



TAA 2024: Evidence-based, patient- oriented hearing aid verification and fine tuning for adults.

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Acknowledgements

- Paula Folkeard, Au.D. and Mohamed Rahmbe have contributed specific content to this presentation.
- Funding for research and/or implementation of published tools related to the content of this talk has arisen from partnerships with Audioscan and Ahead Simulations.
- **NOTE: Some of the videos in this talk cannot be shown in the handout. You can check out my 20Q with Gus Mueller from December 2023 on AudiologyOnline.**

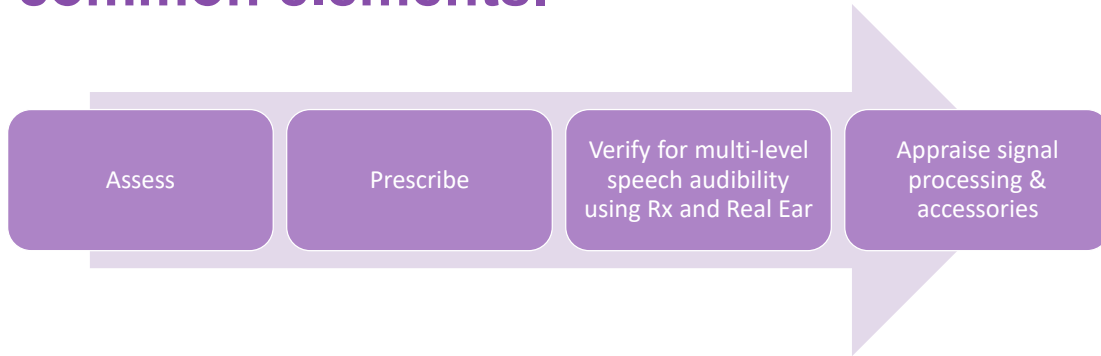
Learning outcomes

- Identify and contrast new methods that enhance well-established verification tools such as simulation of real-ear measurement and the Speech Intelligibility Index.
- Identify and contrast new reasons to use headphones during on-ear verification, including co-listening and assessment of adaptive signal processing.
- Contrast and evaluate options in fitting and verifying niche and emerging classes of hearing aids including BiCROS hearing aids and OTC devices.

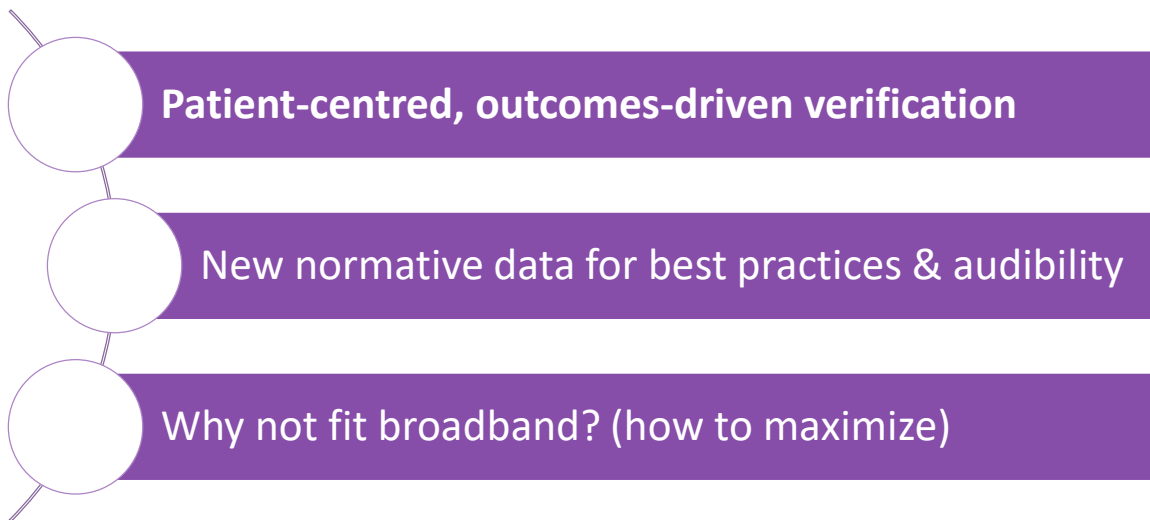
Good evidence supports routine verification with fine-tuning as a best practice.

Pediatric protocols & guidelines	Adult protocols & guidelines	Systematic reviews
<ul style="list-style-type: none"> • AAA (2013) • APSO (2022) • Program-specific protocols • Clinician-fit is more accurate than default-fit hearing aids. 	<ul style="list-style-type: none"> • AAA (2006) currently in review • APSO (2021) • Validated procedures from the ACHIEVE trial (Sanchez et al., 2022). 	<ul style="list-style-type: none"> • Verified hearing aids provide more benefit for adults. • Hearing aids fitted with prescriptions improve self-reported listening ability & hearing-related quality of life.

These protocols & guidelines share common elements.

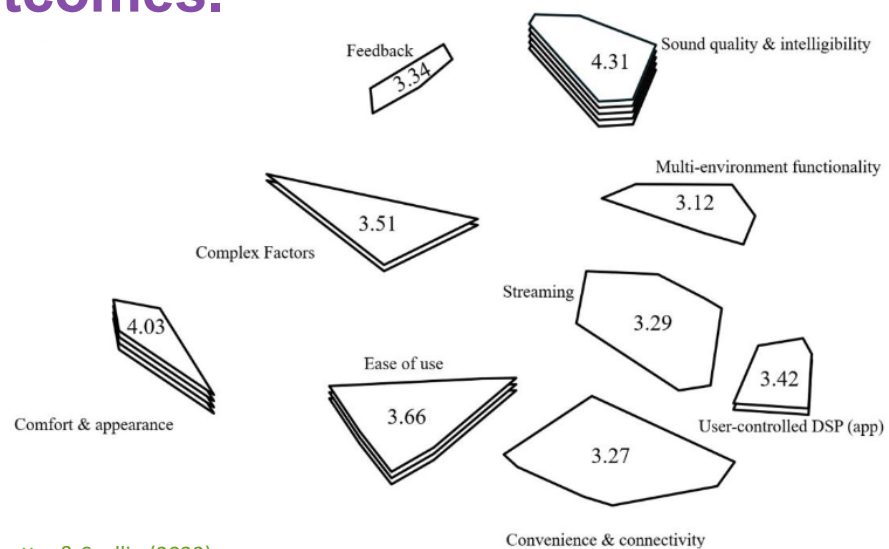


Top Ten for Today: 1-3





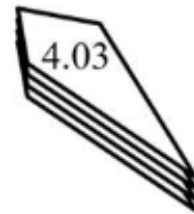
Linking verification & fine tuning to better outcomes.



[Saleh, Folkeard, van Eeckhoutte, & Scollie \(2022\)](#)

The most important cluster is also the starting point for all best practice protocols.

- Audible speech.
- Smooth, broad bandwidth.
- Low distortion.
- Balanced loudness between ears.
- Acceptable loudness for loud sounds.
- Good physical fit and form factor.



Comfort & appearance

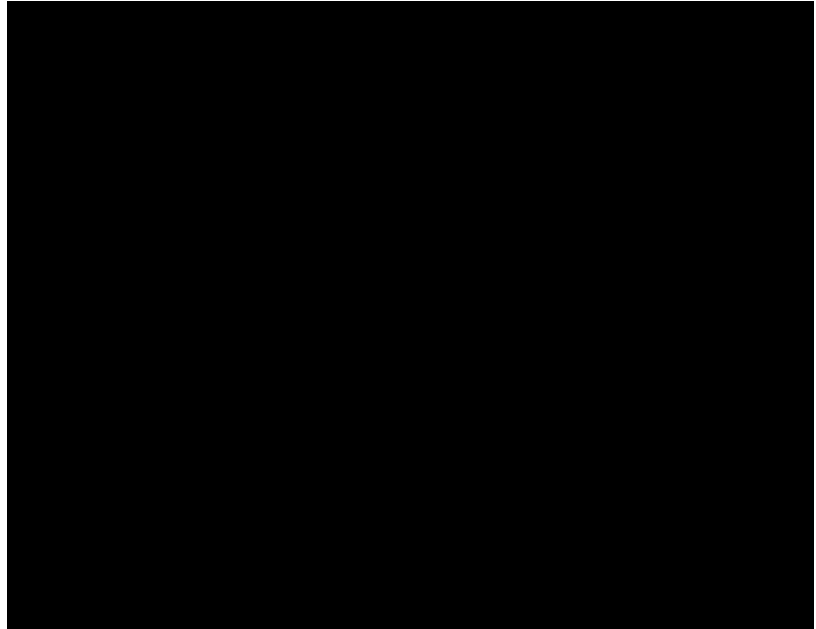
[Saleh, Folkeard, van Eeckhoutte, & Scollie \(2022\)](#)

Using headphones for co-listening.

- Hearing what they hear.
- Picking up on noise, distortion, intermittency, or feedback.
- **Today's hearing aids sound good – don't be afraid to listen to them.**
- **Think about workplace accessibility.**

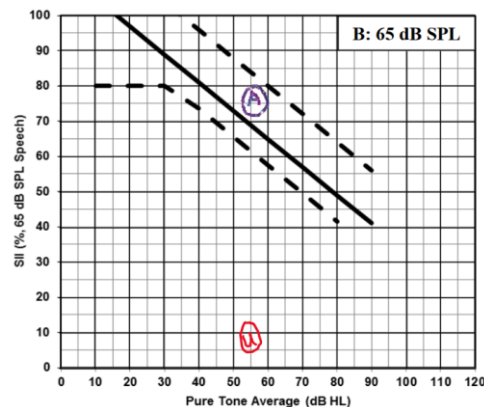


Video: Fitting for speech audibility, with co- listening.



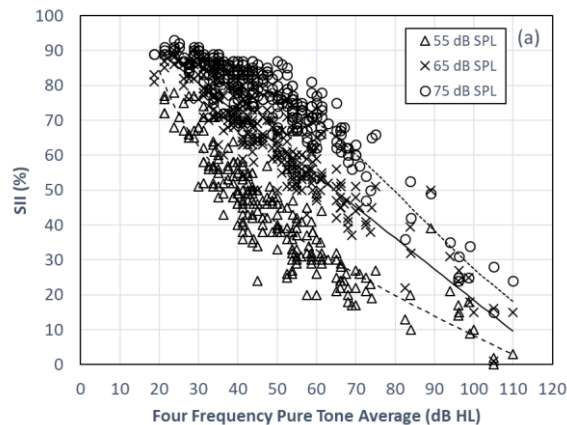
New metrics on aided speech audibility & goodness of fit to targets

- You might already know about these ranges for children from Marlene Bagatto's PedAMP protocol [for download](#) and in the original paper by Sheila Moodie et al ([2016](#)).



New metrics for use with adults are now available.

- For DSLv5-adult:
- Background evidence is available from in the original paper by Andre Dao, Paula Folkeard, Sandra Baker et al., (2021).



New metrics for use with adults are now available.

- This is the closeness of the fit to targets.
- It uses a Root Mean Square Error (RMSE).
- Sloping and profound losses are harder to fit, so have higher RMSE.



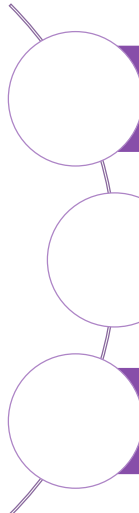
**Incorporating SII
into your
counselling –
tools.**

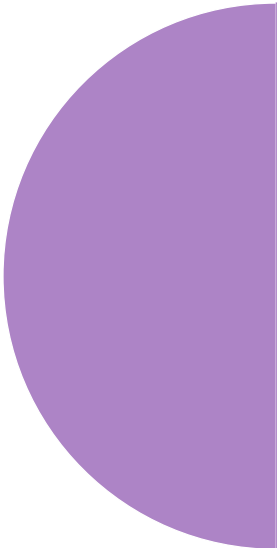
**Post-fitting
counselling...**

**Incorporating SII into your counselling –
What do you think is useful for patients?**

- A. Differences between unaided and aided (benefit)
- B. Aided values in the typical range (quality of service)
- C. Using aided SII to predict expected speech recognition performance (outcomes).
- D. All of the above, depending on the situation.

Top Ten for Today: 1-3

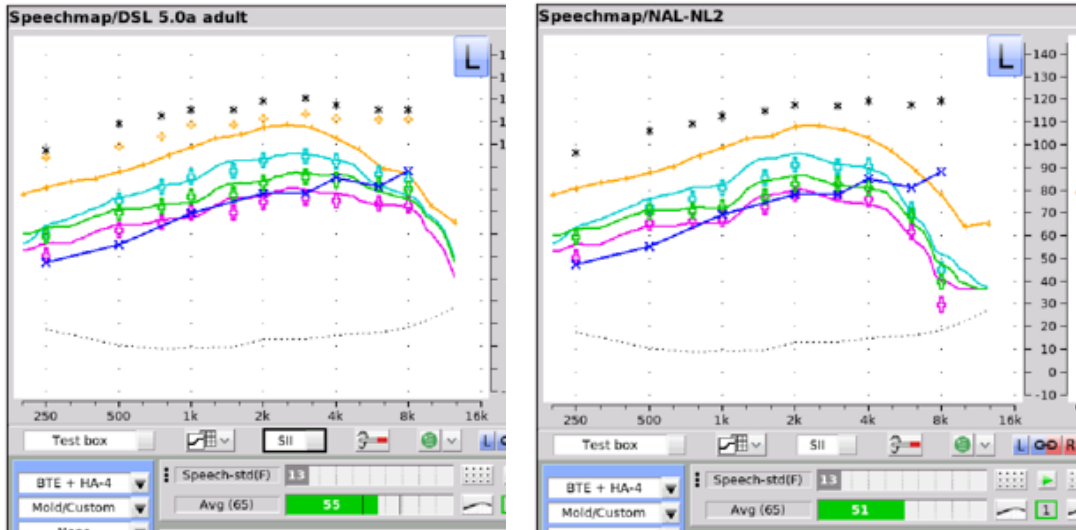
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- 1 Patient-centred, outcomes-driven verification
 - 2 New normative data for best practices & audibility
 - 3 Why not fit broadband? (how to maximize)



Extended bandwidth fittings in regular air conduction hearing aids for older adults.

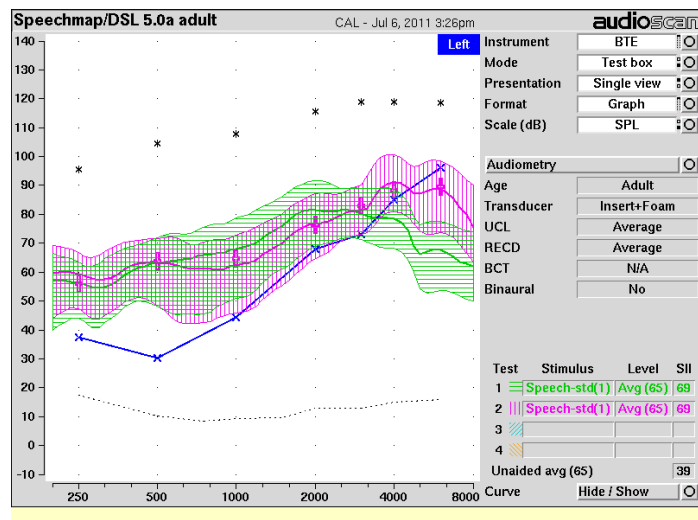
Van Eeckhoutte et al, (2020)
<https://doi.org/10.1080/14992027.2020.1750718>

Be aware that some prescriptive targets roll off high frequencies, limiting our use of extended bandwidth.



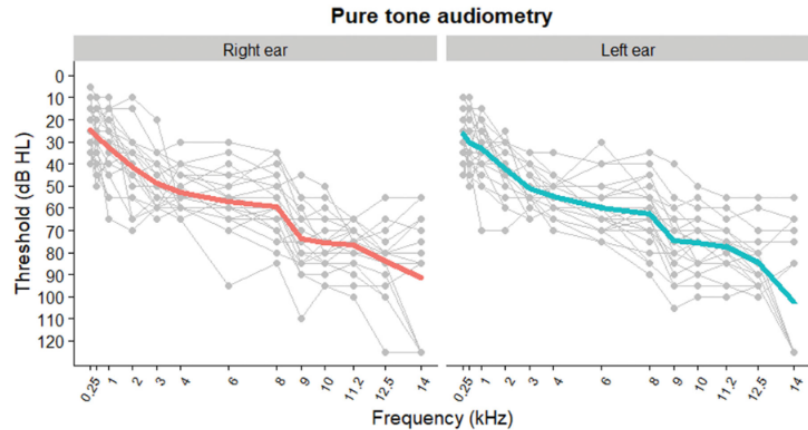
Here's an overlay example for a gently sloping loss:

- This the bandwidth difference between what is **possible** and what is **typical**.

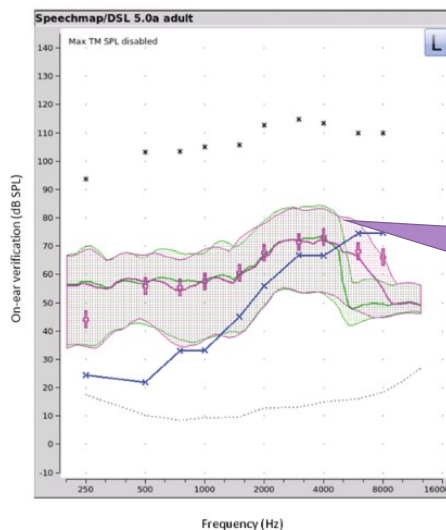


Participants and hearing aid fitting:

- N = 26 adults (69 y average)
- Fitted with DSL v5 using 2017-2018 RIC devices
 - 4 week use period
- Measurement of actual hearing aid bandwidth as fitted.
- Outcomes measured post-acclimatization.

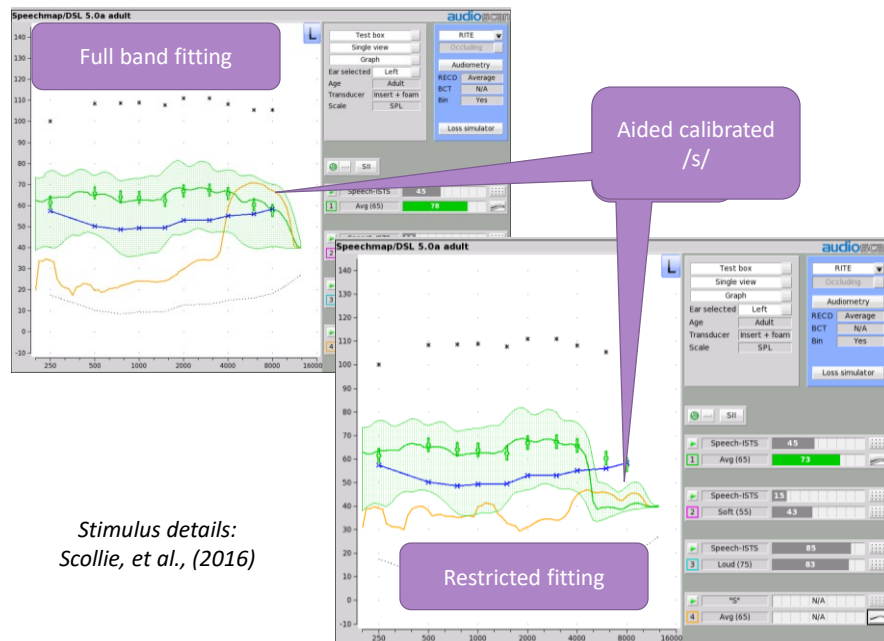
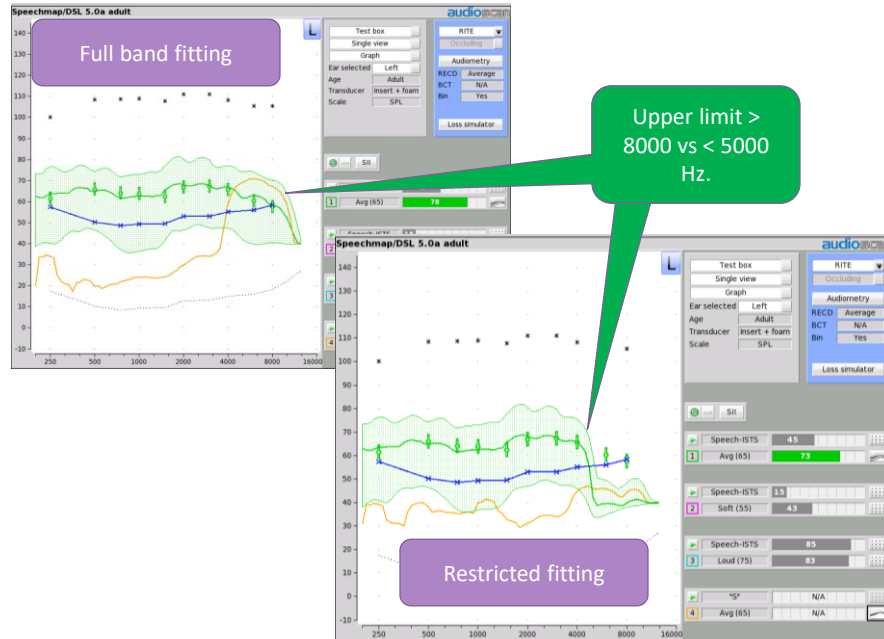


The aided output was manipulated with the hearing aid software to remove output >5 kHz. This setting was only used in lab.



Fullband condition was to about 6500 Hz on average.

Less than Earlens but still broader than older hearing aids.



Stimulus details:
Scollie, et al., (2016)

Extended bandwidth increased loudness.

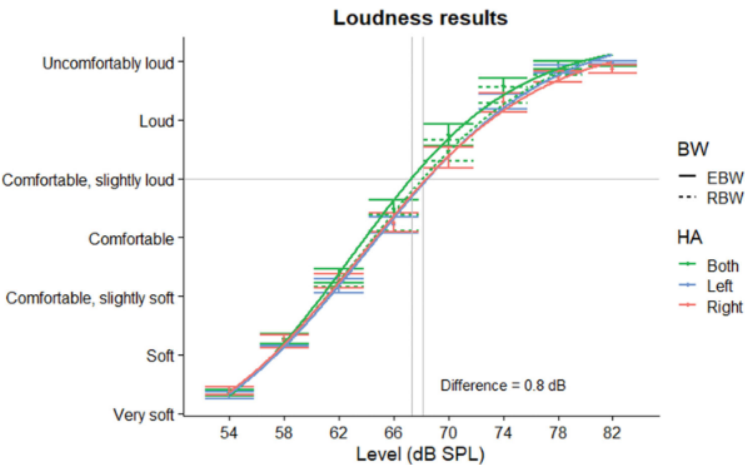


Figure 4. Mean loudness judgments from all participants for EBW, RBW, bilaterally and monaurally (only EBW) aided listening conditions. Error bars show one standard error of the mean. Sigmoidal fits for each condition are plotted in the form of thin lines in the same colour on top of the data. EBW = Extended Bandwidth, RBW = Restricted Bandwidth, HA = hearing aid (colour in the online version).

Extended bandwidth produced a small improvement in high frequency speech sound recognition.

Table 2. Differences in consonant confusions between the EBW and RBW conditions.

		Response differences																							
		B /b/	CH /tʃ/	D /d/	F /f/	G /g/	H /h/	J /dʒ/	K /k/	L /l/	M /m/	N /n/	P /p/	R /r/	SH /ʃ/	S /s/	TH /θ/	T /t/	V /v/	W /w/	Y /j/	Z /z/			
Stimuli	B	6	0	0	1	-1	0	0	0	0	-3	0	0	-1	0	0	-1	0	-3	2	0	0	0	0	
	CH	0	7	-1	0	0	0	1	0	-1	0	0	0	0	-3	-1	0	-2	0	0	0	0	0		
	D	0	0	0	-1	2	-1	0	1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0		
	F	0	0	0	0	0	2	1	-1	0	0	0	1	0	0	-1	0	-1	-1	0	0	0	0		
	G	1	0	-1	0	1	0	1	-1	-1	0	-1	1	0	0	0	0	0	0	0	0	0	0		
	H	1	0	0	1	0	0	0	1	0	0	-1	0	0	-2	0	0	1	0	0	0	0	-1		
	J	0	6	-1	-2	0	-1	-4	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0		
	K	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	1	0	0	0	0		
	L	0	0	0	0	1	0	0	1	-1	0	-5	0	5	0	0	0	0	0	-1	0	0	0		
	M	0	0	0	0	0	0	0	0	-1	-6	3	1	0	0	0	0	0	0	0	2	1	0		
	N	0	0	1	0	0	-1	0	0	0	0	0	-1	0	0	0	0	-1	0	2	0	0	0		
	P	-1	-1	0	-1	0	0	0	6	0	0	0	0	-3	0	0	0	0	0	0	0	0	0		
	R	-1	0	-1	0	0	0	0	0	0	2	-1	0	2	0	0	0	0	0	0	-1	1	-1		
	SH	0	-4	0	-2	0	-1	0	0	0	0	-1	1	0	0	6	0	0	1	0	0	0	0		
	S	0	1	-2	-13	0	-7	0	-2	-1	-2	-1	-3	0	1	36	-4	0	0	0	0	0	-3		
TH	-4	0	3	6	-1	0	0	1	0	0	0	-1	-1	0	-1	-1	1	-2	-1	0	0	1			
T	0	-6	0	0	-1	1	-1	-13	-1	-1	0	0	0	0	0	0	-1	22	0	0	0	0			
V	3	0	-1	2	-3	-1	0	-1	-1	0	0	0	0	0	0	0	-2	0	6	2	0	-4			
W	-1	0	0	1	-1	0	0	0	0	0	-1	0	0	1	0	0	0	0	3	-3	0	1			
Y	0	0	0	0	-1	-3	-2	0	0	0	0	0	0	0	0	0	1	0	3	1	2	-1			
Z	-5	0	-3	1	-1	0	0	0	0	-1	-1	-1	-1	0	0	0	-1	0	-10	-1	0	24			

Positive values on the diagonal indicate better performance in the EBW condition. Absolute values equal to or more than 10 are shown in bold font and underlined.

Similar performance as for Earlens: S, T, Z improved:

		Response																									
		B	CH	D	F	G	H	J	K	L	M	N	P	R	SH	S	TH	T	V	W	Y	Z					
Stimulus	B	11	0	0	1																						
	CH	0	7	-1	0																						
	D	-1	0	3	-1																						
	F	0	0	1	2																						
	G	0	0	3	0																						
	H	1	0	0	0																						
	J	0	8	-1	-2																						
	K	0	1	0	0	0	0	0	-2																		
	L	0	0	0	0	1	0	0	1	-2																	
	M	0	0	0	0																						
	N	0	0	2	0																						
	P	-1	-1	0	-5																						
	R	-1	0	-1	0																						
	SH	0	-7	0	-2																						
	S	0	1	-4	-12																						
	TH	-3	0	3	5	-2	0	0	1	0	0	-1	-1	-1	-1												
	T	0	-6	0	-1	-1	1	-4	-13	-1	0	0	2	0	0	-1											
	V	4	0	-2	2	-3	-1	0	0	-1	0	0	0	0	0	0	-3										
	W	-1	0	0	1	-1	0	0	0	0	-1	0	-1	1	0	0	0	0									
	Y	0	0	0	0	-1	-3	-2	0	0	0	0	-1	0	0	0	1	0	3								
	Z	-4	0	-5	2	-3	-1	0	0	-1	-1	-1	-2	1	0	1	-1	0	-13	0	1						

Similar to Alexander (2016); Consistent with Stelmachowicz et al. (2004); Dubno & Levitt (1981)

Preference results were skewed toward preference for extended bandwidth (but not for all listeners):

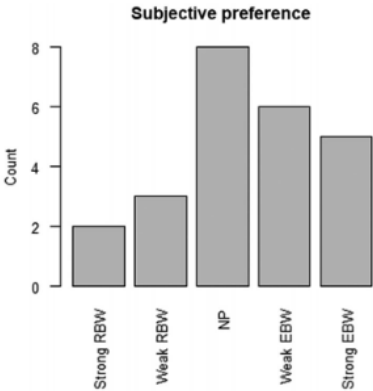
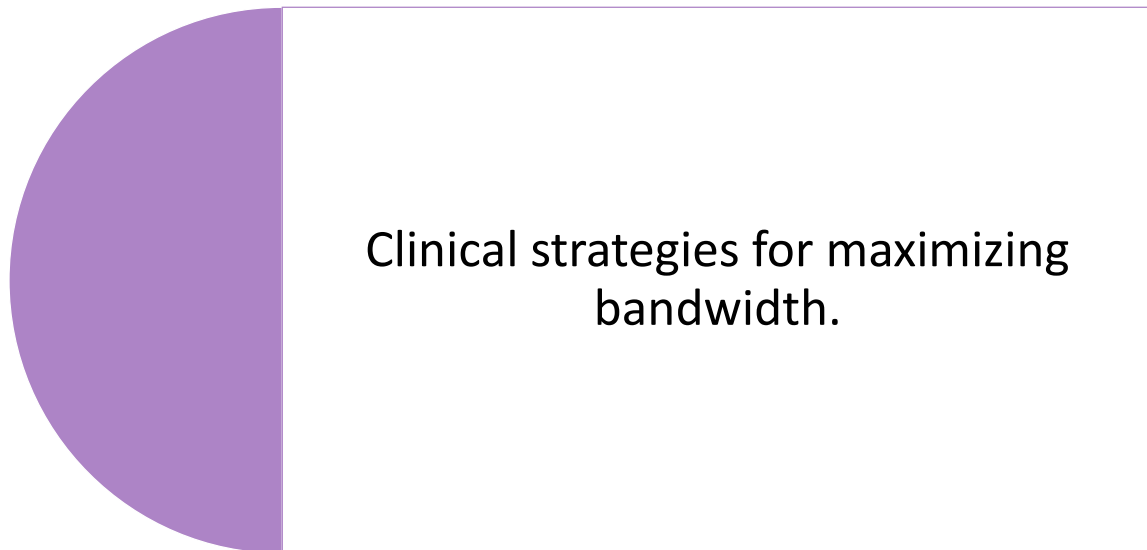


Figure 5. Subjective preference as measured by a paired comparison task. RBW = Restricted Bandwidth, NP = No Preference, EBW = Extended Bandwidth.



Do: Routine verification while fine tuning, aiming for a broadband fitting.

Fitting low and to acceptance for new users: a common strategy.

But do we stay there?

What about working adults who need to hear really well?

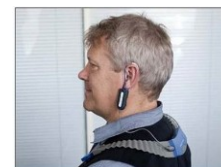
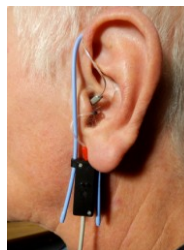
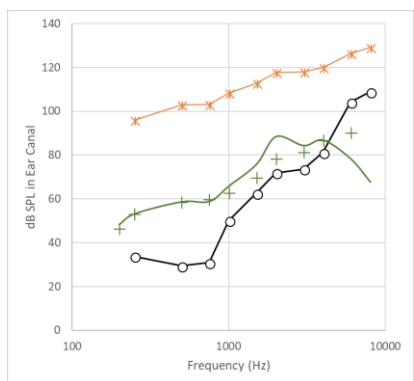
Do: Measure the RECD and gain a more accurate SPLogram.

Skip the insertion gain.

Skip the TDH headphones.

Use speech as the test signal and ask about loudness and intelligibility. Choose a language that the person can understand.

Most of us who verify will map the auditory area in dB SPL. (terms: speechmapping, SPLogram, REAR, in situ)

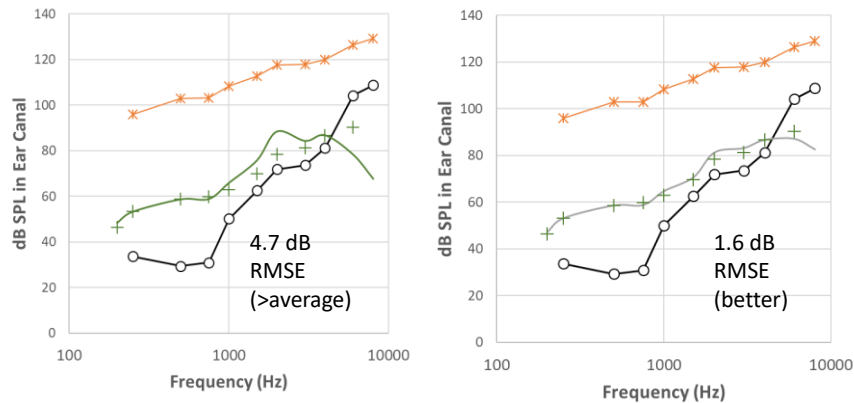


https://en.wikipedia.org/wiki/Real_ear_measurement

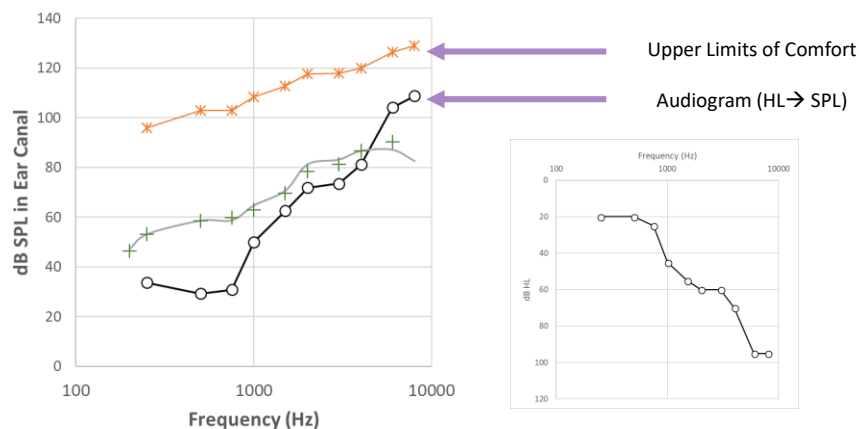
<https://www.audiologyonline.com/articles/verification-counseling-digital-hearing-instruments-13085>

ANSI S3.46, 2013

When we do this, we view the fitting against the auditory area, not against insertion gain.

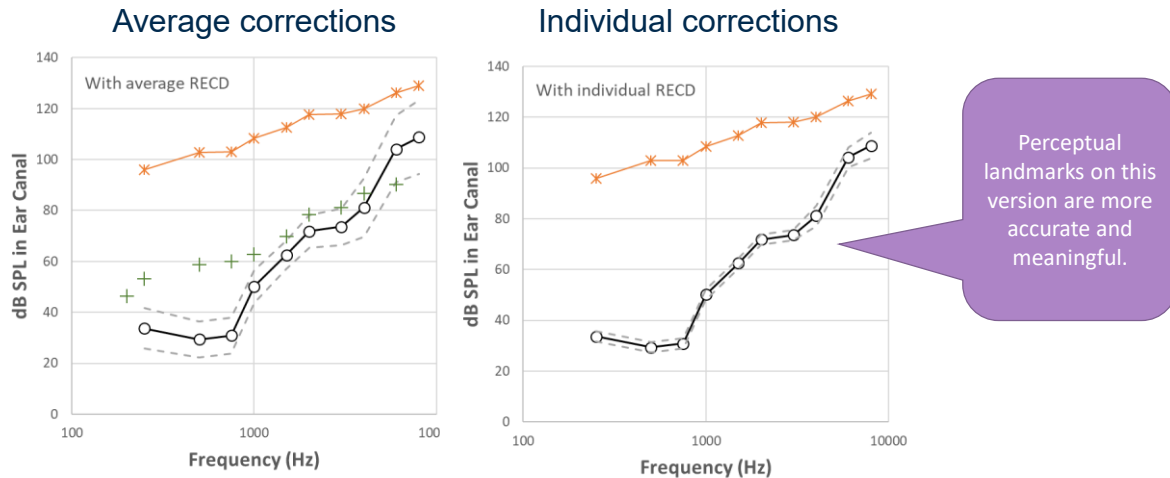


When we do this, we view the fitting against the auditory area.



Seewald et al., 2005, influenced by earlier work the 1980's by Skinner & Pascoe

If we use average RECDs, the prediction is less accurate:

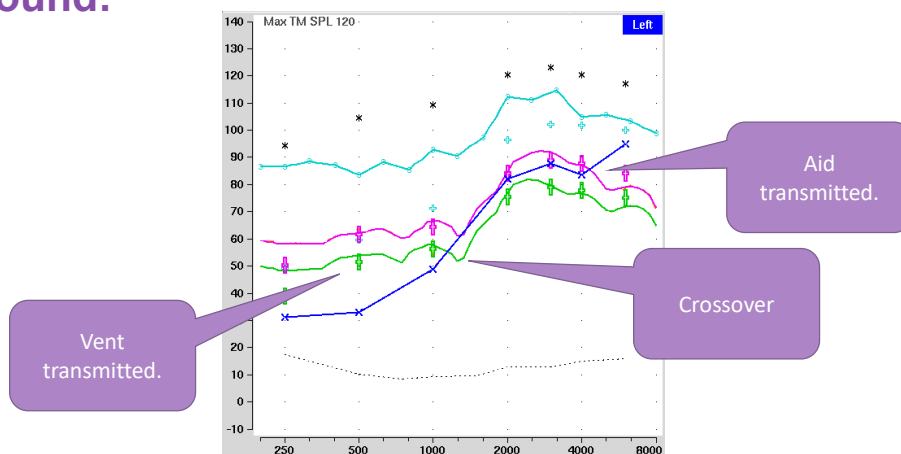


Top Ten for Today: 4-6

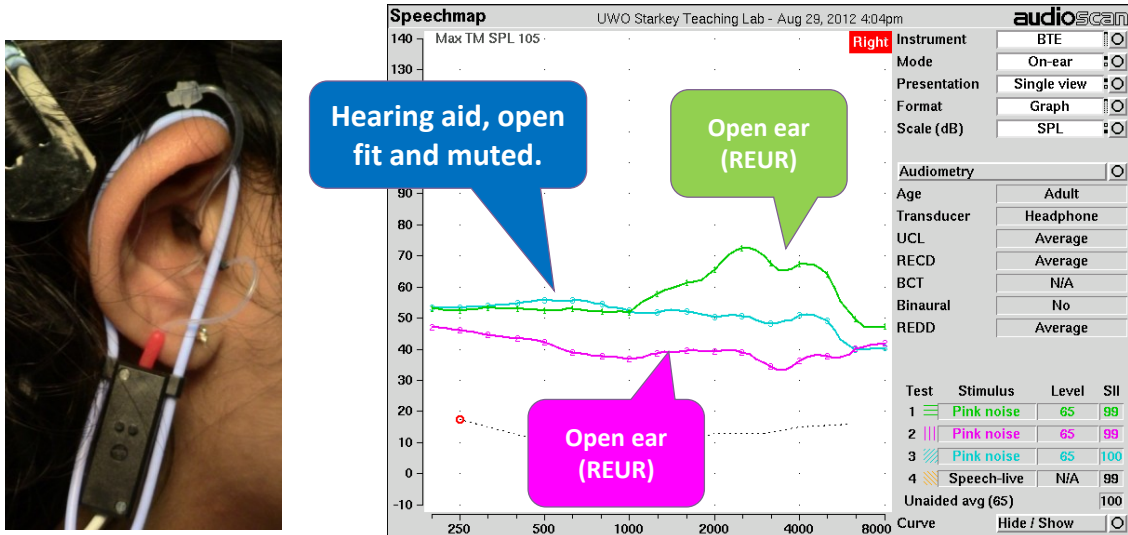
- Deep dive on open fittings
- Noise reduction signal processing
- Telephones & streamed signals

Open fits and on-ear fits to target.

The Real Ear Aided Response (REAR) measures the combined vent-transmitted and aid-transmitted sound:



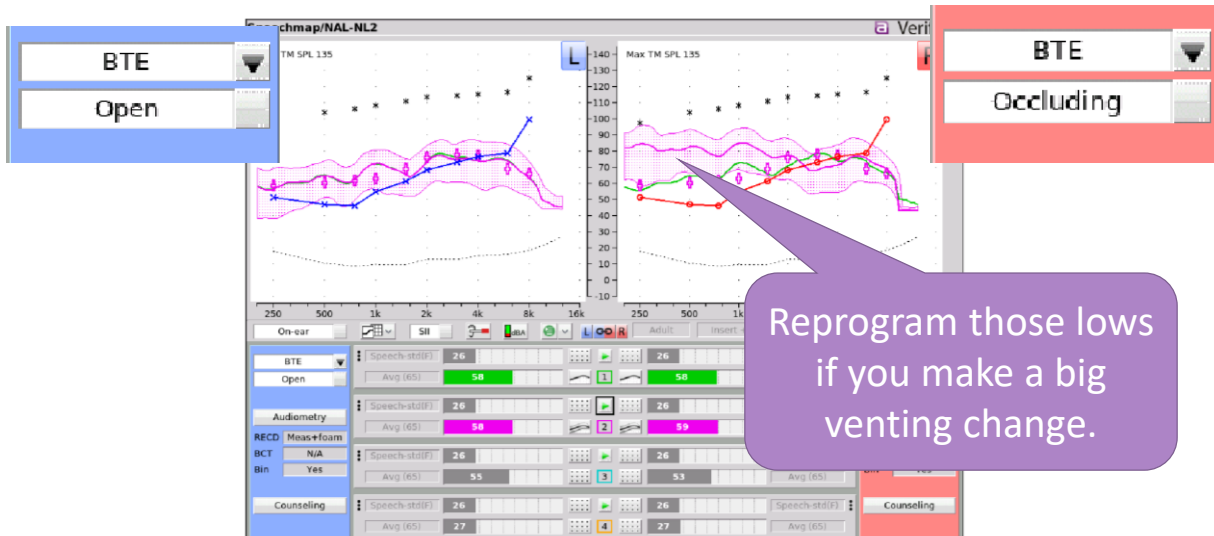
If we want to know how much sound is coming in through a vent we can measure the REOR.



If you are verifying on ear:



Vents can change a fitting a lot! Here's an earmold change without compensating the programming for the difference.



Top Ten for Today: 4-6

- Deep dive on open fittings
- Noise reduction signal processing
- Telephones & streamed signals

Open fits and test box fit to target. Why?

Pre-fitting.

Troubleshooting.

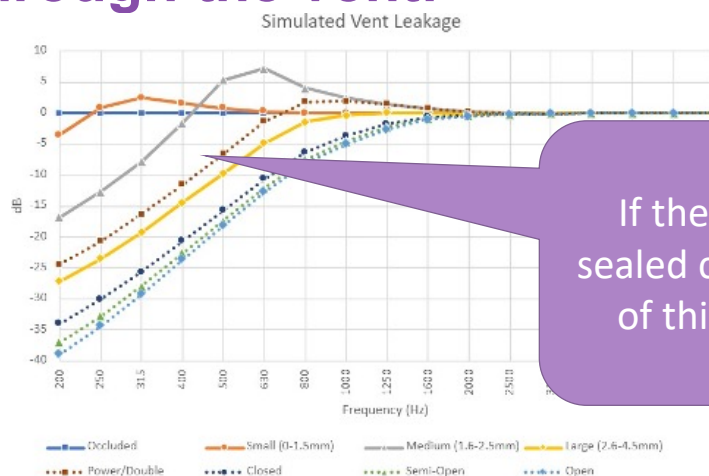
Checking aids back in from repair.

Simulations for demos or teaching purposes.

Checking out a new product.

(oh yeah and for kids)

On ear, some aided sound exits the ear through the vent:

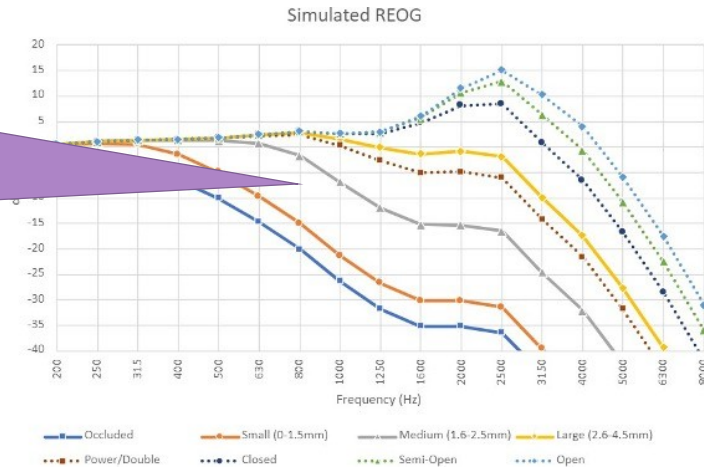


If the aid is on a sealed coupler, none of this happens.

<https://www.audiologyonline.com/articles/audioscan-vent-corrections-27884>

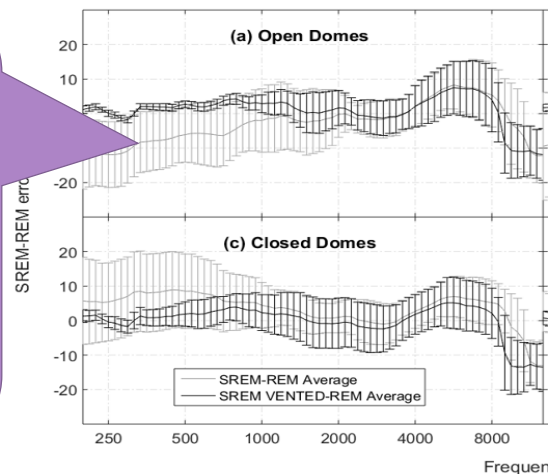
On ear, some unaided sound enters through the vent, and there may be a residual open ear resonance as well.

If the aid is on a sealed coupler, none of this happens.



These two factors lead to low-frequency error if we fit to targets on a sealed coupler, and the fitting is not sealed on the ear.

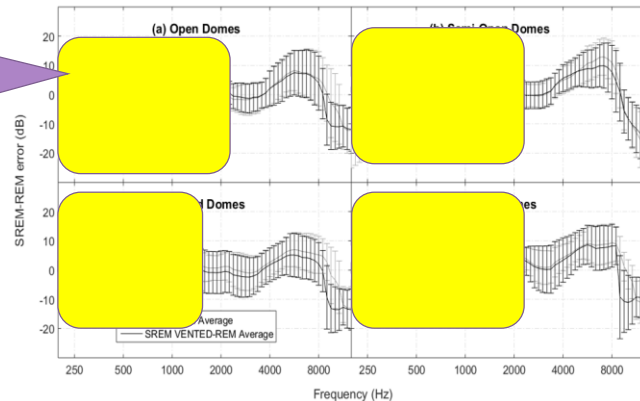
With open domes, usually little gain is programmed in to the fitting. It will look “under target” in the low frequencies, even though it’s ok on the ear because the coupler seals better than the dome.



After this model was applied in software, the coupler (test box) fittings provided a closer prediction of on-ear levels.

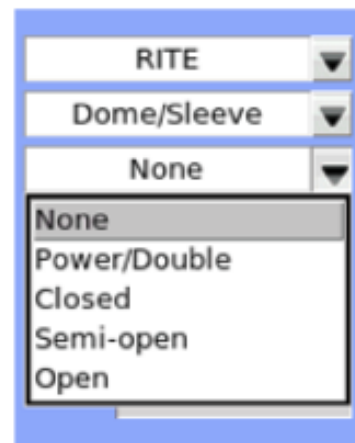
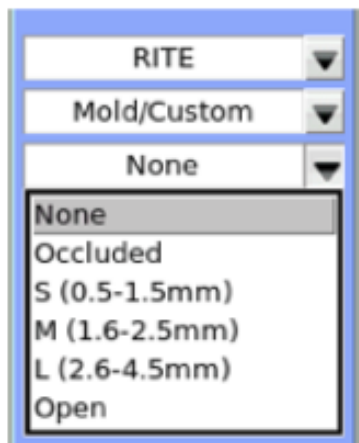
Mostly in the low frequencies.

More effect the more open the dome.

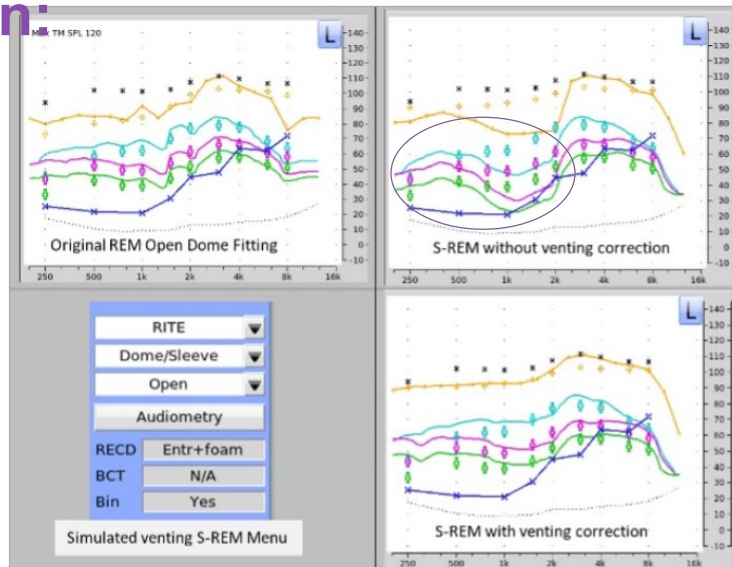


[Scollie et al., 2022](#)

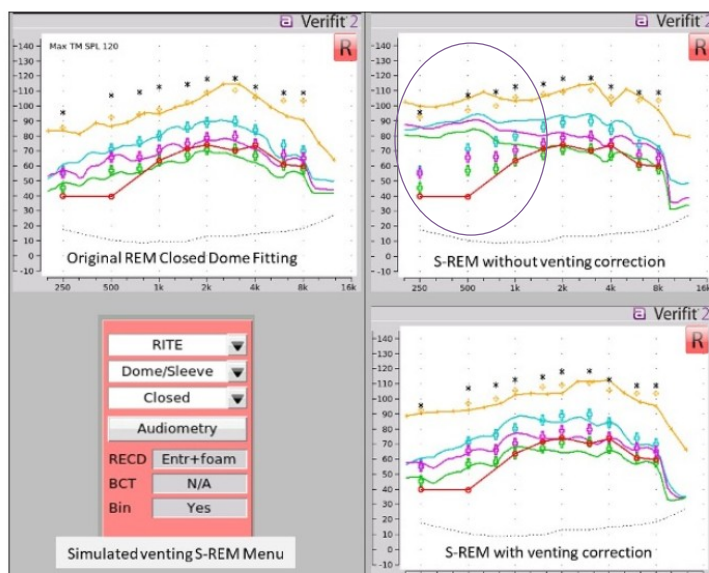
Here are the menu items for this feature:



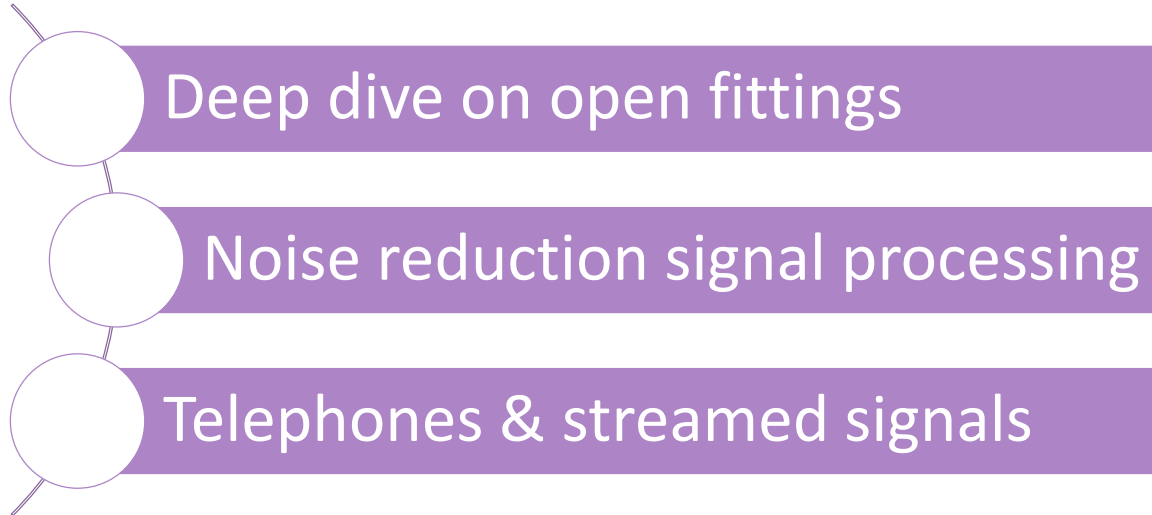
This case has little low frequency gain:



This case has some low frequency gain:



Top Ten for Today: 4-6

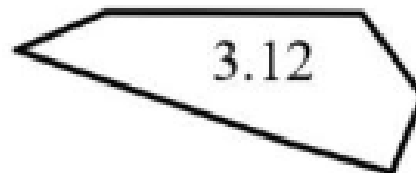


Support hearing well in noise.

(agrees with MarkeTrak & other studies)

- Strength of NR
- Narrowness/adaptation of directionality
- Use of remote microphones
- User-controlled dsp

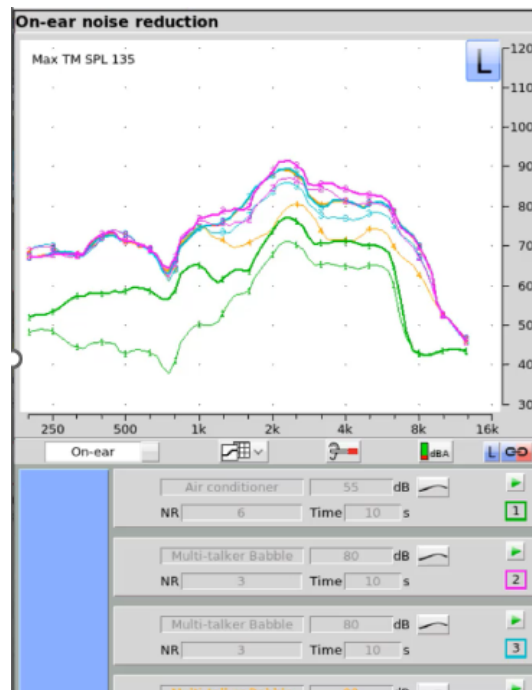
Multi-environment functionality



[Saleh, Folkeard, van Eeckhoutte, & Scollie \(2022\)](#)

How strong is the noise reduction setting?

Article describing [how much NR systems vary](#), and pediatric considerations.

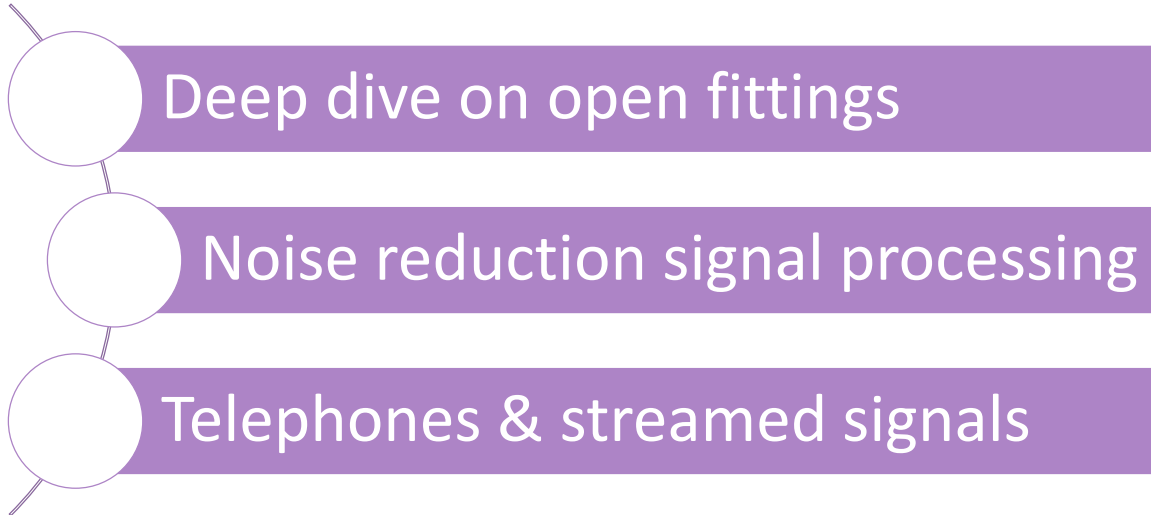


How strong is the noise reduction setting?

Article describing [how much NR systems vary](#), and pediatric considerations.

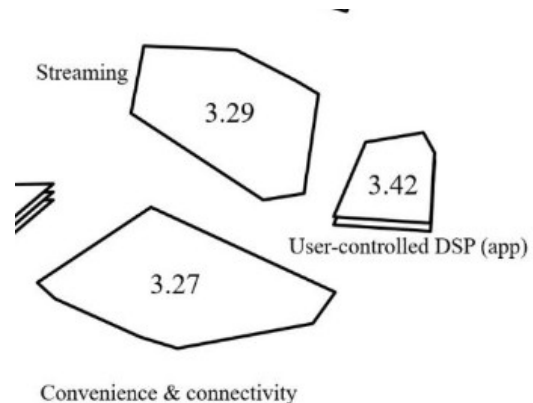
Is the hearing aid's noise reduction system effective?

Top Ten for Today: 4-6



Apps & connections:

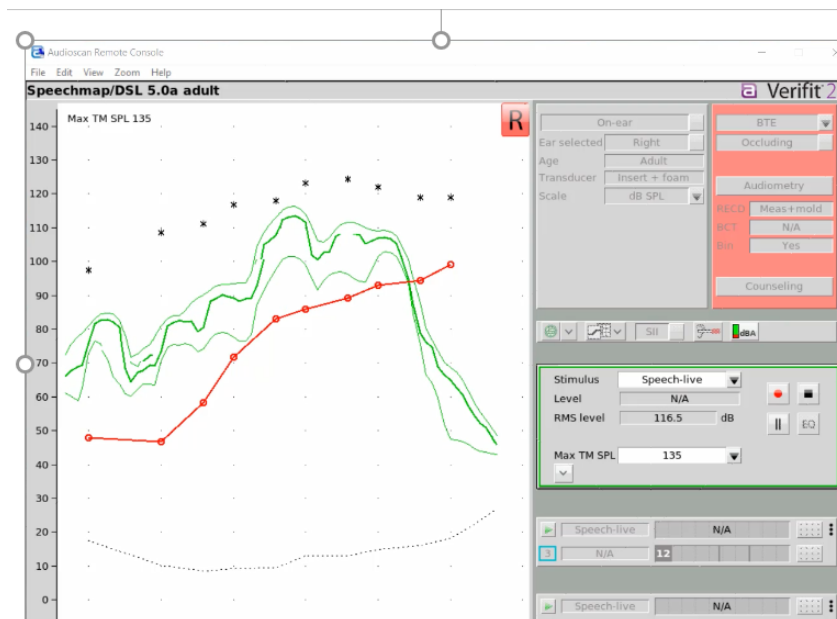
- **Streaming for music**
- **Telephone connectivity & levels**
- Coaching, coaching, coaching



[Saleh, Folkeard, van Eeckhoutte, & Scollie \(2022\)](#)

Using headphones for co-listening.

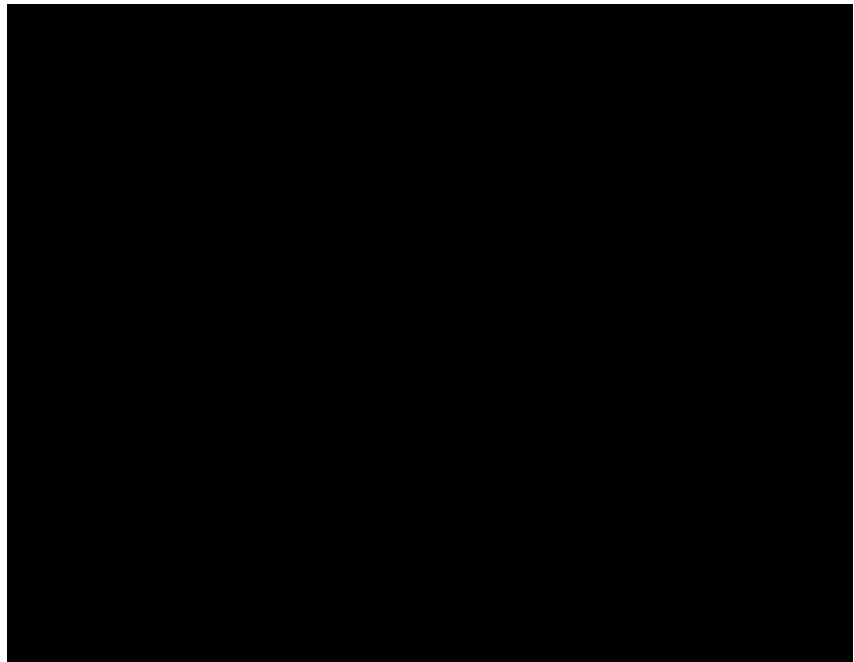
- Hearing what they hear.
- Picking up on noise, distortion, intermittency, or feedback.
- Coaching on device use (alerts, beeps, streaming signals).
- **It's easier to know if a device is streaming if you listen to it. Doing it this way helps keep the devices in normal use position.**



Open fits often roll off the lows. How does this affect streamed sound?

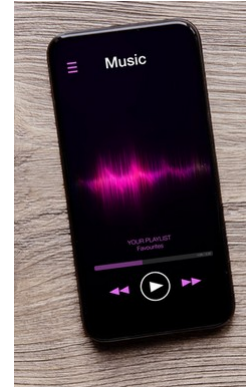


**Video:
Using
verification
systems to
check T-
coils and
Bluetooth
streaming.**

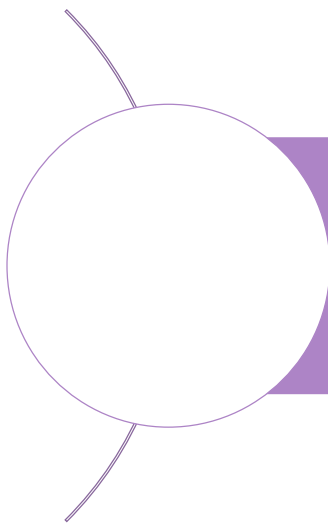


For programs that do not include vent-transmitted sound, consider the role of 'bass compensation':

- In the low frequencies:
 - This audibility will be missing from a streaming program.
- In that program, I can verify the low frequency response by:
 - Using the streamed sound as my test signal.
- One practical challenge I will have in doing this is: I have to disconnect from programming in order to stream so I can't verify and fine tune at the same time.



Top Ten for Today: 7-9



Telephones &
streamed signals

Remote Microphone Benefit

Echo and noise are difficult for patients with hearing loss.

A Bluetooth remote microphone can help improve the signal to noise ratio.

Demo: N2 audiogram fit to DSL 5.0 in a room with typical classroom acoustics (R_{60} - 665 ms).

Without Remote Mic

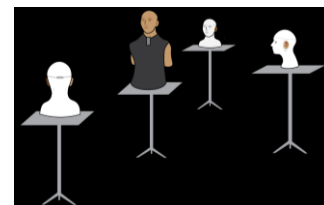
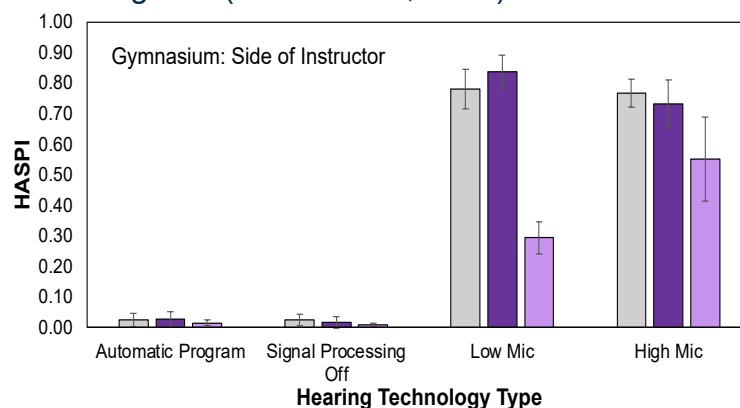


With Remote Mic



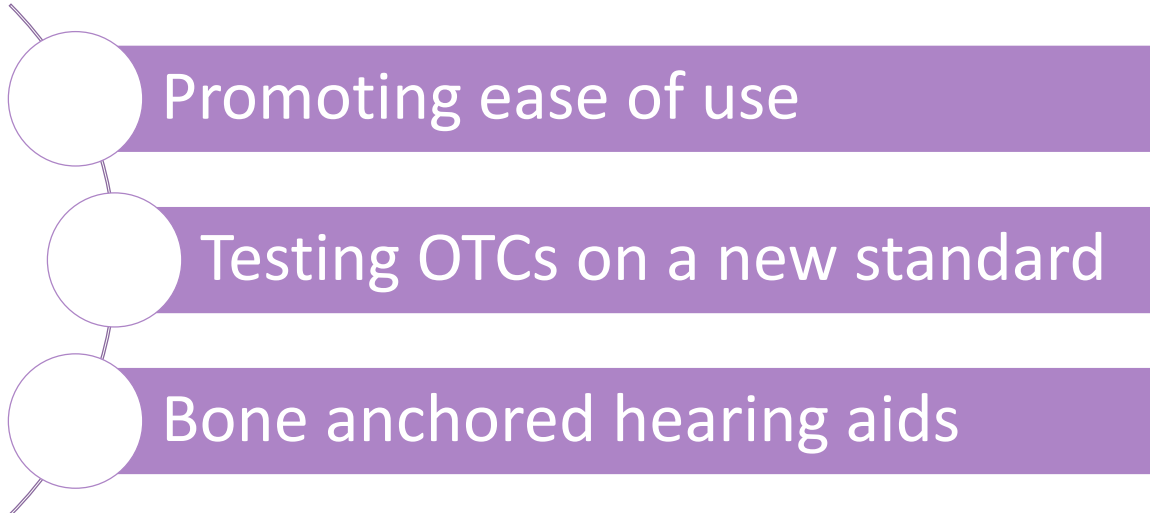
Where might that matter most? What type of microphone?

- One place is at exercise facilities! A major barrier to hearing well at the gym is lack of microphone use by fitness instructors, for adults who have hearing loss (Rahme et al, 2022).



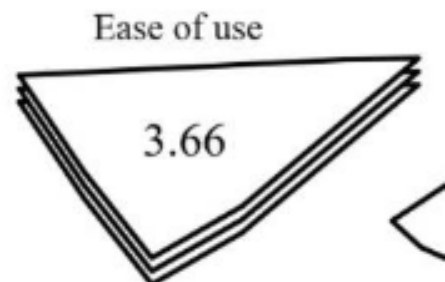
Rahme et al. (in preparation)

Top Ten for Today: 7,8,9



Ease of use:

- How can we more effectively teach complex device use?
- User signals (beeps, voice commands) are important, but you can't hear them when they are on the user's ears... or can you?

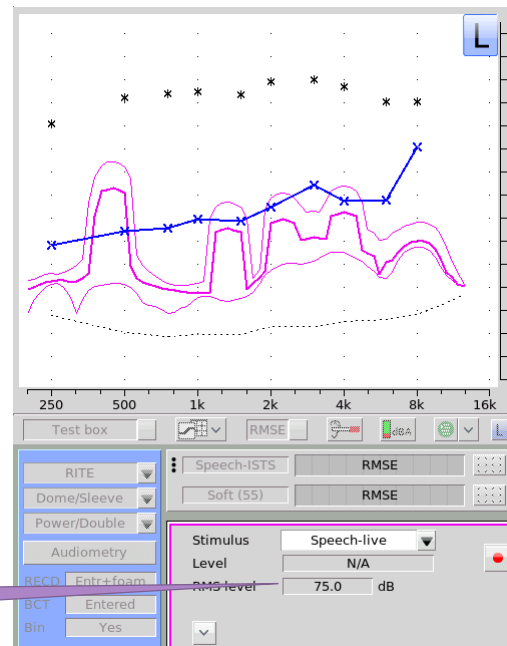


Using headphones for co-listening.

- Hearing what they hear.
- Coaching on device use (alerts, beeps, streaming signals).
- **It's easier to know when a device makes a beep or other user signal if you listen to it. Use coaching is more effective if feedback is in real time.**



You can see & co-listen to user beeps and other device-generated signals while coaching on their use and adjusting them to preference.



Top Ten for Today: 7,8,9

- Promoting ease of use
- Testing OTCs on a new standard
- Bone anchored hearing aids

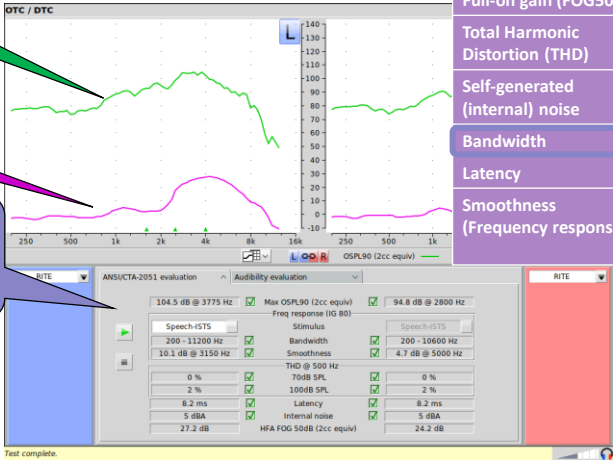
Comparing ANSI s3.22 to ANSI-CTA at a glance			
Conceptually similar	Measure	ANSI s3.22	ANSI-CTA
	Maximum output limit (OSPL90)	Pass if the aid is within tolerance of it's own spec sheet.	Pass based on FDA pass/fail criteria. Some criteria are just descriptive.
	Full-on gain (FOG50)		
	Total Harmonic Distortion (THD)		
	Self-generated noise/EIN		
	Bandwidth		
	Battery current		
Different	Latency		
	Smoothness		
	Telecoil output		
	RF interference		

ANSI-CTA-2051 & FDA OTC CTA

2cc output for at 90 dB SPL input.

Estimated REIG for 80 dB SPL input. (measured on coupler)

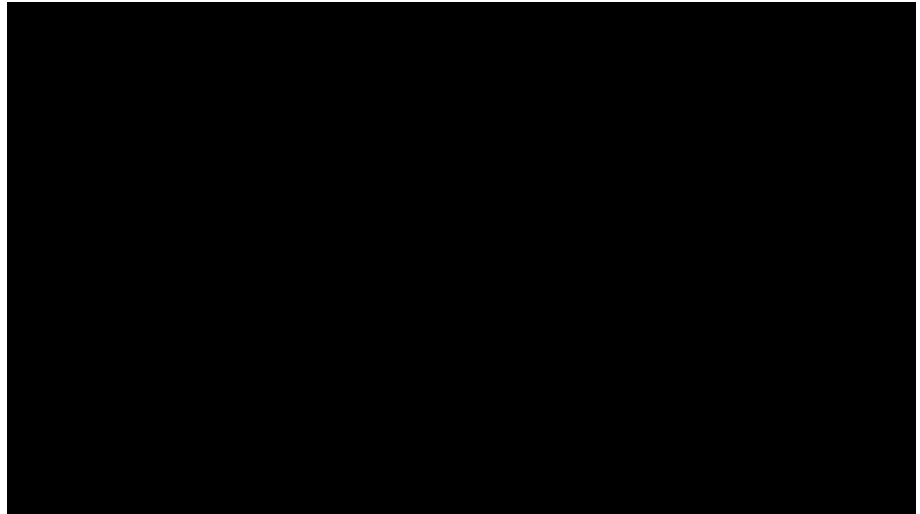
Meets technical requirements with speech input



Top Ten for Today: 7,8,9

- Promoting ease of use
- Testing OTCs on a new standard
- Bone anchored hearing aids

**Fitting for
speech
audibility
with bone
anchored
hearing
aids.**



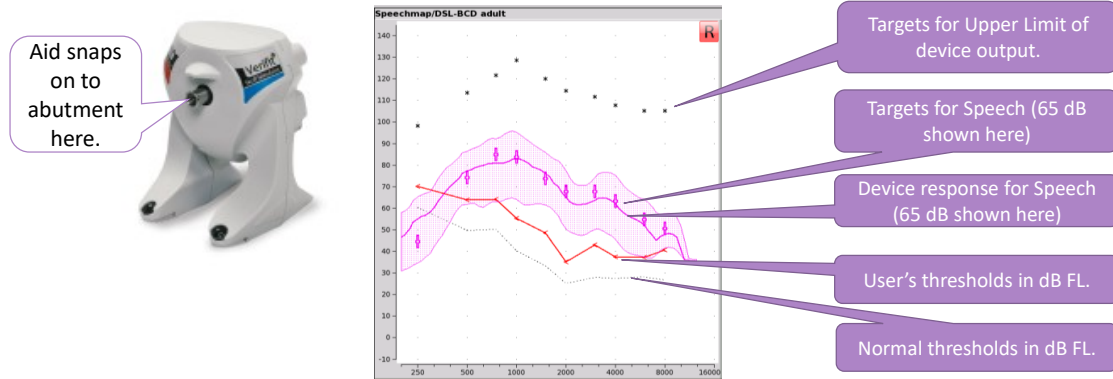
Case: A user of a bone conduction device who wishes to pair their hearing aids to their smartphone via Bluetooth.

- Their new hearing aid has arrived, you just had a cancellation, and this is not a device you have used before.
- What to do?

Top Ten for Today: 7,8,9

- Promoting ease of use
- Testing OTCs on a new standard
- Bone anchored hearing aids

Ensuring audibility of sound for adults who use bone-anchored hearing aids on abutments.



Hodgetts & Scollie, (2017) [DSL prescriptive targets](#); Scollie, Hodgetts & Pumford (2018) [How to use the targets & skull simulator](#)

DSL targets can be used for test box verification in VF1 (check serial number) or VF2.



Unplug the air conduction coupler(s) and plug the skull simulator into the test box.

Tip: Remember to calibrate the air conduction mics first! This needs to happen before you move to the skull simulator if not already done/stored.



Position the skull simulator sideways to the speaker. *This points the directional mic on the hearing aid to the speaker.*

Tip: If you are testing right you should see red. If left, you should see blue.

2a VSS PLACEMENT FOR VERIFIT (VF-1)

LEFT DEVICE



RIGHT DEVICE



Tip: Extender for VF-1 placement.

2b VSS PLACEMENT FOR VERIFIT2 (VF-2)

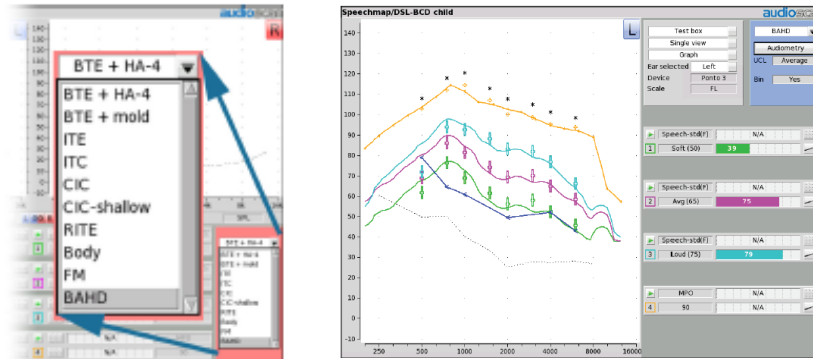
LEFT DEVICE



RIGHT DEVICE



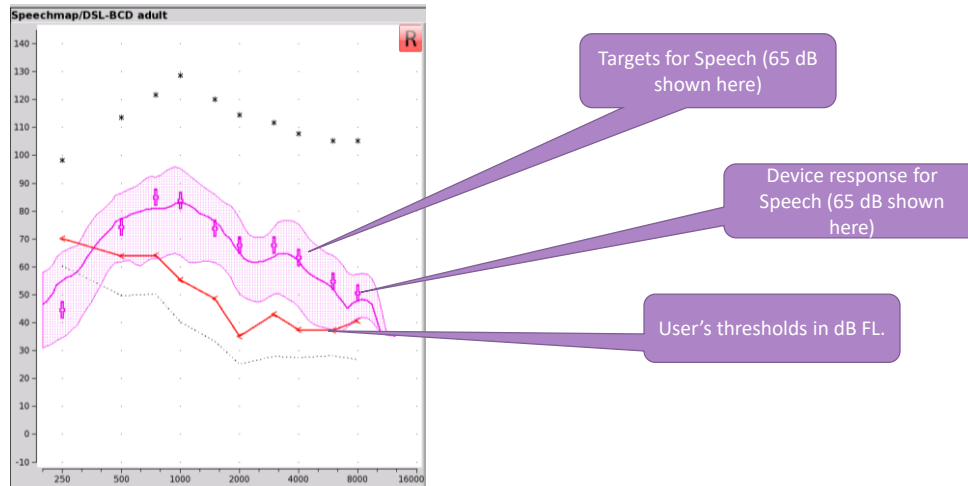
Select “BAHD” and choose DSL-BCD adult.
You’ll enter direct bone thresholds next (not shown).



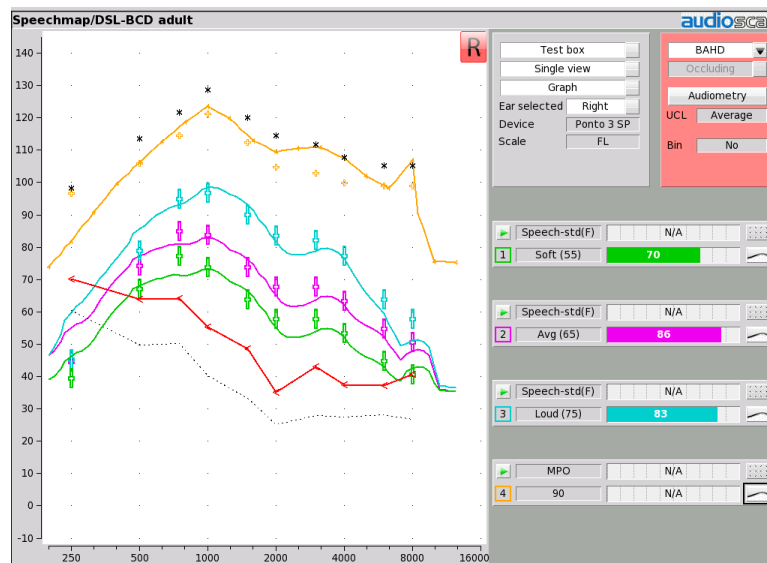
Snap on the hearing aid onto the skull simulator.
Position the reference microphone near the front hearing aid microphone.



Verify and fine-tune to targets to fit a full audible bandwidth (note low frequency differences).



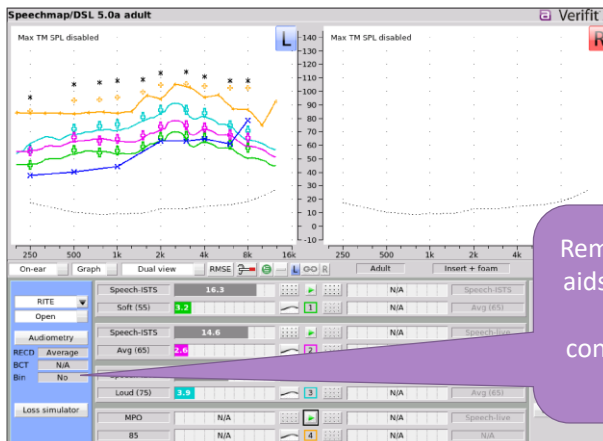
Multilevel verification example.



Top Ten for Today: #10!

**Verification of BiCROS
hearing aids: not just
matching target!**

Step 1. Fit the hearing aid to the aided ear

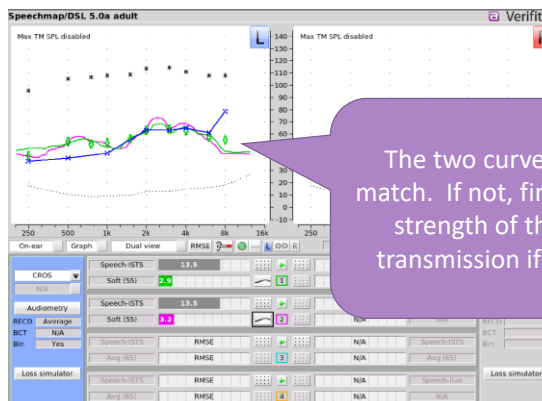


Remember – even though there are hearing aids in both ears, the sound is only going to the left ear and therefore should be considered a monaural fit without binaural corrections.

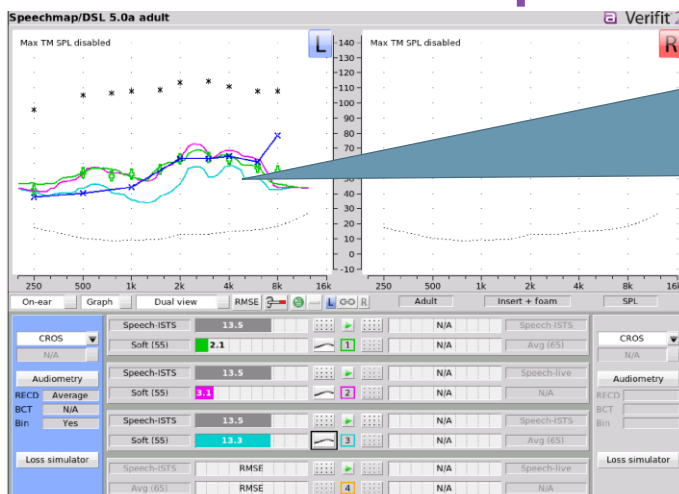
Step 2. Check the BiCROS is functioning



Once the aid is fitted, turn the patient 45° so that the left ear is away from the speaker. Change the instrument choice on the system to CROS. Leave the 55 dB curve from the fitting on screen. Run the same speech signal used for the fitting in Test 2.



Working and Not Working BiCROS can be seen with this procedure.



Test 3 shows a BiCROS that was not functioning.

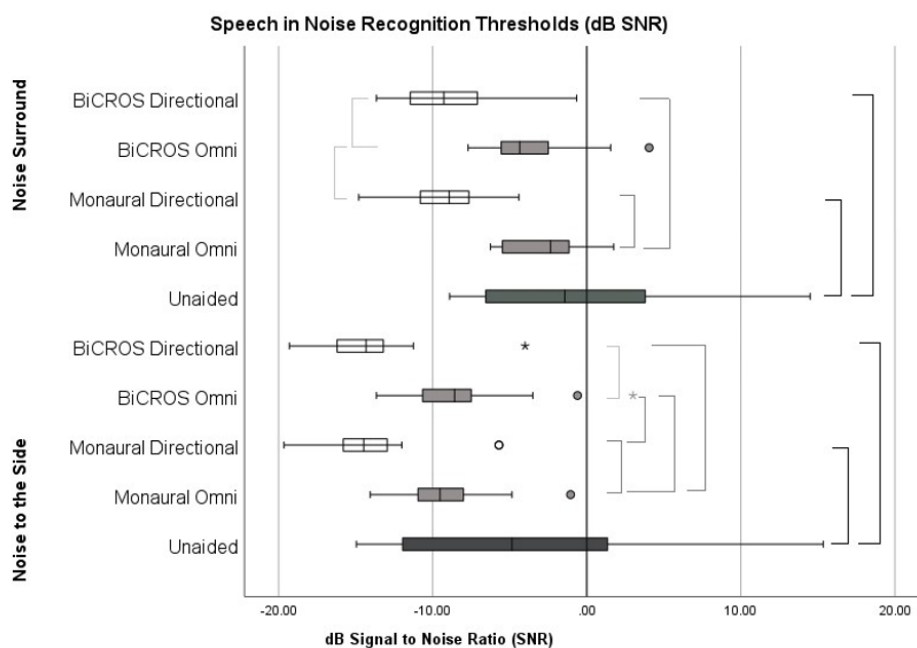
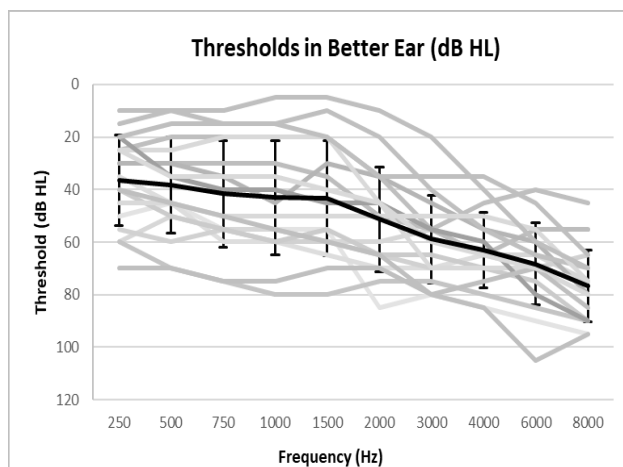
Fine tune to increase transmission gain.

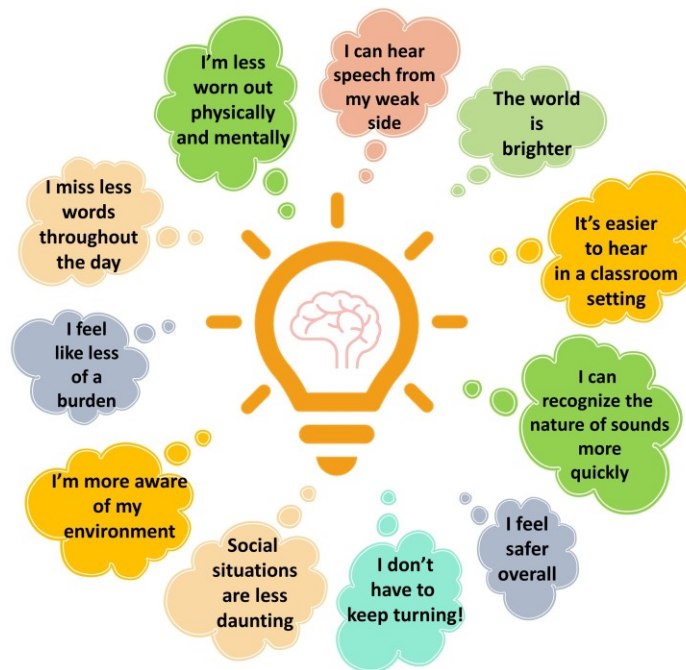
BiCROS Clinical Trial with verified aids.

Clinicaltrials.gov: NCT05379231

Saleh et al., 2024, IJA

Eighteen patients, age range 61-91 years.

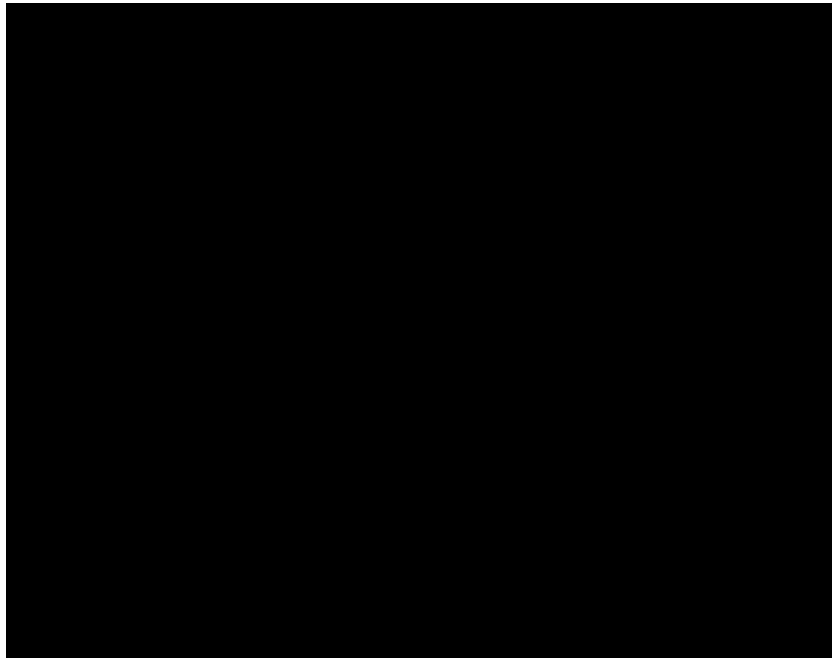




Verified, fine-tuned BiCROS fittings:

- Were worn and acceptable in a real world trial.
- Had better outcomes in lab when combined with directionality (and so did the unilateral fittings).
- **Provided the desired results of awareness on the LUHU side in real-world listening situations.**

BiCROS verification.



Recap for Monday Morning:

- 1) Ensure audibility using patient-centred, outcome-focused strategies.
- 2) Use norms to interpret fittings for audibility & fit to target.
- 3) Consider ambitious bandwidth for patients who can benefit.
- 4) Watch the open fits and use verification wisely.
- 5) Check strength of noise reduction (they vary).
- 6) Fit and fine tune phone & streaming.
- 7) Co-listen to device user alerts, verify & fine tune to preference.
- 8) Consider new test standards for OTCs.
- 9) Fit and verify bone anchored hearing aids.
- 10) Fit and demonstrate BiCROS hearing aids.

Thanks for your time today!

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Download our research [here](#).

