Introduction

- What is the smallest difference in hearing threshold levels between the left and right ears that requires masking in children?
- With asymmetrical hearing loss, there is a risk that sound presented to the test ear could cross the head and be detected by the (better) non-test ear. When this cross hearing happens, masking noise can be applied to the non-test ear to allow the true hearing to be tested.
- The risk of cross hearing is determined by Interaural attenuation (IA), defined as the drop in intensity of the acoustic signal from the test ear transducer to the non-test cochlea. IA is highly variable between individuals, and it can be influenced by transducer type, transducer-ear coupling, test frequency, and the ear canal size and condition.
- Values of IA measured in adult participants can be used to infer the minimum asymmetry at which masking should be recommended in clinical audiometry. For air-conduction stimuli, this minimum asymmetry is currently ≥ 40 dB for supra-aural earphones or ≥ 55 dB for insert earphones.
- We wanted to understand if estimates of IA in children, under clinical test conditions, are different from those seen in the adult studies under controlled research conditions, and what implications this may have for the application of masking in clinical practice.

Methods

With HRA approval, we reviewed our clinical database of audiograms for children (aged 8 months to 16 years) showing ear-specific results obtained using the relevant age-appropriate behavioural clinical procedures. They were measured during standard clinical care using a mix of Otometrics Aural, Complex KC35, and Grasson Stadler GS 67 audiometers with either supra-aural Telephonics TDH-39P headphones or E-A-RTONE 3A insert earphones with foam tips.

Audiograms were selected for analysis if all of the following criteria were satisfied at that frequency:

I. Values of better ear air conduction hearing threshold level (HTL), poorer ear not-masked air conduction HTL, poorer ear masked air conduction HTL were all documented at single clinic visit
II. Any air-bone gaps recorded were ≤ 15 dB
III. The transducer type was clearly indicated
IV. There was evidence of cross hearing, operationally defined as a deterioration of more than 15 dB in the HTL of the poorer ear when comparing the masked and unmasked conditions.

Estimated IA was calculated for each subject for each stimulus frequency at which cross hearing had been identified, using the difference between the not-masked air-conduction HTL of the poorer ear and the better ear.

Results & Discussion

Results

| Table 1 | Table 2 |

| IA measures published for adults subjects are based on small subject numbers (between 6 and 30 [5, 6]). Our study extends that data to include IA estimates in children aged 8 months to 16 years, with some caveats associated with the retrospective use of our clinical data:

- Low subject numbers as shown in tables 1 and 2
- Not-masked bone conduction values were not always available for every stimulus frequency for every child

Discussion: Variations with Age or stimulus frequency

Test frequency: For all children (aged 8 months - 16 years) collectively there was no significant effect of stimulus frequency on the mean estimated IA for any transducer. However, for inserts, there were significant differences in the mean estimated IA between the oldest (a) 16 years) and the youngest age group (b) 2 years and (c) 10 years.

<table>
<thead>
<tr>
<th>No of data points</th>
<th>10</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>0-7</td>
<td>0-4</td>
<td></td>
</tr>
<tr>
<td>Median (dB)</td>
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<td>65</td>
<td>70</td>
</tr>
<tr>
<td>Variance</td>
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<td>100</td>
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</tr>
<tr>
<td>Mean (dB)</td>
<td>65</td>
<td>70</td>
<td>75</td>
</tr>
</tbody>
</table>

Discussion: Study limitations

IA measures published for adults subjects are based on small subject numbers (between 6 and 30 [5, 6]). Our study extends that data to include IA estimates in children aged 8 months to 16 years, with some caveats associated with the retrospective use of our clinical data:

- Low subject numbers as shown in tables 1 and 2
- Not-masked bone conduction values were not typically available, which could lead to under-estimates of IA but reflects the compromised data available to paediatric audiologists when attempting to make decisions about the need for masking in clinical practice.

Discussion: Implications for masking

In our clinic, audiologists are encouraged to apply masking in cases where they suspected cross hearing, even if the asymmetry would not have been sufficient to require masking based purely on our guidelines. This means masking was sometimes applied for asymmetries less than 40 dB for supra-aural headphones and 55 dB for inserts. Looking at audiograms showing evidence of cross hearing, how many would have contained one or more inaccurate thresholds had the audiologist not applied this extra masking?

Conclusions

Under clinical conditions, cross hearing in children should be considered when the difference between the better ear and poorer ear not-masked air conduction thresholds is ≤ 40 dB for inserts with foam tips in children under 13 years. Cross hearing can also occur for interaural differences as small as 30 dB with supra-aural headphones in some individuals. For insert earphones we speculate that the deep and snug fitting of foam tips which could be achieved with adult subjects under laboratory conditions was not replicated by audiologists in this paediatric clinical setting, resulting in lower values of estimated IA for inserts.

Acknowledgements

Thank you to all the Audiology staff at the Royal South Hants Hospital, Southampton, UK for supporting this study and providing valuable comments on the presentation of results.