1986

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Running head: EFFECTS OF NOISE AND MUSIC

In partial fulfillment of the requirements

for the Honor's Program

Ouachita Baptist University

1985-86

Approved by:

Abstract

Forty-eight subjects from a university general psychology class took a series of four timed arithmetic tests of two differing complexities. Vocal music was played during half of the tests while instrumental music was played during the other half. Results were analyzed for the number of problems correct, number attempted and percentage of problems answered correctly. Results showed that subjects in the instrumental music condition had a significantly higher number of problems correct and attempted than the vocal condition, but the percentage correct was not significantly higher. Results for task complexity showed difficult problems had a significantly lower number correct and attempted and also a significantly lower percentage correct than easy problems had. An analysis of the interaction between music condition and task complexity was not significant.

The Effects of Noise and Music Upon Task Performance

Many studies have been conducted on the effects that noise and music have upon performance of various tasks. This project will survey various experiments done in the area and will conclude with an experiment designed to extend our knowledge of such effects.

One of the earliest experiments on varying types of music (Gatewood, 1921) centered on the effects of using music in an architectural drafting room. Forty-five varied musical selections were played while men worked in the room, unaware that an experiment was in progress. After the experiment, a questionnaire was given to the subjects (56 men). Forty-nine subjects said that music seemed to make work easier; five disagreed. Forty-seven said that music was not a distraction; while only six said that it was. Instrumental selections were preferred over vocal ones, with familiar music being greatly preferred to unfamiliar music. In an informal interview conducted afterwards, twenty-two of the men said that music actually sped up their work because they kept time with the rhythm. Forty-one stated that music kept them in better spirits, and twenty said that music provided a rest between work periods. Thus, the music seemed to make the men enjoy their work more; this enjoyment facilitated work performance.

Jerison (1954) conducted a counting experiment under two different noise conditions to assess their effects. The subjects were required to maintain three different counts simultaneously. Three lights of varying colors were each flashed a differing number of times per minute. Subjects were required to press a key under a light every Nth time the light flashed (N= 4, 7, or 10). The task took place uninterrupted for two hours. The control group performed two hours in quiet while the experimental group performed the first hour in white noise (100 decibels) and the second hour in quiet. White noise is a mixture of sound waves extending over a wide frequency range (Gove, 1981) and sounds somewhat like static. Decibel refers to the intensity of the sound. Sixty decibels is the approximate measure of ordinary speech; a car air horn is recorded at about 90 decibels and a sonic boom registers at approximately 130 decibels (Hassett, 1980). Results showed that errors increased significantly over time for all subjects; errors for the longest count and slowest light were most frequent and increased most rapidly; the control group performed significantly better; and the second half hour of performance under noise was markedly worse than the first. Thus, "mental counting" did deteriorate significantly during the noise condition when compared to the quiet condition. This may have been due to both noise and fatigue.

Woodhead (1964) studied the effects that a burst of noise (100 decibels) had on an arithmetic task. In two experiments, a number was displayed on a screen and memorized. A second number was then displayed and the subject was to subtract the second number from the first. In the first experiment, a single burst of noise was given during memorization to determine if noise during memorization had an effect on calculation accuracy. In the second experiment, memorization took place in quiet with the burst of noise occuring during calculation. In these experiments, the effect of noise was measured by calculation errors and amount of time needed for calculation. Both groups were compared with control groups tested in quiet. The results showed that if a burst of noise occurred during memorization, calculation was more likely to be wrong than in the control group. When noise was presented during the calculation period, the over-all calculation times and accuracy of the noise and quiet groups were comparable. However, the noise initially produced a slow rate of responding. As the test proceeded, this rate of responding increased considerably without affecting test accuracy. Thus, noise during memorization seems to have a detrimental effect upon accuracy; this does not occur when noise is presented during calculation.

In testing various noise conditions, Carlin and Saniga (1983) used the Goldman-Fristoe-Woodcock test of selective attention to assess the difference between quiet and background noises. The background noises included a noise below 2000 hertz or cycles per second (sounding like a fan), a tape of cafeteria noise, and a tape of someone speaking. The results showed that the performance of subjects in the voice condition was significantly better than in the two other conditions.

In a study by Wolf and Weimer (1972), four conditions of quiet, speech, music, and industrial noise were tested for their effects on arithmetic performance. The subjects were given arithmetic problems of equal difficulty to complete under each condition. Performance under the music condition was found to be significantly better than under industrial noise. There was no significant difference between any of the other groups. Wolf and Weimer stated that this difference might have been due to the familiarity of music over industrial noise rather than a difference between actual noise types.

Bailey, Patchett, and Whissell (1978) had subjects perform a "monotonous" task under four varying noise conditions. These were: no noise, continuous 95 decibel white noise, 95 decibel white noise presented in a regular pattern, and 95 decibel white noise presented in an irregular pattern averaging a one-second burst every four seconds. A "monotonous" task as defined by McBain (1961) is one requiring (a) very little variability, (b) continuous attention from the subject, and (c) minimum cognitive activity. The "monotonous" task consisted of striking out the letter "e" in an irrelevant type-written passage for nine minutes. The nine-minute time span was divided into three equal blocks of time. The experimenter put a mark on each subject's paper at the end of each time block. Results showed no main effects due to noise. There was a significant decrease in the number of correctly identified "e's" in the third block as compared to the first and second. An interaction between blocks and noise upon number of lines completed was significant only in the second trial block. Separate analysis of the second trial block showed that the patterned noise group had a significantly higher ratio of correct responses than the other three noise conditions, yet the number of lines completed was significantly lower. Thus in this experiment, number of "e's" correctly marked showed no noise effects. The amount of response (number of lines completed) showed an inhibitory effect to patterned noise, while accuracy of response showed a facilitative effect in the same condition.

Geringer and Nelson (1979) examined the effects of background music upon a musical task. In the experiment, college students took a timed test which required decoding musical riddles. Subjects were music majors and non-music majors. The conditions consisted of: background-music-plus-task; background-music-only; and task-only.

The excerpt of music was repeated four times during the music conditions at a level of 65 decibels. Results showed that music majors had a significantly greater number of correct responses than non-music majors. Background music did not significantly affect performance, nor was there a significant effect between major and background music. The same results also held true for number of responses attempted. Geringer and Nelson concluded that:

> It is not surprising that music students responded more frequently and more accurately than non-majors on a cognitive music task. It is, however, interesting that background music did not appear to facilitate or inhibit trained musicians in a manner different from the musically naive subjects (p. 45).

This may be due to the fact that both groups could have learned equally well how to block out environmental stimuli when performing a cognitive task.

In a study by Fogelson (1973), popular music was found to have an adverse effect upon reading test performance. Eighth grade students, divided into Bright/Non-Bright intelligence groups and Music/No-Music noise conditions, were given a reading test consisting of eighty questions. An instrumental version of several showtunes was played during the Music condition. Both Bright/No-Music and Non-Bright/No-Music groups outperformed the matching groups with music. Also, an analysis of the combined Music conditions versus the No-Music conditions showed music as a distractor. An analysis of variance showed that music condition, ability, and the interaction between the two were all significant.

The effects of differing levels of music loudness were measured on a mathematics test with problems of increasing complexity (Wolfe, 1983). Four conditions were used in this experiment: task-only, task-plus-background music at 60-70 decibels, task-plus-background music at 70-80 decibels, and task-plus-background music at 80-90 decibels. After testing, a self-report questionnaire was given to the subjects. The variable of loudness had no significant effect on task performance. However, on the questionnaire, a significantly higher number of subjects from the 80-90 decibels group said that the music did interfere with computation. It is not certain as to why this inconsistency appeared.

Etaugh and Michalis (1975) conducted an experiment testing the effects upon task performance when music was chosen by the subject rather than by the experimenter. This was done in order to test Wolf and Weimer's (1972) hypothesis that unfamiliar sounds are more distracting than familiar ones. It was predicted that the more frequently individuals studied to music, the less it would adversely affect task performance. Subjects, sixteen male and sixteen female undergraduate students, were given two reading comprehension tests. One test was administered in quiet surroundings. The second test was administered while a subject-preferred record album was playing. Data was collected on how frequently each subject studied to music. Results showed that females performed significantly poorer in the music condition than in the no-music condition, while males performed equally well in both conditions. Data concerning frequency of studying to music showed that females studied to music less frequently than males. Therefore, this evidence supports Wolf and Weimer's hypothesis that unfamiliar noises are more distracting than familiar ones.

Task complexity may be a large factor in how noise affects performance. Boggs and Simon (1968) used simultaneous tasks to test the hypothesis that noise would increase one's perceptual load, reduce reserve capacity, and thus lead to decremental performance on a secondary task. Thus, Boggs and Simon hypothesized that performance would be worse on a task of greater complexity. The first task was a reaction time task of varying difficulty involving perceptual-motor skills. The second, an auditory-monitoring task, had a constant difficulty level. The noise was a 0.5 second burst of sound produced by a bandsaw cutting aluminum which was intermittently sounded throughout the experimental trial. The researchers believed that the first task did not require as much attention and used up only a part of the subjects' perceptual capacity. Subjects were thus able to concentrate fully on the first task. A secondary task would use up the remaining perceptual capacity. Any deleterious effect of the music would show up as a hindrance to performing the secondary task. Results showed noise did have a significant deleterious effect on performance of the secondary task, with the amount of decline varying as a function of task complexity. The more complex primary task made greater demands on the perceptual load of subjects and left less unused capacity for the secondary task. When the noise was introduced, this further reduced the capacity load and increased errors on the secondary task.

Houston (1969) also did an experiment to determine the effects of noise on task complexity. In this experiment, two separate tasks of varying complexity were tested under quiet and noise conditions. The first task involved color-word recognition. Names of colors were printed in a differing color ink and the subject would have to name the color of ink the word was printed in. For example, the word "blue" was printed in red ink. The subject would have to respond to the red ink rather than to the word "blue". In order to respond to the color of ink rather than to the word, subjects had to inhibit response to the word. In the second task, the subject had to name the color of ink a non-word (such as asterisk) was printed in. This involved no inhibition. The subjects were exposed to a variety of noises through earphones at a level of 78 decibels. Completion times for each test were measured for the tasks. Houston hypothesized that any differences in responding were due to inhibition. This is especially true for the color-word test because inhibiting a response to noise would help with the inhibition needed for this test. Significant differences were found for both levels of difficulty in each task. In the color-word task, the time for completion was less in noise than in quiet; however, the color-name task took a greater amount of time to complete in noise than quiet. The interaction between noise condition and type of task was significant, while the interaction between noise condition and task complexity was not. Thus, attending to a noise helps performance where inhibition is required, but does not help on a task where inhibition is not required.

Park and Payne (1963) conducted an experiment testing the effects of noise level and task difficulty in performing division. The twenty minute division tests consisted of "easy" (single-digit divisor) problems and "difficult" (two-digit divisor) problems. The noise levels consisted of room noise (50-70 decibels) and a 98-108 decibel noise produced by an air horn. The results showed no significant difference due to noise level or for the interaction between noise level and task difficulty. However, difficulty of problems did significantly affect performance. Statistical tests showed that scores did not vary significantly between the two noise conditions for the difficult group. However, scores for the easy groups did vary significantly. The significant difference between score variations for the easy groups contrasts with Broadbent's 1955 study (cited in Park & Payne, 1963) which states that easier tasks are less affected by noise than are more difficult ones.

In a study with tenth grade students, Mowsesian and Heyer (1973) tested the effects of music on test-taking performance. Standardized arithmetic, spelling and self-concept tests were given with the differing conditions consisting of quiet, rock, folk, classical-instrumental, and classical-vocal music conditions. An information sheet was also given to gather demographic data. Statistical tests showed that no significant difference occured between conditions. Subjects preferred rock music to the other types, yet rock music did not significantly affect results. The demographic information showed that many of the students studied to music. This may account for the lack of significant differences between the control and music conditions.

A study by Belsham and Harman (1977) contrasting vocal and instrumental music found vocal music to be more distracting. College students served as subjects for a visual recall test. The subjects were shown a photograph for sixty seconds during each music condition and then answered a twenty-item questionnaire pertaining to the photograph while the music continued. The vocal group had significantly more errors than the instrumental group, thus showing that vocal music seems to have a detrimental effect on performance when compared to instrumental music.

In summary, Gatewood (1921) found that subjects reported the presence of music had a facilitative effect upon work performance. However, no measurement of actual output was mentioned.

In a counting experiment conducted by Jerison (1954), the effects of noise and fatigue were both tested. Jerison found that performance decreased over time as a result of fatigue. He also found the decrease was more significant during a noise condition than during a quiet condition. This indicates that an interaction between noise and fatigue causes performance to deteriorate significantly.

The noise Jerison (1954) used for his experiment was constant at a level of 110 decibels. Woodhead (1964) studied the effects of a 100 decibel burst of noise on an arithmetic task. A number was memorized and then a second number was was subtracted from the first. Results showed that the noise negatively affected calculation when it was presented during memorization. When the noise was presented during calculation, test results were similar to control groups tested in quiet.

Bailey et al. (1978) had subjects perform a task under conditions of no noise, continuous white noise, white noise in a regular pattern, and white noise in an irregular pattern. After analyzing the data, they were able to find that the number of correctly marked "e's" showed no effects due to noise, the number of lines completed showed an inhibitory effect to patterned noise while accuracy improved during patterned noise. This shows that the same experiment, depending on how the dependent variable is defined, can have differing results. Therefore, it is important to be extremely precise when collecting and analyzing data.

The previous tests were done mainly to see whether or not noise of any type affected performance. Varying types of noise conditions are often the object of tests. This is done to assess the effects of one noise as compared to another. Carlin and Saniga (1983) found that task performance of subjects was significantly better in a condition of someone speaking than in a condition with a noise sounding like a fan or a condition with cafeteria noise. This conflicts the results of a previous experiment done by Wolf and Weimer (1972) in which speech was found to have no significant effect upon performance. Conflicting results, however, could be due to the differing task types which subjects were to perform (selective attention versus arithmetic).

Results from various studies concerning background music are often conflicting. Geringer and Nelson (1979) tested the effects of background music on performance of a musical task and found that background music did not significantly affect performance. Geringer and Nelson concluded that the results may have been due to the subjects learning to block out external stimuli when performing a mental task. In contrast, Fogelson (1973) found that popular music had a significantly adverse affect on eighth grade students taking a reading test. Geringer and Nelson used college students and played "background" music while the subjects completed a musical task. Fogelson, on the other hand, used eighth graders and played "popular" music while the subjects took a reading test. Since two different subject types and two different task types were used with only broad categories being specified for the music type, it is not known to what the discrepancy between findings is due.

In an experiment testing the effects of differing levels of music loudness on task performance, Wolfe (1983) found no significant difference between any of the conditions. However, questionnaires filled out by the subjects showed that a significantly higher number of the subjects thought that the loudest level did, in fact, interfere with performance. It is not certain why there was a difference between the subjects' perception of performance and actual performance. To date, no follow-up studies on this matter were found. Etaugh and Michalis (1975) did a study to assess the effects upon task performance when the subject chose the music as a function of frequency of studying to music. The results showed that the less frequently the subject studied to music the more adversely the music affected performance during the experiment. This seems to indicate that if a person studied to music only occasionally, the music would have a much more adverse effect upon studying than if a person often studied to music.

Boggs and Simon (1968) and Houston (1969) did studies centering on task complexity. Boggs and Simon found that music did have a more deleterious effect upon a task of greater complexity. However, Houston found differing results. In a task that involved inhibition, Houston found that the noise actually aided performance in a task of greater complexity. When the subject had to inhibit responding to the music, he was aided in a task involving inhibition. However, Houston found the opposite to be true in a task not involving inhibition; the music actually hindered performance.

Park and Payne (1963) found that noise had a greater effect on difficult problems than easy ones, while Broadbent (1955) found easy problems to be affected more. In their experiment involving four differing types of music, Mowsesian and Heyer (1973) found that vocal and instrumental music had the same effect upon test performance. In contrast to this, Fogelson (1973) used instrumental music and found that it did have a deleterious effect upon performance. Also, Belsham and Harman (1977) found vocal music to be significantly more distracting than instrumental music. This experiment will center on both music type and task difficulty in hopes of clearing up some of these discrepancies. In many previous cases, the music was kept at a low volume level, often below that of normal conversation. This has often shown to have no significant effect upon performance (Geringer & Nelson, 1979; Houston, 1969; Park & Payne, 1963). Therefore, music for this experiment will be kept at approximately 80 decibels, a level slightly below that of an automobile horn.

Method

Subjects

Forty-eight students from a general psychology course served as subjects. Extra class credit was given as an inducement for participation.

Materials

Instrumental and vocal versions of two-minute sections of a taped song ("Little Flowers" by Danny Lee) were used as background music and played at a level between 75-80 decibles. The task consisted of four arithmetic tests of two varying complexities. The simple test contained one- and two-digit numbers used in addition, subtraction, multiplication, and division problems (Duncan, 1978, vols. 3, 4). The difficult test contained numbers of three of more digits (Duncan, 1978, vol. 6). Problem type and order were kept constant throughout. Each test was fifty problems in length and was designed to be too long for subjects to finish in the alloted time.

Procedure

The experiment took place in a small conference room with subjects sitting across a table from one another. The tape player used was positioned within five feet of each subject.

Subjects were told they would be taking a series of four arithmetic tests lasting two minutes each. Subjects were also told music would be played during each two minute section.

The four conditions tested were instrumental music-difficult problems, instrumental music-easy problems, vocal music-difficult problems, and vocal music-easy problems. Order of the conditions was completely counterbalanced with two subjects participating in each condition.

Subjects began working the first test when the first section of music began, stopped working when the music stopped, turned to the next part of the test and began working again when the music started again. This was repeated throughout the experiment. Test papers were collected at the end of the entire testing session.

Results

Analyses were done for the number of problems correct, number attempted and percentage of problems correct. Results showed that the instrumental music condition had a significantly higher number of problems attempted (38.4 v 35.02) and correct (34.65 v 31.25) than the vocal music condition ($p < .01$, $p < .05$, respectively). The percentage of problems correct was not significant.

Results for task complexity showed that the difficult problems had a significantly lower number of problems attempted (23.21 v 50.21), number correct (18.69 v 47.21), and percentage correct (80.86 v 92.57) than the easy problems ($p < .01$ for all).

An analysis of the interaction between music condition and task complexity was not significant for the number of problems correct, number attempted, or percentage correct.

Table of Means

Number Attempted

	E	D	$\bar{X}$
V	23.90	11.13	17.52
I	26.31	12.08	19.20

Number Correct

	E	D	
V	22.38	8.88	15.63
I	24.83	9.81	17.32

Percentage Correct

	E	D	
V	92.88	80.52	86.70
I	92.25	81.20	86.72

Discussion

The present study shows that vocal music had a more deleterious effect than instrumental music upon subjects' speed in taking timed arithmetic tests and, consequently, reduced the total number of correct answers. However, vocal music did not significantly affect the percentage of problems the subjects were able to answer correctly.

In comparing difficult problems to easy problems, subjects were able to attempt significantly fewer difficult problems during the time alloted. Because fewer problems were attempted, the total number correct was less. Subjects also answered a significantly lower percentage of difficult problems correctly.

There was no significant interaction between music type and task difficulty. These finding support Belsham and Harman's (1977) findings that vocal music is more distracting than instrumental music and conflict with Mowsesian and Heyer (1973) who said that vocal and instrumental music have the same effect.

Since no interaction between problem difficulty and music was found, these findings conflict with those of Park & Payne (1963) who said that noise had a greater effect on difficult problems. The findings also contrast Broadbent's findings which stated easy problems were affected more. These conflicting results could be to the fact that music was used instead of noise. The music may have been more familiar than the noise and therefore, less distracting (Wolf & Weimer, 1972; Etaugh & Michalis, 1975).

In summary, if a student is studying to music, it is best to study to instrumental music rather than vocal because vocal music tends to slow the student down more. Although the percentage of difficult questions correct was significantly lower than that of easy problems, the culprit was not the music but rather the difficulty level of the task itself. Therefore, a student should study the same whether he is listening to vocal or instrumental music. Thus, this study shows that vocal music will slow down a person's mental performance, especially on more difficult tasks, but will not actually hinder the work that is completed.

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