Modelling Speech Intelligibility in Hearing-Impaired Listeners

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Introduction

Hearing-impaired listeners typically show decreased speech intelligibility in noisy environments. Hearing losses have been quantified in terms of reduced sensitivity and reduced spectral as well as temporal resolution.

To find effective ways to compensate for a hearing loss, a better understanding of the relationship between basic psycho-acoustical measures and the deficits to understand speech of hearing-impaired listeners would be helpful.

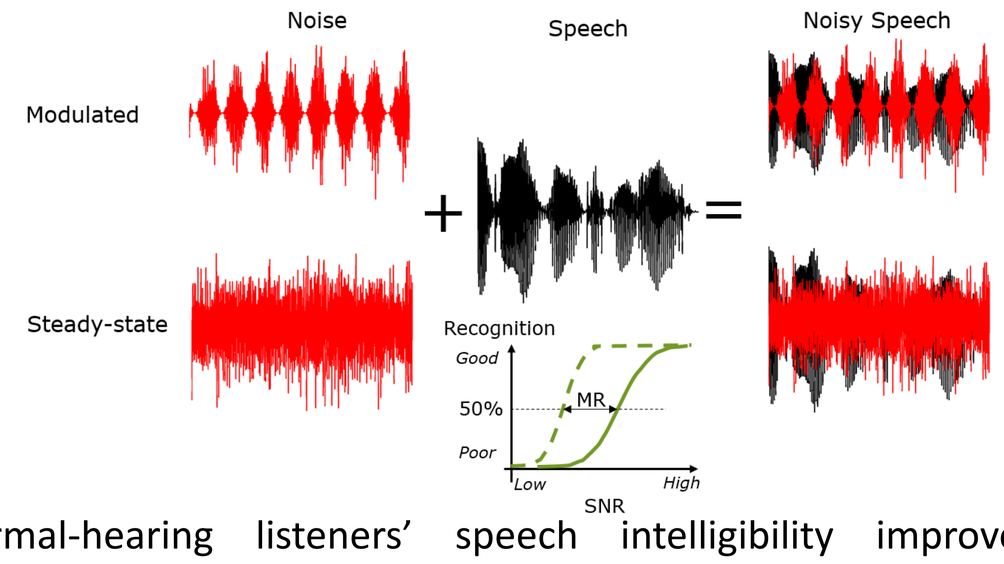
One speech understanding deficit in hearing-impaired listeners is their decreased masking release (MR) in fluctuating noise.

This work investigates the relationship of psycho-acoustical measures and the decreased MR in a model framework.

Hypothesis

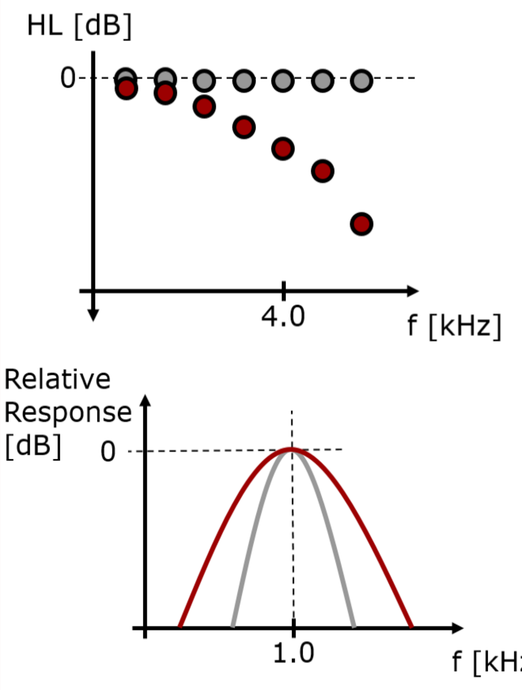
A speech intelligibility model can help to quantify the causes for reduced masking release obtained in hearing-impaired listeners.

Masking Release: Improvement of Speech Intelligibility



Normal-hearing listeners' speech intelligibility improves in fluctuating noise as compared to steady-state noise. The release in hearing-impaired listeners is smaller (Festen and Plomp, 1990).

Psycho-Acoustical Measures and Masking Release



Sensitivity is reduced in hearing-impaired listeners (●) compared to normal-hearing listeners (●). Several studies have established a link between sensitivity loss and reduced masking release (e.g. Bernstein and Grant, 2009)

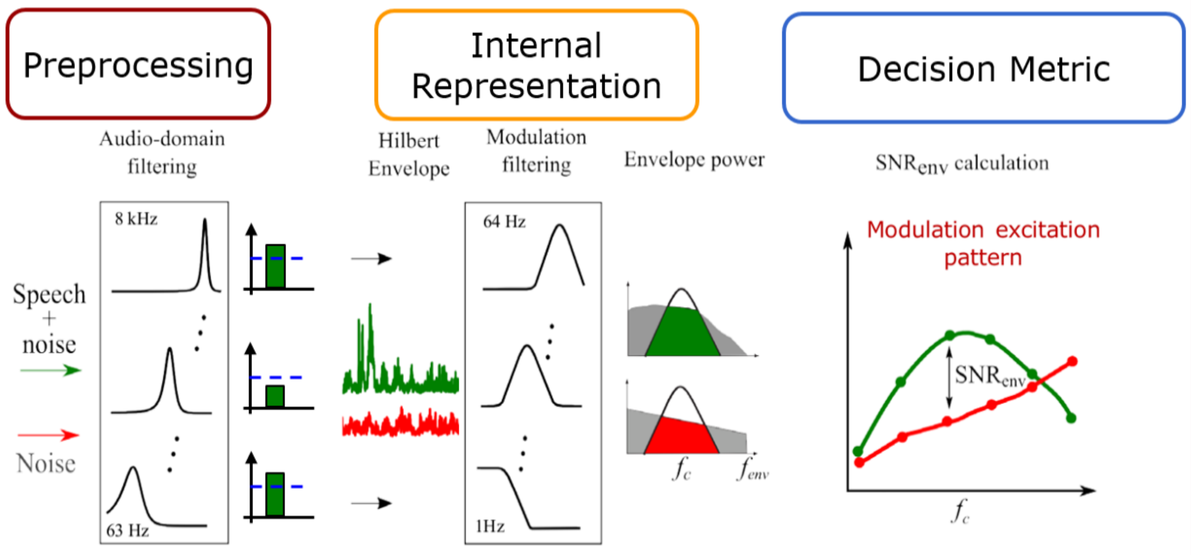
Spectral resolution in hearing-impaired listeners (—) compared to normal-hearing listeners (—) decreases. It has been argued to affect masking release; however, no correlation has been established (e.g. Strelcyk and Dau, 2009).

Temporal resolution in hearing-impaired listeners is affected. Increased forward masking as well as a deficit in temporal fine structure (TFS) processing have been observed.

A correlation between temporal resolution and speech intelligibility in fluctuating noise has been established (e.g. Hou and Pavlovic, 1994). The degree to which reduced temporal resolution is responsible for the reduced masking release is not clear.

Speech-Based Envelope Power Spectrum Model

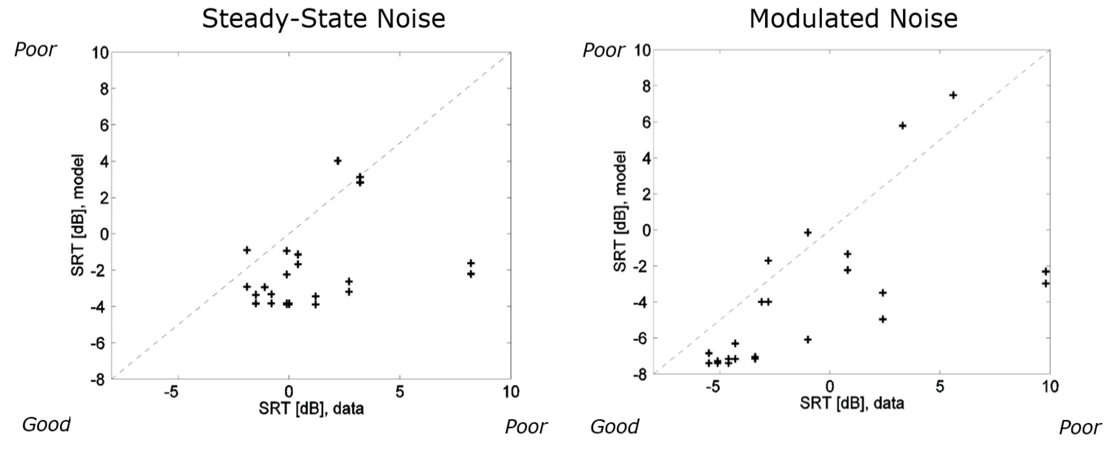
The speech based envelope power spectrum model (sEPSM; Jøregensen *et al.*, 2013) predicts speech intelligibility based on a SNR in the envelope domain. After a peripheral filter bank the envelope of each channel is extracted and put through a second filter bank called the modulation filter bank. A SNR in this domain is used as a decision metric to judge speech intelligibility.



Results

The speech based envelope model with an incorporated sensitivity loss is able to predict masking release accurately (±1dB in all but 4 out of 28 cases).

However, both the steady-state and modulated thresholds are predicted as too good (too low). Further details of a hearing loss need to be accounted for in the model to accurately predict these thresholds.



Conclusions

MR predictions are accurate solely based on a modeled loss of sensitivity

- Steady-state and modulated noise predictions are not

Future: Improve Steady-state and modulated predictions

- by incorporating other hypotheses (e.g. spectral resolution).
- by improving the integration stage of the model to also account for band limited speech in normal-hearing listeners.

References

Festen and Plomp, 1990: "Effects of fluctuating noise and interfering speech on the speech-reception threshold for impaired and normal hearing", JASA.

Bernstein and Grant, 2009: "Auditory and auditory-visual intelligibility of speech in fluctuating maskers for normal hearing and hearing-impaired listeners.", JASA.

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Jøregensen *et al.*, 2013: "A multi-resolution envelope-power based model for speech intelligibility", JASA.

Acknowledgement

The work leading to this deliverable and the results described therein has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement n° PITN-GA-2012-317521.