IMASH Conference
October 6, 2011
Salt Lake City

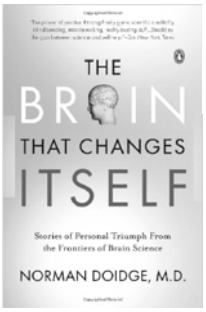
Diagnosis, Fitting and Counseling Strategies To Improve Long-Term Hearing Aid Acceptance

David J. Smriga, M.A.
Audiologist
Hearing Industry Consultant

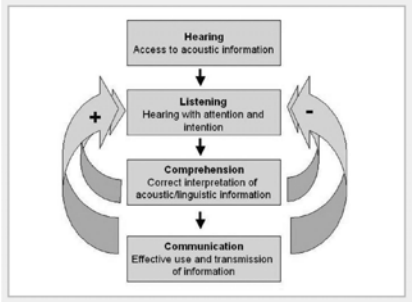
The Case of a Woman Perpetually Falling

Redesigning The Brain

Inspiring Stories of Cortical Neural Plasticity



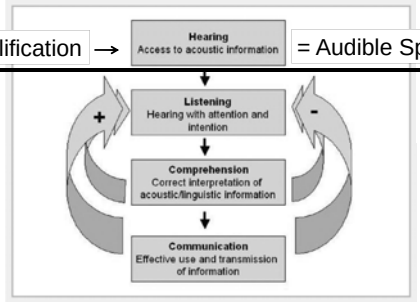
The Elements of Communication



Kiessling J., Pichora-Fuller MK, Gatehouse S., et al.: "Candidature for the delivery of audiological services: Special needs of older people" Int J Audiol 2003:42(2):S92-S101

The Elements of Communication

Amplification → = Audible Speech



Kiessling J., Pichora-Fuller MK, Gatehouse S., et al.: "Candidature for the delivery of audiological services: Special needs of older people" Int J Audiol 2003:42(2):S92-S101

The "Fundamentals"

- The goal of amplification is to restore *speech audibility*
  - The focus of the fitting process to make this happen, and to verify it
- Gain is a tool used to restore audibility, but its presence does not verify that audibility has been restored

The "Fundamentals"

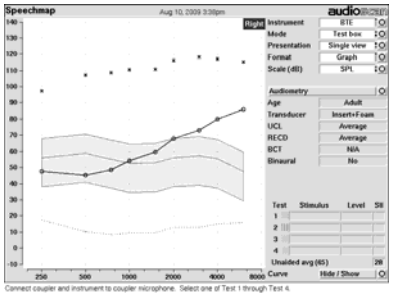
- Dynamic amplification can only be effectively evaluated in the presence of dynamic stimulation
- Amplification addresses only the peripheral aspects of audibility
  - Maximized speech audibility is not appropriate for all "traditional" peripheral hearing losses

The "Fundamentals"

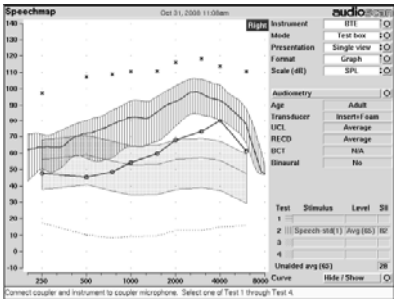
- Normed "targets" are not always an individual's "audibility-targets"
- In addition to audible speech, some measure of brain exercising is needed to maximize communication
- There is no substitute for solid science

Speechmap® Audibility Verification

The Basic Speechmap Screen - Verifit



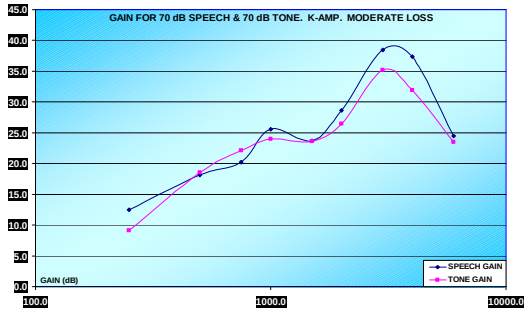
The Aided Speech Banana - Verifit



Why Output Instead of Gain?

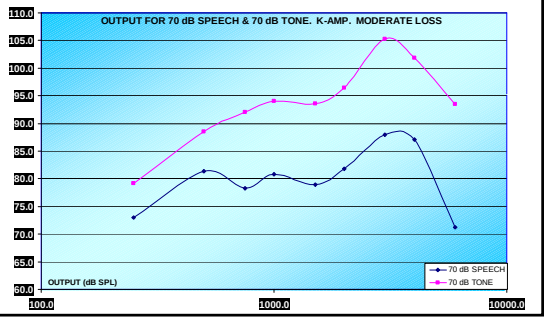
For this compression hearing aid...

Gain for speech ≅ Gain for tones



Output for speech is

much less than output for pure tones.



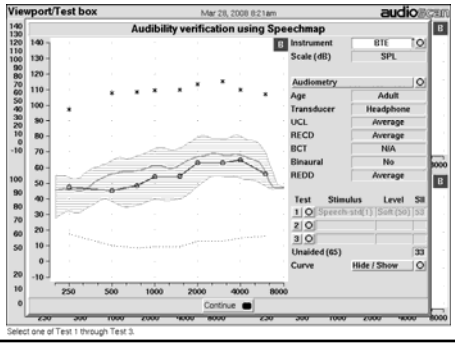
Speech Is An Excellent WDRC Measurement Stimulus

- It IS the most important input signal that the patient will want to hear well and comfortably
- It interacts with multi-band compressors in a more realistic way than tones
  - band interactions across frequency
  - changing intensity

Speechmap Fitting Protocol

- Test 1:
  - Input: 50dB STD speech
  - Goal: To adjust the gain of the aid so that at least the middle line of the aided speech banana hovers above the SPL threshold line

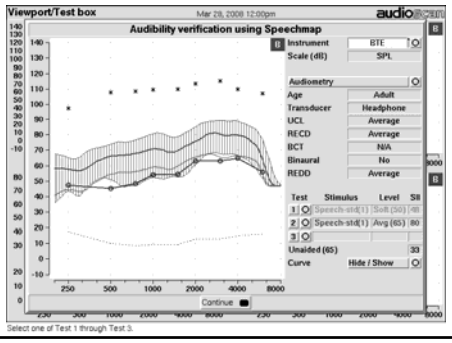
Test 1 Result



Speechmap Fitting Protocol

- Test 2:
  - Input: 65dB STD speech
  - Goal: To verify that the bottom line of the aided speech banana is just above threshold
    - Use compression settings to adjust the width of the banana

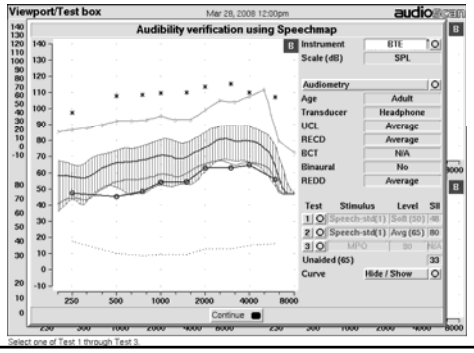
Test 2 Result



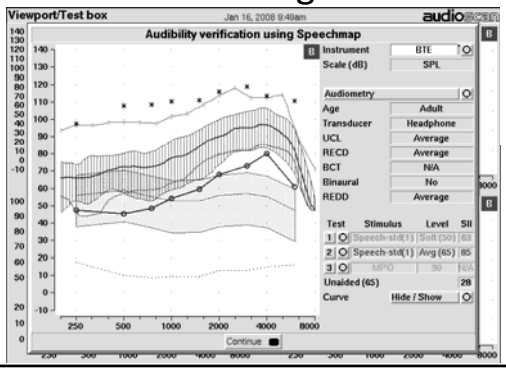
Speechmap Fitting Protocol

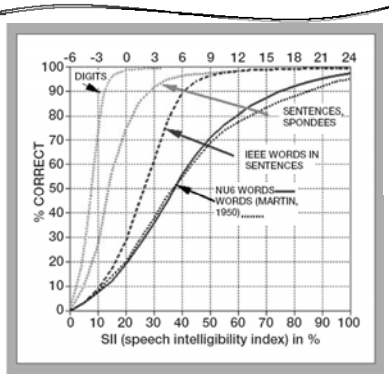
- Test 3:
  - Input: MPO Sweep
  - Goal: To adjust the MPO of the aid so that the blue dots come as close as possible to the UCL asterisks without being above them

Test 3 Result



The Counseling Screen





Killion, M., Meuller, H.G., "Twenty Years Later: The New Count-The-Dots Method", Hearing Journal, January 2010, pp 10-15

Now, let's relate all of this back to fitting targets.

DSL 5.0a

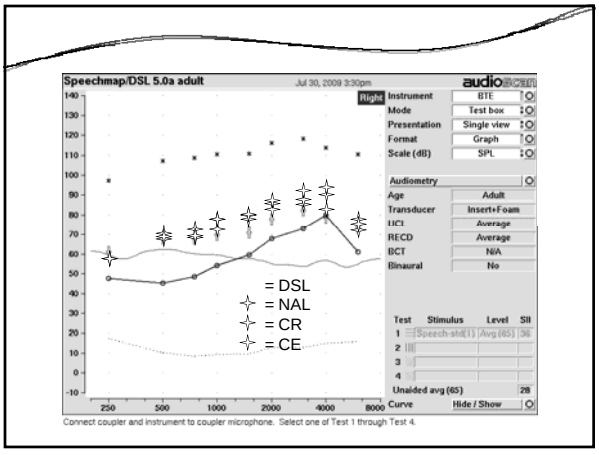
- Goal: to make speech audible for as broad a range of frequencies as possible
- Output based targets
  - Incorporates average RECD and average REUG into target calculations
- Targets are different than prior versions of DSL

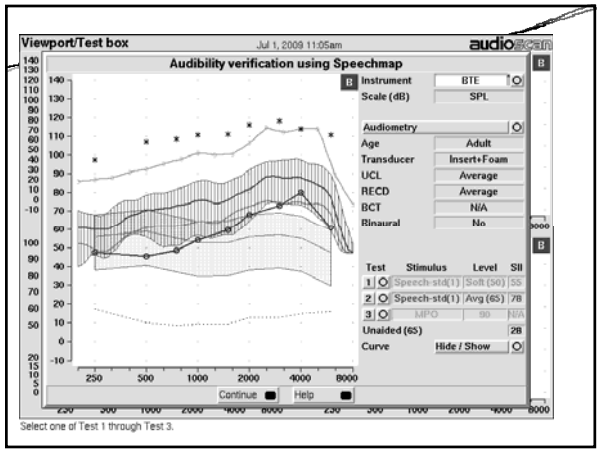
NAL-NL1

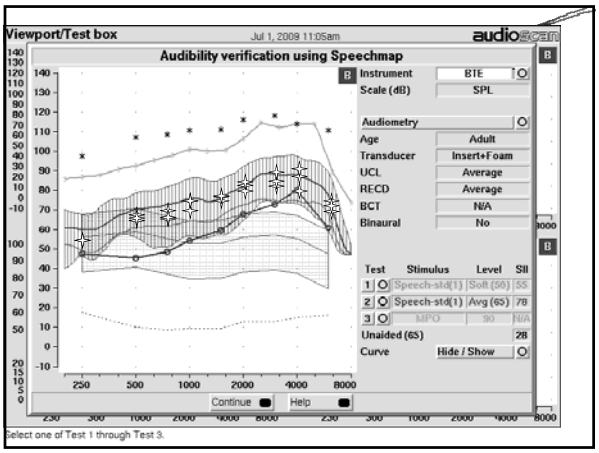
- Goal: To amplify speech such that all bands are perceived with equal loudness
- Gain based, but modified by Audioscan to become an output target
  - Using the same adult average RECD and REUG used in DSL

Cambridge Aims

- Camfit Restoration
  - To amplify sounds that are soft, comfortable and loud to a normal hearing person so that they are soft, comfortable and loud for the HA wearer. (Stated goal of IHAFF fitting method).
- Camfit Equalization
  - To amplify speech to produce the same loudness in each critical band. It has been argued that this is likely to give the highest intelligibility for a given overall loudness.





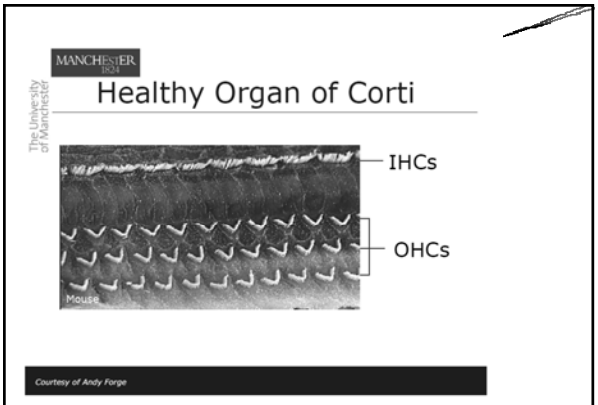


What Does the Speechmap Protocol Provide You?

- Verification that soft speech energy is audible to the patient
- Verification that average speech energy is comfortably positioned within the patients audible range
- Verification that UCL levels can not be exceeded, regardless of stimulus type
- Verification that the patient's recruitment has been accommodated

Recruitment Accommodation Clinical Protocol

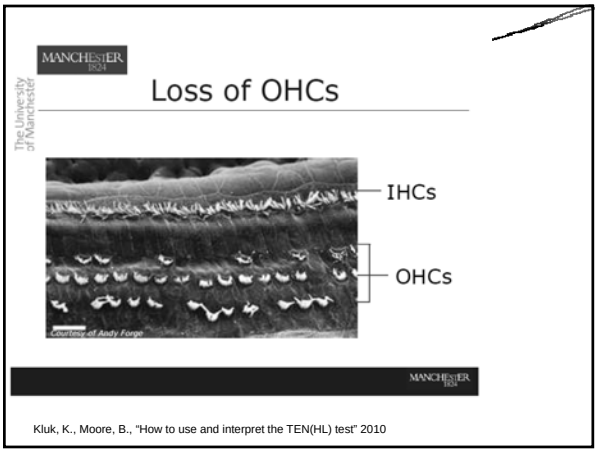
- At initial assessment visit:
  - Obtain RECD measurement
- Prior to fitting visit
  - Program aid and do Speechmap protocol in Test-Box mode
- At fitting visit
  - Do Speechmap protocol in On-Ear mode



Kluk, K., Moore, B., "How to use and interpret the TEN(HL) test" 2010

Healthy Outer Hair Cells (OHC's)

- Normal absolute thresholds
- Sharp tuning on the basilar membrane – good frequency selectivity
- Non-linear input-output functions due to healthy cochlear mechanics

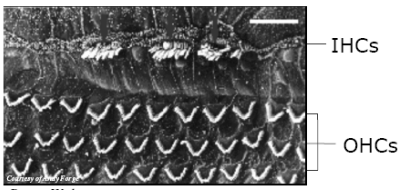


Kluk, K., Moore, B., "How to use and interpret the TEN(HL) test" 2010

Consequences of OHC Loss

- Elevated absolute threshold
- Broader tuning curves on the basilar membrane – reduced frequency selectivity
- Difficulties in understanding speech especially in background noise
- More linear input-output functions due to loss of cochlear mechanics
- Recruitment

Loss of IHCs



Bronx Waltzer mutant mouse

Consequences of IHC Loss

- Reduced efficiency of transduction leads to elevated thresholds
- "Noisy" transmission of information in the auditory nerve
- No transduction of basilar membrane vibration

Cochlear Dead Regions

- Regions in cochlea were inner hair cells and/or neurons are effectively not functioning at all
- Vary considerably from person to person
- Most often located toward the basal end of the basilar membrane

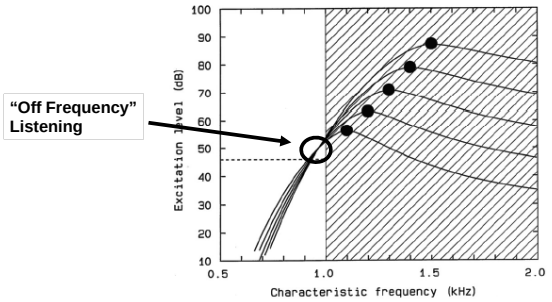
- The data of Vinay and Moore (2006) indicate that, for each test frequency:
  - 59% or more of ears had a dead region when the absolute threshold was greater than 70dBHL.
  - **Therefore, a dead region may be present when the absolute threshold is greater than 70dBHL.**

Vinay, and Moore, B. C. J. (2006). "Prevalence of dead regions in subjects with sensorineural hearing ... ear. (in press).

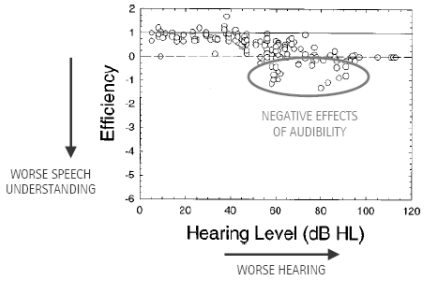
How Common Are Dead Regions?

For HL thresholds . . .	The likelihood of dead regions is . . .
55dB or less	Rare
55dB to 70dB	Possible
Greater than 70dB	Increasingly Common

Dead Region "Audibility"

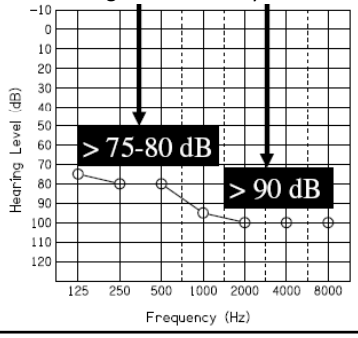


Is high-frequency amplification always beneficial?



from Hogan & Turner, JASA 1998

A Dead Region is also likely if:



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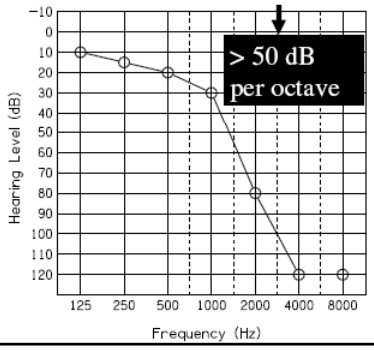

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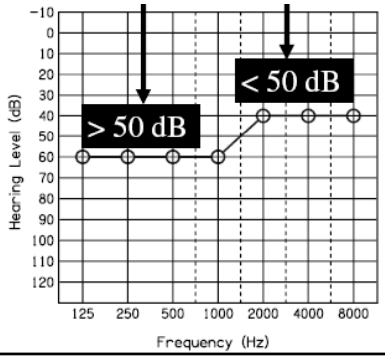

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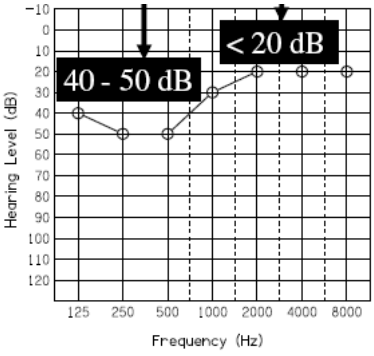


Dead Regions and Audiograms

- It is not possible to determine from the pure tone audiogram alone whether or not a patient has a dead region.
- Yet, proper diagnosis of a dead region is critical for amplification decision making and counseling.

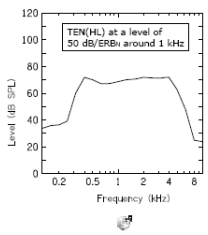
The TEN Test

- Threshold-Equalizing Noise (TEN) Test
  - Two versions:
    - TEN (SPL) Moore et.al, 2000
    - TEN (HL) Moore et. Al. 2004
- Simple and fast enough for clinical application
- Based on detection of pure tone in the presence of a special noise

Moore, BCJ, et.al., "New Version of TEN Test with Calibration in dB HL" Ear and Hearing, 2004::25, 478-487

Threshold Equalization Noise (TEN)

The noise is designed to produce almost equal masked thresholds in dB HL over the range 0.5 to 4 kHz, for normally hearing listeners and for listeners with hearing impairment but without dead regions.



Equipment

- Two-channel audiometer with TDH style headphones
  - Capable of sending two channels of input stimuli simultaneously to one ear
- CD player
- TEN (HL) CD

Procedure

- Obtain absolute threshold for each audiometric frequency using a final 2dB step size
- Set the TEN level (if possible) 10dB above the absolute threshold above the test frequency , or in the frequency region of interest.
- Measure the masked threshold using a final 2dB step size

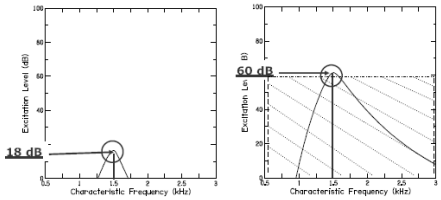
Criteria for Dead Region

- Masked threshold is 10dB or more above the TEN level/ERBn
- AND, masked threshold is 10dB or more above the absolute threshold

Rationale behind the TEN(HL) test

Normal Hearing

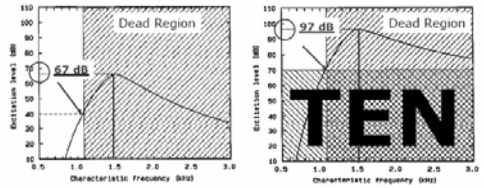
In quiet | In 60 dB/ERB$_N$ TEN



Rationale behind the TEN(HL) test

High-frequency Dead Region above 1.1 kHz

In quiet | In 70 dB/ERB$_N$ TEN



Moore, B.C.J. 2001. Dead regions in the cochlea: Diagnosis, perceptual consequences, and implications for the fitting of hearing aids. Trends Amplif. 5, 1-34.

Obtaining the **TEN(HL)** CD

http://hearing.psychol.cam.ac.uk/dead/TENCD.html

The preferred method of payment is by cheque or money order in pounds sterling or US dollars. The cost is UK £15 or US $32 including shipping. The cheque/money order should be made payable to B.C.J. Moore and sent to:

Prof. Brian C.J. Moore
Department of Experimental Psychology
University of Cambridge
Downing Street
Cambridge CB2 3EB, England

Be sure to include the mailing address where the CD should be sent.

Verifying Digital Performance

Verifying
Frequency Lowering and Frequency Transposition Functions

The Concept Behind Changing Output Frequency Content

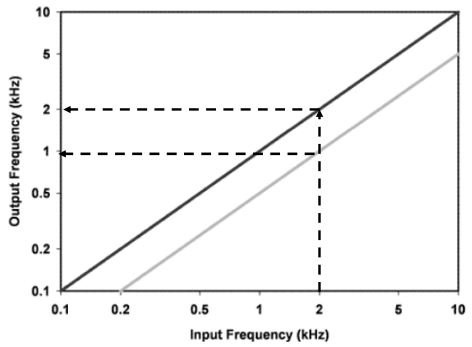
- Some hearing losses have un-aidable regions where important speech information exists
- Re-positioning input energy in these regions to regions that are aidable can provide access to these important speech ques

The Solution: Frequency Shifting

- For many people with severe-to-profound hearing impairment in the higher frequencies, frequency shifting can improve signal audibility
- Numerous different frequency lowering schemes have been developed and evaluated
- Some of these schemes have been shown to improve speech understanding

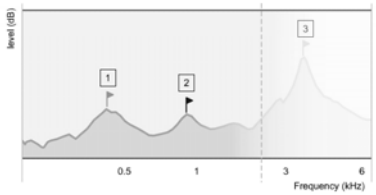
Hugh McDermott, Professor of Auditory Communication and Signal Processing
University of Melbourne, Phonak Virtual Audiology Conference, May, 2009

Practical frequency-shifting techniques



Frequency Shifting Approaches

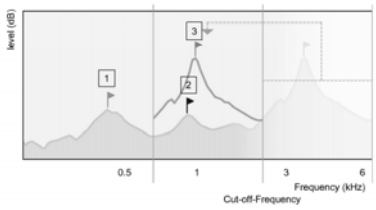
- Frequency Transposition



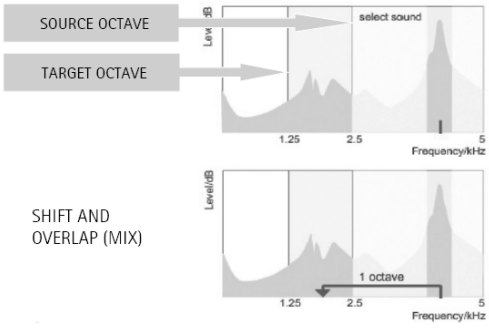
Myirel Nyffeler, Speech Study Coordinator, Phonak Hearing Instruments, Switzerland, Phonak Virtual Audiology Conference, May, 2009

Frequency Shifting Approaches

- Frequency Transposition

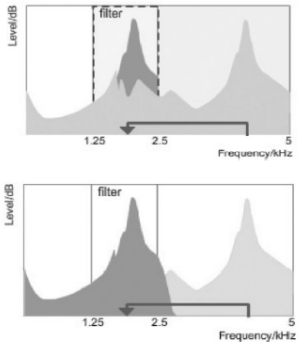


Widex *Inteo* 'Audibility Extender'



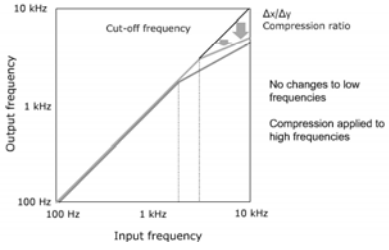
Widex AE – continued

FILTER OUTPUT SIGNAL 'TO LIMIT MASKING EFFECT'



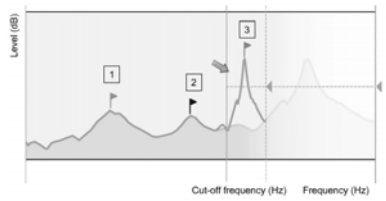
Frequency Shifting Approaches

- Frequency Compression

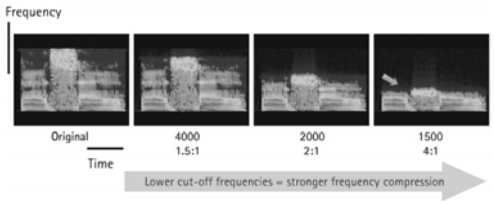


Frequency Shifting Approaches

- Frequency Compression



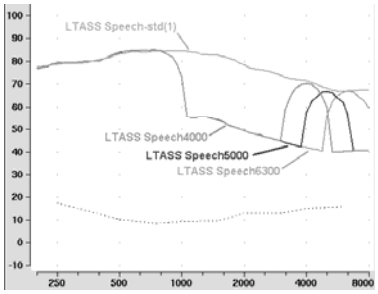
Effect of parameters when processing /aSa/



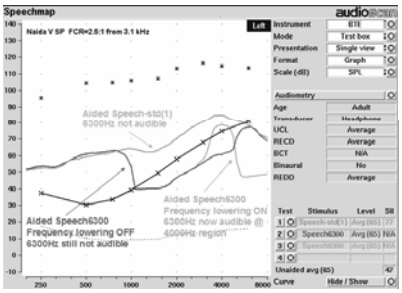
Software Release V3.4

- Main New Features
  - Frequency Lowering Verification

Frequency Lowering Input Stimuli



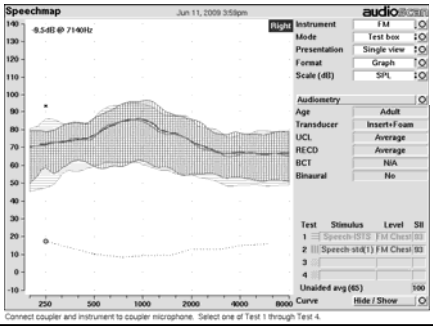
Frequency Lowering Test Result Example



Software Release V3.4

- Main New Features
  - Frequency Lowering Verification
- ISTS (International Speech Test Signal)
  - Incorporates the phonemic elements of several languages into a single speech test signal

Carrot Passage and ISTS LTASS Bananas

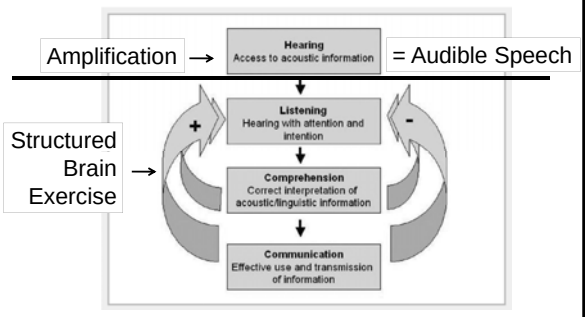


Rehabilitation Resources

L.A.C.E.
Listening and Communication Enhancement

Sweetow R, Henerson-Sabes J. "The need for and development of an adaptive listening and communication enhancement (LACE) program" J Am Acad Audiol 17:358-558 (2006)

The Elements of Communication



Kiessling J., Pichora-Fuller MK, Gatehouse S., et al.: "Candidature for the delivery of audiological services: Special needs of older people" Int J Audiol 2003:42(2):S92-S101

LACE Components

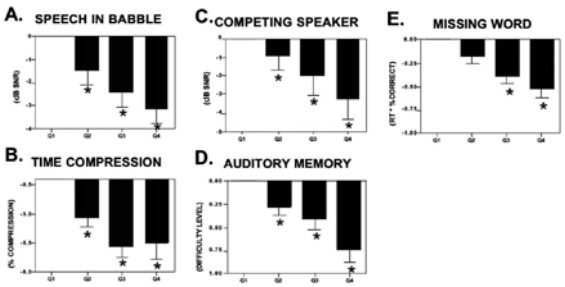
- Speech in babble (30%)
- Time compressed speech (20%)
- Competing speaker (20%)
- Auditory working memory (target word) (15%)
- Missing word (15%)
- Interactive communications supplements
  - Managing acoustic environments
  - Assertive listening skills
  - Care & maintenance of hearing aids
  - ALD's
  - Realistic expectations

Validation Study

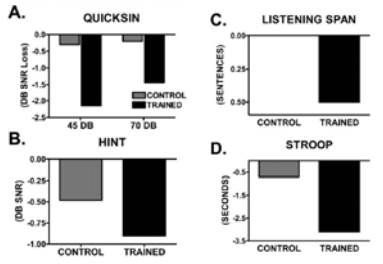
- Three validation components
  - On-Task Objective Measures
  - Off-Task Objective Measures
  - Subjective Measures
- Subject Group
  - 65 patients with varying degrees of aidable SNHL
- Measurement Intervals
  - Baseline – 2 days prior to training
  - After two weeks of training
  - After four weeks of training
  - 4 weeks post training

Sweetow R, Henerson-Sabes J. "The need for and development of an adaptive listening and communication enhancement (LACE) program" J Am Acad Audiol 17:358-558 (2006)

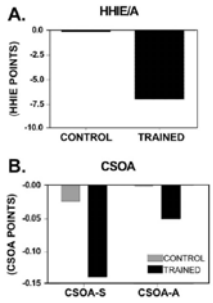
Validation Study: On-Task Results



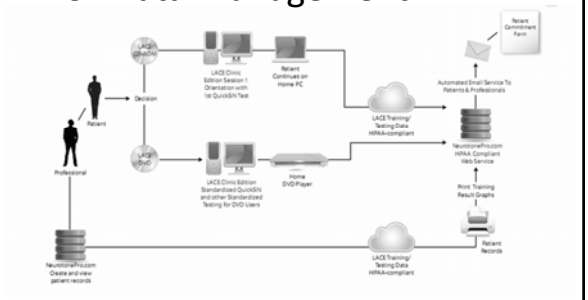
Validation Study – Off-Task Results



Validation Study – Subjective Measures



LACE Data Management



Speech Mapping of Open-Fit Technology

Minimal Occlusion

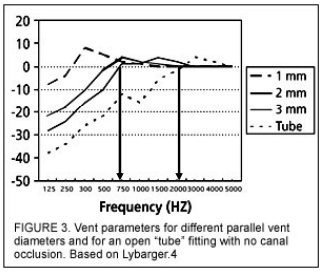


FIGURE 3. Vent parameters for different parallel vent diameters and for an open "tube" fitting with no canal occlusion. Based on Lybarger.4

Lybarger S. Earmolds. In: Katz J, ed. Handbook of Clinical Audiology, 3rd edition. Baltimore: Williams and Wilkins; 1985: 885-910.

An Open-Fit Verification Protocol

- Select "Open" in Instrument menu
- Run "Equalization" with instrument on ear but turned off.
- Turn instrument on
- Run Test 1 with instrument on ear and turned on
- Adjust gain and compression to maximize SII without invoking feedback
- Turn aid off and run TEST 2
- Use the fitting screen as a counseling tool

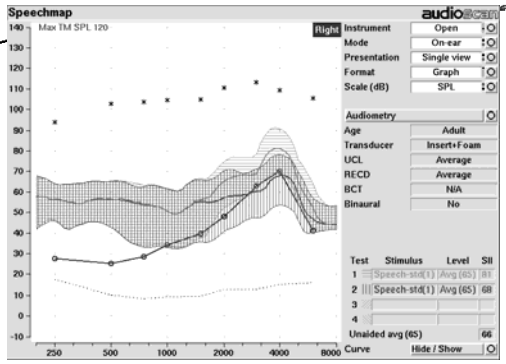


FIGURE 5: The pink shaded area is the eardrum SPL "speech banana" for 65dB speech input measured at the probe tip with the open-fit hearing aid turned OFF. The green shaded area is the eardrum SPL "speech banana" with the same hearing aid turned ON. The difference between the two indicates where amplification has reached the eardrum.

Procedural Summary

- The fundamental goal of amplification should be to restore speech audibility
  - For patients with good IHC function, audibility should be available for as broad a range of frequencies as possible
- It is essential to diagnose IHC function when pathology is suspected
- Full and effective long-term integration of restored speech audibility requires brain exercise and some time