The Differential Effects of Acoustic Discriminations on Operant Learning Performance and Neurogenesis in Male and Female Zebra Finches

Kristena L. Newman[1], Rebecca Kalendareva[2], Andrea Silverstein[2], Katelyn Urena[2], Carolyn L. Pytte[1,2]

[1]Psychology Department, The Graduate Center, City University of New York, [2]Psychology Department, Queens College, City University of New York

Introduction and Methods

- Neurogenesis, the production of new neurons, occurs throughout life in all animals investigated (Cayre et al., 2002).
- Successful learning of certain tasks may increase new neurons, but only if the learning is sufficiently challenging (Curlik and Shors, 2011; Clelland et al., 2009).
- Songbirds are a useful model because they learn their songs similarly to how humans learn language (Doupe and Kuhl, 1999)
- The caudomedial nidopallium (NCM) is necessary for conspecific song discrimination learning and receives new brain cells (Chew et al.,1996).

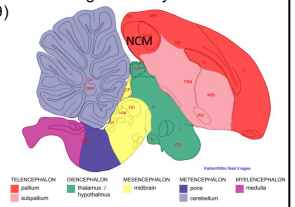


Figure 1. Sagittal section of the zebra finch brain at 0 mm from the midline. Retrieved from the ZEBrA database.(Oregon Health & Science University, Portland, OR 97239; http://www.zebrafinchatlas.org)

Question: Does learning a harder task increase new neurons more than learning an easier one?

1. Go/No Go Discrimination Learning Task:

4 experimental conditions: Injected with BrdU- new cell marker- learn task to criterion
4 learning controls: BrdU-injected with experimental counterparts, exposure, no operant learning

- Hard Discrimination: Songs recorded from siblings
- Easy Discrimination: Songs recorded from unrelated songbirds
- Song pairs scored for similarity using acoustic software (SAP, Tchernikovski, 2011)

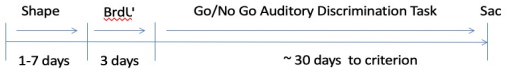


Figure 2. Behavioral timeline. Birds reach learning criterion at 80% or better discrimination in two consecutive 100-trial bins. Birds are sacrificed the following day with controls.

2. Immunohistochemistry and Microscopy:
Double-labeled co-localized (BrdU+/Hu+) cells in NCM are counted.

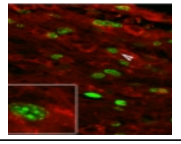
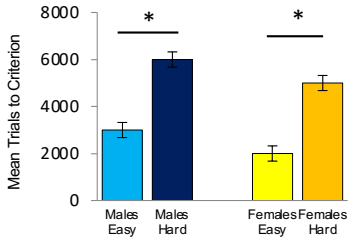


Figure 3. Double-labeled BrdU+ nucleus (green), red color indicates Hu+ neuron. 60x magnification.

Expected Results

Figure 4. It will take longer for birds in the "Hard" conditions to learn relative to birds in the "Easy" conditions.



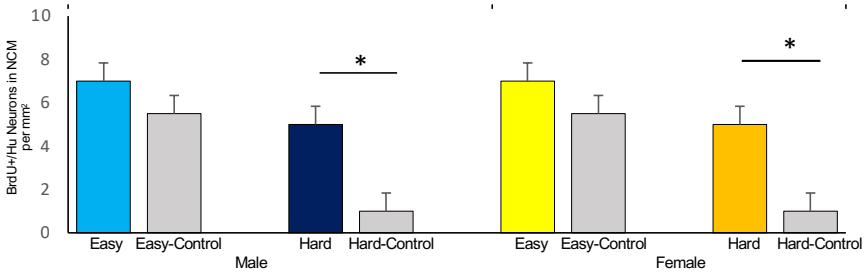
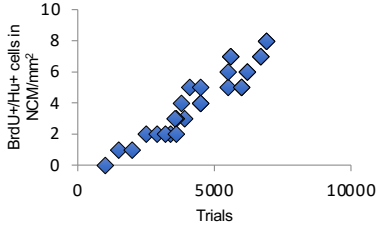


Figure 5. Successful learning of a harder discrimination task will result in greater numbers of surviving new neurons relative to controls. There will be no difference in neuronal numbers betweer birds in the easy learning task and their controls.

Figure 6. There will be a positive relationship between learning trial number and new neurons. There will be greater numbers of new neurons in birds that require greater trial numbers to reach learning criterion.



Conclusions

- We predict that successful learning of the harder learning task will increase new neurons relative to their respective learning controls. However, learning the easier task will not result in more new neurons relative to their respective learning controls.
- These findings may inform non-pharmacological treatments for mitigating the effects of neurodegenerative diseases and mood disorders, both of which may be improved by increased neurogenesis.

References

Cayre, M., Malaterre, J., Scotto-Lomassese, S., Strambi, C., & Strambi, A. (2002). The common properties of neurogenesis in the adult brain: from invertebrates to vertebrates. *Comparative Biochemistry and Physiology, 132,* 1-15.

Chew, S. J., Vicario, D. S., & Nottebohm, F. (1996). A large-capacity memory system that recognizes the calls and songs of individual birds. *Proceedings of the National Academy of Sciences*, *93,* 1950–1955.

Clelland, C., Choi, M., Romberg, C., Clemenson, G. Jr, Fragniere, A., Tyers, P., Jessberger, S., Saksida, L., Barker, R., Gage, F., & Bussey, T. (2009). A Functional Role for Adult Hippocampal Neurogenesis in Spatial Pattern Separation. *Science, 325,* 210-213.

Curlik, D. M., & Shors, T. J. (2011). Learning increases the survival of newborn neurons provided that learning is difficult to achieve and successful. *Journal of Cognitive Neuroscience, 23,* 2159-2170.

Doupe, A. J. & Kuhl, P. K. (1999). Birdsong and human speech: Common themes and mechanisms. *Annual Review of Neuroscience, 22,* 567-631.

Acknowledgements

This work was funded by Doctoral Student Research Grant Round 14, awarded to Kristena Newman.