



Introductory Notes as Motor Preparatory Motor Gestures Underlying Zebra Finch Song

Soseh Asadoorian, Emily Sugg, Kevin Bien, Samantha Shah, Zoe Esquivel, Diana Villalta Palencia, Bentley Altman, Crystal Ibe, Brenton G. Cooper
 Psychology Department, Texas Christian University, Fort Worth, TX 76129

Introduction

Before song begins, zebra finches sing a highly variable sequence of introductory notes that are short-duration, non-stereotyped sounds (Daliparthi et al., 2019) (Figure A). The introductory notes are postulated to function as a preparatory motor phase to help transition to executing the stereotyped song (Rajan & Doupe, 2012). However, this hypothesis has not been subjected to a rigorous experimental hypothesis test. Disruption of preparatory neural activity leads to a delay in motor execution. We reasoned that disrupting introductory notes by presenting an external stimulus during the introductory notes would delay song execution if they are a preparatory motor gesture.

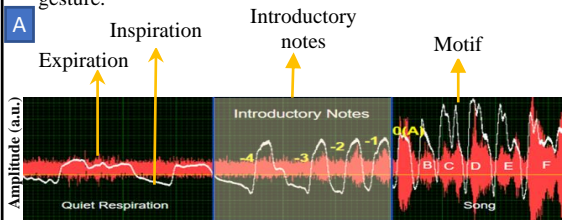


Figure A The bird's song is composed of a variable number of introductory notes (INs), a fixed sequence of ~3-8 syllables that make up the motif, and the motif is sung one or more times, forming a song bout. . Expiration (EP): supra-atmospheric air pressure- Inspiration (IP): sub-atmospheric air pressure.

Methods

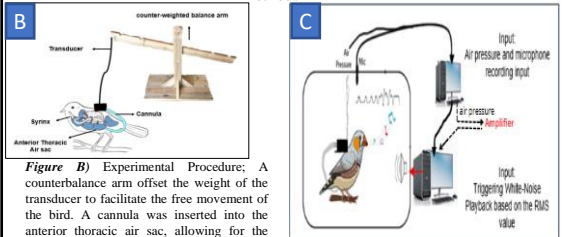


Figure B Experimental Procedure: A counterbalance arm offset the weight of the transducer to facilitate the free movement of the bird. A cannula was inserted into the anterior thoracic air sac, allowing for the measurement of sub-syringeal (below the vocal organ) air pressure. **Figure C** Recording setup and procedure.; sub-syringeal air pressure recording with playback of sound during the introductory note sequence. Two different conditions of playback white-noise.

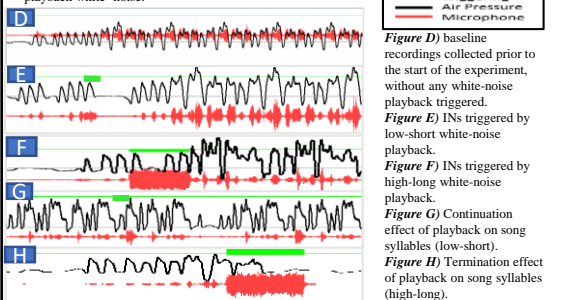


Figure D baseline recordings collected prior to the start of the experiment, without any white-noise playback triggered. **Figure E** INs triggered by low-short white-noise playback. **Figure F** INs triggered by high-long white-noise playback. **Figure G** Continuation effect of playback on song syllables (low-short). **Figure H** Termination effect of playback on song syllables (high-long).

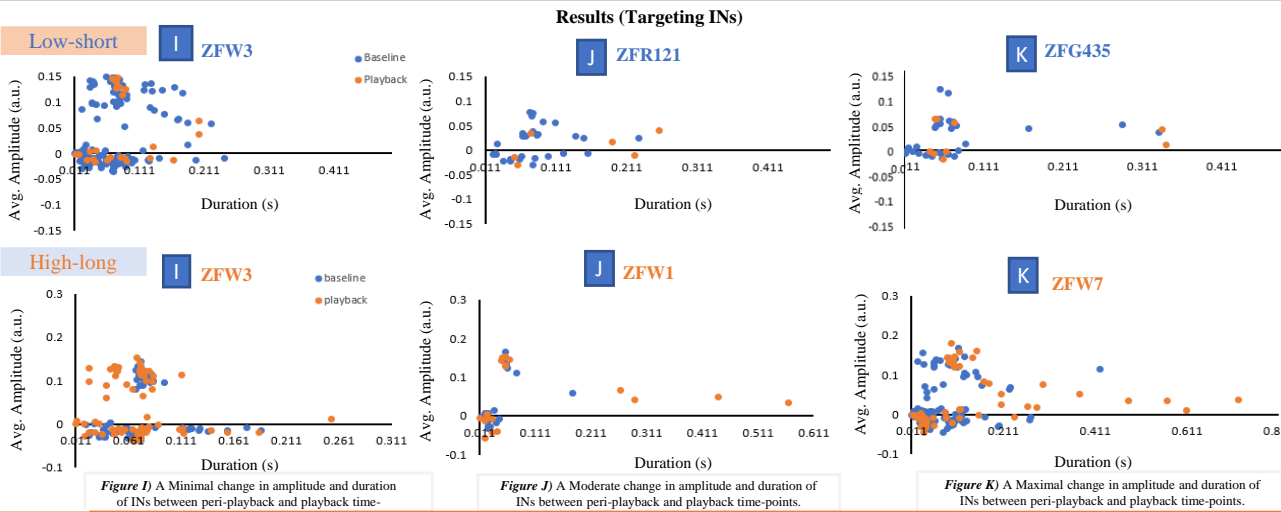


Figure I A Minimal change in amplitude and duration of INs between peri-playback and playback time-points. **Figure J** A Moderate change in amplitude and duration of INs between peri-playback and playback time-points. **Figure K** A Maximal change in amplitude and duration of INs between peri-playback and playback time-points.

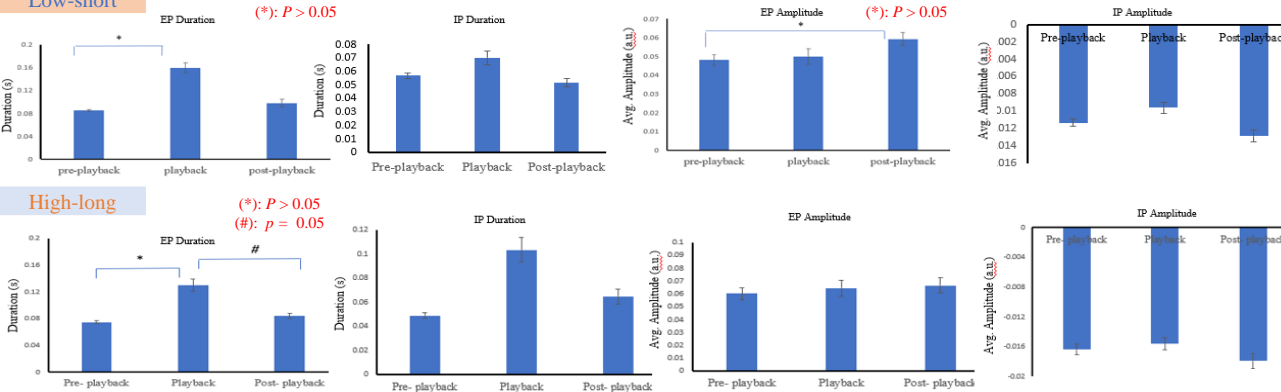
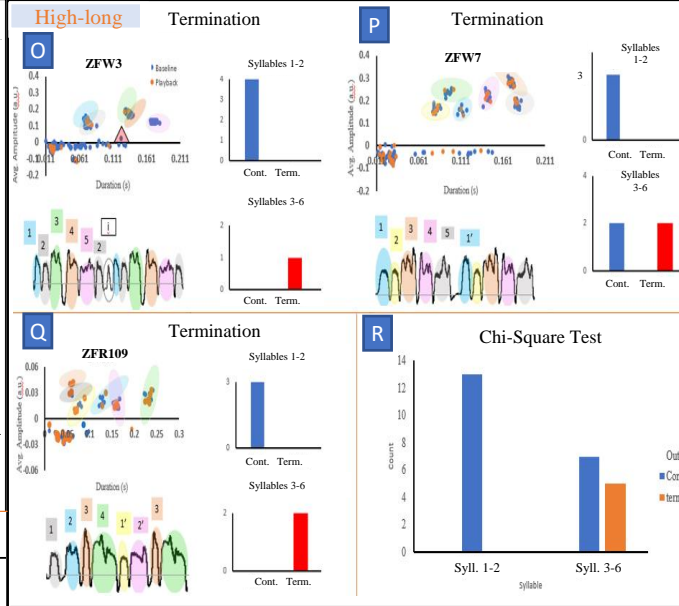


Figure L Bird ZFR109 was frequently targeted on early song syllables and exhibited one termination effect under the low-amplitude, short-duration playback condition in first syllables. **Figure M** Bird ZFW13 was targeted only on the first syllables, and under the low-amplitude, short-duration condition, illustrated one termination effect of playback on the first syllables out of 4 overall white-noise playbacks. **Figure N** A chi-square test of independence indicated non-significant association between the low-amplitude, short-duration playback condition and response type (continuation vs. termination) in both early and late syllables of the first motif, $\chi^2(1, N = 27) = 2.10, p = .15$



Figures O, P, Q ZFW3, ZFW7, and ZFR109 illustrated termination event when later syllables were targeted by high-long condition. **Figure R** The Pearson chi-square test was significant, $\chi^2(1, N = 25) = 6.7$. The high-amplitude, long-duration playback induced termination in the later syllables in 20% of overall playback for bird ZFW3, 40% for ZFR109, and 33% for ZFW7.

Discussion

- 1- The both low-short and high-long white-noise playback conditions produced prolonged EP pulses (i.e., abnormal breath holding) during playback compared to the pre-playback condition, during IN performance, which suggests that birds modify preparatory processes to facilitate the transition into song production under perturbed conditions.
- 2- The initial syllables of the first motif remain highly consistent and stereotyped in this study (i.e., under both high and low amplitude white-noise stimuli), appearing resistant to interruption by external auditory stimuli (i.e., no effect of auditory stimuli).
- 3- Intense auditory perturbations (e.g., high amplitude white-noise) can disrupt song production during later syllables of the first motif, suggesting that these later elements are more variable and less stereotyped than the initial components. The fact that later syllables are more variable suggests that motor sequences are not consistently "locked in" in motor execution phase. Instead, there may reflect gradual changers over time, where stability is strongest at initiation and gradually relaxes.

Acknowledgment: We thank Lindy Bledsue for expert animal care.