Voice Aligned Compression (VAC+)

Oticon's proprietary fitting rationale

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oticon
life-changing technology

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Speaker Disclosure

Relevant financial relationships:

- Employee of Oticon, Inc. and receives a salary
- Author & Associate Editor, Plural Publishing, Inc.

Non-financial relationships:

- Past-president American Academy of Audiology

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Learner Outcomes

1. After this course, participants will be able to describe two key benefits of the Voice Aligned Compression (VAC+) proprietary fitting rationale.
2. After this course, participants will be able to list the options available to verify Oticon's proprietary fitting rationale when completing real ear measures, including use of the SII.
3. After this course, participants will be able to describe the results of a pilot study examining the audibility provided by VAC+ and measures of subjective experience.

Risks / benefits

- The applicability and accuracy of the course content may vary by the clinical, geographical, and cultural context; you should evaluate the course accordingly.
- As healthcare is rapidly evolving, new findings may change the validity of the information presented in this course. Providers should always consult the latest research and guidelines from professional associations.
- The interventions discussed in this course may be limited in generalizability, requiring practitioners to consider specific individual and population factors.
- The course may not cover all possible risk factors, diagnostic methods, or treatment options, and complex cases may require additional considerations.
- Healthcare providers should apply cultural competence and sensitivity to ensure effective and respectful care based on their patients' diverse needs.
- Providers should always evaluate the limitations of diagnostic and screening tools, considering their potential for false results as well as any ethical implications.
- It is the responsibility of course participants to critically evaluate the evidence from multiple sources to guide professional practice.

Agenda

1. Introduction
2. Assumptions underlying rationales
3. The evolution of VAC+
4. VAC+ in Genie2
5. Verification of VAC+
6. Pilot study results of VAC+ research
7. Conclusions

What is the **main goal**
of a **hearing aid fitting?**

To fit hearing aids that meet your client's unique needs and preferences












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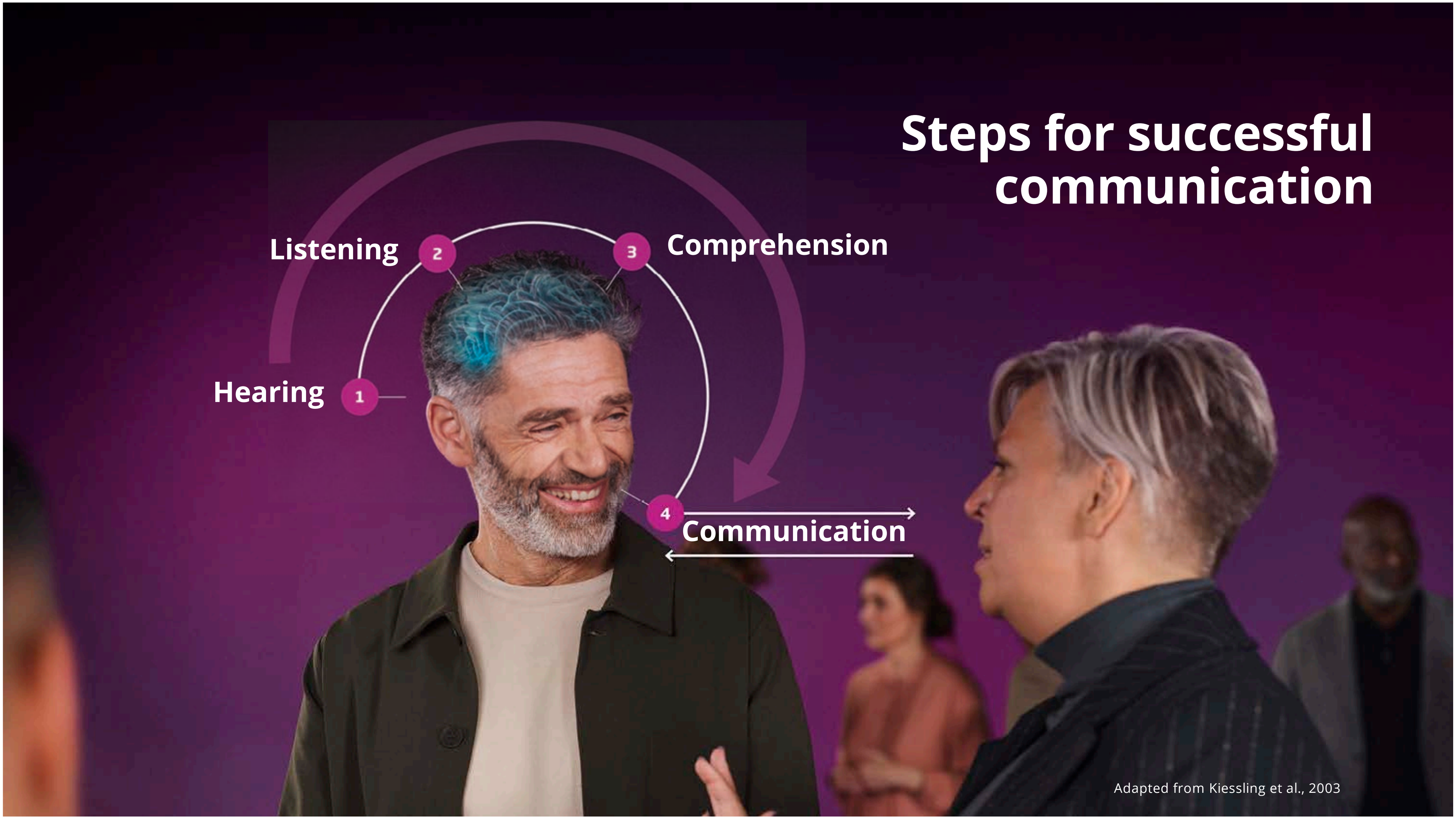
BrainHearing™


Steps for successful communication
Listening
2
3
Comprehension
Hearing
1
4
Communication
Adapted from Kiessling et al., 2003

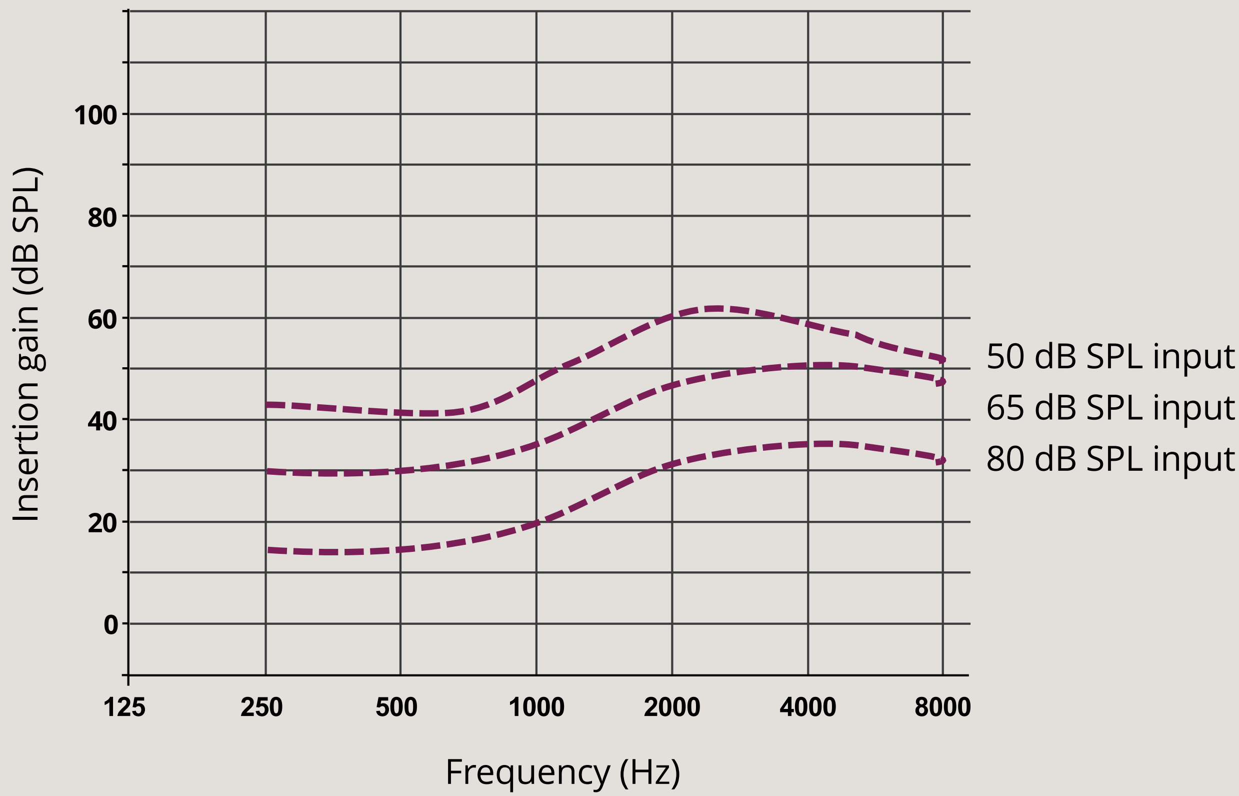
Fitting rationales

Algorithms that guide the prescription of gain

Fitting rationales and compression

Provide gain targets based upon the client's characteristics

Example of
VAC+ targets



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"In general, prescriptive methods are based on the assumption that using the patient's pure-tone thresholds, and perhaps some supra-threshold measures, hearing aid gain and/or output can be *prescribed* that will result in the best fitting for the average patient for the desired attributes (e.g. intelligibility, sound quality, listening comfort)…With modern hearing aids the intent is also to accomplish these goals for a wide range of sound input levels and listening environments. There are a number of variables to consider, and no single procedure is going to get it perfect for all patients all the time".

-Ricketts, T. A., Bentler, R., & Mueller, H. G. (2019). Essentials of Modern Hearing Aids: Selection, Fitting, & Verification. Plural Publishing, Inc.

A possible misconception

So, if I perfectly **match prescription targets**, my patient will be happy with the sound of their hearing aids?

"In general, prescriptive methods are based on the assumption that using the patient's pure-tone thresholds, and perhaps some supra-threshold measures, hearing aid gain and/or output can be *prescribed* that will result in the best fitting for the average patient for the desired attributes (e.g. intelligibility, sound quality, listening comfort). With modern hearing aids the intent is also to accomplish these goals for a wide range of sound input levels and listening environments. There are a number of variables to consider, and no single procedure is going to get it perfect for all patients all the time".

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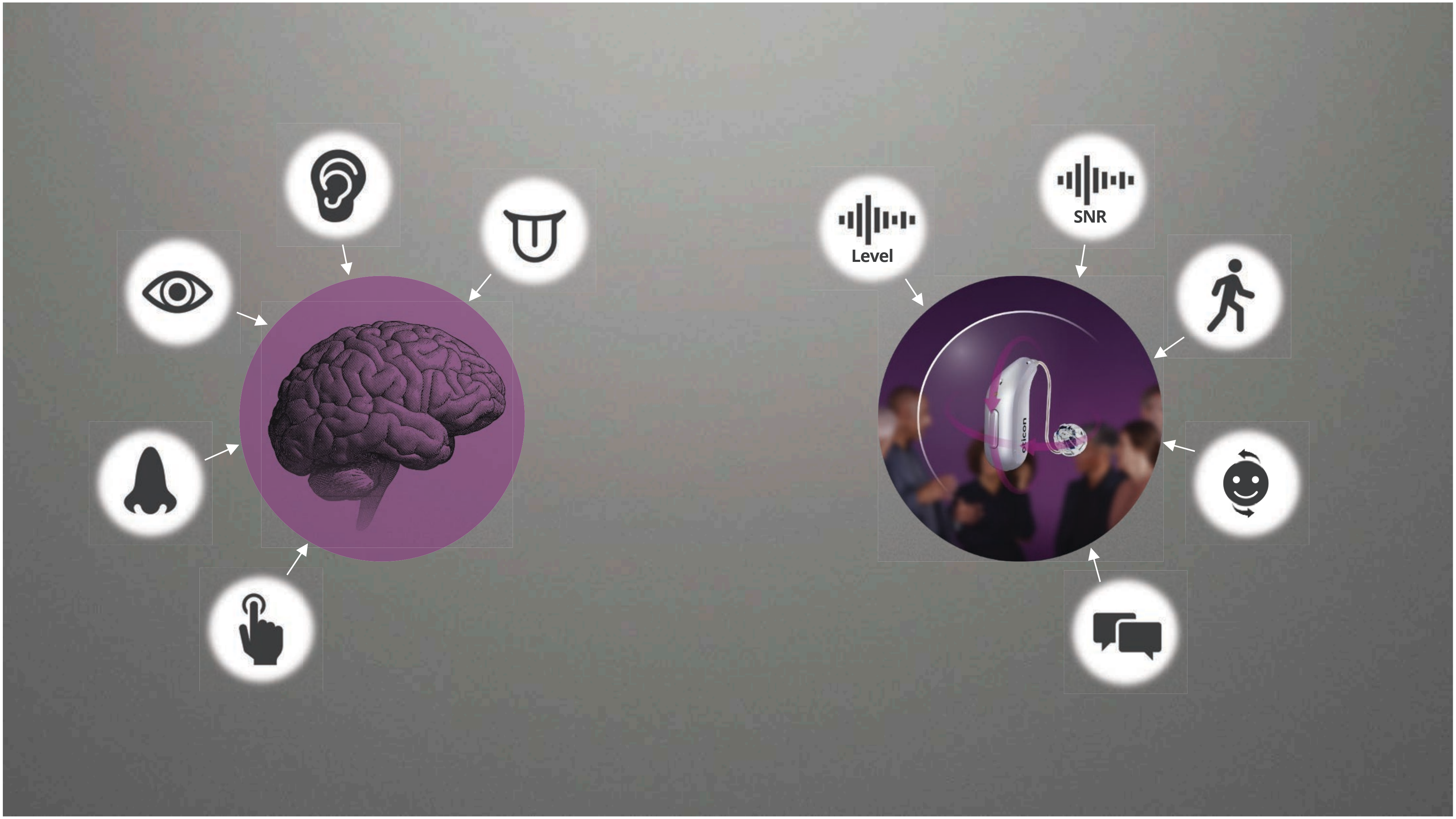
Level
SNR
oticon


TAP
TAP

precision care

“Most medical treatments are designed for the "average patient" as a one-size-fits-all-approach, which may be successful for some patients but not for others…The goal of precision medicine is to target the right treatments to the right patients at the right time.”

https://www.fda.gov/medical-devices/in-vitro-diagnostics/precision-medicine

https://www.library.ucdavis.edu/guide/ebp-resources/

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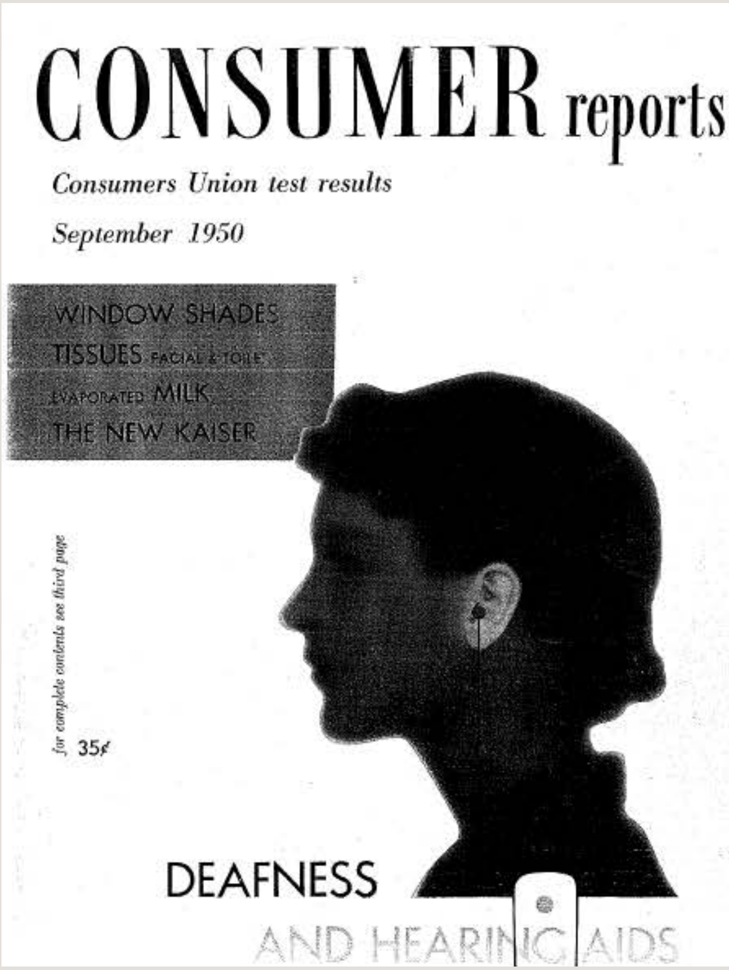

Again, an "audiogram"—that is, the curve showing relative loss of hearing at various frequencies—is drawn by determining the *least loud sound* of a particular pitch that you can hear. This is the "threshold of audibility." But research has shown that a threshold audiogram may be a wholly misleading guide to the way you hear sounds louder than threshold sounds. Since the earphone delivers sounds well above threshold levels, fitting a hearing aid to your threshold audiogram was a wholly illogical procedure.

The whole elaborate theory of "selective amplification" was finally disposed of in 1947, when Dr. Hallowell Davis and his associates published their findings. They had started their Federal research project at Harvard with the usual "personalized fitting" theory, and had constructed a "master hearing aid" which could be set for a wide range of frequency response curves. They then tried various curves on a group of trained hard-of-hearing listeners, and gauged the results by means of carefully designed tests of speech intelligibility. Their finding was that two types of curves were suitable to practically all of the hard-of-hearing subjects tested.

The "selective amplification" theory is still being pushed by some companies, but CU believes that it is on its last legs. It has outlived its usefulness even to those companies which have profited most from it over the past two

HEARING AIDS

AN EXPERIMENTAL STUDY
of
DESIGN OBJECTIVES

BY

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Project Supervisor

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R. J. MARQUIS　D. A. ROSS

The validation of the laboratory studies by large-scale clinical testing at one of the Army Aural Rehabilitation Hospitals, which had originally been planned, has not been undertaken. The termination of the wartime activities of the Office of Scientific Research and Development is partly responsible for this curtailment, but the unexpectedly simple and definite result of the laboratory experiments makes the large-scale validation seem less vital than was anticipated. The results also seem to show that individual testing with the Master Hearing Aid is unnecessary for the satisfactory selection of hearing aids for the majority of patients (1),[1] so that in an unexpected way the second objective has also been largely attained. We believe, in other words, that we have disproved the fundamental assumption of the desirability of "selective amplification" based on the characteristics of the individual's audiogram.

	Subject	Age	HL Type
1	RA	44	Mixed
2	FB	49	Mixed (presumed otoscerlosis)
3	HB	53	Mixed (presumed otoscerlosis)
4	BD	30	Mixed
5	BL	70	Mixed
6	DL	43	Mixed (presumed otoscerlosis)
7	HM	40	Mixed (presumed otoscerlosis)
8	RR	46	Mixed
9	JH	17	SNHL
10	IS	23	SNHL
11	RW	48	SNHL
12	PP	25	SNHL (? – only 1 BC threshold shown)
13	WW	23	SNHL (probably - no BC responses)
14	MD	?	Unknown (no BC performed)
15	TR	?	Unknown (no BC performed)
16	MC	52	Unknown (no audiogram – presumed SNHL)
17	FS	64	Unknown (no audiogram – presumed SNHL)
18	RC	37	Unknown (no audiogram - presumed conductive)

- Normal hearing function relies on 30+ different structures/functions that must work in a precisely coordinated sequence

Outer Ear

- Pinna (Auricle)
- External auditory canal (meatus)

Middle Ear

- Tympanic membrane (eardrum)
- Malleus
- Incus
- Stapes
- Eustachian tube
- Middle ear muscles (tensor tympani and stapedius)
- Middle ear ligaments and joints (e.g., incudomalleolar and incudostapedial joints)

Inner Ear (Cochlea)

- Oval window
- Round window
- Scala vestibuli
- Scala tympani
- Scala media (cochlear duct)
- Basilar membrane
- Tectorial membrane
- Organ of Corti
- Inner hair cells
- Outer hair cells
- Supporting cells (e.g., Deiters', Hensen's, Claudius' cells)
- Stria vascularis
- Spiral ligament
- Endolymph and perilymph fluids

Auditory Nerve and Spiral Ganglion

- Spiral ganglion neurons
- Peripheral processes of spiral ganglion neurons (connect to hair cells)
- Central axons of spiral ganglion neurons (form auditory nerve)
- Cochlear nerve (branch of CN VIII)
- Myelin sheaths (Schwann cells)

Other Key Interfaces

- Synapses between hair cells and auditory nerve fibers
- Blood supply to cochlea and auditory nerve (e.g., labyrinthine artery)

Known, well-documented causes of hearing loss

Genetic Causes

Syndromic

- Waarden-burg syndrome
- Usher syndrome
- Pendred syndrome
- Branchio-oto-renal syndrome
- Alport syndrome
- Jervell and Lange-Nielsen syndrome
- Stickler syndrome
- Treacher Collins syndrome

Non-syndromic

- DFNB1 (GJB2/GJB6 mutations) – Connexin 26/30
- DFNA2 (KCNQ4 mutations)
- DFNB4 (SLC26A4 mutations without goiter)
- Mitochondrial mutations (e.g., MT-RNR1)

Prenatal & Perinatal Causes

- Congenital cytomega-lovirus (CMV)
- Congenital rubella
- Congenital toxo-plasmosis
- Congenital syphilis
- Congenital herpes simplex virus
- Perinatal hypoxia or anoxia
- Hyper-bilirubinemia
- Low birth weight or prematurity
- Ototoxic exposure in utero (e.g., aminoglycosides)

Infectious Causes (Postnatal)

- Meningitis
- Measles
- Mumps
- Varicella (chickenpox)
- Labyrinthitis
- Otitis media (recurrent & chronic)
- Syphilis (acquired)
- Lyme disease
- HIV/AIDS

Noise-Induced Hearing Loss

- Occupational noise exposure
- Recreational noise (e.g., concerts, headphones)
- Acoustic trauma (e.g., explosions, gunfire)

Ototoxic Medications & Substances

- Amino-glycoside antibiotics (e.g., gentamicin)
- Cisplatin (chemo-therapy)
- Loop diuretics (e.g., furosemide)
- Salicylates (e.g., high-dose aspirin)
- Quinine and antimalarials
- Industrial solvents (e.g., toluene, styrene)

Autoimmune & Inflammatory Disorders

- Auto-immune inner ear disease (AIED)
- Cogan's syndrome
- Rheumatoid arthritis (secondary)
- Lupus (SLE-related vasculitis)

Neoplastic Causes

- Vestibular schwannoma (acoustic neuroma)
- Meningioma (CPA angle)
- Metastatic tumors to temporal bone

Trauma

- Temporal bone fracture
- Barotrauma (diving, flying)
- Perilymph fistula
- Blast injury

Age-Related (Presbycusis)

- Sensori-neural de-generation due to aging
- Cochlear synap-topathy ("hidden hearing loss")

Structural and Developmental Abnormalities

- Enlarged vestibular aqueduct
- Mondini mal-formation
- Michel aplasia
- Ossicular chain mal-formation or fixation
- Atresia of the external auditory canal

Idiopathic & Other

- Sudden sensori-neural hearing loss (idiopathic in most cases)
- Ménière's disease
- Superior canal dehiscence

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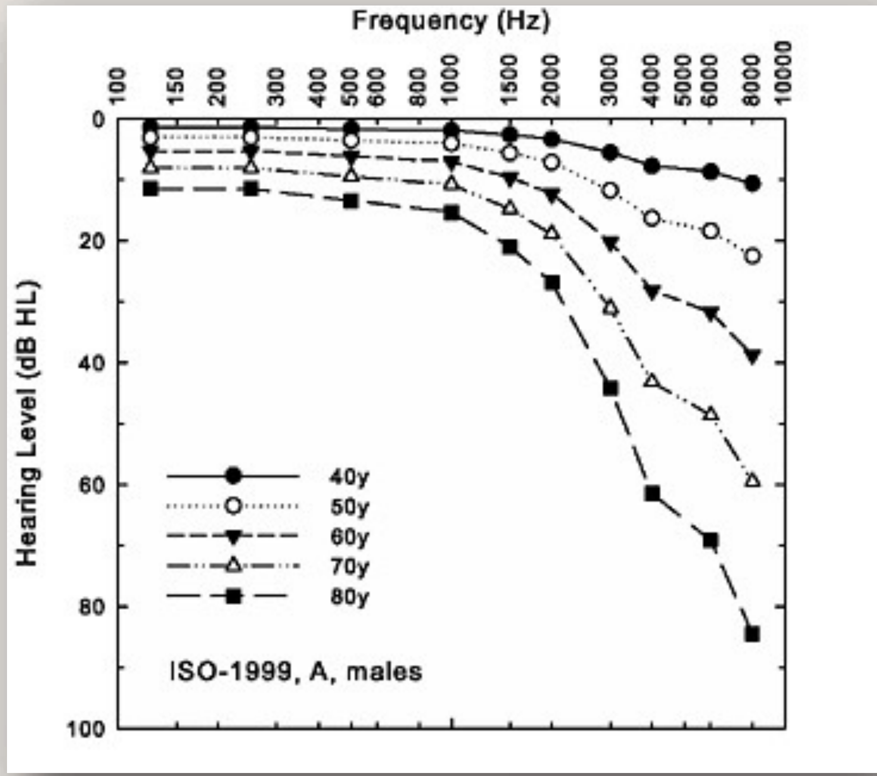
Normal Hearing Loss



Dobie, 2015

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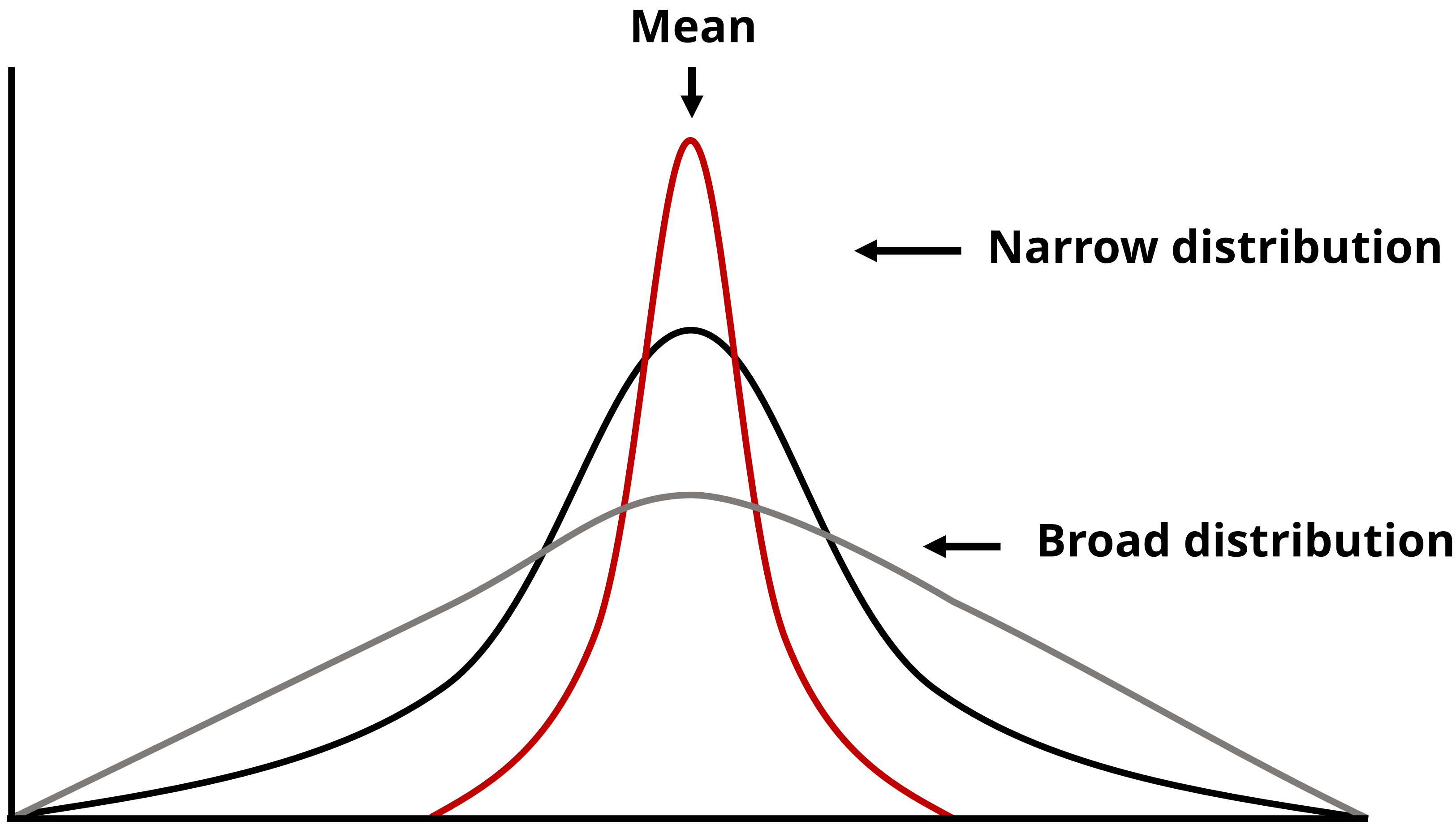
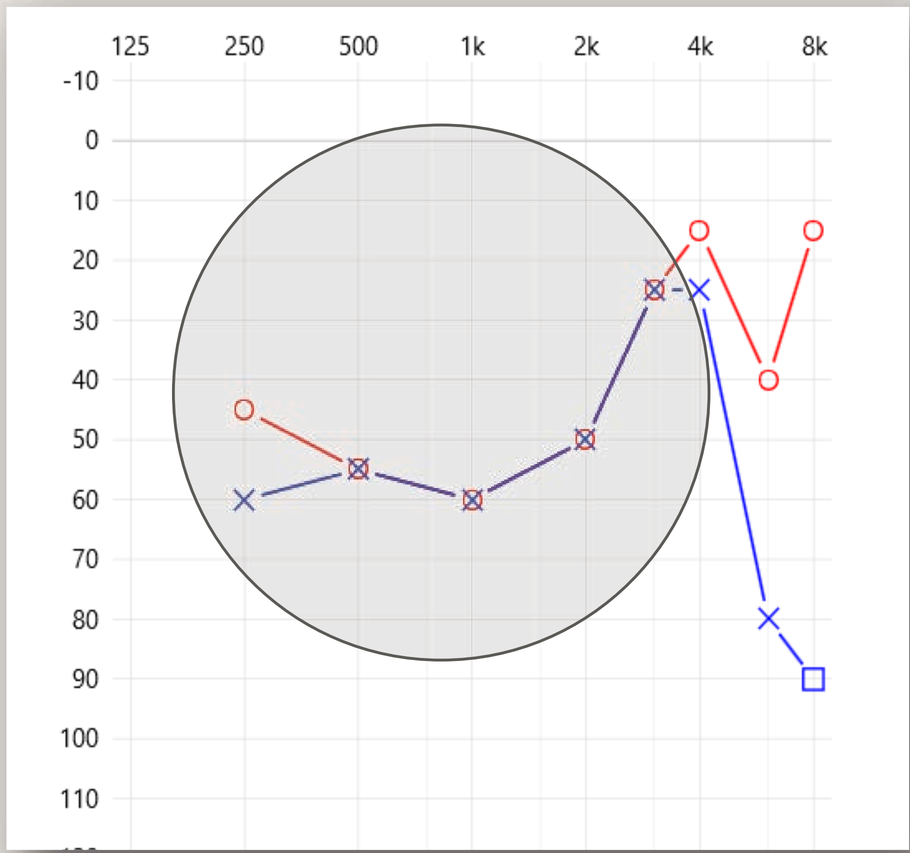

Mean
Narrow distribution
Broad distribution


The importance of history & context

Case Example

- 30-year-old female
- Reports normal hearing until after experiencing hearing loss and tinnitus after a concert

- How would assumptions and average fitting data affect hearing aid fitting?



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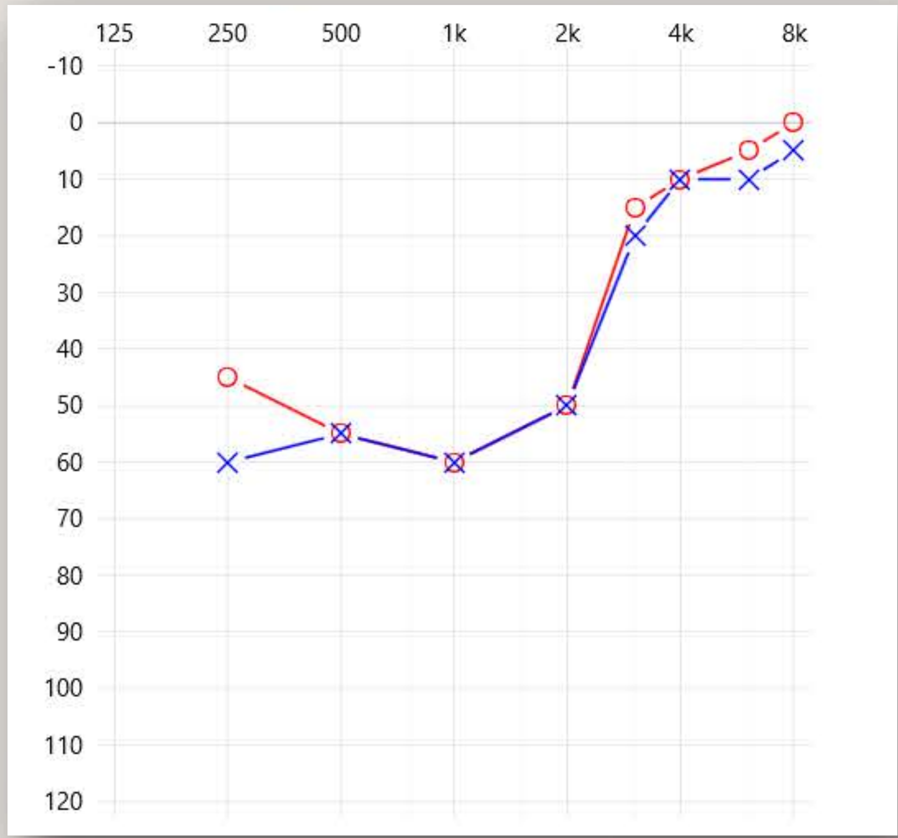
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250
500
1k
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4k
8k
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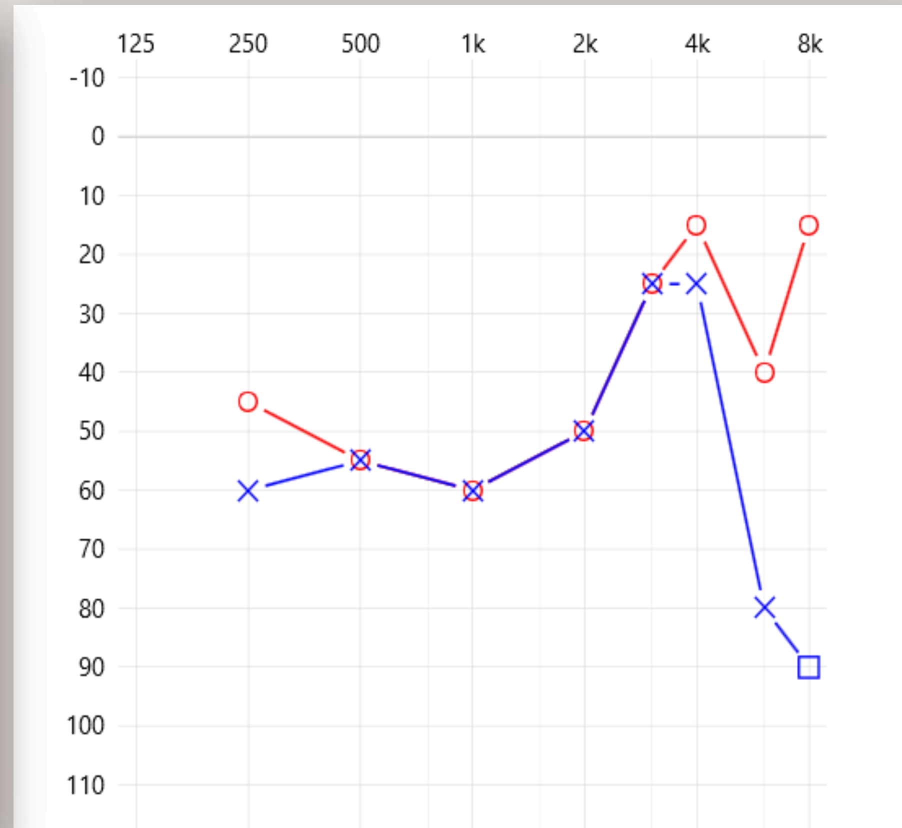
100
110
120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90
100
110

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"An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem"

– John Tukey

precision care

“Most medical treatments are designed for the "average patient" as a one-size-fits-all-approach, which may be successful for some patients but not for others…The goal of precision medicine is to target the right treatments to the right patients at the right time.”

https://www.fda.gov/medical-devices/in-vitro-diagnostics/precision-medicine

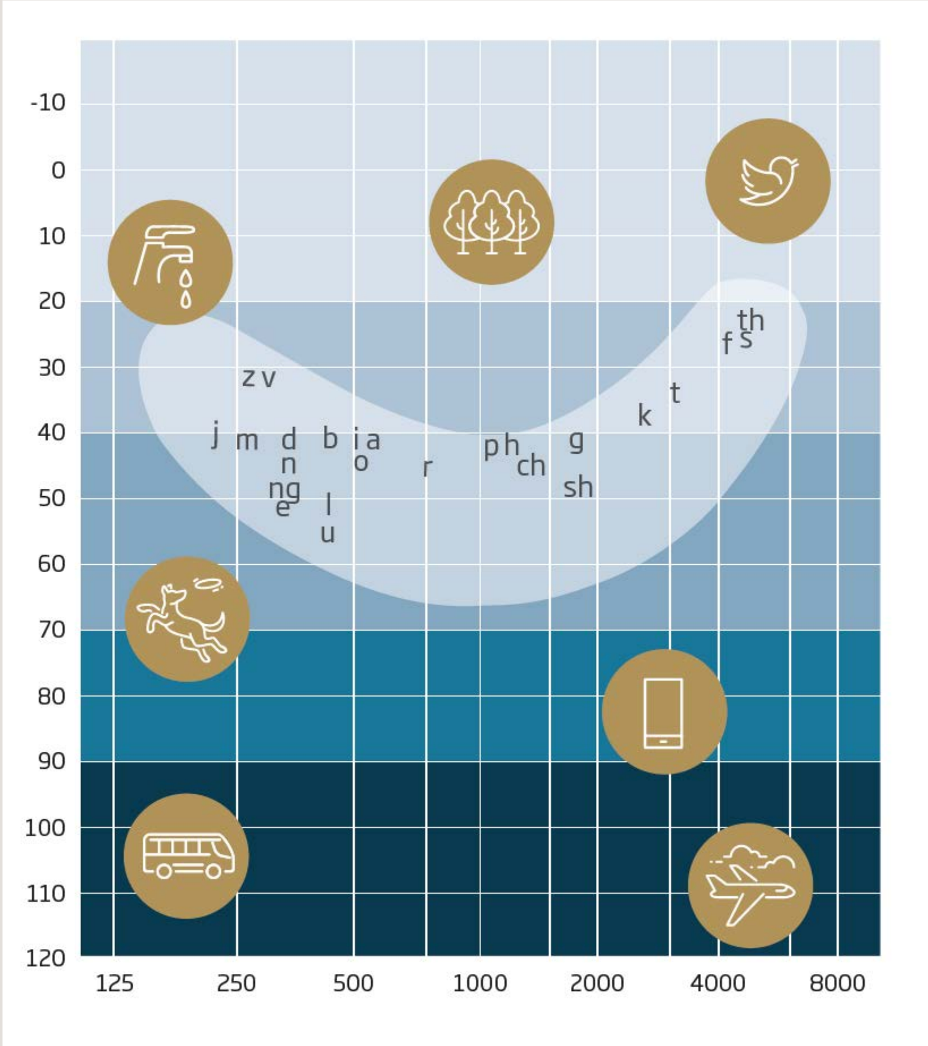

Eriksholm Research Center
https://www.eriksholm.com/publication

Background to fitting rationales

The challenge of prescribing gain

A wide range of input levels and listening environments

Restore
audibility



-10
0
10
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k t
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The challenge of prescribing gain

A wide range of input levels and listening environments

Restore **audibility**

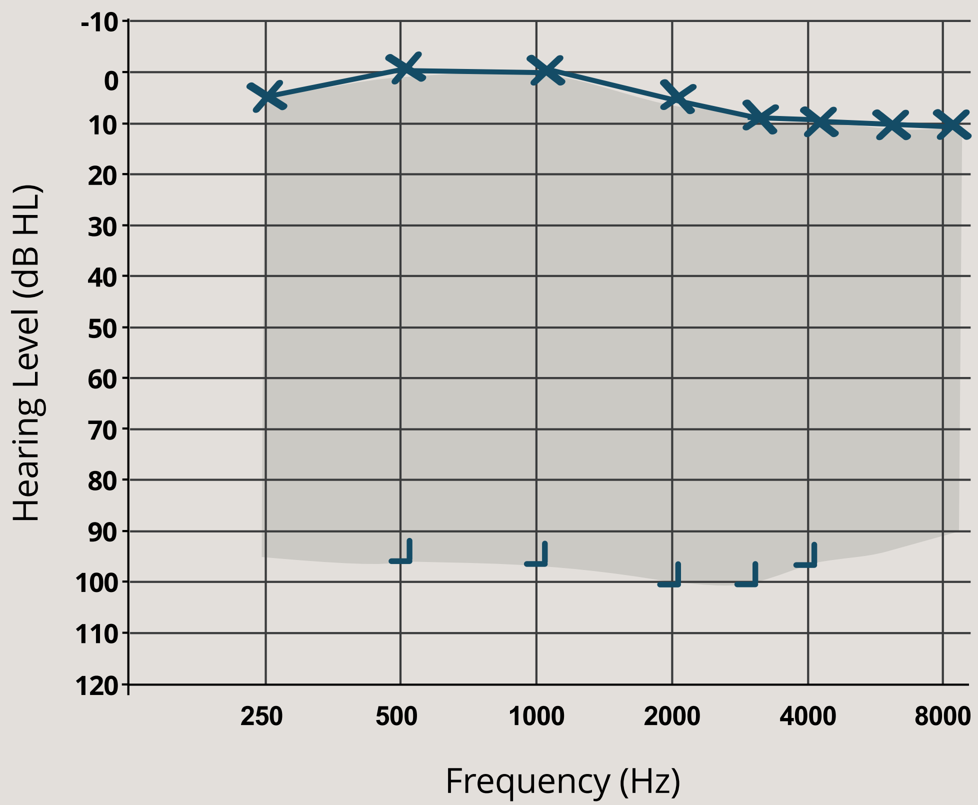
Maximize **speech intelligibility**

Avoid **overamplifying**

Protect residual **hearing**

Dynamic range

Normal hearing



Large dynamic range

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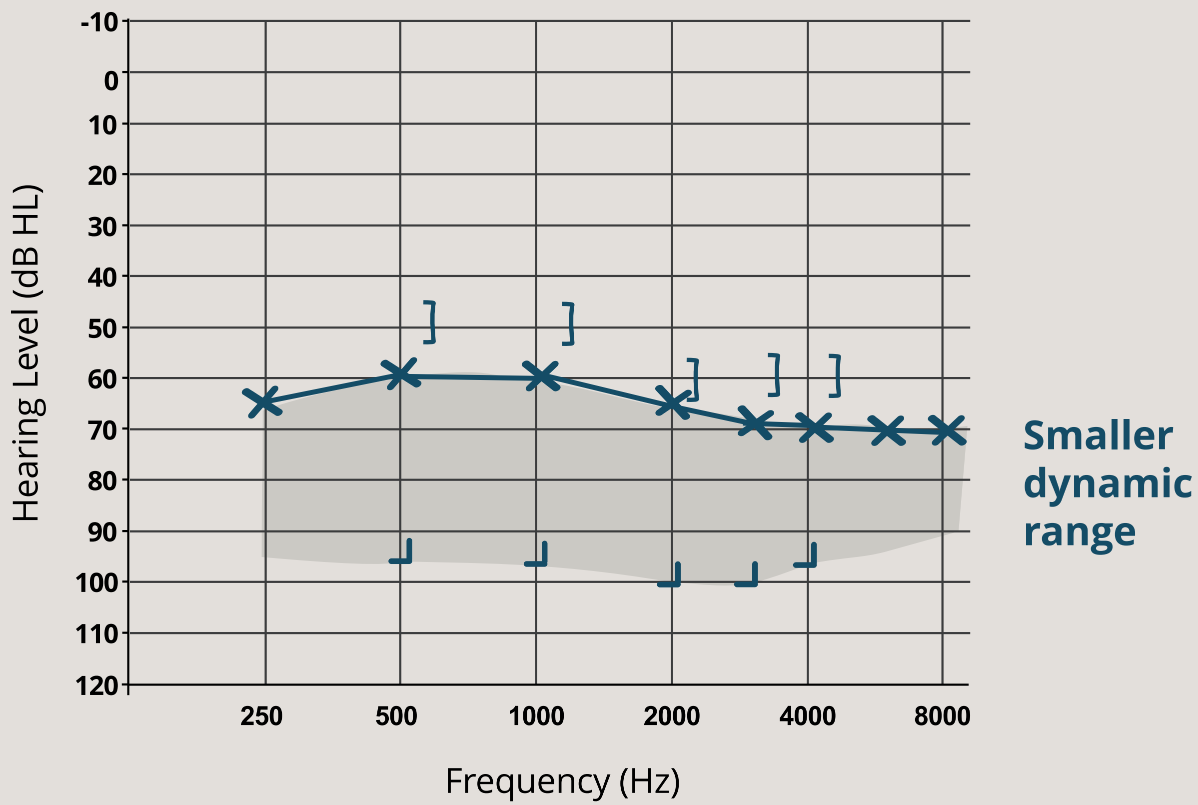
Dynamic range

Sensorineural hearing loss



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The challenge of prescribing gain

A wide range of input levels and listening environments

Restore **audibility**

Maximize **speech intelligibility**

Preserve **sound quality**

Avoid **overamplifying**

Protect residual **hearing**

Ensure **comfort**

Which algorithm should I use?

It depends which assumptions you are willing to make.

What are some assumptions we might make?

- All speech is valuable
- Restore audibility as much as possible
- Prescriptive approach
- Correct for threshold loss
- Measurable hearing is useable hearing
- The more bandwidth the better
- Make the full range of inputs fit
- Both ears contribute equally
- Closed ear canal
- Listening in quiet
- Speech is the signal of interest

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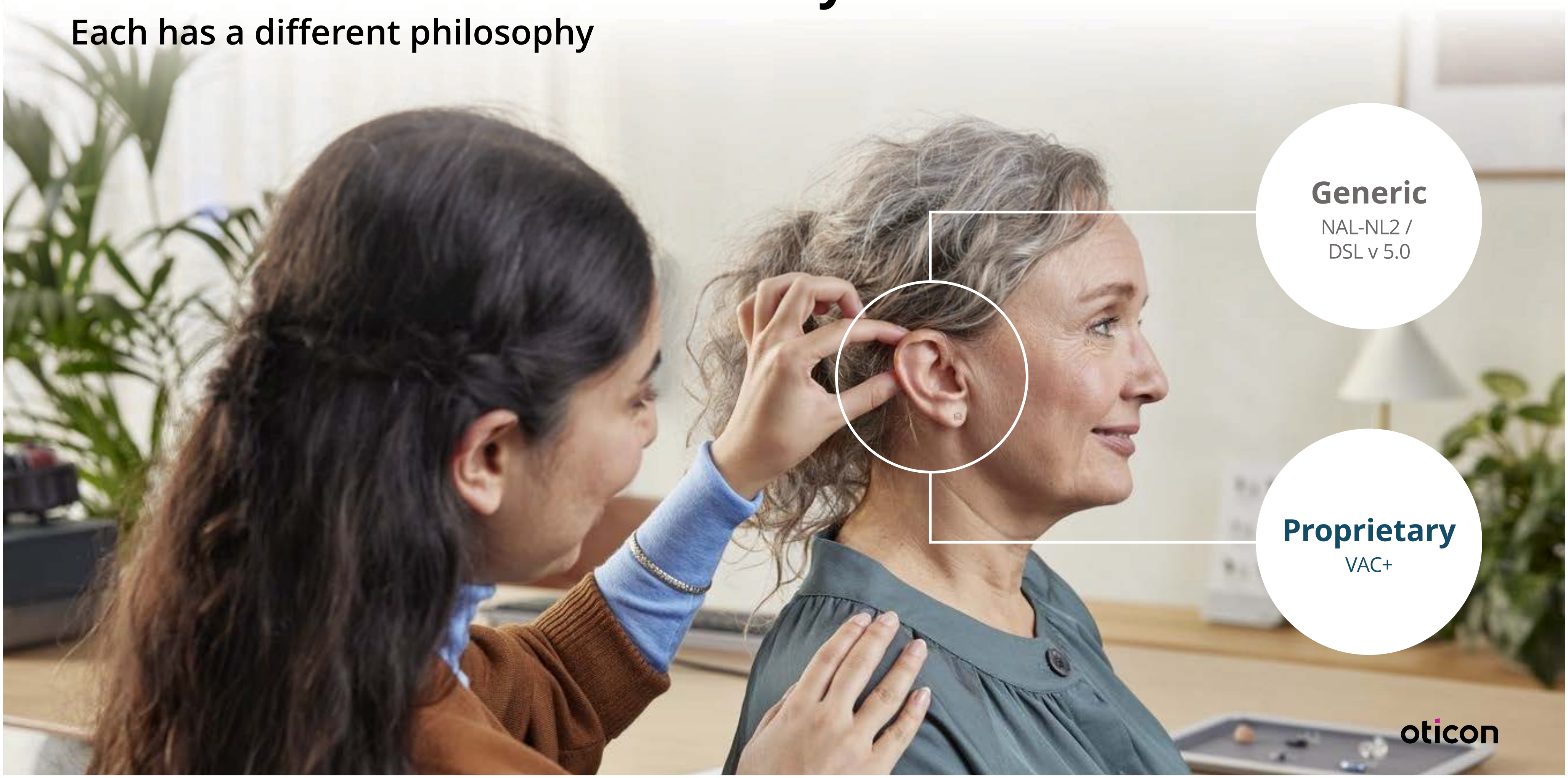
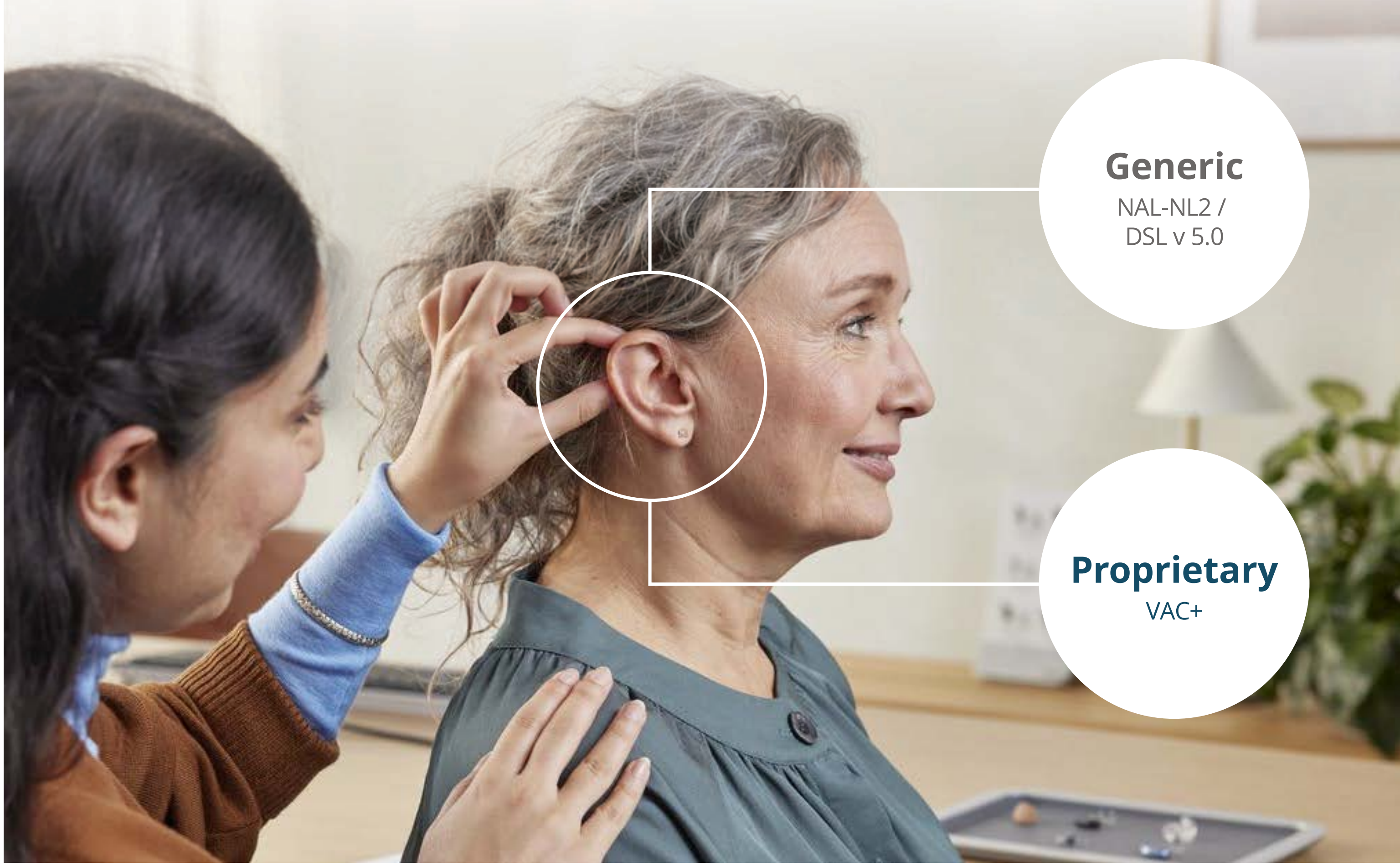
Which rationale is best for my client?

Each has a different philosophy



Which rationale is best for my client?

Each has a different philosophy



Standardized approach

Length of time between revisions

Built and updated to support innovations

Historically, **limited information** released

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Generic rationale

NAL-NL2

Philosophy	Latest update	Personalization	Targeted rationales
Maximize speech intelligibility	2011	Experience	Binaural
Ensure overall loudness comfortable		Gender	Open fitting
		Age (child / adult)	
		Language	

Generic rationale

DSL v 5.0

Philosophy	Latest update	Personalization	Targeted rationales
Audibility of speech at all frequencies	2005	Infant / child / adult	Binaural
Normalize loudness at each frequency		Listening environments	Conductive hearing losses

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Oticon’s proprietary rationale

VAC+

Philosophy	Latest update	Personalization	Targeted rationales
Natural sound	**2024**	Soft sounds	Open fitting
Audibility		Brightness	Complex audiograms
Comfort			

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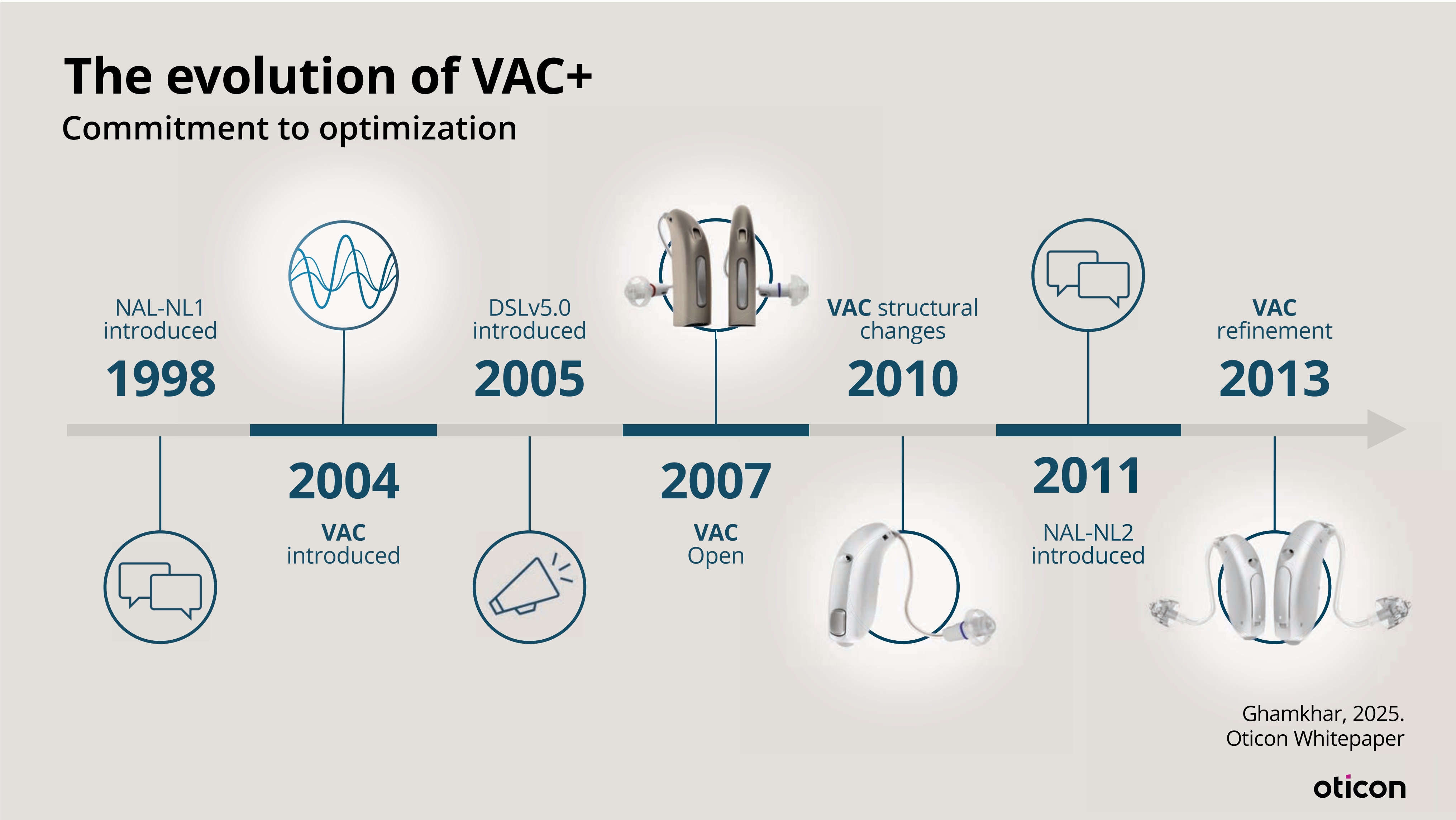
Evolution


The evolution of VAC+
Commitment to optimization
NAL-NL1 introduced
1998
2004
VAC introduced
DSLv5.0 introduced
2005
2007
VAC Open
VAC structural changes
2010
2011
NAL-NL2 introduced
VAC refinement
2013
Ghamkhar, 2025.
Oticon Whitepaper
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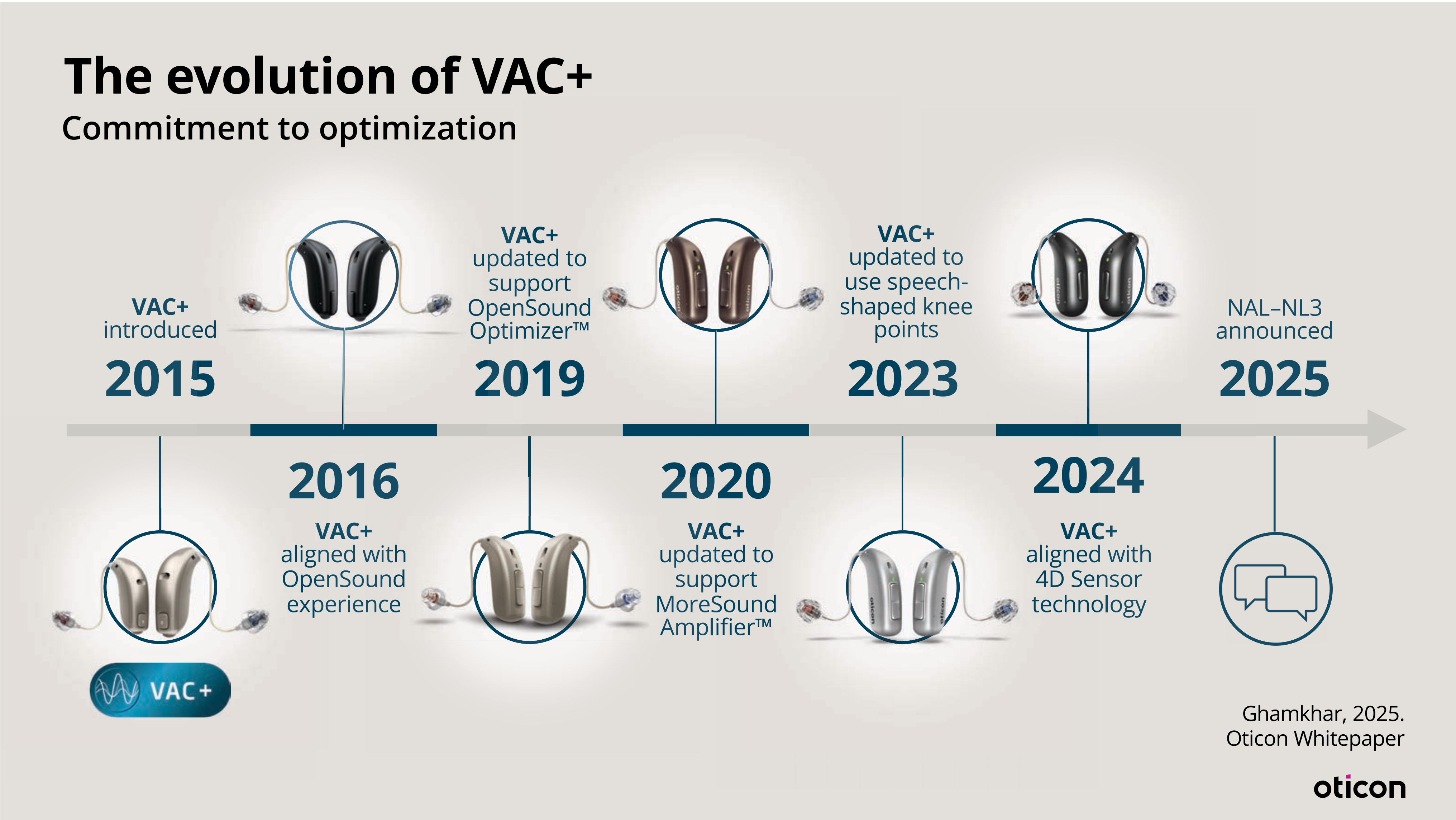
The evolution of VAC+
Commitment to optimization
VAC+ introduced
2015
2016
VAC+ aligned with OpenSound experience
VAC+ updated to support OpenSound Optimizer™
2019
2020
VAC+ updated to support MoreSound Amplifier™
VAC+ updated to use speech-shaped knee points
2023
2024
VAC+ aligned with 4D Sensor technology
NAL–NL3 announced
2025
VAC+
Ghamkhar, 2025.
Oticon Whitepaper
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Validation of VAC+

Continuous and rigorous internal testing

Small scale development tests

To assess **performance** with **hardware** and **signal processing**

Larger scale development tests

To validate **audiological performance**

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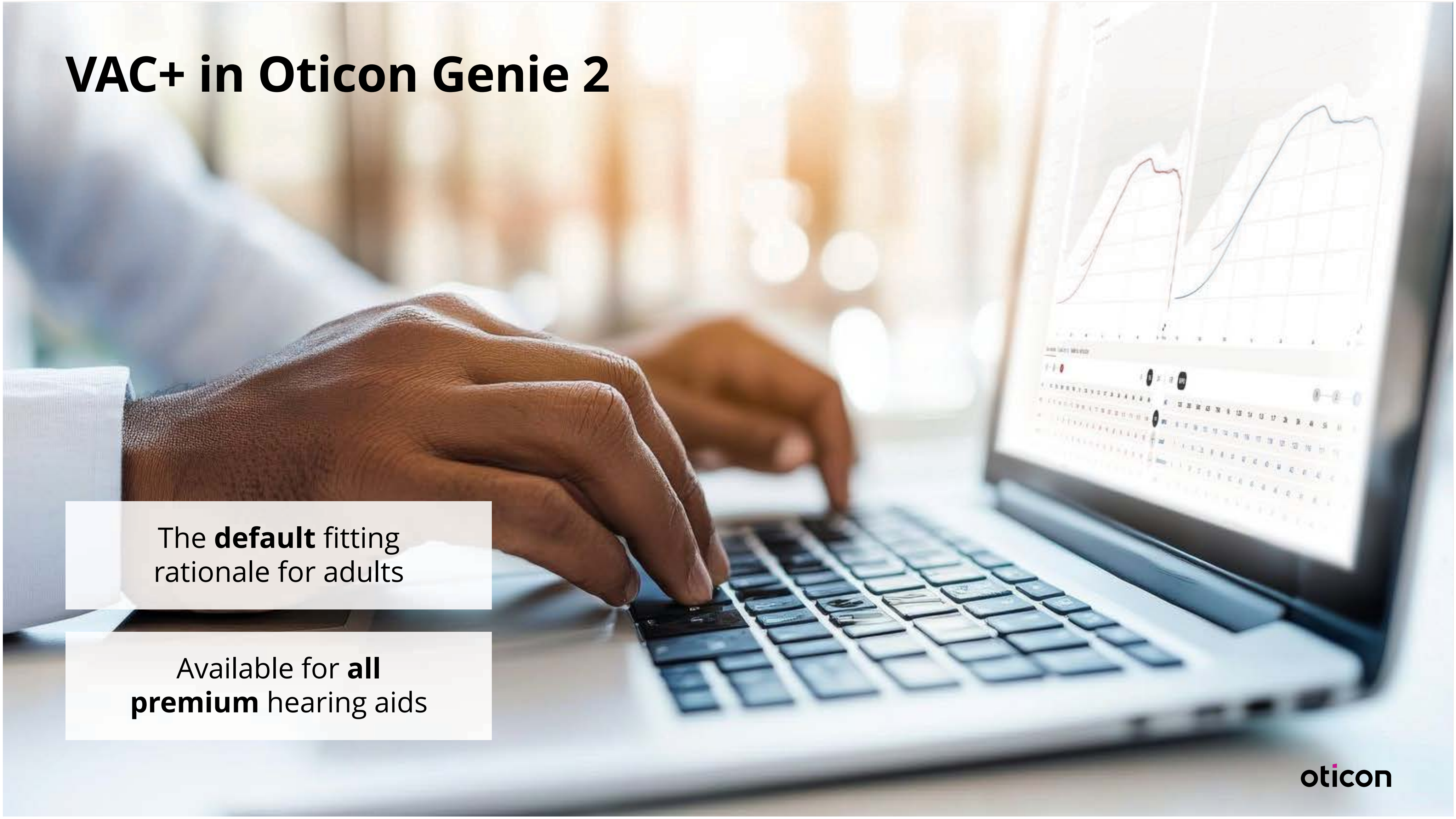
VAC+ in practice

VAC+ in Oticon Genie 2



The **default** fitting rationale for adults

Available for **all premium** hearing aids

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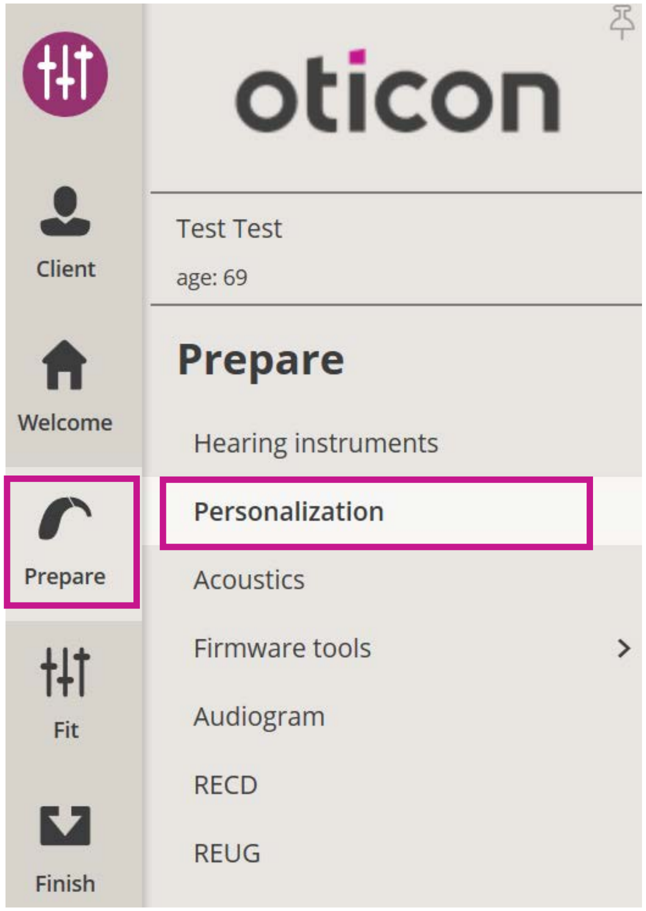
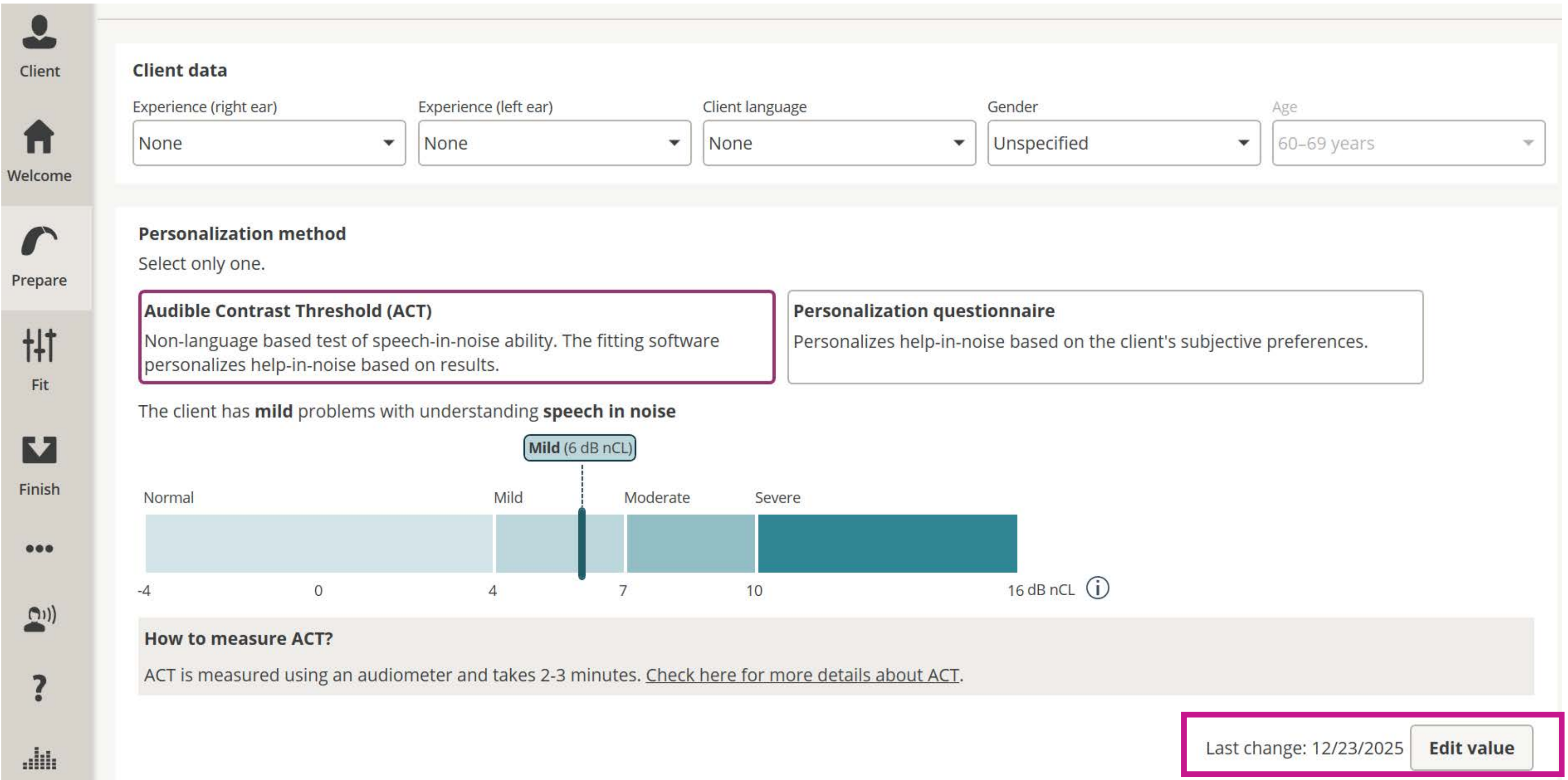
Personalization

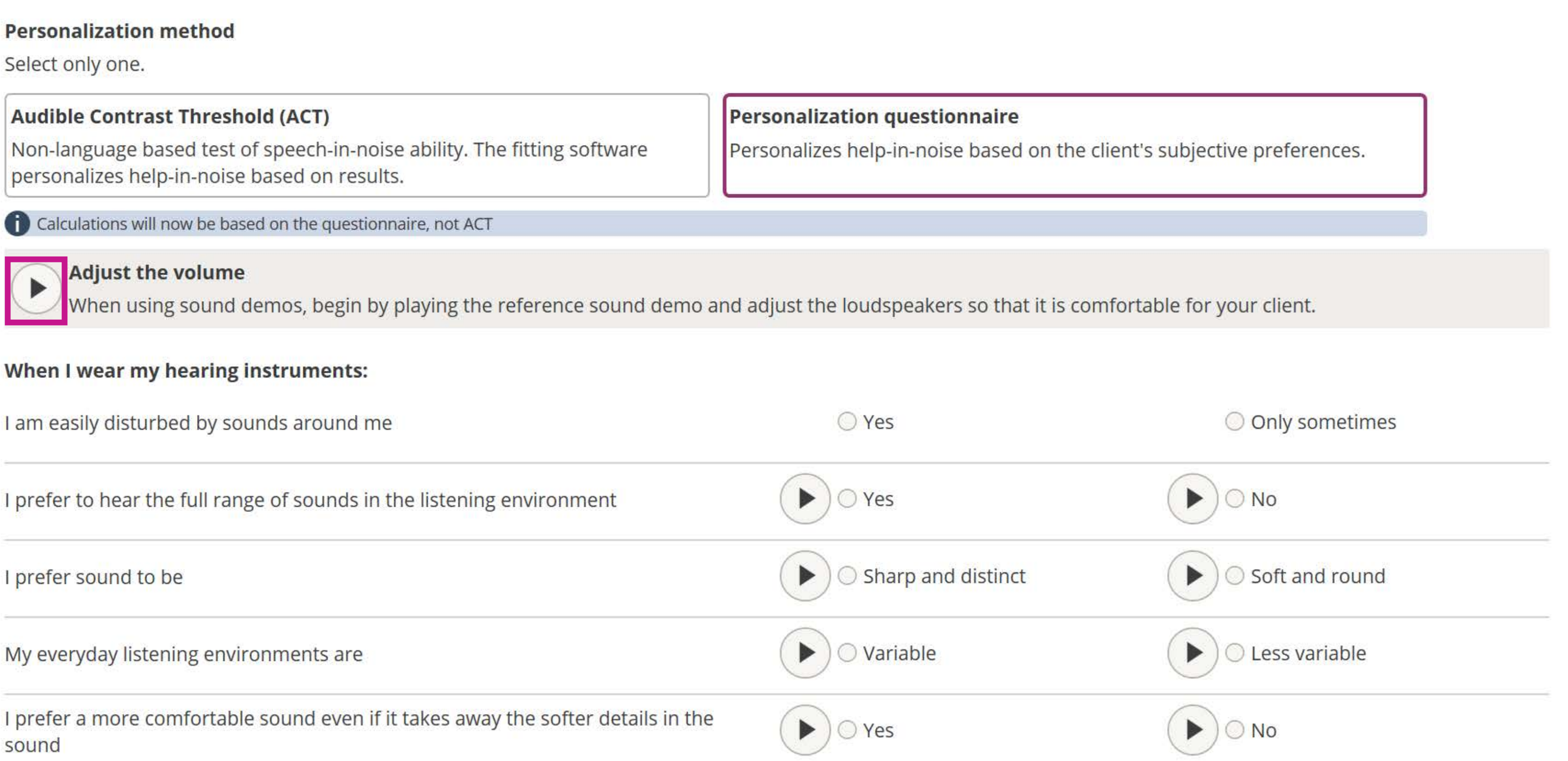


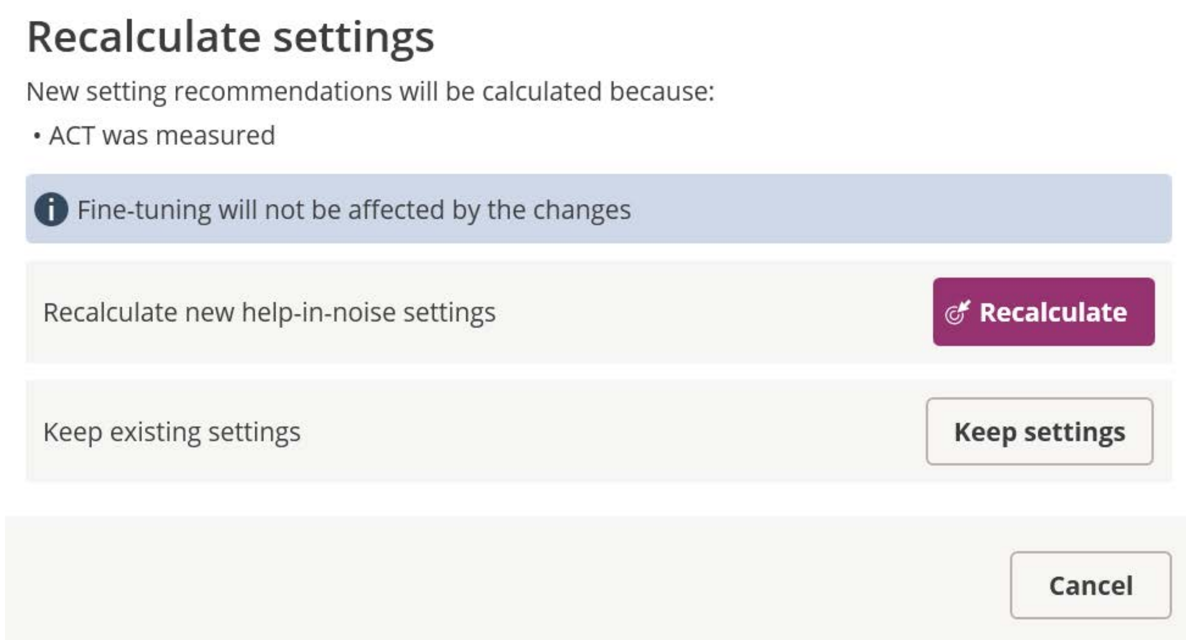
Personalization Parameters

Personalization via ACT



Personalization Questionnaire




Recalculate settings
New setting recommendations will be calculated because:
• ACT was measured
Fine-tuning will not be affected by the changes
Recalculate new help-in-noise settings
Recalculate
Keep existing settings
Keep settings
Cancel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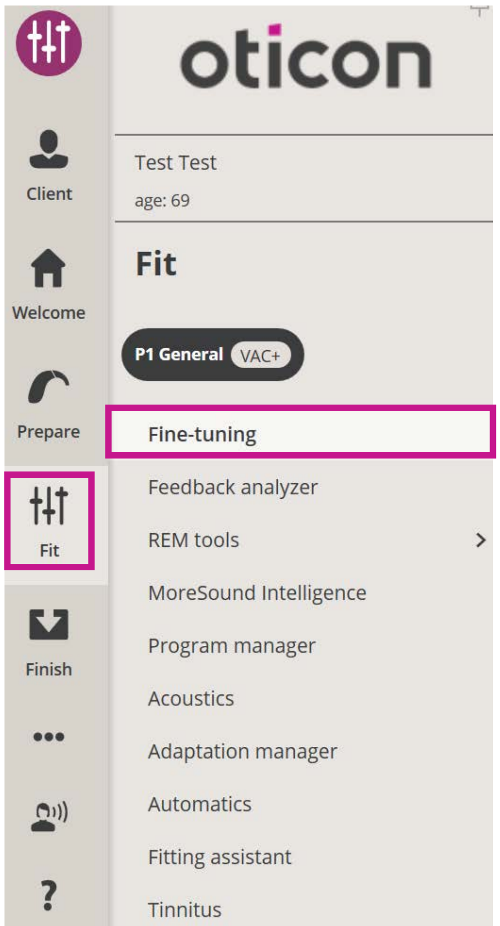
Client
Welcome
Prepare
Fit
Finish
Test Test
age: 69
Prepare
Hearing instruments
Personalization
Acoustics
Firmware tools
Audiogram
RECD
REUG
P1: General (VAC+)
Insertion gain
Graph settings
P1: General (VAC+)
dB
ANSI S3.5 (ICRA Stationary)
Target 65
Simulated 65
Reserve gain
10 dB
Bass dome, double
Grip Tip, closed
Grip Tip, open
LiteTip
MicroMold, long
MicroMold, short
MicroShell Detect, long
MicroShell Detect, short
Earpiece
Bass dome, double
125
250
500
1k
2k
4k
8k
Hz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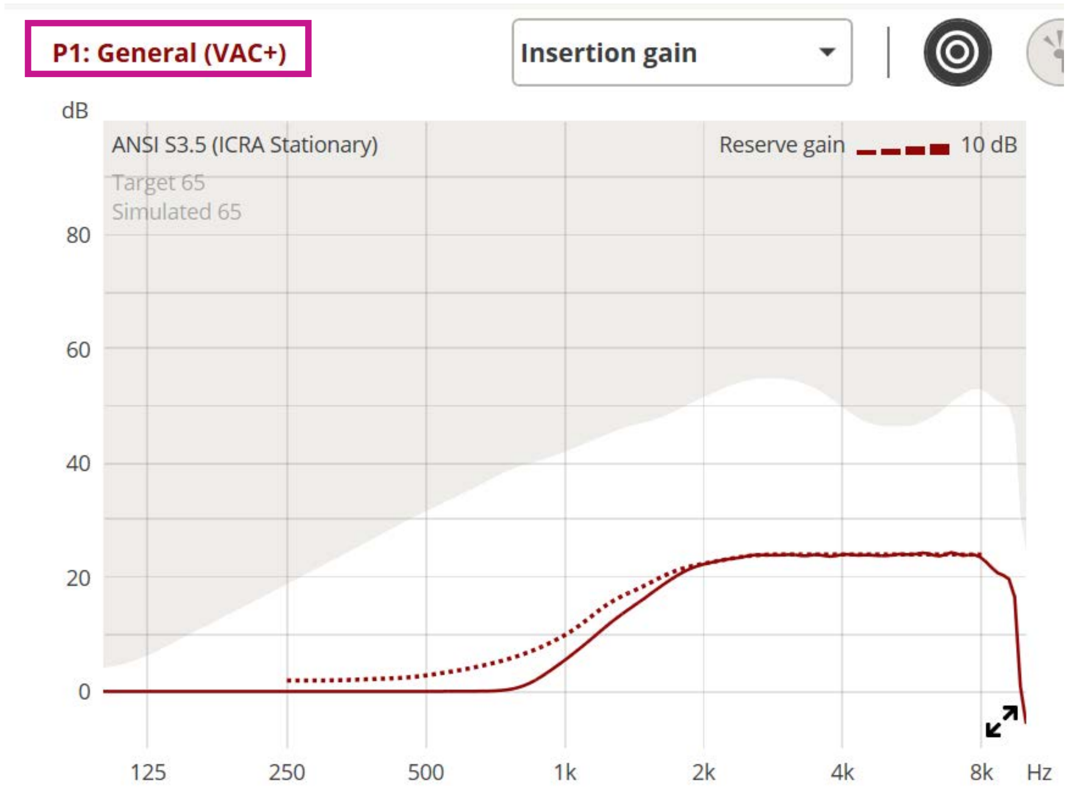
Test Test
age: 69
Fit
P1 General VAC+
Fine-tuning
Feedback analyzer
REM tools
MoreSound Intelligence
Program manager
Acoustics
Adaptation manager
Automatics
Fitting assistant
Tinnitus
Client
Welcome
Prepare
Fit
Finish


P1: General (VAC+)
Insertion gain
dB
ANSI S3.5 (ICRA Stationary)
Target 65
Simulated 65
Reserve gain
10 dB
80
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125
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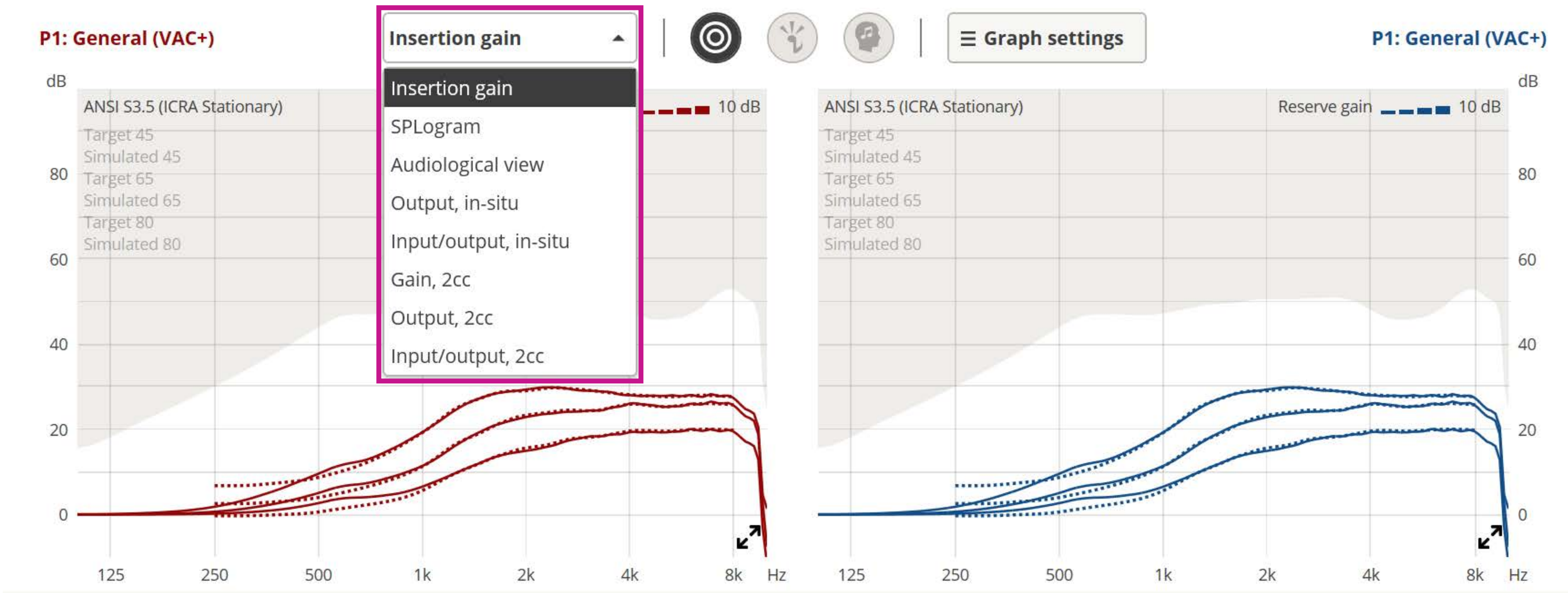
1k
2k
4k
8k
Hz

Graph Types



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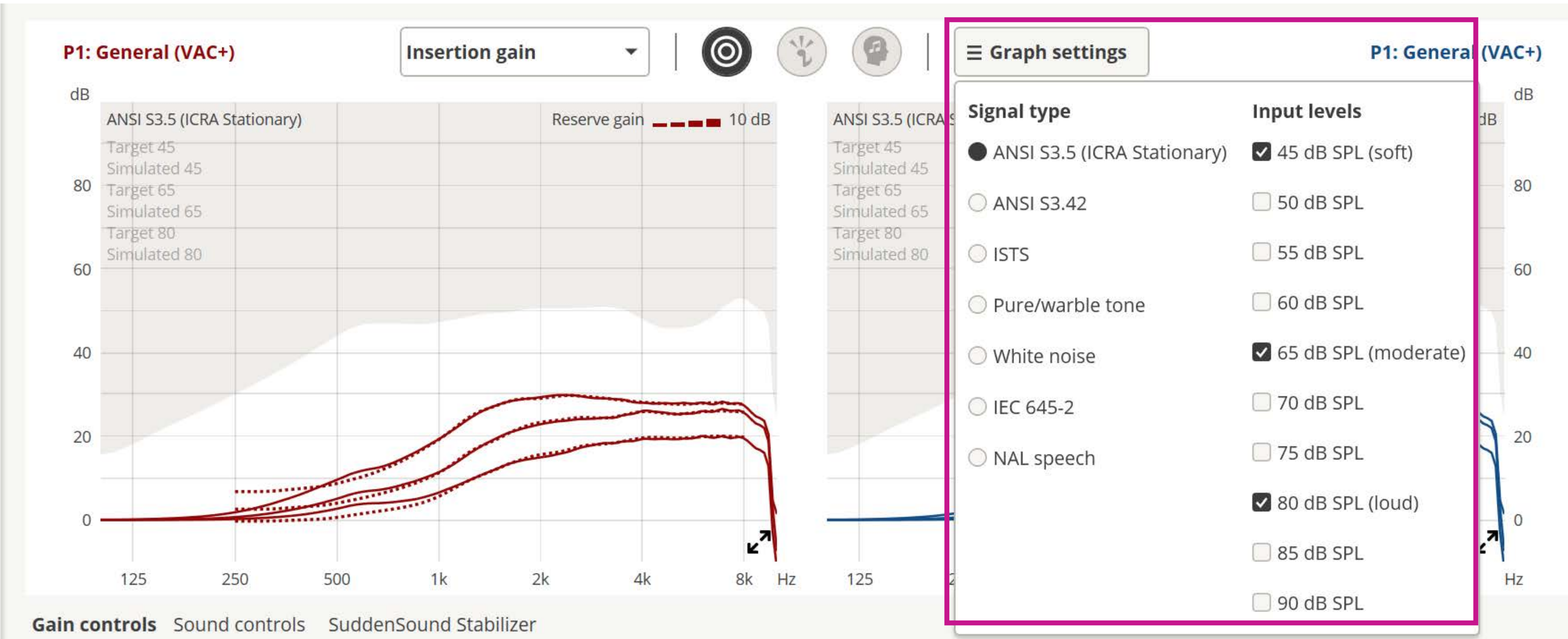
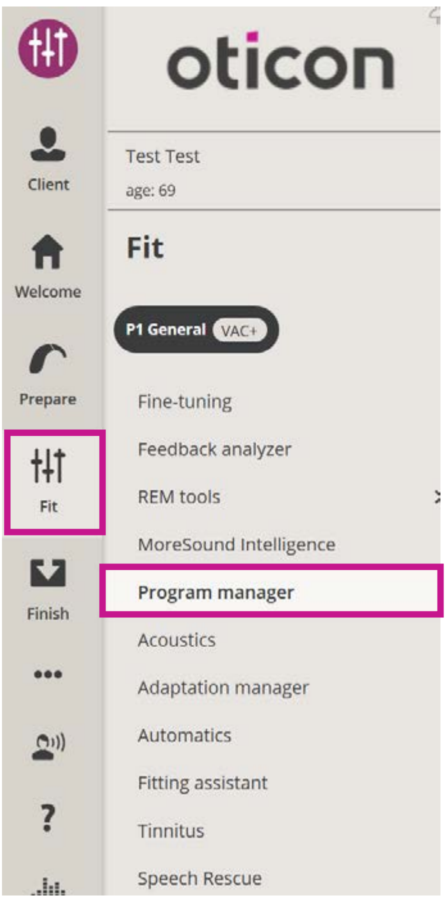
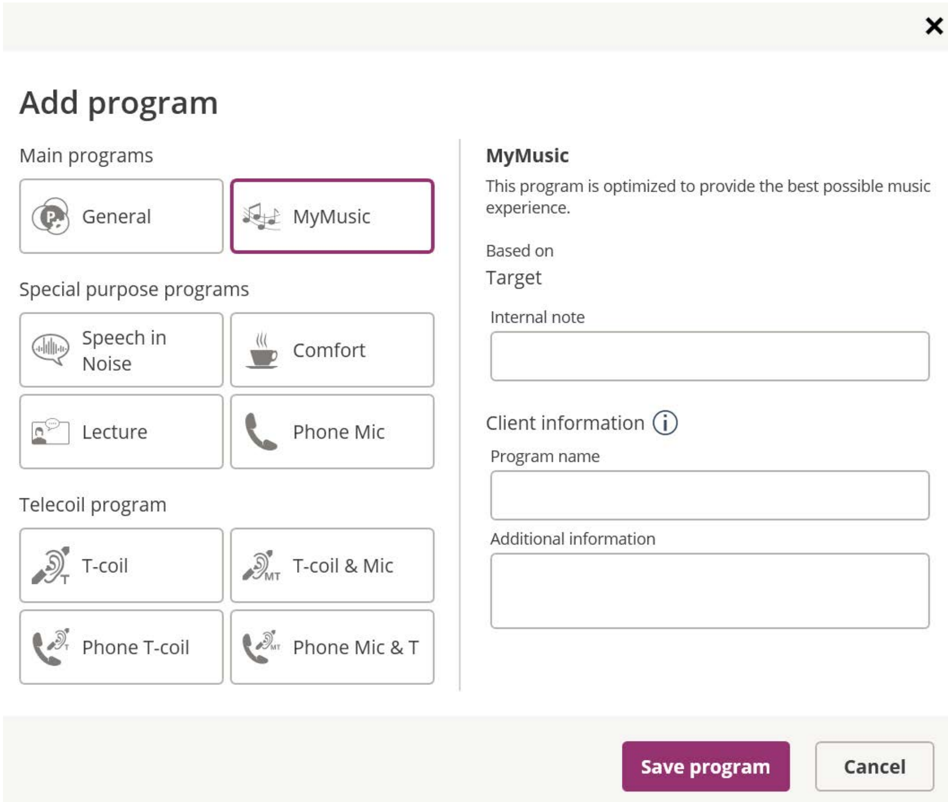
Graph Settings



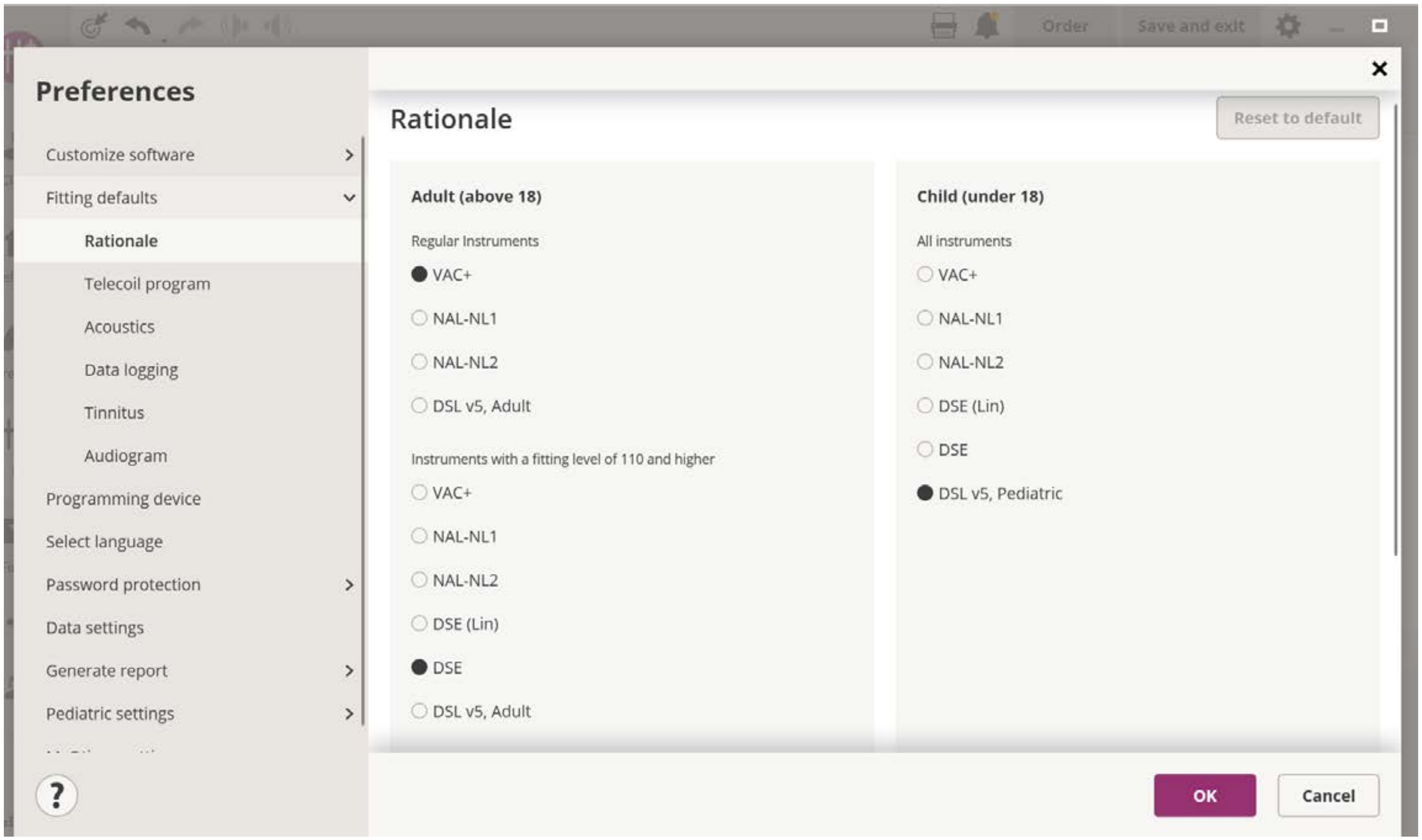
Changing prescriptive algorithms



Additional & Special Purpose Programs



Gain Preferences



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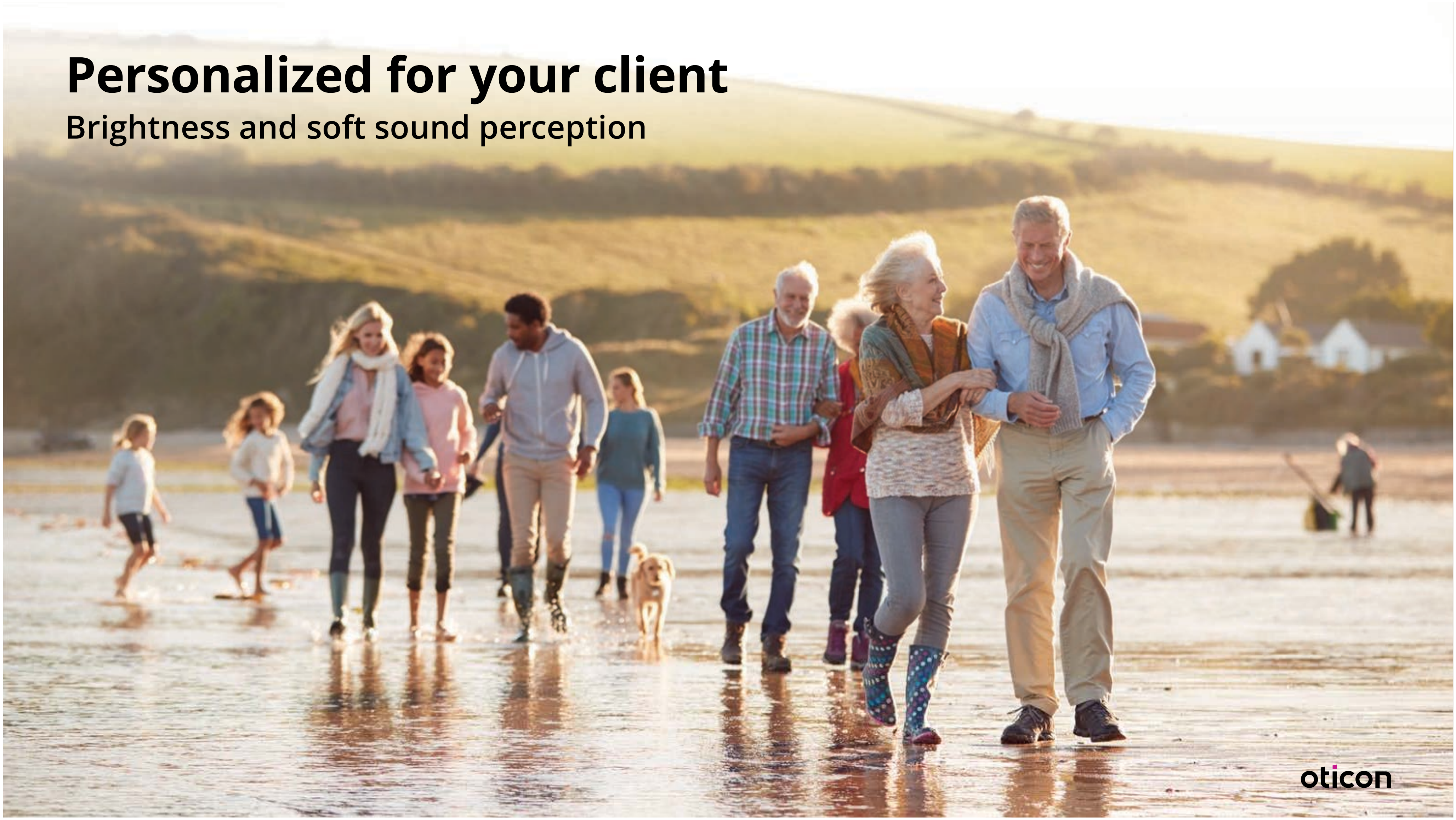
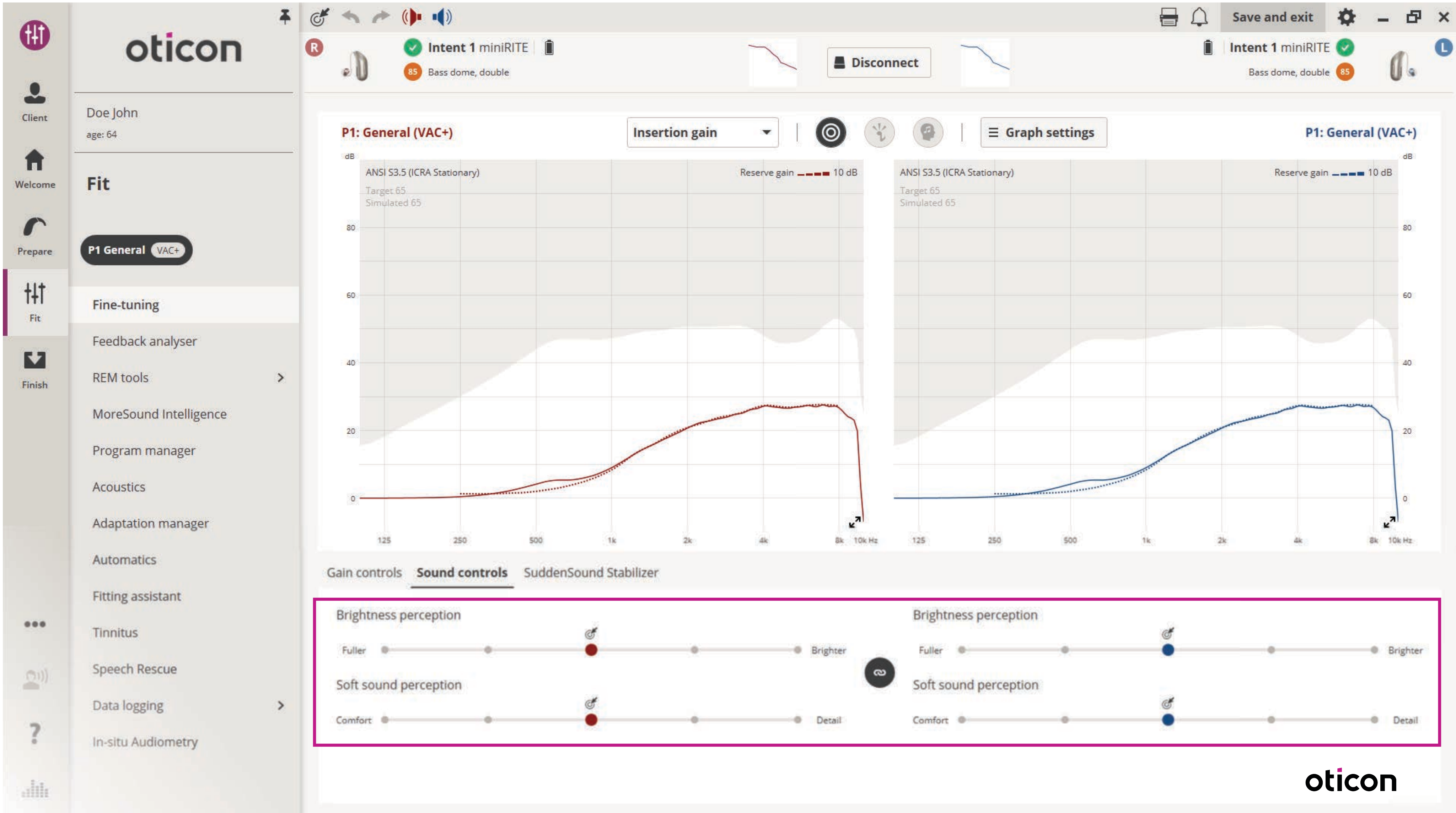

Personalized for your client
Brightness and soft sound perception



oticon
Client
Welcome
Prepare
Fit
Finish
Doe John
age: 64
Fit
P1 General VAC+
Fine-tuning
Feedback analyser
REM tools
MoreSound Intelligence
Program manager
Acoustics
Adaptation manager
Automatics
Fitting assistant
Tinnitus
Speech Rescue
Data logging
In-situ Audiometry
Save and exit
Intent 1 miniRITE
Bass dome, double
Disconnect
P1: General (VAC+)
Insertion gain
Graph settings
ANSI S3.5 (ICRA Stationary)
Reserve gain 10 dB
Target 65
Simulated 65
Gain controls
Sound controls
SuddenSound Stabilizer
Brightness perception
Fuller
Brighter
Soft sound perception
Comfort
Detail
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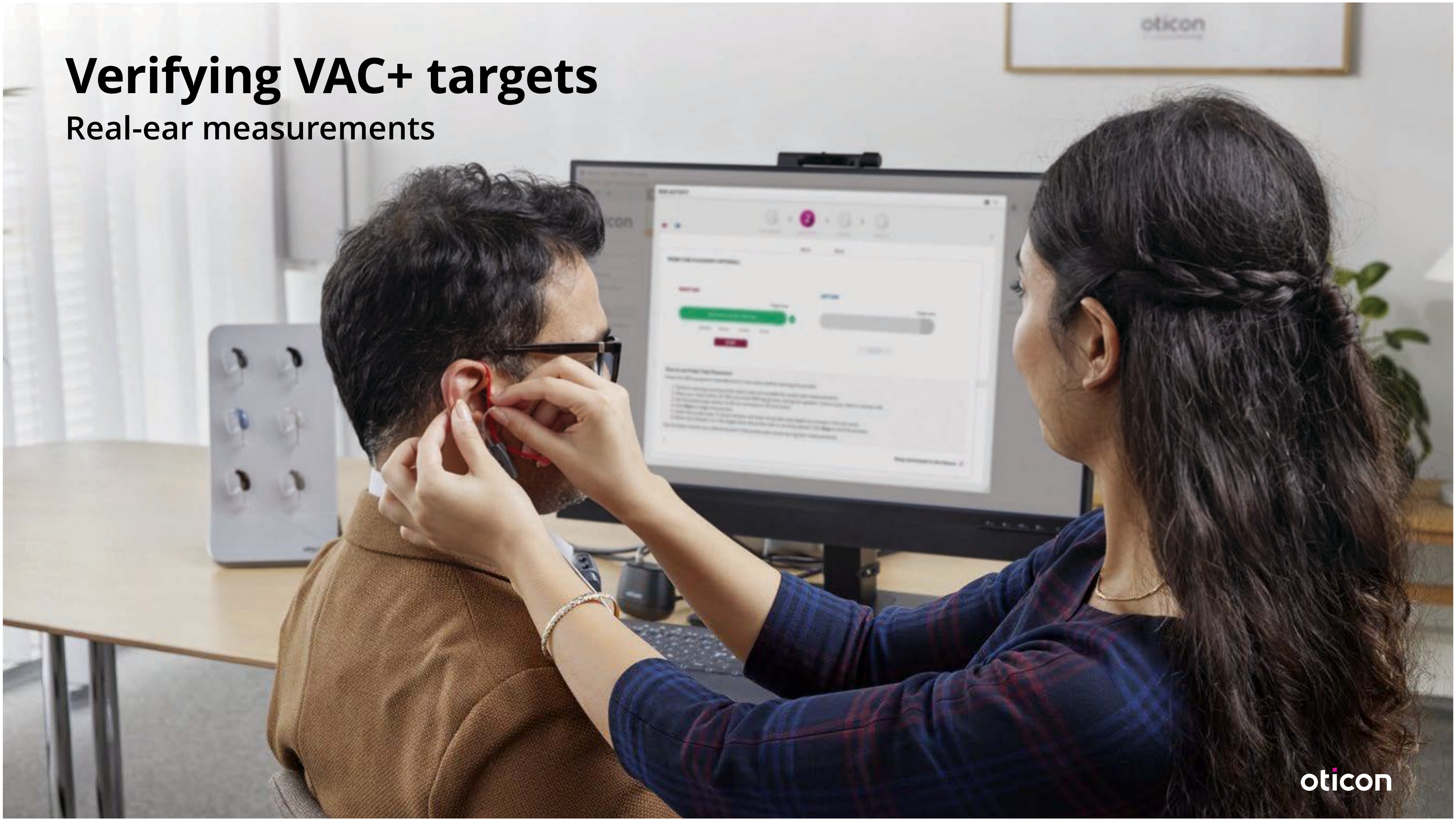
Verifying VAC+ targets

Real-ear measurements



Important Points About REM

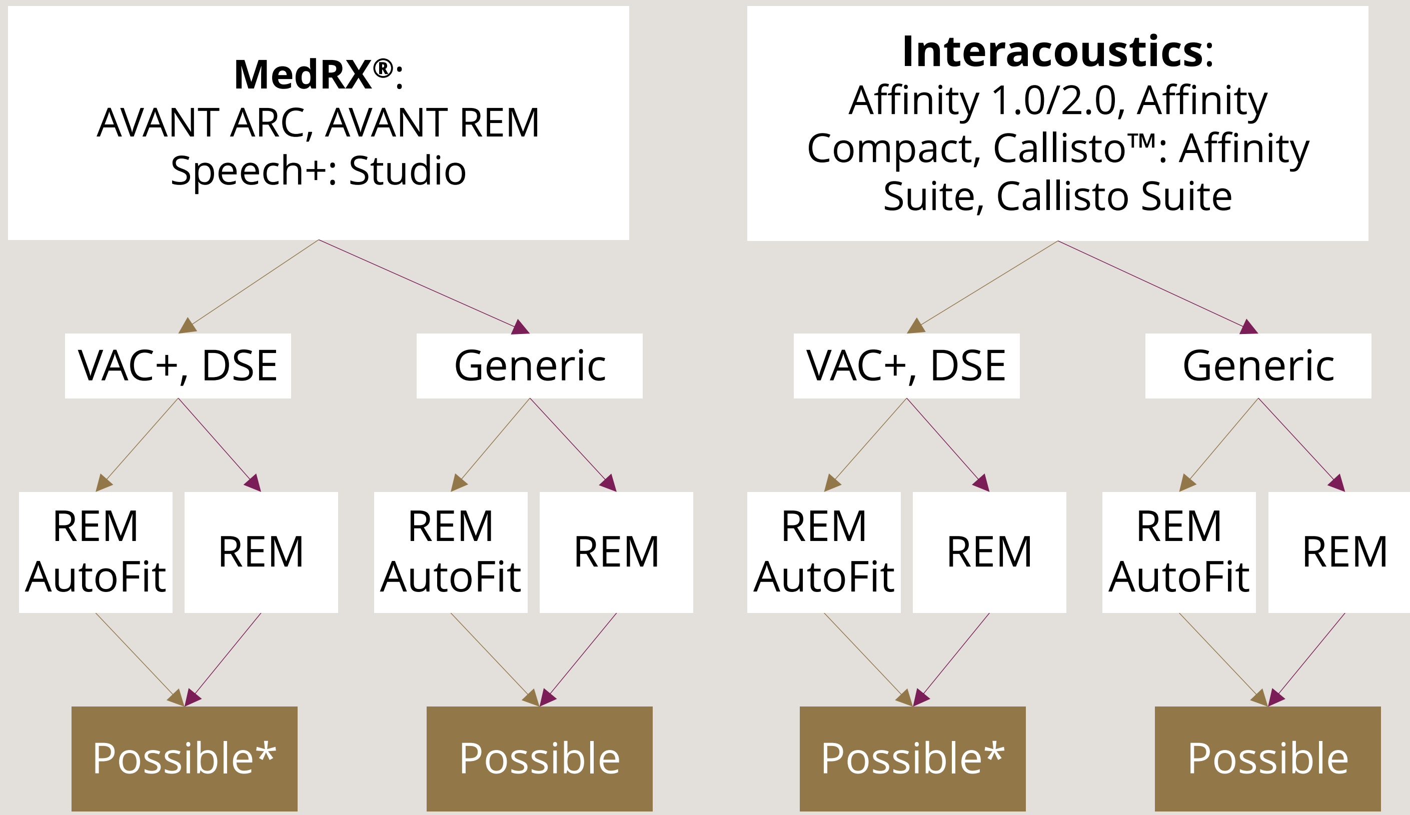
- Performing real ear measurement is not the same thing as matching targets.
- Real-ear is about measuring what is happening in the ear canal.
- It CAN be used to match targets
- Regardless of which algorithm you choose to use and whether or not your clinical expertise leads you to deviate from those targets, you should perform testing to determine what is happening in the patient's ear canal

Can I verify using Oticon targets?

What fitting system are you using?

Which rationale do you want to use to verify?

Do you want to use AutoFit or Conventional REM?



*To perform conventional REM with VAC+/DSE, the REM module needs to be launched from the REM tool in Oticon Genie 2. Note: Generic rationales refer to non-proprietary rationales such as NAL-NL2 and DSL v5

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Can I verify using Oticon targets?

What fitting system are you using?

Which rationale do you want to use to verify?

Do you want to use AutoFit or Conventional REM?

- **Audioscan®**: Verifit® 1/2
  - VAC+, DSE
    - REM AutoFit → Not Possible
    - REM → Not Possible
  - Generic
    - REM AutoFit → Possible
    - REM → Possible
- **Natus Aurical Freefit**: Otosuite®
  - VAC+, DSE
    - REM AutoFit → Possible
    - REM → Limited as VAC+/DSE is not supported
  - Generic
    - REM AutoFit → Possible
    - REM → Possible

*To perform conventional REM with VAC+/DSE, the REM module needs to be launched from the REM tool in Oticon Genie 2. Note: Generic rationales refer to non-proprietary rationales such as NAL-NL2 and DSL v5

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Verifying using the Speech Intelligibility Index (SII)

Assessing how much of the **speech signal is audible** to the client

Using the SII for Hearing Aid Fittings

AJA

Tutorial

The Speech Intelligibility Index: Tutorial and Applications for Children Who Are Deaf and Hard of Hearing

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ABSTRACT

Purpose: Speech audibility refers to how much access a listener has to the acoustic cues that comprise spoken communication. The Speech Intelligibility Index (SII) is a measure of speech audibility that has had increasing use in pediatric audiology to quantify auditory access with and without hearing aids. This tutorial focuses on clinical applications of the SII in children who are deaf and hard of hearing (DHH).
Method: We discuss the calculation of the SII and the current clinical tools that calculate aided and unaided SII. We describe practical uses of the SII throughout the steps of audiologic care, including at diagnosis of hearing loss, hearing technology candidacy, hearing aid verification, and long-term management of children who are DHH. Common questions about clinical applications of the SII are addressed throughout the tutorial. Finally, we present three case studies that illustrate the application of SII to clinical decision making and counseling with children and their families.
Conclusions: The SII has multiple applications in pediatric audiology. Speech audibility can support device candidacy and management decisions for children who are DHH.

Wiseman, K. B., Sapp, C., Stiles, D., Walker, E. A., & McCreery, R. W. (2025). The Speech Intelligibility Index: Tutorial and Applications for Children Who Are Deaf and Hard of Hearing. *American journal of audiology*, 1–17. Advance online publication. https://doi.org/10.1044/2025_AJA-24-00267

AUDIOLOGYONLINE
a Continued family site

20Q: Using the Aided Speech Intelligibility Index in Hearing Aid Fittings

Level: Intermediate | 1 Hour | Course: #31978

Course Description

This course explains the Speech Intelligibility Index (SII) and how hearing care professionals can integrate it into their hearing aid fittings. It is written in an engaging Q & A format.

Presenters

Susan Scollie, PhD

Scollie, S.D. (2018). 20Q: Using the aided speech intelligibility index in hearing aid fittings. AudiologyOnline, Article23707. Retrieved from www.audiologyonline.com

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Evidence from a clinical investigation

Highlights from a clinical investigation

Ghamkhar, 2025.
Oticon Whitepaper

VAC+ performed **comparably to NAL-NL2**

25% improvement in **subjective overall hearing** with VAC+

Higher SII at 50dB for VAC+ than for NAL-NL2

Methods

Participants

8 first-time hearing aid users

Aged between **52** and **82** years (mean = 68)

Bilateral sensorineural hearing loss

No known **cognitive impairment**

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Methods

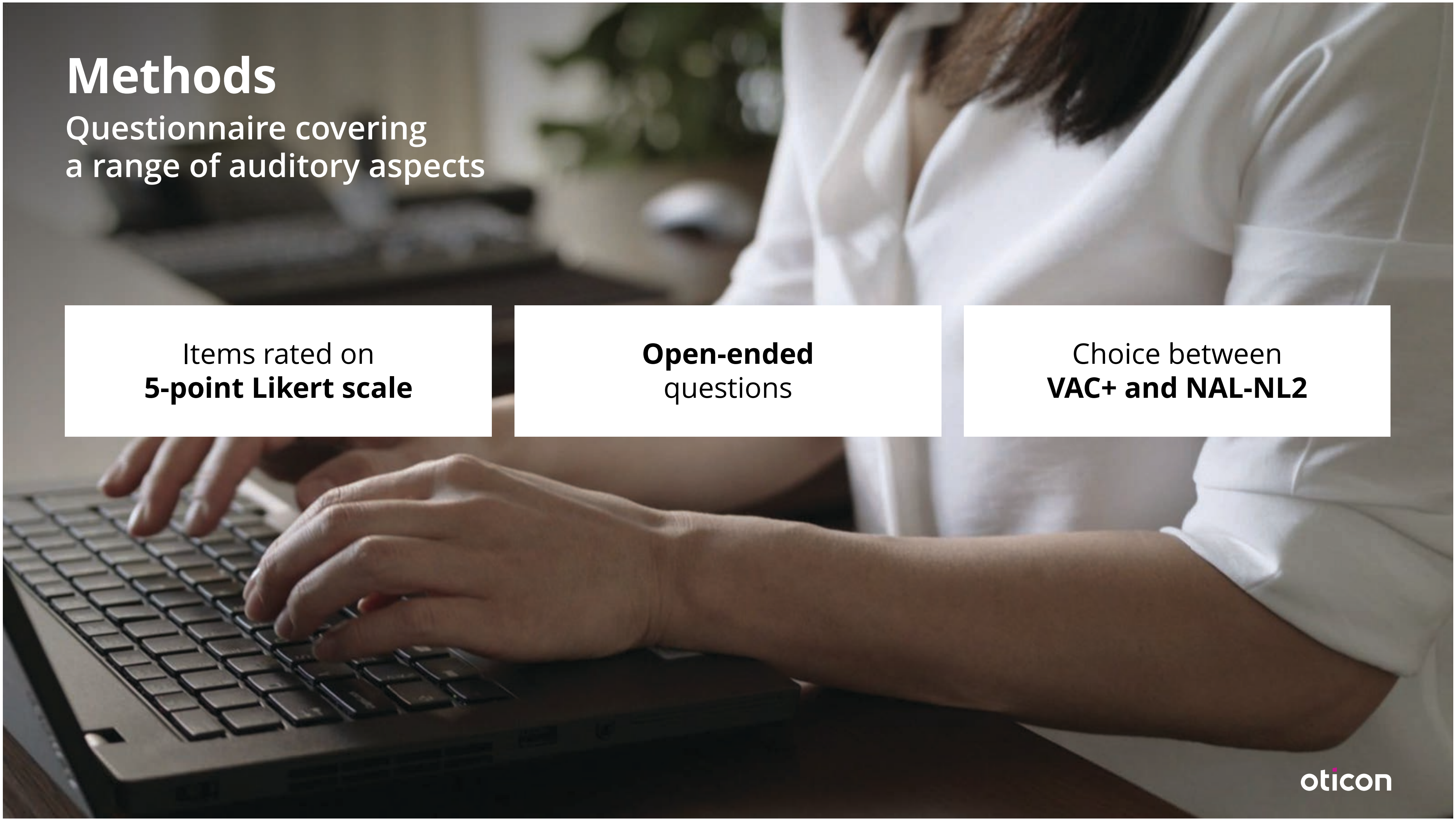
Trials of VAC+ and NAL-NL2

	1	2	3
Group **V**	VAC+	VAC+ NAL-NL2	NAL-NL2 Both
Group **N**	NAL-NL2	NAL-NL2 VAC+	VAC+ Both

oticon

Methods

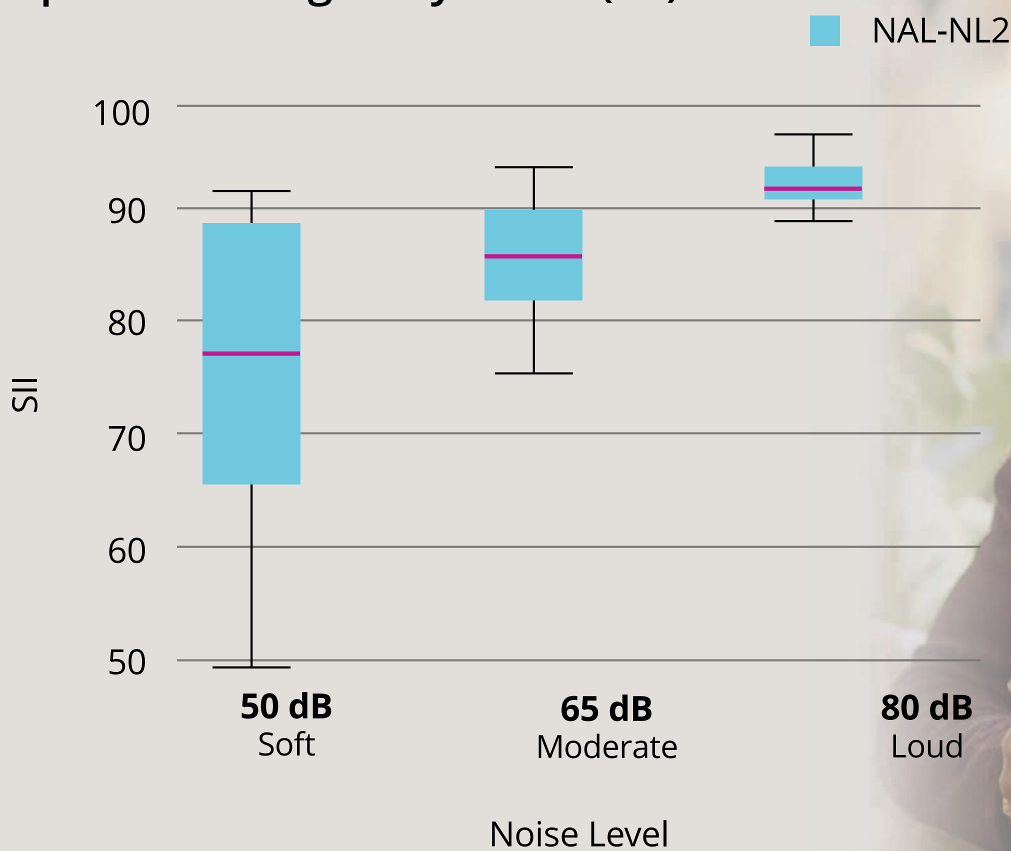
Questionnaire covering a range of auditory aspects



Items rated on **5-point Likert scale**	**Open-ended** questions	Choice between **VAC+ and NAL-NL2**

Results

Speech intelligibility index (SII)



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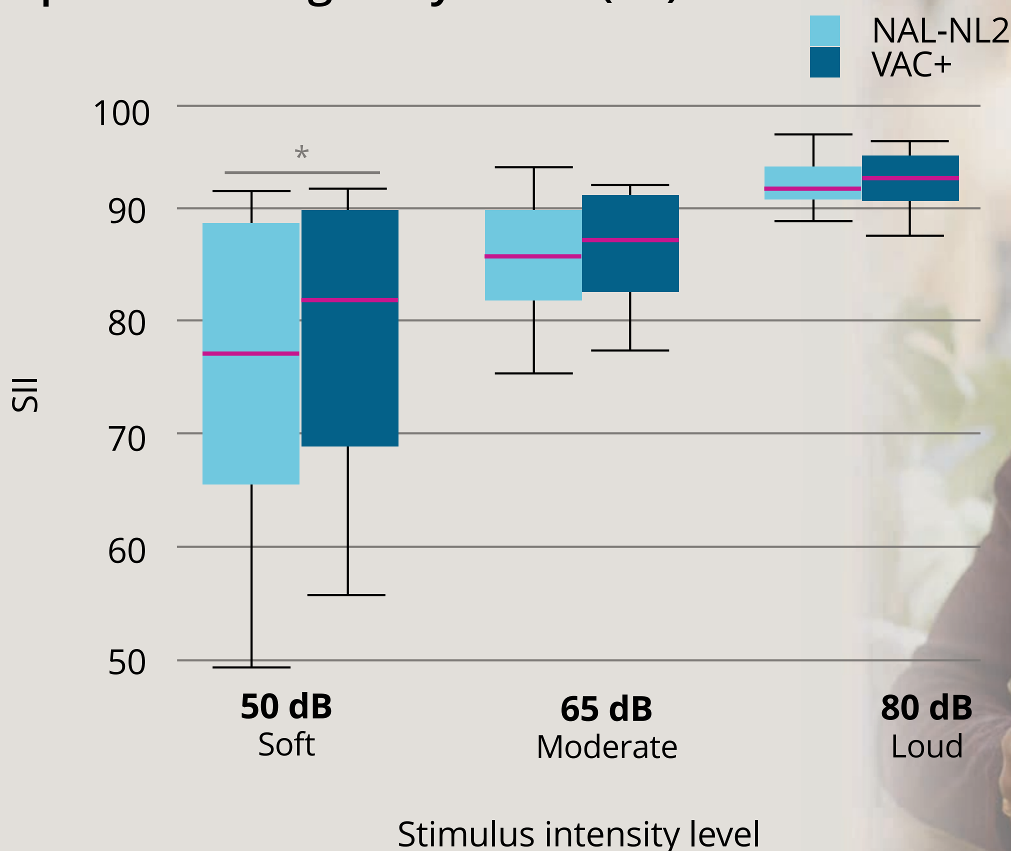
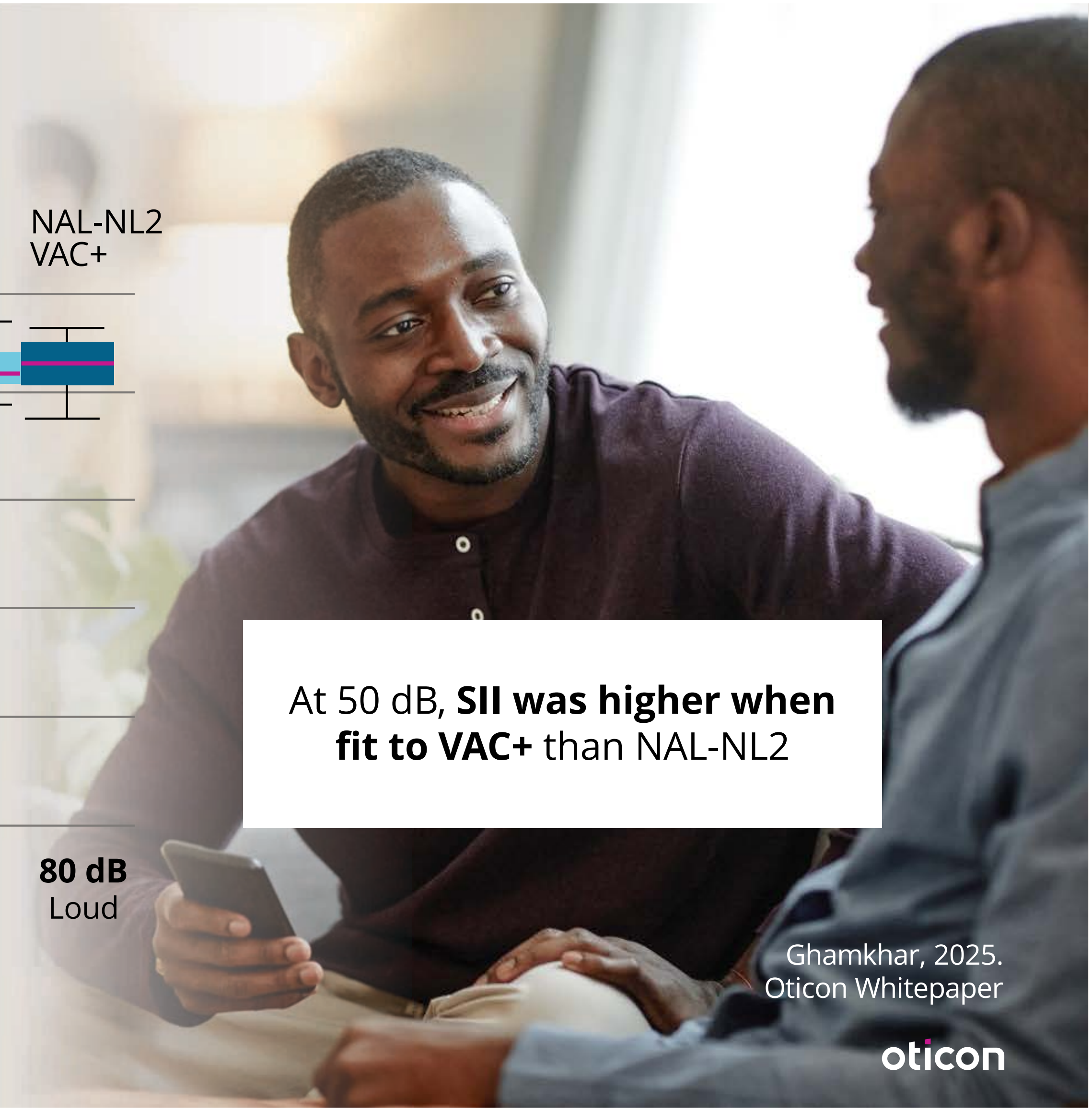
Results

Speech intelligibility index (SII)





At 50 dB, **SII was higher when fit to VAC+** than NAL-NL2

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Results
Questionnaires
Adaptation time
Speech clarity
Sound quality
Listening comfort
Help in loud environments
No difference or preference between rationales for the majority of questionnaire items
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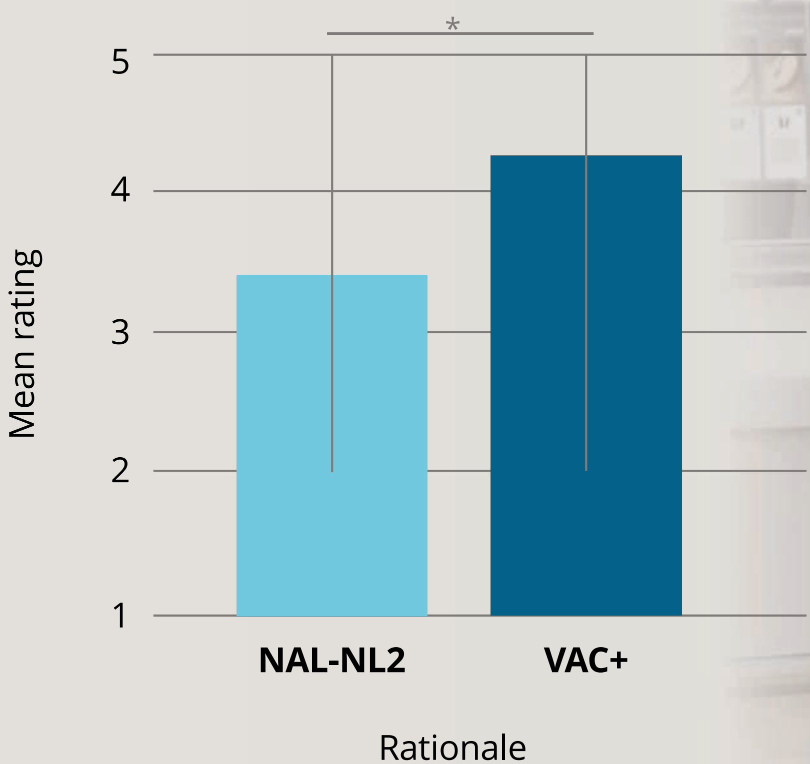
Results

Perceived improvement in overall hearing



25%

improvement in subjective overall hearing when fit to VAC+

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Conclusion

VAC+ provided **better access to soft speech**

VAC+ gave a **25% improvement** in **overall hearing experience**

VAC+ is a **clinically valid rationale** and a **great alternative to NAL-NL2**

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Learn more...

The Oticon VAC+ fitting rationale. [White paper]

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