

# The effect of music on teenagers in combatting stress and improving performance

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## SUMMARY

Mental health disorders, especially those related to stress and anxiety, are some of the most critical issues facing teenagers today. While previous studies have focused on music's effect on brain development and rehabilitation, there is a significant gap in understanding music's effect on teen mental health. As one of the most avid consumers of music, teenagers' frequent exposure to music can be utilized to combat the growing teen mental health crisis. We hypothesized that participation in music activities by teenagers would alleviate their stress levels and improve their performance. This research investigated how exposure to active versus passive music affects a teenager's ability to perform a challenging task, namely a Sudoku puzzle, under stressful conditions. The study tested 75 high school teenagers in a Bay Area high school, split into 2 groups: students singing in a choir (active music) and students listening to low-fidelity music (passive music). Our results showed that active participation in music activities like choir yields a significantly greater improvement in performance compared to passive listening for brief time periods. Additionally, the more a participant listened to music, the better they appeared to manage stress levels and improve their performance on everyday tasks. Most participants reported listening to music while doing everyday tasks to relieve stress, boost mood, and improve focus. These results reinforce the importance of music in helping teens cope with stress and combat the growing mental health crisis. Schools and music teachers can use these findings to advocate for universal access to music programs.

## INTRODUCTION

Stress and mental health disorders like anxiety and depression are impacting many teenagers today. Nearly two in three teenagers nationwide experience elevated levels of stress exceeding that of adults (1). Additionally, many teens report feeling overwhelmed, depressed, sad, or tired due to stress (2). The age group of 11 to 17 years is the most likely to score high in moderate to severe depression categories when screened for mental health (3). Teens that are female, underrepresented minorities, and from lower socioeconomic classes reported higher levels of stress (3). Several factors are driving this crisis, including increased academic and social pressure, family situations, and biological changes (4).

The COVID-19 pandemic has further exacerbated teen stress with more than a third (37%) of high school students feeling stress-related anxiety and depression during the pandemic (5). These mental health issues can have detrimental effects on teens, including sleep deprivation, poor decision-making, and deteriorating physical well-being (1).

There are countless benefits to music, and its use as a form of therapy has been a significant focus topic for researchers. Previous studies have demonstrated the rehabilitating effect of music on various age groups, from enhancing cognitive abilities in babies to alleviating depression symptoms in kids and the elderly (6, 7). Music has also been shown to benefit problem solving capabilities; learning to play an instrument as a child may potentially lead to higher academic performance and IQ as an adult (8). Active music therapy can also improve children's ability to solve puzzles and arithmetic problems (9). Music has been shown to improve mood and mental health and positively impact behavior (10, 11). These findings advocate for the use of music therapy to improve cognitive performance, especially under high stress conditions like school.

Numerous studies have investigated the neurological intersection between music, stress, and performance. Studies have shown the link between stress and the activation of the autonomic nervous system (ANS) and the Hypothalamic-Pituitary-Adrenal axis (HPA), while participation in a range of music activities has been shown to regulate the ANS and HPA axis, serving as a therapeutic mechanism to relieve stress (12, 13). Additionally, musical improvisation and listening have been shown to influence the amygdala in adults by releasing endorphins to regulate emotional processes such as the stress response (12). There is also a positive correlation between stress and mental illnesses, with stress-induced high cortisol release associated with damage to the hippocampus and other regions of the brain, leading to mental illnesses like depression (14). However, since music has been shown to increase hippocampal neurogenesis and repair, music could be used as a form of therapy to reduce the impact of stress (15-17). These results support a positive correlation between music and improved mental health.

The impact of active versus passive participation in music therapy has been a niche, yet existing topic of research. Active music participation involves direct engagement with music, requiring both physical and cognitive involvement through activities such as singing, composing, or playing an instrument. Passive music participation, on the other hand, involves listening to music without actively creating or engaging with it. One study showed that active participation in music therapy, as opposed to passive participation, improved cognition and behavior (18). Another study showed that active participation was more effective in regulating the

sympathetic nervous system than passive participation (19). Additional studies on choral singing also show the benefit of breath control and its effect on the vagus nerve and impact to the sympathetic nervous system, thus reducing the effect of stress (20). These results show evidence for the claim that active participation in music therapy has significantly greater benefits on patients' cognitive ability and stress response relative to passive participation.

Despite the vast body of research on music as a therapy mechanism, the focus on the impact of music on teens is nascent. A research study in 2016 analyzed the impact of music on the emotions of 269 teenagers, where the results indicated that most students (69%) experienced positive sentiments, including joy, relaxation, relief, and motivation, while listening (21). But beyond that, the limited number of existing studies have focused primarily on the effect of music to treat severe depression (22). Additionally, existing studies on teens and adolescents have been sub-scale with small sample sizes (23). While current reviews have indicated that music therapy may successfully alleviate teen depression and anxiety, there is a reported need for larger studies (23, 24).

Based on the known benefits of music, further research on the effect of music in helping teenagers deal with the growing mental health crisis is critical and urgent. Statistics show that teens are among the most avid consumers of music, with nearly 82% of teens listening to music every day (25). Despite the prevalence of casual music listening among teenagers, only 18.5% of students participate in music programs in high school, and only 78% of high schools offer music programs (26). As a result, both passive and active music participation could present promising intervention therapies to help teenagers deal with stress and improve their cognitive performance.

The purpose of this study was to explore music as an effective means of addressing the growing mental health crisis among teenagers. We hypothesized that participation in music activities by teenagers would alleviate their stress levels and improve their cognitive performance. Further, we compared the effects of passive and active music exposure, offering insight into the most effective ways to address the prevalent stress levels reported by teenagers. To simulate stress teenagers face in everyday life, our study used a timed Sudoku puzzle to evaluate a teen's ability to perform under stress. Based on a study conducted on 75 teenagers, our results showed that active participation in choir yielded a significant improvement in Sudoku performance under time pressure compared to participants who passively listened to music. The results of this study begin to address the gaps in understanding the impact of music exposure on teen mental health. Adults and educators should use these findings to design programs to increase active participation in music (through programs such as choir) in schools and other settings.

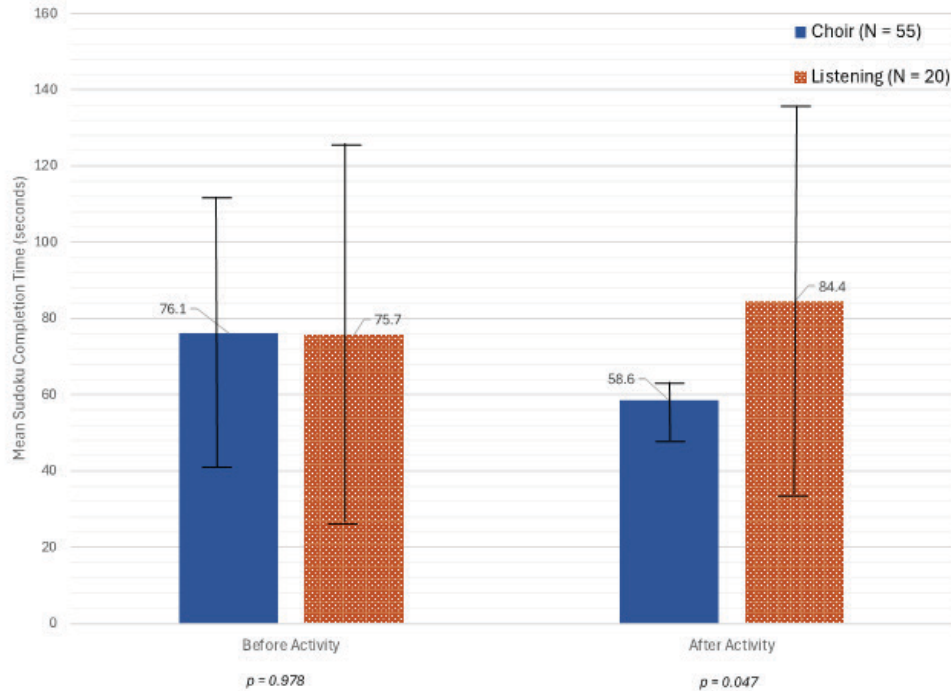
## RESULTS

The study aims to test whether participation in music activities could help teenagers lower their stress levels and improve their cognitive performance. We investigated how exposure to active versus passive music affects a teenager's ability to perform a challenging task, namely a Sudoku puzzle, under stressful conditions. We divided the participants into 2 experimental groups, with 55 subjects participating in choir

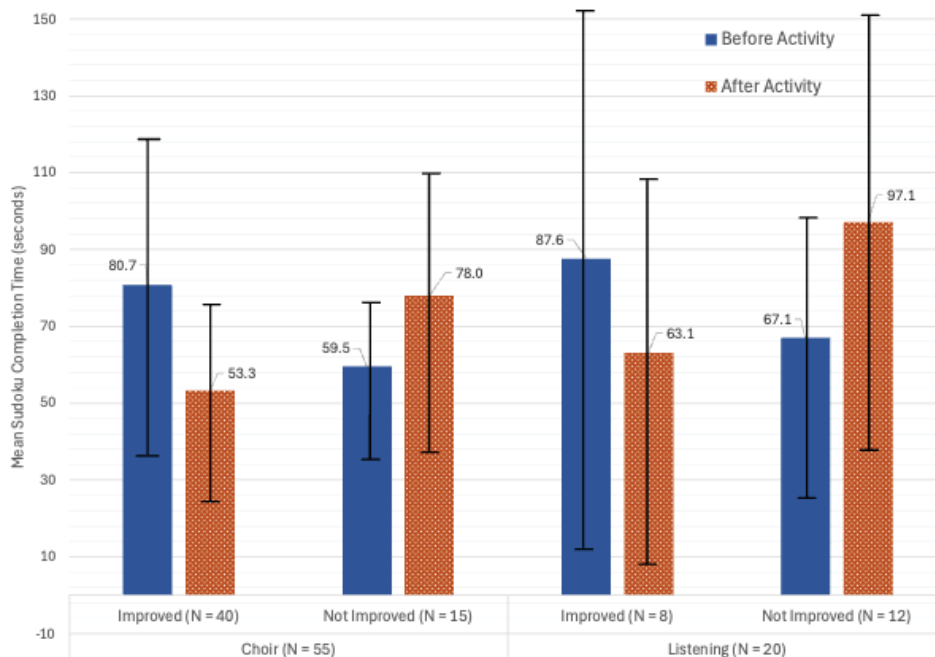
(active participation) and 20 subjects listening to music (passive participation). We had more participants in the choir group since it was easier to access the high school choir class compared to recruiting students to volunteer for music listening sessions during or after school. All participants were high schoolers aged 13 to 18 and each group was approximately 70% female and 30% male. All participants in both groups participated in the Sudoku puzzle and completed the survey. The choir participants participated in an 80-minute choir period, while the listening group listened to music for 20 minutes during lunch. The difference in time of music activity between the two groups was due to the difference in the available time for each period (choir class versus lunch period). We administered a Sudoku test to participants before the music activity and another one after the activity to assess their cognitive performance, and asked participants to self-report the completion time. We administered the same Sudoku puzzle to both groups before the music activity and then a different second puzzle to both groups after the activity. Participants also completed a survey that tracked their music listening habits. We analyzed the Sudoku completion time for both groups, before and after the music activity, to assess the impact of the music activity.

Before the music activity, the choir group (active participation) completed the Sudoku puzzle in an average time of 76.1 seconds, while the listening group (passive participation) averaged 75.7 seconds (**Figure 1**). The difference in Sudoku completion times between the two groups was not statistically significant ( $t$ -test,  $p$ -value > 0.05), indicating that their Sudoku performance was similar. After the music activity, the choir group's average Sudoku completion time decreased to 58.6 seconds, and the listening group's time increased to 84.4 seconds (**Figure 1**). This difference in Sudoku completion time between the two groups was statistically significant ( $t$ -test,  $p$ -value < 0.05). The choir group participants decreased their Sudoku completion time by an average of 17.5 seconds after actively engaging in an 80-minute choir session. In contrast, the listening group participants increased their Sudoku time by an average of 8.7 seconds after passively listening to music for 20 minutes. The average change in Sudoku completion time between the two groups was also significant ( $t$ -test,  $p$ -value < 0.05). These results provide statistically significant evidence that active participation in music activities may have a greater positive impact on Sudoku performance than passive music listening. Passive listening, in short term, is likely to have minimal effects on Sudoku performance.

In addition, a higher percentage of choir participants improved their Sudoku completion time compared to the listening group (**Figure 2**). In the choir group, 40 of the 55 students (72%) improved their Sudoku completion time after choir participation, with an average improvement of 27.4 seconds. The remaining 15 students added an average of 18.5 seconds to their starting Sudoku time, showing a deterioration in Sudoku performance. In the listening group, only 8 of the 20 students (40%) improved their Sudoku completion time after listening to music, with an average improvement of 24.5 seconds. The remaining 12 students increased their time by an average of 32.7 seconds, showing a deterioration in Sudoku performance. These results suggest that active music participation may potentially improve performance more than passive music participation.



**Figure 1: Sudoku completion time by type of music exposure (N=75).** Participants were tested for impact of music activity on the time taken to complete a Sudoku puzzle. Participants completed a Sudoku puzzle before and after participating in an active (choir class) or passive (listening to music) music activity. There was no significant difference in mean Sudoku time between the two groups before the music activity (*t*-test, *p*-value < 0.05). In contrast, there was a significant difference in mean Sudoku time between the two groups after the music activity (*t*-test, *p*-value < 0.05). Error bars denote mean +/- standard deviation.



**Figure 2: Breakdown of the two groups by participants that improved and did not improve their Sudoku completion time (N=75).** Participants were tested for impact of music activity on the time taken to complete a Sudoku puzzle. Participants completed a Sudoku puzzle before and after participating in an active (choir class) or passive (listening to music) music activity. For each group, participants were further split into “Improved” and “Not Improved” based on the self-reported time taken to complete Sudoku puzzle before and after music activity. In the choir group (active participation), 40 out of 55 participants improved their Sudoku time after exposure to 80-minute choir period. In the listening group (passive participation), 8 out of 20 participants improved their Sudoku time after listening to music for 20 minutes. Error bars denote mean +/- standard deviation.

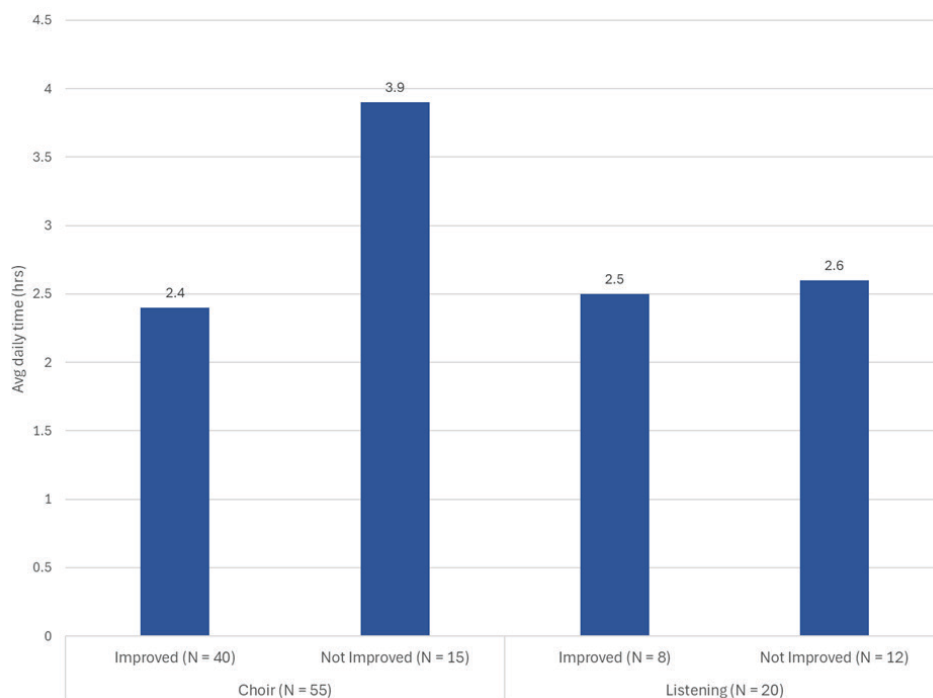
We analyzed the survey results to understand differences in music listening habits, including frequency (daily duration), reason (e.g., relieve stress, focus) and timing (e.g., homework, relaxing). The survey showed that teenagers across both groups listened to music for more than two hours daily on average. In both groups, participants who did not improve their Sudoku performance had higher daily average music listening times (3.9 hours for the choir group and 2.6 hours for the listening group) and lower Sudoku initial times (59.5 seconds for the choir group and 67.1 seconds for the listening group), relative to the participants who improved (Figure 2, Figure 3). These results show that listening to music daily may have long-term benefits on cognitive performance.

We also wanted to understand if teens were purposefully listening to music to improve their cognitive performance while doing activities like homework or to relieve stress. All participants reported listening to music while doing a range of activities, with homework and relaxing as the two most common activities across both groups. 80% of all participants listened to music while doing homework and 76% listened to music while relaxing. Other activities that were reported while listening to music included during class, driving, exercising, sleeping, and walking (Figure 4). The top three responses participants gave across all groups, when asked why they tend to listen to music, were to boost mood, relieve stress, and improve focus. 77% of participants listened to music to boost mood, 72% to relieve stress, and 57% to improve focus. The other responses included distraction, relaxing, and dealing with loneliness (Figure 5).

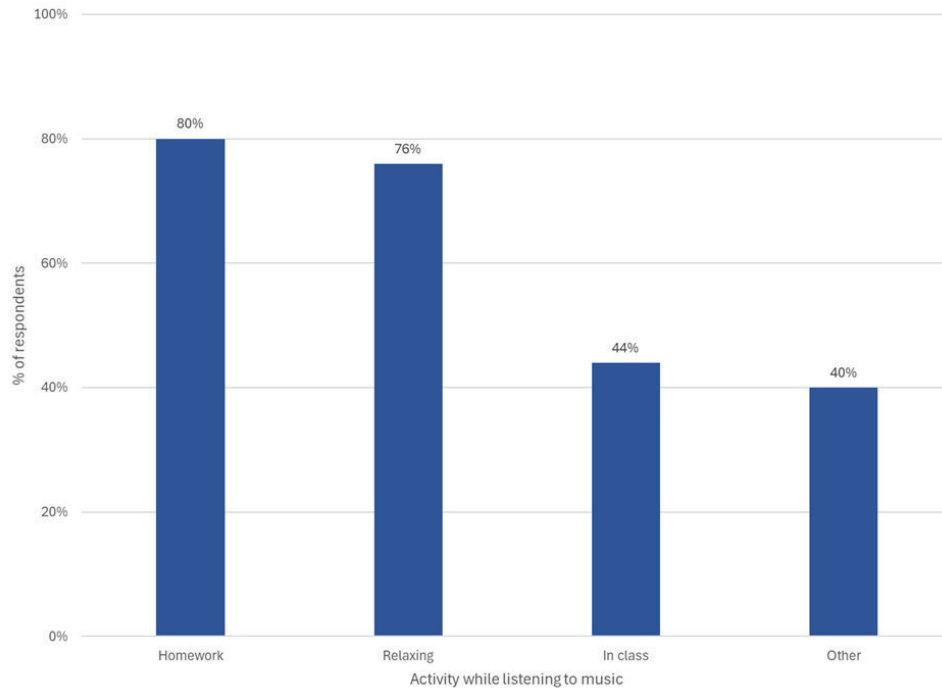
## DISCUSSION

This study aimed to understand the impact of active and passive music activities on teenagers' cognitive performance under stress. Our hypothesis was that music activities, especially ones that encourage active participation, would significantly improve cognitive performance. We investigated two types of music activities, choir (active) and lo-fi music listening (passive), and evaluated their effects on performance on timed Sudoku puzzles. We found that participants in the choir group (active) had significant improvement in Sudoku performance relative to the listening group (passive). These results may support the idea that active participation in music activities like choir has a greater positive effect on student performance than passive listening. Our findings are similar to those of previous studies showing the benefits of active music participation on improved cognition, performance, and emotional health in kids (8–11) but adds a focus on teenagers specifically. This study demonstrates comparable results on teens who are under increased stress. In contrast to the choir group, the participants in the study's listening group did not, on average, show improvement in their Sudoku performance. The impact of passive listening in prior studies has been mixed. The results of this study align with previous findings that showed no impact from passive listening (19). However, they differ from other research indicating that even passive music listening can provide short-term cognitive performance benefits (27).

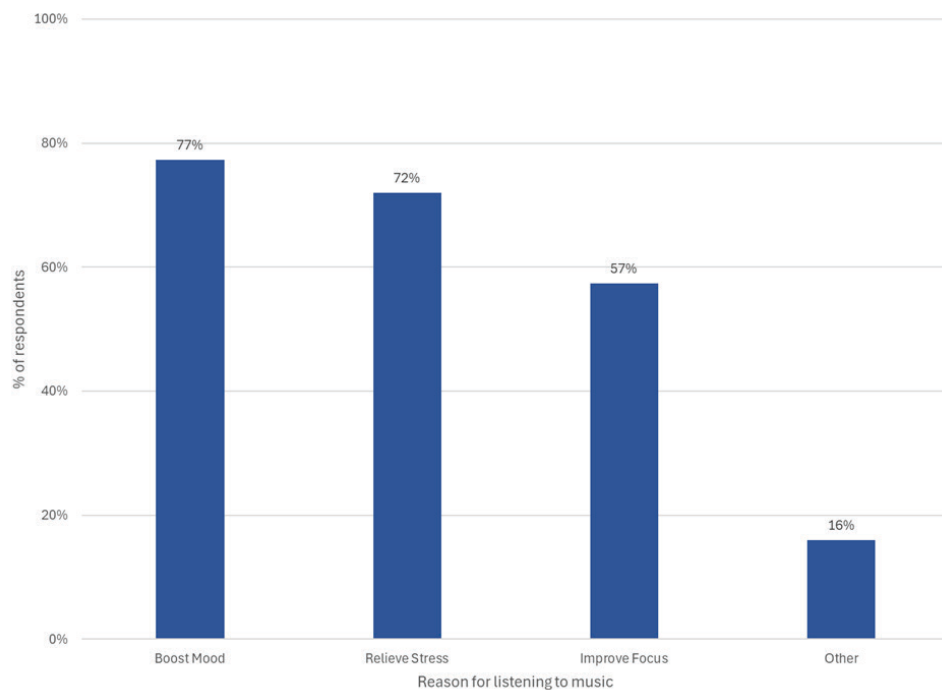
Across both groups, the participants that had shorter Sudoku completion times before the music activity reported higher daily music listening. This inverse relationship between the number of hours the participants listen to music daily and their initial Sudoku times may suggest that participants



**Figure 3: Average daily time spent listening to music in Hours (N=75).** Participants in both the choir and listening group were asked to complete a survey to understand their daily music listening habits. For each group, participants were further split into “Improved” and “Not Improved” based on the self-reported time taken to complete Sudoku puzzle before and after music activity. For participants whose Sudoku times improved and did not improve, the average self-reported daily hours of listening to music was calculated.



**Figure 4: Everyday activities during which participants listened to music (N=75).** Number of respondents who reported listening to music during various activities. Teenagers in both groups (choir and listening) filled out a survey on music listening habits and types of activities during which they listened to music. The survey responses on the top three activities while listening to music every day were while doing homework (80%), while relaxing (76%) and during class (44%). Other responses included exercising (27%), sleeping (16%), driving (15%), cooking, and working (13%).



**Figure 5: Reasons for participants' listening to music in everyday life (N=75).** Number of respondents who reported listening to music for various reasons. Teenagers in the choir and listening groups filled out a survey on music listening habits and the reasons for listening to music. The top three responses across all groups of participants when asked why they tend to listen to music were to boost mood (77%), to relieve stress (72%), and to improve focus (57%). Other responses included for calming, distraction, and fun (16%).

who listen to more music daily perform better (even before music exposure activity). While prior research has focused on the short-term impact of listening to music on cognition and emotions, there is a gap in understanding the long-term effect of listening to music. Our findings begin to address this gap.

The survey results show that the top three reasons participants listen to music were to relieve stress, boost mood, and improve focus. Other responses included calming, distraction, and for fun. Additionally, the top three activities during which participants listened to music was while doing homework, relaxing, and in class. Other activities included exercising, sleeping, and driving.

The study's results reinforce the importance of music in helping teens combat stress, boost their mood, and improve their cognitive performance. Participating in a structured music activity like choir may have performance benefits immediately following the exposure. In addition, listening to music every day may have a lasting effect on teens' performance, as demonstrated by the initial performance boost of those who reported higher levels of daily music listening.

The results of this study bridge an important gap in understanding ways to help teens cope with rising mental health issues. This data supports previous studies that suggest music's therapeutic effect on participants. However, this study is specific to teenagers and shows the effects of music programs in school as well as listening to music in combating everyday stress. Teenagers and their families can use this study to highlight the positive effects of listening to music or participating in a music elective at school. Schools and music teachers can use these findings to advocate for implementing more music programs in schools and oppose cuts to their funding (28). The benefits of music and music programs are vital to teens' continued growth and development, and our findings emphasize the need for all students to have access to them.

For future investigations, changes could be made to limit the amount of bias and conflicting variables. First, making the music exposure across tests the same duration would further improve the comparison of our results. Second, self-reported time taken to complete Sudoku may have led to bias, and in the future, using an unbiased third-party to time each participant could limit this. Additionally, participants in both groups could have had prior musical experiences, like playing an instrument, which could affect the results. Participants in both groups may have also had various levels of comfort with Sudoku puzzles, which could affect their completion time. The participants in the choir group had a higher daily average of listening to music. The participants in the choir group also had longer exposure to music throughout the year than the listening group, and this could have played a role in their performance. Lastly, although we tried to select two Sudoku puzzles of similar difficulty, choosing them at random might have resulted in varying difficulty levels, leading to the time taken being affected by this variable. In the future, this bias can be minimized by adding a third experimental group as a negative control where they solve both Sudoku puzzles back-to-back without any musical activity. We could also repeat this study with cognitive tests such as the Mini-Mental State Examination or Montreal Cognitive Assessment (29).

This study can be expanded to assess different genres of music like lyrical versus non-lyrical music, as well as other music programs like orchestra and band. Being able to

evaluate the brain activity and stress levels pre- and post-exposure to music through MRI scans or measurement of cortisol levels would add depth to our understanding of the role of music in mitigating stress and mood. Given the higher prevalence of mental health issues in girls, future research can explore the impact of music on participants of different genders. This study can be used by teenagers, their families, and schools to highlight the positive effects of listening to music or participating in a music elective at school.

## MATERIALS AND METHODS

This study tested 75 high school students at a Bay Area school between the ages of 13 and 18. The goal was to assess students' performance on Sudoku puzzles before and after exposure to different types of music participation. Participants were divided into two groups: choir (active) and listening (passive) music exposure. There was no reward or compensation offered for participants in either group. The choir group had 55 students who participated in the assessment during an eighty-minute choir period. The participants were recruited from the choir class in the local high school with consent from the teacher and the participants. Participants were given two different six-by-six Sudoku puzzles to solve, at the beginning and the end of the period, respectively. The listening group had twenty students who listened to low-fidelity (lo-fi) music in a room for 20 minutes without any distractions. Low-fidelity music is defined as music with mellow beats used for relaxation. The same set of six-by-six Sudoku puzzles was used to measure their performance (time taken to solve the puzzles) before and after listening to music. For both groups, there was a clock projected on the screen and the participants self-reported the time taken to solve each Sudoku puzzle. The average Sudoku completion time between the two groups was compared before and after the music activity using a student's *t*-test.

Both groups additionally filled out a questionnaire about their music listening habits, including how long they listened to music, the activities during which they listened to music, and what their reasons for listening to music were (Appendix). Once the data was collected from both groups, several statistical analyses were performed on the data.

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