)	
Right internal pallidum (Platel et al., 1997)	
Right superior frontal gyrus (Platel et al., 1997)	
Left superior frontal gyrus (Platel et al., 1997)	
Right middle frontal gyrus (Platel et al., 1997)	
Precentral gyrus (Platel et al., 1997)	Precentral gyrus (Lazar et al., 2000)
Left precuneus (Platel et al., 1997)	
Left middle occipital gyrus (Platel et al., 1997)	
Left insula (Platel et al., 1997)	
Left inferior Broca's area (Platel et al., 1997)	
Primary auditory cortex (Brown et al., 2004)	
Auditory association cortex (Brown et al. , 2004)	

Superior temporal sulcus (Brown et al. , 2004)	
Middle temporal gyrus (Brown et al. , 2004)	
Right superior temporal pole (Brown et al. , 2004)	
Insula (Brown et al. , 2004)	
Left subcallosal cingulate cortex (Brown et al. , 2004)	
Left anterior cingulate cortex (Brown et al. , 2004)	Pregenual anterior cingulate cortex (Lazar et al., 2000)
Left retrospenial cortex (Brown et al. , 2004)	
Right hippocampus (Brown et al. , 2004)	Hippocampal formation (Lazar et al., 2000)
Left ventral striatum (Blood & Zatorre, 2001)	
Dorsomedial midbrain (Blood & Zatorre, 2001)	Midbrain (Lazar et al., 2000)
Bilateral insula (Blood & Zatorre, 2001)	
Thalamus (Blood & Zatorre, 2001)	
Anterior cingulate cortex (Blood & Zatorre, 2001)	Pregenual anterior cingulate cortex (Lazar et al., 2000)
Supplementary motor areas (Blood & Zatorre, 2001)	
Bilateral cerebellum (Blood & Zatorre, 2001)	
	Putamen (Lazar et al., 2000)
	Parahippocampal formation (Lazar et al., 2000)
	Septum (Lazar et al., 2000)
	Caudate (Lazar et al., 2000)
	Amygdale (Lazar et al., 2000)
	Prefrontal cortex (Lazar et al., 2000)
	Parietal cortex (Lazar et al., 2000)
	Temporal cortex (Lazar et al., 2000)
	postcentral gyrus (Lazar et al., 2000)

As can be derived from *Table 1*, there are lots of different brain areas active while listening to music and also while meditating. *Table 1* also presents those brain areas which are active in both cases. These are the *precentral gyrus*, parts of the *anterior cingulate cortex, hippocampal formations* (or *hippocampus*) and the *midbrain*. This is an important initial point to argue, because without similar brain areas activated while listening to music and while meditating, it would be impossible to further argue that these brain areas are important for the induction of an altered state of consciousness. But is it possible to argue that these active brain areas are indeed related to a changed state of consciousness? As you can see from *Table 1*, there are a lot of other brain areas which are not active in both cases. Furthermore listening to music and meditation are not identical actions, moreover they are pretty different. These facts lead to the assumption that the similarities of both activities in the four mentioned brain areas must eventually relate to similar functions in inducing a changed state of consciousness. The question arising now is, whether these areas identified are really related to a changed state of consciousness. Again previous research results will help to identify the functions of the brain areas found to be active under both situations.

The first area of interest is the precentral gyrus. According to Cooke and Graziano (2003, p. 4) the precentral gyrus might contribute to the sensory guidance of movement. This function not really seems to contribute to an altered state of consciousness. But maybe there is a relation to one important aspect of a changed state of consciousness, namely the enhancement of sensory stimulation. Thus this area is eventually activated because of an induced altered state of consciousness, which enhances the sensory guidance of movements such as heartbeat or the movement of the lung. This is maybe the case when someone starts to intensely feel and concentrate on his/her heartbeat or breathing, while experiencing a changed state of consciousness.

Moreover they identified the precentral gyrus as a key for unconscious defensive movements. They obtained this result in a study with monkeys, when they electrically stimulated their precentral gyri. The stimulation of this area lead to defensive movements. A very interesting finding was that even anesthetized monkeys showed defensive movements such as “shifting the head away from the sensory receptive fields, shrugging the shoulder and rapidly lifting the hand into the space near the side of the head as if to block an impending impact.” (Cooke & Graziano, 2003, p. 4). This brought Cooke and Graziano (2003) to the conclusion that these defensive movements must be from unconscious nature. But is this function important for an altered state of consciousness induced by music or meditation?

This function does not explain the feeling, that someone experiences while being in an altered state of consciousness, but it must be an important background-function, essential for survival. An altered state of consciousness or trance state is somehow comparable to anesthesia. While staying in such a state it is of enormous importance for persons that they have efficient defense systems, such as the one implemented by the precentral gyrus. An activation of this brain area while listening to music or meditating could thus be due to being dependent on unconscious defensive actions while staying in an altered state of consciousness.

The second brain area which was active in both cases was the anterior cingulate cortex. The anterior cingulate cortex is related to different functions, which are now discussed. First, according to Critchley and his co-workers (2003, p. 2140), the anterior cingulate cortex is related to cognitive processes involving attentional demand and executive control. In the context of an altered state of consciousness, these findings are very interesting, because a changed state of consciousness is related to loss of conscious control of action and thus the executive control in such a state is not anymore important. But the function of the anterior cingulate cortex in attentional demand has more in common with a changed state of consciousness. This is because one’s attention while listening to music or while meditating is very high. You focuse yourself extremely on one thing, for example on a frequently occurring rhythmical pattern in music or on your imagination while meditating, which in turn should help to experience a changed state of consciousness.

Second, the anterior cingulate cortex is related to response inhibition and attentional selection (Critchley et al. 2003, p. 2140). Attentional selection goes hand in hand with the further discussed attentional demand. It means that someone selects one thing on which he/she focuses his/her attention as previously discussed to be important for music and meditation. The function of response inhibition in the context of an altered state of consciousness is pretty relevant here. This is due to the fact that a changed state of consciousness is related to loss of conscious control of actions and thus in such a state one`s response mechanisms are inhibited. This clearly shows that listening to music and of course meditating can lead to an altered state of consciousness.

The last function found to be related to the anterior cingulate cortex and important for this topic are bioregulatory processes, including amongst others respiration, blood pressure and heart-rate (Critchley et al., 2003, p. 2140). This leads to the explanation that while meditating or listening to music one’s respiration, blood pressure and heart-rate decreases, because of relaxation and thus reaching an altered state of consciousness is facilitated.

Referring to *Table 1* also the hippocampus was active in both cases - listening to music and meditation. According to Gerrig and Zimbardo (2008, p. 92), the hippocampus plays an important role in the acquirement of explicit memory. This function seems not to be important for the explanation of an altered state of consciousness via music or meditation. But a very interesting finding in relation to the hippocampus is that the majority of the cannabinoide receptors carrying cells are in the hippocampus (Gerrig & Zimbardo, 2008, p. 185). When smoking marihuana, cannabinoids, which are psychoactive substances binding to the receptors and leading to an altered state of consciousness, enter the human brain (Gerrig & Zimbardo, 2008, p. 185). The hippocampus is thus essential to experience an altered state of consciousness when smoking marihuana. Maybe the activity in this brain area has thus an important function for the possibility to experience an altered state of consciousness via listening to music or meditation.

The last brain area found to be activated by both music and meditation is the midbrain. According to Sahraie and his co-authors (1997, p. 9408) the midbrain is amongst others related to unconscious processing of visual stimuli. This means that people can process things which they do not consciously observe. With respect to an altered state of consciousness this could be related to uncontrolled imagination which eventually indicates that something that spontaneously comes to your mind, like different pictures or a landscape, is due to an activation of this brain area while listening to music or meditation, which in turn processes an unconscious visual stimulus. This could further explain the phenomenon of seeing oneself from above while experiencing a changed state of consciousness. This uncontrolled imagination is an important aspect of such a changed state of consciousness and thus provides evidence for similarly activated brain areas.

In summary, it has been shown that there are four different brain areas active in both cases, namely listening to music and meditating. These areas are the *precentral gyrus*, parts of the *anterior cingulate cortex, hippocampal formations* (or *hippocampus*) and the *midbrain*.

The precentral gyrus is connected to different actions such as sensory guidance of movement and unconscious defensive movements. Unconscious defensive movements are of interest here, because they are important for survival while experiencing an altered state of consciousness. Furthermore the function of sensory guidance of movement can be related to enhancement of sensory stimulation, which is an important aspect of an altered state of consciousness.

The anterior cingulate cortex is also related to different functions such as cognitive processes involving attentional demand and executive control, response inhibition and attentional selection. Attentional demand and attentional selection are related to an altered state of consciousness, because while experiencing such a state one’s attention is very high and often focused on one thing, which in turn raises the possibility to reach an altered state of consciousness. The second function strongly related to an altered state of consciousness is response inhibition. This is due to the fact that such a state is related to loss of conscious control of actions and thus ones response mechanisms are inhibited.

The third brain area is the hippocampus. The hippocampus is most probably very important for experiencing an altered state of consciousness because of its importance for the induction of such a state under the influence of marihuana. This importance is due to the fact that the hippocampus is the area in the brain with the majority of cannabinoide receptor cells, to which the psychoactive substances of marihuana – cannabinoids – bind.

The last brain area, active in both cases, is the midbrain. The midbrain can be related to a changed state of consciousness because of its function in unconscious processing of visual stimuli, and thus could explain the phenomenon of uncontrolled imagination.

With respect to the sub-question it has been shown that there are similar brain areas active while listening to music and while meditating. According to the functions of these brain areas, music listening and meditating should really produce similar changed states of consciousness. Moreover it seems that all the discussed brain areas have an important meaning and contribution to an altered state of consciousness and of course, without activating these areas via passive music or meditation, it would not be possible to experience such a changed state of consciousness. All the discussed findings lead to the hypothesis that *there are similar brain areas activated via passive music or meditation, which are important to experience a changed state of consciousness.*

2.2.2 Music, meditation and longterm-effects on brain areas

Again, some important terms for this chapter have to be defined. The first relevant not previously explained term in this chapter is the *inferior temporal gyrus*. Its location in the brain is shown in *Fig. 5* with the violet circle around it.

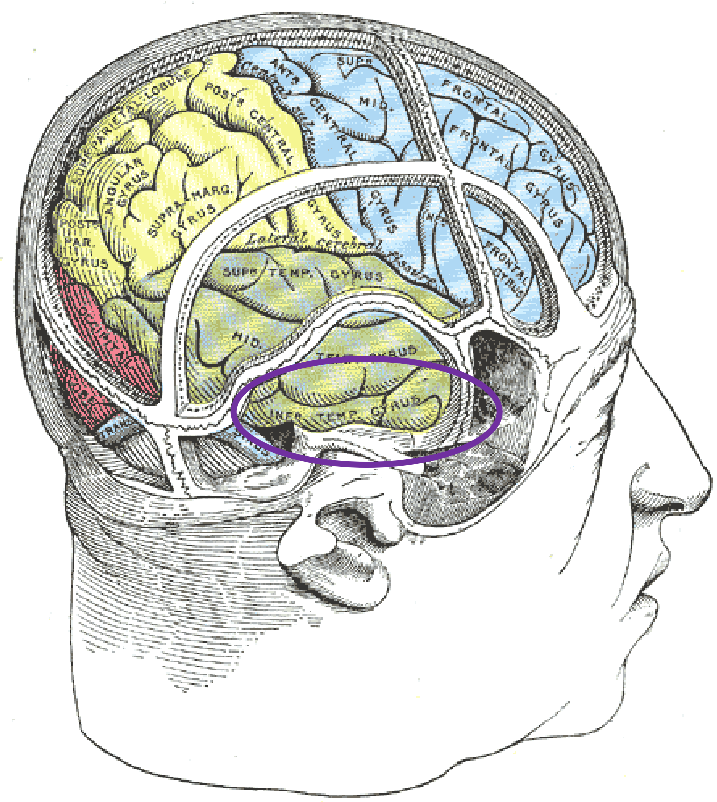

Fig. 5: Human brain with its different gyri (URL: http://en.wikipedia.org/wiki/File:Gray1197.png) abgerufen am 25.3.2012

Next is the term *grey matter*. Grey matter is a major component of the central nervous system, which consists of cell bodies, dendrites and arteries. The word grey is due to the fact that these areas look grey in a formalin fixed preparation.

The question to this topic is: Does long-term practice of active music and meditation have the same effects on the brain because of their function in inducing an altered state of consciousness?

Possible answers are:

Long-term practice of active music and meditation does not have the same effects on the brain.

Long-term practice of active music and meditation have similar but slightly different effects on the brain

Long-term practice of active music and meditation have the same effects on the brain by inducing an altered state of consciousness.

The following pages try to elaborate whether long-term practice of active music and meditation have the same effects on the brain. In this chapter, previous research results concerning the effects of long-term practice of both actions on different brain areas were compared to find out whether there are similar changes in the brain structure. In the following, changes in the brain structure are understood as changes in grey matter volume in certain brain areas. Table 2 represents the findings of this exploration.

Table 3: Comparison of the effects of active music and meditation on changes in grey matter volume in different brain areas

Changes in grey matter volume	
Active music	**meditation**
Primary motor area (Gaser and Schlaug, 2003, p. 9242)	
Somatosensory area (Gaser and Schlaug, 2003, p. 9242)	
Premotor area (Gaser and Schlaug, 2003, p. 9242)	
Anterior, superior, parietal areas (Gaser and Schlaug, 2003, p. 9242)	
Inferior temporal gyrus bilaterally (Gaser and Schlaug, 2003, p. 9242)	Left inferior temporal gyrus (Luders et al., 2009, p. 674-675)
Left cerebellum (Gaser and Schlaug, 2003, p. 9242)	
Left Heschl’s gyrus (Gaser and Schlaug, 2003, p. 9242)	

Left inferior frontal gyrus (Gaser and Schlaug, 2003, p. 9242)	
	Right thalamus (Luders et al., 2009, p. 674-675)
	R. orbito-frontal cortex (Luders et al., 2009, p. 675)

As shown in *Table 3* there is only one brain area which profits from both music making and meditation with a change in its grey matter volume. This brain area is the inferior temporal gyrus. According to Gaser and Schlaug (2003) and Luders and his co-workers (2009), in both cases long-term practice leads to an increase of grey matter volume in the inferior temporal gyrus. As argued previously in *chapter 2.1.* this brain area can eventually be related to an altered state of consciousness, because practicing music and meditation are different activities and thus the only possibility to explain the same effect of two different activities on the same brain area, is that these two activities have an altered state of consciousness in common. This leads to the further assumption that active music and meditation have the same effect on the brain structure because of a similarly changed state of consciousness. Moreover it shows us that music and meditation do not only have immediate but also long-term effects on the brain.

The question arises, whether the identified brain area is in fact related to an altered state of consciousness?

According to Onitsuka and his co-authors (2004, p. 1603) the inferior temporal gyrus is related to *visual perception*. Therefore, there is a connection to the previously (*chapter 2.1.)* mentioned function of the midbrain - unconscious processing of visual stimuli. Visual perception can be related to imagination, an important aspect of an altered state of consciousness. As explained before, imagination can be divided into controlled and uncontrolled imagination. The only relevant way to explain imagination while playing music is when someone gets as deeply into music making that the „real world“ around her/him disappears and she/he starts to repeat melodic phrases or rhythmical patterns. This person experiences uncontrolled things like walking in the wood or on the sea-side. Due to the fact that such a state of imagination is part of an altered state of consciousness it becomes obvious that this brain area is related to it. To reinforce this point, imagination is extremely important for meditation. Mostly you start meditating with controlled imagination. This means that you consciously for example visualize love in form of a light to enter a higher meditative state. At one point of meditation you loose the conscious control of your actions and experience a changed state in which it is pretty possible to experience uncontrolled imagination. In accordance to the discussed findings the increase of grey matter in the inferior temporal gyrus, brought about by both music and meditation, must also have a common underlying mechanism, namely the repeated induction of an altered state of consciousness and thus the training of the respective brain area, which responds by an increase of mass, similar to training in different sport disciplines.

In summary, long-term practice of active music making and meditation leads to an increase of grey matter volume in the same brain area. This brain area is the inferior temporal gyrus, an area related to visual perception. Visual perception can also be understood as imagination, wich is an important aspect of an altered state of consciousness. Thus music and meditation could have an impact on the brain structure in the inferior temporal gyrus by activating an altered state of consciousness with uncontrolled imagination.

With respect to the sub-question, it has been shown that long-term practice of active music making and meditation has the same effects on the brain. Moreover it has been demonstrated that these effects result from the power of music and meditation to activate an altered state of consciousness. In turn, this leads to the hypothesis that *long-term practice of both active music and meditation leads to an increase of grey matter in the inferior temporal gyrus* as a response to the continuous induction of an altered state of consciousness.

Until now, it has been shown that music has an effect on altered states of consciousness and that the same brain areas are activated by music and meditation. These two findings support the experimental investigations of this master thesis. Related to the main topic of this master thesis it is further important to see whether there exist brain waves which are related to a meditative or deeply relaxed state. If there are such brain waves, it could be possible to affect them through external frequencies (like musical rhythmn or pitches) and thus be able to provoke a meditative or relaxed state in a person.

2.3 Meditation and EEG studies

As discussed above it is important to evaluate whether there are certain brain waves which can be related to a meditative state. In case of the existence of specific brain waves it should be possible to affect the brain at these frequencies with external frequencies like flashing light or further musical rhythmns or pitches (as discussed in chapter 4.1). Two types of brain waves, namely alpha- and theta waves appear to be related to a meditative state. Thus it is hypothesized that the activity of alpha- and theta waves is increased via meditation.

To obtain the most likely answer, this chapter will discuss relevant results of studies concerning meditation and EEG-measures.

It is important again to explain some terms, which will occur in the following chapter. EEG means Electroencephalogramm and refers to the recording of electrical activity of the brain (Gerrig & Zimbardo, 2008).

Alpha waves are specific neural oscillations of the brain which can be measured by EEG. Their frequency ranges from 8 to 12 Hz. Other specific neural oscillations of the brain are theta waves. Their frequency ranges from 4 to 7 Hz. This chapter will discuss different EEG activities in different areas of the brain. Thus it is important to summarize the most important areas of the brain.

Fig. 6 shows the different areas and directions of the brain, highlighted by different colours. As can be seen there are four different main areas called lobes. These are the frontal lobe (in red), the parietal lobe (in purple), the temporal lobe (in green) and the occipital lobe (in blue).

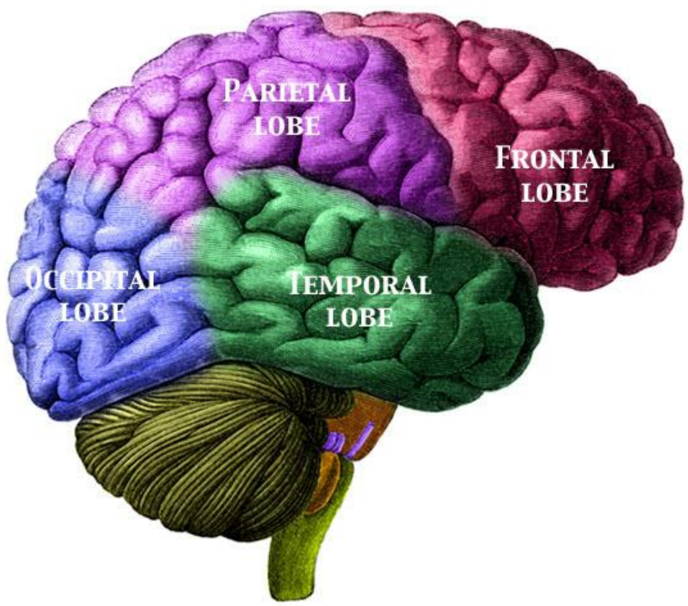

Fig. 6: Different areas of the brain

URL: http://upload.wikimedia.org/wikipedia/commons/e/ed/BrainLobesLabelled.jpg

The different directions of the brain can be seen in *Fig. 7*. These specific terms help to understand the proper position.

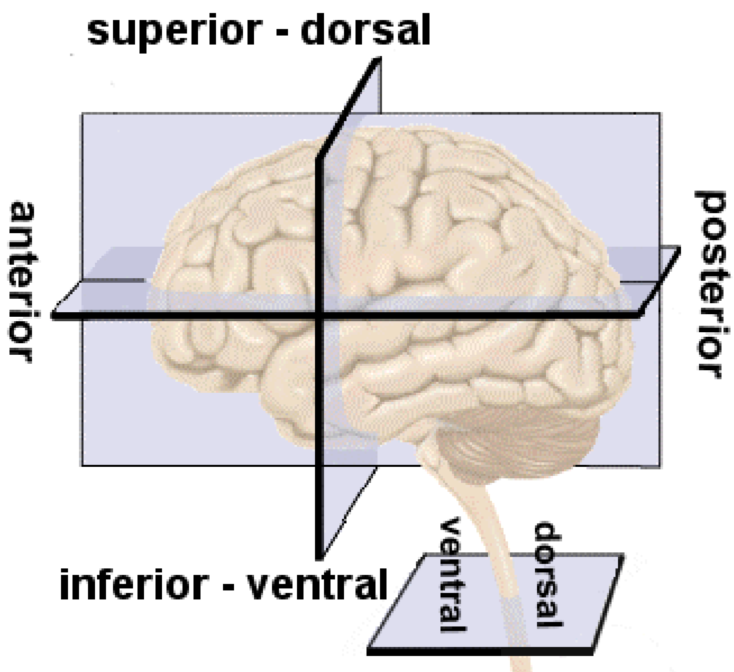

Fig. 7: Directions of the human brain

URL:http://homepage.smc.edu/russell_richard/Psych2/Graphics/Brain_directions__planes_-_small.gif

There is a large body of literature on EEG and meditation. The differences in their results are also somehow large. While some find alpha-activation, other find more theta, both, or even a higher betha activation. The reason for this appears to be simple and is due to the large number of different meditation styles used for the particular studies (Cahn & Polich, 2006). Therefore it is important to reclaim again meditation and its subdisciplines. According to Cahn and Polich (2006) there are main types of meditation. These are mindfulness and concentrative meditation. „Mindfulness practices involve allowing any thoughts, feelings or sensations to arise while maintaining a specific attentional stance" (Cahn & Polich, 2006). Instead „concentrative meditational techniques involve focusing on specific body sensations such as breath." (Cahn & Polich, 2006). It is important to mention that both types overlap in their approach toward similar goals, which is attention. In the first case attention to open perceptivity and in the concentrative case, attention to a specific object (Cahn & Polich, 2006). Although there are lots of different practices, the results similarly result in reported changes in self-experience (i.e. experience of self not centered on the individual's body scheme and mental contents) (Cahn & Polich, 2006). Moreover, according to Cahn and Polich (2006) there are also different states and traits of consciousness, which are induced via the meditation practice.

> *State refers to the altered sensory, cognitive, and self-referential awareness that can arise during meditation practice, whereas trait refers to the lasting changes in these dimensions that persist in the meditator irrespective of being actively engaged in meditation. (Cahn & Polich, 2006, p. 181)*

Furthermore, scientists agree that it is sometimes difficult to assign one specific mediation technique to exact one of the two types, concentrative, or mindfulness meditation (Ivanovski & Malhi, 2007). Therefore scientists talk about a continuum from concentrative to mindfulness (Ivanovski & Malhi, 2007). Because of the presence of many different meditation techniques it is difficult to obtain a universal finding on EEG and meditation.

In addition the difference in EEG studies on meditation may be due to lab situations that impair relaxation, methodological differences, participant-experimenter interactions and expectation influences (Cahn & Polich, 2006). According to Cahn and Polich (2006) it is not well studied how EEG measurements might be affected by the age of the meditator and by his/her personality (aspects like introversion versus extroversion, or anxiety level). This further explains the diversity of findings on meditation and EEG.

Since the large difference of the particular meditation techniques and the methodological differences in EEG studies on meditation should be clearer now, the most important studies concerning EEG and meditation will be discussed and it will be shown which brain waves or frequencies could be the most important for meditation.

Ahani et al (2014) carried out a study on EEG and mindfulness meditation with 34 novice meditators. Mindfulness meditation was based on Mindfulness- Based Stress Reduction and Mindfulness-Based Cognitive Therapy (Ahani et al, 2014). While the experimental condition comprised 15 minutes of a sitting mindfulness meditation they learned, the control condition consisted of listening to a 15 minute National Public Radio podcast. It turned out that different frequency bands showed differences in experimental and control conditions (Ahani et al, 2014). In detail, EEG spectral analysis showed an overall significant increase in power during meditation in beta and theta bands and a smaller but also significant increase in alpha bands (Ahani et al, 2014).

Moreover they mention that the systematic review is consistent with their alpha findings. According to Ahani et al (2006, p.7) "most studies show higher alpha power during meditation relative to controls." The same counts for theta waves.

Another study analyzed EEG changes during Zen meditation in 20 normal adults and correlated their result with personality traits (Takahashi et al, 2005). An increase in fast theta power and slow alpha power on EEG was found mostly in the frontal area. Equal to the results of Takahashi et al (2005), Aftanas and Golosheikin (2002) found that experienced meditators showed an increase in theta- and slow alpha powers in the frontal regions while meditating.

Slow alpha in the frontal area is said to reflect enhanced internalized attention, whereas fast theta power reflects enhanced mindfulness (Takahashi et al, 2005). According to Takahasi and his co-workers (2005, p. 200), internalized attention could be described as the "manipulation of one's attentional focus", whereas mindfulness could be understood as the "maximization of the breadth and clarity of self-awareness". As internalized attention and mindfulness are typical for a meditative state, it seems to be clear that these frequencies are more active when meditating. The specific Zen meditation applied for their study is called Su-Soku, a meditation practice that does not require any special training, because sustained attention and breath control are the only requirements. (Takahashi et al., 2005)

Interesting in this study is that Takahashi et al (2005) divided the frequency bands of theta and alpha into theta1 (4.3-5.86 Hz), theta2 (6.25-7.81 Hz), alpha1 (8.2-

9.77 Hz) and alpha2 (10.16-12.89 Hz). Thus their findings are more precise and can shed light to the most important frequencies in the brain related to a meditative state. In relation to this, Salansky et al (1998, p. 398) state that the "sub-divison of the spectrum into traditional bands lacks a theoretical basis and may not be the optimal way to represent the functional relationship with cognitive states". Moreover according to Salansky et al (2003), even minimal frequency changes, like 0.3 Hz in clinical practice can be of importance, which further argues for a more discrete differentiation of EEG components. Furthermore, this would lead to a better interpretation of electrical activity responses of the brain to different sensory treatments, like drugs, light or sound (Salansky et al, 2003).

As previously mentioned, significant increases of fast theta (theta2) and slow alpha (alpha1), mostly in the frontal area of the brain, were found to be related to a meditative state. Furthermore, as there was no significant association between their percent changes, Takahashi et al (2005, p. 204) assume that the changes in the alpha- and theta activity "may be independently involved in the behaviors of the mind during meditation."

Takahashi et al (2005) also conducted HRV[1] (heart rate variability) measurements in this study. This is particularly interesting since they found that the percent change in the slow alpha power in the frontal area was negatively correlated with that in nuLF[2] as well as LF/HF[3]. As a decrease in nuLF and LF/HF indicates an inhibition of sympathetic tone, this significant negative correlation shows that the increase of the activity of alpha1 in the frontal area (reflecting internalized attention) is related to an inhibitory effect on sympathetic activity too (Takahashi et al, 2005). Since an inhibition of sympathetic activity is related to relaxation, this finding supports the assumption that alpha activation is important for meditation, as it is related to relaxation and further internalized attention.

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[1] Heart Rate Variability (HRV) is measured through electrocardiogram (ECG) and is a parameter of the neurovegetative activity and autonom function of the heart and describes its ability to frequently change the time interval between heartbeat to heartbeat according to certain stresses. (Hottenrott, 2002)

[2] nuLF means normalized units of Low Frequency (Takahashi et al, 2005)

[3] LF/HF means an estimate of the LF/HF ratio (Takahasi et al, 2005)

Moreover Takahashi et al (2005) found that the percent change in theta2 power in the frontal area is positively correlated with that in nuHF[4]. Since an increase of nuHF indicates an acceleration of parasympathetic tone, this significant positive correlation shows that the increase of the activity of theta2[5] in the frontal area (reflecting mindfulness) is related to an acceleration of parasympathetic activity too (Takahashi et al, 2005). Parasympathetic activity is related to recovery and also relaxation. Thus these results further support the assumption that theta activity is important for meditation.

Furthermore Lagopoulos et al (2009) found a significantly increased alpha and theta power when participants were meditating. In detail the significant increases of alpha- and theta power were found in the posterior, frontal and temporal-central regions of the brain (Lagopoulos et al, 2009), which fits to the previous mentioned results.

In their study they looked at the effect of nondirective meditation on EEG changes. As a nondirective meditation technique they used acem meditation, which "does not require volitional direction of attention toward a specific subjectively experienced state of mind" (Lagopoulos et al, 2009). Moreover it is similar to mindfulness meditation, because it allows "any thought, memory, emotion, or sensation to emerge and pass through the awareness of the practitioner" (Lagopoulos et al, 2009) without attempting to "control the current content" (Lagopoulos et al, 2009). To meditate, the practitioner mentally repeats a multisyllable sound, with no semantic, emotional, or symbolic meaning. Their study consisted of two different conditions. In one condition participants had to do acem meditation for 20 minutes with there eyes closed, whereas subjects in the other condition just had to rest quietly in a chair with their eyes closed for 20 minutes. It has to be mentioned here, that there is a big difference in alpha activity when eyes are closed or opened. In detail, closing the eyes leads to an increase of alpha activity (Bazanova & Vernon, 2013). The results of increased alpha and theta power in the meditation condition are therefore interesting, because it shows that

[4] nuHF means normalized units of High Frequency (Takahashi et al, 2005)

these changes seem to be typical for meditation as they cannot be achieved through normal resting.

To understand the importance of the results that the activity of alpha and theta power is significantly increased through meditation, the associations of alpha- and theta waves will be explained again.

Alpha activity, according to Lagopoulos et al (2009) is associated with relaxation and the lack of active cognitive processes. These associations are also typical for meditation, which possibly explains the increased activity of these brain waves. On the other hand, theta activity is associated with "alertness, attention, the efficient processing of cognitive and perceptual tasks, orienting, working memory, and affective processing, with frontal theta activity indicative of concentration" (Lagopoulos et al, 2009). Therefore, increases in theta activity might be due to cognitive processing and awareness while meditating. Moreover,

> *theta power, greater in frontal and temporal-central regions than in posterior regions, may be meditation specific and suggests neural processing in the frontal midline (anterior cingulate cortex), and limbic areas, all of which have been previously implicated in meditation. These areas are known to have a prominent role in emotion processing. In contrast, alpha waves were more abundant in posterior regions, which is compatible with reduced cognitive processing in sensory-related areas. (Lagopoulos et al, 2009)*

This further supports the assumption that an increase of alpha- and theta activity is specific for meditation.

But a review of the literature also showed different findings. Lehmann and his co-workers (2001, as cited in Cahn & Polich, 2006), investigated Tibetan buddhist practices and found an increase of gamma power (35-44Hz), whereas Jacobs et al (1996, as cited in Cahn & Polich, 2006) found a decreased frontal beta power in their study on mantra based relxation. Although there are contrary findings, where no increased alpha- or theta activtity has been found, they are just a few, and results of increased alpha-and theta activity predominate. The study of Cahn and Polich (2006) represents a summary of relevant literature on meditation and EEG and supports this statement. They (Cahn & Polich, 2006) state that the primary findings have implicated increases in theta and alpha band power and decreases in overall frequency. With this statement they refer to the results of Andresen (2000), Davidson (1976), Delmonte (1984), Fenwick (1987), Pagano and Warrenburg (1983), Schuman (1980), Shapiro (1980), Shapiro and Walsh (1984), Shimokochi (1996), West (1979, 1980) and Woolfolk (1975). Indeed, there is a large body of studies which proof that an increase of alpha- and theta activity is related to meditation.

Moreover Cahn and Polich (2006) refer to Fenwick et al (1977) and Williams and West (1975) who suggest, based on the outcome of their studies that meditation seems to be a condition between being awake and sleeping. This further argues for the importance of meditation for more scientific studies, as it should be able to describe the phenomenon of altered states of consciousness, and since meditation is much easier to be analyzed in lab situations than altered states like trance or ecstacy.

In addition, Lo and Leu (2005) examined the specific frequencies of the alpha band when subjects practised Zen Meditation. They found that the dominant frequency was 9.26 Hz. This fits into the previously discussed studies where it was found that slow alpha (8.2-9.77 Hz) seems to be important for meditation (Takahashi et al, 2005).

According to the discussed findings, fast theta- and slow alpha- waves are important to experience a meditative state.

But is it actually possible to influence the activity of the brain with acoustic frequencies, which are below the hearing threshold?

2.4 Effects of Infrasounds on humans

As questioned previously: Is it possible to influence the activity of the brain with acoustic frequencies? This chapter will try to demonstrate that infrasounds, equally if below or above the threshold of hearing have an effect on the human brain and thus are capable of changing mood or intensifying a meditative state. Before discussing relevant resarch results, it will be explained how hearing works and what infrasounds are. Infrasounds are important for this master thesis, as their frequency ranges from 0 to 20Hz and thus involves the frequency range of alpha-waves (8 - 12Hz) and theta waves (4 - 8 Hz), the possible effect of which on humans in meditating and relaxing will be investigated in the experimental part of this thesis.

2.4.1 Hearing and the inner ear

To understand possible effects of infrasounds on humans it is important to explain one important part of the ear for the detection of frequencies. This part of the ear is the inner ear.

The organ of Corti, a part of the inner ear, is shown in *Fig. 8*. As can be seen, it contains one row of inner hair cells[6] (highlightened with a red circle) and three rows of outer hair cells[7] (highlightened with a blue circle).

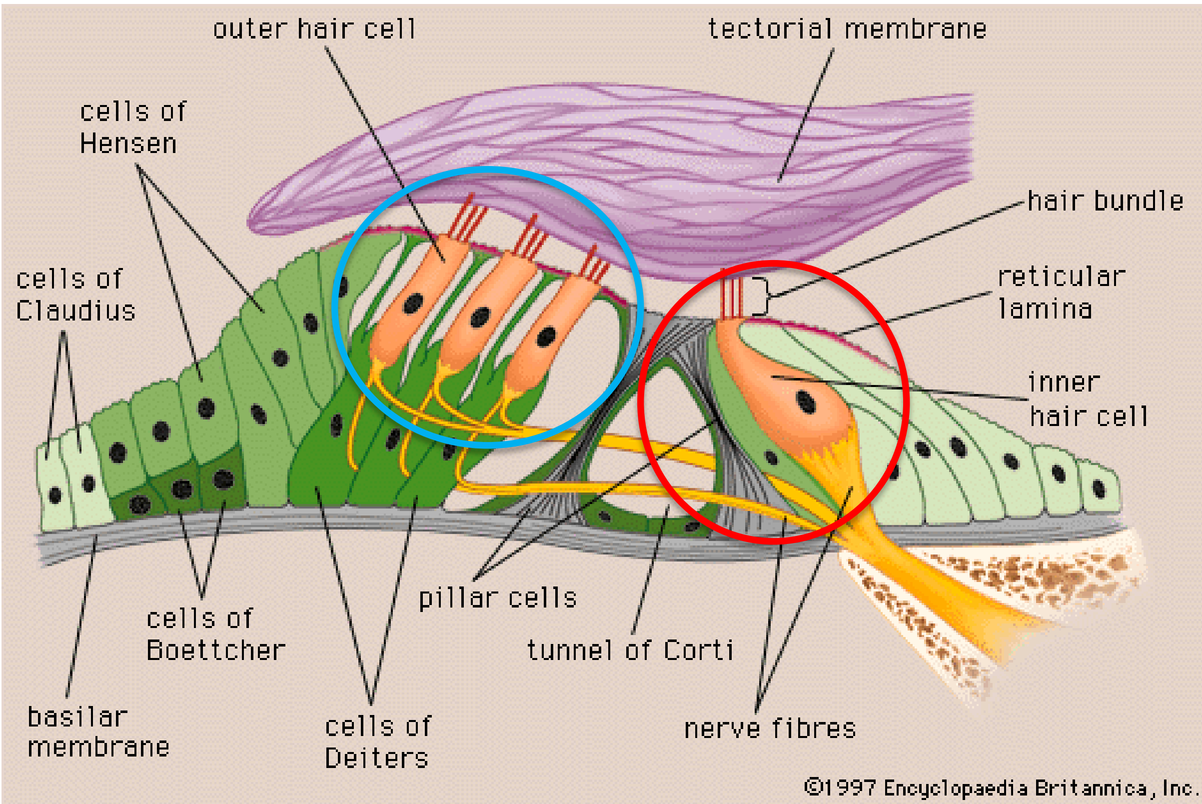

Fig. 8: Organ of Corti.

URL: http://neuronbank.org/wiki/images/c/ce/OrganofCorti.gif

When a sound reaches the ear, inner hair cells are stimulated. Furthermore

> *approximately 95% of the fibers that transmit impulses that will be experienced as "hearing" are myelinated with one fiber contacting one inner hair cell. On the other hand, another type of nerve fiber, which is not myelinated, synapses with a number of outer hair cells. These fibers have been assumed to be unresponsive to sound.* (Persinger, 2014, p. 509)

[6] The acronym of inner hair cells is IHC.
[7] The acronym of outer hair cells is OHC.

The assumption that outer hair cells are unresponsive to sound is wrong. Salt and Hullar (2010) were able to show that at 5 Hz outer hair cells can be stimulated at sound pressures 40 db below those that stimulate the inner hair cells, which is associated with conscious hearing. On the other hand, to experience sound at 10 Hz, the sound pressure level must be around 100 db. Then 10 Hz can stimulate the inner hair cells. When just outer hair cells are stimulated the information is unconscious. Outer hair cells are most sensitive to frequencies below 30 Hz. When the sound pressure level (dB) does not exceed the hearing threshold, low frequencies are more perceived as whole body pressures than sound (Persinger, 2014). According to Persinger (2014) the arrangement of the the ear with inner and outer hair cells is analogous to the rods and cones of the eye.

2.4.2 What are Infrasounds?

Infrasound is the description of frequencies in the range of 0 up to 20 Hz, thus corresponding to the frequencies the closest under the hearing threshold. Furthermore Infrasounds are omnipresent in modern life. They are generated by

> *"natural sources such as earthquakes and wind [...] and are common in urban environments, and as an emission from many artificial sources: automobiles, rail traffic, aircraft, industrial machinery, artillery and mining, explosions, air movement machinery including wind turbines, compressors and ventilation or air-conditioning units, household appliances such as washing machines, and some therapeutic devices." (Leventhall et al., 2003, p. 54)*

Other natural sources of infrasounds are mountain ranges, incoming meteors, tornados (1000km away), or volcanic explosions (Persinger, 2014). One good example for a natural source of infrasound is a moving car with an open window. If you are sitting in such a moving car with an open window it can happen that a terrible, painful infrasound is perceived. The painful experience is a kind of humming pressure at the ears and is due to an extremely high sound pressure level.

It is said that the audible noise for humans lies between 20 and 20 000 Hz, which decreases with age (Leventhall et al., 2003). According to Salt and Kaltenbach

(2011, p. 2) "serious misconceptions about low frequency sound and the ears have resulted from failure to consider in detail how the ear works". There are pathways in the brain which do not involve conscious hearing and distribute responses to infrasound (Salt & Kaltenbach, 2011). According to Salt and Kaltenbach (2011) for many years it has been wrongly assumed that what you can't hear can't affect you. This misinterpretation is due to equating the sensitivity of hearing with sensitivity of the ear. As this interpretation says that sound that cannot be heard is insufficient to stimulate the ear, it neglects the present knowledge of the physiology of the ear and thus is incorrect (Salt & Kaltenbach, 2011). It is widely accepted that hearing occurs through the IHC. The important difference between IHC and OHC is that OHC are stimulated at much lower levels than IHC (Salt & Kaltenbach, 2011). The difference in IHC and OHC from a physiological point of view is that type I fibers from the IHC terminate on the main output neurons of the cochlear nucleus, whereas type II fibers from OHC terminate in the granule cell regions of the cochlear nucleus (Salt & Kaltenbach, 2011). This granule cell system connects to numerous auditory and non-auditory centers of the brain, where some of them are directly involved in auditon, but others are connected to functions as diverse as attentional control, arousal, startle, the sense of balance and the monitoring of head and ear postion (Godfrey et al., 1997, as cited in Salt & Kaltenbach, 2011). This finding is important for the topic of the effects of alpha- and theta wave frequencies (infrasounds) on meditation, as non audible infrasound stimulates OHC whose fibers terminate amongst others in centers responsible for i.e. attentional demand or arousal. As discussed in previous chapters attentional demand and arousal are important features of a meditative state. Thus this finding shows a further possible connection of infrasound and meditation.

As already mentioned it was also found out that frequencies below 20 Hz are audible at high enough levels (Leventhall et al., 2003). According to Leventhall et al (2003) a lot of different studies (Corso, 1985; Lydolf & Møller, 1997a; Lydolf & Møller, 1997b; Moller & Andresen, 1984; Møller & Andresen, 1984; Watanabe & Møller, 1990a; Watanabe & Møller, 1190b; Whittle et al., 1972; Yeowart, 1976; Yeowart & Evans, 1974) have well established the threshold region at low frequencies. It was found that for example a frequency of 4 Hz is audible at about 107 dB, 10 Hz at 97 dB, 20 Hz at 79 dB and 50 Hz at 46 dB. Furthermore it was found that "about 15 Hz, there is a change in threshold slope from approximately 20 dB/ocatve at higher frequencies to 12 dB/octave at lower frequencies." (Leventhall et al., 2003, p. 13) As Leventhall et al (2003) states that the reason for this is not clear and that it should be due to a different aural detection process, because it happens at a frequency range where the "tonality of the auditory sensation is lost" (Leventhall et al., 2003, p. 13), it is assumed that this different aural detection process has something to do with the stimulation of OHC. In fact, at lower frequencies (around 30 Hz and below), the sound is not anymore perceived as constant, meaning that the sound is perceived with intermittence (Persinger, 2014). Thus, low frequency noice including infrasounds is clearly detectable by humans when the sound pressure level is high enough. Moreover according to Berglund et al (1996, p. 2989) "it should be noted that the absence of conscious (auditory) detection does not automatically mean that the noise has no other effects on the human body."

It has been shown that the human brain includes a specific area which responds to infrasound. This brain area seems to be the contralateral temporal cortex, that includes "primary and interpretational regions from the auditory stimulation" (Persinger, 2014, p. 508). It has to be highlighted again that outer hair cells are more sensitive to infrasounds than inner hair cells. It was also shown that at 5 Hz outer hair cells can be stimulated at sound pressures 40 dB below those that stimulate the inner hair cells, which are associated with conscious hearing (Salt and Hullar, 2010).

Since the function of hearing frequencies, especially low frequencies, and the term infrasound is clear the next step is to discuss relevant literature on the effects of infrasounds on humans. The following chapter will try to find answers to the question whether infrasound is able to influence humans.

2.4.3 Infrasound and its effect on humans

It has to be anticipated, that "people can respond, if at all, quite differently to the same physical stimulus" (Persinger, 2014, p. 503). This citation is important as it reflects the human nature in many points. There are quite a lot of different studies on infrasounds and their effects on humans, which provide different results and opinions from infrasound as a benefit to infrasound as a hazard, from observed effects on well-being to effects on the activity of the brain. Thereby it is not important whether the effects on humans are consciously or subconsciously, since Persinger (2014) states that neurosciences show that stimuli can significantly affect the brain directly without the person's awareness. Relevant studies concerning the effects of infrasound on human will be discussed.

According to the physical principle that every object has its frequency, also our body has its frequencies. In other words, this means that our body emits sound. Due to the fact that the sound pressure level of the body's inner frequencies are too low to be audible, we don't perceive them. For example the frequency of the human head is between 8 Hz to 12 Hz, the thoracic cavity is between 4-6 Hz, the heart is around 5 Hz, or the abdominal cavity is betweeen 6-9 Hz (Cheng et al, 2010). Oster and Jaffe (1980) found that the dominant frequency of muscle sound is between 22 and 28 Hz at sound pressure levels between 60 and 70 dB. According to Persinger (2014) about 90 dB would be necessary to be audible for humans. These sounds can be easily amplified by contraction over the ears, which are the most sensitive organs to detect and differentiate pressure variations (Persinger, 2014).

> *To demonstrate this, raise the elbows and then place the thumbs over the ear openings. A vibrating sound (around 20Hz) is perceived and becomes louder when the fists are tightened (muscles are tense). (Persinger, 2014, p. 506)*

This example should demonstrate that low frequencies are audible for humans and that every organ has indeed its own frequency. According to the principle of superposition of waves (constructive[8] and destructive[9] interference) and also to resonance phenomena, it means that the body's own frequencies should be manipulable. An interesting point with resonance phenomena is, that they allow relatively weak stimuli, when they are temporally and spatially congruent with the system, to significantly affect the stability of the system (Persinger, 2014). Thus intrinsic frequencies of the body should be able to be affected by extrinsic frequencies, and vice-versa, when we imagine the radio with a weak signal, the signal of which gets better when humans get closer or even touch it, or electroacoustic devices the signals of which can be interrupted when persons stand in a certain position next to these devices.

The importance of studies on infrasound has become clear over the past years, as infrasound (i.e. from wind turbines) has been associated with negative feelings. Bruel and Olesen (1973) demonstrated that increases in infrasound pressure during inclement weather is a strong correlate of sickness (as cited in Persinger, 2014). Moreover, one room of a university where unbalanced and overdesigned heating motors generated vibrations was associated with frequent intraclass conflicts and emotional behaviors. These social behaviors ceased when the motors were inactivated (Persinger, 2014). Furthermore, Evans and Tempest (1972) showed that frequencies between 1Hz and 20 Hz at 115 dB to 129 dB produced a 30-40% increase in reaction time as well as sensations of lethargy (as cited in Persinger 2014). In addition, Alves-Pereira and Castelo Branco (2007) identified the vibroacoustic disease or vibroacoustic syndrom among workers within the aeronautical industries (as cited in Persinger, 2014). This vibroacoustic syndrome occurs "with a specific pattern and magnitude of infrasound and low-frequency sound" (Persinger, 2014, p. 516). The most common symptoms of the identified disease are "sensitivity to sound, depression, irritability, preference to be socially

[8] Constructive interference desribes the phenomenon that when two waves with the same frequency, travelling in the same direction meet each other crest by crest the resultant wave has a higher magnitude, because it is the sum of the individual magnitudes. (Pain, 2005)

[9] Destructive interference describes the phenomenon that when two waves with the same frequency, travelling in the same direction meet each other crest by trough the resultant wave has a smaller magnitude or even adds to zero, because it is the difference in the individual magnitudes. (Pain, 2005)

isolated, decreased cognitive skills, sleep disruptions, episodes of dizziness, and intermittent sudden tachycardia." (Persinger, 2014, p. 516)

The fact that there is an official disease (vibroacoustic diesease) which is related to infrasound and low-frequency sound, shows the importance of studies on infrasound. These results on infrasounds, which show that it can have a negative effect on humans, do not necessarily counterargue the hypothesis that infrasound can facilitate meditation and thus is of benefit.

Since these studies did not focus on specific frequencies within the infrasound range, the negative effects could be due to frequencies in the range of others than alpha or theta waves. In support of this assumption is the fact that there are results on both positive and negative effects of infrasound on humans, as will be further discussed. Hence it is assumed that negative or positive effects of infrasound on humans depend on the specific infrasound frequency and on the individuals brain activity. The following citation of Persinger (2014, p. 523) supports this assumption:

> *Human beings can be described as both mechanical and energetic organisms. There are multiple sources of stimuli that exhibit energetic equivalents whose values in turn converge with those essential for the function of the cell, the organ, and the organism. The frequencies that have been defined as infrasound, from natural, manufactured, and as yet unknown sources, have the capacity to resonate with the human body.*

Furthermore Kasprzak (2007) investigated the effects of infrasounds on activation levels of humans. The study comprised acoustic stimuli at 7 Hz at a sound pressure level of 120 db, 18 Hz at 120 db and 40 Hz at 110 db with an exposure time to each of the stimuli of 20 minutes in every case. The activation level was measured using a self-assessment questionnaire, known as the Activation-Deactivation Adjective Check List (AD ACL) (Kasprzak, 2007). 7 Hz at 12 db was found to be responsible for a significant increase of the Deactivation- Sleep effect. The other two stimuli at 18 Hz and 14 Hz showed no significant results. Thus it seems possible that 7 Hz at 120 db is able to change the activity of the brain at theta-level (6-8 Hz) which are said to be related to recovery and relaxation, leading to an increase of deactivation. In another study Kasprzak (2014) tested the effects of 20 minutes long infrasounds on humans. The stimuli were recordings of wind turbine noise at a distance of 750 meters. The frequency components above 20 Hz were then filtered out (Kasprzak, 2014). EEG measurements of the brain activity were recorded. The results indicate some changes in the EEG signal. In detail it was shown that exposure to infrasound led to a decrease in the amplitude of alpha- and theta waves (Kasprzak, 2104), but these findings were not significant. This could be due to the fact that the stimulus comprised the whole infrasound range from 0 Hz to 20 Hz.

In addition, Damijan and Wiciak (2005) exposed subjects to infasounds at 7 Hz and 18 Hz at a sound pressure level of 120 db for 20 seconds each. It was demonstrated that the harmonic frequency at 7 Hz lead to a significant driving response effect in the EEG, which means that the dominating frequency of the brain activity is that of the stimulus, in this case 7 Hz (Damijan & Wiciak, 2005). This driving response effect "occurs at the moment the exciting signal is applied" (Damijan & Wiciak, 2005, p. 73). Although the other stimulus at 18 Hz did not reveal a significant effect, this finding is interesting because it shows that infrasounds can have an effect on the brain`s electrical activity. But it has to be mentioned that the report of this study lacks methodological details. Thus it is not clear whether the found effect or whether the not found effect are due to methodological errors or wrongly applied statistical analyses.

Some could argue that the effects of infrasounds on humans could be due to the vibrations which stimulate sensors of the skin. But as previously explained, outer hair cells in the inner ear are responsible for the reaction to infrasounds. Strengthening this point, Yamada et al (1983, as cited in Leventhall, 2003, p.22) found that the threshold for hearing of profoundly deaf people "was 40-50 db above the hearing threshold of those with normal hearing up to 63 Hz and more at higher frequencies". Since deaf people have recognized the frequencies with a higher sound pressure level than normal hearing subjects, this demonstrates that perceiving low frequencies is primary due to the ear.

Moos (1963; 1964, as cited in Leventhall, 2003) found that road traffic accidents and school absences showed higher correlations on days of intense infrasonic disturbances, than on days with mild infrasound.

Fecci et al (1971, as cited in Leventhall, 2003) showed that workers who were exposed to the noise from air conditioning, whose noise peaked at 8 Hz with a level of 80 db, exhibited a much higher percentage of drowsiness than the non-exposed population.

Moreover Landström and Byström (1984, as cited in Leventhall, 2003) found that infrasound affects the pattern of sleep minutely. In detailed frequencies of 6 Hz and 16 Hz at 10 db above the hearing threshold are related to a reduction in wakefulness. According to the previously discussed theta waves, the stimulus of 6 Hz could have increased the activation of theta activity in the brain, which is also related to sleep.

Landström and his co-workers (1991, as cited in Leventhall, 2003) made an EEG-study and found that noise at 16 Hz and 125 db is an effective stimulus of reduced wakefulness. The stimuli in this study were frequencies at 6 Hz and 16 Hz at 10 db below and 10 db above the hearing threshold. Only the stimuli above the threshold led to a reduced wakefulness (Leventhall, 2003). This result is interesting as it may indicate that only infrasounds above the hearing threshold are able to affect the human brain. Furthermore, they found that exposing deaf and normally hearing participants to 6 Hz at 115 db for 20 minutes, reduced wakefulness only among the normally hearing participants (Leventhall, 2003). This further argues for the previously stated argument that the effects of infrasounds depend on chochlear stimulation and not on vibrations stimulating sensory cells of the skin. A further interesting result of the study of Landström and his co-workers (as cited in Leventhall, 2003) was that during a repeated 42 Hz signal at 70 db wakefulness was reduced, while a repeated signal of 1000 Hz at 30 db led to an increase in wakefulness. The result that low frequencies led to reduced wakefulness may be due to a relaxing effect of these frequencies.

While Fecci et al (as cited in Leventhall, 2003) found effects of infrasound below the hearing threshold in humans, Landström et al (as cited in Leventhall, 2003) found similar effects above the threshold of hearing. According to Leventhall et al (2003, p.39), since the stimulus of Fecci and hic co-workers also contained broadband noise and higher frequencies, Fecci et al "may have been mistaken in attributing the effects observed to the frequencies below 20 Hz." Thus it is not clear whether the effects found in the study of Fecci and his co-authors, is due to infrasound below the hearing threshold.

Furthermore, it has been shown several times that low frequency noise causes a worse performance of tasks (Leventhall et al., 2003). For example Waye et al (1997) showed that coping strategies for cognitive demands were worse when participants were exposed to low frequency noise (31.5 Hz at 70 db) and that these frequencies interfered more strongly with performance.

Another study of Waye et al (2001) showed that low frequency noise (31.5 Hz at 40 dbA) may reduce available information processing resources, because it seems to be more difficult to ignore or habituate to it. In some sense this counts for low frequencies in facilitating a meditative state, because meditation is related to a reduction of cognitive processes or information processing.

Another study investigated the effects of low frequency noise emitted from aplliances in or near domestic buildings (Mirowska & Mroz, 2000). They showed that the test group (with infrasound) suffered more from annoyance and sleep disturbance and was less happy, less confident and more inclined to depression (Mirowska & Mroz, 2000). This study again proofs that infrasound has an effect on humans. In this case the effect was negative. The exact frequencies in the infrasound-range causing the negative effects are not mentioned in the study, thus this finding is not in conflict with the assumption that frequencies in the range of theta or slow alpha could have a positive effect on humans.

Leventhall et al (2003) states that the found biological effects of infrasound on humans are sometimes contradictory. For example, Karpova and his co-workers (as cited in Leventhall et al., 2003) showed that workers who were exposed to infrasound of 5 Hz and 10 Hz at 100 db and 135 db (simulating industrial sound) "reported feelings of fatigue, apathy and depression, pressure in the ears, loss of concentration, drowsiness, and vibration of internal organs." (p. 55). On the contrary, a study of long distance drivers with trucks exposed to infrasound at 115 db did not give any significant effects similar to the previously mentioned one.

The reason for this could be the following: A common problem of the older literature on infrasound seems to be the fact that results are often related to infrasound as a whole. But infrasound ranges from 0 Hz to 20 Hz and it has been well established that different frequencies in this range have different effects. Thus contrary effects found in studies not looking at specific frequencies and taking infrasound as a whole are likely due to the fact that different frequencies were investigated within the infrasound-range.

Important for the topic of meditation is the fact that long-term exposure of pilots to infrasounds of 14 Hz or 16 Hz at 125 db led to decreased alertness and alteration of hearing threshold and time perception. This finding is therefore interesting as the mentioned effects produced through infrasound are comparable to feelings of a meditative state. Athough these frequencies are not in the alpha or theta range they are important for further discucsion, since they proof the effects of infrasound on humans and a possible relation to meditation.

Evans and Tempest (1972, as cited in Leventhall et al., 2003) found that 30 % of subjects that were exposed to frequencies from 2 Hz up to 10 Hz at 120 db to 150 db via earphones had nystagmus[10] within 60 seconds at 120 db. The effect was worst at 7Hz. The higher the intensities, the faster the onset of nystagmus. It has to be stated here that no complaints of discomfort were found for any of the subjects (Leventhall et al., 2003).

According to Salansky et al (1998, p. 395) it is well known that light and sound stimulations are used for treatment of "depression, migraine, anxiety and sleep disorders". In their study Salansky et al (1998) point out that individual treatment alignment is important. This means that amongst others, sound stimulations are influenced by indiviual properties. Thus variable frequencies should be used to stimulate the brain depending on the individual organism's own rhythmn. According to the outcome of the experiment of this master thesis, it means that possible

[10] nystagmus is the term for involuntary eye movements and is used to study vestibular effects in humans (Leventhall et al., 2003)

results could be due to a stable frequency which is not able to fit exactly the own individual brain waves. From an evolutionary point of view it is stated that organism sensitivity is associated with external low-frequency oscillations

> *with specific evolutionary sensing mechanisms that were developed to derive valuable biological information from the normal magnetic field of the earth or to compensate for the effects of geological and meteorological electromagnetic fields (Salansky et al, 1998, p. 396).*

These electromagnetic fields are related to some amplification in the organism and further it has been shown that they affect various physiological systems (Salansky et al, 1998). One of the possible biophysical mechanisms of electromagnetic fields is based upon resonance interaction processes within the cell structures (Salnsky et al, 1998). For the discusson of the effect of infrasound on humans, the following citation of Salansky et al (2003, p. 396) should not be missed:

> *The human body is constantly bombarded by energy generated by the sun, the universe, geomagnetic sources as well as from man-made sources (e.g. electricity and its resulting megnetic fields). Since all energies have a frequency and intensity and because light, sound, touch, smell, and taste function through the reaction to these frequencies, all human senses can be affected. All individuals are different and will react differently to environmental exposures, so specific frequencies must be accessed for helpful and harmful effects.*

According to Salansky et al (2003) resonance phenomena and complex dynamics of compound potentials might play one of the most important roles in brain organization, which further highlights the importance of frequencies and further studies on the effects of frequencies on humans.

Since any biological properties vary between individuals, a high degree of frequency variability was found in different subjects. Although there is a frequency variability between different subjects, a remarkable intra-subject stability was found for these frequencies (Salansky et al, 1998).

Moreover, according to Salansky et al (1998) a change of the brain activity to rhythmic sensory stimulation is not limited to visual modality. These driving effects have also been found by somesthetic and auditory stimuli in humans (Salansky et al, 1998). Salansky and his co-authors (1998) further state that changes of endogenous organism rhythms, like respiratory rate, heart rate and EEG rhytmns lead to changes in the functional state of organisms. These changes can be seen through an increase of the central nervous systems sensitiveness to "external low-frequency stimulation, non-specific central nervous system reactivity to rhythms stimulation and resonance phenomena in different organism systems." (Salansky et al, 1998, p. 401)

Furthermore rhythmic EEG components are related to different physiological organism systems and are said to function as organizational properties within the brain, and individual EEG frequencies can be used as sensory stimulation and treatment efficiency improvement (Salansky et al, 1998).

The positive effects of an increased alpha wave activity are well known. Therefore alpha EEG biofeedback training is used for reduction of stress or anxiety disorder. These effects could also be evoked through meditation and /or alpha wave sound, if the hypothesis holds true. At least music or alpha wave frequencies could ease the increase of alpha activity through meditation.

Biofeedback training is important with respect to changing the activity of the brain through external stimuli as it shows that humans are able to consciously change their activity and control narrow frequency bands without the influence of external stimuli, hence just by themselves. It was found for example that subjects are able to control two-dimensonal (vertical and horizontal) movement of a curser on a computer screen with the use of two channels of bipolar alpha EEG activity. While the subject`s vertical movement of the cursor was provided by a 10 Hz EEG component, horizontal movement was provided by an 11 Hz component (Salansky et al, 1998). The use of EEG components to control or steer computer programs has become popular today. The phenomenon is that users can control actions in computer softwares just by thoughts and imaginations via an EEG. The BCI (means Brain Computer Interfaces and is a part of the institute of neural engineering) at the TU Graz invented an EEG software which allows users to play World of Warcraft just by controling their character with the activity of different brain waves. As it is possible to consciously control brain waves it should also be possibly to externally influence them, via i.e. infrasounds.

From the literature it appears clear that individual specific EEG components can be used for stimulation (Salansky et al, 1998). Therefore there are approaches to register the patient's own endogenous rhythms and automatically send them to a feedback device, which adapts it for stimulation (Salansky et al, 1998).

Typically studies involve higher levels of infrasounds for limited periods (up to 24 hours). Furthermore Salt and Kaltenbach (2011) state that there are no studies on the effects of long-term infrasound exposure on humans. Hence effects of infrasounds on people living near wind turbines are not clear.

According to Salt and Kaltenbach (2011) some studies on infrasounds miss to find statistically valid findings, because they are A-weightening the sound measurements (dBA). This means that sound measurements are corrected according to human hearing sensitivity and therefore low frequency components are mostly not further considered (Salt & Kaltenbach, 2011). Thus, in such cases it is impossible to find significant effects of infrasound (below the hearing threshold) from wind turbines on humans. If hearing is the important factor A-weighting does make sense, but to see whether low frequency components, with sound pressure levels not exceeding the hearing threshold, do have an effect on human, dBA makes no sense.

As can be seen from the discussion of the relevant literature above, both positive and negative effects have been found for infrasounds on humans. Furthermore it should be clear now, that infrasounds do have an effect on humans. Moreover it seems that infrasound below the hearing threshold also affects humans. Thus the experimental part of this master thesis will investigate frequencies with sound pressure levels closely below the threshold of hearing.

2.4.4 Infrasounds and their effects on animals

It is also important to look at possible effects of infrasound on animals, as this might shed light to similar effects on humans. The procedure of testing animals and to relate the results to humans is common in the sciences, as most of the time it is not possible to carry out experiments with humans due to ethical reasons. The results of animal studies are said to be a good indicator of human effects. Thus looking at studies on the effect of infrasound on animals appears to be logical and of important value for argumentation. Alekseev and his co-workers (1985, as cited in Leventhall et al., 2003) found that exposure to 4 Hz up to 10 Hz at 120 db to 125 db led to short-term arterial constriction and capillary dilatation in the myocardium. Longer exposure led to nuclear deformation, mitochondrial damage and other pathologies (Leventhall et al., 2003). The most prominent effects were found after exposure to 10 Hz up to 15 Hz at 135 db to 145 db (Leventhall et al., 2003). Nekhoroshev and Glinchikov (1991, as cited in Leventhall, 2003) further showed that exposure of 8 Hz and 16 Hz at 120 db to 140 db for three hours per day for 1 to 40 days on rats and guinea pigs led to morphological and physiological changes in the myocardium.

Moreover Svidovyi and Kuklina (1985, as cited in Leventhall, 2003) showed that 8 Hz at 100 db and 140 db for three hours per day led to significant changes in the conjunctiva (i.e. swelling of the cytoplasm and decrease in the lumen of the capillaries). Also changes in the liver (damage of nuclei, intracellular membranes and mitochondria of rat hepatocytes in vivo) due to infrasound exposure have been detected by Alekseev et al (1987, as cited in Leventhall, 2003). The infrasounds used were frequencies of 2 Hz, 4 Hz, 8 Hz, or 16 Hz at 90d b to 140 db for three hours per day for five to 40 days (Leventhall, 2003). The changes were more pronounced at 8 Hz and 16 Hz compared to 2 Hz and 4 Hz. Exposures for more than 25 days induced irreversible changes (Leventhall et al., 2003). These findings are interesting since also sound pressure levels below the human hearing threshold led to changes.

In relation to the effects on the brain, Nishimura and his co-workers (1987, as cited in Leventhall, 2003) found that 16 Hz at 100 db to 120 db led to a reduction in the rate of working, probably due to an impaired concentration in rats. As 16 Hz is related to beta waves it seems that the results obtained are due to an increased brain activation at 16 Hz, as beta waves are associated with sleep, which could explain an impaired concentration.

In another study, Cheng and his co-workers (2012) found that infrasound exposure of 16 Hz at 130 dB for one hour on cultured rat hippocampal neurons significantly resulted in axonal degeneration (relatively independent of neuronal cell death (Cheng et al, 2012). These findings on axonal degeneration are interesting because, according to Cheng et al (2012), a growing evidence suggests that axonal degeneration is responsible for a variety of central nervous system dysfunctions (Song et al, 2006; Coleman & Perry, 2002; Finn et al, 2000). Feeling of indisposition, decrease in memory and performance, sleep disturbance and headache are some examples of possible central nervous system dysfunctions (Cheng et al, 2012). Furthermore Liu and his co-workers (2004, as cited in Cheng et al., 2012) found that long-term exposure to infrasound caused apoptosis of rat hippocampal neurons *in vivo*.

A further study on the effects of infrasound on adult rats showed that 16 Hz at 130 dB led to a significant decrease of the number of newly generated cells in the subgranular zone. These effects ceased after some days of infrasound exposure. Thus, such effects of infrasounds with a certain sound pressure are said to be temporary but not permanent.

Moreover, according to Liu et al (2010) it was found that infrasound exposure led to histopathological or histomorphological changes or impairments in liver, myocardium and lung (Nekhoroshev & Glinchikov, 1992; Svidovyi & Glinchikov, 1987; Alekseev et al, 1983). There are obviously quite a lot of studies (only a few have been mentioned here) proofing the significant effect of infrasound on animals.

Another interesting study investigated the effects of cannabis on rat brain activity. It was shown that potent agonists of brain cannabinoid receptors (CP55940) influenced brain waves. In detail, decreased hippocampal theta and prefrontal gamma and a disrupted theta-frequency coherence between the two structures has been observed. These changes in the brain waves led, amongst others, to reduced accuracy of task performance (Kucewicz et al., 2011). The results show the importance of brain waves and thus also frequencies. Furthermore these findings are interesting as they show that cannabis, which leads to an altered state of consciousness, induces such a mental state through changing the brain activity and influencing brain waves. Thus it looks like the approach to change the brain activity with alpha- and theta wave frequencies to reach a changed state of consciousness is plausible.

According to the discussed literature it is clear that animals can be significantly influenced with infrasounds.

2.4.5 Binaural beats and their effects on humans

Binaural beats are usually applied in the frequency range of infrasound. When two different frequencies are played one to each ear simultaneously, a third frequency will be heard, which is the subtraction of both incoming frequencies. This third perceived frequency is called binaural beat. Binaural beats are said to influence the brain activity at the frequency of the perceived binaural beat and are therefore applied for i.e. relaxation or concentration. Although binaural beats are famous it seems that their status is not legitimate. This is due to the fact that it seems that *monaural beats*[11] evoke better effects (Becher et al., 2014) and that studies on binaural beats are rare, contrary and mostly no effect is found on subjective well-being and EEG activity.

To give an example, one study tested the effects of an alpha binaural beat of 10 Hz and a beta binaural beat of 20 Hz on EEG activity (Vernon et al., 2014). The study revealed no significant results (Vernon et al., 2014). Thus it has to be assumed that binaural beats do not have an effect on the brain activty and cannot infleunce it.

Another study on the effects of binaural beats on brain activity, where participants were exposed for five minutes to binaural beats at 1 Hz (delta), 5 Hz (theta), 10 Hz (alpha) and 20 Hz (beta) did not achieve significant results (Gao et al, 2014). It can

[11] Monaural beats means that two different frequencies are played together on both ears at the same time and a third frequency (wich is the subtraction of the both) will be perceived. Contrary to binaural beats, the two slightly differing frequencies are played on both ears and not just one frequency on one ear.

therefore be concluded that the human brain does not have a tendency to change its dominant EEG frequency under binaural beats stimulations (Gao et al, 2014).

Furthermore it has been found that binaural beats in the beta range (16 Hz to 24 Hz) in comparison to binaural beats in the theta/delta range (1.5 to 4 Hz) have a positive effect on psychomotor performance and mood (Lane et al., 1997). As this is just a comparison between two different binaural beat stimulations and was not compared with a control group, the results suffer from methodological errors.

Another study which looked at the effects of binaural beats on the brain activity measured with EEG, compared two different conditions (Wahbeh et al., 2007). The experimental condition consisted of a 30 minutes auditory stimulus of binaural beats at 7 Hz with an overlay of pink noise (sound of rain) and the control condition consisted of the same auditory stimulus but without a binaural beat. No significant differences between both conditions have been found for any of the EEG measures (Wahbeh et al., 2007). But a significant increase of the Profile of Mood States depression subscale was found for the experimental condition compared to the control group (Wahbeh et al., 2007). Furthermore, also a significant decrease in immediate verbal memory recall in the experimental condition compared to the control condition has been found (Wahbeh et al., 2007). Another study was also not able to show any effect of binaural beat on the brain activity, but this study found significant effects of binaural beats on mood and verbal memory recall. Since there was no effect on brain activity, the change in mood and decrease in verbal memory recall must be due to something else. It could be due to an experimenter-participant-interaction, meaning that the subjects in the experimental condition knew that they are in a somehow special situation. But it could also be due to a wrongly applied EEG measurement. It is also possible that the effects observed are due to the binaural beat perceived as unpleasant and as a distraction, and therefore had no effect on brain activity. Since this is not clear it has to be assumed again that binaural beats do not affect humans.

A further study showed that binaural beat stimulation around 2 to 8 Hz on young elite soccer players significantly improved subjective ratings of sleep and awakening quality, sleepiness and motivational state, but it had no impact on their perceived physical state (Abeln et al., 2014). This study shows an effect of binaural beats on humans, however, since the majority of the discussed studies on binaural beats until now showed no significant effect, it has to be assumed that binaural beats do not affect humans. Furthermore the found effect of the study of Abeln and his co-workers (2014) could be due to another variable not collected in their study.

The shortness of this chapter is due to the reason that, according to the discussed literature, it has to be assumed that binaural beats are not able to change mood or EEG activity in humans. The fact that binaural beats do not have an effect on humans is no argument against the thesis that infrasound has an effect, since binaural beat is physically not present and is only a psychological phenomenon. Thus, it can be further assumed that, as the physical infrasound frequency is not present, it cannot have any effect on humans, because it cannot trigger resonance phenomena, nor can it follow the principle of superposition of waves. It seems that the popularity of binaural beats is due to the "magical" phenomenen of perceiving a third frequency which is physically not present. Furthermore, also the fact that two different frequencies are played simultaneously on one ear each, may also support the interest in binaural beats and an imagined effect on humans.

2.5 Summary

In this chapter the four discussed topics will be summarized.

As discussed in *chapter 4.1* it can be said that the opinions on music and its effect in inducing a changed state of consciousness, such as trance, are different.

While Neher (1962), Kartomi (1973), Arrien (1996), Haerlin (1998), Hutson (2000) and Sundar (2007) believe in the ability of music in inducing a trance-state, Rouget (1985) and Fachner (2006) negate it.

As discussed it seems that the power of music in inducing a changed state of consciousness lies in the repetitive rhythmns (Neher, 1962; Kartomi, 1973; Arrien, 1996; Haerlin, 1998; Hutson, 2000 and Sundar, 2007).

Rouget (1985) on the other hand points out that music is not universal in inducing a changed state of consciousness, because people in Ghana can reach a trance state spontaneously without music. This argumentation is misleadingly, as it just states that there are also other factors which can trigger an altered state of consciousness, and it does not deny that music itself can have a universal property in inducing a changed state of consciousness.

Moreover in life it is normal that a lot of different factors can lead to a special state, i.e. illness or weight loss. As an example, smoking can lead to serious illnesses such as lunge cancer, but there are also other factors which can lead to this illness. Only because of the existence of other factors we cannot deny the fact that smoking can lead to serious illnesses. As we cannot deny this special case, we cannot deny the music's ability in inducing an altered state of consciousness.

Furthermore a lot of studies proof the effect of rhythmic flashing light at certain frequencies on the activity of the brain (photo-driving) and the related change of consciousness. Therefor it can be supposed that such phenomenons can be produced by other frequency-stimuli as well, like acoustic stimuli.

As the cited studies are sometimes lacking information, results and profound argumentation, it is important to have new studies concerning this topic. Therefore this masters thesis will try to find an answer in an empirically valid way.

In *chapter 4.2* it was demonstrated that there are four similar brain areas activated by listening to music and meditating. These are the *precentral gyrus*, parts of the *anterior cingulate cortex, hippocampal formations* (or *hippocampus*) and the *midbrain*. It was further shown that each of these areas has a function which can be related to an altered state of consciousness. According to Kjaer and his co-workers (2002, p. 255) an altered state is understood as the experience of three different aspects wich are an enhancement of sensory stimulations, loss of conscious control of actions and imagination. As discussed, all the brain areas found to be active, contribute at least to one of these functions. Thus they seem to be really important brain areas for experiencing altered states of consciousness. Since there are similar brain areas activated by both actions, passive music and meditation, it is reasonable to assume that these altered states of consciousness are similar.

Moreover it was shown that long-term practice of both active music making and meditation have the same effects on the brain structure. In detail, both actions lead to an increase of grey matter volume in the inferior temporal gyrus. It was further shown that the inferior temporal gyrus is related to an altered state of consciousness because of its function in visual perception, which can be understood as imagination, an important aspect of an altered state of consciousness. With respect to the fact that long-term practice of active music and mediation have the same effect on grey matter volume of the inferior temporal gyrus, and that music and meditation activate the same brain areas important for an altered state of consciousness, it seems very likely that music and meditation induce similarly altered states of consciousness.

This result is given under the premise, that the brain areas which were found to be active in both cases (passive music and meditation), are really activated, as argued, because of their function in inducing an altered state of consciousness and not because of another function, not related to such a state. If for example the activation of these brain areas is a consequence of another stimulus, the main hypothesis would not hold true. However, the hypothesis receives strong support by the effects of long-term practice of both active music and meditation on the grey matter volume of the inferior temporal gyrus. Again this increase of grey matter could be the consequence of another stimulus during both actions. In this case the respective brain areas would have to be activated or changed because of another stimulus mediated/communicated by music or meditation, and which does not relate to an altered state of consciousness.

Summarizing, in view of the results presented, it appears to be reasonable to assume that music and meditation are capable of inducing an altered state of consciousness. Nevertheless, there are open questions remaining, which will have to be addressed by further investigations.

As discussed above, it appears to be pretty reasonable that the simultaneous use of passive music and meditation facilitates the entering into an altered state of consciousness during meditation because it activates the same brain areas, which are important for experiencing an altered state of consciousness.

Moreover it is hypothesized that the identified brain areas activated or changed similarly by music and meditation, are generally the brain areas necessary to actually experience an altered state of consciousness. In other words, the physiological action of these brain areas could explain an altered state of consciousness.

To illustrate the possibe physiological pathway to an altered state of consciousness the following model was designed.

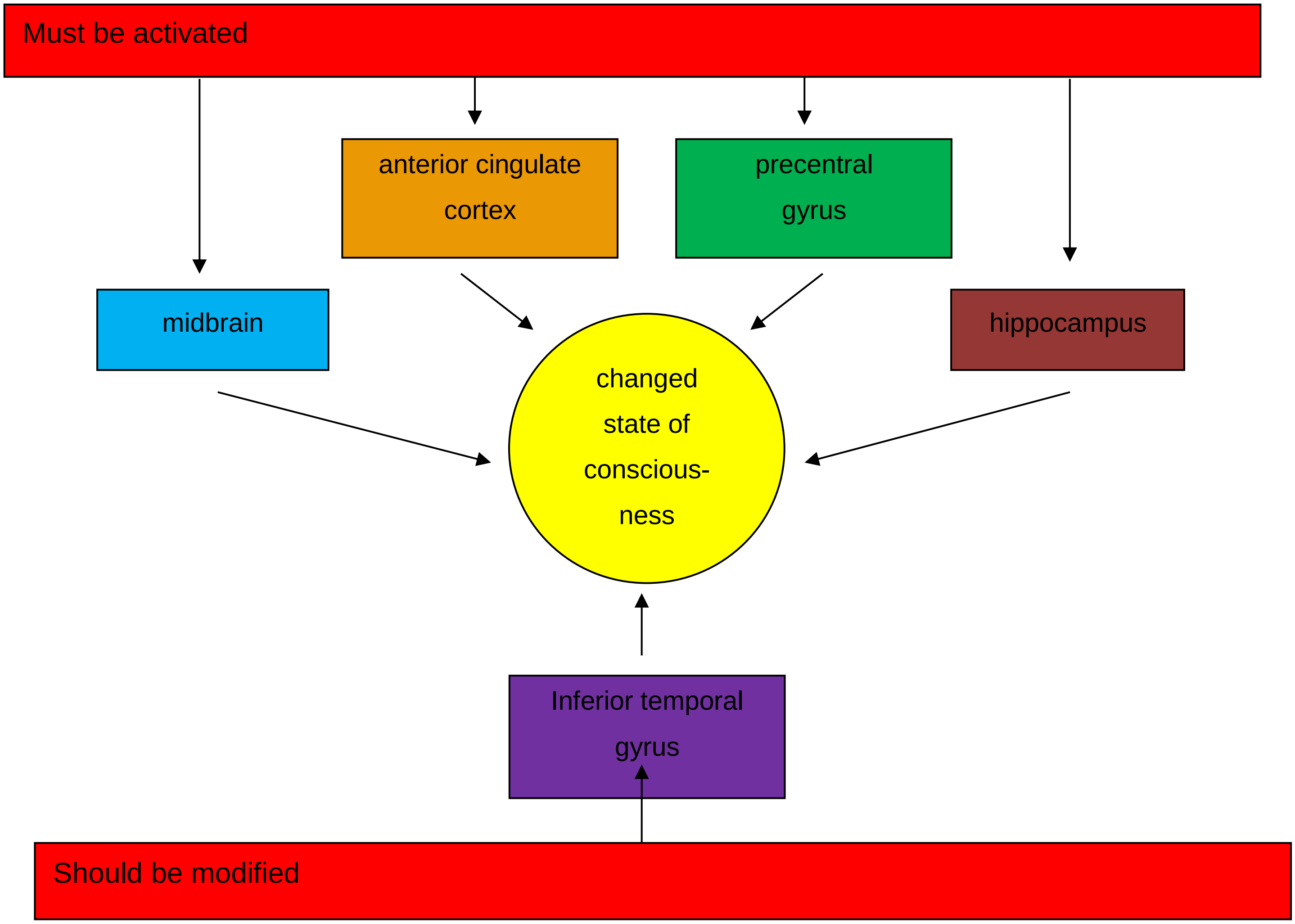

Fig. 9: Model of the possible physiological pathway to an altered state of consciousness

This model shows the four brain areas in humans which have to be activated and one brain area which should be be modified so that someone can experience an altered state of consciousness.

If these hypotheses hold true, then more successful and easier ways to experience an altered state of consciousness could be provided. This would be of course very helpful for mankind, because altered states of consciousness are related to relaxation, enhancing power and healing. For example it could be determined which kind of music stimulates the five important brain areas to experience an altered state of consciousness the most. This of course would require further research. Magnetic resonance imaging (MRI) studies would be useful to investigate which kind of music activates these brain areas the most. Moreover it would be interesting to find out whether there is proof for the above stated model of the physiological pathway to an altered state of consciousness. Furthermore, it would be interesting to find out whether stimuli other than music or meditation have an effect on these brain areas and can induce altered states of consciousness. Last, it would also be interesting to find out whether such states can in fact activate self-healing mechanisms. Are altered states of consciousness, induced by music, meditation or other means the medicine of tomorrow?

The large amount of studies on meditation and EEG discussed in *chapter 4.3* sheds more light to specific brain oscilllations active during meditation. In summary it was found that alpha- and theta activity is significantly increased while meditating (Ahani et al, 2014; Lagopoulos, 2009; Lo & Leu, 2005; Takahashi et al, 2005; Aftanas & Golosheikin, 2002; Andresen, 2000; Shimokochi, 1996; Fenwick, 1987; Delmonte, 1984; Shapiro & Walsh, 1984; Pagano & Warrenburg, 1983; Schuman, 1980; Shapiro, 1980; West, 1980; West, 1979; Davidson, 1976; Woolfolk, 1975). Furthermore it was found that these two brain waves are mostly significantly increased in the frontal area of the brain (Lagopoulos, 2009; Takahashi et al, 2005; Aftanas & Golosheikin, 2002). Alpha activity in this area is related to internalized attention, whereas theta activity in the frontal area is related to mindfulness (Takahashi et al, 2005). Of further interest are recent studies, which state that not the whole alpha and theta bands are specific for meditation, but actually the slow alpha (8.2-9.77 Hz) and fast theta (6.25-7.81 Hz) appear to be most important (Takahashi et al, 2005; Aftanas & Golosheikin, 2002; Lo & Leu, 2005). It is important to state here in addition that the findings reported for most studies did not split alpha bands into smaller ones, like slow and fast alpha. Thus it can be assumed that these studies would eventually have come to similar results.

To give an easy overview of the disussed findings on meditation and EEG the following *table 4* was designed.

Table 4: Results on Meditation and EEG of alpha- and theta waves

Results on meditation and EEG of alpha- and theta waves	
Paper	**Results**
Takahasi et al, 2005	increase of slow alpha and fast theta activity in frontal area
Ahani et al, 2014	increase in power in alpha, beta and theta bands
Aftanas & Golosheikin, 2002	increase in theta- and slow alpha powers in the frontal area
Lagopoulos et al, 2009	increase in alpha- and theta power in posterior, frontal and temporal-central regions
Andresen (2000), Davidson (1976), Delmonte (1984), Fenwick (1987), Pagano and Warrenburg (1983), Schuman (1980), Shapiro (1980), Shapiro and Walsh (1984), Shimokochi (1996), West (1979, 1980) and Woolfolk (1975)	increase in theta- and alpha band power and decrease in overall frequency
Lo and Leu, 2005	dominant frequency was 9.26Hz

The large amount of studies demonstrating a significant increase of theta and alpha waves when meditating, leads to the assumption that the increase of both alpha-and theta waves are characteristic for a meditative state. Although some previously mentioned studies were not able to proof an increase (Lehmann et al, 2004; Jacobs et al, 1996), they are limited and it is assumed that the differences of their findings can be explained by the methodology applied, since the large majority of studies on EEG and meditation found an increase of alpha- and theta activity when meditating.

As further discussed, it seems to be convincing that the frequency range from higher theta (≈6-8Hz) to lower alpha (≈8-10Hz) is the most important for meditation (Lo & Leu, 2005; Takahashi et al, 2005; Aftanas & Golosheikin, 2002;).

Thus, the following experiment will consist of a condition with a frequency band ranging from 6 to 10 Hz, played repeatedly to the subjects, to see whether, similar to a photo-driving effect, acoustic frequencies can also influence the activity of the brain. Moreover, because of a kind of "alpha-wave hype" in the alternative scene with binaural beats and other stimulations, which have no scientific proof, it seems to be necessary also to study this topic in a scientifically valid way.

Fig. 10 shows a model which was designed to highlight the relation of alpha- and theta waves to meditation and to show a possible biological pathway from the beginning of meditation until the feeling of a meditative state, with a focus on brain waves activity.

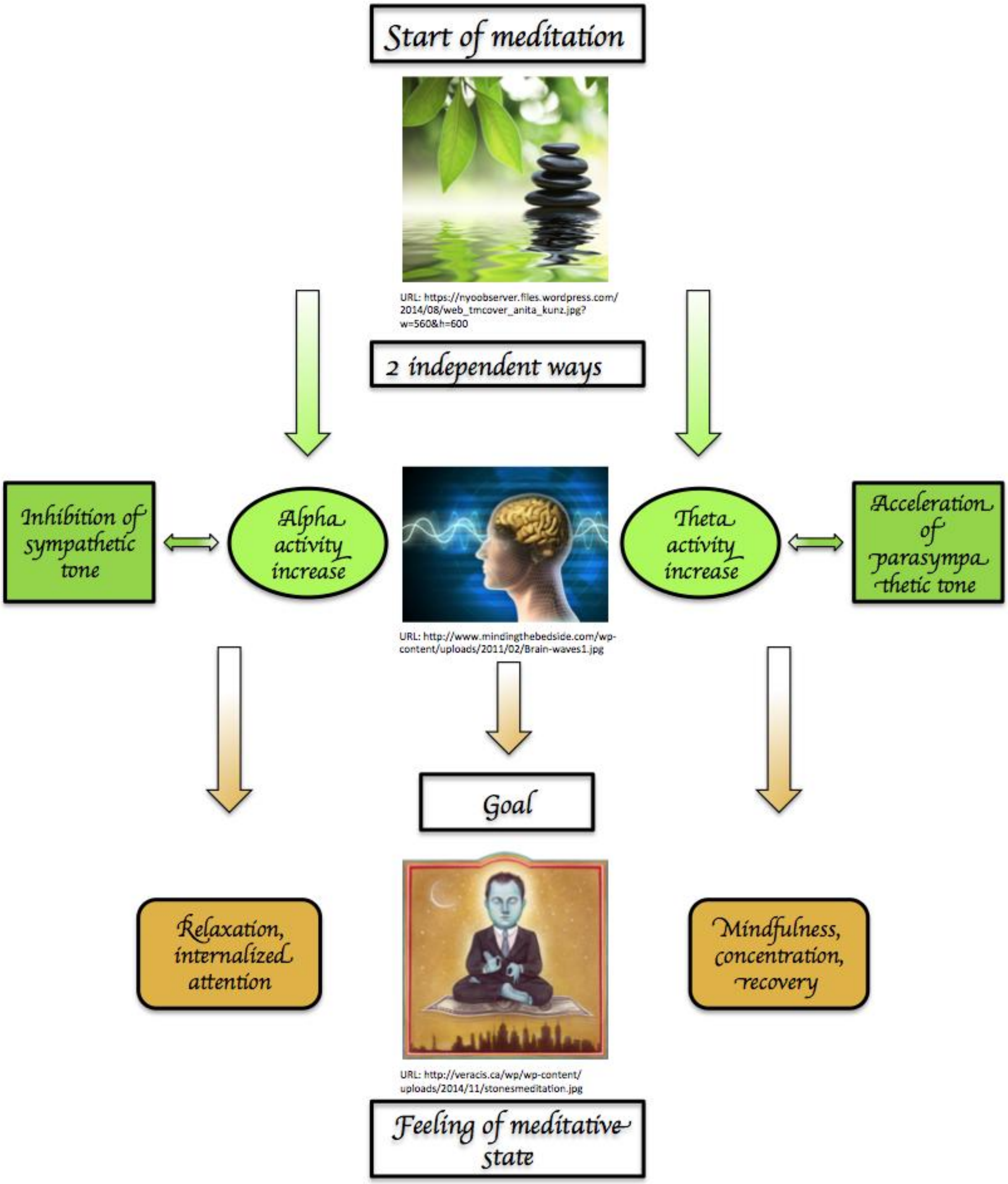

Fig. 10: Model of the possible biological pathway (focused on brainwaves) from the beginning of meditation until the feeling of a meditative state.

In *chapter 4.4* three topics have been discussed to evaluate whether the questioned effect of infrasounds on human wellbeing and brain activity really takes place. These three topics were the effects of infrasounds on humans, the effects of infrasound on animals and the effects of binaural beats.

According to the first topic it can be summarized that infrasounds really affect people. Most studies have been found to proof a negative effect than a positive one. But as previously discussed, the found negative effects could be due to other frequencies than that of alpha- or theta waves. Furthermore, the negative effects found must not be of negative value for the topic of meditation. To give an example, it was found that certain frequencies lead to an increase in reaction time as well as sensations of lethargy (Evans & Tempest, 1972) which was, related to the cited study, a negative effect, but concerning a meditative state, an increased reaction time could be due to the experienced altered state while meditating. Most important here is that it was found that infrasounds in fact really affect humans. Thus it can be assumed that although mostly negative effects have been found, positive ones are also possible when using the right frequency and sound pressure level. Furthermore, it is possible that infrasounds positively affect people as some studies proofed such an effect. The discussed results furthermore depend on the applied sound pressure levels, as infrasounds exceeding a certain sound pressure level are consciously detectable by humans (see *chapter 4.4.2*). In most of the cases the sound pressure levels for the infrasounds have been above the hearing threshold. But other studies also proofed a significant effect of infrasound below the hearing threshold of humans. For the experimental investigation in this master thesis this implies, for the alpha- theta- wave frequency condition, that a stimulus closely below the hearing threshold will be used.

The second topic on the effects of infrasound on animals, showed that infrasounds affect animals. Animals used for the studies were rats and guinea pigs. Infrasounds significantly affect the cell structure in a way as certain processes are inhibited or destroyed within the cell, i.e. axons.

In the majority of cases infrasounds were above the hearing threshold. One study also proofed the effect of infrasounds below the hearing threshold on the animal's liver cell structure (Alekseev et al, 1987). As studies with animals are good indicators for similar effects on humans, the significant result of infrasound on animals is another argument for the effects of alpha wave-frequencies on meditation.

The third and last topic discussed was about binaural beats, as they are applied at the frequency range of infrasound. Binaural beats seem not to affect the human brain activity. It is assumed that this is due to the fact that the binaural beat (or third frequency), which has the infrasound frequency, is physically not present and just a phenomenon of perception. Since this frequency is physically not present it cannot evoke resonance with the brain waves, nor can it lead to a superposition of similar waves. Only one discussed study proofed an effect of binaural beats on improved subjective ratings of sleep and the awakening quality, sleepiness and motivational state, but it had no impact on the perceived physical state of the subjects (Abeln et al., 2014). Since the majority of the discussed studies on binaural beats until now showed no significant effect, it has to be assumed that binaural beats do not affect humans. Furthermore, the observed effects of the study of Abeln and his co-workers (2014) could be due to another variable not collected in their study.

3. Empirical Study

The rationale for this master thesis is to explore possible effects music may have on meditation. Furthermore this thesis tries to show that frequencies below the hearing threshold can influence humans. Therefore two experimental questions will acompany this thesis.

1) Does music have an effect on meditation?
2) Do alpha-theta-wave frequencies have an effect on meditation or relaxation?

To be able to answer these questions in a statistically valid way, different kinds of music (relaxing and arousing) will be compared with no music, and also alpha-theta-wave frequencies (6-10 Hz frequency band) will be compared with no music.
In relation to these questions different hypotheses can be formulated:

H1) Relaxing music has a positive effect on meditation compared to no music and arousing music.
H2) Arousing music has a negative effect on meditation compared to no music and relaxing music.
H3) Alpha-theta-wave frequencies have a positive effect on meditation or relaxation.

Testing these hypotheses will be the content of the following chapters.

3.1 Introduction

To obtain physiological values, the following study used a galvanic skin response (=GSR) measuring instrument. GSR is also known as electrodermal response (=EDR) amongst others and it describes the measurement of electrical conductance of the skin (Benedek & Kaernbach, 2010). This electrical conductance changes with the moisture level of the skin. The moisture level is influenced by sweat glands, which are associated with the sympathetic nervous system. This means that higher activity of the sympathetic nervous system leads to an increase of sweat gland activity, which in turn leads to a higher moisture level and therefore also to an increased skin conductance (Benedek & Kaernbach, 2010). Thus GSR is used to measure psychological or physiological arousal. A special software, named Ledalab (Benedek & Kaernbach, 2010) has been used to compute different interesting values describing GSR. This study used the value CDA.SCR for analysis. CDA.SCR is the average phasic driver within a given response window. According to Benedek and Kaernbach (2010), this score represents phasic activity within a given response window most accurately. At the same time it does not fall back on classic skin conductance response amplitudes.

3.2 Pretest

A pretest was designed to evaluate the best music pieces for the conditions „relaxing“ and „arousing“.

3.2.1 Methods

The pretest comprised two parts. One part evaluated relaxing music while the other one evaluated arousing music. The pretest consisted of eight participants. One of them was excluded, because the participant mentioned background noise produced by the CD-Player. Thus the pretest was run with a PC instead of a CD-Player. All together 7 participants (3 women and 4 men) finished the pretest. The participants ranged in their age from 27 to 62, with a mean of 35.5.

Every participant was tested with the same equipment. The testing equipment consisted of a Compaq 615 Laptop, Sony MDR-V55 earphones and a Yamaha RDX E-700 amplifier.

The preselection of the different music pieces used for the pretest was done according to the findings of Rickard (2004) and Rentfrow & Gosling (2003). According to Rickard (2004) relaxing music should be "soft calm and melodious" (p.376), whereas arousing music should be "rhythmic, dynamic and less melodious" (p.376). Moreover Rentfrow and Gosling (2003) found that heavy metal shows a strong correlation to negative affects like angry and bitter as well as energetic and loud. Genres like hip hop, electronic music (like dubstep) correlate with boastful rhythmic and simple. These findings go hand in hand with the findings of Rickard (2004). Thus the preselection of music included pieces fitting the above mentioned criteria.

The following two tables (*Table 5* and *6*) list all the music pieces, which had been selected for the pretest, divided in relaxing and arousing with their corresponding genre.

Table 5: shows the preselection of relaxing music pieces for the pretest

Music piece	**Genre**
Beethoven Piano Sonata, Op. 13 No. 8, Pathétique II	Classic / piano music
Beethoven - Mondscheinsonate	Classic / piano music
Chopin - Nocturne, Op. 9 No. 1	Classic / piano music
Chopin - Nocturne, Op. 9 No. 2	Classic / piano music
Chopin - Nocturne, Op. 15 No. 1	Classic / piano music
Chopin - Nocturne, Op. 15 No. 3	Classic / piano music
Chopin - Nocturne, Op. 37 No. 1	Classic / piano music
Chopin - Nocturne, Op. 55 No. 1	Classic / piano music
Chopin - Prélude, Op. 28 No. 4	Classic / piano music
Chopin - Prélude, Op. 28 No. 6	Classic / piano music
Chopin - Prélude, Op. 28 No. 7	Classic / piano music
Chopin - Prélude, Op. 28 No. 21	Classic / piano music
Chopin - Regentropfen Prélude, Op 28, No. 15	Classic / piano music
Debussy - Claire de Lune	Classic / piano music
Debussy - Rêverie	Classic / piano music
Debussy, Sarabande pour le Piano	Classic / piano music
Erik Satie - Gnossienne No.1	Classic / piano music
Erik Satie - Gnossienne No.2	Classic / piano music
Erik Satie - Gnossienne No.3	Classic / piano music
Erik Satie - Gnossienne No.4	Classic / piano music
Erik Satie - Gnossienne No. 5	Classic / piano music
Erik Satie - Gymnopédie No.1	Classic / piano music
Erik Satie - Gymnopédie No.2	Classic / piano music
Erik Satie - Gymnopédie No.3	Classic / piano music
Schumann - Kinderszenen Op.15, I. Von Fremden Ländern und Menschen	Classic / piano music

Table 6: shows the preselection of arousing music pieces for the pretest

Music piece	Genre
Bloodspot - By the Horns	Death Metal
Bloodspot - Consumed By Hatred	Death Metal
Bloodspot - Death Illusion	Death Metal
Bloodspot - Volcanos	Death Metal
Booba - Bakel City Gang	Hip Hop – Rap Hardcore
Das EFX – Hardcore Rap Act	Hip Hop
Deficiency - A Way Out Of Nowhere	Melodic Trash Metal
Deficiency - Unfinished	Melodic Trash Metal
Gore Elohim - Electric Lucifer	Hip Hop
Gore Tex - Momentary Of Lapse Of Reason	Hip Hop
György Ligeti _ Requiem	Klassik - Avantgarde
Immortal – All Shall Fall	Death Metal
Kaaris - Zoo	Hip Hop
Non Phixion -There is no future (ft._necro)	Hip Hop
Olivier Messiaen - Quatuor pour la fin du temps	Klassik - Avantgarde
Ornette Coleman - Free Jazz	Free Jazz
Pierre Boulez - Structures I & II	Klassik - Avantgarde
Skrillex - Bangarang feat Sirah	Dubstep
Skrillex - DnB Ting	Dubstep
Skrillex - First Of The Year	Dubstep
Skrillex - Kill Everybody	Dubstep
Skrillex - Rock n Roll	Dubstep
Skrillex - Try it out [ft Alvin Risk]	Dubstep
Skrillex -Ragga Bomb with Ragga Twins	Dubstep
Stockhausen - Helikopter Streichquartett	Klassik - Avantgarde
Stockhausen - Klavierstück IX	Klassik – Avantgarde
Stockhausen - Luzifers Abschied	Klassik – Avantgarde
Stravinsky - Rite of Spring Sacrificial Dance	Klassik
System Of A Down - Chop Suey!	Alternative Metal

The Prodigy - Breathe	Drum and Bass
The Prodigy - Firestarter	Drum and Bass
The Prodigy - Wild Frontier	Drum and Bass

The pretest took around 45 minutes per participant. Each participant started randomly with either the relaxing or the arousing part of the pretest. Also the presentation of the music pieces, of both parts, was in a randomized order. For each music piece the participants were asked to turn the volume of the amplifier to a comfortable volume. Each volume was documented by the experimenter, to be able to reconstruct the sound pressure level afterwards in the lab. As the sound pressure level (SPL) has an effect on the perception of music, this was an important step to make sure to be able to control the variable SPL in the main study and to see whether there are big differences in the ratings of subjective comfortable volumes.

The participants also had to rate 4 different rating scales from 1 to 7 (1 stood for „not at all“ and in ascending order 7 for „a lot“) for each music piece. First participants were asked to rate „how relaxing the music piece is“, second, „how arousing the music piece is“, third „how familiar they are with the music piece“ and fourth, „how much they liked the music piece“.

3.2.2 Results

The mean ratings were calculated for the relaxing and arousing parts. For the relaxing part of the pretest the music pieces with the highest mean ratings on relaxing and simultaneously with the lowest mean scores on arousing and familiarity were chosen. Low scores on familiarity were favoured because it makes it possible to control the variable familiarity and to avoid the influence of familiarity on the outcome of the main study. *Table 7* shows the music pieces which were chosen for the relaxing part. For both the relaxing and the arousing condition of the main study, music pieces were chosen to obtain a duration of 30 minutes. This was necessary, as participants had to meditate for 30 minutes in the main study.

Table 7 shows the music pieces chosen for the relaxing part

Chopin - Nocturne, Op. 37 No.1
Chopin - Nocturne, Op. 55 No.1
Chopin - Prélude, Op. 28 No. 7
Debussy - Rêverie
Erik Satie - Gnossienne No.1
Erik Satie - Gnossienne No. 2
Erik Satie - Gnossienne No. 3
Erik Satie - Gymnopédie No. 3

Table 8 shows the number of participants (N), mean ratings, standard deviation (SD), minimum and maximum for "relaxing“, "arousing“, "familiarity“ and "liking" for the relaxing part of the pretest.

Table 8: shows the mean scores for the music pieces of the relaxing part of the main study

	N	mean	SD	minimum	maximum
Relaxing	7	6.13	0.573	5.50	7
Arousing	7	1.98	1.135	1	4.25
Familiarity	7	3.57	1.757	1.88	6.38
Liking	7	5.55	1.168	3.75	7

For the arousing part of the pretest the music pieces with the lowest mean ratings on relaxing and familiarity and simultaneously with the highest mean scores on arousing were chosen for the main study. *Table 9* shows the music pieces, which were chosen for the arousing part.

Table 9 shows the music pieces chosen for the arousing part

Bloodspot - By the Horns
Bloodspot - Consumed By Hatred
Bloodspot - Death Illusion
Bloodspot - Volcanos
Deficiency - Unfinished

Immortal - All Shall Fall
Skrillex - Bangarang feat Sirah
Skrillex - DnB Ting
Skrillex - Rock n Roll
Skrillex - Try it out [ft Alvin Risk]
Skrillex -Ragga Bomb with Ragga Twins
~~Stockhausen – Helikopter Streichquartett~~ ↓
The Prodigy – Wild Frontier

Since „Stockhausen – Helikopter Streichquartett“ is the only music piece representing the classic-avantgarde genre, it was removed to enable an internal consistency of the arousing music pieces by their type and genre. Instead of „Stockhausen – Helikopter Streichquartett“ „The Prodigy – Wild Frontier“ was chosen as it is the next best rated music piece (according to the previously mentioned criteria).

Table 10 shows the number of participants, mean ratings, standard deviation, minimum and maximum for „relaxing“, „arousing“, „familiarity“ and „liking“ for the arousing part of the main study.

Table 10: shows the mean scores for the music pieces of the arousing part of the main study

	N	MW	SD	Minimum	Maximum
Relaxing	7	1.55	0.448	1.17	2.42
Arousing	7	5.73	0.736	4.75	6.67
Familiarity	7	2.06	0.575	1.17	3.08
Liking	7	2.76	0.499	1.92	3.42

As mentioned already before, the volume was documented to control the mean comfortable loudness. The mean volume adjustments for each music piece had been computed. *Table 11* and *12* show the mean voulme ratings for the relaxing ad arousing music pieces.

Table 11: shows the mean volume ratings for the relaxing music pieces

name	mean volume	rounded
Chopin - Nocturne, Op. 37 No.1	21.57	22
Chopin - Nocturne, Op. 55 No.1	22.29	22
Chopin - Prélude, Op. 28 No.7	20.71	21
Debussy - Rêverie	21.57	22
Erik Satie - Gnossienne No.1	21.43	21
Erik Satie - Gnossienne No.2	21.57	22
Erik Satie - Gnossienne No.3	21.43	21
Erik Satie - Gymnopédie No.3	22.71	23
mean	**21.66**	**22 (sd=0.707)**

Table 12: shows the mean volume ratings for the arousing music pieces

name	mean volume	rounded
Bloodspot - By the Horns	12.29	12
Bloodspot - Consumed By Hatred	13	13
Bloodspot - Death Illusion	12.57	13
Bloodspot - Volcanos	12.71	13
Deficiency - Unfinished	12.43	12
Immortal - All Shall Fall	14.29	14
Skrillex - Bangarang feat Sirah	12.14	12
Skrillex - DnB Ting	14	14
Skrillex - Rock n Roll	12.14	12
Skrillex - Try it out [ft Alvin Risk]	13.29	13
Skrillex -Ragga Bomb with Ragga Twins	13.14	13
The Prodigy – Wild Frontier	14.29	14
mean	**13.02**	**13 (sd=0.793)**

In a room of the *Institute of Electronic Music and Acoustics* the testing situation of the pretest was readjusted with the same equipment used in the pretest. The earphones were placed on a head simulator (see *Fig. 11*) to be able to get the real sound pressure level which arrives at the ears of the participants. The sound was sent to the headphones with an external soundcard, able to produce frequencies from 6 to 10 Hz. The external sound card was connected with an HP laptop.

Fig. 11: shows the head simulator and the reconstructed testing situation

A calibrated signal of exactly 94dB was played to the head simulator and recorded. This recorded signal was then analyzed and taken as the reference value to compute the mean sound pressure levels of the different music pieces. As the mean volume values differ between 12 and 14 for relaxing and 21 and 23 for arousing, a pink noise of 1 kHz with an amplitude of 0.5 and 30 seconds duration was produced and played to the head simulator with the volumes 12, 13, 14, 21, 22 and 23 to compute their differences in dB. *Table 13* shows the volume values and their corresponding dB values.

Table 13: shows the volume values and their corresponding dB (rounded)

volume	**level**	**dB (rounded)**
12	-33	69 dB
13	-31	71 dB
14	-29	73 dB
21	-17.3	85 dB
22	-15.5	87 dB
23	-14.3	88 dB
calibrating signal	-8	94 dB

As shown in *Table 13* the mean value (13) of all the arousing pieces corresponds to 71dB. Therefore the minimum (69dB) and maximum (73dB) mean volume ratings for each arousing music piece are 2dB above or below this. This difference is very low and therefore applicable. Moreover it can be seen that the mean value (22) of the relaxing music pieces corresponds to 87dB. This is 2dB above the mean minimum (85dB) value and just 1dB below the mean maximum (88dB) value of each relaxing music piece. Again this is such a small difference that there is no real discrepancy. Since the differences in sound pressure level are small, the overall mean volume values for relaxing and arousing are applied to all the selected music pieces. Thus the variable loudness is controlled for the main study and it can be assumed that possible results of the main study are not due to the loudness. Moreover as can be seen in *Tables 11 and 12* the standard deviation is really low for the volume values (relaxing sd=0.707 and arousing sd=0.793)

Furthermore, all the selected music pieces have been recorded via the head simulator with their mean volume value (see *Tables 11* and *12*). These recordings have then been analyzed according to loudness units in dBA with the software *ableton live*. The following *Table 14* shows the dBA for all the music pieces.

Table 14 shows the computed dBA for all the selected music pieces

Name of file	dB_A (LU)
Bloodspot - By the Horns	81.1
Bloodspot - Consumed By Hatred	80.9
Bloodspot - Death Illusion	79.8
Bloodspot - Volcanos	79.9
Deficiency - Unfinished	81
Immortal - All Shall Fall	79
Skrillex - Bangarang feat Sirah	82.6
Skrillex - DnB Ting	81.3
Skrillex - Rock n Roll	82.9
Skrillex - Try it out [ft Alvin Risk]	83
Skrillex -Ragga Bomb with Ragga Twins	81.1
The Prodigy – Wild Frontier	78.8
Chopin - Nocturne, Op. 37 No.1	76.1
Chopin - Nocturne, Op. 55 No.1	71.6
Chopin - Prélude, Op. 28 No. 7	76.7
Debussy - Rêverie	77.9
Erik Satie - Gnossienne No.1	77.1
Erik Satie - Gnossienne No. 2	74.7
Erik Satie - Gnossienne No. 3	75.4
Erik Satie - Gymnopédie No. 3	66.4

Table 14 shows the differences in dBA between the single music pieces is bigger than the previously dicussed differences. These are due to the different recordings and compressions of the music pieces. But, as previously mentioned all the music pieces in the main study are played with the overall mean volume ratings. Thus these differences in dBA become less in the main study and are therefore not of interest for the discussion.

Furthermore the ability of the headphones to produce frequencies from 6 to 10 Hz was tested with the head simulator. A 6 to 10Hz frequency band was produced and then recorded with the head simultaor via the headphones. The recorded signal was further analyzed according to the sound pressure level and whether by-products like higher audible frequencies were produced due to technical limitations of the headphones.

Two different headphones, namley *Sony MDR-V55* and *Beyerdynmics DT 770 Pro* were tested, and it turned out that the Sony headphones produced more misleading higher frequencies with audible artifacts. As the Beyerdynamics headphones did not produce audible artifacts at a particular SPL, these headphones were used for the main study. It has to be mentioned that the Beyerdynamics headphones were used by every participant and in every condition. In relation to the before mentioned calibrated signal, the Beyerdynamics headphones, played the 6 to 10Hz frequency band with 71.81dB left and 73.43dB right. As mentioned already in chapter 4.4, these values are below the hearing threshold.

3.2.3 Discussion

Based on the mean scores in *Tables 8 and 10*, the chosen music pieces for the conditions relaxing and arousing, evoke the right feelings in the participants. While the mean score of „relaxing“ is really high for the relaxing music pieces (mean=6.13, sd=0.573, n=7), it is really low for the arousing music pieces (mean=1.55, sd=0.448, n=7). On the other hand, the mean score of „arousing“ is really low for the relaxing music pieces (mean=1.98, sd=1.135, n=7), but really high for the arousing music pieces (mean=5.73, sd=0.736, n=7). For both the relaxing music condition and the arousing music condition, the mean ratings on familiarity are low (relaxing: mean=3.57, and arousing: mean=2.06). This is a good outcome as it can be assumed that possible results found in the main study are not affected by familiarity with the music pieces. Furthermore the selected music pieces really evoke the feelings they should (arousing and relaxing). The mean ratings on liking are much higher for the relaxing music pieces (mean=5.55 and sd=1.168) than for the arousing music pieces (mean=2.76 and sd=0.499). As liking of the music pieces might have an effect on the results, the variable musical preference will be controlled with the STOMP-R questionnaire in the main study.

The differences between the sound pressure level of the selected music pieces is is very small and it can thus be assumed that SPL will not have any influence on the outcome of the main study. Furthermore the Beyerdynamics seem to be good in producing 6 to 10 Hz frequencies, as they do not produce audible artifacts and reach about 73dB maximum at these frequencies. This level is below the hearing threshold (97dB are necessary for 10 Hz). Therefore it can be assumed, that the Beyerdynamics are acceptable headphones for the purpose in the main study.

3.3 Main Study

3.3.1 Introduction

The focus of the main study is to answer the two experimental questions:

1) Does music have an effect on meditation?

2) Do alpha-theta-wave frequencies have an effect on meditation or relaxation.

In relation to these questions different hypotheses have been stated.

1) Relaxing music has a positive effect on meditation compared to no music and arousing music.

H3) Alpha-theta-wave frequencies have a positive effect on meditation or relaxation

2) Arousing music has a negative effect on meditation compared to no music and relaxing music.

3) Alpha-theta-wave frequencies have a positive effect on meditation or relaxation compared to no music.

In this context, positive effects on meditation have been collected in different ways, like with a concentration test, an anxiety questionnaire and galvanic skin response measurements. Moreover positive effect has been evaluated by ratings on the easiness or time to get into a meditative state, as well as the felt degree of relaxation, intensity, happiness, tranquilization and tiredness while being in a meditative state.

To prove these hypotheses, the main study consisted of 4 different conditions namely “relaxing music”, “arousing music”, “no music” and “alpha-theta wave frequencies”.

3.3.2 Material

For the arousing music condition, the selected music pieces from the pretest were cut into 40 to 60 seconds parts. Only the most stressful parts of each music piece have been taken into account. Then they were randomly arranged to obtain 30 minutes of music. This combination was necessary to prevent participants of getting used to the music and facilitate a more relaxed state. For every part there was a short fade-in and -out.

For the relaxing music condition all the selected music pieces from the pretest were also randomly arranged to obtain 30 minutes of music. Here again, each music piece consisted of a fade-in and -out.

The produced 6-10HZ frequency band audio file lasted exact 8 minutes and 18.5 seconds. Thus 3 of these files were arranged. The last one had been cut at 30 minutes.

The "no music" condition consisted of no sound.

At the end of every condition a bell-sound, indicating the end of meditation, was added.

3.3.3 Methods

The main study was carried out in a within-subject design. This means that every participant participated in every condition. The conditions were randomly assigned to the participants to prevent sequence effects. The first testing of every participant started with an introduction (see *appendix*) explaining the following steps of the experiment and the fact that they will meditate twice with music and twice without music. They did not get any further information. For example they were not told that there is arousing and relaxing music, and that one of the two conditions without music consisted of alpha-theta-wave frequencies. Furthermore they were asked to give their age, sex and the meditation technique currently practiced. The instruction was followed by the STOMP-R[12] questionnaire (Rentfrow & Gosling, 2003). This questionnaire tests the musical preferences with a list of 23 music genres participants have to rate (see appendix for the whole STOMP-R questionnaire). The results were then differentiated into 4 categories, namely: “Reflective and Complex”, “Intense and Rebellious”, “Upbeat and Conventional” and “Energetic and Rhythmic”.

After the STOMP-R, participants had to answer the STAI-X[13] questionnaire (Laux et al, 1981). This questionnaire is divided into two different questionnaires, one asking for the current state of anxiety, and the other one asking for general anxiety

[12] STOMP-R means "short test of music preferences - revision"
[13] STAI-X means "state trait anxiety inventory - original form X"

(trait), each consisting of 20 different items. For the whole STAI-X questionnaire used in this study see *appendix*.

The STAI-X is followed by a short concentration ability test, named d2-R (Brickenkamp et al, 2010).

In this test participants have to cross out all the d’s with two bars in sum (see *Fig. 12*).

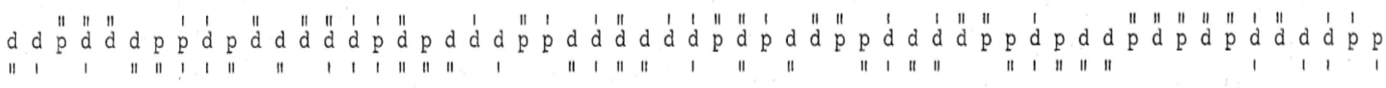

Fig. 12: One row of the d2-R questionnaire

Participants had to work as fast and as correct as possible. For each row they had a maximum time of 20 seconds. After 20 seconds the experimenter tells them “stop, next row”. Usually participants do not finish one row in that time. The test comprises 14 rows.

After the d2-R participants had to meditate for 30 minutes. They were instructed to sit down on a chair in front of a white wall. To sit in front of a white wall while meditating is typical in Zen meditation. As the majority of expert meditators in this study were Zen meditators every participant had to sit in front of a white wall to enable an internal consistency and to avoid effects of different sitting positions on the outcome of the study. The participants then put on the headphones, and the electrodes for the galvanic skin response (=GSR) measurement were placed on the index- and middle finger of the non-dominant hand. Before placing these electrodes, their fingers, as well as the electrodes were desinfected with alcohol to guarantee conductivity and proper measurements. A "neulog GSR sensor" and "USB module", connected to the HP laptop, were used for GSR-measurements. The measurments were recorded by the "neulog software". GSR recordings were measured in microsiemens (µS) and done for the whole 30 minutes of meditation with 10 values per second. All participants were instructed to meditate in the same way as they usually practice meditation. When they never practiced meditation before, they were told to think of a hill with a big wonderful tree. They are sitting under this tree and looking up into the blue sky, where there are some little clouds passing. Furthermore they were told to imagine putting all their occuring thoughts and problems into the clouds and watch them pass by. This should help them to get rid of thoughts and problems and easily getting into a meditative state. After 30 minutes participants heard a bell-sound which indicated the end of the meditation. The same bell-sound occurred after every condition. Therefore participants do not start questioning why they had to wear headphones in the conditions of “no music” and “alpha-theta wave frequencies”, when they didn’t hear anything. This point further made sure that they don’t anticipate that there was a difference between the two silent conditions. Important to add again here is the fact that the participants did not know about the alpha-theta wave frequencies. They were just told that they will meditate twice with no music. This further made sure that possible differences between “no music” and “alpha-theta wave-frequencies” are really due to effects of frequencies from 6Hz to 10Hz.

After meditation participants were asked to rate different ratingscales designed for this study on the experienced meditative state (for the whole questionnaire on the meditative state see *appendix*). The rating scales consisted of numeric choices from 1 to 7, where 1 stood for "not at all" and in ascending order 7 for "a lot". In the following the different questions for the rating scales are listed:

1) *Wie intensiv war der erlebte meditative Zustand?*
2) *Wie einfach war es in einen meditativen Zustand zu kommen?*
3) *Wie entspannend war die Meditation für Sie?*
4) *Wie glücklich fühlten Sie sich während der Meditation?*
5) *Wie sehr hat Ihnen die Meditation gefallen?*
6) *Wieviel beruhigter sind Sie nun, im Vergleich zu vor der Meditation?*
7) *Wie müde waren Sie durch die Meditation?*
8) *Wie schnell sind Sie circa in einen meditativen Zustand gekommen?*

The rating scale for question number 8 did not use the numeric choices from 1 to 7. Instead participants were asked to mark when they thought that they first got into a meditative state (see *Fig. 13*). The answers were then converted into values from 1 to 7 to enable statistical analysis. "1 - 5 Minuten" corrsponded to "1" and in ascending order "gar nicht" to "7".

Fig. 13: Possible choices for question 8

The rating scales were followed by the STAI-X questionnaire again. This time just the state questionnaire was taken, to explore possible effects of the different meditation conditions on anxiety.
After this the participants had to do the d2-R again, to explore possible effects of the different meditation conditions on concentration ability.
The first testing of every participant took about 60 minutes.
The second, third and fourth testing of every participant were in the same order. Only the introduction, the STOMP-R and the trait questionnaire of the STAI-X were not repeated by the participants. These testings took around 45 minutes each.
As a "thank you"- gift, every participant got a coupon for a sound meditation unit at Meditas. Thanks to Mona Schramke (leader of Meditas) for sponsoring this study and the help to find participants.

3.3.4 Participants

22 persons participated in the main study. 3 participants dropped out due to not having enough time. Thus 19 participants completed the whole experiment. 11 out of these participants fell into the criteria of meditation novices, whereas 8 fell into the criteria of meditation experts. While recruiting, participants were asked for their level of expertise in meditation, according to the following ranking:

Wieviel Erfahrung hast du mit Meditation?

1 = gar keine

2 = einmal probiert

3 = ein wenig

4 = ich meditiere immer wieder

5 = ich meditiere seit mindestens 1 Jahr regelmäßig

6 = ich meditiere schon mehr als 3 Jahre regelmäßig

7 = Profi/ Experte – langjähriges regelmäßiges Meditieren

Participants with a higher ranking than 4, where assigned to meditation experts, whereas the ones with a ranking lower than 5 to meditation novices.

The mean expertise for meditation novices was 2.36 with a standard deviation of 1.286. The mean expertise for meditation experts was 5.63 with a standard deviation of 1.061.

Meditation experts were mostly recruited from meditation centres in Vienna. 6 of them were from two different Zen meditation centres, whereas 1 was from a concentration based sound meditation centre. The other one was recruited by a friend of the experimenter. Every meditation expert practiced a meditation type focusing on concentration, as argued in chapter 3.3. This was necessary to make sure that no other type of meditation which tends to evoke more betha or gamma brain waves is practiced.

Meditation novices were recruited via facebook, work and friends. No friends of the experimenter participated in the main study.

The mean age of the participants was 28.9 (sd=10.07) with a minimum of 20 and a maximum of 53 years. Only one person of the participants was male.

4. Results

As the main study comprised two different experimental questions, the results chapter will report significant outcomes in two separate chapters. The first experimental question asked, whether music has an effect on meditation. This question was statistically analyzed with the data of the conditions "relaxing music", "arousing music" and "no music". The second experimental question asked, whether alpha-theta wave frequencies have an effect on meditation/ relaxation. This question was statistically analyzed with the data of the conditions "no music" and "alpha-theta wave frequencies".

Differences between meditation experts and novices

First it is interesting to see that there are differences between meditation experts and novices in there ratings and GSR-measurements. A univariate analysis of variance (ANOVA) controlling for the confounding variable "trait anxiety" shows a significant difference between meditation experts and novices on CDA.SCR in the condition "no music" (p=0.023, F=6.310, n=19). When meditating with "no music" meditation novices (mean=0.092, sd=0.081, n=11) show a significantly lower CDA.SCR than meditation experts (mean=0.168, sd=0.147, n=8), indicating a more relaxed state over the whole 30 minutes of meditation.

A univariate ANOVA with the confounding variable "trait anxiety" shows a significant difference between meditation experts and novices in there musical preference in the category "Upbeat and conventional" (p=0.01, F=8.595, n=19). Meditation novices (mean=26.73, sd=2.901, n=11) like musical genres, representing "upbeat and conventional" more than meditation experts (mean=22, sd=2.268, n=8). Another univariate ANOVA with the confounding variable "trait anxiety" shows a significant difference between meditation experts and novices on the intensity of the meditative state when listening to relaxing music (p=0.041, F=4.923, n=19). When listening to relaxing music meditation experts (mean=5, sd=1.511, s=8) experienced the meditative state more intense than meditation novices (mean=3.36, sd=1.433, n=11).

A Kolmogorov-Smirnov-test showed that the variable "intensity_no music" is not normally distributed (p=0.013, K-S=0.224). Therefore a nonparametric test was applied to test differences between meditation experts and novices on the felt intensity when meditating with no music. A Mann-Whitney-U-Test showed a significant difference between meditation experts and novices (p=0.014, U=-2.457, n=19). When meditating without music meditation experts (mean rank=13.63, n=8) experienced the meditative state as more intense than meditation novices (mean rank=7.36, n=11).

Furthermore the variable "easiness_alpha-theta" is also not normally distributed (p=0.039, K-S=0.202). A nonparametric Mann-Whitney-U-test showed a significant difference on the easiness to get into a meditative state between meditation experts and novices when meditating with alpha-theta-wave frequencies (p=0.018, U=-2.356, n=19). It is easier for experts (mean rank=13.44, n=8) to get into a meditative state than for novices (mean rank=7.5, n=11).

The variable "more tranquilized_alpha-theta" is not normally distributed either (p=0.00, K-S=0.301). A Mann-Whitney-U-test showed a sginificant difference between meditation experts and novices on "more tranquilized_alpha" (p=0.019, U=-2.346). When meditating with alpha-theta-wave frequencies, meditation experts (mean rank=13.44, n=8) felt more tranquillized after meditation (compared to before meditation) than meditation novices (mean rank=7.5, n=11).

Moreover a univariate ANOVA controlling for the confounding variable "trait anxiety" showed a significant difference between meditation experts and novices on "tired_alpha-theta" (p=0.008, F=9.299, n=19). When meditating with alpha-theta-wave frequencies, meditation experts (mean=5.125, sd=0.991, n=8) become more tired than meditation novices (mean=3, sd=1.265, n=11).

The variable "duration_relaxing" is also not normally distributed (p=0.008, K-S=0.234). A Mann-Whitney-U-test showed a significant difference between meditation experts and novices on "duration_relaxing" (p=0.01, U=-2.578, n=19). When meditating to relaxing music, meditation experts (mean rank=6.19, n=8) got faster into a meditative state than novices (mean rank=12.77, n=11).

Furthermore the variable "duration_alpha-theta" is also not normally distributed (p=0.024, K-S=0.213). A Mann-Whitney-U-test showed a significant difference between mediattion experts and novices on "duration_alpha" (p=0.011, U=-2.528, n=19). When meditating with alpha-theta-wave frequencies, meditation experts (mean rank=6.25, n=8) got faster into a meditative state than meditation novices (mean rank=12.73, n=11).

For an overview of the discussed significant results see the following *Table 15*.

Table 15: Shows the significant results on the differences between meditation experts and novices

Results		
Difference with mean scores	**Significance**	**Statistical analysis**
CDA.SCR - no music: meditation experts (0.168) vs. meditation novices (0.092)	p=0.023	Univariate Analysis of Variance controlling for "Trait Anxiety"
Musical preference - upbeat and conventional: meditation experts (22) vs. meditation novices (26.73)	p=0.01	Univariate Analysis of Variance controlling for "Trait Anxiety"
Intensity - relaxing music: meditation experts (5) vs. meditation novices (3.36)	p= 0.041	Univariate Analysis of Variance controlling for "Trait Anxiety"
Intensity - no music: meditation experts (13.63) vs. meditation novices (7.36)	p=0.014	Mann-Whitney-U-Test
Easiness - alpha-theta: meditation experts (13.44) vs. meditation novices (7.5)	p=0.018	Mann-Whitney-U-Test
More tranquilized - alpha-theta: meditation experts (13.44) vs. meditation novices (7.5)	p=0.019	Mann-Whitney-U-Test
Tiredness - alpha-theta: meditation experts (5.125) vs. meditation novices (3)	p=0.008	Univariate Analysis of Variance controlling for "Trait Anxiety"
Duration - relaxing music: meditation experts (6.19) vs. meditation novices (12.77)	p=0.01	Mann-Whitney-U-Test
Duration - alpha-theta: meditation experts (6.25) vs. meditation novices (12.73)	p=0.011	Mann-Whitney-U-Test

Effects of music on meditation

In the following statistical analyses are carried out for the three conditions "relaxing music", "arousing music" and "no music". A repeated measurements ANOVA controlling for the confounding variable "trait anxiety" showed a significant effect on "state anxiety" after meditation (p=0.033, F=4.244, n=19). Posttests with pairwise comparisons showed a significant difference between state anxiety after meditating to "relaxing music" and "arousing music" (p=0.025, I-J=-8.316, n=19), and between "no music" and "arousing music" (p=0.038, I-J=-7.947, n=19). All the participants showed higher anxiety after meditating with arousing music (mean=39.47, sd=14.053, n=19) than with relaxing music (mean=31.16, sd=7.529, n=19). They also showed higher anxiety after meditating with arousing music, than with no music (mean=31.53, sd=7.493, n=19).

Furthermore a repeated measurments ANOVA controlling for the confounding variable "trait anxiety" showed a significant effect on the degree of relaxation (p=0.013, F=5.784, n=19). Posttests with pairwise comparisons showed a significant difference between the degree of relaxation when meditating to "relaxing music" and "arousing music" (p=0.027, I-J=1.842, n=19), and between "no music" and "arousing music" (p=0.009, I-J=1.737, n=19). The participants showed a higher degree of relaxation when meditating with relaxing music (mean=5.05, sd=1.471, n=19) than with arousing music (mean=3.21, sd=1.813, n=19), and when meditating with no music (mean=4.95, sd=1.353, n=19) than with arousing music.

Another repeated measurements ANOVA controlling for the confounding variable "trait anxiety" showed a significant effect for the felt happiness while meditating (p=0.031, F=4.359, n=19). Posttests via pairwise comparisons showed a significant difference between the felt happiness when meditating with relaxing music and arousing music (p=0.025, I-J=1.421, n=19). Participants were happier when meditating with relaxing music (mean=5.11, sd=1.449, n=19) than with arousing music (mean=3.68, sd=1.827, n=19).

Moreover a repeated measurments ANOVA controlling for the confounding variable "trait anxiety" showed a significant effect on the liking of the meditation (p=0.003, F=8.557, n=19). Possttests with pairwise comparisons showed a significant difference between liking when meditating to relaxing music and arousing music (p=0.002, I-J=1.895, n=19), and when meditating without music and arousing music (p=0.043, I-J=1.263, n=19). Participants liked meditating with relaxing music (mean=5.42, sd=1.465, n=19) more than with arousing music (mean=3.53, sd=1.775, n=19), and meditating without music (mean=4.79, sd=1.398, n=19) more than with arousing music.

Furthermore a repeated measurements ANOVA controlling for the confounding variable "trait anxiety" showed a significant effect of the tranquillized effect after meditation compared to before meditation (p=0.002, F=9.670, n=19). Posttests with pairwise comparisons showed a significant difference between being more tranquillized after meditation when meditating with no music and arousing music (p=0.001, I-J=2.053, n=19). Participants were more tranquillized after meditation when meditating with no music (mean=5.26, sd=1.240, n=19) than with arousing music (mean=3.21, sd=1.903, n=19).

Moreover a variable called "State-anxiety_change" was computed. This variable is the result of the values of state anxiety after meditation minus the values of state anxiety before meditation. A repeated measurements ANOVA controlling for "trait anxiety" showed a significant effect for the change of state anxiety (p=0.03, F=4.397, n=19). Posttests via pairwise comparisons showed significant differences between the change of state anxiety when meditating with relaxing music and arousing music (p=0.031, I-J=7.684, n=19), and no music and arousing music (p=0.025, I-J=9.158, n=19). Participants were less anxious when meditating to relaxing music (mean=5.47, sd=6.586, n=19) than to arousing music (mean=-2.21, sd=11.627, n=19), and when meditating without music (mean=6.95, sd=6.745, n=19) than with arousing music.

For an overview of the discussed significant results see the following *Table 16*.

Table 16: Shows the significant results on the effects of music on meditation

Results		
Difference with mean scores	**Significance**	**Statistical analysis**
State Anxiety after meditation: relaxing music (31.16) vs. arousing music (39.47)	p=0.025	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
State Anxiety after meditation: no music 31.53) vs. arousing music (39.47)	p=0.038	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Degree of relaxation: relaxing music (5.05) vs. arousing music (3.21)	p= 0.027	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Degree of relaxation: no music (4.95) vs. arousing music (3.21)	p=0.009	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Happiness: relaxing music (5.11) vs. arousing music (3.68)	p=0.025	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Liking: relaxing music (5.42)vs. arousing music (3.53)	p=0.002	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Liking: no music (4.79) vs. arousing music (3.53)	p=0.043	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
More tranquilized: no music (5.26) vs. arousing music (3.21)	p=0.001	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Change of State Anxiety: relaxing music (5.47) vs. arousing music (-2.21)	p=0.031	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"
Change of State Anxiety: no music (6.95) vs. arousing music (-2.21)	p=0.025	Posttest: Pairwise Comparisons controlling for "Trait Anxiety"

Effects of alpha-theta-wave frequencies on meditation and relaxation

In the following, statistical analyses were carried out with the two conditions "no music" and "alpha-theta-wave frequencies".

A repeated measurements ANOVA controlling for the confounding variable "trait anxiety" showed a significant difference between the easiness of getting into a meditative state when meditating with no music and with alpha-theta-wave frequencies (p=0.037, F=5.151, n=19). It was easier for the participants to get into a meditative state, when meditating without music (mean=4.42, sd=1.895, n=19) than with alpha-theta-wave frequencies (mean=3.47, sd=1.896, n=19).

Another repeated measurements ANOVA controlling for the confounding variable "trait anxiety" showed a significant difference between feeling more tranquillized after meditation, when meditating with no music, than with alpha-theta-wave frequencies (p=0.035, F=5.226, n=19). Participants felt more tranquillized after meditation, when meditating with no music (mean=5.26, sd=1.240, n=19) than with alpha-theta-wave frequencies (mean=4.42, sd=1.953, n=19).

As discussed earlier, it was found out that there are significant differences between meditation experts and novices. Thus statistical analyses are furthermore done independendly for experts and novices.

For an overview of the discussed significant results see the following *Table 17*.

Table 17: Shows the significant results on the effects of alpha-theta-wave frequencies on meditation

Results		
Difference with mean scores	**Significance**	**Statistical analysis**
Easiness: alpha-theta (3.47)vs. no music (4.42)	p=0.037	Repeated measurements ANOVA
More tranquilized: alpha-theta (4.42) vs. no music (5.26)	p=0.035	Repeated measurements ANOVA

Effects for meditation novices seperately

To be able to see changes in GSR over time, the 30 min GSR-measurements have been divided into six 5 minutes sections. This allows to detect possible changes of smaller time intervals, which might be interesting. One participant had to be excluded due to measurements problems. A repeated measurements ANOVA controlling for "trait anxiety" showed an almost significant difference between CDA.SCR in the time from 20min to 25min when meditating to no music and to alpha-theta-wave frequencies (p=0.057, F=4.922, n=10). Meditation novices showed a lower CDA.SCR value when meditating with alpha-theta-wave frequencies (mean=0.0683, sd=0.065, n=10), than without music (mean=0.0981, sd=0.075, n=10) This indicates a physiologically measured more relaxed state under alpha-theta-wave frequencies. When the time interval was increased to 10 minutes, signifcant effects ceased.

For an overview of the discussed significant results see the following *Table 18*.

Table 18: Shows the almost significant result for meditation novices seperately

Results		
Difference with mean scores	**Significance**	**Statistical analysis**
CDA.SCR 20min to 25min: alpha-theta (0.0683)vs. no music (0.0981)	p=0.057	Repeated measurements ANOVA

Effects for meditation experts seperately

A repeated measurements ANOVA controlling for "trait anxiety" showed a significant difference between the felt intensity of a meditative state when meditating without music and with alpha-theta-wave frequencies (p=0.037, F=7.142, n=10). Meditation experts felt a more intense meditative state when meditating without music (mean=5.88, sd=0.835, n=8), than with alpha-theta-wave frequencies (mean=4.50, sd=1.690, n=8).

Moreover a repeated measurements ANOVA controlling for "trait anxiety" showed a significant difference between the subjective degree of relaxation when meditating without music and with alph-theta-wave frequencies (p=0.045, F=6.397, n=8). Meditation experts experienced a higher degree of relaxation when meditating without music (mean=5.63, sd=1.302, n=8) than with alpha-theta-wave frequencies (mean=5.25, sd=1.669, n=8).

Another repeated measurements ANOVA controlling for "trait anxiety" found a significant difference between the experienced happiness when meditating without music and with alpha-theta-wave frequencies (p=0.046, F=6.274, n=8). Meditation experts were happier when meditating without music (mean=5.00, sd=1.690, n=8) than with alpha-theta-wave frequencies (mean=4.00, sd=1.069, n=8).

Furthermore a repeated measurements ANOVA controlling for "trait anxiety" showed a significant difference between the liking of the meditation when meditating without music and with alpha-theta-wave frequencies (p=0.028, F=8.282, n=8). Meditation experts liked the meditation more when meditating without music (mean=5.38, sd=1.188, n=8) than with alpha-theta-wave frequencies (mean=4.50, sd=1.069, n=8).

A repeated measurements ANOVA controlling for "trait anxiety" found an almost significant difference between the tiredness when meditating without music and with alpha-theta-wave frequencies (p=0.065, F=5.087, n=8). Meditation experts became more tired when meditating with alpha-theta-wave frequencies (mean=4.75, sd=1.753, n=8) than without music (mean=3.63, sd=2.199, n=8).

Interesting compared to the previous result is, that a bivariate correlation showed a significant negative correlation bewteen trait anxiety and tiredness when meditating with alpha-theta-wave frequencies (p=0.007, R=-0.595, n=19).

For an overview of the discussed significant results see the following *Table 19*.

Table 19: Shows the significant results for meditation experts seperately

Results		
Difference with mean scores	**Significance**	**Statistical analysis**
Intensity: alpha-theta (4.5) vs. no music (5.88)	p=0.037	Repeated measurements ANOVA controlling for "Trait Anxiety"
Degree of relaxation: alpha-theta (5.25) vs. no music (5.63)	p= 0.045	Repeated measurements ANOVA controlling for "Trait Anxiety"
Happiness: alpha-theta (4.00) vs. no music (5.00)	p=0.046	Repeated measurements ANOVA controlling for "Trait Anxiety"
Liking: alpha-theta (4.50) vs. no music (5.38)	p=0.028	Repeated measurements ANOVA controlling for "Trait Anxiety"
Tiredness: alpha-theta (4.75)vs. no music (3.63)	p=0.065	Repeated measurements ANOVA controlling for "Trait Anxiety"

Qualitative Results

As participants were asked to additionally write down what they want to mention or intersting things they experienced during meditation, qualitative data has been collected. Some participants also started to talk to the experimenter who in turn took notes of what the participants said. In the following the obtained data will be discussed. The focus will be on interesting notes and terms which were mentioned more than just once by different participants (for all the notes see *appendix*).

Relaxing

Participants stated wonderful music to the relaxing music condition. Some of them heard windy noises or background sounds. Some of them also mentioned that they experienced these noises as distracting. These sounds were background sounds on the audio files. One participant stated a short panic attack. Another one mentioned that she wasn't able to focus that much on her meditation technique due to the music. But she experienced the meditative state as much more intense

Arousing

Some of the participants mentioned that the music was agressive, and that they tried not to evaluate the music, but that this was difficult. Also the fast switches between the music pieces made it more difficult to get into a meditative state. Two participants (meditation experts) mentioned that they found it intersting to meditate to distracting music, as they had to work harder on their meditative state. They experienced it as a good challenge. One participant said that the music made her aggressive.

No music

Some of the particpants reported distracting background noises like high pitches. These noises were produced by public transports (tram) from outside.

Alpha-theta-wave frequencies

Participants reported that they were not as distracted by the background noises from public transports outside than under the condition without music. They had the impression of experiencing the background noises in another way than without music.

Furthermore the participants reported, that they heard three times a short clicking noise. This clicking noise is produced at the onset of the 6-10Hz frequency band. As the audio file of the frequency band started three times in the 30 minutes meditation these three experienced clicking noises are due to the audio file. One participant reported a strong feeling of dizziness and that she got devious ears. Another participant mentioned that her head felt twitchy, and asked whether there was really nothing played by the headphones. Moreover one participant got a big sensation of heat in the last 5 minutes of meditation.

In general, one participant mentioned that the goal of Zen meditation is not to evaluate, thus not being either happy or unhappy. Therefore she said that ratingscales concerning happiness or liking cannot really be answered.

5. Discussion

Many significant results were obtained. In the following these results will be discussed and put into relation to the mentioned hypotheses.

The significant difference in GSR measurements between meditation experts and novices (lower CDA.SCR or higher physiologically relaxed state for novices) while meditating with "no music" might be due to the fact that mediation experts are used to meditate with no music and thus the experimental artificial situation might have stressed, or influenced them more as meditation novices, since this was not the usual situation. If this is the right explanation, the fact that there is no difference while meditating to "alpha-theta wave frequencies" might mean that this condition was not experienced as the usual situation without music for meditation experts, and shows that alpha- theta wave frequencies affected them. Thus this might be a first argument for an effect of these frequencies on brain waves.

Contrary it was found that meditation experts experienced the meditative state as more intense than novices when they listened to no music. This might be also due to the fact that meditation experts are trained to meditate without music. But the question arises why meditation experts show a lower physiologically relaxed state (higher CDA.SCR) but a higher experienced intensity. The answer to this might be that an intense meditative state is not a deeply relaxed state, and this might be due to the fact that in a meditative state people experience out-of body sensations or highly concentrated states, which would not be able in a deeply relaxed state, which is maybe more similar to a tired state.

Moreover it was found that meditation experts subjectively rated the tranquillizing effect of meditating with alpha-theta-wave frequencies as higher as meditation novices. This significant outcome strengthens the previously stated physiological finding of the GSR measurements. Since the hypothesis is that alpha-theta wave frequencies stimulate once own brain waves in the corresponding frequencies with resonance phenomena or superposition of waves, and since meditation is said to produce more such brain waves in humans, meditation experts might faster produce such brain waves by themselves and thus are more likely to be influenced by an auditive stimulation of 6 to 10Hz frequencies. Further support to this argument are the results that it is easier for meditation experts to get into a meditative state when listening to alpha-theta-wave frequencies than for meditation novices and that meditation experts get faster into a meditative state than novices when listening to alpha-theta-wave frequencies. Moreover it was found that listening to these frequencies made meditation experts more tired than novices. This is another argument for an effect of 6-10 Hz frequencies on humans, indicating that a higher relaxed state can also lead to tiredness.

In addition it was observed that meditation experts get faster into a meditative state than novices when listening to relaxing music. This might be due to the fact that meditation experts are used to meditation and that relaxing music helps them to get faster into a meditative state. It was also shown that meditation experts experienced the meditative state as more intense than meditation novices, when listening to relaxing music. This further shows that relaxing music really has an effect on meditation.

The fact that most of the differences between experts and novices can only be found under the condition of alpha, shows that alpha seems to have an effect on the brain waves of meditation experts.

Concerning the effects of music on meditation over all the participants it was shown that meditating with arousing music led to significantly higher anxiety (tested with STAI-X) than relaxing music and no music. This shows that arousing music has a negative effect on meditation. Furthermore it was shown that the degree of relaxation was lower when meditating with arousing music than with relaxing music or no music. This outcome seems to be obvious, but it proofs the good quality of the obtained data. It was also shown that participants liked meditating with arousing music less than with relaxing music and no music. Moreover it was found that participants felt happier when they meditated with relaxing music than with arousing music. This is another argument for the negative effect of arousing music on meditation and a first argument for a positive effect of relaxing music on meditation, as the condition "no music" showed no significant differences with arousing music. Furthermore it was found that participants got less anxious when meditating with relaxing music and with no music than with arousing music.

Contrary arousing music led to a higher anxious state after meditation. This again is proof for the hypothesis that arousing music has a negative effect on meditation compared to relaxing music and no music and shows that music might be used as a distractor for meditation. Furthermore it shows that music has an effect on meditation.

The positive effect of relaxing music on meditation is not confirmed at this stage, because it was shown that participants were more tranquilized after meditation when meditating with no music than with arousing music. Here no difference between relaxing music and arousing music was found. It seems that relaxing music has the same effect on meditation as no music. Maybe this outcome has been provoked by background noise on the audio files of the relaxing music, which participants described as distracting. It's possible that relaxing music would show a positive effect on meditation compared to no music without background noise. On the other hand, when participants meditated without music they heard the background noise produced by the outside public transports and cars, which might equalize the effect of background noise on relaxing music audio file.

In relation to the effects of alpha-theta-wave frequencies on meditation it was found that it was significantly easier for participants to get into a meditative state when meditating without music than with 6-10Hz frequencies. Although the effect of 6-10Hz frequencies seems to be negative compared to no music, it shows that alpha-theta-wave frequencies do have an effect on humans, as the outcome is significantly different to no music. Participants also felt significantly more tranquillized after meditating with no music than with alpha-theta-wave frequencies. Again this is proof for an effect of 6-10Hz frequencies on humans, but at the same time it also opens the question, whether 6-10Hz might have a negative effect on meditation or relaxation.

Interesting at this point is that meditation novices showed an almost significant lower CDA.SCR when meditating with alpha-theta-wave frequencies than with no music. This means that novices showed a much more relaxed state under 6-10Hz frequencies. First it has to be mentioned that this finding argues again for an effect of alpha-theta-wave frequencies on meditation. The kind of effect is still unclear, as it seems here, different to the previously discussed findings, that 6-10 Hz frequencies have a positive effect on meditation and relaxation. A possible answer is that the GSR measurements are bad, or an error occured in the whole method section of the study. Another, maybe more likely answer is that there are different relaxed states. It is therefore assumed that there is a difference between a relaxed tired state and a relaxed meditative state. This could answer the discrepancy in the discussed outcomes. While a relaxed meditative state facilitates getting into a meditative state and leads to a more tranquillized state, a relaxed tired state handicaps this state due to tiredness. The interesting thing is that in both cases there is relaxation. As the GSR measures the physiological degree of relaxation, no difference between these two different relaxed states can be seen. It seems to be obvious that a tired relaxed states leads to a lower CDA.SCR than a meditative relaxed state, as in a meditative state people experience quite different sensations and a higly concentrative state, which might not be as relaxing for the body itself as it is in a tired relaxed state.

Thus it is assumed that listening to 6-10Hz frequencies leads to a more relaxed state via tiredness, and is thus not positive for a meditative state.

Since a possible effect of these frequencies on humans is explained with the superposition of waves, another possible answer is that the induced waves did delete the existing ones and not intensify them.

A further look at the results for meditation experts stregthens the previous results and the stated assumption. It was found that meditation experts experienced a more intense meditative state, a higher degree of relaxation, a higher happiness level, when meditating with no music than with alpha-theta-wave frequencies. Moreover it was shown that meditation experts also liked meditating with no music more than with 6-10Hz frequencies. It’s interesting that these effects have not been found for the novices. Thus it seems that alpha-theta-waves influence meditation experts more than meditation novices. This could be due to several reasons such as that meditation experts are used to meditate witout music and are distracted by 6-10Hz frequencies. It could also be due to meditation experts producing more brain waves in the frequency range of 6-10 Hz as these are more active under meditative states, and thus are more influencable from outside arriving frequencies in this range.

A further important finding is that meditation experts got more tired (p=0.065) when meditating with alpha-theta-wave frequencies than with no music. This strengthens the previously made assumption that there are two different types of relaxation, and that the stimulation with 6-10Hz frequencies leads to a more tired relaxed state. In relation to these findings it is interesting that (as discussed in *chaper 4.4*) Karpova and his co-workers (as cited in Leventhall et al., 2003) showed that workers who were exposed to infrasound of 5 Hz and 10 Hz at 100 db and 135 db reported feelings of fatigue amongst others. It can be seen that also previous research had come to similar results, which is further strengthening the assumption that an auditive stimulation of 6-10Hz frequencies provokes tiredness.

Moreover it was shown that meditation novices had a lower CDA.SCR from minute 20-25 when meditating with 6-10Hz frequencies than with no music. Important to discuss is the fact that the effects on CDA.SCR from minute 20-25 ceased when the time interval was increased to 10 minutes. Why did alpha-theta-wave frequencies only have an effect on GSR from minute 20-25? While one answer could be accidental, another answer could be that after 20 minutes of exposure to 6-10 Hz frequencies the brain started to adapt to these frequencies. Whenf we look at the discussed literature in *chapter 4.1*, we can see that previous research assumed that a constantly repeated rhythmn has to be continued at least for 13-15 minutes until this rhythmn, expressed in beats per seconds, affects brain waves at the same frequencies (Arrien, 1996). This is an argument for the validity and importance of the obtained result. According to this, it has to be assumed that the brain has to be stimulated with frequencies for a particular period of time, until it starts adapting to these frequencies. That this effect ceased after 25 minutes, could thus be due to the participants anticipating the end of the study and thus got into a more aroused state. It appears obvious, as this effect was only found with meditation novices, which are not used to meditate for 30 minutes. Thus 30 minutes of sitting quiet, calm and trying to meditate can be really striking and thus can increase arousal with time. Therefore this effect becomes much more important.

Furthermore its striking that meditation experts showed no significant differences in their GSR measurements. Why did alpha-theta-wave frequencies have a short physiologically measureable effect on meditation novices but not on meditation experts? And vice-versa, why did alpha-theta-wave frequencies have subjective effects on meditation experts but not on meditation novices?

There are different possible answers to this question. Maybe the GSR measuring hardware didn't work properly. A more likely answer is the difference of expertise in meditation. As most of the meditation novices did not have a lot of experience in meditation, they were more focused on trying to get into a meditative state than being aware of how they feel. Thus they did not subjectively perceive any differences. Whereas meditation experts don't have to focus that much of getting into a meditative state and thus experience differences consciously. The found physiological effect of 6-10Hz frequencies from minute 20 to 25 could be due to relaxing tiredness provoked through resonance phenomena or superposition of waves. The fact that there is no such effect for meditation experts might be due to the fact that meditation experts consciously perceived that they are getting tired, and thus tried to counteract tiredness to stay in a meditative state. This conflict might have influenced the GSR measuremnts and of course also the subjective ratings. It is also possible that counteracting tiredness prevented them of getting into a tired relaxed state which might have diminished CDA.SCR. This assumption is supported by the previously discussed finding that meditation experts rated the subjectively perceived tiredness when meditating with alpha-theta-wave frequencies more pronounced than with no music. Moreover no subjective effects were found for meditation novices, which further argues for the stated assumption.

Looking at the qualitative results it seems to be obvious that the background noises of the relaxing music audio file influenced participants in a negative way. It is possible that this further influenced the outcome of this study and thus it's still not clear whether relaxing music has a more positive effect on meditation than no music. Further investigations should be carried out concentrating on a high quality of the audio files with no background noises. On the other hand participants have also been distracted by background noises in the conditions „no music“ and „alpha-theta-wave frequencies“. In this case the background noises were not produced from the audio file, but from public transports outside the lab. Since every condition included background noise it could be assumed that it is negligible. But it could also be argued that artificial background noise on an audio-file with music is more distracting than naturally occuring background noise from outside.

Concerning the effects of alpha-theta-wave frequencies, it is interesting that participants reported a kind of altered experience of the background noises when listening to 6-10Hz frequencies than when listening to no music. It is possible that the sense of hearing is influenced by frequencies below the hearing threshold. Furthermore the fact that some participants perceived a difference between the two conditions „6-10Hz frequencies“ and „no music“ shows that these frequencies below the hearing threshold do have an effect on humans. Further interesting is that three different participants reported negative sensations when listening to alpha-theta-wave frequencies. They reported dizziness, experience of heat in the last 5 minutes, devious ears and the feeling of a twitchy head. Interesting to add at this point is that (as discussed in *chapter 4.4*) Alves-Pereira and Castelo Branco (2007, as cited in Persinger, 2014) identified the vibracousitc syndrom as a consequence of exposure to infrasound. The symptoms of this disease include amongst others dizziness. Thus previous research showed results similar to the mentioned feelings of some participants. This seems to argue for a negative effect of 6-10Hz frequencies. A possible effect of these frequencies on humans is explained via the physical law of the superposition of waves. There are possible effects these frequencies can have on the brain waves. On one hand they can intensify the existing brain waves, but on the other hand they can delete the existing brain waves. Thus it is furthermore possible that the condition of „alpha-theta-wave frequencies“ lead to an intensification of existing brain waves in some particpants (leading to positive effects), but to a deletion of existing brain waves in other participants (leading to negative effects). While this assumption can explain discrepancy in the findings of 6-10 Hz frequencies between experts and novices, it is also possible that the mean values are not representing the data, as it seems like there is no effect, although there is an effect.

It has to be stated here that participants heard three clicking sounds in the „alpha-theta-wave frequencies“ condition, which might have influenced the outcome of the study.

6. Conclusion

According to the discussed findings it can be summarized that arousing music has a negative effect on meditation in different aspects. Although the GSR measurements did not show any significant effects on CDA.SCR there have been a lot of different subjectively rated significant effects like a higher state anxiety (measured with a standardized questionnaire), less happiness, less relaxation, or less tranquillization. Moreover the stated hypothesis that arousing music has a more negative effect on meditation than relaxing music and no music holds true.

As further discussed the hypothesis that relaxing music has a more positive effect on meditation than no music and arousing music is just partly true. No doubt, relaxing music has a more positive effect than arousing music, but there is no difference between the effect of relaxing music and no music on meditation. As there was background noise on the relaxing music audio file, the outcome of the study was influenced and it is still possible that relaxing music has a more positive effect on meditation than no music. Nevertheless this study did not prove such an effect.

Moreover the last hypothesis that alpha-theta-wave frequencies have a more positive effect on meditation than no music, is also just partly true. As previously discussed, it can be summarized that alpha-theta-wave frequencies have a positive effect on a relaxed state achieved through tiredness and also on physiological measurements of relaxation (GSR). On the other hand these frequencies have a negative effect on a relaxed state achieved through meditation. At least this study shows that frequencies below the hearing threshold indeed influence humans and that alpha- theta wave frequencies can be used to increase tiredness, which can be really helpful.

Further Research

It would be interesting to test whether infrasounds really influence acuesthesia (as discussed under qualitative results) and in which way they do so. Possible findings could be used to explore new ways of noise prevention.

Moreover it would be important to replicate this study focusing on relaxing music with a higher number of participants and audio files in high quality with no background noise.

To explore possible effects of 6-10Hz frequencies on brain waves it would be important to have a study just concentrating on infrasounds with EEG measurements. EEG data would enable to show a possible deletion or enforcement of brainwaves through infrasounds. Moreover different conditions with different frequency bands or single frequencies should be applied in such a study and it should also be studied, which SPL is best or necessary to stimulate the human brain.

The effect of frequencies in other ranges on humans should be explored. Maybe positive effects on humans could be detected and used as therapy (i.e.: concentration enhancement).

Practical Imlpications

What is the use of this study? What are practical implications?

Alpha-theta-wave frequencies could be used against sleeping disorders. They could help people to easier fall asleep. Moreover they could be therapeutically used as stress prevention tools, due to their physiologically relaxing effect.

Another practical implication is the certainty that the kind of music used for meditation should be consciously chosen, as too arousing music has a negative effect on meditation.

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Appendix

1) Instruction for particpants

Lieber Versuchsteilnehnmer,

vielen Dank für die Teilnahme am Experiment. Das Experiment besteht aus mehreren Teilen. Es beginnt mit einem kurzen Fragebogen der deinen aktuellen und generellen Gemütszustand erfragt. Danach wirst du gebeten einen kleinen Konzentrationstest zu machen.

Darauf folgt der Hauptteil der Studie mit einer 30 minütigen Meditation. Hierbei wirst du Kopfhörer tragen. In den insgesamt 4 Testungen wirst du 2 mal Musik hören und 2 mal keine Musik hören. Bitte übe die Meditation so aus, wie du es gewohnt bist. Wenn du noch keine Erfahrung mit Meditation hast, werden dir vom Versuchsleiter einleitende Tipps für Meditation gegeben. Auch wenn dir die Musik nicht gefällt, bitten wir dich trotzdem weiter zu versuchen zu meditieren. Des Weiteren wird dein Hautleitwert über ein Hautleitwert-Messgerät gemessen. Dieses hat keinerlei Auswirkungen auf dich und deinen Körper. Das Ende der 30 minütigen Meditation wird durch einen Glockenton signalisiert.

Danach wirst du erneut gebeten einen kleinen Konzentrationstest und einen Fragebogen zu deinem aktuellen Gemütszustand durchzuführen. Zum Schluss folgt ein letzter kurzer Fragebogen.

Bitte beantworte alle Fragen ehrlich! Es gibt keine richtigen oder falschen Antworten. Die gesamte Studie ist anonym. Es werden keinerlei Daten von dir gespeichert oder weitergegeben.

Hier noch 3 Fragen zu deiner Person.

Geschlecht:

Alter:

Meditationstechnik die von dir angewendet wird:

2) STOMP-R

Bitte bewerten Sie Ihre Präferenz für jede der aufgelisteten musikalischen Genres anhand der vorgegebenen Werte. 1 steht dabei für "mag ich gar nicht" und in aufsteigender Reihenfolge 7 für "mag ich sehr"

1-----------------2-----------------3-----------------4-----------------5-----------------6----------------
-7

mag ich weder mögen
mag ich
gar nicht noch nicht mögen
sehr

1. _____ Alternative
2. _____ Bluegrass
3. _____ Blues
4. _____ Classical
5. _____ Country
6. _____ Dance/Electronica
7. _____ Folk
8. _____ Funk
9. _____ Gospel
10. _____ Heavy Metal
11. _____ International/Foreign
12. _____ Jazz
13. _____ New Age
14. _____ Oldies
15. _____ Opera
16. _____ Pop
17. _____ Punk
18. _____ Rap/hip-hop
19. _____ Reggae
20. _____ Religious
21. _____ Rock
22. _____ Soul/R&B
23. _____ Soundtracks/theme song

Music preference dimensions scoring:

Reflective & Complex: 2, 3, 4, 7, 11, 12, 13, 15

Intense & Rebellious: 1, 10, 17, 21

Upbeat & Conventional: 5, 9, 14, 16, 20, 23

Energetic & Rhythmic: 6, 8, 18, 19, 22

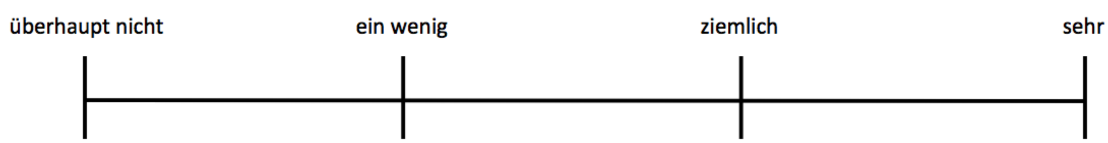
3) STAI-X

Im Folgenden Fragebogen finden Sie eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann. Bitte lesen Sie jede Feststellung durch und wählen Sie aus den vier Antworten diejenige aus, die angibt, wie Sie sich **jetzt**, das heißt **in diesem Moment**, fühlen.

Es gibt keine richtigen oder falschen Antworten. Überlegen Sie bitte nicht lange und denken Sie daran, diejenige Antwort auszuwählen, die Ihren **augenblicklichen Gefühlszustand** am besten beschreibt.

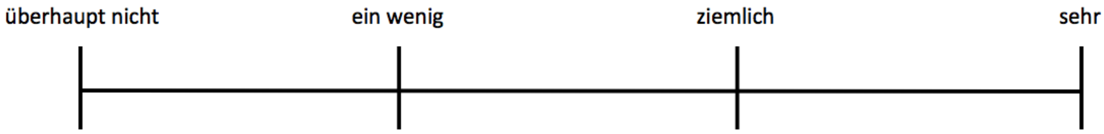
Ein Beispiel:

Ich bin überanstrengt

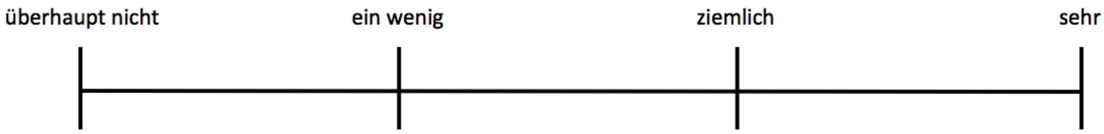


Bitte machen Sie ein Kreuz bei der Antwort die für Sie im Moment zutrifft.

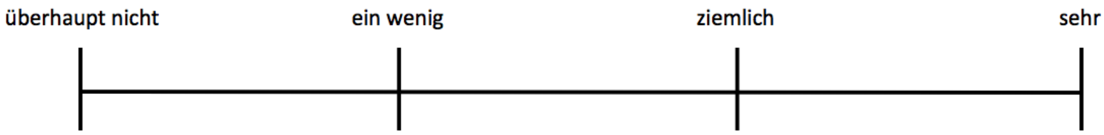
Ich bin ruhig



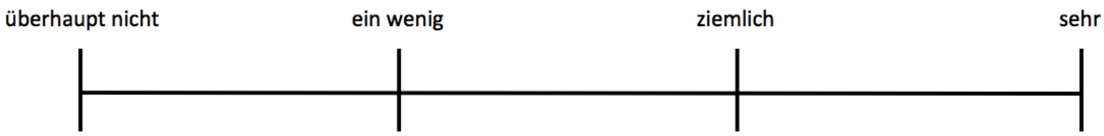
Ich fühle mich geborgen



Ich fühle mich angespannt



Ich bin bekümmert



Ich bin gelöst

überhaupt nicht ein wenig ziemlich sehr

Ich bin aufgeregt

überhaupt nicht ein wenig ziemlich sehr

Ich bin besorgt, dass etwas schiefgehen könnte

überhaupt nicht ein wenig ziemlich sehr

Ich fühle mich ausgeruht

überhaupt nicht ein wenig ziemlich sehr

Ich bin beunruhigt

überhaupt nicht ein wenig ziemlich sehr

Ich fühle mich wohl

überhaupt nicht ein wenig ziemlich sehr

Ich fühle mich selbstsicher

überhaupt nicht ein wenig ziemlich sehr

Ich bin nervös

überhaupt nicht ein wenig ziemlich sehr

Ich bin zappelig

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin verkrampft

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin entspannt

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin zufrieden

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin besorgt

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin überreizt

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin froh

überhaupt nicht | ein wenig | ziemlich | sehr

Ich bin vergnügt

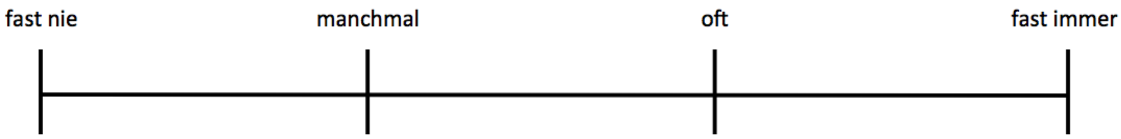
überhaupt nicht | ein wenig | ziemlich | sehr

Anschließend finden Sie ebenfalls eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann. Bitte lesen Sie wieder jede Feststellung durch und wählen Sie aus den vier Antworten diejenige aus, die angibt, wie Sie sich **im Allgemeinen** fühlen.

Es gibt keine richtigen oder falschen Antworten. Überlegen Sie bitte nicht lange und denken Sie daran, diejenige Antwort auszuwählen, die am Besten beschreibt, wie Sie sich **im Allgemeinen** fühlen.

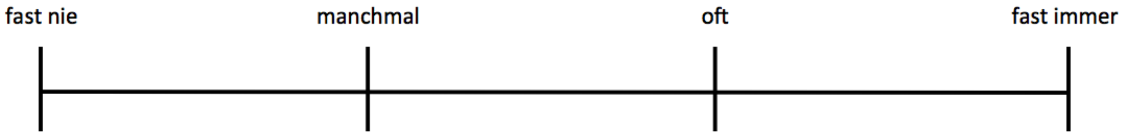
Ein Beispiel:

Ich kann mich gut entspannen

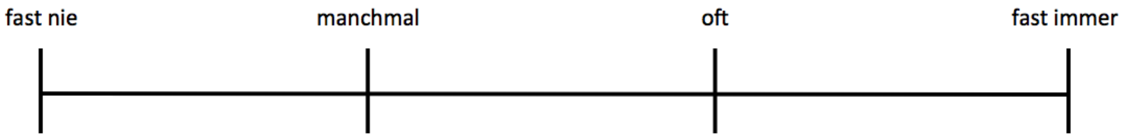


Bitte kreuzen Sie die Antwort an, die für Sie im Allgemeinen zutrifft.

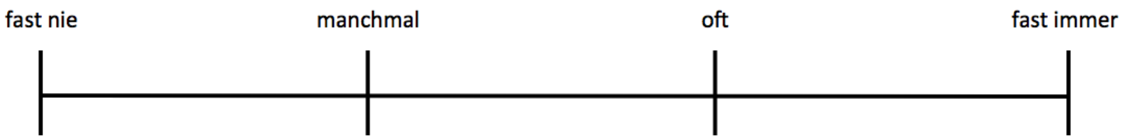
Ich bin vergnügt



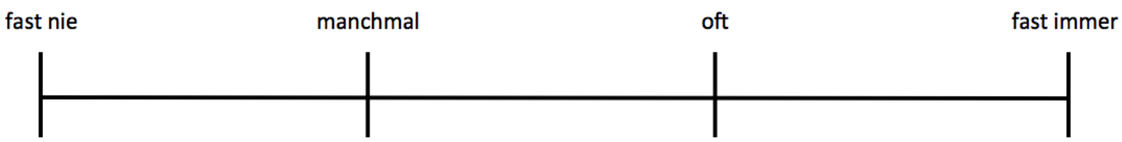
Ich werde schnell müde



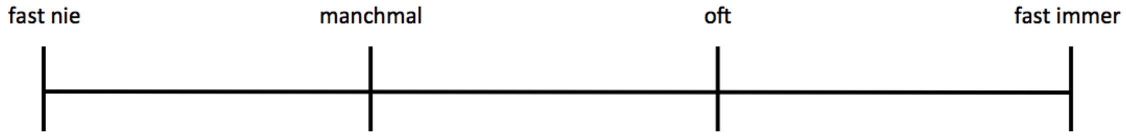
Mir ist zum Weinen zumute



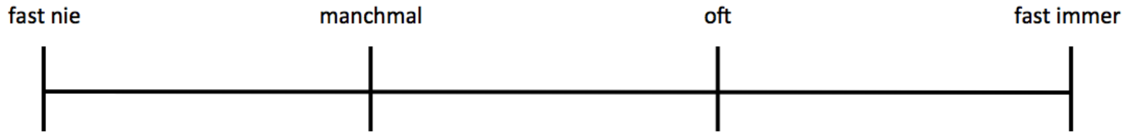
Ich glaube, mir geht es schlechter als anderen Leuten



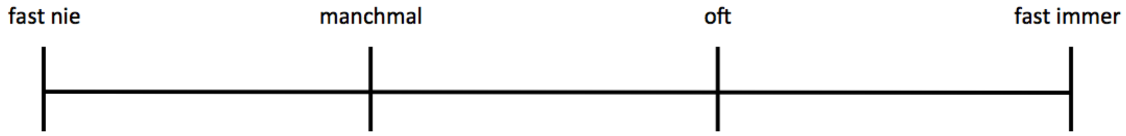
Ich verpasse günstige Gelegenheiten, weil ich mich nicht schnell genug entscheiden kann



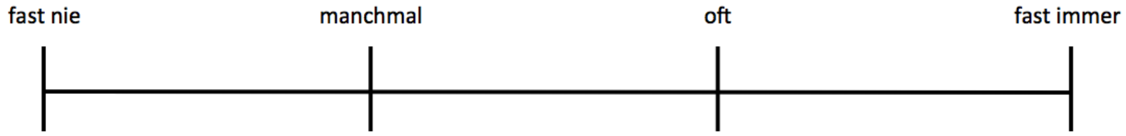
Ich fühle mich ausgeruht



Ich bin ruhig und gelassen



Ich glaube, dass mir meine Schwierigkeiten über den Kopf wachsen



Ich mache mir zu viel Gedanken über unwichtige Dinge

fast nie | manchmal | oft | fast immer

Ich bin glücklich

fast nie | manchmal | oft | fast immer

Ich neige dazu, alles schwer zu nehmen

fast nie | manchmal | oft | fast immer

Mir fehlt es an Selbstvertrauen

fast nie | manchmal | oft | fast immer

Ich fühle mich geborgen

fast nie | manchmal | oft | fast immer

Ich mache mir Sorgen über mögliches Missgeschick

fast nie | manchmal | oft | fast immer

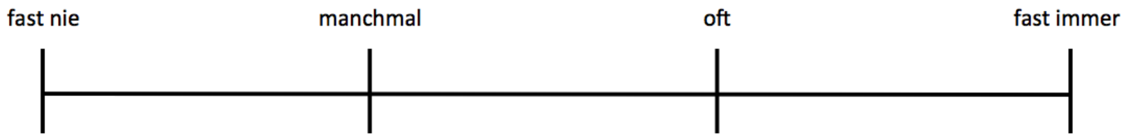
Ich fühle mich niedergeschlagen

fast nie | manchmal | oft | fast immer

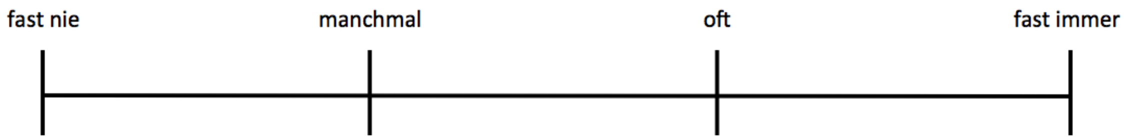
Ich bin zufrieden

fast nie | manchmal | oft | fast immer

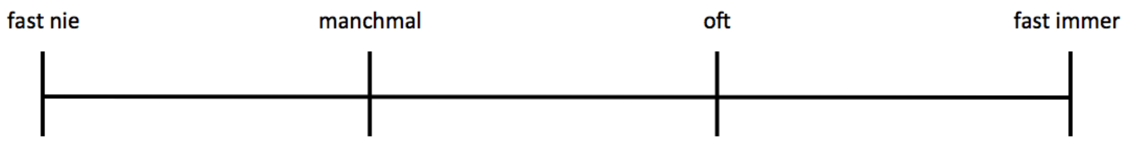
Unwichtige Gedanken gehen mir durch den Kopf und bedrücken mich



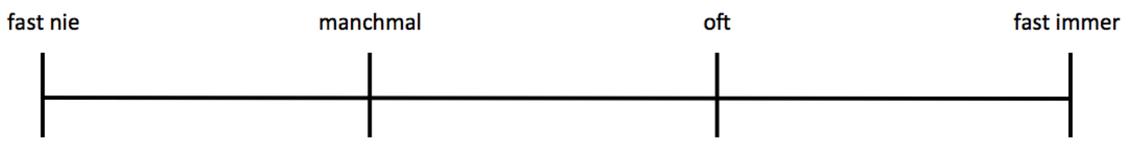
Enttäuschungen nehme ich so schwer, dass ich sie nicht vergessen kann



Ich bin ausgeglichen



Ich werde nervös und unruhig, wenn ich an meine derzeitigen Angelegenheiten denke

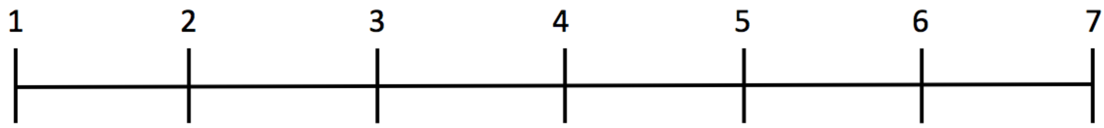


4) Rating Scales

Bitte beantworten Sie die folgenden Fragen intuitiv, schnell und ohne lange nachzudenken. Es gibt keine richtigen oder falschen Antworten.
Bitte kreuzen Sie bei den folgenden Fragen den Wert an, der Ihrer Meinung nach am Besten passt. Hierbei stehen Ihnen in aufsteigender Reihenfolge 7 Werte zur Verfügung. 1 steht dabei für "gar nicht" und in aufsteigender Reihenfolge 7 für "sehr".

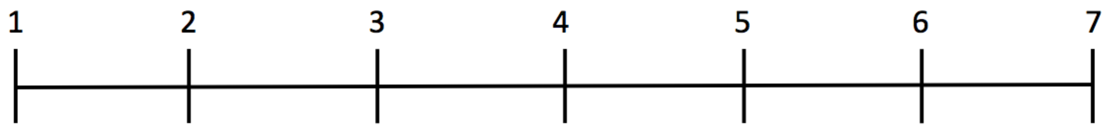
Wichtige Anmerkung: Wenn von einem meditativen Zustand die Rede ist, ist folgendes gemeint: Ein bewusstseinsveränderter Zustand wie zum Beispiel Veränderung des Denkens, der Zeitwahrnehmung, der Kontrolle, der Emotionen, des Körperempfindens und der Wahrnehmung von Bedeutung und Wichtigkeit.

1) Wie intensiv war der erlebte meditative Zustand?



1 = gar nicht -------- 7 = sehr

2) Wie einfach war es in einen meditativen Zustand zu kommen?



1 = gar nicht -------- 7 = sehr

3) Wie entspannend war die Meditation für Sie?

1 2 3 4 5 6 7

1 = gar nicht -------- 7 = sehr

4) Wie glücklich fühlten Sie sich während der Meditation?

1 2 3 4 5 6 7

1 = gar nicht -------- 7 = sehr

5) Wie sehr hat Ihnen die Meditation gefallen?

1 2 3 4 5 6 7

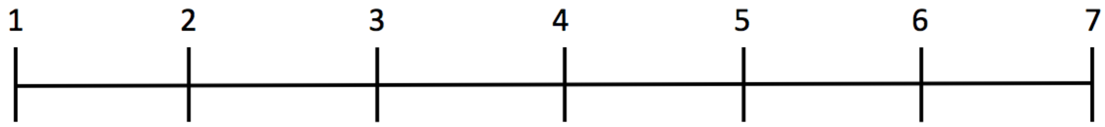
1 = gar nicht -------- 7 = sehr

6) Wieviel beruhigter sind Sie nun, im Vergleich zu vor der Meditation?

1 2 3 4 5 6 7

1 = gar nicht -------- 7 = sehr

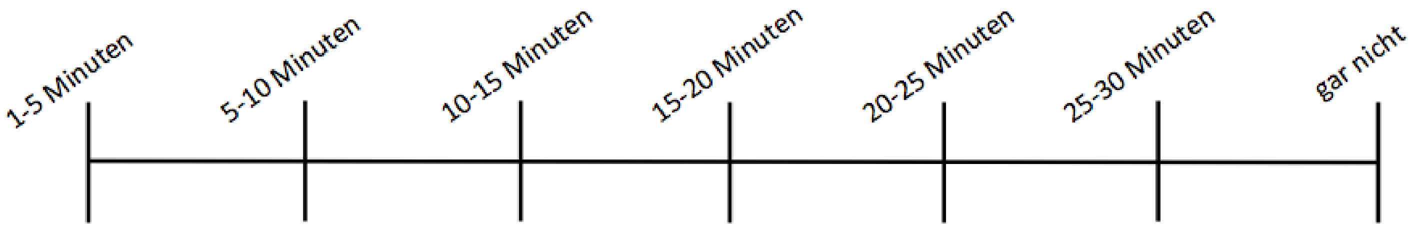
7) Wie müde waren Sie durch die Meditation?



1 = gar nicht -------- 7 = sehr

Die folgende Frage hat wieder 7 verschiedene Antwortmöglichkeiten zur Verfügung. Bitte beantworten Sie die folgende Frage intuitiv, schnell und ohne lange nachzudenken. Es gibt keine richtigen oder falschen Antworten.

8) Wie schnell sind Sie circa in einen meditativen Zustand gekommen?



9) Gibt es etwas das Ihnen während der Meditation aufgefallen ist?

10) Möchten Sie noch etwas in Bezug auf die Meditation erwähnen, dass noch nicht gefragt worden ist? Bitte nutzen Sie den nachfolgenden Platz um dies zu tun.

5) Qualitative results

Relaxing music

jede Menge / Normalerweise sitze ich ohne Musik. Da ich teilweise die Musikstücke kannte, kamen Erinnerungen aus der Kindheit hoch. Wir sitzen mit der Idee, nicht zu merken, ob uns etwas gefällt oder nicht. Daher empfinde ich es als etwas irritierend, meine Meditation zu "werten".
Augenzucken ab ca. 20 Minuten; Gefühl als wäre eine Störquelle angegeangen. Konnte dann die Konzentration schwer halten. (ab ca. 20 minuten berichtet sie war sie gestresst --> sie hat etwas wie einen Wind gehört --> Das Rauaschen der Klaviermusik ist ab Minute 18 lauter - möglicherweise war dies die Störquelle --> sie wollte die Kopfhörer schon fast abnehmen
Ablenkung durch wunderschöne Musik am Anfang doch sehr groß
wunderbare Musik / (sie ist eingeschlafen)
nicht der fokus auf die Tecnik --> war nicht so möglich --> aber durch die Musik war ein anderer Zustand in einen meditativen Zustand möglich der ihr (laut ihr) einen intensiveren meditativen Zustand ermöglichte --> kurz: weniger Fokus auf "Muh" beim Ausatmen --> dafür aber intensiverer meditativer Zustand als sonst --> war auch schon bei "stressend" so
wurde sehr müde, aber angenehmes Gefühl / war ziemlich schnell in der Meditation drinnen
eigentlich nicht
Bei der Musik (klass. Klavier) ist zu hören, wenn das Pedal getreten wird. Bei manchen Aufnahmen klingt es, als würde im Hintergrund jemand mit einem sehr dicken Edding auf Papier zeichnen.
kurzer Angstzustand
Hintergrundgeräusche hinter der Klaviermusik
je lauter die Musik desto leichter schaltet man ab
das Musik nicht förderlich ist
Hintergrundgeräusche / Filmmusik "Ziemlich beste Freunde"
Ich habe ab ca. 15/20 min Geräusche aus meiner Rücken-/Wirbelsäulengegend, besonders beim Einatmen, wahrgenommen (Muskelstränge oder Sehnen? Keine Ahnung) / Zwischendurch hätte ich lieber keine Musik gehabt
Beim Wechsel der Musik wechselt auch die Tiefe der Meditation
Ich habe im Hintergrund immer ein Rauschen wahrgenommen und konnte mich dadurch nicht wirklich auf die Musik einlassen, obwohl mir diese eigentlich gefallen hat. Ich fand die Musik grundsätzlich entspannend, aber das Rauschen hat mich trotzdem gestört.

Arousing music

die laute und "agressive" Musik kann durchaus entspannend sein/ elektro sound hingegen habe ich als unangenehm empfunden
zu Beginn keine persönliche Gedankenwelt, trotz Bewertung der Musik Fokus auf Übung möglich; gegen Ende tendenziell gestresst und überreizt; (" sie sagt sie war sehr beeinflusst von der Musik und ihrer Bewertung --> dann hat sie es aber geschafft")
Herzrasen / mir wurde übel
Zustand hat sich mit dem Musikwechsel verändert
optische Halluzinationen
Musik, die ich kannte (Skrillex) hat mich sehr "gefangen" --> Fokus auf Musik

gegen Ende hin wurde es immer anstrengender
Die Wechsel zwischen den Liedern haben mich wieder herausgerissen, mit elektronischer Musik ("Dubstep") war es leichter für mich abzuschalten als mit Metal.
Das der Zustand (Musik) der Meditation nicht förderlich ist / es hat sich mir die Frage nach der Sinnhaftigkeit dieses Tuns gestellt und auch der Relevanz der Daten…
Lieder haben sich wiederholt / es war eher lustig als entspannend
Schwierig in einen meditativen Zustand zu kommen da zu schnelle Musikwechsel (und diese hoch [oder doch?] sehr bass-/taktlastig
Metal hat mich sehr angespannt. Ich hatte das Gefühl. Dass ich etwas aggressiv werde.

no music

Sitzposition war angangs nicht so gut, generell wäre sitzen auf einem Kissen vermutlich besser. Anfangs hatte ich Herzklopfen.
Schwierigkeit, meditativen Zustand klar von Haöbschlaf zu unterscheiden
starke Störgeräusche durch Umgebung
ein quietschendes Fenster, 2mal; Schritte im Raum kurz; Phantasien, Erinnerunge; Bewegung davor (davon?) Weg als lösend empfunden (Gesamtsichtveränderung); Idee künstlerische Arbeit / zum Schluss Kopfhörer gespürt
Die Zeit ist sehr schnell vergangen, als bei der 1. Sitzung um 14:00
(von mir: aufeinmal hat ein Saxophonspieler draußen zu spielen begonnen)
mehrmals weggenickt / Ohrwürmer, die ich nicht ausblenden konnte / (sie sagte, dass sie diesesmal nicht meditieren konnte)
mein Telefon hat geklingelt
an einigen Stellen einen hohen Ton gehört, der relativ unangenehm war (Notiz von mir: ich denke das war die Straßenbahn")
Zu Beginn: es war sehr schwer an nichts zu denken und abzuschalten

alpha- theta wave frequencies

Ich habe 1 mal die Augen geöffnet und ca. 3 Sekunden später was ein höheres Geräusch zu hören. Mehrmals (3mal) kamen Piepsgeräusche. [sie dachte, dass sie etwas über die Kopfhörer wahrgenommen hat --> wollte wissen ob ich etwas abgespielt habe / sie hat vermutlich die Umgebungsgeräusche (Bim) wahrgenommen aber sagte, dass diese im Vergleich zu "ohne Musik" anders waren --> möglicherweise Verzerrung der Umgebungsgeräusche durch die Wellen. / Ihr KOpf fühlt sich zappelig an / Sie siagt sie kann sich fast nicht auf die Fragen konzentrieren / sie wirkt etwas verwirrt auf mich und daneben/ Beim state test zu t2 hat sie "Gehirn zappelig" und "Kann mich nicht konzentrieren" geschrieben.
sehr starkes Hitzegefühl 5 min vor Ende, plötzlich enorme Unruhe, hatte das Gefühl, nicht mehr still sitzen zu können ("sie spricht davon, dass sie 2 mal so richtig weggedrifftet ist --> also in einen meditativen Zustand.")
Der Sessel war weniger bequem.
Sie hatte am Vorabend ein hartes, anstrengendes Gespräch. Das erschwerte ihr das ganze Anfangs. Sie war in Gedanken beim Gespräch.
leise Wahrnehmung durch die Kopfhörer (laute Töne) / keine Regung von Glück oder Unglück in diesen 30 Minuten. Leere, nichts Denken…
kein durchgehend meditativer Zustand
im Vergleich zu "ohne Musik" 1 Stunde davor, war es laut ihr viel leichter --> auch sie berichtet wieder dass sie die Umgebungsgeräusche gar nicht wahrgenommen
Die "Wolken" haben die Richtung gewechselt, was gar nicht so angenehm war. Gong zum Ende hat mich erschreckt. (Notiz von mir: "Sie beschrieb den Zustand als insgesamt intensiver [als stressend] --> insgesamt 2. Durchgang)
ohne Musik war es schwerer in einen meditativen Zustand zu kommen
3mal kam ein Geräusch auf dem rechten Ohr
es kam ihr länger vor als die Meditation "Aufreibend" und "ohne Musik"
mein Telefon hat geläutet; 2mal war ein kurzes Knacken zu hören
3, 4 mal Geräusche (kurz)
starkes Schwindelgefühl, Gefühl wie bei beschlagenen Ohren nach einiger Zeit
Ganz ohne Musik hat mich irgendwie auch irritiert, weil es ja trotzdem nie ganz ruihg ist - andere Geräusche werden dominant Und meine Hände/ Handgelänke fühlten sich so unfassbar schwer an. ("die Meditation kam ihr länger vor als die anderen --> auch länger als "ohne Musik"
Hatte den Eindruck Geräusche zu hören ("es ist ihr anders vorgekommen als die anderen Testungen --> vor allem eben die Umgebungsgeräusche / Geräusche")

general

2mal 12 Personenzimmer; 1mal HS 27 und 1mal Besucherzentrum --> die 2 letzteren waren viel ruhier --> verfäclsche Ergebnisse (auch bei Anna Maringer)
Ratings wie glücklich oder Gefallen ist bei Zen laut ihr nicht möglich. --> man versucht nicht wertend zu sein - also weder glücklich noch unglücklich --> möglicherweise rausnhemen
sie hatte für die 2. Zeile des d2r "danach" mehr Zeit (--> zu spät gestoppt)
"ohne Musik" und "alpha" wurden beide im Besucherzentrum getestet
Ich habe persönlich das Gefühl, dass es Herrn Dosen nicht gefreut hat und er bewusst gegen die Ergebnisse gearbeitet hat. --> Das heißt beim Konzentrationstest zu Zeitpunkt 2 habe ich das Gefühl, dass es Ihn einfach nicht gefreut hat gscheit zu arbeiten.