The Effects of Background Music and Noise on Verbal Working Memory

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Abstract

Verbal working memory was examined as affected by background music and background noise. English speaking volunteers between the ages of 18 and 30 years were asked to participate by studying and recalling word lists in the presence of background music and noise. The background music and noise conditions did not have significant effects on performance except where volunteers reported after testing that they found music distracting while studying. The results indicate that studying in silent environments is most conducive to verbal working memory.
The Effects of Background Music and Noise on Verbal Working Memory

In a 2008 survey of 3000 children, 10% of those surveyed were found to have poor working memory which was detrimental to learning (Durham University, 2008). If working memory can be enhanced through the use of music or the avoidance of distracting noise, new and more helpful methods of teaching can be developed. Many students find studying to be a difficult thing to do well. This is not necessarily due to the difficulty of the subject matter, but finding a study area conducive to learning. Students may find themselves distracted by irrelevant noises and unable to focus, or may find complete silence allows their mind to wander and lose task orientation.

Many students attempt to enhance their learning by listening to music while studying. Though some find music helps them to focus, others report music as being another distraction. Improved teaching strategies and learning methods can be developed by studying the importance of the effects of outside stimuli on students. In 1971, the average reading scale score for 17-year-olds was 285. Today, the score is 286 indicating that in the last 39 years, education methods have not evolved (U.S. Department of Education, 2009).

Most people believe that education is the most important thing in life short of food and shelter. Without proper working memory, education will falter. Teachers often do not recognize faulty working memory and so do not make any special effort to address the problem (Durham University, 2008). Many studies have been performed on the effect of background music and noise on working memory. Though there is some conflicting data, in general, studies seem to reveal trends in the consequences of noisy or musical environments during learning.

*Verbal Working Memory*
Working memory is important for everyday tasks. Its function is to retain knowledge while the brain performs other cognitive tasks. There is some dispute over the way that working memory functions. Some believe it is a temporary storage system while others believe it is a system that allows other cognitive systems to work simultaneously (Baddeley, 1986; Pickering, 2006). However the system may best be described, the function it performs is crucial to learning. General working memory is the term applied to working memory as a universal system or function. Specific working memory is the phrase used to define working memory in a specific process such as verbal working memory.

Verbal working memory is a specific process within short term memory that is responsible for the temporary storage of verbal information. It is also known as the phonological (or articulatory) loop, which includes two components. The store component holds phonological information for only a matter of seconds until the second component, subvocalization, occurs and the items are rehearsed through inner speech then brought back through the articulatory loop. Verbal working memory is imperative for early reading development. The letters in each word must be converted into sounds, which in turn must be briefly stored until the last letter has been converted to a sound, and all the sounds can then be read as one word.

Effects of Background Music on Verbal Working Memory

Music has been found to be beneficial to memory in certain situations. The most beneficial situation seems to be learning languages and reading skills (de Groot, 2006; Hall, 1952; Jaušovec, Jaušovec, & Gerlič, 2006; Register, et al., 2007). Studying a foreign language with music playing in the background can increase word recall by up to 11.6% with an average of 8.7% (de Groot, 2006). This data seems related to findings that music improves general
Having background music present while practicing reading skills can improve reading ability by a mean gain of anywhere from 2.37% (Hall, 1952) to approximately 21% (Jaušovec, et al. 2006). The experiment studied eighth and ninth graders' reading comprehension during study hall periods with or without background music present. Almost 58% of students improved on the follow-up test with the experiment group testing a mean of 2.37% higher than the control group. The results of this experiment, however, showed that no student scored lower on the follow-up test than they had on the first. The results showed students who had been previously identified as having the lowest ranking in achievement testing displayed the most improvement with background music present. Of the eighth graders ranked as the lower achieving half of the population, 55.56% showed significant improvement on the follow-up test compared to those ranked as the higher-achieving half of whom only 44.26% showed significant improvement.

Over the entire population, the lower-achieving ninth graders were found to have improved the most from background music.

The results showing that background music seems to best help students who are identified as under-performing are supported by a more recent study (Register et al., 2007) which explored the effects of music on the reading comprehension of second graders and students with a specific reading disability. The students were tested on word decoding, word knowledge, and reading comprehension. Both experimental and control groups showed significant improvement in word decoding and word knowledge. Though both of these groups did show improvement in reading comprehension, neither group improved significantly. The students with the reading disorder significantly improved in all three areas of study bringing their mean test total from a pretest
score of 76.63 to a post test score of 91.25. The mean post test total scores of the normal second graders also improved significantly. The normal second grade control group post test total mean was 92.37, while the normal second grader experiment group post test total mean was 94.30. It has been speculated that this beneficial effect can only help the student improve to the best of their ability and not to exceed it (Hall 1952; Jaušovec, et al., 2006; Register et al., 2007).

Music can excite certain areas of the brain which are also associated with the perception, memorization, and production of language, syntax, and abstract sequences (Jaušovec, et al., 2006). The control group in this study scored significantly lower than any other group. The group which listened to music during both learning and testing was recorded as having less complex EEG patterns which is believed to signify greater focus on the task. In a different study (Register, et al. 2007) it was found that during sessions including background music, students consistently remained focused on their tasks. Support for this claim is found within a study of story recall in children who were provided music and the opportunity for movement (Cole, 2008). These children were found to remain more focused on the story which correlated with high story recall. The experimental condition which provided the least improvement for this study combined low movement opportunity and non-syncopated music which may have caused the students to lose focus. Another cause of lost focus in these experiments may be music choice.

Many studies reported that the students who liked the background music performed better when tested (Cole, 2008; Hall 1952; Jaušovec, et al., 2006). One experiment compared the effects of Mozart's music to that of Brahms (Jaušovec, et al., 2006). The participants who listened to Mozart scored a mean of 38.67, those who listened to Brahms scored a mean of 29.42, and the control group who listened to no music scored a mean of 30.30. Though this study did
not gather information about participant preference for the music used, it does show an obvious difference in choice of background music.

Effects Background Noise on Verbal Working Memory

Background noise is defined as noise which is not important to whatever is the main focus of attention. Noise can either increase or decrease attentional capacity. Attentional capacity is dependent on what kind of noise is being produced and exactly how loud the noise is. Decibels, dB, is the standard unit of measure for volume or loudness. Many experiments have tested noise based on decibels to test whether or not noise, or noise volume, had an effect on learning. There are many different aspects of noise that need to be taken into consideration such as frequency, pitch, amplitude, and consistency (Baker & Holding, 1993). Noise attunes attentional capacity and increased activity for relevant information. Replication studies have since been conducted but show similar results only if the factors of time, sex, and the different processes of recall were eliminated.

Overall, the specific noise that is present is the main factor in having a positive or negative effect on learning and recall. Background noise from aircraft, road traffic, and trains have all been shown to impair learning (Enmarker, Boman, & Hygge 2006; Hygge, 2003; Wible, Nicol, & Kraus, 2004). Continuous speech or verbal noise that is irrelevant has no effect or at least no significant effect unless compared to children with learning problems (Hygge, 2003). This supports evidence that normal children are unaffected by background speech, but children with learning problems are affected by having slower recall times (Wible, Nicol, & Kraus, 2004). Background noise also has no effect on most people when dealing with the same noise over a long period of time, such as living near an active train track. Eventually, a person becomes
accustomed to the noise of the environment and is unaffected by it.

Intermittent, especially aperiodic, noise in test conditions always impairs performance during and after learning. Higher frequency tones have more of a negative effect on memory than lower frequency tones. The more intense the sound the more it affects performance. In children between ages 12 and 14, boys identified as lower performing scored equally in noise and quiet settings, compared to normally performing boys, and both lower, and normally performing girls who showed a significant difference between noise and quiet settings (Hygge, 2003).

Noise can affect working memory in a positive way if it is a consistent part of the background. The noise must not be overly distracting and must be low enough dB to not interrupt the working memory process (Baker & Holding, 1993). Some studies have shown that as noise volume increases, the wider the capacity of learning becomes because of the arousal state. Continuous, non-intermittent noise such as classical music or white noise may have a positive effect. Noise negatively affects recall and recognition when the information is harder to encode, is brand new, or is not related to other stored information (Smith, & Broadbent, 1981). If related information is stored, new information is easier to encode regardless of what type of background noise is present.

**Interactions**

The interactions of background music and background noise on working memory have not been an area of study. Because the effects of one or the other seem to correlate strongly on their own, the interactions have not been focused on. It is possible that the effects of background noise may have been the cause of the results of some studies of the effects of background music. No study has specified that the participants were deliberately kept from hearing noises other than
music, such as machines, computers, the noises of other participants, or nearby conversation. Though it was not expressly stated, it is assumed that due to the nature of the studies on music, the experimenters would have controlled the conditions. This study attempts to discover if background music or background noise have a significant effect on verbal working memory by testing individuals learning new, novel, vocabulary in the presence of these factors. The results of this study may impact the study habits, or learning environments of students in the future.

Method

Participants

The participants were chosen by recruiting library patrons. Fourteen people agreed to participate. A total of 14 participants were used. The participants included nine males and five females. All participants spoke English fluently. Nine of the participants identified English as their primary language. One of the participants reported himself as having been clinically diagnosed with a hearing problem. Three participants reported themselves to have been clinically diagnosed with a learning disability. Ages of participants ranged from 18 to 30 years. Participants' education levels ranged from a high school diploma to a master's degree.

Materials

Music the participants heard was a recording of Mozart's "Eine Kleine Nachtmusik." Mozart was chosen because of the Mozart Effect. The specific piece was chosen because it had no vocals and the dynamics were fairly consistent throughout. The background noise recording was of ambient noise recorded by the researchers in a cafe. The location recorded was chosen because it included mechanical noises and unattended speech.
Each participant received 16 response sheets (See Appendix C.). They received and signed a consent form. They saw the attached word lists (See Appendix A.) via poster board. The background noise and music were played from a notebook computer.

The participants completed and returned the background questionnaire including demographic questions about education, gender, age, and study habits (See Appendix B.).

Procedure

**Condition 1: Silence**   The experiment took place in a meeting room in a quiet area of the library. Once the participants were assembled in the testing room, they received a consent form before the experiment began. Once all consent forms were collected, the numbered response sheets were distributed and told not to pick up their pens until instructed. The participants were told that they would be presented with a list of words and given 30 seconds to memorize the list after which they would be given 30 seconds to reproduce the list on the supplied sheets. The first list was shown for 30 seconds and then removed. The participants were then instructed to reproduce the list immediately. After 30 seconds, they were asked to put their pens down and pass forward the paper. This was repeated three additional times under the same condition. The tasks were designed to measure accuracy of verbal working memory in four different conditions.

**Condition 2: Music only**   The participants were told that the testing procedure would remain the same. Music began playing before the first word list was shown to participants and remained throughout all four tests in this condition.

**Condition 3: Noise only**   The participants were told that the testing procedure would remain the same. The background noise recording began playing before the first word list was shown to
Condition 4: Music and Noise  The participants were told that the testing procedure would remain the same. The background noise and music recording both began playing before the first word list was shown to participants and remained throughout all four tests in this condition.

After all conditions were completed, the participants completed a background questionnaire. After completion, they were thanked for their participation and allowed to ask questions before leaving.

Results

This study measured the effects of background music and background noise on the accuracy of verbal working memory.

Effects of Background Music

The presence of background music was not statistically significant, $F(1, 11) < 1$.

Effects of Background Noise

The presence of background noise was not statistically significant, $F(1, 11) = 2.748$, $p < .126$.

A separate analysis with background noise and reported helpfulness of music during studying as factors indicated that participants who reported background music as being a distraction to studying performed significantly better with no background noise present (See Table 1) $F(1, 11) = 6.985$, $p < .011$. 

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Insert Table 1 here
Interaction of Background Music and Background Noise

The interaction of background music and background noise was not statistically significant, $F(1, 11) < 1$. Other interactions were measured with either music, noise, or music and noise together. The other factors were ascertained from the background questionnaires and included the following: gender, age, learning disabilities, studying with music, study with noise, report noise as helpful, primary language, hearing problems, education level, average study time, difficulty learning vocabulary words, or music preference. All these interactions yielded results that were not significant.

Discussion

This study investigated the effects of background music and background noise on verbal working memory. The participants performed word memorization and recall tasks while exposed to a variety of background noise and music conditions. Results did not support the original hypothesis that the chosen stimuli would significantly affect verbal working memory as measured by our tests.

Background Music

This experiment ascertained no significant data to support the claim that participants who enjoyed the selection of background music performed any better than those who did not (Cole, 2008; Hall 1952; Jaušovec, et al., 2006). Background music seems to provide extra stimulus which causes distraction while trying to memorize or immediately recall words. The results of this experiment conflict with previous results which found background music to be beneficial, increasing word recall by up to 11.6% (de Groot, 2006; Hall, 1952; Jaušovec, Jaušovec, &
Gerlič, 2006; Register, et al., 2007). These conflicting results may be due to the differences in experiment procedures.

*Background Noise*

Background noise also seems to provide only a distraction from word memory and recall. In our experiment we used noise recorded and played back at a low volume which may have affected our results. Our results supported those of Hygge (2003) who found no significant effect of background noise on verbal working memory, but dispute the findings of others which show a positive effect (Baker and Holding, 1993).

The only condition in which significant results were found was in the case that the participant reported that music caused them to feel distracted when studying. These participants had significantly higher scores when background noise was not present. This data supports findings that unattended sound negatively affects recall of new, unrelated information (Smith, & Broadbent, 1981).

*Background Music and Noise*

The lack of significant effects of either factor individually support our next finding that both background music and background noise played at the same time produce no significant improvement or decrease in testing scores. No other data was available to compare with these results. No other conditions related to demographic information or testing conditions yielded significant results.

The thought of using background stimuli to aid in learning has been around for many years. Personal reports of the benefits and detriments of background noise or music fluctuate. This calls for official studies to be conducted. The literature regarding these studies indicates that
the presence of background music does aid in learning but not always significantly. Background noise, for the most part, impairs learning but if it is continuous, below 85db, and not of a high frequency that it can be helpful. Other factors that may need to be more closely monitored are the qualities of noise and music such as pitch, amplitude, and frequency. Because so many different testing methods have been used, the variations in results may stabilize if a more comprehensive experiment could be performed. In addition to different testing methods, many experiments focus on different aspects of learning and can produce conflicting results. Memory for verbal skills may be enhanced by background sounds but memory for numbers may suffer. Recall with information that is of abundance in memory is easier and recall of familiar subjects that are commonly known are easier.

More and varied experiments are needed in this area to provide a better understanding of the specific effects of these factors on working memory. The facilitation of education is important in our society and if learning can be enhanced, it should be considered socially responsible to do so.
References


Table 1

Mean (and standard deviation) of number of correct answers as a function of presence or absence of Background Noise and Reported Helpfulness of Music During Studying (N = 14)

<table>
<thead>
<tr>
<th>Presence of Background Noise</th>
<th>Reported Helpfulness of Music During Studying</th>
<th>Noise Present</th>
<th>No Noise Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Music Helpful</td>
<td>6.7 (1.2)</td>
<td>6.4 (1.4)</td>
</tr>
<tr>
<td></td>
<td>Music Not Helpful</td>
<td>6.6 (0.18)</td>
<td>7.8 (0.9)</td>
</tr>
</tbody>
</table>
Appendix A
Please write down all the words you can remember on the blanks below.

_______________________
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Appendix B
Appendix B

Please answer every question. When you are finished, please turn in your paper and you may leave. No identifying information will be retained.

1. What is your gender?

2. What is your age in years?

3. Have you been clinically diagnosed with any learning disability?

4. Do you study while listening to music?
   - If you answered yes to question 4, do you find it helpful or distracting?

5. Do you study in noisy environments?
   - If you answered yes to question 5, do you find it helpful or distracting?

6. What is your primary language?

7. Do you have any clinically diagnosed hearing problems?

8. What is your highest level of education?

9. On average, how many hours do you spend studying each week?

10. Please rate how easy you find memorizing vocabulary words by marking anywhere on the scale below:

    |_____________|_____________|_____________|_____________|
    very difficult        very easy

11. Did you like the music used in this experiment?
Appendix C
CONDITION #1

Word list #1
book
cold
eight
girl
his
like
new
place
sheet
blast

Word list #2
body
christmas
comes
feeling
lecture
normal
people
record
sugar
water

Word list #3
air
big
butter
comb
day
fast
go
hat
dive
more

Word list #4
hot
good
friendly
look
meal
large
chair
college
describe
city

CONDITION #2

Word list #1
son
thumb
was
you
black
coat
egg
got
him
barge

Word list #2
breakfast
pay
link
finish
letter
notice
perfect
repeat
summer
weather

Word list #3
party
red
sheer
spoon
thought
foot
working
bed
building
cloth
Word list #4
think
walk
sky
special
room
call
pound
honest
house
make

CONDITION #3

Word list #1
mare
page
vex
snow
though
warm
year
bag
clock
dairy

Word list #2
above
build
clothing
dollar
friend
minute
outside
person
result
sunshine

Word list #3
date
effect
fat
grill
hip
is
lunch
morning
on
ball

Word list #4
seed
bread
shirt
song
tree
wasp
woman
young
very
paper

CONDITION #4

Word list #1
high
know
men
out
self
smart
clean
want
wrong
smell

Word list #2
window
answer
busy
coffee
evening
hour
dinner
part
public
steady
Word list #3
fork
shop
speak
sun
tired
war
with
band
best
complete

Word list #4
click
could
dry
false
future
hear
if
live
money
off