

Hearing Through the Protectors

How hearing protection changes speech understanding and what to do about it.



The classic scene

Supervisor: Hey – you aren't wearing your earplugs. That's the third time this week!

Employee: I know I know! But I just can't hear Joe's instructions! I had to take them out. It's not my fault!

This classic interaction is played out everyday in the workplace. Employees, who struggle to hear, may remove their hearing protection temporarily and some may simply stop wearing hearing protection altogether. This response is likely to create a much bigger permanent communication problem: noise-induced hearing loss. In the meantime, worker complaints like this one may cause an employer to wonder:

“Is it reasonable to expect my employees to hear the sounds they need while they are wearing hearing protection?”

After all, it does seem a bit counterintuitive to block the same sounds the wearer is trying to hear.

Understanding how hearing protection changes sound is an important step towards ensuring employees are appropriately protected from hazardous sound without impeding their safety or productivity. Hearing protection, worn properly, will decrease all sounds: both unwanted sounds (noise) and useful sounds such as speech and warning signals. With some attention, most communication issues can be resolved or at least improved. This article explains how hearing protection affects auditory communication and suggests approaches to overcoming difficult listening situations.

The ears on overdrive

The human hearing mechanism works most effectively at low and moderate sound levels. High sound levels, 85 dBA or greater, overdrive the auditory system and introduce distortion within the ear itself. Like the poor fidelity of overdriven speakers, overdriven ears cause signals to lose clarity, making speech difficult to understand. Wearing earplugs or earmuffs in a high noise environment is comparable to wearing sunglasses in intense sunlight. The filtering decreases the intensity and glare of bright sunlight to permit a more relaxed viewing experience. Like the photos in Figure 1, a day at the beach without sunglasses is harsh, causes squinting and perhaps a headache and early fatigue. But viewed through sunglasses the scenery is much more pleasant, the details easier to discern and the shadows and colors apparent. Likewise, hearing protection reduces the overall sound input that reaches the inner ear, allowing the auditory system to work more comfortably and effectively.

It takes two to communicate

Wearing hearing protection causes other changes. First, is a phenomenon called the *occlusion effect*. When the ears are blocked or plugged, external sounds become softer, but internal sounds seem louder and “echo” inside the head. People describe their own voice as “booming” or like “talking in a barrel.” As a result, when wearing hearing protection, employees are likely to speak more softly. Secondly, people tend to talk more quickly when wearing hearing protectors in noisy environments. The combination of talking more softly and quickly has obvious implications; the listener has more difficulty understanding the speaker. In the opening scenario, the employee removed his hearing protection to hear

better, however, the speaker is still talking less loudly and too quickly, and the listener is hearing the factory sound at high levels. The problem isn't solved by removing hearing protection and will only become worse over time as hearing is damaged.

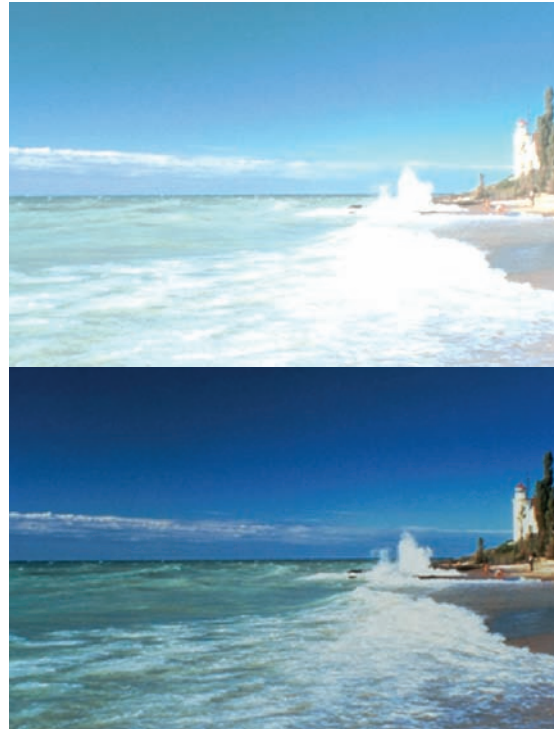


Figure 1 - Visual analogy demonstrating how sunglasses improve vision by reducing visual overload.

Hearing protection and understanding speech in noise

Researchers have long studied the effects of background noise on the ability to understand speech. Speech discrimination (SD) is measured by asking subjects to repeat specific words presented in a variety of controlled listening conditions. The SD is the percentage of correct responses. Key factors in SD performance are: 1) the listener's hearing ability, 2) the level of speech compared to the level of the background noise (also called signal-to-noise ratio), 3) the specific word list and context of the message, and 4) use of visual cues, if the listener is allowed to see the speaker. By comparing SD for subjects, both with and without hearing protection, the effects of the hearing protection are revealed. Some generalizations made from the scientific literature are summarized below:

- Normal-hearing listeners wearing hearing protection,
 - SD **improves** in high noise levels, greater than or equal to 85 dBA
 - SD is **unchanged** in moderate noise levels about 80 dBA
 - SD **worsens** in low-to-moderate noise levels, less than 80 dBA.
- Hearing-impaired listeners wearing hearing protection: results are not as definitive, however suggest,
 - SD is **unchanged** in high noise levels, greater than or equal to 85 dBA
 - SD is **worse** in low-to-moderate levels of background noise, 80

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dBA or less.

Hearing Protector Effects on Speech Discrimination			
	Low Sound Levels <80 dBA	Moderate Sound Levels About 80 dBA	High Sound Levels > 85 dBA
Normal-Hearing	Decreased	Unchanged	Improved
Hearing Impaired	Decreased	Decreased	Unchanged

• Hearing protector type

Studies aren't extensive enough to differentiate SD differences based on the type of hearing protector. However hearing protection type is a factor in the ability to localize sound. Finding a sound in open space depends on subtle differences in amplitude and timing between when the sound reaches the right and left ears. Maintaining the natural state of the outer ear is important to receiving these clues. Earplugs, which only occlude the ear canal, have less of an effect than earmuffs that block the entire outer ear. If localizing sound is critical to job performance, earplugs are generally a better choice than earmuffs.

Tactics for improving speech communication in noise

Based on the information already discussed, how can an employer help workers improve speech communication in a noisy work environment?

The tactics discussed here **presume the employees are wearing hearing protection.**

- Teach employees to speak more loudly and distinctly
To compensate for the occlusion effect and the tendency to speak quickly in noise, instruct employees that speaking **LOUDLY** and **CLEARLY** (more loudly than they think they need too) is critical to understanding. It is most helpful for the speaker to make these accommodations; the listener should not be removing hearing protection.
- Know the background noise
Remember that speech understanding becomes poorer for persons wearing hearing protectors as background noise levels decrease. Hearing protection isn't generally needed in environments less than 80 dBA, and if used, may jeopardize communication and safety. However in moderate-to-high noise environments, speech understanding can improve. Ensure that employees are properly using hearing protection in noise at 85 dBA and higher.
- Use visual clues for speech whenever possible
Teach employees to watch the speaker's face. The listener can watch the lips and facial expressions of the speaker to supplement the auditory information, ultimately increasing understanding. Use hand gestures when possible.
- Develop key words or phrases specific and meaningful to the work environment
Most jobs have repetitive cycles and use language specific to the job task. Work with employees and supervisors to identify specific

words or short phrases that can convey the same information as longer messages. Train employees to substitute "code" words. For example: "go fiber 3" might be substituted for "deliver packaging supplies to Building-3 room. Develop a "wait & hear" approach to verify communication takes place before the employees leave.

- Practice makes perfect
Research has shown that employees who routinely work in noise will adapt to the poor listening conditions, and eventually outperform inexperienced subjects. Because of the brain's plasticity, it has the ability to adapt its neural connections. Thus, with time it can learn to fill in the gaps for what it doesn't hear by integrating all the information - visual, contextual, and behavioral - so that SD can improve with experience. Encourage new and seasoned employees to work together.
- Increase the signal-to-noise ratio
Understanding speech becomes easier as the speech signal becomes louder than the background noise. Specialty hearing protection devices are available that amplify speech while limiting the output to a safe level. These are particularly useful in intermittent noises and for hearing-impaired workers or for jobs where communication is critical.
- Use visual or vibrotactile alerting systems
When hearing is difficult, add vision. Flashing lights, colored light sequences, etc., can supplement or be substituted for horns or beepers. Cell phones on vibrate mode and text messaging may also be helpful for alerting workers, particularly those with hearing loss.
- Develop individual plans for hearing-impaired workers
Recognize employees with hearing loss who may need special accommodations. Often the professional supervisor (audiologist or physician) of the audiometric testing portion of the hearing conservation program can be a resource for developing plans for individual workers with hearing loss. For more information, refer to Occupational Safety and Health Administration Safety and Health Information Bulletins: *Hearing Conservation for the Hearing Impaired Worker* at <http://osha.gov/dts/shib/shib122705.html> and *Innovative Workplace Safety Accommodations for Hearing Impaired Workers* at <http://osha.gov/dts/shib/shib072205.html>.
- Develop a job-specific protocol for determining auditory needs
Some jobs require more critical communication capabilities than others. There is no "one-size-fits-all" approach to determining what hearing criteria should be applied or how employees should be evaluated for hearing/communication ability. Key to developing a protocol is to investigate the job tasks, employee responsibilities, and the work environment for each job. Next, the individual employee's hearing ability should be considered. Some situations will require evaluation beyond pure-tone hearing tests and an audiologist may need to be consulted (Tufts, 2009). Examples of hearing protection considerations include use of earplugs rather than earmuffs when sound localization is imperative, and use of lower-attenuation devices

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rather than higher-attenuation devices when background noise is low.

“Is it reasonable to expect my employees to hear the sounds they need while they are wearing hearing protection?”

Clearly, employers and employees both win if the answer to this question is a resounding “Yes!” To achieve this definitive answer, each individual case should be considered regarding noise exposure, hearing protection, the job tasks specific to communication needs, and the individual employee’s ability to perform them. Many times, simple modifications such as fitting hearing protection appropriately and teaching employees better communication strategies can be made to enhance communication while reducing the risk of hearing loss from hazardous noise. When hearing-critical jobs are identified, more elaborate investigation may be needed. Employees who consistently remove hearing protection in order to hear are essentially giving a cry for help. *Can you hear it?*

Hearing Conservation Resources

American Academy of Audiology
www.audiology.org

Council for Accreditation in Occupational
Hearing Conservation
www.caohc.org

E-A-R Hearing Conservation Educational
Page www.e-a-r.com/hearingconservation/

National Hearing Conservation Association
www.hearingconservation.org

NIOSH
www.cdc.gov/niosh/topics/noise/
OSHA etool: Noise and Hearing Conservation
www.osha.gov/dts/osta/otm/noise/index.html

References

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