Coupling Matters: Understanding the Acoustic Effects of Domes, Earmolds and Encased Receivers

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Learning Outcomes

Formulate more acoustically informed decisions regarding dome vs. earmold selection.

Understand more accurate venting concepts to balance openness, transparency, feedback control and sound quality.

Use coupling solutions for troubleshooting with hearing aid complaints.

Limitations/Risks

The applicability and accuracy of the course content may vary by the clinical, geographical, and cultural context; you should evaluate the course accordingly.

Healthcare providers should apply cultural competence and sensitivity to ensure effective and respectful care based on their patients' diverse needs.

It is the responsibility of course participants to critically evaluate the evidence from multiple sources to guide professional practice.

Coupling matters: Understanding the acoustic effects of domes, earmolds and encased receivers

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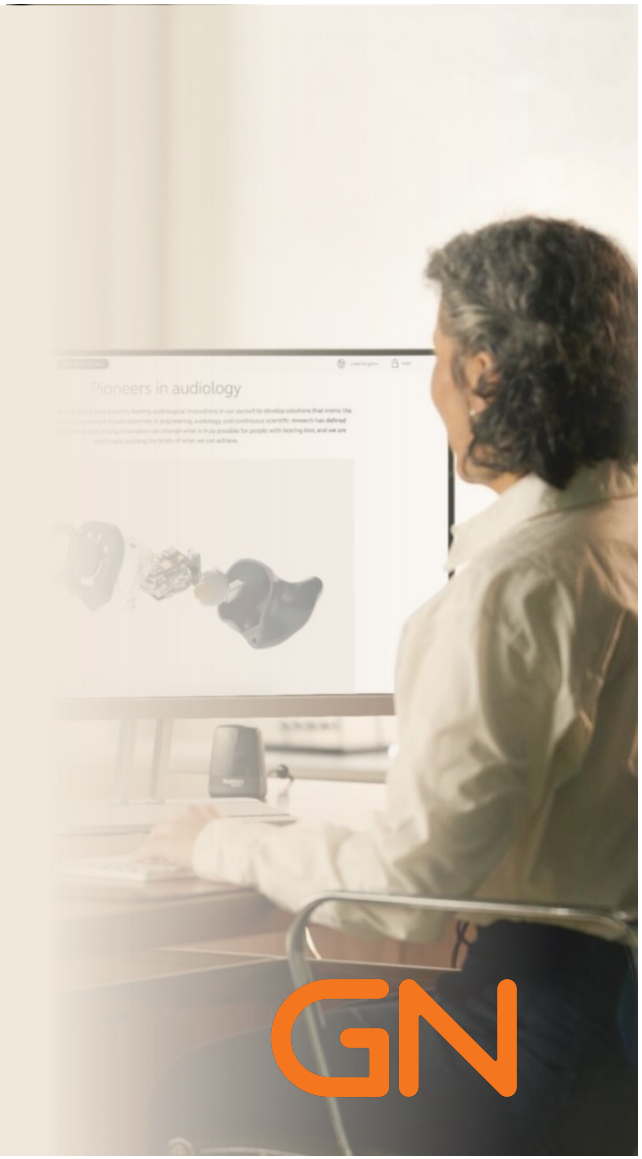
Global Audiology, GN Hearing

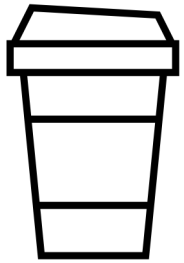


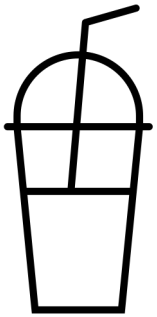
Overview

- Review of ear coupling
- Effects of ear coupling
- Selection for fitting
- Selection for solution

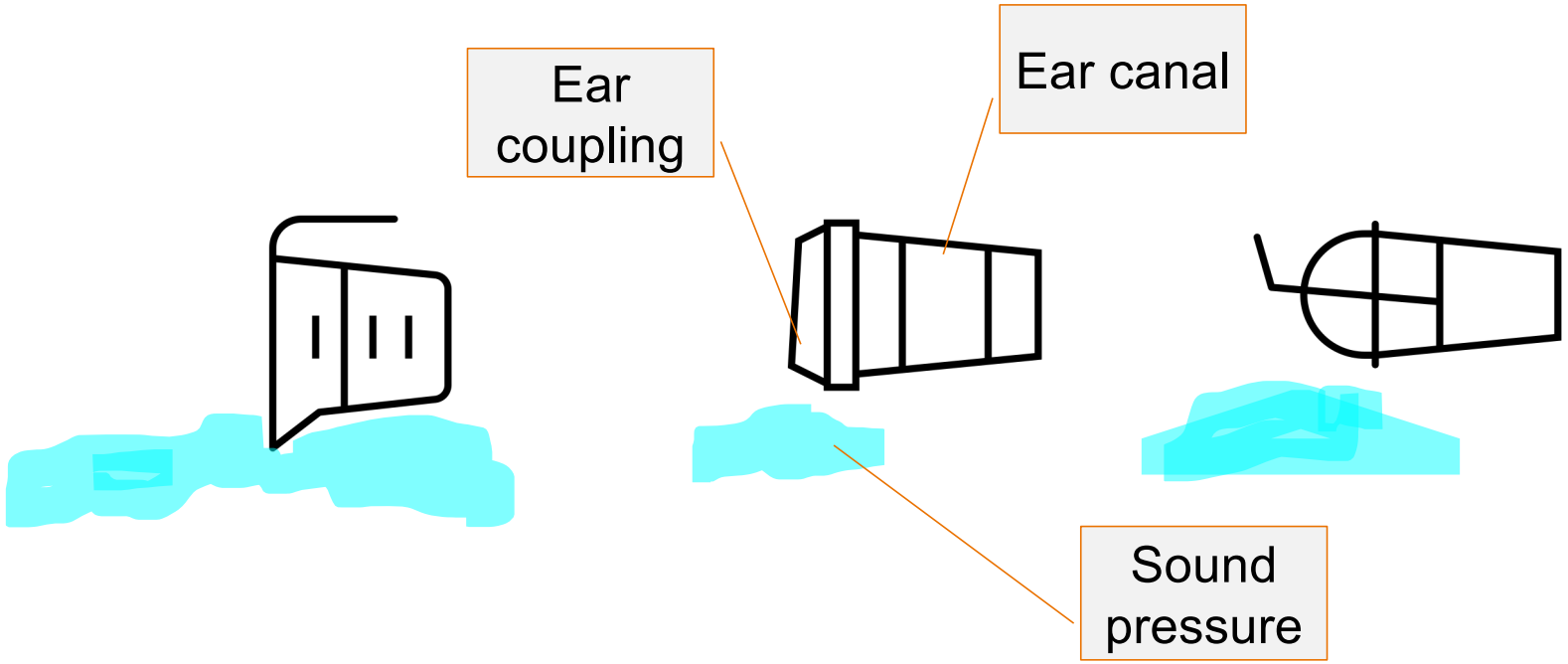
Review

Review - What is ear coupling, really?

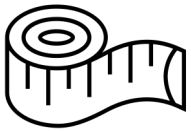




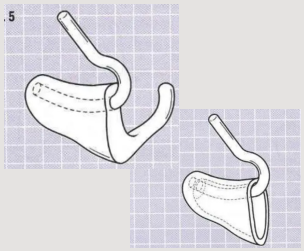
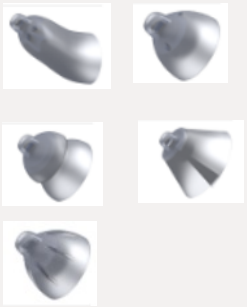
Review - What is ear coupling, really?



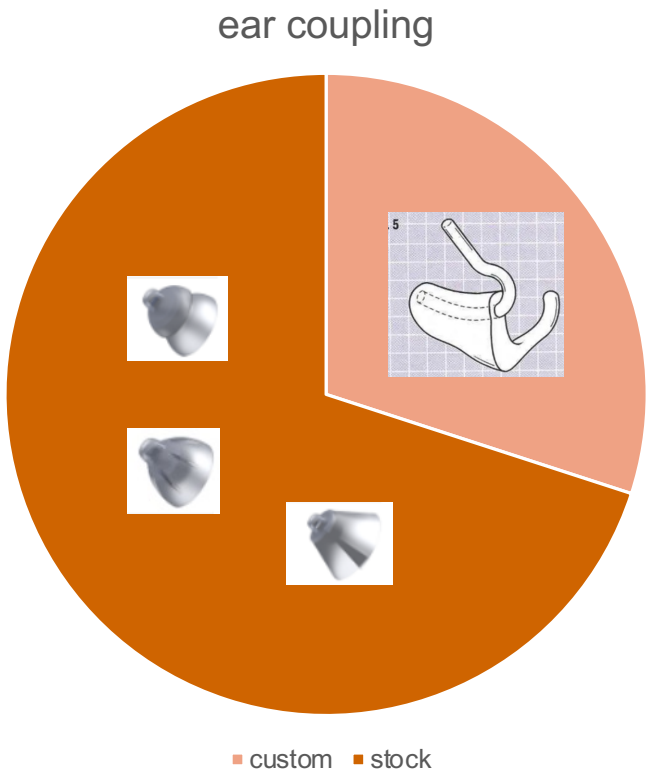
Effects



Review - Effects

The “lids”	Type	style	size	depth	venting
	Custom mold	• Solid • Hollow	• custom	• custom	• None through 4mm
	Stock dome	• open • Semi occluded • occlusive	• XS to XL		• Occlusive through open

Review - Effects



Cubik, 2022 (Ear&Hearing)

Review - Effects

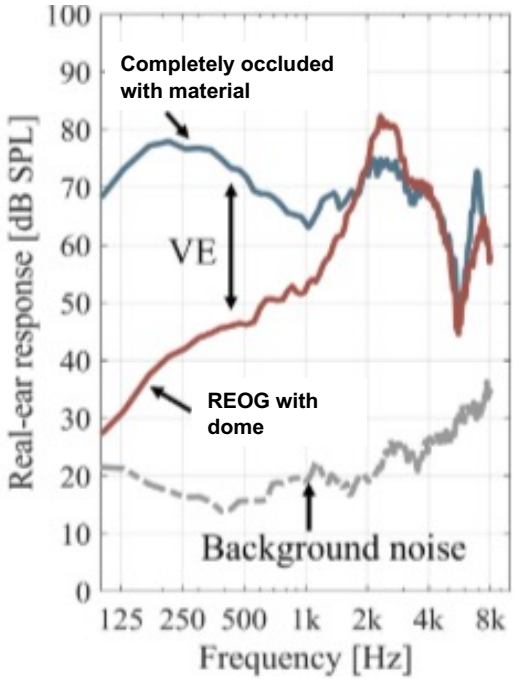
The Acoustics of Instant Ear Tips and Their Implications for Hearing-Aid Fitting

Cubick, Jens[1]; Caporali, Sueli[1]; Lelic, Dina[1]; Catic, Jasmina[1]; Vikær Damsgaard, Anne[1]; Rose, Steen[1]; Ives, Terri[1]; Schmidt, Erik[1]

- 58 ears
- 5 domes types – open, 2 varieties of semi open, tulip, and double dome
- Evaluated
  - objective occlusion via vent effect
  - subjective occlusion via rating
  - reinsertion effects
  - acoustic transparency

Review - Effects

- 3 principles to apply:
  - Vent effect – compare complete occlusion to earpiece occlusion (REOG)
  - Transparency – compare REUG to REOG
  - Subjective occlusion – wearer's sense/tolerance of occlusion

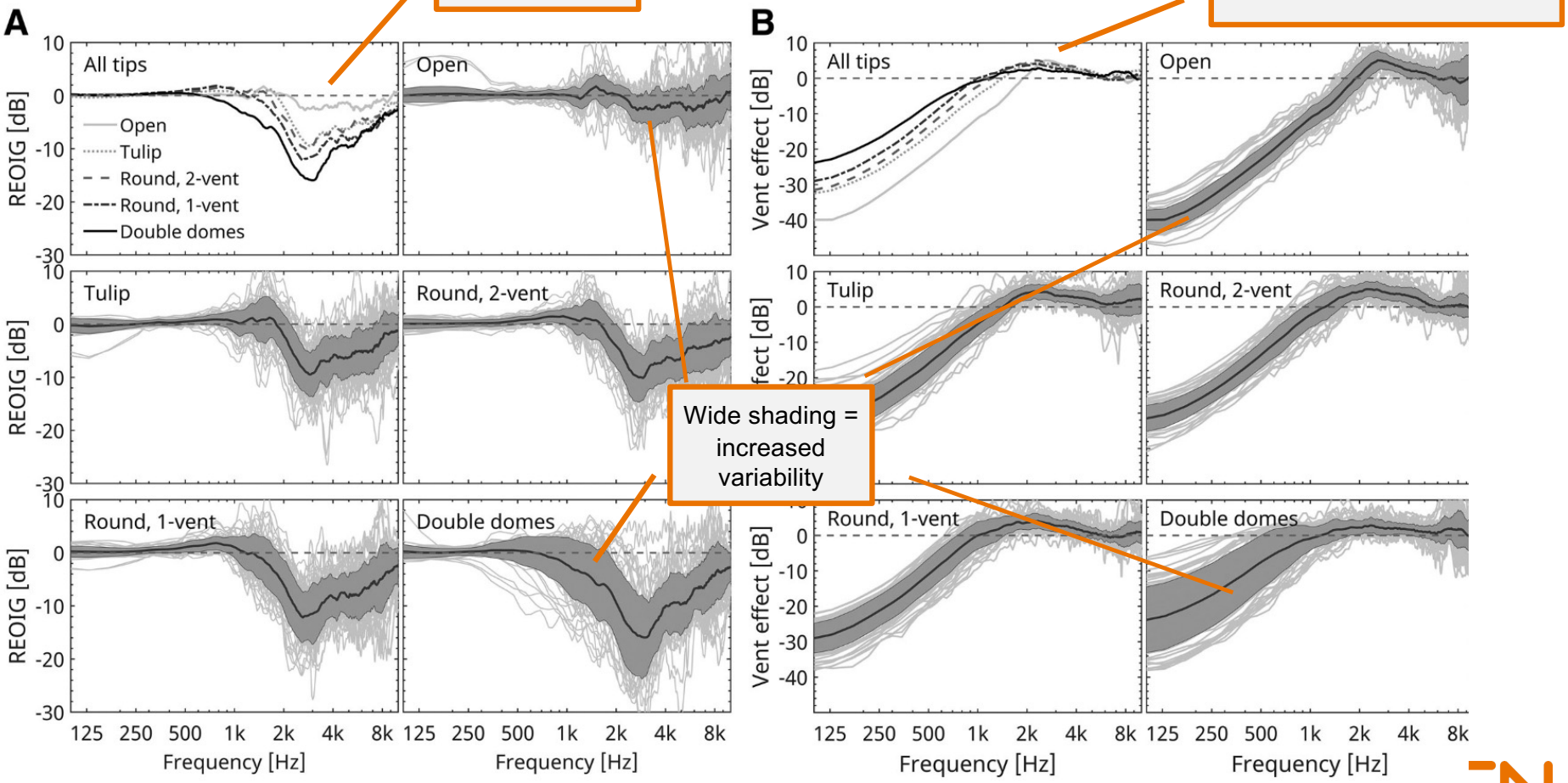


Review - Effects

Transparency: 0 = most like the open ear

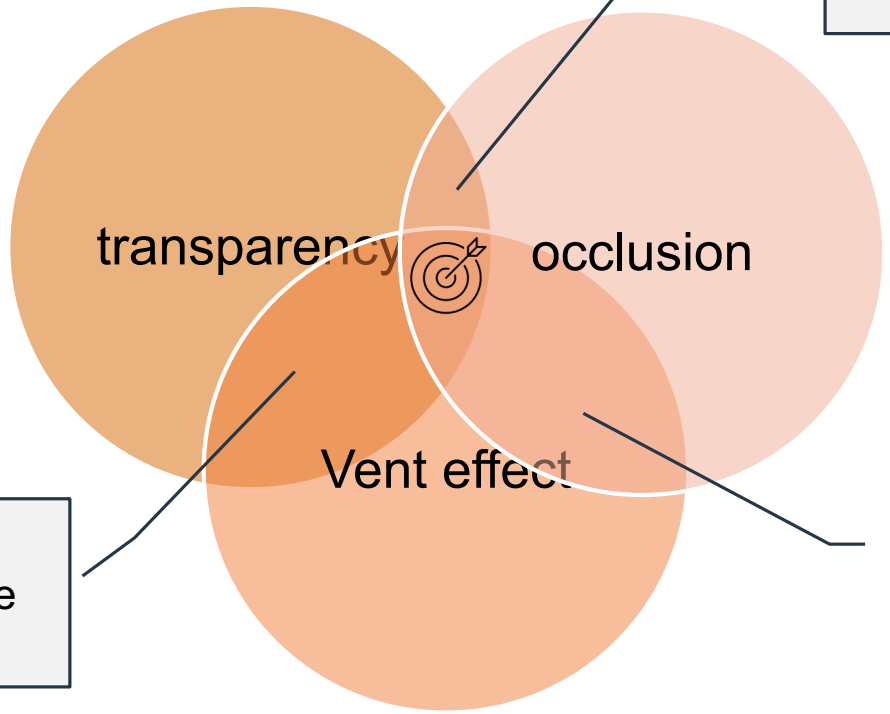
Vent effect: 0 = full occlusion

Wide shading = increased variability



A, Average REOIG across 58 ears for the five ear tips (top left) and (B) average VE across 58 ears for each ear tip (top left). The remaining panels in each sub-figure show the average REOIG or VE per tip (thick line) +/− one standard deviation (shaded area). The light gray lines represent individual measurements. REOIG indicates real ear occluded insertion gain.

Review - Effects



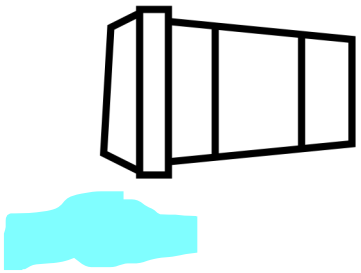
transparency and occlusion are related with low Hz gain, but inversely related without gain

Vent and transparency are related

Vent and occlusion are inversely related

Selection for Fitting

Fitting

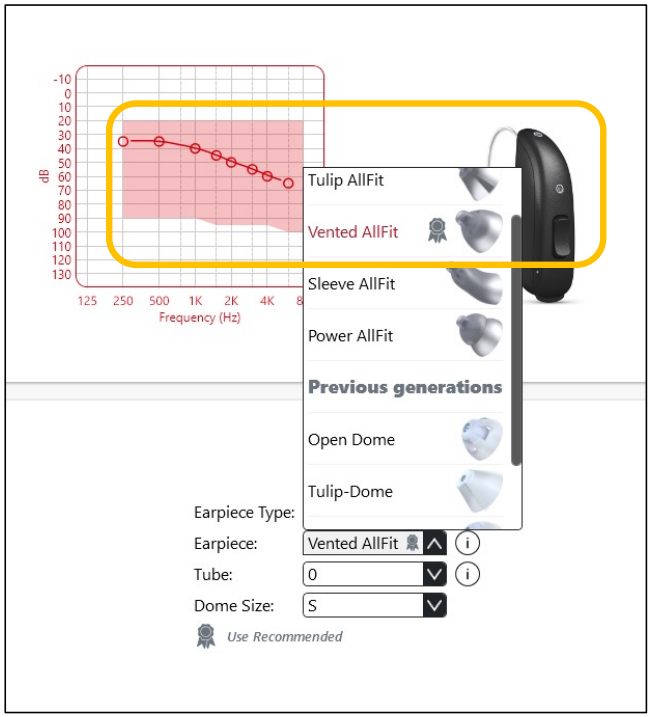


Decision based on *objective* information:

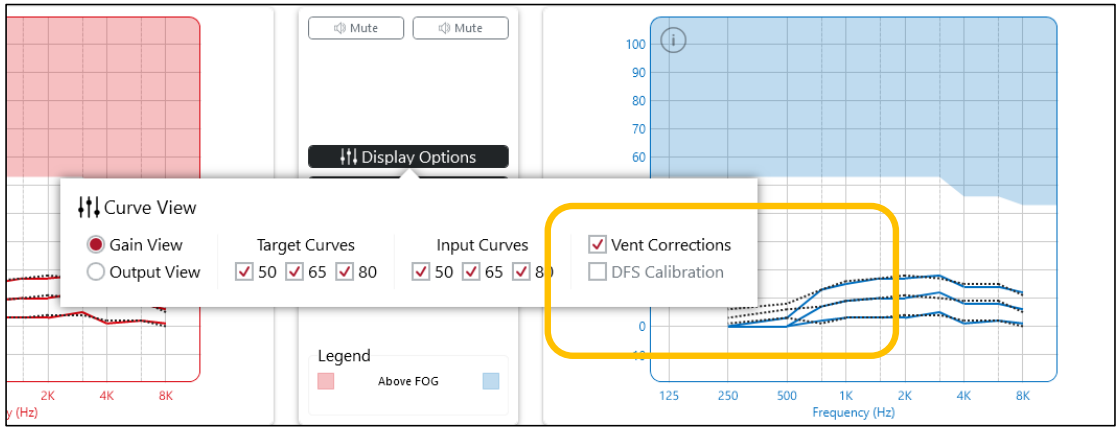
- How much leakage are you (the HCP) willing to tolerate?
- What size lid do we need for the cup?
- Will the wearer be able to use the this on their own?

Fitting – How much leakage?

Recommendation Badge



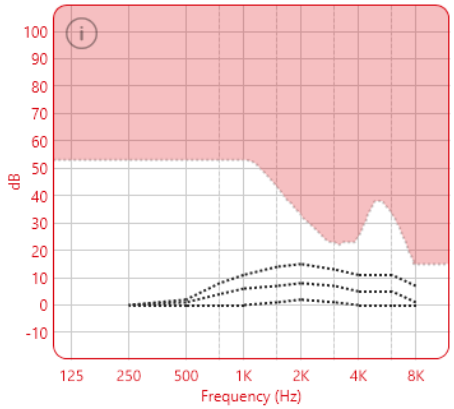
Vent Correction View

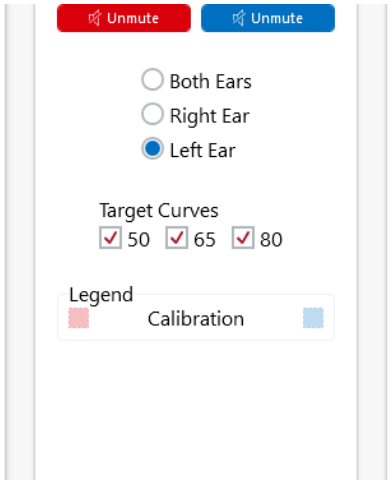


Fitting – How much leakage?

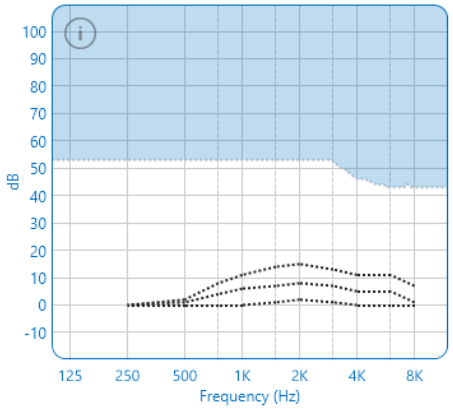
Calibration Curve

Open fitting =
deep calibration curve





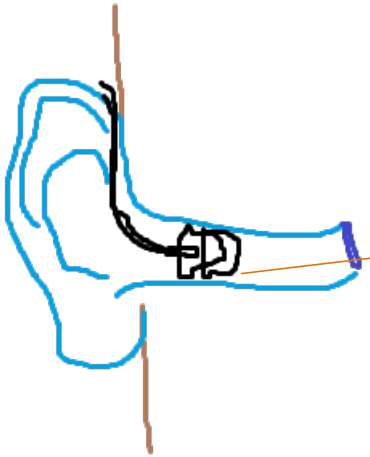
Occluded fitting =
shallow calibration
curve



Fitting – What size lid?

- Canal shapes and sizes vary therefore choosing the correct size ensures the correct function

Too small = gaps from not meeting canal wall



Too large = gaps from crumpling or folding

Dome Portfolio

Legacy domes		AllFit domes
 3 sizes (S,M,L)	Open	 5 sizes (XS,S,M,L,XL)
 3 sizes (S,M,L)	“Vented”	 5 sizes (XS,S,M,L,XL)
 3 sizes (S,M,L)	Power	 4 sizes (S,M,L,XL)
 1 size	Tulip	 2 sizes
	Sleeve	 3 sizes (S,M,L)

Market Surveys




Sample Questions:

- What dome sizes do you feel are missing or needed?
- Which types of domes are missing these sizes?
- Do you think that GN domes “collapse” too easily?
- Would a larger fish box/tackle box be too large if it had more dome sizes in it?
- Are there any types of domes missing from GN’s offering which you would like to see?

Market Survey Results

- "we need a larger dome option"
- "there should be an intermediate size dome between small and medium"
- "it would be great to have a universal/non-custom micromold"
- "more size options for tulip domes"
- "need better wax protection, wax gets stuck in domes"
- "need better durability – patients with dexterity issues easily tear their domes"

Jabra SESAME studies

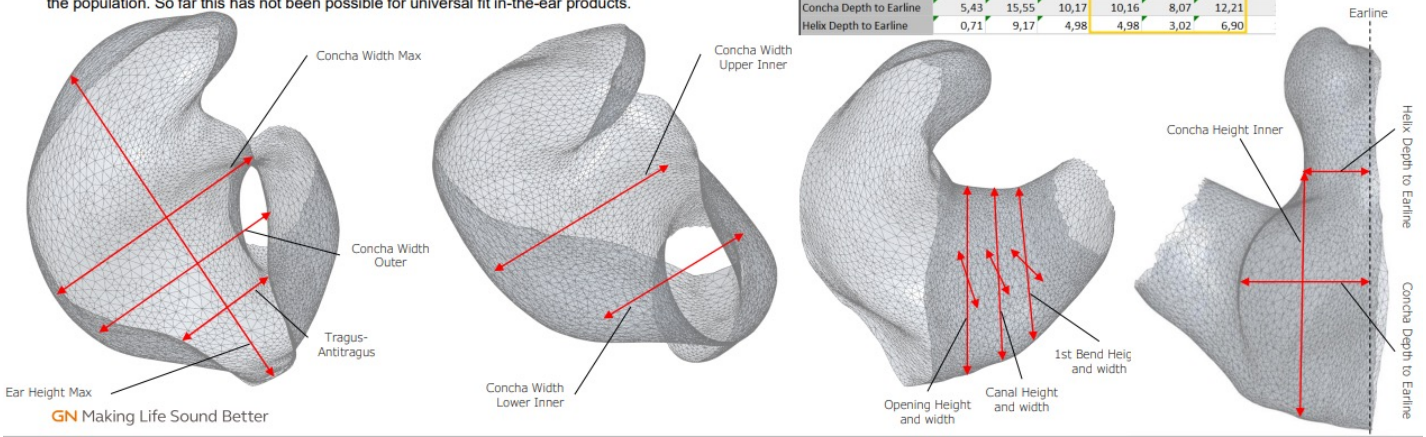
Comfort Design Guide – In-ear dimensions

To guide the earbud design and run the Fit Simulations 14 critical measurement points are used. Using the Mean Shape Ear as reference, the SESAMe tool generates a normal distribution on the exact same dimensions on a randomized sample of 10.000 out of the 62.000 ears. The reference points and measurements are found in the comfort library CREO files.

In general there is very poor correlation between the different dimensions, which means we cannot talk about "small or large" ears: An ear with a very narrow canal may well have a very wide concha. An exception is that there is correlation in the dimensions of the ear canal opening and the 1st bend: Height, width and ratio between them correlates nicely in the same ear. Across ears, the ear canal height, width and ratio bewteen them varies greatly.

Best practice for human factors design is to design for the 5th to the 95th percentile of the population. So far this has not been possible for universal fit in-the-ear products.

Measurements	Minimum	Maximum	Median	Mean	5 percentile	95 percentile
Tragus-Antitragus	2,33	16,57	10,09	10,10	7,31	12,90
Concha Width Outer	6,54	24,62	16,10	16,11	12,81	19,49
Concha Width Max	11,01	27,56	19,26	19,26	15,87	22,77
Concha Width Lower Inner	6,40	19,06	12,96	12,96	10,28	15,70
Concha Width Upper Inner	12,85	28,49	19,69	19,71	16,62	22,89
Concha Height Inner	9,75	24,83	17,50	17,49	14,89	20,08
Ear Height Max	20,42	40,03	30,53	30,55	26,59	34,54
Opening Height	9,70	23,14	15,88	15,92	13,10	18,98
Opening Width	3,82	14,73	8,96	8,98	6,56	11,45
Canal Height	7,42	21,11	13,66	13,71	10,77	16,79
Canal Width	1,92	13,84	7,95	7,95	5,40	10,49
1st Bend Height	5,49	19,45	11,98	12,05	9,15	15,12
1st Bend Width	2,41	13,32	7,81	7,80	5,44	10,17
Notch Width	2,41	12,27	7,67	7,67	5,60	9,73
Concha Depth to Earline	5,43	15,55	10,17	10,16	8,07	12,21
Helix Depth to Earline	0,71	9,17	4,98	4,98	3,02	6,90

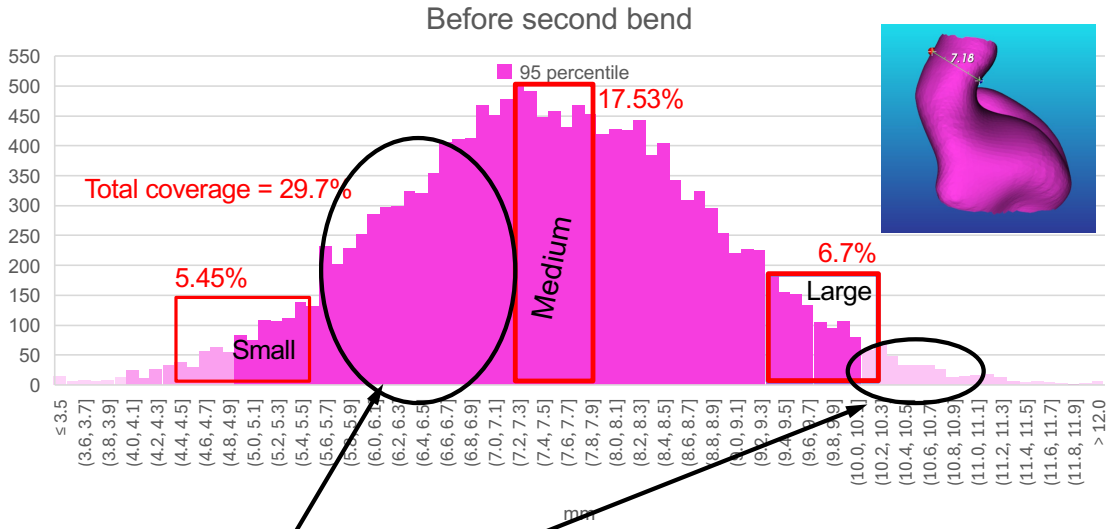


GN Making Life Sound Better

Dome Size Distribution: Market Feedback and SESAME data

Most common feedback:

- The gap between SF3 Small and Medium is too big, we need a size in between
- The Large dome is not big enough



SF3	
Size designation	Diameter [mm]
Open / Closed	mm
Small	5.09
Medium	7.64
Large	10.0

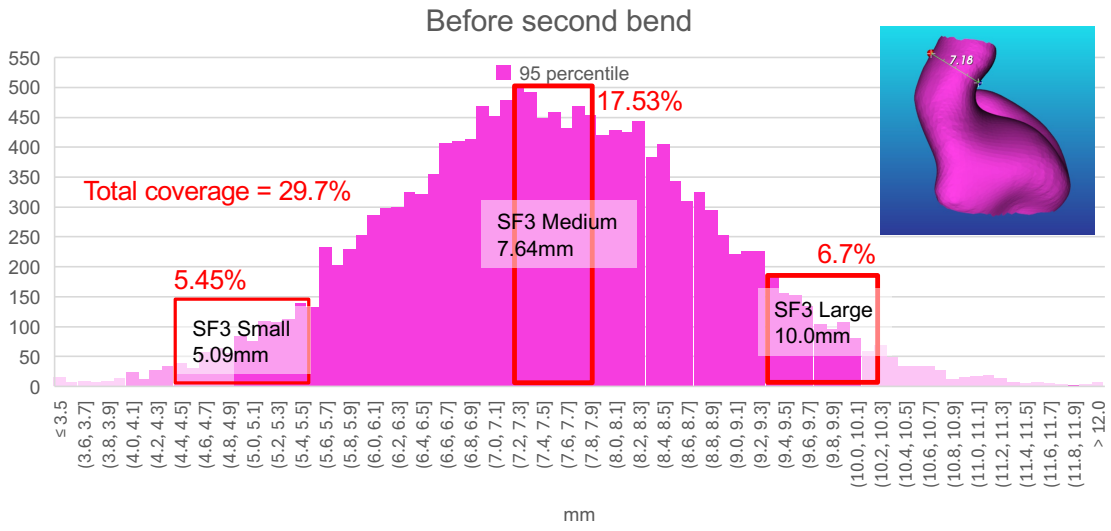
"We need a size between Small and Medium"

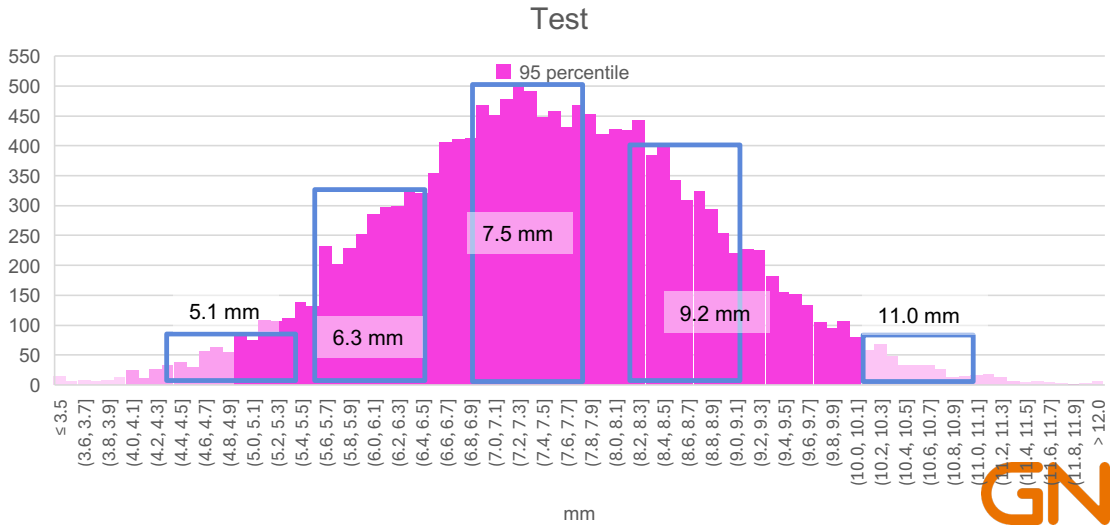
"We need a size bigger than large"

Improving the Distribution

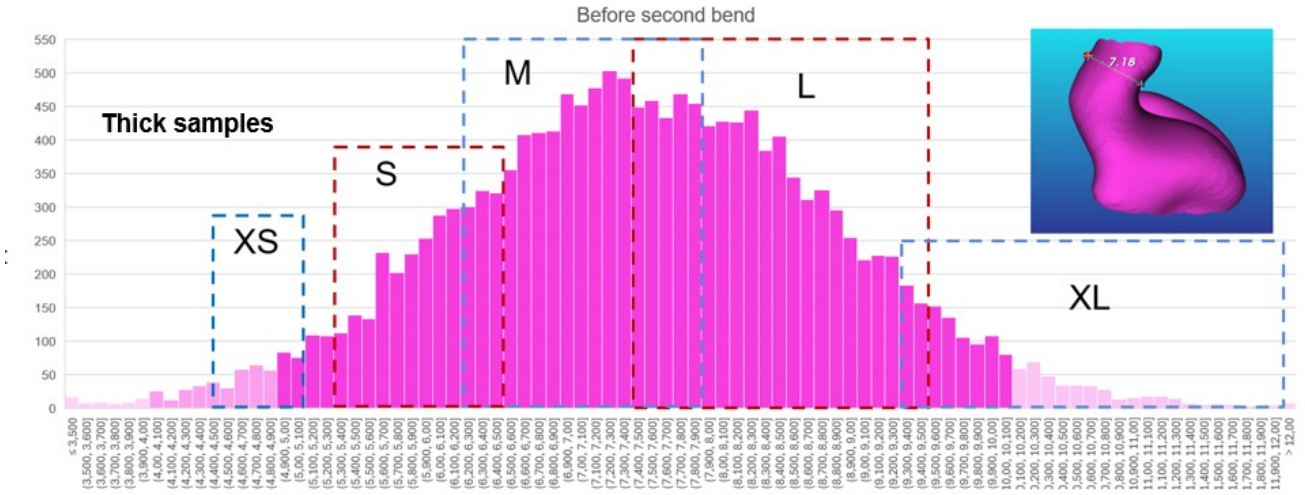
SF3 distribution	
Size designation	Diameter [mm]
Open / Closed	mm
Small	5.09
Medium	7.64
Large	10.0

AllFit distribution propsal
Diameter [mm]
Open / Closed
5.1
6.3
7.5
9.2
11.0



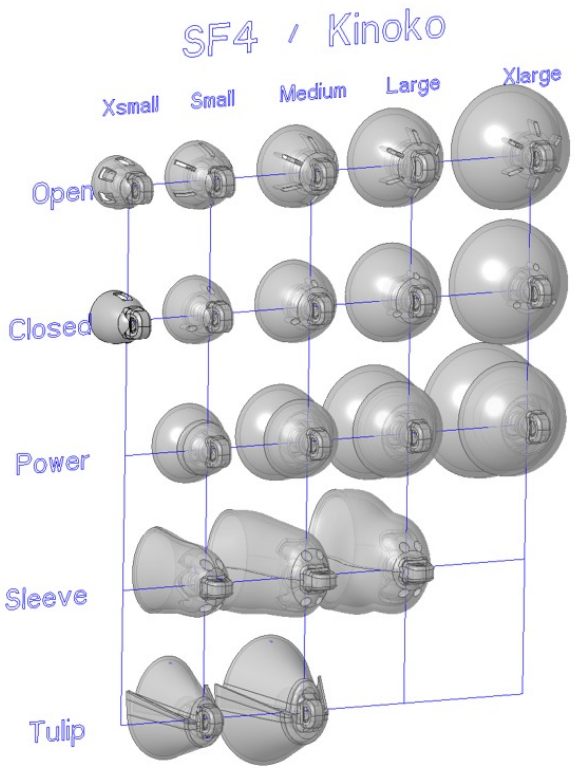


Final Size Distribution

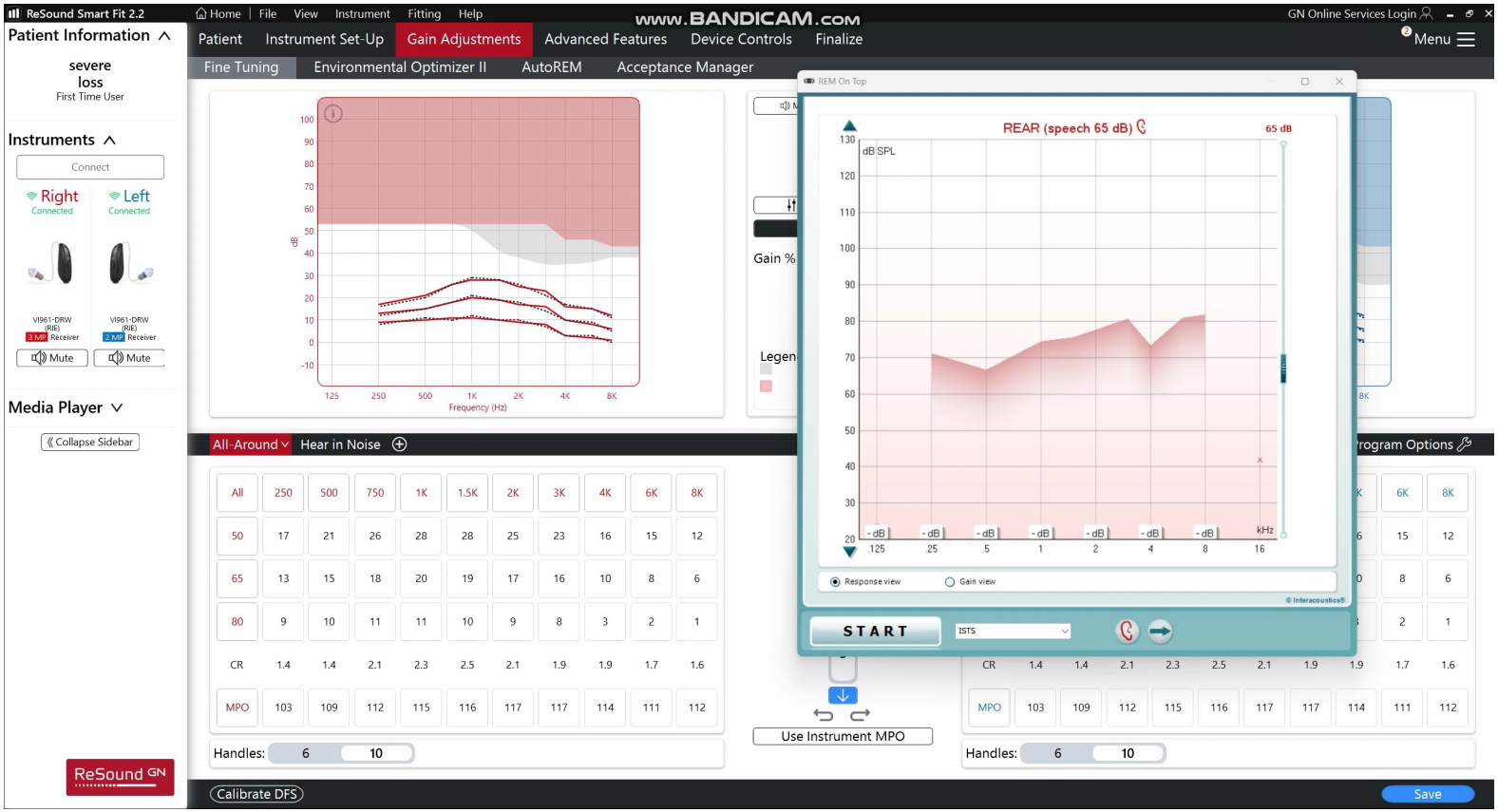


Final Size Diameters

Kinoko size distribution Protos spring 2025	
	Diameter [mm]
Open / Closed	
X-small	5.0
Small	6.5
Medium	7.9
Large	9.5
X-large	12.0
Power	front + rear dome
Small	5.1 + 7.6
Medium	7.6 + 9.2
Large	9.2 + 11
X-Large	11 + 13
Sleeve	Dimension just behind front slope
Small	5.2 x 6.8
Medium	6.1 x 8.4
Large	7.7 x 9.6
Tulip	
Small	8.9 x 10.0
Medium	11.6 x 12.5



Fitting – How much leakage? + What lid size?

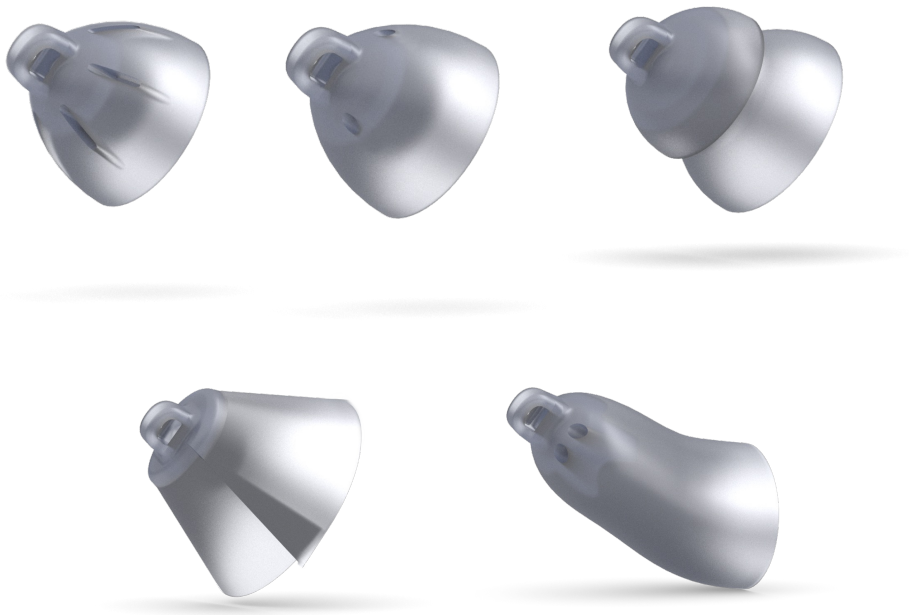


Fitting – Will the wearer be able to use this on their own?

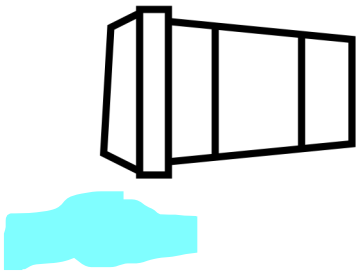
- Studies on reinsertions on domes find:
  - Experience matters! Those that have more experience with dome insertion can insert repeatedly without variability
  - A small amount of variability is found between insertions with lesser experienced users
  - Open domes were reinserted with the least amount of measured variability, double domes with the most

- Considerations:
  - Can the wearer insert the earpiece correctly on their own?
  - Practice makes perfect

Solution: Wax protection improvements based on market feedback



Fitting



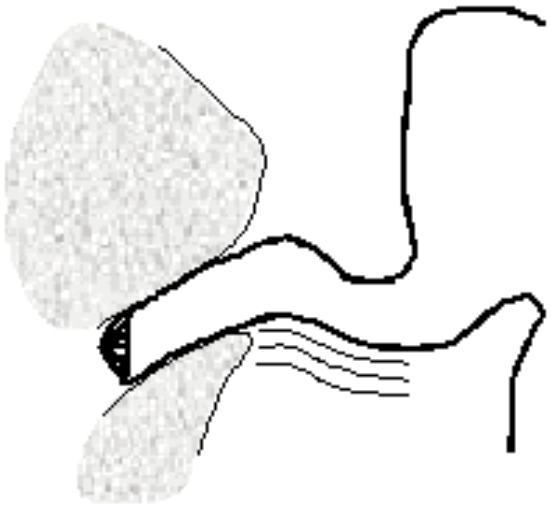
Decision based on *subjective* information:

- How much occlusion is the wearer willing to tolerate?
- How does the earpiece look in the ear?

Fitting - How much occlusion is the wearer willing to tolerate?

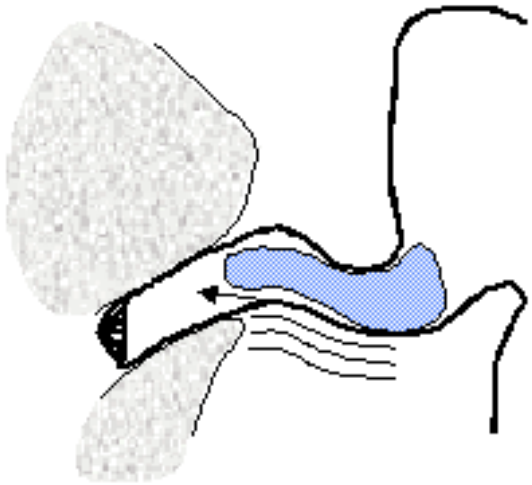
- How is occlusion created?
  - With low transparency earpieces: Low frequency sound pressure at the eardrum created by vibration from vocalizing
  - With high transparency earpieces: Direct and indirect low frequency sound combining in the ear canal

What is Occlusion?



- When a person speaks or chews, the vibrations in the vocal tract are coupled to the bones of the skull and tissues connected to these bones.
- Consequently, the cartilaginous walls in the ear canal will vibrate, thus generating a sound.
- Normally this wouldn't create a problem, as most of the generated sound will escape out of the ear canal.

What is Occlusion?



- When a person is wearing a hearing aid it creates a problem
- The generated sound is trapped within the residual canal volume and the intensity of the patient's own voice increases – especially in the low frequencies

Fitting - How much occlusion is the wearer willing to tolerate?

Low transparency earpieces: Low frequency sound pressure at the eardrum created by vibration from vocalizing

↑↓

High transparency earpieces: Direct and indirect low frequency sound combining in the ear canal

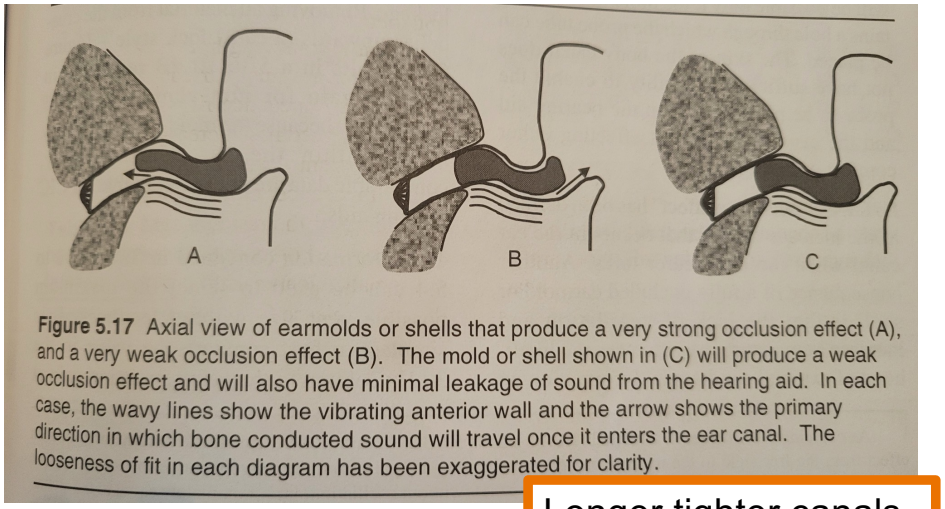
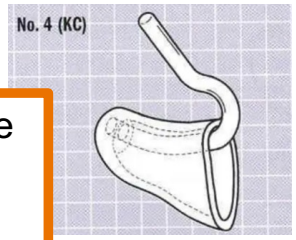


Figure 5.17 Axial view of earmolds or shells that produce a very strong occlusion effect (A), and a very weak occlusion effect (B). The mold or shell shown in (C) will produce a weak occlusion effect and will also have minimal leakage of sound from the hearing aid. In each case, the wavy lines show the vibrating anterior wall and the arrow shows the primary direction in which bone conducted sound will travel once it enters the ear canal. The looseness of fit in each diagram has been exaggerated for clarity.

Longer tighter canals can reduce vibration



Hollow molds require less venting than solid to achieve the same effects

Fitting - How much occlusion is the wearer willing to tolerate?

J Am Acad Audiol 20:480–491 (2009)

Comparison of Vent Effects between a Solid Earmold and a Hollow Earmold

DOI: 10.3766/jaaa.20.8.3

Francis Kuk*
Denise Keenan*
Chi-chuen Lau*

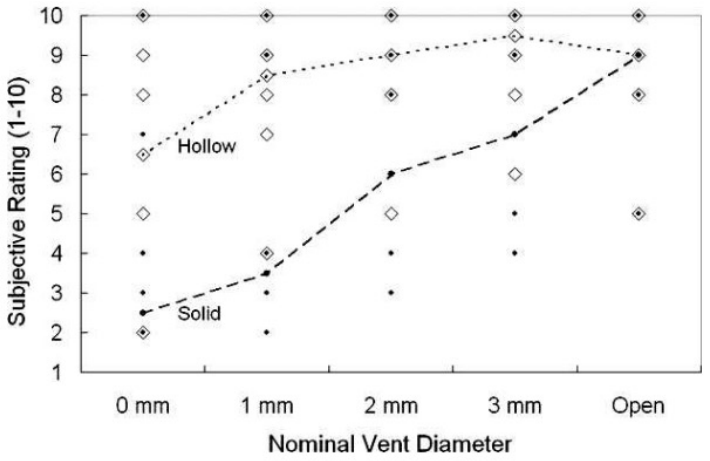
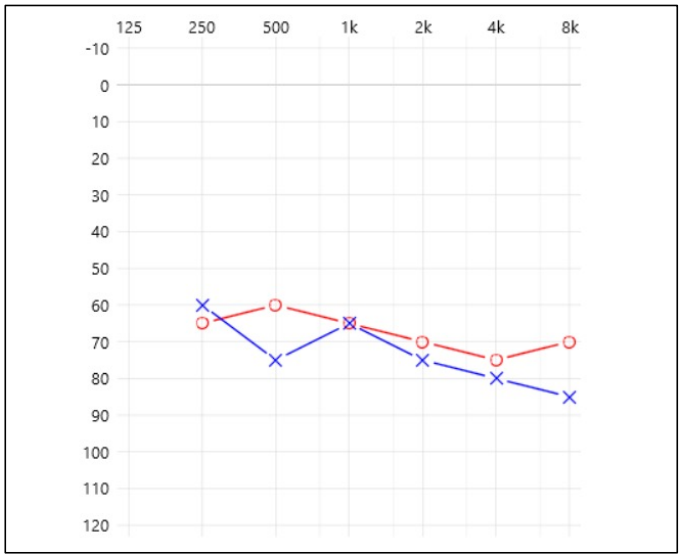


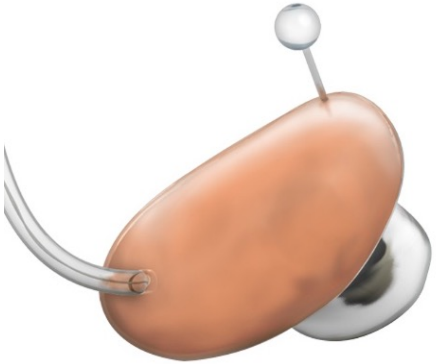
Figure 6. Scatterplot of subjective ratings (1–10 scale) of own voice for different vent diameters. Ratings obtained with a hollow earmold are shown with diamonds, and those for a solid earmold are shown with black dots. Median ratings are connected with a dotted line for the hollow earmold and a dashed line for the solid earmold. The higher the rating, the more acceptable s the voice quality.

Hollow molds blend the qualities of high and low transparency by providing less occlusion effect and plugging up the ear canal

Fitting - How does the earpiece look in the ear?

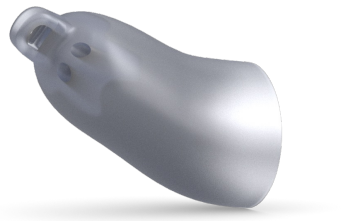
- UP encased receiver allows for smaller, more cosmetically appealing choice for greater hearing loss

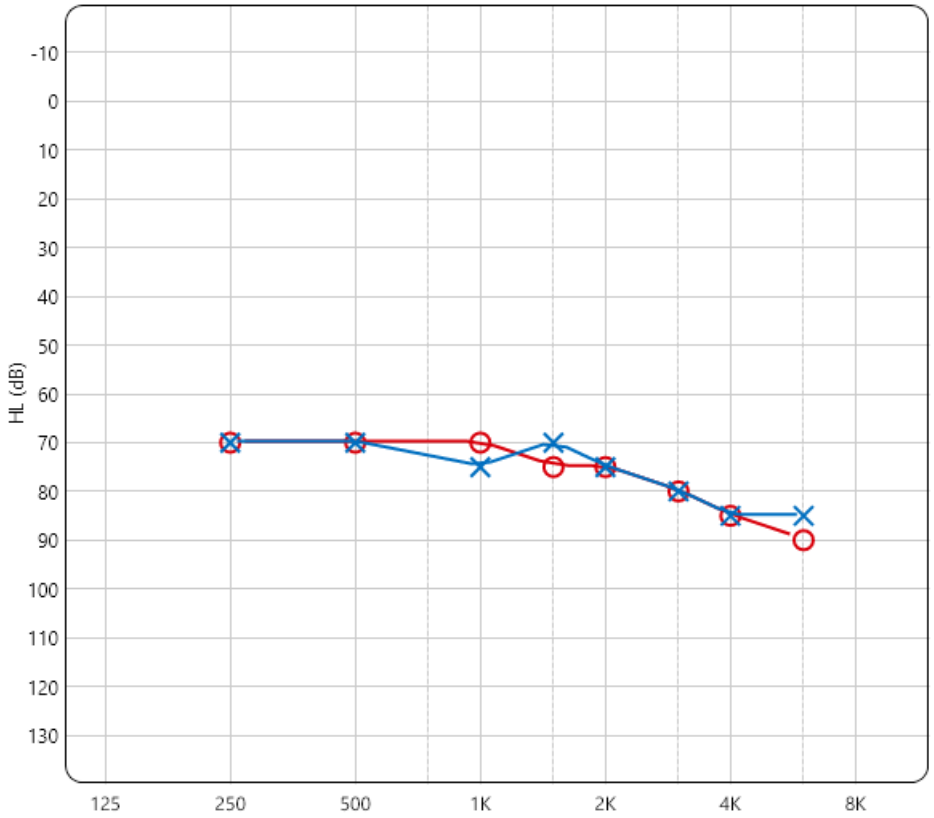




Fitting - How does the earpiece look in the ear?

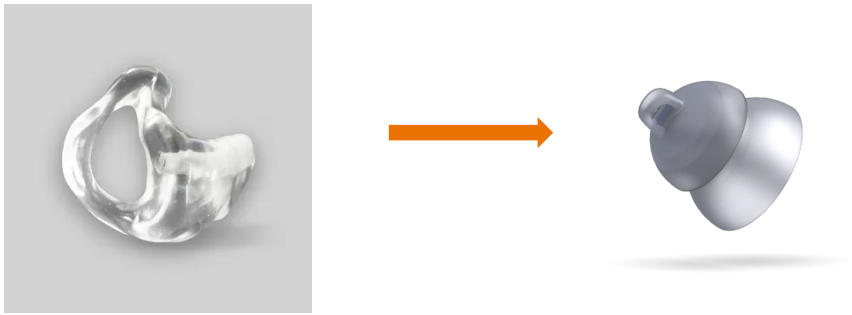
- With proper sizing the sleeve can be use temporarily in place of a mold

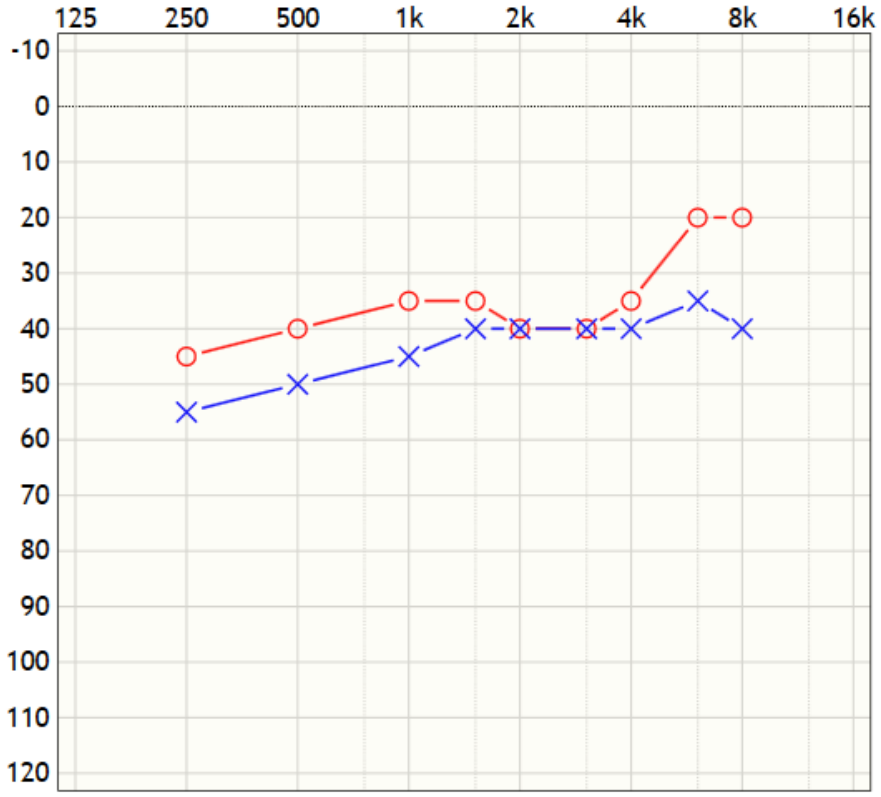




Fitting - How does the earpiece feel in the ear?

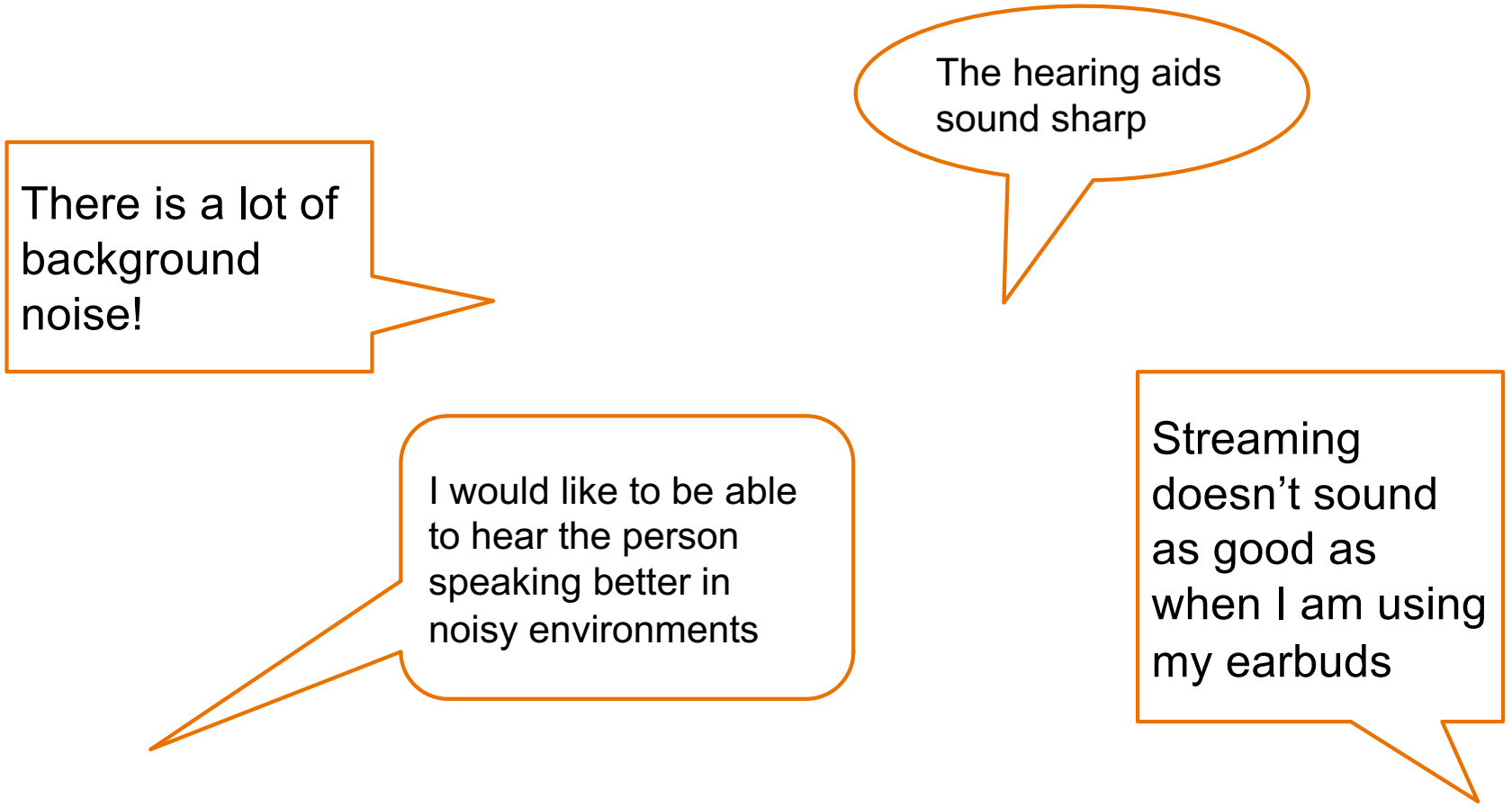
- The best coupling is the one that the patient will wear





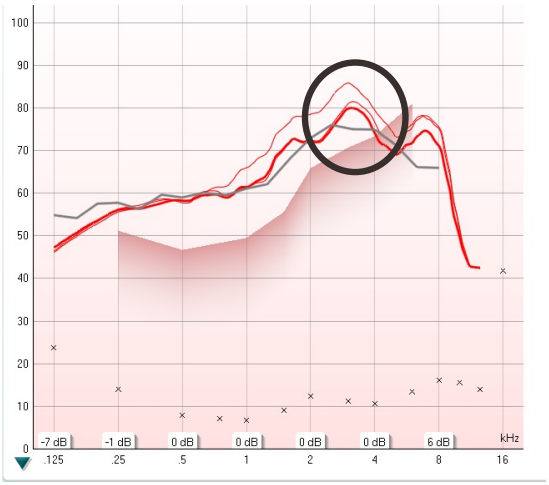
Selection for Solution

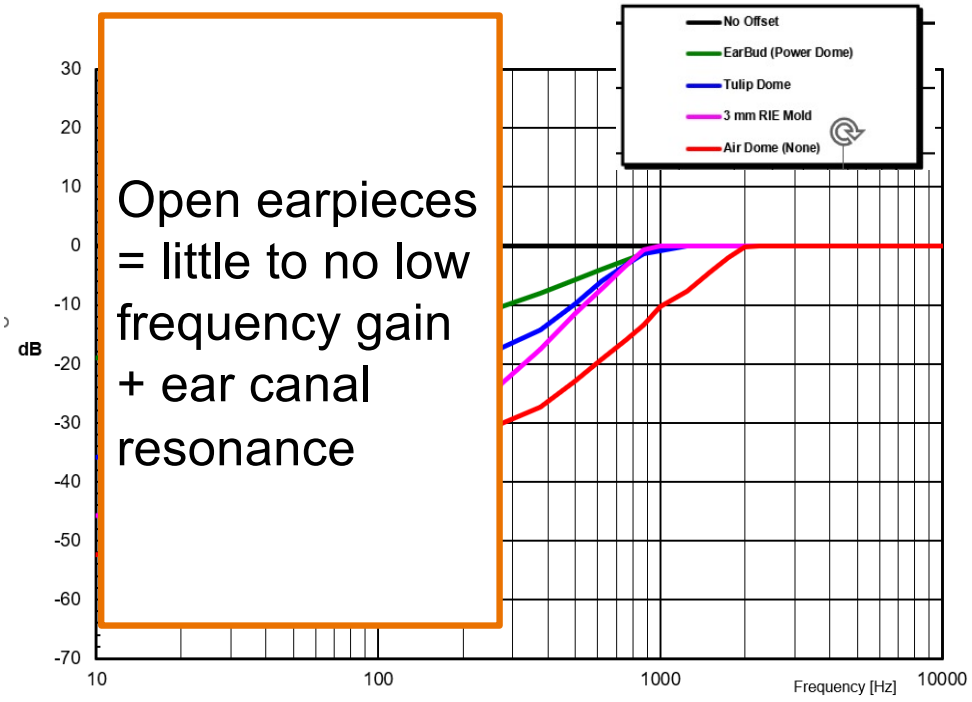
Fitting for solutions



Solutions – The hearing aids sound sharp

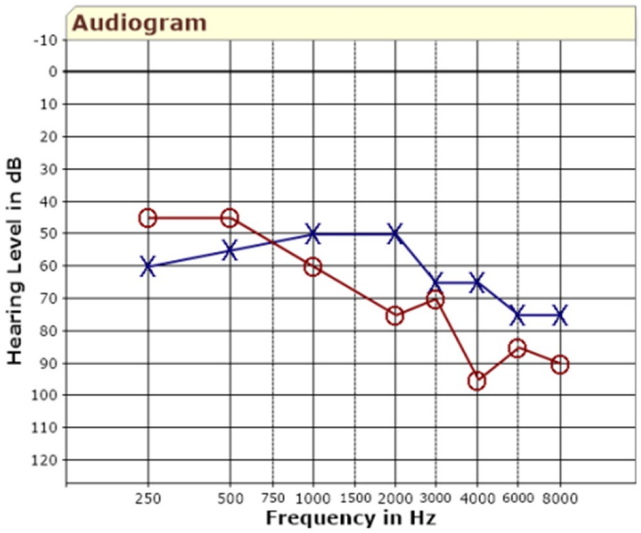
- Problem: No bass combined with a boost in the high pitches can cause sound quality issues
- Solution: choose the most occlusive dome the wearer will tolerate





Open earpieces = little to no low frequency gain + ear canal resonance

Case Study: The Composer and Venting



Solutions – Streaming doesn't sound great

- Problem: No bass combined with a boost in the high pitches can cause sound quality issues – same as previous. Earbuds behave more like double dome.
- Solution: choose the most occlusive dome the wearer will tolerate to minimize comb filter, loss of bass and ear canal "spikes"

	Allowance of background sound into canal (Comb filter)	Loss of bass (vent effect)	Attenuation of ear canal properties
Open	No attenuation to outside sound	Completely vented	none
Tulip and Vented	Outside sounds below 1k	Streaming primarily above 1k	About 10dB
Power	Outside sound below 600Hz		16dB

Solutions – There is a lot of background noise

- Problem: open fittings do not provide passive noise reduction
- Solution: choose the most occlusive dome the wearer will tolerate

Speech recognition in noise using bilateral open-fit hearing aids: The limited benefit of directional microphones and noise reduction

Lennart Magnusson*,†, Ann Claesson*,†, Maria Persson*,† & Tomas Tengstrand*

*Department of Audiology, Sahlgrenska University Hospital, Gothenburg, Sweden, and †Department of Audiology, Institute of Neuroscience and Physiology, University of Gothenburg, Sweden

- Slight increase in benefit with addition of noise reduction for closed fittings versus open

Tech Topic | February 2005 Hearing Review

By Francis Kuk, PhD, Denise Keenan, MA, Marianne Sonne, MA, and Carl Ludvigsen, MS

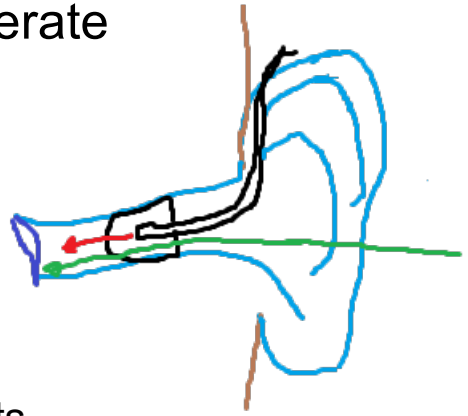
- Insertion loss decreases as the vent increases, ie less attenuation

Solutions – I would like to hear those speaking better while in background noise

- Problem: open fittings may not be offering enough gain to leverage the directionality in the hearing aid
- Solution: choose the most occlusive dome the wearer will tolerate

Open Versus Closed Hearing-Aid Fittings: A Literature Review of Both Fitting Approaches

Alexandra Winkler ✉, Matthias Latzel, and Inga Holube



  - If there is a 10dB+ difference between direct (green) and amplified (red) sound, the louder will dominate thus decreasing the effects of the directional microphones
  - Directivity was greatest at low or moderate input levels for open fits
  - Directivity was greatest for closed fittings in an objective measure
  - SRTs improved 3.3 dB with closed directional fittings when compared to open

Solutions – I would like to hear those speaking better while in background noise

Effectiveness of directional technology in open-canal hearing instruments

Bentler, Ruth; Wu, Yu-Hsiang; Jeon, Julie

- The frequency ranges that are affected by venting will also have no directional benefit, ie up to 1.5Hz for completely open fits
- Directivity in the high frequencies is accessible where gain is available

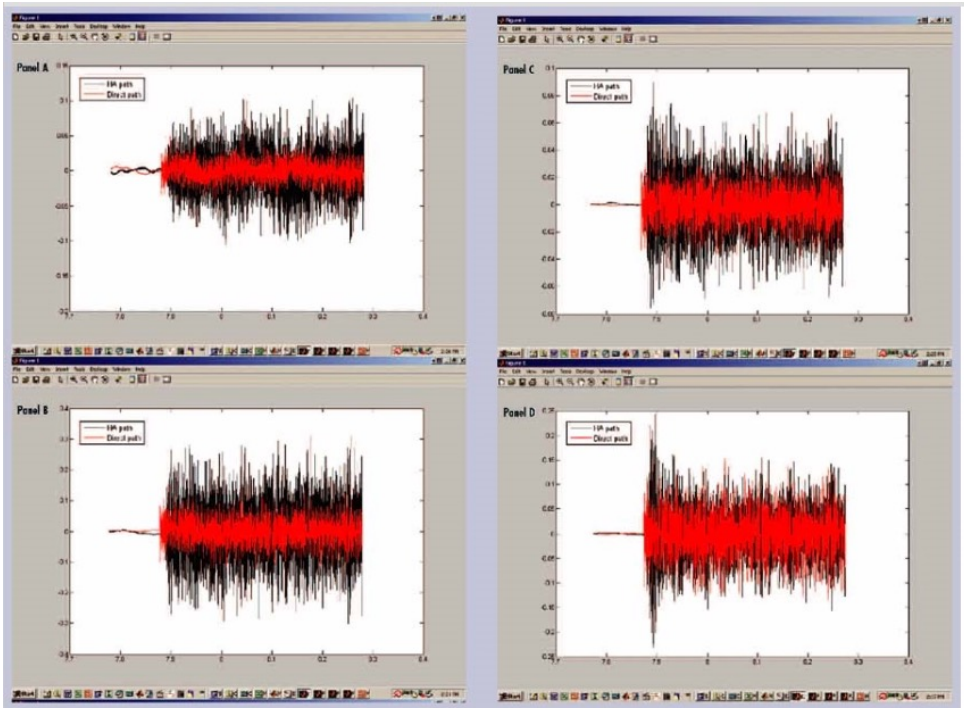


Figure 5

Time waveforms of the output from an open-canal fitting (measured on KEMAR) shown separately as the direct (red) and amplified (black) pathways. Input levels for the four panels are: (a) 55 dBA, (b) 65 dBA, (c) 75 dBA, (d) 85 dBA

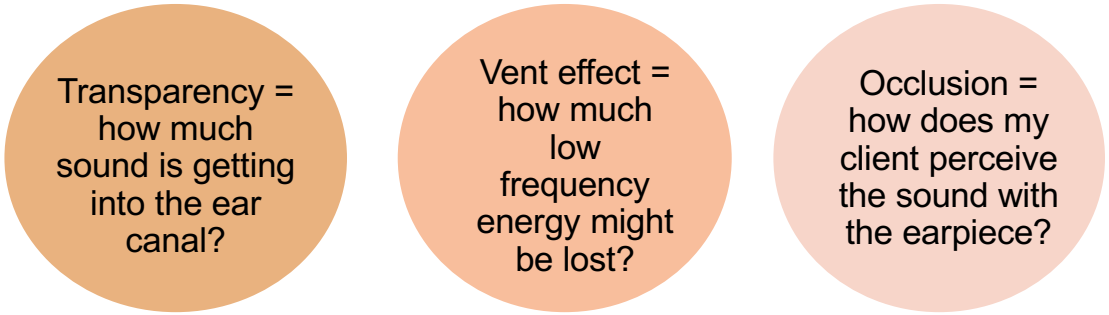
Source

Effectiveness of directional technology in open-canal hearing instruments

The Hearing Journal59(11):40,42,44,46-47, November 2006.

Summary

- Remember the 3 principles:



- Use the earpiece to your advantage!
  - Sound quality
  - Gain
  - Directional benefit
  - Comfort
  - Cosmetics
  - Noise reduction
  - Naturalness
  - Flexibility

Thank you!