Figure 1: League of Legends logo.

EmpaLeague:
How Music Can Affect Stress Levels While Playing League of Legends

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Abstract
Video games and the eSports (electronic Sports) scene are beginning to become more and more popular with games like League of Legends and Fortnite. I contemplated how affect could relate to games like these. I examine in this study how affective music could have an affect on a player's heart rate (from now on HR) and thus an effect on the user's stress levels. With the usage of Empatica's E4 wristband, and an Android application I set out to do just this. My results show that there is a relationship between music and a person's heart rate during a stressful gaming session. As the e-Sport's scene continues to grow and grow I believe we will need more studies like this one to help us understand the relationship between games and affect.

Introduction
The e-sports scene continues to grow [1], as more exciting games are developed and released there will be greater and greater advances in video game technology. Games that have a competitive scene tend to be more popular because like conventional sports, games that have a popular eSports scene have very strong supporters(fans) within the community who root for their favorite teams and players. One such game which I previously mentioned is the most popular MOBA (Multiplayer Online Battle Arena) world-wide, League of Legends. With tens of millions of players logging in monthly to play League of Legends (from now on LOL), it surpasses any other game so far in viewership and player count. Many video games today are already experimenting with human affect and how a game can have an effect on human emotion, as well as, how human affect can be used to change the properties of a game. However, there is a sever lack of research involving this absolutely massive game.

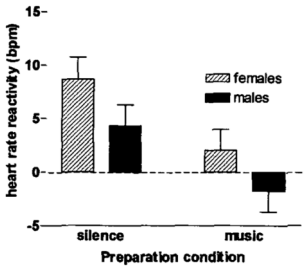

Figure 2: This graph taken from the study by Knight and Pickard's study shows the bpm of both the male and female participants in the control vs the experiment[1].

Research involving LOL tends to lean toward the massive growth of its eSports scene, and there is virtually no research conducted related to the game and human affect or human emotion.

In this paper I present EmpaLeague a system that seeks to test how music affects a person's heart rate and thus their stress level, while playing LOL.

Related Work

I look at human affect and heart rate in response to an affective stimulus which, in the case of this study, is music. There are a number of studies involving music and its correlation with human emotion, physical conditions, and the one focused on in this study, heart rate. The ideas and studies around how music affects human emotion are mainly rooted in psychology

Humans have tried for a long time to understand the inner workings of our own being including how we think and why we believe the things we do. There are numerous factors that have a lasting and impactful affect on ourselves and our states of being and mindset such as . Some of these things we are consciously aware of but some are more subconsciously affecting us and our state. Music is one of the things that implicitly has an affect on our being.

More specifically relaxing music has been shown to have a positive "psychological effect on the human body" [3]. As most know heart rate (HR) varies depending on what kind of situation someone is in, and more often than not when one is in a tense situation where one experiences anxiety or stress the HR tends to increase. Thus anxiety and stress directly affect the beats per minute(BPM) of the heart [3].

In the medical field there are many current studies pertaining to "relaxing" music, and how it can produce a positive effect on a patient's stress and anxiety. So this begs the question: What happens when you combine a stressful situation with relaxing music? Will the music aide the user in becoming less stressed than they normally would be without the music?

This is precisely the problem that Wendy Knight and Nikki Pickard set out to solve in their study [1]. There study consisted of 84 participants who were asked to prepare for an oral presentation "either in silence and or in the presence of Canon in D major by Pachelbel" [1]. The results of the study, some of which shown in Figure 1, showed that in the presence of music, while preparing the oral presentation, participants were significantly positively impacted. Both male and female participants heart rate and anxiety levels were significantly lowered when preparing for the oral exam with the music as apposed to without [1].

The study by Knight and Pickard shows the significance that music plays in influencing the human HR, and it also aligns with the study done by Tan et al. that showed the heart rate and HR variability is impacted by music in general [3]. It also The study served as a major inspiration for this paper and the reason that Canon in D major was chosen as the affective music used in this study. Knight's study inspired me to test how we could could potentially use affective music to help League of legends players remain calm and reduce anxiety levels while playing the game.

Figure 3: Empatica's E4 wristband used to measure heart rate

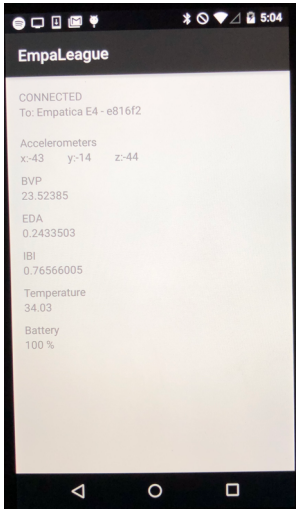

Figure 4: A picture of the EmpaLeague application running on a Nexus 5.

Methodology

Based on the previous study mentioned by Knight and Pickard I created a system to test if relaxing music could lower the heart rate and thus the anxiety level of a participant playing the game league of legends.

The system consisted of three fundamental parts: an android application based on the sample project provided on Empatica's website, the Empatica E4 wristband (pictured left in Figure 2) used to measure the HR values of the participants, and a setup where the participant could play League of Legends comfortably. The overarching goal was to detect an increase in the participant's HR and trigger the play of Canon in D major by Pachelbel in order to try and decrease the HR.

Preparation and Experimentation

Participants were read a script briefly explaining what they were going to be participating in on the day of the experiment and that the only information that would be gathered was: HR values and the response to the qualitative survey given after the game sessions. The survey was only for gathering qualitative data and made the use of a 1-5 Likert scale.

Participants were asked to play two games of LOL. They were instructed before the first game to play normally and try their best to "win". The participants were also asked to play the same "role" as well as the same character for both of the games so as to try and keep the games somewhat consistent and minimize variability between games. The participants consisted of those who were already familiar with the game and how to play, so no instruction regarding playing other than the ones already mentioned were given.

While the participant was loading into each game they were instructed to turn the Empatica E4 wristband on. The reason behind starting the application and wristband before they got into game was so the device could gather the proper values in order to calculate an accurate resting HR. When the participant finished the game they were given a 10-minute break, this was to try and get their HR back to a resting one.

In preparation for the second game the participants were told that during the game, a song would be played on an increase in HR, and that this was planned so they should continue to play normally.

Data Collection Process & HR Increase Calculation

The HR values were collected with an android application run on a Nexus 5 (pictured left in Figure 3). The E4 streamed the data to the android application and on disconnect of the device all the values were written to a text file on the SD card.

An increase was detected with the use of a threshold. The threshold was calculated as an 12% increase to the simple moving average (SMA) value, which was calculated from a collection of 15 HR values received from the E4. The SMA was calculated every time the device received a new HR value from the E4. If the SMA was ever greater than the threshold, this was considered as an increase in the HR of the participant. This increase is what triggered the start of the music which aimed to slow the user's heart rate.

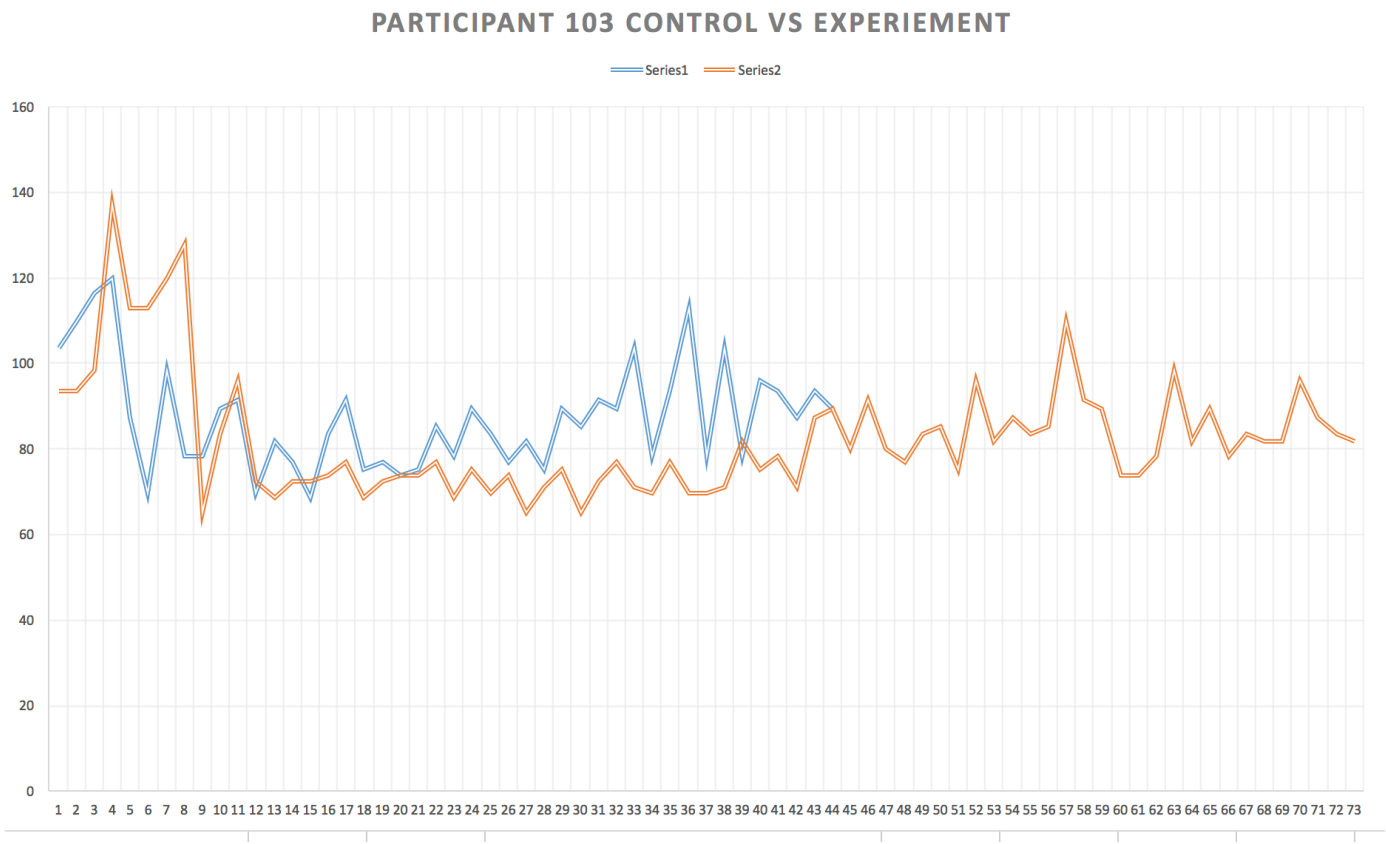

Figure 5: This graph helps to visualize the difference the music had on the participant's hear rate during the game. Series 1 is the participant's HR during the control both series are at points in the game where the application detected an increase in the participant's HR. The only difference is that Series 1 did not have music and Series 2 did have music.

Results

The result of my statistical analysis resulted in a significant p-value ($p<0.05$) in both of my participants. The graph above (Figure 4) will hopefully aide in understanding the impact that the song had during the experiment. Figure 4 shows the HR values for Participant 103. The blue Series is the control test and the orange series is the experiment. The Control had no

	Variable 1	*Variable 2*
Mean	87.51231768	82.65564147
Variance	157.2932192	205.4392424
Observations	44	73
Pooled Variance	187.4368164	
Hypothesized Mean Difference	0	
df	115	
t Stat	1.858688187	
P(T<=t) one-tail	0.032814065	
t Critical one-tail	1.65821183	
P(T<=t) two-tail	0.06562813	
t Critical two-tail	1.980807541	

Figure 6: Pictured is the results of the t-test for participant 103.

	Variable 1	*Variable 2*
Mean	101.5959592	94.27785172
Variance	235.2773322	350.5514433
Observations	130	152
Pooled Variance	297.4430136	
Hypothesized Mean Difference	0	
df	280	
t Stat	3.551941564	
P(T<=t) one-tail	0.00022426	
t Critical one-tail	1.650313819	
P(T<=t) two-tail	0.00044852	
t Critical two-tail	1.9684725	

Figure 7: Pictured is the results of the t-test for participant 102.

music while the experiment did. In both moments that these HR values were collected the participant was experiencing an increase in HR which indicated a stressful/tense moment during the game session.

Unfortunately, I was only able to gather data from two participants who were both male, however after running a paired t-test on both of their data sets I found a significant p-value for both. The data that I used from both participants was the set of HR values during a stressful/tense moment in the game where their HR increased enough to trigger song play. However, during the control, the song **was not** played while during the experiment game the song **was** played.

The results of the t-test can be seen on the left (Figure 5 & 6). I believe both were significant with participant 102 having a p-value of 0.001 and participant 103 a value of 0.03.

Additionally, the qualitative survey resulted in a good view of how the music choice was received with both participants agreeing that the song in question was indeed describable as "relaxing".

Discussion

In this section I will talk about some of the choices I made in designing the study and explain, to my best ability, why I made the choice I did. Furthermore, I will go into detail on some of the potential changes I would make to the study in the subsection: Future Work.

Threshold Calculation

Starting off, why did I go with a 12% increase in HR to calculate the threshold? This is because of the accuracy of the E4 wristband and the knowledge I gained from the pilot study. I noticed during experimentation with the E4 device, that the value received was sometimes higher than what it actually was.

Initially I had a 10% increase in mind, this is because it is the value usually used as a standard "significant increase" in someone's normal resting heart rate. After doing some pilot testing I believed that a 10% increase would be too sensitive a value and was concerned that the system would not work as intended, and thus I upped the percentage to 15%. After further pilot testing the system seemed to be working as intended. However, I had the participant during the pilot study manually increase their heart rate through physical activity, such as running or jumping. This proved to be a problem during initial testing because the participant's HR did not increase as much as it did during the pilot study where the participant performed some act of physical exertion. This is why I settled on a 12% increase.

Future work

In terms of running the experiment again I think I would make a number of substantial changes that would lead to better results.

Firstly, I would like to try a different device for gathering the HR values because I believe a more accurate medical device would provide better results and more accurate data.

Secondly, I believe my decision to only play the "relaxing music" during a stressful moment during the game session was the wrong choice. I believe I should have played the song either the entire time during the

game or opted to play multiple songs over the length of the experiment.

Finally, as far as potential applications of the system and ideas presented in this study, I believe there is an enormous amount of progress to be made in relation to the field of Human affect and video games. I think that music is a large part of human emotion and is a strong influencer of it. Future studies like this one need to take the music into consideration because of this very reason. Music is too impactful on human affect to be ignored. Especially in the field of video games, every single game has at least one if not many different pieces of music within it. This study can be beneficial as a building block for future experiments that are similar.

Conclusion

The creation of EmpaLeague allowed me to see whether or not affective music could positively affect someone playing League of Legends and I was satisfied with the results and product that I created. I am excited to hopefully see more research around such a popular game like League of Legends, as well as many like it, and in the area of HCI (human computer interaction). I know both will continue to progress and grow into truly great research subjects. I hope this study might inspire others to participate in studies involving their own personal favorite games and areas of HCI.

References

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