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Assessment of Functional Hearing Ability

A functional hearing assessment was carried out at the Noise and Communication Unit, Hearing Research Laboratory, at the University of Ottawa. It included, in addition to standard audiologic evaluations, tests of speech perception, sound detection and sound localization. These tests were performed with and without hearing aids, under the protocol "Protocol for the evaluation and analysis of auditory functions for RCMP members", submitted to the RCMP on March 26, 2007. Individual results of the functional assessment tests, summarized in this report, will help the medical team at RCMP in making more informed decisions about the member's operational suitability.

Otoscopy and tympanometry

Upon visual inspection, the external ear canal and eardrum appear normal, bilaterally.

During tympanometry, the air pressure in the external ear canal is increased and decreased to measure eardrum movement, or compliance. Results are classified into 5 types. Type A indicates eardrum and ossicular chain mobility within normal limits. Type A_s refers to reduced compliance, or accrued middle ear stiffness, whereas type A_d represents insufficient middle ear stiffness (high compliance). Type B, a flat tympanogram, indicates little or no eardrum movement, thereby suggesting fluid in the middle ear cavity. Finally, type C refers to negative pressure within the middle ear cavity, possibly attributable to eardrum retraction or Eustachian tube dysfunction.

Results for tympanometry could not be obtained due to an inability to maintain a good seal of the test probe.

Pure tone audiometry

Pure tone audiometry is a measure of hearing sensitivity performed in quiet, for each ear separately. Hearing thresholds, the softest sounds heard by the individual 50% of the time, are measured in air-conduction and bone-conduction. Pulsed pure tones of various frequencies are presented through insert headphones during air-conduction audiometry to assess the global function of the outer, middle and inner ear, whereas a bone conduction vibrator placed on the mastoid (behind the ear) is used to assess inner ear function during bone-conduction audiometry. Hearing thresholds are plotted as a function of test frequency on a graph, the audiogram.

[illegible] audiogram (performed on January 28, 2019 at Connect Hearing [illegible]") for the right ear depicts hearing thresholds within normal limits up to 1500 Hz, followed by a sloping moderate to profound sensorineural hearing loss. In the left ear, hearing thresholds are within normal limits up to 500 Hz, followed by a mild sloping to profound sensorineural hearing loss.

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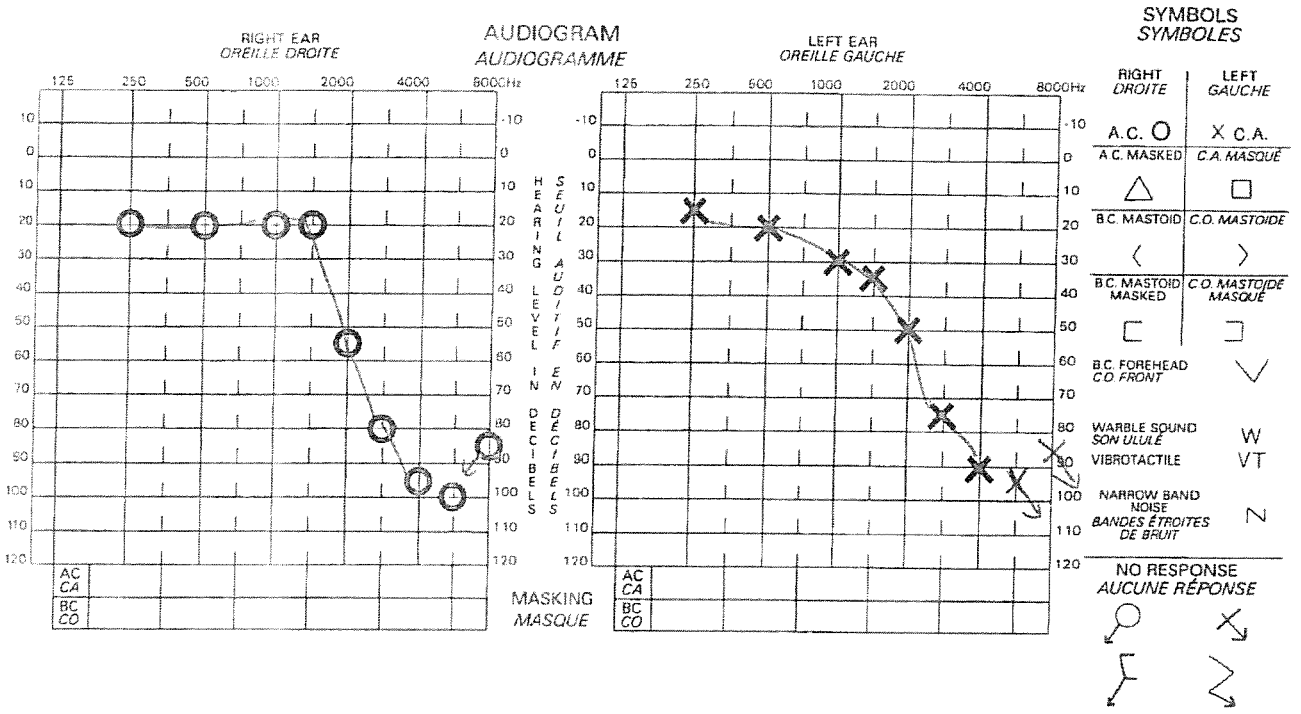

Unaided and aided Hearing in Noise Test (HINT)

The Hearing in Noise Test (HINT – Nilsson et al., 1994; Vaillancourt et al., 2005) is a measure of speech recognition in quiet and in various conditions of noise. Sentences are presented from directly in front of the individual, whereas speech-spectrum noise originates from three distinct locations to form the 4 HINT conditions: 1) speech in quiet (Quiet), 2) noise presented from the front (Noise Front – NF), 3) noise presented from the right (Noise Right – NR), and 4) noise presented from the left (Noise Left – NL). Noise is presented at a fixed level, usually 65 dBA. The level of the sentences is varied based on the individual's responses, being decreased following a correct repetition of the entire sentence and increased following an incorrect repetition.

During the test, the individual is asked to repeat whatever is heard, and to guess if necessary. A different 20-sentence list is presented in each condition to measure the Reception Threshold for Speech (RTS), defined as the presentation level or signal-to-noise ratio (S/N ratio) at which the individual is able to repeat the sentences correctly 50% of the time. Results are expressed in dBA for the quiet condition, corresponding to the average presentation level of the sentences, and in dB S/N for the noise conditions, representing the average level of the sentences relative to the noise level (speech level minus noise level). A Noise Composite score is also computed using the following formula: [(2*NF + NR + NL)/4]. The composite score equally weighs the contribution of directional hearing, as measured in Noise Right and Noise Left, and non-directional hearing, as measured in Noise Front, and represents the overall functional ability of the individual for speech perception in noise under binaural listening conditions.

HINT results are compared to average RTS values obtained in a population of individuals with normal hearing (normative data). A higher than normal RTS indicates that the individual requires a more favourable (higher) presentation level or S/N ratio than the average individual with normal hearing to

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reach the same speech recognition performance. For example, a 4 dB deviation from the average normative RTS suggests that the individual in question would require a presentation level or S/N ratio 4 dB higher than that required by the average individual with normal hearing to reach the same speech recognition performance. In a given noisy setting, the individual with a higher RTS would therefore experience poorer speech recognition than his counterparts with normal hearing.

The RTS value, the percentile value of the score in relation to the normative distribution of scores and a pass/fail recommendation based on the screening criterion are reported for each HINT condition. Aided and unaided RTS values are also compared to document the benefit provided by the individual's hearing aids. The screening criterion for the various noise conditions consists of the 5th percentile performance of individuals with normal hearing. The 5th percentile was chosen as an appropriate criterion as it represents the poorest performances amongst a group of individuals with normal hearing. Typically, the criterion could not be more stringent than the 5th percentile as some people with normal hearing would not be able to meet the required performance level. On the other hand, a more lax criterion cannot be proposed at this point in time, until supported by further work. Given that average speech levels for conversations at 1 meter in quiet conditions are approximately 40, 57 and 65 dBA for whispered, normal and raised speech, respectively, the criterion for the quiet condition was set at 40 dBA, ensuring that RCMP members are able to understand various levels of speech, including whispered speech, at typical conversational distances.

HINT condition – English	Unaided results			Aided results – Program 1 (Automatic)			Aided results – Program 2 (Noise)		
	RTS	Percentile	Pass/ Fail	RTS	Percentile	Pass/ Fail	RTS	Percentile	Pass/ Fail
Quiet (dBA)	41.3	N/A	F	31.8	N/A	P	NT	NT	NT
Noise Front (dB S/N)	0.1	0.391	F	-2.0	36.0	P	-1.8	30.3	P
Noise Right (dB S/N)	-1.4	0.001	F	-5.4	4.3	F	-3.3	0.079	F
Noise Left (dB S/N)	-0.2	0.001	F	-3.6	0.031	F	-3.3	0.008	F
Noise Composite (dB S/N)	-0.4	0.001	F	-3.3	1.4	F	-2.5	0.108	F

Unaided results do not meet the specified criteria in any of the HINT quiet and noise conditions.

In both hearing aid programs used by [redacted], results meet the specified criteria in quiet but not in noise. Aided speech recognition in noise does not meet the specified criterion, as indicated by a Noise Composite score worse than the 5th percentile criterion.

Unaided and aided localization of short duration signal

This procedure is a measure of one's ability to identify the location of a sound that comes from different randomly selected locations behind and to either side. The target stimulus, a 65-dBA broadband noise (0.25-8 kHz) lasting 0.25 seconds, was chosen to represent urgent situations. Twelve loudspeakers placed

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1 meter from the center of the individual's head are used, each loudspeaker being separated from the next by 15°. Localization is tested in three conditions, with the loudspeakers placed behind, to the right and to the left of the individual. Localization in the left/right dimension is assessed in the first condition, whereas localization in the front/back dimension is evaluated in the side conditions.

Localization results are expressed as the number of right/left and front/back confusions. The impact of localization errors on safety depends largely on the type of error committed. While right/left and front/back confusions can significantly impact safety, within-quadrant errors, consisting of confusing adjacent loudspeakers for example, are presumed less critical.

The number of right/left and front/back confusions is compared to the scores obtained by individuals with normal hearing tested in the same test conditions. A pass/fail recommendation based on the screening criterion and the functional gain provided by the hearing aids are also reported. Again, the screening criterion will consist of the 5th percentile performance of individuals with normal hearing until further work is carried out.

Localization condition	Performance criterion	5th percentile	Unaided results		Aided results – Program 1 (Automatic)		Aided results – Program 2 (Noise)	
			Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
Loudspeakers behind	# of R/L confusions	3	0	P	0	P	NT	NT
Loudspeakers to the right	# of F/B confusions	4	6	F	9	F	9	F
Loudspeakers to the left	# of F/B confusions	4	6	F	5	F	5	F

unaided and aided localization performances are good when sound sources are behind, with no left/right errors. However, unaided and aided localization abilities deteriorate when sound sources are to either side, as indicated by more frequent front/back confusions.

Conclusion

Unaided results reveal speech recognition abilities that do not meet the specified criteria in any of the HINT quiet and noise conditions. With hearing aids, results meet the specified criteria in quiet but not in noise.

Unaided and aided sound localization results meet the specified criterion when sound sources are behind (assessing left/right localization), but not when sound sources are positioned to either side (assessing front/back localization), as indicated by frequent front/back confusions.

In closing, it should be noted that modifications to the hearing aids (type, make, model, settings, etc.) could affect performance on any test assessing an individual's hearing abilities. Therefore, results expressed in this report apply solely to the hearing aid settings in effect on the date of this evaluation.