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„Effects of Music Listening on Stress Recovery: The Role of Self-Selected Music"

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Introduction

Music has been a companion of humankind since its earliest stages (Altenmüller, 2018). While its evolutionary origins and purpose are debated, there is widespread consensus that music is capable of affecting behaviour and mind notably. Often seen as the antecedent of language, music is considered to play a vital role in several aspects of social life, such as partner selection, organizing group behaviour, and expressing and solidifying identity (Altenmüller, 2018). Besides influencing social life, music appears to have significant impact on humans on an individual level as well. Its capability to evoke emotions and influence cognitive processes has led to extensive research interest (Rentfrow & Levitin, 2019). In addition, potentially life-improving as well as healing qualities of music have intrigued scholars throughout the course of history (Altenmüller, 2018; Zanders, 2018). In the 18th century the idea of autonomous music arose, denying music as an artform to serve any purpose beyond its own sake (de la Motte-Haber, 2017). However, this idea sparked ongoing controversy as the complete separation of music from its functions does not seem feasible. The applications of functional music are especially relevant for health sciences as music is considered beneficial for physical and mental well-being (Kreutz, 2017). Despite being intertwined noticeably, music listening and music making are usually investigated separately (Kreutz, 2017). Effects of music listening on stress have been studied in experimental settings (Thoma et al., 2013) as well as in everyday life (Linnemann et al., 2015, 2018). Beneficial effects of music listening on both psychological and physiological stress response have been observed repeatedly (de Witte et al., 2020). However, results are not always conclusive and underlying mechanisms and influencing circumstances are yet to be investigated sufficiently (Panteleeva et al., 2018). Beside musical properties and contextual factors, interindividual differences seem to play a key role in the effectiveness of music listening to reduce stress. Such differences pertain to personality, musicality, and personal preferences of individuals (Liljeström et al., 2013). Especially personal preferences appear to be a crucial factor as unpreferred prescribed music may even evoke negative emotions and enhance the stress response (Yehuda, 2011). Therefore, paying attention to music preferences seems essential for using music listening as a tool for stress management. Letting participants select the music for relaxation by themselves allows to incorporate personal preferences into study designs (Groarke & Hogan, 2019). The presented thesis aims to investigate the role of self-selection in detail, examining the effects of music listening on the recovery from a stressful task.

Theoretical Background

Stress

The concept of stress is widely present in everyday language, often referring to a feeling of tension and overload (Semmer & Zapf, 2018). Although the term is diversly used in today's society, some commonality seems to underlie the concept of stress. Stress, its impact on health, and coping with stress are major topics in health psychology and have been studied extensively (Cook & Wood, 2020; Knoll et al., 2017). However, there is no general agreement in defining the concept. Stress theories can be divided along three main categories (Knoll et al., 2017). Stress can be described as an array of stressors, stimuli that are perceived as demanding or overcharging, and the process of mastering them. Other theories describe stress as typical reaction patterns, especially physiological reactions. Finally, some theories understand stress as the interaction of external stimuli and the reaction of individuals. These include the *transactional theory of stress* by Lazarus which is one of the most influential stress theories (Lazarus & Folkman, 1984). Here, stress is defined 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). A key component of the theory is cognitive appraisal. Thus, individuals evaluate the demands of present situations as well as their own resources to meet them. In case demands are perceived as threatening and resources as insufficient, situations can be experienced as stressful. Beside cognitive processes, stress experience seems to be accompanied by typical emotional states, such as fear, anger, and frustration (Semmer & Zapf, 2018). It should be noted that in literature the term *state anxiety* is sometimes used synonymously for stress-related experience, especially when referring to physiological reactions (e.g., Panteleeva et al., 2018; Parada-Cabaleiro et al., 2020). However, the term state anxiety is also used to define the emotional response to stress (de Witte et al., 2020). The characteristic physiological responses that are associated with stress experience include activity of the nervous system, endocrinological systems, and the immune system (von Dawans & Heinrichs, 2018). As stress experience is reflected on multiple levels, biopsychosocial approaches are necessary to capture the mechanisms of stress (Cook & Wood, 2020; Halbreich, 2021).

Generally, researchers differentiate between acute and chronic stress (Abdallah & Geha, 2017; Radenbach et al., 2015; Semmer & Zapf, 2018). The acute stress response is reflected in two of the major physiological stress systems, the autonomic nervous system (ANS) and the hypothalamus-pituitary-adrenal (HPA) axis (von Dawans & Heinrichs, 2018). The ANS plays a key role in regulating vital functions, such as digestion, respiration, and the cardiovascular system. In contrast to the immediate stress response of the ANS, the HPA axis reflects a more delayed stress response that mainly operates via the release of adrenal cortisol (von Dawans & Heinrichs, 2018). Among other effects, the release of cortisol generally increases metabolism and suppresses the immune system providing resources to deal with the stressor (Cook & Wood, 2020). Both systems serve adaptive functions that mostly refer to immediate reactions like fight-or-flight behaviour, enabling the organism to react to potential threats (Cook & Wood, 2020).

After exposure to a stressor is terminated the stressor-induced response is changing, which reflects the process of stress recovery (Haynes et al., 1991). The physiological response is regulated by the organism via feedback loops of the stress systems deactivating stress-related activity and restoring pre-stressor conditions (von Dawans & Heinrichs, 2018). However, stress recovery is considered to not necessarily proceed in a linear and unidirectional course, allowing the organism to stabilize its stress response (Haynes et al., 1991). The process of adapting to acute stress to achieve stability of stress related systems is termed *allostasis* (McEwen, 2017). Moreover, in case of frequent stress experience the allostatic regulation processes can wear out resulting in dysregulations like inactivity or overactivity (McEwen, 2017; McEwen & Seeman, 1999). These dysregulations are called *allostatic load/ overload* and reflect the experience of chronic stress, referring to the experience of continuous strain in response to a stressor (Halbreich, 2021).

Stress and Health

Although the stress response serves adaptive functions such as fight-or-flight behaviour, maladaptive consequences can affect physiological and psychological health, especially in long-term activation or inability to counterbalance stress reactions (Knoll et al., 2017). Experiencing high and frequent stress levels is associated with various illnesses and an increased mortality risk (Uchino et al., 2007). Adverse influences of stress are especially evident for cardiovascular diseases (Gerber & Schilling, 2018). Thus, stress is considered to contribute to the long-term development of cardiovascular diseases by facilitating risk factors and the progression of coronary atherosclerosis (Steptoe & Kivimäki, 2013). High levels of perceived stress are associated with risk factors such as hypertension and elevated cholesterol (Gawlik et al., 2019). At least in some parts, stress also seems to be adversely related to morbid obesity, intestinal disorders, immune disorders, and cancers (Gerber & Schilling, 2018; Halbreich, 2021). Beside the risk for physical health, experiencing stressful life events is also linked to the development of mental disorders, especially posttraumatic stress disorder, depressive disorders, and anxiety disorders, which are often referred to as stress-related disorders (Smoller, 2016). Moreover, stress is associated with impairments of cognitive abilities

(Ludyga, 2018), cognitive decline (Ávila-Villanueva et al., 2020; Chen et al., 2019), and sexual dysfunction (Hamilton & Meston, 2013).

Stress-related health risks seem to relate mostly to chronic stress experience. In contrast, acute stress appears to be inevitable and might even promote growth and resilience (McEwen, 2017). This is often described by the term *eustress* which is associated with rewarding qualities by overcoming challenges. However, health risks of both acute and chronic stress are investigated as they are intertwined heavily and seem to impact health in an interplay (Halbreich, 2021; Radenbach et al., 2015). Accordingly, adverse effects haven been observed specifically for the acute stress response. For example, in patients with advanced coronary atherosclerosis acute stress might trigger cardiac events (Steptoe & Kivimäki, 2013). Acute stress seems to facilitate cardiac dysfunctions like arrhythmias and myocardial ischemia (Ziegelstein, 2007). Moreover, cardiovascular activity during acute stress in terms of heightened blood pressure is associated with a higher cardiovascular disease mortality risk (Carroll et al., 2012). In addition, adverse effects of acute stress on mental health have been demonstrated. For example, both chronic and acute stress are associated with the onset of major depressive episodes (Hammen et al., 2009). Further adverse effects of acute stress have been observed, such as impairments of decision making (Wemm & Wulfert, 2017) and unhealthy eating behaviours (Rutters et al., 2009).

Furthermore, the recovery from acute stress seems to play an important role for the effects of stress on health. Adverse effects of stress have been associated with dysfunctional or lacking recovery after episodes of acute stress (Sonnentag, 2018). It should be noted that stress recovery might not be activated automatically after the exposure to the stressor is over (Brosschot et al., 2016). Therefore, interventions to actively approach and facilitate stress recovery are in demand (Almén, Lisspers, Öst, et al., 2020). The need for effective stress interventions is further enhanced by significant social costs that are related to the increased risk for diseases and the overall effects from stress at the workplace (Elfering et al., 2018). Beside sports and exercise (Fuchs & Klaperski, 2018), cultural activities (Tuisku et al., 2016), and elaborated recovery management interventions (Almén, Lisspers, & Öst, 2020), music activities are discussed as effective interventions for stress recovery (de Witte et al., 2020).

Music Listening and Stress

Using music to improve well-being and health has a long history (Rentfrow & Levitin, 2019; Zanders, 2018). Facing the search for effective strategies, applying music to stress interventions has gained attention increasingly (de Witte et al., 2020; Wong et al., 2021). Music has been shown to facilitate relaxation and affect several physiological health-related parameters (Chanda & Levitin, 2013; Kreutz, 2017; Thoma & Nater, 2012). Furthermore, beneficial effects of music education and music training on health and well-being have been demonstrated (Kreutz, 2017). Therefore, music interventions are discussed as effective and cost-efficient strategies to facilitate stress regulation (de Witte et al., 2020). For example, music interventions are used in clinical settings to reduce pain, anxiety, and stress with patients undergoing medical procedures (Nilsson, 2008). Music interventions include various music activities, such as listening to music, making music, and other interactions with music in a therapeutic process (de Witte et al., 2020). Moreover, music therapy programmes have been developed which oftentimes are institutionalized and require special education and training for practitioners (Zanders, 2018). Music interventions with therapeutic purposes are usually distinguished from recreational music interactions and passive music listening (Magee et al., 2017). However, music interventions can be offered without any specific guidance as well, mainly as purposeful music listening provided by health care professionals or self-administered (de Witte et al., 2020). Different interactions with music such as making music and listening to music go hand in hand with each other (Kreutz, 2017). However, they are usually investigated separately and appear to differ in their effects on the stress response (Fallon et al., 2020; Kreutz, 2017). Mere listening is the most common music intervention (Wong et al., 2021). As music listening inevitably occurs during other music activities as well, investigating its effects on the stress response is crucial for determining the relationship of music and health (Kreutz, 2017). Beneficial effects of mere listening to music for health and stress have been observed repeatedly. For example, researchers have investigated how exposure to background music can affect mood and relaxation (de la Motte-Haber, 2017). In addition, effects of music listening on the stress response have been studied in both experimental settings (Thoma et al., 2013; Yehuda, 2011) as well as in everyday life (Linnemann et al., 2015, 2018). Various stress-related outcomes seem to be affected by music listening. This includes subjective stress ratings, emotional states, and several physiological stress measures.

Music Listening and the Psychological Stress Response

Subjective ratings of stress and relaxation have been found to be affected beneficially by music listening in experimental settings (Burns et al., 2002; Elliott et al., 2014). In addition, studies investigating effects of music listening in everyday life have demonstrated that music listening is effective for reducing self-reported stress levels (Linnemann et al., 2015, 2018). However, in some studies significant effects on ratings of stress and relaxation have not been observed (Peck et al., 2020; Thoma et al., 2013). Another frequently used self-report measure for investigating effects of music listening is the assessment of mood and stress-related emotions. Generally, music has been shown to effectively evoke an emotional response in listeners (Juslin et al., 2010; Lundqvist et al., 2009). In studies using stress-inducing procedures music listening interventions have been observed to effectively enhance positive emotions and reduce negative emotions (de la Torre-Luque, Díaz-Piedra, et al., 2017; Groarke & Hogan, 2019; Radstaak et al., 2014). However, some studies have not observed beneficial effects on emotional states through music listening (Fallon et al., 2020; Thoma & Nater, 2012). It is important to note that the respective studies vary considerably regarding measurement approaches and the range of recorded emotions, for example happiness, excitement, anxiety, anger, sadness, tension, and depressive symptoms. Due to this heterogeneity, conclusions are limited and further research is necessary to determine how effects of music listening on the stress response are reflected on an emotional level (Panteleeva et al., 2018).

Music Listening and the Physiological Stress Response

Beside psychological stress measures, effects of music listening have been investigated for a variety of physiological stress indicators. This includes studies that examine the effects of music listening on activity of the HPA axis measured via cortisol levels. Music listening has been repeatedly found to decrease cortisol levels in clinical settings with patients undergoing medical procedures (Koelsch et al., 2011; Mottahedian Tabrizi et al., 2012; Uedo et al., 2004). However, as significant effects are not always observed, this seems to be primarily the case for minor medical interventions (Thoma & Nater, 2012). Additionally, music listening has been found to come along with decreased cortisol responses in everyday life assessments (Helsing et al., 2016; Linnemann et al., 2015). Experimental studies using stress inducing procedures have demonstrated that music listening appears to reduce the cortisol response (Suda et al., 2008) and lead to a faster cortisol recovery (Khalfa et al., 2003). Nonetheless, the results should be interpreted with caution due to relatively low sample sizes. In studies with larger samples significant effects of music listening on cortisol levels have not been observed (Peck et al., 2020; Thoma et al., 2013). Furthermore, music listening has been repeatedly found to affect activity of the ANS. In clinical settings with patients undergoing medical procedures, music listening interventions seem to reduce heart rate, blood pressure, and respiration rate (Nilsson, 2008). Moreover, effects of music listening on cardiovascular activity have been demonstrated in lab-based studies. Several cardiovascular parameters have been observed to be modulated by music listening, such as heart rate, blood pressure, peripheral blood flow, and respiration rate (Sokhadze, 2007; Trappe & Voit, 2016). However, both decreasing and increasing effects of music listening on cardiovascular activity have been reported which seems to be mainly influenced by musical properties especially tempo (Kulinski et al., 2021; Radstaak et al., 2014).

In addition, some experimental studies using stress-inducing procedures have found no significant effects of music listening on cardiovascular activity (Elliott et al., 2014; Peck et al., 2020; Thoma et al., 2013). While these studies examined heart rate as an indicator for the cardiovascular response, other cardiac parameters might give further insight in cardiovascular processes related to stress and health. Thus, music listening has been found to beneficially affect heart rate variability (Kulinski et al., 2021) and nonlinear cardiac parameters (de la Torre-Luque, Díaz-Piedra, et al., 2017; de la Torre-Luque, Caparros-Gonzalez, et al., 2017) that are considered to reflect the complexity of the cardiovascular stress response more accurately (Bornas et al., 2015). Further indicators for activity of the ANS have been examined by previous research. For example, music listening during the recovery from a stress-inducing procedure has been found to reduce skin conductance (Fallon et al., 2020). Other studies use the biomarker salivary alpha-amylase (sAA) which can serve as an indicator for stress-related activity of the ANS (Nater & Rohleder, 2009). Music listening in everyday life has been found to come along with decreased levels of sAA (Linnemann et al., 2015). Additionally, music listening before a stress-inducing procedure has been found to reduce elevated sAA levels during recovery although this effect did not reach significance (Thoma et al., 2013). Beside the effects on the two major physiological stress systems, the ANS and the HPA axis, music listening appears to affect further physiological processes that are related to stress and health, such as brain activity, brain chemistry, and the immune system (Chanda & Levitin, 2013; Koelsch et al., 2016; Yehuda, 2011).

In sum, results on the effects of music listening on stress are not always conclusive and further research is necessary to determine potential health implications of music listening. While both the presence and absence of effects on various stress indicators have been observed, studies show high heterogeneity in their methodological and design approaches (Panteleeva et al., 2018). Given the variety of indicators for the stress response, studies differ in their choice of outcomes and measurement procedures and comprehensive approaches are scarce (Thoma et al., 2013). In addition, methodological standards are not consistently realized, such as the inclusion of a theoretical framework, the adherence to a priori sample size estimations, and detailed display of eligibility criteria (Panteleeva et al., 2018). It should also be noted that music listening is considered to sometimes cause stress, especially if it is perceived as unpleasant (Yehuda, 2011). Therefore, researchers focus on the question of which factors influence the effectiveness of music listening for stress relief. Determining underlying mechanisms and favourable circumstances seems crucial to understand how music listening can serve as a tool for stress relief. This also holds particular relevance for incorporating music in therapeutic interventions (Panteleeva et al., 2018).

Mechanisms of Music Listening for Stress Relief

Although stress-reducing effects of music listening have been demonstrated repeatedly, there is no comprehensive model to explain these effects (Yehuda, 2011). Several potential mechanisms are discussed that are considered to play a role. For example, music might serve as a distractor shifting attention away from the stressor and stress-related cognitions and emotions. The distractive potential of music is used as an explanation for stress-reducing effects of music listening in clinical settings (Mok & Wong, 2003; Nilsson, 2008). In contrast, music listening has been found to not necessarily lead to a decrease of rumination and stressor-related thoughts (Radstaak et al., 2014). Moreover, investigating effects of music listening in everyday life, Linnemann et al. (2015) observed that music listening even was associated with an increase in stress if participants' reason to engage in music listening was to distract themselves. They concluded that contextual factors such as characteristics of the stressor determine whether distraction through music listening promotes stress relief. Furthermore, expectancy mechanisms are discussed to explain stress-reducing effects of music listening (Yehuda, 2011). Listeners might expect music to influence their psychological state and help them to relax which in turn facilitates stress reduction. Accordingly, stronger efficacy beliefs about the music's effectiveness to reduce stress have been found to predict greater regulation of stress and negative affect (Groarke & Hogan, 2019). Beside the cognitive mechanisms of distraction and expectancy, the potential of music to elicit emotions in listeners is considered to play a major role in affecting the stress response (Thoma & Nater, 2012). Music is considered to enable contagion of emotions (Juslin & Västfjäll, 2008; Lundqvist et al., 2009). Emotions induced in listeners have been found to be congruent to emotions expressed by the music that was listened to. Therefore, listening to relaxing music might help individuals to regulate the stress response by evoking equivalent emotional states (Lundqvist et al., 2009).

In addition to psychological mechanisms that might explain the effects of music listening on the stress response, researchers have identified underlying physiological processes. Thus, music listening appears to affect neurochemical systems that are also activated by rewards (Chanda & Levitin, 2013). This might explain the potential of music to generate enjoyment and pleasure that help listeners to regulate stress. Neuropsychological research has demonstrated that the neural response to music listening is reflected in a complex interplay of various brain systems (Chanda & Levitin, 2013; Koelsch, 2010). For example, music listening initiates brain stem reflexes that mediate changes of the ANS such as cardiovascular activity (Juslin &

Västfjäll, 2008). However, the role of various brain systems is not yet understood completely and further research is in demand (Koelsch, 2010). Another prominent explanation for effects of music listening on the stress response is the process of *entrainment* (Yehuda, 2011). According to this explanation characteristics of musical stimuli elicit physiological resonance in a mutual manner. This might also serve as an explanation why measures of the ANS seem to be affected by music listening. The physiological processes of the ANS as well as the musical characteristics are composed of oscillations that are considered to synchronize while listening to music (Yehuda, 2011). Accordingly, slow and rhythmic music has been observed to decrease heart rate, blood pressure, and respiration (Bernardi et al., 2006; Hilz et al., 2014; Nilsson, 2008).

Most likely, more than one of the mechanisms mentioned above play a role in the relationship between stress and music and further comprehensive research is in demand (Yehuda, 2011). Furthermore, it has been demonstrated that the context of music listening, properties of the musical stimuli, and interindividual differences appear to influence the effectiveness of music listening for stress relief.

Influence of Context

Several contextual factors as well as the applied dosage seem to moderate the effectiveness of music listening for stress relief. One factor is the timing of music listening in relation to the stressor. In other words, it seems to be relevant whether the music is presented before, during, or after a stressful event. Earlier studies investigated the effects of music listening during stressful events, for example during surgeries and other medical procedures (e.g., Uedo et al., 2004). Furthermore, stress reducing effects have been observed with music listening before and after medical procedures (Nilsson, 2008). Overall, it seems that for clinical settings, music listening is more effective when it is presented before or during the intervention as well as during minor interventions as compared to more serious medical procedures (Thoma & Nater, 2012). In addition, lab-based experimental studies with stress inducing procedures vary regarding the timeline of stressor and music listening intervention. Stress-reducing effects have been observed in studies with music listening during stress recovery, thus presented after the stressor (Fallon et al., 2020; Groarke & Hogan, 2019; Khalfa et al., 2003). In contrast, for music listening before stressful events beneficial effects on the following stress response seem to be absent (Peck et al., 2020; Thoma et al., 2013). Therefore, it can be concluded that music listening might not be effective for preventing stress in experimental settings and appears to be more suitable during recovery (Peck et al., 2020). Considering that the most effective timing of music listening seems to depend on the characteristics of the stressor (medical procedure versus experimental stressor) emphasises the need for further research to determine ideal timing patterns. Furthermore, regarding the most effective duration of music listening previous research provides little insight (Linnemann et al., 2018). While durations of music intervention in lab-based studies can vary greatly, an investigation of music listening in everyday life by Linnemann et al. (2018) suggests that at least 20 minutes of music listening is necessary to substantially affect the stress response. Another situational factor that seems to play a role is the social context. Studies paying attention to the social context of music listening have demonstrated that the presence of others influences emotional reactions and the stress response (Liljeström et al., 2013; Linnemann et al., 2016). The presence of a close friend or partner seems to come along with a higher intensity of emotions and a higher chance of experiencing positive emotions than listening to music in solitude (Liljeström et al., 2013). Investigation of music listening in everyday life indicate that the presence of others enhances stress-reducing effects (Linnemann et al., 2016).

Influence of Musical Properties

As types of music can vary greatly, researchers have analysed which musical properties are most effective for reducing stress (Parada-Cabaleiro et al., 2020). Not all kinds of music seem to be appropriate for reducing stress (Jiang et al., 2013). However, defining what musical properties characterise relaxing music appears to elude a definite answer (Elliott et al., 2011; Tan et al., 2012). Different genres of music are associated with different intentions to regulate emotions and arousal (Cook et al., 2019). Some studies have observed an advantage of classical music compared to pop, jazz, hard rock, or heavy metal music for stress relief (Burns et al., 2002; Chafin et al., 2004; Labbé et al., 2007; Trappe & Voit, 2016). However, it should be noted that these observations might pertain to the specific classical music pieces that have been chosen by the researchers rather than the general genre (Chafin et al., 2004). Therefore, researchers are investigating the role of more fundamental musical properties, such as tempo, melody, frequency, and the use of lyrics. Regarding the tempo of music, slow beats (about 60 to 80 beats per minute) are considered to be relaxing (de Witte et al., 2020; Tan et al., 2012). Slower tempo has been associated with decreased arousal of respiratory and cardiovascular measures (Bernardi et al., 2006; Hilz et al., 2014). The relationship of music tempo and heart rate is even considered to be proportional (Nilsson, 2008). Nevertheless, faster rhythms might also contribute to relaxation effects of music listening as pauses and decelerations seem to be especially relevant for inducing relaxation (Bernardi et al., 2006). Regarding melody, rhythmic structure, and instrumental range low complexity seems to characterise relaxing music (Tan et al., 2012). Whereas a wider pitch range and higher complexity in harmony are associated with higher perceived relaxation. Comparing music conditions, amplified to vary in frequency, has shown that high-frequency components of music seem to play a greater role for reducing stress than low-frequency components (Nakajima et al., 2016). For the presence of lyrics in musical stimuli previous research demonstrates ambiguous results as both distracting and comforting effects have been observed (de Witte et al., 2020; Elliott et al., 2011).

Altogether, results on the effectiveness of various music types are not always conclusive. Generally, music with positive valence and low arousal seems to be advantageous for stress relief (Sandstorm & Russo, 2010). However, musical properties associated with calmness are not necessarily considered indispensable for the occurrence of stress-reducing effects. For example, Sharman & Dingle (2015) investigated the effects of listening to extreme music (i.e. music with negative valence and high arousal) after an anger inducing procedure. It should be noted that the sample consisted solely of individuals with a preference for extreme music. No increase in negative emotions due to extreme music but an increase in positive emotions was observed. In conclusion, effects of varying music types seem to depend on interindividual differences especially individual preferences for certain types of music.

Influence of Individual Factors

Several individual factors have been identified to play a role in the effectiveness of music listening for stress relief. For example, different age groups seem to be affected differently by music listening. In their response to music listening, older adults show greater increase in positive affect and decrease in negative affect compared to younger adults (Lima & Castro, 2011; Vieillard et al., 2012). This shift towards positivity could explain why music listening seems to be more effective for stress relief in older adults than in younger adults (Groarke & Hogan, 2019). Furthermore, sex differences have been observed regarding the response to music listening. Female participants have been observed to show a heightened physiological response to aversive music stimuli compared to male participants (Nater et al., 2006). Sex differences have also been demonstrated for the effects of music listening on the recovery from a stress-inducing procedure (de la Torre-Luque, Díaz-Piedra, et al., 2017). Female participants exhibited greater negative emotional responses but lower levels regarding cardiovascular measures throughout stress induction and recovery compared to male participants. Furthermore, music training (i.e. receiving music education or pursuing music-related professions) seems to influence the individual response to music listening (Bernardi et al., 2006; Lima & Castro, 2011; Yehuda, 2011). Music training in an individual's biography is associated with a higher sensitivity to affective components of music and a higher physiological response to music rhythms (Bernardi et al., 2006). However, previous research has demonstrated no significant impact of music training on the effectiveness of music listening for stress relief (Jiang et al., 2016). Personality traits also can serve as an explanation for why some individuals tend to experience greater stress relief through music listening than others (Liljeström et al., 2013). Different personality traits are associated with individual tendencies of emotional experience of music such as the intensity of emotions and the extent of positive versus negative emotions. However, potential modulating effects of personality could stem from their role in shaping music preferences (Schäfer & Sedlmeier, 2009). Personal music preferences can be considered as the major individual factor that influences effectiveness of music listening for stress relief. They seem to determine whether music is considered relaxing or is even rejected in favour of no music exposure at all (Salamon et al., 2003). Beside personality, age, physiological conditions, and innate auditory preference, all have been found to influence the development of music preferences (Schäfer & Sedlmeier, 2009).

The important role of music preferences for stress relief has also been demonstrated in experimental settings. As personal preferences have been found to modulate the influence of music valence and arousal, they are considered to be more important for stress relief than musical properties (Jiang et al., 2013, 2016). However, the mechanisms behind the development of music preferences and their impact on the effects of music listening are yet to be identified sufficiently. To incorporate personal preferences in study designs, researchers can let participant select the music listened to by themselves. Most studies use prescribed music to investigate stress-reducing effects of music listening that allows to control for the influence of various musical properties (Groarke & Hogan, 2019). However, letting participants choose the music by themselves might help to increase ecological validity, as it reflects music listening in everyday life more closely.

Self-Selection of Music

To implement self-selection of music in study designs, researchers can let participants choose from a selection provided by the researcher or use music based on a previously submitted individual selection of the participant (Groarke & Hogan, 2019). Effects of self-selected music have been studied for a range of stress-related outcomes. Some studies have demonstrated, that listening to self-selected music during recovery from a stressor task benefits a reduction of self-reported stress levels and negative affect as well as the enhancement of positive affect (de la Torre-Luque, Díaz-Piedra, et al., 2017; Groarke & Hogan, 2019; Radstaak et al., 2014). Furthermore, listening to self-selected music is also associated with beneficial effects on the physiological stress response. Respective effects have been demonstrated for cardiovascular measures (de la Torre-Luque, Díaz-Piedra, et al., 2017). In addition, reduced cortisol levels have been observed for listening to self-selected music on daily occasions over a two-week period (Helsing et al., 2016).

Beside the indications of an effective stress reduction, it can also be argued, that self-selected music has an advantage over researcher-selected music for reducing stress. Self-selected music generally seems to evoke emotions of greater intensity than prescribed music (Liljeström et al., 2013). Several reasons are discussed to contribute to an advantage of self-selected music. First, higher ratings of liking, which are expectably the case for self-selected music compared to prescribed music, seem to facilitate stress-reducing effects of music listening (Jiang et al., 2013, 2016). Jiang et al. (2013) refer to appraisal theory as an explanation, assuming that the listener's evaluation of the music is more important for affecting the emotional response than the musical stimulus itself. Second, familiarity is discussed to play a role, as it appears to be crucial for the emotional engagement with music (Pereira et al., 2011). Familiar music has been found to effectively evoke vivid autobiographical memories (Belfi et al., 2016). Therefore, familiarity with musical stimuli could facilitate the experience of positive emotions that accompany memory associations (Liljeström et al., 2013). Nevertheless, familiarity appears to be less important than liking for stress-reducing effects (Groarke & Hogan, 2019; Jiang et al., 2016). Fourth, self-selection of music is linked to a higher sense of control over the situation, compared to prescribed music. The degree of a sense of choice and control has been found to predict the engagement with music and how the music is evaluated (Krause & North, 2017). Finally, participants perception of the effectiveness of music listening for helping them to relax seems to influence stress-reducing effects. For self-selected music, efficacy beliefs have been found to predict regulation of stress and negative affects stronger than familiarity (Groarke & Hogan, 2019).

Studies that examine the effects of listening to self-selected music in experimental designs with stress inducing procedures are scarce (Groarke & Hogan, 2019). This scarcity is especially prevalent for studies that directly compare conditions with self-selected music to researcher-selected music. Burns et al. (2002) investigated the effects of music listening for 10 minutes before performing a stressful mental rotation task on 60 undergraduate psychology students. The increase in relaxation ratings and decrease in state anxiety was greatest for the self-selected music condition compared to researcher-selected classical or hard rock music but lower than the control group. However, this pattern was not observed for physiological stress measures, namely heart rate, frontalis muscle activity, and skin temperature. In another study by Labbé et al. (2007), 56 college students listened to either self-selected, researcher-selected classical, researcher-selected heavy metal music, or stayed in silence for 20 minutes after performing a stressful cognitive speed test. Only self-selected music was observed to decrease heart rate significantly among the conditions. Additionally, the self-selected music condition showed a greater decrease in state anger than the two researcher-selected music conditions but not compared to the control group. For relaxation ratings and state anxiety, no advantage of self-selected music was observed as only the heavy metal group showed no beneficial effects. Peck et al. (2020) examined effects of listening to either self-selected music, researcher-selected music, or white noise on the stress experience of 109 participants before undergoing a stress inducing procedure. No differences in effects on self-report affect, heart rate, skin conductance, or salivary cortisol were observed between the conditions. Given the scarcity and inconclusiveness of previous studies, further research comparing self-selected and researcher-selected music conditions in experimental designs is required. Understanding the role of self-selection could help to determine how stress reducing effects of music listening can be achieved.

Research Question and Hypotheses

The objective of the presented thesis is to investigate the role of self-selection for the effectiveness of music listing for stress relief. Specifically, it is questioned whether self-selected music shows an advantage over researcher-selected music. Therefore, two music conditions with participants listening to either researcher-selected music or self-selected music and a control group with participants remaining in silence are compared regarding the recovery from a stressor task. Combined assessments of both psychological and physiological stress indicators are considered essential to get comprehensive insight in the effects of music listening on the stress response (Linnemann et al., 2017). Thus, self-reported stress levels as a subjective stress measure and heart rate as an objective stress measure are compared between the three research conditions. Accordingly, the following hypotheses are specified:

H1.1(1): Participants listening to music during recovery from a stressor task show greater reduction in self-reported stress levels than participants not listening to music.

H1.2(1): Specifically, participants listening to self-selected music show greater reduction in self-reported stress levels than participants listening to researcher-selected music

H2.1(1): Participants listening to music during recovery from a stressor task show greater reduction in heart rate than participants not listening to music.

H2.2(1): Specifically, participants listening to self-selected music show greater reduction in heart rate than participants listening to researcher-selected music.

Methods

The presented master thesis is embedded in a superordinate research project that is conducted at the Department of Clinical and Health Psychology of the University of Vienna by Univ.-Prof. Dr. Urs Nater and Yichen Song, MA ("The Effect of Music on Stress Recovery"). Expanding the findings of its precursor study from Thoma et al. (2013), the project pursues the objective of investigating effects of music listening on the stress response. Therefore, the effects of acoustic stimulation (music and water sounds) on the recovery from a stress-inducing procedure are examined in a laboratory-based setting. Various outcomes for both psychological and physiological stress response are included, namely self-reported stress measures, salivary biomarkers, cardiovascular and respiratory indicators, and electrodermal activity.

Participants

A priori sample size estimations of the superordinate project using G*power (Faul et al., 2007) indicated that at least 25 participants for each of the research conditions were required, considering power of $1 - \beta = .08$, an alpha criterion of $\alpha = .05$ and an effect size of $f = 0.34$, based on previous research of the precursor study from Thoma et al. (2013). Restriction to female sex was implemented to allow for comparability with the precursor study and to control for sex related differences in the physiological and psychological stress response that have been observed in previous research (Liu et al., 2017; Nater et al., 2006). To control for other confounding factors potentially influencing biomarker measurements, the following criteria for eligibility were specified: age 20 to 30, no smoking, no pregnancy or breastfeeding, no current illness, no chronic somatic illnesses, no visual impairments (if not correctable with glasses or contact lenses), no current mental disorder or psychiatric illness (depression, psychosis, anxiety disorders, eating disorders within the last 5 years), no diagnosis of major depression or anxiety disorders in the past, no stay in the tropics in the last 6 months, no vaccinations in the last 2 weeks, BMI of 18 to 25, no excessive alcohol use (substance abuse within the last 2 years, regular consumption of more than 8 drinks), no drug intake in the last year or cannabis in the past 14 days, no (dental) surgery in the last 8 weeks, no other health-related anomalies (tumors, meningitis, accidents, etc.), no use of psychotropic pharmaceuticals in the past 14 days, no intake of cardiovascular medication, no use of medication affecting hormonal balance, no hormonal contraception, and a regular menstrual cycle. To ensure unobstructed participation, fluency in German was an additional criterion. Furthermore, no previous experience with the stressor task and no personal relationships with study team members were required. Additional music-related criteria were the absence of hearing impairment or chronic tinnitus as well as the absence of absolute hearing and the absence of pursuing music-related professions or studies by participants.

For the presented thesis, an overall sample of $N = 79$ participants was analysed. Figure 1 shows an overview of the recruitment process as well as the dropouts at different timepoints on the course of the study. Participants were recruited via online flyers in social media forums containing brief information about the general subject of the study. Additionally, main inclusion criteria were stated (females, age 20 to 30, no hormonal contraception, a regular menstrual cycle, no smoking, no somatic illnesses or mental disorders, no over- or underweight, and fluency in German) as well as information about the duration and location of the procedure and compensation of 40 EUR. Interested participants were asked to contact the study via email and then received a reply email, asking for contact information and to schedule a pre-screening telephone interview. Structured interviews were conducted to gather information regarding the inclusion criteria in detail, taking about 20 minutes (for interview guideline see Appendix C.).

Study Design

A between-subjects design was used, examining the effects of music listening (independent variable) on the recovery from a stressor task, the Trier Social Stress Test (TSST; Kirschbaum et al., 1993). The TSST is a widely used protocol for a standardized stress inducing procedure that utilizes psychosocial stressors. The protocol includes an anticipation phase and a presentation phase composed of a speech and a verbal mental arithmetic task. After undergoing the TSST, participants were recovering according to three randomly assigned research conditions, a) listening to researcher-selected music, b) listening to self-selected music, or c) a control group with no specific auditory stimulus. Subjective and objective stress levels (dependent variables) were measured at five timepoints throughout the in-lab testing procedure and were compared between the three research conditions.

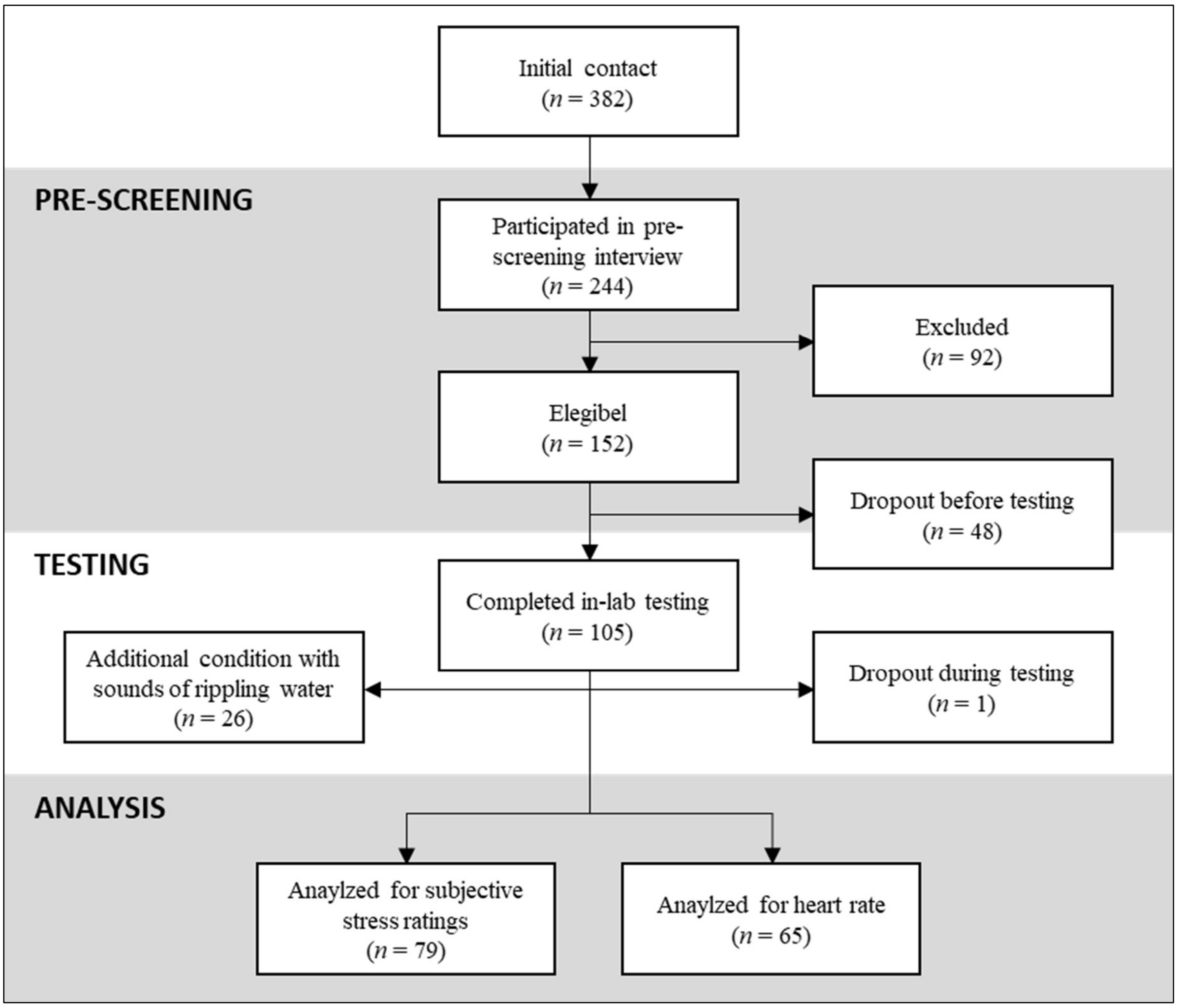
Measures

Subjective Stress Response

Subjective stress levels were measured with Visual Analogue Scales (VAS; Lesage et al., 2012), submitted at each measurement timepoint among a short series of self-report measures of stress-related emotions. For stress levels, participants were asked to mark the degree of their current feeling of stress on a 100 mm line, labelled only at the endpoints with ‘0’ and ‘100’. VAS are discussed as a suitable tool for measuring current subjective stress levels in experimental settings and are efficient for repeated measurements, as is the case for the presented study (Lesage et al., 2012).

Figure 1

Flow chart of recruitment and sampling process



Objective Stress Response

Heart rate was assessed with the electrocardiogram-equipment ecgMove 4 (movisens GmbH, Karlsruhe, Germany). Participants were asked to wear a chest belt that recorded cardiac parameters continuously throughout the procedure. To determine the heart rate for each measurement timepoint, a two-minute time frame of heart rate data was cut out for each of the timepoints using the software UnisensViewer version 1.12.38.0 (movisens GmbH, Karlsruhe, Germany). This time frame was simultaneous to the other stress measurements as the two minutes were used for saliva sampling and gathering self-report data like the VAS stress measurement. The software DataAnalyzer version 1.13.5 (movisens GmbH, Karlsruhe, Germany) was used to generate numeric heart rate values for the assessed cardiac data. As data analysis with this software provides heart rate values for one-minute periods, two values were generated for each measurement timepoint. Mean values of the two values were calculated to generate a single heart rate value for the respective time frames of each measurement timepoint. In some cases (n = 13) recordings of cardiac parameters were impaired so heavily that no credible values of heart rate could be generated. Such impairments occurred during the procedure as participants were moving around and the chest belt was not attached sufficiently. Therefore, these cases were excluded from further analyses leaving a sample of n = 65 participants regarding heart rate analyses.

Sense of Control

Along with the VAS for stress levels, an additional VAS was submitted at each timepoint to measure participants' sense of control. Participants were asked to mark the degree of how much they feel in control of the current situation on a similar line, labelled only at the endpoints with '0' and '100'.

Intervention Evaluation

Directly after the intervention period a self-report questionnaire was conducted, asking the participants to evaluate the intervention along 5-point Likert scales ranging from '1' to '5' with additional labels at each endpoint namely 'gar nicht' (not at all) and 'sehr' (very). Participants were asked to rate how much they liked the intervention. A feeling of nuisance was measured, asking participants to rate how much they were bothered by the intervention. Furthermore, efficacy beliefs for relaxation were measured, asking to rate how strongly they believed the intervention helped them to relax. In the two music conditions, ratings for liking, nuisance, and efficacy beliefs referred to the presented music (Appendix D.), whereas in the control group, ratings referred to the current part of the procedure, as no specific auditory stimulus was presented to the participants (Appendix E.). Additional music evaluations were gathered exclusively in the two music conditions, asking participants to rate familiarity with the music and efficacy beliefs for distraction.

Chronic Stress

The Short Screening Scale for Chronic Stress (SSCS) a 12-item short version of the Trier Inventory for Chronic Stress (TICS; Schulz et al., 2004) was used to asses chronic stress. The SSCS was submitted as part of the series of psychometric online questionnaires that were conducted at the beginning of the in-lab testing procedure. Participants rate the extent of work overload, social overload, and chronic worrying in the last three months along a 5-pont Likert scale labelled with 'nie' (never), 'selten' (seldom), 'manchmal' (sometimes), 'häufig' (often), and 'sehr häufig' (very often). Internal consistency of $\alpha = .91$ indicates satisfactory reliability of the SSCS (Schulz et al., 2004).

Procedure

If a potential participant met all criteria during the pre-screening telephone interview, she was invited to schedule an appointment for in-lab testing taking place in the second half of the participant's follicular phase. Recruitment and in lab-testing were conducted from December 2020 until July 2021. Due to regulations regarding the Covid-19 pandemic, participants were asked to bring a valid negative SARS-CoV-2-test result or use an antigen test provided by the study team upon arrival at the lab.

Prior to in-lab testing, participants received an email, confirming the testing date, including a link to an additional pre-screening online questionnaire, and stating pre-testing requirements with a checklist (Appendix F.). The pre-screening online questionnaire was conducted via the Unipark programme of EFS Survey (Tivian XI GmbH, Hürth, Germany) and was used to screen for any psychiatric symptoms and extent of psychological fatigue. Requirements for the participants prior to in-lab testing were stated to control for diurnal fluctuation of hormonal conditions and to avoid malfunctions of the objective stress measures. Participants were asked to avoid any extreme physical strain 2 days prior. For the day prior to in lab-testing, they are asked to refrain caffeine or alcohol consumption in the evening, chewing gum, sports or exercising, and any skincare applications (e.g., lotions, cremes, oils) to their arms and chest. For one hour prior to in-lab testing, participants were asked to refrain eating, brushing teeth, and showering. Additionally, they were asked to inform the study team if they experienced any irregularities in their menstruation cycle in the week prior to in-lab testing or if they observed any symptoms of illness. Furthermore, participants were asked to send a list of ten music pieces each, for music they prefer to listen to for relaxation and for activation or motivation. Therefore, a template was attached to the confirmation email (Appendix G.) Reminder emails were sent to the participants 2 days prior to in-lab testing, reminding them of completing the online questionnaire and transmitting the music list and the pre-testing requirements.

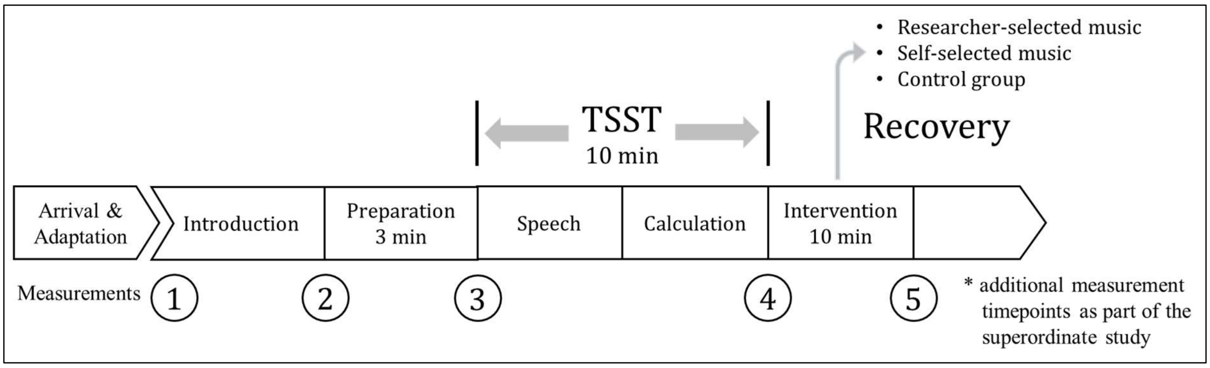
In-lab Testing

One participant per day passed through the in-lab testing procedure, each starting at around 2 pm and taking about 120 minutes. Figure 2 shows an overview of the in-lab testing procedure. Upon arrival, participants were received by a test administrator and were asked to conduct a questionnaire regarding Covid-19 regulations (i.e., presence of symptoms, high risk of infection circumstances) and sign an agreement of contacting the study team in case of any signs of infection during the week following the testing procedure (Appendix H.). If no negative test result was provided by the participant, she was asked to conduct a SARS-CoV-2-antigen test provided by the study team. Then, participants were informed briefly about the procedure and asked to sign informed consent (Appendix I.). Furthermore, a brief questionnaire was conducted to check whether the participant paid attention to the pre-testing requirements (Appendix J.). Then, participants were introduced on how to proceed the subjective and the objective (saliva sampling) stress measurements. Next, participants were assisted by the test administrator with putting on the electrocardiogram-equipment monitoring physical parameters which they were going to wear throughout the whole procedure. After that, participants had 30 minutes to adapt before the measurements were collected, marking the first timepoint and baseline (T1). During adaption, participants were asked to fill out a series of psychometric questionnaires about their stress reactivity, resilience, traumatic experiences, personality traits, chronic stress, perceived stress, coping styles, and music preferences. The questionnaires were conducted via Unipark (Tivian XI GmbH, Hürth, Germany) and were completed at the end of the procedure if not during the adaptation period.

Next, participants were brought to the testing room and were introduced to the TSST, telling them they have to perform a job interview in front of two interviewers. The roles of the interviewers were acted by two trained other members of the study team sitting behind a desk in the testing room. Participants were asked to state their qualifications for a job of their choice and were told that their speech would be recoded by a microphone and a camera. After the introduction, participants were asked to conduct the second measurement (T2). Then they had three minutes of preparation for their speech in which they could prepare notes, although they were not allowed to use them during their speech. The introduction was followed by the third measurement (T3). Participants were asked to start their qualification speech, which was timed for five minutes. After that, participants were asked to perform a calculating task for additional five minutes, having to subtract in steps of 17 from 2043 and verbally confirm every interim result. In case of errors, they were asked immediately by the interviewer to start from the beginning again. After a fourth measurement (T4), participants were brought back by the test administrator to the first room. Depending on the randomly assigned condition, participants were listening to a) music selected by the research team, namely “Miserere” by Allegri, which has shown to have stress reducing effects in previous studies (Nater et al., 2006; Thoma et al., 2013), b) self-selected music, according to their previously submitted music list, or c) no specific acoustic stimulus during a recovery period of ten minutes. A fourth condition, listening to sounds of rippling water, was implemented in the superordinate project but was not used for the presented thesis, as nature sounds are considered to distinctly influence the stress response (Alvarsson et al., 2010; Thoma et al., 2018). The music was presented via headphones and in all three conditions participants were asked to lay down on a recliner with a blanket provided if needed by the participant. After that, the fifth measurement took place (T5), followed by additional measurements 20 minutes (T6), 30 minutes (T7), 45 minutes (T8) and 60 minutes (T9) after the TSST. After the procedure, participants were provided with a debriefing and were asked to leave contact information in order to receive monetary compensation of 40 EUR.

Figure 2

Overview of the in-lab testing procedure



Note. The circled numbers represent the five measurement timepoints.

Ethical Aspects

The superordinate research project of the presented thesis was approved by the Ethics Committee of the University of Vienna (application number 00508). At the beginning of the pre-screening telephone interview, participants were informed about the purpose and procedure of the interview as well as their right to deny answers and end the interview at any time. Personal data of interview-participants was stored to retain contact information. Testing data following the interview was stored separately and was anonymised by usage of participant codes. Informed consent about the testing procedure was conducted at the beginning of the in-lab procedure, including information about the purpose of the study as well as data storage and processing (see Appendix I.). Participants were informed about their right to withdraw from the testing procedure and to request deletion of their non-anonymised data at any time. As an effective stress induction of the TSST requires some extent of naivety, participants were not informed about the testing procedure in detail. Therefore, after the last measurement participants were provided with a debriefing explaining the purpose of this concealment as well as the randomly assignment to one of the research conditions.

Statistical Analysis

Data analyses were conducted with IBM SPSS Statistics (Version 26.0). Repeated measure analyses of variance (rmANOVA) were calculated for each VAS stress levels and heart rate to undertake a manipulation check, investigating whether stress levels increased during TSST. The Greenhouse-Geisser correction was used to take account of violations of sphericity. In addition, stress reactivity scores were generated to identify potential outliers. Therefore, the mean values of T2, T3, and T4 were calculated forming a pre-intervention stress level. In three cases of heart rate data, one of the values was missing and the pre-intervention level was calculated with the remaining two values. Stress reactivity was quantified as a delta (pre-intervention level minus baseline), with higher values indicating a greater reactivity to TSST. The time courses of cases with negative stress reactivity were investigated individually, namely four cases with negative stress reactivity regarding VAS stress and five cases with negative stress reactivity regarding heart rate. However, no overlap between cases with negative stress reactivity of both stress measures was observed. These cases were not excluded as they showed no major fluctuations from the average stress patterns and baseline levels were controlled for in further analyses.

For testing the hypotheses, analyses of covariance (ANCOVA) were calculated with each VAS stress and heart rate as dependent variables. T5 was used exclusively as the post-intervention stress level, as the applied stress measures in the presented thesis are not considered to show significant time lag (cf., von Dawans & Heinrichs, 2018). Stress recovery was quantified as the delta (pre-intervention minus post-intervention stress level) for each VAS stress (Δ_{VAS}) and heart rate (Δ_{HR}), with higher values indicating a greater reduction of subjective stress and heart rate. As recommended by previous studies, baseline values (T1) and chronic stress levels (SSCS) were included as covariates (Thoma et al., 2013). Violations of homogeneity of regression slopes were precluded as interaction terms were not statistically significant. For post-hoc group comparisons, the use of planned contrasts was premeditated, examining whether the music listening groups show greater stress reduction compared to the control group and subsequently, whether the self-selected music group shows greater stress reduction than the researcher-selected music group (Field et al., 2012).

For additional analyses, an ANCOVA was calculated to examine post-intervention levels of sense of control controlling for baseline levels. Furthermore, a series of Kruskal-Wallis tests was calculated comparing conditions regarding each measure of intervention evaluation. Spearman's rank correlations were calculated to investigate relations between measures of music evaluation and reduction of both VAS stress and heart rate. As measures of intervention evaluation showed deviations from normal distributions, indicated by Shapiro-Wilk tests, the use of nonparametric statistics was implemented.

Results

Sample Characteristics

The overall sample of $N = 79$ participants analysed in the presented thesis has an average age of $M = 23.57$, $SD = 2.93$. Participants were mainly of Austrian (67.1%) and German (16.5%) nationality while other nationalities included Hungarian (3.8%) and Serbian (2.5%) as well as one participant each (1.3%) of dual Austrian-German, dual Suisse-German, Ukrainian, Spanish, Italian, Bosnia-Herzegovinian, Slovakian, and Egyptian nationality. Furthermore, the sample consists of a high proportion of participants with an academic degree (83.5%). No significant differences between the research conditions have been observed regarding age, $F(2, 76) = 0.63$, $p = .534$, partial $\eta^2 = 0.02$, as well as chronic stress levels (SSCS), $F(2, 76) = 0.16$, $p = .855$, partial $\eta^2 = 0.01$.

Manipulation Check

For testing the effectiveness of stress induction with the TSST, rmANOVAs were calculated for both VAS stress levels and heart rate. For VAS stress levels, a significant difference between timepoints, $F(3.50, 273.12) = 105.20$, $p < .001$, partial $\eta^2 = 0.57$, was demonstrated. As shown in Table 1, Bonferroni-corrected post-hoc tests revealed significantly higher average VAS stress levels at pre-intervention timepoints (T2, T3, and T4) than at baseline (T1) and post-intervention (T5). There were no significant differences between T2, T3, and T4 as well as between T1 and T5. The rmANOVA for heart rate demonstrated a significant main effects as well, $F(2.97, 180.00) = 58.35$, $p < .001$, partial $\eta^2 = 0.49$. As shown in Table 2, Bonferroni-corrected post-hoc tests revealed significantly higher average heart rate at pre-intervention timepoints (T2, T3, and T4) than at baseline (T1) and post-intervention (T5) with significantly higher values at T4 than at T2 and T3. Moreover, average heart rate was significantly higher at baseline than at T5.

Subjective Stress Levels

Comparing the conditions in average subjective stress recovery (Δ_{SR}), an ANCOVA controlling for baseline levels and chronic stress (SSCS) showed no significant main effect, $F(2, 74) = 1.68$, $p = .193$, partial $\eta^2 = 0.04$, with the highest average shown in the control group (Table 3).

Heart Rate

An ANCOVA was calculated to compare conditions regarding heart rate recovery (Δ_{HR}) controlling for baseline levels. No significant main effect was observed, $F(2, 61) = 1.50$, $p = .231$, partial $\eta^2 = 0.05$, with the highest average in the control group (Table 4).

Table 1

Pairwise comparisons between measurement timepoints for VAS stress ratings

Timepoints	M_{Diff}	*SE*	*p*	95%-CI for M_{Diff}	
				Lower level	Upper level
1 – 2	-32.75	2.79	< .000	-40.82	-24.67
1 – 3	-34.79	2.68	< .000	-42.52	-27.05
1 – 4	-37.34	3.07	< .000	-46.20	-28.48
1 – 5	-0.80	2.46	> .999	-7.90	6.31
2 – 3	-2.04	1.92	> .999	-7.60	3.52
2 – 4	-4.60	2.97	> .999	-13.18	3.99
2 – 5	31.95	2.54	< .000	24.61	39.29
3 – 4	-2.56	2.65	> .999	-10.21	5.10
3 – 5	33.99	2.36	< .000	27.17	40.81
4 – 5	36.54	2.58	< .000	29.11	43.98

Note. VAS = Visual Analogue Scale; CI = confidence interval. Adjustments with Bonferroni-correction applied for all pairwise comparisons.

Additional Analyses

Sense of Control

Levels of VAS sense of control were compared at T5, calculating an ANCOVA with baseline levels as covariate. No significant main effect was observed, $F(2, 75) = 0.81$, $p = .449$, partial $\eta^2 = .02$. As shown in Table 5 the lowest average was observed for the self-selected music group.

Table 2

Pairwise comparisons between measurement timepoints for heart rate

Timepoints	M_{Diff}	*SE*	*p*	95%-CI for M_{Diff}	
				Lower level	Upper level
1 – 2	-6.95	0.98	< .000	-9.80	-4.09
1 – 3	-6.77	1.17	< .000	-10.18	-3.37
1 – 4	-13.85	1.33	< .000	-17.72	-9.98
1 – 5	3.81	1.22	.026	0.27	7.36
2 – 3	0.18	1.21	< .999	-0.33	3.69
2 – 4	-6.90	1.48	< .000	-11.22	-2.59
2 – 5	10.76	1.66	< .000	5.93	15.60
3 – 4	-7.08	1.11	< .000	-10.32	-3.84
3 – 5	10.59	1.20	< .000	7.08	14.09
4 – 5	17.66	1.20	< .000	14.18	21.14

Note. CI = confidence interval. Adjustments with Bonferroni-correction applied for all pairwise comparisons.

Table 3

Average subjective stress recovery

Group	*n*	Unadjusted		Adjusted [a]	
		M	*SD*	*M*	*SE*
RM	25	30.45	16.61	30.29	3.59
SM	27	32.44	16.50	32.81	3.49
CG	27	39.31	19.72	39.09	3.46

Note. RM = researcher-selected music; SM = self-selected music; CG = control group.

[a] adjustment calculated with covariates T1 = 20.29 and SSCS = 34.43.

Table 4

Average heart rate recovery

Group	*n*	Unadjusted		Adjusted [a]	
		M	*SD*	*M*	*SE*
RM	21	11.70	11.34	10.61	1.81
SM	21	15.04	9.70	13.96	1.81
CG	23	12.80	6.20	14.79	1.77

Note. RM = researcher-selected music; SM = self-selected music; CG = control group.
[a] adjustment calculated with covariate T1 = 80.38

Table 5

Average post-intervention levels of sense of control

Group	*n*	Unadjusted		Adjusted [a]	
		M	*SD*	*M*	*SE*
RM	25	65.52	26.27	65.80	4.75
SM	27	58.48	25.20	57.89	4.57
CG	27	63.74	24.99	64.08	4.57

Note. RM = researcher-selected music; SM = self-selected music; CG = control group.
[a] covariate calculated with T1 = 66.58.

Intervention Evaluation

Kruskal-Wallis tests revealed significant main effects for all measures of intervention evaluation, namely liking, nuisance, efficacy beliefs, and activation (see Table 6).

Bonferroni-corrected pairwise comparisons showed that average levels of liking in the researcher-selected music group were significantly lower than in the self-selected music group ($z = -6.62$, $p < .001$, $r = 0.75$) and in the control group ($z = -4.54$, $p < .001$, $r = 0.51$). While ratings of liking were higher in the self-selected music group than in the control group, no significant difference was observed ($z = 2.13$, $p = .100$, $r = 0.24$).

For ratings of nuisance, lowest average levels were observed in the control group. While they were significantly lower than in the researcher-selected music group ($z = 2.66$, $p = .023$, *r*

= 0.30), the difference was not significant compared to the self-selected music group ($z = 0.98$, $p = .977$, $r = 0.11$). No significant difference for ratings of nuisance was found between the two music groups ($z = 1.67$, $p = .284$, $r = 0.19$).

Highest levels of efficacy beliefs were observed in the self-selected music group, significantly higher than in the researcher-selected music group ($z = -3.04$, $p = .007$, $r = 0.34$) but not significantly higher than in the control group ($z = 0.75$, $p = .454$, $r = 0.08$). While the researcher-selected music group showed the lowest efficacy beliefs, the difference was not significant compared to the control group ($z = -2.30$, $p = .064$, $r = 0.26$).

Average ratings of activation in the researcher-selected music group were significantly lower than both in the self-selected music group (z = -3.85, p < .001, r = 0.43) and in the control group (z = -3.22, p = .004, r = 0.36). While ratings of activation were highest in the self-selected music group this difference was not significant compared to the control group (z = 0.64, p = .523, r = 0.07).

Table 6

Group comparisons regarding measures of intervention evaluation

Variable	*H*	*p*	Mean ranks		
			RM (*n* = 25)	SM (*n* = 27)	CG (*n* = 27)
Liking	45.51	< .001	17.60	56.50	44.24
Nuisance	7.20	.027	46.50	38.54	33.94
Efficacy beliefs	9.95	.007	28.96	47.33	42.89
Activation	18.86	< .001	25.22	48.76	44.93

Note. df = 2; RM = researcher-selected music; SM = self-selected music; CG = control group.

Music Evaluation

Table 7 shows descriptive characteristics of the measures of music evaluation separately for both music conditions. As shown in Table 8 no significant correlations of measures of music evaluation with both subjective stress recovery and heart rate recovery were observed. This was the case for both music conditions.

Table 7

Descriptive characteristics of music evaluation

Variable	RM (n = 25)				SM (n = 27)			
	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*
Liking	1	5	2.88	1.27	4	5	4.89	0.32
Familiarity	1	5	3.00	1.38	1	5	4.78	0.80
Efficacy beliefs for relaxation	1	5	3.28	1.34	2	5	4.33	0.73
Efficacy beliefs for distraction	1	4	2.52	1.05	1	5	3.89	1.05

Note. RM = researcher-selected music; SM = self-selected music; Min = Minimum; Max = Maximum.

Table 8

Spearman's rank correlations of stress recovery and measures of music evaluation

Variable	RM				SM			
	Δ_{SR} (n = 25)		Δ_{HR} (n = 21)		Δ_{SR} (n = 27)		Δ_{HR} (n = 21)	
	ρ	*p*	ρ	*p*	ρ	*p*	ρ	*p*
Liking	.23	.262	.33	.144	.32	.106	-.26	.258
Familiarity	.14	.499	-.20	.390	-.44	.827	-.37	.103
Efficacy beliefs for relaxation	.27	.199	.17	.476	.10	.607	.22	.337
Efficacy beliefs for distraction	.09	.655	-.19	.421	.56	.563	.22	.330

Note. RM = researcher-selected music; SM = self-selected music; Δ_{SR} = subjective stress recovery; Δ_{HR} = heart rate recovery.

Discussion

The presented thesis investigates the effects of music listening on the recovery from the TSST as a stressor task. The results from the rmANOVAs indicate that the TSST had a significant stress-inducing effect. Thus, the participants' VAS stress ratings and heart rate were significantly higher at the three pre-intervention timepoints, T2, T3, and T4, than at baseline level T1. These timepoints are linked to the TSST procedure as both T2 and T3 refer to the expectation of the stressor while T4 was conducted directly after the stressor. Both VAS stress levels and heart rate decreased during the intervention period as levels at T5 were found to be significantly lower than at the pre-intervention timepoints. This was expected as participants were no longer exposed to the stressor. The decrease reached baseline levels regarding VAS stress levels, whereas average post-intervention heart rate was found to be even lower than baseline levels.

It was hypothesised that participants listening to music during recovery from TSST show greater reduction in self-reported stress levels and heart rate than participants not listening to music. Additionally, self-selected music was expected to have an advantage over researcher-selected music in the effectiveness for stress relief. For both the subjective and objective indicators of the stress response, no significant differences between the research conditions have been demonstrated. However, additional analyses indicate that self-selected music was evaluated favourably by participants in comparison to researcher-selected music.

Effects of Music Listening on the Subjective Stress Response

For subjective stress levels reported via VAS, differences between the three research conditions were not significant. Thus, it can be concluded that music listening did not influence the subjective stress recovery in the presented study. In contrast, previous research has demonstrated effective reduction of self-reported stress and stress-related emotions through music listening (de Witte et al., 2020; Panteleeva et al., 2018). Effects of music listening on self-reported stress have been found in lab-based experiments using the TSST as a stressor task. For example, Groarke & Hogan, (2019) observed a greater reduction of negative affect for a self-selected music condition compared to a control condition. Significant effects were demonstrated for VAS stress ratings as well as VAS ratings of nervousness, upset, sadness, and regulation of depressed affect. However, contradicting results have been reported as well. For example, Thoma et al. (2013) investigated the effects of music listening before undergoing the TSST. Regarding VAS stress ratings, no significant differential effect was observed for preventing stress with music listening compared to silence or listening to water sounds. In addition, the absence of significant effects on stress-related emotions was demonstrated in studies with music listening during recovery from the TSST (de la Torre-Luque, Caparros-Gonzalez, et al., 2017; Fallon et al., 2020). It should be noted that dosage effects might have influenced the results of the presented study as duration of a musical stimulus seems to play a role in the occurrence of stress-reducing effects (Linnemann et al., 2018). While Fallon et al. (2020) examined effects of 5 minutes of music listening, Groarke & Hogan (2019) 10 minutes, and de la Torre-Luque, Caparros-Gonzalez, et al. (2017) 15 minutes, the 10 minute intervention duration of the presented study was applied due to comparability with the precursor study of Thoma et al. (2013) and appears to comply with previous research practice. However, Linnemann et al. (2018) studied effects of music listening on stress in everyday life and determined a minimum of 20 minutes of music listening for stress reducing effects to occur. In addition, Thoma et al. (2013) argue that the TSST might be too strong as a stressor for stress reducing effects of music listening to occur in subjective stress ratings. This could serve as an explanation of the inconclusiveness of previous research and should be considered when interpreting the findings of the presented study.

While not significant, the greatest average stress reduction was observed for the control group. A similar pattern has been demonstrated in previous research by Burns et al. (2002), who observed the greatest increase in relaxation ratings during recovery from a stressor task for the control group followed by self-selected music, researcher-selected classical music, and finally researcher-selected hard rock music. The results indicate that music listening might have been unsuitable for the participants in recovering from the TSST as a relatively strong stressor. Music listening has been found to not only reduce but also cause stress (Yehuda, 2011). This seems to depend primarily on individual factors such as personal preference but could also be influenced by situational aspects. The additional analysis of intervention evaluation by the participants revealed that feelings of nuisance were lowest for the control group. For the immediate recovery from the TSST music listening might have been irritating and inappropriate. To explain why music listening might reduce stress, its potential to distract listeners from stress-related thought is discussed frequently (Nilsson, 2008; Radstaak et al., 2014). Supporting this theory, studies examining effects of music listening during surgical procedures have found music to be an effective cognitive distractor (Nilsson, 2008). However, experimental studies using stress inducing procedures showed no differential effects of music listening regarding the degree of rumination that participants experienced during stress recovery (Chafin et al., 2004; Radstaak et al., 2014). It might be possible that participants experience the need for processing stress-related thoughts. Distractions caused by musical stimuli could hinder them in doing so and therefore create feelings of nuisance and disturbance. In contrast, it can be considered that music listening might also intensify stress-related thoughts as it induces self-reflection (Radstaak et al., 2014). Altogether, feelings of nuisance and stress-related thoughts evoked by the musical stimuli could have counterbalanced its stress reducing effects. Future research is necessary to identify contextual factors that might facilitate the occurrence of unfavourable effects of music listening.

Effects of Music Listening on the Objective Stress Response

In addition to the subjective stress measures, effects of music listening were examined for heart rate as an indicator of activity of the ANS. As it was the case for VAS stress ratings, no significant differences between the research condition were observed with the highest average heart rate recovery in the control group. In contrast, previous research has demonstrated decreasing effects of music listening on heart rate repeatedly (Kulinski et al., 2021; Nilsson, 2008). However, studies examining the effects of music listening on heart rate show great heterogeneity and the findings are not always conclusive (Panteleeva et al., 2018). The absence of significant effects of music listening on heart rate was observed by previous studies using TSST as a stressor task. This was the case for study designs investigating preventive effects of music listening with interventions taking place before undergoing the TSST (Peck et al., 2020; Thoma et al., 2013). Although the results of the presented study suggest that music listening had no advantage for the cardiovascular recovery, these findings should be interpreted cautiously. Heart rate reflects time-related properties of the heartbeat, but other cardiovascular parameters might reflect stress-related activity more adequately (Brugnera et al., 2018; de la Torre-Luque, Caparros-Gonzalez, et al., 2017). Beside stressful arousal, heart rate might also reflect feelings of activation or excitement. De la Torre-Luque, Díaz-Piedra, et al. (2017) observed beneficial effects of music listening during recovery from the TSST on cardiovascular measures. However, this was not the case for heart rate but rather for frequency-domain and nonlinear parameters. Further research including additional measures of cardiovascular activity is needed to identify the role of cardiovascular arousal for the effects of music listening on the stress response.

The Role of Self-Selection

As no significant differential effects on both stress measures have been observed, the results indicate that self-selected music has no advantage for stress relief compared to researcher-selected classical music. This was the case for subjective stress measured via VAS stress ratings. Previous research has demonstrated similar results for subjective stress measures. Peck et al. (2020) observed no differential preventive effects of listening to self-selected music compared to researcher-selected classical music before undergoing the TSST. This included

VAS ratings of discomfort and excitement as well as physiological measures, namely salivary cortisol levels, heart rate variability, and indicators for electrodermal activity. Moreover, Labbé et al. (2007) observed that listening to either self-selected music or researcher-selected classical showed a decrease in state anxiety, relaxation ratings indicating that both musical stimuli had similar effects on the subjective stress recovery from a stress inducing procedure. However, the music conditions showed differences in heart rate as only participants in the self-selected music condition experienced a significant decrease due to the music listening intervention. Similarly, in the presented study the self-selected music group showed greater heart rate recovery than the researcher-selected music group. However, the differences did not reach significance. After adjusting for baseline levels as a covariate, the difference in average heart rate recovery between the two music groups was greater than the difference between averages of the self-selected music group and the control group. This trend indicates that the researcher-selected music was least suitable for regulating arousal of the cardiovascular response. These results were unexpected as the musical stimulus in the researcher-selected music condition is characterised by slow tempo and calming musical properties and has shown relaxing effects in previous research (Nater et al., 2006). Music tempo is associated with cardiovascular arousal in a proportional relationship as higher music tempo appears to come along with an increase in heart rate, respiration rate, and blood pressure (Hilz et al., 2014; Nilsson, 2008). It should be noted that no data about the musical characteristics in the self-selected music group was recorded. As participants were instructed to select music they prefer for relaxation, they might have selected music that was similar in tempo and other music characteristics compared to the musical stimulus in the researcher-selected music group. To get further insight into the role of arousal, results of the additional analyses regarding music evaluation should be taken into consideration. Hence, ratings of perceived activation were significantly lower in the researcher-selected music group than in the other two conditions. While highest ratings were observed in the self-selected music group, the difference was not significant compared to the control group. Taken together, the results suggest some degree of divergence between psychological and physiological indicators of arousal. Accordingly, a study by Sharman & Dingle (2015) has demonstrated that even high arousal music has shown to elicit a positive psychological response. Participants with a preference for extreme music passed through an anger inducing procedure which led to increased heart rate. Listening to extreme music during the recovery was found to sustain heart rate while the silence control group showed a decrease. However, music listening appeared to elicit positive emotions. Sharman & Dingle (2015) concluded that positive emotions were facilitated due to the congruence of music and participants physiological arousal. Therefore, depending on personal preferences, high arousal music could be considered suitable for stress relief for some individuals even though it does not lead to a decrease of cardiovascular arousal.

While there was no significant advantage of self-selected music for stress reduction, additional analyses revealed that music was evaluated favourably compared to researcher-selected music. Thus, ratings of liking of the intervention were highest in the self-selected music group. Although ratings were not significantly higher compared to the control group, the difference was significant compared to the researcher-selected music group. Furthermore, the ratings of nuisance for the self-selected music group were not significantly higher compared to the control group which showed the lowest ratings of nuisance. In contrast, the researcher-selected music group showed significantly higher ratings of nuisance compared to the control group. Taken together, these results suggest that letting participants select music themselves could be beneficial for avoiding feelings of nuisance or even stress caused by music listening. In other words, self-selected music might have an advantage over prescribed music because unfavourable effects that counterbalance or hinder stress-reducing effects are less likely to occur. This can serve as an explanation why participants in the self-selected music group showed greater average stress recovery than participants in the researcher-selected music group although the difference was not significant.

Measures of music evaluation were examined more closely for the two music conditions to get further insight in the role of self-selection. Various factors, such as liking and pleasantness, familiarity, and efficacy beliefs, have been identified by previous research to play a role in explaining potential advantages of self-selected music over prescribed music (Groarke & Hogan, 2019; Jiang et al., 2016; Pereira et al., 2011). Comparing the descriptive characteristics of measures of music evaluation between the music conditions shows that variance of participants ratings is higher in the researcher-selected music group. These results were expected, as participants in the self-selected music group were listening to music based on instructions to select music they generally prefer for relaxation. It should be noted that some participants in the self-selected music showed low ratings of efficacy beliefs for both relaxation and distraction. This indicates that even though some participants were listening to music they generally prefer for relaxation, the musical stimulus was not suitable for the specific situation. To explore any influence on the effectiveness of music listening for stress recovery, correlations between measures of music evaluation and both subjective and objective stress recovery were examined. However, calculated correlations were far from significance for both music conditions. For the self-selected music group, these results can be explained by the lack of variance regarding measures of music evaluation. For the researcher-selected music group the results indicate that the degree of neither liking, familiarity, or efficacy beliefs had any influence on the subjective and objective stress recovery. In contrast, previous studies have demonstrated significant effects regarding these factors when examining stress-reducing effects of music listening. For example, Jiang et al. (2016) investigated the effects of listening to prescribed music on the recovery from a stressor task. They observed that liking was a greater predictor for stress recovery than arousal and valence of the music whereas familiarity did not serve as a significant predictor. Similarly, a study by Groarke & Hogan (2019) demonstrated that although familiarity predicted some effects of affect regulation through listening to self-selected music after undergoing the TSST, this was not the case for stress regulation. Moreover, efficacy beliefs were found to significantly predict regulation of stress and negative affect during recovery. Beside liking, familiarity, and efficacy beliefs, feelings of choice and control are discussed to play a role in explaining potential advantages of self-selected music for stress relief (Groarke & Hogan, 2019). Therefore, an additional analysis was conducted comparing participants' VAS ratings of sense of control after the intervention. In the presented study no significant difference in post-intervention levels of sense of control was observed between the three research conditions. Other than expected, participants who listened to self-selected music showed the lowest average levels of post-intervention levels of sense of control. This can be explained partly with the selection process used in the study. For the researcher-selected music group the musical stimulus was prescribed without any choice by the participants. In contrast the musical stimulus for the self-selected music group was derived from an individual music list according to the participants personal preferences. However, during the intervention, participants in the self-selected music group could not choose freely which song they wanted to listen to but were provided with a previously generated playlist of their preferred songs. Choosing musical pieces is considered to be highly dependent on contextual factors (Krause & North, 2017). Therefore, the effectiveness of music listening for stress relief and its perceived efficacy might be influenced not only by personal preferences but by an interplay of preference and situational characteristics. This is reflected by the results of intervention and music evaluation, as low ratings of efficacy beliefs even occurred in the self-selected music group. In other words, even though individuals generally like a certain musical stimulus and perceive it as relaxing, they might find it unsuitable or even bothersome in a specific situation. Personal preferences of music are considered to fluctuate between different situations (Schäfer & Sedlmeier, 2009). This fluctuation can be explained by the impact of varying music functions that individuals seek to fulfil when listening to music (Schäfer, 2016; Schäfer & Sedlmeier, 2009). Recovering from a stressful event, individuals might prefer low arousal music to calm themselves, high arousal music to distract them or match their emotional state, or even no music at all to focus on processing the experience. Future research is necessary to disentangle the role of various influencing factors on the effectiveness of music listening for stress relief. Hence, situational factors, musical properties, and interindividual differences should be examined comprehensively, considering interaction effects between individuals and context.

Strengths and Limitations

When discussing the results of the presented thesis, some limitations should be taken into account. Primarily, the study was not designed with particular and exclusive regard to the specific hypotheses of the presented thesis as it was embedded in a superordinate project. Therefore, some design elements are included that do not add incremental value for examining the hypotheses but could influence the results. For example, self-report measurements at each timepoint included far more than VAS ratings of stress and sense of control leading to an extent of assessments that was larger than necessary for testing the hypotheses of the presented thesis. As given by the general design of the superordinate study, a highly controlled lab-based experimental setting was implemented. Using the TSST to induce stress allows to investigate the effects of music listening on the acute stress response following a standardized stressor. The experimental setting helps to minimize cofounding influences beside the musical stimulus. However, ecological validity is substantially limited in the presented study. Although the intervention in the self-selected music group might reflect music listening in everyday life more closely than incorporating researcher-selected music exclusively, transferring the results to real-life environments is limited. Influenced by various contextual factors, music listening in everyday life seems to be closely linked to other activities (Kreutz, 2017). As mentioned above, participants were not completely free in selecting specific musical stimuli, rather they were presented with music based on previously submitted playlists. Thereby, no information could be obtained about the selection process of the participants. Further comprehensive studies in daily life settings are needed that investigate the multitude of contextual factors influencing the effectiveness of music listening for stress relief (Linnemann et al., 2017).

Several restrictions of eligibility were specified for sampling to minimize potential influences on the psychophysiological stress response. Thus, restrictions regarding sex, age, and various somatic and mental health conditions allow for high controllability. However, the homogeneity of the sample leads to limited generalization of the results beyond the specific sample. It should be noted that some of the demographic characteristics have been found to play a role for the effects of music listening on stress. For example, older adults seem to benefit more effectively from music listening compared to younger adults (Groarke & Hogan, 2019).

Moreover, sex-related differences have been observed for effects of music listening on stress recovery (de la Torre-Luque, Díaz-Piedra, et al., 2017). Future research should extend the results to more diverse samples and actively compare demographic groups to allow for more generalized interpretations.

Furthermore, as the test administrators had to select the respective musical stimuli presented to the participant according to the randomly assigned condition, no complete blinding of allocations to the research conditions was implemented. Therefore, the occurrence of expectancy biases can not be excluded. Moreover, demand effects are considered to play a role in designs using stress inducing procedures (Parada-Cabaleiro et al., 2020). Participants might understand the intention of the stress inducing procedure. This could influence their behaviour and evaluations which particularly affects self-report measurements. To reduce demand effects, no detailed information about the procedure as well as about the allocation to the different research conditions was given in advance. Hence, when referring to the study, only the terms "stress" and "recovery" were used by pre-screening interviewers and on the recruitment flyer while the study team's interest in investigating effects of music listening on the stress response was not mentioned explicitly. To blind allocations for participants, submission of music list was asked from participants across all research conditions. In addition to relaxing music, participants were asked to fill out a second music list with music they prefer for activation to further conceal the study teams intentions.

As combined assessments of psychological and physiological stress indicators are considered essential for investigating effects of music listening on the stress response (Linnemann et al., 2017), both subjective and objective stress measurements were included in the presented study. Therefore, heart rate was included as a stress outcome variable serving as an objective indicator of ANS activity. However, as mentioned above, focussing exclusively on heart rate as a single parameter of the heartbeat only allows for limited conclusions to be drawn about stress-related cardiovascular activity (Brugnera et al., 2018; de la Torre-Luque, Díaz-Piedra, et al., 2017). Additional indicators of ANS activity and further measures of the physiological stress response should be included in future research to get comprehensive insight in the effects of music listening on stress recovery. As the human stress response is reflected in multiple psychological and physiological processes, multidimensional approaches seem indispensable for determining the effects of music listening.

Implications and Outlook

Although effects of self-selected music on the stress response have been investigated in experimental lab-based settings as well as daily life, respective research is scarce (Groarke &

Hogan, 2019; Helsing et al., 2016). Especially studies that directly compare research conditions with either self-selected or researcher-selected music are required to determine the role of self-selection in the effectiveness for stress relief. In the presented study self-selection of musical stimuli was implemented via music lists that were submitted by participants in advance of in-lab testing. Future research should consider other ways of implementing self-selection that reflect music selection in daily life more closely. For example, in previous research participants were asked to choose music from a selection provided by the experimenter (Chafin et al., 2004). Hence, music selection might come along with a greater sense of choice and control which is considered to play an essential role in the effectiveness of music listening for stress relief (Groarke & Hogan, 2019; Krause & North, 2017).

The presented results provide indications that, in the presented study, silence was more suitable for stress recovery than music listening. Although differential effects regarding stress recovery were not significant, silence was evaluated favourably as higher ratings of liking and efficacy beliefs and less feelings of nuisance were reported in the control group. To further investigate whether silence has an advantage over music listening for recovering from the TSST, additional control conditions should be implemented in future research. For example, previous studies have included active control conditions with non-musical stimuli such as white noise (Peck et al., 2020), audio books (Radstaak et al., 2014), or radio reports (Groarke & Hogan, 2019). This could provide insight in stress enhancing and other unfavourable effects of music listening. Furthermore, Radstaak et al. (2014) suggest to include instructions that ask participants to consciously focus their attention on the music presented during the intervention. Thereby, ruminative thinking related to the stressor task might be reduced, which could potentially enhance stress-reducing effects of music listening. As unfavourable effects of music listening might hinder its potential for stress relief, future research should investigate which circumstances facilitate their occurrence and identify the role of stress-related thoughts.

While listening to self-selected music showed no significant advantage over researcher-selected music for stress recovery, additional analyses suggest that its evaluation by the participants was more beneficial than that of the control group. Therefore, self-selected music might have an advantage in avoiding unfavourable effects of music listening. These results have implications for the application of music listening interventions. Practitioners offering music listening interventions should consider some elements of choice in the selection of musical stimuli. As defining characteristics of music that are perceived as stress-reducing remains inconclusive (Elliott et al., 2011; Tan et al., 2012) and effects appear to be dependent on contextual factors (Krause & North, 2017), paying attention to personal preferences could help to achieve effective stress reduction.

Conclusion

The presented thesis aimed at investigating the effects of music listening on the recovery from a stressor task. Specifically, it was questioned whether self-selected music has an advantage over researcher-selected music. No significant differential effects have been found regarding self-reported stress and heart rate. Moreover, the control group showed the greatest reduction in both self-reported stress and heart rate, indicating that silence might have been more suitable for recovery. However, further analyses revealed that listening to self-selected music was evaluated favourably, especially in comparison to researcher-selected music. This included ratings of liking, efficacy beliefs, and the occurrence of feelings of nuisance. Therefore, it can be concluded that letting participants select musical stimuli by themselves could help to avoid unfavourable effects of music listening. Subsequently, even though no significant differential effects were observed, self-selected music might have an advantage over prescribed music for reducing stress. At any rate, the results suggest that self-selected music has no disadvantage compared to prescribed music although musical characteristics are less controllable and might vary notably between individuals. Further research is necessary to investigate how personal music preferences interact with musical properties and contextual factors. To determine the role of self-selection in stress reducing effects of music listening, comprehensive approaches should consider both subjective and objective indicators of the stress response.

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Appendices

Appendix A. Abstract (English)

Music listening has been observed repeatedly to beneficially affect the psychological and physiological stress response. However, effective stress reduction seems to be influenced by various contextual and individual factors especially personal music preferences. Letting participants select the music by themselves allows to incorporate personal preferences into experimental studies. The objective of this thesis was to investigate the role of self-selection for the effectiveness of music listening for stress relief. Seventy-nine healthy female participants (mean age $M = 23.57$, $SD = 2.93$) completed a stress inducing procedure, the Trier Social Stress Test (TSST). Afterwards they recovered for ten minutes according to three randomly assigned conditions: listening to either a) researcher-selected music, b) self-selected music, or c) a control group without a specific acoustic stimulation. Subjective stress ratings and heart rate were measured at five timepoints throughout the procedure. It was hypothesised that the music groups, specifically participants listening to self-selected music, show greater stress reduction than the control group during recovery. No significant group differences have been found for subjective stress ratings and heart rate with the greatest average reduction in the control group. The results indicate that music listing during recovery from the TSST has no advantage for stress reduction. Additional analyses revealed that self-selected music was evaluated favourably by the participants in comparison to researcher-selected music. This leads to the conclusion that letting participants choose their own music could help to avoid adverse effects of music listening such as feelings of nuisance.

Keywords: acute stress, music listening, subjective stress, heart rate, Trier Social Stress Test (TSST)

Appendix B. Abstract (German)

Es wurde wiederholt beobachtet, dass sich Musikhören positiv auf die psychologische und physiologische Stressreaktion auswirkt. Eine effektive Stressreduktion scheint allerdings von verschiedenen kontextuellen und individuellen Faktoren abhängig zu sein, insbesondere persönlichen Musikpräferenzen. Indem Musik durch Versuchspersonen selbst ausgewählt wird, können Musikpräferenzen in experimentelle Studien integriert werden. Das Ziel dieser Arbeit war es, die Rolle der Selbstauswahl auf die Effektivität von Musikhören zur Stressreduktion zu untersuchen. Eine Stichprobe von 79 gesunden, weiblichen Teilnehmerinnen (Alter: M = 23.57, SD = 2.93) absolvierte eine Stress-induzierende Prozedur, den Trier Sozialen Stresstest (TSST). Anschließenden erfolgte eine zehnminütige Erholungsphase entsprechend drei randomisierten Bedingungen: dem Hören von a) durch die Forschenden vorgegeben Musik, b) selbstausgewählter Musik und c) eine Kontrollgruppe ohne einen spezifischen akustischen Reiz. Subjektive Stress-Ratings und die Herzrate der Teilnehmerinnen wurde zu fünf Zeitpunkten währen dem Versuchsablauf erfasst. Dabei wurde die Hypothese aufgestellt, dass Musikhören, insbesondere selbstgewählte Musik, vorteilhaft für die Stressreduktion während der Erholung sei. Es wurden keine signifikanten Gruppenunterschiede hinsichtlich subjektivem Stresserleben und Herzrate festgestellt, wobei die größte durchschnittliche Reduktion während der Erholungsphase in der Kontrollgruppe beobachtet wurde. Die Ergebnisse deuten darauf hin, dass Musikhören keinen Vorteil für die Stresserholung nach dem TSST hat. Weiterführende Analyse zeigten, dass selbstgewählte Musik positiver bewertet wurde als vorgegebene Musik. Daraus kann geschlossen werden, dass eine Selbstauswahl dazu beitragen könnte, unerwünschte Effekte von Musikhören, wie das Empfinden von Störung oder Lästigkeit, zu vermeiden.

Schlüsselbegriffe: akuter Stress, Musikhören, subjektiver Stress, Herzrate, Trier Sozialer Stresstest (TSST)

Appendix C. Telephone interview guideline

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: [redacted])

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 biologische **Geschlecht** haben Sie?

□ weiblich

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

Ausschluss anderes Geschlecht:

Vielen Dank für Ihre Antwort.
Wir sind uns bewusst, dass Geschlecht ein mehrdimensionales Konstrukt ist. Da wir jedoch im Rahmen unserer Studie biologische Daten erheben, die durch Geschlechtshormone beeinflusst werden, ist es für 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

Haben Sie eine **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** [Impftermine anstehend?]
□	□	**(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: ____

Haben Sie aktuell eine diagnostizierte **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 Testung 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, bräuchte 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 1 bis 2 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 D. Intervention evaluation questionnaire for the music groups

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

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

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

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

Appendix E. Intervention evaluation questionnaire for the control group

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

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

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

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

Appendix F. Pre-testing checklist

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Erinnerungs-Checkliste für Labortermin in der Campus-Vienna-Biocenter

Zum vereinbarten Termin werden biologische Marker im Speichel erfasst und Hautmessungen durchgeführt. Es ist daher wichtig, dass Sie bestimmte Dinge im Vorfeld beachten, um mögliche Störfaktoren, welche diese biologischen Marker und Ihre Hauteigenschaften beeinflussen können, auszuschalten.

am Ende bzw. in den Tagen nach Ihrer Menstruationsblutung

Ca. 1 Woche vor dem Labortermin

- ✓ Der Termin sollte in einem bestimmten Zeitraum Ihres Menstruationszyklus stattfinden, der gegen Ende bzw. nach der Menstruation und vor dem Eisprung einzugrenzen ist. Wir haben gemeinsam telefonisch diesen Zeitraum eingegrenzt, basierend auf dem errechneten Datum, wann Ihre Monatsblutung beendet ist. Falls jedoch Ihre Monatsblutung unerwartet wesentlich früher oder später als errechnet einsetzt, bitten wir Sie, mit der Versuchsleitung in Kontakt zu treten.

-2 Tage

Zwei Tage vor dem Labortermin

- ✓ Bitte nehmen Sie zwei Tage vor dem Termin **keine extremen körperlichen Anstrengungen** auf sich.

-1 Tag

Der Tag vor dem Labortermin

- ✓ Am Abend vor dem Labortermin und am Tag selbst bitten wir Sie, **kein Koffein und keinen Alkohol** zu konsumieren.
- ✓ Bitte treiben Sie am Tag vor dem Labortermin **keinen Sport**.
- ✓ Bitte verwenden Sie in den 24 Stunden vor der Testung **keine Lotions, Cremes, Öl, Moisturizer**, usw. auf Ihren Armen. Für die Herzratenaufzeichnung werden Sie während der Testung einen Brustgurt tragen. Bitte verwenden Sie auch in diesem Bereich keine Bodylotion.
- ✓ Bitte kauen Sie am Tag vorher und am Tag selbst **keinen Kaugummi**.
- ✓ Bitte informieren Sie die Studienleitung, falls Sie sich nicht **gesund** fühlen (akute Erkältung, Schmerzen o.ä.).

Tag des Labortermins: -1 Stunde

Am Tag des Labortermins: 1 Stunde vor dem Termin

- ✓ Wir bitten Sie, **eine Stunde** vor dem Labortermin (d.h. ab 13 Uhr) **keine Nahrung aufzunehmen** und **nicht die Zähne zu putzen** oder sich zu **duschen**.

Weiter auf der nächsten Seite

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Bitte informieren Sie das Studienteam vor Ihrem Termin, falls bei Ihnen folgende Symptome auftreten oder in den letzten 14 Tagen aufgetreten sind:

- Fieber
- Wiederholter trockener Husten
- Halsschmerzen
- Kurzatmigkeit
- Veränderung des Geruchs- oder Geschmackssinns

Zudem bitten wir Sie, das Studienteam zu informieren, sollten Sie…

…in den letzten 14 Tagen **positiv auf SARS-CoV-2 getestet** worden sein.

…in den letzten 14 Tagen engeren **Kontakt** mit einer Person gehabt haben, die mit dem Coronavirus (COVID-19, SARS-CoV-2) infiziert war (Test positiv) bzw. unter Verdacht steht, mit dem Coronavirus infiziert zu sein.

…in den letzten 14 Tagen in einem **Corona-Risikogebiet** gewesen sein.

…sich in den letzten 14 Tagen in **Quarantäne** oder angeordneter **„Selbstbeobachtung"** befunden haben.

Die Studienteilnahme erfolgt unter der **Einhaltung der Covid-19-Verhaltens- und Hygiene-Regeln der Universität Wien**. Folgende Maßnahmen und Regeln werden zur Sicherheit aller Beteiligten ergriffen:

- Einhalten des Mindestabstandes und/ oder Schutzmaßnahmen (z.B. Mund-Nasen-Schutz)
- Desinfektion und Reinigung der verwendeten Materialien
- Symptomerfassung aller Beteiligten
- Temperaturmessung aller Beteiligten
- Erfassung aller Beteiligten (Name, Datum) zum Zwecke der Rückverfolgung und Kontaktaufnahme im Falle einer Infektion

Vielen Dank für Ihr Verständnis und Ihre Mithilfe!

Appendix G. Template for list of preferred music

Musikliste

	Musik, die ich zum Entspannen höre			Musik, die mich aktiviert/motiviert	
	Name des Songs	Name des/der Künstler*in		Name des Songs	Name des/der Künstler*in
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		

Appendix H. Covid-19 confirmation

Wir bitten Sie um die umgehende Abklärung und Kontaktaufnahme bei einem Covid-19-Verdachtsfall.
Vielen Dank für Ihre Mitarbeit und Ihr Verständnis!

Falls bei Ihnen in der Woche nach der Studienteilnahme folgende Symptome auftreten:

- Fieber
- Wiederholter trockener Husten
- Halsschmerzen
- Kurzatmigkeit
- Veränderung des Geruchs- oder Geschmackssinns

oder falls Sie in der Woche nach der Studienteilnahme positiv auf SARS-CoV-2 getestet werden,

bitten wir Sie, umgehend Ihren Hausarzt oder die Hotline 1450 zu kontaktieren. Zudem bitten wir Sie, bei einem Verdachtsfall umgehend die Studienleitung zu informieren:

Studienleiter: Univ.-Prof. Dr. Urs M. Nater
E-Mail: [redacted]
Tel.: [redacted]

Oder mittels einer E-Mail an: [redacted]

Hiermit bestätige ich, dass ich die Fragen vollständig und wahrheitsgemäß beantwortet habe und verpflichte ich mich, umgehend die Studienleitung zu informieren, falls ich in der darauffolgenden Woche nach der Studienteilnahme Symptome an mir feststelle.

____ ____

Nachname, Vorname Datum, Unterschrift

Appendix I. 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. gesundheitlichen) 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 ([redacted]).

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.

Kontaktperson: Univ.-Prof. Dr. Urs M. Nater
Telefonisch erreichbar unter (Bürozeiten): [redacted]
Per E-Mail erreichbar: [redacted]

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): [redacted], Per E-Mail erreichbar: [redacted] 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 J. Pre-testing requirements questionnaire

Bitte beantworten Sie folgende Fragen vollständig und wahrheitsgemäß.
Bei Fragen wenden Sie sich jederzeit an die Versuchsleitung.

War Ihre Anreise körperlich anstrengend?

□ Ja, eher anstrengend □ Nein, eher nicht anstrengend

Wann haben Sie das letzte Mal ein koffeinhaltiges Getränk getrunken?

□ heute, um ____ Uhr □ nicht heute

Wann haben Sie das letzte Mal etwas gegessen?

□ vor weniger als einer Stunde, um ____ Uhr □ vor mehr als einer Stunde

Wann haben Sie sich das letzte Mal sportlich betätigt?

□ in den letzten 24h □ nicht in den letzten 24h

Wann haben Sie das letzte Mal Alkohol getrunken?

□ in den letzten 24h □ nicht in den letzten 24h

Fühlen Sie sich gesund?

□ Ja □ Nein

Haben Sie heute ein Medikament (z.B. Schmerzmittel) **eingenommen?**

□ Ja □ Nein

Welches?
____

Wann?________________________________

Wann waren Beginn und Ende Ihrer letzten Menstruationsblutung?

Beginn Ende (falls schon vorbei)

___/___/___ (TT/MM/JJ) ___/___/___ (TT/MM/JJ)