EARLY INDICATORS OF NOISE INJURY

Delving into ‘hidden hearing loss’: Perspectives from an Australian behavioural study

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Australian Hearing Hub

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SYDNEY
Research question

- Is there a relationship between levels of noise exposure and auditory processing difficulties?
- What is the influence of musical training in preventing or reducing auditory processing difficulties?
Participants

- Normal or ‘near to normal hearing’
- Normal tympanometry
- 30 – 55 years of age
- History of noise exposure and/or musical experience

(n = 124)
Test battery

- Measured
- Self-reported

Speech in noise

Cochlear and neural function

- OHC
- IHC low-threshold
- IHC high-threshold

Cognitive abilities

- Kaufman Brief Intelligence Test (KBIT)
- Test of Everyday Attention (TEA)
- Digit Span Forward & Back (DSF/DSB)
- Reading Span Task (RST)

Musical training

- Music USE questionnaire

Noise exposure

- Lifetime Noise Exposure

Lisn-S, NAL Dynamic Conversations Test (NAL DCT)

SSQ-12

Weber Questionnaire

Audiometry
- DPOAE
- MOCR Contralateral OAE suppression

Amplitude Modulation (AM)
Temporal Fine Structure (TFS1)
TEN elevation

Measuring sound values

Creating sound value™
Main finding

No straightforward relationship between overall lifetime noise exposure and auditory processes or functional outcomes, i.e., speech in noise measures.
Noise exposure – is there an alternative way to quantify it?

- night club exposure
- noise exposure from shooting
- acceptable lifetime exposure
- overall exposure with / without hearing protection

Noise Exposure (Pa²h) =

\[
[4 \times T_{\text{lifetime hours}} \times 10^{0.1 (L_{\text{Aeq-100}})}]_{\text{leisure activity 1,2,3,n}} + [4 \times T_{\text{lifetime hours}} \times 10^{0.1 (L_{\text{Aeq-100}})}]_{\text{workplace 1,2,3,n}}
\]

### Results

**Auditory processes**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>TFS1</th>
<th>TEN avg</th>
<th>AM 90 Hz</th>
<th>AM 4 Hz</th>
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<td></td>
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<tr>
<td>Age</td>
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<tr>
<td>Tinnitus</td>
<td>0.16</td>
<td>0.37</td>
<td>0.16</td>
<td>-0.37</td>
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<tr>
<td>Ototoxicity</td>
<td>0.36</td>
<td>0.48</td>
<td>0.36</td>
<td>0.48</td>
<td>0.27</td>
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<tr>
<td>Hyperacusis</td>
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<tr>
<td>TTS</td>
<td>0.48</td>
<td>0.50</td>
<td>-0.35</td>
<td>-3.81</td>
<td>-0.24</td>
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<td><strong>Music Training</strong></td>
<td>4.21</td>
<td>2.95</td>
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<td>-3.81</td>
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<tr>
<td>Music Production</td>
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<td>67.01</td>
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<tr>
<td>MOCR</td>
<td>41.17</td>
<td>10.63</td>
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<td>-0.08</td>
<td>-0.29</td>
<td>-0.27</td>
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<td>Low-freq hearing</td>
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<tr>
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<tr>
<td>Ext-high freq hearing</td>
<td>22.66</td>
<td>17.74</td>
<td>-0.08</td>
<td>-0.29</td>
<td>-0.29</td>
<td>-0.10</td>
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<td><strong>Attention (TEA)</strong></td>
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<td>Digit Span</td>
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<td>Noise exposure</td>
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<td>-0.21</td>
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</table>

**Correlations and multiple regression weights**

- **Not significant**

Higher music training = better TFS, AM and TEN

Higher MOCR strength = better AM and TEN

Better Digit Span = poorer TFS?

AM 90 Hz Model Strength \( (r^2=.29, p<.01) \)

TFS Model Strength \( (r^2=.30, p<.006) \)
Results

Functional outcome measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>LiSN-S HC</th>
<th>NAL DCT</th>
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<tr>
<td><strong>Mean SD r b β</strong></td>
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<td>45.0</td>
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<td>Tinnitus</td>
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<tr>
<td>Ototoxicity</td>
<td>0.4</td>
<td>0.5</td>
<td>0.21</td>
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<tr>
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<td>0.3</td>
<td>0.5</td>
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<td>TTS</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>Music training</td>
<td>4.2</td>
<td>3.0</td>
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<tr>
<td>Music production</td>
<td>35.0</td>
<td>67.0</td>
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<tr>
<td>MOCR</td>
<td>41.2</td>
<td>10.6</td>
<td>0.28</td>
<td>0.04</td>
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<tr>
<td>Low-freq hearing</td>
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<td>4.6</td>
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<tr>
<td>High-freq hearing</td>
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<tr>
<td>Reading Span</td>
<td>48.7</td>
<td>11.2</td>
<td>0.03</td>
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<tr>
<td>Noise exposure</td>
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<td>TFS</td>
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<td>0.22</td>
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<td>Amp mod 4Hz</td>
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<td>Amp mod 90Hz</td>
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<tr>
<td>TEN elevation</td>
<td>0.3</td>
<td>2.7</td>
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</tbody>
</table>

**Correlations and multiple regression weights**

- LiSN-S Model Strength ($r^2=.38, p<.002$)
- NAL DCT Model Strength ($r^2=.44, p<.01$)

Increasing age = higher self-reported listening difficulty and poorer performance on LiSN-S and NAL DCT

Lower MOCR strength = higher self-reported listening difficulty

Poorer EHF = higher self-reported listening difficulty and poorer performance on LiSN-S and NAL DCT

Better attention & memory = better performance on LiSN-S and NAL DCT

Poorer TFS = poorer performance on LiSN-S and NAL DCT
Results – EHF & TFS

EHF

TFS

Creating Sound Value™
Results – RST & TEA

Reading Span

Everyday Attention

LiSN-S HC SRT (dB)

Reading Span Percentage Score

TEA combined score
Those with high noise exposure who still performed well:

Subj 1: > avg TFS, TEA, music tg
Subj 2: > avg TFS, TEA, music tg
Subj 3: > avg TFS, TEA, RST, music tg
Subj 4: > avg TEA, EHF, RST, music tg
Subj 5: > avg TFS, TEA, EHF, RST
Subj 6: > avg TFS, EHF, music tg

Those with low noise exposure who perform poorly:

Subj A: < avg EHF, TFS, TEA, RST
Subj B: < avg EHF, TFS, TEA, music tg
Subj C: < avg EHF, TFS, music tg
Subj D: < avg TEA, RST, music tg
Subj E: < avg TFS, RST, music tg
Subj F: < avg RST, music tg
70% of professional musicians performed above the mean on speech-in-noise.
Observations

✓ **Extended high frequencies**: a sign of early noise damage?
✓ **TFS**: sign of damage or hallmark of finely tuned auditory system
✓ **Attention**: compensatory effect
✓ **Musical training**: link to better attention and TFS

These seem to be protective and/or compensatory factors

**Diagnosis**: need to look beyond noise exposure – other factors affect performance and need to be considered (constellation of factors affect performance / may be markers of HHL)

**Rehabilitation**: training related to attention and music-based training – a promising future direction.
Limitations and future directions

- Speech in noise task vs. word recognition test
- Age of our cohort
- Musicians
- Size of test battery
EINI – Phase II

1. Cortical potentials evoked by speech

2. Iterated-ripple noise

3. Speech ABR

4. ABR evoked by clicks

5. EFR
Aims of Hearing Experiences Survey

1. Identify the main features of difficult communication environments
2. Explore key difficulties and impacts experienced by participants with hearing difficulties
3. Identify strategies these participants may be willing to adopt
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