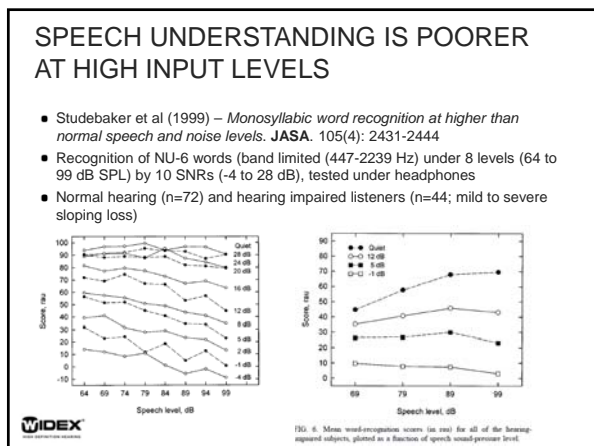


Is it the fault of the person?
Or is it the fault of the hearing aid?

WIDEX



DIFFERENCE BETWEEN EXPECTED AND MEASURED SPEECH SCORES

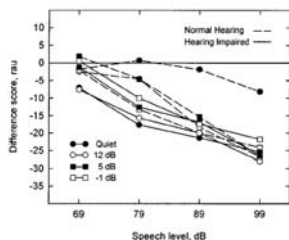
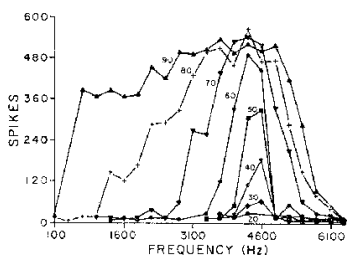


FIG 9. Mean differences between observed and expected performance (in rau) for the normal hearing subjects versus the hearing-impaired subjects. The data for both groups have been corrected for changes in audibility. The calculations assume the speech dynamic range equals 40 dB.



PHYSIOLOGICAL STUDIES SHOW SPREAD OF EXCITATION AT HIGH INPUT LEVELS



TAKE HOME MESSAGE

Hearing at high input levels, in both quiet and noise, is poorer than hearing at a lower input level as long as audibility is ensured
 This is true for both normal hearing and hearing impaired listeners



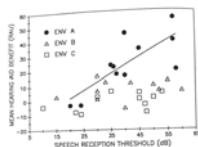
STUDIES SHOWED POORER AIDED THAN UNAIDED PERFORMANCE

- Fletcher (1922) reported intelligibility of nonsense syllables presented in quiet decreased when they were highly amplified
- Work in the 50's and 60's showed that speech intelligibility at a constant SNR decreased as intensity increased from 80 to 130 dB SPL. Some showed the decrease even when the speech level exceeded a conversational level
- Because hearing impaired people need to hear sounds at a higher level, this action suggests that hearing impaired people may:
 - Show a decrease in aided benefit as input level increases beyond a conversational level
 - Show minimal or negative benefit from the use of hearing aids at a high input level



STUDIES SHOWED POORER AIDED THAN UNAIDED PERFORMANCE

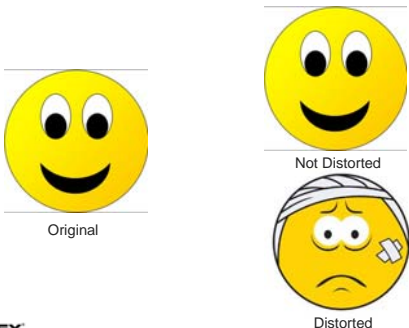
- Cox and Alexander (1991) – *Hearing aid benefit in everyday environments. Ear Hear, 12(2):127-139*
- Three matched groups of 11 subjects, each in one of three environments. Tested with Connected Speech Test (CST)
 - Living room setting (A) – speech at 55 dB A, multi-talker babble – 48 dB A
 - Reverberant setting (B) – speech at 63 dB A, noise at 55 dB A
 - Noisy setting (C) – speech at 64 dB A, noise at 62 dB A
- Hearing aids were BTE, linear, omnidirectional, analog or hybrid (18 models)
- CST benefits
 - Environment A – 24%
 - Environment B – 7%
 - Environment C – -1%
- Audibility does not guarantee intelligibility
- Distortions within hearing aids



The main reason why aided hearing is poorer than unaided hearing is ...




WHAT IS DISTORTION?



Original


Not Distorted

Distorted




WHY IS IT RELEVANT TO CARE ABOUT LISTENING AT A HIGH INPUT LEVEL?

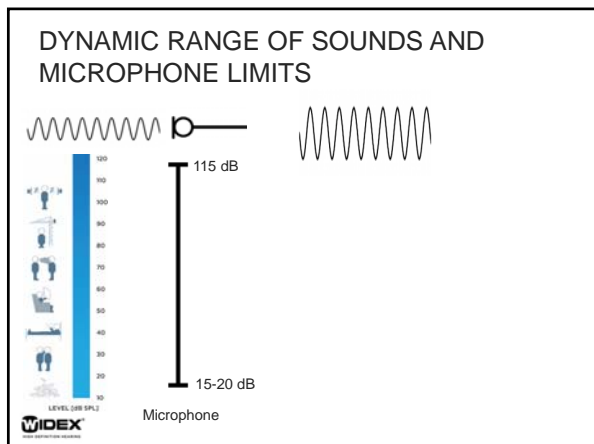
- Neitzel et al (2004) showed that around 20% of everyday sounds exceed 70 dB (A) and only 1% exceeds 90 dB (A). (However, the levels reported are typically average levels. Instantaneous levels reaches/exceeds 100 dB SPL)
- However, these loud sounds are frequently associated with socializing, entertaining and transportation – a large portion of leisure activities
- Kockhin (2010) reported that consumer satisfaction with hearing aids increases when the number of situations in which the hearing aids perform well increases
- Thus, improvements in aided performance at high input levels could further enhance a wearer's overall satisfaction with hearing aids

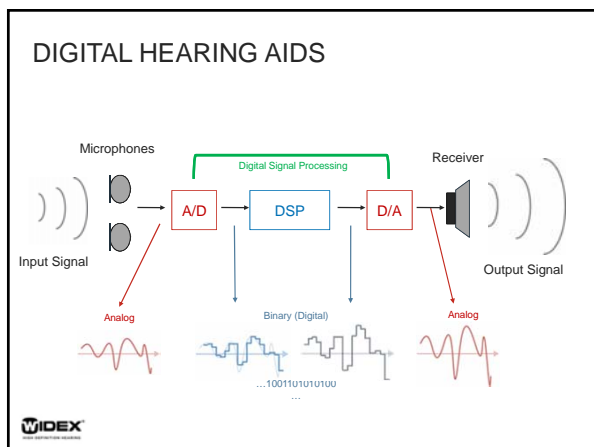


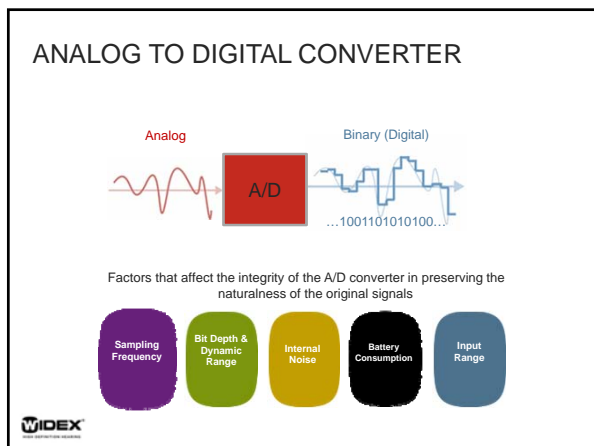
MAKING BETTER AIDED PERFORMANCE (THAN UNAIDED)

1. Minimize distortions occurring at the input and output stages
 - a) True input technology
 - b) Adequate MPO
 - c) Binaural fitting
2. Reduce gain as input increases (keep output low)
 - a) WDRC
 - b) Gain target
 - c) Noise reduction
3. Enhance signal-to-noise ratio
 - a) Directional mic
4. Broadband hearing aid with minimal vent









BIT DEPTH (OR RESOLUTION)

- Number of bits (n) increases,
 - RESOLUTION increases (not related to magnitude of input)
 - #intervals = 2^n
 - Example, 10 bits = 2^{10} or 1024 intervals
 - Dynamic range increases
 - 1 bit = 6 dB (idealized)
 - Sound quality improves
 - Larger data file

WIDEX

ADC EFFECT ON INPUT RANGE

Insufficient bits

Insufficient bits

WIDEX

REALISTIC DYNAMIC RANGES

115 dB

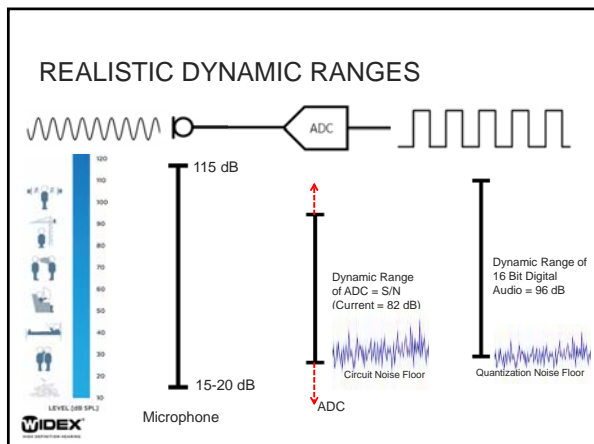
15-20 dB

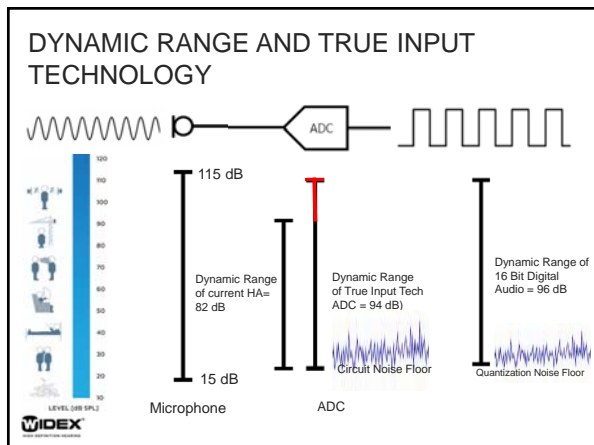
Microphone

Dynamic Range of 16 Bit Digital Audio = 96 dB

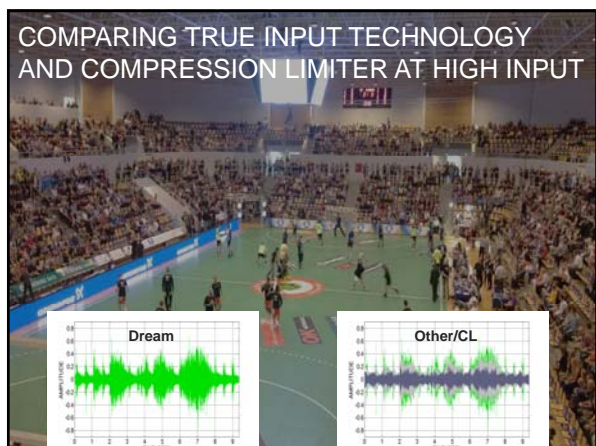
Quantization Noise Floor

WIDEX







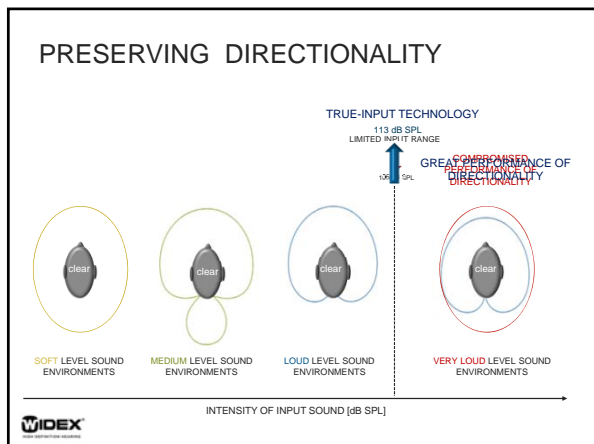


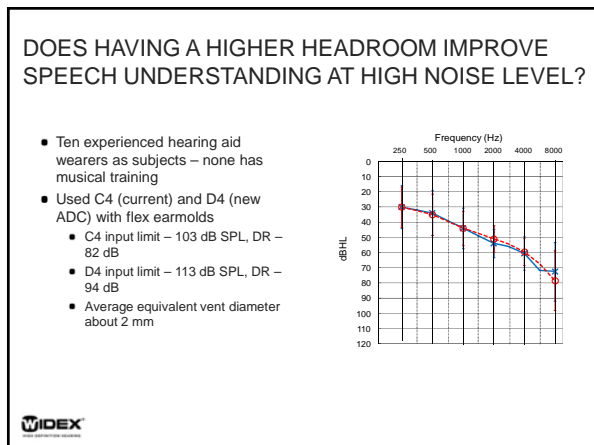
WHICH HAS A HIGHER INPUT LIMIT (103
VS 113 DB SPL)?

WIDEX
THE PROFESSIONAL HEARING

WHICH HAS A HIGHER INPUT LIMIT (103
VS 113 DB SPL)?

WIDEX
THE PROFESSIONAL HEARING






STIMULUS PREPARATION

- Recorded NU-6 (full list) through KEMAR with Zwislokci coupler and ER11 microphone; output filtered with diffuse field inverse (DFI) filter
- Hearing aids (C4 and D4) were programmed to a flat 50 dB HL set to (a) omni mic, no NR (b) adaptive directional mic with NR. The same default MPO was used. Occluding earmold
- Speech front, noise sides and back at 106 dB-C. SNR = -3, 0, and +3
- Subjective test (of music and discourse passages) at 0 and -30 dB re: saturation in CLEAR, about 108-113 dB SPL peak in a pairwise manner in quiet
- The output of the HA was about 1-2 dB higher than the input level
- Subjects tested under headphone at "loud, but not uncomfortable"
- Test conditions and word lists were counterbalanced
- Double-blind design

WIDEX
HEARING AID TECHNOLOGY





AN EXAMPLE OF THE TEST WORDS

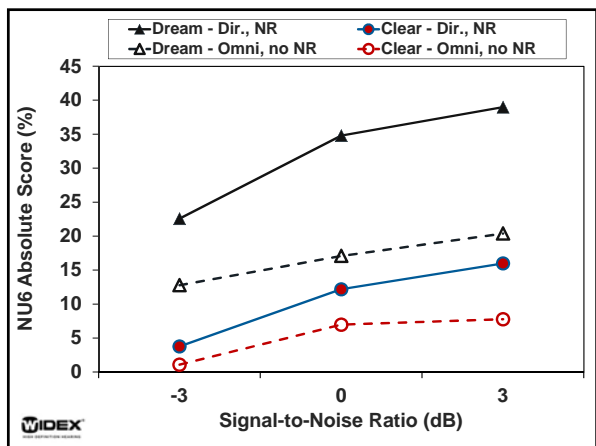
Clear Dream

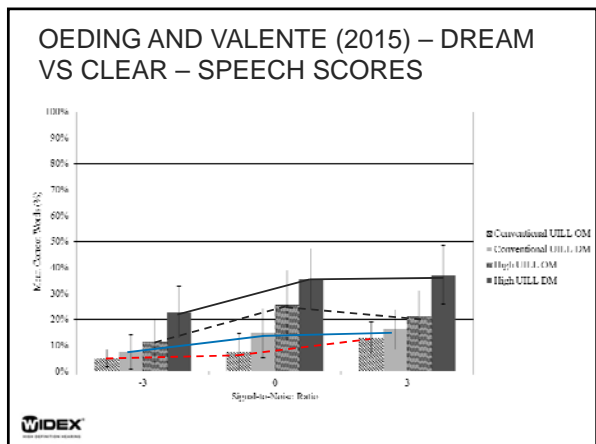


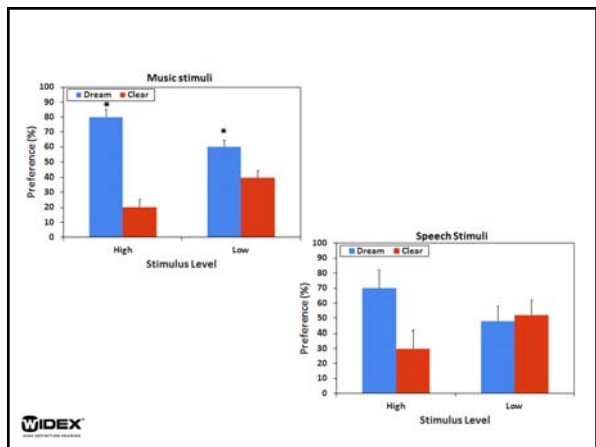
AN EXAMPLE OF THE TEST WORDS

Clear Dream



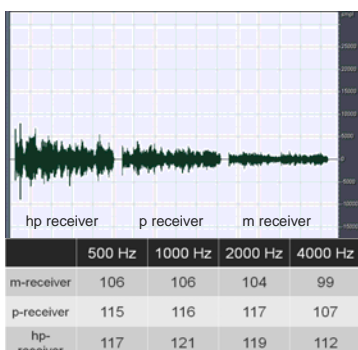




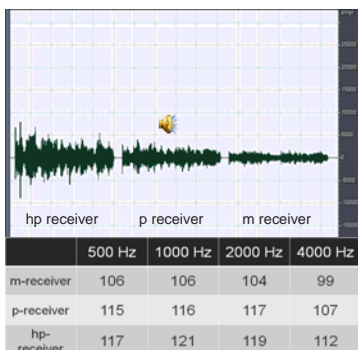
TAKE HOME MESSAGE

THE ADC, DESPITE BEING 16 BITS, MUST HAVE A HIGH INPUT LIMIT AND A LARGE DYNAMIC RANGE
(ASK FOR HIGHEST AND LOWEST LEVELS, NOISE FLOOR, CURRENT DRAIN)

IMPORTANCE OF ADEQUATE MPO



IMPORTANCE OF ADEQUATE MPO

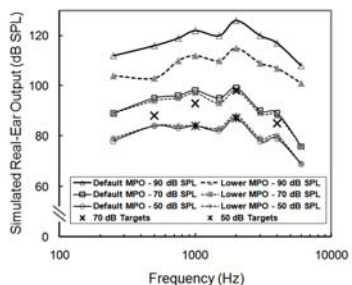


EFFECT OF MPO ON SPEECH IN NOISE

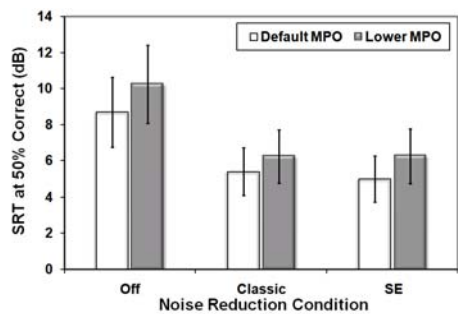
- **Purpose:** To demonstrate the degradation in speech intelligibility in noise when the MPO of the wearers' hearing aids was lowered by 10 dB from the default.
- **Design:** The effect of input level (68 dB SPL 75 dB SPL), MPO setting (default and default-10), and noise reduction algorithm (off, classic, SE) was studied on the HINT
- **Subjects:** Eleven adults with a moderately severe to severe sensorineural hearing loss
- **Procedure:** Participants were fit with the Widex m4-19 behind-the-ear hearing aids binaurally in the default frequency response and MPO settings. The hearing aids were adjusted to the following MPO (default, default-10) by noise reduction (off, classic, SE) conditions (total of 6) and evaluated on HINT



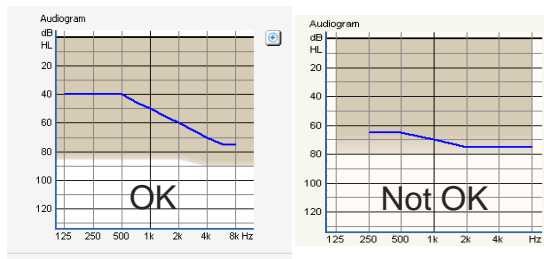
MPO (OR OSPL90) VALIDATION STUDY (KUK ET AL., JAAA, 2011)



MPO AFFECTS SPEECH IN NOISE ABILITY (AND SO IS WIDEX NOISE REDUCTION)



TAKE HOME MESSAGE - MAKE SURE HEARING LOSS IS >15 DB FROM THE LIMIT OF THE FITTING RANGE



DO HEARING AIDS WORK AT HIGH INPUT LEVELS?

(COMPARING AIDED AND UNAIDED PERFORMANCE)

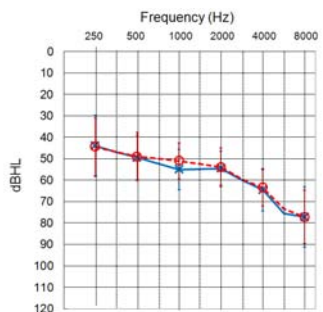


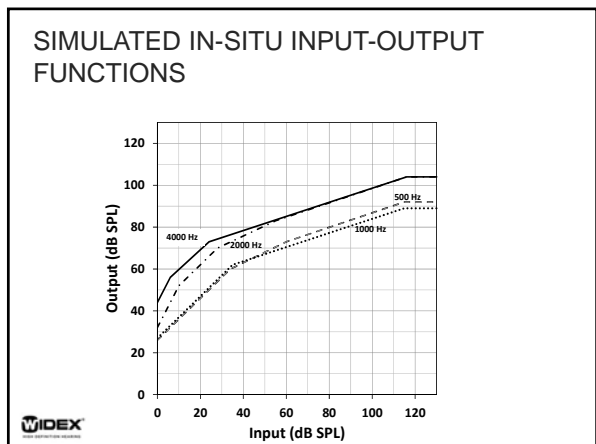
SPEECH UNDERSTANDING AT MULTIPLE INPUT LEVELS - DESIGN

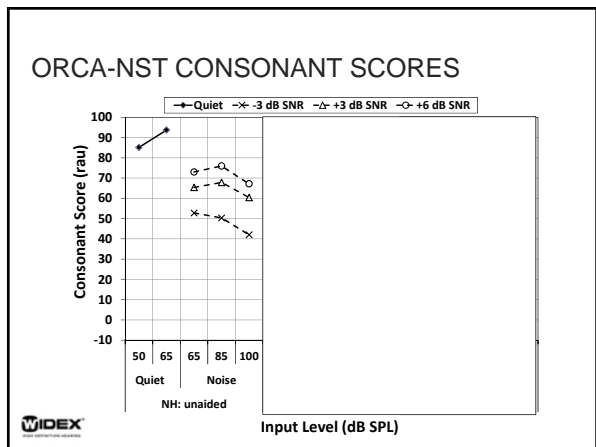
- Objective – to estimate performance of hearing aids on speech intelligibility at different input levels and compare them to unaided performance and normal performance
- Subjects – 10 moderate hearing loss (70 yrs), 5 normals (25 yrs)
- Fitting – DREAM Fashion fit to NAL-NL2 target using frequency-output curve to adjust aids, HD locator, super-gain feedback, Trusound Softener, SE
- Test conditions
 - speech (ORCA-NST) in quiet at 50 and 65 dB SPL
 - Speech (ORCA-NST) in noise at 65, 85, and 100 dB SPL at -3, +3 and +6 SNR
 - Speech front, noise surround (90°, 180°, 270°)
 - Subjective preference/comparison between aided and unaided of speech/music
 - All testing conducted under insert-earphone recorded through Dream Fashion coupled to Fritz's head (manikin)

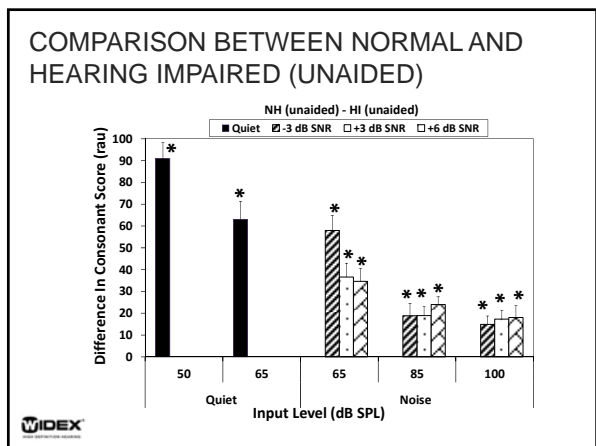


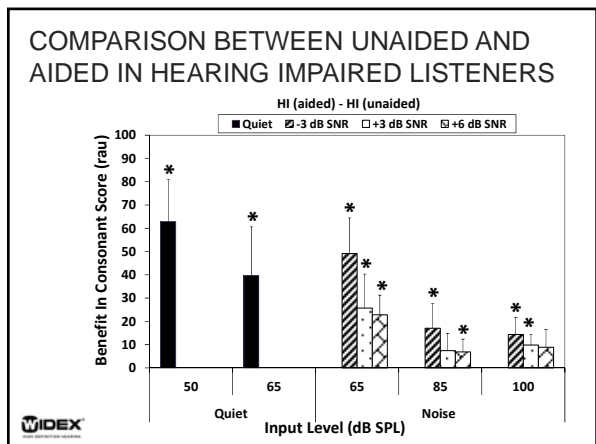
STUDY ON SPEECH UNDERSTANDING AT MULTIPLE INPUT LEVELS

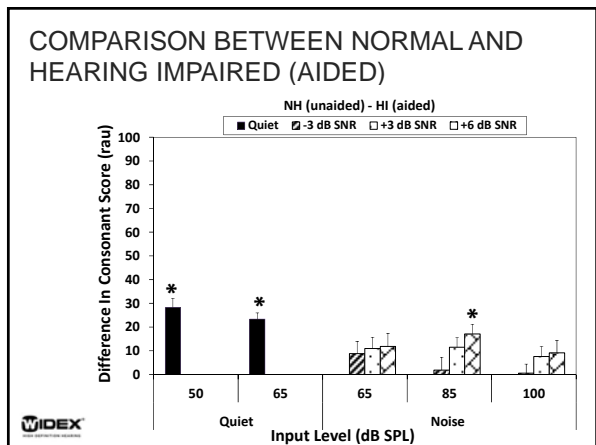


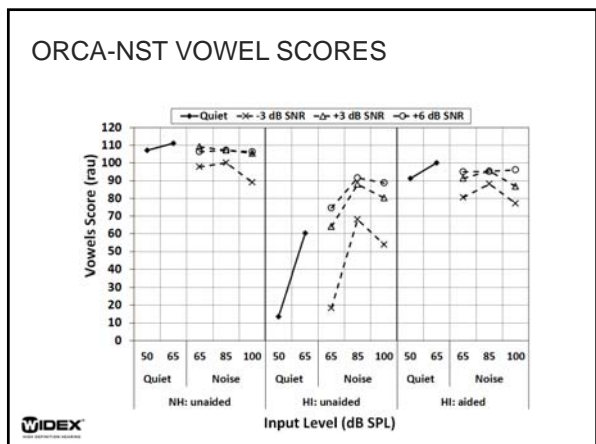




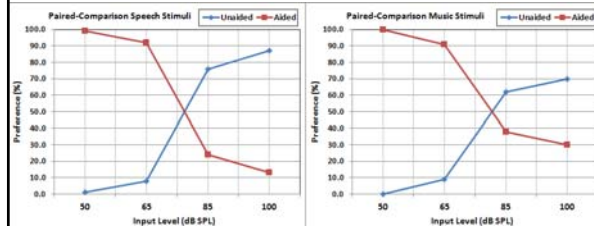








SPEECH UNDERSTANDING AT MULTIPLE INPUT LEVELS – SUBJECTIVE PREFERENCE



TAKE HOME MESSAGES

- Normal hearing listeners have difficulty with speech understanding in loud noisy situations
- The DREAM provides benefits even at high input levels
- Aided performance in the hearing impaired subjects was similar to (slightly poorer than) that of normal hearing listeners



HOW TO ENSURE MAXIMUM SPEECH UNDERSTANDING AT HIGH INPUT LEVELS

- Choose a hearing aid with a high input dynamic range (input issue)
- Choose a hearing aid that is within the fitting range of the loss – MPO issue
- Choose a hearing aid with a broad frequency response
- Choose a WDRC hearing aid
 - Use a nonlinear prescriptive formula that essentially has negative gain at high input
 - Maintain linearity of output at high levels (lowered linear gain or SA-WDRC)
- Include noise reduction – and choose comfort setting
- Include use of adaptive directional mic – affects input stage saturation and improves SNR
- If possible, choose occluding earmolds



HOW TO SET RIGHT EXPECTATIONS IN PATIENTS FOR LISTENING AT HIGH INPUTS

- Measure patient's speech in quiet and speech in noise abilities as part of the clinical protocol
- Beware of the decrease in intelligibility even in normals
- Beware of the issue of effective audibility
- Beware of the HA features that could benefit speech in noise at a high input level
- Familiarize with the results of the current study
 - Hearing aids do provide benefits at high input levels
 - Normals also have difficulties at high input levels
 - At very high input levels and poor SNR, hearing impaired and normals are very similar in performance