Human Cortical Representations of Simultaneous Fast FM and Slow AM

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Complex Modulations in Speech

Envelope

Fine structure
Complex Modulations in Speech

Envelope

Fine structure
Our Stimuli

Carrier: 550 Hz pure tone

\[ f_{AM} = 0.3, 0.7, 1.7, 3.1, 4.9, 9.9, 13.8 \text{ Hz} \]

\[ f_{FM} = 37.7 \text{ Hz} \]
Neural response to our stimuli

• 1. Neural representation of fast FM (at $f_{FM}$)?
• 2. Neural representation of slow AM (at $f_{AM}$)?
• 3. Interactions between neural representations of fast FM and slow AM?
MEG Response to Temporal Modulations

**Acoustic Stimulus**

AM at 3 Hz

**Cartoon Neural Response Measured by MEG**

3 Hz oscillation phase locked to the stimulus

-down arrow-

**Fourier Transform**

Power spectrum of the response

1 Hz 3 Hz 5 Hz
Neural response to our stimuli

Power Spectrum

\[ f_{\text{AM}} = 3.1 \text{ Hz}, \quad f_{\text{FM}} = 37.7 \text{ Hz} \]
Neural response to our stimuli

$\phi_{AM} = 3.1 \text{ Hz}, \quad \phi_{FM} = 37.7 \text{ Hz}$
Neural response to our stimuli

$\dot{f}_{AM} = 3.1 \text{ Hz, } \dot{f}_{FM} = 37.7 \text{ Hz}$
Neural response to our stimuli

$\dot{f}_{AM} = 3.1 \text{ Hz}, \quad \dot{f}_{FM} = 37.7 \text{ Hz}$
Interactions between Neural Responses

- Neural responses at $f_{FM} \pm f_{AM}$, $f_{FM} \pm 2f_{AM}$ indicate the power or phase of the neural response at $f_{FM}$ is fluctuating with fundamental frequency $f_{AM}$.

\[ f_{AM} = 3.1 \text{ Hz}, \quad f_{FM} = 37.7 \text{ Hz} \]
Neural Response at $f_{FM}$

- The power rather than phase locking of the neural response at $f_{FM}$ decreases with increasing $f_{AM}$. 

![Graph showing neural response at $f_{FM}$ and $f_{AM}$]
Neural representations of Complex Modulations

• 1. The properties of slow Amplitude Modulations are represented by not only the neural response at $f_{AM}$ but also the temporal dynamics of the neural response at $f_{FM}$.

• 2. The properties of slow Amplitude Modulations affect the neural representation of fast Frequency Modulation, but only in magnitude, not in reliability (phase-locking).
Thank you!
Neural Response at $f_{AM}$

- The power rather than phase coherence of the neural response at $f_{AM}$ decrease with increasing $f_{AM}$, consistent with previous studies on modulation transfer function.