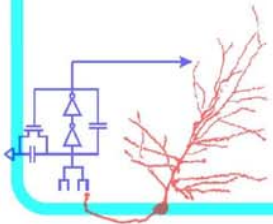


Human Cortical Representations of Simultaneous Fast FM and Slow AM

Nai Ding, Jonathan Z. Simon

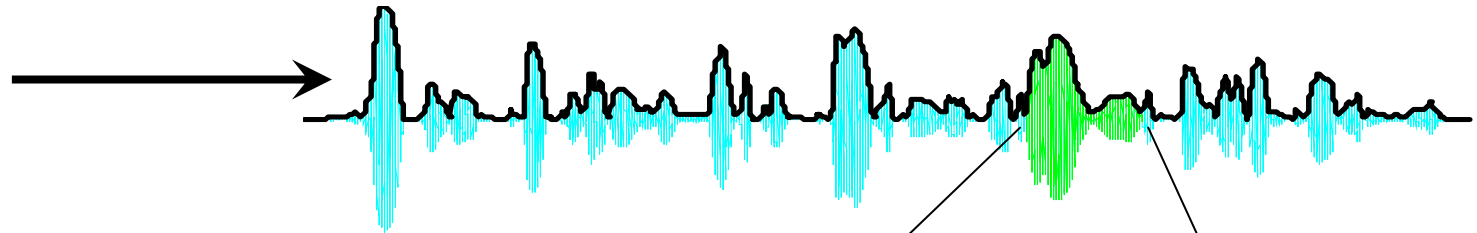
Electrical Engineering / Biology

University of Maryland, College Park

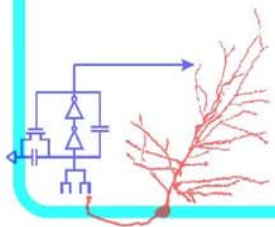
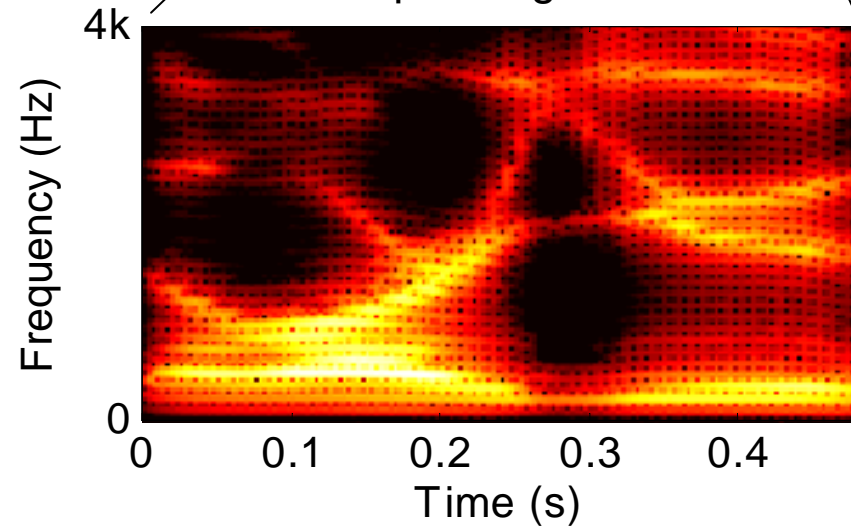


Complex Modulations in Speech

Envelope

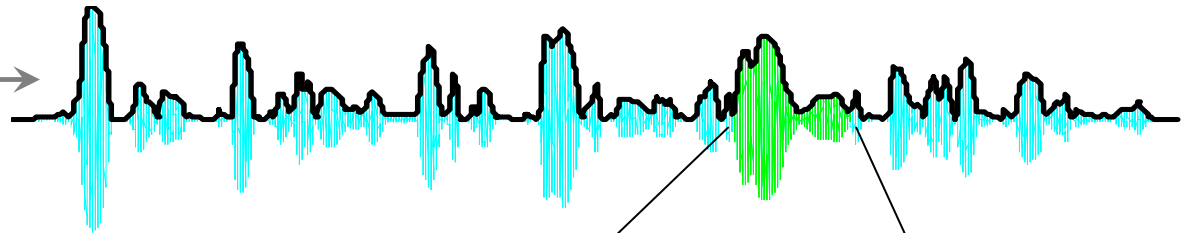


Spectrogram

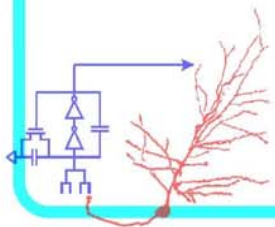
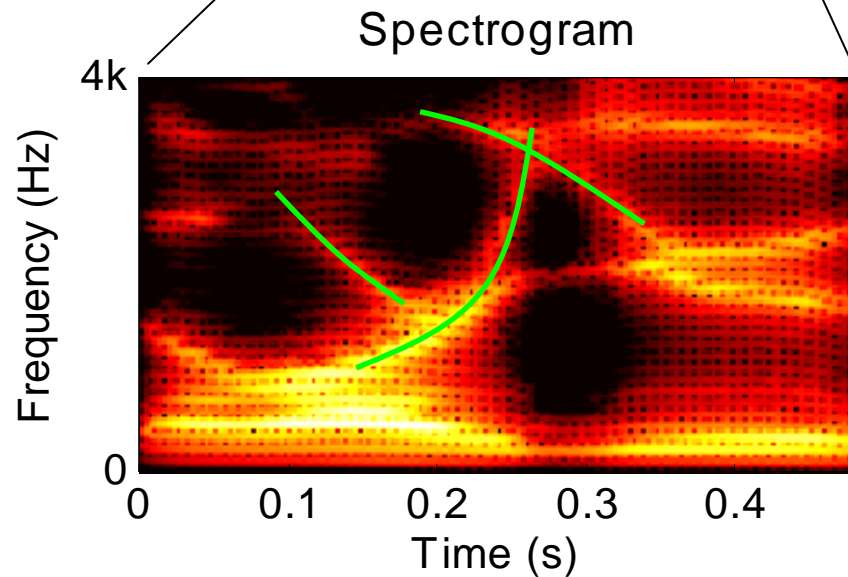


Complex Modulations in Speech

Envelope



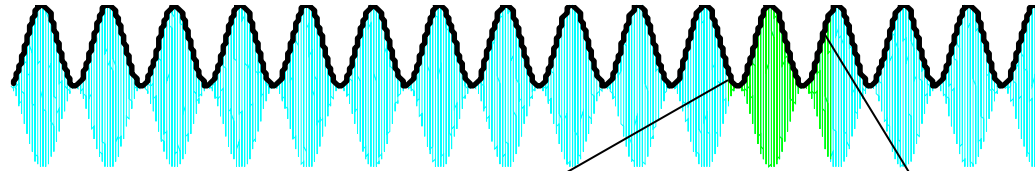
Fine structure



Our Stimuli

Envelope

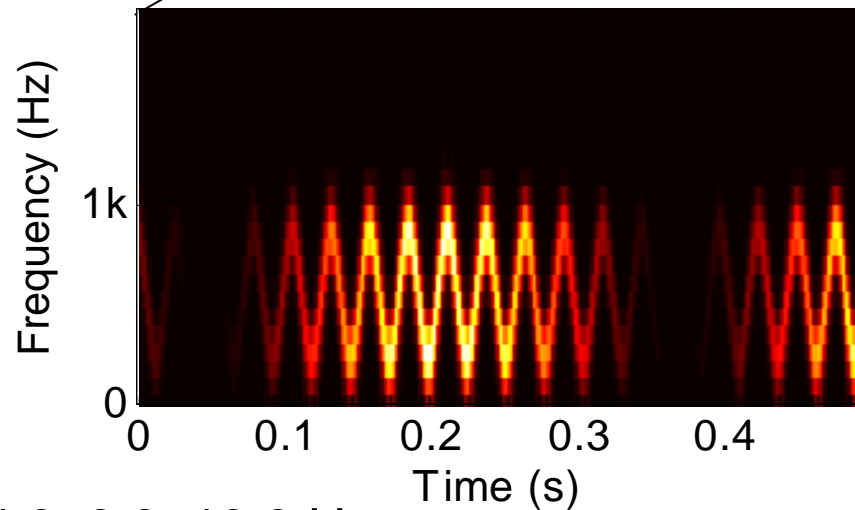
AM rate: 3.1 Hz



Spectrogram

Fine structure

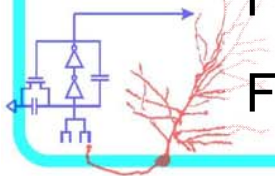
FM rate: 37.7 Hz



AM rate: 0.3, 0.7, 1.7, 3.1, 4.9, 9.9, 13.8 Hz

FM rate: 37.7 Hz

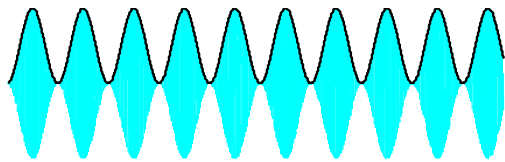
FM range: 220 Hz to 880 Hz



MEG Response to Temporal Modulations

Acoustic Stimulus

AM at 3 Hz



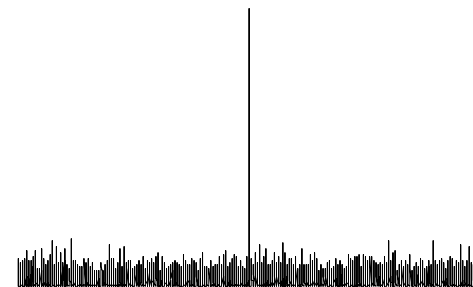
**Cartoon Neural Response
Measured by MEG**

3 Hz phase locked oscillation

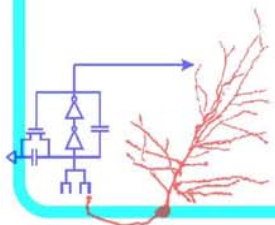


Fourier Transform

Power spectrum of MEG response



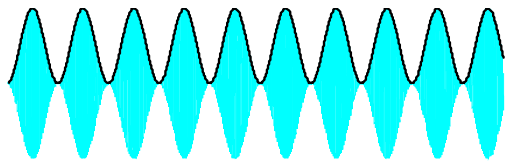
1 Hz 3 Hz 5 Hz



MEG Response to Temporal Modulations

Acoustic Stimulus

AM at 3 Hz



**Cartoon Neural Response
Measured by MEG**

3 Hz phase locked oscillation



Fourier Transform

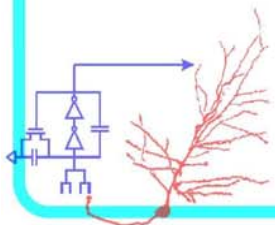
Power spectrum of MEG response



3 Hz

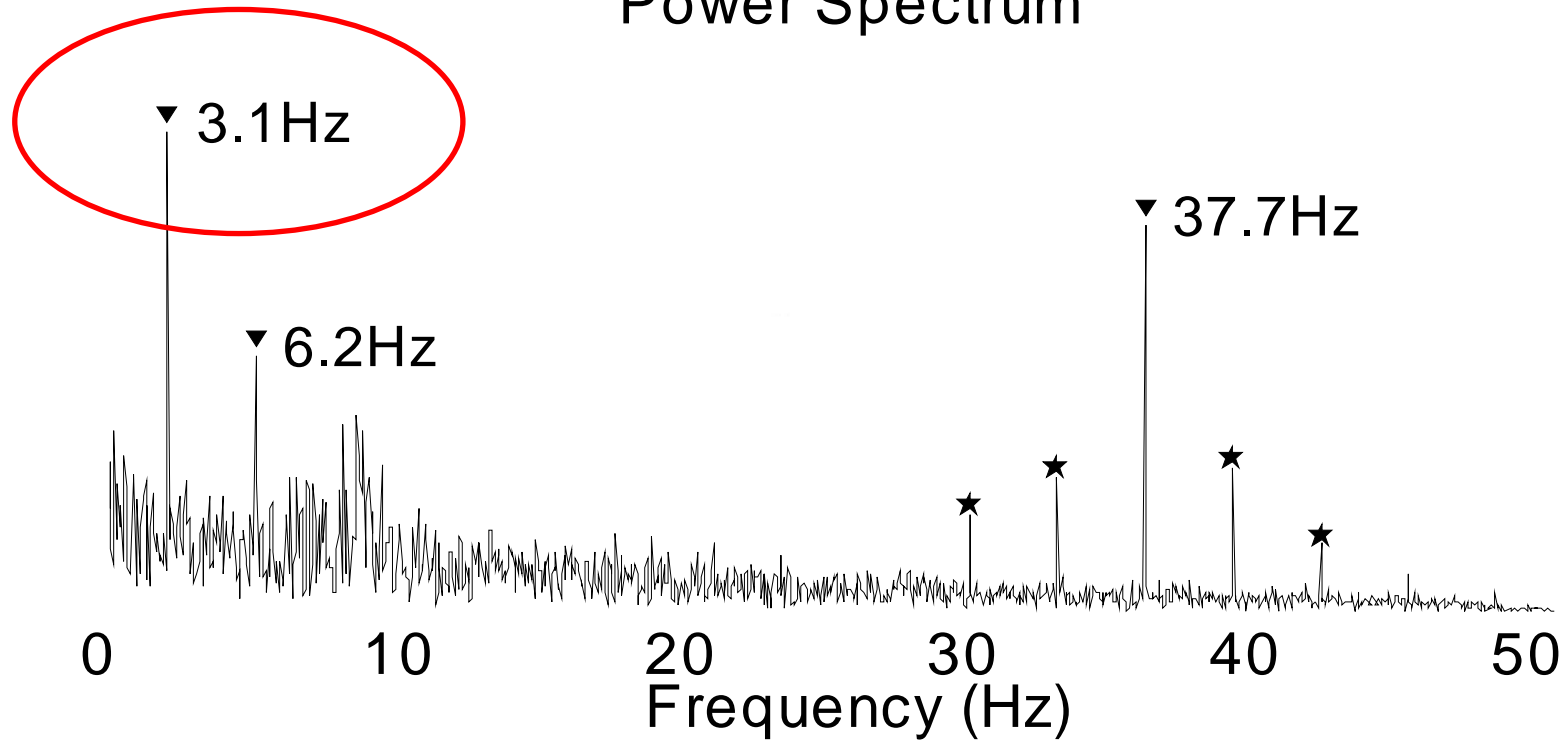
1 Hz 3 Hz 5 Hz

Computational Sensorimotor Systems Laboratory

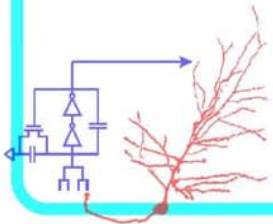


Neural response to our stimuli

Power Spectrum

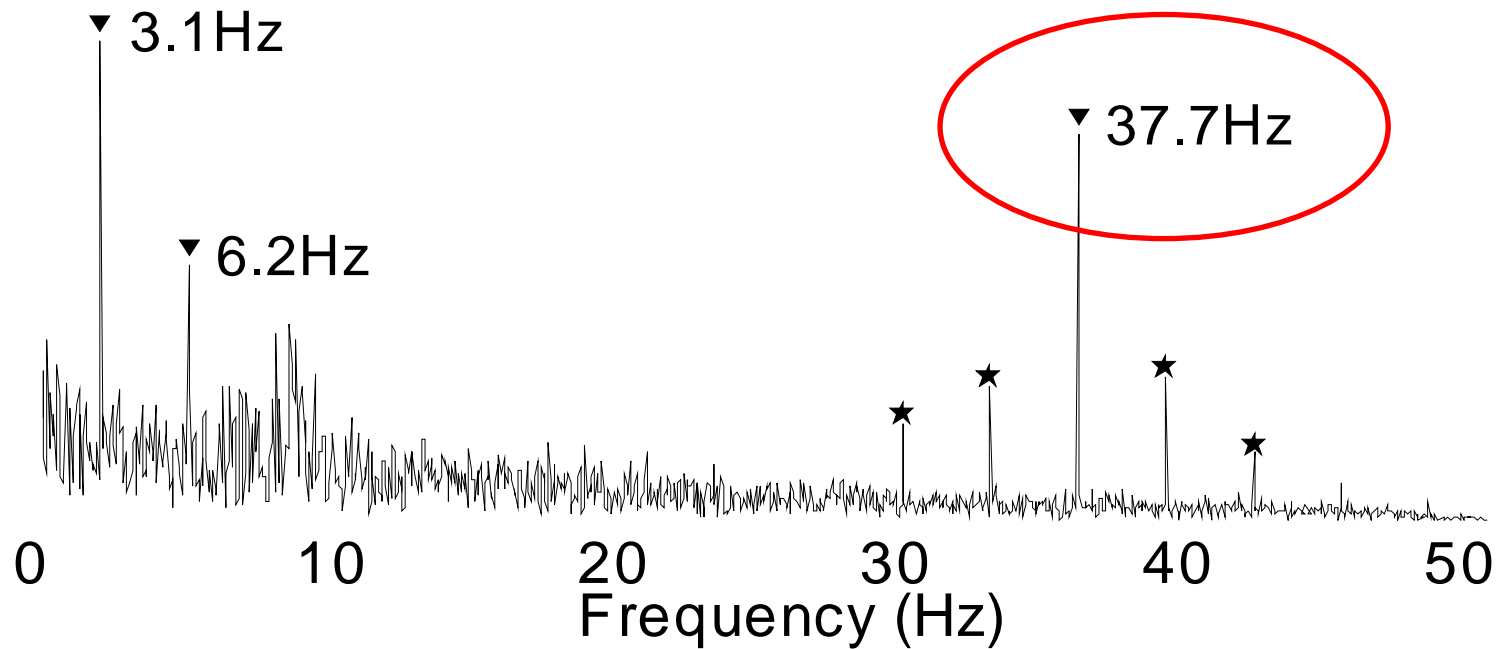


AM rate = 3.1 Hz, FM rate = 37.7 Hz

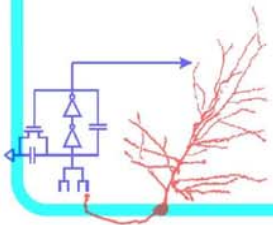


Neural response to our stimuli

Power Spectrum

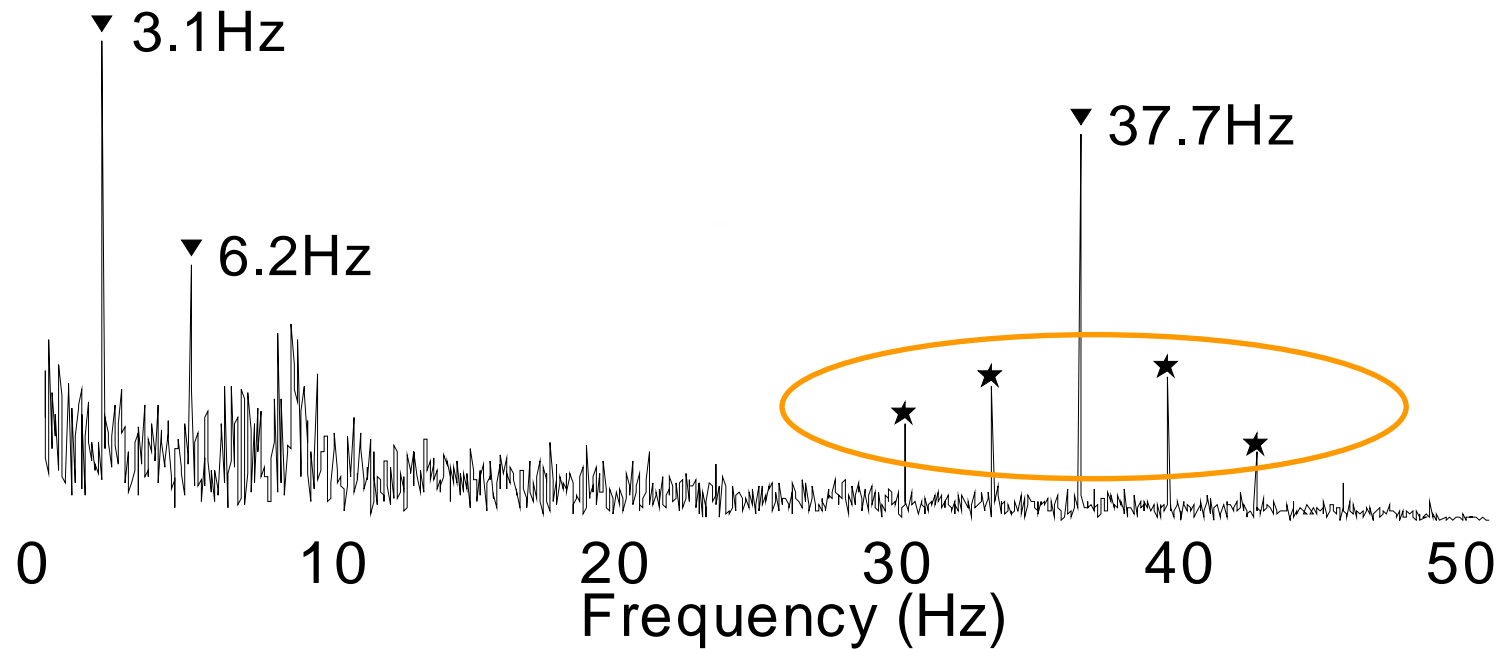


AM rate = 3.1 Hz, FM rate = 37.7 Hz

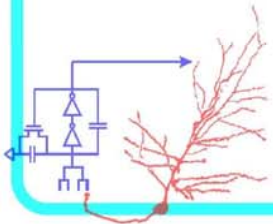


Neural response to our stimuli

Power Spectrum

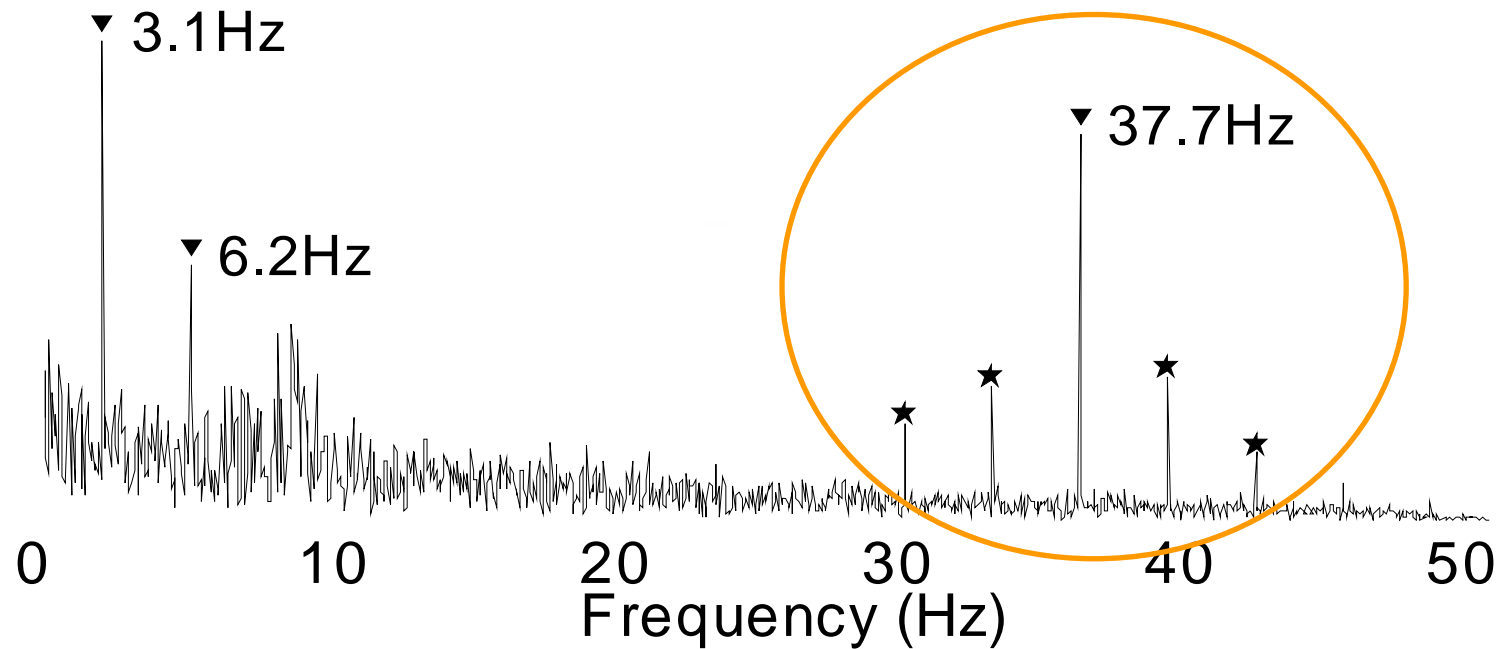


AM rate = 3.1 Hz, FM rate = 37.7 Hz

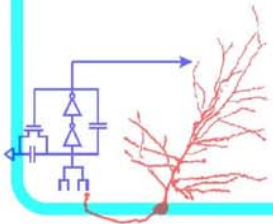


Neural response to our stimuli

Power Spectrum



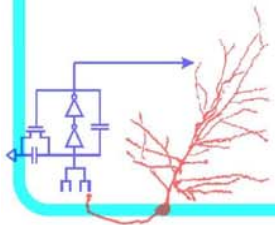
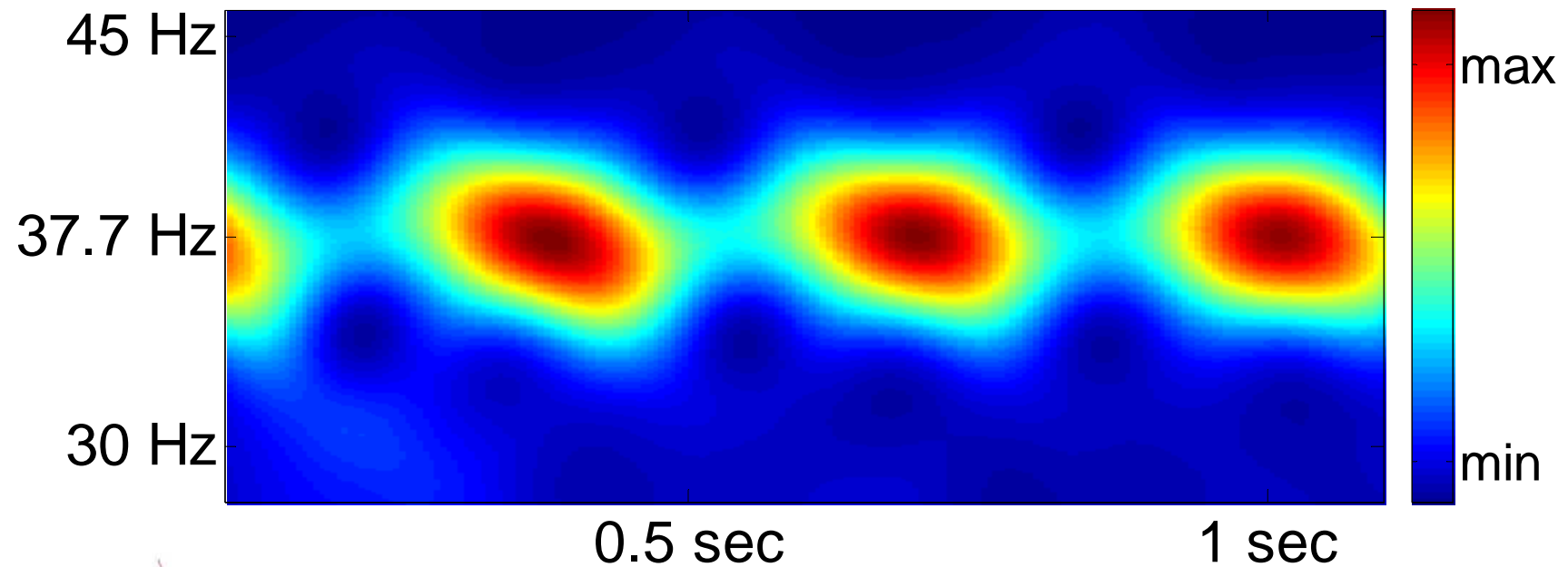
AM rate = 3.1 Hz, FM rate = 37.7 Hz



Interactions between Neural Responses

AM rate = 3.1 Hz, FM rate = 37.7 Hz

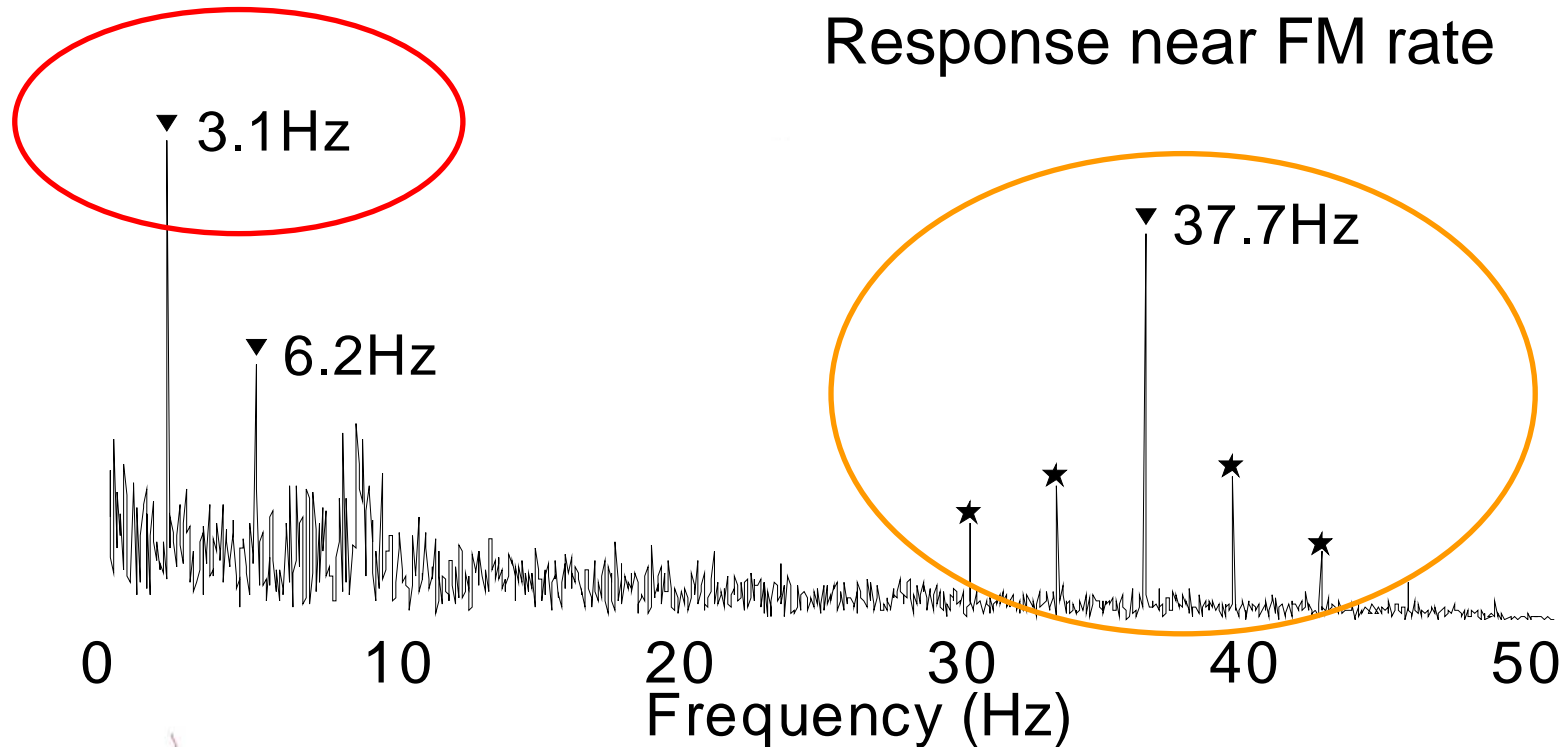
Spectrogram



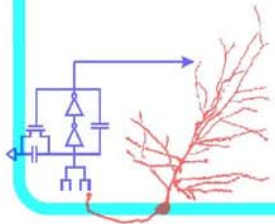
Dual neural representations of slow AM

Response at AM rate

Power Fluctuation of the Response near FM rate

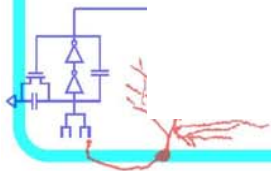
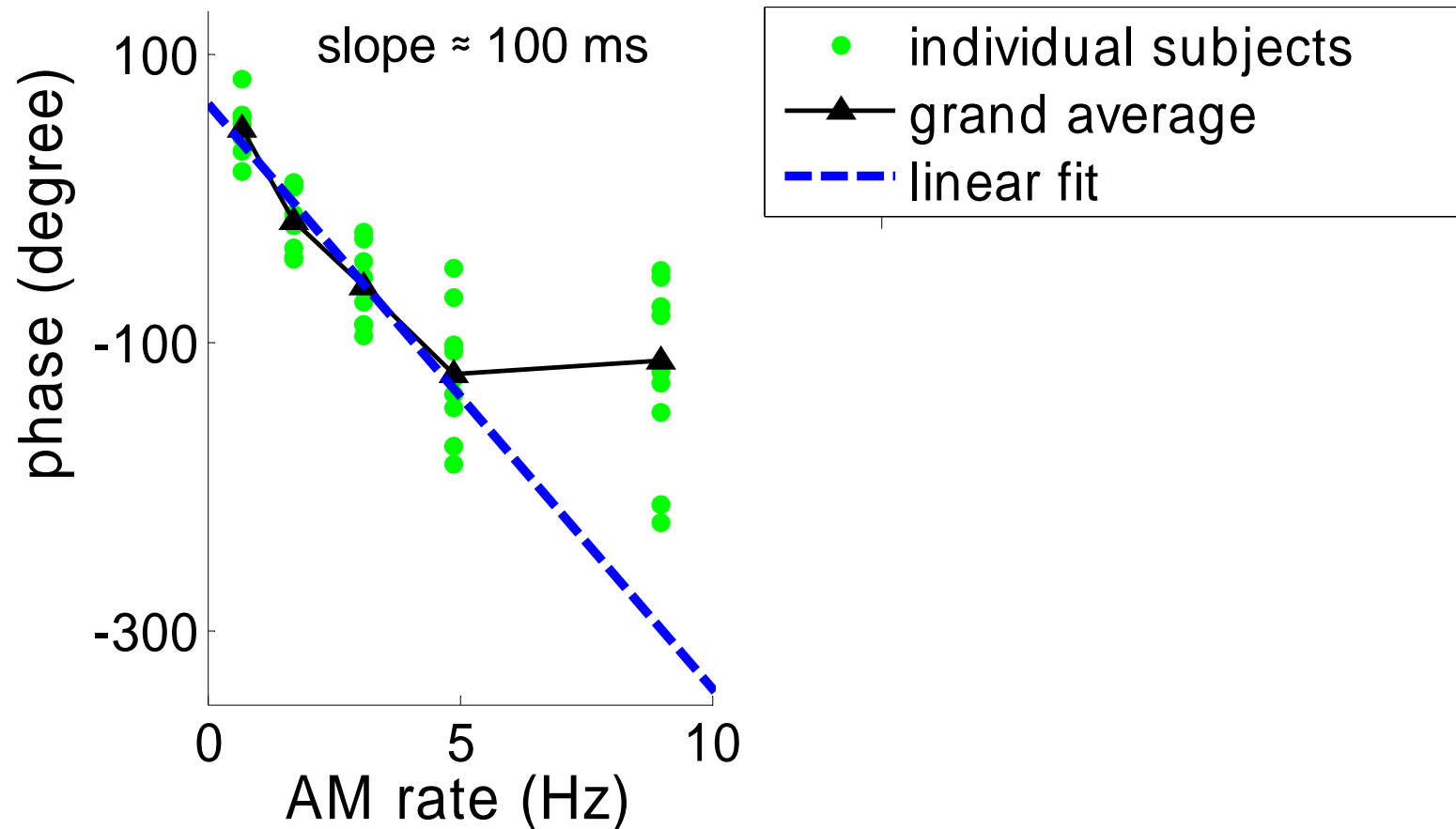


AM rate = 3.1 Hz, FM rate = 37.7 Hz



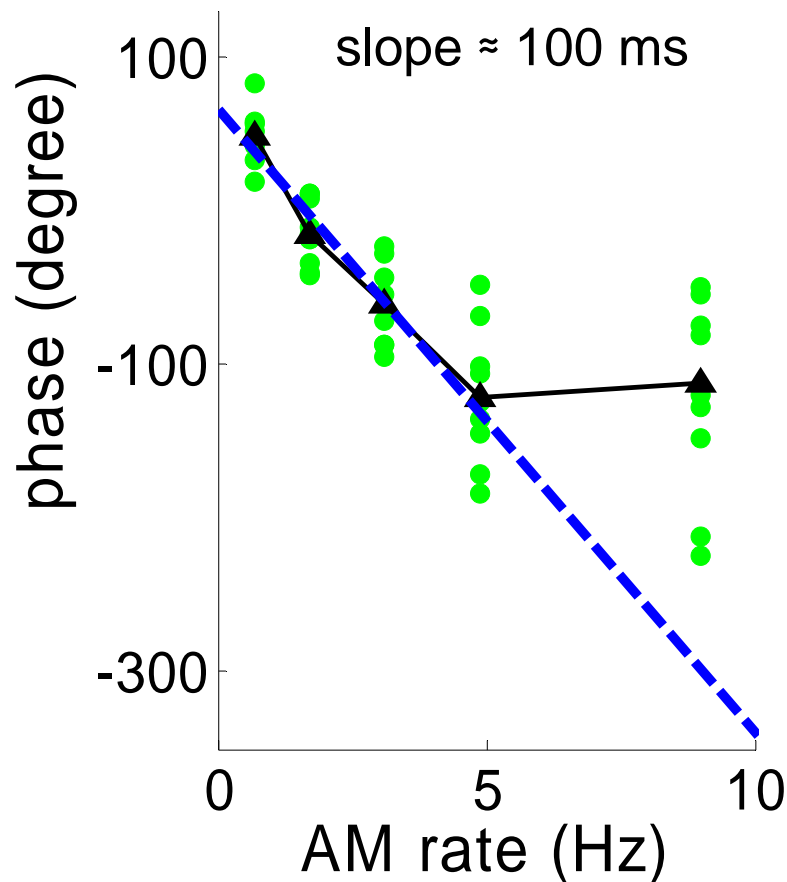
Phase & Latency of responses to AM

Response at AM rate

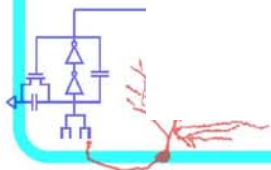
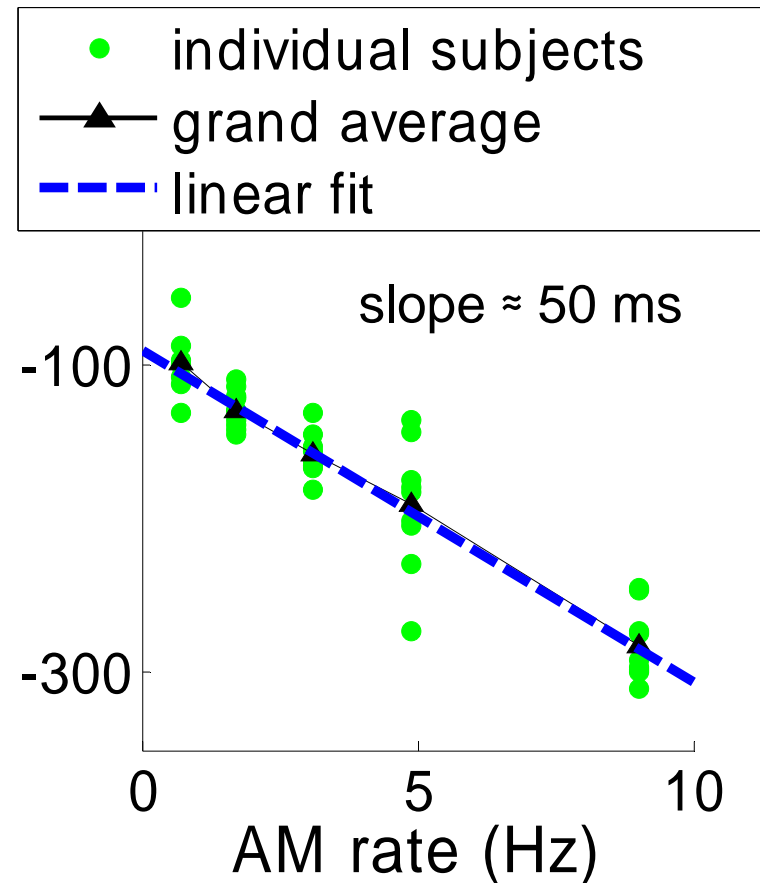


Phase & Latency of responses to AM

Response at AM rate

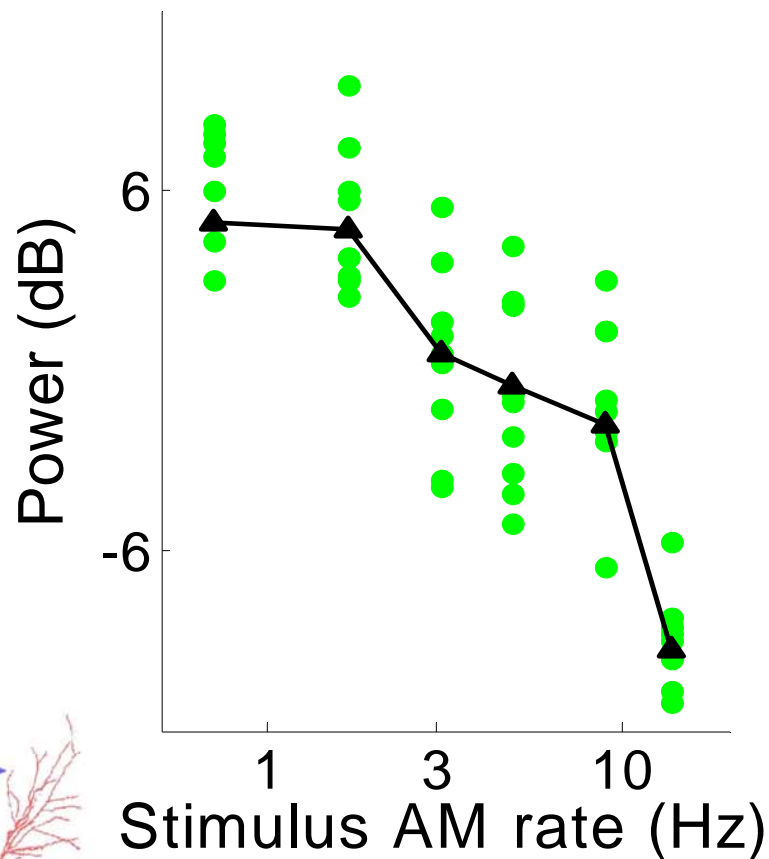


Power Fluctuation of the Response near FM rate

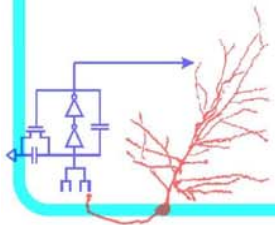
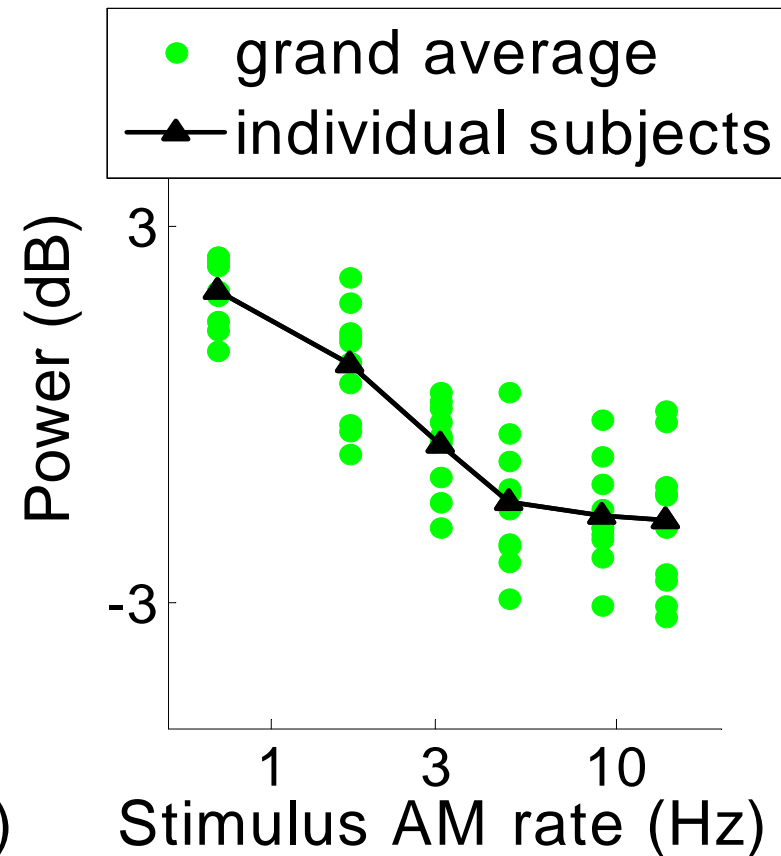


Power of responses to AM

Response at AM rate



Power Fluctuation of the Response near FM rate



Distinct Neural Representations of AM and FM

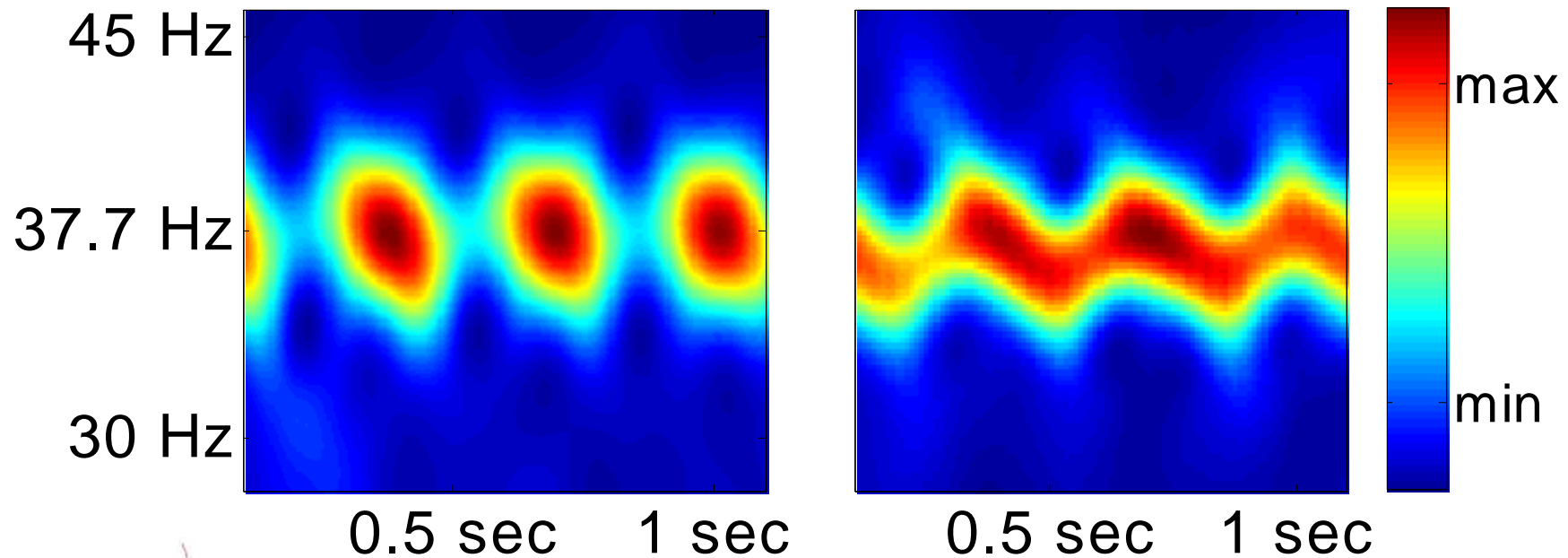
FM rate: 37.7 Hz

AM rate: 37 Hz

AM rate: 3.1 Hz

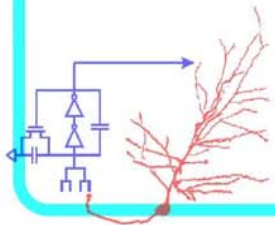
FM rate: 3 Hz

Neural Response Spectrogram



(Ding & Simon, 2009)

(Luo et al. 2006)

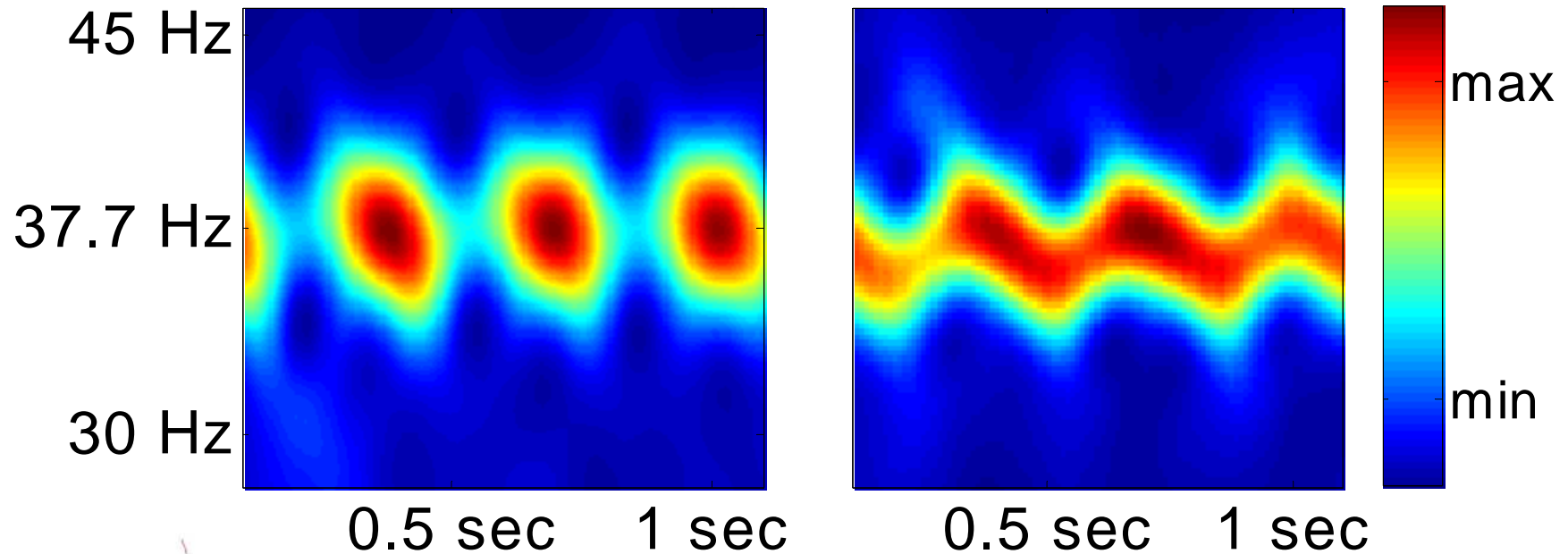


Distinct Neural Representations of AM and FM

FM rate: 37.7 Hz
AM rate: 3.1 Hz

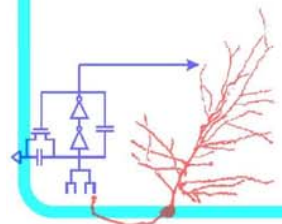
AM rate: 37 Hz
FM rate: 3 Hz

Neural Response Spectrogram



(Ding & Simon, 2009)

(Luo et al. 2006)



Distinct Neural Representations of AM and FM

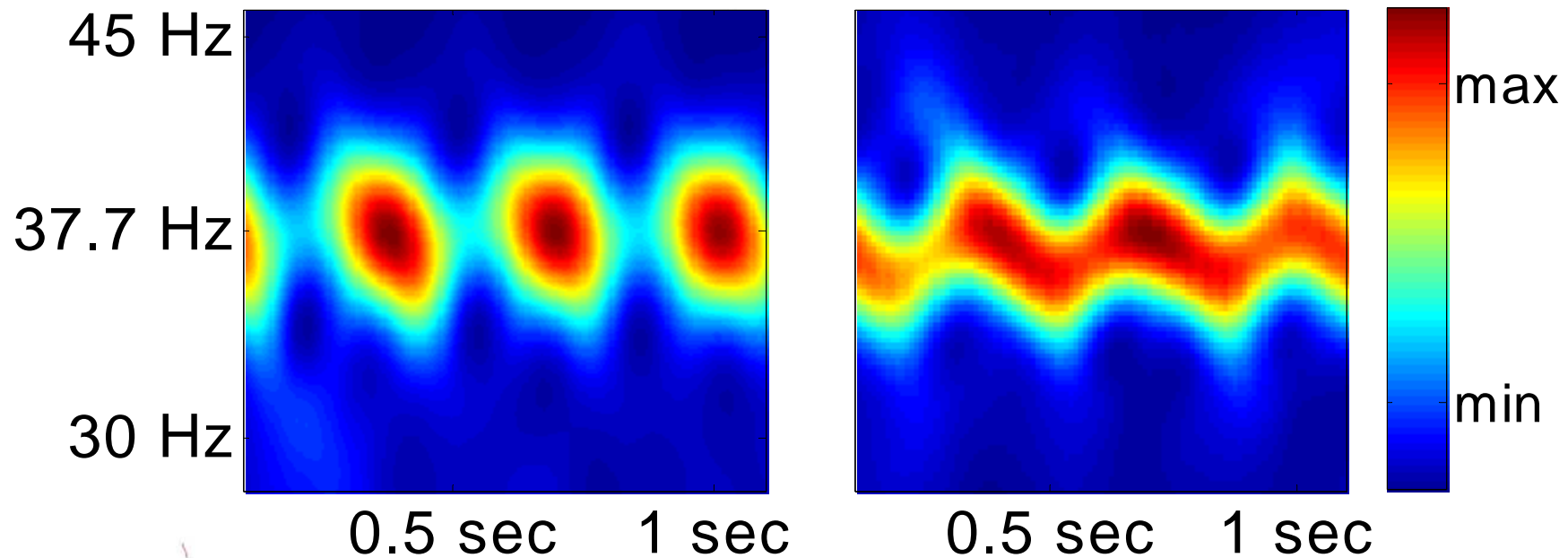
FM rate: 37.7 Hz

AM rate: 3.1 Hz

AM rate : 37.7 Hz

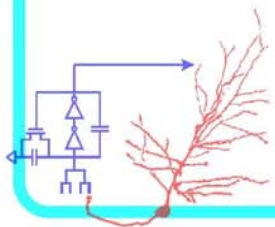
FM rate : 3.1 Hz

Neural Response Spectrogram



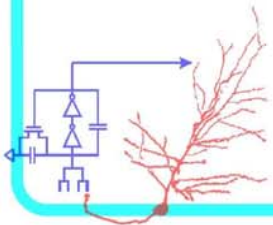
(Ding & Simon, 2009)

(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!

