Automated detection of behaviours used to assess temperament in rhesus macaques

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Introduction

Assessing temperament, as measured by individual differences in the response to various novel objects or conditions, is a valuable tool in the management of captive non-human primates [1], [2]

The most commonly used method to analyse monkey temperament is through focal observations which require trained personnel and is time consuming to implement

The aim of this project was to develop automatic methodologies based on computer vision to detect and identify the main behaviours used to assess monkey's temperament

Temperament Test

The subjects were 73 rhesus macaques all 3 years old. For testing the focal individual was separated from their group and placed in a 1.2m x 3.6m section of their cage (Figure 1a). The animals were provided with familiar food, followed by a novel food and 2 novel objects

All the foods and objects were positioned on a wooden shelf located outside the cage (Figure 1a). The cage area was set up with one camera at the side of the (Camera 1) and one camera in front on a tripod (Camera 2)

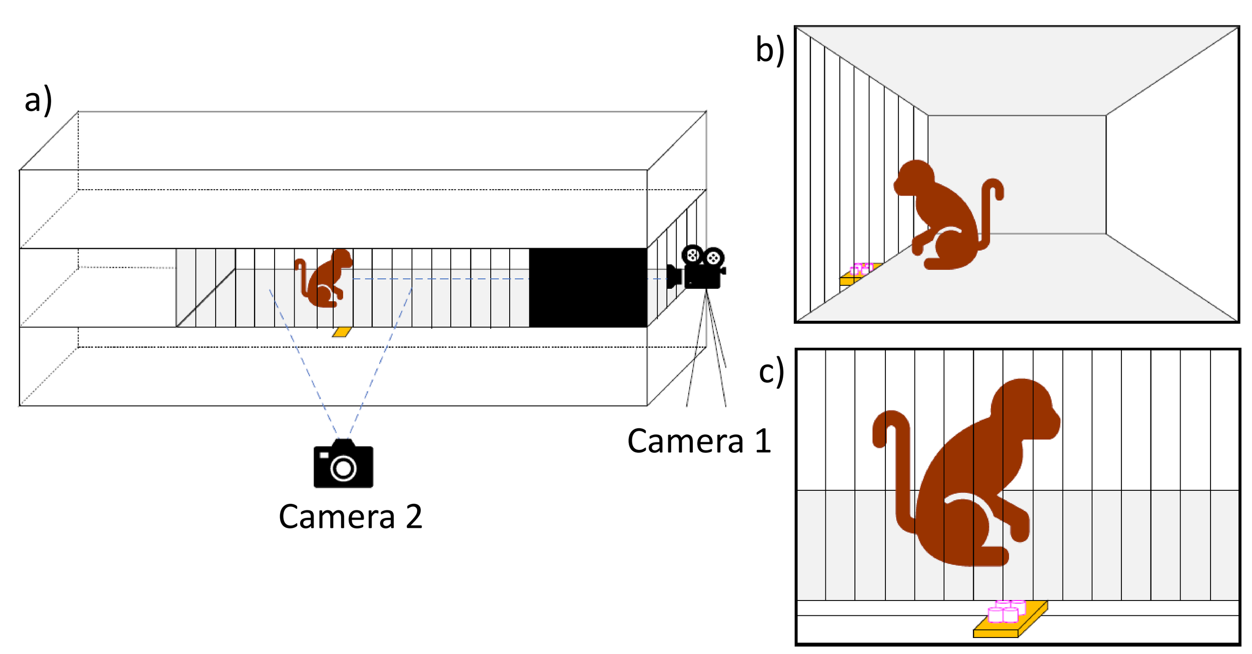
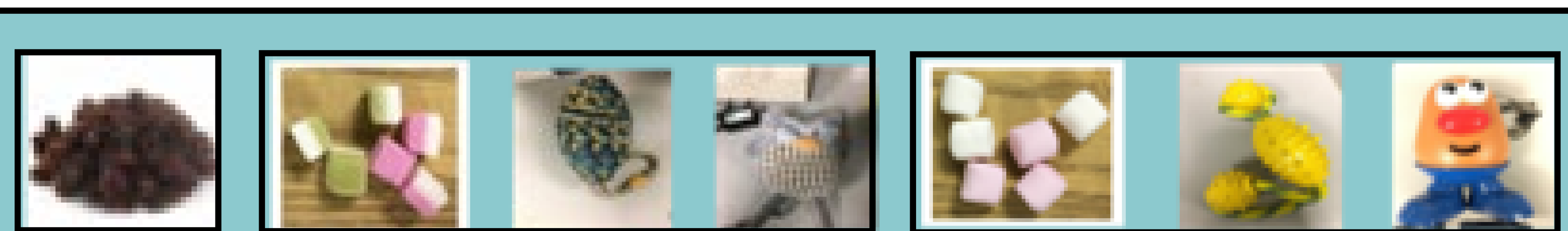


Figure 1.
a) Diagram of cage area where the Temperament Test was conducted. Two cameras were used to record the tests: one pointing to the side of the cage (Camera 1) and one pointing in front of the cage (Camera 2)
b) View from Camera 1
c) View from Camera 2



Familiar Food | Stimulus Set 1 | Stimulus Set 2

Automated Model

Three different models based on deep learning methods were trained on the videos of the temperament tests

Tracking Model

DeepLabCut[3], an open-source pose estimation toolbox, was used to train a deep neural network on the videos from Camera 1

The coordinates provided by this model was used to identify periods of movement

Interaction Model

A second DeepLabCut model was trained on videos from Camera 2

This model in combination with the object detection model was used to detect when the monkey interacted with the food or objects

Object Detection model

A YOLACT [4], [5] model was trained on videos from Camera 2 to identify the foods and objects and create a region of interest around them

This model successfully identified the six different classes

Validation

All three models were compared with the expert's observations (ground truth) and tested for precision, accuracy in presence/absence of monkeys in frame, and for presence/absence of specific behaviours

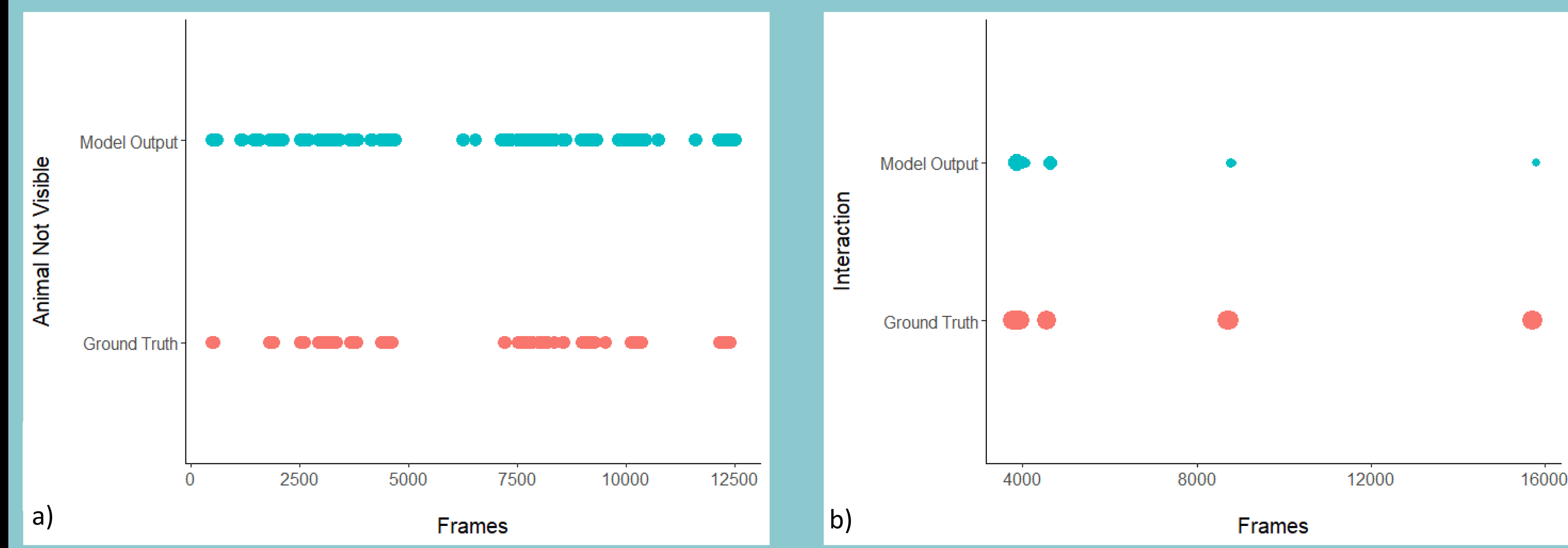
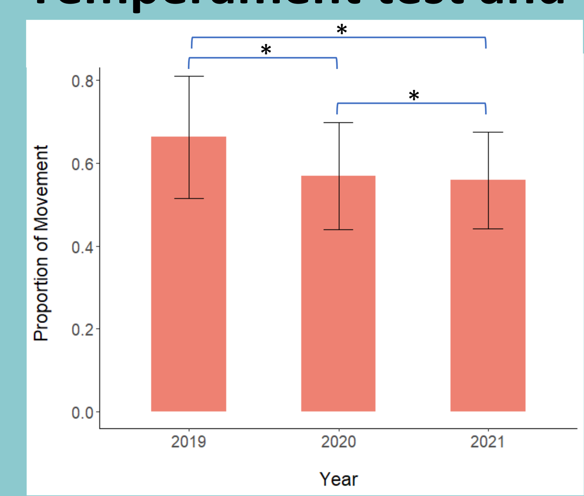


Figure 2. a) Example of comparison of data from a single monkey between the Tracking Model output and the ground truth.
b) Example of comparison of data from a single monkey between the Interaction Model output and the ground truth

Applications

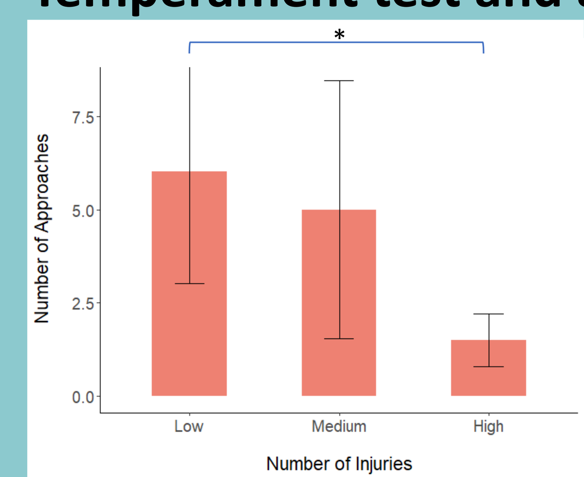
We applied all three models to videos of 73 individual temperament tests Here we present two examples of using the outputs to answer specific research questions

Temperament test and the impact of the Covid-19 pandemic



Using the tracking model we were able to calculate the amount of movement during the temperament test conducted between 2019 and 2021. There was a significant reduction in movement between 2019 (pre-pandemic) and 2020/2021. During the early stages of the pandemic the number of staff at the centre was significantly reduced as was the amount of human interaction with the monkeys.

Temperament test and adverse events



We investigated the impact of the number of injuries the animal had throughout their life before the temperament test had on the approach to novelty. Animals with a high number of injuries had a significant reduction in the number of approaches to the novel objects.

Conclusion

With our models it was possible to obtain critical information to assess monkey's behaviour with a minimal need of human work. The outputs corresponded well with the data from the human observers and also produced new measures such as the total amount of movement. This measure in particular would be very time consuming for a human observer to code. We have shown two potential applications of the models and found significant differences in the amount of movement among cohorts tested before and after the start of the Covid-19 pandemic

References

[1] K. Coleman, L. A. Tully, and J. L. McMillan, "Temperament correlates with training success in adult rhesus macaques," *Am. J. Primatol.*, vol. 65, no. 1, pp. 63–71, Jan. 2005. [2] K. Coleman and P. J. Pierre, "Assessing Anxiety in Nonhuman Primates," *ILAR J.*, vol. 55, no. 2, pp. 333–346, Jan. 2014. [3] A. Mathis *et al.*, "DeepLabCut: markerless pose estimation of user-defined body parts with deep learning," *Nat. Neurosci.*, vol. 21, no. 9, pp. 1281–1289, Sep. 2018 [4] D. Bolya, C. Z. Fanyi, X. Yong, and J. Lee, "YOLACT Real-time Instance Segmentation.".[5] S. Ray and M. A. Stopfer, "Argos: A toolkit for tracking multiple animals in complex visual environments," *Methods Ecol. Evol.*, vol. 13, no. 3, pp. 585–595, Mar. 2022.