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Hearing Aids in Noisy Workplaces: a good or bad solution?

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Introduction

Noise remains a common contaminant in many workplaces. A number of workers with a personal or occupational hearing loss must, on a daily basis, face the consequences of diminished hearing sensitivity, which can compromise one's safety and that of others because of the attendant difficulties it creates in perceiving auditory signals, in understanding speech in noise and in identifying the location of sound sources (localization). Hearing aids can potentially be used in the workplace to maintain auditory awareness of the surroundings and allow hearing-impaired individuals to work in a safe, effective, and autonomous manner. This option however raises concerns as to the effectiveness of hearing aids in optimizing those hearing abilities required to perform various job duties and in amplifying sounds to levels deemed safe, while at the same time reducing industrial noise to limit further worsening of the hearing loss.

Very few scientific studies have addressed the use of hearing aids in noisy workplaces. Thus, little is known on the frequency of this practice and its associated risks. It should be noted that, in this context, noisy workplaces are not limited to work environments characterized by noise levels exceeding regulatory limits, but also include softer environments in which the use of hearing aids could potentially lead to over-amplification. To guide future research endeavors in this field, a research activity was carried out by means of gathering information from health care professionals, manufacturers and the scientific literature, which focused on: 1) documenting the frequency of hearing aid use in noisy workplaces, 2) identifying the tools available to health care professionals to document the risk of over-amplification, 3) determining whether or not hearing aids can support listening and communication needs without further exacerbating the hearing loss or compromising safety, and 4) determining if other amplification and protection technologies (for example level-dependent hearing protectors) can help improve, or at least not hinder, auditory performance at work.

The multi-pronged activity was supported/funded by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST, Quebec). This article briefly summarizes a portion of the work, particularly the literature review on the effects of directional microphones and noise reduction algorithms on speech perception in noise, and that of hearing aids on sound localization.

Frequency of hearing aid use in noisy workplaces

While the research activity did not allow precise identification of the number of workers using hearing aids in noisy Quebec workplaces, 84% of the health care professionals surveyed (n=198) reported that they have been confronted, at least once during the last 5 years, by a worker using, or considering using, hearing aids in a noisy workplace. The lack of valid tools to assess the risk of over-amplification, of clear guidelines on how to adequately manage these cases, and of solid mechanisms for collaboration amongst the various professionals involved in the worker's care, were often cited as significant obstacles to an optimal, client-centered, approach to case management. In addition to the role of each professional not being clearly understood, sharing information between the various professionals seems to be lacking when it comes to identification of the noise characteristics (type, level, spectrum) at a workstation, the auditory requirements of the job and the recommendations to be made to both the worker and the employer. In many instances, recommendations are aimed at protecting a worker's residual hearing; hence, the use of hearing aids is discouraged. However, such a discouragement may underestimate the need to understand in noise for safe and effective work performance. Health care professionals have every reason to feel ill-equipped since a literature review neither revealed any clear conclusions as to the risk of over-amplification with hearing aids, nor allowed identifying a valid, reliable and standardized method to document or predict this risk, while also taking into consideration current technologies.

Literature review on the effects of hearing aids on speech understanding in noise and on sound localization

To better guide health care professionals in their decision to recommend or discourage the use of hearing aids in noisy workplaces, it was deemed essential to first document the effectiveness of hearing aids in supporting those hearing abilities that are required for safe, efficient and autonomous performance at work. More specifically, the effects of noise reduction algorithms and of directional microphones on speech perception in noise, and that of hearing aids on sound localization, were investigated.

Reference documents in audiology and in occupational health and safety were extracted from various databases. Given the rapid growth in hearing aid technologies, only articles published after 2000 were retained for further analysis.

The following sections briefly summarize the state of knowledge. At the outset, it should be noted that most articles deal with sound environments that poorly reflect the acoustical conditions (sound levels, frequency content, reverberation time, etc.) of typical noisy workplaces, which greatly limits the generalization of results to the target population of noise-exposed workers.

Effect of noise reduction algorithms on speech perception in noise

Despite different methodologies used from one study to the next to assess the potential improvement in speech perception in noise associated with noise reduction algorithms, a significant improvement was noted in only 4 (Chung et al., 2009; Prosser et al., 2009; Peeters et al., 2009; Oliveira et al., 2010) of the 18 articles selected for further analysis; no improvement nor deterioration was found in the other studies. Noise reduction algorithms could however help reduce overall noise exposure levels (i.e. Chung et al., 2009). It is imperative during the intervention process to instill realistic user expectations as to their potential benefits, such as improved listening comfort, listening effort and sound quality (i.e. Zakis et al., 2009), even despite the sometimes minimal information made readily available to health care professionals on the specific algorithms developed by various hearing aid manufacturers.

Effect of directional microphones on speech perception in noise

In a sample of 21 articles selected for analysis, variability was noted not only in the methodology used to document the benefit of directional microphones for speech percep-

tion in noise relative to the performance of omnidirectional microphones, but also in the magnitude of this benefit. While the directional benefit (compared to omnidirectional) on measures of speech reception thresholds was found to be as much as 15 dB (i.e. Compton-Conley et al., 2004), the majority of articles reported an average benefit of 2-5 dB (i.e. Keidser et al., 2007; Klemp & Dhar, 2008; Kim & Bryan, 2011). It would seem that the magnitude of the directional benefit is highly dependent on methodological elements, among others, the type and number of noise sources, the position of the noise sources relative to that of the target speech, the number of microphones on each hearing aid, the directivity pattern (cardioid vs hyper-cardioid) and type (adaptive vs fixed) of directional microphone, and the type of ear mold fitting (open vs closed). Adaptive directional microphones can yield an additional advantage over fixed directional microphones (i.e. Blamey et al., 2006), but this advantage diminishes in the presence of diffuse noise (i.e. Valente et al., 2006). Furthermore, compared to closed ear mold fittings, open fittings seem to reduce the directional benefit (Magnusson et al., 2013).

Finally, user-reported subjective benefits related to directional microphones have been documented in some studies (i.e. Bentler, 2005), although not in all (i.e. Gnewikow et al., 2009). In one study (Palmer et al., 2006), it was reported that a third of users could not subjectively differentiate between directional and omnidirectional modes, one third of users preferred the omnidirectional mode and the remaining third favored the directional mode.

Effect of various hearing aid technologies on sound localization

For sound localization, the 18 reviewed articles explored various different conditions of hearing aid use, including aided vs unaided performances, unilateral vs bilateral amplification, open vs closed fittings, microphone position and directivity pattern, various processing strategies (noise reduction algorithm, binaural communication, frequency compression), the hearing aid acclimatization period, and different combinations thereof. The effect of many of these factors on sound localization remains inconclusive, with positive, neutral and/or negative effects being reported in the literature.

In general, sound localization performances are better unaided than aided, particularly in the front/back dimension (i.e. Vaillancourt et al., 2011), and bilateral amplification yields better results than unilateral amplification (i.e. Kobler et al., 2002). The effect of microphone position remains inconclusive, with contradictory results stemming

from various studies. Moreover, contrary to a common belief amongst professionals, directional microphones could prove superior to omnidirectional microphones, particularly for the resolution of front/back confusions (i.e. Silotto, 2007; Chung et al., 2008; Groth et al., 2011).

Different signal processing strategies can also impact on sound localization abilities, particularly if they substantially modify the cues used by the auditory system to identify where sounds originate. Indeed, dynamic compression operating differently in both ears can hinder spatial perception by creating a sensation that sounds are diffuse and in movement (i.e. Wiggins et al., 2012). It is difficult to draw any clear general conclusions as to the effect of various hearing aid parameters on sound localization given the small number of studies addressing specifically a given parameter, the interaction between various parameters and the diversity of methodologies used to study their effect.

Finally, sound localization performances of a hearing aid fitting can improve over time compared to that measured immediately after fitting, although not necessarily (i.e. Best et al., 2010). The acclimatization period, during which the user gradually becomes more proficient with amplification, can last a few months; its duration varies as a function of, among others, the user's age and cognitive functions.

Lessons to be learned from the literature

Results from the literature review are, for the most part, not readily generalizable to the target population of this research activity (noise-exposed workers with hearing impairment). The stimuli, the noisy environment, the work organization, the listening and communication requirements specific to the workplace, as well as the hearing status and other characteristics of individual workers, can prove to be significantly distinct from the methodological elements found in the articles selected for analysis. Briefly stated, the available scientific data do not allow demonstrating clearly that hearing aids can be used to fully support all hearing abilities required to perform work tasks in a safe and autonomous manner. However, neither do the data demonstrate, with any degree of certainty, that the use of hearing aids poses a risk to worker safety.

Other available options?

Given the uncertain impact of hearing aids on the hearing abilities required for safe and effective job performance, a review of alternative or complementary options to hearing aid use was warranted. One such option is the use of powered level-dependent hearing protectors that amplify soft sounds while protecting against loud sounds. Despite

significant technological advancements in the field of level-dependent hearing protectors, and their generally favorable appreciation by workers compared to conventional hearing protectors, it seems that no single device has yet been sufficiently well-designed and demonstrated to fully and reliably restore environmental awareness in all listening conditions to a level obtained without hearing protection. Furthermore, a flexible and personalized adjustment and fitting, based on the hearing-impaired worker's characteristics and needs, remains relatively limited with powered hearing protection, especially when compared to what is possible with hearing aids. It is also difficult to select a specific product that could meet the needs of both the worker and the workplace, given the limited disclosure by manufacturers as to the parameters and operational modes of their products. Hence, before systematically recommending their use to hearing-impaired workers, further studies are required which also take into account various safety issues.

A “good-practice” guide for health care professionals

The multi-pronged research activity, carried out over the past two years, raised more questions than it provided answers. It is however clear that a collaborative and multidisciplinary effort is urgently required to develop a “good practice” guide for the management of hearing-impaired workers in noisy workplaces by hearing health professionals. To reach this objective, at least three research endeavors are anticipated: 1) development of a valid method to assess noise exposure levels with hearing aids, in order to avoid over-amplification, 2) development of an intelligent hearing aid/hearing protector specifically designed for use in noisy workplaces, and thereafter, 3) development and maintenance of a guide to assist in the selection of an adequate device that can play the dual role of protecting hearing and improving listening and communication abilities. Hopefully these projects will be completed in the near future as there is a pressing need for such tools within the community of health care professionals who deal with hearing-impaired workers. And while our research activity focused on the context at play in Quebec, it is foreseeable that similar needs are felt in many industrialized countries.

In conclusion our team currently recommends that health care professionals use the precautionary principle by which hearing aids should only be considered for use in noisy workplaces as a last resort after an initial consideration of noise reduction in the workplace and of all other options. The other options include adaptation of the workstation/workplace to modify the listening, communication and lo-

calization requirements of the job function and to allow, where possible, support from or reliance on other sensory modalities (visual, vibratory). In cases where hearing aids are deemed appropriate, the risk of over-amplification and the worker's safety must be systematically accounted for and

adequately managed by all concerned professionals. In the absence of clear, evidenced-based guidelines, consultation, coordination and cooperation among the various stakeholders is critical to achieve recommendations that do not compromise the worker's health and safety, or that of others.

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