Early Detection of Adult Hearing Loss: Next Steps to Clinical Practice

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Clinical Learning Objectives

• Understand the limitations of calibration methods currently used for audiometers and OAE instruments.

• Identify the frequency range of interest for early identification of age-related hearing loss.

• Evaluate the relative value of objective tests such as OAEs as early indicators of age-related hearing loss.
The Human Hearing Range

[Graph showing the human hearing range with a red box highlighting the limits of range of current OAE systems]
Completely Impractical for the Hearing Clinic!
Hardware Used in NU-HARP Research

Wideband, linear system
Comfortable
Stability reduces subject noise
But bulky and not convenient to use!
• Built prototype hardware and software.

• Initial phase at NU with 4-hour battery on ~400 individuals.

• Refinement of hardware and software.

• Second phase at NU and UI Hospital clinics with streamlined battery.

• Sample stands at ~1200 individuals.

• Presenting data today from 350 “otologic normals” between 10 - 65 years old.
Age Groups
- 10–21 yrs (n=84)
- 22–35 yrs (n=101)
- 36–45 yrs (n=53)
- 46–55 yrs (n=62)
- 56–65 yrs (n=52)

Threshold (dB SPL) vs. Frequency (Hz)
25-29 yo
change between 30-45 yrs

All subjects qualify as clinically normal
• Thresholds do not show a decline with age at the lowest frequencies.

• Monotonic decline up to 6 kHz, steeper slopes with increasing frequency.

• A second, fast phase of decline observed at 8 kHz and above.
DPOAE Loss (dB re: 10-14 yo)

Age = 10 - 14

Frequency (kHz)
Current measurement limits ignore the frequency range most sensitive to age related changes in hearing.

Moving the standard to a more pristine state of hearing reveals clinically relevant auditory aging as early as 20 - 25 years of age.

Dramatic expansion of affected frequency range and decline in function between 30 and 45 years of age.

OAEs serve as an “early warning system” for age-related decline in auditory function providing a 5-year lead over hearing thresholds.

The “edge/corner” of hearing thresholds or OAEs efficiently reveals age related changes.
track edge of auditory function

objective, behavioral thresholds, speech perception in noise, CEDRA

questionnaire, objective, behavioral thresholds, speech perception in noise

OAEs +ABR

objective including middle ear

objective & automatic
objective, behavioral thresholds, speech perception in noise, CEDRA

amplification at multiple price points

objective, behavioral thresholds, speech perception in noise

auditory training

OAEs

environmental modifications

+ABR

hearing protection

objective including middle ear

awareness & education

objective & automatic
NU-ER Probe Design
The ER-10X Research Probe

• The probe microphone preamplifier, programmable calibrator and control logic and USB interface will be contained in a 1U rackmount box.

• Probe temperature regulation, humidity monitoring and memory to store microphone compensation and sensitivity information will also be incorporated into the unit and accessed through the USB.
The Human Hearing Range
NU-ER Probe History

ER-10C

ER-10X
NU-ER ER-10X Probe

Deep insertions are comfortable and the probe is stable
NU-ER ER-10X Probe

An ear-muff hearing protector fits easily over the ear with the probe inserted, providing ~50 dB passive isolation from environmental noise for testing in non-ideal locations.
NU-ER Probe Performance

Large Dynamic Range and System Distortion

\[ L_1 = 72; \quad L_2 = 72 \text{ FPL} \]
\[ f_2 / f_1 = 1.2 \]

\[ 2f_1 - f_2 \quad \text{DPOAE} \]

Noise Floor

System Distortion

\[ \text{SPL (dB)} \]

\[ \text{f}_2 \text{ (Hz)} \]
NU-ER Probe Performance

Large Dynamic Range and System Distortion

\[ L_1 = 72; \ L_2 = 72 \text{ FPL} \]
\[ f_2 / f_1 = 1.2 \]

SPL (dB)

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000 20000

\[ 2f_1 - f_2 \]
\[ \text{DPOAE} \]

9/2013
7/2014

Noise Floor
System Distortion
NU-ER Probe with Wireless Interface
NU-ER Probe with Wireless Interface
NU-ER Probe with Wireless Interface
NU-ER Probe with Wireless Interface
NU-ER Probe with Wireless Interface
Thank You