What is auditory neuropathy (AN)?

- Hearing disorder affecting the connections between the ear and the brain.
- Classic diagnostic definition: Absent ABRs despite present OAEs\(^1\).
- Better definition: A hearing phenotype characterized by a lack of subcortical neural synchrony, manifesting as absent ABRs that cannot be explained by sensorineural or conductive hearing loss.
- Causes: unknown, genetic, or acquired (typically acute illness in infancy, such as hyperbilirubinemia).
- CDC estimates about 5-7% of pediatric hearing loss cases are AN\(^2\).

AN is a relatively new hearing disorder

- First identified in the early 1980’s\(^3\), “auditory neuropathy” coined in the 1990’s\(^4\).
- Not mainstream consideration for pediatric hearing loss until late 1990’s/early 2000’s.
- As a result, the first major cohort of AN patients are now in their 20’s.
- There may also be adults with hearing problems attributable to undiagnosed AN.

Evaluating hearing in AN is challenging

- Auditory function can fluctuate.
- AN is not mutually exclusive from sensorineural hearing loss
- Tremendous variability within the AN population itself.
- But, two clinical hallmarks: absent or grossly abnormal ABRs and absent acoustic reflexes.

Expected results from comprehensive hearing evaluation

<table>
<thead>
<tr>
<th>Test</th>
<th>Expected Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tymps</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td><strong>Acoustic Reflexes</strong></td>
<td>Always absent</td>
<td>Red flag, particularly in children where an ABR study is difficult</td>
</tr>
<tr>
<td>OAEs</td>
<td>Typically present, but variable</td>
<td>Typically OAE amplitudes are larger than normal, but can be absent or disappear over time</td>
</tr>
<tr>
<td>Audiograms</td>
<td>Variable</td>
<td>Runs the gamut from completely normal to moderate-severe sensorineural hearing loss</td>
</tr>
<tr>
<td>ABRs</td>
<td>Always absent</td>
<td>Easy to mistake cochlear microphonic for ABR</td>
</tr>
<tr>
<td>MLRs</td>
<td>Typically present</td>
<td></td>
</tr>
<tr>
<td>CAEPs</td>
<td>Typically present</td>
<td></td>
</tr>
<tr>
<td>Speech in Quiet</td>
<td>Typically normal</td>
<td>Usually excellent, assuming accounting for audibility in cases of SNHL</td>
</tr>
<tr>
<td>Speech in Noise</td>
<td>Severely impaired</td>
<td>Substantial difficulty hearing speech in noise</td>
</tr>
</tbody>
</table>

\(^1\) Thus the importance of using OAEs and ABRs in newborn hearing screening!
\(^3\) Kraus et al. (1984) *Laryngoscope*
\(^4\) Starr et al. (1996) *Brain*
AN listeners have extreme difficulties understanding speech in noise, but normal recognition in quiet

- Word recognition: similar to controls in quiet, identify 50-75% fewer words in noise⁵.
- Sentence recognition: similar to controls in quiet, but <1st percentile in noise⁶.
- Listening with 2 ears boosts sentence recognition considerably.

AN listeners struggle to process fast temporal cues in sound

- Poor at detecting a brief tone embedded in noise⁷.
- Perceptual and neurophysiological (MMN) evidence of poor processing of temporal contrasts in speech sounds, such as /b/ vs. /g/⁸, but, normal processing of slower temporal contrasts, such as /b/ vs. /w/.

AN listeners do not exhibit a frequency-following response (FFR), confirming the FFR relies on subcortical neural synchrony

- Double dissociation: subcortical neural synchrony necessary and sufficient for FFR; auditory cortices necessary and sufficient for CAEPs.⁹
- Even for stimuli within the range of auditory cortex phaselocking, subcortical neural synchrony is necessary to generate the FFR¹⁰; cortical activity may contribute.

AN provides fundamental insights into the importance of subcortical neural synchrony

- Neural synchrony is necessary to hear in noise and generate an FFR.
- FFR requires subcortical synchrony. FFR reflects neural mechanisms underlying speech-in-noise recognition.
- Normal OAEs and hearing thresholds do not guarantee normal auditory function.
- By extension, mild forms of dyssynchrony may account for everyday listening challenges¹¹.

Our speculations about AN and what it tells us about normal hearing

- Lack of acoustic reflexes means AN listeners live without the ear's protective mechanisms in noise. This may elevate risk of developing sensorineural hearing loss in adulthood.
- AN illustrates important role of binaural hearing to recognize speech in noise.
- Subcortical synchrony is important for sound awareness – ability to detect a new sound amid a complex soundscape.

For more information: www.brainvolts.northwestern.edu

⁵ Kraus et al. (2000) JARO
⁶ White-Schwoch et al. (2020) JAMA-Oto
⁷ Kraus et al. (2000) JARO
⁸ Kraus et al. (1993) Ear Hear; Kraus et al. (2000) JARO
⁹ White-Schwoch et al. (2019) J Neurophysiol
¹⁰ White-Schwoch et al. (2021) J Neurophysiol
¹¹ Anderson et al. (2012) J Neurosci