The Effect of Rhythm on Math and Language Test Performance

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Abstract

This research attempts to clarify some of the inconsistent findings in the literature on music and learning by focusing on the rhythm of the background music (whether it is regular or irregular) and what type of material is being learned (math or language). Participants listened to a regular, irregular, or no background beat, and completed either a math or language test. Those in the math test group performed better (i.e., they got a higher percentage of questions correct) when they listened to a regular rhythm as opposed to an irregular rhythm. Background rhythm had no effect on those in the language test group. Implications for both educators and researchers are discussed.

Keywords: music, learning, rhythm, distraction, math, language

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With the prevalence of mp3 players and headphones, background music has become readily available to students in the classroom. Many students indicate a preference for listening to music while they complete schoolwork, as they claim it helps them concentrate. School administrators, however, are not convinced of these benefits, and many have banned personal mp3 players from schools (Domitrek & Raby, 2008). Although considerable research has been conducted to investigate the possibilities of enhancing student learning through music, the results have been mixed, with some studies finding that music facilitates learning (e,g, Angel, Polzella, & Elvers, 2010; Cockerton, Moore, & Norman, 1997), some finding that it hinders learning (e.g., Anderson & Fuller, 2010; Cassidy & MacDonald, 2007; Perham & Vizard, 2010), and some finding that it has no effect at all on learning (Moller, 1980; Wolfe, 1983).

One challenge with this research is that music is comprised of many different elements (e.g., melody, harmony, instrumentation, pitch, tempo, rhythm), each of which could be considered a separate variable. Given the difficulties in isolating and/or controlling for these variables, it is not surprising that the research on whether music affects learning is inconclusive. In this study we decided to strip away most of these elements and study only one specific aspect of music: whether it has a regular or irregular rhythm. In addition, given evidence of a unique connection between music and math (Bahr & Christensen, 2000), we were interested in whether music rhythm has differing effects depending on the type of material being learned (i.e., math vs language). This study aims to further our understanding of how learning is affected by external factors (such as music), in order to better advise educators, students, and parents on how to manage these outside factors both inside and outside the classroom.

Music and General Test Performance

The study of the effect of music on learning is not new, with studies dating back at least as far as the 1930s (e.g., Fendrick, 1937). The results are varied, resulting in confusion as to whether music helps or hinders learning. Some recent work has found negative effects of background music on learning. For example, Anderson and Fuller (2010) found that the performance of grade seven and eight students on a reading test was significantly worse when they listened to top hit singles compared to when they listed to no music. Cassidy and MacDonald (2007) showed that completion of cognitive tasks was poorer while listening to background sound (music and noise) compared to a silent background. Perham and Vizard (2010) discovered that serial recall was weakest for music and changing-state conditions (sequence of random digits) and strongest in a quiet steady state surrounding. In a study on the effects of pop music on the cognitive performance of introverts and extraverts, Furnham and Bradley (2007) showed that the pop music negatively impacted immediate recall on a memory test and that the impact was greater for introverts than for extraverts. A theoretical argument for the negative effect of background music on performance is proposed by Konecni (1982) and North & Hargreaves (1997), [Stephanie – please add this to the reference section] who suggest that music processing occupies cognitive space and that performance is hindered when it must compete with background music for processing.

Although the above research suggests that background sounds are detrimental to performance, some researchers have found the opposite effect. In a study by Cockerton et al. (1997), undergraduate students completed more questions and obtained more correct answers with background music than no background music. Angel et al. (2010) found that the speed of spatial reasoning and the accuracy of linguistic reasoning increased with the use of background music (specifically, Mozart) in a university study to examine the influence of fast tempo on cognitive performance. Hallam, Price, and Katsarou (2002) found that calming music helped both math and memory performance, while Schellenberg, Nakata, Hunter, and Tamoto (2007) found that more lively classical music was better than slower classical music at improving performance. Schellenberg and colleagues (2005; 2007) suggest that the positive effects of background music on learning are mediated by mood and arousal, whereby the music creates a positive mood in listeners, which then helps them learn better.

Finally, some studies have found that background music had no significant effect on task completion. For example, Wolfe (1983) found no significant difference in math test scores with four levels of music loudness, and Moller (1980) found no significant difference in math test scores under three different conditions (no sound, white noise sound and background music).

Researchers have also looked at the effect of various aspects of the music itself. For example, research on the “Mozart effect” (Rauscher, Shaw, & Ky, 1993) found that test scores on an IQ test were higher after listening to a piano sonata by Mozart, although subsequent research suggests that this effect is short-lived and only applies to one particular type of spatial task (Hetland, 2000). There is also some evidence that the type of music is a key variable in whether it facilitates or hinders performance. Henderson, Crews, and Barlow (1945) found that pop music had a detrimental effect on performance on a reading test, whereas classical music did not. Freeburne and Fleischer (1952) found that jazz music caused participants to read faster than classical, pop, and semi-classical music, although type of music did not result in differences on a comprehension test. More recently, research has found that rock and roll music has a detrimental effect on math and verbal test performance, but not comprehension (Tucker & Bushman, 1991), up-tempo classical music facilitates performance better than slower classical music

(Schellenberg et al., 2007), loud music is more distracting than quiet music, but it does not negatively affect actual performance (Wolfe, 1983), and that test performance is better with familiar music than with unfamiliar music (Hilliard & Tolin, 1979).

These varied results suggest that there are elements of the music itself that may produce negative or positive effects on test performance, but many of these elements are difficult to control, and the potential for confounds is high because often in these studies only one piece of each type of music is played and thus may not serve as an exemplar of one particular genre of music. In addition, music is comprised of so many elements that it is difficult to isolate what it is about the music that is having (or not having) an effect on test performance. This may account for some of the conflicting findings.

One element of music that has not been examined in as much detail is the rhythm of the background music. Existing literature suggests that background music with a slower tempo is more effective than music with a faster tempo at facilitating recall (Oakes & North, 2006), although others suggest that, rather than specific tempos, it is changes in tempo that affect arousal, which then affects spatial ability and recall (Balch & Lewis, 1996; Husain, Thompson, & Schellenberg, 1992). In addition, regularity of temporal structure has been linked with increased task accuracy and response time (Ellis & Jones, 2009; Jones, 1987; Tillmann & Lebrun-Guillaud, 2006). Thus, it would appear that, when considering the effect of background music on task performance, the regularity and predictability of the beat is important. We proposed that when the rhythm of the background music is not predictable (i.e., it is irregular), is will negative affect concentration, thus diminishing performance on a given task.

Another potentially important factor to consider is the type of task being performed. There are a number of different measures of task performance that have been used in the existing literature (e.g., memory/recall, reading comprehension, verbal ability, spatial ability, mathematical tasks), making it difficult to fully understand the effects of background music because it may affect different tasks in different ways. For example, the positive effects of classical music (i.e., the “Mozart Effect”) have only been found for specific spatial tasks (Hetland, 2000). Few studies measure more than one type of task. Thus, in this study, two different tasks were included: one involving language and one involving mathematics. We reasoned that the cognitive resources required to complete these tasks may be quite different, and thus they might be differently affected by background sounds. The connection between math and music is well documented (Vaughn, 2000); musical rhythm is based on mathematics, and musicians tend to perform better in math than non-musicians (Bahr & Christensen, 2000). It would be expected, therefore, that a regular rhythm based on a specific time signature might facilitate math performance. Conversely, an irregular rhythm that is not based on a regular time signature might be detrimental to math performance. Language ability, in part because it is not mathematically based but also because the average student uses language more often than math, and thus it requires fewer cognitive resources, might be less affected overall by background sounds. Thus, our prediction was that math performance, compared to language performance, would be most positively affected by a regular beat and most negatively affected by an irregular beat.

Overview

The purpose of this study was to investigate the effects of regular rhythm, irregular rhythm and no background rhythm on mathematical and verbal/linguistic tasks. Specifically, it examined whether the background has a different impact on math and verbal reasoning and whether the regularity of the rhythm affects performance differently than irregularity of rhythm.

This study was a 3 (rhythm: regular, irregular, none) x 2 (test: math, language) experimental design, in which participants listened to either a regular, irregular, or no beat via headphones while attempting to answer either math or language questions. Because the language questions did not require any calculations, we predicted that there would be a general difference in performance on the math and language tests. Specifically, we predicted main effects of type of test on the number of questions completed and on the number of questions that participants got correct, in that participants would complete more questions and get more questions correct in the language condition compared to the math condition. However, we were most interested in the percentage of questions that participants got correct (which would control for overall differences in difficulty between the two types of test). We expected there to be an interaction between type of test and rhythm, whereby participants would get more questions correct in the regular rhythm condition compared to the irregular rhythm condition, but only in the math condition.

Methods

Participants

Participants were 136 undergraduate students (93% female) from a small university in Southern Ontario. They were recruited from introductory Psychology or Concurrent Education courses. The average age of participants was 19.5 years (*SD*=3.60). They were given partial course credit for their participation.

Procedure

Participants were tested at computers in private cubicles in groups of one to three. They were randomly assigned to one of six conditions. After the experimenter gave instructions to participants, they initiated the experiment on the computer using Cedrus SuperLab software. All responses were inputted to an individualized data file that was collected after the participants left the laboratory.

Participants first answered some questions unrelated to this study. After this, the participants were presented with a screen that instructed them to stop and wait for further instruction. Once all participants were ready, the experimenter set a timer for ten minutes and instructed them to press a key to initiate the experiment. Depending on the experimental condition, participants were presented with either math or language questions. The math questions required basic calculations involving addition, subtraction, multiplication, division and fractions. The language questions tested knowledge of basic grammar and vocabulary. In order to manipulate rhythm, participants listened through studio headphones to either a regular or irregular beat, or no sound stimulus at all. The beats were created using a sample audio file of an acoustic studio kick drum. The regular beat was presented at 120 beats per minute (BPM), the irregular beat was a random presentation of the same audio file. Participants were instructed to answer as many questions as they could within the ten minute time frame. After the ten minutes, the participants were instructed to stop. Additional questions assessing general anxiety, distraction, and mood were administered via a paper and pencil measure. Participants were thanked and debriefed.

Materials

Anxiety. Anxiety was measured using the S-Anxiety subscale of the State-Trait Anxiety Inventory for Adults (Spielberger, 1983). The subscale consists of 20 items that evaluate how respondents feel "right now, at this moment" (e.g., "I feel calm" (reverse scored) and "I feel anxious"), measured on 7 point scales where 1 = *not at all*, and 7 = *very much so*.

Distraction. Distraction was measured using a ten item scale developed for this study. Items included "I felt distracted during the test" and "I had to exert a lot of effort to concentrate", measured on 7 point scales where 1 = *not at all*, and 7 = *very much so*.

Mood. Mood was measured with the 20-item Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988). Participants were asked to rate how they felt at that moment (e.g., "interested", "distressed") on a 7 point scales where 1 = *not at all*, and 7 = *very much so*. The scale measures positive mood (10 items) and negative mood (10 items).

Results

An exploration of the data revealed 4 outliers, so they were removed from the data. The analyses were conducted with and without these outliers, and the results did not change significantly.

In order to test whether there were differences in overall performance between the math and language tests, we conducted 2 (type of test: math, language) × 2 (rhythm: regular, irregular, none) ANOVAs on the number of questions completed and the number of questions correct. As we expected, there was a main effect of type of test on the number of questions completed, F (1, 121) = 81.23, $p < .001$, $\eta^2 = .40$, whereby those in the language condition (M = 43.04, SD = 11.71) finished significantly more questions than those in the math condition (M = 26.33, SD = 8.94). There was no main effect of rhythm and no interaction effect.

Similarly, there was a main effect of type of test on the number of questions correct, F (1, 121) = 36.21, $p < .001$, $\eta^2 = .23$, whereby those in the language condition (M = 20.28, SD = 8.63) got significantly more questions correct than those in the math condition (M = 12.22, SD = 6.71). There was also a significant main effect of rhythm on the number of questions correct, F (2, 121) = 3.29, $p < .05$, $\eta^2 = .05$. Multiple comparisons revealed a marginally significant difference (p = .08) between the regular and irregular rhythm conditions, whereby those in the regular rhythm condition (M = 17.88) got more questions correct than those in the irregular rhythm condition (M = 13.69). There was no difference between either the regular and irregular conditions and the no rhythm condition (M = 16.91). There was no interaction effect.

We were most interested in the individual and combined effects of type of test and rhythm on percentage of questions correct. There were no main effects of either type of test or rhythm. As predicted, however, there was a significant interaction, F (1, 121) = 4.15, $p < .05$, η^2 = .06. An analysis of the simple effects showed that those in the regular rhythm group (M = 55) got a significantly higher percentage correct than those in the irregular rhythm group (M = 38), but only in the math condition, F (2, 57) = 4.12, $p < .05$, $\eta^2 = .13$. There were no significant differences between those in the regular or irregular conditions and the no rhythm condition (M = 48) (see Figure 1). There were no differences in tempo in the language condition.

In order to test other possible effects of type of test and rhythm, we conducted ANOVAs on anxiety, distraction, and mood. There were no effects on anxiety or mood, but there was a main effect of rhythm on distraction, F (2, 121) = 40.22, $p < .001$, $\eta^2 = .39$. Multiple comparisons revealed that participants reported significantly more distraction in both the regular

(M = 5.34) and irregular (M = 5.14) conditions than in the no rhythm condition (M = 2.66). There was no main effect of type of test and no interaction.

Discussion

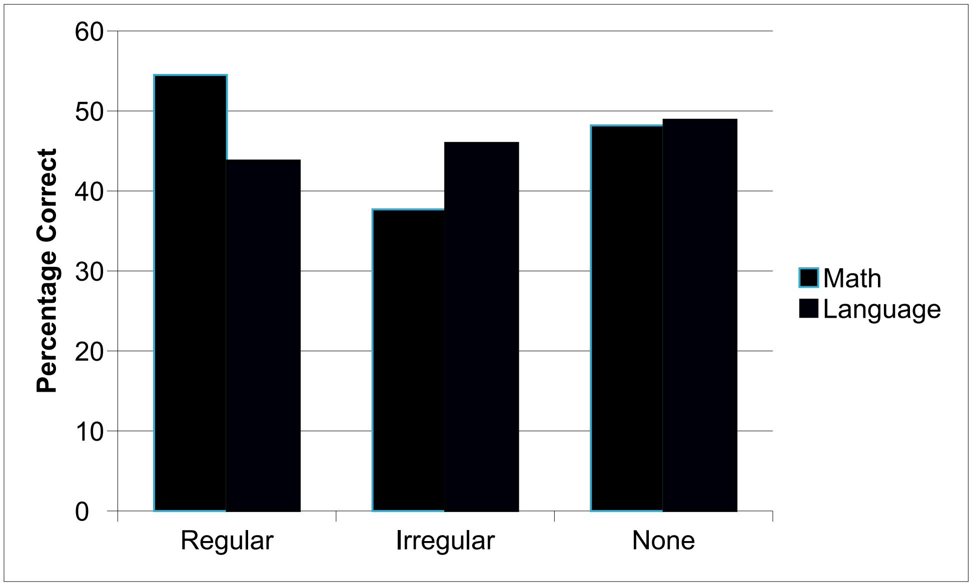
Our results showed that the regularity of background sounds can have an effect on test performance. Participants who listened to a beat played at a regular rhythm performed better than those who listened to a beat played at an irregular rhythm. This effect, however, only held for performance on a math test; rhythm had no effect on performance on a language test. Participants who listened to the regular rhythm scored significantly higher on the math questions than those who listed to a beat played at an irregular rhythm. While those in the regular rhythm group also scored higher than those who listened to no background sounds, the difference was not significant.

We also found that the type of test and the rhythm of the background sound had no effect on participants' anxiety or mood. Participants did report being more distracted when there was any kind of background sound (i.e., a regular or irregular beat) compared to when there was no background sound other than ambient noise. These findings suggest that the effects of background sounds on math performance are not mediated by anxiety, mood, or distraction. In fact, participants in the math group performed well in the regular rhythm condition despite reporting the same level of distraction as those in the irregular rhythm condition.

These findings suggest that when considering whether there is an effect of background music on learning, two additional factors may need to be considered: the type of music, and the type of learning. Because math scores were higher in the regular rhythm condition, it may be that music with a regular, predictable rhythm is more conducive to learning math than is more challenging music. In addition, it appears that language learning is less affected by background sounds, regardless of how unpredictable or distracting those sounds are. This is important from a research perspective, because it suggests that these two potential moderators of the background music/learning relationship should be considered in future research. From an applied perspective, these findings suggest that there are some situations in which educators and parents should more closely monitor what students are listening to, rather than considering blanket bans on music while studying.

Figure 1

Type of test × rhythm interaction on percentage of questions correct



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