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Binaural Hearing and Speech Laboratory

INTRODUCTION

It has been shown repeatedly that pulse-rates used in clinical Cochlear Implant (CI) processors are high enough to represent the speech envelope, but too high for bilateral CI (BiCI) patients to utilize interaural time differences (ITDs)...

Limitations due to the pulse rate

Table comparing High rates (> 900 pps) and Low rates (< 300 pps) with envelope sampling and ITD sensitivity.

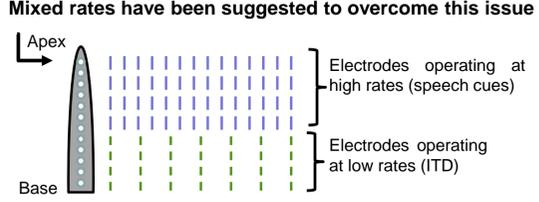


Fig. 1 Illustration of a mixed rate strategy. The four most apical electrodes operate at high rates while the four basal electrodes operate at low rates

Previous work by authors from this lab investigated the potential of a multi-electrode, mixed-rate strategy. BiCI patients were sensitive to ITDs when a combination of high and low rates was presented to different electrodes...

STUDY AIM

Does the mixed-rate strategy allow listeners to access both speech and ITD cues, and enable binaural unmasking?

- Does it depend on how speech and ITD cues are distributed across frequency channels?
Does it depend on the signal-to-noise ratio (SNR)?

METHODS

- Listeners: 19 Normal hearing listeners in separated into 3 mixed-rate groups (7 Apical High, 8 Basal High, 4 Interleaved; Aiming for 10 in each group)
Vocoded stimuli presented over circumaural headphones
Implementing the mixed rates into a Tone Vocoder (16 channels)

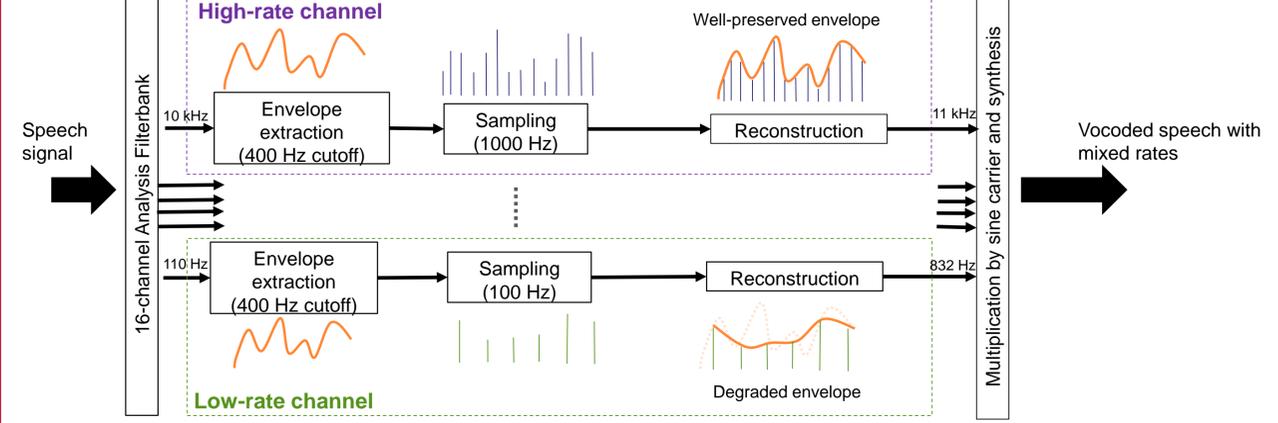
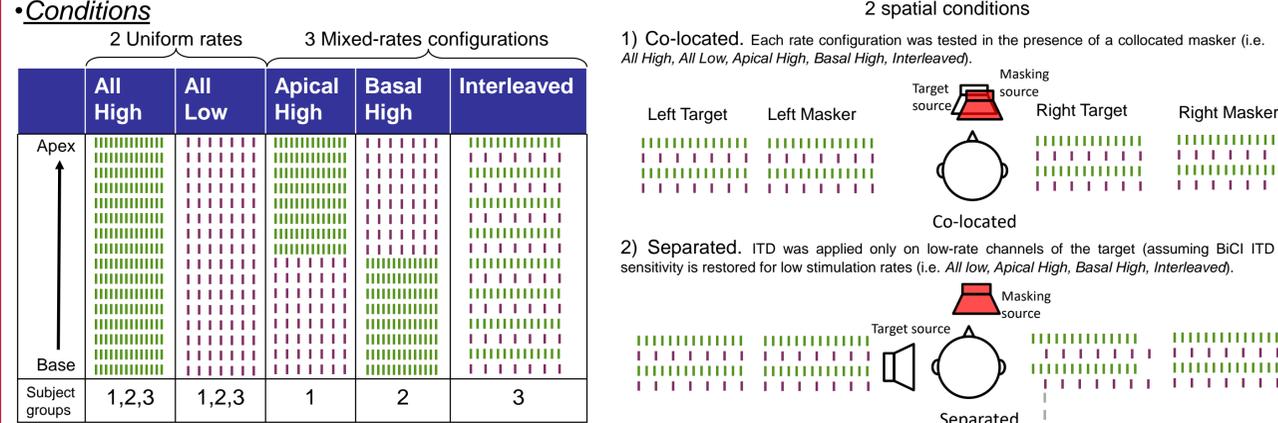


Fig. 2 Mixed rates were simulated by downsampling the envelope at a high or low rate depending on the channel. This resulted in a well-preserved or degraded envelope in high-rate (in purple) and low-rate (in red) channels, respectively.



- Procedure: Consonant Nucleus Consonant words test (closed set of 50 words, Fig. 3)
Speech-Shaped Noise maskers

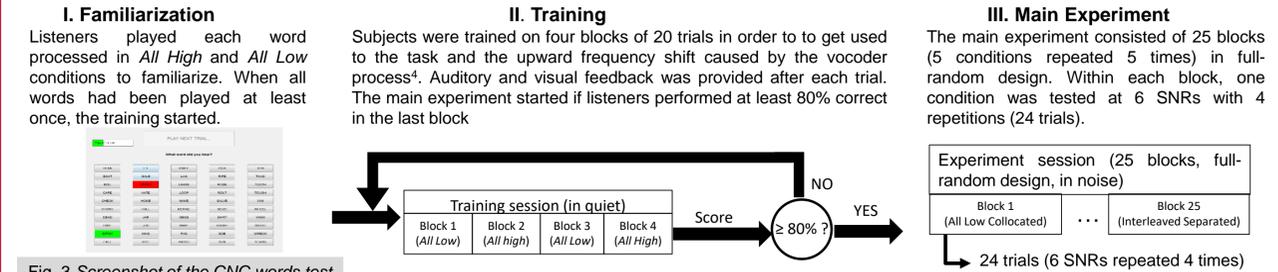


Fig. 3 Screenshot of the CNC words test

RESULTS

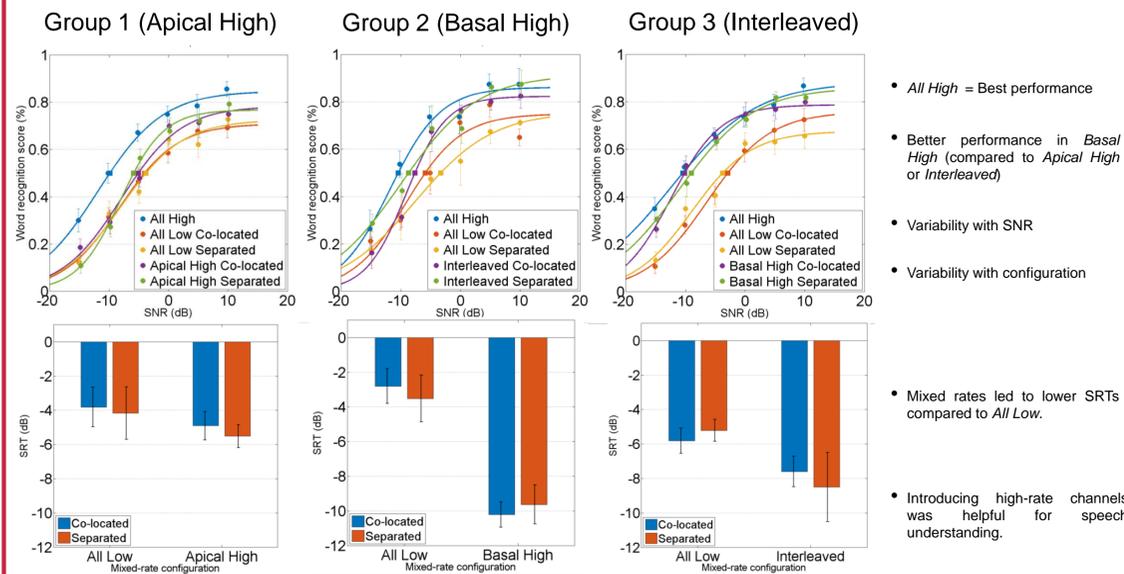


Fig. 4 Top row: Recognition scores averaged across listeners for each subject group (columns) as a function of SNR (X-axis) and mixed-rate configuration (color). Bottom row: averaged Speech Reception Thresholds (SRT; SNR for 50% intelligibility) across listeners in the All Low and mixed-rate configurations in the co-located (blue) and separated conditions (red).

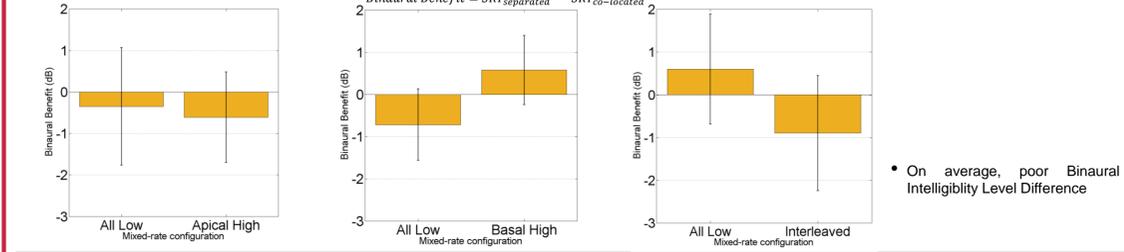


Fig. 5 Averaged Binaural Benefits across listeners computed as the difference in SRTs obtained in the separated and co-located conditions in each mixed rate configuration (X-axis) and for each group (panels).

DISCUSSION

Most of the time, highest scores were observed in the All High condition, when the envelope is the best preserved. In many cases, NH listeners could exploit the presence of ITDs in some frequency channels to improve their word recognition. This suggests that listeners could access and process both speech and binaural cues in order to unmask the target signal...

- 1) Ceiling Effect: For high SNRs, the benefit due to ITDs is very limited.
2) No phase locking: ITDs were introduced at frequency channels too high for NH listeners.
3) No integration of speech cues: the target signal heard spatially separated from the noise contains degraded envelopes.

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