Mechanisms for Complex Feature Selectivity in the Songbird Auditory Forebrain

C. Daniel Meliza[1], Zhiyi Chi[2], and Daniel Margoliash[1]

[1]University of Chicago, [2]University of Connecticut

Neurons in many secondary sensory areas exhibit high selectivity for specific stimuli. These representations are thought to underlie the ability of animals to quickly recognize complex objects under a wide range of conditions, but it is not well understood how this selectivity is built up from the simpler response properties of neurons at earlier stages of processing. The songs of European starlings (*Sturnus vulgaris*) incorporate large repertoires of motifs (each a complex vocalization circa 1 s in duration) that are unique to each individual bird, and contribute to individual recognition by song [1–3]. We explored the receptive field properties of cells in the caudomedial mesopallium (CMM), which respond selectively to learned songs and may contribute to vocal recognition behavior [4]. In a series of awake-restrained and urethane anesthetized recordings from 5 starlings, we recorded the responses of 70 well-isolated single units in CMM to novel and familiar motifs. Out of 59 neurons that gave significant responses to at least one motif, 36 (61%) were significantly selective, responding robustly to only a small number of motifs. Selective neurons had significantly lower spontaneous firing rates, and exhibited phasic firing patterns, with one or more precisely timed peaks of excitation. Because these response properties are poorly predicted by linear spectrotemporal receptive field (STRF) models [4], we examined instead if CMM neurons were responding to multiple auditory features of the stimuli. Motifs were decomposed into spectrotemporal features that corresponded to stereotyped vocal gestures, which are employed by many individuals. Both selective and non-selective neurons responded robustly to these features when they were presented in isolation, but whereas nonselective neurons tended to give excitatory responses to a broad range of features, selective neurons responded to exhibited excitatory responses to a few features and suppressive responses to many other features. The responses of CMM neurons to motifs could be predicted from the sum of the excitatory and suppressive contributions of the constituent features with a high degree of accuracy (median correlation coefficient = 0.50; inter-quartile range 0.24–0.68; 86 motifs, 40 neurons). These data suggest that CMM neurons achieve specificity for particular stimuli by sampling from disjoint regions of an underlying feature space, and by making use of the temporal interplay between excitation and suppression to further narrow tuning.

Acknowledgments

This work was supported by NIH grants DC007206 and F32DC008752 (CDM).

References

[1] M. Eens. Understanding the complex song of the European starling: an integrative approach. *Advances in the Study of Behavior*, 26:355–434, 1997.

[2] T. Q. Gentner and S. H. Hulse. Perceptual mechanisms for individual vocal recognition in European starlings, Sturnus vulgaris. *Anim Behav*, 56(3):579–594, Sep 1998.

[3] T. Q. Gentner and S. H. Hulse. Perceptual classification based on the component structure of song in European starlings. *J Acoust Soc Am*, 107(6):3369–3381, Jun 2000.

[4] T. Q. Gentner and D. Margoliash. Neuronal populations and single cells representing learned auditory objects. *Nature*, 424(6949):669–674, Aug 2003.