

Personality and Tempo: Exploring the Relationship Between Music and Cognition

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I. INTRODUCTION

In contemporary American society, music is more present and readily available than ever before. In a time where music can so easily be accessed through a variety of different sources, the need to understand the impact of music on cognitive functioning becomes increasingly important. The effects of music on cognitive functioning have been of interest to three types of researchers: applied psychologists interested in whether the presence of music can increase productivity while completing cognitive tasks, cognitive psychologists in studying how the presence of music affects attention and processing; and personality theorists in studying how types of personalities differentially respond to musical stimuli (Furnham 1999). While the cognitive impact of music has been studied by various credible researchers, there is a lack of significant research exploring the cognitive impact of music on a high school student population. There is evidence that music differentially impacts the physiological responses of premature infants and the activity levels of children aged three to four, but highschool student populations remain largely unexplored (Kotsopoulou, Hallam 2010). Music is more prevalent in high school populations than perhaps any other group in the United States, with an overwhelming number of students frequently opting to complete homework or study course material while listening to music. As a member of the highschool student population who bears witness to peers constantly studying material and completing homework while listening to music, my experiment is significant in determining whether music is helpful or a hindrance for my peers' cognitive functioning. Beyond simply determining the impact of music on cognitive functioning, this experiment combines and expands upon research from various credible researchers to explore the relationship between levels of extraversion and cognitive task performance in the presence of

music, and the differential impact of tempo level of music on cognitive performance. In other words, this experiment seeks to answer the question: does music tempo impact the cognitive functioning of introverts and extroverts differently?

II. LITERATURE REVIEW

The Differential Response of Introverts and Extroverts to Musical Stimuli

It has long been questioned whether people of differing personality types respond differently to musical stimuli. The prevailing hypothesis is that introverts, people who are more shy and reticent, have a negative cognitive response in the presence of music (Furnham 1999). Extraverts, people who are more outgoing and overtly expressive, are expected to have increased or unchanged cognitive performance in the presence of music (Furnham 1999). Adrian Furnham, a renowned applied psychologist and professor at University College London, conducted research confirming this hypothesis, finding that while in the presence of musical stimuli, introverts performed markedly worse on both short term immediate recall tasks and reading comprehension tasks compared to when the tasks were completed in a silent condition (Furnham 1999). Contrary to Furnham's hypothesis, however, was the fact that extraverts also had decreased performance when performing the cognitive tasks with musical stimuli, although cognition was marginally less decreased when compared to the test performance of introverts (Furnham 1999). Furnham's research suggests that, especially for introverts, functions such as memory and reading comprehension decrease in the presence of background music, implying that introverts have different optimal study methods than extroverts, and thrive better in quiet and controlled environments (Furnham 1998).

While Furnham's research appears to confirm that introverts perform worse under musical conditions, research from Matias complicates this conclusion. 49 participants of varying ages designated as introverts and extroverts (27 extraverts and 22 introverts with ages ranging from 18 to 69 years old) completed memory tasks in the presence of silence, simple music, and complex music (Matias 2014). For the memory task, participants were given a list of word pairings which they had 4 minutes to study while under the influence of the three different listening conditions: silence, simple music, and complex music (Matias 2014). The results of the memory test indicated that there was no significant effect of level of extraversion on memory, as introverts and extroverts scored similarly well (Matias 2014). These findings complicate the findings of Furnham's and cast doubt on the true effects of personality type on cognitive functioning.

While the findings of Matias and Furnham yield different conclusions about the relationship between level of extraversion and cognitive responses to music, research done by McKelvie seems to substantiate the findings of Furnham. McKelvie found that introverts opt to listen to music while studying much less than extroverts, citing decreased attention span and retention rates while studying with music (McKelvie 2002). Additionally, introverts are far more likely to listen to the music at a lower volume than extroverts (McKelvie 2002). While McKelvie's study doesn't explicitly prove that introverts have decreased cognitive functioning in the presence of music, it can be hypothesized that their choice to utilize music less in an academic context is due to a marginal decrease in their cognitive ability when music is present. Furthermore, tests conducted by McKelvie in silent conditions revealed that introverts, at least in this focused study of randomly selected undergraduate students, were naturally operating at a

higher level of cognitive arousal; extraverts' cognitive levels were markedly lower in the silent condition when compared to introverts. This finding suggests that extraverts may employ music as a source of arousal to elevate their naturally low levels, whereas introverts rarely do so since they are already functioning in a higher range (McKelvie 2002). Further substantiating McKelvie's findings about the differential study habits of introverts and extroverts is another independent test done by Adrian Furnham that showed that there was a significant difference between introverts and extroverts with respect to how often they listen to music whilst working, with indications showing that extraverts listen to music significantly more often than introverts (Furnham 1998). While work by Matias and Furnham contradicts the claims that the presence of music enhances cognitive performance, it is clear that extraverts, specifically the ones tested in McKelvie's study and Furnham's independent test, *believe* the presence of music leads to greater cognitive arousal (McKelvie 2002).

This topic of the *perceived* impact of music on cognitive levels compared to the *actual* impact of music has been explored by various researchers. During a research experiment testing this phenomenon of the actual versus perceived effects of music, participants were instructed to write creatively while listening to music; their papers were then graded for writing ability and creativity. One group was assigned a listening condition of "exciting" music, another was assigned "calming" music, while the last group worked in silence (Hallam 2015). Additionally, participants who were in the music conditions were required to fill out a questionnaire asking them how the music made them feel along with how they perceived the music would impact their writing performance. The results were then recorded into multiple tables that referenced the participant's perception of music and how it impacted their creative writing (Hallam 2015).

There was a significant difference in the writing scores among the three groups of tested students, particularly between the exciting music group compared to the silent and calming music groups. The students in the exciting music group performed the worst, while the students in the calming music and silent condition performed approximately equally. The data collected revealed significant differences between the groups in aspects of writing which appeared to require planning and creative cognitive processing rather than learned writing skills, suggesting that differences between the groups were a result of the cognitive response to the music condition (Hallam 2010). In terms of the perceived impact of the music on the subject's writing ability, the participants in the exciting music group were more likely to report that the presence of the music would help their creative writing ability compared to the students in the calming music category (Hallam 2010). These differences in the perceived impact of music and the actual effects of music highlights a disparity and misconception on the impact of music on cognitive ability. Based off the majority of studies examined, music seems to function as more of a distractor than an enhancer of cognitive ability, yet subjects are likely to believe that faster, more exciting music enhances their cognition.

The Role of Distraction in Cognitive Performance

Many researchers believe that music, or any background noise, primarily functions as a distractor and subsequently leads to decreased cognitive functioning. This hypothesis was tested by Belojevic in an experiment consisting of the administration of a mathematical test completed in the presence of different forms of background noise. A mathematical test was designed based on simple arithmetic, and test subjects were placed in rooms of varying background noise (Belojevic 2010). Urban street noise was recorded and played to participants in the noise rooms,

with 5-6 participants in each room. Along with the mathematical questions, the participants filled out a survey asking to what degree they felt distracted by the background noise, and a short term memory test was conducted as well (Belojevic 2010). The results of introverts and extroverts were compared, and the results showed that introverts were much more likely to report being distracted during noise conditions than extroverts, and a highly negative correlation was found between the personality traits of extraversion and annoyance during mental processing in noise (Belojevic 2010). These results are concurrent with Eysenck's conclusion that extroverts are much more capable of focusing and being mentally engaged in environments with potentially distracting stimuli (Belojevic 2010). Agreeing with this finding is an independent test done by Furnham which found that introverts were much more likely than extroverts to perceive background noise as a distractor when completing cognitive tasks (Furnham 1998). Despite this difference in perception, the test scores between introverts and extroverts in Furnham's experiment were almost identical (Furnham 1998).

An experiment done by Speer lends further insight into Furnham's findings, with Speer concluding that the attitudes of participants towards music as a distractor played a key role in their performance on the task (Speer). If the subject believed that the music would distract them, they performed worse in the music condition, and vice versa (Speer). It is important to note, however, that the raw data from Speer's study indicate that participants had increased cognitive performance scores under the music condition than under both the speech and silence conditions (Speer). This seems to go against the belief of many researchers that music almost always serves as an inhibitor, not an aid, to cognitive functioning. Complicating the findings of Furnham and Speer is a study done by Chamorro-Premuzic. Participants completed the Baddeley Reasoning

Test, sections of the scholastic aptitude test (SAT), the alternate uses test, the Neuroticism-Extraversion-Openness Five Factor Inventory test, and a post-test questionnaire under different listening conditions (Chamorro-Premuzic 2009). The listening conditions ranged from general office noise to hip hop music. The findings of this study found that while speech and office noise seemed to have similar impacts on each personality type, extraverts performed markedly better than introverts when completing tasks in the presence of musical stimuli (Chamorro-Premuzic 2009). Results showed no significant correlations between level of Extraversion and how distracting participants found dialogue speech, music, or noise. However, there was a significant positive correlation between Extraversion and one's probability of studying with background music (Chamorro-Premuzic 2009). Clearly there are significant differences in the findings of researchers concerning how music differentially distracts introverts and extroverts. Research by Dove suggests that the level of distraction one feels actually has less to do with extraversion, than it does with each subject's level of academic achievement (Dove 2009). Dove's experiment consisted of the administration of cognitive tests under differing distraction conditions. These tests examined multiple cognitive functions, such as reading comprehension, language skills, concentration, spatial orientation and problem solving (Dove 2009). Tests were completed with stimulating background music, sedative background music, and no background music present (Dove 2009). The results suggested that academic achievement is the primary factor that ties into test performance, not introversion or extraversion, as speculated by Furnham and others (Dove 2009). On the other hand, research done by Freeburne found that there is no significant relationship between level of intelligence and the influence of music distraction upon either rate of reading or reading comprehension (Freeburne 1952). This

clearly contradicts the research done by Dove, and leaves the topic of musical distraction very ambiguous and open to further research.

Cognitive Impact of Music of Low Tempo (60 BPM) VS High Tempo (140 BPM)

A topic of interest that hasn't been researched extensively is the difference between music of low tempo (60 bpm or less) vs high tempo (140 bpm or less) in terms of its effects on cognitive functioning. An experiment done by Mayfield tests the different effects these music types have on cognitive performance. Undergraduate students were asked to look up and record closing stock prices from the Daily Stock Price index and then calculate percentage changes for each week (Mayfield 1989). The undergraduates were split up to complete the tasks in three different conditions: a control condition in which no music was played, experimental Condition 1 in which slow-paced (approximately 60 beats/min.) music was played, and experimental Condition 2, in which fast-paced (approximately 140 beats/min.) music was played (Mayfield 1989). The performance was measured by counting how many boxes on the stock-pricing-coding sheet were completed, and qualitative performance was measured by determining the percentage of correct answers on the stock-price-coding sheet (Mayfield 1989). The students in the faster paced music condition more frequently reported being distracted than the students in the slow paced music condition (Mayfield 1998). In terms of performance, the fast paced condition group significantly outperformed the slow paced group, while the fast paced group and control group has approximately similar performances (Mayfield 1998). These results are strange as the people in the fast paced group reported being more distracted than the slow paced group, yet still

significantly outperformed them (Mayfield 1998). Confirming Mayfield's study is an experiment done by Husain testing the cognitive impact of music of low and high tempos. Husain administered a spatial-visual test designed to test cognitive functioning to 36 undergraduate students, and had the students complete the test in music conditions of low tempo (60 BPM) and high tempo (140 BPM). The experiment found significantly increased performance on the spatial-visual test in the presence of high tempo music when compared to the low tempo condition (Husain 2002). My research plans to expand on the research of Mayfield of Husain and either confirm or reject their findings.

Hypothesis

After analysis of foundational sources, the researchers of this experiment hypothesize that both high tempo (140 BPM) and low tempo (60 BPM) music will impair the cognitive ability of participants when compared to a silent, control condition. Additionally, we hypothesize that while both personality types (introverts and extroverts) will have decreased cognitive functioning in the presence of music, extroverts will have less of a decrease in cognition than introverts while listening to high tempo music. On the other hand, introverts are expected to have less of a decrease in cognition than extroverts while listening to low tempo music. When comparing introverts to themselves, we hypothesize that introverts will have higher cognitive functioning while listening to low tempo music than while listening to high tempo music. When comparing extraverts to themselves, we hypothesize that extraverts will have higher cognitive functioning while listening to high tempo music compared to the low tempo music. Overall, we believe that both introverts and extroverts will have decreased cognition when in the presence of music, regardless of tempo.

III. METHODS

Population

Participants were selected from Granada Hills Charter High School, a public, four year institution located in Southern California's San Fernando Valley. Granada Hills Charter High School (GHCHS) is a highly diverse, middle-income campus, with a median household income of \$74,222. GHCHS is also co-ed with its large student population (4480 students) consisting of fifty percent females and fifty percent males. The diverse, middle income, suburban features of GHCHS allow the experimental data gathered to be easily generalized to a large number of United States High School populations.

Sample Selection

Participants were selected through a stratified random sample based upon the gate through which they enter school. Students were proportionally selected from each gate, meaning that the percentage of students selected for the experiment was directly proportional to the percentage of students who enter school through that entrance each morning (Figure 1). All four grades (freshman through seniors) were considered in the sample selection process. After the selected students gave their consent, they were asked to provide their school email where they were sent the dates of the experiment, the classroom where the experiment would take place, and details of what they would be required to bring on the date of the experiment. Using this sample selection method, sixty-four participants were selected and participated in the experiment.



Source: GHC Website

Figure One

Materials

Chromebooks: All GHCHS students are issued chromebooks. The chromebooks were used for administration of the Eysenck personality questionnaire and for contact of participants prior to the experiment to notify them where and when the experiment was taking place.

Classroom: A classroom was provided by a faculty member of GHCHS. The classroom was used as the building within which the experiment was conducted.

Music Speaker: A JBL portable speaker was used to play the high tempo and low tempo music. The speaker was placed in the front of the experiment room and each participant was equidistant from the source of music to ensure each participant was affected equally by the presence of music.

Implementation

The experimental design of this experiment was closely modeled after independent tests by Furnham, while incorporating the low and high tempo music aspects of Husain's experiment. Subjects were informed that the experiment is confidential and participation can be ceased at any time. The participants were first administered the Eysenck personality questionnaire to be completed on their chromebooks. The Eysenck personality questionnaire consists of 25 questions that are answered using a likert scale, where participants rate their response to the question from strongly disagree to strongly agree. The questionnaire designates participants as either introverts or extroverts based on their responses(Furnham). The semi-interquartile range of scores on the questionnaire was used to select participants who had high and low extraversion scores. Participants were given three minutes to complete the questionnaire, more than enough time to finish.

Participants were then required to complete three cognitive tasks. All three tests administered were immediate visual recall tests (IVRT) modeled after the British Ability Scales range of tests. Participants were given a piece of paper with 15 pictures of everyday objects, such as a car or an apple, and were given one minute and thirty seconds to memorize as many of the objects as they can. Once one minute and thirty seconds passed, the papers with the images were collected from the group of participants. The participants were then required to list as many of

the objects as they could on a separate piece of blank paper provided to them. The participants were given one minute and 30 seconds to write down as many images as they remember, and each correct object listed was worth one point. There is no way to have any points deducted, and the highest score possible was 15, with all 15 images listed correctly. The three immediate recall tests were very similar, with the only difference being the everyday objects on the papers.

The three tests were completed in different listening conditions. Two types of music were used for the study. The first music type was music of high arousal, which is classified as music with a tempo exceeding 140 beats per minute. The second type of music played was music of low arousal, which is classified as music with a tempo below 60 beats per minute. In order to situate the experiment in the most modern context possible, each song played had lyrics, as it is most common for high school students to study while listening to lyrical music. The duration of each musical selection (low arousal and high arousal) was approximately 5 minutes: long enough to last for the duration of the memory process, the collecting of the visual recall papers, and the writing down of the images. The recording of the exact same music was used for each participant of the experiment. The order of assignment of each visual recall test was randomized to ensure that no effect of fatigue or residual distraction could confound the results of the experiment. One visual recall task was completed in silence, another task while listening to music of low arousal (60 beats per minute), and another with music of high arousal (140 beats per minute). The subjects listened to the music from a portable JBL speaker equidistant from each participant. Completing all three cognitive tests took no longer than 20 minutes. In all, the experiment took approximately 30 minutes to complete. After each cognitive test was completed, participants were debriefed, and thanked for their participation.

IV. RESULTS

There were three predictors analyzed that, in theory, could affect participants cognitive functioning: level of extraversion, music tempo, and the presence of music versus silence.

Table 1. The means and standard deviations for introverts and extraverts for each of the tests under each condition

Treatment condition	Introvert			Extravert		
	Mem. 1	Mem. 2	RC	Mem. 1	Mem. 2	RC
Music						
Mean	14.4	10.8	6.2	15.6	15.6	9.2
SD	2.61	2.39	1.48	2.19	2.19	1.10
Music off						
Mean	14.8	14.4	9.0	13.6	13.6	9.6
SD	3.03	2.70	2.00	2.70	1.79	1.67

Mem. 1 is the short-term memory recall score; Mem. 2 is the recall score after 6 minutes; RC is the reading comprehension multiple-choice answer score.

Table 1

Table 1 shows the difference in mean scores and standard deviations on the IVRT for music vs silence for Adrian Furnham's experiment. Level of extraversion is considered as a variable and was determined using the Eysenck personality questionnaire. Furnham's experiment deals only with two listening conditions: music and silence.

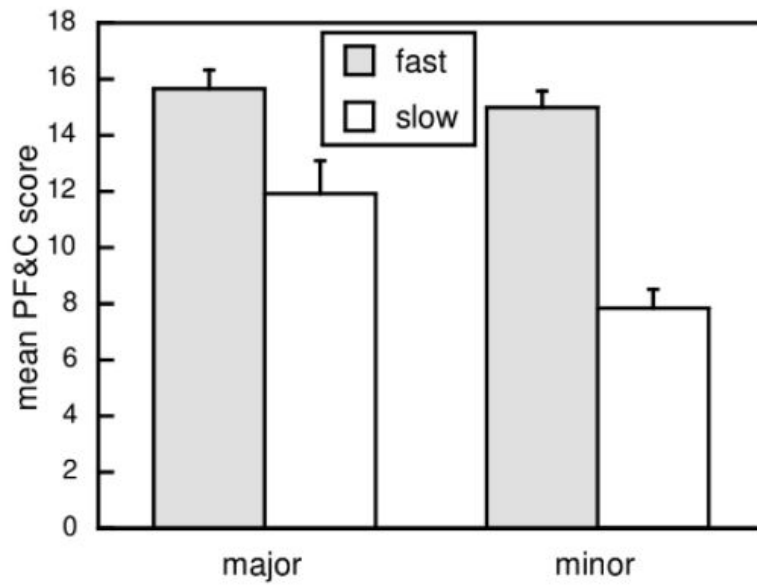


Table 2

Table 2 analyzes the mean difference in IVRT scores in high tempo vs low tempo music from Hussain's experiment. Hussain's experiment does not deal with levels of extraversion, but instead deals only with the difference in IVRT scores for music of high and low tempo.

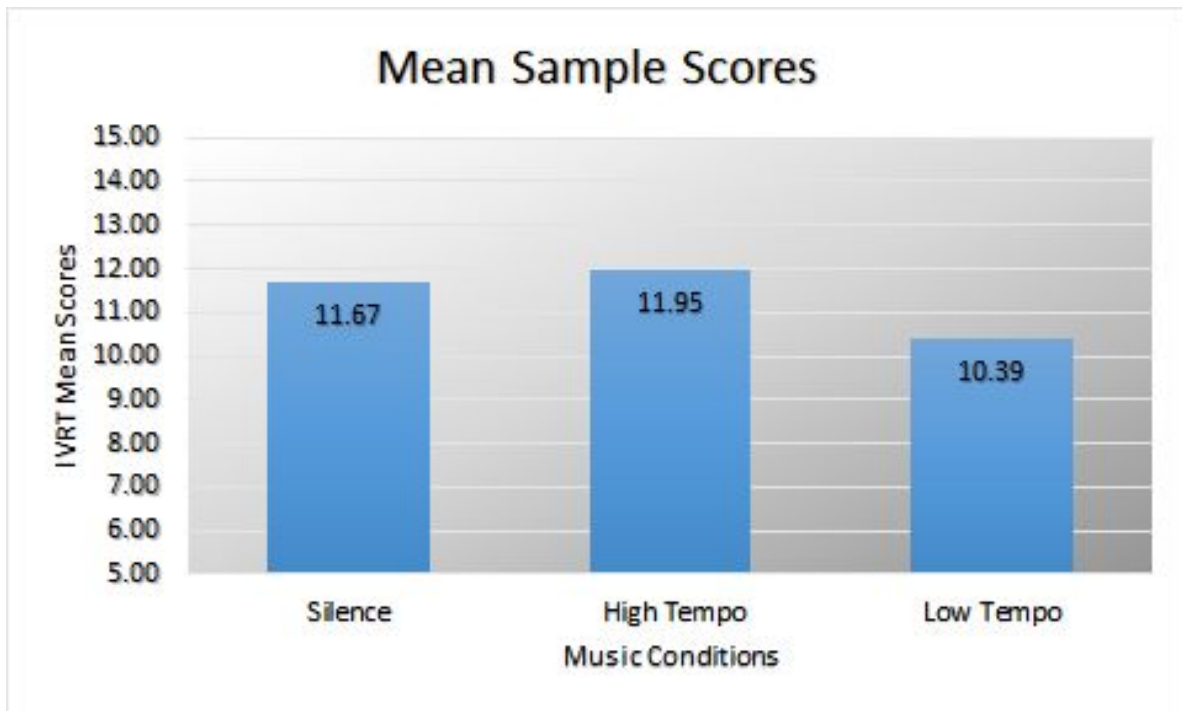


Table 3

Table 3 compares the differences in means for each musical condition in my experiment. Three musical conditions were considered for my experiment: silence, low tempo, and high tempo. Scores were collected using a one through fifteen grading scale. A score of fifteen means that the student correctly listed all fifteen images on the IVRT, while a score of 0 means the student did not list any images correctly. The use of three listening conditions, including silence, is a combination of experiments from Hussain and Furnham and seeks to reconcile their findings with one another.

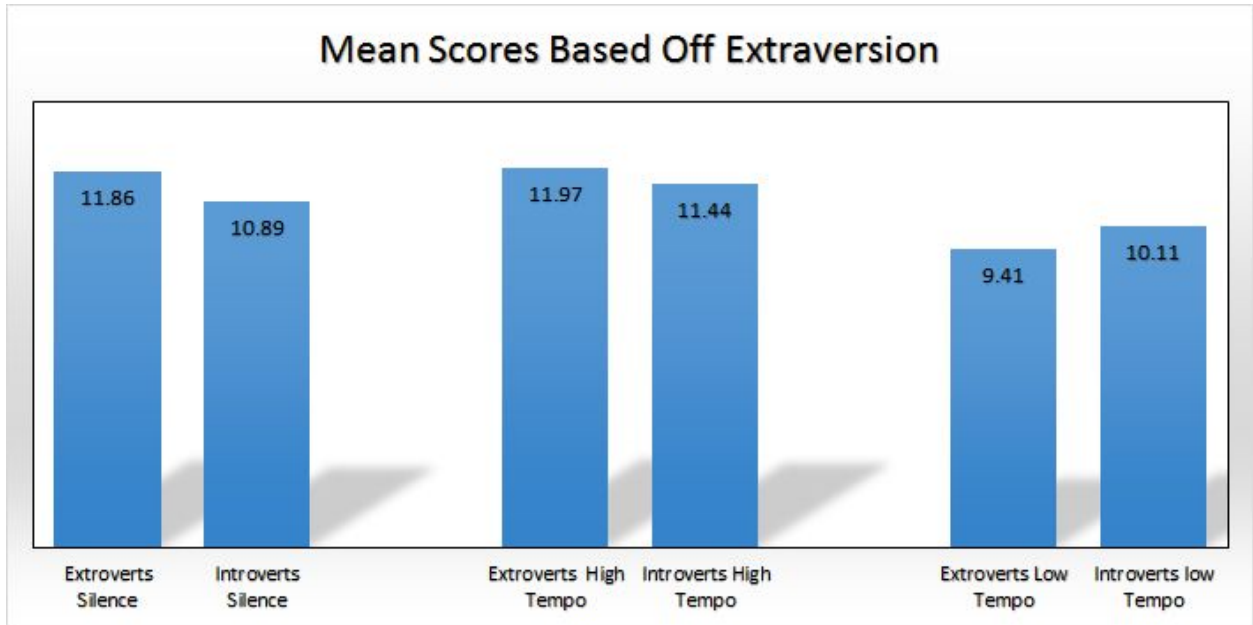


Table 4

Table 4 compares the mean scores of introverts and extroverts in different music conditions.

Level of extraversion was calculated using the Eysenck personality questionnaire. Each student completed three IVRTs in three listening conditions: silence, high tempo music, and low tempo music. The consideration of level of extraversion, music tempo, and silence versus music effectively incorporates and combines elements of Furnham's and Hussain's experiments.

V. DISCUSSION

Table 5 summarizes the differences in mean scores on the IVRT in different music conditions and includes Pearson's correlations for significance.

Compared Means	Mean 1	Mean 2	P-Value	Statistically Significant?
Pop Silence Vs Pop High tempo	11.67	11.95	0.13	No
Pop Low Tempo Vs Pop High Tempo	10.39	11.95	0	Yes
Pop Silence vs Pop Low Tempo	11.67	10.39	0	Yes
Introverts Silence Vs Extravert Silence	10.89	11.86	0.82	No
Introverts High Tempo vs Extravert High Tempo	11.44	11.97	0.04	Yes
Introvert Low Tempo Vs Extravert Low Tempo	10.11	9.41	0.01	Yes

Table 5

As seen in the table above, four of the six conditions tested yielded statistically significant results.

Introverts and extroverts in Silence

After analyzing the mean scores of introverts and extroverts in the silence condition for the IVRT, Pearson's correlations revealed a lack of a statistically significant difference between the two groups. This corroborates the findings of Furnham, who concluded no main effect of introversion/extroversion on cognitive performance for silent conditions (Furnham 1998). Additionally, this finding reveals no significant difference in intelligence or visual recall skill between the two sample groups when in a control condition, meaning statistically significant differences between the two groups cannot be confounded with intelligence levels.

Low Tempo Versus High Tempo

When ignoring levels of extroversion, analysis of the overall mean difference in scores for the low tempo music condition versus the high tempo music condition yields statistically significant findings. The mean score of the high tempo group was significantly higher than the mean score of the low tempo group, suggesting that listening to background music of high tempo while completing cognitive tasks is more likely to improve cognitive functioning than listening to music of low tempo. This finding is in direct agreement with the findings of Hussain who concluded that there is a significant improvement in cognitive functioning when in the presence of high tempo music when compared to low tempo music (Table 2). My hypothesis predicted that introverts would perform better in low tempo music and extroverts would perform better in high tempo music. My hypothesis was partially correct in that extroverts performed significantly better in the high tempo music condition, but introverts performed better in the high tempo condition as well, a significant deviation from my initial thoughts. While Husain's findings would suggest this result, I hypothesized that differences in personality would be significant enough to alter the ways in which participants respond to music of different tempo. Introverts, who are more shy and reticent individuals, were expected to respond more positively to low tempo music as the calm and relaxing nature of it more closely ties into their personality type. Extroverts, people who are more outgoing and overtly expressive, were expected to respond better to high tempo music as it's exciting and arousing nature better aligns with their personality type.

High Tempo Versus Silence

While there was a significant improvement in cognitive functioning when comparing the high tempo condition to the low tempo condition, it is important to point out that there was not a statistically significant difference in mean scores between the high tempo condition and the silence condition. This finding is extremely important as it suggests that there is a lack of evidence that listening to any type of music while performing cognitive tasks is able to improve cognitive functioning (Darwich 2016). This finding is in agreement with Furnham, who found a lack of evidence that any music conditions could improve cognition when compared to a silent, control condition (Furnham 1999).

Introvert High Tempo Versus Extravert High Tempo

When comparing the performance of introverts and extroverts in the high tempo condition, there was a significant difference in the mean scores, with extroverts displaying significantly higher cognitive functioning than introverts. This supports my initial hypothesis, and suggests that extroverts have a more positive cognitive response to fast paced music than introverts. Considering this finding stems from a combination of Furnham's and Hussain's experiment, it cannot be corroborated by the foundational sources. However, Furnham's study suggests that extroverts respond more positively to music in general, which may explain the significant finding in my experiment.

Introvert Low Tempo Versus Extrovert Low Tempo

The collected data suggests that introverts perform significantly better on the IVRT in the low tempo condition when compared to extroverts. This suggests that introverts' cognitive functioning decreases less in the presence of low tempo music than extroverts. This finding supports my hypothesis and is expected based upon multiple sources examined. The work of Hussain suggests that low tempo music leads to decreased performance on the IVRT, and this was affirmed by my experiment. What isn't mentioned in the foundational sources is the fact that introverts perform better than extroverts in low tempo conditions, but this can be assumed based upon the personality differences of introverts and extroverts(Wiering 2015).

VI. CONCLUSION

Limitations

It's important to note that underrepresentation of introverts may have been an impactful factor in my research and data collection. Of the 64 participants selected in my sampling process, only 20 were designated by the Eysenck personality questionnaire as introverts. Ideally, we'd like at least 30 introverts and 30 extroverts to satisfy the central limit theorem and assure that the sampling data is normally distributed, as well as to control the impact of outlying data and reduce variance. However, graphing the sampling distribution revealed an approximately normal distribution with no outlying data, allowing us to robustly assume the data is approximately normally distributed. For future research purposes, it may be beneficial to have randomly selected participants take the Eysenck personality questionnaire prior to coming in for the

immediate visual recall tests, so the experimenter could determine whether or not the participant's personality type was needed to assure equal representation.

Another limitation was the use of a music speaker instead of individual headphones for the administration of the music of differing tempos. In reality, most highschool students tend to listen to music through headphones (or earphones) when doing homework or studying, so the use of a speaker is not perfectly representative of the typical highschool listening experience. While there is no evidence that listening with earphones would have significantly impacted any aspect of the data, a more genuine listening experience would have been achieved using earphones. However, it's important to note that each participant was placed equidistant from the music speaker to assure that proximity to the source of music would not be a confounding factor on the other tested variables in the experiment.

The type of music played could also be a factor that impacted the results of the experiment. For the sake of most closely replicating a typical high school listening experience, the music selected was modern, lyrical music that could conceivably be listened to by an everyday highschool student. It's possible that if different music was used, say non-lyrical, classical music, the results of the experiment could have been different and perhaps led to an increase in cognition in the listening condition(Elkoshi 2015).

Implications

In all, my experiment suggests that listening to music when performing cognitive tasks does not improve cognitive functioning, but potentially hinders it. While there was a slight

improvement in IVRT scores in the high tempo music condition compared to the silent condition, it is important to point out that the the difference was not statistically significant. This suggests that there is a lack of evidence that listening to any type of music while performing cognitive tasks is able to improve cognitive functioning. This brings into question why huge numbers of high school students opt to listen to music while studying or doing homework. In reality, the music is not helping them, but potentially hurting them. This implication is significant for those looking to maximize their work potential. There is no evidence that the presence of background distraction (music, talk, etc.) can actually facilitate performance in cognitive tasks, even for extroverts, while it seems clear that it nearly always impairs the performance of introverts. These findings are significant for highschool students, as well as people working in offices or other communal work environments. It's clear that music can potentially be a significant hindrance to one's cognition, so this must be taken into consideration by workers and employers looking to maximize their cognitive potential.

Additionally, my study suggests that introverts and extroverts respond to musical stimuli in a way that's in line with their underlying personality traits. Research by Adrian Furnham found that extroverts are far more likely to listen to music while working in a daily setting, while introverts are more likely to find music distracting and opt to work in silence (Furnham 1998). This finding was corroborated in my experiment by the fact that extroverts generally responded more positively to musical stimuli, when ignoring musical tempo levels. In terms of differences in personality and its impact on response to differing tempo levels, we saw both introverts and extroverts respond more positively to music that fits their general personality traits. Introverts responded significantly better than extroverts in the low tempo condition, and extroverts

responded better in the high tempo condition, suggesting that differences in personality are a relevant factor in cognitive response to musical stimuli. It's unclear what mental processes cause these differing responses, and future research should examine the cognitive science behind this phenomenon.

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