COMMUNICATING THE SAME MESSAGE WITH DIFFERENT MEDIA: AN EXAMPLE FROM HEARING LOSS PREVENTION

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ABSTRACT

Multiple versions of an educational message can reach a diverse population more effectively than a single version. For instance, some workers are trained in formal classrooms while others are self-taught. The National Institute for Occupational Safety and Health has developed multiple versions of a hearing loss simulator (an interactive software package, a Web-based module, and an electronic slide show) to show how a single set of information can be readily adapted to different delivery methods. The three versions of the simulator were developed with a minimum of effort and expense compared to a single, less-flexible version. The interactive software is best for training sessions led by a hearing conservation professional, the Web pages are best suited for an individual worker, and the slide show is best for a small, more-generalized, training class. This paper will describe additional advantages and disadvantages of different delivery systems and will show what considerations are helpful in designing content that can be readily adapted to alternate presentations.

WHY IS A HEARING LOSS SIMULATOR IMPORTANT?

Although noise-induced hearing loss is the most common occupational disease (National Center of Health Statistics [NCHS], 1993), most people don't adequately protect themselves from harmful noise (Berger et al., 1996). Changing behaviors to increase hearing conservation has turned out to be especially challenging for a variety of reasons. In some cases, workers may not know how to protect their hearing. In other cases, obstacles may prevent them from taking action. Often, the obstacles are obvious—hearing protectors are not available, noise control solutions are expensive or otherwise impractical, or the worker has little control over reducing noise.

A more subtle obstacle is lack of motivation to take preventive action. Clearly, nobody wants to have poor hearing. However, the threat of a potential hearing loss sometime in the distant future may not be enough motivation for action in the present, especially with all the other events vying for a busy worker's attention. Another problem is that because noise-induced hearing loss is usually gradual and workers don't experience the same kind of physical pain associated with other types of workplace hazards, they don't realize that hearing nerves can be permanently damaged by excessive sound levels.

To add to all of the preventative challenges, there are also a number of myths about hearing loss.

Myth: I can build up a resistance to noise—my ears will eventually get "toughened up" so they won't get hurt.

In fact: *There is no way to build a resistance to noise. Excess noise damages the cells and nerves of the ear and these cells and nerves cannot be repaired or replaced. Continued exposure results in continued damage, not "toughening."*

Myth: Noise can't hurt me unless it's painfully loud.

In fact: *Noise becomes potentially hazardous around 85 dBA*[4] *and only begins to cause pain at much louder levels around 140 dBA. In between is a large range of dangerous noise levels.*

Myth: I can duck in and out of a noisy place before it can affect my ears.

In fact: *Noise that is loud enough can damage the ears instantly. Also, many short exposures can add up and cause damage similar to continuous exposure.*

Myth: My hearing will probably come back after I stay away from noise for awhile.

In fact: *Your hearing will never come back once the ear is permanently damaged.*

Myth: Even if I lose some hearing, I can get hearing aids—they will restore my hearing just like my eyeglasses work for my eyes.

In fact: *Hearing aids don't work as well as glasses. At best, hearing aids will restore some ability to understand conversation and experience the sounds around you, but they don't sound "normal."*

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[4]"A significant risk to miners of material impairment of health from workplace exposure to noise over a working lifetime exists when miners' exposure exceeds an 8-hour time-weighted average (TWA_8) of 85 dBA." Mine Safety and Health Administration. Health Standards for Occupational Noise Exposure. *Federal Register*, vol. 64 no. 176, p. 49548, 9/13/1999.

All these myths reflect a misunderstanding of the mechanisms of hearing loss. In particular, they ignore the painless,cumulative damage that occurs to the sensory cells in the inner ear. They also ignore the irreversibility of hearing nerve damage.

Before these myths can be debunked and workers can be receptive to taking action to protect their hearing, they must understand the nature of a noise-induced hearing loss. Unfortunately, it is difficult to describe such a subjective sensory experience, just as it is difficult to describe the concept of "pink" to a blind person. Rather than attempting to *tell* workers that their hearing will become "dull" and that they will have difficulty hearing high-pitched voices or understanding conversation over background noise, safety trainers need to take a more direct approach by having workers experience hearing loss first-hand. Since it would be clearly unethical to have workers experience a true permanent hearing loss, or even a temporary threshold shift, a simulation is a realistic alternative.

The hearing loss simulator developed by the National Institute for Occupational Safety and Health (NIOSH) uses an established standard method of estimating the effects of noise exposure. The specific formula is taken from an American National Standard Institute (ANSI) document entitled "Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment" (ANSI S3.44-1996 [R2001]). This standard is based on a number of studies that report actual hearing levels in individuals who had a wide range of exposures to noise, including a population that was carefully screened to have had no noise exposure at all. By including nonexposed individuals, changes in hearing due to aging (known as "presbycusis") can also be predicted and separated out from noise-induced changes.

Other researchers have used different populations and mathematical techniques to arrive at slightly different ways to calculate the risk of noise-induced hearing loss (see Prince et al., 1997, for a discussion of the issue and of an alternative technique based on a NIOSH survey). There is also a great deal of variability in individual susceptibility to noise-induced hearing loss. However, there is no real dispute over the basic relationship: Greater noise exposures over longer time periods result in more hearing loss.

USING THE SIMULATOR FOR EFFECTIVE TRAINING

Two primary goals drove the development of the simulator. The first goal was to make the results of excessive noise exposure as obvious as possible, and the second goal was to make the simulation as widely available as possible.

The first goal was easy. Hearing loss simulation is an established training technique that was already available in two basic forms, either "canned" recordings or specific demonstrations produced with specialized audio equipment. A typical recorded simulation would be an educational CD or audiotape that contains recordings of the sounds that both normal and hearing-impaired people would hear. The impaired tracks have been processed through filters to selectively reduce the frequencies most affected by noise exposure (typically in the range of 3000 to 6000 Hz). On some tracks, the loss is gradually "dialed in" so the trainee can hear the affected frequencies fade away little by little. On other tracks, the transition is abrupt, which serves to make changes immediately evident. Interaction with the simulation is limited to replaying the recordings and skipping back and forth between the normal and impaired sounds. Depending on the playback device in use, this may be cumbersome.

A more interactive simulator is available as an audio instrument. These instruments are sophisticated electronic machines designed for use in audiological clinics, and they allow a clinician to control both the nature of the sounds (speech, background, etc.) and the type of impairments (high- versus low-frequency loss, etc.). The main drawbacks of these devices are their high cost and complexity so that a physician or audiologist is required to operate them. Because of these limitations, only a very small percentage of workers who may be at risk of noise induced hearing loss have the opportunity to experience a simulation.

Therefore, wide dissemination became the most important remaining goal for an improved hearing loss simulator. Now that virtually all workers have access to a personal computer either at home, in a training facility, or at a local library, computer "interaction" became the primary focus for an inexpensive interactive simulator. NIOSH funded development work by Michael and Associates, Inc., State College, PA, to create a software version of the hearing loss simulator. Commercially available sound software libraries made this objective feasible at very low development costs, while the sophisticated sound capabilities of even the most modest computers made it possible to incorporate a large number of features.

The full software package is an extremely flexible interactive training tool; however, its flexibility could become a liability in some training situations. Users must follow a series of steps just to set it up and get usable sounds from it, so they need to spend some time familiarizing themselves with the basic functions. Generating the correct sounds in the correct sequence requires following a training script or having significant expertise in the field of hearing loss prevention. Not all users will have the time or resources to make the best use of the full software package; instead, they will need something simpler and more straightforward. To meet this need, two other variants on the simulator were developed. One is a computerized interactive slide show, and the other is an Internet Web page. The advantages and disadvantages of each version in different training settings are described in table 1.

Table 1.—Advantages and disadvantage of three versions of hearing-loss simulator

Version	Advantages	Disadvantages
Full simulator	High flexibility	Must be installed on PC
	Many scenarios	Some learning time
	More functions	Requires more trainer expertise
	Customizable sounds	No background information
Computerized slide show	Can be used by individual trainee	Only a few canned sounds available
	Includes background information	Cannot be tailored to site or trainees
Web page	Can be used by individual trainee	
	Accessible by any Web-connected PC	Only a few canned sounds available
	Simple and quick	Cannot be tailored to site or trainees

AUTHORIZING TOOLS

Both the Web page and the slide show were constructed using basic, readily available software. The slide show was constructed using Microsoft[5] PowerPoint 2000, and the Web page was built with Microsoft FrontPage 2000. Products from other software companies could also have been used–nothing about the Web page or slide show required any Microsoft-specific features. For instance, the Web page just uses standard HTML code and could have been generated in any HTML editor or even a generic text editor. The slide show makes use of simple animation and multimedia functions that are common to most other products on the market.

SOUND PROCESSING

The tools needed to generate the sounds in the simplified training packages were only slightly more specialized than the authoring tools. It was important to create filtered recordings that would simulate the individual frequency losses of a person with a noise-induced hearing loss. Fortunately, many such tools are available at modest cost ($100 or less). For the sounds in the slide show and Web simulators, Syntrillium's[6] CoolEdit 2000 was used. First, the software's transformation function was used to create a filter with frequency characteristics similar to the hearing levels of a 45-year-old individual who had been exposed to 95 dBA of noise per 8-hour work day over a 25-year career. This represents a very noisy job, although there are some jobs that are even noisier. Then a recording of a male speaker reading a series of hearing loss messages (the same recording as used in the full simulator) and a combination of the male speaker and a mining background noise (continuous haulage machine) were processed. The resulting files were saved in both the common WAV format for the slide show and MP3 format for the Web page. By using the MP3 format, a significant file size reduction was achieved at the expense of a small loss in sound quality resulting from the format's "lossy" compression. This size reduction is important for Web pages because many users may have slow Internet connections, and the long download times required for uncompressed sounds would discourage users from accessing the simulator.

[5]Microsoft Corp., Redmond, WA.
[6]Syntrillium Software Corp., Phoenix, AZ.

WEB PAGE

The Web page is the simplest version of the simulator (figure 1). It consists of a single page with instructions to listen to four sound samples by clicking on four icons in order. The icons play a normal male voice recording and the same voice as heard with a noise-induced hearing loss. Next, the user can hear the voice with machine background noise both with and without a hearing loss. The page is intended as a very brief introduction to the concept of noise-induced hearing loss and has no provision for adjusting exposure durations or modifying the types of sounds. These functions may be added to a later version of the site once the functions are evaluated in the full simulator. The target audience for this version is an individual worker who is accessing the Internet from home, a training room at work, or some other access site. In the future, the page will contain links to additional supporting publications and sites and allow downloading of other versions of the simulator.

COMPUTERIZED SLIDE SHOW

The computerized slide show has much more content and interactivity than the Web page. It uses the same preprocessed simulated sounds as contained in the Web page and embeds them into a series of slides. It also surrounds the simulation with a brief lesson about the nature and causes of noise-induced hearing loss and finishes with a review of actions that workers can take to protect their hearing. Selected slides for the background, simulation, and action portions of the presentation are shown in figure 2. This version of the simulator is mainly intended for safety and health instructors to use as part of their hearing loss training sessions. It is self-contained, requiring only a Windows PC to operate. Instructions on navigating from one screen to the next and activating the simulated sounds are displayed right on the screen. Although designed for use in small training rooms, its simplicity makes it also appropriate as a self-paced training exercise for an individual worker.

FUNCTIONS AND CONTROLS OF THE FULL SIMULATOR

The full simulator offers a number of controls to give the trainer flexibility to tailor the training to the audience and training needs. This places considerable responsibility on the trainer, but the resulting interactive possibilities can be worth it. Below is a description of all of the essential functions in the prototype simulator that are currently being evaluated (see figure 3 for a view of the main control screen). These functions are likely to change somewhat in the final release and in subsequent versions as improvements are made on the basis of user feedback.

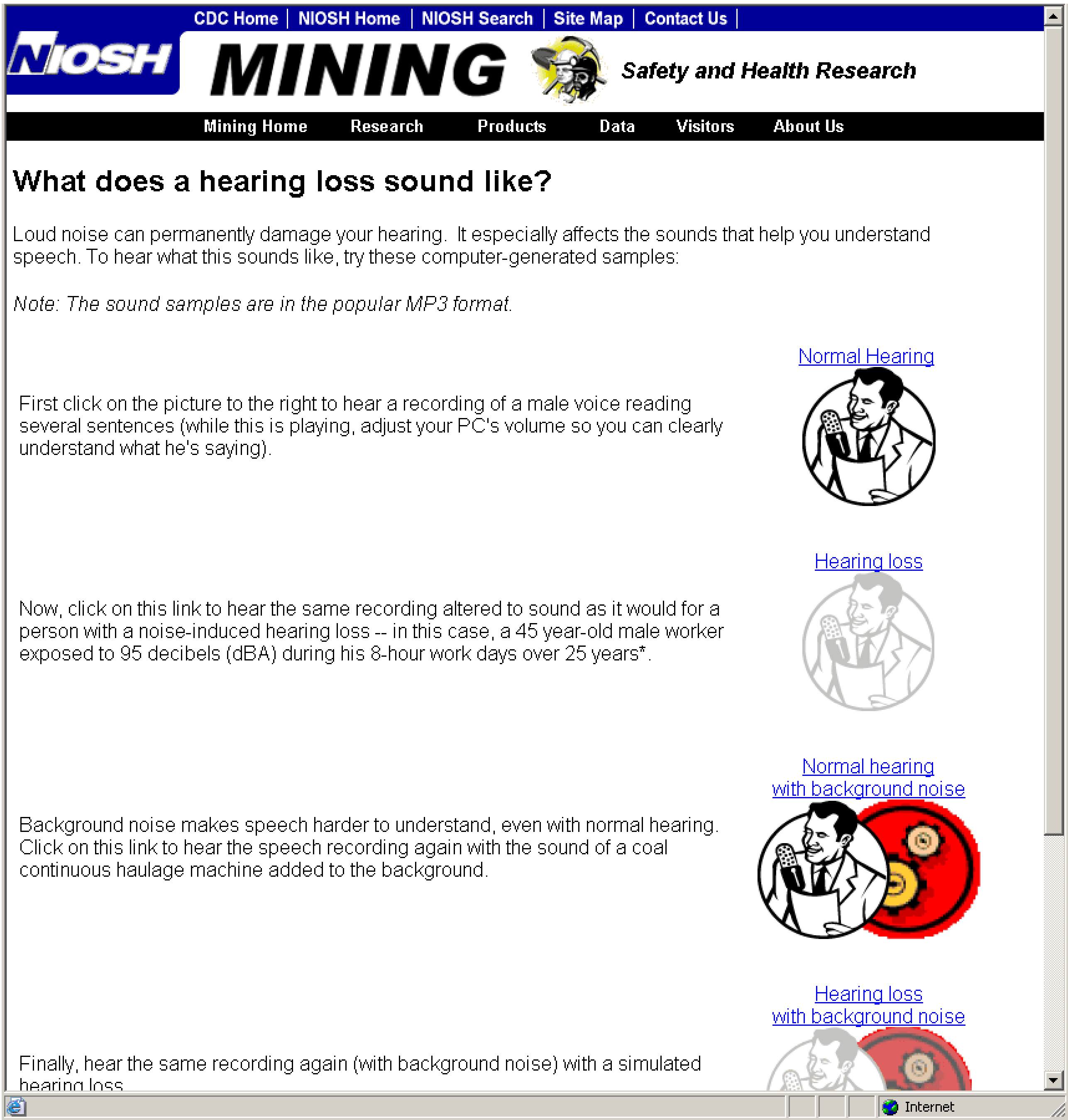

Figure 1.–Prototype Web page version of hearing loss simulator.

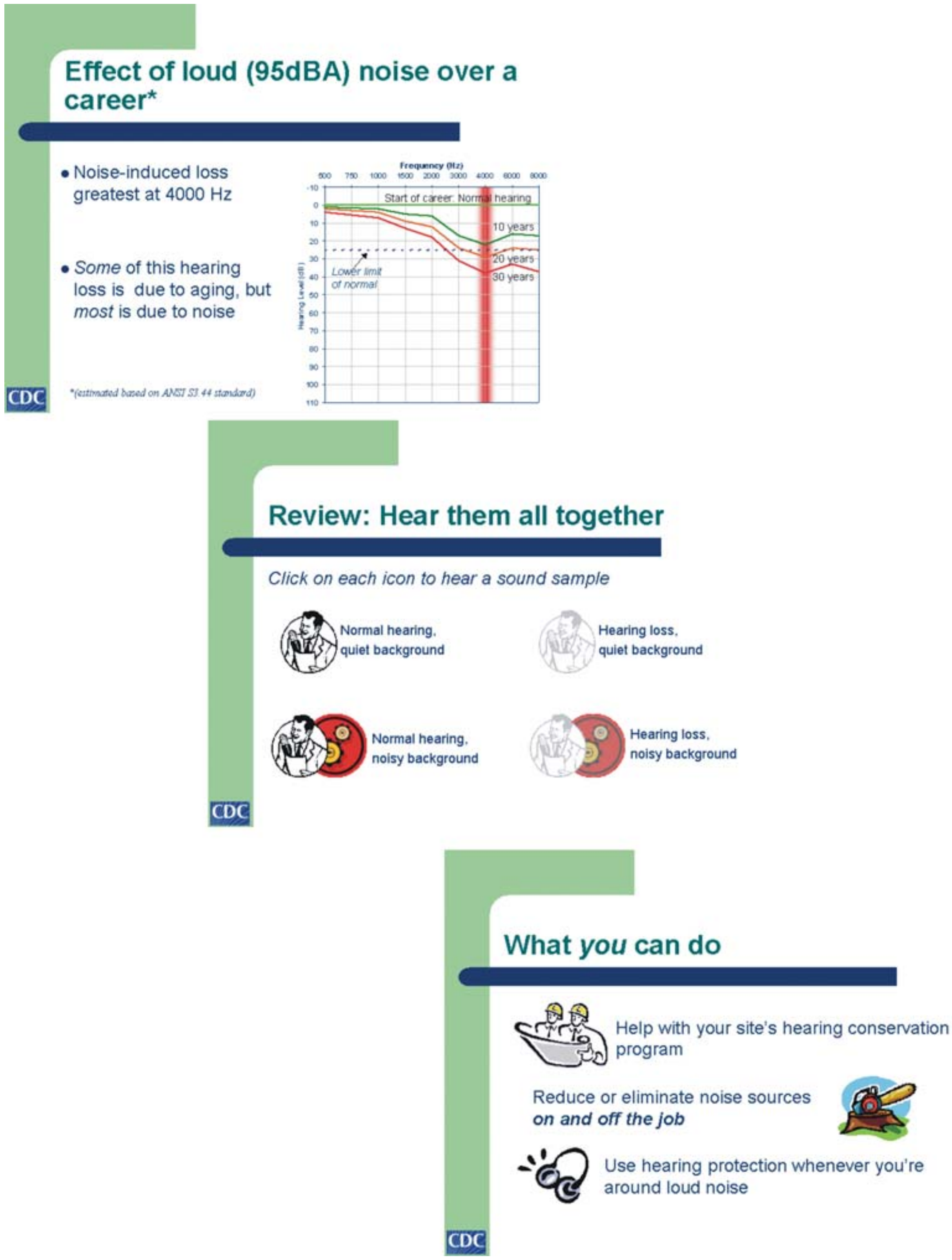

Figure 2.—–Sample screens from computerized slide show version of NIOSH hearing loss simulator.

Foreground Sound

Human speech is used as the default foreground sound because it is both the most complex and most important signal workers need to perceive. The simulator allows the choice of either a male or female voice recording. However, the simulator also allows the user to record a foreground sound of his or her choice through the computer's sound hardware. Some trainers could use this capability to record a special warning signal or other sound that is likely to be heard at a specific facility.

Background Sound

Background sounds often severely tax a listener's ability to hear and/or comprehend the intended message. The simulator allows the choice of several types of background sounds, including some recorded worksite sounds (continuous miner, haulage machine, drill) and some more generic background noises (male or female "speech babble," white noise, etc.). The user can also control the signal-to-noise ratio, that is, the relative loudness of the foreground and background sounds. In practice, a range of -10 to -20 signal-to-noise ratio seems to work best.

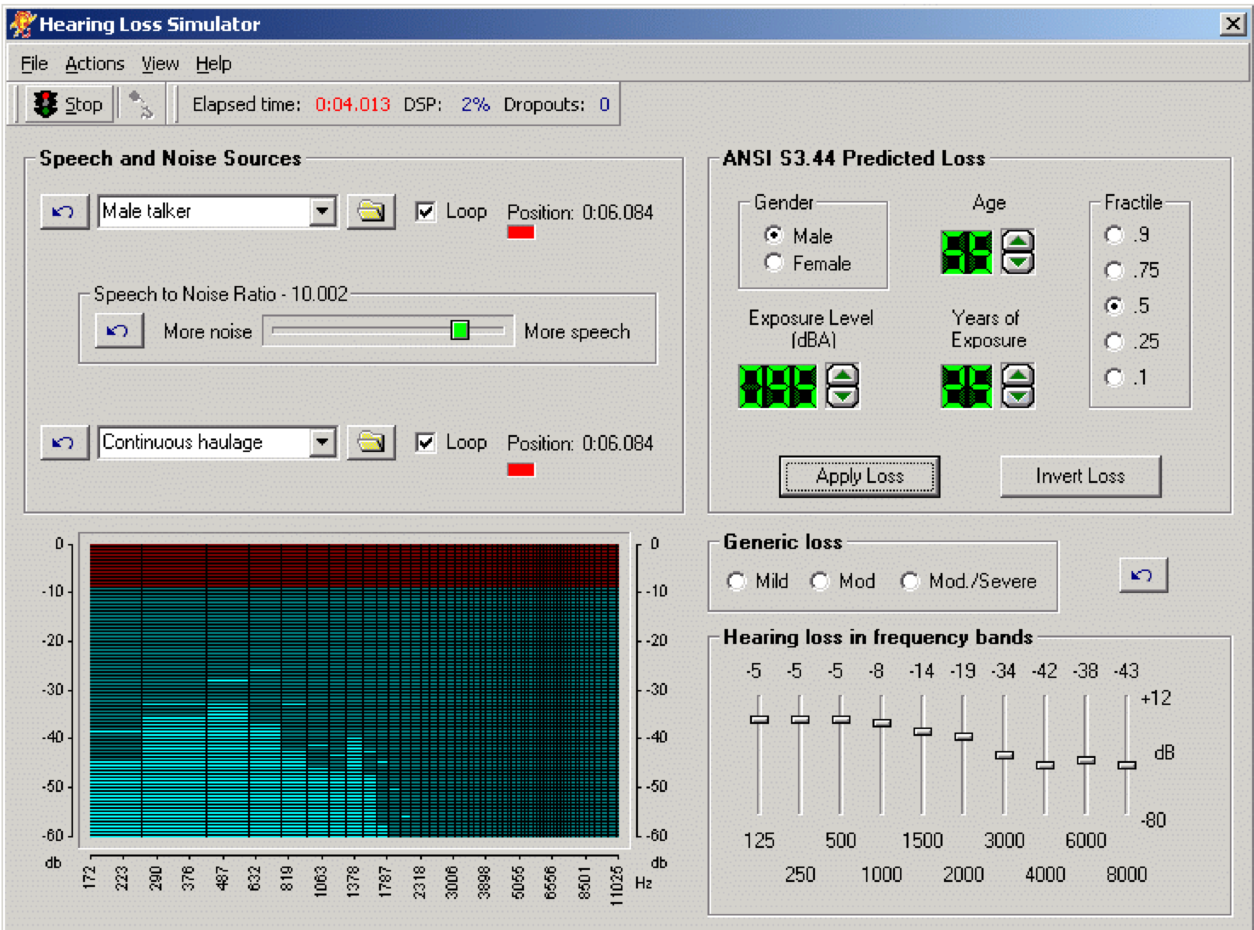

Figure 3.—Main control screen, full version of NIOSH hearing loss simulator.

Noise Exposure Level

The first ingredient of overall sound exposure is noise level. As expected, high-intensity sound levels cause much more hearing damage than lower levels. The effect of different levels of past noise exposure can be simulated by entering the desired A-weighted sound level in decibels.

For simplicity, a single decibel A number is set in the simulator, although workers may correctly point out that the sound levels they are exposed to vary considerably over time. Because of this, the decibel A value should represent an estimate of the average exposure over the simulated time period, commonly referred to as the time-weighted average (abbreviated as TWA).

Years of Exposure

Time is the second major ingredient of exposure. This is set in years to represent a noisy period in the simulated individual's life. For instance, it can be set to cover a single noisy portion of a career (for example, 10 years of working with a loud machine) or multiple noisy periods added together. The time entered assumes exposure during normal working days of around 8 hours, not continuous round-the-clock noise exposure.

Age

Some hearing loss occurs as people age, but age alone seldom causes a severe hearing loss or deafness. ***One of the major lessons to be learned from the simulator is that aging usually causes much less hearing loss than does noise exposure.*** The simulator shows this by demonstrating the hearing loss due to age alone. The age-related losses are usually mild and affect the highest frequencies the most. The additional and more substantial hearing loss due to noise can be added on top of age-related loss to show the effects of noise, especially on speech frequencies.

Gender

Males tend to have higher levels of hearing loss than females who have had the same noise exposure, so the program allows the user to specify the simulated worker's gender.

Population Distribution

Noise does not affect everyone to the same extent. To account for variations within the population, the ANSI S3.44 standard specifies expected hearing loss for different population fractiles. The program allows the user to specify the 0.1, 0.25, 0.5, 0.75, and 0.9 fractiles. For instance, a worker at the 0.1 fractile would have more hearing loss than 90% of the equally exposed population. Those at the 0.75 fractile would have more hearing loss than just 25% of the population. One use of this would be to show the range of impairment that could be expected. For instance, the 0.9 fractile could be used to reach the workers who believe (for whatever reason) that they may be less susceptible to noise-induced hearing loss. This 0.9 fractile level could be presented as the *minimum* loss that would be expected based on the set exposure, and that most workers exposed at this level will have *even more* hearing loss. Most workers will have no way of knowing their susceptibility to noise, so this control should usually be set on the expected population median (0.5 fractile) to start with.

Invert Loss

Once a loss is simulated, it can be "inverted" by clicking on the "Invert Loss" button. This has the effect of raising the sound level by an amount equivalent to the hearing loss at each frequency. To an imperfect extent, the boosted playback can compensate for a hearing loss to give a trainee an idea of what it would be like to regain his/her normal hearing. There will inevitably be imperfections in this illusion, however. The fidelity limitations of any mechanical playback system and the complexity of the auditory system make it impossible to "reverse" a hearing loss perfectly. Also, in cases of severe hearing loss, boosting the sound enough to compensate for a large deficiency could generate hazardous sound levels. Still, presenting hearing-impaired trainees with an approximation of normal hearing should be sufficient to show how much they have lost and reinforce how valuable their remaining hearing capacity is.

Preset Generic Losses

For a quick simulation of a hearing loss, there are three preset generic levels of noise-induced hearing loss that can be selected: mild, moderate, and moderate/severe. In each case, the greatest amount of loss is shown at 4000 Hz, with surrounding frequencies impaired to a lesser extent.

Frequency Sliders

A row of 10 slider controls for different frequency bands permits even more flexibility. Most of the time, frequency bands are automatically adjusted by the software to reflect a predicted hearing level as a result of noise exposure. They can also be directly manipulated by the user. This could be done, for instance, to enter a trainee's actual audiogram directly into the simulator program. Then, others who have no hearing loss could, in effect, hear with the same ears as the person whose test results were entered. Also, since each slider can be manipulated independently, the user can illustrate the effects of a hearing loss in each frequency band. For instance, a warning beeper may become much less audible as a result of a loss in a single frequency band.

SCENARIOS

The full power of the simulator can be shown by working through some instructive scenarios. Some of these were alluded to above, but a good training plan using the simulator should work through a series of scenarios using trainee input to tailor the lesson to the audience. Below is a list of some of the many possible scenarios that could be presented.

OLDER WORKER, NOISE EXPOSED

This scenario is one of the most important ones to include in a training session, especially with younger workers. A hypothetical older worker, perhaps nearing retirement, would be described. He (or she–the program can simulate either) should be characterized as in the range of 55-65 years old with 35-45 years of exposure to 90-100 dBA. Selection of numbers in these ranges can depend on what is typical in the user's workplace or industry. The trainer can demonstrate the significant hearing loss this worker will have going into retirement.

OLDER WORKER, NO EXPOSURE

Immediately following a demonstration about a hypothetical noise-exposed older worker, the trainer can set the exposure years to zero and simulate an equivalent worker with no exposure. This will serve to counter any assumption that the first worker's hearing loss was a natural consequence of aging. Instead, they will see that a relatively small amount of high-frequency loss is expected in older workers, but that noise exposure is responsible for much more of the damage.

MID-CAREER WORKER

Especially if the training class includes a large number of mid-career trainees, a worker with 10-20 years of exposure should be simulated. Based on this worker, several progressions can be followed. For instance, additional exposure-years can be added to show the accumulation of more hearing loss. It also allows comparison with an older nonnoise-exposed worker, which then allows the trainer to make the point that, with enough exposure, a 30-year-old worker may have, in effect, 50-year-old ears.

INDIVIDUALIZED: INVERT LOSS

The simulator can also be used as an individualized training and counseling tool. For instance, the trainer can show a worker how his/her hearing test results can be entered directly into the simulator using the frequency band sliders. By next selecting the "Invert Loss" function, the trainee can be given a hint of what his/her hearing would be like if the hearing loss had been avoided. Switching back to the original loss profile, the trainer can then drag the sliders down to show the additional loss that would occur after further noise exposure.

MAKING ADAPTABLE CONTENT

Making a training product that can be adapted to several different formats can be either easy or difficult. Obviously, very different formats (say, a professional quality video and a small informational sticker) will make for a challenging conversion. Likewise, similar formats (say, an informational card and a brief brochure) will be relatively easy. Regardless of how different the formats are, the conversions will be even easier if some simple steps are taken while preparing the content.

Extra difficulties arise in adapting content that was not designed with conversion in mind. For instance, a training product is often developed for one medium and then shelved. When it becomes clear later that it would be beneficial to have other versions of the product, a considerable amount of new adaptation work usually needs to be done. For instance, if a video is produced and later someone decides to turn it into a booklet, they may then need to transcribe the narration for editing into printed text and re-photograph the visual elements. With a small amount of forethought and planning, a core set of content for a training product can be developed and used to "spin off" multiple versions. This will not eliminate all the work needed to tailor the content to different media, but it will reduce it considerably.

TEXT

Even the most visual training products usually have *some* text component. A video may have a script to be read by actors or a narrator. Signs and emblems are often accompanied by a user's or instructor's text. Many versions can be extracted from a single "master" text with appropriate modifications. This will be easier if the master is kept as a simply formatted, comprehensive electronic document. One good way to start this is to build a simple HTML Web page that's accessible to the development team. The team can then view and revise the master on a shared Intranet site. If HTML formatting is kept to a minimum (heading tags, simple tables, etc.), the resulting text can be easily imported into a word processing or desktop publishing package for more extensive formatting.

PHOTOGRAPHS AND OTHER STILL IMAGES

If producing video, take still pictures at the same time. For instance, commercial movies have almost always had professional photographers take "publicity stills" during filming. These still photos are almost always sharper and better posed than an individual frame from the movie and are essential for posters and other marketing materials. They also become useful later for books and other publications about the film. Even though training videos are produced on a much more modest scale than commercial movies, their example can still be followed. It is much easier to take still photographs of a scene set up for a video than to re-create it later. Also, although still frames can be extracted from a video stream, the results are of far lower quality than a decent still photograph.

A high-quality digital master of each photograph should be kept in the development team's archive. If the originals were taken using conventional photographic film, a digital master can be made by scanning the negatives with a film scanner, or many photo labs will create high-quality digital images on a CD at the time of processing. From these master digital versions, smaller, faster-loading files can be converted using photo editing software. For printed materials, the images should have their resolution reduced very little, if at all.

DRAWINGS, DIAGRAMS, AND ARTWORK

As with photographs, it will be easiest to generate different versions of illustrations if there is a high-quality digital original. For these types of images, the best electronic format is referred to as "vector-based." For example, Windows metafiles, PostScript[7] files, and most illustration software files are considered vector-based. These can be kept in vector format when used in document preparation or presentation software, but should usually be converted to a bitmap format (for example, GIF) for Web pages. Most illustration software will convert vector drawings into a bitmap of whatever size is needed for a Web design.

AUDIO

Sound recordings should be maintained in uncompressed digital format (for example, WAV). This can be later compressed, if needed, for limited-bandwidth presentation over the Web, but the compression cannot be reversed to obtain the original sound quality. For instance, the sounds used in the hearing loss simulator were recorded in CD-quality uncompressed digital format (44,100 16-bit samples per second). These sound files were used without further compression in the full package and PowerPoint versions, but were compressed to 128 bit/sec MP3 format for the Web pages. This enabled significant reduction in sound file sizes; the "normal male" recording was reduced from 3.2 to around 0.5 MB with very little perceptible loss in sound quality.

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[7]Adobe Systems, Inc., San Jose, CA.

VIDEO

New ways of showing video content are rapidly becoming practical. Videocassettes almost completely replaced film for training in the early eighties. Now, videocassettes are facing competition from digital versatile disks (DVD), streaming Web-based video, and other new technologies. The best way to keep video in a form that can readily be adapted is, again, to maintain a high-quality digital master. This has become relatively easy with the advent of inexpensive consumer-grade miniDV equipment. These camcorders and other devices connect to a computer though high-speed ports, and the downloaded video can be archived and edited with no further loss in quality. Basic video editing tools are now included with current computer operating systems for Windows and Macintosh[8] systems, and more flexible software is available for less than $100. For use in a training room, the edited videos can be copied to tape a regular VCR or “burned” on a DVD or CD writer. If the video is also intended to be viewed on the Web, it can be converted to a compressed streaming format such as RealMedia[9] or Windows Media[10] (ASF) using tools that are inexpensive or even free.

EVALUATING THE SIMULATOR’S EFFECTIVENESS

The ultimate goal of all three versions of the hearing loss simulator is to reduce hearing loss by motivating workers to take self-protective actions. Behind this statement is a complex process that has several steps, each of which could be evaluated. First, has the message been communicated? That is, do the trainees understand that exposure to hazardous noise over a long enough period of time will result in an irreversible hearing loss? Next, how motivating is the message? How strong is the desire or intention to take action relative to all the trainees’ other desires and needs? Third, what (if any) behavioral change resulted? Do the trainees maintain the noise controls on their equipment better? Do they wear earplugs or other hearing protection more often? Finally, the true outcomes must be evaluated, that is, do the trainees avoid noise-induced hearing loss as a result of their actions?

INITIAL REACTIONS TO ALL VERSIONS

The simulators are brand new, so evaluation is in just the first stages. Currently, NIOSH is working with organizations that want to use the simulators in their training to collect feedback from trainees. This feedback consists of questions about trainees’ reactions to the simulator. Was it easy to understand? Could they hear the difference between the normal and simulated loss conditions? Did they learn something new? Answers to these questions will help refine the simulators and provide information about how best to deploy them. This evaluation is also appropriate to all versions of the simulator.

KNOWLEDGE AND BELIEFS

The next evaluation will look at how effective the simulators are at imparting knowledge and changing beliefs. Do trainees have a better understanding of the relationship between noise, exposure time, and hearing loss? Do they know that noise-induced hearing loss is permanent? Are they still susceptible to the “noise myths”? Do they intend to take any specific actions to protect their hearing? These factors can be assessed through brief questionnaires or interviews. Ideally, they will be assessed at three points: before training, immediately after training, and several weeks following training to determine how much information was retained. For the full simulator and the slide show version, this information can be collected by the instructors. The Web version will offer the opportunity to collect this information online from users who agree to provide it. While asking online users to provide information can be convenient for both the users and the developers, there is much less control over who participates and other conditions that could affect the validity of the data. Consequently, the Web version will probably be evaluated with a known sample of participating users.

BEHAVIORS AND HEARING LOSS OUTCOMES

Changed knowledge and beliefs do not necessarily translate into effective hearing conservation actions, however. The behavioral and illness outcomes of the training, especially for the full version and the slide show version, will be investigated. The Web version, because of the otherwise beneficial openness of the Web, does not lend itself to this type of full evaluation. The NIOSH Hearing Loss Prevention Unit (HLPU) will be used in these efforts. The HLPU is a mobile testing trailer that can be taken to any training site for detailed hearing evaluations. This facility contains a system that can easily test one hearing conservation behavior: Correct use of earplugs. The multistation earplug fit-testing system can be used to determine, through the use of specially designed headphones, how much noise reduction is achieved at each frequency. Better trained and motivated workers are able to obtain significantly more protection from their earplugs (Berger et al., 1996). If the simulator motivates workers to protect their hearing, the trained workers can be expected to take the time to fit their earplugs better.

While it is important to evaluate hearing protection behaviors under controlled settings, behaviors at the workplace are a better predictor of long-term hearing conservation

[8]Apple Computer, Inc., Cupertino, CA
[9]RealNetworks, Inc., Seattle, WA.
[10]Microsoft Corp., Redmond, WA.

efforts. In this evaluation, the hearing conservation actions taken by workers on the jobsite will be tabulated. For instance, do they maintain the noise control devices and treatments on their equipment? How many suggestions do they make about reducing noise? How well do they comply with administrative controls that are in the site's hearing conservation program?

Finally, the ultimate outcome is the reduced incidence of noise-induced hearing loss. This can be assessed by long-term tracking of hearing levels as measured by a standard audiogram. Effective training should result in a lower rate of measurable noise-induced hearing loss. By tracking hearing levels, particularly between 3000 to 6000 Hz, changes in hearing thresholds that may reflect either reduced or continued noise exposure can be detected. While no one can determine whether the noise exposure occurred at work or off the job, it's not really necessary to distinguish between the two for these training efforts. These in-depth studies will be most feasible with the full simulator and the slide show version. Effective training will teach workers to protect their hearing regardless of where they are. The training message should emphasize that workers' responsibility for their own health does not begin and end at the front gate. Maintaining their hearing will have a positive impact on their work and the overall quality of their lives.

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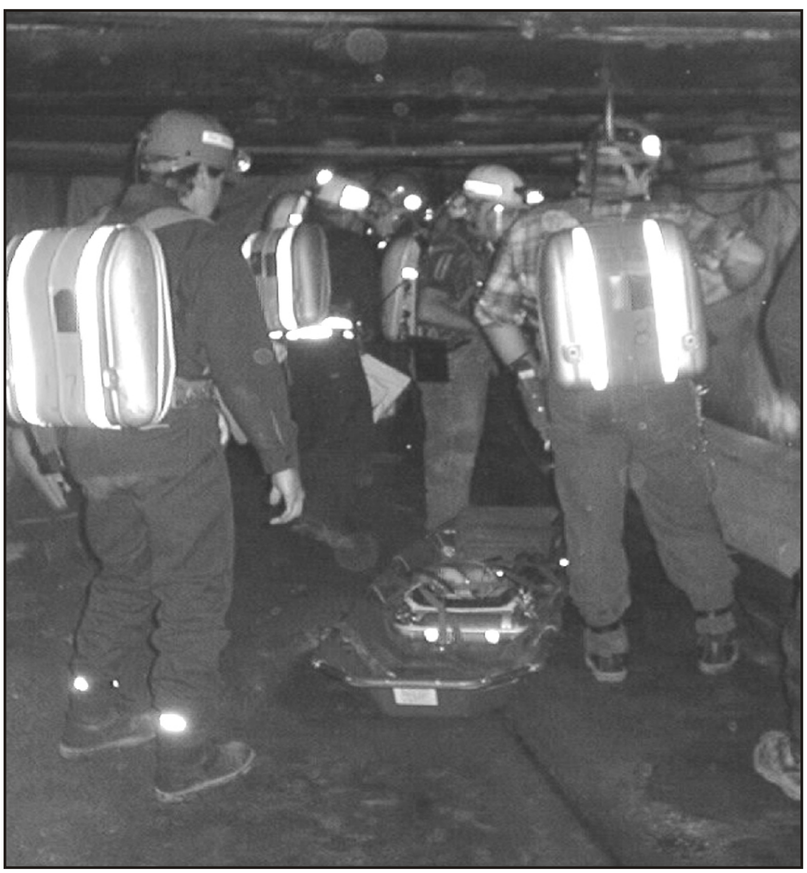
Strategies For Improving Miners' Training



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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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