HEARING STANDARDS FOR FISHERIES & OCEANS CANADA

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Introduction The Canadian Coast Guard (CCG) and Conservation & Protection (C&P) departments of Fisheries and Ocean Canada are reviewing their medical standards for safe and effective operations. Task-analysis studies have identified a range of hearing-critical jobs in the CCG and C&P. These jobs are often performed in noise and involve different auditory skills. A sufficient level of auditory performance is needed from each worker to prevent safety risks for the employed personnel and general public. A project was undertaken to develop and validate a protocol suitable for screening CCG and C&P personnel, and to establish hearing standards based on occupational requirements. Currently, decisions are only based on audiograms, which are not sufficiently predictive of occupational performance, especially in noisy workplaces.

Methods The present approach is based on the use of screening measures of functional hearing abilities that can be directly linked to actual performance under the noise conditions and auditory demands for job functions in the CCG and C&P. Based on the task-analysis studies, we assume that performance of hearing-critical tasks in the CCG and C&P are related to skills in speech intelligibility, signal detection and localization. The functional measures retained are the Hearing In Noise Test (HINT) and the Sound Localization In Noise Test (SAINT) [1]. Both tests can be administered over headphones or in the sound field, in quiet and noisy background, and have well-established norms. Two screening versions of these tests are considered: (1) a headphone version, which is generally more reliable, and (2) a sound field version for use when hearing aids or other devices is worn. The HINT is an adaptive sentence intelligibility test performed in speech spectrum noise. The SAINT involves detection and localization of a voice signal in crowd noise, and a gunshot in helicopter noise.

We also assume that the screening versions of the functional tests can be empirically related to the ability to perform auditory tasks in the CCG and C&P noise environments. Validation of this assumption requires acoustic recordings taken onboard vessels and at other locations where hearing-critical tasks are performed. Noise environments are then re-created in the laboratory for controlled listening experiments. The spectral content, level and the diffuse nature of the noise field are reproduced to ensure realistic simulations. The target signals of the screening HINT (speech) and SAINT (voice, gunshot) tests are retained in the simulated listening environments, but the reference noises are substituted by CCG and C&P noises [2]. Statistical modelling is then applied to determine how signal-to-noise ratio (SNR) and scores in the HINT and SAINT screening tests affects auditory performance in the simulated CCG and C&P noise environments. Finally, we utilize appropriate scenarios describing the most critical situations of speech communication, signal detection and localization in the CCG and C&P job functions. These scenarios are required to establish the actual SNR levels in hearing-critical situations.

Results and discussion Noise measurements were made in all hearing-critical environments of the CCG and C&P. Over 112 recordings were made during a wide range marine, air or land operations [2]. Expert panels assisted in grouping the data into 15 environments or locations relevant to CCG and/or C&P personnel. In each location, noise samples were extracted for listening experiments with 45 normal-hearing individuals. Performance-intensity (PI) functions were then derived for speech intelligibility, signal detection and localization tasks in all 15

locations, allowing predictions of the functional abilities to be made among normals in the CCG and C&P noise locations. The slopes of the PI functions were found to be very similar across noise locations, and the data was pooled to obtain a normalized PI functions for each task. Individual PI functions per location were then obtained by shifting the normalized PI function by an amount equal to the estimated SNR for 50% correct performance (i.e., intelligibility, detection, or localization accuracy) at each location.

The left curve in Figure 1 shows the resulting speech intelligibility PI function for an individual with a screening HINT threshold of –6 dB (average normal) at example location X. Across CCG and C&P noise locations, the SNR offset for 50% intelligibility varied from –7 to –15 dB (Location X = -9.5 dB). The right curve shows the PI function for a hypothetical individual with screening HINT thresholds of +2 dB. Intelligibility decrements with elevated HINT thresholds are modelled by shifting the PI function for normals to the right by an amount equal to the threshold elevation of the individual (8 dB in this example).

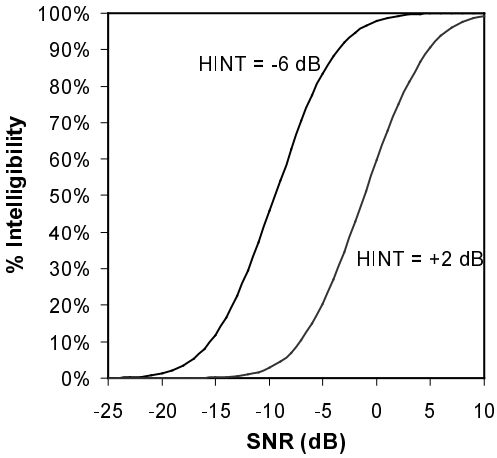

Figure 1: PI functions in Location X

To establish the actual performance in a specific hearing-critical situation, the target signal must be defined. For example, if one assumes sustainable shouted speech at a 1.5-m distance in free field (79 dBA), the actual SNR can be computed for the entire distribution of noise levels at a given location. At location X, the noise level varies from 62 to 85 dBA, which would correspond to a range of SNR from –17 to +6 dB. The compound speech intelligibility score is then calculated from the PI function applicable to each individual given the HINT screening threshold. For location X, the predicted intelligibility is 98% and 75% for the two hypothetical individuals with average normal and elevated HINT thresholds, respectively. It is also possible to use these data to set a minimal level of performance required (say 90%) and determine the HINT screening threshold needed to achieve this level (< -1.2 dB for location X). It is also possible to account for the confidence interval of the HINT screening test (2 dB). The same principles can be applied to critical situations of signal detection and localization.

This approach combines the use of efficient, reliable and sensitive screening measures of functional hearing abilities with an empirically based and validated relationship to predict actual performances in hearing-critical situations. Objective and defendable hearing screening standards are then derived for the CCG and C&P personnel given the minimal level of task performance required [Project funded by Fisheries & Oceans Canada].

Keywords: Noise and communication, Hearing-critical jobs, Task performance.

References

[1] Soli, S.D. & Vermiglio, A. (1999). “Assesment of functional hearing abilities for hearing-critical jobs in law enforcement,” Report for the California peace officers standards and training commission, 29 pp.

[2] Laroche, C., Giguère, C. & Soli, S.D. (2002). “Development and validation of hearing standards for Canadian Coast Guard seagoing personnel and C&P seagoing and land-based personnel Phase II,” Technical Report for CCG/C&P (Stage 2), 34 pp. and appendices.