VOCAL LEARNING IS AT ODDS WITH NON-VOCAL DEXTERITY

Pedro Tiago Martins[*1]

[*]Corresponding Author: pt.martins@ub.edu
[1]Psycholinguistics and Neurolinguistics Lab, University of Ljubljana, Ljubljana, Slovenia

1. Introduction

In this work, I propose that vocal learning complexity is at odds with non-vocal dexterity. In order words, given some conditions generically required for vocal learning behavior, species lacking appendages fine-tuned for grasping, object manipulation, etc. ('prehensile appendages') are more likely to display complex vocal behavior than species which do have and expertly use such appendages. I hypothesize that the use of the mouth or analogous structures (and those adjacent to it) for all or most object manipulation and interaction promotes complex vocal behavior. Conversely, the existence of appendages tuned for fine control relegates the vocal apparatus to simpler vocal, feeding, and manipulation behaviors. In conjunction (and indeed in constant interaction) with several other factors, this relationship helps shape the vocal learning phenotype.

This hypothesis has implications for how vocal learning and related abilities evolved across species, and emphasizes the importance of ecological and behavioral factors for this capacity. This is in contrast with much of the vocal learning literature which tends to be focused on neural mechanisms alone.

2. A closer look

The species to look at in order to study this relationship are *accepted* and *possible* vocal learners. Here I consider vocal learning in a broad sense (Ghazanfar, Liao, & Takahashi, 2019; Martins & Boeckx, 2020; Fischer, Wegdell, Trede, Dal Pesco, & Hammerschmidt, 2020), not tied to a very specific neural circuit nor limited to imitative behavior, which is crucial for the current hypothesis.

Given a set of factors in place (sound production anatomy, some kind of neural circuitry subserving control of that anatomy, functional and ecological pressures promoting and shaping vocal behavior), this hypothesis adds that well-developed prehensility in appendages not related to vocal behavior (e.g., "hands"), pushes species away from complex vocal behavior, while the lack of such appendages or dexterity thereof brings species closer to it. Indeed, for the most part, vocal learning is displayed most clearly by species with not a lot of dexterity (several bird

orders, pinnipeds—flyers and swimmers), while other, more dexterous species with apparently the right mix of factors in place display it in a more arduous, peculiar, or simple manner—to the point where they are often not accepted as vocal learners (e.g., non-human primates, rodents).

The following independent reasons for this relationship are put forward as part of the hypothesis:

1. lack of manual dexterity puts emphasis on mouth and adjacent structures for object manipulation, fostering the development of those structures, which are recruited for volitional control when vocalizing

2. for prehensile species, vocal control requires greater effort than forelimb/manual control (Koda, Kunieda, & Nishimura, 2018)

3. flyers and swimmers tend to cover much larger areas, and need to communicate across larger distances (Janik and Slater (1997) allude to this)

3. Flyers, swimmers, and beyond

This work brings together ecological, anatomical, developmental, and neural data on a range of species (birds, cetaceans, pinnipeds, elephants, bats, rodents, and primates) in an attempt to corroborate the hypothesis proposed. Humans, which are clearly a dexterous *and* vocal learning species, are seemingly an outlier in the relationship I propose here and deserve special attention. A multidimensional approach is followed, according to which there are no magic-bullet explanations for the evolution of particular cognitive abilities. Indeed, this work defends and adds to the notion that the vocal learning capacity and the factors that contribute to it are not all-or-nothing affairs, but rather nuanced (Wirthlin et al., 2019; Martins & Boeckx, 2020; Ravignani & Garcia, 2022).

Acknowledgements

I thank Cedric Boeckx, Andrea Ravignani, and members of the Cognitive Biology of Language Group (University of Barcelona) for discussion and suggestions on this idea and on other ideas and topics that led to it. This proposal relies in part on work funded by the Portuguese Foundation for Science and Technology (FCT) in the form of a PhD fellowship (grant SFRH/BD/131640/2017).

References

Fischer, J., Wegdell, F., Trede, F., Dal Pesco, F., & Hammerschmidt, K. (2020). Vocal convergence in a multi-level primate society: Insights into the evolution of vocal learning. *Proceedings of the Royal Society B: Biological Sciences*, *287*(1941), 20202531.

Ghazanfar, A. A., Liao, D. A., & Takahashi, D. Y. (2019). Volition and learning in primate vocal behaviour. *Animal Behaviour*, *151*, 239–247.

Janik, V. M., & Slater, P. J. (1997). Vocal Learning in Mammals. In *Advances in the Study of Behavior* (Vol. 26, pp. 59–99). Elsevier.

Koda, H., Kunieda, T., & Nishimura, T. (2018). From hand to mouth: Monkeys require greater effort in motor preparation for voluntary control of vocalization than for manual actions. *Royal Society Open Science*, *5*(11), 180879.

Martins, P. T., & Boeckx, C. (2020). Vocal learning: Beyond the continuum. *PLOS Biology*, *18*(3), e3000672.

Ravignani, A., & Garcia, M. (2022). A cross-species framework to identify vocal learning abilities in mammals. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *377*(1841), 20200394.

Wirthlin, M., Chang, E. F., Knörnschild, M., Krubitzer, L. A., Mello, C. V., Miller, C. T., Pfenning, A. R., Vernes, S. C., Tchernichovski, O., & Yartsev, M. M. (2019). A Modular Approach to Vocal Learning: Disentangling the Diversity of a Complex Behavioral Trait. *Neuron*, *104*(1), 87–99.