An Investigation into the Effect of Programme Music on Attention and Working Memory

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Abstract

The present study investigated the effects of programme music on attention and working memory, employing the use of both a modern instrumental music and no-music control. Previous research has established a positive association between music and increased performance on cognitively demanding tasks. The current sample (N=25) consisted of 11 males and 14 females, with ages ranging from 18-29. A between-groups, experimental design was employed, which featured three separate conditions, which were classified by the independent variable, which was type of music (programme, modern or no-music). Working memory was measured by the *n*-back, whilst attention was measured using The Continuous Performance Test. Results indicate that there was no significant difference in performance between groups on either of the dependent variables of attention and working memory, not supporting the hypotheses. A main effect was detected for inter-stimulus intervals on impulsivity, however the differences in impulsivity levels between the millisecond intervals were only slight. The effects of impulsivity and musical training on results were investigated in an exploratory manner. Implications of the current study and future recommendations are discussed.

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Introduction

Music is a stimulus which is present in everyday life. It is experienced and employed by billions of people daily, in both a recreational and professional manner. The relationship between music and cognition has emerged as a topic of significance to both the scientific and general populations. The finding which sparked this interest was that of the "Mozart Effect", which was termed in reference to the findings generated by the Rauscher, Shaw & Ky (1993) study, which detected a short-term rise in performance in spatial temporal reasoning tasks as a result of exposure to Mozart's Sonata for Two Pianos in D Major K.448. The findings of this study were misinterpreted by the general public which resulted in immense repercussions, as the media promoted the belief that exposure to Mozart's compositions had the power to bolster intelligence levels. Belief in the effect became so compelling and widespread that the Governor of Georgia (USA) proposed for every child that was born in the state to receive a CD, which comprised of musical works including those of Mozart in order to "make children smarter".

From a research perspective, the investigation into the effect of music on cognition has encompassed a wide range of music types and different aspects of cognitive function. Investigations into music from the Romantic period (Nantais & Schellenberg, 1999; Sun, Wei & Yue, 2011), the Baroque period (Riby, 2013; Gu, Zhang, Zhou & Tong, 2014) and modern music (Morton, Kershner & Siegel, 1990; Schellenberg, 2005) have all yielded results which suggest that it is not solely Mozart's sonatas which have the power to positively influence performance on cognitive tasks. Due to this, the arousal and mood hypothesis was proposed which attributes the rise in cognitive performance to increases in arousal and mood as a result of the music (Nantais & Schellenberg, 1999; Schellenberg, 2001, 2005; Thompson, Schellenberg & Husain, 2001).

Programme music can be defined as a composition with the ability to evoke imagery, emotions, feelings and thoughts associated with a non-musical event (Riby, 2013). There is gap in the literature concerned with the effect of programme music on cognitive processes albeit the fact that the characteristics associated with this type of music are designed to evoke emotion and arousal. The current literature review examines and critically evaluates the existing literature surrounding the effects of music on the cognitive processes of attention and working memory.

The Mozart Effect

The effect of music on cognitive function has become an interdisciplinary research topic of interest over the last few decades. “Music makes you smarter”, the misinterpreted claim which was born from the Rauscher, Shaw & Ky (1993) study which observed a “Mozart Effect”, which refers to a short-term increase in performance on spatial-temporal tasks after listening to 10 minutes of the Sonata for Two Pianos in D Major K.448 by the famous composer. These findings attracted a lot of attention and thus lead to an abundance of research investigating the effect of listening to Mozart on spatial reasoning (Rauscher, Shaw & Ky 1993, 1995; Chabris, 1999; Nantais & Schellenberg 1999; Thompson, Schellenberg & Husain, 2001; Husain, Thompson & Schellenberg, 2002). However, the results from this study should be interpreted with caution, as scores from participants in the Mozart condition were compared with scores from participants in a silence or relaxation tape condition (Rauscher, Shaw & Ky, 1993). It has been suggested that the differences in performance between the groups may have been partly due to differences in mood and arousal between the Mozart and control conditions (Schellenberg, 2001).

Rauscher *et al.* (1995) conducted a secondary study which also appeared to provide support for the existence of the Mozart Effect, by administering pre-test spatial-temporal reasoning tasks and dividing the participants into groups based on their performance. The experimental conditions were then carried out across 5 days as follows, participants in the silence group sat in silence for 10 minutes each day before being administered the paper folding and cutting task, the Mozart group listened to 10 minutes of a sonata prior to beginning the task and the mixed group were tested after listening to a minimalist piece, a short story or a piece of repetitive dance music respectively, on consecutive days. The study produced mixed findings. After the first day, participants in the Mozart condition showed a greater improvement in performance than did those in the silence and minimalist music conditions, which appeared to show support for the researchers' previous claim. However, the results from all of the other testing sessions remained to be the same with no condition showing improved performance over the other. The results from this study can also be seen to be problematic in terms of validity. The effect portrayed in their previous study (Rauscher, Shaw & Ky, 1993) was only replicable during the first session, which may have been due to the low levels of cognitive arousal derived from sitting in silence or listening to a minimalist piece of music. Neither the repetitive dance music nor the minimalist music had any significant effect when compared to results from the Mozart condition (Rauscher, Shaw & Ky, 1995). The lack of evidence to support the effect from the consecutive sessions also raises further questions about the validity of the original effect. The lack of investigation into mood and cognitive arousal as factors which may have influenced the differences in performance between groups were also overlooked in this replication (Schellenberg, 2001).

As many of the fallouts associated with the widespread attention generated by the Mozart Effect have been directed towards how to make children smarter, it is of interest to explore whether the effect does in fact relay onto children in the same way as the adult samples which were employed in the previous literature. Črnčec, Wilson & Prior (2006) investigated the possible presence of the Mozart Effect in children, using popular music and silence controls, which examined the effect from the perspective of the arousal and mood hypothesis. There was no evidence found which would indicate that the Mozart Effect is present with children. Thus, it would be pertinent to suspend the advertising of Mozart as a tool to enhance children's brains, until such supporting evidence has been found to warrant such a claim.

An EEG study investigating the Mozart Effect in adults and the elderly compared brain activity after listening to Mozart's sonata with that which was produced following exposure to a sonata by Beethoven. Brain waves related to attention, memory and cognition increased in activity after the participants listened to Mozart. However, no changes in brain activity were observed following exposure to Beethoven (Verrusio, Ettorre, Vicenzini, Vanacore, Cacciafesta & Mecarelli, 2015). The results generated by this study are indicative of evidence which supports the claim that Mozart's sonata has the ability to enhance cognitive function on the neurological level, the possible reasons for this have yet to be expanded upon. In future, multiple musical comparisons may be employed in neurological studies in order to ascertain that Mozart is the sole music which can induce such an effect in the brain.

A meta-analysis examined a mixture of approximately 40 published and unpublished studies which had attempted to recreate the Mozart Effect, including the original research carried out by Rauscher, Shaw & Ky (1993). Contrary to the aforementioned evidence, the findings indicated that there was little empirical evidence present which supported any cognitive performance enhancing effect brought on by exposure to Mozart. Due to the inclusion of unpublished studies, this paper was able to overcome any publication bias which may have impacted on the nature of the results. This research provides a comprehensive review of the experimental literature associated with the Mozart Effect, revealing that spatial abilities may not be as easily improved by simply listening to the famous composer as once claimed (Pietsching, Voracek & Formann, 2010). Overall, albeit the abundance of research investigating the topic, employing the use of varied research methods, speculation remains surrounding the existence of the Mozart Effect due to the consistent presence of mixed results displayed by the literature.

Mood and Arousal

Nantais & Schellenberg (1999) however, replicated the Mozart Effect using both the original sonata and a piece by Schubert, in comparison to silence, which suggested that any cognitively arousing piece in the classical or romantic styles could produce the same effect. A meta-analysis of 16 studies investigating the Mozart Effect (Chabris, 1999) produced a small intermittent effect, the cause of which was concluded to be an enjoyment arousal, a direct result of listening to the music (Thompson, Schellenberg & Husain, 2001). The nature of the Mozart Effect may thus be due to the arousal and mood hypothesis, which states that listening to music, which is an example of an enjoyable stimulus, has the ability to influence emotions and arousal levels. It has been suggested throughout the literature that it may be this change in mood and level of arousal, as a consequence of the music, that may have a positive effect on levels of cognitive performance, however the perceived effects are only short-tem (Nantais & Schellenberg, 1999; Schellenberg, 2001, 2005; Thompson, Schellenberg & Husain, 2001; Husian, Thompson & Schellenberg, 2002).

An attempt to partially deconstruct the Mozart Effect lead to an investigation into the mediating factors which have been suggested as the possible basis for the original perceived positive effect of Mozart on spatial reasoning task performance (Rauscher, Shaw & Ky, 1993). Jones, West & Estell (2006) conducted a study which examined the Mozart Effect from several different perspectives proposed by previous research, which attempt to provide an explanation for the effect, those being associated with heightened arousal levels possibly induced by the music, and musical preference as mediating factors which bring about an increase in cognitive performance. In comparison to a no-music control group, participants who were exposed to Mozart performed significantly better. When perceived arousal level was considered as a covariate, it was observed that the music ceased to be a predictor of improved performance. Musical preference was not found to have any effect. This study demonstrates that the Mozart Effect is in all probability, a result of increased arousal levels, which arise as a result of the music. Suggestions for future comparisons include the use of an equally upbeat piece of music in order to investigate the possible arousal explanation for the Mozart Effect properly, as relaxation tapes have the capacity to lower arousal.

A study carried out by Riby (2013) using Vivaldi's Four Seasons found that the movement entitled "Spring" had a positive effect on performance in memory and attention. This study also highlighted the fact that emotion and arousal can promote cognitive performance. The concept of programme music, which can be defined as a composition with the ability to evoke imagery, emotions, feelings and thoughts associated with a non-musical event (Riby, 2013), was introduced. This was suggested to produce an increasingly positive effect, due to its characteristics, on the cognitive functions of attention and memory, which was supported by the results of this study. A study investigating the effects of background music on performance in mathematics in students, used a between groups design in order to examine the effects of the music on a sense of achievement, habits of mind, anxiety in relation to being tested and the participant's disposition towards the music. The results concluded that the background music did have a positive influence on the increase of correct scores in the mathematics assessment (Sagge Jr., 2014). Schellenberg (2005) discussed that upbeat, modern and age appropriate music may also have a positive effect on emotion and arousal, which provides a novel outlook as much of the older research centres around the effects of classical music, which includes that of Mozart. The effect of music on certain aspects of cognitive performance has been well documented, yielding mixed results, however the majority point to such observed effects being due to the elevation of mood and arousal as a direct result of listening to the music, which may be identified as an enjoyable stimulus.

The Effect of Positive Emotions on Cognitive Processes

The Mozart Effect may also be examined from the perspective of a theory which suggests that the association between cognition and mood may be explained by the increased levels of the neurotransmitter dopamine in the brain, which are present when a positive mood is induced (Ashby, Isen & Turken, 1999). A number of cognitive processes are influenced by positive affect and the effects of dopamine on the function of the prefrontal cortex. These include working memory, the establishment of long term memories and innovative problem solving skills, this in turn influences performance on a variety of cognitive tasks. The effect of music on performance in these cognitive tasks may thus be explained from the perspective of the music acting as an enjoyable stimulus, which subsequently may increase levels of positive affect or arousal, leading to improved cognitive processing and performance on certain tasks which aim to assess this (Schelleberg, 2001). Positive affect can be interpreted as even a slight rise in positive emotions that occur in reaction to experiences in everyday life (Ashby, Isen &

Turken, 1999) and even mild variances in these emotions can have an effect on cognitive function (Isen, 1999).

Music and Working Memory

Working memory has a number of definitions associated with it, one of which describes the construct as the "ensemble of components of the mind that hold information temporarily in a heightened state of availability for use in ongoing information processing" (Cowan, 2016). Relative to the characteristics of other cognitive processes, it is complex and multi-facetted, and reliable measures of such have been debated (Kane, Conway, Miura & Colflesh, 2007; Schmiedek, Hildebrandt, Lövdén, Wilhelm & Lindenberger, 2009). An emerging body of research has identified the potential positive effects that music can have on working memory capabilities.

The effect of music composed by Chopin on working memory was investigated using the n-back task and measured using an electroencephalogram (EEG). The music was shown to increase participants' working memory performance (Sun, Wei & Yue, 2011). Chopin was a composer who was prevalent during the Romantic period of music (1830-1900) and thus his compositions were in the romantic style. A secondary study which employed the use of EEGs examined the influence of music from the Baroque era (1600-1750) on the cognitive processes associated with learning, which include memory and attention. The use of the n-back as a measure of working memory was also employed in this research. The Baroque music was found to increase learning efficacy (Gu, Zhang, Zhou & Tong, 2014). Along with demonstrating the use of the n-back as an appropriate measure of working memory when investigating the potential effects of music on cognitive function, these studies exhibit that it is not just music from the Classical era (1750-1820), such as Mozart, that can have a positive influence on certain aspects of cognitive processing, but that different styles of music may also have an effect.

Hallam, Price & Katsarou (2002) examined the effects of music perceived to be calming, when compared to music which was described as irritating and aggressive, on cognitive performance associated with memory in a sample of primary school children. Participants who were tested with the calming music exhibited greater memory performance in comparison to the unpleasant music and silence control conditions. The observed effects of music on cognitive performance identified in this study provide supporting evidence for the arousal and mood hypothesis, as the perceived pleasantness of the music had an impact on the results. A study was conducted which explored the effect of background music on executive attention capabilities employing the use of two types of music, that which included vocals and solely instrumental music. It was found that vocal music had a negative impact on cognitive performance and working memory capacity (Kang & Lakshmanan, 2017). This research highlights the concept that it is exclusively instrumental music that may enhance cognitive abilities, and that accompanying vocals in background music may serve as an encumbrance when executing cognitively demanding tasks (Bell, 1916).

Investigations into the long-term effects of musical training on working memory performance have yielded positive results, indicating that musicians may have enhanced working memory abilities when compared to non-musicians (George & Coch, 2011; Hou, Chen, Wang, Lin, He, Li & Dong, 2014; Talamini, Caretti & Grassi, 2016). Bergman Nutley, Darki & Klingberg (2014), through a longitudinal design, examined the effects of the regular practise and performance of a musical instrument on working memory capabilities in a sample of children and young people. The results concluded that musical practise had a positive influence on working memory. The hours spent playing a musical instrument were also positively associated with the increasing development of working memory capacities. This research demonstrates the cognitively beneficial outcomes which may arise from long-term musical training. Thus far, the empirical evidence appears to support that music may have a positive influence on working memory.

The Effect of Positive Emotions on Attention

The broaden hypothesis was derived from Fredrickson's broaden-and-build theory of positive emotions, which refers to the idea that positive emotions may have the ability to broaden an individual's thought-action repertoire along with their scope of attention (Fredrickson, 2004). The broaden hypothesis focuses on the effect of positive emotions on broadening the scopes of attention and cognition as well as expanding the assortment of thoughts, actions and concepts in the mind at that time (Fredrickson & Branigan, 2005). Evidence to support this theory in terms of the broadening effect of positive emotions on attention was provided by Fredrickson & Branigan (2005) by the means of an experiment which yielded results which suggested that the scope of attention present by those who were experiencing a positive emotion was broader than in those who were not experiencing any particular emotion at all. This finding was in line with the claim made by Derryberry & Tucker (1994), regarding the broadening effect that positive emotion has on attention capacities. The evidence associated with this theory may also have implications towards the understanding of the mediating factors associated with the Mozart Effect, in relation to the arousal and mood hypothesis.

Music and Attention

Attention can be defined as a "process that selects stimulus elements for further processing, leading to the interpretation of whatever stimuli were picked up" (Dowling, 1990). Morton, Kershner & Siegel (1990) conducted an experimental study which investigated the effects of music on attention and memory in a sample of young boys using a silence control comparison. The music employed by this study was Pink Floyd's "The Wall". Music exposure was positively associated with superior performance in relation to both attention and working memory abilities. This research demonstrates that the use of various genres of music may elicit the same responses as classical music. The increase in performance associated with the music group was interpreted as being due to arousal levels, which provides further support for the concept that the music may simply be facilitative of this. A study was carried out which examined the influence of background music on attention and performance in the workplace. Comparisons in performance levels were made between instrumental music and music which contained lyrics. The latter significantly impaired performance levels associated with attention and concentration (Shih, Huang & Chiang, 2012). This study provides further evidence against the use of music which contains vocals when high levels of cognitive performance on tasks are desired.

Borling (1981) conducted a study in which the effects of both stimulating and sedative music were explored in relation to ability to focus attention. The results concluded that the sedative music condition yielded higher levels of performance in focusing attention than the stimulating music condition. An investigation into the effects of varied styles of background music on attention and information acquisition was conducted in a sample of children. Music which had a slow tempo did not have much of an effect on the two processes. However, background music which had a fast tempo had a negative effect on attention when compared to the control condition which did not feature the use of any music (Wakshlag, Reitz & Zillmann, 1982). The aforementioned studies appear to suggest that music of a fast-paced nature may have unfavourable effects on attention levels, a possible explanation for this may be the fact that highly engaging music may lead to distraction from the tasks presented.

Another study was carried out using workers as participants and investigated the effect of background music on listener attention (Huang & Shih, 2011). It was concluded that the music had a positive influence on attention, however, the listener's music preference, as in particular like or dislike towards the music, had a large influence on this outcome, which is in line with the previous literature (Nantais & Schellenberg, 1999). A study was carried out which examined the possible relationship between long-term musical training and improved sustained attentional abilities. Trained musicians displayed superior attention in relation to performance on the tasks in comparison to non-musicians (Wang, Ossher, Reuter-Lorenz & Wang, 2015). The results of this study provide further support to the cognitive benefits which may be associated with formal musical training. Overall, the content of the previous literature concerning the subject would suggest that music may have a positive influence on attention, provided that consideration is given as to which type of music is played, as aggressive and fast-paced music may be of more distraction than benefit.

The Current Study

Rationale

As the positive effect of music on cognitive performance appears to be grounded in the suggestion that music, as an enjoyable stimulus, influences mood and arousal which subsequently has a short-term effect on cognitive abilities, (Nantais & Schellenberg, 1999; Schellenberg, 2001, 2005; Thompson, Schellenberg & Husain, 2001; Husain, Thompson & Schellenberg, 2002; Riby, 2013) it is reasonable to suggest that programme music, which is in its nature designed to evoke emotion, thoughts and feelings (Riby, 2013), would have a positive influence on cognitive function. Despite this, there is a gap in the literature concerned with the effects of programme music on performance in cognitive processing tasks which the current research seeks to address. The programme music chosen for use in the current research is a piece by Tchaikovsky entitled Romeo and Juliet Fantasy Overture, this piece was employed due to both its repute as an particularly famous example of programme music, and the evidence which suggests that music from the Romantic period may induce the same observed effects as that of Mozart (Nantais & Schellenberg, 1999; Sun, Wei & Yue, 2011; Riby, 2013; Gu, Zhang, Zhou & Tong, 2014). This study will explore the effects of programme music on two aspects of cognitive function, those being attention and working memory. The empirical evidence provided by the previous literature suggests that performance in tasks associated with attention and working memory may be positively influenced by the presence of music (e.g. Morton, Kershner & Siegel, 1990; Hallam, Price & Katsarou, 2002; Huang & Shih, 2011; Sun, Wei & Yue, 2011; Riby, 2013; Gu *et al.*, 2014). These cognitive processes have been chosen in order to investigate the implications of music in a learning and study environment, and to examine whether the music would have a positive impact on attention and working memory.

A secondary investigation into the effect of modern instrumental music is also proposed in order to make a comparison between the two genres as opposed to solely making comparisons with a silence condition. This is due to the suggestion that an aspect of the effect that listening to Mozart had on cognitive performance was due to the silence or repetitive, minimalistic music control conditions being boring and unarousing (Schellenberg, 2001), and that equally upbeat music comparisons may aid to mediate this effect (Schellenberg, 2005; Jones, West & Estell, 2006). Music which contains vocals has been demonstrated to negatively impact performance on attention and working memory capacity (Shih, Huang & Chiang, 2012; Kang & Lakshmanan 2017). Thus, instrumental music has been chosen in order to control for this. This research may have future implications in providing evidence for the use of certain study habits and the atmosphere in which students immerse themselves whilst studying. The previous literature has also identified musical training and practise as a variable which may have a positive effect on cognitive performance (Bergman Nutley, Darki & Klingberg, 2014; Wang, Ossher, Reuter-Lorenz & Wang, 2015), thus an exploratory investigation into the possible effect of musical training on performance in attention and working memory will also be carried out.

Research Aims

This research aims to investigate the effects of programme music on performance in attention and working memory, employing the use of both an instrumental music and a no-music control. Based on the previous literature, two hypotheses were developed.

Hypothesis one states that higher scores on performance in attention will be observed in the programme music condition in comparison to modern instrumental music and silence.

Hypothesis two states that higher accuracy scores on performance in working memory will be observed in the programme music condition in comparison to modern instrumental music and silence.

The primary aims associated with the current research are hypothesis driven, however an additional exploratory investigation into the effect of musical training on performance in attention and working memory will also be carried out.

Method

Sample

The sampling method used in order to obtain participants for this research was convenience sampling. 25 participants took part in this study, consisting of 11 males and 14 females. The sample did not contain any vulnerable participants. Ages of participants ranged from 18–29, with a mean age of 21.52 and a median age of 21 (SD = 2.22). Written informed consent was obtained from each participant prior to the beginning of the experiment. The sample consisted of 19 non-musicians and 6 musicians, those of which played 1–3 different instruments, have been playing music regularly for the past 7–15 years and spend 1–7 hours weekly playing music. The sample was divided amongst the 3 conditions as follows, 8 participants were assigned to the silence condition, 9 participants were assigned to the programme music condition and 8 participants were assigned to the modern music condition. The sample size associated with the current study was relatively small, however this was due to the nature of the study whereby each participant was tested individually, with combined administration of the measures and detailed instructions totalling a time of approximately 35–45 minutes. Due to the amount of time spent actively participating, this required a large amount of commitment from the sample as the use of rewards were not employed. The frequencies for the sample are presented in *Table 1* below.

Design

This research employed the use of a between-groups, lab-based experimental design. The structure of this design consisted of three separate conditions wherein the independent variable was type of music. Two types of music were used, programme music and modern instrumental music, along with a control condition which substituted silence for the music.

The dependent variables in the current study consisted of attention, impulsivity and working memory. A between-groups design was chosen for this study due to the use of the *n*-back (Kirchner, 1958) as a measure of working memory. A practise effect resulting in increasing performance is associated with this task, and therefore it may have influenced the results should a within-groups design have been implemented. All data collected was quantitative in nature, with no qualitative elements present.

Table 1. *Displaying frequencies for the current sample (N=25).*

Variable	Frequency	Valid Percentage
Gender		
Male	11	44
Female	14	56
Musician		
No	19	76
Yes	6	24
Condition		
Silence	8	32
Programme	9	36
Modern	8	32

Measures

n-back

The *n*-back (Kirchner, 1958) is a computerised task which was designed as a measure of working memory. The task requires participants to accurately respond to a visual stimulus which was presented *n* trials before, with *n* representing the number of trials between the stimulus reoccurring. This research employed the use of a dual 3-back version of the task, which encompasses two distinct dimensions which are comprised of letters and the spatial location of squares. The Psychology Experiment Building Language (PEBL) version of the program was used, consisting of 4 practise blocks and 3 test blocks. Each test block was comprised of 21 trials lending to a possible maximum accuracy score of 42 for each block. The trials progressively increased in difficulty from the 1-back block, to the 2-back, to the 3-back block. Overall, the task, including practise blocks, lasted approximately 15 minutes.

The Continuous Performance Test

The Continuous Performance Test (Conners, 2000) is a computerised task which measures attention and impulsivity by detecting responses to a target stimulus. The stimuli were individually presented in the form of Go or NoGo targets. Go targets were represented as any letter of the alphabet, excluding the letter X. NoGo targets were represented by the letter X. Participants were required to respond by pressing the spacebar each time that a Go target was presented. Conversely, NoGo targets demanded a lack of response, requiring the participant to refrain from hitting the spacebar any time that an X appeared. Varied inter-stimulus intervals exist between the manifestation of stimuli, these ranged from 1000, 2000 and 4000 milliseconds. Commission errors arise as the result of a response being made to a NoGo target, these errors serve as a measure of impulsivity. Therefore, omission errors occur due to the participant's failure to respond to a presented Go target, such errors are indicative of levels of attention. The PEBL version of this program was employed for this study, which is timed to 14 minutes.

Music

Programme

The programme music which was chosen for use in the current study was Tchaikovsky's Romeo and Juliet Fantasy Overture. This is a famous piece which has the power to evoke powerful imagery and emotions in the listener. Its themes range from vibrant to dark with changes in tempo in correspondence to this. It is a vivid, renowned example of programme music. The piece is 19:10 minutes long and was placed on a continuous loop until the experiment was finished.

Modern Instrumental

The modern instrumental music employed by this study was a piece entitled Ocean by artist John Butler. This piece is also quite upbeat, vibrant and rhythmic, and is played on a single 12-string guitar. It is 11:39 minutes in length. This piece was also placed on a continuous loop until the participant had finished both computerised tasks.

Procedure

Permission was sought from, and awarded by the board of ethics in the National College of Ireland to conduct this research study. Participants were required to give informed written consent prior to the beginning of the experiment. A detailed information sheet (see App. A) outlined what participation in this research would entail, how the data would be stored, and dissemination processes. A list of participants' rights was also issued to the participant, alongside the consent form (see App. B). Prior to the beginning of the computerised tasks, a short written questionnaire (see App. C) concerned with demographic information and musical ability was given to the participant, along with an allocated participant ID number. The participant ID numbers were randomly allocated to each member of the sample, beginning 01. After providing further verbal instruction as to the nature of the tasks and the sequence in which they would appear, time was allowed for responding to any queries which may have arisen in relation to any aspect of the experiment and a participant's involvement in such. Depending on the allocated experimental condition, the relevant music was played at a set volume from the moment that the first computerised task was initiated until the final task was completed. In the control condition, whereby silence replaced music as the independent variable, all other aspects associated with the experiment remained identical. Utilising the PEBL program, the battery of computerised cognitive tests ran without pause, and when one was finished the next would begin automatically, with no additional input needed on the participant's behalf. The tasks ran in a set order, beginning with the CPT, the duration of which was 14 minutes, directly followed by the 3-back version of the *n*-back which ran for approximately 15 minutes. Once the tasks were completed, the program window closed automatically. Participants were then quickly debriefed and any further questions which may have arisen from the completion of any aspect of the tasks were answered. Data was subsequently collected and sent for analysis.

Data analysis

All data was subsequently inputted into IBM SPSS version 23 for subsequent analysis. Descriptive statistics in the form of basic measures of central tendency (mean, median, range and standard deviation), variance and distribution were generated in order to ensure no violation of the assumptions of the relevant inferential analyses. Mixed between-within groups analyses of variance (ANOVA) were chosen as the methods of inferential analyses due to the relative robustness of the test when presented with small sample sizes and non-normally distributed data. The first mixed ANOVA was carried out which compared accuracy on the dependent variable of working memory within groups on the 3 blocks of the *n*-back and between groups on the independent variable of type of music. The second mixed ANOVA compared omission errors within groups on millisecond inter-stimulus intervals and between groups on the type of music condition. The data collected which was associated with attention was quite small which led to it being non-normally distributed. The final mixed ANOVA compared commission errors within participants on millisecond inter-stimulus intervals and between groups on the type of music. Three independent samples t-tests were conducted as exploratory analyses, which explored the differences in scores between musicians and non-musicians. The first independent samples t-test compared mean accuracy rates on the *n*-back between musicians and non-musicians. The second t-test was concerned with differences in mean omission errors between the two groups. The final independent samples t-test compared mean commission errors between the groups of musicians and non-musicians.

Results

Descriptive Statistics

Descriptive statistics including means (M) and standard deviations (SD) for all continuous variables are presented in Table 2. Mean accuracy rates for the *n*-back appear to remain relatively stable across each block, producing a 95% confidence interval of 88.18-91.90 for total scores, which is moderately high. The Shapiro-Wilk test of normality indicated normally distributed data ($p > .05$) for scores on the *n*-back, which was also supported by the presence of a Gaussian distribution upon inspection of a histogram and a relatively linear shaped QQ plot. The overall presence of omission errors was quite low with a total mean score of 3.2 and 95% confidence intervals of 1.13-5.27. The data in relation to scores for attention appeared to be non-normally distributed upon inspection of the tests of normality ($p < .001$) and the overall shape of the positively skewed, leptokurtic distribution. The mean amount of commission errors remained relatively constant across each of the 3 time intervals. 95% confidence intervals for impulsivity range from 15.67-20.41, which are moderate. The distribution of the data associated with scores on impulsivity appeared to be relatively normally distributed, this was determined upon review of the test of normality ($p > .05$) along with the Gaussian distribution present on a histogram, and the linear pattern observed on the QQ plot.

Table 2. *Displaying descriptive statistics for all continuous variables.*

	Mean (95% Confidence Intervals)	Std. Error Mean	Median	SD	Range
1-back block	30.56 (29.53-31.59)	.50	31	2.49	25-35
2-back block	30.20 (29.46-30.94)	.36	30	1.8	27-34
3-back block	29.28 (28.46-30.94)	.40	29	1.99	25-34
n-back Total	90.04 (88.18-91.90)	.90	90	4.5	80-100
Omission Errors 1000	1.60 (.35-2.85)	.61	1	3.03	0-13
Omission Errors 2000	1.08 (.26-1.90)	.40	0	1.98	0-8
Omission Errors 4000	.52 (.20-.84)	.15	0	.77	0-3
OE Total - Attention	3.2 (1.13-5.27)	1	1	5.02	0-23
Commission Errors 1000	5.36 (4.28-6.44)	.53	5	2.63	1-10
Commission Errors 2000	6.64 (5.77-7.51)	.42	7	2.13	2-11
Commission Errors 4000	6.04 (5.08-7.00)	.47	5	2.34	3-10
CE Total - Impulsivity	18.04(15.67-20.41)	1.15	18	5.73	7-29
Years Playing	2.48 (.54-4.42)	.94	0	4.69	0-15
Hours Practice Weekly	.80 (.06-1.54)	.36	0	1.8	0-7

Inferential Statistics

Independent Samples t-test

n-back Accuracy – Working Memory

An independent samples t-test was conducted to compare *n*-back accuracy rates between musicians and non-musicians. There was not a significant difference in accuracy between the two groups, t(23) = -.282, p = .78, two-tailed, with musicians (M = 90.5, SD = 6.77) scoring higher than non-musicians (M = 89.89, SD = 3.75). The magnitude of the difference in the means (mean difference = -.61, 95% CI: -5.05 to 3.84) was small (Cohen's d = .116).

Omission Errors – Attention

A second independent samples t-test was conducted to compare omission errors between musicians and non-musicians. There was not a significant difference in omission errors between the two groups, t(23) = .384, p = .704, two-tailed, with non-musicians (M = 3.42, SD = 5.35) scoring higher than musicians (M = 2.5, SD = 4.18). The magnitude of the difference in the means (mean difference = .92, 95% CI: -4.04 to 5.88) was small (Cohen's d = .193).

Commission Errors - Impulsivity

A third independent samples t-test was conducted to compare commission errors between musicians and non-musicians. There was not a significant difference in commission errors between the two groups, t(6.33) = .141, p = .892, two-tailed, with non-musicians (M = 18.16, SD = 5.09) scoring higher than musicians (M = 17.67, SD = 8.02). the magnitude of the difference in means (mean difference = .491, 95% CI: -7.91 to 8.89) was small (Cohen's d = .075).

Mixed Between-Within Groups Analysis of Variance (ANOVA)

n-back Accuracy – Working Memory

There were no outliers, as assessed by boxplot. The data was normally distributed, as assessed by Shapiro-Wilk's test of normality, ($p > .05$). There was homogeneity of variances ($p > .05$) and covariances ($p > .05$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity indicated that the assumption of sphericity was met for the two-way interaction, $\chi^2(2) = 1.826$, $p = .401$.

The main effect of *n*-back block did not show a statistically significant difference in n-back scores across the different blocks, $F(2, 44) = 3.069$, $p = .057$, partial $\eta 2 = .122$. The main effect of group did not show a statistically significant difference in *n*-back scores between the groups in different musical conditions, $F(2, 22) = .332$, $p = .721$, partial $\eta 2 = .029$. There was not a statistically significant interaction between conditions and blocks on scores, $F(4, 44) =.250$, $p = .908$, partial $\eta 2 = .022$. Results are displayed in Figure 1.

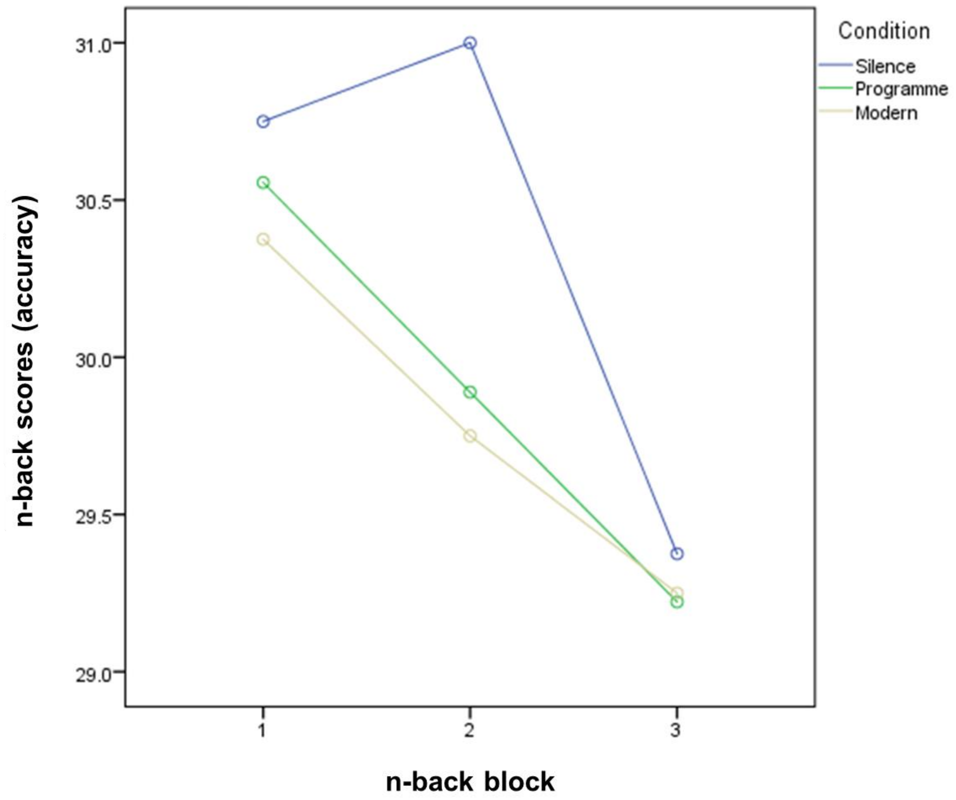

Figure 1. *Displaying distribution of accuracy scores between groups on n-back.*

Omission Errors - Attention

There were several outliers present, as assessed by boxplot. The data was not normally distributed, as assessed by Shapiro-Wilk's test of normality ($p < .001$). There was homogeneity of variances ($p > .05$) but not covariances ($p < .05$), as assessed by Levene's test of homogeneity of variance and Box's M test, respectively. Mauchly's test of sphericity indicated that the assumption of sphericity was not met for the two-way interaction, χ^2 (2) = 7.454, p = .024.

The main effect of CPT ISI did not show a statistically significant difference in Omission Errors at the different inter-stimulus intervals, F(1.54, 33.877) = 2.715, p = .093, partial η2 = .110. The main effect of group did not show that there was a statistically significant difference in Omission Errors between the groups in different conditions, $F(2, 22) = .822$, $p = .453$, partial $\eta^2 = .070$. There was not a statistically significant interaction between condition and inter-stimulus intervals on Omission Errors, $F(3.08, 33.877) = .990$, $p = .411$, partial $\eta^2 = .083$. Results are displayed in Figure 2.

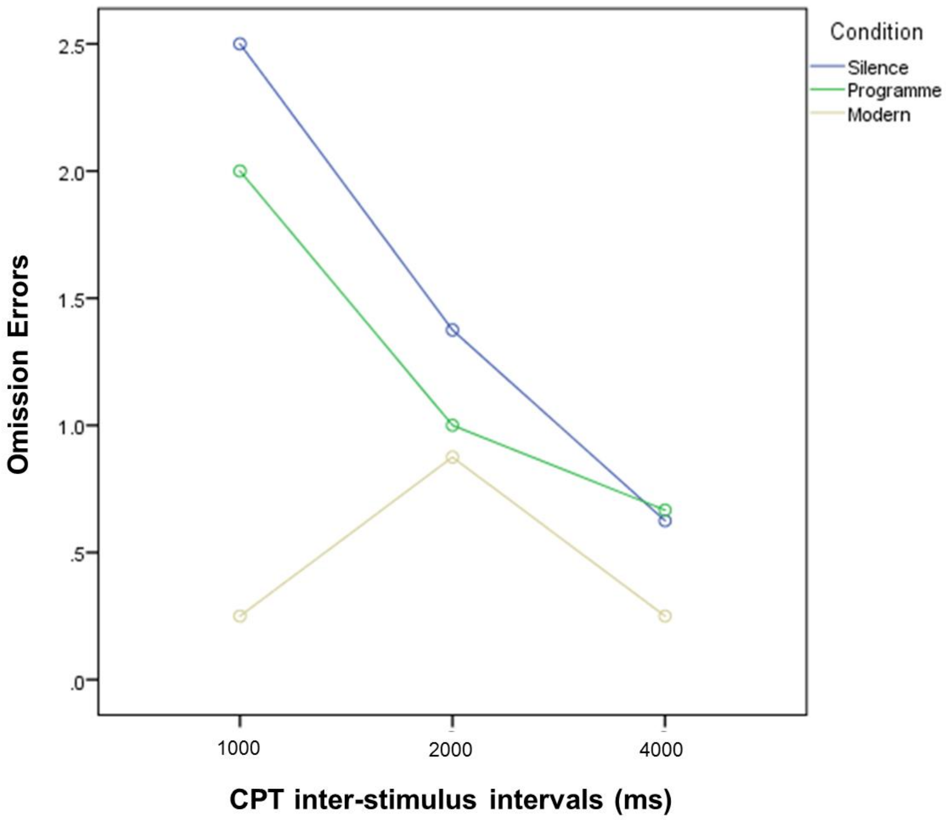

Figure 2. *Displaying distribution of scores between groups on Omission Errors.*

Commission Errors - Impulsivity

There were no outliers, as assessed by boxplot. The data was normally distributed, as assessed by Shapiro-Wilk's test of normality, ($p > .05$). There was homogeneity of variances ($p > .05$) and covariances ($p > .05$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity indicated that the assumption of sphericity was met for the two-way interaction, $\chi^2(2) = 1.073$, $p = .585$.

The main effect of CPT ISI showed a statistically significant difference in Commission Errors at the different inter-stimulus intervals, $F(2, 44) = 3.568$, $p = .037$, partial $\eta 2 = .140$. The main effect of group did not show that there was a statistically significant difference in Commission Errors between the groups in different conditions, $F(2, 22) = .994$, $p = .386$, partial $\eta 2 = .083$. There was not a statistically significant interaction between condition and inter-stimulus intervals on Commission Errors, $F(4, 44) = 1.135$, $p = .352$, partial $\eta 2 = .094$. Results are displayed in Figure 3.

A Bonferroni post hoc test revealed a borderline significant difference ($p = .057$) in commission errors between inter-stimulus intervals of 1000ms and 2000ms. There was not a significant difference ($p = .497$) in commission errors between ISI 2000ms and 4000ms. There was not a significant difference ($p = .603$) in commission errors between ISI 1000ms and 4000ms.

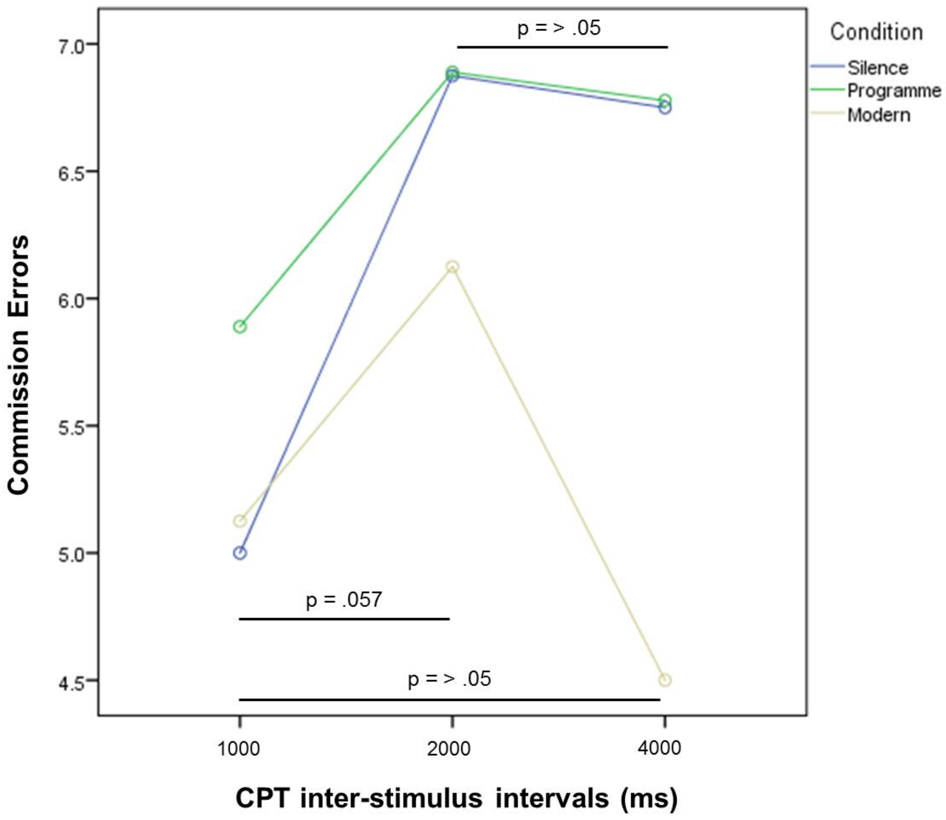

Figure 3. *Displaying distribution of scores between groups on Commission Errors.*

Discussion

The current research aimed to investigate the effects of programme music on attention and working memory performance, employing the use of both instrumental modern music and no-music control conditions. Two research hypotheses were investigated. The first hypothesis stated that exposure to programme music would result in higher scores on performance in attention, in comparison to performance observed when exposed to modern instrumental music or silence. The second hypothesis stated that listening to programme music would yield higher accuracy scores on performance in working memory compared to scores obtained whilst listening to modern instrumental music or silence. An exploratory investigation into the effects of musical training on performance in attention and working memory was also carried out.

The results obtained by the current study did not support the first hypothesis, whereby there was no significant difference in performance between the programme music, modern instrumental music and no-music conditions in relation to levels of attention. Regarding the second hypothesis, the results did not provide evidence to support it, as there was no significant difference in accuracy rates on the working memory task between the programme, modern and silence conditions. In relation to the second variable which was measured by the CPT, there was no significant difference between each of the musical conditions on impulsivity levels. However, there was a significant main difference observed for the effect of inter-stimulus intervals on impulsivity levels, which was unexpected. There was no significant difference between musicians and non-musicians on attention, working memory and impulsivity levels. The results concerned with impulsivity and musical training were examined on an exploratory basis and were not hypothesis driven in nature.

Attention

Exposure to music was not found to have an influence on attention levels, irrespective of music type. No differences in omission errors were detected between the two music conditions and the no-music control. Inter-stimulus intervals varying by milliseconds also failed to have any significant effect on attention. Albeit the lack of statistically significant results, there were certain trends in performance visible upon inspection of the graph (Figure 2.). Attention levels remained relatively similar for both the programme music and no-music group, with less errors being made as the inter-stimulus intervals increased in milliseconds. The modern instrumental music group however, made less errors overall across the changing ISIs than those in the programme music and silence control groups. Although relationships cannot be inferred from these results, the modern music group displayed slightly higher levels of attention than the programme and no-music groups.

The findings associated with the current study are not consistent with the existing literature, which previously reported that music may have a positive influence on attention levels (Morton, Kershner & Siegel, 1990; Huang & Shih, 2011; Riby 2013). According to the arousal and mood hypothesis, the elevation of mood and arousal levels brought upon by listening to music, may have a positive effect on performance related to certain cognitive processes, (Nantais & Schellenberg, 1999; Schellenberg, 2001, 2005; Thompson, Schellenberg & Husain, 2001; Husain, Thompson & Schellenberg, 2002) including attention (Fredrickson, 2004; Fredrickson & Branigan, 2005). However, some research has suggested that music which is fast-paced and overly arousing may have a negative effect on attentional abilities (Borling, 1981; Wakshlag, Reitz & Zillmann, 1982). A significant effect was not found in either direction in the present study, however the group exposed to programme music made slightly more omission errors than the group who listened to modern music, perhaps this may have been due to the programme music possibly being too arousing, which may have had a negative effect on attentional levels. This suggestion is entirely speculative in nature, and further research is required.

Working Memory

Although the results associated with the effect of music on working memory were not significant, there were some slight trends in the data which were evident upon review of Figure 1. Results related to the 1-back block show that all three groups were relatively similar in relation to accuracy on the task. Accuracy rates on the 2-back block decreased slightly for both the programme and modern instrumental music groups. However, there was a slight increase observed by the no-music control group. By the 3-back block, all three groups decreased in accuracy on the working memory task, as expected. These trends were extremely small and the differences in accuracy rates between the groups were not significant, however it would appear that the no-music control group performed marginally better than the two groups which were exposed to music.

The current study did not find any relationship between exposure to music and working memory performance. This result was not in line with the existing literature investigating the influence of music on working memory capabilities, as predominantly positive effects have been reported by the previous research (Morton, Kershner & Siegel, 1990; Sun, Wei & Yue, 2011; Riby, 2013; Gu, Zhang, Zhou & Tong, 2014). The reason for this may also have been due to arousal levels, as Hallam, Price & Katsarou (2002) concluded that music which was loud and stimulating had negative effects on working memory, whilst calming music promoted increased memory performance. Similar to the possible effects on attention levels, it may be speculated that the arousal level associated with the music employed by the current study was too high, and subsequently did not have the positive effect expected on working memory, which may be consistent with the slight trends which were observed within the data.

Impulsivity

Unexpectedly, a significant main difference in impulsivity levels was found between the millisecond inter-stimulus intervals of the CPT. However, similar to the two previously discussed dependent variables, no significant effect was found for the type of music on amount of commission errors. A borderline significant effect was present between the ISIs of 1000ms and 2000ms, whereby impulsivity levels increased for all three groups. The trends present in Figure 3 demonstrate a marginally better performance by the modern music group, as the amount of commission errors remained less overall compared to the programme music and no-music groups, which were very similar. The trends in differences in performance between the groups were extremely small and non-significant, thus no effects of music on impulsivity levels can be inferred. As aforementioned, this finding was unexpected and made part of an exploratory investigation. There is a gap in the literature surrounding the possible effects of music on levels of impulsivity, also concerning the effects of inter-stimulus intervals on impulsivity when exposed to music, which future research should look to address.

Musical Training

As part of an exploratory analysis, musical training was not found to have an effect on performance associated with either attention, working memory or impulsivity. Differences in scores were miniscule, albeit favouring the musicians group on all three dependent variables, and effect sizes were diminutive. These findings were not consistent with the previous literature, which suggests that musical training and practising an instrument is beneficial to cognitive functions including, but not limited to, attention and working memory (George & Coch, 2011; Hou *et al.*, 2014; Bergman Nutley, Darki & Klingberg, 2014; Wang *et al*., 2015; Talamini, Caretti & Grassi, 2016).

Major Implications

The current study expands upon the existing literature which encompasses the effects of music on the cognitive processes associated with learning, primarily attention and working memory. It also brings into focus the gap in the literature surrounding the potential effects of programme music on aspects of cognition, and the effects of music on impulsivity. No meaningful relationships can be inferred as a result of this research, however certain trends in the data may be suggestive of small effects, which may become present upon further extensive research.

Limitations

There were numerous limitations associated with the present study. The primary limitation is in relation to sample size, as the number of participants who took part in this study was inadequate to detect any potential effects between the variables. This was predominantly due to time constraints, as participants were tested individually and the experiment took approximately 45 minutes to complete. This required considerable dedication from the participants, as rewards for participation were not offered due to a lack of funding. Secondly, the Continuous Performance Test was not an ideal computerised task to measure levels of attention, as the probability of making a substantial amount of omission errors was quite small. The participants reported that the music was distracting in relation to their concentration on the tasks involved in the experiment, this may have been due to the volume of the music, which may have been too loud and thus may have hindered performance. As mood and arousal levels were not measured as a component of this research, it was potentially impossible to determine any possible causal relationships between the variables.

The the fact that there was no break in between the CPT and the *n*-back may have also influenced the results, as the participants reported feeling mildly stressed directly following the experiment, which may have prompted negative effects on performance. Confusion surrounding the instructions relating to completion of the *n*-back task was also prevalent among the participants, even after completing the practise trials. Perhaps an amendment to the PEBL program to include a small number more practise trials would aid to dispel any uncertainty regarding how to complete the task. Considerations relating to the practise effect present in this task should also be taken into account.

Future Recommendations

There are a number of recommendations for future research which arise from the completion of the current study. Further investigation into the potential effects of programme music on cognitive function should be examined in relation to various other processes which are involved in learning. Reliable measures of mood and arousal should also be employed in order to investigate the mediating factors surrounding the potential effect of music on aspects of cognition. Aside from exclusively investigating older styles of music such as classical and romantic, an emphasis should be put on exploring the effects of modern music on learning, as this is the genre most prevalent within the general population. This study also demonstrated slightly higher performance on the cognitive tasks from the modern music group, however relationships cannot be inferred from these results which demonstrates the need for further research relating to this subject. Research should be carried out which investigates the effect of music and inter-stimulus intervals on impulsivity as there is a gap in the literature concerning this topic, and this study has shown that there may be a relationship present between these variables. The effects of formal musical training on the development of cognitive functions should also be considered as a topic for future research, as previous literature has suggested that a relationship may be present. However, this should be explored further in order to ascertain whether the observed effects are consistent and hold validity. The aforementioned limitations should also be taken into consideration for any future research similar to the present study.

Conclusion

The current study aimed to examine the effects of programme and modern instrumental music on attention and working memory, in order to investigate the possible benefits of music in a study atmosphere. The results of this study did not reveal any reliable positive effects of the music on the aforementioned cognitive processes, which are heavily involved in the learning process, as was hypothesised. By the means of an exploratory investigation, inter-stimulus intervals were found to have a small effect on impulsivity levels, however, further research is required in order to interpret these findings. An investigation into compared performance levels between musicians and non-musicians did not reveal any differences between the groups, which contradicted the previous literature surrounding the topic.

Overall, the present research has added to the existing literature regarding the effects of music on cognitive processes, and has also served to highlight topics of potential importance for future research in this area. In conclusion, the mediating factors associated with why music has an influence on cognition have yet to be fully understood, however perhaps future researchers should leave Mozart to rest and turn the attention to the effects of modern music on cognitive function, as exposure to such has become an established part of daily interaction in society.

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Appendices

Appendix A

Participant Information Sheet

An Investigation into the Effect of Programme Music on Attention and Working Memory

You are being invited to take part in a study which is investigating the effects of programme music and modern instrumental music on attention and working memory as part of an undergraduate dissertation in the National College of Ireland. This study has been approved by the NCI ethics committee for research with human participants. There are no known ethical risks to you or associated to your participation in this study. Your participation in this study is completely voluntary.

What participation in this study entails:

In this study you will be asked to complete a number of computerised tasks whilst listening to one of three conditions, which are programme music, modern instrumental music or silence.

- The first computerised task which you will be asked to complete is called the Continuous Performance Test and it measures attention. The task is 14 minutes long and requires you to watch the screen as letters will flash at different intervals. You will be asked to press the spacebar each time any other letter of the alphabet appears apart from the letter X.

- The second computerised task which you will be asked to complete is the *n*-back, which measures working memory. This task has several levels and uses letters and squares. In the 1-back version, you must press the shift key when the new stimulus matches the one that was shown immediately before. In the 2-back version, you must press the shift key when the same stimulus occurs two trials before, which means skipping the trial immediately before. In the 3-back version, you must press the shift key when the same stimulus occurs three trials before, which means skipping the two trials immediately before. There will be several practice trials and detailed instructions given on the computer prior to the beginning of the task itself.

The allocated type of music which you will be listening to will be played from when you begin the tasks until you finish both tasks. The condition in which you will be placed will be chosen at random.

The study should take approximately 30 minutes to complete and will be contained in one session.

Participant's rights:

You have the right to withdraw from the study at any time without penalty or explanation. You also have the right to ask that any data that you have provided be withdrawn or destroyed.

You have the right to refuse to answer any question that is asked to you and the right to omit from completing any tasks that are asked of you without penalty.

You have the right to ask questions about any of the procedures involved in this study. If you have any questions regarding the content of this information sheet, please inform the researcher prior to the beginning of this study.

Any data that you provide will be completely anonymous and will not be traced back to you in any way. As a participant ID system is being used, you will not be required to provide any information that could potentially identify you using the data that you have supplied. With regard to dissemination, upon completion this study may be made available to the public on the National College of Ireland Thesis Institutional Repository (TRAP) through the library.

Appendix B

Informed Consent Form

An Investigation into the Effect of Programme Music on Attention and Working Memory

This study is investigating the effects of programme and modern instrumental music on attention and working memory through two computerised tasks, those being the Continuous Performance Test and the *n*-back. The tasks will be completed in one of three conditions, listening to a piece of programme music, listening to a piece of modern instrumental music or in silence. The condition will be chosen at random.

By signing this consent form you acknowledge that:

- You have fully understood the content contained in this information sheet in its entirety.
- Any questions you may have had regarding this information sheet and any aspect of the study have been answered accordingly.
- Your participation in this study is completely voluntary and you have the right to withdraw at any time without penalty.

Participant's Signature

Date

<u>Appendix C</u>

Participant Questionnaire

Please fill out this short form and return it to the researcher prior to the beginning of the experiment

Participant ID: ______________________

Gender: ___________________________

Age: ______________________________

*****The following questions relate to a musician defined as someone who can play at least one musical instrument at **<u>higher</u>** than a beginners standard

Are you a musician? (Y/N) ____________

If yes, how many instruments do you play?(higher than a beginners standard)

____

How many years have you been playing music regularly? _______________

How many hours of practise a week? _______________