EFFECTS OF AUDITORY FREQUENCY AND MANNER OF PRESENTATION OF SIGNALS ON JUDGMENT OF DISTANCE BY BLIND INDIVIDUALS

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ABSTRACT

EFFECTS OF AUDITORY FREQUENCY AND MANNER OF PRESENTATION OF SIGNALS ON JUDGMENT OF DISTANCE BY BLIND INDIVIDUALS

by Lynn E. Miner

This study is concerned with the auditory skills of blind individuals. The purpose of this thesis was to analyze the effect of auditory frequency and manner of presentation of signals on the judgment of distance by blind individuals. Three primary variables were investigated in this study. They were auditory frequency, distance from a sound source, and presentation of the auditory stimulus.

Thirty-six visually handicapped students from the Michigan School for the Blind participated in this experiment. Each subject was presented a certain set of conditions at a distance of ten feet from the sound source in the test room. Next, he was disoriented in the test room and repositioned at another predetermined distance. He was then instructed to walk forward until he again perceived his distance from the sound source as ten feet. The varying conditions for the subjects were auditory frequency, distance from the sound source, and manner of presentation (continuous vs. intermittent) of the auditory stimulus.

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The error judgment in perceived distance for each subject was measured and recorded. An analysis of variance was computed to determine the significance of differences between mean scores.

No statistically significant results were obtained. None of the F ratios were significant at the .05 level of confidence. The interactions between these variables were computed and found to be nonsignificant at the .05 level of confidence. The major findings of this study do not indicate that auditory frequency, distance from the sound source, and the manner of presentation of the auditory stimulus are significant variables affecting the perception of distance from the sound source by the blind.

Approved by [signature]

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By

Lynn E. Miner

A THESIS

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DEDICATION

Dedicated -- not to a person but to a profession which is devoted to serving people. May we never lose sight of our goal.

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The writer wishes to express his profound appreciation to those who have given advice and guidance in the preparation of this thesis.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Our senses keep us informed of the happenings in our environment. These senses, especially the distance senses of sight and hearing, help us orient to our surroundings. Individuals with diminished visual acuity are, of necessity, forced to rely on audition in gaining information about their environment.

> Through hearing, a blind person can learn to evaluate personality. . . . Through changes in pitch, rhythm, and quality of tone he can note the various moods corresponding to the gamut of the emotions. How well he is able to associate the various aspects of the human voice with the emotions will depend upon his intelligence, intuition and experience in contact with people.[1]

Blindness imposes certain basic limitations on the blind individual. Each limitation necessitates definite adjustments in the learning process for the visually handicapped. First, blindness places restrictions in the range and variety of experiences in which the individual may partake. The visual and tactual senses experience considerable limitations. Second, blindness imposes restrictions in the control of the environment and the self-concept in relation to the environment. Vision gives

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[1]Carl Weiss, "Reality Aspects of Blindness As They Affect Case Work," The Family, (February, 1946), p. 12.

us a great deal of control over our environment. Finally, blindness imposes restrictions on mobility and orientation. This is probably the most serious of all restrictions and the one with which this thesis is most directly concerned. The blind child cannot change his immediate environment; he is dependent on the assistance of others. This dependence could affect his social relationships and lead to self debasement.[1]

The role of auditory skills in mobility and orientation is immensely important. Unfortunately, however, as Rusalem suggests,

> In the area of mobility, we have largely been playing by ear. We have been aware that certain procedures work better than others and that blind persons differ in their ability to use various travel techniques. However, we have lacked the basic orientation which might make our work scientific and which would hasten the day when most blind persons could travel independently. It would be argued that even our present knowledge is not being effectively dissemenated, and that is probably true.[2]

Rusalem adds that the

> . . . loss of the ability to get about has been a crucial problem in the rehabilitation of the blind. Frequently, the success of a variety of the social and vocational services depends upon preliminary success in teaching independent travel. Lack of mobility can isolate a blind person from his environment.[3]

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[1]Paul A. Zahl, Blindness, (Princeton, New Jersey: Princeton University Press, 1950), p. 92.

[2]Herbert Rusalem, "Research in Review," New Outlook for the Blind, LII, No. 8 (1958), p. 313.

[3]Ibid.

He goes on to limit the problem as follows: "The nub of the problem is that there is sufficient auditory information in the environment if the crucial properties of the sound field could be perceived and recognized."[1]

Lowenfeld described the problem similarly when he stated:

> The most important factor in increasing the blind child's ability to gain experiences is his own ability to get about and secure stimulation by himself. How to learn his way in familiar and unfamiliar surroundings is a never-ending task that begins with the blind child's first steps.[2]

One auditory skill essential to effective mobility and orientation is mastery of sound localization. Sound localization is the process of determining the distance and direction of an acoustic stimulus. Three coordinates are fundamental to this ability: a judgment of distance and the interaction of two angles. A majority of existing studies have concentrated on the determination of the direction of the acoustic stimulus. Other studies relative to sound localization are comparative studies which deal with differences among the blind and sighted. The orientation of this thesis is toward the role of distance, auditory frequency and pulsation in sound localization.

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[1] *Ibid*.

[2] Berthold Lowenfeld, *Our Blind Children*, (Springfield, Ill.: Charles C. Thomas Pub., 1956), p. 164.

Statement of the Problem

For the blind individual to become mobile, he must learn to take advantage of available sensory clues. This includes mastery of certain basic auditory skills. The purpose of this research is to investigate the effects of auditory frequency and manner of presentation of signals on judgment of distance by blind individuals. The scope of this thesis is restricted to the above mentioned auditory signals.

Definitions

The following terms are defined for clarification in this study:

Auditory frequency.--The three frequencies explored are 500, 2000, and 8000 cycles per second.

Manner of presentation.--Both continuous and intermittent tones were utilized.

Judgment of distance.--The individuals conception of the space between himself and the source of the auditory stimulus. In this instance each person was asked to make a judgment of ten feet between himself and the source of the stimulus.

Blind individuals.--Thirty-six braille students at the Michigan School for the Blind. Most of the participants were totally blind. Students with light perception utilized blindfolds.

Two other terms, while not directly involved in this study, need definition. The terms are frequently employed when referring to the rehabilitation of the blind.

Mobility.--The term used to denote the ability to navigate from one's present fixed position to one's desired position in another part of the environment.[1]

Orientation.--The process of utilizing the remaining senses in establishing one's position and relationship to all other significant objects in one's environment.[2]

Questions Posed at Outset

Questions posed at the outset of this study were:

1. Do certain auditory frequencies allow for a more accurate judgment of distance than other auditory frequencies?
2. How does initial distance from a sound source affect the blind individual's perception of another predetermined distance?
3. Which type of presentation allows for a more accurate judgment of distance: a continuous or intermittent tone?
4. Is there a dependence of presentation (continuous vs.

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[1]"Orientation and Mobility Terms" (American Association of Instructors of the Blind, St. Louis, Mo., March, 1962), p. 1. (Mimeographed.)

[2]Ibid.

intermittent) on distance from the sound source in the auditory perception of a distance of ten feet?

5. Is there a dependence of auditory frequency on initial distance from a sound source in the auditory perception of a distance of ten feet?
6. Is there a dependence of auditory frequency on presentation (continuous vs. intermittent) in the auditory perception of a distance of ten feet?

CHAPTER II

REVIEW OF THE LITERATURE

In the area of mobility and orientation of the blind, little systematic information is available regarding the function of auditory sensations. The bulk of available information consists of comparative studies contrasting the blind and sighted on auditory performance tasks. Most of these studies are concerned with sound localization.

One of the few studies dealing with the role of pitch was conducted by Cotzin and Dallenbach. They investigated the function of pitch in the perception of obstacles by the blind. This phenomenon is sometimes referred to as "facial vision." As a result of their investigation, they indicated that "aural stimulation by reflections from the obstacles is both a necessary and sufficient condition for object perception." They concluded further that "changes in pitch are the basic clues of the perception of obstacles by the blind, and that they do not occur unless the higher partials, approximately 10,000 cps and above, are present in the stimulus sounds."[1]

Supa joined forces with the above authors in an

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[1]M. Cotzin and K. M. Dallenbach, "Facial Vision: The Role of Pitch and Loudness in the Perception of Obstacles by the Blind," American Journal of Psychology, LXIII (1950), p. 512.

earlier study of obstacle perception by the blind. Their study was exhaustive in nature and represented an important contribution to the final solution of this problem. Seven experiments were conducted, three preliminary experiments and four main experiments. The preliminary experiments were exploratory and normative. Blind and sighted subjects, all with blindfolds over their eyes, were placed at various distances in front of either a wall or a portable masonite board. They were asked to walk toward the obstacle and (1) indicate their first perception of it and (2) to approach it as closely as possible without touching it. In each of the preliminary experiments, twenty-five trials were obtained from each subject. The average distance and mean variation of the subject's first perception and final appraisal were computed for the statistical data of tables. In the first experiment the end wall of a large hall was the obstacle and the starting point of the subject varied. In the second experiment the screen was the obstacle and its position was varied; the subjects started from a fixed point. In the third experiment the position of both the subject and the screen was varied. The authors found that while the blind in this study possessed a high degree of ability to perceive obstacles at a distance, the sighted could easily acquire this ability with practice.

The purpose of the four main experiments by Supa, Cotzin, and Dallenbach was to control certain sensory cues.

The first main experiment was conducted in order to determine whether pressure sensations aroused by reflected air waves were necessary to the perception of obstacles. The second main experiment was designed to ascertain whether or not aural stimulation by reflected sound waves was a necessary condition for the perception of obstacles. In the third main experiment the exposed areas of the skin were left open to air and sound waves but all auditory stimuli were drowned out by a masking sound conducted to a set of headphones worn over the ears of the subject. In the fourth main experiment each subject was placed in a sound proof room with high-fidelity headphones over his ears through which he could listen to the sounds of the experimenter who, carrying a microphone, walked in another room towards the obstacle. All subjects were able to report first perceptions and final appraisals in this experiment where only ear stimulation could play a role. Their most general, relevant conclusion to be noted here was that "aural stimulation is both a necessary and sufficient condition for the perception of obstacles."[1]

Fletcher investigated the accuracy with which blindfolded subjects could localize the distance of sound sources. Three main variables were studied. They included the distance of the sound source from the subjects, the frequency

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[1]M. Supa, M. Cotzin, and K. M. Dallenbach, "Facial Vision: The Perception of Obstacles by the Blind," American Journal of Psychology, LVII (April, 1944), p. 183.

of the sound source, and the audible angle at the subjects. His findings indicated that the subjects could localize the distance of sound sources with more than chance accuracy. Distance was the only significant variable.[1]

A study by McCarty and Worchel makes reference to the possibility of a mechanism similar to the one used by bats in their environmental orientation.

> It is known that bats use a type of vocal radar to guide them in utter darkness, and thus it would seem that a similar mechanism is at work in humans; but if an object is closer than fifty feet the echo and original sound blend to such an extent that they cannot be heard separately by the human ear.
>
> Work by Cotzin and Dallenbach, however, indicated that rather than being the pure echo, it was a difference in tone between the original sound and the echo. This is known as the Doppler Shift, and it is the same as the often observed difference in the sound of a car as it approaches and then recedes."[2]

In other words, the blind perceive objects when they hear a rise in pitch of the echo (Doppler Shift). This difference in frequency with its relative intensity and manner of presentation tells them where the obstacle is located.

Griffin has investigated some of the variables in sound localization. He stated that a thermal noise (100 through 12,000 cps) was more effective in detecting an obstacle than were pure tones. He also noted that pure

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[1]John L. Fletcher, "Localization of Sounds in Depth," U. S. A. Medical Research Laboratory Report, MXMLVII, No. 302 ii (1957), p. 14.

[2]M. McCarty and P. Worchel, "Rate of Motion and Object Perception in the Blind," New Outlook for the Blind, XLVIII (November, 1954), p. 315.

tones of 10,000 cps and higher provided for more accurate detection of obstacles than the frequencies 125-8000.[1]

One of Griffins' studies dealt with the acoustical orientation of the oil bird, steatornis. He made an acoustic analysis of the sound emitted by this bird while flying about in a totally dark cave. By emitting sounds the bird was able to avoid obstacles while in flight. The most appreciable components of the emitted sounds were between 6000 and 10,000 cps. The average frequency was 7000 cps; the duration of each sound was about one msec. with intervals between sounds averaging 2.6 msec. When the ears of the bird were plugged, they lost their echolocation ability.[2]

An investigation into the function of auditory frequencies in sound localization was authored by Fedderson, Jeffres, Sandel and Teas. They stated:

> We may conclude that the localization of high frequency pure tones, where there is no cue provided by the onset of the tone, demands a difference of level at the two ears which can be provided only by tones above 5000 cps. At the lower frequencies where diffraction around the head is less and the differences of level, therefore, smaller, the subject consistently underestimates the azimuth angle. This underestimation decreases with increasing frequency and increases with increasing

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[1] Donald R. Griffin, Listening in the Dark, New Haven: Yale University Press, 1958), p. 308.

[2] Donald R. Griffin, "Acoustic Orientation in the Oil Bird, Steatornis," National Academy of Sciences, XXXIX, No. 8 (1953), pp. 884-93.

azimuth angle.[1]

One of the parameters of the present study is concerned with the presentation of the stimulus. Both continuous and interrupted tones are utilized. Zwislocki, Hellman, and Verillo conducted a study in this regard. It was their impression that

> Neural responses to pulses seem to be more easily detected and quantified than responses to other sound stimuli. Consequently, in the search for physiological correlates of certain characteristics of psychophysical responses, pulse stimuli appear particularly attractive.[2]

von Békésy has written of the spatial attributes of sounds. He stated:

> Perception of the distance of a sound depends upon characteristics of the sound field that still are not well understood, but in the experimental situation the apparent distance was determined simply by loudness. The less the loudness, the farther away from the head the sound image seemed to be, and when the loudness remained constant this distance was always the same.[3]

The ratio of the direct sound to the reverberant sound intensity has been suggested by Fletcher as a factor influencing depth localization. He specified that

> . . . either a reduction in loudness or a decrease in ratio of direct to reverberant sound intensity, or both, cause the sound to appear to move away from the observer.

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[1]W. E. Fedderson _et al._, "Localization of High Frequency Tones," _Journal of the Acoustical Society of America_, XXIX (September, 1957), pp. 399-91.

[2]J. Zwislocki, R. P. Hellman, and R. T. Verillo, "Threshold of Audibility for Short Pulses," _Journal of the Acoustical Society of America_, XXIV, No. 10 (1962), pp. 1648-52.

[3]Georg von Békésy, _Experiments in Hearing_, (New York: NcGraw-Hill Co., Inc., 1960), p. 280.

> . . .It has not been found possible to put these relationships on a quantitative basis. Probably a given loudness change, or a given change in ratio of direct to reverberant sound intensity, causes different sensations of depth depending upon the character of the reproduced sound and upon the observer's familiarity with the acoustic conditions surrounding the reproduction. Since the depth localization is inaccurate even when listening directly, it is difficult to obtain sufficiently accurate data to be of much use in a quantitative way. Because of this inaccuracy, good auditory perspective may be obtained with reproduced sounds even though the properties controlling depth localization depart materially from those of the original sound.[1]

The auditory skills of blinded individuals training with pilot dogs were investigated by O'Neill, Oyer, and Baker. The purpose of their study was to determine whether a significant relationship existed between the ability of blinded individuals to use a pilot dog successfully and their hearing acuity, hearing discrimination, and sound localization ability. Fifty-three subjects were administered a battery of tests which included the following: (1) pure tone threshold tests, (2) sound discrimination tests, and (3) sound localization tests. The trainees under study were evaluated for each subject's relative skill in the use of a pilot dog by trainers employed in the Pilot Dog training program. The results suggested that auditory acuity and the ability to localize sound may determine

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[1]Harvey Fletcher, Speech and Hearing in Communication, (Princeton, New Jersey: D. Van Nostrand Co., Inc., 1958), pp. 221-22.

proficiency in the use of a pilot dog by a blinded person.[1]

In summary, the literature contains several studies which are related to this thesis. It suggests that the higher auditory frequencies should allow for the greatest accuracy in the judgment of distance from a sound source. The main variables affecting the auditory perception of the distance of a sound source include auditory frequency, the distance from the sound source, the manner of presentation of the auditory stimulus, the intensity of the auditory stimulus, and the acoustical characteristics of the environment.

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[1]John O'Neill, Herbert Oyer, and Donald Baker, "Auditory Skills of Blinded Individuals Training With Pilot Dogs," Journal of Speech and Hearing Research, I, No. 3 (September, 1958), pp. 262-67.

CHAPTER III

SUBJECTS, EQUIPMENT AND PROCEDURES

Subjects

The subjects for this study were thirty-six high school students at the Michigan School for the Blind. Nineteen boys and seventeen girls participated in the study. All subjects were required to pass a pure tone hearing test at a ten-decibel level for each ear. The following frequencies were employed: 500, 1000, 2000, 4000, and 8000 cps.

All students had been examined by an ophthalmologist and declared legally blind prior to their admission to the school. All of the students were totally blind. The few who had light perception were blindfolded before being exposed to the testing situation.

All except three of the thirty-six subjects had lost their visual acuity before the age of two. Most of the subjects had been blind since birth; retrolental fibroplasia was the major cause for the visual losses as indicated by the ophthalmological reports. The three remaining subjects had lost their vision at age three, five and sixteen respectively.

Only students with average or above average intelligence as determined by school achievement were utilized. All subjects were randomly selected within the visual, auditory and intellectual restrictions mentioned.

Equipment

The experiment was conducted in a room which had been partially treated with acoustical tile. A table indicating the acoustical specifications of the room is found in Appendix A. These specifications were computed by the Building Division of the State of Michigan.

Pure-tone signals were generated for the experiment by a Maico Audiometer, model H1-B. The pure tones were directed from the audiometer through a six inch speaker, type #6 CM-47 manufactured by the Oxford Electrical Corporation. The three pure tones presented were 500 cps, 2000 cps, and 8000 cps.

Procedures

Prior to the experiment each student had satisfactorily passed a pure-tone screening test at ten decibels in each ear for the frequencies previously mentioned. The following instructions were read to the subjects before the experiment began:

> In just a moment you will be asked to listen closely to a particular tone. You will be exactly ten feet from that tone. Next you will be taken back a greater distance from that tone and asked to walk forward until you again think you are ten feet from that tone. A guide rope is provided as an aid in walking a straight line. Remember: walk forward until you are ten feet from the tone. Once you have estimated the correct distance, remain standing still until further instructions are given. Do you have any questions?

The speaker was positioned one foot from a wall and five feet above the floor. A fifty-five foot guide rope was fastened between the speaker and a pole. The speaker was positioned at the approximate head level of the subjects and pointed toward the head of each subject.

After the subject had the opportunity to hear the stimulus at exactly ten feet from the sound, an irregular path was followed, thus attempting to disorient the individual. One of three different starting distances was employed for each subject. Subjects were positioned at either 26 feet, 38 feet, or 50 feet from the auditory signal. One of two types of auditory signals (continuous vs. intermittent) was presented to each subject. The intermittent tones were manually pulsed every .5 second for a .5 second duration.

The table in Appendix B indicates the intensity of the stimuli presented. The intensity was presented at 50 decibels above audiometric zero. Audiometric zero for each frequency was ascertained by determining the threshold tested at a distance of three feet from the sound source. This procedure was conducted in the sound field of the actual test room on a pair of normal ears.

Once the subject had completed his estimate of ten feet, his judgment error was measured. The judgment error was the distance between the exact ten foot mark and the heels of the subject. The error was recorded in inches and employed as the basic measure or score in the experiment.

Three fundamental conditions were explored in this experiment. There were several levels for each condition. Each combination of conditions, or events, was presented to two randomly selected subjects from the sample of thirty-six. The table in Appendix C indicates the specific combinations of events presented to each subject.

The first condition examined was auditory frequency. Three different auditory frequencies were presented. They were 500 cps, 2000 cps, and 8000 cps. One of the purposes of this study was to determine if certain auditory frequencies allow for a more accurate judgment of distance than other auditory frequencies.

The second condition investigated in this study concerned the type of presentation of the auditory signal. The two types of presentation were continuous tones and intermittent tones. Another purpose of this thesis was to determine which type of presentation allows for more accuracy in the judgment of distance from a sound.

The third condition of this study dealt with the manner in which the blind individual's initial distance from a sound source affected his perception of a distance of ten feet. The subjects were randomly placed at three different starting distances from the sound source. Those distances were 26 feet, 38 feet, and 50 feet.

CHAPTER IV

RESULTS AND DISCUSSION

Results

A 3 x 3 x 2 factorial analysis of variance was employed to determine the significance of differences between mean scores.[1]

Six basic questions were posed at the outset of this study, namely:

1. Do certain auditory frequencies allow for a more accurate judgment of distance than other auditory frequencies?
2. How does initial distance from a sound source affect the blind individual's perception of another pre-determined distance?
3. Which type of presentation allows for a more accurate judgment of distance: a continuous or intermittent tone?
4. Is there a dependence of presentation (continuous vs. intermittent) on distance from the sound source in the auditory perception of a distance of ten feet?
5. Is there a dependence of auditory frequency on initial distance from a sound source in the auditory perception

[1]Allen L. Edwards, Experimental Design in Psychological Research, (rev. ed.; New York: Rinehart Co., Inc., 1960), p. 201-07.

of a distance of ten feet?

6. Is there a dependence of auditory frequency on presentation (continuous vs. intermittent) in the auditory perception of a distance of ten feet?

The results of the analysis of variance are indicated in Table 1.

TABLE 1

ANALYSIS OF VARIANCE

Source of Variation	Sum of Squares	d. f.	Mean Square	F
Frequency (F)	1927.72	2	963.86	....
Distance (D)	264.05	2	132.03	....
Presentation (P)	7921.79	1	7921.46	3.24*
F x D	21233.79	4	5308.45	2.33*
F x P	169.73	2	84.87	....
D x P	5401.06	2	2700.53	1.66*
F x D x P	4907.75	4	1226.94	....
Within Treatments	41825.56	18	2323.64	....
TOTAL	83651.12	35		

*The resulting F was not statistically significant at the .05 level of confidence

Inspection of Table 1 reveals that no significant F ratios were obtained at the .05 level of confidence. The triple interaction variance (F x D x P) was combined with the Within Treatments variance in an effort to further evaluate for significant results. No significant F scores, however, resulted from this procedure at the .05 level of confidence.

Discussion

There was no statistically significant difference in the three frequencies relative to judgments of distance. No one frequency yielded more accurate judgments over another. Auditory frequency was not demonstrated to be a significant variable as it pertained to a judgment of distance from a sound.

There was no statistically significant difference in the three starting distances relative to the judgment of a sound source.

There was no statistically significant difference in manner of presentation of the stimulus relative to a judgment of distance. Neither the continuous nor the intermittent tone was demonstrated as allowing a more accurate judgment.

After assessing the statistical significance of the three parameters of this study, the interaction among these variables was computed. The interaction of presentation by distance was not statistically significant as it pertains to accuracy in the judgment of distance. The interaction of frequency by distance was not statistically significant relative to accuracy in the judgment of distance. The interaction of frequency by presentation was not a statistically significant variable influencing the accuracy in judgment of distance.

The physical dimension of the auditory stimulus in the present investigation was held constant for each subject. Due to the acoustical properties of the room, however, the subjects may have perceived variations in intensity for the various distances. These variations in intensity were measured by a Mine Safety Appliance sound pressure level meter. The ambient noise in the test room at ten feet from the sound source was 46 db. The auditory frequencies presented were analyzed by a narrow band filter with a range of 200 cps above and below each frequency. The measurements are indicated in Table 2.

In this regard Békésy notes that "an increase in loudness produces a clear reduction in the distance of the diffuse image. Thus it seems that loudness has an effect upon the perceived distance only in the absence of the other more determinant physical cues."[1]

There are several factors which might account for the negative results of this study. One factor is the size of the sample utilized. A larger sample might have yielded significant results, especially with regard to the frequency by distance interaction. The frequency by distance F ratio obtained was 2.33; an F ratio of significance at the .05

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[1]Békésy, op. cit., p. 304.

level of confidence is 2.93. As previously suggested, a larger sample might have indicated significant results.

TABLE 2

SOUND PRESSURE LEVELS IN TEST ROOM

Frequency Analyzed	Distance from Sound Source	Sound Pressure Level
500 cps.	10 feet	55 db.
500 cps.	26 feet	56 db.
500 cps.	38 feet	51 db.
500 cps.	50 feet	52 db.
2000 cps.	10 feet	41 db.
2000 cps.	26 feet	38 db.
2000 cps.	38 feet	36 db.
2000 cps.	50 feet	39 db.
8000 cps.	10 feet	56 db.
8000 cps.	26 feet	40 db.
8000 cps.	38 feet	33 db.
8000 cps.	50 feet	32 db.

Another factor which might account for the negative results of this study concerns the acoustic characteristics of the test room. Although the reverberation time for the room was relatively low (1.24 seconds), it is conceivable that the time lag and accompanying distortions might have influenced the subjects perception of distance from a sound source. Conducting this same experiment in an anechoic chamber might reveal different findings.

It is particularly interesting to note that frequency did not play a significant role in the perception of distance from a sound source by the blind. This finding stands in contradiction to some of the findings in the review of the literature. Griffin, for example, stated that the higher pure tones (around 10,000 cps) provide for more accurate perception of obstacles than the lower frequencies (125-8000 cps). Again, the acoustical characteristics of the room might account for this apparent discrepancy.

In summary, the findings of this study do not support the hypothesis that auditory frequency, method of presentation, and distance as defined in this thesis are significant variables relative to the blind individual's judgment of distance from a sound source. Both the size of the sample and the acoustical characteristics of the test room are factors which might account for the negative results.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This study is concerned with the auditory skills of blind individuals. It investigates one aspect of the ways blind individuals utilize sound in mobility and orientation. The purpose of this thesis was to analyze the effects of auditory frequency and manner of presentation of signals on judgment of distance by blind individuals. Six basic questions were posed at the outset of the research. These questions were initially posed in Chapter I and elaborated on in Chapter IV.

A review of the literature revealed some studies which related to this thesis but none which had a similar experimental design. Earlier research by Cotzin and Dallenbach[1] and more recent investigations by Griffin[2] infer that the higher auditory frequencies might allow for the greatest accuracy in the judgment of distance from a sound source.

Several authors[3,4] have indicated some of the variables affecting the perception of the distance of a

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[1]Cotzin and Dallenbach, op. cit., p. 512.

[2]Griffin, Listening in the Dark, loc. cit.

[3]Harvey Fletcher, op. cit., pp. 221-22.

[4]Békésy, op. cit., p. 208.

sound source. These variables include auditory frequency, distance from the sound source, manner of presentation of the auditory stimulus, intensity of the auditory stimulus, and acoustical characteristics of the environment.

The experimental procedure utilized thirty-six visually handicapped students at the Michigan School for the Blind. Each of them had normal hearing and average intelligence or above average intelligence. Nearly all of the subjects were blind at birth.

Three primary variables were investigated in this study. The first variable was auditory frequency. The three frequencies utilized were 500 cps, 2000 cps, and 8000 cps. Another variable was the manner of presentation of the sound stimulus. Both a continuous tone and an intermittent tone were employed in the experimental procedure. The pure tone auditory signals in this study were generated from an audiometer through a speaker into the test room. The third variable was the distance from the sound stimulus. The subjects were positioned at three different distances from the sound source; those distances were 26 feet, 38 feet, and 50 feet.

The subjects were led into the test room and given the instructions outlined in Chapter III. Next, they were taken to a location exactly ten feet from the sound stimulus. Each subject was randomly presented one stimulus. It was one of the three frequencies mentioned above and was presented as a continuous tone or an intermittent tone. The table in Appendix C indicates the exact conditions for each subject.

After the subjects had the opportunity to hear their stimulus at a distance of ten feet from the sound source, they were disoriented in the room and repositioned at either 26 feet, 38 feet, or 50 feet from the sound stimulus. Their instructions were to walk forward until they again perceived the distance of ten feet from the sound source. Their only clue was the auditory stimulus presented to them. Each subject participated in just one condition.

The error judgment for each subject was measured and recorded. An analysis of variance was computed to determine the significance of differences among mean scores. The results of the statistical computation revealed nonsignificant findings. None of the F scores were statistically significant at the .05 level of confidence. This study indicated that auditory frequency, distance from the sound source, and manner of presentation of the auditory stimulus were nonsignificant variables affecting the perception of distance from a sound source by the blind. The interactions between these variables were also nonsignificant at the .05 level of confidence. It is conceivable, however, that a larger sample and a change in the acoustical specifications of the environment might find one or more of these variables more significant than indicated in this study.

Conclusions

The following conclusions are noted on the basis of the results obtained in this investigation:

1. It cannot be said that any of the auditory frequencies investigated allows for a more accurate judgment of distance from a sound source than the others.
2. It cannot be said that the initial distance from a sound source affects blind individuals' perception of another predetermined distance.
3. It cannot be said that either type of presentation (continuous vs. intermittent) allows for a more accurate judgment of distance than the other.
4. It cannot be said that there is a dependency of presentation (continuous vs. intermittent) on distance from the sound source in the auditory perception of a distance of ten feet.
5. It cannot be said that there is a dependency of auditory frequency on initial distance from a sound source in the auditory perception of a distance of ten feet.
6. It cannot be said that there is a dependency of auditory frequency on presentation (continuous vs. intermittent) in the auditory perception of a distance of ten feet.

Implications for Future Research

It would be interesting to repeat this experiment with a larger number of subjects. Since the F for frequency by distance interaction was almost statistically significant at the .05 level of confidence, a larger sample might yield significant results.

Additional research relative to the function of auditory signals in the perception of distances is needed. It might be found that some type of mechanical guidance device emitting an auditory signal could be utilized by the blind in negotiating the obstacles of their environment. Also, such a device might be employed by the military in detecting obstacles at distances which cannot now be located by conventional means.

BIBLIOGRAPHY

Books

Davis, Hallowell, and Silverman, Richard. Hearing and Deafness. New York: Holt-Rinehart and Winston, Inc., 1960.

Edwards, Allen L. Experimental Design in Psychological Research. rev. ed. New York: Rinehart and Co., Inc., 1960.

Fletcher, Harvey. Speech and Hearing in Communication. Princeton, New Jersey: D. Van Nostrand Co., Inc., 1958.

Griffin, Donald R. Listening in the Dark. New Haven: Yale University Press, 1958.

Hirsh, Ira J. The Measurement of Hearing. McGraw-Hill Co., Inc., 1958.

Lowenfeld, Berthold. Our Blind Children. Springfield, Illinois: Charles C. Thomas Pub., 1956.

Newby, Hayes A. Audiology. New York: Appleton-Century-Crofts, Inc., 1958.

von Békésy, Georg. Experiments in Hearing. New York: McGraw-Hill Co., Inc., 1960.

Zahl, Paul. Blindness. Princeton, New Jersey: Princeton University Press, 1950.

Articles

Cotzin, M., and Dallenbach, K. M. "Facial Vision: The Role of Pitch and Loudness in the Perception of Obstacles by the Blind," American Journal of Psychology, LXIII (1950), 512.

Fedderson, W. E. et al. "Localization of High Frequency Tones," Journal of the Acoustical Society of America, XXXIX (September, 1957), 988-91.

Fletcher, John L. "Localization of Sounds in Depth," U. S. A. Medical Research Laboratory Report, MCMLVII, No. 302 ii (1957), 14.

Griffin, Donald R. "Acoustical Orientation in the Oil Bird, Steatornis," National Academy of Sciences, XXIX, No. 8 (1953), 884-93.

McCarty, B., and Worchel, P. "Rate of Motion and Object Perception in the Blind," New Outlook for the Blind, XLVII (November, 1954), 316.

O'Neill, John, Oyer, Herbert, and Baker, Donald. "Auditory Skills of Blinded Individuals Training With Pilot Dogs," Journal of Speech and Hearing Research, I, No. 3 (September, 1958), 262-67.

Supa, M., Cotzin, M., and Dallenbach, L. M. "Facial Vision: The Perception of Obstacles by the Blind," American Journal of Psychology, LVII (April, 1944).183.

Weiss, Carl. "Reality Aspects of Blindness As They Affect Case Work," The Family, (February, 1954) 12.

Zwislocki, J., Hellman, R. P., and Verillo, R. T. "Threshold of Audibility for Short Pulses," Journal of the Acoustical Society of America, XXIV, No. 10 (1962), 1648-52.

Unpublished Material

American Association of Instructors of the Blind, "Orientation and Mobility Terms," St. Louis, Missouri, March, 1962. (Mimeographed.)

Appendix A

Appendix A

ACOUSTICAL SPECIFICATIONS OF ROOM WHERE STUDY WAS CONDUCTED*

Surface	Material	Area	Coef.	Absorb.
Ceiling	Tectum 2"	5800	.65	3700
Floor	Asphalt Tile	5700	.03	171
Wainscott	Plastic Paint	2250	.06	135
Walls	Painted Block	5260	.06	314
Walls	Tectum 2"	2037	.65	1324
Air	143,000 cu. ft.			143
TOTAL				5787

Room dimensions: 62 feet by 92 feet
5,700 square feet
143,000 cubic feet

Reverberation time:

Formula: $T = \frac{.05V}{a}$

$T = \frac{.05\ (143,000)}{5857}$

$T = 1.24$

Key:

T = reverberation time

V = room volume

a = total absorbtion

*Source: Building Division, State of Michigan

Appendix B

Appendix B

INTENSITY OF THE STIMULI

Cycles Per Second	Minimum Audible Sound Field In Reference to Attenuator Setting*	Intensity Level Of Presented Stimuli in Reference to Attenuator Setting
500	35 db.	85 db.
2000	30 db.	80 db.
8000	30 db.	80 db.

*The intensity of the stimuli utilized in this emperical study was presented at 50 decibels above the minimum audible field. The minimum audible field was ascertained by determining the threshold for each of the three frequencies tested at a distance of three feet from the source. This procedure was conducted sound field in the actual test room on a pair of normal ears.

Appendix C

Appendix C

PRESENTATION OF STIMULI

Subject Number	Starting Distance	Frequency Tested	Tone Presentation
1	26 feet	500 cps.	Intermittent
2	38 feet	500 cps.	I
3	50 feet	500 cps.	I
4	26 feet	2000 cps.	I
5	38 feet	2000 cps.	I
6	50 feet	2000 cps.	I
7	26 feet	8000 cps.	I
8	38 feet	8000 cps.	I
9	50 feet	8000 cps.	I
10	26 feet	500 cps.	Continuous
11	38 feet	500 cps.	C
12	50 feet	500 cps.	C
13	26 feet	2000 cps.	C
14	38 feet	2000 cps.	C
15	50 feet	2000 cps.	C
16	26 feet	8000 cps.	C
17	38 feet	8000 cps.	C
18	50 feet	8000 cps.	C
19	26 feet	500 cps.	I
20	38 feet	500 cps.	I
21	50 feet	500 cps.	I
22	26 feet	2000 cps.	I
23	38 feet	2000 cps.	I
24	50 feet	2000 cps.	I
25	26 feet	8000 cps.	I
26	38 feet	8000 cps.	I
27	50 feet	8000 cps.	I
28	26 feet	500 cps.	C
29	38 feet	500 cps.	C
30	50 feet	500 cps.	C
31	26 feet	2000 cps.	C
32	38 feet	2000 cps.	C
33	50 feet	2000 cps.	C
34	26 feet	8000 cps.	C
35	38 feet	8000 cps.	C
36	50 feet	8000 cps.	C

Appendix D

Appendix D

ERROR JUDGMENT FOR EACH SUBJECT IN INCHES

Subject	Error Judgment
1	54 Inches
2	7 Inches
3	54 Inches
4	10 Inches
5	111 Inches
6	216 Inches
7	28 Inches
8	51 Inches
9	85 Inches
10	72 Inches *
11	6 Inches
12	39 Inches
13	7 Inches *
14	34 Inches
15	55 Inches
16	9 Inches
17	21 Inches
18	22 Inches
19	192 Inches
20	10 Inches
21	7 Inches
22	46 Inches
23	5 Inches *
24	31 Inches
25	120 Inches
26	72 Inches
27	11 Inches
28	8 Inches *
29	31 Inches
30	2 Inches
31	3 Inches *
32	120 Inches *
33	47 Inches *
34	8 Inches
35	58 Inches
36	35 Inches *

*Nearly all of the subjects tended to overestimate the judgment of ten feet. The asterisk indicates those subjects who underestimated the judgment of ten feet.

MEAN SCORES IN INCHES OF ERROR JUDGMENTS

Variable	Conditions of Variable	Mean Score
Frequency	500 cps.	40.27 Inches
	2000 cps.	57.08 Inches
	8000 cps.	43.33 Inches
Presentation	Continuous	32.06 Inches
	Intermittent	61.72 Inches
Distance	26 feet	46.42 Inches
	38 feet	43.83 Inches
	50 feet	50.42 Inches
F x P	500 cps. - Continuous	26.33 Inches
	2000 cps. - Continuous	44.33 Inches
	8000 cps. - Continuous	25.50 Inches
	500 cps. - Intermittent	54.17 Inches
	2000 cps. - Intermittent	69.83 Inches
	8000 cps. - Intermittent	61.17 Inches
F x D	500 cps. - 26 feet	81.50 Inches
	500 cps. - 38 feet	13.50 Inches
	500 cps. - 50 feet	25.75 Inches
	2000 cps. - 26 feet	16.50 Inches
	2000 cps. - 38 feet	67.50 Inches
	2000 cps. - 50 feet	87.25 Inches
	8000 cps. - 26 feet	41.25 Inches
	8000 cps. - 38 feet	50.50 Inches
	8000 cps. - 50 feet	38.25 Inches
F x D	Continuous - 26 feet	17.83 Inches
	Continuous - 38 feet	45.00 Inches
	Continuous - 50 feet	33.33 Inches
	Intermittent - 26 feet	75.00 Inches
	Intermittent - 38 feet	42.67 Inches
	Intermittent - 50 feet	67.50 Inches