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"The Effects of Relaxing Music on Subjective and Physiological Stress Level and Mood"

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Abstract

Research suggests that music has beneficial effects on health, which are frequently attributed to its ability to reduce stress and improve mood. However, empirical research on stress- and mood-regulatory effects of music listening after acute stress exposure is scarce and inconsistent. Therefore, the aim of the present paper was to expand previous research by investigating the effects of music on subjective stress level, biological stress responses, and mood as well as their interrelation to each other. In this laboratory-based experimental study, fifty-four healthy female subjects underwent a standardized psychosocial stress test and were then randomly allocated to one of the following recovery conditions: listening to participant-relaxing music or resting in silence. Subjective stress level and mood were measured and saliva samples were taken multiple times throughout the experiment. Results indicated that the stressor caused a significant increase in subjective stress level, salivary cortisol concentration, and negative mood. Unlike expected, the effects of listening to relaxing music on post-stress recovery, when compared to sitting in silence, did not differ significantly regarding subjective stress level, salivary cortisol concentration, or mood. Self-reports of mood correlated strongly with subjective stress level, whereas no significant correlation was found between salivary cortisol concentration and either subjective measure. Further experimental research is required to fully understand the beneficial effects of relaxing music as well as the relationship between psychological and physiological recovery from acute stress.

Key words: cortisol, mood, music listening, stress

Zusammenfassung

Zahlreiche Forschungsergebnisse haben gezeigt, dass sich das Musikhören positiv auf Stress und Stimmung auswirken kann. Die wenigen Studien, die stress- und stimmungsregulierenden Wirkungen des Musikhörens nach akuter Stressbelastung in einem kontrolliertem Laborsetting untersuchten, zeigen jedoch widersprüchliche Ergebnisse. Ziel der vorliegenden Arbeit war es daher, bisherige Forschungserkenntnisse zu diesem Thema zu erweitern, und zwar durch die Untersuchung der Auswirkungen von Musik auf das subjektive Stressniveau, die biologischen Stressantworten und die Stimmung sowie deren Wechselbeziehung zueinander. In dieser experimentellen Laborstudie wurden vierundfünfzig gesunde weibliche Probandinnen einem standardisierten psychosozialen Stresstest unterzogen und anschließend per Randomisierung einer der folgenden Erholungsbedingungen zugeteilt: Hören selbstgewählter entspannender Musik oder Erholung in Stille. Das subjektive Stressniveau und die Stimmung wurden im Verlauf des Experiments wiederholt gemessen sowie Speichelproben entnommen. Die Ergebnisse zeigten, dass der Stresstest zu einem signifikanten Anstieg des subjektiven Stresslevels, der Speichelcortisol-Konzentration und negativer Stimmung führte. Entgegen den Erwartungen unterschieden sich die Effekte des Hörens entspannender Musik auf die Erholung nach akutem Stress hinsichtlich des subjektiven Stresslevels, der Speichelcortisol-Konzentration oder der Stimmung nicht signifikant von jenen des Sitzens in Stille. Die wahrgenommene Stimmung korrelierte stark mit dem subjektivem Stresslevel, wohingegen keine signifikante Korrelation zwischen der Speichelcortisol-Konzentration und den beiden subjektiven Maßen gefunden wurde. Weitere experimentelle Forschung ist erforderlich, um die positiven Auswirkungen von entspannender Musik sowie die Beziehung zwischen psychologischer und physiologischer Erholung von akutem Stress vollständig zu erklären.

Schlüsselbegriffe: Cortisol, Musikhören, Stimmung, Stress

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Introduction

Stress is an omnipresent phenomenon all over the world. According to recent studies, the prevalence of stress in the general population increased significantly over the past few years (Lakhan et al., 2020; Mahmud et al., 2022). While stress is adaptive in the short term, prolonged elevated stress exposure can lead to numerous mental and somatic health problems which in turn impose significant health care costs (American Psychological Association [APA], 2017; Chrousos, 2009; Selye, 1956). An effective psychophysiological recovery from stress appears to play an important role in attenuating these negative stress-related health consequences (Adiasto et al., 2022). Therefore, it is of great interest to find easily accessible and inexpensive methods that promote efficient stress recovery and thus prevent stress-related disorders.

Music listening has frequently been proposed by previous research to be an effective method for facilitating stress recovery (e.g., de Witte et al., 2020; Wong et al., 2021). A great number of previous research has shown that music listening can lower stress, subjectively as well as physiologically (e.g., Adiasto et al., 2022; de Witte et al., 2020). Besides the stress-reducing effects of music listening, there is also a large body of research showing that music listening is an effective medium for altering moods and emotional states (e.g., Campbell et al., 2020; Hennessy et al., 2021; Lesiuk, 2010; Murrock, 2005; Lesiuk, 2010). However, existing literature on the stress-reducing and mood-improving effect of music listening does not always report consistent findings (e.g., Fallon et al., 2020; Ilie & Rehana, 2013; Khalfa et al., 2003; Sandstrom & Russo, 2010). Especially studies examining the potentially positive effects of listening to music from a multi-dimensional perspective, by comparing self-report measures of stress and mood to biological markers of stress, are scarce and show ambiguous findings (deMarco et al., 2012; Thoma et al., 2013). Therefore, the aim of the present work is to examine the effects of music listening after an acute stressor on subjective stress levels, biological stress responses, and mood as well as their interrelationship in a controlled laboratory setting.

Theoretical Background

Stress

In the following section, the concept of stress is defined and approached from its psychological as well as biological side. Subsequently, the effects of stress on health are described.

Definition of stress

To date, there is no general agreement on a standard definition of stress in the scientific discourse. Hence, stress can be seen within different contexts and can therefore be defined in different ways (Feneberg & Nater, 2020). One of the earliest concepts associated with stress is homeostasis, which is the ability of an organism to maintain internal equilibrium by adapting to constantly changing internal and external conditions (Cannon, 1929). Thus, stress occurs in situations of serious perceived or real threat to homeostasis (Chrousos, 2009). Lazarus, one of the most eminent psychological stress researchers, defines stress as "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus & Folkman 1984, p. 19). That is, stress typically occurs in situations in which the requirements of the situation outweigh the resources of the individual (Lazarus & Folkman, 1984).

Conditions or situations that trigger stress are termed stressors (Semmer & Zapf, 2017). Throughout life, we are exposed to an uncountable number of potential stressors. According to Mason (1968), psychological stimuli that trigger stress responses share specific characteristics, namely novelty, unpredictability, uncertainty, and ego-involvement. However, a particular stressor is not always accompanied by the same reaction patterns (Mason, 1968). Whether a stressor triggers a stress reaction depends on a complex interplay of a variety of factors. That is, the stress response depends on objective parameters of the stressor, such as duration, intensity, and frequency, as well as on subjective assessments of the individual, such as evaluation of the stressor, coping strategies, previous experiences, individual stress sensitivity, and social environment (Nater et al., 2011). As the responses to stressors can be both emotional and physical, the phenomenon of stress must be approached from its psychological as well as its biological side (Nater et al., 2011).

Psychological side of stress

There are a number of different psychological approaches to the study of stress. One of the most popular theoretical concepts in psychological stress research for explaining stress is the *transactional stress model* according to Lazarus and Folkman (1984). This theory emphasizes the importance of cognitive evaluation. According to that theory, not the objective nature of the stimuli or situations is decisive for the stress response, but rather the subjective evaluation by the affected person (Lazarus & Folkman, 1984). According to Lazarus, situations can be evaluated as positive, irrelevant, or stressful (Lazarus & Folkman, 1984). This initial evaluation of an event is called *primary appraisal*. When a situation is experienced as stressful, it can be interpreted as harm or loss, a threat, or a challenge. While harm or loss refers to strains that have already occurred, anticipated stress can be interpreted as a threat if the person considers his or her resources to be insufficient in relation to the demands. Such an anticipated strain is interpreted as a challenge if the person believes that he or she can meet the requirements with special effort. This primary appraisal is followed by a second appraisal, which is intended to assess whether sufficient resources are available to successfully cope with the stressor (*secondary appraisal*) (Feneberg & Nater, 2020; Nater et al., 2011; Semmer & Zapf, 2017). After this assessment process, coping strategies are applied. In a third step, the effectiveness of the coping strategies is evaluated. This possibility of the modification of the primary evaluation is called *reappraisal*. If coping was successful, the situation will be rated as less threatening or as an interesting challenge in the future. If coping was inadequate, the perceived threat increases. In short, stress is viewed in terms of a transactional relationship between the situation and the evaluation of personal resources in this model (Lazarus & Folkman, 1984).

Biological responses to stress

Individuals also respond to stressful stimuli on the biological level. The brain is one of the key organs mediating stress responses. When the brain interprets a situation as threatening or stressful, it initiates a physiological stress response which encompasses autonomic, neuroendocrine, metabolic, and immune system components (McEwen, 2008). The primary physiological system that mediates the human stress response is the hypothalamus-pituitary-adrenal (HPA) axis. The starting point of the HPA axis is the paraventricular nucleus (PVN), which is located in the hypothalamus. In stressful situations, the PVN is activated and secretes the corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP). These hormones then lead to the synthesis and secretion of adrenocorticotropic hormone (ACTH) in the anterior pituitary gland. ACTH eventually reaches the adrenal cortex via the bloodstream where it triggers the production and secretion of glucocorticoids like cortisol (Feneberg & Nater, 2020; Lupien et al., 2009; Russell & Lightman, 2019; Tsigos & Chrousos, 2002). Additionally, the adrenal medulla secretes the catecholamines adrenaline and noradrenaline (Lupien et al., 2009). To prevent prolonged activation of the HPA system, it is regulated by negative feedback loops aimed at maintaining specific hormone levels and homeostasis. Once the perceived stressor has abated, cortisol regulates its own production, as it contributes to the inhibition of CRH and ACTH release. Overall, a healthy stress response is characterized by a rapid increase in cortisol levels, followed by a fast decrease when the stressful situation is over. This is a highly important homeostatic mechanism since too high or too low cortisol levels can have detrimental effects on health and well-being (Stephens & Wand, 2012).

Stress recovery

As described in the previous section, the human stress response is deemed adaptive if it is of short duration and is directly succeeded by a recovery phase after the stressful stimulus has ceased (Adiasto et al., 2022; Stephens & Wand, 2012). During this phase, homeostasis is being reestablished and stress-induced psychophysiological changes return to baseline levels (de Kloet et al., 2005; de la Torre-Luque et al., 2017). Hence, stress recovery can be conceived as "the process of unwinding that is opposite to the neuroendocrine, physiological, and psychological activation that occurs during the stress response" (Adiasto et al., 2022, p. 3). On a biological level, this is reflected, for example, in a slowing of the heart rate, lower blood pressure, and a decrease in salivary alpha-amylase activity and cortisol levels (Adiasto et al., 2022). Psychologically, stress recovery is usually perceived as a decrease in disagreeable states, which is commonly mirrored in decreased evaluations of "self-reported stress, anxiety and negative affect, along with higher ratings of relaxation and positive affect" (Adiasto et al., 2022, p.3).

Stress-induced health consequences

The human stress response is very adaptive and essential for survival in the short term. However, it can have detrimental health consequences in case of prolonged activation (Selye, 1956). One explanatory approach for the long-term effects of repeated or chronic exposure to stress is the concept of allostatic load (McEwen, 1998). The term allostasis describes the organism's strategies to adapt to a constantly changing environment by keeping various body systems in balance in their function despite adverse circumstances. Therefore, our physiological response to a stressor that could threaten our psychological and/or physical integrity is an attempt to keep our body in a state of equilibrium (Nater et al., 2011). The organism must be able to initiate such allostatic processes when they are needed, but also to shut them down once the situation is over. A too frequent use of these processes leads to wear and tear and inefficient regulation. This is called *allostatic load* which in the long run leads to *allostatic overload* (McEwen, 1998). Allostatic overload occurs when the key mediators of the stress response, such as cortisol, epinephrine, and cytokines, are released for prolonged periods of time, causing them to become unbalanced. This, in turn, deregulates the activity of other biomarkers like insulin, glucose, lipids, and brain neurotransmitters, with consequent effects on multiple interdependent biological systems such as the cardiovascular, immune, metabolic, and the neurological system (Juster et al., 2010; Lupien et al., 2018; McEwen, 2017). This chronically increased or dysregulated allostasis and the associated prolonged physiological changes can lead to the development of a number of diseases (Lupien et al., 2018; McEwen, 1998, 2017). Disorders that can be attributed to acute stress include various kinds of pain, gastrointestinal problems, and panic attacks (Chrousos, 2009), whereas chronic stress may result in psychological and physical health problems such as depression, anxiety disorders, cardiovascular diseases, diabetes, and sleep problems (American Psychological Association [APA], 2017; Chrousos, 2009; Guidi et al., 2021; Mariotti, 2015; Tsigos & Chrousos, 2002). Moreover, allostatic overload and chronic stress make us more prone to engage in health-damaging behaviours like insufficient physical activity, poor diet, smoking and excessive alcohol consumption, which in turn make us more susceptible to disease (Guidi et al., 2021; Lupien et al., 2018; McEwen, 2017). The development and severity of such stress-induced health consequences depend on the nature, magnitude, controllability, and duration of the stressor as well as on biological vulnerability (i.e., genetic, epigenetic, and constitutionals factors), the person's psychological resources as well as on environmental factors (Chrousos 2009; Lupien et al., 2018; McEwen, 2008, 2017; Schneiderman et al., 2005).

As stated above, repetitive or chronic exposure to stress has been associated with a variety of adverse health effects, which often go hand in hand with an overuse of medications or frequent utilization of the health care system (Guidi et al., 2021; Lupien et al., 2018). Therefore, it is of utmost importance to identify possible ways and interventions to counteract the detrimental effects of stress and, consequently, improve public health. To address this issue, literature on the relationship between stress and music, a potential stress-reducing factor, will be revised in the following section.

The Effects of Music

The following section addresses the effects of music on stress and mood in detail. Furthermore, various potential influencing factors and underlying mechanisms are described.

The effects of music on stress

Throughout history, music has played an important role in people's lives (Yehuda, 2011). Music has been commonly linked to a variety of beneficial effects on health and well-being (de Witte et al., 2020). Among these, the effects of music on stress reduction are of particular interest in the existing literature (Chanda & Levitin, 2013; de Witte et al., 2020). For the purpose of stress reduction, music has frequently been applied in various forms, for example in the form of active music-making, music therapy, music listening in combination with guided imagery or progressive muscle relaxation, as well as mere music listening (Chanda & Levitin, 2013; de Witte et al., 2020; Yehuda, 2011). There is a growing number of studies demonstrating the stress-reducing effects of music listening in a variety of settings and populations (e.g., Bradt et al., 2013; Chanda & Levitin, 2013; de Witte et al., 2020, 2022; Fancourt et al., 2014; Finn & Fancourt, 2018; Fu et al., 2019; Gillen et al., 2008; Harney et al., 2022; Khan et al., 2018; Panteleeva et al., 2018; Pelletier, 2004; Sittler et al., 2021; Wong et al., 2021). In the clinical context, listening to relaxing music before, during, and after medical procedures has been associated with reduced stress and/or anxiety as well as decreases in physiological stress measures (Bradt et al., 2013; Chanda & Levitin, 2013; Finn & Fancourt, 2018; Fu et al., 2019; Gillen et al., 2008; Khan et al., 2018). Moreover, music has been shown to effectively decrease physiological and psychological stress-related measures in various clinical settings such as mental health care, medical settings, and surgery, in both clinical populations such as patients with dementia, intensive care hospital patients, as well as healthy subjects (Bradt et al., 2013; Chanda & Levitin, 2013; de Witte et al., 2020, 2022; Fancourt et al., 2014; Finn & Fancourt, 2018; Fu et al., 2019; Gillen et al., 2008; Harney et al., 2022; Khan et al., 2018; Panteleeva et al., 2018; Pelletier, 2004; Sittler et al., 2021; Wong et al., 2021). Besides the clinical context, listening to music has also been associated with lower stress-related measures in healthy people in everyday life (Linnemann et al., 2015, 2016, 2018; Strahler et al., 2019; Wuttke-Linnemann et al., 2019). Furthermore, there is an extensive number of laboratory-based studies that have investigated the effects of music listening on various psychological and physiological stress measures in healthy individuals, with most of them supporting the stress-reducing effects of music (Burns et al., 2002; de la Torre-Luque et al., 2017; Gerra et al., 1998; Groarke et al., 2020; Groarke & Hogan, 2019; Ilie & Rehana, 2013; Jiang et al., 2013; Khalfa et al., 2003; Koelsch et al., 2016; Labbé et al., 2007; Ooishi et al., 2017; Sandstrom & Russo, 2010; Tervaniemi et al., 2021; Thoma et al., 2013; Trappe & Voit, 2016). However, a recent systematic review and meta-analysis of experimental studies found non-significant effects of music listening on various stress-related outcomes in healthy subjects, suggesting that the effects of music listening might be greater in clinical contexts than in situations of acute stress in experimental settings (Adiasto et al., 2022).

In general, music listening seems to influence the stress response on both a subjective and physiological level (e.g., Chanda & Levitin, 2013; de Witte et al., 2020, 2022; Finn & Fancourt, 2018). In the following section, the effects of listening to music on certain psychological, physiological and neuroendocrine measures of stress are discussed in more detail.

The effects of music listening on the psychological stress response. Numerous studies have found positive effects of music listening on psychological stress parameters (e.g., DeMarco et al., 2012; de Witte et al., 2020; Linnemann et al., 2015; Harney et al., 2022; Pelletier, 2004; Wong et al., 2021). In previous experimental studies, stress has frequently been induced in a laboratory setting in order to control for potentially confounding variables and to allow causal inferences between music listening and subjective stress-related measures (Burns et al., 2002; Groarke et al., 2020; Groarke & Hogan, 2019; Labbé et al., 2007; Sandstrom & Russo, 2010). In a laboratory-based study by Groarke and Hogan (2019), for example, listening to self-chosen music following an acute stress induction was associated with a greater reduction in subjective stress levels compared to non-music control groups. According to another study, the effects of music listening on subjective stress seem to be influenced by the valence and arousal dimensions of music (Sandstrom & Russo, 2010). This has been shown in a study by Sandstrom and Russo (2010), in which music with positive valence and low arousal was found to be most effective in promoting subjective stress recovery following acute stress.

In some other experimental studies, music was found to increase relaxation and reduce state anxiety, two constructs that are both strongly associated with stress (Burns et al., 2002; Groarke et al., 2020; Harney et al., 2022; Jiang et al., 2013; Labbé et al., 2007; Panteleeva et al., 2018). Groarke et al. (2020), for example, investigated the effects of self-selected and researcher-selected music on state anxiety in undergraduate students. It was found that both types of music significantly decreased participants' perceived post-stressor state anxiety compared to a silent control group (Groarke et al., 2020). These effects of music listening on relaxation and anxiety appear to vary depending on the type of music (Burns et al., 2002; Labbé et al., 2007). In this regard, two studies showed that listening to classical or self-selected music after stress induction significantly reduced state anxiety and increased feelings of relaxation compared to listening to heavy metal music, hard rock music, or sitting in silence (Burns et al., 2002; Labbé et al., 2007). Heavy metal music was not only ineffective in increasing relaxation, but actually increased anxiety levels (Labbé et al., 2007). In addition to the music type, music preference also seems to play a role in the effects of music listening on anxiety (Jiang et al., 2013). Jiang et al. (2013) investigated the impact of soothing and stimulating music and music preference on stress recovery from a stressful mental arithmetic test in female music education students. Following stress induction, subjects were assigned to one of four conditions, either listening to preferred sedative music, preferred stimulative music, unpreferred sedative music, or unpreferred stimulative music. When the music was not preferred, sedating music was found to be more effective in reducing levels of tension and anxiety compared to stimulating music. In the case of preferred music, on the other hand, tension or anxiety levels did not differ significantly between sedative and stimulative music. These results indicate that the effects of relaxing and stimulating music on stress recovery appear to be dependent on music preference (Jiang et al., 2013).

Despite the large number of studies reporting positive effects of music listening on various stress-related psychological measures, there are also studies in which no beneficial effects of music listening on subjective stress parameters could be found. Sokhadze (2007), for instance, compared the effects of pleasant music, sad music, and white noise on subjective stress measures after stress induction by aversive visual stimulation. Findings demonstrated that pleasant music, sad music, and white noise were ineffective in reducing subjective stress levels post-stressor (Sokhadze, 2007). Similar non-significant effects were observed in a study by de la Torre-Luque et al. (2017), who examined the effects of a researcher-selected relaxing music track on subjective feelings of anxiety after an acute laboratory stress task. For this purpose, subjects either listened to a relaxing music tune or sat in silence for 15 minutes, after undergoing the stress induction protocol of the Trier Social Stress Test (TSST). In this study, no significant differences could be found between the groups regarding subjective reports of anxiety after the intervention (de la Torre-Luque et al., 2017).

All in all, most of the aforementioned investigations provide evidence for a stress-reducing effect of music listening (de Witte et al., 2020; Linnemann et al., 2015; Harney et al., 2022; Pelletier, 2004; Wong et al., 2021). However, the laboratory-based studies that examined the effects of music listening on subjective stress-related outcomes after acute stress exposure show mixed results, so no definite conclusions can be drawn yet in this regard (Burns et al., 2002; de la Torre-Luque et al., 2017; Groarke et al., 2020; Groarke & Hogan, 2019; Labbé et al., 2007; Sandstrom & Russo, 2010; Sokhadze, 2007).

The effects of music listening on the biological stress response. In order to obtain a more thorough understanding of the stress-reducing effects of music, it is important to consider not only self-reported levels of subjective stress but also objective measures of physiological stress. In previous research, listening to music has often been associated with several neuroendocrine and physiological alterations that are regarded as favourable for stress recovery (de Witte et al., 2020; Chanda & Levitin, 2013; Pelletier, 2004; Finn & Fancourt, 2018). For instance, music listening has been linked to a decrease in heart rate, blood pressure, skin conductance, and cortisol (Burns et al., 2002; Fancourt et al., 2014; Khalfa et al., 2003; Knight & Rickard, 2001; Labbé et al., 2007; Sandstrom & Russo, 2010). Positive effects of music listening on cortisol, which is an index for HPA-axis activation, have been shown, for example, in clinical settings where music was listened to before, during, or after stressful medical procedures, as well as in everyday situations (Bradt et al., 2013; Chanda & Levitin, 2013; de Witte et al., 2020; Fancourt et al., 2014; Finn & Fancourt, 2018; Fu et al., 2019; Linnemann et al., 2015; Wong et al., 2021). There are, however, only few studies that have investigated the effects of music listening on cortisol levels in a controlled laboratory setting (Ilie & Rehana, 2013; Khalfa et al., 2003; Knight & Rickard, 2001; Peck et al., 2021; Ruiz Gallo et al., 2016; Thoma et al., 2013; Yamamoto et al., 2007).

Experimental studies that examined the effects of listening to music on cortisol prior to stress induction report inconsistent findings (Knight & Rickard, 2001; Peck et al., 2021; Ruiz Gallo et al., 2016; Thoma et al., 2013). Ruiz Gallo et al. (2016), for example, compared the effects of listening to researcher-selected relaxing music, participant-selected music, or sitting in silence for 15 minutes before stress induction by the TSST, a standardized psychosocial stressor, in a sample of healthy college students. In this study, both listening to researcher-selected relaxing music and participant-selected music prior to the TSST prevented significant increases in salivary cortisol concentration due to the stressor compared to sitting in silence (Ruiz Gallo et al., 2016). However, other studies found music to be ineffective in preventing a stress-induced increase in cortisol concentration (Knight & Rickard, 2001; Peck et al., 2021; Thoma et al., 2013). This was the case, for example, in a study by Thoma et al. (2013), who compared the effects of listening to researcher-selected relaxing music, the sound of rippling water, or resting in silence prior to an acute stressor in a sample of healthy female subjects. In this study, music listening prior to a stressor was not effective in buffering cortisol response to a psychosocial stressor but rather increased it. However, music listening promoted a faster physiological stress recovery following acute stress in this study (Thoma et al., 2013).

Based on these findings it may be suggested that listening to relaxing music is not effective in preventing cortisol increases in response to a future stressor, but rather facilitates recovery following a stressor (Thoma et al., 2013). There is, however, a relative scarcity of laboratory-based research that investigates the effects of music listening on cortisol levels after stress induction and findings of previous experimental studies are mixed (Ilie & Rehana, 2013; Khalfa et al., 2003; Yamamoto et al., 2007). In two studies with a similar research design to the present study, relaxing music was shown to be more effective in decreasing cortisol levels after stress exposure than sitting in silence (Ilie & Rehana, 2013; Khalfa et al., 2003). Among these, is a study by Khalfa et al. (2003), in which male university students were exposed to the TSST before being assigned to either the experimental group, which listened to relaxing music during the recovery phase, or the control group, which sat in silence for the same amount of time. The results showed that salivary cortisol levels decreased more rapidly in subjects that were listening to relaxing music after the stress task than in those who were recovering from stress in silence (Khalfa et al., 2003). In a similar study by Ilie and Rehana (2013), undergraduate students were randomly assigned to one of three groups, either playing or listening to a piece of relaxing music or sitting in silence for ten minutes after being exposed to the TSST. Individuals who played or listened to music during the stress-recovery phase showed a significant decline in cortisol concentrations compared to those who sat in silence (Ilie & Rehana, 2013). Another study with a similar research design, however, did not find a beneficial influence of music listening after a stressful task on cortisol levels (Yamamoto et al., 2007).

Given the limited number of studies that have examined the effects of music listening on cortisol levels following an acute stressor in a controlled laboratory setting and the conflicting findings of these studies, no definitive conclusions can be made yet about whether listening to music affects stress-induced cortisol concentrations. Thus, further research on the relationship between music listening and the physiological stress response, more specifically the responses of the HPA axis, is needed.

The effects of music on mood

Previous research suggests that many of the beneficial effects of music on health are attributed to its ability to evoke emotions and moods (Juslin, 2010; Murrock, 2005). Moods are generally defined as subjective affective states of low intensity that are relatively long-lasting. Emotions, on the other hand, are commonly described as shorter, but more intense feelings which are usually directed towards a specific object or event (Garrido, 2014; Scherer & Zentner, 2001). Affect has been used as a generic term that encompasses both, mood and emotion (Scherer & Zentner, 2001). Despite the conceptual distinction between mood, emotion, and affect, these terms are often used synonymously in the literature (Hu, 2010).

Existing literature shows that the regulation of emotions and mood are among people's main reasons to engage in music listening (Garrido et al., 2013; Juslin, 2010; Juslin et al., 2008, 2011; Randall & Rickard, 2017; Saarikallio & Erkkilä, 2007; Schäfer et al., 2013; Schäfer & Sedlmeier, 2010; Thoma et al., 2012), and music listening has been shown effective in doing so in various settings (Campbell et al., 2020; Dingle et al., 2021; Fallon et al., 2020; Garrido & Schubert, 2015; Groarke & Hogan, 2019; Helsing et al., 2016; Hennessy et al., 2021; Ilie & Rehana, 2013; Innes et al., 2016; Juslin & Västfjäll, 2008; Lesiuk, 2010; Lynar et al., 2017; McFerran et al., 2015; Murrock, 2005; Murrock & Higgins, 2009; van den Tol & Edwards, 2015). A recent study, for example, investigated the effects of music listening on mood and well-being during the COVID-19 pandemic in healthy subjects (Hennessy et al., 2021). Results showed that individuals who felt more affected by the pandemic were more likely to listen to music to feel better and showed stronger enhancement of their mood after listening to music during the pandemic (Hennessy et al., 2021). Music listening has also been found to be beneficial in improving mood and well-being among clinical populations such as neurological patients (Raglio et al., 2015), adults with early memory loss (Innes et al., 2016), stroke patients (Baylan et al., 2016; Särkämö et al., 2008), people with ADHD (Zimmermann et al., 2019), and patients on a solid organ transplant unit (Bergh & Silverman, 2018).

Despite the abundant evidence for the mood-altering effects of music, it has been suggested that listening to music may be less effective at enhancing mood when people are initially in a stressed affective state (McFerran et al., 2015). Only few studies, however, have addressed this issue by examining the effects of music listening on mood and affect regulation following acute stress (Groarke & Hogan, 2019). Among them is an experimental study by Fallon et al. (2020), who examined the impact of music on stress reduction and mood in a sample of psychology students. For this purpose, subjects were exposed to a laboratory stressor and were then allocated to one of three recovery conditions, in which they were instructed to either listen to a preselected music piece, improvise on a xylophone, or sit in silence for five minutes. The results showed that a brief five-minute intervention of music listening or music improvisation after an acute stressor task can have a positive effect on aspects of mood (Fallon et al., 2020). A similar laboratory-based study examined the effects of self-chosen music listening on affect regulation after stress induction (Groarke & Hogan, 2019). Therefore, after undergoing the TSST, participants were randomly assigned to either the experimental group, which listened to self-chosen music for ten minutes, or the active control group, which listened to an experimenter-chosen radio documentary. Subjects that listened to music showed a greater reduction in negative affect compared to the control group. This finding indicates that listening to self-selected music can be an effective means of affect regulation at times of acute stress (Groarke & Hogan, 2019).

Although the previously mentioned studies suggest positive effects of music listening on mood and affect, there are also studies that have not found significant results in this regard (Ilie & Rehana, 2013). This was the case, for example, in a study by Ilie and Rehana (2013), in which participants either listened to or played a piece of relaxing music on an app or sat in silence for ten minutes after undergoing a stress-inducing procedure. Individuals in all three groups rated themselves as feeling less negative, more pleasant, and calmer after the intervention. However, the self-reports of mood and arousal measures did not differ significantly between groups (Ilie & Rehana, 2013).

All in all, most of the existing literature suggests that music can be an effective medium for improving mood (e.g., Fallon et al., 2020; Garrido, 2015). However, due to the paucity of investigations about the effects of music listening on mood after acute stress as well as the heterogeneous outcome measures of mood used in these studies, further research addressing this issue is needed.

Characteristics of relaxing music

As shown in the previous section, listening to music can be used to reduce and recover from stress in various environments (Adiasto et al., 2022; Bradt et al., 2013; Chanda & Levitin, 2013; de Witte et al., 2020, 2022; Fancourt et al., 2014; Finn & Fancourt, 2018; Fu et al., 2019; Gillen et al., 2008; Harney et al., 2022; Khan et al., 2018; Panteleeva et al., 2018; Pelletier, 2004; Sittler et al., 2021; Wong et al., 2021). However, not all music is appropriate for the purpose of stress reduction and relaxation (Gerra et al., 1998; Labbé et al., 2007; Nater et al., 2006; Tan et al., 2012; Trappe, 2010). There seem to be specific intrinsic characteristics of music that are perceived as relaxing by listeners (de Witte et al., 2020; Tan et al., 2012). One of the most important factors associated with music-related relaxation and stress reduction appears to be music tempo (de Witte et al., 2020). Especially slow music with a tempo of 60-90 bpm has often been associated with relaxing effects in previous research (de Witte et al., 2020, 2022; Finn & Fancourt, 2018; Tan et al., 2012). In general, there seems to be a negative correlation between music tempo and perceived degree of relaxation, with music with a slower tempo being perceived as more relaxing than music with a faster tempo (Chanda & Levitin, 2013; Tan et al., 2012). Other musical features that appear to be associated with perceived relaxation are high pitch range and harmonic complexity, as well as low melodic, rhythmic, and instrumental complexities (Tan et al., 2012). Moreover, music with both positive valence and low arousal appears to be the most effective for the recovery from acute subjective and physiological stress, as opposed to music with high arousal and negative valence (Jiang et al., 2016; Sandstrom & Russo, 2010).

When comparing the effects of different music genres, classical music has been shown in a number of studies to have the greatest effects on the reduction of stress and physiological arousal as well as on the improvement of emotional states (Finn & Fancourt, 2018; Gerra et al., 1998; Jiang et al., 2013; Labbé et al., 2007; Trappe, 2010). On the other hand, opposite effects have been assumed for other genres such as heavy metal and techno, which have been found to be ineffective for relaxation and stress reduction in several studies (Burns et al., 2002; Gerra et al., 1998; Jiang et al., 2013; Labbé et al., 2007; Nater et al., 2006; Trappe, 2010). These genres appear to generate psychophysiological activation, stress, and anxiety rather than reduce it (Labbé et al., 2007; Nater et al., 2006; Trappe, 2010).

Potential influencing factors

In addition to specific characteristics and intrinsic properties of music, there is also a number of extramusical factors that are likely to have an influence on a person's response to music. For example, previous research suggests that emotional responses to music change with age (Vieillard & Gilet, 2013). Older adults have been shown to experience music more positively and to show greater decreases in negative affect after listening to music than younger adults, which further suggests that music might be most beneficial for stress reduction in older adults (Cohrdes et al., 2020; Groarke & Hogan, 2019; Lee-Harris et al., 2018; Lima & Castro, 2011; Vieillard & Gilet, 2013). Moreover, sex differences in psychophysiological responses to music listening have been observed in previous research, with women appearing to be more influenced by musical stimuli than men (de la Torre-Luque et al., 2017; Gupta & Gupta, 2016; Nater et al., 2006; Pelletier, 2004; Wuttke-Linnemann et al., 2019). Another factor that has been shown to influence individual responses to music is musical expertise and training (e.g., Kantor-Martynuska & Horabik, 2015). Musically trained individuals appear to be emotionally and physiologically more responsive to music listening than musically untrained individuals (Angulo-Perkins et al., 2014; Gerstgrasser et al., 2022; Juslin et al., 2011; Kantor-Martynuska & Horabik, 2015; Pelletier, 2004). Furthermore, differences in personality traits among listeners have also been shown in previous research to partly account for differences in responses to music (Chanda & Levitin, 2013; Gerstgrasser et al., 2022; Kantor-Martynuska & Horabik, 2015; Miranda, 2020). Moreover, music preference and familiarity with the music have been shown in several studies to correlate positively with listeners' perceived relaxation and to play an important role in the stress-reducing potential of music (Jiang et al., 2013, 2016; Tan et al., 2012). Further individual factors that have been shown to affect the responses to music include personal associations with the music, cultural and social factors, as well as mood state (Bradt et al., 2013).

Regarding the selection of music, there is no general consensus in the literature as to whether music chosen by the participants or music selected by the researcher is more beneficial in stress reduction. Some studies suggest that music pre-selected by the researchers may have a greater effect on stress recovery than self-selected music, as it is typically based on the musical properties found in classical and relaxing music, which are considered to have a positive effect on relaxation and stress reduction (Labbé et al., 2007; Pelletier, 2004). However, there is also opposite evidence that indicates that self-selected rather than researcher-selected music may be more effective in reducing stress (Chanda & Levitin, 2013; Juslin et al., 2008; Leardi et al., 2007). This has partly been attributed in previous research to the feelings of perceived personal control over some aspects of the situation that result from individuals being able to choose music that they perceive as relaxing (Chanda & Levitin, 2013; Groarke & Hogan, 2019; Labbé et al., 2007; Linnemann et al., 2016). In a recent meta-analysis, however, the way the music is selected has been found to not influence music's effectiveness in stress reduction (de Witte et al., 2020). Hence, there are inconsistencies across studies regarding the most effective type of music selection for stress reduction.

Although the aforementioned factors have all been shown to contribute to the relaxing and stress-reducing effect of music to some degree, there appears to be no general agreement on which of the factors should be considered most.

Potential underlying mechanisms of action

To date, there is no general agreement on the specific mechanisms underlying the effects of music on stress and mood. However, recent neuroscientific studies have proposed some mechanisms that appear to be involved in the stress-reducing effects of music (e.g., Chanda & Levitin, 2013; Juslin & Västfjäll, 2008; Koelsch, 2014). First, music appears to activate the mesolimbic dopaminergic system (Blood & Zatorre, 2001; Chanda & Levitin, 2013; Koelsch, 2014; Koelsch et al., 2011; Menon & Levitin, 2005), which leads to increases in dopamine and corresponding deactivation of brain structures which are related to stress and cortisol signalling (Chanda & Levitin, 2013). Furthermore, music may also reduce stress-related negative emotions and feelings, such as anxiety, worries, fear, restlessness, or nervousness (de Witte et al., 2022; Juslin & Västfjäll, 2008; Pittman & Kridli, 2011). This has been attributed in previous studies to the down-regulatory effects of music on the activity in brain areas such as the amygdala, which are involved in the regulation of emotional processes (Blood & Zatorre, 2001; de Witte et al., 2020; Koelsch, 2014, 2020; Koelsch et al., 2006; LeDoux, 2000; Moore, 2013). Another plausible explanation for the beneficial effects of music listening on stress levels is that musical stimuli consume cognitive resources (Koelsch & Siebel, 2005) and may therefore serve as a distractor from stressful feelings or thoughts and aversive states (Bernatzky et al., 2011; Chanda & Levitin, 2013; de Witte et al., 2020; Murrock, 2005; Nilsson, 2008).

According to the explanatory approaches described above, listening to music activates brain areas involved in positive emotional states and deactivates those associated with stress-related negative emotions and cortisol release (Blood & Zatorre, 2001; Chanda & Levitin, 2013; Koelsch, 2014; Koelsch et al., 2011; Menon & Levitin, 2005). Therefore, it may be assumed that there is a certain correlation between the subjective and physiological effects of listening to music on stress. However, the existing literature provides ambiguous findings in this regard (Fancourt et al., 2014; Linnemann et al., 2019). While in some studies subjective results are in line with physiological results, other studies report discordant results between psychological and physiological effects of music listening (DeMarco et al., 2012; Fancourt et al., 2014; Gerra et al., 1998; Linnemann et al., 2015; Thoma et al., 2013; Wuttke-Linnemann et al., 2019). Further research examining the correlation between physiological and self-report stress-related measures is therefore needed to more thoroughly understand the complex effects of music on stress and its underlying mechanisms.

Research Question and Hypotheses

As reported in the previous sections, music listening has been shown effective in reducing both physiological and psychological stress as well as improving mood in a number of studies (e.g., de Witte et al., 2020; Murrock, 2005; Wong et al., 2021). Despite this significant body of research, many of the aforementioned studies have certain shortcomings that need to be addressed. For example, many of them did not use a valid, standardized stressor or did not control for confounding factors (Campbell et al., 2020; Ooishi et al., 2017; Tervaniemi et al., 2021; Yamamoto et al., 2007). The few existing studies that investigated the effects of music listening on subjective stress, cortisol, or mood following an acute stressor in a controlled laboratory setting show ambiguous findings. Whereas some of them reported music listening to be associated with lower levels of subjective stress (Burns et al., 2002; de la Torre-Luque et al., 2017; Jiang et al., 2013; Labbé et al., 2007; Sandstrom & Russo, 2010), salivary cortisol (Ilie & Rehana, 2013; Khalfa et al., 2003), and improved mood (Fallon et al., 2020; Groarke & Hogan, 2019), others have found no beneficial effects in post-stressor levels of these parameters when compared to a non-music control condition (Ilie & Rehana, 2013; Sokhadze, 2007; Yamamoto et al., 2007). Thus, no final conclusions about the effectiveness of music listening can be drawn yet. In addition, to the best of my knowledge, no study to date has yet investigated the relationship between self-report measures of stress and mood and physiological measures of salivary cortisol in the context of music listening.

To address the aforementioned shortcomings of previous research, experimental research is required to get a more complete understanding of the effects of music listening on these factors as well as their interaction with each other in a controlled laboratory setting. This issue is being addressed in the present master's thesis, which leads to the following research question: Does listening to self-selected relaxing music after stress induction decrease subjective and physiological stress levels and improve mood? Considering findings from previous investigations, the following three hypotheses can be formulated:

H1: Individuals listening to self-selected relaxing music during recovery from a psychological stress test show a higher reduction in perceived stress levels and salivary cortisol concentration than individuals who sit in silence.

H2: Individuals listening to self-selected music during recovery from a psychological stress test show greater improvement in their mood than individuals who sit in silence.

H3: The higher the subjective and physiological stress reduction, the higher the mood improvement.

Methods

Study Design

The present study is part of a larger research project ("The Effect of Relaxing Music on Stress Recovery") which has been conducted by Univ.-Prof. Dr. Urs Nater and Yichen Song, BSc, MA. A *between-subject* design was used to compare the effect of music on stress recovery among four conditions in a laboratory setting. After undergoing a social stress test (Trier Social Stress Test, TSST; Kirschbaum et al., 1993), participants were randomly assigned to one of the following conditions: a participant-selected music condition, a researcher-selected music condition, a non-music acoustic control condition and a non-acoustic control condition. Randomization was attained by alternately assigning participants to one of the groups. In this master's thesis, only two of the conditions have been investigated: the participant-selected music group, in which participants listen to their preferred relaxing music, and the non-acoustic control condition, in which participants rest without any acoustic stimulation.

Participants

To estimate the optimal sample size, an a priori G*power analysis was conducted. It revealed that, to reach an effect size of f=0.34 in power of 80% and an alpha criterion of 0.05, at least 25 participants are required for each condition. Only females were selected for this study in order to control for gender differences in HPA axis response to psychological stress (Kirschbaum et al., 1999; Stroud et al., 2002; Uhart et al., 2006) and in psychophysiological and emotional responses to music listening (Nater et al., 2006) as well as to compare the findings to a precursor study (Thoma et al., 2013).

For this study, interested participants were recruited through online advertisements on social media (see Appendix A). In a telephone interview (Appendix B), potential participants were then screened for inclusion criteria. The criteria for eligibility of the participants included: female sex; body mass index (BMI) between 18-25kg/m^2; 20-30 years of age; German as native language; no pregnancy and breast-feeding. Several further exclusion criteria have been considered to control for their cofounding effect on the biological measurements: self-reported or diagnosed anxiety, depression, and stress; diagnosed somatic or psychiatric disorder; psychoactive substances or excessive consumption of alcohol or tobacco; professional or amateur-level musician; regularly training or practicing relaxation methods or mindfulness; hearing deficits or absolute hearing. Furthermore, all subjects were required to have a regular menstrual cycle and to not use hormonal contraceptives (Feneberg & Nater, 2020; Kirschbaum et al., 1999; Thoma et al., 2013). The experimental sessions have been related to the women's follicular phase of the menstrual cycle to avoid hormonal influences (Kirschbaum et al., 1999). Moreover, participants were required to not have had previous experience with the TSST as well as no personal relationships with the study team members. Participation in the study was voluntary and each participant received 40€ for full participation or a proportional compensation in case of earlier termination.

Ethical Approval

The study protocol was approved by the ethics committee of the University of Vienna. Written informed consent was obtained from all participants before the experiment.

Psychobiological Stress Induction

To induce moderate levels of psychological stress, all participants underwent the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), which has been shown in previous studies to reliably increase HPA-axis activity as well as to activate the autonomous nervous system (Dickerson & Kemeny, 2004; Kirschbaum et al., 1993; Kudielka et al., 2007). The procedure followed the standard TSST protocol (Kirschbaum et al., 1993) with some minor modifications. First, the subjects were taken to the test room, where a female experimenter introduced them to the upcoming task. They were informed that the test consists of a preparation phase (3 min), a public speaking task (5 min), and a mental arithmetic task (5 min). Both tasks were carried out in front of a committee which consisted of two members (one female and one male) who were sitting at a table, dressed in white lab coats. The committee members communicated in an unresponsive manner and did not provide any verbal or nonverbal feedback to the participants. Subjects were told that they will be videotaped for later analysis of their performance, behavior, gestures, and facial expressions.

The first task was preceded by a preparation time of three minutes, in which participants were allowed to take notes to prepare their talk. After three minutes, the participants were instructed to step forward to the marked spot in front of the committee and to start their speech, without using their notes. In the public speaking task, participants had to take on the role of a job applicant and were asked to present their personal qualities that make them particularly qualified for the position. After five minutes, one panel member interrupted the speech and subsequently explained the mental arithmetic task. In the mental arithmetic task, the participants were requested to serially subtract 17 from the number 2043. Whenever the subjects made a calculation error, they had to restart the calculation from the first digit.

Measures

Demographic information such as age, gender, nationality, the highest level of education achieved, and employment status was collected using a demographic questionnaire. In order to pre-screen potential participants and to verify the criteria for eligibility of interested participants, the Patient Health Questionnaire (PHQ; Löwe et al., 2002), the Beck Depression Inventory (BDI; Jackson-Koku, 2016) as well as the Multidimensional Fatigue Inventory (MFI; Smets et al., 1995) were used.

For the analysis of salivary free cortisol, saliva samples were collected by SaliCaps© (IBL, Hamburg, Germany) repeatedly throughout the experiment. Cortisol has been shown to be an indicator of the HPA axis activity and a valid biomarker of stress (Kirschbaum & Hellhammer, 1994). An increase in salivary cortisol concentration occurs with a time delay and generally reaches its maximum level approximately 20 to 30 minutes after stress induction (Feneberg & Nater, 2020). For saliva collection, the participants were instructed to swallow once and then accumulate saliva by not swallowing for two minutes. Then, the subjects were asked to transfer all accumulated saliva into the Salicap using a straw. After completion of each session, all saliva samples were stored in a freezer at -20°C at the Biochemical Laboratory of the Department of Psychology, University of Vienna until they were analyzed. At the end of the investigation period, salivary cortisol levels of all subjects were biochemically analyzed using a luminescence immunoassay (LIA) (IBL, Hamburg, Germany). Inter- and intraassay coefficients of variation were below 10%.

To measure the perceived psychological stress levels of the participants, the Visual Analog Scale (VAS; Lesage et al., 2012) was filled out by the participants several times throughout the experiment. Therefore, the subjects were asked to mark their subjective stress score on an unmarked 100mm ruler from 0 (“not at all”) to 100 (“very much”) (see Appendix C). This single-item measure has been shown to be efficient in assessing perceived stress (Elo et al., 2003; Lesage et al., 2012).

To assess mood, a short version of the German mood questionnaire (Mehrdimensionaler Befindlichkeitsfragebogen [Multidimensional Mood questionnaire; MDBF]; Hinz et al., 2012) was used (Appendix D). The MDBF measures a person’s current mood state on the three dimensions “good versus bad mood,” “wakefulness versus sleepiness,” and “calmness versus restlessness” (Hinz et al., 2012). In this master’s thesis, only the dimension “good versus bad mood” was used as an outcome measure. This subscale consists of the four items „At the moment I feel… (1) good (“gut”) (2) content (“zufrieden”) (3) bad (“schlecht”) (4) uncomfortable (“unwohl”). The items were rated on a Likert scale from 0 (not at all) to 5 (very much) (Hinz et al., 2012). The internal consistency (Cronbach's alpha) of the scales of the short form ranges from $\alpha = .73$ to $\alpha = .89$ (Steyer et al., 1994).

Other questionnaires administered included the Primary Appraisal and Secondary Appraisal Questionnaire (PASA; Gaab, 2009), Perceived Stress Reactivity Scale (PSRS; Schlotz et al., 2011), Resilience Short Scale (RS; Schumacher et al., 2005), Childhood Trauma Questionnaire (CTQ; Maercker & Bromberger, 2005), NEO-Five Factor Inventory (NEO-FFI; Borkenau & Ostendorf, 1993), Brief-Cope (Knoll et al., 2005), 12-Item Screening Scale for Chronic Stress (SSCS; Schulz et al., 2004), the Perceived Stress Scale (PSS; Klein et al., 2016) and the Music Preference Questionnaire (MPQ; Nater et al., 2005). Also, heart rate, skin conductance, and salivary alpha-amylase were measured throughout the experiment but were not analyzed in this thesis.

Procedure

To control the fluctuation of hormone levels throughout the day (Edwards et al., 2001; Nater et al., 2007), all examinations took place between 2 pm and 5 pm at the Biochemical Laboratory of the Department of Psychology, University of Vienna. Subjects were instructed in advance to abstain from eating and drinking anything except water as well as not to brush their teeth one hour before the experiment. Moreover, they were told not to consume any alcoholic or caffeinated drinks within 48 hours prior to the study as well as to avoid intense physical exercise the 24 hours before the experiment.

Upon arrival at the laboratory, the experimenter briefly explained the procedure of the experiment to the participants, who were then asked to sign written informed consent (see Appendix E). Subsequently, the Movisens devices (Movisens GmbH, Karlsruhe, Germany) were attached. These instruments were worn throughout the whole experiment to continuously monitor heart rate and skin conductance. Then, participants were given instructions and a demonstration of how to take saliva samples with the SaliCaps© (IBL, Hamburg, Germany), and the saliva collection was practiced.

Subsequently, the subjects were asked to fill out some of the questionnaires mentioned above on a computer. The experimenter left the room and waited in a different room while the participant was answering the questionnaires.

Thirty minutes after the arrival of the participant at the laboratory, the first measurement was done (T1), which served as the baseline measure. Therefore, both saliva samples and subjective measurements (MDBF; Hinz et al., 2012; VAS; Lesage et al., 2012) were obtained.

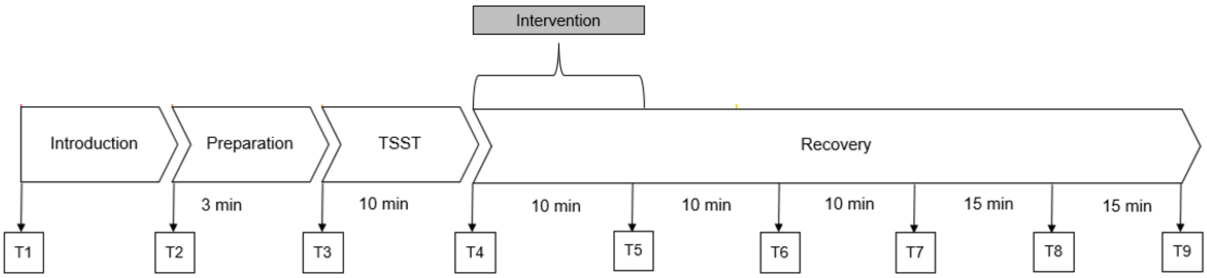
After the first measurement, the subjects were taken to the test room, where the experimenter explained the upcoming task. Following the brief introduction, a second measurement was done (T2). After that, they had three minutes to prepare their speech. After the preparation time and right before the TSST, another measurement was done (T3). Then, the experimenter left the room, and the participants underwent the TSST in front of a committee. Right after the two tasks of the TSST, the experimenter came back into the room and another measurement was conducted (T4).

After the completion of the TSST, the recovery phase started. Therefore, the subjects were led back to the intervention room where they were placed on a comfortable chair and were put on headphones. At this point, participants were randomly assigned to one of the conditions. In the self-selected music group, participants listened for ten minutes to a personalized playlist with their preferred relaxing music tunes which they sent us beforehand. The control group was sitting in silence for the same amount of time. In order not to be disturbed by ambient noise, they were put on headphones as well. The subjects were asked to sit as still as possible for the ensuing ten minutes. They were allowed to close their eyes, but they should try not to fall asleep. The experimenter switched off the lights and left the room for the time of the intervention. After ten minutes, the experimenter came back in and another measurement was done immediately after the intervention (T5). For the remaining recovery time, the subjects were asked to read or skim through nature magazines that were provided by the experimenter. The experimenter left the room and came in several times for further measurements 20 minutes (T6), 30 minutes (T7), 45 minutes (T8), and 60 minutes (T9) after the TSST.

At the end of the experiment, the physiological sensors were detached, and participants were debriefed by the experimenter about the goal of the study and the nature of the stressor. Furthermore, they were informed that their performance had not been videotaped. Eventually, participants received an expense allowance for participating in the study and were dismissed by the experimenter. The experimental procedure is illustrated in Figure 1.

Figure 1

Study procedure



Results

Statistical Analysis

Statistical analyses were performed using SPSS (27.0) software packages (IBM, Armonk, NY). Before statistical procedures were applied, the normal distribution and homogeneity of variance of the data were tested using a Shapiro-Wilk and Levene's test. In case of missing data, cases were excluded listwise prior to data analysis.

For the analysis of salivary cortisol concentration, the area under the curve with respect to increase (AUCi) was calculated with the trapezoidal formula by Pruessner et al. (2003). The AUCi is defined generically as the "area under the curve above the baseline minus the area above the curve below the baseline" (Fekedulegn et al., 2007, p. 658). It balances the amount of increase versus decrease and can be considered a parameter of change of the measurements over time (Fekedulegn et al., 2007). In this thesis, the AUCi between T5 and T9 was used for the analyses.

For the evaluation of subjective stress reactivity, the delta measures of subjective stress responses were calculated by subtracting baseline values before the stressor (T1) from the peak values after the stressor (T4). To estimate a subjective stress recovery value, the values of the last time point of the recovery period (T9) were subtracted from the peak values right after the stressor (T4).

For the calculation of changes in mood in response to the intervention, difference scores in mood were calculated between the peak values after the stressor (T4) and values at the end of the recovery phase (T9).

The time course of subjective stress levels, salivary cortisol concentration, and mood were analysed using repeated measures ANOVAs and Friedman-tests, respectively. Subsequent Bonferroni-adjusted post-hoc analyses were used to calculate the statistical significance of differences between specific timepoints of interest. Statistical values were corrected by the Greenhouse-Geisser procedure if the sphericity assumption was violated.

To test the proposed hypotheses, the scale means of the calculated measures of AUCi, stress recovery, and mood change were compared between the two groups using t-tests for independent samples. Additionally, analyses of covariance (ANCOVA) were computed to compare group means controlling for the effect of potential covariates. Moreover, correlations between physiological and subjective stress measures and mood levels were computed as Spearman correlations. For all analyses, p-values <.05 were considered statistically significant (two-tailed). If not stated differently, all results are given as means (M) ± standard deviations (SD).

Sample Characteristics

All main participant characteristics are detailed in Table 1. A total of fifty-four healthy female subjects participated in the study. Most of the participants had Austrian (59.3%) or German (22.2%) nationality. Subjects had a median age of 23.7 years (*SD* = 2.93, range: 18-30) and a mean body mass index of 21.39 kg/m^2 (*SD* = 2.06, range: 17.69-26.84). The vast majority of the participants had a high-school diploma (87%) or advanced technical college entrance qualification (5,6%).

BDI scores ranged between 0 and 26 (*M* = 7.92, *SD* = 6.79). Five subjects were classified as mildly depressed, and four as moderately depressed (Jackson-Koku, 2016). Additional analyses did not reveal any significant influence of depression scores on subjective and biological parameters. Therefore, no subject was excluded from statistical analyses due to depression. The mean sum score of chronic stress, as measured by the SSCS, was 34.56 (*SD* = 7.00; range = 20-53). Regarding perceived stress reactivity, the mean sum score of the PSRS was 21.61 (*SD* = 4.09, range = 12-30). The median perceived stress level (PSS) within the previous month was 31.96 (*SD* = 2.98, range = 26-39), which indicates high levels of perceived stress in our sample (Klein et al., 2016).

Data on music preference for several music genres, as assessed by the Music Preference Questionnaire (MPQ; Nater et al., 2005), are shown in Figure 2. Music listening was considered as being important for subjects of both groups (music group: *M* = 4.37, *SD* = 0.79, control group: *M* = 4.22, *SD* = 1.01). The most preferred music genres within the total sample were Pop (*M* = 3.75, *SD* = 1.16), Rock (*M* = 3.64, *SD* = 1.30), and Soul/Funk (*M* = 3.47, *SD* = 1.23). Preferences for Latin and folk music were significantly higher in the control group compared to the music group.

Randomization led to an allocation of 27 participants to the experimental group and 27 subjects to the control condition. To assess the randomized assignment to groups, demographic variables (age, BMI, educational level) and means of control variables (BDI, SSCS, PSRS, PSS) were compared between the groups. No significant differences were found among the groups for any of the variables (see Table 1).

Table 1

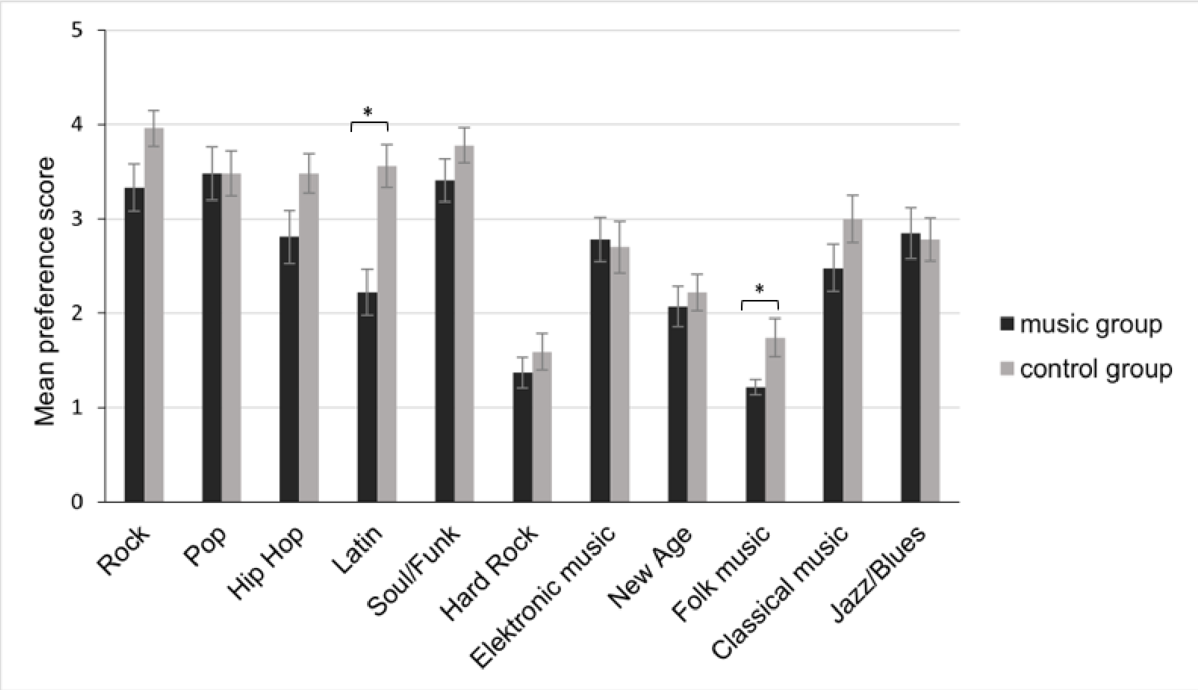
Psychometric characteristics of the study sample

Characteristic	**MG (*n*=27)**	**CG (*n*=27)**	**p-value**
Age (years, mean ± SD; range)	23.4 ± 3.5; 18-30	24.1 ± 2.3; 20-29	0.41
Nationality (*n*, %)			0.09
Austria	19 (70.4%)	13 (48.1%)	
Germany	6 (22.2%)	6 (22.2%)	
Other	2 (7.4%)	8 (29.6%)	
Highest educational level (n, %)			0.84
Advanced technical college entrance qualification	2 (7.4%)	1 (3.7%)	
High-school diploma	23 (85.2%)	24 (88.9%)	
Other graduation	2 (7.4%)	2 (7.4%)	
BMI (kg/m^2, mean ± SD; range)	21.4 ± 2.2; 18.1-26.8	21.4 ± 1.9; 17.7-24.6	0.89
BDI (mean ± SD; range)	7.3 ± 5.5; 0-26	8.5 ± 7.9; 0-26	0.53
SSCS (mean ± SD; range)	35.1 ± 7.2; 23-53	34.0 ± 6.9; 20-50	0.59
PSRS (mean ± SD; range)	21.3 ± 3.8; 15-30	21.9 ± 4.4; 12-28	0.62
PSS (mean ± SD; range)	31.5 ± 2.5; 27-39	32.4 ± 3.4; 26-39	0.24

Note. n = valid cases, MG = music group, CG = control group, BMI = Body mass index, BDI = Beck Depression Inventory, SSCS = Screening Scale for Chronic Stress, PSRS = Perceived Stress Reactivity Scale, PSS = Perceived Stress Scale

Figure 2

Mean preference scores for music genres, for each experimental condition separately



Note. Error bars represent standard error of the mean. * $p < .05$

Main Results

Subjective stress level

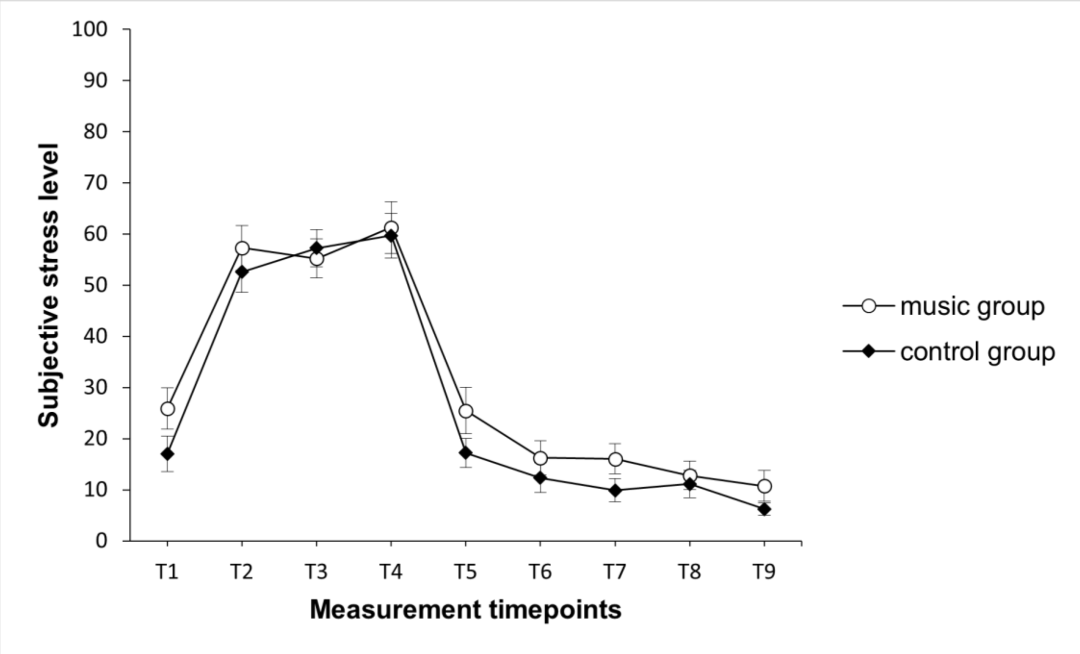
Baseline subjective stress levels did not differ significantly between the two conditions (Mann-Whitney-U-Test: $U = 259.50$, $Z = -1.818$, $p = .07$). This shows that the groups were equally stressed at baseline.

Figure 3 shows the changes over time of the subjective perception of stress (VAS) during the course of the experiment. Results of a Friedman-test showed that mean subjective stress levels differed statistically significantly between measurement timepoints ($X^2(8) = 284.04$, $p < .001$). Bonferroni-adjusted post-hoc analysis was conducted to compare stress levels between measurement timepoints of interest. The analysis showed that subjective stress levels increased significantly from baseline (T1) to post-stress induction (T4). This indicates that the psychological stress protocol had a significant impact on participants' levels of self-reported stress ($z = -3.48$, $p < .001$, $r = .47$). Subsequently, perceived stress levels decreased significantly from the peak right after the TSST (T4) to the end of the recovery period (T9) ($z = 5.69$, $p < .001$, $r =$

.77). Subjective stress levels at the end of the experiment were significantly lower than at baseline (z = 2.213, p = .001, r = 0.30).

Figure 3

Course of the subjective stress levels (VAS)

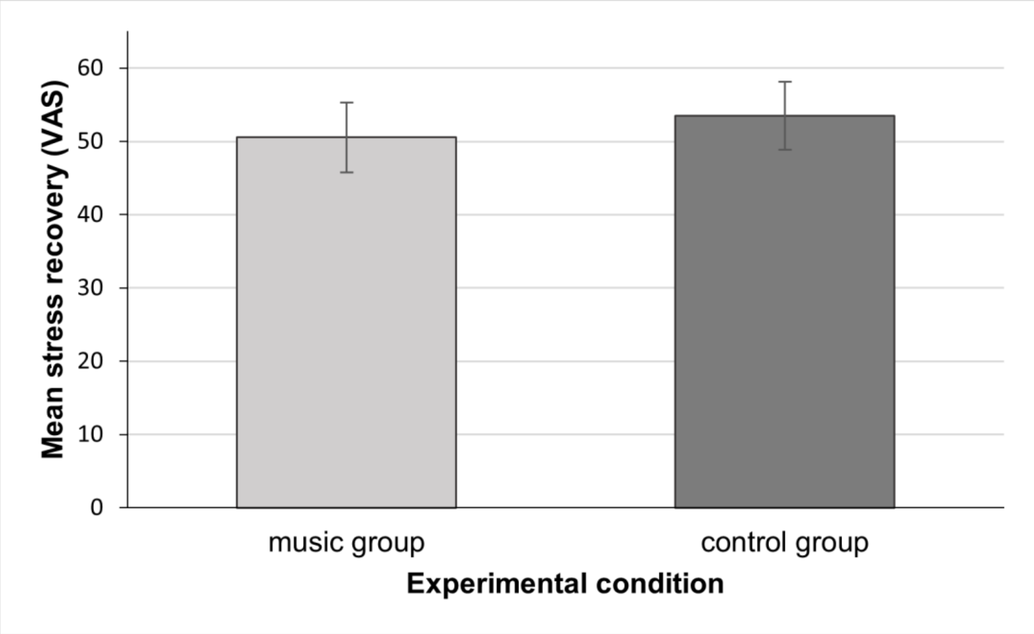


Note. Error bars represent standard error of the mean.

To test whether participants that listened to music after the stressor perceived a greater reduction of subjective stress levels compared to participants who did not listen to music, a t-test for independent samples was performed. Results of the t-test revealed that the perceived stress recovery (ΔVAS) did not differ significantly between groups (t (52) = 0.785, p = .66). Figure 4 displays the average recovery of subjective stress levels from T4 to T9, for each experimental condition separately.

Figure 4

Mean subjective stress recovery



Note. Error bars represent standard error of the mean.

Given their predictive power in the previous studies (Thoma et al., 2013), chronic stress and depression were entered as covariates. Therefore, an additional one-factorial covariance analysis (ANCOVA) was performed. After adjusting for chronic stress and depression as possible cofounding variables, still no significant differences in stress recovery could be found between the groups ($F(1, 50) = 0.284$, $p = .59$, partial $\eta^2 = .006$).

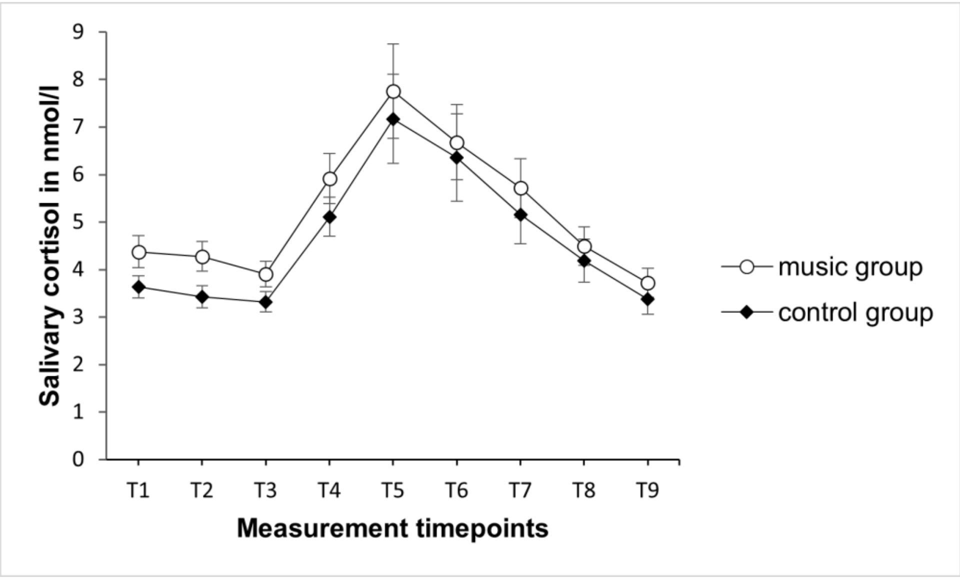
Salivary cortisol

Cortisol values were temporarily z-transformed to facilitate the identification of outliers. One subject of the control group was excluded from further analysis due to cortisol levels that deviated more than three standard deviations from the mean. As raw cortisol values were not normally distributed (Shapiro-Wilk test: $ps < .05$ for 6 of 9 measurement timepoints) and positively skewed (skewness: 0.61-1.17), a base 10 logarithmic transformation was applied. The logarithmic transformation led to a normal distribution of cortisol values. All subsequent analyses were performed using the logtransformed cortisol values. For comprehensibility and better comparability with the values in other studies, only untransformed data are presented in figures and tables.

Baseline salivary cortisol concentrations did not differ significantly between the two groups (T (51) = 1.251, p = 0.22). A repeated measures ANOVA with a Greenhouse-Geisser correction indicated that mean salivary cortisol levels showed a statistically significant difference between measurements, F(1.411, 71.948) = 25.316, p < .001, partial η^2 = .33. One subject of the control group was excluded from this analysis due to an insufficient amount of saliva at T3. Bonferroni-adjusted post-hoc analysis revealed a significant increase in salivary cortisol levels in response to the TSST compared to pre-stressor baseline levels (M_{Diff} = -.21, SE = 0.04, 95%-CI [-.35, -.07], p < .001). This demonstrates that the acute laboratory-induced psychological stressor was found to induce considerable changes in the concentrations of cortisol. Salivary cortisol levels were highest at timepoint 5 (i.e., about 15 minutes after the end of the stress test) and thereafter decreased gradually until the last timepoint of the recovery period (all ps < .001). Cortisol responsiveness to the stressor did not differ significantly between groups (p = .83). Salivary cortisol levels returned to baseline at the end of the recovery period (p = .76). The course of salivary cortisol levels throughout the experiment is displayed in Figure 5.

Figure 5

Course of salivary cortisol levels



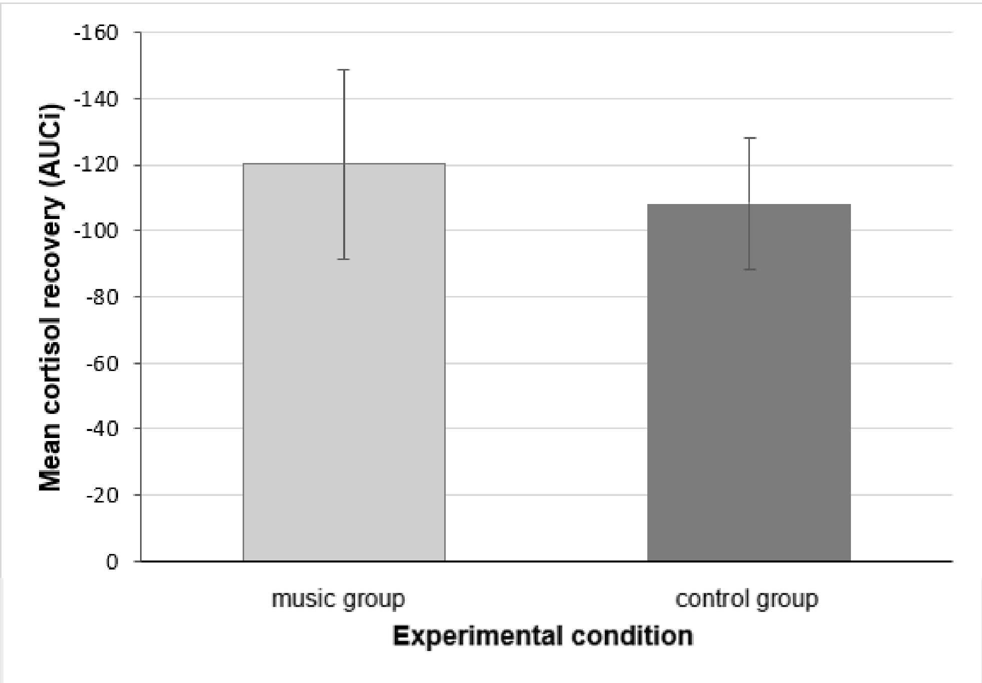
Note. Error bars represent standard error of the mean.

In order to examine whether participants that listened to music after the stressor had a higher reduction in salivary cortisol concentration compared to participants who did not listen to music, a t-test for independent samples with the AUCi as a dependent variable was computed. Results of the t-test did not reveal any significant differences in AUCi between groups ($T(51) = .378$, $p = .71$) (see Figure 6).

To control for the influence of baseline salivary cortisol levels as well as depression, an additional one-factorial covariance analysis (ANCOVA) has been performed. After adjusting for baseline salivary cortisol levels and depression as possible cofounding variables, still no significant differences in AUCi could be found between the groups ($F(1, 49) = .240$, $p = .63$, partial $\eta^2 = .005$).

Figure 6

Mean salivary cortisol decrease (AUCi)



Note. Error bars represent standard error of the mean.

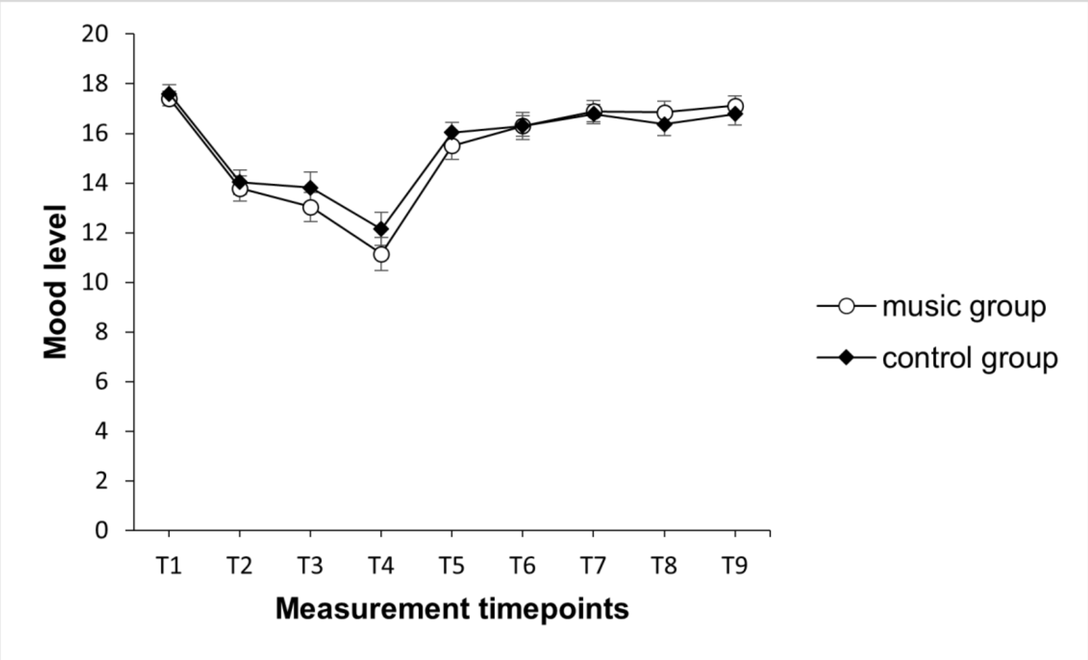
Mood

For the dimension “bad versus good mood” of the MDBF, baseline values did not differ significantly between the groups (Mann-Whitney-U-Test: U = 323.00, Z = -.734, p = .46).

Mean mood levels changed significantly over time in the total group, as assessed by a Friedman-test ($X^2(8) = 213.332$, $p < .001$). Bonferroni-adjusted post-hoc analyses showed a significant decrease in mood in response to the TSST (T4) compared to baseline levels (T1) (z = 5.33, p < 001, r = .73). That is, stress exposure significantly affected participants’ moods. Mood improved significantly from the first measurement post-stressor (T4) to the last time point of the recovery period (T9) (z = -4.623, p < .001, r = .63). The mean mood changes over time are illustrated for each group separately in Figure 7.

Figure 7

Course of the mood levels (MDBF)

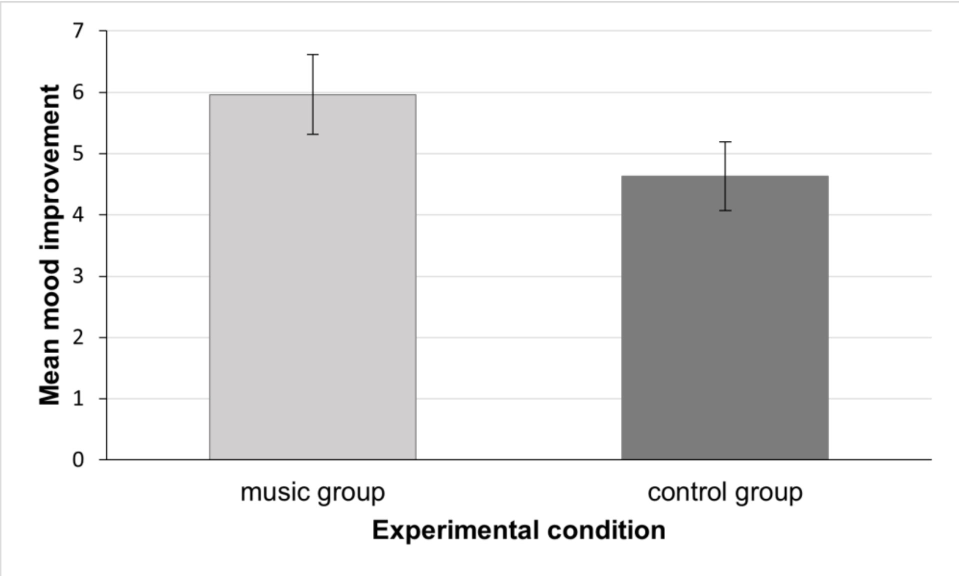


Note. Error bars represent standard error of the mean.

In order to answer the second hypothesis, we checked for differences in mood improvement after stress induction between groups. Exploratory analysis revealed that the Δmood data of the control group was not normally distributed (Shapiro-Wilk test: p = .02). Therefore, a Mann-Whitney-U-Test was computed. Results revealed that the perceived mood improvement (Δmood) in the aftermath of the stress test did not differ significantly between groups (U = 299.50, Z = -1.132, p = .26) (see figure 8).

Figure 8

Mean mood improvement



Note. Error bars represent standard error of the mean.

To control for the influence of chronic stress and depression, an additional one-factorial covariance analysis (ANCOVA) has been computed. The residuals of the control group were not normally distributed (Shapiro-Wilk test: p = .01). Therefore, bootstrapping with 1000 replications was used to generate more precise standard errors. After adjusting for chronic stress and depression as possible cofounding variables, differences in mood improvement between the groups remained non-significant (F(1, 50) = 2.363, p = .13).

Correlation analysis

To test the third hypothesis, a Spearman correlation was computed to investigate the relationship between subjective and physiological stress recovery and mood improvement. The analysis revealed that the correlation between recovery of subjective stress levels (ΔVAS) and salivary cortisol reduction (AUCi) was not significant (p = .67, Spearman's ρ = .06). Neither was the correlation between salivary cortisol reduction (AUCi) and mood improvement (Δmood) (p = .43, Spearman's ρ = -.11). However, mood improvement and recovery of subjective stress level did correlate strongly (Spearman's ρ = .63, p < .001). That is, the greater the participants' reduction in subjective stress levels during the recovery period post-stressor, the higher their mood improvement. These results only partly support the hypothesis of an interrelation between these three variables (see Table 2).

Table 2

Correlation between recovery values of mood, subjective stress level, and salivary cortisol concentration

			Δmood	Δstress	AUCi cortisol
Spearman-Rho	Δmood	Correlation coefficient	1.000	.632**	-.110
		Sig. (2-tailed)	.	.000	.431
	Δstress	Correlation coefficient	.632**	1.000	.060
		Sig. (2-tailed)	.000	.	.670
	AUCi cortisol	Correlation coefficient	-.110	.060	1.000
		Sig. (2-tailed)	.431	.670	.

Note. ** p < .001

Discussion

The aim of the present master's thesis was to investigate the effects of relaxing music on subjective stress level, biological stress responses, and mood. For this purpose, all subjects were first exposed to a standardized laboratory stressor. The analyses revealed that the stress protocol led to psychophysiological changes in the subjects, which were reflected in a significant increase in salivary cortisol concentration, self-reported stress levels, and negative mood. Based on previous research, it was hypothesized that listening to self-selected relaxing music during recovery from the psychosocial stress test would lead to a higher reduction in perceived stress levels and salivary cortisol concentration and better mood improvement than sitting in silence. Furthermore, a positive correlation between subjective stress levels and salivary cortisol concentration, as well as a negative correlation between psychophysiological stress measures and mood were expected.

First, music listening as well as sitting in silence decreased psychological stress levels as well as salivary cortisol concentration. Contrary to expectations, however, the results of the present study did not reveal significant differences in perceived stress recovery or salivary cortisol recovery between subjects who listened to relaxing music and those who sat in silence. These findings contrast those of previous studies which found that music listening is effective in reducing stress psychologically (e.g., Sandstrom & Russo, 2010) as well as physiologically (e.g., Khalfa et al., 2003). The non-significant results of this study on the effects of music on salivary cortisol levels reflect the inconclusive and insufficient body of evidence, with some studies suggesting positive effects of music listening on cortisol concentrations (Ilie & Rehana, 2013; Khalfa et al., 2003) and others finding no effects (Yamamoto et al., 2007). Consequently, the question about the impact of music listening on stress-induced salivary cortisol responses remains unanswered.

One possible explanation for the conflicting findings might be some methodological differences between the studies. For example, the studies used distinct musical stimuli to examine the stress-reducing effects of music (e.g., de la Torre-Luque et al., 2017; Sandstrom & Russo, 2010). Furthermore, different types of stressors were used for stress induction (e.g., Burns et al., 2002; Jiang et al., 2013; Labbé et al., 2007). Moreover, different measures were used to operationalize subjective stress (e.g., Sokhadze, 2007). In the present study, subjective stress levels were assessed with a single-item measure. Although this item has been shown to efficiently assess subjective stress (Elo et al., 2003; Lesage et al., 2012), a more extensive measuring instrument might provide more reliable results (Linnemann et al., 2015). Together, these methodological differences may account for the inconclusive results.

Furthermore, the sample of the current study reported high levels of perceived stress within the month prior to the study. This may also partly explain the non-significant results, as previous studies have suggested that music listening might be less effective in reducing stress in the presence of intensive or chronic stress (Fancourt et al., 2014; Thoma et al., 2013).

Another possible explanation for the non-significant differences between groups might be that sitting in silence, which was used as a control condition in this study, is also an effective method for stress reduction. In a study by Burns et al. (2002), sitting in silence has been shown to be even more effective in increasing relaxation and reducing anxiety than listening to music. Thus, both experimental conditions used in this study seem to be potential stress-reducing methods.

With regard to self-reported mood change following the stressor, no significant differences were found between the music and the control condition. Mood improved significantly after the intervention in both groups. The lack of superiority of the effects of music listening on mood over to those of sitting in silence could be explained by the findings of a study by McFerran et al. (2015), who found that listening to music was less effective at regulating mood when people felt stressed. The results are, however, inconsistent with other previous studies that support the effect of relaxing music on mood improvement after acute stress induction (Fallon et al., 2020; Groarke & Hogan, 2019; Ilie & Rehana, 2013). One possible explanation for this discrepancy between the studies may be the different scales that have been used to measure mood. In the present thesis, mood was assessed on a two-dimensional scale ranging from bad to good mood. By summarizing the values of the single items to one single dimension, information might have been lost. Thus, independent evaluations of the individual items may have provided further information.

Furthermore, the results of the present study only partly support the hypothesis of an interrelation between self-report measures of stress and mood and salivary cortisol concentration. In accordance with the hypothesis, the degree of change in subjective stress level paralleled that of mood, with a highly significant positive correlation between mood improvement and subjective stress recovery. That is, the greater the participants' subjective stress reduction during the post-stressor recovery period was, the greater their mood improvement. However, other than anticipated, salivary cortisol levels did not correlate significantly with either subjective measure. This finding is inconsistent with previous studies which found positive correlations between cortisol and subjective stress (Helsing et al., 2016) as well as negative correlations between cortisol and mood (Ilie & Rehana, 2013; McKinney et al., 1997). Other studies, on the other hand, found no association between salivary cortisol and subjective stress level, therefore suggesting a certain degree of independence between these subjective and physiological stress outcomes (Feneberg et al., 2021;

Linnemann et al., 2015; Ruiz Gallo et al., 2016). One potential reason that the correlations between self-report measures of stress and mood and salivary cortisol were not significant in the present study might be the different temporally specific patterns of the variables. While subjective measures seem to have a more immediate response, stress-induced changes in biological stress measures such as salivary cortisol occur with a time delay (Feneberg & Nater, 2020). Although the time delay in cortisol response has been taken into account in the present study, it is recommended for future studies to examine in more detail the complex and temporal dynamics of the individual stress recovery outcomes.

In addition, the way the recovery values were calculated in the present study may have contributed to the non-significant correlations. While all values of the recovery period were used for the calculation of the recovery value of salivary cortisol concentration, the recovery values of subjective stress and mood were obtained by subtracting the post-recovery values from the post-stress values. Although this approach is generally reasonable, it may oversimplify the intricate changes that might occur during stress recovery and disregard important information.

Limitations and Implications for Future Research

There are some limitations to the present study that need to be mentioned. First, the study sample was relatively homogenous. Generally, the study had very strict inclusion and exclusion criteria, which, on the one hand, improves internal validity by controlling for a number of potential confounding variables, but on the other hand limits the generalizability of the findings beyond this particular population (de la Torre-Luque et al., 2017; Peck et al., 2021; Thoma et al., 2013). Therefore, future investigations should include a more diverse sample to allow more general conclusions.

Furthermore, the artificial setting of the present laboratory-based study limits the generalizability of the findings to everyday life. Although experimental studies are essential for drawing causal inferences about the effects of relaxing music on stress and mood, future studies should also assess the role of music listening on stress and mood in natural situations to increase ecological validity of the data.

Another potential point of criticism is that self-selected music, which has been examined in this thesis, likely varies among individuals in terms of its musical properties such as tempo, rhythm, or genre, and there might be different conceptions about what kind of music is relaxing. Therefore, future studies should control for musical properties and possible mediators and compare self-selected to experimenter-selected music in order to determine the most effective music characteristics for stress reduction and mood improvement.

Another aspect that should be considered is that the study took place during the Covid-19 pandemic. It has been shown that the prevalence of mental health problems like depression, anxiety, impaired mood and stress in the general population was elevated during the COVID-19 pandemic (Hendriksen et al., 2021; Lakhan et al., 2020; Mahmud et al., 2022; Xiong et al., 2020), which might have affected the baseline levels and results in the present study. Furthermore, due to safety measures related to the pandemic, the participants and the experimenter wore a face mask throughout most of the experiment. This could also have impacted the participants' reactions to the stressful situation, as they were unable to observe any facial expressions from the experimenter. Moreover, it is possible that individuals who volunteered to participate in the study despite the lockdown share certain traits, which might have led to a selection bias.

To sum up, future studies should consider the limitations of this study in order to help answer more generalizable questions about the interaction between relaxing music, stress, and mood.

Conclusion

In conclusion, the results of this work do not sufficiently support the assumption that listening to self-selected relaxing music after stress induction is a successful instrument for reducing subjective and physiological stress levels and improving mood. As expected, a highly significant positive correlation between mood improvement and subjective stress recovery was found. However, other than anticipated, salivary cortisol concentration did not correlate significantly with either subjective measure. Future studies should therefore address the questions that could not be fully answered in this study to provide generalizable findings on the effects of music listening on stress and mood and the relationship between subjective and physiological factors.

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Appendix A: Recruitment Flyer

universität wien

Music & Health Lab

Studienteilnehmerinnen gesucht

Stress und Erholung

40 €
Aufwands-entschädigung

Für eine psychologische Stress-Studie suchen wir gesunde, weibliche Teilnehmerinnen. Die Studie untersucht verschiedene Einflussfaktoren auf die Wirkung von Stress.

Um an der Studie teilnehmen zu können, sollten folgende Kriterien auf Sie zutreffen:

- weiblich, 20–30 Jahre
- keine hormonelle Verhütung, regelmäßiger Zyklus
- kein regelmäßiger Nikotinkonsum
- kein Unter- oder Übergewicht, keine körperlichen und psychischen Erkrankungen
- Deutsche Muttersprache oder fließende Deutschkenntnisse

Aufwand und Aufwandentschädigung

- Online-Fragebogen (Dauer: ca. 20 Minuten) und ein Termin am Campus-Vienna-Biocenter 5, 1030 Wien (Dauer: ca. 2,5 Stunden; Ort: Campus-Vienna-Biocenter 5, 1030 Wien)
- Ausfüllen von Fragenbögen zu Stress und Befinden
- Abgabe von Speichelproben für Messung von Stressmarkern
- Messungen an der Haut
- Aufwandsentschädigung von 40 €

Sollten Sie Interesse haben, senden Sie bitte eine E-Mail mit dem Betreff *„Stress und Erholung"* an:

recoverym99@univie.ac.at

Sie bekommen dann weitere Informationen per E-Mail zugesendet.

Projektleitung: Univ.-Prof. Dr. Urs Nater (urs.nater@univie.ac.at)
Yichen Song (yichen.song@univie.ac.at)
Universität Wien – Fakultät für Psychologie – Klinische Psychologie des Erwachsenenalters – Music & Health Lab

Appendix B: Telephone Interview

Telefoninterview Leitfaden: Studie „Stress und Erholung“

Guten Tag, ich heiße [Name des Interviewers]. Könnte ich bitte mit <Name> sprechen?

[Falls ja]: Ich bin MitarbeiterIn der Abteilung für Klinische Psychologie der Universität Wien, Sie haben sich interessiert, an einer Studie zum Thema „Stress und Erholung“ teilzunehmen. Im Zuge dessen würde ich Ihnen gern einige Fragen stellen.

Bevor wir anfangen, möchte ich Ihnen noch einige Informationen geben. Ich lese Ihnen jetzt eine standardisierte Einleitung zur Studie vor. Das Interview wird ca. 10-20 Minuten Zeit in Anspruch nehmen [falls die Teilnehmerin gerade keine Zeit hat, einen anderen Termin vereinbaren]. Die an Sie gestellten Fragen werden sich inhaltlich auf Ihre Person, Ihre Gesundheit und medizinische Informationen konzentrieren. Ihre Angaben werden selbstverständlich vertraulich behandelt. Die hier gesammelten Daten werden ausschließlich von Mitarbeitern der Studie bearbeitet. Sie können jederzeit entscheiden, bestimmte Fragen nicht zu beantworten oder das Interview abzubrechen. Dieses Interview soll uns helfen zu entscheiden, ob Sie eine geeignete Kandidatin für die Studie sind. Wenn Sie alle Kriterien erfüllen, werden wir im Anschluss an das Interview einen weiteren Termin vereinbaren.

Wenn Sie noch weitere Fragen bezüglich Ihrer Rechte in dieser Studie haben, kann ich Ihnen gerne die Nummer des verantwortlichen Projektleiters geben, Prof. Dr. Urs Nater. Auch wenn Sie insgesamt noch weitere Fragen zu der Studie haben, können Sie Prof. Urs Nater an der Abteilung für Klinische Psychologie anrufen. Die Nummer kann ich Ihnen auch zukommen lassen.

(Univ. Prof. Dr. Urs Nater: +43 (1) 4277/47220)

INTERVIEWER: Haben Sie die Instruktionen verstanden? [bestätigen]

JA: [weitermachen]

NEIN: [die Instruktionen erneut vorlesen]

Sind Sie damit einverstanden, an diesem Interview teilzunehmen?

JA: [weitermachen]

NEIN: [Ausschluss – Screening beenden]

Interviewer [Kürzel] ______________________

Screening-Code für Telefoninterview [Kürzel_Datum_Nr] ____________________________________

Wie sind sie auf die Studie aufmerksam geworden?

____

Welches **Geschlecht** haben Sie?

□ weiblich

□ männlich [Ausschluss] □ anderes: ________ [Ausschluss]

Ausschluss anderes Geschlecht:

Vielen Dank für Ihre Antwort.
Wir sind uns bewusst, dass Geschlecht ein dimensionales Konstrukt ist. Da wir jedoch im Rahmen unserer Studie biologische Daten erheben, die durch Geschlechtshormone beeinflusst werden, ist es fü unsere Studie unabdingbar, dass sich die Interessentinnen und Interessenten eindeutig einem biologischen Geschlecht zuordnen. Anderenfalls sind die biologischen Daten für uns nicht auswertbar. Daher bitten wir um Ihr Verständnis, dass Sie die Kriterien für den Studieneinschluss nicht erfüllen und keine weiteren Termine auf Sie zukommen werden.
Falls Sie noch irgendwelche Fragen haben, können Sie uns gerne kontaktieren.
Vielen Dank!

Wie **alt** sind Sie?

_____ (Einschluss 20-30 Jahre)

Wann ist Ihr Geburtsdatum?

____

BMI: Wieviel wiegen Sie und wie groß sind Sie?

Größe _________ cm

Gewicht _________ kg

BMI = Gewicht/Größe² (Einschluss 18-25)

BMI in Rekrutierung.xlxs im Reiter „BMI" berechnen

Sind Sie **schwanger oder stillen** Sie derzeit?

□ Nein

□ Ja [Ausschluss]

Sind Sie **professionelle Musikerin**, **studieren Sie Musik** bzw. Musikwissenschaften, oder beschäftigen Sie sich ansonsten **beruflich mit Musik** (z.B. Tontechnikerin, Verkäuferin in Instrumentengeschäft, Musiklehrerin)?

□ Nein

□ Ja [Ausschluss]

Haben Sie ein **absolutes Gehör**?

□ Nein

□ Ja [Ausschluss]

Rauchen Sie?

□ Nein

□ Ja, nur am Wochenende, Party-/Gelegenheitsraucher?
→ solange nicht zu regelmäßig → nächste Frage

□ Ja, regelmäßig [Ausschluss]

Können Sie dreieinhalb Stunden nicht rauchen, ohne dass Sie Entzugserscheinungen oder starkes Verlangen nach einer Zigarette verspüren?

□ Ja

□ Nein [Ausschluss]

Trinken Sie regelmäßig **Alkohol**? (Substanzmissbrauch innerhalb der letzten 2 Jahren regelmäßiger bzw. übermäßiger Konsum [♀≥8]) 1 = kleines Getränk (z.B. 0,33l Bier oder 1/8 Wein)

□ Nein

□ Ja, Substanzmissbrauch > 2 Jahre; < 8 Getränke

(1 = kleines Getränk (z.B. 0,33l Bier oder 1/8 Wein)

□ Ja, Substanzmissbrauch < 2 Jahre; ≥ 8 Getränke [Ausschluss]

Nehmen Sie **Drogen oder psychoaktive Substanzen** (z.B. Amphetamine, MDMA, Barbiturate, Cannabinoide, Benzodiazepine, Kokain, Opiate)?

□ Nein

□ Ja, Cannabis > 2 Wochen und Andere > 1 Jahr

□ Ja, Cannabis < 2 Wochen und oder Andere < 1 Jahr [Ausschluss]

Nehmen Sie **regelmäßig Medikamente**?

(UNSICHER: Bitte bringen Sie Ihre Medikamente zum Telefon und lesen Sie sie mir vor)

□ Nein

□ Ja, Psychopharmaka > 2 Wochen

□ Ja, Psychopharmaka [Ausschluss]

□ Ja, Herz-Medikamente (z.B. Betablocker) [Ausschluss]

□ Ja, immunosuppressive Medikamente (z.B. Prednison) [Ausschluss}

□ Ja, nämlich ________________________ (Abklären) → [Ausschluss?]

Nehmen Sie **regelmäßig Medikamente**, die einen Einfluss auf den Hormonhaushalt haben, oder auch hormonhaltige Kontrazeptiva, wie z.B. die Pille?

(UNSICHER: Bitte bringen Sie Ihre Medikamente zum Telefon und lesen Sie sie mir vor)

□ Nein

□ Ja, Hormonelle Kontrazeptiva (z.B. "Pille") → [Ausschluss]

□ Ja, nämlich ________________________ (Abklären) → [Ausschluss?]

Ist Ihre Periode in etwa regelmäßig / mehr oder weniger regelmäßig?

□ Ja

□ Nein, starke Schwankungen [Ausschluss]

→ Kennen Sie den Grund Ihrer unregelmäßigen Periode?

□ Nein

□ Unsicher

□ Ja, welcher Grund: ________________

Sind Sie zurzeit gesund (keine Grippe, Erkältung)?

□ Nein [Ausschluss]

□ Ja

Leiden Sie an einer **chronischen körperlichen Erkrankung**?

□ Nein

□ Ja, nämlich _______________ (Abklären) → [Ausschluss ?]

→ Liste auf nachfolgender Seite vorlesen und ankreuzen.

Krankheiten-Liste:

Nein	Ja	
□	□	**Schädigungen des Gehörs** (Bsp.: Hörbeeinträchtigung oder chronischer Tinnitus)
□	□	**Chronische oder akute entzündliche Hauterkrankungen**
□	□	**Allergien/Überempfindlichkeitsreaktionen** (Medikamente, Pflaster, Latexhandschuhe, Heuschnupfen, Gräser, Pollen)
□	□	**Herzerkrankungen** (Bsp.: koronare Herzerkrankung, Angina pectoris, Herzinfarkt, Herzrhythmusstörungen, Herzfehler, Herzinsuffizienz)
□	□	**Lungen- und Atemwegserkrankungen** (Bsp.: Lungenentzündung, Asthma, chronische Bronchitis, Tuberkulose)
□	□	**Lebererkrankungen** (Bsp.: Hepatitis, Gelbsucht, Leberverfettung)
□	□	**Bluthochdruck oder extrem niedriger Blutdruck**
□	□	**Chronischer Schmerz**
□	□	**Nieren- und Harnwegserkrankungen** (Nieren-/Nierenbeckenentzündung, Nieren-/Blasensteine)
□	□	**Stoffwechselerkrankungen** (Bsp.: Diabetes mellitus, Hypercholesterinämie, Hyperuricämie)
□	□	**Erkrankungen des Verdauungstraktes** (Bsp.: Magenerkrankungen, chronische Darmerkrankungen)
□	□	**Neurologische Erkrankungen**
□	□	**Infektionserkrankungen** (Bsp: HIV, Hep., TBC)
□	□	**Schilddrüsenerkrankungen**
□	□	**Autoimmunerkrankungen** (Bsp: Rheumatische E., Gastritis A, Neurodermitis, Schilddrüsen, MS)
□	□	**Erkrankungen des Skelettsystems/ Muskelerkrankungen**
□	□	**Bluterkrankungen** (Bsp.: entstehen blaue Flecken auch ohne besonderen Anlass, Anämie)
□	□	**Tropenaufenthalt die letzten 6 Monate**
□	□	**Impfungen die letzten 2 Wochen**
□	□	**(Zahn-)OPs in den letzten 8 Wochen** (Narkose, Art des Eingriffs, ausstehende Heilung)
□	□	**Sonstige Besonderheiten** (Bsp.: Hauterkrankungen, Tumorerkrankungen, Hirnhautentzündung, Unfall)

Sind Sie **blind** oder in Ihrer **Sehfähigkeit** stark eingeschränkt?

(Anmerkung: starke Einschränkung, die nicht durch eine Brille/Kontaktlinsen behebbar ist)

(Anmerkung: eventuell abklären, ob Sehkraft soweit erhalten ist, dass ein selbständiges Ausfüllen der Fragebögen problemlos möglich ist UND Seh-Einschränkung nicht ab der Kindheit bestehen, da Gehör vermutlich dann besser geschult)

□ Nein

□ Ja, blind / wesentlich eingeschränkt [Ausschluss]

□ Unsicher (im Team besprechen), Grund: ____

Leiden Sie aktuell unter einer diagnostizierten **psychischen Störung**?

□ Nein

□ Ja, aktuelle Major Depression oder Angststörung [Ausschluss]

□ Ja, aktuelle Essstörung (innerhalb der letzten 5 Jahre) [Ausschluss]

□ Ja, Psychose/Schizophrenie [Ausschluss]

□ Ja, andere: ______________________________ [Ausschluss?]

Waren Sie jemals in **psychotherapeutischer Behandlung**?

□ Nein

□ Ja

→ Warum und wann wurden Sie behandelt?

□ Major Depression oder Angststörung [Ausschluss]

□ Ein anderes psychologisches Problem, bitte beschreiben (falls unsicher, im Team abklären):

____

Sprachkenntnisse: Nachfragen, falls nicht offensichtlich, dass Deutsch beherrscht wird.

Ist Deutsch Ihre Muttersprache / Sprechen sie flüssig Deutsch?

□ Ja

□ Nein [Ausschluss]

Vorerfahrung mit Stresstests

Haben Sie Vorerfahrungen mit Stresstests (z.B. Studium/Vorlesung, Studienteilnahme)?

□ Nein

□ Ja

Falls „Ja", bitte beschreiben Sie die Stressaufgabe. Wie sah diese Aufgabe aus?

□ TSST [Ausschluss]

□ andere Stressaufgabe

Kennen Sie jemanden, der/die bei der Studie mitwirkt? Wenn ja, wen?

____

Finale Entscheidung:

□ Einschluss

□ Ausschluss

Bei Ausschluss: Dürfen wir Sie ggf. noch einmal einladen?

□ Ja

□ Nein

Bei Eignung und Einverständnis zur Teilnahme seitens des Probanden:

Movisens/ Brustgurt:

Es folgen nun noch ein paar Informationen und Fragen zum Ablauf der Testung. Im Rahmen der Studie werden wir Sie bitten, Fragebögen auszufüllen und Speichelproben zu sammeln, um darin biologische Maße wie das Stresshormon Cortisol zu bestimmen. Außerdem möchten wir Ihre Herzfrequenz erfassen und würden Sie daher bitten, für die Zeit der Testung einen Brustgurt zu tragen. **Dafür müssten Sie kurz Ihr T-Shirt anheben. Ist dies für Sie in Ordnung?** Ist es außerdem in Ordnung, **dass die Versuchsleitung, welche weiblich ist, Ihnen diesen Brustgurt anlegt**?

□ Ja □ Nein

Terminvereinbarung

Für diese Studie ist es wichtig, dass die Testung in einem bestimmten Zeitraum des Menstruationszyklus stattfindet, der Follikelphase. Optimaler Weise in der zweiten Hälfte der Follikelphase, welche 4-7 Tage nach der Menstruation beginnt. Um diesbezüglich einen Termin für die Testung zu vereinbaren, brauchte Ich noch folgende Angaben:

Durchschnittliche Zykluslänge ________ Tage

Durchschnittliche Menstruationslänge ___________ Tage

Zeitpunkt des letzten Menstruationsbeginns _______________ (Datum)

Zeitraum in File „Menstrual cycle – Testzeitraumkalkulator.xls"" berechnen

→ Möglicher Zeitraum von ____________ bis ____________

Entscheidung über Einschluss:

1. Einschluss (Accept):

Vielen Dank! Wenn Sie möchten, können wir uns direkt einen Termin ausmachen.

- Sie bekommen von mir jetzt noch eine Mail mit Informationen über das weitere Vorgehen. Ich bitte Sie diese Mail sorgfältig zu lesen und auf die Anweisungen genau zu achten. Sie werden unter anderem gebeten einen Online-Fragebogen auszufüllen und eine Musikliste anzufertigen. Außerdem wird ein Termin enthalten sein, an dem die Studie stattfinden soll.
- Zu Ihrer und unserer Sicherheit bitten wir Sie, einen negativen Corona/Covid-19 Test, der nicht älter als 48 Stunden ist, zur Testung mitzubringen. Sollte es Ihnen nicht möglich sein, in diesem Zeitraum einen Test zu machen, bitten wir Sie uns zu kontaktieren.

Wenn Sie die Mail erhalten haben, lassen Sie uns bitte wissen, ob Sie den Termin akzeptieren.

Sollten Sie in den nächsten 3 Tagen keine Mail von uns erhalten, bitten wir Sie uns zu kontaktieren.

2. Ausschluss (Reject):

Wir haben im Moment sehr strenge Ausschluss-Kriterien. Sie gehören leider nicht zu unserer benötigten Zielgruppe. Falls sich das ändern sollte, dürften wir uns erneut bei Ihnen melden? Trotzdem vielen Dank für Ihr Interesse, haben Sie noch Fragen?

3. noch Ausstehend (Pending):

Vielen Dank für Ihr Interesse. Ich werde mit meinem Team besprechen, ob Sie eine geeignete Kandidatin für unsere Studie sind und mich in Kürze bei Ihnen melden.

Appendix C: Visual Analogue Scale (VAS)

Wie sehr fühlen Sie sich gestresst?

0 gar nicht — 100 sehr stark

Appendix D: Mehrdimensionaler Befindlichkeitsfragebogen (MDBF)

Im Moment fühle ich mich...

	überhaupt nicht				sehr
entspannt	☐	☐	☐	☐	☐
gelassen	☐	☐	☐	☐	☐
gut	☐	☐	☐	☐	☐
ruhelos	☐	☐	☐	☐	☐
zufrieden	☐	☐	☐	☐	☐
schlecht	☐	☐	☐	☐	☐
müde	☐	☐	☐	☐	☐
schlapp	☐	☐	☐	☐	☐
ausgeruht	☐	☐	☐	☐	☐
unwohl	☐	☐	☐	☐	☐
munter	☐	☐	☐	☐	☐
unruhig	☐	☐	☐	☐	☐

Appendix E: Informed Consent

TeilnehmerInneninformation und Einwilligungserklärung zur Teilnahme an der Studie:

Stress und Erholung

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer,

wir laden Sie ein, an der oben genannten Studie teilzunehmen.

Ihre Teilnahme an dieser Studie erfolgt freiwillig. Sie können jederzeit, ohne Angabe von Gründen, Ihre Bereitschaft zur Teilnahme ablehnen oder auch im Verlauf der Studie zurückziehen. Die Ablehnung der Teilnahme oder ein vorzeitiges Ausscheiden aus dieser Studie hat keine nachteiligen Folgen für Sie.

Diese Art von Studien ist notwendig, um verlässliche neue *wissenschaftliche* Forschungsergebnisse zu gewinnen. Unverzichtbare Voraussetzung für die Durchführung von Studien ist jedoch, dass Sie Ihr Einverständnis zur Teilnahme an dieser Studie schriftlich erklären. Bitte lesen Sie den folgenden Text sorgfältig durch und zögern Sie nicht, Fragen zu stellen.

Bitte unterschreiben Sie die Einwilligungserklärung nur

- wenn Sie Art und Ablauf der Studie vollständig verstanden haben,
- wenn Sie bereit sind, der Teilnahme zuzustimmen und
- wenn Sie sich über Ihre Rechte als Teilnehmer/in an dieser Studie im Klaren sind.

1. Was ist der Zweck der Studie?

Mit dieser Studie wollen wir verschiedene Einflussfaktoren auf die Wirkung von Stress untersuchen. Um diese Zusammenhänge überprüfen zu können, möchten wir mit Ihnen eine Untersuchung durchführen, die ähnlich wie bei einer Schulprüfung eine körperliche Stressreaktion hervorrufen wird.

2. Wie läuft die Studie ab?

Die Studie wird an der Fakultät für Psychologie der Universität Wien durchgeführt. Für diese Studie würden wir Sie bitten, Fragebögen auszufüllen und an einem Laborexperiment teilzunehmen, welches an der Fakultät für Psychologie stattfindet. Während des Labortermins werden Ihre Atmung und Ihre Herzrate mit Sensoren, die am Körper angebracht werden, gemessen. Zudem werden wir zu neun Zeitpunkten Speichelproben nehmen. Bei der Messung von Atmung und Herzrate sowie der Speichelprobenentnahme handelt es sich um harmlose, nicht-invasive Messungen, welche mit keinerlei Schmerzen verbunden sind. Die Studie wird insgesamt maximal 150 Minuten dauern.

Der Stresstest, der im Labor durchgeführt wird, ist vergleichbar mit einer Schulprüfung in der Sie verschiedene Aufgaben erfüllen müssen. Am Anfang und am Ende der Studie werden wir Sie bitten, ein paar einfache Fragebögen auszufüllen. Am Ende der Studie steht Ihnen der oder die jeweilige VersuchsleiterIn in einem Abschlussgespräch gerne für Fragen zur Verfügung.

Für die Teilnahme an der Studie müssen Sie bestimmte Teilnahmebedingungen erfüllen. Um dies zu klären, würden wir im Vorfeld der Studie ein Telefoninterview mit Ihnen durchführen.

Für unsere Studie suchen wir Personen, die zwischen 20 und 30 Jahre alt sind, weiblich, Deutsch als Muttersprache haben (oder vergleichbares Niveau), und deren BMI zwischen 18 und 25 kg/m² liegt. Leider müssen wir Personen ausschließen, die schwanger sind oder stillen, bestimmte Medikamente zu sich nehmen, regelmäßig rauchen, übermäßig viel Alkohol zu sich nehmen, Drogen nehmen oder an einer schweren körperlichen oder psychischen Erkrankung leiden. Zudem sollten die TeilnehmerInnen keine professionell oder laienhaft ausgebildeten Musiker sein oder regelmäßig Entspannungs- oder Achtsamkeitsübungen durchführen. Die Teilnehmerinnen sollten außerdem einen mehr oder weniger regelmäßigen Zyklus haben.

Da die Testung während einer bestimmten Phase Ihres Menstruationszyklus geplant werden muss, bitten wir Sie, uns Informationen über Ihre letzte Periode und Ihre durchschnittliche Zykluslänge zu geben.

3. Worin liegt der Nutzen einer Teilnahme an der Studie?

Es ist nicht zu erwarten, dass Sie aus Ihrer Teilnahme an dieser Studie einen (bspw. gesundheitli chen) Nutzen ziehen werden. Durch Ihre Teilnahme erhalten Sie einen Einblick in die psychologische Forschung und helfen uns dabei, die Einflüsse von Stress auf soziale Prozesse untersuchen zu können. Die Ergebnisse dieser Studie können dazu beitragen, dass unter Berücksichtigung des potenziellen Nutzens von Stress langfristig neue Diagnose- und Behandlungsstrategien an stressbedingte Störungen angepasst werden können.

4. Gibt es Risiken bei der Durchführung der Studie und ist mit Beschwerden oder anderen Begleiterscheinungen zu rechnen?

Wir gehen davon aus, dass die Durchführung des Stresstests unangenehm für Sie sein kann. Darüber hinaus sind mit der Studie keinerlei Risiken verbunden.

5. Hat die Teilnahme an der Studie sonstige Auswirkungen auf die Lebensführung und welche Verpflichtungen ergeben sich daraus?

Durch die Ausschlusskriterien ergeben sich folgende Anforderungen: Bitte machen Sie 24 Stunden vor der Untersuchung keinen Sport und vermeiden Sie körperlich anstrengende Aktivitäten 10 Stunden vor dem Termin. Auch möchten wir Sie bitten, 24 Stunden vor der Untersuchung auf Kaugummi zu verzichten, da dies die Ergebnisse der Speicheluntersuchungen beeinflussen könnte. Des Weiteren verzichten Sie bitte 18 Stunden vorher auf Alkohol und koffeinhaltige Getränke (z.B. Kaffee, Limonade, Energy Drinks), und mindestens 60 Minuten vor Beginn der Studie sollten Sie auf Essen und Zähneputzen verzichten. Darüber hinaus hat diese Studie keine Auswirkungen auf Ihre Lebensführung.

6. Was ist zu tun beim Auftreten von Beschwerdesymptomen, unerwünschten Begleiterscheinungen und/oder Verletzungen?

Sollten im Verlauf der Studie irgendwelche beschwerlichen Symptome, Begleiterscheinungen, Krankheiten oder Verletzungen auftreten, müssen Sie diese der Versuchsleitung umgehend mitteilen.

Bitte achten Sie zudem auf die Kontaktmöglichkeiten, die unter Punkt 10 angeführt sind.

7. Wann wird die Studie vorzeitig beendet?

Sie können jederzeit, auch ohne Angabe von Gründen, Ihre Teilnahmebereitschaft widerrufen und aus der Studie ausscheiden, ohne dass daraus für Sie irgendwelche Nachteile entstehen.

Es ist aber auch möglich, dass die Versuchsleitung entscheidet, Ihre Teilnahme an der Studie vorzeitig zu beenden, ohne vorher Ihr Einverständnis einzuholen. Die Gründe hierfür können sein:

a) Sie können den Erfordernissen der Studie nicht entsprechen
b) Die Studienleitung hat den Eindruck, dass eine weitere Teilnahme an der Studie nicht in Ihrem Interesse ist

8. In welcher Weise werden die im Rahmen dieser Studie gesammelten Daten verwendet?

Ihre wissenschaftlichen Daten werden zunächst in pseudonymisierter Form elektronisch abgespeichert. Pseudonymisierung bedeutet, dass ein Dokument erstellt wird, das Ihren Namen mit den wissenschaftlichen Daten über einen Code verbindet. Dieses Dokument wird an einem separaten Ort aufbewahrt und ist ausschließlich der Projektleitung zugänglich. Sobald die Datenauswertung abgeschlossen ist, wird dieses Dokument vernichtet. Ab diesem Zeitpunkt sind die Daten anonymisiert, d.h. sie können nicht mehr mit Ihnen als Person in Zusammenhang gebracht werden.

Nach der Anonymisierung sind die wissenschaftlichen Daten in codierter Form Fachleuten zur wissenschaftlichen Auswertung zugänglich. Die Weitergabe der Daten erfolgt ausschließlich zu statistischen Zwecken und Sie werden darin ausnahmslos nicht namentlich genannt. Auch in etwaigen Veröffentlichungen der Daten dieser Studie werden Sie nicht namentlich genannt. Ihr Name wird in keiner Weise in Berichten oder Publikationen veröffentlicht, die aus der Studie hervorgehen. Nach der Teilnahme haben Sie die Möglichkeit, bis zur vollständigen Anonymisierung Ihre Studiendaten löschen zu lassen. Einen etwaigen Widerruf Ihrer Einwilligung bzw. einen Rücktritt von der Studie müssen Sie nicht begründen. Im Falle eines Widerrufs werden die im Rahmen der Studie erhobenen persönlichen Daten gelöscht. Um diese Schritte einzuleiten, kontaktieren Sie bitte den verantwortlichen Projektleiter, Herrn Prof. Dr. Urs M. Nater (Liebiggasse 5, A-1010 Wien, +43-1-4277-47220, urs.nater@univie.ac.at).

9. Entstehen für die Teilnehmerinnen Kosten? Gibt es einen Kostenersatz oder eine Vergütung?

Durch Ihre Teilnahme an dieser Studie entstehen für Sie keine zusätzlichen Kosten. Als Vergütung für Ihren Zeitaufwand erhalten Sie nach der Untersuchung einen Betrag von € 40,-. Bei einem vorzeitigen Abbruch der Studie erhalten Sie einen Betrag bemessen daran, wie lange Sie an der Studie teilgenommen haben.

10. Möglichkeit zur Diskussion weiterer Fragen

Für weitere Fragen im Zusammenhang mit dieser Studie steht Ihnen die Versuchsleitung gerne zur Verfügung. Auch Fragen, die Ihre Rechte als TeilnehmerIn in dieser Studie betreffen, werden Ihnen gerne beantwortet.

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11. Einwilligungserklärung

Name der teilnehmenden Person in Druckbuchstaben: ....

Geb. Datum: ....

Ich erkläre mich bereit, an der Studie *Stress und Erholung* teilzunehmen.

Ich bin von „..." ausführlich und verständlich über Zielsetzung, Bedeutung und Tragweite der Studie und die sich für mich daraus ergebenden Anforderungen aufgeklärt worden. Ich habe darüber hinaus den Text dieser TeilnehmerInneninformation und Einwilligungserklärung gelesen, insbesondere den 4. Abschnitt (Gibt es Risiken, Beschwerden und Begleiterscheinungen?). Aufgetretene Fragen wurden mir von der Studienleitung verständlich und ausreichend beantwortet. Ich hatte genügend Zeit, mich zu entscheiden, ob ich an der Studie teilnehmen möchte. Ich habe zurzeit keine weiteren Fragen mehr.

Ich werde die Hinweise, die für die Durchführung der Studie erforderlich sind, befolgen, behalte mir jedoch das Recht vor, meine freiwillige Mitwirkung jederzeit zu beenden, ohne dass mir daraus Nachteile entstehen. Sollte ich aus der Studie ausscheiden wollen, so kann ich dies jeder Zeit schriftlich oder mündlich bei Univ.-Prof. Dr. Urs M. Nater veranlassen.

Ich bin zugleich damit einverstanden, dass meine im Rahmen dieser Studie erhobenen Daten aufgezeichnet und ausgewertet werden.

Ich stimme zu, dass meine Daten zunächst pseudonymisiert und nach Abschluss der Datenauswertung, d.h. zum Zeitpunkt der Veröffentlichung der Daten, dauerhaft in anonymisierter Form elektronisch gespeichert werden. Die Daten werden in einer nur der Projektleitung zugänglichen Form gespeichert, die gemäß aktueller Standards gesichert ist.

Sollte ich zu einem späteren Zeitpunkt, die Löschung meiner Daten wünschen, so kann ich dies schriftlich oder telefonisch ohne Angabe von Gründen bei Univ.-Prof. Dr. Urs M. Nater (Telefonisch erreichbar unter (Bürozeiten): +43-1-4277-47220, Per E-Mail erreichbar: urs.nater@univie.ac.at) veranlassen. Ich bin mir bewusst, dass dies nur möglich ist vor Abschluss der Datenauswertung, d.h., bis zum Zeitpunkt der Veröffentlichung der Daten, da die Daten ab dem Zeitpunkt anonymisiert werden, und eine Zuordnung zwischen den Daten im Datensatz und meiner Person dann nicht mehr möglich ist.

Den Aufklärungsteil habe ich gelesen und verstanden. Ich konnte im Aufklärungsgespräch alle mich interessierenden Fragen stellen. Sie wurden vollständig und verständlich beantwortet.

Eine Kopie dieser Teilnehmerinneninformation und Einwilligungserklärung habe ich erhalten. Das Original verbleibt bei der Studienleitung.

(Datum und Unterschrift der/des Teilnehmerin/Teilnehmers)

....

(Datum, Name und Unterschrift der Studienleitung)

....

Appendix F: Abstract

Abstract

Research suggests that music has beneficial effects on health, which are frequently attributed to its ability to reduce stress and improve mood. However, empirical research on stress- and mood-regulatory effects of music listening after acute stress exposure is scarce and inconsistent. Therefore, the aim of the present paper was to expand previous research by investigating the effects of music on subjective stress level, biological stress responses, and mood as well as their interrelation to each other. In this laboratory-based experimental study, fifty-four healthy female subjects underwent a standardized psychosocial stress test and were then randomly allocated to one of the following recovery conditions: listening to participant-relaxing music or resting in silence. Subjective stress level and mood were measured, and saliva samples were taken multiple times throughout the experiment. Results indicated that the stressor caused a significant increase in subjective stress level, salivary cortisol concentration, and negative mood. Unlike expected, the effects of listening to relaxing music on post-stress recovery, when compared to sitting in silence, did not differ significantly regarding subjective stress level, salivary cortisol concentration, or mood. Self-reports of mood correlated strongly with subjective stress level, whereas no significant correlation was found between salivary cortisol concentration and either subjective measure. Further experimental research is required to fully understand the beneficial effects of relaxing music as well as the relationship between psychological and physiological recovery from acute stress.

Key words: cortisol, mood, music listening, stress

Appendix G: Zusammenfassung

Zusammenfassung

Zahlreiche Forschungsergebnisse haben gezeigt, dass sich das Musikhören positiv auf Stress und Stimmung auswirken kann. Die wenigen Studien, die stress- und stimmungsregulierenden Wirkungen des Musikhörens nach akuter Stressbelastung in einem kontrolliertem Laborsetting untersuchten, zeigen jedoch widersprüchliche Ergebnisse. Ziel der vorliegenden Arbeit war es daher, bisherige Forschungserkenntnisse zu diesem Thema zu erweitern, und zwar durch die Untersuchung der Auswirkungen von Musik auf das subjektive Stressniveau, die biologischen Stressantworten und die Stimmung sowie deren Wechselbeziehung zueinander. In dieser experimentellen Laborstudie wurden vierundfünfzig gesunde weibliche Probandinnen einem standardisierten psychosozialen Stresstest unterzogen und anschließend per Randomisierung einer der folgenden Erholungsbedingungen zugeteilt: Hören selbstgewählter entspannender Musik oder Erholung in Stille. Das subjektive Stressniveau und die Stimmung wurden im Verlauf des Experiments wiederholt gemessen sowie Speichelproben entnommen. Die Ergebnisse zeigten, dass der Stresstest zu einem signifikanten Anstieg des subjektiven Stresslevels, der Speichelcortisol-Konzentration und negativer Stimmung führte. Entgegen den Erwartungen unterschieden sich die Effekte des Hörens entspannender Musik auf die Erholung nach akutem Stress hinsichtlich des subjektiven Stresslevels, der Speichelcortisol-Konzentration oder der Stimmung nicht signifikant von jenen des Sitzens in Stille. Die wahrgenommene Stimmung korrelierte stark mit dem subjektivem Stresslevel, wohingegen keine signifikante Korrelation zwischen der Speichelcortisol-Konzentration und den beiden subjektiven Maßen gefunden wurde. Weitere experimentelle Forschung ist erforderlich, um die positiven Auswirkungen von entspannender Musik sowie die Beziehung zwischen psychologischer und physiologischer Erholung von akutem Stress vollständig zu erklären.

Schlüsselbegriffe: Cortisol, Musikhören, Stimmung, Stress