LEARNING, A MAJOR FACTOR INFLUENCING PREFERENCES
FOR HIGH FIDELITY REPRODUCING SYSTEMS

DISSERTATION

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Chapter I

INTRODUCTION AND STATEMENT OF THE PROBLEM

During recent years, considerable interest has been shown in "high fidelity" sound reproduction by the general public. The sale of "high fidelity" phonograph records during 1954 showed an increase of 20 per cent over the previous year. It is predicted that in 1955, 15 per cent more "high fidelity" phonograph records will be sold than in 1954. "Hi Fi" commercial phonographs are currently being marketed by such well known companies as R.C.A. Victor, Magnovox, Stromberg-Carlson, Motorola, Columbia and others. It has been estimated that \$241,000,000 worth of high fidelity components and component parts were sold in 1954 (Folsom, 4). This represents an increase over 1953 "high fidelity" component sales of about 50 per cent. Books designed to acquaint the public with high fidelity are now available. There are a number of new magazines such as High Fidelity, Audio and Music At Home which disseminate information about "high fidelity".

In spite of this growing interest in "high fidelity" sound reproduction, there is no universally accepted definition of "high fidelity" (Hoefer,7). Consumer Reports (15, p.281) points out that this may in part be a function of the fact that, "High fidelity is not an attained state; it is the pursuit of an unattainable ideal". An ideal "high fidelity" system would, according to Carl Hoefer (7), exhibit the following characteristics.

1. The full frequency range of the human ear.
2. The full dynamic range of a symphony orchestra.
3. Absolute freedom from distortion of any sort.
4. Absolute freedom from extraneous noise.

Since the characteristics listed above are unobtainable, a practical definition of "high fidelity" might read as follows: High fidelity reproduction is the reproduction of music, speech and sound with as much faithfulness and realism to the original production as possible. For purposes of this experiment the term, "high fidelity", will refer to any reproducing system which has: one, a frequency response of 30-15,000 C.P.S., plus or minus 0.2 decibels; two, all measurable forms of distortion held to one per cent or less; and three, noise generated within the sys-

tem 60 decibels or more below the peak signal level.

In view of the interest in high fidelity sound reproduction alluded to earlier, it would seem important to gain a clearer appreciation of some of the factors which influence our preferences for this type of reproduction. One important factor which influences our preferences for sound reproduction is the frequency range of the reproduced sound. Another factor influencing our preferences for sound reproduction is the amount of high frequency and low frequency emphasis or de-emphasis of the reproduced sound. This latter factor will be referred to in this experiment as "tonal balance". The research which will be described in this paper was confined to the two above mentioned factors.

Prior experiments have indicated that the average listener prefers a restricted frequency range in monaural reproduced speech and music. Chinn and Eisenberg found that when listeners heard classical music alternately reproduced over a 160-3,500 C.P.S. frequency range and a 30-9,000 C.P.S. frequency range, 58 per cent of the listeners prefer the narrow frequency range while only 15 per cent of the

listeners preferred the wide frequency range. Professional musicians showed an even greater preference for the narrow frequency range with 73 per cent preferring the narrow range while 5 per cent preferred the wide range.

It is interesting to note that in the Chinn and Eisenberg (3) study, subjects who owned frequency modulation radios showed a greater preference for the wide frequency range. Two possible explanations may be offered for this finding: either the "FM" set owners bought the "FM" sets because they originally preferred a wider frequency range reproduction of radio programs, or the "FM" set owners learned to prefer the wider frequency range after listening to their sets over a period of time.

Bauer (1), using phonograph records, found an even greater preference for a narrow frequency range reproduction of music. In his experiment 71 per cent of his subjects preferred a high frequency cutoff at 3,000 C.P.S., 21 per cent preferred a high frequency cutoff at 5,000 and only 8 per cent preferred a cutoff frequency above 5,000 C.P.S.

Olson (14), using popular music performed by a six piece dance band, found that 69 per cent of his

listeners preferred an unrestricted frequency range while 31 per cent of his listeners preferred a high frequency cut off at 5,000 C.P.S. Part of the discrepancy between the findings of Olson and of Chinn and Eisenberg can probably be accounted for in terms of the differences in methodology. Olson used acoustically treated panels around the dance band to produce the 5,000 C.P.S. cut off. Chinn and Eisenberg used Columbia classical music "master" records as the stimulus material, and single-section, prototype band-pass filters to produce the high and low frequency cut offs.

Olson (14,p.549) has cited three hypotheses which have been advanced to account for the preference of listeners for a restricted frequency range in monaural reproduced speech and music.

1. "The average listener after years of listening to the radio and phonograph has become conditioned to a restricted frequency range and feels that this is a natural state of affairs."
2. Musical instruments are not properly designed and would be more pleasing and acceptable if the production of fundamentals and overtones in the high frequency range were suppressed.
3. The distortions and deviations from true reproduction of the original sound are less objectionable with a restricted frequency range."

The writer would like to propose a fourth hypothesis to account for the preference of subjects for a restricted frequency range in monaural reproduced speech and music.

4. The average listener after listening to the radio, phonograph and live sound sources for many years has developed specific "sets" for music and speech, emanating from a particular source, to sound a particular way. For example, when we hear music coming from a radio, we have a "set" to hear a restricted frequency range. When we go to the concert hall our "set" changes and we expect an unrestricted frequency range. When music or speech reproduction differs perceptibly from the listener's established "set" he will not like this reproduction.

An explanation based upon the above hypothesis could account for the apparently irreconcilable fact noted earlier, that musicians who have had the longest contact with "live" music prefer a very restricted frequency range reproduction of music.

If one postulates the existence of "sets" for different frequency ranges it seems reasonable to postulate the existence of "sets" for different "tonal balances". Haynes (6, p.17), in discussing factors influencing studies of audio-reproduction quality says: "Many observers know that the average musician sitting in a symphony orchestra never hears the complete orchestra in its best balance. A French

horn player who has had his instrument wrapped around him for twenty years of 'experience' certainly acquires an unusual musical perspective." Accordingly, one would predict that the tonal balance preferences of flute players would be quite different from the tonal balance preferences of tuba players.

Statement of the Problem

The following hypotheses have been formulated for test in this experiment:

1. The average college student will prefer music and speech reproduced within a restricted frequency range to music and speech reproduced over an unrestricted frequency range.
2. The frequency range preferences of the average college student will be, in part, a function of the type of music to which he is listening.
3. Learning plays an important role in determining preferences for sound reproducing systems, and hence continued contact with a particular system will produce statistically significant shifts in preference for that system.
4. If continued contact with a sound reproducing system produces shifts in preference for that system, the shifts in preference will be greatest for the type of music heard most frequently over that system.
5. A significant correlation will be found between the tonal balance preferences of musicians, and the highest and lowest de-

tectable frequency of the instruments
which they play.

The research to be presented in the following chapters has two distinct phases. One phase of the research consists of surveys of the frequency range preferences of college students and the tonal balance preferences of musicians. The other phase is an experiment designed to determine the effect of continued contact with a reproducing system upon preferences for that system.

Chapter II

APPARATUS AND EXPERIMENTAL DESIGN

For the survey of frequency range and tonal balance preferences of subjects for music and speech, three things were necessary: first, a stimulus in the form of phonograph records; second, an electro-acoustic reproducing system of adjustable properties; and third, subjects disposed to indicate preferences for the stimuli.

Stimulus Materials

The stimulus materials used in the experiment were five phonograph records selected for their wide frequency range characteristics, low harmonic and intermodulation distortion, quiet surfaces and wide program appeal. The following is a list of the phonograph records used in the experiment:

1. Bach, Fantasia Y Fuga en Sol Minor by Alfonso Vega Nunez, Organist, Cook recording, LP 1056.
2. Schubert, Quartet No. 14 D Minor, 3rd and 4th movements, by Budapest String Quartet, Columbus LP recording, ML 4832.

3. Music from the Broadway Production, House of Flowers, Number 3, 4 and 5, by Percy Faith Orchestra, Columbus LP recording, CL 640.
4. Moussorgsky and Ravel, Pictures at an Exhibition, Number 9 and 10, Arturo Toscanini and NBC Symphony Orchestra, RCA Victor recording, LM 1838.
5. Kinney and Honeycutt, Dog Meets Man, read by Raymond Massey, RCA Victor recording, 45 EP, ERA-217.

Electroacoustic Reproducing System

The phonograph "pick up" used in the experiment was equipped with a General Electric Magnetic Cartridge and diamond styli (Model RPX-053). This transducer has a frequency response of 30 - 15,000 C.P.S. and has been described by an independent testing laboratory as having, "... good frequency response, relatively clean transient response and very low intermodulation distortion at lower velocities". (Consumer Reports, 15, p. 285) The transcription arm was a Clarkstan 16 inch Transcription Arm which had been adjusted to provide a stylus pressure of seven grams.

The high and low cutoff filter, which was the A1-901 General Electric Record Filter, was connected between the cartridge and preamplifier unit of the

amplifier. A diagram of the electroacoustic reproducing system is shown on page 13. The filter was rewired to provide the following frequency ranges:

1. 180 C.P.S. - 3,000 C.P.S.
2. 120 C.P.S. - 5,000 C.P.S.
3. 90 C.P.S. - 9,000 C.P.S.
4. 30 C.P.S. - 15,000 C.P.S.

The filter produced a sharp cutoff of twelve decibels per octave for both the high frequency tones and the low frequency tones. The chart on page 12 shows the overall system response curves for the different high and low cutoff filters.

The turntable used in the electroacoustic reproducing system was a Rek-O-Kut model LP-743 which has a noise level 30 decibels below the average recording level.

The amplifier was a Bell model 2200C. This amplifier has a built in pre-amplifier for use with magnetic cartridges. The amplifier has a power output of 20 watts with less than 0.3% distortion. The frequency response of the amplifier is 20 - 20,000 C.P.S. with a hum level 80 decibels below rated output.

The speaker system was an Altec "Voice of the

Chart 1

Four System Response Curves for
High and Low Cutoff Filters

Curve 4	Frequency Range of 30 - 15,000 C.P.S.
Curve 3	Frequency Range of 90 - 9,000 C.P.S.
Curve 2	Frequency Range of 120- 5,000 C.P.S.
Curve 1	Frequency Range of 180- 3,000 C.P.S.

Chart 2

Diagram of Electroacoustic Reproducing System

Turntable &
Transcription
Arm

Hi & Low
Cut off
Filter

Amplifier with
Built in
Pre-Amplifier

Speaker
System

Theater" speaker system, which consisted of a 15" loudspeaker employing a folded horn for low frequencies and a multicellular horn for high frequencies. The frequency response of the speaker system was relatively flat from 30 C.P.S. to 20,000 C.P.S.

Subjects

The 119 male and 91 female subjects serving in the first phase of the experiment on frequency range preference were Ohio State University students. The subjects ranged in age from sixteen to twenty-six years of age with approximately 85 per cent of the subjects falling between the ages of seventeen to nineteen years of age.

One hundred and ten of the subjects were secured from classes in the elementary course in psychology. One of the requirements of this course is that the student must participate in three hours of experimentation outside of the classroom. Since this is a required course for most of the colleges at Ohio State University, it may be assumed that a fairly representative sample of the freshmen student body was obtained. The remaining 99 students were secured from two elementary music appreciation classes which

are open to students in all colleges except students majoring in music.

Information regarding the subjects' musical background and record playing facilities was secured by means of a questionnaire attached to the answer sheet. A copy of the questionnaire and answer sheet is included in Appendix D. The questionnaire was filled out by the subjects just prior to the administration of the preference test.

Approximately half of the subjects had not studied music or had studied music less than one year. Twenty-three per cent of the subjects had studied music from one to four years. Nine per cent of the subjects reported having studied music from nine to twelve years.

Eighty-nine per cent of the subjects said they had access to phonograph record playing equipment. Seventy-nine per cent of the subjects said that their phonograph was from one to five years old. Only 2 per cent of the subjects said that their phonograph was over ten years old.

Of the 180 subjects who reported owning or having access to phonograph records, 12 per cent said

that none of the records in their collection were "popular dance records" as opposed to classical records. Twenty-five per cent of the subjects said that ten per cent of their record collection was composed of "popular dance records". Only one per cent reported having all "popular dance records" in their collection. A more complete description of the subjects serving in the frequency range preference experiment may be found in appendix B.

Unfortunately it was impossible to secure a measure of the amount of hearing loss of the subjects. The writer feels however that this cannot be interpreted as a criticism of the experiment. In an earlier study by Steinberg, Montgomery and Garner it was found that the least amount of hearing loss occurred for persons in the age range of ten to nineteen. (20, p.293) Since 85 per cent of the subjects fell within the age range of seventeen to nineteen, one may assume that the subjects as a whole have average or below average hearing loss.

The thirty-four male and twenty female subjects serving in the second phase of the survey on tonal balance preferences were all Ohio State University students. The subjects ranged in age from sixteen

to twenty-nine years of age with approximately ninety per cent of the subjects falling between the ages of seventeen to nineteen years of age.

This group of subjects was composed of advanced musicians from the Ohio State University Band and Little Orchestra. The mean number of years of musical study was 9.87 with a standard deviation of 3.51. When the musical instrument of each one of the subjects was listed, almost all of the major band and orchestra instruments were represented. A more complete description of the musicians serving in this phase of the experiment may be found in appendix C.

Method for Determining Frequency Range Preferences

The method used to determine the frequency range preferences of the subjects was similar to the one employed by Chinn and Eisenberg (3). The subjects in groups of approximately forty were seated in a large room in the music building on the Ohio State University campus. The room in which the experiment was conducted is the room normally used for all music appreciation classes.

The speaker system was in the front of the room, approximately ten feet in front of the first row of

seats. Midway between the speaker system and the first row of seats was a 5" by 12" signal box. The front of the signal box was covered by a thin, white, translucent sheet of cardboard. Two letters, "A" and "B", one above the other, were glued on the inside surface of the cardboard front. Two ten watt light bulbs were placed inside the signal box so that the experimenter could illuminate either letter.

The turntable, amplifier, filter box and controls for the signal lights were placed in the back of the room. A Pierce Wire Recorder dual foot switch (Model 195) used to present the signal lights and the filter box were operated by the experimenter. An assistant started and stopped the turntable and changed the phonograph records.

The change from one frequency range to another was accomplished manually by turning two four-pole selector switches on the filter box. The experimenter was of the opinion that a manual operation of the high and low pass filter switches was preferable to an automatic changing and timing device. The former procedure allowed the experimenter to avoid changing the frequency range at the same time that a marked change occurred in the instrumentation, time

or character of the music. It follows that since there was occasionally some variation in the A-B-A presentation time relationships, manual operation of the signal light changes was also necessary so that the frequency range change and the signal light change would coincide.

At the beginning of the experiment, the experimenter introduced himself to the group of subjects and told them that they were participating in an experiment on different sound systems. They were then asked to fill out the questionnaire which had been placed on the arm of their chair. Approximately eight minutes were required for the completion of the questionnaire by the subjects. The subjects then were told that they would hear music played under two different conditions. Their task was to select the presentation which they found most pleasing. They were told that they would know when the method of presentation had been changed by a concurrent change in the signal light located in front of the speaker system. For example, when the subject saw the light change from "A" to "B" he knew that the method of presentation had been changed. The experimenter emphasized that there were no right nor wrong answers.

The order for presenting the frequency ranges was randomized by means of a table of random numbers. Each of the four frequency ranges used in the experiment was compared with every other frequency range, making a total of six comparisons for each of the phonograph records.

The phonograph music was played under one frequency for ten seconds. Then the frequency range was changed for the next twenty seconds, followed by a return to the first condition for ten seconds. In other words, the subjects received an A-B-A presentation. A five second interval between judgments, during which there was no music or speech, was provided so that the subject could record his preference on the answer sheet. A copy of the answer sheet and questionnaire may be found in appendix D.

Design of the Learning Experiment

The following chart illustrates the experimental design used to determine if continued contact with music reproduced under a wide or narrow frequency range would produce shifts in preference for that frequency range.

Chart 3

Design of the Learning Experiment

Frequency Range Pre-Test	Intervening Activity	Frequency Range Post- Test
<hr/>		
Part I		
Experimental group (thirty students from music appre- ciation class)	Thirteen ses- sions of music reproduced under 30-15,000 C.P.S. frequency range.	Experimental group.
Control group (thirty 401 psy- chology students matched with ex- perimental group on basis of pre test.)	None	Control group
<hr/>		
Part II		
Experimental group (thirty 401 psy- chology students)	Twelve sessions of music repro- duced under 180-3,000 C.P.S. frequency range.	Experimental group
Control group (thirty 401 psy- chology students matched with experimental group on basis of pretest.)	None	Control group
<hr/>		

In part one of this learning experiment, the subjects in the two music appreciation classes and the control subjects from the 401 psychology classes were given a pre-test to determine their initial frequency range preferences. The four music phonograph records described earlier were used for this purpose. The subjects made six judgments for each of the phonograph records, and so could be assigned a "frequency range preference score" from zero to twenty-four. This was equal to the number of times he preferred the wider frequency range to the narrower frequency range. On the basis of this pre-test score, thirty subjects in the experimental group were matched with thirty subjects in the control group. The experimental group then heard music records reproduced over the same electroacoustical reproducing system that was used in the pre-test, except that the filter box was set to pass all frequencies between 30 - 15,000 C.P.S. The experimental group listened primarily to organ, symphony orchestra, and string quartet music. Thirteen sessions of recorded music for an average of forty minutes per session, over a period of six and one-half weeks,

was presented to the experimental group. The control group received no organized program of music listening during this period. At the end of six and one-half weeks a post-test was given the experimental and control groups. This enabled the experimenter to determine if the wide frequency range of 30 - 15,000 C.P.S., which was the least preferred frequency range at the outset of the experiment, would be more preferred by the experimental group than by the control group.

Part two of the frequency range preference experiment was very similar to part one. The main differences between them were that the experimental group in part two heard string quartet, organ and symphony orchestra music reproduced under a frequency range of 180 - 3,000 C.P.S. The experimental group received twelve sessions of recorded music, an average of fifteen minutes per session, over a period of five and one-half weeks. The control group again did not participate in any such program. The same four music phonograph records were used for the pre-test and post-test as in part one, but in addition the previously cited speech record was included.

At the end of the five and one-half weeks, a

post-test was given to the experimental and control groups. The scores of the experimental and control groups were then compared to determine if the experimental group had shifted their preferences more for the narrow frequency range than had the control group.

Method for Determining Tonal Balance Preferences

The method used to determine the tonal balance preferences of subjects was essentially the same as the method described earlier to determine the frequency range preferences of subjects.

The different tonal balances were achieved by varying the settings of either the bass or treble control on the amplifier. The electroacoustical reproducing system is identical to the one shown on page 13 with the exception that the filter box was removed from the system.

By varying the treble control on the amplifier, it was possible to produce a -28 decibel to +18 decibel variation at 15,000 C.P.S. By varying the bass control, it was possible to produce a -17 decibel to +15 decibel variation at 40 C.P.S. Five knob positions on the bass and treble controls were used, the "flat position", -2, +2, -4 and +4. The

over-all system response for the different tonal balances is shown in the charts on pages 26 and 27. When each of the five treble tonal balances were compared with every other treble tonal balance, a total of twelve comparisons was possible. In a similar manner, the five bass knob positions provided for a total of twelve bass tonal balance comparisons. Thus, for each of the two phonograph records used in the tonal balance preference test, the subjects made twelve judgments in which the amount of bass emphasis was varied and twelve judgments in which the amount of treble emphasis was varied. This made a total of twenty-four treble tonal balance judgments and twenty-four bass tonal balance judgments for the two phonograph records. The two phonograph records used for this phase of the experiment were the symphony orchestra record and the string quartet record described earlier.

The tonal balance preference test was administered in the auditorium of the School of Music on the Ohio State University campus. The auditorium was chosen because this is the rehearsal room for the Ohio State Band and Little Orchestra, whose members served in the experiment. Every attempt was

Chart 3

System Response Curves for the Five Treble Tonal Balances

Numbers under curves: / 4, / 2, 0, -2, -4
refer to amplifier knob positions.

Chart 5

System Response Curves for the Five
Bass Tonal Balances

Numbers under curves: +4, +2, 0, -2, -4
refer to amplifier knob positions.

made to simulate an actual band or orchestra rehearsal. The test was conducted at the regularly scheduled rehearsal time. The subjects got out their instruments prior to the experiment. Some of the subjects who played smaller instruments held them on their laps during the experiment. This was done in the hope that any musical "set" developed during the previous rehearsals would carry over into the tonal balance preference test.

The loudspeaker system was placed on the stage of the auditorium approximately seven feet from the front of the stage. The subjects in groups of approximately forty were seated in the auditorium. The loudspeaker system was approximately twenty-five feet from the first row of seats. The signal box was placed four feet in front of the loudspeaker. The other components of the electroacoustic reproducing system were located behind a curtain on the left of the loudspeaker system.

The answer sheet and instructions to the subjects were the same as those used in the Frequency Range Preference Test. The subject was assigned a treble tonal balance score from zero to twenty-four, depending upon the number of times he preferred the treble

emphasized on the two phonograph record reproductions. He was also assigned a bass tonal balance score from zero to twenty-four depending upon the number of times he preferred the bass emphasized on the two phonograph records.

Chapter III

RESULTS

Before presenting the findings of this investigation, a brief description of some of the statistics will be given. A technique has been described by Kendall (8, p. 421) for estimating the true ranking of m sets of n rankings. Kendall says,

"... the object whose rank is one is that for which the sum of ranks is least; that whose rank is two is the one for which the sum of ranks is least but one; and so on. For example, if there are three rankings of five objects totaling nine, seven, four, ten, fifteen, we should take the third as rank one, the second as two, the first as three, the fourth as four and the fifth as five."

Kendall (8) says that a more general method of investigating preferences involves presenting the $\binom{n}{2}$ different pairs of n objects to m observers and noting their preference for each member of the pairs. The $\binom{n}{2}$ preferences of m observers may be presented in tabular form by an n by n table in which the diagonal is blocked out.

In this experiment the $\binom{n}{2}$ or 6 frequency range preferences for each of the m or 210 observers is

represented by a four by four table. For this experiment, the frequency range whose rank is four is that for which the sum of the preferences is least.

Kendall describes a Coefficient of Agreement whereby the similarities of judgments for m observers may be investigated. The Coefficient of Agreement is unity if and only if there is complete agreement in the comparisons. "Its minimum value is not -1.0 except when $m = 2$." (Kendall, 8, p. 428) The formula for the Coefficient of Agreement (u) is

$$u = \frac{2 \Sigma}{\binom{m}{2} \binom{n}{2}} - 1 \quad (\text{Kendall, 8, p.427})$$

The formula for the calculation of Σ for an n by n table is

$$\Sigma = \Sigma(\chi^2) - m \Sigma(\chi) / \binom{m}{2} \binom{n}{2} \quad (\text{Kendall, 8, p.435})$$

In the above formula $\Sigma(\chi)$ refers to the summation either above or below the diagonal of the n by n table. The probability that the obtained distribution of preferences could arise by chance may be determined by the formula

$$\left\{ \Sigma - \frac{1}{2}N \binom{m}{2} \frac{m-3}{m-2} \right\} \frac{4}{m-2} \quad (\text{Kendall, 8, p.433})$$

(Kendall, 8, p.433)

in which Chi-square is distributed with

$$v = \frac{Nm(m-1)}{(m-2)^2} \quad (\text{Kendall, 8, p.433})$$

degrees of freedom. In the above two formulas

$$N = \binom{n}{2}.$$

The other statistics employed in describing or interpreting the finding of this investigation are so widely used that the experimenter feels a discussion of them is unnecessary.

Frequency Range Preferences of Subjects for Music Reproduced Under Four Different Frequency Ranges

The preferences of 210 subjects for the string quartet record is shown in Table 1. The ranking of the four frequency ranges is given at the right of the table. A rank of one means that this frequency range was the most preferred frequency range. Throughout the remainder of this chapter the first letter of the words: Narrow, Medium, Wide and Very Wide will refer to the frequency ranges of 180 - 3,000 C.P.S., 120 - 5,000 C.P.S., 90 - 9,000 C.P.S., and 30 - 15,000 C.P.S. respectively.

Table 1

Frequency Range Preferences of 210 Subjects
for the String Quartet Record

Frequency Range	N	M	W	VW	Sum of Pref- erences	Rank
N {180-3,000 C.P.S.}		118	98	126	342	1
M {120-5,000 C.P.S.}	92		117	112	321	3
W {90-9,000 C.P.S.}	112	93		130	335	2
VW {30-15,000 C.P.S.}	84	98	80		262	4
$u = .018 \quad v = 6.086 \quad X^2 = 28.423 \quad P = > .001$						

From the above table it is evident that the narrow frequency range of 180-3,000 C.P.S. was the most preferred frequency range for the reproduction of the string quartet record used in the experiment. Similarly, the widest frequency range of 30-15,000 C.P.S. was the least preferred frequency range.

The frequency range preferences of 210 subjects for the symphony orchestra record are shown in Table 2.

Table 2

Frequency Range Preferences of 210 Subjects
for the Symphony Orchestra Record

Frequency Range	N	M	W	VW	Sum of Pref- erences	Rank
N {180-3,000 C.P.S.}		89	102	96	287	4
M {120-5,000 C.P.S.}	121		105	119	345	1
W {90-9,000 C.P.S.}	108	105		110	323	2
VW {30-15,000 C.P.S.}	114	91	100		305	3
$u = .0038 \quad v = 6.086 \quad X^2 = 10.923 \quad P = < .05$						

From the above table it is evident that the medium frequency range of 120 - 5,000 C.P.S. was the most preferred frequency range for the reproduction of the symphony orchestra record used in this experiment. The low Coefficient of Agreement ($u = .004$) indicates, however, that the subjects differed widely in their preferences for the four frequency ranges. A possible explanation for this lack of agreement will be offered in the next chapter.

The frequency range preferences of 210 subjects for the organ record are shown in Table 3.

Table 3

Frequency Range Preferences of 210 Subjects
for the Organ Record

Frequency Range	N	M	W	VW	Sum of Pref-erences	Rank
N (180-3,000 C.P.S.)		101	94	124	319	3
M (120-5,000 C.P.S.)	109		89	126	324	2
W (90-9,000 C.P.S.)	116	121		128	365	1
VW (30-15,000 C.P.S.)	86	84	82		252	4
$u = .02 \quad v = 6.086 \quad \chi^2 = 33.173 \quad P = > .001$						

It is evident from this table that the wide frequency range of 90-9,000 C.P.S. was the most preferred range for the reproduction of the organ record used in this experiment.

The frequency range preferences of 210 subjects for the popular dance record are shown in Table 4.

Table 4

Frequency Range Preferences of 210 Subjects
for the Popular Dance Record

Frequency Range	N	M	W	VW	Sum of Pref- erences	Rank
N (180-3,000 C.P.S.)	108	88	118		314	3
M (120-5,000 C.P.S.)	102		115	115	332	2
W (90-9,000 C.P.S.)	122	95		146	363	1
VW (30-15,000 C.P.S.)	92	92	64		251	4
$u = .03$ $v = 6.086$ $X^2 = 45.173$ $P = >.001$						

As in the case of the organ record, Table 4 indicates that the wide frequency range of 90-9,000 C.P.S. was the most preferred frequency range for the reproduction of the popular dance record used in this experiment.

The frequency range preferences of sixty-eight subjects for the speech record are shown in Table 5.

Table 5

Frequency Range Preferences of 68 Subjects
for the Speech Record

Frequency Range	N	M	W	VW	Sum of Pref- erences	Rank
N (180-3,000 C.P.S.)		27	34	26	87	4
M (120-5,000 C.P.S.)	41		30	34	105	3
W (90-9,000 C.P.S.)	34	38		37	109	1
VW (30-15,000 C.P.S.)	42	34	31		107	2
$u = .0053 \quad v = 6.275 \quad X^2 = 8.478 \quad P = < .20$						

From this table it is clear that the wide frequency range of 90-9,000 C.P.S. was preferred to all others for the reproduction of the speech record used in this experiment. The low coefficient of agreement ($u = .005$) indicates, however, that the subjects differed widely in their preferences for the four frequency ranges.

Effects of Learning On Preferences
for A Very Wide Frequency Range

The pre-test and post-test mean preference scores for the experimental and control groups on the four music records used in the experiment are

shown in Table 6. It will be recalled that each subject made six judgments for each of the records used in the frequency range preference test. He was assigned a preference score based upon the number of times he preferred the wider frequency range presentation to the narrower frequency range presentation.

In Tables 6 and 7 which follow, the mean differences was computed by the formula

$$MD = M_3 - M_4 \quad (\text{Mc Nemar, 12, p. 73})$$

The standard error of the difference was computed by the formula

$$D = \frac{1}{N} \sqrt{N \sum d^2 - (\sum d)^2} \quad (\text{Mc Nemar, 12, p. 22})$$

The standard error of the mean difference was computed by the formula

$$\sigma MD = \frac{\sigma d}{N-1} \quad (\text{Mc Nemar, 12, p. 74})$$

The "t" value was computed by the formula

$$t = \frac{MD}{\sigma MD} \quad (\text{Mc Nemar, 12, p. 224})$$

Table 6

Effect of Continued Contact with Music
Reproduced Under A Very Wide Frequency
Range in Producing Shifts in Preference
for This Frequency Range

Record	Group	Mean Pre- test Score	Mean Post- test Score
String Quartet	Exp.	$M_1 = 2.500$	$M_3 = 3.266$
	Control	$M_2 = 2.533$	$M_4 = 2.566$
	Mean Diff. $M_3 - M_4 = .700$ $t = 2.07$ $P = >.05$		
Symphony Orchestra	Exp.	$M_1 = 2.666$	$M_3 = 3.466$
	Control	$M_2 = 2.700$	$M_4 = 3.266$
	Mean Diff. $M_3 - M_4 = .200$ $t = .656$ $P = <.10$		
Organ	Exp.	$M_1 = 3.033$	$M_3 = 4.533$
	Control	$M_2 = 2.966$	$M_4 = 3.000$
	Mean Diff. $M_3 - M_4 = 1.533$ $t = 6.70$ $P = >.001$		
Popular Dance	Exp.	$M_1 = 2.666$	$M_3 = 2.966$
	Control	$M_2 = 2.633$	$M_4 = 3.000$
	Mean Diff. $M_3 - M_4 = .034$ $t = .112$ $P = <.10$		
Total for Four Records	Exp.	$M_1 = 10.800$	$M_3 = 14.266$
	Control	$M_2 = 10.800$	$M_4 = 11.800$
	Mean Diff. $M_3 - M_4 = 2.466$ $t = 3.58$ $P = >.01$		

From this we gather that listening to music reproduced under a 30-15,000 C.P.S. frequency range produced preference shifts for a wider frequency range reproduction of organ and string quartet music. Although a demonstrable shift in preference for a wide frequency range did not occur with the symphony orchestra music, the trend was in the direction predicted.

No evidence for shifts in preference for wide range reproduction of popular dance music was observed. It is interesting to note the order of magnitude of the preference shifts. The preference shift was greatest for the organ record, next for the string quartet record, next for the symphony orchestra record and smallest for the popular dance record.

Effects of Learning on Preferences for A Very Narrow Frequency Range

The question next arises as to whether the phenomenon observed with wide frequency range reproduction is duplicated with exposure to a very narrow frequency range reproduction. Table 7 shows the pre-test and post-test mean preference scores for the four music records and one speech record.

Table 7

Effect of Continued Contact With Music
Reproduced Under A Very Narrow Frequency
Range in Producing Shifts in Preference
for This Frequency Range

Record	Group	Mean Pre- test Score	Mean Post- test Score
String Quartet	Exp.	$M_1 = 2.266$	$M_3 = 1.900$
	Control	$M_2 = 2.300$	$M_4 = 2.566$
	Mean Diff. $M_4 - M_3 = .666$ $t = 3.707$ $P = >.001$		
Symphony Orchestra	Exp.	$M_1 = 3.267$	$M_3 = 2.800$
	Control	$M_2 = 3.267$	$M_4 = 3.100$
	Mean Diff. $= .300$ $t = 1.403$ $P = <.10$		
Organ	Exp.	$M_1 = 3.333$	$M_3 = 2.400$
	Control	$M_2 = 3.333$	$M_4 = 3.066$
	Mean Diff. $= .666$ $t = 2.940$ $P = >.01$		
Popular Dance	Exp.	$M_1 = 2.000$	$M_3 = 2.400$
	Control	$M_2 = 2.000$	$M_4 = 2.633$
	Mean Diff. $= .233$ $t = .7644$ $P = <.10$		
Speech	Exp.	$M_1 = 3.266$	$M_3 = 3.733$
	Control	$M_2 = 3.400$	$M_4 = 3.533$
	Mean Diff. $= .200$ $t = 1.034$ $P = <.10$		
Total for Four Music Records	Exp.	$M_1 = 10.566$	$M_3 = 9.200$
	Control	$M_2 = 10.633$	$M_4 = 10.833$
	Mean Diff. $= 1.633$ $t = 2.42$ $P = >.02$		

From this table it is evident that listening to music reproduced under a 180-3,000 C.P.S. frequency range produced significant preference shifts for a narrow frequency range reproduction of organ and string quartet music. Listing the records in order of magnitude of preference shifts, we find the greatest shift for the string quartet and organ records, next for the symphony orchestra record, next for the popular dance record and the smallest shift for the speech record.

Relationship Between Frequency Range Preferences
and Number of Years of Musical Study
of the Subjects

The subjects who reported having studied music were divided into two groups: those who had studied music from one through seven years and those who had studied music from eight through twelve years. The mean frequency range preference scores of these two groups of musicians along with the mean frequency range preference score of subjects who had studied less than one year are shown in Table 8.

It will be recalled that a high frequency range preference score means that the subject preferred the wide frequency range reproduction of music more often

than he preferred the narrower frequency range reproduction of music. A low frequency range preference score would indicate just the reverse.

Table 8

Relationship Between Frequency Range Preference Scores and the Number of Years of Musical Study of the Subjects

Group	N	Frequency Range Preference Score	Sigma
Subjects with less than one year of musical study	95	$M_1 = 11.274$	3.6
Subjects with one through seven years of musical study	102	$M_2 = 11.000$	4.2
Subjects with eight through twelve years of musical study	22	$M_3 = 9.455$	4.2
Significance of difference between means	$M_1 - M_2 = .274 \quad C.R. = .69$		
	$M_1 - M_3 = 1.819 \quad C.R. = 3.57$		

The data show that subjects who had studied music for eight through twelve years preferred music reproduced within a narrower frequency range than did subjects who had studied music less than one year. The difference between subjects with less than one

year of musical study and subjects with eight through twelve years of musical study could not have occurred because of an age difference since only two of the subjects in the latter group were over nineteen years of age.

Sex Differences On Frequency
Range Preference Test

Table 9 shows the mean frequency range preference scores for the male and female subjects serving in the experiment.

Table 9

Frequency Range Preference Scores
for Male and Female Subjects

Sex	N	Mean Frequency Range Pref- erence Score	Sigma	Sig. of Diff. between M ₁ & M ₂
Male	119	M ₁ = 11.966	4.04	C.R. = 4.27
Female	91	M ₂ = 10.351	3.73	

Correlation Between Instrument Played
and the Amount of Treble Emphasis
Preferred in the Reproduction of A Symphony
Orchestra Record and A String Quartet Record

The fourteen different kinds of musical instruments played by the musicians were grouped according to the highest frequency of the instrument whose absence could be detected by listener 80 per cent of the time. This grouping was based upon the data presented by Snow (18). Chart 6 shows the eight groupings and the musical instruments in each of the groupings. No differentiation between instruments within a group was attempted.

The correlation between the treble tonal balance preference scores of fifty-four musicians and the instruments they play is shown in Table 10.

Chart 6

Instruments Grouped According to Highest
Frequency Whose Absence Could Be Detected
By Listeners 80 per cent of the Time

Group	Instruments
I	Piano
II	Tuba
III	French Horn
IV	Double Bass
V	Cello Saxophone Trombone Trumpet Viola
VI	Bassoon Clarinet
VII	Oboe
VIII	Flute Violin

Table 10

Correlation Between Instrument Played
And Amount of Treble Emphasis Music Subjects
Preferred in the Reproduction of A Symphony
Orchestra Record and A String Quartet Record

Treble Tonal Balance
Preference Score

19								1
18								
17					1	1		
16						1	2	1
15					2			
14	1				1	1		2
13								
12				1		1		
11						1		
10	1				2			1
9	1				2	1		1
8			1		1	1		1
7								
6	2							
5	3		1	1	1			
4	4				4			
3	1	1			2			
2			1	1				
1	1		1					
	I	II	III	IV	V	VI	VII	VIII

Instruments Grouped Into Sight Groups on
The Basis of the Highest Frequency Whose
Absence Could Be Detected by Listener
80 Per Cent of the Time

Correlation = .58

No. of Subjects = 54

Correlation Between Instrument Played and
the Amount of Bass Emphasis Preferred in
the Reproduction of A Symphony Orchestra
Record and A String Quartet Record

The musical instruments played by the musicians were grouped according to the lowest frequency of the instrument whose absence could be detected by listeners 80 per cent of the time.

Chart 7 shows the nine groupings and the musical instruments in each of the groupings.

The table on page 49 shows the correlation between the bass tonal balance preference scores of fifty-four musicians and the instruments they play.

Chart 7

Instruments Grouped According to Lowest
Frequency Whose Absence Could Be Detected
By Listeners 80 Per Cent of the Time

Group	Instruments
I	Flute Violin
II	Oboe
III	Trumpet
IV	Clarinet French Horn Saxophone Viola
V	Trombone
VI	Piano
VII	Cello
VIII	Bassoon
IX	Double Bass Tuba

Table 11

Correlation Between Instrument Played and Amount
of Bass Emphasis Music Subjects Preferred in the
Reproduction of A Symphony Orchestra Record and
A String Quartet Record

Bass Tonal Balance
Preference Score

19									1
18									
17									
16						2			
15				3		2			1
14						1	1		1
13	1			3		2			
12		1	2	3		3		1	1
11	1	1	1			4	1		
10	2			1	1				
9	1		2	3					
8	1			2					
7				1					
6									
5									
4	1			1					
3									
2									
1			1						
	I	II	III	IV	V	VI	VII	VIII	IX

Instruments Grouped Into Nine Groups on the
Basis of the Lowest Frequency Whose Absence
Could Be Detected by Listeners 80 Per Cent
of the Time

Correlation = .50

No. of Subjects = 54

Chapter IV

DISCUSSION OF RESULTS

The data that have been obtained indicate that college students prefer to hear music and speech reproduced within a restricted frequency range. Instead of high-fidelity reproduction, they actually prefer a frequency range restriction of reproduced music and speech. These findings are in agreement with the findings of other experimenters, namely Chinn and Eisenberg (3), Webster and Mc Peak (21), and Bauer (1). In all three of the above experiments, an electroacoustical reproducing system of adjustable properties was used to determine frequency range preferences for music and speech.

An investigation by Saunders, as cited by Moir (13) of the acoustical characteristics of musical instruments in common use also lends support to the finding that people prefer music reproduced within a restricted frequency range. Saunders found that the best violins which he studied were characterized by a response which fell off fairly rapidly above 4,000 C.P.S., while bad models had a response which was well

maintained up to and beyond 6,300 C.P.S. At the low frequencies the best violins were characterized by a well maintained output, while the response of the bad models fell off rapidly. The same results were also obtained when good and bad pianos were compared. Snow (18), in an earlier experiment, found, however, that many orchestra instruments had readily audible musical tones in the frequency range from 10,000 - 14,000 C.P.S., yet remained popular.

Moir (13, p.24), in discussing preferences for range says, "It is common experience that the majority of the ordinary members of the public prefer to operate the radio receiver with the tone control in the position that minimizes the 'top' response". One explanation for this is that "top cut" minimizes amplitude distortion. Moir believes, however, that pleasing and perfect reproduction may not be the same things. To assume that they are is, according to Moir (13, p. 24), to "... imply that the present range of musical instruments has reached perfection".

Hawkins (5) has attempted to reconcile the apparent discrepancy between the results of experiments which find a preference for a restricted frequency range and experiments which find a preference for an unrestricted frequency range. Hawkins identifies a factor which he calls

"audience attitude" or "audience objective". He maintains that there are two types of listening: one in which a person is primarily doing something else, rather than listening to the program material, and the other in which all of one's attention centers on the program material. For the first type of listening, Hawkins believes that a restricted frequency range might be preferred. For the second type of listening, an unrestricted frequency range might be preferred. The experimental results just described in Chapter III by the writer cast considerable doubt on the explanatory usefulness of Hawkins' distinction. The reader will recall that in the results described in Chapter III, college students preferred a restricted frequency range although their "attitude" was one of giving complete attention to the program material.

One of the hypotheses advanced by some experimenters to account for preferences for restricted frequency ranges is that distortions and deviations from faithful reproduction are less objectionable with a restricted frequency range. (Olson, 14) That this factor is operative in frequency range preference experiments is not denied. The writer, however, questions the applicability of this hypothesis in

accounting for all of the experimental findings in regard to frequency range preferences. Studies by Massa, and by Braummuhl and Weber, cited by Moir (13), on the minimum discernible distortion in reproducers, support the generally accepted figure of 5 per cent distortion as the desirable upper limit for a high quality reproducer system. Since the distortion in the electroacoustic reproducing system used in the writer's experiment was less than the minimum discernible distortion for reproducers, it becomes evident that the above hypothesis alone cannot account for the preference of subjects for a restricted frequency range.

A second hypothesis developed to account for preferences for narrow frequency range reproduction states that musical instruments are not properly designed and would be more pleasing and acceptable if the reproduction of fundamentals and overtones in the high frequency range were suppressed. (Moir, 13) The present experiment was not designed to test this hypothesis. As was pointed out on page 50, however, the evidence in support of and against this hypothesis is somewhat contradictory.

A third hypothesis advanced by some experimenters, to account for the preference of subjects for a re-

stricted frequency range, states that the listener after years of listening to the radio and phonograph has become conditioned to a restricted frequency range and feels that this is a natural state of affairs. (olson, 14) This hypothesis is not contrary to a hypothesis proposed by the writer to the effect that, continued contact with a reproducing system results in the development of specific "sets" for music and speech emanating from this system to sound a particular way. When music or speech reproduction differs perceptibly from the listener's established "set" he will not like this reproduction. The preference of the average person for a restricted frequency range reproduction of music and speech would, according to the above hypothesis, be a function of the fact that this is the type of reproduction which the listener has learned to associate with radios and phonographs. Olson's (14) data indicate that subjects prefer an unrestricted frequency range for "live" music performances. This discounts the third hypothesis cited earlier, which states that after years of listening to the radio and phonograph, the listener has learned to feel that a restricted frequency range is a natural state of affairs. By postulating the exis-

tence of "sets" relative to live music performance and other "sets" relative to reproduced music, both the data of Olson (14) and the data of this experiment can be reconciled. In the former experiment the subjects had a set to hear an unrestricted frequency range because this is the range they have learned to expect from "live" music performances. In the latter experiment the subjects had a set to hear a restricted frequency range because this is the range they have learned to expect from a phonograph.

The paradoxical finding of this experiment and previous experiments, that musicians prefer a more restricted frequency range reproduction of music than does the average person, can be handled very nicely within the framework provided by the above hypothesis. If one is willing to grant the assumption that musicians as a group listen to more reproduced music than does the average person, it becomes obvious then that musicians have more numerous opportunities to develop "sets" for a restricted frequency range. One may argue that musicians have more contact not only with reproduced music but with live music as well. This is obviously true; but the "set" which is operative when a musician is playing a concert would appear to be quite different from the "set" which is

operative when the musician is at home listening to his phonograph or radio. Table on page 43 indicates that musicians prior to extensive musical training (eight to twelve years) are not significantly different from non-musicians in their frequency range preferences. Apparently this preference of musicians for a restricted frequency range reproduction of music develops only after extended musical training.

In Chapter I an experiment was cited which indicates that "FM" set owners preferred a wider frequency range reproduction of music and speech than did the average public. Two explanations were advanced to account for this finding. The "FM" set owners either bought their "FM" sets because they originally preferred a wider frequency range reproduction of radio programs, or the "FM" set owners learned to prefer the wider frequency range after listening to their sets over a period of time. The data reported in Table 6, page 39 indicates that the latter explanation could account for the wider frequency range preference of "FM" set owners. From Table 6 it is evident that subjects learn to prefer the frequency range which they hear in a particular situation.

It is interesting to note that not all of the

records used in the pre-test of frequency range preferences of the experimental group showed the same amount of preference shift. From Tables 6 and 7, we can conclude that measured frequency range preference shifts are greatest for the test records which are most like the "training records". The precise shape of this stimulus generalization gradient cannot be determined from the data of this experiment. It would appear, however, that the gradient is relatively broad.

In part I of the frequency range preference experiment, subjects were trained to prefer a very wide frequency range reproduction of recorded music. The "training records" for part I consisted mainly of organ records and symphony orchestra records along with some string quartet records. According to Table 6, page 39 the greatest preference shift occurred on the organ record. The string quartet record was next in order of magnitude of preference shift followed by the symphony orchestra record and then the popular dance record. Theoretically, the subjects should have shown a greater frequency range preference shift on the symphony orchestra record than they did on the string quartet record. The experimenter feels that this discrepancy might have been due to the fact that

the music on the symphony orchestra record was less sustained in character than on the other records. The music on the symphony orchestra record had numerous changes in "tone color", "rhythmic figures", and "dynamics" which would make paired comparison judgments difficult for subjects. When subjects, familiar with the variable under investigation in the frequency range preference experiment were asked to pick out the "higher fidelity presentation", they were able to do so only 71 per cent of the time for the symphony orchestra record. The mean per cent correct identification for the other records was 89 per cent. This would seem to indicate that possibly subjects had greater difficulty making paired comparison judgments on the symphony orchestra record than on the other records.

In part II of the frequency range preference experiment, subjects were trained to prefer a very restricted range reproduction of recorded music. The training records for part II of the frequency range preference experiment consisted mainly of string quartet records and organ records along with some symphony orchestra records. According to Table 7, page 41 the greatest preference shift occurred on the

string quartet record and the organ record. The symphony orchestra record was next in order of magnitude of preference shift, followed by the popular dance record, and then the male speech record. This is precisely the order which had been predicted for the preference shifts. Transfer of training was greatest for the "test records" which most closely resembled the "training records".

The correlation tables on pages 47 and 49 indicate that there is a significant relationship between the instrument a musician plays and the tonal balance which he prefers on reproduced music. The flute and violin players prefer to hear the treble emphasized while the tuba and double bass players prefer to hear the bass emphasized. One could attempt to account for this relationship by saying that the musicians who originally preferred a treble emphasis bought and learned to play flutes and violins while the musicians who originally preferred a bass emphasis bought and learned to play tubas and double basses. It would appear to the writer that an explanation based upon learning principles could most readily account for the data. Musicians learn to prefer a tonal balance which is similar to the one which they hear when they are participating in musical organiza-

tions.

It should be noted that because of the nature of the sample of musicians employed in the tonal balance experiment, the two correlation coefficients ($r = 0.58$ & 0.50) are probably underestimates of the true relationship between instrument played and tonal balance preferences. The musicians used in the sample were all students in the School of Music at Ohio State University. One of the requirements of the School of Music is that students must learn to play instruments other than the one on which they major. Music students are encouraged to gain some degree of proficiency on at least one other instrument. Ample opportunities are provided for the music student to participate in musical organizations with his second instrument. This heterogeneity of musical experience would tend to produce conflicting musical "sets" with the resultant attenuation of correlation coefficients between the musician's major instrument and his tonal balance preferences.

One finding of this experiment is contrary to the findings of previous investigators. Chinn and Eisenberg (3) have reported finding no significant sex differences in preferences for music reproduced within a restricted versus an unrestricted frequency range.

In this experiment males preferred a significantly wider frequency range reproduction of music than did females. For the last judgment in the frequency range post-test, sixty of the subjects were asked to tell in a short paragraph why they preferred one presentation rather than the other presentation. The most common responses of the female subjects who preferred the restricted frequency range are listed below.

"I like the deeper tones more so than the treble."
"It was easier to listen to."
"It seemed to have more soft tones."
"I liked the more mellow sounding quality."
"It had a dreamy effect."

Male subjects who preferred the restricted frequency range tended to give the following responses:

"I could hear the bass better."
"The instruments sounded plainer."
"The solo instrument stood out better."

Of particular significance is the fact that the most common response given by both male and female subjects who preferred the restricted frequency range was that, "It sounded more natural".

A dreamy effect or a more mellow effect is often associated with a restriction in the frequency range reproduction of music. (Hawkins, 5, p.19) An analysis

of the responses of female subjects indicated that there seemed to be a tendency for girls to prefer a "dreamy presentation" of the reproduced music. There is insufficient data to determine if the female subjects preferred a "dreamy presentation" more often than did the male subjects. If this were the case, however, it would provide at least a partial explanation for the obtained sex differences in frequency range preferences. Data by Steinberg, Montgomery and Garner indicates that female subjects have less hearing loss for high frequencies than do males. (20, p. 293) It is possible that attenuation of the high frequencies might make the music presentation more comfortable for female subjects to listen to.

In concluding, the writer would like to emphasize the need for caution in generalizing from the data presented. It will be recalled that the subjects employed in the experiment were drawn from a highly select group, namely college students. The five phonograph records which served as the stimulus material were not typical of phonograph records in general. The categories: string quartet, symphony orchestra, organ, popular dance and male speech were used for convenience in presenting the data and it was not

meant to imply that the phonograph records in the categories were completely representative of a type of music. In addition, the electroacoustic reproducing system used in the experiment was, in one sense, unique. It is a generally accepted fact that two apparently identical loudspeaker systems will have somewhat different response characteristics. It is conceivable that a different reproducing system of comparable quality might give somewhat different results. In spite of the highly select nature of the sample, the non-representativeness of the stimulus material and the uniqueness of the reproducing system, the results of this experiment are in substantial agreement with the results of previous experiments.

Chapter V

SUMMARY AND CONCLUSIONS

This experiment was designed to investigate two of the factors which influence preferences for high fidelity sound systems, the frequency range of the system and the tonal balance of the system.

Studies in the past have found that subjects prefer a restricted frequency range reproduction of music and speech. In order to account for this preference, the writer proposed the following hypothesis:

The average listener after listening to the radio, phonograph and live sound sources for many years has developed specific "sets" for music and speech, emanating from a particular source, to sound a particular way. When music or speech reproduction differs perceptibly from the listener established "set" he will not like this reproduction.

In order to test the above hypothesis an electroacoustic reproducing system of adjustable properties was employed. Subjects from 401 Psychology classes and elementary music appreciation classes indicated their preferences for four different frequency range reproductions of music and speech phonograph records. Subjects serving in the experimental

group received an organized program of music listening in which phonograph record music was reproduced over either a very wide frequency range or a very restricted frequency range. At the close of the listening program, the subjects' frequency range preferences were compared with the frequency range preferences of subjects who had received no organized program of music listening. The results indicate that continued contact with music reproduced over a particular frequency range will produce shifts in preference for this frequency range.

Additional evidence in support of a "set" or learning hypothesis comes from an examination of the tonal balance preferences of musicians. Musicians in the Ohio State Band and Little Orchestra indicated their preferences for phonograph record music reproduced with varying amounts of treble and bass emphasis and de-emphasis. The results indicate that there is a significant relationship between the tonal balance preferences of musicians and the instrument they play.

The following are the major conclusions of this experiment:

1. The average college student prefers music and speech reproduced over a restricted frequency

range rather than an unrestricted frequency range.

2. The frequency range preferences of college students is in part a function of the type of music to which they are listening.
3. Males prefer a less restricted frequency range reproduction of music than do females.
4. Learning plays an important role in determining preferences for sound reproducing systems. Continued contact with a particular system produces shifts in preferences for that system.
5. Musicians prefer a tonal balance of reproduced music which is related to the highest and lowest detectable frequency of the instrument which they play.

The following are questions which arose during the course of this experiment, and which require additional analysis:

1. One assumption, which is implied in the research which has been presented is that the total stimulus configuration which impinges upon the listener can serve as a cue for the appropriate listening "set". An implication of the above assumption is that the subjects in the experimental group who were trained to prefer a more or less restricted frequency range would show less transfer of training in a different testing situation. One would predict that the amount of transfer of training would be a function of the similarity between the training room and the testing room.
2. The results presented in this experiment indicates that when the frequency range of reproduced music and speech is manipulated by a person other than the listener, the listener will prefer a restricted frequency range. The

type of behavioral prediction which we are probably most interested in making is, what frequency range would the listener prefer if he manipulated the controls himself. The present experiment provides no information on this question.

3. The results of the tonal balance phase of the experiment indicates that musicians tend to acquire unusual musical perspectives. One would predict that the conductors of musical organizations would prefer less tonal balance distortion of reproduced music than do regular musicians. Non musicians should, according to the hypothesis proposed in this experiment, prefer less tonal balance distortion of reproduced music than do musicians.
4. The method employed in this experiment offers an objective technique for investigating stimulus generalization gradients for different types of music. The results of such experimentation have theoretical implications for both music and psychology.

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APPENDIXES A, B, C AND D

APPENDIX A

Instructions to Subjects

The following instructions were read to the subjects by the experimenter.

"This is a study in which we are comparing different sound systems. Before we hear any music however, I would like to have you fill out the questionnaire which is in front of you."

Approximately eight minutes were required for completion of the questionnaire by the subjects.

"As I have mentioned before, this is a study in which we are comparing different sound systems.

You will hear music played under many different conditions. Your task is to select the presentation which you find most pleasing.

On this stand you will see a signal box which will light up the letters, "A" and "B". These letters when lighted will signal which of two different methods of presentation you are hearing. For example, as long as letter "A" remains lighted you will know that you are hearing the music under condition "A" when letter "B" lights up you will know that the method of presentation has been changed. You will have the opportunity to hear the two methods of presentation change twice, first "A" then "B" then "A" again. After "A" has been presented the second time, there will be a brief pause in which you will mark your preference on the answer sheet. Then we will go on to the next pair of presentations.

Your answer sheet has room for twelve judgments. However, we will make only six judgments for each of the four records.

Are there any questions before we start?

Remember, there is no right or wrong answer, just indicate which presentation was most pleasing for you."

APPENDIX B

Characteristics of Subjects Serving in
Frequency Range Preference Experiment

Table I

Number of Years of Musical Study
of Subjects

Years of Study	No. of Subjects
0	95
1-2	17
3-4	28
5-6	24
7-8	15
9-10	13
11-12	5
Mean = 2.83	Sigma = 3.44

Table II

Phonograph Record Playing Facilities of
Subjects

Type of Phonograph	No. of Subjects
Table model	105
Console model	68
Hi Fi model	7
No phonograph	23

Table III

Age of Phonograph of Subjects

Age in Years	No. of Phonographs
1 - 5	142
6 - 10	35
11 - 15	3

APPENDIX B (Cont.)

Table IV

Per Cent of Record Collection Estimated By
Subjects to Be "Popular Dance Records"

% of Record Collection	No. of Subjects
0%	22
10%	45
25%	37
50%	38
75%	25
90%	11
100%	2

Table V

Number of Subjects Listing Popular Or
Classical Records As the Records They Enjoy
Listening to the Most

Type of Records	No. of Subjects
2 Popular Records	55
2 Classical Records	64
1 Popular and 1 Classical	30
Unclassifiable	48

APPENDIX C

Characteristics of Subjects Serving
Tonal Balance Preference Experiment

Table VI

Number of Years of Musical Study of Subjects

Years of Study	No. of Subjects
0 - 2	0
3 - 5	6
6 - 8	10
9 - 11	24
12 - 14	9
15 - 17	3
18 - 20	2

Table VII

Major Instrument of Musicians

Type of Instrument	No. of Subjects
Bassoon	1
Cello	2
Clarinet	6
Double Bass	3
Flute	3
French Horn	4
Oboe	2
Piano	14
Saxophone	5
Trombone	1
Trumpet	6
Tuba	1
Viola	2
Violin	4

APPENDIX D

Questionnaire and Answer Sheet Used in Frequency
Range and Tonal Balance
Experiment

Name _____ College _____ Class _____
Rank _____

What musical instruments, if any, do you play? _____
_____. (Circle major instrument.)

Number of years of musical study: _____

Do you now, or have you in the past performed in any musical organizations? If so, list.

1. _____ Yrs. _____ 3. _____ Yrs. _____

2. _____ Yrs. _____ 4. _____ Yrs. _____

Is there a record player in your home? Yes _____ No _____

Name of record player _____

Console _____ Table Model _____

Approximate age of phonograph: 1-5 yrs. _____
6-10 yrs. _____ 11-15 yrs. _____
16-20 yrs. _____

What per cent of phonograph record collection are popular dance records?
0% _____ 10% _____ 25% _____ 50% _____ 75% _____ 90% _____
100% _____.

Title of two phonograph records you enjoy listening to the most?

1st _____ 2nd _____

What musical radio or T.V. programs do you listen to regularly?

1. _____ 3. _____

2. _____ 4. _____

Indicate preference by circling either A or B

<u>Record I</u>	<u>Record II</u>	<u>Record III</u>	<u>Record IV</u>
1. A B	1. A B	1. A B	1. A B
2. A B	2. A B	2. A B	2. A B
3. A B	3. A B	3. A B	3. A B
4. A B	4. A B	4. A B	4. A B
5. A B	5. A B	5. A B	5. A B
6. A B	6. A B	6. A B	6. A B
7. A B	7. A B	7. A B	7. A B
8. A B	8. A B	8. A B	8. A B
9. A B	9. A B	9. A B	9. A B
10. A B	10. A B	10. A B	10. A B
11. A B	11. A B	11. A B	11. A B
12. A B	12. A B	12. A B	12. A B

AUTOBIOGRAPHY

I, Roger Edward Kirk, was born in Princeton, Indiana, February 23, 1930. I received my secondary school education in the public schools of Columbus, Ohio. My undergraduate training was obtained at The Ohio State University, from which I received the degree Bachelor of Science in Education in 1951. From the Ohio State University, I received the degree Master of Arts in 1952. While in residence at the Ohio State University, I acted in the capacity of graduate assistant to Professor Francis P. Robinson during the year 1953-54. In September, 1954, while still in residence at the Ohio State University, I received an appointment as teaching assistant. I held this position for a year and a half while completing the requirements for the degree Doctor of Philosophy.