Florida Academy of Audiology

From the Lab to the Clinic

Francis Kuk, Ph.D., CCC-A, FAAA
Director, Widex ORCA-USA

2015 Annual Convention - *B All That You Can B*
August 6-8, 2015
B Resort & Spa - Lake Buena Vista, FL

MY THREE POINTS …

- Hearing aids can provide speech in noise benefit at loud, noisy situations
- Hearing impaired people cannot tell back from front - You can help them to localize better
- Active demonstration with the hearing aid features enhances your patient’s use of their hearing aids

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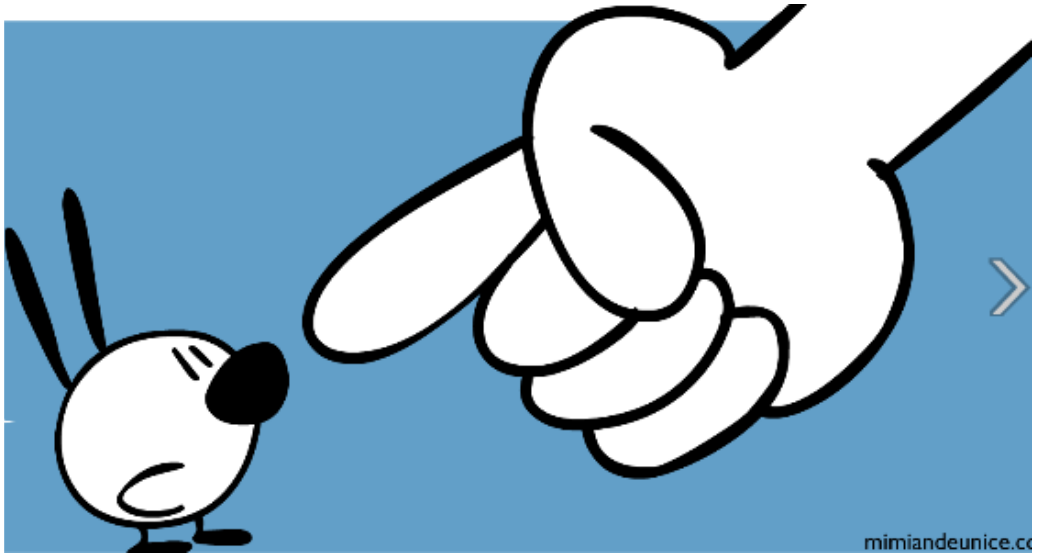
HIGH DEFINITION HEARING

BUT ....



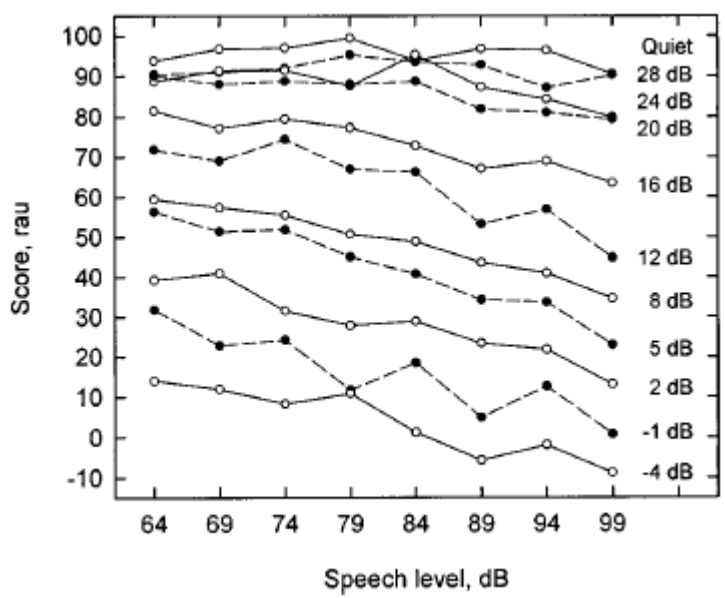
Is it the fault of the person?
Is it the fault of the hearing aid?
Or is it the fault of both?

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

- 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 reach/exceed 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

SPEECH UNDERSTANDING IS POORER AT HIGH INPUT LEVELS

- Studebaker et al (1999) – *Monosyllabic word recognition at higher than normal speech and noise levels*. **JASA**. 105(4): 2431-2444
- Recognition of NU-6 words (band limited (447-2239 Hz) under 8 levels (64 to 99 dB SPL) by 10 SNRs (-4 to 28 dB), tested under headphones
- Normal hearing (n=72) and hearing impaired listeners (n=44; mild to severe sloping loss)



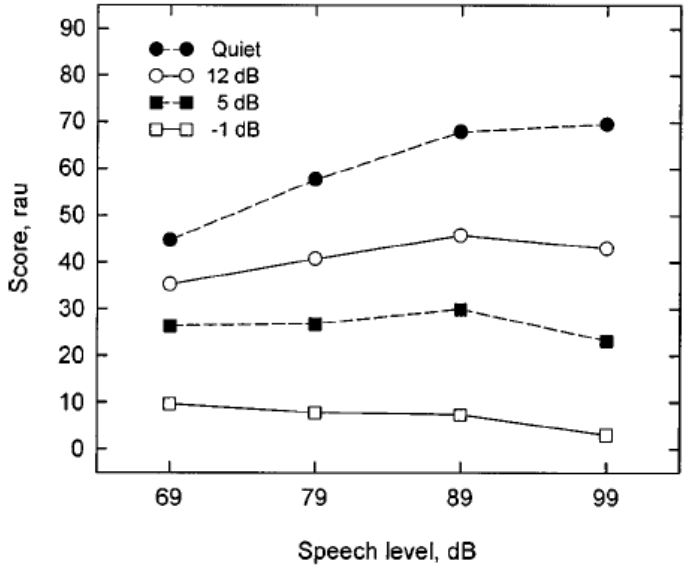


FIG. 6. Mean word-recognition scores (in rau) for all of the hearing-impaired subjects, plotted as a function of speech sound-pressure level.

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DIFFERENCE BETWEEN EXPECTED AND MEASURED SPEECH SCORES

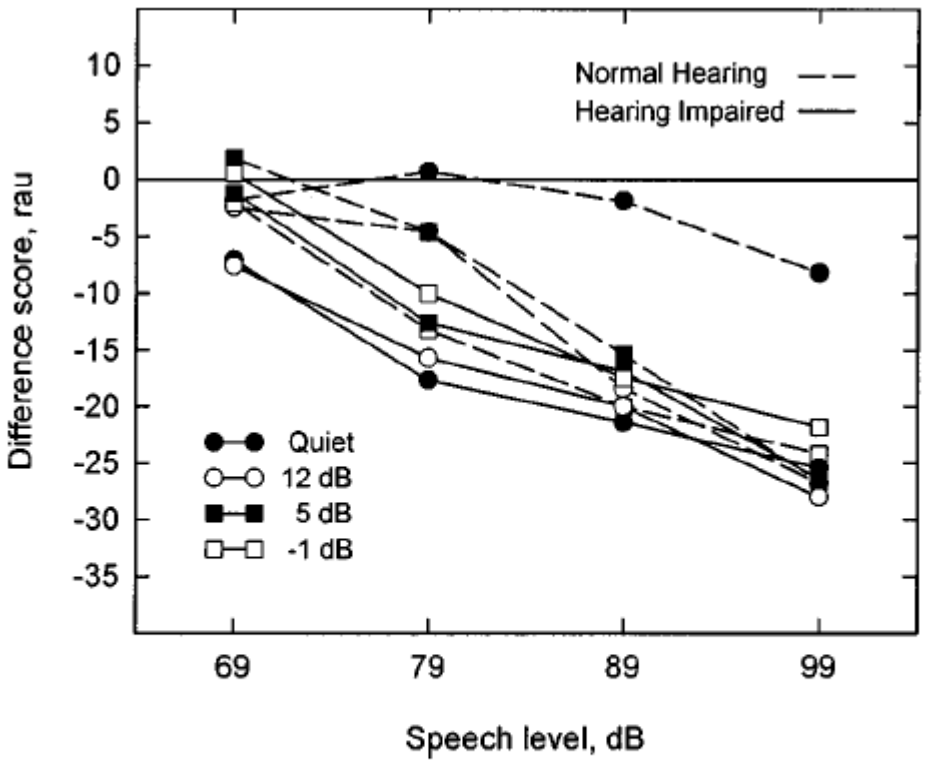

FIG. 9. Mean differences between observed and expected performance (in rau) for the normal-hearing subjects versus the hearing-impaired subjects. The data for both groups have been corrected for changes in audibility. The calculations assume the speech dynamic range equals 40 dB.

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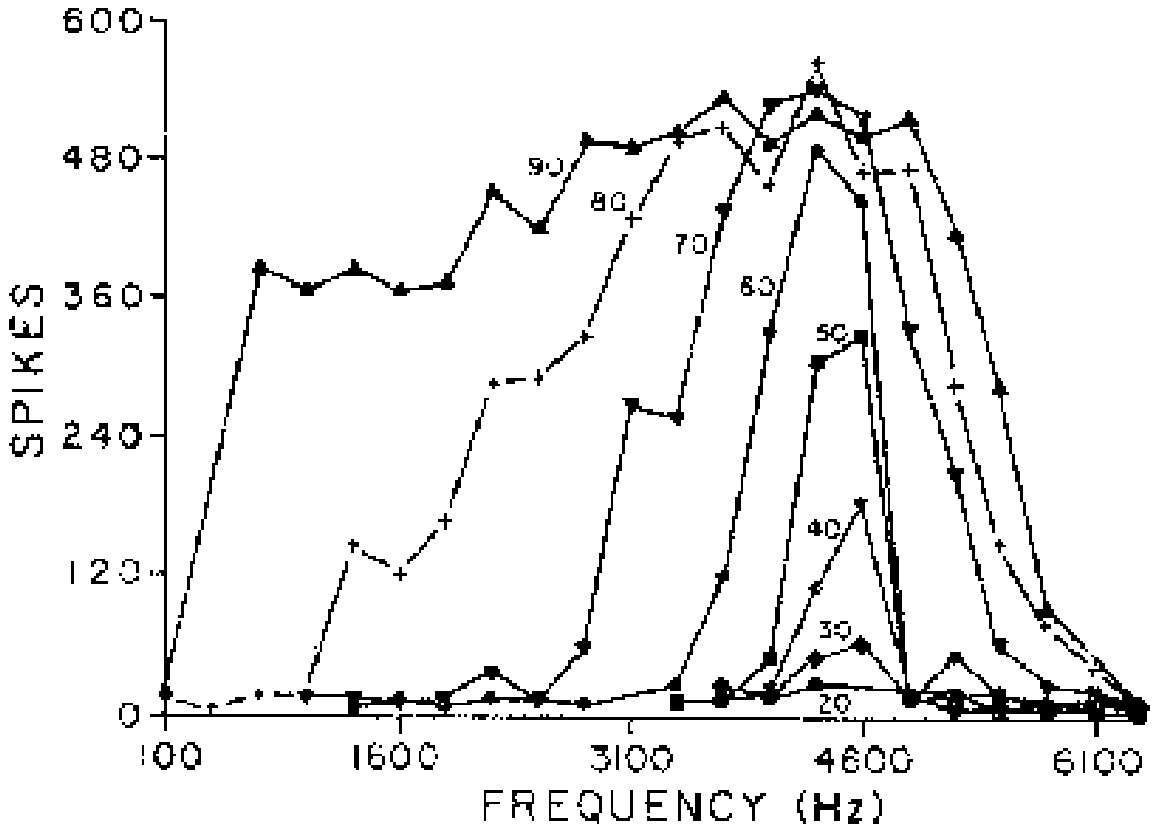
PHYSIOLOGICAL STUDIES SUGGEST SPREAD OF EXCITATION AT HIGH INPUT LEVELS



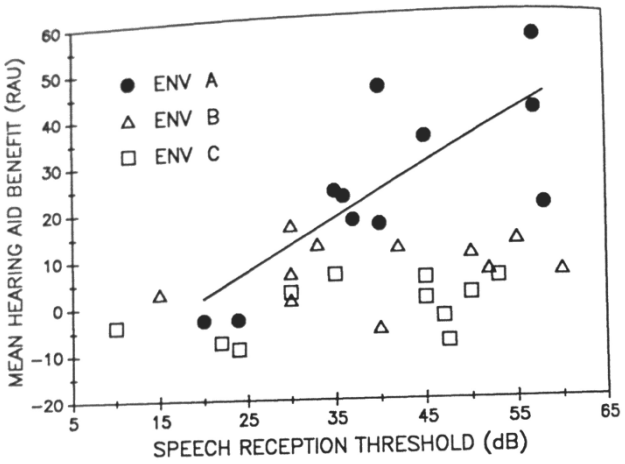
TAKE HOME MESSAGES

Hearing at high input levels, in both quiet and noise, is poorer than hearing at a conversational level.

This is true for both normal hearing and hearing impaired listeners.

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



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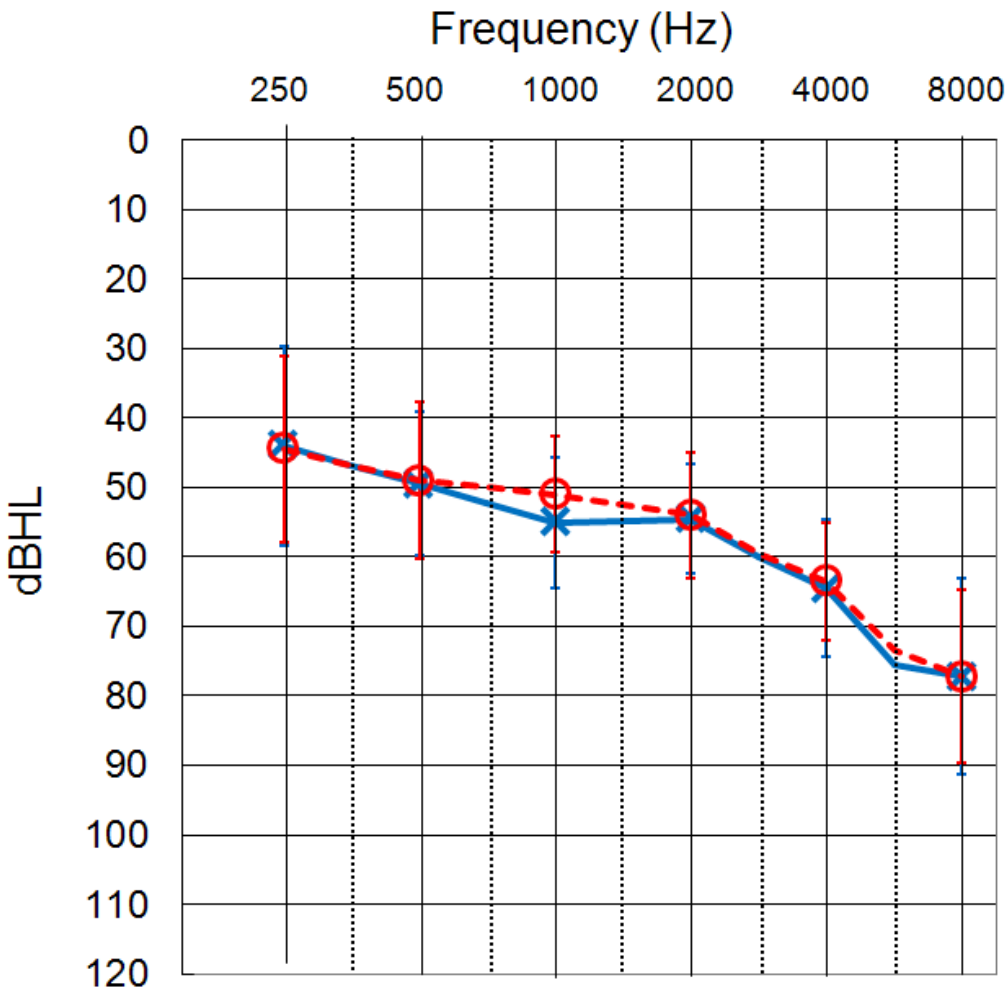
The main reason why aided hearing is poorer than unaided hearing
is …

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 (90^0 , 180^0, 270^0)
  - 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 (mannequin)

STUDY ON SPEECH UNDERSTANDING AT MULTIPLE INPUT LEVELS



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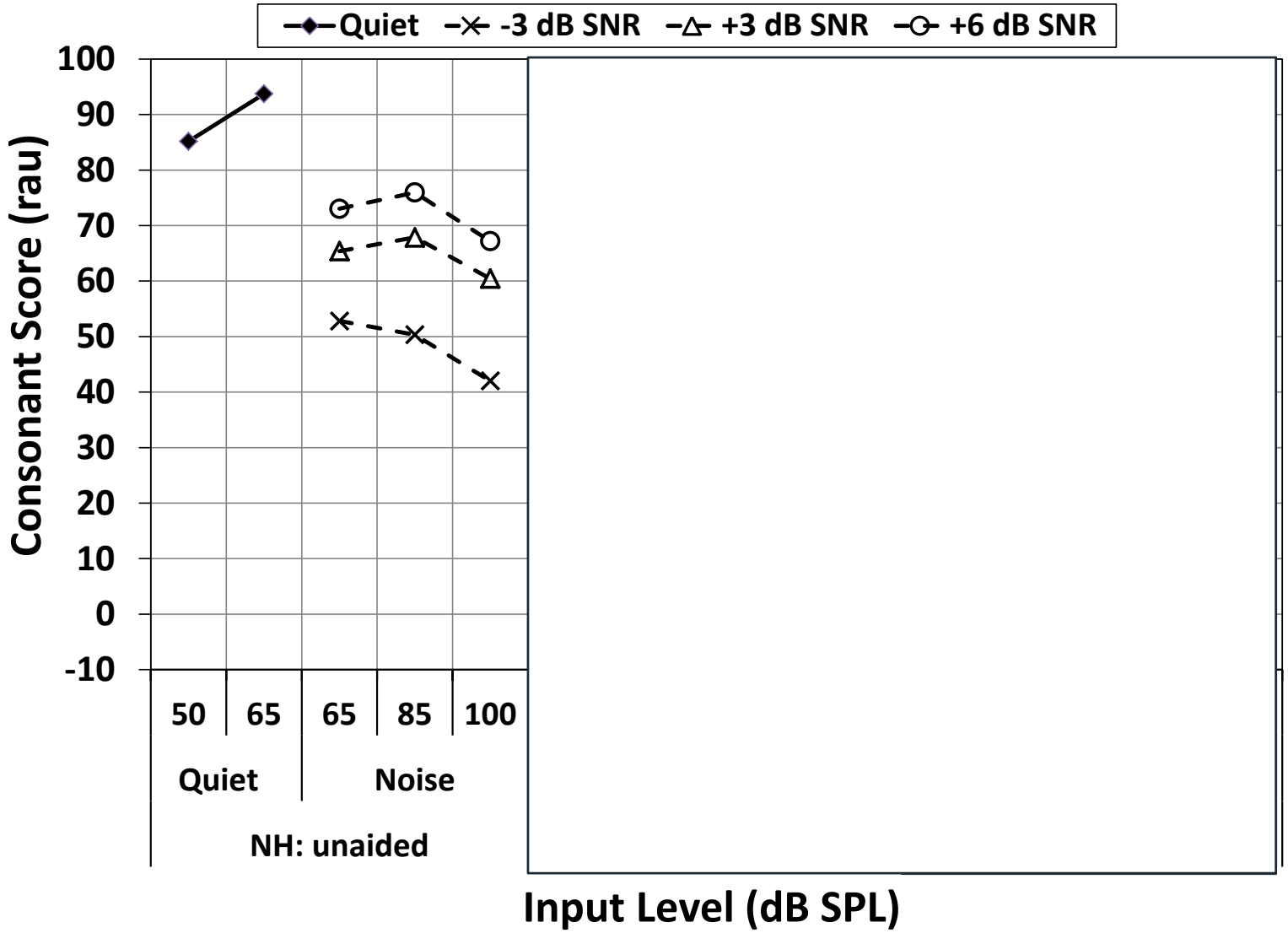
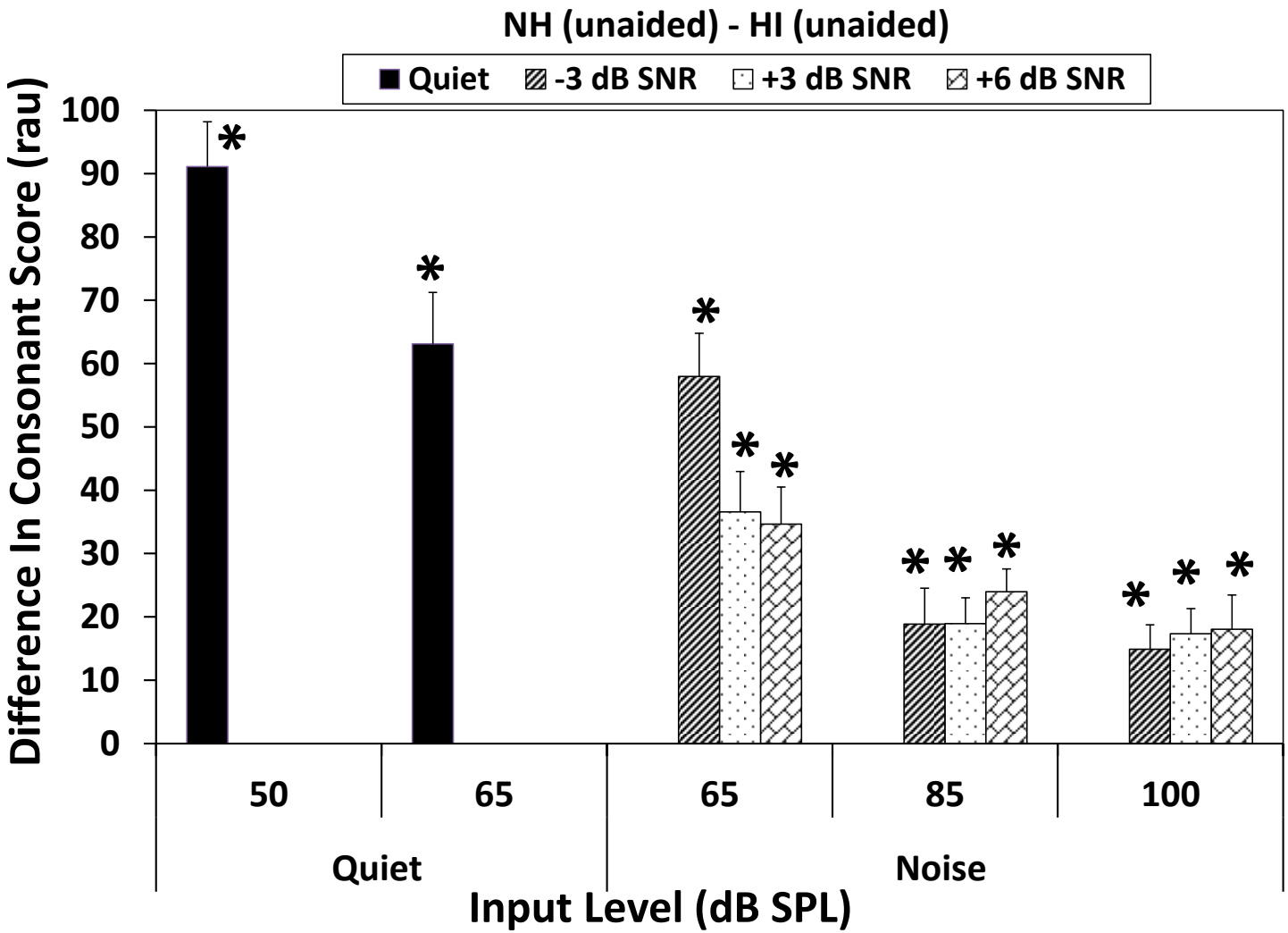
ORCA-NST CONSONANT SCORES



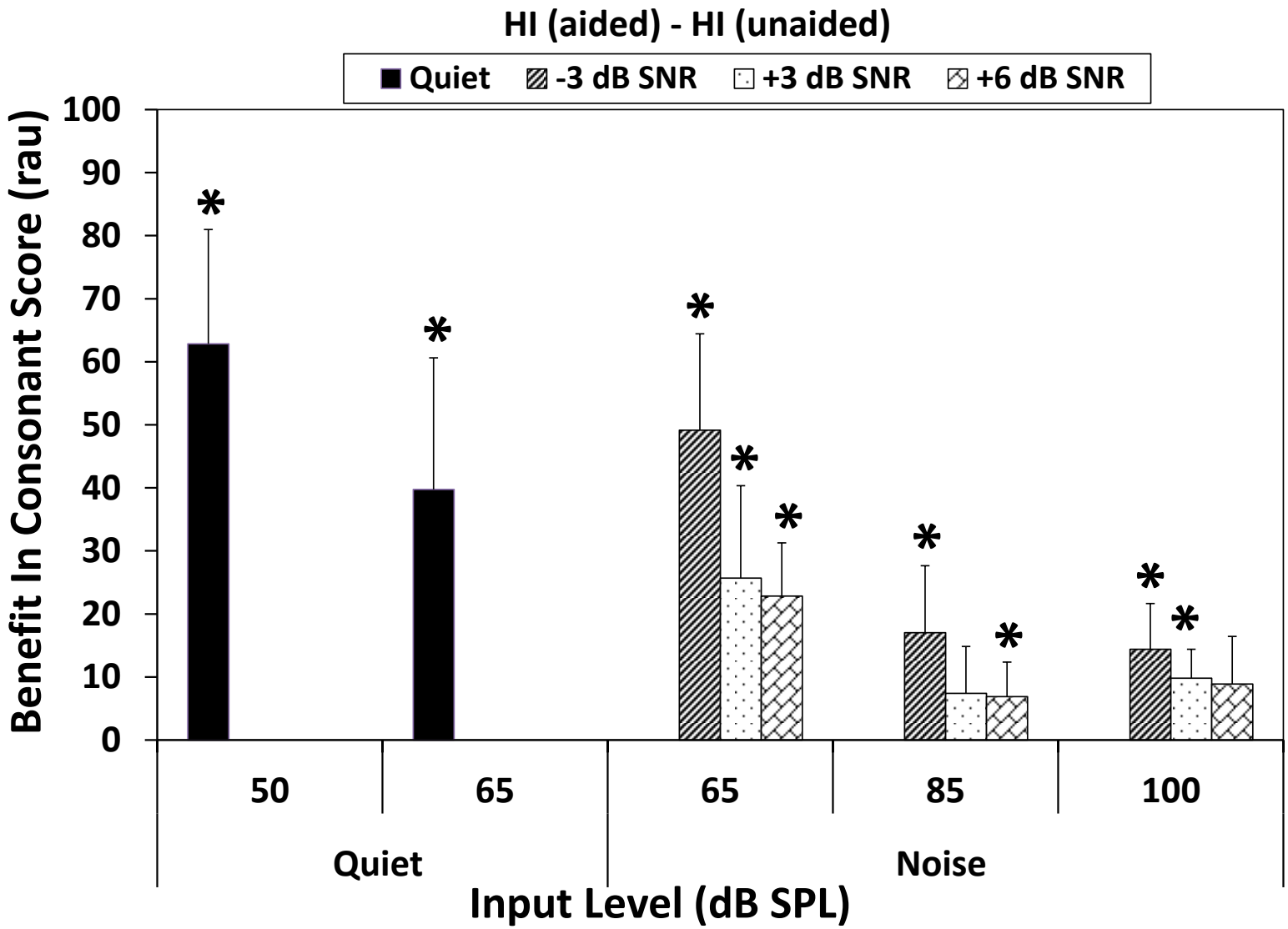
WIDE
HIGH DEFINITION HEARING

COMPARISON BETWEEN NORMAL AND HEARING IMPAIRED (UNAIDED)



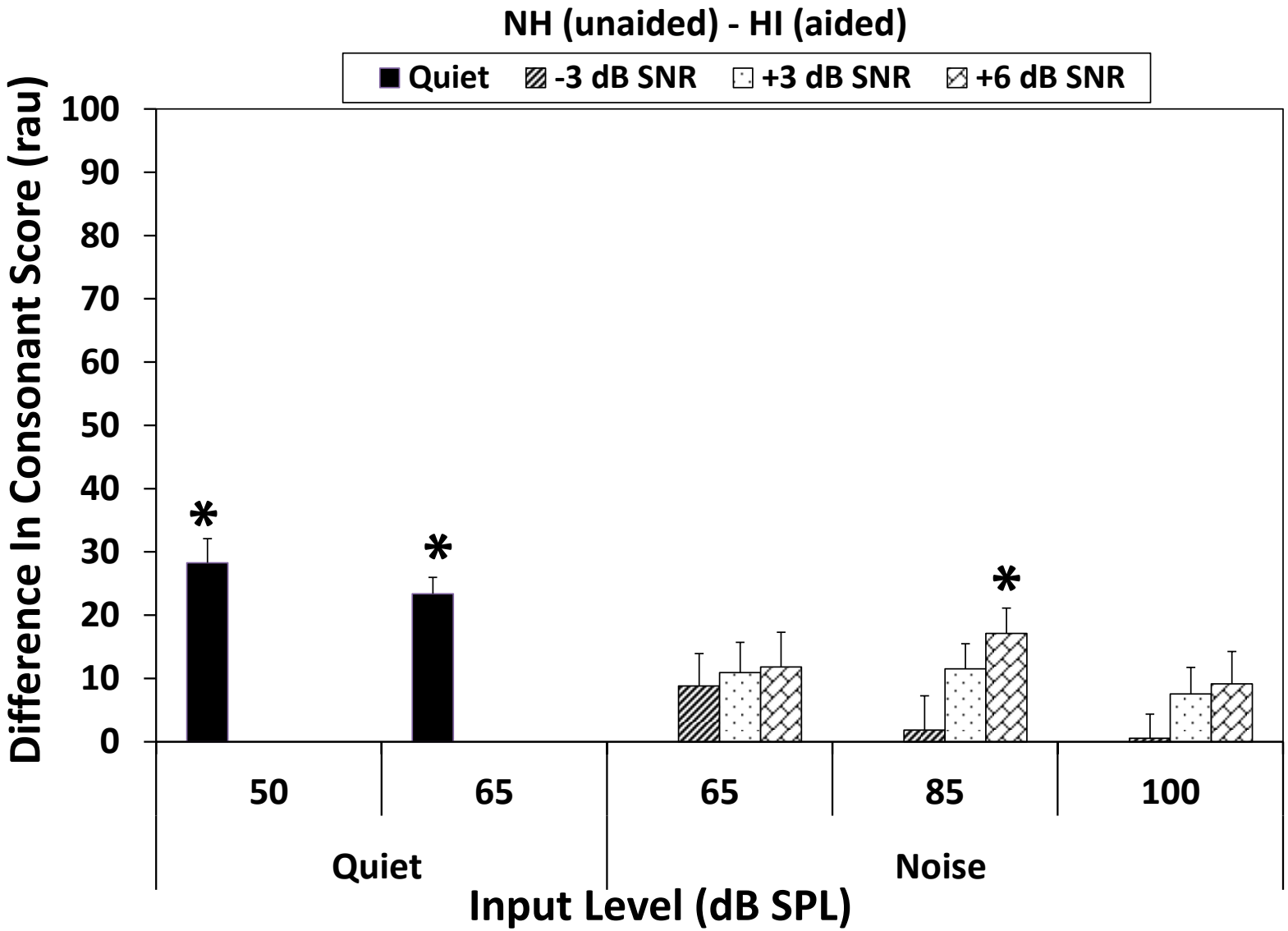
WIDEX
HIGH DEFINITION HEARING

COMPARISON BETWEEN UNAIDED AND AIDED IN HEARING IMPAIRED LISTENERS



WIDEX
HIGH DEFINITION HEARING

COMPARISON BETWEEN NORMAL AND HEARING IMPAIRED (AIDED)



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TAKE HOME MESSAGES

- Hearing aids do provide benefits at a high input level (but only if the input and output stages are high enough)
- Performance (speech understanding and subjective preference) plateaued and/or decreased above 85 dB SPL for both aided and unaided
- Normal hearing people perform just as poorly as hearing impaired people in loud noisy situations at a negative SNR
- Normal hearing people perform better than hearing impaired people at a more positive SNR

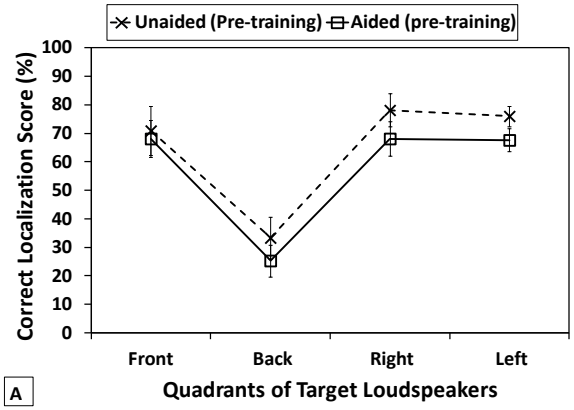
HOW TO SET RIGHT EXPECTATIONS IN PATIENTS FOR LISTENING AT HIGH INPUTS

- Measure patient's speech in quiet and speech in noise abilities as part of the clinical protocol
- Beware of the "roll-over" phenomenon 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

TRAINING FRONT-BACK LOCALIZATION

IS LOCALIZATION A PROBLEM?

- Widex ORCA-USA lab testing showed that average correct rate of front-back localization is 55% for front and 22% for back with subjects' own aids and 70% for front and 30% for back in the unaided condition (head movement not allowed)
  - Front-back localization is poor unaided
  - Front-back localization is poor even when aided
  - Aided front-back localization may be poorer than unaided



- Even people who reported no localization problems in real life showed poor performance during laboratory evaluation
  - People compensate (with other cues) in real life
- Hearing impaired people experience more localization difficulties as their hearing loss increases (Bryne and Noble)

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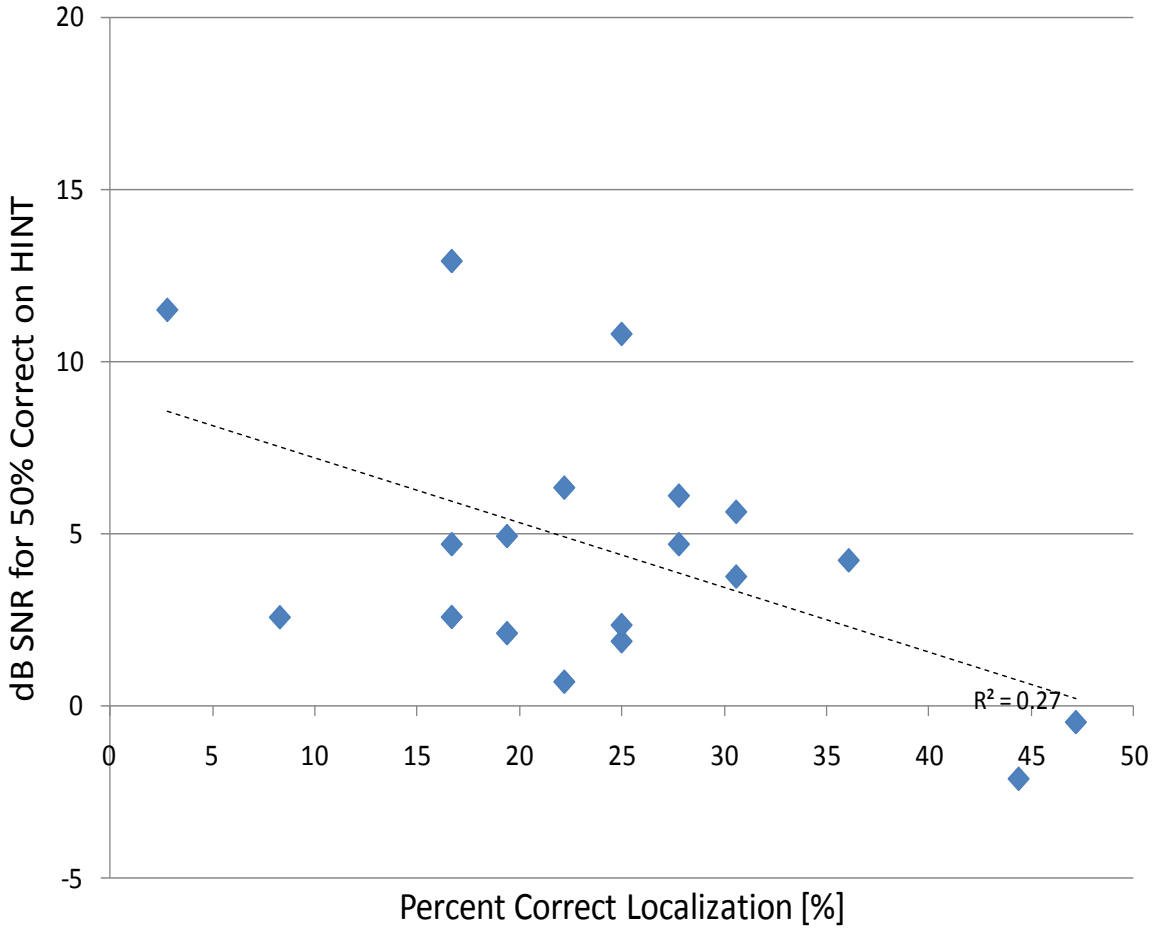
WHY IS LOCALIZATION IMPORTANT?

- Safety
- Spatial (or 3D) feeling – externalization
- Aesthetic experience – pairing visual and audio input
- Source identification
  - E.g., Best et al (2007)
- Potential improvement of speech understanding in noise
  - Complaints such as “I have difficulty hearing in noise” may mean “I have difficulty hearing in noise because I do not know who is talking to me” (from a distance)
  - Being able to locate the source of a speaker in a crowded place and pair visual cues may improve intelligibility/communication in noise
  - Focus attention (e.g., Kidd et al (2005)
  - More relaxed hearing
- Localization and speech in noise may be linked somehow (Hirsch, 1950; Noble et al, 1995; Potts et al, 2009; Ching, 2004)

UNAIDED LOCALIZATION AND SPEECH INTELLIGIBILITY



(Source: ORCA-USA, internal data)

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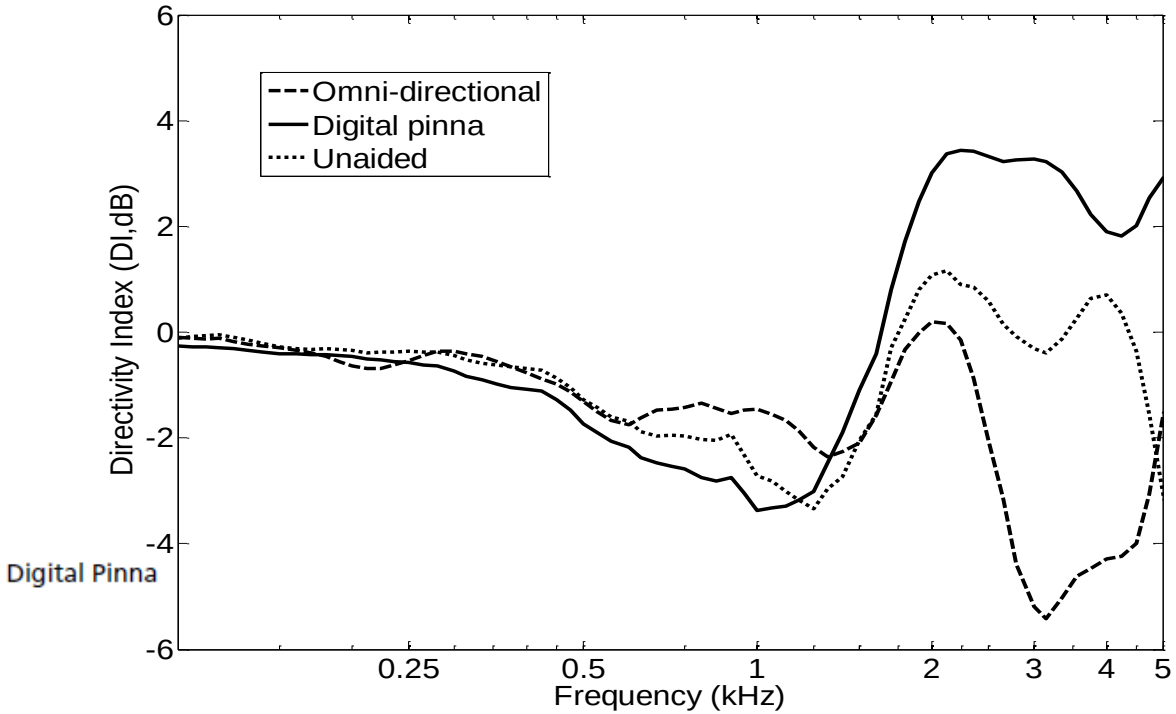
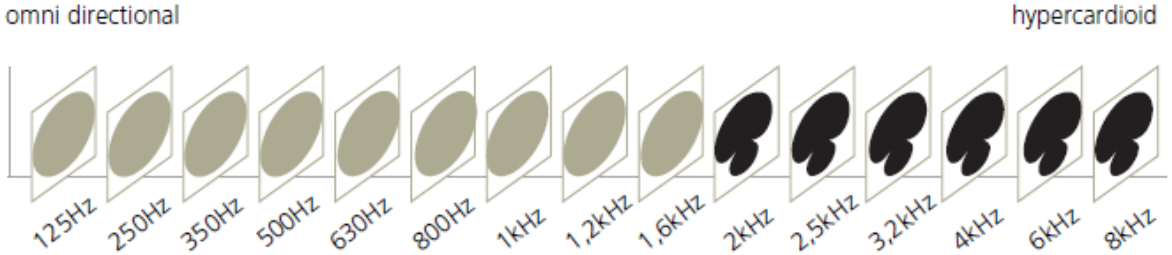
HEARING AID FEATURES TO PRESERVE/ ENHANCE LOCALIZATION CUES

- Vertical localization
  - Broadband amplification with extended high frequencies
  - Open fit, if possible?
- Horizontal localization
  - Slow acting compression to preserve temporal characteristics
  - Inter-ear matching of phase and intensity differences (with unaided)
  - Open fit – for low frequencies below 1500 Hz
  - Broadband or sufficient highs
- Front-back localization
  - Pinna shadow compensation algorithms
  - Directional microphones, especially in highs

PINNA SHADOW COMPENSATION FOR BTE



Digital Pinna



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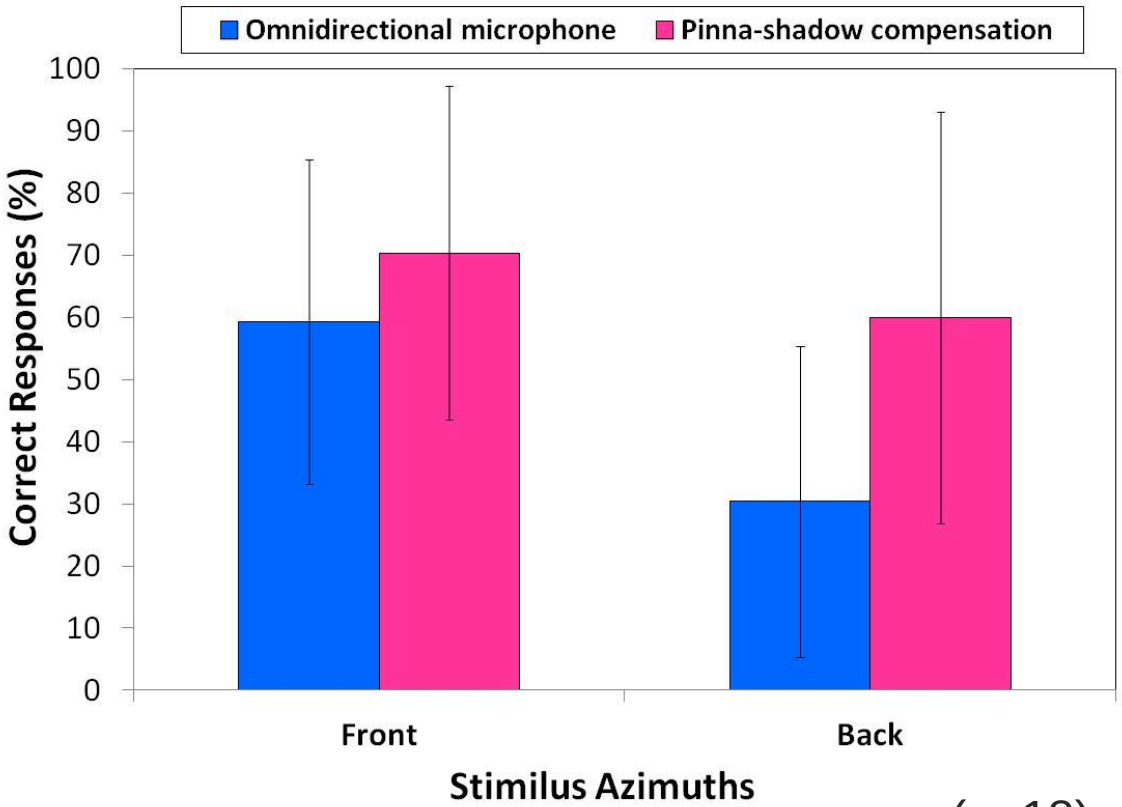
DIGITAL PINNA - IMPROVING FRONT- BACK LOCALIZATION (Kuk et al, 2013)



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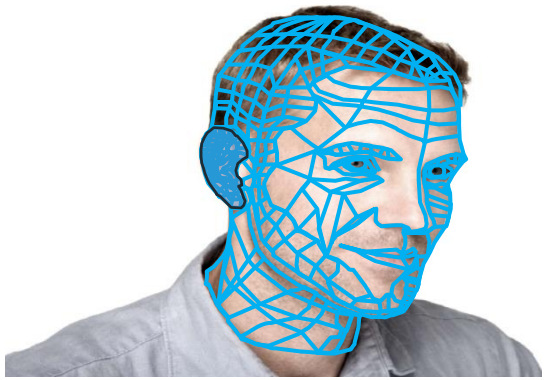

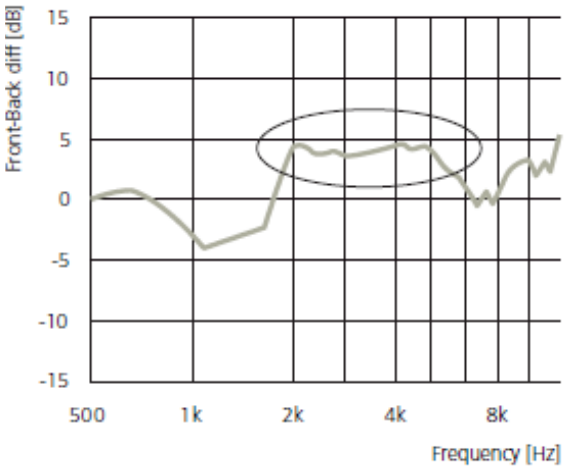

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REASONS WHY WE THINK WE CAN TRAIN PEOPLE TO LOCALIZE

- Previous studies (Kumpik et al, Irving and Moore) were able to train people to localize even when one ear was plugged
  - Suggest brain is plastic and can be trained
    - but these were normal listeners and younger than typical HI
  - Correlates also seen in other sensory modalities
  - Speech in noise training also successful
- Enough learning theories so the ingredients for a successful program can be designed
  - What are the ingredients?
- We provide the actual hearing aids with the proper acoustic factors
  - DP
  - Inter-ear compression
  - Daily repeated use of “proper” acoustic cues – may be more generalizable

KEY TO SUCCESS - MAINTAINING MOTIVATION

Stimuli are changed adaptively to keep motivation

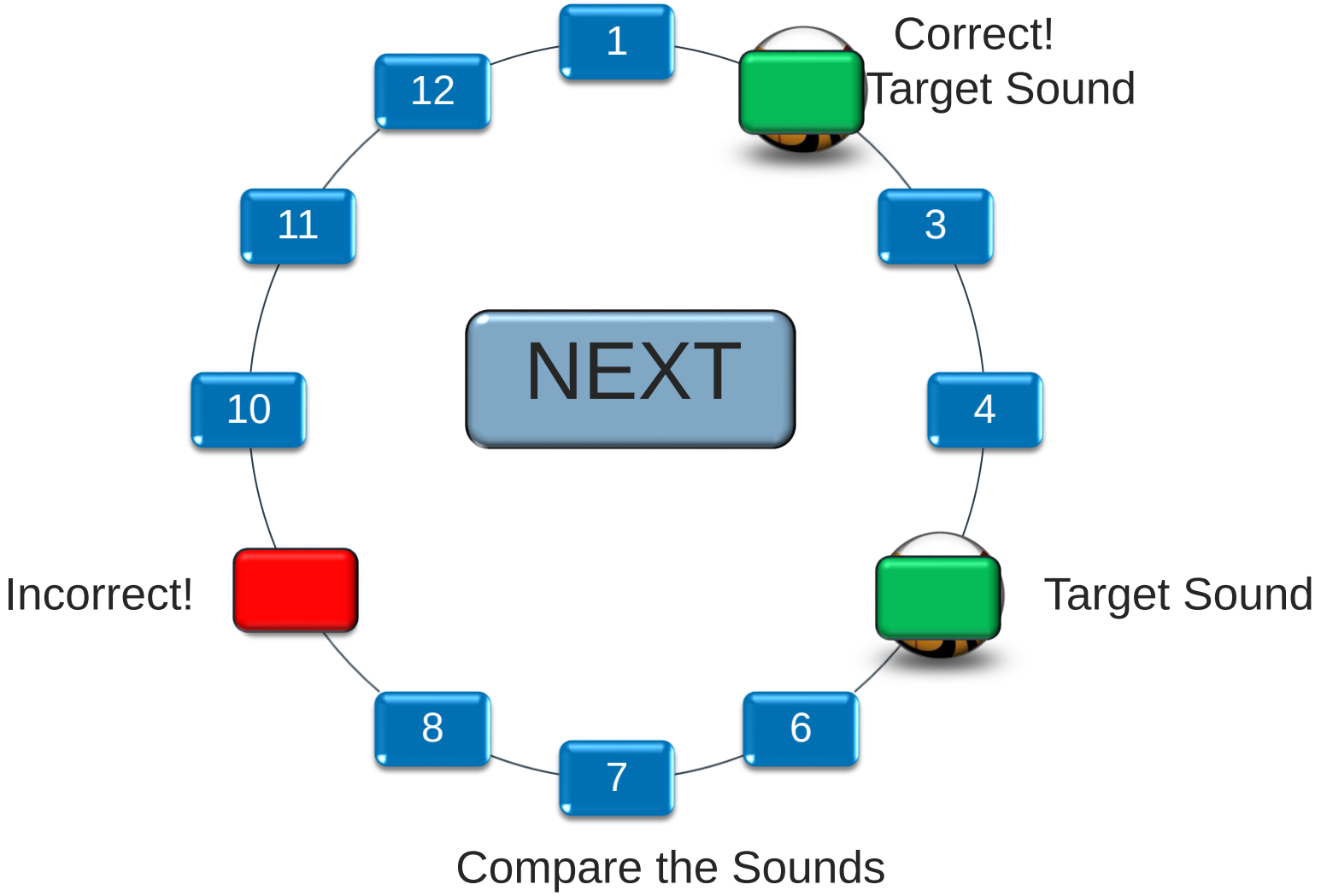
Provide immediate feedback and self-paced learning

Vary criteria to maintain feeling of success

ADAPTIVE TRAINING -STIMULI

- It is easier to perceive a difference if the stimulus contrast is “large” or if the stimulus condition is easy
  - Duration of stimulus from 3s to 300ms (300, 500, 1000, 2000 and 3000 ms)
  - Front-back attenuation – digital pinna +8, 4, 2, 0 dB
  - Based on the results of the tests a hierarchy was used to determine the stimulus duration and back plane attenuation for training
- Three high-pass signals (above 2000 Hz) were used
  - High pass noise
  - Speech
  - Telephone ring
- Each stimulus was randomly presented 3 times each from the 12 loudspeakers for a total of **108** test items per trial

TRAINING FOR SUCCESS - FEEDBACK FOR IMMEDIATE ERROR CORRECTION



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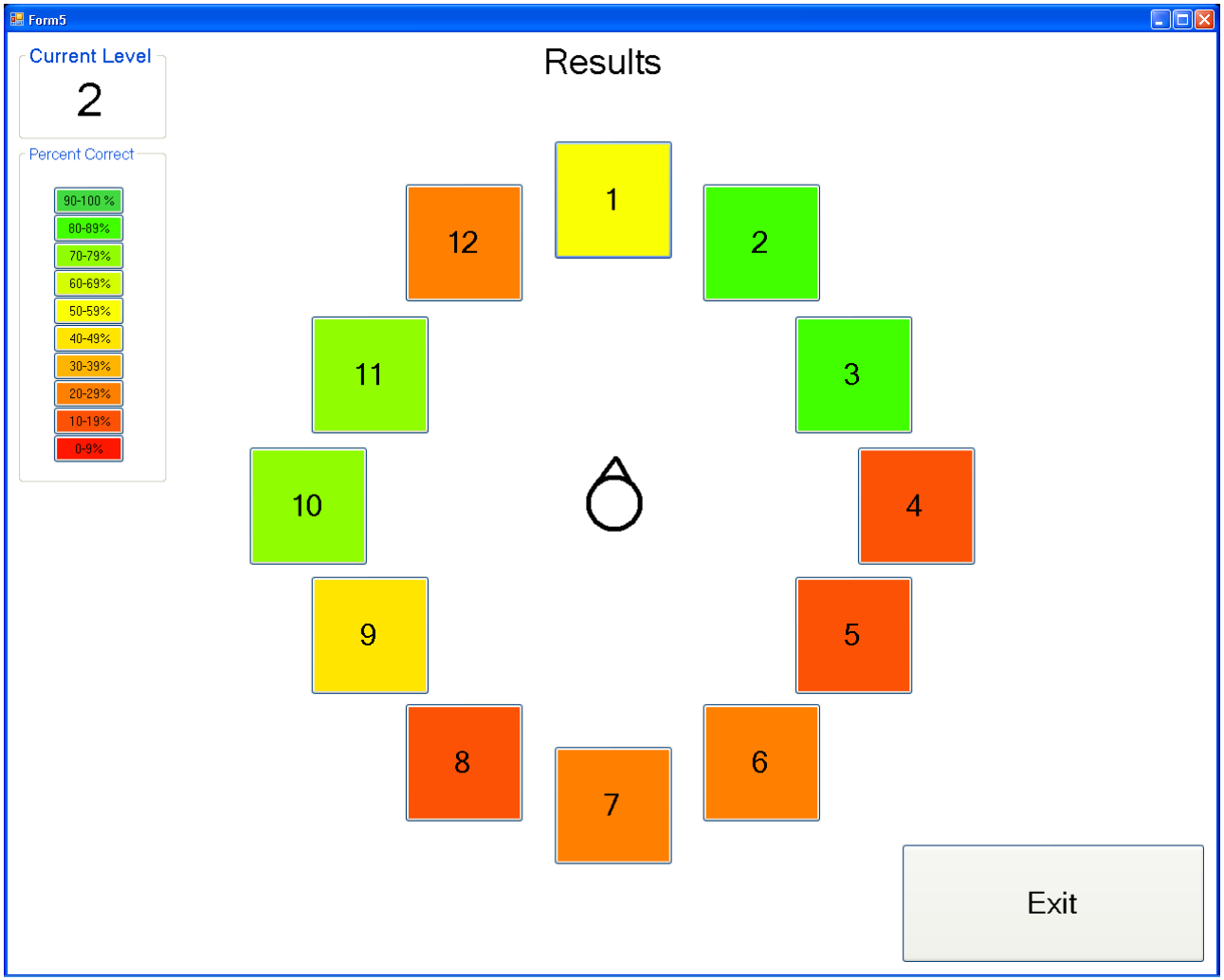
ADAPTIVE TRAINING – CRITERIA OF SUCCESS

- It is more motivating to get it correct than to get it incorrect, e.g., relaxed criteria at the beginning & tightened later
  - Criterion of correct from 60^0, 30^0, and 0^0
- Success on a longer/more attenuated/easier criterion will lead to the use of a shorter, less attenuated, more stringent criterion in the next trial

MONITORING OF PERFORMANCE



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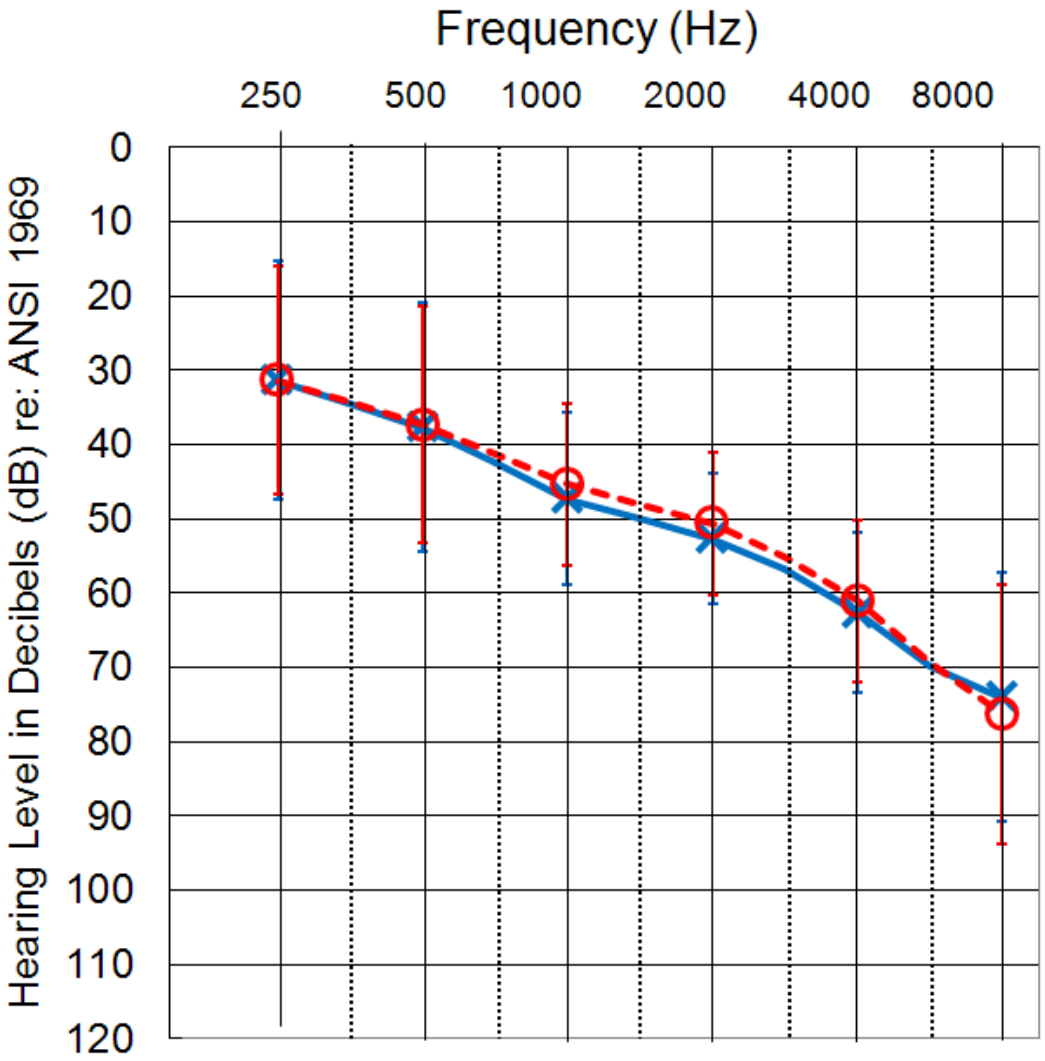
SUBJECT AUDIOGRAM



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DISTRIBUTION OF PARTICIPANTS IN EACH STUDY GROUP

	Group 1	Group 2	Group 3
No. of males	2	3	2
No. of females	3	2	3
Median age (Yrs)	75	70	74
No. of BTE users	3	2	2
No. of Poor localizer	1	2	2
Mean high frequency pure-tone average (dB HL)	51	52	56
Mean unaided presentation level (dB SPL)	87	83	84
Mean aided presentation level (dB SPL)	70	70	70

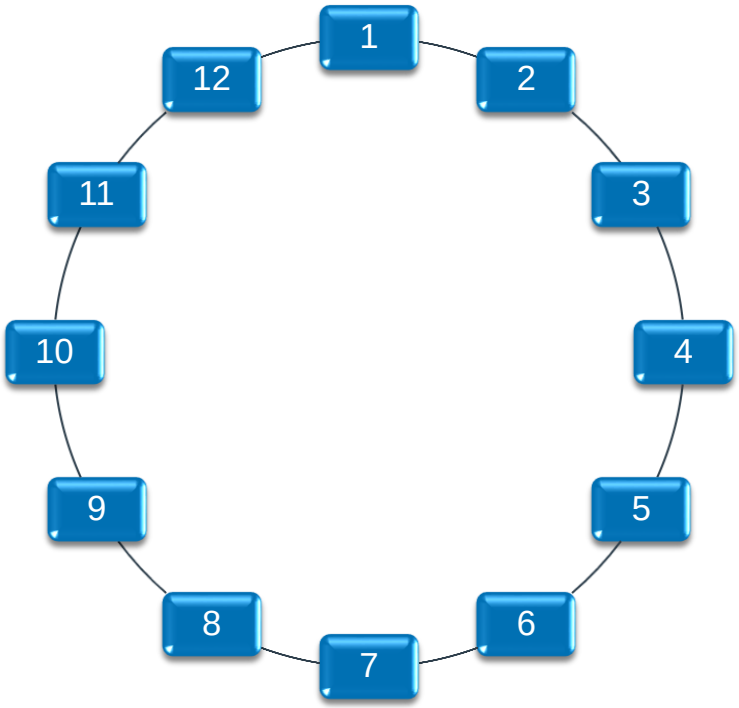
RECAP OF OVERALL DESIGN

- Fifteen hearing impaired subjects with bilaterally symmetrical mild to moderate sensorineural hearing loss
- Using the Clear m-CB-model hearing aids

Group 1	No Training	No Training	No Training
Group 2	Lab Training	Home Training	No Training
Group 3	Home Training	Lab Training	No Training
	Baseline	1 month	2 month	3 month

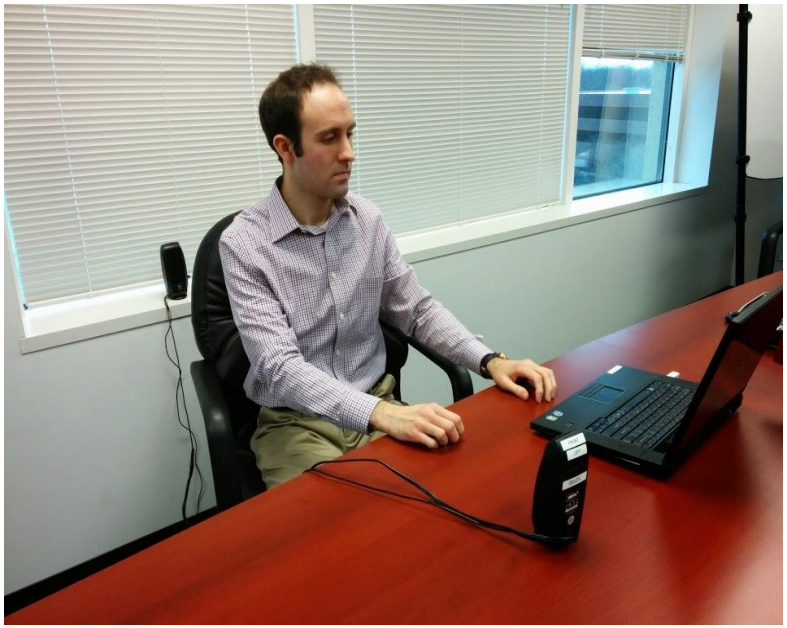
LOCALIZATION LAB TRAINING/TESTING

- 12 loudspeaker array
- During each session, subjects performed baseline test (300 ms, 0 dB attenuation) without feedback
- Received training with feedback (1.5 hr)
- Tested again on baseline condition (300 ms)
- Repeated for 6-8 sessions within a month
- Tested other stimulus conditions during baseline, two weeks, one, two, and three months

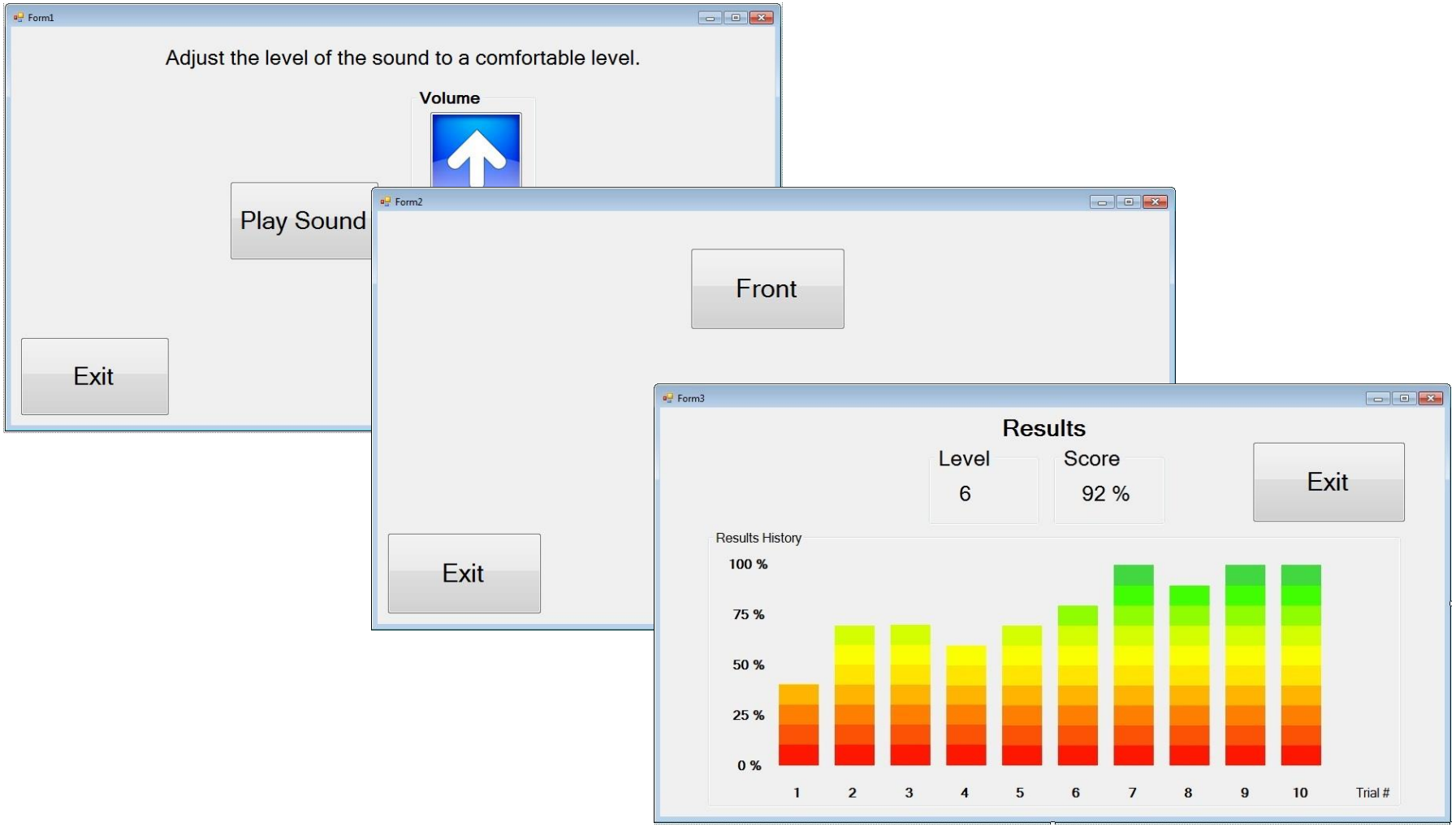


HOME TRAINING

- Training used computerized materials and was also adaptive in nature
  - One loudspeaker placed in front of listener and one behind the listener
  - Ten sounds from a list of 30 available sounds were randomly chosen
  - Each of the ten sounds was presented 3 times from the front and the back [3 x 2 x 10 = 60 items]
  - Listener indicated on computer screen from where they thought it originated [front or back]; feedback provided
  - Performance data were saved so listener can compare daily results and track performance
  - Trainings were 30 minutes; 5 times per week for 4 weeks



HOME TRAINING SCREENS



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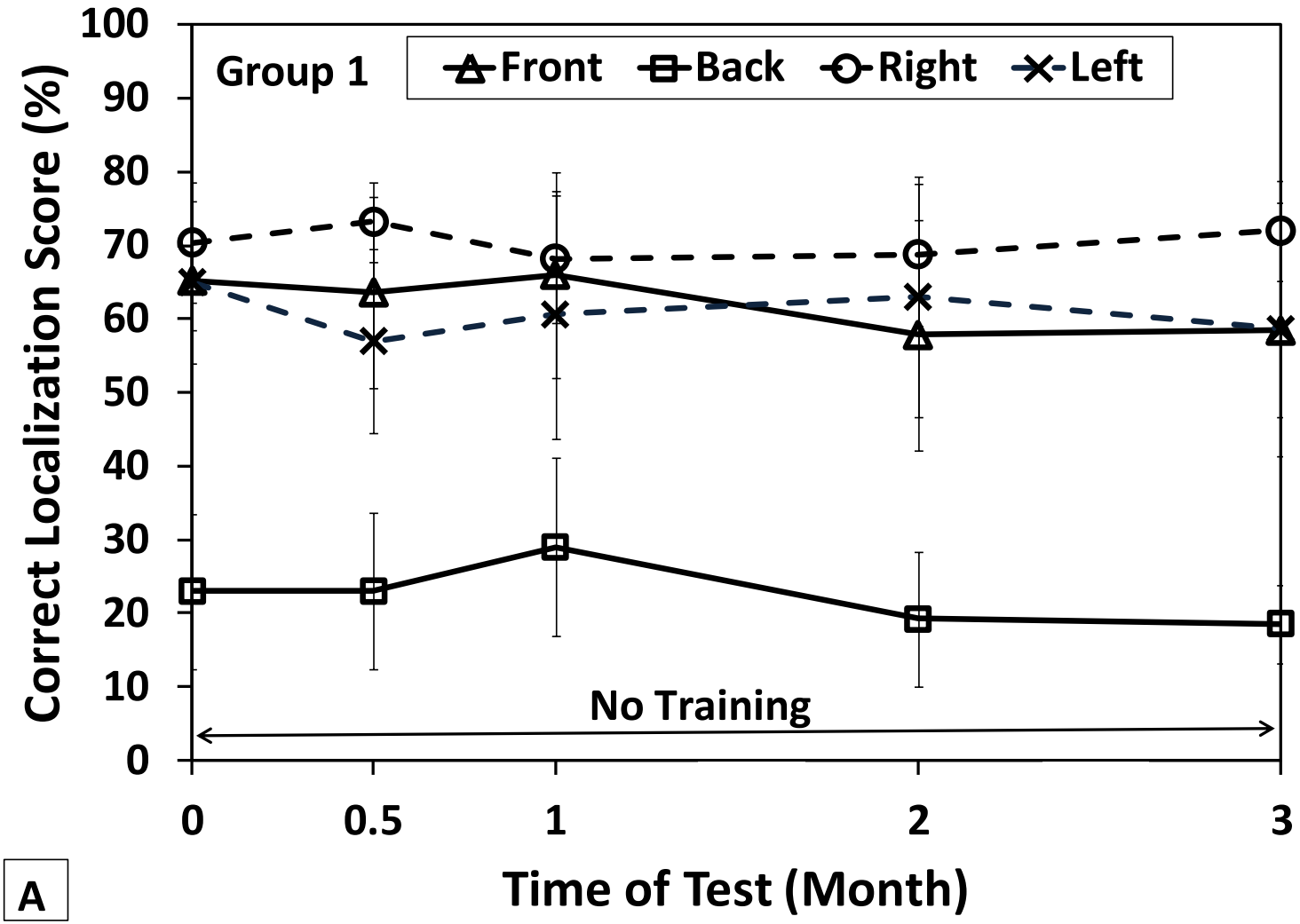
CONTROL GROUP



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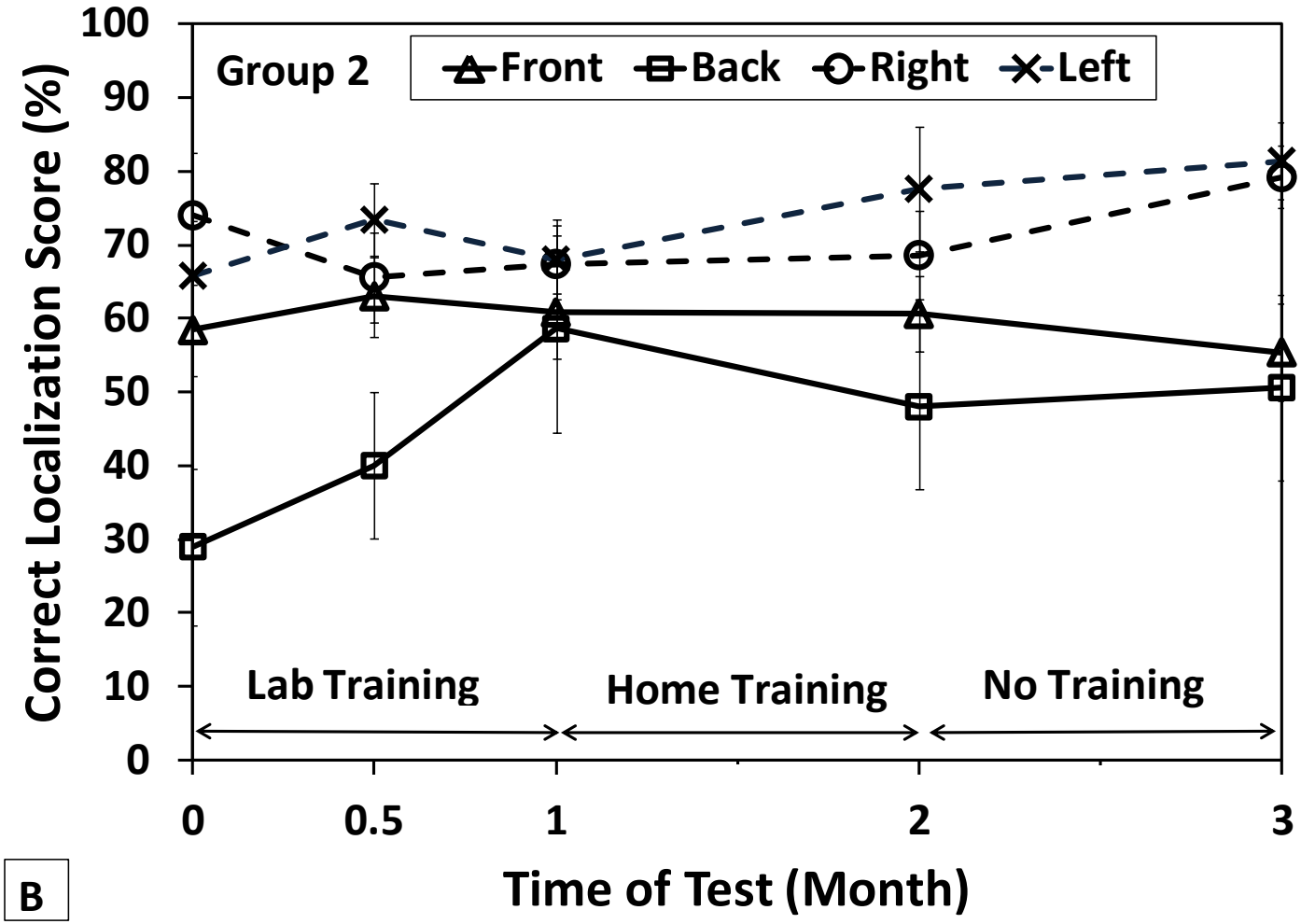
GROUP 2: LAB TRAINING FOLLOWED BY HOME TRAINING



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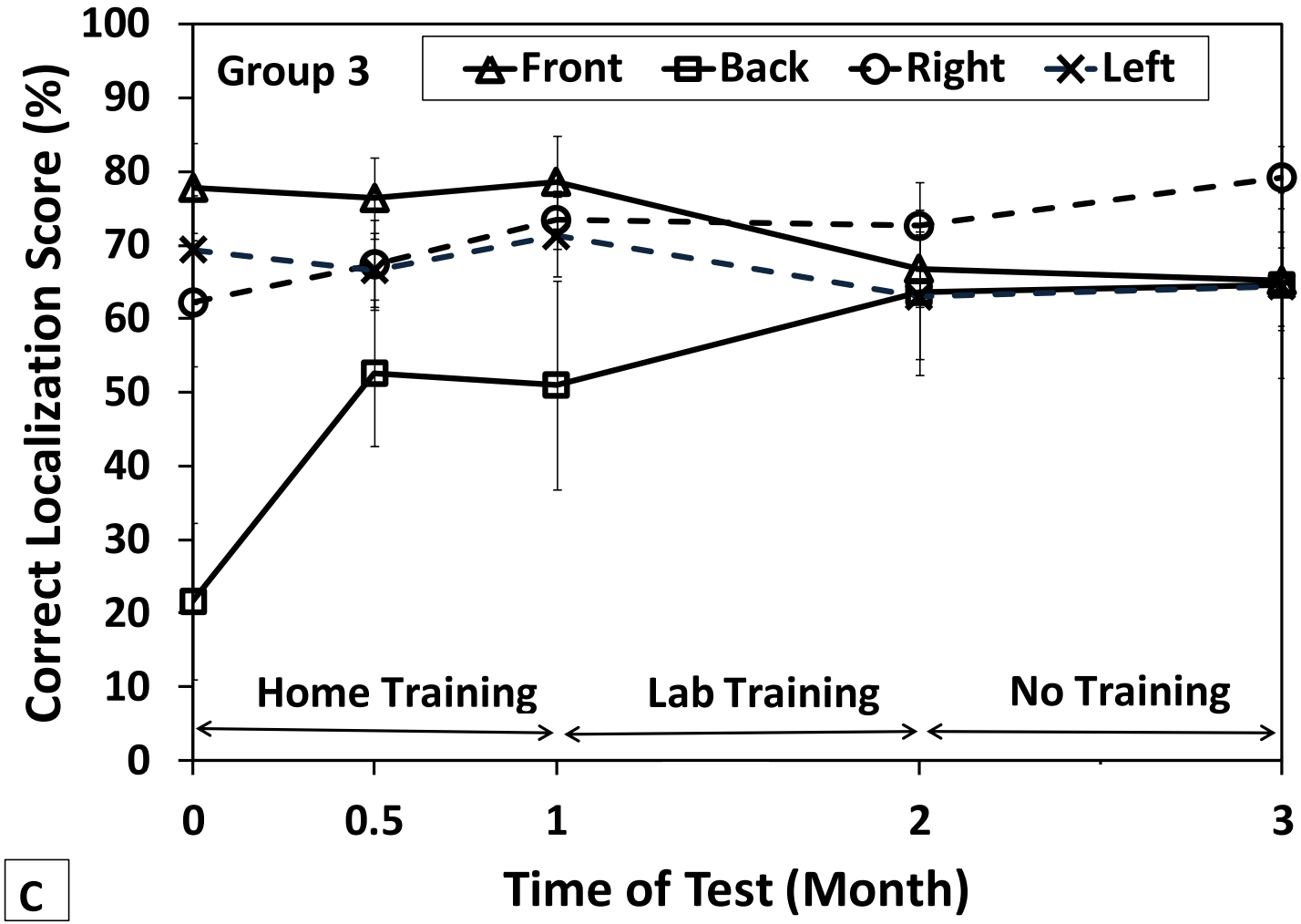
GROUP 3: HOME TRAINING FOLLOWED BY LAB TRAINING



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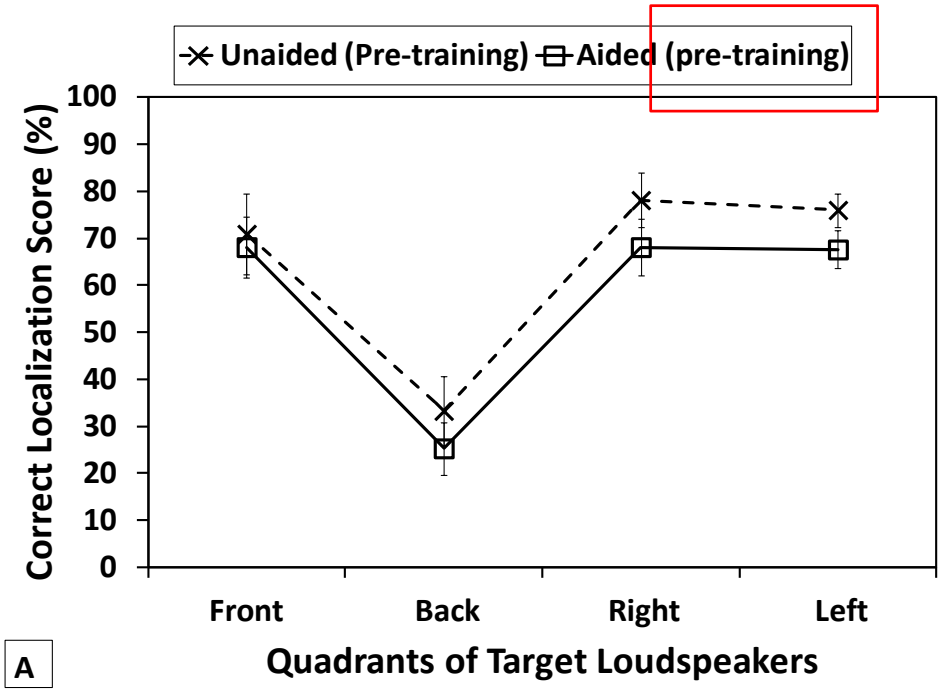
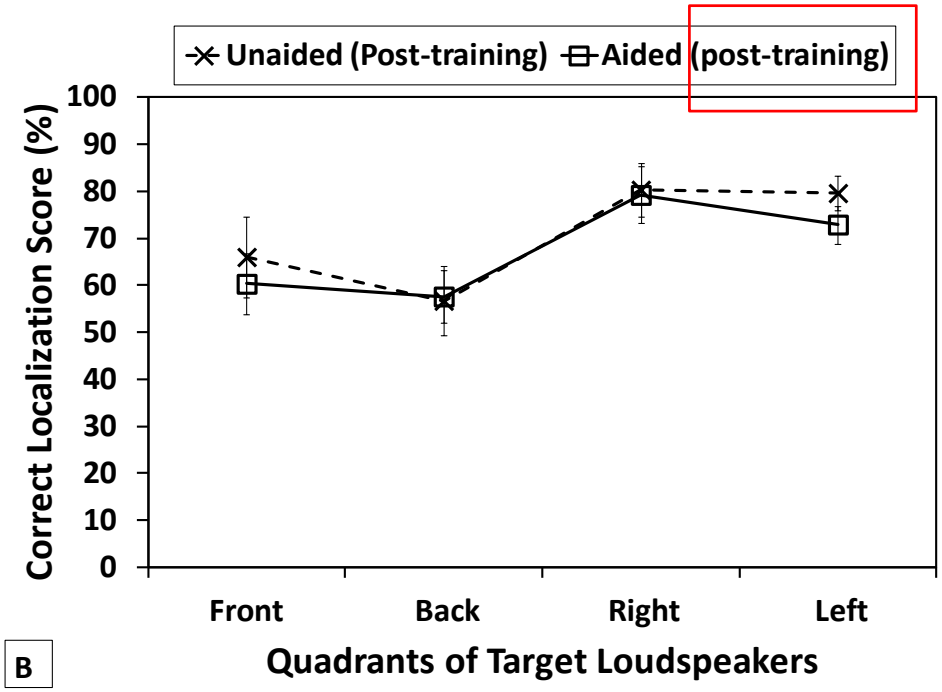
COMPARING UNAIDED AND AIDED PERFORMANCE





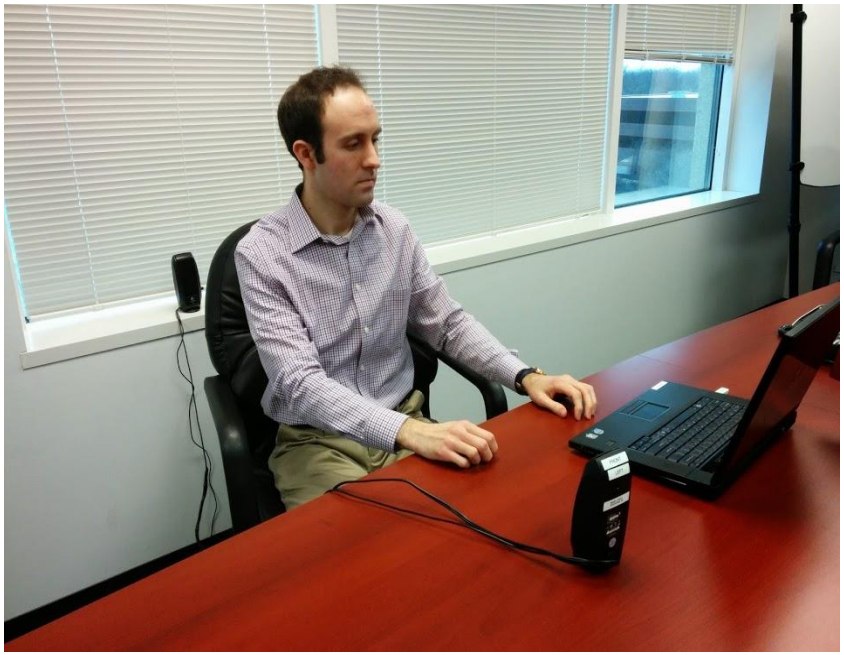
SUMMARY ON LOCALIZATION TRAINING

- Acoustic compensation to restore localization cues alone is not sufficient to improve localization (control group)
- Laboratory training improved localization (Group 2)
- Home training improved localization (Group 3)
- The effect of training generalized to unaided and other stimulus conditions
- The most significant improvement was seen during the first 2 weeks to 1 month of training
- Real-world impact of training is an externalization of sounds (more spatial hearing)

HOW CAN YOU HELP YOUR PATIENTS TO LOCALIZE

- Do order BTE/RIC with DP feature
- Inter-ear feature may help localization and 3D percept in some patients
- Not everyone will be successful
- The take-home training consisted of a computer program and two loudspeakers positioned at 0° and 180°.
- Instruct patients to associate source of sound with percept, especially front-back
- Access home training program at

https://dl.dropbox.com/s/ael5wsq29xl69k9/ORCA%20Home%20Localization%20Training%20Program.zip



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Training Left-Right Localization in CROS/BiCROS wearers

CHALLENGES FOR PEOPLE WITH ONE UNAIDABLE EAR (CROS/BICROS CANDIDATES)

- No more binaural cues
  - Loss of input from unaidable ear – head shadow results in loss of high frequency audibility
  - Loss of binaural summation – sounds are softer
  - Loss of binaural squelch – speech in noise poorer
  - Loss of interaural cues – sounds are always heard in good or aidable ear, loss of spatial (3D) perception

- Difficulty with speech understanding, especially in noise
- Difficulty with localization

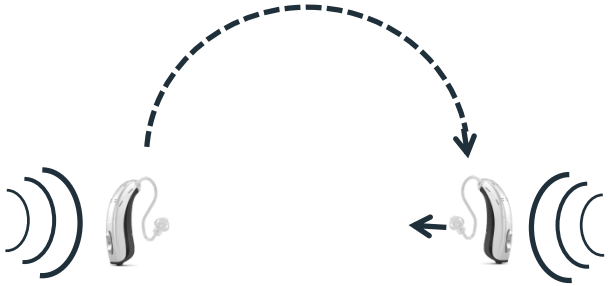
- CROS/BiCROS does not restore binaural cues; but it does restore audibility on the poorer side despite the loss of their spatial origins

WIDEX CROS MODELS AND COMPATIBILITY

Transmitter

WIDEX CROS-FUSION

WIDEX CROS-FASHION



Receiver

WIDEX DREAM™ 440
WIDEX DREAM™ 330
WIDEX DREAM™ 220
WIDEX DREAM™ 110

Receiving hearing aids: all DREAM models

WIDEX®
HIGH DEFINITION HEARING

WIDEX **CROS** W/ TRUE INPUT TECHNOLOGY

Omni/Locator microphone

Omni/Locator microphone

Volume control

On/ off switch

On/ off transmission

WidexLink & True Input Technology (113 dB SPL)

Slim design

Efficient battery life (#312 battery, 0.9 mA)

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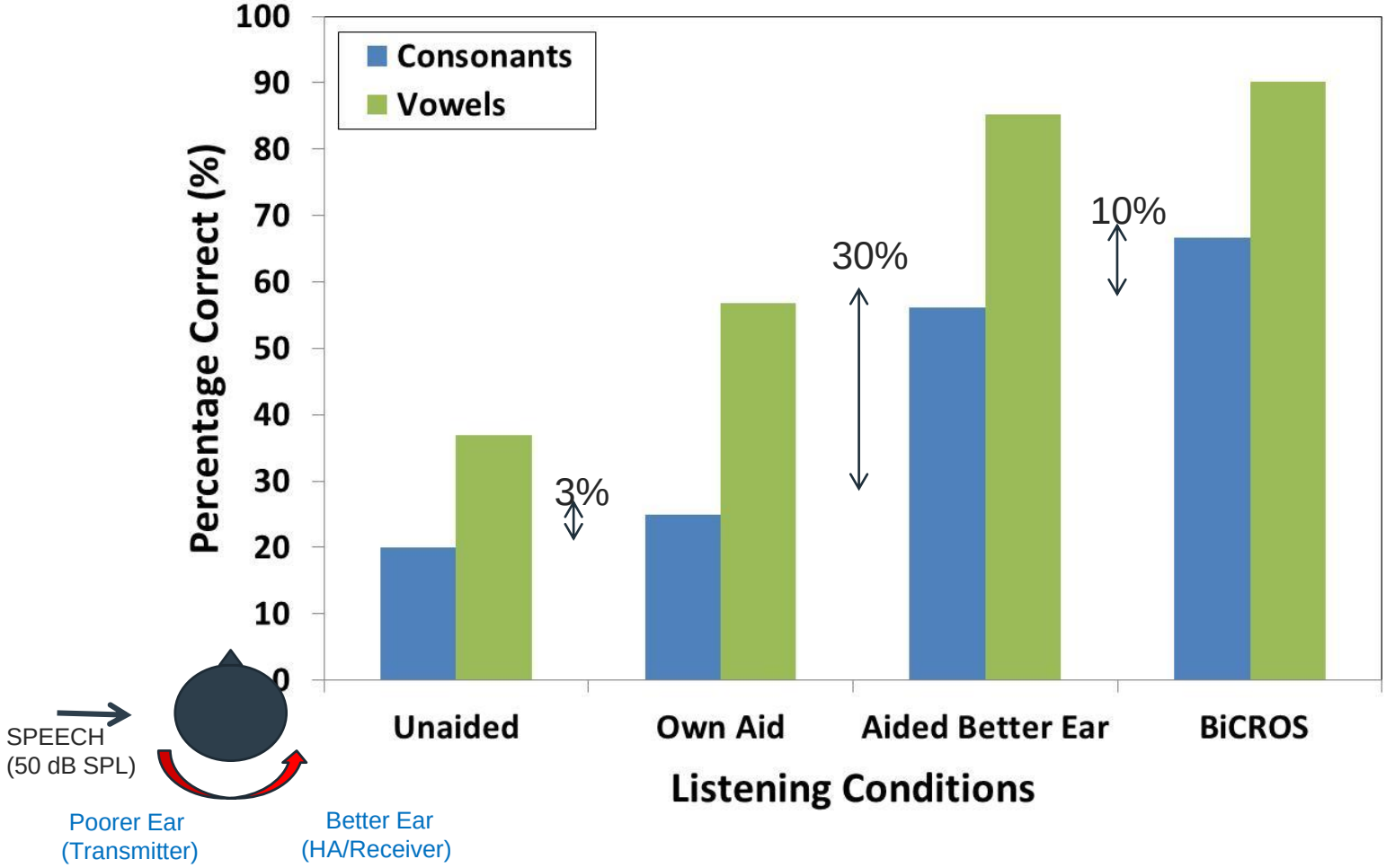
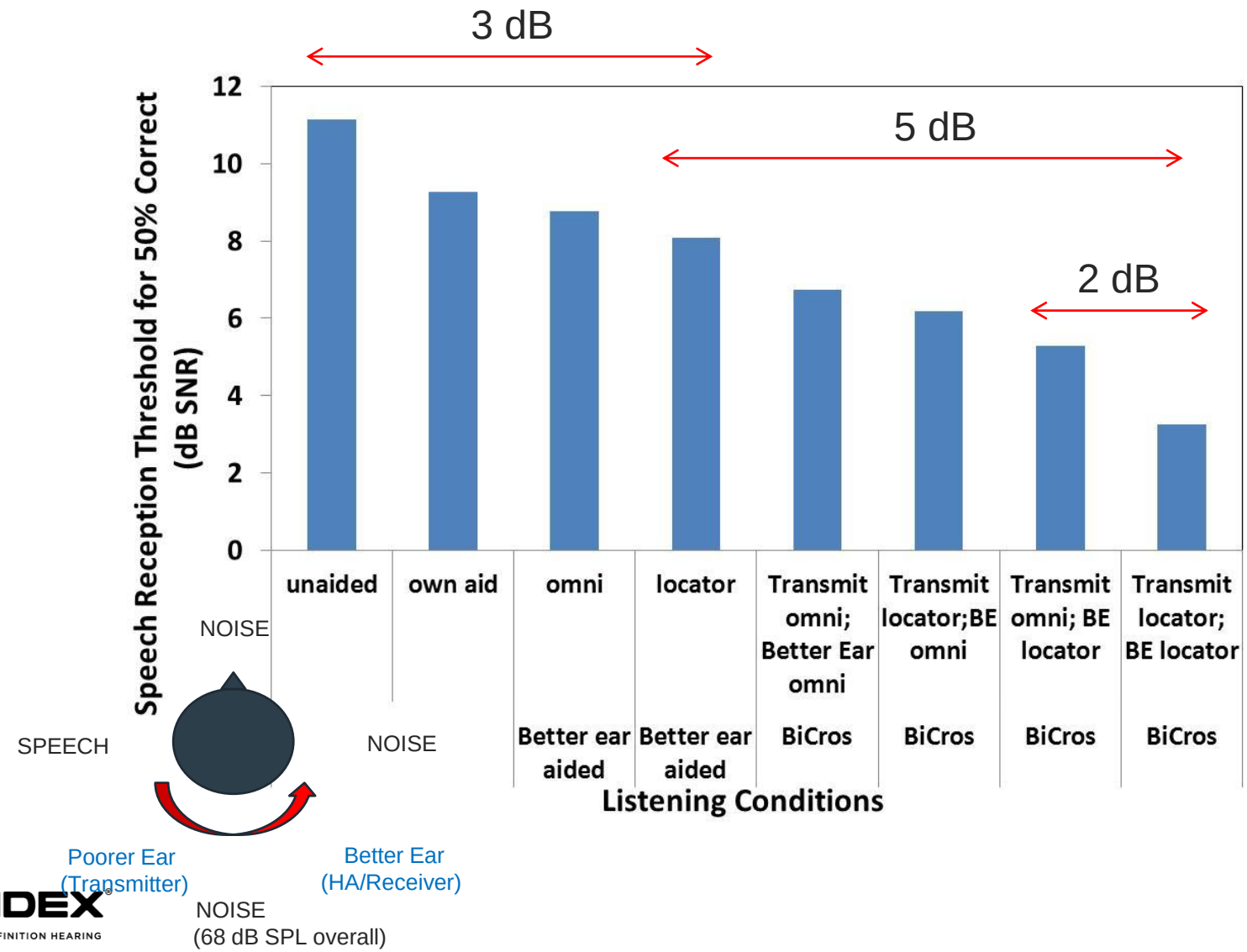
HIGH DEFINITION HEARING

ADVANTAGE OF BICROS – SPEECH FROM POOR EAR SIDE - QUIET



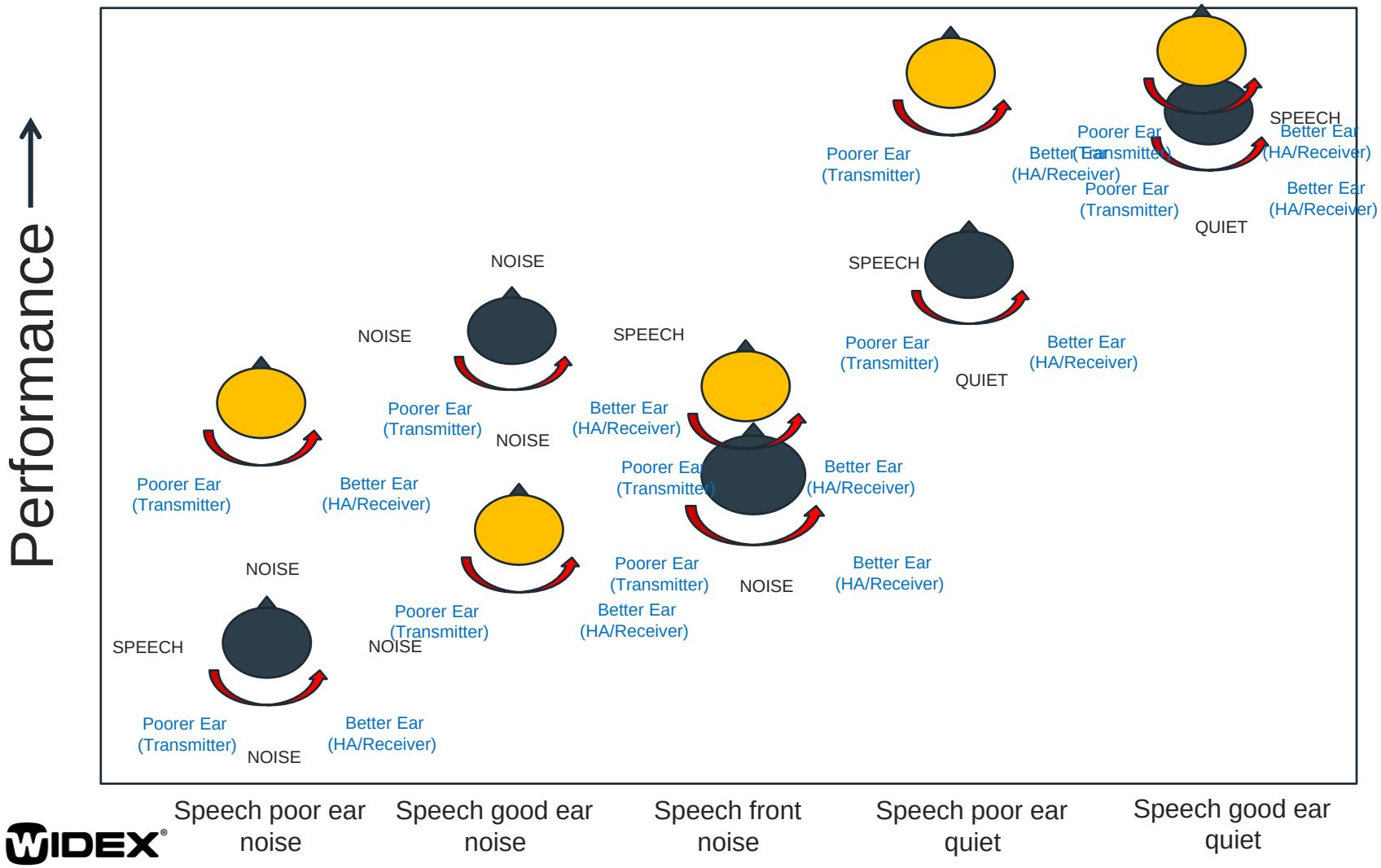
WIDEX
HIGH DEFINITION HEARING

ADVANTAGE OF BICROS – SPEECH FROM POOR EAR SIDE IN NOISE



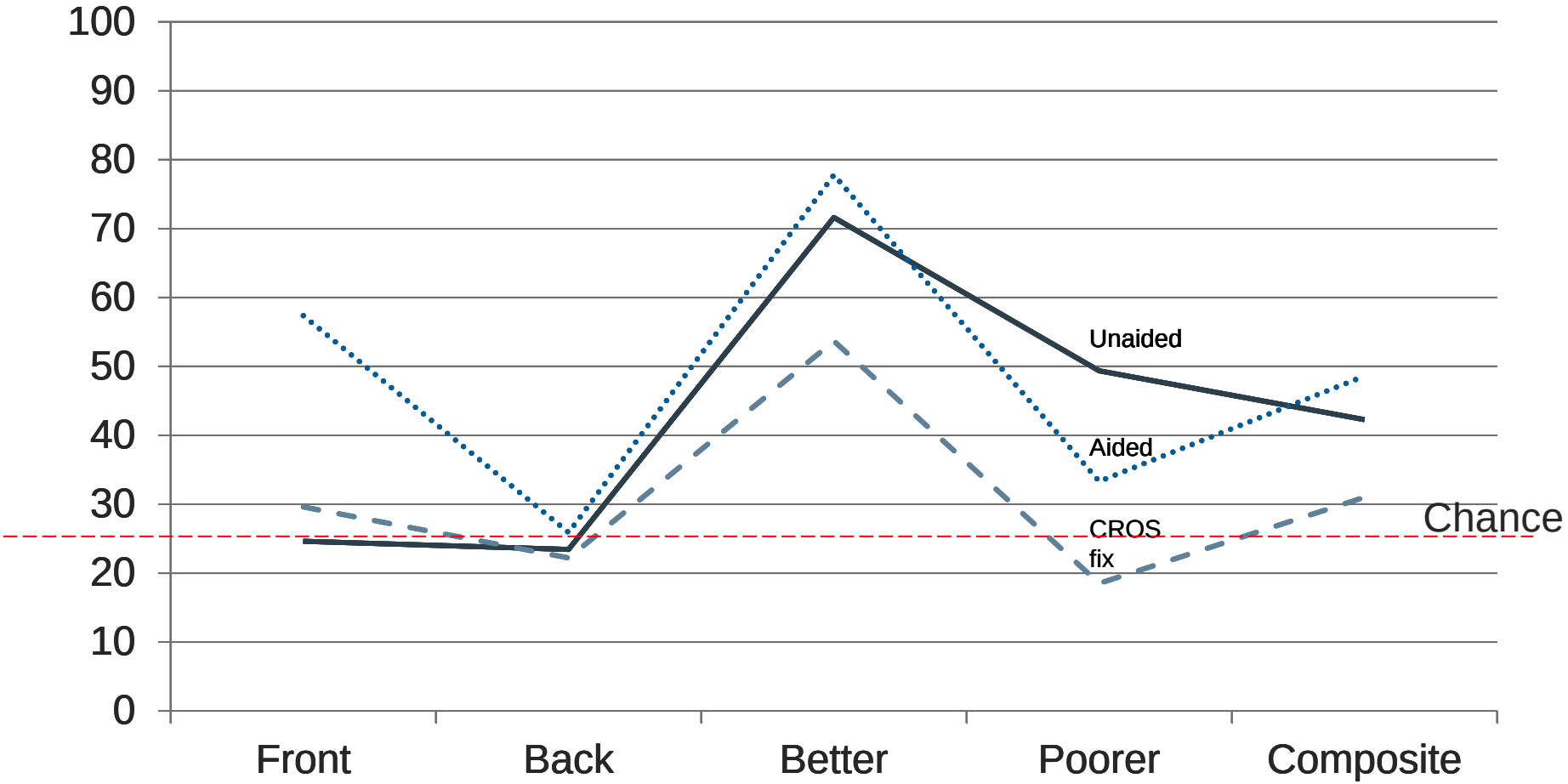
WIDEX HIGH DEFINITION HEARING

CROS/BICROS: BENEFITS AND LIMITATIONS



WIDEX HIGH DEFINITION HEARING

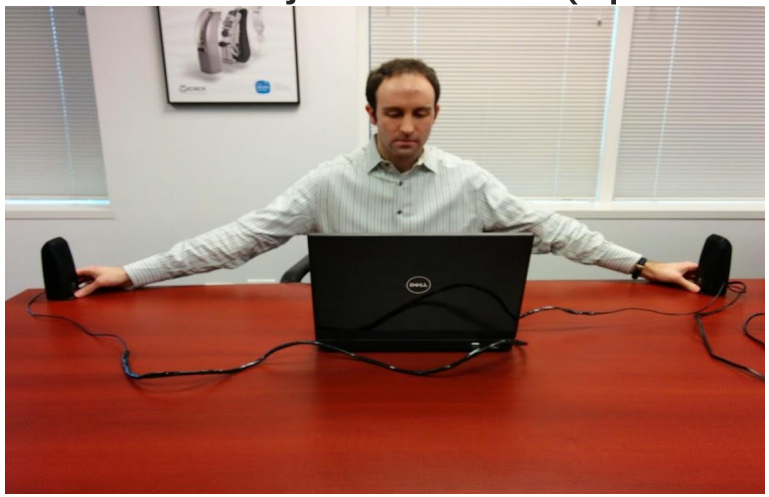
LOCALIZATION BICROS WEARERS



WIDEX®
HIGH DEFINITION HEARING

ADJUSTING ON/OFF AND VC FOR SPEECH

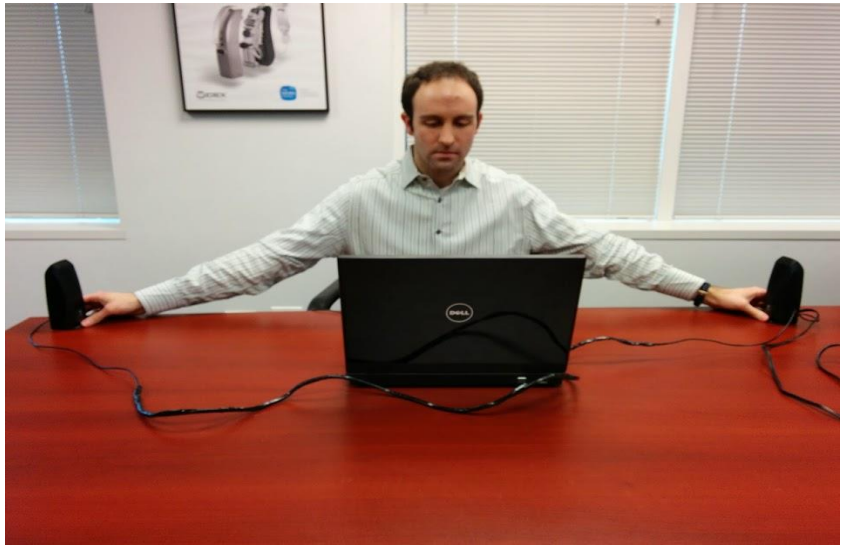
- Clinician action: present speech to good/bad ear randomly (in noise)
- Client action: Turn OFF the CROS mic (bottom of CROS)
- Ask: Does speech sound clearer?
- Answers
  - YES, Better – adjust VC (up and down) on HA to make speech even clearer
  - NO, Worse – turn CROS mic back on. Adjust CROS VC (up and down) to make speech better
  - No Difference – turn CROS mic back on. Adjust HA VC (up and down) to make speech better.
- Practice until familiar



WIDEX®
HIGH DEFINITION HEARING

ADJUSTING ON/OFF & VC SWITCHES FOR LOCALIZATION

- Clinician action: present sound from loudspeaker randomly (in noise)
- Client action: Turn OFF the CROS mic (bottom of CROS)
- Ask: Is there a change to the sound loudness?
- Answers
  - NO, same loudness – sound from HA side
  - NO, or slightly softer – sound from front/back.
  - YES, can’t hear sound or very soft – sound from CROS mic side
- Practice until familiar



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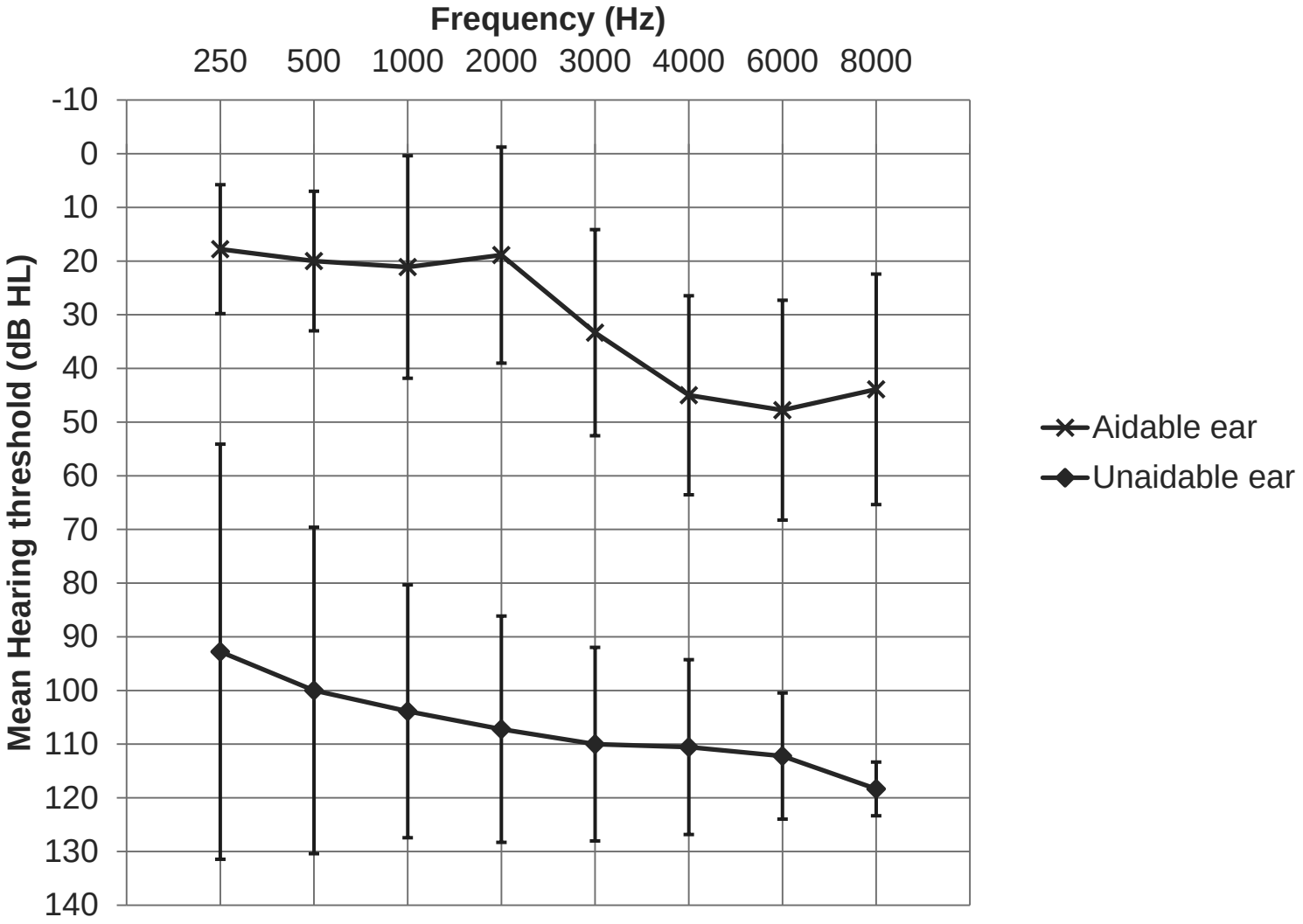
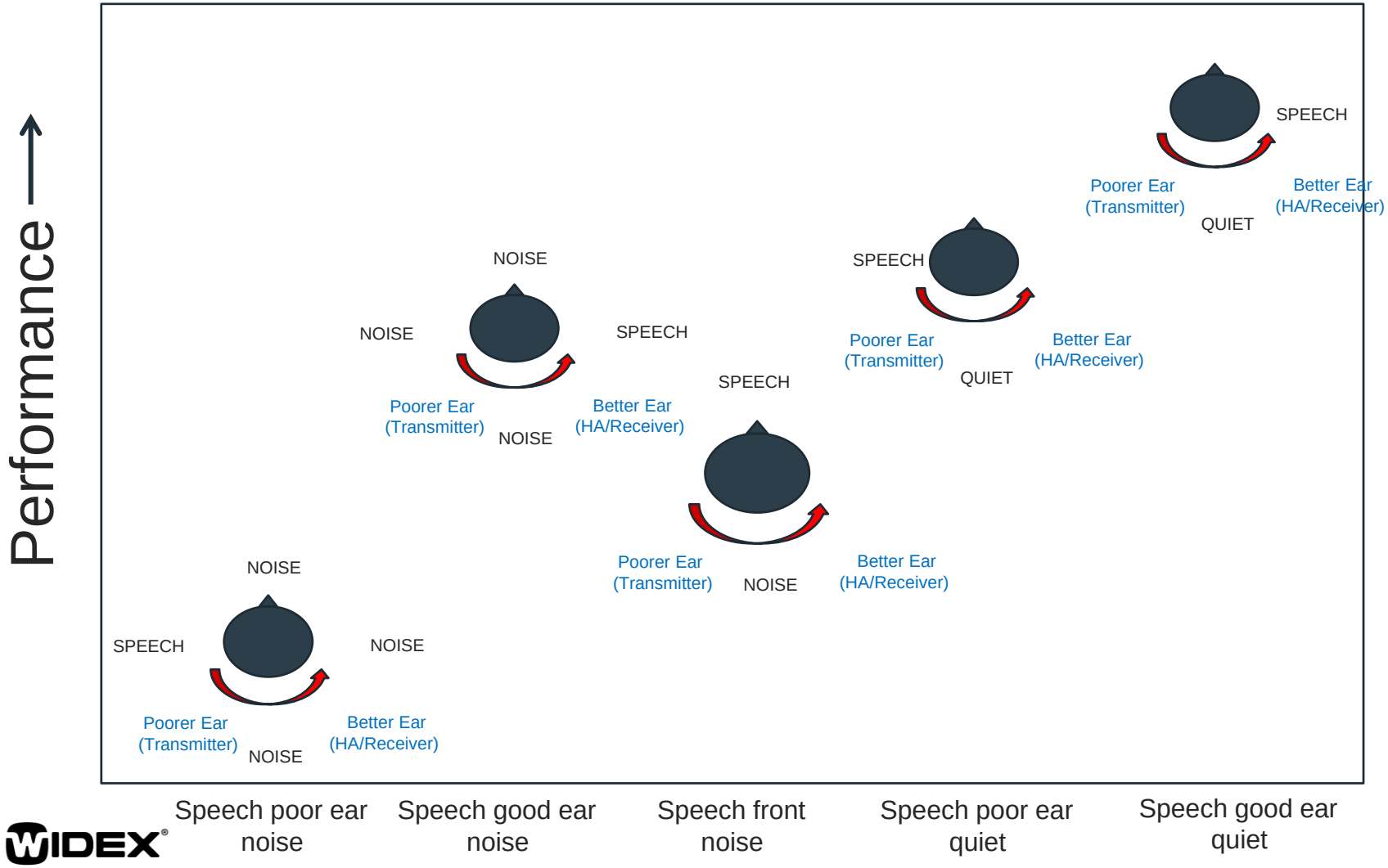
HIGH DEFINITION HEARING

SUBJECT AUDIOGRAM



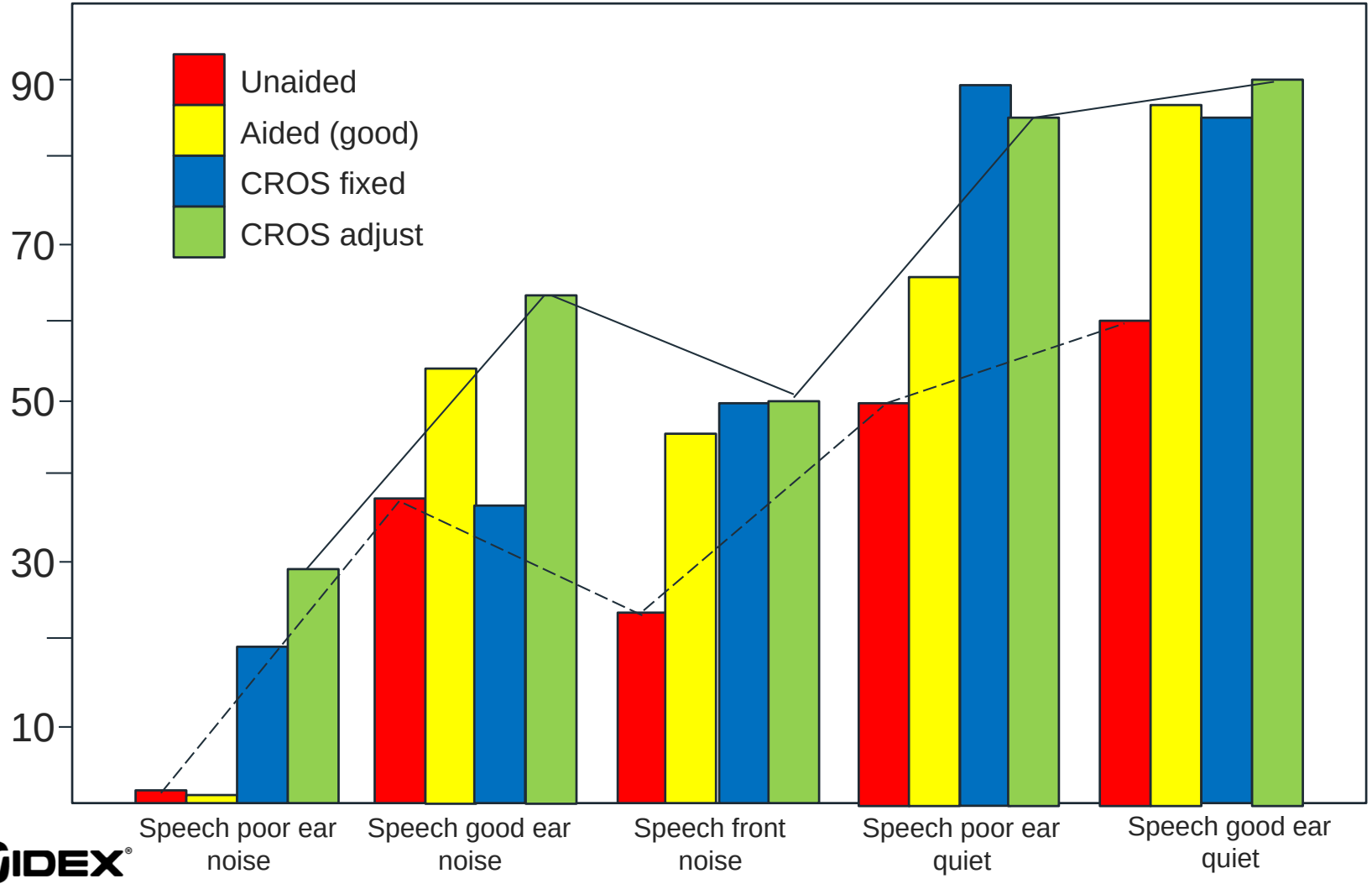
WIDEX®
HIGH DEFINITION HEARING

TEST CONDITIONS (RE: AZIMUTHS) FOR SPEECH UNDERSTANDING



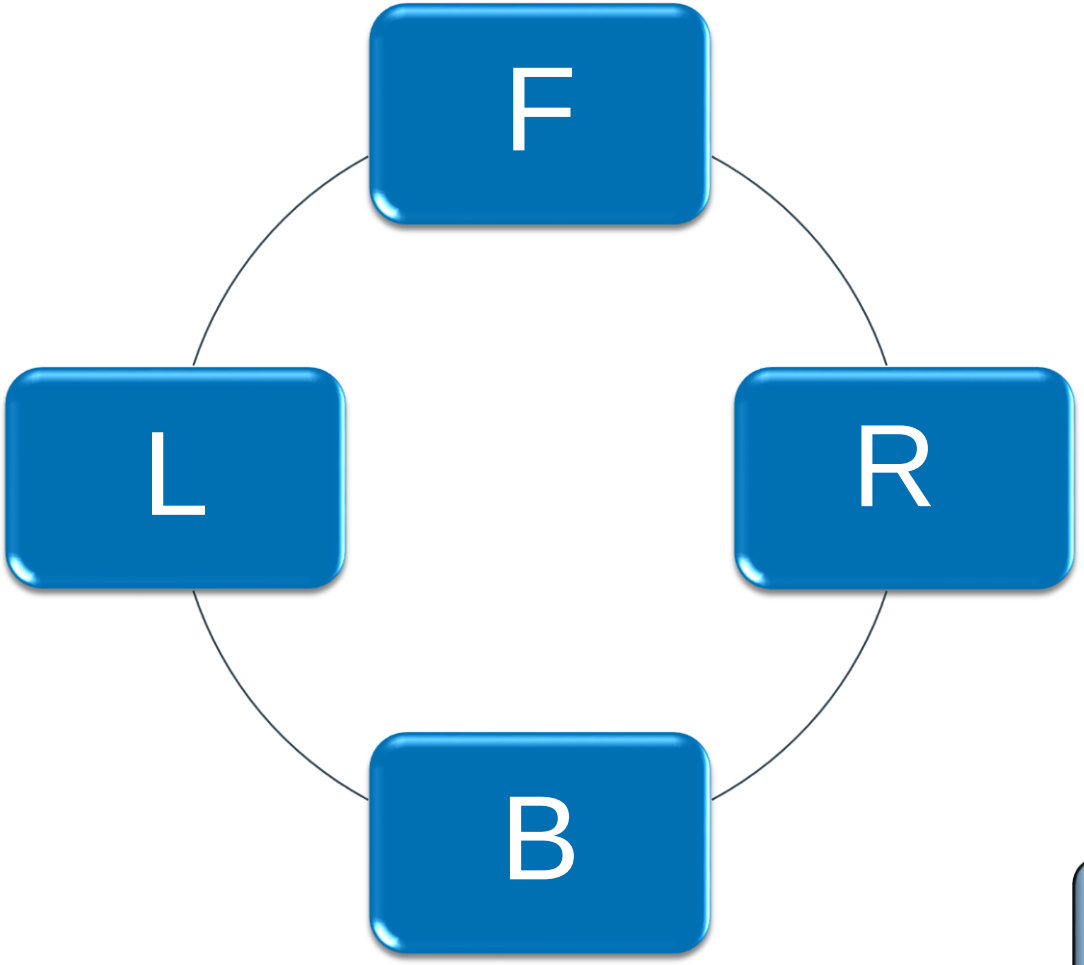
WIDEX HIGH DEFINITION HEARING

SPEECH IDENTIFICATION (NU-6) UNDER VARIOUS CONDITIONS



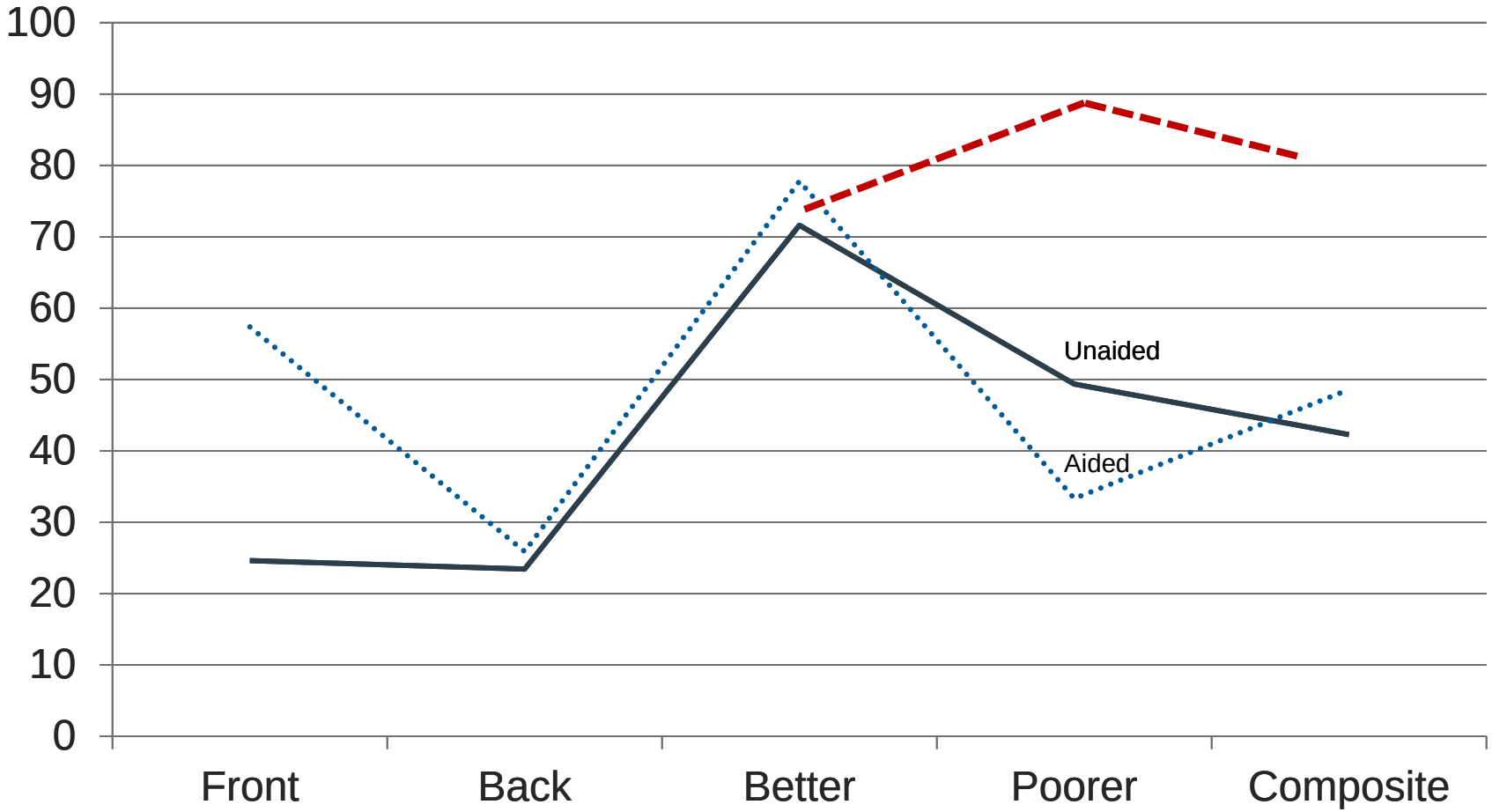
WIDEX®
HIGH DEFINITION HEARING

FOUR-LOUDSPEAKER ARRANGEMENT LABORATORY TESTING AND TRAINING



NEXT

LOCALIZATION – LEFT/RIGHT ONLY



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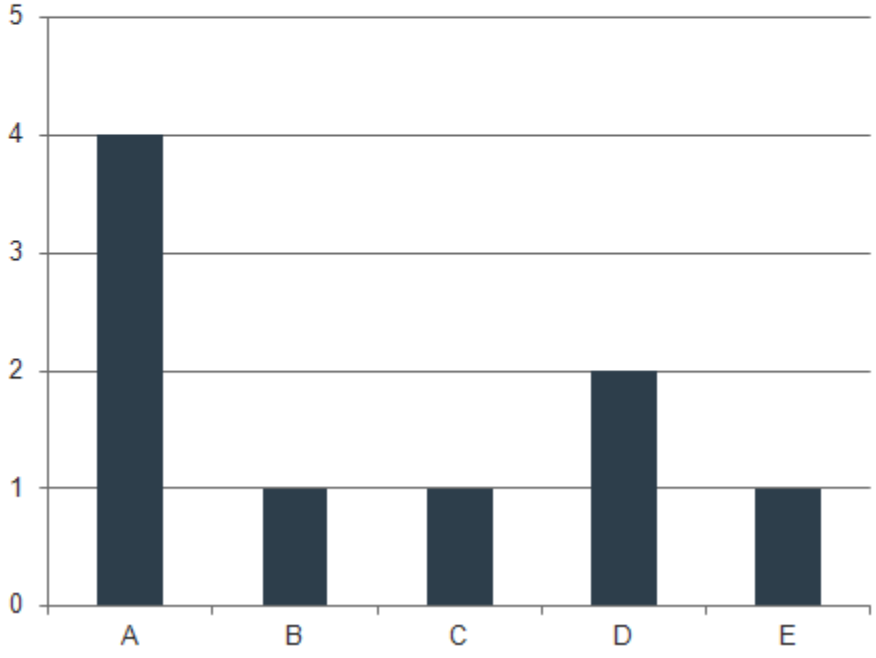
HIGH DEFINITION HEARING

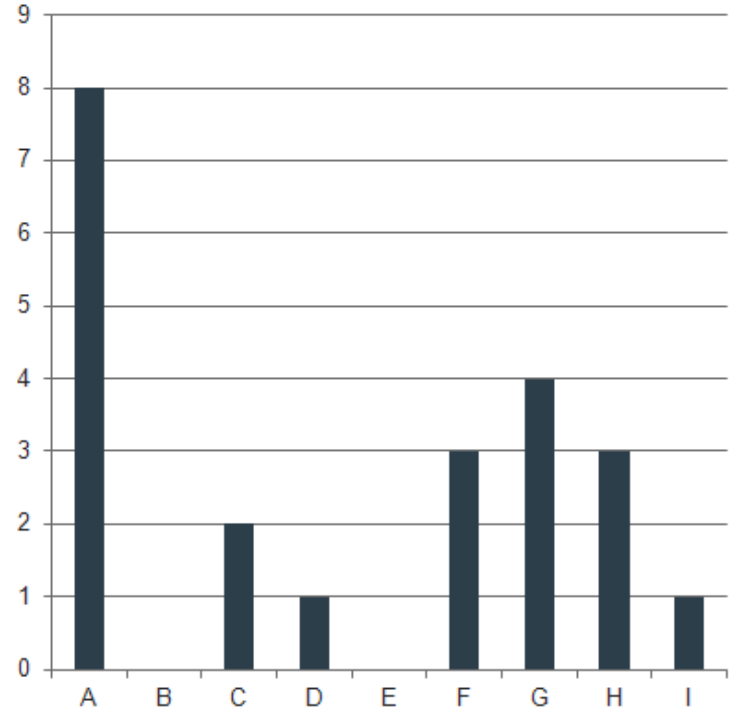
BICROS USE PROFILE

Question		Response	Frequency
3. How often do you turn off the CROS?	A	Three or more times each day	4
	B	Once or twice each day	1
	C	Three or more times during the week, but changes are not made every day	1
	D	Once or twice during the week	2
	E	Never	1



WIDEX®
HIGH DEFINITION HEARING

BICROS USE PROFILE



Question		Response	Frequency
4. When do you turn off the CROS?	A	When sounds are too loud	8
	B	When sounds are too soft	0
	C	When speech is to the side of my good ear	2
	D	When noise is to the side of my good ear	1
	E	When speech is to the side of my bad ear	0
	F	When noise is to the side of my bad ear	3
	G	When speech is not clear	4
	H	When I can't tell where sound is coming from	3
	I	Other –"Driving with window down"	1

WIDEX®
HIGH DEFINITION HEARING

TAKE HOME MESSAGES ON LOCALIZATION AND BICROS STUDIES

- Localization is a learned skill that is dependent on physical, acoustic cues as well as cognitive functions including memory.
- Thus, to improve localization performance, considerations on hearing aid factors and cognitive restructuring are needed
- Hearing aid factors
  - Preservation of binaural cues – bilateral aids, inter-ear connectivity
  - Preservation of acoustic cues – ITE/ITC, BTE with pinna compensation, extended bandwidth, minimal difference in phase characteristics between bilateral pair
- Cognitive restructuring
  - Localization training programs
    - Most people need front/back training and not left/right (other than CROS candidates)
  - Pragmatic
    - Ease of portability and ease of use
  - Ensuring motivation to learning
- Active demonstration/practice as seen in BiCROS study is critical

Thank You!