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HEARING LEVELS OF CHILDREN TESTED AT 7 AND 11 YEARS A NATIONAL STUDY

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Introduction

The National Child Development Study is a longitudinal study of all the children (approx. 17,000) in England, Scotland and Wales born in one week of March 1958. During the Perinatal Mortality Survey (Butler and Alberman, 1969) and subsequent follow-up studies at seven (Davie, Butler and Goldstein, 1972) and eleven (Davie, 1973) considerable data were collected concerning the development of these children. The two follow-up studies included pure tone audiometric testing and clinical hearing testing of the subjects. In the present paper we present the results of analyses of the audiometric data in terms of overall hearing performance at two different ages, together with sex and social class comparisons. Results of the clinical hearing tests will be reported in a future paper. A third follow-up study recently completed for the subjects aged 16 years yielded further data and these will also be presented at a later date.

Subjects and Methods

The subjects were those 11,370 at the 7 year follow-up and those 12,406 at the 11 year follow-up for whom audiometric data were available. At each of those ages school medical officers arranged an audiogram test for the study children. These were carried out using the audiometers, facilities and procedures locally available. This has several implications for the quality of the data collected: First, audiometers were probably of variable efficiency; for example, Martin (1967) found the general standards of performance of British audiometers presented to the Royal National Institute for the Deaf for calibration, to be 'poor'. Secondly, even audiometers carefully calibrated may not produce identical results if different earphones are used, though the vast majority of earphones used with British audiometers for the period in question were the TDH 39 receivers in MX-41/AR type of cushion (Rice and Coles, 1967). Thirdly, of the persons carrying out the audiograms only some 60% were qualified audiometricians, the remainder being mainly medical officers or nurses. Fourth, ambient conditions probably varied considerably. It has long been known that audiogram data from surveys usually diverge to some degree from those obtained under laboratory conditions (e.g. Dadson and King, 1952; Glorig, 1966). Thus, although the present results would be expected to yield estimates which are biased and more variable than those obtained from standardised conditions, they do represent norms for the conditions under which testing is typically carried out. Otologically defective children (comprising about 5-6% of the sample: Sheridan, 1972) were not excluded from the present estimations.

Estimation of Percentile Norms: Estimates have been made of the 10th, 50th and 90th percentiles of hearing loss for each frequency at each age. The estimation procedure was as follows: The raw data were available as the numbers of children in each hearing loss category to the nearest 5dB, these categories being grouped as follows: Up to 0, 5 or 10, 15 or 20, 25 or 30, 35 or 40, 45 or 50, 55 or 60, 60 or more. From these distributions the cumulative percentages at the boundaries of these intervals were readily calculated and plotted on probability paper against an arithmetic scale of hearing loss. For all the frequencies this plot was very close to a straight line up to just over the 90th percentile of hearing loss, after which it departed from linearity with increasing slope. Thus, a straignt line fitted to those points in this percentile range should provide efficient and unbiased estimates for the 10th, 50th and 90th percentiles. The fitting was done by eye, since in all cases the plotted points were almost collinear. In order to obtain an approximate estimate of the standard errors of the estimates it was assumed that the percentiles were estimated using the mean and standard deviation calculated from a grouped normal distribution based on the cumulative sample size upon which the fitted straight line was based (just over 90% of the total). By this method the 50th percentile had an estimated standard error of about 0.045dB and the 10th and 90th percentiles had standard errors of about 0.050dB. Approximate 95% confidence interval widths are therefore respectively 0.18 and 0.20dB. These values are well below the sensitivity of a normal audiometer (Martin, 1967).

Comparisons of hearing loss distributions: Two types of comparisons were made. First, the average hearing loss of different groups of children were compared, for example, that of boys and girls. For this purpose the grouped distributions were arranged in a 2×k contingency table and the average losses compared by carrying out the equivalent test for linear trend in the proportions across the k columns of the table (Armitage, 1955).

To study differential changes in distributions at 7 and 11 years (for example, between boys and girls at a given frequency) a 2×k table of the grouped distributions at 11 years for each sex was arranged for each 7 year distribution group. A test for differences between the linear trend lines for each 7 year group was then carried out (Armitage, 1966). Significant differences therefore imply mean differences between the sexes in terms of 11 year distributions for a given 7 year group. One limitation of this analysis is that we have been unable to make any allowance for the unreliability of the 7 year estimates. The presence of large measurement error would we believe lead to larger sex differences than are actually present, so that our present estimates of differences should be reduced. Unfortunately, we have no data bearing on this, and the present results should be treated with a certain amount of caution.

The second comparison was that between ages and between left and right ears for the same children. In this case the grouped distributions were arranged as a k×k contingency table and the equality of the marginal distributions tested (Bhapkar, 1966).

Results

The comparison of left and right ears showed significant differences at only one frequency (1,000 cps) at 7 years and two frequencies (250 and 1,000 cps) at 11 years. Since these differences were minimal the remaining data have been presented in terms of 'better ear' only; this procedure minimises the quantity of data whilst representing the best possible hearing acuity of individuals in the sample.

The distributions of subjects across the categories of hearing loss at the two ages are shown in Table 1. The audiometric thresholds expressed in percentile standards for the total sample on the frequencies recorded at the two ages are shown in Table 2 and plotted in Fig. 1. There is a paucity of audiometric data on representative samples of British children so that comparisons are difficult. The thresholds recorded here appear to be considerably lower than those recently reported in a localised Scottish survey for children of this age range

Table 1. Data of audiometric performance at 7 and 11 years; grouped by loss in decibels re-audiometric zero for better ear (percentages).

Frequency (Hz)	*Age*	*0*	*–10*	*–20*	*–30*	*–40*	*–50*	*50+*	*Total N*
250	7	11.5	42.9	37.4	7.0	1.0	0.1	0.05	11.106
	11	10.8	42.6	38.1	7.9	0.5	0.08	0.04	12.406
500	7	10.0	39.4	41.7	7.6	1.1	0.1	0.08	11.343
	11	9.3	42.8	39.6	7.6	0.5	0.1	0.01	12.398
1000	7	21.0	49.9	25.4	3.1	0.4	0.1	0.1	11.370
	11	22.7	52.8	21.7	2.3	0.3	0.1	0.08	12.398
2000	7	29.1	50.3	18.2	1.8	0.3	0.1	0.09	11.362
	11	37.4	48.9	12.3	1.1	0.2	0.1	0.07	12.398
4000	7	34.0	46.1	17.0	2.1	0.5	0.2	0.1	11.358
	11	41.2	45.3	11.8	1.3	0.3	0.1	0.07	12.398
8000	7	25.0	43.9	24.8	4.4	1.3	0.4	0.2	11.233
	11	37.4	43.5	16.3	2.2	0.4	0.2	0.12	12.386

Table 2. Percentiles of audiometric loss at ages 7 and 11 years.

(Tested for equality of 7 and 11 year distributions of hearing loss grouped as 0, 5 or 10, 15 or 20, 25 or 30, 35+)

Frequency (Hz)	*Age*	*10th*	*50th*	*90th*	X^2 *on 4 D.F.*
250	7	−0.5	9.0	19.0	32.91***
	11	0.0	9.5	19.0	
500	7	0.0	9.5	19.5	51.11***
	11	0.0	9.5	19.0	
1000	7	−3.5	6.0	16.0	66.59***
	11	−3.5	5.0	14.0	
2000	7	−5.0	4.0	14.0	287.27***
	11	−6.5	2.5	11.5	
4000	7	−6.5	3.0	13.5	248.58***
	11	−8.0	1.5	11.5	
8000	7	−5.0	6.0	18.0	713.58***
	11	−8.0	3.0	14.6	

*** p<0.001

(Lenihan, *et al.,* 1971). However, they compare favourably with the thresholds reported in a national survey of American children if we take the ISO zero-reference as very close to that of the British Standard (P.H.S., 1972; Davis, 1965). The results clearly indicate an improvement in hearing acuity between the ages of 7 and 11, especially in the higher frequencies, which is in line with the well known trend leading to a peak at puberty (Reymert and Rotman, 1946; Lenihan, *et al.,* 1971).

Table 3 shows the median audiometric losses for boys and girls separately at 7 and 11. Boys exhibited a slightly lower median loss than girls over most frequencies at 7 years. There was some evidence that the improvement between 7 and 11 was substantially greater for boys than for girls, as has been reported in other studies (Reymert and Rotman, 1946; Leniham, *et al.,* 1971). The tendency at 11 years for boys to have lower thresholds than girls in the lower frequencies (250-1,000 cps) and vice versa for higher frequencies confirms similar observation in American studies (P.H.S., 1975).

The median audiometric losses for social classes, grouped into Manual or Non-Manual according to fathers' occupations, are shown in Table 4. These indicate a consistent superiority

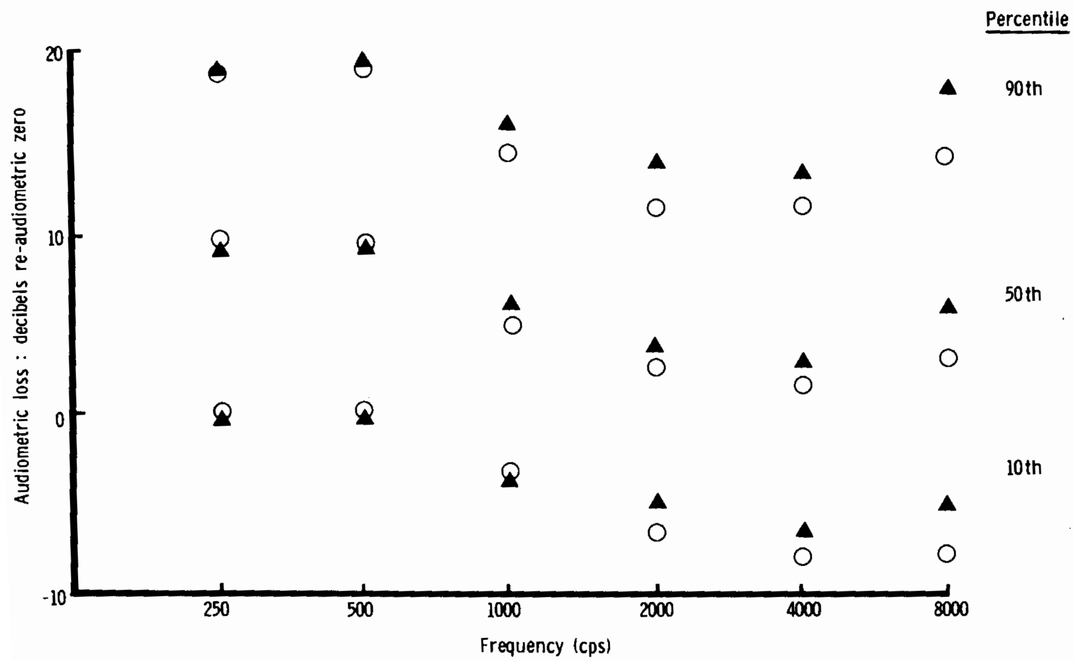

Fig. 1. Percentiles of audiometric loss in decibels for 'better ear' of the total sample of children at ages 7 and 11 years.
▲ 7 yrs; ○ 11 yrs.

Table 3. Median audiometric loss of boys and girls at ages 7 and 11 years.
(Tested for linear trend boys vs. girls, hearing loss grouped as in Table 2)

Frequency (Hz)	*Age*	*Boys*	*Girls*	X^2 *on 1 D.F.*
250	7	8.5	9.5	43.17***
	11	9.0	9.5	46.53***
500	7	10.0	10.5	24.18***
	11	9.5	9.5	54.45***
1000	7	5.5	6.0	17.92***
	11	5.0	5.5	42.12***
2000	7	4.0	4.0	6.76**
	11	2.5	2.0	18.87*
4000	7	3.0	3.5	4.04*
	11	2.0	2.0	25.76***
8000	7	6.0	6.6	0.80
	11	3.0	2.0	21.22***

* 0.05 > p > .01
** 0.01 > p > .05
*** 0.001 > p > .01
Otherwise p > .01

Table 4. Median audiometric loss of two social classes (fathers' occupation) at ages 7 and 11 years.
(Tested for linear trend manual vs. non-manual, hearing loss grouped as in legend to Table 2)

Frequency (Hz)	*Age*	*Non-Manual*	*Manual*	X^2 *on 1 D.F.*
250	7	9.0	11.5	30.87***
	11	9.0	9.5	20.79***
500	7	9.5	10.5	28.36***
	11	9.0	10.0	10.09*
1000	7	5.5	6.0	30.50***
	11	4.0	4.5	1.25
2000	7	3.5	4.0	21.98***
	11	2.0	2.5	0.00
4000	7	3.0	3.5	19.42***
	11	1.0	1.5	0.04
8000	7	5.0	6.0	26.37***
	11	2.0	2.5	0.04

* 0.05 > p > 0.01
** 0.01 > p > 0.05
*** 0.001 > p > 0.01
Otherwise p > 0.01

of audiometric performance on the part of the Non-manual group at both ages. The differences at 11 years, however, were only significant in the lower frequencies, indicating a relative change between 7 and 11 years.

Discussion

Because of the limitations imposed by test conditions we have not intended in this paper to present accurate standards of hearing levels among children. Nevertheless, the estimates obtained can be said to approximate the norms for children of this age group under the typical test conditions at that time. It is difficult to estimate the degree to which these diverge from those obtainable under laboratory conditions, but comparisons of the present variabilities (standard deviations) with those reported in an American standardised survey (P.H.S., 1972) on children of this age range suggests that it might not be exceedingly large. An approximation to an overall picture may also be of use to clinicians and researchers, especially in view of the paucity of national data on school children. Our results suggest, for example, that audiometric thresholds may be lower than those reported in a local study (Lenihan, *et al.*, 1971). On the other hand the results generally confirm the progressive improvement noted by other workers among children up to adolescence; a follow-up study on the same children aged 16 years, now being analysed, may shed further light on this developmental pattern. The sex and social class differences reported here broadly agree with previous findings; whilst the former remain as yet inexplicable it seems likely that audiometric thresholds among children from manual groups will be elevated relative to those of children from non-manual groups because of the greater prevalence of middle ear infections and other otological conditions among such children (Davie, *et al.*, 1972).

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