Neural mechanisms underlying song recognition in the zebra finch higher auditory cortex

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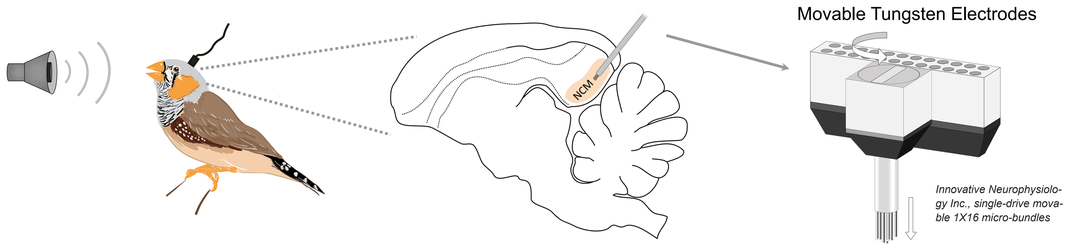
Introduction

Zebra finches learn to sing from conspecific tutor's song, meanwhile they can be trained to discriminate various conspecific songs other than tutor's song. The zebra finch higher auditory cortex, caudomedial nidopallium (NCM), is thought to be involved in conspecific perception and tutor song memorization. A small subsets of neurons in the NCM show highly selective auditory responses to tutor's song but **whether the large population of NCM neurons detect various conspecific songs, and if so, which acoustic features are targeted by these neurons** is unknown. To answer this question, we performed chronic extracellular recording of neuronal activities from the NCM in freely behaving adult zebra finches and tested their auditory responses to the playbacks of various song stimuli.

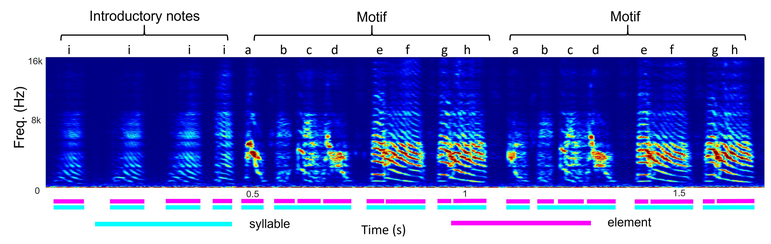
Experimental design

Extracellular recordings of NCM neurons in freely behaving adult male zebra finches



Q1 : Given the large variety of zebra finch conspecific songs, whether NCM neurons detect all kinds of songs or only a subset?

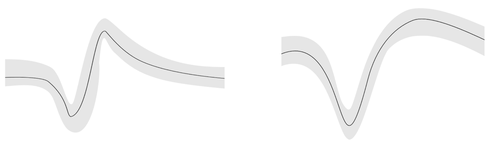
Stimuli: 22 different representative zebra finch songs



Each zebra finch song consists of syllables/elements arranged in a specific sequence

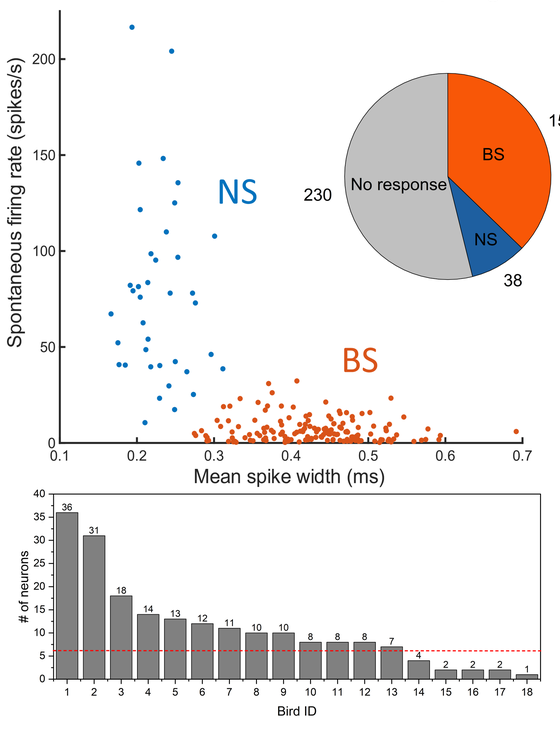
NCM neurons from each bird detect almost all zebra finch songs as a population; while each neuron detects only a subset of songs.

1. NCM neurons consisted of broad spiking (BS) and narrow spiking (NS) neurons

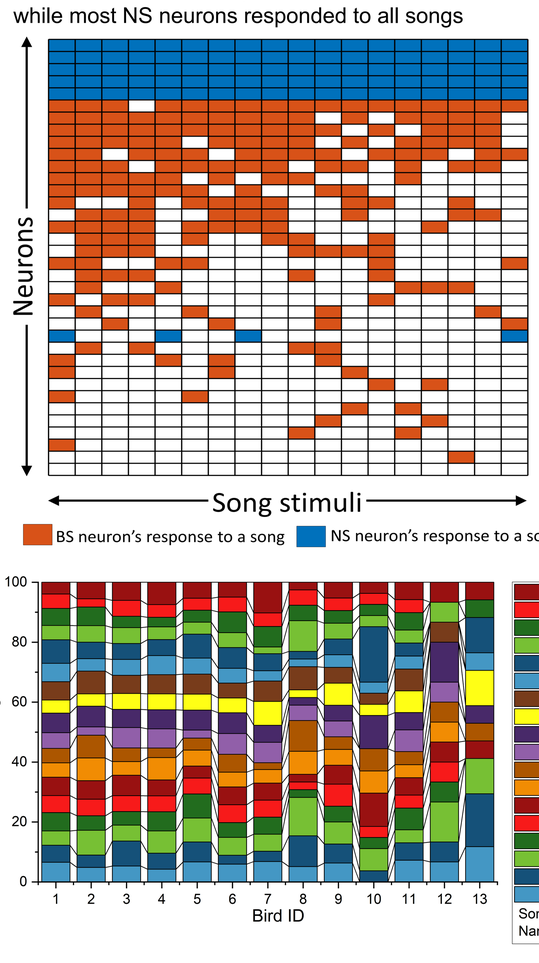


NS : Narrow spiking

BS : Broad spiking

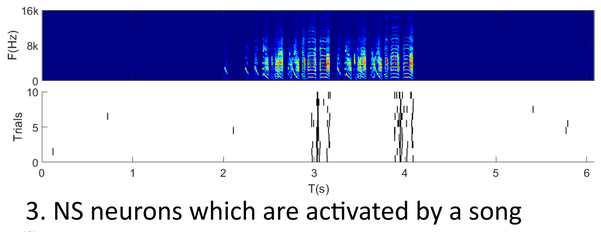


2. Most BS neurons responded to small subsets of songs, while most NS neurons responded to all songs

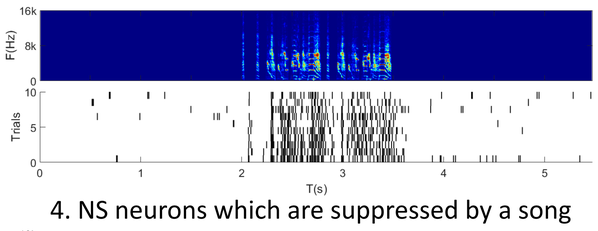


Q2 : Given the heterogeneity of each neurons' response to songs, how many types of neurons can be classified ?

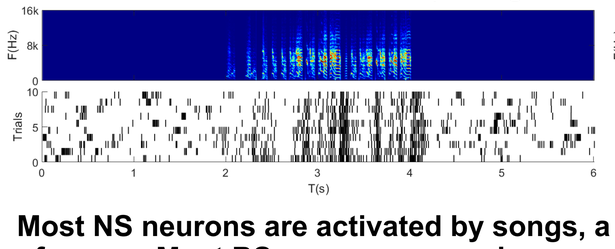
1. BS neurons which respond to subsets of a song



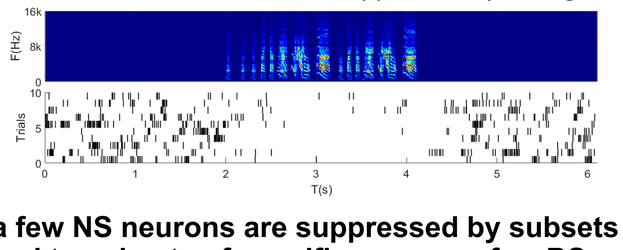
2. BS neurons which respond to the whole song



3. NS neurons which are activated by a song



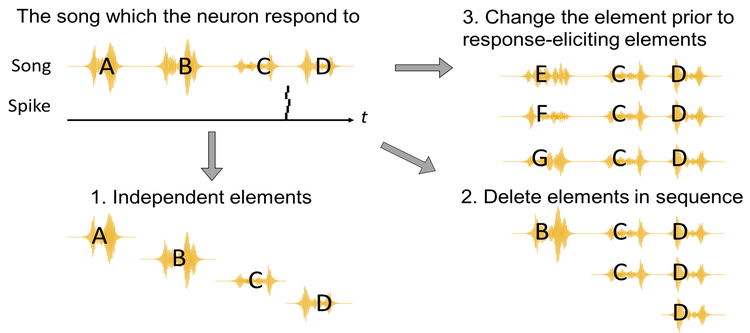
4. NS neurons which are suppressed by a song



Most NS neurons are activated by songs, a few NS neurons are suppressed by subsets of songs; Most BS neurons sparsely respond to subsets of specific songs , a few BS neurons respond selectively to specific songs during the whole stimuli duration.

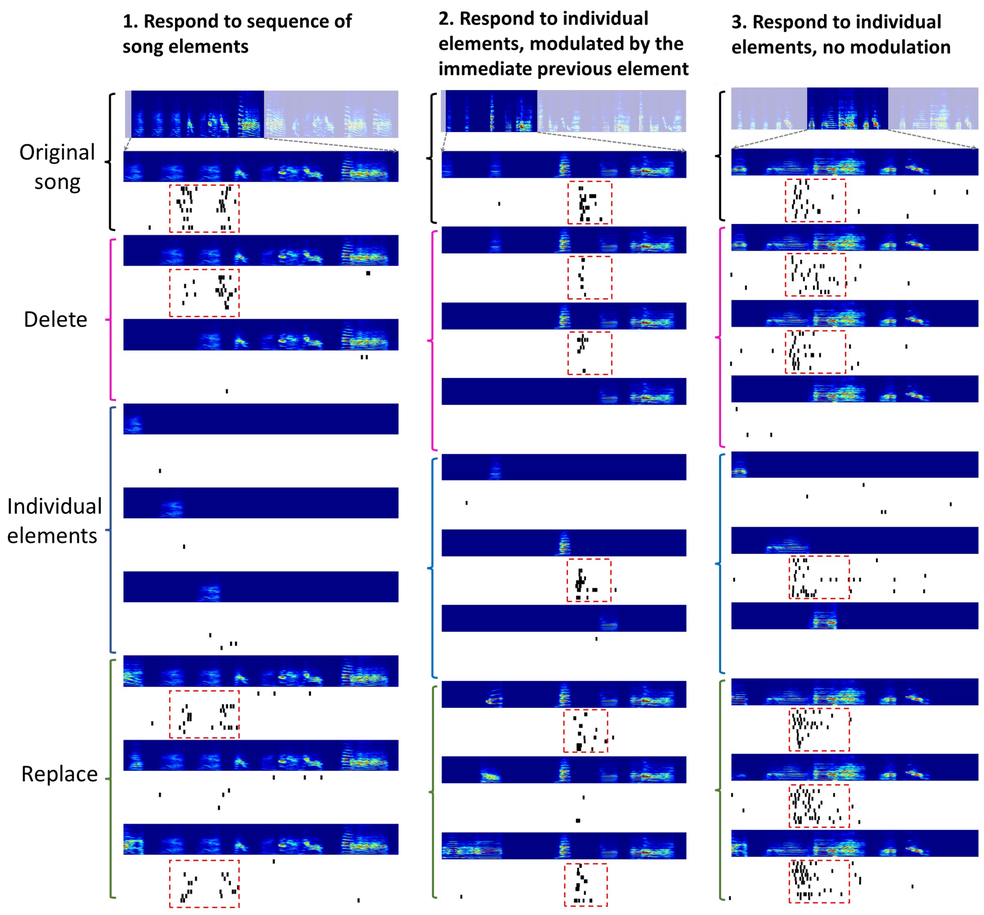
Q3 : As the dominant neuron types in NCM, whether BS neurons detect specific song elements or sequence of song elements?

Stimuli set :

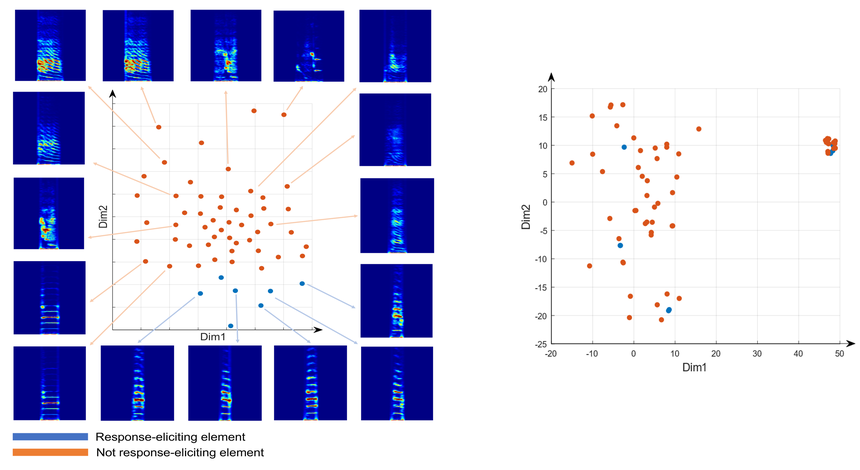


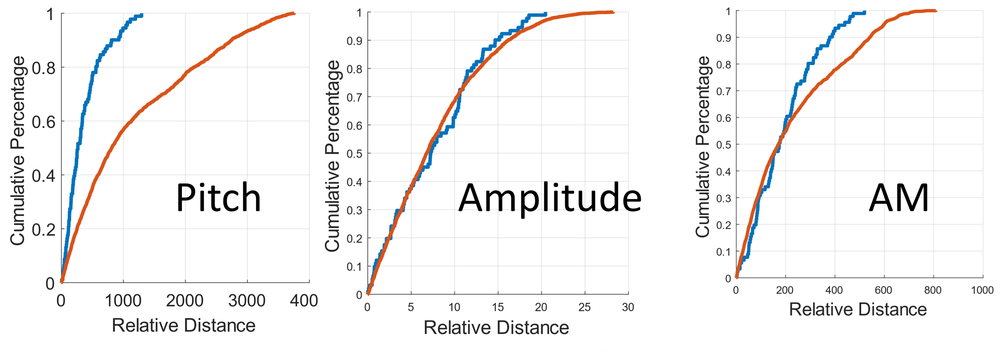
Most BS neurons (21/24) respond to individual elements, subsets (15/21) of these neurons' response are modulated by the immediate previous element. Other neurons (3/24) respond to sequence of song elements.

1. Examples of three different response patterns to songs



Q4: Whether neurons which respond to individual elements detect those elements by targeting specific acoustic features?





Only 1/24 BS neurons only respond to elements from different songs which are very similar to each other. The rest 23/24 BS neurons also respond to elements which are not highly similar. Response eliciting elements cannot be classified by any of the single acoustic features, but statistically they are relatively similar in pitch.

Summary

1. Individual NCM neurons detect various zebra finch songs as a population.
2. NS/BS neurons can be further classified to four types by their response to songs.
3. Most BS neurons detect individual elements while the rest detect sequence of song elements.
4. Most BS neurons do not target a single acoustic feature.

Conflict of interest: The Authors declare that there is no conflict of interest.