SPAU338
Hearing Aids II

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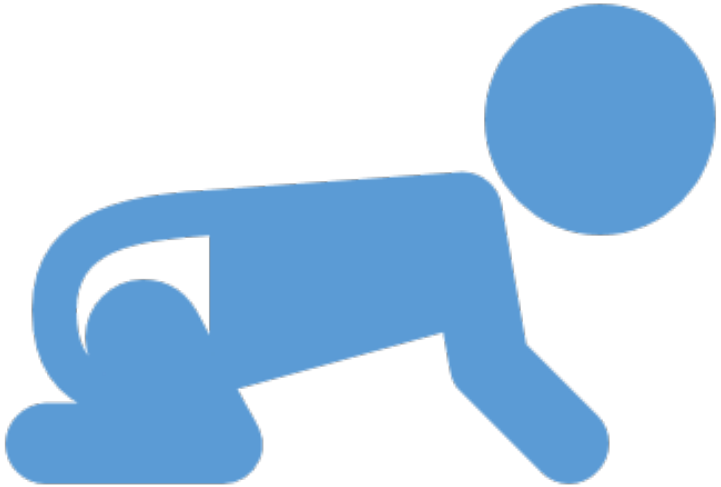
Framework for Fitting Hearing Aids to Infants and Children



HA Management

Why is Paediatric Habilitation Different to Adult Rehabilitation?

- An audiologist's job is to manage the whole family, the hearing-impaired child is only the product of that management
- Patient feedback is limited
- Effective management is ought to be applied over limited time window to achieve desired outcomes
- Multidisciplinary
- Children rely on amplification to develop speech and language and to acquire knowledge of the world around them.

Goal of Infant Hearing-Aid Fitting?

- Give consistent audibility of speech signals
- At safe and comfortable listening levels
- For adequate development of speech and language
- To promote cognitive, academic, social and communication skills and performance
- And therefore improve patients' Quality of Life (QoL)
- Consists of 4 stages: Assessment, selection, verification, and validation.

Hearing Aid Management

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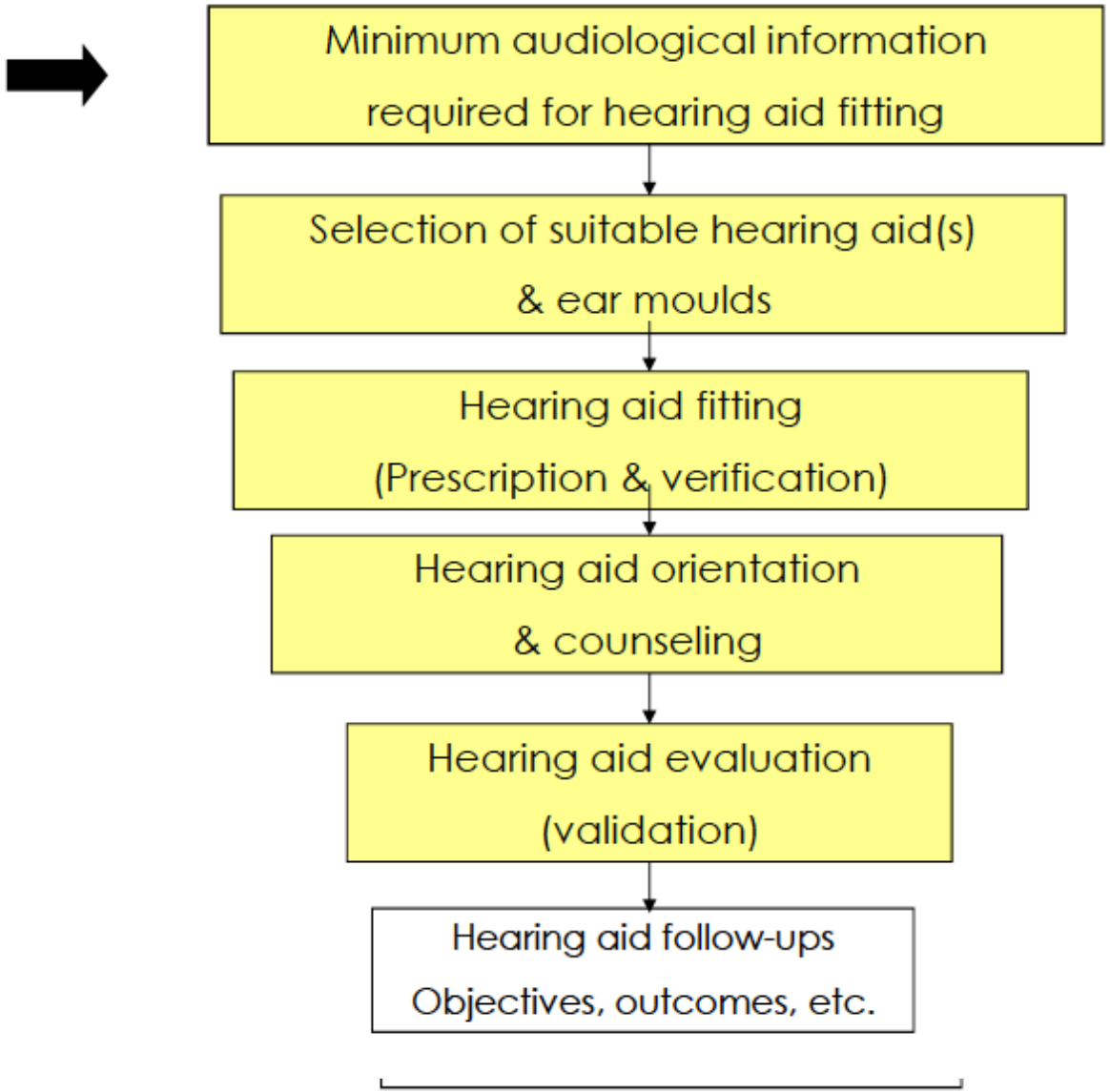

Factors for audiologists to consider

- Audiometric results (degree, nature, and aetiology of loss)
- Immediate family needs, support, networks and culture
- Need to optimize auditory stimulation and plasticity
- Additional social context and disabilities (e.g. visual impairment, cognitive difficulties, syndromes, cerebral palsy)
- Other factors (medical, social, cultural)

Minimum audiological information required for HA fitting

- We need ear-specific and frequency specific threshold estimates for air and bone conduction before proceeding with the prescription and fitting of amplification for infants and young children

- Estimated hearing levels from newborn ABR:
  - ✓ Minimum of one high frequency (e.g. 4 kHz)and one mid-to-low frequency (e.g. 1 kHz) threshold in each ear
  - ✓Ideally thresholds at 3 or 4 frequencies to improve fitting accuracy
  - ✓Indication of the type of hearing loss (conductive, sensorineural or mixed)
    - BC ABR thresholds at one or more frequencies
    - Additional information provided through HF Tympanometry

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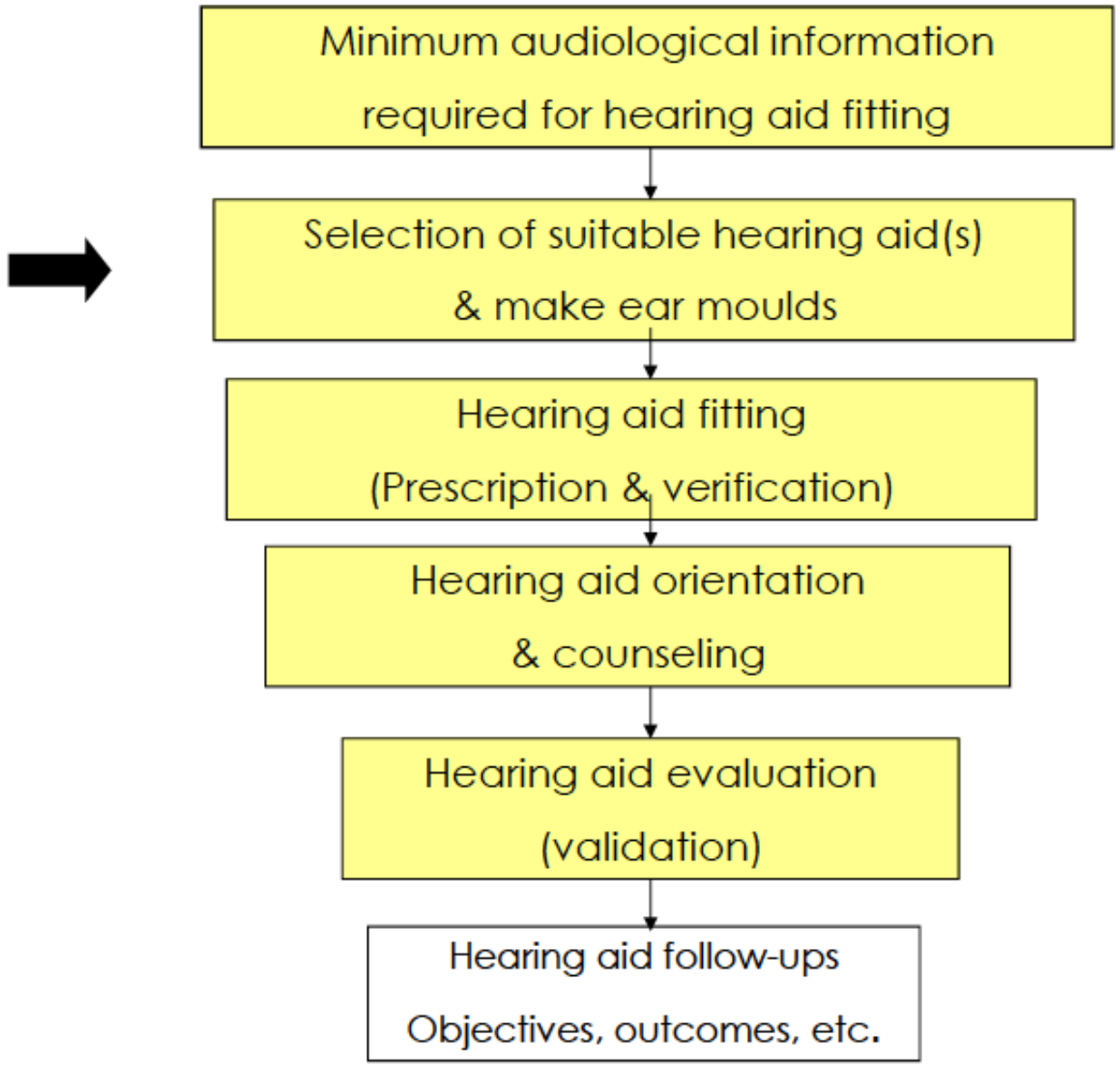


Hearing Aid Selection - Considerations

- Size and shape (practically wearable for a small baby)

- Paediatric features
  - ✓ Tamper-proof battery drawer
    - Recommended for all children under 5
    - Can use supra seals or ear gear for security and splash protection
  - ✓Paediatric ear-hook (improves retention behind smaller ears)
  - ✓Ease of operation (off/on switch and other controls)
  - ✓Compatibility with FM or equivalent systems

Ear Gear

- Stretchy material sleeve that slips over the HA or CI
- Helps protect hearing device from the effects of dirt and moisture as well as securing them to clothes
- Recommended for active children, particularly those that enjoy lots of sports

https://www.gearforears.com

Hearing Aid Selection

- Monaural vs binaural
  - Fit binaurally unless contraindicated (e.g. dead/ unusable ear, discharging ear, microtia, etc.)
  - Potential deprivation effects
  - Increased plasticity in infant and child auditory system
- Body worn (BW) – no longer used except in exceptional cases
- BTE vs BC (Bone conductor)
  - Essentially all hearing aids have become digital
  - Some BC aids remain analogue

Hearing Aid Selection

- Generally fit BTE's for infants and young children because:
  - ✓ Ears too small for ITE's, especially in very young children
  - ✓ BTE's are more reliable
  - ✓ Need for regular earmould renewal to accommodate growth in the first 8-10 years of life
  - ✓ BTE's allow provision of loan aids during repairs
  - ✓ FM/DMI compatibility
  - ✓ BTE's allow more venting
  - ✓ BTE's have a wider fitting range
  - ✓ BTE's generally use larger battery size so easier to manage and longer life
  - ✓ BTE's safer than ITE's in cases of breakage

Earmould Selection

Selection of earmould characteristics

- A critical part of the amplification process
- Must be deep
- Must be excellent fit to ensure amplification
- Audiometric info – higher the gain, the better fit requirement
- Child is learning own speech through hearing aids – must be able to hear their own vowel quality

Good ear impressions:

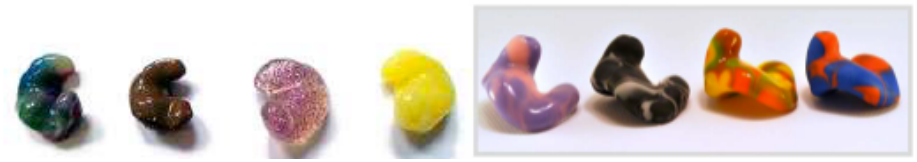
- Impression canal length (to 2nd bend)
- May finish impression with gentle finger press
- Ensure all concha and helix information obtained (esp tragus)
- Be very careful with grommets/ T-tubes
- Ask parents to photograph moulds if poor fit

Earmould Features

- Tubing
  - Regular wall vs. thick wall
  - Parallel tubing or Libby horn?
  - Stay dry tubing
  - Tube lock
  - Teach parents to re-tube
- Venting
  - Generally no venting in babies and young children
  - Venting in older children dependent on audiometric data, ear size, discharge, occlusion, etc.
- Open fittings
  - Considered in older children with mild mid + high frequency HL, significant occlusion, etc.

Earmould Style & Material

- In babies and young children use soft material (silicone and low shore) for comfort and to minimize feedback
- Carved moulds may reduce feedback
- Firmer materials (e.g. soft and hard acrylic) and different styles (e.g. skeleton) can be considered in older children (may be important for venting)
- For ear prone to discharge: hard materials and spare set of moulds
- Pictures/ colours



Impressions for growing ears

- Up to 6 months – monthly
- Up to 12 months – Every 2 months
- Up to 3 years – 3 or 4 times a year

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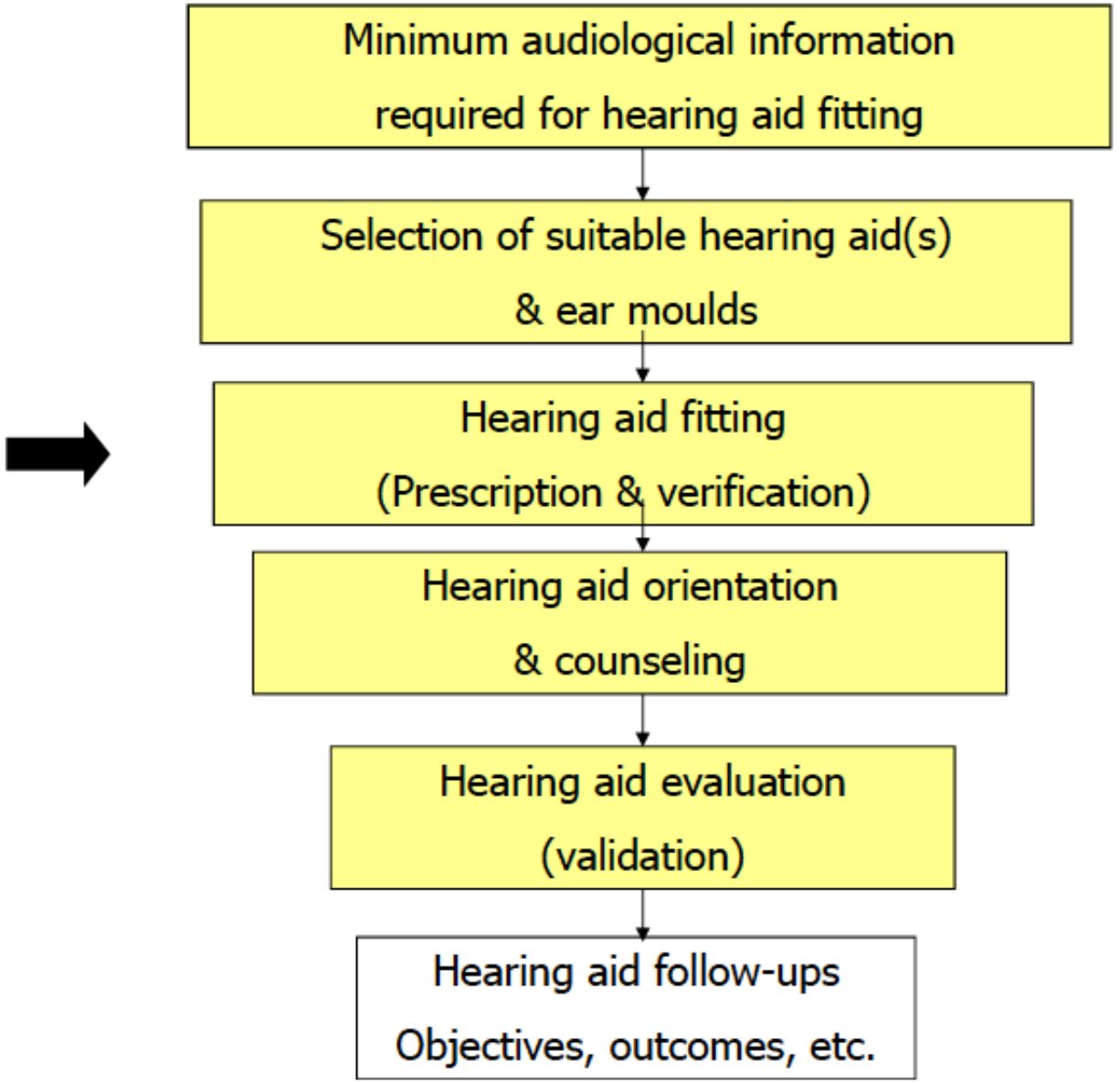


Hearing Aid Fitting

- The options: REMs/ RECD/ Average coupler values

- Why do we verify things?

  - To compare and verify the real ear acoustical characteristics of a HA to a prescription target
  - As younger children cannot give subjective responses (feedback), more emphasis is placed on matching target
  - REIG varies from 2cc coupler data by a clinically significant amount (principle behind measured RECDs)
  - Quality standards: BSA, BAA, MHAS, and MCHAS recommended **every** patient undergoes suitable verification as appropriate

RECD - Definition

- Difference between the SPL measured in the occluded ear canal and SPL measured in 2cc coupler
- RECD = Real Ear Response – Coupler Response

RECD - Aim

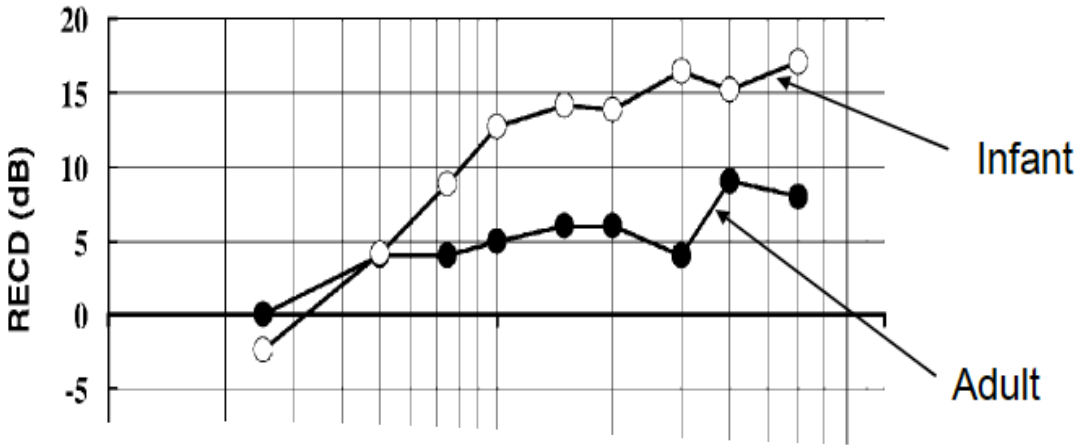
- To convert HA performance measured in a 2cc coupler into real ear HA performance

(If you know the acoustic difference between a 2cc coupler and child's occluded ear canal then you can add the difference to the HA coupler response to predict what is happening in the child's ear canal)

RECD

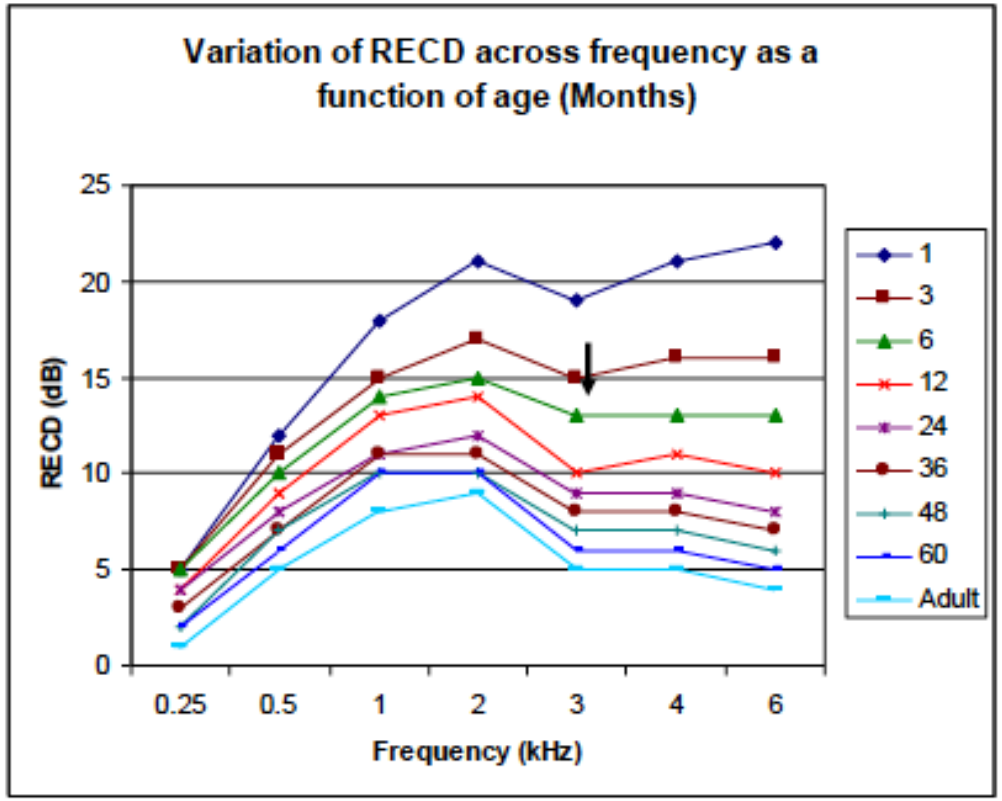
- RECD in infants should be positive increasing towards higher frequencies
  - Value of RECD in low frequency should be 0-10dB
  - Value of RECD in high frequency can go up to 25dB in a child

Typical infant and adult RECDs (Bagatto et al. (2002; infant) and Munro and Davis (2003; adult))



RECD

- Positive values indicate the extent to which levels measured in the Real Ear exceed levels measured in the coupler
- The smaller the ear canal (younger the child), the greater the SPL measured at the ear drum, hence the greater the RECD



RECD as a function of different ages (in months). Data reported by Scollie, Seewald & Jenstad (1998)

RECD

- Higher inter-subject variability especially in very young infants
- Largest changes in RECD occur in first 2 years of life (important to measure whenever possible rather than relying on age-related average)
- RECD will change with fit of earmould. We should therefore re-measure the RECD every time moulds are changed but in practice:
  - Every 3 months up to 2 years old
  - Every 6 months up to 2-5 years old
- Measure RECD for both ears if possible but using one measured RECD for both ears is better than using average
- HA response should be modified accordingly whenever RECD is re-measured

RECD

Probe tube insertion:

https://www.youtube.com/watch?v=tI_Iwni9Avg&feature=youtu.be

RECD

- Input signal: Use a modulated speech-shaped noise signal (ISTS/ICRA)
- HA should be on the everyday listening program with all its usual features left on (with the exception of frequency lowering), highest acclimatization level and the correct vent size having all been selected
- Verify at 50, 65 and 80dB input levels: tolerance +/- 5dB 250 – 4000 Hz

NAL – NL 1 & 2

- Aims to maximise speech intelligibility whilst keeping overall loudness no greater than that perceived by a normal hearing person listening to the same sound.
- Can prescribe in both REIG and REAG.
- Not specifically developed for use with infants & young children. RECD is an added option (not an integral portion of the formula)

NAL-NL2 uses a uses a range of factors other than the audiogram to prescribe performance. It prescribes language dependent gain-frequency response shapes, compression speed dependent compression for those with severe or profound hearing loss, and varies the overall gain with age, gender, and experience

DSL v5

- Aims to provide the user with an audible & comfortable signal in each frequency region
- Prescribes real ear aided gain (REAG) rather than real ear insertion gain (REIG)
  - To achieve a consistent SPL at the eardrum
- Advocates use of RECD so convenient for use with infants & young children
  - Age-related average RECD values embedded, for use if not possible to measure RECD
- Does not attempt to equalise loudness but rather make sound comfortably loud across frequencies
- Prescription specifically designed for the needs of young children developing speech and language.
  - Rationale anticipates that child needs to hear own vocal output

Differences in prescription formulae

- DSL prescribes more overall gain than NAL for all audiometric configurations
- For sloping high frequency HL, NAL provides less high frequency gain as these frequencies will not contribute to 'effective audibility'
- For flat HL, DSL prescribes more low frequency gain

Differences in prescription formulae for children

- DSL m[i/o] increases gain by 7 dB for medium level inputs, provides less gain for high level inputs, and provides more gain for low level inputs for children (Scollie et al., 2005)
- NAL-NL2 prescribes 5 dB more gain for medium input levels, less for high input levels, and more for low input levels for children than for adults (Keidser, Dillon, Flax, Ching, & Brewer, 2011)
- Both methods also allow for a higher compression ratio for children relative to adults

Differences in prescription formulae for children

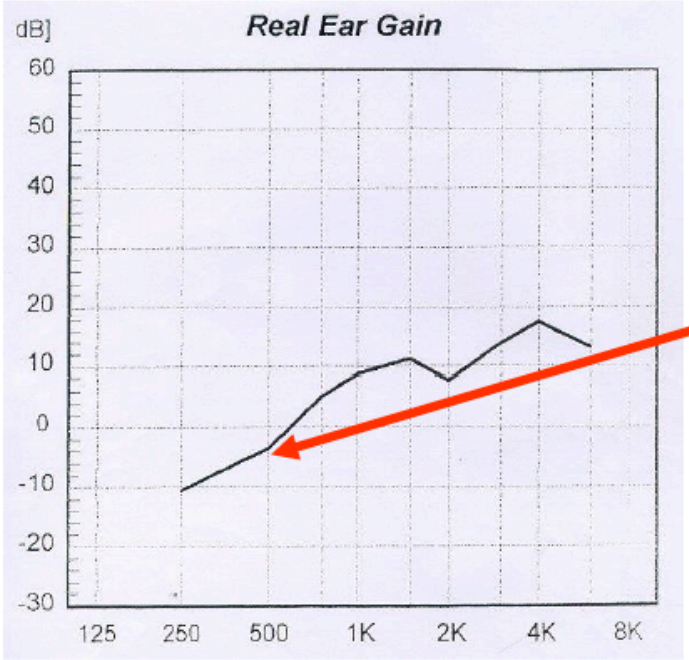
- Despite differences in gain-frequency response, both prescriptions are effective for children (Ching, Scollie, Dillon & Seewald, 2010)
- Randomised control trial showed both groups of children developed language similarly to hearing peers (as long as they were fitted before 6 months of age) (Ching, Dillon et al, 2006)
- Language outcomes were the same for both groups at the age of 3yo (Ching, 2012)

Let’s watch

https://www.youtube.com/watch?v=EyeIUW-WrJ0

RECD Troubleshooting

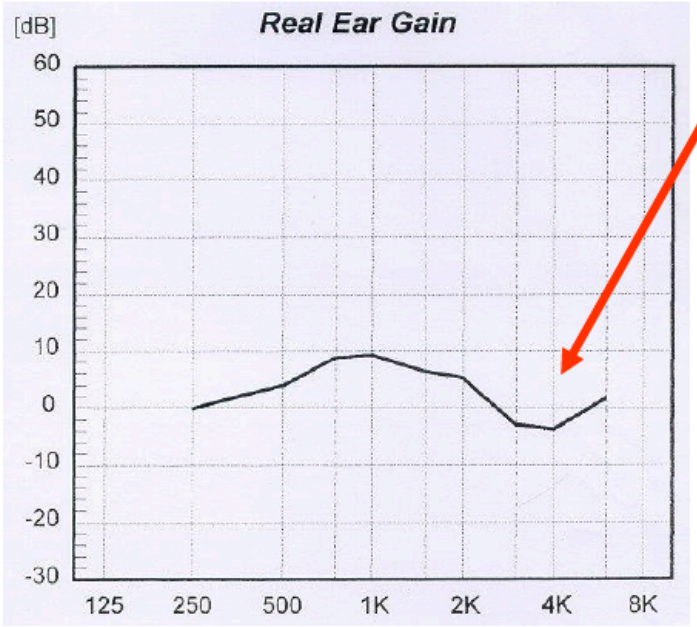
Leakage around mould



Leakage around mould:

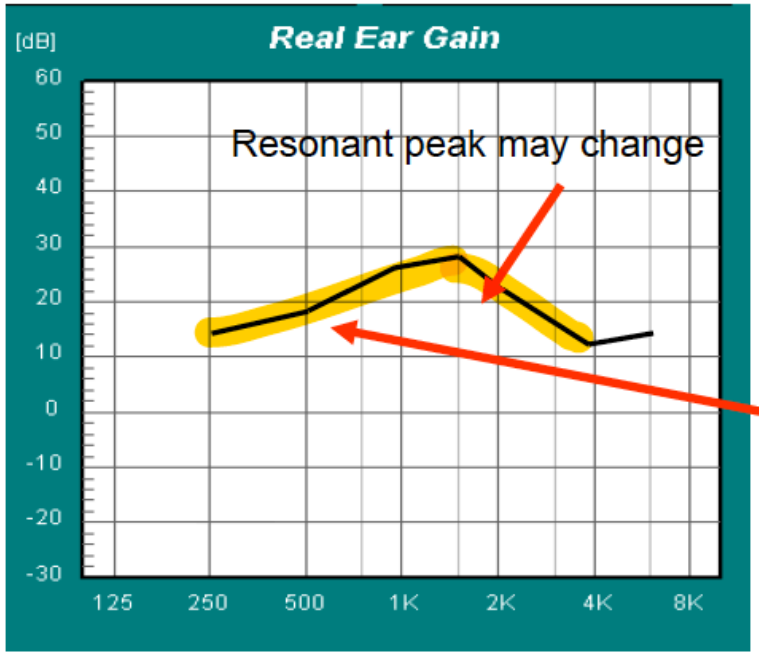
- Low frequency sound escapes, giving negative RECD in low frequencies.
- Re-insert mould & try to reduce leakage.

Sub-optimal Probe-tube Placement



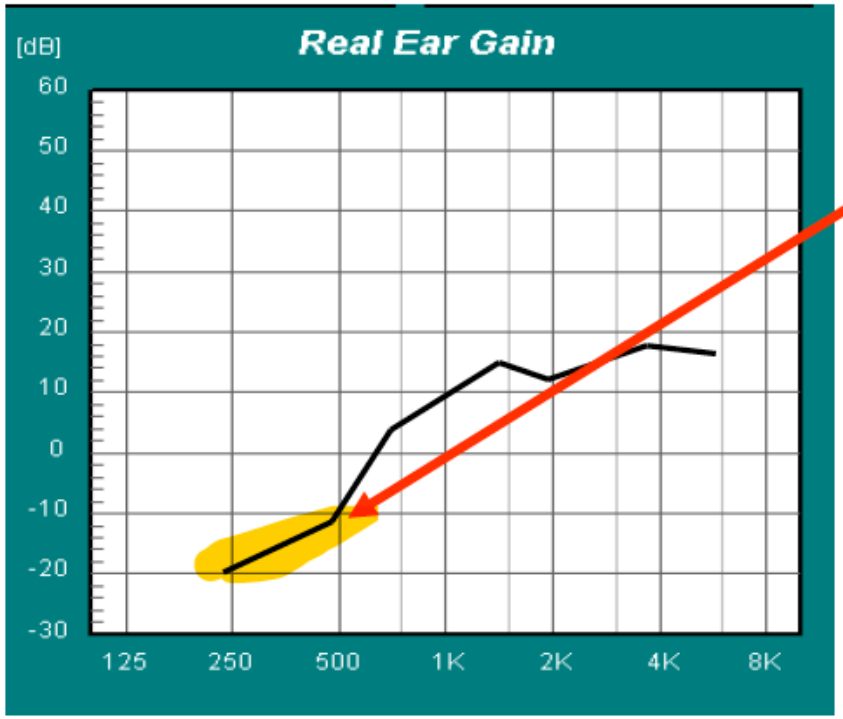
- High freq tail-off.
- Ensure the probe fit is within 5-6mm of TM
- Can use REUR to assess probe position

OME



- Causes slight reduction in ear canal volume
- Increased positive values in the low and mid frequencies
- Check with tympanometry

Grommet/ Perforation



- Increases ear canal volume – produces negative RECD in low frequencies
- Negative low freq values typically between -10 & -15dB
- Will lead to more prescribed low freq gain (consider implications if perf heals / grommet blocks)

Hearing Aid Management

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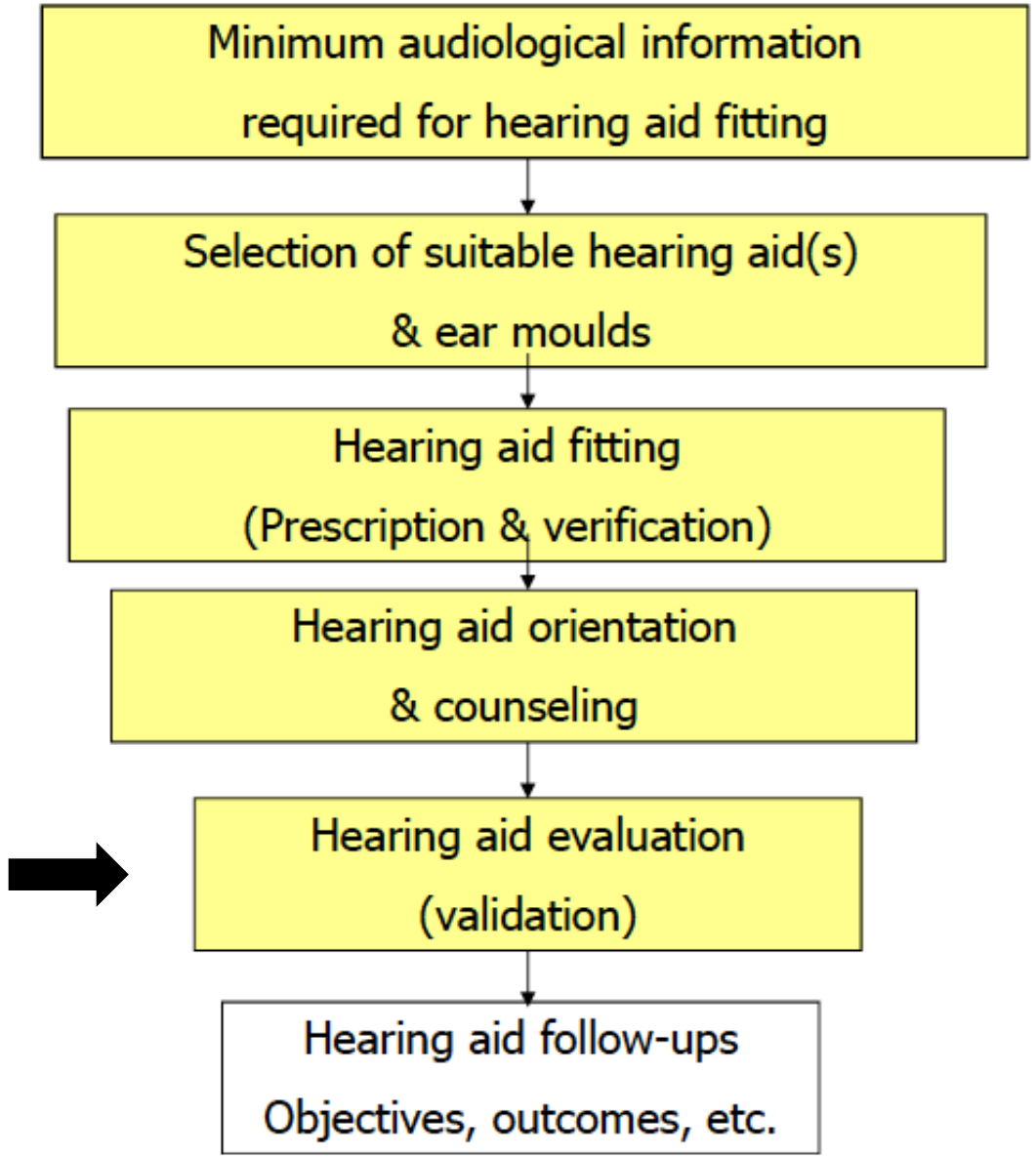


Hearing Aid Validation

- Evaluate impact of hearing aid intervention in infants and children with hearing loss
  - Changes in behaviour with / without HA
  - Observation of responses with HAs on (detection)
  - Discrimination between speech-based sounds
  - Vocalisations in response to speech
  - Localisation of direction of sounds
  - Discomfort in response to speech or sounds
  - Recognition of words
  - Changing vocalisations of child
  - Speech development progress of child

Hearing Aid Validation (Weinstein, 1997)

- Verification: confirms hearing aid (HA) gain matches prescription (NAL/DSL) targets
  - Assumption by experts that verification equals benefit
- Validation: assesses treatment efficacy
  - Treatment effectiveness: does HA improve speech intelligibility (objective outcome measures)
  - Treatment efficiency: are settings optimal for speech intelligibility (objective outcome measures)
  - Treatment effects: does HA improve quality of life (self assessment questionnaires)

What can be used to demonstrate effective HA?

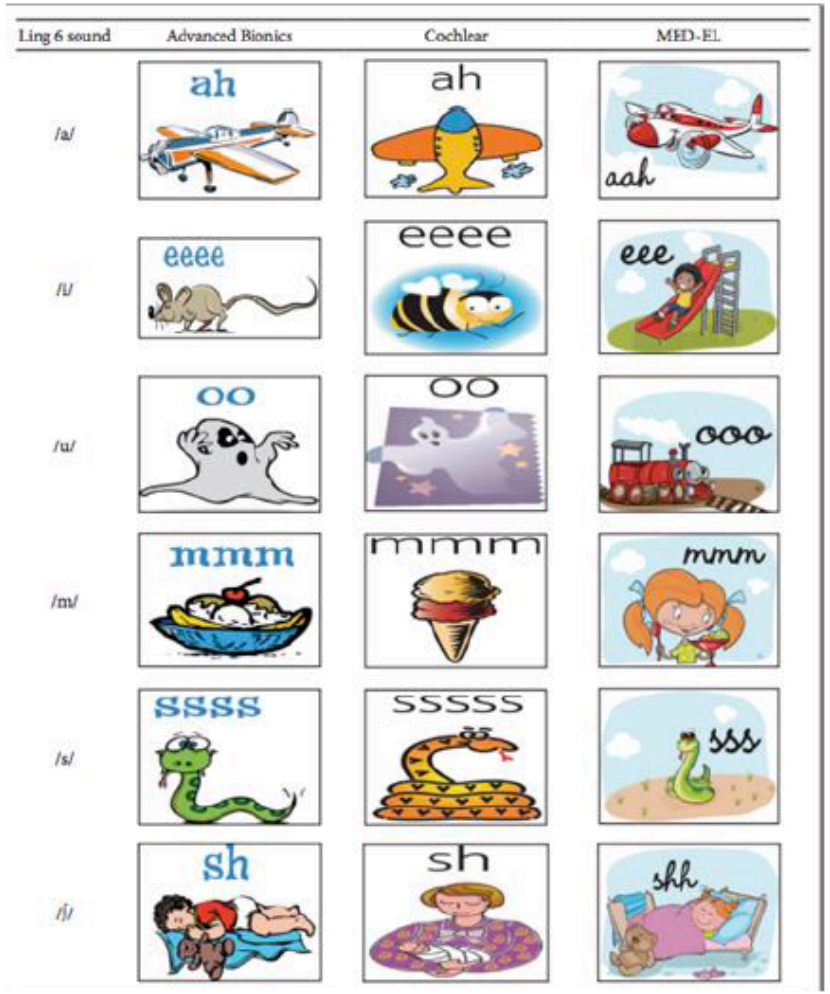
- Sound detection
- Voice discrimination
- 'Mother-ease' vocal recognition
- Word recognition
- Phrase and sentence recognition
- Variable presentation in quiet and noise
- Localisation or spatial awareness

Tests used on a regular basis

(South London Habilitation Peer Review Support Group Survey)

- Ling Sounds
- McCormick Toy Test
- Kendall Toy Test
- Manchester Picture Test
- Consonant Confusion Task
- Auditory Performance Task
- Manchester Junior Word List
- AB Word List
- BKB Sentences

Ling Sounds


Ling 6 sound
Advanced Bionics
Cochlear
MED-EL
/a/
ah
ah
aah
/i/
eeee
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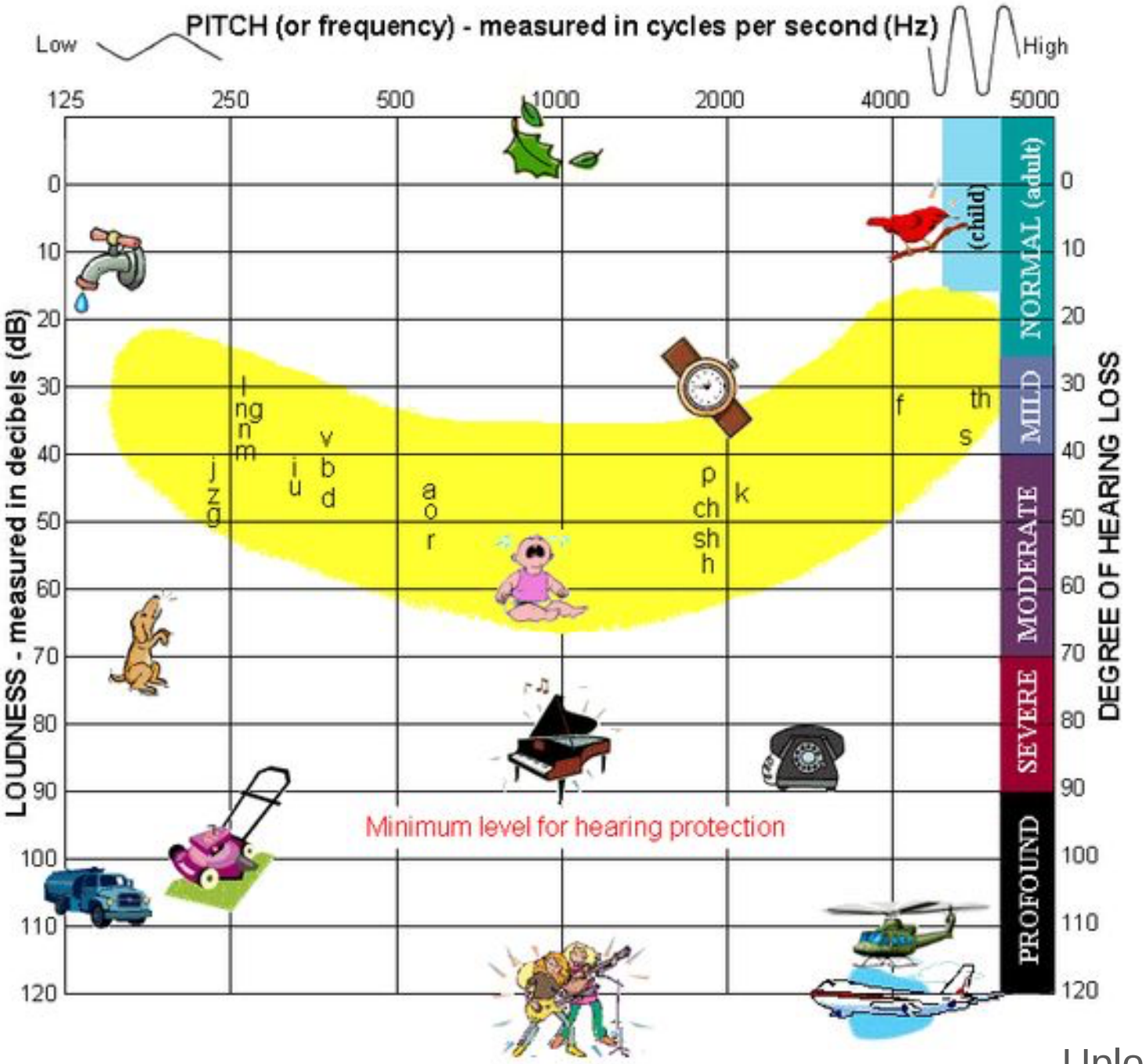


Ling Sounds & Formant Spectrum

LING SOUND	1ST FORMANT	2ND FORMANT	3RD FORMANT	4TH FORMANT
OO	200-500	650-1100		
AH	525-775	825-1275		
EE	150-450		2300-2900	
SH			1500-2000	4500-5500
S				5000-6000
TH				6000
M	250-350	1000-1500	2500-3500	

Hierarchy of Listening

4. Comprehension - The ability to show understanding of spoken words/sentences

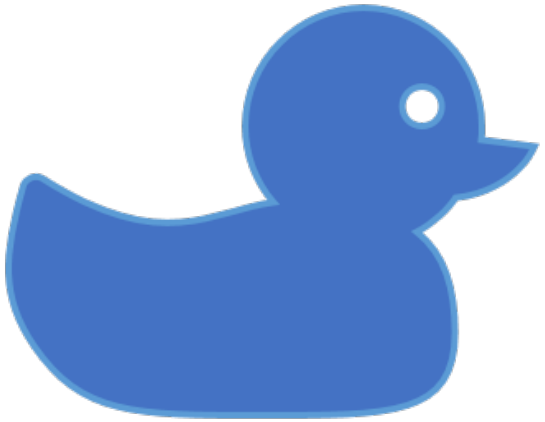
3. Identification - The ability to reproduce a speech stimulus through imitation

2. Discrimination - The ability to perceive similarities and differences among two or more speech stimuli

1. Detection - The ability to respond to the presence and absence of sound

McCormick Toy Test

- Pair of toys which have similar vowels / dipthongs, but differ in consonants (closed set)
- From around 2 years of age, although can be performed from around 18 months with some children
- No recommended upper age limit but generally up to 4 yo
- Scoring: criteria for passing this test is when a child gives 4 correct responses out of 5 requests at 40 dB(A)
- Limitations: Closed set- if discriminates vowel / dipthong correctly, has 50/50 chance of getting it right



Manchester Picture Test

- No specified age range – suggested developmental / language age of 3-5 yo – those too old for toy tests but unable to perform open-set tasks
- Consists of six word lists each containing six test words (closed set)
- Each word being represented in a matrix of four pictures, i.e. test word and three distracters
- Used mainly with older children for whom the toy tests are not thought to be appropriate
- Pass score: 5/6 (83%)

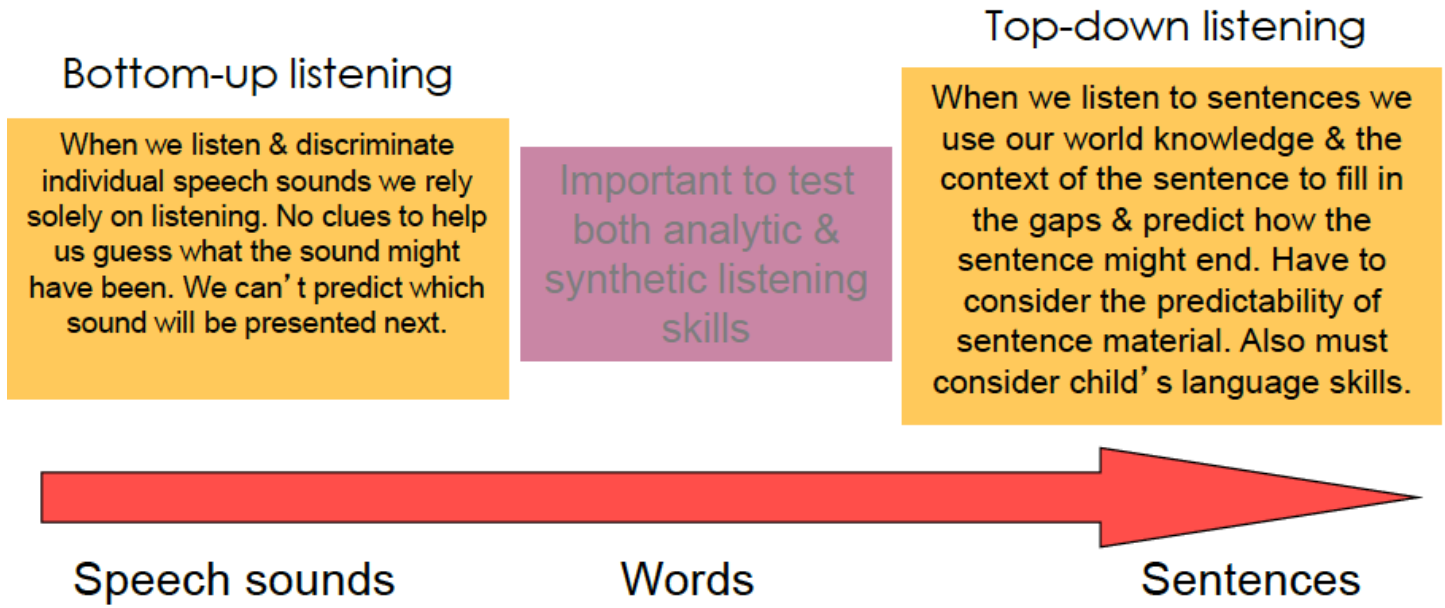
AB Wordlist

- Suggested age from 10 years to adult
- Each word has 3 phonemes (consonant – vowel – consonant) = 30 phonemes (10 vowels and 20 consonants) in each list
- Scoring: phoneme scoring

BKB Wordlist

- Age 6 onwards (theoretically 5yo for NH, 8yo for HI)
- 21 lists of 16 sentences with 50 key words per list
- Open set
- Scored by key words
- Context = 'clues'- easier than single words. Good for establishing function level in children who have poorer speech perception, e.g. teens with significant losses who were perhaps identified later or were not good aid users

Speech Perception Test Material



The Parrot

- Portable automated speech
- It consists of a speaker and connecting cable along with one or more handsets. Each handset is customized to perform a specific test and comes complete with the test materials required to conduct that test

Test	Suggested age
Ling Sounds	
McCormick Toy Test	From around 2 yo
Kendall Toy Test	From around 2 yo
Other – English as an Additional Language	From around 2 yo
Manchester Picture Test	3-5 yo
Consonant Confusion Task	3-6 yo
Auditory Performance Task	6yo +
BKB sentences	Age 6 onwards (theoretically 5yo for NH, 8yo for HI)
AB word list	10yo +

Jane Madell (2015) Speech testing protocol

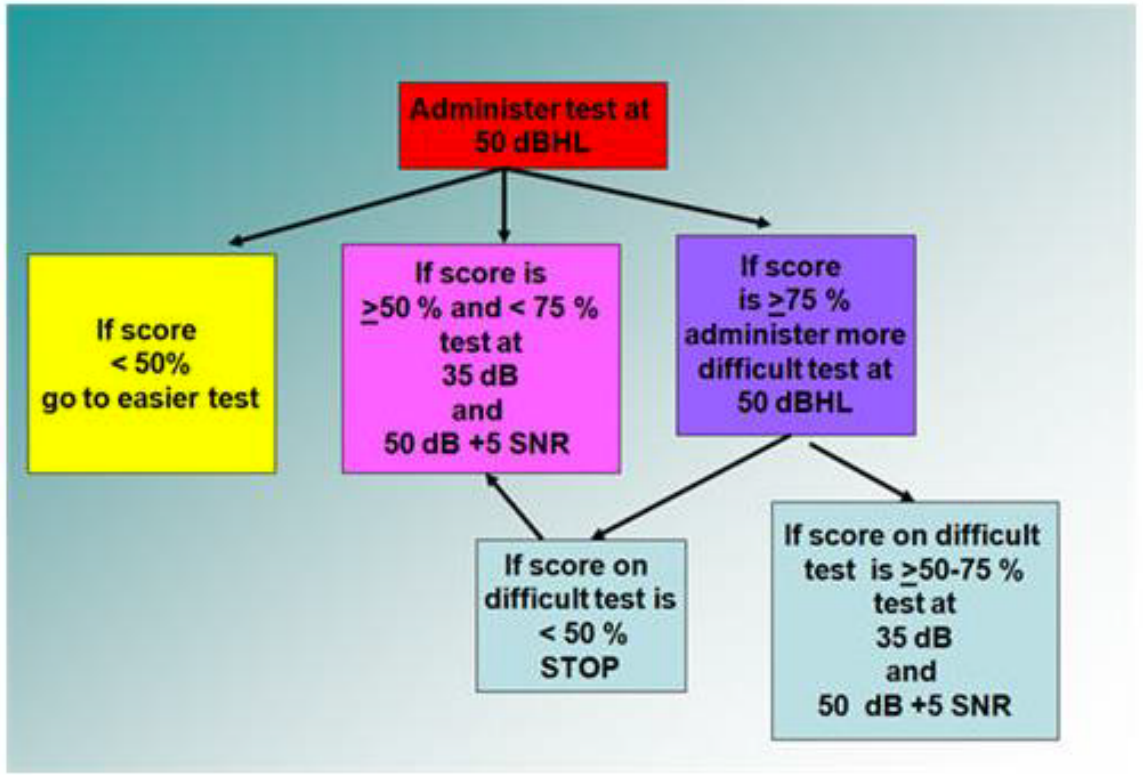
- For aided children should test at:
  - normal conversational level (50 dB HL)
  - soft conversational level (35 dB HL)
  - normal conversational level in competing noise (50 dB HL with speech babble at +5 SNR)
- Suggested scoring:

  Excellent: 90-100%

  Good: 80-89%

  Fair: 70-79%

  Poor: < 70%



*Adapted from the chapter on Speech Perception in PediatricAudiology: Diagnosis, Technology and Management (Madell& Flexer, 2008)

After you're done testing:

- Do the results reflect their audiogram?
- If not, why not?
- Does the child have appropriate access to sound?
- How can these results guide our management? Have we maximised their technology?
- Does the child have access but has not yet learned to perceive differences?
- Are the errors truly speech perception or something else?

Hearing Aid Management