THE EFFECTS OF BACKGROUND MUSIC ON COGNITIVE PERFORMANCE

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By

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Abstract

Multiple studies have indicated that performing cognitive tasks while listening to auditory stimuli, such as music, could possibly involve greater cognitive processing (Kiger, 1989). However, while previous research has investigated the effects of music on comprehension reading, what studies lack are the effects different types of music may have on cognitive performance. The purpose of this study is to investigate the effects of music that people prefer the most versus the least, and determine whether this enhances or diminishes their capabilities to perform reading comprehension tasks accurately and attentively under such background music. Twenty undergraduate students at the University of Arizona with normal hearing thresholds were recruited to perform reading comprehension tests under three particular conditions: no music, music they prefer, and music they have the least interest in. The hypothesis is that participants will have the easiest time performing the reading comprehension with no music, some trouble focusing with music they enjoy, and the greatest difficulty focusing when listening to music they do not enjoy.

The Effects of Background Noise on Multitasking

Introduction

In todays society it has become a common habit for people, especially students, to study and work on assignments for classes while listening to music. For many, music has become an essential part of ones daily life and is a way for people to complete work in a more pleasurable way or to even increase alertness. However, past studies have shown both benefits and constraints to people who listen to music and how it can affect their cognitive processing and memory. Dr. Kiger (1989) states in his research " music can improve productivity on repetitive tasks". Dr. Kiger believes that upbeat music when played in intervals, not consistently, can help improve efficiency. He stresses that the reason why people may listen to music during work is to enhance their ability to focus and to prevent them from becoming bored. However, Angel, Polzella, & Elvers (2010) believes that popular music may " interfere with challenging tasks and comprehension tasks". Therefore in one research study the power of music is shown to both boost and block ones cognition while performing various tasks. In another study the effect of upbeat music on cognitive processing in older adults was examined. Their results indicated that older adults who listened to upbeat music improved their processing speed and both upbeat music and downbeat helped improved memory (Bottirioli, Rosi, Russo, Vecchi, & Cavallini, 2014) . Other studies have looked into how music can impact the mood of the listener based on upbeat or downbeat music. Upbeat music was found to facilitate a more hyperactive mood (Baddeley, 2003). But once again in such studies the types of upbeat and downbeat music or genres were not stated clearly. However, other studies have founded that background music can have disturbing and interfering effects on the listener and can disrupt

performance on cognitive tasks (Polzella and Schoeling, 2004). It also been stated that the more complex a task may be, the more music will have a dampening effect on ones cognition (Cockerton, Moore, & Norman ,1997). Furnham and Strbac (2010) investigated how music can affect cognitive processing in introverts and extroverts. Their results revealed that introverts performed more poorly on complex cognitive tasks as compared to extroverts while listening to music. This study shows how music can negatively affect one based on their personality type. In summary, it appear that listening to music while performing cognitive tasks can have positive or negative effects depending on the type of task and personality type.

What many of these studies did not mention is the type of music they are playing when testing their participants. Most studies classify their stimuli as "upbeat" versus "downbeat" music. However what is upbeat music? Upbeat music can range from a fast beat country music song, to hip-hop, to even fast tempo classical music. It appears that no one has investigated whether music that participants prefer versus dislike has any affect on their performance. Can preference of music either benefit or degrade cognitive performances on tasks? The reason this question is so vital is because in past research it was never indicated whether the participants enjoyed the upbeat music they wee forced to listen to when being examined or the downbeat music, such a preference can affect a participants results which will affect the study's outcome. This study will look into preference and consider it as an important factor on affecting cognition.

When talking to students at the University of Arizona I would ask whether people were capable of listening to music while studying and doing homework or whether it interfered with their ability to concentrate. Surprisingly I found a balance of people who

were able to listen to background music while performing such tasks while others stated they are unable to focus and need to be in a quiet environment. In this thesis, background music is classified as music that is played while the listener's primary focus is on another task in which they are performing. The purpose of this study is to dig deeper into the types of music people are listening to and how preference of music types can affect their cognition and memory versus no music.

This study investigates how the preference of different types of music and no music can affect ones cognition while performing reading comprehension tasks. Our hypothesis is that participants will score the lowest and take the longest time to complete the passages while listening to music they dislike, perform moderately well to music they enjoy, and perform the best and take the least amount of time to complete the task in the music condition. This study will also provide information as to whether music can interfere with a participant's ability to focus under complex tasks.

Methods

In order to evaluate this question, three reading comprehension tests were chosen from the Gray Oral Reading Tests. The reading comprehension tests were all-different, but were equal in difficulty and consisted of a story with four questions to answer afterwards. Three different passages were used so that subjects would read and answer questions under each of the three conditions: no music, music the participant enjoys, and music the participant dislikes. Music that the participants preferred and disliked were based on their own preference choice and was played through the online radio station Pandora at a level of 60dB HL played through a smartphone stereo analog output into both auxiliary inputs of a GSI clinical audiometer. The music was played through supra-aural headphones (TDH-

50P), with channel 1 going through the right ear and channel 2 to the left ear. Output was set using the Hl dial of the audiometer, with the input level set to average 0dBV. Comprehension accuracy was assessed by tallying questions answered correctly. The participants were timed during each condition with a maximum of 5 minutes allowed to read and answer questions. Timing is an important factor that was assessed in order to evaluate if one condition took longer for the participant over the other. The participant's memory was also considered in this experiment, as they were not allowed to refer to the paragraph when answering questions about the story. At the end, participants were given a questionnaire that asked them to judge the difficulty of answering questions and being able to concentrate under each condition.

Participants

Twenty native English speakers with normal hearing thresholds participated in this experiment. The participants were all undergraduate students from The University of Arizona between the ages of 20-22 years old. All participants were females from the Kappa Alpha Theta sorority who voluntarily participated in this study.

Hearing Screening

In order to ensure eligibility for those who wanted to participate, otoscopy and pure tone screening were both administered to see if the participants would qualify for the study. Participants were required to pass a hearing screening for pure tone thresholds between 500-4,000Hz at 20dB HL. This process was done through a computer based audiometer called a GSI Audio Star Pro and supra aural headphones (TDH-50P). The supra aural headphones were also used throughout the experiment when the participants were listening to music. The purpose of wearing headphones in order to listen to the music

through Pandora was to allow consistency of level rather than just playing the music

through speakers. All testing was performed in a sound treated booth in order to prevent

other background noises from interfering with the participant's ability to focus and read

the passages in order to answer the questions.

Reading Comprehension Passages

Three reading comprehension passages appropriate for the ages of 18+ were chosen from

the Gray Oral Reading Tests- Version 5. The three passages are different, but equal in

difficulty, in order to make sure participants did not remember their answers from a

previous passage when reading under subsequent conditions. Passage presentation was

also randomized across participants in order to ensure that the same passage was not

given under the same condition every time. This also helps eliminate any effect of one

passage being either easier or harder compared to the others. For example, a passage based

upon the conservation of honeybees for one participant might be read under no music, but

for the next participant it will be read under music they enjoy. At the end of each passage

participants answered four written multiple choice questions based upon what the

participant had just read. The participant however was not allowed to refer to the

paragraph when answering questions; they have to rely on their memory of what they

read. Questions can vary from what the overall passage was about to specifics about

characters as well as the defining a vocabulary term presented in the passage. The

participants must read the passages and answer the four questions under 5 minutes for

each condition.

Music

After I performed otoscopy and a hearing screening on the participants I asked them their favorite genre of music is or a particular singer they enjoy. I also asked them to name a particular genre or singer that they do not enjoy. I then downloaded music from the participant's preferred and not preferred music into Pandora. Pandora is a free web based music station that can be downloaded onto any smartphone that allows one to listen to various genres and artists. The smartphone was connected to the audiometer through stereo auxiliary inputs. The supra aural headphones the participants wear during the task calibrated to the audiometer and by setting the input level via vu meter I was able to control the output of the music accurately for every song. Once I started the timer, the music was turned on and the participant immediately began reading. For example, many participants did not enjoy country or classical music therefore I would type in "country music" into Pandora and an entire station of country songs would play. In some cases, participants preferred or disliked particular artists vs. genre such as Ellie Goulding, Carrie Underwood, Kygo, etc. The preference for each participant was completely determined by the listener.

Questionnaire

A questionnaire was given at the end of the study in order to see how participants felt about the overall study as well as their ability to focus under no music, music they enjoy, and music they did not enjoy. The questionnaire was structured upon the Likert scale where each participant was asked to rate his or her opinion on each question where (1) meant easy and (5) meant extremely difficult, (3) was neutral. The questions that were asked were 1. "Overall rate the difficulty of this experiment" 2. "Rate your ability to answer

questions under no music" 3. "Rate your ability to answer questions under music you like"

4. "Rate your ability to answer questions under music you do not like 5. "Rate your ability

to concentrate under no music" 6. "Rate your ability to concentrate under music you like"

and finally 7. "Rate your ability to concentrate under music you do not like". The

questionnaire was one of the most valuable pieces of data that helped us indicate what

conditions were easiest and most difficult for the participants.

Presentation

In order to control for consistency throughout this experiment, each participant listened to

the music under supra aural headphones at a level of 60dB HL. The participants were also

given only five minutes to read a passage and complete the four questions under all three

conditions(five minutes per passage, for a total of 15 minutes per participant).   As stated

earlier, participants were not allowed to refer back to the passages when answering

questions.

Procedure

After participants consented to partaking in the experiment they were taken to a sound

booth at the University of Arizona's Speech, Language, and Hearing building room 315. The

first step in this experiment was evaluating the participant's ears. This was done through

otoscopy where I examined both ears to make sure the eardrums of the participants were

clear and healthy. The next step was performing a hearing screening through a pure tone

assessment on an audiometer. Patients were asked to press a button every time they heard

a tone. Tones were played at 20dB Hl on the given frequencies 500, 1,000, 2,000, and 4,000

Hz. These are the particular frequencies that are important for speech perception. If the

participants heard all of the tones, they were able to continue on with the experiment. The

next step was asking the participants what type of music or artist they liked and disliked

(as described previously). This allowed me to download songs to Pandora in advance. In

addition, the participants were given a piece of paper folded in the middle, this way they

cuould only see the passage when reading and when they turned the page over, they could

only see the questions. Participants were told they have 5 minutes to complete the passage

and answer the questions. Once they were done reading the passage they were to flip over

the piece of paper to answer the questions. I was watching them the entire time to make

sure they conformed to the instructions. This cycle was performed three times under the

conditions no music, music they enjoy, and music they do not enjoy. Under the conditions

of music they dislike and liked they were asked to put on supra aural headphones in order

to listen to the music. The music was played at 60db HL. I notified each participant when

they were allowed to start and asked them to notify me by raising a finger when they were

done. After the participant was done with one passage under a certain condition I gave

them the second passage under the next condition and the process repeated of reading,

answering questions, and signaling me within the 5 minutes when they were done. No one

needed the entire five minutes to complete the task. Once participants had completed all

three conditions they were given a questionnaire. The purpose of the questionnaire was to

get an honest opinion of how the participants felt during the experiment and under each

condition, as well as which conditions were easier and harder for them personally. After

the questionnaire was completed the students were free to leave. The entire experiment for

all participants took under 30 minutes.

Results

The average scores for the four questions for each condition, Quiet (no music),

Pleasant (music they liked) and Unpleasant (music they did not like) were 2.45, 1.60 and

2.35, respectively. Average time taken to complete the task for each condition (in seconds)

was 148.8, 189.5 and 182.5 respectively. **Table 1** shown below depicts the mean of correct

scores answered and the standard deviations for the 20 participants under the three

conditions of no music, music they liked, and music they enjoyed. **Figure 1** below is a

graphic representation of the means and standard deviations shown in **Table 1.**

Table 1			
	N	Mean	Std. Dev.
Quiet	20	2.45	0.887
Pleasant	20	1.60	0.681
Unpleasant	20	2.35	0.671

The purpose of measuring time was to see whether participants were able to read the

paragraph and answer questions quicker under a certain condition versus the others.

Table 2 shown below depicts the mean of time taken to complete each task, the standard

deviations for the 20 participants under the three conditions of no music, music they liked,

		N	Mean	Std. Dev.	Min	Max
Table 2						
Qtime		20	148.80	22.673	80	178
Ptime		20	189.50	25.956	127	229
UPTime		20	182.55	22.166	150	229

and music they enjoyed, as well as the maximum and minimum times for each condition.

The first analysis constructed was a repeated measures analysis (ANOVA) in which was tested for accuracy. A second statistical test was analyzed called "Sphericity Assumed" tests in which concluded that the three conditions were significantly different from each other since the results of a difference of .002 was concluded and this is smaller than the typical alpha level of .05. A non parametric test (Friedman) was also included in order to assess if the ranks for accuracy scores were different. The scores were different and in fact there was a probability less than .001, $p < .0005$; meaning the accuracy differences were significant.. **Figure 1** depicts the average scores on a scale from zero to four for answers scored correctly under the three conditions of no music, pleasant music, and unpleasant music on a bar graph.
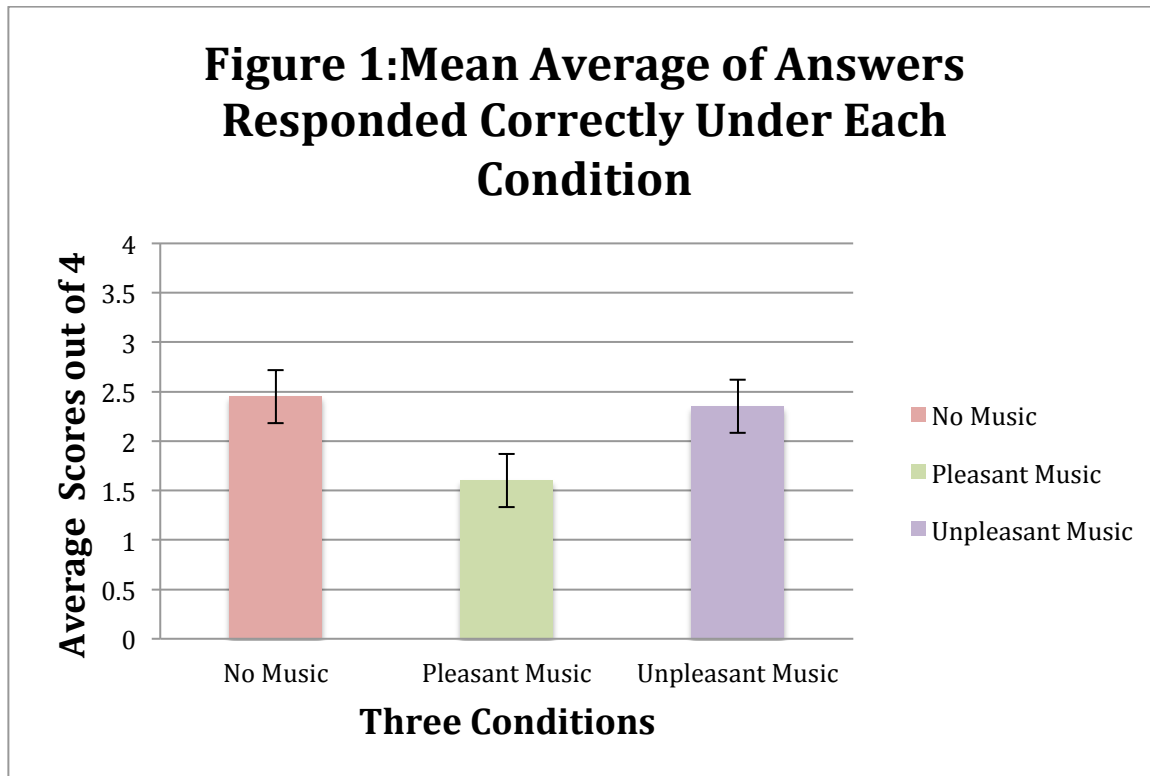
Figure 1: A visual representation in a bar graph showing the average scores of correct answers among the 20 participants under each of the three conditions.

A repeated measures analysis (ANOVA) and Friedmans non-parametric test were also conducted in order to analyze for time. Percentiles are also shown to show a comparison. **Figure 2** below shows the average times of completing the task within 5 minutes under no music, pleasant music, and unpleasant music in a bar graph.
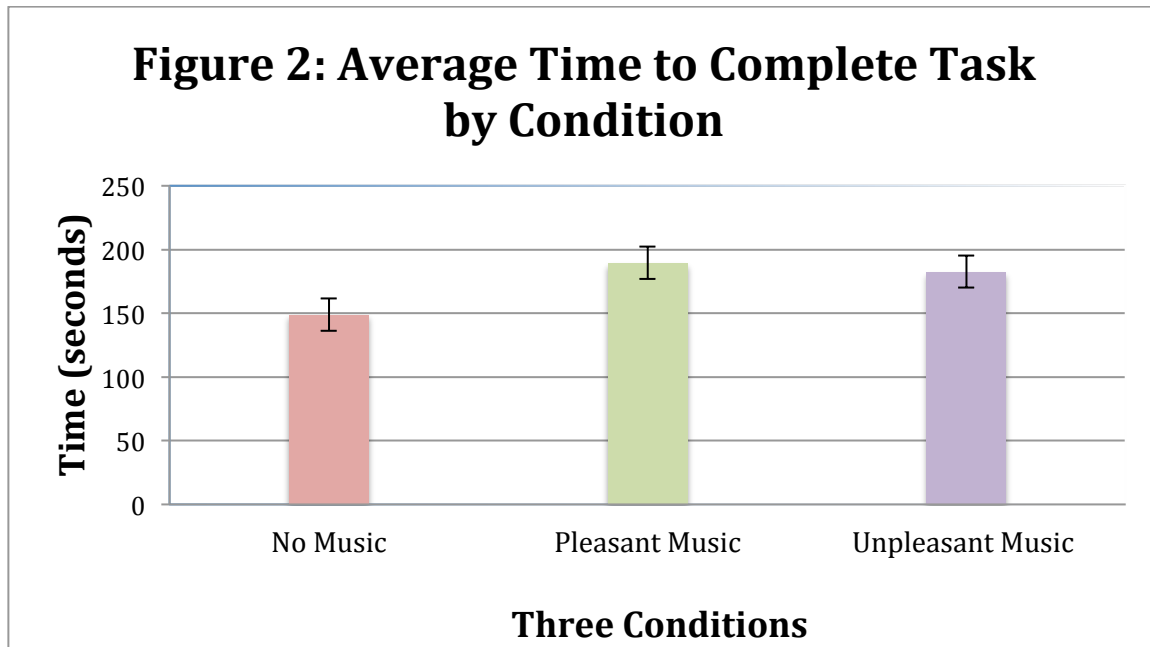
Figure 2: Average Time to Complete Task by Condition

Time (seconds) — y-axis: 0, 50, 100, 150, 200, 250

Bars: No Music (~150), Pleasant Music (~190), Unpleasant Music (~182)

Three Conditions

Figure 2: Note that the time on the y- axis has been converted into seconds. This graph shows that participants took the longest time completing the task under pleasant music and the shortest amount of time under no music.

Another analysis was assessed to look at the ratings based on the questionnaires. The purpose of the questionnaire ratings analysis was to see an average score within each question based on the level of difficulty for the participants. **Table 3** (below) helps show the means and standard deviations of the average scores rated among the twenty participants under each question. Scores around 1 meant the participants felt a sense of easiness toward the question, 3 being neutral, and 5 being they had the most difficult time in that area whether it be their ability to answer questions or concentrate under a particular condition. The ability to answer questions under each condition and the ability to concentrate were two vital factors that were asked in this questionnaire.

Item Statistics			
	Mean	Std. Deviation	N
1. Overall rate the difficulty of this experiment	3.10	0.718	20
2. Rate your ability to answer questions under no music	1.60	0.883	20
3. Rate your ability to answer questions under music you like	3.70	0.657	20
4. Rate your ability to answer questions under music you do not like	3.40	0.940	20
5. Rate your ability to concentrate under no music	1.25	0.550	20
6. Rate your ability to concentrate under music you enjoy	3.80	0.768	20

Table 3: The following table shows the mean averages and standard deviations for each question answered on a Likert Scale where (1) means the participant found the ability to focus and concentrate easiest under the condition and (5) meaning they found it most difficult.

Pairwise conditions were also evaluated for both averages of correct answers and averages in time in order to see significant differences among the conditions; where condition 1 was quiet, condition 2 was pleasant music, and condition 3 was unpleasant music. Based on the statistical data, conditions 1 differed from conditions 2 with a value of (p=0.006). Conditions 2 differed from conditions 3 with a value of (p=0.000). However, conditions 1 and conditions 3 did not differentiate because there was a significance value of (p=0.694) and therefore is classified as non-significant. Thereby the average scores of correct answers showed significant differences within the conditions of no music versus unpleasant music as well as pleasant music versus unpleasant music. In terms of the

pairwise conditions for time, conditions 1 and 2 were significantly different with a value of

(p<.05) or more precisely (p=0.000). The same p result was also seen within the conditions

of 1 and 3. However, conditions 2 and 3 were not significant because there was a

significance value of (p= .373). Therefore the only conditions that showed significant

differences within time was quiet versus pleasant music and quiet versus unpleasant

music.

In addition, a secondary analysis was assessed to look at the ratings also based on

the questionnaires. However, this analysis looked at whether participants own personal

perceptions of the experiment would correlate with their scores. After analyzing the data

there seemed to be no correlation between the participant's perception of the conditions

and task versus their actual scores and timings on each task. There only seemed to be a

correlation within their own perception and their scores when it came to their ability to

concentrate under no music. This means participants felt as though concentrating under

no music was easy and this also correlated with a higher score of accuracy and a faster time

under no music. However the same cannot be said for conditions two and three.

Discussion

The purpose of this study was to answer two important research questions: 1) Does

music affect ones cognitive performance when completing complex tasks (such as reading

comprehension passages) and 2) Can the preference of music have an affect on ones

cognitive performance on complex tasks such as music one likes versus dislikes? Another

question that was brought up within the study was whether a participant's personal

opinion on a study would correlate with their actual results. Based on the data analysis

there was a significant difference within conditions of no music and pleasant music. Based

on the average mean scores participants tended to score higher under no music and lowest

under pleasant music. There was also a significant difference within conditions of pleasant

music versus unpleasant music. However, there was no correlation of differences between

no music and unpleasant music within the statistics of the data. These results were in semi

correlation with time accuracy. With time no music and unpleasant music showed

differences in significance as well as no music and pleasant music. The reason why pleasant

music and unpleasant music did not show a significance of differences in correlation could

be that both conditions were under music and this naturally would increase the time for a

participant because its more distractive. Participants completed the reading

comprehension tasks quicker under no music and longer under music they preferred.

However, there was not a correlation between participant's opinion of the study based on

the questionnaire form and the participant's scores and time from the tasks.

The results of the study only support half of the effortful hypothesis that music does

in fact affect ones cognitive performance. However, although it was hypothesized that

participants would score higher and complete the passage faster under no music it was also

hypothesized that participants would score the lowest and take the longest on the reading

passages under music they disliked. However the experiment and data proved the second

portion of the hypothesis to be incorrect. In fact, participants tended to score lower and

took longer under music they preferred versus disliked. The reasoning behind why this

occurred is better explained through the questionnaire that was given to the participants at

the end of the experiment. Participants rated their ability to answer questions and

concentrate under music they liked as the most difficult condition versus answering

questions under no music and music they disliked. From both screening participants and

asking them why they circled the ratings they did, participants told me that the reason why

listening to music they enjoyed made it difficult for them to concentrate was that it was

more distracting than music they disliked. Some participants even shared that they would

sing along with the lyrics instead of focusing on reading the passages which made

answering the questions more difficult as well as taking longer to complete the task. All but

two participants had agreed that reading and completing the passages was easiest under

no music.

　　　　Additional comments were collected from each participant regarding why they

chose certain genres of music unpleasant. For example, one participant chose classical

music as music she found unpleasant because her parents had forced her to take violin

classes when she was around seven years old. She said taking those classes were a

nightmare and ever since then she cannot stand any type of classic music. Other

participants chose specific artists instead of genres for music they disliked, as well as for

music they found pleasant. Many participants after completing the study shared , shared

that they were going to change their study habits after realizing how music affected their

ability to concentrate. In fact, three participants told me after the study they would stop

listening to music they enjoy when studying and try to study and complete assignments in

a quiet environment.

　　　　The results of this study are consistent with Polzella and Schoeling (2004) research

in that background music can have disturbing and intrusive effects on the listener and can

disrupt performance on cognitive tasks. What this study aimed to discover was whether

particular preferences of music could affect ones cognition and how even music that

participants enjoy can have disruptive affects on their cognitive performance. It is interesting to see how preference of music can affect ones cognitive performance and the ability to concentrate. Perhaps what students once believed could help them focus and remain alert when completing assignments can actually negatively affect their abilities to retain the information they are learning as well as their ability to concentrate.

Constraints and Future Directions

With the restriction of time, the range of participants was limited to only women from the University of Arizona's Kappa Alpha Theta sorority. Therefore the pool of participants in this study was very limited and not an equal representation of the male and female population. Another limitation in this study is that the entire experiment was conducted in a sound booth at the University of Arizona's Speech, Language and Hearing building. In the sound booth all background noise was blocked out and this is not an accurate representation of real life situations and environmental noises that surround us on a day-to-day basis.

In order to strengthen this study, future testing would include more men in order to represent a more realistic population of males and females. As far as the sound booth goes this was used for consistency of environment but further testing should include more real life situations where other background noises can be allowed in the participation room. In addition to recruiting, there should be a variety of ages tested to see whether these results will correlate with other adults, especially older adults or those who wear hearing aids. It would also be interesting to test musicians and see if they are able to concentrate less or more when performing other tasks since they are accustomed to music in their lives. A follow up with those participants who want to change their studying habits under no music

would strengthen this study's findings if perhaps their grades went up or asking them if they felt it was easier to retain information without music versus before with music. Another vital component of this study that needs to be further researched is whether there is or is not a correlation between ones own opinion of how they felt in a study versus the outcome of their results. Further research within this particular condition of the study should be examined to see if ones own perception of difficulty within a certain matched with low scores under that same condition. Hopefully this research I will be able to continue and examine.

Acknowledgements

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