MAX-PLANCK-INSTITUT FÜR BIOLOGISCHE INTELLIGENZ (IN GRÜNDUNG)

AMGEN Scholars Program

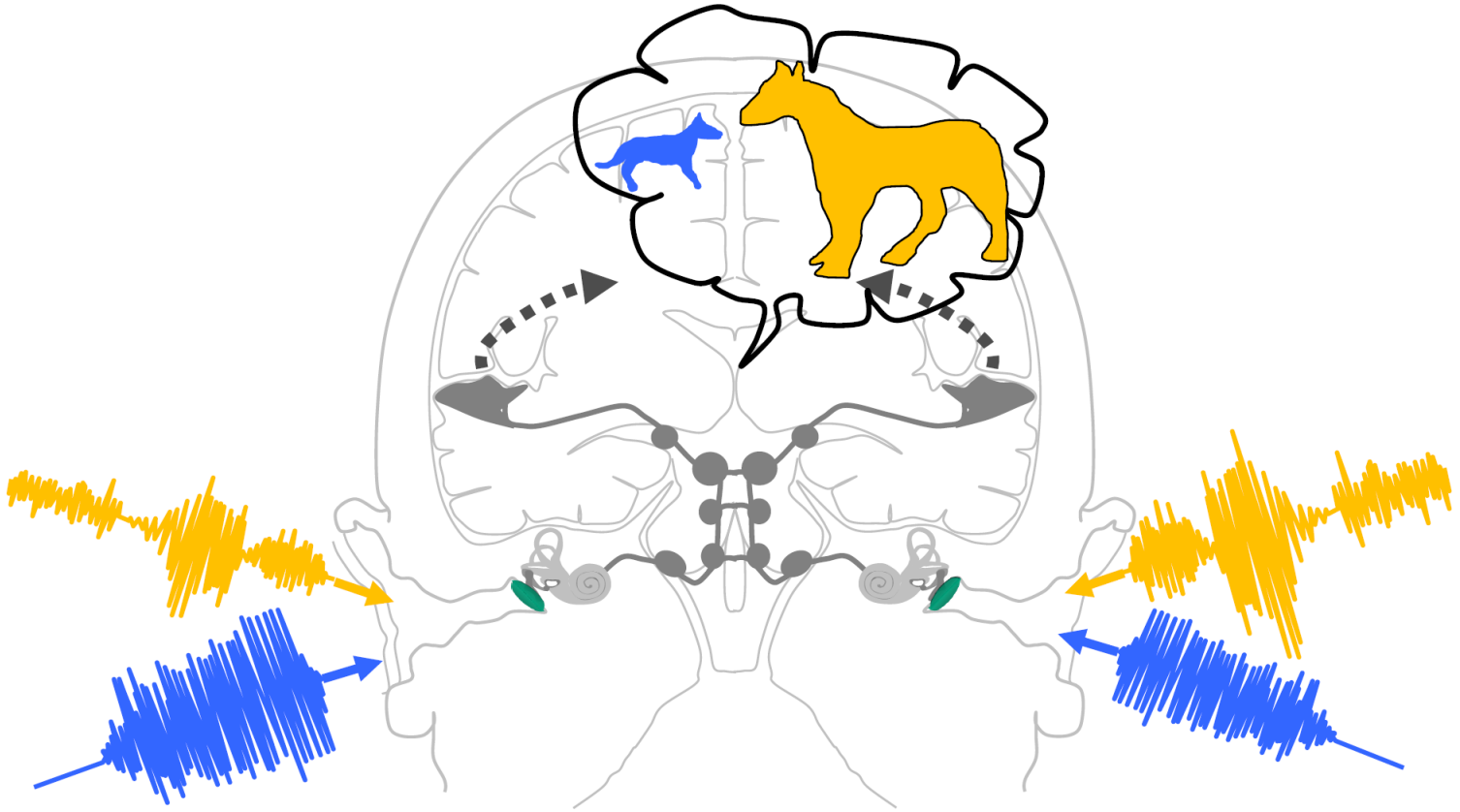
Decoding the representation of space in the auditory cortex

Marija Nedeljković

Slice of Science Workshop

17. August 2022

The brain constructs our entire (360 °) auditory world with information from just two „microphones“ (our ears).



B. Grothe

We know a lot about the physical cues we use to encode space, but little about how the brain represents this encoding.

Psychophysical (human) experiments indicate that neuronal tuning toward the front is of particular importance…

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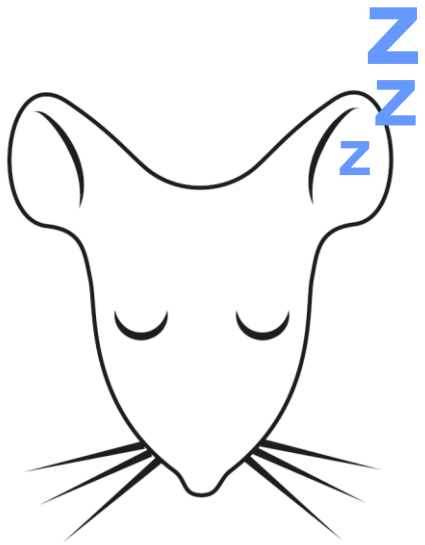
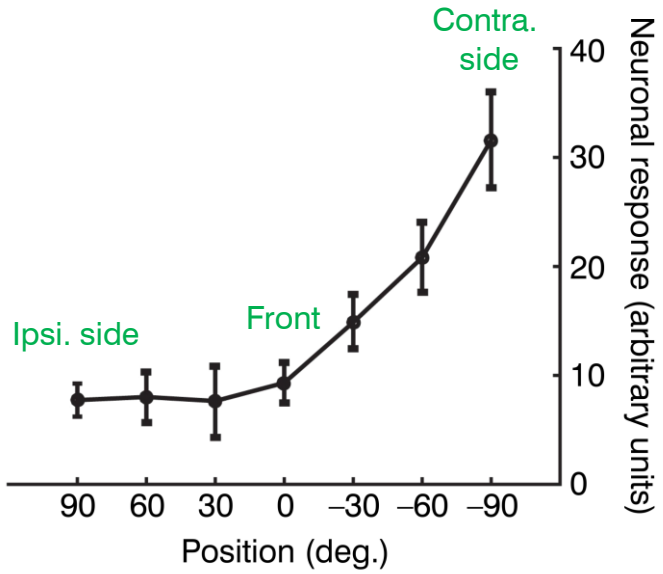
… but research in animal models have been thus far insufficient to support or contradict this claim…

A major hurdle has been that most animal studies have been performed in anaesthetised preparations.



Matthias Gumbert



Adapted from Panniello et al. (2018)

In anaesthetised animals, there is no evidence for prominent tuning toward the front!

So, we compared spatial tuning in the auditory cortex of mice between anaesthetised and awake states using chronic Ca-imaging.

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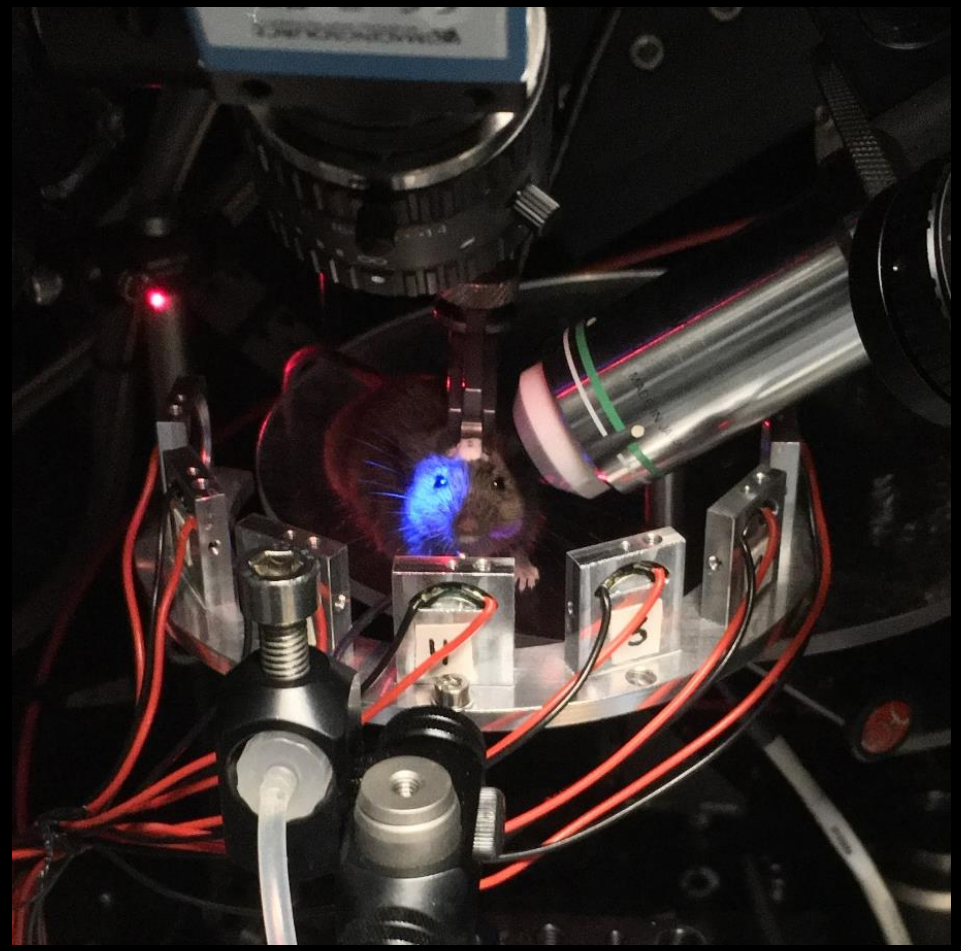
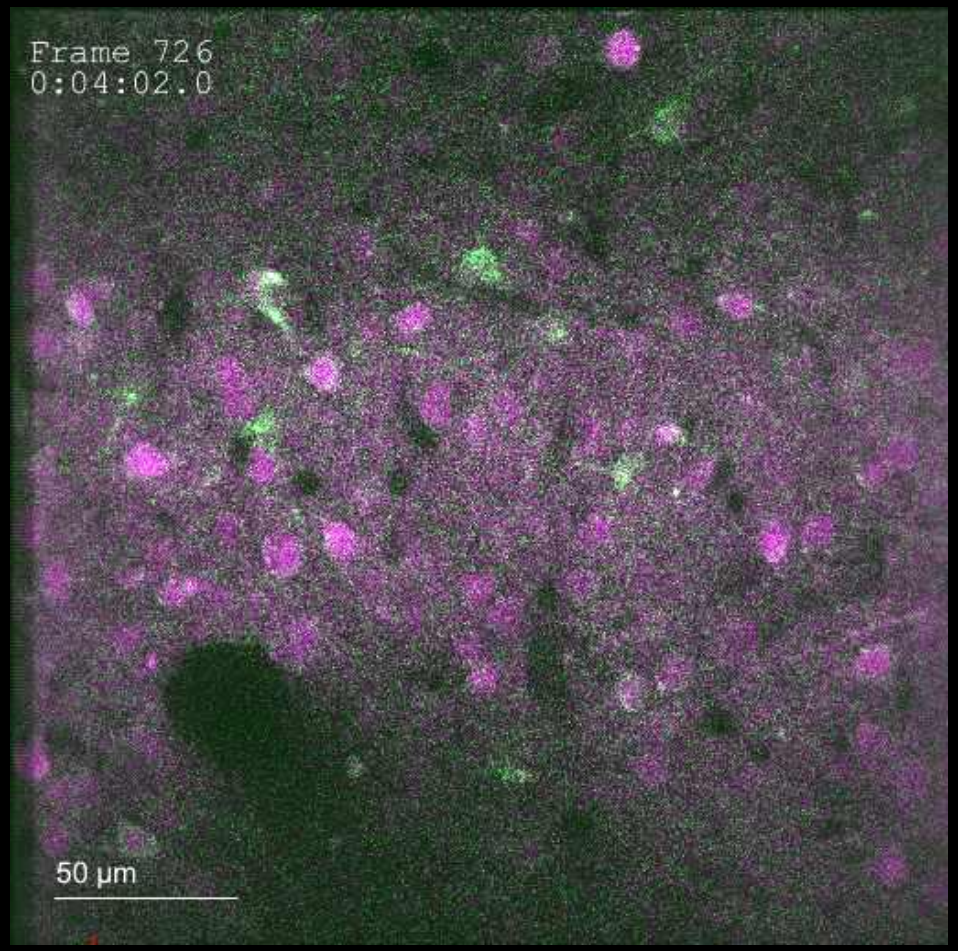




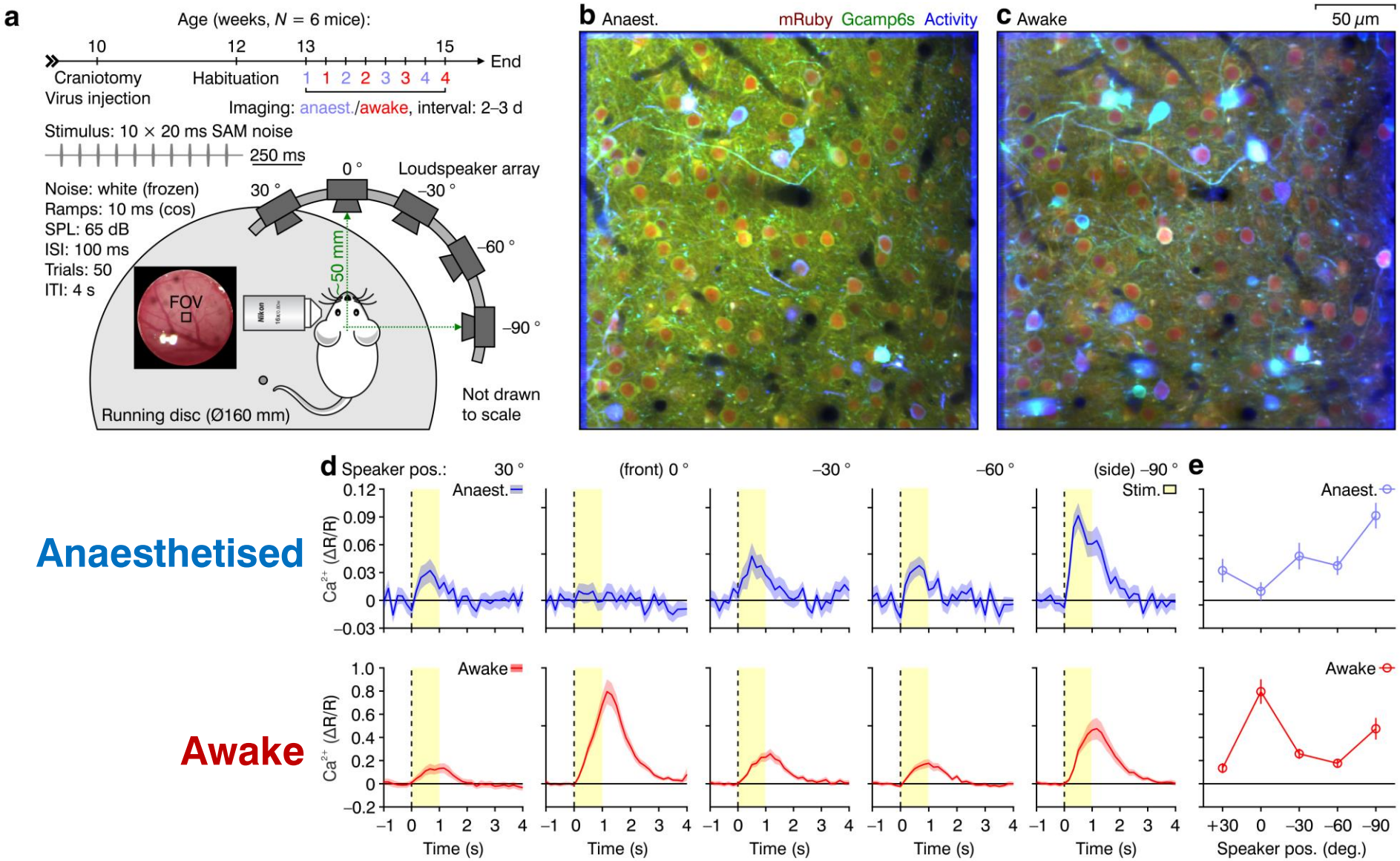
Matthias Gumbert

The setup

Calcium levels are a proxy of neuronal activity.

Green: calcium indicator (GCamp6s)
Magenta: structural marker (mRuby2)

We found prominent tuning toward the front in awake animals!



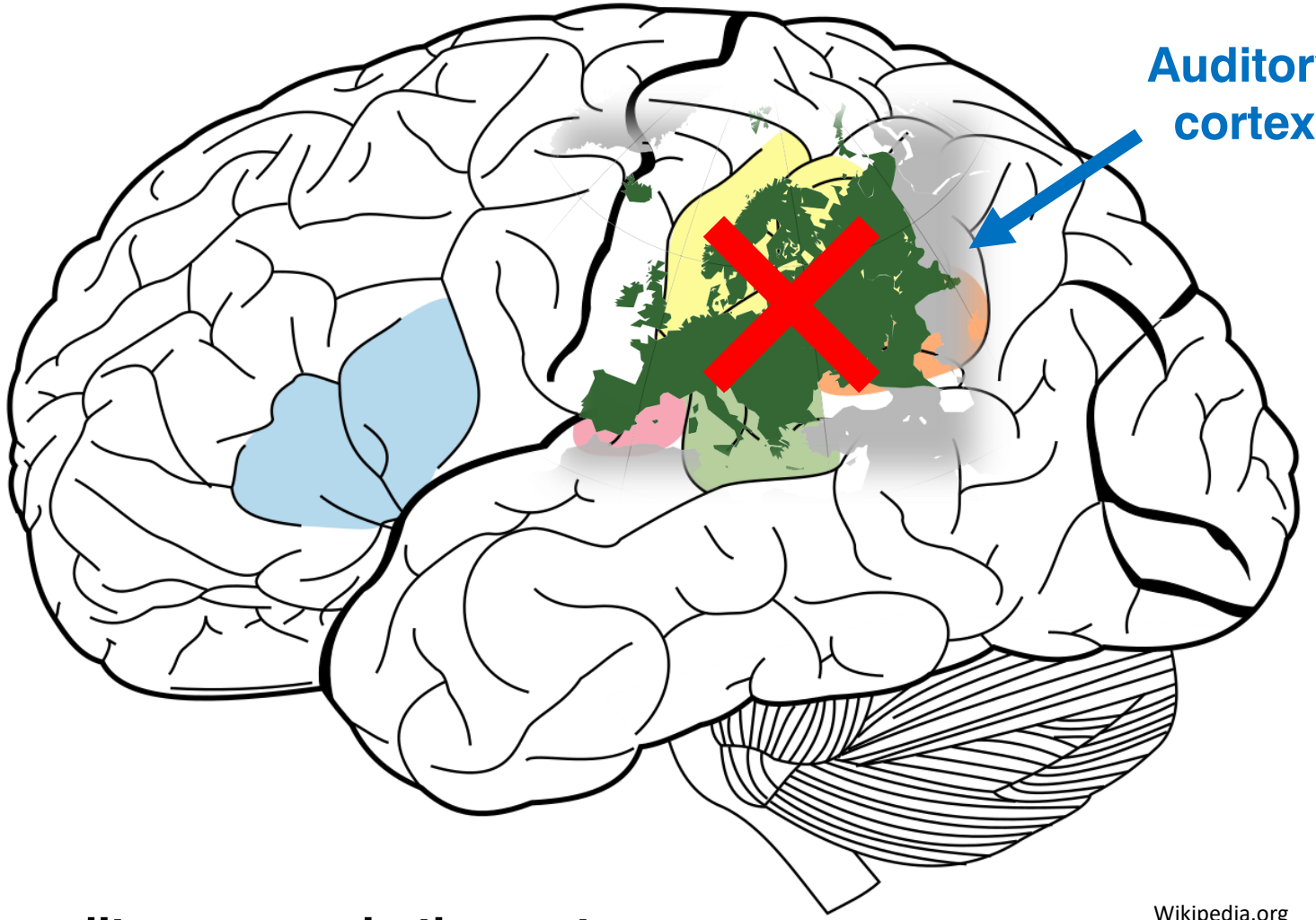
Anaesthetised

Awake

Contra. tuned

Front tuned

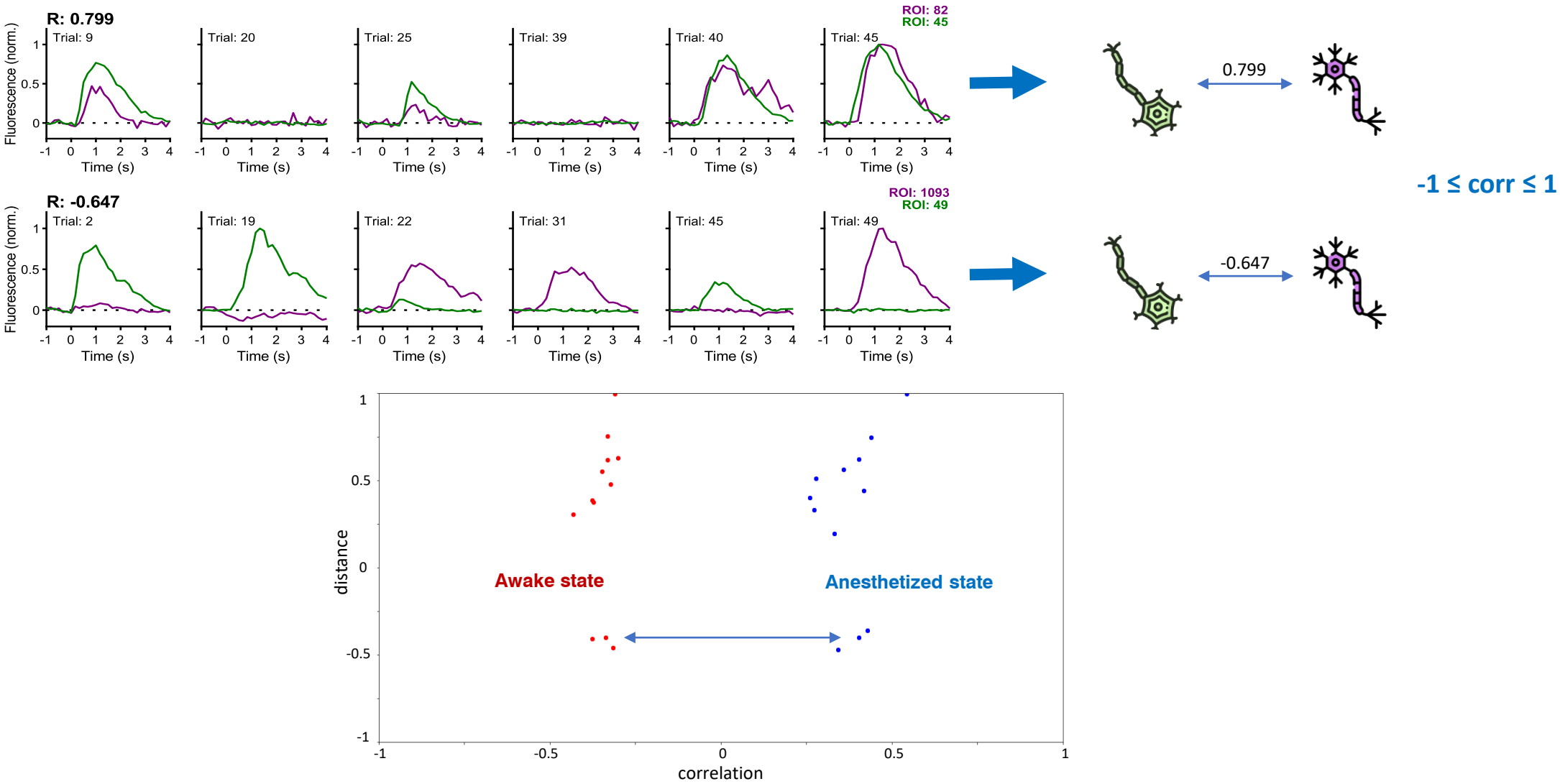
But we still have a problem: how to understand how the population of neurons encodes space under different states?



Wikipedia.org

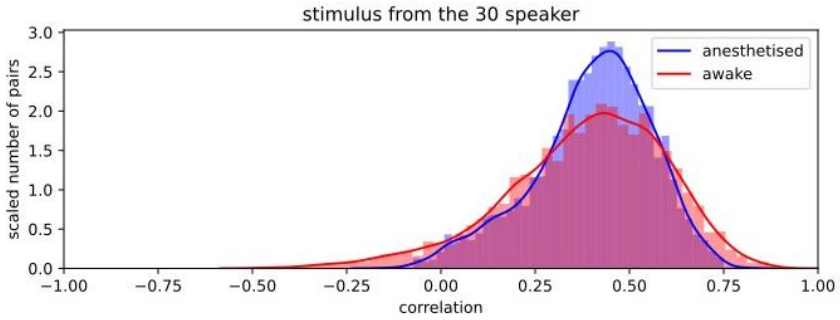
There is no „map“ of auditory space in the cortex,
so positions cannot be simply „read-out“ based on location in the brain!

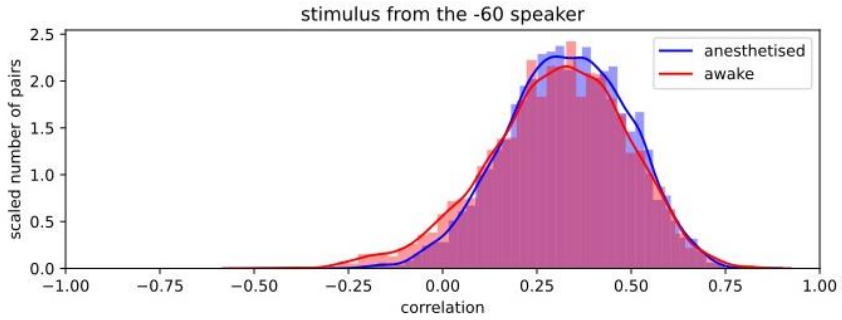
Correlations between the single neurons

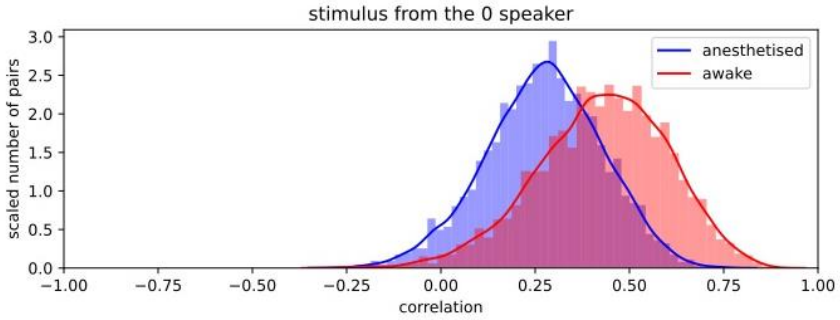


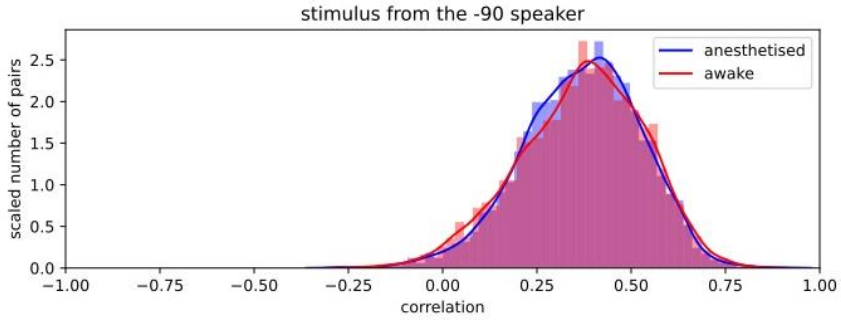
Correlation is used to describe the linear relationship between two continuous variables!

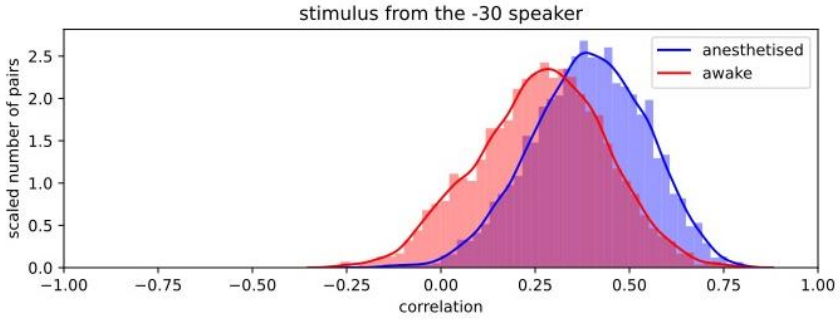
Correlations between the single neurons

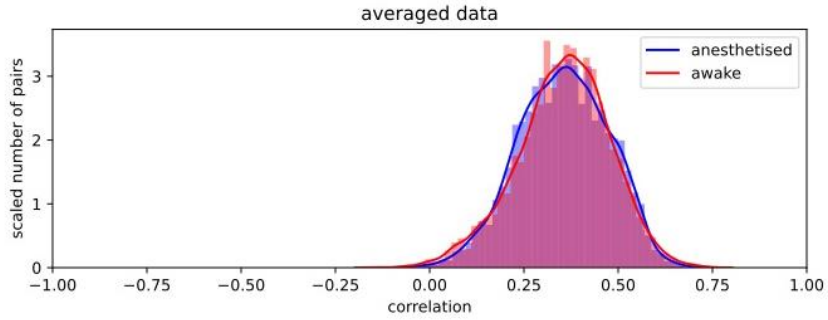






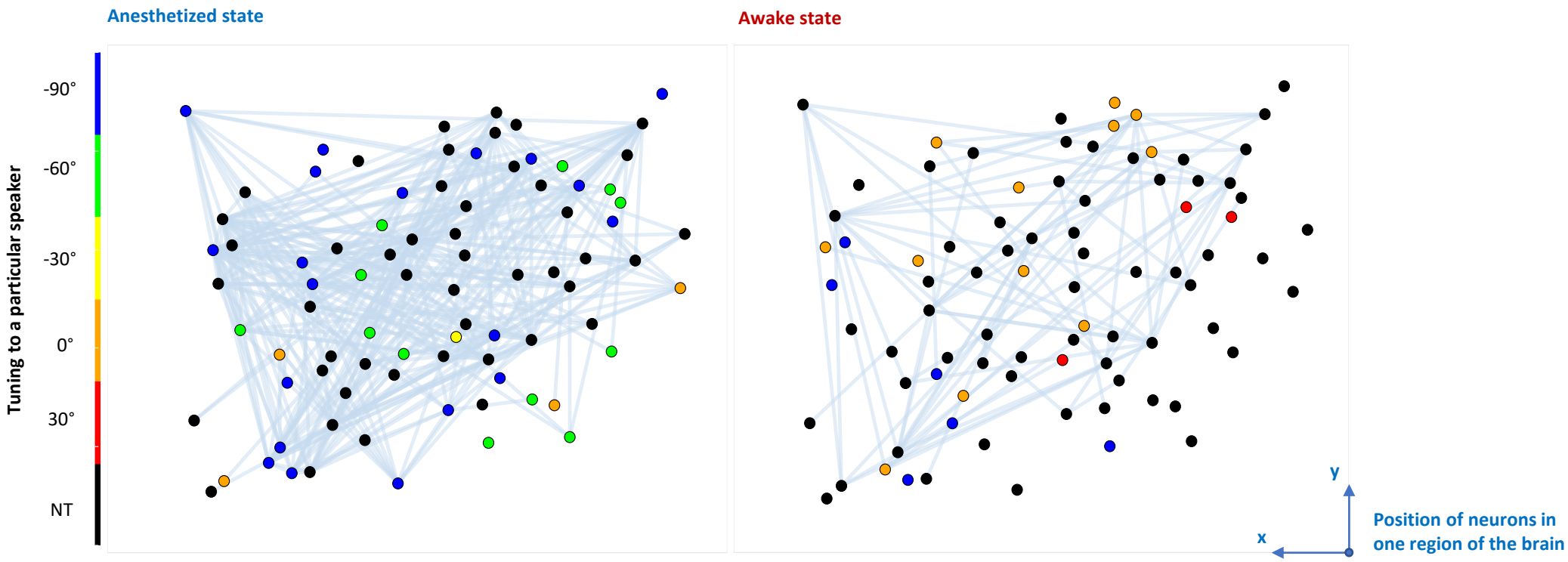






We need to look at the individual speakers for some changes to be seen!

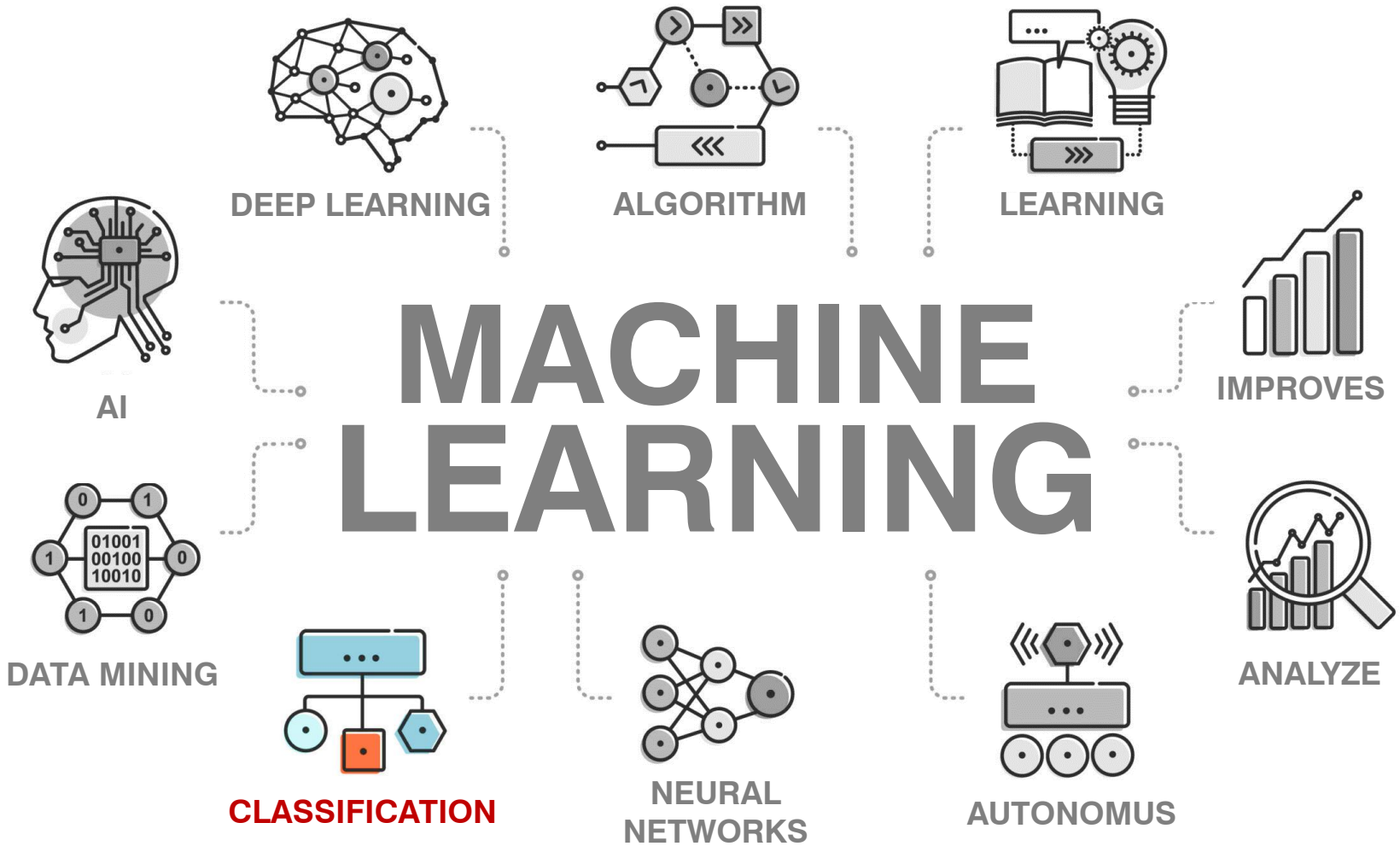
Correlations between the single neurons



Group of neurons that are tuned to different speakers in anesthetized, shift their tuning to the front speaker in the awake state.

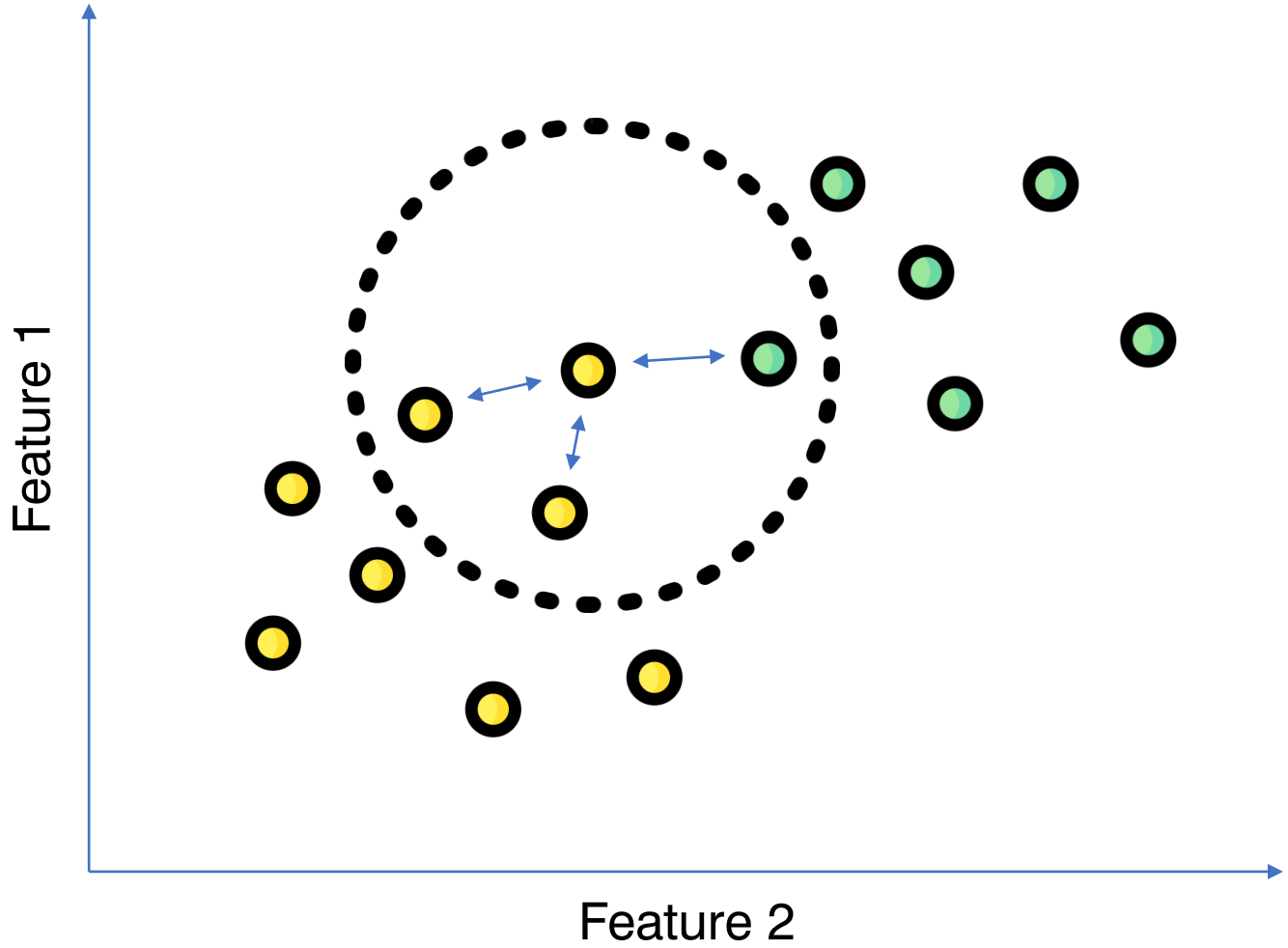
The differences between the two conditions are significant!

What is Machine Learnig?

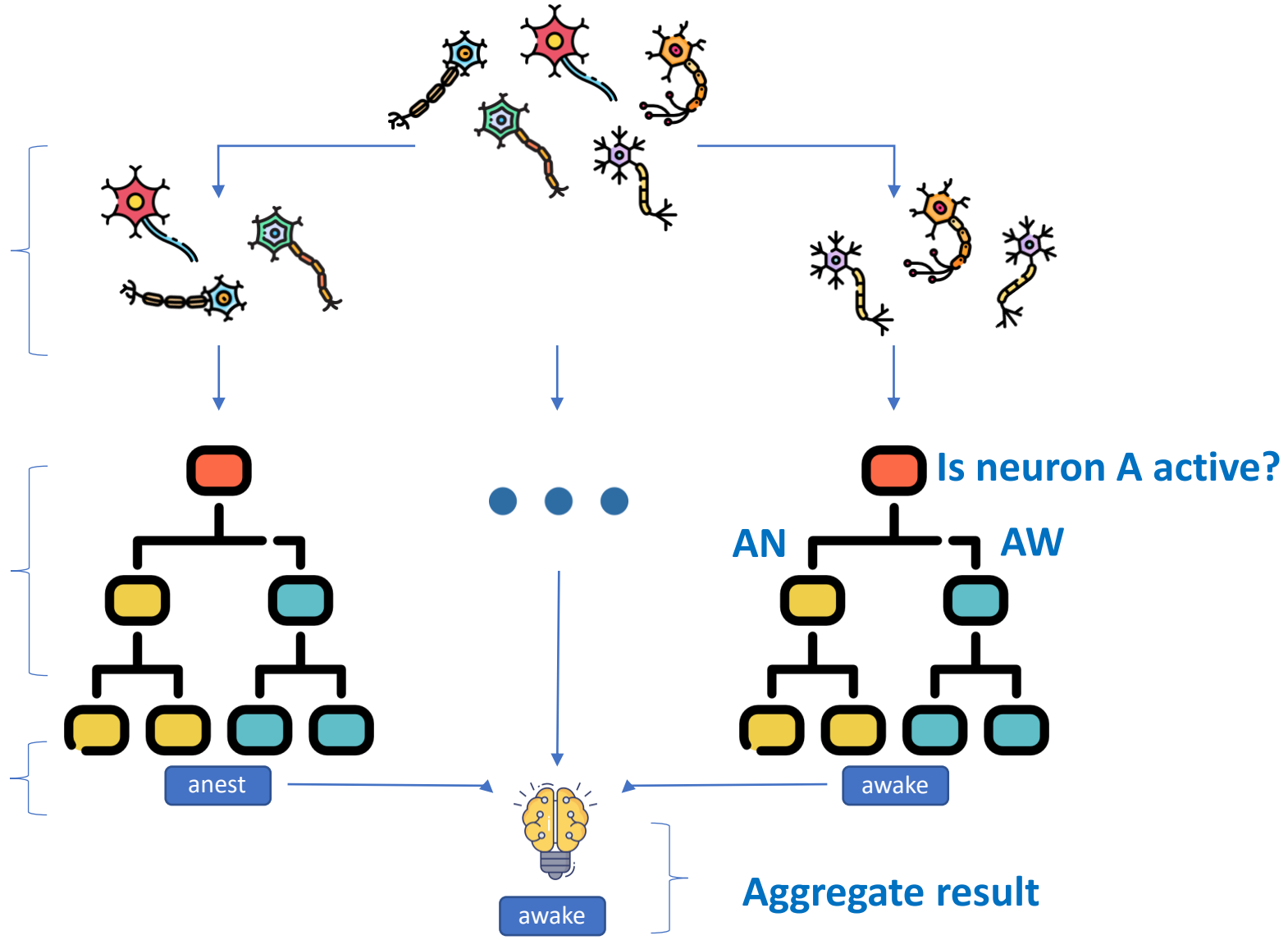


mathematical models of data -> computer learns without direct instructions

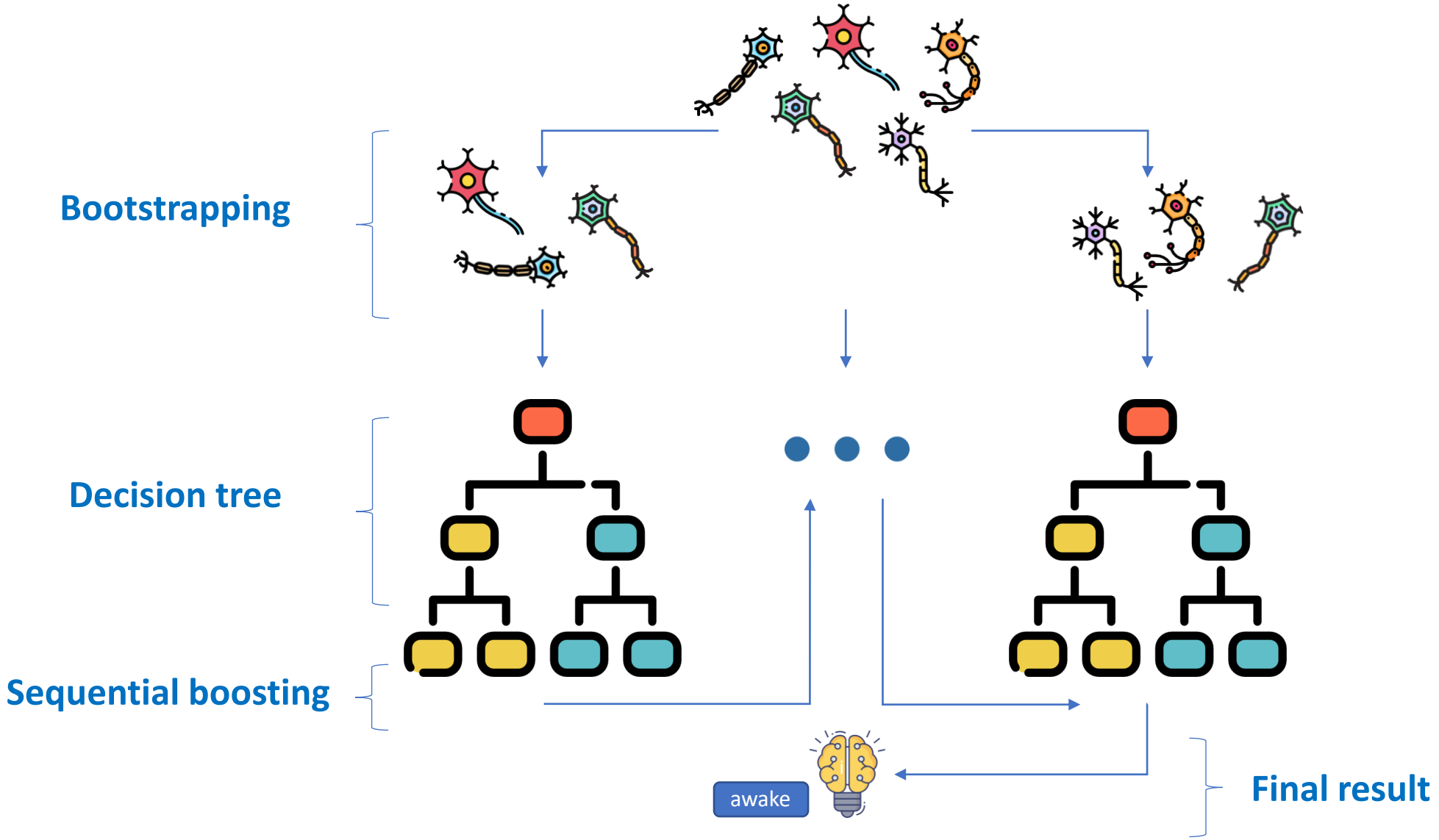
K-Nearest Neighbors (KNN)



Random Forest (RF)



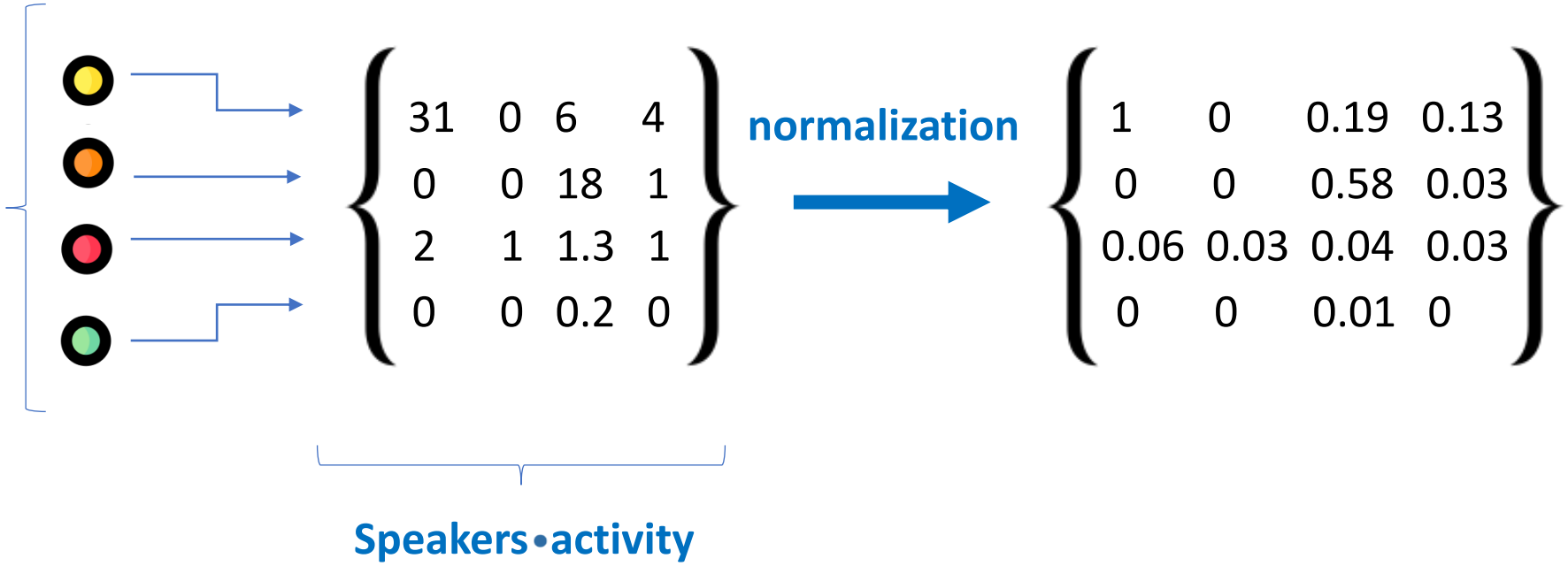
Extreme Gradient Boosting (XGboost)



Data preparation for the modeling

Number of matrices = sessions•trials

Number of neurons in a region



Before classification, all data were normalized and divided into a train and test set that respectively amount to 70%, and 30% of the initial dataset.

Classification of data on anesthetized and awake state

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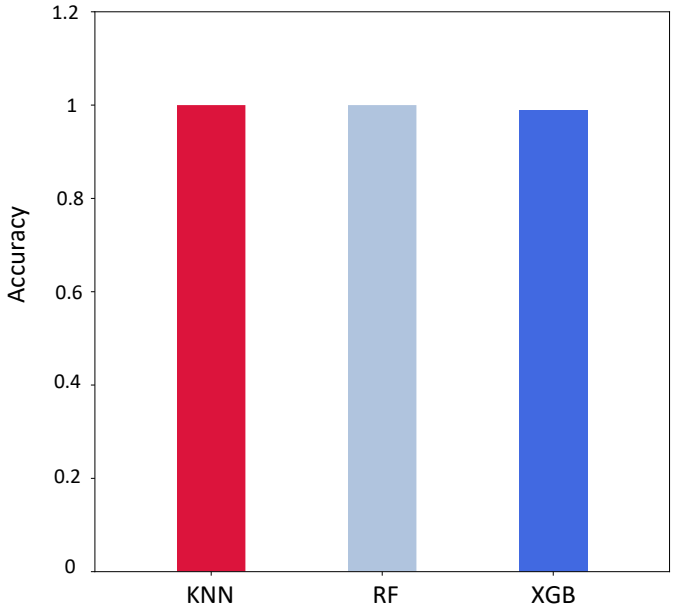
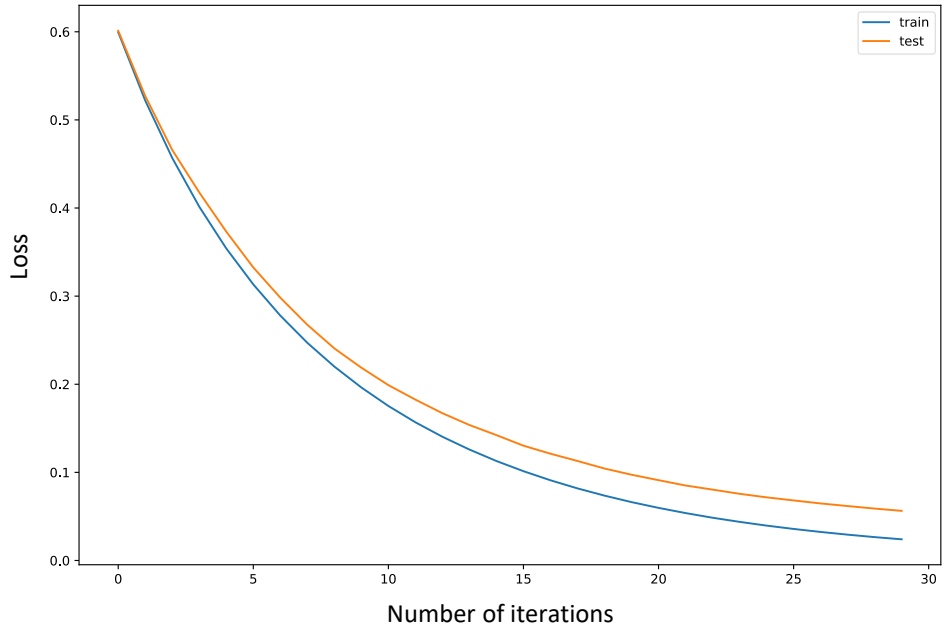
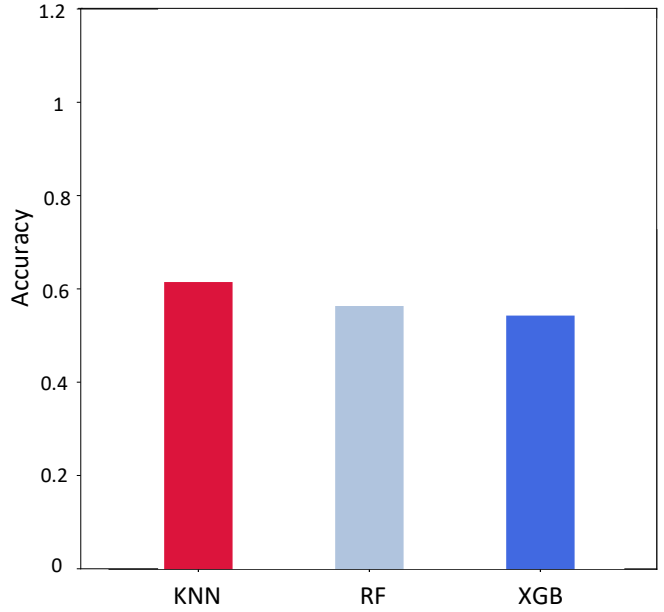
Training and testing on all sessions



Xgboost loss function



Training and testing on different sessions

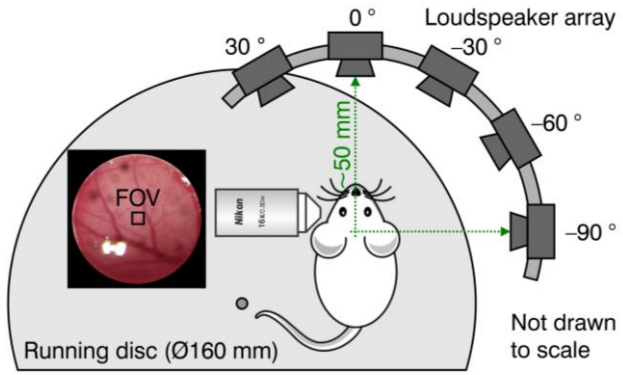


- Training and evaluation of data on all sessions were performed with the accuracy of slightly more than 99% for all of the classifiers.

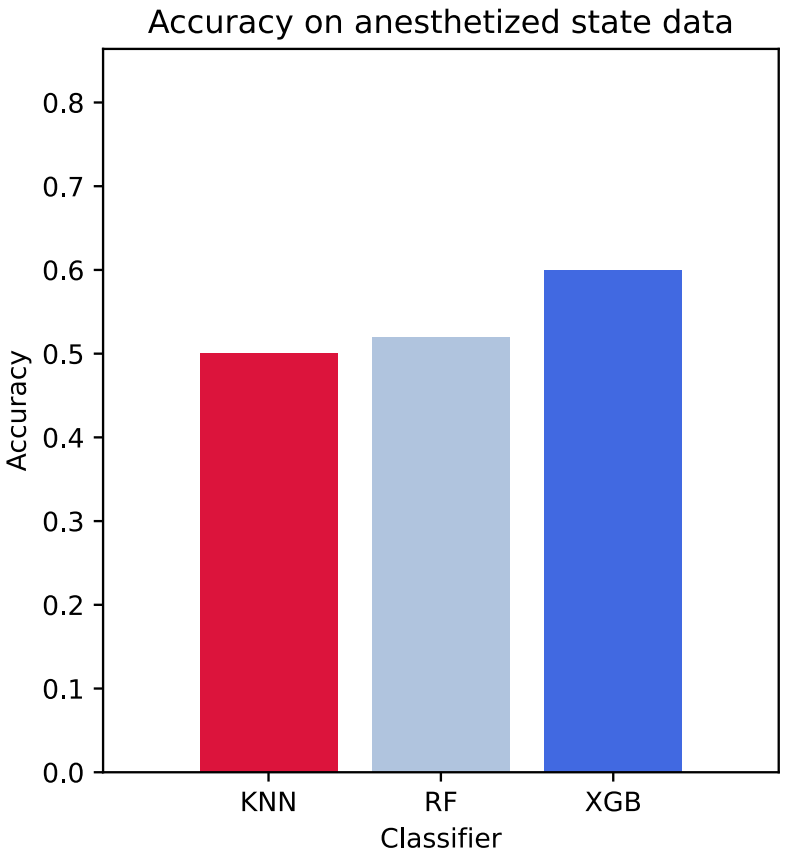
- On the contrary, training models on 3 different sessions and evaluating them on 4th shows much worse results. **noisy brain -> hard separation of different sessions**

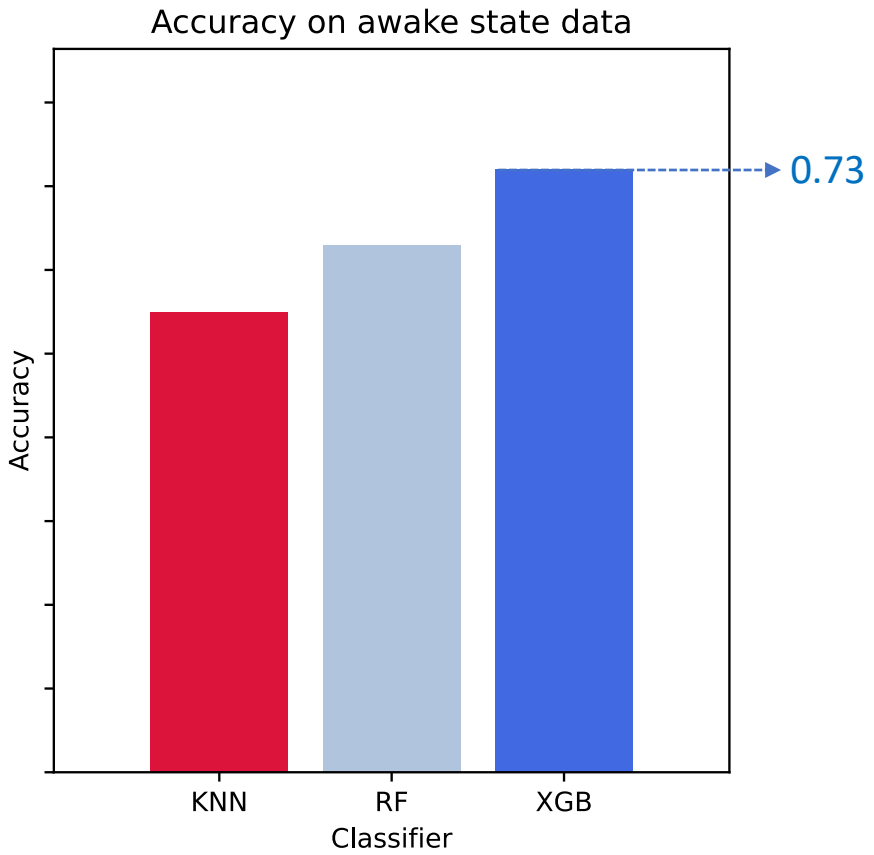
Classification of data on 2 different speakers

Problem of classification of neuronal activity on all 5 different speakers is found out to also be a hard problem, because of the very sensitive data.



The highest division accuracy have classes of data obtained when the speaker at 30° and speaker on the totally opposite side (-90°) were active.





Next steps

Improving existing models

Extracting and analyzing features

Implementing new models

Questions?

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