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Relaxation via Cross-Modal Adaptation: Autonomic Nervous System Responses and Subjective Relaxation Efficacy of Mindfulness Meditation and Music Therapy

Cody Spears
Minnesota State University Moorhead

Abstract. Cross-modal adaptation, sensory conflict that causes bodily adaptation and healing, may be used to facilitate relaxation. Previous research has shown that music and mindfulness meditation increase subjective relaxation and autonomic nervous system relaxation responses. It was hypothesized that mindfulness meditation would cause greater subjective relaxation and greater autonomic nervous system responses during relaxation than instrumental music therapy. College students listened to relaxing audio and answered a Relaxation Inventory survey after treatment to gauge their subjective relaxation responses. Analysis of four one-way ANOVAs found the hypothesis to be only partially supported. The Cognitive Tension Scale was the lone subsection to show a significant difference between the mindfulness meditation and control groups. These results suggest that cross-modal adaptation via mindfulness meditation is more effective for mental relaxation than a quiet break, but is not necessarily better than music therapy.

There are many meditation and relaxation techniques used in the therapeutic world to help reduce stress, anxiety, and depression. Some of these mindfulness and meditation techniques have been adapted from Eastern religious practices to be used in Western medicine (Simkin & Black, 2014). Meditation has long been part of religious enlightenment practices for Buddhist and Hindu sects, but the practices of the Abrahamic religions may also create a sort of meditative state of consciousness, as seen in deep prayer or faith healing sessions. These meditation techniques can also increase subjective feelings of spirituality in practitioners (Geary & Rosenthal, 2011). Other relaxation therapies, such as music therapy and progressive muscle relaxation (PMR), have been used by psychologists to reduce stress and anxiety. PMR was shown to be effective in helping college students to relax (Dolbier & Rush, 2012). While inexperienced practitioners may still receive benefits, meditative practices have been shown to elicit greater responses in more experienced meditators (Davidson & Kaszniak, 2015; Dolbier & Rush, 2012). While there is evidence that each of these practices can assist with relaxation and reduction of negative symptoms, there is little data to explain why meditation, guided imagery, and music therapy work.

Mindfulness meditation is a meditation and relaxation technique that involves paying attention to how one's body exists at the present moment, often by focusing on one's heartbeat or breath. Per Bedford's (2012) major theory review of mind-body interactions on perception, mindfulness meditation can be used as a means for cross-modal adaptation, meaning that sensory conflicts cause bodily adaptation for healing or other bodily responses. Bedford explains that this works in a similar way as vision and proprioception

adaptation when looking through a prism. Looking through a prism causes one's vision to be skewed to a certain degree. If a person is asked to point at an object viewed through a prism, the person's arm will appear to be pointing at a different angle than the person's proprioception, or relative bodily location, relays to the person's brain. This sensory conflict causes cross-modal adaptation over time since the person's proprioception must adapt to the skewed vision. This adaptation is evident after the prism is removed, because the person's arm will point away from the target object in a skewed manner consistent with the degree of vision skew when the prism was present. The adaptation effect is reversed over time as the person's normal vision causes the person's proprioception to change back to normal. The body's understanding of itself adjusts to conflicted sensory inputs in order to survive and heal.

This ability of the body to adjust is due to the immune system acting as the sixth sense. According to Blalock and Smith (2006), building on Blalock's landmark 1984 proposal that the immune system is the sixth sense, the immune system works as a sensory organ. Since the immune system can detect injuries or foreign objects in the body and react accordingly to keep the body healthy, mindfulness meditation could be used to influence the mind-body connection and, therefore, cause immune system responses. Knowing that mindfulness meditation could be used to create the sensory conflict necessary for cross-modal adaptation, it stands to reason that it could also be used to elicit autonomic nervous system responses via the same principle. This study provided further data to assist in understanding how mindfulness meditation and music therapy could influence relaxation.

Music therapy has been used to help improve patient experience in many aspects of treatment, but researchers have little understanding of how music therapy affects listeners. Music relaxation has been used to help reduce anxiety and pain during medical procedures, such as gastrointestinal procedures, as well as reduce blood pressure (Salmore & Nelson, 2000). Playing relaxing music in hospitals has helped intensive care unit patients sleep better and lowers their heart rates (Su et al., 2012). In diabetes patients music therapy and music-assisted relaxation and imagery (MARI) have been shown to reduce stress levels more so than diabetes self-management education/training (DSME/T) alone (Mandel, Davis, & Secic, 2013). Interestingly, patients' musical preference does not change which music piece is most effective for relaxation purposes (Perez-Lloret et al., 2014). The current study compared meditation and music alone to see which, if either, was most effective for elicitation of autonomic nervous systems relaxation responses and subjective relaxation reporting.

In order to biologically track the relaxation response, researchers in the current study wanted to use a finger pulse sensor to measure heart rate variability (HRV), which is a measure of individual differences between each beat of the heart. High-frequency HRV (HF-HRV) is an accepted mechanism for collecting and analyzing the relaxation responses of the autonomic nervous system. Tracking HF-HRV could therefore allow researchers to quantify relaxation without having to rely solely on subjective self-report from participants. Shearer, Hunt, Chowdhury, and Nicol (2015) found that meditation therapy had more effect on HRV than dog therapy. High-frequency HRV increases due to meditation have also been shown to be related to smoking cessation success (Libby, Worhunsky, Pilver, & Brewer, 2012). Peng, Koo, and Yu (2009) found that music therapy combined with aromatherapy led to increased HF-HRV responses during relaxation.

Subjective perception is an important factor in stress, anxiety, and depression. Previous studies have found that meditation can lead to altered perceptions of time, space, and body in long-term practitioners

(Berkovich-Ohana, Dor-Ziderman, Glicksohn, & Goldstein, 2013). Costa and Barnhofer (2015) found that mindfulness meditation reduces depression symptoms, but maintenance of the lowered symptoms requires further training. Costa and Barnhofer also suggested that overcoming negative thinking is the most important factor in depression symptom reduction, but the rapid reduction in symptoms is not a precursor to a full elimination of depression symptoms. Geary and Rosenthal's (2011) mindfulness study found increases in subjective spiritual experiences and reductions in self-reported stress even at follow-up a year after the treatment.

There are limitations to the effectiveness of music therapy, mindfulness meditation, and the related meditation practices, though. One study found that participants with personalities labeled as perfectionist show decreased HRV responses to meditation relative to non-perfectionist participants (Azam et al., 2015). This shows that some people may not be able to let go of stressors as easily as others, depending on the situation and the participant's personality. Steinhubl et al. (2015) found decreases in HRV in response to meditation, which is the opposite of the expected result. These unexpected results might be due to troubles with data viability and differing analysis methods, according to researchers. The researchers did find, however, decreased blood pressure in response to meditation when using continuous wireless tracking devices (Steinhubl et al., 2015). Lumma, Kok, and Singer (2015) showed that some meditations are specifically meant to increase arousal rather than assist in relaxation. Likewise, some mindfulness meditation scripts and musical pieces have been created to elicit arousal responses or enhance certain aspects of life. Musical piece selection is important during music therapy, as Perez-Lloret et al. (2014) found that musical variations such as tempo and rhythm caused relaxation effects to wane, particularly when parts of the music were quickening. This study shows that even pieces of music thought to be “relaxing” may incorporate portions that excite listeners and, thereby, disrupt the relaxation process. The current study utilized slow and unvaried instrumental relaxation music, as well as mindfulness meditation scripts designed to decrease arousal, to isolate the relaxation effects of music and mindfulness meditation on the autonomic nervous system.

Bedford (2011) noted that stronger perceptual conflicts caused stronger cross-modal adaptations. Since mindfulness meditation can be specifically scripted to create these strong perceptual conflicts while music cannot, it was hypothesized that mindfulness meditation would cause greater subjective relaxation and greater autonomic nervous system responses during relaxation than instrumental music therapy. This hypothesis was in direct opposition to the finding of Warth, Keßler, Hillecke, and Bardenheuer (2015) wherein music therapy provided greater subjective relaxation and greater increases in HF-HRV than spoken-word meditation. Also, the music therapy of the Warth et al. (2015) study included vocal improvisation, while the current study did not.

The current study employed a mindfulness meditation script that was specialized to increase subjective feelings of relaxation. Since it was not possible to create a script for instrumental music, the music selected was slow and musically unvaried as to not unconsciously excite the participant. This study sought to provide further information about whether mindfulness meditation or music therapy is most effective at reducing feelings of stress and creating greater autonomic nervous system relaxation

responses. This study expanded upon the results of Warth et al. (2015) while changing some methodological procedures to more closely study the efficacy of mindfulness meditation versus instrumental music therapy. Subjective relaxation was measured via self-report, while autonomic nervous system responses were measured via heart rate pulse tracking using a finger pulse sensor.

Method

Design

The current study employed a single factor between-subjects design wherein relaxation technique was the independent variable. Participants were randomly assigned to one of three relaxation technique groups: control, music, and mindfulness meditation. The dependent variables were the participant's pulse and subjective report of relaxation.

Participants

College undergraduate students from Minnesota State University Moorhead were the participants in this study. The sample included 77 volunteers recruited via a sign-up sheet. MSUM psychology professors gave compensation in the form of class extra credit for participation in the study. The age range of participants was 18-45 years of age (M = 21.27, SD = 4.90). Participants were 76.62% females and 23.38% males, which is consistent with the demographic of the psychology department.

Materials

The stimuli for the current study included a mindfulness meditation audio clip and a relaxation music audio clip. Both recordings were ten minutes long and were used with permission from the creators of each stimulus. The mindfulness meditation audio from YouTube creator TheHonestGuys (2016) contained instructions to focus on heartbeat, breath, and relaxation. The relaxation music was a ten-minute excerpt from an instrumental piece with slow and unvaried tempo and rhythm from YouTube creator YellowBrickCinema (2015).

The Relaxation Inventory, a 45-question survey that uses a 5-point Likert scale for each question, allowed tracking of subjective relaxation as it relates to physiological tension, physical assessments, and cognitive tension (Crist, Rickard, Prentice-Dunn, & Barker, 1989). The Physiological Tension section contained fifteen questions about body tension responses, the Physical Assessment section contained twenty questions about relaxation feelings, and the Cognitive Tension section contained ten questions about worries and thoughts. The Likert scale ranged from *strongly disagree* (1) to *strongly agree* (5), with the Physiological Tension and Cognitive Tension sections being reverse scored. Combining the maximum Likert score with the number of questions in each section, the Physiological Tension section had a maximum score of 75, the Physical Assessment section had a maximum score of 100, and the Cognitive Tension section had a maximum score of 50. A demographic survey with age and sex questions was added to the end of the Relaxation Inventory.

The pulse sensor equipment was a Nonin Model 2500 PalmSAT Hand Held Pulse Oximeter owned by the MSUM Psychology department. A notebook was used to store the pulse data. A computer was also used to play the mindfulness meditation and relaxation music audio clips, with headphones being used instead of speakers.

Procedure

Upon arrival, participants were given an informed consent sheet to read and sign. Participants were randomly assigned to either the control group, the music group, or the mindfulness meditation group. Once seated in front of the computer, participants were given headphones. The researcher connected the pulse finger sensor to the participant’s index finger, started the pulse tracking system, noted the participant’s pulse, and removed the sensor from the participant’s finger. The researcher then instructed the participant to sit

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comfortably in the chair, close their eyes, and quietly listen to the music or mindfulness meditation. Participants in the control group were asked to sit quietly on their own, similar to the other groups but with no music or script playing. Participants were instructed to let the researcher know when the stimulus stopped playing. The researcher played the stimulus for the music and mindfulness meditation participants on the computer and immediately leave the room.

The researcher had a timer set for ten minutes so that the researcher knew when to return to the room in the event that participants failed to notify the researcher of the stimulus's end. After ten minutes the researcher returned to the room. The researcher then took the participant's pulse a second time by connecting the pulse finger sensor to the participant's index finger, starting the pulse tracking system, noting the participant's pulse, and removing the sensor from the participant's finger once the pulse had been noted. Participants then answered all the questions on the Relaxation Inventory and demographic survey using the provided pen. Participants were fully debriefed after answering all the survey questions. The researcher allowed the participant a chance to ask any further questions about the study or to voice any concerns. Once questions and concerns had been answered, the participant was thanked for their participation and dismissed.

Results

To test the hypothesis that mindfulness meditation would cause greater subjective relaxation and greater autonomic nervous system responses during relaxation than instrumental music therapy, the study data was analyzed using four one-way ANOVAs. The one-way ANOVA was used because the IV was a single factor variable with three levels. The four DV means include the mean post-treatment pulse rate and three means from the sections of the Relaxation Inventory: Physiological Tension Scale, Physical Assessment Scale, and Cognitive Tension Scale. It was predicted that participants in the mindfulness meditation group would score higher in all DVs than the music therapy group. Furthermore, the music therapy group was predicted to score higher than the control group across all DVs.

Analysis of the four one-way ANOVAs found the hypotheses to be only partially supported. The Cognitive Tension Scale was the lone subsection that showed a significant difference between two of the IV levels, $F(2, 74) = 3.92$, $p < .05$. Post-Hoc analysis using Tukey's HSD showed that participants in the mindfulness meditation group ($M = 42.08$, $SD = 8.82$) were more cognitively relaxed than participants in the control group ($M = 35.2$, $SD = 8.92$), $p < .05$. There was, however, no difference between the music therapy group ($M = 37.81$, $SD = 8.86$) and the control group or mindfulness meditation group, $ps > .05$. Refer to Figure 1.

Results for the Physical Assessment Scale were marginally significant, $F(2, 74) = 2.70$, $p = .074$. Post-Hoc analysis using Tukey's HSD showed that participants in the mindfulness meditation group ($M = 82.27$, $SD = 8.90$) were marginally more physically relaxed than participants in the music therapy group ($M = 73.31$, $SD = 15.71$), $p = .059$. While this result was not presently statistically significant, it may have fallen within the acceptable range had the sample size been larger. The data showed no difference between the control group ($M = 77.52$, $SD = 16.03$) and the mindfulness meditation group or music therapy group, $ps > .05$. Refer to Figure 2.

There were no statistical differences across the mindfulness meditation, music therapy, and control groups for the

Physiological Tension Scale, $F(2, 74) = 1.81$, $p > .05$. There were also no statistical differences across the mindfulness meditation, music therapy, and control groups for the post-treatment pulse readings, $F(2, 74) = .77$, $p > .05$. Refer to Figures 3 and 4.

Discussion

The purpose of this study was to compare the effectiveness of mindfulness meditation with music therapy as relaxation techniques. Participants self-reported subjective relaxation feelings while the researcher measured pulse rate. Results of this study showed no significant differences between the two techniques and the control group, except in the Cognitive Tension Scale. Considering the small effect size of the difference in cognitive relaxation for the mindfulness meditation group versus the control group, it can be concluded that mindfulness meditation has a slightly stronger relaxation effect on cognitive processes than a simple quiet break. The current study cannot conclude, however, that mindfulness meditation is better for cognitive relaxation than music therapy. The Physical Assessment Scale showed a marginally significant result favoring mindfulness meditation over music therapy, but these results cannot be verified without a larger sample size.

The results of this study show that mindfulness meditation was able to create more cognitive relaxation than the control group, but that there was no difference between the mindfulness meditation and music therapy conditions. Implications for these results would include the efficacy of mindfulness meditation as a more robust cognitive relaxation technique for college students than short study breaks. This could mean that college students who are more cognitively relaxed due to mindfulness meditation would perform better on cognitive tasks than college students who did not employ mindfulness meditation breaks. Since previous research has shown greater responses in experienced meditators (Davidson & Kaszniak, 2015; Dolbier & Rush, 2012), mindfulness meditation results might become stronger over time.

Several limitations presented themselves during this study. Using a convenience sample of only Midwestern psychology undergraduate students impacted the availability of participants. Specifically, this study struggled with finding enough participants for ideal sample sizes, possibly due to decreased awareness of research opportunities. Given the time frame allowed for this study and the difficulty with recruitment, gathering 77 of the desired 90 participants was tolerable.

Further issues with this study were related to where the study was performed. The available room was on the third floor, meaning that participants often arrived to the study immediately after having walked up three flights of stairs. Participants often remarked that the journey had been tiring. Further room issues included the temperature of the room. Although the researcher attempted to keep the room comfortable, a lack of airflow meant the room could get warmer than was optimally comfortable at times. This temperature increase was especially true on days when many participants signed up for the study as there was no time between participants to get fresh cooler air into the room to reduce the temperature. Finally, the study room was near other classrooms, meaning that ambient classroom noise created distractions for the control group. The researcher could not minimize these distractions as the control group was not allowed audio to drown out the ambient noise. Room distractions might have been lessened by using a different room or noise-canceling headphones, but the researcher decided against these changes to not introduce new confounds beyond the existing confounds that became apparent later in the study.

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Due to equipment availability, the researcher was not able to track HRV as was originally planned. The pulse machine the researcher was able to find in the MSUM Psychology department did not come with HRV tracking software. Therefore, HRV tracking was scrapped in favor of the simpler pulse readings, which also turned out to present problems. Readings for participant pulse were often difficult to validate. The pulse machine used in this study had a tendency to be inconsistent and perhaps overly sensitive. The pulse reading on the machine would change quickly up and down and would sometimes rapidly jump after several seconds of seeming to be consistent on a reading. This called into question the validity and reliability of this particular pulse machine for the purposes of this study. These pulse machine troubles might have been tied to the aforementioned participant arousal related to climbing stairs to the third floor or the distractions of ambient noise. A more robust pulse machine, such as an arm cuff, could have possibly been used, but this would have meant a more personally invasive procedure for the study participants.

This study had several strengths despite the possible confounds. Most notably, the audio clips used for the mindfulness meditation and music therapy groups were readily available for public consumption. This means that any person with access to YouTube on the internet would be able to find and employ the mindfulness meditation or music therapy used in this study as relaxation techniques for stress-reduction. The audio clips used in this study also represent a standard sample of relaxation audio that the general public would be likely to try, as the clips presented for this study were chosen based on having a large number of views in their categories and time constraints. Likewise, the reality of the distractions that presented in this study are normal college life occurrences, meaning that anyone attempting to use relaxation techniques in the middle of a college campus is likely to deal with similar distractions. These real world factors help to make the results of this study more generalizable to a larger population.

Future research should involve more longitudinal studies to confirm and compare the differences between experienced meditators (Davidson & Kaszniak, 2015; Dolbier & Rush, 2012) and inexperienced meditators for relaxation responses. Researchers would also be well-served by creating custom mindfulness meditation scripts designed to target the three scales of the Relaxation Inventory. Focused mindfulness meditation scripts might allow researchers to better understand how participants react physically and cognitively. Once there is a better understanding of the individual scale responses, researchers may be able to create custom mindfulness meditation scripts that allow for better overall combined relaxation across the three Relaxation Inventory scales. Likewise, future researchers should work with musicians to create custom music therapy pieces targeted for specific relaxation or healing properties. Controlling for tempo and rhythm should help to increase relaxation (Perez-Lloret et al., 2014), but further studies might be able to target how music effects relaxation responses physically and cognitively. Custom made meditations and music designed specifically for therapeutic uses would likely cause stronger mind-body connection responses, leading to greater relaxation and healing via cross-modal adaptation, as Bedford (2011) suggested.

More stark differences might also be found if similar studies were conducted in temperature controlled rooms with more robust ventilation than what was available to the researcher. Likewise, a noise-controlled

room or noise-canceling headphones could be employed to remove distractions for all participant groups. Future research into these types of relaxation techniques would be best served by allowing participants to sit long enough before the study to return to a calm baseline. This would remove the possible arousal confounds that presented in this study.

Mindfulness meditation, guided imagery, and music therapy offer a wide variety of options for future research directions. While the current study tested for relaxation responses, future research might also test for arousal or healing responses by using pieces specifically designed for these purposes. Also, since the current study showed a stronger cognitive response, more studies should be performed using brainwave analysis to study how the brain reacts to these relaxation techniques. Finally, the holistic medicine community and some sound therapists have begun to use binaural beats and isochronic tones for meditation and relaxation. Even specific frequencies, known as the solfeggio frequencies, are purported to have healing properties. These sounds might help to strengthen the existing effects of relaxation techniques, but more scientific study is needed to confirm their efficacy.

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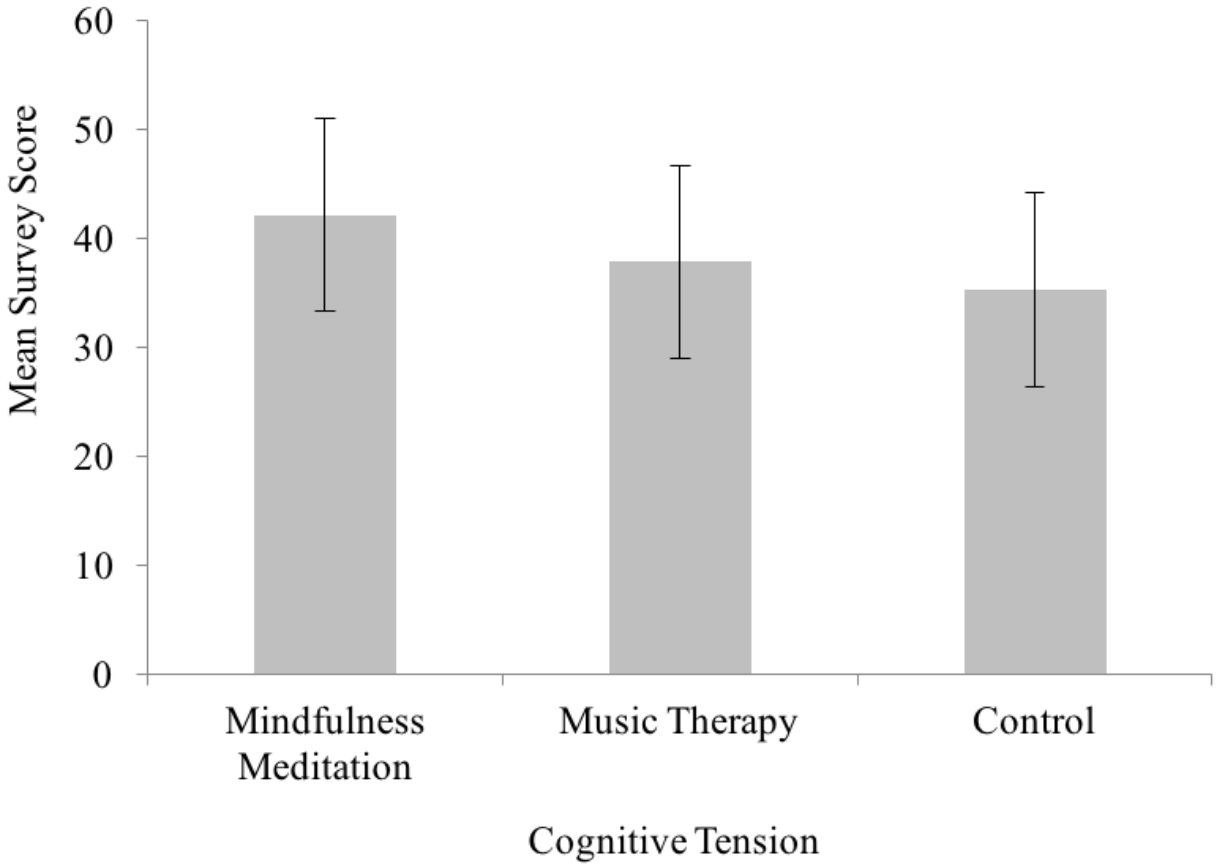

Figure 1. Cognitive Tension Scale. Mean total score across conditions for the 10 Cognitive Tension questions of the Relaxation Inventory. Participants in the mindfulness meditation group (M = 42.08, SD = 8.82) were more cognitively relaxed than participants in the control group (M = 35.2, SD = 8.92), $F(2, 74) = 3.92$, $p < .05$. There was, however, no difference between the music therapy group (M = 37.81, SD = 8.86) and the control group or mindfulness meditation group, $ps > .05$.

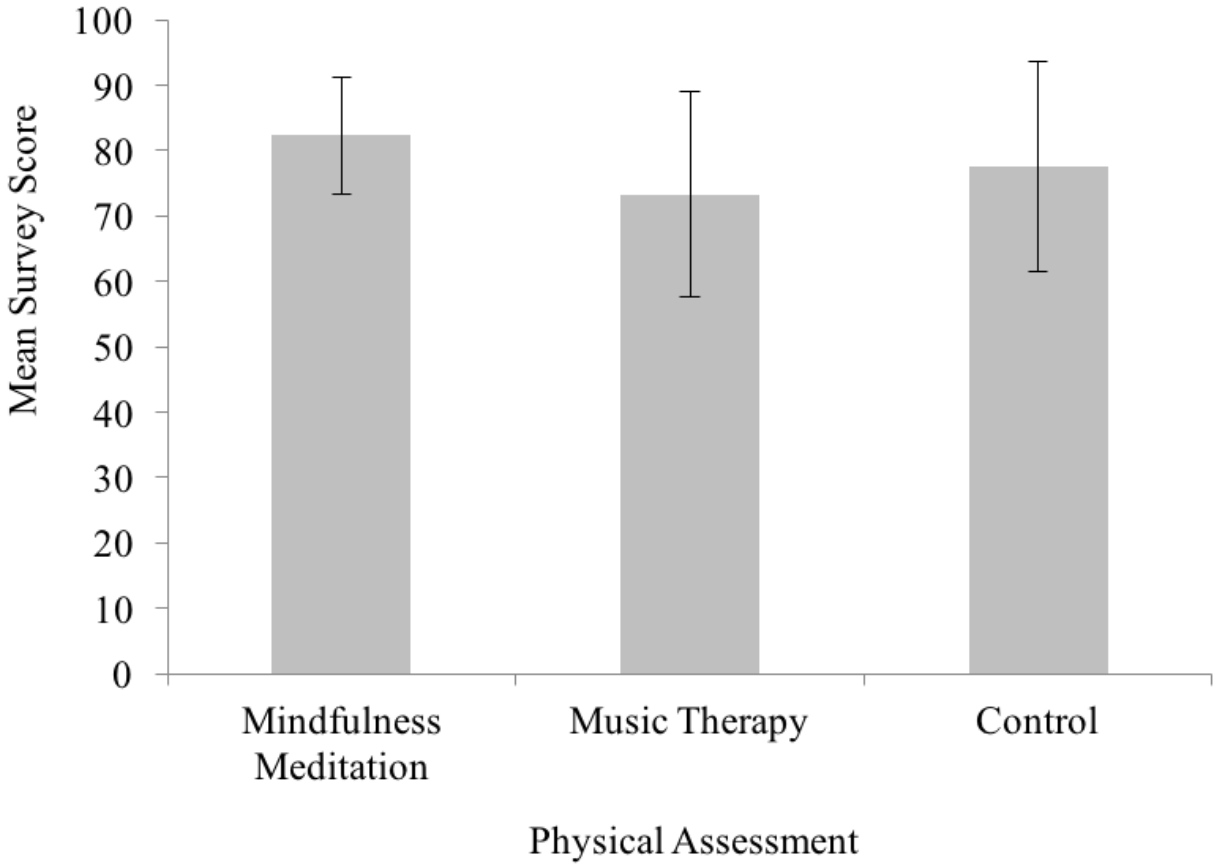

Figure 2. Physical Assessment Scale. Mean total score across conditions for the 20 Physical Assessment questions of the Relaxation Inventory.

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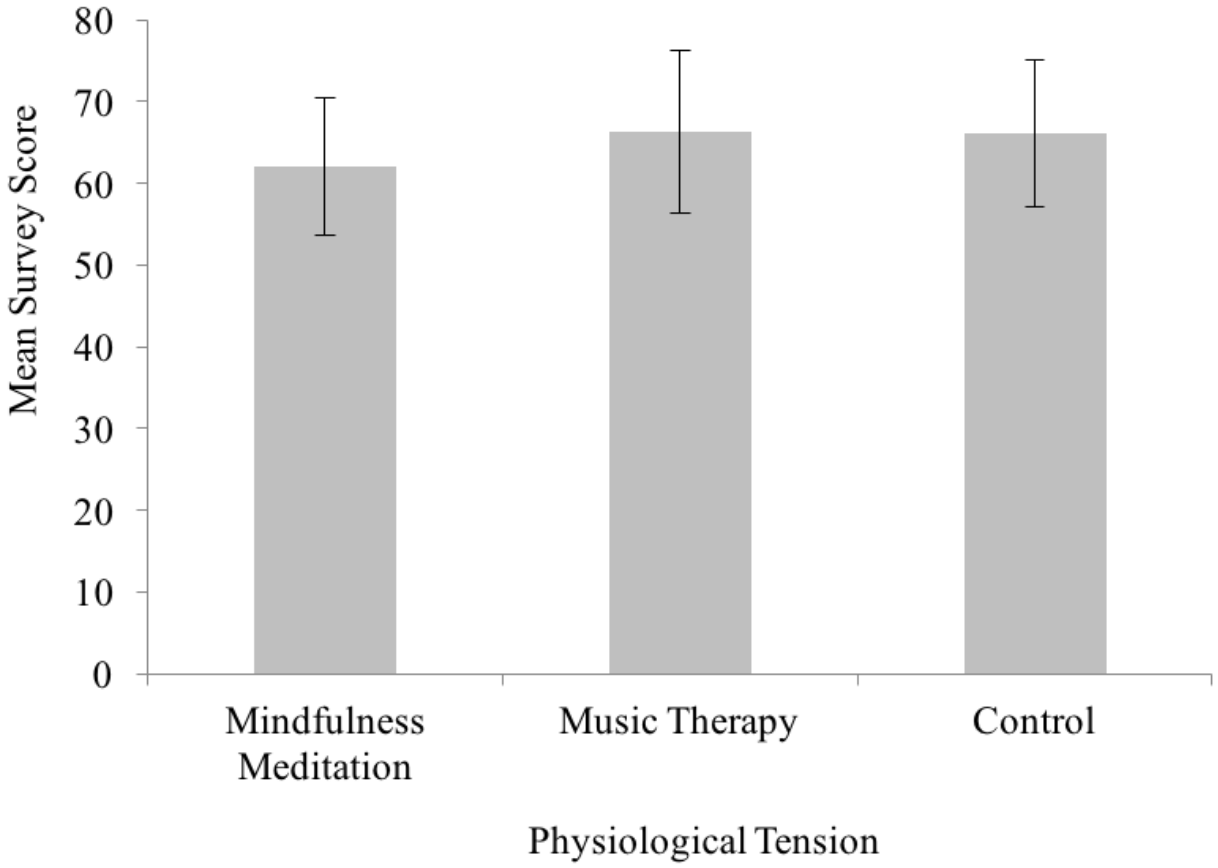

Figure 3. Physiological Tension Scale. Mean total score across conditions for the 15 Physiological Tension questions of the Relaxation Inventory.

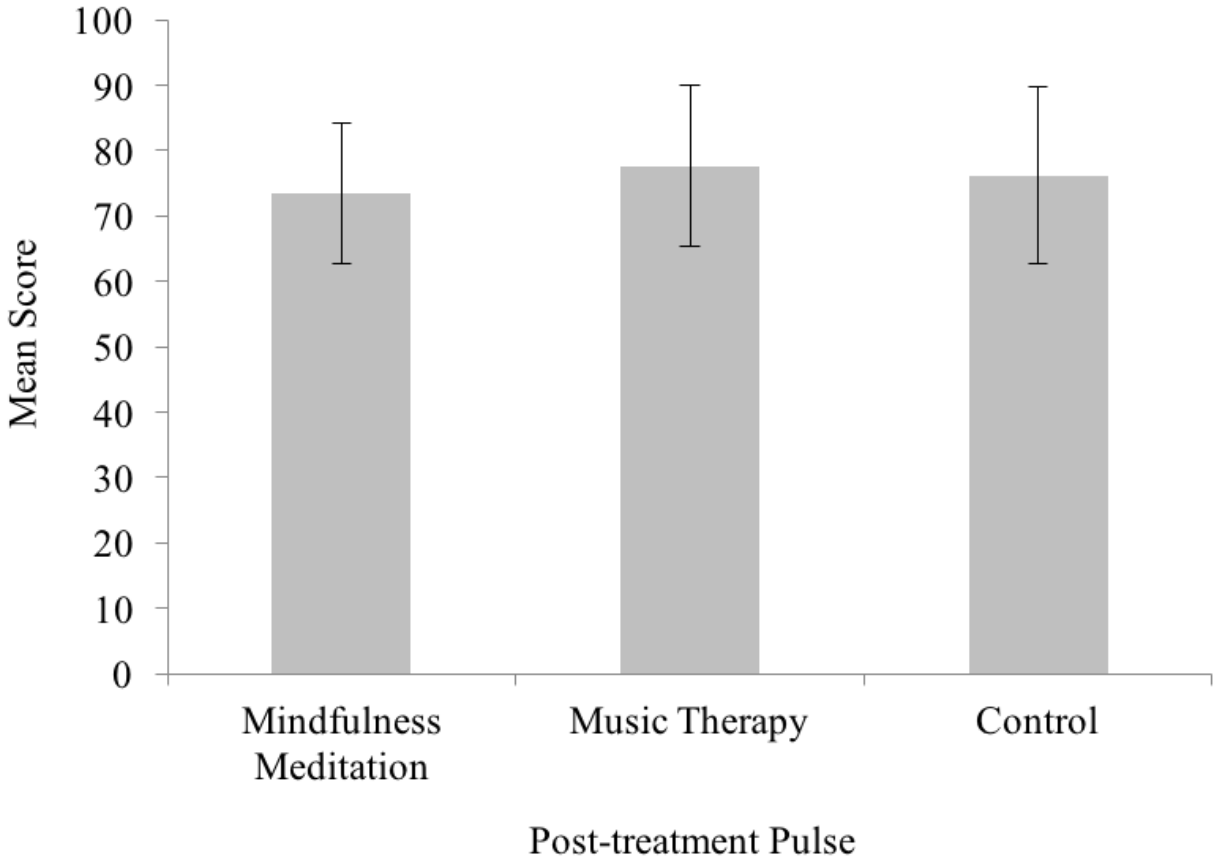

Figure 4. Post-treatment Pulse. Mean post-treatment pulse across conditions.