



Sound Localisation

Tips & Information for Users of Cochlear Implants

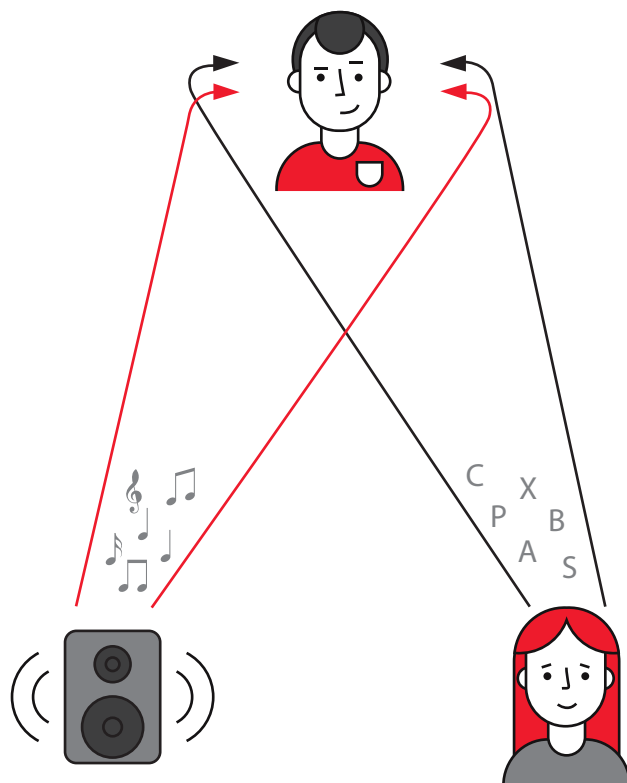
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Which Sound Where?

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

You have received your cochlear implants and now it is important to achieve good hearing results with your devices in both ears. The ability to identify the direction or origin of a sound source is an important skill. This skill is called "sound localisation." With regular practice, you can develop this ability. Here you will receive tips and information about sound localisation as well as exercises that can easily integrate 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 localise a sound, to recognize where it comes from, is called "sound localisation." It is necessary to hear sound with both ears (bilaterally) to localise sounds. This holds true for people with typical hearing, as well as for users of hearing aids or cochlear implants. It is very difficult, if not impossible, to locate the direction of a sound accurately by listening with only one ear.

2. How Does "Sound Localisation" 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 localise sounds helps us to sort out individual sounds from our environment and to spot dangerous situations. For example, 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 to observe the speaker. Turning to the sound source allows better access to visual cues (e.g., speechreading) and improves the volume of the signal relative to the background noise. Quickly localising a speaker in a group makes it easier for us to understand speech and listen attentively.

2.3. Detecting Movements Through Sound

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

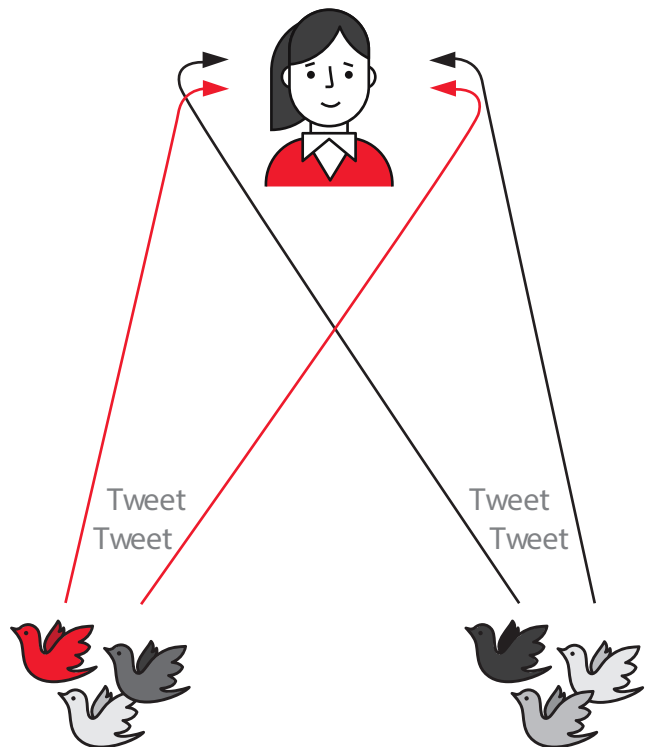
The ability to use sound to predict or follow movements enables us to fully participate in the 3D world of hearing. It improves our orientation and thus enhances our personal safety in daily life – at work, at home, or on the street.

3. How Does "Sound Localisation" Work?

When we hear a sound coming from our right, the sound waves reach the right ear first and 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, these are referred to as the interaural (between the ears) time, loudness, and frequency differences. We make use of these slight differences to localise sounds to 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 localise a sound when it comes directly from one side than when it comes from the front. Similarly, it is easier to localise 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 Localise Sounds?

4.1 Our Surroundings

Our ability to localise sounds is dependent on our environment. 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)
- Types of speakers/sounds (e.g., male vs. female voices, accented vs. native speech)

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

4.2 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 localising sounds reaches its peak at about 10 years of age and gradually starts to decrease from about 40 years of age.¹ This particularly affects our ability to differentiate between "front – behind" and to orient 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

4.3 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 localising sounds.^{3, 4, 5, 8} This difference is particularly valid for users with a cochlear implant in one ear and a hearing aid 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 or hearing aid. It is important that hearing sensitivity is the same or very similar in both ears.

TIP: Check the setting of your audio processors and hearing aids with your audiologist or technician. Equal loudness perception for both ears is important.

4.4 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 localise sounds with practice. Remember, it may take up to 12 months until you improve your skills. This interval will vary widely depending on when your hearing loss began and when you received your cochlear implant(s).^{6, 7} The shorter the time span between your loss of hearing and implantation, the faster the ability to localise sounds develops. Children who were either born with a hearing loss or lost their hearing at a very young age, and received their two cochlear implants much later, usually do not have much experience in localizing sounds. They need several years to develop this ability.

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

5. Should Children Practice Sound Localisation?

Yes, children also have to gain experience with orienting themselves by hearing with two ears. As mentioned above, the ability to localise sounds develops over time. With earlier implantation, children can start picking up sound cues and gain valuable experience localising sounds. Children as well as adults have to develop this ability.⁵ Children need to practice localising sounds to develop good overall auditory skills with their device(s).

All of the following exercises and tips are suitable for adults and children. Develop a habit of observing and talking about environmental sounds with your child as you go through your daily routine. First, describe to your child **WHAT** you hear. Then, talk with your child about **WHERE** the sound has come from. In this way, your child not only learns to differentiate between voices and other sounds but also learns to localise sounds at the same time. When young children turn their heads toward a sound, you know they have started to localise. For older children, in addition to games in a group, such as "I Spy" (with sounds), hand clapping games and nursery rhymes are ideal for practicing sound localisation in a playful way.



Exercises to Improve Your Ability to Localise Sounds

Best Ways to 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?", From "Where?"

Pay attention not only to WHAT or WHOM you hear but also to WHERE you hear something. With practice, you will be able to tell where a sound comes from and then track or predict its movement.

Exercises for Sound Localisation

E A S I E R	Known Sounds in a Familiar Setting from a Known Location	Q U I E T
	Known Sounds in a Familiar Setting from an Unknown Location	
	Unknown Sounds in a Familiar Setting from an Unknown Location	
	Tracking Sounds in Quiet	
H A R D E R	Known Sounds in a Familiar Setting from a Known Location	N O I S E
	Known Sounds in a Familiar Setting from an Unknown Location	
	Unknown Sounds in a Familiar Setting from an Unknown Location	
	Unknown Sounds in an Unfamiliar Setting	
	Tracking Sounds in Noise	



Instructions

All exercises build upon the skills targeted in the Basic Exercise. Read the description on how to perform the Basic Exercise and practise this while varying the sounds, location, or setting as suggested in Exercises 1-7. Take time to develop accuracy and ease within each exercise before proceeding to more advanced ones.

1 Localising Known Sounds in a Familiar Setting to a *Known Location*

The aim of this exercise is to localise a known sound to a known location in a familiar setting. For example, can you distinguish and orient to the chime from the microwave on a kitchen countertop or to the sound of water dripping in the sink? Before you begin, remember to arrange the area so that the environment is optimal for listening. Please also consider:

- Reducing background noise (turn off the radio and the TV!)
- Selecting a small number of target sounds at the start
- Choosing target sounds that are distinctly different (e.g., high/low pitch)

The Basic Exercise:

- 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
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- Including voices during practice. For example, have a person call you from different directions, distances, and eventually from outside your field of view (e.g. another room). Experiment with familiar and unfamiliar voices according to the recommendations in each exercise
 - Making sure targets sounds come from different directions (behind, in front, left, right)



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 Localising Known Sounds in Familiar Setting to an *Unknown Location*

Modify the Basic Exercise by asking someone to change the position of the sound source(s) (e.g., a friend places your phone in a different spot). Revisit the description of the Basic Exercise and consider ideas to raise the level of difficulty as needed.

3 Localising Unknown Sounds in a Familiar Setting to an *Unknown Location*

Modify Exercise 2 by asking someone to hide unknown or unusual sound sources. Repeat all the steps of the Basic Exercise and raise the level of difficulty as before.

4 Tracking Sounds in Quiet

Your task is to localise voices or other sounds and then track where they move. Start in a quiet room or area where you can control the noises which are present. Here are some ideas for practice:

- Identify the sound and try to follow its movement (e.g., a vacuum cleaner). Does it come from your left? In which direction is it moving?
- Track footsteps or voices of known people indoors. For example, try to identify how people are moving (e.g., running, walking) and where they are going. Is someone walking towards you from your right and passing you on your left?



5 Localising Known Sounds in a Familiar Setting to a Known Location *with Background Noise*

Modify the Basic Exercise by adding background noise and thus raise the level of difficulty.

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

6 Localising Known Sounds in a Familiar Setting to an *Unknown* Location with Background Noise

Modify Exercise 5 by asking someone to change the position of the sound source(s) (e.g., a friend places your phone in a different spot). Remember to vary the types of background noise (talking, music, wind) as well as the position of the noise source.

7 Localising *Unknown* Sounds in a Familiar Setting from an Unknown Location with Background Noise

Modify Exercise 6 by asking someone to hide different or unusual sound source(s) (e.g., using an unfamiliar alert or new ringtone on a mobile phone). Begin with a few new or unique sounds and progress to more targets as you improve. Also, you can vary the position of sound sources and consider locations that are high or low (vertical axis) as well as those in front or behind (horizontal axis) you. As before, remember to experiment with different types of background noise too.

8 Localising Unknown Sounds in an *Unfamiliar Setting* 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 are focusing 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

9 *Tracking Sounds in Noise*

Your task is to localise voices or other sounds and then track them in space as they move. Here are some ideas to try:

- Listen for sounds from an open window (e.g., passing car, lawn mower). Follow the sound and try to predict its movement.
- Track voices and/or other sounds around you in public. Where is the mother with the child? Where is the siren sound coming from?

TIP:

- Be patient with yourself – it takes time.
- Try to practice every day by paying attention to the localisation 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. Sound localisation can only develop when there is an equal perception of loudness between ears or hearing devices.
- 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. Practising in a group is fun and you can support each other.

References

- 1 Abel, S., Giguère, C., Consoli, A., & Papsin, B. (2000). The effect of aging on horizontal plane sound localization. *Journal of the Acoustical Society of America*, 108 (2), 743-752.
- 2 Ashmead, D., Davis, D., Whalen, T., & Odum, R. (1991). Sound localization and sensitivity to interaural time differences in human infants. *Child Development*, 62, 1211-1226.
- 3 Babkoff, H., Muchnik, C., Ben-David, N., Furst, M., Even-Zohar, S., & Hildesheimer, M. (2002). Mapping lateralization of click trains in younger and older populations. *Hearing Research*, 165, 117-127.
- 4 Brown, K. & Balkany, T. (2007). Benefits of bilateral cochlear implantation: A review. *Current Opinion in Otolaryngology, & Head and Neck Surgery*, 15, 315-318.
- 5 Buss, E., Dillon, M., Rooth, M., King, E., Deres, E., Buchman, C., Pillsbury, H., & Brown, K. (2018). Effects of cochlear implantation on binaural hearing in adults with unilateral hearing loss. *Trends in Hearing*, 22, 1-15.
- 6 Gordon, K., Jiwani, S., & Papsin, B. (2013). Benefits and detriments of unilateral cochlear implant use on bilateral auditory development in children who are deaf. *Frontiers in Psychology*, 4, 1-14.
- 7 Laske, R., Varaguth, D., Dillier, N., Binkert, A., Holzmann, D., & Huber, A. (2009). Subjective and objective results after bilateral cochlear implantation in adults. *Otology & Neurotology*, 30, 313-318.
- 8 Mertens, G., De Bodt, M., Van de Heyning, P. 2017. Evaluation of long-term cochlear implant use in subjects with acquired unilateral profound hearing loss: Focus on binaural auditory outcomes. *Ear & Hearing*, 38, 117-125.
- 9 Thomas, J.P., Neumann, K., Dazert, S., Voelter, C. 2017. Cochlear implantation in children with congenital single-sided deafness. *Otology & Neurotology*, 38, 496-503.





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