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Spectro-temporal modulation sensitivity and discrimination in normal hearing and hearing-impaired listeners

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Introduction

When a signal varies in its properties along the time and frequency, this is considered a modulation. Speech signals exhibit temporal and spectral modulations. The sensitivity to these modulations has been studied in normal-hearing (NH) listeners, yielding temporal, spectral and spectro-temporal modulation transfer functions (Dau et al. 1997, Edain & Bero 2007, Chi et al. 1999). Recently, Mehraei et al. (2014) showed significant differences between normal-hearing and hearing-impaired (HI) listeners in spectro-temporal modulations (STM) detection and also the relation between STM sensitivity to speech intelligibility in noise. Moreover, Henry et al. (2005) showed large differences in STM discrimination tasks. The present study attempted to establish the limits of STM perception in NH listeners and two groups of HI (with either good or poor speech intelligibility).

Motivation

The reduced STM sensitivity in HI listeners has been ascribed to temporal fine structure processing deficits and a loss of frequency selectivity (Bernstein et al. 2013, Mehraei et al. 2014). The main assumption of this study is that the individual differences in STM sensitivity can be related to the existence of supra-threshold distortions (Plomp, 1986).

Research Questions

Q1: Where are the limits of STM perception in NH listeners for narrow-band noise carriers?
Q2: Can supra-threshold distortions be characterized by STM detection thresholds?

Experiment I: Limitations in STM sensitivity and discrimination in NH listeners

Method

Subjects: 15 Young NH listeners
Procedure: 3ACF, 1 up 2-down
Stimuli: Level: 35 dB SL
Modulated 1 octave band

Results

Fig. 2: A) Detection thresholds for temporal (TMD), spectral (SRD) and spectro-temporal modulations (STM). The STM thresholds were lower (better than) only TMD
B) Spectro-temporal ripple discrimination (STRD) and Spectral (SRD) ripple discrimination for 1-octave band modulated noises.

There was no significant difference for this frequency conditions. STRD threshold was lower and was found less suitable for a clinical set-up.

Experiment II: Spectro-temporal modulation sensitivity and hearing deficits

Method

Subjects: 23 subjects were divided in three groups by means of the SICQ* questionnaire for Speech: 5 NH, 9 HIa, 9 HIB

STM detection:
- 2 conditions: 1 kHz, f1 = 4 Hz
- 4 kHz, f1 = 4 Hz
- 8 kHz, f1 = 4 Hz
- 16 kHz, f1 = 4 Hz

Level: SPR = 30 dB + 20 Log
- 3 JFC, 1 up 3-down procedure

TM detection:
- Same frequencies (1 and 4 kHz) and f1 (4 kHz)

Results

Fig. 3: STM sensitivity individual results (ears) for the NH, HIa and HIB groups. Results at 0 dB show the subjects which were not able to perform the test.
- No condition at 4 kHz, HIa presented reduced STM thresholds. HIB showed a difference with NH of 9 dB and 11 dB of 12
- There was a significant difference between the two HI groups (p<0.05) at 4 kHz but not at 1 kHz.
- Some of the subjects were not able to detect the STM in both conditions.

Conclusion

In the present study the HI listeners were divided in two groups by means of the SICQ questionnaire. Significant differences were observed between the two groups in STM. Overall, these results suggest that the two groups may be affected by different impairments. Within the Better HiEaring Rehabilitation (BEAR) project, a new battery test will provide information about the hearing deficits beyond the audiological. The results from the present study suggests that spectro-temporal modulation detection might be a good candidate for characterizing hearing deficits towards a clinical profiling.

References
