



Sound Localization

Tips & information for users of cochlear implants

Which sound where?

TIPS & INFORMATION ON HOW TO PRACTICE THE ABILITY TO LOCALIZE SOUNDS FOR USERS OF COCHLEAR IMPLANTS

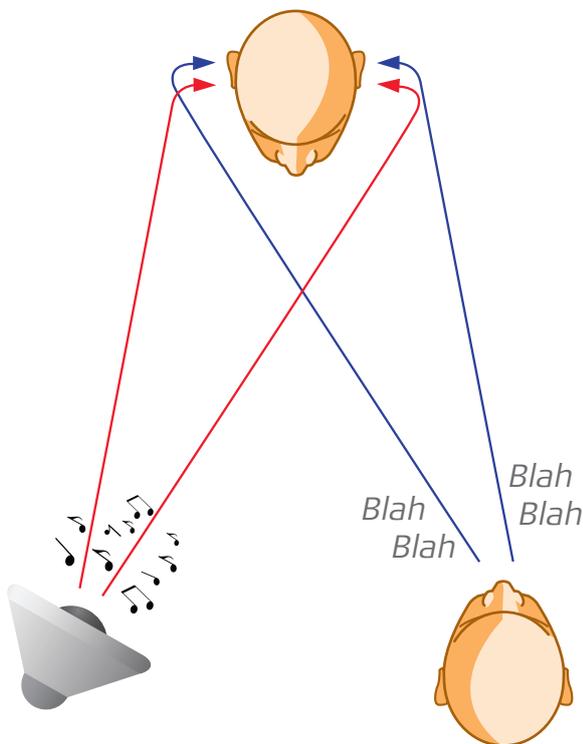
You have received your cochlear implants (CIs) and now it is important to achieve good hearing results with your devices in both ears. An important ability to develop is the ability to perceive the direction of sounds as people with normal hearing would. This skill is called "sound localization." You can develop this ability by practicing on a regular basis. This brochure will provide you with some tips and information on sound localization as well as exercises that can easily be integrated into your daily routine. Your partner, family, friends, and colleagues can support you in doing these exercises to achieve the best possible results with your hearing implant systems and to improve your ability to locate sounds!

1. Where does the sound come from? Where is the speaker?

The ability to localize sound, to recognize where the sound comes from, is called "sound localization." It is necessary to hear sound with both ears (bilaterally) to localize sounds. This holds true for people with normal hearing, as well as for users of hearing aids or cochlear implants. It is very difficult, if not impossible, to accurately locate the direction of a sound by listening with only one ear.

2. How does "sound localization" help me?

As soon as babies can turn their heads, they instinctively find the source of a sound and try to look at it. This helps them to develop an image of the people and things surrounding them. This multi-sensory image of the world is based on visual, tactile and acoustic cues in the environment.



2.1. Avoiding dangerous situations

Our ability to localize sounds helps us to sort out individual sounds from our environment and to spot dangerous situations. Traffic is the best example for this. In traffic it is crucial to know WHERE an unknown sound comes from. As soon as we know where the sound comes from, we can decide whether we are in danger. Think of squealing tires or a very loud, unknown bang, for example. When you know where the sound comes from, you can look and react, if necessary!

2.2. Improving your understanding of speech

Speech understanding is always better when we can turn towards the speaker and watch him/her. Especially in noisy surroundings, being able to find the speaker visually will help the listener distinguish the speech louder and clearer than the background noise. Quickly localizing a speaker in a group makes it easier for us to understand speech and attentive listening becomes easier.

2.3. Detecting movements through sounds

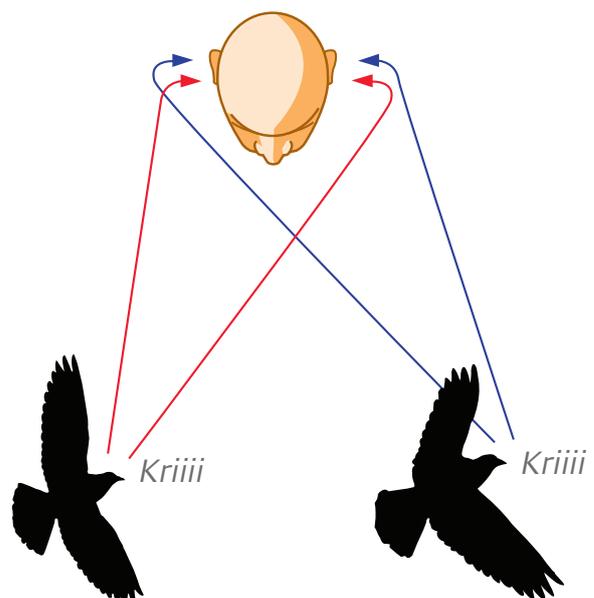
As soon as we hear WHERE a sound comes from, we can picture the movement of people and objects. For example:

- A person is approaching me from behind and passes me on my right
- A siren moves away from me to my left

The ability to use sound to predict or follow movements enables us to fully participate in the 3D world of hearing. It improves our orientation and thus enhances our personal safety in daily life – be it at work, at home, or on the street.

3. How does "sound localization" work?

When we hear a sound coming from our right, the sound waves reach the right ear first and only then the left ear, which is in the auditory "shadow" cast by our head (head shadow). At the same time, the sound is heard louder in the right ear and its pitch and frequency range is perceived differently on the right side compared to the left side. In technical terms, this is referred to as the interaural (between the ears) time, loudness and frequency difference. We make use of these slight differences to localize sounds and their sources.



Therefore, we hear the signal in the right ear earlier and louder than in the left one; this is the cue that the sound source is located to our right. It is usually easier for us to localize a sound when it comes directly from one side than when it comes from the front. Similarly, it is easier to localize a sound when we hear it coming from the front than from behind.

It is also easier to distinguish sounds on a horizontal level (directly from one side, behind us, in front) than on a vertical level (at eye-level, at knee-level, above us). This holds true for people with normal hearing as well as for users of cochlear implants.

4. What influences our ability to localize sounds?

Our surroundings

Our ability to localize sounds is dependent on our surroundings. Our hearing is primarily influenced by:

- Acoustic conditions (closed or open space, presence of an echo, presence of curtains and carpets that muffle sounds)
- Background noise (music, radio, TV, birds, wind)
- Number of speakers/sounds (the fewer, the easier to distinguish)
- Ability to distinguish different types of speakers (e.g. male/female voice; accent)

TIP: Consider your surroundings and the choice of sound sources (speaker/type of sound source) for your training!

Age

The ability to orient yourself using sound alone has to be developed. Babies can already turn their heads toward a person speaking. Our accuracy in localizing sounds reaches its peak at about 10 years of age¹ and gradually starts to decrease from about 40 years of age. This particularly affects our ability to differentiate between "front – behind" and to orientate ourselves by means of sounds ahead of us. The ability to perceive time differences decreases with age, but the ability to distinguish between different volumes and frequencies remains the same.²

Equal ability to hear in both ears

A distinctly different ability to hear in both ears – especially related to loudness – usually leads to difficulties in localizing sounds.³ This in particular is valid for users of cochlear implants in one ear and hearing aids in the other. Your audiologist or therapist can help you experiment with and then find the best possible setting for the audio processors of your hearing implant systems and hearing aid. It is very important to be able to hear equally loud on both sides.

TIP: Check the setting of your audio processors and hearing aids with your audiologist or technician. Make sure that you hear equally loud on both sides!

Experience with Cochlear Implants:

Loss of hearing and time span between implant surgeries

Experience shows that users of cochlear implants are able to acquire the ability to localize sounds with practice. But you have to be patient – it may take up to 12 months until you improve your skills. This time span varies widely depending on when you became deaf⁴ and the time span between receiving your cochlear implants.⁵ The shorter the time span between your loss of hearing and implantation, the faster the ability to localize sounds develops. Children who were either born deaf or became deaf at a very young age, and received their two CIs much later, usually do not have much experience in localizing sounds. They need several years to develop this ability.

TIP: Remember: Sound localization relies on experience and can be practiced. Start now!



¹ For details see: Ashmead et al., 1991., ² For details see: Babkoff et al., 2002; Abel et al., 2000; Tyler et al. 2006., ³ For details see: Abel et al., 2000; Mosnier et al., 2009, ⁴ For details see: Brown et al., 2007; Nava et al. 2008., ⁵ For details see: Laske et al., 2008.

5. Do children have to practice their ability to localize sounds?

Yes! Children also have to gain experience with orienting themselves by hearing with two ears. As mentioned above, the ability to localize sounds develops over time. The earlier your child has received his cochlear implants, the sooner he starts picking up sound cues and gains valuable experiences localizing sounds. Children as well as adults have to develop this ability. Children need to practice localizing sounds to improve quickly and develop good overall hearing skills with their two CIs.

All of the following exercises and tips are suitable for adults and children. Ask your child WHAT he hears. Also ask WHERE the sound comes from. Integrate these questions into your daily routine. This way your child learns to differentiate between voices and sounds and learns to localize sounds at the same time. When infants turn their heads toward a sound, you know they have started to localize. For older children, in addition to games in a group, such as "Blindman's Buff" or "I Spy" (with sounds), hand clapping games and nursery rhymes are ideal for practicing sound localization in a playful way.



Exercises to improve your ability to localize sounds

How to best practice?

Preparation: Set the audio processors to similar loudness.

You should be able to hear equally well and equally loud on both sides. Do not start practicing until the processors of both implants are set to equal loudness. This may take a couple of months of programming – especially when there was some time between your implantations – until you have found the best setting for you.

From "What?" to "Where?" and "From Where?" to "To Where?"

Pay attention not only to WHAT or WHO you hear but also to WHERE you hear something. All it takes is a little practice and you will be able to tell where a sound comes from and then track or predict its movement.

1 Recognizing known sounds in familiar surroundings from a *known spot*

The aim of these activities is try to consciously localize a known sound (e.g. the ring tone of your phone) at home.

This exercise also is the basic exercise for all other exercises.

Preparation:

Arrange your familiar surroundings in such a way that it turns into the ideal listening environment for you. Pay attention to the following:

- Reduce background noise (turn off the radio and the TV!)
- Select a small number of target sounds
- Choose target sounds that are distinctly different (e.g. high/low pitch)
- Make sure targets come from different directions (behind, in front, left, right)

TIPS:

- Sit, if possible, on a swivel chair and consciously pay attention to the sounds in your field of view
- Pay attention to WHERE you locate the sounds
- Turn your head in the direction you think the sound is located and check whether you can see the sound source
- Listen to the sound in front of you while your eyes are closed, turn your head and listen again in the changed position
- Change the position of your head and find out when you can hear the sound best
- Try to turn your head exactly towards the sound source several times

Making it more difficult:

- Integrate more sounds into the exercise
- Choose targets that sound similar
- Place the sound sources closer to each other
- Position yourself in different parts of the room
- Change from one room to another room
- Integrate sounds that are out of your field of view
- Close your eyes while practicing. This further sharpens your hearing!

② Recognizing known sounds in familiar surroundings from an *unknown spot*

Modify exercise 1 by asking someone to change the position of the sound source(s) (e.g. a friend places your phone in a different spot). Repeat all the steps of exercise 1 and raise the level of difficulty as you did in exercise 1!

③ Recognizing unknown sounds in familiar surroundings from an *unknown spot*

Modify exercise 2 by asking someone to hide unknown or unusual sound sources. Repeat all the steps of exercise 1 and raise the level of difficulty as in exercise 1!

④ Have *people* call you

Modify exercise 1 by having someone call you in your familiar surroundings. Change this exercise by:

- Having the person say a short sentence
- Having the person say a longer sentence
- Having the person call you from different directions
- Having the person call you from out of your field of view (e.g. from another room)
- Having different people call you

You can combine all listed variations and thus make this exercise more difficult. But do not change too many things at once. Be patient with yourself!

5 Recognizing known sounds in familiar surroundings from different spots *with background noise*

Modify exercises 1–4 by adding background noise and thus raise the level of difficulty.

- Practice with background noise (e.g. turn on the radio, theTV)
- Change loudness/number of (target) sounds
- Change loudness/number of background noise sources

6 Recognizing unknown sounds in *unfamiliar surroundings* with background noise

It is most difficult for us to hear everyday sounds in unfamiliar surroundings with background noise and to orient ourselves by means of these sounds.

- Sit in a park, in a restaurant or next to some busy place, close your eyes and consciously pay attention to the sounds around you
- Turn your head to spot the source of a sound you focus on
- Ask different people to call you in these surroundings from different positions. Check whether you turn your head in the right direction and you can spot the person

Change this exercise by:

- Choosing an increasingly noisy environment
- Also paying attention to sounds you are not familiar with
- Asking someone to phone you unexpectedly



7 *Tracking movement with your ears*

Your task is to localize sounds and then track where these sounds move to.

- Track a sound and try to predict its movement (e.g. a passing car). Does it come from your left? What direction is it moving? To your right? Is someone walking towards you from your right and passing you on your left?

Start in "easy" surroundings and slowly increase the level of difficulty:

- Start in familiar surroundings:
Track the steps or voices of known people, or of a known sound, that is moving (e.g. the vacuum cleaner)
- Try to track people and sounds around you in public. Where is the mother with the child? Where did the car come from?

8 *Practice in a group*

You can do all these exercises in a group (e.g. a self-help group) or together with your family. Go ahead and try games from childhood days! Practicing in a group is fun and you can support each other. Give it a try!

Some useful tips:

- Be patient with yourself – it takes time.
- Try to practice every day by paying attention to the localization of sounds into your daily hearing experience. By doing so you will soon notice a difference!
- To stay motivated, measure your success. Visit your clinic and ask your audiologist to test your abilities
- Do not forget to adjust/check the setting of the processors of your cochlear implants to ensure best results. You can only make progress when your "ears" are set right!

6. For further reading

- [1] Ashmead, D.H., Davis, D., Whalen, T., Odom, R. (1991), Sound localization and sensitivity to interaural time differences in human infants. *Child Dev* 62: 1211-1226.
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- [3] Abel, Sh. M., Ciguère, Ch., Consoli, A., Papsin, B.C. (2000). The effect of aging on horizontal plane sound localization. *J Acoust Soc Am* 108 (2): 743-752.
- [4] Brown, K.D. & Balkany, Th. J. (2007). Benefits of bilateral cochlear implantation: a review. *Curr Opin Otolaryngol Head Neck Surg* 15: 315-318.
- [5] Laske, R.D., Varaguth, D., Dillier, N., Binkert, A., Holzmann, D., Huber, A. M. (2009). Subjective and objective results after bilateral cochlear implantation in adults. *Otol Neurotol* 30: 313-318.



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