An Analysis of the Influence of Background Music on the Sustained Attention of College Students using the Sustained Attention to Response Task (SART)

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Abstract

Aims: In order to better understand the way in which background music influences cognitive states such as sustained attention, this study set out to examine attentional states during the sustained attention to response task (SART) between music present and music absent conditions. This study aimed to expand on the current research of the influence of background music on attention, as the existing findings have conflicting evidence that supports both sides of the argument of whether or not background music improves attention. The final aim of this study was to investigate the range of the inverted U curve of attention and arousal in the context of the SART. It was hypothesized that an effect will be seen in the music present condition in some capacity. **Method:** The SART was completed by all of the participants (*n*= 30) in both music present and music absent conditions. Differences in reaction time (RT), number of errors, as well as difficulty, and interest in the task were measured between conditions, age, and gender. **Results:** The main finding in this study indicated a significant difference in the number of errors made between conditions as fewer errors were made in the SART during the music present condition when compared to the music absent condition. Investigations into differences in RT, difficulty, and interest between conditions did not yield significant results. Additionally, a relationship between RT and the number of errors between gender and age did not result in a significant finding. **Conclusion:** The findings from this study indicate that background music may have a positive influence on attention as it reduced the number of errors made by participants in the sustained attention task.

Contents

Introduction

The topic of attention has been widely discussed in philosophy as well as garnering a wide base of research on the topic within cognitive psychology and cognitive neuroscience (Andrade & Walker, 2020). The aim of this particular literature review will look at variables that may influence attention with a specific focus on background noise and background music as well as to evaluate the current state of the research surrounding the topic. It is expected that this review will provide a fresh outlook on the attention research that is relevant in the field of psychology today and identify the existing gaps in the research. This paper will include a discussion of the history as well as how the topic of attention research has evolved throughout the years. The theories and implications of attention research will also be discussed in this review as well as in the context of research of the presence and absence of background music. As well as this, an in-depth analysis of the existing research will be conducted and examined under a critical lens in order to design a research study that attempts to address some of the issues that have been brought up in past studies.

Attention

According to Mounts (2012), research into attention first began when Henry Titchener named attention as a core field within psychology and noted by Geissler that no area of psychological experimentation is left untouched by the factor of attention making it an important topic to research (Lindsay, 2020). Attention itself carries multiple definitions in the context of psychology, however, one of the first explanations of attention came from philosopher and psychologist William James in his 1890 book on the principles of psychology. James (1890) described attention as “the taking of possession by the mind, in clear and vivid form of one out of what seems several simultaneously possible objects or trains of thought” (p. 403-404). Other definitions have attempted to further capture a more precise description of attention, one such being made by Anderson (2009) who defined it as

the accurate allocation of limited cognitive resources. James (1890) also noted in his book that everyone knows what attention is and has experienced it in some form. However, Hommel et al., (2019) challenged this statement and noted that it was quite the opposite in that no one knows what attention is and argued that the term "attention" is a term in cognitive science that is misleading and should be replaced with a focus on process mechanisms which have an effect on task performance.

It is reported that the main components of attention are sustained, selective, alternating, and divided attention, however, this paper is only concerned with sustained attention as well as the mechanisms that can have an effect on it (Commodari, 2017; Fortenbaugh et al., 2018; Hahn et al., 2008). The term sustained attention refers to a state of attention, alertness, and vigilance that is maintained over a period of time (Zanto & Gazzaley, 2019). A wide array of cognitive processes make it possible for an individual to sustain their attention (Esterman & Rothlein, 2019). This type of attention has been linked to the anterior insula/operculum, thalamus as well as dorsal anterior cingulate cortex which combine to create the cingulo-opercular network (Esterman & Rothlein, 2019; Sadghiani & D'Esposito, 2015). It has also been associated with activations of both frontal and parietal cortical locations in the brain particularly in the right hemisphere (Sarter et al., 2001). According to both Zanto & Gazzaley (2019) and Esterman & Rothlein (2019), additional research into the neuroanatomy associated with sustained attention needs to be conducted in order to acquire a further understanding of attention overall.

Measuring sustained attention

When it comes to measuring sustained attention the most straight forward way is to observe and measure fluctuations of attention through response times during continuous performance task focus activities (Esterman & Rothlein, 2019). One task focus activity for measuring sustained attention is the psychomotor vigilance task (PVT) popularised by David

F. Dinges for the main purpose of being used in sleep studies however, in recent years it has been used as a measurement of sustained attention (Sinclair et al., 2013). The PVT, although can be an accurate measure of sustained attention, can be considered an impractical method in applied contexts as it has a duration of 10 minutes (Basner et al., 2011). This is an important note as it has been reported that the longer a participant sustains their attention, the more attention slips occur (Basner et al., 2011). Shorter PVT's have been created such as the 90-second and the 2-minute version, however it has been noted that these versions are too insensitive to be accurate (Basner et al. 2011).

For this reason, this study aims to utilize the sustained attention to response task (SART). The SART was developed in 1997 by Robertson et al. to measure sustained attention and is also used in sleep studies (Chan et al., 2004; Gool et al., 2020). It is a task run on a computer that accurately measures response time to a sequence of frequent stimuli (Peebles & Bothell, 2004). The task has a duration of 4 minutes and requires the participant to press the spacebar when a number from 0-9 appears on the screen but refrain from pressing the spacebar when the number 3 appears on the screen (Gool et al., 2020). Past research has shown that the SART has been successful at uncovering lower-than-average activity cingulo-opercular network as well as frontoparietal activity in those with sleep disorders that can impair their ability to sustain their attention (Gool et al., 2020). However, there has been a study declaring that the SART does not measure sustained attention but is more likely to measure motor control or response strategy as the participant relies on the speed at which they can make the decision to press the spacebar or not depending on the stimuli however, the same could be said for the psychomotor vigilance task (Mensen et al., 2021).

Inverted U curve of arousal and performance

The relationship between arousal and performance on a graph can be described as an inverted U curve indicating that too much or too little arousal leads to poor performance and

there is a “sweet spot” when it comes to the level of stimulation required for peak performance during a task (Kiss & Linnell, 2021; Unsworth & Robinson, 2018). However, in the context of this information, some studies have used the low-arousing psychomotor vigilance task when investigating the influence of music on sustained attention which may imitate the monotony of real-life tasks to optimize the effect of the presence of music (Kiss & Linnell, 2021). However, it could be said that the psychomotor vigilance task is too little stimulation to yield promising and reliable results that accurately represent the “sweet spot” for stimulation required for optimal performance. This, as well as previous critique of the task, is why many other studies have used other means to measure attention such as the flanker task, attention network test, and the Chu attention test (Cloutier et al., 2021; Fernandez et al., 2020; Mensen et al., 2022; Shih et al., 2012). However, there is yet to be a study using the SART when investigating the effects of music on sustained attention to the knowledge of the researcher.

Background music and sustained attention

When examining sustained attention, the factors that may cause deficits, or improvements in both arousal, mind wandering, and motivation should be discussed. As well as attentional deficits, many other factors can influence levels of sustained attention such as age, motivation, and the presence of background music (Kiss & Linnell, 2021; Zanto & Gazzaley, 2019) which is the focus of this study. Kiss and Linnell (2021) have noted that researching the topic of the effects of background music on attention has important theoretical and practical implications for expanding knowledge in both the basis of attentional function as well as the real-life circumstances in which listening to background music may be beneficial to attentional performance. Many studies have investigated the possible influence of music on sustained attention however there has been conflicting results on the matter (Cloutier et al., 2020; Kiss & Linnell, 2021).

Some studies provide evidence for a positive outcome on attention where music is involved such as enhancing the processes of selective attention (Fernandez et al., 2020), enhancing sustained attention (Kiss & Linnell, 2021), music without lyrics improving worker productivity and attention performance (Shih et al., 2012), improving attention control in children (Kasuya-Ueba et al., 2020), as well as improving attention during monotonous tasks (Ünal et al., 2013). Some studies have also seen negative effects on attention tasks in the presence of any noise (Nadon et al., 2021) as well as the presence of music reportedly hindering cognitive processes such as attentional control performance in older and younger adults (Cloutier et al., 2020). Other studies have reported that the presence of music has little to no influence on attention (Brodsky & Slor, 2013; Cloutier et al., 2020, Fernandez et al., 2020). However, these results may be influenced by a myriad of confounding variables such as the type of music played, if the music contains lyrics, if it is the preferred music of the participant or even the age of the participants themselves which result in a negative or positive effect observed.

Studies have shown that the type of music that participants listen to while completing attention tasks has an effect on participant performance (Kiss & Linnell, 2021). A number of studies chose classical music or music without lyrics for their participants to listen to for simplicity and the idea that music with lyrics may be a distraction and cause a deficit in attentional performance tasks (Buckhard et al., 2018; Cloutier et al., 2020; Shih et al., 2012). However, it has also been said that music that is familiar to the participants has been shown in the past to have a strong and positive correlation between participant pleasure, arousal, and less mind wandering in comparison to music that is not familiar to the participants (Cloutier et al., 2020; Kiss & Linnell, 2021; van der Bosch et al., 2013). Therefore, allowing participants to listen to their preferred music during an attention task may be of benefit to a study in producing more reliable results rather than a distraction.

Kiss and Linnell (2021) took the type of music into account when conducting their study and required their participants to choose their own preferred background music when performing the PVT. The results from this study reveal that in low-demanding attention tasks, there was a decrease in mind-wandering states as well as an increase in task focus but it did not have an effect on the response times (Kiss & Linnell, 2021). However, results seen in a condition of chosen classical background music in the higher demanding attentional task such as the flanker task, present a slower reaction time (RT) in comparison to silence, possibly indicating that the levels of arousal are too high for peak performance in the task to occur (Cloutier et al., 2020). It was recommended by Kiss and Linnell (2021) that a task demanding more attention such as the SART, should be investigated under music-present and music-absent conditions in order to investigate the full range of the attention-performance inverted-U curve.

Other factors influencing attention

As well as the type of music the participants listened to, the age and number of participants recruited in the studies also seemed to make a difference in outcomes. When participants were between the ages of 20 and 30, results found no positive or negative effect on the presence of music on attentional states (Burkhard et al., 2018); however, in a more recent study where participants were in a similar age range (between 19 and 32), a positive effect was found in the participant performance on an attention task (Kiss & Linnell, 2021). The results between these similar studies may differ due to the differences in which attention was measured. Burkhard et al. (2018) measured attention using a visual continuous performance task (VCPT) which lasted for 60 minutes and required the participants to press a button when two pictures matched, however, the study by Kiss and Linnell (2020) used the previously discussed PVT which lasted approximately 12 minutes overall which requires participants to press a mouse button as soon as they see the hand of a clock moving. As stated

previously, the longer an individual has to hold their attention on a specific task, the higher the frequency of attentional slips that occur (Basner et al., 2011). A study by Cloutier et al. (2020) also looked at attentional control in both younger and older adults in the presence of background music and also found that music impaired performance in an attention task but the results did not differ on age. However, older adults reported the chosen classical music to be more pleasing than younger participants which could have possibly had an effect on the arousal of the younger participants leading to poor performance on the attention task (Cloutier et al., 2020). Yet a study by Callaghan et al. (2017), contradicts this as less attentional errors should be seen in younger adults overall as more time is required for older adults to narrow their attentional focus.

On the topic of a relationship between gender and attentional states, some studies have stated that in the presence of music, there is a difference between genders. An older study conducted by Jing et al. (2012) states that during complex cognitive tasks on perception and spatial reasoning, male participants made more errors than female participants when rock music was playing. However, a study conducted in 2001 by Chan, indicated no differences at all in scores on the SART between age, gender or level of education. These results may have differed due to different measures, while Jing et al. (2012) used perception and spatial reasoning tasks, Chan (2001) used the SART. Recent research on gender and attention is very limited which presents a gap to be filled within the literature.

This Present Study

The current state of the literature shows a lack of consensus on the possible influence that music has on attentional states. One point that all of the studies mentioned is that more research in the area is needed in order to expand the knowledge of cognitive processes involved in attention. Where the studies differ, however, is the inconsistency and a lack of a result that concludes the question of a possible correlation between music and heightened

attentional states. The inconsistent and conflicting results across studies on the possible effect of music on sustained attention make it difficult to conclude whether or not background music has an effect at all on attention tasks. This study will follow the recommendations for future research and investigate the effects of background music on sustained attention in college students by using the SART and allowing participants to choose their own music to account for personal preference in attempts to help come to a conclusion on the matter.

Apropos to the previous research on this topic, the following is a list of the research questions and hypotheses for this current study.

Research question 1: Will RT differ between the conditions? Hypothesised outcome for research question 1: RT will differ between the conditions wherein RT will be faster for those in the music present condition.

Research question 2: Is there a difference in the frequency of errors made by participants between the conditions? Hypothesised outcome for research question 2: A higher frequency of errors will be observed in the music absent condition and fewer errors will be observed in the music present condition.

Research question 3: Is there a difference in participant perceived difficulty and interest in the task between conditions? Hypothesised outcome for research question 3: Lower perceptions of difficulty and higher levels if interest will be seen in the music present condition.

Research question 4: Will age be related to slower RT and a higher frequency of errors? Hypothesised outcome for research question 3: RT and frequency of errors will have a correlation to age.

Research question 5: Will gender be related to RT and a higher frequency of errors?

Hypothesised outcome for research question 4: RT and frequency of attentional slips will not correlate to gender.

Methods

Participants

The sample used in this research study consisted of 30 participants (females= 21, males= 9). The age of the participants ranged from 18–43 years old (*M*= 23, *SD*= 7.42). All of the participants completed the SART in both music present and music absent conditions. A webpage including details of the study was shared through links the social media sites WhatsApp, Instagram, and Snapchat. As well as this, the webpage was also accessible by scanning a QR code on the recruitment posters that were placed around the National College of Ireland (NCI) college campus with their mobile device. Placing the posters on the NCI college campus ensured that the majority of individuals who saw the posters were likely to be the desired population of college students while the social media post was shared online and promoted to advertise to college students. Participants were urged to share the details of the study with other college students utilizing a snowball sampling technique.

As this research was conducted under the Psychological Society of Ireland's code of ethical guidelines as well as NCI Ethical guidelines and procedures, participants were required to be at least 18 years of age in order to participate in the study. Informed consent was required from the participants prior to the commencement of the tests by signing a consent form. Demographics such as gender and age were required for this study and were provided by the participants after providing informed consent. The exclusion criteria for this study require individuals with attentional disorders and sleep disorders to refrain from participating in the study as it may affect their attentional performance during the study as well as affect or skew the final results.

Measures

Demographics. Participants were asked to state their gender by choosing from a dropdown list of the options male and female. As well as this, participants were asked to provide their age by typing it onto the demographics form (see Appendix 1 for further detail).

Preferred background music. Participants were required to create a 6- minute playlist on their phone of their preferred background music to listen to during the music present condition of the study. No restrictions were set on the type of music that the participants could choose and it was not required of the participants to share the playlist with the researcher however using earphones during the task was optional.

Psychology Lab. Psychology Lab 2 within NCI was used to test participants. It was booked using a link provided by the supervisor of this study based on the availability of participants. This slot could be easily rescheduled or cancelled based on the participant's request. Within the room were two desks, three chairs, and the laptop used for the study.

Sustained Attention to Response Task. The Sustained attention to response task (SART) is a sustained attention test conducted on a computer (Chan et al., 2004; Robertson et al., 1997). This task was accessed through Millisecond by Inquisit (see Appendix 2). Participants are required to press the spacebar on the keyboard every time they see a number from 1-9 with the exception of the number 3 where the participants are asked to refrain from pressing the space bar (Chan et al., 2004; Cheyne et al., 2009; Robertson et al., 1997). The overall task lasts for an average of 6 minutes which includes a 2-minute practice period. There are a total of 225 digits presented on the screen over the course of the task with 25 of these being the number 3. Each digit is presented on the screen for 250ms in five different randomly assigned font sizes in order to increase the cognitive demand for processing the numerical values presented. The font sizes ranged from 12mm-19mm. The digit is then followed by a mask with a duration of 900ms. Throughout the task, participants are presented

with a mind-wandering probe to monitor their mind-wandering states throughout the study and to ensure that attention was kept on the task. The SART was found to be accurate in measuring sustained attention through the dull task of pressing a spacebar to digits on a computer screen (Robertson et al., 1997). The SART in this study measured RT and errors between conditions.

Post-Task Survey. After completion of the SART, participants are prompted after each condition to complete the SART post-task survey where they are asked to rate on a Likert scale their perceived difficulty of the task (1= very easy, 2= moderately easy, 3= neither easy nor difficult, 4= moderately difficult, 5= very difficult) as well as the interest in the task (1= not at all interesting, 2= a little interesting, 3= somewhat interesting, 4= pretty interesting, 5= highly interesting (Cheyne et al., 2009; Robertson et al., 1997) (see Appendix 3).

Design

This study utilized a quantitative approach using an experimental design to address the research questions. The participants are required to complete the task in both conditions i) with music and ii) without music, meaning that a within-group design was followed. The dependent variable of attention is measured using the subjective measures of attention such as response time (RT) in milliseconds (ms) obtained from the SART. The independent variables are the presence and the absence of music. A counterbalanced approach was utilized when presenting the conditions in which participants will take the test. This means that half of the participants completed the task (i) with music first and then (ii) without music the second time around and the other half of the participants completed the task (ii) without music first and then (i) with music the second time around. This controlled any possible confounds which may have arisen from the sequence effects which ensured internal validity.

Procedure

Participants were approached to participate in the study both online through social media advertisements as well as posters hung on the NCI college campus (see Appendix 4). By clicking a link or scanning a QR code on their mobile device, the participants were given access to a webpage where they were provided with all of the information that they need in order to understand the nature of the study (see Appendix 5). This webpage included details about the researcher, the details of the study, what their experience should be when participating, inclusion and exclusion criteria as well as any potential risks that may occur during the study. After reading through the webpage, an email was sent to the researcher from the individual expressing interest in participating. A date, time, and location were arranged for each participant to meet up with the researcher in order to conduct the study. After their participation, their details and contact information are deleted from the researcher's inbox to ensure participant anonymity.

The day before their participation, participants were reminded of the study time and location, reminded to bring headphones, and to prepare 6 minutes of their preferred music to listen to during the music condition of their participation. Upon showing up at their pre-discussed time and location, participants signed a document providing their informed consent (see Appendix 6) to participate in this study as well as being reminded that they have the option to withdraw at any point during the study. Each consent form was locked in a cabinet to ensure the privacy of the participants. The participants were also asked to provide their age and gender to account for demographical information during the statistical analysis stage (see Appendix 1). They did not proceed with the study until this consent and demographical information were provided.

Participants were then seated in front of a computer which presented instructions for the task on the screen. The participant was required to read through the instructions and any questions the participant had were answered at this stage. The participant then ran through a

2-minute practice run of the SART. A series of numbers from 1 to 9 were displayed on the screen and participants were requested to press the space bar after every number except for the number 3. This task had a duration of 4 minutes and participants completed it twice. One time with the presence of music and one time in the absence of music. Participants then completed a post-task survey once the SART is completed in both conditions (see Appendix 3).

Counterbalancing of conditions was put in place so the participant may be asked to complete the task with music first and then without it or the reverse of these conditions where they were required to complete it first without music and then with music. The condition that was experienced first by the participant was allocated in a manner that ensured that half of the participants (n=15) had music as their starting condition while the other half (n=15) had no music as their starting condition.

Upon completion of the task in each condition, participants were immediately debriefed and then rewarded for their participation with a goodie bag containing a lollypop, a packet of gummy bears, a packet of crisps, and a chocolate bar. Within the debrief form, participants were provided with information on the research aims of the study along with contact information for the researcher if the participant had any further questions (see Appendix 7). In the event that distress was experienced at any point during the duration of the study, a link to a text helpline was provided within the debrief.

Results

Statistical analyses were performed on the subjective measures of attention such as RT and the number of errors as well as examining a possible correlation between these variables with age and gender. Participant-reported difficulty and interest post-task was examined between the conditions to investigate if one condition was perceived as easier in focusing their attention to the task. The dependent variable in this study is the SART while the independent variables are music present and music absent testing conditions. The sample consisted of 30 participants (*n*= 30), 70% of the participants were female (*n*= 21) and 30% of the participants were male (*n*= 9). In Table 1, the descriptive statistics for the categorical demographic variable of gender is presented.

Table 1

descriptive statistics for the categorical variable of gender (N=30)

Gender	Frequency	Valid %
Female	21	70
Male	9	30

Descriptives for the continuous variables of age, total RT (ms) and total errors are displayed in Table 2. The ages of the participants ranged from 18-43 with a mean age of 23.23 years (*SD*= 7.42). The Total RT from both conditions was measured in milliseconds (*M*= 796.03ms, *SD*= 196.63ms). The Total Errors from both conditions ranged from 2-47 errors with a mean of 28.5 errors (*SD*= 13.53). Preliminary analyses were run to ensure that the variables of Total RT (ms) and Total Error followed the assumptions of normality and the homogeneity of variances. The Normal Q-Q plots obtained during the preliminary analysis of

Total RT(ms) displayed that the data for this variable was not normally distributed (Shapiro-Wilk, p=.009), however, the data was normally distributed for total errors (Shapiro-Wilk, p=.105). Therefore, non-parametric statistical analyses such as the Wilcoxon-Signed Rank Test as well as the Mann-Whitney U-test were conducted to run the appropriate inferential analyses on this dataset.

Table 2

descriptive statistics for the continuous variables of age, Total RT(ms), and Total Error (N=30)

	M[95% CI]	*Median*	*SD*	*Range*
Age	23.23 [20.46, 26]	21	7.42	18-43
Total RT (ms)	796.03 [722.61, 869.45]	722.80	196.63	513.95-1182.90
Total Error	26 [20.95, 31.05]	28.50	13.53	2-47

Inferential Statistics

In order to compare the means between the RTs of both the conditions of music and no music, a Wilcoxon-Signed Rank Test was conducted. It was hypothesized that there would be a statistically significant difference between the RTs of the conditions. A preliminary analysis was conducted in order to ensure that there was no violation of the assumptions of normality, linearity, and homoscedasticity. A slightly faster RT was seen in the condition of the absence of music while completing the task, however, the results did not elicit a statistically significant difference in RT between conditions, z= -1.78, p= .075. (See Appendix 8 for the mean RT between conditions).

The Wilcoxon-Signed Rank Test was also used to compare the mean errors made between the two conditions. It was hypothesized that there would be fewer errors in the music condition and a higher number of errors in the no music condition. A preliminary analysis was conducted again to ensure that there was no violation of the assumptions of normality, linearity, and homoscedasticity. Results indicated that there were more errors made in the no music condition (n= 19, M=12.37) when compared to the number of errors made in the music condition (n= 5, M= 13). There was a statistically significant difference in the errors made between the groups, z= -2.44, p= .015. Calculations of the correlation between the number of errors made and the no music condition display that this result indicates a medium effect size, d= -0.445. (See Appendix 9 for the mean number of errors made between conditions)

To investigate differences in the perceived difficulty of the task between the conditions as well as to investigate any differences in the interest that participants had in the task between the conditions, a Wilcoxon-Signed Rank test was conducted. It was hypothesized that there would not be any statistically significant differences in difficulty or interest between conditions. Although there were slightly higher scores of difficulty in the no music condition (n=8) when compared to the music condition (n=6), no significant difference in difficulty was found between the conditions, z= -.85, p= .394 (see Appendix 10). In addition to this, no statistically significant difference was seen in the interest of the task between conditions, z= -1.90, p= .057. This indicates that regardless of the presence or absence of music, the participants' interest levels did not differ to a statistically significant degree (See Appendix 11 for further detail)

A Spearman's rank correlational analysis was conducted to examine a possible relationship between age and RT as well as the number of errors. It was hypothesized that older participants would have slower RTs and a higher number of errors. The preliminary analysis scatterplot graph shows a slightly lower RT as well as a slightly higher number of

errors. However, the results of the analysis indicated a very weak non-monotonic correlation between age and RT, $r(28) = .02$, $n=30$, $p = .924$. Similar results were seen when investigating a correlation between age and the number of errors as there was a very weak correlation observed, $r(28) = -.10$, $n=30$, $p = .583$.

The final statistical analysis that was conducted was the Mann Whitney-U test was conducted to compare the differences in RT and the number of errors between males and females. It was hypothesized that there would not be a statistically significant difference in RT and number of errors between males and females. Male participants appeared to have a slightly higher RT and a lower number of errors when compared to female participants. However the results concluded that the differences in RT and between males and females did not yield statistically significant results, $z = 94$, $p = .982$. Additionally, there did not seem to be a statistically significant difference in the number of errors between males and females, $z = -.272$, $p = .786$.

Discussion

There are many factors that may have an influence on attention, however, the goal of this study was to investigate the influence of music on sustained attention using the SART. There is conflicting evidence in research on the influence that music has on attention and this study aimed to use subjective measures of attention such as RT and the number of errors to investigate differences between the music present and music absent conditions. Additionally, differences in RT and total errors were examined across age and gender. The perceived difficulty that the participants experienced as well as their interest in the study were recorded to investigate if the SART fell into the area of peak performance indicated by the inverted U curve in the music present condition when compared to the music absent condition (Kiss & Linnell, 2021; Unsworth & Robinson, 2018).

The first hypothesis predicted a difference in participant RT between the music present and music absent conditions. In particular, it was predicted that RT will be faster in the music present condition. However, this hypothesis was not supported by the results as although the RT was minimally faster in the music-absent conditions, there was not a statistically significant difference. This indicates that the RT of the participants to the stimuli on the SART did not change to a significant degree between the conditions which aligns with previous findings that RT is similar across conditions (Nadon et al., 2021), but conflicts with another study that found that RT was faster in music present conditions (Cloutier et al., 2020). One possible reason for this result could be due to the SART being too arousing in order for peak performance for RT in the music present condition to occur possibly placing at the high end of the inverted U curve. Another reason for this result may be due to the type of music that the participants listened to during the task or if this music contained lyrics as which has been previously seen to hinder performance on attention tasks (Mendes et al., 2021; Kämpfe et al., 2011; Shih et al., 2012).

A statistical analysis was conducted to investigate if the number of errors differed between conditions. The hypothesis for this research question predicted that there would be a difference in the number of errors made between the conditions with fewer errors made in the music present condition in comparison to the music absent condition. In line with the hypothesis, a statistically significant difference was seen between conditions, as participants made fewer errors in the music present condition while more mistakes were made in the music absent condition. These findings may suggest that listening to music does not increase RT but it may have an impact on the number of errors made in an attention task. These results are in alignment with past research that the frequency of errors made during an attention task is fewer in a music present condition in comparison to a music absent condition (Cloutier et al., 2020; Nandon et al., 2021).

The third research question was interested in if there was a difference in the reported difficulty of the task and the participant interest in the task between conditions. It was hypothesised that in this study, the music present condition would have lower levels of reported difficulty and higher levels of reported interest. A similar study has found that music present conditions where the participants are familiar with the music have more feelings of pleasantness during the task and therefore higher levels of interest when compared to the music absent condition (Kiss & Linnell, 2021), however, the results do not align with the findings from this study and may differ due to the PVT being the attention task used in their study. There were no statistically significant differences in the results of either of the analyses on difficulty and interest between conditions. To the knowledge of the researcher, no other studies on the SART have investigated levels of difficulty between conditions possibly due to the limited research on the use of the SART for testing between these particular conditions. These results in particular may support the idea that the difficulty of the SART in combination with musical stimuli may be too much stimulation to fall into the “sweet spot”

for peak performance of faster RT in the inverted U curve, however there is not enough evidence to support this idea completely.

Research questions 4 and 5 investigated differences in RT and errors across age and gender. It was hypothesized that there would be a relationship between age and RT and errors which is a hypothesis supported by previous research (Callaghan et al., 2017). Although a slightly higher number of errors was seen in individuals aged 30+, no statistically significant relationship was seen between age and RT or between age and the frequency of errors. These results conflict with previous findings from a study conducted by Cloutier et al. (2020) which found that older adults present slower RT but fewer errors when compared to younger adults. With regards to the relationship between gender and RT and the frequency of errors, it was hypothesized that there would be no relationship between gender and RT or the number of errors. A slightly higher RT and a slightly lower number of errors were seen in male participants but similarly to age, no significant results were seen in relation to gender and RT or the number of errors. In alignment with these results, in a study investigating the effect of age, gender, and education on SART performance, it was seen that age, gender, and education level minimally impacted performance on the SART (Chan, 2001). These results conflict with previous findings that female participants make less errors than male participants (Jing et al., 2012). However, different results may be observed with a sample that is more generalizable to the general population.

Implications

The findings from this study have theoretical and practical implications of importance for the topic of sustained attention and subsequent research. This study has demonstrated that background music does have some influence on attentional states in the way that the number of errors made may be affected, however, these findings do not resolve the conflict in results from previous studies and further research is required in order to come to a conclusion on the

matter. Supported by previous research, the findings from this study may be useful in inventing music-based interventions for individuals with attentional deficits as well as being a useful tool to increase attentional states and decrease the number of errors made in monotonous focus tasks such as driving, studying as well as working. It is possible that positive effects can be observed from listening to music while doing an attention task, however, the results of this study did not observe significance other than the analyses on the number of errors between conditions. Future research should explore the SART on a broader sample to enhance the generalisability of the results. It is also recommended that future studies investigate the difficulty of the task and the interest of participants during the task across conditions possibly in a different attention task to explore the full range of the inverted U curve.

Limitations

There are several limitations to the current study that are of note. To begin, the relatively small sample, the type of participants recruited (college students), and the snowball sampling approach greatly limited the generalisability of the results to a larger population. Secondly, the methodological choices were constrained by the limited resources within funding as well as from the college so future research should look at different sustained attention tasks that may be better measures of attention for this particular area of research. Another limitation to this study was that the music that the participants listened to during the music present condition of the task was not requested by the researcher, therefore it is unknown whether the tempo, genre, lyrics, or emotional tone of the music may have an impact on the results for this particular study and future research should investigate this to gain a deeper understanding of these possible confounding variables.

Additionally, some problems occurred when gathering the data as the college-provided website that was used to access the task in this study began stalling and only

presenting the practice round thus, the demo software version of Inquisit was required in order to run the study which was a great inconvenience and may have impacted the first participant's results and experience of the study. To resolve this issue, future research should acquire a more reliable means to test the participants to ensure that no participant has to do the study twice, or have a bad experience in the study.

Conclusion

This study aimed to expand on previous research and on the current understanding of the impact of background music on the sustained attention of college students using the SART. This current study was the first study to the knowledge of the researcher to investigate background music on attention in an Irish college student context. The main finding in this study indicated that fewer errors were made on the task in the music present condition when compared to the music absent condition. This finding in particular adds to the existing literature on the topic as it supports the hypothesis that music does influence attentional states. However, the other four research questions focusing on the difference in RT between conditions, differences in RT between age and gender, number of errors between males and females, and finally the difficulty of the task and interest in the task between conditions did not result in any statistically significant findings indicating that music does not have a big influence on sustained attention. The findings of this study both support and contradicts findings from previous studies as this area of research has not been able to come to a conclusion on the matter to which extent music influences our attentional states. The findings from this study also highlight the importance of research within this area as the main question of whether music impacts attentional states has yet to come to a cohesive conclusion and more research is required.

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Appendices

Appendix 1

Demographics form

Participant number:____

AGE (in years):_____

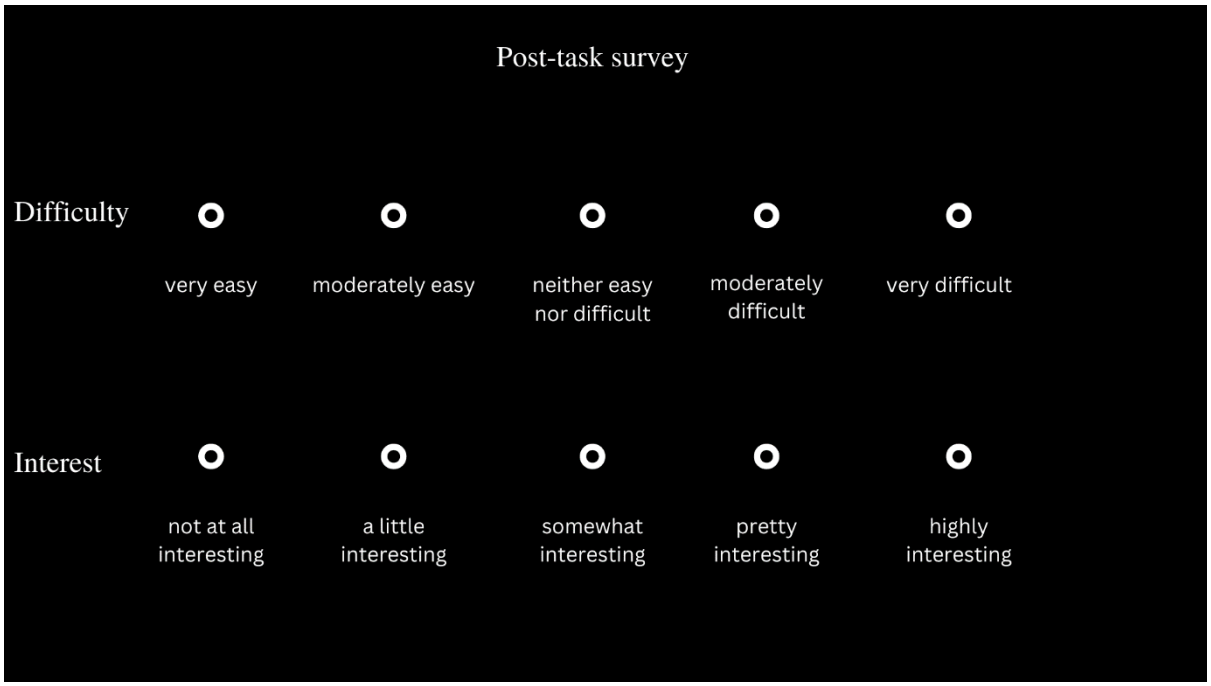
GENDER: ☐ Female ☐ Male

Appendix 2

Link used to access the SART: https://www.millisecond.com/download/library/sart

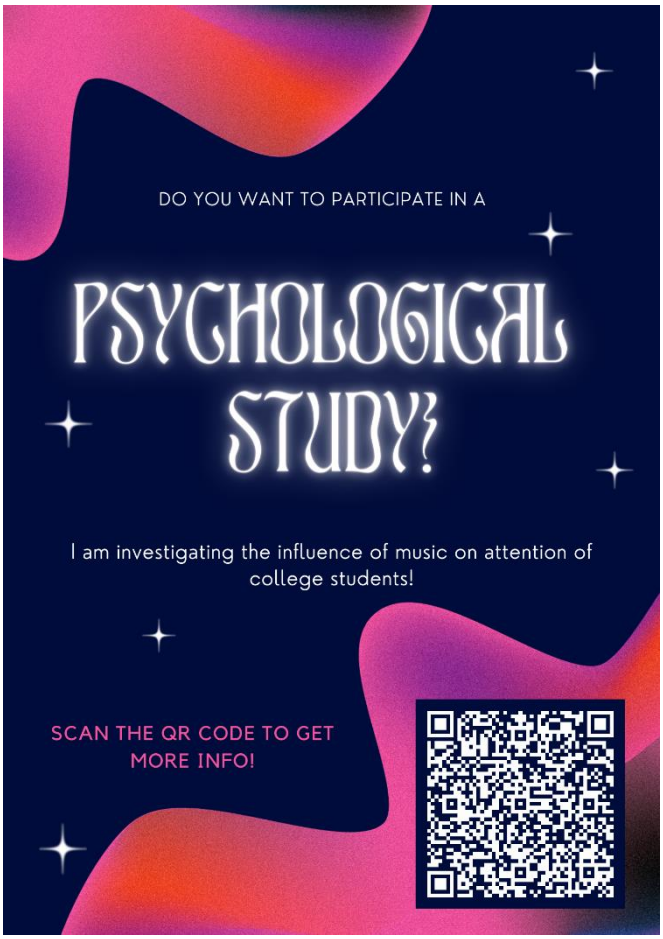
Appendix 3

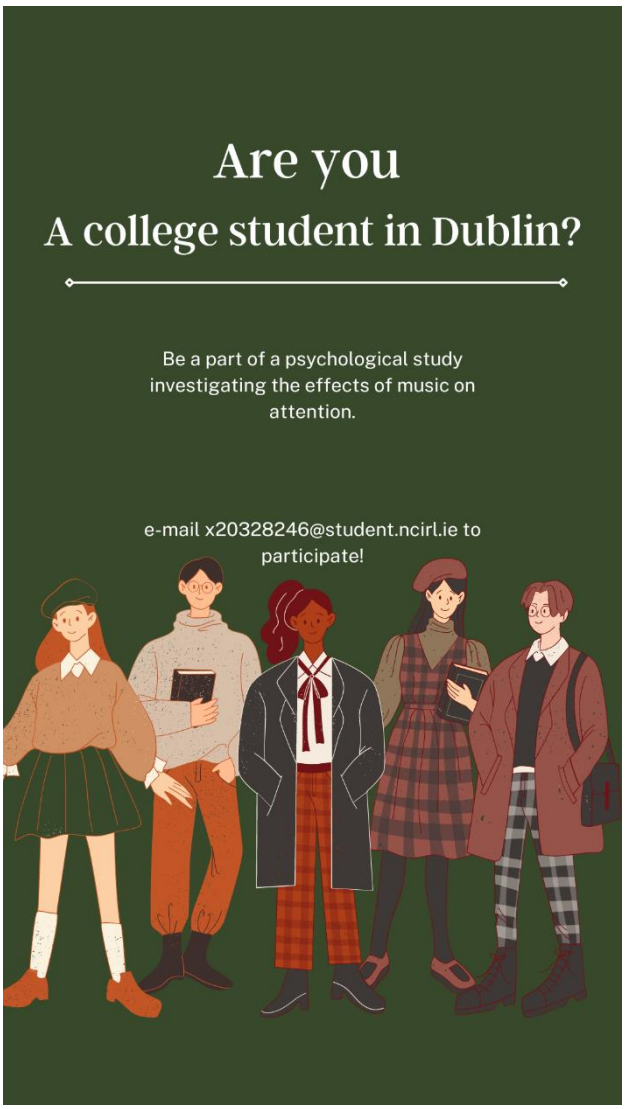
Below is the post-task survey for the SART



Appendix 4

Appendix 1 presents the poster that was hung around the NCI campus as well as the social media advertisements for the study.





Appendix 5

Link to the webpage on the information on the study: https://kindly-street-b2c.notion.site/The-Effects-of-Background-Music-on-Sustained-Attention-of-College-Students-de0c7d8702224daf8bae335c789d4392

Introduction

You have been approached to participate in a psychological study. **Please take your time to read through this document as it discusses the research process and what your role will be upon deciding to participate.**

If you have any questions, comments, or concerns, please contact me directly using the details located at the bottom of this sheet.

About Me

My name is Robyn Browne and I am just like you, a college student. I am a final year Psychology student at the National College of Ireland (NCI), and as a part of my degree, my fellow classmates and I must carry out our own independent research project.

The study and your experience

My research study aims to determine if background music affects scores on a sustained-attention task. This task will take 12 minutes to complete overall and is known as the SART. This project is supervised by a psychology researcher and lecturer at NCI, Dr. Michelle Kelly. Participants are asked to attend a physical meeting in order to complete the study.

Your experience in this study

- Upon contacting the researcher, you will be given a date, time, and location for your individual test. If this date or time does not suit you, please contact me using the provided details at the bottom of the sheet.
- When you arrive you will be asked for some general information such as your age and gender for demographical use and also required to provide your informed consent.
- Following this, you will be asked to complete an attention task. This task only takes 6 minutes to complete each time and you will be asked to do it twice (12 minutes overall), once with music and once without music. You may choose your own music to listen to while completing one of the tasks.

It should be known that it is within your participant's rights to withdraw from the study at any time throughout the process without penalty regardless of if you have completed the study or not, you will receive a lollypop as thanks for your participation.

Participation requirements

Do I Have to Take Part?

Your participation in this research is **completely voluntary** and you have the right to withdraw from the study at any point during the process without penalty or consequence.

You can participate if you fit the inclusion criteria:

- You are a **college student**
- You are **over the age of 18**
- You **DO NOT** have a diagnosis of attention deficit hyperactive disorder (ADHD) or attention deficit disorder (ADD)

Risks & Benefits

There are no direct benefits for you to participate in this research. However, you will experience what it will be like to take part in a psychological experimental study that will contribute to research that helps us understand human cognition and the factors influencing attention. There is a very low possibility of risk of harm to the participants upon completing this study. In the case that you are harmed during the duration of the study, you will receive an appropriate debriefing

Confidentiality & Data

Your participation in this study will be kept completely anonymous. You will not be asked your name. All data collected from this study will be de-identified and treated with the strictest confidence. I, the researcher, will be responsible for the data so if you require your data to be withdrawn from the study you must contact me directly. You must be made aware that the data may be stored for secondary data analysis if requested under my institution however you will be completely anonymous. If not stored for secondary data analysis, it will be stored for 5 years and then destroyed in accordance with NCI's data guidelines.

What will happen to my results?

The results and write-up of this study will be presented in my final dissertation which will be submitted to the National College of Ireland as well as be included in an oral presentation toward my final grade.

Contact Information

Researcher: Robyn Browne

X20328246@student.ncirl.ie

Supervisor: Dr. Michelle Kelly

Michelle.Kelly@ncirl.ie

****To participate you must contact me (the researcher) expressing your wish to participate. ****

Additionally, if you have any questions, comments, or concerns do not hesitate to contact me or my supervisor directly through e-mail.

Appendix 6

The Effects of Background Music on the Sustained Attention of College Students using the Sustained Attention to Response Task (SART)

Consent Form

Please Confirm that the following statements are true.

In agreeing to take part in this research study, I am made aware that:

- This purposed research project has been approved in principle by the department of ethics committee which means that the committee does not have any concerns about the methods and procedures detailed by the researcher. However, it is the researcher's own responsibility to adhere to the ethical guidelines in their dealings and correspondence with participants as well as the collection and handling of data.

- If I have any concerns about the participation, I am aware that I may refuse to participate or withdraw at any stage by verbalizing my wishes to withdraw to the researcher.

- I understand that once my participation in this study is complete, I cannot withdraw my data as it will be fully anonymized.

- I have been fully informed as to the nature of the study and I agree voluntarily to participate

- All of the data from this study will be anonymous and confidential. The data collected from all of the participants will be compiled, analysed, and submitted in a report to the psychology department within the school of business.

- I am aware that my data will be kept and managed in accordance with the NCI data retention policy, and that my anonymous information may be archived in an online data repository and be used for secondary data analysis. No participants will be identifiable at any point.

- At the conclusion of my participation, any questions, comments, or concerns I have will be fully addressed.

☐ **Please tick the box if you have read and agree with all of the above information**

☐ **Please tick the box to indicate that you are providing informed consent to participate in this research study**

Date: / /

_____ _____

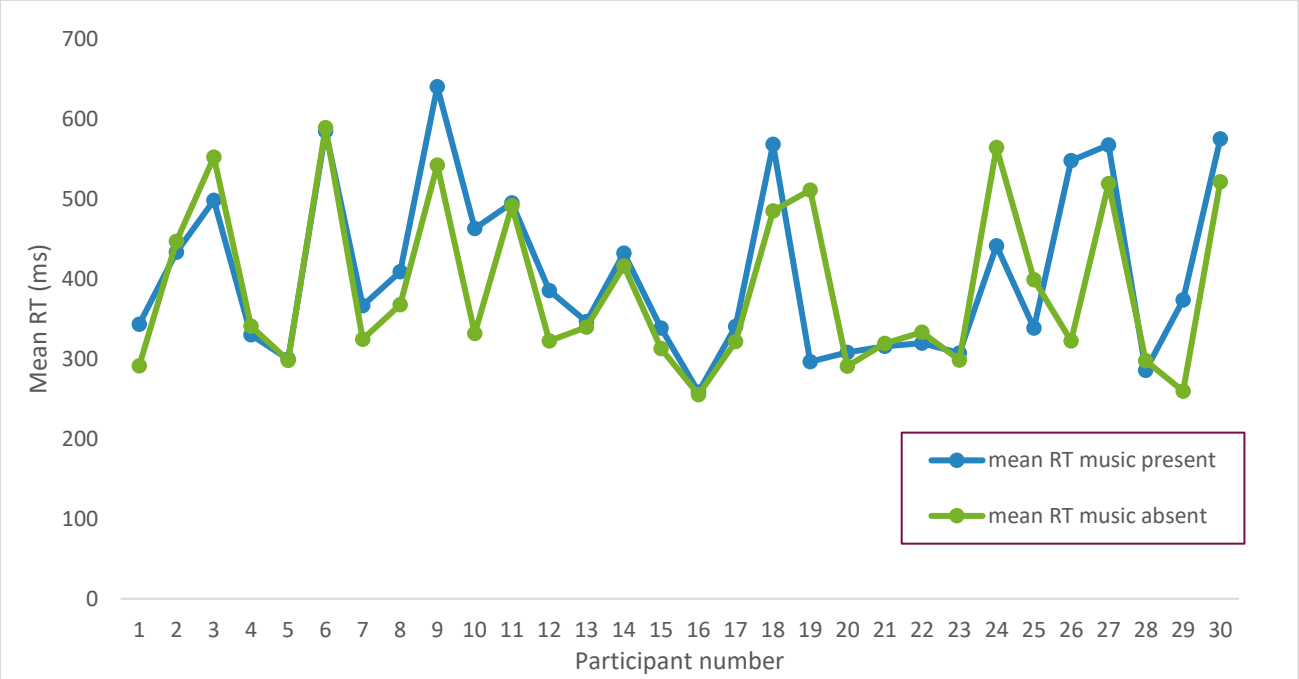
Participant signature Researcher signature

Appendix 7

Below is the form used to de-brief the participants on the study

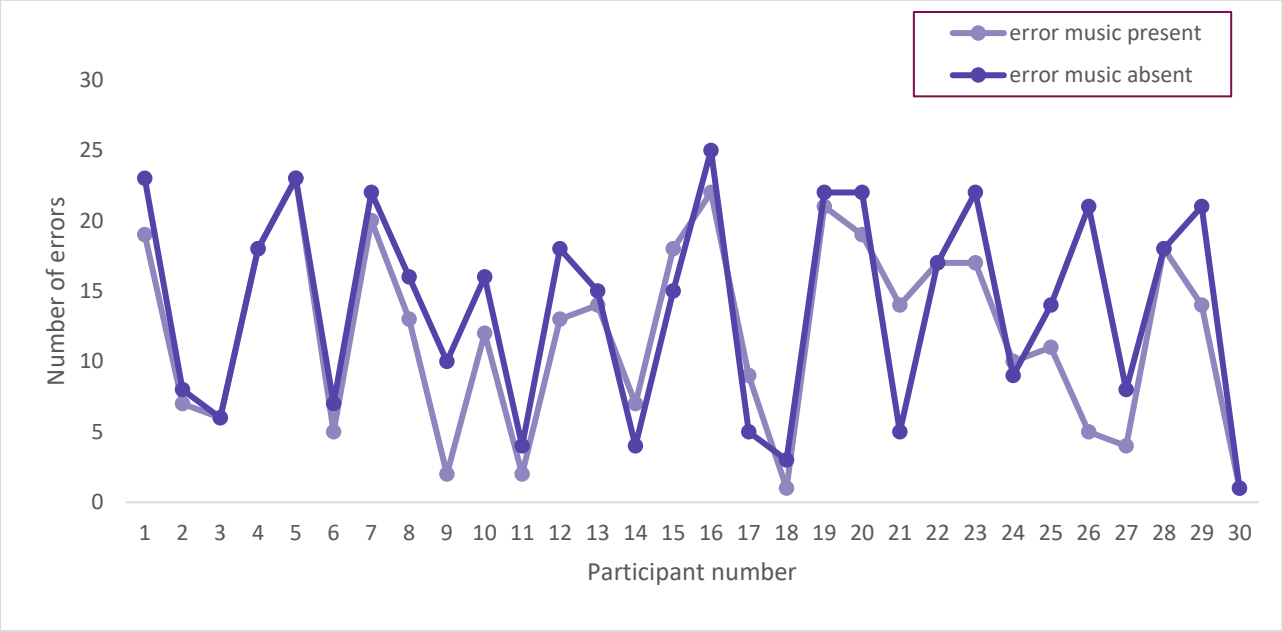
Appendix 8

The line graph below depicts the reaction times (RT(ms)) of each participant in i) the music present condition, and ii) the music absent condition.



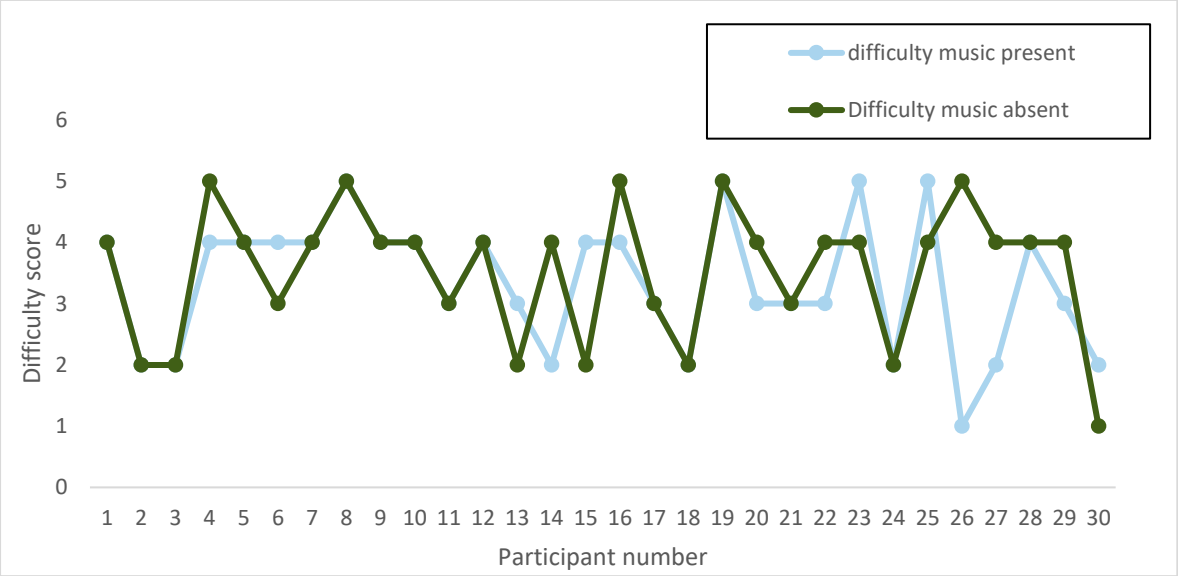
Appendix 9

This line graph depicts the mean numbers of errors made by each participant in the i)music present condition and ii) the music absent condition.



Appendix 10

The line graph below depicts the reported difficulty of the task between both music present and music absent conditions.



Appendix 11

The line graph below depicts the reported interest in the task between the music present and music absent conditions.