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LONGITUDINAL STUDY OF HUMAN HEARING: ITS RELATIONSHIP TO NOISE AND OTHER FACTORS
I. Design of Five Year Study; Data from First Year

FELS RESEARCH INSTITUTE
YELLOW SPRINGS, OHIO 45387
AND
AEROSPACE MEDICAL RESEARCH LABORATORY

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A serial study has begun of auditory thresholds in children aged 6-17 years. These thresholds have been related to noise exposure, otological findings, recreational habits and general health. Data from the first year show that thresholds tend to be lower in older children although they had more noise exposure. The increase in noise exposure with age is particularly marked in the boys.

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SUMMARY

This report describes a serial study of auditory thresholds in children 6 to 17 years of age. These hearing level thresholds, together with detailed information from noise exposure, otological, recreational, and medical histories, data relating to physical size and maturity, and findings from otological inspections were obtained serially from a group of Southwestern Ohio children. The major aims of the study were to determine the variation among children in their patterns of change in thresholds and to analyze the relationships between the changes in their thresholds and possible environmental and biological factors. The present report includes the design of the study, some analyses of the data collected early in the study and a brief outline of the analytic procedures that will be applied when longer sets of serial data are available.

Satisfactory auditory threshold examinations have been obtained since 26 January 1976, after some initial difficulties with audiometric test equipment. Data from 280 audiometric examinations of children are analyzed in this report. The threshold means of these children are near but slightly below audiometric zero (ANSI-1969) for the lower tonal frequencies, but are 2 to 3 decibels higher at frequencies of 4000 and 6000 Hertz. Older children (12 to 17 years) have lower mean thresholds at all frequencies than the younger children (6 to 11 years). Perhaps hearing ability increases slightly with age or perhaps older children are more able to perform the testing task. In general, the mean and median thresholds are 2 to 6 decibels lower than those recorded in U. S. national surveys. There are indications that some abnormal otological findings are associated with hearing loss and that auditory thresholds decrease during adolescence especially in girls. Lateral differences in thresholds were relatively common and, occasionally, were large; large lateral differences in threshold increments were not observed.

Six-monthly increments in thresholds were obtained on 76 children. The threshold increments are distributed normally with means of zero at the lower frequencies. However, at 4000 and 6000 Hertz, the increments are significantly different from zero in the direction of poorer hearing. This effect is most evident in the older children, although their overall mean thresholds are lower. This is in general agreement with the view that noise is an important determinant of the auditory thresholds of children. The data indicate that girls have slightly lower mean thresholds than boys which may reflect behavioural differences; boys have more noise exposure than girls.

Quantitative scores have been derived from total noise exposure histories and interval noise exposure histories. The total noise exposure histories refer to the period preceding the time when each history was taken; the interval noise exposure histories relate to noise exposure since the previous record (either a noise exposure history or an interval noise exposure history) was obtained. There is an increase in total noise exposure (all sources combined) with age. This change with age is more pronounced in boys. The thresholds decrease significantly with age whether levels or increments are considered. There appear to be some associations between otological abnormalities and auditory threshold increases over six-month periods. The associations between noise scores and threshold levels are not significant although some trends are present. While there were no statistically significant changes in mean auditory thresholds, participant groups reporting exposure to loud TV, loud stereo, hi-fi or radio, loud vehicles, power tools, being near or using farm machinery and playing amplified musical instruments all had slightly higher mean thresholds than the groups of participants not reporting such exposures. Farm machinery and amplified musical instruments demonstrated the strongest trends and certainly all these categories need further investigation.

There is suggestive evidence that rate of maturing is associated with auditory thresholds such that rapid maturation, especially in girls, is associated with lower thresholds (better hearing). Stature was associated with thresholds in a similar fashion, i.e., taller children within the same age and sex group tend to have lower thresholds. These effects are interrelated because rapidly maturing children tend to be tall.

A library of computer programs for the analysis of data from auditory threshold examinations, noise exposure questionnaires, medical histories, and growth and maturation assessments has been developed. This will be used as further data are recorded and it will be expanded, in particular to allow the analysis of serial changes by curve fitting techniques.

There are no previous studies of children dealing with auditory thresholds, possible environmental factors and possible biological factors that could affect these thresholds. Yet such studies are necessary to determine whether the changes in thresholds observed in cross-sectional data are due to marked changes in a sub-sample of children or changes that occur in all children. The information resulting from the study in relation to the effects of environmental noise on the hearing levels of children and youth will be of great value to the Environmental Protection Agency and the USAF.

This study aims to determine the changes in auditory patterns in children as they become older and to relate these patterns to environmental and developmental changes. Clearly the study design is appropriate for this aim and it has a great potential to determine the relationships between thresholds, noise exposure and strictly biological variables.

PREFACE

The work described in this report was supported by The Environmental Protection Agency and the Bioacoustics Branch of the Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base, Ohio.

Special thanks are due to Dr. H. E. von Gierke of the Aerospace Medical Research Laboratory who conceived the need for this project and, after many years of effort, succeeded in obtaining the necessary funding. Assistance has been given also by Captain Mark Stevenson and Dr. C. W. Nixon of the Aerospace Medical Research Laboratory. In addition, we are grateful to Mrs. M. Fischer, Mrs. L. Naragon and Mrs. E. Roche, who have recorded the auditory thresholds and collected the questionnaire information. Considerable computer programming has been done by Mr. T. Spragle, Mr. R. Schutte, Mrs. F. Tyleshevski and Mr. W. Walker.

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INTRODUCTION

While environmental noise can adversely affect people of all ages, children as a group may require special consideration. One reason for such consideration is the possibility that children are more susceptible to a loss of hearing ability as a result of noise exposure than adults. Another reason is that children, at various times, may be exposed to certain types of noise that may not be recognized as possibly influencing hearing. The noise exposure of a pre-school child who lives next to a busy freeway and who plays outside often, is an example.

Furthermore, the effect of any significant hearing loss on a child may be more severe than on an adult from the point of view of causing a learning disability. Good hearing is necessary for learning and communication, especially in childhood when speech abilities and listening strategies are less well developed than in adulthood. But even if a hearing loss did not lead to learning disabilities, any permanent change in the hearing ability of a child can be considered more significant than a similar change in an adult simply because the child can be expected to live longer. Despite all this, there have not been any effective studies of hearing loss in children in relation to environmental factors.

The determination of serial auditory thresholds in the same children, as they relate to other information such as health history, noise exposure history and maturity, is important if proper and timely decisions are to be made with respect to the control of various sources of environmental noise. Currently, it is assumed, in most analyses of environmental noise impact, that occupational noise exposure data from an industrial situation can be applied directly to estimate the effects of noise on children. The validity of this assumption has not been demonstrated.

Auditory thresholds in children are very likely to be correlated with the auditory thresholds in the same individuals when adult, although relevant data have not been reported. A convincing demonstration of this requires recording multiple serial auditory thresholds in the same individuals; data at two points in time yielding a single increment for each child are unlikely to provide a convincing answer. Understanding of the factors that influence hearing levels during childhood prior to any changes due to occupational noise exposure will allow better understanding of the significance of the changes in hearing thresholds due to occupational noise exposure. In turn, this should lead to appropriate regulations in regard to important sources of noise, e.g., lawnmowers.

One might ask at this time, "How do we even know if there is a noise exposure problem with children?" Perhaps the best circumstantial evidence of such a problem is the data from the Public Health Surveys conducted by the National Center for Health Statistics (Roberts and Huber, 1970; Glorig and Roberts, 1965). These surveys show that at 4000 Hz there is no practical difference between the hearing levels of boys and girls at age 11, but by the age of 18-24 years there is a definite worsening in the hearing levels of men while those of women remain unchanged. In fact, one can describe this difference in the statistical distributions of hearing levels at 3000 Hz and 4000 Hz between adult men and women by stating that, in respect of hearing levels, the 20 year old men have aged about 20 additional years. In other words, the statistical distribution of hearing for 40 year old women is approximately the same as that for 20 year old men. There is no corresponding effect for the audiometric frequency of 1000 Hz.

It should be recalled that these National Surveys were cross-sectional. While they provide excellent sets of national reference data, they cannot provide any information about changes in individuals. This sex difference requires further documentation, the distribution of changes within individuals must be established and these changes must be related to possible causal factors both environmental and biological. Potential biological factors include previous illnesses, body size and rate of maturation.

An unresolved question is, "Why does this difference between men and women at 3000 Hz and 4000 Hz occur?" Possibly noise exposure is greater for teenage boys than for girls, but proof is lacking. However, other possible factors might account for the difference in whole or in part. There could be sex differences in susceptibility to noise, or sex differences in the way in which normal hearing develops irrespective of noise exposure. Furthermore, health related factors could influence the distribution of hearing thresholds at the age of 18 years. It was to answer such questions that this study was started. From the occupational noise exposure data as well as laboratory studies, it is known that the auditory frequencies from 3000 Hz to 6000 Hz are the most susceptible to typical environmental noise. While the maximum levels of exposure that are acceptable for adults are at least tentatively established, there are no existing data on which corresponding levels for children could be based.

This initial report is the first step in obtaining some, but not all, of the answers needed. The audiometric data have not been recorded over a long enough time span to be of a truly longitudinal nature since at the most only 2 or 3 audiograms have been obtained for any one participant.

Consequently, the data currently available are inadequate for detailed analysis of individual variations in susceptibility to various environmental factors such as noise. Likewise, the development of individual hearing threshold patterns cannot be assessed without more serial data points.

This report provides a cross-sectional data base together with analyses based on increments. Auditory thresholds of the population studied are related to data from detailed total noise exposure histories (total exposure to time of record), interval noise exposure histories (noise exposure since the previous history was obtained; usually a 6-month period), health histories, otological inspections, anthropometric examinations and assessments of maturity. The auditory threshold levels found in the present study are compared with those reported by others. These analyses are sufficient to indicate that when more data become available as the study continues, and when curve fitting techniques are applied to longer runs of serial data, it is reasonable to expect that a significant contribution will be made to understanding the development of hearing and the quantitative effects of environmental noise on the auditory thresholds of children.

BACKGROUND

HEARING ABILITY IN CHILDREN

Jordan and Eagles (1963) studied 4078 school children who were broadly representative of all school children of that age in the Pittsburgh area, except that non-whites were somewhat over-represented. In this group, the median thresholds were lower than the 1951 American Standard Audiometric Zero especially at low frequencies. However, when adjusted using ANSI-1969 standards the median threshold values are all well above zero (Table 1). There were only slight differences in thresholds between whites and non-whites, and between boys and girls. There was an increase in hearing acuity to about 12 years, after which the cross-sectional data show a loss in hearing acuity. This change occurred about one year earlier in girls than boys, indicating that the rate of maturation might be involved directly or indirectly. There was an elevation of auditory thresholds in those with pathological tympanic membranes. Jordan and Eagles did not attempt to establish any relationships between auditory threshold levels and noise exposure.

Ciocco and Palmer (1941) conducted a large scale investigation of school children (N = 13,982) in Washington, D.C. Unfortunately, most of their observations were made using a phonographic audiometer to test the hearing ability of the children, in groups of about forty. There is ample evidence that this procedure lacks specificity and sensitivity, and that it is unreliable (Fowler and Fletcher, 1926, 1928; Rodin, 1927, 1930; Laurer, 1928; Burnap, 1929; Freund, 1932; Rowe and Drury, 1932; Partridge and MacLean, 1933; Rossell, 1933). Ciocco and Palmer (1941) did, however, obtain air conduction thresholds for about 1400 of their group (700 with hearing losses and 700 normal on testing with the phonographic audiometer). Also, they retested some children after intervals of 3 and 5 years. They did not report distribution statistics for thresholds but classified the audiograms into groups. A loss at high frequencies was common and often bilateral. Abnormal records were more common at older ages, and more common in boys than girls for high frequencies.

Roberts and Huber (1970) reported population estimates for auditory threshold levels in the United States for children aged 6-11 years. The data were obtained by individual air conduction testing with pure-tone audiometers. The data were reported with reference to the 1951 American Standard Audiometric Zero; in the present review, they have been adjusted to compensate for the differences between this standard and ANSI-1969. The adjustment factors used are

TABLE 1. MEDIAN THRESHOLDS (DB) IN RELATION TO AMERICAN STANDARD AUDIOMETRIC ZERO FOR CHILDREN AGED 5-14 YEARS (JORDAN AND EAGLES, 1963).

FREQUENCY	RIGHT	LEFT
500	7.1	7.1
1000	4.4	4.4
2000	3.8	3.3
4000	1.6	2.0
6000	8.2	8.8

given in Table 2. The median thresholds reported by Roberts and Huber (1970) are very close to those from the Pittsburgh study of Jordan and Eagles (1963). In these cross-sectional data, there is a fall in auditory thresholds with increasing age during the age range 6-11 years, especially at lower frequencies (Roberts and Huber, 1970). This may reflect differences in attention or the fit of the ear phones rather than auditory function.

Roberts and Ahuja (1975) reported corresponding national estimates for auditory thresholds in United States youths aged 12-17 years. Using the ANSI-1969 set of zero values, substantially less than half the youths have thresholds below zero; only at 1000 and 2000 Hertz do about half the youths reach this level. The thresholds increase with frequency; this increase is rapid in the 2000 to 6000 Hertz range. In youths aged 12 to 17 years, the median thresholds show little change with age in girls. In boys, however, there are gradual decreases, particularly at 6000 Hertz (Roberts and Ahuja, 1975). It should be noted that, as in the survey of 6-11 year olds (Roberts and Huber, 1970), these observations were made using audiometers calibrated in 5 decibel steps.

TABLE ... ADDED TO REPORTED THRESHOLDS USING ... AMERICAN STANDARD AUDIOMETRIC ZERO ... SIMILAR TO THOSE THAT WOULD HAVE BEEN OBTAINED USING THE ANSI-1969 REFERENCE DATA (... AND OYER, 1971).

[illegible]	dB
	14.0
	10.0
	8.[illegible]
	[illegible].0
	[illegible]

... (19[illegible]5) reported population estimates for ... United States adults. Data from ... (18-24 years) are relevant to the present ...

... hearing acuity from 3 to 15 years in cross-sectional ... has been reported (Black, 1939; Kennedy, 19[illegible]). ... clear whether such changes represent ... or whether they reflect better ... instructions and/or better fit of the ...

... slightly lower in girls than boys ... and Eagles, 1963). Ciocco and ... losses are about 2.[illegible] times ... girls at high frequencies. Because ... at each age, they considered ... puberty could not be responsible.

... (197[illegible]) found that in youths aged 12 ... thresholds are higher in boys than girls ... based on the better ear, are very ... Hertz. These sex-associated ... with age for the higher frequencies ... Roberts and Huber (1970), however, ... the 6-11 year age range.

TABLE 3. MEDIAN THRESHOLDS, ADJUSTED TO ANSI-1969, FOR ADULTS AGED 18-24 YEARS (GLORIG AND ROBERTS, 1965) RIGHT EAR ONLY

FREQUENCY	MEN	WOMEN
500	+ 8.0	+ 7.0
1000	+ 5.0	+ 4.0
2000	+ 8.5	+ 5.5
4000	+ 8.0	+ 4.0
6000	+17.5	+12.5

RACE

Roberts (1972) reported that white children, aged 6-11 years, have lower thresholds than Negro children at frequencies of 1000, 2000 and 4000 Hertz. At lower and higher frequencies Negro children have slightly lower thresholds than the whites.

Roberts and Ahuja (1975) in a national survey of youth aged 12-17 years reported that white youths have lower thresholds than Negro youths at frequencies of 1000, 2000 and 4000 Hertz, but not at 500 and 6000 Hertz; these differences are small (0.6 to 1.4 decibels) but all are statistically significant, except that at 500 Hertz.

DEMOGRAPHIC CHARACTERISTICS

Roberts and Ahuja (1975) found no consistent pattern of differences in auditory thresholds dependent upon size of place of residence. The thresholds tend to be higher in the low income groups and in those groups with low levels of parental education. Similar findings were obtained in the other surveys of children and adults (Roberts and Huber, 1970; Glorig and Roberts, 1972).

Roberts (1972) reported that, in children aged 6-11 years, hearing sensitivity tends to increase with family income and with parental education. In addition, she reported that the associations between auditory thresholds and size of place of residence are not significant statistically in this age range.

Preschool children from lower socioeconomic groups make more errors in auditory discrimination tests than more privileged children even after the effects of chronological age and intelligence quotient are partialled out (Clark and Richards, 1966). The possible factors (e.g., illness, nutrition, motivation) were not elucidated.

OTOLOGICAL EXAMINATION

Roberts and Federico (1972) reported data concerning the prevalence of ear, nose and throat abnormalities and their relationship to hearing threshold levels and medical events. The data were obtained from a national probability sample of 7119 children and were weighted to obtain national estimates for the United States. The prevalence of abnormalities was obtained by averaging the prevalence for the two sides. The external auditory meatus was completely occluded in 7.2 percent, the drum was not visible in 10 percent, it was dull in 5.7 percent, bulging in 0.3 percent, red in 1.2 percent and perforated in 0.4 percent of ears. These authors reported higher thresholds in children with a history of earache (difference from normal about 1.5 decibels), in those with perforated drums (difference about 2 decibels), in those with running ears (difference about 1.5 decibels) and in those with abnormal or red drums (difference about 3 decibels). Others (Ciocco and Palmer, 1941; Jordan and Eagles, 1963) have reported that when the tympanic membrane is abnormal on examination the auditory thresholds tend to be higher by 2 to 3 decibels and, if it is perforated, the auditory thresholds are from 12 to 15 decibels higher.

Ciocco and Palmer (1941) showed that serial changes in thresholds are related to the later but not the earlier state of the tympanic membrane and that this relationship occurred at medium frequencies only.

LATERAL DIFFERENCES

Jordan and Eagles (1963) and Ciocco and Palmer (1941) reported a lack of systematic lateral differences in auditory thresholds. Glorig and his co-workers (1957) reported, however, that the right ear thresholds were lower in boys at most frequencies although girls had lower thresholds at the higher frequencies. Roberts and Huber (1970) found no tendency for a particular side to be the better in children aged 6-11 years. They did find the magnitude of lateral differences increased with the frequency of the tone.

The lateral differences found in 12-17 year olds in the survey of Roberts and Ahuja (1975) also increase at higher frequencies. The differences are larger than those found in corresponding studies of United States children aged 6-11 years (Roberts and Huber, 1970) and adults (Glorig and Roberts, 1965). Furthermore, in 12-17 year olds, the left ear tends to have poorer hearing; there was no trend to non-fluctuating lateral differences among the 6-11 year olds but there was a similar pattern among the adults included in the other national surveys (Glorig and Roberts, 1965; Roberts and Huber, 1970).

AUDITORY THRESHOLDS AND NOISE

It has been suggested that permanent changes in thresholds due to noise are noted first in boys aged 16 to 18 years and that firearms and farm machinery are the usual sources (Weber et al., 1967; Litke, 1971).

Although it has been suggested that children are more susceptible than adults to temporary threshold shifts at the same frequency as a tone presented at 100 decibels, the data are inconclusive, in part, because the thresholds have been tested too soon after the stimulus (Hirsh and Bilger, 1955; Harris, 1967; Fior, 1972). There is experimental evidence, however, that exposure to loud noises causes more histological damage in young than in adult guinea pigs (Jauhiainen et al., 1972) and that kittens lose more sensitivity than cats when exposed to intense sound (Price, 1976). Temporary threshold shifts in humans, as a result of playing with toy cap guns have been reported (Marshall and Brandt, 1974).

Cohen et al. (1973) reported a correlational study of children living in apartments. The analyses were based on floor level (which had rather high negative correlations with noise) and subsets of intelligence tests. The coefficients were positive, large and significant in those living in the apartment 4 years or longer; they were not significant for those living in the apartment 3 years or less. Floor levels were correlated significantly with auditory discrimination also. Data from other groups divided by residence were analyzed also. A stepwise regression in those who had been in the apartment 4 years or more showed floor level was more important in regard to auditory discrimination than father's education, number of children in the family or grade level. The authors concluded that the duration of residence in the apartment and therefore the duration of the noise was related to the impairment of auditory discrimination and that this led to learning handicaps.

This conclusion may be correct, but one cannot be sure in the absence of serial data. One question in particular remains unanswered: did the children differ in hearing ability before they came to live in the apartment house? As pointed out by Mills (1975), the correlation between hallway noise near windows overlooking an expressway was high but that between expressway noise level and the noise levels within the apartments was considerably lower. Furthermore, it is unreasonable to assume that the total noise exposure of the children occurred within the apartment building.

SERIAL FINDINGS

Ciocco and Palmer (1941) reported findings for school children reexamined for pure tone air conduction thresholds after intervals of 3.5 (N = 543) and 5 years (N = 552). About half of each group had been selected as having a probable hearing loss, and about half as being normal after group testing with a phonographic audiometer. There were marked differences between pairs of records; for example, 90 percent of the pairs separated by 3.5 years differed by 5 decibels or more. The changes tended to be greater at high frequencies and similar in each ear.

HEARING AIDS

Powerful hearing aids may produce marked threshold shifts in the direction of hearing loss in children (Kinney, 1961; Macrae and Farrant, 1965; Macrae, 1968, 1968a; Roberts, 1970). This may be related to the cause of the hearing loss. It has been reported that losses are greater in the aided ears of children with deafness due to meningitis but not in those in whom the deafness is due to maternal rubella or perinatal causes (Barr and Wedenberg, 1965).

RELIABILITY

Jordan and Eagles (1963) reported mean interobserver differences of 1.3 to 8.8 decibels with the larger differences tending to occur at the lower frequencies. The audiometers used were graduated in 5 decibel steps.

SUMMATION

Consideration of the available literature relating to thresholds in children indicates that:

-- hearing acuity tends to increase until 12 years; later there is a loss in boys but little change in girls,

-- sex differences in the thresholds are slight to 12 years,

-- auditory thresholds are higher in those with abnormal tympanic membranes,

-- from 6 to 17 years, white children have lower thresholds than black children at 1000, 2000 and 4000 Hz. At lower and higher frequencies the differences are in the opposite direction and most are not signficant,

-- auditory thresholds are unrelated to the size of place of residence and they are higher in low income groups,

-- thresholds are higher in children with abnormal tympanic membranes or a history of earache,

-- lateral differences tend to increase with age; hearing ability tends to be poorer in the left ear,

-- data relating auditory thresholds to noise exposure are sparse but temporary shifts do occur,

-- serial findings are scarce. Apparently, rapid changes are common, particularly at higher frequencies. Threshold changes are related to the later but not the earlier state of the tympanic membrane, and

-- powerful hearing aids can cause a loss of hearing acuity.

Because so little is known (many of the above statements being tentative), it was considered essential that auditory thresholds be studied in children in relation to the factors likely to be associated with them, in particular environmental noise. There are no satisfactory studies of hearing loss as a function of age before 16 years, the factors responsible for the development of a sex difference in these levels after 12 years are unknown (it is not even clear whether there factors are biological or environmental) and, finally, it is not known to what level of noise children can be exposed without increases in hearing thresholds. These questions will remain unanswered until there is a serial study based on appropriate types of data collected at many examinations over a sufficient time span. It was with this attitude that the present study was planned. The report describes the design of the study and analyses of some early data. A start has been made but longer serial records are needed before longitudinal analyses will be possible.

SAMPLE AND METHODS

SAMPLE

Two groups of children each approximately equally divided by sex, are being studied. The majority (N = 177) are participants in the Fels Longitudinal Study who were aged between 4 and 18 years at their first audiometric examination. Due to the expectation that auditory changes within individual children might be more marked during pubescence and early adolescence, it was decided that a group of middle school students from Yellow Springs would be enrolled to increase the sample sizes at these ages. Consequently, 47 children aged 12.5 to 13.5 years at the commencement of the study were enrolled. The total study population is 224.

The participants in the Fels Longitudinal Study live in Southwestern Ohio and were born between 1928 and 1972. They were enrolled before birth at the rate of about 15 per year. Their homes are within 30 miles of Yellow Springs, about 35 percent living in cities of medium size (population 30,000-60,000), about half in small towns (population 500-5,000) and the remainder on farms. The educational and occupational patterns for these three groups do not follow the usual urban-rural differences. About 15 percent of the fathers are professionals or major executives, 35 percent are businessmen, 35 percent are tradesmen or white collar workers and the remaining 15 percent are skilled or semiskilled laborers. About 60 percent of the parents attended a year or more of college and about 60 percent of them were born in Ohio. In general, they were of middle socioeconomic level. These children were enrolled in utero. Commencing in 1929, about 15 children joined the study each year. The middle school children were reasonably representative of the Yellow Springs community; in general they tended to be of middle socioeconomic status. The children in each group were "normal" in the sense that they were not selected because of the presence of any recognized disease or disorder.

Approval was obtained from the Fels Institutional Review Board (8 August 1975) in regard to the protection of human subjects. In accordance with Institute policy, this approval has been renewed annually. The families of Fels participants were informed of the study in a Newsletter on 1 October 1975.

In September, 1975, The superintendent of the Yellow Springs schools, and subsequently the Board of Education approved our contacting their pupils through the school system. Messages to be taken home were distributed by the teachers to the 90 children in the schools [illegible] 3.5 years. Signed permission forms were [illegible] the parents of 22 boys and 25 girls; 13 of [illegible] are black. It was considered appropriate to [illegible] whom permission was obtained because it was [illegible] level of long-term cooperation would not match that of the Fels participants.

DATA COLLECTED PREVIOUSLY

The children in the Fels Longitudinal Study were enrolled into the program prenatally. Data were recorded serially, and continue to be recorded, at regularly scheduled visits that are fixed in timing and are unrelated to the illness experiences of the children. Examinations are scheduled for 1, 3, 6, 9. and 12 months and then 6-monthly to 18 years after which they are made annually to 24 years in boys and 22 years in girls. When the participants visit Fels, radiographs of the left hand are obtained (for the assessment of skeletal maturity), stature, weight, and other anthropometric dimensions are taken and a detailed medical history is obtained. Until mid-1975, a complete physical examination was made at each visit; this has been reduced to an interval medical history accompanied by the measurement of blood pressure and pulse rate. As a result of these other procedures, there is a very large body of early and concurrent data available for these Fels participants that is relevant to auditory thresholds.

EQUIPMENT

An audiometric booth (Tracor [illegible]142B) with a window in the door and an electrical harness was installed at The Fels Research Institute in mid-July 1975. The internal dimensions are 6'4" x 6'0" x 6'6" (193.0 x 177.8 x 193.0 cm). The noise reduction is 44 to 59 decibels at the [illegible] being tested. The booth has been placed in a [illegible] part of the building and decorated with animal [illegible] would be more attractive for young children. A two-way intercommunication system was supplied by [illegible]. Three Fels staff members were trained in audiometric testing at Wright-Patterson Air Force Base. Subsequently, two other staff members were trained and all five gained experience in the administration of the detailed questionnaires.

There were problems with the equipment, particularly the patch panel of the booth, necessitating [illegible] work by the supplier. After this work was completed, testing began using Fels employees as [illegible]. In this trial testing, it was discovered [illegible] was unsatisfactory even when [illegible] added. This led to further testing and [illegible] booth was found to be still defective. [illegible] returned to attend to this but did not rectify all the problems. Further tests of equipment were made by Wright-Patterson personnel and while some problems were corrected, others remained. These equipment problems are very similar to those encountered by Jordan and Eagles (1962). Finally, the audiometer (Ekstein Brothers, Model EB-500) was returned to the factory and temporarily replaced by an automatic audiometer (Grayson-Stadler, Model 1703) that was used from 8 December 1975 to 26 January 1976, at which time the automatic audiometer was replaced by a Grayson-Stadler Audiometer, Model 1707, which is calibrated in 2 decibel intervals.

The latter manual machine and the associated equipment have performed in a completely satisfactory manner. There have not been any equipment problems since 26 January 1976. Equipment calibration is performed 3-monthly, in addition to biological checking each time it is used. There are considerable doubts about the accuracy of the auditory thresholds recorded before 26 January 1976 because of changing and malfunctioning equipment. The other data (questionnaires, histories, otological inspection, size, maturity), recorded before 26 January 1976, were, of course, not influenced by these early equipment difficulties. Therefore, for the integrity of the study, only those threshold data collected on or after 26 January 1976 are being used for analyses.

TESTING PROCEDURES

Otological Inspection - Immediately before a participant's auditory threshold levels are assessed, each tragus, meatus, and ear drum is examined by one of the research assistants that have been trained to do this work. The findings are recorded on the "Auditory Threshold Level Recording Form" (Appendix A).

Thresholds - Thresholds are tested in the order 1000, 2000, 4000, 6000, 1000, 500 Hertz with the right ear first. All intensities are measured relative to ANSI - 1969 audiometric zero. In the analysis of data, the second value at 1000 Hertz is being used.

The testing is done by one observer at each examination, with observers assigned randomly. The threshold is obtained at each frequency by beginning at a low sound intensity and increasing the intensity until the participant signals that he has heard the tone. The attenuation is then increased by 10 decibels and decreased by 6 decibels with small increases and decreases to delineate the threshold as accurately as possible. This is repeated three times for each tone in each ear.

The thresholds are also recorded on the "Auditory Threshold Level Recording Form" (Appendix A). Comments about the continuity and completeness of testing and the nature of the responses by the participant are recorded both in general and for each frequency.

Questionnaires - A set of very detailed questionnaires has been developed to ascertain the level of noise exposure. The data obtained using these questionnaires allow an analysis of the relationships between auditory thresholds and environmental factors.

There are two very similar questionnaires:

(i) "The Biographical, Noise Exposure and Otological History" (Appendix B) was administered to each participant at the first audiometric examination.

The data obtained by means of this questionnaire concern: personal identification, family structure and occupations, recreational activities, work activities, noise exposure history (guns, toys, hobbies, mechanical equipment, place of residence, TV, music) and an otological history (family and personal information concerning hearing loss, previous testing, infections, discharge, tinnitus). This noise exposure history is used to obtain a quantitative noise exposure score for each individual for his lifetime prior to the first examination.

(ii) The "Interval Audiometry Questionnaire" (Appendix C) is very similar to the otological history part of the preceding questionnaire, and is administered at the second and subsequent audiometric examinations. It contains questions relating to change of address, noise exposure, otological history, changes in general health and the possible occurrence of menarche since the previous visit. The figures written beside the coding squares on this questionnaire are the revised weightings being applied in the computation of the noise scores. The interval noise exposure questionnaire is used to obtain a total noise exposure score for each individual for the 6-month interval prior to testing. In addition, the data are used to obtain an event score, a chain saw score, and a gun score (Appendix D). These scores are obtained to identify those individuals most likely to have been injured by noise exposure.

Other Procedural Aspects - These include:

(i) A visit for audiometric testing alone requires the participant to be in the Institute for about 50 minutes. Because of the large amount of data that has to be obtained from each participant, both for this study and for others, some additional visits specifically for the audiometric study have become necessary.

(ii) Skeletal maturity assessments (Greulich and Pyle, 1959; median of bone-specific skeletal ages; interpolating between standards to the nearest 3 months when this appears appropriate) have been made for boys and girls in the Fels Longitudinal Study. These assessments are not made for the middle school participants.

(iii) The stature of each Fels participant is recorded to the nearest millimeter at each examination using a Harpenden anthropometer.

(iv) Some children with a marked hearing loss have been identified and referred to appropriate physicians. Their problems are described under "Hearing Problems" in the RESULTS section.

RELIABILITY

The otological history for the Fels participants is highly reliable because these data have been obtained 6-monthly since birth. There is evidence that histories obtained over long intervals may be less reliable (Ciocco and Palmer, 1941). Inter- and intra-observer differences have been obtained for thresholds determined on Fels staff. With the present audiometer these differences are small for all frequencies and compare favorably with those reported by Jordan and Eagles (1963) (Table 4).

The stature measurements are highly accurate (mean interobserver difference 0.3 cm, s.d. 0.15 cm, N = 420; Roche and Davila, 1972). Technicians assessing skeletal maturity have been trained using a system shown to be satisfactory (Roche et al., 1970) and have reached levels of accuracy equal to, or better than, those reported by experienced research workers and pediatric roentgenologists (Johnston et al., 1973).

PROGRAMMING

Much more computer programming has been necessary than originally envisioned. In part, this has resulted from changes in the computer facility at The Fels Research Institute and, in part, from the analysis of the elaborate questionnaires. The programs that are available are:

<u>AUDIO</u> -- From user-supplied specifications, this program selects a subsample of all audiometric examinations and computes the following:

TABLE 4

INTRAOBSERVER DIFFERENCES

(N = 7 for each observer)
(Left ear only)

	Frequency	mean	s.d.
Observer 1	500	2.53	1.94
	1000	3.27	2.33
	1000	4.41	2.92
	2000	1.47	0.85
	4000	2.94	2.05
	6000	2.86	2.54
	means	2.91	2.10
Observer 2	500	3.27	2.95
	1000	2.29	2.43
	1000	2.20	2.19
	2000	2.29	1.38
	4000	1.06	1.38
	6000	2.20	1.40
	means	2.22	1.96

-- A listing of data for each examination sorted by participant identification number and examination date. The listing includes ID#, examination date, birth date, age, sex, examiner, all otological examination comment codes, and, at each tonal frequency for right, left, and better ear, as well as the lateral difference, auditory threshold levels and/or increments.

-- For each tonal frequency in each ear, a frequency distribution including the level of attenuation, number of individuals, and proportion of the total at that level.

-- For each tonal frequency, general distribution statistics of thresholds and/or increments in right, left, better ear and lateral differences. These statistics include sample size, mean, standard deviation, gamma one measure of skewness, the significance level of the t value for gamma one, gamma two, measure of kurtosis, and the significance level of the t value for gamma two.

-- For each tonal frequency, maximum, minimum, and 10th, 25th, 50th, 75th, and 90th percentiles of right, left, better ear and lateral differences.

-- Prevalence table of the scores from the physical ear examination and general comments, separated by ear and by sex.

<u>SRTA</u> -- This program separates noise questionnaire data into history and interval files by sex in preparation for AUDREAL.

<u>AUDREAL</u> -- This program operates on data from noise exposure questionnaires. It checks all input data for logical inconsistencies or errors and lists any invalid data by ID number and visit date. From user supplied specifications and options the program will calculate from either history or interval data, the following:

-- a separate noise score for each question according to assigned weightings,

-- total noise score, events score, gun score and chain saw score,

-- frequency distributions for each question score and for the total scores, and

-- an output file of all computed scores by individual. This file is used as input for other programs.

DUMP -- This program makes line printer copy of any output file from AUDREAL. The AUDREAL record is too large to use a conventional system utility command.

SRTSCORE -- This program uses output files from AUDREAL. Its purpose is to generate appropriate input files for our general purpose descriptive statistics program, DISTAT. Utilizing user specified options, the following may be done:

-- grouping by sex,

-- grouping by age,

-- missing data codes verified, and

-- selected questionnaire items omitted.

DISTAT -- This general purpose program computes descriptive statistics for any series of input variables. The statistics computed include: sample size, mean, standard deviation, gamma one measure of skewness, t value for gamma one, gamma two, measure of kurtosis, and t value for gamma two, maximum, minimum, and 10th, 25th, 50th, 75th and 90th percentiles. These statistics can be computed for any age and sex category at the option of the user.

SPFEED -- This program prepares an input file and control commands for the general purpose Spearman rank correlation program, SPRACC.

SPRACC -- This program, using the input file from SPFEED, computes the Spearman rank correlation coefficient for pairs of input variables. The program outputs the number of variables pairs used, the correlation coefficient and the significance of it.

RESULTS AND DISCUSSION

DATA BASE

Since 12 August 1975, a total of 449 audiometric examinations have been made. This includes 49 children with one examination, 125 with two, and 50 with three examinations at approximately 6-month intervals. For reasons outlined later, the auditory threshold data included in the present analyses are those obtained after 26 January 1976; however, the noise exposure histories, interval questionnaires, health history and otological inspection results for the entire period are included. Since 26 January 1976, there have been 280 examinations of 198 individuals, from 5 to 18 years of age.

Early in the study it was found that reliable and complete thresholds could not be obtained from children aged less than 6 years, and at times the audiometric examinations interfered with their cooperation in the regular Fels program. Of the total examinations subsequent to 26 January 1976, there are 14 that are incomplete; 8 of these are for children 6 years of age or younger. Examinations on children under 6 years of age have now been discontinued. This decision affects very few children; almost all are now more than 6 years old.

Audiometric examinations are made six monthly, approximately on birthdays and "half-birthdays." Therefore, in the analyses, an age for example, "6 years" refers to all those children measured on or about their sixth birthday (i.e., children between 5.75 and 6.24 years). The exact age distribution of the examinations is given in Figure 1. Of the 280 examinations, 145 were of females, and 135 of males. It is clear from Figure 1 that the number of children in each age group is fairly uniform, except for the smaller numbers at 5 and 18 years and the larger numbers at 13 and 14 years. The latter is due to the addition of local school children to the Fels sample in this age range, as explained earlier. The distribution of children at each age is rather evenly divided between the sexes.

The data subsequent to 26 January 1976 come from examinations on 152 Fels participants and 46 of the local school children. There are 117 individuals with one examination, 80 with two, and one with three examinations. The 76 children with two examinations separated by 5 to 7 months form the sample for analyses of 6-monthly increments of hearing levels. Four children had their repeated examinations separated by intervals outside the 5-7 months range. Among these 76 children there are 35 boys and 41 girls; and 24 children from 6 to 11 years, and 52 from 12 to 17 years.

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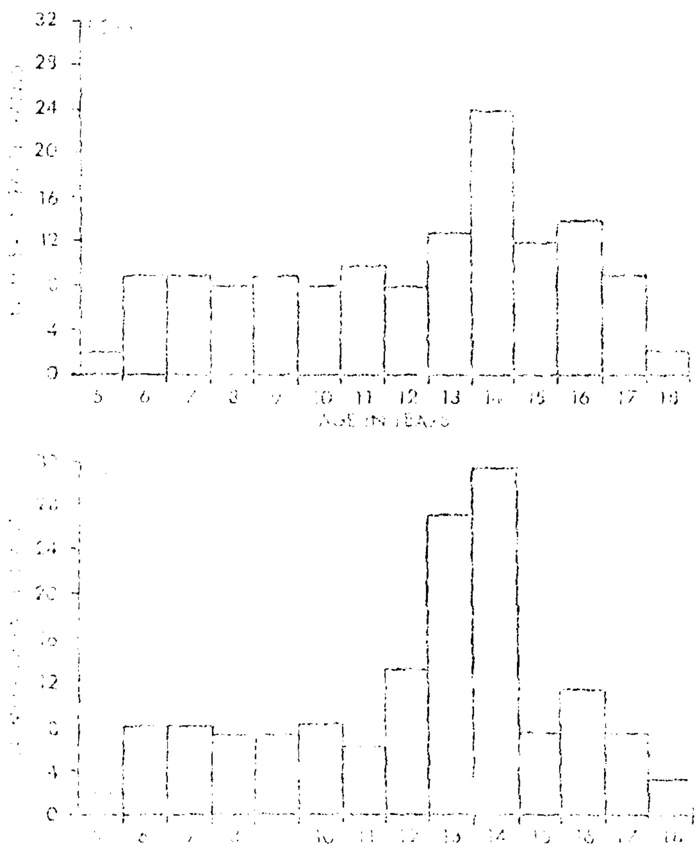

FIGURE 1 - NUMBER OF AUDIOMETRIC THRESHOLD EXAMINATIONS OF BOYS AND GIRLS AT EACH AGE

TESTING CONTINUITY AND PARTICIPANT RESPONSES

Continuity and completeness of the auditory threshold testing procedure and the quality of participant responses were evaluated by the technician at each examination. The items regarding these aspects of the test and the appropriate definitions of the corresponding scores are included on pages 2 and 3 of Appendix A. The prevalences of each of these scores are given in Table 5 for boys and girls of two age groups. The children represented in Table 5 comprise all children tested since August, 1975. Complete test data were obtained in [illegible] percent of those aged 6-11 years and in 96.5 percent of those aged 12-17 years. The percentage in whom the quality of response was graded "good" varied from 69 to 84 percent within sex and age groups being almost the same in each sex and higher in the older groups.

Continuity - [illegible] percent of the younger boys completed the test without interruption (score = 0), while of the older boys [illegible] percent were able to complete the test without resting. The corresponding percentages for girls were 61 percent for younger girls, and 83 percent for older girls. In both age groups boys were slightly more likely to complete the test without a break than girls. A short interruption in the testing between ears (score = 1) for both sexes was much more common in the younger children than in the older children, although there was little evidence of a systematic age difference in the frequency of interruptions during the testing of a particular ear (scores 2 and 3). Multiple interruptions in the overall testing procedure (score = [illegible]) were slightly more common in the younger children than in the older children.

There was little difference between the two age groups in the percentage of individuals who had to be retested at some future date (score = 5); however, while 2 percent of the younger boys and [illegible] percent of the younger girls insisted that the test be discontinued (score = 6), none of the older children requested that the test be terminated. These findings are consistent with our earlier findings concerning a higher frequency of incomplete examinations in children younger than 6 years old.

Responses - There was little difference between the sexes in frequency of good responses (score = 0), though good responses were a little more common among the older children than among the younger children. From 2 to 5 percent of the children gave false responses often (score = 1). This was about as common in older children as in younger children, and about as common in boys as girls. Erratic responses, guessing, disinterest, and restlessness of participants (scores [illegible], 3, 4, 5, 9) were slightly more common in younger children, especially the boys.

TABLE 5. PERCENTAGE OF CHILDREN WITH SPECIFIC SCORES REGARDING THRESHOLD TESTING

Age Group	Score	BOYS Continuity of Testing	BOYS Quality of Responses	GIRLS Continuity of Testing	GIRLS Quality of Responses
<u>6-11 Years</u>					
	0	67	65	61	68
	1	17	4	20	5
	2	0	0	0	0
	3	2	4	5	0
	4	8	4	5	2
	5	2	2	0	0
	6	2	2	7	0
	7	0	0	0	0
	8	2	13	2	18
	9	--	6	--	7
<u>12-17 Years</u>					
	0	88	79	83	79
	1	0	5	3	2
	2	3	0	0	1
	3	1	1	3	4
	4	1	0	4	1
	5	5	0	2	0
	6	0	1	0	2
	7	0	0	0	0
	8	3	14	4	11
	9	--	0	--	0

Based on approximately the following sample sizes: 6-11 years, 85 boys, 75 girls; 12-17 years, 122 boys, 139 girls.

OTOLOGICAL INSPECTIONS

Preceding the testing of auditory thresholds, an otological inspection was given each participant to record deviations from normality. In each category a score of zero indicates a normal finding. The definitions of the findings indicated by each of the other scores of the otological inspection are given in Appendix A. Tables 6 and 7 give the score prevalences for right and left ear of boys and girls of two age groups. The sample represented in these tables includes all children examined since testing commenced in August, 1975.

There is little difference between age groups or sexes in the frequency of abnormal tragi, almost all being normal, and a maximum of 2 percent in any age group being considered "very large" (score = 1). The most frequent meatal abnormalities concerned obstructions of the auditory canal and small or slit-like meati. The younger girls tend to have more problems with obstructions than the older girls. In the 6 to 11 year age group, 15 to 17 percent of the girls had at least partial obstruction of the auditory canal in one ear. None of the children examined had perforated ear drums, and about one percent of the ears examined had some drum scars, probably due to spontaneous or induced perforations that had healed.

The most common abnormalities are those dealing with the ability to see the cone of light reflected from the ear drum on otoscopic inspection. In about 20 percent of the inspections, the cone of light was not seen because of auditory canal occlusion. The rather high frequencies of scores other than zero or 1 for this item may indicate the inexperience of the technicians, rather than ear pathology. Three to 12 percent of boys and girls had drums that were dull in appearance, lacking the lustre typical of the normal tympanic membrane. There was little difference between the age groups, although in older boys this tended to be more common than in girls. From 1 to 3 percent of the children inspected had ear drums that were red, suggesting some inflammation. The frequencies of additional comments (score = 8) suggests that the number of categories for each item could be increased, or that many of the participant's present conditions are not readily classifiable.

HEARING PROBLEMS

Otolaryngological examinations were made of children found to have hearing problems during the investigation. A child was identified as having a hearing problem if one or more auditory thresholds were at or above 30 decibels. There have been five such children.

TABLE 6A. PERCENTAGE OF CHILDREN 6 TO 11 YEARS OF AGE WITH SPECIFIC SCORES ON OTOLOGICAL INSPECTION (RIGHT EAR).[1]

Score	Tragus	Meatus	Ear Drum	Cone of Light	Color
			BOYS		
0	98	81	88	66	81
1	0	0	0	18	1
2	--	4	0	9	6
3	--	6	0	--	0
4	--	0	--	--	0
5	--	4	--	--	--
6	--	0	--	--	--
8	2	6	12	7	12
			GIRLS		
0	100	72	75	53	73
1	0	0	0	25	3
2	--	15	4	13	5
3	--	4	1	--	0
4	--	3	--	--	0
5	--	1	--	--	--
6	--	0	--	--	--
8	0	5	20	8	19

1. See appendices A and B for score definitions. Based on approximately 85 boys and 75 girls.

TABLE 6B. PERCENTAGE OF CHILDREN 6 TO 11 YEARS OF AGE WITH SPECIFIC SCORES ON OTOLOGICAL INSPECTION (LEFT EAR).[1]

Score	Tragus	Meatus	Ear Drum	Cone of Light	Color
			BOYS		
0	98	78	87	53	79
1	0	0	0	22	2
2	--	5	0	16	6
3	--	6	0	--	0
4	--	2	--	--	0
5	--	5	--	--	--
6	--	0	--	--	--
8	2	6	13	8	13
			GIRLS		
0	100	69	77	59	73
1	0	3	0	21	1
2	--	11	4	11	3
3	--	5	0	--	0
4	--	1	--	--	0
5	--	3	--	--	--
6	--	0	--	--	--
8	0	8	19	9	23

1. See appendices A and B for score definitions. Based on approximately 85 boys and 75 girls.

TABLE 7A. PERCENTAGE OF CHILDREN 12 TO 17 YEARS WITH SPECIFIC SCORES ON OTOLOGICAL INSPECTION[1] (RIGHT EAR).

Score	Tragus	Meatus	Ear Drum	Cone of Light	Color
			BOYS		
0	98	80	83	59	70
1	2	1	0	24	1
2	--	7	2	11	7
3	--	4	0	--	0
4	--	0	--	--	0
5	--	4	--	--	--
6	--	2	--	--	--
8	0	2	15	7	22
			GIRLS		
0	99	82	82	57	78
1	1	4	0	22	1
2	--	9	5	13	4
3	--	1	0	--	0
4	--	0	--	--	0
5	--	3	--	--	--
6	--	1	--	--	--
8	0	1	13	7	17

1. See appendices A and B for score definitions. Based on approximately 122 boys and 139 girls.

TABLE 7 B. PERCENTAGE OF CHILDREN 12 TO 17 YEARS WITH SPECIFIC SCORES ON OTOLOGICAL INSPECTION[1]
(LEFT EAR)

Score	Tragus	Meatus	Ear Drum	Cone of Light	Color
			BOYS		
0	98	80	82	63	66
1	2	0	0	20	2
2	--	7	2	10	12
3	--	4	1	--	0
4	--	0	--	--	1
5	--	3	--	--	--
6	--	2	--	--	--
8	0	3	15	7	19
			GIRLS		
0	99	78	81	55	78
1	1	3	0	27	1
2	--	9	2	12	4
3	--	1	1	--	0
4	--	0	--	--	1
5	--	4	--	--	--
6	--	1	--	--	--
8	0	3	16	6	16

1. See appendices A and B for score definitions. Based on approximately 122 boys and 139 girls.

No. 9037. At the time this 1[illegible]-year-old [illegible] examined at Fels she had a cold, but the right ear [illegible] were normal, while those in the left ear were [illegible] (46-54 decibels) for 1000, 2000 and 4000 Hertz. [illegible] light was not seen in the left ear. She had [illegible] noise exposure but was aware of the hearing loss [illegible] the left ear - associated with bronchopneumonia when young. [illegible] tested at The Dayton Children's Medical Center and the findings at Fels were confirmed. Bone conduction was [illegible] in the left ear. The tympanogram indicated a normal middle ear. The stapedius reflex thresholds were [illegible] the left ear. It was concluded that her unilateral [illegible] to the previous pneumonia and that [illegible]

No. 530. When this 17-year-old [illegible] Fels the levels were about 70-80 decibels [illegible] all f[illegible] in both ears. He has a moderate[illegible], hi[illegible] exposure. He wears an aid for his hearing [illegible] to have had congenital heart disease but [illegible] was suggested to the parents that [illegible] rehabilitation.

No. 574. This 15-year-old girl was examined [illegible] Fels. The thresholds at the first visit were [illegible] decibels, except at 4000 Hertz in the left ear [illegible] threshold was about 40. At the second visit the results [illegible] similar. Earlier records were obtained from [illegible] and it appears that there has been [illegible] thresholds since 1969. She had otitis media [illegible] years, 3 months. She plays drums - but no other [illegible] history of noise exposure was obtained. Her [illegible] teacher) also has a hearing loss.

No. 533. This 16-year-old boy's thresholds were recorded as +30 to +76 decibels. There was some concern that the audiometric leads may have been improperly positioned (this was very soon after the new audiometer was delivered). Because the participant lives some distance from Fels, it was inappropriate to ask him to return immediately. He was referred to an otolaryngologist who reported that he was within normal limits. His thresholds were +10 to +30 decibels with only small differences between ears and frequencies, but those for bone conduction were somewhat higher than those for air. It was decided that this boy would be watched carefully.

No. 691. This 7-year-old boy was examined twice at Fels. His thresholds were about +5 to +22 with a slight tendency for them to be greater at the higher frequencies at the first examination. At the second examination they were +4 to +18 with a marked tendency to increase at 500 and 8000 Hertz. The right meatus was very narrow.

He has had above average noise exposure (firecrackers, radio) and he has had otitis media. His mother has a hearing loss ("20-40%") and she has the TV louder than the boy would wish. He has had one ear infection in the past six months.

THRESHOLDS

<u>General Findings</u> - When the entire sample of boys and girls, examined after January 26, 1976, is considered across ages, several generalizations can be made about threshold levels. Table 8 shows that the distributions of auditory thresholds are significantly and positively skewed and are significantly leptokurtic. This is true at each frequency and for each ear. The degree of non-normality is rather constant across frequencies.

In both ears, the threshold means at 4000 and 6000 Hertz are 2 to 3 decibels higher than those at the lower frequencies; these differences are significantly different by t-test ($p < 0.01$). The deviations from normality of the distributions may invalidate the exact significance of the differences based on a parametric statistical test. However, the results are sufficient to indicate reduced aural acuity at the higher frequencies.

There is a similar degree of variation about the mean threshold at each frequency, as evidenced by the standard deviations (Table 8), ranging from about 7 to 9 decibels. Likewise, the standard error of the mean at any frequency is near 0.5 decibels. In Tables 8 through 16, as for Tables 23 through 31, headings of "SKEW" and "KURT" indicate skewness (g_1) and kurtosis (g_2), respectively. "PSKEW" and "PKURT" are the significance levels for the t statistic testing for skewness or kurtosis. A value of .0001 is given when the significance is less than or equal to .0001 and likewise a value of 1.0 is given if the significance is greater than .9999. The extent of the variation is evident also from the percentiles of the thresholds (Table 8). The range of the middle quartiles is about 8 to 10 decibels. Thus, 50 percent of the threshold values are within 4 or 5 decibels of the median.

Interestingly, a considerable proportion of the participants have thresholds at -10 and -12 decibels. The latter is the lower limit of the audiometer used in this study. This is partially evident from the percentiles (Table 8). At each frequency the proportion of children with thresholds at or below -10 decibels is near 9 percent for the right ear, and near 15 percent for the left ear. A larger proportion of 12 to 17 year olds have these low thresholds than 6 to 11 year olds. This is shown graphically for the right ear in Figures 2 to 6. These figures are discussed in detail later.

TABLE 8 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN THE STUDY SAMPLE (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	277	0.21	8.00	3.25	0.0001	25.41	0.0001
1000	281	-0.75	7.87	3.95	0.0001	34.50	0.0001
2000	281	-0.87	7.64	3.33	0.0001	28.12	0.0001
4000	280	1.51	8.55	3.95	0.0001	39.01	0.0001
6000	278	2.06	9.58	3.00	0.0001	24.14	0.0001
LEFT EAR							
500	266	-0.86	8.14	3.40	0.0001	28.39	0.0001
1000	271	-2.04	9.08	4.53	0.0001	33.47	0.0001
2000	270	-2.78	8.62	3.83	0.0001	27.99	0.0001
4000	269	0.98	9.65	3.29	0.0001	23.70	0.0001
6000	269	1.46	9.61	1.91	0.0001	13.37	0.0001
BETTER EAR							
500	278	-2.15	7.58	3.92	0.0001	35.37	0.0001
1000	281	-3.46	7.23	5.28	0.0001	55.24	0.0001
2000	281	-4.11	7.35	4.37	0.0001	39.64	0.0001
4000	280	-1.57	8.12	4.49	0.0001	46.33	0.0001
6000	279	-1.33	8.71	2.86	0.0001	22.96	0.0001
LEFT-RIGHT DIFFERENCES							
500	265	-1.04**	5.61	-0.21	0.1491	4.45	0.0001
1000	271	-1.13*	7.68	3.45	0.0001	28.49	0.0001
2000	270	-1.78**	7.33	2.02	0.0001	15.62	0.0001
4000	269	-0.49	8.65	1.17	0.0001	5.59	0.0001
6000	268	-0.73	8.32	-0.20	0.1732	0.13	0.9813

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-8.0	-4.0	0.0	4.0	8.0	74
1000	-12	-8.0	-5.0	-2.0	2.0	6.0	78
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	72
4000	-12	-8.0	-4.0	2.0	6.0	10.0	90
6000	-12	-8.0	-4.0	2.0	6.0	12.0	90
LEFT EAR							
500	-12	-10.0	-6.0	-2.0	2.0	8.0	76
1000	-12	-10.0	-6.0	-4.0	0.0	6.0	82
2000	-12	-12.0	-8.0	-4.0	0.0	6.0	76
4000	-12	-10.0	-4.0	0.0	6.0	8.0	86
6000	-12	-10.0	-6.0	2.0	8.0	12.0	78
BETTER EAR							
500	-12	-12.0	-6.0	-2.0	0.0	6.0	74
1000	-12	-10.0	-8.0	-4.0	0.0	4.0	78
2000	-12	-12.0	-8.0	-6.0	-2.0	4.0	72
4000	-12	-12.0	-6.0	-2.0	2.0	6.0	86
6000	-12	-12.0	-8.0	-2.0	4.0	8.0	78
LEFT-RIGHT DIFFERENCES							
500	-30	-6.0	-4.0	0.0	2.0	6.0	26
1000	-30	-8.0	-4.0	-2.0	2.0	4.0	60
2000	-30	-10.0	-6.0	-2.0	2.0	6.0	56
4000	-26	-10.0	-4.0	0.0	4.0	8.0	46
6000	-24	-12.0	-6.0	0.0	4.0	10.0	22

* $.01 < p \leq .05$

** $p \leq .01$

Comparison of Age Groups and Sexes - The threshold distributions of boys (Table 9) are more skewed and less leptokurtic than those of the girls (Table 10) at corresponding frequencies. At several frequencies the measures of skewness and kurtosis for girls are on the borderline of significance, whereas for boys there is highly significant, positive skewness and leptokurtosis at all frequencies.

At every frequency girls have lower mean thresholds than boys, and their percentiles tend to be lower than the corresponding ones for boys (Tables 9 and 10). In addition, the girls tend to have smaller threshold variances.

For both boys and girls, the younger age group, 6 to 11 years old, generally has normally distributed threshold distributions (Tables 11, boys; 12, girls). As in the total sample, the younger females tend to have lower means and medians at each frequency than the boys; however, the differences are not statistically significant. The differences between sexes for mean thresholds in the older age group of 12 to 17-year-olds (Tables 13 boys; 14, girls) are similar to the overall sex differences, largely because this group comprises about two-thirds of the total sample. The same is true for medians and other percentiles.

One finding consistent with observations on the total sample, and present in each age and sex group, is that hearing thresholds tend to be higher at the 4000 and 6000 Hertz frequencies than at the lower frequencies. As will be discussed in a later section, these higher frequencies also have larger six-monthly increments than the lower frequencies.

When the 6 to 11-year-olds (Table 15) are compared as a group to the 12 to 17-year-olds (Table 16), it can be seen the older group has lower mean and median thresholds at each frequency. The entire distribution for the older children is shifted towards lower threshold levels relative to the younger group. This can be seen by comparing corresponding data for the two groups, as shown in Tables 15 and 16 and Figures 2 through 6. These figures show the proportion in each age group hearing at specific auditory threshold levels in the right ear at each tonal frequency. There is a shift toward lower thresholds at most frequencies in the older group.

Furthermore, there is a significant Spearman rank correlation between age and auditory thresholds in the better ear at every frequency (Table 17). The correlations are negative and in the range of -.2 to -.4, being generally larger at the lower frequencies. This means that as the children get older their thresholds get lower; that is, they

TABLE 9 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN BOYS

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	134	1.00	9.33	3.79	0.0001	26.15	0.0001
1000	136	0.13	9.34	4.50	0.0001	33.58	0.0001
2000	136	-0.47	9.09	3.83	0.0001	27.58	0.0001
4000	136	2.01	10.10	4.73	0.0001	39.88	0.0001
6000	134	2.78	10.95	3.86	0.0001	28.01	0.0001
LEFT EAR							
500	133	0.41	9.18	4.40	0.0001	32.52	0.0001
1000	134	-1.25	9.49	5.18	0.0001	41.86	0.0001
2000	134	-2.13	9.25	4.64	0.0001	35.64	0.0001
4000	134	1.43	9.78	4.72	0.0001	39.38	0.0001
6000	134	2.69	10.79	2.50	0.0001	15.68	0.0001
BETTER EAR							
500	135	-1.16	8.89	4.69	0.0001	35.97	0.0001
1000	136	-2.38	8.91	5.51	0.0001	46.32	0.0001
2000	136	-3.24	8.85	4.72	0.0001	36.24	0.0001
4000	136	-0.99	9.67	5.27	0.0001	45.60	0.0001
6000	135	-0.28	10.05	3.52	0.0001	24.98	0.0001
LEFT-RIGHT DIFFERENCES							
500	132	-0.77	5.22	-0.61	0.0042	1.35	0.0019
1000	134	-1.28 **	5.19	-0.39	0.0635	2.75	0.0001
2000	134	-1.58 **	5.32	-0.47	0.0241	1.45	0.0009
4000	134	-0.52	7.33	0.11	0.9389	0.17	0.9845
6000	133	-0.14	8.06	-0.36	0.0813	0.13	0.9976

FREQUENCY (HERTZ)	MIN	10	25	PERCENTILES MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-7.0	-4.0	0.0	4.0	8.0	74
1000	-12	-8.0	-4.0	-2.0	4.0	6.6	78
2000	-12	-10.0	-6.0	-2.0	4.0	6.6	72
4000	-12	-8.6	-2.0	2.0	6.0	10.0	90
6000	-12	-8.0	-4.0	2.0	8.0	12.0	90
LEFT EAR							
500	-12	-8.0	-4.0	0.0	4.0	8.0	76
1000	-12	-10.0	-6.0	-2.0	2.0	7.0	82
2000	-12	-10.0	-6.0	-4.0	2.0	6.0	76
4000	-12	-9.0	-4.0	1.0	6.0	8.0	86
6000	-12	-10.0	-4.0	2.0	8.0	14.0	78
BETTER EAR							
500	-12	-10.0	-6.0	-2.0	2.0	6.0	74
1000	-12	-10.0	-6.0	-4.0	0.0	4.6	78
2000	-12	-12.0	-8.0	-4.0	0.0	4.0	72
4000	-12	-12.0	-6.0	-2.0	2.0	6.0	86
6000	-12	-12.0	-8.0	0.0	4.0	10.0	78
LEFT-RIGHT DIFFERENCES							
500	-20	-8.0	-2.0	0.0	2.0	6.0	14
1000	-24	-8.0	-4.0	-2.0	2.0	4.0	16
2000	-22	-8.0	-4.0	0.0	2.0	4.0	14
4000	-16	-11.0	-4.0	0.0	4.0	8.0	20
6000	-22	-11.2	-6.0	0.0	5.0	10.0	20

** $p \leq .01$

TABLE 10 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN GIRLS

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	143	-0.53	6.45	0.90	0.0001	2.29	0.0001
1000	145	-1.57	6.11	0.76	0.0005	1.35	0.0012
2000	145	-1.24	5.96	0.57	0.0055	0.70	0.0800
4000	144	1.03	6.78	0.39	0.0531	0.20	0.9524
6000	144	1.39	8.09	0.50	0.0129	0.23	0.9210
LEFT EAR							
500	133	-2.12	6.74	0.38	0.0663	-0.52	0.2134
1000	137	-2.80	8.63	3.66	0.0001	20.07	0.0001
2000	136	-3.41	7.93	2.41	0.0001	10.59	0.0001
4000	135	0.53	9.55	1.75	0.0001	5.73	0.0001
6000	135	0.24	8.13	0.15	0.8420	-0.66	0.1110
BETTER EAR							
500	143	-3.09	5.97	0.38	0.0567	-0.05	1.0000
1000	145	-4.47	5.03	0.52	0.0096	0.12	0.9986
2000	145	-4.94	5.49	1.06	0.0001	2.09	0.0001
4000	144	-2.13	6.30	0.31	0.1169	0.07	1.0000
6000	144	-2.32	7.14	0.50	0.0136	0.25	0.8921
LEFT-RIGHT DIFFERENCES							
500	133	-1.31 *	5.97	0.09	0.9860	6.08	0.0001
1000	137	-0.98	9.53	3.61	0.0001	22.61	0.0001
2000	136	-1.97 *	8.89	2.39	0.0001	13.72	0.0001
4000	135	-0.46	9.81	1.55	0.0001	6.33	0.0001
6000	135	-1.32	8.55	-0.05	0.9999	0.13	0.9973

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-8.0	-4.0	-2.0	4.0	7.2	28
1000	-12	-10.0	-6.0	-2.0	2.0	6.0	24
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	20
4000	-12	-7.0	-4.0	0.0	6.0	10.0	22
6000	-12	-10.0	-4.0	2.0	6.0	12.0	24
LEFT EAR							
500	-12	-12.0	-6.0	-2.0	2.0	8.0	14
1000	-12	-12.0	-8.0	-4.0	0.0	6.0	54
2000	-12	-12.0	-8.0	-4.0	0.0	4.6	46
4000	-12	-12.0	-6.0	0.0	4.0	8.8	46
6000	-12	-12.0	-6.0	0.0	6.0	10.0	24
BETTER EAR							
500	-12	-12.0	-8.0	-4.0	0.0	4.0	16
1000	-12	-12.0	-8.0	-4.0	-2.0	2.0	10
2000	-12	-12.0	-10.0	-6.0	-2.0	2.0	20
4000	-12	-12.0	-6.0	-2.0	2.0	6.0	20
6000	-12	-12.0	-8.0	-2.0	2.0	6.0	24
LEFT-RIGHT DIFFERENCES							
500	-30	-6.0	-4.0	-2.0	2.0	6.0	26
1000	-30	-8.0	-5.0	-2.0	2.0	4.4	60
2000	-30	-10.6	-6.0	-2.0	0.0	6.0	56
4000	-26	-10.0	-6.0	0.0	2.0	8.0	46
6000	-24	-14.0	-6.0	0.0	4.0	10.0	22

* $.01 < p \leq .05$

TABLE 11 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN BOYS 6-11 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	51	1.96	7.80	0.99	0.0036	0.90	0.1672
1000	52	0.92	7.87	0.88	0.0080	0.77	0.2333
2000	52	0.15	6.61	0.61	0.0640	0.88	0.1758
4000	52	2.38	5.93	-0.37	0.2691	-0.33	0.9504
6000	51	3.10	7.86	0.33	0.6804	0.06	1.0000
LEFT EAR							
500	50	1.48	6.50	1.09	0.0018	1.91	0.0046
1000	51	-0.39	5.97	0.43	0.1921	-0.58	0.7386
2000	51	-1.80	6.39	0.55	0.0958	0.25	0.9912
4000	51	1.33	5.65	-0.38	0.2540	-0.63	0.6987
6000	51	3.96	7.89	0.11	0.9965	-0.05	1.0000
BETTER EAR							
500	52	-0.23	6.36	1.17	0.0008	2.72	0.0002
1000	52	-1.69	5.92	0.56	0.0848	-0.24	0.9934
2000	52	-2.62	6.27	0.71	0.0314	0.75	0.2456
4000	52	-0.69	5.40	-0.25	0.8087	-0.58	0.7408
6000	52	0.88	7.12	0.00	1.0000	-0.65	0.6840
LEFT-RIGHT DIFFERENCES							
500	49	-0.98	5.69	-1.01	0.0036	1.86	0.0060
1000	51	-1.37	5.86	-1.25	0.0005	3.00	0.0001
2000	51	-1.92*	5.18	-1.19	0.0007	3.07	0.0001
4000	51	-1.14	6.94	-0.06	1.0000	0.28	0.9807
6000	50	0.76	7.47	-0.47	0.1645	0.88	0.1828

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-6.0	-4.0	0.0	6.0	12.0	26
1000	-12	-7.4	-5.5	0.0	4.0	12.8	24
2000	-12	-8.0	-4.0	0.0	4.0	8.0	22
4000	-12	-6.0	-2.0	2.0	6.0	10.0	14
6000	-12	-7.6	-2.0	4.0	8.0	14.0	26
LEFT EAR							
500	-10	-6.0	-2.0	0.0	4.5	8.0	24
1000	-12	-7.6	-4.0	-2.0	4.0	8.0	14
2000	-12	-10.0	-6.0	-2.0	4.0	5.6	18
4000	-12	-6.0	-4.0	2.0	6.0	8.0	12
6000	-12	-9.6	0.0	4.0	8.0	15.6	24
BETTER EAR							
500	-12	-7.4	-4.0	-2.0	4.0	6.0	24
1000	-12	-8.0	-6.0	-2.0	2.0	7.4	14
2000	-12	-10.0	-8.0	-2.0	2.0	4.0	18
4000	-12	-10.0	-4.0	0.0	2.0	6.0	10
6000	-12	-10.0	-2.0	0.0	4.0	11.4	16
LEFT-RIGHT DIFFERENCES							
500	-20	-10.0	-3.0	0.0	2.0	6.0	10
1000	-24	-8.0	-4.0	0.0	2.0	5.6	10
2000	-22	-9.2	-4.0	-2.0	0.0	4.0	8
4000	-16	-13.6	-4.0	0.0	2.0	8.0	18
6000	-22	-7.8	-4.0	2.0	4.0	10.0	16

* $.01 < p \leq .05$

TABLE 12 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN GIRLS 6-11 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	43	0.93	5.58	0.25	0.8460	0.39	0.9342
1000	44	-0.18	5.10	-0.39	0.2705	-0.55	0.7969
2000	44	-0.32	5.03	0.00	1.0000	-0.34	0.9603
4000	43	2.37	7.56	0.33	0.7237	0.01	1.0000
6000	43	3.21	7.33	0.48	0.1802	0.37	0.9472
LEFT EAR							
500	35	0.69	6.74	-0.24	0.8997	-0.60	0.8054
1000	39	-1.03	6.49	0.52	0.1680	-0.31	0.9822
2000	39	-2.31	5.83	0.02	1.0000	-0.92	0.2127
4000	37	1.14	7.30	0.39	0.6831	-0.17	0.9999
6000	37	1.46	7.08	-0.03	1.0000	-0.79	0.2986
BETTER EAR							
500	43	-0.60	5.99	0.04	1.0000	0.17	0.9999
1000	44	-2.23	5.37	-0.04	1.0000	-0.67	0.7014
2000	44	-3.64	4.61	-0.05	1.0000	-0.74	0.2925
4000	43	-0.70	6.31	0.01	1.0000	-0.55	0.8019
6000	43	-0.23	5.89	-0.27	0.8196	-0.77	0.2803
LEFT-RIGHT DIFFERENCES							
500	35	0.00	5.02	-0.84	0.0344	0.94	0.2279
1000	39	-0.46	6.15	0.01	1.0000	0.95	0.1972
2000	39	-2.26 *	6.23	-0.04	1.0000	-0.73	0.6893
4000	37	-1.62	7.04	-0.28	0.8427	0.78	0.3030
6000	37	-2.27	7.78	0.30	0.8045	1.06	0.1608

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-6.0	-2.0	0.0	4.0	7.2	16
1000	-12	-7.0	-4.0	0.0	4.0	6.0	8
2000	-12	-7.0	-4.0	-1.0	4.0	6.0	12
4000	-12	-6.0	-4.0	2.0	8.0	11.2	22
6000	-12	-6.0	-2.0	2.0	8.0	13.6	24
LEFT EAR							
500	-12	-12.0	-4.0	0.0	6.0	10.0	14
1000	-12	-10.0	-4.0	-2.0	2.0	10.0	14
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	10
4000	-12	-8.4	-6.0	2.0	6.0	9.2	20
6000	-12	-10.0	-4.0	2.0	6.0	10.4	16
BETTER EAR							
500	-12	-10.4	-4.0	0.0	4.0	7.2	16
1000	-12	-11.0	-6.0	-2.0	0.0	6.0	8
2000	-12	-10.0	-7.5	-4.0	0.0	3.0	6
4000	-12	-10.0	-6.0	0.0	4.0	6.0	14
6000	-12	-10.0	-4.0	0.0	4.0	8.0	10
LEFT-RIGHT DIFFERENCES							
500	-16	-6.0	-2.0	0.0	4.0	6.0	8
1000	-18	-6.0	-4.0	0.0	2.0	8.0	14
2000	-16	-10.0	-6.0	-2.0	2.0	6.0	10
4000	-22	-8.8	-6.0	-2.0	3.0	6.4	16
6000	-18	-14.4	-6.0	0.0	2.0	6.4	22

* $.01 < p \leq .05$

TABLE 13 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN BOYS 12-17 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	80	0.12	10.18	4.71	0.0001	32.01	0.0001
1000	80	-0.73	10.14	5.80	0.0001	42.53	0.0001
2000	80	-1.08	10.31	4.44	0.0001	28.89	0.0001
4000	80	1.58	12.21	4.66	0.0001	31.63	0.0001
6000	80	2.53	12.72	4.11	0.0001	25.53	0.0001
LEFT EAR							
500	80	-0.70	10.35	5.11	0.0001	35.00	0.0001
1000	80	-2.17	11.12	5.51	0.0001	38.42	0.0001
2000	80	-2.40	10.75	4.93	0.0001	32.76	0.0001
4000	80	1.30	11.80	4.55	0.0001	30.50	0.0001
6000	80	1.60	12.34	2.95	0.0001	15.94	0.0001
BETTER EAR							
500	80	-2.10	10.10	5.35	0.0001	37.61	0.0001
1000	80	-3.22	10.32	6.07	0.0001	45.12	0.0001
2000	80	-3.85	10.15	5.31	0.0001	36.38	0.0001
4000	80	-1.50	11.71	5.15	0.0001	35.19	0.0001
6000	80	-1.20	11.63	3.98	0.0001	24.26	0.0001
LEFT-RIGHT DIFFERENCES							
500	80	-0.82	4.93	-0.20	0.8141	0.45	0.7605
1000	80	-1.45**	4.49	0.56	0.0355	2.10	0.0003
2000	80	-1.33**	5.48	-0.11	0.9854	0.36	0.8662
4000	80	-0.28	7.65	0.21	0.8012	-0.02	1.0000
6000	80	-0.93	8.41	-0.24	0.7427	-0.23	0.9775

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-8.0	-4.0	0.0	2.0	6.0	74
1000	-12	-8.0	-4.0	-2.0	1.5	4.0	78
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	72
4000	-12	-10.0	-4.0	2.0	5.5	11.8	90
6000	-12	-8.0	-4.0	0.0	7.5	12.0	90
LEFT EAR							
500	-12	-8.0	-6.0	-2.0	2.0	5.8	76
1000	-12	-10.0	-7.5	-4.0	0.0	5.8	82
2000	-12	-11.8	-6.0	-4.0	0.0	6.0	76
4000	-12	-12.0	-4.0	0.0	5.5	8.0	86
6000	-12	-10.0	-8.0	2.0	7.5	13.8	78
BETTER EAR							
500	-12	-10.0	-6.0	-2.0	0.0	4.0	74
1000	-12	-10.0	-8.0	-4.0	-2.0	2.0	78
2000	-12	-12.0	-8.0	-6.0	-2.0	3.8	72
4000	-12	-12.0	-6.0	-2.0	2.0	6.0	86
6000	-12	-12.0	-8.0	-2.0	3.5	9.8	78
LEFT-RIGHT DIFFERENCES							
500	-12	-8.0	-3.5	0.0	2.0	6.0	14
1000	-14	-6.0	-4.0	-2.0	1.5	4.0	16
2000	-18	-8.0	-5.5	0.0	2.0	5.8	14
4000	-16	-10.0	-4.0	0.0	5.5	9.8	20
6000	-22	-12.0	-6.0	0.0	5.5	10.0	20

** $p \leq .01$

TABLE 14 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN GIRLS 12-17 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	95	-1.22	6.71	1.21	0.0001	3.28	0.0001
1000	96	-2.10	6.33	1.18	0.0001	2.35	0.0001
2000	96	-1.77	6.04	0.50	0.0398	0.20	0.9859
4000	96	0.35	6.18	0.11	0.9811	-0.44	0.7293
6000	96	0.77	8.40	0.57	0.0196	0.14	0.9990
LEFT EAR							
500	95	-2.93	6.48	0.60	0.0151	-0.10	1.0000
1000	95	-3.33	9.34	4.16	0.0001	21.74	0.0001
2000	94	-3.70	8.70	2.67	0.0001	10.69	0.0001
4000	95	0.38	10.44	1.86	0.0001	5.49	0.0001
6000	95	0.00	8.43	0.23	0.7267	-0.66	0.1796
BETTER EAR							
500	95	-4.25	5.43	0.48	0.0509	0.23	0.9697
1000	96	-5.48	4.24	0.58	0.0182	0.95	0.0488
2000	96	-5.69	5.26	0.92	0.0005	0.55	0.2585
4000	96	-2.96	5.93	0.08	0.9979	-0.81	0.0927
6000	96	-3.08	7.53	0.81	0.0016	0.71	0.1408
LEFT-RIGHT DIFFERENCES							
500	95	-1.71*	6.31	0.30	0.2179	6.72	0.0001
1000	95	-1.22	10.73	3.69	0.0001	20.13	0.0001
2000	94	-1.77	9.92	2.45	0.0001	12.25	0.0001
4000	95	-0.02	10.83	1.60	0.0001	5.38	0.0001
6000	95	-0.84	8.84	-0.16	0.8899	-0.09	1.0000

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-10.0	-4.0	-2.0	2.0	6.8	28
1000	-12	-10.0	-6.0	-4.0	0.0	6.0	24
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	18
4000	-12	-8.0	-4.0	0.0	6.0	8.0	16
6000	-12	-10.6	-6.0	0.0	5.5	12.6	24
LEFT EAR							
500	-12	-12.0	-8.0	-4.0	0.0	6.0	14
1000	-12	-12.0	-8.0	-4.0	-2.0	2.8	54
2000	-12	-12.0	-10.0	-6.0	0.0	5.0	46
4000	-12	-12.0	-6.0	0.0	4.0	10.0	46
6000	-12	-12.0	-8.0	0.0	6.0	10.0	24
BETTER EAR							
500	-12	-12.0	-8.0	-4.0	0.0	2.0	14
1000	-12	-12.0	-8.0	-6.0	-4.0	0.0	10
2000	-12	-12.0	-10.0	-6.0	-4.0	0.6	10
4000	-12	-12.0	-8.0	-2.0	0.0	4.0	10
6000	-12	-12.0	-10.0	-4.0	2.0	6.0	24
LEFT-RIGHT DIFFERENCES							
500	-30	-6.8	-4.0	-2.0	0.0	4.8	26
1000	-30	-8.8	-6.0	-2.0	0.0	4.0	60
2000	-30	-12.0	-6.0	-2.0	0.0	6.0	56
4000	-26	-10.0	-4.0	0.0	2.0	10.0	46
6000	-24	-12.6	-6.0	0.0	6.0	10.0	22

* [illegible]

TABLE 15 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN 6-11 YEAR OLDS (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	94	1.49	6.86	0.93	0.0005	1.45	0.0039
1000	96	0.42	6.73	0.78	0.0021	1.48	0.0031
2000	96	-0.06	5.91	0.49	0.0443	0.99	0.0402
4000	95	2.38	6.68	0.08	0.9980	0.14	0.9990
6000	94	3.15	7.58	0.40	0.1058	0.26	0.9402
LEFT EAR							
500	85	1.15	6.57	0.51	0.0501	1.03	0.0440
1000	90	-0.67	6.17	0.47	0.0615	-0.39	0.8091
2000	90	-2.02	6.13	0.37	0.1378	-0.02	1.0000
4000	88	1.25	6.36	0.08	0.9983	-0.10	1.0000
6000	88	2.91	7.62	0.11	0.9784	-0.14	0.9991
BETTER EAR							
500	95	-0.40	6.17	0.72	0.0042	1.90	0.0003
1000	96	-1.94	5.65	0.35	0.1521	-0.25	0.9488
2000	96	-3.08	5.57	0.61	0.0131	1.00	0.0399
4000	95	-0.69	5.80	-0.11	0.9811	-0.45	0.7262
6000	95	0.38	6.58	-0.04	1.0000	-0.51	0.2968
LEFT-RIGHT DIFFERENCES							
500	84	-0.57	5.41	-1.00	0.0004	1.82	0.0009
1000	90	-0.98	5.97	-0.66	0.0101	2.29	0.0001
2000	90	-2.07**	5.63	-0.56	0.0256	0.90	0.0707
4000	88	-1.34	6.95	-0.16	0.8967	0.60	0.2411
6000	87	-0.53	7.71	-0.13	0.9466	0.70	0.1710

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-6.0	-2.5	0.0	4.5	9.0	26
1000	-12	-6.6	-4.0	0.0	4.0	8.0	24
2000	-12	-8.0	-4.0	0.0	4.0	6.0	22
4000	-12	-6.0	-2.0	2.0	6.0	10.0	22
6000	-12	-6.0	-2.0	2.0	8.0	14.0	26
LEFT EAR							
500	-12	-6.0	-3.0	0.0	5.0	8.8	24
1000	-12	-8.0	-4.0	-2.0	4.0	8.0	14
2000	-12	-10.0	-6.0	-2.0	2.0	5.8	18
4000	-12	-6.2	-4.0	2.0	6.0	8.0	20
6000	-12	-10.0	-2.0	3.0	8.0	12.2	24
BETTER EAR							
500	-12	-8.0	-4.0	0.0	4.0	6.0	24
1000	-12	-8.6	-6.0	-2.0	2.0	6.0	14
2000	-12	-10.0	-8.0	-4.0	0.0	4.0	18
4000	-12	-10.0	-4.0	0.0	4.0	6.0	14
6000	-12	-10.0	-4.0	0.0	4.0	10.0	16
LEFT-RIGHT DIFFERENCES							
500	-20	-6.0	-2.0	0.0	2.0	6.0	10
1000	-24	-8.0	-4.0	0.0	2.0	6.0	14
2000	-22	-10.0	-6.0	-2.0	2.0	6.0	10
4000	-22	-12.0	-4.0	-2.0	2.0	8.0	18
6000	-22	-10.0	-6.0	0.0	2.0	10.0	22

** $p \leq .01$

TABLE 16 - DESCRIPTIVE STATISTICS OF AUDITORY THRESHOLD LEVELS IN 12-17 YEAR OLDS (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	175	-0.61	8.47	4.16	0.0001	32.92	0.0001
1000	176	-1.48	8.29	5.23	0.0001	46.14	0.0001
2000	176	-1.45	8.24	4.13	0.0001	33.77	0.0001
4000	176	0.91	9.40	4.77	0.0001	43.39	0.0001
6000	176	1.57	10.59	3.49	0.0001	25.86	0.0001
LEFT EAR							
500	175	-1.91	8.52	4.51	0.0001	37.85	0.0001
1000	175	-2.80	10.18	5.06	0.0001	33.96	0.0001
2000	174	-3.10	9.69	4.18	0.0001	27.37	0.0001
4000	175	0.80	11.06	3.39	0.0001	20.85	0.0001
6000	175	0.73	10.40	2.40	0.0001	15.46	0.0001
BETTER EAR							
500	175	-3.27	7.96	5.30	0.0001	48.45	0.0001
1000	176	-4.45	7.69	7.05	0.0001	72.62	0.0001
2000	176	-4.85	7.90	5.48	0.0001	48.85	0.0001
4000	176	-2.30	9.03	5.27	0.0001	49.44	0.0001
6000	176	-2.23	9.63	3.52	0.0001	25.46	0.0001
LEFT-RIGHT DIFFERENCES							
500	175	-1.30**	5.72	0.11	0.9131	5.63	0.0001
1000	175	-1.33*	8.45	4.17	0.0001	30.07	0.0001
2000	174	-1.56*	8.17	2.32	0.0001	15.03	0.0001
4000	175	-0.14	9.48	1.35	0.0001	5.38	0.0001
6000	175	-0.88	8.62	-0.19	0.2988	-0.11	0.9986

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-12	-8.8	-4.0	-2.0	2.0	6.0	74
1000	-12	-8.6	-6.0	-2.0	0.0	4.0	78
2000	-12	-10.0	-6.0	-2.0	2.0	6.0	72
4000	-12	-10.0	-4.0	0.0	6.0	8.6	90
6000	-12	-10.0	-6.0	0.0	6.0	12.0	90
LEFT EAR							
500	-12	-10.0	-6.0	-2.0	2.0	6.0	76
1000	-12	-10.0	-8.0	-4.0	0.0	4.0	82
2000	-12	-12.0	-8.0	-4.0	0.0	6.0	76
4000	-12	-12.0	-6.0	0.0	4.0	8.8	86
6000	-12	-12.0	-8.0	0.0	6.0	12.0	78
BETTER EAR							
500	-12	-12.0	-8.0	-4.0	0.0	2.8	74
1000	-12	-12.0	-8.0	-4.0	-2.0	0.0	78
2000	-12	-12.0	-10.0	-6.0	-2.5	2.0	72
4000	-12	-12.0	-6.0	-2.0	2.0	6.0	86
6000	-12	-12.0	-9.5	-3.0	2.0	8.0	78
LEFT-RIGHT DIFFERENCES							
500	-30	-8.0	-4.0	-2.0	2.0	6.0	26
1000	-30	-8.0	-4.0	-2.0	0.0	4.0	60
2000	-30	-10.0	-6.0	-2.0	2.0	6.0	56
4000	-26	-10.0	-4.0	0.0	4.0	10.0	46
6000	-24	-12.0	-6.0	0.0	6.0	10.0	22

* $.01 < p \leq .05$

** $p \leq .01$

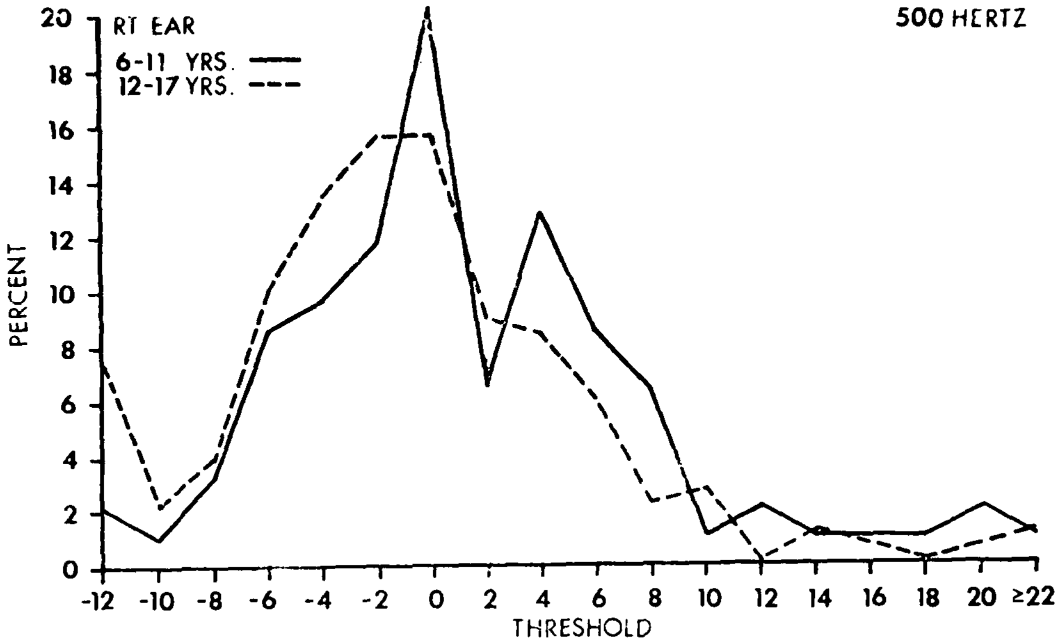

FIGURE 2 - PROPORTION OF CHILDREN IN 6-11 YEAR OLD AND 12-17 YEAR OLD AGE GROUPS HEARING AT SPECIFIC AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI - 1969) MEASURED AT 500 HERTZ IN THE RIGHT EAR

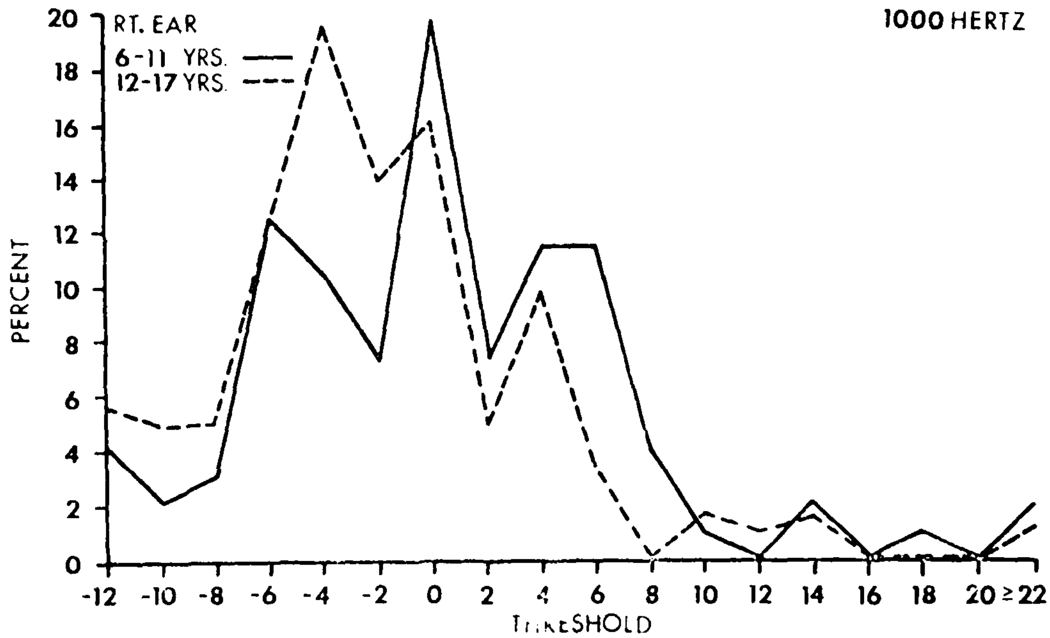

FIGURE 3 - PROPORTION OF CHILDREN IN 6-11 YEAR OLD AND 12-17 YEAR OLD AGE GROUPS HEARING AT SPECIFIC AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI- 1969) MEASURED AT 1000 HERTZ IN THE RIGHT EAR

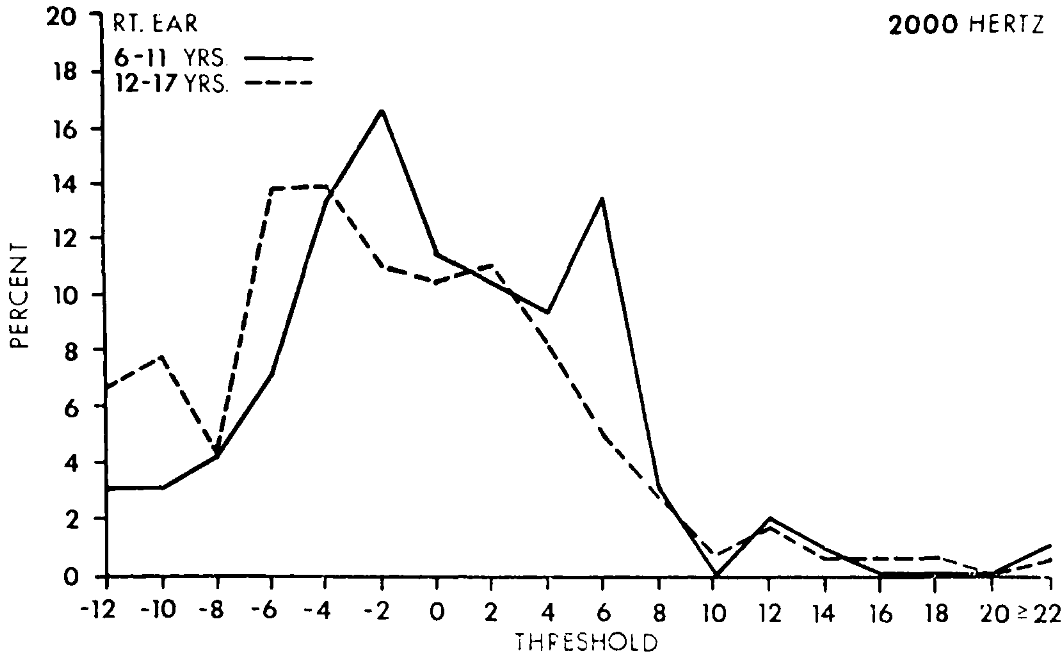

FIGURE 4 - PROPORTION OF CHILDREN IN 6-11 YEAR OLD AND 12-17 YEAR OLD AGE GROUPS HEARING AT SPECIFIC AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI - 1969) MEASURED AT 2000 HERTZ IN THE RIGHT EAR

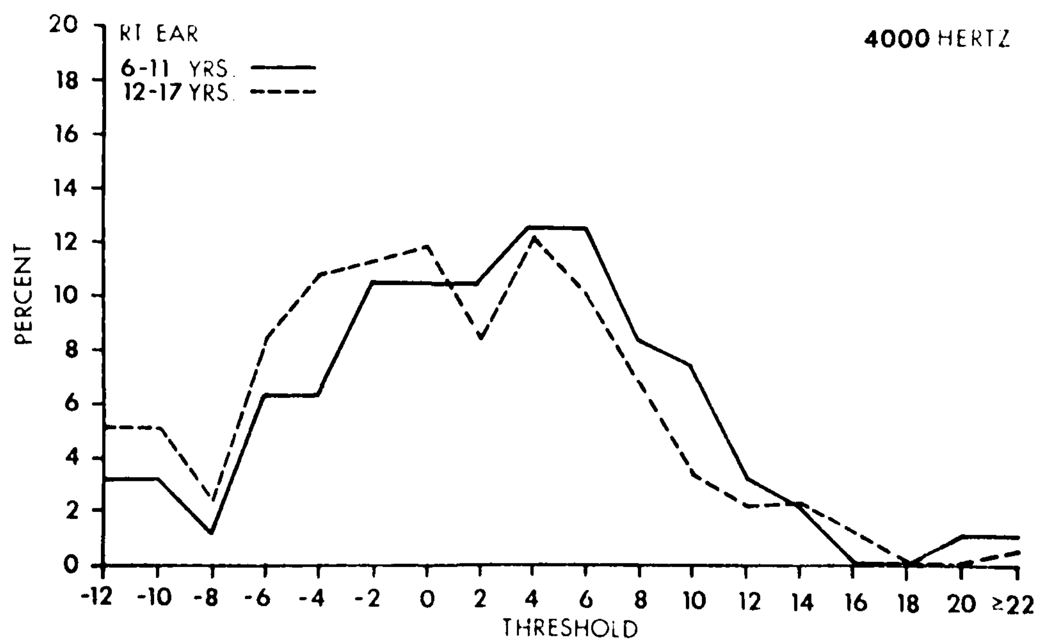

FIGURE 5 - PROPORTION OF CHILDREN IN 6-11 YEAR OLD AND 12-17 YEAR OLD AGE GROUPS HEARING AT SPECIFIC AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI - 1969) MEASURED AT 4000 HERTZ IN THE RIGHT EAR

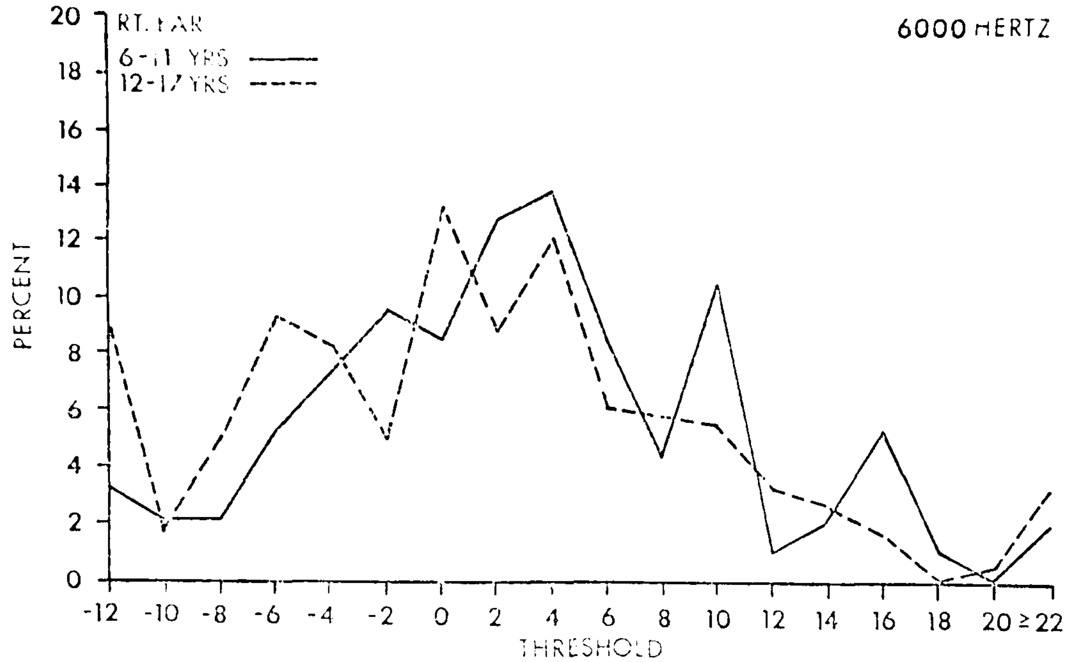

FIGURE 6 - PROPORTION OF CHILDREN IN 6-11 YEAR OLD AND 12-17 YEAR OLD AGE GROUPS HEARING AT SPECIFIC AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI - 1969) MEASURED AT 6000 HERTZ IN THE RIGHT EAR

hear better. When the correlations within each sex are examined, it becomes clear that the girls are primarily responsible for the significant correlations in the overall sample, especially at the lower frequencies where the correlations range from -.4 to -.5. In the boys, the correlations are much lower (-.1 to -.2) and are only just significant in two cases; however, they are negative at each frequency.

One explanation for the relative lack of younger children hearing at attenuation levels of -10 and -12 decibels and the significant negative correlations with age is that younger children may not concentrate sufficiently to reach their "true" thresholds. This explanation would account for the slightly higher means of the younger children and the significant correlations. If the difference between the age groups is real, and not due to sampling error, nor lack of concentration in younger children, an alternative explanation is that hearing may improve slightly with age as a result of some developmental change.

TABLE 17 SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN AGE AND AUDITORY THRESHOLD IN BETTER EAR OF BOYS AND GIRLS

	Boys and girls		Boys		Girls	
Frequency (Hertz)	n	Correlation Coefficient	n	Correlation Coefficient	n	Correlation Coefficient
500	203	-.384**	98	-.242	105	-.499**
1000	203	-.285**	98	-.088	105	-.472**
2000	205	-.312**	98	-.205*	107	-.399**
4000	204	-.190**	98	-.153	106	-.216*
6000	204	-.144*	98	-.152	106	-.123

* .01 p .05
** p .01

The greater non-normality of the threshold distributions of the older group, as well as the greater variance, are also evident in Figures 2 through 6. Some of those individuals in the older group with thresholds greater than 20 decibels have thresholds <u>much</u> greater than 20 decibels (i.e., in the 40 to 80 range). No one in the younger group has a threshold greater than 24 decibels.

<u>Fels Auditory Thresholds Compared with National Data</u>- Comparisons of the threshold distributions of the Fels and National Center for Health Statistics (NCHS) samples are presented in Figures 7 through 11. These figures show the proportion of the 12 to 17 year olds in each sample that fall into the five auditory threshold ranges. While these figures deal only with findings for the right ear, the results for the left ear are similar. The skewness and leptokurtosis of the distributions are evident. At each frequency, the Fels distribution is shifted toward lower thresholds (i.e., better hearing) compared to the NCHS distributions.

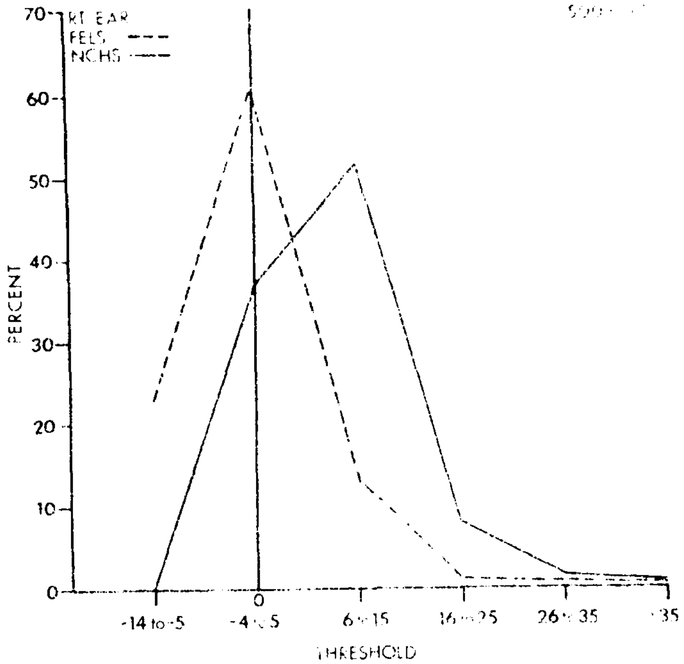

FIGURE 7 -- PERCENTAGE FREQUENCY DISTRIBUTION OF AUDITORY THRESHOLDS (DECIBELS) AT 12-17 YEARS FROM FELS AND NCHS SAMPLES (ROBERTS AND AHUJA, 1975) RE AUDIOMETRIC ZERO (ANSI-1969): 500 HERTZ, RIGHT EAR

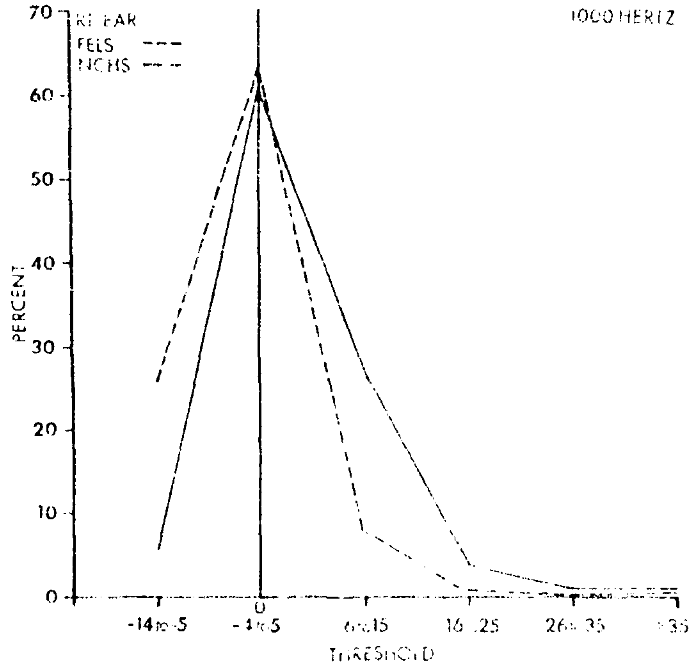

FIGURE 8 - PERCENTAGE FREQUENCY DISTRIBUTION OF AUDITORY THRESHOLDS (DECIBELS) AT 12-17 YEARS FROM FELS AND NCHS SAMPLES (ROBERTS AND AHUJA, 1975) RE AUDIOMETRIC ZERO (ANSI-1969): 1000 HERTZ, RIGHT EAR

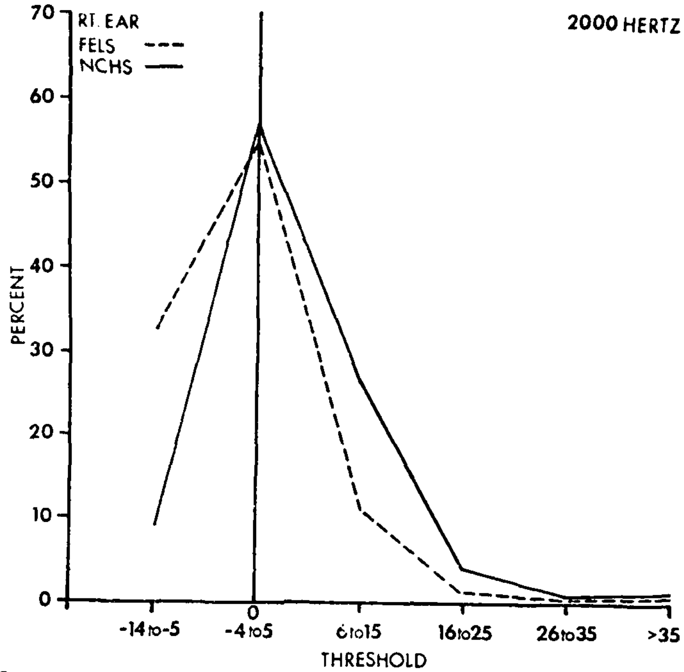

FIGURE 9 - PERCENTAGE FREQUENCY DISTRIBUTION OF AUDITORY THRESHOLDS (DECIBELS) at 12-17 YEARS FROM FELS AND NCHS SAMPLES (ROBERTS AND AHUJA, 1975) RE AUDIOMETRIC ZERO (ANSI-1969): 2000 HERTZ, RIGHT EAR

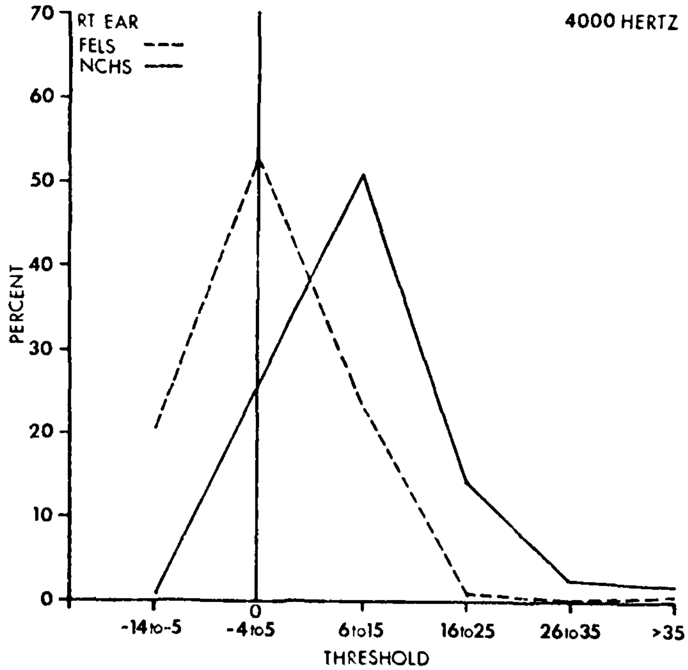

FIGURE 10 - PERCENTAGE FREQUENCY DISTRIBUTION OF AUDITORY THRESHOLDS (DECIBELS) AT 12-17 YEARS FROM FELS AND NCHS SAMPLES (ROBERTS AND AHUJA, 1975) RE AUDIOMETRIC ZERO (ANSI-1969): 4000 HERTZ, RIGHT EAR

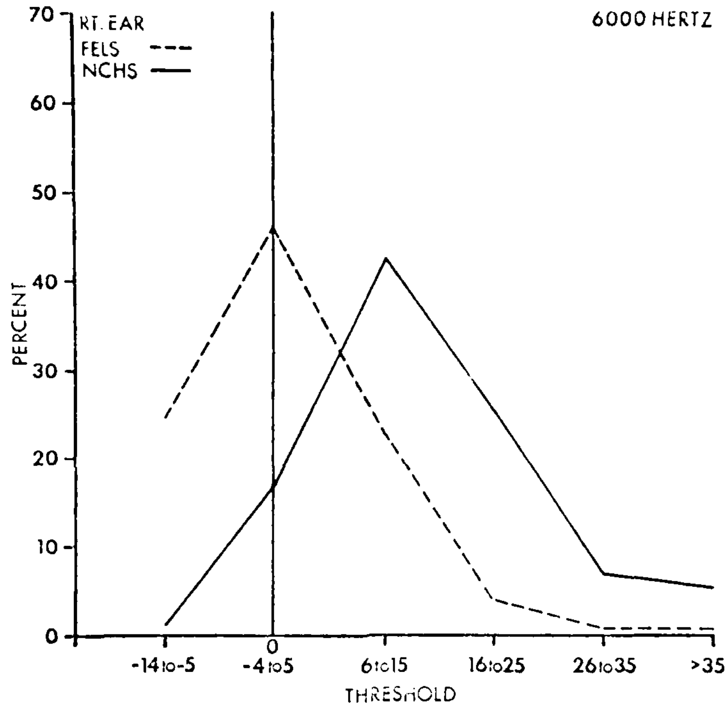

FIGURE 11 - PERCENTAGE FREQUENCY DISTRIBUTION OF AUDITORY THRESHOLDS (DECIBELS) AT 12-17 YEARS FROM FELS AND NCHS SAMPLES (ROBERTS AND AHUJA, 1975) RE AUDIOMETRIC ZERO (ANSI-1969): 6000 HERTZ, RIGHT EAR

In Figures 12 through 21, the median threshold levels for the right ear of Fels boys and Fels girls are presented with the corresponding NCHS medians at each age. Tables 18 through 21 present the median thresholds for right, left, and better ear for the NCHS and Fels samples. The irregularity of the Fels curve is probably due to relatively small sample sizes at each age (see Figure 1). For each sex, at almost every frequency, the Fels medians generally indicate lower thresholds compared to the National sample. In general, the Fels and NCHS medians follow parallel courses across age. An exception to this is seen at 4000 Hertz (Figures 18-19) where the NCHS data show a precipitous drop (6 decibels) in hearing ability between 11 and 12 years of age. It should be noted that the reference data for 6 to 11 year olds, and those for 12 to 17 year olds, are from different NCHS cross-sectional surveys. Consequently, the marked change in median thresholds from 11 to 12 years of age at 4000 Hertz probably represents sampling error or instrument variation rather than biological development. That this occurs in cross-sectional surveys, even those unusually well planned and based on large representative samples, such as NCHS, emphasizes the need for

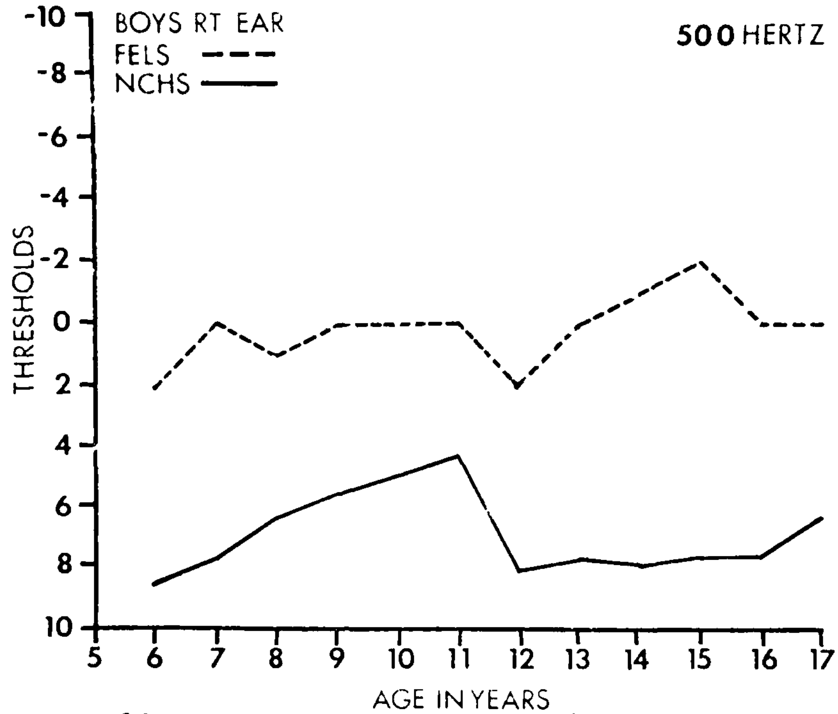

FIGURE 12-FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIZ ZERO (ANSI-1969) MEASURED AT 500 HERTZ IN THE RIGHT EAR OF BOYS

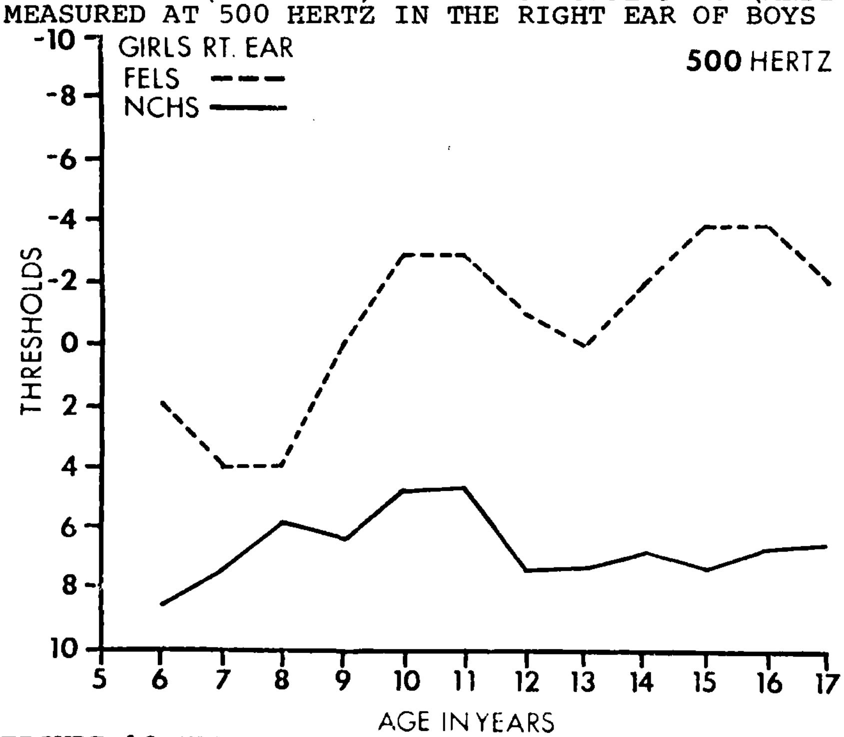

FIGURE 13-FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 500 HERTZ IN THE RIGHT EAR OF GIRLS

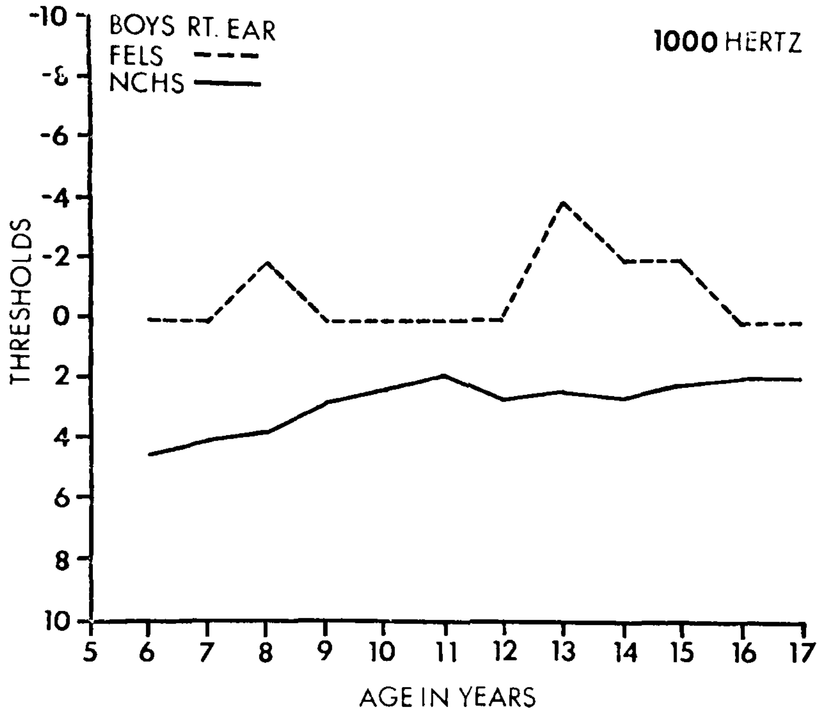

FIGURE 14-FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 1000 HERTZ IN THE RIGHT EAR OF BOYS

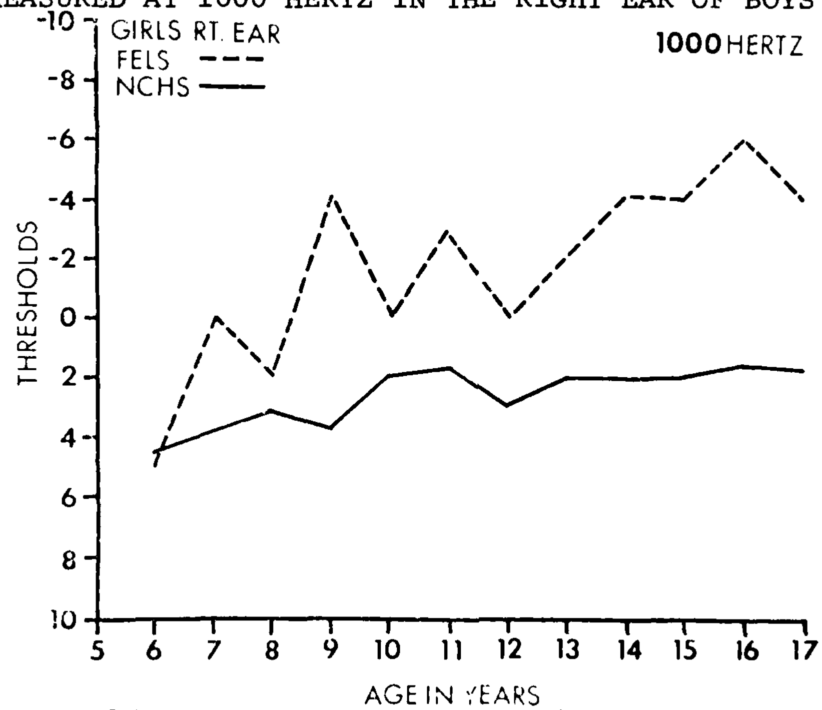

FIGURE 15-FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 1000 HERTZ IN THE RIGHT EAR OF GIRLS

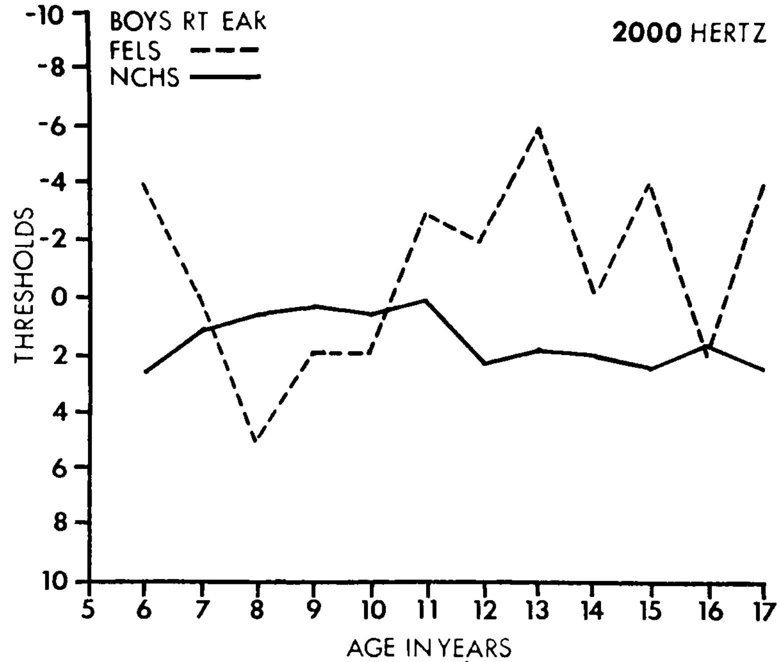

FIGURE 16-FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 2000 HERTZ IN THE RIGHT EAR OF BOYS

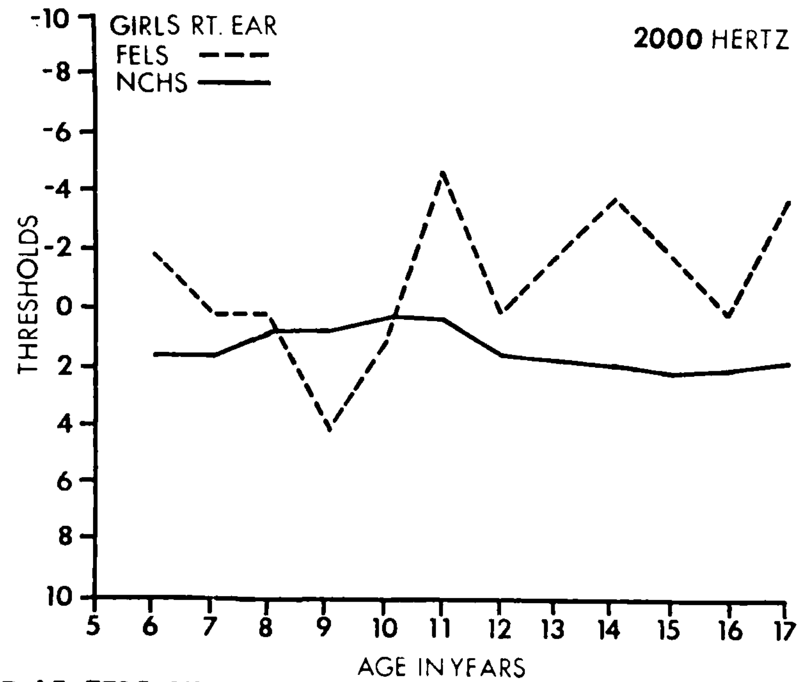

FIGURE 17-FELS AND NCHS SAMPLES (ROBERTS AND HUBER; 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 2000 HERTZ IN THE RIGHT EAR OF GIRLS

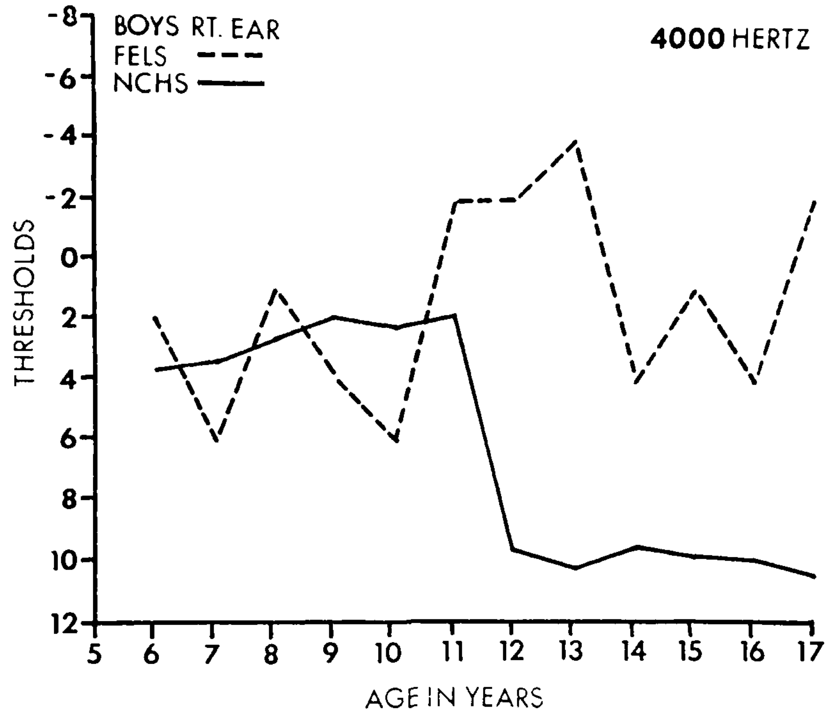

FIGURE 18 - FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 4000 HERTZ IN THE RIGHT EAR OF BOYS

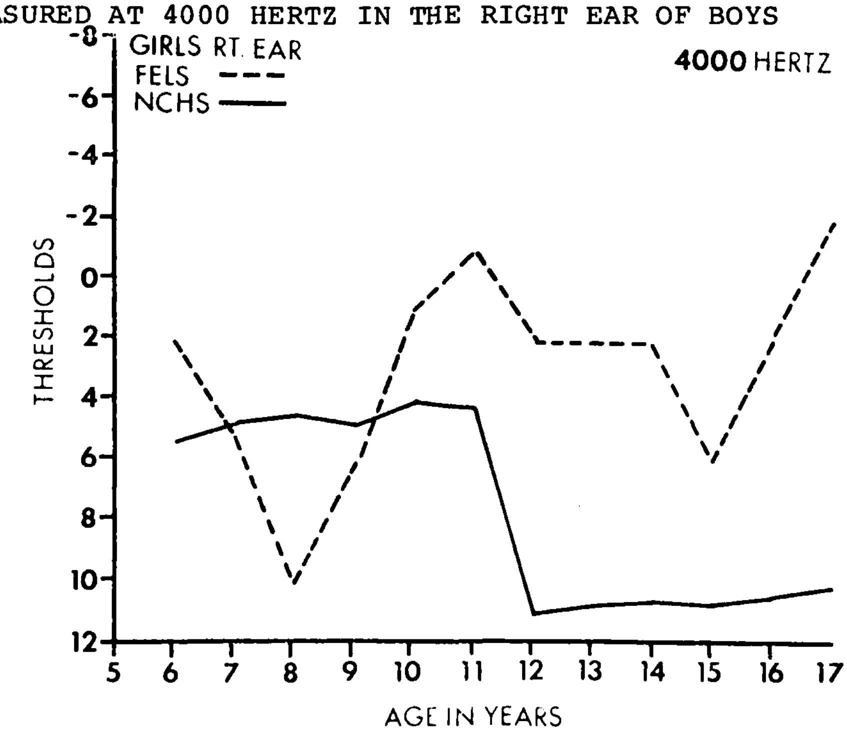

FIGURE 19 - FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 4000 HERTZ IN THE RIGHT EAR OF GIRLS

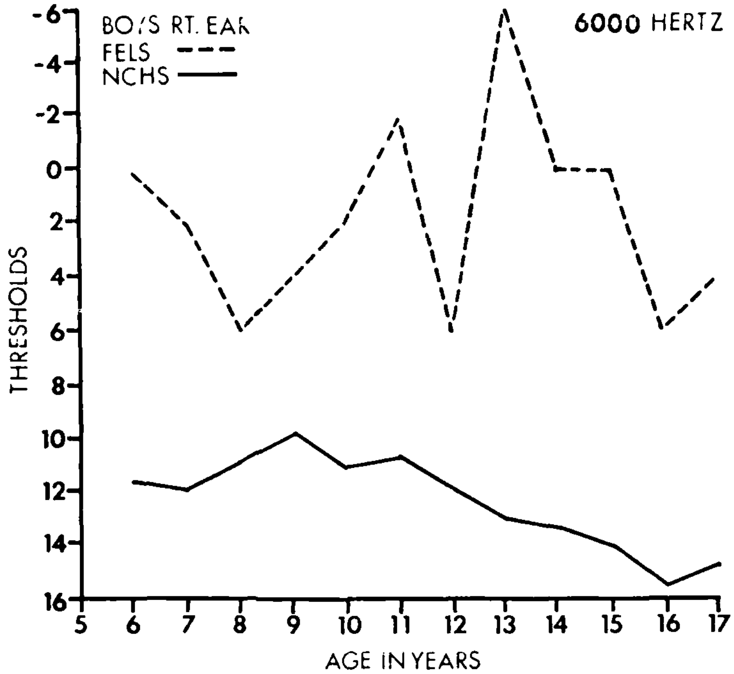

FIGURE 20 - FELS AND NCHS SAMPLES (*ROBERTS AND HUBER,* 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 6000 HERTZ IN THE RIGHT EAR OF BOYS

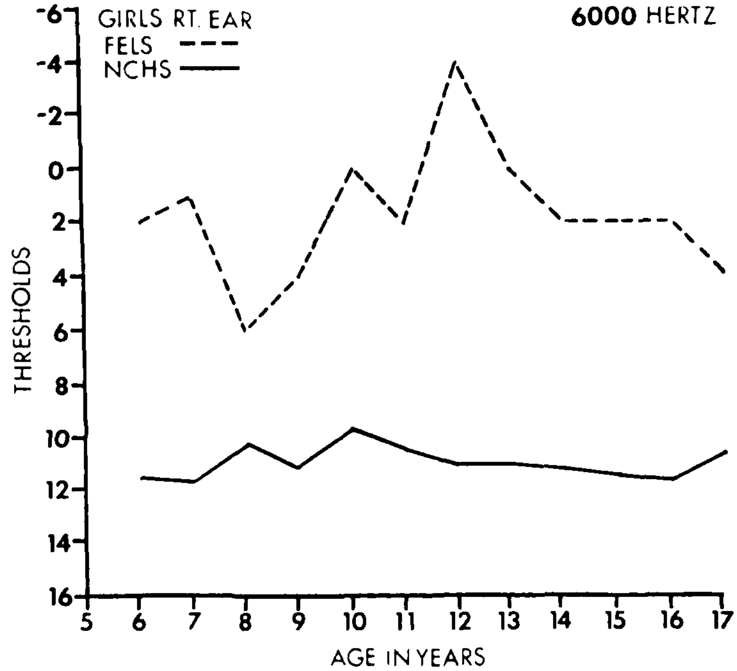

FIGURE 21 - FELS AND NCHS SAMPLES (ROBERTS AND HUBER, 1970; ROBERTS AND AHUJA, 1975) COMPARED FOR MEDIAN AUDITORY THRESHOLDS (DECIBELS) RE AUDIOMETRIC ZERO (ANSI-1969) MEASURED AT 6000 HERTZ IN THE RIGHT EAR OF GIRLS

TABLE 18. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN BOYS BY AGE: 6-11 YEARS, UNITED STATES, 1963-65 (FROM ROBERTS AND HUBER, 1970).

Ear and tonal frequency	Total 6-11 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.
Right ear							
500 Hertz	6.2	8.4	7.6	6.3	5.5	4.9	4.2
1000 Hertz	3.2	4.5	4.0	3.7	2.7	2.3	1.8
2000 Hertz	0.9	2.6	1.1	0.6	0.3	0.6	0.1
4000 Hertz	2.7	3.6	3.3	2.6	1.9	2.2	1.8
6000 Hertz	11.0	11.6	11.9	10.9	9.8	11.1	10.7
Left ear							
500 Hertz	6.5	8.4	7.7	6.4	6.0	5.5	4.9
1000 Hertz	3.5	4.8	4.5	3.7	2.8	2.7	2.3
2000 Hertz	1.4	2.3	2.1	1.3	0.8	0.9	0.7
4000 Hertz	3.1	4.0	3.7	3.2	2.7	2.6	2.7
6000 Hertz	12.1	11.7	12.0	11.6	12.0	12.0	12.9
Better ear							
500 Hertz	4.8	6.7	6.4	4.7	4.0	3.5	2.8
1000 Hertz	1.8	3.0	2.8	2.2	1.1	0.8	0.0
2000 Hertz	-0.8	0.4	-0.3	-0.9	-1.6	-1.1	-1.4
4000 Hertz	0.7	1.9	1.3	0.5	0.1	0.4	0.0
6000 Hertz	8.4	8.9	8.7	8.0	7.7	8.5	8.4

TABLE 18A. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN BOYS BY AGE: 12-17 YEARS, UNITED STATES, 1966-70 (FROM ROBERTS AND AHUJA, 1975).

Ear and tonal frequency	Total 12-17 yrs.	12 yrs.	13 yrs.	14 yrs.	15 yrs.	16 yrs.	17 yrs.
Right ear							
500 Hertz	7.6	8.0	7.7	7.9	7.6	7.6	6.3
1000 Hertz	2.2	2.6	2.3	2.5	2.1	1.9	1.9
2000 Hertz	2.2	2.3	1.9	2.1	2.5	1.7	2.5
4000 Hertz	9.9	9.6	10.2	9.6	9.8	10.0	10.4
6000 Hertz	13.6	11.9	13.0	13.4	14.0	15.5	14.8
Left ear							
500 Hertz	8.1	8.3	8.6	8.3	8.2	7.8	7.4
1000 Hertz	2.9	3.2	3.2	2.8	2.9	2.4	3.0
2000 Hertz	3.1	3.1	3.1	3.1	3.6	2.7	2.8
4000 Hertz	11.6	11.3	11.4	11.3	11.5	11.9	12.2
6000 Hertz	15.0	13.7	14.9	13.9	15.6	15.7	17.2
Better ear							
500 Hertz	5.9	6.4	6.2	6.2	5.9	6.0	4.7
1000 Hertz	1.1	1.3	1.4	1.3	1.0	0.9	0.9
2000 Hertz	0.9	1.1	0.7	0.9	1.1	0.6	1.0
4000 Hertz	8.5	8.3	8.6	8.3	8.1	8.7	9.1
6000 Hertz	11.1	9.8	10.6	10.8	11.2	12.0	12.4

TABLE 19. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN GIRLS BY AGE: 6-11 YEARS, UNITED STATES, 1963-65 (FROM ROBERTS AND HUBER, 1970).

Ear and tonal frequency	Total 6-11 years	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.
<u>Right ear</u>							
500 Hertz	6.3	8.5	7.4	5.9	6.4	4.8	4.7
1000 Hertz	3.2	4.6	3.8	3.2	3.8	1.9	1.7
2000 Hertz	0.8	1.5	1.5	0.6	0.6	0.1	0.2
4000 Hertz	2.5	3.3	2.6	2.4	2.7	2.0	2.2
6000 Hertz	10.9	11.6	11.7	10.3	11.2	9.8	10.6
<u>Left ear</u>							
500 Hertz	6.4	7.8	7.5	6.0	6.4	4.8	5.1
1000 Hertz	3.0	4.4	4.0	2.8	3.3	1.8	1.7
2000 Hertz	0.8	1.8	1.6	0.5	0.6	0.2	-0.3
4000 Hertz	3.0	3.3	3.6	3.0	3.3	1.9	3.1
6000 Hertz	11.4	11.2	12.4	10.3	11.7	11.7	11.7
<u>Better ear</u>							
500 Hertz	4.7	6.4	6.0	4.1	4.6	2.9	3.2
1000 Hertz	1.5	2.8	2.2	1.4	1.7	0.2	-0.3
2000 Hertz	-1.2	-0.2	-0.3	-1.3	-1.6	-1.9	-2.0
4000 Hertz	0.5	1.2	1.1	0.3	0.8	-0.4	0.1
6000 Hertz	8.1	8.5	8.8	7.5	8.0	7.5	8.1

TABLE 19A. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN GIRLS BY AGE: 12-17 YEARS, UNITED STATES, 1966-70 (FROM ROBERTS AND AHUJA, 1975).

Ear and tonal frequency	Total 12--17 years	12 yrs.	13 yrs.	14 yrs.	15 yrs.	16 yrs.	17 yrs.
Right ear							
500 Hertz	7.0	7.4	7.3	6.8	7.3	6.7	6.6
1000 Hertz	2.0	2.5	2.1	2.1	2.0	1.7	1.8
2000 Hertz	1.8	1.5	1.7	1.8	2.1	1.9	1.7
4000 Hertz	8.7	9.0	8.8	8.6	8.7	8.5	8.2
6000 Hertz	11.2	11.1	11.1	11.3	11.5	11.7	10.7
Left ear							
500 Hertz	7.4	7.6	7.7	7.4	7.3	6.7	7.4
1000 Hertz	2.3	2.4	2.4	2.3	2.1	2.4	2.1
2000 Hertz	2.0	2.0	2.1	1.9	2.5	2.0	1.8
4000 Hertz	9.7	9.7	10.1	9.7	9.8	9.5	9.4
6000 Hertz	12.4	11.3	12.8	12.3	12.9	13.3	12.2
Better ear							
500 Hertz	4.9	5.5	5.3	4.8	4.8	4.2	5.0
1000 Hertz	0.8	1.0	0.8	0.9	0.8	0.8	0.7
2000 Hertz	0.3	0.1	0.2	0.4	0.7	0.4	0.1
4000 Hertz	6.8	7.2	7.1	6.8	6.8	6.4	6.5
6000 Hertz	9.2	8.7	9.0	9.3	9.6	9.6	9.1

TABLE 20. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN FELS <u>BOYS</u> 6-11 YEARS OF AGE.

Ear and tonal frequency (Sample Size)	Total 6-11 years (52)	6 yrs. (9)	7 yrs. (9)	8 yrs. (8)	9 yrs. (9)	10 yrs. (7)	11 yrs. (10)
<u>Right ear</u>							
500 Hertz	0.0	2.0	0.0	1.0	0.0	0.0	0.0
1000 Hertz	0.0	0.0	0.0	-2.0	0.0	0.0	0.0
2000 Hertz	0.0	-4.0	0.0	5.0	2.0	2.0	-3.0
4000 Hertz	2.0	2.0	6.0	1.0	4.0	6.0	-2.0
6000 Hertz	4.0	0.0	2.0	6.0	4.0	2.0	-2.0
<u>Left ear</u>							
500 Hertz	0.0	2.0	0.0	-1.0	1.0	0.0	-1.0
1000 Hertz	-2.0	0.0	4.0	1.0	-4.0	0.0	-3.0
2000 Hertz	-2.0	-4.0	-2.0	4.0	-1.0	-2.0	-8.0
4000 Hertz	2.0	0.0	2.0	4.0	2.0	4.0	-2.0
6000 Hertz	4.0	4.0	4.0	6.0	5.0	4.0	1.0
<u>Better ear</u>							
500 Hertz	-2.0	0.0	-2.0	-2.0	-2.0	0.0	-3.0
1000 Hertz	-2.0	-4.0	0.0	-2.0	-4.0	-2.0	-3.0
2000 Hertz	-2.0	-6.0	-4.0	4.0	-2.0	-2.0	-8.0
4000 Hertz	0.0	0.0	0.0	0.0	0.0	2.0	-3.0
6000 Hertz	0.0	0.0	2.0	5.0	2.0	0.0	-3.0

TABLE 20A. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN FELS BOYS 12-17 YEARS OF AGE.

Ear and tonal frequency (Sample Size)	Total 12-17 years (80)	12 yrs. (7)	13 yrs. (13)	14 yrs. (24)	15 yrs. (12)	16 yrs. (15)	17 yrs. (9)
Right ear							
500 Hertz	0.0	2.0	0.0	-1.0	-2.0	0.0	0.0
1000 Hertz	-2.0	0.0	-4.0	-2.0	-2.0	0.0	0.0
2000 Hertz	-2.0	-2.0	-6.0	0.0	-4.0	2.0	-4.0
4000 Hertz	2.0	-2.0	-4.0	4.0	1.0	4.0	-2.0
6000 Hertz	0.0	6.0	-6.0	0.0	0.0	6.0	4.0
Left ear							
500 Hertz	-2.0	0.0	-2.0	-2.0	0.0	-2.0	-2.0
1000 Hertz	-4.0	-4.0	-4.0	-4.0	0.0	-2.0	-2.0
2000 Hertz	-4.0	-6.0	-6.0	-2.0	-4.0	-4.0	-6.0
4000 Hertz	0.0	-2.0	-2.0	1.0	0.0	2.0	0.0
6000 Hertz	2.0	4.0	-4.0	0.0	2.0	4.0	-4.0
Better ear							
500 Hertz	-2.0	0.0	-4.0	-4.0	-3.0	-2.0	-6.0
1000 Hertz	-4.0	-4.0	-6.0	-4.0	-4.0	-4.0	-2.0
2000 Hertz	-6.0	-6.0	-6.0	-4.0	-6.0	-4.0	-6.0
4000 Hertz	-2.0	-2.0	-6.0	-2.0	-1.0	2.0	-4.0
6000 Hertz	-2.0	4.0	-8.0	-4.0	0.0	0.0	-4.0

TABLE 21. MEDIAN HEARING LEVELS IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN FELS GIRLS 6-11 YEARS OF AGE.

Ear and tonal frequency (Sample Size)	Total 6-11 years (44)	6 yrs. (8)	7 yrs. (8)	8 yrs. (7)	9 yrs. (7)	10 yrs. (8)	11 yrs. (6)
Right ear							
500 Hertz	0.0	2.0	4.0	4.0	0.0	-3.0	-3.0
1000 Hertz	0.0	5.0	0.0	2.0	-4.0	0.0	-3.0
2000 Hertz	-1.0	-2.0	0.0	0.0	4.0	1.0	-5.0
4000 Hertz	2.0	0.0	3.0	8.0	4.0	-1.0	-3.0
6000 Hertz	2.0	2.0	1.0	6.0	4.0	0.0	2.0
Left ear							
500 Hertz	0.0	1.0	4.0	6.0	1.0	-2.0	0.0
1000 Hertz	-2.0	-5.0	0.0	0.0	-2.0	-4.0	-2.0
2000 Hertz	-2.0	2.0	2.0	-2.0	-5.0	-7.0	-8.0
4000 Hertz	2.0	7.0	4.0	2.0	2.0	-1.0	-5.0
6000 Hertz	2.0	4.0	0.0	4.0	4.0	3.0	0.0
Better ear							
500 Hertz	0.0	0.0	0.0	4.0	0.0	-5.0	-3.0
1000 Hertz	-2.0	1.0	0.0	0.0	-4.0	-6.0	-3.0
2000 Hertz	-4.0	-2.0	0.0	-2.0	-6.0	-7.0	-9.0
4000 Hertz	0.0	0.0	0.0	2.0	2.0	-3.0	-6.0
6000 Hertz	0.0	2.0	-1.0	2.0	4.0	-2.0	0.0

TABLE 21A. MEDIAN HEARING IN DECIBELS RE AUDIOMETRIC ZERO (ANSI-1969) IN FELS GIRLS 12-17 YEARS OF AGE

Ear and tonal frequency (sample size)	Total 12-17 yrs. (95)	12 yrs. (13)	13 yrs. (27)	14 yrs. (31)	15 yrs. (7)	16 yrs. (11)	17 yrs. (7)
Right ear							
500 Hertz	-2.0	-1.0	0.0	-2.0	-4.0	-4.0	-2.0
1000 Hertz	-4.0	0.0	-2.0	-4.0	-4.0	-6.0	-4.0
2000 Hertz	-2.0	0.0	-2.0	-4.0	-2.0	0.0	-4.0
4000 Hertz	0.0	0.0	0.0	0.0	4.0	0.0	-4.0
6000 Hertz	0.0	-4.0	0.0	2.0	2.0	2.0	4.0
Left ear							
500 Hertz	-4.0	-3.0	-4.0	-2.0	-6.0	-4.0	-8.0
1000 Hertz	-4.0	-4.0	-4.0	-6.0	-6.0	-6.0	-6.0
2000 Hertz	-6.0	-4.0	-4.0	-6.0	-4.0	-6.0	-10.0
4000 Hertz	0.0	0.0	0.0	0.0	0.0	2.0	-2.0
6000 Hertz	0.0	3.0	0.0	-2.0	0.0	2.0	0.0
Better ear							
500 Hertz	-4.0	-3.0	-4.0	-2.0	-6.0	-4.0	-8.0
1000 Hertz	-6.0	-4.0	-6.0	-6.0	-6.0	-8.0	-6.0
2000 Hertz	-6.0	-6.0	-4.0	-6.0	-4.0	-6.0	-10.0
4000 Hertz	-2.0	-6.0	0.0	-2.0	0.0	-4.0	-4.0
6000 Hertz	-4.0	-6.0	-4.0	-4.0	0.0	0.0	0.0

serial studies to establish the true changes that are occurring. Although the best reference data available are probably those from NCHS there are differences between the NCHS and Fels samples, e.g., sample sizes, age range, racial distribution, geographical distribution, screening and testing procedures.

Increments - The increments are the changes in threshold levels from one visit to the next. They are calculated so that a positive value indicates a rise in threshold and, therefore, a change in the direction of a hearing loss. The calculations are made from pairs of examinations since 26 January 1976 and represent a time interval of 5 to 7 months. The total number of increments is 78. The age distribution of the children at the most recent examinations is given in Table 22.

The increments for the entire sample, with ages and sexes combined, are presented in Figures 22 through 31. Table 23 gives the summary statistics for these distributions. None of the distributions have significant skewness but there is significant kurtosis, at 1000 Hertz in the right ear (Figure 24).

Only the mean increments for the higher frequencies (6000 Hertz, right ear; 4000 Hertz, left ear) are significantly different from zero as determined by t-test (Table 23). Positive mean increments that are significantly different from zero for the higher frequencies imply a shift in the direction of hearing loss is occurring at these frequencies.

To determine which subgroup of the sample, if any, is contributing most to this effect, Tables 24 through 31 are presented. Because there are so few increments for each age interval, the age differences that will be examined are those between two age groups: 6 to 11 years old and 12 to 17 years old, using the age at most recent examination. In some categories, the sample sizes are quite small.

Tables 24 and 25 give the distribution statistics for threshold increments for children 6 to 11 years old and 12 to 17 years old, respectively. The increments are greater at 4000 and 6000 Hertz than at the lower frequencies; this is true in both age groups. However, the only mean increment to be statistically different from zero ($p < 0.05$) is that at 4000 Hertz (left ear) in the older children.

Tables 26 and 27 present the summary statistics of increments for boys and girls, respectively. The trend toward larger mean increments at the higher frequencies is present in both sexes, but is more pronounced in boys. In boys, the mean increments are significantly different from

TABLE 22. AGE DISTRIBUTION OF CHILDREN WITH AUDITORY THRESHOLD LEVEL 6-MONTHLY INCREMENTS

Age in years	Boys	Girls
5.75- 6.74	0	1
6.75- 7.74	2	3
7.75- 8.74	2	4
8.75- 9.74	3	1
9,75-10.74	2	3
10.75-11.74	3	1
11.75-12.74	3	3
12.75-13.74	2	9
13.75-14.74	10	10
14.75-15.74	1	1
15.75-16.74	4	4
16.75-17.74	4	2

TABLE 23 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN THE STUDY SAMPLE (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	76	-1.24	7.10	-0.10	0.9948	0.12	1.0000
1000	78	-0.46	7.19	-0.01	1.0000	1.95	0.0006
2000	78	-0.28	5.12	-0.15	0.9379	0.21	0.9878
4000	77	1.48	6.70	-0.02	1.0000	-0.24	0.9789
6000	77	2.00*	7.87	0.01	1.0000	0.08	1.0000
LEFT EAR							
500	72	-0.11	8.16	-0.07	0.9996	0.08	1.0000
1000	75	0.03	6.61	-0.08	0.9992	0.58	0.2935
2000	74	0.97	5.82	0.43	0.1228	0.51	0.7172
4000	73	3.73**	7.07	0.18	0.8790	-0.35	0.8922
6000	73	0.79	10.47	-0.08	0.9990	-0.82	0.1368
BETTER EAR							
500	76	-0.42	6.70	0.09	0.9965	0.09	1.0000
1000	78	0.05	6.17	0.69	0.0115	1.39	0.0102
2000	78	0.21	5.01	-0.02	1.0000	0.06	1.0000
4000	77	2.52**	6.33	-0.10	0.9943	-0.49	0.7346
6000	77	1.19	7.94	0.18	0.8844	-0.06	1.0000
LEFT-RIGHT DIFFERENCES							
500	72	1.06	7.28	-0.04	1.0000	0.10	1.0000
1000	75	0.51	6.30	0.27	0.6869	1.38	0.0119
2000	74	1.43	6.01	0.52	0.0614	1.89	0.0011
4000	73	2.14*	8.33	0.06	0.9999	0.10	1.0000
6000	73	-1.15	10.51	-0.63	0.0243	0.08	1.0000

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-20	-10.0	-6.0	-2.0	4.0	8.0	16
1000	-24	-8.2	-4.0	0.0	2.5	6.2	22
2000	-14	-6.2	-2.5	0.0	4.0	6.0	14
4000	-14	-8.0	-3.0	2.0	6.0	10.0	18
6000	-18	-6.4	-4.0	2.0	6.0	12.0	20
LEFT EAR							
500	-24	-11.4	-4.0	0.0	6.0	10.0	18
1000	-18	-8.8	-2.0	0.0	2.0	8.0	16
2000	-12	-6.0	-2.0	0.0	4.0	9.0	20
4000	-12	-6.0	0.0	4.0	8.0	12.0	20
6000	-20	-13.2	-8.0	0.0	9.0	14.0	24
BETTER EAR							
500	-16	-10.0	-4.0	0.0	4.0	6.0	16
1000	-14	-8.0	-4.0	0.0	2.0	8.0	20
2000	-12	-6.0	-4.0	0.0	4.0	6.0	14
4000	-12	-6.0	-2.0	2.0	7.0	10.0	18
6000	-16	-10.0	-4.0	0.0	8.0	10.0	24
LEFT-RIGHT DIFFERENCES							
500	-16	-8.0	-4.0	1.0	5.5	10.0	18
1000	-18	-6.0	-4.0	0.0	4.0	8.0	20
2000	-16	-4.0	-2.0	0.0	6.0	9.0	24
4000	-18	-7.2	-2.0	0.0	8.0	16.0	22
6000	-32	-14.0	-6.0	0.0	7.0	11.2	16

* .01 < p ≤ .05

** p ≤ .01

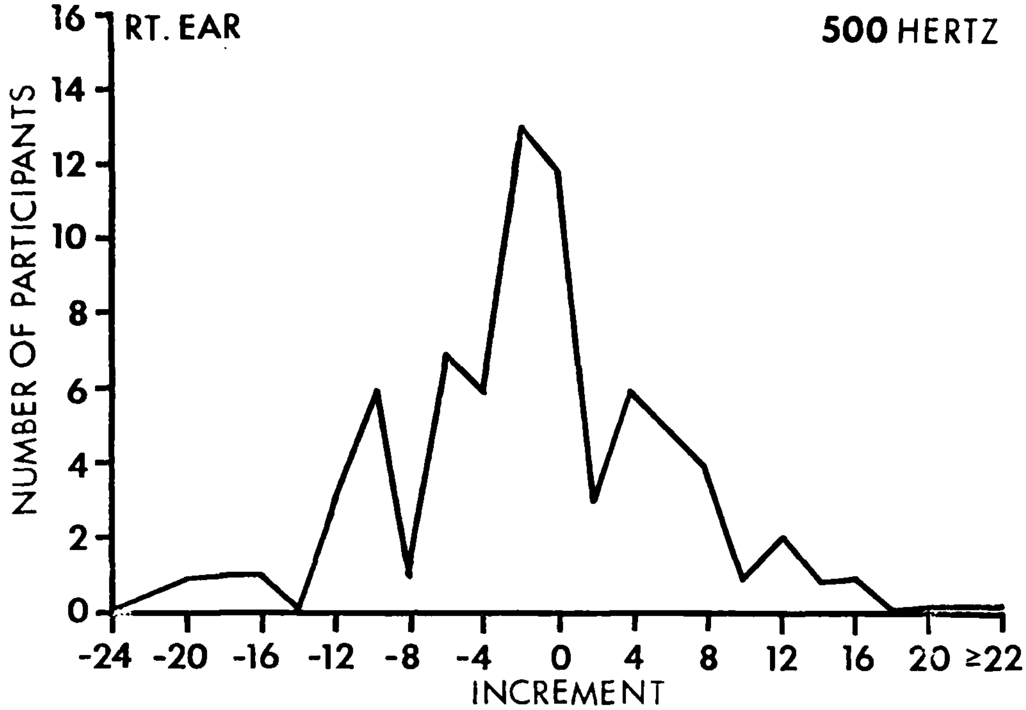

FIGURE 22 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 500 HERTZ IN THE RIGHT EAR

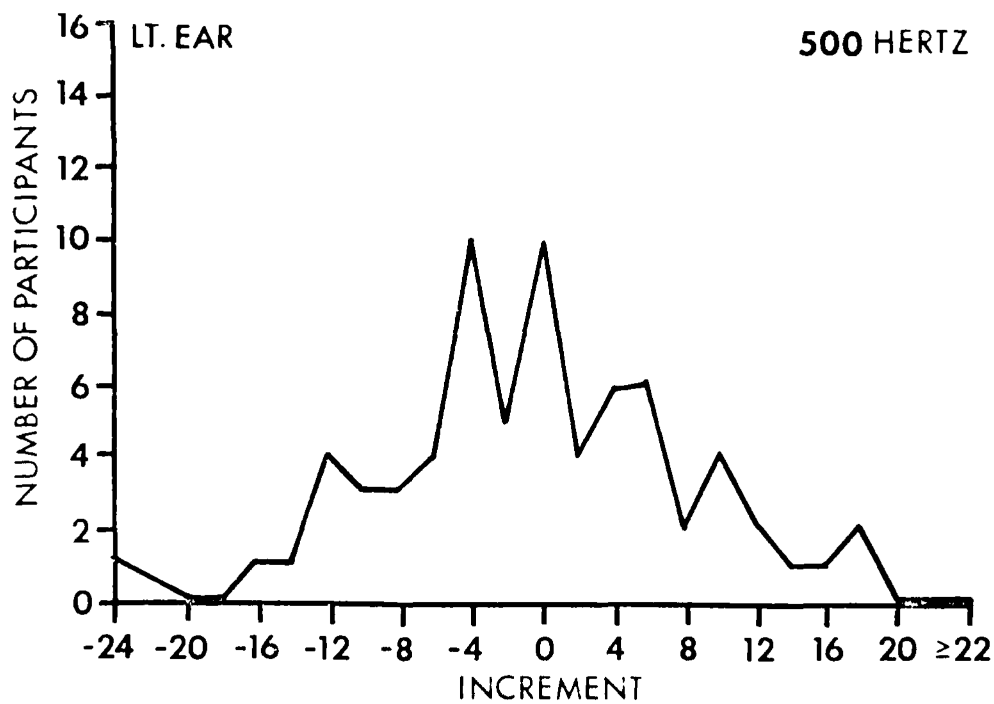

FIGURE 23 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 500 HERTZ IN THE LEFT EAR

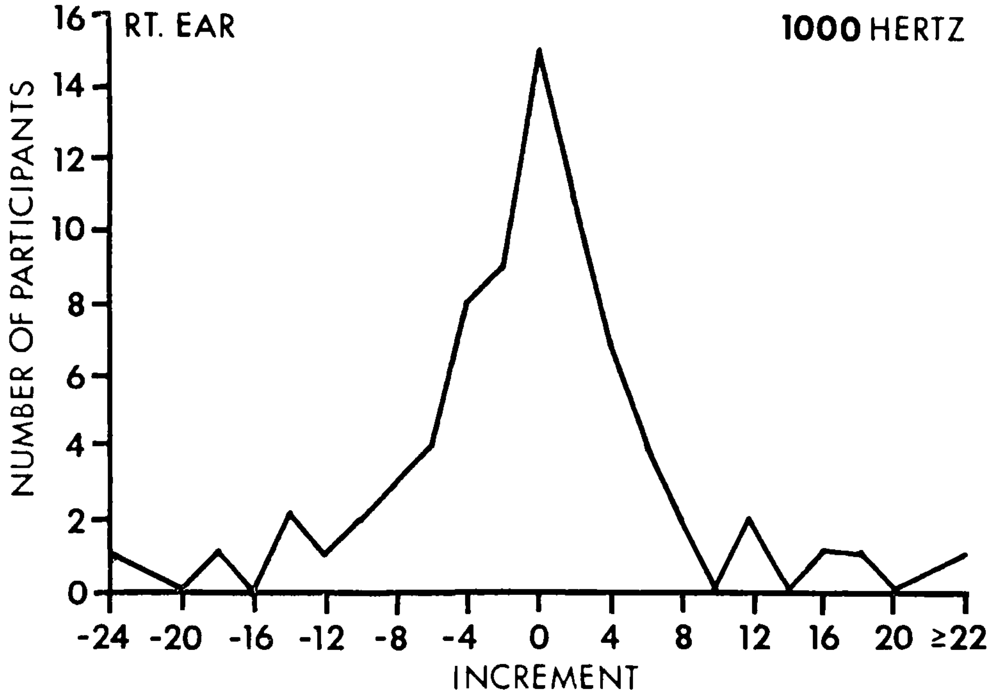

FIGURE 24 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 1000 HERTZ IN THE RIGHT EAR

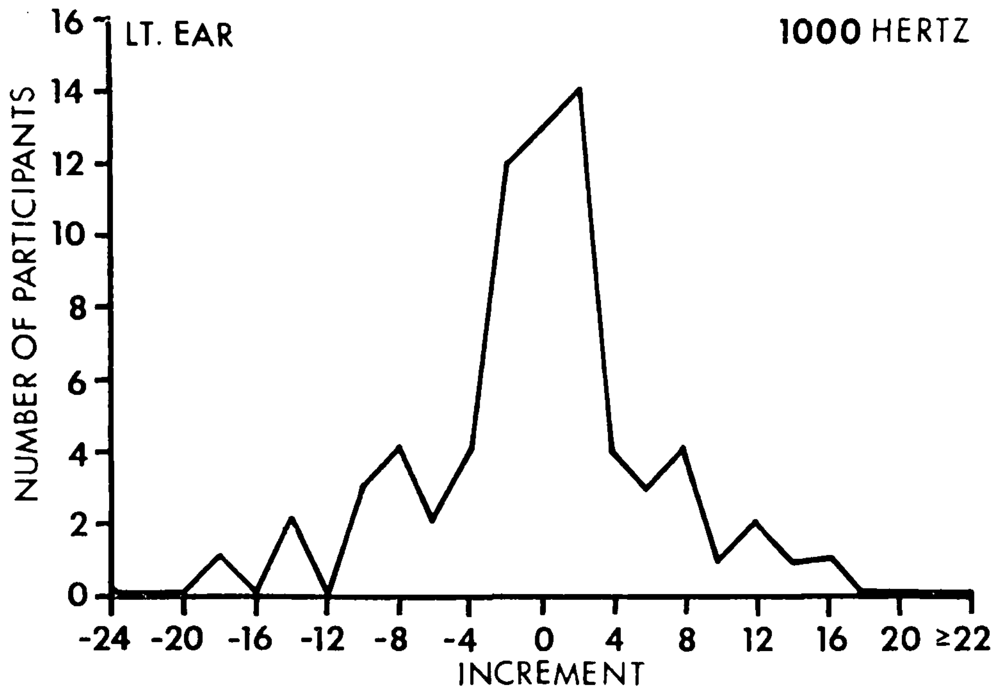

FIGURE 25 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 1000 HERTZ IN THE LEFT EAR

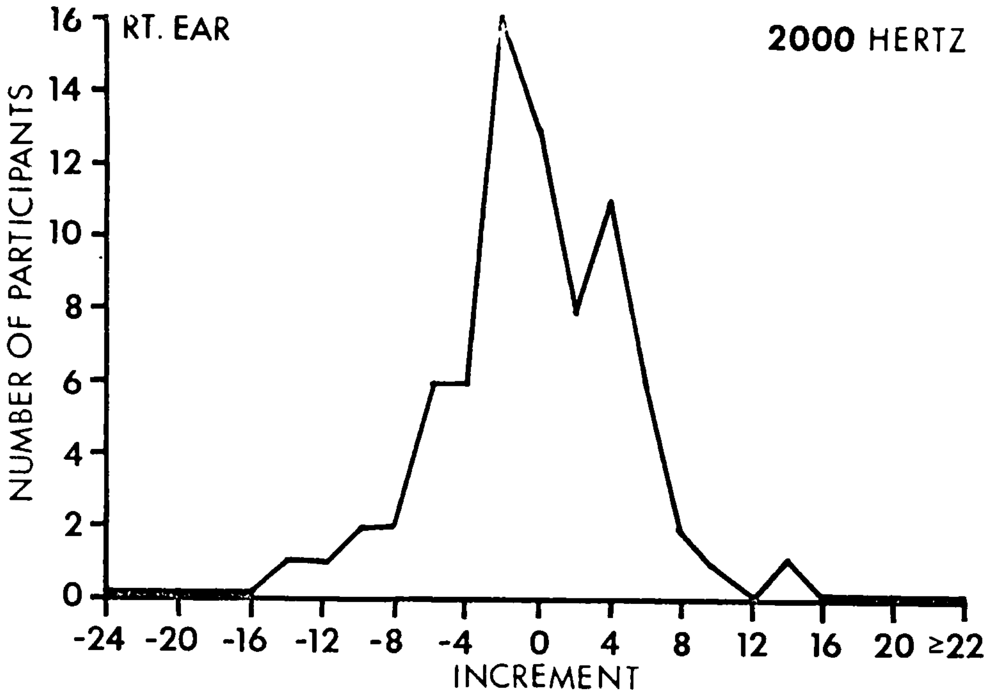

FIGURE 26 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 2000 HERTZ IN THE RIGHT EAR

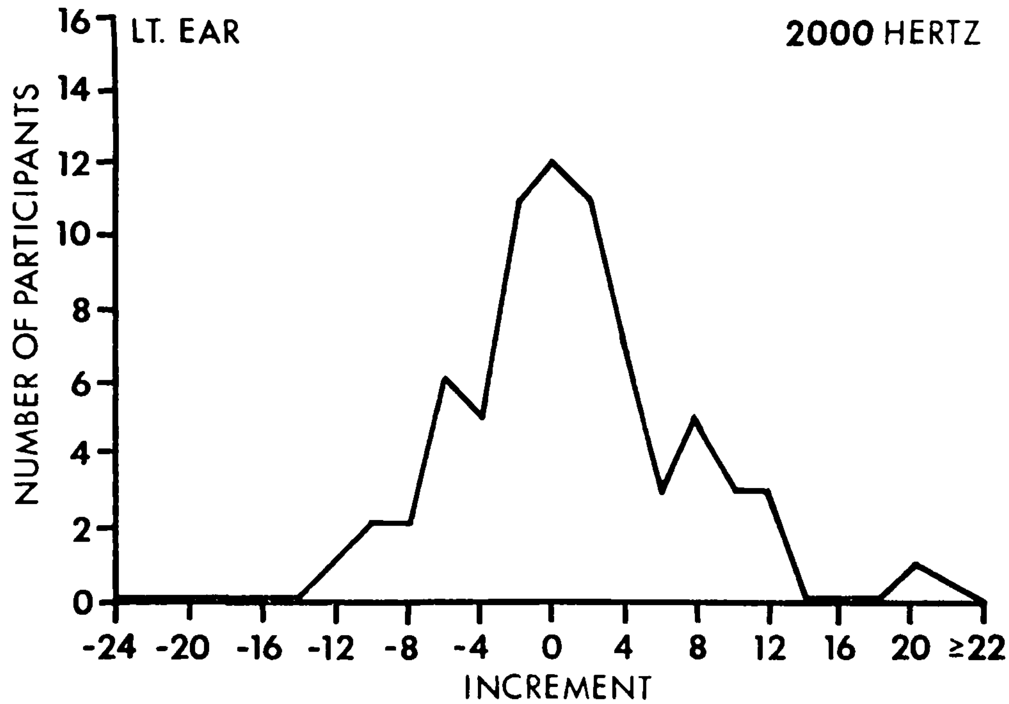

FIGURE 27 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 2000 HERTZ IN THE LEFT EAR

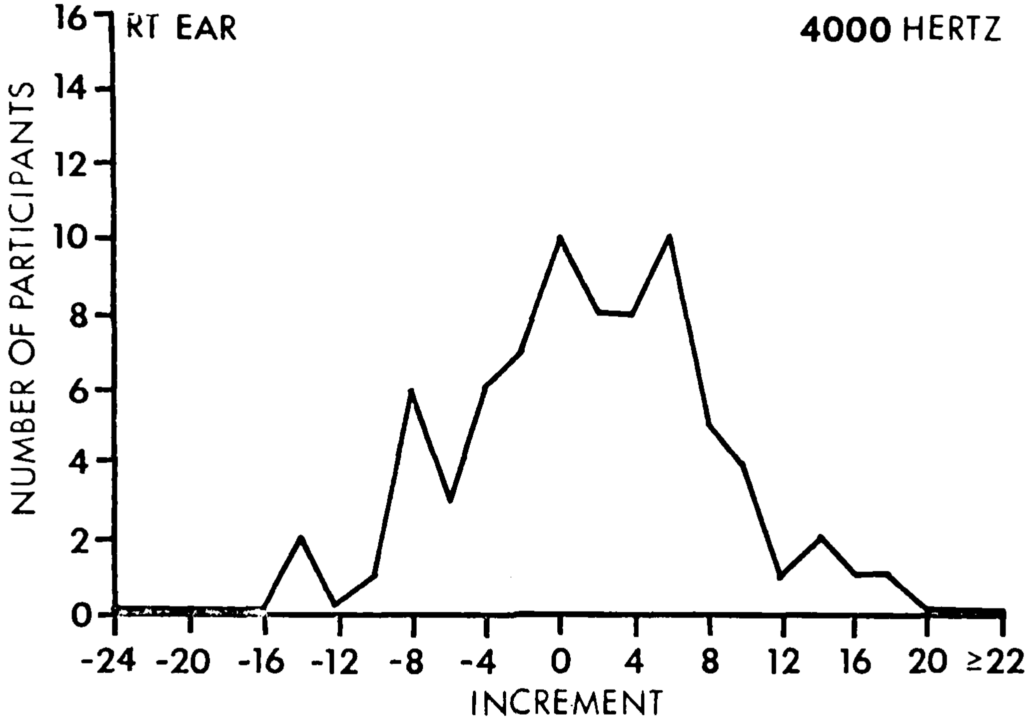

FIGURE 28 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 4000 HERTZ IN THE RIGHT EAR

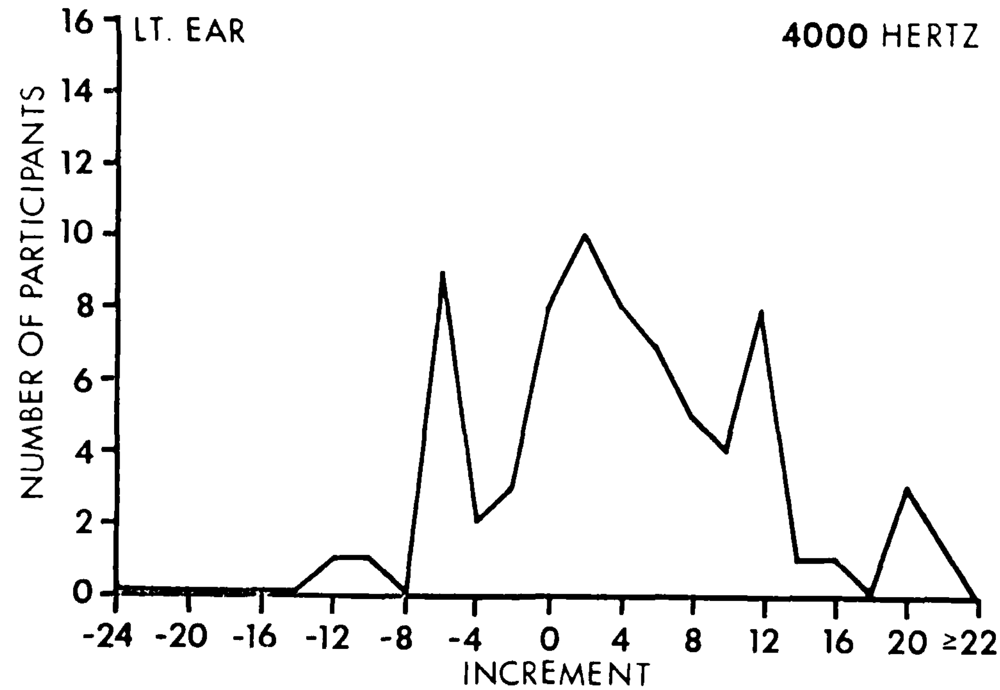

FIGURE 29 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 4000 HERTZ IN THE LEFT EAR

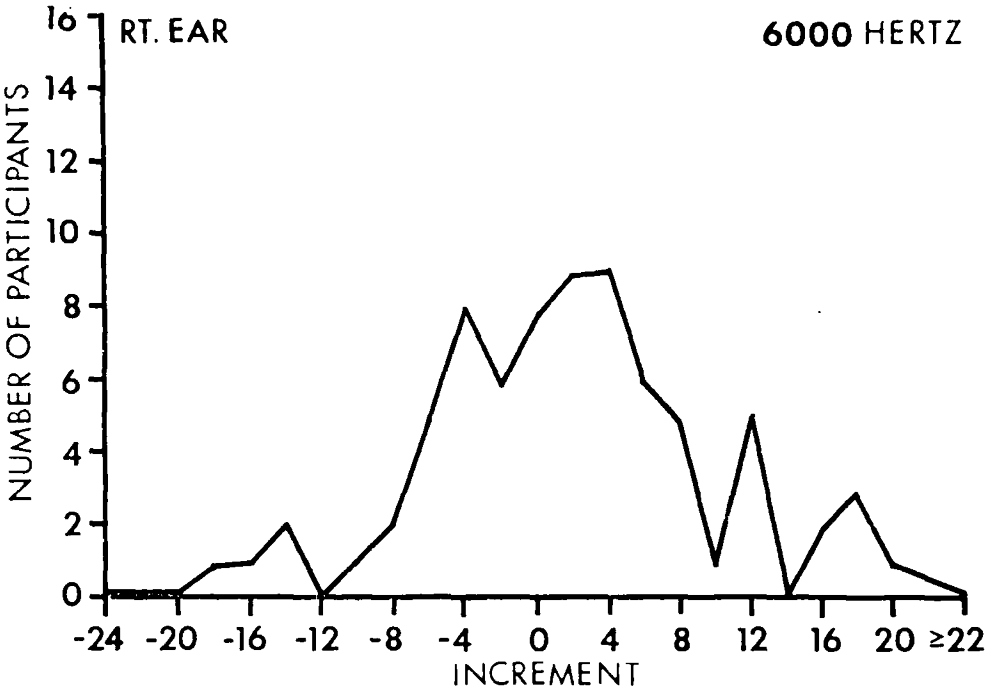

FIGURE 30 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS *MEASURED AT 6000* HERTZ IN THE RIGHT EAR

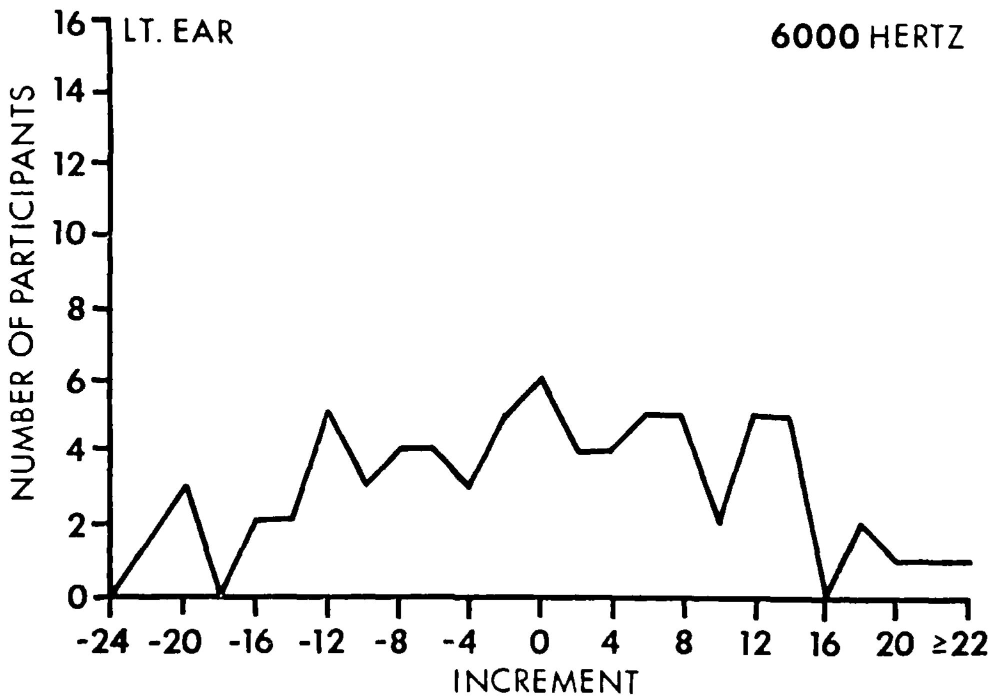

FIGURE 31 - FREQUENCY DISTRIBUTION OF SIX-MONTHLY INCREMENTS (DECIBELS) FOR CHILDREN AGED 6-17 YEARS MEASURED AT 6000 HERTZ IN THE LEFT EAR

TABLE 24 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN 6-11 YEAR OLDS (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	24	-0.50	6.76	-0.15	0.9977	0.83	0.7319
1000	25	0.00	9.26	-0.05	1.0000	0.86	0.7039
2000	25	0.48	4.81	0.58	0.2126	0.55	0.8999
4000	24	1.42	6.11	0.54	0.2562	0.23	0.9998
6000	24	2.08	7.70	0.26	0.9343	-0.48	0.9477
LEFT EAR							
500	20	0.90	9.48	-0.60	0.2413	0.34	0.9954
1000	23	-0.52	8.83	-0.28	0.9142	-0.68	0.8313
2000	23	0.78	5.68	-0.36	0.8231	-0.82	0.7463
4000	21	1.81	6.72	0.17	0.9963	-0.49	0.9545
6000	21	-0.19	10.93	-0.39	0.7992	-0.79	0.7808
BETTER EAR							
500	24	0.50	6.83	0.06	1.0000	-0.22	0.9998
1000	25	0.48	7.69	0.51	0.2730	0.30	0.9968
2000	25	0.88	5.07	0.45	0.6948	-0.06	1.0000
4000	24	1.50	6.78	0.24	0.9485	-0.21	0.9999
6000	24	-0.25	8.35	0.51	0.2802	-0.14	1.0000
LEFT-RIGHT DIFFERENCES							
500	20	1.00	7.91	0.01	1.0000	-0.40	0.9867
1000	23	-0.43	8.29	0.13	0.9996	0.27	0.9990
2000	23	0.43	5.53	-0.61	0.2022	1.58	0.0881
4000	21	-0.10	8.26	0.06	1.0000	-0.57	0.9149
6000	21	-2.57	10.22	-0.19	0.9922	-1.44	0.1360

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-18	-9.0	-4.0	0.0	4.0	7.0	16
1000	-24	-10.4	-6.0	0.0	4.0	13.6	22
2000	-8	-6.0	-2.0	0.0	4.0	6.0	14
4000	-8	-7.0	-3.5	1.0	5.5	9.0	18
6000	-14	-7.0	-3.5	1.0	7.5	14.0	18
LEFT EAR							
500	-24	-11.6	-4.0	1.0	7.5	11.8	18
1000	-18	-14.0	-4.0	0.0	4.0	11.2	16
2000	-10	-9.2	-2.0	2.0	4.0	8.0	10
4000	-12	-6.0	-3.0	2.0	6.0	11.6	16
6000	-20	-19.2	-7.0	0.0	7.0	11.6	20
BETTER EAR							
500	-14	-9.0	-4.0	1.0	5.5	9.0	16
1000	-14	-10.0	-4.0	0.0	4.0	11.2	20
2000	-8	-6.0	-3.0	0.0	4.0	8.0	14
4000	-12	-7.0	-4.0	2.0	5.5	10.0	18
6000	-14	-11.0	-7.0	-1.0	4.0	13.0	20
LEFT-RIGHT DIFFERENCES							
500	-14	-11.8	-4.0	2.0	4.0	11.8	18
1000	-18	-13.2	-4.0	0.0	6.0	9.6	20
2000	-16	-4.0	-2.0	0.0	4.0	7.2	12
4000	-18	-9.6	-5.0	-2.0	7.0	11.6	16
6000	-20	-17.2	-13.0	2.0	6.0	9.6	14

TABLE 25 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN 12-17 YEAR OLDS (BOYS AND GIRLS COMBINED)

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	52	-1.58	7.29	-0.05	1.0000	-0.23	0.9939
1000	53	-0.68	6.08	-0.07	0.9999	1.49	0.0208
2000	53	-0.64	5.27	-0.37	0.2615	-0.23	0.9936
4000	53	1.51	7.00	-0.19	0.9102	-0.48	0.8246
6000	53	1.96	8.02	-0.09	0.9995	0.17	0.9995
LEFT EAR							
500	52	-0.50	7.66	0.24	0.8311	-0.31	0.9639
1000	52	0.27	5.45	0.54	0.1023	0.76	0.2432
2000	51	1.06	5.94	0.72	0.0295	0.82	0.2092
4000	52	4.50 **	7.12	0.16	0.9658	-0.42	0.8845
6000	52	1.19	10.36	0.08	0.9999	-1.03	0.1108
BETTER EAR							
500	52	-0.85	6.66	0.10	0.9983	0.13	1.0000
1000	53	-0.15	5.38	0.72	0.0271	1.52	0.0180
2000	53	-0.11	5.00	-0.25	0.8138	-0.18	0.9992
4000	53	2.98 **	6.12	-0.26	0.7911	-0.67	0.2967
6000	53	1.85	7.74	0.02	1.0000	0.05	1.0000
LEFT-RIGHT DIFFERENCES							
500	52	1.08	7.11	-0.06	1.0000	0.20	0.9985
1000	52	0.92	5.23	0.81	0.0143	0.83	0.1980
2000	51	1.88	6.21	0.83	0.0134	1.46	0.0256
4000	52	3.04 *	8.27	0.06	1.0000	0.26	0.9860
6000	52	-0.58	10.67	-0.80	0.0159	0.63	0.6966

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-20	-11.4	-6.0	-2.0	4.0	8.0	14
1000	-18	-9.2	-4.0	0.0	2.0	6.0	18
2000	-14	-9.2	-4.0	0.0	4.0	6.0	10
4000	-14	-8.0	-3.0	2.0	6.0	10.0	16
6000	-18	-7.2	-4.0	2.0	6.0	12.0	20
LEFT EAR							
500	-16	-11.4	-6.0	0.0	4.0	10.0	18
1000	-10	-8.0	-2.0	0.0	2.0	7.4	16
2000	-12	-6.0	-2.0	0.0	4.0	10.0	20
4000	-10	-6.0	0.0	4.0	9.5	12.0	20
6000	-20	-12.0	-8.0	1.0	11.5	14.0	24
BETTER EAR							
500	-16	-10.0	-5.5	0.0	4.0	5.4	14
1000	-10	-8.0	-4.0	0.0	2.0	6.0	18
2000	-12	-7.2	-4.0	0.0	4.0	6.0	12
4000	-10	-6.0	0.0	4.0	8.0	11.2	14
6000	-16	-9.2	-3.0	2.0	8.0	10.0	24
LEFT-RIGHT DIFFERENCES							
500	-16	-8.0	-3.5	0.0	6.0	10.0	18
1000	-8	-5.4	-2.0	0.0	4.0	8.0	18
2000	-10	-5.6	-2.0	2.0	6.0	10.0	24
4000	-18	-5.4	-2.0	2.0	8.0	16.0	22
6000	-32	-14.0	-6.0	0.0	8.0	12.0	16

* $.01 < p \leq .05$

** $p \leq .01$

TABLE 26 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN BOYS

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	36	-1.06	7.46	-0.45	0.2527	0.15	1.0000
1000	36	-0.44	7.62	0.05	1.0000	3.00	0.0003
2000	36	1.00	4.60	0.05	1.0000	1.21	0.1127
4000	36	2.44*	6.76	0.04	1.0000	0.07	1.0000
6000	36	1.94	6.80	0.21	0.9412	0.15	1.0000
LEFT EAR							
500	36	-0.94	8.22	-0.36	0.7211	0.17	0.9999
1000	36	-0.28	5.80	0.13	0.9959	0.73	0.7059
2000	36	2.39*	5.61	0.84	0.0315	0.78	0.3111
4000	36	3.83**	6.80	0.01	1.0000	-0.32	0.9825
6000	36	0.50	10.00	-0.27	0.8554	-1.03	0.1777
BETTER EAR							
500	36	-0.06	6.67	-0.07	1.0000	-0.02	1.0000
1000	36	0.11	6.81	0.64	0.1017	1.47	0.0535
2000	36	1.72	4.78	0.04	1.0000	-0.01	1.0000
4000	36	3.28**	6.38	-0.18	0.9695	-0.16	1.0000
6000	36	0.72	7.25	0.03	1.0000	-0.77	0.6809
LEFT-RIGHT DIFFERENCES							
500	36	0.11	7.50	-0.04	1.0000	-0.46	0.9069
1000	36	0.17	5.54	0.94	0.0163	2.68	0.0009
2000	36	1.39	6.03	1.58	0.0002	3.48	0.0001
4000	36	1.39	9.12	-0.11	0.9995	-0.25	0.9976
6000	36	-1.44	10.31	-0.70	0.0717	-0.16	1.0000

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-20	-10.6	-5.5	0.0	4.0	8.0	14
1000	-24	-8.6	-4.0	0.0	3.5	4.0	22
2000	-12	-4.0	-2.0	0.0	4.0	6.0	14
4000	-14	-6.6	-2.0	3.0	6.0	11.2	18
6000	-14	-6.6	-2.0	2.0	4.0	12.0	18
LEFT EAR							
500	-24	-12.0	-5.5	0.0	5.5	10.0	16
1000	-14	-8.6	-3.5	0.0	2.0	6.6	16
2000	-6	-4.6	-2.0	2.0	6.0	10.0	20
4000	-12	-6.0	0.0	4.0	9.5	12.0	20
6000	-20	-14.6	-8.0	2.0	8.0	14.0	18
BETTER EAR							
500	-14	-10.0	-2.0	0.0	4.0	7.8	14
1000	-14	-10.0	-2.0	0.0	2.0	6.6	20
2000	-10	-4.0	-2.0	2.0	6.0	8.0	14
4000	-12	-6.0	-1.5	4.0	7.5	10.6	18
6000	-14	-8.6	-4.0	0.0	6.0	9.2	16
LEFT-RIGHT DIFFERENCES							
500	-16	-10.6	-4.0	0.0	5.5	10.0	16
1000	-12	-6.0	-4.0	0.0	4.0	6.0	20
2000	-8	-4.0	-2.0	0.0	3.5	9.2	24
4000	-18	-10.4	-2.0	0.0	8.0	16.0	20
6000	-30	-15.2	-7.5	1.0	6.0	10.0	14

* $.01 < p \leq .05$

** $p \leq .01$

TABLE 27 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN GIRLS

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	40	-1.40	6.84	0.30	0.7809	-0.08	1.0000
1000	42	-0.48	6.90	-0.09	0.9998	0.22	0.9984
2000	42	-1.38	5.35	-0.12	0.9979	-0.53	0.8292
4000	41	0.63	6.61	-0.10	0.9995	-0.75	0.2992
6000	41	2.05	8.79	-0.08	1.0000	-0.27	0.9926
LEFT EAR							
500	36	0.72	8.13	0.23	0.9120	-0.43	0.9285
1000	39	0.31	7.35	-0.21	0.9274	0.20	0.9994
2000	38	-0.37	5.77	0.16	0.9837	-0.32	0.9801
4000	37	3.62**	7.41	0.31	0.7926	-0.50	0.8712
6000	37	1.08	11.04	0.05	1.0000	-0.84	0.2663
BETTER EAR							
500	40	-0.75	6.79	0.23	0.8977	0.09	1.0000
1000	42	0.00	5.64	0.70	0.0532	0.49	0.8628
2000	42	-1.10	4.88	-0.04	1.0000	-0.04	1.0000
4000	41	1.85	6.28	-0.03	1.0000	-0.87	0.2293
6000	41	1.61	8.57	0.20	0.9329	0.01	1.0000
LEFT-RIGHT DIFFERENCES							
500	36	2.00	7.04	0.01	1.0000	0.58	0.8167
1000	39	0.82	6.98	-0.10	0.9997	0.58	0.7974
2000	38	1.47	6.07	-0.48	0.2061	0.22	0.9987
4000	37	2.86 *	7.54	0.48	0.2104	-0.02	1.0000
6000	37	-0.86	10.84	-0.56	0.1497	0.11	1.0000

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-16	-10.0	-6.0	-2.0	2.0	8.0	16
1000	-18	-9.4	-4.0	0.0	2.5	8.0	16
2000	-14	-9.4	-6.0	-2.0	4.0	5.4	10
4000	-14	-8.0	-4.0	0.0	6.0	9.6	14
6000	-18	-7.6	-4.0	2.0	8.0	15.2	20
LEFT EAR							
500	-16	-10.6	-4.0	0.0	6.0	12.6	18
1000	-18	-10.0	-2.0	0.0	4.0	12.0	16
2000	-12	-8.2	-4.0	0.0	2.5	8.2	12
4000	-10	-6.0	-1.0	2.0	8.0	12.8	20
6000	-20	-12.4	-7.0	0.0	11.0	14.8	24
BETTER EAR							
500	-16	-9.8	-6.0	0.0	4.0	6.0	16
1000	-10	-7.4	-4.0	0.0	2.0	8.0	16
2000	-12	-8.0	-4.0	0.0	2.0	4.0	12
4000	-10	-6.0	-3.0	2.0	7.0	10.0	14
6000	-16	-11.6	-4.0	0.0	8.0	10.0	24
LEFT-RIGHT DIFFERENCES							
500	-16	-6.6	-2.0	2.0	5.5	12.0	18
1000	-18	-6.0	-4.0	0.0	4.0	12.0	18
2000	-16	-6.2	-2.0	1.0	6.0	10.0	12
4000	-12	-6.0	-3.0	2.0	8.0	16.0	22
6000	-32	-14.8	-6.0	-2.0	8.0	14.0	16

* $.01 < p \leq .05$

** $p \leq .01$

zero ($p < 0.05$) at 4000 Hertz for the right and left ears and at 2000 Hertz in the left ear. In the girls, however, only at 4000 Hertz in the left ear is the mean increment statistically significantly different from zero ($p < 0.05$).

When comparisons are made by age groups, as expected, positive mean increments at higher frequencies tend to be more evident in the older age group. Tables 28 and 29 present these data for males, and Tables 30 and 31 present the data for females. The Spearman rank correlations between age and 6-month auditory threshold increments were computed for right, left, and better ear (Table 32). For sexes combined there are no signficiant correlations; however, when sexes are analyzed separately, a striking trend becomes apparent. In boys the correlation coefficients, while generally small, are all positive. A few are significant at the .05 level of significance. In girls, while none of the correlations are significant, all are negative. In both cases the sample size is small and may account for either the lack of significance or a spurious trend. If this trend is real, it implies that in boys increments tend to increase as the boys get older, indicating hearing loss, while the opposite is true in girls. This trend is consistent with the significant positive correlations between age and the threshold levels in girls.

Lateral Differences - The mean thresholds for the left ear are consistently lower than right ear means at corresponding frequencies. This may be an artifact of our testing procedure. As the right ear is always tested first, better performance due to practice and familiarity with the tone might be expected for the left ear. The mean of the lateral individual differences is often in the range of -1 to -2 decibels, indicating consistently higher thresholds in the right ear.

Table 8 gives the descriptive statistics for left less right auditory thresholds at each frequency. Differences that are significantly different from zero, as determined by a t-test, occur at the lower frequencies (500, 1000, and 2000 Hertz). All mean differences are negative indicating lower thresholds (i.e., better hearing) in the left ear. The levels of significance may be altered by the significant deviations from normality of the distribution of the differences at some frequencies. However, significant differences are consistent with the trend found in the right and left ear threshold means. The effect seems to be present in both boys and girls, (Tables 9 and 10) and more pronounced in the older children (Tables 15 and 16).

There are no significant lateral differences at any frequencies between boys and girls in either age group (6 to 11-year-olds; 12 to 17-year-olds) with a single exception at

TABLE 28 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN BOYS 6-11 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	12	-1.00	7.11	-1.00	0.1133	0.27	0.9999
1000	12	-2.00	11.22	0.11	1.0000	0.12	1.0000
2000	12	1.83	5.22	0.76	0.2334	0.03	1.0000
4000	12	2.17	6.46	0.75	0.2413	0.74	0.9082
6000	12	2.00	8.27	0.02	1.0000	-0.74	0.9074
LEFT EAR							
500	12	-3.33	8.71	-0.85	0.1812	0.13	1.0000
1000	12	-1.17	6.29	-0.40	0.8904	-0.35	0.9991
2000	12	2.67	4.77	-0.10	1.0000	-1.19	0.6978
4000	12	0.33	5.84	-0.43	0.8622	-0.47	0.9912
6000	12	-2.83	10.14	-0.45	0.8444	-1.46	0.2357
BETTER EAR							
500	12	-0.83	5.81	-0.80	0.2074	-0.24	1.0000
1000	12	-0.83	8.72	0.69	0.2814	0.37	0.9984
2000	12	3.17	5.29	0.31	0.9636	-0.56	0.9730
4000	12	1.83	7.51	0.33	0.9456	-0.06	1.0000
6000	12	-1.33	8.24	0.39	0.9007	-0.65	0.9454
LEFT-RIGHT DIFFERENCES							
500	12	-2.33	7.02	-0.14	0.9999	-1.06	0.7532
1000	12	0.83	8.07	0.76	0.2337	0.30	0.9998
2000	12	0.83	3.86	0.36	0.9257	-1.21	0.6874
4000	12	-1.83	8.07	-0.03	1.0000	-0.47	0.9911
6000	12	-4.83	11.36	0.17	0.9995	-1.60	0.1916

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-18	-15.6	-2.0	0.0	4.0	7.4	8
1000	-24	-21.0	-7.5	-2.0	4.0	16.6	22
2000	-6	-4.8	-2.0	1.0	5.5	11.6	14
4000	-8	-7.4	0.0	2.0	4.0	14.4	18
6000	-14	-11.0	-3.5	1.0	10.0	14.8	16
LEFT EAR							
500	-24	-20.4	-7.0	-4.0	3.5	7.4	8
1000	-14	-12.8	-3.5	-1.0	2.0	8.2	10
2000	-6	-4.8	-1.5	2.0	7.5	9.4	10
4000	-12	-10.2	-3.5	1.0	4.0	8.8	10
6000	-20	-18.8	-14.5	0.0	6.0	8.8	10
BETTER EAR							
500	-14	-12.2	-3.5	0.0	3.5	6.0	6
1000	-14	-12.8	-8.0	-1.0	3.5	15.2	20
2000	-6	-4.8	0.0	2.0	7.5	12.2	14
4000	-12	-9.6	-3.5	2.0	4.0	15.6	18
6000	-14	-12.8	-8.0	-1.0	4.0	13.0	16
LEFT-RIGHT DIFFERENCES							
500	-14	-13.4	-8.5	-2.0	2.0	8.2	10
1000	-12	-10.2	-4.0	0.0	6.0	15.8	20
2000	-4	-4.0	-2.0	1.0	3.5	7.4	8
4000	-18	-15.0	-7.0	-2.0	3.0	11.4	12
6000	-20	-19.4	-14.0	-6.0	5.5	12.2	14

TABLE 29 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN BOYS 12-17 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	24	-1.08	7.78	-0.21	0.9764	-0.14	1.0000
1000	24	0.33	5.13	1.26	0.0081	3.76	0.0002
2000	24	0.58	4.31	-0.69	0.1437	0.92	0.3181
4000	24	2.58	7.04	-0.25	0.9438	-0.35	0.9911
6000	24	1.92	6.14	0.39	0.7733	0.40	0.9792
LEFT EAR							
500	24	0.25	7.88	0.04	1.0000	-0.87	0.7098
1000	24	0.17	5.62	0.55	0.2453	0.78	0.7616
2000	24	2.25	6.08	1.04	0.0266	0.87	0.7095
4000	24	5.58**	6.67	0.02	1.0000	-0.75	0.7818
6000	24	2.17	9.71	-0.15	0.9978	-1.38	0.1314
BETTER EAR							
500	24	0.33	7.14	0.08	1.0000	-0.36	0.9881
1000	24	0.58	5.79	0.66	0.1615	1.52	0.0961
2000	24	1.00	4.45	-0.36	0.8091	-0.59	0.8854
4000	24	4.00**	5.78	-0.51	0.2831	-0.61	0.8695
6000	24	1.75	6.65	-0.09	1.0000	-1.07	0.2416
LEFT-RIGHT DIFFERENCES							
500	24	1.33	7.57	-0.07	1.0000	-0.48	0.9469
1000	24	-0.17	3.91	-0.06	1.0000	-1.16	0.2061
2000	24	1.67	6.92	1.45	0.0028	2.27	0.0137
4000	24	3.00	9.34	-0.26	0.9278	-0.21	0.9999
6000	24	0.25	9.53	-1.27	0.0076	1.84	0.0438

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-20	-11.0	-6.0	-1.0	4.0	10.0	14
1000	-10	-5.0	-2.0	0.0	2.0	4.0	18
2000	-12	-4.0	-2.0	0.0	4.0	6.0	8
4000	-14	-7.0	-2.0	4.0	7.5	12.0	16
6000	-10	-7.0	-2.0	2.0	4.0	10.0	18
LEFT EAR							
500	-14	-11.0	-5.5	0.0	6.0	11.0	16
1000	-10	-8.0	-3.5	0.0	2.0	7.0	16
2000	-6	-5.0	-2.0	0.0	5.5	11.0	20
4000	-6	-5.0	0.5	6.0	12.0	13.0	20
6000	-14	-12.0	-7.5	3.0	11.0	14.0	18
BETTER EAR							
500	-14	-10.0	-2.0	0.0	4.0	13.0	14
1000	-10	-8.0	-2.0	2.0	2.0	7.0	18
2000	-10	-4.0	-2.0	0.0	5.5	6.0	8
4000	-8	-6.0	0.5	5.0	8.0	11.0	14
6000	-10	-8.0	-3.5	2.0	8.0	10.0	14
LEFT-RIGHT DIFFERENCES							
500	-16	-8.0	-4.0	0.0	6.0	12.0	16
1000	-8	-5.0	-3.5	-1.0	4.0	5.0	6
2000	-8	-5.0	-2.0	0.0	3.5	12.0	24
4000	-18	-11.0	-2.0	3.0	9.5	16.0	20
6000	-30	-12.0	-5.5	2.0	7.5	10.0	12

** $p \leq .01$

TABLE 30 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN GIRLS 5-11 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	12	0.00	6.66	0.93	0.1402	0.15	1.0000
1000	13	1.85	6.95	0.50	0.7841	-0.72	0.9055
2000	13	-0.77	4.21	-0.12	1.0000	-1.17	0.6876
4000	12	0.67	5.93	0.14	0.9999	-1.59	0.1951
6000	12	2.17	7.46	0.55	0.7556	-0.70	0.9223
LEFT EAR							
500	8	7.25 *	6.92	-0.16	1.0000	-1.22	0.7771
1000	11	0.18	11.26	-0.32	0.9595	-1.42	0.2690
2000	11	-1.27	6.08	-0.20	0.9986	-1.48	0.2464
4000	9	3.78	7.64	0.24	0.9962	-1.62	0.2481
6000	9	3.33	11.53	-0.55	0.8097	-0.58	0.9844
BETTER EAR							
500	12	1.83	7.74	0.21	0.9966	-1.14	0.7178
1000	13	1.69	6.73	0.41	0.8660	-0.69	0.9188
2000	13	-1.23	3.96	-0.02	1.0000	-1.39	0.2428
4000	12	1.17	6.29	-0.02	1.0000	-1.59	0.1945
6000	12	0.83	8.67	0.54	0.7601	-0.29	0.9999
LEFT-RIGHT DIFFERENCES							
500	8	6.00 *	6.68	0.36	0.9630	-0.96	0.8778
1000	11	-1.82	8.69	-0.37	0.9244	-0.89	0.8531
2000	11	0.00	7.10	-0.55	0.7722	0.17	1.0000
4000	9	2.22	8.39	0.13	1.0000	-1.45	0.3037
6000	9	0.44	8.11	-0.50	0.8486	-1.43	0.3084

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-8	-7.4	-5.5	-1.0	3.5	13.0	16
1000	-8	-7.2	-3.0	0.0	6.0	14.4	16
2000	-8	-7.2	-4.0	0.0	3.0	5.2	6
4000	-8	-7.4	-4.0	-1.0	6.0	9.4	10
6000	-8	-7.4	-3.5	1.0	7.5	15.6	18
LEFT EAR							
500	-4	-4.0	1.5	8.0	11.5	19.8	18
1000	-18	-17.2	-14.0	2.0	8.0	15.2	16
2000	-10	-10.0	-8.0	0.0	4.0	7.2	8
4000	-6	-6.0	-3.0	2.0	11.0	16.0	16
6000	-20	-20.0	-3.0	6.0	11.0	20.0	20
BETTER EAR							
500	-10	-8.8	-5.5	3.0	6.0	14.8	16
1000	-8	-7.2	-4.0	0.0	7.0	12.8	16
2000	-8	-7.2	-4.0	-2.0	3.0	4.0	4
4000	-8	-7.4	-5.5	2.0	6.0	10.0	10
6000	-12	-11.4	-4.0	0.0	4.0	17.0	20
LEFT-RIGHT DIFFERENCES							
500	-4	-4.0	2.5	4.0	11.0	19.8	18
1000	-18	-17.2	-6.0	0.0	4.0	10.8	12
2000	-16	-13.6	-4.0	0.0	4.0	10.8	12
4000	-10	-10.0	-5.0	0.0	9.0	16.0	16
6000	-12	-12.0	-8.0	2.0	7.0	10.0	10

* $.01 < p \leq .05$

TABLE 31 - DESCRIPTIVE STATISTICS OF SIX-MONTHLY INCREMENTS IN AUDITORY THRESHOLD LEVELS IN GIRLS 12-17 YEARS OLD

FREQUENCY (HERTZ)	N	MEAN	SD	SKEW	PSKEW	KURT	PKURT
RIGHT EAR							
500	28	-2.00	6.95	0.09	1.0000	-0.61	0.8432
1000	29	-1.52	6.73	-0.41	0.7111	-0.08	1.0000
2000	29	-1.66	5.83	-0.04	1.0000	-0.72	0.7617
4000	29	0.62	6.97	-0.15	0.9946	-0.74	0.7455
6000	29	2.00	9.41	-0.20	0.9733	-0.44	0.9458
LEFT EAR							
500	28	-1.14	7.55	0.41	0.7204	0.14	1.0000
1000	28	0.36	5.39	0.50	0.2604	0.44	0.9519
2000	27	0.00	5.71	0.34	0.8093	-0.11	1.0000
4000	28	3.57 *	7.47	0.31	0.8415	-0.30	0.9951
6000	28	0.36	11.00	0.26	0.9134	-0.92	0.2875
BETTER EAR							
500	28	-1.86	6.16	-0.03	1.0000	0.34	0.9877
1000	29	-0.76	5.03	0.66	0.1228	0.84	0.6843
2000	29	-1.03	5.31	-0.05	1.0000	-0.15	1.0000
4000	29	2.14	6.37	-0.04	1.0000	-0.73	0.7507
6000	29	1.93	8.66	0.05	1.0000	0.00	1.0000
LEFT-RIGHT DIFFERENCES							
500	28	0.86	6.83	-0.07	1.0000	0.71	0.7731
1000	28	1.86	6.06	0.72	0.0993	0.02	1.0000
2000	27	2.07	5.64	-0.24	0.9357	-0.81	0.7161
4000	28	3.07 *	7.39	0.63	0.1491	0.34	0.9874
6000	28	-1.29	11.68	-0.47	0.2821	-0.13	1.0000

PERCENTILES

FREQUENCY (HERTZ)	MIN	10	25	MEDIAN	75	90	MAX
RIGHT EAR							
500	-16	-12.0	-6.0	-2.0	1.5	8.2	12
1000	-18	-12.0	-4.0	0.0	2.0	6.0	12
2000	-14	-10.0	-6.0	-2.0	4.0	6.0	10
4000	-14	-10.0	-4.0	0.0	6.0	10.0	14
6000	-18	-14.0	-4.0	2.0	8.0	16.0	20
LEFT EAR							
500	-16	-12.0	-6.0	-1.0	4.0	8.6	18
1000	-10	-8.0	-2.0	0.0	2.0	8.4	14
2000	-12	-6.4	-4.0	0.0	2.0	10.4	12
4000	-10	-6.0	0.0	3.0	8.0	12.8	20
6000	-20	-12.2	-8.0	-2.0	11.5	14.4	24
BETTER EAR							
500	-16	-12.0	-6.0	-1.0	3.5	4.0	14
1000	-10	-8.0	-4.0	-2.0	2.0	6.0	14
2000	-12	-10.0	-4.0	0.0	2.0	4.0	12
4000	-10	-6.0	0.0	2.0	8.0	12.0	14
6000	-16	-12.0	-3.0	0.0	8.0	10.0	24
LEFT-RIGHT DIFFERENCES							
500	-16	-8.4	-2.0	0.0	4.0	8.4	18
1000	-8	-6.0	-2.0	0.0	5.5	12.0	18
2000	-10	-6.4	-2.0	2.0	6.0	10.0	12
4000	-12	-4.2	-1.5	2.0	7.5	16.2	22
6000	-32	-18.2	-6.0	-2.0	8.0	14.2	16

* $.01 < p \leq .05$

TABLE 32 - SPEARMAN RANK CORRELATION COEFFICIENTS BETWEEN AGE AND 6-MONTH AUDITORY-THRESHOLD INCREMENTS IN BOYS AND GIRLS

Frequency (Hertz)	Boys & Girls		Boys		Girls	
	n	r	n	r	n	r
Right Ear						
500	75	-.044	34	.054	41	-.161
1000	75	-.001	34	.233	41	-.243
2000	77	-.103	34	.091	43	-.281
4000	76	-.013	34	.168	42	-.146
6000	76	.023	34	.200	42	-.117
Left Ear						
500	71	.048	34	.338*	37	-.253
1000	72	.056	34	.306	38	-.183
2000	73	-.064	34	.055	39	-.180
4000	72	.070	34	.392*	38	-.248
6000	72	-.032	34	.266	38	-.307
Better Ear						
500	75	.000	34	.225	41	-.202
1000	75	.082	34	.404*	41	-.220
2000	77	-.031	34	.013	43	-.146
4000	76	-.018	34	.175	42	-.193
6000	76	.008	34	.190	42	-.150

* $.01 < p \leq .05$

6000 Hertz in 6 to 11-year-olds, (Tables 11-14). In this case, the mean lateral difference is positive in the boys, indicating a higher left ear threshold, but in the girls the opposite is true.

The striking lateral differences seen in the mean auditory thresholds are not present in the mean increments. However, at 4000 Hertz there is a significant positive lateral difference (Table 23). This implies that during a six-month interval there was a greater threshold shift toward hearing loss in the left ear than in the right ear. The statistical significance is present only in the groups that include 12 to 17-year-old girls (Tables 24, 26, and 30). Since this result is limited to one group and only one frequency, no biological importance is attached to it; it might have occurred by chance alone.

NOISE EXPOSURE

At each examination a detailed questionnaire was completed regarding noise exposure. Different questionnaires were administered on the first examination (Appendix B) and on subsequent examinations (Appendix C). The responses to the noise exposure questions were weighted differentially to allow a quantitative noise assessment for each question. The individual question scores were then summed to provide a single total noise score. The scoring system that was used is given in Appendix C. In addition, three other scores were derived (chain saw, gun, and event) to evaluate particular events that might be important in a participant's noise exposure. These derived scores are outlined in Appendix D.

Noise exposure is considered separately for the questionnaires taken on the first visit, representing the total previous noise exposure history (Appendix B); and questionnaires completed on subsequent six-monthly visits (Appendix C) representing noise exposure for the appropriate preceding interval. The major differences between the total noise exposure history and the interval noise exposure history are in the phraseology of the questions regarding the time periods of noise exposure. For question 23 of the total noise exposure history regarding the duration of exposure to power tools, "occasionally" was weighted 1.0, and "often" was weighted 5.0 in the calculation of this component of the total noise exposure history score. Other than this alteration, the various noise exposure scores were calculated in an identical manner for the total noise exposure histories and the interval noise exposure histories.

The summary statistics, including the ranges for the scores, for each noise-related question, and the derived scores, are given in Table 33 for boys and girls. With few

TABLE 33. NOISE HISTORY SCORES FOR CHILDREN 6-17 YEARS.

Question	Mean	S.D.	Median	Minimum	Maximum
		BOYS			
9 home	0.1	0.4	0.0	0.0	2.0
10 T.V.	0.0	0.2	0.0	0.0	2.0
11 stereo	1.5	1.4	1.5	0.0	5.3
12 instrument	0.8	1.4	0.0	0.0	7.0
13 live rock	0.0	0.1	0.0	0.0	0.8
14 toys	0.0	0.0	0.0	0.0	0.0
15 motorbikes	1.6	2.2	0.0	0.0	10.0
16 eng/firewks	0.5	0.8	0.0	0.0	3.0
18 guns	0.3	2.1	0.0	0.0	20.5
23 tools	3.0	2.8	1.7	0.0	10.0
24 machinery	0.6	1.2	0.0	0.0	4.0
Chain saw	0.5	2.2	0.0	0.0	10.0
Gun	35.8	48.0	0.0	0.0	100.0
Event	3.4	1.6	3.0	0.0	7.0
Total	8.1	6.0	7.2	0.0	29.9
		GIRLS			
9 home	0.2	0.5	0.0	0.0	2.0
10 T.V.	0.0	0.0	0.0	0.0	0.0
11 stereo	1.5	1.3	1.5	0.0	8.0
12 instrument	0.8	1.3	0.0	0.0	5.3
13 live rock	0.0	0.3	0.0	0.0	3.2
14 toys	0.0	0.0	0.0	0.0	0.0
15 motorbikes	1.8	2.0	2.0	0.0	10.0
16 eng/firewks	0.0	0.4	0.0	0.0	3.6
18 guns	0.0	0.0	0.0	0.0	0.0
23 tools	2.4	2.1	1.7	0.0	6.7
24 machinery	0.3	1.0	0.0	0.0	4.0
Chain saw	0.9	2.9	0.0	0.0	10.0
Gun	13.6	34.4	0.0	0.0	100.0
Event	3.2	1.5	3.0	0.0	8.0
Total	7.1	4.3	6.6	0.0	18.4

Based on data from approximately 100 boys and 103 girls.

exceptions, the distributions of the scores are significantly skewed, being truncated at zero. This, of course, is why the means and medians are not coincident, and why many of the medians are zero. For data of this nature, only non-parametric statistical approaches are appropriate.

There are few sex differences in median scores, and in most cases there is little difference between the maximum score for any item for girls compared to that for boys. Boys do have a notably higher maximum score for the gun question (No. 18) compared to that of the girls. However, the derived gun score, calculated differently from that of question 18, indicates that girls and boys had the same maximum gun score, although the mean gun score for boys (35.8) was greater than that for the girls (13.6). The maximum total score is markedly greater in boys than girls although the means and medians show only small sex differences.

The summary statistics for the scores from the interval noise exposure histories (Appendix C) are given for boys and girls in Table 34. The ranges of scores for interval noise exposure are generally greater than the corresponding scores from the total noise exposure histories, although the general pattern of scores is similar in both noise exposure histories. Sex differences are most clearly seen in the maximum scores for each item; the boys generally having higher maximum scores than the girls, especially for question 16 (fireworks), 23 (power tools), and the chain saw and gun scores. An exception to this pattern is the maximum scores for question 12, concerning playing an instrument; the girls having a maximum score of 8.7, compared to 4.8 for the boys. Percentiles for total noise scores from the total noise histories and the interval noise histories are given for boys and girls in Table 35.

The total noise scores obtained from the total noise exposure histories and the interval noise exposure histories are compared in Figure 32. The similarly skewed character of the two curves can be seen, although the greater range of the scores from the interval noise exposure histories is evident.

The four points at the extreme for the interval noise exposure scores represent four participants with unusually high scores. Three of these extreme scores are for boys and one is for a girl. These extreme scores result primarily from exploding a large number of firecrackers (question 16), except for one boy (score = 101.3) who received his unusual noise exposure from operating, or being near, power tools (question 23), particularly gasoline lawn mowers.

The event score was devised in an attempt to quantify noise exposure through identifying the number of different types of events that may be important sources of noise

TABLE 34. INTERVAL NOISE SCORES FOR CHILDREN 6-17 YEARS.

Question	Mean	S.D.	Median	Minimum	Maximum
		BOYS			
9 home	0.0	0.0	0.0	0.0	0.0
10 T.V.	0.7	1.0	0.5	0.0	6.0
11 stereo	2.2	1.8	2.3	0.0	8.0
12 instrument	0.5	1.1	0.0	0.0	4.8
13 live rock	0.0	0.2	0.0	0.0	1.6
14 toys	0.0	0.0	0.0	0.0	0.0
15 motorbikes	1.4	1.7	0.0	0.0	6.0
16 eng/firewks	6.0	23.7	0.0	0.0	210.0
18 guns	2.2	7.7	0.0	0.0	54.0
23 tools	8.4	15.7	3.3	0.0	113.7
24 machinery	0.4	1.1	0.0	0.0	4.0
Chain saw	0.9	3.1	0.0	0.0	20.0
Gun	1.0	9.8	0.0	0.0	100.0
Event	2.6	1.5	2.0	0.0	7.0
Total	21.5	31.8	11.7	0.0	232.7
		GIRLS			
9 home	0.0	0.1	0.0	0.0	1.0
10 T.V.	0.7	1.1	0.5	0.0	6.0
11 stereo	2.2	1.6	2.4	0.0	6.6
12 instrument	0.7	1.4	0.0	0.0	8.7
13 live rock	0.0	0.2	0.0	0.0	1.6
14 toys	0.0	0.0	0.0	0.0	0.0
15 motorbikes	0.9	1.5	0.0	0.0	6.0
16 eng/firewks	1.8	9.4	0.0	0.0	70.0
18 guns	0.6	2.4	0.0	0.0	15.2
23 tools	3.3	6.4	0.0	0.0	40.0
24 machinery	0.2	0.6	0.0	0.0	3.0
Chain saw	0.0	0.3	0.0	0.0	3.0
Gun	0.0	0.0	0.0	0.0	0.0
Event	1.9	1.5	2.0	0.0	6.0
Total	10.5	13.5	6.5	0.0	81.0

Based on data from approximately 103 boys and 110 girls.

TABLE 35. PERCENTILES FOR TOTAL NOISE SCORES FROM TOTAL NOISE EXPOSURE HISTORIES AND INTERVAL NOISE EXPOSURE HISTORIES.

	Percentiles				
Questionnaire	10	25	50	75	90
	Boys				
Total	1.5	3.3	7.2	11.7	16.6
Interval	1.4	5.1	11.7	22.4	58.0
	Girls				
Total	1.8	3.7	6.6	9.2	13.3
Interval	1.8	3.3	6.5	12.6	20.2

Based on total noise exposure histories from 104 boys and 106 girls and interval noise exposure histories from 104 boys and 112 girls.

exposure for a child. As shown in Tables 33 and 34, there is little difference between boys and girls in the number of important noise events experienced. The interval data show higher total event scores for boys after 14 years. This can be seen in Figure 33 which presents median event scores obtained from total noise exposure histories and interval noise exposure histories at each age for boys and girls.

Definite age trends are not apparent for median total noise exposure history event scores, (Figure 33). Although there appear to be no systematic sex differences, nor age trends in median event scores from the interval noise

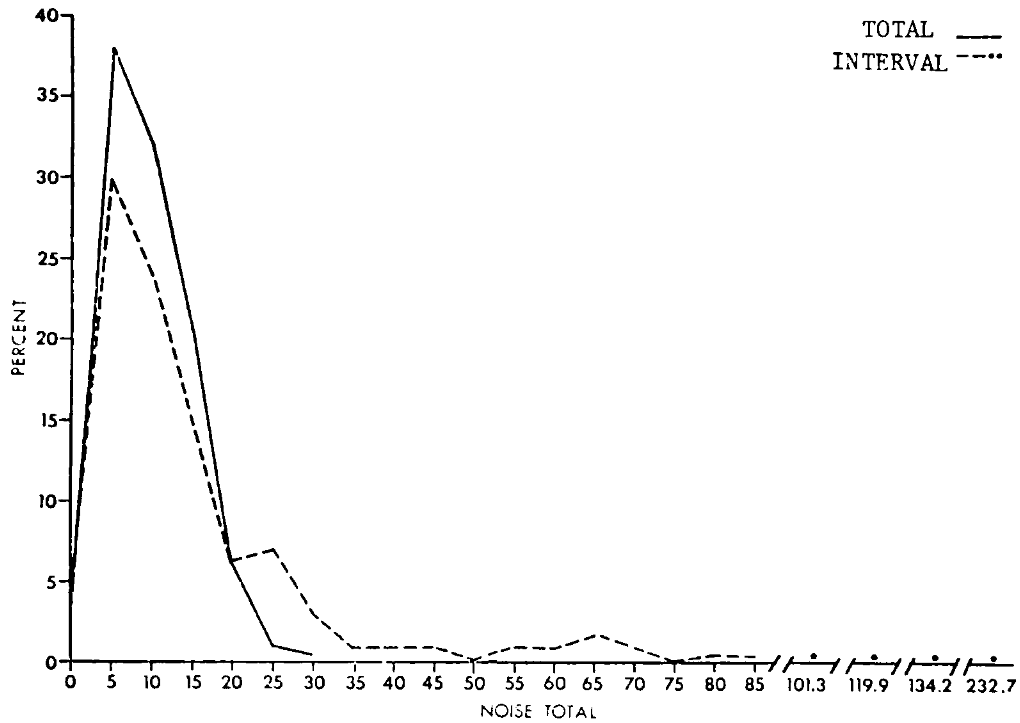

FIGURE 32 - PERCENTAGE DISTRIBUTIONS OF TOTAL NOISE SCORES FOR ALL CHILDREN FROM TOTAL NOISE EXPOSURE HISTORIES AND INTERVAL NOISE EXPOSURE HISTORIES

exposure histories in the preadolescent years, there seems to be a small, but definite, adolescent spurt in median noise events for boys; rising from a median of 2.0 at 13 and 14 years of age to a median of 4.0 at 16 and 17 years of age. No such adolescent trend is apparent in the median number of noise events experienced by girls.

The total noise scores and the total event score are imprecise and susceptible to large errors in estimating the sound levels resulting from various activities. One person's exposure to a "loud stereo" system or "loud vehicle" may be 10, 20 or more decibels higher than that of another person giving the same response to the question. For this reason an alternative method of anlaysis was devised. Information contained in the questionnaire was used to group participants into those reporting exposure to a particular category of noise and those who were not exposed to that noise. The means and medians of each group were compared. The nine categories selected are the components of the total event score (Appendix D). While these categories are arbitrary, they are considered to be the most likely sources of noise exposure. They are summarized below.

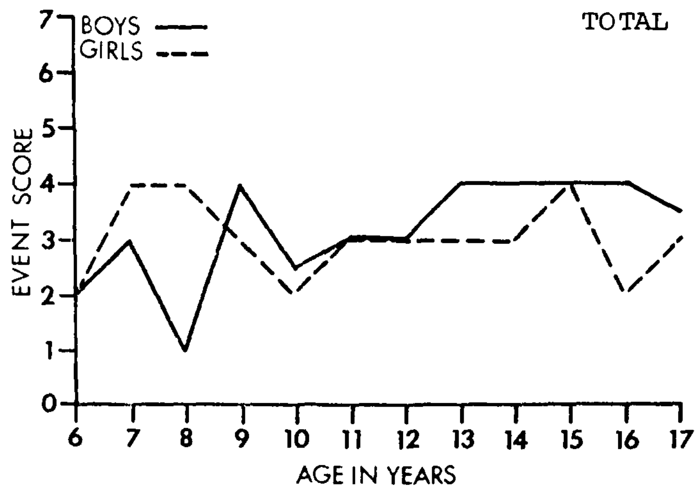

FIGURE 33 - MEDIAN EVENT SCORES FROM TOTAL NOISE EXPOSURE HISTORIES AND INTERVAL NOISE EXPOSURE HISTORIES FOR BOYS AND GIRLS

Flight Pattern - Participant lives within 100 feet of a road or flight pattern.

Loud TV - Participant considers the TV is usually loud when he or she watches it.

Loud Music - Participant considers the volume of a radio or stereo system is loud, as opposed to medium or quiet, when he or she is listening to it.

Amplified Musical Instrument - Participant plays an amplified musical instrument.

Loud Vehicles - Participant is often near or involved with motorcycling, motorboating, drag or auto racing, go-carting, minibiking, etc.

Fireworks - Participant had been within 50 feet of exploding firecrackers or small gas engines.

Near Firearms - Participants fired or were near someone else firing a gun larger than a .22 caliber.

Power Tools - Participants were near others using power tools, such as drills, saws, gasoline lawn mowers, etc.

Farm Machinery - Participants used or were often near farm machinery.

The percentage of participants for two age groups that reported exposure to the various categories are summarized in Figure 34. For most noise categories, a slightly higher percentage of children in the 12-18 age group reported exposure than the younger age group. The only exception was loud TV, in which a larger proportion of younger children were exposed. However, there is very little difference between the two age groups in porportion exposed to any noise category.

Figure 35 presents the age-specific medians for the total noise scores for boys and girls obtained from the total noise exposure histories. These are similar in each sex from 6 to 12 years of age, later the median noise totals for the boys rise sharply, causing marked sex differences in the median noise totals during most of the adolescent years.

The median total noise scores obtained from the interval noise exposure histories (Figure 36) indicate more consistent sex differences and age trends than those seen in the total scores from the total noise exposure histories. For boys and girls, the median total noise scores from the interval histories increase systematically with age. At most ages, boys have greater median total noise scores than girls, the differences becoming most pronounced after the age of 10 years, when the boys medians increase rapidly. The difference between boys and girls becomes greatest at 16 years of age when it is 16.5.

The age trend in the total noise scores is shown by Spearman rank correlation coefficients of total noise with age. Spearman rank correlation coefficients of total noise with age (Table 36). The total noise scores from the total noise exposure histories correlate with age +0.55 for boys and +0.26 for girls, while the correlations between the

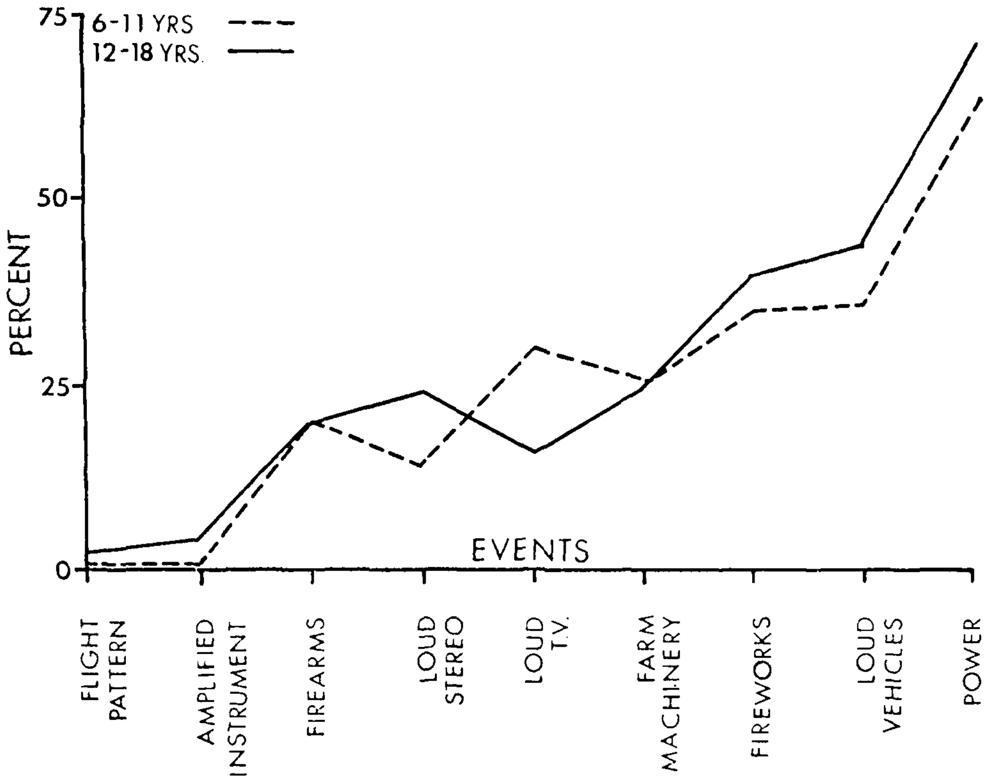

FIGURE 34 - PROPORTION OF CHILDREN 6-11 YEARS OLD AND 12-18 YEARS OLD REPORTING EXPOSURE TO SPECIFIC NOISE EVENTS

interval noise exposure scores and age are +0.45 in boys and +0.28 in girls. All these correlations are highly significant ($p < 0.01$).

A number of questions on the interval noise questionnaire are "flagged" primarily to indicate changes in the activity patterns of the participant and his family that may be related to noise exposure. The percentage of children with "flagged" responses to questions from the interval noise exposure history are given in Table 37. The precise questions asked are found in Appendix C. The data in Table 37 generally indicate there is little change in jobs, hobbies, recreation, etc., that are possibly noise related; the highest percentage of changes (12%) concerned participants changing jobs that could have altered noise exposure.

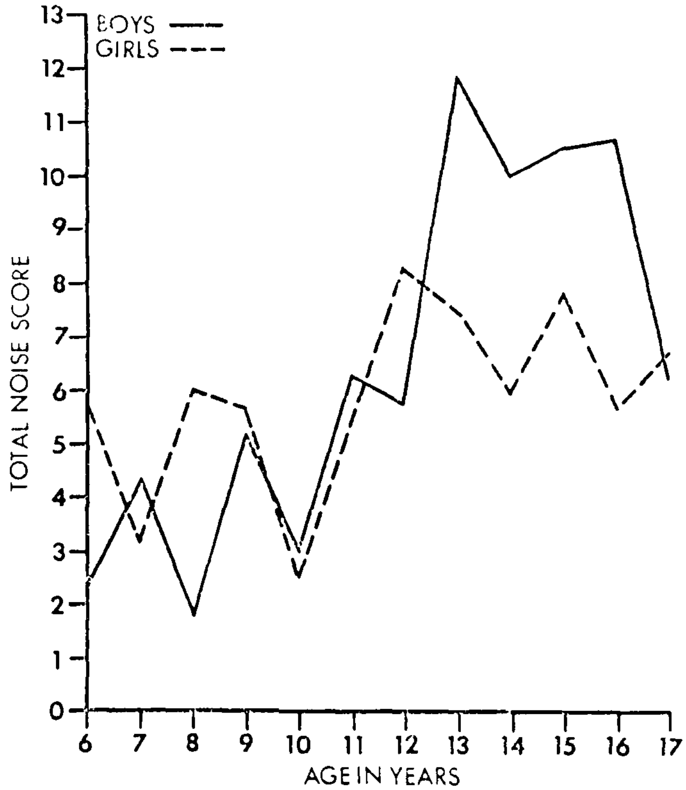

FIGURE 35 - MEDIAN TOTAL NOISE SCORES FROM TOTAL NOISE EXPOSURE HISTORIES FOR BOYS AND GIRLS

CHILDREN WITH UNUSUAL HEARING LOSS OVER SIX MONTHS TIME

Hearing loss over the period studied is indicated by large positive increments in thresholds. Children were selected who had threshold increments greater than the 90th percentile (Table 23) for at least four frequencies considering both ears; there were four such children.

No. 594. This is a thirteen year-old girl who had six-month increments of 10 and 12 decibels at 2000 Hertz and 4000 Hertz, respectively in the right ear, and increments of 12, 20, and 18 decibels at 2000 Hertz, 4000 Hertz, and 6000 Hertz, respectively in the left ear. Her increments at the other frequencies range from -2 to 6 decibels; these increments do not differ greatly from those in the rest of the sample. She had a cold, but no ear problems at the time of the second examination, and had a rather normal otoscopic inspection. Although the technician considered the girl's right ear responses at the first visit were somewhat erratic,

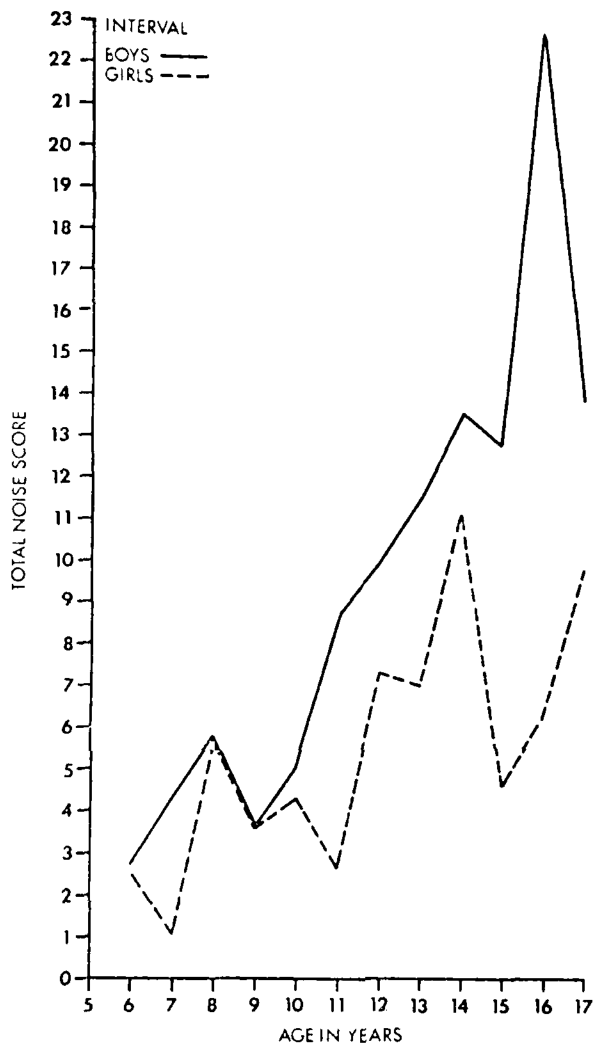

FIGURE 36 - MEDIAN TOTAL NOISE SCORES FROM INTERVAL NOISE EXPOSURE HISTORIES FOR BOYS AND GIRLS

the technician was rather confident of the accuracy of the recorded levels. The girl's total noise scores were moderate, 8.9 and 16.9, for her first and second visits respectively. For the latter visit most of the noise exposure came from questions 10 and 23, recording an average of six hours of loud television per day, and 12 hours (total) of being close to gasoline lawnmowers and electric power tools (lawn edgers, drills, etc.) during the six-month interim. In brief, there is little apparent reason to indicate that the hearing loss was due to otological abnormalities, general health, or the testing procedures per se but excessive noise may have been a factor.

TABLE 36.- SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN AGE AND NOISE SCORES

Noise Scores		Boys and Girls		Boys		Girls	
Period	Type	n	r	n	r	n	r
Total	Total	210	.430**	104	.552**	106	.257**
Total	Event	209	.334**	104	.510**	105	.133
Interval	Total	225	.353**	111	.447**	114	.276**
Interval	Event	224	.085	110	.254*	114	-.057

* $.01 < p \leq .05$

** $p \leq .01$

No. 697. This is an 8-year-old girl who had a hearing loss at each frequency except 6000 Hertz. The six-month increments of 12 and 16 decibels at 1000 and 5000 Hertz, respectively in the right ear, and 12 decibels at 5000 Hertz in the left ear are all above the 90th percentiles for those frequencies. In addition, increments of 10 decibels at 4000 Hertz in the right ear, and 8 decibels at 1000 Hertz in the left ear are coincident with the 90th percentiles at those frequencies. The tester indicated the girl was rather fidgety during the second visit, but was not concerned about the quality of the girl's responses. The otological inspections indicated meatal abnormalities, particularly for the left ear. There was no indication that an interim general health condition was responsible for the hearing loss. The girl's total noise scores (total period and interval) for the two visits were 8.7 and 3.3, which approximate the 75th and 25th percentiles respectively for total noise distribution. At the latter visit, the girl said she was now going to a rifle range weekly, although her

TABLE 37. PERCENTAGE OF CHILDREN WITH SPECIFIC QUESTIONS "FLAGGED" ON INTERVAL NOISE EXPOSURE HISTORIES.[1]

	Question	Percentage of Children
17	family hobbies	5
19	jobs	12
20	father's job	1
21	mother's job	0
22	hobbies	5
26	hearing protectors	5

[1]See Appendix C for definitions of questions. Based on data from 218 children.

responses to question 18 concerning guns do not indicate excessive noise exposure (gun score = 0). Other than some meatal abnormalities, there is little apparent reason for the recorded hearing loss.

No. 801. This is a 7-year-old boy with increments greater than the 90th percentile at four frequencies in the right ear, and at two frequencies in the left ear. These increments are 22, 14, 18, and 16 decibels at 1000, 2000, 4000 and 6000 Hertz, respectively, in the right ear; and 10 decibels at 1000 and 2000 Hertz in the left ear. The other increments show little change except an 8 decibel decrease at 500 Hertz in the right ear. His otological inspection was normal except that a cone of light was not seen at either visit. During the second examination, the boy talked frequently thoughout the testing procedure, somehow cut his finger on the arm of the chair, and apparently was very sleepy (9:00 a.m.), yawning between talking and worrying about the small cut. It appears that the marked hearing losses indicated by the boy's increments are artifactual due to inattention, distraction, etc., during the second visit. His total noise scores (total period and interval) at the visits were very low, 2.0 and 3.7, respectively.

No. 9027. This is a 13-year-old girl who demonstrated unusual hearing loss, particularly in the right ear. The six-month increments ranged from 12 to 16 decibels in the right ear, including all frequencies in that ear except 2000 Hertz. In addition, the girl had an increment of 10 and 24 decibels at 4000 and 6000 Hertz, respectively in the left ear. At the second visit, the girl complained of some dizziness, earache, and intermittent ringing in both ears. In answer to the questionnaire, the girl reported she was swimming daily for 5 to 6 hours. The girl's parents were notified appropriately. It seems probable that the unusual hearing loss was due to ear infection. Her noise scores for this period were within normal limits.

No. 9028. This is a 14-year-old boy with large threshold increments, at low frequencies in both ears, and some hearing loss at all frequencies, except at 6000 Hertz in the right ear. The six months' increments were 12 and 18 decibels at 500 and 1000 Hertz, respectively, in the right ear; and 12 decibels at 4000 Hertz, and 16 decibels at 500 Hertz and 1000 Hertz in the left ear. The boy complained of a cold, sore throat, and mild sinusitis at the second visit. At both visits, the otological inspection was normal except for altered cones of light. The boy's total noise scores (total period and interval) were moderate, 3.3 and 8.3 respectively, for successive visits. Almost all this noise exposure score came from question 11 (listening to radio or stereo) and question 23, (using a power lawn mower). The hearing losses found probably reflect reduced hearing acuity due to illness.

ASSOCIATIONS BETWEEN AUDITORY THRESHOLDS AND GENERAL HEALTH AT TIME OF TEST, AND RESULTS FROM OTOLOGICAL INSPECTION

Participants were selected who were below the 10th percentile (better hearing), or above the 90th percentile (poorer hearing) in their auditory thresholds at each frequency. The percentage of these children with abnormal otoscopic inspections and general health are given in Table 38. The prevalence of each of the scores and their definitions for this part of the examination are given in see Tables 6 and 7 and Appendix A.

In Table 38 the overall prevalences of abnormal findings in the health and otoscopic inspection are compared for the two groups using angular transformation for differences between proportions (Sokal and Rohlf, 1969). Children with higher thresholds (poorer hearing) tend to have slightly more abnormal responses to the general health question, although the difference is not significant. Most of the abnormal responses for both groups to this item are due to colds or sinusitis.

TABLE 38. PERCENTAGE OF CHILDREN WITH ABNORMAL HEALTH HISTORIES OR OTOLOGICAL INSPECTIONS WHOSE AUDITORY THRESHOLDS ARE BELOW 10TH PERCENTILE LEVELS (BETTER HEARING), AND ABOVE 90TH PERCENTILE LEVELS (POORER HEARING) FOR THE RIGHT EAR. SEXES AND AGES ARE COMBINED.

Frequency (Hz)	n	General Health	Tragus	Meatus	Drum	Cone of Light	Color
			< 10th Percentile				
500	20	20	0	10	15	30	20
1000	25	8	4	4	0	32	12
2000	15	20	0	7	13	40	33
4000	24	8	0	8	4	37	17
6000	24	21	0	12	21	42	33
Total	108	15	1	8	10	36	63
			> 90th Percentile				
500	22	32	0	14	14	50	18
1000	22	27	0	9	9	41	18
2000	23	13	0	26	13	43	22
4000	20	25	0	20	25	45	20
6000	24	25	0	17	8	21	17
Total	111	24	0	17	14	40	19
t_s		1.79	-1.42	1.98*	0.76	0.54	-2.16*

*p <0.05

There is no difference in the prevalence of abnormal tragi between the two groups. Although children above the 90th percentiles for thresholds have abnormal eardrums and light findings slightly more frequently, the differences are not significant. The results show,however, that children with better hearing (< 10th percentile) do have significantly fewer meatal abnormalities. This is consistent with the findings of Roberts and Federico (1972), who reported significant increases in auditory thresholds associated with complete obstruction of the auditory canal (usually by cerumen) in the NCHS survey. In the present study various auditory canal obstructions were among the most common findings classified as meatal abnormalities (see Tables 6 and 7). The comparison of the two groups indicates also that there are significantly more abnormalities regarding ear drum color in the group with better hearing. This may be due to lack of clinical experience of our technicians, or may indicate an inappropriate examination criterion, or simply the vagaries of sampling and of constructing criteria for qualitative traits.

ASSOCIATIONS BETWEEN THRESHOLDS AND SIZE AND MATURATION

To assess the associations between auditory thresholds and size, stature was correlated with the auditory threshold of the better ear measured at the same examination for the Fels series. The Spearman rank correlation coefficients for boys and girls are given in Table 39. There is little association between attained stature and auditory thresholds in boys. For girls, significant negative correlations at the lower frequencies indicate that taller girls tend to have lower auditory thresholds; that is, better hearing at these frequencies than the shorter girls.

The relative skeletal maturity (skeletal age less chronological age) indicates those children who are advanced or retarded in skeletal development relative to the standard, and is a measure of the relative biological age or maturation of the individual. The Spearman rank correlation coefficients between relative skeletal maturity and auditory thresholds in the better ear of boys and girls are given in Table 40. Little consistent pattern is apparent in correlations in the total sample and in the 6 to 11-year-old group. However, in the 12 to 18-year-old group, the correlations between relative skeletal maturity and auditory thresholds are all negative, suggesting that the more rapidly maturing children tend to have lower auditory thresholds. This is true particularly in girls and at the lower frequencies. The small sample size may account for the lack of statistical significance or alternatively for a spurious trend in this age group. If these results reflect biological phenomena it may be that there is a maturational component

TABLE 39. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN STATURE AND AUDITORY THRESHOLDS IN BETTER EAR OF BOYS AND GIRLS

Frequency (Hertz)	Boys		Girls	
	n	r	n	r
		6-12 year olds		
500	50	-.102	43	-.367*
1000	50	.122	43	-.252
2000	50	.107	44	-.599**
4000	50	-.008	43	-.247
6000	50	-.016	43	-.071
		12-18 year olds		
500	47	.004	60	-.253*
1000	47	.290*	60	-.273*
2000	47	.075	61	-.299*
4000	47	.206	61	-.048
6000	47	.001	61	.102

* $.01 < p \leq .05$
** $p \leq .01$

TABLE 40. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN RELATIVE SKELETAL MATURITY (SKELETAL AGE--CHRONOLOGICAL AGE) AND AUDITORY THRESHOLDS IN THE BETTER EAR

Frequency (Hertz)	Boys n	Boys r	Girls n	Girls r
		Total Sample		
500	68	-.029	63	.012
1000	68	-.071	63	-.116
2000	68	.169	65	.074
4000	68	-.049	64	.133
6000	68	-.044	64	.097
		6-11 years		
500	38	.015	40	.097
1000	38	-.033	40	-.082
2000	38	.401*	41	.213
4000	38	-.032	40	.183
6000	38	.150	40	.253
		12-18 years		
500	29	-.106	21	-.433*
1000	29	-.206	21	-.493*
2000	29	-.105	22	-.397
4000	29	-.087	22	-.140
6000	29	-.228	22	-.193

*$.01 < p \leq .05$.

TABLE 41. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN AGE AT MENARCHE AND AUDITORY THRESHOLDS IN THE BETTER EAR OF GIRLS

Frequency (Hertz)	N	r
500	48	-.110
1000	48	-.022
2000	48	-.121
4000	48	.068
6000	48	.112

associated with increases in hearing acuity during puberty and adolescence, or during adolescence the more rapidly maturing girls may somehow be better at performing the tasks necessary to the auditory testing situation.

The Spearman rank correlation coefficients between auditory thresholds and age at menarche (first menstural flow) are given in Table 41. This sample includes the Fels girls and some of the middle school girls. Age at menarche is an indicator of rate of sexual maturation. None of the correlations in Table 41 are significant; however, those at the low frequencies are negative, suggesting that more rapidly maturing girls tend to have higher auditory thresholds. This is in the opposite direction to that expected considering the above results relating to skeletal maturation. Certainly the possibility of developmental associations between maturation and auditory thresholds needs further investigation.

TABLE 42. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN INTERVAL TOTAL NOISE SCORE AND AUDITORY THRESHOLDS IN BOYS AND GIRLS

Frequency (Hertz)	n	Correlation Coefficient
500	223	-.090
1000	223	.004
2000	224	.057
4000	223	.034
6000	223	-.040

ASSOCIATIONS BETWEEN AUDITORY THRESHOLDS AND NOISE SCORES

Almost all examinations after 26 January 1976 were repeat visits for most participants; therefore, the total noise scores from the interval noise exposure histories were used to investigate associations with auditory thresholds and 6-month increments in auditory thresholds.

In the sample as a whole, there is no significant association at any frequency between auditory threshold and previous interval total noise exposure score as measured by the Spearman rank correlation. Table 42 gives the correlation coefficients at each frequency. Likewise, when the sample is broken into age groups and sexes (Table 43) no significant correlations are found.

When the relationship between the total noise scores from the interval noise exposure histories and 6-month auditory threshold increments was investigated, a similar lack of association was apparent. In Table 44 the Spearman rank correlations are reported for right, left, and better ear in boys and girls. Table 45 gives the correlations between interval chain saw score and 6-month auditory threshold increments; none are significant. There were too few participants with a positive interval gun score to calculate the corresponding correlations.

TABLE 43. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN INTERVAL TOTAL NOISE SCORE AND AUDITORY THRESHOLDS IN BETTER EAR OF BOYS AND GIRLS BY AGE GROUPS

Frequency (Hertz)	Boys n	Boys Correlation Coefficient	Girls n	Girls Correlation Coefficient
		6-11 year olds		
500	44	-.140	36	.082
1000	44	-.037	36	.205
2000	44	.005	37	-.075
4000	44	-.052	36	-.029
6000	44	-.210	36	-.071
		12-18 year olds		
500	66	-.150	76	.081
1000	66	.012	76	.110
2000	66	.157	76	.221
4000	66	.039	76	.152
6000	66	.063	76	.100

While there were no significant correlations between noise scores and hearing measurements, this does not imply that they are not related. The relative imprecision associated with the derivation of the various noise scores has been alluded to previously. In general, girls have slightly better hearing than boys and less variation in threshold measurements. This may reflect differences in behavior resulting in less noise exposure, and therefore, less hearing loss due to noise exposure. This explanation is supported by the fact that the threshold differences between boys and girls are larger in the 12 to 17-year-olds than in the 6 to 11-year-olds. Moreover, the total noise exposure scores show a marked sex difference only in the older group,

TABLE 44. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN INTERVAL TOTAL NOISE SCORE AND 6-MONTH AUDITORY THRESHOLD INCREMENTS IN BOYS AND GIRLS

Frequency (Hertz)	Boys & Girls n	Boys & Girls r	Boys n	Boys r	Girls n	Girls r
Right Ear						
500	75	-.061	34	-.252	41	.091
1000	75	-.038	34	-.146	41	.038
2000	77	-.215	34	-.471**	43	-.145
4000	76	.063	34	.028	42	.089
6000	76	-.058	34	.292	42	.082
Left Ear						
500	71	.046	34	.041	37	.083
1000	72	-.078	34	-.222	38	.140
2000	73	-.044	34	-.245	39	.017
4000	72	.010	34	-.121	38	.100
6000	72	.035	34	-.002	38	.054
Better Ear						
500	75	-.004	34	-.192	41	.113
1000	75	-.070	34	-.226	41	.050
2000	77	-.028	34	-.295	43	.025
4000	76	.071	34	-.131	42	.193
6000	76	.048	34	.004	42	.085

** $p \leq .01$

TABLE 45. SPEARMAN RANK CORRELATION COEFFICIENTS (r) BETWEEN INTERVAL CHAIN SAW SCORE AND 6-MONTH AUDITORY THRESHOLD INCREMENTS

	Right Ear		Left Ear	
Frequency (Hertz)	n	Correlation Coefficient	n	Correlation Coefficient
500	74	.014	70	.014
1000	74	.036	71	-.053
2000	76	.077	72	-.095
4000	75	-.045	71	.007
6000	75	-.041	71	-.136

with boys having the higher total noise exposure. Therefore, if noise is having an adverse effect, older boys should have higher thresholds. This is consistent with our findings. Finally, the 6-month increments are larger in the direction of hearing loss in the older group, and more pronounced in boys.

The associations between hearing and the noise event categories described previously, as measured by group differences suggest important sources of noise that may affect hearing. Large and significant non-normality is present in the threshold distributions of the two groups of each event category at each frequency. This precludes the use of a t-test to compare the means. However, a casual comparison of the means indicates that all differences are very small (generally less than two decibels) and significant differences are clearly not present. Since 4000 Hertz is the frequency that would presumably be most sensitive to noise damage, the means, standard deviations, and sample sizes of the two groups for each event for the better ear are presented in Table 46. The events are ordered in decreasing differences (exposed - unexposed) between the means. A positive difference, therefore, indicates that the exposed group has a higher mean threshold (poorer hearing) than the unexposed group.

TABLE 46. DESCRIPTIVE STATISTICS FOR AUDITORY THRESHOLD LEVELS AT 4000 HERTZ IN GROUPS EXPOSED AND NOT EXPOSED TO SPECIFIC NOISE EVENTS

Event	Difference	Exposed			Unexposed		
	$\bar{X}_e - \bar{X}_u$	$\bar{X}_e$	SD	n	$\bar{X}_u$	SD	n
Fireworks	-1.75	-2.53	6.12	101	-0.78	9.40	154
Loud radio	- .88	-2.18	5.46	53	-1.30	8.87	202
Flight pattern	- .51	-2.0	8.80	3	-1.49	8.30	255
Power tools	.50	-1.34	8.94	180	-1.84	6.37	75
Near firearms	.59	-1.02	6.72	51	-1.61	8.61	204
Farm machines	.75	-0.94	6.61	66	-1.69	8.77	189
Loud T.V.	1.61	-0.22	4.91	54	-1.83	6.27	201
Amplified inst.	1.83	-0.29	6.16	7	-1.54	8.31	248
Loud vehicles	2.02	-0.33	10.50	107	-2.35	6.00	148

Instead of means, it is often more appropriate to look at the medians and other percentiles. When the 90th percentiles of the exposed and unexposed groups are compared at 4000 Hertz in the better ear, there are only very small differences for any event. In no case is the difference more than two decibels.

Use of the better ear data may mask differences in the hearing levels. Close examination of the data reveals that the largest differences occur in the left ear of children in the 12-18 year age group. The analysis of these data with respect to the changes in percentiles of auditory thresholds shows definite shifts toward poorer hearing in those reporting exposure to amplified musical instruments, loud vehicles, power tools, loud T.V. and farm machinery (Figure 37). Although there were too few exposures (only six) for the 90th percentile (10 percent of the sample has poorer hearing) to be meaningful, there is an apparent difference between medians and means for the amplified music. Exposure to loud vehicles and power tools resulted in a shift of two decibels at the median and 90th percentile. While this shift is small, it should help further refine the questionnaire in these areas. Exposure to farm machinery resulted in a similar two-decibel shift in the median. However, the 90th percentile showed a larger, 7.5 decibel, shift. Such a large change may indicate that exposure to farm machinery is a significant problem with respect to noise-induced hearing loss. Before a more definitive statement can be made, however, more data need to be aquired.

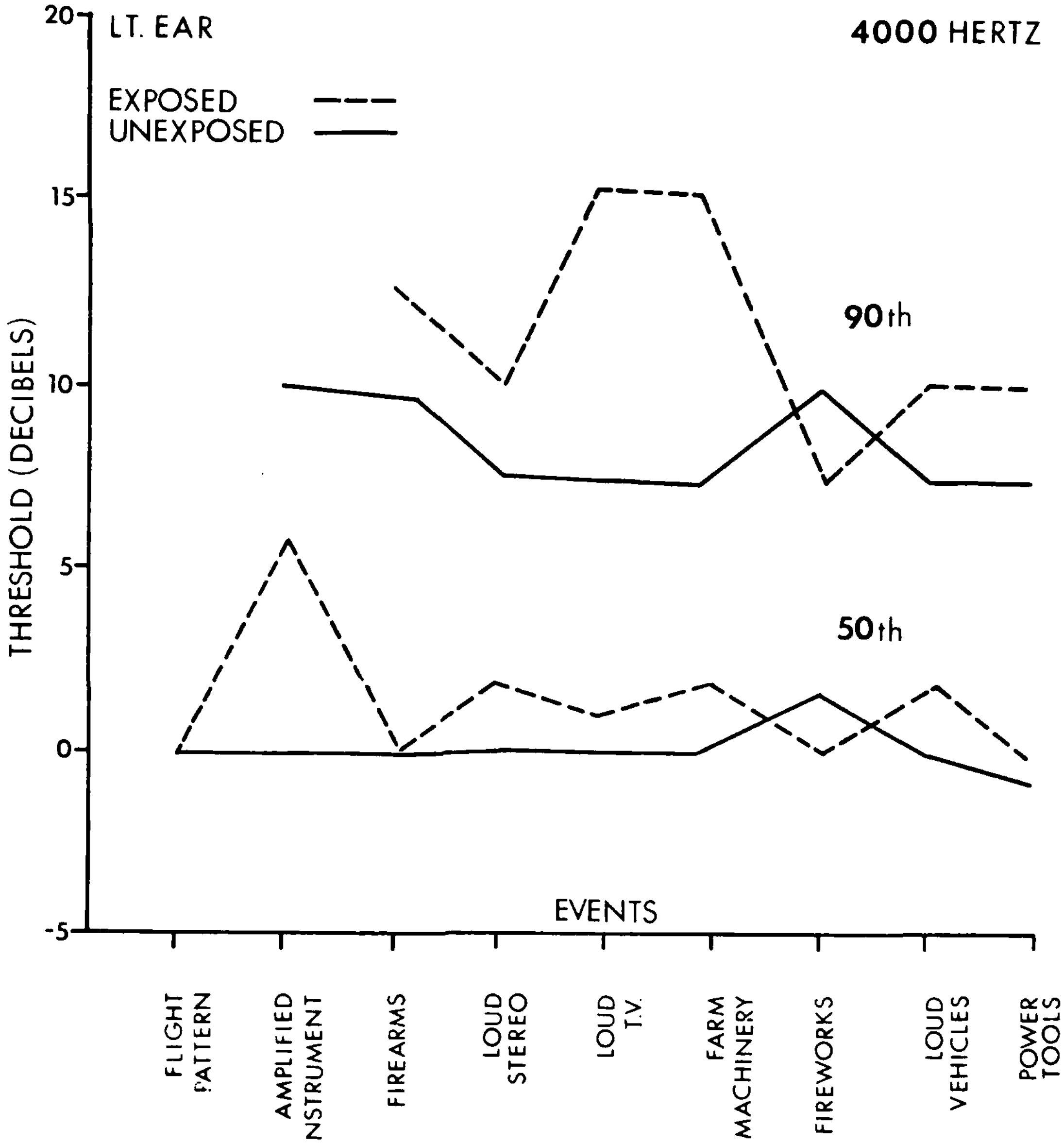

FIGURE 37 - LEFT EAR, AUDITORY THRESHOLD LEVEL MEDIANS AND 90TH PERCENTILES AT 4000 HERTZ IN 12-18 YEAR OLDS EXPOSED TO SPECIFIC NOISE EVENTS

CONCLUSION

Environmental noise may have adverse effects on the auditory thresholds of people of all ages but there are convincing reasons why the hearing of children should be examined with particular care. Further, serial studies offer several advantages over cross-sectional studies. The major reasons why serial studies of auditory thresholds in children are needed are:

1. Children may be more susceptible to noise damage than adults.

2. Children may be exposed to different sources of noise than adults; some of these may not be recognized currently as influencing hearing.

3. Hearing loss in a child may have more severe effects on learning and communication than a similar loss in an adult.

4. Hearing thresholds during childhood may be correlated with hearing ability in adult life.

5. Some effects found in cross-sectional studies may not be general trends in all individuals, but either artifacts of sampling or reflect marked changes in subgroups.

6. A longitudinal study is the only way to determine whether the effect of noise on an individual's hearing is temporary or permanent.

7. A longitudinal study, especially in children, allows one to examine the effect of developmental and growth changes on hearing levels, and to separate these from environmental effects.

This multi-year serial study was undertaken because of the factors enumerated above and because so little is known about environmental and developmental effects on hearing in children. Since the findings reported here represent only the first year of data collection, the findings should be considered preliminary; the study is only beginning to meet its full potential. Furthermore, because fewer than half the participants in the study had suitable multiple measurements of auditory thresholds, most of the present data are cross-sectional rather than longitudinal.

The group constituting the Fels sample has relatively good hearing. The mean and median thresholds at almost all frequencies are 2 to 6 decibels lower than those from United

States national surveys (Roberts and Federico, 1970; Roberts and Ahuja, 1975) for children of corresponding ages. Probably these differences reflect dissimilarities between the Fels and national samples in many aspects, e.g., geographical, socioeconomic, racial factors.

There are indications that some abnormal otological findings may be associated with hearing losses. Also of interest are analyses of auditory thresholds in relation to body size and sexual and skeletal maturity. There is a suggestion of possible developmental correlates because the auditory thresholds decrease during adolescence, especially in girls. Rapidly maturing children tend to have lower thresholds than others although this requires further investigation.

Consistent and sometimes large lateral differences in thresholds occurred. These may be due to testing procedures or, perhaps, represent biological differences; further studies are needed to clarify this. Lateral differences are not present in the increments, which suggests that these differences are likely to be due to testing artifacts.

The older group of children (12 to 17-year-olds) had lower thresholds than the younger group (6 to 11-year-olds): a much larger proportion of the older children were hearing at the lowest possible limit of the audiometer. In addition, there is significant negative correlation between age and thresholds. This may mean younger children cannot perform the testing task well enough to reach their "true" thresholds; an alternative explanation is that hearing ability may improve slightly during the middle childhood years.

Auditory thresholds tend to be higher at 4000 and 6000 Hertz than at the other frequencies tested in each group examined. Similarly, at these frequencies, the mean 6-month increments in thresholds are consistently larger (decline in hearing ability) than at lower frequencies. This finding is consonant with the view that noise might be important with regard to auditory thresholds of children. The higher frequencies (especially 4000 Hertz) are the more sensitive to damage by noise, whether permanent or temporary threshold shifts are considered. Therefore, the higher initial thresholds and larger increments at higher frequencies may result from noise exposure.

In general, girls have slightly lower mean thresholds than boys and less variation in threshold measurements at a given age. This may reflect differences in behavior resulting in less noise exposure, and therefore less hearing loss due to noise exposure. This explanation is supported by the fact that threshold differences between boys and girls are larger in the 12 to 17-year-olds than in the 6 to 11-year-olds. Moreover, the median total noise exposure scores show a marked sex difference only in the older group, with boys having the higher total noise exposure. Therefore, if noise is having an adverse effect, older boys should have higher thresholds. This hypothesis is consistent with the present data. Finally, the 6-month increments are larger, in the direction of hearing loss, in the older group and more pronounced in boys. Because the thresholds of girls tend to be lower and less variable than those of boys, the sex differences may reflect less noise exposure in the girls. Certainly the trend of increasing sex differences in mean thresholds with age is in accordance with the trend of increasing sex differences in noise exposure although the correlations between noise exposure scores and auditory thresholds were not significant.

It is clear that participants in the study have a wide range of noise exposure and a wide range of sources of this noise. The noise exposure histories of many participants suggest high levels of noise exposure. The current quantification procedure applied to the noise exposure histories is imprecise. However, the concept should be retained because it allows comparisons that are very difficult to make qualitatively. While the quantitative noise exposure scores from the interval and total noise exposure histories are important measures of noise exposure, the formula by which they are derived may be modified in the future. Empirical modifications based on the distributions of each question score, and relationships with the data from other questions concerning noise, and dosimeter studies will be helpful in this regard.

The qualitative approach allows the identification of specific noise events that may be significant biologically. Therefore, it is very important. The various data concerning noise exposure indicate fireworks and being near firearms were not problems in this sample with respect to noise-induced hearing loss, although the potential for considerable hearing loss from the use of firearms has been demonstrated in other studies. Loud stereo, hi-fi, or radio; loud vehicles; loud television, and power tools may be associated with some elevation of auditory thresholds in the present sample; such findings in these noise categories indicate the need for further investigation. Being near or using farm machinery and playing amplified musical instruments are two categories that appear to be most implicated as possible causes of auditory threshold changes in the study population.

The major long-term aims of this study are to determine the pattern of auditory threshold levels in children and to relate changes in these thresholds to developmental and environmental events (particularly noise exposure). While it is too early in the study to establish patterns or unequivocally relate changes to specific events, it is clear from the preliminary findings that the design, sample, and methodology of the study are ideally suited for the attainment of these long-term aims. The preliminary findings of sex and age effects, as well as relationships among thresholds, increments, noise exposure and other related measurements, only hint at the potential of this study to answer important questions that relate to human hearing.

RECOMMENDATIONS

Overall age trends can be derived from cross-sectional studies, but developmental trends within individuals may be masked in the data from such studies. Only in a longitudinal study can one determine patterns of change within individuals. Furthermore, the effects of developmental and environmental influences on these changes in individuals can be studied if appropriate serial data are available. The present study was designed with this attitude in mind. It is to be of at least 5 years' duration and both biological and environmental variables are to be collected.

Longitudinal studies, by their nature, do not reach their full potential until there are at least 5 data points per participant that are reasonably separated by age. Therefore, it is imperative that this study continue so that patterns of change in hearing thresholds in these children can be analyzed and these changes related to environmental and developmental factors.

A likely cause of decreases in hearing acuity is excessive environmental noise; therefore the identification of specific sources of noise that relate directly to hearing loss in individuals is of great importance. As the study continues, portable dosimeters will be used to measure the levels of noise exposure from various sources reported in questionnaires and the questionnaires will be evaluated and verified. This will allow the development of an improved weighting system to obtain total noise exposure scores for the total period before the first examination and the intervals between examinations. It is clear that the collection of much more data is necessary to investigate properly and hopefully answer many of the important questions discussed in this report.

A final salient point relates to the specific study population. For a longitudinal study to be successful, one needs a study group that will continue to participate. The Fels record in this regard is unique. The extremely high level of continued cooperation and participation is well established and proven. Another aspect that makes the Fels group so appropriate for this study is the existence of health and growth data recorded previously and concurrently that allows analyses of the relationships between these factors and auditory thresholds.

APPENDIX A

AUDITORY THRESHOLD LEVEL

RECORDING FORM

Name____________________ ☐☐☐ Clan ☐☐☐☐ Subject Number (1-7)

☐☐ Month ☐☐ Day ☐☐ Year — Date of Test

☐ Tester (8-14)
1 = Eileen
2 = Lee
3 = Marty

☐ Sex
1 = male
2 = female

Subject's Birthdate: ☐☐ Month ☐☐ Day ☐☐ Year (15-21)

OTOSCOPIC EXAMINATION

Tragus. Right ear ☐ Left ear ☐ (22-23)

0 = normal
1 = very large
8 = other--see comments
9 = no examination

Comments:____________________

Meatus. Right ear ☐ Left ear ☐ (24-25)

0 = normal
1 = completely closed
2 = badly obstructed with wax, dirt, hair, almost closed
3 = very small or slit-like opening but unobstructed
4 = small opening badly obstructed with wax
5 = much wax, etc. in canal but not obstructed
6 = canal open but rather inflamed (very red) looking
8 = other--see comments
9 = no examination

Comments:____________________

Ear Drum. Right ear ☐ Left ear ☐ (26-27)

0 = normal
1 = perforated
2 = not seen because meatus small or obstructed
3 = scarred
8 = other--see comments
9 = no examination

Comments:____________________

Ear Drum, Cone of Light. Right ear ☐ Left ear ☐ (28-29)

0 = cone of light seen
1 = cone of light not seen because meatus too small or obstructed
8 = other--see comments
9 = no examination
2 = cone of light not seen for other reasons

Comments:____________________

APPENDIX A
(continued)

AUDITORY THRESHOLD LEVEL RECORDING FORM

Name ______________________________

Ear Drum, Color. Right ear ☐ Left ear ☐ (30-31)

0 = normal
1 = very red and inflamed looking
2 = dull
3 = yellowish
4 = redder than normal, but not inflamed looking
8 = other--see comments
9 = no examination

Comments ______________________________

GENERAL HEALTH AT TIME OF TEST ☐ (32)

0 = normal, not ill
1 = has "cold," but no ear problems
2 = is congested due to "sinus allergy"
3 = both ears "stopped up"
4 = right ear "stopped up"
5 = left ear "stopped up"
6 = has ear infection, but no earache
7 = has ear infection, with earache
8 = other--see comments
9 = not recorded

Comments ______________________________

COMMENTS ABOUT HEARING TEST

Continuity and completeness of testing ☐ (33)

0 = testing completed, no breaks
1 = testing completed, one short (< 5 min) break between ears
2 = testing completed, one short (< 5 min) break during testing of right ear
3 = testing completed, one short (< 5 min) break during testing of left ear
4 = testing completed, took more than one break (specify in comments)
5 = testing completed, certain frequencies retested (specify in comments)
6 = testing discontinued, participant insisted (tired, restless, etc.)
7 = testing discontinued, responses too irratic (lack of cooperation, etc)
8 = other--see comments

Comments ______________________________

AUDITORY THRESHOLD LEVEL RECORDING FORM

Name______________________________

Responses of participant [ ] (34)

0 = normal good responses or better
1 = often signaled when no tone played
2 = participant disinterested, not trying hard
3 = participant's responses seemed somewhat irratic
4 = participant very restless and "fidgety"
5 = participant talked frequently throughout test
6 = participant claimed to hear extraneous noises during test (explain in comments)
7 = participant's parent in booth during testing
8 = other--see comments
9 = participant did well at the beginning but lost concentration toward end of test

Comments____
____

Comments written for individual frequencies

right ear [ ] (35) left ear [ ] (36)

0 = no comments written
1 = 1000 HZ
2 = 2000 HZ
4 = 4000 HZ
5 = 500 HZ
6 = 6000 HZ
8 = comments at more than one frequency

RIGHT EAR AUDITORY THRESHOLD LEVEL

Comments: ____

Frequency				Columns
1000				(45-47)
2000				(48-50)
4000				(51-53)
6000				(54-56)
1000				(57-59)
500				(60-62)

LEFT EAR AUDITORY THRESHOLD LEVEL

Comments: ____

Frequency				Columns
1000				(63-65)
2000				(66-68)
4000				(69-71)
6000				(72-74)
1000				(75-77)
500				(78-80)

APPENDIX B

BIOGRAPHICAL, NOISE EXPOSURE, AND OTOLOGICAL HISTORY QUESTIONNAIRE
(Do not ask Fels participants circled questions.)

A. General Information

1. Clan number ☐☐☐ A 1 - 3
2. Subject number ☐☐☐☐ A 4 - 7
3. Name ____________________ [1] A 8
4. Today's date ☐☐ ☐☐ ☐☐ A 9 - 14 (mo. day yr.)
5. Questionner
   - Eileen ☐ A 15
   - Lee ☐ A 16
   - Marty ☐ A 17
   - Roger ☐ A 18
   - Other ☐ A 19 __________ Specify
6. Sex of participant
   - Male ☐ A 20
   - Female ☐ A 21
7. Participant's birthdate ☐☐ ☐☐ ☐☐ A 22 - 27 (mo. day yr.)
8. What is your address and phone number?

address: ____________________ Street

A 28 A 29 (b l a n k)

____________________ City State

____________________ Zip Telephone

B. Noise Exposure History

9. Have you ever lived very near a busy road (such as a state highway or freeway), airport, noisy factory, downtown in a city, etc.?

   ☐ no A 30 ☐ yes A 31

   a) busy road or airport within 100 ft. of road or flight pattern ☐ A 32

      100 ft. to 100 yds. from road or flight pattern (length of football field) ☐ A 33

      Greater than 100 yds ---------------- ☐ A 34

   b) How long have you lived there? ☐☐ years A 35 - 36

   c) Other ☐ A 37

      specify ____________________

      ____

10. How would your parents rate the sound volume of the TV when you watch it the most?

- quiet ☐ A 38
- average ☐ A 39
- loud ☐ A 40

a) How many hours a day (average) do you watch TV? ☐☐ A 41 - A 42

11. Have you ever listened to radio, stereo, hi-fi tapes, or records?

☐ no A 43 ☐ yes A 44

a) What percentage of the time do you listen with headphones?

- never ☐ A 45
- less than 1/4 of the time ☐ A 46
- between 1/4 and 1/2 of the time ☐ A 47
- between 1/2 and 3/4 of the time ☐ A 48
- greater than 3/4 of the time ☐ A 49

b) About how many hours each day do you listen?

- less than one ☐ A 50
- 1 - 2 ☐ A 51
- 3 - 4 ☐ A 52
- more than four ☐ A 53

c) How loud do you like the volume?

- quiet ☐ A 54
- medium ☐ A 55
- loud ☐ A 56

d) What type of music do you usually listen to?

- hard rock - - soul ☐ A 57
- pop - - country - - western ☐ A 58
- classical ☐ A 59

12. Have you ever played a musical instrument or sung with a band?

☐ no A 60 ☐ yes A 61

a) Instrument__________________ ☐☐ A 62 - 63

- amplified ☐ A 64
- not amplified ☐ A 65

b) About how many hours per week have you played it? ☐☐ A 66 - 67

c) Do you mostly play with a
- rock band? ☐ A 68
- marching or concert band? ☐ A 69
- orchestra? ☐ A 70
- by yourself? ☐ A 71

13. Do you listen to more than about one hour of live rock music each week?

no	yes	Approximate number of hours/week ☐☐	A 74 - 75
A 72	A 73		

☐1 A 80

CARD B - Col. 1-7, same as A ☐2 B 8

14. Have you ever played with any very loud toys?

no	yes
B 9	B 10

a) Cap guns, pop guns, air guns
1. Rarely - (less than 1 hr/wk) ☐ B 11
2. Occasionally - (1-2 hrs/wk) ☐ B 12
3. Frequently - (4-6 hrs/2k) ☐ B 13
4. Very often - (more than 7 hr/wk) ☐ B 14

b) Other toys ☐ B 15
Specify______________________________

15. Have you ever done or been around much motorcycling, motor boating, drag or auto racing, go-carting, minibiking, etc.
(estimate times while engine is running)

no	yes
B 16	B 17

a) Motorcycles, outboard motor boats ($\geq$ 35 H.P. engines)
1. Rarely - (less than 1 hr/wk ☐ B 18
2. Occasionally - (2-7 hrs/wk) ☐ B 19
3. Frequently - (7-15 hrs/wk) ☐ B 20
4. Very often - (more than 15 hrs/wk) ☐ B 21

b) Minibikes, auto or drag racing, snowmobile, go-carts, small outboard or inboard motor boats
1. Rarely - (less than 1 hr/wk) ☐ B 22
2. Occasionally - (2-7 hrs/wk) ☐ B 23
3. Frequently - (7-15 hrs/wk) ☐ B 24
4. Very often - (More than 15 hrs/wk) ☐ B 25

c) Other ☐ B 26
Specify______________________________

16. Have you ever played with any loud or explosive devices (except guns; e.g., small gas-driven engines like on model airplanes); fireworks, etc.)

☐ no B 27 ☐ yes B 28

a) Firecrackers (within 50 ft. of explosives)
1. Seldom - (once or twice in 6 mos.) ☐ B 29
2. Occasionally - (3-5 times in 6 mos.) ☐ B 30
3. Often - (more than 6 times in 6 mos.) ☐ B 31

Estimate total no. exploded since last visit ☐☐ B 32 - 33

b) Small gas-driven engines (e.g., model airplanes) (while engine is running)
1. Seldom - (less than 1 hr/mo ☐ B 34
2. Occasionally - (1-4 hrs/mo) ☐ B 35
3. Often - (more than 1 hr/wk) ☐ B 36

c) Other ☐
Specify____________________ B 37

17. What are your parents' hobbies and recreational activities?

activities____________________

B 38 B 39
(b l a n k)

To be judged by questionnaire giver: Are any of these a noise-relevant activity? ☐ no B 40 ☐ yes B 41

18. Have you ever fired or been around anyone else firing a gun since your last visit?

☐ no B 42 ☐ yes B 43

a) Who fired?
you ☐ B 44
someone else ☐ B 45

B 46 - B 48
B 47 - B 50
(b l a n k)

b) What type of gun?
rifle or shotgun ☐ B 51
pistol ☐ B 52

c) What caliber?
.22 or smaller ☐ B 53
larger than .22 ☐ B 54

d) How do you shoot?
right handed ☐ B 55
left handed ☐ B 56

B 57 - 59

e) Did you wear hearing protectors? ☐ no ☐ yes B 60 - 61

f) How many hours per month do you shoot (average) or are around someone else shooting? ☐☐ B 62 - 63

g) For how many years? ☐☐ B 64 - 65

19. Have you ever been employed?

☐ no ☐ yes job description____________________

B 66 B 67

To be judged by questionnaire giver: Is this a noise-relevant job? ☐ no ☐ yes B 68 - 69

20. What is your father's occupation?

Occupation:____________________

B 70 B 71 (b l a n k) Employed by:____________________

To be judged by questionnaire giver: Is this a noise-relevant job? ☐ no ☐ yes B 72 - 73

21. What is your mother's occupation?

Occupation:____________________

B 74 B 75 Employed by:____________________

(b l a n k)

To be judged by questionnaire giver: Is this a noise-relevant job? ☐ no ☐ yes B 76 - 77

$\boxed{1}$ B 80

CARD C Col. 1-7 same as B

$\boxed{3}$ C 8

22. What are your hobbies or recreational activities?

activities____________________

C 9 C 10
(b l a n k)

To be judged by questionnaire giver: Is this a noise-relevant activity? ☐ no ☐ yes C 11 - 12

23. Have you ever used or been around power tools? (e.g., drills, saws, sanders, grinders, etc.)

		(1 = yes 0 = no)	yes or no	Occas-ionally	Often	
no	yes	electric tools (drills, saws, sanders, grass edgers, etc.)	☐	☐	☐	C15-17
C 13	C 14	grinders	☐	☐	☐	C18-20
		gas lawnmowers, edgers, etc.	☐	☐	☐	C21-23
		chain saws	☐	☐	☐	C24-26
		other	☐	☐	☐	C27-29

Specify______________________________

____

24. Have you ever used farm machinery or been close by when it is operating? (e.g., tractors, combines, etc.)

☐ no C 30 ☐ yes C 31

a) Tractors or combines
   1. Rarely - (less than 1 hr/mo) ☐ C 32
   2. Occasionally - (1-8 hrs/mo. (up to 2 hrs/wk) ☐ C 33
   3. Frequently - (2-10 hrs/wk) ☐ C 34
   4. Very often - (more than 10 hrs/wk) ☐ C 35

b) Other motor-driven farm equipment ☐ C 36
   Specify______________________________

____

25. What sports have you participated in for more than a few hours?

a) none ☐ C 37
b) swimming ☐ C 38
c) baseball ☐ C 39
d) football ☐ C 40
3) soccer ☐ C 41
f) basketball ☐ C 42
g) bowling ☐ C 43
h) bicycling ☐ C 44
i) tennis ☐ C 45
j) horseback riding ☐ C 46
k) gymnastics ☐ C 47
l) other ☐ C 48
   Specify______________________________

____

26. Have you ever worn hearing protectors for any reason other than shooting?

☐ no C 49 ☐ yes C 50

a) Worn protectors
1) when driving tractor or mowing ☐ C 51
2) when near power tools or other machinery ☐ C 52
3) other ☐ C 53
Specify ______________________________
____

C. Otological History

27. Have you noticed a temporary or permanent change for any reason in your ability to hear or understand spoken words?

☐ no C 54 ☐ yes C 55

a) Where did this trouble occur most often?
at home ☐ C 56
at school ☐ C 57
at work ☐ C 58
other ☐ C 59
Specify ______________________________

b) When did you first notice the change?
☐☐ year C 60 - 61

C 62 Blank

28. Since your last visit, have you had any roaring or ringing in your ears?

☐ no C 63 ☐ yes C 64

a) roaring ☐ C 65
ringing ☐ C 66

b) right ear ☐ C 67
left ear ☐ C 68

c) frequency
once ☐ C 69
2-5 times ☐ C 70
more than 5 times ☐ C 71

d) duration
less than 45 minutes ☐ C 72
1-12 hours ☐ C 73
about 1 day ☐ C 74
more than a day ☐ C 75

e) Did you go to a doctor and/or receive treatment?

no	yes
☐	☐
C 76	C 77

f) How old were you when it started? ☐☐ years C 78 - 79

1 C 80

CARD D Col. 1-7 same as C

4 D 8

29. Have you ever had any earaches, ear infections, running ears?

no	yes
☐	☐
D 9	D 10

a) Which?
ear infection ☐ D 11
ear ache ☐ D 12
running ears ☐ D 13

b) Which ear(s)?
right ☐ D 14
left ☐ D 15

c) Frequency
once ☐ D 16
2-5 times ☐ D 17
more than 5 ☐ D 18

d) Duration ☐☐ days D 19 - 20

e) How old were you when it started? ☐☐ years D 21 - 22

f) Did you go to a doctor and/or receive treatment?

no	yes
☐	☐
D 23	D 24

REMINDER NON-FELS ONLY

D. General Health

30. Which of the following problems have you ever been bothered by?

a) high blood pressure ☐ D 25
b) diabetes ☐ D 26
c) allergy ☐ D 27
d) sore throat ☐ D 28
3) mumps ☐ D 29
f) encephalitis ☐ D 30
g) meningitis ☐ D 31
h) high fever (greater than 103 degrees) ☐ D 32
i) excessive mouth breathing ☐ D 33
j) sinusitis ☐ D 34
   mild ☐ D 35
   moderate ☐ D 36
   severe ☐ D 37
k) dizzy spells ☐ D 38
   occasional (1/6 mo.) ☐ D 39
   frequent (1/mo.) ☐ D 40
   very frequent (more than 1/mo.) ☐ D 41
l) none of the above ☐ D 42
m) any other health problem not mentioned above ☐ ☐ (no yes) D 43 - 44
   explain ____________________________
   ____

31. Have you ever been hospitalized?

☐ no D 45 ☐ yes D 46

a) For what and how long? ____________________________
____
____

32. Have you ever had any of the following medications?

a) streptomycin ☐ D 47
b) neomycin ☐ D 48
c) kanomycin ☐ D 49
d) quinine ☐ D 50
e) large amounts of aspirin (more than 8 in a day or 20 in a week) ☐ D 51
f) none of the above ☐ D 52

33. Are there any other medications that you have taken regularly?

☐ no D 53 ☐ yes D 54

a) What and how much?______________________________

____

34. Have you ever been unconscious (either knocked out, fainted, blacked out, seizure, etc.)?

☐ no D 55 ☐ yes D 56

a) How many times? ☐ D 57

b) What was the cause each time?

accident	☐	D 58
fainting	☐	D 59
seizure	☐	D 60

c) How long were you unconscious each time?

a few seconds	☐	D 61
less than a minute	☐	D 62
5 minutes to an hour	☐	D 63
more than an hour	☐	D 64

35. Have you ever had any vision or hearing problems resulting from an illness or an accident?

☐ no D 65 ☐ yes D 66

a) What?_______________________________________

____

36. (Girls only) When did you have your first period?

month	☐☐	D 67 - 68
year	☐☐	D 69 - 70
not yet	☐	D 71

37. If you answered "yes" to Question 30, Part H (Have you ever had a high fever?), complete the following:

a) How old were you? ☐☐ years D 72 - 73

b) How long did it last? ☐☐ days D 74 - 75

38. Were your tonsils removed?

☐ no D 76 ☐ yes D 77

39. Have you ever had frequent colds?

☐ no D 78 ☐ yes D 79

☐ 1 D 80

CARD E., COL. 1-7 same as D

☐ 5 E 8

E. Information for Initial Audiometry History

40. Do you think your hearing is:

☐ Good E 9 ☐ Fair E 10 ☐ Poor E 11

a) If fair or poor, is loss in:

right ear ☐ E 12
left ear ☐ E 13

b) What do you think caused the loss?

illness ☐ E 14
accident ☐ E 15
other ☐ E 16
explain ____________________

____

c) Have you seen a doctor about your hearing loss?

☐ no E 17 ☐ yes E 18

d) Have you received any treatment?

☐ no E 19 ☐ yes E 20

medical ☐ E 21
surgical ☐ E 22
hearing aid ☐ E 23
other ☐ E 24
explain ____________________

____

41. Have you had your hearing tested before?

no	yes	
E 25	E 26	

a) When? ☐☐ year E 27 - 28

b) Where?

doctor's office	☐	E 29
school	☐	E 30
other	☐	E 31

explain ________________________________

____

c) How?

audiometer	☐	E 32
spoken voice	☐	E 33
tuning fork	☐	E 34
other	☐	E 35

explain ________________________________

____

d) What were you told about the results?

nothing	☐	E 36
good or notmal hearing	☐	E 37
loss in right ear	☐	E 38
loss in left ear	☐	E 39

42. Does anyone in your family have a hearing loss?

no	yes
E 40	E 41

a) Who?

mother	☐	E 42
father	☐	E 43
sister	☐	E 44
brother	☐	E 45
other	☐	E 46

explain ________________________________

____

b) How old was relative when loss started or was first complained of? ☐☐ years E 47 - 48

If exact age isn't known, was relative

Under 40	☐	E 49
Over 40	☐	E 50

c) Did loss occur ☐ suddenly ☐ gradually E 51 - 52

(APPLICABLE ONLY AFTER SEPTEMBER 1976)

43. Do you ride a bus to school?

☐ no ☐ yes

a) One way? a) ☐ E55
b) Both ways? b) ☐ E56
c) Number of days each week? c) ☐ E57
d) About how long does the bus ride last one way? (mins.) d) ☐☐ E58-59

F. General Information (not to be put on computer cards)

43. Father's name:
44. Mother's name:
45. Names and ages of brothers and sisters:

a.
b.
c.
d.
e.
f.
g.
h.

☐1 E 80

APPENDIX C

WITH SCORING SYSTEM

INTERVAL AUDIOMETRY QUESTIONNAIRE
(Do not ask Fels participants circled questions.)

A. General Information

1. Clan number ☐☐☐ A 1-3
2. Subject number ☐☐☐☐ A 4-7
3. Name ______________________ ______________________ [1] A 8
4. Today's date ☐☐ ☐☐ ☐☐ A 9-14 (mo. day yr.)
5. Questioner
   - Eileen ☐ A 15
   - Lee ☐ A 16
   - Marty ☐ A 17
   - Roger ☐ A 18
   - Other ☐ A 19 ______________ Specify
6. Sex of participant
   - male ☐ A 20
   - female ☐ A 21
7. Participant's birthdate ☐☐ ☐☐ ☐☐ A 22-27 (mo. day yr.)
8. Has your address changed since your last visit?
   ☐ no A 28 ☐ yes A 29
   new address: ______________________ street
   ______________________ city state
   ______________________ zip telephone

B. Noise Exposure History

9. Is your present home very near a busy road (such as a state highway or freeway), airport, noisy factory, downtown in a city, etc.?
   ☐ no A30 ☐ yes A31
   a) busy road
      - within 100 ft. of road ☐ A32 0
      - 100 ft. to 100 yds. from road (length of football field) ☐ A33 0
      - greater than 100 yards from road ☐ A34 0
   b) airport
      - lives under the flight pattern ☐ A35 2
      - lives near flight pattern ☐ A36 1
   c) other ☐ A37 Flag
      specify ______________________
      ____

10. How would your parents rate the sound volume of the TV when you watch it the most?

No. HOURS (41,42) X INTENSITY (38-40)

quiet	☐	A 38	0.1
average	☐	A 39	0.25
loud	☐	A 40	1.0

a) How many hours a day (average) do you watch TV? ☐☐ A41-42

11. Since your last visit have you listened to radio, stereo, hi-fi tapes, or records?

☐ no A43 ☐ yes A44

a) What percentage of the time do you listen with headphones?

never	☐	A 45	1.0
less than 1/4 of the time	☐	A 46	1.25
between 1/4 and 1/2 of the time	☐	A 47	1.5
between 1/2 and 3/4 of the time	☐	A 48	1.75
greater than 3/4 of the time	☐	A 49	2.0

a x b x c x d

b) About how many hours each day do you listen?

less than one	☐	A 50	0.25
1-2	☐	A 51	0.5
3-4	☐	A 52	1.0
>4	☐	A 53	2.0

c) How loud do you like the volume?

quiet	☐	A 54	.1
medium	☐	A 55	1.0
loud	☐	A 56	2.0

d) What type of music do you usually listen to?

hard rock--soul	☐	A 57	1.25
pop--country--western	☐	A 58	1.0
classical	☐	A 59	1.0

12. Since your last visit have you played a musical instrument or sung with a band?

☐ no A60 ☐ yes A61

a) Instrument ______________ ☐☐ A 62-63

amplified	☐	A 64	2
not amplified	☐	A 65	1

b) About how many hours per week have you played it? ☐☐ A66-67

$\frac{a \times b \times c}{5}$

c) Do you mostly play with a

rock band?	☐	A 68	2.0
marching or concert band?	☐	A 69	1.75
orchestra?	☐	A 70	1.5
by yourself?	☐	A 71	1.0

13. Do you listen to more than about one hour of live rock music each week?

☐ no A72 ☐ yes A73

Approx. no. of hours/week ☐☐ A 74-75

No. OF HOURS x 0.4

CARD B- col. 1-7 same as A [2] B8

14. Have you played with any very loud toys since your last visit?

[ ] no B9 [ ] yes B10

a

a) Cap guns, pop guns, air guns
1. Less than 1 hr/wk [ ] B11 0.0
2. 1-2 hrs/wk [ ] B12 0.0
3. 4-6 hrs/wk [ ] B13 0.0
4. More than 7 hr/wk [ ] B14 0.0

b) Other toys [ ] B15 Flag
Specify______

15. Since your last visit, have you done or been around much motorcycling, motor boating, drag or auto racing, go-carting, minibiking, etc.?

[ ] no B16 [ ] yes B17

(estimate times while engine is running)

a) Motorcycles, outboard motor boats ($\geq$ 35 H.P. engines)
1. Less than 1 hr/wk [ ] B18 2
2. 2-7 hrs/wk [ ] B19 3
3. 7-15 hrs/wk [ ] B20 4
4. More than 15 hrs/wk [ ] B21 5

a + b

b) Minibikes, auto or drag racing, snowmobile, go-carts, small outboard or inboard motor boats
1. Less than 1 hr/wk [ ] B22 2
2. 2-7 hrs/wk [ ] B23 3
3. 7-15 hrs/wk [ ] B24 4
4. More than 15 hrs/wk [ ] B25 5

c) Other [ ] B26 Flag
Specify ______

16. Since your last visit, have you played with any loud or explosive devices (except guns; e.g., small gas driven engines like on model airplanes; fireworks, etc.

[ ] no B27 [ ] yes B28

a) Firecrackers (within 50 ft. of explosives)
once or twice in 6 mos. [ ] B29
3-5 times in 6 mos. [ ] B30
more than 6 times in 6 mos. [ ] B31
Estimate total no. exploded since last visit [ ][ ] B32-33

total no. exploded + b
5

If >99 Then a letter code is used To Group within 100 intervals.

b) Small gas driven engines (e.g., model airplanes) (while engine is running)
1. Less than 1 hr/mo [ ] B34 1.0
2. 1-4 hrs/mo [ ] B35 2.0
3. More than 1 hr/wk [ ] B36 3.0

c) Other [ ] B37 Flag
Specify______

17. Have your parents or any of your brothers or sisters changed their hobbies or recreational activities since your last visit? (especially related to noise increase or decrease)

[ ] no B38 [ ] yes B39

new activities______

To be placed by questionnaire giver:
Is this a noise relevant activity? [ ] no B40 [ ] yes B41 Flag

18. Have you fired or been around anyone else firing a gun since your last visit?

☐ no B42 ☐ yes B43

a) Who fired?
☐ B44 ☐ B45
you / someone else

i) how many rounds (bullets)? ☐☐☐ B46-48

ii) did you wear hearing protectors? ☐ 1.0 ☐ 0.1
no B49 / yes B50

iii) what type of gun?
rifle or shot gun ☐ B51 1.0
pistol ☐ B52 1.5

iv) what caliber:
.22 or smaller ☐ B53 0.5
larger than .22 ☐ B54 10.0

ii x iii x iv + 10 log i +
d x e x F + 10 Log c x 1.25

b) How do you shoot?
right handed ☐ B55
left handed ☐ B56

c) How many rounds (bullets)? ☐☐☐ B57-59

d) Did you wear hearing protectors ☐ 1.0 ☐ B60-61 0.1
no / yes

e) What kind of gun?
rifle or shot gun ☐ B62 1.0
pistol ☐ B63 1.5

f) What caliber:
.22 or smaller ☐ B64 0.5
larger than .22 ☐ B65 10.0

19. Have you worked at any new jobs (especially noise-related ones) or changed job since your last visit?

☐ no B66 ☐ yes B67

job description______________________________

____

To be judged by questionnaire giver: Is this a noise relevant job? ☐ no ☐ yes	B68-69 Flag

20. Has your father's occupation changed isnce your last visit?

☐ no B70 ☐ yes B71

new occupation______________________________
employed by______________________________

To be judged by questionnaire giver: Is this a noise relevant job? ☐ no ☐ yes	B72-73 Flag

21. Has your mother's occupation changed since your last visit?

☐ no B74 ☐ yes B75

new occupation______________________________
employed by ______________________________

To be judged by questionnaire giver: Is this a noise relevant job? ☐ no ☐ yes	B76-77 Flag

CARD C col. 1-7 same as H [3] C8

22. Have you taken up any new hobbies or recreational activities since your last visit?

[ ] no C9 [ ] yes C10

new activities________________

To be judged by questionnaire giver:
Is this a noise relevant activity? [ ] no [ ] yes C11-12 Flag

23. Since your last visit, have you used or been around power tools for more than a total of about one hour in six months? (e.g., drills, saws, sanders, grinders, etc.)

[ ] no C13 [ ] yes C14

$\frac{a \times 2b \times c \times 2d}{3}$

	(1 = yes 0 = no) yes or no	hours near since last visit	
a. electric tools (drills, saws, sanders, grass edgers, etc.)	[ ]	[ ][ ]	C15-17
b grinders	[ ]	[ ][ ]	C18-20
c gas lawnmowers, edgers, etc.	[ ]	[ ][ ]	C21-23
d chain saws	[ ]	[ ][ ]	C24-26
e other	[ ]	[ ][ ]	C27-29

Flag

specify________________

24. Since your last visit, have you used farm machinery or been close by when it was operating? (e.g., tractors, combines, etc.)

[ ] no C30 [ ] yes C31

a

a) Tractors or combines
- Less than 1 hr/mo [ ] C32 0
- 1-8 hrs/mo (up to 2 hrs/wk) [ ] C33 1
- 2-10 hrs/wk [ ] C34 3
- More than 10 hrs/wk [ ] C35 4

b) Other motor driven farm equipment [ ] C36 Flag

specify________________

25. Has your participation in sports altered since your last visit? Since your last visit, what sports have you participated in for more than a few hours?

- a) none [ ] C37
- b) swimming [ ] C38
- c) baseball [ ] C39
- d) football [ ] C40
- e) soccer [ ] C41
- f) basketball [ ] C42
- g) bowling [ ] C43
- h) bicycling [ ] C44
- i) tennis [ ] C45
- j) horseback riding [ ] C46
- k) gymnastics [ ] C47
- l) other [ ] C48

specify________________

26. Since your last visit, have you worn hearing protectors for any reason other than shooting?

☐ no C49 ☐ yes C50 Flag

worn protectors
a) When driving tractor or mowing ☐ C51
b) When near power tools or other machinery ☐ C52
c) Other ☐ C53
specify________________

C. Otological History

27. Since your last visit, have you noticed a temporary or permanent change for any reason in your ability to hear or understand spoken words?

☐ no C54 ☐ yes C55

a) Where did this trouble occur most often?
at home ☐ C56
at school ☐ C57
at work ☐ C58
other ☐ C59
specify________________

b) Cause of change:
illness (earaches, stopped up ears, etc.) ☐ C60
accident ☐ C61
other ☐ C62
specify________________

28. Since your last visit, have you had any roaring or ringing in your ears?

☐ no C63 ☐ yes C64

a) roaring ☐ C65
ringing ☐ C66

b) right ear ☐ C67
left ear ☐ C68

c) frequency
once ☐ C69
2-5 times ☐ C70
more than 5 times ☐ C71

d) duration
less than 45 minutes ☐ C72
1-12 hours ☐ C73
about 1 day ☐ C74
more than a day ☐ C75

e) did you go to a doctor and/or receive treatment?

☐ no C76 ☐ yes C77

CARD D col. 1-7 same as ([4] D8

29. Since your last visit, have you had any earaches, ear infections, running ears?

[ ] no D9 [ ] yes D10

a) Which?
   ear infection [ ] D11
   ear ache [ ] D12
   running ears [ ] D13
b) Which ear(s)?
   right [ ] D14
   left [ ] D15
c) Frequency
   once [ ] D16
   2-5 times [ ] D17
   more than 5 [ ] D18
d) Duration
   less than a day [ ] D19
   2-4 days [ ] D20
   4-7 days [ ] D21
   more than 1 week [ ] D22
e) Did you go to a doctor and/or receive treatment?

   [ ] no D23 [ ] yes D24

REMINDER NON-FELS ONLY

D. General Health

30. Since your last visit, which of the following problems have you been bothered by?

a) high blood pressure [ ] D25
b) diabetes [ ] D26
c) allergy [ ] D27
d) sore throat [ ] D28
e) mumps [ ] D29
f) encephalitis [ ] D30
g) meningitis [ ] D31
h) high fever (> 103°) [ ] D32
i) excessive mouth breathing [ ] D33
j) sinusitis [ ] D34
   mild [ ] D35
   moderate [ ] D36
   severe [ ] D37
k) dizzy spells
   occasional (1/6 mo.) [ ] D38
   frequent (1/month) [ ] D39
   very frequent (more than 1/month) [ ] D40 [ ] D41
l) none of the above [ ] D42
m) any other health problem not mentioned above [ ] no [ ] yes D43-44

explain ______________________________
____

31. Since your last visit, have you been hospitalized?

☐ no D45 ☐ yes D46

a) For what and how long?______________________

32. Since your last visit, have you had any of the following medications?

a) Streptomycin ☐ D47
b) Neomycin ☐ D48
c) Kanomycin ☐ D49
d) Quinine ☐ D50
e) Large amounts of aspirin (more than 8 in a day or 20 in a week) ☐ D51
f) none of the above ☐ D52

33. Are there any other medications that you have taken regularly since your last visit?

☐ no D53 ☐ yes D54

a) What and how much?______________________

34. Since your last visit, have you been unconscious (either knocked out, fainted, blacked out, seisure, etc.)?

☐ no D55 ☐ yes D56

a) How many times ☐ D57
b) What was the cause each time?
accident ☐ D58
fainting ☐ D59
seisure ☐ D60
c) How long were you unconscious each time?
a few seconds ☐ D61
less than a minute ☐ D62
5 minutes to an hour ☐ D63
more than an hour ☐ D64

35. Since your last visit have you had any vision or hearing problems resulting from an illness or an accident?

☐ no ☐ yes D65-66

a) What?______________________

36. (Girls only) When did you have your first period?
month ☐☐ D67-68
year ☐☐ D69-70
not yet ☐ D71

37. Do you ride a bus to school?

☐ 072 no ☐ 073 yes

a) One way? a) ☐ D74
b) Both ways? b) ☐ D75
c) Number of days each week? c) ☐ D76
d) About how long does the bus ride last one way? (mins.) d) ☐☐ D77 D78

APPENDIX D

ADDITIONAL SCORES DERIVED FROM THE
INTERVAL AUDIOMETRY QUESTIONNAIRE (appendix 3)

1. <u>EVENT SCORE:</u> The number of events a child experienced which are thought to be particularly important in their noise exposure.

Maximum possible = 9

Those scored:

1)	9b	lives under a flight pattern	(col. A 35)
2)	10	listens to TV loudly	(col. A 40)
3)	11c	listens to music loudly	(col. A 56)
4)	12a	plays an amplified instrument	(col. A 64)
5)	15	has been around motorcycles motorboats, drag racing, etc.	(col. B 17)
6)	16	has played with explosive devices or gas engines	(col. B 28)
7)	18	has fired or been around someone else firing a gun	(col. B 43)
8)	23	has used or been around power tools	(col. C 14)
9)	24	has used or been close to farm machinery	(col. C 31)

2. <u>GUN SCORE:</u> Score to identify those who might have been exposed to unusual noise due to guns or shooting.

-- if item 18 (col. 43) is yes

without hearing protectors gun score = 10·B65(1)·B60(1) + 10log B57-59

with hearing protectors gun score = 10·B65(1)·B61(0.1) + 10log B57-59

3. <u>CHAIN SAW SCORE</u>: To identify those who have been close to or have operated chain saws

if C 24 mark yes

Score = 10 + logC25-26.

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