Exploring the Mozart Effect on Dutch University Students

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Abstract

The increasing use of music in everyday life resulted in growing research on the effectiveness of background music on emotion and performance. One prominent finding in this context is that of the Mozart effect, which is described as the positive influence of exposure to Mozart's music on emotions and spatio-visual performance. Replication studies on the Mozart effect show results both consistent and inconsistent with this finding, indicating a level of inconclusiveness in research on this topic. In an attempt to contribute to the existing theory on the Mozart effect, the present study explored the effect of exposure to Mozart's music on emotions and spatio-temporal skills in Dutch university students. This was done by having 36 students spend twenty minutes performing a set of three sudoku puzzles, 18 of which first listening to a Mozart sonata for ten minutes, and all filled out the Positive and Negative Affect Schedule (PANAS) both before and after the task. Results show that neither students' emotions nor their performance on the puzzles were influenced by exposure to Mozart. As no earlier studies in this research area mentioned the use of sudoku puzzles as a task, further research about the Mozart effect on sudoku performance, as well as other tasks related to visual pattern analysis, is encouraged. Correcting for musical ability and preference of music is also advised for future studies, as this was not done in this research, and these variables are hypothesized to play a considerable tole in the Mozart effect.

Exploring the Mozart Effect on Emotion and Performance in Dutch University Students

Over the past decades, the availability of music in everyday life has increased significantly. Where in the past people had to buy vinyl records or cd's to play at home, the breakthrough of music applications such as Napster and iTunes enabled users to effortlessly download songs made by thousands of artists over the world and play them wherever they desired, using nothing more than an mp3-player or mobile phone and an internet connection (Cockrill, 2012; Krause et al., 2013). This growing simplicity to listen to music has showed an increase in the use of music in the background while doing things, including tasks such as studying or solving problems. For example, university students reported studying with music on to increase relaxation and focus, as well as blocking out other noise (Hu et al., 2020). This growing tendency to use music for study-related tasks showed positive effects on users' emotional states; research has indicated significant increases in positive emotions and motivation because of background music, which in turn has a positive effect on learning outcomes (Mutlu-Bayraktar, 2024). However, the extent to which background music is effective for task performance is influenced by the type of music played and the way the listener responds to it. While engaging in performance-based tasks, people usually listen to music that does not have any lyrics (Shih et al., 2012), is slow-paced (Strachan, 2015) and is not heavily liked or disliked by the user (Huang & Shih, 2011). These preferences can be explained by the cognitive load theory, which states that the presence of multiple elements affecting the working memory can result in a cognitive overload, which significantly decreases cognitive performance (Sweller, 2011). Music with lyrics or a fast pace might become to cognitively demanding for the working memory to properly process the task at hand. In other words, background music should not be the primary focus of attention while studying or solving problems.

A form of music that could be effective for studying is classical music (Goltz & Sadakata, 2021). Within this genre, the type of which the effectiveness has been studied explicitly are Mozart sonatas. Rauscher et al. (1993) researched the effects of this music on spatio-temporal performance by having participants listen to it for ten minutes before completing a spatial abilities task, where others either listened to a relaxation tape designed to lower blood pressure, or to nothing at all. The tasks consisted of Pattern Analysis, a Matrices test and a Paper Folding and Cutting (PFC) task. The results showed a direct positive effect of the sonatas on the performance on the PFC task specifically, as the spatial abilities of the participants listening to this music were significantly higher than those of the other groups. The findings started a series of studies trying to collect more evidence for the positive influence of Mozart's music on performance, to which many refer as the "Mozart effect". This resulted in many studies which found positive effects of exposure to Mozart music on spatio-temporal abilities (Jenkins, 2001; Ivanov & Geake, 2003; Jones et al., 2006; Jones & Estell, 2007; Pelayo, 2014; Kusuma et al., 2024). One of these is a replication study by Thompson et al. (2001), which also found positive effects of listening to a Mozart sonata beforehand on PFC task performance. In this study, participants would perform a spatial abilities task after listening to either an energetic Mozart sonata, a sad Albinoni adagio, or no music. The Mozart group showed significantly better performance than the other two groups, and the study provides evidence that this is due to the higher notes and tempo present in Mozart's music enhancing arousal and mood, which in turn positively influences motivation and performance. This subconscious influence by an intervention (such as exposure to music) on motivation is referred to as emotional priming (Loizou et al., 2014). This emotional priming effect was also found in a study by Jones et al. (2006), where the Mozart effect was only present as a result of increased arousal due exposure to the sonata beforehand. A different way in which emotions influence task performance is explained by a study on high school students (Pelayo, 2014). In this study, students reported becoming more relaxed by the music at first, and after further exposure they became more motivated to do the task, even enjoying it because of the music in the background. This difference in responses to exposure to Mozart (aroused versus relaxed) shows that it is not yet known how exactly the Mozart effect works, and it can be suggested that the influence of the music differs per individual.

The way the Mozart effect occurs can be explained by its influence on cortical activity. Research found that by playing Mozart, the cortical column gets aroused in a way that it enhances recognition and classification abilities for similarly looking objects (Mountcastle, 1997; Rauscher & Shaw, 1998). Other effects on brain activity have also been found, including a study that saw significant decreases in epileptiform activity in the brains of people suffering from a seizure (Hughes et al., 1998). The overall effect Mozart has on the brain is highly believed to be the result of the complex architecture of the music, with many musicologists referring to it as a sort of science.

While evidence in favour of the Mozart effect has been found, there are also studies which found no significant influence of Mozart on emotions and spatial abilities. For example, a replication study by Steele et al. (1999) found no significant differences in spatial ability between people who listened to Mozart before the tasks and people who did not. This indicates that exposure to Mozart does not always influence task performance. As of now, the main influence that the Mozart sonata seems to have is improving one’s mood, and even that is not always the case; a study regarding the Mozart effect in children saw no significant changes in mood and arousal after playing the sonata (Črnčec et al., 2006). The study by Jones and Estell (2007) mentioned earlier on the Mozart effect on high school students did find, beside their main result of the positive influence of Mozart on spatial abilities, a correlation between the latter and emotional arousal, but listening to Mozart had no effect on emotion in this study.

As of now, there does not seem to be clear proof that using background music while performing a task improves the results of said task. While there are studies that found a positive influence, there is also a significant amount of literature that did not find such effects, as was also found by De La Mora Velasco and Hirumi (2020). In their literature review about background music they indicated a rather even division of positive, negative and no correlations between background music and task performance, reported in the forty studies included. As for the Mozart effect, an earlier meta-analysis found little evidence that the sonata actually improved task performance (Pietschnig et al., 2010). The reviews provide evidence for what was already suspected; there is no significant effect of background music on spatial task performance.

In the existing literature regarding the Mozart effect, there is only a handful of studies researching the music's influence on university students. In an attempt to generate more data for this topic, the present study will explore the effect that playing a Mozart sonata before a spatial reasoning task will have on university students' performance on said task. As literature suggests that the Mozart effect relies rather largely on the positive effect listening to a sonata has on emotions, the role of emotional priming will also be considered in this research. Therefore, the following research questions have been developed:

Q1: To what extent does listening to a Mozart sonata before a spatial reasoning task influence emotions in Dutch university students?

Q2: To what extent does listening to a Mozart sonata before a spatial reasoning task influence task performance in Dutch university students?

Method

Participants

This study was performed on 36 university students with a mean age of 21.2 years (*SD* = 2.17). Demographic characteristics of the participants are shown in Table 1. The fact that all participants were Dutch was not decided beforehand~~,~~ but occurred coincidentally. Most participants (34 out of 36) were selected through snowball sampling, as they were asked to participate and invite others to participate as well, under the condition that these others were studying at a university at that time. The other two participants were selected through self-selection sampling with an incentive, as they signed up for the study online using a system

Table 1

Demographic Characteristics of Participants

Demographic characteristic	Experimental group		Control group	
	n	%	n	%
Gender				
Female	3	17	8	44
Male	15	83	10	56
Nationality				
Dutch	18	100	18	100
Study type				
Bachelor	15	83	15	83
Master	3	17	3	17

through which university students can partake in studies, in exchange for credits (*Test Subject Pool BMS*, n.d.).

Materials

Spatial Reasoning Task

To test the participants' spatial reasoning, the task that they have performed consisted of three sudoku puzzles [Appendix]. The first two puzzles started out with 51 empty cells each, the last one had 45 cells to be filled out. The puzzles were taken from a sudoku website and were of medium difficulty (*Sudoku Medium Online - Play Medium Level Sudoku Puzzles for Free*, n.d.). This level seemed the most fit for the participants to perform, as they would eventually get twenty minutes to solve the puzzles and experienced players should be able to finish one or two puzzles within this window, but probably not three. Through this way, the possibility that all participants will finish all puzzles would be decreased, preventing a ceiling effect from occurring.

Music

To test the influence of listening to Mozart beforehand on performance and emotion, Mozart's Piano Concerto No. 23 in A major (K. 488) was used (Am4d3usM0z4rt, 2011). To play this sonata to the participants, a Bluetooth speaker was used to which a mobile phone was connected. Through this phone, the YouTube app was used to play the Mozart sonata.

Positive and Negative Affect Schedule

To measure the emotions of the participants before and during the task, the Positive and Negative Affect Schedule (PANAS) was used (Watson et al., 1988). The PANAS is a survey using twenty items related to affect. Ten of these items are about positive affect (e.g. 'active' or 'enthusiastic'), and ten about negative affect (e.g. 'scared' or 'nervous'). By using the PANAS, the participants indicated the extent to which they related to the items at that moment using a five-point Likert scale (1 being ‘not at all’, and 5 being ‘very much’). Research proved that the PANAS is a valid and reliable scale to assess affect in adults (Crohnbach’s α >.84 for both positive and negative items), which makes it a sufficient and trustworthy tool to measure emotions in this study (Crawford & Henry, 2004).

Procedure

The study was carried out either in a silent classroom or at participants’ homes. Participants who signed up through SONA were immediately given the opportunity to sign up for a one-hour time slot, during which they would be performing the task. The participants who were asked to participate in the study by the researcher would directly discuss a time to perform the test. The number of participants present per time slot depended on the number of participants that signed up for that time slot. Participants were seated at a table. First, the participants were asked to write their initials on each form they filled out. This was done to make sure that forms filled out by the same participant would stay together.

Before the task, students were informed that they would spend twenty minutes performing a problem-solving task. Participants belonging to the Mozart group were told that they would first listen to Mozart for ten minutes, participants in the control group were not told about the role of Mozart in this study. Neither group was told that one group would listen to Mozart beforehand and one would not. This was done so that they would not be aware of the fact that exposure to Mozart was the independent variable. The participants were asked to fill out the informed consent form to officially agree with participating in the study and give permission for their data to be used in this study. Then, their demographics (age, gender, nationality) were gathered. Filling out these two forms took approximately five minutes. Following the consent form and the gathering of demographic data, the participants were asked to fill out the PANAS for the first time. This also took about five minutes. After filling out the PANAS, the students would either spend ten minutes listening to a Mozart sonata or skip this part and continue to the next step. Students who were in a room together would always be assigned to the same condition, so either everyone present in the room would listen to Mozart for ten minutes, or nobody would. When the ten minutes were up, the participants were handed out a sheet with three sudoku puzzles and given the instruction that they had twenty minutes to individually work on them and get as far as they could. They were told that it is okay if they made mistakes on any of the puzzles and/or were unable to finish all three of them within the twenty minutes. They were also asked to write down the time they finished a puzzle. This was done in order to see how much time was spent on each puzzle. After the twenty minutes, the students who were not finished yet were asked to stop working on the sudoku and the sudokus were taken back from them. Then, the students were asked to fill out the same PANAS they filled out before the task, to reflect on their feelings during the task. This again took about five minutes. After filling out the PANAS for the second time, the study was finished. The students received a debriefing letter with information about the study they just participated in, including an email address to which they could send an email if they were to have any questions or wanted to know more about the study and the results. They were given the opportunity to withdraw from the study, now that they had received the true scope of the research. Whether they would or would not decide to withdraw from the study, they would either way be thanked for their time afterwards.

Data analysis

The collected data was analysed using Microsoft Excel and RStudio. First, the participants' total scores on the sudokus would be graded. This was done using a formula that compared the number of correct cells to the total number of cells. In this formula, a point would be granted per correctly filled cell. The total score would be increased for participants finishing all three puzzles more quickly. The formula used was the following:

*TotalScore = TotalCorrect / (1 + ((1200 – Time) / 1200)) / 147 * 100*

Here, *TotalScore* is the final score the participants received expressed in percentages, *TotalCorrect* is the total amount of correctly filled cells in the sudoku puzzles, and *Time* is the total time spent on completing all three sudokus expressed in seconds. The number 1200 represents the number of seconds participants would have to solve the puzzles, and the number 147 represents the total number of cells to be filled out. To compare the differences of the two groups, a t-test was performed in RStudio.

After the total scores on the puzzles were calculated, the PANAS scores before and after the task were compared. This was done by comparing the scores on the negative items and those on the positive ones separately. For both groups, the average difference per item per participant was calculated for both the positive and the negative items, and these averages were compared between the groups. The average difference would be calculated using the following formulas:

NegDiff = (NegItems2 – NegItems1) / 10

PosDiff = (PosItems2 – PosItems1) / 10

For the first formula, *NegDiff* is the average difference in indicated scores on the negative items (1-10) per participant, *NegItems2* is the sum of all scores indicated on the negative items in the second PANAS, and *NegItems1* is the sum of all scores indicated on the negative items in the first PANAS. The second formula works the same, but here the scores on the positive items (11-20) were used. Again, the differences of the two groups were compared by performing a t-test in RStudio.

Results

To what extent does listening to a Mozart sonata before a spatial reasoning task influence emotions in Dutch university students?

The control group overall reported a higher increase in negative emotions during the task than the Mozart group (Table 2). The t-test performed on the difference between the Mozart group and the control group showed a p-value of 0.67 and a 95 percent confidence interval between -2.50 and 3.84. Since the p-value is not below 0.05 and the confidence interval includes 0, the results are not statistically significant.

As for the positive items, both groups reported an average decrease in positive emotions during the task (Table 3). For the Mozart group, the average decrease is relatively close to zero, but the positive emotions of the control group dropped more than two points on average. As for the difference between the two groups, the t-test resulted in a p-value of 0.21 and a 95 percent confidence interval between -6.09 and 1.42. This means that these results are also not statistically significant.

Table 2

Differences in Negative Items Between First and Second PANAS

	Mozart group		Control group		$t(33)$	p
	M	SD	M	SD		
Difference in negative items	.239	.502	.306	.430	.428	.672

Table 3

Differences in Positive Items Between First and Second PANAS

	Mozart group		Control group		$t(31)$	p
	M	SD	M	SD		
Difference in positive items	-.011	.545	-.244	.635	-.609	.214

To what extent does listening to a Mozart sonata before a spatial reasoning task influence task performance in Dutch university students?

Table 4 shows that the Mozart group scored slightly higher overall, with a difference in average scores of around 0.3%. The lowest reported score was the same for both groups, with these participants having the exact same amount of correctly filled cells. The t-test run in RStudio showed a p-value of 0.96 and a 95 percent confidence interval between -0.16 and 0.15. This means that the difference in total scores between the two groups can be concluded as not statistically significant.

Table 4

Total Scores on Sudoku Puzzles

	Mozart group		Control group		$t(32)$	p
	M	SD	M	SD		
Total score	.392	.257	.389	.194	-.045	.964

Discussion

Implications

The purpose of this study was to find out whether the Mozart effect would be found in Dutch university students performing a spatial reasoning task. The results of this study show that changes in reported emotions during the task did not differ between participants who were exposed to Mozart beforehand and participants who were not. In addition, there were also no statistically significant differences in task performance between the two groups. Therefore, the present study found no evidence for a Mozart effect in Dutch university students. This is in line with the meta-analysis by Pietschnig et al. (2010), which found little evidence for a Mozart effect. According to Rauscher and Shaw (1998), the main reason researchers fail to find the Mozart effect in their studies, as is the matter here, is their method used. One of the aspects of the method is the task that the participants will perform. The initial study by Rauscher et al. (1993) used three different tasks, with the Paper Folding and Cutting (PFC) task being the only task in which performance rates were higher for participants who listened to Mozart beforehand, indicating that the Mozart effect merely happens in this type of tasks. Rauscher and Shaw (1998) referred to the work of Mountcastle (1997), who found that the cortical column gets aroused as a result of exposure to Mozart. This part of the brain is associated with spatio-temporal ability, which can explain the effect on the PFC task. In the present study, a different type of task was used, namely sudoku puzzles. A reason that performance on this task was not enhanced due to exposure to Mozart could be the fact that the cortical column is not as important for performance on a sudoku as it is for the PFC task, meaning that the wrong part of the brain gets aroused. However, since no other literature about the Mozart effect on different types of skills and associated brain sections has been found, this question is yet to be answered.

Another part of the method in which this study differs from that of Rauscher et al.

(1993) is the way participants of the Mozart group were informed to listen to the sonata. In the latter study, participants were encouraged to actively listen to the music, as if they would have to ask questions about it afterwards. This encouragement was not given to the participants in the present research, which could have altered the effect the music has had on them. In this study, the participants in the Mozart condition were simply asked to listen to the music without performing any distracting activities such as using their phone or reading a book, but they were not asked to sit in complete silence paying attention only to the music. The difference in listening instructions could be an explanation for the fact that Mozart had no statistically significant influence on emotion in this study. This, in turn, could be a reason that task performance was not affected, as this influence is explained by emotional priming (Thompson et al., 2001; Jones et al., 2006). The lack of reported changes in emotion during the task could also be explained by the average duration of the Mozart effect. Rauscher et al. (1993) mentioned that the Mozart effect is temporal and is only present for ten to fifteen minutes. This is backed up by Jenkins (2001), who found no effect lasting longer than twelve minutes. Since the sudoku task in this study lasted twenty minutes, it could be that the Mozart effect has already (partly) worn off when the participants filled out the PANAS for the second time. However, the existing literature does not provide enough information about the long-term effects Mozart has on emotions, making further research necessary.

Limitations

Unlike some earlier research, this study is limited in that it has not accounted for differences in music familiarity and preference. If this would have been done, the results could in some way have been explained by this variable. Thompson et al. (2001) indicated having used participants with an average number of 2.75 years of music training prior to the study, which could be a variable playing a role in their positive results regarding the Mozart effect. Other studies also mentioned potential positive influences of musical ability on the

Mozart effect, naming the relationship between musical and visuospatial skills as a possible reason for this (Črnčec et al., 2006; De La Mora Velasco and Hirumi, 2020). Music preference is also believed to play a role, as Huang and Shih (2011) state that heavily liked or disliked music might be distracting for people performing a task. Therefore, people who have a strong affiliation or aversion for Mozart's music, might not experience the same effect as people who do not. However, further research about this is required, in which the present research eventually did not play a role.

Another limitation of this research is the lack of participants in the study. Only 36 students were able to partake in the study, of which 18 belonged to the Mozart group and 18 to the control group. This number cannot be seen as a large enough sample size to truly say something about the results found in this study. In addition, the female participants in this study were underrepresented; just over 30 percent of the participants were women, and all others were men (11 versus 25). Even though it is not believed that gender is an influence, this study has become somewhat less applicable to general populations, as not all genders have been represented evenly. The lack of participants and uneven distribution of genders are mainly the result of the way participants have been gathered for this study. Initially, students would have the opportunity to sign up for the study through the SONA system (*Test Subject Pool BMS*, n.d.). However, the response rate appeared to be very low, as only two participants were gathered through this system. This difficulty in finding enough participants through this system resulted in the decision to reach out to friends and family who were attending a university at that moment~~,~~ and ask them to participate to the study. Most people available and willing to participate happened to be men, and with the limited time and resources in mind, the number of (female) participants could not be increased in time.

A third limitation, which was also a result of the difficulty in finding participants, was the lack of consistency in time and environment when performing the study. In contrast to most other studies, this one was not performed at the same time by all participants in the one room. Instead, students engaged in the task on separate occasions on various locations, and with altering numbers of people per occasion. For example, some people performed the task in a classroom, being there alone with the researcher, while others did it in the comfort of their own living room, together with multiple other participants. These differences were again a result of the limited time available for collection of data, and the lack of overlap in availability between the participants. These differences in time of day and environment, and possible inconsistencies with participants' preferences, might have influenced the data to an extent. For example, it is shown that people tend to perform better on tasks when they are conducted at a time consistent with their time-of-day preferences (Kirby & Kirby, 2006). People who prefer working in the morning will be likely to not perform at their best when asked to do a task in the evening, and vice versa. Tiredness might also play a role in this, as one group of participants reported performing the task after some relatively busy and energy-demanding days. As a result of these differences, the setting of the data collection is not standardized, meaning that environmental factors influencing the data cannot be ruled out.

Future Research

Despite differences between this study and earlier ones, as well as the limitations present here, the results of this study can serve as support against the suggestion that Mozart influences emotion and performance on spatio-temporal tasks in university students. The specific guidelines provided by Rauscher and Shaw (1998) about how to perform the study suggest that the Mozart effect will only occur under highly specific circumstances, and these were not present here. The most prominent manner in which this study differs from previous ones is the task used. Before this study, no literature had been found that tested the Mozart effect on sudoku puzzles. While this can be an explanation for the neutral effect Mozart had on performance here, this study does contribute to the widening of the range of tasks the

Mozart effect has been tested on. In addition, this study potentially opens the door for people to perform further research on the Mozart effect on performance in visual pattern analysis tasks such as sudoku puzzles, possibly under more standardized and less limited circumstances.

As emotion was also not significantly affected by exposure to Mozart, the suggestion can be made that there is another variable playing a role in this correlation. Earlier studies already reported factors such as musical ability (Črnčec et al., 2006) and preferred music (Jones & Estell, 2007) to be important predictors of emotional change through musical exposure, but research on this is still inconclusive. Future researchers should therefore be advised to take these factors into account when investigating the Mozart effect, or the effect of any music in this context.

Conclusion

This study did not find a significant effect of exposure to Mozart on both emotion and task-performance. Failure to exactly copy the methodology of Rauscher et al. (1993) is believed to play a prominent role in these results, as both the performed task and the listening instructions for the Mozart group differed from this. Limitations such as absence of data regarding musical ability and preference, as well as the lack of participants and environmental inconsistencies, are also believed to have affected the outcome of this study. Future researchers in this field are encouraged to expand research on the Mozart effect using different tasks~~,~~ and advised to account for differences in musical ability and preference.

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Appendix

Sudokus Used in the Study

Sudoku 1:

8		1	5		4		2	6
		9	6	7				
					9	4	7	
4								
9		5			8			2
		3		2		1		
				4	7	6		5
5	9	8		1		7		
				5				

Sudoku 2:

	3							9
			8					2
	2	7			4			
9			4	5		8		
1					6	9		
3	7	4			2		6	
4	9	6		7		2		
			3	6				
	5		2				9	1

Sudoku 3:

		8				3		
			8	2				4
2	7		5		4			
	9	2				6		7
8	3			6		4		
					5			2
3	1	7	2	9			4	6
					7		9	3
	2	4	6	5	3		8	1