immersive HeLPS

I-HeLPS

The *Immersive* Hearing Loss and Prosthesis Simulator

USER GUIDE

Sensimetrics Corporation
Malden, Massachusetts

March 2013

Warranty

Sensimetrics Corporation warrants for a period of 90 days that this product will be free from defects in materials, workmanship, or recording. If I-HeLPS does not work as described in the accompanying documentation, and your problem cannot be resolved, Sensimetrics will either provide a fully-functioning replacement or authorize you to return the product for a refund.

Technical Support

One year of free technical support for I-HeLPS is provided from the date of purchase. If you need technical support, please visit the I-HeLPS website www.sens.com/I-HeLPS and click on the Support link for help with known problems and for answers to Frequently Asked Questions (FAQs). If your problem is not addressed there, send a description of it by email to tech-support@sens.com.

Acknowledgements

Development of I-HeLPS was supported by SBIR grant DC005446 from the National Institute on Deafness and Other Communication Disorders.

Copyright

SAFETY WARNING

I-HeLPS is designed to makes sounds difficult to hear for people who are not accustomed to the loss of auditory cues. As a hearing health professional, you should exercise your best judgment in providing this device to clients for use outside your office or clinic. If you provide an I-HeLPS unit for use outside your supervision, be sure to caution your clients not to use it in situations in which the loss of auditory cues may be dangerous, such as crossing streets, driving, or in the vicinity of operating machinery, including household appliances.

CONTENTS

INTRODUCTION

I-HeLPS – the Immersive Hearing Loss and Prosthesis Simulator – is a wearable headset system for simulating the auditory communication difficulties associated with hearing loss along with the benefits provided by hearing aids and cochlear implants. I-HeLPS is a binaural system, with independent loss and prosthesis characteristics for the left and right sides; it provides simple controls for quickly switching among loss and prosthesis settings; and it can be used in everyday settings without occupying hands or eyes.

The characteristic of I-HeLPS that makes it unique is that it shifts the listener's auditory thresholds for ambient sounds to match a specified hearing loss. The listener is *immersed* in the soundscape that is the input to the simulation so that he or she will be able to experience a simulated hearing impairment for the everyday sounds in the environment. Such a change in hearing ability can immediately demonstrate the problems of hearing loss and the characteristics of auditory aids.

I-HeLPS consists of two main components: 1) a headset tethered by a USB cable (to be connected to a Windows PC), and 2) a graphical interface running on the PC for controlling the simulation. Up to three hearing specifications and three prosthesis specifications can be specified at a time, and one of each can be selected for the real-time immersive simulation.

I-HeLPS is designed to provide demonstrations in several settings: in counseling for families of hearing-impaired and deaf persons; in hearing aid fitting; in hearing-conservation and public education programs; and in training audiologists and educators of the deaf. Specification of hearing loss and prosthesis characteristics is to be done by a knowledgeable hearing health professional – ***you***. In this *User Guide* reference is made either directly to "you" or to the "operator" as the person using the interface to specify hearing losses and prostheses. The "listener" is the normal-hearing person who dons the headset and listens to the simulation, while the "patient" or "family member" is the person whose hearing is being simulated.

GETTING STARTED

Software and Hardware Installation

Insert the I-HeLPS USB drive into a USB slot on your computer, navigate to the top-level folder of that drive, and double-click on the program ‘setup.exe’, which initiates the I-HeLPS installation process. The Choose Destination Location screen lets you install I-HeLPS to the folder you specify. Unless you have a reason to do otherwise, simply proceed with the default option by clicking ‘Next’.

After installation of the I-HeLPS PC interface software you can remove the USB drive, but you should save it and not overwrite it. In addition to the installation files, which you would need if you ever have to re-install I-HeLPS, there are speech and noise stimulus files on the drive that may be useful to you (explained below).

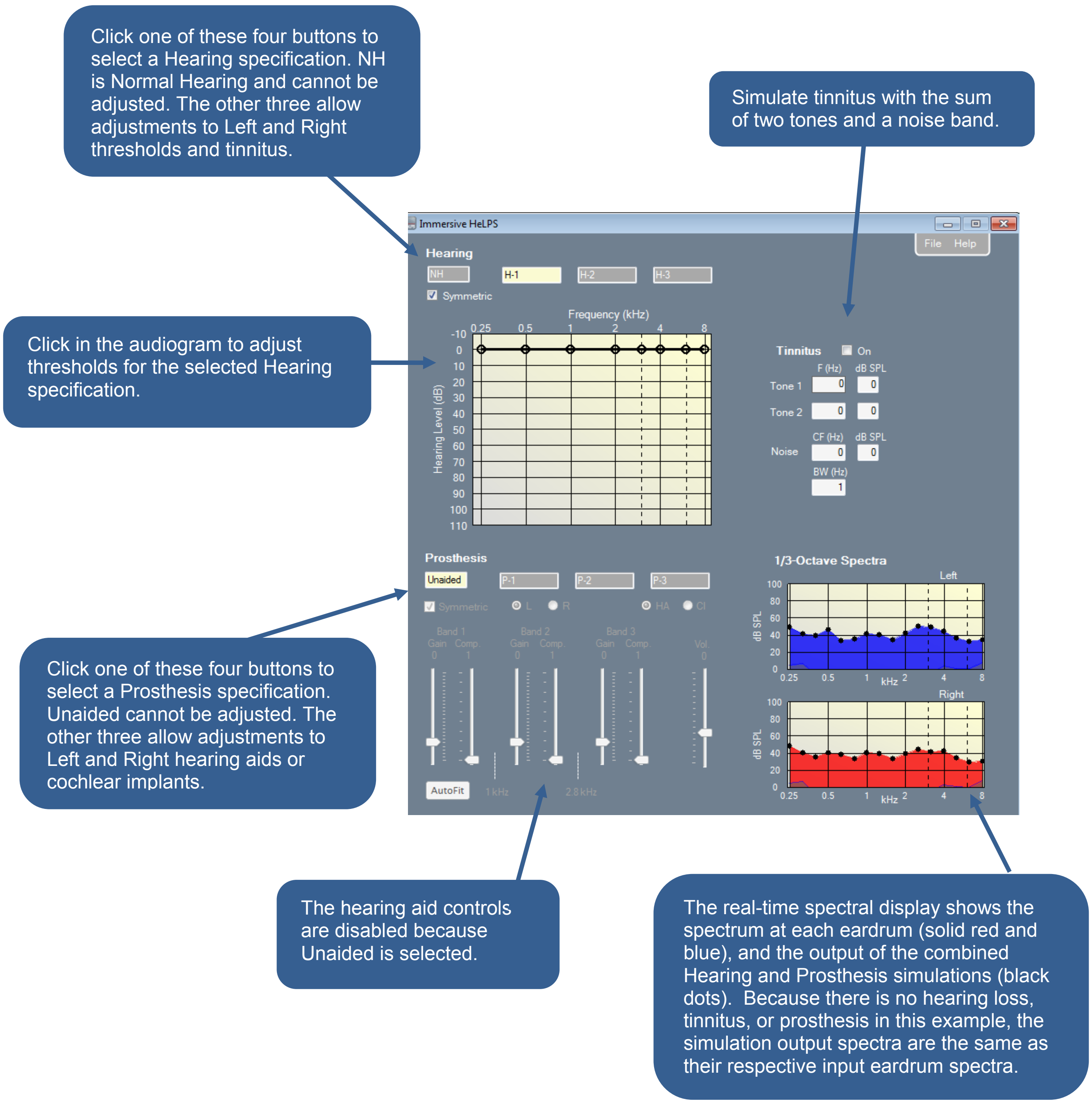
The only hardware installation required is to connect the headset’s USB cable to a USB slot on your computer. The operating system will recognize and register the USB audio device contained in the headset, and I-HeLPS will automatically set its record and volume controls.

After the headset has been connected and registered, click the I-HeLPS shortcut on your desktop to start.

NOTE: The I-HeLPS headset must be connected to a USB slot on your computer BEFORE starting I-HeLPS, every time you use it.

Quick Start

You can start using I-HeLPS immediately. When you start the program you will see the I-HeLPS interface as shown here. These brief descriptions of the controls should be sufficient to get you started. More detailed descriptions are given in the following sections of this *User Guide*.

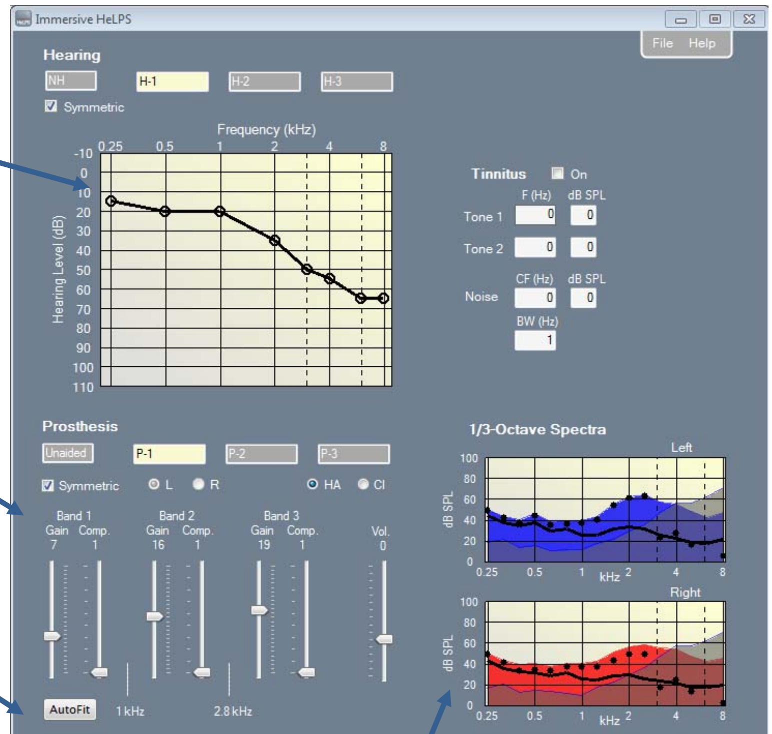


This example shows that Hearing Specification H-1 has been selected. It has a left-right symmetric loss and no tinnitus. A symmetric hearing aid is also in effect.

Symmetric thresholds are shown by a black curve; asymmetric thresholds are red and blue.

A hearing aid has three frequency bands with controls for gain and compression in each band.

AutoFit provides hearing aid gain and compression settings based on thresholds.



The plotted spectra are:

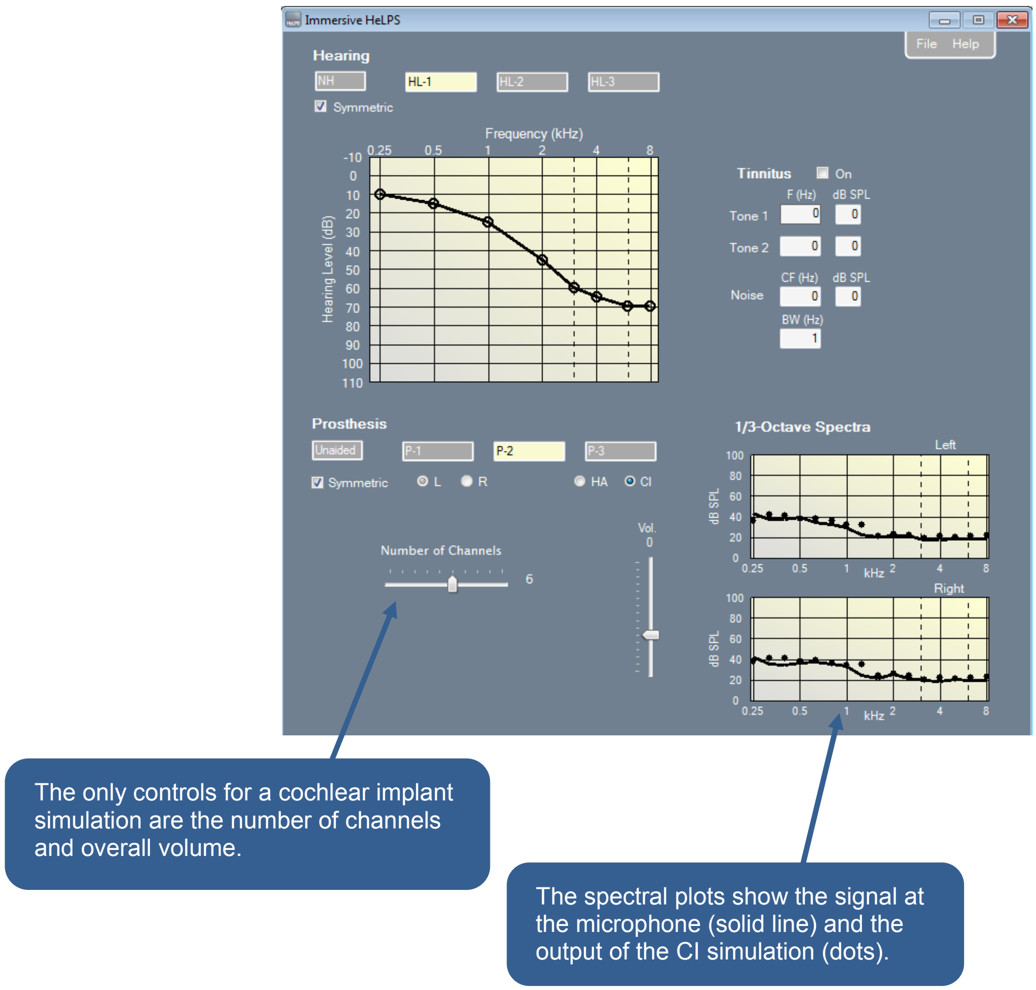
black line – the signal at the microphone.

red/blue – the signal at the eardrum (after the hearing aid, before the HL simulation). The difference between the red or blue curve and the solid black curve reflects hearing aid gain.

black dots – signal output from the hearing loss simulation (without the masking noise). This signal spectrum reflects both the hearing aid gain and the HL simulation processing.

dark shading - masking noise that is used as part of the hearing loss simulation. Signal audibility is indicated by the extent to which the signal output spectra (dots) are above the masking noise (dark shading).

This final example shows selection of a cochlear implant (CI) as the prosthesis. When a CI is selected the specified thresholds for that ear (or both ears if Prosthesis is Symmetric) are disregarded. The output of the simulation represents only that from the CI, with no acoustic contribution.



SIMULATED HEARING SPECIFICATION

Hearing Loss

Adjustable hearing specifications can be associated with the three selection buttons initially labeled H-1, H-2, and H-3. The specification associated with Normal Hearing cannot be modified. Thresholds for the left (L) and right (R) ears are adjusted by either clicking or dragging on the audiogram. Thresholds must be specified at the six octave frequencies from 250 Hz to 8 kHz plus the two inter-octave frequencies of 3 and 6 kHz. Thresholds represent a pure recruiting hearing loss with no conductive component.

If the Symmetric checkbox is checked, then all L thresholds will be equal to the corresponding R thresholds. Symmetric L and R thresholds are plotted in black. When they are asymmetric, L and R thresholds are plotted in blue and red, resp. Also, when hearing is asymmetric, L thresholds are entered by using the left mouse button and R thresholds are entered with the right mouse button.

The interface imposes a limit on the AC threshold in order to avoid loudness discomfort from the masking noise that is used for hearing loss simulation. These limits, which vary from 70-85 dB SPL across frequency, are large enough to render almost all everyday sounds inaudible. When a limit is reached a graphic notice will be presented.

Tinnitus

You can simulate tinnitus on either side with a stimulus composed of two continuous tones and a band of noise. Each tonal component is specified by its frequency (F) and level (dB SPL), and the noise band by its center frequency (CF), bandwidth (BW), and overall level (dB SPL). The maximum tinnitus level allowed is 80 dB SPL. If the hearing specification is symmetric any tinnitus will be delivered identically on the two sides, and the font in the tinnitus entry boxes will be black. If the hearing specification is not symmetric, then the side for which tinnitus is specified is determined by the side last click in the audiogram, and is indicated by the font color – blue for left and red for right.

The I-HeLPS Hearing Loss Simulation Algorithm

The I-HeLPS algorithm for simulating hearing loss is designed to produce for the listener the absolute detection thresholds (i.e., hearing levels) and sensation of loudness recruitment that correspond to a specified hearing loss. A recruiting hearing loss of H_R dB is modeled as a threshold shift with a rapid rise in output level over some recruitment range, r, as signal level exceeds threshold, until full recruitment is reached. Figures 1 illustrates the simulation in terms of an input/output (I/O) plot. In this plot the input quantity, on the abscissa, is the sound level in one frequency band at the eardrum of a normal-hearing listener. The output, on the ordinate, is the level of the sound at the eardrum delivered by the hearing loss simulation. Note that these plots give sound levels relative to the normal absolute threshold for the frequency band. On average, therefore, sounds that exceed an output level of 0 dB will be heard and those below 0 dB will not be heard. The dotted line for $out = in$ would obviously represent a simulation of normal hearing.

The example I/O plot in Figure 1 shows a recruiting loss of 70 dB. For this loss the simulator output level (red line) is below threshold (i.e., the output is less than 0 dB) for input signal levels up to the specified threshold shift of 70 dB. As the input level increases above 70 dB, the simulator output level rises rapidly over the recruitment range *r* of 20 dB. For input levels beyond the recruitment range, a region called full recruitment, output level increases 1 dB per 1 dB increase in input level and the output level is equal to the input level (*out* = *in*).

Similar processing is performed in all frequency bands, with the degree of hearing loss, H_R, controlling the position of the curve. The recruitment range *r* is 20 dB in all bands.

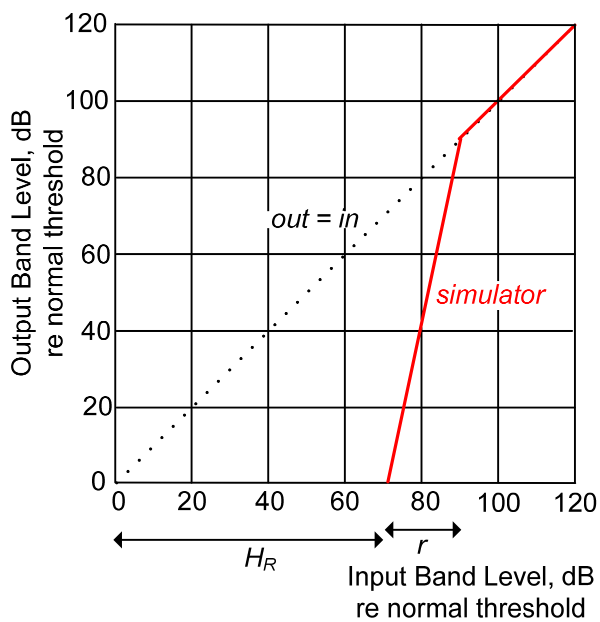


Figure 1. Example I/O plot for one simulator band showing a recruiting hearing loss H_R = 70 dB with a recruitment range *r* = 20 dB.

The signal processing required to achieve the I/O characteristic just described is relatively straightforward. It requires running estimation of the input sound level over a short time interval within each bandpass-filtered channel, and control of an attenuator through which the bandpass signal passes. The amount of attenuation to be imposed at any moment is given by the vertical distance between the simulator output characteristic and the *out* = *in* line. For recruiting hearing losses, more attenuation is applied to lower sound levels than to higher sound levels. This use of automatic gain control (AGC) for simulating hearing loss, which was first described by Villchur (1977), produces generally good agreement of speech-reception tests between listeners with actual hearing losses and listeners with simulated losses matched to the actual losses (Duchnowski and Zurek, 1995; Lum and Braida, 2000).

The difficulty in making an *immersive* simulation of hearing-loss (and prostheses) stems from the fact that ambient sound reaches the listener's ear directly. This problem is illustrated by the functional block diagram of one side (left or right) of an immersive simulator shown in Figure 2. Ideally, the simulator (lower branch) would pick up the ambient sound with a microphone and process that signal first by a prosthesis-simulation algorithm and then by a hearing-loss simulation algorithm. The output of these simulation algorithms would then be delivered to an earphone, producing audible sound at the listener's ear. The problem is that ambient sound reaches the ear – via bone conduction and/or leakage through the headset – bypassing the simulation. These alternate paths are lumped together and denoted the Direct Path (the upper branch) in Figure 2.

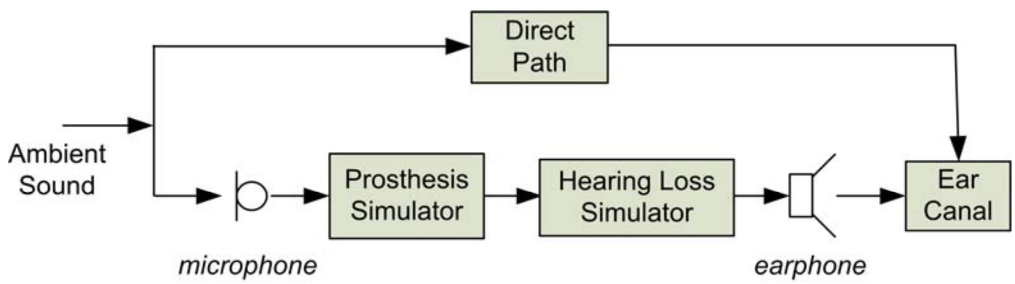
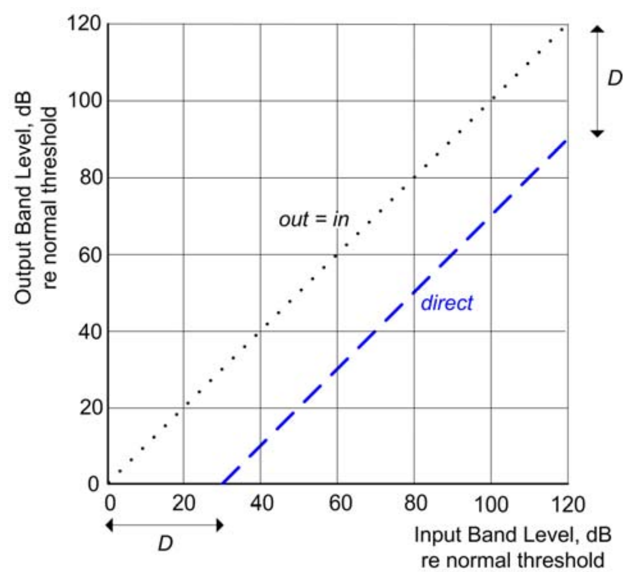


Figure 2. Diagram showing one channel of an immersive simulator (lower branch) along with the direct acoustic path (upper branch).

Even with a very good hearing protector, like the I-HeLPS headset, ambient sound can be attenuated by at most only 40-50 dB, and usually less at low frequencies (Berger and Killion, 1989). The level of direct-path sound can be plotted on an I/O plot like we examined before. Figure 3 shows an example of a direct-path component that is attenuated by D = 30 dB relative to the open ear. We have no control over this direct path sound; we must accept it at the level determined by the hearing protector in use. This direct-path sound obviously limits the degree of hearing loss that can be simulated because it is not possible for the total sound level in the listener's ear canal to be less than the level of the direct sound.

Figure 3. An example I/O plot for one simulator band showing the direct path component at D = 30 dB.



The audibility of direct-path sound must be minimized to enable control of the sound delivered to the listener's ear by the simulator. This minimization is achieved in I-HeLPS through the addition of masking noise to the simulation. Judicious use of masking noise, along with AGC processing and attenuation from the headset, allows for immersive simulation without interference from direct path sound (Zurek and Desloge, 2009). The algorithm as illustrated in Figure 4. The level, L_N, of masking noise in each band (the gray swath), and the simulator's AGC characteristic, are jointly adjusted so that the simulator output emerges from the noise and becomes audible at the specified input threshold. In the example in Figure 4, a hearing loss of H_R = 70 dB is simulated with a direct path attenuation of D = 30 dB. Note that the direct path signal is below the noise, and so is masked by it, at low input levels. The direct path component begins to exceed the noise level a few dB above the threshold of 70 dB. However, at levels above threshold (70 dB) the AGC-processed output signal also grows above the noise, and at a faster rate than the direct path. So the output signal in the listener's ear canal is dominated by the processed simulator output at high levels. To summarize, the signal processing for immersive hearing loss simulation is based primarily on AGC, with the addition of noise to mask the direct path sound at sub-threshold levels. At supra-threshold levels the direct path sound is masked by the simulator output.

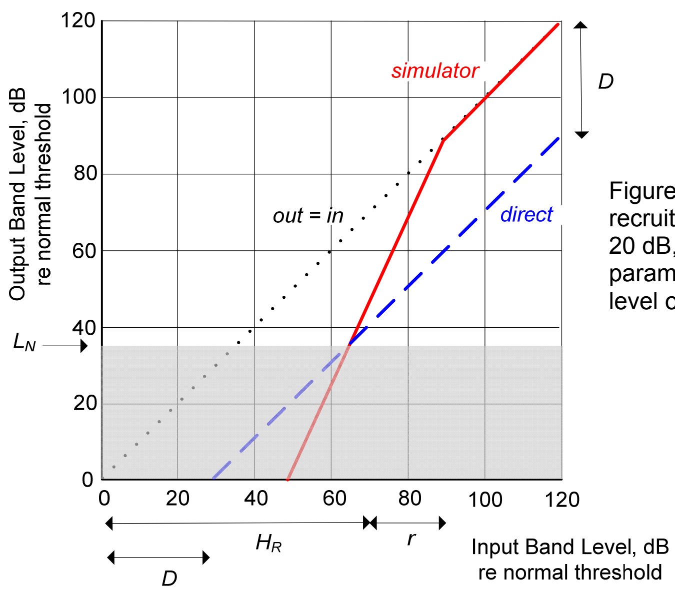
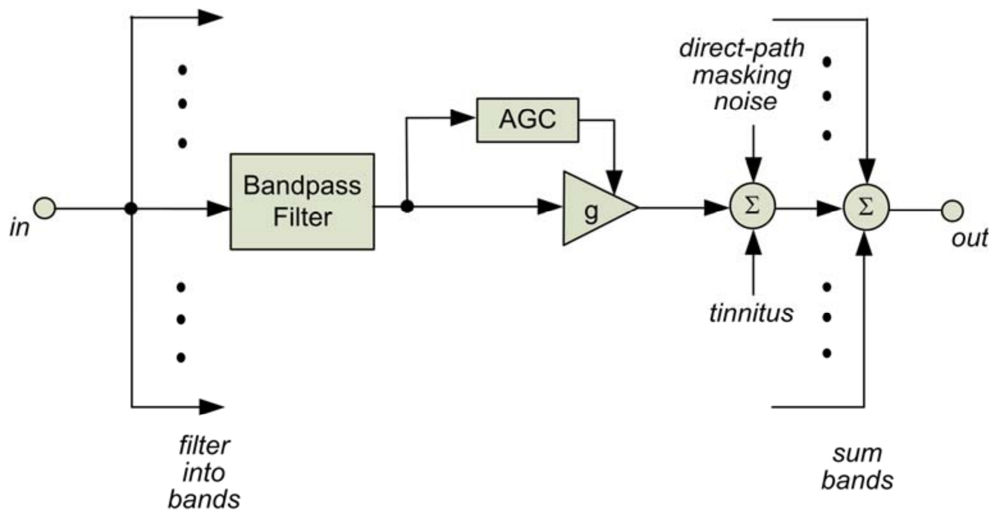


Figure 4. An example I/O plot for one simulator band with a recruiting hearing loss H_R = 70 dB, recruitment range r = 20 dB, and direct-path attenuation D = 30 dB. These parameter values result in a direct-path-masking noise level of L_N = 34 dB.

Figure 5 shows a block diagram of the hearing loss simulation algorithm. Two primary signal-processing operations are performed in each frequency band: 1) an AGC adjusts the level of the signal through the band, as described above; and 2) noise is added to mask the direct-path signal at low levels. Processing in different frequency bands has the same form, but uses different parameters, in general, for the AGC and additive noise. Tinnitus is simulated by adding the specified signals at the output, after the hearing loss simulation.

Figure 5. Block diagram showing the signal processing in one band of the hearing loss simulation



Other algorithm details:

- the input level in each band is estimated from a time-average of the square of the bandpass-filtered microphone signal with a time constant of 14 msec;
- simulations for left and right sides are independent of one another;
- the direct-path masking noises are uncorrelated between sides;
- if tonal tinnitus is specified for the two sides at the same frequency, those tones will be coherent; noise tinnitus is uncorrelated between sides.

Simulation Limitations

There are several limitations to the I-HeLPS hearing loss simulations that you should understand in order to make valid and effective use of the system.

Background noise

As discussed above, background noise is needed to allow the simulation to be immersive, which enables the use of any ambient sound source for demonstrations. However, this steady noise is not a realistic feature of actual hearing losses, and naïve listeners may wonder why they hear this noise when they don the I-HeLPS headset. The best strategy for helping listeners disregard the masking noise is, first, to warn them that it will be present before they don the headset, and second, as soon as they don the headset, get them to attend to a target signal in the environment, such as a person speaking to them. See Demonstration Tips below for suggested explanations of the noise.

Maximum hearing loss

The largest degree of hearing loss that can be simulated by I-HeLPS at any frequency is limited primarily by the loudness discomfort of the masking noise needed to mask the direct path. As the simulated hearing loss increases so does the required noise level. Eventually a point is reached where the masking noise becomes uncomfortably loud.

The loudness-discomfort limit on hearing loss simulated with I-HeLPS varies with frequency between 75 and 85 dB HL. These limits were chosen so that the level of masking noise in any 1/3-octave band is never greater than 75 dB SPL, which results in safe levels for extended listening. A simulated hearing loss set to these maximal threshold levels will render inaudible almost any sound in everyday environments. The limits on total hearing loss are imposed automatically in the I-HeLPS interface. A warning is shown when a limit is reached while adjusting thresholds.

Hearing One's Own Voice and Occlusion

When a person speaks, the internally-generated sound of the voice is partially conducted via bones and tissues to the person's cochleae and can be heard. Because this pathway obviously bypasses the I-HeLPS microphone and hearing loss simulation, the listener will hear his or her own voice to a greater extent than a person with an actual hearing loss. This is an unavoidable limitation of the simulation. If an I-HeLPS listener inquiries about this, you should explain that the simulation applies only to external sound, not to their own voice (or other internally-conducted sounds such as their own footsteps, finger snaps, claps, etc.).

Another complication arises from the fact that use of the headset gives an occlusion effect. As a result, the bone-conducted sound of one's own voice (and other internally-generated sounds) will receive low-frequency amplification relative to open-ear listening. This will occur even if you are listening with Normal Hearing and No Aid. Listeners should be warned of this difference as needed. Note, however, that the occlusion effect <u>is</u> associated with the use of hearing aids. Thus, when a hearing aid is being simulated by I-HeLPS, the occlusion from the headset is a simulation (albeit uncontrolled) of the occlusion effect with actual hearing aids.

Disruption of sound localization cues

Because the left and right microphones are placed on the sides of the I-HeLPS headset near the ears, the interaural cues for sound localization – interaural delay and level difference – are approximately preserved. However, the cues that result from acoustic interactions with the pinna will clearly be lost. Such cues underlie the ability to localize sounds in the elevation dimension and to disambiguate front from back sources.

Suprathreshold distortions and central deficits

The hearing loss simulation implemented by I-HeLPS is designed to duplicate the threshold shift and loudness recruitment of a specified hearing loss. This simulation gives a good match to the performance of listeners with actual hearing impairments on a variety of psychoacoustic and speech-reception tasks. Some hearing-impaired listeners, however, exhibit performance that is clearly worse than simulated-loss listeners on such tasks. Currently, the 'suprathreshold distortions' that underlie such poorer performance are not sufficiently understood to enable them to be simulated. The I-HeLPS hearing loss simulation also does not account for cognitive or central deficits that might lead to poorer performance on psychoacoustic or speech-reception tasks. Such deficits are not simulated by I-HeLPS.

SIMULATED PROSTHESIS SPECIFICATION

I-HeLPS provides simulations of hearing aids and cochlear implants, in addition to unaided listening. Adjustable prosthesis specifications can be associated with the three selection buttons initially labeled P-1, P-2, and P-3. The specification associated with the Unaided button cannot be modified.

Unaided

If Unaided is selected, the microphone signal is processed to represent the signal at the eardrum with open-ear listening. This signal is then passed to the hearing loss simulator.

Prosthesis Selection

If one of the adjustable Prosthesis specifications is selected the controls below the selection buttons will be enabled. As with hearing specifications, a prosthesis specification can be symmetric or not. If symmetric, the L and R prostheses are identical. If the prostheses are not symmetric, then you must specify, using the L and R buttons, which side is being controlled. Note that switching between L and R asymmetric prostheses does not change the processing, so there is no change in audio output or displayed spectra. It only changes which side is adjusted by the controls.

Hearing Aid

If a hearing aid is selected, the controls for adjusting the aid characteristics will be enabled and the microphone signal (solid black line) will be added to the spectral display. There are seven controls for a hearing aid:

- the gain, G_i, in each of three frequency bands (i = 1,2, 3);
- the compression ratio, C_i, in each of the three bands; and
- an overall volume control.

These controls are explained with the block diagram of hearing aid processing shown in Figure 6. The signal from either omnidirectional microphone is subjected first to the volume control, and then to a three-band compressor, which provides independent automatic gain control in the three frequency channels. The lowest band extends from 0 to 1 kHz, the middle band from 1 to 2.8 kHz, and the highest band from 2.8 to 16 kHz. The Mic-to-Eardrum block represents a linear filter that compensates for the change in acoustic response at the eardrum cause by insertion of a hearing aid.

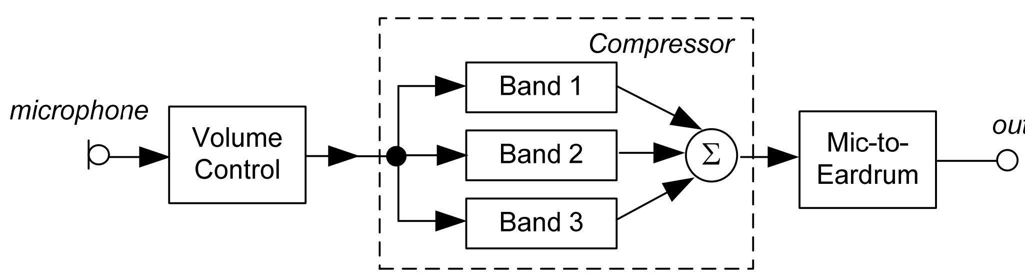


Figure 6. Block diagram of the prototype hearing aid implemented by HeLPS.

The input/output (I/O) characteristic within each compressor band is controlled by the Gain and Compression Ratio sliders in the I-HeLPS interface. The procedure is illustrated in Figure 7 which shows an I/O function for the i^{th} band. The goal of this compressor is to provide amplitude compression over the middle range where input signal levels are most frequently found while limiting the maximum output level. The I/O curve is consequently composed of three straight lines. The low-level line segment has a slope of one, the middle segment a slope of $1/C_i$ where C_i is the compression ratio, and the high-level segment a slope of zero at an output level of O_{max}. In addition, a specific input level is defined to be the 'pivot point,' which is used in two ways. First, it is the point at which the band gain G_i is defined. Second, it is the point around which the compression line segment rotates. P_i and O_{max} are constants, while G_i and C_i are set through the interface. The values of the pivot point parameters, P_i, are [58, 47, 45 dB] for bands [1, 2, 3] and the value of O_{max} which is the same in all three bands, is 90 dB. The temporal parameters for each band of the compressor are the attack and release times, which are set to 1 and 100 msec, respectively.

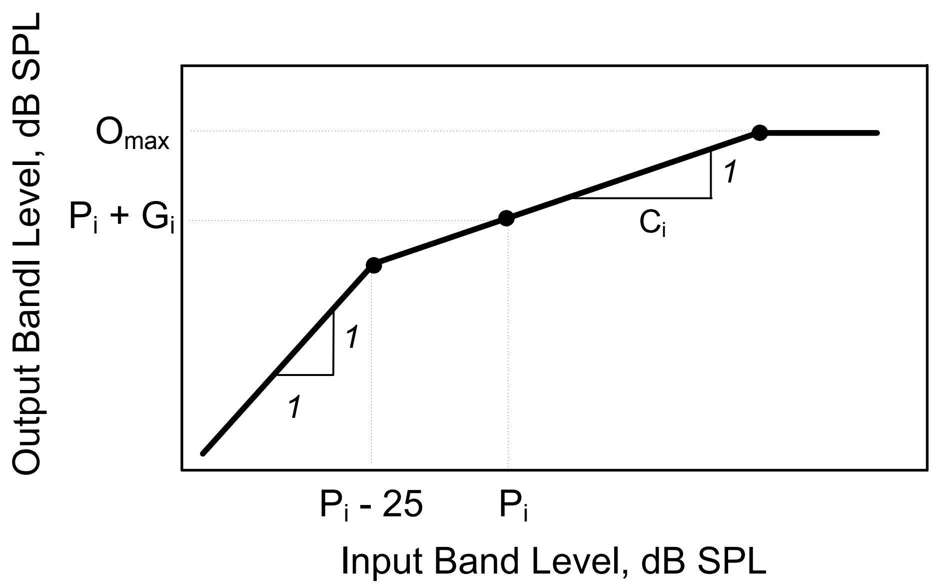


Figure 7. Example I/O characteristic for one channel of a compression hearing aid.

AutoFit

Fitting a hearing aid to a specific hearing loss can be time consuming. In order to reduce that time for you, I-HeLPS provides a means of achieving a quick initial setting of gain and compression parameters based on the currently-selected hearing specifications. Clicking the AutoFit button will apply a simple algorithm to generate gain and compression parameters for both sides based on the L and R thresholds of the currently-selected hearing specification. AutoFit provides initial estimates and you will likely need to adjust them further to achieve an acceptable response.

Simulation Limits

The gain through one band of an I-HeLPS hearing aid can be as large as 50 dB at the pivot point (the sum of the largest settings of the volume control and the band gain), and even larger at lower levels, depending on the compression ratio. But an I-HeLPS aid, like an actual aid, is subject to acoustic feedback and so will not typically be capable of achieving those maximal gains.

Cochlear Implant

Selecting Cochlear Implant as the simulated prosthesis brings up a window with the only relevant controls, which are: 1) the number of channels in the simulation, which can be any integer between 1 and 10, and 2) an overall volume control. These controls are explained with the help of the block diagram in Figure 8. The signal from either microphone is subjected first to the volume control, and then to implant simulation processing. The processing performed within each simulation channel is shown in the inset in Figure 8. After bandpass filtering the input signal, a time-varying estimate of band power is calculated by squaring and lowpass filtering. This time-varying envelope is used to modulate bandpass filtered pulse train.

Specifying N results in the audio band from 0.1 – 9 kHz being separated into N channels of equal octave width. Variation in the number of channels can be used to adjust the quality of the signal representation, roughly simulating the variability in psychoacoustic performance across implantees. A larger number of channels leads to better performance (see the later section on Demonstration Tips). Note that the number of channels in the simulation is not directly related to the number of channels in a CI user's implant. The number of simulation channels is only a means of controlling the level of performance that can be achieved and should not be taken as a model of the number of channels in an actual implant.

Simulation Limits

When a cochlear implant is simulated, the hearing thresholds for that ear are disregarded, and the simulator output represents stimulation via the implant only. Be aware that, because left and right prostheses are independent, the acoustic signal from the non-implant side will continue to be processed by the hearing loss and hearing aid (or Unaided) simulations. In order to simulate monaural CI use with bilateral profound hearing loss, it is necessary to use a maximal hearing loss on the non-implant side.

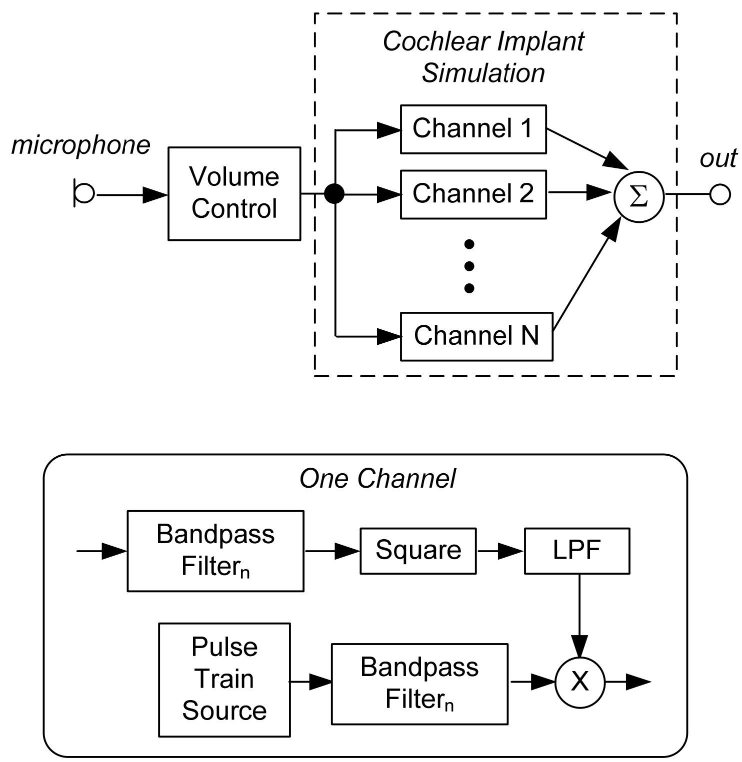


Figure 8. (Upper) Block diagram of the prototype cochlear implant simulation. (Lower) The processing performed within one channel of the simulation.

SPECTRAL DISPLAYS

The real-time spectral displays show important signals in the simulation processing system. The 1/3-octave spectra of Left and Right signals are:

black line – the signal at the microphone.

red/blue – the signal at the eardrum.

black dots – output of the simulation (without masking noise).

dark shading - masking noise used for hearing loss simulation.

However, not all signals are shown at all times. Which signals are displayed depends on the type of Prosthesis selected.

If the Prosthesis selection is:

Unaided - the black line is not shown because there is no simulated microphone. Audibility is indicated by the extent to which the simulation output lies above the masking noise.

Hearing Aid - all four signal spectra are shown. The difference between the signal at the microphone (solid black curve) and the eardrum signal (red or blue) reflects the effective insertion gain of the aid. The simulation output reflects both the hearing aid gain and hearing loss simulation processing. As with Unaided listening, signal audibility is indicated by the extent to which the simulation output exceeds the masking noise.

Cochlear Implant - only the microphone signal and the simulation output are shown. The eardrum signal and acoustic thresholds are irrelevant.

SAVING AND IMPORTING

At any time you can Save or Load an individual Hearing or Prosthesis specification. If you right-click on one of the Hearing or Prosthesis specification buttons, a menu will appear containing Save and Load items. If you select Save the specification associated with that button will be saved to a file. If you select Load the specification that was previously saved to the file you select will be loaded and associated with that button. The file extension is .hrng for Hearing specifications and .pros for Prosthesis specifications.

You can also save (or load) all of the current Hearing and Prosthesis specifications to (or from) a file. This collection of specifications is called a *configuration*, and the file in which it is stored has the extension .cnfg. The Save and Load configuration commands are found under the File menu.

DEMONSTRATION TIPS

Providing demonstrations of hearing losses and prostheses that are technically accurate will depend on you becoming familiar with I-HeLPS simulations. But making those demonstrations meaningful to listeners so that they correctly appreciate the impact of a hearing loss and the benefit of an aid will depend on other factors. It will require that listeners have some understanding of what they will be listening to and that they are presented with effective acoustic signals for demonstrating the points you wish to make. Done properly, demonstrations will convey to listeners very quickly, through first-hand experience, the communication difficulties faced by their family member.

Guiding Listeners' Expectations

It will be helpful if, before giving a demonstration, you briefly make the following points to listeners.

• ***Listening through I-HeLPS is NOT, literally, what a hearing loss sounds like.***

Try to help listeners understand that I-HeLPS *makes sounds inaudible* to the same degree as an actual loss. It provides a <u>functional</u> equivalence, not a <u>perceptual</u> equivalence. I-HeLPS reduces the ability to hear surrounding sounds and to understand what is being said to match the patient's abilities with an actual hearing loss.

• ***You will hear background noise.***

The noise is needed to cover up sounds to the degree required to simulate the hearing loss accurately. A person with hearing loss does not hear the steady noise that is heard in the simulator.

• ***Focus on hearing the sounds in your environment, and ignore the steady noise.***

It is the ability to hear surrounding sounds that is matched to the patients hearing loss being simulated. Stress to listeners that they should pay attention to the sounds around them and disregard the noise.

• ***Your own voice may sound strange.***

If the issue arises, inform listeners that their own voice will sound unusual, and that the simulation does not apply to their voice. Encourage them to listen, with minimal speaking.

If you are demonstrating a cochlear implant, you may want to make these points:

• ***The I-HeLPS cochlear implant simulation is NOT, literally, what an actual cochlear implant sounds like.***

You should make clear that the simulation is only our best guess as to what an implant "sounds like."

• ***The number of channels in the I-HeLPS simulation is not the same as the number of electrode channels in an implant.***

If the issue arises, make clear to the listener that the number of simulation channels only provides a means of controlling listening performance, and should not be taken as a literal equivalent to the number of channels in an actual implant.

• ***Performance can be very different for different CI users.***

CI users show a considerable range of performance on speech tests. The lowest levels of performance correspond approximately to that obtained with 2-4 simulation channels, while the best performance seen with CI users corresponds to the use of about 8-10 simulation channels (Dorman and Loizou, 1998; Friesen et al., 2001). If you are demonstrating for someone whose family member is about to be implanted, then it would be appropriate to demonstrate the high and low ends of the range, and a middle value for the level of performance that can be expected. If you are demonstrating for the family of someone whose performance is known, then select a number of simulation channels that approximates that performance.

Live Speech Demonstrations

Speech is both the most important and most familiar signal that we hear. So the most effective demos make use of it. To demonstrate a hearing loss, simply engage the listener in conversation, and switch from normal hearing to the loss while continuing to talk. The listener's ability to follow the conversation will be directly related to the severity of the simulated loss. If the loss is sufficiently large, a hearing aid or cochlear implant can then be switched on to demonstrate the benefit immediately. Switch among these conditions (Normal Hearing/Unaided, Hearing Loss/Unaided, and Hearing Loss/Aided) as many times as you and the listener desire. Remember that if you really want or need to communicate to the listener, as opposed to demonstrating the inability to understand speech, you should switch to a condition where he or she can understand you.

When you are demonstrating Hearing Loss, you might take advantage of the opportunity to demonstrate the benefits of speechreading (lipreading) to the family of the patient. If the listener is struggling to understand the conversation, demonstrate the assistance that speechreading provides by blocking versus showing your face while you speak. It may be difficult for the listener to appreciate the benefit with running conversation. So try isolated words or short phrases, with and without visual cues. A good demo is to show, and then hide, your lips when producing the consonants /s/, /sh/, and /f/, as in the words 'sue', 'shoe', and 'food'. These consonants are usually the first to be lost because of their weak high-frequency energy combined with the typical pattern of greater hearing loss in the high-frequency region. They are, on the other hand, highly distinguishable when the lips are visible.

Another important demo is the benefit of clear speaking. Careful speaking improves distinctions both in speech sounds and in lip shapes. Speaking clearly can make a big difference for persons with impaired hearing whether they are listening only or listening and speechreading. Keeping lips visible and speaking clearly are the two most important messages that should be conveyed through these demos for enhancing communication with the hearing-impaired family member.

Electronic Sources

For extended demonstrations you may wish to use an electronic source rather than speaking yourself. In those cases you can present sounds from loudspeakers or other audio devices such as a radio or TV.

There are, however, a couple considerations when using an electronic sound source:

1 - The sound source should be played at a realistic level. If the playback level is higher or lower than normal, then the effect of the simulated hearing loss will be inaccurate.

2 - The frequency response of the playback system can affect the demonstration. The most common problem will be that the playback does not reproduce low-frequency sounds well. This will cause the demonstrated loss to appear worse than it should.

To provide you with easily accessible and reproducible demonstration material for speechreading, I-HeLPS comes with a collection of audio-visual recordings of people speaking simple sentences. This corpus provides a useful source for speech demonstrations like those just described. These sentences can be found on the I-HeLPS USB drive in a folder named AV_Sentences. They can be played from your computer using a player such as Windows Media Player or VLC.

Also provided are noise samples that can be used as background interference (these are in a folder named Backgrounds). If you want to demonstrate listening to speech in noise with a hearing loss, and with an aid, you can start a playlist of sentences while background noise is looped.[1]

Demonstrations of Hearing Loss with Non-Speech Sounds

People who listen to I-HeLPS are usually surprised to be made aware of the many low-level background sounds in our environments that are lost with a hearing loss. By monitoring such sounds with normal hearing we stay tuned in to our surroundings – they assist with our "situational awareness." Becoming suddenly deprived of the familiar sounds of other people moving about, paper rustling, or a chair squeaking contributes to a sense of unease that you are missing something and that you need to put other senses on higher alert.

These kinds of effects can be easily demonstrated with such simple acts as tapping your fingers or a pen on a table, or rattling keys (a good high-frequency source). If appropriate, with unaided hearing loss in effect, walk out of the listener's view for a moment and then re-appear from an unexpected direction.

A small set of recorded environmental sounds are provided with I-HeLPS (in the folder named Environmental Sounds). These can be played with Windows Media Player or an alternative player such as VLC.

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[1] *A note on playing two sources* -- Usually you will want to play a noise to serve as background interference for hearing target sounds such as the AV sentences. However, if you use Windows Media Player to play media files you will find that you can play only one file at a time. Another audio player, called VLC, does allow multiple files to be played simultaneously. VLC can be downloaded free from http://www.videolan.org/vlc/. Using VLC you can start a background noise looping (repeating) and then, in a second VLC window, start playing from a playlist of target sentences. You will have a separate volume control for each window for adjusting speech-to-noise ratio.

Demonstrating Tinnitus

Tinnitus is best demonstrated with no hearing loss because the masking noise that is required as part of the hearing loss simulation can be confused with the simulated tinnitus. Keeping demonstrations of hearing loss and tinnitus separate will lead to better understanding of each.

If you have information on the tinnitus characteristics you wish to simulate then you can use that to guide your selection of tone and noise parameters. A single tone is associated with what would be called a steady tinnitus, while two tones or a narrow band of noise would simulate the tinnitus sensation that is sometimes described as “crickets.” In most cases, though, you will have to choose the most common default of “high-frequency ringing.” This can be simulated with a single tone at about 6 kHz and 50 dB SPL. Tinnitus is usually matched to relatively low sounds levels.

Demonstrating Hearing Aids

The I-HeLPS simulation of a hearing aid does what an actual hearing aid does, which is amplify sound. One thing that naïve listeners often comment on about hearing aids is how loud they are even with modest (< 20 dB) gain, and how alarming loud transients are. This in itself is an important demonstration because it makes family members aware of that aspect of hearing aid use. In other demonstrations with hearing aids you might show the effect of low- versus high-frequency gain, and acoustic feedback, which can be readily created by increasing high-frequency gain. The main demonstration to give with hearing aids, of course, is the benefit in speech reception when there is a substantial hearing loss.

Demonstrating Cochlear Implants

As mentioned earlier, if you want to simulate a unilateral cochlear implant with profound deafness, be aware that left and right simulations of hearing losses and prostheses are independent. The acoustic signal from the non-implant side will continue to be processed by the hearing loss and hearing aid (or Unaided) simulations. In order to simulate a monaural CI with bilateral profound hearing loss, it is necessary to use a maximal hearing loss on the non-implant side.

When demonstrating a CI the emphasis should be on the contrast between unaided and aided performance with a profound loss, NOT between aided performance and normal hearing. Listeners are struck by how bad the simulated CI sounds (compared to their normal hearing or listening with a hearing aid). But the important point of course is that the person with profound hearing loss hears essentially nothing, and that is the appropriate reference. Emphasize how much more information is conveyed by the simulated CI compared to unaided listening.

Allow the listener some time to get used to the sound of the CI simulation. It is very strange to new listeners and requires some learning, unlike listening with a hearing aid.

Miscellaneous Tips

A good general rule is to plan and prepare for the demonstration you want to give. Have the I-HeLPS headset connected, the program started, and Hearing and Prosthesis specifications entered before the listener arrives. It wastes time and detracts from the effectiveness of the demonstration if you have to make adjustments while switching among listening conditions.

Also, if you are demonstrating losses greater than about 70 dB you should provide the listener the opportunity to hear the masking noise briefly to determine if he or she would find the masking noise uncomfortably loud with extended listening.

TECHNICAL SUPPORT

If you need technical support, please visit the I-HeLPS website at www.sens.com/I-HeLPS and click on the Support link for help with known problems and for answers to Frequently Asked Questions (FAQs). If your problem is not addressed there, send a description of it by email to tech-support@sens.com.

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