Impact of Acoustic Environments on Listening Effort: A Pilot Pupilometry Study

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1. Introduction

Real-life listening conditions for cochlear implant (CI) users often involve background noise, reverberation, and speech interference, which notably impair communication and speech intelligibility compared to normal hearing individuals. Even mild reverberation has an impact on reduced speech intelligibility for CI recipients. Pupillary responses can reflect listening effort [1], with challenging acoustic environments causing pupil dilation. This study explores how vocoded speech, simulating CI listening conditions, impacts listening effort across different acoustic environments, aiming to investigate speech perception under varying acoustic conditions.

2. Methodology

A pilot listening test experiment involved a normal-hearing participant using speech data from The University of Canterbury Auditory-Visual Matrix Sentence Test (UCAMST) [2]. The speech was passed through vocoder to simulate CI sounds with 8 channels [4]. The study replicated acoustic environments in seminar and chapel rooms at distances of 2 and 5 meters using 16 loudspeaker arrays, with speech originating from the front [3]. A Tobii Spark eye-tracker objectively measured peak pupil dilation (PPD). Participants fixated on a screen 50 cm away and typed the words they heard while pupil diameter was recorded. There were 100 stimuli across 10 conditions, each repeated 10 times.

3. Results

Table 1 shows PPD and accuracy across various conditions. Vocoded speech substantially increased PPD, indicating higher listening effort, and reduced accuracy compared to unprocessed speech. Notably, accuracy was lowest in the chapel 5m vocoded condition, with only (20% accuracy). The highest PPD (3.09 mm) occurred in the seminar 5m vocoded condition, highlighting increased listening effort in vocoded auditory environments.

4. Conclusion

Vocoded speech considerably increased listening effort, as shown by higher PPD, and decreased task performance accuracy, particularly in larger rooms and at greater distances. Future studies will include real CI listeners and a more diverse range of acoustic environments to further validate these results.

Table 1: PPD and accuracy across various conditions.

Conditions	PPD (mm)	Accuracy (%)
baseline (unprocessed)	2.98	100
baseline (vocoded)	3.05	90
seminar 2m	2.96	100
seminar 5m	2.87	100
chapel 2m	2.96	100
chapel 5m	2.90	100
seminar 2m (vocoded)	3.03	70
seminar 5m (vocoded)	3.09	80
chapel 2m (vocoded)	3.05	90
chapel 5m (vocoded)	3.07	20

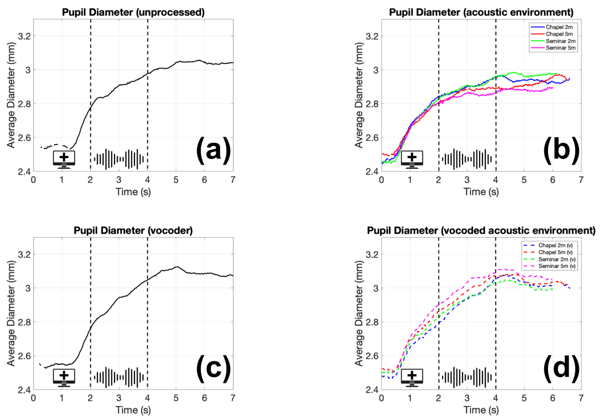

Figure 1: Combined average pupil diameter for: (a) baseline (unprocessed), (b) acoustic simulation, (c) baseline (vocoded), (d) vocoded acoustic simulation.

5. References

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