ReSound LiNX 3D: Details and benefits of Binaural Directionality III

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GN Making Life Sound Better

Financial disclosure

John A. Nelson is employed as the Vice President of Global Audiology Training and Education at GN Hearing and ReSound. He has financial relationships in the products and services communicated, compared and evaluated in this presentation.

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Learner Objectives

List the main features of ReSound's Binaural Directionality III

List three different listening situations and how Binaural Directionality III would provide important environmental sounds

Describe the benefits of Binaural Directionality compared to other directional options

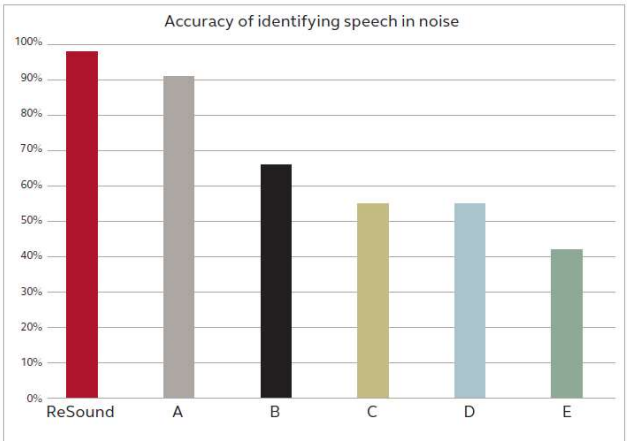
Environmental classifiers: Critical staring point

Tested environmental classifiers from six manufacturers

Evaluated in a test box with looped sound files and read data logging

Sound files included

- Quiet
- Speech babble
- Conversation with various background noises and levels (e.g., part, train station, grocery store)
- Noises (e.g., hand mixer)



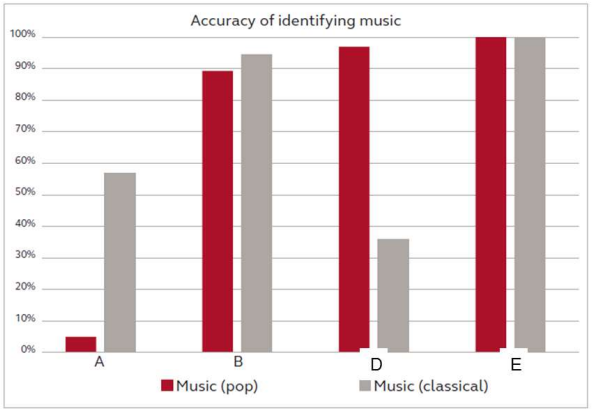
Music Classification: Limited accuracy

Tested music classifier from four manufacturers

Evaluated in a test box with looped sound files and read data logging

Two different genres of music

Note: Brand E was least accurate for speech-in-noise



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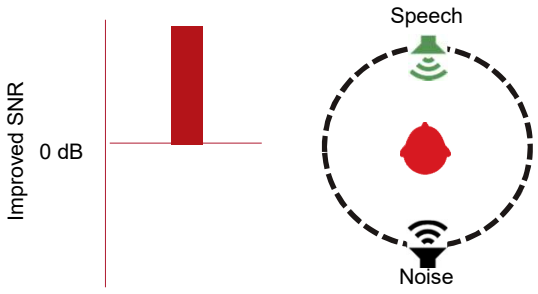
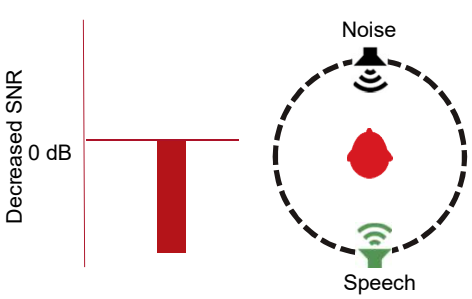
Directional: Benefit or Deficit?

Directional Benefit



Directional Deficit



Note: Binaural omni-directional compared to binaural directional

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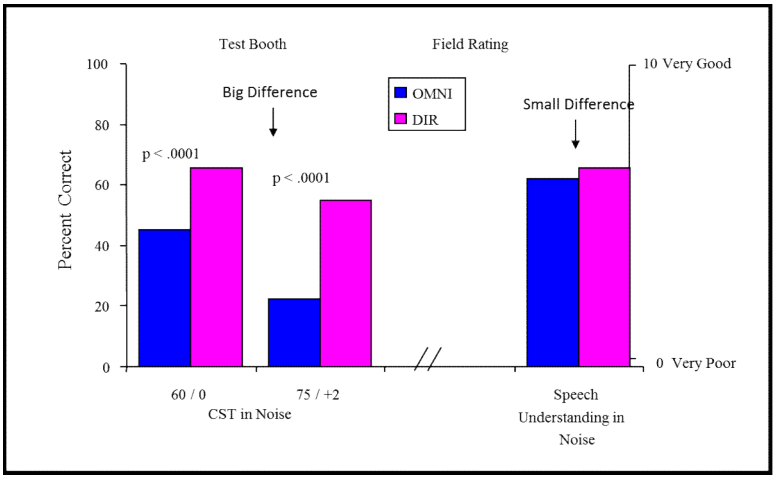
Directional benefit: Real world?



Source: Efficacy Studies at Walter Reed Army Medical Center, Walden, Surr, & Cord, 2003

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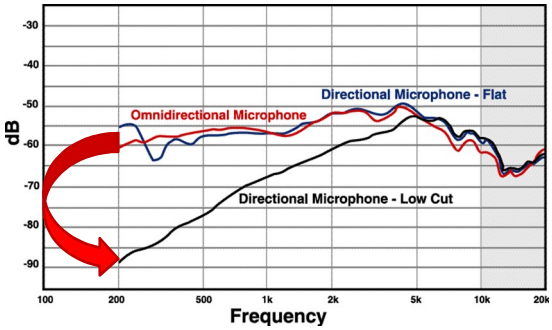
Directional physics: Low-frequency roll off

Low-frequency wavelength exceeds the distance between the microphones

Results in reduced low-frequency hearing aid output and reduced audibility of low-frequency sounds

Cutoff frequency dependent on microphone spacing



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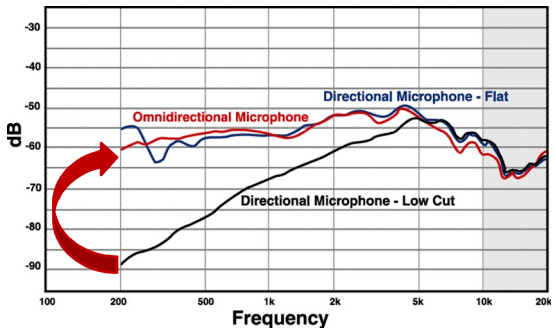
Audibility for directionality: Low-frequency equalization

Increased low-frequency gain equalizes roll off and provides improved audibility

Results in increased occlusion, noise, & wind noise

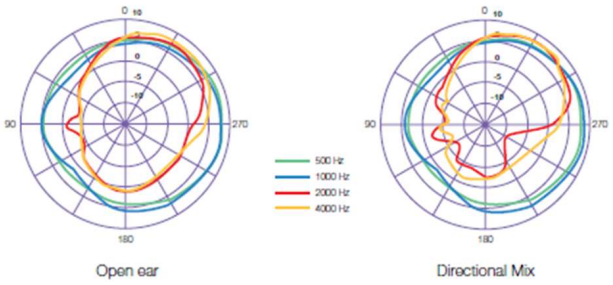


ReSound Directional Mix Processing

Low frequencies are omni-directional – like the natural open ear

High frequencies are directional – increased speech understanding

Provides rich sound quality, enhanced speech understanding, and low-frequency localization cues



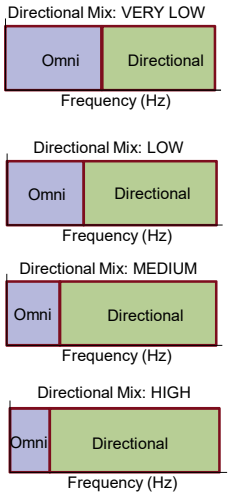
Directional Mix Processing: What is the Directional Mix?

Directional Mix is the crossover frequency between omnidirectional and directional processing

Aventa provides a unique prescription based on the individual's

Audiogram

Hearing aid selected



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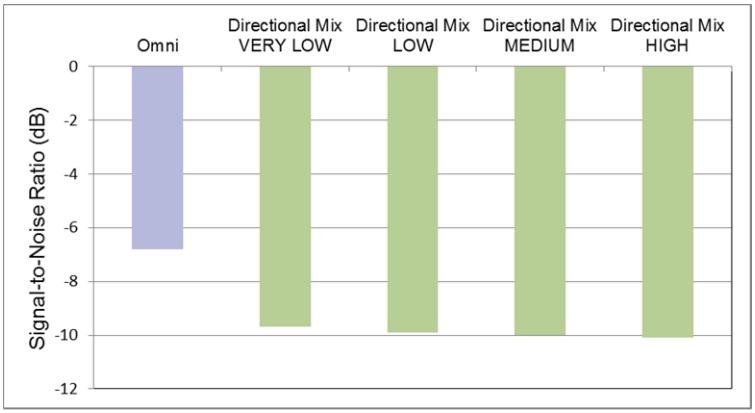
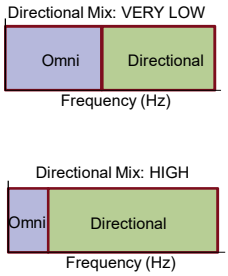
Directional Mix Processing: Benefit for open fittings



(Moeller & Jespersen, 2012)



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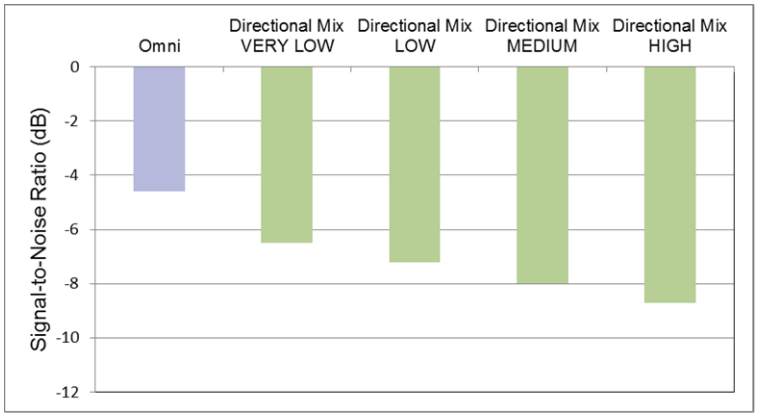
Directional Mix Processing: Benefits for traditional venting



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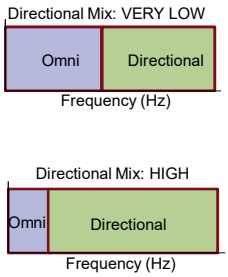

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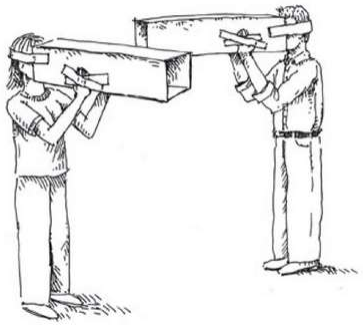
Tunnel listening: A directional disadvantage

Bilateral directional improves the ability to understand sounds directly in front of the listener

Sometimes referred to as tunnel listening, it removes the listener from the acoustic environment



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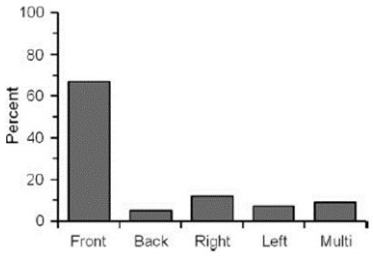
Important sounds cannot be predicted by a hearing aid

A hearing aid cannot determine what a hearing aid user would like to listen to

Significant portion of active listening is not from in front



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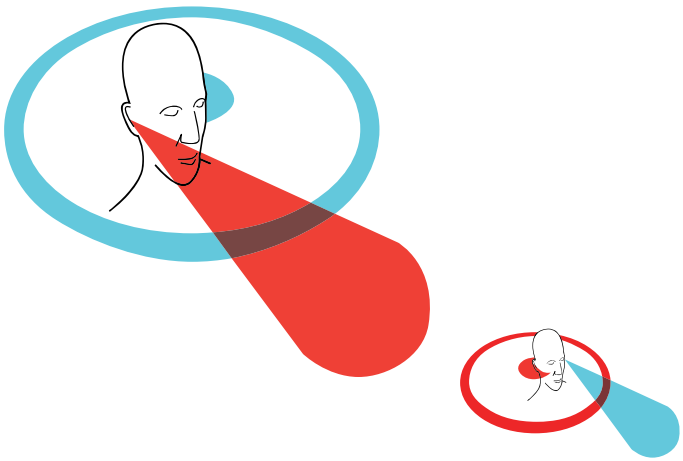
ReSound Natural Directionality II



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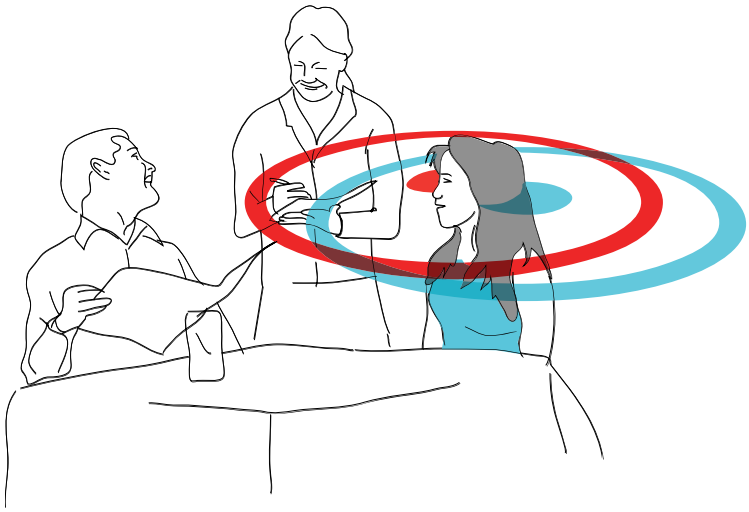
Omni/Omni mode



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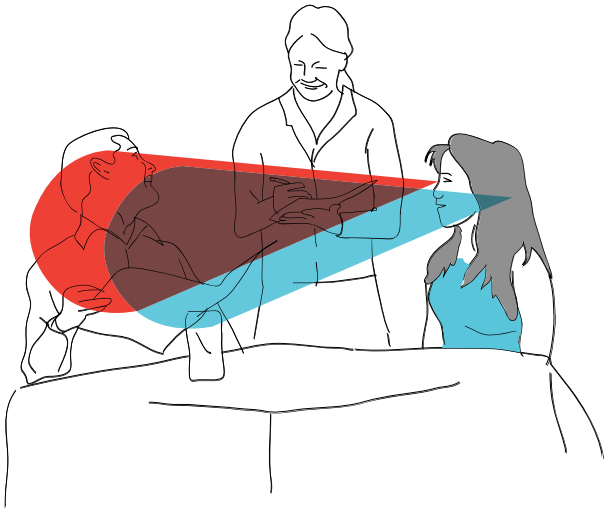
Directional/Directional mode



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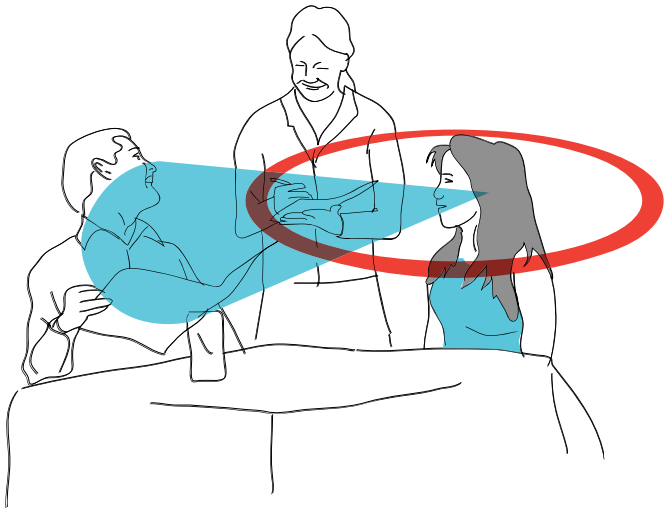
Asymmetric Directional mode



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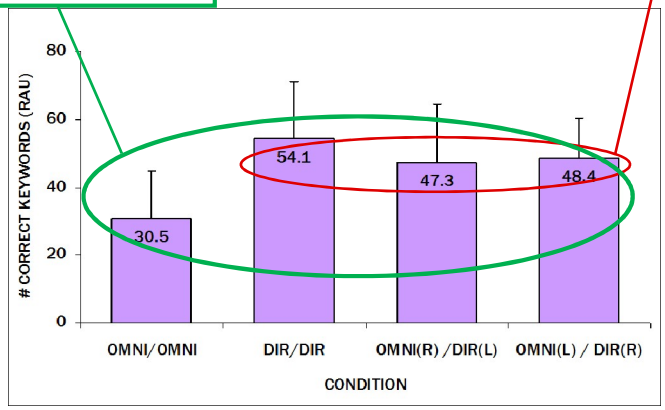
Asymmetric directionality: Laboratory results

Significantly better ($p < .001$)

No significant difference



Cord, Walden, Surr & Dittberner (2007). Field evaluation of an asymmetrical directional microphone fitting. JAAA

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Binaural directional beam – Tunnel hearing

Asymmetric directionality - Analogy

Real world listening situations

Real world listening situations are not controlled environments

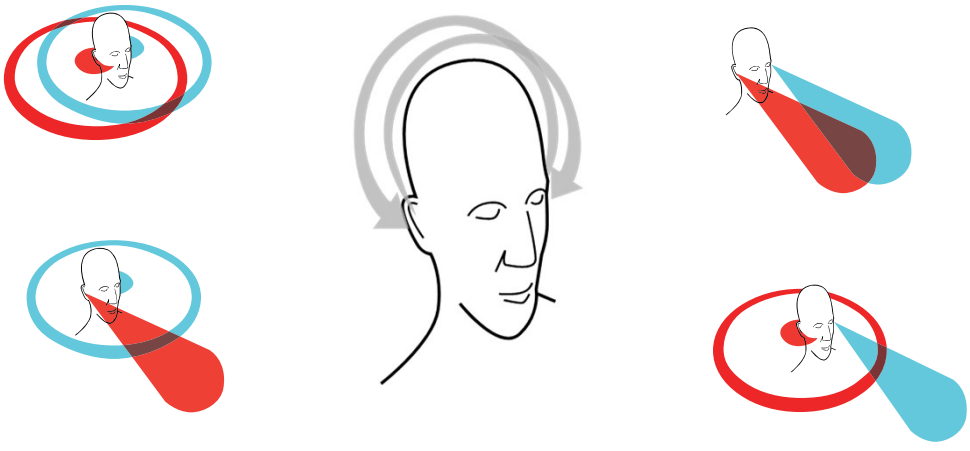
Bilateral omnidirectional is often preferred, especially in quiet and single speaker situations

Bilateral directional is usually preferred if the speaker is in front of and near to the listener and noise is to the sides and the back

Bilateral directional is not correct choice if speaker is not in front of the listener

It is difficult to make automatic switching decisions on the acoustic environment. This is especially true for adaptive systems cancel the loudest sound not from the front – which might be the signal of interest.

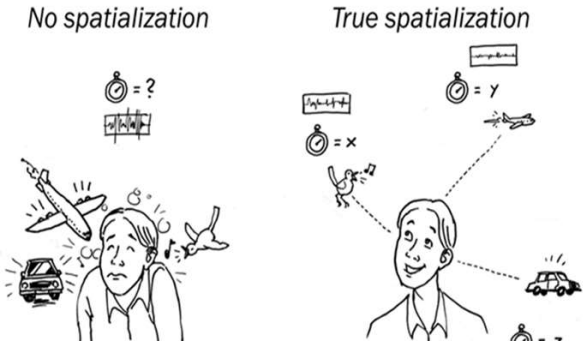
ReSound Binaural Directionality



Binaural Directionality: Spatial Sense

Allows an auditory image of the environment to be formed

Spatial hearing also creates a sense of natural sound quality



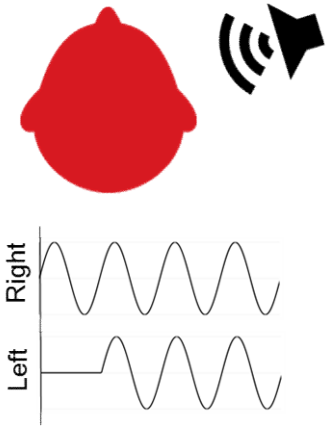
Interaural time difference

When sound does not come from directly in front or behind, an interaural time difference occurs

Time of arrival and phase differences of the sound between two ears are used by the brain

Cues are detectable for low-frequency sounds and for the speech envelope, ITD is the dominate cue

Dominant localization cue

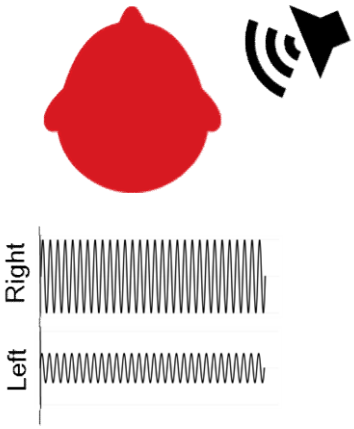


Interaural loudness differences

Sound diffracts off the surface of the head, creating a "shadow" on the side away from the source

Sounds at the far ear will be lower in intensity

Cues are detectible for high-frequency sounds



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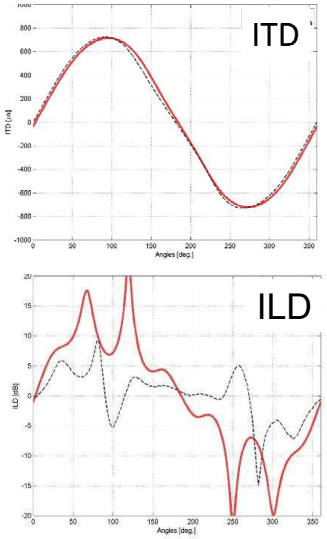
ITD preserved: Directional Mix Processing

Desired open-ear response is red line

ReSound e2e is the black line

ITD preserved

ILD errors can reduce sound quality as it will sound less natural if spatial cues not maintained



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Preserving spectral cues

BTE and RIE models have microphones placed above the pinnae

Distortions to the spatial sound image as pinnae spectral cues are reduced compared to open ear

Need to compensate for the artificial microphone position

Dual microphone processing is applied to mimic an open-ear response

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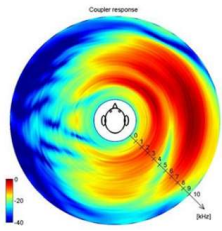
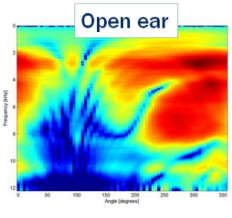
Spectral characteristics: Natural ear

Head-related spectral cues are plotted by frequency, amplitude and azimuth (angle)

Left graph: Low frequencies are closer to the center and higher frequencies are to the outer of the circle. Azimuth is the angle around the head in counter-clockwise rotation. Amplitude is by color.

Right graph: Vertical axis is frequency (low-frequencies at the top). Horizontal axis is the azimuth or angle (counter-clockwise rotation).





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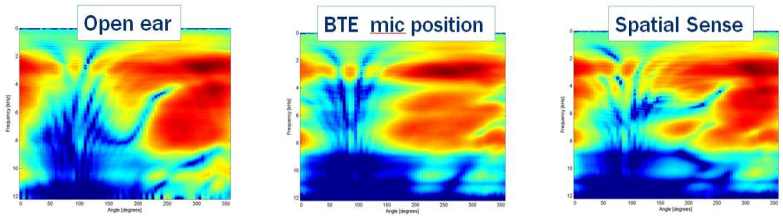
Spectral characteristics: BTE and RIE

BTE microphone position: Spectral cues are distorted as signal travels to the top of the pinna to BTE microphone location and pinna, concha, and ear canal resonances and shadows are eliminated

Spatial Sense: Spectral cues lost due to BTE/RIE microphone placement are digitally applied so spectral cues are more similar to the open ear



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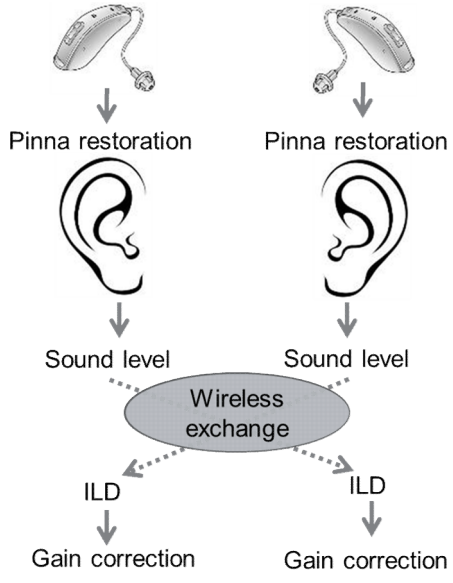
ReSound Spatial Sense processing

Pinna restoration applied (BTE & RIE) to accommodate for lost spectral characteristics due to microphone placement

Sound level at the hearing instrument microphone is recorded to determine the interaural level difference (ILD)

Data wirelessly exchanged between devices for compression compensation preserving the ILD



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Non-Linear Amplification and ILD

60dB SPL	Unamplified ILD = 10dB	70dB SPL
10dB	Non-Linear Gain	5dB
70dB SPL	Non-Linear ILD = 5dB	75dB SPL

Non-Linear Amplified ILD error = 5dB

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Spatial Sense: Mimics inhibitory function

60dB SPL	Unamplified ILD = 10dB	70dB SPL
10dB	Non-Linear Gain	5dB
-5dB	Spatial Sense Correction	0dB
65dB SPL	Spatial Sense ILD = 10dB	75dB SPL

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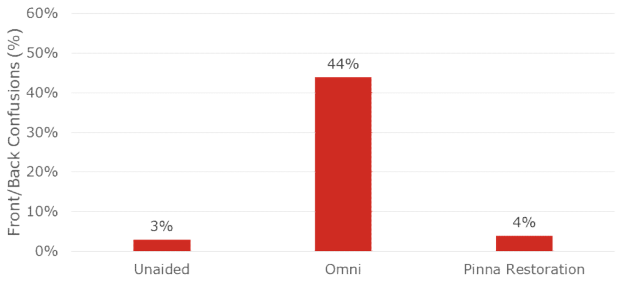
ReSound Spatial Sense: Improved localization of sounds

Restoring ILDs with Spatial Sense decreases front-back confusions for localization



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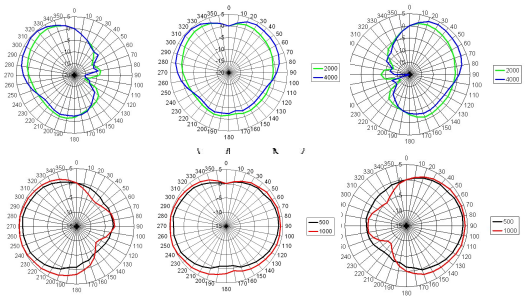
Binaural Auditory System: Awareness Strategy



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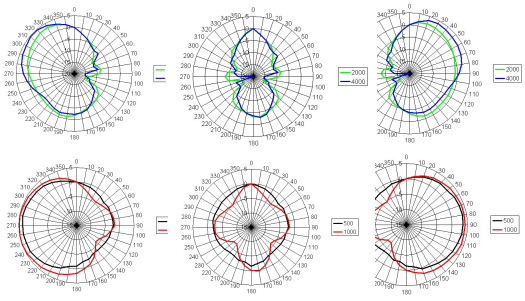
Binaural auditory system: Better ear strategy



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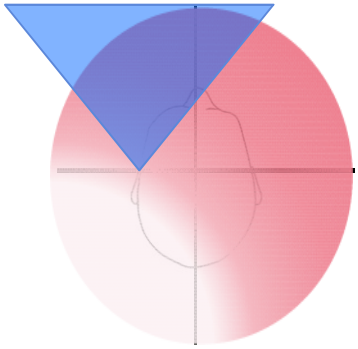
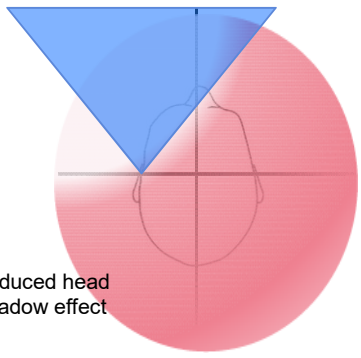
A whole new directional system

Binaural Directionality II



Binaural Directionality III



Reduced head shadow effect

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Effect of Binaural Directionality III: Clinical research

Three listening situations were evaluated:

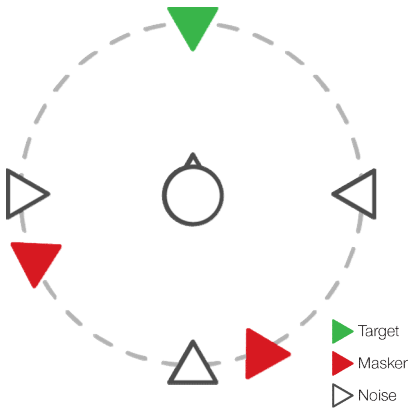
1. **Noise**
2. **Multiple location speech maskers**
3. **Speech stimuli target**

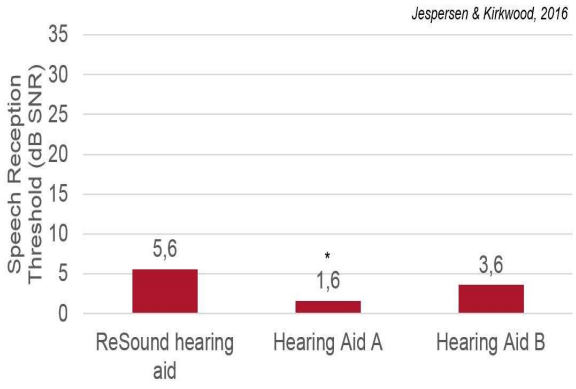
Difficult listening situations but more real-world than traditional directional studies

Devices evaluated

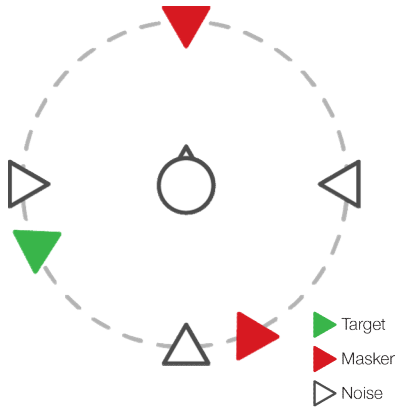
1. **ReSound LiNX 3D with Binaural Directionality II**
2. **Two premium hearing aids with binaural beamforming directional processing**

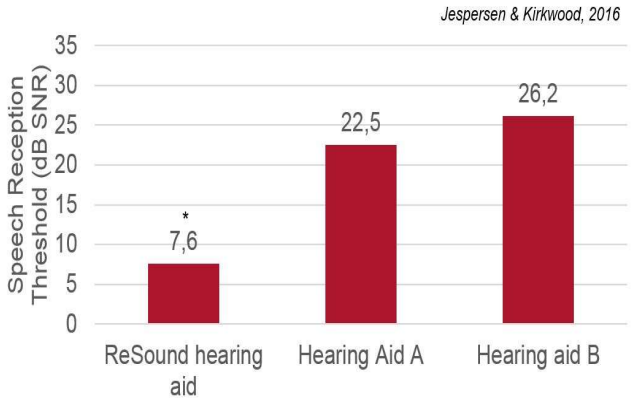
Test condition: Talker front





Test condition: Talker left





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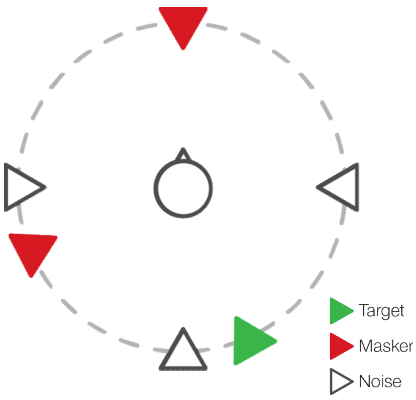
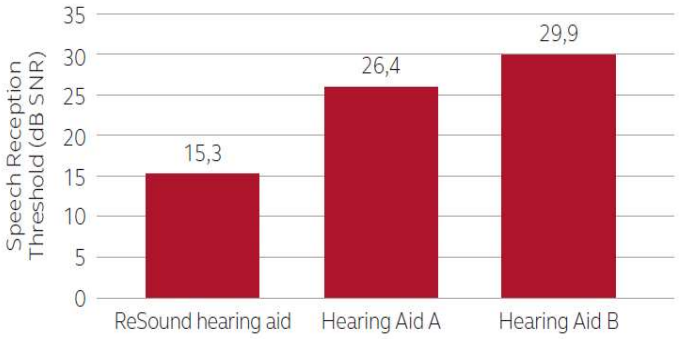
Test condition: Talker behind





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ReSound Binaural Directionality

Provide improved audibility of desired signal

Provides an improved signal-to-noise ratio for sounds from the front

Do not remove listener from acoustic environment

Provide high sound quality

ReSound directional options: Product families

ReSound LiNX 3D Level 9: Binaural Directionality III

ReSound LiNX 3D Level 7: Binaural Directionality

ReSound LinX 3D Level 5: Natural Directionality II

Thank you