HeLPS v2

HeLPS V2

Hearing Loss and Prosthesis Simulator

USER GUIDE

Sensimetrics Corporation
Malden, Massachusetts

Warranty

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

Technical Support

One year of free technical support for HeLPS is provided from the date of purchase. If you need technical support, please visit the HeLPS website www.sens.com/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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Acknowledgements

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Music Credits

"Eine Kleine Nachtmusik allegro" composed by Wolfgang A. Mozart,
    performed by the Advent Chamber Orchestra
"Hungarian Rhapsody No. 2" composed by Franz Liszt,
    performed by the National Military Band
"Polonaise in A Flat Major, Op. 53" composed by Frederic Chopin,
    performed by Paul Pitman
"Jingle Jazz" written and performed by Quantum Jazz
"Orbiting a Distant Planet" written and performed by Quantum Jazz

CONTENTS

INTRODUCTION

HeLPS – the Hearing Loss and Prosthesis Simulator – simulates the auditory communication difficulties associated with hearing loss along with the benefits provided by hearing aids and cochlear implants. HeLPS allows flexible demonstrations in several contexts: during hearing aid fitting; when counseling families of hearing-impaired and deaf persons; in hearing-conservation and public education programs; and in training audiologists and educators of the deaf.

HeLPS provides a graphic interface on your computer for controlling the simulation and listening to the simulator’s output. To allow the listener to use speechreading, HeLPS provides audio/visual stimuli with the audio component processed by the simulator. Hearing and prosthesis characteristics are specified separately for the left and right sides, with convenient controls for selecting loss and prosthesis settings, talkers, signals, and background noise.

After Installation and Setup, described in the next section, you can proceed to the Quick Start section to become familiar with the operation of HeLPS. Subsequent sections of this *User Guide* explain the simulation algorithms and use of the control interface.

SOFTWARE INSTALLATION AND AUDIO SETUP

Software Installation

Insert the HeLPS USB drive into a USB slot on your computer. Navigate to the top-level folder of that drive and double-click the file ‘setup.exe’ to launch the installer. Then follow the on-screen installation instructions.

After installation is complete, you can run HeLPS by clicking the icon that was installed on your desktop, or by going to the Windows Start Menu, then to All Programs, and selecting HeLPS.

Sound Level Calibration

Before using HeLPS a calibration must be performed to set the audio output level from your computer.

1) Connect headphones to your computer’s headphone jack. Because the headphones will be used by many people listening to the demonstrations, you should use circumaural headphones with cushions that can be easily cleaned.

2) Start HeLPS and you will see a reminder to calibrate. This calibration step should be performed each time you use HeLPS because settings can be changed between uses.

3) Click on Calibrate in the upper left of the interface window and an audio passage will start playing. Adjust the output volume controls on your computer so that the loudness of this passage heard over the headphones is equal to that experienced in a face-to-face conversation at a distance of 1 meter.

With earphones connected directly to your computer the only volume controls will be Windows' internal volume controls. These controls are accessed by right-clicking the small loudspeaker icon located in the taskbar on your desktop and selecting Open Volume Mixer (or by going to Control Panel > Hardware and Sound > Adjust System Volume). The Volume Mixer will show sliders for the components on your system that produce sound. Find the ones that control the sound that is playing and adjust them to achieve the criterion loudness. It is important that, once the sound level calibration is done, the volume controls remain fixed while you are using HeLPS.

WARNING!

HeLPS is capable of delivering sound levels up to 100 dB SPL. Be careful when conducting demonstrations, especially with simulated hearing aids, to avoid sounds being uncomfortably loud for the listener.

Fortunately, the accuracy of HeLPS simulations is not sensitive to the output level, making this loudness-based calibration adequate. The more important calibration is at the input to the simulation because it is the level of the input signals relative to the elevated thresholds that primarily determines the audibility of signals and the intelligibility of speech. Small errors in output level affect loudness, which is important when estimating the annoyance of amplified sounds, but less important when estimating intelligibility.

If you are presenting the simulation output via loudspeakers (which is appropriate for some types of demonstrations), the same type of calibration must be performed and maintained. For more information on using loudspeakers with HeLPS, see "Loudspeaker Presentation" in the "Demonstration Tips" section in this *User Guide.*

QUICK START

You can start using HeLPS immediately after it has been installed. When you start the program you will see the HeLPS interface as shown below. 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*.

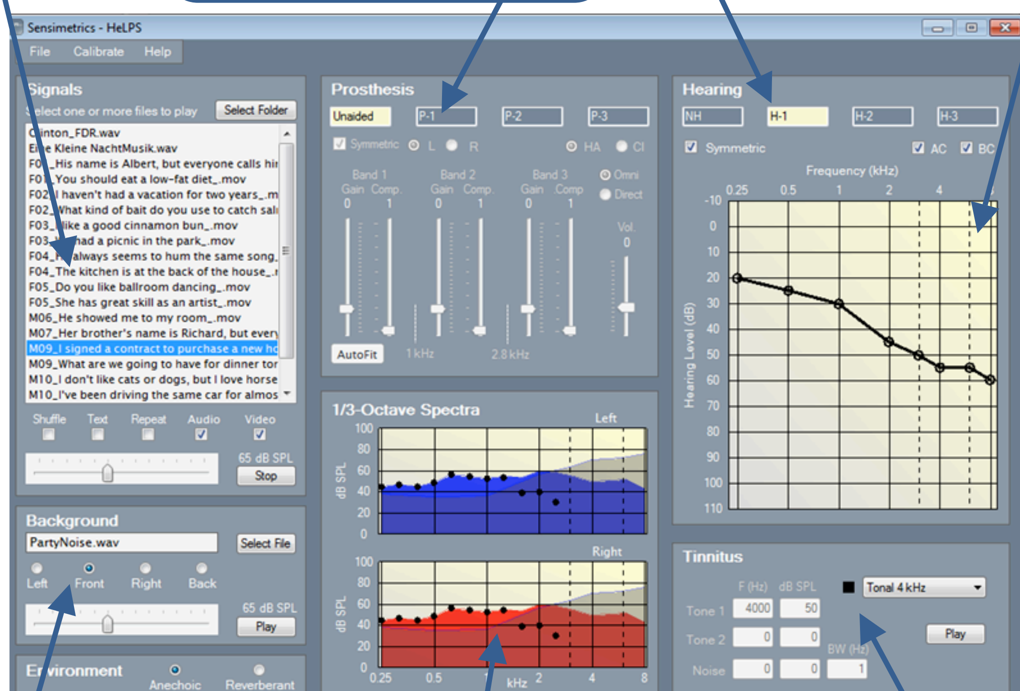
Videos are shown in a separate window.

Click one of these four buttons to select a Hearing specification. NH is Normal Hearing and cannot be adjusted. The other three allow adjustments to Left and Right thresholds and tinnitus.

Select one or more signals.

Click one of these four buttons to select a Prosthesis specification. Unaided cannot be adjusted. The other three allow adjustments to Left and Right Prostheses.

Click in the audiogram to adjust thresholds for the selected Hearing specification. Left-Right symmetric thresholds are shown with a black curve.

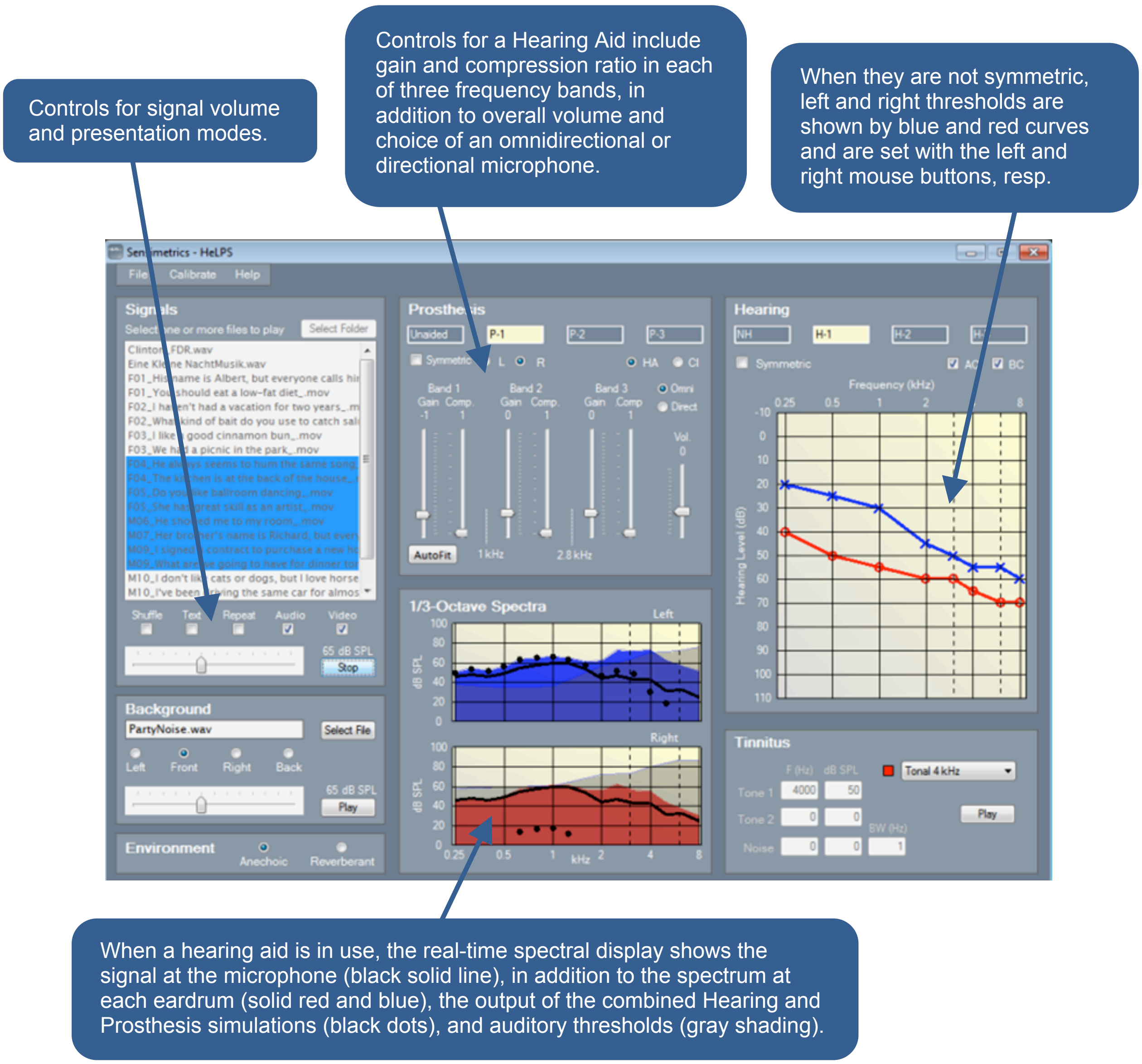


Select background interference and control its volume and direction of arrival.

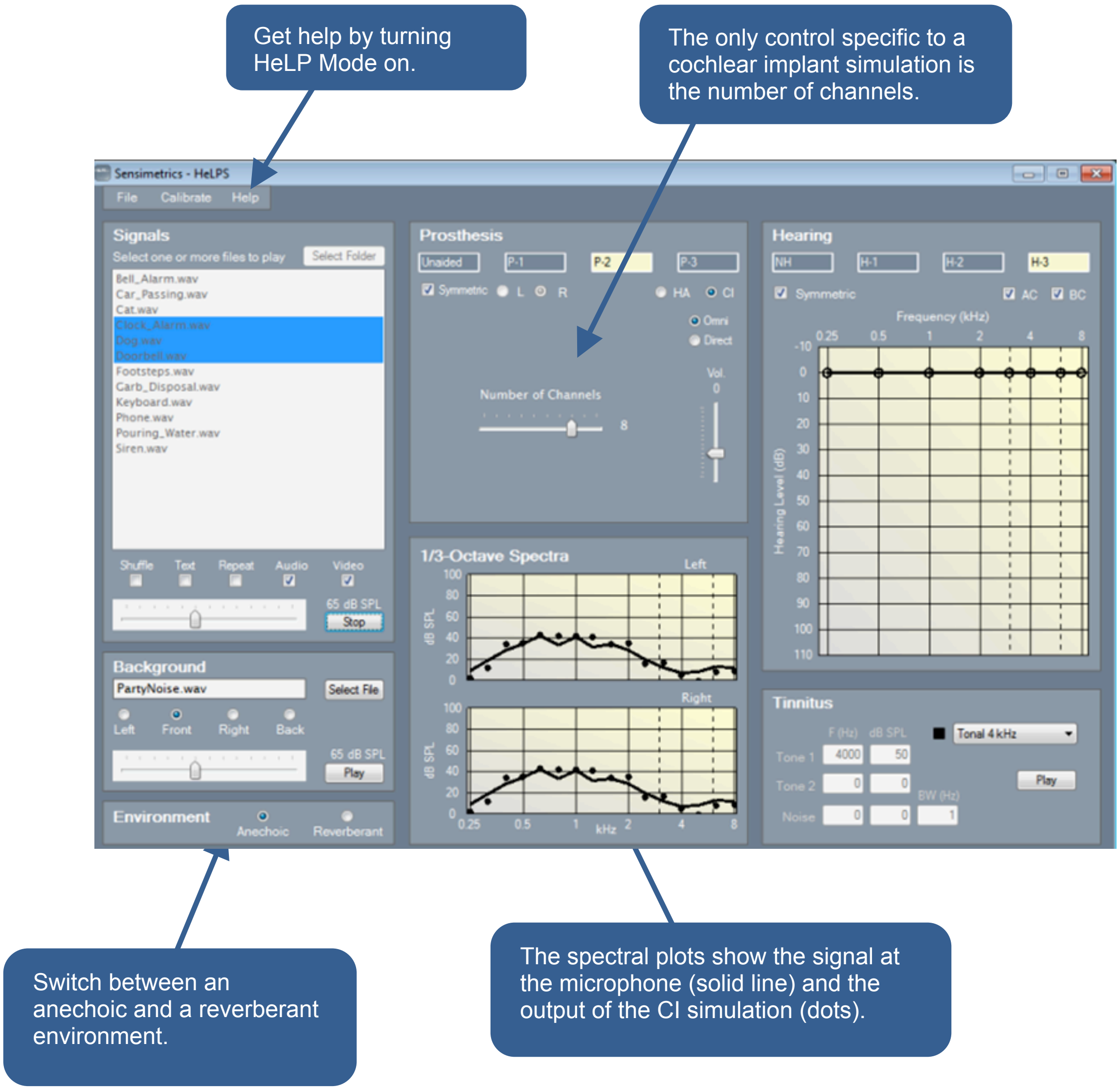
The real-time spectral display shows: the spectrum at each eardrum (solid red and blue), the output of the combined Hearing and Prosthesis simulations (black dots), and auditory thresholds (gray shading).

Select or synthesize tinnitus.

The next example shows Hearing Specification H-2 selected. It has asymmetric losses and no tinnitus. An asymmetric hearing aid has been specified.



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

A hearing specification comprises the air-conduction (AC) and bone-conduction (BC) thresholds for the left (L) and right (R) ears plus L and R tinnitus. 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.

Hearing Loss

Thresholds 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.

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 thresholds are entered by using the left mouse button, and are plotted in blue, and R thresholds, plotted in red, are entered with the right mouse button.

The checkboxes labeled AC and BC determine which type of threshold will be adjusted. If both AC and BC are selected then adjustments in the audiogram will result in equal AC and BC thresholds. AC thresholds are plotted with solid lines with symbols, while BC thresholds are plotted with dashed lines with no symbols.

The AC and BC thresholds that are entered in a hearing specification determine the conductive and recruiting components, H_C and H_R, respectively, of the total hearing loss, HL, as described below (in "The HeLPS Hearing Loss Simulation Algorithm"). In the HeLPS simulation, these hearing loss components are related to the audiometric measurements by

$$H_R = BC,$$
$$H_C = AC – BC \text{ (aka ‘air-bone gap’)},$$

and

$$HL = H_C + H_R = AC.$$

The interface enforces the constraint that, at each frequency, the BC threshold cannot be larger than the AC threshold (BC ≤ AC). If you try to make a BC threshold larger than the AC threshold, the interface will automatically change the AC threshold to be equal to the adjusted BC threshold.

Tinnitus

You can simulate tinnitus independently on both sides. Some common types of tinnitus have been synthesized and are available as pre-sets. You can also, by selecting <custom> in the drop-down list, create a new tinnitus by specifying parameters for two 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 (F), bandwidth (BW), and overall level (dB SPL). The simulated tinnitus is formed by summing the tones and noise. The maximum allowed level for any of the three components is 80 dB SPL. If the hearing specification is symmetric any tinnitus will be delivered identically on the two sides. If the hearing specification is not symmetric, then the side for which tinnitus is specified is determined by the side last clicked in the audiogram.

The HeLPS Hearing Loss Simulation Algorithm

The HeLPS simulation algorithm uses a model of hearing loss that allows simulation of two types of loss – conductive and recruiting. Consider first conductive hearing loss, which is modeled as a fixed frequency-dependent attenuation of the input signal. The degree of conductive threshold shift in a frequency band is denoted as H_C.

Figure 1 shows the simulation of an example conductive loss in the form of an input/output (I/O) plot. In this plot the input quantity, plotted on the abscissa, is the sound level in a given frequency band at the listener's eardrum with no simulation or device in place (i.e., open ear). The output, plotted on the ordinate, is the level of the sound at the listener's eardrum contributed by the hearing loss simulation. The dotted line labeled *out=in* represents normal hearing. Note that these I/O plots give sound levels relative to the normal absolute threshold for the band. On average, therefore, sounds that exceed an output level of 0 dB will be heard by a normal-hearing listener and those below 0 dB will not be heard.

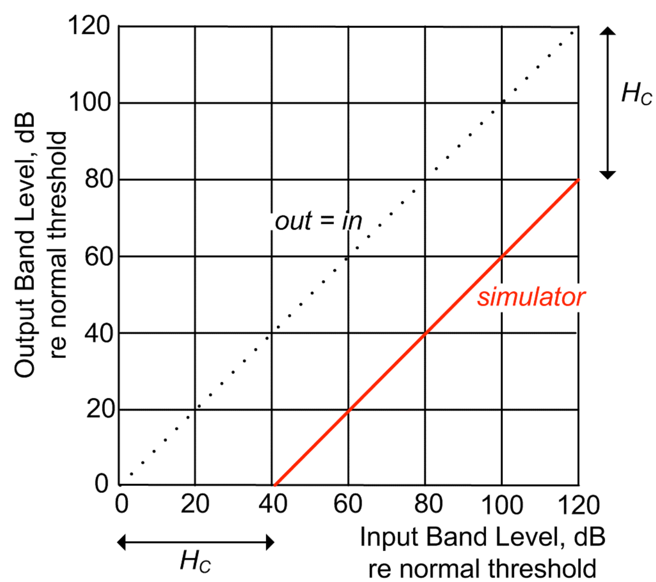


Figure 1. Example I/O plot for one simulator band showing a conductive hearing loss of H_C = 40 dB.

Because a conductive loss is modeled as a fixed attenuation, a 40 dB conductive loss results in the simulator output level simply being 40 dB lower than the input level. Simulator output sounds begin to be audible (i.e., exceed 0 dB output level) when the input reaches 40 dB, with the output level continuing to increase 1 dB per 1 dB increase in input level above threshold.

Now consider recruiting hearing loss, which is the second type of hearing loss allowed in the simulation algorithm. A recruiting loss of H_R dB is modeled as a threshold shift with a rapid rise in output level as signal level increases over some *recruitment range r* above threshold, until *full recruitment* is reached. At that point, output level increases 1 dB per 1 dB increase in input level.

Figure 2 shows the I/O plot for a recruiting loss of 70 dB (H_C = 0, H_R = 70). For this type of loss the simulator output level is less than 0 dB for input signal levels below the specified threshold-relative input level of 70 dB. As the input level increases above 70 dB, the simulator output level rises rapidly over the recruitment range of *r* = 20 dB in this example. Because there is no conductive loss, the output level at and above the point of full recruitment is equal to the input level (*out=in*).

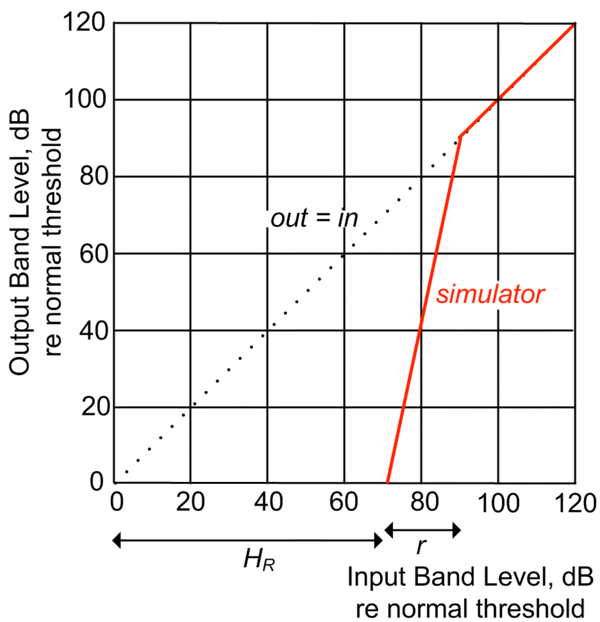


Figure 2. An example I/O plot for one simulator band showing a recruiting hearing loss H_R = 70 dB with a recruitment range *r* = 20 dB.

What happens with a mixed loss? Figure 3 shows the simulator I/O plot for a hearing loss with a conductive component of 20 dB and a recruiting loss of 50 dB (H_C = 20, H_R = 50). In this case the simulator output still begins to exceed 0 dB when the input level reaches the total hearing loss (HL= H_C +H_R) of 70 dB. The output still has a recruitment range of 20 dB, but now, because of the conductive component, the simulator output in the full-recruitment region remains 20 dB below the input level.

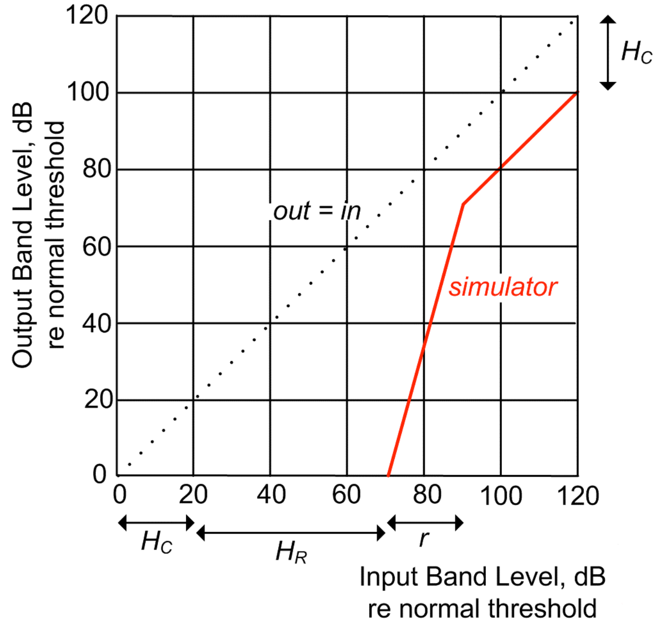


Figure 3. An example I/O plot for one simulator band showing a mixed hearing loss with H_C = 20 dB and H_R = 50 dB, with a recruitment range *r* = 20 dB.

The signal processing required to achieve the simulator I/O characteristics just described is relatively straightforward. The processing for one side is shown in Figure 4. The input signal is first filtered into bands. The sound level of each bandpass signal is then estimated over a short time interval, and this estimate is used to control the gain, *g*, of an attenuator through which the filtered signal passes. This automatic gain control (AGC) is varied to achieve the desired I/O characteristic for that band, as shown in the examples above. In terms of the I/O plot, the attenuation needed as a function of input level is given by the vertical distance between the simulator output characteristic and the *out=in* line. For recruiting hearing losses, this distance is a function of the running estimate of input level; more attenuation is applied to lower sound levels than to higher sound levels. Processing in different frequency bands has the same form, but uses different parameters for the AGC.

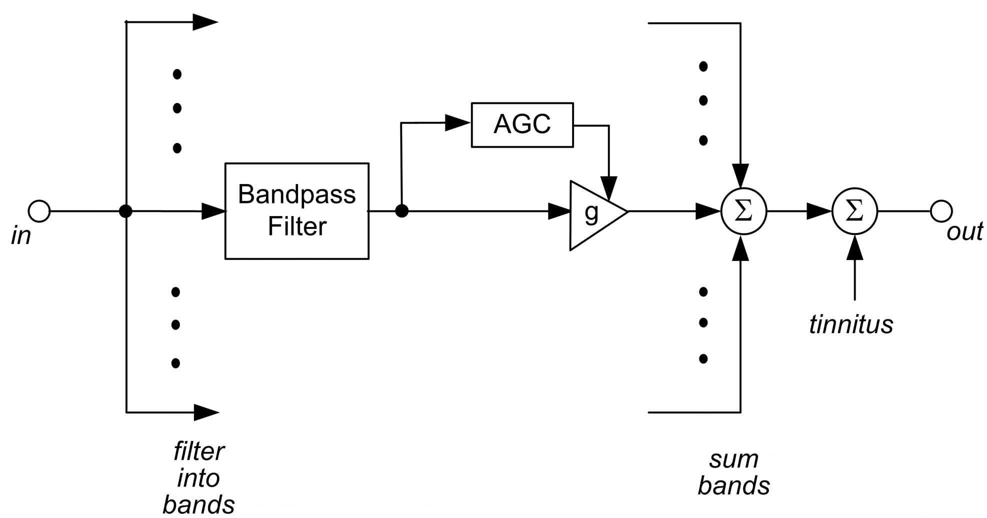


Figure 4. Block diagram showing the simulator signal processing for one side.

The use of AGC to simulate recruiting hearing loss was first described by Villchur (1977) and later studied by Duchnowski and Zurek (1995) and Lum and Braida (2000). Those studies have shown reasonably good agreement of scores on psychophysical and speech-reception tests between listeners with actual hearing losses and listeners with simulated losses matched to the actual losses. The validity of a hearing loss simulation that incorporates only threshold shift and recruitment is supported by numerous other studies that have used noise-masking simulations of hearing loss, which achieve audibility restrictions like those obtained with AGC (Zurek and Delhorne, 1987; Humes et al., 1987; Dubno and Dirks, 1993).

I/O plots characterize the steady-state response of the simulator. However, because the input level must be estimated over some short time interval, there will be system transient responses to changes in level. In HeLPS, the input level estimate is obtained by forming a running average of the square of the bandpass-filtered input signal, with a time constant of 14 msec. This degree of temporal resolution was chosen as a trade-off that minimizes the effects of audible distortion (with a shorter time constant) and sluggish response (with a longer time constant).

Although only one side of the HeLPS hearing loss simulator has been discussed here, the simulation is bilateral, with independent operation on the left and right sides.

Simulated tinnitus is added to the output of the hearing-loss simulation. If tonal tinnitus is specified for the two sides at the same frequency, however, those tones will be coherent. Noise tinnitus is uncorrelated between sides.

Simulation Limitations

There are several limitations to the HeLPS simulations that should be understood in order to make valid and effective use of the system.

Ambient Sounds. Because typical headphones provide little sound attenuation, the listener will be able to hear ambient sounds easily, which is of course inconsistent with the demonstration of hearing loss. To achieve maximal impact, demonstrations should be given in quiet places.

Suprathreshold and/or Central Deficits. The hearing loss simulation implemented by 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. Currently, the factors that underlie such poorer performance are not sufficiently understood to be simulated. The HeLPS hearing loss simulation also does not account for cognitive or central deficits that might lead to poorer performance than can be achieved by a young person with normal hearing listening to the simulation.

SIMULATED PROSTHESIS SPECIFICATION

HeLPS provides simulations of hearing aids (HAs) and cochlear implants (CIs), in addition to unaided listening. A prosthesis specification comprises all relevant information about the prostheses for the two ears. 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

With an Unaided specification the input signal is passed through a 'transparent' hearing aid – one that has 0-dB gain and no compression.

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.

In addition, there is a choice between an omnidirectional and a directional microphone for each side.

These controls are explained with the help of the block diagram of hearing aid processing shown in Figure 5. The microphone of a HeLPS hearing aid can be either omnidirectional or directional. Either type of microphone is simulated with sensing points on a rigid-sphere model of the head. The directional microphone response in free space has the cardioid polar response pattern shown in the inset. Directional microphone processing includes compensation to make the on-axis (0^o) frequency response the same for omnidirectional and directional microphones.

The signal from the 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 caused by insertion of a hearing aid.

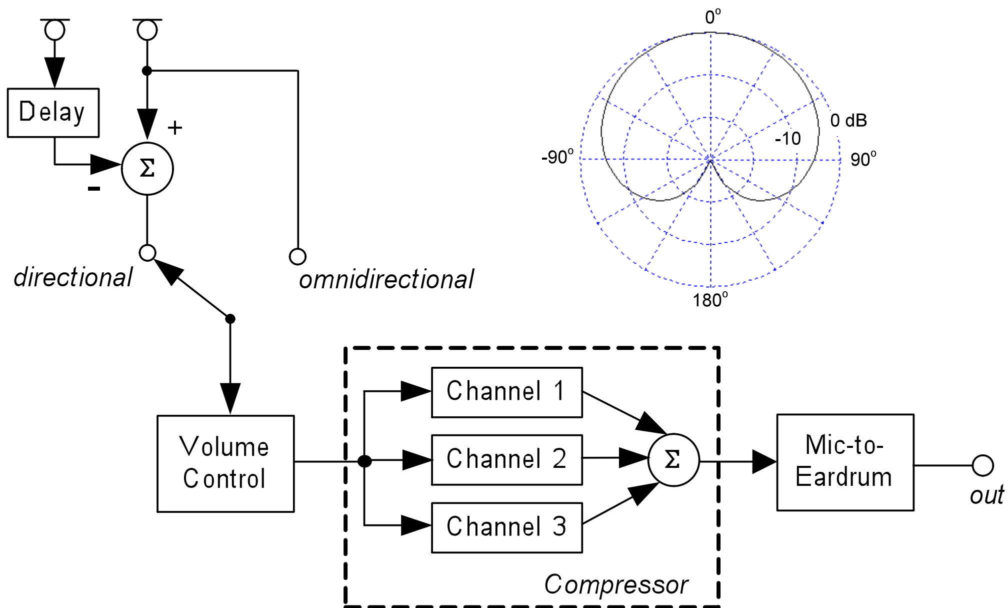


Figure 5. Block diagram of the prototype hearing aid implemented by HeLPS. The inset shows the polar response of the directional microphone.

The I/O characteristic within each compressor band is controlled by the Gain and Compression Ratio sliders in the HeLPS interface. The procedure is illustrated in Figure 6 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 (dB/dB), 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.

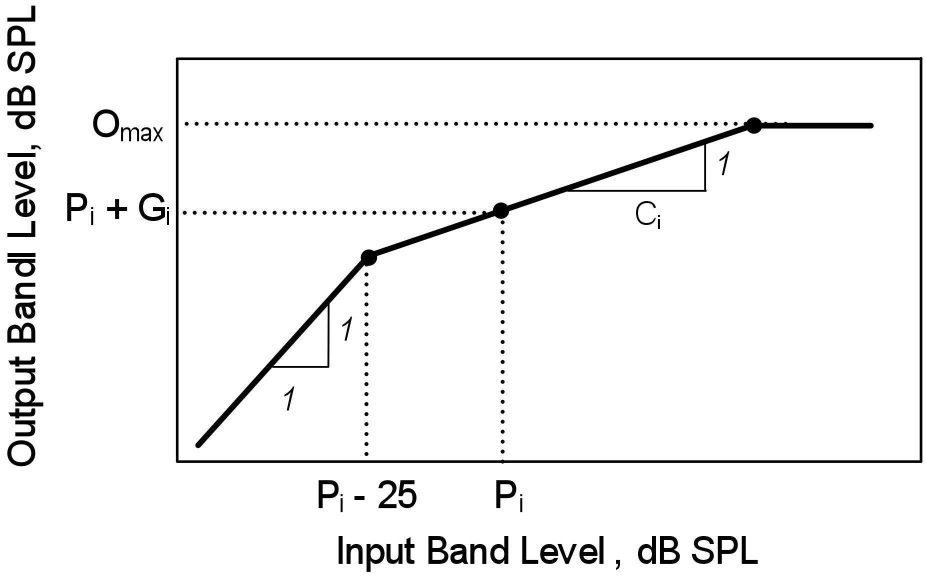


Figure 6. Example I/O characteristic for one channel of a compression hearing aid.

AutoFit. Fitting a hearing aid to a specific hearing loss can be time consuming. In order to reduce that time for you, 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 that you will likely need to adjust further to achieve an acceptable response.

Simulation Limitations. An important difference between real hearing aids and HeLPS hearing aids is that there is no feedback in HeLPS aids. Consequently, there is no limit to the maximum gain that can be provided by a simulated aid. With actual hearing aids a point of instability will be reached as gain is increased.

Cochlear Implant

The HeLPS cochlear implant simulation is shown in Figure 7. The pre-processing is the same as for hearing aids: selection of an omnidirectional or a directional microphone and volume control. The number of channels, N, in the simulation is an important parameter. Specifying N results in the audio band from 0.1 – 9 kHz being separated into N channels of equal width in octaves. The number of channels can be varied to adjust the quality of the signal representation and the resulting psychoacoustic performance, with a larger number of channels leading to better performance.

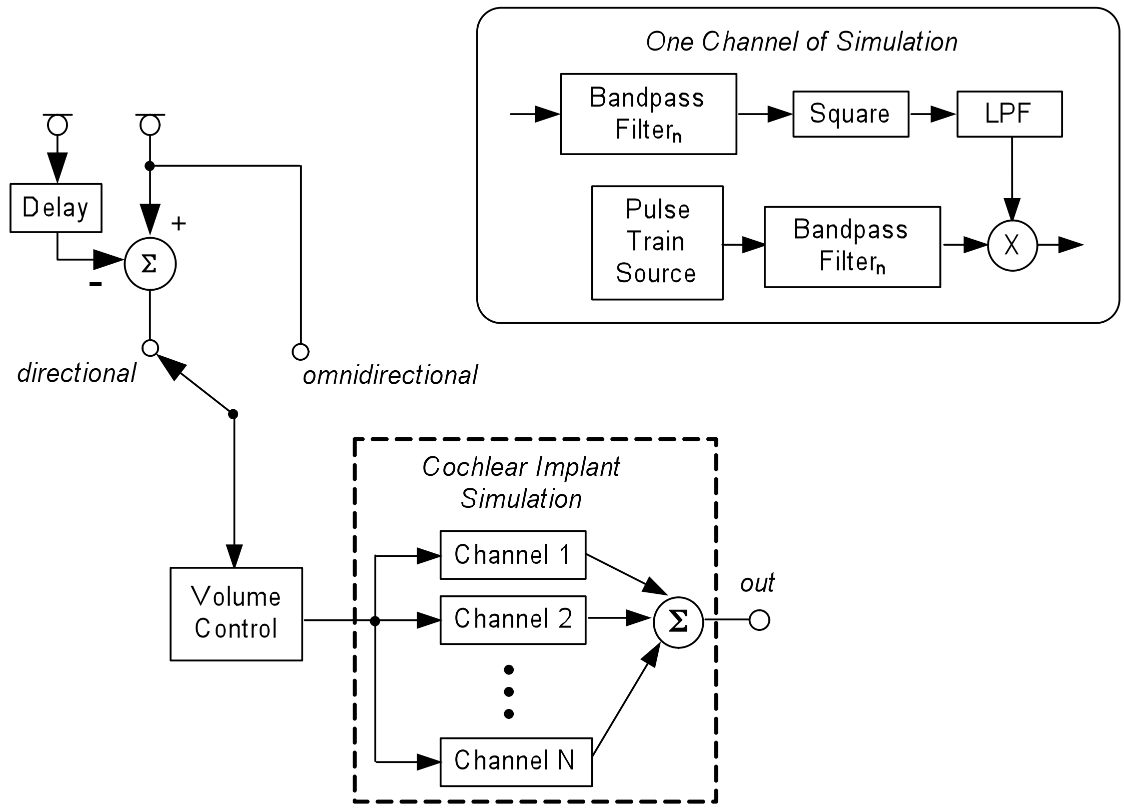


Figure 7. Block diagram of the prototype cochlear implant simulation. The processing performed within any one channel of the implant simulation is shown in the inset.

It is important to note that the number of channels in the CI simulation is not simply related to the number of channels or electrodes in an actual implant. The number of simulation channels only provides a means of controlling spectral resolution and, thereby, psychoacoustic performance, and should not be taken as a literal equivalent to the number of channels in an actual implant.

The processing performed within any channel of the cochlear implant simulation is shown in the inset of Figure 7. This simulation processing is similar to that described in the literature (e.g., Friesen et al., 2001) in which the envelopes of bandpass filtered signals modulate either noise band or tone carriers. A pulse train carrier is used in HeLPS because it provide a closer approximation to the constant-rate pulse trains used in actual implants than does a noise or tone carrier.

Simulation Limitations. Simulating a cochlear implant for a normal-hearing person is more complicated than simulating acoustic stimulation with hearing aids. A person who uses a cochlear implant typically has a hearing loss that is severe-to-profound or profound. Yet this very large hearing loss, which is most often due to hair cell damage or loss, is circumvented with direct electrical stimulation of the auditory nerve. The loss of information along the pathway from acoustic signal, through the implant, to representation in the central auditory system is still poorly understood. The unexplained variability in performance of implantees on psychoacoustic and speech-recognition tasks (e.g., Munson, et al., 2003), and the difficulty in predicting implanted performance from pre-implantation measures, reflect this basic ignorance.

The accuracy of current state-of-the-art cochlear implant simulations is correspondingly limited. Performance of listeners using the simulation is controlled only by varying the number of channels. Unlike the case of acoustic hearing, where threshold shifts provide a fairly accurate basis for simulating performance on speech-recognition and psychoacoustic tasks, there are no such clinical measurements that can be used to customize the simulation to a specific cochlear implant user.

The complexity of cochlear implants also requires an accommodation to the HeLPS simulation. Because cochlear implant users receive electrical stimulation that by-passes the acoustic path, it is impossible to simulate simultaneously their threshold shifts and the loudness of the stimulation they receive. If implantees' very large losses were simulated accurately, the audible stimulation that could be delivered acoustically would be very loud. Actual implantees, however, receive their electrical stimulation at levels that go down to their absolute detection thresholds, and so can be very soft.

The accommodation that has to be made for HeLPS simulation of cochlear implants is to disregard any hearing loss specified in the audiogram. 'Hearing' with a CI is treated as a special case, different from acoustic hearing. You will see that when a CI is selected, changes in specified thresholds have no effect and do not enter into the simulation of a CI.

INPUT SIGNALS

HeLPS operates on digital signals stored on your computer. There are two types of inputs – signals and backgrounds – and these have separate controls in the HeLPS interface. The distinction between them is that signals can be either audio-video or audio-only files and they are usually presented once (but can be repeated). Backgrounds, on the other hand, are audio-only files that are automatically looped (repeated) to present continuous background interference. Collections of signals and backgrounds suitable for demonstrations are provided in the HeLPS Media Library described below.

The signal processing implemented in HeLPS relies on a particular simulation model. Specifically, this model assumes that a single-channel input to the simulation was picked up by a free-field microphone at the center–head position of the listener with the listener absent. Signals are assumed to arrive from straight ahead of the listener, while backgrounds can arrive from any one of the four directions indicated on the interface controls: Left, Front, Right, and Back. The simulated acoustic environment can be either anechoic or reverberant. Appropriate transformations (free-field-to-microphone or free-field-to-eardrum) are applied to achieve left and right inputs.

A variant of this simulation model applies to stereo signals. If you use a two-channel signal or background, then those left and right signals are treated as the inputs to the simulation and the room- and head-related transformations are bypassed.

HeLPS Media Library

The HeLPS Media Library is a collection of audio-video (AV) and audio-only files that can be used for demonstrations. Some of those demonstrations are described in the "Demonstration Tips" section. Here we only describe the important features of the files.

All of the audio in the HeLPS Media Library are monaural signals that have been scaled so that when the output volume control has been calibrated correctly the delivered sound levels are consistent with the dB SPL scales in the interface. Sounds that, unlike conversational speech, have no typical sound level (e.g., a car passing) have been scaled to a natural loudness when played back at 65 dB SPL.

Audio-only files are in .wav format. AV files are in .mov format.

The contents of the HeLPS Media Library will be installed in a folder of the same name in the My Documents folder on your computer. You can move or copy these files to any other location on your computer, or re-organize them, as you like. As you become familiar with the content of the HeLPS Media Library you may want to select those sounds that you like to use for demonstrations and store them in one folder.

The HeLPS Media Library folder contains the following six subfolders.

1. Passages. These AV and audio-only passages, which range in duration from 13 seconds to almost 3 minutes, provide speech with a continuous context. Two of the passages are in Spanish.

2. AV Sentences. This is a collection of audio-visual recordings of talkers speaking simple sentences. The names of the files in this folder are all in the following form:

Xij_Text_.mov

where

X	is either "M" or "F" to indicate the talker is male or female;
ij	is a two-digit number identifying the talker;
Text	is the text of the sentence.

For example, one such sentence is: `M10_I don't like cats, but I love dogs_.mov`. The filenames have this format so that you can deliver the sentences with or without the text displayed at the bottom of the video window. The text can be shown by checking the Text box. Note that this behavior only applies to AV files with filenames in the exact format described above.

The sentences are spoken by 15 talkers who display a wide range of auditory and auditory-visual intelligibility. Talkers numbered 1-10 are adults and the five with numbers greater than 10 are children.

3. AV Viseme Contrasts. This is a small, specially-constructed corpus of AV recordings of isolated words. The files with similar names contain words that differ by a single distinctive visual cue, or viseme. This arrangement enables simple demonstrations of lipreading. For example, the words 'fat', 'pat', 'rat', and 'that' form one such set, with words that differ in their initial consonant. There are four files in this folder that have those four words in the text section of the filename (e.g., `F02_fat pat rat that_1.mov`). Unlike the AV Sentences, however, the content of this file is the word 'fat' only, spoken by female talker 2. The other words in this set are in files `F02_fat pat rat that_2.mov`, which contains 'pat', `F02_fat pat rat that_3.mov`, which has 'rat,' and `F02_fat pat rat that_4.mov`, which has 'that.'

A lipreading demonstration can be presented by first checking the Text box, so that the alternative words are displayed. Then inform the viewer that each of the next few presentations will be one of those words, and ask the viewer to guess which one after each is presented. In most cases the visual cues alone are sufficient to distinguish among the alternative words.

4. Backgrounds. These are several common interfering sounds (e.g., babble, traffic) that are intended for use as Backgrounds in the interface. They are all at least 15 seconds in length and can be looped to form a continuous background.

5. Environmental Sounds. This is a small collection of everyday non-speech sounds, such as those made by animals, vehicles, and household appliances.

6. Music. This folder contains a few samples of classical, jazz, and folk music as well as some instrumental solos.

Importing Signals

You can import both AV and audio-only signals as inputs to HeLPS. Video files must be in .mov format and audio-only files in .wav format. The audio component can be at any sample rate, but it will be re-sampled to 44.1 kHz for processing in HeLPS. Depending on whether your signal has one or two channels, it will be treated according to the monaural or stereo processing models, respectively, as described above. In order to be consistent with the HeLPS processing assumptions and the on-screen scales of dB SPL, the audio components should be scaled to an RMS of -35 dB re full scale.

SPECTRAL DISPLAYS

Real-time spectral displays show important signals in the simulator. These Left and Right displays show:

black line – the third-octave spectrum of the signal at the microphone of a prosthesis.

red/blue – the third-octave spectrum of the signal at the eardrum.

black dots – the third-octave spectrum of the output of the simulation.

dark shading – absolute threshold for third-octave sounds.

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

If the Prosthesis is:

Hearing Aid - all four variables are shown. The difference between the eardrum signal (red or blue) and the signal at the microphone (solid black curve) reflects the effective insertion gain of the aid. The simulation output reflects both the hearing aid gain and the HL simulation processing.

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

Unaided - the black line is not shown because there is no simulated microphone.

SAVING AND LOADING SPECIFICATIONS

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 HeLPS simulations. But making those demonstrations meaningful so that listeners 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 direct experience, the communication difficulties faced by their family member.

A good general rule is to plan and prepare for the demonstration you want to give. It wastes time and detracts from the effectiveness of the demonstration if you have to make adjustments while switching among listening conditions. So, in preparation for a demonstration:

- connect the headphones to your computer's audio jack
- start HeLPS
- check audio level calibration
- enter or load the Hearing and Prosthesis specifications for the upcoming demo
- have the Signal and Background stimuli ready for easy access
- listen to the demos of these conditions yourself so that you know what the listener will be hearing, which can help prepare you for their reactions.

When introducing the simulation to the family member of a hearing-impaired patient, you may want to point out that, because perceptions are private, we cannot know what an actual hearing loss 'sounds like.' But note also that HeLPS provides a good simulation of the limitations on functional ability resulting from the hearing loss.

In a typical demonstration you will use the speech videos provided in the HeLPS Media Library. When the listener has the headphones on and is ready to listen, start first by presenting a few sentences with normal hearing and no prosthesis. These will familiarize the listener with the sentences, and you can confirm with the listener that they sound natural. Then, with sentences continuing to play, switch to the family member's hearing loss. Let the listener hear a few sentences in that condition, switch back to normal hearing for one or two sentences, then back to hearing loss. The listener's ability to understand the speech with simulated hearing loss will, or course, be directly related to the severity of the loss. From your preview you will know approximately how well the speech can be understood with simulated loss and will be prepared to summarize the patient's disability.

What you demonstrate next will depend on many factors, including the severity of the loss, the patient's age, and the family member's reaction to the demonstration. The following are the most common demonstrations that can be given after the initial demonstration of hearing loss.

Lipreading

You can demonstrate the benefits of lipreading easily with HeLPS. Simply play a list of sentence videos while the simulated hearing loss is in effect. Use the Video switch in th Signals Control panel to turn the video on and off. Ideally, there would be a noticeable improvement with visual cues. But achieving a clear demonstration of lipreading benefit can be difficult for a couple reasons. First, if listening with hearing loss to audio-only stimuli is either too easy or too difficult, then the addition of visual cues may not result in a noticeable improvement. Performance while listening to audio-only needs to be 'on the edge' to get the clearest improvement from the addition of lipreading. Second, people often have difficulty extracting visual cues from long passages. For this reason, HeLPS provides sets of isolated monosyllabic words that differ within a set by one phoneme (the AV Viseme Contrasts in the HeLPS Media Library). An example of one such set is "chat", "hat", and "sat". You can present those words audio-only first and ask the listener which word was spoken. If there is substantial high-frequency hearing loss it should be difficult to distinguish them. Then present them with visual cues and the distinctiveness of the different lip positions for the initial consonants should make the task very easy.

Hearing Aids

The 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 sounds are even with modest (< 20 dB) gain, and how alarming loud transients are. These in themselves are important demonstrations because they make family members aware of those aspects of hearing aid use. In other demonstrations with hearing aids you might show the effect of varying the gain in the three frequency bands, and the effect of switching between an omnidirectional and a directional microphone.

The main demonstration to give with hearing aids, of course, is the benefit to speech reception when there is a substantial hearing loss. To do this, start a list of sentences playing, select the patient's hearing loss under Hearing, and switch between the hearing aid and Unaided Prosthesis specifications.

Background Noise

People with hearing loss often have great difficulty understanding conversations in noisy settings, even with a hearing aid. To demonstrate to a normal-hearing family member, first get the hearing loss entered and set the signal and background levels so that with normal hearing you can understand about half of the words spoken. The talkers in the AV Sentences corpus vary in their intelligibility and so the signal-to-background ratio needed to achieve 50% words will also vary. (With talker F01, for example, setting the signal and background at 65 and 70 dB SPL, respectively result in about 50% words). Present this signal-plus-background to the listener, first with normal hearing and then with the hearing loss.

Non-Speech Sounds

Hearing loss affects the audibility of all sounds, of course, not only speech. To demonstrate the effect of the patient's hearing loss on non-speech sounds, select some of the environmental sounds and music selections that are provided in the HeLPS Media Library. Present these sounds with and without hearing loss first to demonstrate what is not being heard by the patient. Then add a hearing aid, and contrast this to unaided normal hearing to show that it is difficult for a hearing aid to restore natural sound quality.

Tinnitus

Tinnitus can be demonstrated at any time with any degree of loss and with any hearing aid; tinnitus cannot be simulated with a cochlear implant. The pre-set simulations are some of the more commonly-reported tinnitus sounds. If you have information on the tinnitus characteristics you wish to simulate then you can use that to customize tinnitus by selection of tone and noise parameters. A single tone is associated with what would be called a steady tinnitus, while two tones or a narrowband 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. Even so, many people find tinnitus simulation discomforting; be prepared to stop it after a short time.

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 is that a person with profound hearing loss hears essentially nothing, so unaided silence 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.

There are several demonstrations with CI listening that are instructive. The benefit of lipreading can usually be demonstrated clearly with a simulated CI. In addition, the strongly degrading effect of background noise on speech understanding should be demonstrated. With the most favorable setting of 10 channels, listeners should be able to understand simple speech fairly well. But the addition of noise at 0 dB speech-to-noise ratio will render the speech completely unintelligible – even though it is still quite understandable with a moderate or severe hearing loss. Another characteristic of CI listening is the loss of musical pitch (as well as voice pitch in speech). Present some music samples to demonstrate that only the strongest rhythm of music, with no sensation of melody, will be conveyed through the CI simulation.

Other points that you may want to make:

• *The 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 approximation of what an implant "sounds like."

• *The number of channels in the 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.

Loudspeaker Presentation

When there is more than one person who is to listen to a demonstration, it would be efficient to deliver the simulator output to all of them in parallel rather than have them listen sequentially with one set of headphones. One way to achieve simultaneous listening is to use multiple sets of headphones connected in parallel. Audio adapters that enable connection of multiple headsets to one audio output jack can be obtained from consumer electronics outlets. Assuming that your audio system is capable of driving the desired number of headsets, and assuming that the headsets are all the same model as those supplied with HeLPS, the only other consideration is that all of the listeners have a good view of the video display, if there is one.

Another solution for multiple listeners is to deliver the output signals from loudspeakers. This approach has several limitations, however, that arise because the left and right simulator outputs are designed to be delivered to left and right calibrated earphones. Delivering them instead to loudspeakers can be done if the loudspeakers are set up and calibrated properly and then used with an understanding of the limitations. Follow these steps if using loudspeakers.

1) Position the two loudspeakers to either side of, and equally displaced from, the video display (if any). The angle from straight-ahead of the listener to either loudspeaker should be between 30^{o} and 60^{o}, and equal for the two loudspeakers. Try to keep the distance from the loudspeakers to the listener's location as short as practically possible (within about one meter) in order to minimize effects of room reverberation.

2) After the loudspeakers are positioned, perform a calibration like that described in the Software Installation and Audio Setup section of this *User Guide*. Play the calibration phrase from the loudspeakers and adjust the volume to achieve the criterion loudness.

3) When giving demonstrations with loudspeakers, keep in mind that the simulation will be invalid for any condition in which separation of the signals to the two ears is critical. For example, it would make no sense to attempt to simulate a highly-asymmetric hearing loss using loudspeakers because the signal intended for the better ear will be delivered also to the poorer ear, and vice versa. Likewise, a large hearing aid gain on one side will result in that amplified signal reaching both ears when using loudspeakers. These constraints result in the simple rule: *When using loudspeakers, only simulate hearing losses and prostheses that are left-right symmetric.*

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