AN INVESTIGATION OF THE EFFECTS OF LOW-INTENSITY ULTRASONIC TONES UPON THE PERFORMANCE ON THE SEASHORE MEASURES OF MUSICAL TALENTS

A Thesis

Presented to

the Faculty of the Graduate School

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Jack T. Waggoner

Houston, Texas

June, 1949

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ABSTRACT

This study is an investigation of the effects of high-frequency ultrasonic stimulation upon the perception of pitch, time, loudness, timbre, rhythm and tonal memory as tested in the Measurements of Musical Talents of Dr. Carl E. Seashore.

The purpose of this study was to investigate a problem that could possibly be related directly to a scientific theory of the psychological effects of music upon people. This study may also be related in some way to a determination of the effects of ultrasonic tones.

Materials used in this study were:

(1) The Seashore "Measures of Musical Talents" Records Form B.

(2) A record playing machine for the playing of the Seashore records which contained the test used in this study.

(3) A high frequency sound producing machine capable of producing tones of 20,000 v. p. s. and 10,000 v. p. s.

The Seashore examinations were administered to 100 students of the University of Houston during 30 examining sessions. There was a random sampling obtained of 39 female students and 61 male students. Each of these students was asked to classify themselves as either

musical or non-musical for purposes of securing a sampling that would give a wide range of scores on the sections of the tests administered.

From a sampling of 42 students considering themselves musical and the 58 classified as non-musical, an adequate range of scores was obtained on all sections of the tests given.

During the administration of the Seashore tests, the high-frequency ultrasonic tone was applied to the even-numbered items on each section of the Seashore Examinations. Each item consists of two examples, the subject reporting on the relationship of the second example to the first.

The tests were then graded and the mean scores on each half of each section of the examinations were determined from the frequency distributions obtained.

Afterwards the means of the raw scores on the stimulated portions of each section of the test were compared to the corresponding means of raw scores on the non-stimulated portions.

It was found that there were differences between the means of the even and odd-items on the sections of timbre and pitch of statistical significance.

On the section of timbre, the difference between the means was analysed by the "correlated means" method and found to be significant at the .01 level. This indicates that this difference is not likely to be due to chance alone. Some other factor, such as the ultrasonic tone which was the only known variable between the two halves of each section, may have been operating in such a manner as to aid in the perception of the even-items. A possible "carry-over" effect of this tone, however, may have hindered the perception of the odd-numbered items rather than improved the scores on the even-numbered items.

On the section of pitch perception the differences between the means of the halves of each section were checked by the "correlated means" method of statistical evaluation and were found to be significant at the .05 level. This indicates that chance alone is not likely to be the explanation of the differences between these means. The only known variable was the ultrasonic tone and possibly this factor could be the explanation for the differences, however, the techniques employed in this study do not indicate a definite causal relationship of the ultrasonic tone.

This study seems to point out the necessity for further studies in order to adequately determine the effects of ultrasonic tones on human behavior. Such a determination may also lead to a more scientific theory as to the effects of music upon man.

ACKNOWLEDGMENTS

I wish to express my sincere thanks to Mr. George T. Bird for the aid given to me in this thesis. Without his technical work in the construction of the ultrasonic tone generator used in this investigation, it would have been impossible for me to conduct this study.

I wish also to express my sincere thanks to Doctors Franklin L. Stovall and Laurie T. Callicutt for the patient and invaluable assistance they have given me in the preparation of this thesis.

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CHAPTER I

INTRODUCTION

In the past there has been much information published concerning the effects of music from philosophical, psychological and esthetical points of view. These musical effects have been accepted as being present only in the audible range, but such an assumption has not been scientifically established. It is the contention of this thesis that research dealing with the inaudible range should be of assistance in the evolution of an adequate theory of music as well as an aid in determining the physiological and psychological implications of ultrasonic[1] tones.

I. THE PROBLEM

Statement of the Problem. It is the purpose of this study to determine whether subliminal high frequency ultrasonic tones of low intensity have an effect upon the perception of individuals, under ordinary test conditions, of the musical factors of pitch,

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1 Throughout the remainder of this thesis, the term "ultrasonic" shall be used to refer to those tones and sounds whose frequencies are above the audible range of the human ear.

time, timbre, loudness, rhythm and tonal memory, as determined by the Measures of Musical Talents test of Dr. Carl E. Seashore.

Importance of the study. Differences of opinion have existed concerning the effects of music upon human beings. These controversies have centered upon the audible tones and it has been the general assumption that the psychological effects of music would not exist beyond the range of the human ear. Research in this ultrasonic area may provide not only data as to the physiological effects of these sounds, but also may clarify the "mystical" speculation concerning music's enchanting powers over human beings. It is the purpose of this study to begin an investigation of certain aspects of the psychological effects of ultrasonic tones in relation to the development of an adequate theory of music and to the physiological reactions to these tones.

CHAPTER II

REVIEW OF THE LITERATURE

It has long been noted that the effects of music upon human beings have been potent. In ancient times much mysticism was attributed to these effects. In modern times, the physiological effects have been scientifically investigated and have been objectively reported upon. A number of these effects has been well summarized in the following quotation from the article, "The Place of Music In Healing" by Cardinell and Burris-Meyer.

1. Increases metabolism (Tartschanoff, Dutton).
2. Increases or decreases muscular energy (Fere, Tartchanoff, Scripture).
3. Accelerates breathing and decreases its regularity (Binet, Weed, and Guilbrant).
4. Produces marked but variable effect on blood volume, pulse, blood pressure (Hyde, Scalafino).
5. Lowers the threshold for sensory stimuli of different modes (Diserens, Krakov).
6. Tends to reduce or delay fatigue and consequently increases muscular endurance (overlap of No. 2) (Diserens).
7. Speeds up voluntary activities, such as typing or writing (Diserens).
8. Increases extent of muscular reflexes employed in writing, drawing, etc. (Diserens).
9. Reduces normal suggestibility (Diserens).
10. Influences the electrical conductivity of the body as manifested by increased fluctuations of the psycho-galvanic index (Diserens).

11. Can facilitate attention (Talbot and Darlington).

12. At the Harvard Fatigue Laboratory experiments now in progress, the findings of which will shortly be published in detail, indicate the possibility that certain kinds of music for certain people can sustain attention to prolonged psychomotor performance above and beyond the effects of drugs. This precludes possible adverse effects such as might be experienced through the use of benzedrine.

13. Other studies have established the relations between specific auditory stimuli and nervous tension.[2]

Many experiments have been made in which arbitrary sounds, definable as music, have engendered the above measurable reactions. Since these psychological reactions seemingly have an emotional concomitance, the audible stimulus, originally music, or a non-arbitrary stimulus interpreted according to musical idiom, can be used to produce quite a large range of emotional reactions. These somatic effects of music are noted in both the musical and non-musical alike, but these effects are transient and the moral hangovers or uplifts from music seem to be negligible. The immediacy of these effects, however, does not preclude the use of music for eliciting desired moods at desired times.

Studies of Muzak Corporation. An example of an effective use of music is indicated by the research studies of the Muzak Corporation, which was conducted during the years of 1946 to 1947. This study consisted of three separate investigations

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Burris-Meyer, Harold and Richmond L. Cardinell, "The Place of Music in Healing." (The Journal of the Acoustical Society of America, Vol. 17, No. 3, January, 1946) p. 234.

of the use of music in offices, in "fatigue industries", and in "boredom industries". It was conducted in twenty-four cities throughout the United States located in the Northeast, North Central, Middle Atlantic, Southeast, South Central, Central and Pacific portions of the United States. These studies provided data concerning the musical preferences and likes of the population and also much information concerning the use of music to elicit certain desired moods as well as to relieve fatigue in these industries.

> However, "studies of the psychological and physiological effects of . . . elements (of music) on people at work are in their infancy. We know a number of things that music can do to people, but we do not have many laws governing the combinations of the ingredients which bring about the effects".[3]

Thus the technique by which music has been made to do a specific and predictable job in industry has developed upon the assumption that musical sounds can be used to relieve fatigue and to elicit predictable moods within the listener. The lack of scientific research in this area has brought about specific attention by private concerns to the necessity of general laws concerning the effects of music upon human beings and as to how these effects can be elicited.

The existing theories concerning musical effects are varied and numerous, but all are speculative at present. For this study the theories and research dealing with this problem shall

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3 Langer, Susanne K., Philosophy in a New Key (New York, Penguins Books, Inc., 1948) p. 171.

be classified into three areas; those of the aesthetical, philosophical, and psychological. In each of these areas there are wide and divergent opinions concerning the phenomena of music. It is not the intention of this study to present thoroughly an over-all picture of the writings or studies in any one of these areas, but merely to indicate the prevalent or the more important ideas, in the opinion of the investigator, that have been presented.

Philosophical Approach to Problem. The philosophy of music and the psychology of music are ambiguously enmeshed in their explanations of human reactions to music. In the realm of the philosophy of music the center of the investigation of the nature and function of music has been shifted several times. In Kant's day reason was the highest art. This relegated music to the lowest of the aesthetical endeavors because of it's primary appeal to the emotions. William James interpreted man's reactions to music as "a mere incidental peculiarity of the nervous system with no teleological significance." Helmholtz, Wundt, and Stumpf based their inquiries into the function of music upon the idea that music was a form of pleasurable sensation. Other theories as to the power of music have dealt with it as an emotional response. "This led Plato to demand, for his ideal state, a strict censorship of modes and tunes lest his citizens be tempted by weak and voluptuous airs to indulge in demoralizing emotions."[4]

During the past decade the most prevalent philosophical idea concerning music has been that its essence is self-expression and that music is an emotional catharsis. If this were the case, musical activity would be brought within the compass of modern psychology. However, it seems that sheer self-expression requires no artistic form, and though we can "use" music to work off our subjective experiences, this is not its primary function. If self-expression is not the primary function of music, then wherein lies its significance? According to Susanne K. Langer,

> If music has any significance, it is semantic not symptomatic. Its 'meaning' is evidently not that of a stimulus to evoke emotions nor that of a signal to announce them; if it has an emotional content, it 'has' it in the same sense that language 'has' its conceptual content--symbolically. It is not usually derived from affects nor intended for them; but we may say, with certain reservations, that it is about them. Music is not the cause or the cure of feelings but their logical expression . . ."[5]

The short-comings of investigations of the symbolic value of the musical idiom probably lies in the fact that it has not been treated logically. More recent studies have attempted to begin such an investigation. In so doing, it has been noted that to be symbolic it is necessary to have formal characteristics which are analogous to whatever is purported to be

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4 Langer, Susanne K., Philosophy in a New Key (New York, Penguins Books, Inc., 1948) p. 171.

5 Ibid., p. 176.

symbolized. That musical structures logically resemble certain dynamic patterns of human experience is a well established fact. Concerning the usefulness of so-called musical dynamics to describe forms of mental life, Wolfgang Kohler wrote,

> "Quite generally the inner processes, whether emotional or intellectual, show types of development which may be given names usually applied to musical events, such as: crescendo and diminuendo, accelerando and ritardando."[6]

Further the more naturalistically inclined critics have made the comparison between the forms of music and those of feeling, by assuming that music exhibits patterns of excitation occuring in the nervous tissues, which are the physical sources of emotions. However, this has been definitely metaphysical thought with little scientific knowledge behind it. The question then arises as to the possibility of research involving the use of ultrasonic tonal relations to determine whether it is merely excitation of the nervous tissues, or whether music is a stimulation which derives its significance from the associations within the mind of the listener. Such research may not be a means of the determination of the "excitation" quality of music, however there seemingly should be information in this area of value in the evolution of an adequate philosophical concept of music. To the investigator, the more likely explanation of this phenomenon is that music

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6 Kohler, Wolfgang, Gestalt Psychology (New York,., 248-249).

seems to articulate forms which language cannot set forth, since human feelings are much more concurrent with musical forms than with the forms of language. In other words, music seems to sound the way moods feel. "Not communication, but insight is the gift of music".[7]

This may possibly be in keeping with the aesthetical ponderings of Richard Wagner. He felt that through his music it would be possible to bring about a realization within his listeners of his own philosophical ideas. To assist him he developed the "Leitmotif" or "Leading Motive". This was nothing but musical symbolism wherein certain melodic patterns were used to indicate certain ideas of the composer, aspects of the play and appearances on stage of certain leading characters. About this Wagner said,

> "What music expresses, is eternal, infinite and ideal; it does not express the passion, love, or longing of such-and-such an individual on such-and-such an occasion, but passion, love or longing in itself, and this it presents in that unlimited variety of motivations, which is the exclusive and particular characteristic of music, foreign and inexpressible to any other language." [8]

This is without a doubt a sincere attempt to give to music certain communicative qualities. Probably no other innovation has caused so great a controversy within the history of music than this communicative idea or "program music" idea. It may be noted, however, that Richard Wagner was merely one of the

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7 Langer, op. cit., p. 198.

8 Ibid., p. 179.

foremost exponents of this communicative idea of music, not the originator. In fact later exponents of this idea went much further than Wagner, as can be illustrated by the statement of a New York critic,

> "Strauss, in the heyday of his programmatic frenzy, went so far as to declare that a day would come when a composer could compose the silverware on the table so that the listener could distinguish the knives from the forks."[9]

A resolution of this controversy must of necessity await further study probably along psychological lines rather than the continued armchair philosophizing of the esthetes. The investigation of music as a communicative vehicle revolves around the question of the symbolic value of the musical idiom. A thorough study of this question seems to the investigator to require the presentation of certain melodic patterns, that tend to elicit predictable emotional responses, in such a manner that would differ from the known type of perception of these tones. In this way it may be ascertained whether the relational characteristics of the tonal waves carry a symbol which has a definite psycho-biological reactive significance of and by itself, or whether the symbol gains its significance through the emotions aroused by aural associations with these tonal waves within the mind of the listener? Such a study then would involve the presentation of these melodic patterns of known significance in an area, such as the ultrasonic

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9 *Ibid.*, p. 179.

one, since there the tonal waves could be reproduced in a similar relational way in order to be, in effect, the same melodic pattern yet presented in such a fashion as to require a means of perception that probably is essentailly different from the known aural perception. Such a presentation may indicate whether there is a biological concomitance for these tonal relations or whether these waves must be aural to have significance.

Of course, this investigation would involve many preliminary studies concerning the psychological and physiological effects of ultrasonic vibrations upon human behavior. This thesis is merely one of the many preliminary studies that will be necessary before adequate theories concerning the value of the musical idiom can evolve.

Psychological Approach to Problem. The psychology of music still contains much metaphysical and philosophical thoughts concerning musical effects. Psychological research has dealt mainly with observations of physiological reactions to music and analyses of physical sounds. This is indicated in the work done by Dr. Carl E. Seashore and his associates and reported upon in his work "The Psychology of Music". Dr. Seashore said,

> "What a listener shall hear in music depends upon what he is, or is capable of putting into it, that is, hearing into it. Hearing then is not a mere registering of sounds. It is a positive active reconstruction in the mind of the listener."

If this be the case, the actual sounds and tones are merely the skeleton upon which the listener mentally reconstructs them into a meaningful experience for himself.

"However, the musician has but one medium—the physical sound."[10] Upon this assumption musical psychologists have proceeded to direct their research concerning characteristics of physical sound. This was thought necessary since an understanding of the stimulus (sound waves) was considered essential before an understanding of the effects of this stimulus could be developed. However, this has not dealt with the symbolic nature of sound waves or tonal relationships. Without the inclusion of this symbolic aspect of the musical medium, it's significance seems to be lost. Thus psychological research should begin to realize this symbolic nature of music and attempt to include this information in the realm of the psychology of music.

In certain other areas of psychological investigation concerning audition, information seems to exist which could be of value in dealing with the symbolic nature of the musical idiom. In the research of Dr. Dallenbach, conducted at Cornell University, regarding the perception of obstacles by the blind, the importance of high frequency perception was

10 Seashore, Carl E., The Psychology of Music. McGraw Hill Book Company, New York, 1938. p. 13.

discovered. His research determined that the obstacle sense of the blind is the result of high frequency echoes above eight thousand cycles per second off the obstacles. It was noted in this study that the blind were in no way cognizant of the means of perceiving objects.[11] Thus further research of the unconscious or possible subliminal psychological effects of high frequency vibrations upon humans seems to be suggested by this investigation. An amusing incident which took place at Johns Hopkins University is appropriate to note here. Professor R. W. Wood, Research Professor of Physics at the University, was called in on dress rehearsal night concerning a special effect which the author of the play desired. The author wanted the theatre to be blacked out and a shrill audible whistle played to denote the turning back in time of the scene of the play to a hundred and forty five years previous. The effect seemed to be inadequate so Professor Wood lugged a forty foot organ pipe backstage and on opening night along with the other stated effects an inaudible sound was sent out over the orchestra. The audience reacted violently and departed from the theatre in panic. Here can be noted the effect of subliminal tones upon human perception. They could not hear these tones and yet on the previous night during the absence of the inaudible sound no

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11 Unpublished address delivered to Psychology Club of the University of Houston, Houston, Texas, November, 1948.

significant effects were noted. This event seems unequivocally to indicate certain psychological implications of the range of audibility below that of human perception.[12]

Other research in the areas of chemistry, biology, and physics have indicated the usefulness and effectiveness of high-intensity ultrasonic tones. Dr. E. Newton Harvey and Dr. Alfred E. Loomis have reported on the effects of ultrasonic vibrations of high intensity on microscropic specimens of various cell species. It was noted that the cells could be torn up inside without obvious outer effects to the cells. It was also noted that eggs could be "stirred" without injury to the cell wall or enveloping membrane.[13] Rapid death of bacteria and red blood cells of frogs in suspensions as well as destruction of areas of the cerebral cortex of dogs, which brought about disturbances in muscular coordination, blindness, (in one case), and gross and microscopic brain lesions, were noted by Drs. Lynn, Zwemer and Chick in a study conducted at Columbia University in 1942.[14]

In the realm of chemistry, it has been discovered that ultrasonic high-intensity vibrations can be used to bring about

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12 Finlay, Walter L., "Soundless Sound Waves," Scientific American, p.118-119 and 216-217.

13 Harvey, E. Newton and Afred E. Loomis, "The Physiological Effects of Supersonic Waves," Science Monthy, Sept., 1929, p. 285-287.

14 Lynn, J. G., Raymond L. Zwemer and Arthur J. Chick, "The Biological Application of Focused Ultrasonic Waves," Science, July 31, 1942, p. 119-120.

better mixtures of chemicals. The sounds can also act as catalysts to speed certain chemical reactions.

In the realm of physics, there has been applications of ultrasonic vibrations to practical situations such as the use in measurement of the thickness of metals as well as the detection of flaws therein. Ultrasonic vibrations have also been applied to molten metals enabling much more uniform mixtures to result, thus making for the development of stronger metals and alloys.

An examination of these effects of high-intensity ultrasonic vibrations, noted previously, may suggest the need of further research in psychology that would deal primarily with the effects of these ultrasonic tones upon human behavior. This can best be illustrated by quoting a statement of Dr. Hallowell Davis.

> " 'Discomfort' implies that some sense organ is affected; but some combinations of intensity, frequency, and duration of exposure may possibly injure without the usual warning of discomfort. For the benefit of personnel working in high intensity sonic or ultrasonic fields we should establish both discomfort and danger knowledge. The Ultrasonics Panel of the Aeronautical Board desires particulary to receive any relevant well-authenticated observations, either positive or negative, particularly concerning the effects of high-intensity sound or ultra-sonics on the sense organs and the nervous system." [15]

In summary, various approaches to the problem of the explanation of the effect of music upon man have been

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15 Davis, Hallowell, "Biological and Psychological Effects of Ultrasonics," Journal of the Acoustical Society of America, Vol. 23, No. 2, February, 1949. p. 607.

presented. Most of them have been metaphysical in nature and not entirely scientific. The more recent theories, however, seemed to indicate that music is not just a sound but a symbolic semantic. The complete value and power of the musical symbol or idiom is still far from being determined. This study is merely one of many preliminary investigations that will be necessary before an accurate estimation of "why" and "how" music affects people can be made. An approach to this investigation has been suggested in which the musical symbol of known significance would be reproduced at a level which would be above the range of human audibility. In such a manner the ideas that music is merely an excitation of the nervous tissues which are the seat of the emotions may be verified. It would be necessary to determine first whether it is possible for these tones to affect us, without being painfully intense. It thus becomes the purpose of this study to begin an investigation of the possibility of psychological effects of low-intensity high frequency ultrasonic tones upon human behavior.

CHAPTER III

MATERIALS USED AND METHODS EMPLOYED

Materials. The Measures of Musical Talents examination, Series B, of Dr. Carl E. Seashore were used in this investigation. This test consists of three twelve-inch phonograph records which contain tones and tone patterns of known differences. The test is divided into six sections; those of pitch, loudness, time, timbre, rhythm, and tonal memory. The first four of these sections include fifty items whereas the latter two sections contain thirty items. In the first four sections, as item consists of two tones that are played in rapid succession. The subjects are asked to report on the differences in these items. In the section on pitch perception, they are asked to tell whether the second tone is higher or lower than the first tone. In loudness perception, they tell whether the second tone is stronger or weaker than the first. The section of time requires the students to report as to whether the second tone is longer or shorter than the previous one. In timbre, it is asked whether the second is the same as the previous one or different from the first in tone quality. The section of rhythm consists of two rhythm patterns played in rapid succession. The subject must tell whether the second pattern is the same as or different from the preceding pattern. The tonal memory section items consist of two series of tones

In the second series of tones, the number of the tone that is changed in relation to the previous series of tones is asked to be noted.

The subjects indicated their choice of answers to the above noted items on answer sheets that were furnished for this purpose. The entire test consisted of alternate-response items. It was suggested in the standardized instructions that those items whose answers were vague or unknown should also be answered. This procedure enabled the subjects to indicate an answer for all items by making between the dotted lines underneath the desired responses.

The highest possible raw score on the sections of Pitch, Loudness, Time and Timbre was fifty. The raw score was the number of correct responses. The highest possible raw score on the odd-numbered and even-numbered items of these sections was twenty-five. On the sections of Rhythm and Tonal Memory, it was possible to make a raw score as high as thirty. The highest possible raw score on either the even-numbered items or odd-numbered items was fifteen.

The tests were hand scored by means of scoring keys which made for ease and correctness of scoring. By placing the key, which was a similar answer sheet with perforations of the correct responses, over the answer sheet to be scored the indicated correct responses could then be counted and raw scores on the even-numbered and odd-numbered items to be computed.

This Seashore test was selected for this research mainly for the keenness of aural perception that is required in its performance. Its relation to the field of music may not be as definite as claimed by its author, but the musical nature of this test cannot be questioned. For this research, it was considered imperative that the test be of a musical nature; i. e., presented by means of the musical medium. The _Measures of Musical Talents_ do consist of such material and for this reason was considered adequate for our study. It also was useful as a drawing card for subjects; thus enabling the investigator to secure an adequate sampling.

Along with the equipment necessary for the playing of the Seashore records, a high frequency ultrasonic amplifier was included among the materials used in this investigation. This was a Class B, Push-Pull power amplifier with the frequency response characteristic flat up to 25,000 vibrations per second[16] and with a power output maximum of 20 watts. This Hartley oscillator provided a driving signal of 20 kilocycles, or 20,000 v. p. s. The output of the amplifier was fed to a high-frequency University model "Tweeter" speaker. This speaker has a characteristic to reproduce up to 15,000 v. p. s. without any drop-off of audio signal power output. The measured input

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During the remainder of this thesis, the abbreviation "v. p. s." will be used for the expression "vibrations per second."

to the speaker was from 4 to 6 watts at 20,000 v. p. s. The sound energy output of the speaker was estimated to be approximately one-half watt. This estimation was based on the output-input relationship of the speaker established at 10,000 v. p. s.

For this investigation, a small intensity ultrasonic tone was used in order to investigate the effects of the presence of such tones in the minute perceptual test situation set up by the Seashore examination. As has been noted the previous investigations of ultrasonic tones have dealt mainly with tones of high-intensity. It is the purpose of this study to inquire into the human psychological reactions to ultrasonic tones of small intensity. This may indicate the possible use of low-intensity painless ultrasonic tones as a means of the investigation of the symbolic value of music and the resulting physiological reactions of humans to these symbols. The sound produced by this high-frequency sound generator was inaudible since the human ear is incapable of hearing tones above the frequencies of 15,000 to 16,000 v. p. s. This frequency range is the accepted upper limit of the audible range, but individual differences make a definite estimation of this point impossible. The presence of the ultrasonic inaudible tone was determined by an alternate audible frequency of 10,000 v. p. s. This was accomplished by a three-stop control switch, the stops being, in order, "off" "20,000 v. p. s." and

"10,000 v. p. s.". This order enables the immediate application of the inaudible tone with the possibility of checking its presence with the audible tone at frequent intervals.

Sources of Data. One hundred students of the University of Houston were tested during thirty examining sessions. The sampling of these students was of a random nature, determined largely by the availability of subjects. Sixty-one male and thirty-nine female students were tested. These subjects were instructed to rate themselves as either "musical" or "non-musical". The purpose of this procedure was to secure test scores that would be of an adequate range to provide a distribution that would represent the extremes of performance as well as average performances on this test. The ratings of the subjects indicated that there were 42 subjects who considered themselves "musical" whereas there were 58 non-musical subjects. This sampling may indicate an over-balance of poor performers, but since the distribution was noted as the sampling was being secured, and since an adequate distribution was being obtained, it was deemed unnecessary to attempt to secure a more equal number in each category.

Procedure. The Seashore examinations were administered to students in Room 218 of the Roy Gustav Cullen Building, University of Houston. The room was not sound-proof since for purposes of this study, a small amount of distracting noises was desired in order to determine the possibility of effects of the ultrasonic tone above and beyond those of mere distractions of attention. The subjects were placed in a position in front of the ultrasonic speaker so that they were in a direct line from this speaker. This was deemed necessary since it was believed that the ultrasonic tones would likely be reflected by the bodies of the subjects, thus leaving "blind-spots" behind them. This was eliminated by placement of the subjects in such a manner as to reduce those "blind spots" to a minimum. This procedure permitted all subjects to be exposed to the ultrasonic extra-stimulus tone. The maximum distance of any of the subjects from the speaker wasapproximately ten feet, but in most cases was six feet or less.

As the examinations were being given the ultrasonic tone of 20,000 v. p. s. was applied during the even-numbered items of each section of the tests. The construction of the amplifier made it possible to apply the ultrasonic tone for short intervals so that this tonal stimulus was only present during the even-items. This procedure enabled the division of the sections of the tests into the stimulated halves or even-numbered items and into the non-stimulated halves or odd-numbered items.[17]

The difficulty of the items on the sections of the

17 During the remainder of this thesis the stimulated portion of the test will be referred to as the "Even-numbered" items and the non-stimulated portion will be referred to as the "Odd-numbered" items.

Seashore test become progressively greater.[18] In order to divide the test into halves of equal difficulty it was necessary to choose the even or odd-items for stimulation. The even-numbered items were chosen for the stimulated portion since these items gave the investigator more time to coordination the application of the ultrasonic tone with the items of the test to be stimulated.

The subject's raw scores on the even-numbered items and the odd-numbered items were then tabulated.[19] For each subject there were two scores for each section. These scores were arranged into frequency distributions that are included in the tables within the next chapter. The mean, standard error of the mean, and the standard deviation of each distribution was computed. The standard error of the obtained mean served as a check on the statistical reliability of the obtained means of the odd and even item scores on each section. The differences, if any, between the obtained means of each section were noted. The standard errors of each of these obtained differences were then computed in order to determine the reliability of these obtained values. The critical ratios of the differences between the obtained means were then

18 Seashore, Carl E., Don Lewis and Joseph G. Saetveit, "Manual of Instructions and Interpretations for the Seashore Measures of Musical Talents (1939 Revision)", Camden, New Jersey; R. C. A. Victor Division, Radio Corporation of America, p. 17.

19 The method of scoring has been noted previously in this thesis under "Materials used.".

checked at the .05 level, the level at which the chances are 95 out of 100 that the existing differences may not be explained by the operation of the chance factor alone but may be due to other factors that may be affecting the performances.

CHAPTER IV

RESULTS OF THE INVESTIGATION

The statistical results of this investigation are included in the tables that appear throughout this section. The frequency distributions of the total raw scores on each half of the section of <u>pitch</u> perception compose a portion of Table I. Also included in this table are the means or average scores of each distribution. The obtained mean of the odd-item portion of this section is 17.48, which is slightly larger than the obtained mean of 16.84 for the even-items. The standard deviation of the first or odd-item distribution is 3.376 whereas the value of this measure for the even-item scores is 3.452. The difference between the obtained means on pitch perception is .64. This difference, in comparison to the standard error of the difference between the means, gives the critical ratio value of 1.36. Thus, interpreted at the .05 level, this difference of .64 between the two means is not significant. The conclusion then can be made that the differences between the scores on the odd-items and the even-items of this section on pitch perception may be explained in terms of chance alone. In such an event a conclusion concerning the effects of other factors that may have been present cannot be made.

Table II contains the distributions of the total raw scores on the odd and even-items of the section on <u>loudness</u> perception.

TABLE I

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE PITCH SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
	24 - 25	1
10	22 - 23	6
24	20 - 21	19
19	18 - 19	23
18	16 - 17	18
17	14 - 15	13
7	12 - 13	15
3	10 - 11	4
2	8 - 9	2
0	6 - 7	0

$Mean_1 = 17.48$ $Mean_2 = 16.84$

$S.D._1 = 3.376$ $S.D._2 = 3.453$

$S.E.\ Mean_1 = .338$ $S.E.\ Mean_2 = .345$

Difference M_1 and M_2 = .64

S. E. of Difference = .483

Critical Ratio = 1.36

TABLE II

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE LOUDNESS SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
6	24 - 25	4
21	22 - 23	26
35	20 - 21	31
30	18 - 19	20
11	16 - 17	12
5	14 - 15	5
1	12 - 13	1
0	10 - 11	0
2	8 - 9	0
0	6 - 7	0
0	4 - 5	1

$Mean_1 = 19.70$ $\qquad$ $Mean_2 = 19.76$

$S. D._1 = 2.628$ $\qquad$ $S. D._2 = 2.905$

$S. E. Mean_1 = 2.83$ $\qquad$ $S. E. Mean_2 = .291$

Difference M_1 and M_2 = .06

S. E. Difference = .4049

Critical Ratio = .015

The obtained means of the odd and even-items on this section are 19.70 and 19.76 respectively. In this section the mean score for the stimulated items is slightly greater. The standard deviations on the portions of this section, are in the same order as above, 2.828 and 2.905. This would indicate that 68% of the scores on the odd-items of this section fall between the approximate raw score values of 16.83 to 22.53 on the odds and 16.85 to 22.67 on the evens. The .06 differences between the means of this section when compared to the standard error of this difference gives a critical ratio value of .015. The interpretation of this critical ratio at the .05 level indicates a value not statistically significant. In that case also it is possible for the difference between means to be explained in terms of chance alone. In fact, the difference could be in favor of the non-stimulated items. This information precludes the formulation on any further conclusions, however.

Table III concerns the perception of the subjects of the musical factor of time. The obtained means of the halves of this section are 16.42 for the odds and 16.56 for the evens. Again, the larger mean is for the stimulated scores. The standard deviations of the distributions of the odds and evens are 3.54 and 3.104. The difference between the mean of the odd-items and mean of the even items on this section is .14 with a standard error of .4701. This indicates that the

TABLE III

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE TIME SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
	24 - 25	1
4	22 - 23	5
17	20 - 21	9
22	18 - 19	24
23	16 - 17	24
13	14 - 15	22
12	12 - 13	12
6	10 - 11	1
3	8 - 9	1
1	6 - 7	1

$Mean_1 = 16.42$ | $Mean_2 = 16.56$

$S.\ D._1 = 3.54$ | $S.\ D._2 = 3.104$

$S.\ E.\ Mean_1 = .354$ | $S.\ E.\ Mean_2 = .310$

Difference M_1 and M_2 = .14

S. E. Difference = .4701

Critical Ratio = .298

chances are 69 out of a possible 100 that the "true" difference has not been missed by more than .47 raw score units. The critical ratio for this section on time perception is .293 and is too small to be statistically significant at the .05 level. No further conclusions may then be drawn concerning these scores.

In Tables IV and V the frequency distributions of the scores on the odd and even-items of the sections of Rhythm and Tonal Memory perception are presented. The highest possible score on the halves of these sections was 15. This caused the means on these two sections to be lower than the means of the previous sections that have been noted. In both instances the means of the odd-numbered items are greater. According to the statistical procedure described in the previous chapter, the critical ratio of 1.19 for the differences of the means on the rhythm section and of .262 for the critical ratio of the differences of the means on the tonal memory section were obtained. These values are not significant at the .05 level. Since it then is possible to explain these differences in terms of chance alone a definite conclusion cannot be made concerning the effects of other factors.

Table VI contains the distributions of the total raw scores on the odd-numbered items and the even-numbered items of the section of Timbre or tone quality perception. The obtained means of the odd and even items are 17.42 and 18.22

TABLE IV

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE RHYTHM SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
3	15	
6	14	7
12	13	10
17	12	12
19	11	21
20	10	17
8	9	14
9	8	14
6	7	3
1	6	1
0	5	0
0	4	1

$Mean_1$ = 10.76 | $Mean_2$ = 10.42

S. $D._1$ = 2.014 | S. $D._2$ = 2.012

S. E. $Mean_1$ = .201 | S. E. $Mean_2$ = .201

Difference M_1 and M_2 = .34

S. E. Difference = .284

Critical Ratio = 1.17

TABLE V

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE TONAL MEMORY SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
10	15	16
17	14	12
12	13	8
9	12	7
9	11	8
9	10	15
9	9	9
8	8	9
9	7	8
6	6	4
1	5	1
1	4	2
0	1	1

$Mean_1$ = 10.94 — $Mean_2$ = 10.83

S. $D._1$ = 2.943 — S. $D._2$ = 3.095

S. E. $Mean_1$ = .294 — S. E. $Mean_2$ = .310

Difference M_1 and M_2 = .11

S. E. Difference = .4278

Critical Ratio = .262

TABLE VI

FREQUENCY DISTRIBUTIONS OF TOTAL RAW SCORES ON ODD-NUMBERED AND EVEN-NUMBERED ITEMS OF THE TIMBRE SECTION OF THE SEASHORE MEASURES OF MUSICAL TALENTS

Frequency (Odd items)	Interval	Frequency (Even items)
	24 - 25	2
5	22 - 23	10
17	20 - 21	28
26	18 - 19	20
30	16 - 17	19
16	14 - 15	16
5	12 - 13	4
1	10 - 11	0
0	8 - 9	1
0	6 - 7	0

$Mean_1 = 17.42$ | $Mean_2 = 18.22$

$S.\ D._1 = 2.552$ | $S.\ D._2 = 3.026$

$S.\ E.\ Mean_1 = .255$ | $S.\ E.\ Mean_2 = .303$

Difference M_1 and M_2 = .80

S. E. Difference = .3962

Critical Ratio = 2.02

respectively. The standard deviations of these obtained means are in the same order 2.552 and 3.025. The difference between means of .80 is in favor of the stimulated items. The standard error of the mean of the odd-numbered items is .255 while the standard error of this difference is .3963. The critical ratio is 2.02. At the .05 level, this difference is statistically significant. In that case this difference is so great that it can hardly be explained in terms of chance alone. Hence some other factor such as the ultrasonic tones may be operating to the extent that scores are higher on these items than otherwise they would be. A summary of these statistical results is given in Table VII. In three sections, Pitch, Rhythm, and Tonal Memory, the means for the scores on the even-numbered or stimulated items are smaller and in no instances are these differences great enough to be statistically significant at even the .05 level. In the other three sections the differences are greater in favor of the stimulated items and for one of these, timbre, the differences are statistically significant at the .05 level.

The statistical method employed above applies to "uncorrelated means." Since the means of each half of each section of the Seashore Musical test would possibly be more comparable to the statistical idea of "correlated means", it was thought necessary to compute the standard errors of the differences between the means and critical ratios of the sections of Pitch,

TABLE VII

SUMMARY OF STATISTICAL RESULTS

	Means (Odd-items)	Means (Even-items)	Differences M_1 and M_2	S. E. Differences	C. R.
Pitch	17.48	16.84	.64*	.483 (.276)	1.36 (2.31)
Loudness	19.70	19.76	.06	.405	.015
Time	16.42	16.56	.14	.47	.298
Rhythm	10.76	10.42	.34*	.28 (.253)	1.19 (1.37)
Tonal Memory	10.94	10.83	.11*	.428	.262
Timbre	17.42	18.22	.80	.396 (.284)	2.02 (2.80)

*Differences are in favor of scores on non-stimulated items.

Rhythm, and Timbre are noted in parentheses beneath the corresponding measures that were obtained by the initial statistical method.

The new values for the section on pitch perception are a standard error of the differences of .278 and a new critical ratio of 2.31. This critical ratio would then be statistically significant at the .05 level. In such a case the difference between the means of this section is too great to be explained in terms of chance alone, hence, other factors such as the ultrasonic tones may be operating in such a manner as to hinder the perception of the stimulated items of this section. The additional values that were obtained for the section of rhythm are a standard error of the difference between the means of .253 and a critical ratio of 1.37. This critical ratio value is still too small to be of statistical significance even at the .05 level.

On the section of timbre the new critical ratio of 2.80 is statistically significant at the .01 level, the level at which the chances are 99 out of a possible 100 that the differences between the means is not attributable to chance alone. These new data emphasize the fact that the differences between the scores on the odd and even items of the section of timbre may be due to other factors, such as the ultrasonic tones, that may be operating.

The above results are the statistical data that were obtained and the conclusions of this thesis must of necessity be based upon these data. The following observations, however, were also noted by the investigator during the administration of these musical aptitude tests.

Persistent headaches, which lasted for a few hours, were reported by a number of subjects. This information was voluntarily given by the subjects without any inquiries by the investigator. In describing their reactions, at the time of the examination, such phrases as "I can't hear it, but I can feel it!" were used by the subjects. Some described the sensation of the tone as "rather depressing!" In addition to these observations, it was noted that while these tests were being administered there was an excessive collection of wax in the ears of the investigator. This "waxing" was of such an excessive amount as to be noticeably disturbing.

CHAPTER V

SUMMARY AND CONCLUSIONS

I. Summary

It must here be emphasized that the statistical data obtained in this study in no way indicate the manner in which the ultrasonic tone has affected the perception of the items on these examinations. Also, the data do not indicate conclusively that it was the ultrasonic tone that produced the difference since it is possible, though not probable, that chance alone could be the explanation of the difference in most, if not all, the cases.

Though the situations occuring during the presentation of the even-items and the odd-items were almost identical, the possibility of uncontrolled variables during these portions of each section is not entirely precluded and must be noted. The effects of the ultrasonic tones, if any, on the success and failure of items on the Seashore tests may be helpful and enable the subject, or perhaps some subjects, to succeed on items which without these tones they may have failed. Also it is possible that these tones may interfere and prevent success on items that otherwise could be succeeded upon. The results of this study are not conclusive in this regard.

There is the possibility also that the tones may be helpful for some tests and detrimental in others. In fact, the significant difference at the .01 level for timbre perception may indicate the tones were helpful, whereas, they were detrimental for the perception of pitch as indicated by the significant difference at the .05 level.

It also may be that there was a "carry-over" effect from even to odd items so that the scores on both were hindered or helped. Such effects could hardly be determined in view of the techniques used in this study.

With the above stipulations in mind concerning the information obtained, the following suggestions are being made as to the explanations of the ultrasonic effects upon the performances on these tests.

II. Conclusions

If the ultrasonic tone was the explanation for the differences in performance on the timbre section of the Seashore examinations, it is the first suggestion that this tone may have affected the record playing machine during these tests in such a manner as to have caused a clearer and more obvious reproduction of the even-numbered items, thus making the performance of the even-items easier. If this be the case, further research as to the use of ultrasonic tones as aids in reproduction of audible sounds may be indicated.

The second possible explanation for the effects, if there were some, of the ultrasonic tones on the even-items on the performance of the time section of these tests may lie in the reaction of the ear to the ultrasonic vibrations. If this be the case, the interpretations of music as being excitations of the nervous tissues wherein the emotions lie, may be valid. Further research, however, will be necessary to determine whether the emotions lie within such nervous tissues. The physiological reactions of the subjects and of the author that have been noted may also give some information as to the psychological effects of even low-intensity ultrasonic tones upon human behavior.

The third "suggested" explanation of the difference in the scores on the halves of the timbre section is that there may have been a certain phasing in the air of the ultrasonic and sonic tones so as to enable a clearer perception of the tone quality of the second tones of the items in relation to the first tones.

The previous "suggestions" have been made upon the assumption that the difference between the means of the odd-numbered items and even-items of the timbre section is due to the improvement by the subjects on the even-items. This is definitely an assumption and must be treated as such. The possibility of a "carry-over" effect into the odd-items has been noted. If such were the case, it would not have been an improvement by the subjects on the even-items, but a lowering of their ability to perceive the odd-items which might be a manifestation of the fatiguing effect of the ultrasonic tone.

A possible explanation for what effects, if any, that ultrasonic tones may have had on the perception of pitch, as indicated by the tests given, may be that of interference or masking. Another possible explanation may be that of a "fatiguing" effect on the ear by the ultrasonic tones, thus hindering the perception of the even items. This suggestion, however, would probably indicate a general lowering of the over-all performance scores rather than merely the stimulated items.

Again it must be stated that the results of this study are far from being conclusive and the suggested explanations presented herein must be noted as such and not as being indicated by the statistics of this thesis. What can be stated as being indicated by this study is that a vast amount of further research is needed before the determination of the physiological effects of ultrasonic tones can be made. Also the theory of music's effect upon people is in dire need of further investigation possibly according to similar procedures as have been employed in this study.

Suggested follow-up studies of this investigation are:

1. A similar study as the one herein reported upon, but one which would use the "retest" method rather than the "chance halves" method that was used in this study.

2. A study which would involve the use of a rotational ultrasonic speaker rather than a stationary one. This is suggested in light of the directional nature of ultrasonic tones.

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