THE LOMBARD REFLEX AND ITS INFLUENCE ON SPEECH PERCEPTION IN ADULT COCHLEAR IMPLANT USERS

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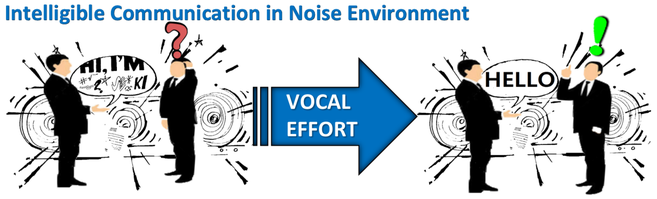
1. Introduction

- **Lombard Effect** - involuntary response a speaker experiences speaking in the presence of noise; cause increase in (E. Lombard, 1911; Hansen, 1996):
  - *Intensity, F0, Speech rate, Spectral slope*
  - *Formant structure, etc.*
- **Previous Study** – cochlear implant (CI) users employed *Lombard effect* during voice communication in challenging listening environments (Lee *et al*, 2015).
- **Goal 1** – Examine the influence of Lombard effect on speech perception of post-lingually deaf CI users.
- **Goal 2** – Investigate how the performance differs from the speech produced in various noisy environments.

Fig1: Intelligible Communication in Noise Environment



2. Stimuli & Subjective Listening Test

Fig. 2: Lombard Speech Collection from NH

- 2 NH speakers participated.
- Produced AzBio sentences (Spar *et al.*, 2012) in 2-way conversation.
- Large crowd (LCR) noise presented at 70 dB, 80 dB, and 90 dB SPL (representing LOM70, LOM80, and LOM90).

Table 1: Biographical Information for CI Participants

Subject	Gender	Age (yrs)	Years of hearing loss	Years implanted	Implant ear	Sound coding strategy
SUB1	Female	62	56	11	Bilateral	ACE
SUB2	Female	66	30	5	Bilateral	ACE
SUB3	Female	59	30	6	Bilateral	ACE
SUB4	Male	69	13	7	Left only	ACE
SUB5	Male	66	55	4	Bilateral	ACE

- 5 post-lingual deaf CI users participated.
- Presented original clean stimuli corrupted by LCR noise at 10 dB and 15 dB SNR.
- Recognition rate was calculated based on the number of words identified.

3. Results

Fig. 3: Acoustic Analysis of Collected Data

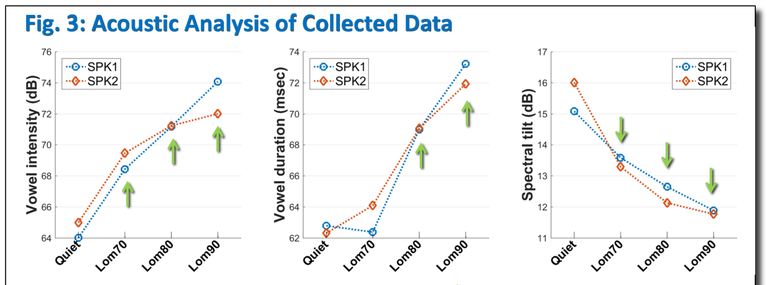
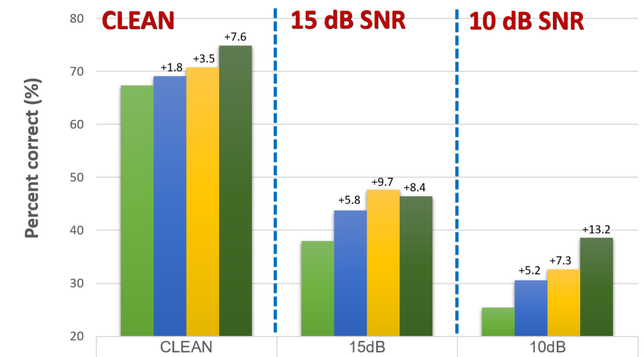


Fig. 4: Average Word Recognition Score of 5 CI Users

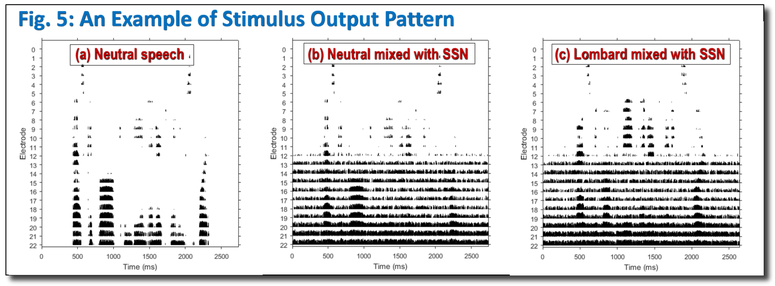


	CLEAN	15dB	10dB
NEUTRAL	67.3	38	25.4
LOM70	69.1	43.8	30.6
LOM80	70.8	47.7	32.6
LOM90	74.9	46.4	38.6

4. Summary & Discussion

- Acoustic/perceptual characteristics of speech under Lombard effect were analyzed.
- Improvement in intelligibility was found when Lombard speech presented to CI users.
- Larger improvements were found when speech was produced in challenging noisy environments (e.g., LOM70 vs LOM90).
- The advantage is also more larger in challenging listening conditions (e.g., 15 dB vs 10 dB SNR).
- The modification of speech production under Lombard effect might contribute to higher intelligibility.

Fig. 5: An Example of Stimulus Output Pattern



5. References

- Lombard, E. (**1911**) “Le signe de l’elevation de la voix [the sign of voice raising]”, Annals des Maladies de l’Oreille et du Larynx 101–119.
- Hansen, J. H. (**1996**) “Analysis and compensation of speech under stress and noise for environmental robustness in speech recognition”, Speech Communication **20**, 151–173.
- Lee, J., Ali, H., Ziaei, A., Hansen, J. H. (**2015**) “Analysis of speech language communication for cochlear implant users in noisy Lombard conditions,” *IEEE ICASSP*, Brisbane, Australia, April, 2015.

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