14 June 2021
VIRTUAL ONLINE WORKSHOP

Real Ear Measurements Workshop

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A complete, practical course in verification of hearing device fittings, from comfort of your home. We will cover all aspects of real ear measurements with renowned experts

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This event will be suitable for hearing care practitioners at beginner or intermediate levels who want to update their skills in real ear measurements. This is designed to be as practical a course as it can be via the virtual medium. After this course, the practitioners should be able to undertake real ear measurements on adult clients in their clinics.

We will complete the course in two separate sessions on separate days:

1° session: scientific principles underlying the common verification techniques

2° session: setting up and verifying various fitting parameters via real ear measurements

14 June 2021: Real Ear Measurements Workshop

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a) Introduction to verification in hearing device fittings and best practice guidance doc: Why do we do what we do?

b) Quick review of prescription targets: Why is it important to select an appropriate method

c) Revisiting the basic verification parameters for stimulus and response: REUR, REOR, REAR and/or speech mapping, OSPL

d) Getting the acoustics right- open vs closed fittings

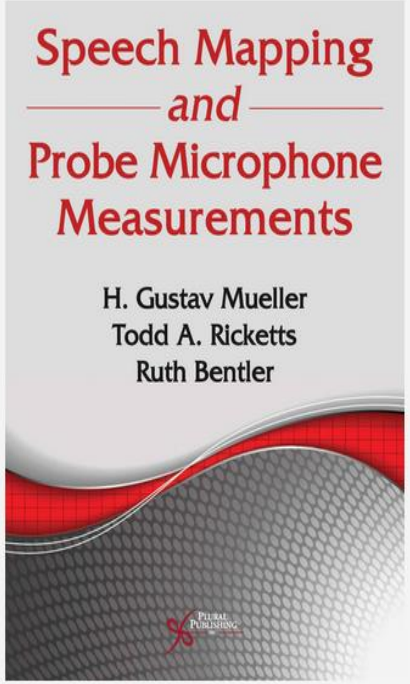
Learning Outcomes:

1. Understanding the scientific principles underlying the common verification techniques
2. Understanding how to use speech intelligibility index in optimising amplification
3. Setting up and verifying various fitting parameters via real ear measurements




Acknowledgements

Introduction to verification in hearing device fittings and BSA PMM doc: Why do we do what we do



Speech Mapping and Probe Microphone Measurements

FIRST EDITION

H. Gustav Mueller, Todd A. Ricketts, Ruth Bentler

Details: 320 pages, B&W, Softcover, 7" x 10"

ISBN13: 978-1-94488-394-2

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Practice Guidance

Guidance on the verification of hearing devices using probe microphone measurements

Date of version: May 2018

Date for review: May 2021

Jindal & Hawkins, 2018

Practice Guidance Document of British Society of Audiology

hiips://tinyurl.com/28pwpt96

Contents

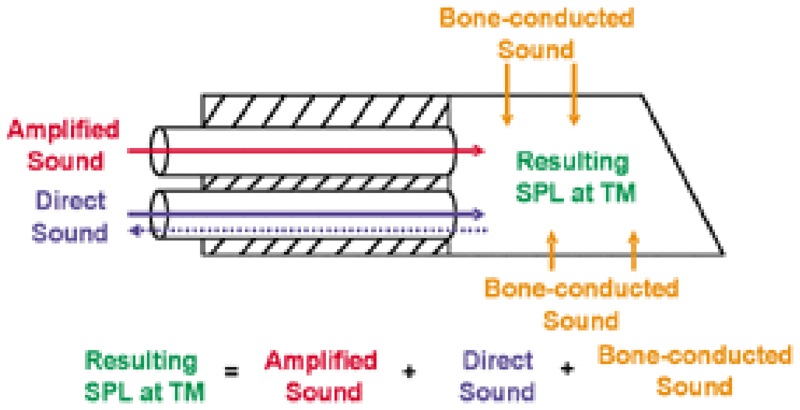
Why do we want to consider adding PMM to our Clinical Practice

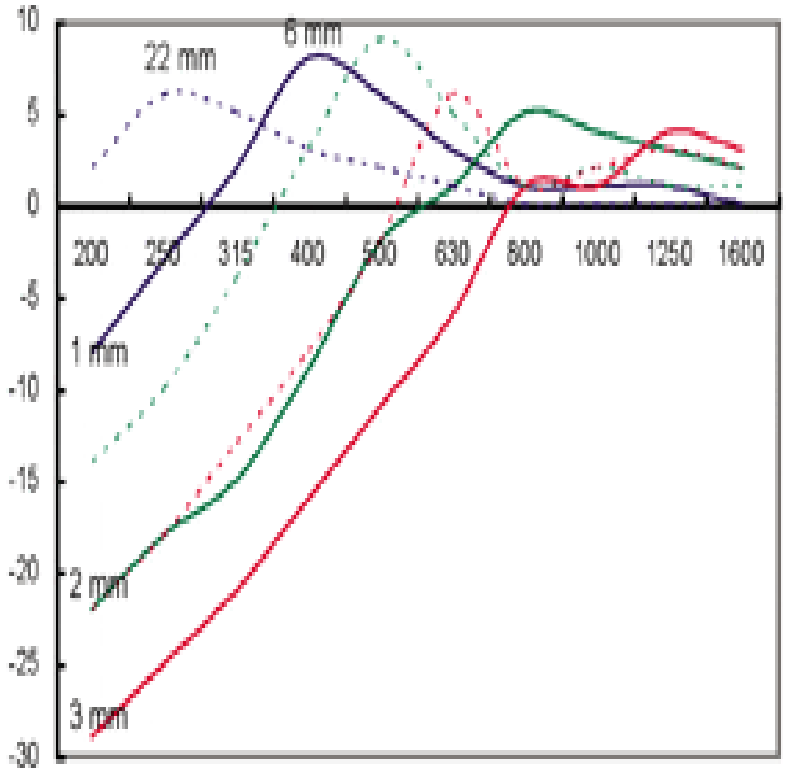
Dealing with Variability: Average vs Individual

Physical properties of ear:

- Size, shape and compliance of ear canal
- Compliance of middle ear

Physical properties of acoustic coupling:





Small differences in ear-drum compliance, even for those that are within the normal range (0.31 to 1.20 cc), can result in as much as a 6.5-dB difference between insertion and functional gain (Preves and Orton (1978)

Preves D, Orton J. (1978). Use of acoustic impedance measures in hearing aid fittings. Hear Instr 29(6):22-24.

Output at 200 Hz is reduced by 7-8 dB with a 1 mm vent diameter, but as much as 28 dB reduction with a 3 mm vent diameter. Thus, an increase in vent diameter leads to a reduction in low frequency output below 1000 Hz.

hiips://www.hearingreview.com/practice -building/practice-management/fitting-tips-how-do-vents-affect-hearing-aid-performance

Internal Variability

J Am Acad Audiol 5: 390–398 (1994)

Intersubject Variability of Real-Ear Sound Pressure Level: Conventional and Insert Earphones

Michael Valente*
Lisa G. Potts*
Maureen Valente†
William Vass‡
Joel Goebel*

Abstract

Measures of the sound pressure level (SPL) near the eardrum were determined at discrete frequencies between 500 and 4000 Hz on 50 ears using TDH-39P and ER-3A earphones with the attenuator of an audiometer fixed at 90 dB HL. Results revealed significant differences in the measured SPL between the two earphones at all test frequencies. Results also revealed large intersubject differences in the SPL measured near the eardrum for both earphones. The results of this study highlight the large intersubject variability associated with measuring the SPL at the eardrum and point out the difficulty in accurately predicting individual performance from averaged group data.

Key Words: Intersubject variability, loudness discomfort level (LDL), real-ear aided response (REAR), real-ear insertion response (REIR)

hiips://www.audiology.org/sites/default/files/journal/JAAA_05_06_05.pdf

Table 1 Mean, Standard Deviation (SD), and Range of Measured Real-Ear SPL for the TDH-39P and ER-3A Earphones at Six Test Frequencies*

	Frequency (Hz)					
Earphone	*500*	*1000*	*1500*	*2000*	*3000*	*4000*
TDH-39P						
Mean	99.3	99.0	98.7	103.1	101.1	95.2
SD	4.9	2.4	3.5	4.6	5.6	7.3
Range	20.0	9.0	16.0	23.0	30.0	36.0
ER-3A						
Mean	88.9	92.9	96.3	99.5	92.6	88.7
SD	5.8	2.9	4.3	5.6	4.0	5.6
Range	23.0	12.0	21.0	29.0	20.0	25.0
Mean Difference	10.4	6.1	2.4	3.6	8.5	6.5

N = 50 ears.

*Also provided is the mean difference in the measure

Intersubject variability with TDH 39 for 90dBHL stimulus with headphones ranges from 9 dB at 1000 Hz to 36 dB at 4000 Hz

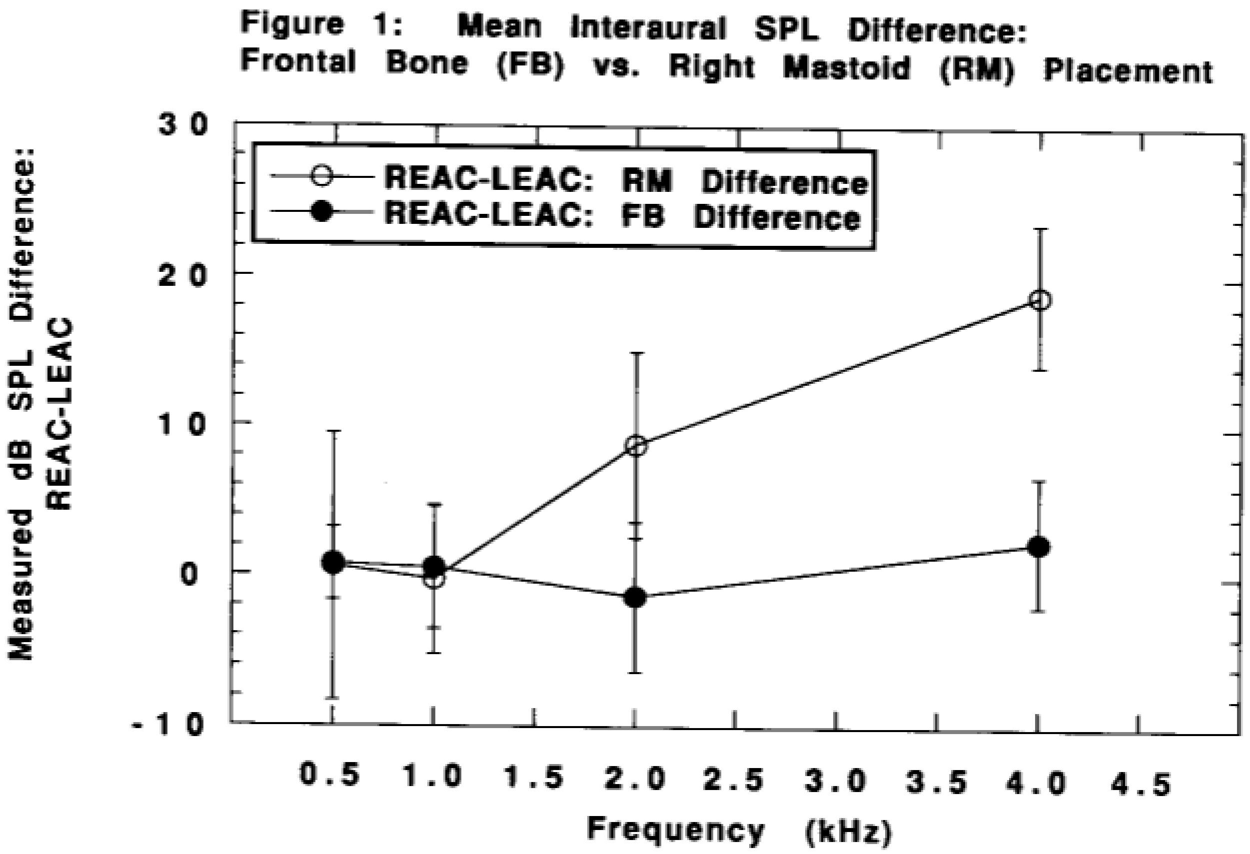


Figure 1 Individual SPL measured near the eardrum at 500 to 4000 Hz for the TDH-39P earphone (N = 50). The "O" represents the right ear and "X" represents the left ear. Also included are ± 1 and 2 standard deviations (SD).

Intersubject variability for 90dBHL stimulus with with ER3A Insert Earphones ranges from from 12 dB at 1000 Hz to 29 dB at 2000 Hz

SSPL/Valente et al

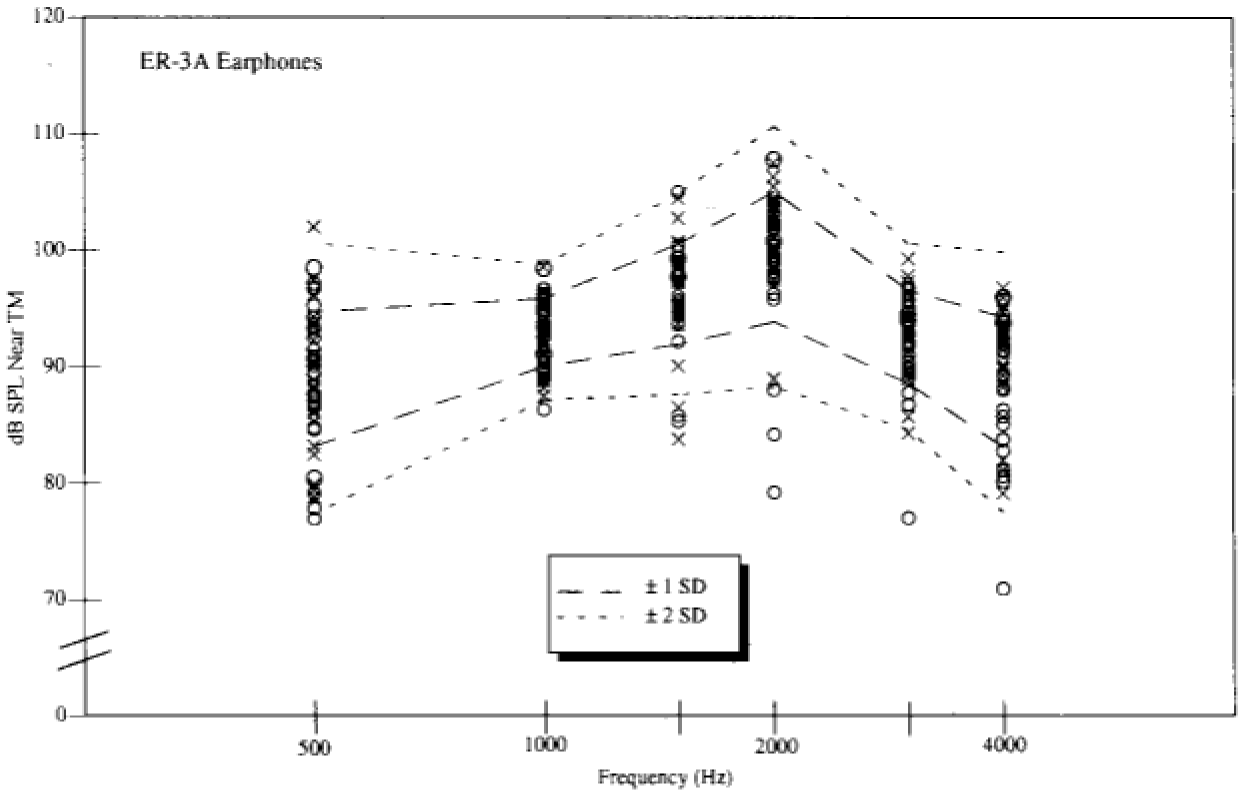


Figure 2 Individual SPL measured near the eardrum at 500 to 4000 Hz for the ER-3A earphone (N = 50). The "O" represents the right ear and "X" represents the left ear. Also included are ± 1 and 2 standard deviations (SD).

Intersubject variability in LDL

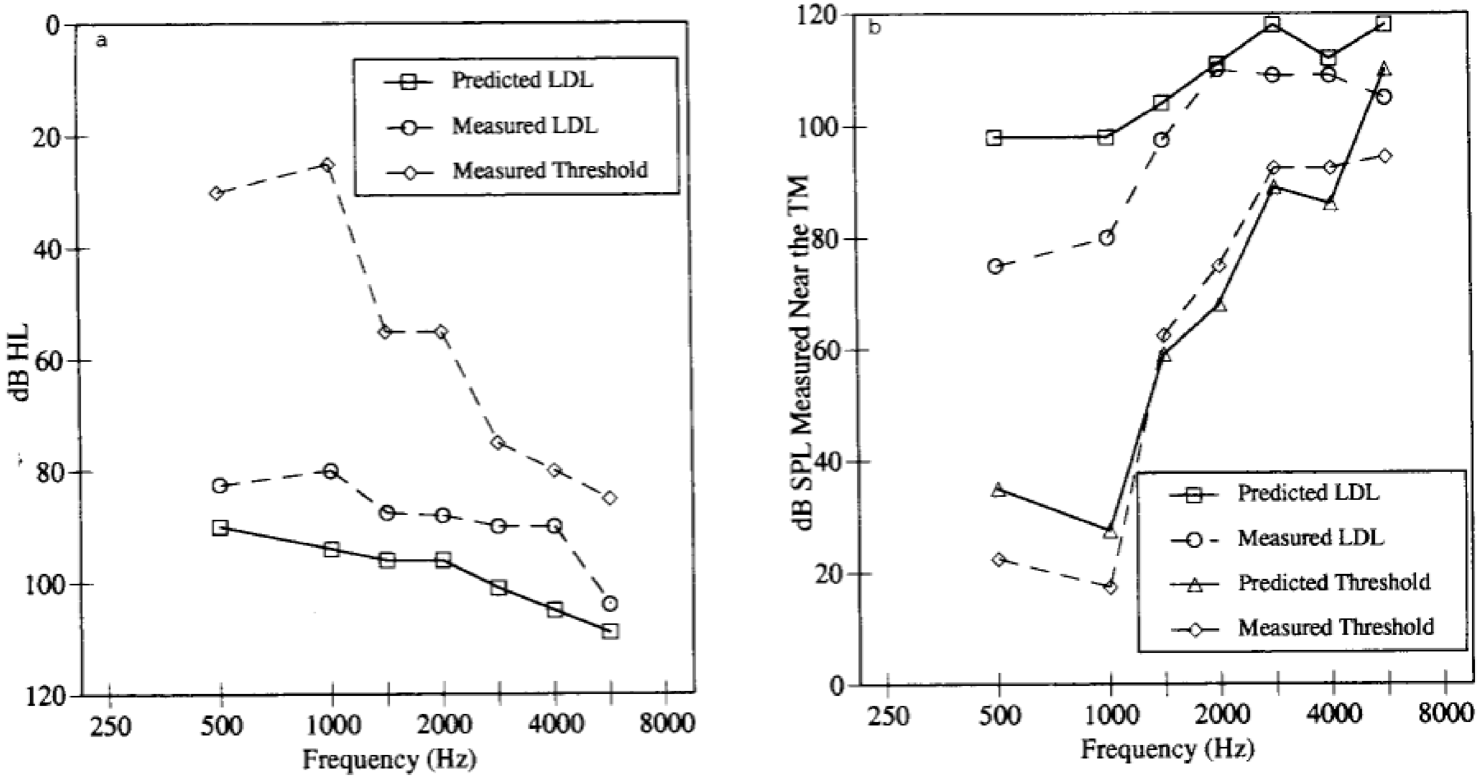
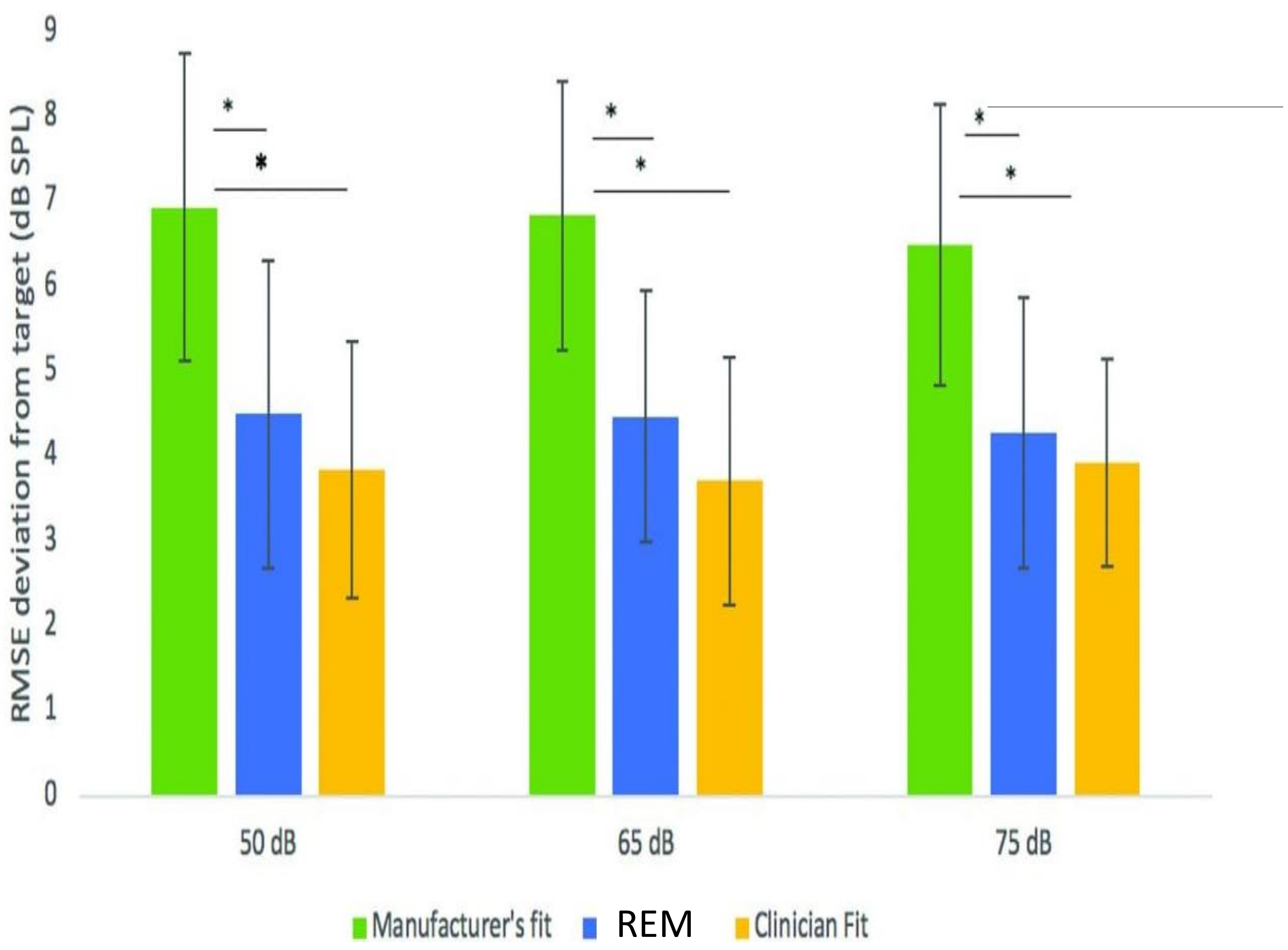
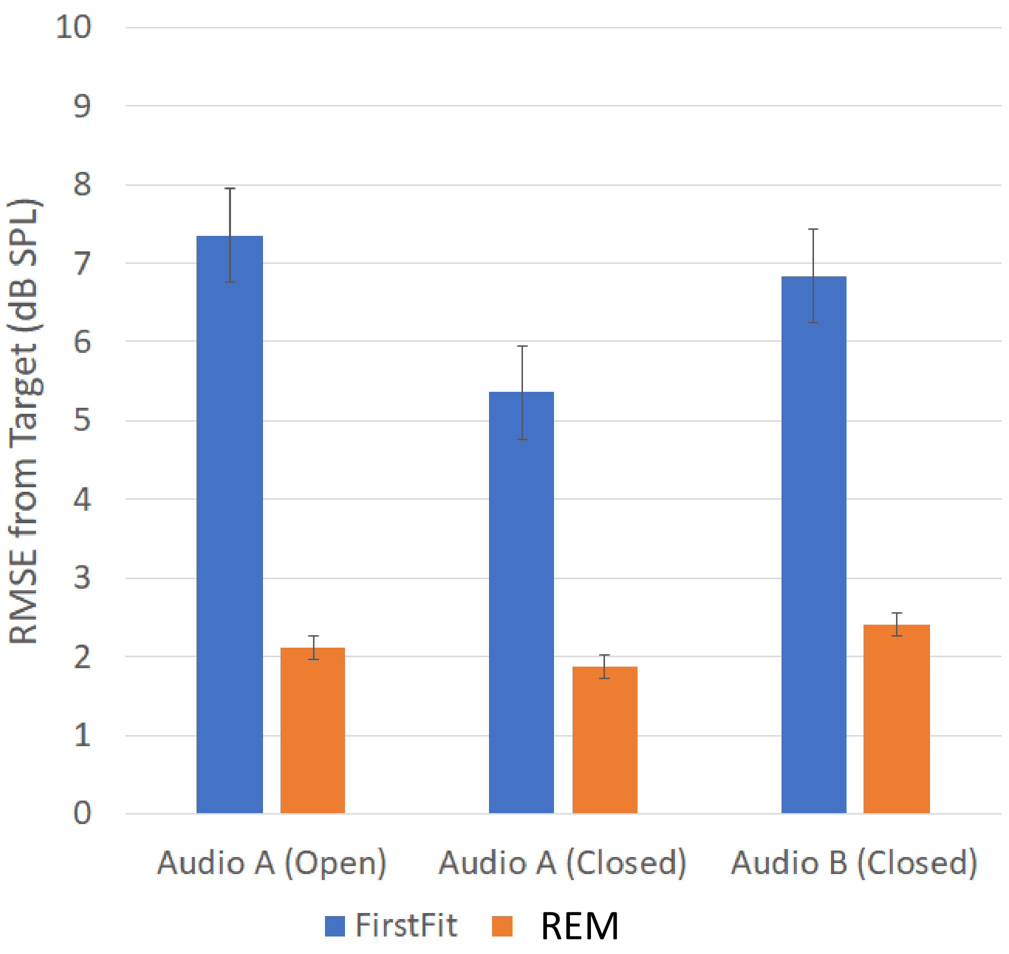


Figure 4 *A*, LDL predicted from threshold using Speechmap™ software for Audioscan and the measured LDL for Subject 2 in dB HL. *B*, Threshold and LDL predicted from threshold (dB HL) using the Speechmap™ software for Audioscan and measured threshold and LDL for Subject 2 in dB SPL.

Fit to Target Accuracy (Folkeark et al, 2018; Mueller & Pumford, 2020)





hiips://www.hearingreview.com/hearing -products/testing-equipment/fitting-equipment/using-autoremfit-for-hearing-aid-fitting-and-verification-evidence-of-accuracy-and-reliability

Differences in Word and Phoneme Recognition in Quiet, Sentence Recognition in Noise, and Subjective Outcomes between Manufacturer First-Fit and Hearing Aids Programmed to NAL-NL2 Using Real-Ear Measures

Michael Valente [1], Kristi Oeding [1], Alison Brockmeyer [1], Steven Smith [1], Dorina Kallogjeri [1]

Affiliations + expand

PMID: 30222541 DOI: 10.3766/jaaa.17005

Abstract

Background: The American Speech-Language-Hearing Association (ASHA) and American Academy of Audiology (AAA) have created Best Practice Guidelines for fitting hearing aids to adult patients. These guidelines recommend using real-ear measures (REM) to verify that measured output/gain of hearing aid(s) match a validated prescriptive target. Unfortunately, approximately 70-80% of audiologists do not routinely use REM when fitting hearing aids, instead relying on a manufacturer default "first-fit" setting. This is problematic because numerous studies report significant differences in REM between manufacturer first-fit and the same hearing aids using a REM or programmed-fit. These studies reported decreased prescribed gain/output in the higher frequencies for the first-fit compared with the programmed fit, which are important for recognizing speech. Currently, there is little research in peer-reviewed journals reporting if differences between hearing aids fitted using a manufacturer first-fit versus a programmed-fit result in significant differences in speech recognition in quiet, noise, and subjective outcomes.

Purpose: To examine if significant differences were present in monosyllabic word and phoneme recognition (consonant-nucleus-consonant; CNC) in quiet, sentence recognition in noise (Hearing in Noise Test; HINT), and subjective outcomes using the Abbreviated Profile of Hearing Aid Benefit (APHAB) and the Speech, Spatial and Qualities of Hearing (SSQ) questionnaires between hearing aids fit using one manufacturer's first-fit and the same hearing aids with a programmed-fit using REM to National Acoustic Laboratories Nonlinear Version 2 (NAL-NL2) prescriptive target.

Research design: A double-blind randomized crossover design was used. Throughout the study, one investigator performed all REM whereas a second investigator measured speech recognition in quiet, noise, and scored subjective outcome measures.

Study sample: Twenty-four adults with bilateral normal sloping to moderately severe sensorineural hearing loss with no prior experience with amplification.

Data collection and analysis: The hearing aids were fit using the proprietary manufacturer default first-fit and a programmed-fit to NAL-NL2 using real-ear insertion gain measures. The order of the two fittings was randomly assigned and counterbalanced. Participants acclimatized to each setting for four weeks and returned for assessment of performance via the revised CNC word lists, HINT, APHAB, and SSQ for the respective fitting.

Results: (1) A significant median advantage of 15% ($p < 0.001$; 95% CI: 9.7-24.3%) for words and 7.7% ($p < 0.001$; 95% CI: 5.9-10.9%) for phonemes for the programmed-fit compared with first-fit at 50 dB sound pressure level (SPL) and 4% ($p < 0.01$; 95% CI: 1.7-6.3%) for words at 65 dB SPL; (2) No significant differences for the HINT reception threshold for sentences (RTS); (3) A significant median advantage of 4.2% [$p < 0.04$; 95% confidence interval (CI): -0.6-13.2%] for the programmed-fit compared with the first-fit for the background noise subscale problem score for the APHAB; (4) No significant differences on the SSQ.

Conclusions: Improved word and phoneme recognition for soft and words for average speech in quiet were reported for the programmed-fit. Seventy-nine percent of the participants preferred the programmed-fitting versus first-fit. Hearing aids, therefore, should be verified and programmed using REM to a prescriptive target versus no verification using a first-fit.

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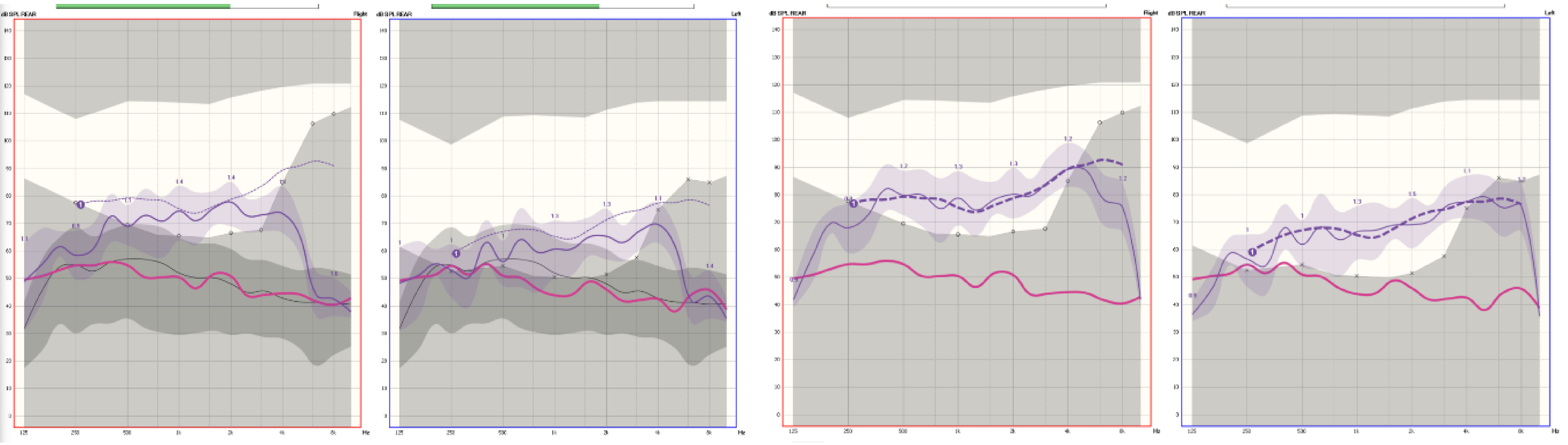
Before target match   After target match



- Evidence suggests that fitting to prescriptive target levels will lead to
  - more comfortable listening, and
  - significantly improved speech quality and intelligibility

  than fittings that deviate significantly from target

  (Byrne, 1986; Byrne and Cotton, 1988; Moore and Glasberg, 1998; Moore et al, 2001; Bentler et al, 2016).

- Also, for children, fitting closely to targets has been shown to
  - ensure consistent audibility (McCreery et al, 2013; 2015), which is an important factor in long term outcomes (Tomblin et al, 2015)

BSA, 2018

Therefore, it is important to verify if the hearing device is achieving the target level of amplification in the individual ear.

PMM are a reliable and accurate procedure for determining how well a hearing device is matching a prescription target, and for adjusting the device in order to improve the match (Aazh & Moore, 2007).

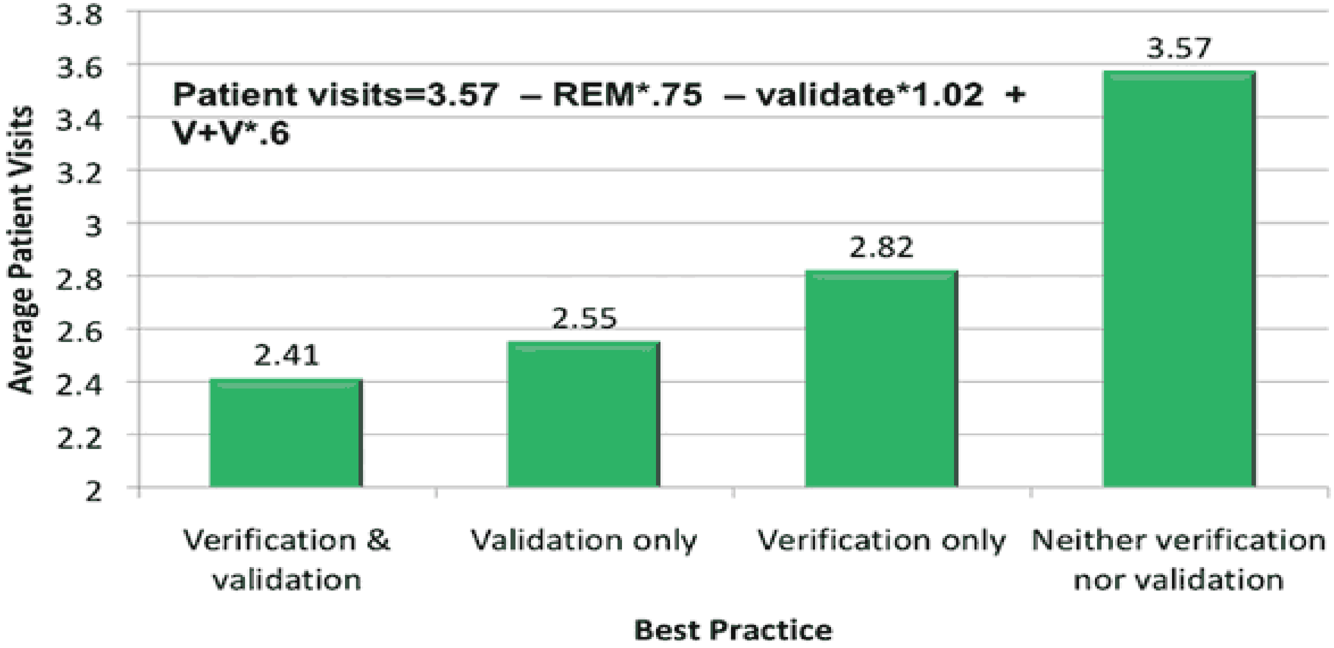
Additionally, they can be used in verifying digital features such as directionality, noise reduction and frequency lowering.

BSA, 2018

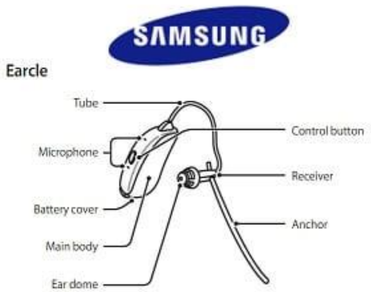
Real World Outcome: Marke Trak

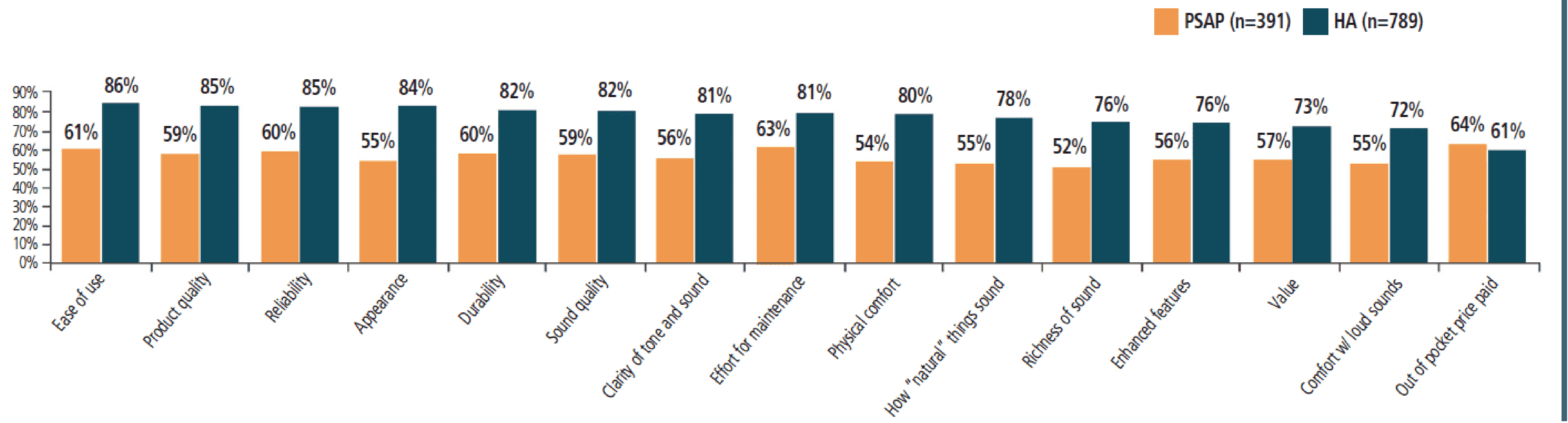
hiips://www.hearingreview.com/hearing -products/marketrak-viii-reducing-patient-visits-through-verification-amp-validation

Combined use of verification and validation will result in an average of 1.2 less visits. When considering the entire US market, this translates to 521,779 fewer patient visits for refittings.



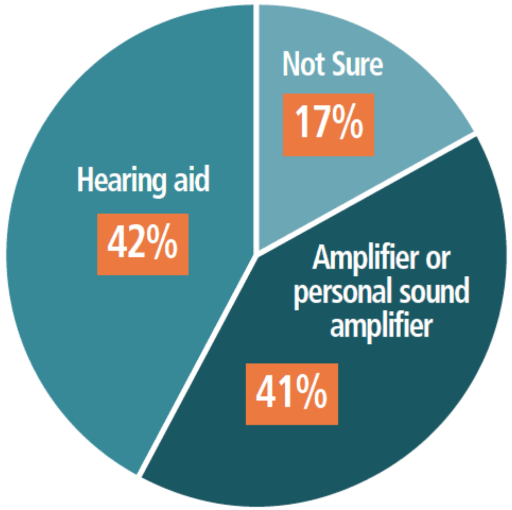
Marke Trak X: HA vs PSAP

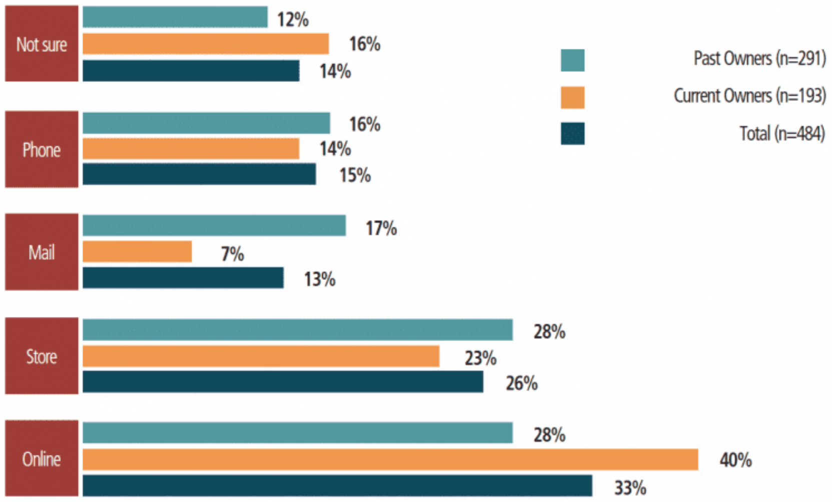


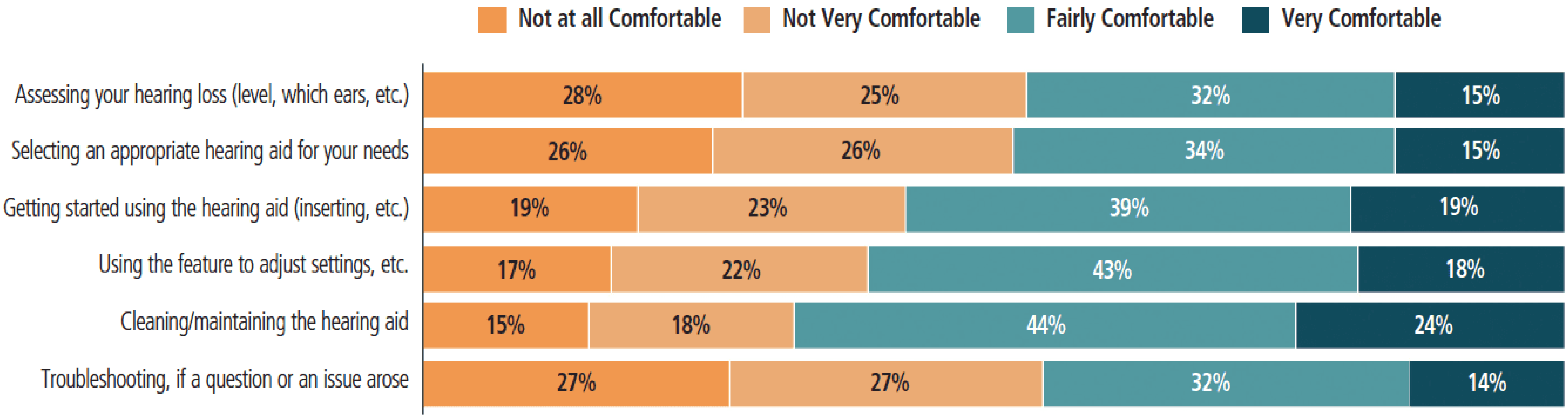


hiips://www.hearingreview.com/uncategorized/marketrak -10-hearing-aids-in-an-era-of-disruption-and-dtc-otc-devices-2

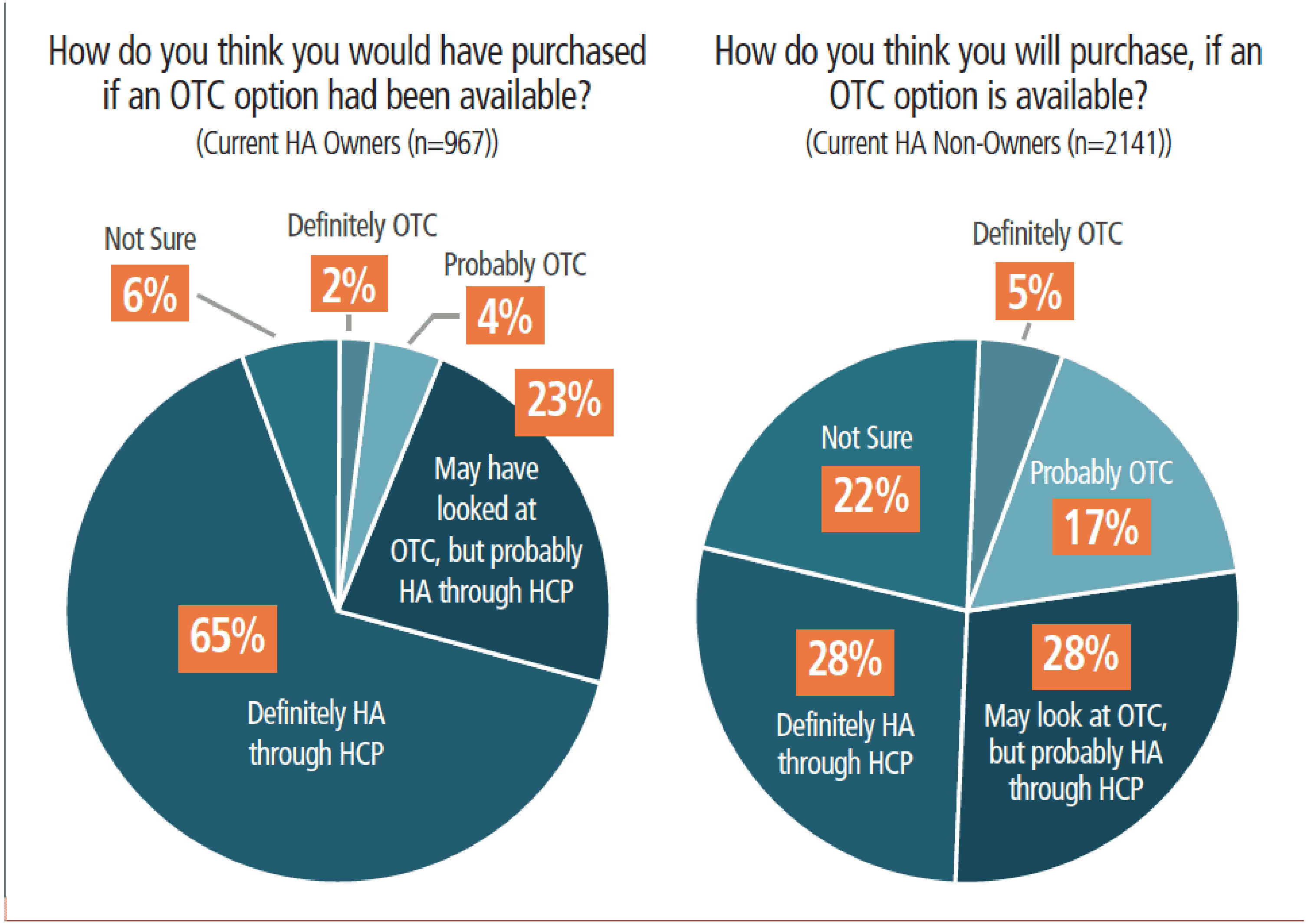
Marke Trak X: PSAP Owners' Satisfaction Rate, Description of Device & Purchase Point







hiips://www.hearingreview.com/uncategorized/marketrak -10-hearing-aids-in-an-era-of-disruption-and-dtc-otc-devices-2



hiips://www.hearingreview.com/uncategorized/marketrak -10-hearing-aids-in-an-era-of-disruption-and-dtc-otc-devices-2

Does probe-tube verification of real-ear hearing aid amplification characteristics improve outcomes in adults? A systematic review and meta-analysis. Almufarrij, I., Dillon, H., & Munro, K. *Trends in Hearing. Apr 2021*.

Systematic review- >1,420 records from seven databases, six experimental studies (published between 2012 and 2019) met the inclusion criteria; five were included in the meta-analyses.

There were moderate and statistically significant positive effects of REM, compared to the manufacturer's initial fit, on speech intelligibility in quiet settings

There were small but statistically significant positive effects of REM on self-reported listening abilities and speech intelligibility in noisy settings

hiips://journals.sagepub.com/doi/full/10.1177/2331216521999563

Benefits of REM- Value add

Correct optimization of volume and digital features

More comfortable fitting

Better hearing device retention rate

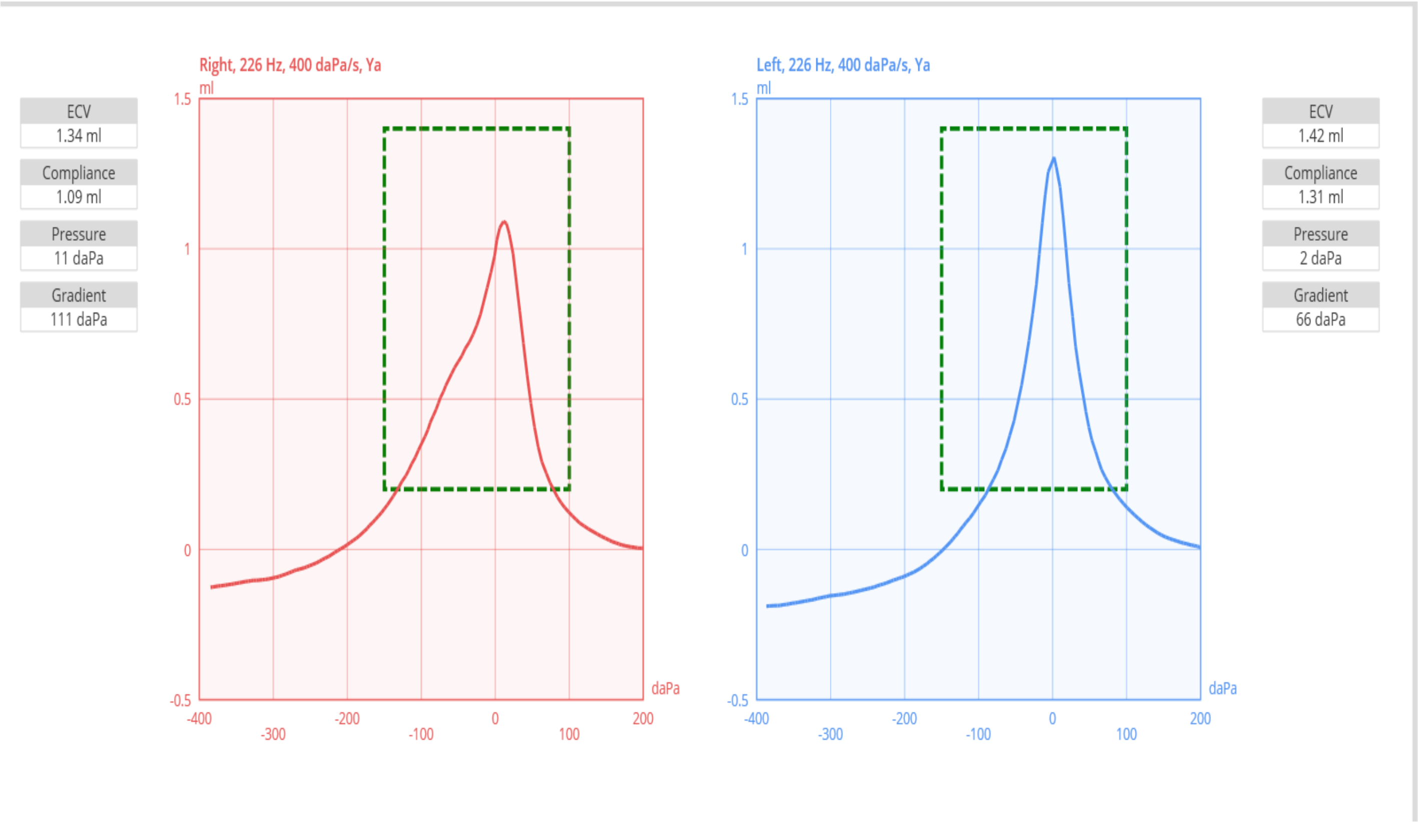
Less follow-up

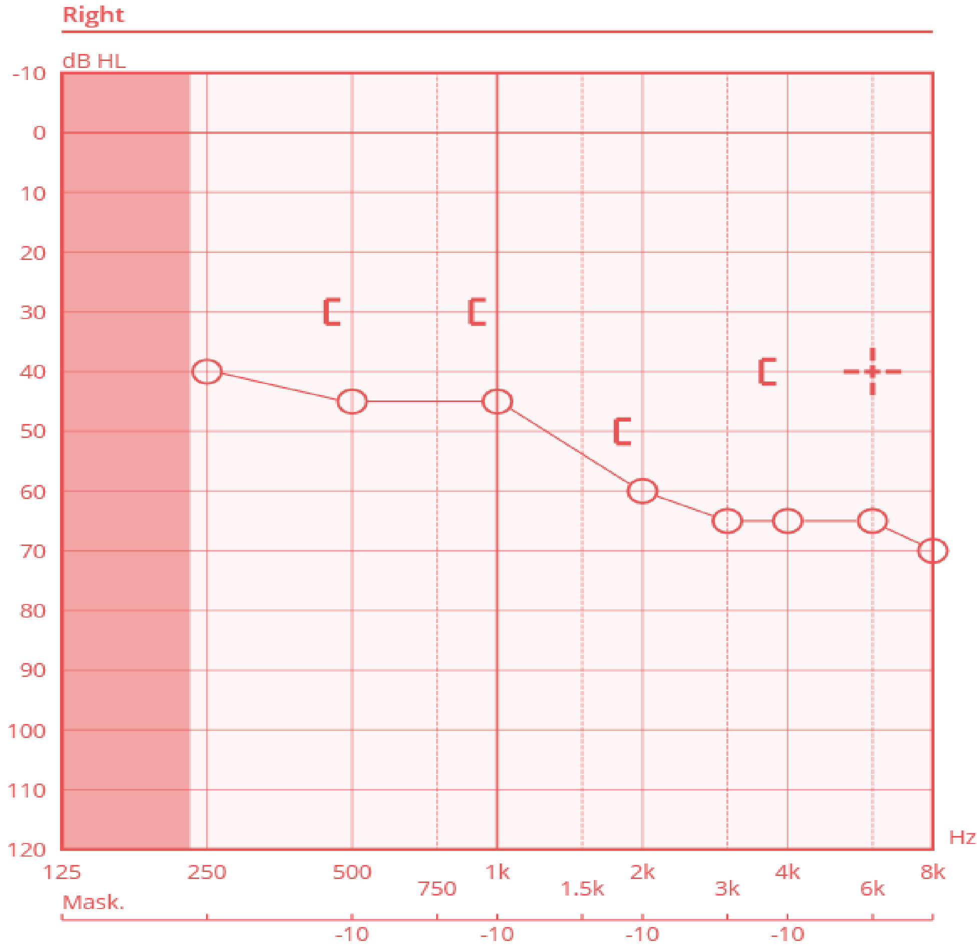
More time for counselling and validation

1. Kochkin S, Beck DL, L Christensen, et al. *MarkeTrak VIII: The impact of the hearing healthcare professional on hearing aid user success. Hearing Review. 2010;17(4):12-34.*
2. *Abrams HB, Chisolm TH, McManus M, McArdle R. Initial-fit approach versus verified prescription: Comparing self-perceived hearing aid benefit. J Am Acad Audiol. 2012;23(10):768-778.*
3. *Kochkin S. MarkeTrak VIII: Reducing patient visits through verification and validation. Hearing Review. 2011;18(6):10-15.*
4. *Amlani AM, Pumford J, Gessling E. Improving patient perception of clinical services through real-ear measurements. Hearing Review. 2016;23(12):12-21.*

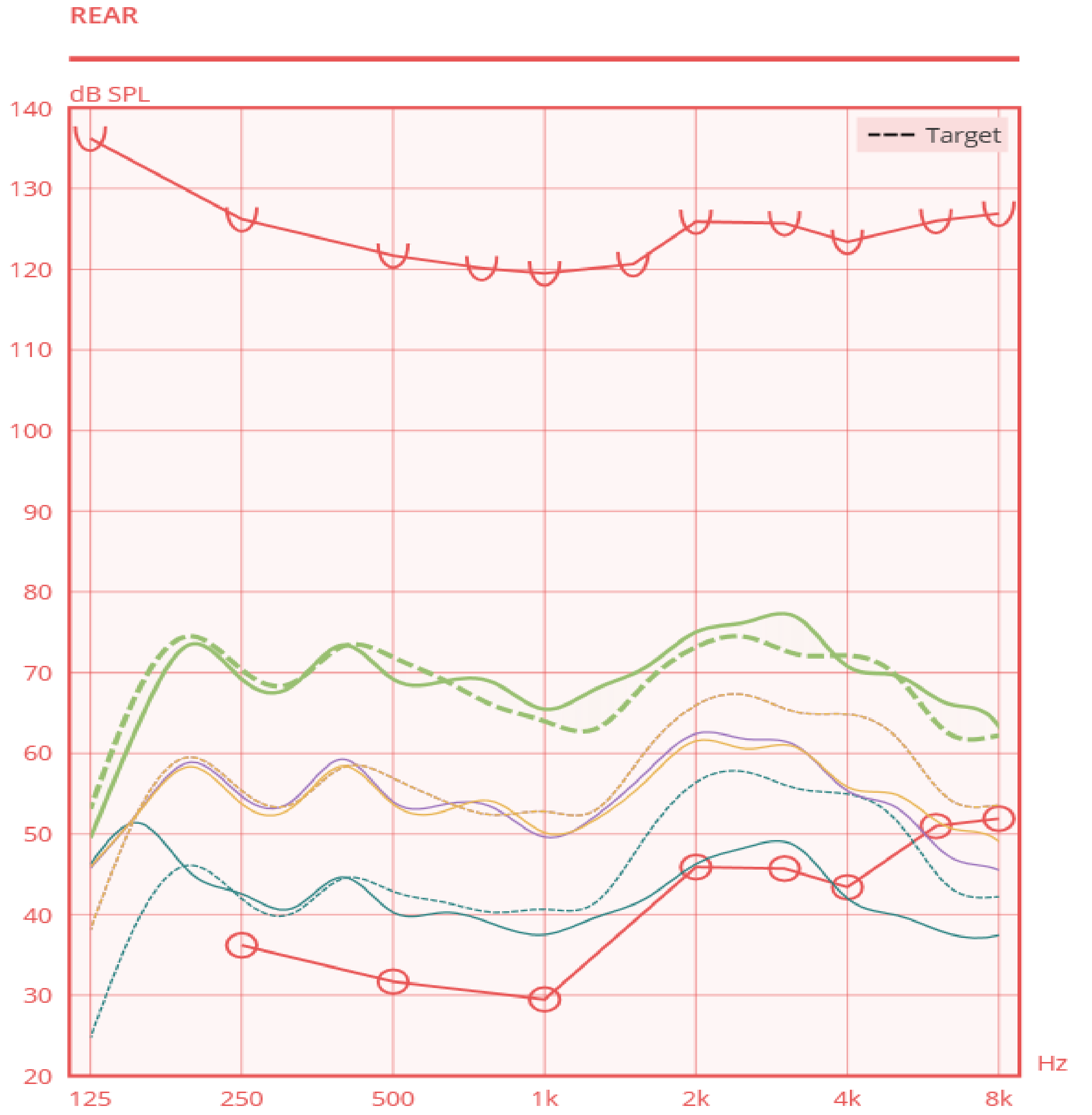
Good quality is good business!

Building the Better Hearing Journey





	Material	List	SNR loss
AC R	Standard	List 01	4.5



Quick review of prescription targets:
Why is it important to select appropriate method

Non-linear Prescriptions- Basic Concepts

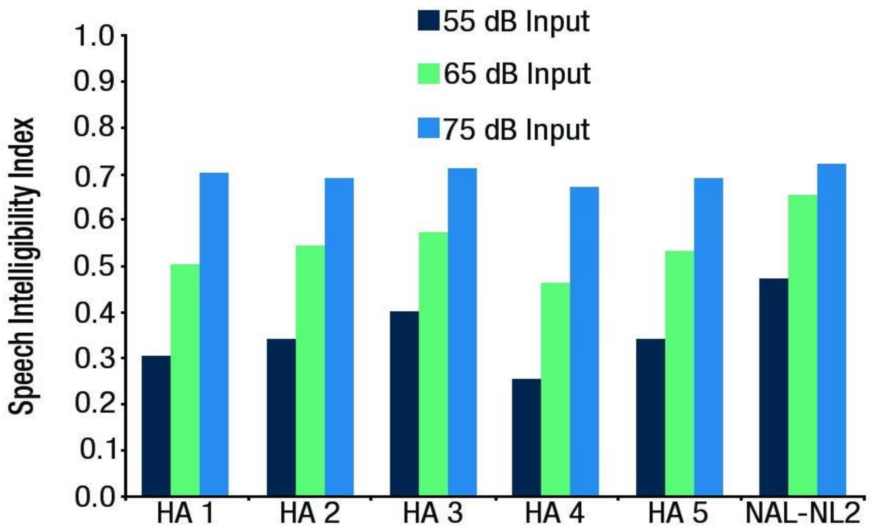
1- NOISE REDUCTION — LOW FREQUENCIES DOWN

2- IMPROVING AUDIBILITY — DYNAMIC RANGE COMPRESSION

3- LOUDNESS NORMALIZATION (RECRUITMENT COMPENSATION) – CHECKING LOUDNESS GROWTH EVERY ½ OCTAVE FREQ BAND SO, E.G. IN SLOPING LOSSES- GREATER COMPRESSION AT HF THAN LF TO RESTORE NORMAL LOUDNESS.

4- AUTOMATIC VOLUME CONTROL

Propriety (Manufacturer’s) Fitting Formula



hiips://www.hearingreview.com/hearing -products/testing-equipment/manufacturers-nal-nl2-fittings-fail-real-ear-verification

Developed mainly with two types of data

- 1) Preferred sound quality
- 2) Initial acceptance data (report from dispensers and returns etc) e.g.
  - -Patient report first fit is too tinny- roll off the high
  - -Audiologist report feedback in first fit- roll off the high
  - - Patient/audiologist say brand X fit is better- make it like brand

NAL NL2

hiips://www.audiologyonline.com/articles/siemens -expert-series-nal-nl2-11355

Siemens Expert Series: NAL-NL2 - Principles, Background Data, and Comparison to Other Procedures. Gitte Keidser, PhD, Harvey Dillon, PhD. October 22, 2012

The goal of NAL-NL2 was specifically to:

1. Keep the loudness less than or equal to normal loudness.
2. Maximize speech intelligibility

Loudness

Adopted the loudness model of Moore and Glasberg (2004):

1) that a sound at absolute threshold has a small but finite loudness;

2) that, for levels very close to the absolute threshold, the rate of growth of loudness is similar for normal ears and ears with cochlear hearing loss;

3) accounts for the loudness recruitment and reduced loudness summation that are typically associated with cochlear hearing loss.

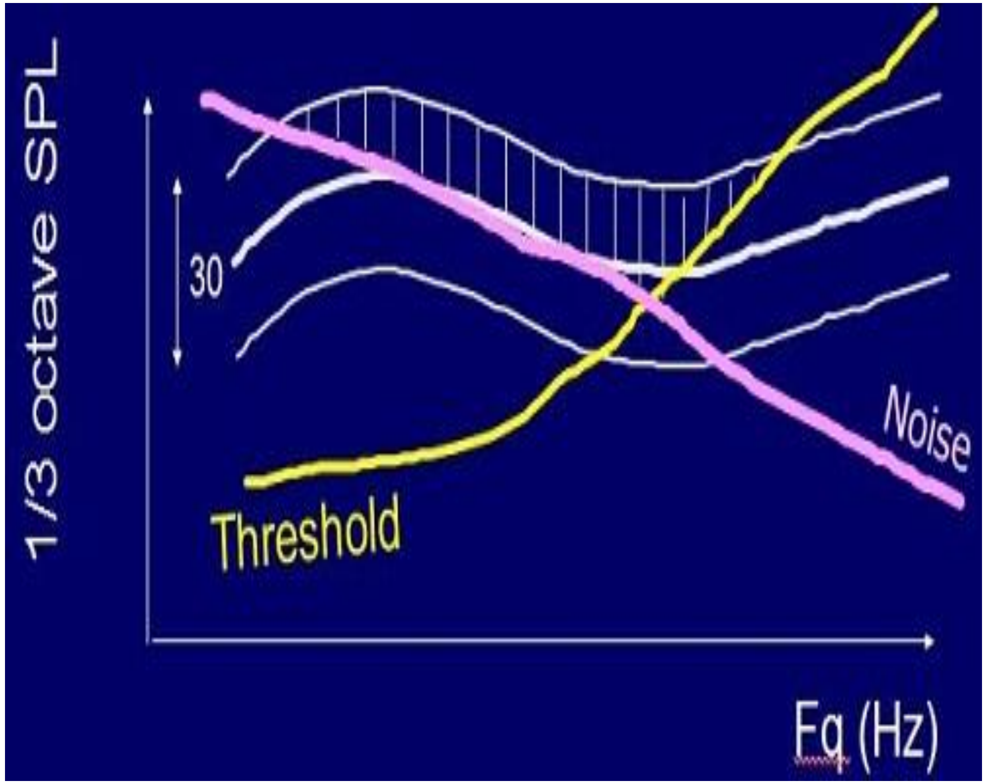
4) the relation between monaural and binaural threshold and loudness;

Intelligibility-I

hiips://www.audiologyonline.com/articles/siemens -expert-series-nal-nl2-11355

Siemens Expert Series: NAL-NL2 - Principles, Background Data, and Comparison to Other Procedures

Gitte Keidser, PhD, Harvey Dillon, PhD. October 22, 2012



The basic rationale for predicting intelligibility is based on the speech spectrum (wrt existing noise floor)

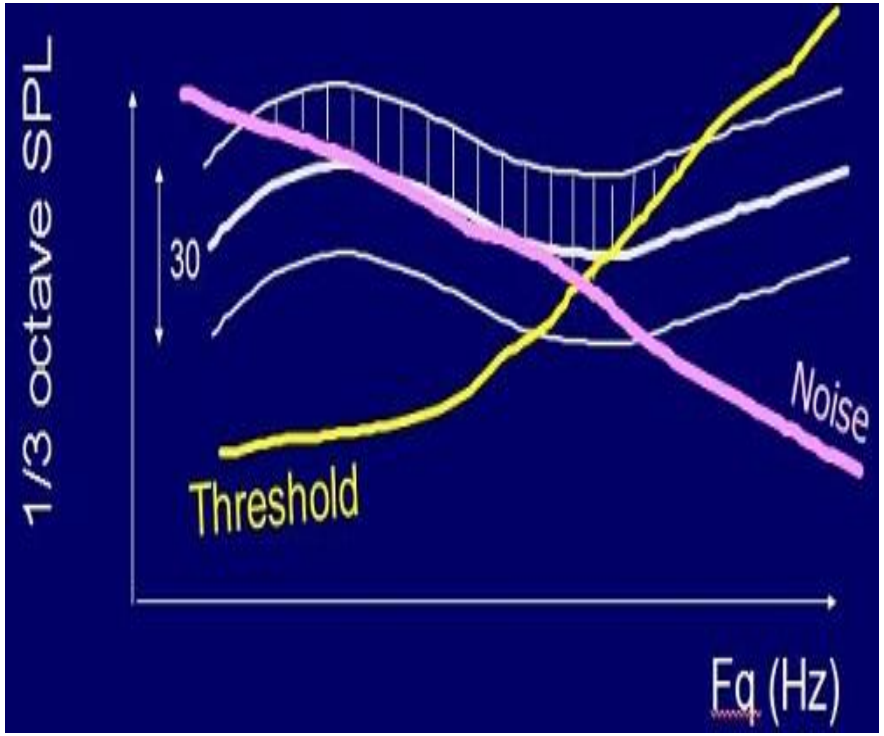
- anything above the threshold is audible, and anything below the threshold is not audible.
- if there is noise present, then we also need to only take into account the parts of the speech spectrum that are above the noise and the threshold.
- only the shaded region is audible, so that is the proportion of the information that is coming through
- we can quantify that by the number of decibels that are audible at each 1/3 octave frequency.

Intelligibility-II

hiips://www.audiologyonline.com/articles/siemens -expert-series-nal-nl2-11355

Siemens Expert Series: NAL-NL2 - Principles, Background Data, and Comparison to Other Procedures

Gitte Keidser, PhD, Harvey Dillon, PhD. October 22, 2012



Very low and the very high frequencies do not contribute as much to intelligibility as the mid frequencies.

- We can multiply each of those audibilities times the importance of each frequency, and that gives a contribution to intelligibility of each frequency.

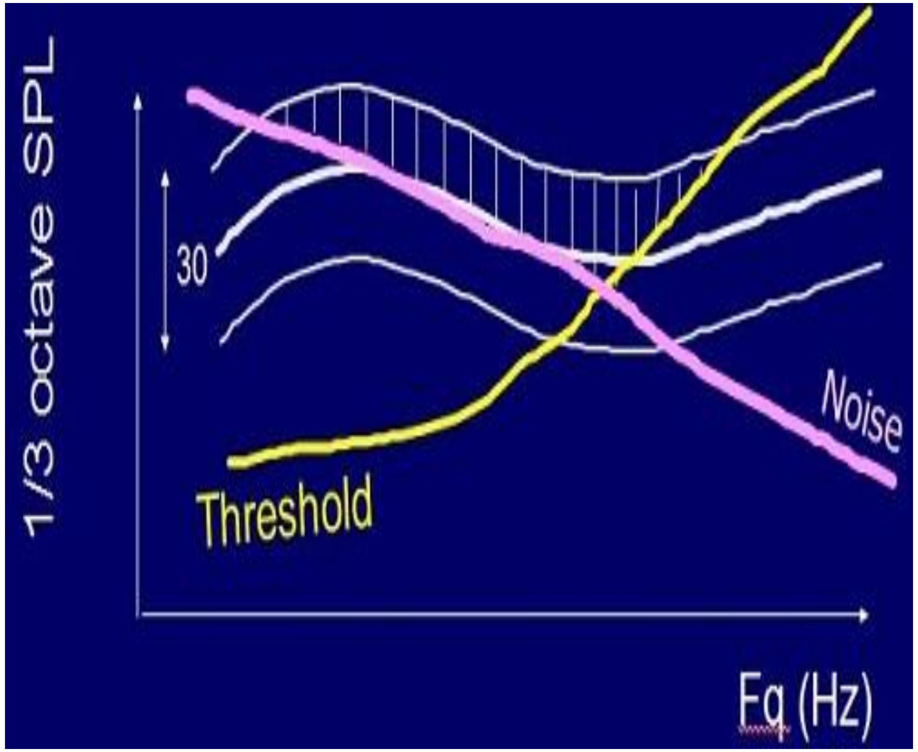
- In the figure here, the calculation comes to 0.3, or 30%. i.e. about 30% of that speech spectrum is audible to the person in this example.

Intelligibility-III

hiips://www.audiologyonline.com/articles/siemens -expert-series-nal-nl2-11355

Siemens Expert Series: NAL-NL2 - Principles, Background Data, and Comparison to Other Procedures

Gitte Keidser, PhD, Harvey Dillon, PhD. October 22, 2012

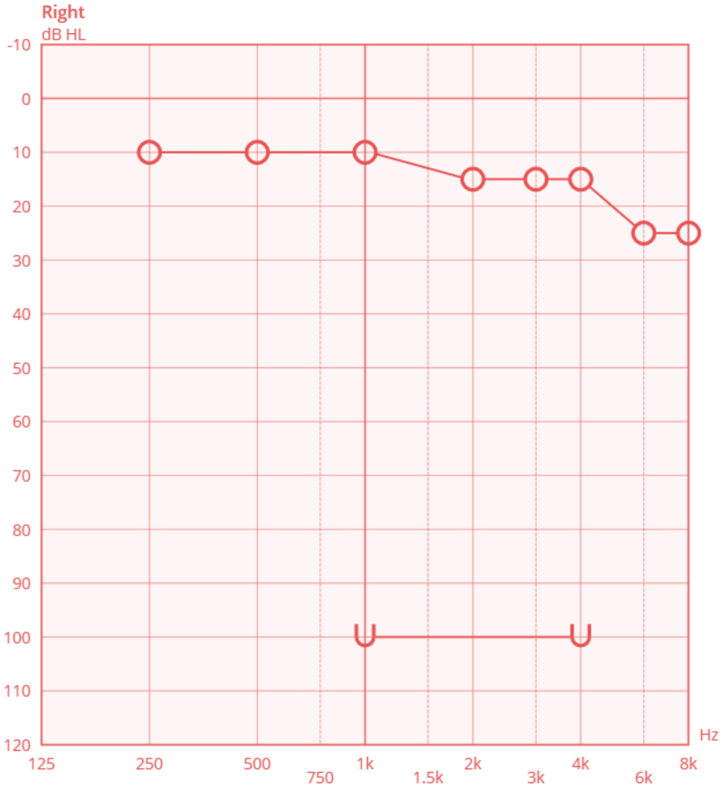


Third twist- if the speech is too loud, intelligibility, (even for normal hearers) goes down due to more spread of masking in the cochlea.

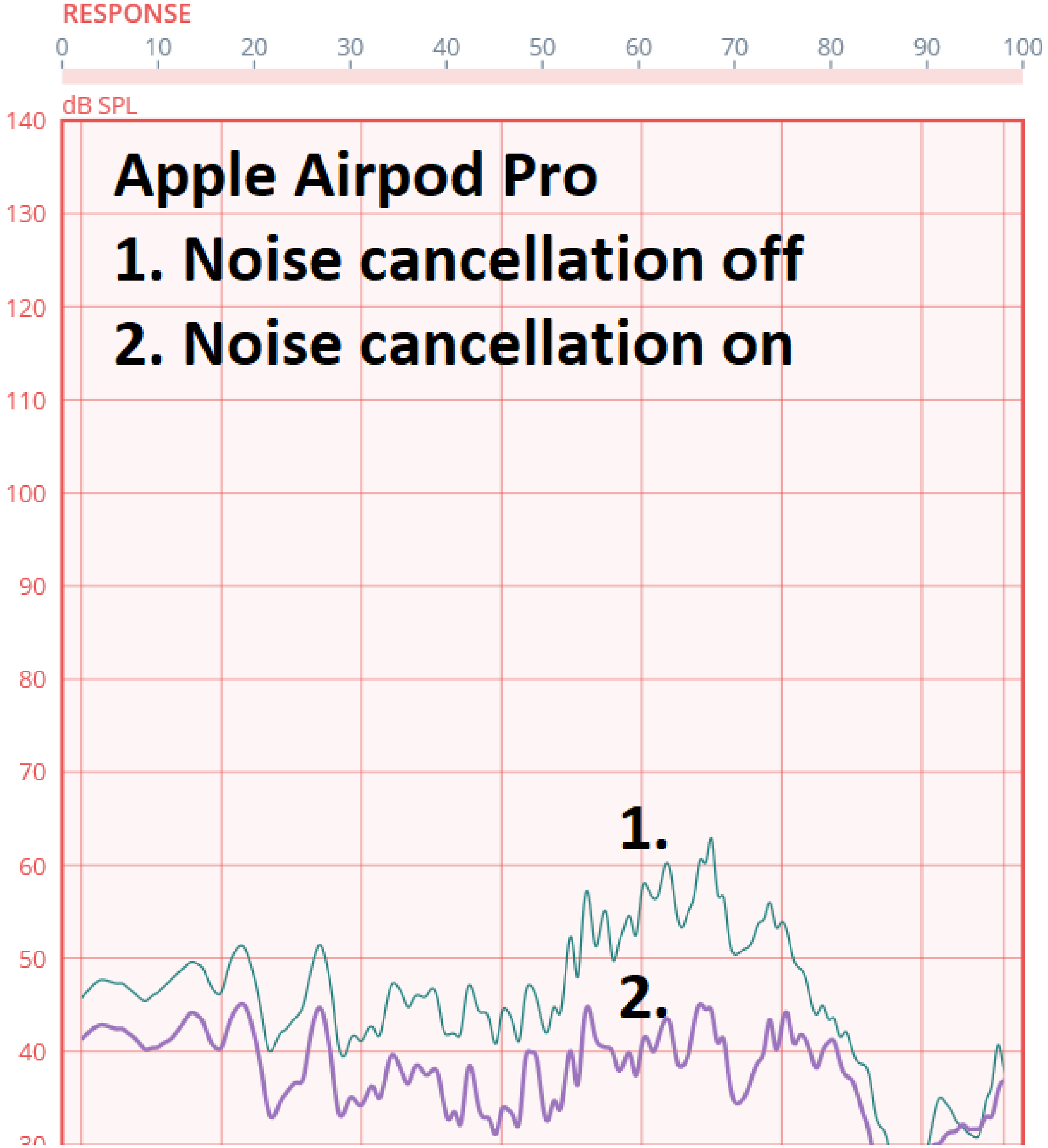
-As the speech level rises above 73 dB, the level-distortion factor decreases below 1 i.e. you get smaller contributions to intelligibility the louder you make it.

Revisiting the basic verification parameters for stimulus and response: 15 Min

PMM Measurement Screen



		125	250	500	750	1k	1.5k	2k	3k	4k	6k	8k
AC R	Thr.		10	10		10		15	15	15	25	25



RESPONSE
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100
dB SPL
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120
110
100
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70
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50
40
30
Apple Airpod Pro
1. Noise cancellation off
2. Noise cancellation on
1.
2.