BACKGROUND MUSIC ON A MENTAL TASK INFLUENCE OF PLAYING TIME ON PERFORMANCE AND HEART VARIABILITY

by

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B.S., Universidad Pontificia Bolivariana,
Medellin, Colombia, 1968

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Industrial Engineering

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1970

Approved by

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ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my major professor Dr. Stephan A. Konz for his patience, advice and encouragement during the preparation of this thesis.

I am also indebted and grateful to my parents for their constant encouragement and financial assistance. It is to them that this thesis is dedicated.

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PROBLEM

INTRODUCTION

One of the problems in today's industry is defined as worker tensions. These tensions are reflected in high absenteeism, tardiness and poor work quality and output.

This problem can be reduced in part by the use of tension relievers. Music could be an effective way to achieve some benefits because human beings are particularly susceptible to music.

BACKGROUND

The first documented application of industrial music goes back as far as 1640 (Lebo, 1955), when music was used by the Jesuits to overcome the Indians' aversion to manual labor. This happened in the earlier stages of the Jesuit state of Paraguay (South America). As the Indians were sent to work in the morning, they marched accompanied by two bands of instruments playing church music and marches, and dances imported from Europe. Music was played during the whole day and when they returned to their village, they were again led by a band.

Diserens and Fine (1939) told of Professor Karl Bucher's, German ethnologist, observations among peasants. He discovered that work of all kinds was accompanied by songs and that the rhythm of the song was similar to that of the work. He concluded that tonal elements are a kind of overflow of activity. It was not until 1910 that someone related work performance and music (Uhrbock, 1961). This was done by L.P. Ayres, a statistician who was attending a six-day bicycle race in New York City. There was a band playing one half of the time. He recorded the average speed of the cyclists while the band was playing and while it wasn't during three separate evenings. Average speed with music was 19.6 mph and without music 17.9 mph.

PERFORMANCE AND PSYCHOLOGICAL EFFECTS

Several experiments and theories have been proposed, related to psychological effects of background music. In 1946 Van de Wall described what he called the general psychological levels of response to music, the sensory-motor reaction and mental responses. The sensory-motor reaction is an involuntary or reflex action of some of the muscles, causing them to contract and set the appendages in motion. The mental responses relate to feelings aroused, or to a critical analysis of the input stimulus. The subjective responses are individually conditioned to a considerable degree.

Licht (1946) said that the psychologic effects of sound may be physiologic or intellectual, depending on quality, intensity and even past or present mental associations. Besides, of all sounds of a given pitch and intensity, the one which best attracts and maintains interest is the human voice. This might be the reason why background music companies use only instrumental selections. Litch discussed the fact that the average human mind is incapable of engaging effectively in two thought processes simultaneously, but that it can accept a multitude of mental stimuli at any one moment. Mackworth (1961) stated an approach to the study of work decrement which considers it to be stimulus oriented. He studied R.A.F. radar operations during World War II. He found a substantial decrease in performance with time. The physiological ability of the operator did not decline since it could be restored almost instantly. It was a psychological decline in performance.

Konz (1964) wrote of the necessity of an input stimuli to the brain. He said that the cortex of the brain must have input stimuli to function at maximum efficiency. He also stated that the brain adapts to any constant or systematic input and soon learns to ignore it. If a variety of stimuli are used it may be possible to overcome the brain's adaptive behavior to a monotonous task. This can be done by adding variety to the operator's environment.

McGrath (1960) found that sonar operators' performance decreased less on auditory monitoring when they looked at a photograph album at the same time. Later, McGrath (1963) found performance to be better on a one hour visual monitoring task when a variety of audio tapes were played than when constant intensity broad-band noise was presented. The tapes included short segments of music, speech, machine noise and other sounds.

Kirk and Hecht (1963) found monitoring performance to be significantly better during the second half of a two hour visual task for subjects monitoring with a varying intensity broad-band noise (64 db) than for those monitoring with a fixed intensity noise (64 db) or in relative "quiet" (61 db).

Studies employing background music support the results found with varied background noise. Tarriere and Wisner (1962) reported that visual vigilance performance was significantly better when music was used as a background stimulus than when motor noise or silence was used. Later, Ware, Kowal, and Baker (1964) found that performance was significantly better on a visual vigilance task when local radio broadcasts were employed as a background than when subjects monitored in silence.

In 1963 Wokoun reported a large difference in visual vigilance performance favoring background music over noise on the first of two monitoring sessions. He concluded that asymmetrical transfer effects prevented the same difference from appearing in the second session, when background conditions were reversed for each group. In contrast, Poock and Wiener (1966) found two music conditions to be of no benefit on a visual task as compared with a background of white noise.

To the problem of why different tonal sounds have a different effect on our frame of mind, Anokhin (1963) stated that sound waves being received by the organs of hearing affect a certain area of the subcortex of the brain. At the same time, minor musical combinations require a greater expenditure of energy from the organism than major combinations. Stimulation of the subcortex, produced by the sound of music, is transmitted to the cortex of the brain, arousing recollections of all past experience-sad or joyous-depending on the nature of the music.

In 1965 Gaston and Schneider said: "Participation in music offers unique sensory experiences ranging from just perceptible responses on the neuro-muscular level to the highest level of human behavior, intellectual meditation and contemplation."

In 1968 Wokoun had 63 subjects working at a vigilance task for an hour while listening to one of three musical programs. While all three programs included the same 23 selections, the ascending program grew steadily more lively, and the descending program grew steadily less lively, while the increasingly variable program progressively increased the contrast between adjacent selections. Results showed that changing the sequence of the 23 selections profoundly affected reaction times and variabilities, as well as individual consistency. Subjects performed the vigilance task better with the ascending program than with the other two programs.

Lucaccini (1968) did a series of experiments on vigilance. His subjects performed a visual detection task under two conditions of irrelevant auditory stimulation, music or noise. The task required the subject to monitor a display for infrequent light flashes from a small light bulb and to report their occurrence by releasing a response lever. He found significantly better performance under music conditions than under noise conditions.

Dannenbaum (1945) concluded that music made people less able to find faults in geometric figures. Kirkpatrick (1943) reported that music hindered work demanding mental concentration, but Smith (1961) found that it did not adversely affect output, error rate or absenteeism. Freeburne and Fleischer (1952) found that students comprehend Russian history just as well with music as without it. Freeman and Neidt (1959) concluded that students can understand a film just as well while listening to unfamiliar background music as when listening to familiar background music. Irvine (1968) used 25 students in three conditions: White noise, Muzak office music and a combination of popular jazz music. They were given a reading comprehension task and an analytical task. He found no significant differences for the different conditions.

These results suggest that the way music affects work output may vary from one situation to another.

Konz (1962) studied the effect of music on productivity of college students in two different monotonous tasks: matching letters and manual assembly. There were two conditions: music and no music. He found that the average improvement during the music period was 17 percent for the assembly and 18 percent for the mental task. Both were significant. Later on, Konz (1964) did a study on productivity of four tasks: manual assembly, mark sensing IBM cards, addition and anagrams. He utilized 20 non-college women for two weeks. The criteria were output and number of errors. He found no significant effect of music on the group's productivity for any of the criteria.

Brown (1965) did a study on the effect of a car radio on driving in traffic. He used eight drivers in light and heavy traffic listening to recorded programs of music and speech. He found that in light traffic, music significantly reduced the frequency with which the accelerator and brake pedals were used, and in heavy traffic it increased the time taken per circuit. Similar results were found by Konz and McDougal (1968) in their study of background music on the control activity of an automobile driver. They used three conditions: silence, slow music and Tijuana Brass type music. They used 24 students and found that they drove significantly faster, and with less weaving, under slow music.

PHYSIOLOGICAL EFFECTS

There also have been studies of the physiological effects of music. In 1892 professors Fere and Tarchonoff (Smith, 1964), working independently, used the ergograph so that graphic records could determine the exact amount of work done by a muscle in a given time, with or without music. Fere used very simple tones and intervals, alternation of tones, and ascending scales. Tarchonoff conducted his experiments with musical selections as stimuli. The similar conclusions were: "1- Music exercises a powerful influence on muscular activity which increases or diminishes according to the character of the melodies employed: 2- When music is sad or slow in rhythm and in minor key, the capacity for muscular work decreases to the point of ceasing entirely if the muscle has been fatigued from previous work."

Hyde (1924) found that music affects the cardiovascular system as measured by the diastolic blood pressure, systolic blood pressure, pulse rate and electrocardiogram. He observed that there was more effect if the person was familiar with the music, liked music and had previous musical training.

The case of the Italian boy who suffered an ax cut which exposed part of his brain was reported by Podolsky (1954). This cut permitted direct observation of his brain. Lively music caused an increase of blood in the brain as well as a faster pulse. Soft, slow music decreased the flow of blood. Podolsky also cited changes in pulse rate under musical stimulation, such as 80 to 96 with waltz music and to 100 or more with a tango.

In a study done by Ellis, Douglas, and Brighouse reported by Podolsky (1954) 36 subjects listened to a series of two minutes talks taken from Reader's Digest articles. A dynamic classical record (Hungarian Rhapsody # 2) increased respiration rate significantly. Using a subdued blues selection and a soothing classical selection the increased respiration rate was not statistically significant. The reaction of individual subjects was fairly specific to the music used. The respiration rate returned to normal levels five minutes after cessation of the music. There was not a significant influence on the heart rate.

Washco (1933) tested 61 subjects for pulse rate and blood pressure while they sat in a chair listening to eight different selections. He concluded that "rhythmic" selections as "The Stars and Stripes Forever" and "Rhapsody in Blue" raised blood pressure and pulse rate while "melodic" selections such as "Invitation to the Waltz" and "Serenade from Madame Butterfly" lowered blood pressure and pulse rate.

Skelly and Haslerud (1952) reported that apathetic schizophrenics are more active while listening to "livelier" music. Shatin, Lussier, and Kotter (1958) found that "stimulating music calmed fearful schizophrenics more than quieter music or silence." With rating of pastel drawings as a criterion, Offer and Stine (1960) noted that both depressed patients and control subjects responded differently to stimulating music, relaxing music, and no music.

Henkin (1955) attempted to pinpoint the significant variables of music through factor analysis. He found two clear cut factors: melody and rhythm and the suggestion that orchestral color might be a third factor. In 1957 he detected two additional factors: a second melodic factor and one which he did not name; later in the same year he related his factor analytic results to galvanic skin response patterns. He found that GSRs are influenced by both the melodic and the rhythmic factors. Interestingly, GSRs did not seem to depend on musical style, dynamics, orchestration, timbre, or other compositional techniques. The GSR response to rhythmic music was a decrease in resistance (increase in arousal); melodic music had an increase in resistance (decrease in arousal).

In 1959, Trazel and Wrede measured galvanic skin response while students listened to three types of music: symphony, operetta, and jazz. It was jazz music that affected behavior most (greater decrease in skin resistance), even though the subjects said they preferred symphonic music.

Weidenfeller and Zimny (1962) extended this finding by measuring galvanic skin responses of depressed and schizophrenic patients to exciting and calming music. Music affected galvanic skin response in both groups, although the depressive patients showed greater response to exciting music. Exciting music produced a decrease, and calming music an increase in GSR. Later, working with normal subjects, Zimny and Weidenfeller (1963) recorded college student's galvanic skin responses and heart rates while they listened to three selections that differed in "exciting" quality. The more exciting music produced a significant decrease in skin resistance (indicating increased emotional arousal) but had no effect on heart rate.

INDUSTRIAL RESEARCH

In 1945, Benson reported what seems to be the first experimental investigation of the effect of music on productivity. This was done by Wyatt and Langdon in 1938 for the Medical Research Council, London. Their investigation was conducted in a factory and used women. It showed an increase in productivity ranging from 6.2 to 11.3 percent while the music was played. They reported -- "Music is an effective antidote to boredom. Different types of music were found to have slightly different effects upon the output."

Harold Burris-Meyer (1943) of Stevens Institute of Technology made studies which showed increased production and less absenteeism. Unfortunately, his comparison period was just the previous year's production. This unsophisticated approach is common to this kind of study.

Burris-Meyer (1943) pioneered the principle of fitting the music tempo to the work group. He found that his test program was more effective than the standard program. He was also the first one to use the principle of tailoring the music to counteract the peaks of fatigue during the day.

Kerr (1945) of R.C.A., by conducting two experiments, confirmed the importance of the proper selection of music. He found that of three types of music played (peppy, sweet, and a combination of the two) production remained at a steadier level on those days in which only "sweet" music was played.

Smith (1947), in an extensive study of music types, found some variation between waltzes and marches, but it was not significant. He also found, although the effect was not statistically significant, that a large proportion of semiclassical music seemed to depress production.

Kerr, in a survey reported in "Music in Industry" (1945), indicated that musical preferences and socio-economic status were correlated. In 1945 Cardinal and Weaver found that music preferences varied with age. Preferences for popular dance and the like declined with age and preferences for semiclassical, waltzes, polkas, and classical increased with age.

Several other factors have been investigated. Smith (1947) found nothing wrong with vocal selections played occasionally. But he thought that in large proportions they tend to disrupt work. It is interesting to point out that companies selling background music use only instrumental music. As a result of the same experiment, Smith concluded that there were no differences between men and women with respect to music.

One of the main findings in Smith's experiment is that the lower the worker's productivity without music, the more music can improve it.

Kerr (1945) divided his results into four categories: 1- Effects on quantity output: five experiments involving twelve comparisons between music and no music showed a favorable learning toward the music days. He stated that in no instance of typical factory work has research indicated a negative effect of music on average quantity of output. 2- Effect on quality output: five experiments involving the comparisons between average quality of output with and without music were conducted. Seven of the ten experimental results were higher without the music. 3- Effects on net good yield (quantity of acceptable units produced per operator/hour): in three experiments involving five comparisons between average net good yield on music days and no-music days, all five of the differences were in favor of music. 4- Effects of general types of music on production: four experiments which evaluated the effects of certain general types of music failed to point toward any great superiority of any one music type, except that music of moderate or fast tempo seems to be more beneficial to production than music of slower subjective tempo.

Fortune magazine (1943) told of a seven month experiment in Minneapolis. Music was played for a month and then discontinued for a week. As a result there was a decline in production of 18.5%. Hough (1943) reported about a 35% accident reduction during a three month music period in a government arsenal.

McDaniel (1945) wrote of a reduction of 75% in employee turnover after the installation of music in a U.S. government office.

So far all studies cite that most of the improvement has been on a simple monotonous task. McGeehee and Gardner (1949) reported a survey done on 142 women working in a complex rug factory operation. The results showed that there was no increase in productivity. This fact was explained by the circumstance that the workers over a long period of time had reached a stable work situation and that the effect of music was not sufficiently strong, in spite of its other salutory aspects, to break up those well established habit patterns. However, the workers accepted the music in the belief that it helped them work and no production was lost.

In a report published in 1958, Muzak Corporation commented on the results of four surveys of the effects of background music on office personnel. Three of these studies were conducted by the management engineering firm of Stevenson, Jordan, and Harrison, Inc. The fourth one was independently made by an executive of a large southern public utility. At Prentice Hall, Inc. (survey #1) the productivity of operators performing a mail insertion operation was measured before music for a five month period, and with music for a seven month period. The 24 operators studied had an increase of 8% in productivity with music.

At Lever Bros. Co. (survey #2) error rates of operators in the check typing section decreased by 39% over the six month period when music was in operation. At Eastern Air Lines, Inc. (survey #3) employee turnover decreased by 53% after the introduction of music. At Mississippi Power and Light Co. (survey #4) key punch operators showed an average production increase of 18% for the "with music" period with a 37% decrease in the number of errors per thousand cards punched.

Another study sponsored by Muzak (1963) was performed by Case & Co. Inc., a management consultant firm in New York. This study, done at the American Machine and Foundry Co., covered a four month period and it showed a 2.8% performance improvement of the test (music) over the control department (without music).

Smith (1961) investigated how music affected the complex mental activity of IBM key punch operators. He found no significant effects of music on output, errors or absentee rates. However, there was a positive change in worker attitude toward the company and work.

In 1966 Muzak published a survey report done by the Institute for Science of Labour at the Mita plant, Nippon Electric Company, Japan. They found a positive response (increase) on the employees output after music was installed.

There are several characteristics background music should have in order to give the maximum benefits. First of all the music should be made to compensate for the fatigue curve. The Muzak Corporation, for example, bases its music on four factors: Tempo (40 to 130 metronome beats per minute), Rhythm (foxtrot, waltz, samba, etc.), Instrumentation (strings, strings-woodwinds, strings-woodwinds-brass, woodwinds-brass, brass), and Orchestra Size (6 to 30 instruments) (Roberts, 1957; "Muzak-Theory and Practice," 1959). Each one of the four factors is assigned an arbitrary point value and the sum of these points is calculated for each music selection. High point values are "lively". More lively music is played at times when the worker is expected to be fatigued.

The second point is that music should be played only a portion of the work period. According to Selvin (1943) constant playing of music is a serious mistake. With continuous playing, the music soon becomes "part of the fixtures" and loses its stimulating value. Opinion on the portion of the work period when music should be played varies. Smith (1947) says twelve percent during the day and fifty percent during the night shift. Benson (1945) says 33 percent and Muzak Corporation in "Music and Muzak," (New York, 1960) says 42 percent.

One important advantage of the music is that if the installation is properly set, noise makes no difference at all. Adding music to the noise does not make the noise louder. Very good results have been obtained in industrial plants where noise measured above 100 decibels. Difference in pitch enables workers to hear the music and forget the noise which is actually crowded into the background.

Another characteristic is that music should be barely noticeable and non distracting. According to Packard (1951) the object is for the music to seep into the subconscious, instead of being listened to consciously. It is not the music itself which increases production but rather the relief from the monotony of the work. Kirkpatrick (1943) said that boredom is due to a consciousness of uniformity and repetition.

HYPOTHESIS

From the literature survey, it can be seen that although music is widely accepted by industry to affect performance favorably, there is still much confusion and contradiction. One of the areas where more confusion exists is the one related to the length of time music should be played. Therefore the present experiment will try to find an approach to the problem, especially in the case of office type work.

METHOD

TASK

Manila IBM cards were used for an alphabetical filing task. All the cards were key-punched with a name (last name first, taken randomly from the Kansas City, Kansas, telephone directory). The first letter of each last name occurred equally frequently with the exception of X. No last names starting with X were used. The cards, in alphabetical order, were punched in columns 56-59 with a number from 1 to 1875 respectively.

These punched numbers were used for detecting errors and to select the cards to be filed. Cards with a number ending in 3 or 9 and 2/3 of the cards with a number ending in 6 (500 of the 1875 cards) were selected as the cards to be filed into the remaining 1375 cards. A random number was punched in columns 50-52 of these 500 cards to permit the ordering of the cards in the same random sequence each time.

APPARATUS

Music was presented by a monoaural RCA tape recorder. It was placed 4 feet away from the subject.

E & M telemetry equipment was used to transmit the EKG to a Beckman recorder. A Beckman Dynograph recorder was utilized to record the heart rate and galvanic skin response. See plates I and II.

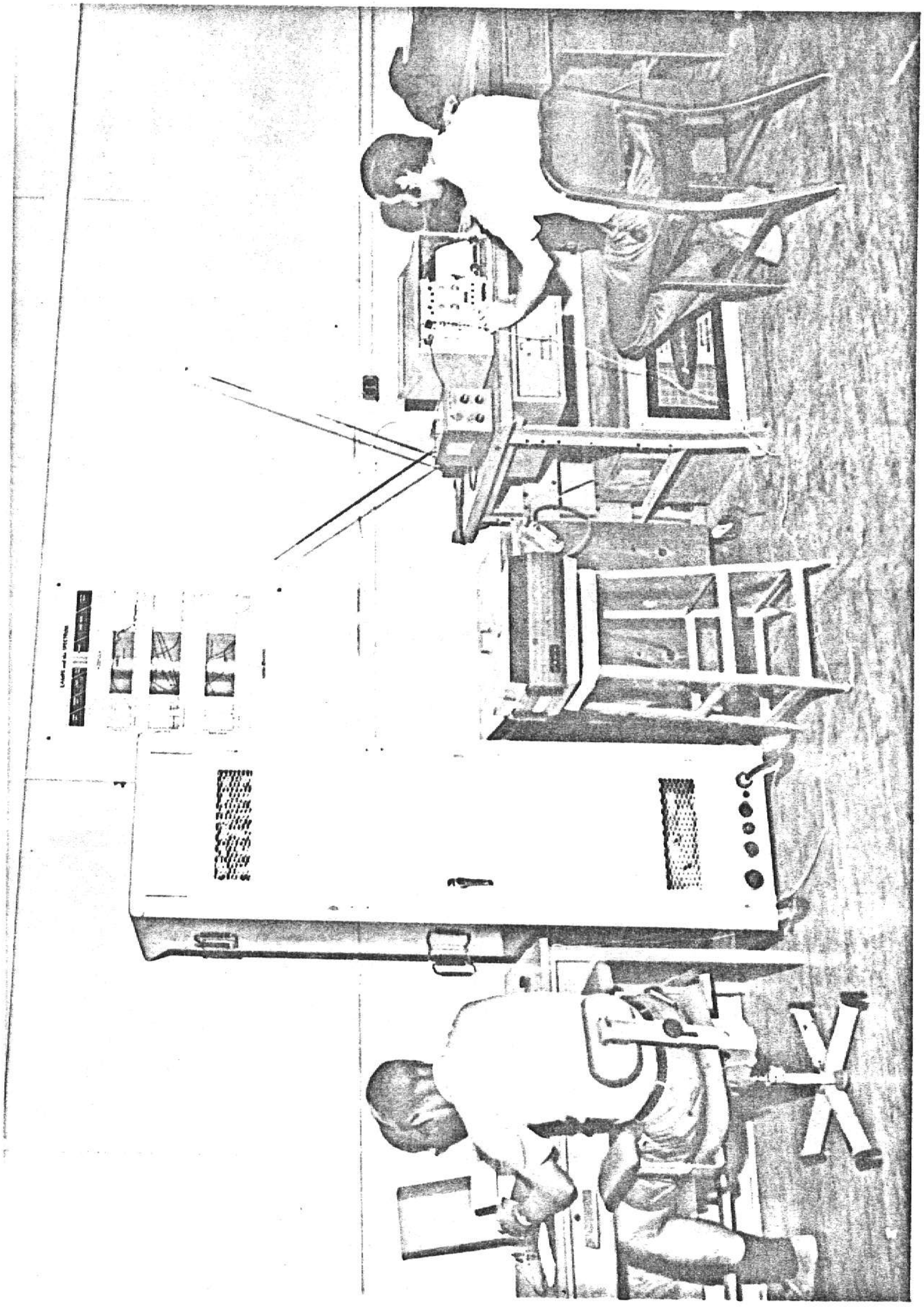
SUBJECTS

Six male graduate students from Kansas State University were paid $10 each for the experiment. They were U.S. citizens in order to avoid

DESCRIPTION OF PLATE I

Photograph shows an overall view of the experimental arrangement.

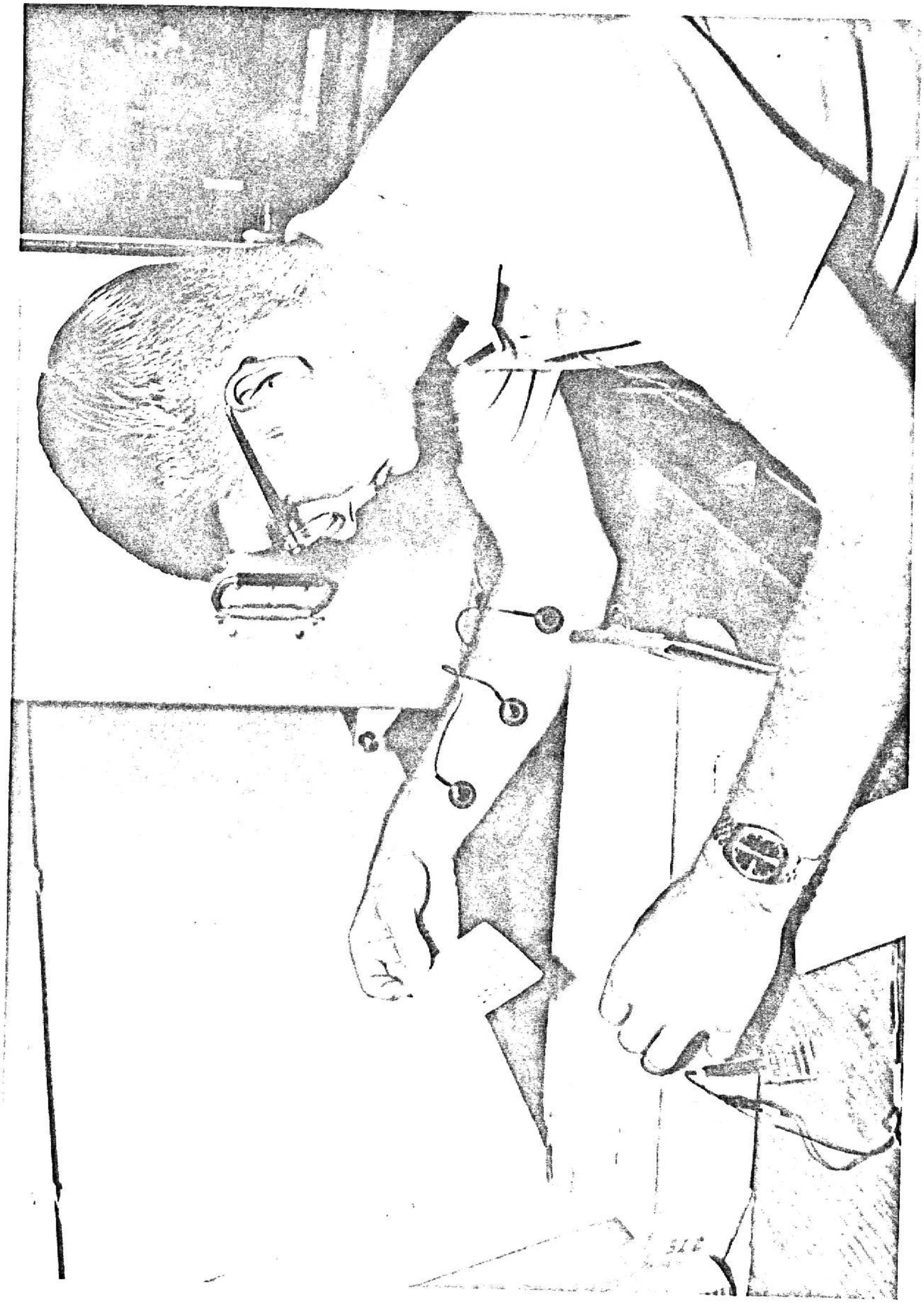
PLATE I



DESCRIPTION OF PLATE II

Photograph shows a close up of the work station. The arm electrodes are for GSR. The E & M transmiter for EKG can be seen in the foreground.

PLATE II



mixed groups. Their age varied between 24 and 34 years (Table 1) with a mean of 29 years. Grade point average ranged from 3.00 to 3.80 with a mean of 3.52. None of them had any musical training and they had normal vision and hearing.

EXPERIMENTAL PROCEDURE

During the experiment, music of the "lively" type (brass and percussion instruments used extensively) was played. Only instrumental music of a nature likely to be familiar to the subjects was used. Tapes were custom made and they included selections such as "Tijuana Taxi", "Cry", and "Wipe Out" (Table 2). The experiment was conducted during the period May 31 through June 13, 1970.

Experiments were run in the Human Engineering Laboratory, at the Industrial Engineering Department. Ambient noise was about 45 db and music was played at 55 dbA (subjects' ear level). The illumination level was 60 footcandles at table height. The environmental temperature ranged between 66 and 80 ^{o}F. The room did not have air conditioning but a fan was working all the time. The experiments were run of different hours of the day (8:30 - 11:00 AM; 2:00 - 4:30 PM and 8:00 - 10:30 PM).

The experiment lasted 150 minutes with the first 30-minute period used to reduce nervousness and learning; no music was played during this period. The subjects worked the 150 minutes without a break.

The 120 minutes of the main task were divided into 40, three-minute periods. Music was played in four (10% of the time), ten (25% of the time), or twenty (50% of the time) of these periods. These music periods were determined by the use of random numbers and are given in Table 3. In order to obtain a random distribution of the music periods, the 40

TABLE 1

SUBJECTS' PERSONAL DATA

SUBJECTS	AGE	GPA	MUSICAL TRAINING	PREFERRED CONDITION
L.A.	32	3.82	NO	50%
S.V.	25	3.25	NO	50%
R.C.	33	3.50	NO	50%
F.P.	24	3.78	NO	50%
A.C.	26	3.80	NO	50%
G.F.	34	3.00	NO	50%
MEAN	29	3.52	NO	50%

TABLE 2

MUSIC SELECTIONS

SELECTION	TIME (min)
Wade in Water	3.07
Taste of Honey	2.56
Tijuana Taxi	2.46
Marjorine	3.04
Melodie D'Amour	2.55
It Happened in Monterrey	3.03
Girl Talk	2.55
Ella	3.15
Spanish Moonlight	2.50
Wipe Out	3.00
Apache	3.08
Windy	2.53
Lady of Spain	3.12
Chypanecas	2.50
Sunshine Superman	3.52
Tangarine	2.07
That's Life	3.36
Cry	2.24
Arrivederci Roma	2.55
Nu Quait E Luna	3.14

TABLE 3

MUSIC PERIODS

PERIOD	10%	25%	50%
1		X	
2			
3			X
4			
5	X		
6			X
7		X	X
8			
9			
10	X		
11			X
12			X
13			
14			X
15		X	
16		X	X
17			
18			X
19		X	X
20			
21		X	
22			X
23			
24		X	
25			X
26		X	
27			X
28			
29			
30			
31			X
32		X	X
33	X		X
34			X
35	X	X	X
36			
37			X
38			
39			
40			X

periods were divided into 2-20 periods and in each one of these two music was randomly distributed in its span.

All the subjects worked alone in each one of the three conditions and they followed the sequence shown in Table 4 in order to balance learning effects.

EKG and galvanic skin response were recorded for each individual. Recordings 10 seconds long were taken during the middle of each of the 40 periods.

The five criteria used were:

Speed of Working

Accuracy

Heart Rate

Heart Variability

Galvanic Skin Response.

TABLE 4

SEQUENCE USED IN THE EXPERIMENT

SUBJECTS	SESSION		
	1	2	3
L.A.	10	25	50
S.V.	25	50	10
R.C.	50	10	25
F.P.	50	25	10
A.C.	25	10	50
G.F.	10	50	25

RESULTS

SPEED OF WORKING

Considering the last 120 minutes of each condition alone (Table 5), the mean in the 10% condition was 0.377 minutes per card vs. 0.381 minutes per card for 25% and 0.390 minutes per card for 50%; thus the 10% condition seems best although the differences were not statistically significant.

When the difference between the first 30 minutes of non-music for a condition and the 120 minutes of partial music was calculated, the 10% condition showed an increase in speed of working of 1% while the 25% condition had a drop of 7% and the 50% had a drop of 11%. However, none of these differences were significantly different either.

The learning curve (98%) for this criterion (Figure 1) was obtained by plotting the average minutes per card per session vs the cumulative minutes of experience.

ACCURACY

Considering the last 120 minutes of each condition alone (Table 6), the 25% condition, with a mean of 1.35% errors, was best, 10%, with a mean of 1.93% errors, was second and 50%, with a mean of 2.46% errors, was worst. The differences were not statistically significant.

Considering the difference between the first 30 minutes of non-music for a condition and the 120 minutes of partial music, again the results favored the 25% condition. The drop in errors for the 25% condition was about 1% while for 10% and 50% the drop was 0.8% and 0.2% respectively.

TABLE 5

SPEED OF WORKING, MINUTES/CARD

SUBJECTS	CONDITIONS								
	10%			25%			50%		
	1-30		31-120	1-30		31-120	1-30		31-120
		-.0186			-.0187			.0284	
L.A.	.5173		.5359	.4226		.4413	.4616		.4332
		-.0229			-.0080			-.0892	
S.V.	.4166		.4395	.3658		.3738	.3570		.4462
		.0042			-.0410			-.0828	
R.C.	.3571		.3529	.3093		.3508	.3897		.4725
		.0537			-.0123			-.0059	
F.P.	.3703		.3166	.3448		.3571	.3750		.3809
		-.0082			.0289			-.0344	
A.C.	.2631		.2713	.3489		.3200	.2344		.2688
		-.0216			-.1449			-.0432	
G.F.	.4545		.4761	.3489		.4938	.3750		.4182
		.0020			-.0275			-.0366	
MEAN	.3790		.3770	.3537		.3812	.3531		.3897

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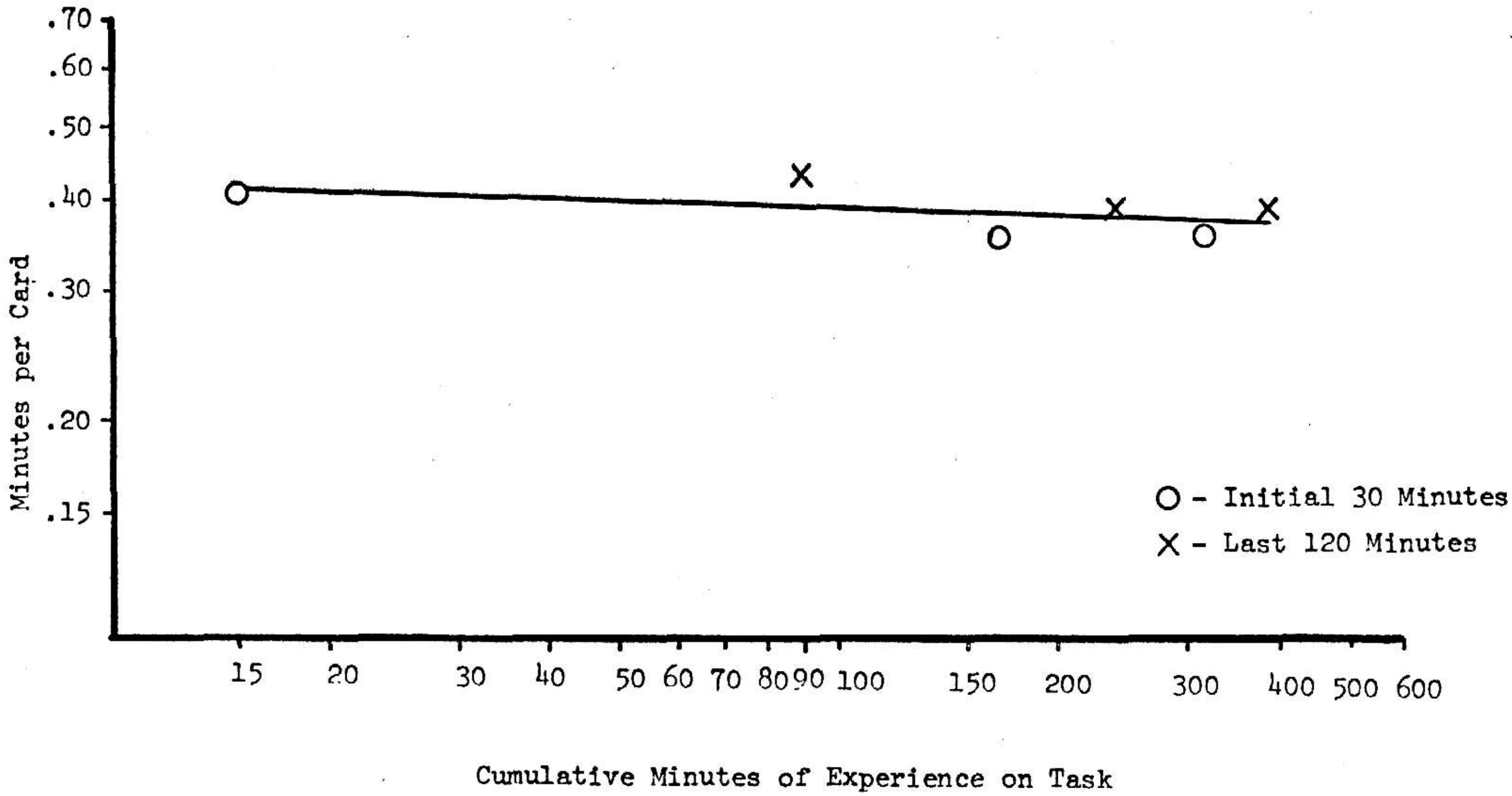

Figure 1. Learning curve for speed of working

TABLE 6

ACCURACY, % OF ERRORS

SUBJECTS	CONDITIONS								
	10%			25%			50%		
	1-30		31-120	1-30		31-120	1-30		31-120
L.A.	3.448	1.663	1.785	4.225	2.387	1.838	1.538	-1.350	2.888
S.V.	1.388	0.290	1.098	2.439	1.816	0.623	0.000	-1.487	1.487
R.C.	1.190	-1.457	2.647	1.030	-0.724	1.754	6.493	2.556	3.937
F.P.	2.250	1.195	1.055	1.149	0.852	0.297	1.250	-0.972	2.222
A.C.	3.508	1.699	1.809	6.976	3.776	3.200	5.468	3.318	2.150
G.F.	4.545	1.383	3.162	0.000	-0.411	0.411	1.250	-0.840	2.090
MEAN	2.721	0.795	1.926	2.636	1.283	1.353	2.666	0.204	2.462

The learning curve (82%) for this criterion (Figure 2) was obtained by plotting the average percentage of errors per session vs the minutes of experience.

When the raw values were corrected for practice (using the learning curve), it was found that the change (drop in errors) from the initial 30 minutes to the last 120 minutes was 0.6% for the 25% condition, 0.2% for the 10% condition and -0.4% (increase) for the 50% condition. None of these differences were significantly different.

The 150 minutes of the task were divided into ten periods of 15 minutes. Assuming a constant speed of working for each one of these periods, the errors assumed to be made in each period were calculated and plotted (Figure 3). In spite of the fact that the experiment was run at different hours of the day, the graph shows a wave shaped curve having the valleys and peaks approximately at the same time for each condition.

HEART RATE

The physiological criteria were used to find out under which music condition the subjects worked more comfortably and with less strain.

The lowest mean heart rate, 80.8 beats per minute, ocurred at the 25% condition. At the 50% condition the mean was 81.4 beats per minute and in the 10% condition, it was 82.4 beats per minute. Using a run test, significant ($p < 0.05$) differences were found between all three means.

When the heart rate was plotted as a 5 point moving average (Figure 4) for the different conditions, the general trend of the curves was downwards, with the steepest decline for the 50% condition.

The decline in heart rate over the 150 minutes was 11.6 beats per

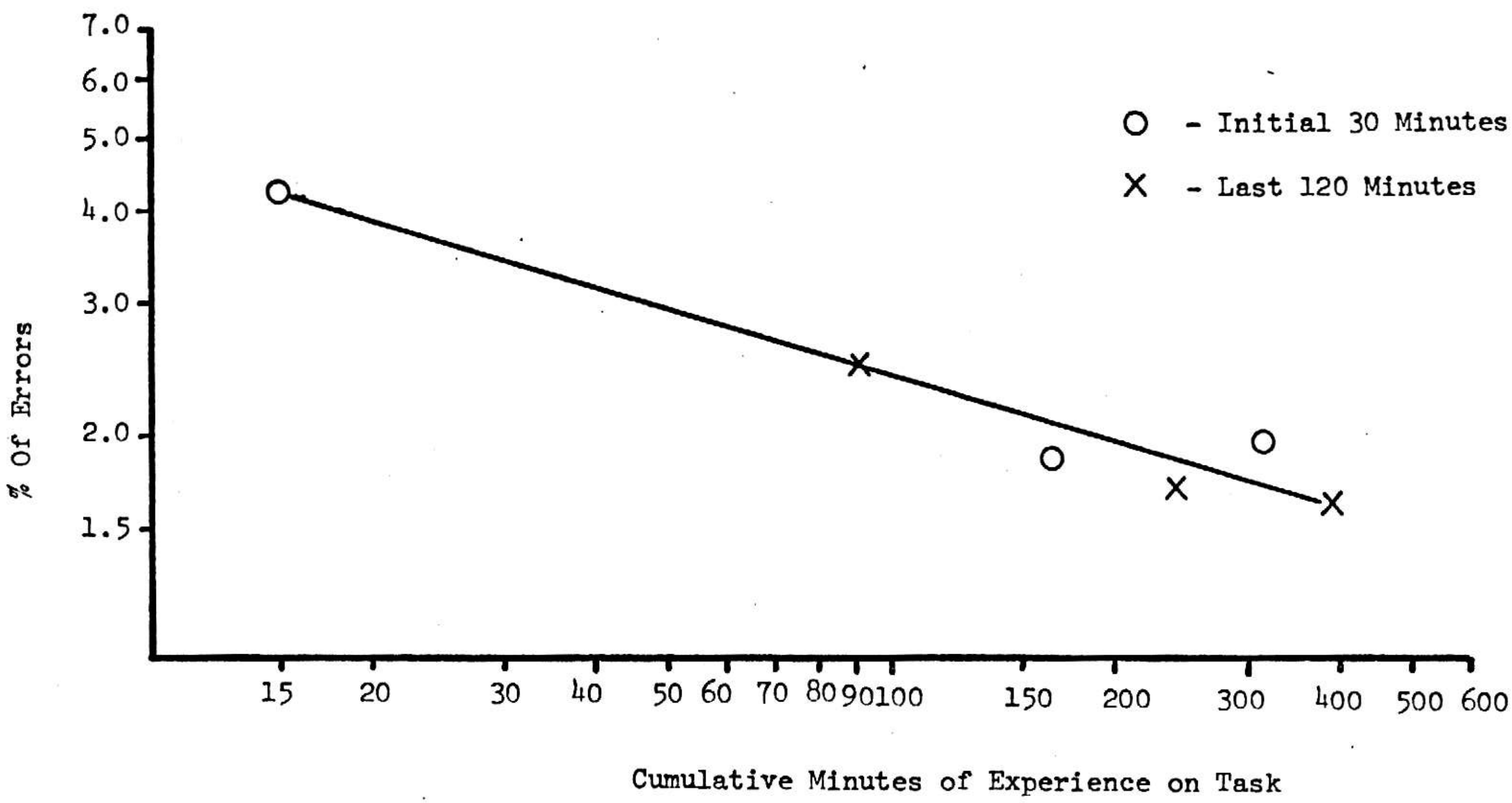

Figure 2. Learning curve for accuracy

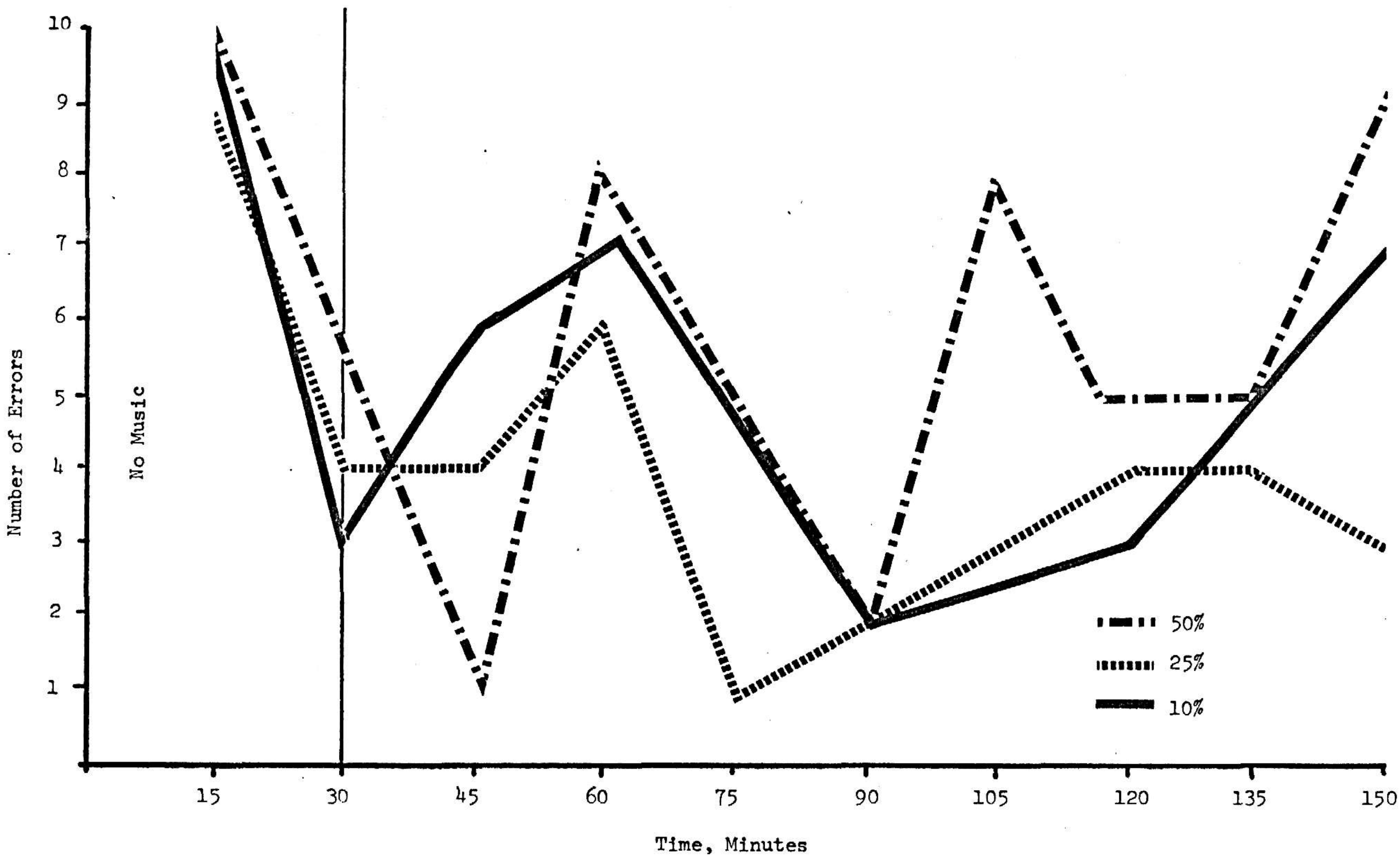

Figure 3. Number of errors vs time

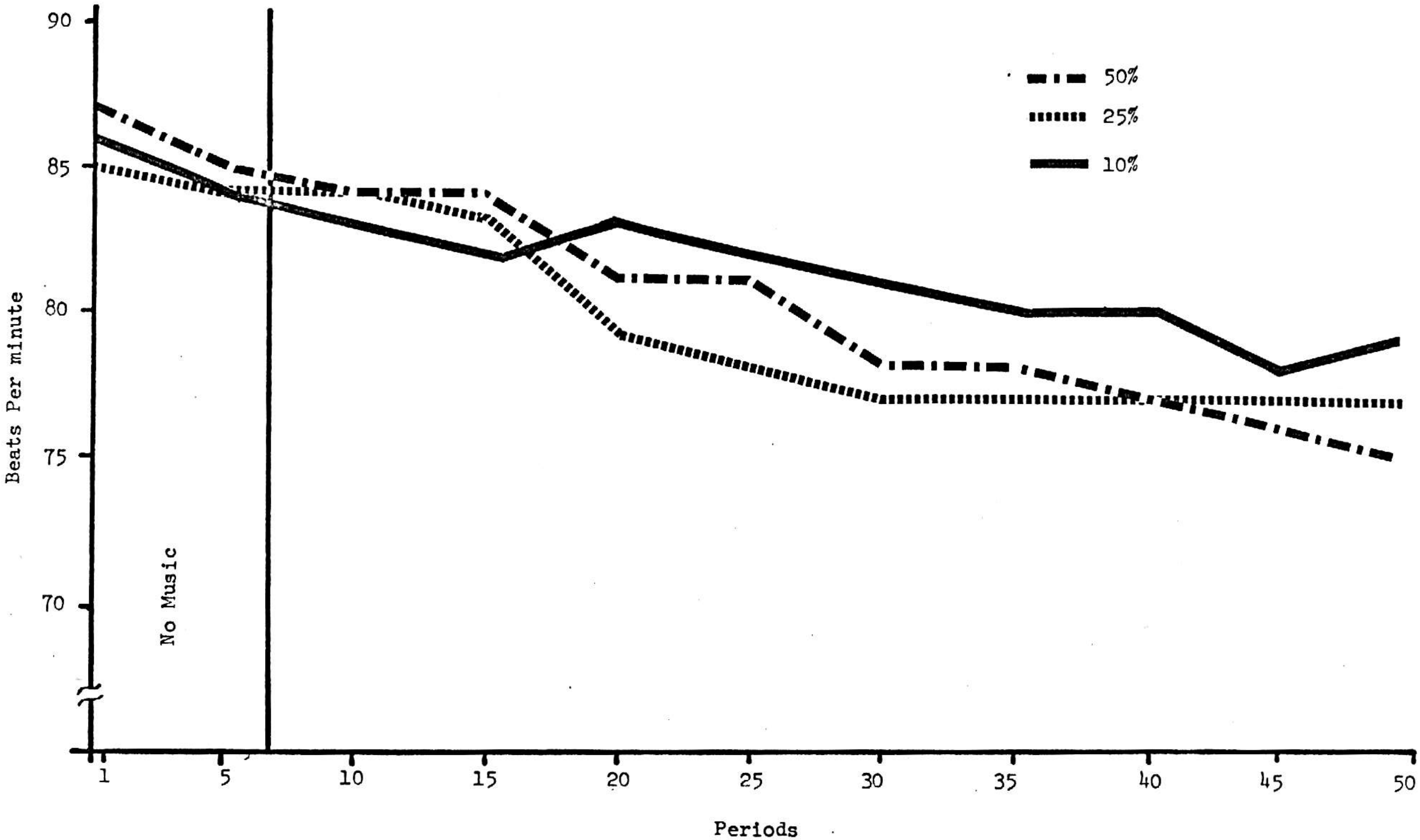

Figure 4. Heart Rate vs time

minute for the 50% condition, 7.3 beats per minute for the 10% condition, and 7.0 beats per minute for the 25% condition. None of these differences were significantly different.

HEART VARIABILITY

Heart variability is calculated as a standard deviation. It is a good index of a subject's level of concentration. A high heart variability value means a low concentration level. As the heart variability decreases the concentration level tends to increase.

Looking at the means in this criterion, for both 25% and 50% the mean standard deviation was 0.032 seconds. The 10% condition had a higher mean at 0.037 seconds. It seems that 25% and 50% were the best conditions, without a big difference between them.

When the values for the six subjects are plotted together as a 5 point moving average (Figure 5), the curves for the three conditions show a wave shape with the peaks and valleys approximately in the same points. The distance, in time, from peak to peak, or from valley to valley, is approximately the same along the whole working period. These points occurred approximately each 36 minutes. There was a general rise during work in all three conditions.

In this criterion, as in heart rate, the 10% condition had the largest fluctuation. The 50% condition has relatively little waviness with an elimination of the peaks.

GALVANIC SKIN RESPONSE

The galvanic skin response, measured by the changes in skin resistance or conductance, is a good index of the amount of emotional arousal.

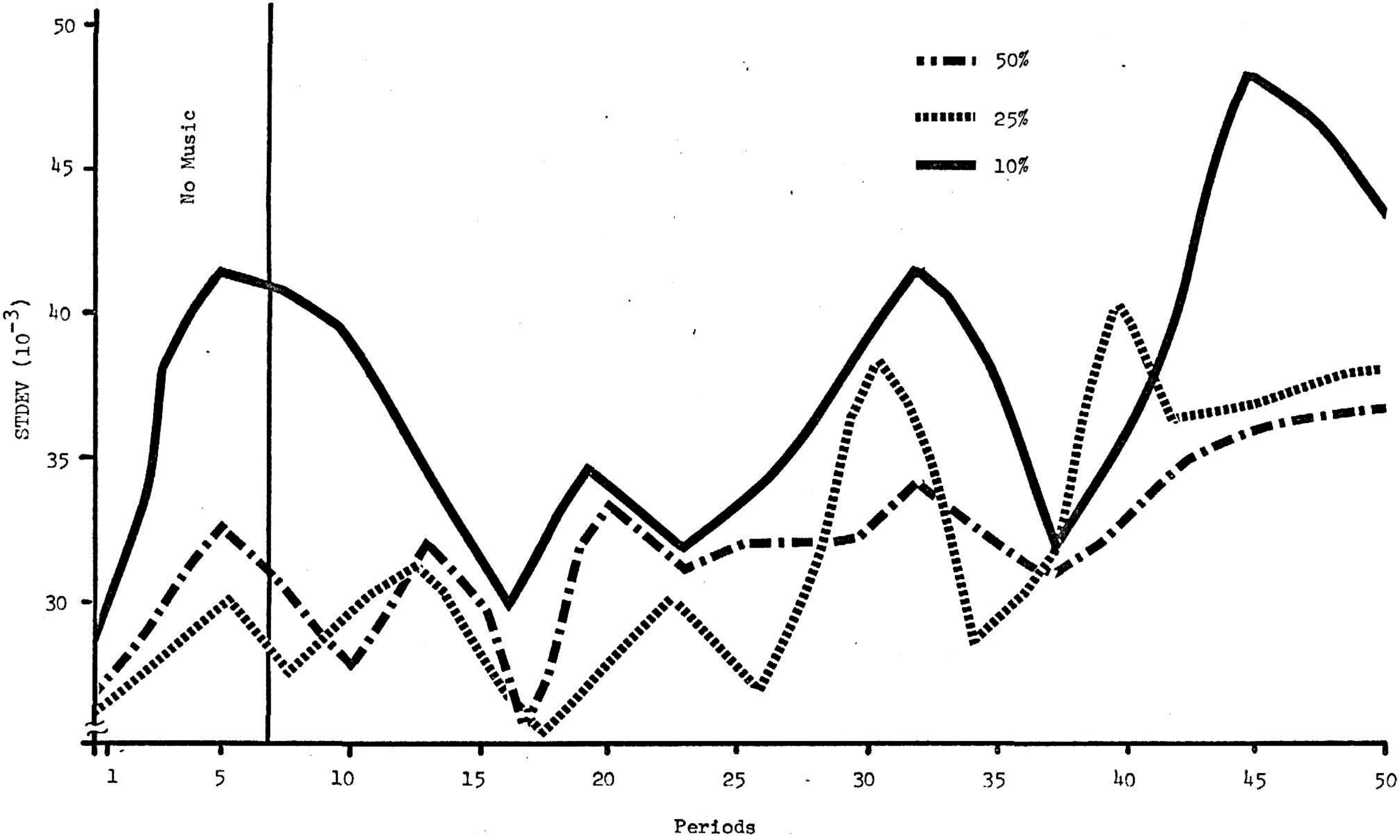

Figure 5. Heart variability vs time

Stimulating music tends to produce a decrease in resistance and calming music produces a decrease in arousal and an increase in resistance. For the monotonous type of task used in this experiment, a high emotional arousal is desirable.

For this criterion, the 10% condition had the highest mean of 52,430 ohms (least stimulation), 25% had 51,863 ohms and 50% had a mean of 51,807 ohms (most stimulation).

When the Wilcoxon Matched-pairs Signed-ranks test was applied to these results, significant ($p < 0.05$) differences were found between all three means.

Figure 6 shows the wave-shaped curve that appeared when the GSR was plotted for the three conditions as a 5 point moving average.

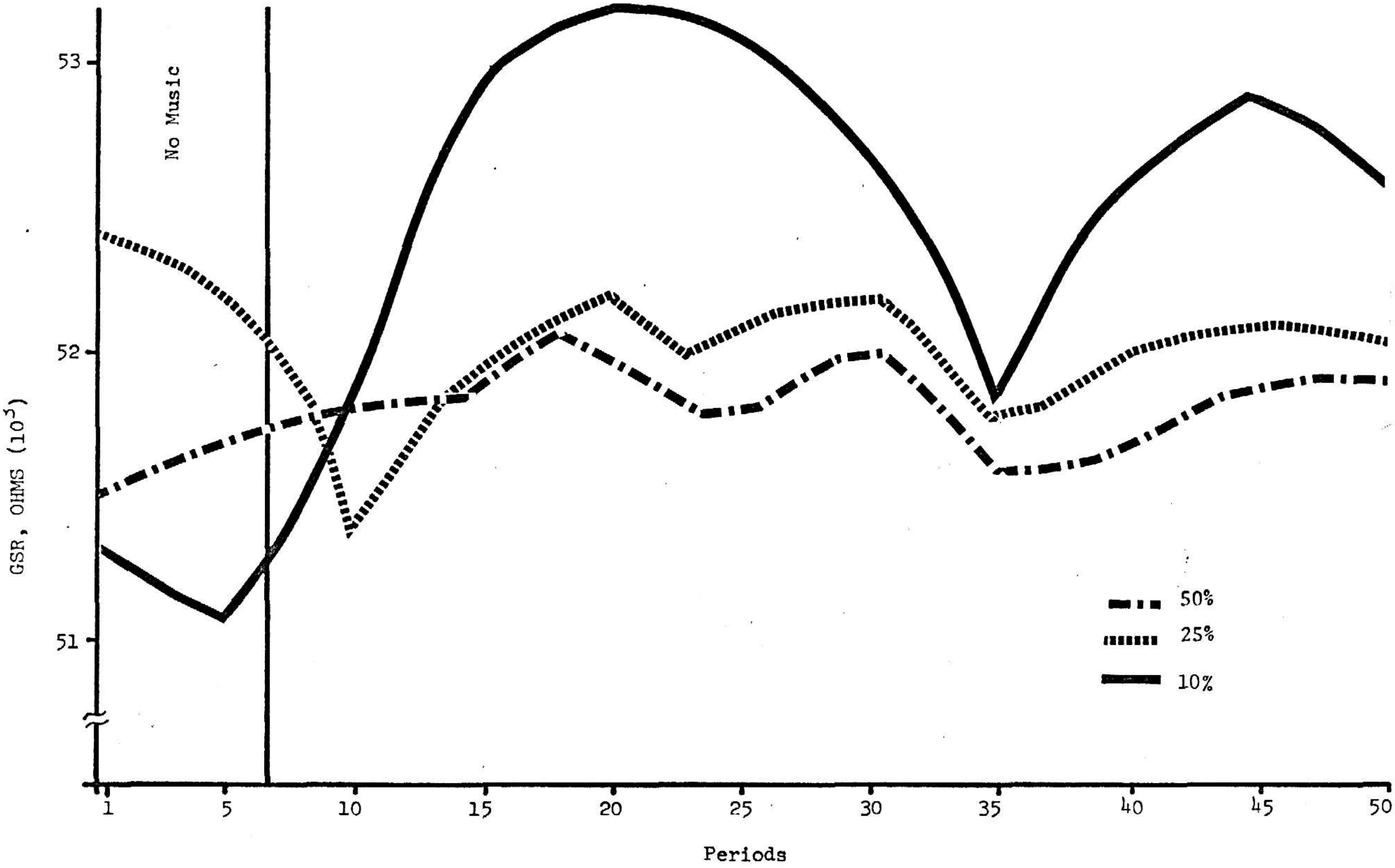

Figure 6. GSR vs time

DISCUSSION

Music did have an effect on subjects' performance in this experiment. Efficiency did not improve considerably, but a big improvement was not expected. In addition, the results are only suggestive due to the lack of statistically significant results.

There is a tremendous learning effect involved in the type of task used in the experiment. This accounts for the large variation within subjects. The amount of effect varied among subjects and criteria.

The performance results can be compared with the ones obtained by Konz and Koe (1969) in a similar task. Their filing rate was 0.256 minutes per card vs. 0.377 minutes per card for the 10% music condition (best condition for this criterion) or 0.390 minutes per card for the 50% (worst condition in this criterion). These differences are probably due to the fact that in Konz and Koe's research there was more social pressure on the subjects, especially because they worked in groups. Another variable that must be considered is that their subjects worked under a bonus system while the subjects in this experiment had a fixed pay whatever their output was.

The subjects in this experiment had an error rate considerably lower than Konz and Koe's subjects. Their subjects had an error rate of 9.5% errors, while this experiment's subjects had an error rate of 2.5% errors in the worst condition (50%), and 1.4% errors in the best condition (25%).

From the speed of working and accuracy viewpoint, a compromise situation seems to stand out. If speed is the main requirement, a low percentage of music seems to be the most appropriate. But if a low percentage of errors is desired, a higher percentage of music (25%) seems to be most suitable.

Although it is very difficult to decide which productivity criterion is most desirable, a generalization can be made in the sense that from the performance standpoint the percentage of music should be between 10 and 25 percent, more toward the 25%. What stands out clearly is that too much music (50%) has a detrimental effect on productivity, at least for this kind of work.

When the physiological criteria are brought into consideration, the results tend to favor the 25% (lowest heart rate and heart variability) and the 50% (lowest heart variability and GSR) conditions. The 10% condition was the worst which is not in agreement with what was found taking the performance criteria into account.

In general, although too much music (50%) can be a work detriment, it helps to increase concentration level and emotional arousal on the subjects. Less music (10%) seems to increase production but at the same time decreases subjects' concentration level and emotional arousal.

Considering the five criteria together, and for the type of music employed (stimulating music), it seems that the optimal musical condition is around 25%. This result approaches the findings of Benson (1945) who said that the best music condition is 33%. At the same time it is quite far from the recommended percentages given by Muzak (Music and Muzak, 1960), 42 percent; and Smith (1947), 12 percent during the day and 50 percent during the night.

The phenomenon of the waves that can be seen in the graphs could be the explanation for the different, and sometimes contradictory, conclusions that some researchers have reached in the field.

The subjects' behavior in a specific task can be depicted reasonably well by such a wave pattern. It can be assumed that different tasks will have different wave patterns. Then, depending on what portion of the wave is analyzed, different results could be obtained.

These waves occurred consistantly in spite of the fact that the experiment was run at different times of the day. There is also certain similarity of waves for errors, heart variability and GSR that can be seen by comparing the three graphs. The peaks and valleys tend to occur approximately in the same area for the three graphs. This implies that there is a relationship between concentration level, emotional stimulation and number of errors.

Although these results are not conclusive, they tend to give a better understanding of the problem of background music.

CONCLUSIONS

All the conclusions are tentative since many of the differences were not statisticahly significant.

1- Speed of working was higher when 10% of music was used. When compared with the non music period (initial 30 minutes), this condition had an increase of 1%. Conditions 25% and 50% had a decrease of 7% and 11% respectively.

2- Accuracy was better in the 25% condition. The drop in errors when compared with the non music period (initial 30 minutes) amounts to 1%; 10% and 50% had a drop of 0.8% and 0.2% respectively.

3- The number of errors made by the subjects behaved in a wave pattern, with the peaks at approximately the same points for the three conditions.

4- The lowest mean heart rate occurred at the 25% condition. But it accounted for the smallest drop. The largest drop was in the 50% condition.

5- For the heart variability criterion, the 25% and 50% condition had the same mean. The 10% condition had a higher mean (lower level of concentration).

6- In the heart variability, a wave-shaped curve, similar for the three conditions, was found. The peaks occurred approximately each 36 minutes.

7- For the galvanic skin response, a significant ($p < 0.05$) difference was found between the three conditions. The lowest (highest emotional arousal) corresponded to 50% and the highest mean (least arousal) to 10%.

REFERENCES

Anokhin, P. : USSR Academy of Medical Sciences, Izvestia, July 10, 1963.

Benson, B. : Music and Sound Systems in Industry, McGraw-Hill, New York, 1945.

Brown, I.D. : "Effect of a Car Radio on Driving in Traffic", Ergonomics, 8, 475-479, 1965.

Burris-Meyers, H. : "Music in the Plant", Factory Management, 101, 98-101, 1943.

Cardinell, R. and Werner, F.M. : "Studies in the Use of Muzak in Life Insurance Company "P", Muzak Corporation, New York, 1945.

Diserens, C. and Fine, H. : A Psychology of Music, Cincinnati, College of Music, 1939.

"Effects of Muzak on Office Personnel" Muzak Corporation, New York, 1958.

Gaston, E.T. and Schneider, E.H. : "An Analysis, Evaluation and Selection of Clinical Use of Music in Therapy", The University of Kansas Press, 1965.

Henkin, R.I. : "A Factorial Study of the Components of Music", Journal of Psychology, 39, 161-181, 1955.

Henkin, R.I. : "An Evaluation of Factorial Study of the Components of Music", Journal of Psychology, 43, 301-306, 1957.

Henkin, R.I. : "Prediction of Behavior Response Patterns to Music", Journal of Psychology, 44, 111-127, 1957.

Hough, E. : "Music as a Safety Factor", Journal of Acoustical Society of America, 15, 124, 1943.

Hyde, I.M. : "Effects of Music on Electro-Cardiograms and Blood Pressure", Journal of Experimental Psychology, 8, 213, 1924.

Irvine, W.F. : "The Effect of Background Music on Productivity of Two Complex Mental Tasks", Research done in the I.E. Dept. Kansas State University, 1968.

Kerr, W.A. : "Experiments on the Effect of Music on Factory Production", Applied Psychology Monograph No. 5, Stanford University Press, 1945.

Kirkpatrick, F.H. : "Takes the Mind Away", Personnel Journal, 22, 225-228, 1943.

Kirk, R.E. and Hecht, E. : "Maintenance of Vigilance by Programmed Noise", Perceptual and Motor Skills, 16, 553-560, 1963.

Konz, S.A. : "The Effect of Background Music on Productivity of two Different Monotonous Tasks", Paper presented at the meeting of the Human Factors Society, New York, 1962.

Konz, S.A. : "The Effect of Background Music on Productivity of Four Tasks", Ph.D. Thesis, University of Illinois, 1964.

Konz, S.A. and McDougal, D. : "The Effect of Background Music on the Control Activity of an Automobile Driver", Human Factors, 10(3), 233-244, 1968.

Konz, S.A. and Koe, B. : "The Effect of Color Coding on Performance of an Alphabetic Filing Task", Human Factors, 11(3), 1969.

Lebo, D. : "An Early Jesuit Contribution to Industrial Music", Music Educator's Journal, 41, 66, 1955.

Licht, S.H. : Music in Medicine, Conservatory of Music, Boston, Massachusetts, 1946.

Lucaccini, L.F. : Vigilance and Irrelevant Stimulation: A Test of the Arousal Hypothesis, Ph.D. Thesis, University of California, Los Angeles, 1968.

Mackworth, N.H. : Researches on the Measurement of Human Performance, Selected Papers on Human Factors in the Design and Use of Control Systems, Dover Publ., New York, 1961.

McGrath, J.J. : "Irrelevant Stimulation and Vigilance Performance", Vigilance: A Symposium, McGraw-Hill, N.Y., 1963.

McGrath, J.J. : "Human Factors Problems in Anti-Submarine Warfare," Technical Report no. 6, The Effect of Irrelevant Environmental Stimulation in Vigilance Performance, Human Factors Research Inc., Los Angeles, 1960.

McGeehee, W. and Gardner, J. : "Music in a Complex Industrial Job", Personnel Psychology, 2, 405-417, 1949.

McDaniel, R. : "How Music Increases Office Production", American Business, 15, 22-26, 1945.

"Music Helps You Work", Fortune, 30 (2), 198, 1944.

Music and Muzak, Muzak Corporation, New York, 1960.

"Muzak Corporation: Fatigue and Music", Institute for Science of Labour, Mainichi Music System, Inc. Japan, 1966.

"Muzak Theory and Practice, Music for Improving Work Tempo," Engineering, 188, 689, 1959.

Muzak Corporation, The Effects of Muzak on Performance in Machine Assembly Operations, New York, 1963.

Offer, D. and Stine, D. : "Function of Music in Spontaneous Art Productions, General Psychiatry, 3, 490-503, 1960.

Packard, W.V. : "Music Battle for Industry's Ear", Iron Age, 168, 75, 1951.

Podolsky, E. Music Therapy, Philosophical Library, New York 1954.

Poock, G.L. and Wiener, E.L. : "Music and Other Auditory Backgrounds During Visual Monitoring", The Journal of Industrial Engineering, 17, 318-323, 1966.

Roberts, J.W. : "Sound Approach to Efficiency", Personnel Journal, 38, 6-8, 1959.

Selvin, B. : "Programming Music for Industry", Journal of Acoustical Society of America, 15, 131, 1943.

Shartin, L. Lussier, L. and Kotter, W. : "Fear in ECT, Its Alleviation Through Music", Psychiatry Quarterly Suppl. 32, 200-223, 1958.

Skelly, C.G. and Haslerud, G.M. : "Music and the General Activity of Apathetic Schizophrenics" Journal of Abnormal Soc..Psychology, 47, 188-192, 1952.

Smith, H.C. : "Music in Relation to Employee Attitude, Piece Work Production and Industrial Accidents", Applied Psych. Monograph, No. 14, 1947.

Smith, J.M. : "Music: A Tool for Scientific Management", Master Thesis, Xavier University, 1964.

Smith, W.A. : "Effects of Industrial Music in a Work Situation Requiring Complex Mental Activity", Psychology Report, 8, 159-162, 1961.

Tarriere, C. and Wisner, A. : "Effects des Bruits Significatifs et non Significatifs au Cours d'une epreuve de Vigilance", Le Travail Humain, 25, 1-28, 1962.

Trazel, W. and Wrede, G. : Hautwiderstandsanderungen Bei Musikdarbietung. (Changes in GSR while Listening to Music) Z. Exp. Anew. Psychol, 6, 293-309, 1959.

Uhrbock, R. : "Music on the Job: Its Influence on Worker Morale and Production", Personnel Psychology, 14, 10, 1961.

Van de Wall, W. : Music in Hospitals, Wm. F. Fell Company Philadelphia, 1946.

Ware, J.R.; Kowal, B..and Baker, R.A. : "The Role of Experimenter Attitude and Contingent Reinforcement in a Vigilance Task", Human Factors, 6, 111-115, 1964.

Weidenfeller, E.W. and Zimny, G.H. : "Effects of Music upon GSR of Depressives and Schizophrenics", Journal of Abnormal Soc. Psychology, 64, 307-312, 1962.

Wascho, A. : "The Effects of Music upon Pulse Rate, Blood Pressure and Mental Imagery," Ph.D. Thesis, Temple Univ., 1933.

Wokoun, W. : "Effects of Music on Work Performance" Technical Memorandum 1-68, U.S. Army, Human Engineering Laboratory, Aberdeen, Maryland, 1968.

Wokoun, W. : "Vigilance and Background Music" Technical Memorandum, 16-63, U.S. Army, Human Engineering Laboratory, Aberdeen, Maryland, 1963.

Zimny, G.H. and Weidenfeller, E.W. : "Effects of Music upon GSR and Heart Rate", American Journal of Psychology, 73 311-314, 1963.

BACKGROUND MUSIC ON A MENTAL TASK
INFLUENCE OF PLAYING TIME ON
PERFORMANCE AND HEART VARIABILITY

by

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B.S., Universidad Pontificia Bolivariana,
Medellin, Colombia, 1968

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Industrial Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

ABSTRACT

An alphabetical filing task was performed while stimulating music was played 10%, 25% and 50% of the time.

Six male subjects worked in the three conditions for 150 minutes and five criteria were recorded: time per card filed, errors, heart rate, heart variability and galvanic skin response.

Although some of the differences were not statistically significant, results tend to show that 25% was the best condition. A lower percentage of music seemed to increase the heart variability and heart rate but at the same time tended to decrease the time per card.

A higher percentage of music tended to decrease physiological stress (heart variability and GSR) but at the same time tended to decrease efficiency.