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„ Listening to relaxing music and its stress-reducing effects “

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Abstract

In modern society, a fair amount of people experience life as very stressful. Stress triggers both physiological and psychological reactions, leading to a complex stress response. However, prolonged exposure to high levels of stress has been associated with various physiological and psychological disorders. To prevent these long-term consequences of stress, listening to music has been proposed to promote stress recovery. This master thesis investigated the impact of listening to relaxing music on stress recovery and considered four potential underlying mechanisms. These mechanisms include positive emotions, distraction, rhythmic entrainment, and pleasure. In this study, the Trier Social Stress Test (TSST) was used to induce psychological stress, followed by different conditions of listening to relaxing music, an audiobook, or sitting in silence. A t-test revealed no significant difference in stress recovery between the music and silence conditions. Concerning the potential underlying mechanisms, no significant correlation between the mechanisms and stress recovery was found. Likewise, another t-test compared stress recovery between the music and audiobook conditions, but no significant difference was found. Nevertheless, the extremely small sample size (N=39) prohibits any definite conclusions. Further limitations and future research are discussed.

Key words: relaxing music, stress-reducing mechanisms, stress recovery, positive emotions, distraction, rhythmic entrainment, pleasure, heart rate

Content

Introduction

People in modern society experience life as very stressful (American Psychological Association, 2022; Australian Psychological Society, 2015). According to a survey by the American Psychological Association (2022), around a third of adults (34%) reported that stress is completely overwhelming most days. In humans, there are both physiological and psychological reactions to stress, leading to a complex stress response including the activation of the hypothalamic-pituitary adrenal (HPA) axis and the activation of the sympathetic nervous system (SNS) (Casey, 2017; McCance et al., 2006; Thoma et al., 2013). However, high levels of stress have been associated with several physiological disorders like cardiovascular and cerebrovascular disease as well as psychological disorders like burnout and depression (Abrams et al., 2020; Australian Psychological Society, 2015; Carroll et al., 2017; Casey, 2017). To prevent such potential long-term consequences of stress, effective stress recovery is key. There have been various activities discussed that may promote a better stress recovery. One of them is listening to music (American Psychological Association, 2017; Australian Psychological Society, 2015).

Stress Definition

In daily life, the term stress is used in a broad way. It is used to refer to both the trigger (stressor) and the physiological and psychological reactions following the trigger (stress response) (Nater et al., 2011). In medicine, Selye (1956) made a common definition of stress: “Stress is a general activation reaction to a stimulus that could mean both a challenge (in a positive way) and a threat (in a negative sense)” (p.32). Stress is a highly complex interaction of multiple parameters. These parameters include external variables like intensity, frequency, or quality of stressor as well as individual variables like appraisal of the stressor and available resources (Nater et al., 2011). Stressors include major life events and trauma but are not limited to that. Minor challenges in daily life can also serve as stressors.

One theory that highlights the psychological dimension of stress is the transactional model of stress and coping by Lazarus & Folkman (1984). According to this theory, the same stressor can lead to a variety of responses in different individuals. In this theory, primary (concerning the stressor) and secondary appraisal (concerning the available resources) take up an important role and determine whether a stress response is initiated. Primary appraisal is the initial cognitive process in which an individual first perceives a potential stressor. This stage involves assessing whether the stimulus is relevant, dangerous, or positive. If the stimulus is perceived as irrelevant for the individual or the outcome is considered positive, the secondary appraisal is not initiated. Only if the stimulus is assessed as dangerous (characterized as damage or loss, threat, or challenge) the subsequent secondary appraisal is triggered. During secondary appraisal, the individual evaluates his*her available resources (e.g. social support) to handle the present stressor. If he*she does not feel capable of handling the situation and that the demands of the situation outweigh the available resources, he*she experiences stress.

Stress Response

In humans, there are both physiological and psychological reactions to stress. Environmental, psychosocial, or physical stressors can be a threat to the balance within the body systems, also referred to as homeostasis (McEwen et al., 1998). When confronted with such a threat, humans can make use of regulatory systems and strategies to adapt to changes in the environment and to maintain homeostasis of vital parameters despite adverse circumstances. This regulatory process is also called allostasis (McEwen et al., 1998; Steinle, 2015).

Physiological Stress Response

On the physiological level, stress leads to a complex stress response including the activation of the hypothalamic-pituitary adrenal axis (HPA) and the activation of the sympathetic nervous system (SNS) (K. L. McCance et al., 2006; Thoma et al., 2013).

HPA Axis

The hypothalamic-pituitary-adrenal axis (HPA) is one of the main stress responses in the body and leads to the release of the stress hormone cortisol (Bear et al., 2020; Tsigos & Chrousos, 2002). The HPA axis begins in the paraventricular nucleus of the hypothalamus. These neurons release corticotropin-releasing hormone (CRH), which then stimulates the secretion of adrenocorticotropic hormone (ACTH) from the anterior pituitary. The released

ACTH travels in the bloodstream to the adrenal gland lying on top of the kidney and stimulates the release of cortisol. Cortisol is the final effector of the HPA axis and participates in the control of body homeostasis. It contributes to the body's physiological response to stress by mobilizing energy reserves and suppressing the immune system and also regulates the stress response itself by exerting negative feedback at the central nervous system (Bear et al., 2020). The HPA axis itself is regulated by the amygdala and the hippocampus in a push and pull fashion. The amygdala activation stimulates the HPA system, whereas hippocampal activation suppresses the HPA system.

Sympathetic Nervous System

The sympathetic nervous system (SNS) is part of the autonomic nervous system (ANS) and innervates most body parts. The ANS regulates involuntary organ functions in the body such as respiration, heart rate, blood circulation, digestion and consists of the autonomic, enteric, and parasympathetic nervous system (C. Kirschbaum & Heinrichs, 2011). The SNS is constantly active, even in non-stressful situations. However, when a stressor occurs, the sympathomedullary pathway (SAM), which includes the activation of the SNS, enables the body to deal with the stressor by triggering a "fight or flight" response. Stimulation of the sympathetic nervous system is accompanied by an increase in activation in most organ systems and leads to a state of overall elevated activity and attention (Waxenbaum et al., 2019). Additionally, the SNS interacts with the immune system and innervates immune organs like the lymph nodes and its responses to stress engage the cardiovascular system (Bear et al., 2020; Waxenbaum et al., 2019).

Stress and Health

The mentioned allostatic physiological responses to stress help humans cope with stressors and protect the body from getting injured. However, chronic exposure to stress and therefore the constant use of allostatic regulations can lead to allostatic load (McEwen et al., 1998). Allostatic load is formed by the cumulative negative consequences for having to adapt to adverse situations for too long. The result can be a damage to body systems and thus a variety of symptoms.

Exaggerated SAM and HPA axis reactions to acute stress exposure can lead to adverse health outcomes (Carroll et al., 2017). For instance, the influential reactivity hypothesis argues that those who frequently show exaggerated cardiovascular reactions to acute stress have an increased risk of cardiovascular disease (Obrist, 1976). In general, high levels of stress have been associated with several physiological disorders such as cardiovascular and cerebrovascular disease as well as psychological disorders like burnout and depression (Abrams et al., 2020; Australian Psychological Society, 2015; Carroll et al., 2017; Casey, 2017).

Music and Stress

Music is a frequently used tool to cope with stress in a variety of different settings (Australian Psychological Society, 2015; Linnemann, 2016; Witte et al., 2020). This includes clinical music therapy interventions as well as listening to music in daily life. Additionally, a growing research body has discussed various beneficial effects of music on stress and studies suggest that music may affect stress reactivity as well as stress recovery (Koelsch et al., 2016; Thoma et al. 2012; Witte et al., 2020). Stress reactivity can be described as an individual’s disposition to respond to a stressor with a stress reaction (Schulz et al., 2005) whereas stress recovery can be defined as the process of unwinding the physiological and psychological activation caused by the stress response (Adiasto et al., 2022; Sonnentag et al., 2022).

A recent systematic review on the effects of music interventions on stress concluded that music-based interventions have a positive impact on both physiological (e.g., heart rate, hormonal levels) and psychological (restlessness, anxiety) stress-related outcomes (Witte et al., 2020). This review included 104 randomized controlled trials with different kinds of music interventions, one of them being listening to music. Music listening itself has been linked to influence neuroendocrine, physiological, and psychological measures that are regarded as beneficial for stress recovery (Fancourt et al., 2014; Koelsch et al., 2016; Koelsch et al., 2011; Linnemann, 2016).

In contrast to these findings, a systematic review of randomized, controlled experimental studies found no significant cumulative effect of music listening on stress recovery (Adiasto et al., 2022). However, due to the small number of 14 included studies and their significant heterogeneity, results should be interpreted with caution. Further research is necessary to investigate whether music listening facilitates stress recovery in healthy individuals or not.

Potential mechanisms underlying the effects of music listening on stress

The exact way in which music might have a stress-reducing effect remains unclear. Adiasto et al. (Adiasto et al., 2022) discuss three different mechanisms of how listening to music might affect stress recovery. These include music-evoked positive emotions, distracting effects, and rhythmic entrainment.

Positive Emotions

Positive emotions have numerous benefits on the body in enhancing effective coping and promoting health (Tugade et al., 2004). Concerning the stress-reducing effects of music, music-evoked positive emotions might enhance a more effective coping and facilitate stress recovery (Adiasto et al., 2022; La Torre-Luque et al., 2017; Tugade et al., 2004). One framework to explain these benefits is the broaden-and-build theory by Fredrickson (Fredrickson, 1998). According to this framework, negative emotions can narrow one’s attention and thoughts and lead to an activation of the autonomic nervous system (Fredrickson & Fowler, 2001). In contrast, positive emotions can reduce this autonomic arousal caused by negative emotions, promote psychological resilience, undo enduring negative emotions, and support cognitive broadening.

In literature, several studies have indicated that preferred relaxing music leads to lower negative affect and higher positive affect (Groarke et al., 2019; Koelsch et al., 2016; La Torre-Luque et al., 2017). For example, La Torre-Luque et al. (2017) conducted a randomized controlled trial in which participants either listened to self-selected preferred relaxing music or sat in silence (control group) after being exposed to a stress task. They concluded that participants in the music listening condition showed lower levels of anxiety and negative affect, and higher levels of positive affect compared to the control condition. However, there are also some contrasting findings. For example, a study comparing stress recovery between a music listening condition, a music improvisation condition and a control condition did not find differences in calmness, excitement, irritation or satisfaction between the control group and the music listening group (Fallon et al., 2020). It should be noted that the music in this study was preselected and all three conditions led to a significant psychological stress reduction. Because of that, these findings do not necessarily conflict with previous findings. Another general problem with these studies is the great variability of the used measurements to assess positive and negative affect. While the broaden-and-build theory explains possible benefits of positive emotions, most of these studies assessed mood and each one used a different tool to do so. La Torre-Luque et al. (2017) used the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), Koelsch et al. (2016) used the Profile of Mood States questionnaire (POMS; Shacham, 1983), Groarke et al. (2019) used Visual Analogue Scales with eight different bipolar affective states and Fallon et al. (2020) used a self-made current mood scale of calmness, irritation, satisfaction, and excitement. Even though there are overlaps in all these measurements and they might be able to show a general tendency of a broad positive and negative affect, one has to keep in mind the different theoretical constructs behind these measurements.

Distraction

A second mechanism could be that music works as a distractor. In this case, listening to music draws the attention away from a potential stressor and therefore reduces rumination and negative affect, which in turn facilitates the stress recovery (Adiasto et al., 2022; Baltazar & Saarikallio, 2019). Radstaak et al. (2011) demonstrated this negative effect of rumination and negative affect on stress recovery on a physiological level. They conducted an experimental study that included a stress exposure task and measured the cardiovascular recovery. Blood pressure recovery was slower when participants watched a movie with negative emotional valence compared to a movie with neutral or positive valence and high levels of rumination correlated with slower blood pressure recovery. Distraction seems to be of particular importance as it is an often-used function of listening to music in daily life. A three-week diary study conducted by van Goethem et al. (2011) showed that distraction was one of the main strategies for listening to music. These results are supported by a study conducted by Linnemann et al. (2015). In this study, 47% of the participants reported to listen to music in daily life in order to distract themselves.

Rhythmic entrainment

A third potential mechanism is rhythmic entrainment. Juslin (2013) proposed a popular framework of the underlying mechanisms of music evoked positive emotions. One of the proposed mechanisms is rhythmic entrainment. In this mechanism, emotions are induced, because body rhythms like respiration become partially or fully synchronized with rhythmic elements of music. This change of physiological rhythms can lead to a change in the listener's affective state through proprioceptive feedback (Juslin, 2013). There is plenty of literature confirming that listening to music can influence respiration and heart rate (Hodges, 2010). For example, music that is fast and accentuated accelerates breathing and heart rate (Gomez et al., 2007). In general, heart rate also increases with emotional arousal or for distinct emotions like anxiety or surprise (Vuilleumier & Trost, 2013). Concerning the stress reducing mechanisms of music, this synchronization of physiological rhythms (e.g. heart rate) with rhythmical elements of the music (e.g. beat) could accelerate stress recovery by decreasing arousal and generating changes in the ANS (Adiasto et al., 2022; Gomez et al., 2007; Vuilleumier & Trost, 2013).

Pleasure

I would like to add one potential mechanism to this list, by considering reward-related processing. Music can be a very pleasing human experience. Listening to pleasurable music has been linked to activate reward-related brain networks (Mas-Herrero et al., 2013). The major components of reward are liking and wanting (Berridge & Kringelbach, 2008). Wanting refers to the motivational component of reward, whereas liking refers to the hedonic component. Dopamine release is causally involved in the wanting and liking of musical rewards (Ferreri et al., 2019). For instance, not only has dopamine release in the striatal system been observed in the anticipation of peak pleasure moments and while listening to desirable sound events, but also on a behavioral level (Salimpoor et al., 2013; Salimpoor et al., 2011). Dopamine release caused by music can in turn trigger opioid stimulation of hedonic hotspots (Berridge & Kringelbach, 2008). In general, liking is caused by the activation of hedonic hotspots (e.g., the NAcc). The stimulation of opioid, endocannabinoid, or other neurochemical receptors within these hotspots lead to a liking reaction (Berridge & Kringelbach, 2008). In turn, these opioid stimulations might also affect the HPA axis. Opioid drugs are known to have a stress-reducing effect (Bershad et al., 2015). A study with opioid partial agonist (buprenorphine) was able to show that the opioid stimulation reduced cortisol responses to psychosocial stress after being exposed to a stress-task (Bershad et al., 2015). Taken together, these findings suggest that music that is perceived as pleasant can affect the opioid system, which in turn can have a stress reducing effect (Berridge & Kringelbach, 2008; Bershad et al., 2015).

Research Gap

Taken together these findings, it remains unclear if listening to relaxing music does facilitate stress recovery in healthy individuals. And if so, the exact mechanisms responsible for facilitating stress recovery need to be addressed.

Research Questions and Hypotheses

In order to tackle this research gap, the main research question of this master thesis is “Does listening to relaxing music accelerate stress recovery?” (RQ1). My first hypothesis to test this research question is “Listening to relaxing music accelerates subjective stress recovery compared to silence” (H1).

If that is the case, the first sub research question is “Which mechanisms of music listening might be responsible for this accelerated stress recovery?” (SQ1). And my second hypothesis to test this first sub question is: “Indices of the four described mechanisms can predict a faster stress recovery” (H2).

To be able to speak of a uniquely strong relaxing effect of listening to music, we have to compare this effect to other possible relaxing stimuli. Therefore, the second sub research question is “Is music listening more effective in accelerating stress recovery compared to other distractors, like listening to an audiobook?” (SQ2) My third hypothesis to test this second sub question is “Listening to relaxing music accelerates subjective stress recovery compared to listening to an audio book” (H3).

Methods

This master thesis is part of an ongoing research project called “effects of music listening after an acute stressor on psychological, cardiovascular and endocrine stress measures and skin barrier recovery”. This project launched in

2019 and takes place at the Department of Clinical and Health Psychology at the University of Vienna. Dr. Jasminka Majdandzic and Univ.-Prof. Dr. Urs Nater lead this project. Data used in this study was collected between January 2020 until October 2022.

Study design

This study was designed as a randomized controlled trial. Participants were randomly assigned to one of three conditions: the music listening condition, which served as the experimental condition, and the audiobook condition and the silence condition, which served as the two control conditions. Before and during the experiment, participants were asked to fill out several questionnaires. Additionally, physiological data like cardiovascular measurements, saliva samples, and transepidermal water loss were assessed during the study sessions and the Trier Social Stress Test (TSST) was used to induce psychological stress. The primary aim of this master thesis is to investigate the impact of listening to relaxing music on stress recovery and to explore indices of four potential underlying mechanisms. Therefore, the randomly assigned listening condition of the participant served as the independent variable, whereas the individual stress recovery served as the dependent variable. In order to assess the individual stress recovery, three different timepoints were relevant. The perceived stress level before performing the TSST (baseline level), after performing the TSST (peak level) and after the listening condition (post level) (see figure 1). To be able to explore potential underlying mechanisms, indices for rhythmic entrainment, pleasure, distraction and positive emotions were collected at different timepoints. For the levels of rhythmic entrainment and positive emotions, the peak stress level (after the TSST), and the post-intervention level (after the music listening intervention) were relevant. The levels of distraction and pleasure were measured in a questionnaire following the music-intervention.

Sample

Participants were mainly recruited by the members of the study team via social media (e.g. in Facebook posts) and by the University of Vienna via a study mailing list. The study has been running since 2019 and therefore has faced several lockdowns and restrictions due to the COVID-19 pandemic. All participants signed an informed consent at the beginning of the experiment and received 45€ for participating in the study.

Exclusion criteria

The study had several exclusion criteria. A first pre-selection took place in the recruitment. The flyers given to the public via a study mailing list and social media listed the general exclusion criteria (e.g. age, sex). Secondly, a telephone-based screening allowed a more specific control of exclusion criteria.

As this study is part of an overall study project, some of the applied exclusion criteria are not relevant for this research question but still affect the sample group. For a more detailed insight into the applied cortisol and alpha-amylase specific exclusion criteria, see Strahler et al. (2017).

A number of general exclusion criteria were applied. Only healthy women aged 18 to 35 years were included. It was required that they were fluent in German in order to follow the instructions given. Pregnancy, the use of hormonal contraceptives, breastfeeding and a menopause had been exclusion criteria. Furthermore, the study had to take place in the follicular phase of the menstrual cycle. Therefore, participants with an irregular menstrual cycle were excluded. They could not have any chronic somatic illness, uncorrectable visual impairment, current mental disorder, or psychiatric illness. Additionally, a tropical stay within the last six months or vaccinations within the last two weeks served as exclusion criteria. Participants with a body mass index below 18 or above 25, who smoked regularly, with excessive alcohol use (=more than eight alcoholic drinks a week), drug intake in the last year or cannabis in the past 14 days had to be excluded. Participants could not have had surgery in the last 8 weeks or have other health-related anomalies. Lastly, the use of psychotropic drugs in the past 14 days and the intake of cardiovascular medication or medication that affects hormones were exclusion criteria.

Additional to these general exclusion criteria, some music related criteria were applied to prevent possible extraneous variables. These music related exclusion criteria include music-related professions, music related studies, hearing impairment or chronic tinnitus and absolute hearing. To guarantee a similar stress induction, participants with previous TSST experience or personal relationships with study team members were excluded. Since the overall research project focuses on skin barrier recovery and includes a tape stripping procedure, some skin and immune specific exclusion criteria were applied. Participants with a chronic or acute inflammatory skin disease, allergies to adhesive tape, eczema or burn marks on the volar forearm and participants that took immunosuppressive drugs were excluded.

Demographic characteristics

A total of N=42 participants passed the screening process and completed the experiment. Ages ranged from 19 to 33 years, with an average of 25.32 years (SD= 3.57). The majority of participants (N=25) possessed the Austrian nationality. Seven participants possessed the German nationality, two the Croatian nationality and eight participants possessed a different nationality (including Chilean, French, Chinese, Italian, Colombian, Swiss, Ukrainian and Hungarian). The vast majority (N=38) completed the higher secondary school (Matura, Abitur), while four participants either completed the lower secondary school (Hauptschule/Volksschule, N=1), middle secondary school (Realschule/mittlere Reife, N=1), a technical college entrance qualification (Fachhochschulreife, N=1) or another unspecified school training (N=1). Due to the recruitment procedure, many participants studied at a university (N=33), while some participants received postsecondary education at a non-university training school (Lehre, N=2), a polytechnic school (Fachhochschule/Ingenieursschule, N=1), some other sort of school (andere Berufsausbildung, N=1) or did not receive any postsecondary education (N=5).

Materials

During the study sessions, the TSST is used to induce psychological stress. In the following section, I will give a detailed description of this Stress test.

Trier Social Stress Test

The TSST (Kirschbaum et al., 1993) is a frequently used tool and has been shown to reliably produce a physiological and psychological stress response (Allen et al., 2017). On a physiological level, this includes an activation of the HPA axis as measured by the concentration of cortisol (serum and saliva) and adrenocorticotrophic hormone (Kirschbaum et al., 1993; Kudielka et al., 2007). It has also been shown to elevate cardiovascular activity, state anxiety, negative affect and perceived psychological stress (Nater et al., 2006; Robles, 2006). The TSST uses elements of social-evaluative threat and uncontrollability to stress participants (Allen et al., 2017). It consists of an interview-style free speech and a mental arithmetic test.

At the beginning of the TSST, the study leader and the participant enter the testing room in which two study members sit behind a desk. One of them interacts with the participant and will be called the active stressor in this paper. The other study member serves as an assistance and will be called the passive stressor henceforth. They are introduced as two experts trained to analyze human behavior. Furthermore, the participant is told that the whole test is being video recorded and assessed by the two so called experts.

The study leader explains the first task, in which the participant has to prepare for a job-interview. The participant must present his*her personal strengths and weaknesses in a free speech in front of the two experts and has 3 minutes to prepare this speech. During the free speech task, the study members are instructed to show little affection and to only ask questions and interrupt the speech when the participant fails to continue or drifts away from presenting his*her personal strengths and weaknesses. After five minutes have passed, the active stressor ends the free speech and explains the second task.
The second task is a calculation task in which participants must count backwards in steps of 17. They start with the number of 2043 and if they make a mistake, they must restart from 2043. They are told to do this as fast as possible and if they are performing well, the active stressor asks them to speed up to increase the probability of an error. This calculation task lasts for 5 minutes.

Stimuli

Each listening condition consisted of several different sets of stimuli. In the following, I will give a brief overview of the stimuli and the task procedure.

Music Condition

In the music condition, participants could choose to listen to one out of five playlists. The playlists themselves had been edited by the research team and consisted of 30 minutes instrumental music that appeared calm, pleasant, and relaxing to the research team. To reduce confounding variables, it was decided that the tempo should not be fast, emotional valence should be neutral or positive, the music should be low-arousing and not include lyrics.

Originally, six playlists had been edited, each one containing one type or genre of music. This included a playlist of ambient, guitar, jazz, classical piano, lofi and lounge music. To ensure that the music was perceived as relaxing, a prestudy with 70 participants (women with the age of 18 to 40 years) had been conducted. Participants had been randomly assigned to listen to either one of the six music playlists or an audiobook of 30 minutes length. Several questionnaires were used to assess the playlists. Affective states were assessed before and after listening to the audio excerpts using an item concerning subjective stress, the Types of Positive Affect Scale (TTPAS; Gilbert et al., 2008), and the Mehrdimensionale Befindlichkeitsfragebogen (MDBF; Steyer, 1997). The audio excerpts were rated using the Bewertung Musikstimulus questionnaire for the music playlists (see appendix) and an analogous rating for the audiobook excerpt (Bewertung Hörbuchstimulus, see appendix). All music playlists led to a significant increase in relaxed positive affect. Additionally, all playlists had been rated as rather relaxing than energizing and as rather cheerful than sad. However, the classical piano playlist scored higher than neutral for item 7 in the Bewertung Musikstimulus questionnaire concerning the evoked emotions, indicating that it might evoke melancholia. Therefore, this playlist was excluded.

Audiobook condition

Similar to the music playlists, five audiobooks were selected by the research team. All five of them have a length of 30 minutes. The topics were chosen to be non-arousing and included audiobooks in the domains of biology, history, cosmology, philosophy and physics.

Control condition

In the control condition, participants were sitting in silence for 30 minutes. They were advised to not fall asleep and were allowed to read magazines.

Measures

This study utilized several measures to operationalize the individual stress recovery and the four potential underlying mechanisms of how listening to relaxing music might affect stress recovery. In the following, I will explain how each variable was assessed and computed.

Stress Recovery

Stress recovery was operationalized via the measures of the perceived stress level. During the experiment, a visual analogue scale was used eight times in order to assess the perceived stress level of the participants. The visual analogue scale (VAS) is a popular tool to assess participant's perceived stress and has been shown to correlate with other stress assessments, supporting its construct validity (Lesage et al., 2012). In this item, the participants were asked "how stressed do you feel?" (in original: "Wie sehr fühlen Sie sich gestresst?") and could rate their perceived stress level by putting a mark on a 10cm long line that ranged from 0/not at all (in original: "gar nicht") to 100/very much (in original: "sehr stark"). To transform this mark to a numeric score, the distance from the mark to the left end of the line was measured with a ruler. This score was used to generate the variable stress recovery by comparing their perceived stress level before performing the TSST (baseline level), after performing the TSST (peak level) and after the listening condition (post level) (see figure 1). To calculate an individual score for the participants, I divided the difference between the peak and post stress level scores (peak-post) by the difference between the peak and baseline stress level scores (peak-baseline). Then, I multiplied this quotient by 100 and obtained an individual stress recovery percentage score. If this value is 100%, the post stress level score was the same as the baseline stress level score. If this value is below 100%, the participants still had an elevated stress level after the listening condition compared to the baseline stress level.

Formula: $\left(\frac{(peak-post)}{(peak-baseline)}\right) x\ 100$ = % stress recovery

Positive Emotions

The level of positive emotions was measured by the Mehrdimensionale Befindlichkeitsfragebogen (Steyer, 1997) in its short version A. This questionnaire consists of 12 Likert items and measures three bipolar dimensions: positive-negative mood (Gute-Schlechte Stimmung), vigilance-fatigue (Wachheit-Müdigkeit) and calmness-restlessness (Ruhe-Unruhe). Even though the MDBF measures mood (long-term, not necessary directed at a source) instead of emotions (short-term, directed at a source), we applied this measurement at different time slots which allows to connect the mood score with certain events and to observe temporal modifications. For my analysis, I used the positive-negative mood subscale which includes four items and has an **internal consistency** (Cronbach's alpha) **of 0.86 (**Hinz et al**.,** 2012**)**. To compute a mean score for this subscale, item 6 (schlecht/bad) and item 10 (unwohl/uncomfortable) were recoded (subtracted from 6) and then added to the item 3 (gut/good) and item 5 (zufrieden/satisfied). The sum score was divided by 4 and resulted in an individual mean score of the positive-negative mood subscale. The MDBF was used 8 times during the study (figure 1). For my analysis, only the third and the fifth measurements were relevant. The third measurement took place after the TSST and served as the peak stress level, and the fifth measurement took place after the music intervention and served as the post-intervention level. I computed the difference between these two scores by subtracting the third measurement (peak) from the fifth measurement (post-intervention). A positive number in this value indicates an increase of positive affect after the music listening condition compared to the peak stress level after the TSST and could therefore indicate that listening to relaxing music increased positive emotions.

Distraction

The level of distraction was measured within the questionnaire to assess the music condition (see appendix, Bewertung Musikstimulus, item 6). This questionnaire was handed out after the music listening task and included a 5-point Likert item asking how much the music has helped the participants to distract themselves (“Die Musik hat mir geholfen, mich abzulenken”). A high value in this item indicates a strong distracting effect of listening to relaxing music for the participants.

Rhythmic Entrainment

The level of rhythmic entrainment was operationalized by analyzing the heart rate measurements. During the whole experiment, participants wore a chest and wrist strap with an attached mobile sensor developed by Movisens (GmbH). The mobile sensor attached to the chest strap was an Ecg Move 4 sensor and was used to monitor the heart rate. The mobile sensor attached to the wrist strap was an Eda Move 4 sensor and was used to monitor electrodermal activity. After the experiment had ended, all data was saved using the SensorManager by Movisens (GmbH). The data was then analyzed using the UnisensViewer by Movisens (GmbH) and cropped into 5 minutes windows. Next, a mean heart rate value from these time windows was computed. For this analysis, two time-windows were selected to be relevant: The heart rate right after the TSST which served as a peak stress score (figure 1, marker 3) and the heart rate after the listening condition which served as a post-intervention score (figure 1, marker 5).

In order to examine a possible effect of the music intervention on the heart rate score, I subtracted the post-intervention score from the peak heart rate score. A high score for this difference indicates that the mean heart rate had been reduced by the listening condition and was lower after the music intervention compared to the peak level after the TSST. In this case, a greater decrease of the mean heart rate between the peak level score and the post-intervention score indicates stronger presumed rhythmic entrainment.

Pleasure

The pleasure participants experienced from the music was operationalized by assessing how much the participants liked the music. The questionnaire that was used to assess the music condition (Bewertung Musikstimulus, see appendix) was handed out after the music listening task and included a 5-point Likert item asking how much participants liked the music (“die Musik hat mir gefallen”, item 1). A high value in this item indicates that the participants liked the music that was played. And a high level of liking indicates that the music was experienced as pleasant and potentially activated reward-related processing.

Procedure

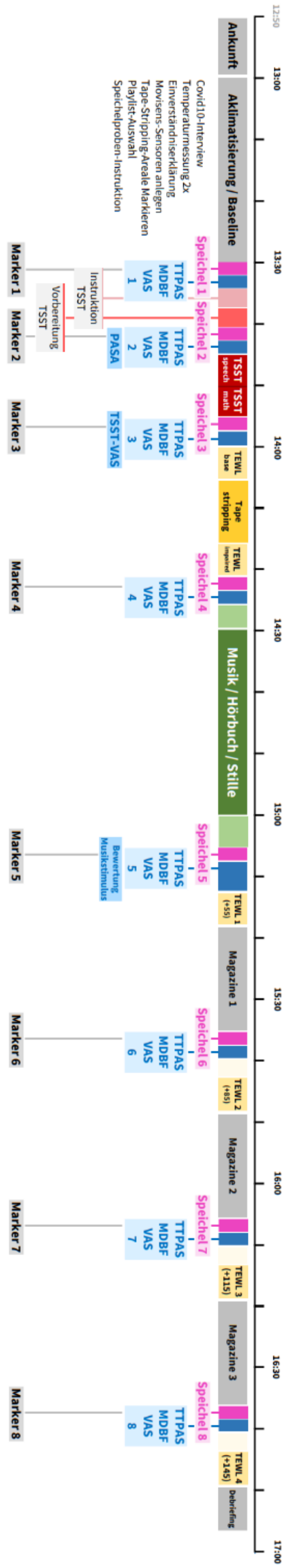

Figure 1. Timetable of laboratory sessions

Before attending the study, participants were asked to fill out a list of online questionnaires. Altogether, this included 19 questionnaires concerning different trait variables (e.g. emotion regulation). The whole experiment lasted for approximately four hours. For a complete timetable of the study, see figure 1. The study team for the experiment consisted of one study leader and one study assistant who were present throughout the whole study. Additionally, two study members conducted the TSST, but did not have contact with participants outside of this task. Participants were asked to wait outside of the laboratory and were then guided to the testing room by the study leader. During the first 30 minutes of acclimatization, participants filled out a consent form and Covid19 interview, got their temperature measured twice, listened to an instruction for the saliva samples and, depending on the experimental condition, selected a music or audiobook playlist. Additionally, the study assistance also applied two mobile sensors for the cardiovascular measurements and marked the tape stripping area for the skin barrier measurements. Next, the baseline measurements were taken. Participants filled out a first set of questionnaires and submitted a saliva sample. Next to the Mehrdimensionaler Befindlichkeitsfragebogen (MDBF; Steyer, 1997), this set of questionnaires included the Types of Positive Affect Scale (TTPAS; Gilbert et al., 2008) and a set of Visual Analogue Scales concerning the perceived stress level (VAS; Lesage et al., 2012).

Afterwards, the study leader informed the participants about the upcoming stress test (TSST; Kirschbaum et al., 1993) and guided them to a different testing room. In this room, the participants had three minutes to prepare for the upcoming speech task (first part of the TSST, see task description of the TSST below). Then, the study leader asked them to complete the second set of the TTPAS, MDBF, VAS data and collected the second saliva sample. Next, the study leader left the room and the participants completed the TSST. At the end of the stress test, the two study members conducting the TSST collected the third saliva sample and the third set of TTPAS, MDBF and VAS data. Afterwards, the study leader reentered the room and led the participants back to the principal testing room. In this room, the study assistance performed the first trans-epidermal water loss (TEWL) measurement as a baseline for the skin barrier recovery analysis. Next, the study assistance conducted a tape stripping procedure and afterwards collected the

TEWL data of the impaired skin (TEWL impaired). Following this, the study leader collected the fourth TTPAS, MDBF, VAS and saliva data. Depending on the condition, the participants were asked to listen to music, an audiobook or to sit in silence for the following 30 minutes. During this time, the study team left the testing rooms. After the 30 minutes had passed, the study leader reentered the room to collect the fifth set of TTPAS, MDBF, VAS and saliva data and additionally handed out a questionnaire for the assessment of the music or audiobook stimuli or the silence condition (see appendix). The study assistance then prepared to perform another TEWL measurement and began with the procedure exactly 55 min after the first TEWL impaired measurement. Next, the participant was left alone in the testing room for around 20 min. During this time, she was allowed to read magazines. The same procedure of the questionnaires and saliva collection, TEWL measurement and magazine reading was repeated three times in intervals of 30 minutes. Altogether, eight sets of TTPAS, MDBF, VAS data, eight saliva samples and four TEWL measurements were collected. At the end of the study, there was a short debriefing, in which the study leader explained the context of the study and the participant had the opportunity to ask questions.

Analyses

My first hypothesis to test research question one was “listening to relaxing music accelerates subjective stress recovery compared to silence”. To test this hypothesis, I performed a t-test with the listening condition (music vs. silence) being the independent variable and stress recovery being the dependent variable. Following the results of a previous conducted similar study by Groarke et al. (2019) which also used the same stress test (TSST) and controlled for subjective stress level, I expected a medium effect size of d=.54. I used GPower (Faul et al., 2007) to calculate the required sample size. With a two-tailed alpha of 0.05 and aiming for a power of 80%, a sample of at least N=55 in each group (music and silence) would be needed (total N= 110).

My second hypothesis to test the first sub question was “indices of the four described mechanisms can predict a faster stress recovery”. To test this hypothesis, I planned to perform a multiple linear regression with data of the participants from the music listening condition. The independent variables would have been positive emotions (operationalized by mood increase), pleasure (operationalized by the liking of the music), distraction (operationalized by assessing the level of distraction) and rhythmic entrainment (operationalized by the decrease in heart rate). Again, the dependent variable would have been the subjective stress recovery. Because there were several both psychological as well as physiological variables in this regression, I predicted the effect size according to the overall effect of music interventions on physiological and psychological outcomes. De Witte et al. (2020) found a small effect size for physiological outcomes (d=.380) and a medium effect size for psychological outcomes (d=.545). Therefore, I expected a small effect size of d=.380. I transformed this effect size into its coefficient of determination (r^2= .0349) and used GPower to estimate the required sample size. I aimed for a power of 80% and calculated that N=374 participants would be needed.

My third hypothesis to test the second sub question was "Listening to relaxing music accelerates subjective stress recovery compared to listening to an audio book". To test this hypothesis, I performed a t-test with the listening condition (music vs. audiobook) being the independent variable and stress recovery being the dependent variable. Again, following the study conducted by Groarke et al. (2019), I expected a medium effect size of d=.54. The t-test was two-sided with an alpha error of 5%. Using GPower, it was calculated that a sample of at least N=55 participants in each group would be needed to achieve a power of 80% (total N=110).

Results

To generate the variable stress recovery, I compared the perceived stress level before performing the TSST (baseline level), after performing the TSST (peak level) and after the listening condition (post level) (see figure 1). I divided the difference between the peak (VAS 3, figure 1) and post stress level (VAS 5, figure 1) scores (peak-post) by the difference between the peak (VAS 3, figure 1) and baseline stress level (VAS 1, figure 1) scores (peak-baseline). Then, I multiplied this quotient by 100 and obtained an individual stress recovery percentage score.

The perceived stress level score of three participants did not increase after the TSST (VAS 3) compared to the baseline (VAS 1). Therefore, the TSST failed to induce stress for these three participants, and they had to be excluded. Thus, the data of N=39 participants was analyzed.

Music vs. Silence

I conducted a t-test to tackle the first hypothesis that listening to relaxing music accelerates subjective stress recovery compared to silence. The listening condition (music vs. silence) was the independent variable and stress recovery was the dependent variable. The t-test was two-sided with an alpha error of 5%. The null hypothesis assumed that the mean stress recovery score in the music condition was equal to the mean stress recovery in the silence condition, whereas the alternative hypothesis expected the mean score of the two conditions to vary.

N=15 participants from the music listening condition and N=11 participants from the control condition were analyzed. Several outliers were observed in the dependent variable perceived stress level. One slight outlier with more than 1.5 times the interquartile range (marked by a circle) and two extreme outliers with more than 3-times the interquartile range (marked by an asterisk) in each group (figure 2). These four extreme outliers were excluded from further analysis due to their extreme values.

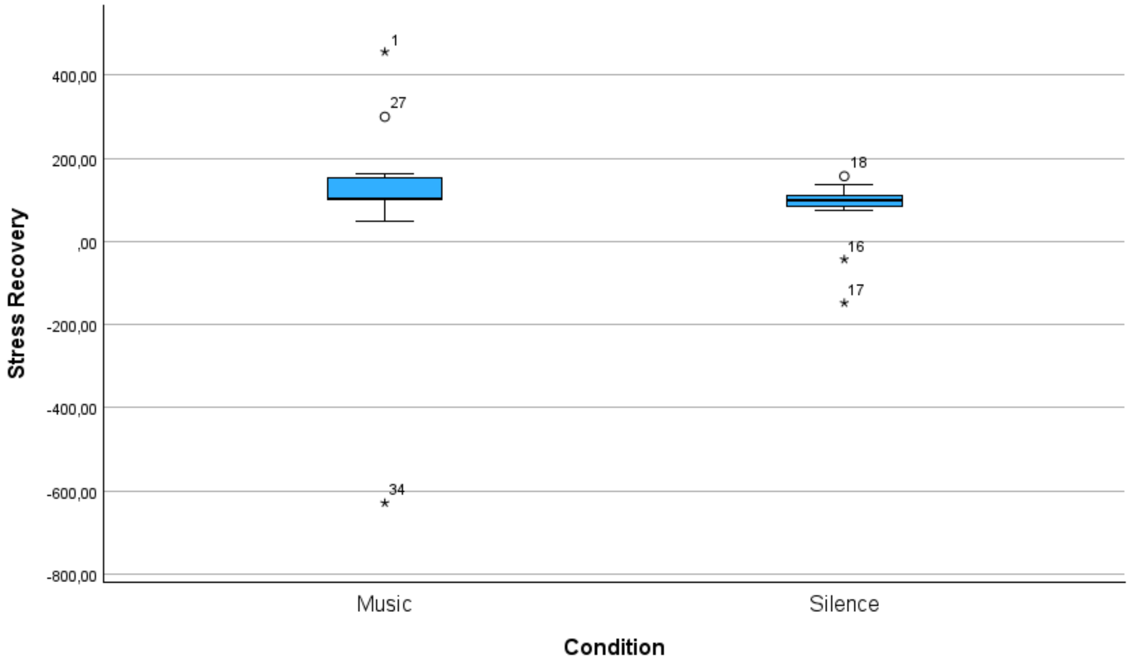

Figure 2. Boxplot of the stress recovery score for participants of the music condition and participants of the silence condition. Slight outliers are marked by a circle and extreme outliers by an asterisk.

I controlled for homoscedasticity with the Levene-test. It was not significant (p=.477) and therefore we can expect homogeneity of variance. The music condition (p<.001) and the silence condition (p=.001) were not normally distributed, as assessed by the Shapiro-Wilk test. However, studies have shown that the unpaired t-test is very robust to violations of normal distribution (Pagano, 2010; Rasch & Guiard, 2004; Wilcox, 2012). Therefore, I continued with the t-test. The mean stress recovery percentage was higher in the music condition (M=127.73, SD=60.77) compared to the silence condition (M=110.24, SD=24.88). The two-sided t-test comparing the mean stress recovery percentage scores showed that this difference of 17.49 percent points (95%-CI[-27.41, 62.38]) between the mean stress recovery percentage of the silence condition and the music condition was statistically not significant ($t(20) = .813$, $p = .426$).

Potential stress-reducing mechanisms

To test my second hypothesis, I planned to perform a multiple linear regression with data of the participants from the music listening condition. However, I only collected data from N=15 participants in the music condition and therefore failed to come close to the required sample size for this analysis (N=374).

Instead of performing the multiple linear regression, I decided to explore the data by looking into the correlations of each initially planned independent variable (mood increase, liking of the music, level of distraction and heart rate decrease) with the stress recovery percentage score.

Because of the rather extreme outliers in the data (figure 2), I decided to calculate nonparametric Spearman's correlations instead of Pearson product-moment correlations. Analyzing data of N=15 participants and expecting a medium effect size for all four correlations, I again failed to collect the required number of participants (N=19) to reach a power of 80%. Additional to the correlation analyses, I looked into the graphic distribution of the data by using scatterplots.

Stress recovery and mood increase

I examined the correlation of stress recovery and mood increase by conduction a Spearman rank correlation test. I computed the individual mood increase score by subtracting the peak level of the positive-negative mood subscale of the MDBF (MDBF 3, figure 1) from the post level (MDBF 5, figure 1). A positive number in this value indicates an increase of positive affect after the music listening condition compared to the peak level after the TSST. The conducted Spearman rank correlation test showed no significant correlation between stress recovery and mood increase (Spearman's ρ = .133, p = .636).

Figure 3 shows a scatterplot of the distribution of the stress recovery values and the mood increase scores. The blue line indicates a regression line and the coefficient of determination for this simple linear regression was r^2= 0.054. The scatterplot shows several outliers from this regression line. As the correlation analysis was not significant, this regression line is for illustration purposes only.

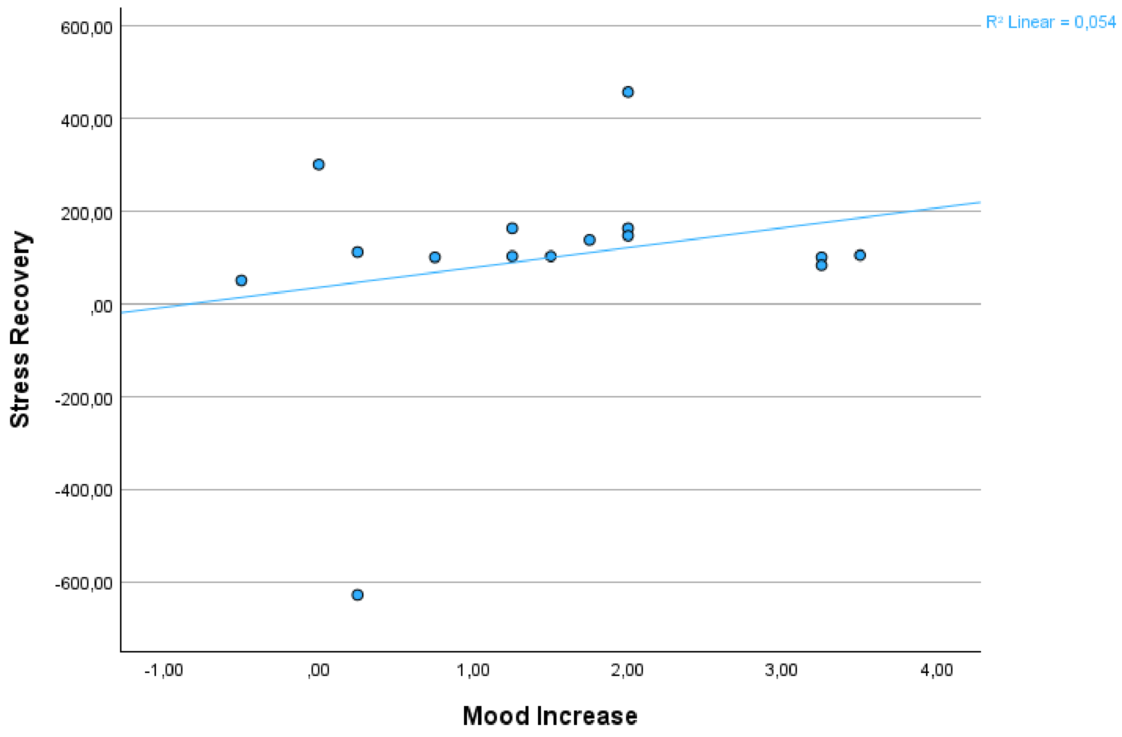

Figure 3. Scatter Plot of stress recovery by mood increase in the music listening condition.

Stress recovery and liking of the music

I examined the correlation of stress recovery and liking of the music by conducting another Spearman rank correlation test. Liking of the music was assessed by the Likert-item one from the Bewertung Musikstimulus questionnaire (see appendix). A high score in this item represents a high liking of the music stimuli. The conducted Spearman rank correlation test showed no significant correlation between stress recovery and liking (Spearman's $\rho = .131$, $p = .642$).

Figure 4 shows a scatter plot of the distribution of the stress recovery values and the liking scores. The blue line indicates a regression line and the coefficient of determination for this simple linear regression was $r^2 = 0.152$. The scatterplot shows some outliers from this regression line. As the correlation analysis was not significant, this regression line is for illustration purposes only.

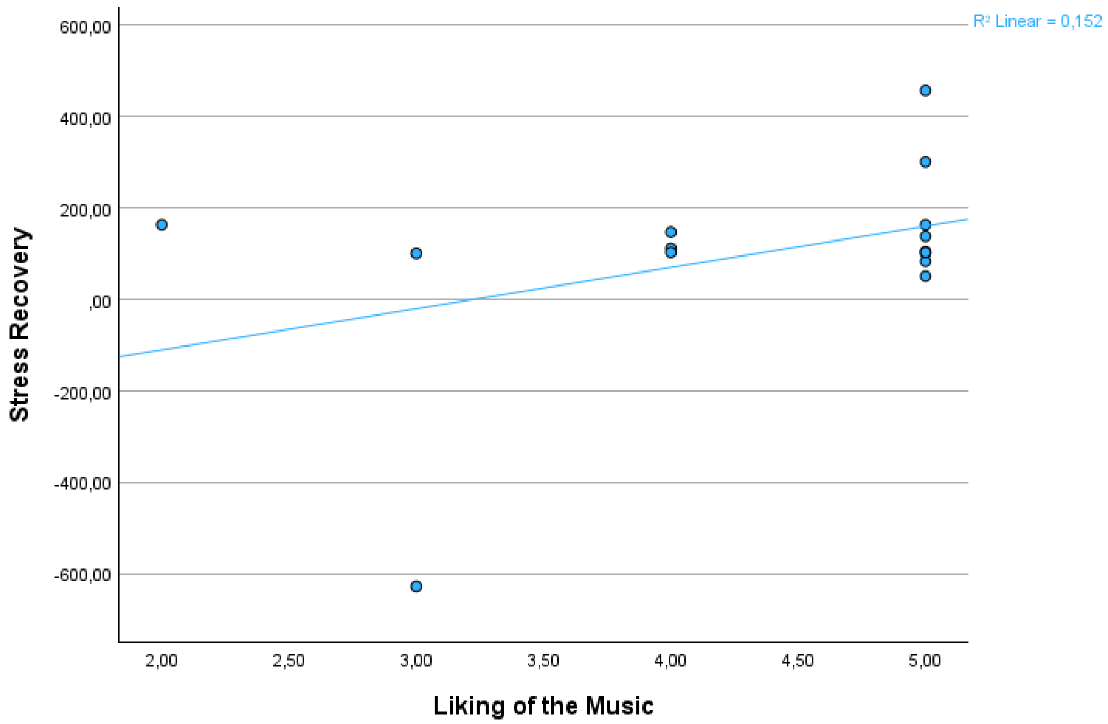

Figure 4. Scatter Plot of stress recovery by liking in the music listening condition.

Stress recovery and distraction

Again, I conducted a Spearman rank correlation test to examine the correlation of stress recovery and distraction. The level of distraction was measured by a 5-point Likert item within the questionnaire to assess the music condition (Bewertung Musikstimulus, item 6). A high value in this item indicates a distracting effect of listening to relaxing music for participants. The conducted Spearman rank correlation test showed no significant correlation between stress recovery and distraction (Spearman's ρ = .377, *p* = .166).

Figure 5 shows a scatter plot of the distribution of the stress recovery values and the distraction scores. The blue line indicates a regression line and the coefficient of determination for this simple linear regression was r^2= 0.079. The scatterplot shows some outliers from this regression line. As the correlation analysis was not significant, this regression line is for illustration purposes only.

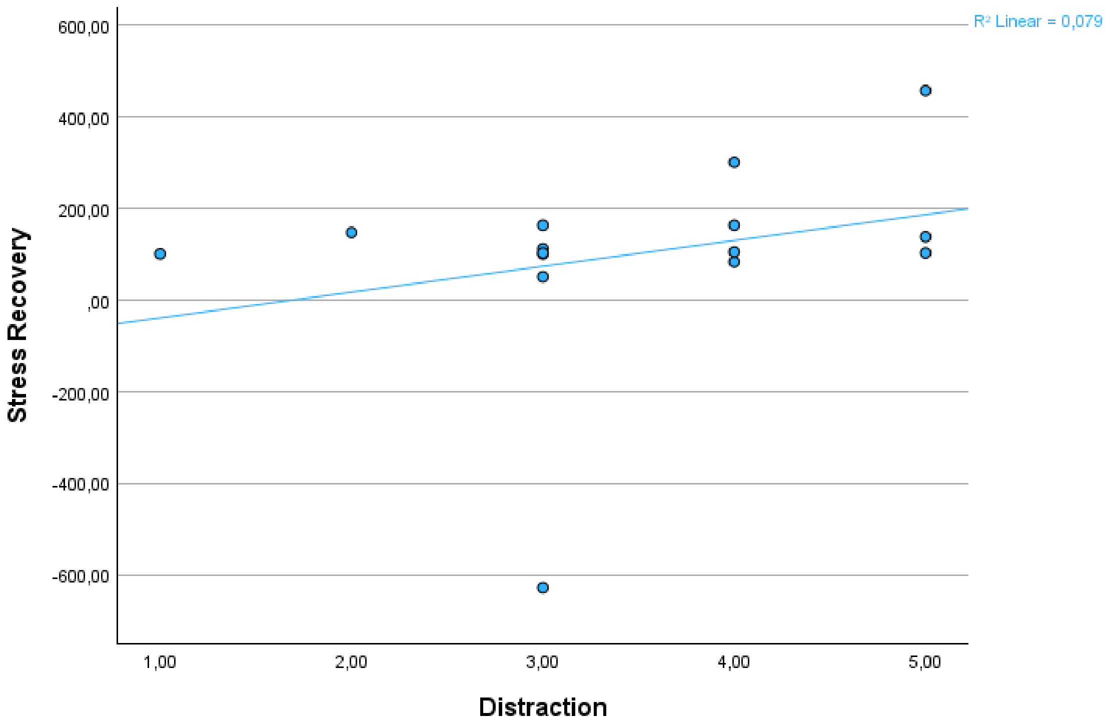

Figure 5. Scatter Plot of stress recovery by distraction in the music listening condition.

Stress recovery and heart rate decrease

I computed the heart rate decrease score by subtracting the post-intervention heart rate score (figure 1, marker 5) from the heart rate score right after the TSST (figure 1, marker 3). A high score for this difference indicates that the mean heart rate had been reduced by the listening condition and was lower after the music intervention compared to the peak level after the TSST. In order to investigate the correlation of stress recovery and heart rate decrease, I conducted another Spearman rank correlation test. However, this spearman rank correlation test did not find a significant correlation between stress recovery and heart rate decrease (Spearman's ρ = .091, p = .746).

Figure 6 shows a scatter plot of the distribution of the stress recovery percentage scores and the decrease in heart rate scores. The blue line indicates a regression line and the coefficient of determination for this simple linear regression was r^2= 0.001. The scatterplot shows some outliers from this regression line. As the correlation analysis was not significant (table 7), this regression line is for illustration purposes only.

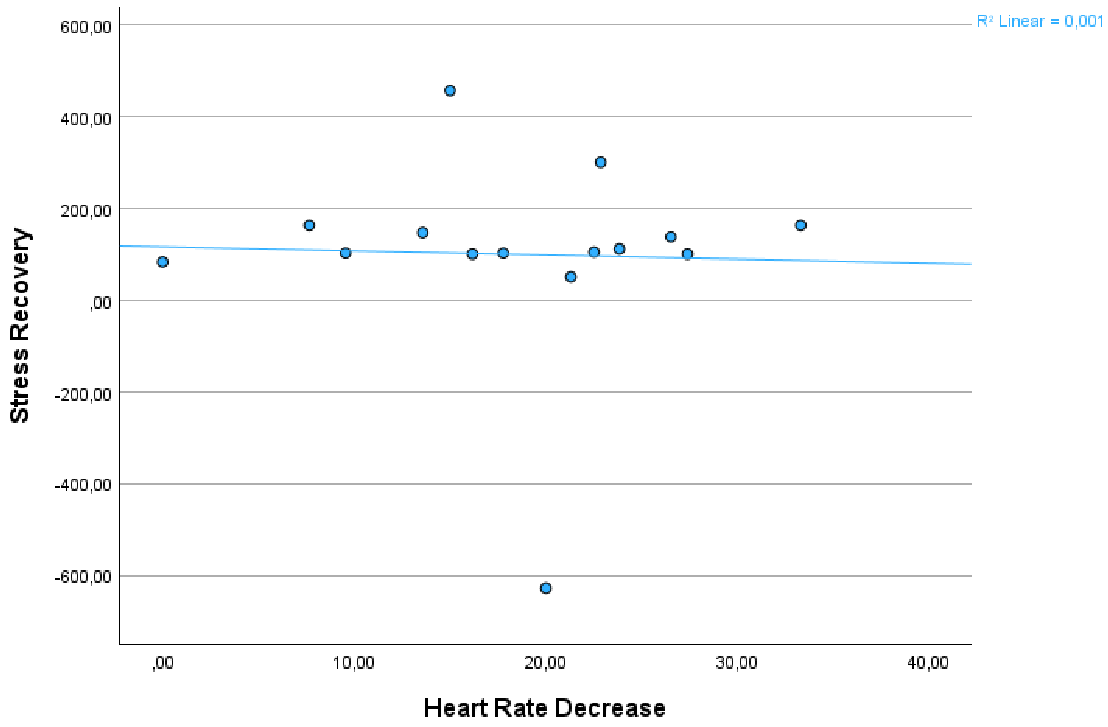

Figure 6. Scatter Plot of stress recovery by heart rate decrease in the music listening condition.

Music vs. Audiobook

I conducted a t-test in order to test the third hypothesis that listening to relaxing music accelerates subjective stress recovery compared to listening to an audiobook. The listening condition (music vs. audiobook) was the independent variable and stress recovery was the dependent variable. The t-test was two-sided with an alpha error of 5%. The null hypothesis expected the mean stress recovery score in the music condition to be equal to the mean stress recovery in the audiobook condition, whereas the alternative hypothesis expected the mean score of the two conditions to vary.

Data sets from N=15 participants from the music listening condition and the N=13 participants from the control condition were analyzed. Several outliers were observed in the dependent variable stress recovery (figure 7). Next to the one slight outlier with more than 1.5 times the interquartile range (marked by a circle) and two extreme outliers with more than 3-times the interquartile range (marked an asterisk) in the music listening condition, there was also one slight outlier in the audiobook listening condition. Again, the two extreme outliers in the music condition were excluded from further analysis due to their extreme values.

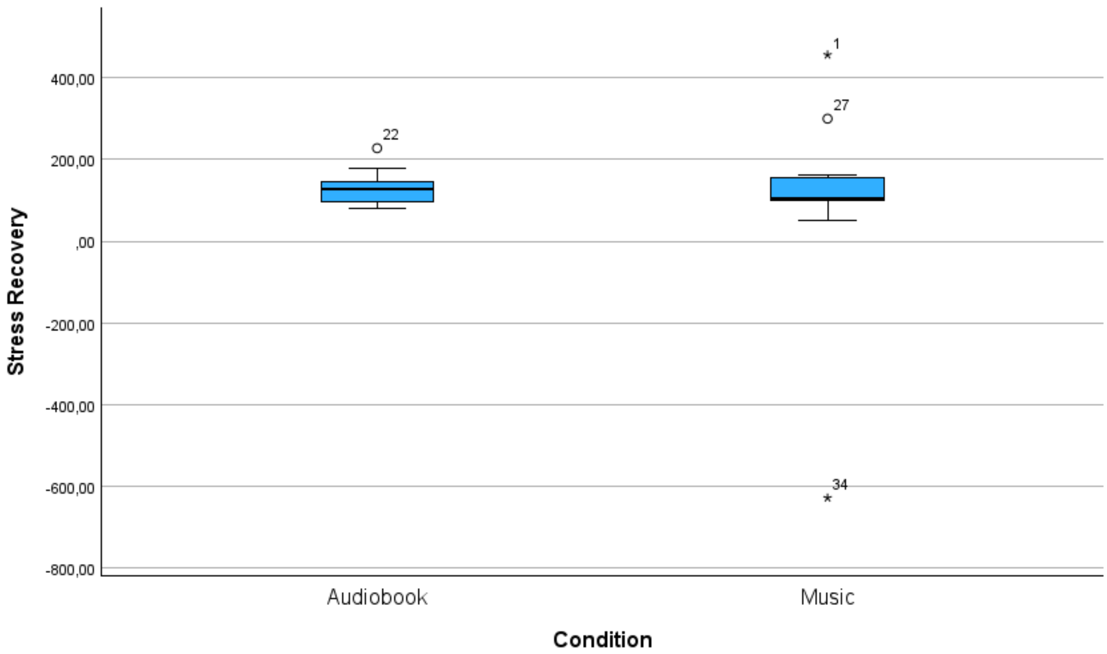

Figure 7. Boxplot of the stress recovery percentage score for participants of the music condition and participants of the audiobook condition. Slight outliers are marked by a circle and extreme outliers by an asterisk.

The audiobook condition was normally distributed, as assessed by the Shapiro-Wilk test ($p < .091$). In contrast, the music condition was not normally distributed (p<.001). However, I can again refer to previous studies that have shown that the unpaired t-test is very robust to violations of the normal contribution (Pagano, 2010; Rasch & Guiard, 2004; Wilcox, 2012). Therefore, I continued with the t-test. I controlled for homoscedasticity with the Levene-test. It was not significant (p=.188) and therefore we can expect homogeneity of variance. Mean stress recovery was slightly lower in the music condition (M=127.73, SD=60.77) compared to the audiobook condition (M=128.01, SD=41.37). This difference of -.28 points (95%-CI[-42.36, 41.81]) between the stress recovery percentage scores of the music condition and the audiobook condition was statistically not significant ($t(24) = -.013$, $p = .989$).

Discussion

This master thesis was motivated by observations of high levels of perceived stress in modern society and the physiological and psychological damage linked to stress (Abrams et al., 2020; Australian Psychological Society, 2015; Carroll et al., 2017; Casey, 2017). To mitigate potential long-term consequences of high levels of stress, effective stress recovery is crucial and listening to music might be a low-cost and effective tool to promote stress recovery (Koelsch et al., 2016; Thoma et al. 2012; Witte et al., 2020). Despite a growing research body examining beneficial effects of music on stress, it remains unclear if listening to relaxing music does facilitate stress recovery in healthy individuals and which mechanisms might be responsible for this effect (Adiasto et al., 2022; Witte et al., 2020).

This study aimed to tackle this research gap by investigating the impact of listening to relaxing music on stress recovery and exploring four potential underlying mechanisms: positive emotions, distraction, rhythmic entrainment, and pleasure. The study was designed as a randomized controlled trial and participants were randomly assigned to either a music listening condition, an audiobook condition, or a silence condition. To induce psychological stress, the Trier Social Stress Test (TSST) was employed and various psychological and physiological measures were collected throughout the experiment. Stress recovery after the TSST served as the main dependent variable and was operationalized by assessing participants' perceived stress level at three key timepoints: baseline stress level before the TSST, peak stress level after the TSST, and post-intervention stress level after listening to relaxing music, an audiobook, or sitting in silence. To explore potential mechanisms, data on rhythmic entrainment (operationalized by assessing the heart rate decrease after the TSST), pleasure (operationalized by assessing the liking of the played music), distraction (operationalized by assessing how much the music helped participants to distract themselves), and positive emotions (operationalized by assessing the mood increase during the music listening condition) were collected throughout the study.

Interpretation of results

To test the thesis' hypotheses, three statistically analyses were conducted. In the following section, I will interpret the results of these analyses.

Music vs. Silence

The first analysis tested the hypothesis that listening to relaxing music accelerates stress recovery compared to sitting in silence. To test this hypothesis, I performed a t-test with the listening condition (music vs. silence) being the independent variable and stress recovery being the dependent variable. The mean stress recovery score in the music condition was M=127.73 (SD=60.77), indicating that, on average, participants completely recovered from the TSST after listening to relaxing music (127.73% recovery) and even reached a lower perceived stress level after the music intervention compared to the pre-TSST baseline level. However, the standard deviation of 60.77 percent points was extremely high, indicating that individual recovery scores could vary between partly recovered to completely recovered. The mean stress recovery percentage in the silence condition was M=110.24 (SD=24.88) and therefore, on average, participants perceived stress level did also completely recover from the stress test after sitting in silence (110.24% recovery). Therefore, the mean stress recovery percentage was higher in the music condition compared to the silence condition. However, this difference of 17.49 percent points between the music and the silence condition was far from significant (p=.426) and therefore we cannot conclude whether listening to relaxing music really does accelerate stress recovery compared to sitting in silence in the general population.

One must keep in mind that I failed to reach the required sample size for this analysis. Instead of N=44 in each group, I analyzed the data of N=13 participants in the music condition and N=9 participants in the silence condition. Thus, I cannot draw any conclusions concerning the first hypothesis. The t-test failed to confirm the first hypothesis that listening to relaxing music accelerates stress recovery compared to sitting in silence, because there was no significant outcome. However, I did not have a sufficiently large sample size to answer this hypothesis and therefore I also cannot conclude in favor of the null hypothesis.

First trends of the collected data seem to point towards a capacity of listening to relaxing music to accelerate stress recovery.

Potential stress-reducing mechanisms

The second analysis aimed to explore the potential underlying mechanisms that might lead to an accelerated stress recovery when listening to relaxing music. I aimed to investigate whether indices of the four described mechanisms can predict a faster stress recovery and planned to perform a multiple linear regression. As the first analysis did not reach significance and therefore failed to confirm the hypothesis that listening to relaxing music accelerates stress recovery, it is also possible that listening to relaxing music might not have a unique effect on stress recovery. Nevertheless, since this absence of significance might be due to the very small sample size and the music listening condition has led to a great decrease in participants' perceived stress level, it is still of interest to see, if one certain mechanism was particularly involved in this decrease. With this in mind, the second analysis is limited to a provisional exploration of hints for potential underlying mechanisms only.

Due to the great discrepancy of the required (N=374) sample size to perform the planned multiple linear regression and the achieved (N=15) sample size, I decided to explore the data by looking into the correlations of indices of the four described mechanisms with stress recovery. In total, I conducted four separate Spearman rank correlation tests, one for each possible underlying mechanism. To explore effects of rhythmic entrainment on stress recovery, I analyzed the heart rate decrease between after the TSST. Pleasure was operationalized by assessing the liking of the played music after the music listening intervention. Distraction was operationalized by assessing how much the music helped participants to distract themselves and positive emotions was operationalized by assessing the mood increase during the music listening condition.

None of these correlations was significant. However, as I again failed to reach the required sample size of N=19, these results need to be interpreted with caution. Even though we cannot draw any conclusions about the actual relations between stress recovery and the four potential underlying mechanisms due to the absence of any significant outcome, the visual examination of the distribution of these analyses might still be of interest to catch first hints. The distribution in the scatterplots showed a positive correlation for three of the possible underlying mechanisms (figure 3,4 and 5). This was the case for the correlation between stress recovery and distraction. In case of a significant outcome and according to Cohen (1988), this would have been a moderate correlation (Spearman's $\rho = .377$, $p=.166$). This is also the case for the correlation of stress recovery and liking of the music. If we would have reached a significant outcome, there would have been a weak correlation between stress recovery and liking of the music (Spearman's $\rho = .131$, $p = .642$). Likewise, we would have seen a weak correlation between stress recovery and mood increase (Spearman's $\rho = .133$, $p = .636$). All three of these correlations would have been positive and therefore a higher score in distraction, liking of the music and a stronger increase in positive emotions would have predicted a higher stress recovery. This type of correlation is in line with theoretical expectations of the underlying mechanisms. Only the changes in heart rate failed to show this trend, as the visual distribution did now indicate any correlation with the perceived stress level score (Spearman's $\rho = .091$, $p = .746$).

Again, we cannot draw any conclusions from this second analysis. There was no significant correlation between any possible predictor with stress recovery. However, I did not obtain a sufficiently large sample size to detect a significant correlation. At its best, the first trends observed in of these correlations might motivate further research.

Music vs. Audiobook

The third analysis aimed to compare the stress reducing effect of music listening and the stress reducing effects of listening to an audiobook. I conducted a t-test in order to test the third hypothesis that listening to relaxing music accelerates subjective stress recovery compared to listening to an audiobook. The audio condition (music vs. audiobook) was the independent variable and stress recovery was the dependent variable.

The mean stress recovery percentage in the audiobook condition was $M=128.01$ ($SD=41.37$), indicating that after listening to an audiobook, on average, participants did not only reach a lower perceived stress level compared to the peak level (after the TSST), but also compared to the baseline level (before being stressed). Comparing the mean scores of the audiobook (M=128.01, SD=41.37) and the music condition (M=127.73, SD=60.77), the audiobook condition predicted a slightly higher stress recovery than the music listening condition. However, this very small difference of -.28 percent points was statistically not significant (p=.989). For this analysis, the same limitations apply as for the first analysis. This means that I failed to reach the required sample size of N=55 in each group and therefore I cannot draw any conclusions concerning the third hypothesis. The conducted t-test failed to confirm the third hypothesis that listening to relaxing music accelerates subjective stress recovery compared to listening to an audio book, because there was no significant outcome. However, I did not have a sufficiently large sample size to answer this hypothesis and therefore I also cannot conclude in favor of the null hypothesis. In contrast to the first analysis, which showed a first trend towards a stronger capacity to accelerate stress recovery for the music condition compared to the silence condition, this first trend could not be observed. The observed mean stress recovery score of the audiobook and music listening condition was extremely similar and even slightly higher in the audiobook condition compared to the music condition.

Limitations

There are several limitations concerning the interpretation and generalizability of these analyses. In the following section, I will discuss these limitations in detail.

Small sample size

As mentioned above, the sample size was very small. This sample size severely reduced the chances to detect potentially existing effects of listening to relaxing music. At the same time, there is a higher chance that this sample was not representative of the population and that it failed to adequately approximate the estimates of population parameters. This makes it more probable to find a random trend in the data and we cannot expect to find the same provisional relation of this data in the broader population.

Homogenous sample

Another major limitation is the highly homogenous sample due to extensive exclusion criteria. A lot of these criteria were necessary, as they allowed to control for confounding factors on the various physiological measures that were applied in this study (for a detailed explanation see Strahler et al., 2017). Nevertheless, they also limit the ability to generalize the findings to a broader population. The results of this study only apply to German speaking and healthy individuals, who have their place of residence in Austria. Additional to this general decrease of generalizability with the amount of exclusion criteria applied, some particularly problematic criteria are worth noting.

Only women were included. However, there were some issues in the procedure of this assessment. In the screening process, participants were asked to identify their "Geschlecht". This German word is problematic, because the term does not differentiate between sex and gender, making it unclear whether participants were referring to their biological sex or their gender identity. Still, a fair amount of people with different gender identities was not included and this diminishes the generalizability for people who do not identify as women. Only young participants aged 18 to 35 were included. By focusing exclusively on young individuals within this age range, the results may not apply to other age groups. The use of music and the exposure to certain music is something that likely differs between age cohorts. It could be that this also affects the perception of music and its influence on stress recovery.

Individuals with a music-related profession, music related studies and absolute hearing were excluded. Excluding participants with music-related professions or studies may systematically eliminate individuals with expertise in music, potentially missing valuable insights. It seems very likely that individuals who choose to study music and/or work in this field differ in their sensibility to music. Mas-Herrero et al. (2013) showed that there are great individual differences in the way one experiences pleasure through music. It seems likely that individuals with a general sensitivity towards music will respond stronger to musical cues or maybe even in a different way. Thus, the exclusion of individuals with a music-related background could limit the generalizability for people with a higher sensitivity towards music to a great degree. In future research, efforts should be made to recruit more diverse samples to enhance the generalizability of the potential stress reducing effects of listening to music.

COVID-19 pandemic

This study was conducted during the COVID-19 pandemic. This may have introduced confounding factors like increased stress levels due to pandemic consequences and the influence of wearing a FFP2 mask during the laboratory sessions (Salari et al., 2020). As stress recovery might be affected by additional stressors and a general elevated stress level, it is uncertain if the results can be generalized to pre- or post-pandemic situations.

Intertwined mechanisms

One main limitation of this master thesis considering the exploration of the underlying mechanisms is the presumably complex intertwined relationship of these mechanisms. This is particularly the case for the mechanism of induced positive emotions. Juslin (2010) argued that there is a complex interplay of multiple induction principles that leads to the range of emotions that can be evoked by music. Next to others, these principles include rhythmical entrainment and aesthetic judgment (Juslin, 2013). Therefore, the concept by Juslin (2010) of how music can evoke positive emotions is already connected with two of the other considered mechanisms that might be responsible for promoting stress recovery. Additionally, the presence of positive emotions might again affect the outcomes of the other mechanisms. For instance, the evoked positive emotions may be calming, distracting and influence participants' perception of music, making it appear more pleasant.

No possible conclusions about causality

Stress is an unpleasant experience that generally leads to certain psychological and physiological changes (Thoma et al., 2013; Kirschbaum & Heinrichs, 2011). The statistical analysis of a correlation between stress recovery and underlying mechanisms can never lead to a conclusion about causality. Furthermore, there are confounding aspects that challenge an interpretation of causality on a theoretical level. Leaving aside the specific impacts of listening to relaxing music, we can expect the decrease of perceived stress level to correlate positively with a change in positive emotions and heart rate (Kirschbaum & Heinrichs, 2011). Because the positive emotions can affect the liking of music (Juslin et al., 2013), we could also expect a correlation between the decrease of perceived stress level and the liking of the music. Hence, it is challenging to determine whether the reduced stress level leads to increased positive affect, increased music liking, and a decreased heart rate, or if it happens the other way around. The level of distraction, however, seems to be more separated from the influence of a reduced stress level. The distracting influence of listening to relaxing music and its ability to shift one’s attention away from a stressor and prevent rumination is a very broad effect that also applies to many other stimuli. While it might be possible that a very stressed person finds it hard to shift their focus away from the stressor and therefore might be unattainable for distracting stimuli, it is unlikely that a participant will state that music helped to distract her*him from the stressor only because that person had a reduced stress level.

Combination of mechanisms

It is also possible that listening to relaxing music could accelerate stress recovery due to a combination of these different mechanisms, which might also benefit from each other. For instance, it seems plausible that in a first step the slow tempo of the music could lead to a reduction of arousal via rhythmic entrainment. Then, music could serve as a distractor, which it might have not been able to do if arousal was too high and thoughts about the stressor too present for the music to actually shift the attention away from the stressor. In a third step, the music could be perceived as pleasant and this rewarding experience could evoke positive emotions. This last step could lead to a state of relaxed positive affect that does not only help to recover from a stressful experience but also to exceed the pre-stressor condition. This is just one possible combination that seems plausible. Any other combination of two or more mechanisms is possible and more research would be necessary to differentiate between the specific contributions of each mechanism.

Limited to relaxing music - other music might involve other mechanisms

This study and all theoretical considerations are limited to the specific effects of relaxing instrumental music. Music is a very complex and multilayered phenomenon with potentially opposing outcomes. While it seams plausible that rhythmic entrainment might be a potential mechanism to promote stress recovery in relaxing music with a steady slow beat, this is not the case in music with a fast and unsteady beat. In the case that fast and stimulating music does promote stress recovery, other mechanisms besides rhythmic entrainment must be responsible for this effect. However, this limitation does not only apply to music with an opposing character. Music that possesses an additional characteristic might embrace additional mechanisms. For instance, music that involves vocal parts and/or lyrics might embrace an additional mechanism, stimulated through the processing of the meanings of the lyrics. Likewise, music that lacks one certain aspect (e.g., a clear rhythmical structure) might lack of certain mechanisms (e.g., rhythmic entrainment). Thus, it is very important to differentiate between the very specific aspects of music that might lead to a certain effect. This leads to the following limitation.

Music as a complex phenomenon composed by autonomous components

In this study project, we used different playlist of music that varied in style, instrumentation, harmonics, etc. This allowed the participants to choose a playlist they like and previous studies have shown that listening to preferred music has a greater impact on positive affect and other stress-related measures. (Adiasto et al., 2022; Jiang et al., 2016; Thoma et al., 2013). However, this also limits the possible interpretation of this study. A differentiated study approach that observes a single component of music listening could have had the capacity to gain insights into the very aspects that are unique to music. In this study design, we combined different music playlist and genres and therefore examined a general effect of differing music on stress recovery. Music listening in this approach is used as a tool to, for instance, calm, distract, and be liked and could be replaced by other tools that help to calm, distract, or are perceived as rewarding (i.e. touch, storytelling, …). The strength of this study is that it compared the broad stress reducing effect of music listening with a control group (silence condition) and a different distractor (audiobook condition). This allows us to investigate whether music served uniquely successful as a tool to distract, uplift, reduce stress, and calm participants, but it does not shed light on the features responsible for a possibly unique effect.

It would be interesting to systematically test different aspects of music. Music listening is already used by a great amount of people as a tool to cope with stress in daily life (Australian Psychological Society, 2015; Linnemann et al., 2015). Yet, this study and current research fails to prove a definite stress reducing and stress recovery promoting effect of listening to music. It is time to focus on the very stimuli that are being used and to analyze the elements that make up this multilayered phenomenon.

Implications

This study implemented controlled experimental conditions with three distinct conditions (music, silence, audiobook). This allowed for a direct comparison of the effects of listening to relaxing music on stress recovery. However, we cannot answer the main research question of this master thesis, whether listening to relaxing music accelerates stress recovery. As explained above, the conducted t-test neither showed a significant outcome nor reached the required strength to support a conclusion. On a speculative level, there might be a first trend towards an affirmation of this research question, but only further research with bigger sample sizes can answer this research question.

Concerning the first sub question about which possible mechanisms of listening to relaxing music might be responsible for an accelerated stress recovery, I cannot add to existing knowledge with these results. As I cannot answer the first research question of whether listening to relaxing music accelerates stress recovery, it is also possible that listening to relaxing music might not have a unique effect on stress recovery and therefore the observed data only mirrors a general decline in perceived stress level caused by the passing of time. Under the assumption of a unique effect of listening to relaxing music, the conducted correlations have not reached significance. Nevertheless, the reverse conclusion cannot be applied either, due to a very small sample size and the high risk of making a Type II error. While not significant, data operationalizing the potential underlying mechanisms pleasure, positive emotions and distraction did show a positive correlation of these three mechanisms with a stronger stress recovery. If this pattern of results would be confirmed in a bigger sample, this would suggest that pleasure, positive emotions, and distraction do play a role in the potential stress-reducing effects of listening to relaxing music. Only further research with bigger sample sizes can shed light into the ways of how listening to relaxing music might affect humans and whether rhythmic entrainment, pleasure, positive emotions and distraction are involved in this effect.

Regarding the second sub question whether music listening is more effective in accelerating stress recovery compared to other distractors, the same limitations apply as to the main research question and the first sub question. The t-test did not reach significance, but I did not have a sufficiently large sample size to answer the third hypothesis and therefore I also cannot conclude in favor of the null hypothesis. However, the mean stress recovery scores of the audiobook condition and the music listening condition were extremely similar. Thus, a first analysis of this limited data does not seem promising to confirm a more effective stress recovery when listening to relaxing music compared to listening to an audiobook. If this null result was also to be found in future research studies with bigger sample sizes, this would indicate that an audiobook is just as effective as listening to relaxing music in reducing stress. Such findings could empathize the role of distraction as a stress-reducing mechanism of listening to relaxing music. However, only further research with bigger sample sizes and a variety of distractors can rule out the possibility that the effect of listening to relaxing music on stress recovery is indeed superior to other distractors.

Future Research

For a better understanding of music, it is important to systematically test different aspects of this complex phenomenon. To demonstrate this differentiated approach, I will name three examples for possible future study designs.

One feature that is unique to western music is the occurrence of intervals. In music, the difference in pitch between two sounds is called interval (Prout, 2011). It would be interesting to conduct a study that investigates the effect of a single interval or a group of few intervals on the perceived stress level (for instance intervals that are commonly known to create tensions).

Music can be seen as a sequence of sounds and certain patterns of sounds generate expectations and predictions about the continuation of the music (Hansen et al., 2017). These expectations can be violated, delayed, or confirmed and thus induce emotional responses in the listener (Juslin, 2013). If the violation of expectancies is pleasant, the music can be perceived as “better than expected” and thus lead to a positive prediction error. If the violation is unpleasant, it can lead to a negative prediction error. And this can lead to tension and suspense (Steinbeis et al., 2006). It would be interesting to investigate whether music with a lot of changes, which are likely to trigger a positive prediction error, has a different effect on perceived stress level compared to music without a lot of changes and compared to music that is likely to trigger negative prediction errors.

Since rhythmic entrainment is one of the considered possible mechanisms responsible for the stress reducing effects of music, it would be interesting to systematically manipulate this aspect of music and analyze its effect on the perceived stress level. A possible study design would be that participants listen to the same music and/or patterns with different paces (e.g. 80bpm, 100 bpm or 120 bpm). It would be important to also vary the type of rhythmical structure (3/4 bar, 4/4 bar) and to vary the proportions of the patterns (downbeats and upbeats) because they are crucial in shaping the feel and groove of a piece (Seidel, 2016). Furthermore, it would be important to compare these structures with music that does not have a clear rhythmical structure (e.g. atmospheric music).

Conclusion

In this master thesis, I investigated the impact of listening to relaxing music on stress recovery and explored potential underlying mechanisms of this effect. Three main analyses were conducted, but due to the very small sample size and other limitations, no definitive conclusions can be drawn.

The implications of this study underscore the need for future research with larger and more diverse samples to gain a better understanding of the stress-reducing effects of listening to relaxing music and its underlying mechanisms. Systematic investigation of different aspects of music, such as intervals, rhythmic structures, and pattern changes, could shed light on specific features responsible for its effects. In-depth exploration of individual mechanisms and their combinations is crucial to unraveling music's complexity as a stress-reducing tool.

Overall, this study cannot offer definitive conclusions about the stress-reducing effects of listening to relaxing music and its underlying mechanisms. Further research is required with robust experimental designs and larger and diverse samples. Music remains a fascinating field of research with the potential to offer valuable contributions to stress management and well-being, and I hope the theoretical considerations of this study will inspire future investigations.

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Appendix

Figures

Abbreviations

TSST – Trier Social Stress Test

HPA – Hypothalamic-pituitary adrenal

TTPAS – Types of Positive Affect Scale

MDBF – Mehrdimensionale Befindlichkeitsfragebogen

VAS – Visual Analogue Scale

TEWL – Trans-epidermal water loss

Questionnaires

Bewertung Musikstimulus

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Die folgenden Fragen beziehen sich auf die Musik, die Sie in dieser Studie gehört haben, und auf Ihr persönliches Empfinden während des Musikhörens.

Für Ihre Bewertungen verwenden Sie wieder die fünf-Punkte-Skala, die von „gar nicht" (ganz links) bis „sehr" (ganz rechts) geht.

Auch bei diesen Fragen ist vor allem Ihre unmittelbare, intuitive Antwort von Interesse. Es gibt keine richtigen oder falschen Antworten! Bitte geben Sie Ihre Antwort schnell und spontan an.

gar nicht	1	2	3	4	5	sehr
Die Musik hat mir gefallen.	○	○	○	○	○	
Die Musik war mir vertraut.	○	○	○	○	○	
Ich habe mich auf die gehörte Musik konzentriert.	○	○	○	○	○	
Die Musik hat mich gestört.	○	○	○	○	○	
Die Musik hat mir geholfen, zu entspannen.	○	○	○	○	○	
Die Musik hat mir geholfen, mich abzulenken.	○	○	○	○	○	
Die Musik hat mich aktiviert.	○	○	○	○	○	

gar nicht	1	2	3	4	5	sehr
Wie sehr fühlten Sie sich während des Musikhörens in die Musik versunken?	○	○	○	○	○	
Wie sehr fühlten Sie sich während des Musikhörens gelangweilt?	○	○	○	○	○	

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr)

MuSkiBa II

VP-Code: 33 - ___ ___ ___

F

Bitte zeichnen Sie bei den folgenden Fragen an der Stelle auf der Linie einen senkrechten Strich ein, die Ihrer persönlichen Einschätzung am meisten entspricht.

Die Musik war...

fröhlich ———————————————— traurig

Die Musik war...

entspannend ———————————————— energetisierend

Welche Emotionen hat die Musik bei Ihnen ausgelöst?

gar nicht	1	2	3	4	5	sehr
Freude	○	○	○	○	○	
Traurigkeit	○	○	○	○	○	
Entspannung	○	○	○	○	○	
Ärger	○	○	○	○	○	
Angst	○	○	○	○	○	
Nostalgie	○	○	○	○	○	
Melancholie	○	○	○	○	○	

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Worauf haben Sie sich beim Hören der Musik konzentriert?

- ○ Ich habe mich beim Musikhören gedanklich (fast) nur mit anderen Dingen als der gehörten Musik beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Musikhören gedanklich deutlich mehr mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.) als mit der gehörten Musik.
- ○ Ich habe mich beim Musikhören gedanklich im etwa gleichen Ausmaß mit der Musik und mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Musikhören gedanklich deutlich mehr mit der gehörten Musik als mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Musikhören gedanklich (fast) nur auf die Musik konzentriert.

Falls Sie sich beim Hören gedanklich auch mit anderen Dingen beschäftigt haben: Welche Emotionen lösten diese Gedanken/Erinnerungen/Tagträume usw. bei Ihnen aus?

- ○ Überwiegend positive Emotionen oder ein entspanntes Gefühl
- ○ Die Gedanken waren überwiegend neutral und lösten weder positive, noch negative Emotionen aus
- ○ Überwiegend negative Emotionen (z.B. Traurigkeit, Wut) oder ein gestresstes Gefühl
- ○ Ich habe mich nur auf die Musik konzentriert.

Bewertung Hörbuchstimulus

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Die folgenden Fragen beziehen sich auf das Hörbuch, das Sie in dieser Studie gehört haben, und auf Ihr persönliches Empfinden während des Hörbuchhörens.

Für Ihre Bewertungen verwenden Sie wieder die fünf-Punkte-Skala, die von „gar nicht" (ganz links) bis „sehr" (ganz rechts) geht.

Auch bei diesen Fragen ist vor allem Ihre unmittelbare, intuitive Antwort von Interesse. Es gibt keine richtigen oder falschen Antworten! Bitte geben Sie Ihre Antwort schnell und spontan an.

gar nicht	1	2	3	4	5	sehr
Das Hörbuch hat mir gefallen.	○	○	○	○	○	
Das Hörbuch war mir vertraut.	○	○	○	○	○	
Ich habe mich auf das gehörte Hörbuch konzentriert.	○	○	○	○	○	
Das Hörbuch hat mich gestört.	○	○	○	○	○	
Das Hörbuch hat mir geholfen, zu entspannen.	○	○	○	○	○	
Das Hörbuch hat mir geholfen, mich abzulenken.	○	○	○	○	○	
Das Hörbuch hat mich aktiviert.	○	○	○	○	○	

gar nicht	1	2	3	4	5	sehr
Wie sehr fühlten Sie sich während des Hörens in das Hörbuch versunken?	○	○	○	○	○	
Wie sehr fühlten Sie sich während des Hörens gelangweilt?	○	○	○	○	○	

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Bitte zeichnen Sie bei den folgenden Fragen an der Stelle auf der Linie einen senkrechten Strich ein, die Ihrer persönlichen Einschätzung am meisten entspricht.

Das Hörbuch war...

fröhlich ________________________________ traurig

Das Hörbuch war...

entspannend ________________________________ energetisierend

Welche Emotionen hat das Hörbuch bei Ihnen ausgelöst?

gar nicht	1	2	3	4	5	sehr
Freude	O	O	O	O	O	
Traurigkeit	O	O	O	O	O	
Entspannung	O	O	O	O	O	
Ärger	O	O	O	O	O	
Angst	O	O	O	O	O	
Nostalgie	O	O	O	O	O	
Melancholie	O	O	O	O	O	

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Worauf haben Sie sich beim Hören des Hörbuchs konzentriert?

- ○ Ich habe mich beim Hörbuchhören gedanklich (fast) nur mit anderen Dingen als dem Hörbuch beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Hörbuchhören gedanklich deutlich mehr mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.) als mit dem Hörbuch.
- ○ Ich habe mich beim Hörbuchhören gedanklich im etwa gleichen Ausmaß mit dem Hörbuch und mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Hörbuchhören gedanklich deutlich mehr mit dem Hörbuch als mit anderen Dingen beschäftigt (z.B. mit Erinnerungen, Zukunftsplänen, Tagträumen, etc.).
- ○ Ich habe mich beim Hörbuchhören gedanklich (fast) nur auf das Hörbuch konzentriert.

Falls Sie sich beim Hören gedanklich auch mit anderen Dingen beschäftigt haben: Welche Emotionen lösten diese Gedanken/Erinnerungen/Tagträume usw. bei Ihnen aus?

- ○ Überwiegend positive Emotionen oder ein entspanntes Gefühl
- ○ Die Gedanken waren überwiegend neutral und lösten weder positive, noch negative Emotionen aus
- ○ Überwiegend negative Emotionen (z.B. Traurigkeit, Wut) oder ein gestresstes Gefühl
- ○ Ich habe mich nur auf das Hörbuch konzentriert.

Bewertung Stille

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr)   MuSkiBa II

VP-Code: 33 - ___ ___ ___   F

Die folgenden Fragen beziehen sich auf den Teil der Studie, in dem Sie sich im Liegestuhl befanden, und auf Ihr persönliches Empfinden während dieser halben Stunde.

Für Ihre Bewertungen verwenden Sie wieder die fünf-Punkte-Skala, die von „gar nicht" (ganz links) bis „sehr" (ganz rechts) geht.

Auch bei diesen Fragen ist vor allem Ihre unmittelbare, intuitive Antwort von Interesse. Es gibt keine richtigen oder falschen Antworten! Bitte geben Sie Ihre Antwort schnell und spontan an.

gar nicht	**1**	**2**	**3**	**4**	**5**	**sehr**
Dieser Teil der Studie hat mir gefallen.	○	○	○	○	○	
Dieser Teil der Studie hat mich gestört.	○	○	○	○	○	
Dieser Teil der Studie hat mir geholfen, zu entspannen.	○	○	○	○	○	
Dieser Teil der Studie hat mich aktiviert.	○	○	○	○	○	
Ich fühlte mich während dieses Teils der Studie gelangweilt.	○	○	○	○	○	

Welche Emotionen hat dieser Teil der Studie bei Ihnen ausgelöst?

gar nicht	**1**	**2**	**3**	**4**	**5**	**sehr**
Freude	○	○	○	○	○	
Traurigkeit	○	○	○	○	○	
Entspannung	○	○	○	○	○	
Ärger	○	○	○	○	○	
Angst	○	○	○	○	○	
Nostalgie	○	○	○	○	○	
Melancholie	○	○	○	○	○	

universität wien
Fakultät für Psychologie

Datum ____ / ____ / ____ (Tag / Monat / Jahr) MuSkiBa II

VP-Code: 33 - ___ ___ ___ F

Während dieses Teils der Studie sind Sie vielleicht gedanklich etwas abgeschweift und haben sich mit z.B. Erinnerungen, Zukunftsplänen, Tagträumen, etc. beschäftigt. Falls dies der Fall war: Welche Emotionen lösten diese Gedanken/ Erinnerungen/ Tagträume usw. bei Ihnen aus?

- ○ Überwiegend positive Emotionen oder ein entspanntes Gefühl
- ○ Die Gedanken waren überwiegend neutral und lösten weder positive, noch negative Emotionen aus
- ○ Überwiegend negative Emotionen (z.B. Traurigkeit, Wut) oder ein gestresstes Gefühl
- ○ Meine Gedanken sind nicht wirklich abgeschweift.

Abstract German

In der heutigen Gesellschaft erleben viele Menschen ein erhöhtes Stresslevel in ihrem Alltag. Stress löst sowohl physiologische als auch psychologische Reaktionen aus, die zu einer komplexen Stressreaktion führen. Ein erhöhtes Stresslevel und langanhaltende Belastung wurden mit verschiedenen körperlichen und psychischen Störungen in Verbindung gebracht. Um diesen langfristigen Folgen von Stress entgegenzuwirken, wird immer wieder diskutiert, das Hören von Musik als Stressbewältigung anzuwenden. Die vorliegende Masterarbeit untersuchte die Auswirkungen des Hörens von entspannender Musik auf die Stressbewältigung und berücksichtigte dabei vier mögliche zugrundeliegende Mechanismen. Diese Mechanismen umfassen die Effekte von positiven Emotionen, einem ablenkenden Effekt des Musikhörens, rhythmischer Synchronisierung körpereigenen und musikalischen Rhythmen und einem Belohnungseffekt, wenn die Musik den Teilnehmer*innen gefallen hat. Der Trier Social Stress Test (TSST) wurde verwendet, um die Teilnehmer*innen zu stressen. Daraufhin haben die Proband*innen entweder entspannende Musik gehört, ein Hörbuch vorgespielt bekommen oder saßen für den gleichen Zeitraum in Stille. Ein t-Test konnte keine signifikanten Unterschiede in der Stressbewältigung zwischen der Musik- und Stille-Gruppe finden. In Bezug auf die möglicherweise zugrundeliegenden Mechanismen wurde keine signifikante Korrelation zwischen den Mechanismen und der Stressbewältigung gefunden. Ebenso ergab ein weiterer t-Test keinen signifikanten Unterschied in der Stressbewältigung zwischen der Musik- und der Hörbuch-Gruppe. Dennoch verhindert die äußerst geringe Stichprobengröße (N=39) eindeutige Schlussfolgerungen. Mögliche Einschränkungen der Studie und zukünftige Forschungsschwerpunkte werden diskutiert.