SENSITIVITY OF THE SKIN TO PURE TONE FREQUENCIES

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ABSTRACT

SENSITIVITY OF THE SKIN TO
PURE TONE FREQUENCIES

by Milen Gray

Two groups, comprising thirty-two adolescents and thirty-two adults, were tested to determine to what degree the sensitivity of the skin, in relation to the ability to perceive changes in vibratory sensitivity, is affected by increasing age. This sensitivity was tested by placing a transducer, against the palm of the subject's right hand. A pure tone was introduced into the transducer from a low frequency audio oscillator at an input intensity of 100 decibels (re 0.002dyne/cm^2). The intensity level was held constant during the course of the study. Frequency was varied logarithmically. The test frequencies for this study ranged from 10 to 2000 cycles per second.

Upon completion of the study the test frequencies were divided into 50 cycle band widths. The total number of responses obtained from the adult and adolescent groups were tabulated for each 50 cycle band width. The responses obtained for each band width were then compared for the adult and adolescent groups only up to a limit of 500cps.

The results of this comparison indicated no statistically significant differences between these groups except in the 1-50cps frequency range. A comparison of tactile sensitivity within each group to sound stimuli of selected frequencies was then made. Within the adult group a statistically significant difference was obtained for two of the three sets of frequencies tested. Within the adolescent group a statistically significant difference was obtained for each of the three sets of selected frequencies tested.

In relation to age as a factor in the ability of the skin to respond to changes in pure tone signals there seems to be little difference between the adolescents and adults used in this study. The only significant difference would be in favor of the adolescent group in responding to low frequency pure tone signals in the 1-50cps range. The greatest differences in cutaneous sensitivity seem to occur within each group. In this respect the adolescent group would seem to have a greater range in cutaneous responses to pure tone signals than would the adults. This, however, is still confined to the low frequency ranges.

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CHAPTER I

THE NATURE AND IMPORTANCE OF THE PROBLEM

This study is concerned with the measurement of perceived changes in vibratory stimuli as a function of age.

The purpose of this study is to analyse the results obtained from adolescents and adults in response to changes in pure tone frequencies introduced through the skin.

It is hoped that this study will provide answers to the following questions:

1. Is there a significant difference between adolescents and adults in the ability to notice graduated changes in pure tone frequencies introduced through the skin?
2. Are there any significant differences in tactile sensitivity in relation to selected pure tone frequencies within the adult population?
3. Are there any significant differences in tactile sensitivity in relation to selected pure tone frequencies within the adolescent population?

Hypotheses

To answer the above questions the following null hypotheses have been proposed.

1. There is no significant difference in the responses of adults and adolescents to changes in pure tone frequencies introduced through the skin.
2. There is no significant difference in tactile sensitivity to selected pure tone frequencies within the adult population.
3. There is no significant difference in tactile sensitivity to selected pure tone frequencies within the adolescent population.

Importance of the Study

It is thought that a measure of cutaneous sensitivity to sound stimuli might be valuable in planning for future developments that would utilize this avenue in the rehabilitation of the hard of hearing person.

Definition of Terms

For the purpose of this study, the terms used are defined in the following manner:

Adolescent Population--Individuals ranging in age from thirteen to twenty-one years of age.

Adult Population--Those individuals over twenty-one years of age.

Cutaneous Area--Relating to the fatty portion of the inner palm of the right hand.

Vibratory Sensitivity--Sensitivity of the skin to stimulation by a vibrating medium as introduced through electrical current.

CHAPTER II

REVIEW OF THE LITERATURE

The Effects of Age on Vibratory Sensitivity

In a review of the literature pertaining to the relationships between vibratory sensitivity and age, a decrease of vibratory sensitivity in the later periods of life has been noted. There tends to be a loss of sensitivity in the ability of the skin to perceive vibration.[1]

According to Pearson other authors have noted the decrease of this sensory modality. This sensitivity seems to be greater in childhood and adolescence and then seems to diminish with age, particularly after the fifth decade. Pearson also found that the ability to perceive vibratory stimuli from the lower extremities becomes impaired in most persons after the fifth decade. Pearson noted that Egger found that although vibratory sensitivity may decrease with advancing age, a number of persons tested by him aged 60, 70, and 80 and one over a hundred retained their acutness of perception.[2]

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[1]James E. Birren, "Vibratory Sensitivity in the Aged," Journal of Gerontology, II (1947), 267-268.

[2]G. H. J. Pearson, "Effect of Age on Vibratory Sensibility," Archives of Neurology and Psychiatry, XX (1928), 482-496.

The Range of Cutaneous Sensitivity

Geldard noted in reviewing the range of frequencies yielding sensations of vibration that whereas it is found that little agreement exists as to what the upper and lower limits are, various curves uniting frequency and threshold amplitude are somewhat universal. Geldard makes note of the maximum sensitivity as being in the region of 250 cycles per second. However, the upper limit is not known because of the technical difficulties of moving the skin at high frequencies.[3]

Cutaneous Sensitivity in Relation to Body Areas

Mason noted that:

> A distinction is frequently made between sensations of touch, relating to light contact, and of pressure, relating to increased application of force

in cutaneous sensitivity studies.[4]

Gilmer found that: (1) The regions of the skin most sensitive to mechanical vibration were those spots which were also highly sensitive to pressure, (2) There was a marked difference between the dorsal and ventral sides of the arm with respect to vibratory sensitivity stimulation.

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[3]F. A. Geldard, "The Perception of Mechanical Vibration," Journal of General Psychology, XXII (1940), 281-289.

[4]R. E. Mason, Internal Perception and Bodily Functioning (New York: International Universities Press, Inc., 1961), p. 344.

In general, the data support the hypothesis that vibratory sensations form a perceptual pattern of feeling of which pressure is but another temporal expression.[5]

Geldard agrees with Gilmer's pressure hypothesis and goes on to state in somewhat different phraseology that "vibration involves a mode of operation of the pressure sense." Geldard in reviewing the literature pertaining to the effect of changing the pressure component of the stimulation noted that Cohen and Lindley (1938), found vibratory thresholds (for a single frequency, 60cps) to be lowered by increased pressure applied to the contactor. This effect they attributed to "mechanical factors of increased compression of tissue which under such circumstances may become a better medium for the conduction of vibration." Godfrey (1934), delivering low frequency vibrations (25-100cps), found resulting sensations to be localized further and further from the fingers with increasing pressure.[6]

Knudsen found that the amplitude of vibration, for a given frequency, seemed to be the important factor in determining the intensity of vibration, and the amplitude of

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[5]B. V. H. Gilmer, "The Measurement of the Sensitivity of the Skin to Mechanical Vibration," Journal of General Psychology, XIII (1935), 42-61.

[6]F. A. Geldard, "The Perception of Mechanical Vibration: I. The History of the Controversy," Journal of General Psychology, XXII (1940), 243-269.

vibration was used in measuring sensitivity. The frequency of a vibrating body must change as much as 15 to 30 percent before a difference is noticeable by the sense of touch. Touch is not well adapted to recognizing small changes of frequency.[7]

Babkin, et al., discovered a clcse relationship between the magnitude of stimulated surface and the measured threshold of perceived vibration: increase of stimulated area leads to decrease of threshold.[8]

Gilmer in a study dealing with the sensitivity to mechanical vibration of different regions of the hand and forearm found that the most sensitive areas tested were the fatty portions of the palmer side of the hand and finger tips. He also noted that larger contacting media gave smaller values when lower frequencies were used; at higher frequencies size was not a variable.[9]

Shewchuk and Zubek studied the discriminatory ability of various skin areas as measured by a means of intermittent stimulation. The technique used was an interrupted

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[7]V. O. Knudsen, "Hearing With the Sense of Touch," Journal of General Psychology, I (1928), 320-352.

[8]V. P. Babkin, O. M. Rozen, L. N. Turmarkina, and R. I. Cherniak, "The Study of Vibrational Sensitivity and the Factors Influencing It," Biofizika, VI (1961), 61-67.

[9]B. V. H. Gilmer, "The Measurement of the Sensitivity of the Skin to Mechanical Vibration," Journal of General Psychology, XIII (1935), 42-61.

air stream that stimulated the tongue, lip, cheek, forehead, neck, tip of the index finger, thumb, back of the hand, forearm and upper arm. For each of these locations a critical frequency of percussion (cfp) was determined. The relationship between (cfp) and pressure was the same for all 10 skin areas tested. The (cfp) for the lip, tongue, and thumb was higher than that of the arms, neck, and cheek.[10]

Békésy commented that it is known that the skin of the arm is less sensitive than the skin on the thumb. He further commented that this difference is a consequence of the fact that the area of the sensory cortex corresponding to a unit of surface on the thumb is much larger than that corresponding to a unit of surface on the arm.[11]

Adaptation and Fatigue of the Skin to Cutaneous Stimulation

Wedell and Cummings studied fatigue of the vibratory sense. They discovered adaptation to be a function of both amplitude and frequency, being greater for the higher values of each. They also found that sensitivity to vibratory stimulation applied to the palm of the hand is reduced

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[10]L. A. Shewchuk and John P. Zubek, "Discriminatory Ability of Various Skin Areas as Measured by a Technique of Intermittent Stimulation," Canadian Journal of Psychology, XIV (1960), 244-248.

[11]Georg von Békésy, Experiments in Hearing (New York: McGraw-Hill Book Co., 1960), pp. 564-565.

5 to 15 decibels after three minutes of continuous stimulation. The loss of sensitivity is greater, the higher the frequency, and the greater the intensity of the fatiguing tone. The effect proved to be somewhat non-specific in that, after three minutes of continuous stimulation, the loss was the same for a test frequency higher than or equal in frequency to the fatiguing one. Less decline had apparently occured if the test frequency was lower than the original.[12]

Katz found that the sense of touch tires very readily but that the vibratory sense shows very little the effects of fatigue.[13]

Relationship Between Cutaneous Sensitivity and Other Modalities

Békésy noted that:

> When continuous vibratory stimuli are presented on the skin the subject can differentiate several attributes: (1) the frequency of the vibration, which is analogous to pitch in hearing, (2) the subjective magnitude of the sensation, which has many features in common with loudness in hearing and (3) the sensation of the lateral spread along the surface of the skin, which corresponds to the volume of the sound in hearing.[14]

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[12]C. H. Wedell and S. B. Cummings, Jr., "Fatigue of the Vibratory Sense," Journal of Experimental Psychology, XXII (1938), 429-438.

[13]K. Katz, "The Vibratory Sense and Other Lectures," The Maine Bulletin, XXXII (1930), p. 10.

[14]Georg von Békésy, "Funneling in the Nervous System," Journal of the Accoustical Society of America, XXX (1958), 399-412.

These three attributes Békésy referred to as vibratory pitch, or pitch; vibratory magnitude, or loudness; and lateral spread.

Hawkes concluded that auditory or cutaneous signals will generally be usable in the situation where the observer's task is to detect the presence or absence of a signal.[15]

Yacorzynski in attempting to determine the minimal number of vibratory thresholds, as a function of amplitude of stimulation at different frequencies noted in conclusion that:

> It is necessary to study the vibratory threshold of an individual case over a number of days in order to get a good approximation of his actual threshold under the conditions studied.[16]

Summary of the Literature

It has been noted, in reference to the relationship between vibratory sensitivity and age, that this sensitivity seems to be greater in childhood and adolescence and then tends to decrease with advancing age but not always consistently. In reference to the range of frequencies yielding sensations of vibration there seems to be little agreement as to the upper or lower limits, although one author notes

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[15] G. R. Hawkes and M. Loeb, "Vigilance for Cutaneous and Auditory Signals," Journal of Auditory Research, I (1961), 272-284.

[16] G. K. Yacorzynski and M. Brown, "Studies of the Sensation of Vibration," Journal of Experimental Psychology, XXVIII (1941), 509-516.

the maximum range of sensitivity as being in the region of 250cps. In cutaneous sensitivity studies a distinction is frequently made between sensations of touch and of pressure. It is generally felt that the use of pressure, relating to the increased compression of tissue, provides a better medium for the conduction of vibration than does that of touch, relating to light contact. There seems to be little specific agreement regarding those areas of the body which may be regarded as more sensitive to vibratory stimulation than others. It has been noted that the sensitivity of the skin to vibratory stimulation tends to diminish after a period of continuous stimulation. This loss of sensitivity appears to be greater the higher the frequency and the greater the intensity of the fatiguing tone. It was noted in some instances with the presentation of vibratory stimuli on the skin the subject can differentiate some attributes which are similar to pitch, loudness and volume in hearing. It was also felt that cutaneous signals can generally be used in situations where the observer's task is to determine the presence or absence of a signal.

CHAPTER III

SUBJECTS, EQUIPMENT, AND TESTING PROCEDURES

Subjects

The first group of subjects participating in this study consisted of thirty-two high school seniors from the Watervliet High School, Watervliet Michigan. The second group of subjects participating in this study consisted of thirty-eight adults drawn from the membership of Lodge 544, Fraternal Order of Elks, Benton Harbor, Michigan and the Benton Harbor chapter of the Kappa Theta Chi sorority. The sole criteria for participation in this study was that of age.

The adult group consisted of thirty-six Caucasians and two Negroes. All members of the adolescent group were Caucasian.

Of the thirty-eight adults tested six were eliminated from this study because of failure to respond to any frequency tested. Their failure to respond to this study is open to question either because of lack of skin sensitivity, misunderstanding of directions, or some other unknown cause. The members of this group consisted of

one male thirty-four years of age, one Negro male sixty-five years of age, three females thirty-five, forty-three, and forty-seven years of age, and one Negro female forty-seven years of age. The remaining thirty-two adult subjects used in this study consisted of twenty-one males and eleven females ranging in age from 24 to 78.4 years with a mean age of 43 years, a median age of 41.6 years and a standard deviation of 4.2 years.

The thirty-two adolescents used in this study consisted of nine males and twenty-three females ranging in age from 16.9 years to 18.7 years with a mean age of 16.2 years, a median age of 17.4 years and a standard deviation of .04 years.

The original seventy subjects were tested during the week of September 30 to October 4, 1963. The adolescent group was tested in the morning and afternoon of October 1, 1963 at the Watervliet High School, in an unused room provided for that purpose. The adult females were tested during the evening of October 1st at the private residence of one of the members of the Kappa Theta Chi sorority. The male adult members of the Fraternal Order of Elks were tested at the lodge hall on the afternoon of and evening of October 3rd and during the afternoon of October 4th.

Equipment

The equipment utilized for this study consisted of the following:

1. One Acoustically Treated Plywood Box.
2. Four - Channel Master 2-1/4" Speakers affixed with a tight membrane over the cone front, mounted on a metal frame in such a manner as to permit variation of pressure on the skin area.
3. A Low Frequency Audio Oscillator, Model No. 202C, Hewlett-Packard, with a constant drive 115 volt synchronous motor attached by a flat drive belt to the frequency dial.
4. One Tape Recorder - Wollensak, Model No. T1500, produced by the Minnesota Mining and Manufactoring Company.
5. Tape recording of broad spectrum white noise.
6. One set of earphones - Telephonics TDH-39.
7. One desk bell.

Procedure

Orientation to the Test Situation

Each subject was asked to participate in a scientific experiment designed to test the sensitivity of the skin to various pure tone frequencies. He was informed that he was not being asked to make evaluations that would involve any

judgements of right or wrong on his part. The use of the earphones and the introduction of broad spectrum white noise to minimize auditory cues was also explained beforehand. The use of the desk bell to indicate individual responses as they were felt was explained. Each subject was requested to ring the bell when he first felt the presence of any type of sensation on the skin and to continue to indicate any subsequent changes or differences noted until a point was reached where no further changes could be felt by the subject under test.

Procedure During Testing Situation

Each subject participating in the study was seated at a table upon which rested an acoustically treated plywood box. Contained within this box were four transducers affixed with a tight membrane over the cone front. These transducers were mounted on a metal frame in such a manner so as to permit variation of pressure on the skin area. This framework was placed in line with an insulated opening in the side of the plywood box through which the subject's right hand was introduced. The subject was requested to place his hand so that the palmer area was facing the first transducer. At this point the transducer was placed firmly against the fatty portion of the palmer area by the tester and the box closed. The subject was then given the

necessary instructions regarding the procedure to be followed during the course of this study:

> When the experiment begins you will at some point begin to experience a type of vibration coming from the speaker cone resting against the palm of your hand. As soon as you become aware of any type of sensation against your palm I want you to ring this desk bell and to continue ringing this bell each time you feel any type of a change in the vibration against your palm. We will continue as long as you are able to experience any type of change in this vibration or until the vibration seems to disappear. Please remember that there are no right or wrong answers involved in this experiment. I am only interested in your reactions to the vibrations felt against the palm of your hand. Do you have any questions at this point?

After the initial instructions had been completed the earphones were placed on the subject's head and broad spectrum white noise was introduced at a volume level pre-determined by the tester. The subject was seated so that a minimum of visual cues would be received through observation of the tester or movements of the frequency dial of the low frequency audio oscillator.

At this point a pure tone of 10cps was introduced to the transducer from the audio oscillator at an input intensity level of 100 decibels (re 0.002dyne/cm^2). This intensity level was held constant during the entire course of this study. Frequency was varied logarithmically. The rate of increase in frequency was controlled by a 115 volt constant drive synchronous motor attached to the frequency dial of the low frequency audio oscillator by a

flat drive belt. Speed was thus held constant during the course of the study. With each response of the subject under test, indicated by the ringing of the desk bell, the corresponding frequency response was read from the frequency dial and entered on a form (see appendix 3, p. 30) corresponding to the cycle units inscribed upon th frequency dial.

The original band width to be tested was 40-900 cycles per second. During the course of each test the initial frequency level was lowered to 10cps and allowed to reach a maximum of 2,000cps as long as the subject continued to respond to the perceived vibration emanating from the transducer. This was done to cover differences in level of response for subjects in the test situation. The elapsed time involved during the experiment was three minutes with an additional four to five minutes for instructions and questions by the subject.

CHAPTER IV

RESULTS AND DISCUSSION

Upon completion of this study the test frequencies 1-2000 cycles per second were divided into 50 cycle band widths ranging from 1-50cps to 1051-2000cps. The total number of responses obtained from the adult and adolescent groups were then tabulated and the number of responses entered for each 50 cycle band width (see Appendix I, pp. 31-32 and Appendix II pp. 33-34).

The total number and percentage of adults and adolescents responding to each 50 cycle band width are presented in Table 1.

The number of adults responding within each 50 cycle band width shows a marked decrease at the 101-150cps level. A similar decrease is noted for the adolescent group at the 151-200cps levels. Although some irregular gain is made for both groups beyond these frequency level up to 651-700cps neither group approaches the 50 percent level of numbers responding. The number of subjects responding to test frequencies 701-750 cps and beyond then diminishes consistently for both groups.

Figure 1 presents a graphic illustration of the reduction in cutaneous sensitivity according to the

percentage of subjects responding within each 50 cycle band width. For the purposes of presentation the percentages listed in Table 1 have been rounded to whole numbers.

TABLE 1 --Number and percentage of adults and adolescents responding to test frequencies in band widths of 50 cycles.

Frequency Range	No. of Adol. Responding Total-32	% Adol. Responding	No. of Adults Responding Total-32	% Adults Responding
1-50	27	86.4	15	48.
51-100	31	99.2	30	96.
101-150	22	70.4	16	50.
151-200	16	50.	9	28.8
201-250	8	25.6	14	44.8
251-300	12	38.4	10	32.
301-350	12	38.4	3	9.6
351-400	6	19.2	7	22.4
401-450	8	25.6	4	12.8
451-500	10	32.	5	16.
501-550	7	22.2	10	32.
551-600	5	16.	10	32.
601-650	3	9.6	3	9.6
651-700	8	25.6	5	16.
701-750	1	3.2	2	6.4
751-800	2	6.4	1	3.2
801-850	4	12.	2	6.4
851-900	4	12.	0	. .
901-950	0	. .	1	3.2
951-1000	5	16.	0	. .
1001-1050	1	3.2	0	. .
1051-2000	1	3.2	2	6.4

The percentage of responses for the adolescent group, in reference to peak response levels below the 50 percent level, at 200cps and for band widths 500,700, and 1000cps presents an almost gradual decrease with frequency

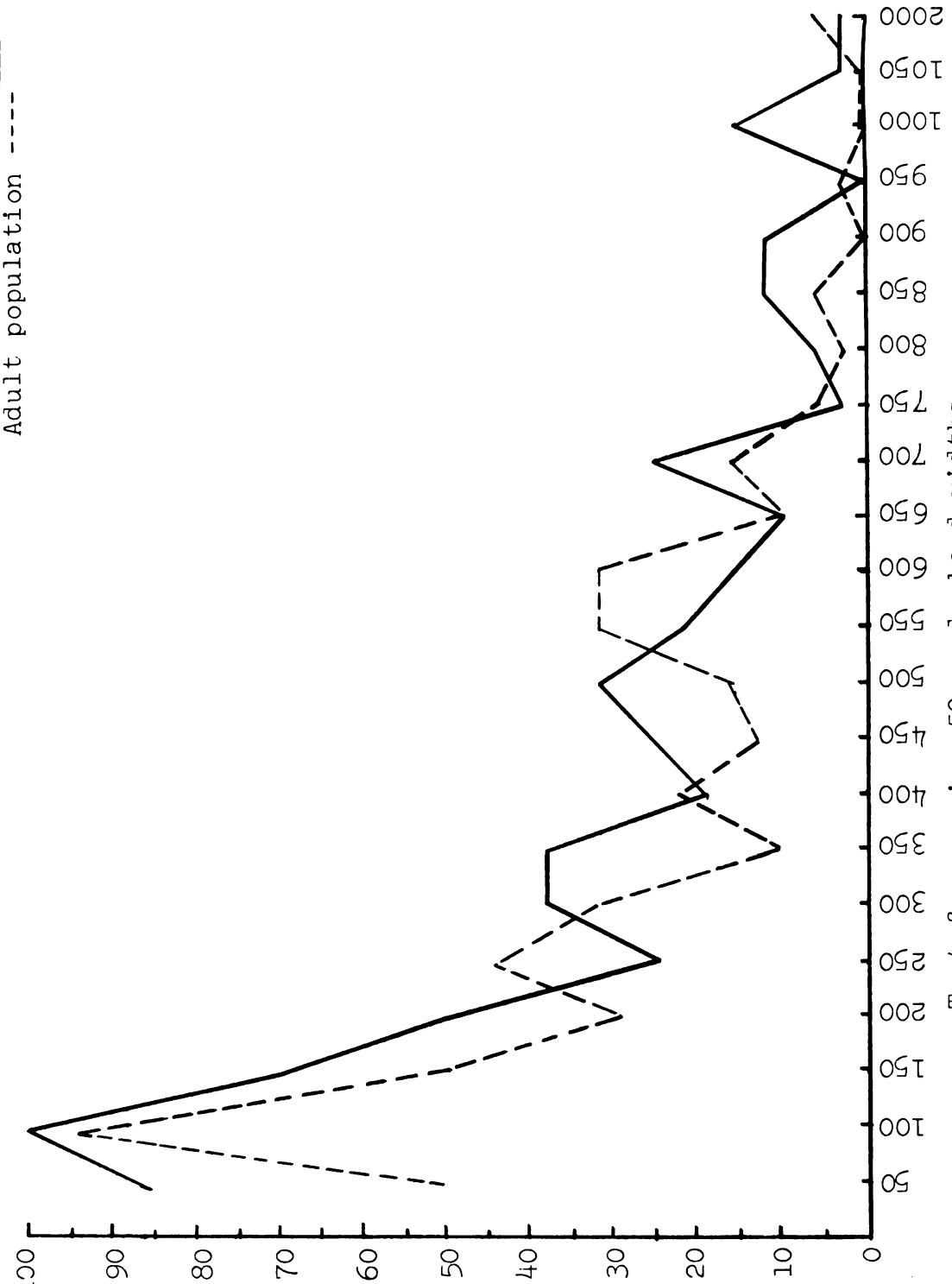


Figure 1.--Percentage of adults and adolescents responding to test frequencies 1-2000cps in 50 cycle band widths.

intervals of 300, 200, and 300cps for the band widths noted above. In comparison, the percentage of adult responses below the 50 percent level at 150cps takes a sharp drop after 240cps; and the peaks remain compressed for band widths 350, 700, 850, and 950cps with frequency intervals of 150, 300, 150, and 100cps for the band widths noted above.

The responses obtained within each 50 cycle band width were then compared for the adult and adolescent groups up to 500cps. The 451-500 cycle band width was used as a cut off point for analysis due to the lack of multiple responses, for either group, beyond this point. The means and *t*-scores obtained from this comparison appear in Table 2.

TABLE 2.--An analysis of responses comparing adolescents and adults for test frequencies 1-500cps in 50 cycle band widths.

Frequency Range	Mean Score Adult	Mean Score Adolescent	df	*t*	Level of Confidence
1-50	0.7500	1.9062	62	4.22	Sig. at 1%
51-100	2.0625	2.5372	62	1.52	Non sig 5%
101-150	1.1562	1.1875	62	0.08	" 5%
151-200	.3750	0.5000	62	.83	" 5%
201-250	.4375	.3125	62	.89	" 5%
251-300	.3125	.3750	62	.52	" 5%
301-350	.0937	.3750	62	1.48	" 5%
351-400	.2500	.1875	62	.54	" 5%
401-450	.1250	.2812	62	1.41	" 5%
451-500	0.1562	0.3437	62	0.99	" 5%

As indicated the only statistically significant difference for these groups appear in the 1-50cps band width beyond the 1 percent level of confidence. This statistically significant difference for the adolescent group at the 1-50 cps level may be due to a greater sensitivity to cutaneous stimulation for this particular range of low frequency pure tone signals than for the adult group.

The responses for the adult and adolescent groups were then analysed separately for a selected set of test frequencies to determine if any significant difference existed within each group in relation to tactile sensitivity. The means and t-scores for the comparisons within the adult group appear in Table 3.

TABLE 3.--A comparison of tactile sensitivity within the adult group to sound stimuli of selected frequencies.

Frequency Range	Mean Score	df	t	Level of Confidence
1-50cps 51-100cps	0.7500 2.0625	62	4.77	Sig. at 1%
1-50 cps 101-150cps	0.7500 1.1562	62	1.11	Non sig. 5%
51-100cps 101-150cps	2.0625 1.1562	62	2.32	Sig. at 5%

The means and t-scores for the adolescent group appear in Table 4.

TABLE 4.--A comparison of tactile sensitivity within the adolescent group to sound stimuli of selected frequencies.

Frequency Range	Mean Score	df	*t*	Level of Confidence
1-50cps 51-100cps	1.9062 2.5312	62	2.03	Sig. at 5%
1-50cps 101-150cps	1.9062 1.1875	62	2.44	" 5%
51-100cps 101-150cps	2.5312 1.1875	62	4.55	" 1%

As indicated the *t*-scores for the adult group are statistically significant at the 1 and 5 percent level of confidence for two of the three sets of selected test frequencies. The *t*-scores for the adolescent group being statistically significant for all three sets of selected test frequencies either at the 5 or 1 percent level of confidence.

In both instances where a statistically significant difference was obtained, to selected pure tone frequencies, within the adult group the critical frequency range was 51-100cps. For the adult group this would appear to be the frequency range which provides the greatest degree of variability in sensitivity to cutaneous stimulation within this population.

For the adolescent group the pure tone frequencies yielding statistically significant differences were the

1-50 and 51-100 cycle band widths. There appears to be a greater range of response to cutaneous stimulation for low frequency pure tone signals within the adolescent group than for that within the adult group.

In reference to Table 2, there does not seem to be any differences, in relation to a decrease in vibratory sensitivity according to age among adolescents and adults except for frequencies ranging from 1-50 cycles per second. The findings in this area are contrary to those noted in Chapter II, p. 4, where sensitivity was reported as being greater in childhood and adolescence and then tending to diminish with increasing age. In some instances (see Table 1 and Figure 1.) the adult group exceeded the adolescent group in different frequency ranges although not significantly so. It is possible that with the use of larger numbers of subjects and more precise equipment that a more significant difference might be found to exist.

During the course of this study, subjects from both the adult and adolescent groups reported that once the pure tone signals, introduced through the skin, reached a certain peak they rapidly diminished until no sensation could be perceived. It would appear that the point where the last response for each subject was recorded (see Appendix I, pp. 31-32 and II, pp. 33-34) may be the last point where any degree of sensation could be perceived by the

subjects tested in this study. This would tend to indicate a wide range of individual thresholds in responses to higher frequency ranges.

Inquiries regarding the type of sensation perceived by individual subjects was almost universally one of pressure which gradually increased and then diminished. A number of comments were also made by the subjects to the effect that as the sensation of pressure increased the signal became localized further and further from the original point of contact.

The six adults who failed to respond to any frequency range (see Chapter III, p. 10) presented a problem which was not expected at the beginning of this study. Although care was taken that all subjects understood the directions before the actual experiment began (see Chapter III, p. 13), it is possible that the subjects failed to understand the directions adequately and as a result did not respond to the test frequencies as desired. It is interesting to note that of the six subjects failing to respond in this study four were females in their middle thirties or late fourties. Another point of interest is the fact that of the only two Negro subjects used in this study both failed to respond to any of the test frequencies.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

Summary

Two groups, comprising thirty-two adolescents and thirty-two adults, were tested to determine to what degree the sensitivity of the skin, in relation to the ability to perceive changes in vibratory sensitivity, is affected by increasing age. This sensitivity was tested by placing a transducer, contained within an acoustically treated plywood box, against the palm of the subject's right hand. A pure tone was introduced into the transducer from a low frequency audio oscillator at an input intensity of 100 decibels (re 0.002dyne/cm^2). The intensity level was held constant during the course of the study. Frequency was varied logariythmically. The test frequencies for this study ranged from 10 to 2000 cycles per second.

Upon completion of the study the test frequencies were divided into 50 cycle band widths. The total number of responses obtained from the adult and adolescent groups were tabulated for each 50 cycle band width. The responses obtained for each band width were then compared

for the adult and adolescent groups only up to a limit of 500cps.

The results of this comparison indicated no statistically significant difference between these groups except in the 1-50cps frequency range. A comparison of tactile sensitivity within each group to sound stimuli of selected frequencies was then made. Within the adult group a statistically significant difference was obtained for two of the three sets of frequencies tested. Within the adolescent group a statistically significant difference was obtained for each of the three sets of selected frequencies tested.

Conclusions

In relation to age as a factor in the ability of the skin to respond to changes in pure tone signals, there seems to be little difference between the adolescents and adults used in this study. The only significant difference would be in favor of the adolescent group in responding to low frequency pure tone signals in the 1-50cps range. The greatest differences in cutaneous sensitivity seem to occur within each group. In this respect the adolescent group would seem to have a greater range in cutaneous responses to pure tone signals than would the adults. This, however, is still confined to the low frequency ranges.

Within the framework of this study it seems justifiable to make the following conclusions:

1. There is no significant difference in the responses of adults and adolescents to changes in pure tone frequencies introduced through the skin, with the exception of the frequency range of 1-50cps.

2. There is a significant difference in tactile sensitivity to selected pure tone frequencies within the adult population.

3. There is a significant difference in tactile sensitivity to selected pure tone frequencies within the adolescent population.

Suggestions For Further Research

In considering the findings which have resulted from this study there are several areas which may prove of interest for further study.

Although the responses of the subjects used in this study were to some extent reactions to just noticeable differences in changes of frequency it is felt that a more precise evaluation of responses to lower and higher frequency ranges could be accomplished by the use of equipment which would record the response of the skin directly without involving overt reactions by the subjects.

Since intensity was one of the variables controlled in this study it would be of interest to note the skin

response to frequency ranges which are presented at different intensity levels.

The investigation of possible relationships between auditory and cutaneous responses to pure tone signals may be of special interest particularly in the lower frequency ranges where there seems to be more sensitivity in cutaneous stimulation to pure tone signals.

APPENDICES

APPENDIX I.--Total Number of Responses, Within 50 Cycle Band Widths, for Test Frequencies 1-2000cps for Adult Population.

Yrs.	Mos.	Sex	1-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700
24	-	M	1	0	0	0	1	0	0	0	0	0	0	1	0	0
28	1	F	1	2	2	0	1	0	0	0	0	1	0	0	0	0
28	5	M	0	0	1	0	0	1	0	0	0	0	0	0	0	0
28	6	F	0	1	0	0	0	0	0	0	0	0	0	0	0	0
31	3	F	0	3	8	2	1	1	0	0	0	0	1	1	0	0
31	10	F	2	3	1	1	1	0	0	0	0	0	0	0	0	0
31	10	F	1	1	0	0	0	0	0	0	0	1	0	0	0	1
33	1	F	0	2	0	0	0	0	0	1	0	0	1	0	1	0
33	9	F	3	1	1	1	1	0	0	1	0	0	1	0	0	0
34	9	M	3	5	2	2	0	1	1	1	0	0	0	1	0	0
35	11	M	2	2	2	1	1	0	0	1	0	0	1	0	0	0
36	9	F	0	1	1	0	0	0	0	0	0	0	0	1	0	0
37	2	M	0	1	0	0	0	1	0	0	0	0	0	1	0	0
39	6	F	0	1	0	0	0	0	0	0	0	0	0	0	0	1
40	2	M	0	2	0	0	0	1	0	0	0	0	1	0	0	0
40	3	M	0	5	2	0	0	0	0	1	1	1	1	0	0	0
43	6	M	1	3	1	0	0	0	1	2	0	0	1	0	0	0
43	9	M	0	3	3	2	0	1	0	0	0	0	1	1	0	0
45	1	M	0	3	0	0	1	0	0	1	1	0	0	1	0	0
45	6	F	2	2	0	0	0	0	0	0	0	0	0	0	0	1
45	9	F	0	1	0	0	0	0	0	0	0	0	0	0	0	0
46	2	M	1	1	6	0	1	0	0	0	0	0	0	1	0	0
46	9	M	2	2	1	1	0	1	0	0	0	0	1	0	0	0
46	11	M	0	2	0	0	0	0	0	0	0	0	1	0	0	0
47	6	M	0	3	2	1	1	1	0	0	0	0	0	0	0	0
48	-	M	0	2	0	0	0	0	0	0	0	1	0	0	1	0
61	9	M	1	1	0	0	1	0	0	0	0	0	0	0	0	0
61	9	M	1	2	0	0	1	0	0	0	0	0	0	1	0	0
64	2	M	0	1	1	0	1	0	0	1	0	0	0	0	0	1
65	8	M	1	2	0	0	0	0	0	0	1	0	0	0	0	0
65	9	M	0	4	0	0	1	1	0	0	0	0	0	0	0	0
78	4	M	2	4	3	1	1	1	1	0	0	1	0	1	0	0

APPENDIX I--Continued

Yrs.	Mos.	Sex	701-750	751-800	801-850	851-900	901-950	951-1000	1001-1050	1051-2000
24	-	M	0	0	0	0	0	0	0	0
28	1	F	0	0	0	0	0	0	0	0
28	5	M	1	0	0	0	0	0	0	0
28	6	F	0	0	1	0	0	0	0	0
31	3	F	0	0	0	0	0	0	0	0
31	10	F	0	0	0	0	0	0	0	0
31	10	F	0	0	0	0	0	0	0	0
33	1	F	0	0	0	0	0	0	0	0
33	9	F	0	0	0	0	1	0	0	0
34	9	M	1	0	0	0	0	0	0	0
35	11	M	0	0	0	0	0	0	0	0
36	9	F	0	0	0	0	0	0	0	0
37	2	M	0	0	0	0	0	0	0	0
39	6	F	0	0	0	0	0	0	0	0
40	2	M	0	0	0	0	0	0	0	0
40	3	M	0	0	0	0	0	0	0	0
43	6	M	0	1	0	0	0	0	0	0
43	9	M	0	0	0	0	0	0	0	0
45	1	M	0	0	0	0	0	0	0	0
45	6	F	0	0	0	0	0	0	0	0
45	9	F	0	0	0	0	0	0	0	0
46	2	M	0	0	0	0	0	0	0	0
46	9	M	0	0	0	0	0	0	0	0
46	11	M	0	0	0	0	0	0	0	0
47	6	M	0	0	0	0	0	0	0	0
48	-	M	0	0	0	0	0	0	0	0
61	9	M	0	0	0	0	0	0	0	0
61	9	M	0	0	0	0	0	0	0	1
64	2	M	0	0	0	0	0	0	0	0
65	8	M	0	0	0	0	0	0	0	1
65	9	M	0	0	0	0	0	0	0	0
78	4	M	0	0	1	0	0	0	0	0

APPENDIX II.--Total Number of Responses, Within 50 Cycle Band Widths, for Test Frequencies 1-2000cps for Adolescent Group.

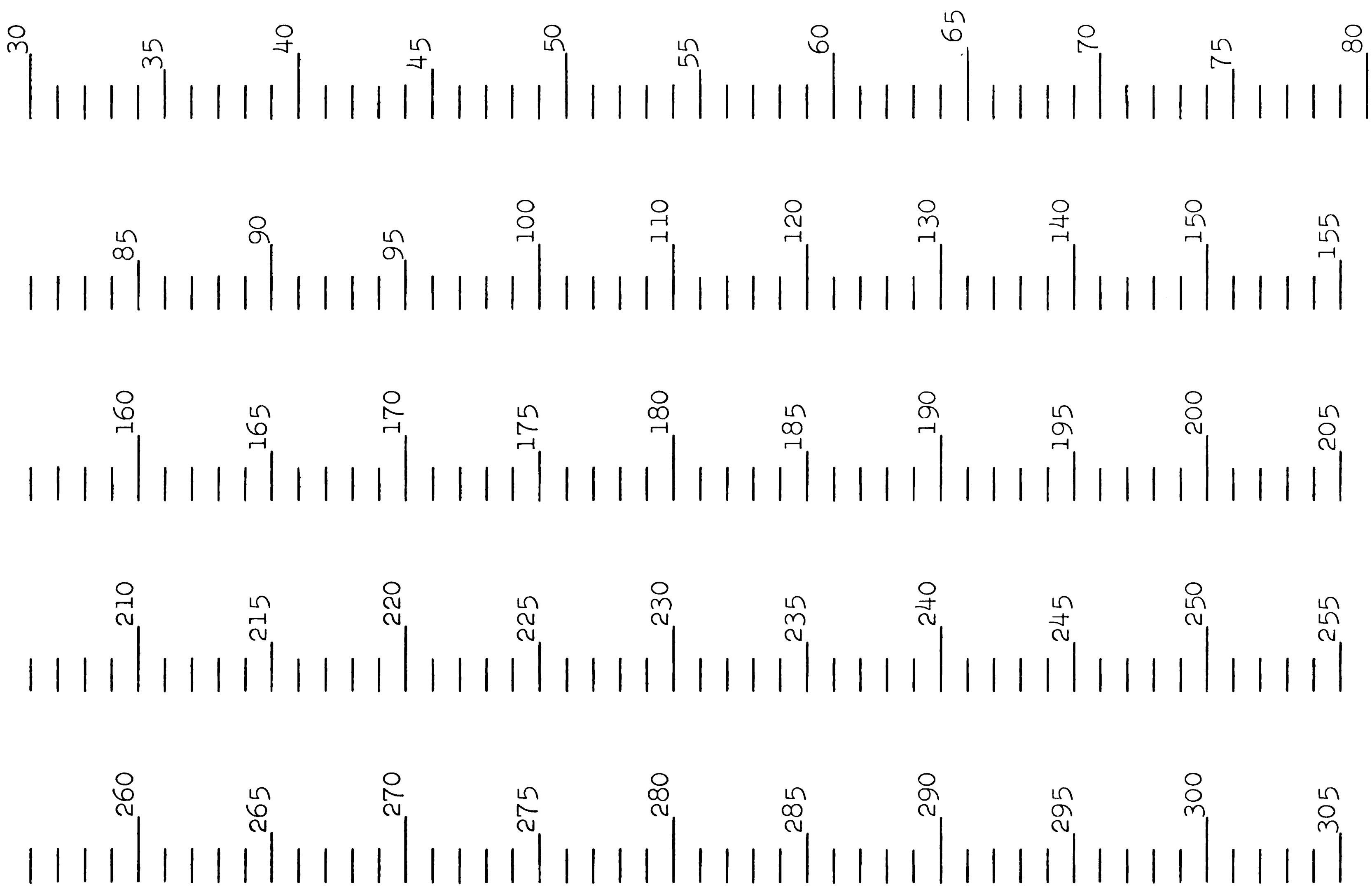
Yrs.	Mos.	Sex	1-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700
16	9	F	1	3	1	1	0	1	0	1	1	0	0	0	0	0
16	10	M	3	3	0	0	0	1	1	0	2	1	0	0	0	0
16	10	M	4	2	0	1	0	1	0	0	0	0	1	0	0	0
16	11	F	0	2	0	0	1	0	1	0	0	0	0	0	0	0
16	11	F	2	2	1	1	0	0	0	1	0	0	0	0	0	1
17	-	M	1	3	0	0	0	0	1	0	0	0	0	1	0	0
17	-	F	2	2	3	1	0	1	0	1	0	1	0	0	1	0
17	-	F	0	2	0	1	0	1	0	0	0	0	0	0	0	0
17	1	F	2	3	1	0	0	0	0	1	1	0	0	0	0	0
17	1	F	2	1	1	0	0	0	0	0	1	0	0	0	0	0
17	1	M	0	5	3	1	1	1	0	0	0	1	0	1	0	0
17	1	M	3	1	2	0	0	0	1	0	1	0	0	0	0	0
17	3	F	1	2	2	1	0	1	0	0	0	1	0	0	0	0
17	3	F	2	3	0	0	0	0	0	0	0	0	0	1	0	0
17	4	F	3	4	0	0	0	1	0	0	0	0	1	0	0	0
17	4	F	2	1	1	0	0	0	0	0	0	0	1	0	0	0
17	5	F	1	3	1	0	0	0	0	0	0	2	0	0	0	0
17	5	F	3	4	0	1	0	0	0	0	0	0	1	0	0	0
17	6	M	0	4	2	0	1	1	1	1	0	0	0	0	1	0
17	7	F	3	3	0	1	0	1	1	0	0	1	0	0	0	0
17	7	F	2	1	1	0	0	0	0	0	0	0	0	1	0	0
17	7	M	1	2	1	0	0	0	0	0	0	0	0	0	1	0
17	8	F	2	2	3	1	0	0	1	0	0	0	0	0	0	0
17	8	M	0	1	1	0	0	1	0	0	0	0	1	0	0	1
17	9	F	2	0	2	0	0	0	1	0	0	1	0	0	0	1
17	9	F	1	4	1	0	0	0	0	0	0	0	0	0	0	0
17	11	F	3	2	0	1	1	0	1	0	1	0	0	0	0	0
17	11	F	3	2	1	1	0	0	1	0	0	1	0	1	0	1
17	11	F	6	2	4	1	1	1	1	0	0	1	0	0	0	0
17	11	F	2	3	1	1	1	0	0	0	1	0	1	0	0	1
17	11	M	2	4	2	1	2	0	0	1	0	1	0	0	0	0
18	7	F	2	5	3	1	2	0	1	0	1	0	1	0	0	1

APPENDIX II--Continued

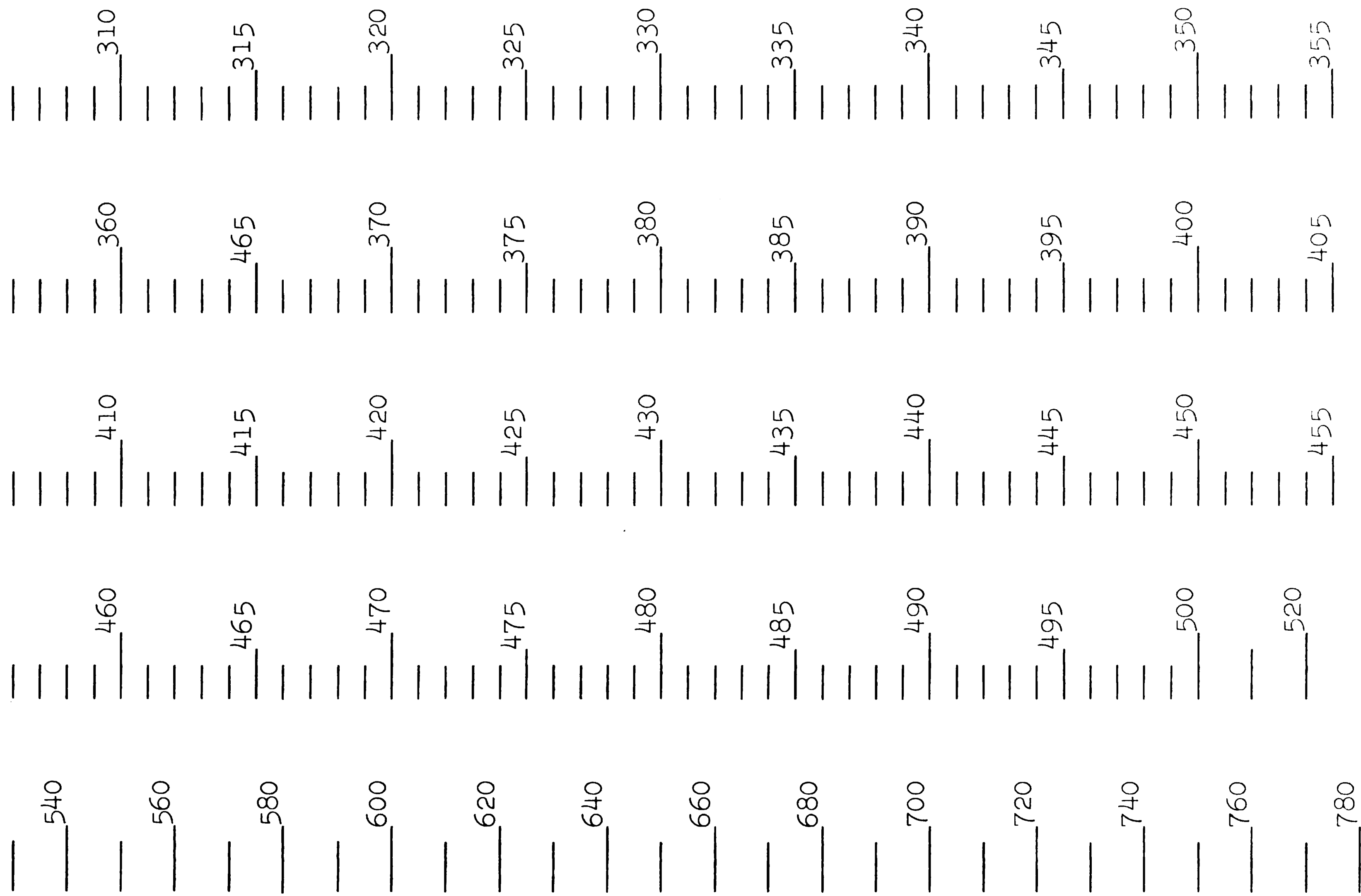
Yrs.	Mos.	Sex	701-750	751-800	801-850	851-900	901-950	951-1000	1001-1050	1051-2000
16	9	F	0	0	0	0	0	0	0	0
16	10	M	0	0	0	0	0	0	0	0
16	10	M	0	0	0	0	0	0	0	0
16	11	F	0	0	0	1	0	0	0	0
16	11	F	0	0	0	0	0	0	0	0
17	-	M	0	0	0	0	0	0	0	0
17	-	F	0	0	0	0	0	0	0	0
17	-	F	0	0	0	0	0	0	0	0
17	1	F	0	0	0	0	0	0	0	0
17	1	F	0	0	0	0	0	0	0	0
17	1	M	0	0	0	0	0	0	0	0
17	1	M	0	0	0	0	0	1	0	0
17	3	F	1	0	0	1	0	0	0	0
17	3	F	0	0	0	0	0	0	0	0
17	4	F	0	0	1	0	0	0	0	0
17	4	F	0	1	0	0	0	0	0	0
17	5	F	0	0	0	0	0	0	0	0
17	5	F	0	0	0	0	0	0	0	0
17	6	M	0	0	1	0	0	1	0	0
17	7	F	0	0	0	1	0	0	0	0
17	7	F	0	0	0	0	0	0	0	0
17	7	M	0	0	0	0	0	1	0	0
17	8	F	0	0	0	0	0	0	0	1
17	8	M	0	0	0	0	0	0	0	0
17	9	F	0	0	0	0	0	0	1	0
17	9	F	0	0	0	0	0	0	0	0
17	11	F	0	0	0	0	0	0	0	0
17	11	F	0	0	1	0	0	0	0	0
17	11	F	0	0	0	0	0	0	0	0
17	11	F	0	0	1	0	0	0	0	0
17	11	M	0	0	0	0	0	1	0	0
18	7	F	0	1	0	1	0	1	0	0

APPENDIX III.--Test form based on logarythmic pure tone frequency scale

Sex______ Age_______ Birth date _______



APPENDIX III.--Continued



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