

# **Technology for People Deaf in One Ear**

*with Normal - or Near - Normal Hearing in the other ear*

*... or People with Monaural Hearing*

From 1967 through 1997 **The National Institute for Rehabilitation Engineering** (N.I.R.E.) had been custom-making and fitting HEARING AIDS and other ASSISTIVE AUDITORY DEVICES, with field testing and on-site user training in people's homes and workplaces. We helped hundreds of people with disabling hearing losses to lead better quality lives in their various social, work and travel environments. This paper is based on data from hundreds of clients successfully helped in this 30-year period ...plus new technologies developed through 2003. *The N.I.R.E. is a non-profit IRS section 501c3 organization which is supported by grants, contributions and volunteer staff. It is devoted to using assistive technology to better the lives of people with permanent, incurable physical disabilities and to help them to remain independent and self-supporting.*

**This paper** is intended to be read by hearing-impaired individuals and family members, by physicians, engineers, technicians, audiologists and hearing aid dispensers, and by educators, employers and employment counselors. It may be especially helpful to people who recently lost hearing in one ear, from illness, accident, stroke, tumor or other cause if the other (good) ear has normal or near-normal hearing. *NOTE: This paper will NOT help people having moderate to severe hearing loss in the one functional ear.*

**Medical & Audiology Services** - We urge that all hearing-impaired individuals be under the care of a qualified Medical Doctor ("otolaryngologist" or "ear, nose & throat physician") ...and an ASHA certified Audiologist - before purchasing hearing aids or assistive hearing equipment.

**The purpose of this paper** is to describe ways for helping people "deaf in one ear ... with normal (or near-normal) hearing in the other ear" to function more efficiently and more comfortably under their usual day to day living, traveling and working conditions. The ear physician should be seen first because he may be able to completely or partially reverse the hearing loss, or to arrest or slow its progression. The audiologist is important for measuring and defining different types of hearing loss and their characteristics. *It is important that both ears be thoroughly evaluated by the audiologist.* Many audiologists do not dispense hearing aids but, instead, provide hearing aid specifications for, and refer patients to local hearing aid dealers. *Some audiologists do, themselves, dispense hearing aids.*

**Hearing Aid Dispensers** are usually commercial dealers who sell and dispense hearing aids. Tested and licensed in most states, these dispensers may or may not be college educated. Typically, they have taken courses in hearing aid dispensing, have been trained by the manufacturers whose products they sell and have passed examinations administered by their state licensing agencies. Of necessity, hearing aid dispensers must test their clients' hearing unaided and with various hearing aids that are fitted and programmed differently. In most areas, dispensers are not permitted to charge fees for their time and professional services. Instead, they are allowed to earn high profits on their sales of hearing aids. They cover their time and overhead costs for testing and other services out of the profits earned by sales. Because they are licensed and regulated, this usually proves fair and effective for hearing aid buyers. All hearing aid dispensers have some technical training, usually by the manufacturers. Some may also have electronics technician or engineering backgrounds. *Some non-profit organizations dispense hearing aids. These types of dispensers are usually found in large cities.*

*Note: The Hearing Aid Dispenser often augments but does not replace the Audiologist.*

## **Terminology ...and Other Background Information**

**Monaural Hearing** is the term for unaided hearing with one ear when the other ear is deaf or near-deaf and no hearing aid is in use. AFTER a crossover hearing aid is in use, the person can be said to have “partly compensated monaural hearing.”

**Binaural Hearing** is the term for normal hearing with two ears, both of which have normal or near-normal hearing characteristics, measured separately and together. The human brain processes the signals from the two ears in a very special, coordinated way. One of the most important of these brain processes is that which cancels background noises so that the person can better discriminate and understand a person’s voice that is mixed in with all the background noise (as in a factory, motorboat, party with loud music, etc.). Another of these brain processes enables a person with two good ears, to hear three or four people speaking at the same time - in a place without background noise – and be able to listen to just the one voice that is of interest. EXCEPTIONS to these benefits occur when a person has lost most or all of the hearing in one ear. (1) Unaided, this person understands very little of human speech under either of the conditions just described. (2) Aided, with an appropriate crossover hearing aid, this person will understand more human speech ... but still considerably less than would be the case if both ears were functioning properly and sending complementary signals to their respective sides of the brain. The brain’s processing of BINAURAL SOUNDS to enhance understanding is comparable to its processing of BINOCULAR IMAGES to give a person stereoscopic vision for better judging the sizes and distances of observed objects. *THE TRUTH IS THIS: The best possible crossover hearing aid will usefully help the person who has lost hearing in one ear. Therefore, it should be purchased and used. However, even the best hearing aids cannot and will NOT restore normal or near-normal binaural hearing to a person deaf in one ear.*

**Sensitivity and Loudness of Perceived Sounds** are additional functions automatically performed by the brain in people with identical hearing in both ears. Sensitivity means ability to detect weak sounds from far away, even if too weak to understand. Loudness means the volume with which the detected sounds are heard – which may vary from too low to much too loud and even painfully loud. In the field of sound engineering, “sensitivity” is comparable to microphone sensitivity and pre-amplification. “Loudness” is related to power output and is regulated by the final power amplifier stage. When a person is deaf in one ear and is using a crossover hearing aid, then these two functions do not track automatically for the sounds sensed on both sides of the head. On the normal-hearing side, the ear is hearing normally without any amplification, and sends its perceived signals directly to the brain. On the deaf side, a microphone is sensing the sounds which are amplified and then delivered to the other ear via a tube or cable. Unfortunately, the microphone and amplifier, on the deaf side, cannot automatically and constantly regulate microphone sensitivity and amplified power output in synchronization with how the brain regulates ear sensitivity and signal strength on the unaided, hearing side. Because the sounds for both sides travel to the brain via the same (good) ear, the brain can vary both at the same time but not each separately. Generally, synchronization of these characteristics remains fairly compatible within reasonable conditions and ranges. However, extremes in either

direction almost always unbalances these characteristics. Even so, most monaural people enjoy better quality lives with a crossover hearing aid than without.

**Hearing Loss (unaided)** refers to the native physical state of a person's hearing ... without the use of hearing aids or other assistive technology. The loss in either ear may be flat across the entire frequency spectrum or it may worsen as the sound pitch or frequency increases. "Hearing Loss" can usually be defined by standardized audiometry testing.

**Basic Types of Hearing Loss:** (1) *Conductive Loss* – this is usually completely correctible by an ear surgeon; (2) *Nerve Loss* – this is usually NOT correctible and requires the use of hearing aids and/or other assistive devices; and (3) *Mixed Loss* – is a combination of conductive and nerve loss. The ENT physician and audiologist, conferring together, can usually determine the ratios of the losses and whether surgery to correct the conductive losses would be beneficial enough to be worth undergoing. Hearing aids may still be needed by these patients, even after conductive loss repair surgery. Even so, hearing may be much better after surgery, in many cases, than it would have been without surgery – even with hearing aids.

**Common Causes of Deafness & Hearing Loss** in either or both ears: (1) *congenital defects* – often but not always non-repairable – sometimes runs in families; (2) *infectious diseases* – such as mumps, measles, German measles, meningitis, etc. – resulting nerve losses usually not medically correctible – more likely to affect children than adults; (3) *exposure to excessive environmental noise* – long term or very intense, short term – resulting in non-correctible nerve damage; (4) *progressive conductive loss due to calcification* of the middle-ear sound-conducting bones – usually correctible surgically; (5) *progressive nerve loss due to diabetes - or chronic high-fat diet* - sometimes reversible with diet changes and/or medication; (6) *progressive nerve loss due to aging and/or unknown factors* – usually not medically correctible and requires hearing aids and/or assistive technology; (7) *damaged eardrums* – usually correctible surgically; (8) fluid in middle- or inner- ear, usually correctible; (8) *brain disease, injury or surgery* – often not correctible; and (9) *cochlear implants* – which can upgrade from "total deafness" to "hearing with severe impairment" but only with the use of special assistive devices and speech discrimination training. These implants not applicable when one ear is normal or near-normal.

**Corrected Hearing Impairment** refers to the functional state of the person *with hearing aids and/or assistive technology* and has to be defined separately for different living or working environments and varying functional conditions. Another term is: "**Residual Hearing Impairments for Defined Activities, Using Hearing Aids.**" This cannot be defined in the lab with standard audiograms. Instead, speech discrimination scores must be developed in the field for each of many different environmental situations. *Note: Some clinics can simulate these real-world conditions for testing purposes to avoid having to take field measurements. Otherwise, testing may need to be done where the hearing-impaired person lives or works.*

**Functional Benefits Needed by Hearing-Impaired** usually include these functions:

- (A) **Ability to hear and recognize sounds and noises** including horns, telephone bells, sirens, alarm clocks, telephone bells, etc. (Hearing Sensitivity and Discrimination.)

- (B) **Ability to recognize direction from which a warning sound is coming.** This requires nearly equal sensitivity and functioning of both ears and is important to have - if possible - for safety reasons. (NOTE: Can only be partly emulated for people deaf in one ear.)
- (C) **Ability to hear and understand isolated speech** without background noise or competing voices. One should be able to hear and understand voices of all pitches, i.e. the voices of children, adult women and adult men.
- (D) **Ability to pick out a single voice** to hear and understand, even when there are competing voices and/or distracting background noises. This requires nearly equal sensitivity and functioning of both ears. One should be able to understand voices of all pitches, i.e. the voices of children, adult women and adult men. (NOTE: This is a continuing but partly lessened deficit for people deaf in one ear, with the best of hearing aids. More costly digital hearing aids may help this slightly more effectively than the less costly analog aids.)
- (E) **Ability to discriminate and recognize individual voices** by their unique sounds and qualities. (NOTE: People who are deaf in one ear may better discriminate different voices using analog, rather than digital hearing aids.)
- (F) **Ability to hear, discriminate and understand voices from electronic equipment** such as telephones, cell phones, radios, CD players, and television receivers.

Functions (A) through (D) and (F) are necessary for completely normal living in the hearing world. (E) is desirable but not absolutely necessary - it is not always achievable. *A person newly DEAF IN ONE EAR - with normal hearing in the other ear - usually needs to enhance functions (B), (D) and (E) as much as possible with the use of an appropriate hearing aid.* Comparative hearing aid trials may show that function (D) is best enhanced with one type hearing aid – and that function (E) is best enhanced by another type – but that there is no hearing aid to enhance both these functions at the same time. If this occurs, it is usually more important to strengthen function (D), even while weakening function (E).

**Deafness in One Ear ... with “Normal” or “Near-Normal” Hearing in Other Ear** may occur rapidly, even in people who previously had completely normal hearing with both ears. Legally, such people are rarely eligible for financial benefits such as Social Security Disability. Functionally, this condition often interferes with a person’s ability to do his work and it can sometimes compel a person to change occupations. It can be distressing in social settings and can even endanger a person’s life near machinery or moving car, trains or airplanes. This paper discusses assistive devices that can help in such situations and explains how they are used, what they can do, what they cannot do, and what functional challenges or deficits are likely to remain. *Note: For purposes of this discussion it is assumed that deafness is total ...or “near-total” in the affected ear – and that hearing is “normal” or “near-normal” in the other ear.*

**Cochlear Implants** sometimes help people totally deaf in BOTH ears. This is a method for directly stimulating the brain, through the auditory nerve, with electrical signals amplified from a microphone and digitized. These implants are usually unsuitable for, and inapplicable to people deaf in one ear - with normal to near-normal hearing in the other ear.

## What Technology Can Help – and How Effectively?

People Deaf in One Ear .. with Normal Hearing in the Other Ear

### For people *Deaf In One Ear - with Normal Hearing in the Other Ear*

CROS or the crossover type of hearing aid is often used in conjunction with the eyeglass frame. The CROS (contralateral routing of signal) system features a microphone behind the deaf ear that senses and then feeds the amplified signal to the better ear. The good ear hears sounds directly, without amplification, through its "open" earmold. It also hears amplified sounds from the other side of the head via a tiny sound-feed tube or wire attached to the open earmold. This type aid may also help make speech easier to understand for people with a mild high-frequency loss. It also helps the user partially determine with slight head movements, from which direction a sound is coming.

**CROS hearing aids come in different configurations**, among them: **Eyeglasses** with all wiring in the temple bars; **Behind-The-Ear** devices which can either be *wired* to each other around the back of the head ... or they can be *wireless* devices using weak radio signals; **In-The-Ear** devices which can be *wired* to each other around the back of the head ... or they can be *wireless* devices using weak radio signals; or **Body Aid** with microphone on one side and a wire to an open earmold on the other side of head, in the good ear. **TELEPHONE USE** is normal for these people. They simply hold the telephone earpiece to the good ear in the normal way.

**CAUTION: Wireless CROS hearing aids use radio signals** which can interfere with electronic instruments and computers. Their use may be banned where cell phones are banned ... as in hospitals, airplanes, and data processing centers. Generally, these more expensive CROS aids are chosen to avoid the need for a tube crossing the back of the head, from one ear to the other. They are more costly to buy and more costly to use because of increased battery power consumption. But they do not offer better performance.

### For people *Deaf In One Ear - with Impaired Hearing in the Other Ear*

The BI-CROS system uses two microphones (one above each ear) that send signals to a single amplifier. Sounds then travel to a single receiver, which transfers them to the better ear via a conventional closed earmold. The user hears amplified sounds from both sides of his head through the one ear. Sometimes better sound discrimination and directional sensing are possible using two separate amplifiers, one for the microphone on each side (instead of a single amplifier). Physical configurations for BI-CROS aids are similar to those for CROS aids, as described above, and paragraphs below.

*Eyeglass frame models* function much the same as behind-the-ear devices, except that the devices fit into an eyeglass frame instead of resting behind the ears. Not many people buy the eyeglass type of aid, but those who do believe it's less obvious, although there is a tube that travels from the temple of the glasses to the earmold in the good ear. But it can be hard to fit this type of aid, and repairs can be problematic. Also, if the aid breaks, the person also loses the benefit of the lenses. *Most people prefer the behind-the-ear devices.* **TELEPHONE USE** for these BI-CROS users must be thoroughly tested with the audiologist or hearing aid dispenser. It will

require listening to the telephone through one or the other hearing aid microphone, probably that for the better (but still impaired) ear. By actual testing, it has to be determined whether the telephone is best used with AIR-conduction ... or with MAGNETIC COUPLING ... from the telephone receiver to the user's hearing aid. If magnetic coupling is better, then the BI-CROS aid should be so equipped.

*Body or "On-The-Body" aids* feature a larger microphone, amplifier, and power supply inside a case carried in the pocket, or attached to clothing. A powered earphone attaches directly to the earmold; its power comes through a flexible wire from the amplifier. Although larger than other aids, the on-the-body aids are more powerful and easier to adjust than other devices. *Body type aids provide poor directional sensing and are not generally recommended for monaural people.*

**Some Typical CROS Applications** enable: (1) a right-deaf person who is driving to hear passengers to his right, in front or back seat; (2) a monaural driver to hear sirens or other street sounds and to be able (with slight head motions) to sense the direction from which the sound is coming; (3) a monaural person sitting at a table to hear other people at the table, on either side; (4) a monaural parent to better, faster and more safely monitor the children; (5) a monaural employee to more normally, more rapidly and more safely work at his or her job; (6) a monaural person to better discriminate and understand another person's speech when competing noise and/or voices are present; (7) a monaural person to better hear and understand lectures, sermons, and theater performances; (8) a monaural person to better hear and understand radio or tv sound at normal volume settings, etc. The benefits of CROS (crossover) hearing aids for people deaf in one ear (with normal or near-normal hearing in other ear) are so great the aid should be used.

**Digital or Analog?** Both types should be tried for at least two weeks, each, and then an informed choice can be made. The analog type costs less and gives more natural sound rendition. The digital type may be worth the substantially higher cost if it automatically gives better loudness regulation, better background noise suppression, and better speech discrimination. Only the user can test both types and then choose that which is best for his lifestyle and activities.

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Readers are invited to contact this Institute for questions or for additional information. There are no costs or obligations of any kind - because grants and contributions fund our service activities.

## **The National Institute for Rehabilitation Engineering**

*A non-profit organization serving people with disabilities*

**P.O. Box 1088 Hewitt, NJ 07421**

**Tel. 1- 800-736-2216 Fax (928) 832-2894**

**E-mail: [nire@warwick.net](mailto:nire@warwick.net)**

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