The Effect of Occluding the Ear on Variations in Voice Level and Fundamental Frequency with Changing Background Noise Level and Talker-to-Listener Distance: A Pilot Study

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1. Introduction
Understanding and modeling vocal effort for talkers wearing HPDs could enable the development of new personal radio systems.

2. Objectives
Measure the changes in:
1. speech level
2. fundamental frequency with changing communication distance and background noise level for subjects wearing HPDs.

3. Materials and methods
- 12 test subjects, 5 distances, 3 noise conditions and 2 different quiet conditions;
- Measurement of individual earplug transfer function;
- Assessment of well-fitted earplug;
- Adjustment of the level of background noise under the earplug.

4. Results
A simple model could be further developed to model speech effort as a function of the intended distance.

5. Conclusions
A simple model could be further developed to model speech effort as a function of the intended distance.

6. Funding Acknowledgement

Table 1: Experimental Conditions

<table>
<thead>
<tr>
<th>Ear Condition</th>
<th>Corresponding Ambient Noise (dB SPL)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-occluded</td>
<td>Quiet (&lt; 50)</td>
<td>1, 5, 10, 20, and 30</td>
</tr>
<tr>
<td>Occluded</td>
<td>Quiet (&lt; 50)</td>
<td>1, 5, 10, 20, and 30</td>
</tr>
<tr>
<td>Occluded</td>
<td>70, 80, 90</td>
<td>1, 5, 10, 20, and 30</td>
</tr>
</tbody>
</table>

Figure 1- Intra-aural communication earpiece

Figure 2- An example of the experimental setup with a participant

Figure 3- An example of a transfer function of a well fitted earplug

Figure 4- The spectral and temporal differences between the simulated residual noise under the earplug and the outside noise

Figure 5- Average increase in speech level, \( \Delta_l \), from the occluded quiet condition over increasing distance and noise levels.

Figure 6- Average increase in F0 level, from the occluded quiet condition over increasing distance and noise levels.