The Effect Distractions Have on Someone's Ability to Solve a Sudoku Puzzle

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Abstract:

Previous research suggests that music and noise may function as distractions that affect cognitive and physical activities. The purpose of this study was to determine if high school students are affected by music and noises in a positive or negative way while completing a Sudoku puzzle. The study was composed of students aged 16-18 who attend the Neighborhood Academy and given three Sudoku puzzles to complete while exposed to two different sounds and a period of silence with a limit of 12 minutes to complete. The most incomplete Sudoku outcomes resulted during exposure to a talking sound in comparison to the control condition (silence) and music exposure. Further results showed no difference between control condition and music exposure. Additionally, individuals who identify as mathematically inclined exhibited an ability to minimize distraction from noise and music scenarios, however, data is insufficient to determine a conclusive outcome. It was concluded that teachers should enforce silence in the classroom, but more research is required for a final determination if music can be proven beneficial in an educational setting..

Introduction

Everyday distractions like talking, music, and cellular devices affect our daily activities and work. Fifty-seven percent of teens said social media distracts them from doing homework (1). Although music may affect someone negatively, teens (aged 12-17) often listen to music while doing homework, and the students say the music improves their focus on the task at hand. (2). While doing a cognitive activity, in this study, a Sudoku puzzle, students may focus more on sounds like a musical beat or talking noises and therefore decrease concentration in comparison to silence. In addition to music, general low-level noise such as background conversation can also prove distracting to students (3). This experiment is important to determine if music benefits students' concentration for school administration to incorporate into the curriculum and strategy to optimize a learning environment, setting students up for academic success. . This study's purpose is to measure the overall outcome of all students ability to concentrate on a cognitively challenging task, a Sudoku puzzle, while being exposed to a variety of background sounds.

Music as a Distractor

While completing an activity, a person may be distracted by sound, or it may help someone concentrate more if sounds, specifically rhythmic beats, affected the activities someone does in daily life (4). A prior study analyzied 30 college-aged students' concentration levels while exposed to three conditions: silence, regular tones at 144 bpm, and randomized tones (4). Participants were instructed to place headphones over their ears and wait. Then, they removed the game pieces from the *Operation* Hasbro game while a timer was running, which would stop when all game pieces were removed(4). The completion time for the average 144 bpm condition differed significantly from both the random and silence conditions ($p < .01$), which did not differ from one another ($p > .05$). Meaning, exposure to music with a regular beat can aid concentration more than exposure to the random sounds in someone's ear (4). Therefore, this suggests that regular, predictable sounds are not a distractor when compared to randomized noise. Additionally, the unexpected noise condition was not worse than silence, suggesting random noise, while it does not help something altogether its task, may not inhibit a person's ability to concentrate successfully.

Even though regular beats may positively affect someone's performance, music may show different results because of the lyrics (5). Gautam wanted to determine whether auditory interference affects visual simple reaction time. For this project, he used 120 healthy male and female college students in Nepal; these students' job was to press a button when an "x" would appear on a screen to see how long it took them to react (5). The students were measured 20 times in silence and 20 times with music playing in the headphones they had on. Gautam found no significant difference in reaction times; the music group was only one millisecond slower compared to the silent group. Since they had 20 times to practice, that may have affected why the scores were so close since, coming into it, they knew what was going to happen. This study is critical because we are not studying reaction time, but logic puzzles that require concentration and visual processing, which might be related due to the optical component. A logic puzzle is more complex than just tapping a timer, so it might matter more on how much concentration a person gives when exposed to a distractor like music.

Lyrics may also affect reading comprehension (6). Schenck, et al. wanted to see if music can affect our cognitive thinking since music is everywhere. Seventeen undergrad students at the University of Minnesota, 18-22 years of age, comprising nine females, 88% of whom were white, were used for this

experiment. They were placed in a room and took a reading comprehension test. The English and Italian music played in two rooms from a portable speaker (6). The students took the timed test listening to the music and rated their level of distraction from 0-10. They found that foreign or native lyrics neither enhance nor hinder reading comprehension (6). In this case, music was found to not affect test-taking skills.

Biofeedback as Distractor

There are many ways to test cognitive performance, such as board games, reaction time, word identification and repetition, test performance, or even solving logic puzzles. Tsurukabuto and Nada- Ku wanted to see if they could find out if biofeedback affects players' puzzle game performance. Biofeedback is the technology where a person gets information about their body or brain while doing a task (7). This biofeedback can improve performance, or it can be a distraction. Ten college students with similar abilities were asked to complete physics and Sudoku puzzles for this experiment (7). The students were divided into two groups; group one did the Sudoku puzzle, then the physics puzzle, and then group two did the reverse with the physics puzzle first, followed by the Sudoku puzzle (7). Each person completed the puzzles, with biofeedback turned on for a few minutes of the session. The biofeedback showed that the more engaged (as measured by brain waves) a person (measured by brain waves), the more sound got softer in their headphones (7). So when people playing the Sudoku puzzle were focused, the sound was lessened. The puzzles were done in a soundproof room with an electroencephalogram to measure concentration/focus.

They found that applying biofeedback while completing Sudoku puzzles could increase one's engagement level (as measured by brain waves), but there was not the same effect with physics puzzles. The biofeedback was able to help the students concentrate more on the Sudoku puzzles because it required them to pay more attention, unlike the physics puzzles, which were easy for them to solve (7). This is important because it suggests the sound may have been a distraction, and being more engaged helped it go away, allowing participants to focus on a difficult task.

Spoken Distractions

Not just sounds or music, but words matter as a distraction too(8). Berg et al. wanted to see if children with attention deficit and hyperactivity disorder (ADHD) were distracted differently than kids without ADHD inside a classroom. This test required seven non-ADHD and seven medicated ADHD 11-year-old kids. The students had to say words randomly projected on a screen while random pre-recorded numbers were spoken out loud through speakers in the room (8). Berg et al. found out that ADHD diagnosed kids did not have slower times, but did have more errors, with the most errors occurring when the distraction came from the left and front directions. The no-distraction setting was the fastest condition, but very similar to the front-facing distraction condition (8). This is one of the few papers discussing distractions in a classroom using actual words. The distraction did increase errors but did not lessen reaction time. Therefore, a speech distraction might also affect concentration on challenging puzzles by increasing error rates and slowing down the participant's response.

As previously mentioned, research on talking distractions and cognitive distractions is limited. Still, there is much research on talking distractions while driving, such as when a passenger talks or a

person uses a mobile device. Papantoniou et al. wanted to see if simple and complex conversations are associated with speed and reaction time changes. For this experiment, 87 healthy participants aged 15-75 had to drive in different road environments: a rural route 2.1 km long and an urban route 1.7 km long. Each course had three distraction conditions (no distraction, conversation with passengers, and using a mobile phone). They found that for an average speed, all drivers drove slowly when in contact with a mobile device, and when there is a passenger in the car, young people do not change speed, but older drivers tend to speed up (9). While in contact with the mobile device, all drivers took longer to react to obstacles and drove slower because they were distracted by their phones and had to slow down to pay attention (9). In conclusion, mostly everyone is affected while driving by talking distractions, especially via mobile phones. Therefore, someone may be easily distracted by talking while doing a logic puzzle and could take longer to finish, just like someone driving takes longer to react to an obstacle and drives slower.

Study Hypotheses

Overall, the research shows that distractions such as talking and music can affect performance. Research also suggests that steady-paced music is less distracting than fast or random-paced music, and talking is usually distracting (4, 8, 9). Therefore this study investigated whether students from The Neighborhood Academy can perform a logic-based puzzle while distracted by talking and music. This is unique because no other study has tested music and talking in the same study. The music and talking may distract the students or help them concentrate more on the sudoku puzzle. In this study, we taught students how to complete a Sudoku puzzle, then instructed them to do so while exposed to either talking or music in headphones as well as in a silent condition. We then scored the number of correct boxes completed in 12 minutes.

We hypothesize that verbal talking and music will affect someone's ability to complete a Sudoku puzzle compared to a control silence condition. This is because research suggests that music may help someone concentrate, or at least not hurt, as long as the music is slow or steady (4, 5, 6). However, research suggests talking is harmful, due to evidence from driving and classroom experiments (8, 9).

Method

A total of 24 students ages 16-18 that attended the Neighborhood Academy participated in the study. All participants were males (54%) and females (45%) and were either in 11th or 12th-grade honors math. All students were African American. A Sudoku puzzle was picked for students to solve under a variety of distractions, as it required intensive concentration and focus, and short-term memory for the students.

Four Sudoku puzzles were classified as ¨easy¨ by an online website (10). The primary researcher completed all four before the participants did, and the average time to complete was 9:00. The students were taught how to properly solve a Sudoku puzzle. We first gave a practice test for both classes, in 11th grade, and after 15 min, no one finished. So we switched to grading each correct box, instead of time for both 11th and 12th-grade classes. We then had to randomize the tests 1-3, so different participants took different Sudoku puzzles for the same distraction, to avoid the effect of one being easier or harder.

For each test, participants had a maximum of 12 minutes to solve the s\Sudoku puzzle. The order the participants took the test was: noise (11), silence, and music (12). For the noise and sound the loudness were: noise with 79.8 dB and a max of 104dB, music was 81.3dB, with a max of 94 dB. This is similar to the volume of a noisy restaurant. One participant finished the Sudoku puzzle in 12 mins two times. Everyone else did not finish in time. For an incentive, if the student attempted all 3 of the Sudoku puzzles for a max of 12 minutes each then they were awarded extra bonus points for math class. One hundred percent of the students present participated. One student was dropped from the study because they missed two or more days of the study. Six students made up one Sudoku when absent during their other free periods.

Results

While in a classroom, a person can be distracted by many things like music and random outburst noises. We gave students four Sudoku puzzles, each for silence, noise, and music, and one for a practice test so the students could understand how to do it. The music was played on a loudspeaker in the classroom and all students had 12 minutes to complete the puzzle.

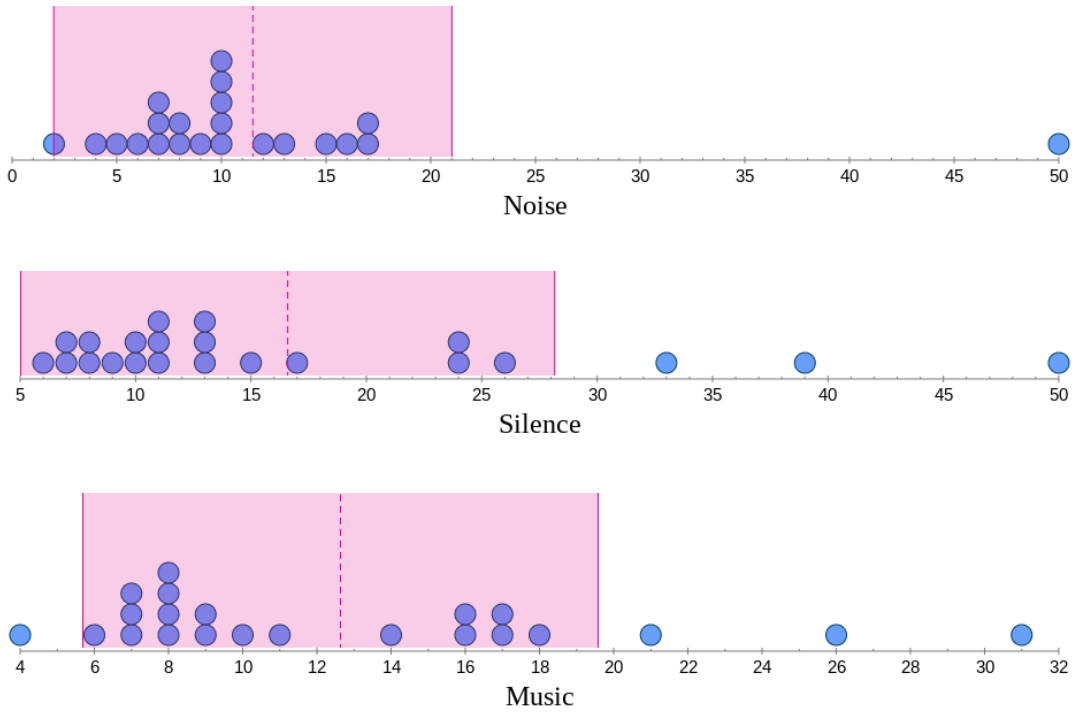

Figure 1. Sudoku scores for all three distraction conditions. *The pictures above show the participant's grade on the Sudoku puzzle in each of the three categories. The noise and silence condition had 11 out of 50 boxes correct with a standard deviation of 9.5, the data was mound shape but with one person scoring 50 out of 50. The music condition had no outliers with a standard deviation of 6.9, and the data was also a mound shape.*

Our main hypothesis was that music and noises, like talking, will affect someone's ability to complete a Sudoku puzzle compared to in silence. The scores were based on the number of boxes completed correctly in 12 minutes with a 50 being all boxes correct. A one-way ANOVA test found a significant effect on the type of distraction for the Sudoku scores ($F(2,42)=4.03, p=0.025$). A Tukey post hoc test found that the silence condition ($M=16.6$, $SD= 11.6$) scored significantly higher than the noise condition ($M=11.5$, $SD=9.5$, $p<0.05$). The music condition was between silence and noise but there was no significant difference ($M=12.6$, $SD=6.9$, $p>0.05$). We were concerned that the only student that had scored 100% on the Sudoku puzzle would have caused a difference in the p-value but, there was no significant change when we reran the test without them.

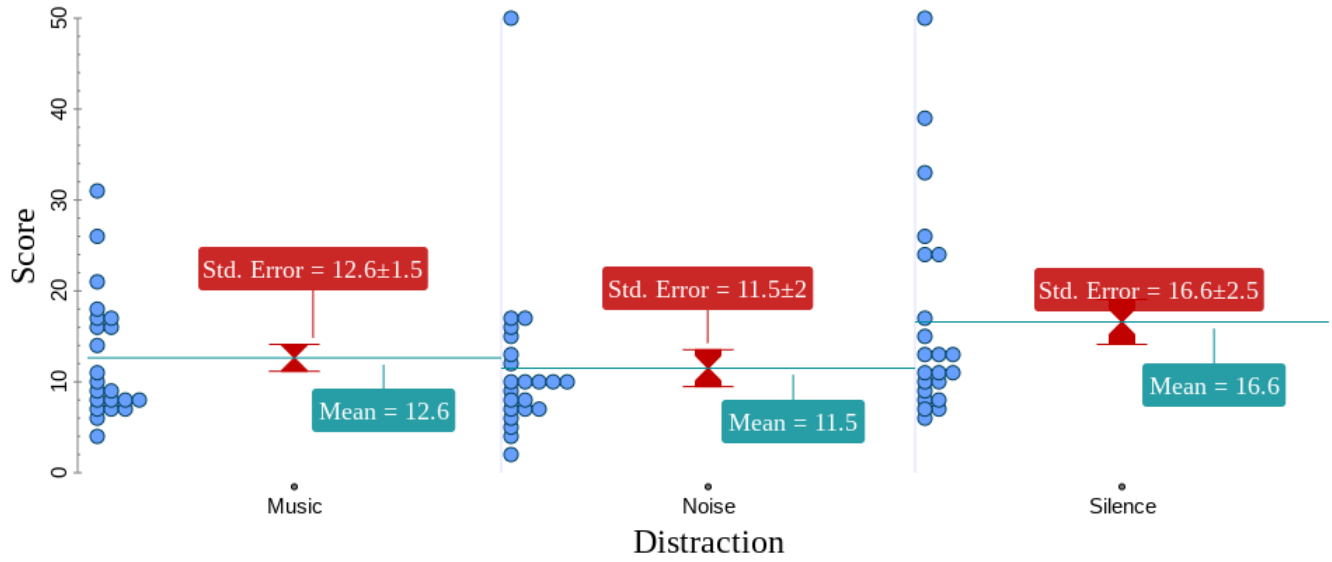

Figure 2. ***The effect of noise and music on cognitive task performance.*** *The horizontal axis is the distraction: music, noise, and silence. The vertical axis is the number of boxes correct on a Sudoku puzzle out of 50. There was a significant difference between noise and silence ($p<0.05$).*

We hypothesize someone's math ability will affect the outcome of taking a Sudoku puzzle with noise, and music. We used students' math grades from semester one for an approximation of cognitive thinking ability to measure the effect of noise and music. We subtracted noise and music scores from the silence scores, to find the effect each had compared to silence. A correlation coefficient r-test did not find a significant relationship between math grades and how much music helped or hurt the student's performance ($r(20)= -0.14$, $p= 0.27$). Students who tended to have higher math grades, tend to be distracted less by the music compared to students with lower grades, but this relationship was not strong enough to be real or significant.

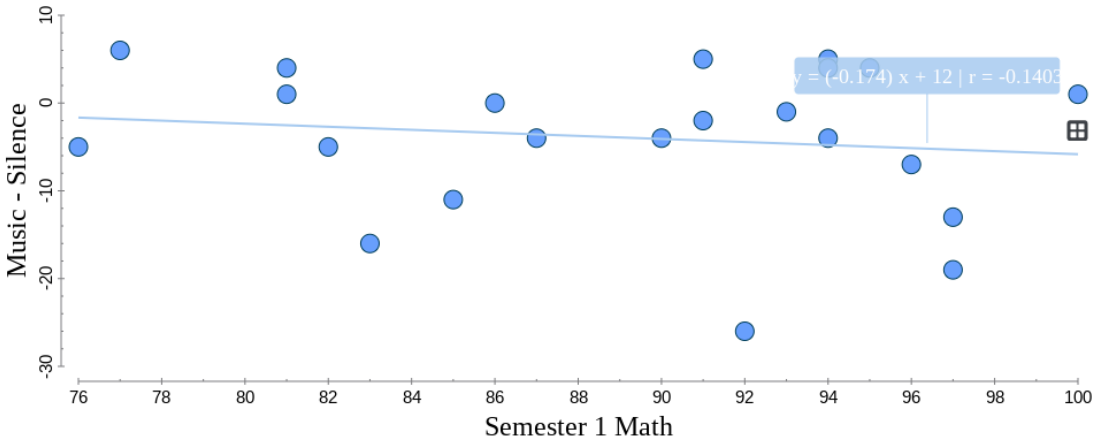

Figure 3: Effect of math grades on distractibility of music. *The horizontal axis is semester 1 math grades. The vertical axis is students' music scores subtracted from their silence scores. A negative number means that the music distracted them and made their score lower than silence, while a positive score means they did better under the music condition. There was no relationship between the two variables (p>0.05).*

Ẃe ran the same analysis for the effect of noise versus silence. We subtracted noise from the silence scores, to find the effect it had compared to silence. A correlation coefficient r-test did not find a significant relationship between math grades and how much music helped or hurt the student's performance (r(20)= -0.11, p= 0.30). Students who have a higher grade in math were distracted less compared to students with a lower grade, but this relationship was not strong enough to be real or significant.

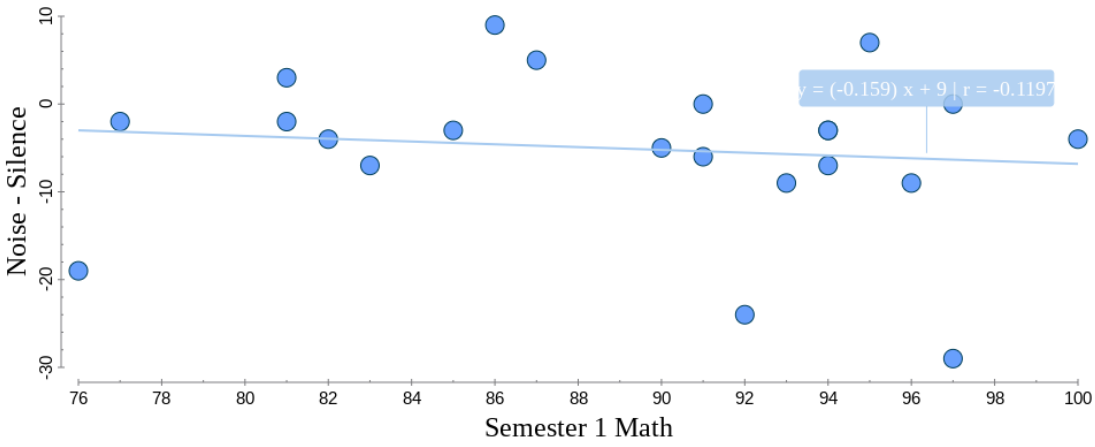

Figure 4: Effect on math grades with disruptive noise. *The horizontal axis is semester 1 math grades. The vertical axis is students' noise scores subtracted from their silence scores. A negative number means that the music distracted them and made their score lower than silence, while a positive score means they did better under the music condition. There was no relationship between the two variables.(p>0.05).*

Discussion

In this study, we wanted to determine if verbal talking and music affect someone's ability to complete a Sudoku puzzle compared to a control silence condition. Our first hypothesis was someone's math ability will affect the outcome of taking a Sudoku puzzle with noise, and music. This was supported by our data (Figure 2), our noise condition was lower than the silence condition, however, the music distraction was not significantly lower than silence. We wondered if cognitive ability as measured by a math grade will affect how we hypothesize that verbal talking and music will affect someone's ability to complete a Sudoku puzzle compared to a control silence condition. This was not supported, while better math grades lead to less distraction, the relationship was too weak to conclude math ability matters when taking a Sudoku puzzle.

Compared to a prior study by Lupus, our results with music are consistent, but with some differences. Lupus found that listening to a regular beat of the music can help someone concentrate and is not a distraction. For our study, we found that music doesn't really help or hurt in a significant way. Music in general in some way can help throughout activities in life that require a certain amount of concentration and cognitive thinking but may vary depending on the type of activity someone is doing. For Lupus's activity, it required concentration but not a lot because it was a board game. On the other hand, our activity was a Sudoku puzzle, which required a lot more concentration and mathematical thinking than a board game. The type of music may be a factor also, Lupus had a regular beat to it but, our beat had a jazzy flow to it, and that may be a reason why it didn't help as the Lupus test did. This is why music was able to help more with the Lupus study than it was able to help ours.

In a prior study by Papantoniou et al, our results with a talking distraction were consistent. Papantoniou et al found that almost everyone is distracted by talking while driving, while our study found that a talking noise, which was the cafeteria sound, did have a significant effect compared to silence. Papantoniou's study took place in a car and had a stronger concentration value than my study. Even though both studies required concentration, each of the studies needed its own type of concentration. For Papantoniou et al, it required surveillance concentration, meaning while driving someone will need to be aware of the surroundings because you will never know when something might jump out in front of the vehicle like a deer and need to be ready to react to it. On the other hand, our study consisted of active concentration, meaning it requires the person to to actually be engaged and do something with full concentration towards it. Even though both of the studies required concentration, it was interpreted differently. From both of these studies we can determine that talking is a distraction in its own unique way.

In addition to the type of distraction, a person's cognitive ability might also affect their ability to solve the puzzle while being distracted. In a prior study by Tsurkabuto and Nada-ku they wanted to see if applying biofeedback would affect solving a Sudoku puzzle and physics word problems. In their study, biofeedback was a possibly distracting sound. Our study on the other hand considered if someone's math grade is higher than it should have an overall better outcome with a Sudoku puzzle while distracted. We found that the actual math grade doesn't really help or hurt and doesn't affect someone's ability to solve a Sudoku puzzle. Despite this insignificant relationship, the relationship was negative; people with higher math grades were less distracted. Tsurkabuto and Nada-ku found that applying biofeedback does help students concentrate more on a Sudoku puzzle but not a physics puzzle, the reason why is that a physics puzzle is more of a knowledge task and really doesn't require a whole lot of math to do. These two studies together suggest but do not prove, the higher a person's ability or skill level, the less they are

affected by a distraction. Higher-skilled people are more efficient at a task, so the outside noise may not overload their mental capacity.

Our study had several limitations, one being the students' ability to solve a Sudoku puzzle. We didn't realize how challenging the puzzle might have been for the students. Another limitation was the actual sounds and noises that were used for the distractions. The distractions were played out of the speaker and were on a constant loop, so after a while, the students could have gotten used to the sound because they kept hearing the same thing. Lastly, I feel our grading system was not the best, we graded the number of boxes that were completed in a certain amount of time, which could have affected the students because they may have felt that there was a time crunch and had to hurry. In the future, I would've practiced more with the students until they were comfortable with taking the Sudoku puzzle more quickly. Also, I would have added more organic sounds that weren't played on a loop so students didn't hear the same beat on repeat. Lastly, I would ultimately grade and time how long it takes to finish the puzzle instead of having the time it needs to be done.

According to our research, students who tended to have a higher math grade, tend to be distracted less by the music compared to students with lower grades. Also it was clear that the noise was a greater distraction than the music compared to silence. Teachers should consider enforcing silence in the classroom, however, our finding with music requires more research so we can't determine for sure how music would impact classroom learning. . It's up to personal preference if someone would like music in a classroom or not.

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