UNIKASSEL VERSITÄT | ÖKOLOGISCHE AGRAR WISSENSCHAFTEN

Detection of multiple feeding behaviors in calves – a comparison of sensor positions and window sizes

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Outline:

Introduction

Animal, Material & Methods

Results & Discussion

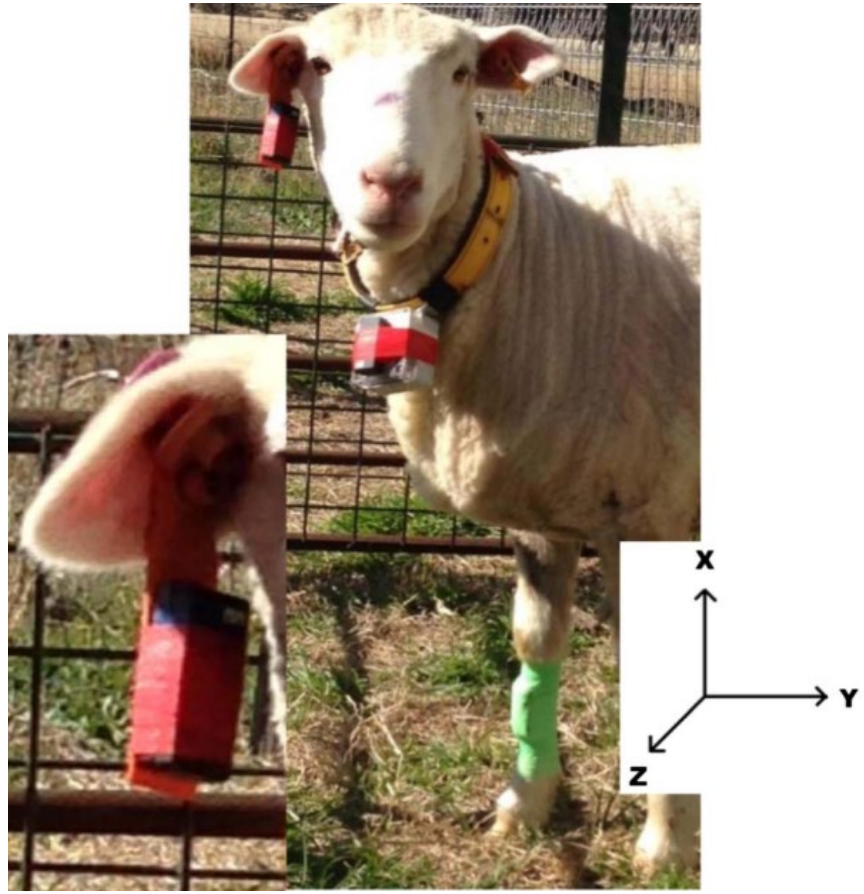
Conclusions

Wearable sensor technology

- Continuous, innovative and objective monitoring
- Extensive use of triaxial accelerometer (Riaboff et al., 2022) to detect posture and activity state
  - Rumination, grazing, resting, lying, walking etc.
- Limited research on utility in calves
  - Suckling
  - ✓ Kour et al., 2018
  - ✓ Carslake et al., 2020
  - ✓ Zipp et al, Addo et al…

Accelerometer placement

- Deployment methods: leg, collar, halter ear-tag etc.
- Ear-worn accelerometers under commercial condition
- Effectiveness of different methods of accelerometer deployment (collar, leg and ear tag) Barwick et al., 2018
- Cheeks in close proximity to the jaw movements and facial muscles



Barwick et al., 2018

Classification models

- Differences across studies:
  - Time window segmentation
  - Machine learning methods
  - Validation approach

Aim

- Compare the effectiveness of triaxial accelerometer sensor placement on the **cheek** versus the **neck** in monitoring calf feeding behaviors – **suckling**, **ruminating** and **feeding**
- Evaluate the influence of varying window sizes : **1s, 5s, 10s, 30s & 60s**

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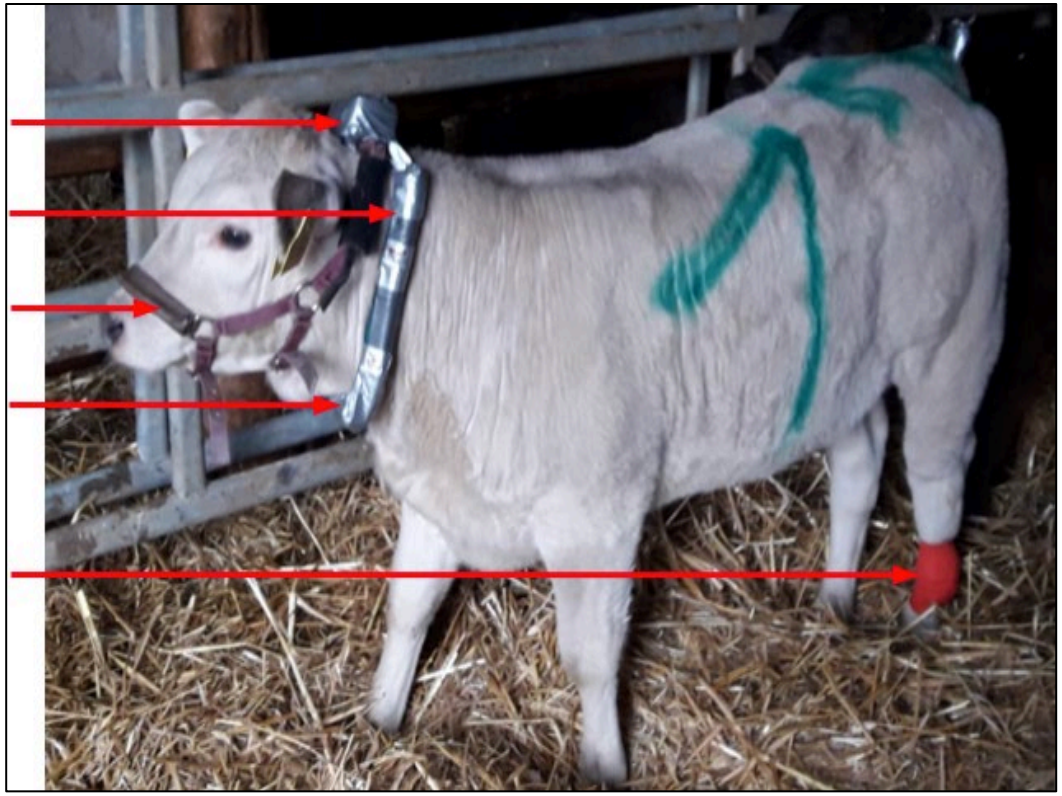
Animals

- 6 Males & 4 Females
- Charolais X Welsh Black
- 61 – 85 days of age
- Fed grass silage, hay and concentrate

Data recording

- MSR Electronics GmbH (145) logger
- 2- 3 days of familiarization
- Recording frequency of 20 Hz (mostly)

March, 2020



Deep-bedded stable

Photo: Freytag

Continuous focal observation

- Time period: 06:30-18:30
- 10 h/animal and split into 30 min observation window
- Pocket Observer (Noldus Information Technology BV)
- Start and stop timestamp of each behavioural activity
- Activities other than *suckling, feeding* and *ruminating* denoted as "**other**"

Photo: Freytag

Behaviour	
Suckling at the udder	Start/Stop
Feeding (eating)	Start/Stop
Ruminating	Start/Stop
Walking	Start/Stop
Lying	Start/Stop
Standing	Start/Stop

Data pre-processing

- Behaviour data integration by timestamp (R software)
- Magnitude of acceleration (MAG) as additional time series
- Feature extraction from raw data
  - ✓ Raw: acc_x, acc_y, acc_z and MAG
  - ✓ 19 features: adapted to Barwick et al., 2018; Benaissa et al., 2019
  - ✓ Summary statistics over fixed time intervals (Epochs): 1s, 5s, 10s, 30s, and 60s
    - Mean, min., max., sd., kurtosis, & interquartile range

meanX
meanY
sd_MAG
IQR_MAG
sdX
minX
mean_MAG
sdZ
sdY
maxY
minY
maxX
max_MAG
min_MAG
meanZ
kur_MAG
minZ
maxZ
meanAll3

Modelling

- Individual prediction model (N=3)
- 2 ML algorithms applied to 5 different datasets (plus a combined data)
  - ✓ Boosted forest implemented JMP software
  - ✓ Random forest (**RF**) – Scikit-learn (Pedregosa et al., 2011)
  - ✓ Training & validation sets – 70%:30%
- Balancing of training dataset in RF (SMOTETomek)
  - ✓ Combination of over- and under-sampling methods
- The permutation importance of variables calculated to rank predictors

$$\text{accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{sensitivity} = \frac{TP}{TP + FN}$$

$$\text{specificity} = \frac{TN}{TN + FP}$$

$$\text{precision} = \frac{TP}{TP + FP}$$

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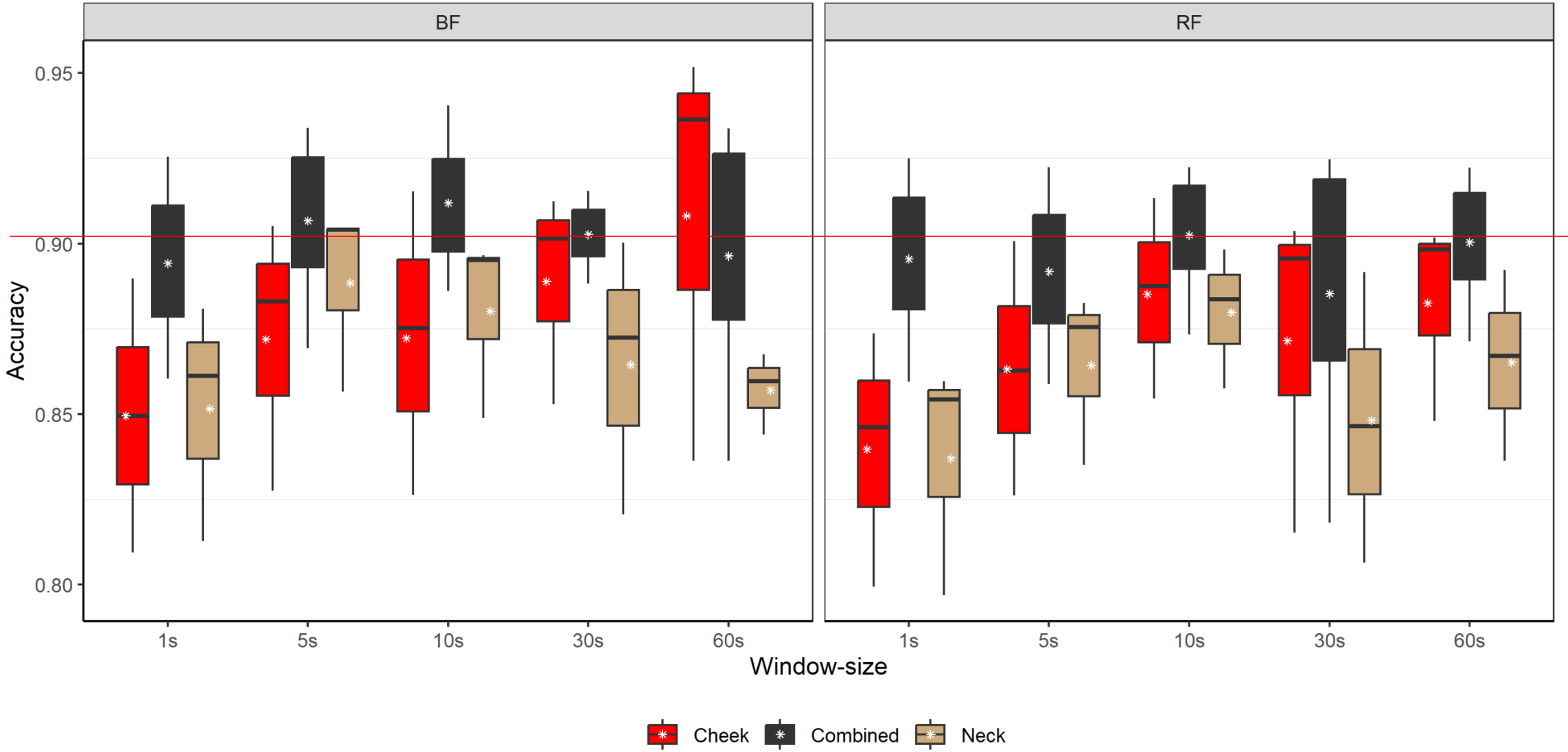
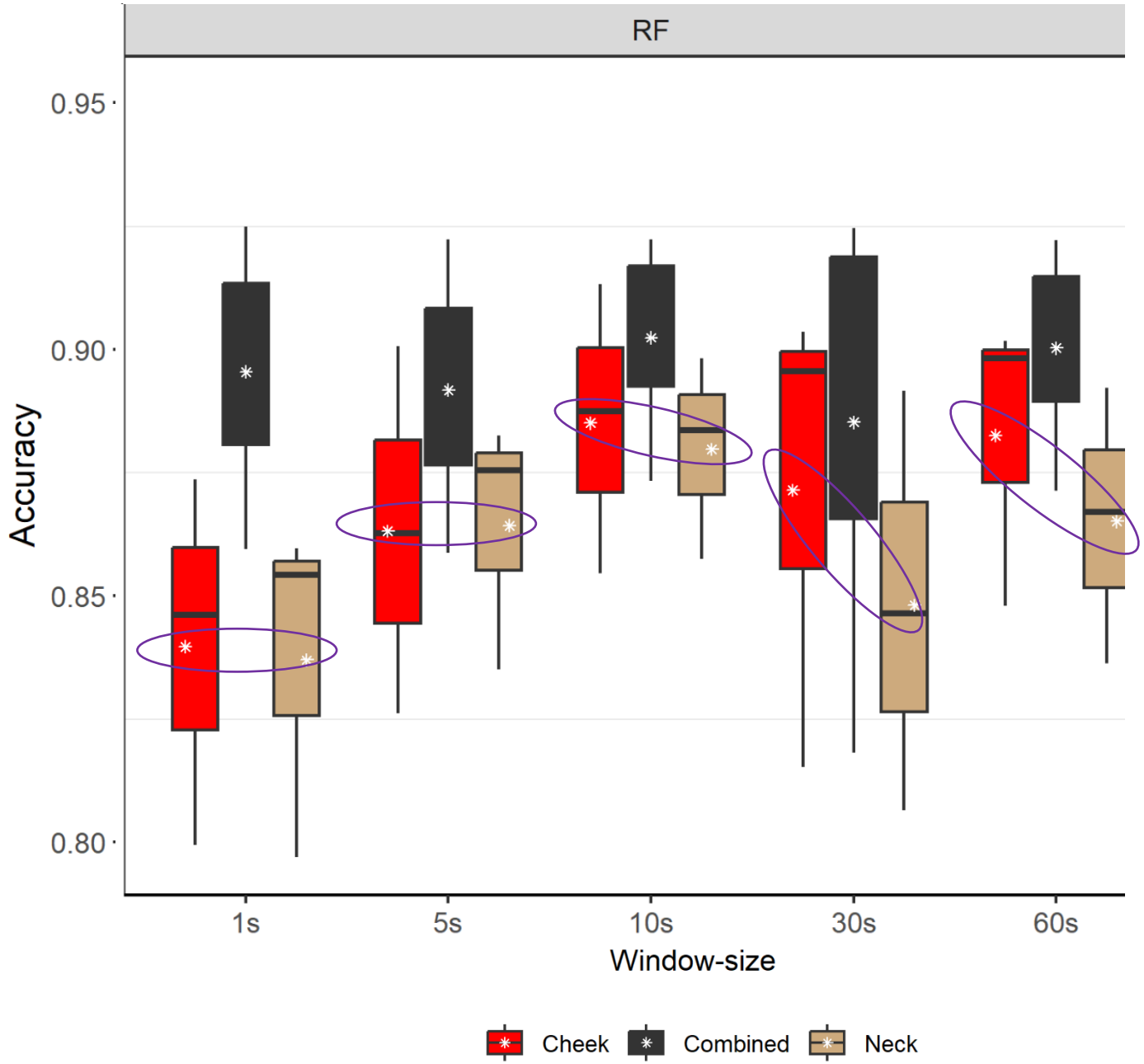
Accuracy

Slightly higher accuracy in BF



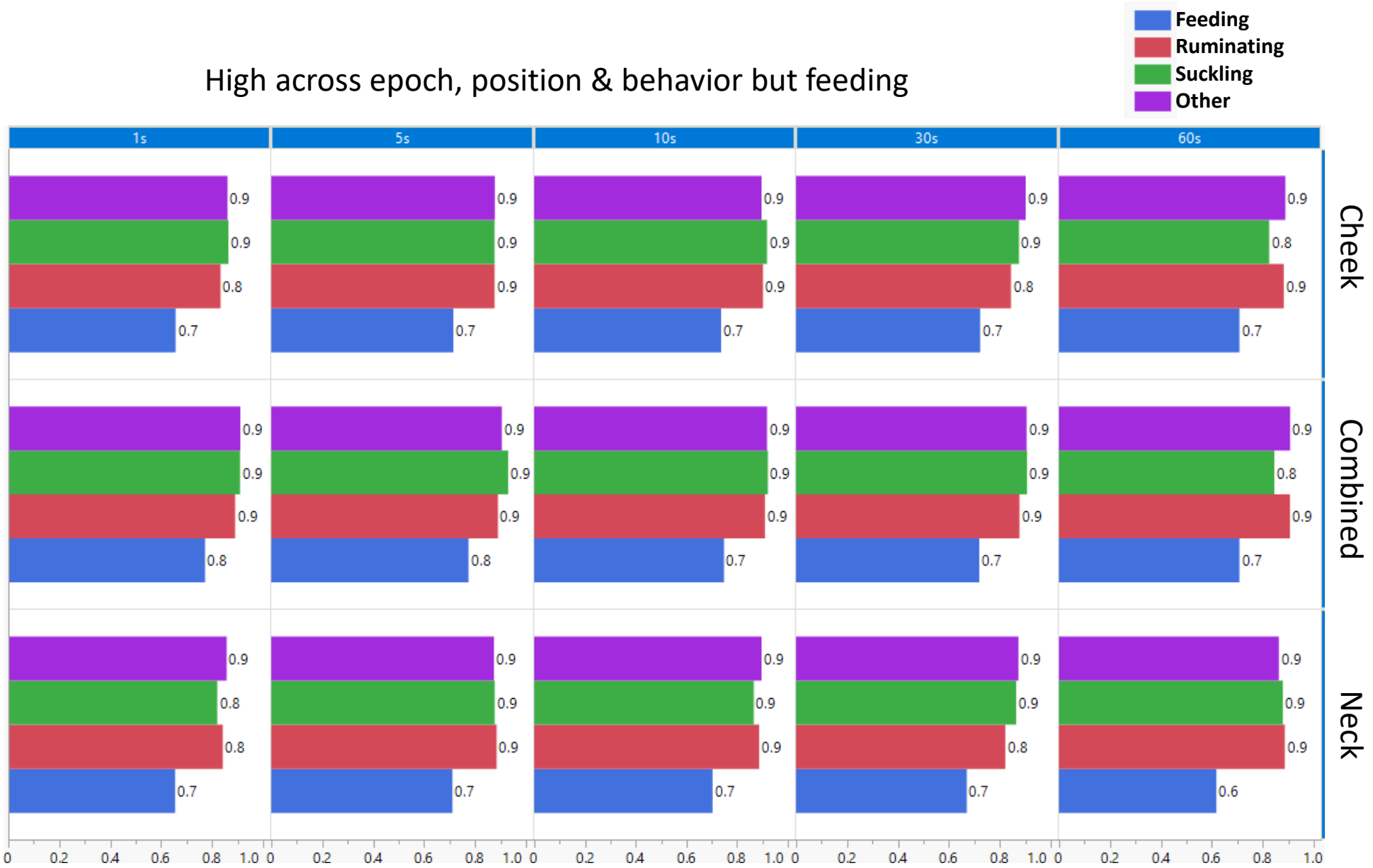
Accuracy

- Cheek-based slightly outperforms from 10s epoch
- Higher accuracies for combined data
- Highest accuracy (90.2%) at 10 s epoch
- 10 s epoch proved effective for detecting posture in sheep (Barwick et al., 2018)

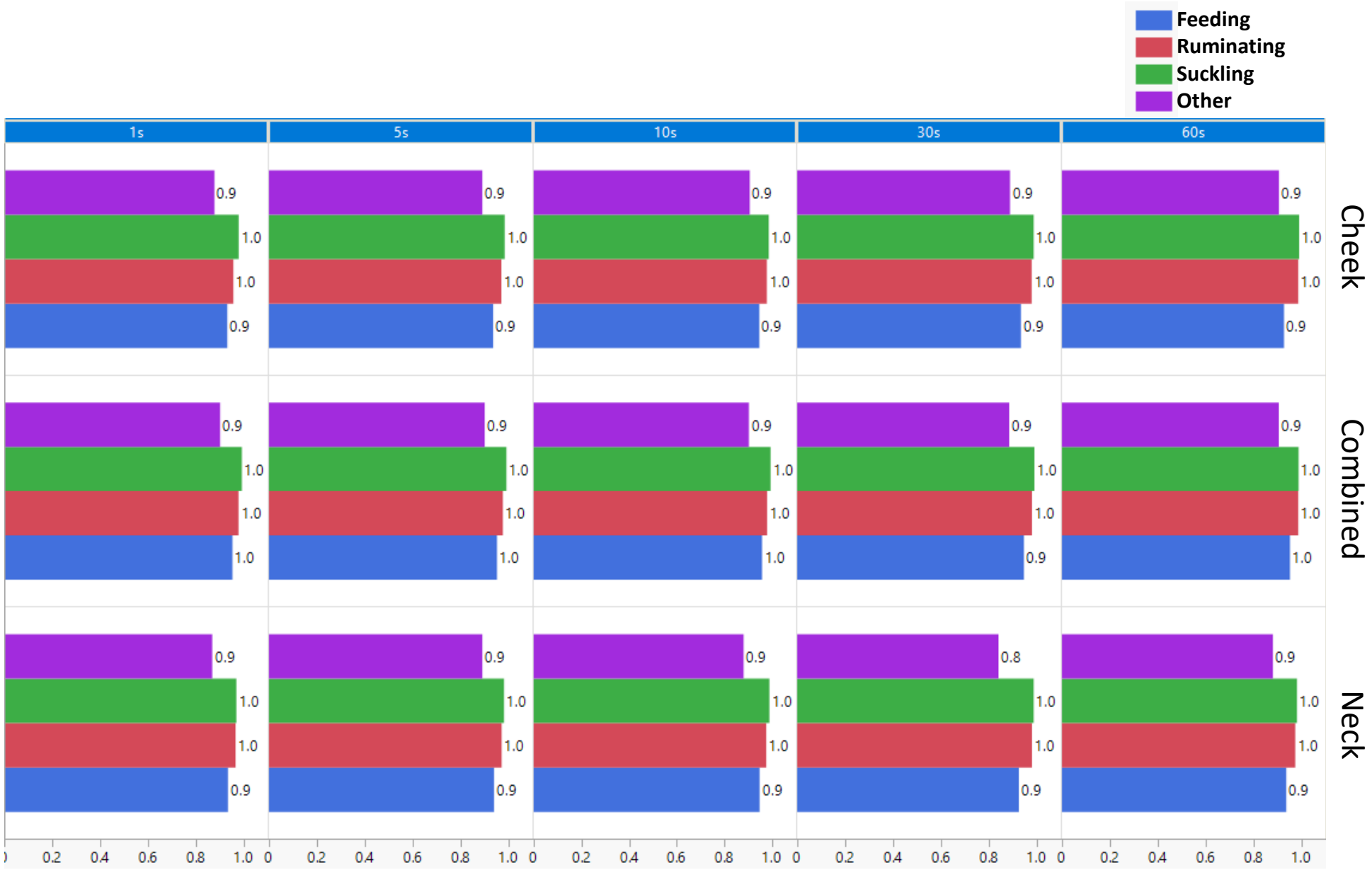


Sensitivity

High across epoch, position & behavior but feeding

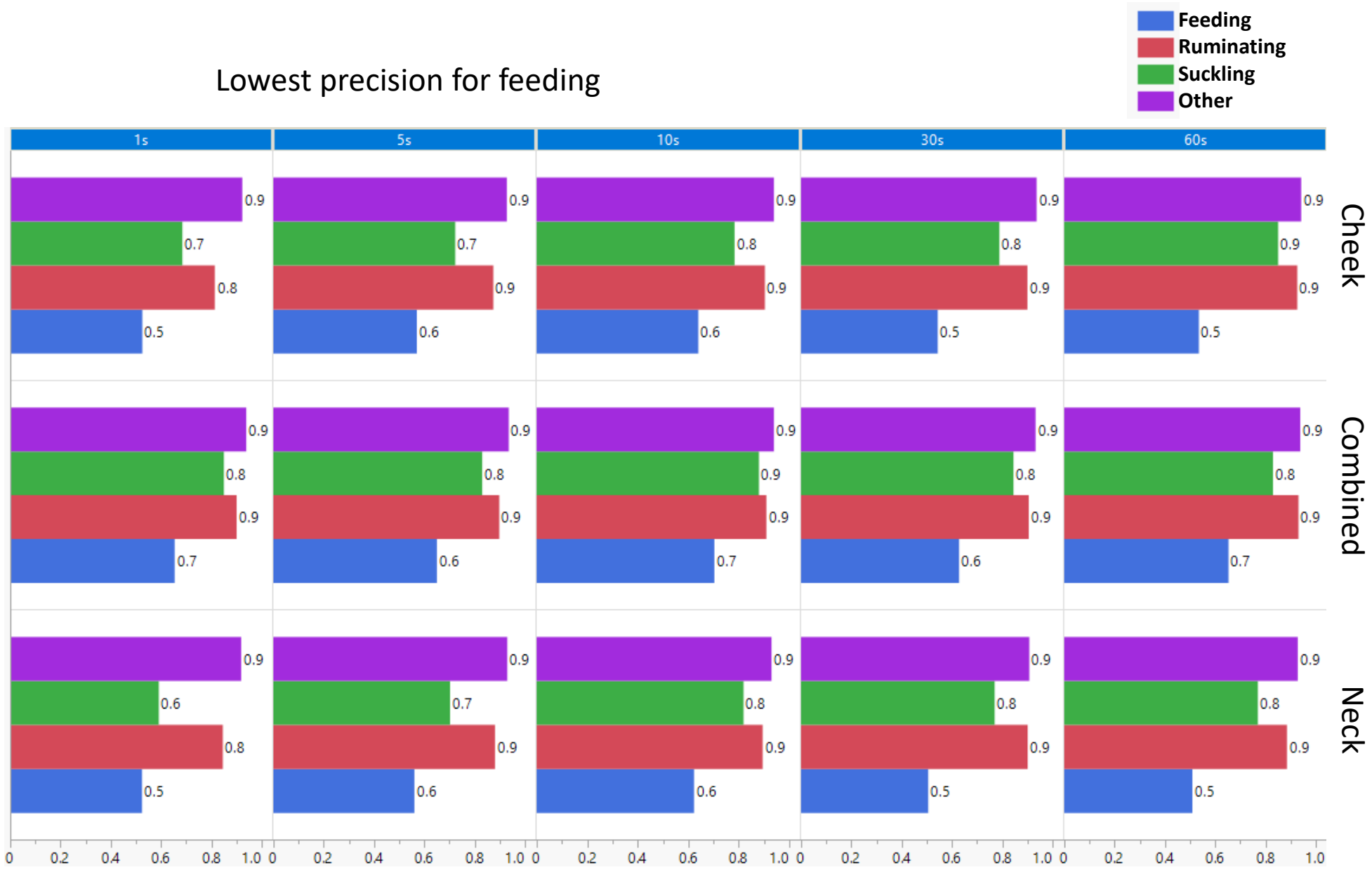


Specificity



Precision

Lowest precision for feeding

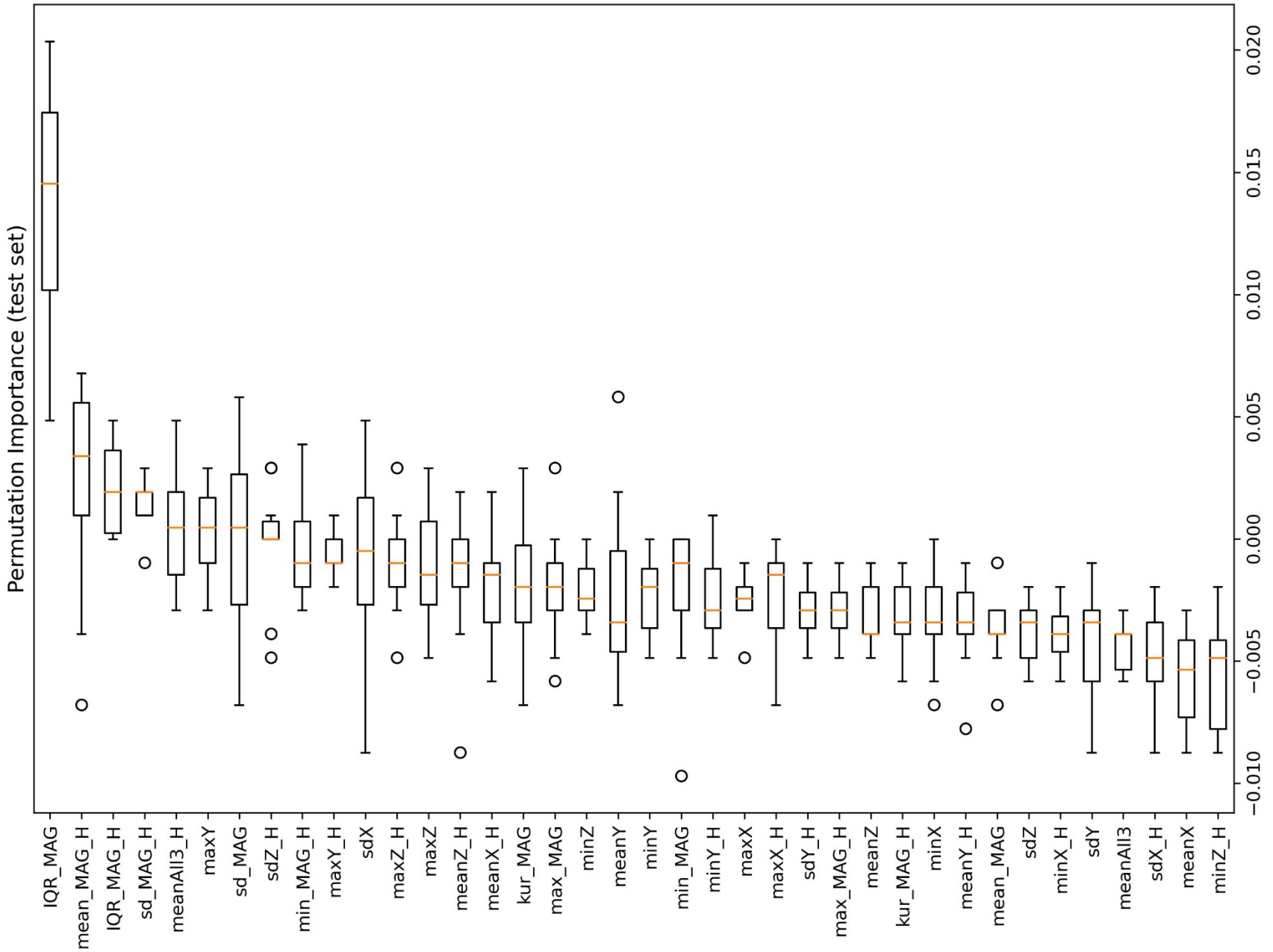


Importance

Ranking

1. IQR of MAG (Cheek)
2. Mean of MAG (Neck)
3. IQR of MAG (Neck)

Combined 10 s Epoch dataset



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- Cheek-mounted halter accelerometers demonstrated higher accuracy compared to neck-base placement when using window sizes greater than 10 seconds
- An optimal window size of 10 seconds yields the highest accuracy
- Further refinement of our methodology is needed to improve the precision in detecting feeding behaviors

Thank you!

References

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