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„Music Empathizers Versus Music Systemizers – The Influence of Music Listening on Subjective Stress Levels"

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Contents

Introduction

Stress is a phenomenon that is quite common in our modern society. Since stress was found to negatively affect psychological and physiological wellbeing (Brinkmann, 2014), it is an important research topic. An individual exhibits stress when there are too many demands and not enough resources in order to cope with these demands (Lazarus & Folkman, 1984). There are two forms of stress: acute and chronic stress. Acute stress occurs due to an immediate threat, whereas chronic stress develops as a reaction to long-term stressors, such as social, economic, or job-related stressors (Bodenmann & Gmelch, 2009; Oxington, 2009). Acute stress is characterized by a sudden onset. On the other hand, chronic stress can be described by a gradual onset. While acute stress is often connected to new and varying demands, chronic stress is accompanied by daily routine and steady environmental conditions (Schulz et al., 2004). Acute stress can lead to outcomes such as exertion, tension, or irritability. Conversely, chronic stress is related to outcomes such as helplessness, social isolation, cardiovascular disease and reduced immune defense (Bodenmann & Gmelch, 2009; Brinkmann, 2014). In previous research, psychological stress was found to be positively correlated with social anxiety and depressive symptomatology (Cohen et al., 1983). Since many people experience stress in their everyday life (Brinkmann, 2014), it is of great importance to investigate stress-reducing mechanisms.

Music-Based Interventions

Music-based interventions have been investigated in a variety of different contexts, such as in pain treatment, sleep disturbances (Kullich et al., 2003), substance use disorder (Hohmann et al., 2017), in Parkinson's disease patients (Thaut et al., 1996), or in cancer patients (Bradt et al., 2016). Investigation on healthy populations showed that music-based interventions are associated with numerous positive effects, such as stress reduction, relaxation, as well as physiological and psychological wellbeing (Daykin et al., 2018; Jiang et al., 2016; Koelsch, 2009; Scheufele, 2000). Music-based interventions can include active approaches, such as singing or playing instruments, as well as receptive approaches, such as music listening (Janzen et al., 2019). Music listening has been found to fulfill different functions. Adaptive functions of music listening were assessed in a relatively recent study, with affect regulatory functions being the most important function of music listening. Mainly, anger regulation, anxiety regulation and stress regulation turned out to be important functions of music listening (Groarke & Hogan, 2018). Since music-based interventions are supposed to be of low risk and relatively

cost-effective (Loewy et al., 2005), they may pose an effective method in promoting wellbeing and in the reduction of stress.

Effects of Music Listening on Subjective Stress Levels

The role of listening to music and its effects on health have been subject to a lot of research. Many studies focused on the question of whether listening to music may have a beneficial effect on subjective stress levels (Helsing et al., 2016; Linnemann et al., 2015). Since psychological stress is correlated to other related terms, such as anxiety, tension, and relaxation (Davis & Thaut, 1989; de Witte et al., 2019; Osman et al., 2012), studies including these constructs are also reviewed below.

A meta-analysis (Pelletier, 2004), including 22 quantitative studies, found that music combined with relaxation techniques leads to a reduction in stress-related arousal. This reduction was found on behavioral, physiological, and self-report levels. A further review and two meta-analyses also investigated the effects of music interventions on physiological and psychological stress levels. The authors included 104 randomized controlled trials with either the psychological outcome measures of stress and (state) anxiety or the physiological outcome measures of heart rate, blood pressure and hormone levels. Their results indicated that there are positive effects of music interventions on psychological and physiological stress levels (de Witte et al., 2020).

Many studies on the relationship between music listening and stress are conducted in everyday life. In an experimental field study by Helsing et al. (2016), researchers compared participants listening to self-selected music to participants relaxing during the same time. In the first week of the study, both experimental and control group were instructed to relax half an hour after arriving home from work. The instruction for the control group did not change in the following two weeks. However, in the experimental condition, instructions for the second and third week were different. In the second week of the study, half of the experimental group participants were instructed to listen to self-selected relaxing music for 30 minutes every day after work at home. The other half listened to self-selected energizing music. In the third week of the study, participants who first listened to relaxing music were instructed to listen to energizing music, and vice versa. Results revealed that participants in the experimental condition experienced a significant reduction in subjective stress level and a reduced cortisol level from the first to the third week, compared to the control group. Concerning energizing versus relaxing music, results indicated that stress levels decreased significantly from the first

week to the week when relaxing music was listened. However, this effect could not be established with the energizing music (Helsing et al., 2016).

The influence of listening to music on subjective stress levels in university students was investigated in another study. The study included an ambulatory assessment design asking participants to rate their subjective stress levels as well as to report their music listening behavior during two different inquiry periods: at the beginning of the semester (control condition) and during the more stressful exam period at the end of the semester (exam condition). Results revealed that mere music listening led to reduced subjective stress levels. Subjective stress levels were reduced the most when the purpose of music listening was relaxation. Analysis of stress intensity demonstrated that subjective stress levels were reduced only during the control condition (Linnemann et al., 2015).

There is evidence that psychological and physiological functioning is more influenced by qualitative aspects of music listening (i.e., reasons of music listening), than by quantitative aspects of music listening (i.e., duration or relevance of music listening). Some reasons for music listening were negatively associated with psychological and physiological functioning, such as “to reduce loneliness”, “to reduce aggression” or “arousing or intensifying specific feelings” (Thoma et al., 2012).

Acute Stress

Several studies investigated the effect of music listening on acute stress. The effect of preferred soothing music on acute stress levels in nurses experiencing high levels of job-related stress was examined in a study by Lai and Li (2011). Participants underwent an alternating design of either a music and chair rest sequence or a chair rest and music sequence. The authors revealed that nurses exhibited a significantly reduced subjective acute stress level when listening to music, compared to the chair rest sequence. Physiological indicators of stress were reduced as well (Lai & Li, 2011). Another study investigated the effect of music imagery or music attention on acute stress (West, 2003). A stressor was induced and subsequently, participants were randomly assigned to one of three conditions: attention to music listening, imagery to music, or silence. In both music groups, researcher-selected music was used. Results indicated that both music groups experienced lower cortisol levels, and lower mood disturbance levels than the silence condition.

In a further study by Linnemann et al. (2016), the authors applied an ambulatory assessment design with participants reporting situations in which they listened to music. They

reported whether they listened to music alone or in the presence of others. It was found that mere music listening did not reduce acute stress when participants listened to music alone. However, when the reason for music listening was relaxation, stress-reducing effects were found. Moreover, the presence of others during listening to music was associated with reduced acute stress levels. The familiarity of the people present or reasons for music listening were irrelevant for this effect.

The effect of intense musical experiences (IMEs) on acute stress has been subject to research in a study by Schäfer et al. (2014). The authors defined an IME as intense experiences that are different from usual musical experiences in that perceptions, feelings and physical reactions are stronger than usual. Narrative interviews were conducted in which participants were asked about their IMEs and about the time that followed these experiences. Results demonstrated that during an IME, participants experienced lower anxiety and stress levels.

However, there is also research demonstrating conflicting evidence. Participants conducted a psychosocial stress test after having listened to researcher-selected music, to the sound of rippling water or after having rested in silence (Thoma et al., 2013). Cortisol levels were highest in participants listening to music and lowest in participants listening to the sound of rippling water. No significant differences in subjective acute stress levels were found between participants in the three groups. The recovery of the autonomic nervous system was faster in the music condition than in the two control conditions indicating that music might be a factor that facilitates autonomic recovery. Concerning psychological stress, the authors assumed that the stressor induced in this study might have been too strong, and thus, the music was not effective in reducing subjective stress levels (Thoma et al., 2013).

The mechanisms behind the stress-reducing effects of music listening were investigated in a study by Jiang et al. (2016). Participants rated their tension as well as their state anxiety levels. After the induction of an acute stressor, participants listened to researcher-selected music and rated valence, arousal, music preference and familiarity with the heard music. After that they reported their tension and state anxiety levels again. Results revealed that music preference, arousal and valence played an essential role in reducing acute stress and that music preference predicted stress reduction the most (Jiang et al., 2016). Similarly, another study focused on different musical features and their effect on acute stress. Sandstorm and Russo (2010) applied various kinds of music (happy, peaceful, agitated, and sad) and investigated their

impact on recovery after the induction of an acute stressor. They revealed that recovery of subjective acute stress was most effective when music had a positive valence and low arousal.

To summarize the previously discussed findings, it can be said that music listening has a positive effect on acute stress levels. However, it should also be mentioned that many studies did not explicitly reveal that they investigated the effects of music listening on acute stress. Rather, it was concluded from the methods section and the respective study's operationalization that rather acute than chronic stress was assessed.

Chronic Stress

Other studies revealed that music listening affects chronic stress levels as well. Air traffic controllers exhibiting high levels of chronic stress were subject to Lesiuk's (2008) study. The experimental group listened to 15 minutes of preferred music for two weeks during their break. During the same time, a control group sat in silence. Psychological anxiety was reduced in both groups, whereas physiological measures of anxiety were not. Narrative comments revealed that listening to preferred music was effective in stress reduction (Lesiuk, 2008). Beck et al. (2015) investigated the effect of guided imagery and music (GIM) on chronic stress levels in patients with work-related stress on sick leave. GIM included listening to researcher-selected music, guided relaxation exercises as well as imagery. In sum, six GIM sessions were applied during a period of nine weeks. The control group received standard care during the same time. Results demonstrated that self-reported chronic stress was decreased in the GIM group compared to the control group.

In conclusion, it can be said that previous research showed positive effects of music listening on chronic stress levels. Nevertheless, it is to say that there are few studies investigating the effects on chronic stress levels in everyday life. The studies discussed above rather consider work-related chronic stress than chronic stress in daily life. Furthermore, the body of research on acute stress is more extensive than on chronic stress. Since chronic stress can have severe consequences on physiological and psychological wellbeing (Bodenmann & Gmelch, 2009; Brinkmann, 2014), research should further investigate the effects of music-based interventions on chronic stress in daily life.

Researcher-Selected and Self-Selected Music

Research has shown that individuals might react differently when music is researcher-selected versus self-selected. Several studies only apply one type of music, i.e., researcher- or

self-selected music. As Helsing et al. (2016) demonstrated, participants listening to self-selected music experienced a significantly reduced stress level compared to a control group. A positron emission tomography (PET) study investigating neural mechanisms during music listening revealed that self-selected music activated brain regions responsible for emotion and reward (Blood & Zatorre, 2001). However, there is conflicting evidence concerning studies investigating the effects of researcher-selected music on subjective stress. A double blind randomized controlled trial investigated the effects of researcher-selected relaxing music on psychological and physiological parameters of stress after the induction of an acute stressor. Results revealed that heart-derived sample entropy was increased in participants listening to music, indicating that participants in the music condition were rather able to adjust to the new context. However, subjective stress levels did not differ between participants in the music condition and participants in the control condition (de la Torre-Luque et al., 2017). Literature on the effects of postoperative researcher-selected music listening on stress and anxiety levels gave evidence that participants experienced less anxiety after listening to music than the control group who rested in silence (Nilsson et al., 2005).

Additionally, there are many studies comparing researcher- with self-selected music. Burns et al. (2002) compared researcher-selected hard rock music, researcher-selected classical music, self-selected music, and a control group in terms of relaxation after the induction of a stressor. Participants in the self-selected and no music group relaxed significantly more than participants in both researcher-selected groups. Another study found that participants listening to researcher-selected classical or self-selected music experienced significantly reduced anxiety following a stressor. Furthermore, their level of relaxation was increased in comparison to the researcher-selected heavy metal and silence condition (Labbé et al., 2007). In a recent study by Groarke et al. (2020) it was examined whether there are differences in anxiety reduction after the induction of a stressor between participants listening to researcher-selected or self-selected music, to a radio documentary or participants remaining in silence. Participants in both music conditions experienced significantly more anxiety reduction than participants in the control condition. However, there was no difference in anxiety reduction between participants in the self-selected versus researcher-selected condition. Another study compared self-selected music, researcher-selected music, and a control group in terms of anxiety and relaxation. Participants listened to music or rested in silence for 15 minutes. There was no difference between the three experimental groups in their relaxation response. Anxiety was reduced significantly more in both music conditions compared to the control condition, but there was no difference between

self-selected or researcher-selected music (Thaut & Davis, 1993). One further study investigated the effect of four different music stimuli on participants' subjective responses. Two researcher-selected musical pieces, one classical and one jazz piece, as well as one "uplifting" self-selected music piece and one control stimulus, which included white noise, were compared. Results indicated that music listening in general is able to evoke mood enhancements, such as relaxation, less anxiety, greater joy and less sadness. Self-selected music was found to induce the most joy, whereas the researcher-selected classical music piece evoked the most relaxation (Lynar et al., 2017).

Considering the aforementioned studies concerning the effect of researcher- and self-selected music, it can be concluded that they both are able to reduce subjective chronic and acute stress. However, the body of literature addressing comparisons between researcher- and self-selected music on chronic stress is still rare since most of the studies focus on acute stress. Moreover, many studies do not explicitly declare whether they investigate effects on acute or chronic stress. In the future, research should therefore clearly distinguish between these two kinds of stress.

Effects of Music Listening on Physiological Stress Levels

Music listening and its effects on stress have not only been examined on psychological level, but also on physiological level (Chanda & Levitin, 2013). In some studies, physiological and psychological stress responses have been found to highly correlate (Schlotz et al., 2008), whereas the authors of a review (Campbell & Ehlert, 2012) only found correlations in 25% of the included studies. Although research is still inconclusive to what extent psychological and physiological stress are associated, in the following, research focusing on stress-related physiological effects of music listening will be briefly discussed.

Physiological effects of stress include the activation of the hypothalamic-pituitary adrenal (HPA) axis, as well as a stronger activation of the sympathetic nervous system. Thus, physiological arousal is increased leading to an increased heart rate, blood pressure and cardiac output. Furthermore, stress causes cortisol release (Brinkmann, 2014; Chanda & Levitin, 2013; Chrousos, 2009). Several studies investigating the effect of music interventions on physiological stress-related outcomes showed that music has the potential to reduce this physiological arousal, leading to decreased cortisol levels, heart rate or blood pressure (Fancourt et al., 2014; Kreutz et al., 2004; Linnemann et al., 2015). The meta-analysis by de Witte and colleagues (2020) revealed that music interventions have a small-to-medium effect

(d=.380) on physiological outcomes of stress. They included studies investigating the effects of music interventions on the physiological stress outcomes heart rate, blood pressure and stress-related hormones. As was demonstrated in a review by Chanda and Levitin (2013), music interventions can reduce β-endorphin and cortisol, hormones that are markers of the HPA axis. However, the authors also revealed that music with stimulating properties leads to, among others, an increase in plasma cortisol and norepinephrine levels, leading to feelings of pleasure. Moreover, it was demonstrated that music, compared to silence, prevents heart rate and systolic blood pressure from increasing when a stressor was induced (Chanda & Levitin, 2013).

GIM therapy was applied in a study investigating effects on mood and cortisol levels (McKinney et al., 1997). Results revealed that GIM led to decreased depressive mood, fatigue and mood disturbance. Cortisol levels were significantly reduced in the GIM conditions, even 7 weeks post-intervention. This finding underlines the assumption that music interventions are also helpful in reducing chronic stress.

Music listening was compared to music improvisation in a relatively recent study (Fallon et al., 2020). After the induction of a stressor, the Trier Social Stress Test, participants were randomly allocated to one of three conditions: music listening, music improvisation or control group. Electrodermal activity (EDA), a physiological indicator of stress, was continuously taken. EDA data showed that only in the music listening group, the physiological stress response was significantly reduced compared to the music improvisation and control group.

Eventually, it is also important to note that the physiological effects of music interventions on stress also depend on the type of music. Bernardi et al. (2009) investigated effects of different musical stimuli on cardiovascular and respiratory variables. They revealed that a synchronization between autonomic responses and music profiles occurred. In particular, blood pressure and heart rate increased proportionally to music with arousing crescendos.

In conclusion, previous research demonstrates that music interventions positively affect physiological stress-related outcomes, such as heart rate, blood pressure, cortisol levels, and EDA measures. These effects depend on the different properties of the music. Finally, music interventions have not only been found to reduce stress on subjective, but also on physiological levels.

Empathizing-Systemizing Theory

The way music is processed is of great interest and can be explained by the concept of Empathizing and Systemizing. The Empathizing-Systemizing theory was first introduced by Baron-Cohen (2002). Both Empathizing and Systemizing refer to a cognitive style explaining how a person perceives the environment. Empathizing refers to the drive to understand others' behavior, identify their emotions, and to react appropriately to them. Moreover, Empathizing includes the prediction of another person's behavior as well as caring about another person's feelings. On the other hand, Systemizing describes the drive to understand the different variables in a system and to recognize the underlying rules. Systemizing also concerns the prediction of the behavior of a system and involves the control over this behavior (Baron-Cohen, 2002). While Empathizing has its focus on human behavior, empathy and sympathy, Systemizing concentrates on lawful and deterministic phenomena (Baron-Cohen et al., 2003). Thus, Empathizing and Systemizing represent two processes that are entirely different and may be processed in different brain areas (Baron-Cohen, 2002). Neuroanatomical research on the differences between Empathizing and Systemizing found differences in brain activation responsible for these two cognitive styles. Individuals scoring high on the Systemizing brain type (S>E) were found to have a larger volume of cingulate and dorsal medial prefrontal structures. These areas are associated with error detection, cognitive control, as well as monitoring. On the other hand, individuals categorized as Empathizers (E>S) demonstrated larger subcortical regions including hypothalamus and ventral basal ganglia. These structures are connected to motivation, reward, emotion and neuroendocrine control (Lai et al., 2012).

The Empathizing-Systemizing theory has been initially associated with autism. An individual can either be brain type E (Empathizer, E>S), brain type S (Systemizer, S>E) or balanced brain type (Baron-Cohen, 2002; Baron-Cohen et al., 2002). Baron-Cohen (2002) characterized Empathizing (E>S) as a rather female property, whereas he described Systemizing (S>E) as a rather male characteristic. According to the author, individuals diagnosed with autism are characterized by the extreme form of the male brain type Systemizing (S>>E). Research in other cultures demonstrates that the Empathizing-Systemizing theory is relatively culture-independent, since these brain types were also investigated in the Japanese population (Wakabayashi et al., 2007).

Music Empathizing and Music Systemizing

The concept of Empathizing and Systemizing was also found to exist in the domain of music (Kreutz et al., 2008). The dimensions of Music Empathizing (ME) and Music Systemizing (MS) are independent of each other and thus extend the Empathizing-Systemizing theory (Baron-Cohen, 2002). As was detected in Empathizers and Systemizers, Kreutz and colleagues (2008) found a significant effect of gender meaning that females are more frequently positive Music Empathizers and negative Music Systemizers while males are more often negative Music Empathizers and positive Music Systemizers. Music Empathizers rather focus on the emotional elements of the music. On the other hand, Music Systemizers rather focus on the music's sonic properties (Greenberg et al., 2015a). Furthermore, Music Empathizers were found to listen to music with the purpose of emotion regulation, whereas Music Systemizers more often state that they listen to music in order to analyze complex structures (Kreutz et al., 2008).

Linnemann et al. (2018) investigated the Music-Empathizing-Music-Systemizing theory in a German sample and found that reasons for music listening in Music Empathizers were activation, distraction, reducing aggression, evoking or intensifying specific emotions, as well as reducing boredom or loneliness. Moreover, Music Empathizers more frequently reported experiencing chills that are evoked by music listening. Underlining the assumption that the purpose for music listening in Music Empathizers is emotion regulation, Linnemann and colleagues revealed that Empathizers listen to music in more different settings. Furthermore, Music Empathizers listen to music more often during other activities as a background sound or when meeting friends. Conversely, Music Systemizers rather listen to music to analyze complex structures. Thus, the music is their center of attention. Music Systemizers more often state that they play music themselves. Moreover, they attend classical concerts more often than Music Empathizers. Furthermore, it was found that Music Empathizers and Systemizers prefer different genres. Music Empathizers prefer rock, pop and hip hop whereas music Systemizers prefer soul/funk, hard rock, classical music and jazz/blues (Linnemann et al., 2018).

Linnemann et al. (2018) suggest that there may be a different processing of music between Music Empathizers and Music Systemizers. The authors assume that Music Systemizers might process music with an emphasis on feature extraction and consequently with an auditory analysis. On the other hand, Music Empathizers are supposed to process music with a focus on later stages during which emotional analysis is performed. During these later stages,

an activity of paralimbic and limbic brain structures can be found as well, and thus a co-occurrence of brain regions associated with emotions and stress-sensitive structures, such as the HPA axis, can be detected. As previously discussed, Empathizing has been found to be correlated with larger hypothalamic brain regions (Lai et al., 2012), and thus, the question remains to what extent ME and MS is correlated with different stress responses.

The question of which musical dimensions are preferred by Empathizers or Systemizers has been discussed in a review by Greenberg et al. (2015a). It is assumed that Empathizers prefer music with emotional, deep, reflective, romantic and gentle characteristics. On the other hand, Systemizers are assumed to prefer complex harmonic, rhythmic, and melodic patterns. Similarly, in the study by Greenberg et al. (2015b) participants were asked to complete questionnaires as well as to react to different musical stimuli by indicating their preference. Individuals high in Empathizing preferred mellow music (R&B, soul, adult contemporary or soft rock). In contrast, participants with high Systemizing scores indicated that they liked music with intense properties (punk, heavy metal or hard rock). While individuals characterized as Empathizers preferred music with low arousal, negative valance and emotional depth, Systemizers preferred music with high arousal, positive valence as well as high complexity (Greenberg et al., 2015a). Before introducing ME and MS (Kreutz et al., 2008), Chamorro-Premuzic and Furnham (2007) investigated potential correlations between characteristic traits, such as personality and ability, and uses of music. The questionnaire-based study revealed that individuals pursue three main aims for music listening: rational appreciation, emotion regulation and music as background for another activity. Correlations were found between rational music listening and openness or intellect. Emotion regulation was associated with introversion and neuroticism. Although this study does not include the concept of ME and MS, it gives an insight into different music listening behaviors and their potential correlates.

In summary, it can be stated that Music Empathizers and Systemizers listen to music for different purposes and have different preferences for musical genres. However, research on ME and MS is still rare, especially the influence of each cognitive style on the subjective stress response, and more research in this area should be conducted. Since Music Empathizers and Systemizers have different reasons for music listening, as well as different music listening behaviors which are, in turn, correlated with different personality factors and activation of brain areas, it might be possible that their responses to music, in particular their stress response after listening to music differs as well.

Emotion Regulation, Stress and Self- or Researcher-Selected Music

Music listening has often been connected to emotion regulation. In particular, research demonstrated that Music Empathizers listen to music intending to regulate emotions. To the best of my knowledge, direct associations between ME, MS, stress and self- or researcher-selected music have not yet been investigated. However, there is a lot of research on music and emotion regulation that might give insight into this association. In the following, research focusing on the connection of emotion regulation, empathy, stress and listening to music will be discussed. Often, research uses the terms emotion, mood and affect interchangeably (Ekkekakis, 2013), and therefore, studies investigating the connection between music and mood regulation or affect regulation will be reviewed as well.

The relationship between empathy and music-induced emotions has been investigated in a study by Miu and Balteş (2012). High empathy was experimentally induced by asking participants to empathize with the performer. Contrary, in the low empathy condition participants were asked to focus on the content of the music in order to induce low empathy levels. Participants watched two different videos of operatic arias with the valences sad or happy. Results demonstrated that induced cognitive empathy elicited physiological activity as well as emotions induced by the music. Furthermore, it was found that the induced emotions in the high empathy condition were strongly correlated with the valence of the music (Miu & Balteş, 2012). Thus, the more empathy an individual has with the music, the more congruent emotions are induced by this music.

Empathy and neurophysiological correlates during music listening have been investigated in a relatively recent study by Wallmark et al. (2018). Participants listened to familiar liked, familiar disliked, unfamiliar liked and unfamiliar disliked music. Trait empathy was assessed via a questionnaire. Results demonstrated that empathy was correlated with the liking of unfamiliar music. Functional magnetic resonance imaging (fMRI) data revealed that the liking of the musical excerpts were associated with brain areas involved in reward. The familiarity of the music led to the activation of large cortical regions, among others, the core empathy network. This association was stronger in individuals with high trait empathy scores. Furthermore, high-empathy participants showed a higher activation of neurophysiological areas connected to executive control, regulation of emotions, mentalizing and cognitive empathy. When listening to familiar music, they experienced an activation of the dorsal striatum, a brain area associated with empathy and musical pleasure. The authors concluded that high-empathy individuals, compared to low-empathy individuals, experience more reward and motivation

during listening to familiar music (Wallmark et al., 2018). These results might lead to the assumption that Music Empathizers experience a stronger response to familiar self-selected music than Music Systemizers. Furthermore, the study by Wallmark et al. (2018) revealed that high empathy was correlated with the liking for unfamiliar music suggesting that Music Empathizers also experience a stronger response to unfamiliar researcher-selected music than Music Systemizers. Similarly, a further fMRI study investigated the association between familiarity and preference for music and neurophysiological correlates (Pereira et al., 2011). Results revealed that rather familiarity, than the preference for the music was relevant for the activation of emotion-related brain areas. The authors concluded that familiarity with music is the key factor for musical appreciation as well as the activation of brain areas related to emotion (Pereira et al., 2011). Additionally, a review including 50 studies on emotion regulation and neurophysiological correlates demonstrated that musical stimuli considered as complex are associated with the activation of the amygdala (Moore, 2013). This suggests that Music Systemizers, who were found to prefer complex music (Greenberg et al., 2015b), are more likely to experience an activation of the amygdala when listening to preferred self-selected music. On the other hand, emotion regulation, especially the reappraisal of negative emotions, has been found to decrease the activation in the amygdala (Ochsner et al., 2002).

Many studies are focusing on music and emotion regulation. A study by Saarikallio and Erkkilä (2007) investigated different mood regulation goals in adolescents. The authors conducted semi-structured interviews and follow-up assessments in which participants recorded their daily music-listening experiences and possible changes in their mood state after listening to music. Mood improvement as well as mood control were found to be the most important regulatory goals when adolescents listened to music. The authors concluded that mood control, in turn, might be related to personal control (Saarikallio & Erkillä, 2007). Self-selected music is connected to self-control (Groarke & Hogan, 2019), and thus might also be connected to mood regulation. Troy and Mauss (2011) identified emotion regulation as a protective factor for stress. Taken together, these results underline the assumption that Music Empathizers, using music for emotion regulation goals, might reduce more stress when listening to self-selected music than Music Systemizers. This assumption is supported by further research. Several studies also support the idea that music listening is a successful method in affect regulation. Groarke and Hogan (2019) applied a randomized controlled trial in which participants were either assigned to a self-selected music condition or a control condition. Participants in the self-selected music condition provided 15 minutes of music they usually use in stressful moments,

whereas participants in the control condition listened to 15 minutes of a researcher-selected radio documentary. Music listening versus listening to the radio documentary took place after the first part of the induced stressor and before the announcement of the second part of the stressor. Participants rated their affect via a visual analog scale. Results revealed that music listening was more effective in affect regulation than listening to a radio documentary. Moreover, the authors concluded that self-selected music might be more effective in affect regulation than a researcher-selected radio documentary due to personal control that participants might experience. According to the authors, experienced control could be important for coping with a stressor (Groarke & Hogan, 2019). Therefore, it might be again assumed that self-selected music leads to more emotion regulation, in particular in Music Empathizers, and in turn, to stress reduction (Troy & Mauss, 2011). Literature on researcher-selected music is less extensive, but since emotion regulation, which is more predominant in Music Empathizers, was identified as a protective factor for stress (Troy & Mauss, 2011), it can be assumed that Music Empathizers exhibit more stress reduction than Music Systemizers when listening to researcher-selected music.

Affect regulation has been subject to research in another study by van Goethem and Sloboda (2011). The diary study focused on everyday music listening situations and mechanisms of affect regulation. Participants recorded cases in which they listened to music and how they felt before and after these listening periods. Furthermore, it was investigated which affects participants tried to regulate. The findings demonstrated that music listening was successful for affect regulation and that many different affects were regulated. The most essential affects to be regulated were stress and sadness. These affects were regulated with the intention to achieve happiness and relaxation. Again, these results underline the assumption that Music Empathizers might reduce more stress than Music Systemizers when listening to self- and researcher-selected music.

Troy and Mauss (2011) revealed that emotion regulation is a protective factor for stress. Especially cognitive reappraisal, an adaptive emotion regulation strategy, was identified as a protective factor for stress (Troy et al., 2010). Furthermore, research on self-selected music demonstrated that self-selected music is preferred by individuals and this preference in turn has been found to help regulate emotions and mood (Schäfer, 2016). Taken together, Music Empathizers listen to music with the purpose of emotion regulation and thus they might reduce more stress when listening to self-selected music than Music Systemizers. Moreover, since Blood and Zatorre (2001) revealed that self-selected music activated brain regions responsible

for emotion, Music Empathizers, processing music on the emotional level, might reduce more stress when listening to self-selected music than Music Systemizers. Concerning researcher-selected music, the literature is less extensive. However, there is evidence that Music Empathizers and Systemizers exhibit different music listening styles and listen to music for different purposes (Linnemann et al., 2018). Furthermore, research on Empathizers and Systemizers showed different brain areas that are activated (Lai et al., 2012). Music Empathizers prefer music with low arousal and Music Systemizers prefer music with high arousal (Greenberg et al., 2015a). Since Music Empathizers pursue the target of emotion regulation which is a protective factor for stress (Troy & Mauss, 2011), it can also be assumed that Music Empathizers experience more stress reduction than Music Systemizers when listening to researcher-selected music.

Summary

To summarize, it can be stated that music listening in general is related to stress reduction (de Witte et al, 2020). Both acute and chronic stress were found to be reduced by music listening interventions (Lai & Li, 2011; Lesiuk, 2008). Furthermore, listening to self-selected music, as well as researcher-selected music were able to reduce subjective stress (Labbé et al., 2007). Research on physiological measures of stress showed that music-based interventions reduced heart rate, blood pressure and stress-related hormones (de Witte et al., 2020). Moreover, listening to self-selected music activated brain regions that are important for emotion (Blood & Zatorre, 2001). Processing of music can be explained by two cognitive styles of music listening: ME and MS. This theory is an extension of the Empathizing-Systemizing theory proposing that Empathizers have the drive to understand and predict the behavior of others and to react appropriately to them, whereas Systemizers have the drive to understand and predict the different variables in a system and to recognize the underlying rules (Baron-Cohen, 2002). Accordingly, Music Empathizers and Music Systemizers use music differently (Linnemann et al., 2018). The purpose for Music Empathizers to listen to music is emotion regulation. Music Systemizers listen to music in order to analyze complex structures (Linnemann et al., 2018). Emotion regulation, in turn, is connected to stress reduction (Troy & Mauss, 2011). Self-selected music is connected to preference for this music and to emotion regulation (Schäfer, 2016). Thus, it might be possible that Music Empathizers reduce more stress – acute and chronic – when listening to self-selected music than Music Systemizers. Concerning researcher-selected music, it can be stated that Music Empathizers listen to music with the purpose of emotion regulation (Linnemann et al., 2018) which is a protective factor

for stress (Troy & Mauss, 2011). Empathizers experience higher levels of empathy (Baron-Cohen, 2002), resulting in higher liking ratings for unfamiliar music (Wallmark et al., 2018). Furthermore, Music Empathizers and Music Systemizers exhibit different music listening styles (Linnemann et al., 2018). Taken together, it can be assumed that Music Empathizers reduce more stress – acute and chronic – than Music Systemizers when listening to researcher-selected music. Music listening is a cost-effective method and has low risk (Loewy et al., 2005) and since it has been found to reduce stress effectively, further investigation in this area should be conducted.

Limitation of Previous Research and Research Gap

Limitations of previous research are first of all that many of the studies do not explicitly declare whether acute or chronic stress is assessed. Since acute and chronic stress have different health outcomes (Bodenmann & Gmelch, 2009; Brinkmann, 2014), future research should differentiate between these two types of stress.

A further limitation of previous research is that many studies concerning acute stress involve the induction of an acute stressor, such as the Trier Social Stress Test. This stressor is supposed to be a relatively strong stressor (Thoma et al., 2013), and thus it would be interesting to assess the effect of music listening on acute stress without the artificial induction of a stressor.

Concerning chronic stress, it can be concluded that there are only a few studies observing the effect of music listening on chronic stress levels, compared to studies observing the effects on acute stress levels. Mostly, studies assessing chronic stress involve work-related chronic stress. However, chronic stress can also be caused by physical, social, ecological or economic stressors (Bodenmann & Gmelch, 2009). Therefore, future research should also assess chronic stress that applies to all of these stressors instead of only applying to the work-related setting.

Moreover, there are a lot of studies that include music listening over a short period of time. In fact, many of them only include one music listening session. Therefore, the effect of a music listening intervention over a longer period of time on subjective acute as well as chronic stress levels should be observed.

Finally, it can be concluded that there is a lot of research concerning the relationship between music listening and subjective stress, as well as music listening and emotions, but to

date, the concept of ME and MS in relation to acute and chronic stress after listening to researcher- or self-selected music has not been studied.

Study Aim and Hypotheses

Considering the aforementioned limitations of previous research and the research gap in the ME-MS literature, this present study aims to investigate the effects of a music listening intervention – comprising ten sessions within a period of three weeks – on acute and chronic stress in Music Empathizers and Music Systemizers. The research question is as follows: Is the reduction of the subjective chronic and acute stress level after listening to self- or researcher-selected music stronger in Music Empathizers than in Music Systemizers? The hypotheses are the following ones:

H1: The reduction of the chronic stress level after listening to music is stronger in Music Empathizers than in Music Systemizers.

H1a: The reduction of the chronic stress level after listening to self-selected music is stronger in Music Empathizers than in Music Systemizers.

H1b: The reduction of the chronic stress level after listening to researcher-selected music is stronger in Music Empathizers than in Music Systemizers.

H2: The reduction of the acute stress level after listening to music is stronger in Music Empathizers than in Music Systemizers.

H2a: The reduction of the acute stress level after listening to self-selected music is stronger in Music Empathizers than in Music Systemizers.

H2b: The reduction of the acute stress level after listening to researcher-selected music is stronger in Music Empathizers than in Music Systemizers.

Methods

Study Design

This current study is embedded in a larger research project with an experimental design including randomized controlled trials with three conditions: frequency-modulated researcher-selected music, unmodulated researcher-selected music, and unmodulated self-selected music (Feneberg et al., 2020). The present study only includes unmodulated self-selected and unmodulated researcher-selected music. This is due to the assumption that frequency-

modulated researcher-selected music is not comparable to unmodulated researcher-selected music and therefore would lead to a distortion of data. This method section clearly focuses on the relevant measurements and parameters of the present study, but also briefly outlines parameters of the overall project in order to convey an impression of this whole project. Participants attended 13 assessments that took place in the laboratory of this study. Assessments included baseline, post, follow-up assessments as well as ten assessments during the intervention period. The intervention period took place within a period of three weeks. In December 2016, testing of participants started in Marburg, Germany. After one year of data collection, in January 2018, the laboratory moved to Vienna, Austria. In Vienna, data collection was resumed in October 2018 (Feneberg et al., 2020).

Participants

Inclusion Criteria

In this experiment men and women within an age range of 18 to 35 years took part. The inclusion criteria for participation were a body mass index between 18.5 and 30 kg/m², speaking fluently German and having a regular menstrual cycle. Furthermore, participants should have been able to come to the laboratory for 10 intervention appointments within a period of three weeks. Inclusion criteria were assessed via self-report.

Exclusion Criteria

Exclusion criteria were having perfect pitch, being a professional musician or doing music-related studies, as well as suffering from a hearing impairment, such as tinnitus or hearing loss. Furthermore, there were several exclusion criteria concerning physical and mental health: cardiovascular disease, artery occlusive disease, hyper-/hypotension, diabetes, extreme visual impairment, chronic pain condition, Raynaud's syndrome, irregular menstrual cycle, pregnancy or breastfeeding, inability to refrain from smoking for more than 2.5 h, regular and problematic alcohol consumption, regular intake of pain medication and/or psychotropic drugs, mental disorders (major depression, anxiety disorder, eating disorder, substance abuse, psychosis, schizophrenia, bipolar disorder), premenstrual syndrome and the inability to self-identify as a man or woman. These exclusion criteria were assessed via self-report.

The overall project, in which this current study was embedded aims to test 30 participants per condition so that all three conditions together aim to comprise 90 participants. Data collection of the overall project is not yet completed. However, this current study's data

collection was determined for a particular time period that has already been completed. As explained above, only participants in the unmodulated self-selected and unmodulated researcher-selected music conditions were included in this study. As only the unmodulated conditions were used for analysis in this study, in the following, these conditions will be referred to as self-selected and researcher-selected music. Seventeen participants took part in this study. Three participants were considered as dropouts since they did not complete all questionnaires. Consequently, these participants were excluded. Participants had an age range between the ages of 20 and 33 (M = 24.86; SD = 3.98). Nine participants were female (64.3%), 5 were male (35.7%). Six participants were allocated to the self-selected music condition (42.9%), 8 were allocated to the researcher-selected music condition (57.1%). Since the participants' testing started in Marburg and the laboratory moved to Vienna after one year of testing, seven participants were tested in Marburg (50%) and the other seven participants were tested in Vienna.

Recruitment, Screening and Instructions

Participants were recruited via advertising on different social media sites, on public notice boards and via announcements in university courses. A flyer, which can be seen in the appendix, was used to advertise the study. An e-mail address which was specially set up for study purposes, was indicated on the flyer. Potential participants got in touch with the study team by sending an e-mail. After participants were recruited, they were asked to take part in a telephone screening in order to verify their eligibility based on inclusion and exclusion criteria. The telephone screening was composed of two different parts. At first, a screening interview was conducted in which participants provided information about their mental and physical health. If participants met the inclusion criteria, the second part of the telephone screening took place during which participants were given further information about the study. Participants were informed that they get a financial compensation of 80€ if they take part in the study. If participants dropped out earlier, they received proportionate compensation. After the telephone screening, participants were sent an e-mail with further information about the study as well as an online link. This link led to an online survey which included several questionnaires assessing, among others, chronic stress via the Screening Scale for Chronic Stress, SSCS (Schulz et al., 2004), and music empathizing/music systemizing via the Music-Empathizing-Music-Systemizing (ME-MS) inventory (Linnemann et al., 2018). Furthermore, additional inclusion and exclusion criteria were assessed.

Participants were asked to fill out the questionnaires before their first appointment at the laboratory. If participants fulfilled all inclusion criteria and did not meet any of the exclusion criteria, they were included in the study. They were sent informed consent which they were asked to sign during the first appointment at the laboratory. If any of the exclusion criteria applied, they were excluded from the study, but received corresponding financial compensation for their time investment. After having filled out all online questionnaires, participants were randomly assigned to one of the three conditions: unmodulated self-selected, unmodulated researcher-selected and frequency-modulated researcher-selected music. Participants were then invited to come to the laboratory for a baseline appointment. They received an e-mail with important instructions for the appointments at the laboratory. These instructions included that participants should not take any analgesic medication on the days of study assessments. Furthermore, participants should not consume alcohol, energizing beverages or food and they should not smoke one hour prior to study assessments. Moreover, they were asked not to do excessive exercise or relaxation techniques one hour prior to the assessments. In order to feel comfortable during the music listening sessions, participants should wear comfortable clothes. These instructions were given to prevent biases in behavioral measures.

Randomization

Participants were randomly allocated to one of the three conditions. Randomization was conducted by researchers who had no interaction with the participants to ensure blinding of the experimenter. Block randomization with varying block lengths of 3,6 and 9 was stratified by gender. There were 90 notes that resulted from randomization. These notes were separately put in envelopes that were stowed away in a locker. After screening and inclusion of new participants, an envelope was drawn by the independent researcher. Information about the condition to which the participant was allocated to was communicated to the scientific co-worker who was responsible for the music during the intervention period.

Blinding

As already mentioned above, the present study was part of an overall project with three different conditions (Feneberg et al, 2020). Although only two of these conditions were part of the present study, in the following, it will be briefly depicted how blinding in this project worked. Participants received the information that they would either be allocated to the frequency-modulated or the unmodulated condition, irrespective of whether music was self- or researcher-selected. However, they were blind concerning their condition – frequency-

modulation or no frequency-modulation – in order to ensure that they were not influenced by their response behavior. Researchers interacting face-to-face with the participants were blinded, too. They only knew if participants were in the self-selected music condition since they transferred the music from their memory stick on the study server. If participants were in the researcher-selected condition, researchers interacting with the participants did not know whether the music was frequency-modulated or unmodulated. The scientific co-worker who was responsible for the music during the intervention period, was informed by the researchers who conducted the randomization, to which condition the participants were allocated. The scientific co-workers were concealed behind a room divider to ensure that neither the researcher nor the participant could guess the condition he or she was allocated to.

Procedure

All assessments were scheduled between 12 and 6 pm. This was due to previous findings showing an influence of chronobiologic rhythms on pain and stress (Hagenauer et al., 2017; Sammito et al., 2016). Baseline and post appointments were scheduled close to the intervention period. The study flow is presented in figure 1. Each session started with a questionnaire assessing the behaviors mentioned above, e.g., if participants took analgesic medication, or smoked less than one hour prior to the appointment etc. Moreover, participants were asked if they were currently more stressed than usual, had poor sleep quality or a shorter sleep duration during the night before the assessment, or if they were currently ill.

Baseline Appointment

At the first appointment in our laboratory, participants were welcomed, were offered some water and the experimenter asked whether the mobile phone was switched off. Information concerning the study was given and participants signed the informed consent. Psychological and biopsychological measurements were taken which are not relevant for the present study, and thus are not explained further. After having assessed all relevant data, ten music listening appointments were arranged that should be closely scheduled to the baseline appointment.

Music Listening Intervention

The music listening intervention included ten appointments with an overall duration of three weeks. The appointments started as explained above, i.e., by welcoming the participants,

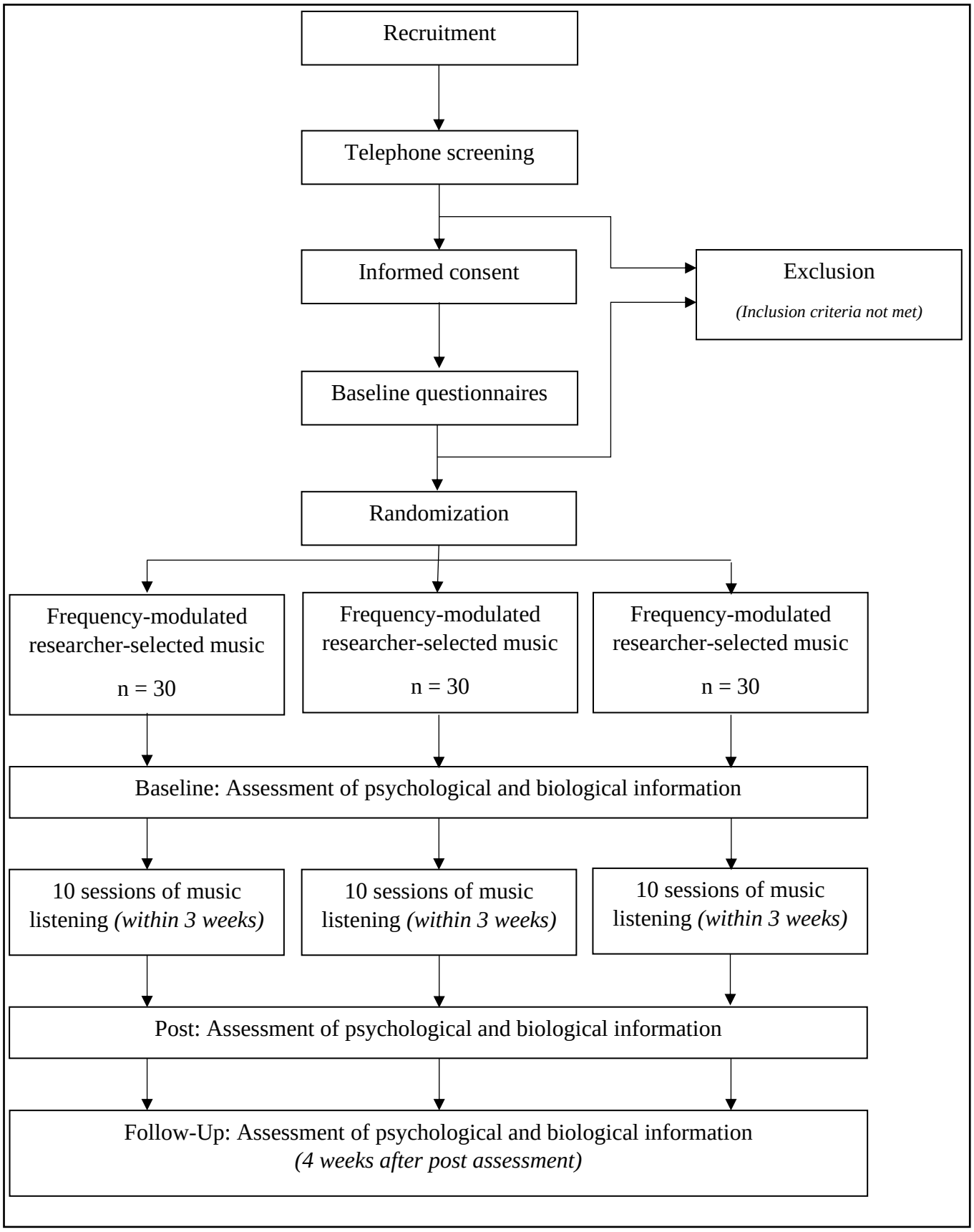

Figure 1. Study Flow of the Superordinate Research Project

offering some water and going through the questionnaire mentioned earlier and another questionnaire concerning the participants' recent music listening behavior. At appointments 1, 3, 6 and 10, biopsychological measurements were taken, as well as a test to induce pain. Since these measurements are not relevant in this study, they will not be explained further. Welcoming of participants and assessing the first questionnaires took place in the first room of the laboratory. After that, the examiner led the participant to a second room, where the music listening intervention took place. Participants were asked to sit on a lounge chair and were given instructions concerning the music listening session. They filled out some more questionnaires, including the visual analog scale, VAS, assessing their acute stress level. Subsequently, they put on headphones provided for music listening. When the music started, they were asked whether they would like to have the volume changed. The scientific co-worker sat behind a room-divider in order to ensure double-blinding of participant and examiner (only relevant in the researcher-selected conditions, as can be seen in the section *Blinding*) and did not interact face-to-face with the participants. He or she started the music and changed the volume if required. The examiner left the room for 60 minutes during which the participant listened to the allocated music. After the music listening session, the examiner entered the room again and asked the participant to complete some questionnaires again. In order to assess acute stress, the VAS was filled a second time. The participant left the second laboratory room and the examiner explained that the session was completed.

Post Appointment

Several days after the music listening period, a post appointment was scheduled. The purpose of this appointment was to assess the effects of the overall music listening intervention. The post appointment was similar to the baseline appointment. Among other questionnaires, the SSCS was assessed to measure chronic stress again.

Follow-Up Appointment

The follow-up appointment was scheduled four weeks after the post appointment. This appointment, again, was similar to the baseline appointment. Chronic stress was assessed another time in order to measure long-term effects of the music listening intervention. After all data were assessed, participants were debriefed concerning their music listening condition, as well as the aims of the study. Furthermore, they were informed that the financial compensation of 80€ would be transferred to their bank account.

Materials

Listening to music was provided via over-ear headphones (beyerdynamic, Heilbronn, Germany). Headphones were connected to two different computers that either played unmodulated self-selected and unmodulated researcher-selected music or frequency-modulated researcher-selected music. Music was presented via a music-delivery system. This system was implemented in a computer, located in a wooden case, that was equipped with a touch display and an amplifier. Music was played via Windows media player software.

Laboratory

As already pointed out in the *Procedure* section, there were two rooms relevant for the testing of participants. These rooms were located in the basement of the Faculty of Psychology at the University of Vienna. The first room served to welcome participants and to assess most questionnaires, among others the SSCS. Furthermore, equipment for the measurement of biopsychological data was applied and the pain test was conducted in this room. In the second room, participants listened to music and filled out some more questionnaires, i.e., the VAS. The scientific co-worker who was responsible for the music was concealed behind a room divider to ensure blinding of participants and examiner.

Music Listening

The intervention period included ten sessions of music listening conducted within a time period of three succeeding weeks. Participants listened to music for 60 minutes each music listening session. Before and after each session, approximately 10 to 20 minutes were needed to welcome participants, give instructions to them and to collect additional data. During each music listening session, the instruction for participants was to remain seated on a lounge chair for 60 minutes and listen to the music via headphones. Each participant listened to the music they were allocated to.

The unmodulated researcher-selected music was part of the so-called *Audiovisuelle Wahrnehmungsförderung* – or *Audiovisual Perception Enhancement* in English (Feneberg et al., 2020) – which is a music listening intervention thought to reduce pain and stress (Olbrich et al., 2015). However, in contrast to the frequency- modulated researcher-selected music, no frequencies were modulated in the unmodulated condition.

In sum, there were six music mixes chosen that included different musical genres, such as classical, instrumental, pop, rock, and world music. Table 1 presents the different albums

played in music listening sessions 1-10. Half of the music mixes were compositions specially designed for the *Audiovisual Perception Enhancement* method and the other half were compositions by known musicians. Since there were only six music mixes, four of these mixes were presented twice during the intervention period. Music was listened via headphones connected to a computer with Windows media player software that did not modulate frequencies.

Table 1

Music Played During Music Listening Sessions 1-10

Music listening session	Title of album	Artist
1	Well-balanced	Oliver Shanti
2	AVWF Classics I	AVWF
3	QE2; Earth Moving	Mike Oldfield
4	Violin Volume I	AVWF
5	The Beatles	Munich Symphonic Sound Orchestra; Classic Dream Orchestra
6	See session 1	
7	See session 4	
8	See session 5	
9	See session 3	
10	Guitar I	AVWF

Participants in the self-selected music condition were asked to bring music with a duration of 120 minutes to the baseline appointment. The instruction was that the music should be their favorite music and that it did not need to meet any criteria. Participants brought the music on a memory stick. During the baseline appointment, this music was copied to the study server. Each music listening session, self-selected music was presented in a different order. Therefore, in each session a screenshot was taken that demonstrated the respective order of the musical pieces.

The frequency-modulated researcher-selected music, that is not relevant in the present study, included the same pieces as depicted in table 1. However, frequencies in this condition were modulated by filtering the harmonic overtones.

Outcome Measures and Operationalization

The relevant variables in the present study include subjective stress measures – acute and chronic – as well as the cognitive style of music listening, ME and MS.

Chronic Stress

Chronic stress was measured via the Screening Scale for Chronic Stress (SSCS; Schulz et al., 2004), including 12 items. This scale is a short version of the Trier Inventory of Chronic Stress that includes nine subscales with 57 items (TICS; Schulz et al., 2004). The TICS originally included nine subscales: Work Overload, Social Overload, Pressure to Perform, Work Discontent, Excessive Demands from Work, Lack of Social Recognition, Social Tensions, Social Isolation, and Chronic Worrying. Items of the SSCS include only five of the original nine different stress subscales: Chronic Worrying, Work Overload, Excessive Demands from Work, Social Overload, Lack of Social Recognition. The items were chosen based on the items that showed the highest loadings on the unrotated first factor of the TICS. The SSCS subscales Chronic Worrying (r = .87), Work Overload (r = .73), Excessive Demands from Work (r = .81), Lack of Social Recognition (r = .68) correlated moderately to high with the nine subscales of the original TICS. Only the subscale Social Overload (r = .45) correlated low with the original subscales. Concerning psychometric properties, the SSCS shows high reliability of r = .887. The internal consistency of the SSCS can be reported with a Cronbach's α = .91.

Participants were asked to fill out the SSCS within the online survey before the baseline appointment and during post and follow-up assessments for the purpose of investigating the long-term effects of the music listening intervention. They were asked how often they experienced a specific situation within the past three months with a five-point-rating scale as possible answers (0 = "never", 1 = "rarely", 2 = "sometimes", 3 = "often", 4 = "very often"). An example of an item of the English version of the SSCS is: "Sometimes I feel overburdened by my responsibilities toward others." (Petrowski et al., 2018).

Acute Stress

Acute stress was measured before and after each music listening session via the VAS. This is a single-item questionnaire in which participants are supposed to rate the sentence "I am feeling stressed". They were asked to indicate their current stress level by marking a position on a continuous scale between 0 (not stressed at all) and 100 (maximally stressed) that has a

length of 100mm. The distance in mm to the beginning of the scale is taken as an indicator for acute stress. The VAS can be seen in the appendix. An advantage of the VAS that has been previously reported is that it represents a relatively quick and straightforward method to determine stress. Furthermore, thanks to its visual properties, misunderstandings due to communication problems can be avoided (Lesage et al., 2012). Psychometric properties demonstrated good performance with a significant correlation of the VAS and the Perceived Stress Scale (PSS-10; Pearson's correlation coefficient $r = 0.58$). The VAS and the Brief Stress Assessment Scale were significantly correlated with a Pearson's correlation coefficient of $r = 0.61$ (Barré et al., 2017).

Music-Empathizing-Music-Systemizing

The third relevant variable for the hypotheses of the current study is Music Empathizing and Music Systemizing, measured via the ME-MS Inventory. This inventory was presented only once in the online survey before the baseline appointment. The ME-MS inventory was introduced by Kreutz et al. (2008) with the purpose to extend the E-S theory (Baron-Cohen, 2002) to the domain of music. Linnemann and colleagues (2018) translated the questionnaire into German. This questionnaire was used in the present study. As Kreutz et al. (2008), Linnemann et al. (2018) found that ME and MS represent two distinct dimensions of music processing. The short version of the ME-MS has shown acceptable internal reliability with a Cronbach's $\alpha = .75$ for the ME scale and a Cronbach's $\alpha = .78$ for the MS scale. In the present study, the long version of the ME-MS inventory was used with the ME scale comprising 24 items and the MS scale comprising 21 items. Additionally, four Empathizing items, as well as four Systemizing items from the original E-S questionnaire (Wakabayashi et al., 2006) were part of the ME-MS questionnaire. Nineteen of the items were negatively stated in order to minimize a bias due to a decrease of attention. An example of an item of the original English version of the ME scale is: "I often experience physical sensations such as tears, shivers etc., when listening to certain pieces of music." The MS scale includes items such as: "Music performance is only important in as much as it underlines the structure of the composition."

Exclusion of Participants

Those participants who did not complete every questionnaire (ME-MS inventory, VAS, SSCS), were excluded from analysis in the present study. First of all, this decision was made due to the reason that the categorization of participants to ME or MS was highly relevant for the hypotheses. Furthermore, especially the development of chronic stress (baseline to post to

follow-up assessment), as well as of acute stress (pre- to post-measures) were relevant for the hypotheses.

Statistical Analysis

In order to test all four hypotheses (1a, 1b, 2a, 2b), ME-MS scores were calculated for each participant. Thus, participants were classified as either Music Empathizers, Music Systemizers or balanced brain types. Following Linnemann et al. (2018), ME-MS scores were calculated by using the difference score ME-MS. Based on the raw sum scores of the ME and MS scales, for each participant the mean of the MS score was subtracted from the mean of the ME score. The resulting score is called difference score. A high difference score indicates that the ME score is high, whereas the MS score is low, or vice versa. On the other hand, a low difference score indicates that ME and MS scores do not differ a lot. A person can be characterized by the ability of ME if the difference score is high in a positive direction. Vice versa, a person can be characterized by the ability of MS if the difference score is high in a negative direction. Cut-off values for ME, MS and balanced brain types were calculated by using the distribution of the difference score among all participants. Participants with a difference score in the range of ±1 SD around the mean of the difference score of the total sample, were characterized as balanced brain types. Participants with a difference score lower than ≤-1 SD below the mean of the difference score of the total sample were classified as Music Systemizers. If a difference score was higher than ≥+1 SD above the mean of the difference score of the total sample, this participant was characterized as a Music Empathizer. Extreme Music Systemizers were participants with a difference score lower than -2 SD below the mean of the difference score of the total sample. According to that, participants were classified as Extreme Music Empathizers if they showed a difference score higher than +2 SD above the mean of the difference score of the total sample.

In the present study, the mean of the difference score ME-MS in the total sample was 0.34 ± 0.35. The difference score in the total sample had a range from -0.44 to 0.75. Based on this distribution, cut-off values were calculated. One participant was classified as an Extreme Music Systemizer, one participant was classified as Music Systemizer. Two participants were categorized as Music Empathizers. Ten participants were balanced brain types. Due to the reason that the sample size in this study was very small and most of the participants could not be assigned to one of the brain types ME or MS, it was decided that a single case study was conducted. In sum, four participants were included: the two Music Empathizers as well as the Music Systemizer and the Extreme Music Systemizer.

To evaluate the chronic stress level of each participant (hypotheses 1a and 1b), raw sum scores of the SSCS scale for each participant were calculated. Since the SSCS was assessed three times - at baseline, post and follow-up appointment - three different SSCS raw sum scores were calculated. The higher the sum scores, the more chronic stress is experienced by an individual. Increases or decreases of chronic stress levels over time were calculated by using percentage increases or decreases from baseline to post assessment and from baseline to follow-up assessment.

The acute stress, operationalized via the VAS, was calculated for each participant as follows: the distance in mm from the beginning of the scale to the point where the participant marked his or her individual stress level was used as an indicator of how stressed the participant was. This score was measured before and after each music listening session, so for every participant, 20 VAS scores were calculated – two for each of the ten music listening sessions. For each participant, mean scores of VAS before music listening as well as after music listening over the whole intervention period were calculated. As explained above, increases or decreases of acute stress levels after each music listening intervention, were calculated by using percentage increases or decreases from pre to post music listening.

Ethical Considerations

As already mentioned in the *Study Design* section, the overall project started in Marburg, Germany, and after one year of data collection, was resumed in Vienna, Austria. Both Local Ethics Committees, at the Department of Psychology at the University of Marburg (2016-27k), as well as at the University of Vienna (00331) granted their approval for the study. Participation in the study was exclusively voluntary. Participants learned that they could exit the study at all times without consequences. Prior to the beginning of the study, each participant received information concerning the procedure and the overall aims of the study. Participants gave informed consent prior to the start of data collection. They were informed that they received 80€ as financial compensation. If they dropped out earlier from the study, they still received financial compensation, adjusted to their time investment. In order to ensure anonymization of the participants, participant codes were used that were assigned to the participant and subsequently used throughout the whole study. After participants completed the study or if they dropped out earlier, they were debriefed and were informed about the condition they were allocated to. Finally, they were asked to give feedback concerning the overall study.

Results

As explained above, a single case analysis was conducted. The reason for this was the small sample size, as well as the fact that most of the participants were not explicitly characterized as Music Empathizers or Music Systemizers, but rather in between. The distribution of ME-MS scores can be seen in table 2.

Table 2

Distribution of the ME-MS Difference Score in the Total Sample

Participant	ME-MS Difference Score
19001	-.44
19010	-.16
19005	.00
19014	.23
19009	.27
19012	.27
19015	.40
19026	.42
19022	.52
19018	.54
19002	.65
19011	.69
19027	.71
19023	.75

Note. The mean of the ME-MS difference score in the total sample was 0.34 ± 0.35

The four participants with the most extreme expression of ME-MS were included in the single case analysis. Participant 19001 and participant 19010 self-identified as Music Systemizers, whereas participants 19027 and 19023 self-identified as Music Empathizers. Half of the participants listened to self-selected music. The other half listened to researcher-selected music. Thus, the data of the Music Empathizers and Music Systemizers in both conditions could be compared. Sum scores of the SSCS are used to depict chronic stress.

Acute stress is described by using the distance from the starting point to the marking in mm. The higher the sum scores, the more chronic stress is experienced. Similarly, the higher

the value for acute stress, the more an individual is stressed. To evaluate changes of acute and chronic stress over time, percentage increase or decrease is used. First, the results of participants in the self-selected music condition will be reported.

Participant 19001

Participant 19001 was allocated to the self-selected music condition. The participant was male, with an age of 26 years, his nationality was German. He was unmarried, in a relationship and had no children. The participant lived in a two-person household. He indicated his highest education with German Abitur. The participant was less than part-time employed. The study took place in Marburg, Germany. The participant self-identified himself as an Extreme Music Systemizer, with a ME-MS difference score of *M* = -.44. The chronic stress level developed as follows: At baseline, the participant had a sum score of 25. After the music listening intervention at the post appointment, the sum score was reduced to 24. Four weeks after the post appointment, during the follow-up appointment, the SSCS sum score was increased up to a sum score of 26. To express the change of chronic stress level in percentage change, it can be stated that from baseline to post, the participant experienced -4% reduction and from baseline to follow-up, his chronic stress increased by +4%. Acute stress levels before music listening averaged to *M* = 1.39 (*SD* = .70). After music listening, the participant indicated his acute stress levels with a mean of *M* = 1.01 (*SD* = .71). Thus, he experienced a reduction in acute stress level of -37.62% as a result of music listening.

Participant 19023

Participant 19023 was allocated to the self-selected music condition. The participant was female, with an age of 20 years. She was of German nationality, unmarried, single and had no children. The participant lived in a two-person household. Her highest education was German Abitur. She indicated that she was less than part-time employed. The study took place in Vienna, Austria. The participant self-identified herself as a Music Empathizer, with a ME-MS difference score of *M* = .75. Her chronic stress level over time changed as follows: At baseline appointment, her chronic stress level had a sum score of 25. After the music listening intervention, a sum score of 32 was assessed. At the follow-up assessment, the participant indicated her chronic stress level with a sum score of 29. Thus, she experienced an increase of +28% from baseline to post assessment, and an increase of +16% baseline to follow-up assessment. The participant had an average acute stress level of *M* = .60 (*SD* = 1.05) before music listening. After music listening the acute stress level increased up to *M* = .62 (*SD* = 1.38).

Thus, an increase of +3.23% in acute stress at the time of pre to post music listening can be recorded.

Figure 2 shows the differences between the two participants in the self-selected music condition in their change of chronic stress levels. The Music Empathizer increased her chronic stress level from baseline to post, as well as from baseline to follow-up assessment. The Music Systemizer, on the other hand, slightly decreased his chronic stress level from baseline to post, and then slightly increased his chronic stress level from baseline to follow-up assessment.

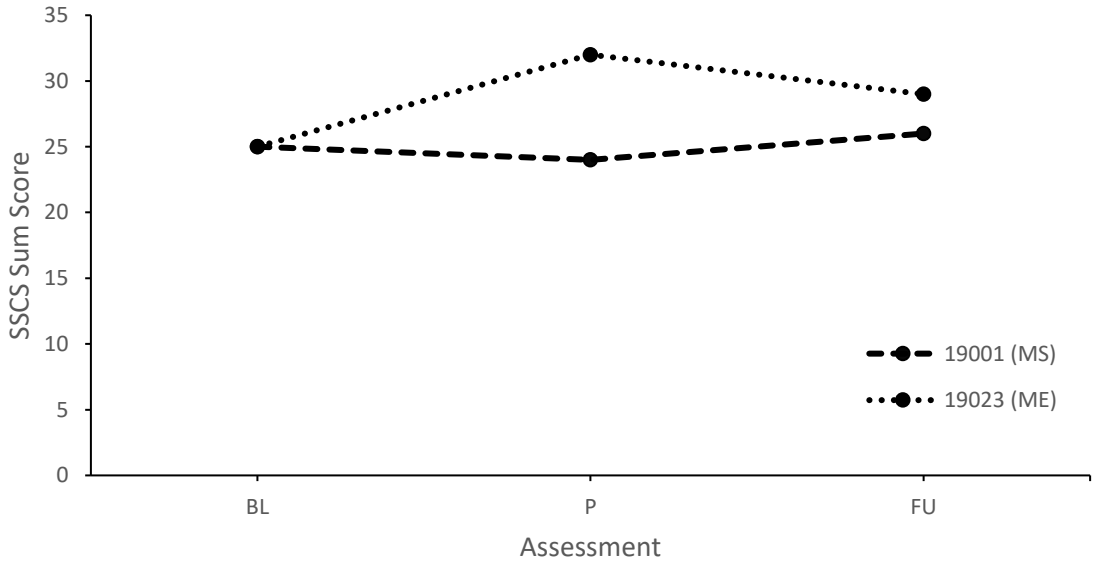

Figure 2. Chronic Stress in Participants Listening to Self-Selected Music

Participants in the self-selected music condition and their change of acute stress levels after listening to music are depicted in figure 3. After music listening, the Music Empathizer demonstrated a minimal increase in average acute stress level. The Music Systemizer experienced less acute stress after music listening.

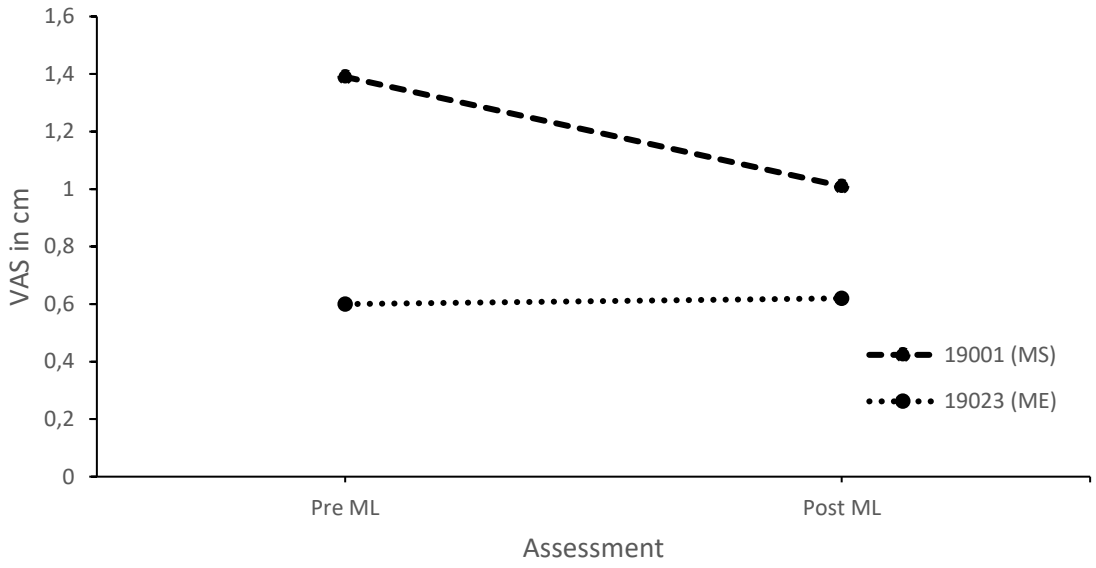

Figure 3. Acute Stress in Participants Listening to Self-Selected Music

The following participants were allocated to the researcher-selected music condition:

Participant 19010

Participant 19010 was allocated to the researcher-selected music condition. The participant was male, with an age of 31 years. His citizenship was German. The participant was unmarried, single, and had no children. He stated that he lived alone. His highest education was German Abitur, and he indicated that he was less than part-time employed. The study took place in Marburg, Germany. The participant self-identified himself as a Music Systemizer, with a ME-MS difference score of *M* = -.16. The change in chronic stress level over time was as follows: At baseline, the participant had a sum score of 21. After the music listening intervention at the post assessment, the sum score was increased with a score of 26. Four weeks later at the follow-up assessment, the sum score amounted to 25. Thus, an increase of +23.81% from baseline to post assessment can be recorded, as well as an increase of +19.05% from baseline to follow-up assessment. The acute stress before music listening averaged to *M* = .47 (*SD* = .29). After music listening, the acute stress level had a mean of *M* = .46 (*SD* = .29). To express this change in percentage change, a reduction of -2.17% from pre to post music listening can be recorded.

Participant 19027

Participant 19027 was allocated to the researcher-selected music condition. The participant was male, with an age of 28 years. He indicated a citizenship other than German. The participant was unmarried, in a relationship and had no children. He indicated that he lived in a two-person household and that his highest education was another graduation than Abitur. He was part-time employed. The study took place in Vienna, Austria. The participant self-identified himself as a Music Empathizer, with a ME-MS difference score of *M* = .71. His chronic stress level over time developed as follows: At baseline appointment, the sum score was 12. At post assessment the sum score increased to a score of 17. Similarly, at the follow-up assessment the sum score was 17. From baseline to post assessment, as well as from baseline to follow-up assessment, the chronic stress therefore increased with a percentage of +41.67%. The participant had an average score of acute stress before music listening of *M* = .68 (*SD* = 1.71). After music listening, he indicated an average score of *M* = .46 (*SD* = 1.30). Thus, his acute stress level from pre to post music listening reduced by -47.31%.

Figure 4 shows differences between participants in the researcher-selected music condition in their change of chronic stress levels. Both participants experienced a similar absolute increase in chronic stress. However, their percentage increase from baseline to post, as well as from baseline to follow-up differs.

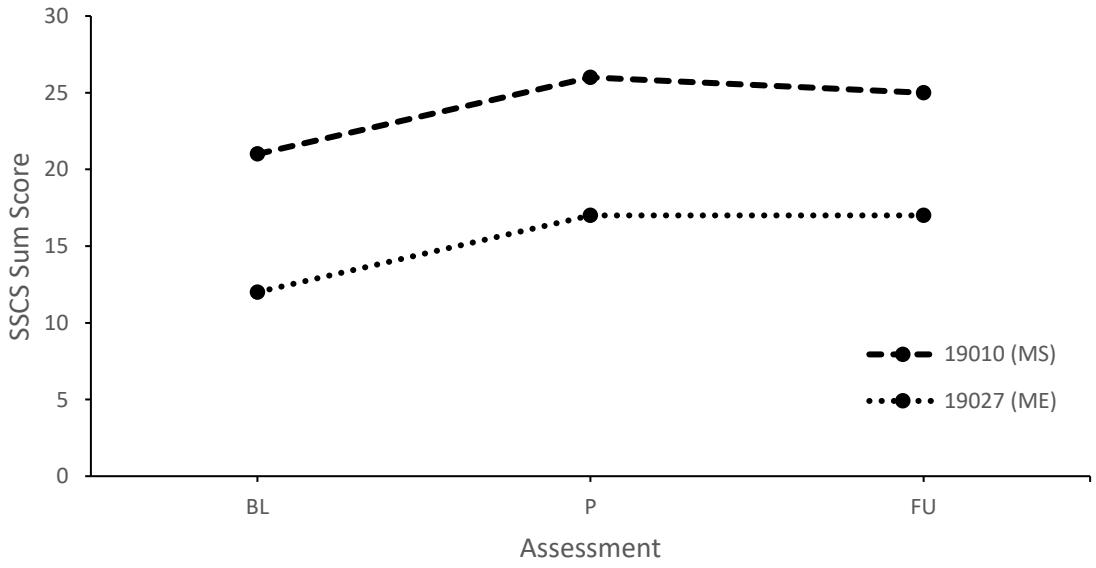

Figure 4. Chronic Stress in Participants Listening to Researcher-Selected Music

Participants in the researcher-selected music condition and their change of acute stress levels after listening to music are depicted in figure 5. The Music Systemizer experienced a decrease in acute stress level after listening to music, whereas the Music Empathizer experienced a minimal increase in acute stress level.

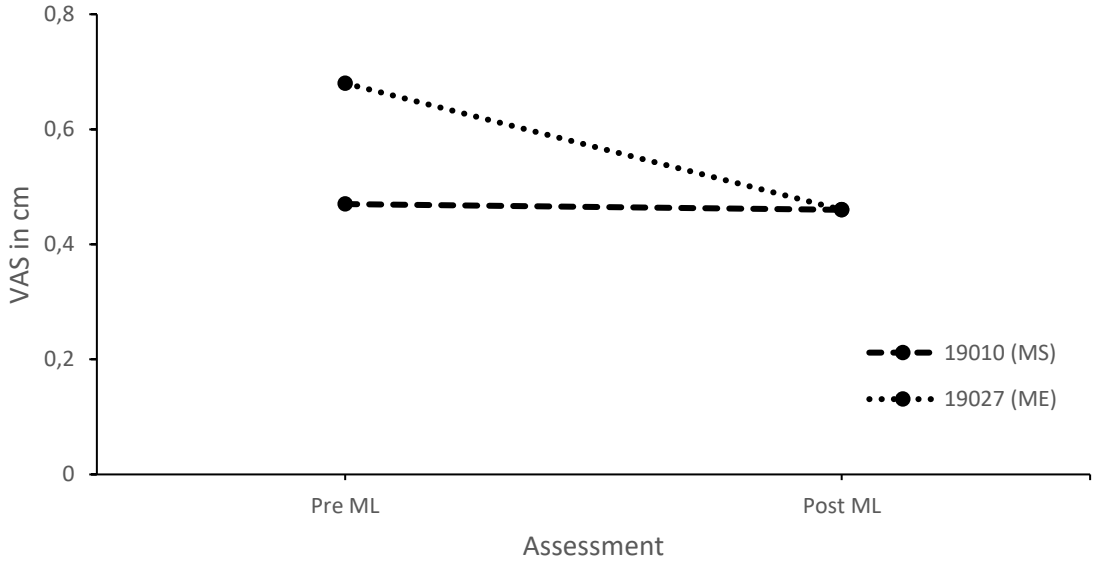

Figure 5. Acute Stress in Participants Listening to Researcher-Selected Music

Discussion

The purpose of the present study was to investigate differences between Music Empathizers and Music Systemizers based on their change in subjective chronic and acute stress levels after a music listening intervention. Participants took part in a music listening intervention that included ten appointments of 60 minutes in which they either listened to self-selected or researcher-selected music. Before the music listening period, participants completed the ME-MS inventory and subsequently were categorized as Music Empathizers, Music Systemizers or balanced brain types. Immediately before and after the music listening intervention, as well as four weeks post intervention, chronic stress was assessed. Acute stress was assessed before and after each of the ten music listening sessions.

Hypothesis 1a assumes that the reduction of chronic stress levels after listening to self-selected music is stronger in Music Empathizers than in Music Systemizers. This hypothesis is not supported by the data analyzed in the present study. In this study, the Music Empathizer

(19023) experienced a stress increase (+28%) from baseline to post assessment, compared to the Music Systemizer (19001), who experienced a small decrease of chronic stress (-4%) from baseline to post assessment. Concerning the time period from baseline to follow-up assessment, both Music Empathizer (+16%) and Music Systemizer (+4%) experienced a stress increase. However, the stress increase was stronger in the Music Empathizer than in the Systemizer. Hypothesis 1b involves the assumption that the reduction of the chronic stress level after listening to researcher-selected music is stronger in Music Empathizers than in Music Systemizers. Data in this study do not support this hypothesis since none of the subjects experienced a chronic stress reduction. From baseline to post assessment, the Music Empathizer (19027) experienced an increase of +41.67%, whereas the Music Systemizer (19010) experienced an increase of +23.81%. During the time period between baseline and follow-up assessment, the Music Empathizer showed an increase of +41.67%, whereas the Music Systemizer showed an increase of +19.05% in chronic stress. Thus, the percentage increase of chronic stress was higher in the Music Empathizer than in the Music Systemizer.

Hypothesis 2a assumed that the reduction in acute stress after listening to self-selected music is stronger in Music Empathizers than in Music Systemizers. However, this hypothesis is not supported by the present data. Conversely, data suggest that the Music Systemizer (19001) experienced a reduction of -37.62%, whereas the Music Empathizer (19023) experienced an increase of +3.23% in acute stress when listening to self-selected music. Hypothesis 2b was that the reduction of the acute stress level after listening to researcher-selected music is stronger in Music Empathizers than in Music Systemizers. This hypothesis is supported by the data in this study. After listening to researcher-selected music the Music Empathizer (19027; -47.31%) reduced more acute stress than the Music Systemizer (19010; -2.17%).

However, results should not be overstated in this study because only four participants were included. Furthermore, no inferential statistics were conducted due to the small sample size. Still, data show more insight into the field of ME-MS and the effects of researcher- or self-selected music on subjective acute and chronic stress levels. Thus, this study provides a basis for further investigating this association in larger samples.

Stress Reduction Through Music Listening

The results of the present study are partly in line with previous research. Many studies found a reducing effect of music interventions on subjective stress and state anxiety (de Witte

et al., 2020; Labbé et al., 2007). Past research also demonstrated that music listening is related to stress reduction on the physiological level (Chanda & Levitin, 2013). Helsing and colleagues (2016) compared a music listening group to a control group actively relaxing during the same time. The purpose of the study was to investigate the effects of music listening on stress in everyday situations. It was found that music listening is able to reduce subjective stress in comparison to an active relaxation group. These results can be partly related to the present study. Only one of the four participants experienced a slight reduction in chronic stress (19001), while the other three participants increased their levels of chronic stress after the music listening intervention. Acute stress, on the other hand, was reduced by three of the four participants in the current study (19001, 19010, 19027). It should be mentioned that in the study by Helsing et al. (2016), it was not clearly stated whether acute or chronic stress was measured. The Perceived Stress Scale was used as an indicator of stress. Since the questions in the Perceived Stress Scale rely on the past month (Cohen et al., 1983), it can be concluded that in the study by Helsing et al. (2016), chronic stress was assessed. In general, it can be observed that many studies do not clearly distinguish between acute and chronic stress (Fancourt et al., 2014). Therefore, in future research, distinctions between chronic and acute stress should be made due to different implications for the clinical setting. First of all, this distinction is relevant because it has different outcomes on health (Bodenmann & Gmelch, 2009; Brinkmann, 2014). Furthermore, it was found that acute and chronic stress affect the immune system differently (Dhabhar & McEwen, 1997) and thus, research should clearly distinguish between these two forms of stress.

Concerning acute stress, the present study partly reveals stress-reducing effects. Two participants experienced a strong reduction in acute stress (participants 19001, 19027), whereas the other participants (19010, 19023) only showed a small effect of music listening. This inconclusive result may be explained by results of past research (Linnemann et al., 2016) in which an ambulatory assessment design was applied. Participants listening to music without the presence of others did not reduce subjective stress. When their purpose of music listening was relaxation, their stress levels were reduced. Listening to music in the presence of others led to stress-reducing effects. Corroborating this finding, Linnemann and colleagues (2015) revealed that music listening had the most stress-reducing effects if participants' listening goal was relaxation. In the present study, the purpose for music listening was not assessed. However, participants were not explicitly instructed to relax during the music listening period. Therefore, it might be possible that the effects on acute stress levels were smaller than expected. Furthermore, participants in the present study listened to music without the presence of others

which has been found to be less stress-reducing than when listening to music in the presence of others. In addition, there is previous research indicating that after the induction of an acute stressor, listening to researcher-selected music was not significantly more effective in subjective stress reduction than listening to the sound of rippling water or resting in silence (Thoma et al., 2013). However, it should also be mentioned that in the present study, overall acute stress levels before music listening were relatively low which might have also affected the results. Thus, more research with a larger sample size is needed to investigate the mediating effects of music listening on acute stress.

Previous literature concerning the effects of music listening on chronic stress demonstrated that six sessions of GIM during a period of nine weeks had positive effects on chronic stress in individuals who were on sick leave (Beck et al., 2015). Furthermore, 15 minutes of daily music listening during the break reduced work-related chronic stress in air traffic controllers (Lesiuk, 2008). Results of the present study are not in line with these findings. The present findings do not indicate that chronic stress is reduced after 10 music listening sessions within a period of three weeks. However, there are differences between our study and the previously mentioned studies. Participants in the study by Lesiuk were air traffic controllers and exhibited high levels of work-related chronic stress. Participants in the study by Beck et al. were on sick leave due to high levels of chronic stress. On the other hand, participants in our study indicated that they worked part-time or less than part-time. Moreover, they were able to take part in our relatively time-consuming study which might suggest that they rather experienced low basic levels of chronic stress. This difference in workload and potentially different basic chronic stress levels might be an explanation for the differing results. Furthermore, it should be stressed that only four participants were included in this study and that results should not be overvalued.

There are several studies providing insight into the question to what extent music itself and possible mediating effects influence the reduction of stress. Jiang et al. (2016) found that the effect of music listening on stress reduction is mediated by preference, arousal and valence. Preference of music was the most important factor for the reduction in acute stress. In the present study, the instruction for participants in the self-selected music condition was to bring their favorite music. Interestingly, participants in the self-selected music condition did not significantly reduce chronic stress. Only the Music Systemizer (19001), but not the Music Empathizer (19023) reduced acute stress. Concerning the researcher-selected music condition, no assumption concerning the liking for the music can be made because preference was not

assessed. To further evaluate mediating effects of music listening and stress reduction, future research should therefore include preference ratings. Moreover, there is research indicating that positive valence and low arousal are factors that facilitate the recovery of subjective acute stress (Sandstorm & Russo, 2016). Further possible mediating effects between music listening and stress may be explained by the experience of IMEs. Schäfer and colleagues (2014) conducted narrative interviews to assess participants' experiences of IMEs. If participants had experienced an IME, they reported lower anxiety and stress levels. The present study did not include the assessment of experienced IMEs or music-induced chills in participants. In future research, it would be interesting to connect the results of the present study to IMEs in order to understand, which factors contribute most to a reduction in acute stress and whether stress reduction was achieved through the experience of such an IME. Another mediating effect between music listening and stress reduction might be the reason for music listening. As demonstrated by Thoma et al. (2012), qualitative aspects of music listening (i.e., reasons of music listening) play a more important role for psychological parameters than quantitative aspects (i.e., duration or relevance of music listening). It might be possible that participants in the present study had different purposes for music listening.

Music Empathizing and Music Systemizing

There are two cognitive styles that can explain musical processing: ME and MS (Kreutz et al. 2008). Previous research suggests that Music Empathizers listen to music with the purpose of emotion regulation. Music Systemizers, on the other hand, are supposed to listen to music in order to analyze complex structures (Linnemann et al., 2018). Concerning self-selected music, research demonstrated that this music is connected to preference, which leads to emotion regulation (Schäfer, 2016). In combination with the findings that emotion regulation is connected to stress reduction (Troy & Mauss, 2011) and that self-selected music was found to activate brain areas responsible for emotions (Blood & Zatorre, 2001), it was hypothesized that Music Empathizers would experience a stronger reduction in chronic and acute stress than Music Systemizers when listening to self-selected music. Furthermore, it was hypothesized that Music Empathizers who are supposed to use music for emotion regulation goals (Linnemann et al., 2018) which is a protective factor for stress (Troy & Mauss, 2011) would experience a stronger chronic and acute stress reduction than Music Systemizers when listening to researcher-selected music. The present data, however, did only partly support these hypotheses. In the self-selected music condition, the Music Empathizer (19023) did neither reduce acute nor chronic stress, whereas the Music Systemizer (19001) reduced acute stress and minimally

reduced chronic stress from baseline to post appointment. In the researcher-selected music condition, chronic stress was increased in both Music Empathizer (19027) and Music Systemizer (19010). Contrary, acute stress was reduced in both participants, with the Empathizer reducing more stress than the Systemizer.

The lack of support for some of the hypotheses might be explained by the fact that a single case analysis was conducted and that only four participants were included. Furthermore, no inferential statistics were conducted. Thus, data in the present study are not as informative as a study including a large sample with participants characterized as either Music Empathizers or Systemizers. A further possible explanation for the lacking finding that Music Empathizers listening to self-selected music experience a stronger acute and chronic stress reduction than Music Systemizers, and that Music Empathizers listening to researcher-selected music experience a stronger acute stress reduction could be that Music Empathizers use music as an emotion regulation tool in diverse situations (Linnemann et al., 2018). However, the situation in the laboratory was rather artificial and the goal for music listening was possibly not emotion regulation. Rather, music was listened because it was part of the study. This might have influenced usual listening habits as well as listening goals in the Music Empathizers.

The effect of music listening on affect regulation was investigated in a study by Groarke and Hogan (2019). They found that listening to music was more effective in affect regulation than listening to a radio documentary. The music was self-selected whereas the radio documentary was researcher-selected. Since self-selected music is related to control, it might be effective in affect regulation (Groarke & Hogan, 2019). However, affect regulation, or emotion regulation, is more predominant in Music Empathizers (Linnemann et al., 2018) and thus, it was hypothesized that Music Empathizers experience a stronger stress reduction when listening to self-selected music than Music Systemizers. In the present study, hypotheses in the self-selected music condition were not supported by the data. The Music Empathizer (19023) in the self-selected music condition did not reduce chronic or acute stress. Similarly, one of the hypotheses in the researcher-selected music condition was not supported. Previous research showed that individuals high in empathy had higher ratings in liking for unfamiliar music (Wallmark et al., 2018). In combination with the findings that emotion regulation is a protective factor for stress (Troy & Mauss, 2011), it was hypothesized that Music Empathizers experience a stronger stress reduction than Music Systemizers when listening to researcher-selected music. The present results did not support this hypothesis in the case of acute stress.

There are multiple possible reasons for the lacking findings in the self- and researcher-selected music conditions. Concerning acute stress, the VAS was used, a scale that is based on subjective perception. This might distort data. Chronic stress might be biased as well since the music listening intervention occupied a lot of time, which could have resulted in an increase in chronic stress. A further study might also give insight into what factors could have influenced the present results. Thomson et al. (2014) investigated different mood regulation strategies through music to psychopathology in young people. They identified seven different strategies. *Discharge* (i.e., the release of negative emotions by listening to music) is a mood regulation strategy that was found to be highly associated with depression, anxiety and stress. *Diversion* (i.e., music used as a distraction from worries and stress) also correlated with higher stress and anxiety levels. This emphasizes that not every emotion regulation strategy is effective in stress reduction.

A further aspect that might have influenced the association between music listening and stress response in Music Empathizers and Systemizers is preference for the music. Preferred musical genres are different in Music Empathizers versus Music Systemizers. In the review by Greenberg and colleagues (2015b), Music Empathizers were found to prefer music with emotional, deep, reflective, romantic and gentle characteristics, whereas music systemizers prefer music with complex harmonic, rhythmic, and melodic properties. Thus, musical preferences could also be an important factor in the present study that account for the participants' stress reactions after music listening. Probably, participants in the self-selected music group liked the music they listened to since the instruction was that they should bring their favorite music. In the researcher-selected music condition participants were not able to choose the music themselves. However, preference for the music was not assessed in the present study. Since preference for music might be a factor that influences the experience of stress (Jiang et al., 2013), it would be interesting to assess the preference for the music in future research.

Another study also examined effects of exposure on liking for the music (Schellenberg et al., 2008). The authors found that exposure of music is connected to liking the music. The quality of music listening, rather than the quantity played an important role in liking for happy sounding music. When participants listened to music incidentally, their liking for the music increased as a function of exposure. When listening was focused their liking ratings were an inverted U-shaped function of exposure. In the present study, it was not assessed whether participants were focused on the music or whether they listened to the music rather incidentally.

This underlines the idea that the participants' resulting stress experiences in the present study might have been influenced by their individual focus on the music.

However, it is not only preference, familiarity or the individual focus on the music that might mediate the relationship between music listening and stress reduction. Research investigating characteristics of music and beneficial effects on anxiety as well as relaxation revealed that there are several music properties that have a large influence on relaxation. These characteristics were slow tempo (80-100 beats per minute), simple and repetitive rhythms, harmonious sounds, medium complexity of the musical piece, few changes in volume and key as well as legato articulation (Elliott et al., 2011). Since the music in the self-selected music condition in the present study did not need to meet any criteria, it is questionable to what extent musical properties of the self-selected pieces influenced the participants' stress responses. There is research corroborating the findings of Elliott et al. on the physiological level. Cardiovascular, cerebrovascular and respiratory data showed that slower rhythms and pauses in the music have a relaxing effect (Bernardi et al., 2006).

Concerning neurophysiological correlates of familiarity with and preference for music, Pereira et al. (2011) demonstrated that familiarity activated emotion-related brain areas. It was concluded that familiarity with the music might be essential in musical appreciation (Pereira et al., 2011). In this study, familiarity with the music in the researcher-selected condition was not assessed. Therefore, it might be possible that the effect of music listening on subjective stress levels was affected by individual familiarity or preference for the researcher-selected music. In contrast, familiarity with the music in the self-selected condition must have been strong since participants were asked to bring their favorite music. Although musical liking was found to be associated with stress reduction (Jiang et al., 2013), the present study only partly shows stress-reducing effects in the self-selected music condition. Contrary to the hypotheses suggesting that Music Empathizers experience a stronger stress reduction than Music Systemizers when listening to self-selected music, the present findings revealed that the Music Systemizer (19001) reduced more stress than the Music Empathizer (19023). Again, these differences might arise from the fact that a single case analysis was conducted and the results are not meaningful enough to be representative for the general population.

To conclude, the effects of listening to researcher- or self-selected music on acute and chronic stress in Music Empathizers and Music Systemizers might have been affected by

familiarity with and preference for the music, as well as by different musical characteristics and the individual focus on the music while listening to it.

Limitations

The present study has several limitations that should be addressed. First of all, the study was conducted as a single case analysis and thus results were based on data from four participants only. This was due to the fact that participants in the condition of frequency-modulated researcher-selected music had to be excluded since this type of music cannot be compared to unmodulated researcher-selected music. Therefore, the sample size decreased to a number of 17 participants. Again, some participants were excluded because they were considered as dropouts since they did not complete all questionnaires. A total of 14 participants remained. Only four participants were categorized as either Music Empathizers or Systemizers and thus a single case analysis was conducted. Therefore, it is relevant to be careful when interpreting the results. In particular, the generalization of the results is questionable. Furthermore, due to the small sample size and the lacking inferential statistics, it is not clear whether the present data are representative for the general population or whether participants must be considered as outliers.

A second limitation that should be addressed is that the overall project in which this study was embedded, was not especially designed with the purpose to investigate the effect of music listening on acute and chronic stress in Music Empathizers or Music Systemizers when listening to self-selected or researcher-selected music. Therefore, not many participants were allocated to the categories of ME or MS. Rather, most of the participants were allocated to the balanced brain type which is in accordance with previous research (Svedholm-Häkkinen & Lindeman, 2016).

In this study, the average age of participants was relatively low (M = 24.86) and most of the participants were part-time or less than part-time employed or were still at university. Thus, the sample is relatively homogenous, and it may be possible that results in this study are not generalizable to the total population. Additionally, previous research revealed that older adults might have better emotion regulation abilities. Therefore, music listening might therefore have different effects on subjective stress levels in older than in younger participants (Groarke & Hogen, 2019).

As already noted above, the generalizability of the results concerning chronic stress should be questioned. First of all, the participants in the present study were part-time or less

than part-time employed. Furthermore, they agreed to take part in the study and consequently came to our laboratory for ten times within a period of three weeks. This indicates that participants were relatively flexible concerning their time management. Therefore, it is possible that participants in this study in general experienced less chronic stress than the total population. This might have led to a distortion of the results which indicated that chronic stress was not reduced after the music listening intervention. Moreover, the time period of four weeks after the music listening intervention (follow-up appointment) might have been too long in order to be able to still show effects of the music listening intervention. Concerning acute stress, this study did not include the induction of an acute stressor. Possibly, participants were too relaxed in order to find large effects of music listening on acute stress levels.

It should also be noted that there is a difference between the researcher- and the self-selected music condition. As already outlined above, participants in the self-selected music condition experienced more control than participants in the researcher-selected music condition. Moreover, they were more familiar with the music and probably liked the music because they were instructed to bring their favorite music. These factors can be considered as confounding variables since participants in the researcher-selected music condition neither experienced control nor were familiar with the music.

Music listening did not reduce acute and chronic stress levels as much as expected. A lot of previous studies demonstrated stress reduction through music listening in daily life. However, the present study was conducted in a laboratory and therefore, participants might have experienced the situation as rather artificial which might have influenced their stress response. Furthermore, due to the low ecological validity it is questionable to what extent results can be extended to everyday life.

However, this study contributes to the research field of Music Empathizing and Music Systemizing and gives insight into the question of how individuals with these different brain types might react to researcher- or self-selected music. The advantages of the present study are first of all that internal validity is high. Moreover, this study gives an insight into the effect of a music listening intervention on both acute and chronic stress. Furthermore, the time period of three weeks, as well as the follow-up period of four weeks after the intervention made it possible to investigate effects of longer duration. Additionally, this study did not assess chronic stress in the work-related setting as in many previously conducted studies, but it assessed chronic stress in general. Finally, this study focused on the mere music listening, rather than music

therapy. This is especially relevant since music listening is much more easily accessible than music therapy and thus has direct implications for stress-reducing methods in everyday life. To the best of my knowledge, this is the first study to address differences between ME and MS concerning their subjective stress level after listening to self- or researcher-selected music.

Prospects

As already discussed, there were only few participants who were explicitly allocated to the ME or MS brain type. Future research should therefore assess ME and MS already during the screening procedure before the inclusion of participants to the study. This would help to find participants who can be explicitly categorized as Music Empathizers or Systemizers and would therefore prevent dropout cases due to lacking categorization to one of the two cognitive styles. Furthermore, the sample in the present study was relatively homogenous and generalizability to the general population is questionable. Therefore, a more diverse sample should be applied and age differences should be concerned as well. Moreover, more research should clearly distinguish between chronic and acute stress since the health outcomes and in turn the implications for therapy are different. Since there is a vast body of research concerning music-based interventions and acute stress but only few literature addressing chronic stress, more research on chronic stress should be conducted. Although the present study was not able to show chronical stress-reducing effects of music listening, it is important to further evaluate how music can be used as a tool to reduce chronic stress in everyday life. Previous research demonstrated that there are different factors that might mediate the association between music-based interventions and stress. Therefore, when investigating the effects of music on stress in Music Empathizers and Systemizers in the future, possible mediating effects such as preference for the music, IME or chills and reasons for music listening should be assessed as well. A vast body of research showed neurophysiological correlates of Empathizing and Systemizing. Differences in activated brain areas between Empathizers and Systemizers were found and therefore, when further evaluating differences between ME and MS in their stress response, neurophysiological correlates should be also considered. To conclude, future research should further investigate effects of researcher- and self-selected music on acute and chronic stress in Music Empathizers and Music Systemizers in order to gain better insight into which method is the most effective.

Conclusion

The present study gave insight into the field of ME and MS and the effects of researcher- or self-selected music on subjective acute and chronic stress levels. Due to the small sample size and the few participants who were allocated to the ME or MS brain type, a single case analysis was conducted. Therefore, the generalizability of the present results is questionable and results should not be overvalued. However, this study represents a basis on which future research can draw on. Stress and its consequences on psychological, physiological and social level is very common in our society. Since music listening is a method that is easily accessible and has low costs, it is a promising tool to reduce stress. Therefore, future research should further investigate to what extent Music Empathizers and Music Systemizers can reduce their chronic and acute stress levels through listening to music.

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List of Abbreviations

EDA……..*Electrodermal Activity*
fMRI……... *Functional Magnetic Resonance Imaging*
GIM……...*Guided Imagery and Music*
HPA…….. *Hypothalamic-Pituitary Adrenal*
IME…….. *Intense Musical Experience*
ME……..*Music Empathizing*
MS……...M*usic Systemizing*
PET…….*Positron Emission Tomography*
SSCS……. *Screening Scale for Chronic Stress*
TICS…….*Trier Inventory of Chronic Stress*
VAS…….. *Visual Analog Scale*

Appendix A

Abstract

Background: Stress has been found to be negatively associated with physiological and psychological wellbeing. Therefore, research has focused on stress-reducing methods and revealed that music listening is effective in reducing both acute and chronic stress. This effect was found for researcher- and self-selected music. The question how music is processed might be explained by the two cognitive styles of Music Empathizing and Music Systemizing. This study aimed to investigate differences between Music Empathizers and Music Systemizers in their subjective acute and chronic stress levels after listening to researcher- or self-selected music. *Methods:* The present study includes a randomized controlled trial in which four participants either listened to ten sessions of researcher- or self-selected music during a period of three weeks. Chronic stress was measured before and after the music listening intervention. Acute stress was measured before and after each music listening session. The cognitive style of music listening was assessed via a questionnaire prior to the intervention. A single case analysis was conducted. *Results:* After the music listening intervention, chronic stress was increased in three participants. Only the Music Systemizer listening to self-selected music minimally reduced chronic stress. Acute stress was strongly reduced in the Music Empathizer listening to researcher-selected music and in the Music Systemizer listening to self-selected music. *Conclusion:* Although the results should not be overstated due to the small sample size, this study represents an insight into the research of Music Empathizing and Music Systemizing and the effects of music listening on subjective stress.

Appendix B

Zusammenfassung

Hintergrund: Es wurde festgestellt, dass Stress negativ mit physiologischem und psychischem Wohlbefinden zusammenhängt. Untersuchungen zu stressreduzierenden Methoden ergaben, dass das Hören von Musik sowohl akuten als auch chronischen Stress wirksam reduzieren kann. Dieser Effekt wurde für fremd- und selbstgewählte Musik gefunden. Die Frage, wie Musik verarbeitet wird, könnte durch die beiden kognitiven Stile des Music Empathizing und Music Systemizing erklärt werden. Das Ziel dieser Studie war es, Unterschiede zwischen Music Empathizern und Music Systemizern in ihrem subjektiven akuten und chronischen Stressniveau beim Hören von fremd- oder selbstgewählter Musik zu untersuchen. *Methoden:* In dieser randomisiert kontrollierten Studie hörten vier Versuchspersonen über einen Zeitraum von drei Wochen entweder zehn Sitzungen von fremd- oder selbstgewählter Musik. Der chronische Stress wurde vor und nach der Musikintervention gemessen. Akuter Stress wurde vor und nach jeder Musikhörsitzung gemessen. Der kognitive Stil des Musikhörens wurde mittels eines Fragebogens vor der Intervention erhoben. Es wurde eine Einzelfallanalyse durchgeführt. *Ergebnisse:* Nach der Musikintervention war der chronische Stress bei drei Versuchspersonen erhöht. Nur der Music Systemizer, der selbstgewählte Musik hörte, wies eine geringe Reduzierung von chronischem Stress auf. Akuter Stress wurde bei dem Music Empathizer, der fremd-gewählte Musik hörte, und bei dem Music Systemizer, der selbst-gewählte Musik hörte, stark reduziert. *Schlussfolgerung:* Obwohl die Ergebnisse aufgrund der geringen Stichprobengröße nicht überbewertet werden sollten, stellt diese Studie einen Einblick in die Erforschung von Music Empathizing und Systemizing und die Auswirkungen des Musikhörens auf subjektiven Stress dar.

Appendix C

Study Flyer

universität wien

Musik und Stressmanagement: Eine musikalische Interventionsstudie ProbandInnen gesucht

Ablauf: Die Studie umfasst insgesamt 13 Termine (davon 10 in drei aufeinanderfolgenden Wochen). Im Detail:

- 10 Musikhörtermine (à ca. 70 - 80 min): Sie hören Ihre Lieblingsmusik oder von uns ausgewählte Musik
- 1 Vortermin und 2 weitere Nachtermine (à ca. 60 min)
- Erhebung biologischer Maße und Ausfüllen von Fragebögen
- Sowie zu einigen Terminen: Durchführen eines (völlig unbedenklichen) Schmerztests

Studienleitung: Univ.-Prof. Dr. Urs M. Nater
Studienkoordination: Rosa M. Maidhof, MSc
Anja C. Feneberg, MSc

Teilnahmevoraussetzungen:

- Zeit, innerhalb von 3 Wochen 10 Termine wahrzunehmen
- Alter: 18 bis 35 Jahre
- Normalgewicht
- Ausreichende Deutschkenntnisse
- Psychische und körperliche Gesundheit
- Keine regelmäßige Einnahme von Schmerzmedikamenten
- Keine momentane Schwangerschaft oder Stillen

Für Ihren zeitlichen Aufwand erhalten Sie eine angemessene Entschädigung. Bei Interesse melden Sie sich bitte unter **music10healthlab@gmail.com** mit Angabe von **Name, Telefonnummer und Erreichbarkeit.**

Appendix D

Visual Analog Scale

Datum ___ / ___ / ___ (Tag / Monat / Jahr) VL:_____ VAS:_____

☐ B ☐ M ____ ☐ F

VP-Code:

VAS

Bitte zeichnen Sie bei den folgenden Fragen an der Stelle auf der Linie einen senkrechten Strich ein, die Ihrer **persönlichen Einschätzung** am meisten entspricht. Die Wertung 0 bedeutet, dass die Aussage überhaupt nicht auf Sie zutrifft und die Wertung 100, dass die Aussage voll und ganz zutrifft.

Ich habe Schmerzen

0 100

Ich fühle mich gestresst

0 100

universität wien