# THE INFLUENCE OF SYNCHRONOUS AND ASYNCHRONOUS RHYTHM AND MUSIC ON PURSUIT ROTOR PERFORMANCE

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

Bernard Mikolitsky

1953

This is to certify that the

thesis entitled

The influence of synchronous and asynchronous rhythm and music on pursuit rotor performance

presented by

Bernard Mikolitsky

has been accepted towards fulfillment of the requirements for

M.A. degree in psychology

Milton Rokeach (M.R.D)
Major professor

Date August 11, 1953.

O-169

# THE INFLUENCE OF SYNCHRONOUS AND ASYNCHRONOUS RHYTHM AND MUSIC ON PURSUIT ROTOR PERFORMANCE


By

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A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF ARTS


Department of Psychology



Year 1953

9-2-53
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## ACKNOWLEDGMENT

Grateful acknowledgment is made to Dr. M. Ray Denny for his advice and assistance throughout the course of this research. The author is grateful to his wife for her empathic support.

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# INTRODUCTION

The aim of the present investigation is to study the effects of music on the performance of a repetitive task similar to that found in industrial situations. Although most of the literature on this topic is impressionistic and anecdotal, there is a small amount of experimental literature in this area, the greater portion of which pertains to the effects of music on quantity and quality of production in defense plants during the World War II period. In this type of setting, experimental conditions are difficult to control, for experimental design is secondary to the status quo of the factory or plant. Of this Kerr (6) writes:

> For a fair interpretation of the industrial music experiments which have been completed, the reader must consider the problem of experimental design and the ways in which this problem has been handled by various experimenters. Unless an industrial experiment is carefully designed, results obtained may be completely obscured or made misleading by important variables not controlled by the original design. Even the best practicable designs often have serious limitations.

In the present study, experimental design can be given primary consideration since the investigation is being conducted in a laboratory setting. As a result, some of the shortcomings inherent in previous designs should be eliminated without introducing new error or limiting the generality of the findings.

In addition to studying the effects of music, we are attempting to isolate one of the several musical variables, rhythm, and ascertain its effects on the performance of a repetitive task. The term 'rhythm' as here used means the regular equally spaced pulsations equivalent to the musicians' term 'tempo' or 'meter'.

The pursuit rotor used in this study is assumed to be a prototype of a paced repetitive psychomotor task. However, it is assumed that any studies which pertain to the effects of either music or rhythm on the performance of any repetitive task could have relevance here.

One of the first experiments in an industrial setting on the effects of music on quantity of output in a repetitive manual task was that conducted by Wyatt and Langdon (12) in which the following experimental design was used.

Period 1 (6 weeks) - No music (i.e., usual conditions of work)
Period 2 (3 weeks) - Dance music from 10:00 to 11:15 and from 4:00 to 5:00
Period 3 (3 weeks) - Dance music in the morning from 9:30 to 10:00 and from 11:00 to 11:45; and in the afternoon from 4:00 to 5:00
Period 4 (2 weeks) - Dance music in the morning from 8:45 to 9:15, 9:45 to 10:15, 10:45 to 11:15, and 11:45 to 12:15; and in the afternoon from 4:00 to 5:00
Period 5 (5 weeks) - No music
Period 6 (5 weeks) - Music played from 10:00 to 11:15 and from 4:00 to 5:00

Results. Production in Period 2 was 6 percent higher than in Period 1; output in Period 3 was 2.6 percent higher than in

Period 1; Period 4 conditions were accompanied by an increase in output of 4.4 percent when compared with Period 1. In Period 5 (no music) production decreased to the level of Period 1 (no music). In Period 6, the type of music was systematically varied i. e. one-steps on Monday, fox-trots on Tuesday, etc. The findings indicate that production in this period is higher with music than without music. The size of the increase correlates perfectly with the tempos of the various types of music, the larger increase being associated with the faster tempos. In summary, the overall difference between music and no music days is statistically significant as is the difference between one-steps over slower music and fox-trots over slower music.

An evaluation of these findings would have to take into account certain weaknesses in the experimental design. The whole study was carried out using only 12 subjects, female factory workers. No control group was used to measure the effects of possible cyclical trends from other causes which might have produced the output trends obtained in this study. No statistical allowance was made for the effects of practice in Period 1 (6-week no music period) on the subsequent Period 2 (3-week music period) in which a 6 percent increase in production was found. There was no randomization of either subjects or conditions in the first five periods, to allow for possible error introduced by the particular sequence of presentation of the various conditions. In Period 6, however, conditions were randomized. Thus, it appears that from the overall experimental design, we are left with only one allowable inference: that faster music enhances production more than does slower music. We may not safely infer, however, that music enhances production more than does no music, on the basis of this study.

In 1938, Humes (4) completed a study of the effects of music on quality in the manufacture of radio tubes. The experiment ran for 16 weeks according to the following design:

1. Check period (5 weeks) - two records per working hour making approximately 64 minutes per day of music
2. Slow period (3 weeks) - tempos with counts from 63 to 80 per minute. First week, one selection every half-hour; second week, two selections consecutively every hour; and third week, three selections consecutively every hour.
3. Fast period (3 weeks) - tempos with counts from 104 to 152 per minute, same schedule as during slow period.
4. Arranged period (3 weeks) - selections ranked daily so that the more familiar would be played first and the less familiar last.
5. No-music period (2 weeks) - Music was discontinued during working hours. This period was intended to cover three weeks, but on the first day of the third week 65 employees petitioned for resumption of music. Music was resumed.

The variables here are: distribution of playing time, tempo of the music, and presence or absence of music. The results show that seven of twelve differences are statistically significant in favor of better quality of production with music. Distribution of playing time was not a significant variable; regarding tempo, either fast <u>or</u> slow music was accompanied by less scrappage (the measure of high quality being a low amount of scrappage) than was the mixed (fast <u>and</u> slow) music.

A priorí, one would expect that quality would improve after 14 weeks of practice. In the above, the no-music period came after 14 weeks of work with music. Yet it was in the no-music period that production was lowest. However, the differential results cannot be wholly attributed to music since no control group was used, nor were either subjects or conditions randomized. (Randomization would allow interfering factors to cancel each other out). Also, inconsistencies in the statistical results suggest that factors other than music may have contributed to the total variance.

Kerr (6) reports a series of studies in which he attempted to remedy some of the methodological weaknesses of the two studies cited above. One weakness pertained to the fact that the various cycles (music and no-music) were so few and so long that interfering factors were maximized in the final results rather than canceled out by randomization. He reasoned also that the effects of music on worker output is more immediate than cumulative. Consequently, he used consecutive four day cycles: two music days followed by two no-music days, for forty days. Subjects were 64 employees engaged in repetitive and manual tasks in the manufacture of Naval Capacitors. The 64 employees represent three groups, each group engaged in a different task of the same type (25, 30 and 9 subjects respectively in each group).

Results. No significant differences were found in mean output between music days and no-music days although each of the groups showed the following increases in output on music days: 0.75 percent, 1.00 percent, and 0.43 percent respectively. However, concomitant with this increase in quantity was a decrease in quality on the music days involving a 9.98 percent and a 14 percent increase in scrappage, respectively for two groups on music days. Since the increase in percent of scrappage represents a small absolute amount, there is still a .57 percent greater good yield with music. Thus the findings on quantity agree with those of other studies but the results on quality are in contradiction to those found by Humes (4).

In the experiment just summarized, Kerr presents no data on the type of music used. Apparently, the type of music was not one of the variables manipulated. In another experiment by the same investigator, the effects of various types of music in addition to the effects of music vs. no-music were studied. Using 46 employees as subjects (40 electronic crystal finishers and 6 crystal assembly workers) the experiment covered a period of 5 months or 107 experimental days, in continuous cycles of three days with music followed by three days without. Three types of music were used: Sweet music (soft, not too heavily accented), Peppy (louder music), Variety (anything from "Tchaikowsky's Symphony No. 5" to "Smoke Gets in Your Eyes"). Both day of week and order of presentation of the three types of music program were randomized as was the variable of music vs. no-music.

Results. For the 40 crystal finishers, quantity of output was 4.82 percent greater with music; for the 6 crystal assembly workers, output was 7.43 percent greater. On quality of output, for the 40 crystal finishers, scrappage was 8.30 percent less with music than without music thereby increasing the net good yield by 9.07 percent. In this experiment, greatest quantity was obtained with peppy music, best quality with variety or sweet music, and highest net good yield with variety music. It should be noted that none of the critical ratios presented by Kerr for the increase in output with music, the decrease in amount of scrappage, or the differences in either quantity or quality of output attributable to type of music is significant. The trends, however, are consistent, in this study and favor the use of music over no-music.

Kerr (6) conducted the following experiment on 520 employees of a radio tube factory, all engaged in manual hand dexterity operations connected with mounting and assembling the intricate parts which compose a radio tube. The 520 employees represent three groups, each group engaged in a different task of the same type (210 engaged in glass-tube operations, 170 in power-tube operations, and 140 in miniature-tube operations, the miniature tube assembly requiring the highest degree of hand-eye coordination because of the minuteness and delicacy of the parts). The experiment ran for 54 days, using a four-day repeating cycle with a different condition each day of the cycle.

Condition 1. Hit Parade. Current popular and recent current popular hit tunes. (Employees ranked these first in popularity)

Condition 2. Waltz-Hawaiian. A random combination of these two slow, sweet types of recordings (third and fifty in popularity).

Condition 3. March-Polka. A random combination of these two "peppy" types of selections (fourth and seventh in popularity).

Condition 4. Less-Music. This consisted of a 25 minute radio program and a 30 minute request program, assumed to be equal in popularity to the Hit-Parade of Condition 1.

Conditions 1, 2, and 3, (collectively called the "more-music" period) called for music to be played about 6 hours per day while Condition 4 (the "less-music" period) called for music only 55 minutes of the day.

Results. During the "more music" period (41 days) there was a mean increase in output of 1.61 percent for the miniature tube operators and for the glass and power tube operators a 1.01 percent increase over the "less music" (13 days) period.

Quality, however, suffered a set back for all three groups in the "more music" period, the decreases in quality amounting to 4.18 percent, 10.53 percent and 1.06 percent for the miniature tube, glass tube and power tube operators respectively. Again, none of the differences presented are statistically significant.

The final experiment reported by Kerr (6) was an attempt to determine whether one technical type of phonograph recording was better than another technical type for the purposes of factory broadcasting. Specifically, an attempt was made to compare the effects of standard RCA Victor phonograph records with the NBC-Orthacoustic records on quantity and quality of workers' output in certain factory operations. Additional variables were types of music: Variety (V), Sweet (S), and Peppy (P) and no-music. Thus the variables are, type of music, type of recording, and music vs. no music. Both type of music and type of recording were randomized. The 60 experimental days, 30 music days and 30 non-music days were made up of 10 six-day cycles of 3 successive days with music, the following three days without music.

Results. Forty electronic crystal finishers and six crystal assembly workers show an increase in output with music of 1.98 percent and 11.50 percent respectively. For the 40 finishers, quality decreased with music .66 percent but at the same time the net good yield was 1.42 percent higher.

The Victor vs. Orthacoustic results show that each type of record has about the same number of advantages and disadvantages. The type of record results are inconsistent e.g. Peppy "Victor" records show the greatest increase in quantity of output while Sweet "Orthacoustic" records have this effect.

Kerr concludes on the basis of all the experiments reported (Wyatt and Langdon's included):

1. In 12 out of 12 comparisons, average output was greater on music than on no-music or less-music days.

2. In 7 out of 10 comparisons, average quality was higher on no-music or less-music days than on music days, while in the other three comparisons the opposite was true.

3. In 5 out of 5 comparisons, average net good yield was higher with music than without music.

4. The evidence so far indicates that the best production is achieved with music that is subjectively of moderate or peppy tempo.

5. Music in these experiments was associated with greater percentage of production increases in those departments not having incentive-wage systems.

6. Additional research is needed on the effects of specific musical factors on efficiency.

Smith (10) studied the effects of music in relation to production on a highly repetitive assembly line operation which was on incentive pay. Two separate shifts with an average of 21 employees on each shift were studied simultaneously for twelve weeks. The results showed that:

1) Production under varying conditions of music increased from 4 to 25 percent. The average increase on the day shift was 7 percent, on the night shift, 17 percent.

2) Maximum production increases were found when music was played 12 percent of the time on the day shift, 50 percent of the time on the night shift.

3) Production tended to decrease with a large increase in the number of semi-classical selections but did not vary with a large increase in the number of vocals. Waltzes were more effective at the opening of the shift than marches.

4) Production increases varied with the hour at which music was played and were greatest during the hours of low production.

5) The more an employee wanted music, the more music tended to increase her production; the lower the employee's production, the more music tended to increase her production; the more the employee's job permitted conversation while working, the more music tended to increase her production.

6) The greater effectiveness of large amounts of music on the night shift corresponded with a greater demand for music on the night shift; the greater effectiveness of varied music corresponded with an expressed preference for varied rather than for special types of music; the greater effectiveness of certain distributions of music corresponded with an expressed preference for such distributions.

Jensen (5) in his study of the influence of two types of music, jazz and dirge upon speed and accuracy of typing, found that with jazz, typing speed did not increase but the number of errors did, when comparison was made with a control group. With dirge music, the number of words decreased. The number of errors also decreased, when compared with a control group. The authors conclude that music is a serious distraction to typists under the conditions of their experiment.

The following are presented as evidence for the evocation power, kinaesthetically speaking, of a regularly recurring auditory stimulus. In response to a regularly recurring sound, Lovell and Morgan (7) found that there were motor accompaniments in time with the regularity of the sound. Ruckmick (9) used a variety of auditory rhythmic stimuli of equally and unequally spaced patterns. His subjects were asked to attend to these stimuli and report verbally their reactions. He found that the Ss muscular movements were an essential part of the rhythmic response. Summarizing, he writes:

> These points are certainly clear: 1) The kinaesthetic complex changes for accent and non-accent; 2) Kinaesthesis on the accent is more intensive and felt as strain or tension, while kinaesthesis on the non-accent is less intensive and is felt as relaxation.

Anecdotally, anyone who has observed the behavior of listeners at a jazz concert, has witnessed the movements of arms and legs as well as other parts of the body including fingers, neck, head and facial muscles responding to the rhythmic beat.

The above suggests that one response to a regularly recurring auditory stimulus is to make regular muscular movements at the same rate. The question for the present investigation is: Would a regularly recurring auditory stimulus have a facilitative effect on a task which required regular muscular movements? It is known that rhythm is effective in verbal learning. For example, poetry is more easily memorized than prose. Muller and Schumann (8) noticed that subjects introduced rhythm into their repetitions of nonsense syllables and that attempts to suppress the rhythm decreased the speed of learning. Elkin (1) found that the less readily the material lends itself to being rhythmized, the more slowly does the learning proceed.

In the area of perceptual-motor learning Harding (3) in his studies of typewriting shows that there is a general tendency for typists to form time patterns out of their key strokes. A positive relation exists between the degree to which this rhythmization is stressed and the subjects' capacity for rapid work. If the Ss are divided into more rhythmical and less rhythmical, the former is about 13 percent faster. He found also that the speed of most learners may be increased if a suitable rhythm is indicated for each word before practice begins.

These studies are related only peripherally to the present investigation since the rhythm was imposed upon the task by the subject himself. In the present study, the rhythm was imposed externally thereby constituting a somewhat different problem.

## STATEMENT OF THE PROBLEM

The present study is an attempt to answer the following questions:

1. What is the effect of music on the performance of a repetitive task under the following conditions:

   a) The pulse of the music is synchronous with the pursuit rotor motion.

   b) The pulse of the music is asynchronous with the pursuit rotor motion.

2. What is the effect of a pulsating metronome on the performance of the same repetitive task under the following conditions:

   a) The pulse of the metronome is synchronous with the pursuit rotor motion.

   b) The pulse of the metronome is asynchronous with the pursuit rotor motion.

## EXPERIMENTAL PROCEDURE

A. Subjects. A total of ninety subjects, naive to the task, was recruited from the introductory classes in psychology at Michigan State College. It was necessary to discard the data of ten Ss in order to achieve five groups matched for sex and for initial performance in a two-minute work period. Thus the data are based on 80 Ss, 16 in each of five groups with 8 males and 8 females in each group. The first 60 subjects were assigned randomly to each of the several groups with a running average of performance scores on the two-minute work period being maintained for each group. Thereafter, the Ss were assigned to groups in such a way that near equality of mean and standard deviation was assured on the two-minute work period.(Table I).

B. Apparatus. A Koerth-type pursuit rotor, hinged stylus, two .01 second Standard Electric Timers and a toggle switch for switching clocks every 30 seconds were used. The black rotor-disk was 27.17 cm. in diameter and the brass target was 1.9 cm. in diameter set 8.1 cm. from the center. The disk turned clockwise at 56 revolutions per minute.

An electric metronome of medium loudness, when sounded at 112 pulses per minute was synchronous with the rotor-disk. When sounded at 123 pulses per minute, the metronome was asynchronous with the rotor-disk.

TABLE I

AVERAGE TOTAL PERFORMANCE SCORED IN SECONDS IN THE TWO-MINUTE WORK PERIOD

| Groups | Control | Synchronous Metronome | Asynchronous Metronome | Synchronous Music | Asynchronous Music |
|---|---|---|---|---|---|
| Mean | 9.98 | 9.73 | 9.81 | 9.62 | 9.75 |
| Standard deviation | 7.87 | 6.85 | 9.68 | 7.74 | 8.55 |
| Standard error of the mean | 2.03 | 1.80 | 2.50 | 1.20 | 2.21 |

Hereafter, the following abbreviations will be used, Sync-met for Synchronous Metronome, Async-met for Asynchronous Metronome, Sync-mus for Synchronous Music, and Async-mus for Asynchronous Music.

TABLE II

EXPERIMENTAL DESIGN

| Groups | 2-Minute Work Period | 2-Minute Rest Period | 6-Minute Work Period |
|---|---|---|---|
| Control | Standard Conditions | - | Standard Conditions |
| Sync-met | Standard Conditions | - | Synchronous Metronome |
| Async-met | Standard Conditions | - | Asynchronous Metronome |
| Sync-mus | Standard Conditions | - | Synchronous Music |
| Async-mus | Standard Conditions | - | Asynchronous Music |

The music used in this experiment consisted of a medley of popular show tunes (Tea for Two, Embraceable You, Somebody Loves Me, Love Walked In, These Foolish Things) played on the piano by an experienced performer and recorded on tape. During the six-minute work periods, the music was played back from the original tape and recorder. Two recordings of the medley were made and used, one at 112 and one at 123 pulses per minute, the slower of the two requiring one less tune to fill up the six-minute period needed for the experiment. Otherwise,the music was the same for both music groups. Thus the music at 112 pulses per minute was synchronous with the rotor, and the music at 123 pulses per minute was asynchronous.

To insure constancy of tempo of the music, the same electric metronome used throughout the experiment pulsated during the recording of the music at the required tempos, 112 and 123 respectively while every effort was made to keep the tempo steady for six minutes.

C. Experimental Design. All groups worked continuously for two minutes, rested for two minutes and then worked continuously for six minutes. The time on target was recorded every 30 seconds. Accurate recording for every 30 seconds of work was accomplished by manually throwing the four pole double throw switch with a rapid thrust at the end of each 30-second period as measured by a stop-watch. E then recorded the reading on the stopped electric timer and reset it to zero.

D. Instructions to Subjects. All Ss were instructed to perform as well as they could, to keep the stylus in a horizontal position and to follow the target with a relaxed rotary movement. The experimenter then demonstrated the operations while repeating the instructions. The Ss were cautioned to begin and stop only when given the signal to do so. If a subject violated any of the instructions he was immediately corrected without interruption of work.

## RESULTS AND DISCUSSION

The data were tested for homogeneity of variance by Fisher's (2) F test. Two sets of tests for homogeneity of variance were performed, one on the five variances of the total time on target for the two-minute work period and the other on the five variances for the total time on target for the six-minute work period. All of the data were found to be homogeneous.

As stated previously, the group means and standard deviations were matched as closely as practicable on their scores in the two-minute work period. Table I (P. 17) indicates the degree to which this matching was accomplished. Since the largest difference between any two means in this table is only .32 and the smallest standard error of the difference is greater than 2.6, none of the critical ratios can exceed .13. In other words, there are no significant differences between any pair of groups in the period prior to differential experimental treatment.

Having met the assumption of homogeneity of variance, the most economical statistic for the experimental work period appeared to be analysis of variance. As indicated in Table III, the obtained F ratio is less than one. Interpreted, this means that the different experimental conditions presumably had no appreciable effects on the several groups. However, examination of Figure 1 (P. 21a) suggests that some trends are present. In

TABLE III

ANALYSIS OF VARIANCE OF THE SIX-MINUTE WORK PERIOD

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Between groups | 4 | 5,007.03 | 1251.76 | 0.787 |
| Within groups (error) | 75 | 119,311.18 | 1590.09 | |
| Total | 79 | 124,318.21 | | |

For d.f. 4 and 75, $F_{.05} = 5.68$, $F_{.01} = 13.61$

spite of the fact that the two groups appear to be more or less the same prior to the introduction of experimental variables, differences appear to be present among them after experimental variables are introduced. In Figure 1, the Sync-met and the Control groups appear to be superior to the other groups. The Sync-met group is superior at all points, the Control group at 7 points.

It should be made clear, however, that the analysis of variance technique is not the most efficient statistic to use in this context since it does not take into account the restriction in sampling brought about by matching. Guilford (2, p. 196) has written:

> It is logical that if we try to keep successive samples constant with respect to the mean on some variable positively correlated with the experimental variable, the means of the latter will also be kept more constant depending upon the extent of the correlation. The standard error of a mean should then be smaller under this restriction.

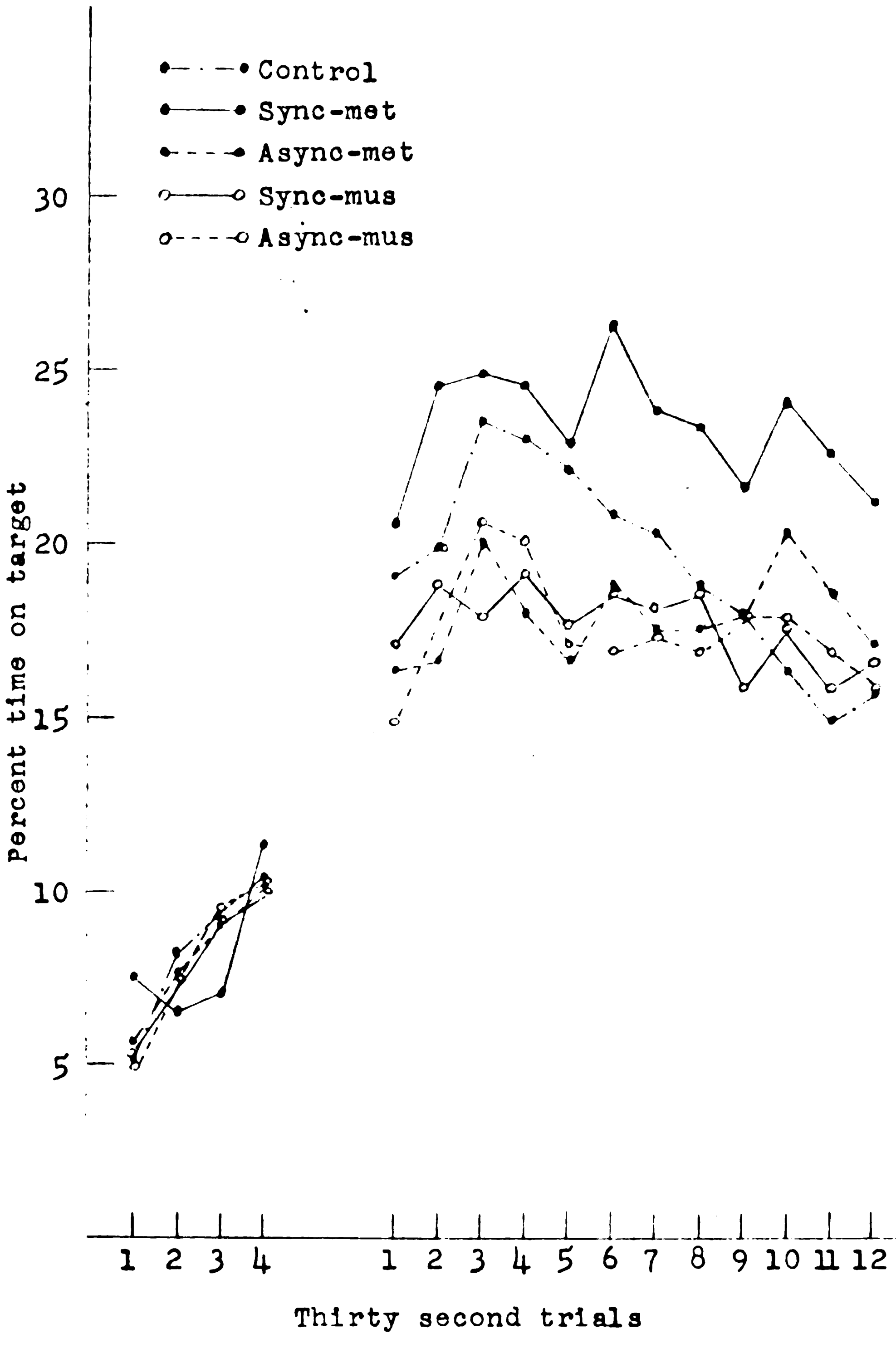


Figure 1 - Performance curves for all five groups before (trials 1-4) and after (trials 1-12) introduction of the several experimental variables.

The formula for the standard error of a difference is then given as:

$$\sigma_{d_M} = \sqrt{(\sigma^2_{M_1} - \sigma^2_{M_2})(1 - r^2_{mx})}$$

in which $r_{mx}$ is the correlation between m, the variable on which the groups were matched - in this study, the means on the two-minute work period - and x, the variable on which we are testing the difference - the six-minute work period. Since the correlations between the two-minute and six-minute scores are very high (Table IV), it is apparent that keeping the means constant in the two-minute period would tend to make the means in the six-minute period constant as well. Table IV gives the correlation coefficients used in calculating the standard error of a difference for matched samples. In each case, the correlation is between performance in the two-minute work period and performance in the six-minute work period, based on 32 $S_s$ for all pairings of the five groups.

TABLE IV

CORRELATIONS BETWEEN THE TWO-MINUTE AND SIX-MINUTE PERIODS FOR ALL PAIRINGS OF THE FIVE GROUPS

| | | | |
|---|---|---|---|
| Control & Sync-met | r .76 | Sync-met & Sync-mus | r .76 |
| Control & Async-met | r .87 | Sync-met & Async-mus | r .72 |
| Control & Sync-mus | r .82 | Async-met & Sync-mus | r .86 |
| Control & Async-mus | r .79 | Async-met & Async-mus | r .84 |
| Sync-met & Async-met | r .81 | Sync-mus & Async-mus | r .82 |

Table V gives the mean, standard deviation and standard error of the mean for the six minute period.

TABLE V

AVERAGE TOTAL PERFORMANCE SCORES IN SECONDS IN THE SIX-MINUTE WORK PERIOD

| Groups | Control | Sync-met | Async-met | Sync-mus | Async-mus |
|---|---|---|---|---|---|
| Mean | 69.99 | 84.49 | 64.96 | 63.75 | 63.62 |
| S.D. | 40.64 | 41.45 | 42.95 | 35.54 | 31.33 |
| Standard error of the mean | 10.49 | 10.70 | 11.09 | 9.17 | 8.09 |

Table VI gives the "t" ratios for the data in Table V.

TABLE VI

"t" RATIOS FOR THE DIFFERENCES BETWEEN MEANS IN THE SIX-MINUTE WORK PERIOD

| | Control | Sync-met | Async-met | Sync-mus | Async-mus |
|---|---|---|---|---|---|
| Control | | 1.50 | .67 | .79 | .79 |
| Sync-met | | | 2.23* | 2.27* | 2.24* |
| Async-met | | | | .16 | .18 |
| Syhc-mus | | | | | .02 |
| Async-mus | | | | | |

For d.f. 30, $t_{.05} = 2.04$, $t_{.01} = 2.75$

*Significant at .05 level of confidence

As shown in Table VI, none of the groups are significantly different from the Control group, though the Sync-met group shows a definite trend toward superiority. The Sync-met group clearly performed better than the Async-met, Sync-mus, and Async-mus groups. In each case, the difference is significant at the .05 level of confidence. According to the table presented by Wilkinson (11, p. 158) the probability of obtaining three significant differences at the five percent level in a group of ten comparisons is .0115. Thus, our three obtained significant differences are much beyond chance expectancy.

The assumption is that the synchronous metronome provided an auditory cue, aiding the simultaneous grouping of eye and arm movements in conformity with the motion of the disk. There is independent evidence to the effect that the grouping of physical movements has a facilitative effect on the performance of motor, tasks, as previously mentioned in the study of typists by Harding (3). Anecdotally, professional swimmers, divers, dancers and track stars are expert in their ability to time and group physical movements. In general, rhythm is probably facilitative because it aids the organization of material into functional units giving accent to certain phases of response and making them stand out as reference points.

The Async-met group performed somewhat more poorly than the Control group and significantly worse than the Sync-met group. It is conceivable that the visual cue of the rotor motion at 56 revolutions per minute tends to elicit one rate of arm motion, while the auditory cue at 123 pulses per minute tends to elicit another rate of arm motion precipitating a conflictful situation. Evidence was cited (7) for the elicitation value of a regularly recurring sound. That a regularly recurring visual stimulus has elicitation value, one need only observe cheer leaders at a football game or a conductor in front of an orchestra.

Unexpectedly, the Sync-mus group was among the poorest in performance. A priori, one would expect that in view of the facilitative effects of a synchronous metronome and the increase in output found by several investigators when music was introduced into a factory setting, that the two variables operating simultaneously in the synchronous music might have a cumulative effect. However, a more careful analysis of the pursuit rotor situation indicates that there is no question of increase in quantity of output since the Ss are forced to work at the same rate due to the constancy of the rotor speed. Only the quality of performance can be influenced on the pursuit rotor. In this respect, our findings are in accord with Kerr (6) who found that in seven out of ten comparisons quality of performance decreased with music. Jensen (5) also found that music was a serious distraction to typists.

Ss of both music groups were asked what effects, if any, they thought the music had on their performance. In general the responses fell into four categories (Table VII). No one suggested that the music might have hindered his performance.

TABLE VII

OPINIONS ON THE EFFECTS OF MUSIC ON PERFORMANCE

| Reply | Number of Ss |
|---|---|
| The rhythm helped | 9 |
| Music had a relaxing effect | 10 |
| Both of the above | 9 |
| No effect | 4 |
| Total | 32 |

Despite the opinion that the music helped, Ss performance with music tended to be inferior to that of the Control group. There are at least three reasons why the music may have been distracting:

a) It afforded a relief from the monotony of engaging in a repetitive task.

b) Nineteen of the 28 Ss affected by the music said that it relaxed them. It may be that relaxation beyond a certain point is not conducive to optimal performance on a pursuit rotor.

c) The music happened to consist of a medley of love ballads which might have evoked personal associations and memories as possible distraction factors. That the effects of music may vary with the type of music when tempo is held more or less constant seems indicated by comparison of the present results with those obtained in an exploratory study by the present author. March music was used which was variably synchronous and asynchronous (range of pulses per minute in this commercial recording was 112-120). Here the group of 12 Ss performed somewhat better than the Control group.

It appears that the synchrony-asynchrony variables were ineffectual when coupled with music. This may have been due partly to the distraction value and partly to the masking effects of the music; the regular pulsations may have assumed a secondary stimulus value to the melody or other aspects of the music. There is evidence that the asynchrony of the asynchronous music was not perceived by the Ss since almost half of the Async-mus group felt that the rhythm helped them. Thus they appear to have been responding to the constancy of tempo rather than to any relationship between the music and the rotor.

The conclusions warranted by this study are as follows:

1) When a regularly recurring sound is definitive and clear, as with a metronome, and in addition is synchronous with the motion required for optimal performance of a paced repetitive task, it has an enhancing effect, at least as compared with other auditory stimulation under otherwise identical conditions.

2) Under the conditions of this experiment music seems to be a distraction factor tending to reduce the quality of performance. With music, the synchrony-asynchrony variable appears ineffectual.

Some questions for future research might be:

1) What are the effects of music on efficiency in a longer period of working time?

2) What would be the effects of playing synchronous music, not during work where it might be distracting but in a pre-work period or during rest, on subsequent performance?

3) What are the differential effects of music of the same tempo but of different style?

4) What is the relationship between a rhythmic (as compared with a non-rhythmic) approach to a task and, objective and phenomenological appraisals of the amount of energy expended?

## SUMMARY

The present study was an attempt to investigate the effects of music and rhythm on the performance of a repetitive task under the following five conditions: music synchronous with and music asynchronous with the pursuit rotor motion, metronome synchronous with and metronome asynchronous with the pursuit rotor motion, and standard or control conditions. There were 16 Ss in each group, eight males and eight females. The groups were matched for mean performance in an initial two-minute period. All groups worked continuously for two minutes under standard conditions, rested for two minutes, and then worked continuously for six minutes under one of the following conditions: Control or standard conditions (no music and no metronome), Synchronous metronome (rotor at 56 r.p.m., metronome at 112 pulses per minute), Asynchronous metronome (rotor at 56 r.p.m., metronome at 123 pulses per minute), Synchronous music (rotor at 56 r.p.m., music at 112 pulses per minute), and Asynchronous music (rotor at 56 r.p.m., music at 123 pulses per minute). The music consisted of a medley of popular show tunes played on the piano and recorded on tape at the two speeds indicated above.

Analysis of variance failed to show any differences between the groups in the six-minute period. Inspection of the

learning curves suggested some definite trends. Consequently an alternative statistical treatment was used to analyze these trends. Such alternative treatment is justifiable because of the matched group procedure.

The results indicate that none of the groups performed significantly different from the Control group though the Sync-met group shows a trend toward superiority. The Sync-met group performed better than each of the following groups: Async-met, Sync-mus, and Async-mus. In each case the difference is significant at the .05 level of confidence. The probability of obtaining three significant differences at the five percent level in a group of ten comparisons is .0115. Thus, the three obtained significant differences are much beyond chance expectancy.

Explanation was attempted in terms of the cue value of the metronome. The poor performance of the Async-met group was explained in terms of the possible conflict between the rates of motion elicited by auditory and visual stimuli co-occurring at different rates.

In spite of the fact that 28 of the 32 Ss in the music groups thought that the music helped them in some way, both groups performed somewhat more poorly than the Control group. This poor performance was interpreted as a qualitative rather than a quantitative decrease which was due to the distraction effects of the music. These findings are in accord with those of other investigators.

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