

Modeling Speech Production in Noise to Code Vocal Effort for Use with Communication Headsets

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CRITIAS

SONOMAX-ETS INDUSTRIAL
RESEARCH CHAIR IN
IN-EAR TECHNOLOGIES

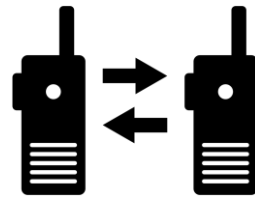


Communication in Noise

Passive HPD

2-Way Personal Radio

Level Dependent HPD



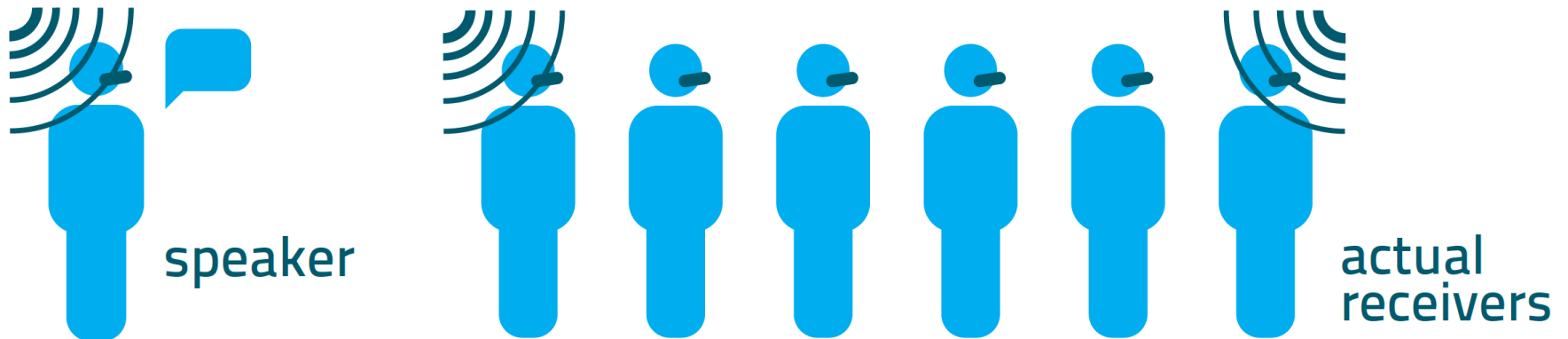
Passive HPD equipped with radio capabilities

Level dependent HPD with 2-Way communication

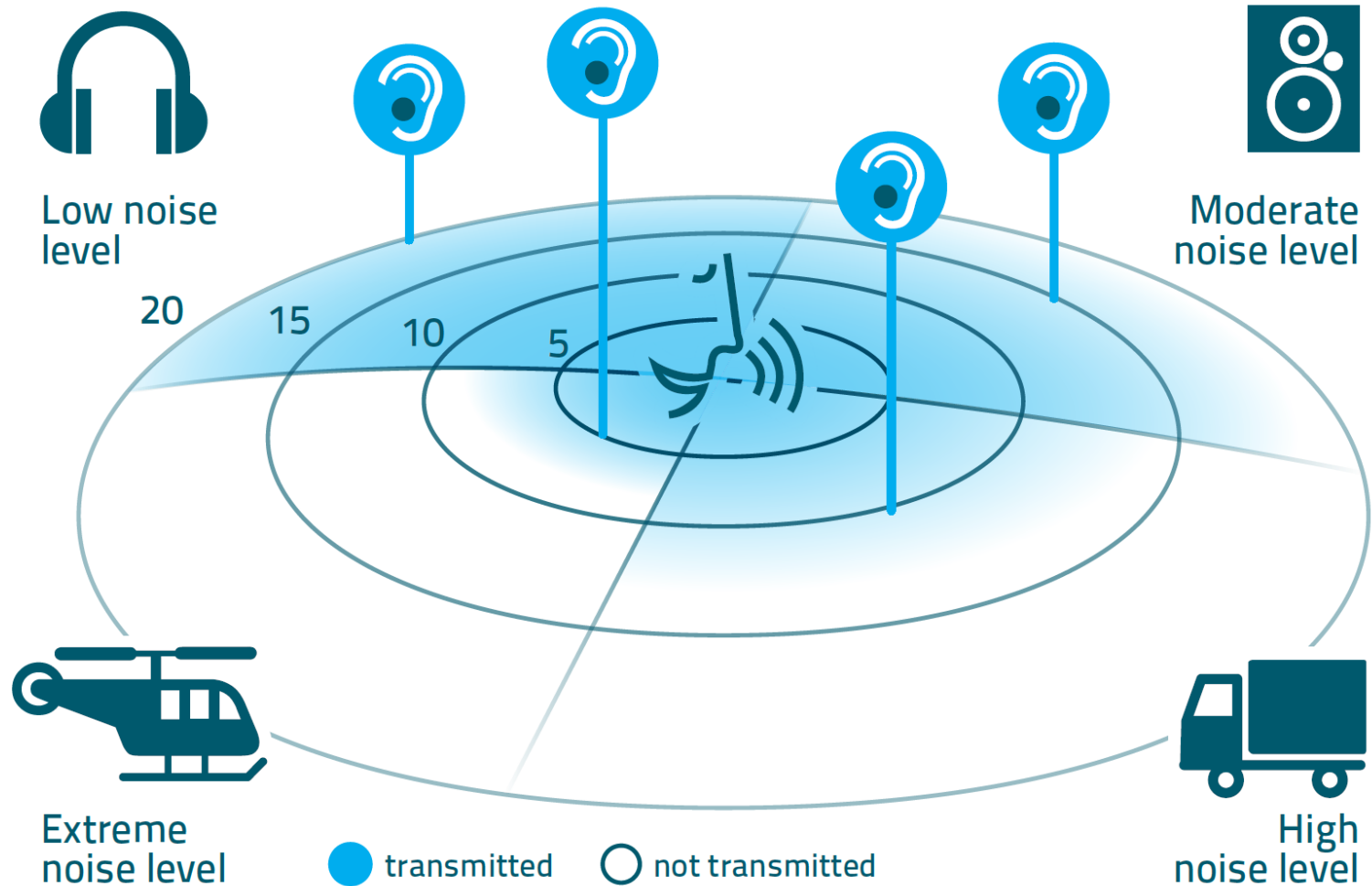


Communication in Noise

No intended Receivers !



Radio Acoustical Virtual Environment

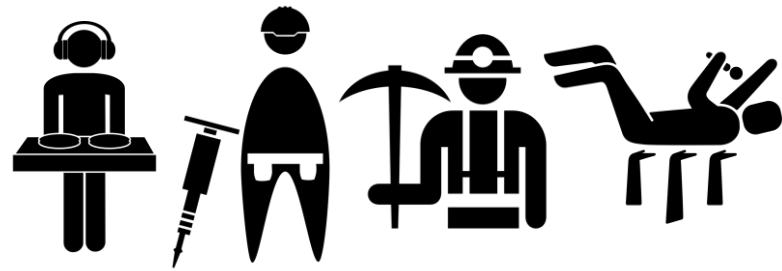


OOO● RAVE

Speech Production

Speakers adjust their vocal effort:

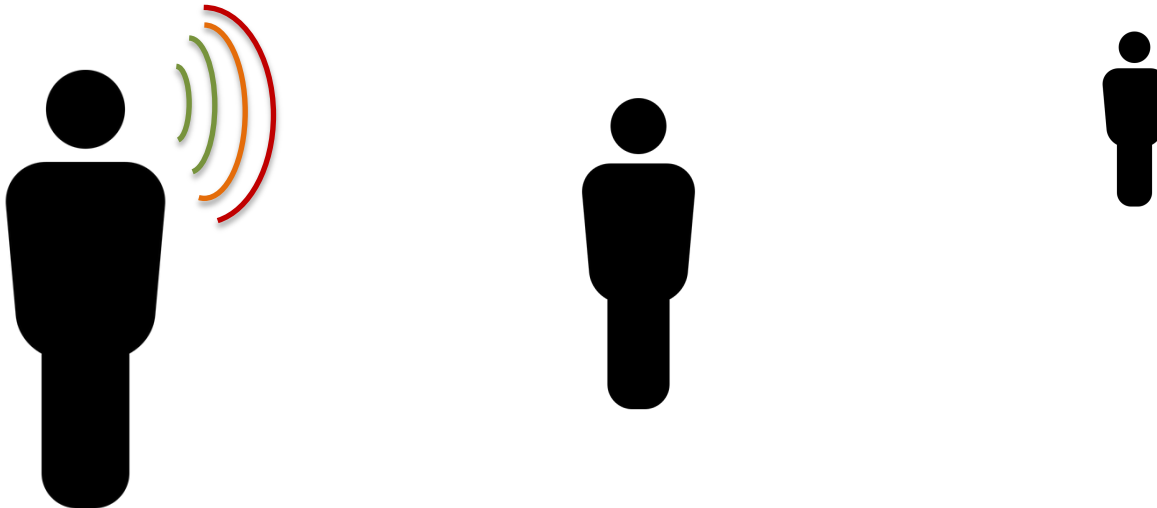
1. In the presence of noise



2. To express emotion



3. To communicate at distances



Speech Production

Open Ear

In Noise :

- ↑ 1-6 dB ↑ 10 dB of noise (Lane and Tranel, 1971)
 - ↑ Fundamental frequency (0.6-2.5 semitones)
 - ↑ Spectral center of gravity
- } (Tufts & Frank, 2003; Lu & Cooke, 2008; Garnier & Henrich, 2014)

With Distance :

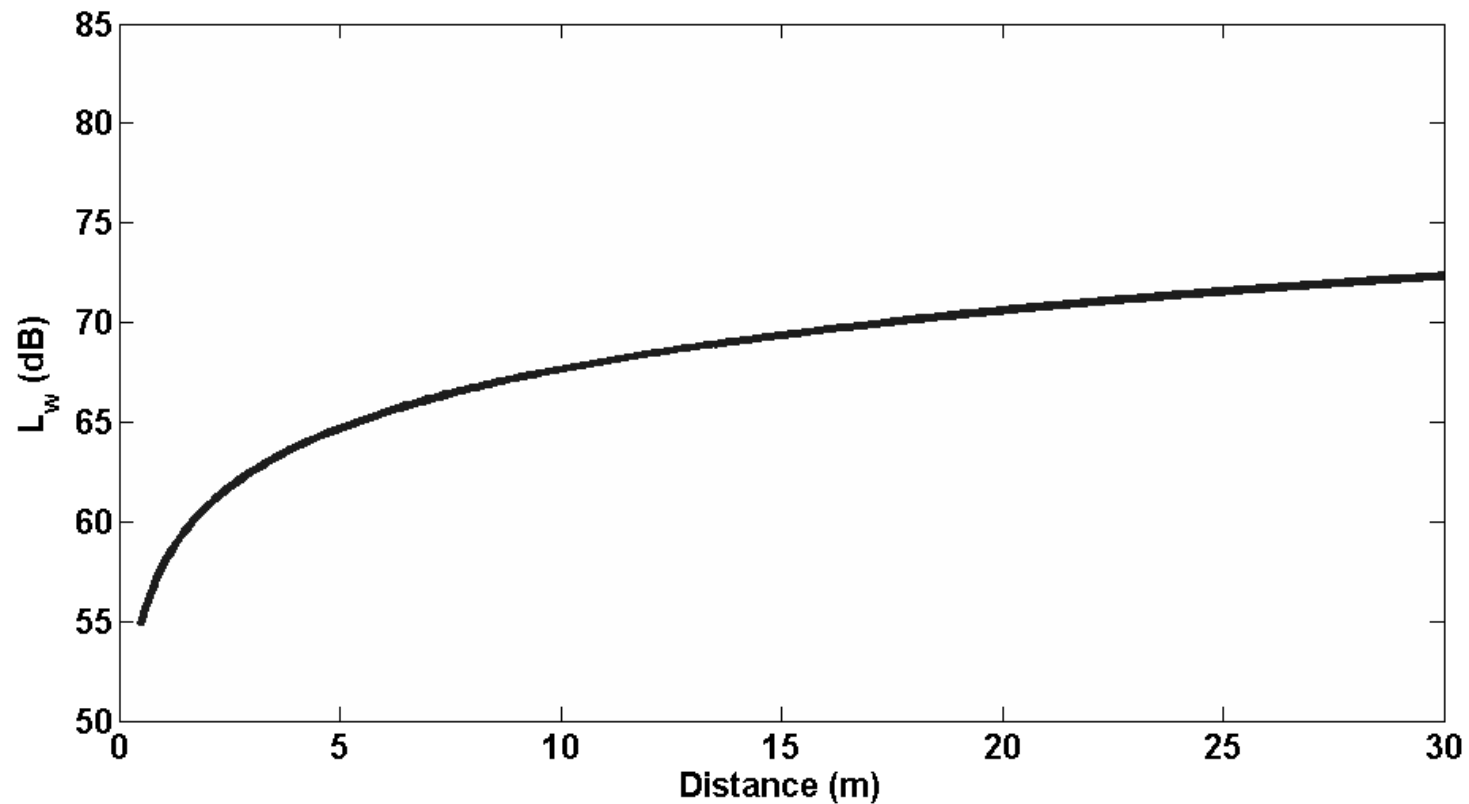
- ↑ 1.3-6 dB as distance doubles (Traunmüller & Eriksson, 2000 ; Pelegrín-García et al. , 2011; Zahorik & Kelly, 2007)
 - ↑ 5 Hz/dB in fundamental frequency
 - ↑ 3.5 Hz/dB in first formant
- } (Liénard & Di Benedetto, 1999)

Speech Production

Open Ear

Distance Model:

$$L_w = 59.54 + 2.96 \times \log_2(d/1.5) \quad (\text{Pelegrín-García et al. , 2011})$$

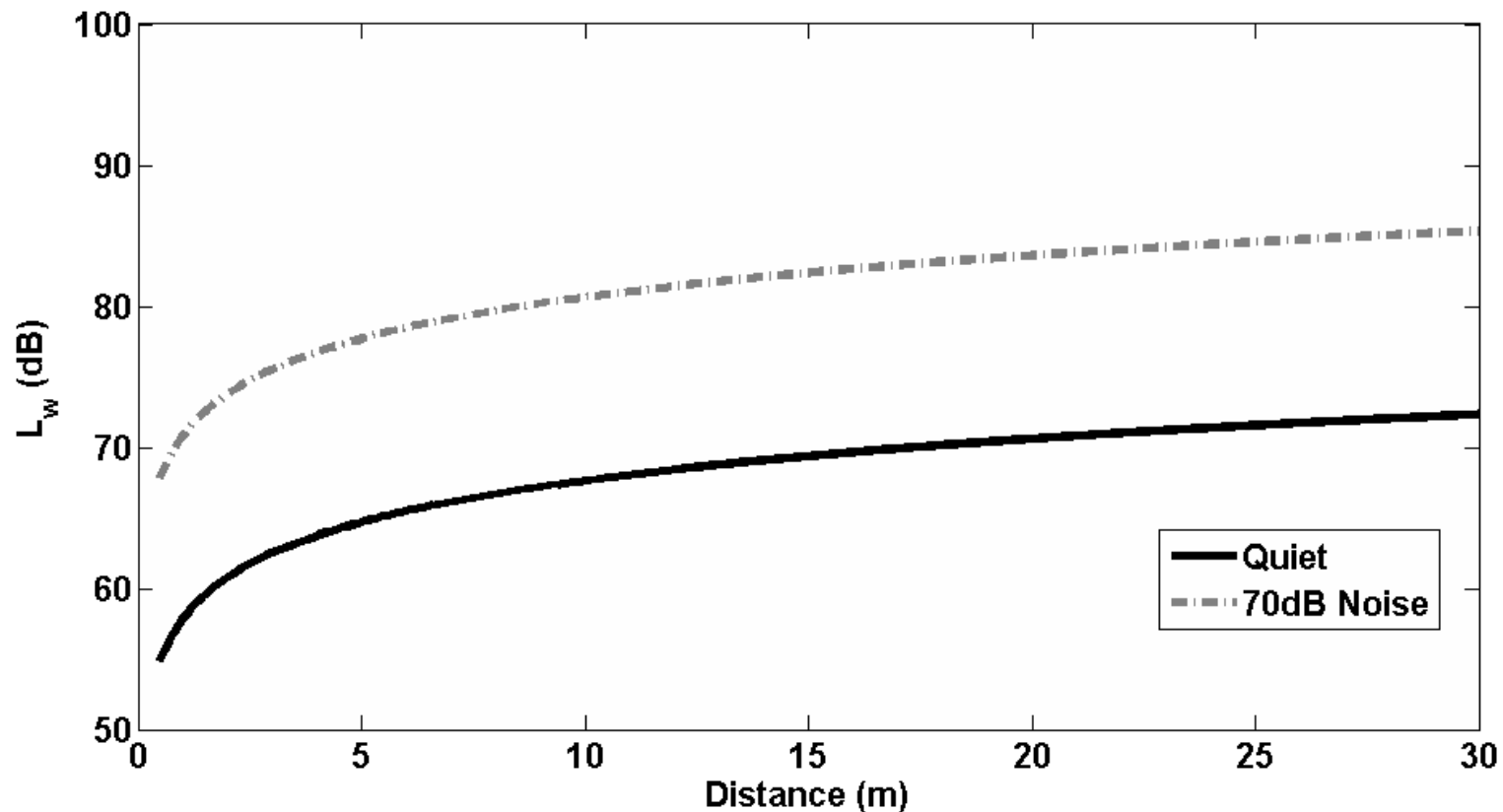


Speech Production

Open Ear

Distance Model in the presence of Noise:

$$L_w = 59.54 + 2.96 \times \log_2(d/1.5) + n \times [10 + 0.3 \times (N - 60)]$$



Speech Production

Occluded Ear

In quiet:

- No significant change in voice level for occluded ear (Tufts & Frank, 2003; Navarro, 1996)

In Noise :

- No significant increase in level at 60 dB noise
 - ↓ 4-11 dB from open ear condition
 - ↑ 1.25 dB for every ↑ 10 dB of noise
- } (Tufts & Frank, 2003)

With Distance :

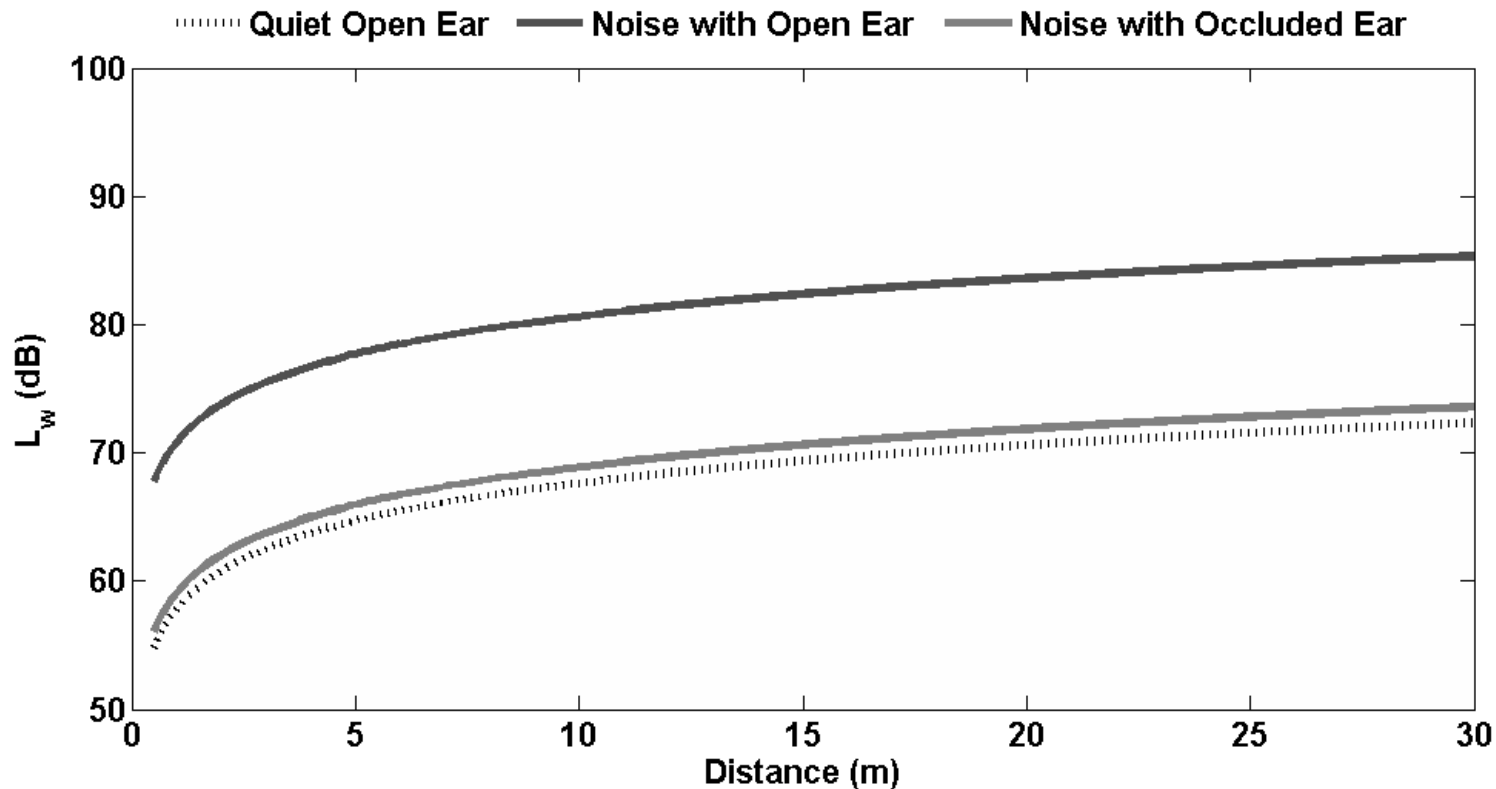
?

Speech Production

Occluded Ear

Distance Model in the presence of Noise for the occluded ear:

$$L_w = 59.54 + 2.96 \times \log_2(d/1.5) + n \times 0.125 \times (N - 60)$$



Speech Production

Occluded Ear

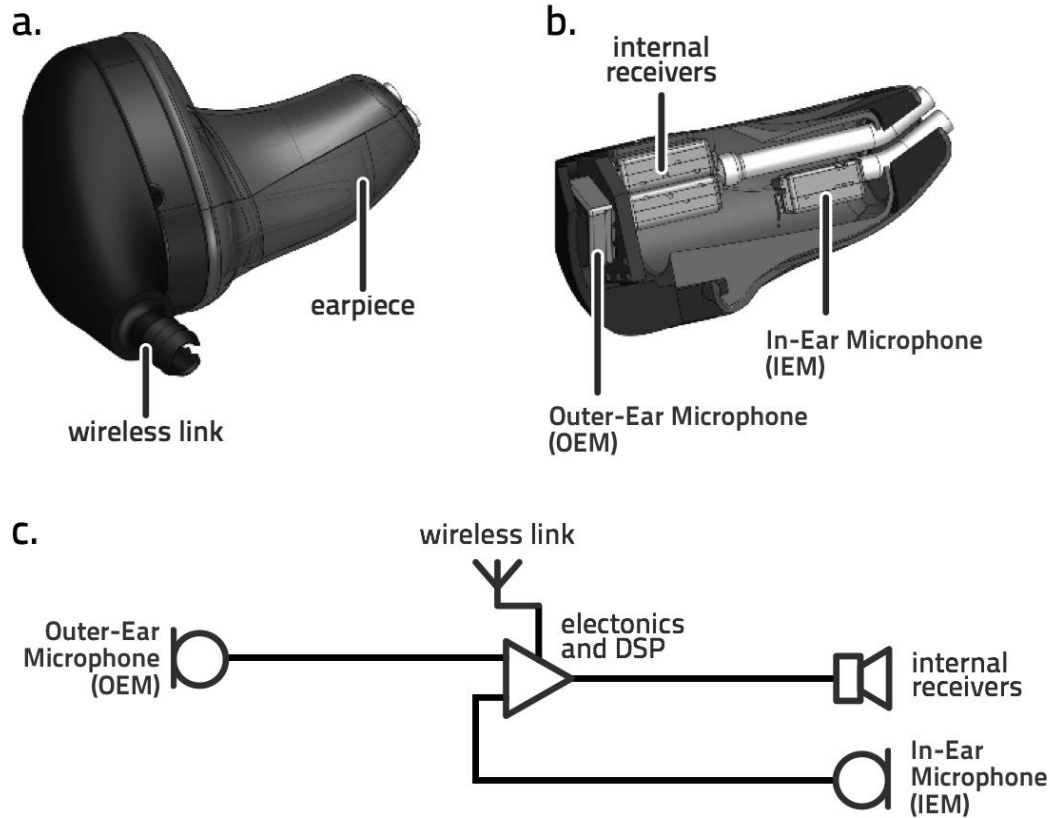
Distance Model in the presence of Noise for the occluded ear:

$$L_w = 59.54 + 2.96 \times \log_2(d/1.5) + n \times 0.125 \times (N - 60)$$

Assumptions:

1. In noise wearing HPDs does not greatly affect the speech production process as a function of the communication distance from the open-ear condition.
1. In quiet wearing HPDs would not affect the speech production process as a function of distance.

Proposed Experimental Protocol



1. It is intra-aural
 - (foam, flange, putty, etc.)
2. IEM, OEM and Miniature loudspeaker
3. RAVE

Proposed Experimental Protocol

- 5 different communication distances:
 - 0.3m, 5m, 10m, 15m, and 20m
- Instruct the listener a color and a digit (repeated 20 times)
 - 20 different times.
 - 4 different colors (Red, Green, Blue, Yellow)
 - 10 different digits (0-9).

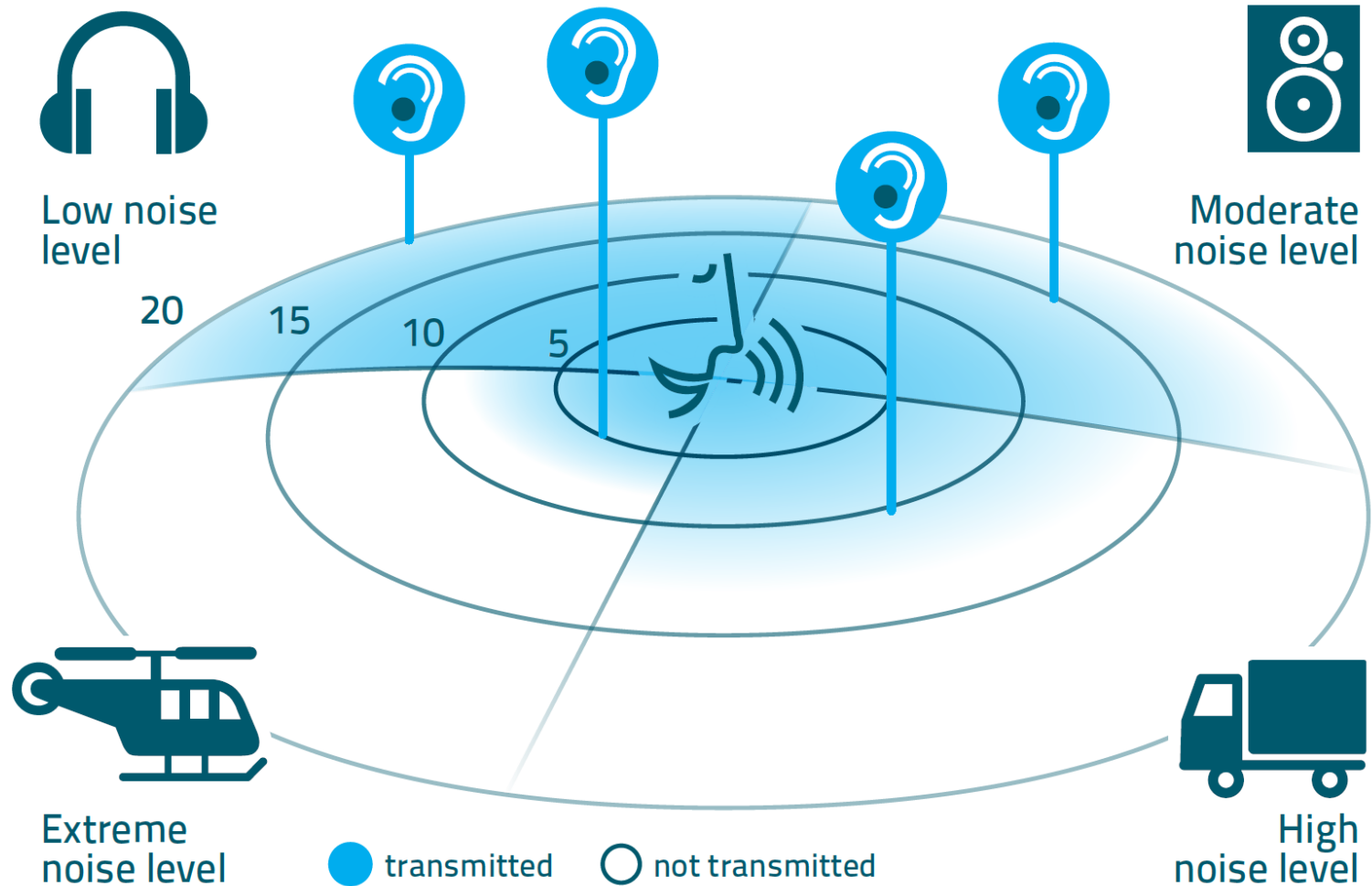
5 conditions:

- in quiet
- in noise ranging from 60 dB to 90 dB
at increments of 10 dB.

Conclusions

- Enhancing communication in noise while using HPDs with personal radios
- Relationship between vocal effort, communication distance and background noise level for occluded ear

Radio Acoustical Virtual Environment



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