Paediatric Amplification

The paediatric technical advisory group (PTAG) of the NZAS recommends following the protocols found in “UNHSEIP Diagnostic and Amplification Protocols” (January, 2016). These guidelines are based on guidelines provided by the University of Western Ontario Paediatric Audiological Monitoring Protocol (UWO PedAMP).

Here is a direct link to the UNHSEIP Diagnostic and amplification protocols.

Evaluation of Hearing Aids in children should involve both verification and validation of the fitting. Techniques used for each can be seen below.

### Verification

- **Real Ear Measures**
- Real-ear to coupler difference (RECD)
- Speech Intelligibility Index (SII)
- Frequency Lowering Verification *(if required)*

### Validation

- Aided Speech Testing
- Questionnaires
- Frequency Lowering Validation
- Cortical Evoked Potential Testing *(if required)*

### Verification

**Real-ear Measures (REMs)**

The guidelines provided in “UNHSEIP Diagnostic and Amplification Protocols” (previously Appendix F) should be followed closely. Below are some further guidelines when performing REMs on young children.

Compression should be assessed for each hearing aid fitted. This is performed by verifying the hearing aid at a soft (50-55 dB SPL), medium (60-65 dB SPL) and loud (70-75 dB SPL) input level and by checking the MPO (90 dB SPL).

In order to “meet target” for a hearing aid fitting PTAG recommends the following:

“Where a fitting rationale contains an acoustical target, each hearing should be verified by REM using an input stimulus appropriate for the hearing aid under test. Tolerances to the prescription rationale of +/- 5dB at frequencies 250, 500, 1000 and 2000 Hz and of +/- 8dB at 3000 and 4000Hz should be achieved in all cases. In addition the slope in each octave should be within +/- 5dB per octave of the target” (British Society of Audiology 2016).

Whilst it is not always easy to meet target above 4000 Hz it is important to note the importance of attempting to provide as much amplification as possible in this region in order to provide better hearing in background noise. Research shows the importance of amplification in the higher frequencies for the speech development of children with hearing loss (Stelmachowicz et al. 2007).
Real-Ear to Coupler Difference (RECD)

The Real-Ear to Coupler Difference (RECD) is a measure used to:

1) Convert the measured threshold obtained during diagnostic testing into dB SPL to account for the change in level of sound in a child’s ear canal compared with that of an adult ear.
2) Account for the differences in the child’s ear and the 2 cc coupler used for simulated verification measures.

The recommendations for how often you should be performing RECD measurements can be found in the “UNHSEIP Diagnostic and Amplification Protocols”.

The Bagatto (2001) article “Optimising your RECD measurement provides tips and advice on optimising the measure” is an excellent reference for tips and recommendations for optimising your RECD measures.

Speech Intelligibility Index (SII)

The Speech Intelligibility Index is a measure that is used to assess the amount of speech that is predicted to be both audible and intelligible to the listener, based on the hearing thresholds and the aided speech spectrum. A score of 0% represents no audible and intelligible speech being heard and 100% represents all of the speech being both audible and intelligible.

The SII is easily calculated nowadays using most real-ear measures systems. This is a verification that the hearing aids are doing the best that they can. You should also look at the percentage of speech intelligibility, especially if it is low and back this up with validation measures to ensure a referral to the cochlear implant team is not necessary, or to support a referral to the cochlear implant team if the SII is poor. It may also guide you to order another hearing aid to fit in clinic and verify and validate to see if this improves the outcome. An example of a case using this is shown below.

Left Ear 3FA calculation

\[3FA = 30 + 25 + 50 = 105 / 3 = 35 \text{ dB HL}\]

SII 55 Left = 73% (taken from REM printout)

SII 65 Left = 81% (taken from REM printout)

Right Ear 3FA Calculation

\[3FA = 30 + 25 + 50 = 105 / 3 = 35 \text{ dB HL}\]

SII 55 Right = 77% (taken from REM printout)

SII 65 Right = 84% (taken from REM printout)
Frequency Lowering

Frequency lowering is a form of distortion that is purposely introduced with the aim of making high frequency sounds audible (AAA). As high frequency sounds are adjusted, ideally, we want the least possible compression/lowering/shifting required to make high frequency sounds audible. The spectral characteristics of the speech signal can be altered by lowering the start frequency too low or by increasing the frequency compression ratio too high. Therefore care must be taken to avoid changing the speech signal significantly when applying such features (McCreery et al. 2013).
Both the UWO and the AAA paediatric amplification guidelines recommend not turning on such features unless the hearing aid is incapable of amplifying such high frequency sounds with conventional amplification. For example, if a child has a significant hearing loss whereby the hearing aid is not meeting target at 4000Hz and the hearing aid is “maxxed out” then it may be appropriate to apply frequency lowering features. You should also consider would it be more appropriate to order and trial a more powerful aid which can meet 4000Hz with conventional amplification. If you have the most powerful aid there is on the market, then you should be considering is this child a suitable candidate for a cochlear implant referral.

It is important to verify what the hearing aid does to the sound when you turn this feature on. Your verification should answer the following questions:

Does turning on frequency lowering create unwanted distortion in the hearing aid?

Does it affect the conventional amplification at lower frequencies?

The following link provides more detailed information on how you can verify these features:-

http://www.dslio.com/?page_id=166
Validation

Aided Speech Measures
All paediatric hearing aid fittings should be accompanied by a form of aided versus unaided testing. Ideally this testing is separate ear aided testing however for some children you may need to begin with binaural aided results. The table below lists the types of speech testing that can be done at different ages.

<table>
<thead>
<tr>
<th>Age</th>
<th>Speech detection thresholds</th>
<th>Speech discrimination</th>
<th>Speech recognition in quiet</th>
<th>Speech recognition in noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3 years</td>
<td>• MLV</td>
<td>• Ling sounds (discrimination)</td>
<td>• ESP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Frequency specific speech phonemes VRA (“ah”, “f”, “sh”, “s”)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Recorded or live voice SPANZ Ling sounds*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cortical Auditory Evoked Potential testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5 years</td>
<td>• MLV</td>
<td>• MLV “sh” vs “s”*</td>
<td>• MLV</td>
<td>• SPANZ or live voice KTT</td>
</tr>
<tr>
<td></td>
<td>• Speech phoneme detection in soundfield</td>
<td></td>
<td>• Recorded SPANZ or live voice PSI sentences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Recorded or live voice SPANZ Ling sounds*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cortical Auditory Evoked Potential testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5 years</td>
<td>• Speech phoneme detection in soundfield</td>
<td>• MLV “sh” vs “s”*</td>
<td>• SPANZ CVC phoneme scores</td>
<td>• BKB-SIN</td>
</tr>
<tr>
<td></td>
<td>• Cortical Auditory Evoked Potential testing</td>
<td></td>
<td>• KTT or PSI</td>
<td></td>
</tr>
<tr>
<td>6+ years</td>
<td>• Speech phoneme detection in soundfield</td>
<td>• UWO Plurals test</td>
<td>• LNT</td>
<td>• LISN-S (with correction for hearing loss)</td>
</tr>
<tr>
<td></td>
<td>• Cortical Auditory Evoked Potential testing</td>
<td></td>
<td>• CVC words</td>
<td>• BKB-SIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• CNC words</td>
<td>• Quick SIN</td>
</tr>
</tbody>
</table>

* picture pointing or speech production
MLV=monitored live voice; ESP=Early Speech Perception (closed set words, pictures and objects); PSI=Pediatric Speech Intelligibility closed set sentences (pictures); LNT=Lexical Neighborhood Test (words, open set)

Note:
- If a test is too difficult for a child you can use one from a lower age level to get the information required rather than for going an aided test result.

It is not recommended to use narrow-band noise, tones or frequency modulated stimuli to measure aided benefit. Current noise reduction and feedback features in hearing aids will aim to reduce such stimuli and therefore may negatively impact your aided testing results. Speech stimuli should ideally be used, as the features in the hearing aids are designed to amplify speech signals.

Below is a graphical representation of the progression of tests over time.

Frequency Lowering

Both AAA and UWO recommend behaviourally assessing the ability to detect (and if possible discriminate) such high frequency sounds (e.g. “sh” and “s”) affected by these hearing aid technologies. The UWO plural test can be used in older children and adults to assess the ability to discrimination between “s” sounds affected by frequency lowering technologies. Alternatively in younger children you might use the ling sounds discrimination test if they can do this. Alternatively you should assess detection of “sh” and “s” with VRA or play audiometry.
Cortical Auditory Evoked Potential Testing

When a child is difficult to test, perhaps because they are in between VRA and CPA or perhaps because they are developmentally delayed, cortical evoked potential testing might be the best way to get information about access to the speech spectrum as soon as possible. Cortical auditory evoked potential testing can see whether the child has access to audible conversational speech sounds. There are a few centres around the country who offer this testing. If you have been unsuccessful in obtaining behavioural test results for a child over a number of occasions it may be useful to discuss the case with an Audiologist at a centre offering CAEP as this may be an appropriate next step.

Questionnaires

Questionnaires must be validated and should not be the only measure of hearing aid fitting success. It should be kept in mind that questionnaires are based on subjective feedback from the parent. The results of the questionnaire should accompanied by objective measures of speech detection and discrimination as described above along with verification of the hearing aids.

LittlEARs® Questionnaire

The LittlEARs® Questionnaire is a questionnaire published by MED-EL as a “parental questionnaire which evaluates auditory behavior in the pre-verbal developmental phase”. This questionnaire is recommended for children developmentally 2 years and under.

LittlEARs® Questionnaire

The LittlEARs® Questionnaire is available for purchase through Med EL (http://www.medel.com/assessment-database/). MED-EL refer to it as the LEAQ (LittlEars® Auditory Questionnaire).

LittlEARs® scoresheet

**Parent Evaluation of Aural/Oral Performance (PEACH)**

The Parent Evaluation of Aural/Oral Performance of Children (PEACH) was developed by Teresa Ching and Mandy Hill of the NAL laboratories based in Sydney. This tool may be used to assess the effectiveness of the hearing aid or cochlear implant fitting. The NZAS recommends the use of this questionnaire for children who are over 2 years old and/or have scored well on the LittLEARs.

**PEACH Questionnaire and Score Sheet**


**PEACH Calculator**


There are other questionnaires that can be used such as the IMP, the COSI-C which may be used in conjunction with these at your discretion.
References


University of Western Ontario Paed AMP. 2016 (13th April) Website: http://www.dslio.com/
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAA</td>
<td>American Academy of Audiology</td>
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<tr>
<td>CPA</td>
<td>Conditioned Play Audiometry</td>
</tr>
<tr>
<td>CAEP</td>
<td>Cortical Auditory Evoked Potential</td>
</tr>
<tr>
<td>DHB</td>
<td>District Health Board</td>
</tr>
<tr>
<td>ESP</td>
<td>Early Speech Perception test (closed set words, pictures and objects)</td>
</tr>
<tr>
<td>KTT</td>
<td>Kendall Toy Test</td>
</tr>
<tr>
<td>LNT</td>
<td>Lexical Neighbourhood Test (words, open set)</td>
</tr>
<tr>
<td>MLV</td>
<td>Monitored live Voice</td>
</tr>
<tr>
<td>PEACH</td>
<td>Parent Evaluation of Aural/Oral Performance</td>
</tr>
<tr>
<td>PSI</td>
<td>Pediatric Speech Intelligibility closed set sentences</td>
</tr>
<tr>
<td>REMs</td>
<td>Real-ear Measures</td>
</tr>
<tr>
<td>RECDs</td>
<td>Real-ear to coupler difference</td>
</tr>
<tr>
<td>UWO</td>
<td>University of Western Ontario</td>
</tr>
<tr>
<td>VRA</td>
<td>Visual Reinforcement Audiometry</td>
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