Epigenetic modulation of auditory memories in zebra finches

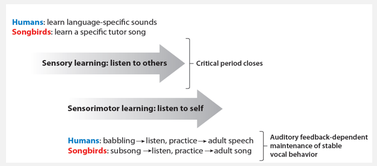
Paige Dadika, Nesha Daneshwar, Luke Collins, Mimi L. Phan, and David S. Vicario

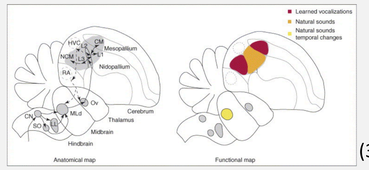
Psychology Department, Rutgers University, New Brunswick, NJ

RUTGERS
Aresty Research Center for Undergraduates

1. Song Learning

Zebra finches are considered to be a model of complex vocal learning similar to language acquisition in humans. Their learning takes place during a critical period and entails two phases, a learning phase where a juvenile bird listens to a tutor and commits the song to memory, and a rehearsal phase where the juvenile vocalizes to produce their own song. The songs produced are very good, but not perfect copies; as a result, every bird produces an essentially unique song that serves individual recognition. Song learning in zebra finches only occurs in males. One particular area of the auditory forebrain, the caudal medial nidopallium (NCM), responds selectively to conspecific vocalizations; it is an area in which long-term memories, including the auditory memory for the tutor song, are stored (2).





(3)

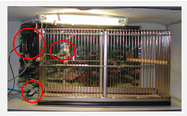
2. HDAC3 represses gene expression needed for long-term memory (LTM) formation

The bird's ability to form lasting memories for the tutor song requires de novo gene expression for neuroplasticity. Epigenetic mechanisms such as histone acetylation usually promotes gene expression, whereas histone deacetylation represses gene expression. HDAC3 is one example of this, as it is a histone deacetylase enzyme that is coded by the HDAC3 gene. HDAC3 is thought to act as a brake implemented when controlling which memories are consolidated into long-term memory (1).

3. Hypothesis

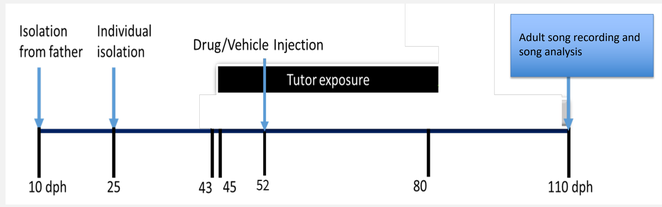
Inhibiting HDAC3 with a chemical agent would disrupt the regulation of memory formation and result in improved song learning ability as well as less variation among vocal imitations.

4. Methods



Tutoring

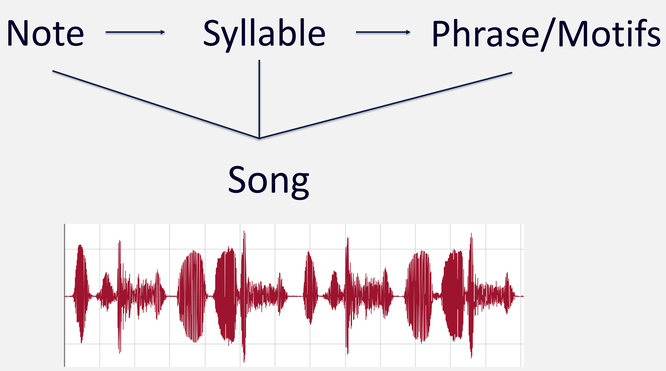
Juvenile male zebra finches were separated from their fathers and were played 10 repetitions of the tutor song twice a day, for 14 consecutive days. During the critical period of song leaning, the juvenile zebra finches received one injection a day of RGFP966, the HDAC3 inhibitor or vehicle.



Song Analysis

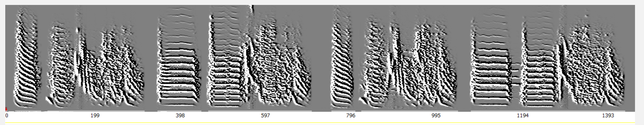
Songs were recorded daily throughout the period of song learning. In adulthood, the crystalized songs were screened to identify the bird's own song (BOS). Once identified, exemplars of the BOS were filtered and trimmed for analysis. A customized software, Sound Analysis Pro, was used to measure the similarity between the BOS and the tutor song.

5. Structure of zebra finch song



6. Song Similarity

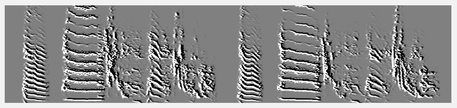
Tutor Song:



y109:

37% similarity

y134:



57% similarity

7. Further Directions

Song data were collected form 7 birds. These data are in various stages of analysis. Once the vocal data are analyzed and contrasted, interpretations and implications of the role of epigenetics on auditory memories can be ascertained.

8. References

1. Phan, M., & Bieszczad, K. (2016). Sensory Cortical Plasticity Participates in the Epigenetic Regulation of Robust Memory Formation. *Neural Plasticity*, *2016*, 7254297–12. https://doi.org/10.1155/2016/7254297
2. Phan, M., Pyette, C., & David S. Vicario. (2006). Early auditory experience generates long lasting memories that may subserve vocal learning in songbirds. *Proceedings of the National Academy of Sciences - PNAS*, *103*(4), 1088–1093. https://doi.org/10.1073/pnas.0510136103
3. Theunissen, F., & Shaevitz, S. (2006). Auditory processing of vocal sounds in birds. *Current Opinion in Neurobiology*, *16*(4), 400–407. https://doi.org/10.1016/j.conb.2006.07.003

9. Acknowledgments

Thank you to the Aresty Research Center for Undergraduates as well as Mimi Phan and the members of the Vicario Lab.