



Spectro-temporal Fine Structure is Critical for Robust Neural Encoding of Speech in Noise

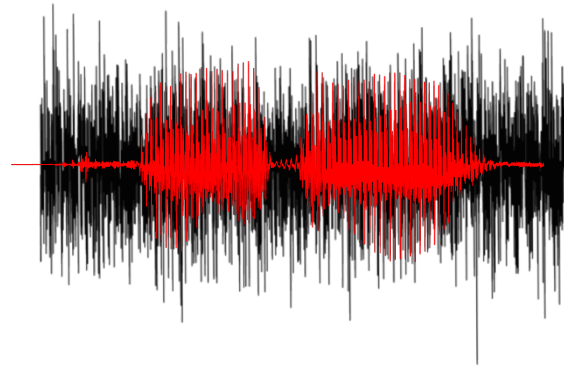
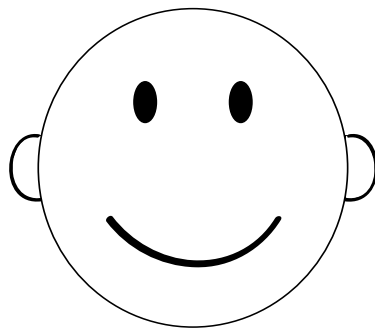
Nai Ding

Monita Chatterjee

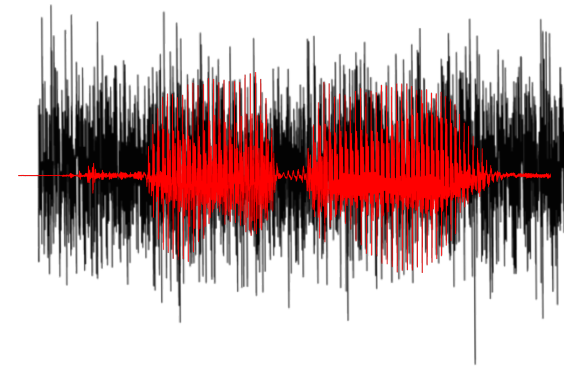
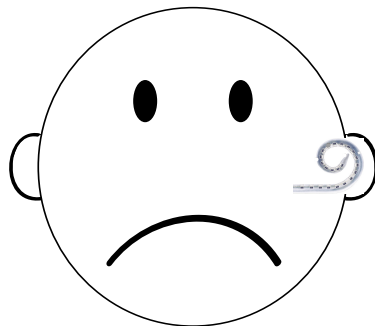
Jonathan Z Simon

2/19/2013

Speech Recognition is Robust to Noise for Normal Hearing Listeners but not for Cochlear Implant Users

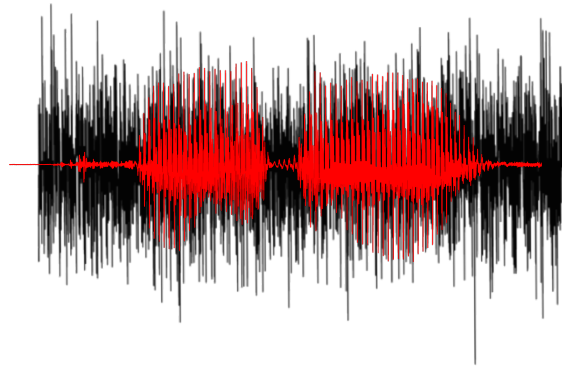
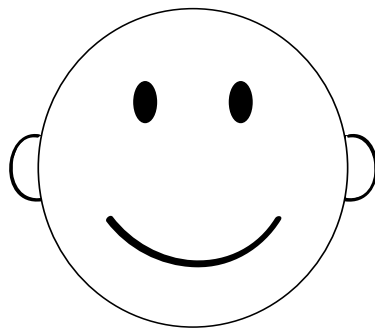


Normal Hearing

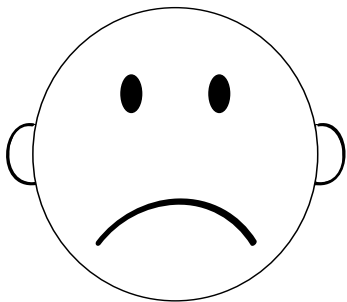


Cochlear Implant
User

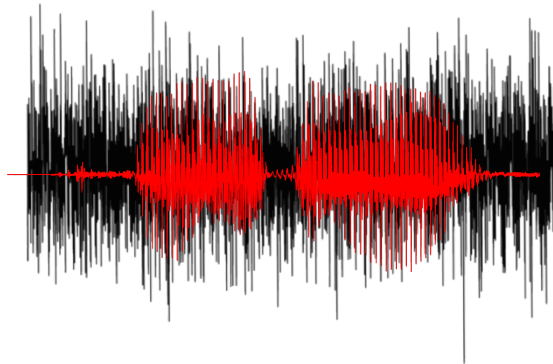
Noise Susceptible Speech Recognition Can be Simulated By Noise Vocoding, Which Removes the Spectro-Temporal Fine Structure



Normal Hearing



Vocoder



Cochlear Implant
Simulated by
a Noise Vocoder

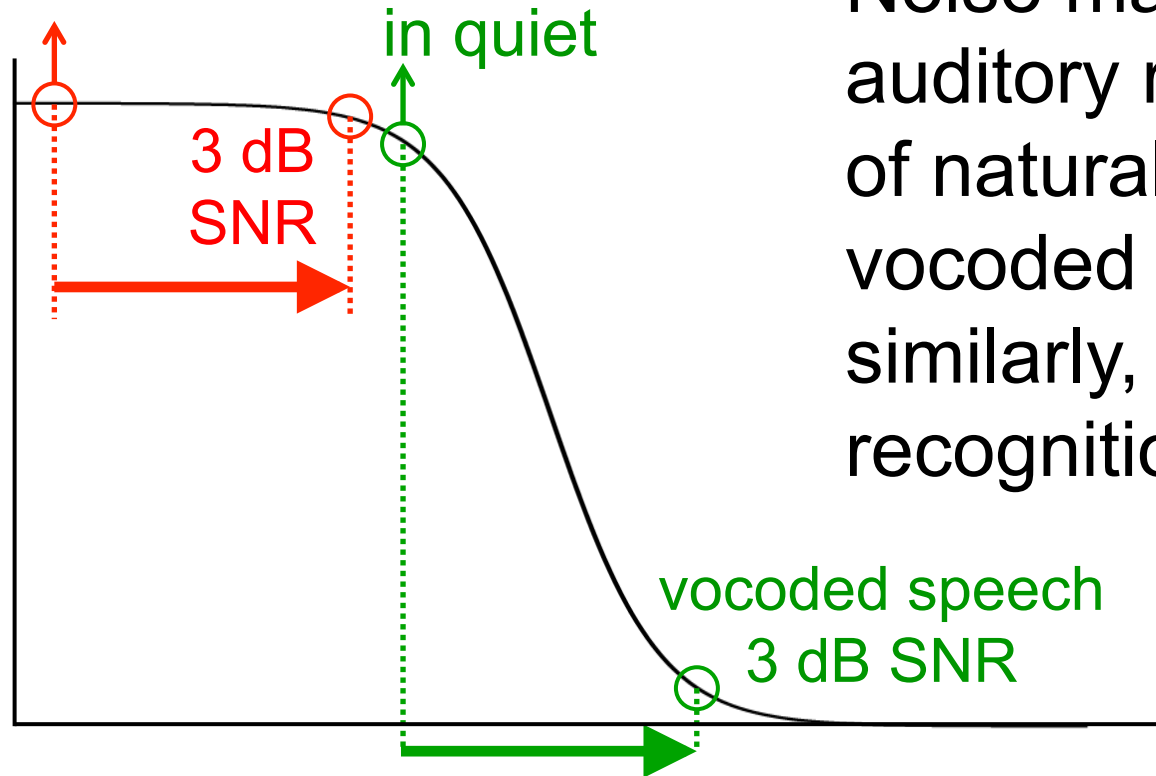
How Does the Spectro-temporal Fine Structure Contribute to Speech Recognition in Noise?

Hypothesis I: Purely a Problem in Speech Recognition?

natural speech
in quiet

vocoded speech
in quiet

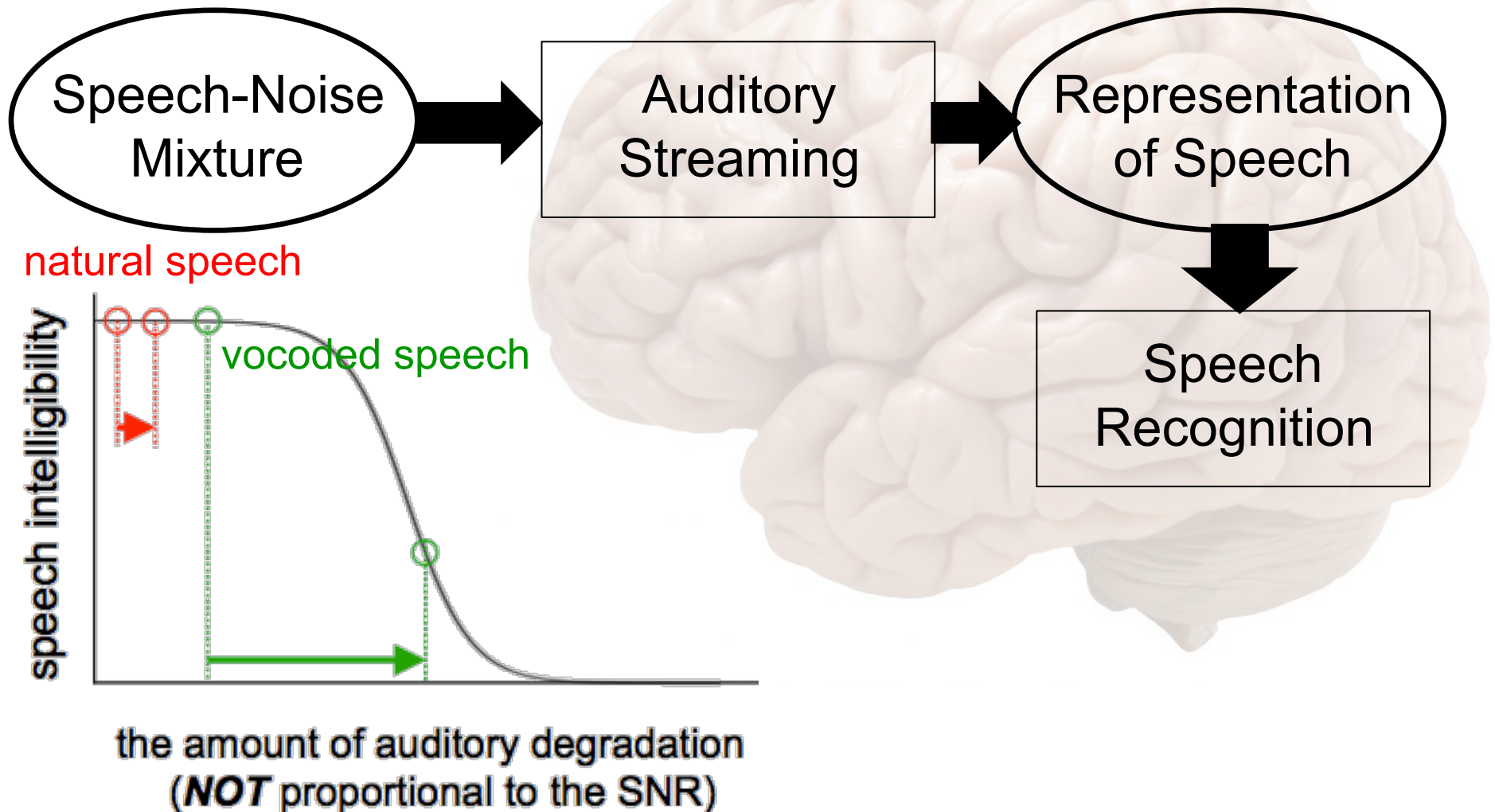
speech intelligibility



the amount of auditory degradation
(proportional to the SNR)

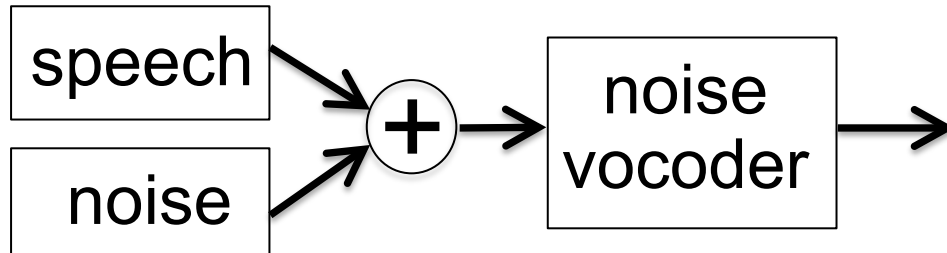
Noise may affect the auditory representations of natural speech and vocoded speech similarly, but speech recognition differently.

Hypothesis II: A Problem in Speech Noise Segregation?

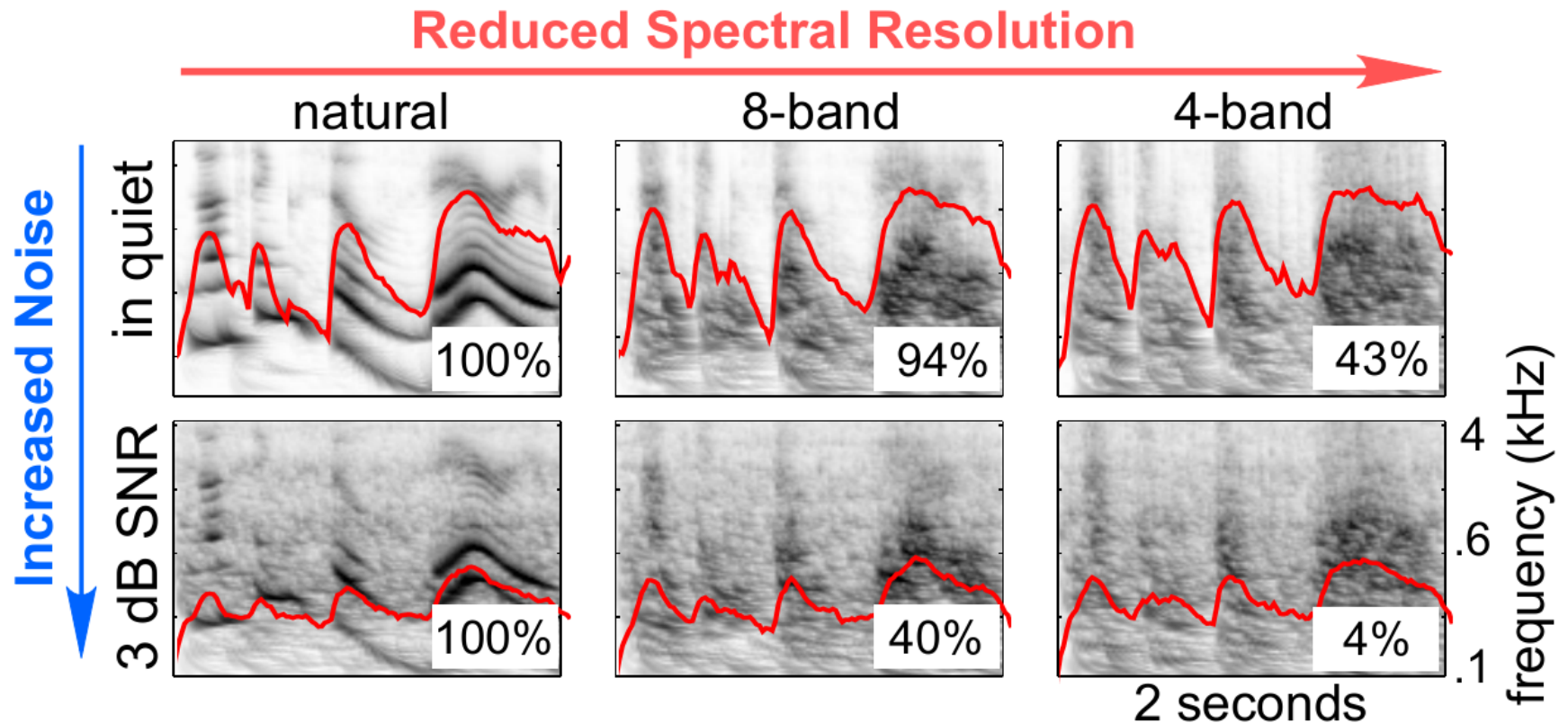


We assess whether auditory streaming plays a role in maintaining the robustness of speech recognition, when the acoustic interference is stationary noise.

Stimuli



A noise vocoder reduces the spectral resolution and preserves the temporal envelope.



Neural Recording using MEG

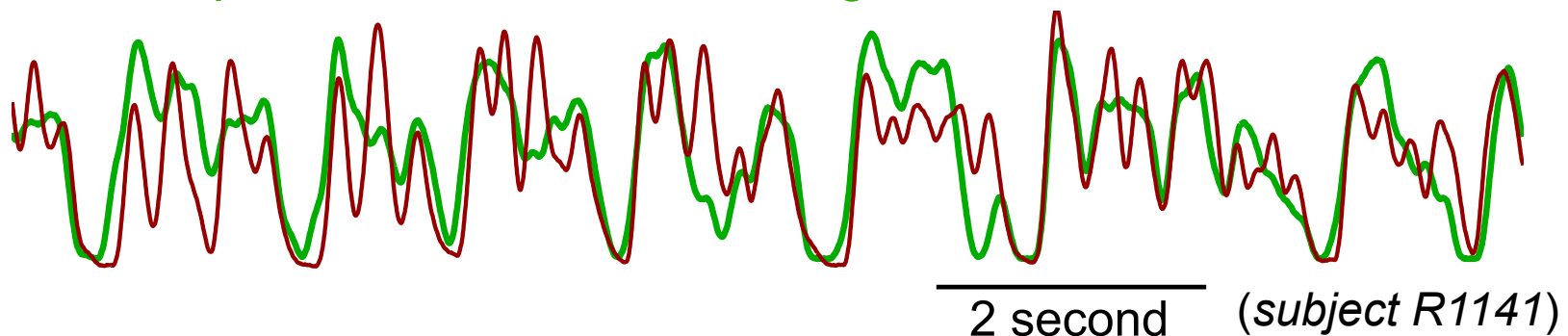
Magnetoencephalography
(MEG)



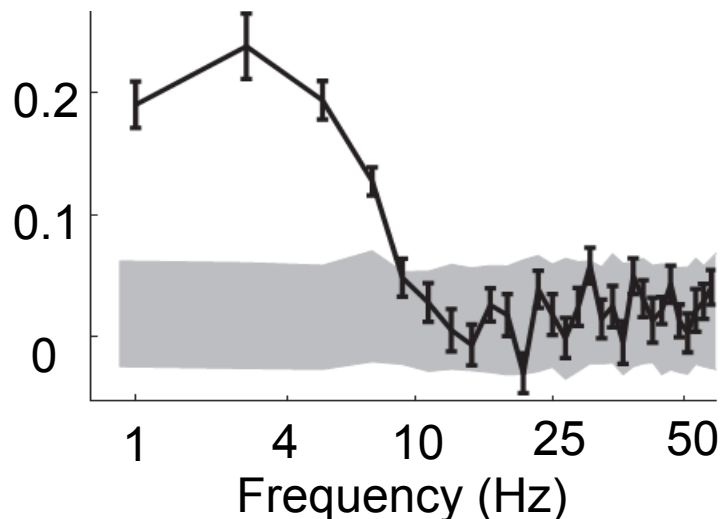
Neural responses are recorded using MEG, while normal hearing listeners listen to a story, either in quiet or in noise, either noise vocoded or not.

The MEG Responses Follows the Slow Temporal Modulations of Speech

— stimulus speech envelope
— processed MEG recording

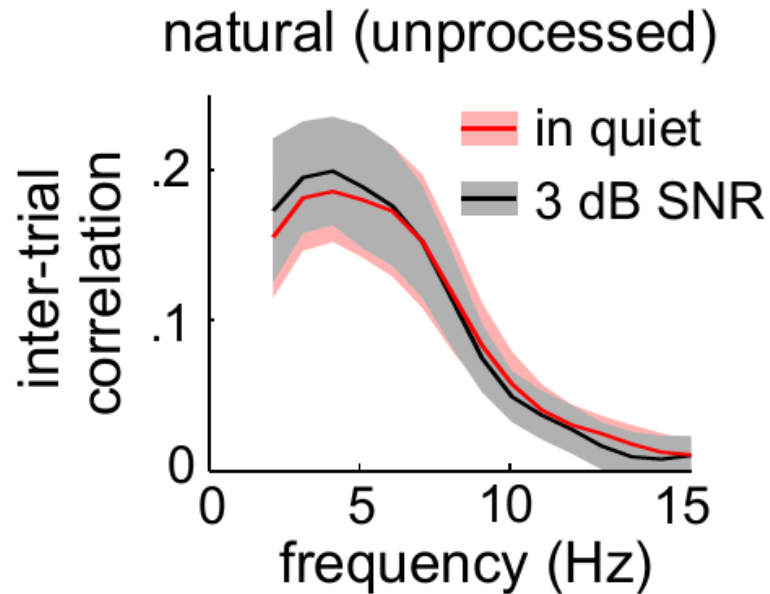


Response Phase-Locking Spectrum



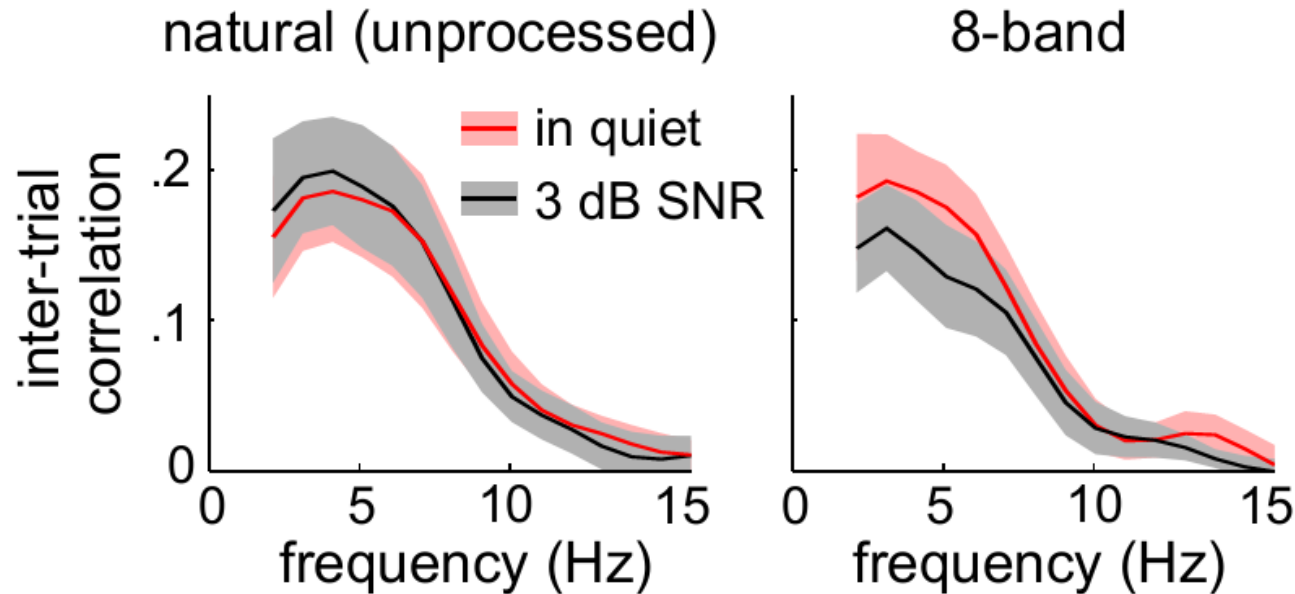
Phase-locked MEG Response
is Observed below 10 Hz.

Response Phase Locking Spectrum: the Effect of Noise



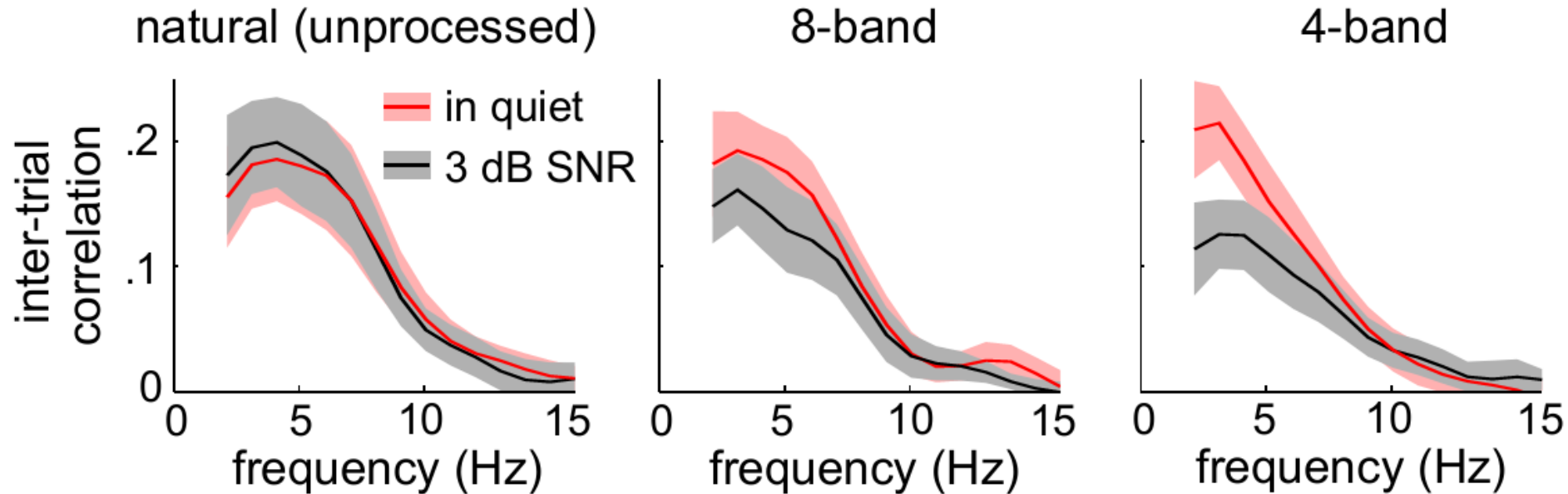
For natural speech, the low-frequency neural response is robust to noise at 3 dB SNR.

Response Phase Locking Spectrum: the Effect of Noise



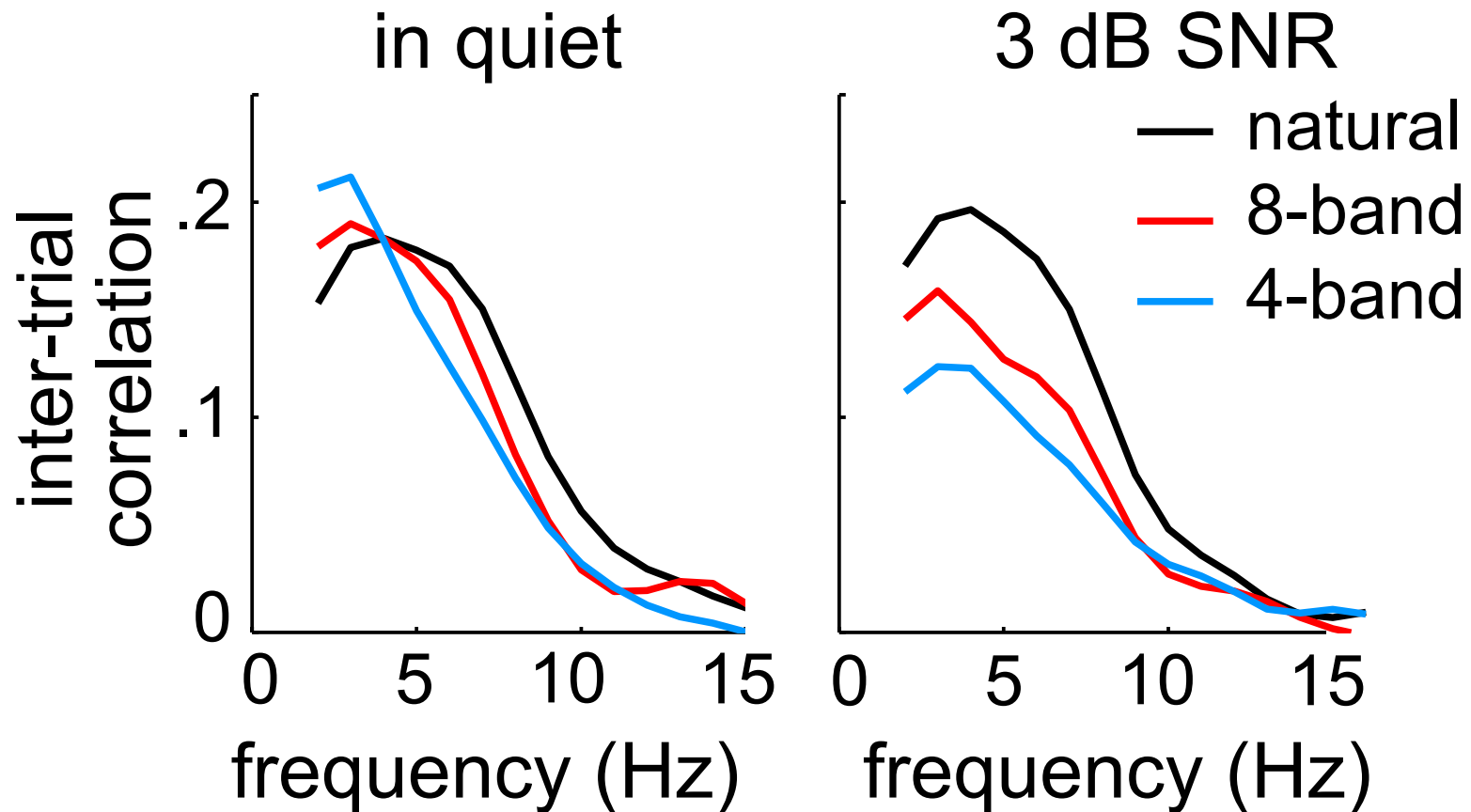
For 8-channel vocoded speech, the neural response is weakened by noise.

Response Phase Locking Spectrum: the Effect of Noise

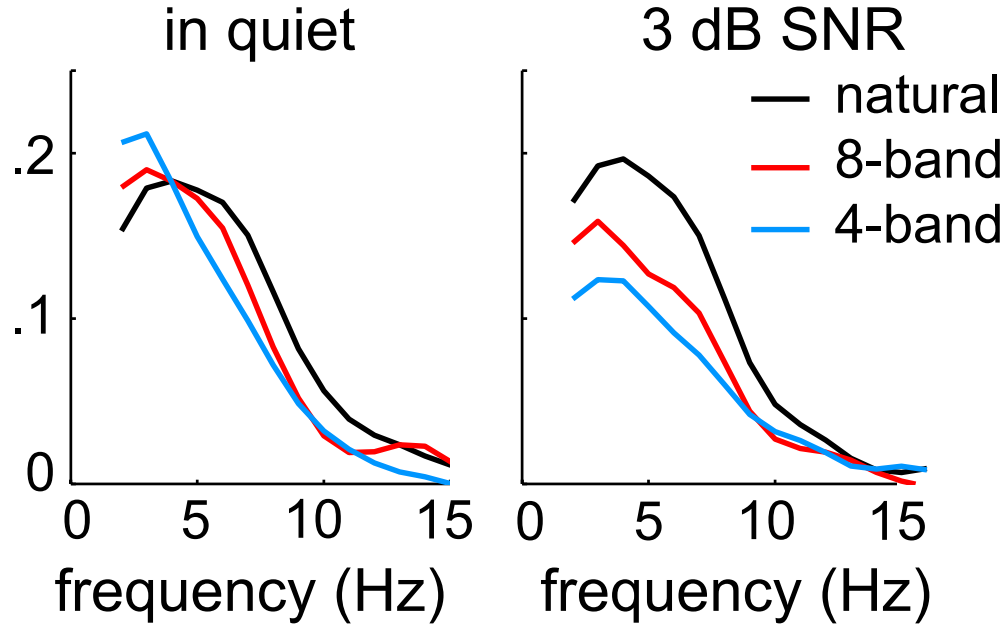


For 4-channel vocoded speech, the neural response is severely weakened by noise.

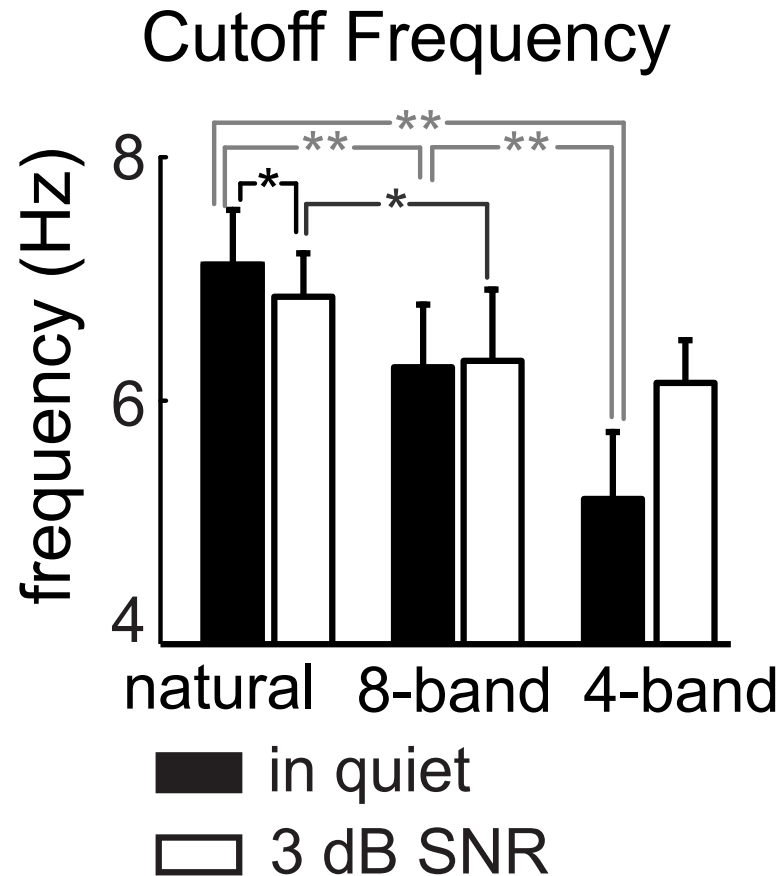
Response Phase Locking Spectrum: the Effect of Vocoding



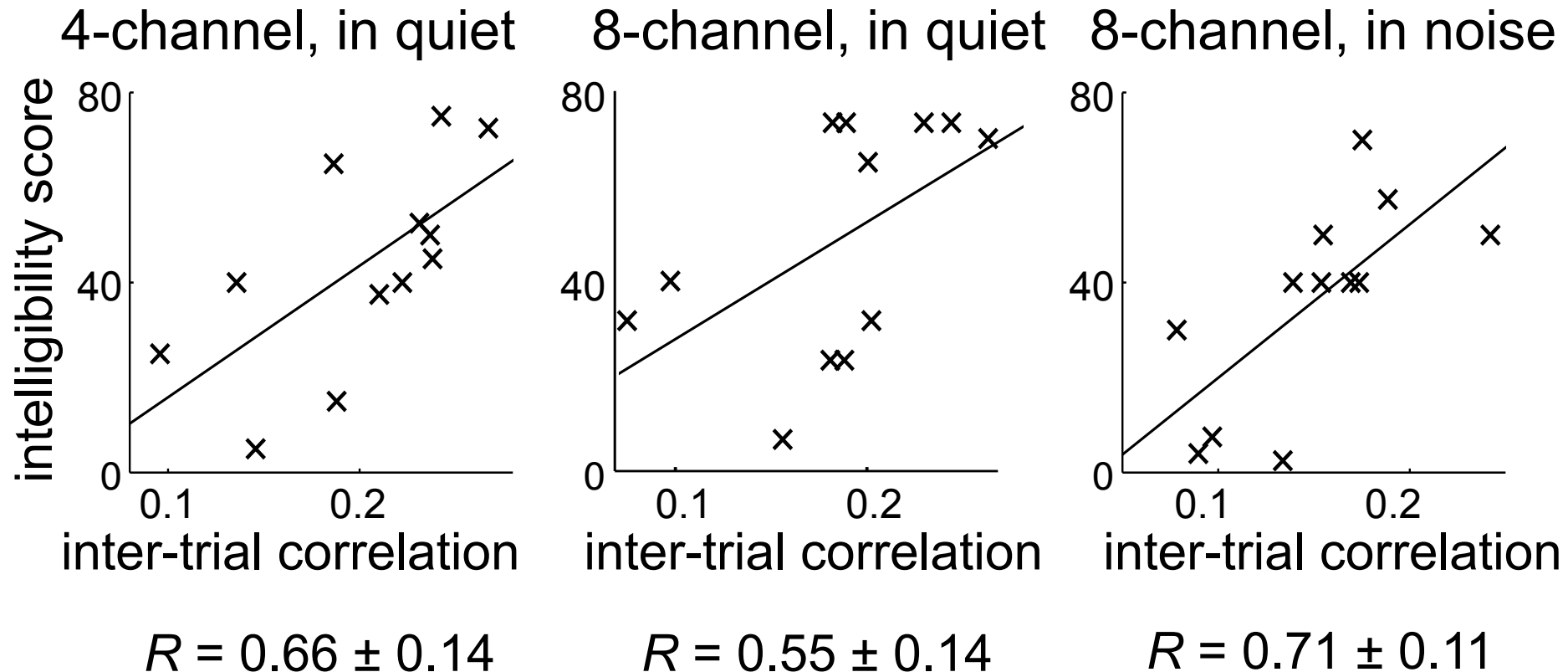
Response Phase Locking Spectrum: the Effect of Vocoding



The response spectrum has a lower cut-off frequency for speech with lower frequency resolution.



Neural Phase-Locking is Correlated with Individual Intelligibility Score



Summary (I)

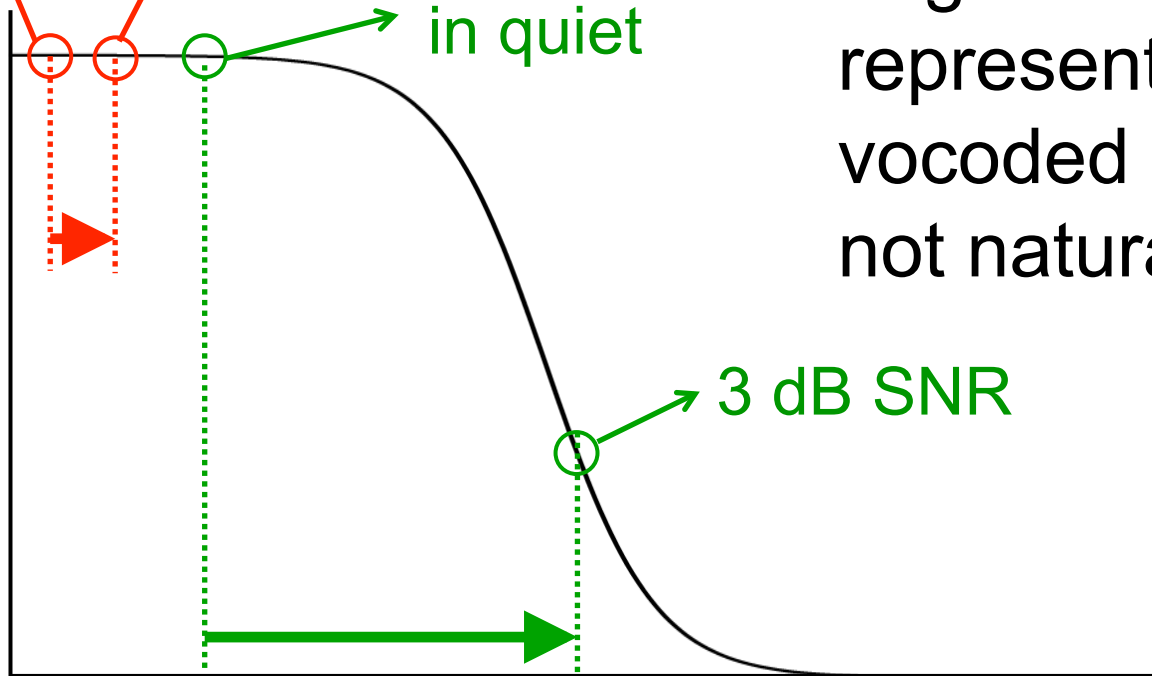
natural speech
in quiet

3 dB SNR

vocoded speech
in quiet

Noise severely
degrades the auditory
representation of
vocoded speech but
not natural speech.

speech intelligibility



the amount of auditory degradation
(**NOT** proportional to the SNR)

Summary (II)

- The spectro-temporal fine structure plays a critical role in segregating speech from noise and building a robust representation of speech in auditory cortex.

Thank you!