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 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, Edin & 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 modulation detection and also the relation between STM sensitivity to speech intelligibility in noise. Moreover, Henry et al. (2005) showed large differences in STM in noise tasks. The present study attempted to establish the limits of STM perception in NH listeners and two groups of HI listeners (with either good or poor speech intelligibility).

Method

Subjects: 15 Young NH listeners
Procedure: 3AFC, 1 up 2-down
Stimuli: Level: 35 dB SL
Modulated 1 octave
- f = 1 kHz
- f = data
f = 6 kHz
- f = data
- f = 6 kHz

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

- f2 = 4 Hz
- f2 = 6 kHz
- 3 IFC, 1 up 3-down procedure

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

Results

Hearing Profiles

Profile A:
- Speech Spatial Quality hearing scale (SSQ) higher than the average. (4.4)
- Hearing loss and communication handicap is captured by the audiogram

Profile B:
- SSQ lower than average
- A speech communication handicap is expected
- Worse frequency and temporal resolution may lead to supra-threshold distortions

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?

Conclusion and Outlook

In the present study the HI listeners were divided in two groups by means of the SSQ chain. 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 hiAring Rehabilitation (BEAR) project, a new battery test will provide information about the hearing deficits beyond the audiogram. 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.

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

Method

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

STM detection:
- 2 conditions:
  - 1 kHz f = 4 Hz
  - 4 kHz f = 4 Hz

- f2 = 4 Hz
- f2 = 6 kHz
- 3 IFC, 1 up 3-down procedure

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

Results

Hearing Profiles

Profile A:
- Speech Spatial Quality hearing scale (SSQ) higher than the average. (4.4)
- Gatehouse & Noble, 2004
- Hearing loss and communication handicap is captured by the audiogram

Profile B:
- SSQ lower than average
- A speech communication handicap is expected
- Worse frequency and temporal resolution may lead to supra-threshold distortions

Experiment II: Spectro-temporal modulation sensitivity and hearing deficits

Method

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

STM detection:
- 2 conditions:
  - 1 kHz f = 4 Hz
  - 4 kHz f = 4 Hz

- f2 = 4 Hz
- f2 = 6 kHz
- 3 IFC, 1 up 3-down procedure

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

Results

Hearing Profiles

Profile A:
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Discussion

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?

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