A Fine-grained Analysis of Zebra Finch Song After Lesions in the LMAN Midway Through Sensorimotor Learning

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Abstract

It has been previously suggested that the Anterior Forebrain Pathway (AFP) is necessary for song learning, but not for song production. This has been demonstrated by the inverse relationship with age of the effects of AFP lesions. To gain further insight into the role the nucleus LMAN plays in song learning and maintenance, we have performed electrolytic lesions mid-way during sensorimotor learning. Song was continuously recorded before and after the lesion. Preliminary examination of the data suggests that the production of repeated and alternating syllables often seen in juvenile song is particularly sensitive to disruptions in LMAN.

Background

- The Anterior Forebrain Pathway is a basal ganglia loop for song learning.
- LMAN provides AFP input to motor pathway.
- Previous LMAN lesion studies showed a premature crystallization of juvenile song.
- LMAN lesions also shown to prevent deafening-induced decrystallization of song.

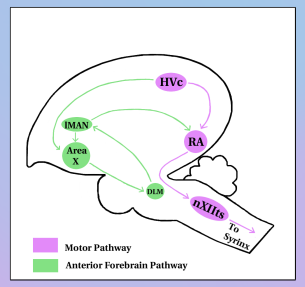

Figure 1. Zebra finch song system.

Methods

Fifteen juvenile male zebra finches were used. Juveniles remained in the breeding cage with the parents until 35dph. Juveniles and fathers were then transferred into a recording studio for tutoring and continuous recording. Bidirectional microphones in the cage were connected to a real-time processer and song was sampled at 24,400 Hz. Bilateral, electrolytic lesions of LMAN (3 penetrations, 2 depths, 200μamps/90 sec) were performed at 55-60 dph. Post-surgery recordings in the studios took place until 90-120 dph. Brains were sectioned at 40μm, and stained alternately for acetylcholinesterase, or with cresyl violet. Extent of lesion was determined from staining present. For song analysis, 15 songs were randomly chosen per day for 3-4 days pre-lesion, and 10-14 days post-lesion.

Primary effect: Repetition

LMAN lesions caused increased syllable repetition in some birds. In all but one case, this was transient. Below is the exceptional (and most dramatic) case.

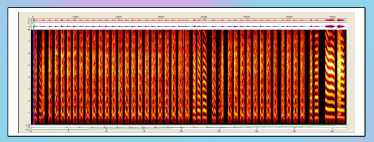

Figure 2. Spectrograph of post-lesion song (Bird 185, 66 dph).

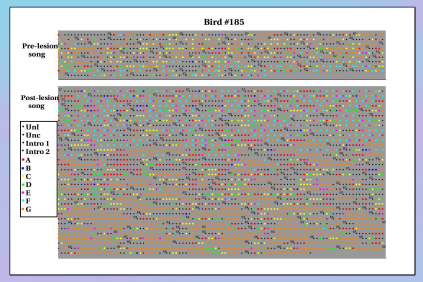

Figure 3. A chronological color map of all syllables recorded from bird 185 pre and post lesion.

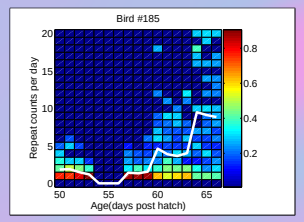

Figure 4. A histogram representing the distribution of repeat counts per day for bird 185. White line represents the average.

Song Analysis

- Songs hand-labeled at syllable level (15 per day; 200-300 per bird).

Quantification of repeat and alternate counts:

- Each syllable is assigned a number equal to the length of the repeating or alternating string to which it belongs.

Repetition							Alternation							
a	b	c	c	c	d	d	a	b	c	b	c	b	c	d	e
1	1	3	3	3	2	2	0	6	6	6	6	6	0	0

  - Distribution of counts/day was plotted and center of mass was calculated (Fig. 4).
- Average longest repeating and alternating strings per day were also calculated.

Secondary effect: Alternation

A few birds with LMAN lesions showed a transient increase in syllable alternation.

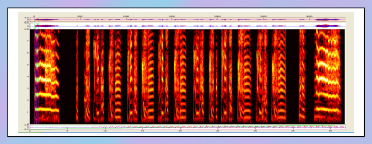

Figure 5. Spectrograph of post-lesion song (Bird 190, 61 dph).

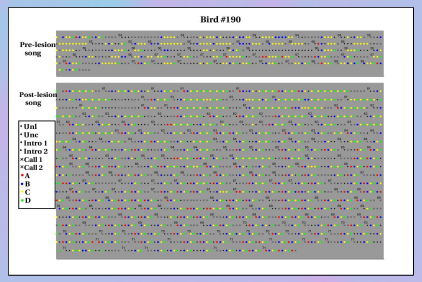

Figure 6. A chronological color map of all syllables recorded from bird 190 pre and post lesion.

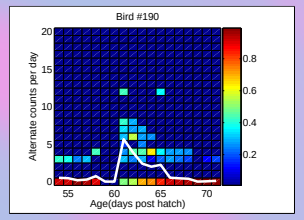

Figure 7. A histogram representing the distribution of alternate counts sung daily by bird 190. White line represents the average.

Extent of lesions

Most birds had moderate lesions; normal volumes of LMAN found in previous studies are in the range of $0.15 - 0.20\,\mathrm{mm}^3$.

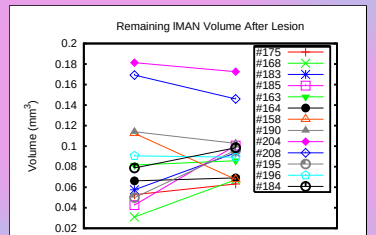

Figure 8. Volume of LMAN tissue remaining after electrolytic lesions in the left and right hemispheres of each bird.

Summary of Results

Of 9 birds with moderate to substantial lesions:

- 3 birds show large increases in either syllable repetions or alternations.
- 4 birds show a trend towards increases in repetitions or alternations.

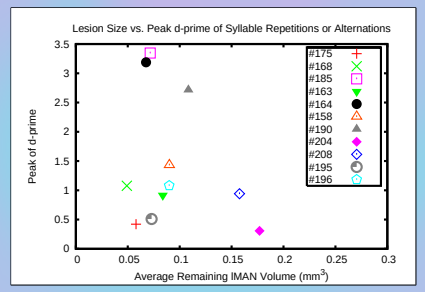

Figure 9. Peak change in syllable repetitions or alternations as a function of the remaining LMAN volume. Change was measured as the maximum d-prime ($\frac{\mu_1-\mu_2}{\sqrt{\sigma_1^2+\sigma_2^2}}$) of the average longest repeating or alternating string per day.

Conclusions

Our data suggests that LMAN lesions may disrupt syllable sequencing, as this was the case for a subset of birds in this study. This was manifested as a transient increase in syllable repetitions and syllable alternations. Previous studies have shown that lesions in LMAN result in reduction of variability in song. Our results suggest these effects on song may be preferentially targetted to syllable transitions.

REFERENCES

Bottjer, S., Miesner, E., & Arnold, A. 1984, Science, 224, 901.

Brainard, M., & Doupe, A. 2001, J. Neurosci., 21, 2501.

Nixdorf-Bergweiler, B. 1996, J. Comp. Neurol., 375, 445.

Scharff, C., & Nottebohm, F. 1991, J. Neurosci., 11, 2896.