Musical Key and Its Effect on Human Stress Levels

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Abstract

This study investigates how different major keys in music– D, E, and F major affect perceived stress levels following cognitively demanding tasks. Although music is widely recognized for its emotional and therapeutic benefits, few studies have isolated musical key as a variable influencing stress reduction. To address this, twenty participants (divided into younger and older age groups), completed three stress-inducing tasks: the Stroop test, word unscrambling, and memory recall. After each task, participants listened to a violin composition in one of the three keys and rated their stress levels before and after using a 7-point Likert scale. The results revealed that E major led to the greatest reduction in self-resported stress, followed by D major, while F major had the least impact. These findings suggest that specific major keys may influence emotional regulation and stress recovery more effectively than others. These results have potential implications for music therapy, mental health interventions, and academic stress management.

Introduction

Stress is widely recognized as a factor contributing to developing emotional and physical health problems, including anxiety disorders, depression, cardiovascular diseases and burnout (de Witte et al., 2020). In response, people may look for medications that calm themselves in order to cope with stress. However, taking medications can be expensive and result in negative side effects such as addiction to the substance as well as long term health risks (de Witte et al., 2020). Besides taking medications, music therapy has gained significant attention for its calming effects on the mind and body. Music therapy is a type of therapy that uses music to support emotional, social, and communication development, especially in people with disabilities or challenges (Wigram and Gold, 2006).Research has shown that listening to music can reduce physiological indicators of stress such as heart rate, blood pressure, reduced anxiety, nervousness and sadness (Hanser, 1985). Music has led to increasing positive outcomes and emotions.

These effects are believed to result from music's influence on brain regions (de Witte et al., 2020). Key brain regions associated with emotional regulation and reward, such as the amygdala, prefrontal cortex, nucleus accumbens, hippocampus, etc., are constantly activated in response to music (Koelsch, 2014). In children who struggle with basic communication skills, music creates a space for interaction. As they learn musical patterns– like rhythms, melodies,

and beats, they start to naturally add their own changes in expression. One key aspect of this emotional connection lies within musical key signatures (Bavarava et al., 2024). For example, major keys are often linked to happiness, confidence, and brightness, while minor keys tend to evoke sadness, tension, or introspection (Hunter et al., 2010). Although there is much research done on the effectiveness of music therapy in reducing stress, there is a dearth of research examining how specific musical elements, such as musical keys, influence stress responses. This study aims to explore if listening to music in E major results in statistically significant reduction in self reported stress levels compared to D major and F major after participants complete cognitively demanding tasks. By narrowing focus to key signatures, the study aims to build a better understanding of how fundamental musical structures contribute to emotional regulation and stress relief.

Methods

This study features an original violin composition, written and performed by the researcher, in three different major keys; D, F, and E majors. Participants completed a set of cognitive tests intended to increase stress levels, then listened to one version of the piece and rated their stress level before and after. The original violin piece used in this study was composed specifically for the experiment to maintain consistency across conditions. The composition featured a moderate tempo, approximately walking pace (around 80 BPM), with a tone that leaned slightly toward the cheerful and uplifting side. The rhythmic structure was simple and steady, without syncopation or dramatic changes, to minimize any unintended emotional tension. The melody considered straightforward motion, avoiding dissonant intervals. In terms of dynamics, the piece maintained a soft to moderate volume throughout, with a gentle crescendo near the end to evoke a sense of lightness. The piece concluded on a high note, reinforcing a positive tonal quality. Instrumentation was limited to solo violin with no accompaniment, lasting approximately 30 seconds per version, ensuring uniform exposure time across all key conditions. The study also compares responses across age groups to examine whether age plays a role in music's effect on stress. A total of 20 participants (N=20) were included, divided into a younger group (ages 13-18) and an older group (ages 35 and above). Participants were recruited from the researcher's personal network and through convenience-based recruitment methods. This makes the sample not fully randomized and may be subject to sampling bias. Participants, however, included family members, peers, and acquaintances. The sample included a relatively even mix of male and female participants, with educational backgrounds ranging from elementary to high school students, college graduates, and individuals currently in the workforce. All individual sessions were conducted virtually on FaceTime to ensure consistency and reduce external distractions. Data collection lasted for approximately 18 days.

To increase stress levels, participants were asked to complete three cognitive challenging tests: the Stroop test (Stroop, 1935), a word unscrambling test (Moss, 2016), and a

short term memory recall test (Erickson & Scott, 1977). These types of tasks are commonly used in psychological research to create moderate cognitive stress, since it requires focus and quick thinking (Prolo et al., 2007). A key feature of this study was time pressure– participants were told that their performance would be timed, although the time was not actually recorded or analyzed as part of the results. The intentional use of time pressure was designed to further increase participant's stress levels. All participants were volunteers who gave verbal and/or written informed consent before participating in the study. Although the study was not submitted to a formal IRB, all procedures were designed to align with standard ethical guidelines for human subject research, including voluntary participation, confidentiality, and the right to withdraw at any time. Prior to the study, they were told that they would be completing three cognitive tasks and that the study aimed to observe their responses. Participants were assured that their data would remain confidential. Their names were not recorded or published. Following the completion of the study, participants were briefed and informed of the study's true purpose: to examine whether different major keys in music could reduce stress levels after cognitively demanding tasks. The debriefing allowed participants to understand how their involvement contributed to the research.

Cognitive Assessments

The stroop test, also known as the color-word naming test, requires individuals to identify the color of the font in which words are displayed, rather than the actual word itself (Jensen, 1965). For example, identifying that the word "BLUE" is written in red ink (see appendix 1 for reference) This may cause interference between the automatic process of reading and the task of color recognition (Stroop, 1935). In the word unscrambling task, participants were presented with a series of jumbled words and asked to rearrange the letters to form English words. The words varied in length and difficulty (see appendix 2 for reference). This task demands problem solving skills, as participants must mentally test different combinations to get to the correct answers (Dunphy et al., 2009). The final task in the stress inducing process was the memory recall test designed to test short term memory under timed pressure (see appendix 3 for reference). This type of memory test primarily targets verbal and perceptual memory where participants retrieve information without being told to use a specific memorization strategy (Groth-Marnat et al., 2009). Research has shown that timed pressure increases stress levels. Under timed pressure, individuals often struggle to adapt to new situations due to reduced information processing and limited behavioral flexibility (Lin et al., 2023). While some studies suggest moderate time pressure can lead to faster decision making, high levels of time pressure have shown to heighten stress and negatively affect performances.

To examine the effects of different major keys on stress reduction following cognitive tasks, participants completed three stress-inducing tests: the Stroop test, a word unscrambling task, and a memory test. After each task, participants listened to one of three musical excerpts– D major, F major, or E major– and then recorded their stress levels on a form online using a Likert

Scale (a scale from 1-7). After each task, participants listened to one of three musical excerpts- D, F, or E major and then recorded their perceived stress levels using a Likert scale via an online form. While the sale was not formally validated, it was designed to capture immediate self-reported emotional stress following each cognitive task. This allowed the study to explore the relationship between stress levels and musical keys.

Appendix 1. Cognitive Tests

Figure 1. Cognitive tests

RINED LGEU KOBSO PALPE

PILACSE RAEHTW GNITH TOCEROB

SOELHC LOFDER NEALTP

NACEL NTAUIE UMPIJNG WGORL

UMISC NIPIRSNIG RFYIGN

Figure 2. Anagrams

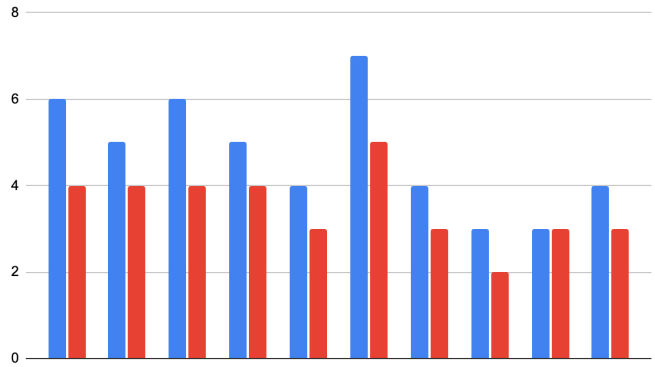
Figure 3. Memory Test

Results

Average stress levels, on a scale from 1-7 (1 indicative of lowest stress, 7 indicative of highest stress), participants reported the highest average stress levels after the Stroop test (mean= 4.45), reflecting a 1.4 increase. This was followed by the word unscrambling task (mean = 4.3) and the memory task, which produced slightly lower stress levels. After listening to the D major clip, participants' stress levels decreased by an average of 1.35 points. The F major clip, played after the word unscrambling task, decreased stress by 0.3 points, showing that it did not have a major effect. The E major clip, played after the memory test, had the greatest effect, reducing stress by 1.4 points. `

Age based differences were also examined. Both older and younger participants began with a similar initial stress level; an average of 3 out of a 1 through 7 scale/ After the Stroop test, both groups'stress levels increased to 4, but following the music clips, stress decrease differed. Older participants averaged a stress level of 2.9, while younger participants averaged a stress level of 3. After the word unscrambling task, the older group reported an average stress level of 5, while the younger group reported 4.5. Following exposure to the musical excerpts, stress levels decreased to 4.1 for the older group and 4.2. for the younger group. Similarly, after the memory test, the older group's average stress level decreased from 4.6 to 3. These patterns suggest that while all three majors reduced stress, E major had the most significant impact, especially following memory-based cognitive tasks (see figure 1-6).

Figure1. Average stress level following Stroop Test and stress level after listening to D Major key in the younger group



Younger Group
Blue: Stress Level after Stroop Test
Red: Stress Level after D major

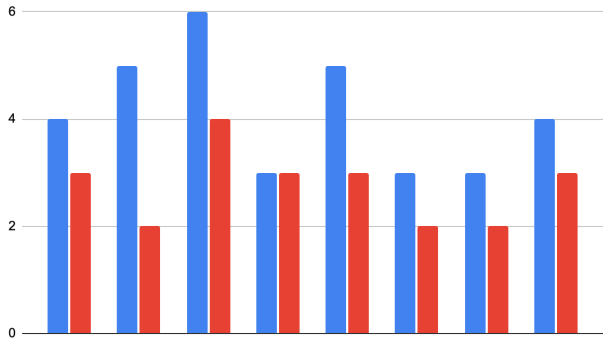


Figure 2. Average stress level following Stroop Test and stress level after listening to D Major key in the older group

Older Group
Blue: Stress Level after Stroop Test
Red: Stress Level after D Major

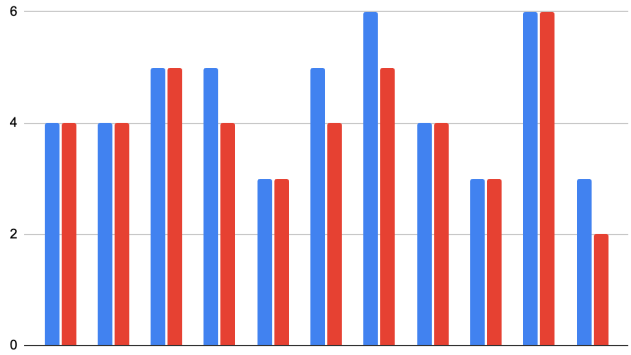


Figure 3. Average stress following word unscrambling tasks and stress level after listening to F Major key in younger group

Blue: Stress level after word unscrambling
Red: Stress level after F Major

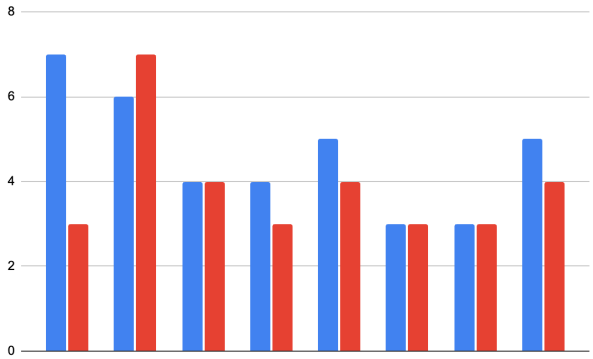


Figure 4. Average stress following word unscrambling tasks and stress level after listening to F Major key in older group.

Blue: Stress level after word unscrambling
Red: Stress level after F Major

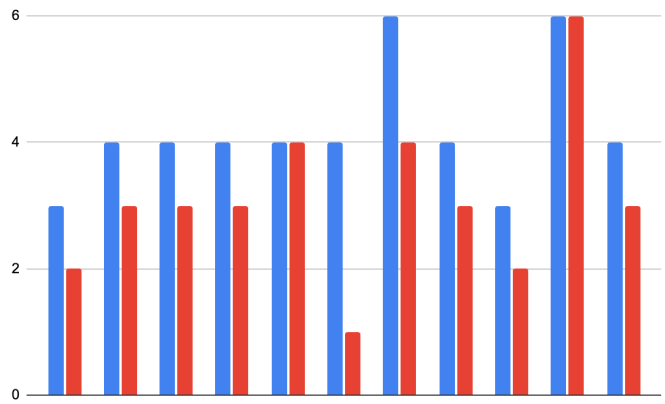


Figure5. Average stress following memory test and stress level after listening to E major in younger group

Blue: Stress level after memory test
Red: Stress level after E major

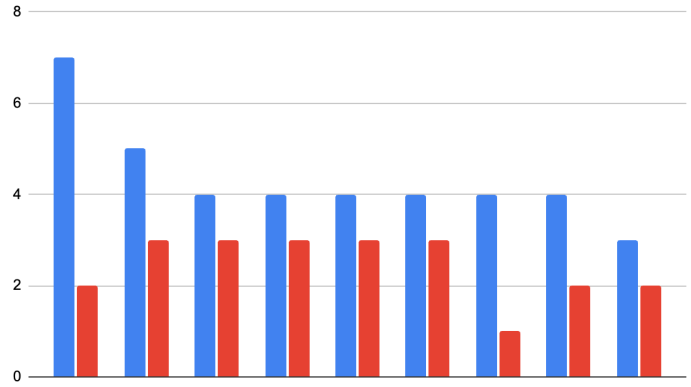


Figure6. Average stress following memory test and stress level after listening to E major in older group

Blue: Stress level after memory test
Red: Stress level after E major

Discussion

The findings of the study indicate that different major musical keys exert distinct effects on stress reduction following a cognitive task. Overall, the E major composition was the most effective, decreasing stress levels by an average of 1.4 points, especially after the memory test. D major also reduced stress after the Stroop test, but had a smaller impact. F major had the smallest effect overall. These results indicate that musical keys can play a role in reducing stress, particularly after mentally challenging activities under timed pressure.

A possible explanation for these results lies in the emotional associations of each key. E major is often described as bright and uplifting such as Vivaldi's "Spring" from The Four Seasons. This may have had a stronger calming effect after cognitively demanding tasks. In contrast, F major has a more mellow quality, which might explain its comparatively weaker impact on stress reduction. D major is commonly associated with a sense of triumph (such as Pachabel's Canon in D major), possibly aiding in stress recovery after tasks. These findings suggest that not only does music have the power to influence emotional states, but the specific key of a composition may enhance or limit its effectiveness. Outside of a research setting, this insight could be useful for designing more effective stress-relief tools in daily life. For example, creating playlists tailored to reduce stress after work or school, incorporating specific keys into music therapy, or introducing calming soundscapes in high pressure spaces such as hospitals, classrooms, or offices.

Limitations

The results of the study should be considered within the context of limitations. The study was conducted virtually over FaceTime, which may have affected participants' experience of the music– differences in speaker quality, background noise, and personal environments could have influenced both stress levels and how the music was presented. Future studies could be conducted in person, eliminating the distractions when done virtually. Additionally, the sample size was relatively small, and only three major keys were tested. This limits the generalizability of the results and leaves open the possibility that other keys (e.g., minor keys) could produce different effects. The music used in the study was a short violin piece that was composed originally. While this allowed for consistency and experimental control, the composition was simple, which may have constrained emotional impact. Another limitation is that the study's sample consisted of healthy individuals, which likely led to generally lower stress levels and failed to capture the full range of stress experiences. In the future, E major should be more widely explored and utilized in music therapy for evaluating its potential therapeutic benefits.

Revised limitations paragraph:

The results of this study should be considered within the context of limitations. The study was conducted virtually over FaceTime, which may have affected participants' listening environments. Differences in speaker or headphone quality, background noise, and distractions

within their physical surroundings could have affected both their stress responses and the way they experienced the music. Future studies should consider conducting sessions in controlled in-person settings to standardize auditory conditions and reduce external interference. Additionally, the sample size was relatively small (20 participants), which limits statistical power and generalizability. As a result, while the trends observed in stress reduction across different major keys are promising, they should be interpreted with caution. A larger and more diverse sample would allow for stronger conclusions. Due to time constraints and reliance on convenience sampling from the researcher's personal network, expanding the sample was not feasible. However, future research should aim to include a broader and more representative group of participants to validate on the study's findings.

The study's participants were all healthy individuals, which may have contributed to the generally mild stress responses and may not reflect how individuals with chronic stress, anxiety disorders, or other mental health challenges would react. Future studies could recruit clinical populations or individuals under naturally higher stress levels to better understand how music in different keys can serve as a stress reduction tool.

Only three major keys were tested (D, F, and E major), which questions how other tonalities, particularly minor keys, might influence stress. Future research could explore a broader range of keys, including minor keys to determine if certain tonal characteristics have stronger emotional or physiological effects. Another limitation concerns the musical piece itself. While using an original composition allowed for control over the melody, the simplicity of the piece may have limited its emotional depth. Future studies might compare simple versus complex compositions, or test a range of genres and instrumentation to observe how musical complexity interacts with emotional regulation.

Conclusion

In the final analysis, although the study demonstrates a clear trend favoring E major in stress reduction, future research should work to further explore these preliminary results. Integrating more complex compositions and a broader range of musical factors (e.g., dynamics, instrumentation, minor keys) may deepen our understanding of how music influences emotional regulation. Additionally, conducting studies with larger, more diverse sample groups and in controlled environments would improve the reliability and generalizability of findings. Ultimately, insights from this research could contribute meaningfully to fields like music therapy, mental health treatment, and educational stress management for improving well being. By focusing on

individual major keys, this study helps fill a gap in the literature, as most existing research explores music's effect on stress more generally without isolating key signature as a variable.

References

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