# CHAPTER 4

# DEGREE OF FM ADVANTAGE AS MEASURED USING AN ADAPTIVE SPEECH TESTING PROCEDURE WITH MILDLY TO PROFOUNDLY HEARING IMPAIRED CHILDREN

## 4.1 : RATIONALE

At the present time there is no standard clinical procedure in existence for ensuring and quantifying advantage when FM units are worn. The purpose of this study is to propose and evaluate a possible adaptive speech test that could be used. This will include examining how well such a measure corresponds with the expected degree of improvement, to what extent this can predict general performance with the FM system, as well as clinical feasibility of the procedure.

## 4.2 : METHOD

### 4.2.1 : Subjects

Forty-two children attending a hearing centre over a period of 2 months acted as subjects in this study. Of these, 11 were normal hearing children, either siblings of hearing impaired children, or cases referred for hearing assessment for a variety of reasons , but were subsequently found to have hearing thresholds less than 10 dB H.L.. These subjects were included in order to provide a basis of comparison with the performance of the hearing impaired children on the task. All were tested on the same day as the speech testing was carried out. The

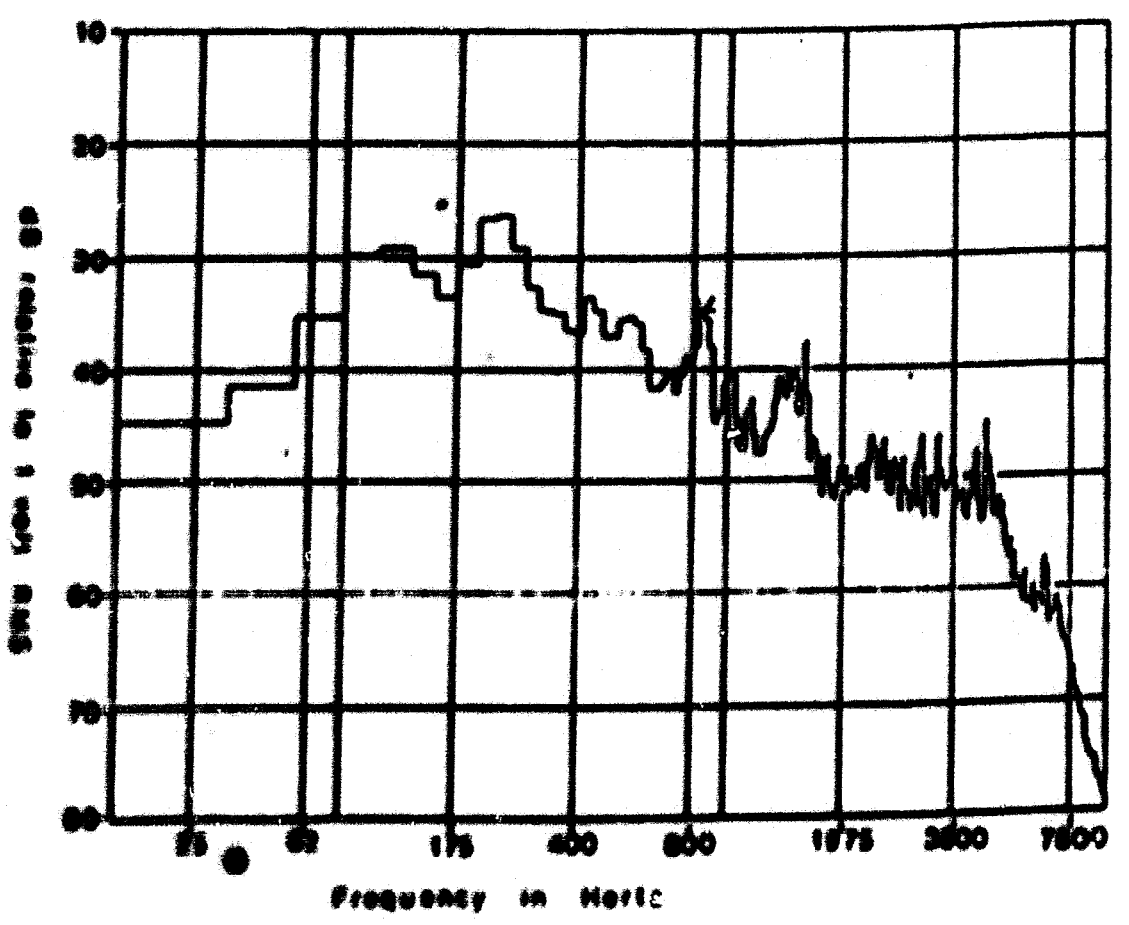
remaining 31 children had sensori-neural hearing losses ranging from mild to profound and had been using hearing aids for a number of years. A description of ages, average three frequency hearing levels for each ear and previous experience using an FM system can be found in Appendix C. To summarise , ages of the subjects ranged from 5 to 17 years (median = 8yrs), 8 had profound hearing losses, 11 were severe, 4 were moderate to severe, 5 were moderately hearing impaired and 3 had mild hearing losses. Seventeen of the hearing impaired children had not had any experience with FM aids before, 9 were considered successful users and 5 had rejected FM use after varying periods of time. The group of older children (subjects 30, 32, 34 - 42) were included as they were also participating in the previous experiment (Chapter 3) and it was desired that some quantitative measure of FM advantage be obtained on them.

### 4.2.2 : Test materials

Three alternate word lists from the Northwestern University Children's Identification of Speech Test (NU-CHIPS, Elliot & Katz, 1980) were used. This is a four-alternative picture pointing response test comprising 50 monosyllable words established to be within the vocabularies of 3 year old inner city American children. A master recording of these using a female speaker of Australian English was copied on to one track of a cassette tape with cafeteria noise on the other track. Each stimulus word was embedded in a burst of the cafeteria noise with a 9 second interstimulus interval. The spectrum of this noise is shown in Figure 4.1. The onset of each stimulus word was positioned 400 msec. after the onset of the noise and the noise continued 500 msec. longer than the longest stimulus word. The noise sample was the same for each

presentation and was amplitude normalised to the level of the speech for each word by use of a VU meter to equate peak levels.

Figure 4.1 : Long term average spectrum of the cafeteria noise measured on Spectral Dynamics 375 analyser (narrow band analysis Hamming window weighting).




4.2.3 : Instructions

The children were read the following instructions which were adapted from the WW-CHIPS test manual :

"You are going to listen through the speaker to a tape of a lady saying some words to you. You will also hear some noise like people talking all together. Listen carefully to each word and look at all the pictures on the page. Point to the picture of the word you hear. Remember to listen to the words and not to the noise. After you point to a picture, I will turn the page and you will listen to the next word. Be sure to listen very carefully because sometimes the words will be very soft. Have a guess even if you are not sure. Do you have any questions?"

Some modification and repetition of these was necessary for the younger and less language competent children.

**4.2.4 : Equipment set up and calibration**

The cassette recording was played on a TEAC A-360 stereo cassette deck, each track connected to a separate channel on a Madsen OB 822 audiometer. This allowed each channel to be independently adjusted in steps as small as 1 dB. The audiometer presented the noise and speech in sound field conditions from two loudspeakers positioned at head height. The stimulus words originated from the speaker located directly in front of the listener and at one metre distant from the ear , chosen to represent an ideal seating location for the child. The noise was presented from the other speaker one metre from the ear but directly behind the listener.

Testing was carried out in a sound proof booth. The noise calibration signal on both tracks of the cassette tape were measured using a Bruel

and Kjaer sound level meter, type 1613, at the ear's position and a correction figure applied to the hearing level shown on the audiometer dial when results were calculated.

All but two of the hearing impaired children wore binaural hearing aids. Twenty-four were wearing Phonak PPC2 hearing aids which use peak clipping as a limiting procedure, and another 7 subjects wore Phonak PPSC or PPSCL's which include a compression limiting circuit. Included in the latter group were 5 children who had to be provided with a different pair of hearing aids for the testing session as their usual aids had no facility for direct audio input. They were temporarily changed over to Phonak supercompression aids, matched as far as possible to within 2 dB of the frequency response and power of their own aids. All children were fitted according to the Byrne and Dillon hearing aid selection procedure (1986), and aids were set on their usual or most comfortable listening level.

Twenty-six of the subjects were tested using the Calaid FM system described in sections 2.2.2 and 3.2.2. The FM on-unit microphone was positioned at 15 cm from the front speaker. This microphone acts in combination with a second auxiliary microphone to create a cancellation effect when a noise signal is detected. At this 15 cm position the noise level was measured to be 58 dBSPL (2 dB softer than at the ear position) and the level of the speech stimuli was 84 dBSPL. Five of the subjects who also participated in paired comparsion experiment (Chapter 3) wore Sennheiser 1013 Mikroport FM systems as described in section 3.2.2. The directional lapel microphone of this was also positioned 15 cm from the front loudspeaker and pointing directly to it.

The volume control wheel of both types of FM system were set to a marker which indicated where a typical 85 dBSPL speech signal from the FM microphone provided the same level of output from the hearing aid as would a 70 dBSPL speech signal at the hearing aid microphone. In view of the greater output of the Sennheiser system when in the SOX mode compared to the combined setting, the FM volume wheel had to be readjusted appropriately to ensure the FM output was kept constant when switching from one mode to the other. However, the Calaid volume wheel was not similarly adjusted to compensate for the relative decrease in output (7 dB) as the setting was changed from FM alone to the combined switch. This was because, as explained in section 3.2.2, the additional damping of the hearing aid microphone when on the C setting (4 dB) reduces the effect this has on the relative S/N ratio obtained through the hearing aid compared to the FM system, and it is mainly only the overall level of the output that is affected. Also it is the way that most Calaid FM systems are worn (see Chapter 5).

### 4.2.5 : Procedure

The NU-CHIPS material was administered using an adaptive speech test procedure, similar to that employed by Hawkins (1984). However, in the present study, the noise level was kept at a constant level of 60 dBSPL as measured at the position of the subject's ear (in line with typical reported classroom noise levels), and the speech signal was varied. This method was selected since actual classroom noise levels are not altered by FM use but the effective level of the speech signal is, as the microphone position or FM volume control is varied. It was thought that this set up may offer greater insight into effects of altering the

absolute speech input levels on speech discrimination abilities. Also these speech levels would be expected to vary considerably over time both between and within speakers. In this way, the resultant signal and noise levels, and thus the S/N ratio, refer to those levels that were present at the position of the hearing aid microphone.

A simple up-down procedure was used to determine the S/N ratio at which 50% speech recognition score was obtained. In order to provide some practice in the task as well as to obtain an estimate of threshold at which to begin the actual test, approximately three reversals were initially carried out using a 5 dB step size. Thereafter this was reduced to 2 dB and the test begun. Sufficient stimulus words were given to provide a minimum of 13 reversals and wherever possible, testing continued until 19 reversals were completed.

The three test conditions, hearing aid microphones alone (H/A), FM microphone alone (FM) and combined hearing aid and FM microphone (C) were administered in counterbalanced order across the group to control for any learning and fatigue effects in the group data. Usually lists A1, B2 and A3 of the NU-CHIPS were used in this order depending on how many stimulus words were required to reach the criterion number of reversals. Once the criterion was reached, testing under the next condition continued from the next word in the list. The exception was with the normal hearing group who were tested only with the one list and in the one (unaided) condition, one third hearing list A1, one third listening to list B2 and the remainder having list A2.

## 4.3 : RESULTS

### 4.3.1 : Degree of FM advantage in FM alone and C listening conditions - group results

Appendix C contains the raw data for all 42 subjects participating in this study, including the 50% speech in noise thresholds (mean of the midpoints of each reversal in the adaptive procedure), standard deviations, standard errors, order of presentation of listening conditions, 3 frequency average hearing losses and age for each subject and each listening condition involved. From this data, the amount of advantage offered by the FM systems was calculated for each hearing impaired subject by subtracting the 50% speech threshold obtained in each FM listening condition from that found in the hearing aid alone condition. The resultant measures for both the Calaid and Sennheiser listeners can be found in Table 4.1. along with the means, standard deviations, standard errors and 99% confidence intervals for each group and listening condition.

Table 4.1 : Amount of FM advantage (in terms of improvement in S/N ratio necessary to obtain a 50% speech threshold) for each listening group in each listening condition

| Calaid FM | combined | FM alone |
|---|---|---|
| n = | 26 | 25 |
| mean | 9.86 dB | 19.00 dB |
| standard deviation | 6.13 dB | 7.44 dB |
| standard error | 1.20 dB | 1.49 dB |
| 99% confidence intervals | 6.88 to 12.84 dB | 15.29 to 22.71 dB |
| **Sennheiser 1013** | **combined** | **SOX** |
| n = | 5 | 5 |
| mean | 9.21 dB | 9.36 dB |
| standard deviation | 5.25 dB | 6.78 dB |
| standard error | 2.34 dB | 3.03 dB |
| 99% c. intervals | -1.58 to 19.98 dB | -4.58 to 23.30 dB |

A one-tailed paired t-test was conducted on the 50% speech in noise thresholds using the data for each subject found in Appendix C to ascertain whether there was a significant difference between listening conditions for each type of FM :

Calaid FM listeners :

C condition versus the hearing aid alone - $t = 8.04$ ($df = 25$), $p<0.0001$

FM alone versus the hearing aid alone - $t = 14.82$ ($df = 24$), $p<0.0001$

C versus FM alone - $t = 6.93$ ($df = 24$), $p<0.0001$

Sennheiser listeners :

C condition versus the hearing aid alone - $t = 3.51$ ($df = 4$), $p<0.05$

SOX versus the hearing aid alone - $t = 2.76$ ($df = 4$), $p<0.05$

C versus SOX - $t = 0.07$ ($df = 4$), $p>0.05$

The results show that, using this measure, there was a significant FM advantage obtained for both types of FM system evaluated when using both the combined and FM alone or SOX modes of operation. Also the S/N ratio required to score 50% speech discrimination was significantly poorer for the combined listening condition than for the FM alone setting on the Calaid FM. There was no similar significant difference shown between the C and SOX settings on the Sennheiser.

### 4.3.2.: Degree of FM advantage shown in individual cases

Mean S/N ratios where 50% performance occurred for each subject in each listening condition are shown in Table 4.2. A one tailed t-test (assuming equal variances) was carried out for each subject in order to

find out how often the individual listener was gaining significant benefit from the FM being evaluated on each setting compared to the hearing aid alone. The significance levels of these statistics are also indicated in Table 4.2.

**Table 4.2 : Mean S/N ratio for 50% performance of each subject in each listening condition ( in dB )**

| Subject no. | h/a | C | FM only |
|---|---|---|---|
| Calaid FM listeners : | | | |
| 1 | 11.6 | -5.5*** | -10.9*** |
| 2 | 5.8 | -2.9*** | -14.3*** |
| 3 | 4.9 | -7.4*** | -18.8*** |
| 4 | 15.2 | -5.9*** | 4.2*** |
| 5 | 19.5 | 9.6*** | -12.4*** |
| 6 | 6.6 | -5.9*** | 6.1*** |
| 7 | 28.1 | 16.2*** | 4.0*** |
| 12 | 35.2 | 12.5*** | 14.3*** |
| 13 | 10.1 | 0.8*** | -3.8*** |
| 14 | 12.7 | -1.6*** | -15.8*** |
| 15 | 8.8 | 2.1*** | -5.9*** |
| 16 | 18.9 | 18.3 | 11.6*** |
| 17 | 11.4 | 6.9*** | -4.6*** |
| 18 | 8.7 | 6.1** | -13.7*** |
| 19 | 8.6 | 1.4*** | -6.2*** |
| 27 | 6.1 | -3.0*** | -11.6*** |
| 28 | 26.6 | *28.4 | 3.5*** |
| 29 | 0.8 | -7.1*** | -13.0*** |
| 30 | 7.3 | -7.8*** | -19.4*** |
| 31 | 13.1 | 3.8*** | -7.6*** |
| 32 | 10.5 | -1.4*** | -14.7*** |
| 33 | 18.3 | 4.3*** | incomplete results |
| 34 | 26.6 | 13.8*** | 9.1*** |
| 35 | 18.2 | 5.5*** | -4.8*** |
| 36 | 18.7 | 4.5*** | -13.7*** |
| 37 | 23.5 | ***26.8 | 13.1*** |
| Sennheiser listeners : | | | |
| 38 | 9.8 | -8.2*** | -8.4*** |
| 39 | 3.0 | -0.2*** | -6.0*** |
| 40 | 13.1 | 7.1*** | 7.2*** |
| 41 | 1.7 | -10.5*** | -12.8*** |
| 42 | 8.3 | 1.6*** | 9.4 |

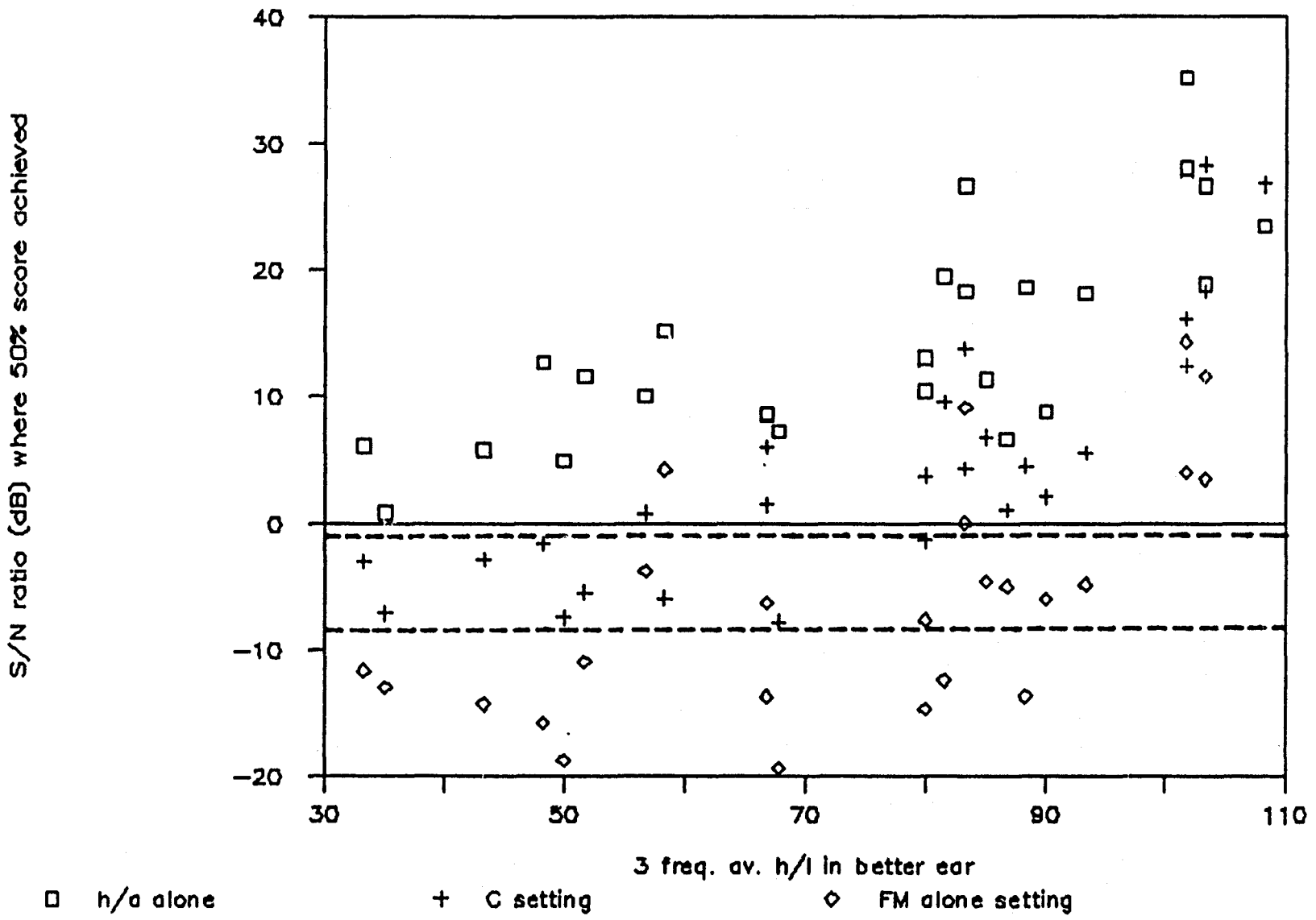
( * denotes p<0.05, ** denotes p<0.01, ***denotes p<.001,
—where asterix is positioned to the left side of the mean value, the hearing aid alone condition showed significant advantage over the FM condition,
—where asterix is to the right of the mean, the FM condition showed significant advantage over the hearing aid alone condition)

These results indicate that for all but 1 of the individual listeners, a significant FM advantage was shown on the FM only setting, and for all but 3 individuals, significant advantage over the hearing aid was also shown on the C setting. In fact, 2 of these latter subjects actually were performing significantly better with their hearing aids alone than through the FM system set on C. For these few subjects showing no significant FM advantage in this way, no reason could be detected why they were not obtaining the benefit that the other subjects were evidencing.

### 4.3.3 : Comparison between performances of normal hearing and hearing impaired listeners

The mean of the speech in noise thresholds for the 11 normal hearing subjects is 57.73 dB SPL and their standard deviations and standard errors are 1.81 dB and 0.545 dB respectively. The 99% confidence interval for these subjects overall is therefore 56.22 to 59.24. Thus normal hearing listeners required a S/N ratio of approximately -1 to -4 dB to attain 50% correct discrimination. Figure 4.2 is a scatter diagram of average hearing loss in the better ear for the hearing impaired listeners using the Calaid, plotted against the S/N ratios at which each achieved a 50% word identification score, for all three listening conditions. The dashed horizontal lines on the graph illustrate the extremes of the 99% confidence interval for the normal listeners.

Figure 4.2 : Scatter diagram with S/N ratio required to achieve 50% word identification plotted against 3 frequency average hearing loss for each of the 3 listening conditions evaluated on the Calaid FM.




The graph shows that there were 28 occurrences of hearing impaired listeners performing equal to or significantly better than the (unaided) normal hearing subjects. Of these 28 performances, 19 were achieved on the FM alone setting, 9 on the C setting, and none in the hearing aid alone condition.

### 4.3.4 : Relationship between degree of hearing loss and size of FM advantage

Figures 4.3 and 4.4 depict how degree of hearing loss is related to FM advantage for the Calaid FM on both the C and FM alone settings.

**Figure 4.3 : Correlation between 3 frequency average hearing loss and size of FM advantage on the C setting**

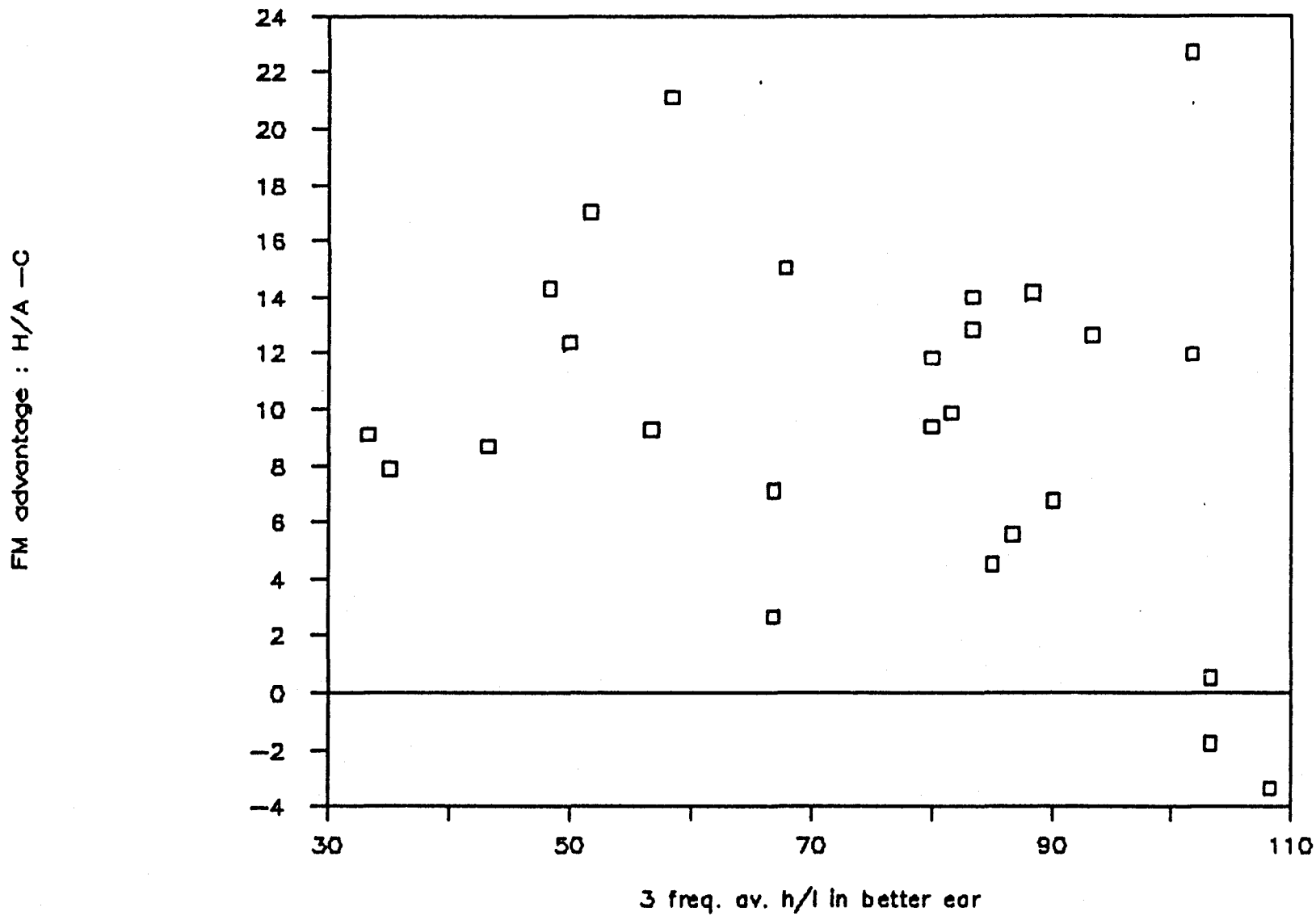
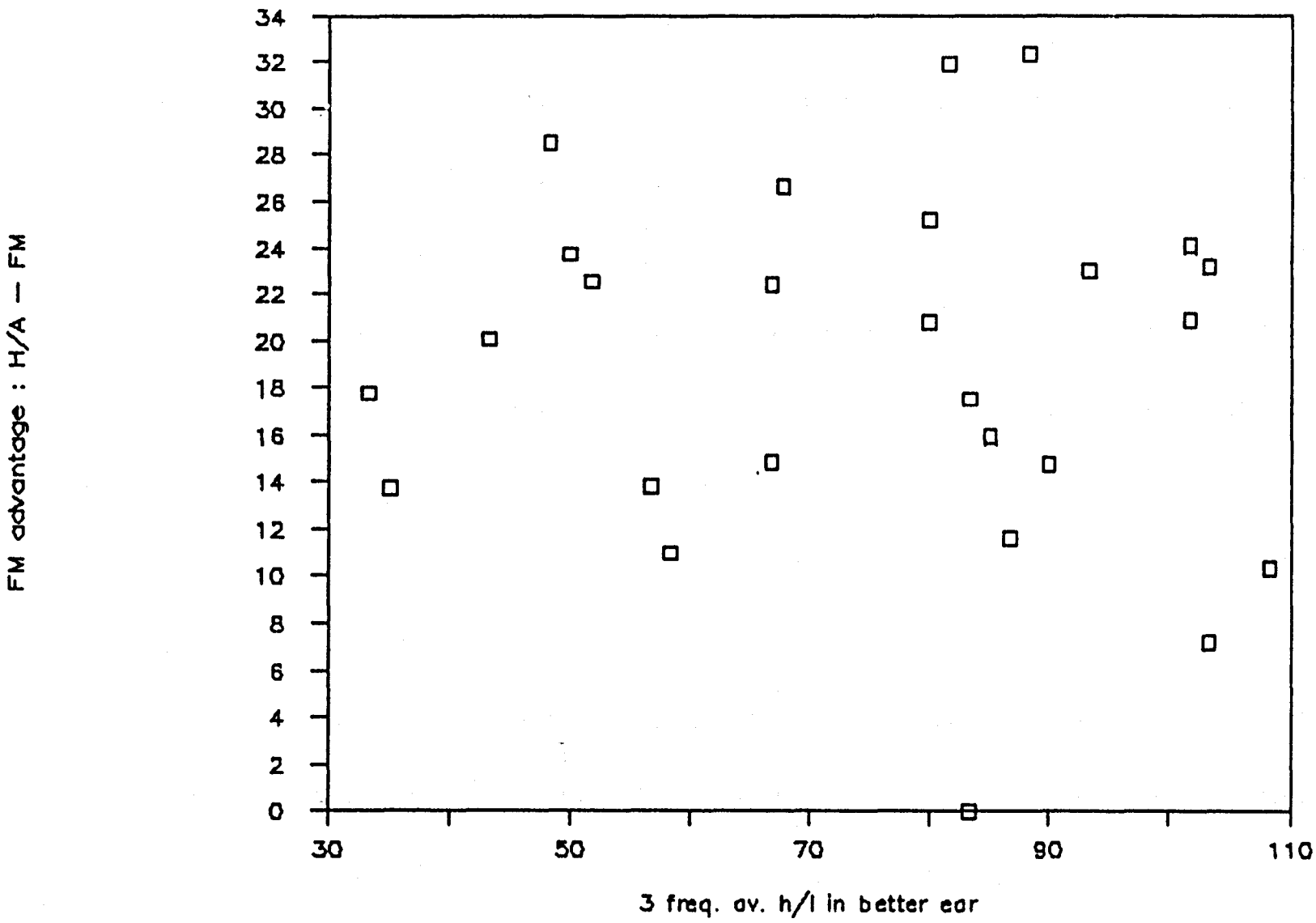


**Figure 4.4 : Correlation between 3 frequency average hearing loss and size of FM advantage on the FM alone setting**




The corresponding Pearson product moment correlation coeficient for these 2 sets of data were -0.1631 and 0.0468 respectively, both of which were not significant at the p = 0.05 level. Thus there is no relationship observed between degree of hearing loss and this measure of FM advantage.

## 4.4 : DISCUSSION

### 4.4.1 : Degree of FM advantage demonstrated

It is clear that a highly significant FM advantage is demonstrated for both types of FM's evaluated according to this adaptive procedure. Specifically, 50% performance on the speech test was obtained at much poorer S/N ratios when the children were listening through an FM system, compared to the S/N ratios necessary to achieve 50% scores through the hearing aid alone. Since speech intelligibility improves as S/N ratio becomes larger, this finding implies that the FM's should promote intelligibility of speech, and indeed this has been found by other studies using traditional speech discrimination tests (Ross & Giolas, 1971; Bankoski & Ross, 1984; Hawkins, 1984) as well as the tracking procedure described in Chapter 2. This significant advantage was shown for both modes of listening through the FM, the combined setting and the FM only or SOX setting, depending on the FM system used. Hawkins (1984) used a similar test procedure except that he kept the speech level constant and, instead, varied the level of the noise, he had the listeners seated 2 metres from the speaker, different speech and noise materials were used and he tested subjects with only mild to moderate hearing loss. He found an average 15 dB improvement in S/N ratio when comparing binaural hearing aids with omni-directional microphones to an FM with only the omni-directional microphone activated. An 18 dB advantage was shown when a directional FM microphone was used. In comparison, the mean advantage for the Calaid FM was 19 dB. The Sennheiser, which uses a directional microphone showed a 9.3 dB average

improvement. However, the same advantage as that shown by Hawkins' data would not be expected due to the different test conditions used.

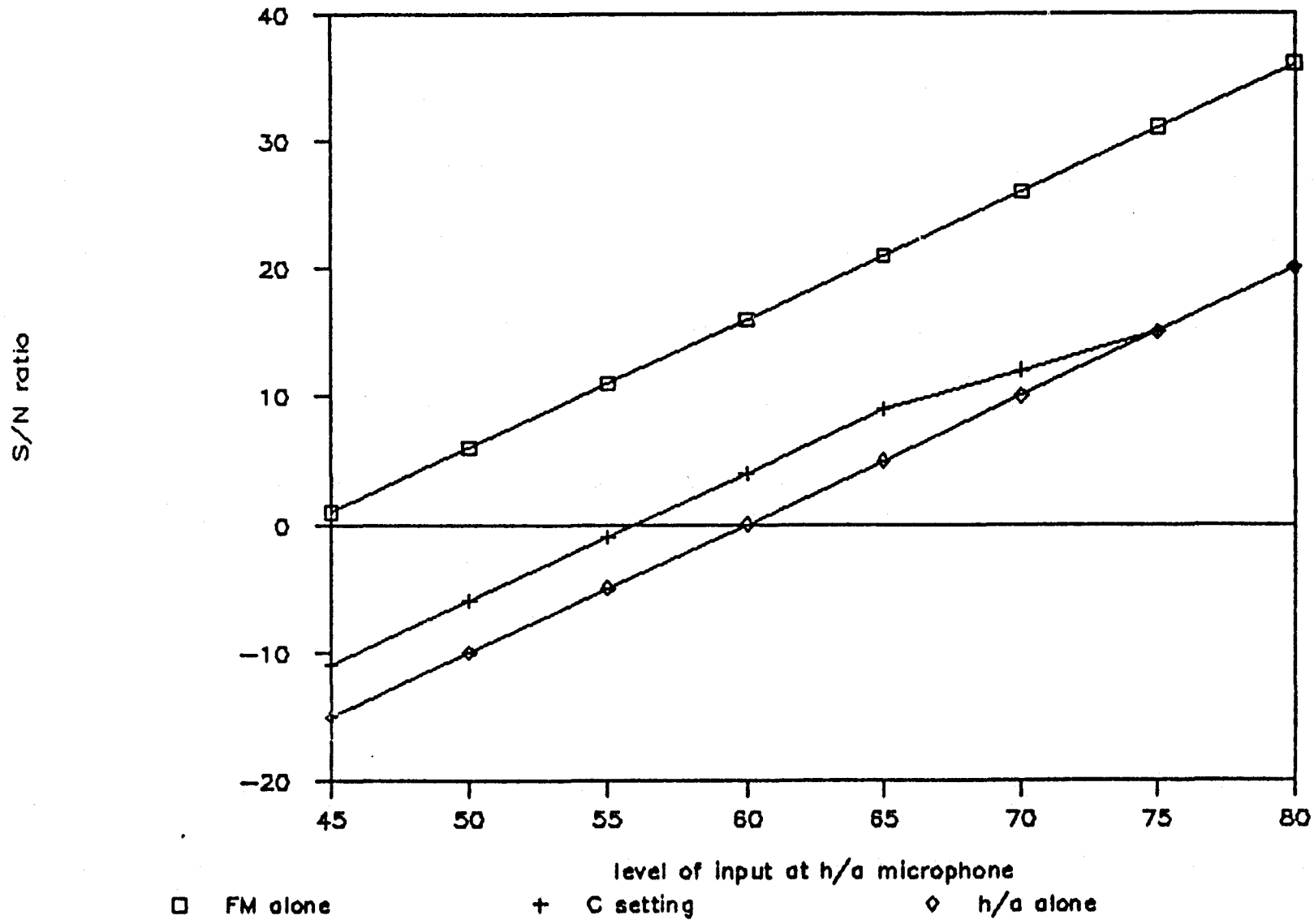
In contrast with Hawkins results, though, is the finding in the present study that on the combined setting, considerable advantage is also shown for both of the FM systems measured (9.86 dB and 9.21 dB). Hawkins found only a 2.1 dB advantage with an equivalent hearing aid/FM arrangement, and this was not statistically significant.

In attempt to explain this discrepancy as well as to examine how accurately the adaptive procedure predicts expected S/N ratio for different listening conditions, effects on the signal and noise levels via each of the amplification pathways used in the experiment were calculated for a number of different signal levels. Due to certain features and properties of the 2 different FM systems used, each must be considered separately.

The factors which influence the S/N ratio in the Calaid listening conditions, apart from the actual signal and noise levels themselves include the effect of the AGC circuit (measured to have a threshold for speech of 79 dB SPL (average peak VU deflection level) at the transmitter microphone, equivalent to 65 dB SPL at the hearing aid microphone), the drop in signal level of 7 dB when the C setting is selected compared to the FM only setting, and the drop in hearing aid microphone sensitivity of 4 dB when the receiver is connected to the hearing aid. Figure 4.5 shows how the S/N ratio through the FM, set on C, is affected differently depending on whether the input speech signal is above or below the AGC threshold. These calculations assume that the

volume control of the receiver is set such that 85 dB SPL at the tramsmitter provides the same level of output from the hearing aid as would a 70 dB SPL speech signal at the hearing aid microphone. Also, the output signal from the aid is a combination of noise and signal, each arriving by the two different pathways (from the FM microphone or via the hearing aid microphone), and added together on a power basis.

Figure 4.5 : Calculated relationship between the level of the speech signal at the hearing aid microphone and the S/N ratio at the hearing aid output (with the noise levels used) that is received for the Calaid FM



At high input levels the signal received from the hearing aid microphone dominates as the gain of the FM is lessened due to the action of its AGC system. At lower levels (but still above AGC threshold), the converse is true - the FM system dominates since the gain of the hearing aid is low relative to that of the FM system the AGC system. Below AGC threshold, however, there is a linear relationship between input level and S/N ratio on the C setting. Therefore, whilst there is a constant 16 dB difference expected between the S/N ratio recieved through the hearing microphone and that offered by the FM system as the input level is varied, the advantage of listening through the FM on the C setting should vary from 0 dB for inputs at the hearing aid microphone of above 75 dB SPL, up to 4 dB for inputs below the equivalent AGC threshold at the hearing aid microphone, that is 65 dB SPL.

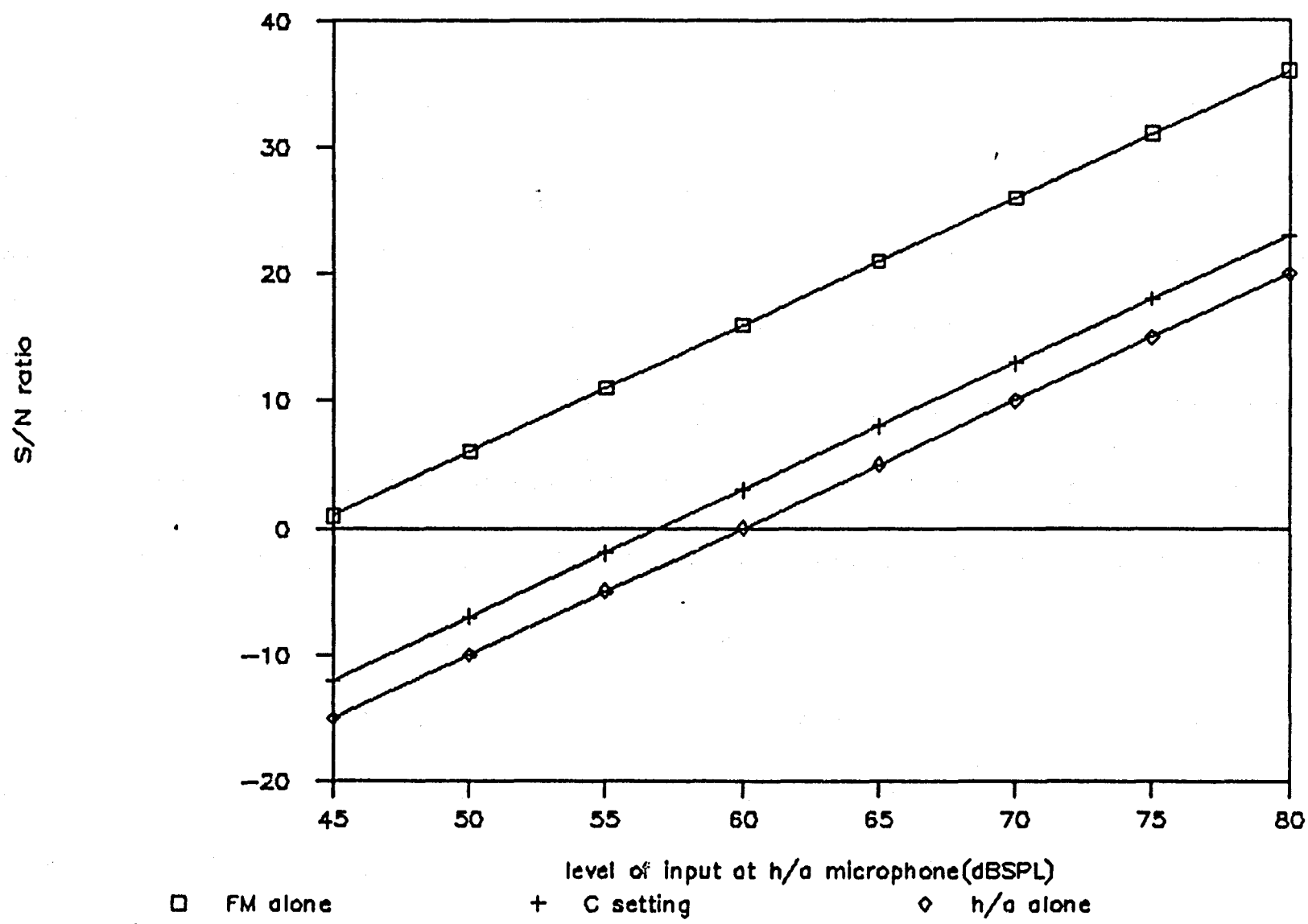
However, these figures only partially correspond with the actual average S/N ratio differences found between the various listening conditions on the Calaid FM. The 16 dB that would be expected from this analysis of the signal and noise pathways is within the 99% confidence interval for the observed mean of 19 dB. Therefore similar advantage is being measured using this procedure and that which would be expected when using the FM only setting.

On the other hand, for the C setting, more advantage is being shown on the adpative speech test results than the expected range of 0-4 dB. The fact that most of the subjects were listening at levels below AGC threshold would lead us to expect a 4 dB advantage but the 99% confidence interval for the observed mean is 6.88 to 12.84 dB,

significantly above this level.

With the Sennheiser, Figure 4.6 shows that there is a constant FM advantage on the FM setting of 16 dB and on the C setting of 3 dB. There is a linear relationship between input levels and the corresponding S/N ratio as the AGC is not operating on these units.

Figure 4.6 : Relationship between the level of the signal at the hearing aid microphone and the S/N ratio that is recieved for the Sennheiser 1013



However, the average observed advantages for the 5 listeners assessed using the Sennheiser are 9.36 dB on SOX and 9.21 dB on the C setting. Examination of the 99% confidence intervals shown in Table 4.1 reveals that for this small group, the expected values are not significantly different from those observed. However, similarly to the Calaid results, the C setting shows significant advantage over the hearing aid alone result, and actually no significant difference from the amount of advantage offered by the SOX setting although we would expect a significant difference according to Figure 4.6. In any case, there are really too few Sennheiser listeners to draw any definite conclusions about the group data.

There is no obvious explanation for this larger than expected advantage found on the C setting. Two alternative possibilities are either that there is some additional effect on the signal of the FM when it is on the C setting which has not been taken into account in this study, or that the adaptive procedure itself is not a sufficiently accurate measure of S/N ratio to account for the actual levels that exist. It is difficult to imagine how the latter could be the case due to the careful construction of the experimental conditions, the well accepted nature of the psycho-acoustic paradigm used and the reasonable sample size tested. Thus it is possible that children are actually gaining reasonable benefit from use of the C setting. This proposition is supported by the wide use of this setting described in Chapter 5, and the benefit demonstrated using the tracking procedure on this setting as was seen in Chapter 2. At any rate, there is a significantly greater advantage for the FM alone condition demonstrated than for the C setting (although not for the small group using the Sennheiser) and this is as

would be expected from Figure 4.5.

The extent to which these S/N advantages can be generalised to classroom conditions also needs to be considered. The relative S/N ratios obtained by the child through the different signal pathways described, depend upon the distance he is seated from the speaker. The further from the speaker, the greater the advantage of the FM system over the hearing aids alone. In this study one metre was chosen as an ideal seating arrangement but, particularly in integrated classes, this would be rarely achieved. Therefore the results obtained here present the minimum degree of advantage that would be available. In addition, in classrooms the background noise would not be expected to originate from a single source as it did in the present experiment, but would be fairly uniform throughout the room. Thus the noise level at the hearing aid microphone would, on average, be no different from that present at the FM microphone. Since in this experiment the noise signal had dropped by 2 dB by the time it had reached the FM microphone, compared to what it was at the hearing aid microphone, this meant that 2 dB extra signal advantage was attributed to the FM condition that would not normally be present. For these reasons it would be preferable to reconstruct the test set up so that 2 speakers positioned at 45 degree angles and equidistant from both the hearing aid and FM microphones were able to create the same noise level at both the pick-up points.

Moreover, the fact that the adaptive procedure presented signals around the listener's threshold meant that the majority of subjects were listening through the Calaid FM when not operating in AGC and, as shown in Figure 4.5, this would result in a greater advantage for the C

setting (by up to 4 dB depending on input speech level) than would be the case if the AGC system was active as it usually would be in common usage. Therefore the method of varying the signal rather than the noise level to obtain various S/N ratios makes the S/N ratio advantage for the C position greater than would be expected in practice. It is suggested that holding the signal level constant and varying the noise level would allow more realistic results to be obtained using the adaptive speech test procedure.

### 4.4.2 : Comparison of the performance of hearing impaired children wearing FM units with that of normal hearing subjects

A considerable number of hearing impaired children demonstrated 50% performance at S/N ratios poorer than those required by the normal hearing subjects (Figure 4.2). Some of these individuals even had hearing losses as poor as 90 dB HL. This means that the FM has more than compensated for the detrimental interaction of background noise level with sensori-neural hearing loss, for these particular hearing impaired children, at least in terms of the S/N ratio they can perform in. Thus even more support has been generated for the use and benefit of FM systems. However, this is not to say that the effects of the hearing loss may be completely counteracted by the FM for such cases. There would still exist the same auditory distortions and pre-existing language delay for these children. Nevertheless the existence of such results certainly confirms that the FM unit should significantly improve the child's chances of minimising the degree of handicap he experiences in the classroom.

### 4.4.3 : Comments about degree of hearing loss and amount of FM advantage

A significant correlation between 3 frequency average hearing loss in the better ear and the measure of FM advantage was not shown in these results (Figures 4.3 and 4.4). Therefore the deafer children on average would seem to be receiving the same degree of benefit, in terms of improved S/N ratio, as their better hearing counterparts, which would in fact be expected. The results of experiment 1 (Chapter 2) also suggested there was no significant correlation between degree of loss and tracking rates, which signifies that the benefits of this improved S/N ratio are actually realised in a speech intelligibility task even for the profoundly deaf. This is despite the fact that some teachers in the survey, described in Chapter 5, felt that no difference was noted in performance for profoundly deaf children when wearing their FM's compared to their hearing aids alone. This observation by teachers is probably due to the limited auditory and language abilities of some profoundly deaf children, who, although they may be receiving an improved signal through their FM's, lack the skills to be able to make use of or demonstrate these advantages in the short term. If anything then, these comments suggest that more effort should be made to provide profoundly deaf children with FM's especially from an early age, and underline the importance of auditory training programmes in order to optimise the effects of this improved signal on the child's reception of speech and consequently his learning potential.

### 4.4.4 : Recommendations for the use of an adaptive speech test to assess degree of FM advantage in the clinic

As stated previously, there are certain amendments that need to be made to the procedure used in order to improve its chances of accurately predicting FM advantage, including rearrangement of the test set up so that equivalent noise level is created at both the hearing aid and FM microphones. In addition, the speech level should be kept constant and the noise level be varied in order to accurately evaluate FM units which incorporate AGC circuitry.

Also the clinician should be aware that the absolute measure of advantage obtained is relevant only to one set of listening conditions and cannot be generalised to the whole range of listening conditions that will be encountered.

However, bearing these limitations in mind, the adaptive speech test procedure described is a reasonably quick way (about 15 to 20 minutes for 3 listening conditions) for clinicians to check that significant FM advantage is available to the listener. For instance, the individual results obtained in this study show that all but 1 of the children tested demonstrated significant improvement in the S/N ratio necessary to attain 50% performance when using the FM only setting and all but 3 showed significant improvement on the C setting. Given that there is some question about what is happening on the C setting in relation to this procedure it may be advisable to merely check the performance on the FM only or SOX setting to ensure the system is working as expected.

Such a test should not take the place of other procedures such as checking there is adequate transmission range and listening checks by the clinician to ensure against any interference or intermittency . Nevertheless, the value of such a procedure is that, at present, adequate electroacoustic evaluation methods for FM systems have not been developed or standardised, although previous research as well as the present study have shown that complete electroacoustic transparency to the signal is not acheived by FM systems (Hawkins & Van Tasell, 1982; Hawkins & Schum, 1985). For these reasons, some verification is needed to show that speech intelligibility is actually enhanced.

In addition, the use of aided threshold testing has been shown to be often misleading (Tomlin & Dillon, 1986) and the adaptive paradigm employed avoids the problems of traditional speech testing methods where adequate sensitivity and reliability is questionable (Chial & Hayes, 1974). Moreover, it is a simple procedure that can be used with even very young children provided the speech materials are carefully chosen, and it can quite easily be set up in the clinic.

The only possible drawback to using this procedure is that it does not demonstrate to the child himself that advantage is being offered by the FM even though it might be clear to the teacher or parent observing, as he is constantly listening at around speech discrimination threshold levels. Therefore some other speech testing must be added to fulfil this motivational purpose. A simple continuous discourse tracking session with and without the FM in +5 dB to +10 dB S/N ratio to simulate classroom conditions could be of benefit here.

In conclusion, this procedure, with the recommended modifications described here, has potential use for audiologists in the clinic. It could be carried out at FM fitting appointments to verify FM advantage and possibly also for cases where complaints about lack of benefit have been made at some later date. This should promote greater confidence in the benefits of the system both for the audiologists and, most importantly, for the parents and teachers to whom the results of any such test should be communicated.

# CHAPTER 5

# BENEFITS AND USE OF FM SYSTEMS : A SURVEY OF TEACHERS, CHILDREN AND PARENTS

## 5.1 : RATIONALE

Very little information has been collected as to how FM systems are regarded and used by children, parents and teachers. In order to examine the extent to which user, situational and equipment factors affect use and perceived benefit of FM systems, as well as to describe general usage patterns, a survey of each user group will be undertaken. It is anticipated that the results will suggest improvements in services that should allow the advantages of FM systems to be better realised.

## 5.2 : METHOD

### 5.2.1 : Background information

Due to the National Acoustic Laboratories' priority system for fitting FM units that exists in NSW, the majority of special units and schools for the hearing impaired at all levels have been provided with FM equipment, almost all being Calaid FM's. Also most integrated students in high school have been offered FM's, usually one of the commercially available systems. Other than these categories, there are some privately purchased systems being used in younger grades, and many

children in the Catholic education system have been provided with FM systems by NAL if nominated as suitable by their teacher of the deaf. Thus at the date this survey was begun, approximately 460 children in special units and about 20 integrated children had been fitted with Calaid FM's. Commercial systems had been fitted to about 160 children in integrated classes.

## The Teacher Questionnaire

### 5.2.2 : Sample population

Attempt was made to contact a range of teachers in N.S.W. who would have come into contact with FM systems over the previous school year. Questionnaires were posted out direct to 82 teachers in special schools and units for hearing impaired children. This covered the total population of teachers of the deaf in these situations who would have been using FM's (state and private). Due to the difficulties in contacting classroom teachers using FM's, however, a small sample was approached by posting 46 questionnaires to be distributed by itinerant teachers of the deaf who visited a representative group of these classes in various educational and geographical areas. It was originally intended that more questionnaires be distributed to normal classroom teachers at high school level, but due to unforeseen circumstances, most of these never reached their destination. Therefore the sample did not adequately represent this group.

### 5.2.3 : Questionnaire design and development

There were 5 general areas covered by the questionnaire with the aim of obtaining details about all aspects of FM use :

A : use and benefit

B : settings and facilities used

C : repairs and support

D : attitude towards use

E. differences attributeable to FM use

A draft questionnaire was initially devised and given to a group of 4 teachers of the deaf who had used the systems themselves and who regularly visited normal classroom teachers who were using FM equipment as well, to provide guidance and support. They judged some of the original questions to be too complicated or technical for classroom teachers to be able to adequately answer, so these were simplified in accordance with these comments. The final version of the questionnaire can be found in Appendix D. There were three question formats : multiple choice, checklists, and open-ended, depending on the type of information required.

### 5.2.4 : Procedure

A total of 128 questionnaires were posted out to teachers in November, a time when many would have been using FM's for most of the school year. All questionnaires included a covering letter to the teachers explaining the rationale and aims of the survey (see Appendix E). Since most

teachers of the deaf had more than one hearing impaired child in their class who was using an FM system, their responses to the questionnaire dealt with their perceptions of this group as a whole. On the other hand, responses from teachers in integrated situations usually only pertained to the one hearing impaired FM user. A stamped addressed envelope was included so that returning the questionnaire would be a simple task. Nearly all the questionnaires which were returned arrived back within 4 weeks.

## Child and Parent Questionnaires

### 5.2.5 : Sample population

Two other types of questionnaire were also administered, although in the form of interviews, one to 15 parents and the other to 52 children who had been issued with FM systems. A representative sample of users was obtained by asking audiologists to interview any cases previously issued with an FM who were seen at hearing centres over a 6 week period. This included any children who had been provided with an FM but were no longer using it. Since approximately 640 children have received units, the sample interviewed would have consisted of just over 10 % of the entire population fitted.

### 5.2.6 : Questionnaire design and development

Several versions of pilot questionnaires were administered to 5 children and 3 parents to assess appropriateness and clarity of items.

A number of questions were subsequently modified so that the format was easier to administer and understand. Copies of the resultant child and parent questionnaires can be found in Appendices F and G respectively. The purpose of the parent questionnaire was mainly to obtain information about children too young to administer the child questionnaire to. In order to allow comparison with the teacher questionnaires, similar areas were covered : FM use and benefits, settings and facilities used, repairs and service, attitude towards use, differences attributable to FM use and (optional) reasons for rejecting the system. However, of necessity, some of the parent questions differed from those on the child's questionnaire due to the different experiences of each group. For the child questionnaires, consideration also had to be given to an appropriate language level for administration to a wide range of hearing impaired children. Again there were 3 question formats : multiple choice, checklist and open-ended. With the multiple choice and checklist items, the interviewers were instructed either to read the alternatives aloud, or if this were too difficult for the child, they were shown the possible responses to read themselves.

### 5.2.7 : Procedure

The questionnaires, accompanied by instructions for administration were provided to 9 audiologists at hearing centres in a range of different locations. They were to interview and record responses from the child if they felt he could cope with the questions, otherwise they were to interview the parents. All children except one who were above infant's school level were able to be interviewed themselves, whilst with younger children, the parents were interviewed about the child's FM

use and observations of their behaviour.

### 5.2.8 : Equipment

The children had been fitted with a variety of FM systems. The majority of these were Calaid FM's as have been described previously in sections 3.2 and 4.2. Also a considerable number were wearing Sennheiser 1013 systems (see section 3.2). The other 2 types were the Sennheiser 1010 and the Phonic Ear 441T - 442R. All of these systems were connected to personal hearing aids (mostly Phonak PPC-2 and PPCL aids) using the direct input facility.

## 5.3 : RESULTS

### 5.3.1. : Response rate and characteristics of response sample :

The questionnaire response rate for the teacher group can be seen in Table 5.1.

Table 5.1 : Response rate for the teacher questionnaires.

| Teachers in special schools and units | teachers in integrated settings | total |
|---|---|---|
| 56/82 (68%) | 22/46 (48%) | 78/128 (61%) |

Description of the educational setting, level of schooling, communication mode, degree of hearing loss, type of FM system and length of experience using it can be found for all groups in Tables 5.2 to 5.5 and Figures 5.1 to 5.2.

Figure 5.1 : Percentages of teacher respondents in special education and mainstream settings according to age group taught.

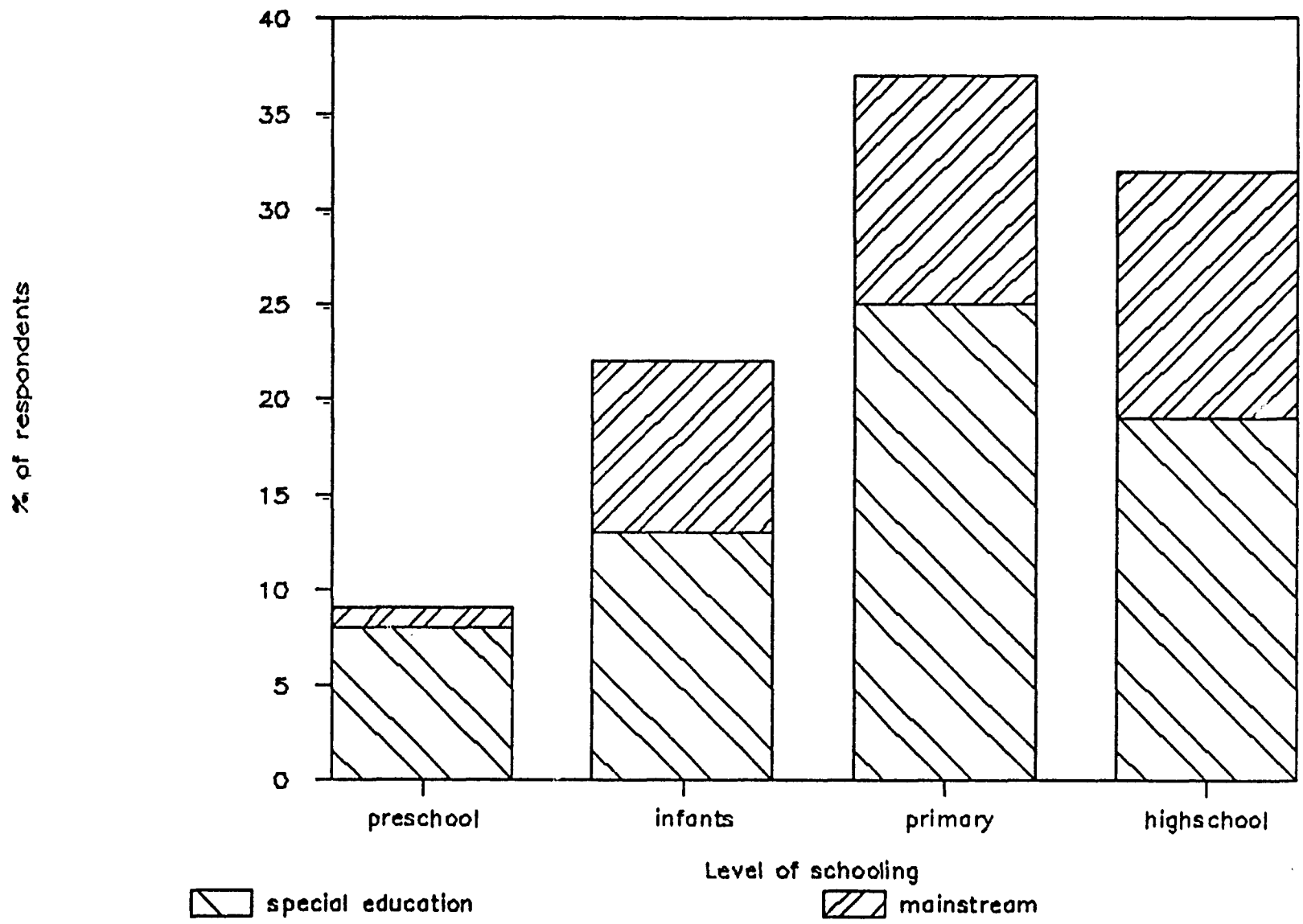


Figure 5.2 : Percentages of children (from child and parent questionnaires combined) in special education and mainstream settings according to age group.

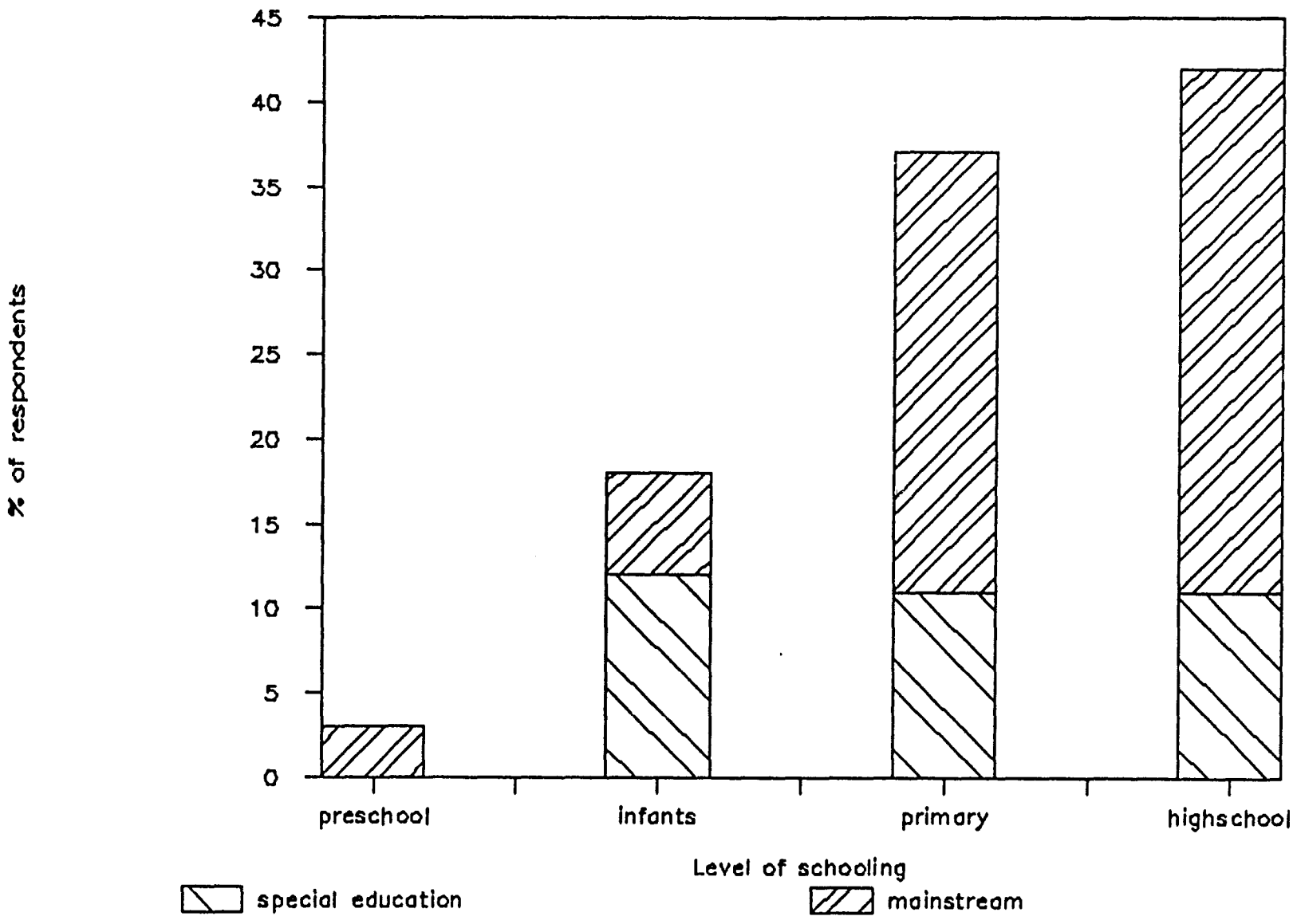



Table 5.2 : Percentages of respondents in special education settings using particular modes of communication

| response group | n | total communication | oral/auditory | cueing |
|---|---|---|---|---|
| teachers | 56 | 66% | 16% | 18% |
| children | 13 | 46% | 31% | 23% |
| parents | 9 | 45% | 22% | 33% |

Table 5.3 : Degree of hearing losses of children in the child and parent response groups.

| Response group | mild | moderate | severe | profound |
|---|---|---|---|---|
| children | 23% | 40% | 31% | 6% |
| parents | 7% | 7% | 29% | 57% |

Table 5.4 : Percentages of each type of FM being used by each response group

| Response Group | Calaid FM | Phonic Ear 441T & 442R | Sennheiser 1013 | Sennheiser 1010 | Telex | Don't know |
|---|---|---|---|---|---|---|
| teachers | 71% | 13% | 5% | 7% | | 4% |
| children | 38% | 17% | 21% | 19% | 4% | |
| parents | 50% | 29% | | | 21% | |

Table 5.5.: Median period of experience using an FM system

| | Median in months |
|---|---|
| teachers | 9 months |
| children | 7 months |
| parents | 9 months |

5.3.2 : Analysis of responses

This section presents a summary of questionnaire responses in the order and under the general headings as they occurred in each of the 3 questionnaires. Refer to the copy of the questionnaires found in Appendices D, F and G. Due to the large amount of data collected, some open-ended responses have not been coded or included. In addition, it was not possible to use any statistical tests for significance of response patterns and trends, since cell frequencies were usually too small to carry out Chi-square tests. The results of the survey for all three respondent groups will therefore be presented descriptively in each of the 5 main areas that the questionnaires addressed. To assist the reader to crossreference the individual questions in the Appendices with the results presented, for each result the particular section and question number has been included for each of the questionnaires. "T" refers to the teacher questionnaire, "CH" to the child questionnaire, and "P" to the parent questionnaire (for example, T-A.1 refers to

teacher questionnaire, section A, question 1).

5.3.2.1 : Aid use and benefit

Since all three questionnaires used slightly different response categories, the results of each of the respondent groups must be described separately. The proportions of responses to each question about use and benefit are shown below in Tables 5.6 to 5.14 and figures 5.3 to 5.7.

Hours of use :

Table 5.6 : Percentage of teachers reporting various FM usage times (T-A.1)

| always | sometimes | infrequently | hardly ever or never |
|---|---|---|---|
| 68% | 16% | 8% | 8% |

Figure 5.3 : Percentages of teachers at different levels of schooling reporting various FM usage times (T-A.1)

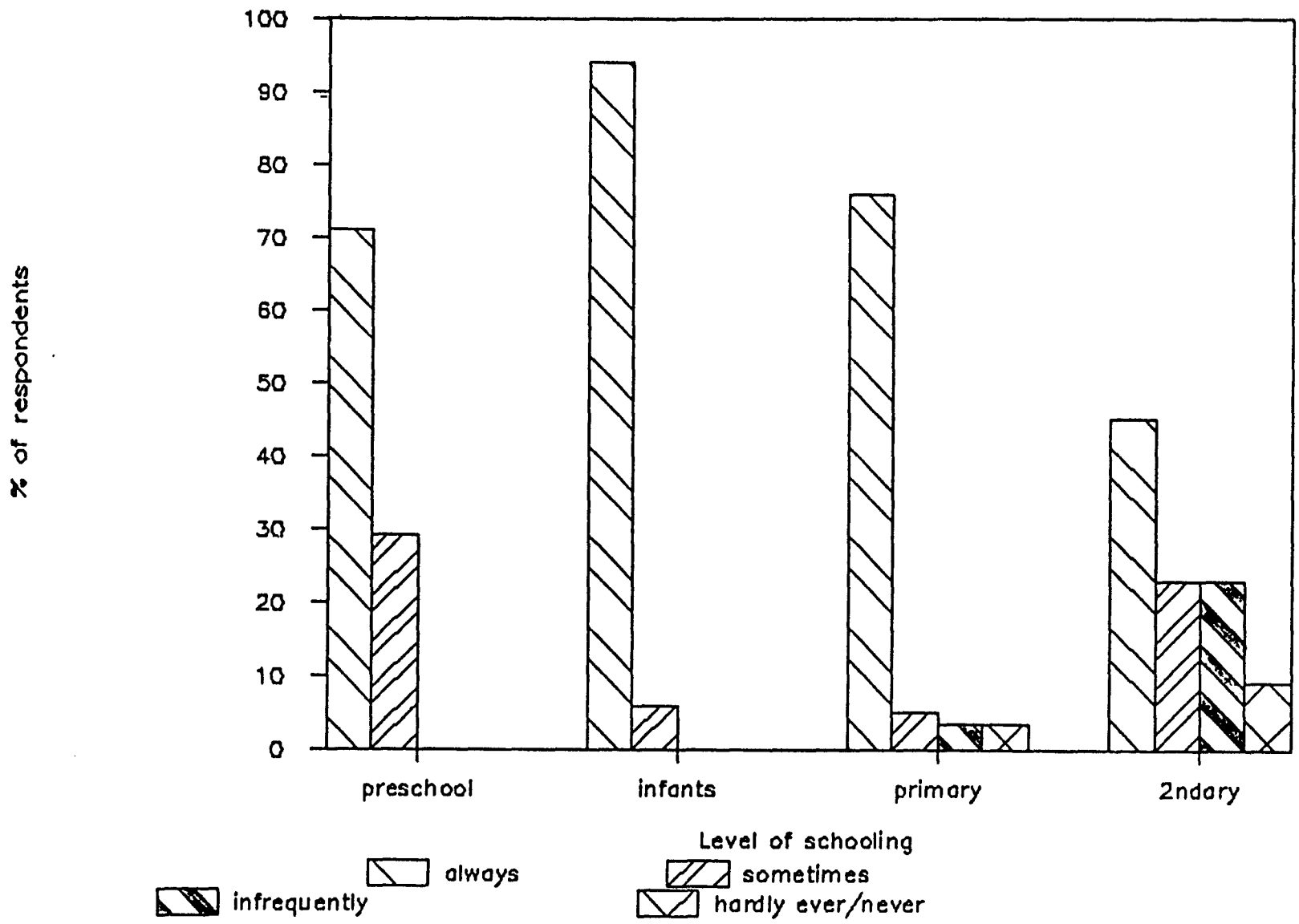


Figure 5.4 : Percentages of teachers in different educational situations reporting various usage times (T-A.1)

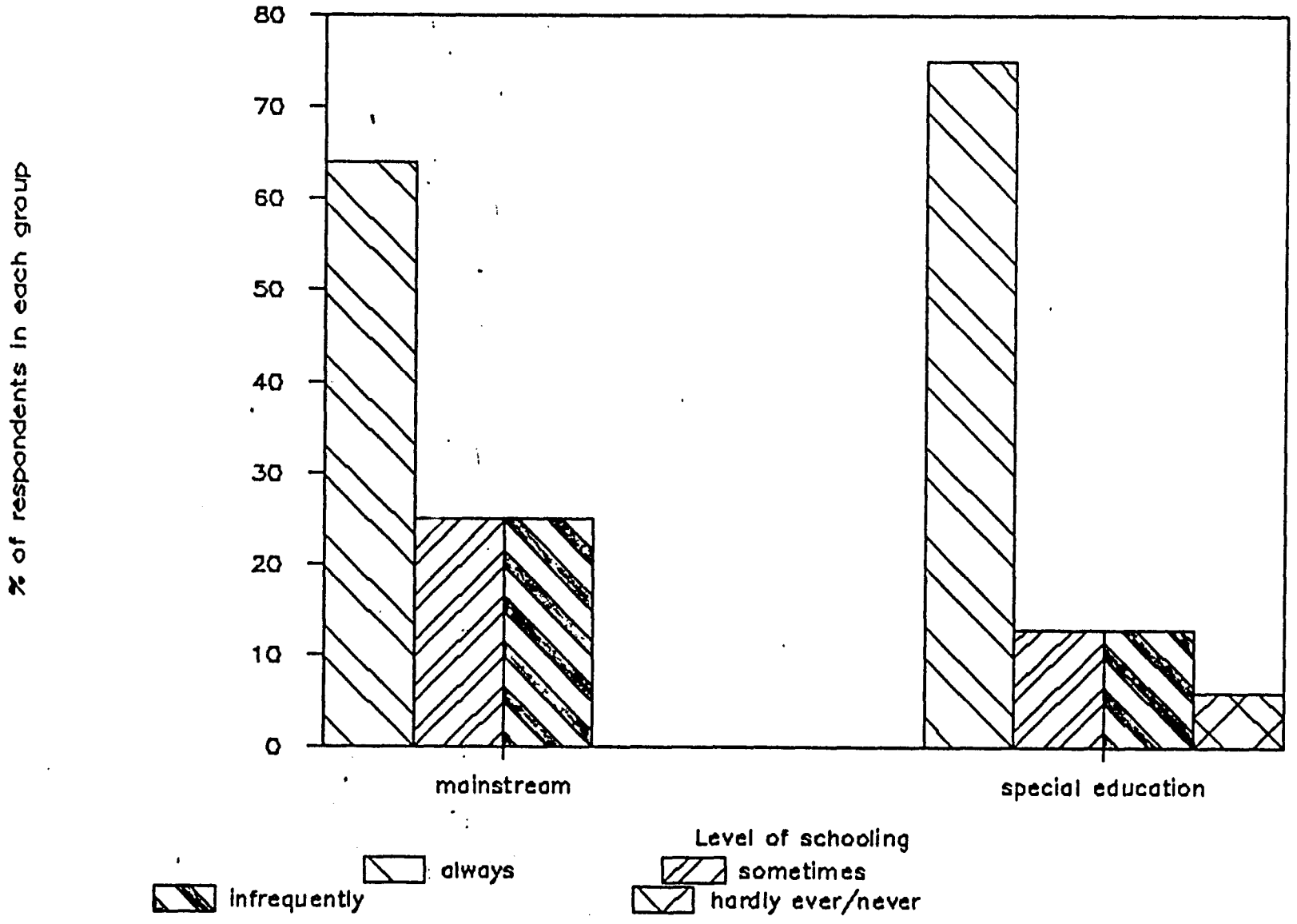



Table 5.7 : Percentages of parents and children reporting various usage times (CH-A.1, P-A.1)

| usual hours of use per day | | | | | mean hrs of use (excluding non-users) |
|---|---|---|---|---|---|
| 0 | 1-2 | 3-4 | 5-6 | 7-8 | |
| 14% | 13% | 21% | 36% | 16% | 4.7 |

Figure 5.5 : Percentages of children at different levels of schooling reporting various FM usage times (from child and parent questionnaires) (CH-A.1, P-A.1)

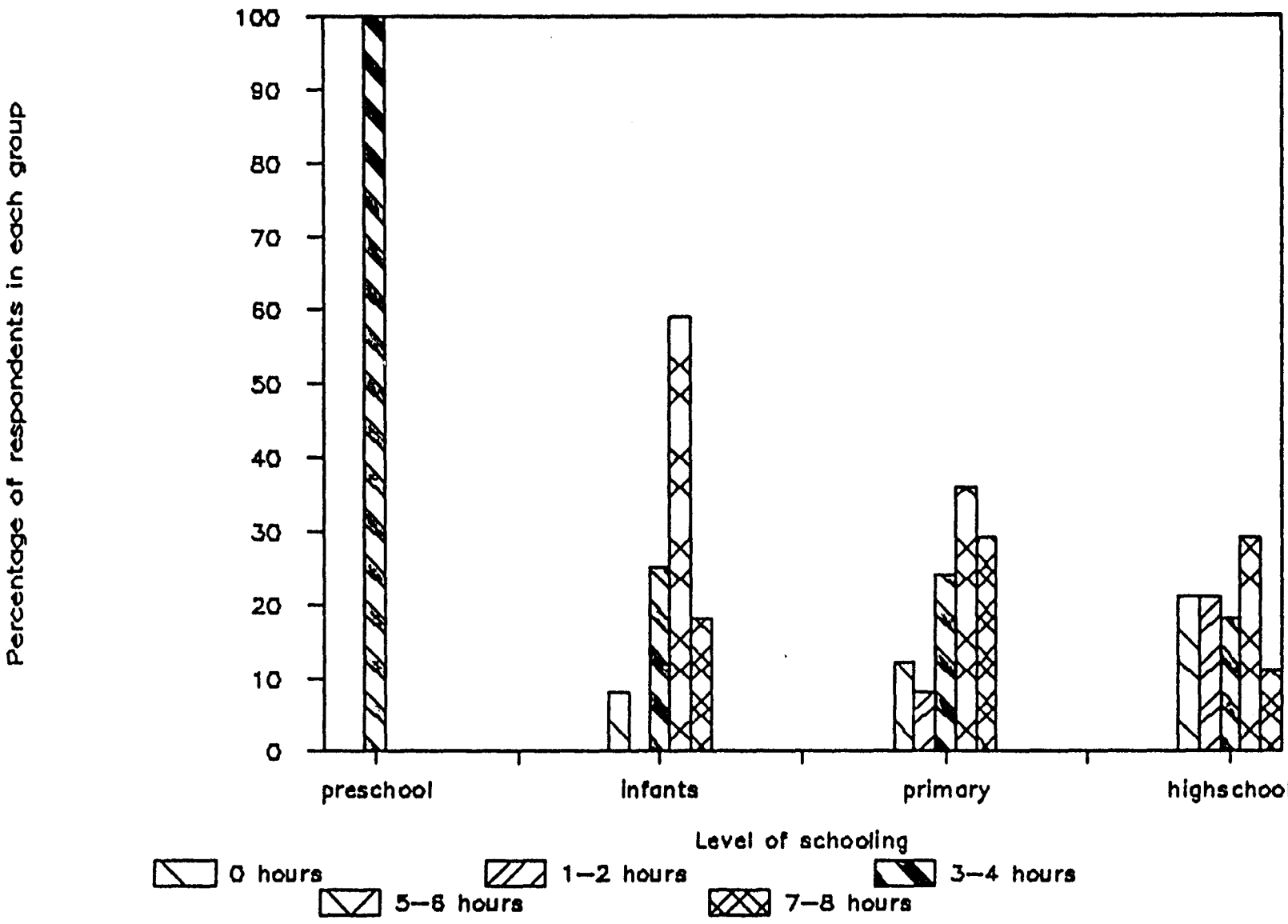



Figure 5.6 : Percentages of children in different educational situations reporting various usage times (from child and parent questionnaires) (CH-A.1, P-A.1)

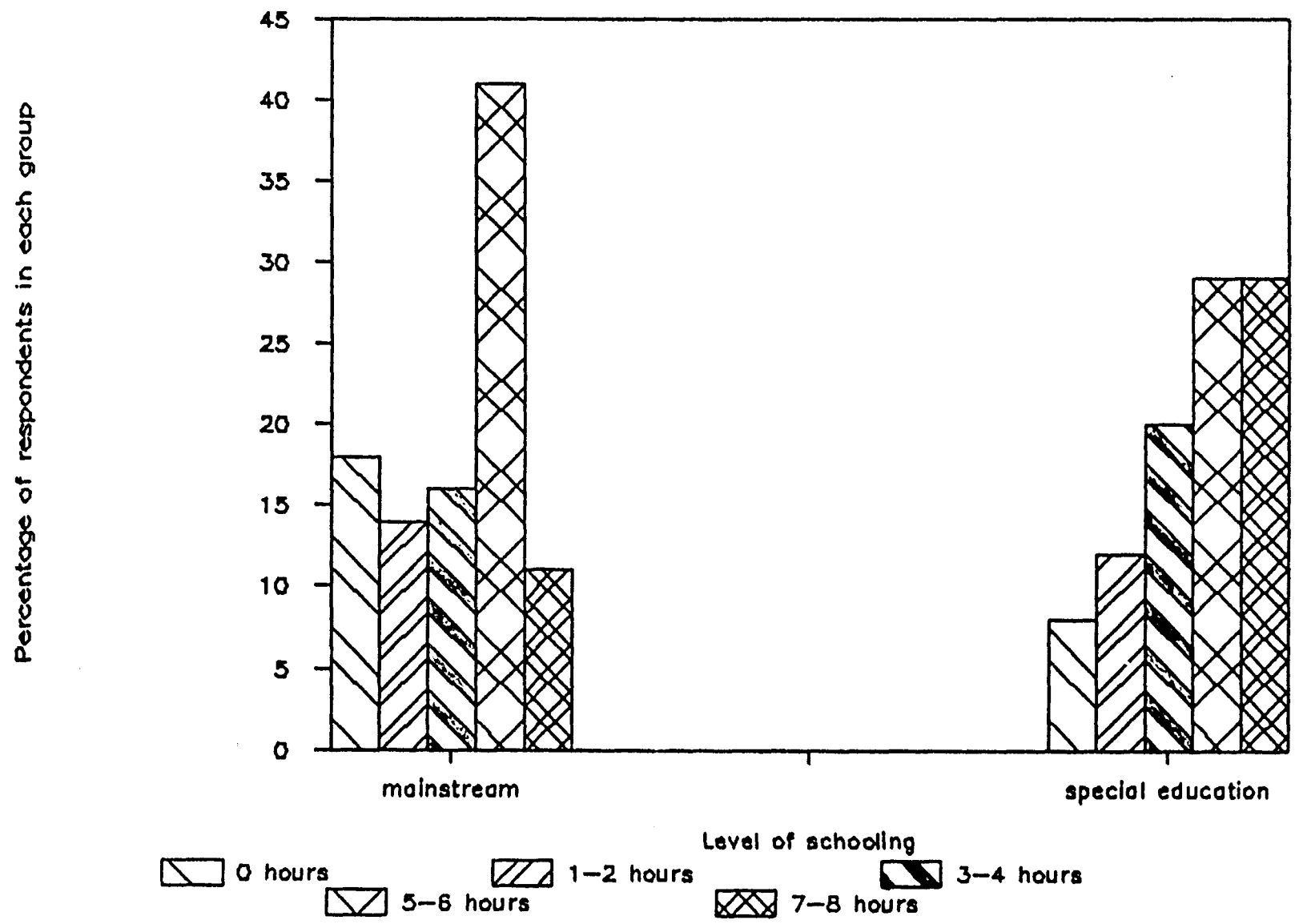
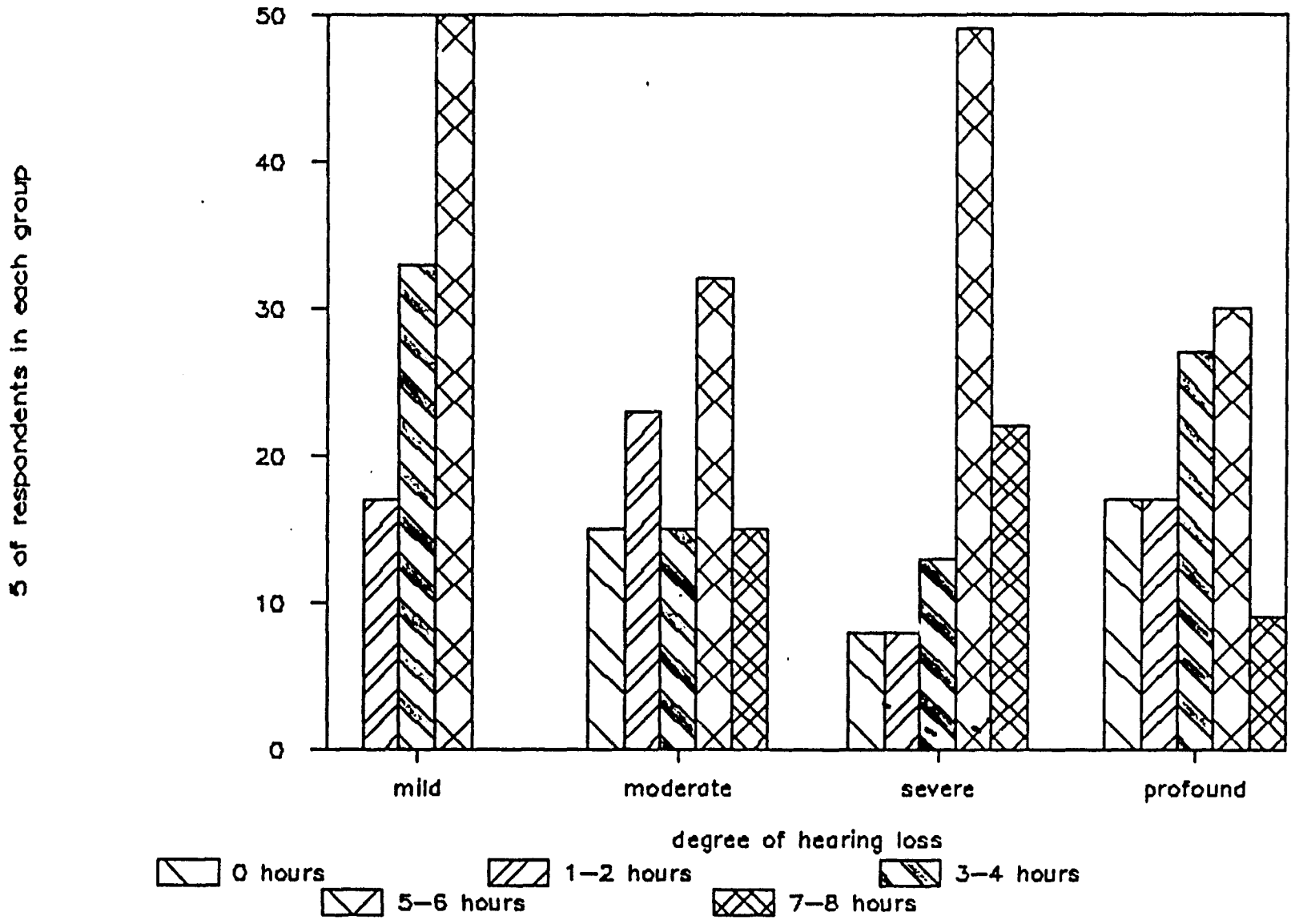


Figure 5.7 : Percentages of children in each hearing loss group reporting various usage hours (CH-A.1, P-A.1)




The non-users :

Thus for all respondent groups there were a small percentage of cases where the FM's were not used at all (11%). Three teachers in a hearing impaired unit in a high school using total communication returned their questionnaires blank as they were no longer using their Calaid FM's due to student non-cooperation, however they did not elaborate further on this. Amongst the child respondents, 12 (23%) said they were never using their FM systems at the time they were administered the questionnaire. Of these, 7 were in high school, 4 in primary school and 1 in infants. Thus 22% the of total number of high school respondents and 17% of the primary school sample had rejected their units. Eleven of these non-users were in integrated settings and the other one was

partially integrated. One had a mild loss, 5 were moderately hearing impaired, 3 had severe losses and 3 were profoundly deaf. The reasons given for rejection are shown in Table 5.8 below.

Table 5.8 : Reasons given for rejection of FM systems (CH-F.1, P-G.1)

| Reason | number of respondents |
|---|---|
| embarrassed, self-conscious | 10 |
| didn't help | 4 |
| hears ok anyway | 3 |
| teacher non-cooperation | 3 |
| too noisy | 2 |
| always broke down | 1 |

Frequency of use of FM's in various situations :

Table 5.9 : Teacher reports of frequency of use of FM's (%) in various school activities (T-A.2)

| amount of use | Activity (% of teacher responses) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | teaching entire class | small group work | indiv-idual academic work | indiv-idual speech/ auditory work | TV radio etc. | class discuss-ions | assem-bly | exc-ursion |
| haven't tried | 4% | 8% | 8% | 35% | 35% | 74% | 41% | 52% |
| most/all of time | 86% | 74% | 74% | 49% | 59% | 5% | 39% | 20% |
| sometimes | 9% | 17% | 13% | 12% | 16% | 12% | 9% | 15% |
| hardly ever or never | 1% | 1% | 5% | 4% | 8% | 9% | 11% | 13% |

Table 5.10 : Child reports of frequency of use of FM's (%) in various activities (CH-A.2)

| amount of use | activity (% of child responses) | | | | | | |
|---|---|---|---|---|---|---|---|
| | at school | on excurs-ions | for homework | with family at home | in car | watching TV | listening to radio/ tapes |
| haven't tried | 9% | 84% | 85% | 54% | 80% | 24% | 60% |
| most/all the time | 48% | 4% | 2% | 2% | 0 | 10% | 0 |
| some-times | 34% | 12% | 11% | 20% | 4% | 42% | 27% |
| hardly ever or never | 9% | 0 | 2% | 24% | 16% | 24% | 17% |

Table 5.11 : Parent reports of frequency of FM use (%) in various activities (P-A.2)

| | activity (% of parent responses) | | | | | |
|---|---|---|---|---|---|---|
| | at school/ preschool | individual speech & auditory training | with TV | in car | out shopping etc | around house/ with family |
| haven't tried | 0 | 21% | 36% | 50% | 57% | 57% |
| most/all the time | 93% | 50% | 7% | 7% | 7% | 14% |
| some-times | 7% | 21% | 14% | 21% | 21% | 7% |
| hardly ever or never | 0 | 7% | 43% | 21% | 14% | 21% |

Degree of benefit of FM's in various situations :

Table 5.12 : Teacher reports of degree of FM benefit in various school activities (T-A.3)

| amount of benefit | Activity (% of teacher responses) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | teaching entire class | small group work | indiv-idual academic work | indiv-idual speech/ auditory work | TV radio etc. | class discuss-ions | assem-bly | exc-ursion |
| great | 47% | 55% | 48% | 54% | 27% | 35% | 43% | 33% |
| moderate | 42% | 32% | 26% | 23% | 55% | 40% | 41% | 39% |
| none | 7% | 12% | 25% | 21% | 18% | 20% | 16% | 28% |
| detri-mental | 4% | 1% | 1% | 2% | 0 | 5% | 0 | 0 |

Table 5.13 : Child reports of degree of FM benefit in various activities (CH-A.3)

| amount of benefit | Activity (% of child responses) | | | | | | |
|---|---|---|---|---|---|---|---|
| | at school | on excurs-ions | for homework | with family at home | in car | watching TV | listening to radio/ tapes |
| great | 40% | 56% | 29% | 26% | 20% | 26% | 34% |
| moderate | 40% | 33% | 57% | 30% | 40% | 50% | 38% |
| no difference | 17% | 11% | 14% | 44% | 40% | 16% | 23% |
| hears worse | 4% | 0 | 0 | 0 | 0 | 8% | 5% |

Table 5.14 : Parent reports of degree of FM benefit in various situations (P-A.3)

| amount of benefit | Activity (number of respondents) | | | | | |
|---|---|---|---|---|---|---|
| | at school/ preschool | individual speech & auditory training | with TV | in car | out shopping etc | around house/ with family |
| great benefit | 86% | 64% | 33% | 43% | 50% | 50% |
| moderate benefit | 7% | 27% | 0 | 29% | 50% | 17% |
| no difference | 7% | 14% | 67% | 14% | 0 | 33% |
| hears worse | 0 | 14% | 0 | 14% | 0 | 0 |

Problems with use :

Sixty-one percent of teachers, 50% of children and 46% of parents reported problems using the FM in at least one of these situations (T-A.4, CH-A.4, P-A.4). For example, a common complaint was that children sometimes heard speech that was irrelevant to them as the teacher often forgot to switch the transmitter off when talking to other children (10 teachers). There were also frequent problems reported with transmission range in assembly with the Calaid FM, and with general reliability of the systems.

Situations of greatest benefit :

The situations where the FM was considered to be of most benefit were categorised and the frequencies of these can be found in Appendix H. Giving instructions to/teaching the whole class was the situation category where teachers most often noticed greatest benefit (32% of

respondents) (T-A.5). For children and parents (CH-A.5, P-A.5), it was "at school" that most benefit was reported from the FM (77% and 86% respectively).

5.3.2.2 : Settings/facilities used

Microphone mode and volume settings :

Table 5.15 : Percentages of teachers not knowing what FM system settings are used (T-B.1)

| "on/off" switches | volume setting | group on which % is based |
|---|---|---|
| 44% | 47% | entire sample |
| 83% | 48% | mainstream teachers |
| 26% | 45% | special unit teachers |
| 14% | 0 | pre-school teachers |
| 35% | 35% | infants teachers |
| 39% | 50% | primary teachers |
| 64% | 68% | high school teachers |

Only the Calaid FM and the Sennheiser 1013 systems have a choice of more than one "on" setting. The number of teachers and children using these settings can be found in Table 5.16.

Table 5.16 : Settings used on the Calaid FM and the Sennheiser 1013 (T-B.1, CH-B.4, P-B.4)

| | number of respondents | | | |
|---|---|---|---|---|
| | combined | FM alone | VOX/SOX | don't know |
| Teachers : | | | | |
| Calaid FM | 22 | 7 | 1 | 22 |
| Sennheiser 1013 | 2 | N/A | 0 | 2 |
| Children : | | | | |
| Calaid FM | 11 | 8 | 0 | 0 |
| Sennheiser 1013 | 4 | N/A | 6 | 0 |
| total % on each setting : | | | | |
| Calaid FM | 68% | 30% | 2% | |
| Sennheiser | 50% | N/A | 50% | |

Sixty-six percent of children and parents who used Calaids or Sennheiser 1013's said they sometimes used other mode settings with varying degrees of success (CH-B.4, P-B.4). Fourteen percent of teachers using Calaid FM's or Sennheiser 1013's were aware of other settings being tried (T-B.3).

Of those respondents who did know the volume setting used on the FM, 77% reported the volume to be set the same as would be recommended by the audiologist, 1% set it below this level, and 21% set the volume higher than what is usually advised by the audiologist (see section 2.2.2). Forty-six percent of children and 0% of parents reported other volume settings to be used from time to time, usually when the teacher's voice was too loud (CH-B.3, P-B.3).

Eight percent of teacher respondents reported they had some problems with either the mode or volume settings settings used. For example, one teacher mentioned complaints from a child about hearing too much noise from other children, and another 2 teachers reported problems with inadequate or too much volume at various times.

Types of microphone options :

Table 5.17 : Types of microphones used by the teacher sample (T-B.4&5)

| Percentage of teachers in each FM group (percentage reporting problems with this type of microphone shown in brackets) | | | |
|---|---|---|---|
| FM type | on-unit | lapel | headworn |
| Calaid | 34%(38%) | 46%(19%) | 20%(78%) |
| Phonic ear | 36%(25%) | 64%(57%) | N/A |
| Sennheiser 1013 | 100%(25%) | N/A | N/A |
| Sennheiser 1010 | 80%(25%) | 20%(0) | N/A |

With the child and parent questionnaires, 38% used on-unit

microphones, 60% used lapel microphones, and only 2% reported using headworn sets. Of these respondents, 25% said they experienced some problem with the microphone they were using (CH-B.6&8, P-B.6&8).

Wearing the units :

Table 5.18 : Most common ways the FM's are worn by teachers (T-B.6)

| FM type | Percentage of teachers in each FM group | | | | | |
|---|---|---|---|---|---|---|
| | Neck | waist | waistband | belt-pouch | pocket | more than one way |
| Calaid | 40% | 37% | 2% | 2% | 2% | 17% |
| Phonic ear | 64% | 27% | 0 | 0 | 0 | 9% |
| Sennheiser 1013 | 0 | 0 | 100% | 0 | 0 | 0 |
| Sennheiser 1010 | 80% | 20% | 0 | 0 | 0 | 0 |

Similarly, with the parent and child respondents, the transmitter was most frequently worn around the neck (79% and 51% respectively) (CH-C.1, P-C.1).

Results of the child and parent questionnaires showed that the receiver was worn as detailed in Table 5.19 (CH-C.1, P-C.1).

Table 5.19 : Frequency of each method of wearing the receiver

| Type of system | % of children in each FM group | | | | | |
|---|---|---|---|---|---|---|
| | neck | waist | waistband | belt-pouch | pocket | other |
| Calaid FM | 12% | 38% | 19% | 0 | 19% | 12% |
| Phonic ear | 17% | 33% | 8% | 17% | 25% | 0 |
| Sennheiser 1013 | 10% | 20% | 0 | 10% | 30% | 30% |
| Sennheiser 1010 | 33% | 44% | 0 | 11% | 0 | 0 |

Thirty-two percent of all teachers reported the FM system they were using was not comfortable to wear (T-B.7). Seventy-two percent of children and 71% of parents said that they felt comfortable wearing their FM units (CH-C.2, P-C.2).

Forty-five percent of all teachers in the sample reported they experienced other problems when wearing the FM, mostly similar to those suggested by the questionniare (T-B.8). For example, 44% of complaints were about the unit bumping on the desk. Thirty-two percent of the combined child-parent sample also complained of problems wearing the systems (CH-C.3, P-C.3). The most frequently cited were cords or antenna getting in the way, and awkwardness and lack of security when the unit was attached to the body.

Table 5.20 shows how the sample rated the systems as to their ease of use.

Table 5.20 : Ease of use of the FM systems (T-B.9, P-C.4)

| | very simple | fair | quite complicated |
|---|---|---|---|
| % of teachers | 78% | 22% | 0 |
| % of parents | 93% | 7% | 0 |

5.3.2.3 : Repairs and support

Faults noticed in the systems :

Table 5.21 : Frequency of noticed faults in the FM units (T-C.1, CH-D.2, P-D.1)

| | often | infrequent | not aware of any problems |
|---|---|---|---|
| % of teachers | 36% | 55% | 9% |
| % of children | 22.5% | 55% | 22.5% |
| % of parents | 14% | 57% | 29% |

Table 5.22 : Specific faults noticed (T-C.2, CH-D.1, P-D.3)

| | funny noises | interference with other FM's | batteries going flat | intermittent FM sound | stopped working/ other |
|---|---|---|---|---|---|
| % of teachers | 55% | 32% | 23% | 36% | 27% |
| % of children | 75% | N/A | N/A | 55% | 32% |
| % of parents | 29% | N/A | N/A | 21% | N/A |

Forty-six percent of parents and children stated that parts of their FM units had broken (CH-D.2, P-D.2). Problems with the batteries or charger were reported by 30 % of the same sample (CH-D.4, P-D.4).

Table 5.23 : Percentages of teachers and parents making comments about the reliability/quality of the systems (T-C.3, P-D.5)

| | positive comments | negative comments | no comment |
|---|---|---|---|
| % of teachers | 12% | 44% | 44% |
| % of parents | 50% | 14% | 36% |

All except one of the parents were satisfied with the repair arrangements offered by NAL (P-D.6).

<u>How and when the FM units are checked</u> :

Twenty-six percent of all teachers said they did not check the FM system daily to ensure it was working - of these 74% were teachers in mainstream education (T-C.4). Of the parent group, only 29% said they checked the system at all (P-D.7). Table 5.24 shows the types of routines used to check the FM's and how common each is.

Table 5.24 : The methods used by teachers and parents to that check FM units are working

| | listening through h/aids | check batteries | check settings | ask kids | functional check i.e. ask questions or do speech test |
|---|---|---|---|---|---|
| % of teachers | 26% | 41% | 4% | 18% | 22% |
| % of parents | 43% | 43% | 0 | 0 | 14% |

Adequacy of advice and instruction provided :

Eighty percent of all teachers felt that they had received adequate instructions on how to use the systems. The remaining 20% who desired further help was comprised of 27% of all mainstream teachers and 17% of all special education teachers (T-C.5). Twenty-one percent of parents also requested further information about the FM (P-D.5). Of all of these requests, 55% asked for more explanation about the alternative settings which could be used and how to make better use of the device in a range of different situations, and 45% asked for intruction on what was the easiest and most reliable way of checking the system was working. All of the parents surveyed were satisfied with the written instructions they had received (P-D.9).

Table 5.25 : Who instructed the teachers in use of the FM system (T-C.6)

| | audiologist | teacher of the deaf | parent | child | written instruction | noone |
|---|---|---|---|---|---|---|
| % of teachers | 65% | 27% | 3% | 9% | 5% | 3% |

5.3.2.4 : Attitude towards using the system

Table 5.26 : Children's ratings of how they liked the sound of their FM (CH-E.1)

| | it's good | it's o.k. | don't like it |
|---|---|---|---|
| % of children | 39% | 49% | 12% |

Table 5.27 : Ratings of child's attitude to wearing the FM by teachers, parents and children according to age group( T-D. 2, CH-E. 2, P-E. 1)

| group<br><br>% of respondents | positive | passive acceptance | negative |
|---|---|---|---|
| total | 49% | 26% | 25% |
| in preschool | 100% | 0 | 0 |
| in infants | 57% | 39% | 4% |
| in primary | 61% | 23% | 16% |
| in high school | 23% | 25% | 52% |

Table 5.28 : Ratings of teacher's attitudes to using FM's by teachers, children and parents ( T-D. 1, CH-E. 3, P-E. 2)

| group<br><br>% of respondents | positive | passive acceptance | negative |
|---|---|---|---|
| total | 71% | 22% | 7% |
| in preschool | 100% | 0 | 0 |
| in infants | 72% | 28% | 0 |
| in primary | 75% | 20% | 5% |
| in high school | 61% | 23% | 16% |

Table 5.29 : Ratings of the attitudes of other normal hearing children to use of the FM by teachers, parents and children ( T-D. 4, CH-E. 4, P-E. 3)

| group<br><br>% of respondents | positive | passive acceptance | negative |
|---|---|---|---|
| total | 44% | 47% | 9% |
| in preschool | 33% | 67% | 0 |
| in infants | 60% | 33% | 7% |
| in primary | 38% | 59% | 3% |
| in high school | 40% | 44% | 16% |

The ratings responses in all these areas were also examined to determine if there appeared to be any differences between mainstream and special education settings. However there were no systematic effects observed for this variable ( see Appendix I)

Table 5.30 : Percentages of children forgetting to bring the units to school or recharge batteries (T-D.3)

| | often | occasionally | rarely or never | not applicable - units kept at school |
|---|---|---|---|---|
| % of children | 3% | 45% | 44% | 8% |

Table 5.31 : Reasons why the FM is not worn as much as it should or could be (T-D.5, P-E.4)

| % of parent & teachers | child self-conscious | nuisance to put on | nuisance to wear | doesn't work | being repaired | no reasons |
|---|---|---|---|---|---|---|
| preschool | 0 | 0 | 25% | 0 | 0 | 50% |
| infants | 28% | 17% | 41% | 10% | 10% | 31% |
| primary | 50% | 17% | 20% | 30% | 23% | 20% |
| high school | 95% | 36% | 32% | 31% | 18% | 5% |

5.3.2.5 : Differences attributable to FM use

Table 5.32 : Degree of assistance offered by the FM in terms of improved performance - teacher and parent responses(T-E.1, P-F.1)

| % of respondents | great improvement | moderate improvement | no improvement | seems detrimental |
|---|---|---|---|---|
| teachers | 31% | 45% | 21% | 3% |
| parents | 64% | 29% | 7% | 0 |

Table 5.33 : The 5 most frequently reported differences the FM makes for the child - teacher, child and parent responses (T-E.2, CH-E.5, P-F.2)

| Group | differences | % of respondents |
|---|---|---|
| teachers | improved speech discrimination abilities | 24% |
| | improved response to teacher's voice | 21% |
| | improved concentration/attention | 19% |
| | increased confidence | 15% |
| | improved school performance | 15% |
| parents | improved comprehension | 43% |
| | better response to speech/teacher's voice | 29% |
| | increased confidence | 21% |
| | improved concentration | 21% |
| | improved speech production | 14% |
| children | clearer signal | 33% |
| | louder signal | 25% |
| | doesn't help | 19% |
| | hears better at school | 12% |
| | better in noise | 8% |

Table 5.34 : The 5 most frequently reported suggestions for improvement of the FM system used - Teacher, parent and child responses (T-E.3, CH-E.6, P-F.3)

| Group | suggested improvements | % of respondents |
|---|---|---|
| teachers | improve reliability/durability | 20% |
| | create a better arrangement for wearing it | 17% |
| | make it smaller | 16% |
| | improve/eliminate the cords | 12% |
| | fit the system when the children are younger | 8% |
| parents | make it smaller | 21% |
| | improve the shoes/connection to the aids | 21% |
| | improve/eliminate cords | 21% |
| | create a better arrangement for wearing it | 14% |
| | have VOX in all systems | 14% |
| children | make it smaller/less obvious | 25% |
| | make cords invisible/get cords out of way | 10% |
| | none, its OK as it is | 10% |
| | improve sound quality | 8% |
| | create a better arrangement for wearing it | 6% |

## 5.4 : DISCUSSION

### 5.4.1 : Comments on the response samples

The degree to which these questionnaire responses can be generalised to the entire population of FM users at large depends upon how representative a sample was surveyed. Whilst all attempt was made to achieve representative sampling, it was acknowledged that at least mainstream teachers at high school level were inadequately surveyed as explained in section 5.1.2. Also the survey involved a large proportion of the specialist teachers of the deaf in the state whilst only a small number of mainstream teachers who would have been using FM units were contacted compared to the total number who would actually be using them. Therefore the relative proportions of mainstream to special education users in the sample did not reflect the true population distribution. For these reasons, responses from mainstream and special schooling have frequently been separated in the description of results as it would be expected that their experiences of FM usage would be different. Furthermore, the response rate from teachers of the deaf was better than for the mainstream teachers (Table 5.1) which may perhaps reflect greater concern and involvement of the former group with the FM units.

It was anticipated that the procedures used for obtaining a random sample of child users would have meant assembling a group that was representative of FM users as a whole. However, a greater proportion of children in mainstream education were surveyed than would be present in the total population of FM users, according to the figures of each group

that have been fitted which were mentioned in section 5.1.1. It could be speculated that this imbalance might be due to the participating audiologists being unable to administer the questionnaires to some children attending special units due to the poorer language skills this group would be expected to have.

Overall, considerably fewer infants and especially preschool children were surveyed in any of the groups, due to the smaller proportion of such children being fitted in accordance with the fitting policy that has been in operation. As can be seen from Table 5.3, a high percentage of these younger FM users (whose parents were interviewed) had profound hearing losses but this probably also reflects the actual fitting trends that exist. This was especially true in the mainstream setting where such children are often only fitted because parents feel the severity of their child's handicap warrants that they purchase an FM system for them.

Table 5.5 reveals that most of the FM users surveyed had been in possession of their FM systems for less than a year. It would be interesting to follow up the survey group in 3 or 4 year's time to ascertain how response to FM use may alter with experience.

Another consideration in interpreting the results is that, particularly with the small parent group interviewed, there were somtimes few respondents in each category of responses, making generalisations from such results difficult. Also the possible inclination of some respondents to report more favourable use of and attitude towards the FM than may actually be the case, is acknowledged.

Bearing such sample limitations in mind, the questionnaires nevertheless present a more comprehensive insight into FM use than has previously been available.

### 5.4.2 : Aid use and benefits

Overall, the amount of time that FM's are used is fairly encouraging, with 68% of teachers reporting they always use the FM system, and 52% of children and parents reporting 5 or more hours use per day (Tables 5.6 and 5.7). However this does seem to be affected by a number of factors. Similar to the findings of Christen (1983) the factor with the greatest influence on FM usage was age. In all cases high school students use their FM's less than do any other age group (Figures 5.3 and 5.5). Children at infants and primary level appear to make most frequent use of their FM's according to these results. There does not seem to be much difference in usage times comparing mainstream to special education settings, although Christen (1983) had reported a greater rejection rate of FM's in special classes and schools for the deaf than in integrated situations. On the basis of responses from children and parents, Figure 5.7 shows greatest use of FM's by those children with severe hearing loss (71% used their systems for more than 5 hours every day). Both moderate and severe groups showed a greater proportion using FM's less than 5 hours per day (53% and 61% respectively).

As for non-users, the overall rejection rate as measured by responses to the child and parent questionnaires (23%) is similar to that discovered by Christen (1983). In contrast, 96% of teachers reported

that the hearing impaired children were using their FM's at least for some part of the day. The remaining 4% were all attending one high school hearing impaired unit (3 classes) and all children had rejected using their systems en masse. However the rejection rate by integrated children may not have been accurately assessed by the teacher questionnaire as teachers may not have even seen the FM if the child had not ever brought it to school, or they may not have filled out the questionnaire thinking it not to be relevant if the child was no longer using it. Also the lack of an adequate sample of integrated high school children in the teacher questionnaire group may have meant those most likely to reject the system were not surveyed by the teacher questionnaire in this study. For the child and parent data, most of those rejecting were integrated, in high school and had moderate hearing losses which suggests this group should be considered at risk for discontinuing FM use. In contrast, Christen found profoundly deaf teenagers in special education to be the most likely to reject in his sample. This change in trends may be due to the present more widespread distribution of FM systems to special classes and schools where all children in the class are fitted and teachers of the deaf are more accustomed to the idea of the FM system as an integral part of deaf education. This would not have been so in the early days of FM fittings, when the systems were newer and less common.

In the present study there were also a considerable proportion of primary school children in integrated settings rejecting FM's (17% of all primary fittings). The trend for high school users to reject is more understandable as these students must approach each separate teacher they have during the day to put on the FM system and must

generally take responsibility for use of the system. In contrast, the primary school child has the assistance of his own full time teacher who has the opportunity to learn to operate and appreciate the benefits of the unit themselves and to support its use. Thus the reasonably high rejection rate of primary children is of some concern.

The most frequent reason given for rejection, however, was self-consciousness (83% - see Table 5.8). This pervasive attitude is thus largely responsible for the degree of rejection in integrated settings where the child with the hearing impairment is made more obviously different from all the other children when he is wearing the FM system. Obviously this is a sentiment not exclusive to high school students - some primary children feel this too. It is likely that a small percentage of children will reject FM use for this reason regardless of any support or intervention and the importance of this issue to the child should be acknowledged. Nevertheless, it is the responsibility of the audiologist to ensure the benefits of FM use are clearly demonstrated to him and for all professionals involved to make every effort to encourage continued FM use. Other reasons for non-use that were reported should all be able to be dealt with by audiologists and teachers of the deaf through use of programmes so the child can become accustomed to the sound of the FM and can appreciate its benefits. Also the development of more durable equipment, better servicing as well as greater support and education for mainstream teachers using the system is required. This should mean that for some children at least, the additive effects of embarrassment about wearing the FM and the amount of problems using it should be lessened.

Tables 5.9 to 5.14 show school to be the place where FM's are most frequently used and are found to provide the greatest benefit. Specifically, the teacher responses show teaching the entire class, small group work and individual academic work to be the school situations where most use is made of the FM systems and where most advantage is seen. Fewer teachers use the FM for individual speech and auditory work, but those that do say considerable benefit is observed in this situation. There are, however, some indications that the FM's may be under-utilised in some situations. For example, only 17% of teachers use the FM with any frequency in class discussions where the transmitter is passed around from child to child but 75% of those who do report moderate to great benefit in this situation. Whilst it is appreciated that this use may not always be practicable in some discussion groups, it should be pointed out to teachers that this may be a beneficial use of the equipment as 75% stated that they had not even tried the FM in this situation.

In addition, use of the FM on excursions, in the car, for homework, listening to radio and tapes and out shopping are all situations where FM use is uncommon yet many users report significant benefit in these settings. In summary, use of FM's at school inside the classroom for teacher oriented lessons is widespread, but use of the systems in a wider range of situations where benefit could be achieved is limited. Moreover, FM use was seldom reported in extra-curricular situations like sports coaching, music etc. Some of these limitations are explained by the 41-46% of respondents reporting problems with use in the specified situations with the occurrence of such comments as "reluctant to use in outdoor or some out of class situations for "fear of loss/ damage",

"cumbersome to wear in physically active lessons", "at little athletics the receiver flapped and slowed her down."

### 5.4.3 : Attitudes towards use

As expected, attitudes seemed to be influenced by factors similar to those affecting use. Ratings from children as to how they liked the sound quality of their FM aids showed that high school children, on average, were more non-committal and actually less negative about this aspect than were the primary school children (Table 5.26). In contrast, the students' attitudes towards wearing the FM's, teachers' attitude towards use and the attitudes of other normal hearing children towards the system were consistently more negative than for any other age group, although there was a gradual trend towards more negative attitudes with increasing age across all groups. Indeed, Table 5.31 indicates teachers and parents felt that almost all high school children restricted their use of FM's because they felt self-conscious about it. These children also felt them to be a greater nuisance to put on and wear than any other group. In all cases the students themselves were the most negative about the FM use, suggesting that the negative attitudes of some teachers and other normal hearing children may have been influenced by the child's own poor attitudes (Tables 5.27 to 5.29). Therefore, although the majority of high school children were making some use of their FM's, their attitudes towards the system were very poor due to their sensitivity to appearing different. A number of the teacher respondents commented that they felt high school level was too late to begin issuing FM aids to students. Apart from the fact that by this stage they were less likely to accept anything that singled them out as

handicapped, they would have also spent most of their education developing strategies to cope with their hearing impairment in the classroom and having reached some level of adjustment or complacency about their difficulties, may have seen no reason to upset this equilibrium. The extent to which this rejection and negative attitude towards FM's by high school students is a function of only having recieved FM's late in their school career, cannot be determined until the next generation of hearing impaired children, growing up regarding the FM as an integral part of their schooling, reach high school level. Previous research with acceptance of hearing aids has shown that similar difficulties with this age group have been experienced where conventional hearing aids are concerned (Lind, 1973, cited in Risberg, 1978; Karchmer, 1977, cited in Sinclair, 1982), and therefore suggests that encouraging use of any types of amplification devices by adolescents will always present some problems.

### 5.4.4 : Differences attributable to FM use

Most of the parents and teachers surveyed felt the child's performance had improved greatly or moderately with the FM aid compared to the hearing aids alone (93% and 76% respectively - Table 5.32). However, given the expectation that the FM will improve performance, and the presumably constant progress of the child in an educational setting anyway, it is difficult to know how much importance to attach to such generalised judgements.

For all groups, the most commonly observed difference that was attributable to FM use was associated with improved speech

intelligibility. Once again, the possible effects of expectations on observations must, however, be acknowledged as this would be anticipated to be the main advantage of FM use. Two other frequently mentioned differences, increased confidence and improved concentration, represent very desirable secondary gains that the FM's appear to be offering, and as such, should provide encouragement for audiological and educational authorities to support the use of FM systems in any way possible.

### 5.4.5 : Settings and facilities used

The majority of children fitted with the Calaid FM used the combined FM-environmental microphone mode (69% - Table 5.16). Only 31% used the FM only setting and 2% the VOX switch. For the Sennheiser, half the children used the combined setting and the other half used the SOX switch, despite the fact that audiologists would have suggested to the children at the fitting that the SOX mode may be better. These findings agree fairly well with the FM listening preferences shown in the paired comparison procedure described in Chapter 3, although the SOX mode on the Sennheiser was used more often by the children in the survey than would have been expected. Similarly to these experimentally determined preferences, the present study reveals that children are more inclined to chose to listen on the C setting than either SOX/VOX or FM alone settings, despite the fact that experiment 3 (Chapter 4) shows these latter arrangements to provide a more favourable S/N ratio and this should result in improved speech intelligibility. As discussed in section 3.4 there are obviously other factors which influence choice of FM mode, apart from the intelligibility of the speech signal. Among the 66% of children and parents and 14% of teachers who reported trying

different FM modes, comments against FM and VOX/SOX settings included "couldn't hear the other kids" (FM alone), "headworn microphone needed for using the VOX switch was too uncomfortable", "children didn't like the effect of their hearing aid microphones switching on and off" (VOX).

Whilst the first two of these problems reflect design faults in the systems or poor use of the available modes, the latter comment provides further support for the idea that children should receive some auditory training programme to allow them to make better use of, and to gain confidence in the FM signal and the different permutations it allows compared to the hearing aids alone. Also teachers and perhaps older children require training in how to use the different modes to best advantage. It may be speculated that the fact so few Calaid FM users selected the VOX option in comparison to Sennheiser users, whereas some children did use the FM alone setting, may be due to the Calaid VOX selector switch being positioned on the transmitter to which only the teacher has access during lessons. It is thus not possible for the child to experiment in order to get used to the sound and benefits of this setting. It is in the hands of the teacher to control when the VOX is used and as 3 teachers who had abandoned using the VOX commented, from their point of view, it is easier for them to remain on the one setting for simplicity of use. It seems reasonable to suggest that either the VOX switch should be under the control of the child, or teachers should be better educated about its benefits.

Another possible reason for the limited use of VOX and FM alone could be that use of the combined position is what audiologists are recommending. No data has been collected on this question but an

attempt was made to survey children who had been fitted by a wide range of audiologists in order to control for such individual variations in advice received. However, should all audiologists be giving the same advice against using FM and VOX/SOX settings, then what is used by teachers and children may reflect this, although the results of the paired comparison procedure (Chapter 3) suggest "C" may be the setting which children initially prefer anyway, regardless of advice. It is possible that audiologists may even have been influenced in their advice by observations of children's preferences. It is hoped that the findings of this project as a whole will provide a more valid basis for audiologists to recommend appropriate FM settings.

The majority of children (77%) were reported to be using the same volume setting as what would have been recommended. However, as 60% said they chose their volume according to what sounded best, presumably this meant that many had experimented with settings and found this to represent a comfortable listening level according to the mode setting they were using, rather than just positioning the volume control as they had been advised. Twenty-one percent were using a higher level than recommended and only one child set it softer which is in agreement with the findings in the paired comparison study (Chapter 3) where the Calaid was mostly preferred on the recommended level and the Sennheiser often higher than this. Thus the recommended volume setting procedure results in a listening level which, for most children, is satisfactory, and therefore presumably optimal for receiving through the aids.

The most frequently used microphone style, if available on the particular unit, was found to be the lapel microphone (46-64%) and,

overall, fewer problems were reported for this type than for on-unit and headworn styles (Table 5.17). The exception was the Phonic Ear lapel microphone where the majority of teacher users reported problems with its use, mostly involving it falling off and getting in the way. There were very few users of headworn microphones, and those who had tried this style had many complaints about its comfort, the ease of adjusting it to fit, and its intrusiveness (e.g. "gets knocked when cueing"). In this way, many of these preferences appear to be related to the particular design characteristics of the microphone involved. Paired comparisions of the microphone styles available on the Calaid (see Chapter 3) suggest that listeners actually showed a tendency to prefer the sound of the headworn microphone, although this was not statistically significant. Given that the headworn microphone creates a constant and ideal microphone-mouth distance and so is not susceptible to the poor positioning sometimes seen with on-unit and lapel microphones (Ross, 1977), it would be of benefit to improve headworn microphone design thereby reducing these problems of user comfort and acceptance if possible.

Transmitters are most frequently worn around the neck, and receivers on the waist as seen in Tables 5.18 and 5.19. Comfort was a problem reported by a minority of users( 32% of teachers, 28% of children, and 29% of parents). There were relatively more complaints about the awkwardness of the units than about the comfort, especially from teachers (45%). Many of these complaints specifically mentioned the transmitters and receivers bumping against furniture and people or falling off. It is possible that such problems could be alleviated by creating a more secure and unobtrusive way of wearing the units.

It is reassuring that most of the teachers and parents surveyed found the FM systems they were acquainted with simple to use (78-93% - Table 5.20) as this is an important pre-requisite to acceptance of any device. These responses also reflect favourably on the instruction they were given about its operation.

### 5.4.6 : Repairs and support

Table 5.21 shows 14-36% of users found their FM's to be faulty on a frequent basis. This is comparable with previous research which has questioned the reliability of FM devices (Hoversten, 1981; Bess, Sinclair and Riggs, 1981, cited in Bess & Logan, 1984). Indeed, teachers were quite critical about the reliability and quality of the systems surveyed, with 44% making negative comments about this aspect of FM use which is obviously a frustration to many. It is of concern to find that 75% of children reported hearing "funny noises" to occur whilst listening through their FM's, and 55% to experience intermittent FM sound. It is possible that many of these particular complaints were due to faults in the "shoes" which provide the direct input connection to the hearing aid and are found to be one of the most common repairs seen in the clinics. Given the large proportion of children reporting these particular faults, every effort should be made to identify and reduce the frequency of such problems due to the disruptions and lack of confidence in the systems such problems cause, as evidenced by teacher comments.

Despite the frequency of reported faults, a few teachers and many

parents were not accustomed to checking the FM on a regular basis. In particular, only a small proportion of teachers in mainstream settings checked the FM's in any way. Whilst it may not be necessary for high school students to have their systems checked as they should be capable of carrying this out themselves, it would seem appropriate that the units used by children at primary school level and below, and especially the profoundly deaf who may not report or detect faults as easily, receive daily checks to ensure that poor quality, intermittent or non-existent signals are avoided. At present the most common way that the FM is checked is to ensure the battteries are operating (Table 5.24). A number of parents and teachers also listen to the FM signal themselves which would be considered effective, but many also complained about the time this took especially in special classes where 6 or 8 units may need to be checked daily, suggesting that this is not always a practicable alternative. The fact that the second most common request from teachers for further instruction about the FM's was to be shown an easy and effective checking procedure indicated that some thought should be given to this, especially while FM equipment faults are so common. This would ideally be in the form of either an electronic device that could allow rapid checking of FM signals even by the children themselves if possible, or a functional procedure that could be used with all children to ensure they are receiving an adequate signal from the FM. The latter would be preferable since it would have the added advantage of educating children to be discerning about the signal they receive and to expect high fidelity and consistency in this.

However, the identification of faults in this way is without point unless effective and accessible repair services are available. There

were only a few complaints from teachers and parents about the existing repair arrangements.

The majority of teachers and parents felt the instructions they received about the FM's were adequate (80% and 79% respectively) and only a slightly greater proportion of teachers in mainstream settings felt their instruction was not adequate for their needs compared to integrated teachers. The most frequent area in which some teachers felt they required more instructions was advice about how to use the systems to best advantage in a range of different situations. Audiologists and itinerant support teachers of the hearing impaired should take note of this deficiency and attempt to provide more guidance in this area.

Finally, the improvements to FM's suggested by parents, teachers and children provide some additional and insightful clues to the problems encountered by and considered most important to users (Table 5.34). Predictably all groups, but particularly children were concerned about the size of the units (23%), although they did not specify whether this was for the receiver only or the transmitter as well. This is a desire that FM designers would hopefully be aiming to achieve anyway, but these responses reinforce the importance of this to users. Improved reliability and durability was a major concern of teachers who have understandably been frustrated by the frequent faults detected in the systems. Obviously the cords leading from the hearing aids to the FM receiver present a further problem for users, as this was also mentioned frequently. A more simply solved improvement that was often requested is to provide a better arrangement for wearing the system. Some of the more enterprising parents had created their own pouches which were

attached to a waistband/belt or worn under the clothing around the neck and these seemed to be better accepted than the other available options. It should not to be too difficult a task to design a more secure and comfortable attachment system which would create a more acceptable unit for the users.

Overall, the results of this survey demonstrate the importance of interactions between FM system, individual users, situations of use and professional support in determining the success of FM fitting. Whilst the improvement in speech intelligibility may be undeniable as shown by chapters 2 and 4 and as reinforced by the comments and responses of the users obtained here, this is moderated by the practical aspects of wearing and using the FM in day-to-day activities. It is the effect of these other factors that must now be addressed if we are to achieve greater success with FM fitting programmes.

# CHAPTER 6

## CONCLUSIONS AND RECOMMENDATIONS

The wide scope of this study has created a more comprehensive view of the factors affecting FM use and benefits than has hitherto been available. The influence of electroacoustic, behavioural and situational variables have all been described. Ultimately a fine balance of a wide variety of factors is necessary to ensure that the optimal benefits of FM systems are realised.

Specifically, the objective measures used in this project (described in Chapters 2 and 4) have demonstrated that significant advantage is offered by FM systems in terms of improved S/N ratios, and that as a result, the intelligibility of connected discourse in classroom situations is significantly improved by FM systems as they are now used. These findings are in accordance with previous research findings (Ross & Giolas, 1971; Bankoski & Ross, 1984; Hawkins, 1984). Such advantages over hearing aids alone were offered regardless of degree of hearing loss (although no very mild losses were evaluated) and were significant for almost every individual tested. This was also despite the fact that some electroacoustic changes were caused by connection of the FM to the hearing aid with the particular systems evaluated in the study. The degree of FM advantage was found to be greatest when the system was set in such a way that only the FM microphone was operating, but significant advantage over hearing aids alone also occurred when the hearing aid microphones were working concurrently as well. The existence of such benefits are particularly reassuring in view of the fact that they can

be demonstrated in conditions which closely simulate the listening conditions that hearing impaired children are faced with daily in the classroom and with the FM systems set as most children are presently wearing them. Also, the fact that some hearing impaired children were shown to achieve superior speech discrimination performance in noise compared to normal hearing children indicates great promise for the use of FM systems.

Due to the universal nature and degree of this benefit, it is therefore imperative that FM systems be offered to all hearing impaired children in such a way as to encourage maximum acceptance and use, if these children are to be provided with the opportunity to fulfil their learning potential.

However, the additional findings of this study (Chapters 3 and 5) have identified the presence of several factors which influence how FM systems are perceived and used by hearing impaired children and their educators, and because of this, in practice act to decrease the amount of possible benefit received. It is in this area that professionals need to address their efforts if greater success of FM fittings is to be achieved.

Firstly, use of the paired comparison procedure described in Chapter 3 offered a unique opportunity to gain insight into the subjective response of hearing impaired children to various aspects of FM processed signals. Indeed, the results showed an unexpected outcome - children do not always prefer to listen to the signal which offers the most intelligible speech. Overall they preferred to listen through the FM on

the combined setting to FM alone and, in fact, many children reported that they found listening through their hearing aids alone to provide a more intelligible signal than either of the FM altenatives. This was completely the opposite to the degree of FM advantage shown in terms of S/N ratio by some of the listeners through the same FM systems. The most plausible explanation for this, and one which was supported by the results, was that without regular exposure to FM processed signals, hearing impaired children are too unaccustomed to the various changes in their auditory environments that this invloves, to be able to initially perceive the benefits. For such children, therefore, the FM unit would not be expected to be considered acceptable on first impression in this regard, and there will consequently be a risk that total rejection of the unit may occur before there has been a chance for the advantages to be realised. This is especially likely to be the case with older aged children where feelings of self-consciousness about wearing the FM have been shown to significantly influence their attitude towards using it, possibly even before they have tried.

For these reasons it is highly recommended that audiologists demonstrate to all children at their fitting appointment that speech perception is enhanced with the FM connected to provide motivation for them to persevere with it. Furthermore, the results of the paired comparison experiment strongly suggest that it may only be through consistent daily use of the particular FM that the actual improvement in speech intelligibility is realised by the child. In order to facilitate this adjustment to FM processed signals it is thus suggested that some form of regular auditory training be instituted for a period of time immediately following fitting of FM units, so that the child is provided

with the opportunity to recognise the benefit in a controlled situation specifically designed for this purpose.

Since the auditory tracking procedure described in Chapter 2 sucessfully demonstrated FM advantage, is quick and simple to administer as well as being ideal for use in noisy classroom situations with a wide variety of age groups, and actually showed that significantly greater improvement in tracking rates was achieved over sessions when wearing the FM compared to the hearing aid alone condition, it is an obvious choice. It is also a procedure that audiologists may find beneficial to use for purposes of initial demonstration of advantage to children at fitting appointments, although some noise would need to be introduced to create a realistic listening situation. The results of such procedures would have the dual purposes of increasing the confidence of the child as well as of the audiologists, teachers and parents who are also involved in using and supporting this equipment. Nevertheless, it may not be as suitable a procedure for those profoundly deaf children who find such a task too difficult without visual cues. A simpler auditory task may need to be devised in these instances.

The additional use by audiologists of the modified adaptive speech test procedure described in Section 4.4 is also advocated at fitting appointments. At present such a technique provides the only functional way to check that the entire system is working as expected for each individual when it is connected to their hearing aids. The mean degree of advantage for particular FM aids and settings could be found by testing a group of representative children to use as a yardstick against which to judge the adequacy of advantage for individual cases. The

results presented in this study may be of use for this, but the degree of advantage expected is, of course, dependent on the listening conditions used. It is also important that the results of this test should be communicated to parents and teachers to further promote motivation and confidence in FM use.

Some of the practical issues involved in using various types of FM equipment have also been described (Chapter 5). The most important problems which were identified and which would appear to be responsible for some restrictions in the use and therefore the advantage of the systems include the unreliability of the equipment, with a high frequency of faults such as "funny noises" interrupting the use and detracting from the perceived benefit of the systems. For a number of teachers and students, such problems had led to a lack of confidence in the FM equipment altogether. Clearly some technical expertise needs to be applied here to identify fault areas and to work towards design of more durable and robust equipment. Also improvement in the way FM's can be attached to the body was called for in order that they be safely and conveniently utilised in a wider range of situations.

Another factor shown to affect attitudes and use was the degree of self-consciousness about the appearance of the FM systems, which was more prevalent with increasing age of the students. It is possible that such problems have been exacerbated by the fact that many of these children have only received their FM systems late in their schooling, when the prospect of suddenly being asked to look more obviously different from other children is a very sensitive issue.

The degree to which FM units are used to best advantage also depends on the users' abilities to apply the systems appropriately in the situations where they will be of greatest benefit and this, in turn, depends on the advice they have been given about settings and use. Evidence shows that the volume control setting which was recommended (based on the aim of amplifying the FM signal to the same level as would be received through the hearing aid in ideal listening conditions) was acceptable to the majority of users. However, the mode settings which were most commonly used did not correspond with that which would be expected to provide the greatest improvement in speech intelligibility - that is the FM alone and VOX/SOX settings. Whether this was due to lack of training using this setting, lack of opportunity to experiment with different settings, the advice given to the clients by audiologists, or a genuine preference against listening through the device in this way needs to be determined by future research, once children have been better trained to adjust to, accept and have confidence in FM processed signals.

Whilst the survey showed that the vast majority of teachers and parents were satisfied with the instructions they had received from other teachers or audiologists, there were several areas where some teachers required further guidance. Specifically there is a need for teachers and parents and probably also children to be provided with quick and efficient procedures to check FM's are working and for them to be advised how best to set and use the FM's in a variety of teaching situations. These are issues where audiologists may need to develop greater knowledge and strategies themselves. The information gained from the present survey could assist with this.

In these ways, the full extent of FM benefit is yet to be made available in practice for many users. It is clear that interactions between FM systems, individual users, situations of use and professional support are all important to determining that optimal advantage is obtained. The present study has elucidated some of these relationships for the first time and provided suggestions as to how the needs of hearing impaired children may be better met.

In summary, then, the results of this evaluation of FM systems provides strong justification for future development of FM equipment and fitting programmes. The professionals involved in using and supporting FM systems can be confident that their efforts will provide the hearing impaired children in their care with an improved signal and therefore a greater chance to learn.