# Deep-learning based behaviour analysis: Odour and colour as cues for foraging in rosy-faced lovebirds, *Agapornis roseicollis*


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## Introduction

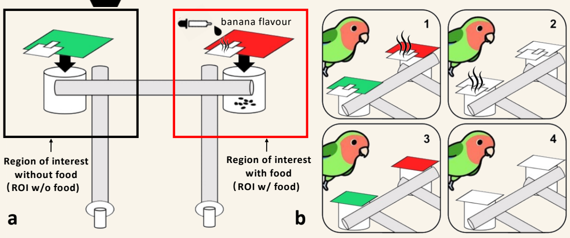
- It is believed that birds rely on vision like other vertebrates in their daily life (Cook, R. G., 2000), yet recent studies reveal birds might also have a good olfaction aiding their foraging, reproduction and social behaviour (Wikelski, M., 2021). Thus, it is meaningful to assess the importance of the role vision and olfaction playing in bird's life, especially in parrots, as only few studies focusing on their vision and olfaction. This study can be integrated and extended into a big picture of our understanding of avian cognition, also the ecological implication of sensory system.
- Animal behaviour study plays a vital role in ecological studies as it can provide important information and implication about how the sense helps animal to survive and reproduce.
- However, such studies are always limited by manual and tedious ethogram annotations. By combining the cutting-edge machine learning analysis and pose-estimation with convolutional neural networks (CNN) training, we first demonstrate how such techniques can be used and aided in the avian behaviour study.

## Objectives

1. To apply deep-learning analysis to aid the behaviour study
2. To investigate the role of vision and olfaction in foraging in rosy-faced lovebirds

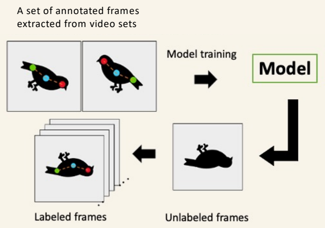
## Methods

### A Experimental design & training



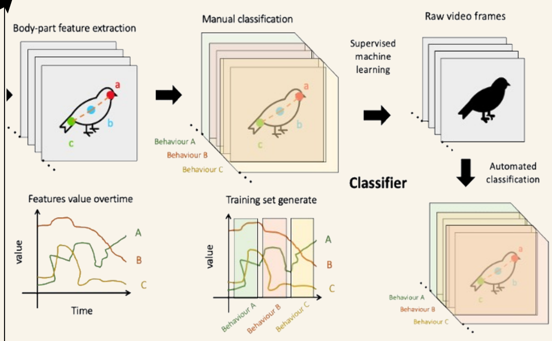

- A U-shape like perch attached two feeders (a) was provided for each bird (n=26). Only red colour paper indicates the food reward. Two drops or no banana flavors were added on the perfume paper that attached to the paper. Four experiments were conducted (b): 1: both cues; 2: olfactory cue; 3: visual cue; and 4: no cues/control group.
- Each experiment contain 2 trials (different position).

### B Pose-estimation




- Open-source software DeepLabCut (Mathis, A., 2018) was used to generate the pose-estimation model based on set of annotated frames extracted from videos.

### C Behaviour classifier




- Based on the data extracted from pose-estimation model, a simple behaviour analysis tool (SimBA) (Nilsson, S. R., 2020) was used for generating the behaviour classifier. The classifier can detect the presence of behaviour with corresponding videos and pose-estimation file.

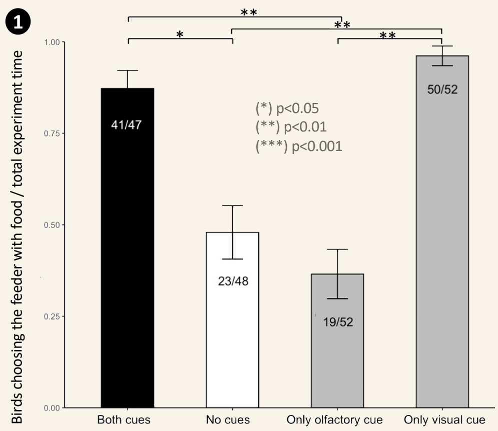
### D Apply to raw videos set

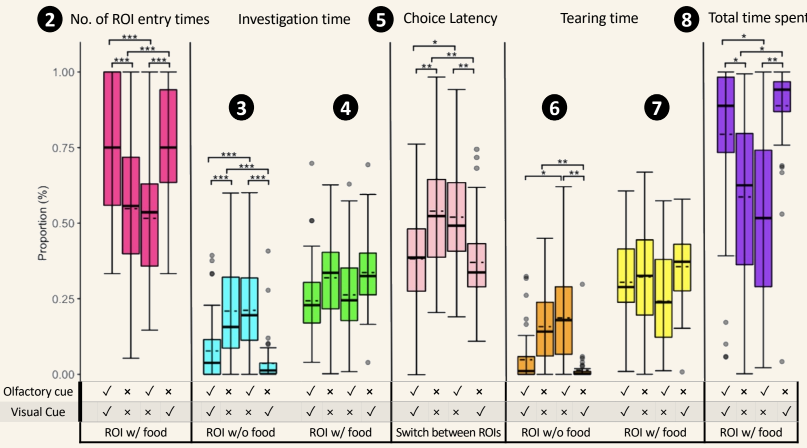

We successfully obtained the result via pose-estimation model and behaviour classifiers.

## Results

- The model showed that birds were significantly more likely to choose the feeder containing food if presented with a visual cue, but there was no difference when presented with either no cues at all or an olfactory cue.

| Response variable | Factor | Effect size | P-value |
|---|---|---|---|
| 1) Choice result | Visual cue | 3.27 | <0.001*** |
| | Olfactory cue | -0.50 | 0.95 |
| 2) No. of ROI entry times | Visual cue | 0.77 | <0.001*** |
| | Olfactory cue | -0.03 | 0.95 |
| 3) Investigation time (ROI w/o food) | Visual cue | 0.17 | <0.001*** |
| | Olfactory cue | 0.01 | 0.09 |
| 4) Investigation time (ROI w/ food) | Visual cue | 0.34 | 0.98 |
| | Olfactory cue | -0.06 | <0.05* |
| 5) Choice latency | Visual cue | 1.51 | <0.001*** |
| | Olfactory cue | -0.08 | 0.07 |
| 6) Tearing time (ROI w/o food) | Visual cue | 0.14 | <0.001*** |
| | Olfactory cue | 0.03 | 0.19 |
| 7) Tearing time (ROI w/ food) | Visual cue | 0.36 | 0.32 |
| | Olfactory cue | -0.09 | 0.12 |
| 8) Total time spent | Visual cue | 0.83 | <0.001*** |
| | Olfactory cue | -0.07 | 0.54 |




- In terms of how different cues affect their choices, when there is a visual cue presented, birds entered or spent more time on the area of feeder containing food rewards, with less hesitation time to make a choice or switch their choice. While when there is an olfactory cue presented or no cues at all, these situations become reverse.
- Also, they performed significantly less investigation and tearing on the feeder containing no food rewards when there was a visual cue, whereas they spent similar time to investigate and tear on the feeder containing food no matter it was with or without any cues.

## Conclusions

- We successfully applied the cutting-edge deep-learning techniques into the present study, which can make animal behaviour study faster and efficient.
- We successfully demonstrated that rosy-faced lovebirds can discriminate the feeder based on visual cue but not on olfactory cue, which may indicate they rely on more on vision than olfaction in foraging.
- It is still possible that rosy-faced lovebirds may use olfaction in other contexts, such as in social behaviour and communication.

## References


- Cook, R. G. (2000). The comparative psychology of avian visual cognition. Current Directions in Psychological Science, 9(3), 83-89.
- Wikelski, M., Quetting, M., Cheng, Y., Fiedler, W., Flack, A., Gagliardo, A., . . . Williams, J. (2021). Smell of green leaf volatiles attracts white storks to freshly cut meadows. Sci Rep, 11(1), 12912. doi:10.1038/s41598-021-92073-7
- Nilsson, S. R., Goodwin, N. L., Choong, J. J., Hwang, S., Wright, H. R., Norville, Z. C., . . . Eshel, N. (2020). Simple Behavioral Analysis (SimBA)–an open-source toolkit for computer classification of complex social behaviors in experimental animals. BioRxiv.
- Mathis, A., Mamidanna, P., Cury, K. M., Abe, T., Murthy, V. N., Mathis, M. W., & Bethge, M. (2018). DeepLabCut: markerless pose estimation of user-defined body parts with deep learning. Nature neuroscience, 21(9), 1281-1289.