

How does the presence of game music influence players' performance in rhythm games?

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Abstract

The music game genre is an ever-growing franchise, and developers need to know what and what not to focus on when creating their games. The goal of this paper is to inform developers on what to focus on through gathering data through an experiment. Our experiment focused on the importance of game music in these games, specifically how they influence gameplay and player's timings.

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Introduction

With the pandemic's effect on the average person's ability to go outside, video games have become more popular^[1,2]. Games that involve music and keeping rhythm as a whole are a popular genre to the general public, may they be hardcore or casual gamers. From Piano Tiles to Beat Saber, all types of games that involve rhythm can be seen across the market. This form of gaming is no new phenomenon either; with Parappa the Rapper being introduced to the public in 1998^[3], games that involve a steady pace of rhythm have been a hit ever since^[3]. This overwhelming popularity of rhythm games and seemingly simple ways

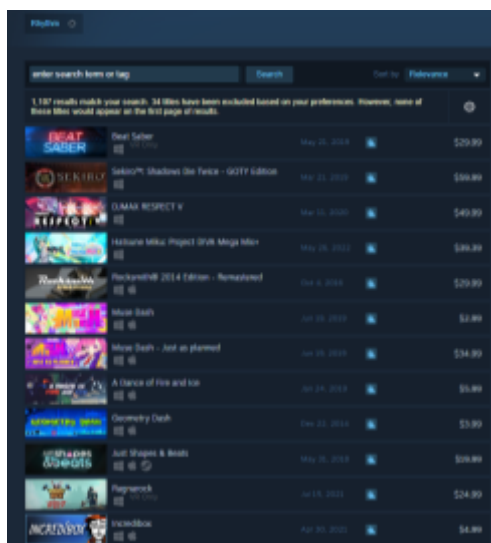


Figure 1: A look at the rhythm section of steam

to develop these games could present opportunities for game developers to enter this music genre of gaming in an accessible way. However, if you were to download steam and take a look in the Rhythm category (Figure 1), you would see a plethora of rhythm games. This overwhelming number of rhythm games makes it difficult for indie developers to promote their games to a mainstream audience. To this end, studies have been made on rhythm games to see what makes them popular and what makes them tick. A study on a rhythm game with a unique

control scheme showed that its uniqueness made it stand out but still gave it a lower enjoyment score than other more mainstream games. An MQP done at WPI had also tried to create a game with a unique style of controller input, but in their post-mortem, had explained that sticking to the more mainstream version of controls had helped in the success of their games. Instead of trying to create a new kind of input for these games, another study was done where the researchers tried to compare two controllers, one from Guitar Hero, and another created to replicate a guitar more accurately. Their results showed that people enjoyed the controller that more accurately replicated a guitar, which might indicate that this is a possible avenue that developers haven't gone down. However, we have yet to see any games replicating this kind of controller function.

A controller that more accurately represents a guitar would be an intriguing avenue to research, but due to time restraints and the resources at our disposal, we cannot replicate the same study that was made. Seeing that in most studies, keeping to tried and true methods for these games seem to be the most successful, we look to replicate that in our experiment. Our

experiment focused on the relation between the music and notes that the players had to input. The sample for our experiment will primarily consist of college students aged between 18-23, as this would be the easiest method for us to obtain data. Ideally, we would have a more varied sample size, but we could not procure more people due to a lack of time and resources. In performing this experiment, we hope to help future developers develop their games and give them a path on what to focus on while working on their games.

Background

Before we go into the details of our experiment and what we did to gather information, we will first talk about what experiments have already been done that involve music games and what game developers could learn from them. From these experiments, we drew our own conclusions and designed our own experiments with our own experience with music games. Given our lack of resources, we developed a simple and informative experiment based on not only the research that has been done on music games but on others that also involve reaction time and enjoyment. From these experiments, the data we show after this chapter can be used by game developers to make sure that they can make a game that stands out to the general populace.

To this end, developers have tried various ways to make their game stand out amongst the crowd, to varying degrees of success. A study conducted in 2019 analyzed the game structure behind mobile games and scored them out of five based on a questionnaire they gave their participants. The results showed that the game with more unique controls had an average lower score overall than the game with more common controls(Figure 2).^[4] Another

study in 2020 replicated the popular game *Beat Saber*, to try and see whether it could be run in a phone VR setting. In their study, they note that “because of [the] unique controls, [players sometimes] find it difficult to get or use a controller.”^[5] Though the study was not focused on the control scheme of the game, it's

important to point out that even this study had problems with game controls, as this

#	Questionnaire	Deemo		Cytus		Lanota	
		Avg	SD	Avg	SD	Avg	SD
1	Does the gameplay have a unique style?	4.52*	0.11	4.22	0.26	4.80*	0.18
2	Does the design of game levels attract me to play the next level?	4.32	0.15	4.22	0.21	4.20	0.16
3	Is the coordination of player and hardware smooth?	3.24	0.18	3.89*	0.25	4.00*	0.28
4	Do you feel immersed in the game?	4.36*	0.16	4.00	0.35	3.80	0.18
5	Do you agree that there are various game levels that you would like play again?	4.16	0.18	4.00	0.27	4.00	0.28
6	Does the game have many challenging targets?	3.92*	0.19	3.00	0.42	3.40	0.46
7	Did you learn the gameplay easily?	4.64*	0.10	4.44	0.17	4.20	0.18
8	Did you like the visual effects coordinated with gameplay?	4.44	0.15	4.56	0.17	4.80	0.22
9	Did you like the character and story settings?	4.92*	0.05	4.00	0.31	4.60*	0.22
10	Do you agree that the music is suitable to the context?	4.68	0.15	4.33	0.35	4.40	0.22
11	Are the score and combo indications not interfering with the play screen?	4.52*	0.13	3.44	0.36	3.80	0.18
12	Is the movement of the finger comfortable?	4.12	0.17	3.89	0.25	3.60	0.46
13	Does the note and music sync well?	4.36	0.24	4.22	0.26	4.20	0.18
14	In-game items (purchase form) smoothly purchased?	4.40	0.15	4.33	0.27	4.20	0.33
	Average	4.33		4.04		4.13	
39	Subjects	25		9		5	

* represents statistically significant ($p < 0.05$) by Tukey test

Figure 2: The Table used while testing mobile games

influenced how we designed our experiment. Regardless of these studies, there have still been other studies that have tried experimenting with unique controls in rhythm games.

An MQP done at WPI had attempted to “experiment with players performing music in a freeform fashion.”^[6] Their game, *Doldrum* (Figure 3),

tried to experiment with a new control scheme to make their game stand out amongst others. However, their post-mortem explains that they found it safer to replicate mechanics that were more similar to other successful rhythm games. Although this is a real-world example of a game failing to work due to creative ambitions,

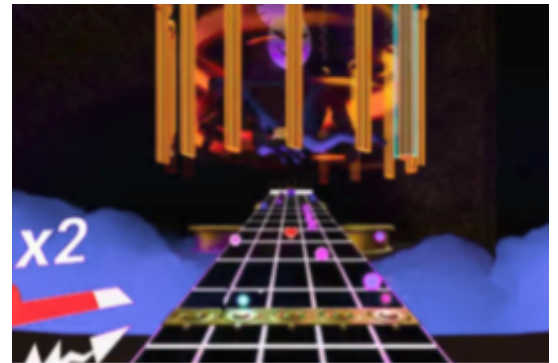


Figure 3: A game of Doldrum being played

research has shown some promise in the form of a new

kind of control. A study was done that was focused on the controllers of music games, wanting to see what made them so enjoyable. Their report showed that people seemed to enjoy controllers more representative of real-world instruments^[7]. For our group, this was an interesting avenue to explore, as it may imply that these kinds of controllers are more enjoyable compared to their more mainstream counterparts, but we ultimately decided not to explore further.

Experimenting with different kinds of controls could be enticing, but we do not possess the resources to create such an experiment. Even as an experiment, designing a rudimentary game around a more realistic controller would be better and ask for user criticisms. Such a design would give us more hands-on experience with what game developers are doing while teaching us more about game design and possibly music design. Another proposed idea was making a game design document for the music game and asking others for their opinion on it. In the end, we decided that such a document may be too abstract for the average person and would not be ideal for data collection. Instead, we decided on a simple experiment to make it more accessible for the average person. Instead of focusing on the controls of a music game, we decided to look into the building blocks of a music game itself.

There are different aspects that a design of a rhythm game can affect a player's experience. On the game mode part, games can be played on a multitude of platforms. In an earlier study, we had observed^[4], that they had experimented with a game named *Cytus*. *Cytus* allows players to enjoy the game everywhere using a portable device. *MaiMai* is an arcade game that focuses more on the interaction between players and machines. This is due to the nature of the arcade game with two machines running the game right next to each other.

Taking the multitude of platforms into account, we decided to settle on a game that could be played on a computer. This allows us to experiment remotely while also being able to experiment with a device that nearly everyone is familiar with.

We noticed that some players might rely on the game music to gain a higher score, while others might pay attention to the pattern of the notes. In the game *A Dance of Fire and Ice*, players can follow the beat in the accompanying music or find the pattern by measuring

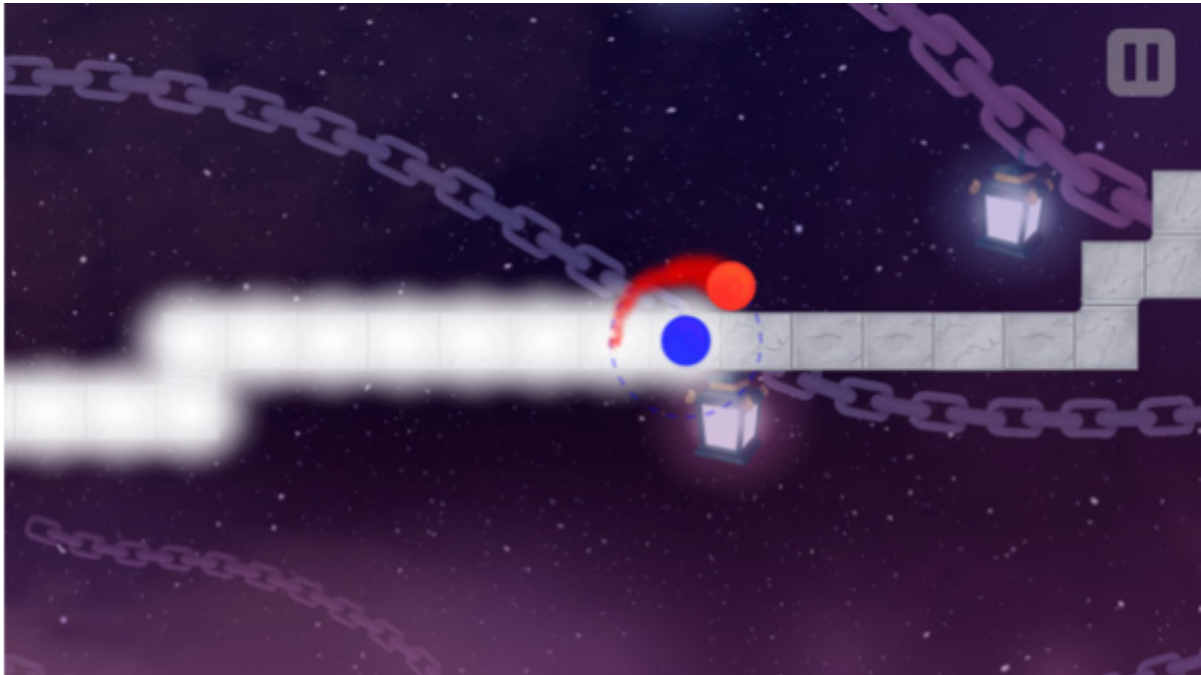


Figure 4: Gameplay of *A Dance of Fire and Ice*

the distance between each note (Figure 4). We had considered using this game to conduct our experiment, but the game itself emphasized keeping on beat with the music, limiting the difficulty we could apply to the game. However, this influenced us to focus on a rhythm game that used a keyboard as a mode of input, as nearly everyone has experience using a keyboard. In the competitive market of rhythm nowadays, it is important to allocate resources among different aspects of the game. Understanding the role of the piece of music can help develop a new popular game. This brought us to our topic: How much can the game music influence the player performance and game experience in a rhythm game?

While rhythm games appear in various shapes, they always have sound cues (game music and feedback sounds) and visual prompts (moving/occurring notes) to aid in accurate note hitting. A research study studying rhythm games' effectiveness in music skill development suggests that rhythm games have no obvious short-term effect on improving rhythm skills^[8]. Another experiment indicates that real-time visual feedback with percussion

rhythm imitation is less effective with timing patterns than with loudness patterns since timing patterns are not easy to learn in a short time^[9]. It is also raised that visual prompts could be distracting when performing imitation tasks. It would only be useful when high-level visual feedback is applied to a low-level performance^[10]. However, contrary to instrumental rhythm imitations, rhythm games rely more on visual prompts since it has no other way of indicating when to hit the note. In the music game player community, it is also raised that sound cues do not necessarily contribute to note-hitting accuracy^[11]. So, it is questionable how different rhythm games and rhythm limitations are regarding note accuracy skills. As a result of that, we want to conduct this experiment to investigate how pure visual feedback rhythm accuracy is compared to accuracy when both visual and sound cues are present.

Methodology

To investigate the note tapping accuracy, we decided to use open-source video games that are easy to learn and provide accuracy after each game. We have considered a couple of games before deciding on *Bemuse*. Of these games, some have overwhelming visual effects (*Musedash*) that could distract players' attention and impair their performance; some have untraditional note patterns (*Dance of Ice and Fire*) that couldn't provide meaningful data in a broader sense. Therefore, we chose *Bemuse*, a Web-based open-source rhythm game. It has notes scrolling down a track, and when it reaches the bottom of the track, the player will hit the note with one of 7 keys accordingly to score.

The score isn't only dependent on whether the player hits but also on how accurate the player hits. The game has a built-in accuracy system that scores each note into five levels: Meticulous, Precise, Good, Offbeat, and Missed. The proportion of each then calculates the score. However, this system doesn't suit the goal of our experiment: simply classifying notes into levels reduces the preciseness of the data. The score also counts the hitting streak, which we have no interest in and will further increase the error.

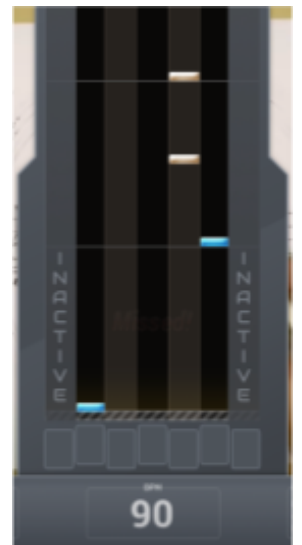


Figure 5: The note highway for Bemuse

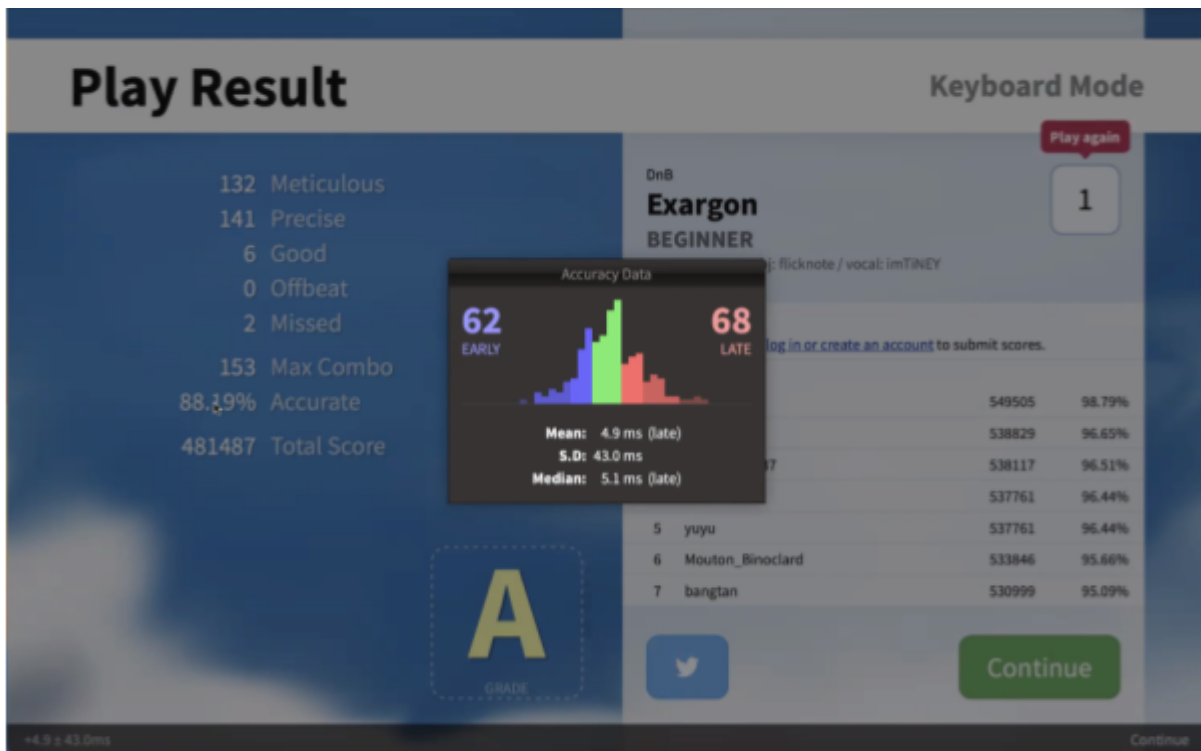


Figure 6: The data screen after a game of Bemuse

We then found that the game also has a built-in standard deviation calculator based on how early or late the player hit each note. There are a couple of advantages of using this value as our data. First, it doesn't count missing notes, which are common when the participants are unfamiliar with the keys to press and when the game is challenging. Excluding missing notes as outliers could improve the preciseness of the standard deviation. Then, it reduces errors caused by computer lag. Since we are experimenting online, the difference between computers can't be controlled. Yet because we only consider the standard deviation, the effect of lags could be overridden. Finally, the standard deviation is easy to analyze, compare and test. Therefore, we chose it to represent accuracy.

However, there is still a drawback to standard deviation. Since it doesn't take into account the mean and median, then in a situation where the player has a preference for constantly clicking a note before or after it arrives, then the error can hardly be captured. So, we are also considering how early/ late the mean/ median is. By analyzing the mean, median, and standard deviation, we could get a comprehensive sense of how accuracy is influenced by the deprivation of music.

As for the participants, we focused on college students aged 18-22 years. One reason is the convenience of recruiting, and the other is maintaining a similar reaction time with

participants. A study by Gottsdanker has shown that age affects reaction time, yet reaction time differences between similar age groups have slight variance (less than 2%) ^[12]. So, considering that our experiment results highly rely on participants' real-time reactions and tapping, this narrow age range does improve the accuracy of experiment results.

Since we had experimented in the summer, we found it difficult to reach out to many participants. Since *bemuse* is web-based, it can be played anywhere using a computer and browser, so we decided to set up a zoom meeting and reach out to the participants online. We also used Google Forms to conduct appointments for the experiment.

As for the procedure, we first let the participants fill out a pre-test survey to collect their information regarding their age, experience with games/ rhythm games, and their experience with music instruments/ music in general. We are collecting these data to see the difference these related factors might make for our experiment data.

Then, the participants are asked to complete a tutorial and one practice song to get used to the controls and become familiar with the keys to press in the following trials. The selected practice song, *Kindly Breeze*, is fairly easy yet includes both note types: short notes and long notes. Long notes must be pressed throughout the duration and released precisely at the end, which could be overlooked in the tutorial. The practice song lets the participants better understand the game mechanisms and thus reduces possible errors caused by mis-hitting.

For the experiment trials, we selected three songs of different speeds, each with two different difficulty levels.

Song	Level	Notes	BPM	Duration(Sec)
<i>Mom</i>	Level 1	117	90	138
	Level 2	155	90	138
<i>OnlyLove</i>	Level 1	67	125	120
	Level 3	271	125	120
<i>Exargon</i>	Level 1	187	170	165
	Level 2	226	170	165

Table 1 Experiment Songs and Levels

Results

Through analysis of our observation data and survey results, we found that the music did influence the player's performance during the gameplay in the 18-23-year-old group. There are a few findings we discovered through analysis of the data:

First, in most cases, participants' performance in the experiment shows that the standard deviation of their note's hit time is usually slightly larger when the game music is off. However, the range of data with and without music is largely-overlapping, especially for the fifth and sixth songs, whose with-music trials have almost the same or even higher standard deviations. This could be influenced by the higher BPM (beat frequency) they have, which could be explored in future experiments with more levels of BPM. Overall, game music's influence on the standard deviation is insignificant. Another finding worth mentioning is that all songs' with and without music trials have similar ranges and standard deviations of standard deviation, which proves that standard deviation is also highly dependent on the song's identity.

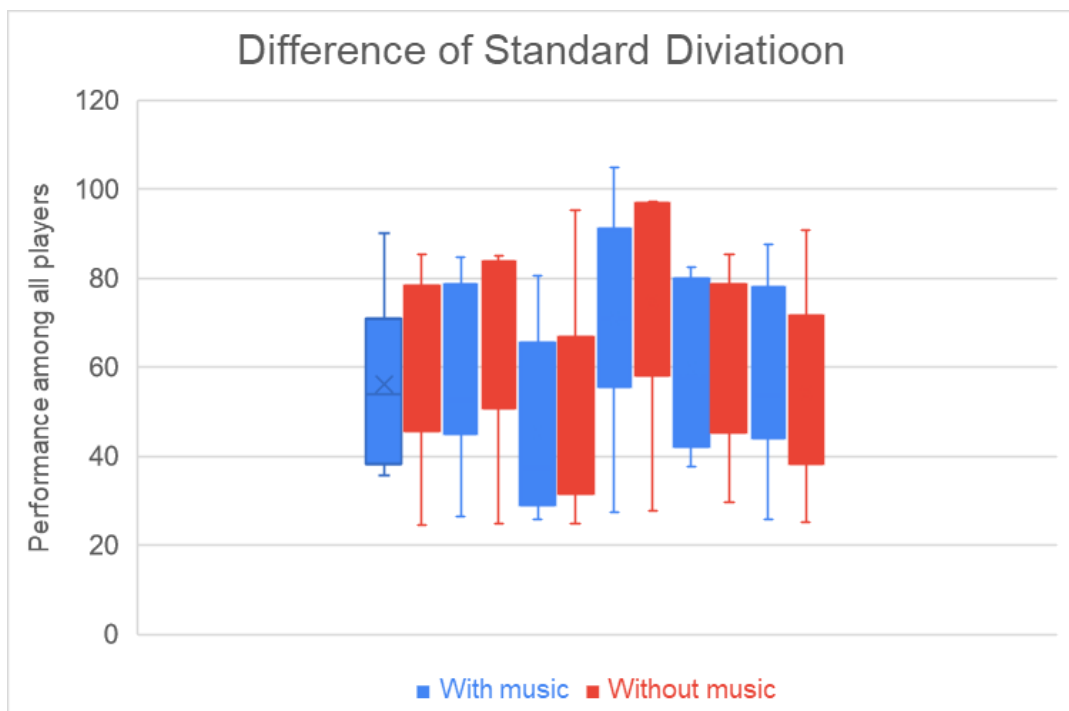


Figure 7 Standard Deviation for Each Song With and Without Music

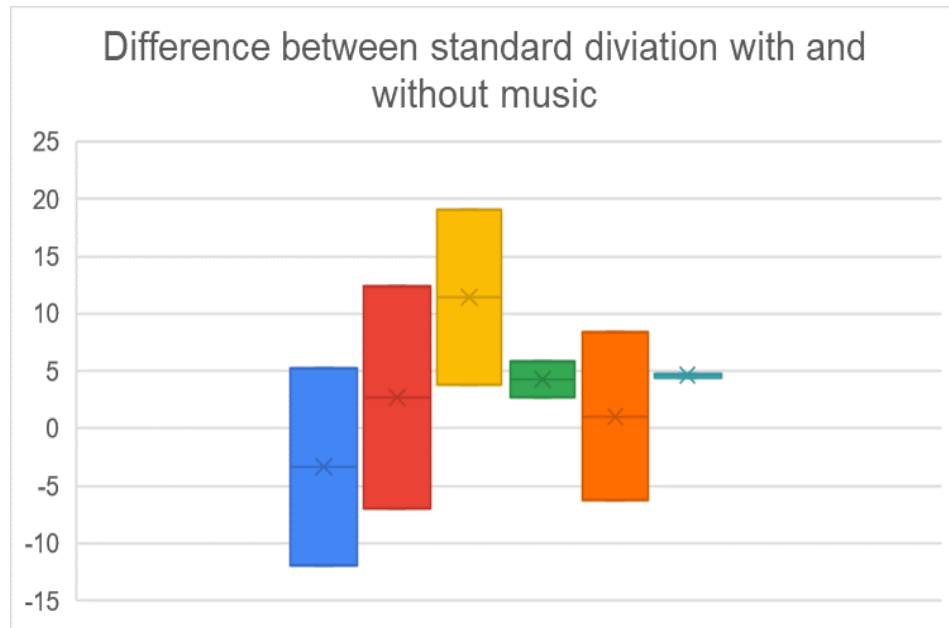


Figure 8 Differences in Standard Deviation Between With and Without Music

Then, in most cases, the mean of hit time from the performance shows that players tend to hit the note early when the music is off. As shown in the graph, there is little overlapping between with and without music ranges. So, there is an obvious link between mean note-hitting time and game music presence.

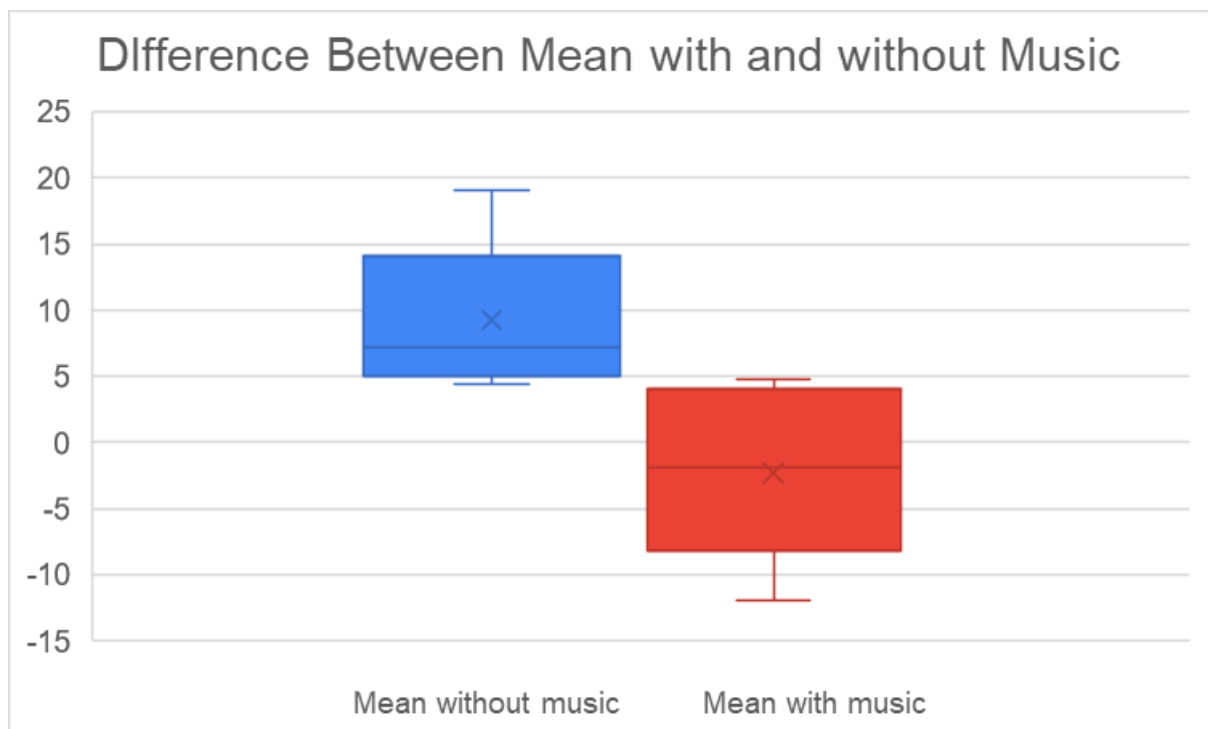


Figure 9 Mean for All Trials With and Without Music

Next, looking at each participant's standard deviation. Except from the fifth one, every participant has a wide range of standard deviations and the fifth participant has a small range standard deviation except from an outlier. From the answers to the pre-questions, the fifth participant is a regular player of rhythm games, and other participants are not. This could lead us to an hypothesis that regularly playing rhythm games could improve the accuracy of note hitting, but further experiment with multiple levels of expertise could better support it.

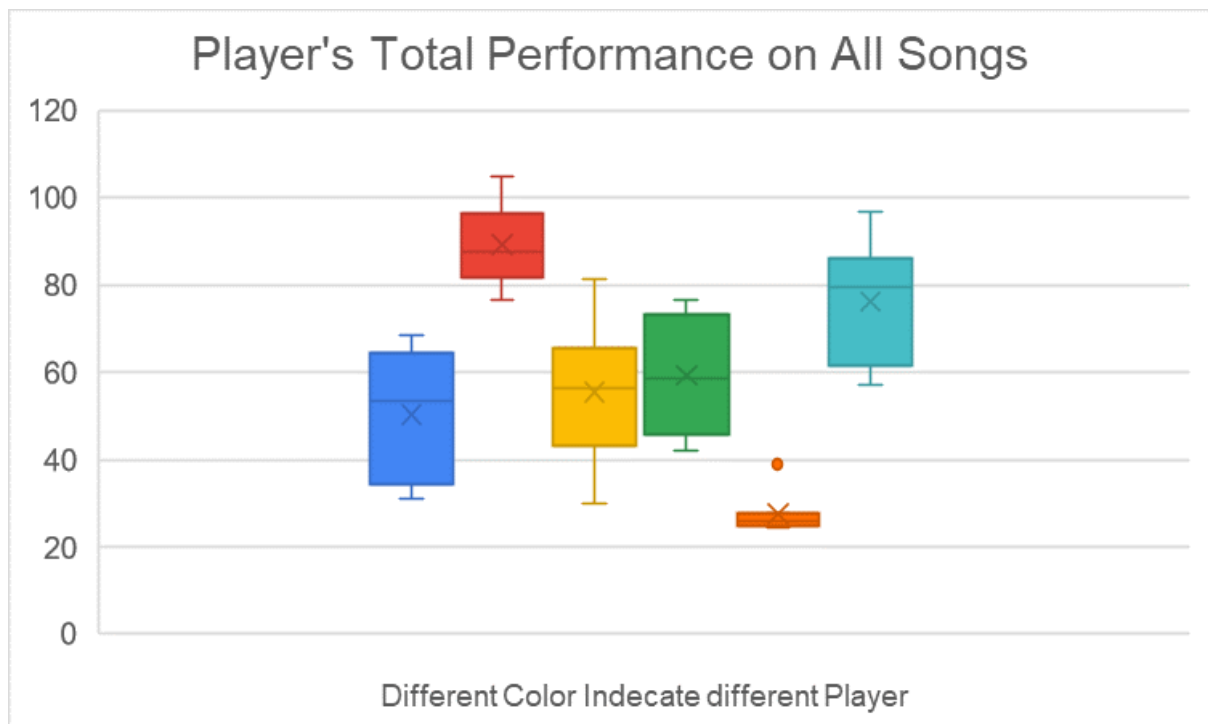


Figure 10 Note-Hitting Standard Deviation of Each Player

Finally, the participants' responses show that players think they can do better without music. And based on the mean data above, it is clear to see that in this game, the music has a negative influence on players' performances. This could be due to the keyboard, PC, and headset lag.

Conclusion

Based on the results, the removal of game music has little influence on the standard deviation yet a significant impact on the mean time shift. This finding isolates the accuracy from preciseness in terms of game music impact. Our hypothesis is that game music helps to predict the hitting point better, canceling their reaction time delay, and therefore makes hittings happen earlier. However, the presence of music does not make note-hitting more precise. The preciseness(standard deviation) depends more on the player's experience and level of difficulty of the song.

Due to a limited participant group, the result of our experiment is still largely arguable. If we could extend our participation, we could recruit with a more diversified population and music-related background and see if it shows similar results.

Meanwhile, there are a couple of variables that we couldn't strictly control. We have separated the with and without music trials for each level, which should prevent the practicing effect that could help participants anticipate the notes. However, since the music trials still precede them, they could still influence the note-hitting accuracy and preciseness. This could be achieved if there is a large number of participants (50 or more) and both their reaction time and skill levels are controlled.

For future rhythm game developers, the balancing of accuracy should reference more to the time shift of the note-hitting. When a player is playing, the game can also gather data for the mean time shift of that player, and automatically adjust note judgement throughout the game.

The results can also be useful for players with hearing defects. The note judging system can be delayed as well to fit their own delayed timing. This can let them better enjoy rhythm games and perform as well as other players.

References

- [1] Yee, A., & Sng, J. (2022). Animal Crossing and COVID-19: A Qualitative Study Examining How Video Games Satisfy Basic Psychological Needs During the Pandemic. *Frontiers in psychology*, 13, 800683. <https://doi.org/10.3389/fpsyg.2022.800683>
- [2] Montgomery, K. C. (2000). Children's Media Culture in the New Millennium: Mapping the Digital Landscape. *The Future of Children*, 10(2), 145. https://link.gale.com/apps/doc/A77875204/AONE?u=mlyn_c_worpoly&sid=bookmark-AONE&xid=030c2451
- [3] Smith, J. (2004). I Can See Tomorrow In Your Dance: A Study of *Dance Dance Revolution* and Music Video Games. *Journal of Popular Music Studies*, 16: 58-84. <https://doi-org.ezpv7-web-p-u01.wpi.edu/10.1111/j.0022-4146.2004.00011.x>
- [4] Song, D. H., Kwang, B. K., & Lee, J. H. (2019). Analysis and evaluation of mobile rhythm games : Game structure and playability. *International Journal of Electrical and Computer Engineering*, 9(6), 5263-5269. <https://doi.org/10.11591/ijece.v9i6.pp5263-5269>
- [5] Octavinus, Pragantha, J., & Andana Haris, D. (2020). Android Rhythm VR Game “Sabeat.” *IOP Conference Series. Materials Science and Engineering*, 1007(1), 12128–. <https://doi.org/10.1088/1757-899X/1007/1/012128>
- [6] Zhang. (2018). *DOLDRUM*. Worcester Polytechnic Institute.
- [7] Wechselberger. (2016). Music Game Enjoyment and Natural Mapping Beyond Intuitiveness. *Security Dialogue*, 47(3), 304–323. <https://doi.org/10.1177/1046878116651024>
- [8] Richardson, P., & Kim, Y. (2011). Beyond Fun and Games: A Framework for Quantifying Music Skill Developments from Video Game Play. *Journal of New Music Research*, 40(4), 277–291. doi:10.1080/09298215.2011.565350

- [9] Sadakata, M., Hoppe, D., Brandmeyer, A., Timmers, R., & Desain, P. (2008). Real-time visual feedback for learning to perform short rhythms with expressive variations in timing and loudness. *Journal of New Music Research*, 37(3), 207–220
- [10] Brandmeyer, A., Timmers, R., Sadakata, M., & Desain, P. (2010). Learning expressive percussion performance under different visual feedback conditions. *Psychological Research*, 75(2), 107–121. doi:10.1007/s00426-010-0291-6
- [11] Hot take: The problem with "rhythm" games. *Reddit.com*. (2022). Retrieved 27 June 2022, from https://www.reddit.com/r/rhythmgames/comments/o28hl8/hot_take_the_problem_with_rhythm_games/.
- [12] Gottsdanker, R. (1982). Age and Simple Reaction Time. *Journal of Gerontology*, 37(3), 342–348. doi:10.1093/geronj/37.3.342

Appendix

Appendix 1: Experiment Questions

Pre-Questions

1. What age are you?
2. Do you have any experience with playing an instrument, and if so for how long?
3. Do you have any experience with composing music, and if so for how long?
4. How often would you say that you play video games?
5. How often would you say that you play video games based on rhythm specifically?
6. How do you think you master rhythm games, generally?
7. Have you played Bemuse?

Post-Questions

1. What were your first impressions of the game you just played?
2. Do you feel that you played the game to the best of your ability?
 - a. If not, what makes you say so?
3. How did the music, or lack thereof, impact your ability to play?
4. On a scale from 1-10 how well do you think you did on the game?
5. Do you feel that you would be able to complete this game without the music?

Appendix 2: Experiment Question Answers

Pre Questions:

Post Questions:

What were your first impressions of the game you just played?

It was pretty difficult for me to read the music at first, but eventually I started to get comfortable with the input.
harder than normal

notes are not in the beat

Good. I need more practice.

bad

Not appropriate to me, since I never played music game with keys more than 2.

Do you feel that you played the game to the best of your ability?

Yes

Yes

No

No

No

Yes

If no, what makes you say so?

notes are NOT in the beat!!!!!!!!!!!!!!

I need more practice.

I don't think I can use that ability anywhere in real life

How did the music, or lack thereof, impact your ability to play?

Because these weren't very complex maps, if I was able to correctly read the map, the timing was not very difficult, even without music.

I will not be affected by my mistakes, and it's harder to catch the rhythm makes performance better

Maybe music can help me get the rhythm.

I think the music in this game negatively affect me that make me unfocus.

7-keys game requires my brain to process much information, but observing only by eyes is limited. Without the help from music, it's hard to play.

On a scale from 1-10 how well do you think you did on the game with music?

4

7

5

6

3

4

H

On a scale from 1-10 how well do you think you did on the game without music?

5

8

6

6

7

2

Do you feel that you would be able to complete this game without the music?

I don't think that I would make very much progress trying to learn harder maps without music

Yes

Yes

Yes

No

Do you have any experience with playing an instrument, and if so for how long?

Played piano for about 8 years (not recently)

Yes, and I have played it for 4 years

No

Yes

NA

Yes. Piano for 6 yrs

Do you have any experience with composing music, and if so for how long?

Very little experience with composing

No

No

no

NA

Yes, for 3 yrs

How often would you say that you play video games?

Several hours a day if time allows

Averagely 3 to 5 hours a day

10 years

not that many times

twice a month

At least 10 hours per week

How often would you say that you play video games based on rhythm specifically?

Around an hour a day

Averagely less than 1 hour a week

6 hours a day

not that many times

rarely

At most one hour per week

How do you think you master rhythm games, generally?

Practicing to get comfortable with the rhythm of a given song

I do it through practice for dozen of times

kind of good

IDK

I am good at only one rhythm game, which takes a long time to master at.

Not too good.

Have you played Bemuse?	What age are you?
No	21
No	18
No	21
No	21
No	22
No	21

Appendix 3: Procedure and Questionnaires

Consent form:

<https://forms.gle/icn97QeP19afrVgz5>

https://docs.google.com/document/d/130HR5QpUk0eMk075yEld8Fty0TKk2jn_QeMrSM687To/edit?usp=sharing

Pre-questions:

<https://forms.gle/8epfvGUuYySFBFBg8>

Game:

<https://bemuse.ninja/>

Instruction: I will first let you play the tutorial and a song for practice, and then a few songs for the actual experiment. I won't give any instruction during games, but don't hesitate to ask any questions during the experiment.

After each game, I need you to stay on the result board and click on the accuracy percentage, then we will record the data for you. We will let you know when to proceed.

Tutorial as tutorial

Kindly breeze as practice

with BGM

1. Mom Level 1:Notes 117, BPM 90, Duration 138 seconds
2. Mom level 2: Notes 155, BPM 90, Duration 138 seconds
3. Only Love Level 1(third):Notes 67, BPM 125, Duration 120 seconds
4. Only Love Level 3:Notes 271, BPM 125, Duration 120 seconds
5. Exargon Level 1(first):Notes 187, BPM 170, Duration 165 seconds
6. Exargon level 1(second): Notes 226, BPM 170, Duration 165 seconds

without BGM

7. Mom Level 1:Notes 117, BPM 90, Duration 138 seconds
8. Mom level 2: Notes 155, BPM 90, Duration 138 seconds
9. Only Love Level 1(third):Notes 67, BPM 125, Duration 120 seconds
10. Only Love Level 3:Notes 271, BPM 125, Duration 120 seconds
11. Exargon Level 1(first):Notes 187, BPM 170, Duration 165 seconds
12. Exargon level 1(second): Notes 226, BPM 170, Duration 165 seconds

Post-questions:

<https://forms.gle/GHUQiud3kMBJi7Ee9>

Total time approximation: 40-55 mins