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?)

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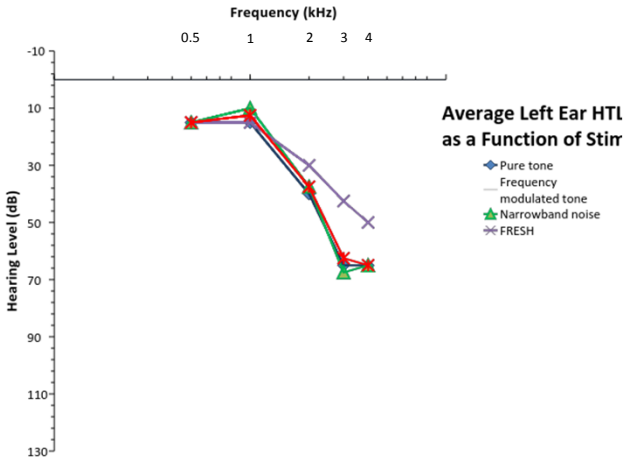
What is this about?



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Masking Noise

Dr Robert Bárány, MD, Vienna (1876 to 1936)

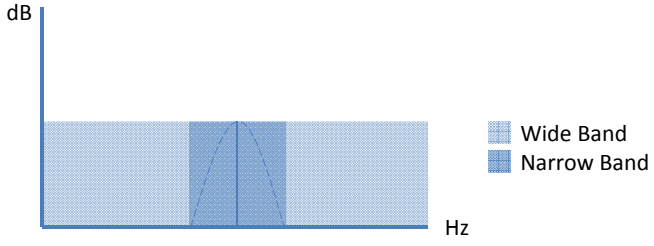
"The Barany Box is inserted in the hearing ear and creates a loud buzzing sound while the examiner shouts in the deaf ear to determine if the patient can hear anything. If the patient cannot hear the words shouted, then the ear is considered "Barany Deaf.""
(Source: www.hearingaidmuseum.com)

"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)

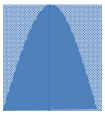
The sound level produced by this Barany Box measured a whopping 110 dB, so if you weren´t Barany Deaf before…

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

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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

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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

	Frequency (Hz)										
	125	250	500	750	1000	1500	2000	3000	4000	6000	8000
For one-third octave-band noise	4	4	4	5	6	6	6	6	5	5	5

(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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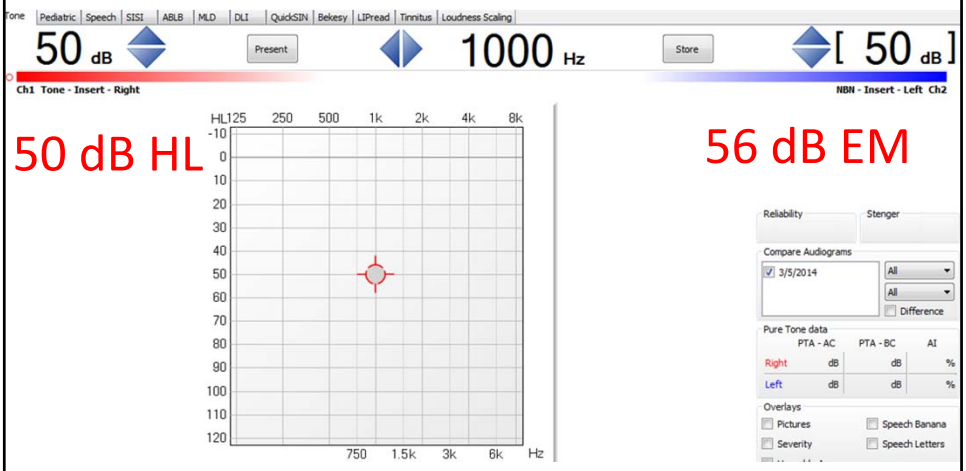
(Extract from ANSI S3.6-2004 American National Standard Specifications for Audiometers)

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



50 dB HL

56 dB EM

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

H. Dillon and G. Walker, Stimuli for audiometric testing.
J. Acoust. Soc. Am., Vol. 71, No. 1, January 1982

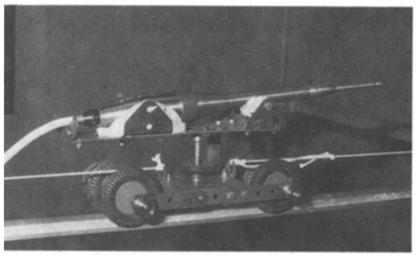


FIG. 1. Microphone mounted on a cable-drawn trolley used to determine sound field distribution within the test room.

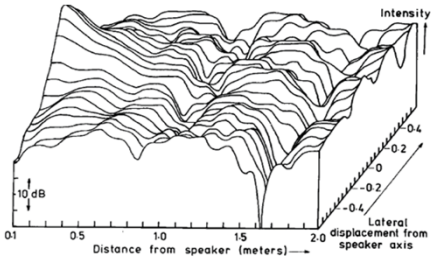


FIG. 2. Sound intensity variations within the test room at a frequency of 1200 Hz. The loudspeaker is located 0.1 m to the left of the center of the left-hand side "wall."

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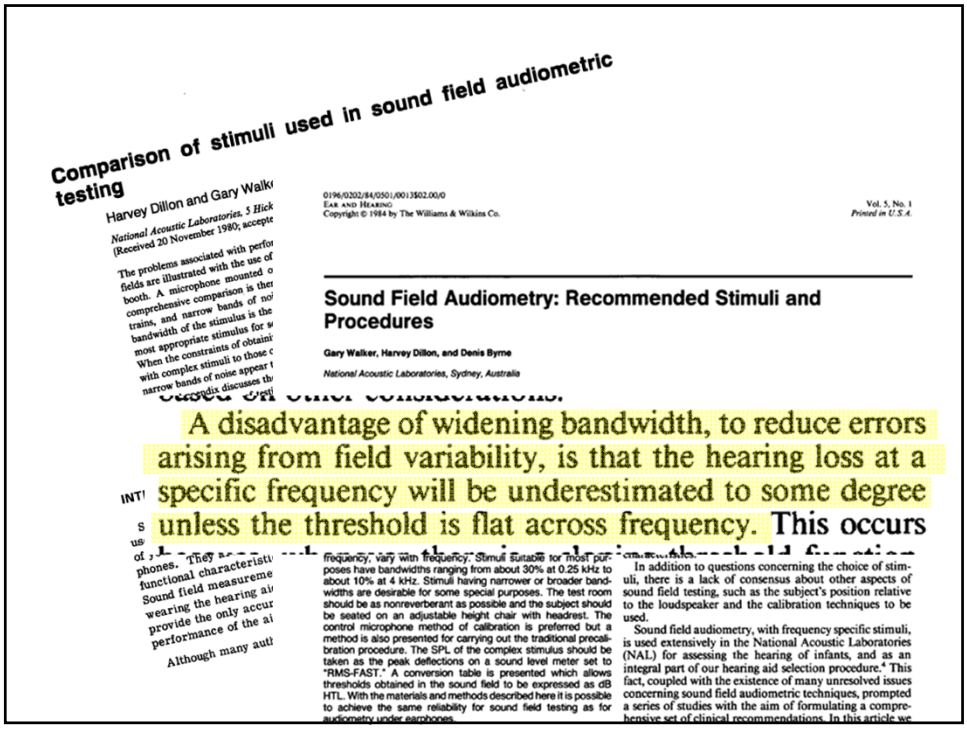

Comparison of stimuli used in sound field audiometric testing

Harvey Dillon and Gary Walk

National Acoustic Laboratories, 5 Hick
(Received 20 November 1980; accepte

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Appendix discusses th

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Sound Field Audiometry: Recommended Stimuli and Procedures

Gary Walker, Harvey Dillon, and Denis Byrne

National Acoustic Laboratories, Sydney, Australia

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

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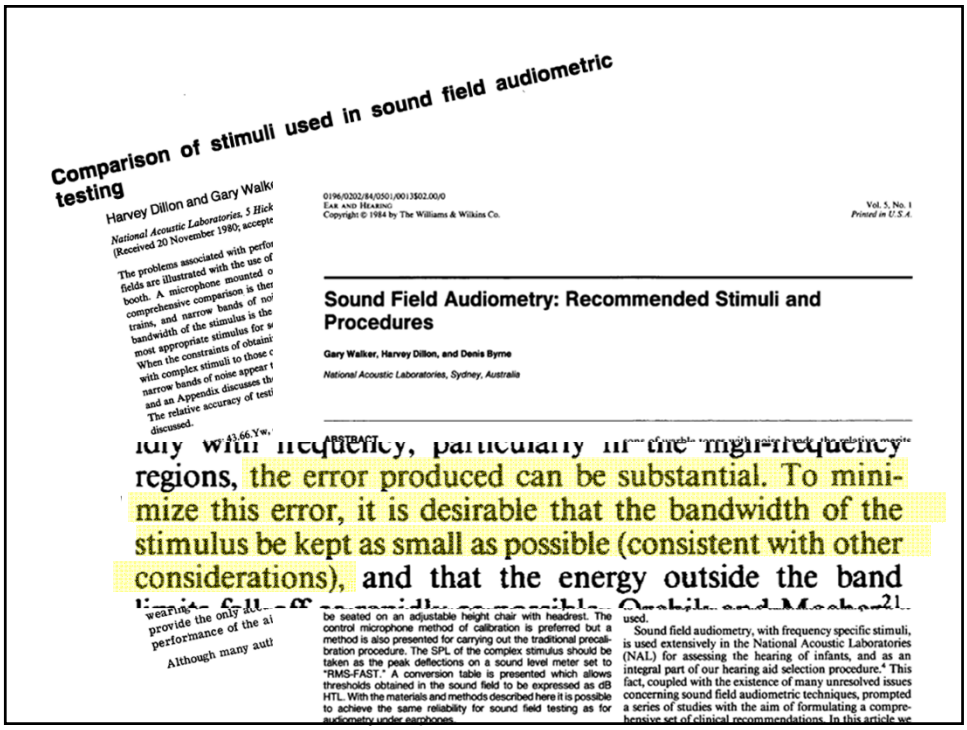
frequency, vary with frequency. Stimuli suitable for most pur-
poses have bandwidths ranging from about 30% at 0.25 kHz to about 10% at 4 kHz. Stimuli having narrower or broader bandwidths are desirable for some special purposes. The test room should be as nonreverberant as possible and the subject should be seated on an adjustable height chair with headrest. The control microphone method of calibration is preferred but a method is also presented for carrying out the traditional precalibration procedure. The SPL of the complex stimulus should be taken as the peak deflections on a sound level meter set to "RMS-FAST." A conversion table is presented which allows thresholds obtained in the sound field to be expressed as dB HTL. With the materials and methods described here it is possible to achieve the same reliability for sound field testing as for audiometry under earphones.

In addition to questions concerning the choice of stimuli, 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 infants, and as an integral part of our hearing aid selection procedure.[4] This fact, coupled with the existence of many unresolved issues concerning sound field audiometric techniques, prompted a series of studies with the aim of formulating a comprehensive set of clinical recommendations. In this article we



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ABSTRACT

idly with frequency, particularly in the high-frequency regions, the error produced can be substantial. To minimize this error, it is desirable that the bandwidth of the stimulus be kept as small as possible (consistent with other considerations), and that the energy outside the band

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be seated on an adjustable height chair with headrest. The control microphone method of calibration is preferred but a method is also presented for carrying out the traditional precalibration procedure. The SPL of the complex stimulus should be taken as the peak deflections on a sound level meter set to "RMS-FAST." A conversion table is presented which allows thresholds obtained in the sound field to be expressed as dB HTL. With the materials and methods described here it is possible to achieve the same reliability for sound field testing as for audiometry under earphones.

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Sloping Audiograms

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

Frequency (kHz)	Maximum Slope (dB/octave)
0.25	11
0.5	13
1.0	16
1.5	21
2	24
3	30
4	34
6	34
8	34

(Walker, Dillon and Byrne, 1984)

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More concerns about NBN filter slopes

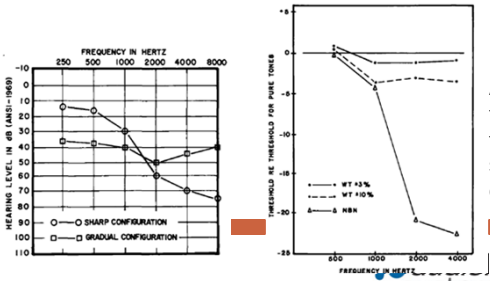
Orchik and Mosher (1975)

"…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

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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.

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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

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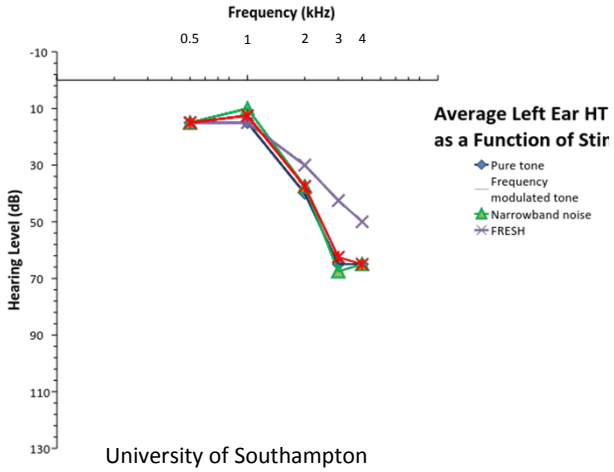
But, what about this?



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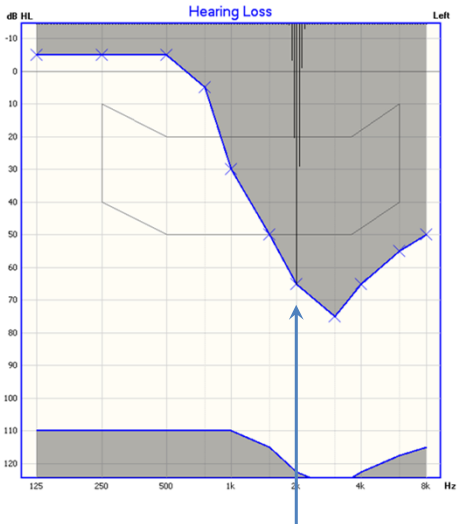
The Disconnect between what we know and what we practice:

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.

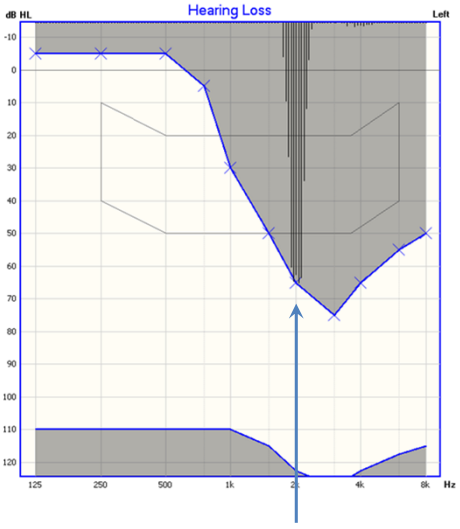
Principle illustrated using the OTOsuite Hearing Loss Simulator



Pure tone stimulus

Test frequency

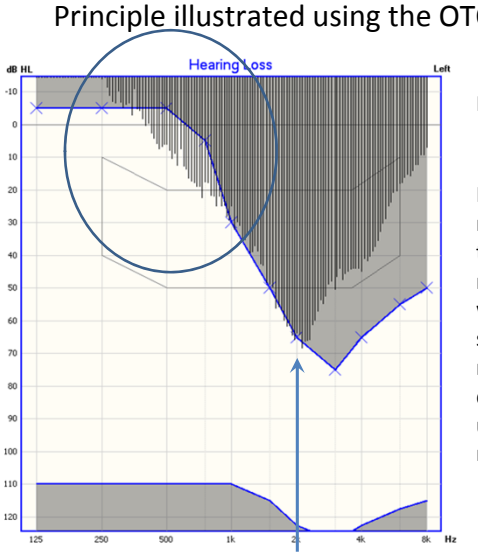
Principle illustrated using the OTOsuite Hearing Loss Simulator



FRESH noise stimulus

Test frequency

Principle illustrated using the OTOsuite Hearing Loss Simulator

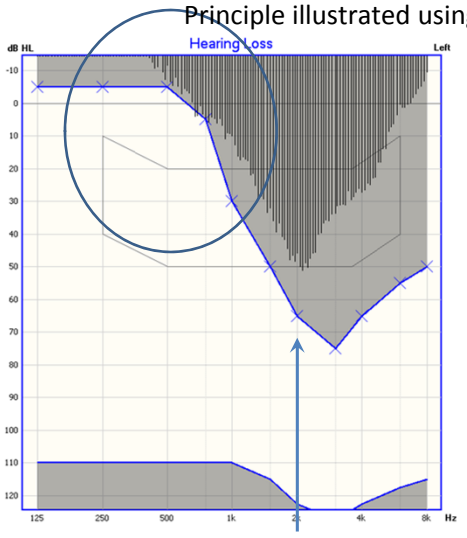


Assumed test frequency

NBN as stimulus

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...

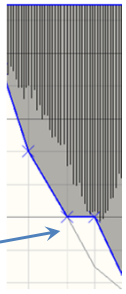
Principle illustrated using the OTOsuite Hearing Loss Simulator



Assumed test frequency

NBN as stimulus

The patient stops responding and we mark the assumed threshold and thus underestimate the hearing loss



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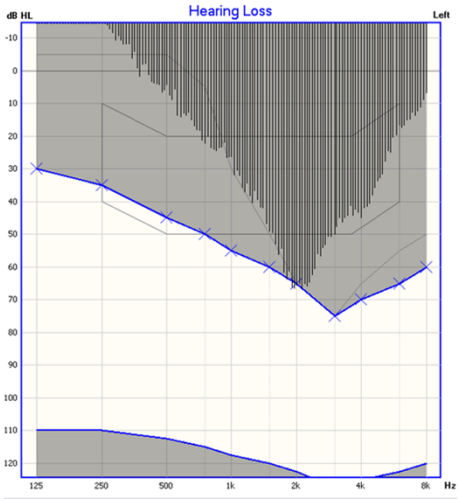


NBN as stimulus

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)

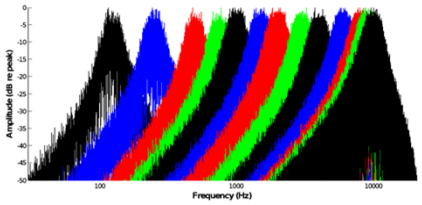
Table 2. Recommended bandwidths of stimuli for use in sound field audiometry

Center Frequency (kHz)	Narrow		Standard		Wide	
	Deviation (% of center frequency)	Band-width (Hz)	Deviation (% of center frequency)	Band-width (Hz)	Deviation (% of center frequency)	Band-width (Hz)
0.25	9.7	24	29	72	58	145
0.5	8	40	24	120	48	240
1	5.7	58	17	170	34	340
1.5	4.3	64	13	195	26	390
2	3.7	74	11	220	22	440
3	3.0	90	9	270	18	540
4	2.7	108	8	320	16	640
6	2.7	162	8	480	16	960
8	2.7	216	8	740	16	1280

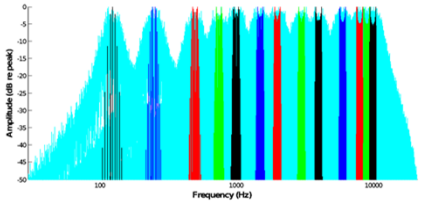
FRESH Noise in Astera control panels

Classic mode

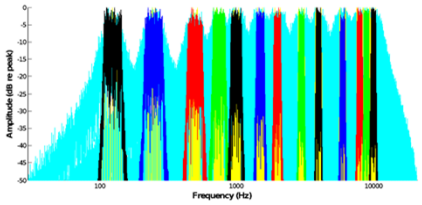
Sunshine mode



NBN



Warble



FRESH

Sound Examples

NBN 500 Hz

FRESH 500 Hz

NBN 1000 Hz

FRESH 1000 Hz

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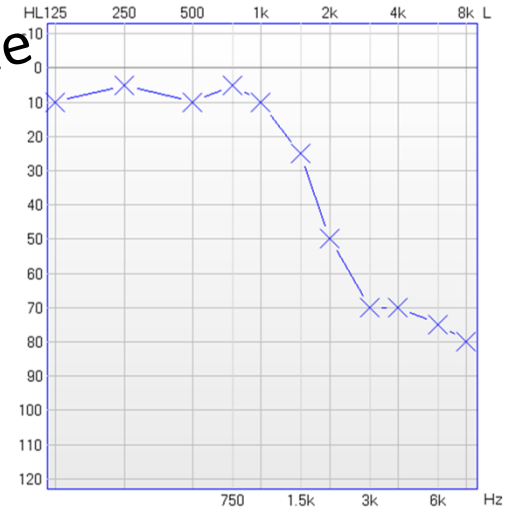
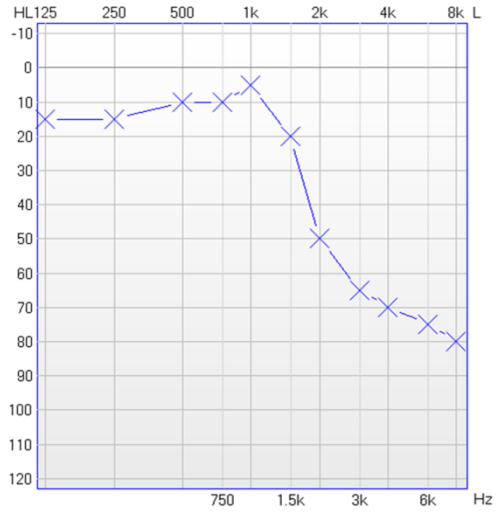
Pure Tone



Pilot study
Subject #1

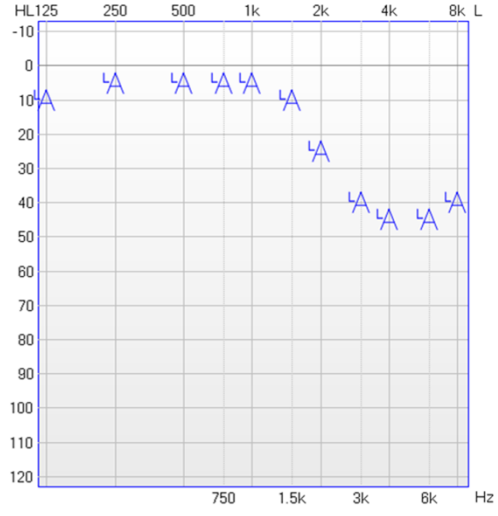
FRESH



Pilot study
Subject #1

Erling B L1 NBN, R2 NBN

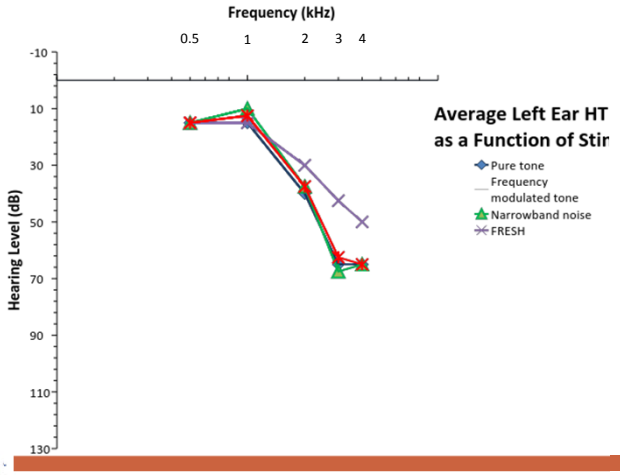
NBN



Pilot study
Subject #1

Erling B L1 NBN, R2 NBN

First subject at ISVR



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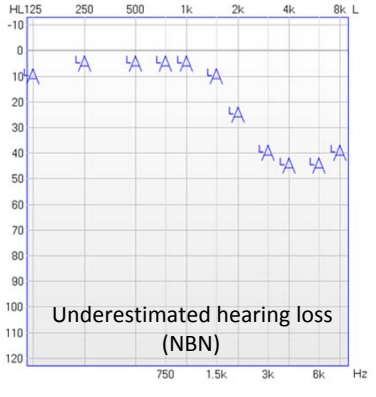
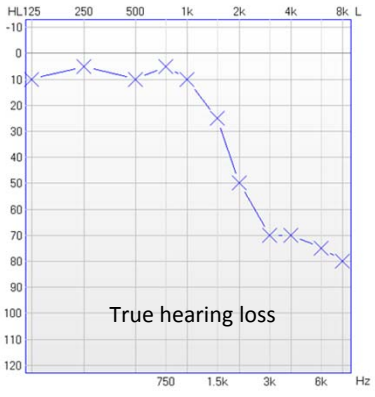
Consequence of NBN

What consequence may the underestimated hearing loss have clinically?



Underestimated hearing loss (NBN)



True hearing loss

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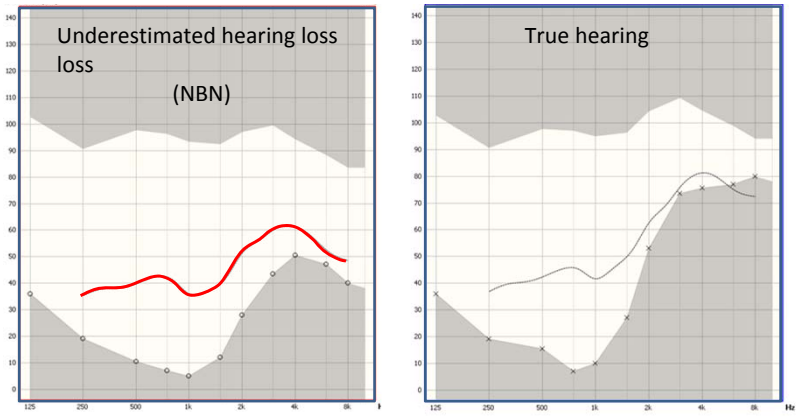
DSL 5 Aided Response Target



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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.

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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???

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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

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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.

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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?

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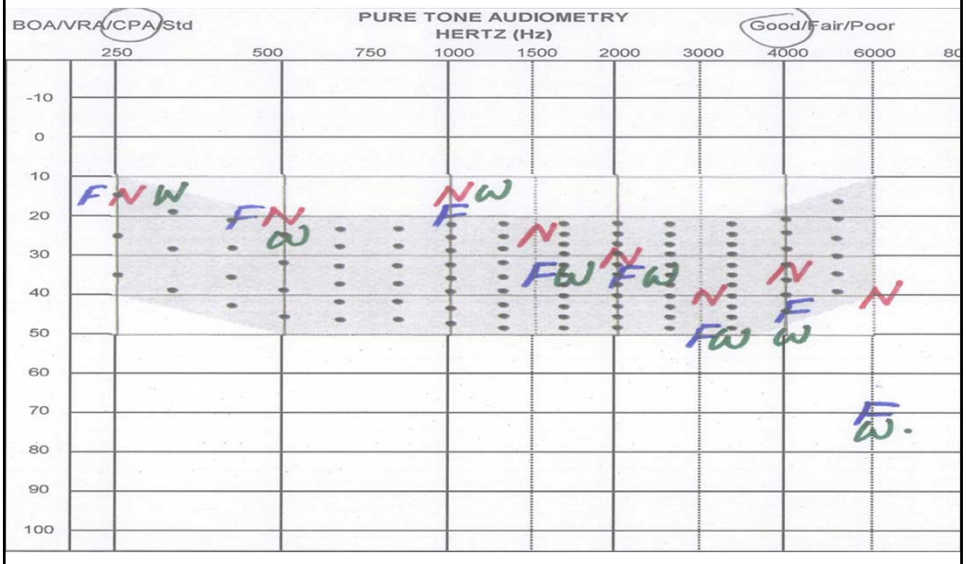
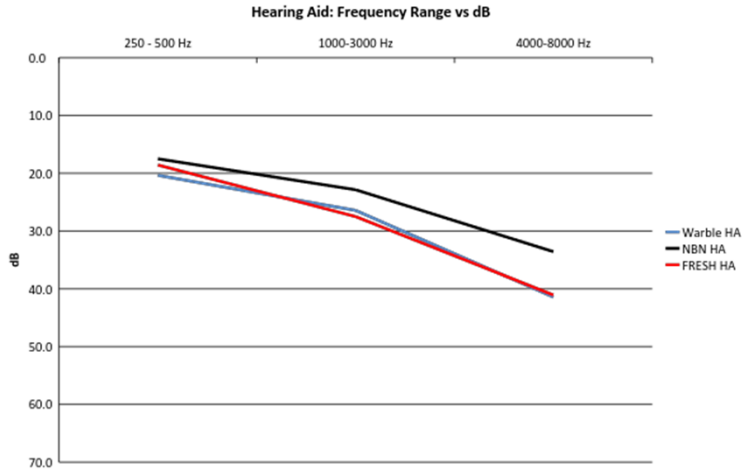
Working Audio



Hearing Aid: Frequency Range vs. dB



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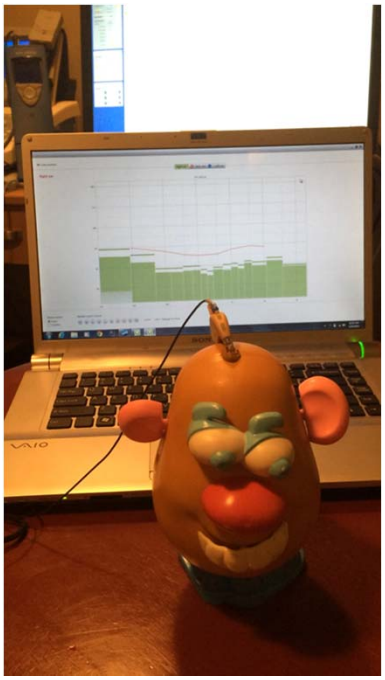
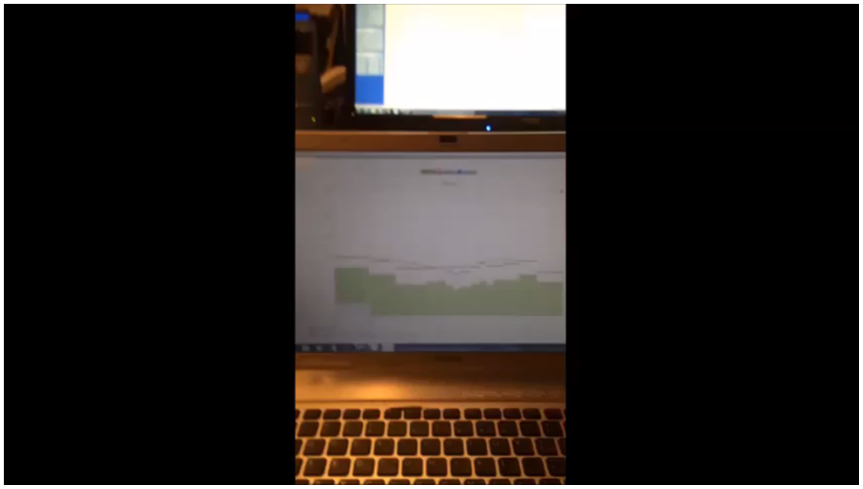


Set up for Hearing Aid Channel Stimulation

Hearing Aid Channels Activated



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Hearing Aid Channels Stimulated

HA 4K response

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500Hz HA channel activation

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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?

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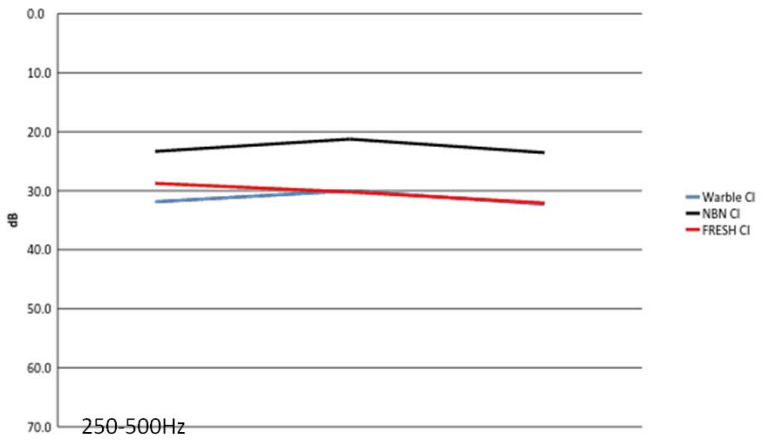
Implant: Frequency Range vs. dB



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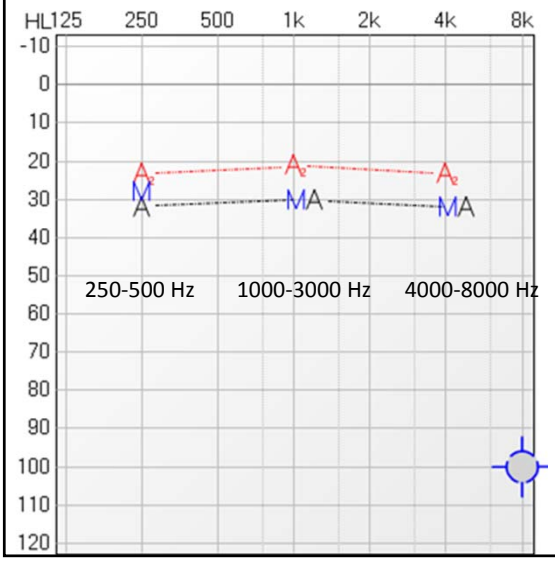
Implants: Frequency Range vs. dB



A_2 is Narrow Band Noise

M is Fresh Noise

A is Warble Tones

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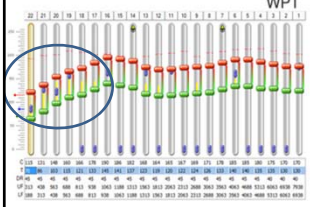
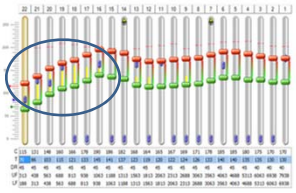
500 Hz

WPT

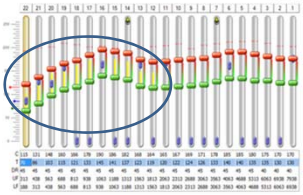


500Hz

FRESH

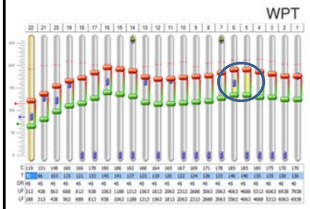


NBN



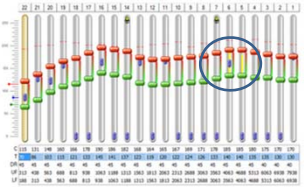
4000 Hz

WPT

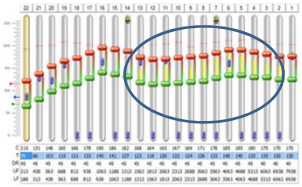


4000Hz

FRESH

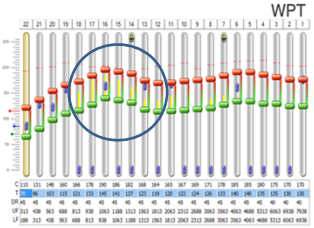


NBN



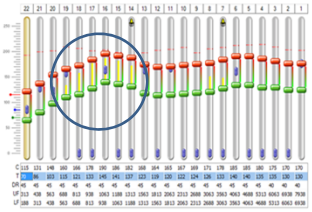
1000 Hz

WPT

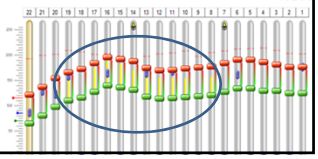


1000Hz

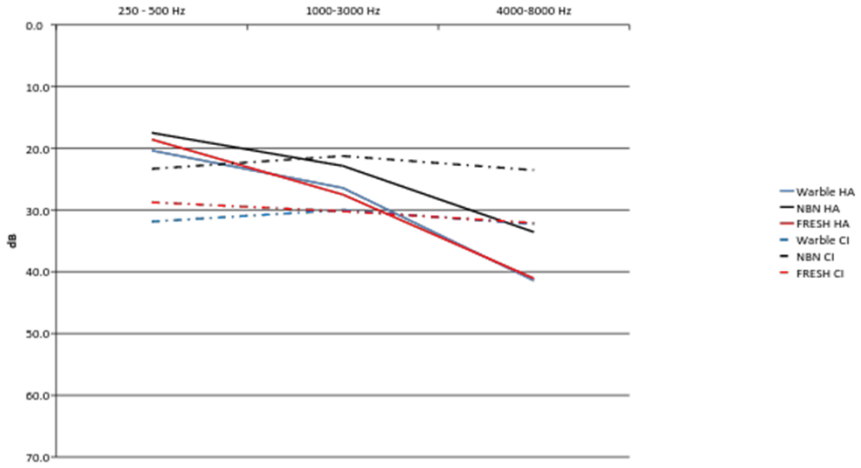
FRESH



NBN



Hearing Aid vs. Frequency Range vs. dB



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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

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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.

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Thank You!!!!

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