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Fitting M&RIE: The impact of a receiver module with canal microphone & resulting benefits for users and hearing care professionals

Megan Quilter, Au.D.

GN Hearing A/S

Receiver in the Ear (RIE) Hearing Instrument

2019, RIEs made up 78.9% of instruments dispensed

- Hearing Care Professionals (HCPs) can stock for demo or fittings
- Comfortable to wear
- Virtually invisible on most
- Wireless connectivity will be more robust
- Users are overall happier



Potential Disadvantages Of RIEs

Despite its many advantages

- Some find the sound quality to be unnatural
- Difficult to acclimate to
- Worst case scenario: detrimental to their listening goals



Fundamental disadvantage: microphone location (above/behind)

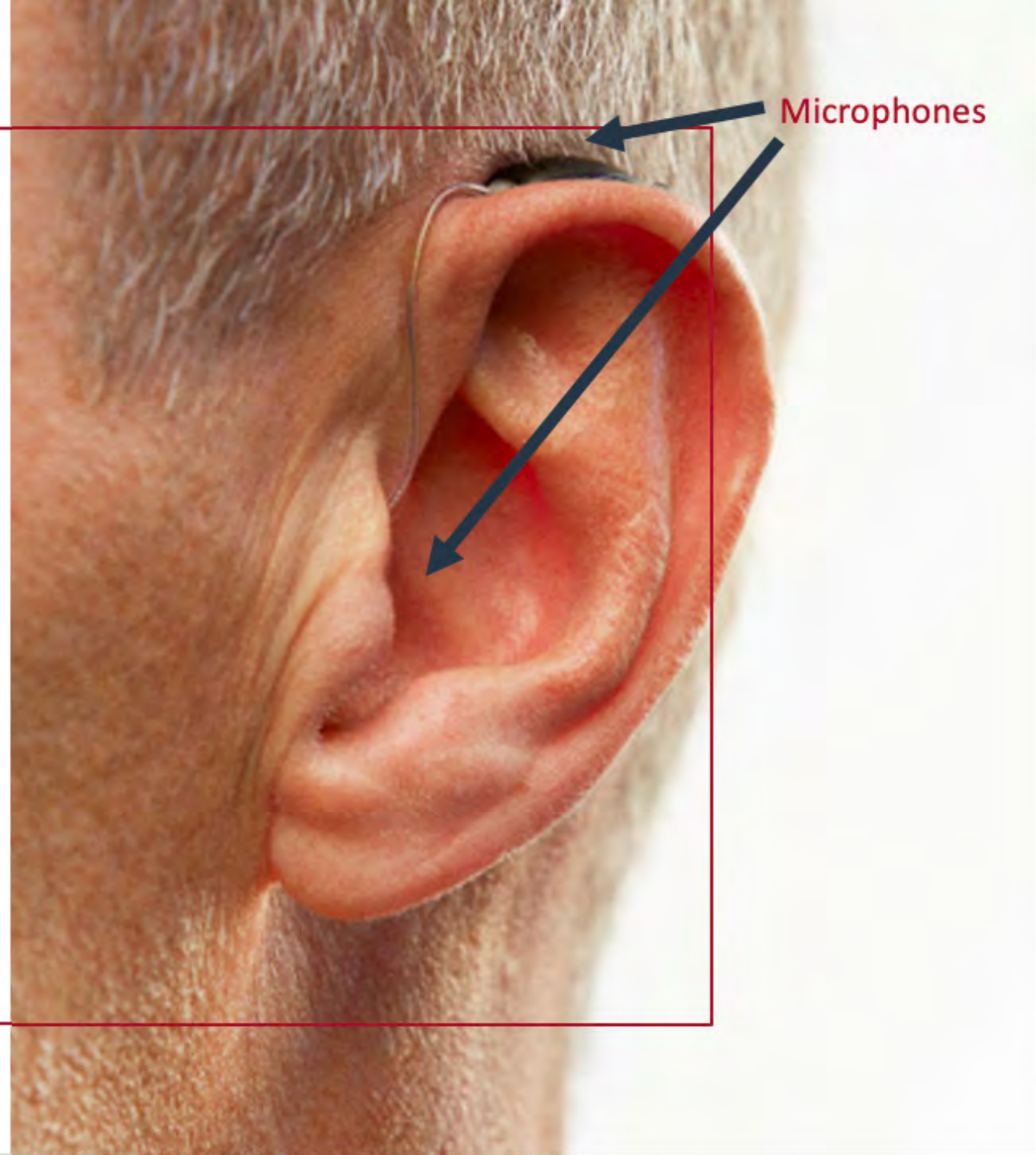
- Sound quality
- Not where sound is naturally picked up and channeled to eardrum
- Brain expects to receive sound that has been shaped by the body, head and ear
- Collection through wrong anatomical position
- Interfere with natural hearing processes, maybe working against the + effects

M&RIE

M&RIE MAKES SENSE

Our individual ear provides

- Our own unique acoustics
- Localization
- Spatialization



How distinct is our auditory perceptual experience?

Determined by:

1. Shape/level of the sound coming in
2. Environment
3. Shaping of sound by the individual head, torso and pinnae

Everyone has their own acoustic cues

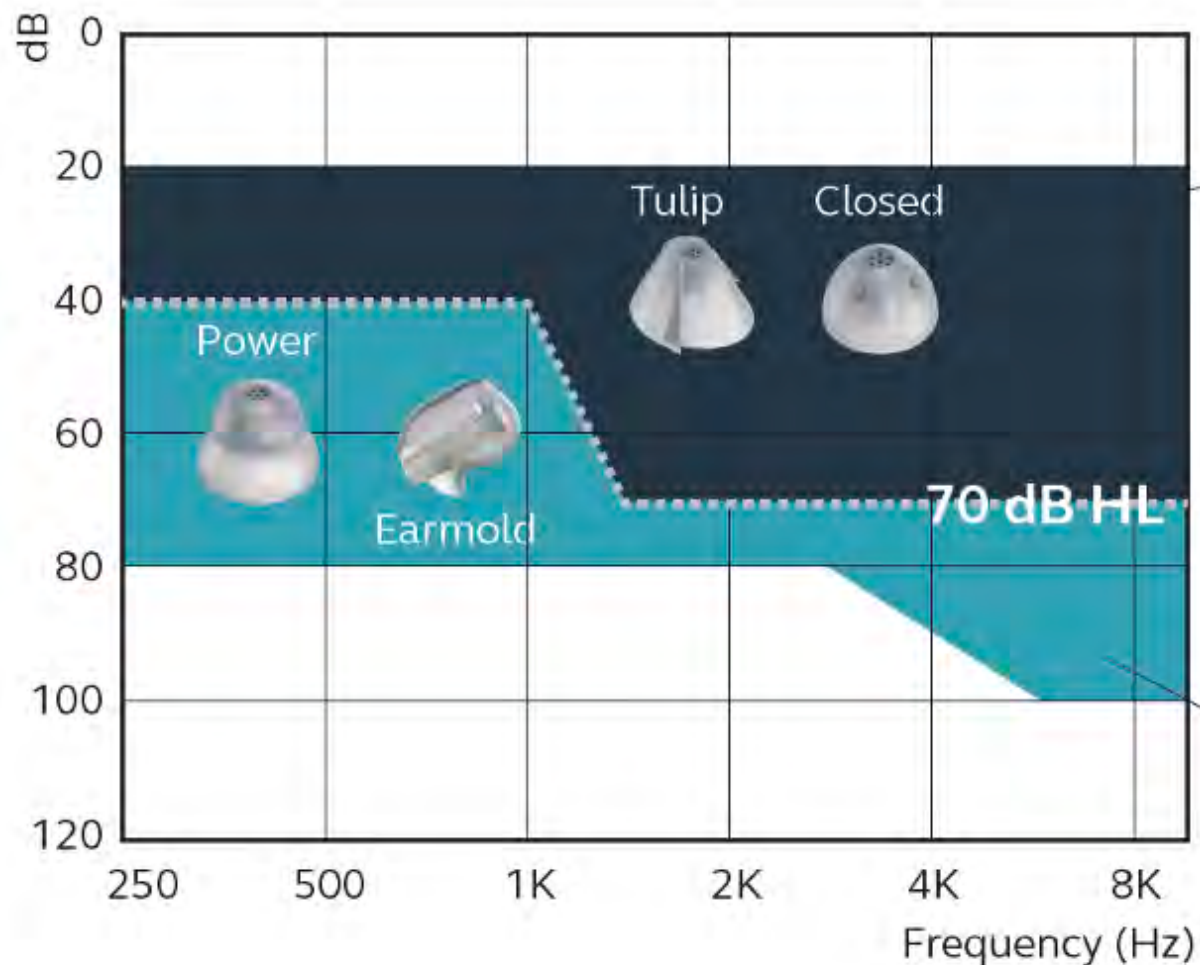
- Localization
- Segregating auditory scenes
- Judgment on sound quality
- Perception of auditory distance





M&RIE
Microphone & Receiver-In-Ear

How to get the most organic sound with M&RIE



Best results are obtained with Closed or Tulip dome



Tulip and Closed domes are rated equally good by users in terms of sound quality, own voice and occlusion; both domes provide the same degree of openness, with a 10 dB vent effect at 500Hz



Tulip and Closed domes increase available stable gain by approximately 3 dB relative to the Open dome



Power domes and earmolds are recommended for users with hearing loss within this range



Earmolds can be customized to any hearing loss severity and are an excellent option for people with moderate-to-severe hearing loss

User Benefits of M&RIE

Reduced
wind noise

Localization

Less
listening
effort

Sound
quality



User Benefits of M&RIE



How does this apply to listening effort?

Everyone experiences listening effort that varies per situation!

***Definition:* The mental resources you deliberately allocate to listen and attend to auditory tasks**

The effect of hearing loss on listening effort:

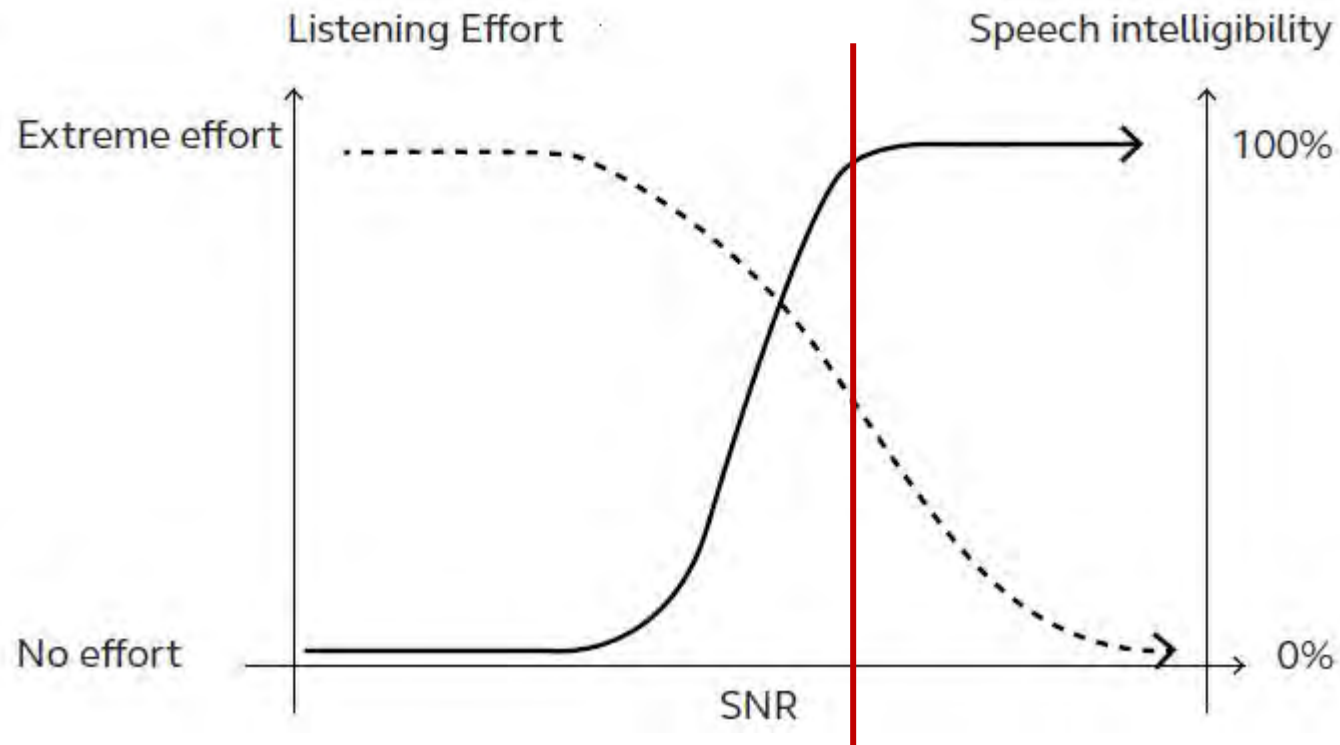
- Effort spent to follow conversations can increase
- Hearing loss may increase listening-related effort and fatigue in our daily lives
- Those who wear hearing aids **report reduction in the stress** associated with not understanding or misinterpreting conversations, and **less mental exhaustion**

Primary goal of HIs:

- Restore audibility for speech comprehension while maintaining safe and comfortable sound levels
- Secondary benefits such as **reduced listening effort** should not be overlooked.

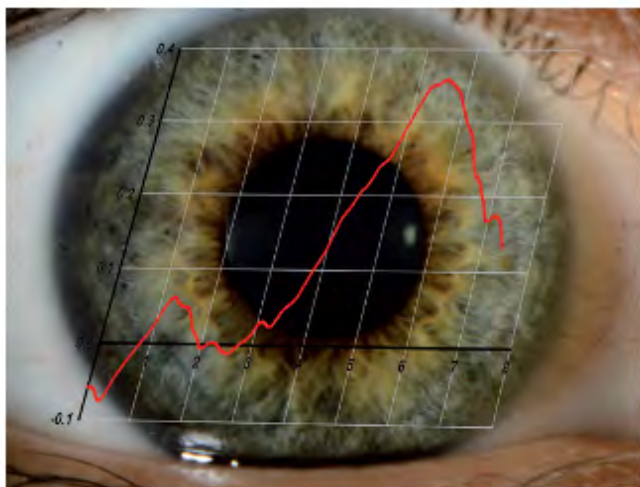
Quantifying Listening Effort

Why: It can capture information about hearing aid benefit that is NOT reflected in measures of audibility or speech understanding

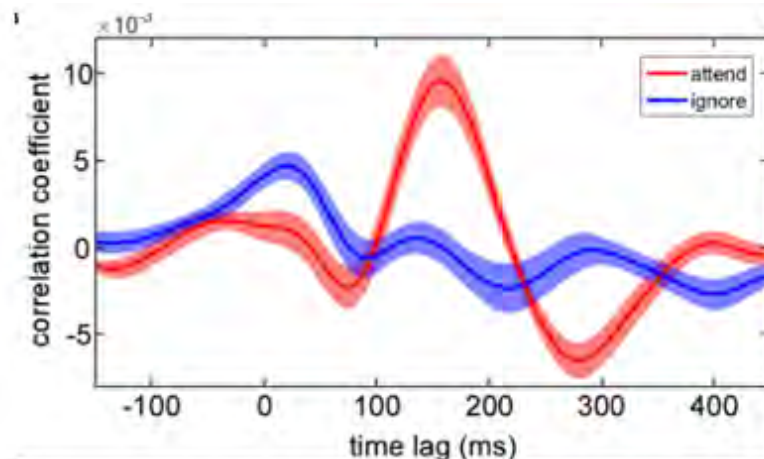


- Effort must be put in to understand at the max level until SNR improves further
- Measuring LE can add nuance to understanding of what is being experienced in various listening conditions

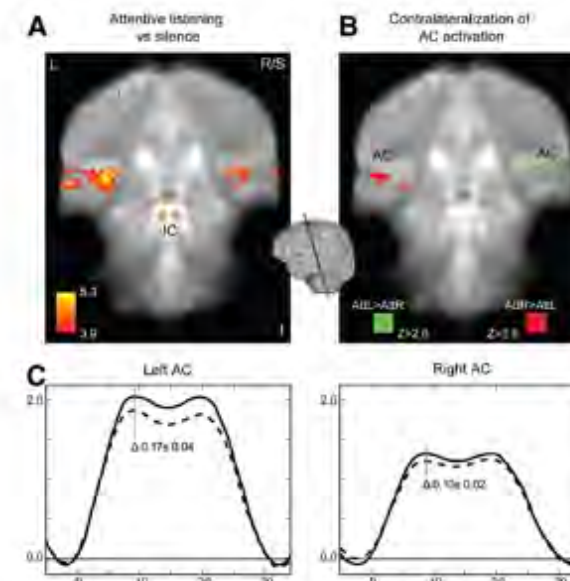
Assessment of Listening Effort



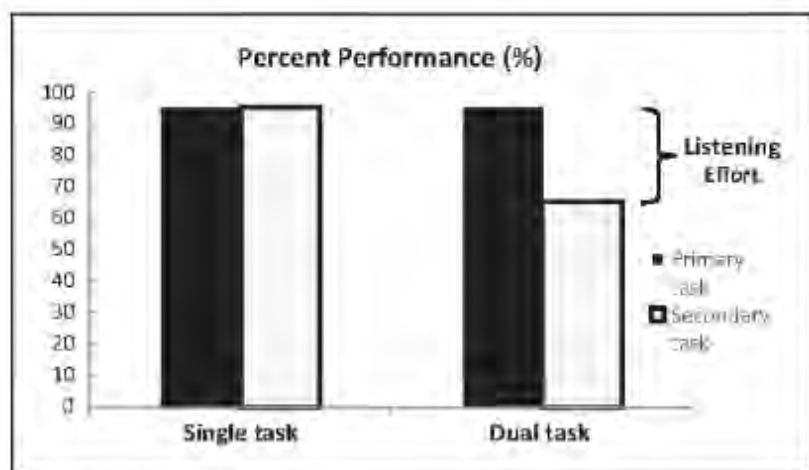
Pupillometry



Electroencephalogram (EEG)



Functional Magnetic Resonance Imaging (fMRI)



Dual task paradigm



Subjectively

Adaptive
Categorical
Listening
Effort
Scaling
Method (ACALES)

Pragmatic Approach



Krueger et al, (2017) took a pragmatic approach for assessment:

1. Fast and easy to implement
2. Utilize equipment common in Audiology research
3. Relatively simple test set up
4. Captures the entire range of listening effort that could be experienced
5. Participants must be actively involved in the procedure

Users' momentary experience of how much effort they are making to listen has clinical relevance

Subjective perception ultimately affects the decision on whether to use the hearing aids

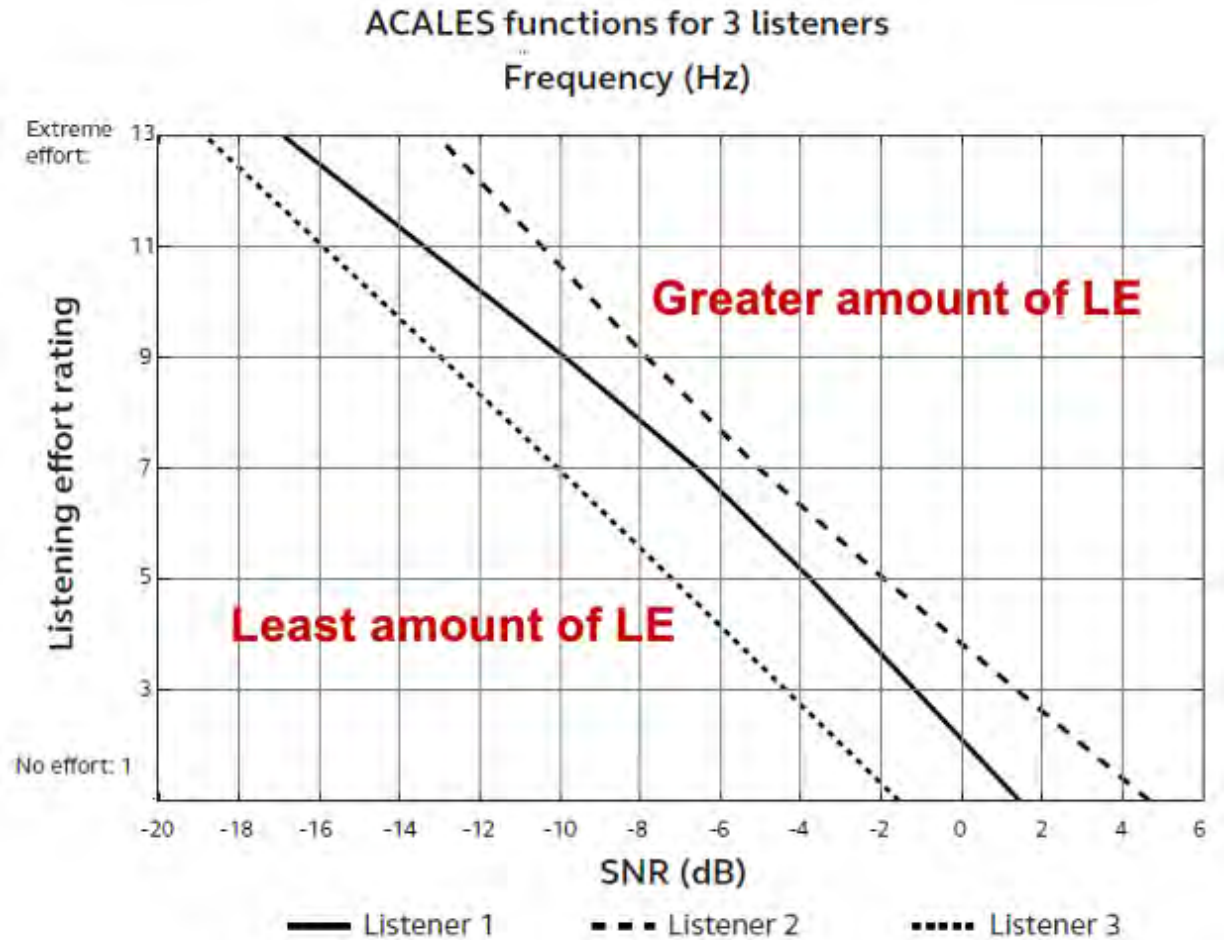
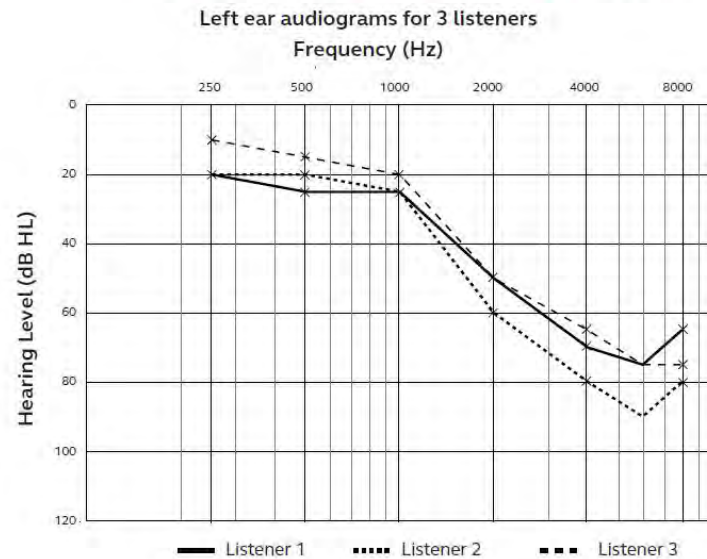
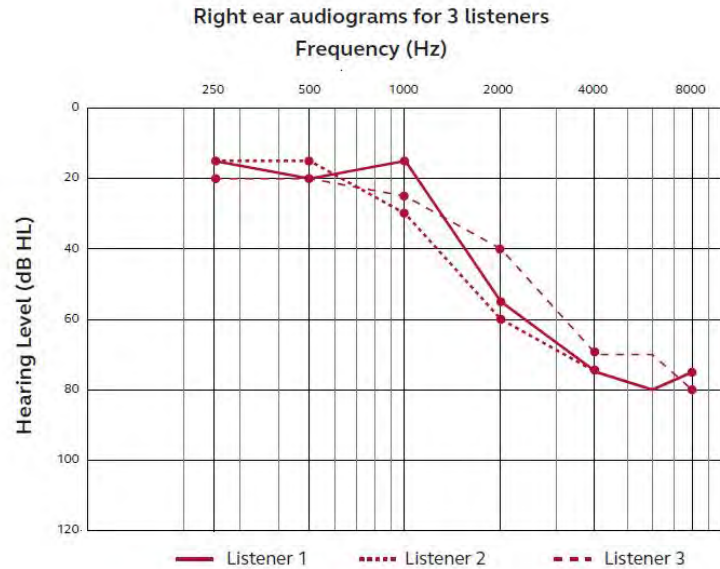
Adaptive Categorical Listening Effort Scaling Method (ACALES)

“ACALES”, developed in Hörzentrum Oldenburg gGmbH

- Requires less than 5 min per condition
- Listeners are presented with target speech in noise for 10-15 seconds
- Rate how effortful it is to follow the speaker
- 13-point categorical scale
- Presentation levels are varied adaptively
- Derivation of listening effort as a function of SNR
- Responses reflect the listeners subjective perception of listening effort during the task

only noise	nur Störgeräusch
extreme effort	extrem anstrengend
===	===
very much effort	sehr anstrengend
===	===
considerable effort	deutlich anstrengend
===	===
moderate effort	mittelgradig anstrengend
===	===
little effort	wenig anstrengend
===	===
very little effort	sehr wenig anstrengend
===	===
no effort	müheless

Plotted Functions Reveal Individual Differences in Listening Effort (LE)



Differences are quantified by SNR

What Else Can We Investigate?



Research question: Will the impact of a receiver module with canal microphone have resulting speech intelligibility and listening effort benefits for users and hearing care professionals?

Methods

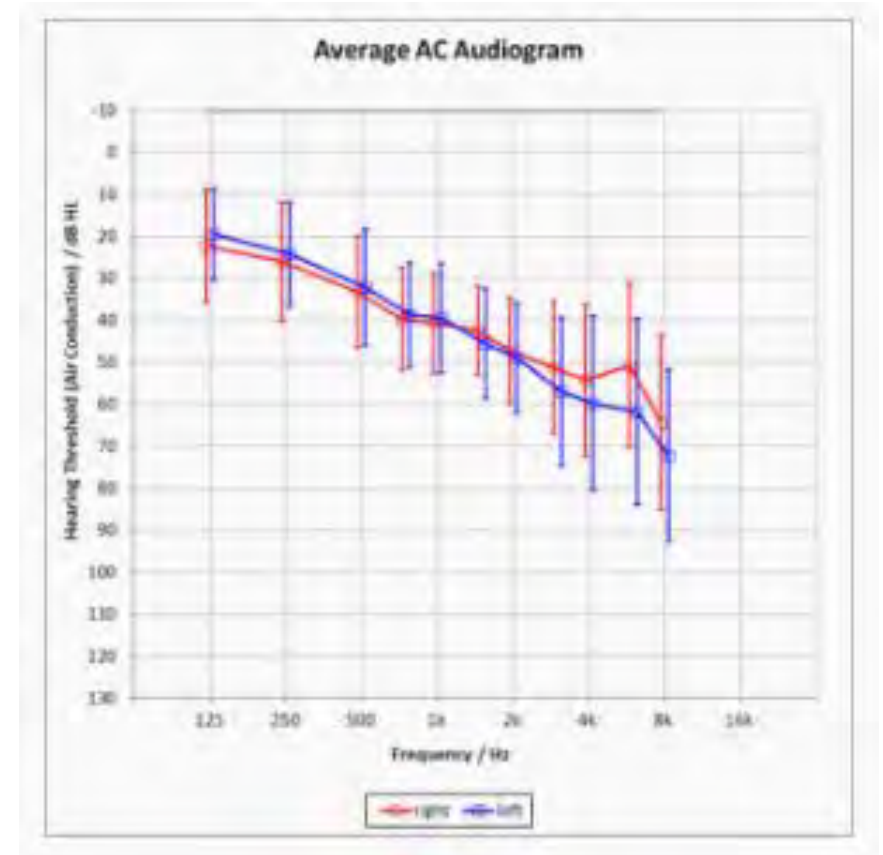


- 24 participants between 58 and 84 years
- Mean: 69.7 years (SD: 6.1 years)
- Male / female: 12 / 12
- Experienced hearing aid user
- Hearing loss: 15.6 years (SD: 12.7 years)
- Experience with hearing aids: 6.2 years (SD: 3.8 years)
- Current hearing aids: 3.5 years (SD: 2 years)



HA Program

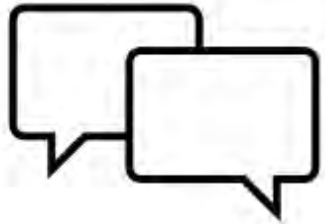
- P1: M&RIE
- P2: Omnidirectional
- P3: Spatial Sense/ Pinna Restoration



Outcome Measures



- Adaptive Categorical Listening Effort Scaling Procedure (ACALES)
Subjectively perceived effort to follow a speaker in background noise



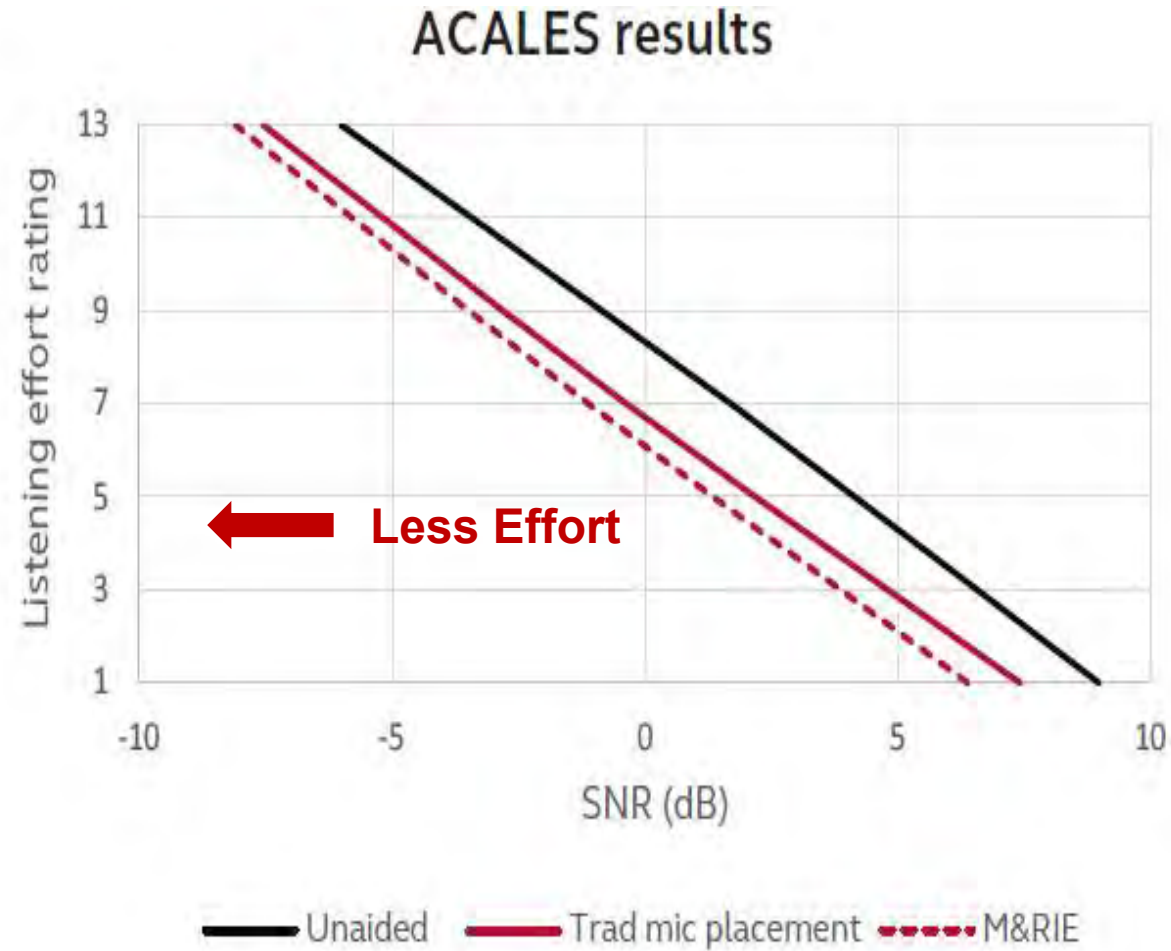
- Göttingen Sentence Test (GÖSA)
Speech recognition in noise test

Test Conditions

	ACALES	GOSA
Unaided	✓	✓
M&RIE *	✓	✓
SureFit 3 Med.Power**	✓	✓

ACALES Results – Relationship between SNR and LE Category

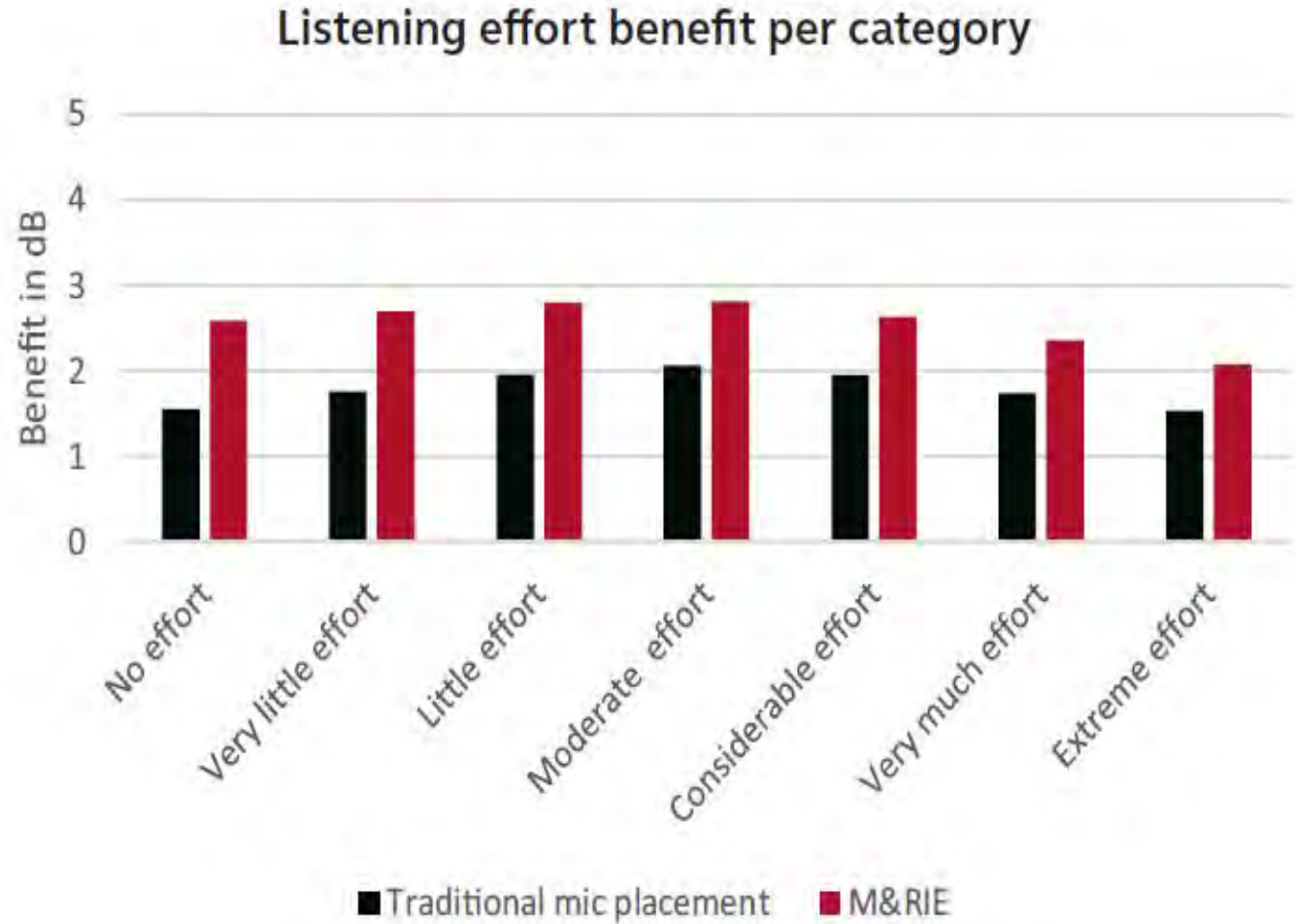
- Mean listening effort functions for aided and unaided conditions*
 - Listening effort (Y)
 - SNR (X)



ACALES Collapsed into SNR at Each Effort Level

Across all categories

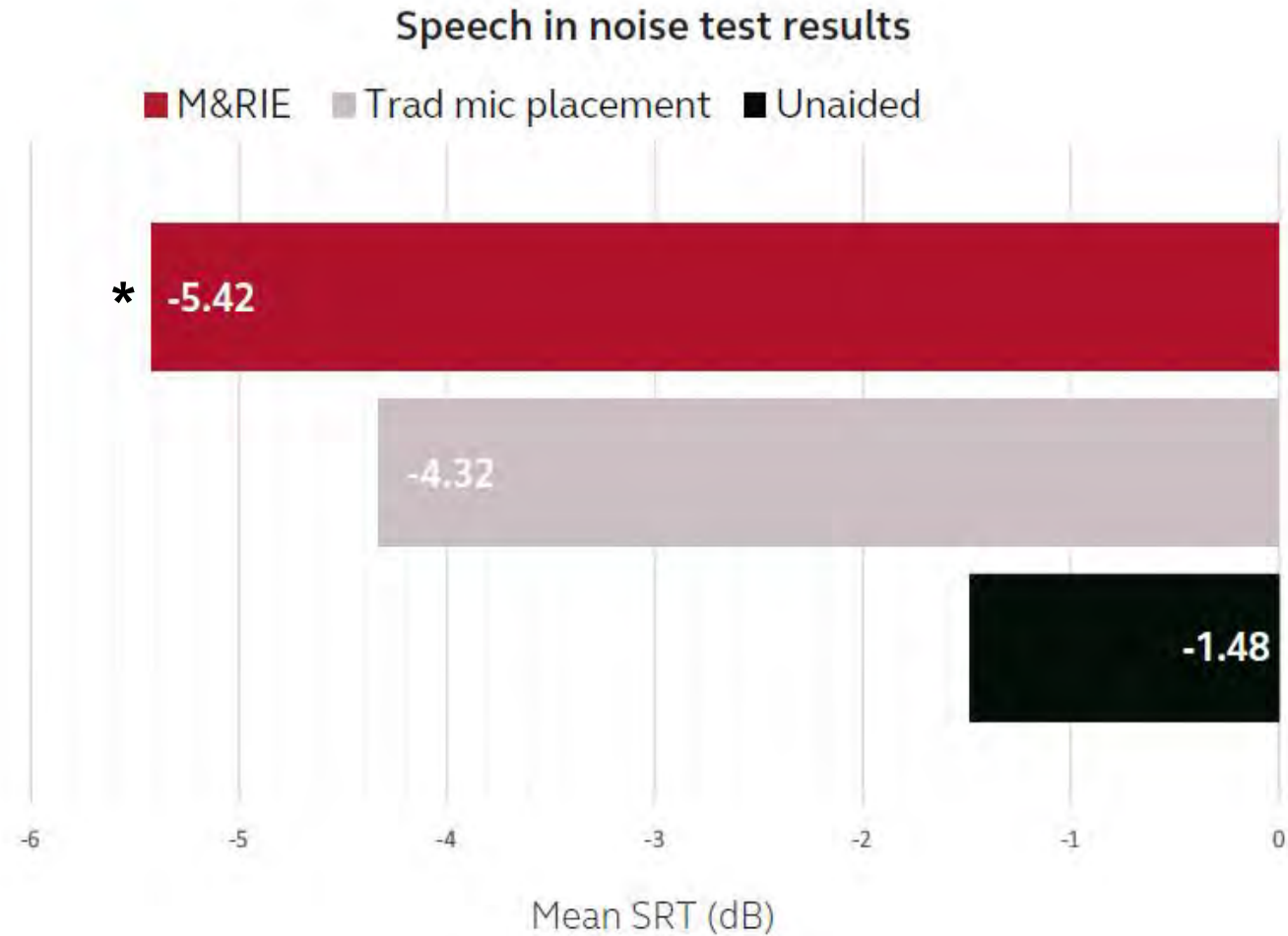
- Mean listening effort benefit with traditional mic placement = 1.8 dB
- Mean listening effort benefit with M&RIE = 2.6 dB*



* Indicates significant result/s

GOSA Results

- Participants showed overall improvement



Results Discussion

GOSA

Statistically significant improvement illustrates an advantage of picking up sound in the ear canal, a much closer way sound naturally enters the ear.

ACALES

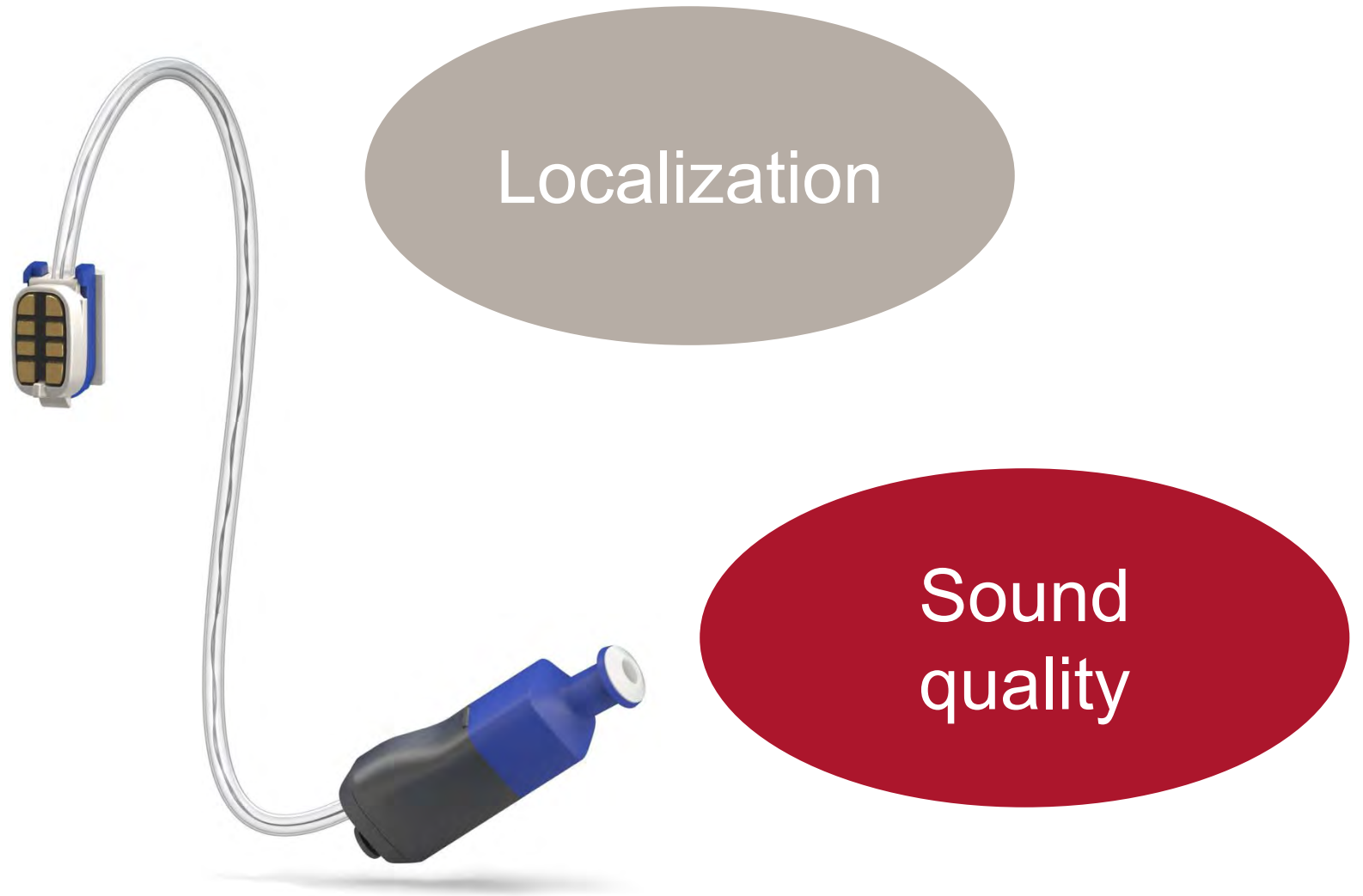
Results confirm how HIs can significantly reduce listening effort

ACALES method shows how the benefit persists even at +SNR where speech intelligibility has reached its maximum.

Clear & consistent trend while using M&RIE's 3rd mic is observable

Clear & consistent trend while using ReSound ONE is observable

User Benefits of M&RIE



Sound Unique for All

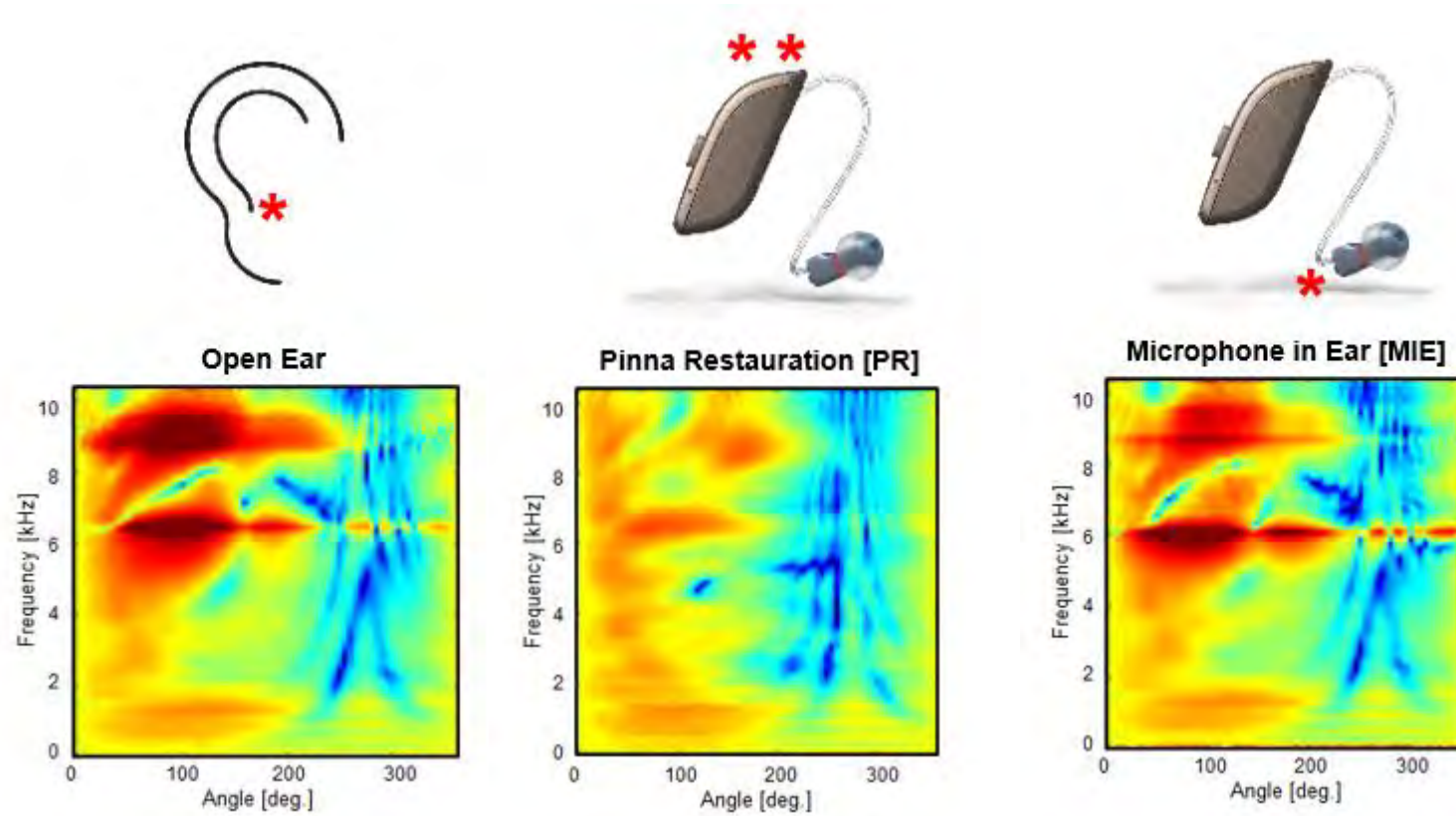


Our outer ears, head and torso uniquely **shape the sound** that enters the ear canal



Provides acoustic cues the brain uses to help us **orient** to our environment, **perceive the depth** and **direction** of sounds, and **untangle overlapping sounds**

Spectrogram Analysis



Sound Quality & Spatial Sound Quality



Participants with normal hearing



Pinna compensation



M&RIE



Office



Cafeteria

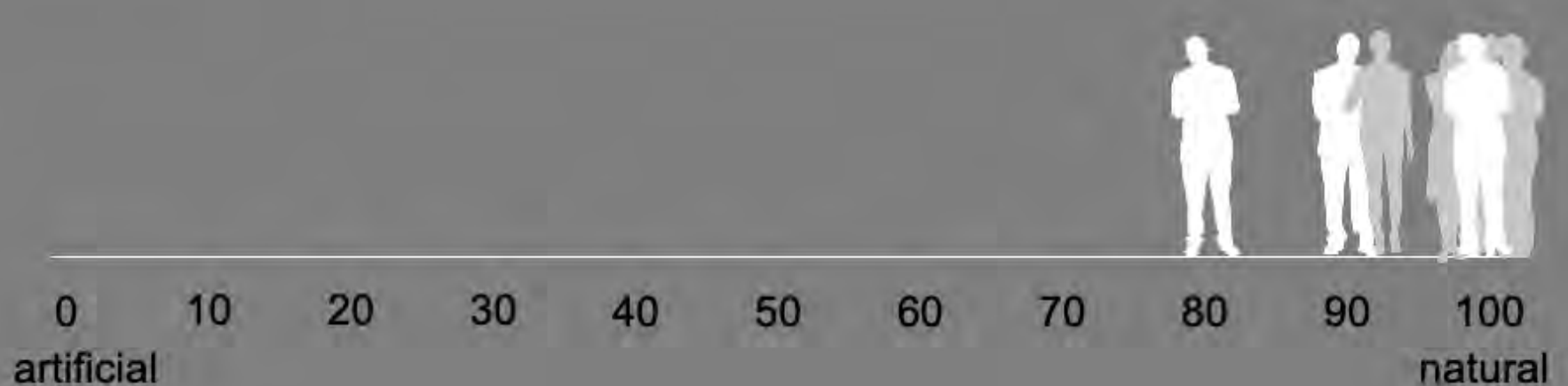


Jazz

Sound Quality

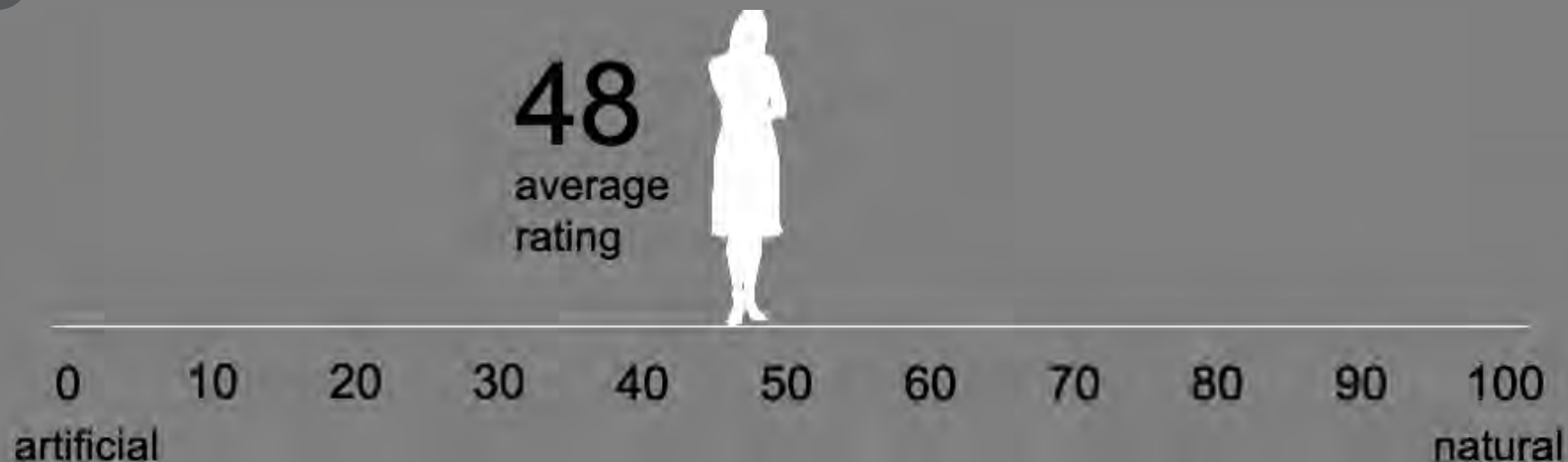
Overall Sound Quality

(attributes: clarity, timbre & naturalness)

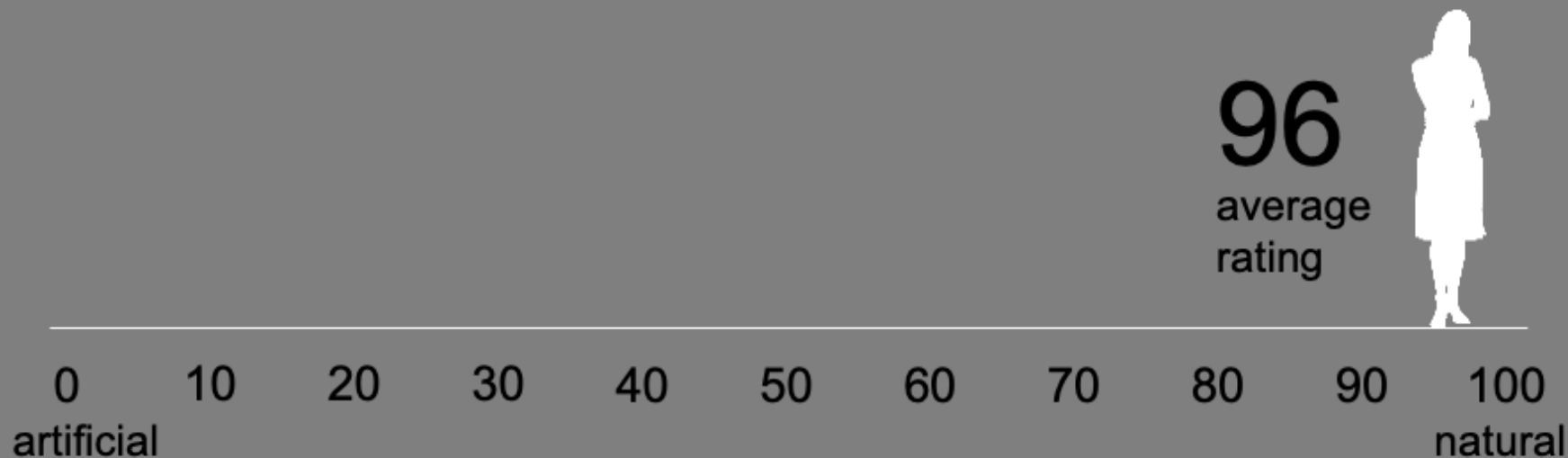


Sound Quality

Overall Sound Quality



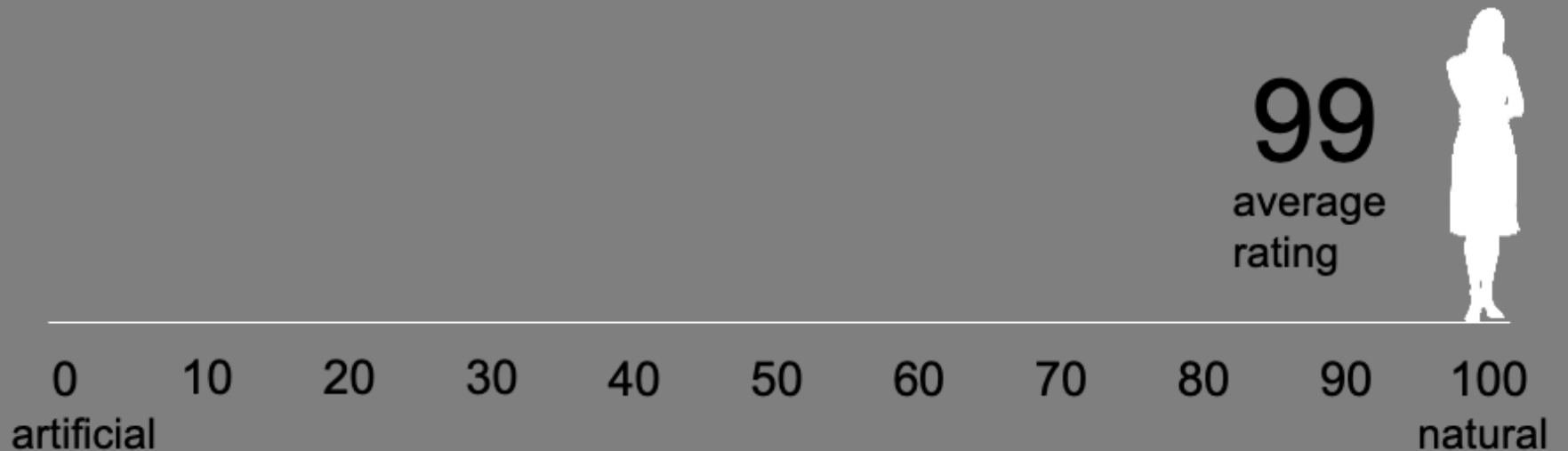
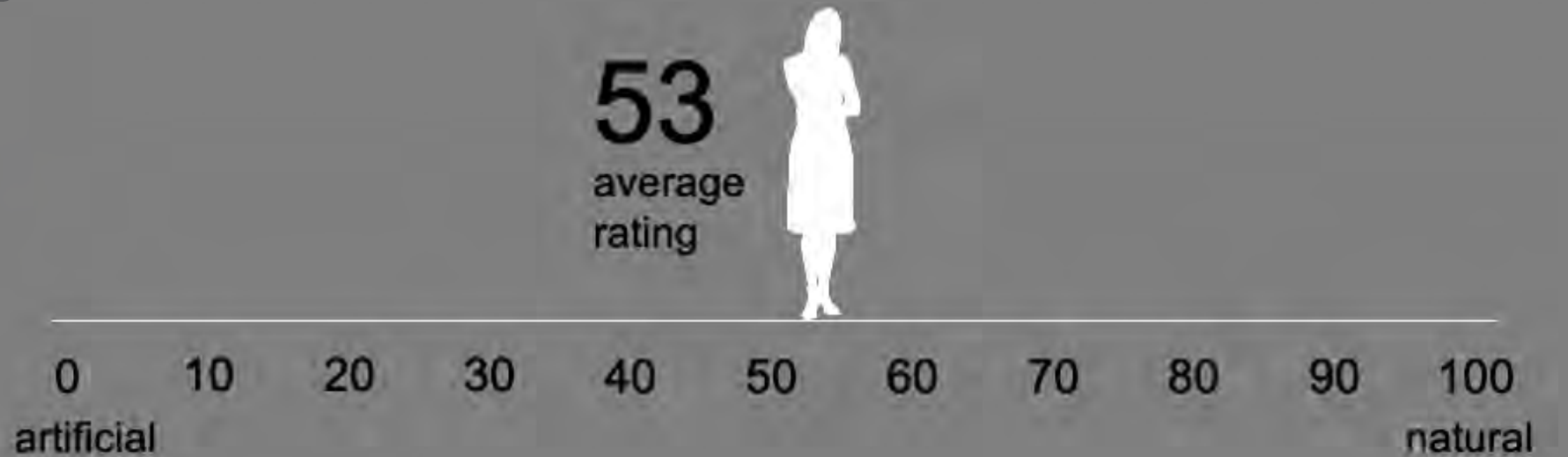
M&RIE



Sound Quality

Spatial Sound Quality

(localize sounds & spaciousness of the room)



Sound Quality

Participants



listeners with normal
hearing
(10 dB flat linear gain)



listeners with bilateral
mild-to-moderate
hearing loss

Sound Quality



Program 1
Omnidirectional



Program 2
Spatial Sense



Program 3
M&RIE



Cafeteria



Traffic



Train station

Sound Quality

Strong preference for M&RIE



listeners with
normal hearing



87%
Preferred M&RIE
over omnidirectional



70%
Preferred M&RIE
over Spatial Sense



listeners with
hearing loss



70%
Preferred M&RIE
over omnidirectional



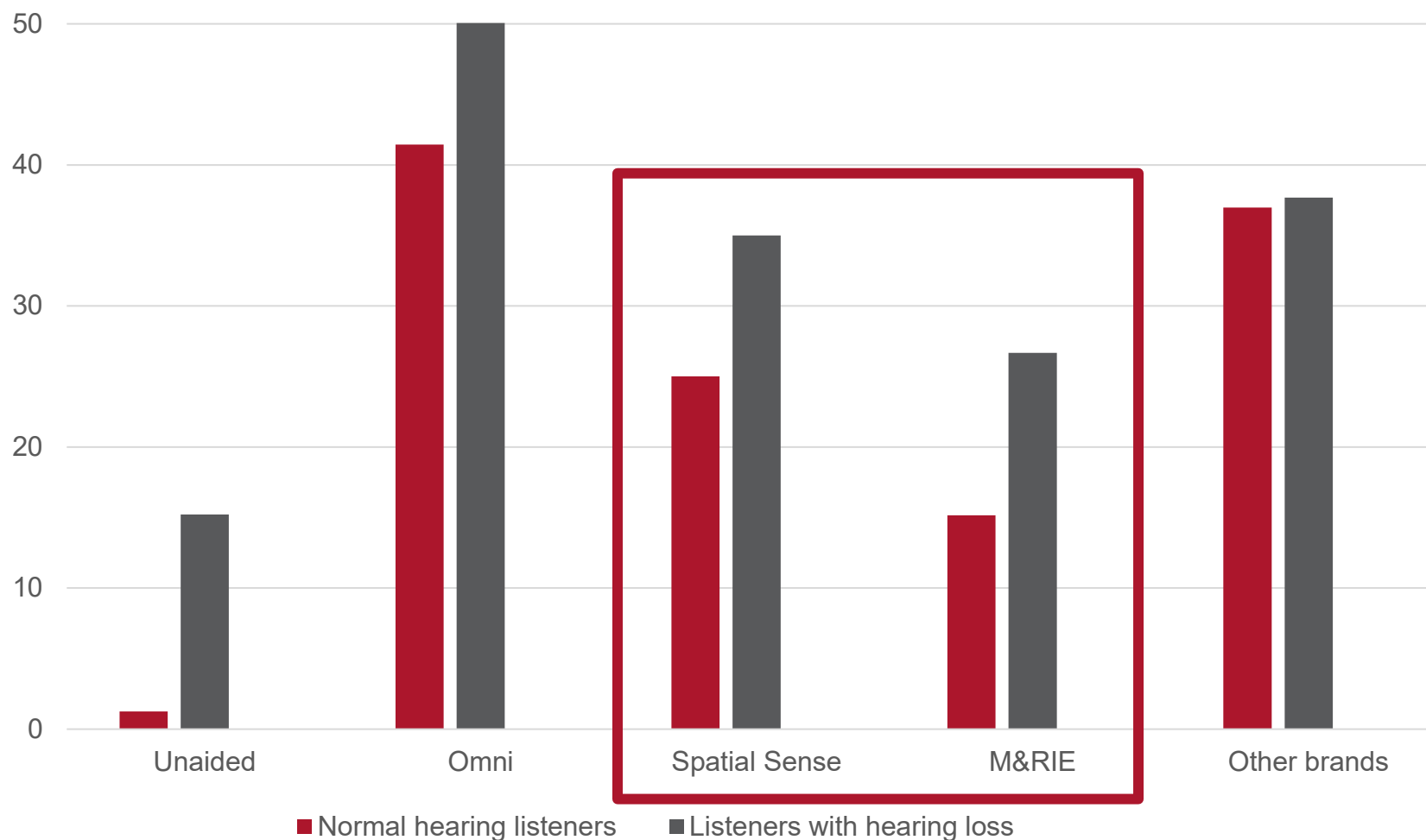
57%
Preferred M&RIE
over Spatial Sense

localization



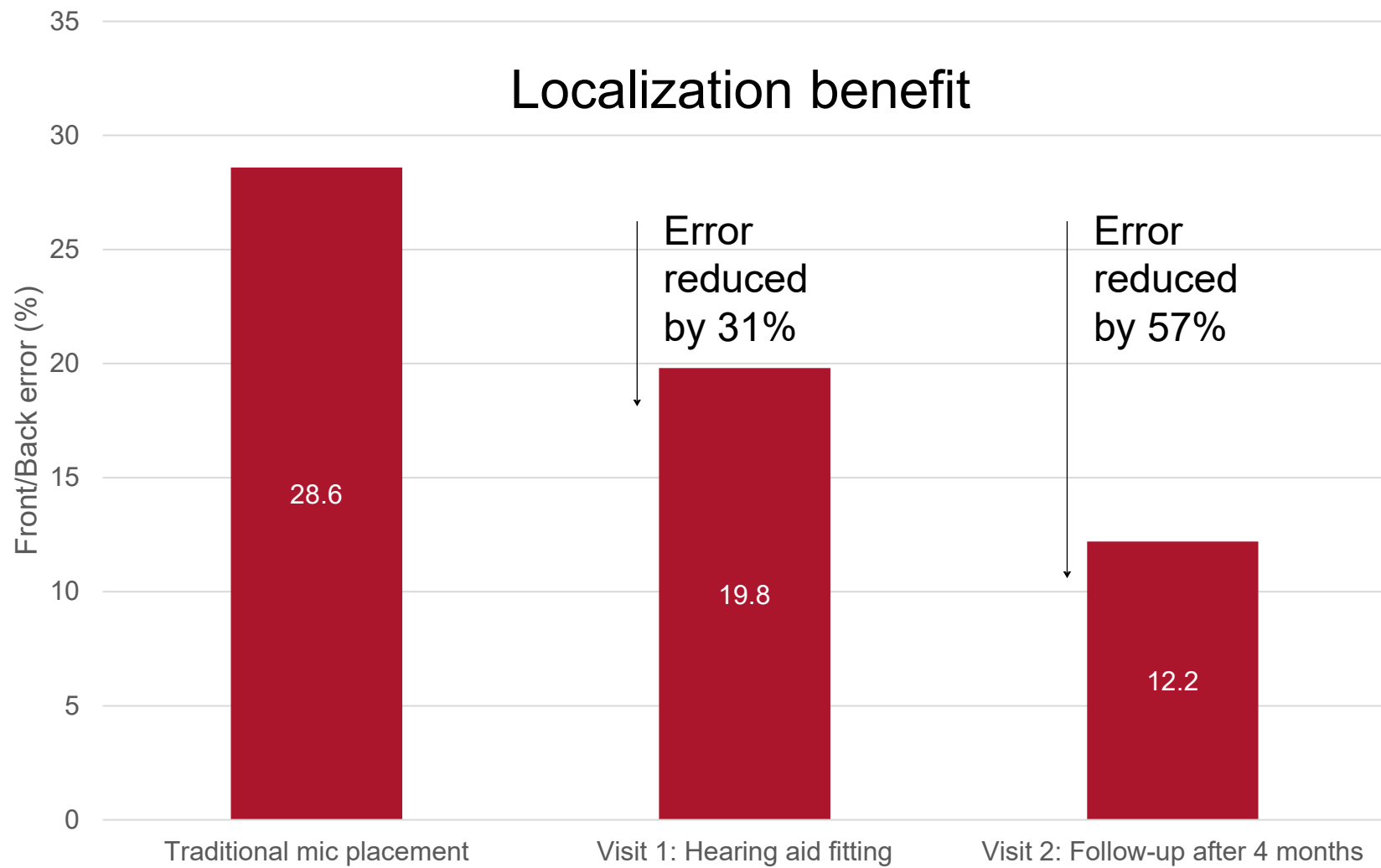
Localization

Average localization error



- M&RIE was the only condition **not** significantly worse than unaided
- M&RIE resulted in significantly less localization error than Omni.
- Spatial Sense resulted in significantly less localization error than Omni.
- M&RIE and Spatial Sense resulted in significantly less localization error than the other brands tested for normal hearing listeners.

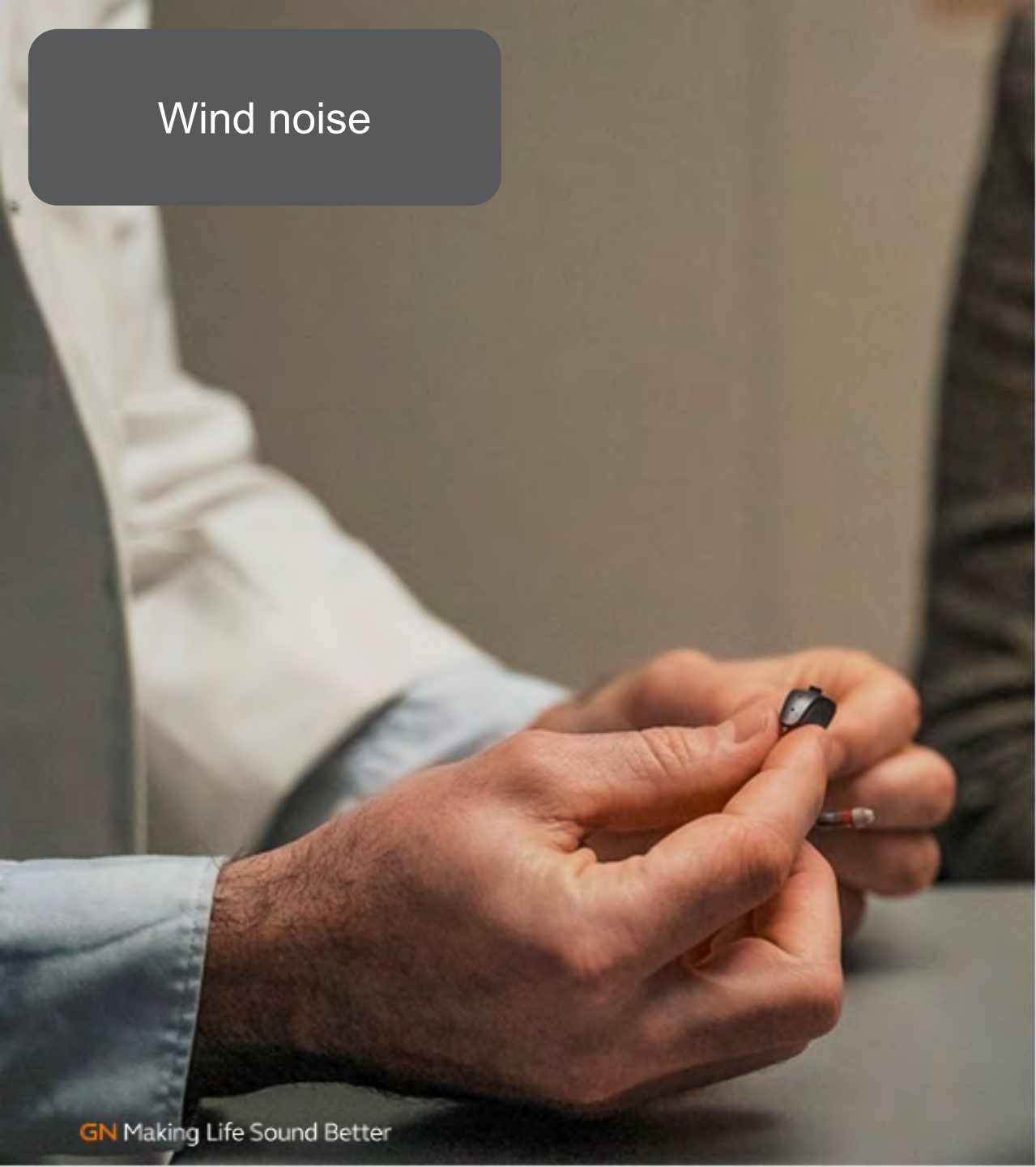




User Benefits of M&RIE

Reduced
wind noise



A person wearing a white lab coat is holding a small, black hearing aid device between their fingers. The background is a neutral, light-colored wall.

Wind noise

Wind noise protection

15dB Natural wind noise protection without reducing gain¹

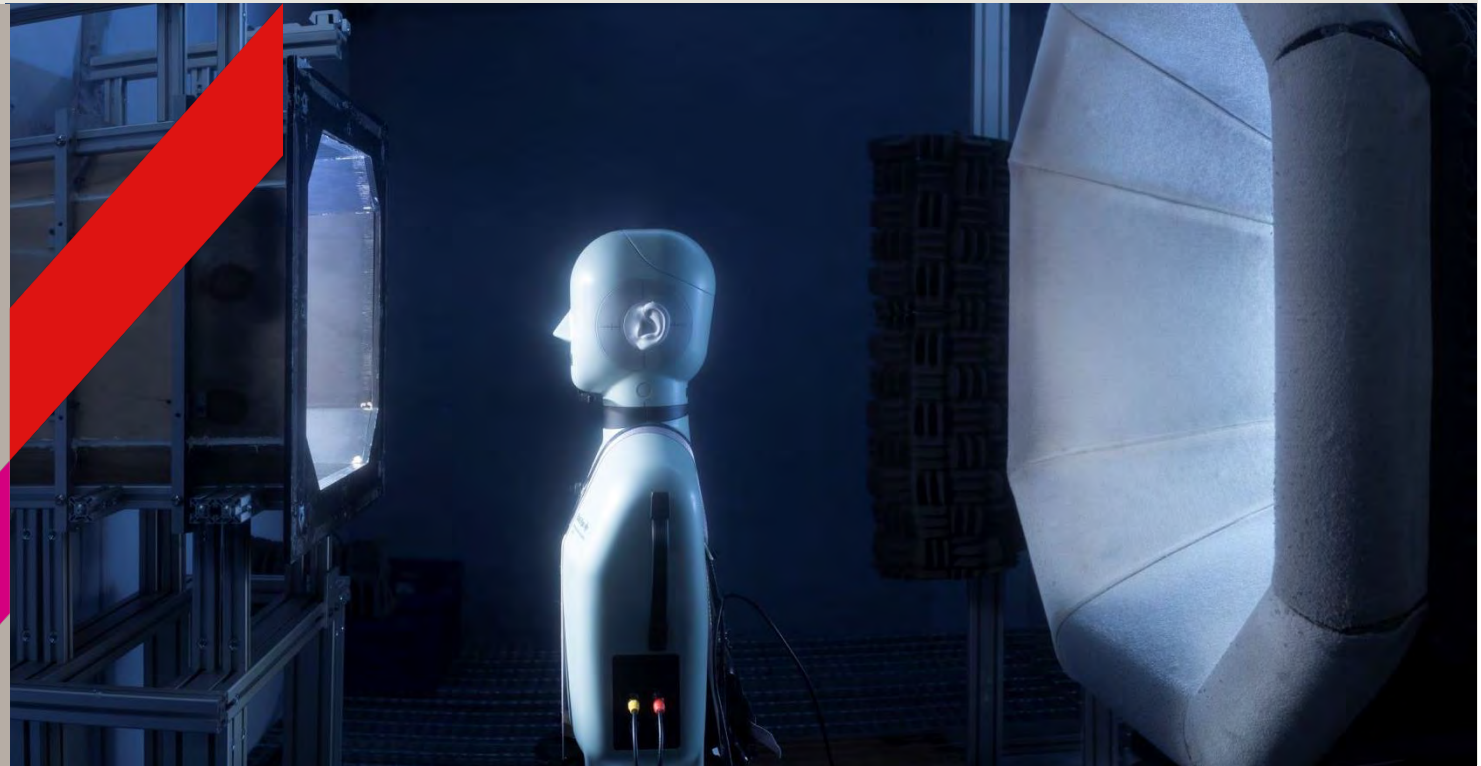
Wind noise benefit

33% Better sound quality rating in wind noise²

1. Groth J. An innovative RIE with microphone in the ear lets users “hear with their own ears”. ReSound white paper, 2020.
2. Andersen P, Schindewolf I, Jespersen C. Less wind noise with M&RIE leads to better sound quality. ReSound white paper, 2021.

Wind tunnel measurements

JOHN NEWALL, PH.D & HARVEY DILLION, PH.D



BEAUFORT WIND SCALE

Wind tunnel setup

Moderate SNHL hearing loss with gain equalized across

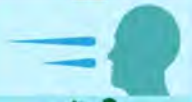
- Program 1 “M&RIE”
- Program 2 “Omni”
- Program 3 “All access directionality” with a high directional mix
- Program 4 “Synchronized soft switching” with “autoscope” and a high directional mix

All trialled with digital wind noise reduction on and off.

Wind speed of 8m/s = 29km/hr = 18mile/hr

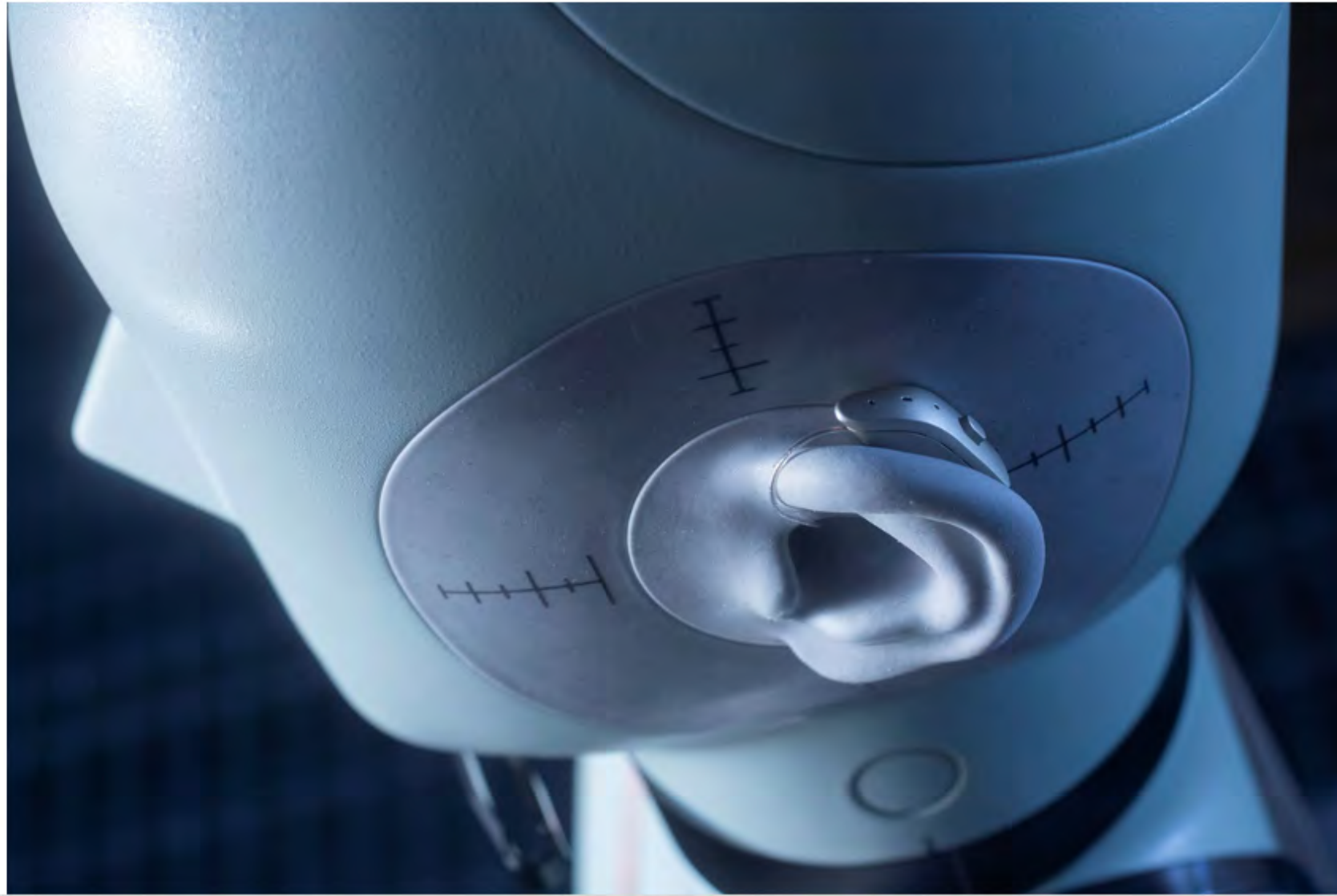
Acoustics: Tulip dome

Acoustic manikin bilaterally fitted

Beaufort Number	Description	Wind speed	Wave height	Sea conditions	Land conditions	
0	Calm	< 1 knot < 1 mph < 2 km/h	0 ft 0 m	Sea like a mirror	Smoke rises vertically	
1	Light air	1–3 knots 1–3 mph 2–5 km/h	0–1 ft 0–0.3 m	Ripples	Direction shown by smoke drift	
2	Light breeze	4–6 knots 4–7 mph 6–11 km/h	1–2 ft 0.3–0.6 m	Small wavelets	Wind felt on face	
3	Gentle breeze	7–10 knots 8–12 mph 12–19 km/h	2–4 ft 0.6–1.2 m	Large wavelets	Leaves and small twigs in constant motion	
4	Moderate breeze	11–16 knots 13–18 mph 20–28 km/h	3–6 ft 1–2 m	Small waves	Raises dust and loose paper	
5	Fresh breeze	17–21 knots 19–24 mph 29–38 km/h	6–10 ft 2–3 m	Moderate waves	Small trees and leaves begin to sway	
6	Strong breeze	22–27 knots 25–31 mph 39–49 km/h	9–13 ft 3–4 m	Large waves	Large branches in motion	
7	High wind, moderate gale, near gale	28–33 knots 32–38 mph 50–61 km/h	13–19 ft 4–5.5 m	Sea heaps up	Whole trees in motion	
8	Gale, fresh gale	34–40 knots 39–46 mph 62–74 km/h	18–25 ft 5.5–7.5 m	Moderately high waves	Twigs break off trees	
9	Strong/severe gale	41–47 knots 47–54 mph 75–88 km/h	23–32 ft 7–10 m	High waves	Slight structural damage	
10	Storm, whole gale	48–55 knots 55–63 mph 89–102 km/h	29–41 ft 9–12.5 m	Very high waves	Trees uprooted, considerable structural damage	
11	Violent storm	56–63 knots 64–72 mph 103–117 km/h	37–52 ft 11.5–16 m	Exceptionally high waves	Widespread damage	
12	Hurricane force	≥ 64 knots ≥ 73 mph ≥ 118 km/h	≥ 46 ft ≥ 14 m	Exceptionally high waves, sea is completely white	Devastation	

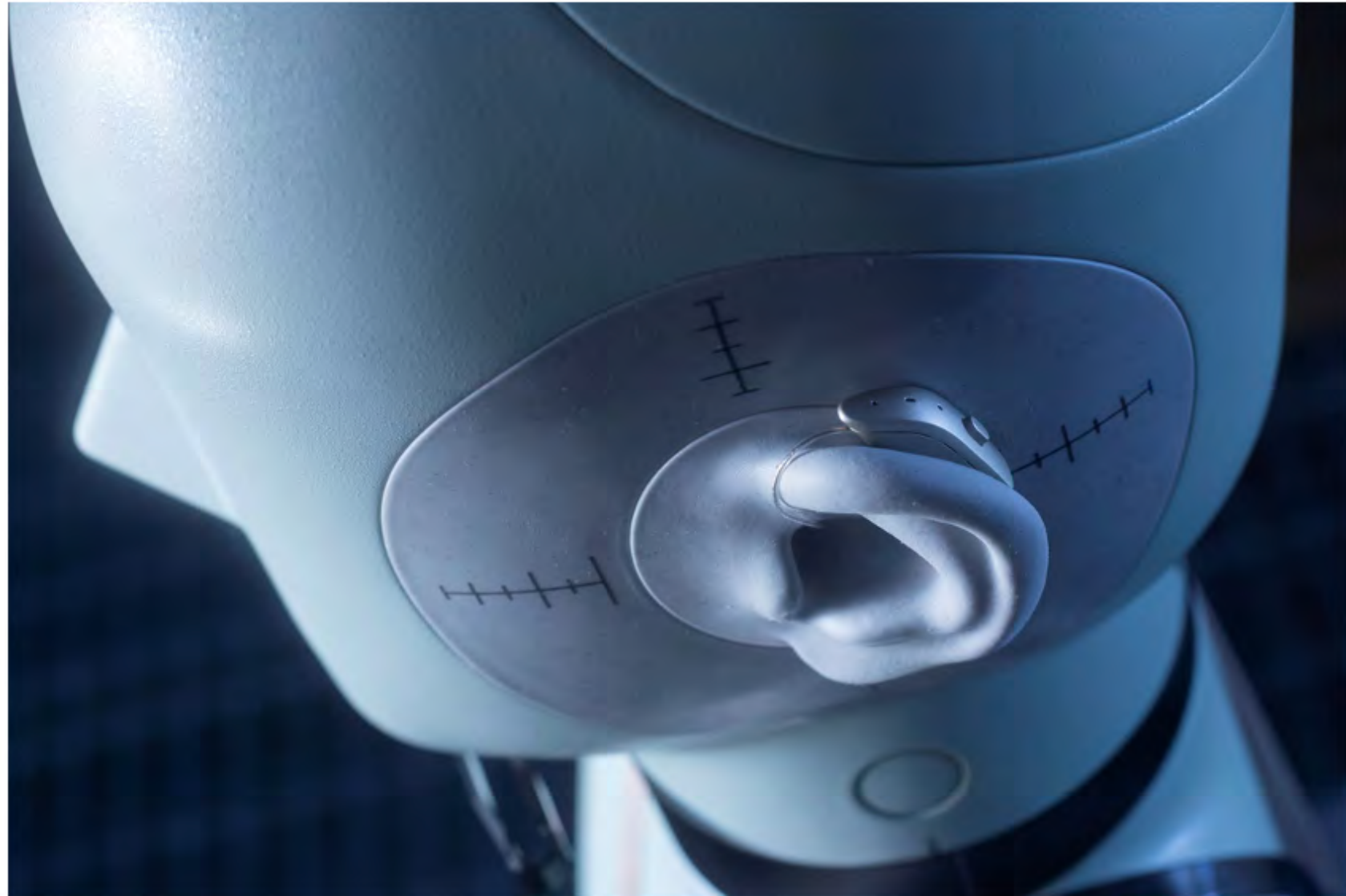
Head on (0° azimuth) Which one is M&RIE?

Program	Noise	Outcome
A		Soft switch
B		All Access
C		M&RIE
D		Omni



Back to wind (180° azimuth) Which one is M&RIE?

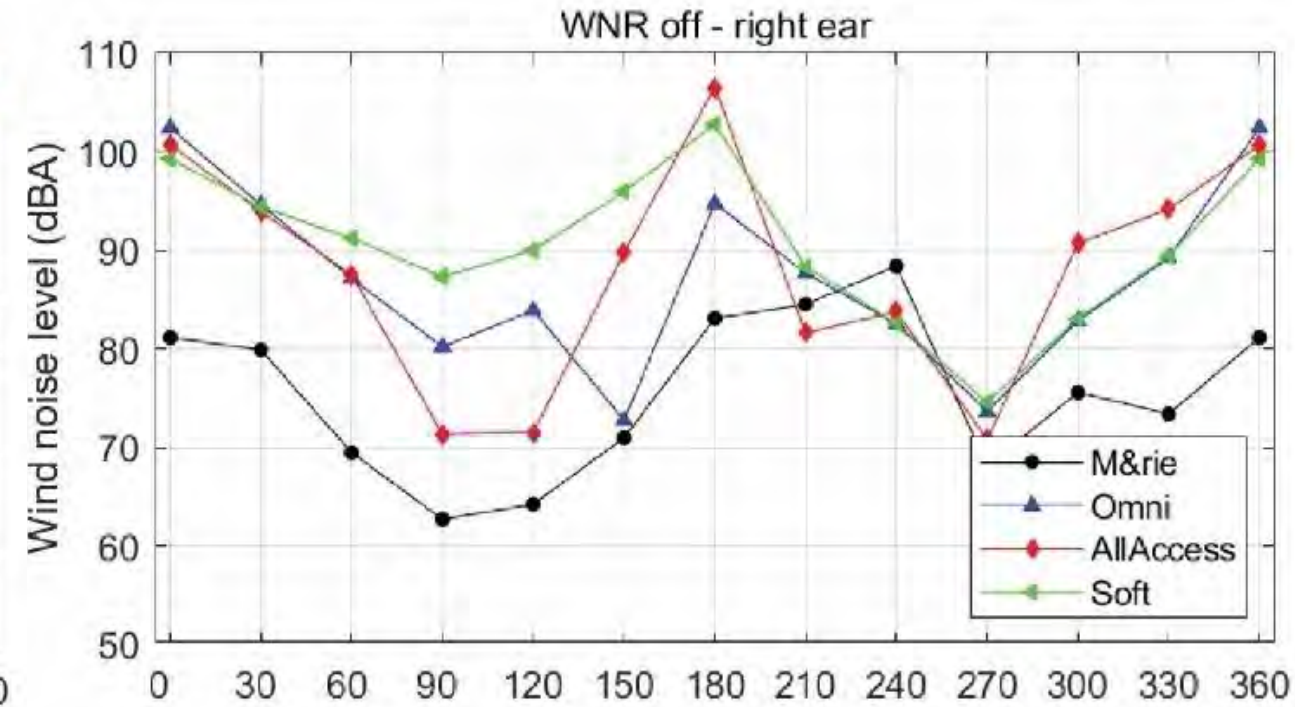
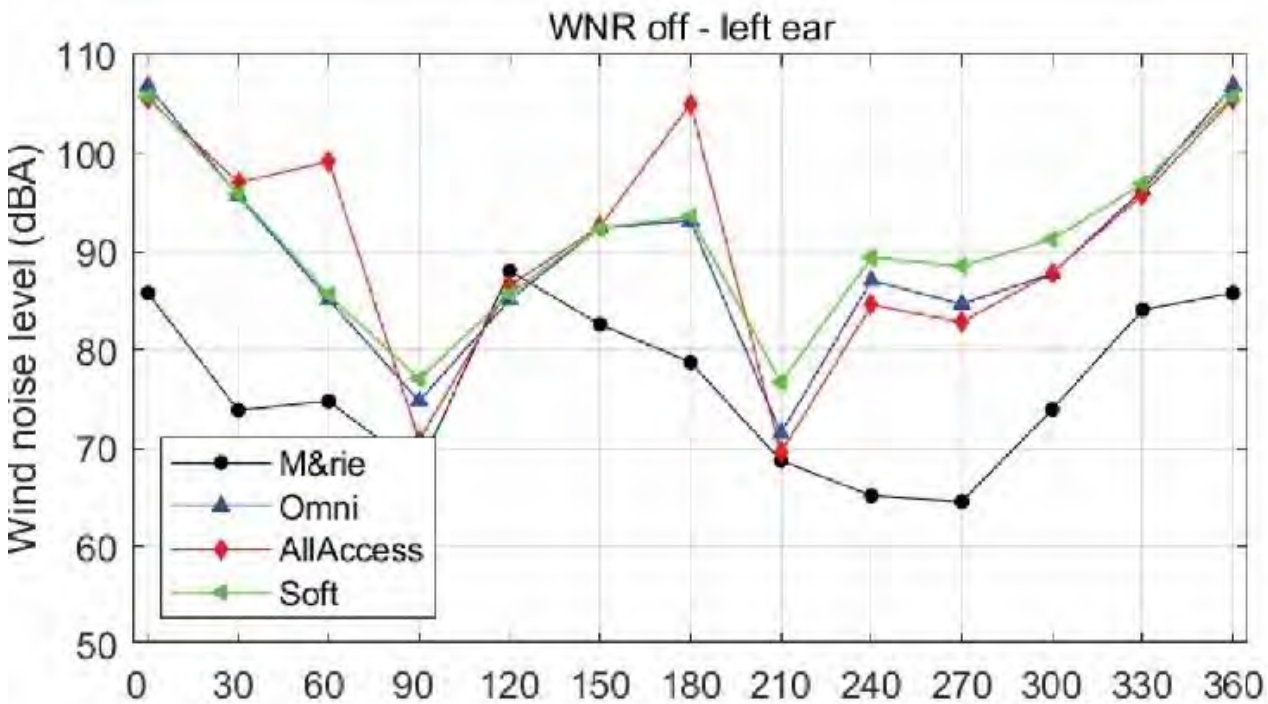
Program	Noise	Outcome
A		M&RIE
B		Omni
C		Soft switch
D		All Access



Wind noise levels by direction of wind

AVERAGED ACROSS FREQUENCY

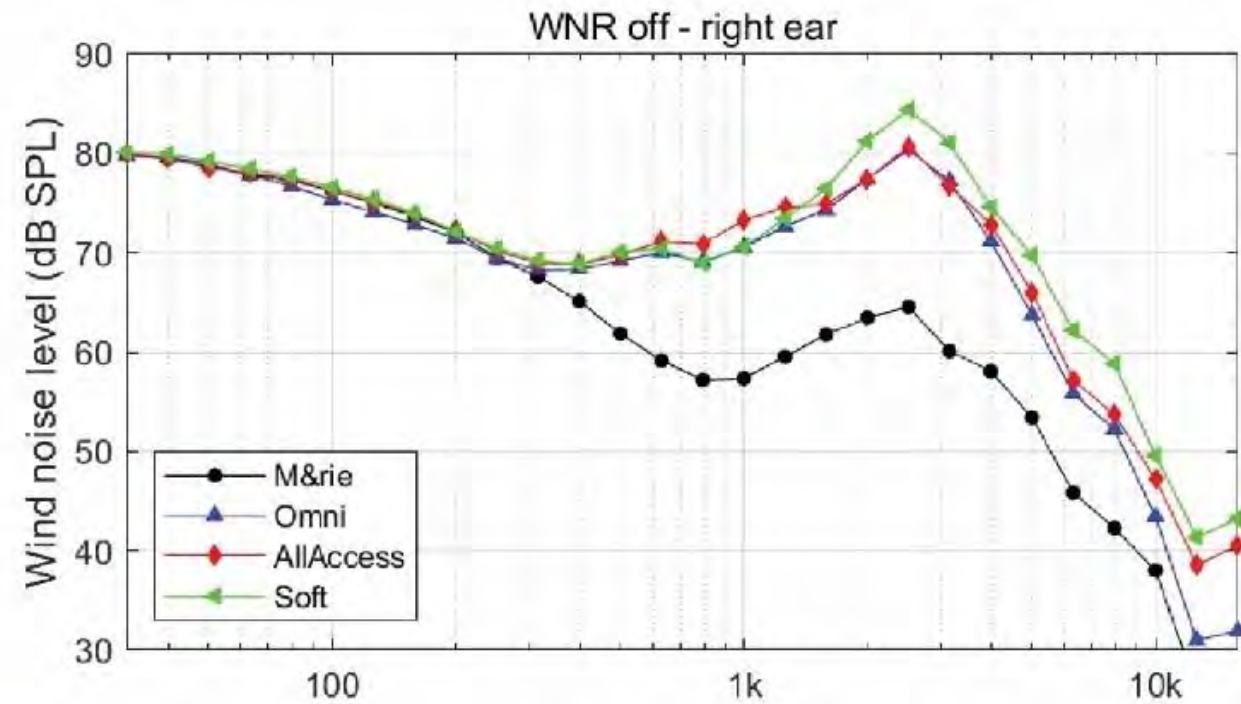
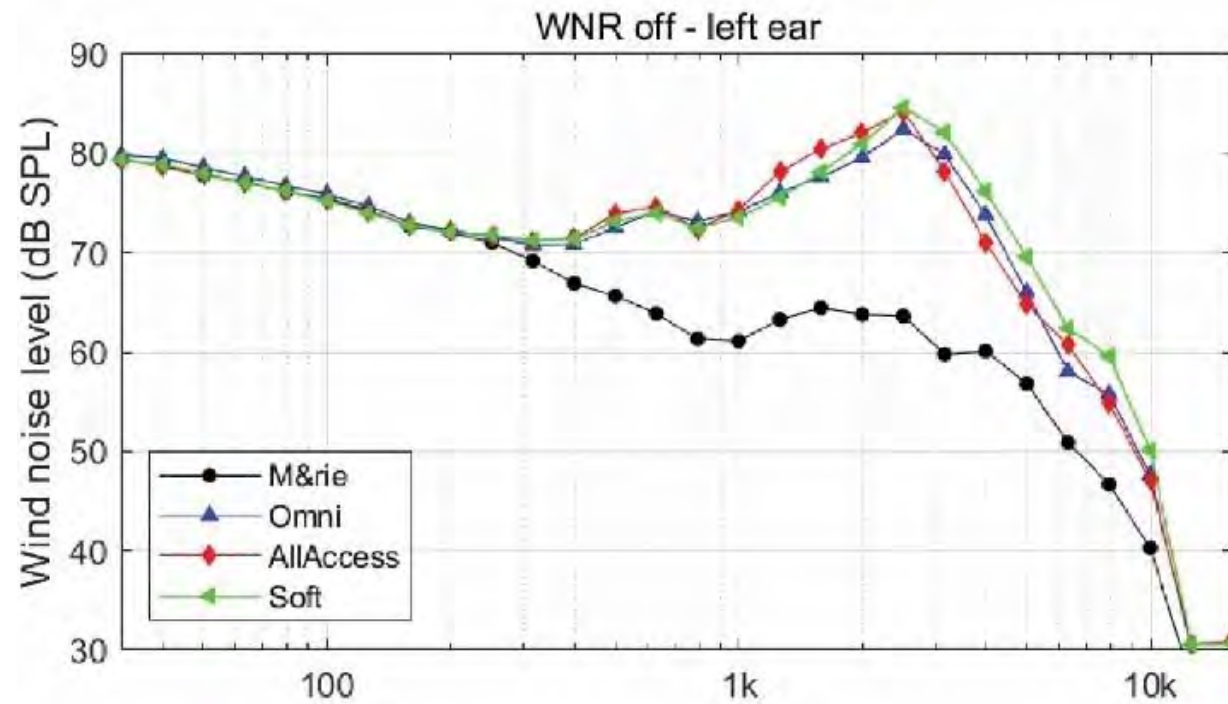
M&RIE clear winner



Wind noise level by frequency

AVERAGED ACROSS ANGLE OF INCIDENCE OF WIND

M&RIE clear winner



Conclusion

Subjective reports of improved performance in windy conditions were clear and significant when M&RIE was compared to a directional microphone

M&RIE technology provides significant benefits in windy conditions and should be considered for all clients with mild to moderately severe hearing loss and an active outdoor lifestyle.

Wrapping it all up

- Sound is shaped by pinna depending on the direction of arrival & frequency of the sound
- Results show:
 - ReSound M&RIE reduces listening effort
 - Speech results when fit with M&RIE show improvement
 - Overall, an advantage of picking up sound in the ear canal is much closer way sound naturally enters the ear.
 - M&RIE and Spatial Sense resulted in significantly less localization error than the other brands tested for normal hearing listeners
 - Reduction in wind noise across all angles for the M&RIE microphone location versus the front microphone location.
- Further improvements have been shown with ReSound M&RIE when allowed to acclimate for longer periods of time

Thank you for your attention!

mquilter@gnesound.com