A cortical ensemble model of pitch perception

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Introduction

Pitch perception

- related to activity in aIHG
- widely related with the identification of repetition times in the auditory nerve
- biophysical mechanism: autocorrelation

Autocorrelation and perceptual integration

- the autocorrelation output is not stable: some kind of slow (cortical) integration is necessary to represent perception
- autocorrelation shows high responses for upper harmonics: can we get rid of them during such integration?

Auditory evoked fields

- MEG recordings mirror perception
- different components of the evoked fields are correlated with different perceptual dimensions
- the N100m is a transient deflection arising ~ 100 ms after onset
- a relation between N100m and pitch perception has been largely reported

References

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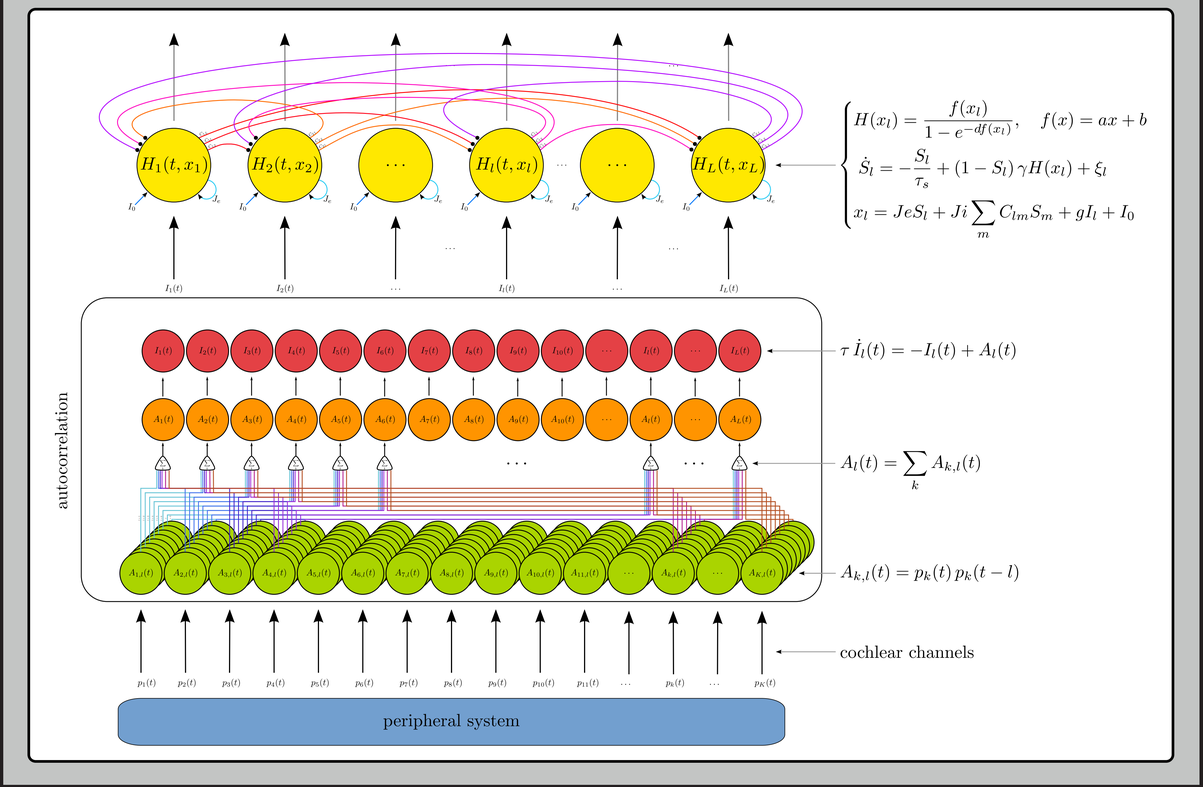
The model

Stages of the model

1. Realistic model of the peripheral auditory system
   - ▷ simulates all peripheral preprocessing
   - ▷ outputs auditory-nerve spike probabilities $p(t,k)$ for each cochlear channel k
2. Subcortical processing $I_l(t)$ (subcortical)
   - ▷ an autocorrelation process transforms the $p_k(t)$ into spectral (lag dependent) representations
   - ▷ responses across cochlear channels are averaged
3. Cortical processing $H(t,x_l)$:
   - ▷ leaky slow integration of the subcortical inputs $I_l(t)$
   - ▷ mutual inhibitions resolve the pitch and originate the N100m trend



Reading the outputs

Perception:

- pitch is represented in the activity in the cortical populations and its characteristic lag l

Electrophysiology:

Hypothesis: the dynamics of the cortical ensembles originate the N100m deflection

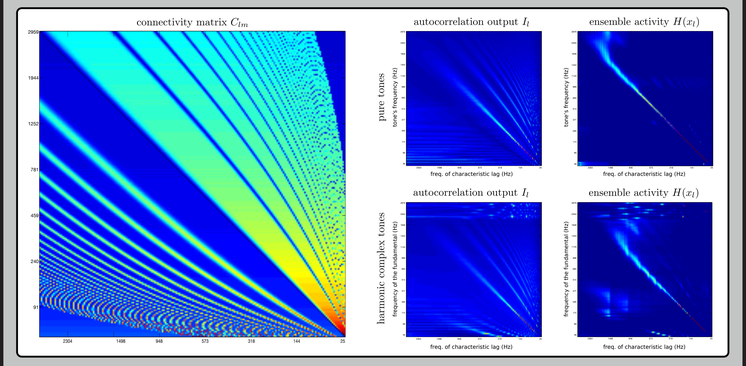
- gating variables dynamics S drive electrophysiology

Connectivity Matrix and perceptual results

The strengths of the inhibition between ensembles C_{lm}

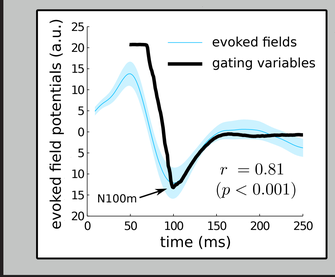
- uniform inhibitions do not cancel upper harmonics
- asymmetric inhibitions bias the responses

Our solution:



Electrophysiology (preliminary results!)

Electrophysiology VS response of the model



Blue: MEG human evoked fields evoked by an unison dyad around the N100m deflection

Black: trend of the dynamics of the aggregated gating variables of the cortical ensembles $\sum_l S_l$ triggered by the same stimulus

Conclusions:

- We introduced a biophysically realistic model potentially able of explaining both, perception and electrophysiology
- A harmonic structure in the connectivities between neural ensembles seems to encode pitch processing
- The N100m deflection can be explained by analysing the dynamics of the network of cortical ensembles:
  1. after onset, a sudden change in the incoming flow I_l drags the populations out a previous state of equilibrium
  2. the populations react by increasing their activation
  3. the activity of the populations trigger the inhibitory processes
  4. the inhibition decreases the activity gradually until a new state of equilibrium is reached