Co-Modulation Masking Release Begins in the Auditory Periphery

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Abstract

Listening in noisy environments is difficult. Neural “de-noising” mechanisms exist to improve the perceptual signal-to-noise ratio in such environments. This de-noising can be quantified using a “co-modulation masking release” (CMR) paradigm. People with hearing loss find noisy environments particularly troublesome, and have much weaker CMR. We tested the hypothesis that non-linear signal processing in the normal-hearing cochlea is the basis of CMR.

Hypothesis: Frequency-dependent suppressive non-linearities in the cochlea result in a neural correlate of CMR in the auditory nerve.

Introduction

Coiling inner and outer hair cells.

Basilar membrane velocity responses to CF-tones (left) and frequency tuning curve showing suppressive regions represented in dashed blue and red lines (right).

Two-tone suppression: an (almost) instantaneous mechanical phenomenon – NOT neural inhibition!

Methods

Surgical preparation and recording
- Anesthetized chinchilla (Chinchilla lanigera).
- Ketamine/xylazine/diazepam.
- Single-unit spike-time recording from ANFs.
- Dorsal fossa approach.
- Ipsilateral cerebellotomoy.
- High impedance glass pipettes (30–90 MΩ).

Signal: Masker Synchronized−Rate Ratio

experiment: 24−May−2017  track:  4 unit:  4 SR:  0 per sec.
RF
CM
CD

Prediction

*Response*

Signal Level

Results

Histogram of LSR fiber showing firing rates effects from RF, CM and CD stimulus conditions with increasing signal level as you go down (top). Signal:Masker Sync-Rate Ratio as a function of increasing signal level (left).

Signal:Masker Sync−Rate Ratio for different noise types.
- Think of this measure as a signal-to-noise ratio, in the response dimension rather than the acoustic.
- Low-pass noise maskers have most effect compared to notched- and high-pass noise maskers.

Basilar Membrane (top left), characteristic frequency of spontaneous rate fibers (top), and frequency tuning curves of several neurons (left).

Analyses:
- Constructed tuning curve to find the unit’s CF and threshold, both used to design the CMR stimuli.
- Vary sound pressure level of a band-stop Gaussian noise in the presence of a CF tone to find the noise level where maximum suppression of the CF-tone driven response occurs.
- Present RF, CD, and CM stimuli in randomized order, for 20 repetitions.

Acoustic stimuli
- Presented signal tone, masked by a SAM tone at fiber’s center frequency (CF) and band-stop Gaussian “flanking band” noise.
- Three acoustic signals used similar in past CMR studies [2,3]
  - RF: SAM + Signal.
  - CM: Signal + SAM + FB in phase with SAM.
  - CD: Signal + SAM + FB out of phase with SAM.

References


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Conclusions and Future Work

- Proof of CMR in the nerve means relevant neural information is already present at the brain’s input.
- Chinchilla ANF data support a role for cochlear non-linearities in mediating across-frequency co-modulation masking release.
  - Important to characterize the strength of this effect in the inputs to brainstem circuits.
  - Doesn’t mean there’s no role for brainstem (or cortical) processing in CMR.

Expected improvement in masked signal-detection threshold when coherent (across-frequency) amplitude modulation is applied to a broadband masker [1].