A FRESH Approach to Pediatric Behavioral Threshold Testing

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Learning Objectives

• The participant will be able to describe the features and benefits of FRESH noise.
• The participant will be able to discuss the inherent problems using Narrow Band Noise in the sound field as a test stimulus.
• The participant will be able to explain how to make informed decisions regarding test protocols and stimuli selection for pediatrics when tested in the sound field in both the unaided or aided conditions.
What is FRESH Noise?

▪ A Narrow Band Noise stimulus designed for the purpose of testing hearing thresholds.
▪ More frequency specific
▪ Designed with extremely steep filter slopes.
▪ Stimulus does not spread beyond the desired frequency range.
▪ Calibrated in dB HL.

(But, don’t we already have Narrow Band Noise?)
Masking Noise
Dr Robert Bárány, MD, Vienna (1876 to 1936)

“The Barany Box is inserted in the hearing ear and creates a loud buzzing sound while the examiner shouts in the deaf ear to determine if the patient can hear anything. If the patient cannot hear the words shouted, then the ear is considered “Barany Deaf.””

[Source: www.hearingaidmuseum.com]

It is scarcely necessary to enumerate the many objections to the use in audiometry of such masking devices as the Bárány noise box and jets of air or water. They are unpredictable in effect and awkward in use.”

(Denes & Naunton, 1952)

The sound level produced by this Barany Box measured a whopping 110 dB, so if you weren’t Barany Deaf before...

NBN Masking

• 1950’s: Advantage of NBN over Wide Band Noise was recognized
  – Masking Efficiency: the relation between a sound's ability to mask and its loudness. A sound with high masking efficiency is one with good masking ability but minimal loudness.
  – 1/3 octave Narrow Band Noise
Effective Masking Level (EML)

The difference in decibels of the level of a tone and the level of a noise that just masks the tone.

Critical Ratio: SNR at threshold when shifted by the noise

Since the NBN masking noise is wider than the critical band, some energy that is “wasted” outside must be accounted for in the calibration

Think of EML this way... as a

Minimal Effective Masking Correction (MEMC):
The correction that must be added to a tone’s levels to arrive at a minimal noise level that will effectively mask that tone.

-Stanley A. Gelfand
Effective Masking Level Corrections

If we want to cover up a tone, the NBN has to be louder than the tone.

This increase or correction factor is built into the audiometer’s masking channel calibration as Effective Masking Noise (EML) according to ANSI Standards for Audiometers.

Amounts in Decibels (dB) to be Added to the Reference Equivalent Threshold Sound Pressure Level (RETSPL) to achieve Effective Masking (dB EM) for One-Third Octave Band Masking Noises

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>750</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>6000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>For one-third octave-band noise</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6</td>
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</tbody>
</table>

[Extract from ANSI S3.6-2004 American National Standard Specifications for Audiometers]

Effective Masking Level Corrections

When you choose NBN on your audiometer, it is displaying the dB level in dB Effective Masking level (dB EM), not dB Hearing Level (dB HL).

Therefore, NBN on your audiometer is intended to be a masking signal, not a stimulus for determining threshold.

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NBN is Calibrated in Decibels of Effective Masking (dB EM)

Problem: Pure tones cause Standing Waves in the Sound Field.

A disadvantage of widening bandwidth, to reduce errors arising from field variability, is that the hearing loss at a specific frequency will be underestimated to some degree unless the threshold is flat across frequency. This occurs because, when the test stimuli are narrowband, the threshold may be artificially lowered by the bandwidth of the stimulus. In addition to questions concerning the choice of stimulus, there is a lack of consensus about other aspects of sound field testing, such as the subject's position relative to the loudspeaker and the calibration techniques to be used. Sound field audiometry, with frequency-specific stimuli, is used extensively in the National Acoustic Laboratories (NAL) for assessing the hearing of ordinary, and as an integral part of our hearing aid selection procedures. A final test, with the exception of many unattended issues concerning sound field audiometric techniques, provides a series of results with the aim of determining a comprehensive set of clinical findings. In this article we...
Sloping Audiograms

Table 1. Maximum threshold slopes which should be measured with standard (or wide) bandwidth stimuli

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Maximum Slope (dB/octave)</th>
</tr>
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<tr>
<td>0.25</td>
<td>11</td>
</tr>
<tr>
<td>0.5</td>
<td>13</td>
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<td>6</td>
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<tr>
<td>8</td>
<td>34</td>
</tr>
</tbody>
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(Walker, Dillon and Byrne, 1984)

More concerns about NBN filter slopes

Orchik and Mosher (1975)

"...realize that the noise parameters, especially bandwidth and filter slope, can result in a significant overestimate of threshold sensitivity in patients with sloping audiometric configurations."

Orchik and Rintelmann (1978)

"...for subjects with sharply sloping high frequency sensorineural hearing losses... narrow band noise may substantially overestimate pure tone threshold sensitivity."

Stephens and Rintelmann (1978)

Average difference from normalized pure tone thresholds per stimulus type for sharp configurations
How did NBN come to be used as a Stimulus?

So, you think you can impress me, huh? Let’s see what you’ve got.

Testing in the Sound Field: Issues

- Testing with NBN only provides a loose estimation of a child’s hearing ability and only with a flat hearing loss.

- Warble and Narrow Band Noise have been used extensively for many years as sound field stimuli for pediatric audiometry.

- These popular stimuli also made their way into pediatric audiometry under headphones and inserts.
But, what about this?

The Disconnect between what we know and what we practice:

Narrow Band Noise was intended to be an Effective Masking Noise under headphones. It was intended to *cover up* a stimulus. It was *never* intended to *be* a stimulus.
Principle illustrated using the OTOsuite Hearing Loss Simulator

Pure tone stimulus

FRESH noise stimulus

Test frequency
If we present a Narrow Band masking noise as stimulus at the same level, the patient will respond to the circled area where the narrow band noise spills over into the audible range. Hence we will continue decreasing the stimulus level until the patient stops responding...

The patient stops responding and we mark the assumed threshold and thus underestimate the hearing loss.
This picture illustrates why there is no evident problem when the hearing loss is relatively flat. The stimulus remains within the inaudible range across all frequencies.

**FREquency Specific Hearing noise**

- The "recipe" used for FRESH noise in the Madsen Astera Audiometer (GN Otometrics) from Walker, Dillon and Byrne (1984)
FRESH Noise in Astera control panels

Classic mode

Sunshine mode

NBN

Warble

FRESH
Sound Examples

NBN 500 Hz  FRESH 500 Hz  NBN 1000 Hz  FRESH 1000 Hz

Pilot study
Subject #1
First subject at ISVR

Consequence of NBN

What consequence may the underestimated hearing loss have clinically?
DSL 5 Aided Response Target

Underestimated hearing loss
(NBN)

True hearing

References

American National Standards Institute. ANSI S 3.6-2004, American national standard specification for audiometers


Gelfand, S. [ ]
Why?

Under Aided conditions, is FRESH Noise consistent with Warbled Pure Tones?
Will the same results be seen during aided testing?

Is there a statistical difference between the 3 stimuli and the thresholds they produce?

Hypothesis: Narrowband noise overestimates aided thresholds compared to WPT and FRESH Noise.

Implications

Underestimating unaided thresholds
Improper/underfit hearing aids

Aided testing in the sound field would yield overestimated thresholds.

Aided detection is crucial for mapping implants
Speech and Language development???
Test Protocol

31 Ears (ages 3-12)
13 Hearing aids
18 Cochlear implants
Utilized CPA or conventional audiometry
Testing completed using Astera Audiometer
Randomized block presentation of stimulus

Statistics

Analysis was performed by an independent statistician (Mr. Andrew Drago, M.S.).
He used a factorial design to look at the factors of channels, frequency, and stimulus interaction.
Looked at HAs and CIs separately.
Hearing Aid Findings

No statistical significance between thresholds obtained with FRESH noise and WPT (Interchangeable)

Significant difference between WPT/FRESH noise and NBN

Frequency is significant. Less variation in the low frequencies and more in the highs

How many channels active were not significant
Why?
Hearing Aid: Frequency Range vs. dB

Set up for Hearing Aid Channel Stimulation
Hearing Aid Channels Activated

Hearing Aid Channels Stimulated

SPL Right Ear at 1000Hz

WPT

FRESH

NBN
HA 4K response

500Hz HA channel activation
Implant Findings

No statistical significance between thresholds obtained with FRESH noise and WPT (Interchangeable)

Significant difference between WPT/FRESH noise and NBN

Frequency was not significant. Significant variation occurred across all frequencies

How many channels active were not significant? Why?
Implants:
Frequency Range vs. dB

A_2 is Narrow Band Noise

M is Fresh Noise

A is Warble Tones
Take Home Message

1) WPT and FRESH Noise are always consistent and interchangeable as test stimuli in the sound field in both unaided and aided condition.

1) NBN overestimated aided thresholds with both HA and CI across the frequency range

1) INSTEAD OF NBN, USE FRESH/WARBLE TONE TO MARK THRESHOLDS

Call for future research

Why do stimulus and frequency have a significant impact?

Does processing, # of channels active, # of electrodes active, processing strategy used have an impact?

Gather more data with larger variance of channels active and it may show more significance.
Thank You!!!!