Machine-learning Approach to Track Sound-Elicited Behavioral Changes

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Background

- Zebra finches (ZFs), a species of songbird, utilize communication signals to not only to relay information to their conspecifics but also to differentiate between them
- Historically, to determine whether ZFs are able to behaviorally differentiate between two conspecific sounds, operant conditioning principles are applied. ZFs are thus tasked with learning two different tasks simultaneously:
  - Response-consequence contingencies
  - The difference between the two sounds
- Human infant (age...) studies have shown that subtle changes in head-turning can be used to study sound-discrimination performance in the absence of operant learning
  - Such experiments can be taxing for confederates whom have to subjectively score multiple videos of ongoing behavior

The goals of the current study were:

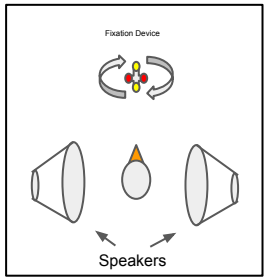
1)Implement a novel 3D pose-estimation software to semi-automatically track ZF behavior

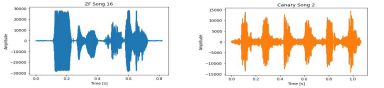
2)Determine ZFs ability to discriminate between two different sounds by tracking subtle changes in behaviors

Methods

Subjects: ZFs were comfortably restrained inside a plastic tube during auditory playback. A camera, atop the ZfS, recorded head movements.

Head Tracking: DeepLabCut (Matthis Lab)



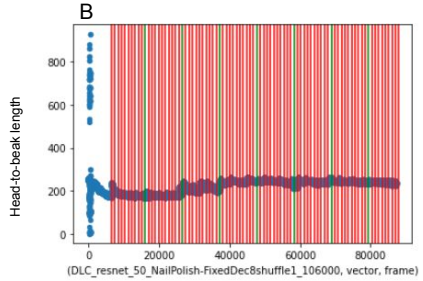


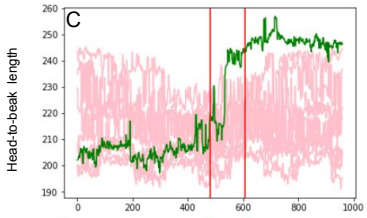
Sound Playback

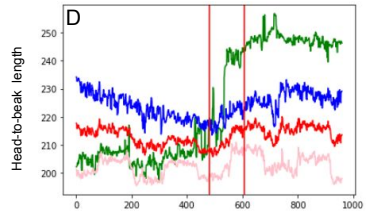
Block 2

$A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}B^{1}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}B^{2}\ldots\ldots\ldots\ldots\ldots\ldots A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}A^{A}B^{10}$

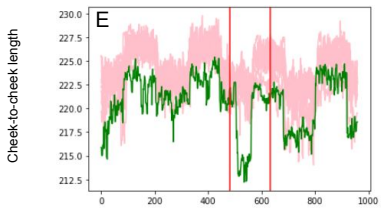
Results

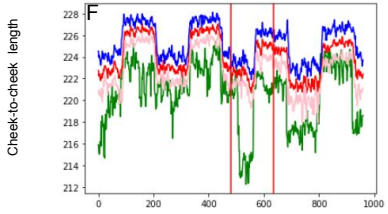






A) GIF of DLC_labeled video, B) graph of head-to-beak as a function of frames within a test video, C) superimposed windows of block 2, standards (pink) and oddball (green), D) Block 2 average of standards (red) with flanking standard error functions (blue and pink) vs oddball (green), E & F) same as C and D but for cheek-to-cheek measurement. Non-parametric testing suggests that a paired comparison of the standard vs oddball length distributions are independent from each other, Z=16.9, p<.001.





Discussion & Conclusion

From what was gathered, there appears to be a response to the oddball stimulus that deviates relative to the responses observed during standard presentations. Further analysis and consistencies are required to make any set conclusions, but these findings are at least consistent with the hypothesis that behavioral data, in the absence of explicit learning (operant conditioning), can prove to be a valuable tool in assessing auditory discimination in Zebra Finches.

Semi-automatic labeling of ZF features via the use of DLC offers a novel and less-taxing manner of tracking behaviors in restrained animals.

Future directions

Principal Component Analysis (PCA) has been applied to the datasets (not shown), derived principal components may offer a generalizable metric across videos and birds (and their movements) to facilitate between-dataset comparisons.

Addition of more cameras will allow for the 3D-like characterization of head movements in response to sounds.

The current approach used a playback paradigm that explicitly tested the birds' ability to differentiate sounds by making the auditory stimuli very distinct and presenting them in a highly contrasting setup. Future approaches will utilize sounds that are more similar, or vary within a similarity continuum, that more closely emulate sound discrimination in a real-world setting.

Currently, to adequately assess bird behavior, subjects were restrained. Future approaches will attempt to categorize behaviors of freely-moving birds (3D dimensions; a difficult task, even for ML algorithms)

References

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