Audiology Refreshers

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Edited by Ann Underwood

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Introduction

Teachers of the Deaf have many issues to deal with in their jobs. The mandatory qualification training for Teachers of the Deaf includes basic audiology. Detail may be forgotten when the knowledge has not been used for some time in daily practice.

This series of articles has been written to give Teachers of the Deaf, students and other professionals working with deaf children quick access to refresh their memory of basic audiological knowledge and practices. It is not intended that these refreshers replace basic training and further information may be gleaned from books on the specific audiological subject.

The Refreshers were originally published over several years in issues of the BATOD Magazine. In this copy some of the details have been updated but otherwise the sheets remain as they were originally although the layout may have changed.

Some relevant articles have appeared in the Magazines which extend and enhance the information in the Refresher series and they have also been included where relevant. It is our intention that updates and new 'Refreshers' will be added to this collection as appropriate.

The Audiology Refresher series was originally conceived by Margaret Glasgow who wrote many of the pages. In addition there have been many colleagues who have contributed pages and articles. I am grateful for their contributions and those who have assisted in the production of this publication especially Rosi Hearnshaw for her technical expertise in redrawing and reorganising the pages, Corinda Carnelley and Liz Beadle for proofing. Most importantly BATOD thanks Oticon for their sponsorship of the work which is made available freely on the BATOD website.

Ann Underwood, BATOD President 2008-2010

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Explanation of audiological terms and procedures

Margaret Glasgow, Educational Audiologist

TYPES OF HEARING LOSS

a) **Conductive hearing loss** occurs in either the outer or middle ear. It may be for example wax blocking the ear canal, glue ear, malformation of the middle ear bones, or a perforated ear drum. It is usually treatable by medication or surgery. Conductive loss may be mild, moderate and fluctuating or long term. Amplifying sounds and paying attention to appropriate position and seating in a classroom can overcome many potential difficulties that children with a conductive loss may experience.

b) **Sensori-neural hearing loss** occurs in and beyond the inner ear. This is permanent and not usually treatable. Many people with this hearing loss in both ears wear hearing aids. This type of hearing loss will affect their perception of some or all of the frequencies of speech. A sensori-neural hearing loss may be mild, moderate, severe or profound.

c) **Mixed hearing loss** is a sensori-neural hearing loss with an additional conductive overlay.

d) **Non-organic hearing loss** (or functional hearing loss) is taken to mean a hearing difficulty which cannot be accounted for by an organic cause.

e) **Auditory neuropathy** (and auditory dys-synchrony) is a hearing disorder where sound is transmitted normally through the middle and inner ear but the signal from the inner ear to the brain is impaired. The signal may be distorted or disorganised.

HEARING LOSS TERMS

Bilateral: both ears have a hearing loss.

Unilateral: one ear has a hearing loss, the other ear has hearing within normal limits.

Asymmetrical: both ears have a hearing loss but one ear has a loss that is significantly different from the other. (This difference must be specified.)

High frequency: the hearing loss at high frequency is significantly worse than that at low frequency.

Low frequency: the hearing loss at low frequency is significantly worse than that at high frequency.

Progressive: hearing loss becomes significantly and permanently greater over a period of time. Remember clinical variation can be up to 5dBHL for air conduction.

Fluctuating: the degree of hearing loss varies significantly over relatively short periods of time eg glue ear.

Sudden: hearing loss is of sudden onset eg meningitis.

Traumatic: hearing loss is due to a physical trauma eg head injury, barotrauma (diving, flying).

Audiometric descriptors for pure-tone audiograms

BATOD National Executive Council wishes to standardise definitions, descriptions and forms used for categorising audiometric descriptors using the following terms based primarily on current hearing threshold levels.

Audiometric descriptor dBHL

Mild hearing loss	21 – 40 dB	
Moderate hearing loss	41 – 70 dB	
Severe hearing loss	71 – 95 dB	
Profound hearing loss	in excess of 95dB	
Type of loss:	conductive sensori-neural mixed	*qualified by (as appropriate)* *bilateral, unilateral, symmetrical,* *high frequency, low frequency*
Age of onset:	congenital acquired – specify age	

Further comment if appropriate: eg progressive, fluctuating, sudden, traumatic

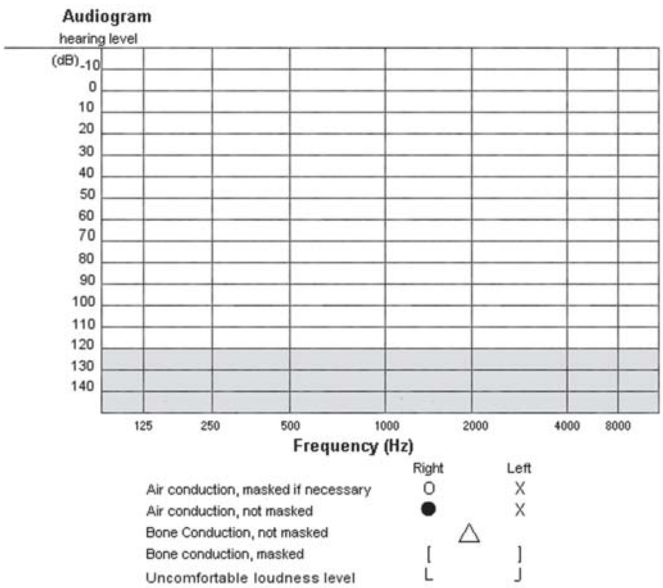
For the purpose of this document these descriptors are based on the average hearing threshold levels at 250, 500, 1000, 2000, 4000 Hz in the better ear. If no response is obtained at any frequency due to severity of impairment, the reading should be given a value of 130 dBHL assuming an audiometer maximum output of 120 dB. Similarly any hearing threshold level better than 0 dBHL shall be given the value of 0 dBHL. Averages do not imply any particular configuration and additional qualifications can be made.

These descriptors and calculations are as recommended by the British Society of Audiology (1988) and endorsed by the British Association of Teachers of the Deaf.

Audiogram format

it is recommended that the audiogram format approved by the British Society of Audiology (1989) is used and completed using the symbols shown.

NB There are no separate symbols for 'masked' and 'not masked' air conduction thresholds. When an air symbol is denoted on the 'final' audiogram it should indicate the true threshold, regardless of whether masking had to be applied or not.



Remarks

Audiometer calibration standards AC BC Tested by:

References

British Society of Audiology (1988) descriptors for pure tone audiograms.

British Journal of Audiology: *22, 123*
British Society of Audiology (1988) recommended format for audiogram forms.

British Journal of Audiology: *23, 265-266*
British Society of Audiology 'Recommended procedures' is available for a small cost from:
BSA Secretariat, 80 Brighton Road, Reading RG6 1PS

The British Society of Audiology (2004) recommended procedures for pure tone air and bone conduction threshold audiometry with and without masking and determination of uncomfortable loudness levels are available for download at http://www.thebsa.org.uk/docs/bsapta.doc

Decibel scales in audiology

Sue Westhorp

©BATOD Magazine November 00 page 11-12

There are a variety of decibel (dB) scales used in many applications of sound intensity measurement.

In audiology the three most commonly used scales are:

- **dBSPL** (dB Sound Pressure Level) for hearing aid performance
- **dBHL** (dB Hearing Level) for pure tone audiograms
- **dBA** for sound field assessments

It is important to have some understanding of these different scales, to recognise which has been used and be able to make a comparison between different assessments that use these different scales.

dBSPL (dB Sound Pressure Level)

dBSPL is the scale used for hearing aid performance. Hearing aid test boxes and manufacturers' specification sheets (hearing aid performance sheets) give measurements in dBSPL.

Sound pressure is measured in microPascals. The range of audible sound is from 20 – 200,000,000 microPascals. The dBSPL scale is a logarithmic scale representing these units in a manageable way. For each 20 decibel increase the sound pressure increases ten times. The recognised threshold of detectability at 1KHz is 20 microPascals and this is the reference 0 in dBSPL.

Figure 1

MicroPascals	dBSPL	Example
20	0	1 KHz just audible
200	20	Rustle of leaf
2,000	40	Quiet speech
20,000	60	Conversational speech
200,000	80	A shout
2,000,000	100	Pneumatic drill
20,000,000	120	Aircraft taking off
200,000,000 0	140	Rocket launching

Figure 2
The graph illustrates the sensitivity of the human ear across the range of frequencies used in audiology

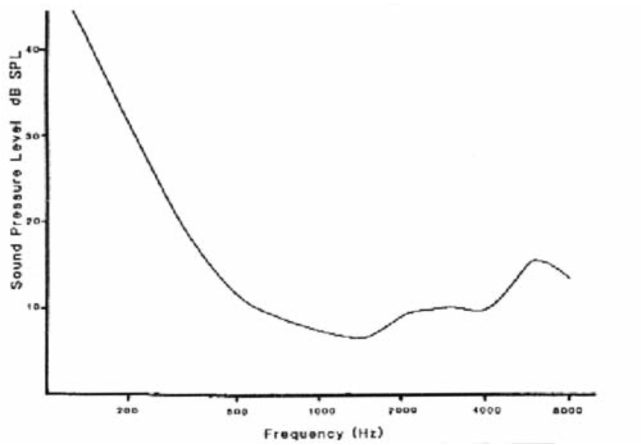
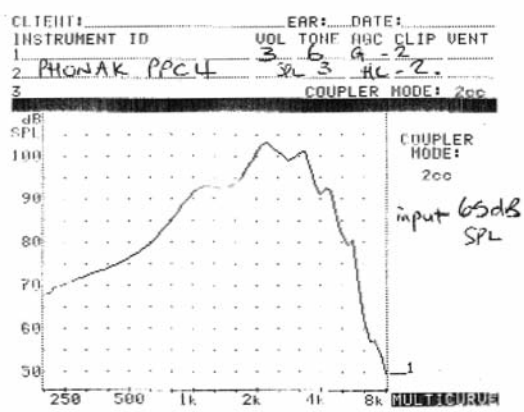


Figure 3
Printout of a frequency response curve for a hearing aid obtained using a hearing aid test box.



dBHL (Decibels Hearing Level)

The pure tone (PT) audiogram form

The pure tone audiogram form is used to record the threshold of detectability of a range of selected frequencies.

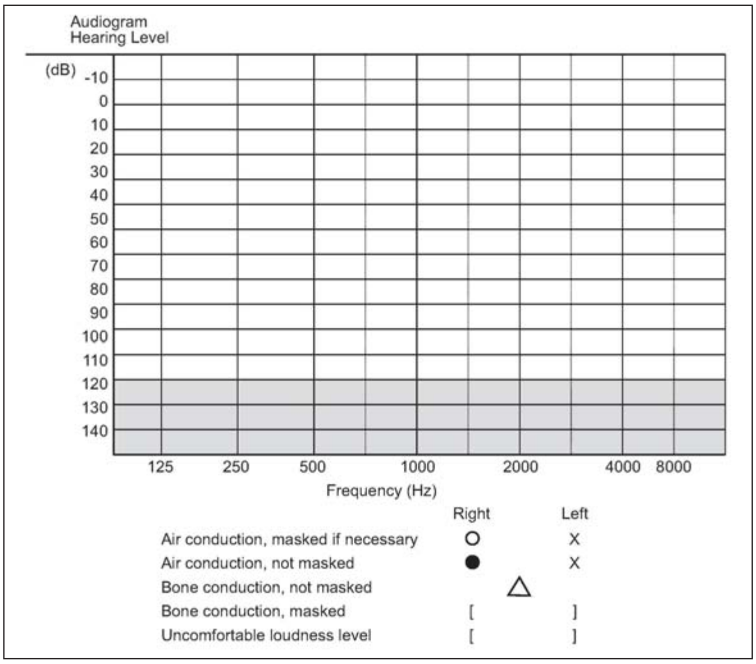


Figure 4

The frequency scale

The accepted layout for an audiogram form is shown in Figure 4. The frequencies are given at the bottom of the form, starting at a low frequency of 125Hz on the left increasing at octave intervals to high frequency 8000Hz (8KHz) on the right.

This band of frequencies has been selected as it covers the range of frequencies found in the sounds of speech.

The decibel Hearing Level (dBHL) scale

The figures running down the left side of the PT audiogram form (figure 4) represent the decibel scale and run from –10 dBHL at the top to 140 dBHL at the bottom.

What is dBHL?

Our hearing is not equally sensitive to each frequency across the speech frequency range. The human ear is most sensitive to frequencies between 500 Hz and 4 KHz.

A norm of threshold sensitivity at each frequency has been established and is indicated by 0 dBHL on the form. 0 dBHL therefore represents the threshold of detectability of each frequency for a normally hearing population, but the zero reference level varies with frequency.

The results plotted on the audiogram form are a comparison of a subject's hearing level with the accepted norm.

A hearing level of 50 dBHL would indicate that hearing is 50dB below the norm (see fig.5). A hearing level of –5 dBHL would indicate that hearing is 5dB better than the norm (see fig.5).

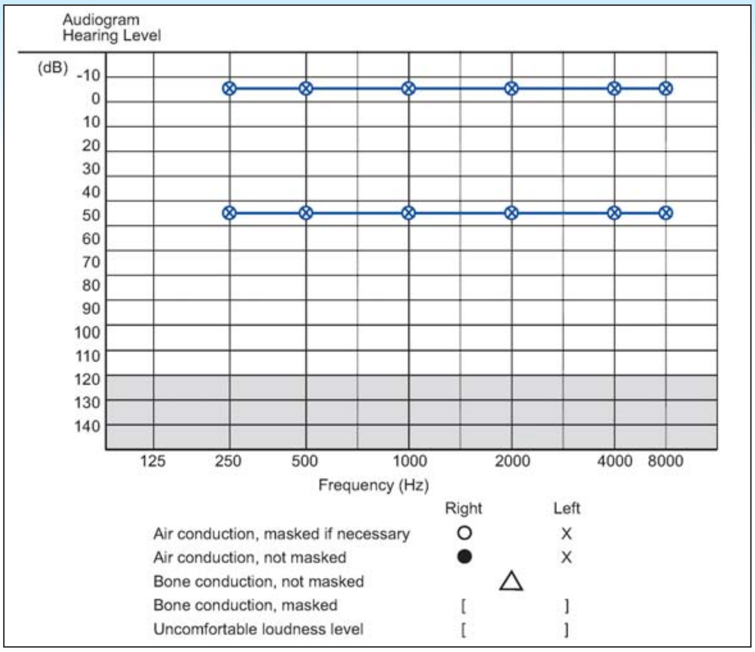


Figure 5 Diagram of audiogram with 50 db flat HL and –5db flat HL

dBA

The dBA scale is used for measures of sound field assessments. Sound field assessments would include speech recognition eg Kendal Toy Test, McCormick Toy Test, Distraction Test, Manchester Junior (MJ) Word Lists, Arthur Boothroyd Lists (AB) and assessments with a warble tone generator.

When these assessments are carried out the level of the voice or sound presented is measured using a sound level meter (SLM) which has a dBA scale.

The dBA scale reflects the sensitivity of the human ear at different frequencies.

The limit of normal hearing is accepted to be at 30dBA across the frequency range.

When sound field assessments are being made with for example a warble tone generator, the SLM is placed alongside the child's ear with the microphone facing the source of the sound. When sounds are presented and the child responds the sound level is measured at the child's ear. This figure is not necessarily the dB level indicated on the dial of the warble tone generator.

An approximate comparison of dBHL and dBA can be made by converting one scale to another. Figure 5 gives an example of a suggested conversion table. There are differing opinions on the dBA/dHL conversion figures. It would be wise to check which your Service has elected to use.

It is possible using such a conversion to plot a sound field result onto an audiogram form so that both will be in dBHL and compare for example an audiogram and aided listening results.

Suggested conversions between the different decibel scales are given in Figure 6 and can provide some guidance in making comparisons between measurements.

Sound field measurements are most usefully presented in the decibel scale on which they were measured (McCracken and Laoide-Kemp 1997).

A calibrated sound field should be used if aided responses to speech stimuli are being evaluated.

McCracken W and Laoide-Kemp S (1997) Audiology in Education. Whurr (Wiley) ISBN 1-86156-017-6

250	500	1KHz	2KHz	4KHz
converting dBA to dBHL ie putting warble tone onto audiogram				
-20	-17	-10	-10	-10
converting dBHL to dBSPL ie to compare audiogram with HA performance				
+25	+11	+7	+9	+9

Figure 6
Diagram of conversion chart

Glue ear and otitis media

Margaret Glasgow ©BATOD Magazine January 01 page 33-34

Fluid in the middle ear (otitis media with effusion) is the most common cause of temporary or fluctuating conductive hearing loss. One in ten children will have acute otitis media at some time. Most children will have an episode of secretory otitis media. Children with sensori-neural hearing loss can also be affected. It is most common in young children up to six years of age because of the position, size and poorer function of the eustachian tubes.

Acute otitis media (ear infection)

This is a viral or bacterial infection in the middle ear. It can occur with colds, sore throats, influenza and other respiratory illnesses. Severe ear ache and a conductive hearing loss can occur.

Secretory otitis media (Glue Ear)

Glue Ear occurs when fluid collects in the middle ear space of one or both ears. Bacteria gets into the middle ear and causes an inflammation of the lining, often after a cold, throat or ear infection. The adenoids often swell, or tonsils become enlarged, blocking the eustachian tube and making the situation worse. The air which is trapped in the middle ear is absorbed by the surrounding cell lining and bony structure and a negative pressure is formed. To balance this negative pressure fluid from the cells drains in to fill up the space. The fluid is often quite thin and runny but in time may become thicker, like glue. If the fluid is infected, the tympanic membrane may burst and blood-stained pus run from the ear.

Obvious signs of Glue Ear

- mouth breathing and/or snoring at night (due to enlarged adenoids)
- speaking loudly or shouting,saying “eh?”, “pardon?” or “what?” more often
- turning volume up on television/failure to hear sounds that can’t be seen eg traffic
- fluctuating hearing or attention.

Diagnosis

Otoscopy gives a view of the condition of the tympanic membrane and tympanometry gives information about the movement of the tympanic membrane, whether there is glue in the middle ear and the state of the eustachian tube. Behavioural tests, pure tone audiograms, including bone conduction and speech discrimination tests all give extra information. The conductive hearing loss may well fluctuate and be mild or moderate in degree.

Sound waves hitting the tympanic membrane are normally conducted across the air-filled cavity of the middle ear by the ossicular bones. However, when the middle ear cavity is full of thick viscous fluid it is more difficult for the bones to move and the sound is therefore dampened. Everyone experiences this when they have a heavy cold and their hearing is affected.

Treatment
There is much controversy over the treatment of Glue Ear. It is often is short term and rarely has a permanent damaging effect on the ear.

The condition may clear up by itself or a variety of treatments may be used:

- medication – antibiotics, decongestants, ear or nose drops
- homoeopathic remedies/dairy free diet
- cranial massage
- hearing aids
- myringotomy – the ‘glue’ is removed from the middle ear after piercing the ear drum with a syringe whilst under anaesthetic
- grommets or T-tubes – these are inserted into the tympanic membrane whilst the child is under anaesthetic. Tonsils and adenoids are sometimes removed at the same time. The grommet allows air to circulate within the middle ear and prevents further build up of glue whilst it is in place. Grommets are temporary and are eased out into the ear canal as the tympanic membrane heals. T-tubes are fitted in more persistent cases eg children with Downs Syndrome. These have to be removed under anaesthetic. Multiple insertion of grommets can badly scar the eardrum.

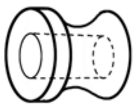
Effects of a conductive hearing loss caused by otitis media

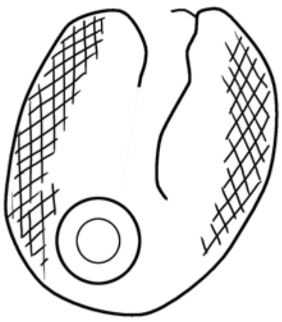
- child may become quiet, withdrawn, irritable, tired and generally less communicative or alternatively child may be more active or physical
- child may use voice less frequently and take less notice of speech
- if child is already speaking, the speech may become less clear
- new words may not be learned and little progress made in the child's speech and language development
- child may experience difficulty at school with literacy and numeracy skills
- child may become unsettled at nursery or school and feel left out of activities
- child may daydream and appear to hear selectively
- child may have poor listening skills due to inconsistent listening experiences.

A child who has recurring conductive hearing loss due to glue ear in the early years may experience hearing losses at times to a threshold of 60 to 70 dBHL. A young child who has consistently had poor hearing will not have the linguistic experience to predict words when heard inaccurately. This results in poor vocabulary and understanding of concepts when starting at nursery or infant school. A conductive hearing loss affects all speech frequencies. Poor speech discrimination of the voiceless fricatives in particular means that the markers for tense, number and possession are missed. The Literacy Hour and Numeracy Strategy in school concentrate on the early introduction of phonics and mental arithmetic. These learning objectives are particularly difficult for children with a fluctuating hearing loss, who may be mistaken for being unresponsive, disruptive or of limited ability.

Children's hearing difficulties are often not identified until their speech and vocabulary do not develop at the normal rate. This may be noticed at home, nursery or infant school. It can affect cognitive, social and linguistic development, particularly for children who may have an additional learning difficulty.

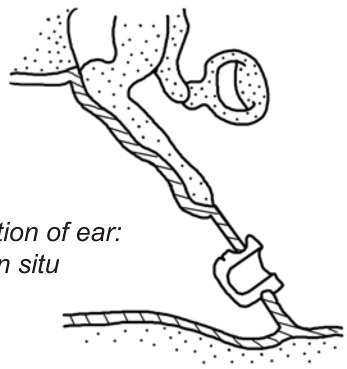
1. Grommet





2. View of eardrum with grommet in situ

3. Cross section of ear: grommet in situ



Visual reinforcement audiometry with insert earphones – part 1

Katie Moger and Margaret Glasgow
Educational Audiologists, Physical and Sensory Support Service in Surrey

Joint venture in setting up the room and procedure by Connevans and Surrey Education's Physical and Sensory Support Service

This article has been written in order to share the experiences of Surrey's Physical and Sensory Support Service in linking with a local manufacturer, Connevans, in order to provide a service that was not available in the local hospitals. We hope that it will be useful to other services who are thinking along the same lines.

Background

In 1996 the inaugural meeting of the South Educational Audiologists Group met in London. Professor John Bamford of Manchester University was invited to speak about Visual Reinforcement Audiometry (VRA) with Insert Earphones (IE). Following this talk, two profoundly deaf children aged 9 months and 18 months were taken separately to Dorset by Margaret Glasgow and Katie Moger to be tested by Educational Audiologists who had set up VRA with IE in a hospital.

Connevans offered Surrey the use of a room for testing and Pauline Hughes, Head of Profession for Surrey's Physical and Sensory Support Service (PSSS) met with the Head of Special Educational Needs Development to ensure this fitted in with Surrey County Council's Development Plan.

Fund-raising began for £8000. Contributors are acknowledged on a plaque in the Surrey Suite corridor at Connevans. Contributions ranged from a few pounds from cake stalls in a nursery school to £2500 from the Burwood Park Foundation.

When the room was completed and all the equipment had been installed, the two Educational Audiologists leading the project together with Connevans decided to call the room 'The Surrey Suite'.

Gathering of information and our own INSET

A day was spent in Dorset with Dr Martin Smith, Head of Service and Educational Audiologist to check the set up and the specific equipment we needed and the names of the suppliers.

At a BATOD South Educational Audiologist Group (SEAG) meeting, Roger Green ran a workshop where he explained how to set up Soundfield VRA and how to calibrate the soundfield.

Roz Pither, Head of Service in Berkshire and Educational Audiologist, gave an INSET to the Surrey Service on VRA. Roger Green was visited at King Edward VII Hospital, Windsor where he demonstrated procedures and protocol for VRA. A letter was sent to Professor Bamford at Manchester University about our proposed layout of the room and he replied with suggestions and advice. PC Werth gave us advice and help re calibration of the equipment and soundfield. Connevans gave us ongoing advice and help with the setting up of cameras, editing, videoing and numerous other snippets of information.

Setting up the Surrey Suite

The original room that had been given for our use proved to need major soundproofing to make it suitable. Connevans therefore offered the use of another room which had the advantage of an adjacent room which we could also use. Noise from heating and lighting appliances were checked and the route from the car park to the room checked for safe access. Connevans made the room acoustically viable by replacing a door with an appropriate wall and treating the walls. The room after treatment still appeared to be acoustically unacceptable and it was decided to put lined curtains around the walls. This was very successful although a great deal of work for the Teacher of the Deaf who volunteered. A system was set up whereby the procedure can be videoed and watched by others in the adjoining room. Soundfield was set up and calibrated with advice from PC Werth.

Purchasing of Equipment

The equipment came from various suppliers or was made by Connevans, our technician and PC Werth. Here is a list of the major items:

1 Kamplex KC 35 clinical audiometer calibrated for insert earphones and bone conduction – PC Werth.

3A insert earphones and foam tips – PC Werth

2 loudspeakers Jamo compact 700 – PC Werth

4 visual reinforcers – juggler, clown, train and flashing light

- Toys for the Handicapped.

2 stands for reinforcers – made by Connevans

3 foot pedals – made by our technician

1 high chair – donation

Chairs and tables – donation from Connevans

Selection of toys – various suppliers

3 security cameras – Reigate supplier

1 television – Reigate supplier

2 video recorders – Reigate supplier

1 digital AV mixer – Reigate supplier

1 tympanometer – PC Werth

1 otoscope – Connevans

2 fabric covers for reinforcers and loud speakers – made by ToD

1 sound level meter for soundfield measurements – PC Werth

Various lengths of leads – made by Connevans and PC Werth

Room layout

Much discussion took place re the layout. The factors taken into consideration were:

- it was not possible to have an observation window therefore the audiometer and tester had to be in the same room as the child
- the person who would be operating the audiometer had to have a clear view of the baby/toddler
- there needed to be enough space for the parent/ carer to sit close to the child
- baby/toddler needed to be positioned so that the speakers and reinforcers were at 45 degrees azimuth
- the cables from the reinforcers, speakers and audiometer had to be made safe
- cameras had to be positioned so that responses and audiometer could be seen on the video.

Trials to check protocols, use of equipment and procedures for VRA with IE.

A great deal of care was taken to ensure that the testers were confident using the equipment and were employing the correct child handling skills for the test. Many hearing babies and toddlers had their hearing checked whilst we were practising and we also checked by testing an adult hearing impaired person who had a known audiogram. PC Werth came during this period and rechecked the insert earphones calibration which is calibrated to dBHL so we do not have to do calculations to achieve our true levels.

Points we learned during the trials

This was a very valuable time and the use of two rooms was soon recognised as being crucial. One room is only used for the test and the other is used for welcoming the family, performing otoscopy and tympanometry, watching the video, explaining the test, parent/carer role and discussing results. Only the child, parent/carer and two testers are in the test room. Others watch the video in the adjoining room. When entering the test room we found the following procedure worked well. The insert earphones were already clipped to the back of the high chair which was positioned so that the baby could not pull the leads. Tester one who operates the audiometer inserts the earphones whilst tester two plays with the baby. If at any time during the test the insert earphones come out, tester one puts them back in. The positioning of the parent/carer needs to be close to the baby but not in the way of the testing. The role of the second tester is not the same as for the distraction test. The tester keeps the baby in the forward position, tries to stop the earphones being pulled out and the attention is controlled in a very low key manner. Often a young baby will sit happily with one toy. This tester helps with the insertion of the insert earphones by keeping the baby amused. S/he is often the one who talks to the parent/carer. Conditioning is more difficult than using soundfield VRA because the second tester cannot hear when the sounds are introduced and sometimes it is helpful to condition by soundfield. An agreed method of communication between the two testers is needed.

Presentation of the stimuli is not ordered as for a conventional pure tone audiogram. Timing of the presentation of the signal is crucial and enough time is needed for the baby to stop checking. An LED on the back of the reinforcer is needed so that tester one can be sure that the reinforcer is working. The baby/toddler may sit in a high chair, at a small table or on parent/carer 's lap. More time is available than in a normal clinic set up and if the baby becomes restless a break can be taken. Parents need to be prepared that results may not be achieved as insert earphones may not be tolerated or the baby does not like the reinforcers.

The Surrey Suite is presented as an opportunity to add to the jigsaw rather than to give a diagnosis.

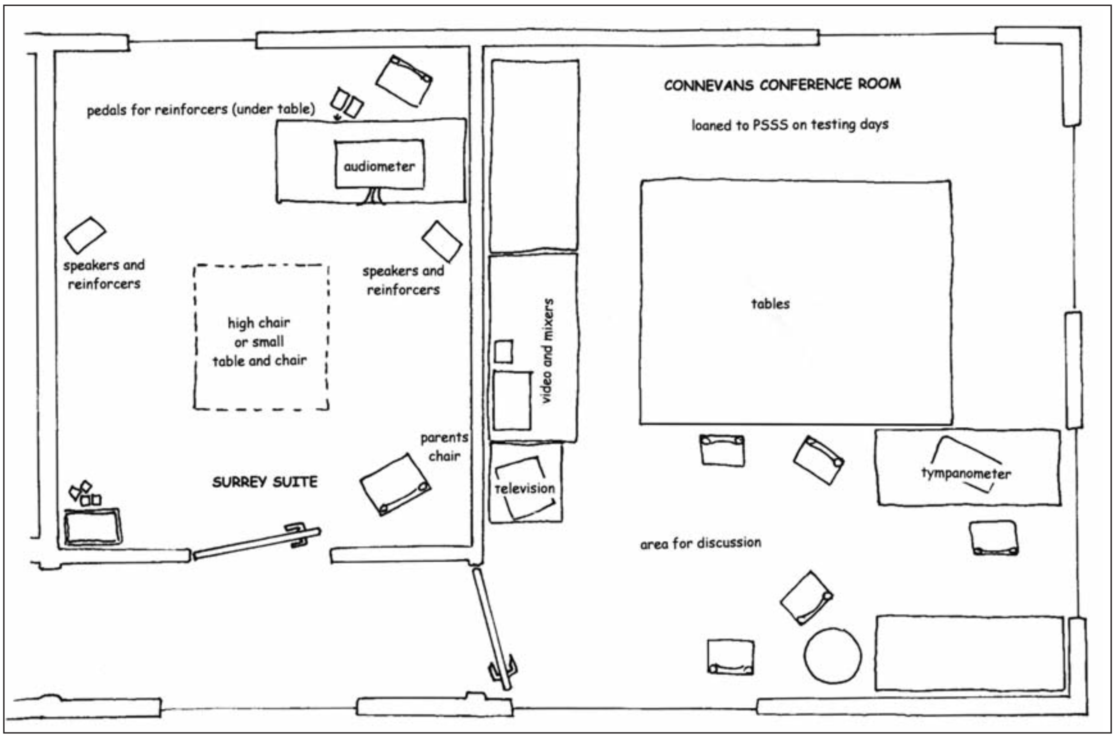
Launch of the Surrey Suite in June 1999

The Surrey Suite was launched nearly three and a half years after attending the talk by Professor Bamford. The Local Press attended and the following people were invited to two afternoon sessions:

- Surrey County Council officials
- Financial contributors
- Health Service Personnel
- Educational Audiologists from neighbouring authorities
- Physical and Sensory Support Team in Surrey
- Audiological manufacturers

A separate launch was given to the Connevans staff.

The project would not have been completed without the teamwork of the PSSS, Surrey County Council, the Health Authorities covering the County of Surrey and the hearing aid and radio aid manufacturers. The Surrey Suite has been successfully running for over a year and we will report on our statistics and findings, including case studies, in a later article.



Floor plan for the Surrey Suite

Visual reinforcement audiometry (VRA) with insert earphones – Part 2

Katie Moger, Sue Jillians and Margaret Glasgow Educational Audiologists, Surrey Physical and Sensory Support Service continue their report of the developing resource supported by Connevans to provide a service of Visual Reinforcement Audiometry (VRA) with Insert Earphones (IE), that was not available in the local hospitals. This article is a follow up to the explanation of how the facility was set up including installation of Insert Earphones and calibration of Sound Field (Magazine January 2001, pages 20-21). Statistics, findings and some case studies are reported.

During the Autumn Term of 1999 a third Educational Audiologist was trained to do VRA with IE and children diagnosed with hearing loss started to be assessed in December.

Thirty five children had their hearing tested at the Surrey Suite. Their ages have ranged from eight months to three years five months. Ages of children with complex needs have ranged from one year six months to seventeen years one month. Seven children have been seen two or three times.

Several children with complex needs have been tested. In one instance the equipment was successfully moved to the school. Children with Downs Syndrome and severe learning difficulties have been tested. A deaf blind boy has visited us three times and each time we have gained additional information.

The Surrey Educational Audiologists and Connevans have welcomed visitors to observe testing procedures. The parents are always asked if they agree to an observer. Consultant Audiological Physicians, Audiology Technicians, Educational Audiologists from other counties/boroughs, Senior Medical Officers, trainee Educational Audiologists have all attended sessions. The exchange of good ideas from their observations and discussions has proved invaluable.

In order to make the best use of Surrey Suite appointment time, we have learned the following: We are aware that children seen in the Surrey Suite attend other hospital appointments, particularly with Consultant Audiological Physicians and at Cochlear Implant Centres. We are careful not to offer appointments too close to other audiological assessments by ensuring that a period of three weeks is left between assessments. Our rôle is to work with the professionals at the hospital the child attends. Our work is not diagnostic but adds to the existing information. We always seek permission from the parents and discuss the appointment with the Consultant Audiological Physician.

The developmental age of the child is also a consideration. We have seen two children who, developmentally, were beyond VRA but who could not manage play audiometry. It is essential to liaise with the referring ATOHI to discuss how the child is functioning. We request previous audiological and pre-school reports and follow up reports in order to keep a comprehensive record of audiological assessments.

We are fortunate to be able to work at the pace of the child and to take necessary breaks so that the child does not become too tired. We allow time to discuss results with the parents/carers and to answer their questions. Parents are giving favourable written and verbal comments indicating they value both the comprehensive nature of the assessment and the time we can give to it. The fact that the ATOHI is often present shows that we work collaboratively.

Margaret Glasgow working in the Surrey Suite

The single most valuable facility has been the use of VRA with bone conduction. Bone conductors are still not designed for small heads but can be used successfully with foam padding.

Case studies

The following case studies illustrate some of the valuable outcomes for our service.

Child A:

Born 26 weeks gestation. Diagnosis at six months (uncorrected)* of severe, possibly mixed, hearing loss. Brainstem Electric Response Audiometry indicated right side response at 70dBnHL and left side no response at 70dBnHL. Child A was fitted with body worn hearing aids (normal).

Seen at the Surrey Suite aged sixteen months (uncorrected)*. VRA with insert earphones and unmasked bone conduction VRA were carried out.

Insert earphones: mild hearing loss left and right.
Bone conduction: within normal limits.
Outcome: Advisory teacher involvement reduced from weekly to monthly visits to family to give support and management.

Child B:

Child B has a first cousin with severe sensori-neural hearing loss. Previous distraction testing indicated a moderate hearing loss and glue ear. A low powered hearing aid was fitted on the right.

Seen in the Surrey Suite aged eighteen months. VRA with insert earphones and unmasked bone conduction were carried out.

Insert earphones: mild hearing loss left and right.
Bone conduction: within normal limits.
Outcome: hearing aid withdrawn by the hospital.

ATOHI involvement reduced from weekly to six monthly visits to monitor development of communication skills.

Child C:

Child C has bilateral meatal atresia. Previous unaided soundfield VRA gave responses at:
70dBA @ 1000Hz
50dBA @ 4000Hz

Child C wears a bone conduction hearing aid. No information on type of hearing loss or aided levels were available. Seen at the Surrey suite age two yrs one month. Bone conduction VRA, headphone air conduction VRA and aided soundfield VRA assessments were made.

Bone conduction: within normal limits

Air conduction: 70 dB hearing loss left and right ears

Aided: Responses across the frequency range at 30/35 dBA

Outcome: Advisory teacher involvement remained the same. Management strategies were refined because of additional information. A suitable candidate for bone anchored hearing aid.

Child D

Child D had meningitis at eleven months, also glue ear. Grommets were fitted at seventeen months and a moderate/severe hearing loss was diagnosed. Low-powered BTE hearing aids were fitted at eighteen months.

Seen at the Surrey Suite at nineteen months. VRA with insert earphones and unmasked bone conduction were carried out.

Insert earphones: hearing within normal limits on the left and a severe loss on the right.

Bone conduction: within normal limits

Outcome: hearing aids are no longer worn. The advisory teacher involvement reduced from weekly to monthly visits to monitor speech and language development.

Child E:

Age seventeen years, has complex needs and has worn high powered BTE hearing aids for several years. School was concerned that child E constantly pulled out the hearing aids and staff queried their value. The equipment was taken to the school placement where a very quiet room was provided. Two Educational Audiologists, the ATOHI and a member of the school staff were present for the assessment.

Air conduction VRA with insert earphones and bone conduction VRA were assessed. Child E's responses to sound stimuli differed from the conventional response of looking for a visual reward. Child E made a definite head turn to look at the Audiologist operating the audiometer. This response was reliable and repeatable.

Insert earphones: severe hearing loss on the right, no measurable hearing on the left.

Bone conduction: severe hearing loss

Outcome: request to hospital to review the hearing aids.

School attitude markedly improved, now believing hearing aids to be beneficial. The student is encouraged to wear hearing aids, also to use an ATU. Feedback reports student wearing hearing aid consistently and appearing more alert and aware. Advisory teacher involvement remains the same for time but is more productive.

Evaluation

For 86 % of children we have used VRA with IE to establish hearing levels in each ear. For 89% of the children unmasked bone conduction measurements were established

For 63% of the children aided or unaided Sound Field results have been achieved.

In 94% of cases additional information to that which the hospitals had reported was obtained.

For 31% of the children the management has been changed. Children with hearing within normal limits have been discharged, others have required less involvement by the ATOHI. Some children were given more appropriate hearing aids and for others the ATOHI has been better informed and therefore able to put in place more appropriate strategies and advice. Pre-school children in Surrey with any hearing loss are visited monthly until we are sure that both their speech and language development are progressing well.

The imminent roll-out of the Universal Neonatal Hearing Screen (UNHS) means that Teachers of the Deaf (ToDs) will have more young babies on their caseloads and audiological information will be incomplete. It is essential that ToDs have as much knowledge as possible about the baby's hearing status in order to advise the families and to monitor the child's development. The Surrey Suite is working collaboratively with other professionals and industry in providing the early information so that preventative working can be established and the child and his/her family have the most appropriate support and management.

Future use of the Surrey Suite

Some ideas are:

- introduction of Oto Acoustic Emissions tests
- hearing aid evaluation
- evaluation of listening skills
- using the video facility to record and evaluate speech and language and development of communication skills
- training other professionals.

uncorrected age refer to the chronological age of the child

corrected age refers to premature babies and their expected developmental stages from birth

Access from the audiological perspective

Presentation by Joseph O'Donnell
Educational Audiologist Donaldson's College, Edinburgh

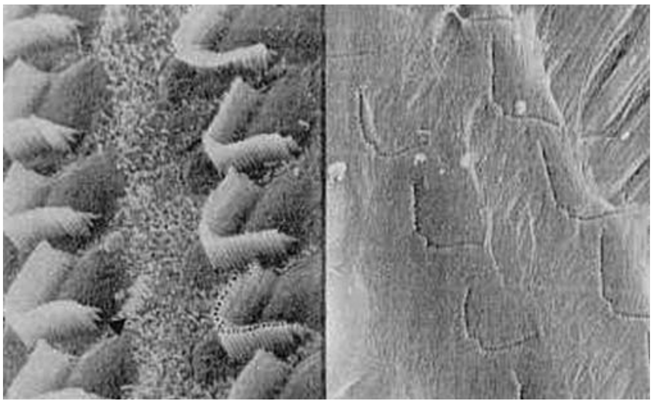
This was a well-received workshop, with lots of information on a very complex and pertinent subject. The presentation was easy to understand and took the non-specialist through complicated audiological issues in simple steps.

Access, in audiological terms, is about access to sound, specifically speech sounds. Hearing aids are the technology used to provide hearing-impaired children with access to speech.

How the cochlea works

We know that 90% of the auditory nerve fibres connect directly to the inner hair cells. There is one row of inner hair cells. There are three rows of outer hair cells and very few auditory nerve fibres (10%) connect directly to the outer hair cells.

The stereocillia tips of the outer hair cells are embedded in the tectorial membrane. Direct measurement of the basilar membrane motion in the early 1970s indicated an important non-linearity in basilar membrane motion. Stimulating an outer hair cell makes it change shape by expanding and contracting. It is believed that these hair cells are the source of the cochlear amplifier.



Outer hair cells photograph. Durrant, J D, and Lovrinic, J H (1995). Bases of Hearing Science. Williams & Wilkins, London.

The theory of amplification in the cochlea

- Low intensity sound enters the cochlea.
- The fluids are displaced but there is insufficient movement to move inner hair cell steriocillia and send a signal to the brain.
- However, minimal displacement is picked up by the outer hair cells and they react by expanding and contracting.
- Since the tips of the outer hair cell steriocillia are embedded in the tectorial membrane its movement is increased.
- This movement moves the inner hair cells.
- The inner hair cells move and send a signal via the auditory nerve to the brain.
- The low intensity sound is heard.

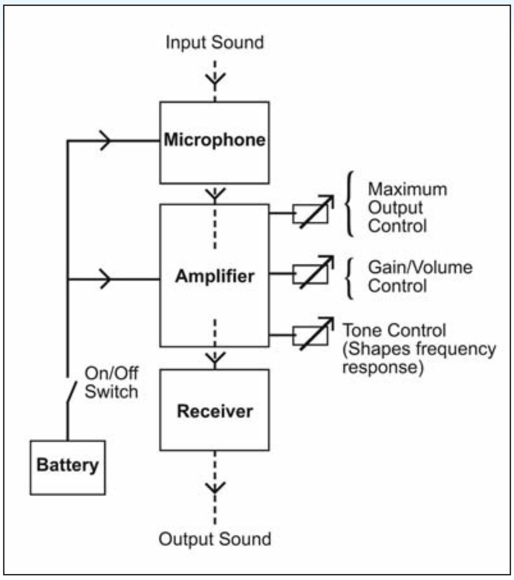
The implications of outer hair cell damage in sensori-neural hearing loss. The normal cochlea acts like a non-linear system ie only low intensity sounds are given amplification. When outer hair cells are damaged or missing the cochlea acts more like a linear system, there is no added amplification to any of the sound inputs.

Different hearing aid technologies

There are three hearing aid technologies, conventional analogue, digitally programmable (DP, Programmable hybrid) and digital DSP, (fully digital).

Analogue signal processing is the representation of a continually changing variable, such as sound, by another physical variable such as electric current.

- The sound pressure level at the microphone is continually changing as is the voltage in the microphone.
- In analogue signal processing the microphone picks up sound and converts it to electrical signals.
- The electrical analogue signal is amplified and shaped in the amplifier.
- Shaping and output limiting is set with a screwdriver potentiometer.
- The processed signal is sent to the receiver to be changed into an acoustic signal.
- The signal is sent to the ear of the hearing aid wearer through the earmould tubing, this is the weakest link in all hearing aid systems.



- There is a limit to the number of complex circuits at the signal processing stage and the more circuits there are the more chance of noise in the signal.

Programmable hearing aids use analogue signal processing but do have a digital chip that allows frequency response and output limiting to be altered by computer.

- Research has suggested that the use of a computer allows for more precise adjustment of the output signal.
- It allows for choice of different programmes from the memory to suit different listening conditions.
- Volume wheel and other switches can be deactivated. The user can have a remote control hand-unit to adjust volume and operation mode.

In digital hearing aids:

- the microphone turns sound into an analogue §electrical signal;
- the signal is sampled a number of times per second (10,000/second or greater);
- sampling allows the analogue to digital converter to turn the electrical signal into a digital equivalent using binary code;
- the microprocessor operates on the digital signal and the digital to analogue converter changes the digital signal back into an analogue electric signal;
- an anti-imaging filter smoothes the signal so it sounds natural again and the receiver converts the analogue electric signal back to sound.

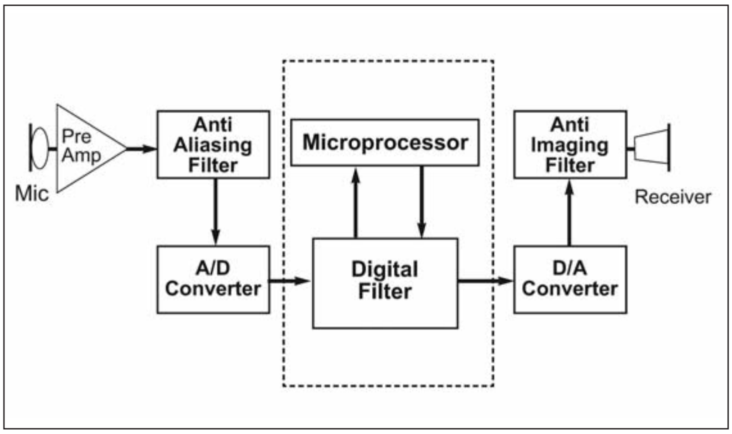


Diagram from: Schweitzer, C (1998). It's about numbers: A primer on the digitisation of hearing aids. The Hearing Journal, 51(11): 15-27.

What is different about digital hearing aids?

- They transform the analogue information from the microphone into ‘bits’ of data - numbers that can be manipulated by a tiny computer;
- Digital signal processing makes it possible to tailor and process the signal more precisely and in ways that are impossible with analogue hearing aids;
- Some digital aids can be very finely adjusted to suit an individual’s hearing loss;
- Many now have noise cancelling systems, speech recognition and feedback suppression systems;
- All digital hearing aids are completely different - different algorithms, number of bands and number of channels.

Advantages of digital processing:

- more pleasant for wearer, sound is clearer and more amplification of soft sounds is possible
- there is less distortion and the best possible sound quality
- flexibility in fitting, specialised functions and ‘intelligent’ compensation
- for the future there will be new capabilities added though software updates.

Real issue

In the near future all hearing aids will be digital. What matters is that the hearing aid provides the best possible amplified, acoustic signal to the impaired ear. The real issue is linear versus nonlinear; it is what we do with the digital chip which matters not the fact that it is digital.

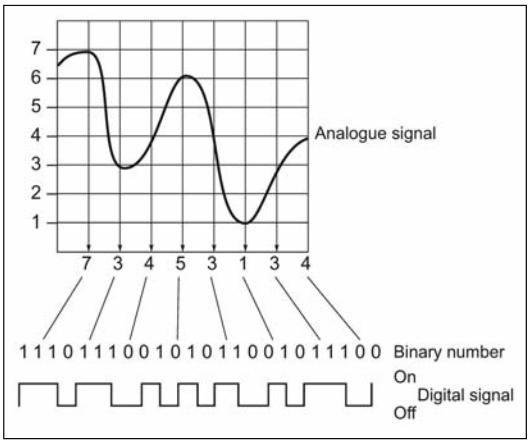
Summary

- The normal cochlear acts like a non-linear amplifier.
- When outer hair cells are damaged the cochlear acts more like a linear system.
- Analogue hearing aids can have sophisticated non linear circuits but there is more chance of noise.
- Digital hearing aids can provide processing power and flexibility without increase in noise.
- Digital hearing aids can provide very sophisticated compression strategies in an attempt to compensate for outer hair cell damage in the cochlea.
- The provision of digital hearing aids should result in more comfortable listening in a wider range of auditory environments.

For the future

There will be more knowledge of how the cochlea works. Better assessments will map the type and pattern of damage in the cochlea.

There will be better understanding of what parts of the speech signal need to be processed and passed to the listener.



How sampling occurs in digital hearing aids

Classroom acoustics: recommended standards

Classroom Acoustic Standards for children with sensori-neural hearing loss

Margaret Glasgow *©BATOD Magazine January 01 page 13*

Unoccupied Ambient Noise Level	should not exceed	35 dB(A)
Reverberation Time	should not exceed	0.4 second across the frequency range 125Hz to 4000Hz
Signal To Noise Ratio	should exceed	20 dB across the frequency range 125Hz to 750Hz
	should exceed	15 dB across the frequency range 750Hz to 4000Hz

Early diagnosis of hearing loss, together with good pre-school guidance, consistent appropriate hearing aid fitting and cochlear implants are making it possible for severely and profoundly deaf pupils to be educated in mainstream classes. The government policy of inclusion also encourages this situation.

It is therefore important to have realistic targets for acoustic conditions in schools in order to influence either existing provision or new building regulations. Good acoustic conditions benefit both hearing and deaf pupils. However, classroom acoustics is only one of many factors which will support or inhibit the successful inclusion of severely and profoundly deaf pupils.

Recommended standards need to be used sensitively and put in the context of other strategies used by pupils and staff. They would be one factor in the learning environment and the impact on individuals will be variable.

Background Noise Levels (BNL) and Reverberation Times (RT) can be improved by:-

- acoustic treatment: carpets, curtains, doors (and closing doors), soft covers on display tables, ceilings etc
- INSET to mainstream teachers re management of hearing loss, use of radio aids and attachments conference mics etc
- Auditory Training Units (ATU)
- good classroom management
- provision of quiet areas
- monitoring and evaluating the use of hearing aids (including modern technology eg digital hearing aids)
- use of radio aid (RA) transmitter input adaptors and leads
- ensuring that deaf pupils' classroom is located to preclude intrusive noise from playing fields, roads etc
- use of visual clues and access through text
- skilled use of radio aid by deaf pupils
  - knowing when it is working correctly
  - being able to assist in fault finding (when old enough)
  - being able to decide the situations when a radio aid is useful
  - using additional leads and adaptors with TVs, computers etc
  - having confidence to explain use to other pupils and teachers
- provision of Soundfield FM System

"Acoustic treatment to reduce background noise level (BNL) is likely to improve reverberation time (RT). If BNL is controlled then apparently high RT has a minimal effect when a radio aid (RA) is in skilled use and set up properly."

Roger Wills, BAAS 29.01.98

The outcomes of severely and profoundly deaf pupils educated in mainstream, unit and resource settings, where BNLs and RTs have not been ideal need to be researched in order to demonstrate the value of the additional strategies that can be successfully used. There are numerous educational and social advantages in attending local mainstream schools and living at home. These should not be underestimated in the overall view of provision.

Classroom acoustics – the DfES' recommendations:

Russell Brett on behalf of A&ICT

©BATOD Magazine February 02 page 23-24

Background to the DfES' position

The DfES produce advisory documents for Local Education Authorities on a range of buildings issues, including classroom acoustics. These documents are published by The Stationery Office (TSO) as Building Bulletins.

Existing guidance on classroom acoustics is in the form of Building Bulletin 87. This document is advisory only. The DfES is currently updating these guidelines and incorporating them into a new Building Bulletin 93 'Acoustic Design of Schools', to supersede the acoustics section of Building Bulletin 87. Furthermore, for the first time, a section on Sound Field Amplification (SFA) will be included in Building Bulletin 93. This is scheduled to be published in March 2002. There has been consultation with Russell Brett who has provided information for these documents and continues to represent BATOD at this level.

Mandatory guidance on classroom acoustics

Recently a revised Building Regulations Part E on acoustics has been out to public consultation. The proposed revision extends the scope from domestic building (eg houses) to include, for the first time, schools as well.

From April 2001 schools have been subject to Building Regulations. It is planned to quote Building Bulletin 93 due out in early 2002 in the new Part E as the compliance document for new school designs.

This document also includes an updated version of the requirements in Building Bulletin 87. Therefore the acoustic criteria will be enforced by Building Control Officers when designers submit their plans for approval.

Summary of Building Bulletin 87 2001 Revision 5

Guidelines for Acoustic Design in Schools

Background noise

- during school hours the background noise should not normally exceed those detailed in table 1
- in general, background noise levels in teaching rooms should not normally exceed 40dBAeq1hr
- for rooms with mechanical ventilation, background noise levels should not fall below 30 dBAeq1hr since the ventilation system can be of actual benefit in masking out noise from adjoining classrooms. Thus background noise levels should fall between 30 and 40 dBAeq1hr
- for the hearing-impaired it is felt especially important to minimise low frequency (LF) noise ie noise below 500Hz but it is recognised that this would be of benefit to all children especially young children
- with the intention of taking LF sound into account, the preferred measurements within the document are 'room noise criteria' or 'preferred noise criterion curves' (NC).

Reverberation

- for recommended reverberation times see table 2 (unoccupied rooms)
- highly reverberant rooms tend to be noisy rooms. There is a tendency for individuals to raise their voice in order to aid comprehension.
- sound-absorbent materials in classrooms tend to be of maximum benefit when placed on the ceiling and rear walls
- large lecture theatres benefit from a central hard area that is acoustically reflective
- in halls, where speech and music are of importance, moveable curtains are an advantage
- reverberation time (RT) should ideally be equal across all speech frequencies
- for music, the RT should be longer below 500Hz. At and above 500Hz the reverberation time should be equal (though in practice this is difficult to achieve above 2kHz).

Open plan environments

- speech should be intelligible up to 5m (ie against background noise)
- it is recommended that the floor should be carpeted
- a sound-absorbing ceiling is recommended
- it is recommended that sound-absorbing screens, of 1.7m height, are used between classrooms
- it is recommended that full-height moveable walls, with seals, are used between classrooms

For the hearing-impaired

- lighting levels are noted to be important
- low background noise is noted to be particularly important
- it is noted that RT should be controlled

Teaching rooms for the hearing-impaired

- background noise should be at least 10dB lower than those indicated in table 1
- a 10dB improvement on those levels indicated in table 1 are also recognised as being important for all children taking into account the incidence of glue ear
- sound field amplification should only be utilised after all measures have been taken to improve acoustics
- SFA systems should, when they are used, be of high quality, not interfere with teacher-pupil relationships, be reliable, robust and easy to use.

Definitions

dBA_{eqT} The equivalent continuous A-weighted sound pressure level. This is a notional steady sound which, over a defined period of time T, would have the same A-weighted acoustic energy as a fluctuating noise eg for a 1 hour school lesson this would be denoted Aeq1hr

RT Reverberation time (RT). The time that is required for the mean-square SPL to decrease 60dB after the sound impulse stops.

NC Noise Criteria (NC). Standard spectrum curves by which a given measured noise may be described by a single NC number.

Table 1 Recommended acoustic standards – background noise levels

Room type/activity	Activity noise level	Tolerance level	Maximum background noise level A_{eq1hr} (dB)
Music rooms			
Teaching, listening, audio	high	low	30
Music practice/group rooms	high	low	30
Ensemble playing	high	low	30
Recording/control room	high	low	25
General teaching, seminar, tutorial rooms and class-bases	average	medium	40
Science Laboratories	average	medium	35
Language laboratories	average	low	40
Commerce	average	medium	40
Lecture rooms	average	low	35
Drama, play reading and acting	high	low	30
Assembly/multi-purpose halls	high	low	35
Audio-visual rooms	average	low	35
Libraries	low-average	low	40
Metalwork/woodwork	high	medium	45
Resource/light craft and practical	high	medium	45
Individual study	low	low	35
Administration offices	average	medium	40
Staff rooms	average	medium	40
Medical rooms	average	medium	40
Withdrawal, remedial work	low	low	35
Teacher preparation	low	low	35
Interviewing/counselling	low	low	35
Indoor sports	high	high	50
Corridors and stairwells	average/high	high	50
Coats and changing areas	high	high	50
Toilets	average	high	50
Indoor swimming pools	high	high	50
Dining rooms	high	high	50
Kitchens	high	high	50
Plant rooms	high	high	65

Table 2 Recommended mid-frequency reverberation time in unoccupied rooms

Type of Room		Approximate size and volume		Mid frequency
Area(m^2)	Height(m)	Volume(m^3)	Seconds	RT in
Primary schools:				
Classroom or class base	30-65	2.4-3.0	72-195	0.5-0.8
Library	12-70	2.4-3.0	29-210	0.5-0.8
Music and drama studio/AV room	30-80	2.4-3.0	72-320	0.8-1.2
Hall (assembly)/PE/movement)	80-200	3.7-6.0	296-1200	0.8-1.2
Dining rooms	80-200	2.4-3.2	192-640	0.5-0.8
Hall (music, drama, PE, AVA, assembly)	80-200	3.7-6.0	296-1200	0.8-1.4
Swimming pool	65-120	3.7-6.0	241-720	<2.0
Kitchens	65-120	2.7-4.0	176-480	1.5
Secondary schools:				
General teaching classroom	50-70	2.4-3.0	120-210	0.5-0.8
Small practical spaces, science, IT, business studies	70-110	2.4-3.0	168-330	0.5-0.8
Large practical spaces, art, metalwork, woodwork, multi-materials, textiles, electronics, food technology	80-135	2.7-3.0	216-405	0.5-0.8
Library	90-300	2.4-3.0	216-900	0.5-1.0
Hall (assembly/rehearsal)	250-550	3.7-7.6	925-4150	1.0-1.4
Dining rooms	250-500	3.7-7.6	925-4150	0.5-0.8
Gymnasium/PE	250-500	5.0-6.0	1250-3300	1.0-1.5
Dance studio	150	2.7-4.0	432-640	0.8-1.2
Drama studio	80-120	3.7-7.0	296-840	0.9-1.1
Swimming pool	100-500	3.0-6.0	300-3000	<2.0
Music rooms:				
Music classroom/recital room	54-91	2.7-3.5	146-319	1.0-1.2
Ensemble rooms	16-50	2.7-4.0	43-200	0.8-1.2
Small teaching/practise/group room	6-10	2.7-3.0	16-30	0.4-0.8
Recording/control room	8-15	2.4-3.0	19-45	0.3-0.8

Sound treatment for classrooms

Pauline Hughes

There are four main aspects to making a comfortable and effective listening environment in any room:

- reducing reverberation
- reducing internal noise
- reducing external noise
- ensuring speakers are heard by all

Reducing reverberation

Hard surfaces tend to reflect rather than absorb sound, causing reverberation. Excessive reverberation reduces the clarity of speech, particularly for hearing aid users. An optimum reverberation rate for hearing aid users is 0.4 of a second.

Objective assessment of reverberation rates can be difficult, but can be done subjectively by hearing aid users themselves. A theoretical reverberation rate can be calculated (may need an acoustic engineer!) by room size and the acoustic properties and dimensions of the internal surfaces, eg walls, ceiling, floors, windows.

The most effective single adaptation to reduce the reverberation rate is to fit totally sound-absorbent cladding to a (low) ceiling. In this way, rooms such as science labs and technical workshops can be brought within optimum rates without fitting carpets or curtains, which would be unsafe or impractical.

Where carpets and curtains or soft blinds can be fitted, they assist sound absorption and have other benefits such as internal noise reduction (carpets) or reducing glare (curtains or blinds).

Wall cladding is not always cost-effective, if walls are used for display purposes: putting sheets of paper on soft wall boards or tiles counteracts the sound absorption.

Reducing internal noise

Excessive noise (ie unwanted sounds) affects all people's (but especially hearing aid users') ability to pick out the 'signal of interest'. The principal source of internal noise in classrooms is the children! Avoid the temptation to raise your voice level above the noise. Noise management should be part of any school's Behaviour Policy and everyone's practice. 'Open plan' environments pose enormous challenges.

Non-human noise comes from an increasing variety of sources. Wherever possible, place deaf pupils at a distance from unavoidable sources of noise. It is particularly important that pupils with unilateral hearing loss don't sit with their hearing ear towards a source of noise.

Reducing external noise

Sources of noise include:

- classes and grass mowers on playing fields
- traffic: road and air; trains
- classes in neighbouring rooms (especially assemblies and PE lessons!)
- machinery in adjacent rooms

Reducing external noise may be through:

- reducing the noise at source where possible
- preventing the noise entering the room with double/secondary or even triple glazing, cladding, heavy duty doors and frames, or sometimes simply closing windows and doors!
- timetabling lessons for hearing aid users to avoid vulnerable rooms or peak times for noise

Noise Source	Possible Solutions
Scraping chair and table legs	◆ carpets ◆ rubber tips on chair and table legs ◆ pupils lift rather than drag chairs and tables!
Clattering pens and pencils	◆ pupils manage the noise ◆ soft pencil cases ◆ table-top pencil holders lined inside and on the bottom with felt
Computers and printers Hubs and Servers	◆ acoustic screens if practical ◆ don't site hubs in teaching rooms wherever possible
Heaters	◆ service and maintain to keep noise to minimal levels ◆ fit new, silent heaters
Aquarium pumps, gerbil wheels etc	◆ buy a new pump ◆ oil the wheel
Workshop machinery: lathes, sewing machines, foodblenders etc	◆ clad or screen where possible ◆ service and maintain to keep noise to minimal levels ◆ switch off at every opportunity ◆ hold plenary/group sessions in a separate area if possible

There are also electrical sources of noise that are undetectable or unnoticed by non-hearing aid users, but can cause interference in hearing aids, radio aids or cochlear implants.

Interference Source	Possible solutions
Old strip lighting	◆ replace with high frequency/ noise ◆ suppressing strip lights
Radiation from computer monitors	◆ fit anti-static screens ◆ buy new 'low radiation' monitors
Mobile phones	◆ confiscate
Mobile phone masts? (controversial)	◆ don't site near school
Cochlear implant processor linked to radio aid	◆ consult CI team re updating the processor

Ensuring speakers are heard by all

Projecting voices so that they carry throughout a classroom of usual size inevitably means raising them if even hearing pupils are all going to hear. Using a soundfield FM system will ensure that all pupils hear the teacher's voice and the teacher can use conversational levels. However, in class discussions and question and answer sessions, unless the microphone is passed around, others' contributions will need to be relayed by the mic wearer. The same principle, of course, applies to using radio aid receivers and transmitters.

All pupils 'hear better' if they can see the speaker's face clearly. As well as helpful positioning of speakers and listeners/watchers, make sure that overhead lighting is adequate to preclude strong shadows and that glare is avoided.

Where curtains or blinds can't be fitted, glare from bright sunshine can be reduced by using sunfiltering film on windows.

Finally

This article was written in 2001. I think the practical suggestions may still be useful: please contact the Magazine Editor if you have other tips or ideas to share. Since I wrote the original piece, Building Bulletin 93 has been implemented, which sets out the acoustic criteria which all new school buildings must comply with. It's worth keeping a copy of section 6, relating to acoustics for hearing impaired pupils, when trying to improve listening conditions in particular schools or classrooms. Although the specifications are for new buildings or major refurbishments, they are clearly set the standard for all learning environments for deaf pupils and, as such, Headteachers and LEAs should be seeking to achieve them.

Soundfield systems

Jeremy Hine, NDCS Technician, *©BATOD Magazine December 02 page 11-12*
with thanks to contributors, Peter Preston, Judith Laughton and Margery Forsyth

The introduction of soundfield systems into school classrooms is on the increase and is beginning to generate much interest. Many school classrooms have poor acoustic conditions caused by high ceilings and large areas of hard surfaces: this leads to high reverberation times (echo) and has a negative impact on speech perception. Another problem is the distance between the teacher and the children: pupils sitting near to the teacher may be able to hear them at a comfortable level above the background noise but as the distance between the pupil and the teacher increases the level of the teacher's voice will decrease, sometimes to the extent that the background noise level is louder than the teacher's voice. To overcome this the teacher will usually raise his/her voice but this only distorts speech and lip patterns (for those who rely on lip reading) and causes vocal strain for the teacher.

The problem can be partially addressed by treating the room acoustically, such as adding carpets, soft coverings on the walls and cushioning the feet of tables and chairs. However, that still leaves the problem of the distance between the teacher and the pupils. Many deaf children use personal FM systems (radio aids). A soundfield system works in a similar way but can benefit the whole class.

What is a soundfield system?

A soundfield system is basically a low powered public address (PA) system. The speaker's voice, usually the teacher's, is relayed to the soundfield receiver via a wireless microphone/transmitter. The signal is then amplified and fed to at least one loudspeaker strategically placed within the classroom. This enables all children to hear the teacher at a constant level wherever they are sitting. The number and position of loudspeakers depends on the size, shape and acoustics of the room. The soundfield system is not a replacement for a personal FM system despite addressing similar issues (noise, distance and reverberation) – a personal FM system can achieve the higher signal to noise ratio (S/N) that deaf children need.

Who benefits from a soundfield system?

Basically everyone but especially children in the following categories:

- children with a temporary hearing loss (such as glue ear)
- children with Attention Deficit Hyperactivity Disorder (ADHD)
- children with Central Auditory Processing Disorder (CAPD)
- children who have English as a second language
- younger children who have not yet developed their language skills to enable them to fill in gaps in speech (auditory closure).

We approached several schools using soundfield systems to tell us about their experiences. The following observations are representative.

Teachers:

- 'The system definitely made a difference for the whole class, including a pupil with hearing impairment.'
- 'The system has reduced the general level of noise in the classroom and improved pupil attentiveness.'
- 'The children are more responsive to teacher direction without the need for a raised voice.'
- 'It is particularly useful during 'carpet time' and whole class teaching sessions when the deaf child benefits most.'
- 'It has raised awareness in the class and in the whole school about the particular needs of deaf children and the difficulties they face.'
- 'It seemed to offer the deaf child more choice in terms of seating position.'
- 'It makes a big difference in assemblies, everyone can hear.'

Children:

- 'We like using the system, it makes it easier to listen.'
- 'Everyone listens and we are much quieter when the teacher is talking.'
- 'We ask the teacher to use the microphone if she forgets.'
- 'I like to use it when I have to read out loud in the classroom, it's easier if everyone can hear me.'
- 'It doesn't matter where you sit, you can still hear.'

There have been a few reported problems but most of these have been as a result of inexperienced use of the system, for example, the incorrect use of the microphones or forgetting to charge the batteries. Almost all users tell of much less strain on their voices and improved responses and participation from all the children. In one school the head teacher covered a lesson for the teacher trialling the system and was so impressed that she immediately placed an order for seven classroom systems and a hall system. Parents of deaf and hearing children have reported very positive feedback. Children already using radio aids are able to link into the soundfield system and the reduction of general background noise within the classroom considerably enhances the listening experience.

Many schools have applied for funding for soundfield systems through the Schools Access Initiative. The majority of schools who had a system for appraisal have gone on to install one or more systems permanently. (Schools can contact Sarah Potter at the DfES for more details on: F020 7925 6148).

For further information about soundfield systems please contact the following suppliers:

AVT Communication Systems Ltd, FREEPOST 1980, Rugeley WS15 1BR
F 01889 583158; Fax: 01889 583158
e-mail: info@avtcomm.co.uk.

BioAcoustics Ltd, 26 Guildford Street, Luton, Bedfordshire LU1 2NR
F 01582 431000; Text: 01582 481411;
Fax: 01582 488227
e-mail: info@bioacoustics.com www.bioacoustics.com.

Connevans Ltd
54 Albert Road North, Reigate RH2 9YR
F 01737 247571; Text: 01737 243134;
Fax: 01737 223475;
e-mail: mail@connevans.com
www.connevans.com

PC Werth Ltd, Audiology House, 45 Nightingale Lane, London SW12 8SP
F 020 8772 2778; Fax: 020 8772 2701;
e-mail: pcwerth@pcwerth.co.uk
www.pcwerth.co.uk

Synergy Learning Ltd, Saltham Barn, Saltham Lane, Chichester PO20 6PU
F 01243 779967; Fax: 01243 532471;
e-mail: sales@synergy-group.co.uk
www.synergy-group.co.uk

Portable soundfield amplification systems (SFA) – their place

Russell Brett

The effects of poor classroom acoustics

The degrading effects of noise and reverberation on listening and speech and language skills in the classroom are well documented in the literature. This negative effect can be observed for all groups of children, including, of course, hearing-impaired children. Additionally there is a group of 'special' children with additional difficulties, including children with English as an alternative language, children with Attention Deficit Disorders and those with learning difficulties. Beyond all of these groups there is evidence that all young listeners are disadvantaged in poor acoustic conditions.

Where the classroom acoustic environment is poor there are two alternatives: 1) to make adjustments to the acoustic environment 2) to provide equipment that can help ameliorate the negative effects.

Justifying altering the acoustic environment

Reverberation and background noise are the main contributors to poor acoustic conditions in schools. Background noise can be generated from within the school or classroom, or from outside. Sometimes it is possible to control the noise level by giving consideration to the use of adjacent classroom space and by reorganising timetables. Sometimes reverberation can be controlled by careful use of display boards and soft furnishings. More often, though, it is the design and fabric of the building that are the causative factors – old buildings with high ceilings and vaulted floors, open-plan classrooms leading on to common work areas, buildings with poor sound insulation or properties situated close to main roads.

The new Building Bulletin 93 (BB93) 'Acoustic Design of Schools' (2003) produced by the DfES sets a very high standard for new school buildings. BB93 gives the performance targets for compliance with requirement E4 from Part E of schedule 1 to The Building Regulations 2000. This ensures that acoustic criteria are now enforced by Building Control Officers when designers submit their plans for approval.

To alter existing buildings can be expensive, although there are many alterations that can be made which are not. Now is the time for schools to be including more ambitious solutions to poor classroom acoustics in their planning. In the context of Inclusive schooling and the SEN and Disability Act, schools must now have in place a disability access strategy which identifies barriers to inclusion for children with SEN and sets targets to remove these barriers.

Similarly, each LEA must have a Disabilty Access Strategy. Funding is available to schools and authorities to implement the plans. Furthermore, Ofsted inspectors will include judgements as to how well the LEA and schools have discharged their responsibilities in this regard, when they inspect schools.

An average reception class will have approximately three children at any one time with significant glue ear. There may also be in that class children from any of the 'special' groups noted above. Bearing in mind that all children benefit from improved acoustics, targeting classroom acoustics on the accessibility plan is easily justified and should be pursued as a first-line approach.

Providing equipment that can help

There is no real alternative to improving classroom acoustics. There are, as every Teacher of the Deaf knows, systems that can help to ameliorate the negative effects – but they all have their disadvantages. The easiest way to help any child manage in a poor acoustic environment is effectively to bring the person speaking closer to the listener – that is, within the direct field. This is the basis upon which all of today's electronic systems work.

Essentially the choice is four-fold:

- a personal FM system used in conjunction with hearing aids
- a personal FM system used with headphones
- a classroom SFA (Sound Field Amplification) system
- a personal SFA system.

None of these systems negates the need for good classroom acoustics, nor should good classroom acoustics prevent their use as the negative effects of distance remain. All Teachers of the Deaf are familiar with personal FM systems. These would continue to be the system of choice for the child with hearing aids. With such a system it is possible to attain a signal to noise ratio (S:N) of 20dB, not possible or desirable with any other system. (Flexer C, 1992). For children who have a minimal or monaural hearing loss and do not have hearing aids, a personal FM system may be used with headphones. The system selected should enable frequency response to be contoured appropriately and for maximum output to be set – not all systems do.

Sound field amplification (SFA) systems

Sound field systems have been gaining wider use in the UK in recent years. An overview of their use, both classroom and portable systems, can also be found in Section 8 of BB93. SFA systems, in general, are intended to make it easier for the child to listen and thus to learn, by comfortably raising the teacher's voice above the background noise. This may be achieved by attempting to provide an even sound field in the classroom or a S:N of +10 to +15dB.

The introduction of amplification into the classroom environment is said to bring about an increase in learning and speed of learning. It is purported to be an effective educational tool capable of bringing about significant improvements for teacher and child in the learning environment.

It is important to remember though that a SFA system will not correct poor acoustics. It will not reduce reverberation time and this may need to be addressed as a separate issue in the classroom.

Additionally, consideration needs to be given to both Health and Safety issues and classroom acoustics when SFA systems are installed and to on-going maintenance. There are considerable implications if accidents occur due to poorly or inadequately fitted systems. Systems should be fail-safe. For example, speakers should have safety chains fitted to catch the loud speaker if the bracket should fail. With regards to the acoustic aspects, there is no defined rationale for setting up a classroom SFA system. Should the aim be to provide an even sound field throughout the room? to maintain a constant S:N? to produce a combination of both? or to target specific areas within the room?

Thus, although it may be possible for the Teacher of the Deaf or Educational Audiologist to set up a SFA system, consideration should be given to whether it is sensible or desirable to do so. There is a number of companies who will provide this service and manufacturers who sell these systems will usually advise on installation and maintenance contracts.

The major advantage of using a classroom SFA system, as opposed to any of the other systems mentioned here, is that it benefits the whole class and the class teacher (in terms of reduced vocal fatigue). Thus, it can be included as part of the school’s accessibility plan and monies accessed.

Using portable SFA systems

Portable SFA systems can be useful for the following groups of children:

1 **Those children who are not able to wear conventional hearing aids but would benefit from a direct link to the teacher**

   This group would include children who are troubled by background noise and effects of distance – children with a monaural hearing loss, children with a minimal hearing loss for whom noise is more of an issue than amplification and those with chronically discharging ears and fluctuating hearing losses.

2 **Those children who would benefit from amplification for reasons other than hearing loss**

   Research has shown that specific groups of children (and adults) benefit from an improved S:N. These would include children with Learning Difficulties, Central Auditory Processing Disorders (CAPD), Attention Deficit Hyperactivity Disorder (ADHD) and those with dyslexia.

3 **Those children who are not able to make use of a personal FM system**

   A child, for a very good clinical reason, may have a hearing aid that is not compatible with Direct Audio Input (DAI) and would therefore benefit from a personal SFA system. This may be chosen in preference to using a personal FM system with a neck loop. (The quality of these can be poor with CIC/ITE aids for example.)

The other group of children for whom a portable SFA is useful is young Cochlear Implant (CI) wearers. Although CIs can be wired to personal FM systems their use is questionable with young children, who are not able to provide information on the quality of input they are receiving. It is, of course, not possible for a parent or Teacher of the Deaf to check through the whole auditory chain with a CI and ascertain whether the system is working appropriately or not. Further, there are issues of 'balancing' and microphone priority, which are best addressed when a child is older and personal FM systems can be set up when the child is 'mapped'.

It is a very simple but important point to remember that where children are integrated into mainstream primary schools (without a unit or resource base) there is no on-site expert available at all times to check what would be a very complex and sophisticated auditory system. However, checking the function of a portable SFA system and arranging repairs is very simple.

Setting up a portable SFA system

A portable SFA system requires very little setting up. The teacher wears the transmitting microphone and the receiver/amplifier unit is placed close to the child.

The amount of amplification available is usually limited by the microphone-speaker distance and auditory feedback as the child is often positioned very close to the teacher – for example in literacy and numeracy sessions when he or she may be seated on the floor.

Most systems will allow 10dB of gain before feedback, which is sufficient considering the speaker unit is within the direct field with respect to the child (ie on the desk in front).

Generally speaking, there is no necessity for the setting up to be technically difficult. The main criterion is that it should be 'easy' for the child to listen – the distinction here between hearing and listening being important. The level of sound should be comfortable and it should sound as though the teacher is actually in front of the child. That is it!

This is something we can do, as Teachers of the Deaf, which is effective, relatively easy and will make a real difference to the lives of the children in our care.

Technology	Advantage	Limitation
Personal FM systems	◆ provide good S:N (+20dB) ie reduce effects of distance between speaker and listener ◆ are easy to use – portable and convenient ◆ can switch between teacher and child's own hearing aids automatically	◆ target one child only ◆ may have frequency response or output not possible to contour or limit ◆ can be lose benefit if child's hearing aid microphones remain live ◆ can make children reluctant to wear them for cosmetic/stigmatising reasons
Classroom SFA systems	◆ improve S:N for all children (10- 15dB) (reduces effects of distance between speaker and listen) ◆ can provide almost an even SF throughout the classroom (no bad positions in room) ◆ can ease strain on the teacher's voice facilitate more natural sounding voice ◆ permit the teacher to know if the system is working	◆ only one way – ie teacher to child – unless a microphone is passed around the class. ◆ do not correct for poor classroom acoustics generally eg long reverberation times
Personal SFA systems	◆ are portable improve S:N (10-15dB) ie address the issue of distance between speaker and listener ◆ permit the teacher to know if the system is working	◆ can be cumbersome to move around between classrooms ◆ do not correct poor classroom acoustics in general ◆ only help the one child ◆ can easily 'feed back' or whistle when volume is turned up

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Aiding the under - one year old

Margaret Glasgow *©BATOD Magazine May 01 page 27-28*

The introduction of the Universal Neo-natal Hearing Screen (UNHS) together with a heightened awareness of hearing behaviour in young babies by parents suggests that many more young babies will be prescribed hearing aids. There are many factors that need to be considered when aiding young babies.

Diagnosis

Normally this is arrived at by a battery of tests: Transient Evoked Oto-Acoustic Emissions (TEOAE), Auditory Brainstem Response (ABR), Distraction Test and Tympanometry.

This can be a lengthy procedure as delayed myelination, conductive hearing loss and unilateral hearing loss can all distort the findings.

The introduction of Visual Reinforcement Audiometry (VRA) with insert earphones (IE) enables many of these babies to have a pure tone audiogram by the age of 9 months. Bone conduction can also be achieved using VRA. These tests give valuable information for appropriate hearing aid fitting and management.

Young babies need regular earmould impressions as their ears grow quickly. This can be every two weeks in the first few months. Earmoulds need to be soft and double dipped, especially for the severely and profoundly deaf children. The turn around of impressions to earmoulds should be three days. The benefit of early diagnosis and appropriate fitting of hearing aids is defeated if the earmoulds do not fit.

Diagnosing a significant hearing loss can be a traumatic experience for parents. Some parents welcome hearing aids whilst others will find it impossible to contemplate putting hearing aids on a very young baby. The peripatetic Teacher of the Deaf needs to be extremely sensitive to this issue.

Hearing aid factors

When hearing aids are about to be fitted there are several factors that need to be taken into consideration:

Ergonomic characteristics of behind the ear hearing aids

- size and shape of hearing aid and elbow relative to the pinna
- weight of the hearing aid
- colour of hearing aid
- volume covers
- battery locks
- hearing aid retainers eg huggies, huckies, phonafix

A parent/carer who feels comfortable with the look and size of the hearing aid is more likely to give baby and family positive feelings.

It is sometimes preferable to fit a body worn hearing aid to any small baby as the baby spends most of his/her time lying down or in a bouncing cradle and this causes acoustic feedback. Also, with body worn hearing aids, the lead separates the microphone and the receiver which helps to stop feedback from ill- fitting earmoulds. Body worn hearing aids are very rarely used now. (March 2009)

The following **electroacoustic** characteristics need to be discussed:

Digital and Analogue Hearing Aids

- all the ergonomic characteristics
- effect of earmould
- NHS or commercial hearing aid
- uncomfortable listening levels
- radio aid facility
- manufacturer’s record for repairing hearing aids
- prompt access to hospital/clinic if hearing aids need adjusting.

Habilitation

Ongoing observation and monitoring of hearing behaviour by parents/carers and all professionals with advice from the Teacher of the Deaf are of paramount importance so that under- and over-amplification are noted and dealt with. Assessment and videoing before hearing aids are fitted are extremely useful. The professionals who fit the hearing aids and earmoulds need feedback about hearing behaviour.

A Family Support Plan could contain:

- Advice for parents about keeping a log or diary of their child's:
  - hearing aids with names and dates of fitting etc.
  - dates of new earmoulds and type of earmould
  - response to sound with comments
  - vocalisation and list of sounds
  - turn taking skills
- Advice for parents/carers on observing hearing behaviour in young children
  - early listening behaviour, especially after hearing aid fitting eg startling, blinking, crying, stilling, eye-widening etc
  - eye contact, early conversation skills, points of reference etc.
- Advice for parents/carers on encouraging listening skills
  - listening to voice, especially mother/father/carer
  - environmental sounds in the home and outside
  - noisy toys and games
  - nursery rhymes and jingles
- Teachers of the Deaf need to complete profiles regularly:
  - before hearing aids have been fitted (if possible)
  - after hearing aids have been fitted (every three months to begin with)

Examples of suitable profiles could be:

Detailed Profile

This covers six areas of development including understanding and expressive language

Pragmatics Profile

This takes time to do but over a period of time parents/carers can see the progress of their child and enjoy adding the milestones

Video record and analysis

Discussion of listening and interactive behaviour and analysis of speech should take place with parents/carers after each videoing session.

The Teacher of the Deaf should ensure maximum liaison and collaboration with parents/carers, hospital personnel including Consultant, Audiological Physician, Scientist, ENT surgeon and all other professionals involved with the baby.

References

1. *Quality Standards in Paediatric Audiology*

The use of stetoclips by parents and others working with deaf children

Richard Vaughan

'Parents and teachers must be provided with a hearing aid kit that must include at least a stetoclip and air puffer for daily maintenance.'

NDCS Quality Standards in Paediatric Audiology, Volume IV, 2000

Regular subjective testing of children's hearing aids is essential and effectively complements the less frequent objective tests carried out by audiologists using specialist equipment.

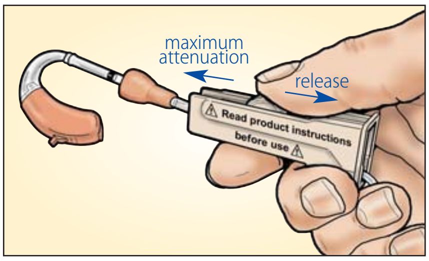
These tests can take many forms, but the most common is the use of a stetoclip (sometimes called a 'listening stick') which enables a hearing person to listen to a hearing aid. The hearing aid should be tested at the child's usual volume setting. A hearing person, listening to the hearing aid on a frequent and regular basis, will be able to detect gradual changes in performance. If it is considered necessary further testing can be recommended.

Concerns have been raised by some professionals about the potential risk to the hearing of a person frequently using a stetoclip listener to check aids in the way described. These risks will be minimised if the following precautions are observed.

The tester should never listen to a hearing aid at a volume level that they find uncomfortable. If a hearing aid has a volume control, this should initially be set to its lowest possible level and the volume gradually increased. One approach is to slowly increase the volume to beyond the user-setting and then reduce it to the usual listening level.

An acoustic attenuator used with a stetoclip allows the tester to listen to the hearing aid, at the user setting but at a comfortable level. Listening at the user setting will allow you to check for distortion. Powerful aids, which are appropriate for the user's condition, may cause damage to normal hearing. When using a stetoclip, an acoustic attenuator should always be used if the loudness of the aid causes discomfort.

One of the most effective attenuators currently available is a device originally demonstrated by the Ewing Foundation.



Some people may recognise the device as an intravenous drip feeder. When it is applied to the tubing of the stetoclip it makes a remarkably good attenuator, smoothly adjusting the volume of sound without loss of quality. Connevans now supplies all their stetoclip listeners with this variable 'roller' attenuator. The tubing also includes a damper which gives a minimum attenuation (approx 10dB) as a precaution.

Attenuators must be available in each test room as well as in any domiciliary box. Teachers of the Deaf, parents, Educational Audiologists and other support workers must also have access to an attenuator. The increasing introduction of digital aids, many of which do not have a full volume control, makes the use of an attenuator vital.

Testing should be carried out in quiet surroundings. Other personnel should be aware that a listening test is being carried out and so avoid making excessive, unexpected sounds.

Ideally, each tester should retain and use their own stetoclip. Otherwise, stetoclips should be cleaned between use (for example, using antiseptic wipes).

- Training must be provided to all staff in the safe and effective use of stetoclips.
- Parents must also be given appropriate advice and provided with written information.
- It should be the responsibility of individual departments to produce guidelines for the staff.

References

1 *Quality Standards in Paediatric Audiology, Volume IV – NDCS, 2000.*
2 *Hearing Aids, A Guide – NDCS, 1997*

Boom microphones

Peter Keen
Senior Specialist Teacher Adviser Hearing Impairment & Educational Audiologist

American research has indicated that speech discrimination was significantly improved using boom microphones with FM systems. Knowing how profit margins can sometimes increase the apparent performance of equipment, I have tried some out with good listeners from my caseload. All testing was done in a quiet room (BNL <30dBA) using AB word lists presented using live voice measured at the ear with a Kamplex KM4 sound level meter in appropriate calibration. All equipment was checked to be working normally.

The first assessment was a Junior pupil with a moderate loss, greater on the high frequencies than the low – fairly typical! She had several months to get used to the different frequency range before assessment.

	60 dBA	50 dBA	40dBA
CRMT 220 + boom mic	100%	97%	97%
CRMT 220 worn on chest	97%	90%	77%

While the 60 dBA (normal voice) perception does not seem to be much better, there is no 'fall off' for the boom mic as the voice gets quieter. To me this indicates a significant improvement in auditory perception. To the young lady in question, the difference was "I can hear what they're whispering now!"

The second case was also a Junior pupil but with a slightly greater loss. After his teacher had used a boom mic long enough for him to have adjusted to it, he achieved the following result:

	60 dBA
CR CRMT 220 + boom mic	97%
CRMT 220 worn on chest	87%
Hearing aids only – no radio	77%

The Third case is a child who was born with a Mild hearing loss which has slowly progressed to Severe, but Profound above 1kHz. DSL targets cannot be achieved above 1500kHz even with the most powerful hearing aids because they over amplify on the low frequencies. She has auditory memory of consonants even though she has been unable to hear them for a while.

	60 dBA
CRMT 220 + boom mic	90%
CRMT 220 worn on chest	77%
Hearing aids only – no radio	63%

I understand that 70% (aided only) speech discrimination for adults who have developed speech and language when hearing and used auditory – oral communication all of their lives is acceptable for use in everyday life. All of my successful (pre-lingual) severe and profoundly deaf mainstream children have had at least 90% speech discrimination via radio aid, even if they could only discriminate 70% (absolute minimum) via hearing aids. This would seem to indicate that for some children, using a boom mic on the transmitter might make life in mainstream a lot easier: for others it could mean the difference between success or failure.

Rechargeable batteries for radio hearing aids and other equipment

Peter Keen
Senior Specialist Teacher Adviser Hearing Impairment & Educational Audiologist

There are different types of rechargeable batteries used in Radio Hearing Aids (RHA's). There are general rules which apply to all rechargeables and some rules which apply to the way the batteries function in different RHA's.

- Rechargeable batteries have 'stored up' electricity inside them. This means that if they are short-circuited, all the stored power can escape in a few seconds. A charged battery short-circuited by a penny in your pocket could give a serious burn. In your handbag it could set fire to the contents!
- When they are charged up they should be kept in the radio aid or left in the charger. RX22 batteries have a black plastic cover to protect the terminals (it often needs an elastic band to keep it in place). Batteries can be kept in a sealed plastic bag: keep them together in a block using an elastic band to prevent the terminals touching.
- Children are not allowed to use rechargeable batteries in school for experiments, eg in science. This means that they must always be supervised 1:1 when equipment is being checked (Health & Safety). This even applies to older Secondary School pupils who are moving towards independence.

Disposing of rechargeables

There 2 safety factors:

1 Short-circuiting.
All rechargeable batteries must be totally drained of power before disposal to avoid short-circuiting. Simply leave the battery in equipment switched on until the battery is flat.

2 Chemicals inside the battery.
Look on the casing. If it says Ni-Cad, these batteries must be recycled by specialists, either through Connevans or through local recycling. Historically some batteries could be disposed of as normal waste however with changes to environmental requirements please check the latest environmental legislation.

For further information check with your county official documentation.

Charging Times

The same/similar batteries used in different equipment will last for a different time. As equipment/batteries get older, hours of use of built-in batteries will shorten.

- Handymic – experience says charge daily when in use. The manufacturers claim: 12 hour charge = 13 hours use, 20 hour charge = 21 hours use.
- Genie – total of 40 hours use for a single charge. There is no need to charge until only 2 bars or less show. When left on charge with charger plugged into unit, the internal computer switches off when 'done'.
- Connevans 220 – each battery has to be charged for 14 hours for 40 hours use (eg a week of school use). The batteries are called RX22's and have a variety of different chargers. Some have to be switched off manually, some are semi-automatic and some are totally automatic, even charging each battery separately according to need.
- Connevans 200 – this is an old system predating the 220. The 14 hour charge for the RX22's only lasts one school day and so needs charging overnight before daily use.
- Other systems (Microport, Solaris etc) have built-in rechargeable batteries and are automatically charged by placing the whole TX and RX in the charger.

A bone anchored hearing aid – what is that?

Sheena Hartland Birmingham Children's Hospital

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This article was written to help demystify the Bone Anchored Hearing Aid (BAHA).

Firstly, what it isn't. It's not:

- a hearing aid attached to a headband
- a relation of the cochlear implant
- a new experimental device which has yet to be proven effective
- a 'Frankenstein' type device attaching a hearing aid to the skull using nuts and bolts!

The concept behind the BAHA was discovered accidentally back in 1952 by a Swedish scientist Dr Per-Ingvar Branemark. He had inserted tiny Titanium cameras into animals in order to measure their blood flow. When he came to remove the cameras he found that living bone had grown around the Titanium holding the cameras securely in place. Instead of ignoring this discovery he set about finding an application for it, the process became known as osseointegration.

The first application was in the dental profession to secure dental prostheses to the jaw. This proved to be highly successful. Since these early beginnings, osseointegration applications continued to develop and now include a range of facial prostheses, securing of wigs and the BAHA. Future developments are likely to include fixation of digits and limbs (exciting times ahead).

The BAHA and its application for hearing-impaired children?

The BAHA is made up of four main components, titanium fixture (screw), abutment, insert and the hearing aid. The fixture and abutment are fitted, behind the ear, in two separate minor operations. A gap of three months is left between the operations to allow osseointegration to take place. The operation presents no risks other than those associated with a general anaesthetic (this procedure is done in one stage and under local anaesthetic in adults). The insert has two functions, firstly, it is the means by which the hearing aid connects to the abutment and subsequently it needs changing every six months to maintain a good connection. Secondly, by being removable it acts as a safety mechanism to protect the insert from trauma.

The insert and hearing aid are fitted approximately one month after the second stage operation. The hearing aid itself has most of the adjustments /accessories found on conventional hearing aids eg radio aid connection, loop system connection, frequency control etc. Cleaning of the skin surrounding the abutment is very simple but very important to prevent infection. It should be done, on a daily basis, by wiping around the abutment with a cotton bud dipped in tap water.

To summarise then, the BAHA is a hearing aid that amplifies using direct bone conduction, thus bypassing the outer/middle ear to stimulate the cochlea.

So who may benefit from the BAHA?

The BAHA is beneficial to patients with a permanent conductive/mixed hearing loss whose average bone conduction thresholds (average of 0.5 – 4KHz) are better than 45dB for the ear level device, or 60dB for the body worn device. These patients can be split into two main groups:

- congenitally malformed/absent ears – this can include malformation of some or all of the outer and middle ear structures. This may be syndromal eg Treacher Collins or Goldenhars syndrome, or non syndromal.
- ear infection or skin irritation – this may be recurrent outer or middle ear infections or skin irritation due to ear mould allergy etc. This group includes problems often encountered with Down syndrome and therefore may offer a good habilitation option for some of these children.

Abutment with insert in situ

Advantages

Most of these children will already be aided with conventional air or bone conduction hearing aids, so what benefits may be gained by having a BAHA and are the benefits sufficient to warrant an operation?

The main advantages of the BAHA are due to the hearing aid being in direct contact with the bone. These advantages are:

- all of the amplified sound is transmitted through the bone rather than being 'lost' through skin and tissue impedance, as is the case with a conventional bone conduction hearing aid
- the sound is constant and does not vary depending upon either the state of the ear as may occur with air conduction hearing aids in an infected ear, or the position/movement of the transducer with a conventional bone conduction hearing aid
- the comfort of the BAHA is a great improvement compared to conventional aiding as there is nothing in the ear to aggravate ear infections or irritations, nor is there any pressure exerted on the skull causing discomfort and headaches as can often be the case with the conventional bone conductors.
- as there is no headband the cosmesis of the BAHA is superior to a conventional bone conduction hearing aid
- as the bone conduction thresholds for these patients are better than the air conduction equivalents, less amplification is needed by the BAHA compared to a conventional air conduction hearing aid to overcome the hearing loss. This may then make sound more natural with less distortion thus benefiting speech discrimination.

Bone anchored hearing aid (dimensions 33 x 20mm)

There are of course some disadvantages with the BAHA as nothing can ever be perfect, and it is obviously up to the parents and child to decide whether the disadvantages are enough to outweigh the possible advantages.

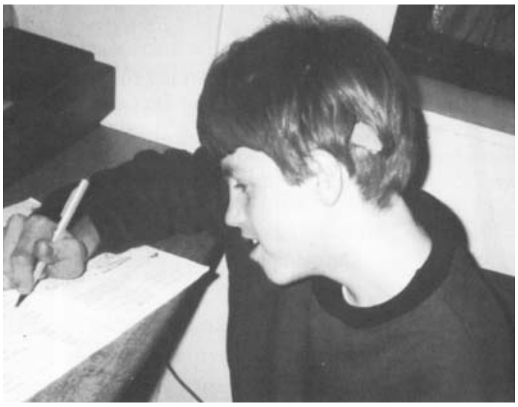
The main disadvantages

- The procedure involves two minor operations.
- A person other than the patient (normally the parent) needs to help with the skin cleaning and with the replacing of the insert.
- The procedure may not be available locally.

Fitting a BAHA

There is wide variation around the country in the lowest age that a BAHA will be offered and implanted. This variation may be due to different protocols and different levels of experience in the fitting of the BAHA to children. In Birmingham we recommend that the BAHA is fitted as soon as possible, so optimum aiding is achieved as early during the child's development as is practically possible, this is especially vital for the maximisation of speech development. Since our programme began in 1988 we have gained more and more experience, and now fit children as young as two years old with great success.

It should be stressed that still the most important factor when considering a child's hearing loss is obviously the early diagnosis, quick fitting of a suitable conventional hearing aid and good follow up support for parent and child. Current NDCS guidelines recommend that diagnosis and fitting be completed by the age of six months for congenital hearing losses.



Finally, nothing in this article may be new you. Although after much time spent on the telephone liaising with professionals around the country it has become obvious that that there is still a lot of mystery surrounding the BAHA. The unscientific nature of this article is intended to help quash some of those mysteries and misconceptions which exist.

All associated professionals must become as confident at managing a BAHA as they are at dealing with conventional aiding. Annual modular courses covering the BAHA are available to offer individual, practical 'hands on' courses for small groups.

Living with my BAHA

Mary Fortune shares her experiences of obtaining and wearing her new BAHA

©BATOD Magazine May 2008 page 43

A bone anchored hearing aid (BAHA) is one of many different hearing aids prescribed on the National Health Service, alongside digital hearing aids and cochlear implants. A titanium plug is surgically implanted into the mastoid bone, an abutment is connected to the plug and a sound processor is connected to the abutment. Titanium is used for the plug because the body osseointegrates the titanium and it conducts like bone – this is called the Branemark Principle.

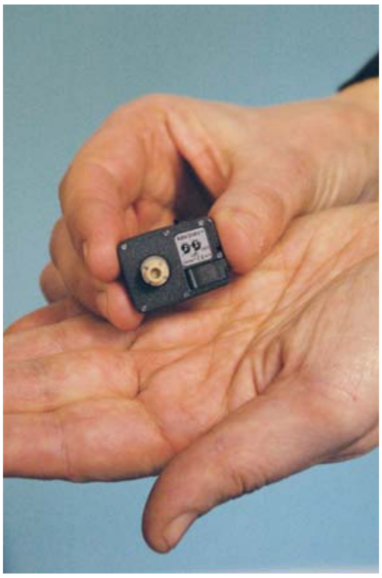
When I was 11 years old, I had a perforated eardrum due to an infection I got from swimming. I was finally referred to an ENT consultant and 35 years later I am still under their care!

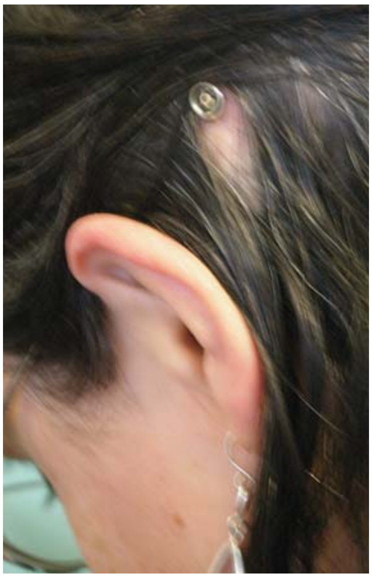
When I was 18, I had a radial mastoidectomy as I had an inflammation of the mastoid bone caused by an infection spreading from the middle ear to the cavity in the mastoid bone. This left me with a mild hearing loss and consequently I started to speak with a louder voice than before as I couldn't monitor my voice properly. Over the years I have suffered from many ear infections, polyps growing in the middle ear, another perforation and catarrh, all of which are low grade things but make you feel off colour and certainly don't help with hearing what is going on. My hearing thresholds have dropped over the years because of this, and about four years ago, they dropped to a moderate level (50dB loss) and my voice got even louder. Just ask my colleagues….

To compensate for this, I would always make sure people were on my right-hand side, and I'd sit at the front of any group, use my good ear for the phone, have the TV and car radio on loud and ask people to repeat things I had not heard or even misheard. I was also finding it much harder to hear my deaf students when supporting them in class if they were sitting on my left side as they would whisper and I couldn't hear them.

One of my students had a BAHA and about two years ago the rep from the company came to talk to us about them as part of our professional development in audiology. When she had finished, some of my colleagues turned to me and said, 'Mary, that's what you need!'

It set me thinking, so I asked my ENT consultant to refer me to the specialist hospital that performed this procedure so I could find out if I was suitable or not. After assessment by audiology and another ENT consultant, I had to trial a post-aural digital hearing aid. I loved it





but had a constant wet ear mould and ear. Finally it gave me a bad ear infection, which required antibiotic treatment. I tried a soft band BAHA one afternoon and that seemed better. After trying the alternative aids and listening to what was involved in acquiring a BAHA I decided to go ahead and a date for day surgery was set.

The procedure took about an hour under local anaesthetic and I chatted to the surgeon as he was working. It was like root canal work at the dentist, as you can hear and feel everything but it doesn't hurt! Honestly!

I now have a titanium abutment in my skull just behind my left ear, up to the right and not in the way of my glasses. The measurements are very carefully drawn out on the skull and care is taken not to shave too much hair from around the site as they prepare it.

After three months, when the metal had embedded into the bone, I returned to get my digital hearing aid, which clipped into the abutment and was set to the lowest setting. The whole process from request to actually wearing the BAHA took about 12 months.

It took me a while to get used to clipping the digital aid in without getting my hair caught in it. It is dark in colour to match my hair so it is almost invisible. It has two microphones: one directional mic for all around sound and one omnidirectional mic for sound directly in front (for example, when I want to listen to my radio in the car it cuts out a lot of the surrounding car noise while driving). I enjoy using the volume control to adjust to different situations.

Initially I had the volume on 1 but as my brain got used to bilateral sound, it was reset to a higher level and I now wear it on volume 2. I hadn't realised how my brain used to cross over sound, and what noise I had been missing. The BAHA also has a socket for an Ipod.

I was given a soft brush to brush off any dead skin that collects around the abutment, a box to keep it in and a transparent tube for others to test the aid by clipping the aid to it and placing it on their mastoid bone. The batteries seem to last a long time and just go dead suddenly. The NHS will replace it once if I lose it, will repair it when required and will upgrade it in three years.

On the plus side it has enabled me to regulate the volume of my voice and people have said I do speak more quietly than before. I can now hear whispers on my left-hand side and people talking in the back of the car more clearly. It is great to hear music and sound in stereo, especially at the cinema and theatre. I feel I can be a positive role model for my students and I completely understand how easy it is to forget your hearing aid in the morning when you are in a hurry!

On the down side, the abutment isn't fully flush with my skull so I can feel it when I lie on my left-hand side in bed, so I have a special pillow I made with a little piece cut out. The hearing aid can flick off when taking a top off or when holding an umbrella too close to the head. I can't wear a hat with the aid on as it just whistles too much when covered. And lastly, I had forgotten how much noise people can make when rustling paper and, when out walking, how noisy wind can be! However, I wouldn't be without my new BAHA!

Mary Fortune is a ToD in Stockport. She is also an NEC member and BATOD North Treasurer.

Neonatal screening for hearing loss

Margaret Glasgow, Educational Audiologist

Since publication, screening has been introduced across the UK.
Information is available at www.hearingscreening.nhs.uk

Explanation of terms

Hereditary hearing loss	is passed to the child by dominant or recessive parental genes
Congenital hearing loss	is present or occurring at birth but not necessarily hereditary
Perinatal hearing loss	occurs in the neonatal period ie from birth to 4 weeks
Acquired hearing loss	is permanent but neither congenital nor hereditary

Targeted neonatal screening for hearing loss takes place at many hospitals. Screening is intended to identify those babies who have a significant hearing loss from within the high risk group.

The most common test used is transient evoked otoacoustic emissions (TEOAE). The normal cochlea, in response to a sound stimulus, emits a corresponding echo which can be detected and measured. The response from a damaged cochlea is reduced or absent.

Some hospitals use the Auditory Response Cradle (ARC) which monitors behavioural / physiological responses to sounds ie head turns, startle responses, body and respiratory movements.

High risk factors for hearing loss include babies:

- admitted to special care baby units for a total of 48 hours or more, including babies with severe anoxia, and jaundice or rhesus incompatibility requiring exchange transfusion
- who have a family history of deafness
- with congenital abnormalities of head or neck
- who have syndromes associated with deafness
- for whose mothers there has been a suspicion of significant intra-uterine infection during pregnancy, eg rubella, toxoplasmosis, CMV, HIV
- whose parents have a consanguineous marriage, eg cousins
- whose mothers have had significant levels of ototoxic drugs (including substance misuse) in pregnancy, or the babies themselves during the perinatal period
- with acquired risk factors, eg bacterial meningitis

Universal neonatal screening has been introduced across the UK further information can be found at www.hearingscreening.nhs.uk

The Department of Health commissioned report [Davis, Bamford, Wilson, Ramkalawan, Forshaw & Wright 1998 *] recommends universal neonatal screening as the most effective way of identifying hereditary, congenital and perinatal hearing loss in children. If universal neonatal screening is adopted by more hospitals there is likely to be an associated affect on the usefulness of the Health Visitor Distraction Test (HVDT) for babies between 6 and 9 months.

There are also implications for the training and practice of Teachers of the Deaf working with increasing numbers of very young babies and their families. [BATOD Magazine May 1998, article by Robert Miller]

* *A critical review of the role of neonatal hearing screening in the detection of congenital hearing impairment. Health Technical Assessment 1997;1(10)*

Electrical response audiometry (ERA)

Margaret Glasgow, Educational Audiologist

Explanation of terms

ABR is Auditory Brain Response, an objective test of hearing

BSER Brainstem Electric Response or Brainstem Evoked Response. This is another term for ABR.

Auditory Brain Response

ABR provides information about hearing threshold without a consciously made response from the child. To be reliably undertaken, the electrical activity of the brain (EEG) must be quiet as in a natural sleep or during general anaesthesia. It is therefore readily undertaken on babies under four or five months of age where behavioural tests to threshold are not possible. It can also assist in the objective assessment of older children including those with complex needs, but sedation or general anaesthesia may be required.

Surface electrodes must be attached to the scalp to record electrical activity from the brain (EEG). Click stimuli are presented through a headphone triggering electrical activity along the auditory pathway up to the brainstem. The electrical activity occurs at a specific time from the onset of the click and is said to be time-locked to the stimulus. By repeatedly collecting these time-locked responses, the random brain activity (EEG) can be calculated using computer averaging techniques, and the response to the sound extracted. In threshold assessments, 1000-2000 clicks are presented and the response builds up in the form of a waveform.

M. Baldwin and P M Watkin, 1997, Diagnostic Procedures, page 47 In Audiology in Education, Edited by McCracken and Laoide-Kemp. Whurr Publishers Ltd London

ABR only gives information about the high speech frequencies, therefore much care has to be taken when using this information to fit a hearing aid. There is also a small group of children with very complex needs whose results may not give a true picture of their functional hearing when tested in this way. It is therefore essential that the ABR result is considered together with other information before coming to any conclusion about threshold levels. Very young babies' and premature babies' results can also give unreliable information. The experience and expertise of specially trained staff is required to apply the test and to interpret the results.

Distraction test

Margaret Glasgow, Educational Audiologist

The distraction test was devised by the Ewings in 1944 and over 50 years later is still being modified and used in clinics and hospitals. It is possible, however, that it may become a targeted screen as universal neonatal screening becomes more widespread. In 2009 the distraction tests is rarely used because of the introduction of neonatal hearing screening.

Purpose of Test

The Distraction Test is a behavioural test of hearing used by Health Visitors in many authorities as a screening test of hearing for babies of six to nine months. The test is also used by paediatric audiologists with children up to 18 months as a diagnostic test and for those who have been referred following screening. It may also be used with older children if they are still at the developmental stage for the test. Test techniques may have to be modified but the rigour must be maintained.

Rationale

The test procedure capitalises on the baby's ability and instinct at this stage to turn and locate a quiet sound of interest presented at ear level outside the visual field.

Criteria

At six to nine months a baby should be able to:

- sit up with minimal support
- have good head control enabling them to turn from the mid line to either side
- visually fix on the object of interest.

The room should be:

- minimum size 4m x 4m
- internally and externally quiet
- visually quiet (all toys, pictures and bright, shiny objects should be covered or remove).

The testers should both:

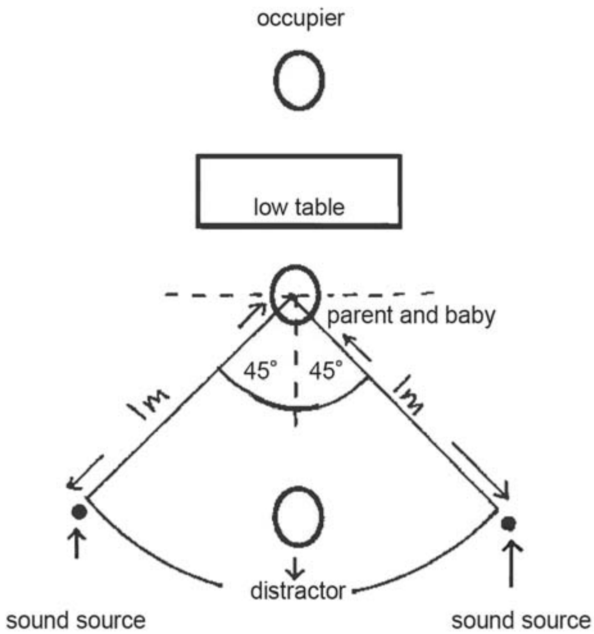
- be appropriately trained
- be physically able to do the test
- be able to hear test stimuli at two metres
- have a refresher course every two years
- have no lisp or voice abnormality.

Procedure

Two trained testers are required. The baby is seated on the parent/carer's lap facing forward and sitting erect. One tester, the occupier, captures and controls his/her attention by a simple activity with, for example a spinning object or small toy on a low table and then covers the object with the baby's hands. The second tester, the distractor, presents the sound stimulus on a horizontal level with the baby's ear at a distance of one metre and at an angle of 45 degrees outside the baby's field of vision. Commonly, the sounds presented are two high frequency and one low frequency. In a screening programme they are presented at minimal levels (< 35 dBA) and for diagnostic testing the threshold of detectability is measured. 'No sound' trials are used to check for searching behaviour.

A high frequency rattle, voice and unvoiced 'sss', are used as sound stimuli and in some areas warble tones (at .5, 1, 2, and 4 KHz) are used. In diagnostic clinics it is usual to use both.

The test is designed to be performed in clinical conditions which are tightly controlled. Testers must be careful not to give the baby olfactory, visual, tactile or auditory clues.



Co-operative test

Margaret Glasgow

Rationale

A child with a developmental age of 18 months should be able to understand the language used to do simple tasks with toys when presented at a minimal listening level.

Criteria

At eighteen to thirty months a child should be able to:

- sit and stand alone without support
- respond to simple verbal instructions in English in a play mode

The tester has to:

- be appropriately trained
- have good child handling skills (particularly when avoiding cues)

Procedure

The toddler is seated at a small table in an appropriate size chair. S/he should be comfortable and have his/her feet on the floor. A shy child may be seated on parent /carer's lap.

The test has two parts:

1 Auditory Discrimination

- Using simple toys a 'giving' game is played. Toys with the same number of syllables and certain acoustic similarities make the test more sensitive, eg mummy (daddy), baby or dolly, teddy. Similarly cup, doll, ball, dog, boat etc. may be used.
- The toys are produced and a check should be made that the child knows each toy eg "Does s/he call this baby or dolly?"
- Each toy is placed on the table and using wooden bricks and a conversational voice the tester demonstrates the game. This can be done by the tester saying, "Lets give this to teddy" etc., or asking Mummy (Daddy) "Give it to Teddy", "Give it to Dolly".

When the child's interest is gained, s/he can play the game. The tester demonstrates the game with the child by guiding his/her hand until it is felt that the child is responding correctly.

- It is then helpful if the brick is given to the child but the tester keeps hold of the brick until s/he has given the command. This stops the child from responding before the command has been given.
- When the child is conditioned the tester should lower his/her voice level to 40 dBA and ensure visual cues are not available. The commands should be given in random order.
- The test should be delivered either in the front, one metre from both ears , or one metre from the left ear and then one metre from the right ear.
- In the diagnostic clinic, if the voice has to be raised above minimal levels, the level is measured using a sound level meter.

If the child will not play this ‘giving’ game, s/he may co-operate to the following:

- “Where are your eyes?”, “Where are Mummy’s eyes?”, “Show me your shoes” etc.
- The dolly, baby or teddy could be used asking similar questions at minimal levels.

2 Auditory Acuity

High frequency sounds are checked by using the distraction test. The high frequency rattle, ‘ss’ and 4 KHz warble tone are presented on both sides.

The test often has to be modified for this age group. Some possible modifications may be:

- The child may wish to stand between parent/carer’s knees
- Presenting the sound at first in the front and continuing it behind.
- Asking the child “Where is that noise?”

No sound trials are important and attention to rigour is necessary eg minimal levels and visual cues.

Pass Criteria

A response at minimal level 40 dBA for the auditory discrimination test and a response at less than 35 dBA to the high frequencies in the auditory acuity test.

It is recommended to use a sound level meter to monitor voice level.

The four-toy eye-pointing test

Margaret Glasgow, Educational Audiologist

The Four Toy eye-pointing test was devised by Barry McCormick. It is the simplest form of speech discrimination test requiring the minimum of cooperation from the toddler. The test is a behavioural test of hearing and is carried out when the child is between 18 and 30 months. This is an age when the child can be most unco-operative!

Purpose of test

The purpose of the test is to establish with the minimal amount of co-operation eg eyepointing, discrimination between two pairs of toys chosen from the McCormick toy discrimination test.

Rationale

A child with a developmental age of 18 months should be able to discriminate toys which are well known to him/her and given at a minimal voice level.

Criteria

At eighteen to thirty months a child should be able to:

- sit and stand alone without support
- understand simple verbal instructions in English

Procedure

The child is seated on his/her parent/carer's knee at a table facing the tester.

- Two pairs of items from the McCormick Toy test are used. These are normally the cup and duck and the spoon and shoe.
- The items are introduced individually and a check made with the parent/carer that the child knows the name. If the child does not know an item a different pair is used.
- The articles are well spaced on the table in an arc.
- At a normal conversation level the tester asks "Where is the shoe?" or "Look at the shoe" etc.
- After two or three tries at a conversational level the voice is lowered to a minimal level of 40 dBA and the face covered to omit visual clues.
- The toys are reshuffled and the game repeated.
- A sound level meter should be used to check sound levels.

Pass criteria

A fixed gaze must be obtained in 4 out of 5 requests at a minimal level of 40dBA.

Performance test

Margaret Glasgow, Educational Audiologist

The Performance Test was another which was first described by the Ewings. It is a test which is demonstrated and is therefore extremely useful for children who have complex language needs or those for whom English is a second language, as verbal instructions are not essential.

Purpose of the Test

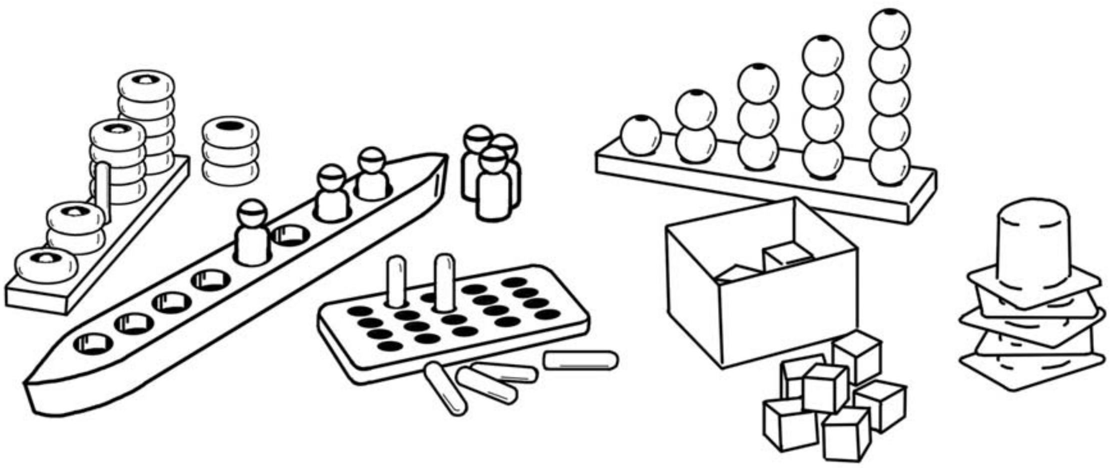
The test is a behavioural test and is carried out when the child is between two and a half and three and a half years developmentally. It is used in community clinics and is a good way of conditioning before using other diagnostic tests eg pure tone audiometry. It is not used so much in diagnostic clinics as if the child is able to do the performance test, s/he can generally do more informative tests.

Rationale

The purpose of the test is to establish the child's ability to respond to both low and high frequency stimuli at minimal levels ie 35 dBA. The word "go" is used as a low frequency stimulus and "ss" as a high frequency stimulus. The test is designed to be of interest to a child at this developmental stage.

Criteria

The test can only be carried out by a child who is developmentally able to wait in order to carry out a simple play task on command. The tester needs good child handling skills.

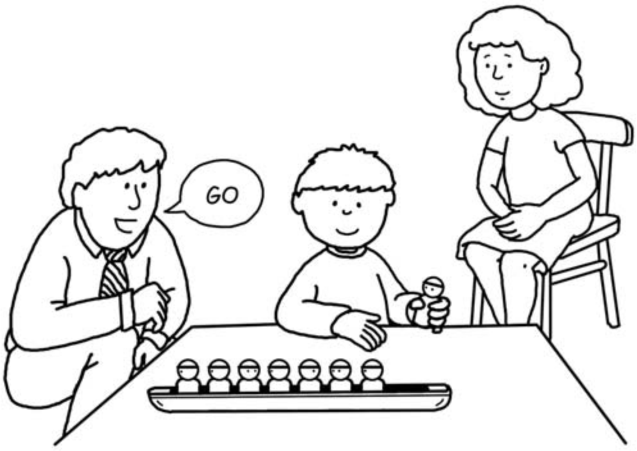


Procedure

The child sits at a small table in an appropriate size chair, with the parent/carer sitting close by. The child should be sitting comfortably with his/her feet touching the floor. The child may sit on parent/carer's lap if s/he is shy or withdrawn.

- A selection of small toys are available for the child to use eg 'men in a boat', peg board, stacking cups, ball on sticks, box of wooden bricks.
- The child is conditioned to respond to a stimulus by putting a man in the boat , ball on a stick, drop a brick in a box etc. On the word 'go' at a conversational voice level the child's hand is guided for example to put a man in the boat. Sometimes it is a good idea to play the game with the parent/carer first.

- When the child can respond reliably on his/her own, the tester uses a small screen in front of his/her nose and mouth to eliminate visual clues and presents the stimulus at a conversational level.
- The voice is quickly lowered to a minimal level ie 35dBA and "o" is used instead of "Go" as the glottal stop 'g' has a broad frequency band.
- The time gap between stimuli must be varied.
- Success must be rewarded.
- Repeat the above points using a different game and the high frequency stimulus "ss". Care must be taken to keep the "ss" unforced and precise otherwise it may encompass other frequencies and invalidate the test.
- The test should be delivered either in the front, one metre from both ears or one metre from the left ear and then one metre from the right ear.



Pass criteria

A child passes the test ONLY if s/he responds to two out of three stimuli at both "go" and "ss" at a minimal level of 35 dBA without any visual clues. It is recommended to use a sound level meter to monitor voice level.

Warble tone generators may be used instead of "go" and "ss". However, a young or very shy child is often more responsive to the voice. When a child responds readily to the warble tones it is usually an indicator that s/he is ready to do a pure tone audiogram.

References (for all behavioural tests)

Screening Hearing Impairment in Young Children, Barry McCormick. Croom Helm
ISBN 0-7099-4643-0
Audiology in Education, McCracken and Laoide-Kemp Whurr Publishers ISBN 1-86156-017-6
Paediatric Audiology 0-5 years second edition, Barry McCormick. Whurr Publishers ISBN 1-897635-25-7

Speech discrimination for the under-fives

Margaret Glasgow, Educational Audiologist

Several speech discrimination tests have been devised to use with toddlers from two to three years old. The Kendall Toy Test (1954) and the McCormick Toy Test (1977) tend to be the most widely used for this age group.

Purpose of the Test

The test should be one of a battery of tests to assess hearing function. A by-product of the speech test is that it often helps the parent/carer to realise that there may be a hearing loss present. Specifically, it tests discrimination of simple English vocabulary.

Rationale

The test identifies the child's ability to point correctly to a toy when its name is spoken at a minimal voice level of 40 dBA. Lip-reading is denied the child by covering the mouth or ensuring the child is not looking when the words are spoken. The toys used in each test are deemed to be familiar to most English speaking two year olds.

Criteria

The test is carried out when a child can identify a number of the toys used in the test and wait for long enough to listen and carry out a simple pointing or giving activity. This test can be effectively used with older children with more complex needs and with young children who have indistinct speech. The tester needs good child handling skills.

Procedure

The child sits at a small table in an appropriate size chair, with the parent/carer sitting close by. The child should be sitting comfortably with his/her feet touching the floor.

The child may sit on a lap if s/he is shy or withdrawn.

- The toys are produced one at a time by the tester who is seated in front of the child, and the child is asked to name them. This is not a requirement of the test but can give valuable information about the quality of speech sounds. If the child does not name the toy the parent/carer is asked if the toy is known.
- Only pairs of toys well known to the child are used in the test.
- The child is conditioned to point to the toys when asked "Where is the..." or "Show me the...". Occasionally a child will only respond to "Give me the....". The tester has to be careful to replace the toy in its original place.
- When the child can respond reliably at a conversational level, the tester uses a small screen to cover his/her nose and mouth to eliminate visual clues and repeats the request at a conversational voice.
- The voice is quickly lowered to a level where the child can correctly identify four out of five of the toys requested.

The voice level is measured by a sound level meter at the child's ear. Sometimes it is possible to get more information by testing a metre to the side of each ear (as for the distraction test).

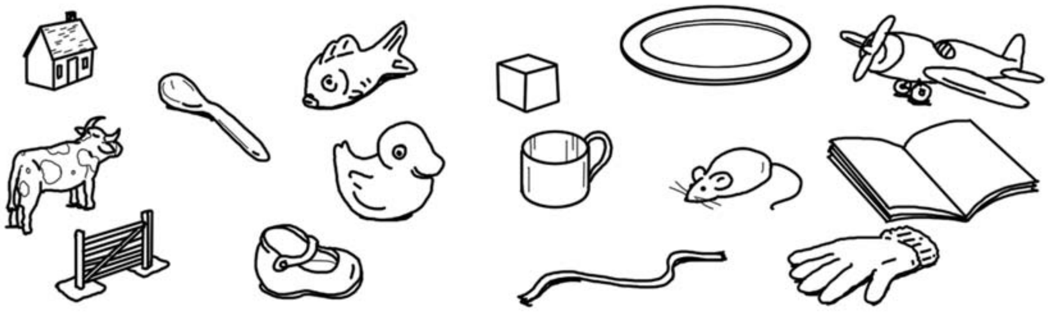
Kendall Toy Test

The test items are grouped according to vowel sounds:

house	cow
spoon	shoe
fish	brick
duck	cup
gate	plate

The distractors are: mouse, book, string, glove, plane

This test can not be bought as a boxed set. It has to be collected by the tester.

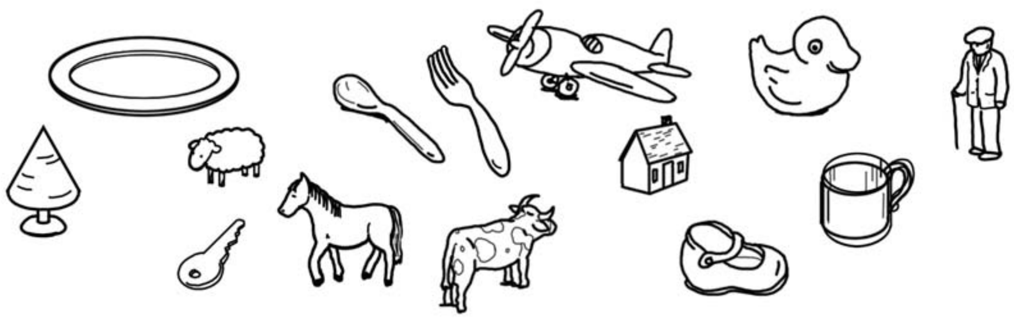


The McCormick Toy Test

The toys are paired items of monosyllables with the maximum degree of acoustic similarity within the constraints of the child's limited vocabulary.

cup	duck
spoon	shoe
man	lamb
plate	plane
horse	fork
key	tree
house	cow

A boxed set of these toys can be purchased from:
J & B McCormick
Woodlands, 18 Nottingham Road, Lowdham
Notts NG14 7AP Tel: 0115 9663961
www.mccormicktoytest.co.uk/



A company called Soundbyte Solutions has produced two automated versions of the McCormick Toy Test known as the Parrot and the Phoenix. Details can be found on www.soundbytesolutions.co.uk

References (for all behavioural tests)

Screening Hearing Impairment in Young Children, Barry McCormick. Croom Helm ISBN 0-7099-4643-0
Audiology in Education, McCracken and Laoide-Kemp Whurr Publishers ISBN 1-86156-017-6
Paediatric Audiology 0-5 years 3rd edition edition, Barry McCormick Whurr Publishers ISBN 1-86156-217-9

Pure tone audiometry (Air conduction)

Margaret Glasgow

The audiometer was introduced in the early 1900s. There are several types of audiometers available now ranging from the simple screening type which measures a restricted range of frequencies and intensities to the complex clinical types used in diagnostic clinics.

Purpose of the Test

Pure tone audiometry assesses hearing sensitivity. It measures the quietest sounds that can be heard at each frequency, in each ear. This is called the 'threshold of detectability' and is measured in decibels of hearing loss (dBHL). 0dBHL represents clinically normal hearing at each audiometric frequency. Air conduction thresholds are measured for pure tones heard through headphones placed over the ears. These thresholds are recorded on a graph called a 'pure tone audiogram' (PTA).

Rationale

To establish the threshold of detectability at specified frequencies in the speech range in each ear.

Criteria

The test can only be carried out if the child/adult is prepared to wear headphones and can wait and indicate in some way that a sound has been heard. The test area must be quiet enough to preclude auditory distractions.

Procedure

The procedure is explained carefully to the testee. A response is made by the testee whenever the test tone is heard, however faintly. The response may be the pressing of a button or the lifting of a finger.

It should be a silent response. The tester should be able to observe the child but not give any clues as to when the tone is being presented.

The procedure should be as follows:

- the better ear (if known) is tested first
- the headphones are colour coded, red for the right ear, blue for the left
- the results are recorded on the audiogram form as circles for right ear thresholds and crosses for left ear thresholds (unmasked)
- the test tone should normally be of 1-3 seconds duration
- the length of time between tones should be varied
- start at 1000Hz 40 dB above the estimated threshold
- increase in 20dB steps until there is a response
- decrease in 10dB steps until there is no response
- increase in 5dB steps until there is another response
- threshold is the lowest level when two out of three responses are achieved when ascending in 5dB steps
- repeat this procedure at 2000, 4000, 8000, 500 and 250 Hz for each ear.

This method is often called the '10 down, 5 up' procedure.

Thresholds may vary on repeat testing especially if it is a different tester or a different audiometer. The test retest variability may be as much as 15 dB at any one frequency.

Pure Tone Audiometry for the under five's or children with additional difficulties.

Most children of three and a half years and over are able to complete pure tone audiometry. Occasionally children from the age of two and a half years are able to co-operate.

The child should be seated at a small table with a parent/carer sitting next to them. The room should be visually and acoustically quiet and any medical equipment covered in case the child is distracted by it. All toys and games should be kept out of sight until needed. The tester should be at the child's side with the audiometer behind the child and out of sight. The tester has to take great care that the child does not see him/her operating the audiometer.

It is sometimes advisable to start with a performance test in order to help the child relax. The child is then conditioned to respond to a pure tone through the head set which is placed on the table or to a warble tone produced through a warble tone generator. The signal should be well above the child's threshold. The response may be a simple game such as dropping a brick in a box, placing a peg in a board or a man in a boat. The activity has to be interesting but simple. Several different activities may be needed in order to keep the child's interest.

The procedure can be carried out by demonstration alone or with the minimum of voiced instructions. If a child is, for example, using a board and pegs and responds when a signal has not occurred, the peg can be removed and a new one given to try again. It is important with some children not to say "No, that was wrong" as they may refuse to continue.

Young children have shorter concentration spans and therefore it is sensible to achieve the air conduction thresholds that will give you the information needed about the key frequencies to acquire speech and language. Thresholds at 1000, 4000 and 500Hz should be achieved in each ear first and then others if the child is still willing.

Pure tone audiometry (Unmasked bone conduction)

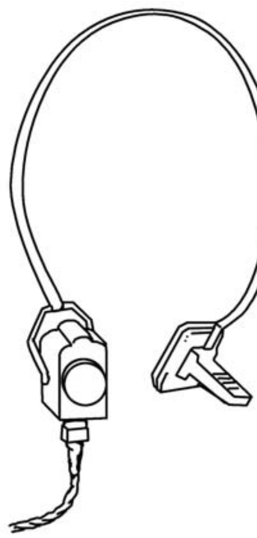
Sue Westhorp

Pure tone audiometry by bone conduction is used in conjunction with air conduction measures to gain more information about the nature of a hearing impairment.

Purpose of the Test

Pure tone audiometry by air conduction, using headphones, determines the quietest sounds that can be heard at each frequency in each ear, i.e. the threshold of detectability (in dBHL). Once this measure has been made, pure tone audiometry by unmasked bone conduction is used to gain more information about the nature of the hearing impairment.

The results recorded by air conduction give an overall level of hearing. This is then refined to determine which part of the hearing mechanism is giving this response. Bone conduction thresholds are measured by introducing pure tones through a vibrator which is placed on the mastoid process. Results are recorded on the audiogram in dBHL.



The vibrator can be placed on either side of the head. The signal by-passes the outer and middle ear and is delivered through the bones of the skull directly to both cochleas. The thresholds recorded will be those of the cochlea responding to the quieter stimulus. This gives information about the sensori-neural component of a hearing impairment.

Results of air and bone conduction are compared to determine the nature of the hearing impairment: conductive, sensori-neural or mixed.

Rationale

To establish the threshold of detectability of the better cochlea.

Criteria

The child/adult is prepared to wear a vibrator on a headband and can wait and indicate in some way that a sound has been heard.

Procedure

Generally air conduction thresholds are obtained first and if these indicate a hearing impairment then bone conduction measures can be made.

The procedure is the same as for air conduction using the 10 down, 5 up method for presentation of tones.

- the vibrator is placed on the mastoid, away from the pinna and hair. The other side of the headband is placed in front of the other pinna, on the cheek so as not to obstruct the ear canal
- the child/adult is instructed to indicate when a tone is heard
- the test tone should be of 1-3 seconds duration
- the length of time between presentations should be varied

- the signal is presented at the threshold of air conduction or just below, taking into account the maximum output of the audiometer
- increase in 5dB steps until there is a response
- decrease in 10dB steps until there is no response
- increase in 5dB steps until there is another response
- threshold is the lowest level where at least half of the responses are achieved ascending in 5dB steps.

Note

Unmasked bone conduction thresholds are indicated on the audiogram form with a small triangle.

The frequencies tested will be dependent on the results of air conduction testing.

Testers need to be aware of vibro-tactile thresholds when employing bone conduction audiometry.

These are recognised to be:

250Hz: 20-40 dBHL

500Hz: 55-70 dBHL

1KHz: 80-85 dBHL

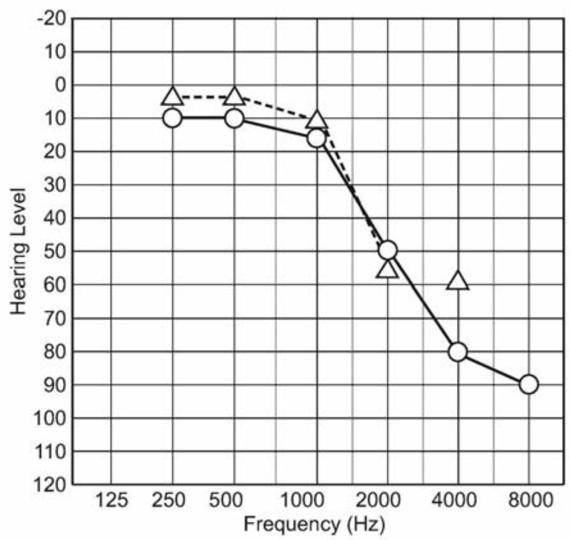
These are levels at which the responses obtained may be to a stimulus that is felt rather than heard.

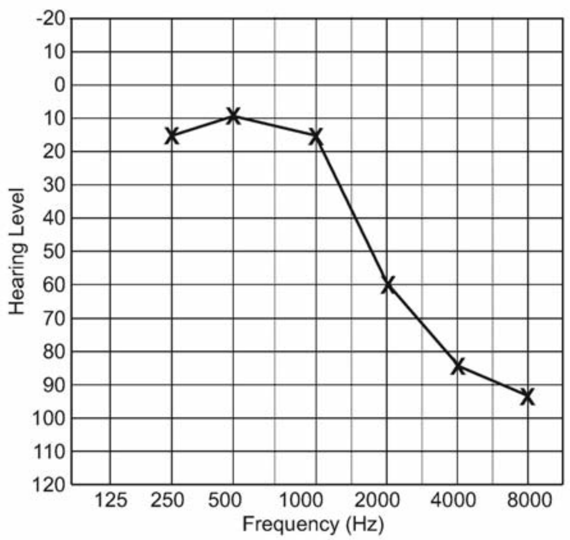
Bone vibrators are limited in their frequency range and the output they can give; up to 30/40 dBHL at 500Hz to 60 dBHL at 1, 2 and 4 KHz.

Interpreting the results

In practice a gap of 15db or more between an air conduction and bone conduction results at any one frequency is generally considered clinically significant.

Certain audiogram configurations make masked bone conduction essential.





Masking in pure tone audiometry

Sue Westhorp

Purpose of the test

The technique of masking is used in order to isolate the test ear and ensure that results obtained are the true thresholds of the test ear.

In pure tone audiometry for both air conduction and bone conduction it is possible that responses obtained are those of the non-test ear.

Rationale

To establish the true threshold of detectability for air and bone conduction.

Air conduction pure tone audiometry

It is possible for sounds introduced into the test ear via headphones to be carried by bone conduction across the skull and stimulate the cochlea of the non-test ear. The amount of sound energy that is lost as it crosses the skull is known as transcranial attenuation. It varies in individuals between 40 and 85 dB. It is accepted that if the difference in thresholds between the air conduction results at any frequency is 40dBHL or greater then it is possible that the response is due to stimulus of the non-test ear.

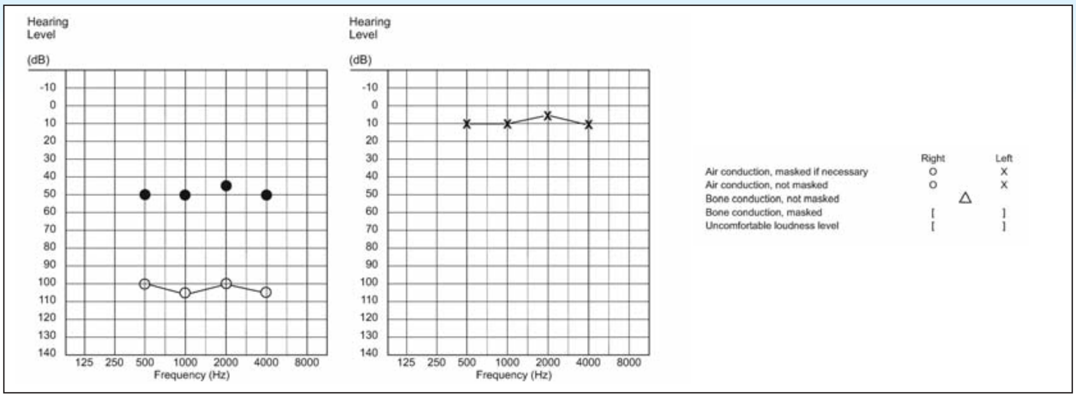
When there is this difference of at least 40dBHL then masking is introduced in order to isolate the test ear and obtain true thresholds.

In masking a narrow band noise centred around the test frequency is introduced into the non-test ear. This noise “occupies” the non-test ear and allows the test ear to respond at its true threshold. Pure tones are presented into the test ear in the usual way until a true threshold can be recorded.

Masking procedure in air conduction testing (This is known as Hood’s technique)

- The procedure uses conventional headphones.
- The adult/child is asked to listen to the narrow band noise in the non-test ear and indicate when it is just audible. Increase the level by 20dB. Instruct the adult/child to ignore this noise and listen for the signal.
- Using the usual 10 down 5 up method, re-measure the threshold of the test ear.
- Increase the masking level by 10dB.
- Re-measure the threshold.
- Repeat the process until for two successive increases in masking level the threshold does not change.
- This gives the true air conduction threshold of the test ear.
- This technique is not recommended for very young children as they can find it difficult to understand what to do. Generally it can be done at around age seven.

Figure 1 gives an example of masking being required for air conduction.



The unmasked results show responses on the right at around 50dBHL and on the left around 10dBHL. As there is a difference of 40dB it is possible that the original responses recorded for the right are in fact the left cochlea responding.

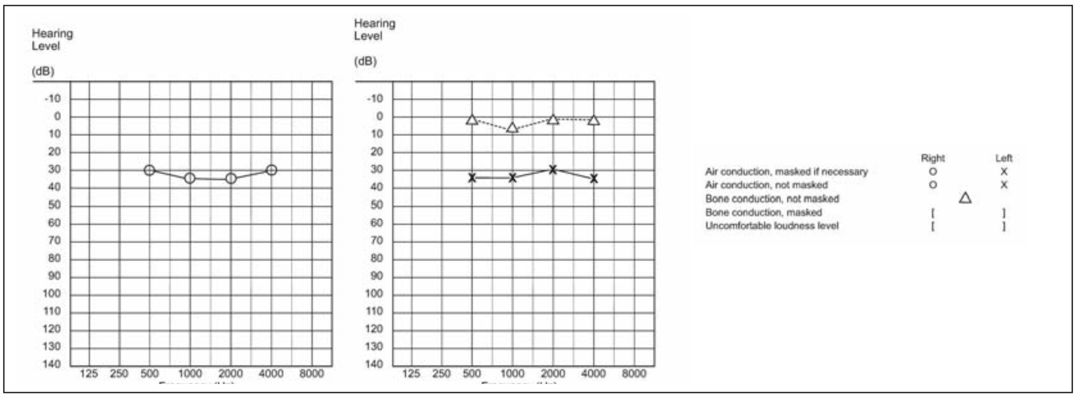
Masking is required to determine the true threshold on the right.

Bone conduction pure tone audiometry

In bone conduction pure tone audiometry masking for bone conduction assessment is required when there is a gap at any frequency of 15dB or more between the unmasked bone conduction result and the air conduction threshold. This is known as the air-bone gap.

Figure 2 shows an example of bone conduction results that require masking.

Air conduction results show a mild hearing loss in both ears. The unmasked bone indicates normal cochlea function in at least one cochlea. With this result it is not possible to know if the right, left or both cochlea are giving this response. Masking is required to determine the response of each cochlea.



Masking in bone conduction testing

- The same method is used as for air conduction.
- The bone conduction vibrator is placed on the mastoid process of the test ear.
- Masking noise is introduced to the non-test ear through an insert earphone which is placed in the ear canal and held in place by a hook over the pinna. The tone is introduced via headphone into the test ear.

Visual reinforcement audiometry

Margaret Glasgow

Visual Reinforcement Audiometry (VRA) has been developed over the last 30 years and is now used in most diagnostic audiological centres and in some community clinics.

Purpose of Test

The test is a behavioural test which can be carried out with young children between the developmental ages of 6 months and 3 years. It can also be used for children with complex needs. Sound field thresholds can be measured with and without hearing aids.

Rationale

Sounds are presented through a loudspeaker or insert earphones and the child responds by turning his/her head and is rewarded with a visual stimulus. The visually-interesting stimulus encourages the child to respond to the sound more often than is the case in the distraction test. Frequency-specific thresholds using warble tones or narrow band noise can be determined using this technique. This is not a test of location.

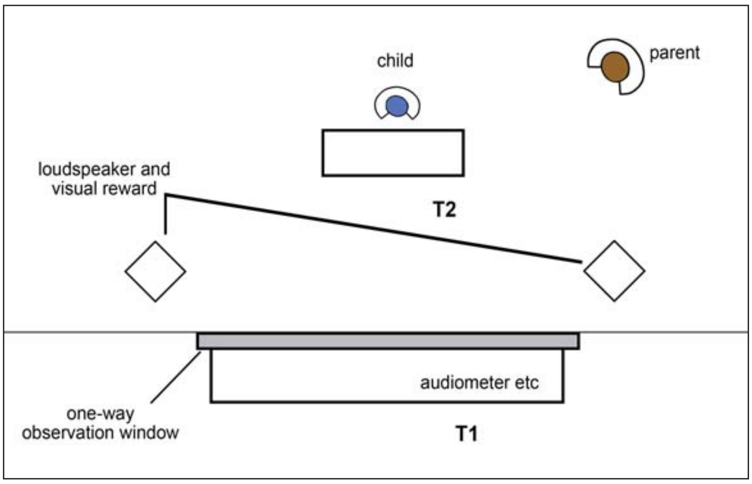
Criteria

The test can be carried out by a child who is able to sit on his/her own or on a parent/carer's lap and by children with complex needs who may need to be lying down. The testers need to be appropriately trained. It is not a distraction test and different skills are needed.

The child is seated comfortably at a small table/high chair or if very young or shy may prefer to sit on parent/carer's lap. The child has a few toys to occupy him/her.

A very young baby is often content with something to hold.

Two room arrangement for VRA.
T1 and T2 are the testers



- The sound and visual reward (usually a flashing light or a moving puppet) are presented at the same time and the child is shown where to look for the reward. The sound stimulus is presented at an intensity level and frequency where it is thought the child may be able to respond.
- This conditioning is repeated until the child is able to anticipate the visual reward and look as soon as the sound is presented.
- When the child is regularly anticipating the reward the sound only is introduced and the visual reward is given after a definite head turn.
- Fairly long gaps in the presentation of sounds are required, otherwise the child will keep checking and it will be difficult to be sure of the response.
- There is no rigid protocol for presenting stimuli. The most useful information is gathered before the child tires. Minimum responses are recorded at 1khz, 4 khz, and 500 khz to gain information across the frequency range.
- Thresholds below normal limits are not usually investigated.

In the majority of cases two appropriately trained testers are needed:

Tester 1 operates the audiometer and gives the visual reward.

Tester 2 is with the child and helps to manage his/her behaviour. This is a low key activity which keeps the child facing forward. S/he gives encouragement during conditioning and is responsible for deciding when /if a different toy needs to be introduced. It is not always necessary for this tester to manage the child's attention after conditioning as some children sit quite happily with a toy and respond to the sounds appropriately. A young child can often be managed effectively by the parent/carer with instructions from the tester.

It is possible to use only one loudspeaker located at 45, 60 or 90 degrees azimuth.

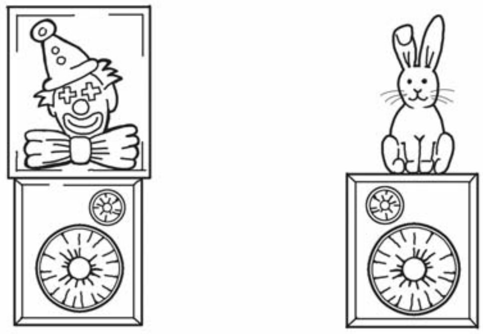
VRA and Bone Conduction

This behavioural test is also used to gain information about bone conduction thresholds using a conventional bone conduction vibrator and headband.

VRA with Insert Earphones

Small earphones can be inserted into the ears which enable sound stimuli to be presented at the tympanic membrane. Thresholds of detectability at specific frequencies can be measured in each ear. Sounds are normally warble tones or pure tones.

This method enables babies as young as 6 to 7 months to give results that can be plotted as a bilateral audiogram and is essential for hearing aid fitting and audiological management.



Loudspeakers and visual reward

Speech Recognition Tests

Sue Westhorp

Several speech recognition tests have been designed for use with adults and young children. The Manchester Junior word list (MJ) is commonly used with children and the Arthur Boothroyd (AB) list with adults and older children.

The MJ lists are considered appropriate for a child with a developmental age of six plus. The AB lists may be used if is it judged that the child has the maturity for that vocabulary. The Manchester Junior list is available as standard lists (25 words) and short lists (10 words). See Figure 1 for examples of the AB and MJ short word lists.

Purpose of the test

The test should be one of a battery of tests designed to assess hearing sensitivity with and without hearing aids as applicable.

Rationale

These tests provide information on the child's ability to hear and comprehend speech. The choice of test will be a function of language level and not necessarily chronological age.

Criteria

The child should be able to repeat the words spoken by the tester or presented through headphones without lip-reading.

Figure 1:

Manchester Junior (MJ) Short Lists			**Arthur Boothroyd (AB) Short Word Lists**		
red	some	dog	ship	fish	thud
snow	not	head	rug	duck	witch
wood	tin	sit	fan	gap	wrap
lid	hat	plant	cheek	cheese	jail
cat	gold	smoke	haze	rail	keys
sweet	this	good	dice	hive	vice
dig	sail	feet	both	bone	get
night	bed	dish	well	wedge	shown
pond	moon	sun	jot	moss	hoof
push	knife	time	move	tooth	bomb

Figure 2: AB WORD LISTS

NAME: A Smith		DATE: 02/01/00	HA: 2 x PPCLA		
LR + / – Volume: 3		**LR + / – Volume 3**	**LR + / – Volume ....**		
Settings		**Settings**	**Settings**		
Voice	**60dBA**	**Voice 50dBA**	**Voice ....dBA**		
Ship	3 of 10%	Fish	3	Thud	....
Rug	3 of 10%	Duck	3	Witch	....
Fan	3 of 10%	Gap	1	Wrap	....
Cheek	2 of 07%	Cheese	2	Jail	....
Haze	2 of 07%	Rail	1	Keys	....
Dice	2 of 07%	Hive	1	Vice	....
Both	3 of 10%	Bone	2	Get	....
Well	3 of 10%	Wedge	0	Shown	....
Jot	1 of 03%	Moss	2	Hoof	....
Move	2 of 07%	Tooth	2	Bomb	....
	24/30+80%	**17/30=56%**			

Procedure

The MJ word lists are monosyllabic. There are 25 words in each standard list, scoring is by whole word and a percentage determined. There is also a series of Manchester Junior short lists with ten words in each list (see figure 1). These are scored by phoneme in the same way as the AB word lists.

The AB word lists have 10 words in each list. Scoring is by phoneme; three phonemes in each word. Each list is scored out of thirty and a percentage determined.

For example the word given is ship. It has three phonemes: sh-i-p

Response is	ship	score 3 points or 10%
Response is	tip	score 2 points or 7%
Response is	pit	score 1 point or 3%

Some testers prefer to give a score of 10% to each word and convert directly to a percentage.

- The test can be presented by live voice or by tape to each ear separately, through headphones.
- If the words are presented by a live voice, the tester sits opposite the child, about a meter away. The child is asked to listen for the word and then to repeat what they have heard. They are encouraged to make a guess if they are not sure. The first list can be read at a conversational voice level with lip-reading to give confidence to the child.
- The voice level is constantly monitored with a sound level indicator placed level with and alongside the child's ear.
- The first list presented without lip-reading is presented at a voice level where it is expected the child should achieve at least 80%.
- The responses are recorded by the tester, scoring whole word for the MJ lists and by phoneme for the AB lists and short MJ lists. The voice level is also recorded.
- The voice level is then decreased in approximately 10dB steps for each subsequent word list until the child scores approximately 50%.
- 40dBA is considered a minimal voice level for the discrimination of speech.
- Words presented by tape via a headphone allow for uniformity of presentation of voice level. The first list is presented at a level where the child might be expected to achieve a maximum score and the test is continued in the same way as for live voice testing. Each ear can be assessed separately.
- When hearing aids are worn, these tests can be presented by live voice to each ear separately or binaurally.

A speech audiogram can be plotted and compared with a normal response (Figure 3). The speech audiogram of a person with a hearing impairment will differ from that of a person whose hearing is within the normal range. Figure 3 curve N shows a speech audiogram for a person with normal hearing. 100% accuracy can be achieved at a quiet voice level, in this example 40dB.

The speech audiogram of a person with a hearing impairment would be shifted to the right ie they need voice to be louder in order to achieve their maximum discrimination. This shift to the right

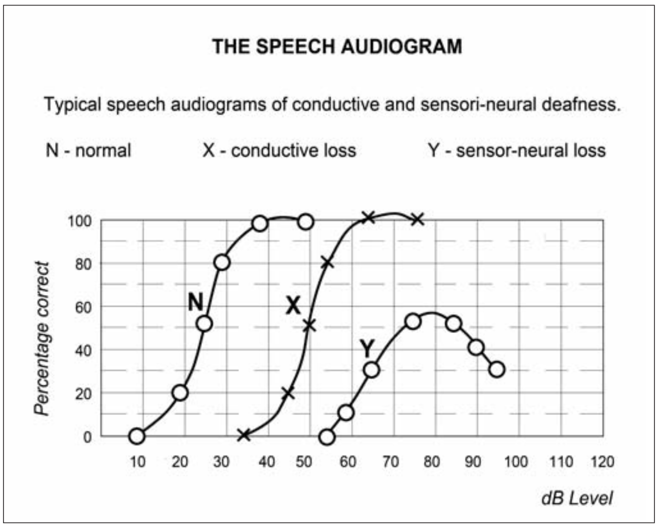


Figure 3

Figure 4

Test used	Conversational voice		Quiet voice	
	Level	Score %	Level	Score %
Aided + lipreading				
Aided – lipreading				
Unaided + lipreading				
Unaided – lipreading				

corresponds to the degree of hearing impairment. For a person with a conductive hearing loss the curve would be shifted to the right and a score of 100% can be achieved (figure 3 curve X).

For a person with a sensori-neural hearing loss a score of 100% may not be achieved. Their curve would be shifted to the right, they would achieve their highest score but increasing the loudness level of the word lists above this level would result in a decrease in discrimination of speech and a falling off of the score (figure 3 curve Y).

It may be appropriate for peripatetic teachers to do a quick assessment in school. Figure 4 gives an example that teachers may find helpful.

This quick test can be done with the MJ short lists or the AB lists, with or without hearing aids and with and without lipreading. It can be used with any child seen in school. The procedure would be to present a list at conversational voice (60dBA) with lip-reading. Note this level and the score achieved on the form. Present the next list at quiet voice (40dBA), record the results, then continue, using the next list and assessing without lip-reading at conversational and quiet voice.

Two pairs of hands and a bite bar!

Ken Higgins, Ewing Foundation Technician

Practical considerations around subjective listening tests of bone anchored hearing aids (BAHA) when used alone or in conjunction with personal FM systems.

This article relates to BAHAs supplied by Entific Medical Systems (formerly Nobel Biocare and Nobelpharma). BAHAs were described in detail in the article 'A Bone Anchored Hearing Aid, What's That?' (Sheena Hartland BATOD Magazine, May 1998).

Children with a conductive loss, or those who have a sensory-neural loss but cannot wear a conventional hearing aid for some reason, may have amplification conveyed by bone conduction.

Traditionally, delivery of amplified sounds has been achieved by the positioning of a vibrating transducer on the mastoid area of the skull. Energy from a conventional body-worn or behind the ear aid is used to activate the transducer. This is held in place by a sprung steel headband similar in appearance to an alice band or tiara.

In an attempt to maintain consistent perceived sound levels it is endeavoured to keep the transducer held at a constant optimum pressure and position. It can be appreciated that this device is not the easiest or most comfortable to wear and that children especially may have difficulties in obtaining optimum benefit. Fortunately use of these bone conducting aids may only be for limited periods due to suppurative ears or whilst awaiting corrective surgery or other treatments.

In more recent years an alternative bone conducting aid has become available in the form of the Bone Anchored Hearing Aid (BAHA). This is sometimes considered for patients who require amplification by bone conduction on a more permanent basis. BAHAs dispense with the headband to hold the transducer in place. Instead an abutment (fixing lug) is surgically implanted into the skull and the vibrating transducer clips securely to it, providing consistent transmission of amplification. This overcomes some of the difficulties encountered when trying to wear the previously discussed bone conduction hearing aid. It must be stressed that BAHA is an option and not appropriate in all cases.

It is recognised as standard procedure to encourage the carers of young post-aural hearing aid users to carry out regular listening tests on their child's hearing aids, as part of good audiological practice. This is usually reinforced by further subjective and objective checks carried out by the child's Teacher of the Deaf, Learning Support Assistant, or Educational Audiologist. The basic equipment required to carry out subjective checks on post aural aids, together with any personal FM system used in conjunction with them is well documented and available at small cost from many sources.

Bite bar

The situation for subjective checking of equipment used by an increasing number of children fitted with BAHAs may be less clear cut, although the necessity for such checks is just as imperative. The device which enables a normally hearing person to listen to a BAHA is a test rod or bite bar, available only through the supplier of the aid. The bite bar may also serve as a tool used in initial audiological assessment of patient suitability for implant.

BAHA with bite bar attached

In theory listening in to a BAHA via the bite bar is easy.

1. Remove BAHA from the child's implanted abutment.
2. Fit the BAHA to the abutment in the end of the bite bar.
3. Grip the other end of the bite bar between the teeth, closing your lips around it.
4. Close off your own ear canals.

These steps allow environmental sounds to be heard through the BAHA, teeth and skull via bone conduction. This now leaves you free to check if the BAHA is functioning well using methods normally used with acoustic aids. Volume control and switch can be tested and slight pressure can be applied to the case to check for internal intermittence or faulty battery contacts. Judgements can be made regarding sound quality. Throughout these tests some handling noises will be heard. The mention of handling noises raises the question, "If you are using your fingers to close off your own ear canals, which pair of hands do you use to check the aid?" Obviously you need to devise your own preferred method of closing off your own ear canals whilst testing – ear defenders, solid moulds, ear plugs etc. This method of checking can also be utilised to test an FM system BAHA combination.

1 Carry out conventional FM only tests, ensuring that the system functions properly as a standalone item.
2. Likewise carry out the above BAHA tests and be confident that this too is working OK as a standalone item.
3 Connect the FM receiver to the BAHA via the audio input adapter and switch the BAHA to the E position (T on the Cordelle).
4 witch the FM receiver on.
5 Switch the FM transmitter on and place it by some sound source at least 4m distant.
6 You should now hear that sound source through the BAHA. Gently squeeze the audio adaptor and flex the leads and connectors whilst listening in. Your sound source should be heard consistently without any intermittence.
7 Now switch the BAHA to the M position. You should still hear the sound source via the FM receiver but also you should hear environmental sounds via the BAHA microphone.

Some people may experience difficulty carrying out tasks whilst holding the bite bar clenched between their teeth. For such people all is not lost, especially if they have access to a friendly Audio-Visual (AV) department or technician. It is relatively simple to attach a small microphone to the bite bar. If this microphone is then fed to a battery powered amplifier and headphones, then listening becomes easier. The BAHA can now be checked at arms length and there is no need to occlude your own ear canals, other than by lightweight amplifier headphones or stetoclip. I use this method myself quite successfully and sound quality from the BAHA or BAHA + FM is good and is repeatable. I would be happy to pass on more detailed information to any interested party should they wish to follow this route.

There is little doubt that, particularly with small children, BAHA s and BAHA FM combinations should be listened into on a regular basis by a normally hearing person, as a parallel to the checks carried out on conventional acoustic aids. However bite bars are listed on Entifics February 2K price list at £80.00 ex.VAT. Anecdotal information seems to suggest that there is debate as to just who should provide the device for use by a responsible adult.

This aspect needs to be formalised to enable adequate provision of bite bars to take place.

One final point concerning BAHA FM combinations relates to the FM receiver output level. Entific normally recommend that on initial fitting of the FM system the output level of the receiver is adjusted and set by themselves. The importance of this is heightened in the case of small children or users who cannot report. Once set it is good practice to record and monitor the output level of the receiver, in particular following a repair where, when returned, the output level could be very different than that set by Entific.

If you are using a Connevans FM system and you have access to a Connevans output level setter (OLS) then life is easy. Alternatively a record of receiver output level can be obtained by the use of a hearing aid test box and a wide band ear receiver which is kept specifically as a reference ear receiver. This second method is not too onerous.

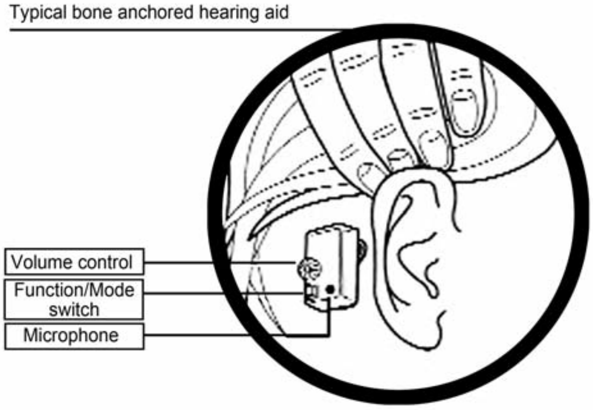
1 Connect the ear receiver to the output socket of the FM receiver via a suitable lead.
2 Snap the ear receiver into the test box 2cc coupler. Lay the coupler and ear receiver on a soft surface outside of the test chamber.
3 Put your FM transmitter microphone into the test chamber and run and print out your curves.

A suggestion has been made that two curves are recorded with transmitter input levels of 65dB and 90dB. These records will enable you to ensure that the FM receiver or any loan FM system is easily adjusted to the level as originally set by Entific.

Margaret Price, Sales and Education Manager
Tel: 07771-880652.

BAHA is a registered trademark.

Ken Higgins is the Ewing Foundation Technician offering technical support to deaf children in education. He would be happy to discuss matters arising from this article or other matters pertaining to technical support. He can be contacted at Deaf Direct, 13 Castle Street, Worcester, WR1 3AD, Tel. 01905-746307 or Mobile 07866-920401.



Drawing from 'Hearing Aids – A guide' with thanks to NDCS

Checking behind-the-ear (BTE) hearing aids

Margaret Glasgow

Hearing aid users who have significant hearing losses need appropriate, working hearing aids, which are worn all the time. It is therefore important that the hearing aids are checked regularly whilst the child is young or is an inexperienced user and cannot alert anyone to the fact that they are not working satisfactorily.

Hearing Aid

A hearing aid consists of three parts:

Earmould and tubing

Hook

Hearing aid (plus audio shoe if used with a radio aid)

If one of these parts is not working the whole system breaks down. When the earmould becomes too small or worn and the hearing aid starts to whistle, a new earmould impression should be taken immediately. The situation will not get better (only worse) and it may take two or more weeks to get new earmoulds. Turning the hearing aid down to stop the whistling means the child/pupil cannot hear sufficiently well to discriminate speech correctly.

Look at......

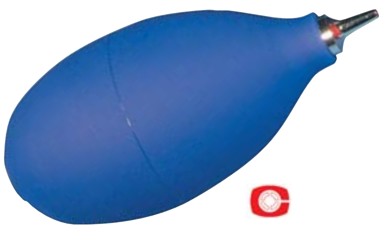
1 earmould and tubing

a) *Is earmould discoloured, rough, torn, chipped?*
If so: **make an appointment for impressions for new earmoulds.**

b) *Is earmould blocked with wax or secretion?*
Is earmould dirty?
If so: **wash in hot, soapy water, rinse and dry.**
Clear droplets of water in the tubing with earmould puffer.

c) *Is the tubing split, squashed, twisted or hard?*
If so: **re-tube earmould**

d) *Is there condensation in the tubing? (You may notice little drops of water in the tubing when the child becomes hot after playing or on a warm day)*
If so: **clear droplets of water with earmould puffer.**



2 hook

a) *Is the hook split, broken etc?*

If so: **take/send hearing aid to the hospital so that the correct hook can be replaced (ensure that it is the same number eg PD1000 and size of hook eg mini).**

b) *Is there condensation in the hook?*

If so: **clear droplets of water by removing the hook and blowing through with the earmould puffer.**

!!!!!! BEWARE !!!!!!
There may be what looks like small pieces of tissue in the hook.
These are filters.
DO NOT REMOVE

3 hearing aid

a) *Is casing damaged?*
b) *Is battery compartment tight?*
c) *Is the on/off switch broken or jammed?*
d) *Is the microphone blocked?*

If so: **Take the hearing aid to the hospital and if it needs repairing get a loan aid. Ensure that the make, model, hook and settings are the same as the original hearing aid.**

Listen to......

a) Turn hearing aid on and turn the volume control to maximum. The hearing aid should whistle.

This information indicates that the battery is working – it does not give information about the quality of sound heard.

No whistle? Check that there is a battery; that it is fully charged; and the right way round in the compartment.

b) Listen to the hearing aid through a stetoclip (with an attenuator for high powered aids). Switch hearing aid on. Turn volume up slowly from off and then back down to child's listening level. Squeeze hearing aid to make sure there is not an intermittent fault or distortion.
IS SPEECH CLEAR?
If not: **Take/send hearing aid to the hospital and ask for a loan aid as above.**

CHILDREN WHO WEAR TWO HEARING AIDS SHOULD ALWAYS HAVE TWO.

Re-tubing and cleaning earmoulds

Margaret Glasgow

Re-tubing earmoulds

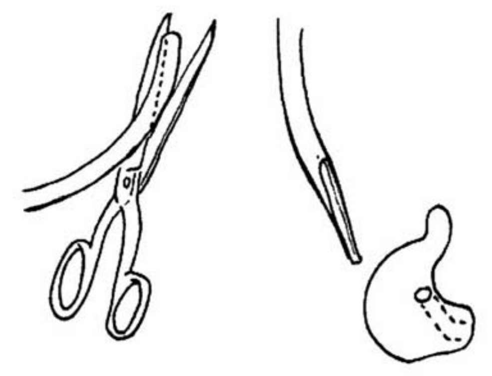
The length of the hearing aid tubing is crucial as it ensures that the hearing aid sits comfortably on the ear and that the microphone is facing forward towards the speaker and not up in the air.

Pre-bent tubing is best and care needs to be taken that the correct thickness of tubing is used eg for powerful hearing aids wide bore, thick walled tubing is usually used.

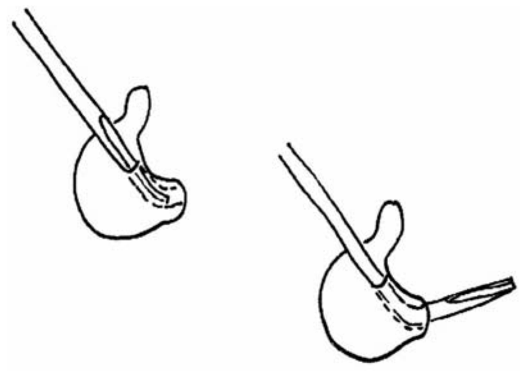
Equipment: **new tubing**
pair of small sharp scissors/scalpel or stanley knife
threader (if necessary)

1 Detach the earmould from the hearing aid.
2 Remove the tubing from earmould being careful not to split the earmould. If the tubing is stuck, soak in hot water for a few minutes and then pull it free.

3 Take a new piece of tubing and cut to a point about 2.5/4cm from one end. This should make threading the tubing through the earmould easier.



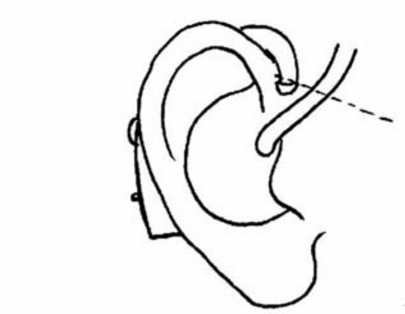
4 Thread the tubing through from the back of the earmould. If using prebent tubing, pull through until the bend touches the back of the earmould.



f A threader may be needed.

5 Cut the excess tubing by the meatus, using scissors/scalpel or Stanley knife.

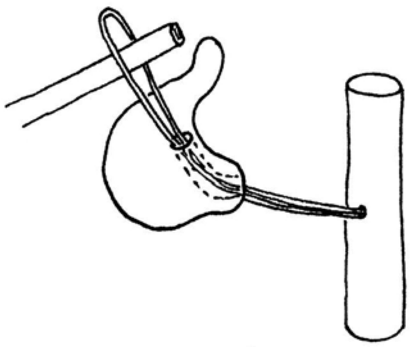
6 Place the hearing aid behind the wearer's ear and mark or cut the tubing just 5mm above the tip of the hook.



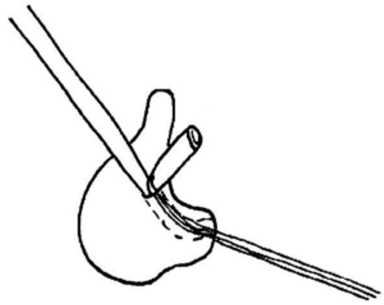
Using a threader

If it is difficult to thread the tubing through the earmould a threader may be used.

1 Thread the threader through the earmould from the front(meatus), hook the tubing through the threader.



2 Pull the threader and the tubing through the earmould (continue from 4).

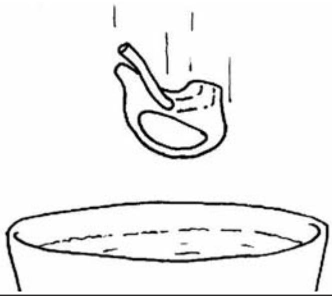


Cleaning Earmoulds

Equipment: **small brush (old tooth brush)**
warm soapy water and towel
earmould puffer

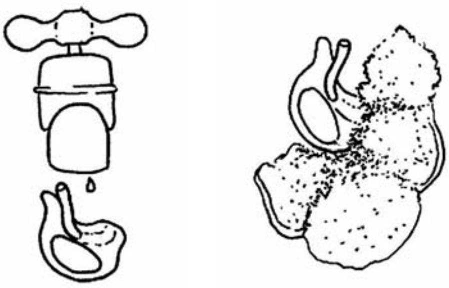
1 Detach hearing aid from earmould.

2 Place the earmould into the warm soapy water and leave to soak for a few minutes. Brush the earmould gently with the soft brush to get rid of all traces of earwax.



3 If there is wax in the tubing, remove it by using the eye end of a darning needle (push the sharp end into a cork to use as a handle) **USE WITH CARE.**

4 Rinse the earmould under the tap and dry.



5 Puff out any water in the earmould tubing and re-attach to the hearing aid.

If the hearing aids have different settings it is a good idea to do one hearing aid at a time so that they are returned to the correct ear. Stickers on the outside of the hearing aids help to ensure they go on the correct ears.

Checking Cochlear Implants

Elizabeth Wood and Sarah Cross, Southampton CI Centre

A cochlear implant is a sophisticated device which electrically stimulates the nerve of hearing. Cochlear implants can help people who are too deaf to benefit from ordinary acoustic hearing aids.

There are three main manufacturers of Cochlear Implants in the UK: Advanced Bionics, Cochlear and Med-El. Each manufacturer has at least one body-worn speech processor and an ear-level speech processor. All the processors have external parts, which can be removed as the patient wishes. Internal parts are implanted during surgery. The checking procedure for each model is different but some basic principles remain the same.

Cochlear Implants need to be working well all the time. The external parts of the device need to be tuned at the Cochlear Implant Centre to suit the individual and this can take a considerable amount of time with a child. It is important to ensure that the speech processor is functioning effectively so the child receives a clear signal at all times and can learn to listen. Young children or inexperienced listeners often cannot identify if something is wrong.

Cochlear Implant equipment should be checked when it is put on and at regular intervals, or at any time when the user is not responding to sound in his/her usual manner.

This is not a comprehensive guide to checking and troubleshooting. Please follow the manufacturer's instructions and/or refer to the Cochlear Implant Centre.

The internal device

The internal device can only be checked at a Cochlear Implant Centre.

The external device

The external parts include:

- speech processor
- leads
- microphone
- transmitting coil/headpiece

Some processors incorporate visual and audible signals when there is a problem eg if the battery is low, if the lead comes unplugged or if the map or programme has a fault or has been damaged by static electricity. Refer to manufacturer's guidelines for further information.

Daily Checks to ensure the Cochlear Implant is working correctly:

A Battery

- change battery according to Cochlear Implant Centre recommendations
- ensure that the battery is charged
- make sure the battery is the correct way round.

B Visual check

- check the external casing of the processor and microphone for cracks, missing switches or other damage
- ensure that the leads are not worn, split or bent
- make sure that the coil is not cracked
- buttons/switches/controls should be on settings as recommended by the Cochlear Implant Centre
- all parts must be plugged in correctly.

C Signal check

The signal check shows that the coil is transmitting sounds from the microphone and processor to the internal device. This may be done by one or more of these methods:

- placing the coil on the body worn speech processor and checking for the appropriate light or symbol
- using a hand-held signal check/test plate and checking for the appropriate light
- checking a series of lights or display on the processor
- lights or bars flash in time to sound.

D Listening check

Most manufacturers can supply a device for checking the microphone. Contact the Cochlear Implant Centre for further information.

Listen for any change in the quality of the sound.

If a fault is found, change the leads or transmitting coil in a systematic way. If you still feel there is a problem contact the Cochlear Implant Centre giving them as much information as possible.

Please contact the Centre if the child does not appear to be hearing sounds as usual or is finding some sounds uncomfortable, even if no obvious fault can be found, as the programme or map may need to be changed.

Checking Body Worn Hearing Aids (Analogue)

Margaret Glasgow

Hearing aid users who have significant hearing losses need appropriate, working hearing aids which are worn all the time. It is therefore important that the hearing aids are checked regularly whilst the child is young or is an inexperienced user and cannot alert anyone to the fact that they are not working satisfactorily.

Parents/carers with a baby or toddler

should be advised to check the hearing aids:

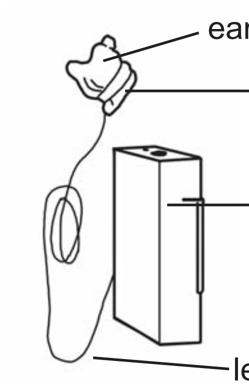
- when they are first put on in the morning
- when they are replaced after a sleep or bath
- at lunch time
- at tea time
- any time when they think the youngster is not responding in his/her usual way to sound.

For school age children:

hearing aids should be checked (together with the radio aid, if used)

- when they arrive at school
- before afternoon lessons
- any time when the pupil is not responding in his/her usual manner to sound.
- any time that the pupil says s/he has a problem with hearing.

A bodyworn hearing aid consists of four parts:



If one of these parts is not working the whole system breaks down. When the earmould becomes too small or worn and the hearing aid starts to whistle, a new earmould impression should be taken immediately. The situation will not get better (only worse) and it may take two or more weeks to get new earmoulds. Turning the hearing aid down to stop the whistling means the child/pupil cannot hear sufficiently well to discriminate speech correctly.

LOOK......

1 Earmould

a) Is earmould discoloured, rough, torn, chipped?

If so: **make an appointment for impressions for new earmoulds**

b) Is earmould blocked with wax or secretion? Is earmould dirty?

If so: **wash in hot, soapy water, rinse and dry**

Clear droplets of water in the tubing with 'earmould puffer'

When having new earmould impressions made make sure that the earmoulds are made for a body worn hearing aid (not a behind the ear hearing aid).

2 Receiver

a) Has it got a washer?

If not: **replace washer (ask hospital if you haven't got a spare)**

b) Is receiver blocked or damaged?

If so: **replace with new receiver (check it is the same type by matching the number or symbol)**

3 Lead

a) Is it frayed, broken etc?

If so: **replace with new lead of the same type and length.**
(Different makes of bodyworn hearing aids have different leads)

b) Is lead knotted?

If so: **untie knot and check for an intermittent fault**
Young babies should have short leads, ask at the hospital.

4 Hearing Aid

a) Is casing damaged?

b) Is battery compartment tight?

c) Does the volume control wheel move smoothly?

d) Is the on/off switch broken or jammed?

e) Is the microphone blocked?

If so: **take the hearing aid to the hospital and if it needs repairing get a loan aid. Ensure that the make, model, length of leads, receiver and settings are the same as the original hearing aid.**

LISTEN ......

a) Turn hearing aid on and turn the volume control to maximum. The hearing aid should whistle.

This information indicates that the battery is working – it does not give information about the quality of sound heard.

No whistle? **Check that there is a battery and that it is fully charged and the right way round in the compartment.**

b) Listen to the hearing aid through a stetoclip (with an attenuator for high powered aids). Switch hearing aid on. Turn volume up slowly from off and then back down to child's listening level. Squeeze hearing aid to make sure there is not an intermittent fault or distortion.

IS SPEECH CLEAR?

If not:
a) **change receiver**
b) **change lead**

If still not working:
take/send hearing aid to the hospital and ask for a loan aid.

CHILDREN WHO WEAR TWO HEARING AIDS SHOULD ALWAYS HAVE TWO.

Checking Digital Hearing Aids

Helen Maiden

Points to remember about digital hearing aids:

- a digital hearing aid may have more than one programme setting - you need to know how to change between the settings and also what each setting is for!
- audiologists usually only set one programme for young children. They either de-activate the other settings or make them the same as the first. This is because children may inadvertently change the programme and be listening inappropriately.
- if there is a volume control, check whether it has been activated.
- remember to use an attenuator, especially when there is no volume control or it is set at a certain level.
- to check through the test box you need to have a Digital Processing Signal.

A digital hearing aid system consists of:

1 Earmould and tubing
2 Hook
3 Hearing Aid (plus audio shoe if used with a radio aid)

LOOK

1 Earmould and tubing

a) Is earmould discoloured, rough, torn, chipped etc?
If so: **make an appointment for impressions for new earmoulds.**

b) Is earmould blocked with wax or secretion? Is earmould dirty?
If so: **wash in hot, soapy water, rinse and dry.**
Clear droplets of water in the tubing with earmould puffer.

c) Is the tubing split, squashed, twisted or hard?
If so: **re-tube earmould.**

d) Is there condensation in the tubing? (You may notice little drops of water in the tubing when the child becomes hot after playing/swimming or on a warm day).
If so: **clear droplets of water with earmould puffer.**

2 Hook

a) Is the hook split, broken etc?
If so: **take hearing aid to the hospital for the correct hook to be fitted.**
b) Is there condensation in the hook?
If so: **clear droplets of water by removing the hook and blowing through with the earmould puffer.**

BEWARE !!!!!!
There may be what looks like small pieces of tissue, blu-tak etc in the hook.
THESE ARE FILTERS. DON'T REMOVE THEM!

3 hearing aid

a) Is casing damaged, cracked, does it flex when squeezed gently etc?

b) Does the audio shoe fit snugly and make a good contact?

c) Does the battery compartment shut firmly?

d) Does the volume control wheel (where appropriate) move smoothly?

e) Are any switches broken or jammed?

f) Is the microphone or are the vents blocked?

If there is a fault:

the hearing aid should be taken to the hospital and a loan aid requested.

LISTEN

a) Turn hearing aid on and cup it in your hands. The hearing aid should whistle.

This information indicates that the battery is working. It does not give information about the quality of sound heard.

No whistle? Check that there is a battery and that it is fully charged and the right way round in the compartment.

Listen to hearing aid through stetoclip.

- Switch hearing aid on. If you can, turn volume control up slowly and then back down to child's listening level. Squeeze hearing aid gently to make sure there is no intermittent crackling or distortion.
- It is essential to use an attenuator when there is no volume control or the volume has been set. The hearing aid may be powerful and too loud to listen to without attenuation!
- If there are different settings on the hearing aids for different situations then a listening check needs to be done in each type of situation to ensure full working order. If there is a remote control, again check the different settings using the remote control while listening in the appropriate environment.

IS SPEECH CLEAR?

If not: **the hearing aid should be taken to the hospital and a loan aid requested.**