Preferred music produces conscious relaxation and physiological ambiguity

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Abstract

Does individual preference influence the emotionally and physiologically relaxing effects of music? Nineteen undergraduate students (11 males, mean age 19.53 years) selected a relaxing song from their own collections, and listened to this music along with Rachmaninoff's Prelude #5 in G Major, and a control period of silence. While listening, participants continuously rated their emotions in a 2-dimensional emotion space (activation on the vertical axis, pleasantness on the horizontal axis) within a LabVIEW virtual instrument. Participants also rated their mood (in pleasantness and activation) after each condition using the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994). Continuous physiological measures of galvanic skin response (GSR), corrugator electromyograph (EMG), heart rate, and skin temperature were recorded using an ActiveTwo system of electrodes and computer software. Continuous reports of pleasantness were higher for subject-chosen music ($p = 0.002$) and activation was lowest for silence ($p = 0.009$). There were different patterns of change through the conditions in GSR ($p = 0.028$) and heart rate ($p = 0.003$). EMG was lowest for subject-chosen music ($p = 0.050$) and skin temperature was lowest for subject-chosen music ($p < 0.001$). Differences in pleasantness and EMG between the 2 music conditions were influenced by participants' years of participation in musical groups, and mood measured by SAM was different after each condition ($p < 0.001$) in both pleasantness and activation. These results suggest that while conscious response to the music indicates a more relaxing effect of subject-chosen music, physiological effects indicate both relaxing and arousing effects.

Introduction

When sitting down to a movie, the opening music can immediately reveal if the movie is classic or contemporary, suggest the cultural backdrop, and draw the viewers into the scene at hand—be it frightening, remorseful, or light and cheery. When one is preparing to exercise, popping in a pair of ear buds with an MP3 player's play-list of motivational energizing music could inspire an extra mile. And switching on the stereo after a full day can effectively echo the emotional peaks and pitfalls, thereby assisting in identifying key emotions and either amplifying them, or diminishing unproductive resentment. During film, exercise, or winding down at the end of the day, music communicates immense amounts of information through tempo, key signature, and tone. Music helps us *feel* about the storyline (of the film or our *lives*).

This emotional connection with music is common across people, places, times, and cultures. Different music induces different emotions in diverse individuals and cultures, but across those cultures music is a form of expression. As will be expressed in the review of the literature, studies have shown positive psychological and physiological response to relaxing music (Goddaer & Abraham, 1994, Gerdner, 1997, Hamel, 2001, Lepage, Drolet, Girard, Grenier, & DeGagné, 2001, McCraty, Barrios-Choplin, Atkinson, & Tomasino, 1998), and more recent work has suggested that music preference can play a role in therapeutic effectiveness (Burns, Labbé, Arke, Capeless, Cooksey, Stealman, & Gonzales, 2002).

Emotion: theory & measurement

This effect of preference could be due to the different sources of emotion induced through music. Bunt and Pavlicevic (2001) explain that connections between music and emotions are associative, iconic, or intrinsic. Iconic connections, or sources of emotion, are common ideas about expressed emotion in music, regarding a certain code of structural devices.

For example, it is often believed that a faster rhythm and increase in volume imply tension, which is therefore likely to induce a feeling of emotional tension in the listener. Now intrinsic connections consider the musical piece as a whole, following the ups and down, the tension and release and in general, the deep structural aspects of the music. While iconic and intrinsic sources are generally shared across people, associative sources are highly individual, because they stem from a person's own experiences and memories. In this sense, music can easily trigger associations with various people, objects, or events -- old friends, the sophomore year of high school, the first dance, or those rough days where sadness pervades. These memories and associations bring with them the emotions from those places, times, and situations. Thus two people could both hear a familiar song and experience completely different emotions due to the different associative sources of those emotions.

The two most commonly used approaches to measurement of emotion are categorical and dimensional (Sloboda & Juslin, 2001). Categorical measurement involves the notion of *basic emotions*. The central theory regarding basic emotions, or emotions as natural kinds, involves the idea that each basic emotion comes with a "package of behavioral and physiological changes that are produced by some causal mechanism" (Barrett, 2006, p. 32). However, Barrett disputes the popular notion of emotions as natural kinds, citing multiple studies that indicate the possibility of fundamental psychological properties beyond the emotions that Western cultures label "happiness," "anger," "fear," and "sadness." Still, the theory of basic emotions that underlies the categorical approach to measurement is not yet completely debunked.

The other approach to measurement of emotions is dimensional (Sloboda & Juslin, 2001). Dimensional measurement places emotions on scales and allows for expression of *amount* of emotion experienced. In a two-dimensional emotion circumplex (Russell, 1980; as cited in

Sloboda & Juslin, 2001), the axes consist of pleasantness and activation, also known as valence and arousal. A primarily dimensional approach based upon this two-dimensional emotion space was used in the current study.

Therapeutic uses of music

After a hard day of work or classes, it is not uncommon for people to come home to listen to music to calm their nerves, or maybe just to match their mood and provide a sense of reinforcement, or reassurance. Music therapy is an intervention growing in popularity, used in treatment for the elderly with behaviors of dementia (Lou, 2001, Goddaer & Abraham, 1994, Gerdner, 1997), for patients heading into critical surgery (Hamel, 2001, Kemper & Danhauer, 2005, Lepage et al., 2001, Yung et al., 2002), and for people who experience the daily stresses of a busy life (McCraty et al., 1998). Typically, music therapy involves a goal of influencing both psychological and physiological states, moving participants into a mood that is more relaxed and at ease, and perhaps slowing heart rate, respiratory rate, and sometimes even affecting specific muscle activity, skin conductance (which measures electrical conductivity in the skin as a result of response of sweat glands) and temperature. These effects will be discussed later in greater detail.

Effects of music intervention on anxiety and agitation in the demented elderly has been pursued by multiple researchers (for a review, see Lou, 2001). One study conducted by Goddaer and Abraham (1994) used the Cohen-Mansfield Agitation Inventory to assess agitated behaviors of the demented elderly after presentations of music and no music during the noon mealtime. Behavior was observed by one trained observer after no music in the first week, relaxing music in the second week, no music in the third week, and then the same relaxing music in week 4. After the 4-week intervention period, overall agitated behavior of 29 demented elderly in this nursing home, had decreased by 63.4% from the baseline. While the study produced results that are encouraging regarding the effectiveness of music on relaxation, validity issues include subjective judgments made by that one trained observer who presumably knew the conditions of the study.

Effects of music on tension, mood, caring, and mental clarity were measured by McCraty et al. (1998) using a Personal Feelings Survey designed by two of the study's authors. Participants completed this one-page survey before and after listening to 15 minutes of popular music in the categories of classical, grunge rock, new age, and designer music. Designer music consists of compositions devised with the intention of inducing a specific feeling in the listener. Participants included adult volunteers from church study groups and teenage subjects from a local summer camp. The researchers hypothesized that the teens would react differently to the grunge rock music, assuming that within the teen sample existed more of a preference for that type of music, though the researchers did not actually take a measurement of preference from any of the subjects. Overall results showed that the designer music session decreased all negative scales (tension, hostility, fatigue, and sadness) and increased all positive scales (caring, relaxation, mental clarity, and vigor). The grunge rock session decreased all positive scales and increased all negative scales, with a greater decrease in caring in the adult sample than the teenage sample. Classical music resulted in a decrease in the negative scales for the adult group, and a decrease in "vigor" for the teenage group. New Age music increased relaxation, and decreased tension, caring, mental clarity, and vigor across both subgroups, with a greater increase in fatigue for the teenage sample than the adults.

This study gave evidence of interesting effects of music on different positive and negative states. However, it lacked proper measurement of preference and subjected the results to possible bias of reactive effects by the participants, who filled out the exact same survey just 15 minutes after having filled it out the first time, with an obvious manipulation in between. Furthermore, the popular music chosen for the study, (grunge rock and new age selections were based on high sales, and the classical selections consisted of Mozart compositions "because of his fame and general popularity," McCraty et al., 1998, p. 77), brings the possibility of individual associative memories, so that the Personal Feelings Survey responses may actually be only a result of the highly personal memories that the music evokes.

In addition to simply affecting emotional states in experimental settings, music is also used as an anxiolytic in pre and peri-operative situations. Because these experiments involved physiological measurements of anxiety, they will be discussed under the next subsection of this literature review. One study investigating physiological and subjective measures of anxiety found no significant adjustment of physiology after music intervention, but did produce significant changes in State-Trait Anxiety Inventory scores. Hamel (2001) conducted a study involving 20 minutes of preselected music played to patients waiting for cardiac catheterization. The state section of the STAI was administered before and after the intervention for the music group, and the control group completed the survey at the start of the experiment, and just before the cardiac catheterization. The STAI scores for the test group (37.84) prior to leaving the unit for cardiac catheterization were significantly lower than the control group (44.34), $p=0.002$. Also, within the test group there was a significant decrease in scores from pre to post intervention, $p=0.003$. The only statistically significant change in physiological measurements was an increase in mean systolic blood pressure for the control group that was not observed in the intervention group, $p=0.007$.

Physiological response to music

Music therapy may bolster the effectiveness of other therapies or pain medications in the treatment of chronic pain. Nickel, Hillecke, Argstatter, and Bolay (2005) examined the effects of music therapy on chronic nonmalignant pain patients. The experimental group received music therapy in addition to standard pharmacological pain treatment, while the control group received the pharmacological treatment only. The Visual Analog Scale (VAS) was used to measure pain intensity, while the Schmerzempfindungs-Skala (SES) collected pain sensation scores. After treatment, 70% of patients in the experimental group had improved significantly, while only 35% of patients in the control group had improved, $p=0.014$.

Nickel et al. (2005) also investigated the effectiveness of music therapy on migraine headaches in children. Participating pediatric migraine patients were divided into 3 groups: music therapy, Petadolex (a migraine medication), and placebo. After a treatment intervention of 3 months, patients were interviewed and psychological questionnaires completed, and headache diaries from all participants were analyzed. The post-treatment measurements indicated that music therapy was significantly more effective than the placebo, with a 71% relative reduction in migraines per month for the music therapy condition versus a 31% reduction for the placebo, $p=0.003$. In the follow-up one year after treatment, relative reduction in migraines was 77% for music therapy, 73% for Petadolex, and 31% for the placebo. Both music therapy ($p=0.018$), and Petadolex ($p=0.044$) were significantly more effective than the placebo. These studies indicate significant effect of music intervention in lessening experienced pain.

Kemper and Danhauer (2005) reviewed multiple studies regarding “Music as Therapy,” examining physiological responses to music in addition to self-report. In a study by Yung, Chui-Kam, and French (2002), men undergoing prostate surgery experienced significantly reduced blood pressure before the surgery due to music intervention. This study used a translated State-Trait Anxiety Inventory (STAI) to measure anxiety, an automated blood pressure monitor, and provided three choices of slow-rhythm music. The difference in STAI (a mean reduction by 2.2 points) was not statistically significant, while change in blood pressure (mean systolic dropped 9.3 points, $p=0.01$; mean diastolic dropped 5.5 points, $p=0.04$) was in fact significant. With the music intervention, mean heart rate was significantly raised by 0.3, $p=0.01$. The authors suggested that the change in heart rate is more related to the initial attitude toward the experiment, rather than the relaxation procedure.

In another study reviewed by Kemper and Danhauer (2005), Lepage et al. (2001) investigated a music intervention before surgery for patients undergoing surgery with spinal anesthesia. Patients were given a wide selection of different types of music to choose from, and both the music intervention group and the control group were given a patient-controlled sedation device (PCS) that delivered 0.25 mg midazolam up to once every five minutes as the patient desired. It was discovered that less anesthesia was required to achieve similar degrees of relaxation in those who had listened to music as compared with the control group (during perioperative period: music intervention: 0.6 ± 0.7 mg, control: 1.3 ± 1.1 mg, $p<0.05$; during surgery: music intervention: 1.2 ± 1.3 mg, control: 2.5 ± 2.0 mg, $p<0.05$).

Despite all of these promising findings, many studies attempting such physiological and psychological change as a result of a music intervention before an unpleasant medical procedure have found little effect (Kemper & Danhauer, 2005). This implies that perhaps the therapeutic effectiveness of music depends on the seriousness of the procedure, or certain individual aspects of the person receiving the intervention. Maybe effective music therapy depends on certain traits in individuals that lead to higher sensitivity to the relaxing effects of music. Another possibility is that certain aspects of the music used in intervention are more therapeutic than others, or even a special combination of musical features leads to therapeutic effectiveness.

Music preference

Some researchers have considered the effects of specific individualized music, or preferred music on mood change. Smith and Noon (1998) examined the concept of preference by using pieces of music that corresponded to the 5 different mood states measured within the Profile of Mood States (POMS). This survey measured student participants' moods before and after listening to 6 different categories of contemporary music (tense, depressed, angry, fatigued, vigorous, as well as a piece of music that could represent all five moods). The pieces of music were determined to fit in separate categories after a pilot study in which university faculty were asked to rate each of 13 pieces of music using a simple questionnaire. The study stretched across six weeks, with participants listening to one category of music on one day for the first week, and then listening to a new category on that day during the second week, and so on. All six pieces of music invoked a change in mood, $p=0.008$. The song for the category "vigorous" produced the greatest positive change in mood, and the only song to produce a mean negative change in mood was Björk's *Enjoy*, within the "tense" category. However, when taken individually, not all the songs produced significant changes in mood. The songs representing "angry" and "all moods" generated significant mood change, $p<0.05$, and the songs for the categories "depressed" and "tense" were also effective in changing mood significantly, $p<0.01$. Small sample size in this study (12 convenience participants) could be responsible for a possible Type II error. While this study did not investigate physiological response, it did focus intensely on changes in mood, and investigated the effects of different kinds of music on mood changes.

These different types of music were very important within a case study conducted by

Gerdner (1997), on a 77 year-old female with Alzheimer's disease and severe cognitive impairment. Here the Cohen-Mansfield Agitation Inventory was used to assess agitated behavior over a lengthy period of time – a total of 14 weeks of intervention. The first six weeks consisted of listening to classical music twice per week for 30 minutes per day, the next two weeks had no music, and in the last six weeks the patient listened to her own preferred music twice per week for 30 minutes per day. While agitated behavior decreased slightly with the classical music, it then increased above the baseline in the two weeks with no music, and subsequently decreased dramatically during the six weeks of preferred music listening. Within this study is the possibility of an order effect, in which the participant took time to acclimate to the music intervention, and reacted more positively to the second intervention. Testing for treatment order effects would strengthen this design.

Gerdner's study is similar to the study conducted by Goddaer and Abraham (1994), in that the primary form of measurement of change was rather subjective judgment by a non-blind observer. Lou (2001) reviewed this study by Gerdner (1997) and after evaluating these studies, concluded that more rigorous research designs are needed to assure higher validity. Such designs could include multiple measurements of psychological, behavioral, and physiological change. If focusing on behavioral changes, researchers could attempt to create a single-blind study in which the behaviors of the people in question are recorded on video, and evaluated without sound (to prevent the observer from knowing if the condition involved music or not).

Types of music and their relation to participants' preference were also considered in a study conducted by Wooten (1992), who evaluated the affective changes after music intervention of 35 teenagers in a psychiatric facility. All subjects listened to both heavy metal music and popular rock music (music was determined based on popular albums within October and

November of 1988). The Positive and Negative Affect Schedule (PANAS) was used to measure affect shifts from a baseline taken the first day of the experiment, (the day before the music intervention). Half of the participants listened to heavy metal music the second day, and the other half listened to the popular rock music. On the third day the assignment of music to groups was reversed. Results of the experiment showed significant reductions in negative affect after each of the conditions. Those participants who indicated preference for heavy metal music (on a 5-point Likert scale) sustained a statistically significant increase in positive affect after listening to heavy metal music, as well as a decrease in negative affect, meaning more feelings of calm, relaxation, attention and energy. Similar changes were not observed in the group indicating preference for rock music after having listened to the rock music. Though a theoretical explanation for the findings was identified by the researcher to be possible identification of heavy metal music with drug use, the study overall indicates the importance of preference in producing positive affective changes in individuals listening to music. Past history and association with certain types of music is an important consideration in effective music therapy, regardless of the context of those associations.

Music therapy is sometimes considered to be more effective when taking place within a situation that induces anxiety. Walworth (2003) investigated the effects of relaxing music on an anxiety-provoking situation, with conditions including preferred genre or artist, specific preferred songs, as well as a control group with no music intervention. Ninety participants were randomly assigned into the three conditions, and those in the preferred music conditions made music selections from a lengthy list provided by the experimenters, (with an additional option for the specific song group to fill in a song not on the list). Both the STAI and a Visual Analog Scale (VAS) were used to assess anxiety before, after, and halfway through the intervention. The VAS used a 100 mm line as an indicator of anxiety, with 0 equal to no anxiety and 100 equal to maximal anxiety. Anxiety was induced via administration of the Stroop color word test, and those in the music intervention groups listened to music, from their selections of either preferred genre/artist or specific songs, while attempting the Stroop test. Results indicated significantly lower anxiety scores on the VAS for both the music groups when compared to the control group, $p=0.05$. However, no significant change in anxiety was measured by the STAI. This study indicates the possibility of holes within the traditional STAI, and further supports the use of additional tests of anxiety, rather than relying on only one form of measurement. However, the subjective and relative nature of the VAS suggests possibility of extremely different interpretations of anxiety and changes in state anxiety, though these differences were likely averaged out across the sample.

Music preference not only affects changes in mood, but also changes in preference of external stimuli. Eifert, Craill, Carey, and O'Connor (1988) investigated the effects of preferred music listening on liking of different uncommon Greek letters. After asking participants to indicate their preference of a number of Greek letters, as well as their preference of a number of songs that they listened to in a pretest, researchers presented each participant's individual group of neutral letters while playing either the chosen 'Liked Vocal Music,' 'Liked Non-Vocal Music,' 'Disliked Non-Vocal Music,' or a 'White Noise Control.' Mood change during the conditioning sessions was measured using five line scales of happy, irritated, anxious, relaxed, and sad. Mood was significantly altered during these conditioning sessions, with a positive mood change in both of the 'Like' conditions and a negative mood change in the 'Dislike' condition. There was no change in mood of the control group subjects. Furthermore, "positive and negative evaluations elicited by the music […] transferred onto the previously neutral letter stimuli"

(Eifert et al., 1988, p.325). The results of this study imply significant power of musical preference on affective evaluations of other objects, or the context in which the individual is experiencing the music. This suggests that music therapy is greatly affected by individual liking of the music presented; for instance, if the client dislikes the music, the entire music therapy experience could be evaluated negatively, and subsequent mood changes are not likely to be positive in nature.

Stratton and Zalanowski (1984) found similar effects of liking on the degree of relaxation attained by participants. Participants listened to 15 minutes of one of 5 different kinds of music or listened to silence, and subsequently completed a questionnaire that rated items such as how relaxed they felt, the pleasurable quality of the experience, liking of the music, and how easily they were able to empty their mind during the session. This experiment found that “the most important factor in relaxation was the degree of liking for the music; significant correlations occurred between liking and relaxation, pleasure, and not thinking” (Stratton & Zalanowski, 1984, p. 184).

Kopacz (2005) suggests that personality traits play a role in musical preference. Participants completed both Cattell’s 16 PF Questionnaire (to assess personality traits), and the Questionnaire of Musical Preferences (devised by the researcher, which identified preferred musical pieces). The music identified by the participants was obtained by the researchers, and analyzed for tempo, changes in tempo, rhythm in relation to metrical basis, number of melodic themes, sound voluminosity (variety of instruments), meter, sound dynamics over the course of the piece, melodics, and leading instrument timbre. The data were then analyzed for correlations and relationships between personality traits and specific aspects of the musical pieces for which participants indicated preference.

In an analysis of variance, Social Boldness was found to have significant relationships with tempo, number of melodic themes, and meter. People with higher scores of Social Boldness tended to identify songs with much faster tempo, higher number of melodic themes, and songs in free time, or with lack of established beat. Also, the factors of Liveliness, Openness to Change, and Vigilance had a significant relationship with number of melodic themes, as determined through analysis of variance. People with higher scores of Liveliness and Openness to Change identified music with more melodic themes, and people with higher scores of Vigilance chose songs with fewer melodic themes.

This study, among others investigating possible correlations between personality and music preference, can further assist researchers as well as music therapists in creating efficient individualized programs for music therapy.

Preferred music & physiology

The following few studies explored the effects of an individual's preferred music on both physiological measures and self-report measures of anxiety. Burns et al. (2002) conducted a study involving the effects of several different types of music on both perceived and physiological measures of stress. Stress was induced in the participants through a warning of a very difficult Mental Rotations Task Test that they would perform following the music listening period. Then participants were randomly assigned into four conditions – three types of music and a control group who sat in silence. Each participant had been instructed to bring their own selection of music that they found to be "relaxing." Groups consisted of self-selected music, rock music and classical music. All participants filled out the State-Trait Anxiety Inventory and a relaxation rating scale before and after their treatment, and recorded physiological measures included skin temperature, frontalis muscle activity, and heart rate. An important strength of the design included the careful effort to control for multiple effects on anxiety and stress. Participants listened to music in a low-lit room with a recliner and two speakers. The plethysmograph was used to collect heart rate data less invasively than by placing electrodes on the chest, although the experimenters did acknowledge that the resulting data would be less accurate. Together, these conditions controlled for aspects of ecological validity.

Results included a lower post-music heart rate for the classical music group than for the control, and increases in relaxation scores for all four groups, with the self-selected music group at 34.66% increase, and the control group at 31.71%, classical group 22.78%, and the hard rock group 18.05%. Scores on the STAI-Y decreased for all groups from before listening to music or silence to after. The largest decrease in anxiety according to this test was for the control group, who sat in silence for 30 minutes. There were also no significant differences between groups in skin temperature measures and electromyograph (EMG) of the frontalis muscle, leading researchers to suggest that these are perhaps not sensitive enough measures of arousal. Overall, researchers concluded that in this study, music promoted more cognitive effects than physiological, and sitting in silence may be the best method for reducing anxiety, though self-selected music also showed some promising significance in relaxation, indicating the power of preference. Also, “hard rock music may compromise an individual’s ability to relax or become less anxious” (Burns et al., 2002, p. 113).

In a nursing intervention study, Lai (1999) examined the effects of music listening on depression in Taiwanese women. In this study, the patient chose what music they would listen to, thus injecting an influence of preference on the effectiveness of the music in producing therapeutic effects. The choices of music included classical, new age, Chinese music, and Oriental new age. Immediate mood state was measured, in addition to several physiological measures: heart rate, respiratory rate, and blood pressure. Measurements were taken before and after a 30 minute period of music listening, and a control group spent the time listening to pink noise, (which is made up of a spectrum of sound frequencies that are narrowed or bent from white noise). Perhaps pink noise was used as the control in this experiment because it is a more naturally occurring sound than white noise, as it is found within physical, biological and economic systems, and music in general leans toward a pink noise spectrum (Pink Noise, from Wikipedia, 2007). In both the music listening group and the control group, heart rate decreased from pre- to post-test measures; however, the decrease was not large enough to be statistically significant. Other important physiological findings include a significant decrease in respiratory rate ($t(14)=3.21$, $p=0.006$) and systolic blood pressure ($t(14)=5.81$, $p=0.000$) for the experimental group that was not exhibited in the control group. Mood states were measured with an adjective checklist, and strength of the correspondence of the adjective to the patient's immediate mood state was rated on a scale from 1 (*not at all*) to 10 (*the strongest possible feeling*). In this study, mood states were a relatively insignificant measure of therapeutic effectiveness, (only the tranquil mood state was significantly affected: experimental group: $t(14)=-2.92$, $p=0.011$; control group: $t(14)=-2.82$, $p=0.014$), perhaps indicating a weak measure of immediate changes in mood. The researcher acknowledged the limitations of a small sample size (15 participants in each condition), as well as the influence of Chinese culture on the placebo effect (in that respect for the health care professional resulted in positive reactions even to the pink noise control group, as discovered during debriefing sessions). Another issue with this study is the lack of validity and reliability testing for the mood state questionnaire used. Despite these limitations, the study contributed to the evidence that music listening can result in physiological relaxation, at least on the level of some autonomic response.

Another study investigating the relationship between musical preference and physiological and subjective measures of mood changes was conducted by Iwanaga and Moroki (1999). Participants rated musical impressions of excitative and sedative music using the Affective Value Scale of Music. These ratings were completed after listening to each 5 minute 48 second piece. Heart rate, blood pressure, and respiration rate were measured continuously throughout the music intervention. Reports of preference for the piece were analyzed along with physiological responses and elicited emotions. Participants reported feeling more relaxation during the sedative music than the excitative, $F(1,90)=78.38$, $p<0.001$. More vigor was experienced by participants during the excitative music than the sedative type, $F(1,90)=6.22$, $p<0.05$. No significant effects were found for preference on ratings of relaxation or vigor to either the sedative or the excitative music. Participants reported higher levels of tension when listening to the excitative music, $F(1,90)=8.59$, $p<0.01$, as well as when listening to music that was not preferred, $F(1,90)=5.29$, $p<0.05$.

Physiological measures demonstrated significant effects of music type on heart rate, $F(1,90)=5.43$, $p<0.05$, such that heart rate was higher on average during the excitative music than the sedative music. Excitative music also induced a higher respiratory rate than the sedative music, $F(1,90)= 9.70$, $p<0.01$, and a greater increment in systolic blood pressure, $F(1,90)=15.82$, $p<0.001$. Diastolic blood pressure increased with the onset of the excitative music, but remained low during the sedative music $F(1,90) = 16.63$, $p<0.001$. No significant effect of preference on physiological changes was observed.

Essentially, this study evidenced effects of preferred music on subjective self-report of tension, but that tension was not exhibited physiologically. Physiological changes that were induced by the music included heart rate, respiratory rate, systolic and diastolic blood pressure alterations.

Summary, Implications & Hypotheses

Overall, research on music therapy opens up new questions regarding specificities. Some studies successfully demonstrated both psychological and physiological effects, while other studies that took place in some of the most stressful conditions (pre-operation) have left us questioning the effectiveness of music in relaxation at all. Other research may demonstrate striking effects of music on mood but not physiological changes, and the impact of personal preference on music has much left to be explored and clarified. Because moods and emotions are so thoroughly connected to bodily states of being, these mixed findings suggest a need for a refining of methodology, with more effective measures of both emotion and physiology, as well as deeper investigation into possible influences of personality traits and musical features.

A meta-analysis was conducted by Pelletier (2004) to examine the efficacy of various approaches to music therapy. Primary findings indicated a significant effect of music combined with relaxation techniques on decreasing arousal due to stress. This stress factor was important in the beneficial aspect of music; music was found to have the least effect in studies without some kind of stress, be it naturally occurring (as in the case of pre-operative anxiety) or experimenter-induced (as in the studies involving the Stroop color word test, or a complicated Mental Rotations Task Test). Another important factor in music therapy efficacy was the combination with other relaxation techniques. Passive music listening had the smallest effect in decreasing stress or anxiety. Type of music presented also had significant effect, with researcher-chosen music selection demonstrating a greater effect on stress reduction than subject-selected music.

While studies have investigated physiological and perceived measures of stress-reduction, research is lacking in the area of continuous measurement of such changes. The current study will investigate the effects of music intervention on perceived and physiological measures, using a continuous report emotion circumplex (Russell, 1980; as cited in Sloboda & Juslin, 2001), measuring moment- to- moment changes in pleasantness and activation, the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994), and multiple electrodes measuring heart rate, galvanic skin response (in the form of skin resistance), skin temperature, and corrugator EMG muscle activity. This study will test the effects on relaxation of music-listening combined with a focused awareness of emotional changes, and will compare researcher-selected music with subject-chosen relaxing music and a silence control. Relaxation is proposed to involve self-reports of lower activation and possibly higher pleasantness, and physiological measurements reflecting lower corrugator EMG muscle tension, higher skin resistance, higher skin temperature, and lower heart rate (Andreassi, 2000).

Main hypotheses for the experiment are as follows:

1. Self-report will reveal greater relaxation with subject-chosen music than with experimenter-chosen music (greater pleasantness, less activation). Generally, studies have found that liking leads to higher ratings of pleasantness, and if the participant dislikes the music, heightened arousal or activation can result.

2. Subject-chosen music will be more relaxing physiologically (lower heart rate, higher skin temperature, higher skin resistance, and lower corrugator EMG response) compared with experimenter-chosen music. Because participants are instructed to select music they find relaxing, subject-chosen music should better induce a state of relaxation for each particular individual, either through iconic or associative sources of emotion. There is also the possibility of a participant strongly disliking the experimenter-chosen music, which likely would result in arousal rather than relaxation.

3. Silence will be physiologically relaxing (higher skin resistance, lower corrugator EMG response, higher skin temperature, and lower heart rate) to participants. It was thought by the experimenter that the control condition would be physiologically relaxing relative to the baseline, simply because the subjects would be sitting for a period of time in a dimly lit room without any arousing stimuli (such as music).

4. Current mood state of the day will affect the relaxing effects of the music. This common validity question arises when investigating emotion. Emotions may be altered by the kind of day the participant has experienced leading up to the session.

5. Mood state initially or after each song will affect the self-report reaction to the next song. This brings up the question of order effects; it is possible that if the participant listens to their chosen music first, he or she may react more positively to the other two conditions, whereas if the experimenter-chosen music is presented first and the participant dislikes it, he or she may react more negatively to the silence, or even more positively to their own music than would have happened otherwise.

6. Preference scores will be positively correlated with pleasantness. Though it is assumed that subject-chosen music will have the highest preference score, there is room for the possibility of participants preferring the experimenter-chosen music. Regardless of which condition is preferred, it is expected that with higher preference comes greater pleasantness in self-report.

Method

Participants

Twenty-eight undergraduate students gave informed consent to voluntarily participate in this study. Extra credit in General Psychology, Psychology of Music, and Western Thought I was offered to 75% of the participants, and the other 25% were acquaintances of the researcher. The data of 19 participants was used; 3 decided not to participate because of inconvenience to their schedules, and the data of 6 participants was incomplete. Of the final 19 participants, there were 11 males and 8 females, ages were 18-22 with a mean age of 19.53 years, years of participation in musical groups was from 1 to 10 with a mean of 5.03 years, and years of private music lessons (instrumental or vocal) ranged from 0 to 13 with a mean of 5.16 years.

Instruments

BioSemi flat Active electrodes (BioSemi, WG-Plein 129, 1054SC Amsterdam, Netherlands) were applied to participants using double-sided adhesive disks and Signa electrode gel by Parker Laboratories, Inc. (286 Eldridge Road, Fairfield , NJ 07004 USA), to measure heart rate, EMG, and attain a ground. A high precision temperature sensor from HP (Agilent 21078A) was attached to measure skin temperature, and two passive Nihon Kohden electrodes were attached for measuring galvanic skin response. Electrodes and sensors were connected to a Windows laptop computer via the ActiveTwo AD-box with battery and the USB2 receiver (BioSemi, WG-Plein 129, 1054SC Amsterdam, Netherlands). ActiView acquisition software was installed on the PC, to record the gathered data. An additional Windows computer was used to present participants with the music, the 2-dimensional emotion circumplex (for image, see Appendix A), preference sliding scales, and the SAM (see Appendix A) via a LabVIEW virtual instrument (National Instruments, Austin, TX). The SAM instrument has been used in multiple studies as measurement of emotional content of pictures and other stimuli, (a few examples include Backs, da Silva, and Han, 2005, Shao-hua, Ning, and Wen-tao, 2005, and Hillman, Rosengren, and Smith, 2004), and as an assessment of mood induction by Jennings, McGinnis, Lovejoy, and Stirling (2000). Signals from the LabVIEW program were sent to the acquisition software PC via the digital port on a National Instruments PCI-MIO-16XE-50 data acquisition board. Music was presented to participants using an Altec Lansing Multimedia Speaker System 2100 (Altec Lansing, 535 Route 6 & 209, Milford, Pennsylvania 18337-0277). Participants were seated in a cushioned office chair, and the room in which the experiment took place was lit by a floor lamp containing a Helical 10 watt bulb.

The program Amadeus (HairerSoft, 5, Bertie Road, CV8 1JP, United Kingdom) was used to edit subject-chosen music to the specified length of 2 minutes. Participants were instructed to select a song (from their own private collections) at least 2 minutes in length that was “relaxing” to them. Generally subject-chosen music included guitar, piano, and soft voice. Some participants chose music of the “alternative” genre, with 2 of the selections involving “alternative rock” or “pop rock” music. Some of the music included sad lyrics, while other pieces were more up beat and up lifting. Amadeus was also used to create a 2-minute period of silence for the control condition. The experimenter-chosen music was Prelude #5 in G Major by Sergei Rachmaninoff. This piece was selected because it consistently produced self-reports of high pleasantness and low activation (Dain, 2004, Fischer & Krehbiel, 2001) and significant correlations of pleasantness with physiological measures of corrugator EMG and GSR (Klein, 2003) in past experiments conducted by the Department of Psychology at Bethel College. For the present experiment the piece was edited by the experimenter to remove a middle section involving a key change and increase in tempo, which was likely to evoke a less pleasant and more arousing response.

Design

In this study, all subjects participated in all 3 conditions, therefore subjects served as their own controls. A pre-test and post-test was present within the design. However, primary data were collected continuously throughout the experiment, through self-report and physiological measurements. Approval was granted for this experiment by the Bethel College Institutional Review Board.

Procedure

Each participant signed up for a specific one-hour appointment time, and either dropped off ahead of time a compact disc containing their chosen song or brought it with them to the experiment. Upon arrival, the participant first was presented with SAM on the computer screen, and asked to move the slider beneath the pictures to the appropriate place on the scale, in order to indicate current level of pleasantness and arousal in response to his/her day so far. Participants were then asked to change into a provided shirt with strategically cut holes, in order to ease the process of electrode application and minimize the potential anxiety of the participant during the procedure.

Electrodes were then applied directly to the skin: for optimal heart rate detection, one was applied in the center of the chest and one on the side of the torso below the left arm; for EMG, 2 electrodes were attached on top of the corrugator muscle directly above the left eye; for the ground, 2 electrodes were attached at the base of the back of the subject's neck; and for galvanic skin response, electrodes were applied one to both the index and middle fingers of the left hand (to free the right hand for use of the computer mouse). The temperature sensor was attached to the thumb of the left hand.

After all electrodes were connected to the ActiveTwo AD-box, and signal strength confirmed, participants listened to all three conditions (experimenter-chosen music, subject-chosen music, and silence) in a random order. (Electrodes were attached for about 5 minutes before the experiment was in process and any physiological measurements taken, thus giving participants some time to acclimate and reducing the potential initial stress of having such equipment attached.) During the music or silence presentation, participants continuously rated their emotions on the 2-dimensional circumplex. After each song or period of silence, the participant was instructed by the computer program to indicate their level of liking for the piece using a slider scale ranging from ‘Dislike very much’ to ‘Like very much,’ and indicated his/her current mood in response to the song using the SAM measure.

Once all three conditions had been completed, the electrodes were removed, and the participant changed clothing and filled out a brief socio-demographic form. The experimenter answered any questions, and instructed the participant to keep the proceedings of the experiment confidential.

Data preparation & analysis

The ActiView acquisition software produced files of all the physiological data at a 256 Hz sampling rate, and the open source EEGLab package (Swartz Center for Computational Neuroscience, University of California, San Diego) was used to section off the data according to events. Events consisted of each of the three conditions as well as a separate baseline period prior to each piece of music or period of silence. (Each participant produced 6 events.) EEGLab also converted the data into text files. An additional LabVIEW virtual instrument (VI) was used to average the physiological data into a sampling rate of 1 per second for each measure. Microsoft Excel was used to calculate individual means of the last 20 seconds of each baseline, and these means were subtracted from the corresponding data obtained during the music or silence periods. This method of calculating physiological change relative to a baseline was used in a study conducted by Witvliet, Ludwig, and Vander Laan (2001).

The LabVIEW VI used during the experiment created a spreadsheet-readable file containing emotion space coordinates for each second of the music. These self-report data were combined in a spreadsheet with the second-by-second physiological data, forming a Level 1 file (see below for further explanation of Level 1 files in HLM analysis).

Because the computer loaded the sound file at different rates each time the virtual instrument was engaged, an unpredictable delay period occurred before the sound file would begin to play. During this delay period, useless emotion data were collected, and the beginnings of all of the emotion rating data files were not synchronized. However, the ends of all of the files were synchronized, because there was no delay after the music stopped playing and before the virtual instrument ceased to collect emotion data. Therefore, the beginnings of all of the LabVIEW data files were trimmed to the length of the shortest data file. This procedure ensured synchrony of data.

After all the data were compiled into a composite file, Systat (Systat Software, Inc., 1735, Technology Drive, Ste 430, San Jose, CA 95110, USA) was used for conversion into an SPSS file, readable by the analysis software used, Hierarchical Linear Modeling (HLM) (Scientific Software International, Inc., 7383 N. Lincoln Avenue, Suite 100, Lincolnwood, IL 60712-1747 USA). An additional file was composed of relevant socio-demographic data, forming the Level 2 file.

HLM was used to test all Level 1 outcome variables (repeated-measures including pleasantness or activation ratings, preference ratings, SAM mood ratings, and physiological data including heart rate, EMG, GSR, and skin temperature) and combinations of these variables for significant interactions with each of the Level 2 variables (socio-demographic information about the participants including years of private music lessons, years of participation in music groups, gender). All models (significant variables and combinations of variables) were saved. The criterion for statistical significance was a p-value of .05 or less.

Additional analyses were conducted using a repeated measures analysis of variance (ANOVA) and paired t-tests in SYSTAT software. The criterion for statistical significance here was also a p-value of .05 or less.

Results

Self-report measures

Within HLM models were built involving both Level 1 and Level 2 variables to investigate specific interactions. Figure 1 displays an example of one of the models created throughout the data analysis. This model explored the statistical significance of interactions between continuous ratings of subject-reported pleasantness and the differences between experimenter-chosen music and subject-chosen music, as well as effects of the number of years of participation in musical groups on both of these variables.

LEVEL 1 MODEL

$$\mathrm{PLEAS0}_{ij} = \beta_{0j} + \beta_{1j}(\mathrm{V2SONGS}_{ij} - \overline{\mathrm{V2SONGS}}_{..}) + r_{ij}$$

LEVEL 2 MODEL

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\mathrm{YRSPART}_{j} - \overline{\mathrm{YRSPART}}_{.}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\mathrm{YRSPART}_{j} - \overline{\mathrm{YRSPART}}_{.}) + u_{1j}$$

Figure 1 HLM model with pleasantness as the outcome variable

In this HLM model, pleasantness is the outcome variable, and predictor variables consist of both years of participation in musical groups and the experimenter-chosen song versus the subject-chosen song. This model generated output that is displayed in Table 1. Pleasantness was significantly greater with subject-chosen music than with experimenter-chosen music, see Table 1, (INTRCPT2, B10). In addition, with more years of participation in musical groups, the difference in self-reported pleasantness for the two musical pieces was smaller. In other words, participants were consistently reporting relatively high pleasantness for their subject-chosen music, and with more years of participation in musical groups, participants also reported greater feelings of pleasantness for the experimenter-chosen music, see Table 1, (YRSPART, B11). Self-reported responses of pleasantness were statistically significant, see Table 1 (INTRCPT2, B00), and with more years of participation in musical groups, participants reported greater feelings of pleasantness throughout the experiment, see Table 1 (YRSPART, B01).

Table 1 HLM output pertaining to the model in Figure 1

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, P0					
INTRCPT2, B00	15.635045	1.895922	8.247	17	0.000
YRSPART, B01	2.720254	0.865191	3.144	17	0.006
For V2SONGS slope, P1					
INTRCPT2, B10	7.435708	2.030049	3.663	17	0.002
YRSPART, B11	-2.246897	0.926399	-2.425	17	0.027

Pleasantness was also significantly higher for subject-chosen music than during the silence control period, model coefficient = 11.748, $t(18) = 4.874$, $p < 0.001$, (for complete HLM output, see Appendix B, Fig. B1). Figure 2 displays the mean continuous measurements of self-reported pleasantness for all three conditions. The effect of the Level 2 variable as a predictor on pleasantness is displayed in Figure 3. Participants with 6 or more years of participation in musical groups reported greater feelings of pleasantness for both conditions, while participants with 5 or fewer years of participation had reports of much lower pleasantness during the experimenter-chosen piece.

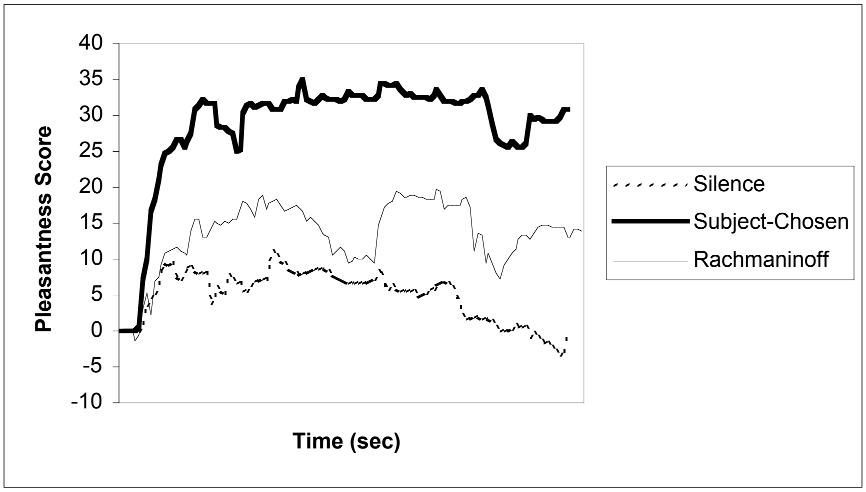

Figure 2. Pleasantness score vs. time. Participants used the emotion circumplex to continuously rate changes in pleasantness throughout all three conditions.

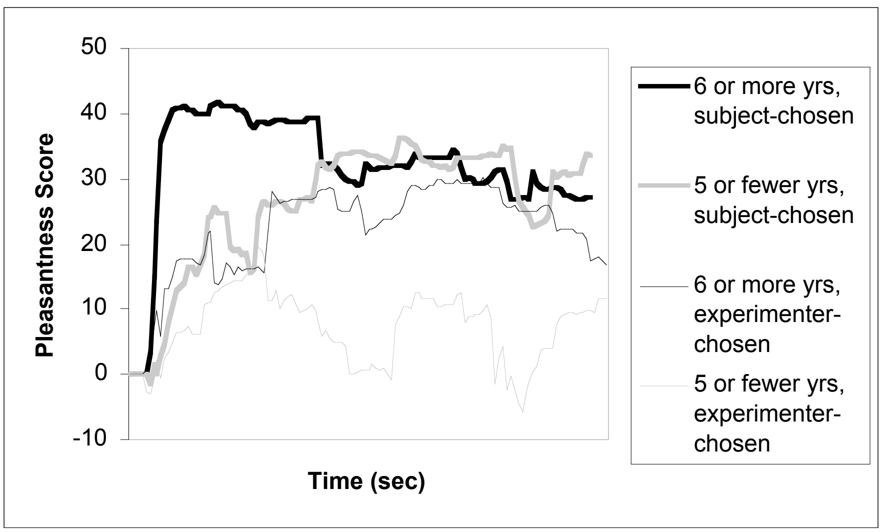

Figure 3. Pleasantness score vs. time for the 2 musical conditions, as a comparison between participants with more and fewer years of participation in musical groups.

Self-reported measures of activation were significantly higher for each of the music conditions, however there was no significant difference between experimenter-chosen and subject-chosen music, $p > 0.36$. The subject-chosen music invoked significantly greater activation than the silence, model coefficient = 5.500, $t(18) = 2.973$, $p = 0.009$. The experimenter-chosen music also induced higher activation than silence, model coefficient = 7.085, $t(18) = 4.344$, $p < 0.001$. Self-reported measures of activation were statistically significant throughout the experiment, model coefficient = -13.837, $t(18) = -5.612$, $p < 0.001$, (for complete HLM outputs, see Appendix B, Figures B2-B4). Mean scores of continuous measurement of self-reported activation throughout the 3 conditions can be viewed in Figure 3.

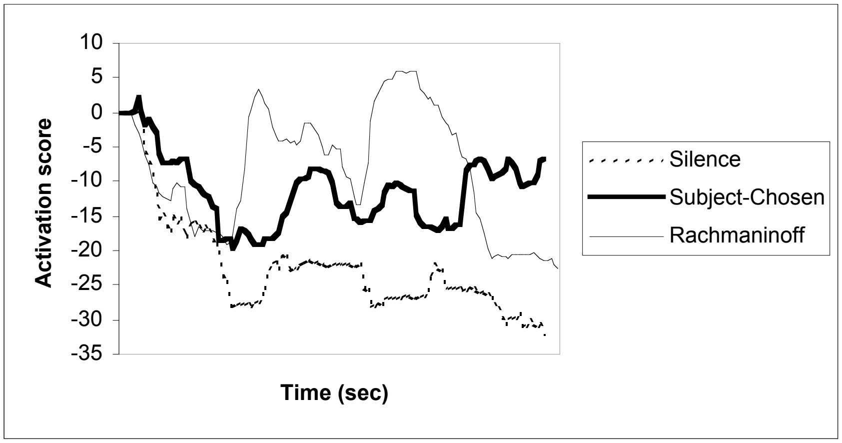

Figure 4 Activation score vs. time. Participants used the emotion circumplex to continuously rate changes in activation throughout all three conditions.

Self-report was also measured by SAM ratings at the start of each session, and after each condition. Means and standard deviations for SAM ratings of pleasantness and activation are displayed in Table 2.Both pleasantness and activation are on a sliding scale from –5 (low) to 5 (high), with 0 as a neutral point.

Table 2. Means and standard deviations of SAM ratings of pleasantness and activation.

Condition	Pleasantness		Activation	
	Mean	S.D.	Mean	S.D.
Initial	1.982	1.577	-1.245	1.803
Silence	0.729	1.265	-2.506	1.721
Subject-Chosen	2.158	1.710	-2.364	1.360
Rachmaninoff	0.812	1.803	-2.314	1.780

A repeated-measures ANOVA, revealed significant differences among the pleasantness means of each condition, $f(3) = 6.052$, $p = 0.001$, as well as among the activation means of each condition, $f(3) = 3.948$, $p = 0.013$. Despite a randomly assigned order of conditions for each participant, significant differences in pleasantness and activation ratings were found, implying that the musical conditions or silence were the basis for these differences. Paired t-tests with Bonferroni adjustment exhibit specific details of the significant differences between each of the conditions, see Table 3.

Table 3. Paired t-test results of differences between all possible pairs of conditions for SAM ratings of both pleasantness and activation.

	Pleasantness			Activation		
Pair	**t**	**df**	**p-value**	**t**	**df**	**p-value**
Initial Silence	3.575	18	0.002	2.739	18	0.013
Initial Subject-chosen	-0.369	18	0.716	3.087	18	0.006
Initial Rachmaninoff	2.336	18	0.031	2.950	18	0.009
Silence Subject-chosen	-3.289	18	0.004	-0.323	18	0.750
Silence Rachmaninoff	-0.221	18	0.828	-0.399	18	0.694
Rachmaninoff Subject-chosen	3.014	18	0.007	-0.139	18	0.891

Physiological effects of subject-chosen music

There was no significant difference in change in heart rate for the subject-chosen versus experimenter-chosen music conditions, $p > 0.62$, or for the subject-chosen music versus silence, $p > 0.59$, or for experimenter-chosen music versus silence, $p > 0.84$, (for complete HLM outputs, see Appendix B, Figures B5-B7). Figure 4 displays consistent variability in heart rate across all three conditions.

Though no significant difference was found among music conditions and silence, time itself as a time-varying covariate revealed significantly different patterns of change over time for the two musical conditions, model coefficient = -0.027, $t(18) = -3.448$, $p = 0.003$, (for complete HLM output, see Appendix B, Fig. B8). This shows that heart rate changed across time in significantly different ways during listening to each of the excerpts of music.

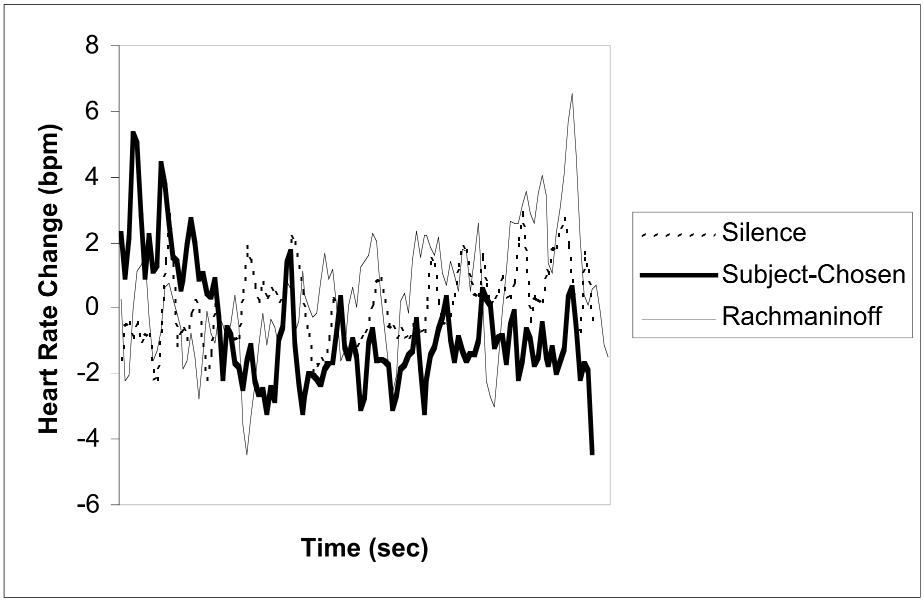

Figure 5. Heart Rate (bpm) vs. time. Heart Rate was calculated by ActiveTwo software, and the graph displays change in heart rate for each of the three conditions.

Skin temperature was significantly lower for the subject-chosen music compared both with silence, model coefficient = -0.110, $t(18) = -2.261$, $p = 0.036$, and with the experimenter-chosen music, model coefficient = -0.106, $t(18) = -4.604$, $p < 0.001$. The difference in skin temperature between silence and the experimenter-chosen music was not statistically significant, $p > 0.96$, (for complete HLM outputs, see Appendix B, Figures B9-B11). Continuous changes in skin temperature for the three conditions can be seen in Figure 5.

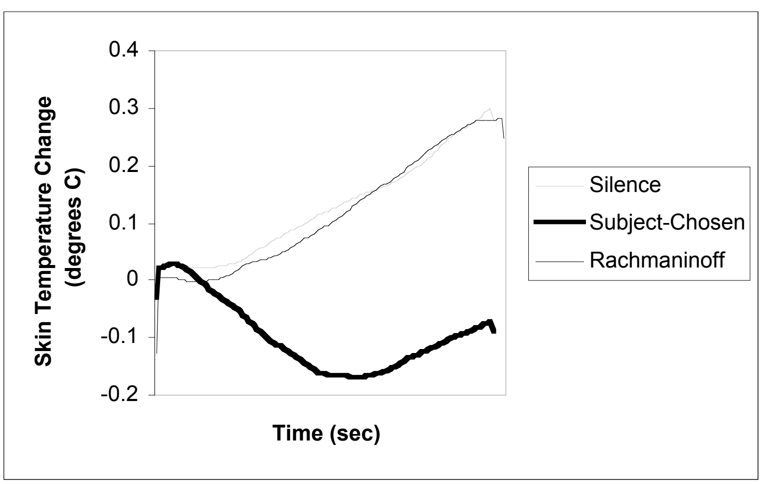

Figure 6. Skin temperature (deg C) vs. time. Mean continuous measurements of skin temperature throughout each of the three conditions.

Differences in skin resistance between the two musical conditions were not significant at the .05 level, but did display a trend of lower skin resistance for the subject-chosen music than the experimenter-chosen music, model coefficient = -259.075825, t(18) = -1.985, p = 0.062. A trend was also found between in differences between silence and the experimenter-chosen music, model coefficient = 202.639836, t(18) = 2.059, p = 0.054, see Figure 6. There was no significant difference between skin resistance changes during subject-chosen music and silence, p > 0.74, (for complete HLM outputs, see Appendix B, Figures B12-B14).

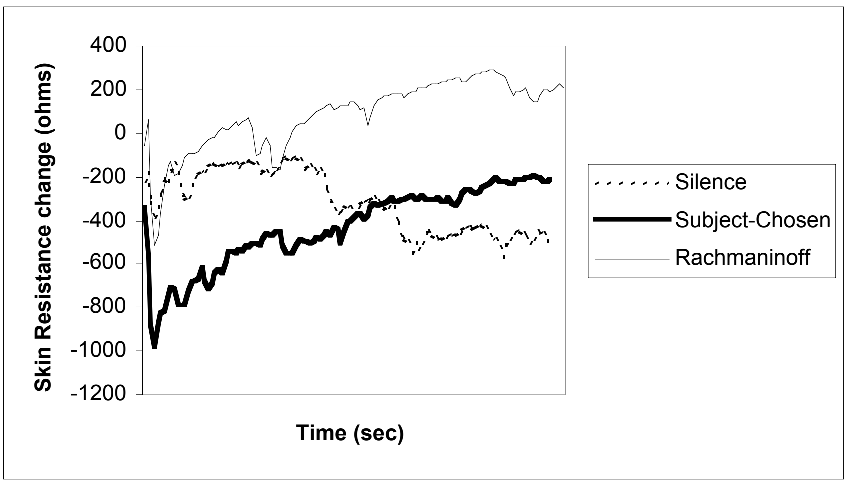

Figure 7. Skin Resistance (ohms) vs. time. Mean continuous measurements of skin resistance throughout each of the three conditions.

Similar to the findings for change in heart rate across time, time was found to be a significant time-varying covariate of skin resistance for the three conditions. Significantly different patterns of change across time for the three conditions were revealed, model coefficient = 3.535, t(18) = 2.396, p = 0.028, (for complete HLM output, see Appendix B, Fig. B15).

Corrugator EMG responses were found to be significantly lower for subject-chosen music than for experimenter-chosen music, model coefficient = -40339.396, t(16) = -2.122, p = 0.050. Differences between silence and the experimenter-chosen (p > 0.40) and between silence and the subject-chosen (p > 0.37) were not statistically significant, (for complete HLM outputs, see Appendix B, Figures B16-B18). See Figure 7 for mean continuous corrugator EMG measurements for the three conditions.

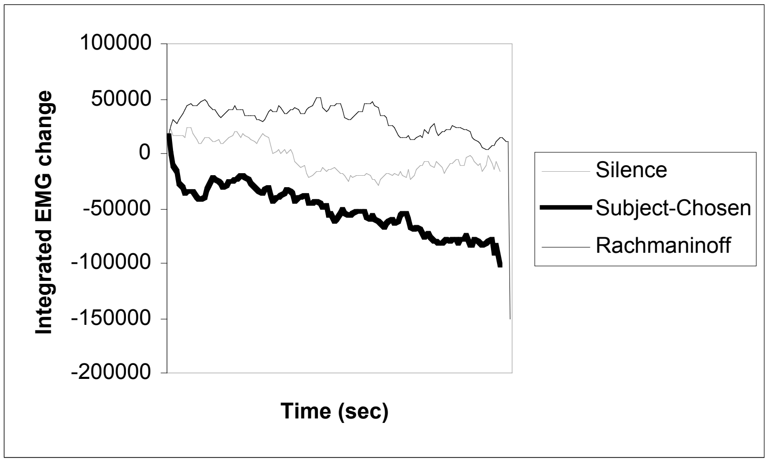

Figure 8. EMG changes vs. time. Mean continuous measurements of corrugator EMG response throughout each of the three conditions.

Effects of silence on physiology and self-report

Silence exhibited no significant effects on skin resistance, p > 0.19, corrugator EMG response, p > 0.90, skin temperature, p > 0.14, or heart rate, p > 0.91. In terms of self-report measures, silence significantly reduced activation, model coefficient = -22.285, t(18) = -7.200, p < 0.001, but had no significant effect on pleasantness, p > 0.22, (for complete HLM outputs, see Appendix B, Figures B19-B24).

Effects of mood state of the day

Upon analysis, initial SAM ratings of pleasantness and activation were not reliable predictors of any of the self-report measures or physiological measures throughout the experiment. All p-values were above 0.50.

Effects of order

SAM ratings of pleasantness and activation before each excerpt were not significantly different, implying that the reaction to a previous song had no effect on the pleasantness and activation ratings of the next song. In the HLM analysis, while the SAM rating of pleasantness is consistently significant as an intercept, model coefficient = 1.545, $t(18)= 5.258$, $p < 0.001$, differences between silence and subject-chosen music, $p > 0.75$, subject-chosen music and the Rachmaninoff, $p > 0.83$, and the Rachmaninoff and silence, $p > 0.93$, were not significant, (for complete HLM outputs, see Appendix B, Figures B25-B27). Similar findings were present for SAM activation ratings. While the SAM rating of activation was significant as an intercept, model coefficient = -1.948, $t(18) = -6.308$, $p < 0.001$, differences between the two musical pieces, $p > 0.97$, silence and subject-chosen music, $p > 0.85$, and silence and the Rachmaninoff, $p > 0.81$, were not statistically significant, (for complete HLM outputs, see Appendix B, Figures B28-B30). This implies that further self-report ratings of pleasantness and activation were statistically significant, and that the order in which the conditions were presented had no effect on these ratings.

Correlation of preference with pleasantness

In HLM analysis, pleasantness was found to be a significant predictor of preference, with higher pleasantness correlating with higher preference, model coefficient = 0.038, $t(18) = 5.355$, $p < 0.001$, (for complete HLM output, see Appendix B, Fig. B31).

Additional measurements & effects

It was important to be certain that the music individuals provided, as their subject-chosen relaxing music, was actually preferred above the experimenter-chosen music listened to during the experiment. In HLM, all possible combinations of the three conditions were significant predictors of preference, see Table 4, (for complete HLM outputs, see Appendix B, Figures B32-B34).

Table 4. HLM analysis of experimental condition as a predictor of preference. The asterisk (*) indicates which condition of the pair was preferred over the other.

Pair	Model Coeff.	t	df	p-value
*Subject-Chosen Experimenter-Chosen	0.892	4.737	18	0.000
*Subject-Chosen Silence	1.895	47.706	18	0.000
*Experimenter-Chosen Silence	0.972	5.345	18	0.000

Just as a Level 2 variable became a significant predictor in the HLM model of pleasantness discussed above, the same Level 2 variable of 'years of participation in musical groups' was also a significant predictor of corrugator EMG response. With more years of participation in musical groups, the difference in corrugator EMG response between the two musical conditions is greater, model coefficient = -40168.485, t(16) = -4.353, p = 0.001, (for complete HLM output, see Appendix B, Fig. B16). So with less experience in musical groups, participants reacted more similarly to the experimenter-chosen music as to their own selection of music, as exhibited by similar amounts of tension in the corrugator muscle, see Figure 9.

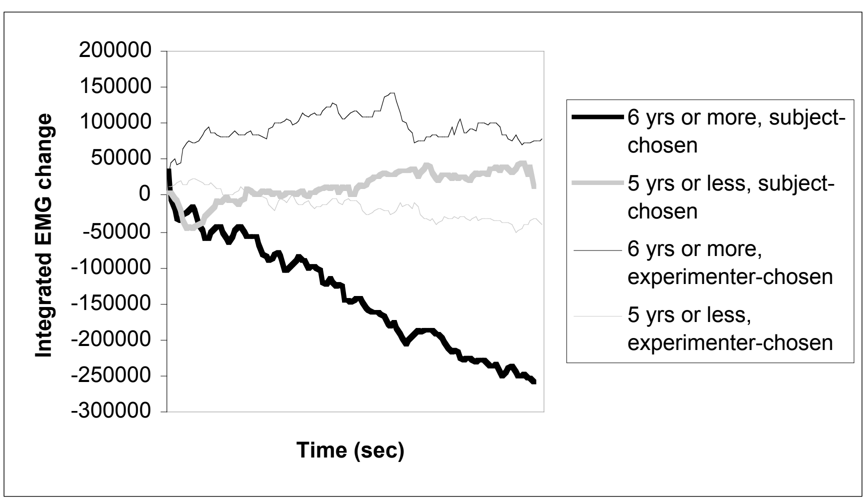

Figure 9. Corrugator EMG response vs. time for the 2 musical conditions in comparison of participants with more and less participation in musical groups.

With more experience in musical groups, participants experienced greater physiological relaxation of the corrugator muscle, and greater tension in this muscle when listening to the Rachmaninoff piece that was chosen by the experimenter.

Additional significant effects throughout the experiment include significant random effects for all HLM models analyzed, with p-values consistently at 0.000. This suggests that individual differences in responses to the conditions were significant, thus further validating significant patterns in self-report and physiological response.

Discussion

Overall, individual preference seems to have a more relaxing effect in terms of self-report pleasantness and activation (although silence induces lower activation scores), and less tension observed in corrugator EMG. Individual preference also appears to invoke a significantly different pattern of change in heart rate over time, in terms of decreasing and maintaining a lower heart rate than what is observed during listening to experimenter-chosen music. On the other hand, listening to preferred relaxing music can be more arousing as evidenced by a decrease in skin temperature and lower overall skin resistance (indicating a stronger emotional response (Andreassi, 2000)). This arousing effect may be due to greater stimulation by the music's associations or aspects that cause the individual to become excited upon listening. Furthermore, both continuous measure and single-measure methods of measuring emotion revealed similar results pertaining to the three conditions of the experiment.

These findings suggest that within the realm of music therapy, individual preference is a significant issue. Despite the firm belief in specific relaxing aspects of therapeutic classical music, individual differences are strong (evidenced by the significant random effects finding of this study), and the concept of relaxation may be more complex than is commonly believed. This study differs from previous studies investigating preference, such as those conducted by Lai

(1999) and Lepage et al. (2001), which provided a selection of music from which participants were to choose. Iwanaga and Moroki (1999), Stratton and Zalanowski (1984), and Wooten (1992) explored effects of preference simply by obtaining preference ratings of the music intervention that was provided. Because the current study asked participants to select music from their personal collections, an entirely different emotional connection with the music is already present. The word "preference" means something different here. Whereas in the other studies, preference could simply mean "which music I dislike the least," the current study allows participants to choose music to which they definitely enjoy listening.

Studies that included specific selections from participants' own music collections (Burns et al., 2002, Walworth, 2003, and Gerdner, 1997) demonstrated generally relaxing effects, but were inconclusive. For example, Burns and colleagues found greater increases in "relaxation" (as determined via a relaxation rating scale) after listening to preferred music, but did not uncover significant physiological changes. The present study investigated physiological change in addition to self-report of emotional change, using a significantly different technique of measurement.

These previous studies conducted on physiological change did not take measurements *continuously* throughout the experimental session. The present study investigated changes in continuous measurements for both self-report and physiology. While continuous self-report of pleasantness and activation indicated relaxation, physiological recordings left the concept of relaxation to be more ambiguous. One explanation is that in some ways individual preferred music is not entirely relaxing, due to its more stimulative nature. Another possibility regards the definition of relaxation and how emotions and physiology relate. Barrett (2006) suggests that our current definitions of emotion and how it relates to physiology are inaccurate, in that the words we use to describe certain emotions are not automatically connected with a neat bundle of behavioral and physiological response. Perhaps this applies to our notion of relaxation as well. Because music is so ubiquitous in many cultures throughout the world, it is unlikely that therapeutic music will simply relax people without inducing an aroused physiological response. Maybe in order to relax while listening to music, some amount of positive arousal must occur (in the case of this experiment, lower skin temperature and lower skin resistance). Of course, too much arousal is certainly likely to detract from other physiological relaxation.

In general, experimental hypotheses were both supported and contradicted. Subject-chosen music was significantly preferred over experimenter-chosen music, and these ratings of preference correlated significantly with high pleasantness ratings. This finding is especially interesting considering the nature of the music chosen by participants. Many of the excerpts contained sad lyrics, some included loud drums and heavy bass riffs, and the data of this experiment suggest that these discrepancies, with the general concept of relaxing music, perhaps are not as important as commonly thought. Enjoyment of the music appears to be important in determining just how relaxing music is to a particular individual. Selections of “relaxing” music may have been made by the participants on the basis of a combination of musical aspects and lyrics that hold unique and significant meaning.

Relaxation implies greater pleasantness and lower activation. While self-report measures revealed greater pleasantness for subject-chosen music, activation was actually lowest for silence. This may be due to the descriptor words on the emotion circumplex, with “fatigued” as one of the words in the deactivated half of the circle. The general concept of relaxation connotes a more positive deactivation than was apparently indicated by participants’ self-report, (as evidenced by the significantly lower pleasantness scores for the silence control period). In other words, perhaps the changes over time during silence reflect a feeling of something like boredom, which is not altogether the same thing as relaxation.

The next hypothesis, pertaining to physiological effects of subject-chosen music, was partially supported. A significantly different pattern of change in heart rate over time was found for subject-chosen music, and corrugator EMG response indicated significantly less tension in the corrugator muscle. Higher physiological arousal during subject-chosen music was evident in significantly lower skin temperature and a pattern of skin resistance change that indicated higher arousal in terms of increased electrical activity in the skin.

Initial mood states of the participants also had no significant effect on self-report or physiological measurements during each condition. Within this experiment, music seemed to have a big effect on mood, but mood did not appear to influence emotional reaction to music. There were also no significant effects of the order of conditions. This implies either that random assignment successfully averaged out any effects of the previous condition, or that participants were not influenced by the order in which the conditions were presented to them.

Years of participation in musical groups had a significant influence on both self-report of pleasantness and EMG response throughout the experiment. Participants with 6 or more years of experience in musical groups reported more pleasantness throughout, and their rating of pleasantness for Rachmaninoff's Prelude #5 in G Major was very similar to their rating for their own music. Furthermore, these participants with more experience exhibited a greater corrugator EMG response to the Rachmaninoff, and much lower EMG response to the music they had selected. Participants with 5 or fewer years of participation in musical groups had a very similar corrugator EMG response to both musical conditions. So the participants with more experience reacted consciously with greater pleasantness to music in general, and with similar conscious responses to their own music and to the Rachmaninoff, but also exhibited more differentiation between their own music and the Rachmaninoff in terms of corrugator muscle tension. Perhaps the additional training of these participants caused them to frown in concentration while listening to the Rachmaninoff, in which case this frowning is not necessarily a negative reaction, but rather a result of more musical training.

Limitations of the experiment include the relatively small sample size, (mean sample size for studies cited in the literature review is n = 61.69, with the exception of case study conducted by Gerdner (1997)), and the relatively short exposure time to each of the three conditions. It is possible that the musical conditions and silence would have produced stronger indication of physiological relaxation if presented for a period longer than 2 minutes, (such as the 30 minute sessions used in the experiment conducted by Burns et al. (2002)). Future studies should be conducted to investigate the effects of different lengths of exposure time on physiological changes.

While this study did not present a clear anxiety-invoking event (such as the Mental Rotations Task Test used in the study by Burns et al. (2002), or the Stroop test implemented in the study by Walworth (2003)), the invasive nature of the physiological recording equipment produced an anxiety-provoking situation. Pelletier's (2004) meta-analysis of music therapy studies indicated the important role this anxiety plays in the effectiveness of music as therapy, explaining, "music had the least benefit in studies with no indication of stress" (Pelletier, 2004, p. 206).

Physiological results of the study may have been affected by participants' use of certain substances such as caffeine, alcohol, or prescription drugs, (as discussed by Andreassi, 2000); however, it is likely that any influences of this type were averaged out across the sample.

Experiments involving physiological measurements should investigate participants' use of such substances, at least within the socio-demographic questionnaire.

Since preference appears to play an important role in the self-report and physiological reactions to music, future research should include investigation of interactions of musical preference with different types of therapeutic music or designed-music within a larger sample of participants. Also, additional research should be conducted to explore the influence of different types of musical experience on the efficacy of different types of music therapy. Participation in musical groups had a significant influence on emotional and physiological response to experimenter-chosen music in this study, and the specifics of these interactions should be explored further.

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Appendix A

Figure A1. The emotion circumplex (Russell, 1980; as cited in Sloboda & Juslin, 2001)

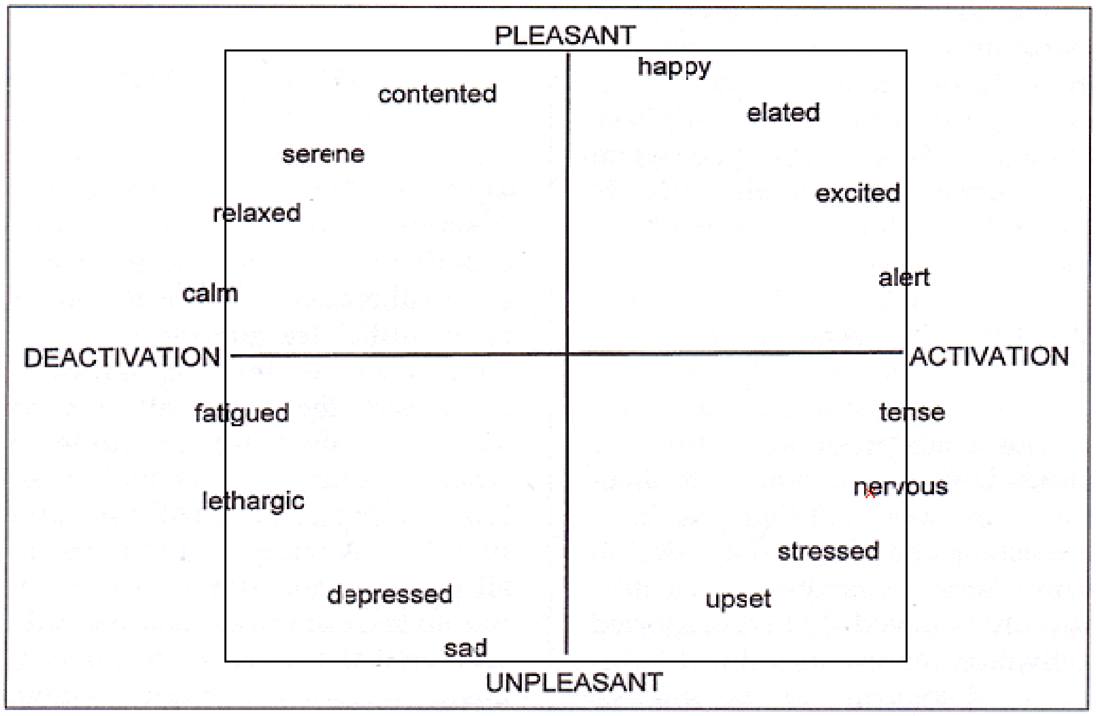
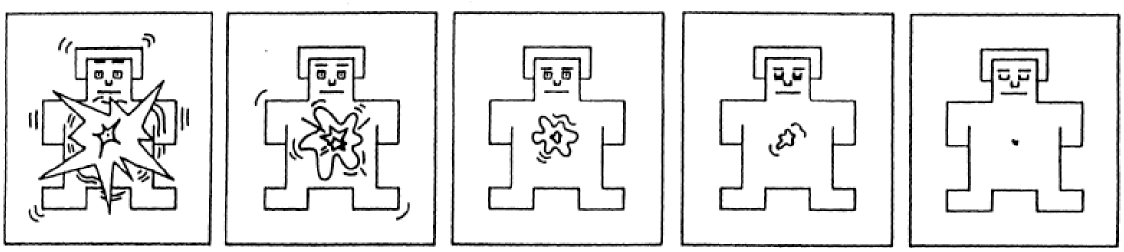
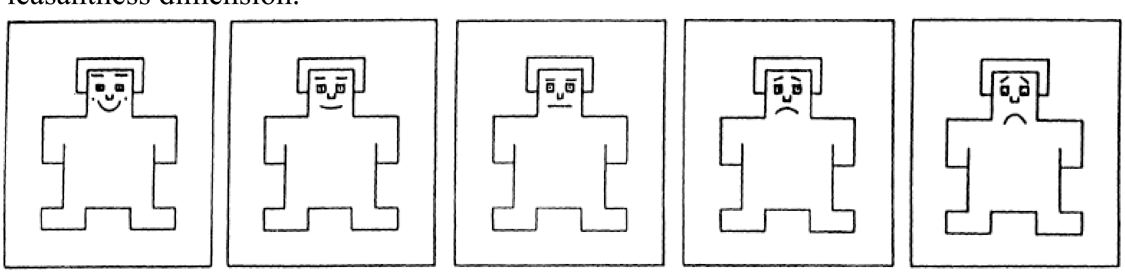


Figure A2. The Self-Assessment Manikin (Bradley & Lang, 1994).

Activation dimension.



Pleasantness dimension.



Appendix B

Figure B1. HLM output for interaction of pleasantness ratings between silence and subject-chosen music.

The outcome variable is PLEAS0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	15.630254	2.317354	6.745	18	0.000
For SILEPREF slope, B1					
INTRCPT2, G10	11.748184	2.410399	4.874	18	0.000

Figure B2. HLM output for interaction of activation ratings between the two musical conditions.

The outcome variable is ACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-13.860631	2.464187	-5.625	18	0.000
For V2SONGS slope, B1					
INTRCPT2, G10	-1.610276	1.740052	-0.925	18	0.367

Figure B3. HLM output for interaction of activation ratings between the subject-chosen music and silence.

The outcome variable is ACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, P0					
INTRCPT2, B00	-13.837074	2.465777	-5.612	18	0.000
For SILEPREF slope, P1					
INTRCPT2, B10	5.499759	1.849650	2.973	18	0.009

Figure B4. HLM output for interaction of activation ratings between the experimenter-chosen music and silence.

The outcome variable is ACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, P0					
INTRCPT2, B00	-13.895144	2.463784	-5.640	18	0.000
For SILERACH slope, P1					
INTRCPT2, B10	7.084591	1.631033	4.344	18	0.000

Figure B5. HLM output for interaction of change in heart rate between subject-chosen and experimenter-chosen conditions.

The outcome variable is HR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-0.061702	0.662926	-0.093	18	0.927
For V2SONGS slope, B1					
INTRCPT2, G10	-0.558789	1.107177	-0.505	18	0.619

Figure B6. HLM output for interaction of change in heart rate between subject-chosen music and silence.

The outcome variable is HR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-0.061702	0.662926	-0.093	18	0.927
For SILEPREF slope, B1					
INTRCPT2, G10	-0.399763	0.745063	-0.537	18	0.598

Figure B7. HLM output for interaction of change in heart rate between experimenter-chosen music and silence.

The outcome variable is HR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-0.061702	0.662926	-0.093	18	0.927
For SILERACH slope, B1					
INTRCPT2, G10	0.165456	0.850641	0.195	18	0.848

Figure B8. HLM output for interaction between time and change in heart rate for all conditions.

The outcome variable is HR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, P0					
INTRCPT2, B00	-0.395252	0.693444	-0.570	18	0.575
For V2SONGS slope, P1					
INTRCPT2, B10	1.050333	1.287895	0.816	18	0.426
For TIME slope, P2					
INTRCPT2, B20	0.005281	0.005229	1.010	18	0.326
For TIMEX2S slope, P3					
INTRCPT2, B30	-0.026554	0.007700	-3.448	18	0.003

Figure B9. HLM output for interaction of change in skin temperature between subject-chosen music and silence.

The outcome variable is TEMP

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.049304	0.045354	1.087	18	0.292
For SILEPREF slope, B1					
INTRCPT2, G10	-0.109732	0.048537	-2.261	18	0.036

Figure B10. HLM output for interaction of change in skin temperature between subject-chosen music and experimenter-chosen music.

The outcome variable is TEMP

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.049304	0.045354	1.087	18	0.292
For V2SONGS slope, B1					
INTRCPT2, G10	-0.105654	0.022946	-4.604	18	0.000

Figure B11. HLM output for interaction of change in skin temperature between silence and experimenter-chosen music.

The outcome variable is TEMP

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.049304	0.045354	1.087	18	0.292
For SILERACH slope, B1					
INTRCPT2, G10	-0.002313	0.048820	-0.047	18	0.963

Figure B12. HLM output for interaction of change in skin resistance between the two musical conditions.

The outcome variable is SR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-218.837693	129.643634	-1.688	18	0.108
For V2SONGS slope, B1					
INTRCPT2, G10	-259.075825	130.497723	-1.985	18	0.062

Figure B13. HLM output for interaction of change in skin resistance between silence and experimenter-chosen music.

The outcome variable is SR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-218.837693	129.643634	-1.688	18	0.108
For SILERACH slope, B1					
INTRCPT2, G10	202.639836	98.415093	2.059	18	0.054

Figure B14. HLM output for interaction of change in skin resistance between silence and subject-chosen music.

The outcome variable is SR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-218.837693	129.643634	-1.688	18	0.108
For SILEPREF slope, B1					
INTRCPT2, G10	-57.358648	175.741319	-0.326	18	0.748

Figure B15. HLM output for interaction time and change in skin resistance for all conditions.

The outcome variable is SR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, P0					
INTRCPT2, B00	-301.670685	139.143746	-2.168	18	0.044
For EXCERPT slope, P1					
INTRCPT2, B10	-14.358306	58.032726	-0.247	18	0.807
For TIME slope, P2					
INTRCPT2, B20	-5.301989	4.699382	-1.128	18	0.274
For TIMEEXEX slope, P3					
INTRCPT2, B30	3.534936	1.475105	2.396	18	0.028

Figure B16. HLM output for interaction of corrugator EMG response between subject-chosen and experimenter-chosen music, in addition to Level 2 effects of years participation.

The outcome variable is EMG

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-8324.574714	26638.533710	-0.313	18	0.758
For V2SONGS slope, B1					
INTRCPT2, G10	-40339.395967	19007.644433	-2.122	16	0.050
YRSPART, G11	-40168.485041	9226.961442	-4.353	16	0.001
YRSPRIV, G12	6523.708484	5568.229828	1.172	16	0.259

Figure B17. HLM output for interaction of corrugator EMG response between silence and experimenter-chosen music.

The outcome variable is EMG

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-8324.574714	26638.356475	-0.313	18	0.758
For SILERACH slope, B1					
INTRCPT2, G10	17342.192067	20535.242316	0.845	18	0.410

Figure B18. HLM output for interaction of corrugator EMG response between silence and subject-chosen music.

The outcome variable is EMG

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-8324.574714	26638.356475	-0.313	18	0.758
For SILEPREF slope, B1					
INTRCPT2, G10	-23373.179986	25743.388183	-0.908	18	0.376

Figure B19. HLM output for change in skin resistance during silence.

The outcome variable is SR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-317.900427	238.961073	-1.330	18	0.200

Figure B20. HLM output for change in EMG response during silence.

The outcome variable is EMG

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-4492.931818	37641.623611	-0.119	18	0.907

Figure B21. HLM output for change in skin temperature during silence.

The outcome variable is TEMP

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.124025	0.080920	1.533	18	0.143

Figure B22. HLM output for change in heart rate during silence.

The outcome variable is HR

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.092700	0.835047	0.111	18	0.913

Figure B23. HLM output for change in activation scores during silence.

The outcome variable is ACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-22.284711	3.095017	-7.200	18	0.000

Figure B24. HLM output for change in pleasantness scores during silence.

The outcome variable is PLEAS0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	4.988886	3.975360	1.255	18	0.226

Figure B25. HLM output for interaction of SAM rating of pleasantness between silence and subject-chosen music.

The outcome variable is MPLEAS0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.545120	0.293865	5.258	18	0.000
For SILEPREF slope, B1					
INTRCPT2, G10	0.057632	0.179076	0.322	18	0.751

Figure B26. HLM output for interaction of SAM rating of pleasantness between subject-chosen and experimenter-chosen music.

The outcome variable is MPLEAS0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.545120	0.293865	5.258	18	0.000
For V2SONGS slope, B1					
INTRCPT2, G10	0.038274	0.184571	0.207	18	0.838

Figure B27. HLM output for interaction of SAM rating of pleasantness between experimenter-chosen music and silence.

The outcome variable is MPLEAS0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.545120	0.293865	5.258	18	0.000
For SILERACH slope, B1					
INTRCPT2, G10	0.018431	0.214409	0.086	18	0.933

Figure B28. HLM output for interaction of SAM rating of activation between subject-chosen and experimenter-chosen music.

The outcome variable is MACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-1.947810	0.308769	-6.308	18	0.000
For V2SONGS slope, B1					
INTRCPT2, G10	0.007125	0.191006	0.037	18	0.971

Figure B29. HLM output for interaction of SAM rating of activation between silence and subject-chosen music.

The outcome variable is MACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-1.947810	0.308769	-6.308	18	0.000
For SILEPREF slope, B1					
INTRCPT2, G10	-0.047632	0.264787	-0.180	18	0.860

Figure B30. HLM output for interaction of SAM rating of activation between silence and experimenter-chosen music.

The outcome variable is MACTIV0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	-1.947810	0.308769	-6.308	18	0.000
For SILERACH slope, B1					
INTRCPT2, G10	-0.053990	0.232585	-0.232	18	0.819

Figure B31. HLM output for interaction between pleasantness and preference.

The outcome variable is PREF0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.834812	0.124918	14.688	18	0.000
For PLEAS0 slope, B1					
INTRCPT2, G10	0.037520	0.007006	5.355	18	0.000

Figure B32. HLM output for interaction of preference with the two musical conditions.

The outcome variable is PREF0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.921626	0.124352	15.453	18	0.000
For V2SONGS slope, B1					
INTRCPT2, G10	0.892444	0.188413	4.737	18	0.000

Figure B33. HLM output for interaction of preference between subject-chosen music and silence.

The outcome variable is PREF0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.921626	0.124352	15.453	18	0.000
For SILEPREF slope, B1					
INTRCPT2, G10	1.894737	0.039717	47.706	18	0.000

Figure B34. HLM output for interaction of preference between experimenter-chosen music and silence.

The outcome variable is PREF0

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.921626	0.124352	15.453	18	0.000
For SILERACH slope, B1					
INTRCPT2, G10	0.971815	0.181834	5.345	18	0.000