Podcast Interview: Allison Doupe and Mimi Kao

PNAS: I’m Jessica Johnson. Welcome to Science Sessions. This week you’ll be listening to Allison Doupe and Mimi Kao. Doupe is a professor of physiology and psychiatry at the University of California, San Francisco’s Center for Integrative Neuroscience, and Kao is a postdoctoral fellow in Doupe’s lab. Together with their colleague Satoshi Kojima, the three neurophysiologists were recently awarded the 2013 Cozzarelli Prize for excellence and originality in the Biological Sciences for their paper titled, “Task-related 'cortical' bursting depends critically on basal ganglia input and is linked to vocal plasticity.”

I spoke with Doupe and Kao about their work with song learning in zebra finches. Male zebra finches learn their song from the father and refine the song throughout their lives, using it to defend territory and attract mates. Few animals learn their vocalizations. Humans, whales, dolphins, bats, and songbirds are among them. Songbirds are unique in that one of their basal ganglia circuits, series of clustered neurons that interconnect brain regions and are involved in animal motor control, is dedicated solely to song learning and execution.

Mimi Kao described the cortical basal ganglia circuit for song in zebra finches.

Kao: There are projections from a cortex-like area to the basal ganglia to the thalamus and back to the cortex. So there’s a loop. There’s been a lot of work looking at the outflow nucleus, the last stage in the loop that projects to the motor areas.

PNAS: Allison Doupe explained the importance of the outflow nucleus to song learning.

Doupe: We know that the outflow of the circuit from this nucleus is required for the bird to change the song at any time. And if you damage it or silence it, the bird produces very stereotype song but can no longer change it.

PNAS: Previous research had shown that damage to the outflow nucleus not only halts song learning, but also prevents song deterioration that normally occurs after a songbird is deafened.

Doupe: As long as you don’t have the input from the cortical basal ganglia circuit, the song doesn’t fall apart after deafening. The deafening situation is one in which the bird is getting altered input. It taught us that the falling apart after deafening is an active process. When there’s dysfunctional feedback, it actually disrupts the song.
PNAS: When the authors damaged an earlier part of the circuit in deafened birds, the basal ganglia, a so-called input nucleus in the circuit, they observed the same result – the song did not deteriorate after deafening.

Kao: This left open a question of whether lesioning upstream silenced this nucleus downstream, the outflow nucleus. So we decided to record neural activity in this outflow nucleus in birds that were both deafened and had basal ganglia lesions to see how the activity changed. And we were surprised. We thought that one possibility was that if you lesioned the input nucleus, that the outflow nucleus was either no longer active during singing or that there was increased firing. And we were wrong on both accounts.

PNAS: After lesioning the input nucleus, the basal ganglia portion of the circuit, singing birds displayed an unexpected firing pattern in the outflow nucleus.

Doupe: Activity went up but instead of being patterned with respect to the song, as it normally is with lots of these bursts which are fast firing, the activity went up and just stayed tonic all the time and then went down at the end of song.

PNAS: The loss of the firing pattern and bursts after lesioning the basal ganglia suggested the critical role of this input nucleus in song plasticity. According to the authors, the results may inform disease research as well.

Kao: We know that the basal ganglia is important for movement, for motor learning, and, in motor diseases, often involve dysfunction of the basal ganglia.

Doupe: In Parkinson’s, Huntington’s, things like that. I think part of what’s relevant here is that people were always thinking that the bursts were pathological. But here we see they’re actually a normal part of the function and very critical to the basal ganglia being able to do its learning role. If we can learn what sort of patterns enable normal motor behavior with this good link between the song and the brain, then you could think about driving that pattern so you wouldn’t just eliminate abnormal behavior, but reinstate the ability to learn things that are important. That would be progress.

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