Hearing aid microphone considerations for binaural hearing: When to select natural or aggressive directional microphone technology?

BY MARK LAUREYNS

Should I use omni-directional or fixed directionality? Does it make a difference if I'm fitting a unilateral hearing loss? **Mark Laureyns** discusses the current evidence on directional microphones and provides practical advice on the systems and when to employ them.

Background

In professional hearing care and protocols, the use of directional microphones in hearing aids is very popular. In recent years, nearly all manufacturers have developed directional microphone technology that respects localisation cues and central auditory processing. On the other hand, we notice that most of the proposed and default settings of high-end hearing aids are based upon more aggressive adaptive directional microphone technologies that may benefit some hearing aid users, but certainly not all.

Hearing loss can lead to front-back, left-right and up-down sound localisation problems and hearing aid fitting can improve front-back and left-right localisation performance. So far, there is no evidence that hearing aid fitting can improve up-down (vertical) localisation.

Binaural hearing and improved sound localisation is essential for understanding in noisy and dynamic sound environments, to reduce listening effort and to allow the user to focus on the signal of interest and to disregard unwanted signals.

Carette et al [1], conducted a study in which localisation performance was evaluated with multiple direction signal processing schemes. As can be seen in Figure 1, both for left-right and front-back localisation, the difference in performance between the best and worst direction schemes are substantial.

Which direction systems are used in hearing aids today?

Omni-directional signal processing, where only one microphone is used and sounds from all directions are treated in the same way. The drawback of this system is that understanding in noise and front-back localisation will be more difficult [1].

Fixed traditional directionality will, in most cases, reduce signals coming from the rear and benefit signals from the front. The drawback of this system is that low frequencies are also reduced, which can lead to a tinny sound quality [2].

Adaptive directionality will automatically adjust the directional pattern by adapting the time difference between the two microphones, to reduce signals not coming from the front as effectively as possible and if they are multiband, this can be done for multiple frequency zones at the same time. The benefit of this system is that it is a very impressive experience to hear how background signals are reduced, but the drawback is that you also reduce the low frequencies and the adaption can have a negative impact on localisation [3].

Asymmetric directionality was introduced to compensate for the fact that direction systems reduce low frequencies and to ensure audibility for all sounds, even when directionality is active. In this system, the hearing aid on one ear will be omni-directional and the hearing aid on the other ear will be directional. The drawback of this system is that left-right localisation is more difficult [1].

Pinna directionality mimics the directionality of the human outer ear. Low frequencies are processed omni-directional and high frequencies are processed directional. The drawback of this system is that it is a less impressive experience than adaptive directionality, but the advantage is that both left-right and front-back directionality is preserved, and the sound quality is better than in most other directional systems [2].

"In recent years, nearly all manufacturers have developed directional microphone technology that respects localisation cues and central auditory processing"

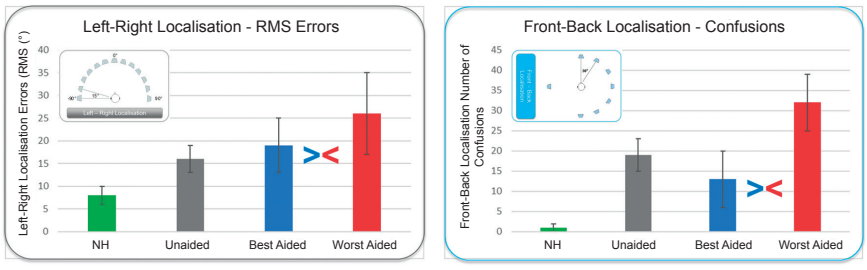

Figure 1. Localisation performance for normal hearing subjects (green bars), hearing impaired subjects (grey bars = unaided but the signals are amplified to ensure audibility; blue bars = aided with the directional system resulting in the best localisation; red bars = aided with the directional system resulting in the poorest localisation). At the left graph, left-right localisation and the units are the rms of the errors. At the right graph, front-back localisation and the units are the number of confusions [1].

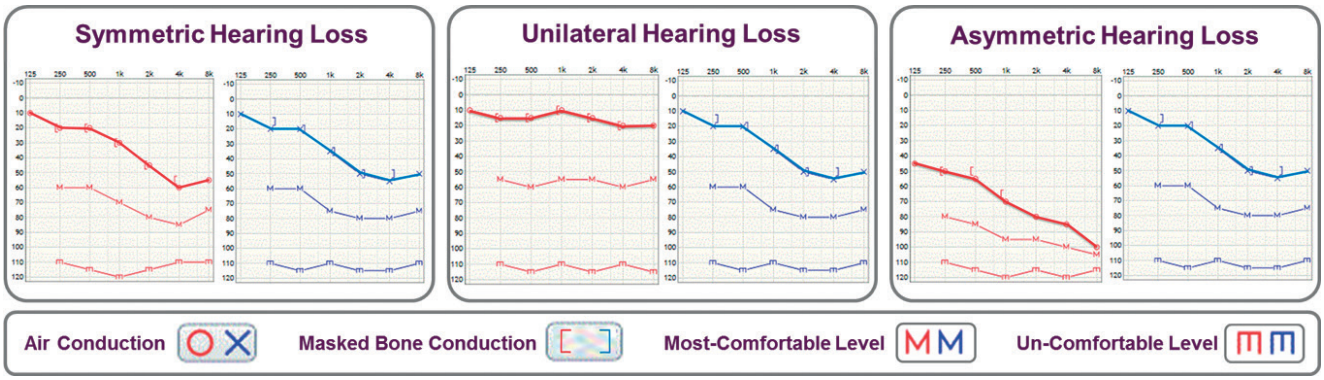

Figure 2. The three configurations of hearing loss discussed in this article.

Protocol to select signal processing that will allow binaural hearing

The protocol to select the most appropriate signal processing will depend on the audiometric configuration (symmetric hearing loss, unilateral hearing loss or asymmetric hearing loss) and on the central auditory processing capacity of the user.

For **symmetric hearing loss with good central auditory processing capacity** (read the ability to localise sounds when audibility is restored), it is essential to select signal processing that preserves localisation cues as well as possible. So, we recommend using pinna directionality for the basic programme.

For **symmetric hearing loss with poor central auditory processing capacity** (read poor ability to localise sounds when audibility is restored), more aggressive directionality like multiband adaptive directionality or comparable can be used. One might even consider the use of remote microphones or FM systems to improve understanding in noise.

For **unilateral hearing loss**, the main goal of the fitting is to restore binaural hearing. In this case we recommend pinna directionality or omni-directional processing. We would suggest caution with any type of automatic adaptation or noise reduction, since this can impact the good balance between both ears. The gain setting of the hearing aids needs to be verified by a balance or localisation test and not just based on a prescriptive formula.

For **asymmetric hearing loss**, the best ear should take the lead in the first fitting. The gain for the worst ear should be verified by a balance or localisation test and not just based on a prescriptive formula. The selection of the directional systems follows the same logic as for symmetric hearing loss. In the case that the worst ear has very poor intelligibility, this ear can be used as a noise reference ear to apply the concept of binaural masking release (the fact that it is easier to understand in noise, when the noise is present at both ears).

Since central auditory processing and localisation capacity are important, both in the pre-fitting and post-fitting assessment and verification, this needs to be incorporated in the fitting protocol. This can be done by performing a localisation test using an array of at least seven loudspeakers in a semi-circle (see Figure 3).

The use of questionnaires like the SSQ [4] can be an alternative way to assess real-life performance.

Conclusions

The hearing care professional needs to be very well-informed on the impact of directional signal processing on binaural hearing and on sound quality.

Most of the directional signal processing schemes used in hearing aids can have a negative impact on localisation, but all manufacturers have systems available that mimic the human ear and preserve localisation cues.

Localisation performance needs to be assessed before and after the selection and fitting of hearing aids. This can be done by localisation tests and using questionnaires. The configuration of the hearing loss also needs to be considered.

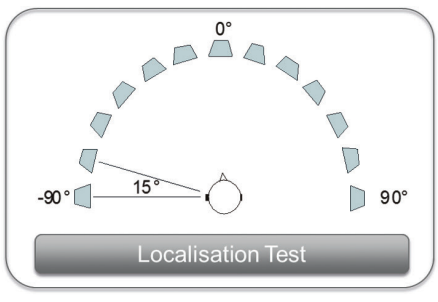

Figure 3. Test set-up for a localisation test.

"We would suggest caution with any type of automatic adaptation or noise reduction, since this can impact the good balance between both ears"

References

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