Human Cortical Representations of Simultaneous Fast FM and Slow AM

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Complex Modulations in Speech

Envelope

Spectrogram

Time (s)

Frequency (Hz)

0
0.1
0.2
0.3
0.4

0
4k

Computational Sensorimotor Systems Laboratory
Complex Modulations in Speech

Envelope

Fine structure

Spectrogram

Time (s)

Frequency (Hz)

0 0.1 0.2 0.3 0.4

0 4k
Our Stimuli

Envelope
- AM rate: 3.1 Hz

Fine structure
- FM rate: 37.7 Hz
- AM rate: 0.3, 0.7, 1.7, 3.1, 4.9, 9.9, 13.8 Hz
- FM rate: 37.7 Hz
- FM range: 220 Hz to 880 Hz
MEG Response to Temporal Modulations

Acoustic Stimulus

AM at 3 Hz

Cartoon Neural Response Measured by MEG

3 Hz phase locked oscillation

Fourier Transform

Power spectrum of MEG response

1 Hz  3 Hz  5 Hz
MEG Response to Temporal Modulations

**Acoustic Stimulus**
AM at 3 Hz

**Cartoon Neural Response Measured by MEG**
3 Hz phase locked oscillation

- Fourier Transform
- Power spectrum of MEG response
  - 3 Hz
Neural response to our stimuli

Power Spectrum

AM rate = 3.1 Hz, FM rate = 37.7 Hz
Neural response to our stimuli

Power Spectrum

AM rate = 3.1 Hz, FM rate = 37.7 Hz
Neural response to our stimuli

Power Spectrum

AM rate = 3.1 Hz, FM rate = 37.7 Hz
Neural response to our stimuli

Power Spectrum

AM rate = 3.1 Hz, FM rate = 37.7 Hz
Interactions between Neural Responses

AM rate = 3.1 Hz, FM rate = 37.7 Hz

Spectrogram
Dual neural representations of slow AM

Response at AM rate

AM rate = 3.1 Hz, FM rate = 37.7 Hz
Phase & Latency of responses to AM

Response at AM rate

slope $\approx 100$ ms

- individual subjects
- grand average
- linear fit
Phase & Latency of responses to AM

Response at AM rate

Power Fluctuation of the Response near FM rate

slope $\approx 100$ ms

slope $\approx 50$ ms
Power of responses to AM

Response at AM rate

Power Fluctuation of the Response near FM rate

- Power (dB)
- Stimulus AM rate (Hz)

• grand average
• individual subjects
Distinct Neural Representations of AM and FM

FM rate: 37.7 Hz
AM rate: 3.1 Hz

AM rate: 37 Hz
FM rate: 3 Hz

Neural Response Spectrogram

(Ding & Simon, 2009)
(Luo et al. 2006)
Distinct Neural Representations of AM and FM

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Neural Response Spectrogram

(Ding & Simon, 2009)
(Luo et al. 2006)
Summary

- Both slow (<15 Hz) and fast (~40 Hz) temporal modulations are represented by phase locked neural responses.

- Slow modulations are represented not only at the slow modulation rate but are also incorporated in the representation of the faster modulation.

- AM and FM have distinct cortical representations.
Thank you!