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An operant conditioning task involving two sense modalities.

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AN OPERANT CONDITIONING TASK INVOLVING TWO SENSE MODALITIES

by

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ABSTRACT

This study was an exploratory investigation of the effects of music upon performance in an operant conditioning task. A series of three experiments was carried out to examine the following aspects of the problem. First, how does background music affect task performance? Second, does music played in synchrony with the task affect performance differently than music out-of-synchrony with the task? Third, does increased intensity of auditory stimulation have any effect upon performance?

The experimental subjects (Ss) were male and female undergraduates at the University of Windsor. The learning task was the same for all Ss, a delayed operant conditioning task on the General Learning Apparatus.

Analyses of variance showed no statistically significant evidence that music affects performance on an operant task. However, the results tended to support the following hypotheses:

1. "Music" groups perform better than "no-music" groups.
2. Groups in which the music is played asynchronous to the task perform better than groups in which the task and music are in synchrony with one another.
3. Increased intensity of auditory stimulation improves performance.

PREFACE

This study began as a result of the author's interest in music, and its ability to induce different behaviors in people. Cross-modality research contributed a great deal to the general framework of this study.

The author would like to express grateful and sincere appreciation to Dr. A. Arthur Smith for his direction and countless goodnesses, and he wishes to thank the subjects who gave so generously of their time.

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INTRODUCTION

> "And as we were saying, the united influence of music and gymnastic will bring them into accord, nerving and sustaining the reason with noble words and lessons, and moderating and soothing and civilizing the wildness of passion by harmony and rhythm."
>
> (Plato, The Republic, IV, D441)

Although this opinion has been expressed in many forms since Plato's day, it is only relatively recently that scientific attempts have been made to demonstrate its truth and explore its consequences. During the past 75 years many experiments have been carried out in an attempt to isolate and explain the effects of music on human behavior. Unfortunately, a great number of the experiments have afforded insignificant conclusions.

Researchers very often regarded music as a "distractor" and this stigma tended to bias experimental procedures and their resultant interpretations (Baker, 1937; Fendrick, 1937; Henderson et al, 1945; Freebourne, 1952; Engel, 1962; Williams, 1962). Most distraction experiments dealt with groups of Ss in task situations, e.g., reading rate and comprehension, arithmetic problems, groups often consisting of simply "music" and "no-music" groups (Henderson, 1945; Engel, 1962). Types of music used ranged from classical, jazz, folk, and rock and roll, to music stressing primitive rhythms as in African drum music (Roberts, 1936). Some even included vocal selections in their repetoire of "distractors" (Henderson, 1945). Almost without exception, (Diserens, 1923; Roberts, 1936), Ss were told that the music they heard played a part in the experiment (Baker, 1937; Fendrick, 1937; Henderson, 1945; Engel, 1962; Williams, 1962). In other words, the E often made the music situation distracting by in effect <u>telling</u> the Ss to pay attention to it.

Results in "distraction" experiments have usually proved conflicting and insignificant (Baker, 1937). For example, the literature dealing with reading rate and comprehension asks the question: "Does listening to specific types of music have any significant effect upon rate of reading and comprehension?" Freebourne & Fleischer (1952) found that jazz music led to a significantly higher reading rate, while other types of music did not seem to alter the rate. They suggested that the marked and regular rhythm in the jazz music aided in making an extra effort, or possibly that extra effort is put forth to overcome the distraction. The latter explanation does not explain why music such as classical and folk, which was also employed in the experiment, did not alter the rate. Other studies of a similar bent show no significant results and even more ambiguous conclusions (Henderson, 1945; Hall, 1952).

Another approach has been to regard music as "sense stimuli" rather than as a "distractor" in experiments. (Diserens, 1923; Ortmann, 1926; Roberts, 1936; Ludin, 1953). Investigations of this type have generally been more sophisticated than the "distraction" experiments. Researchers have studied music on a more refined plane, attending to structural elements that make up the music itself such as rhythm, melody, and harmony, and have attempted to find out how the concept "rhythm", for example, affects human behavior.

Other studies have not labeled the music in their experiment as "distracting" or "stimulating" but have merely played music in the background while Ss were attempting a task. Simple correlations were attempted (fast music produces fast work - slow music produces slow work, etc.). In none of the studies were consistently significant results obtained. (Nelson & Finch, 1962; Baugh, 1965; Newman & Hunt, 1966).

One attempt in this area was made by Smith & Curnow (1966). They attempted to find out if relatively loud background music played in a supermarket affected purchasing behavior. They found that the rate of spending per minute was slightly greater with the music than without, but their results did not approach significance. However, an interesting point made in the same article was that, experimental results to the contrary, management generally assumes that music increases output, and reduces monotony and strain.

Generally then, the literature dealing with music and its effects on human behavior, is ambiguous. It suggests that (1) music produces a decrement in performance (2) music has no effect on performance, and (3) music produces an increment in performance. When music has been found to have a decremental effect, the effect has usually been attributed to "distraction"; when it has been found to have an incremental effect, the effect has usually been attributed to "motivational compensation". When music has been ineffective as a variable the results have been attributed to lack of sensitivity of the task.

One thing stands out in all the music studies;

the Ss were always "doing something" while they listened to the music. Ss were always involved in a task or situation in which more than one mode of sensation was involved, usually the auditory and visual modes. In effect then, the music studies demonstrated cross-modal stimulation in a musical setting.

Recent Experiments Involving Cross-Modal Tasks

Experimental evidence strongly suggests that performance on several types of tasks is improved when more than one sensory modality is involved. Marlatt & Lilie (1966) carried out a study in which a visual CS, a light, and an auditory CS, a tone, equated in intensity to the light by the method of adjustment, were employed with an air puff as the UCS. Their results showed that when the auditory and visual CS's were paired, Ss showed 60 per cent generalized responses in the first four trial block of extinction, relative to Ss receiving orthodox unimodal CS in extinction.

Ries (1966) performed an experiment in which 30 Ss served in a paired-associates learning task using three different sets of color-tone pairs. The data indicated that a "synesthetic"[1] pairing of the colors and tones, based on correlated physical

1 The phenomenon in which a stimulus involving one sensory modality elicits a response belonging to another sensory modality has been defined as "synesthesis".

characteristics of the sense modalities, markedly influenced the rate of acquisition of these pairs. This group learned the pairs with significantly less errors and trials than did the groups in which the pairs were randomly determined even though the "synesthetic" pairings were not preferred in a pre-learning task.

Loeb & Behar (1966) in a study involving perceived durations of auditory and visual stimuli, presented 20 college undergratuates with 75 auditory and 75 visual stimuli of 1, 2, 3, 4, or 5 sec. duration in random order, subjectively equated in intensity, to be rated on an eleven category verbal scale. The important finding was that the average inter- and intra-modality correlations were of the same order of magnitude. The authors concluded that common mechanisms underlie the perceived duration of stimuli presented to different sensory channels.

Sheridan, Cimbalo, et al (1966) in an experiment involving photic and auditory synchronization, obtained pulsed tone thresholds at five frequencies (250, 500, 1000, 2000, and 6000 Hz) from 20 Ss under three conditions of visual surround; darkness, normal ambient illumination, and relatively high-intensity-tone-synchronized photic stimulation. Audio sensitivity to the highest frequency was lowered by visual stimulation of both types. They concluded that audio-visual interactions are intransitive; i.e., concurrent auditory stimulation will improve visual stimulation, while concurrent visual stimulation will impair auditory sensitivity in higher frequency ranges.

Watkins (1964) found that detectability of a light signal increased when a recurrent pattern of noise bursts was substituted for white noise. The pattern responsible for this effect consisted of bursts coincident with the times of possible visual signal occurence. This experiment did not include two sound conditions; silence, and noise continuous except for silent periods coincident with observation intervals.

In a later experiment, 11 Ss were required to judge which of four temporal intervals contained a visual signal in an experiment involving a total of 10,900 trials. Highest detectability of the signal was associated with an acoustic condition having white noise bursts coincident with each observational interval. Those detection scores were significantly superior to a "reciprocal" condition having the identical amount of acoustic time-specification information. Detection was poorest under continuous noise and silence. Simple time cueing was inferred not to provide an adequate explanation of the results (Watkins, 1965).

Another photic facillitation of an auditory detection is outlined by Watkins (1966). As Ss performed a tone detection task, background noise was reduced at possible signal presentation times. When a light stimulus intensified at those times, detectability of the tonal signal was higher than with a "dimming" or a constant light.

In an experiment dealing with manual performance and arousal (Weinstein, 1966), it was hypothesized that white noise would produce arousal and increase performance on the Minnesota Rate of Manipulation Test. Each of 18 Ss was given 300 trials, each trial consisting of a five second period in which the S turned over as many blocks as possible. White noise (100 db) was presented during one-half of the trials. A T-test was in the direction of the hypothesis and was significant.

A similar study was carried out by Berlyne et al (1966). In a paired-associates learning experiment, 75 db white noise during presentation of stimulus and response terms in training trials significantly increased recall in a test trial one day later. White noise after the response made no significant interaction. It produced no effects on anticipations during training or on a test held immediately after training trials.

Hull's Stimulus-Intensity-Dynamism

Hull (1949) postulated a general dynamic molar law based on stimulus intensity which he called "stimulus-intensity-dynamism" (V), the primary principle of which is

> Other things constant, the magnitude of the reaction potential (sEr, i.e., V) has an increasing monotonic relationship to the intensity (i) of the stimulus in question, the increase taking place at a progressively slower rate according to the equation
>
> $$sEr = V = A(1-10^{-b}\log i) \quad p.71$$

Included in the several examples cited by Hull was a stimulus intensity generalization study by Hovland (1937) on human Ss. When the generalization effects of four sound intensities employed were presumably equalized, the amplitude of galvanic skin reactions averaged 10.1 for a stimulus of 40 db and 16.55 for a stimulus of 86 db, the number of reinforcements and everything else being constant. This greater response to a more intense stimulus was believed to have involved stimulus-intensity-dynamism.

Rhythm

Rhythm may be defined as both a stimulus and a response. As a stimulus it may be seen in terms of "a temporal pattern of indivisible unit groups," (Ludin, 1953), or as a response in terms of a Gestalt as "an organizational response of the organism" (Ludin, 1953).

Learning tasks in general are described on a basis of rhythm. Pursuit-rotor learning, associative tasks on the memory drum, and animal experiments utilizing the Skinner Box, to name a few, all have the common factor of time relationships underlying them. If time relationships follow a consistent pattern, a "regular" stimulus pattern or rhythm results. If the time relationships change throughout the experiment, an "irregular" rhythm is the result.

Music too is based partly upon rhythm. Melody and harmony are also major components of any music, but it is the rhythmic qualities which most affect the listener.

> If melody possesses a strong and familiar objective rhythm, the listening is in terms of that rhythm....where the tonal structure is more obvious, the listener's anticipations are whetted even more (Farnsworth, 1958, p.73).

Ortmann (1926, p.22) in an article dealing with the melodic relativity of tones, says

> The preparation of new stimuli through anticipation may result in an added emphasis, if the stimulus coincides with the anticipation, and may require a readjustment, with its resulting confusion, if it does not. Through anticipation, a tone otherwise not emphasized may be stressed for consciousness, and an emphasized tone may be weakened.

Roberts (1936, p.406) in a report dealing with the integrating and disintegrating effects of sound stimuli, says

> The stimulus of the rhythm creates a growing tension demanding a physical release by motor activity which for best effect naturally attunes itself to the pulsations of the stimulus.

The listener may snap his fingers or beat his foot in time with the rhythmic qualities of the music. One theory which is possibly applicable here is the James-Lange theory of emotions. The theory is largely discounted mainly because it assumes an organic basis for initiating functional life. It is based on a type of emotional induction and says

> Music produces emotional reactions that produce "vibrations" in the nervous system, such as a pane of glass vibrates with music.... the human organism vibrates synchronously with music. (Taylor & Paperte, 1958, p.254)

The Present Study

A basic criticism of the literature dealing with music and task situations is the failure of the researchers to "fit the music to the task" or vice-versa. Music has more often than not been chosen on the basis of its familiarity or lack of same, or possibly for its tempo, and has been played "with" rather than "in conjunction with" the task at hand.

In general, cross-modal research shows that when more than one of the senses are stimulated simultaneously, task performance and/or learning are facillitated. (Marlatt & Lilie, 1966; Ries, 1966;

Loeb & Behar, 1966; Sheridan, Cimbalo, et al, 1966; Watkins, 1966; Weinstein, 1966; Berlyne et al, 1966). An important facet of these experiments is the psychophysical equalization of the auditory and visual stimulation used, suggesting that the two types of stimulation must be in some way, complementary, in order that maximum facillitation occurs. Two sources of stimulation acting simultaneously and in a complementary fashion suggests an increase in the total sensory stimulation at the moment of synchrony, and poses an analogy to Hull's stimulus-intensity-dynamism, the essence of which is "the greater the intensity, the greater the response."[3]

If in fact, both music and learning tasks in general are built on the common denominator of rhythm, it would follow, based on cross-modality research, that when a music, with a rhythm identical to that of the learning task at hand, was played in conjunction with that task, i.e., in synchrony with the task, that the total sensory stimulation at the moment of synchrony would result in an improved response to the combined stimulation. In order to create an experimental situation in which the music and visual task stimulations were in synchrony, it was necessary to find 1) an apparatus in which the presentation of the visual stimulation followed a consistent, exactly timed pattern and 2) a piece of music whose rhythmic structure was exactly consistent throughout.

The General Learning Apparatus (G.L.A.) at the University of Windsor is an excellent example of a piece of apparatus that operates on a basis of time relationships. The apparatus when programmed, can demonstrate many human learning processes through a system of stimulus lights, response buttons, and reward lights. Hand-operated timing devices allow the E to adjust the apparatus to any time specifications desired.

A piece of music which has an exactly consistent rhythmic structure is Maurice Ravel's "Bolero". It is an unsurpassed example of perfect time-keeping in music, and features an unrelenting, rhythmic beat which occurs at consistently timed intervals throughout the composition. It resulted from Ravel's efforts to orchestrate a piece around a single, simple, musical theme, and because of his success in this direction, Ravel has been called the "Swiss clock-maker of music."

In the present experiment an attempt was made to compare performance on an instrumental learning task when the visual stimuli (G.L.A. white lights) were presented coincident with the auditory stimuli (repetitive, emphasized beat of "Bolero"), and performance when the two modes of sensation did not coincide. In the former case, the white lights of the G.L.A. came on at exactly the same time as the emphasized beat of "Bolero", while in the latter case there was a time lag between the white light presentation and the emphasized beat. These "synchronous" and "asynchronous" modes of presentation were accomplished by adjusting the G.L.A. time relationships such that the apparatus was "in" or "out of step" with the music.

Originally, the study was expected to involve just one experiment, however, an exploratory study often encounters pitfalls, and two additional experiments were carried out.

CHAPTER II

EXPERIMENT I

Subjects: The Ss were 60 male and female students enrolled at the University of Windsor. In order to obtain a fairly homogenous sample, 32 males and 28 females were used. Fifteen Ss, males and females, were randomly assigned to each of the four groups. No S had prior experience with the experimental task.

Apparatus: The task apparatus was the G.L.A. which is fully described by Cervin, Smith, and Kabisch (1965). There were six subject panels arranged in a hexagon. Removable wooden partitions eliminated visual contact among Ss.

The panels had a row of six white stimulus lights, and a row of six response buttons all numbered 1-6 from left to right (Fig. 1). A green positive reinforcement light located in the left quarter of the panel was used for this experiment. Other lights remained inactive.

In addition to the G.L.A. a Layfayette #820 tape deck was employed in this experiment. An external amplifier, an Eico HF 12, with treble and bass settings fixed throughout the experiment,

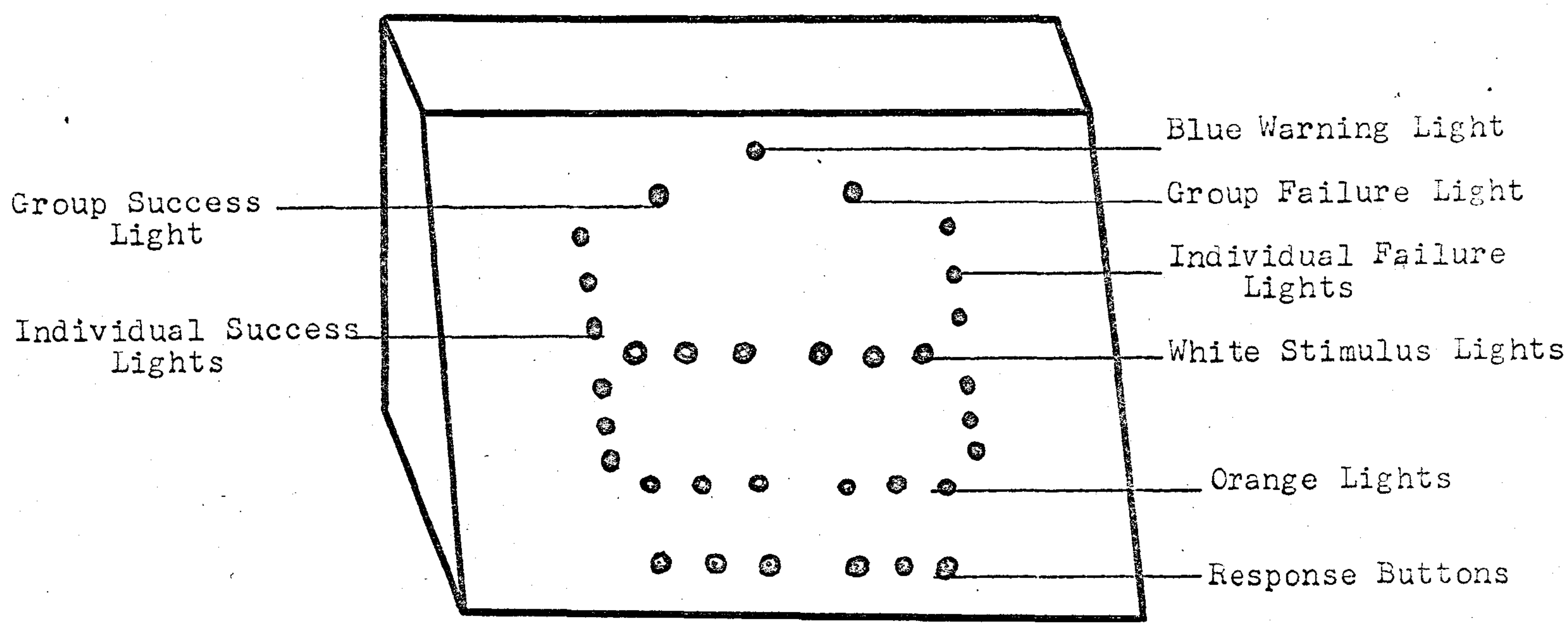

Fig. 1. General Learning Apparatus, (G.L.A.), showing individual subject panel.

served as the power source for the tape deck. The treble control was fixed at minimum treble; the bass control was fixed at maximum bass.

The air conditioning system in the building served as a constant source of white noise at an intensity level of 69 db.

Throughout the experiment auditory input was kept at a relatively high level (approximately 69-71 db), with the average sound level equated on a Scott sound level meter, model 412, so that all auditory stimulation in the experiment was of an equal intensity.

The sound stimuli were reproduced by an 8 ohm high-efficiency speaker, concealed behind an enclosure containing the air conditioning equipment. The enclosure served to baffle the sound giving increased bass performance. In addition, the enclosure dispersed the sound in such a way as to disguise the point-source of the sound. Intensity levels were set prior to each experimental session in such a way that the position of the sound level meter closely approximated the position of the Ss in the experimental situation.

Method: The Ss were seated in a waiting room adjacent to the G.L.A. room for a period of five minutes. During this time the auditory stimulation to be used in their session was played and could be heard by the Ss. They then entered the G.L.A. room and were told to sit at whichever panel they wished. When all Ss were seated, the following instructions were handed to the Ss to be followed as the E read them aloud. Any questions were answered individually by the E.

Your task in this experiment is as follows:

> Each response button is electrically connected with a different white light. Your task is to learn the correct button-light connections.

The experiment will work as follows:

> 1. The blue warning light at the top of your panel will come on first.
> 2. Then a white light will come on. You are to indicate your response to each white light by firmly depressing and releasing one response button. You will have three seconds for your response and please respond to each white light by pressing only one button.
> 3. When you have made a correct choice your green success light will come on after the white light.
> 4. The experiment will begin when the buzzer is sounded.
> 5. Are there any questions?
> 6. Before the experiment we will now have a practice session. Please respond to the white lights by pressing the buttons I call.
> 7. In the experiment proper, the light-button connections will not necessarily be the same as in the practice session, but the ones you learn during the experiment will remain the same throughout the experiment.

The learning task was a delayed operant conditioning task using only training phases. Test phases were not included since the rigid timing required for the synchronization procedures was more easily controlled by the E through the use of training phases only. Each trial involved the following stimulus and response events: Blue light (warning); White light (stimulus); button pressing by S (response); Green reinforcement light (in the case of a correct response by S). The time relationships between these events were: Blue light, 1 second; White light, 3.16 seconds; Green light, 1 second. The selection of these times was based on the time between two consecutive beats in "Bolero", which was a consistent 2.58 seconds.

The "rhythmic" characteristic of the G.L.A. was measured by the repetitive occurrence of the white stimulus light, at an average rate of every 5.16 seconds. Synchrony of the learning task and the music was defined as the simultaneous occurrence of the white light and an emphasized, repetitive beat in the music.

The criterion for learning for the groups was the average number of correct responses per ten blocks of trials (120 trials). To allow for the synchronization of the G.L.A. with the music

"Bolero", data recording was not begun until the second block of trials began. (This second block will be referred to as the "first" block throughout the experiment).

Synchronization was achieved by adjusting the white stimulus light timer until the appearance of the white light coincided with a repetitive "jerk" on the intensity meter of the tape deck signifying the appearance of the emphasized beat.

Four different ways of pairing the auditory stimulation with the learning task were explored in this experiment, with a different group of Ss assigned to each condition.

<u>Group I</u> The onset of a white stimulus light was synchronous with the repetitive beat of "Bolero", i.e., every time the visual stimulus came on, the auditory stimulus was emphasized.

<u>Group II</u> The presentation of the white stimulus light was asynchronous with the repetitive beat of "Bolero", i.e., the onset of the visual stimulus did not coincide with the auditory stimulus. To prevent a repetitive pattern from forming, timing of the stimulus light presentation was altered at the end of each block of twelve trials using a geometric progression throughout this phase of the experiment. At the end of each block of trials,

E adjusted the G.L.A. timings so that the length of the individual trials within alternate blocks altered from 5.16 seconds to 7.74 seconds from block to block.

Group III Solo piano selections by Bill Evans were played throughout the testing period (Verve, V-8683: "Solo-In Memory of His Father"). This piece is composed of polyrhythmic material as opposed to the definitive rhythm of "Bolero", so that any affect on the listener could not be attributed to a consistent rhythm.

Group IV The auditory stimulation throughout the testing period was white noise.

Following the testing situation, Ss in music groups were questioned individually by the E in a separate room. In a pilot study it was found that more information resulted if rather than asking standardized questions immediately, the S was allowed to express what he felt was "going on" first. Eventually however, E asked more standardized questions as for example: "Did you notice any relationship between the music and the task?" It was felt that this approach lessened the chances of missing anything that the Ss may have had to offer the E.

Results: Performance curves were plotted for each of the four groups. These appear in Fig. 2. The curves suggested the four groups performed differently over the trials. To test this statistically, analysis of variance was carried out based on the average number of correct responses for each block of trials for each of the four groups. The results are shown in Table 1.

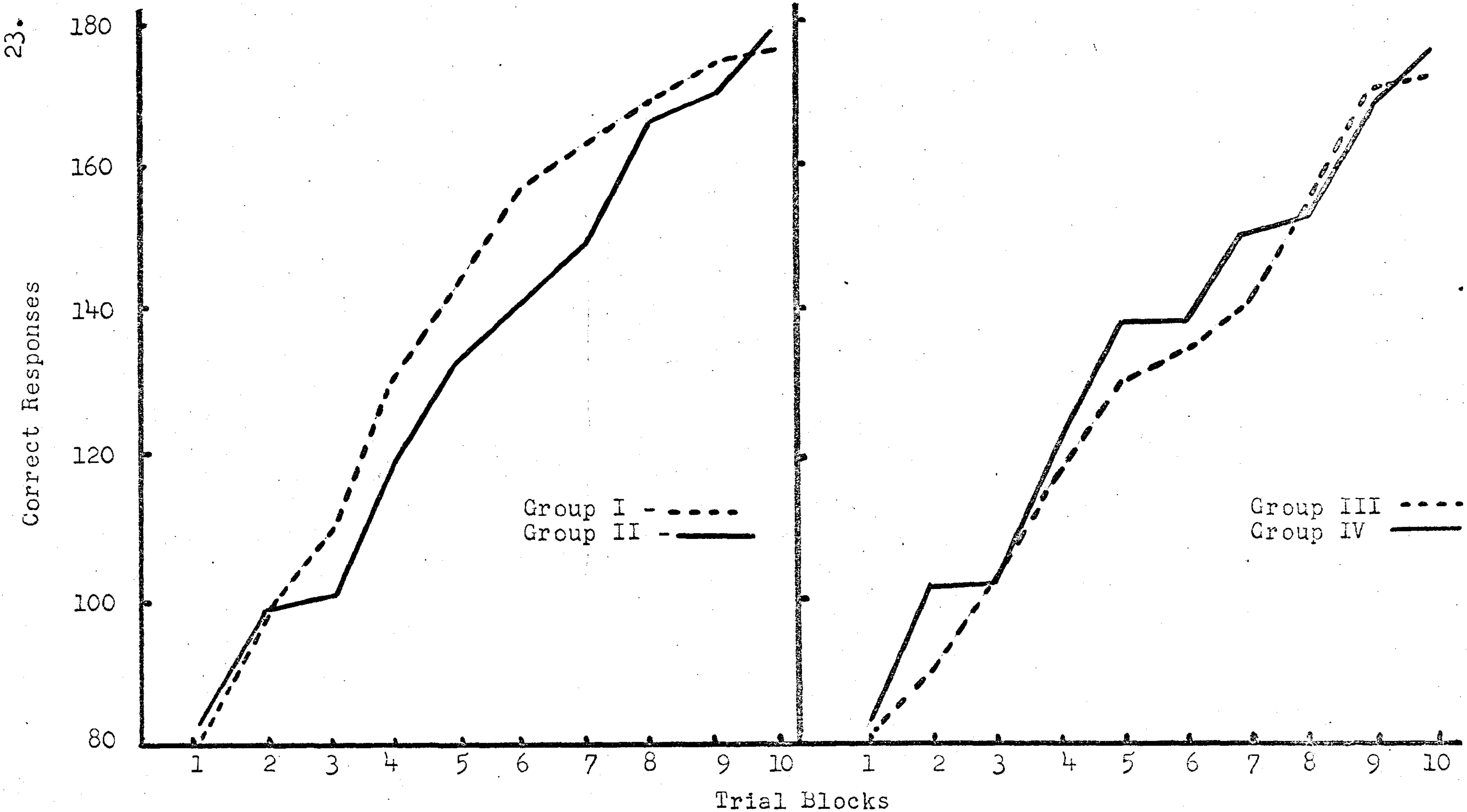

Fig. 2. Performance curves for all groups showing average correct responses for each block of trials.

TABLE 1

Analysis of Variance for Average Number of Correct Responses for Each Block of Trials for All Groups

Source	SS	df	MS	F
Between Ss	1160.53	59	19.67	
A (Music)	36.38	3	12.13	
Ss within groups	1124.15	56	20.07	
Within Ss	3672.80	540	6.80	
B (Blocks)	2619.33	9	291.04	146.25[x]
AB	45.75	27	1.69	.85
B x Ss within	1107.72	504	1.99	

x - significant at the .01 level

The significant "block" effect was to be expected in a learning task of this type. It means simply that all the Ss improved over trials. Neither the music effect or the interaction effect proved significant in the analysis of variance. However, since the learning curves for the four groups differed (Fig. 2), a Newman-Keuls procedure was employed to examine possible individual effects. Table 2 shows the pattern that results.

TABLE 2

Newman-Keuls Test for Comparison of Individual Groups

GROUPS	Group 4	Group 3	Group 1	Group 2
Group 4 (white noise)		X	X	X
Group 3 (Bill Evans)				X
Group 1 (Synchronous Bolero)				
Group 2 (Asynchronous Bolero)				

X - Comparisons significant at the .05 level.

It is clear from the Newman-Keuls analysis that Group II performed significantly lower overall than any other group. Groups I and III performed equally well statistically over the trials.

Conclusion: The results stated here do not uphold the hypotheses. An overall interaction effect was not significant, however the Newman-Keuls test suggested that the groups performances had in some way differed.

One possibility that is inherent in an exploratory study of this nature is that the running of additional Ss might "bring out" the suggested differences.

It was this reasoning that led directly to Experiment II. It was felt that by using the same Ss in both the "synchronous" and "asynchronous" groups, the E could in effect show the desired differences suggested in Experiment I.

CHAPTER III

EXPERIMENT II

Subjects: The Ss were 30 male and female students at the University of Windsor. Eighteen males and twelve females were used and were randomly assigned to one of two groups each consisting of 15 Ss.

Apparatus: The apparatus used was the same as that in Experiment I.

Method: The instructions, experimental task, G.L.A. timings, and recording of responses were the same as in Experiment I. The only differences involved the auditory stimulation and were as follows:

Group I was first exposed to the experimental procedure in an auditory situation of "synchronous Bolero." They were retested after 10 minutes in an auditory situation of "asynchronous Bolero."

Group II was first exposed to the experimental procedure in an auditory situation of "asynchronous Bolero." They were retested 10 minutes later in an auditory situation of "synchronous Bolero."

For both broups the G.L.A. was re-programmed following the initial testing, and Ss were advised that the light-button connections would not necessarily be the same in the second session.

Results: As shown by performance curves in Fig. 4, the two groups performed differently over the 20 trial blocks (10 blocks "synchronous, 10 blocks "asynchronous"). To test for significant differences in the performances, analysis of variance was carried out based on the average number of correct responses for each block of trials for each of the two groups. The results are shown in Fig. 3, and tested for significance in Table 3.

The significant AC interaction is shown graphically in Fig. 3.

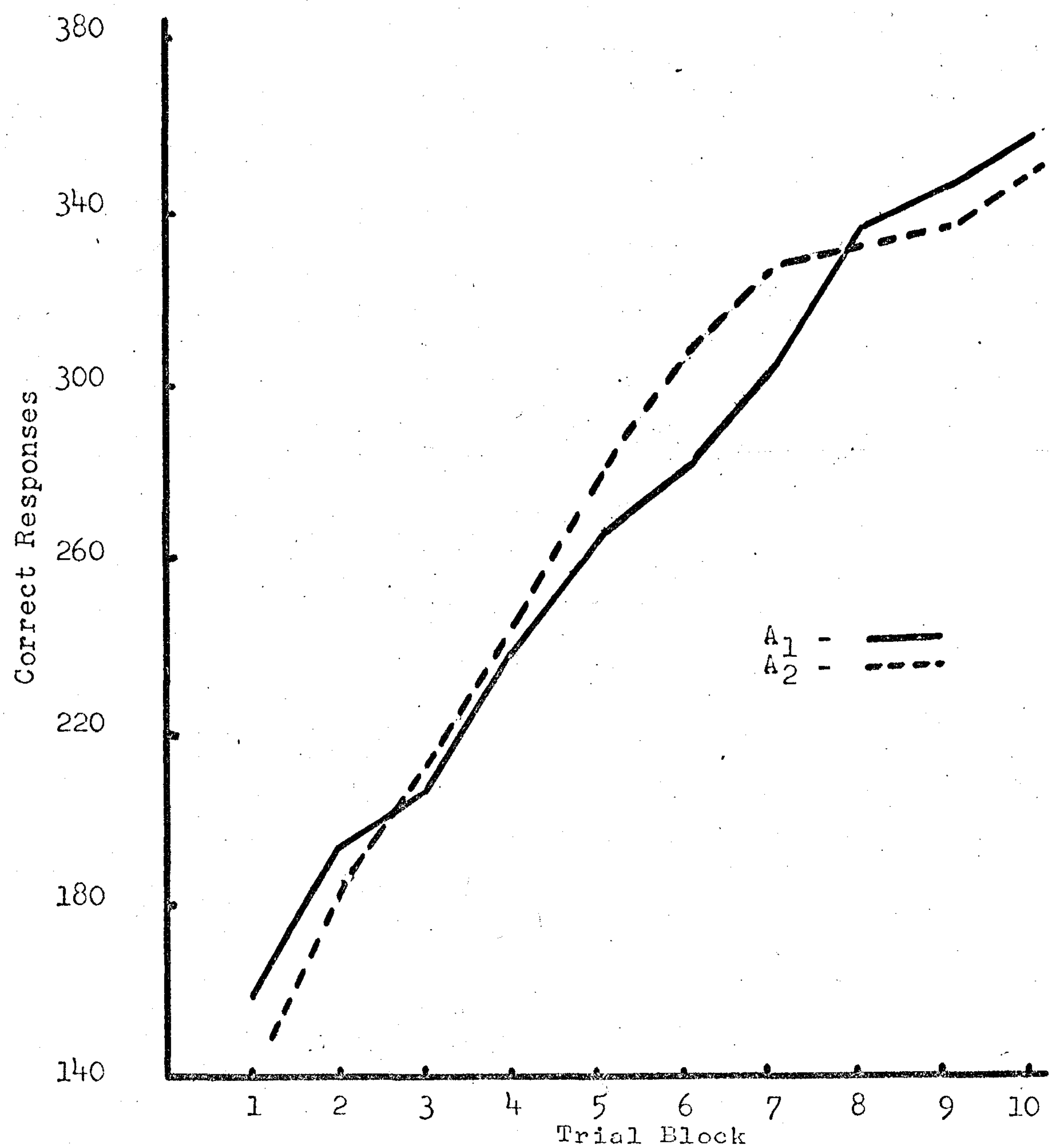

Fig. 3. Total correct responses ($b_1 + b_2$) for both levels of factor A.

In terms of total correct responses, the synchronous and asynchronous groups for both levels of A are compared in Fig. 4.

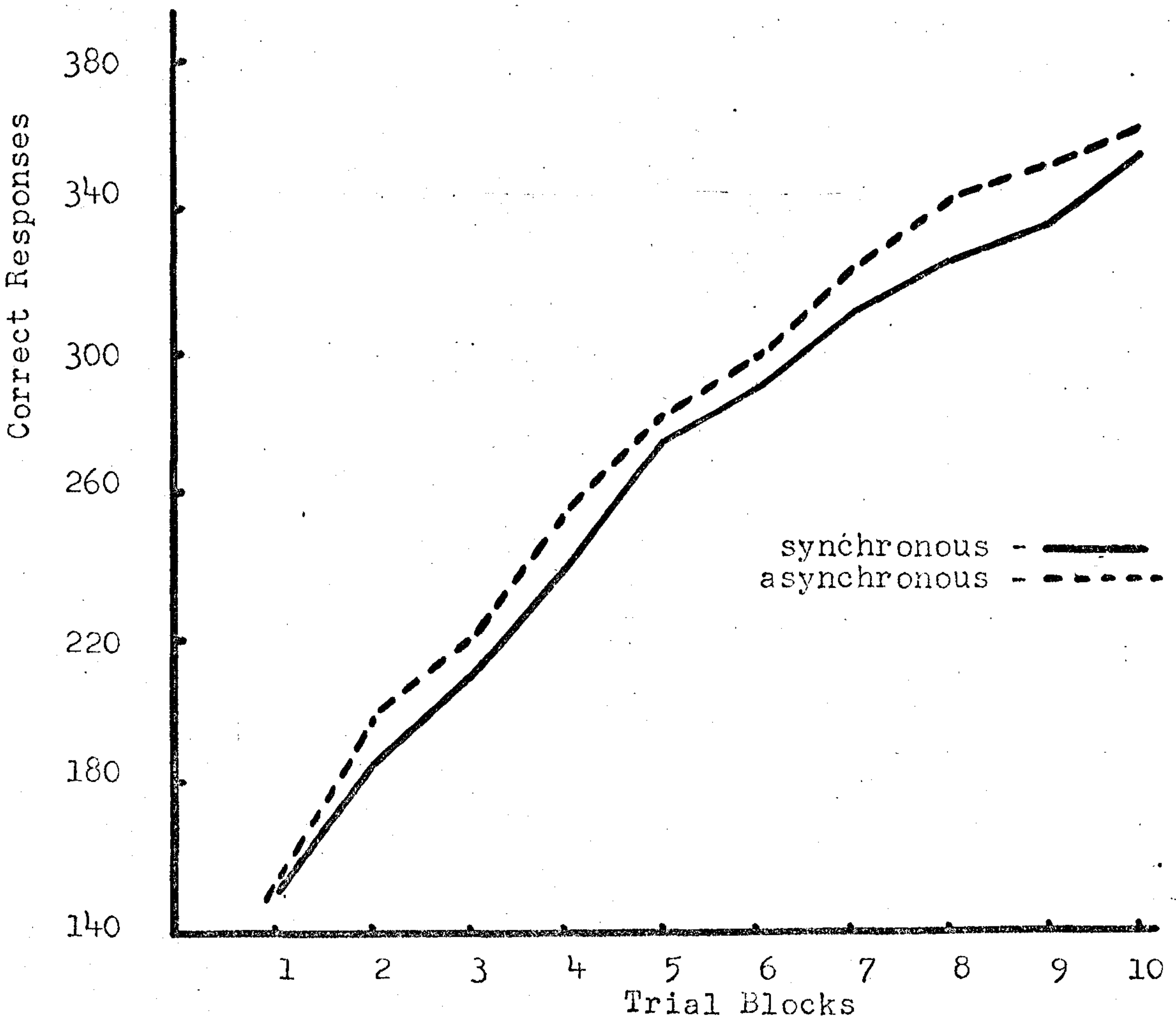

Fig. 4. Comparison of performance in terms of total correct responses for combined synchronous and combined asynchronous groups over both levels of factor A.

TABLE 3

Analysis of Variance for Average Number of Correct Responses for Each Block of Trials (10 x 2) for All Groups

Source	SS	df	MS	F
Between Ss	415.67	29	14.33	
A (order)	.37	1	.37	
Ss within	415.30	28	14.83	
Within Ss	4671.25	570	8.19	
B (synchrony)	10.93	1	10.93	
AB	10.41	1	10.41	
B x Ss within	496.01	28	17.71	
C (Blocks)	2974.87	9	330.54	303.25x
AC	32.91	9	3.66	3.36x
C x Ss within	274.47	252	1.09	
BC	5.15	9	.57	
ABC	3.88	9	.43	
BC x Ss within	862.62	252	3.42	

x - significant at the .01 level

<u>Conclusion</u>: The significant over-all AC effect suggested that the two groups performed differently over the two sets of 10 blocks of trials (Fig. 3). It seemed therefore that the order of presentation, either 1) synchronous-asynchronous or 2) asynchronous-synchronous affected performance.

In both groups, the asynchronous situation led to increased performance (Fig. 4), however the difference did not approach significance. This finding was in accord with Experiment I in which the asynchronous group performed better but not to the point of statistical significance.

The performance of Group II in their first test situation (asynchronous) seemed to be mainly responsible for the overall significant AC effect. There was a rather large decrease in the correct response totals when the same group (II) was retested in the synchronous condition. On the other hand, Group I performed much the same on both the synchronous and asynchronous tasks.

Since the asynchronous sections in both Experiments I and II performed better than the other sections, a possible explanation is suggested for the decrease in Group II's performance in the retest situation. If, in fact, Ss perform better in an asynchronous condition because they "overcome" the distracting qualities of an asynchronous situation, then a "letdown" could be expected in Group II's performance on the retest, a synchronous task. Group I however, improved slightly in the retest situation. In the case of Group I, the increase in performance in the asynchronous situation could have been tempered somewhat by possible boredom and fatigue effects.

One possible source of contamination remained in Experiments I and II. When the "asynchronous" groups were being tested, their stimulus light programs were altered in a geometric progression at the end of each block of trials, in order that an "asynchronous" pattern of responding would not occur. This however changed the task in a sense from that of the other groups in which all time relationships were constant. Partly to overcome this variable, Experiment III was carried out.

CHAPTER IV

EXPERIMENT III

<u>Subjects</u>: The Ss were 60 male and female students at the University of Windsor. Thirty males and 30 females were used and were randomly assigned to one of four groups of 15 Ss each.

<u>Apparatus</u>: The apparatus was the same as in Experiments I and II except for a Grason-Stadler noise generator which was included here.

<u>Method</u>: The instructions, experimental task, G.L.A. timings, and recording of responses were the same as in Experiments I and II. The only differences involved the auditory stimulation and were as follows:

<u>Group I</u> Fifteen Ss were run in the "synchronous Bolero" condition, in which the music was played at the normal rate of 33 1/3 r.p.m., and the white stimulus light was synchronized with the beat as in Group I of Experiment I.

<u>Group II</u> Fifteen Ss were run in an "asynchronous lag" condition, in which the G.L.A timings were the same as for Group I, but the "Bolero" was

played at 32 r.p.m., the slowest rate that could be used without gross distortion. For this group, then, the "Bolero" beat lagged behind the repetitive rate of the white stimulus light.

Group III Fifteen Ss were run in an "asynchronous lead" condition, in which the G.L.A. timing was as before, but the Bolero was played at 34 2/3 r.p.m., an increase in rate equal to the lag of Group II. For this group, the Bolero beat led the stimulus light.

Group IV Fifteen Ss were run in a condition of white noise fed directly through the speaker from a Grason-Stadler noise generator.

In all groups in Experiment III, the auditory stimulation was increased in intensity to an average level of 74 db.

Results: Performance curves were plotted for each of the four groups. These appear in Fig. 5. The curves suggested the four groups performed differently over the trials. To test for significant differences, analysis of variance was carried out based on the average number of correct responses for each block of trials for each of the four groups. The results are shown in Fig. 5 and tested for significance in Table 4.

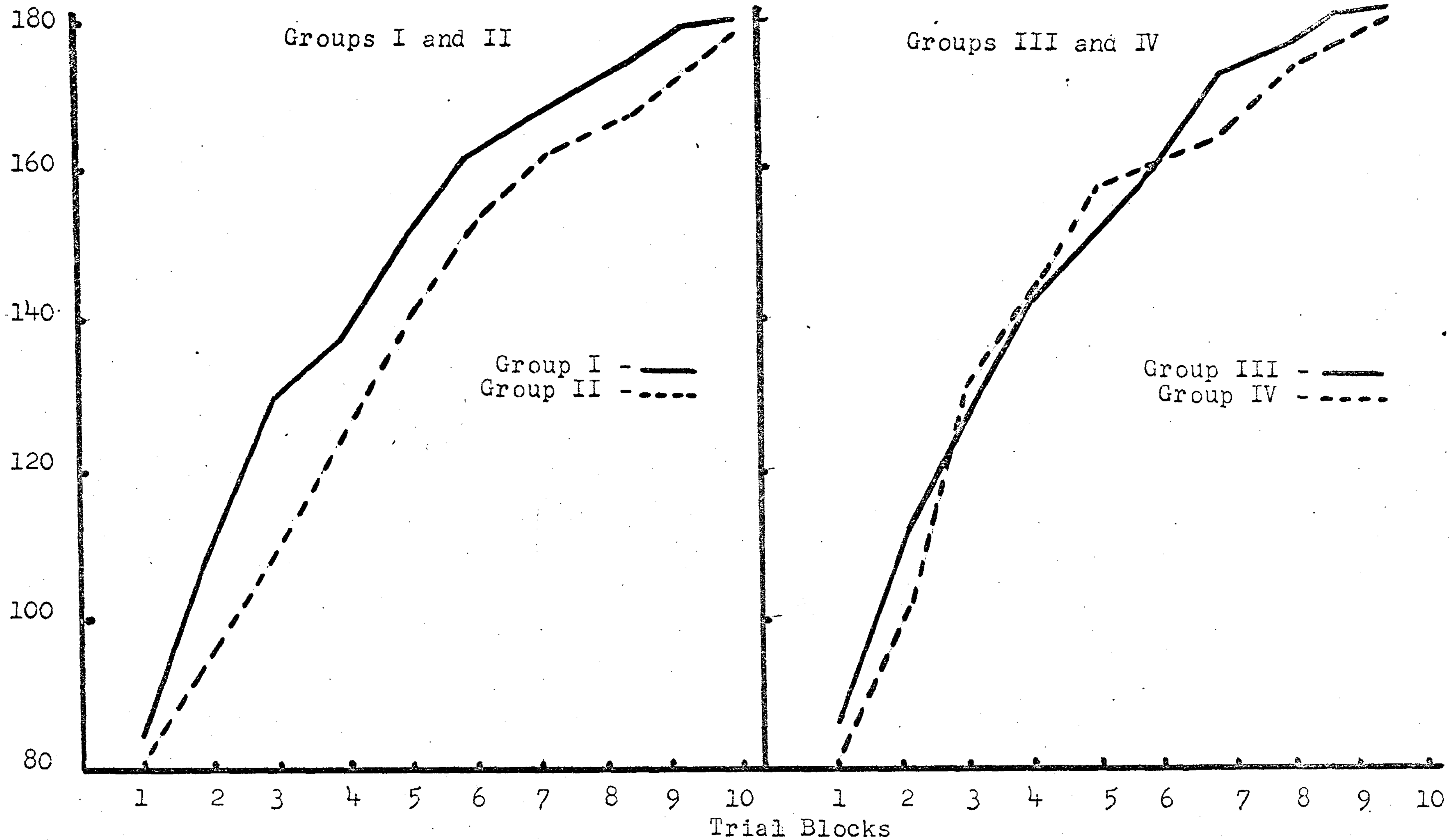

Fig. 5. Performance curves for all groups showing average correct responses at the end of each block of trials.

TABLE 4

Analysis of Variance for Average Number of Correct Responses for Each Block of Trials for All Groups

Source	SS	df	MS	F
Between Ss	839.36	59	14.23	
A (music)	76.84	3	25.61	1.88[x]
Ss within	762.52	56	13.62	
Within Ss	3727.00	540	6.90	
B (Blocks)	2722.92	9	302.55	155.15[xx]
AB	34.80	27	1.29	
B x Ss within	980.95	540	1.95	

x - significant at the .25 level
xx - significant at the .01 level

A barely significant A (music) effect was obtained. As shown in Fig. 6, performance differences between the groups appear to have occurred early in the experiment, in the first block of trials. To test this hypothesis another analysis of variance was performed, the results of which appear in Table 5. In this second analysis, the first block of trials (b), was subtracted from each of the following blocks of trials for all groups, so that the analysis dealt only with the last nine blocks of trials.

TABLE 5

Analysis of Variance for Total Correct Responses in Blocks 2-10 For All Groups

Source	SS	df	MS	F
Between Ss	42622.63	59	722.42	
A	142.20	3	47.40	
Ss within groups	42480.43	56	758.58	
Within Ss	2053.11	480	4.28	
B	1360.90	8	170.11	111.91xx
AB	11.57	24		
B X Ss within groups	680.64	448	1.52	

xx - significant at the .01 level

In addition, simple effects tests were carried out on the first and second blocks of trials, the results of which appear in Fig. 6.

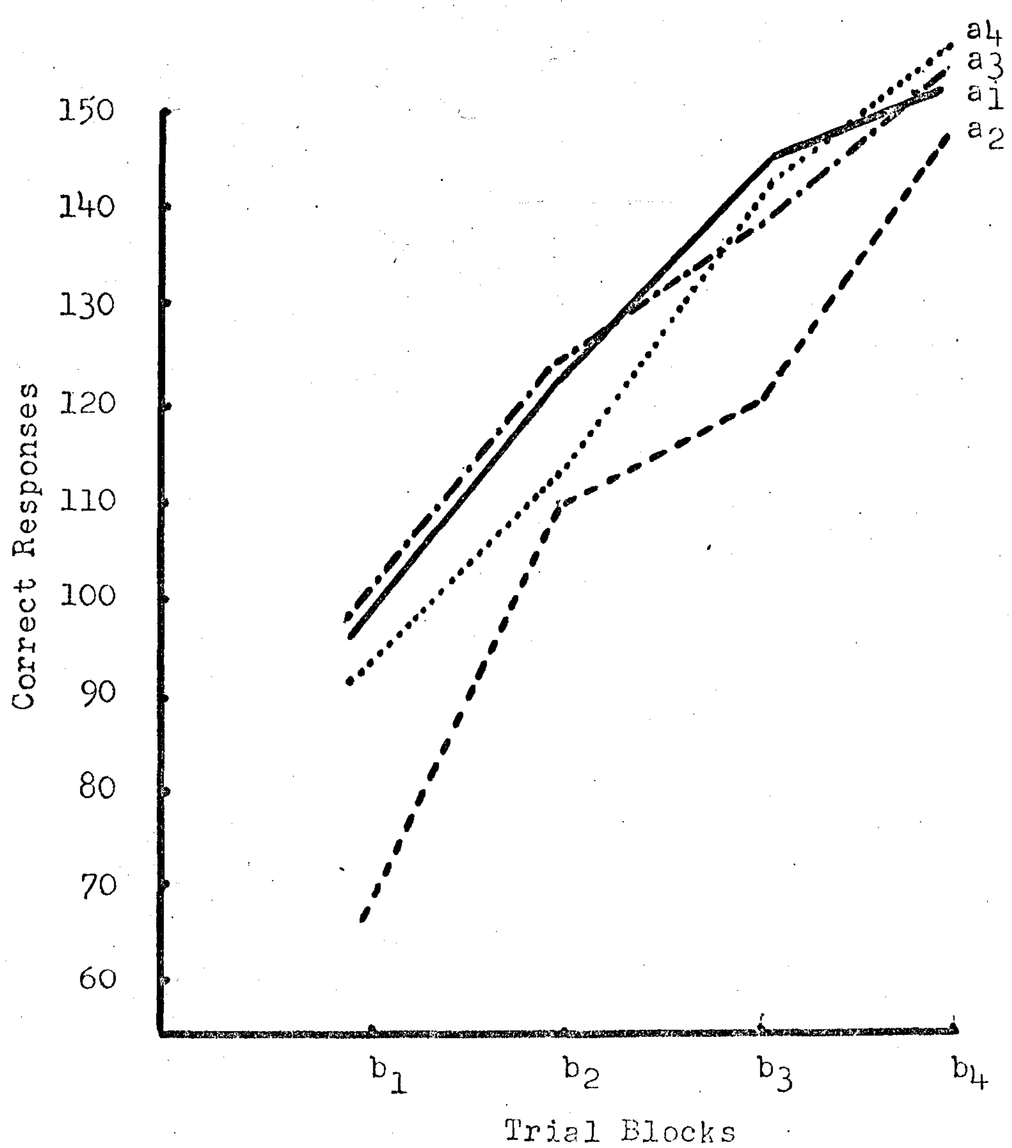

Fig. 6. Profiles of factor B at levels of factor A.

Conclusion: The most obvious result in Experiment III was the increase in the total correct responses for all groups. Over the ten blocks of trials in Experiment III, the average number of correct responses per S was 96.20, compared with an average of only 89.33 in Experiment I and 89.88 in Experiment II. Analogously, this finding seems to support Hull's theorem of "Stimulus-Intensity-Dynamism" (Hull, 1949).

The significant A (music) effect would seem to stem largely from Group II's performance in the early trials (Fig. 6). The simple effects tests proved significant in the first block of trials but not in the second, suggesting that some form of adjustment had occurred. This view is supported by the second analysis of variance in which the first block was subtracted from the remaining nine blocks. Group II had the largest total in this second analysis, showing that it "recovered" the most after the first block of trials.

There was a slight "wow" effect in the music recorded at 32 r.p.m. Several Ss reported this irritation to the E. The 34 2/3 r.p.m. group was not exposed to this irritation since there was no audible distortion at this speed. This irritating effect, coupled with the possible languishing effect of the decrease in tempo, may have made the music more distracting initially to Group II than to Group III and Group I. The fact that Group II showed significantly more improvement over the last nine blocks would seem to support the findings in Experiments I and II in terms of the "overcoming" of asynchrony.

Group III was an asynchronous group and yet they performed much the same as Groups I and IV over the 10 blocks of trials. In this case, the faster tempo (34 2/3 r.p.m.) may have tempered the asynchrony. In terms of total correct responses, Group III still outperformed Groups I and IV but not significantly as did Group II.

CHAPTER V

DISCUSSION

The original hypotheses have not been upheld by the results. It would appear that in this design at least, "synchronization" of two modes of sensation has not improved the task behavior. The hypotheses quite possibly remain good ones. Other researchers may well have supported them in other designs. More than likely, reasons for statistical insignificance in the present study are to be found in the design chosen for the study.

In Experiments I and II, "asynchronous" groups performed better than the other groups. In Experiment III one of the "asynchronous" groups was again the best performer. It would seem that the distracting elements of an "asynchronous" situation are a result of what Broadbent (1957) terms "competing responses." That is, stimuli compete for the Ss attention by eliciting responses in competition with the task response. Broadbent would interpret the asynchronous music here as "noise", and would predict a disrupting effect.

In this study, Ss seemed to adjust to

the situation by overcoming the attention division and subsequent disruption of the task. Learning curves (Figs. 2 & 5) suggest that the Ss concentrate even harder on the task at hand in an attempt to block out competing responses. To support this hypothesis, simple effects tests performed upon the first two blocks of trials in Experiment III show a statistical significance in the first block but not in the second suggesting that the Ss in the "asynchronous" groups did indeed alter their approach to the task over the first block of trials.

In the "synchronous" groups there was a definite time pattern. Every time there was a light there was an emphasized beat. Garcia-Austt (1961) in an experiment dealing with the significance of the photic stimulus and evoked responses in man, found that

> First, the flashes take S by surprise... then through monotonous repetition the flashes lose significance and S becomes disinterested.....if now the flashes are discontinued at regular intervals for constant time periods, there is a new interest added, darkness.... discontinuous flicker stimulation led to dishabituation and an increase in response amplitude.

In the present experiment the "asynchronous" groups are faced with constantly changing time relationships. After the initial "surprise" and concomitant increased attention state, Ss anticipations were in a constant state of dishabituation regarding the relationship between the onsets of the visual stimulus and the emphasized auditory stimulus. Instead of a constant rhythm, a syncopated[1] rhythm resulted. According to Weaver (1939), in syncopated rhythm "the listener's anticipations are strengthened even more." Similarly, Hovey (1928) suggests that an individual involved in a task may not be working at full capacity and any form of distraction may serve as an incentive to increase this capacity.

An interesting finding presents itself when the music and no-music groups are compared. In Experiment I, a comparison of the raw data for the four groups shows that all the music groups outperformed the white noise group. In Experiment III only Group II did not outperform the white noise group. None of the above mentioned comparisons approached significance, however the data suggests that Ss perform slightly better with music than without. A large number of Ss from the music groups claimed that the music made the

1 Shifted emphasis to a tone normally not accentuated in a given rhythmic pattern.

task "more comfortable" or "less boring." An exception was the asynchronous Group II in Experiment III. Here a few Ss complained about the quality of reproduction of "Bolero". Perhaps the slight irritation experienced in this group led to their poorer performance and explains why they were the only asynchronous group that did not outperform the other groups.

The question that must be answered is, If Ss in music groups do in fact outperform Ss in no-music groups (especially the asynchronous groups), then why didn't these music groups mention to the E the fact that they tried harder to overcome the musical distraction? There are at least two reasons for this. First of all, a "visual problem (lights) requires visual fixation... auditory stimulation does not necessitate voluntary attention of subjects and allows extraneous activity" (Fiske, 1964). With the exception of Group II in Experiment III where the auditory stimulation was overtly irritating to some Ss, Ss in the other music groups in all Experiments may not have paid much attention to the music, suggesting that the Ss were unconsciously affected by the music. Similarly, a relatively recent theory concerning the effect of music on human behavior, the "Depth Provocation Theory", says that

> Music, because of its abstract nature, detours the ego and intellectual controls and, contacting the lower centers directly, stirs up latent contents and emotions which may then be expressed and activated through music.
> (Taylor & Paperte, 1958, p.256)

The theory itself is rather abstract, however its bent towards unconscious determination may be applicable to the present study.

Interestingly, the increase in intensity levels (from 69 db - 74 db) in Experiment III would seem to have led to improved performance in all groups. The auditory stimulation in Experiments I and II certainly was at least "normal" listening level or even greater. Duffy (1962, p.62) says that

> For a given individual engaged in a specific task, a certain degree of noise may improve performance, while a lower or higher degree will retard it.

Perhaps the 74 db level was closer to an optimum performance level for this study than the 69 db level, since the raw data showed that three of the groups in Experiment III had greater correct response totals than any of the groups in the first two experiments.

SUMMARY AND CONCLUSIONS

This study was an exploratory investigation of the effects of music upon performance in an operant conditioning task.

The study consisted of three experiments in which a total of 150 male and female undergraduates at the University of Windsor served as the experimental sample. The learning task was the same for all Ss, a delayed operant conditioning task on the General Learning Apparatus.

Two conditions of musical stimulation were compared in this study - 1) music played in synchrony with the learning task, and 2) music played out-of-synchrony with the task. An attempt was also made to compare music and no-music groups.

Analyses of variance showed no statistical evidence that music affects performance on an operant task. However, the results tended to support the following hypotheses:

1. "Music" groups perform better than "no-music" groups.
2. Groups in which the music is played asynchronous to the task perform better than groups in which the task and music are in synchrony with one another.
3. Increased intensity of auditory stimulation improves performance.

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