Machine Learning Approach to Automated Sleep Stage Scoring
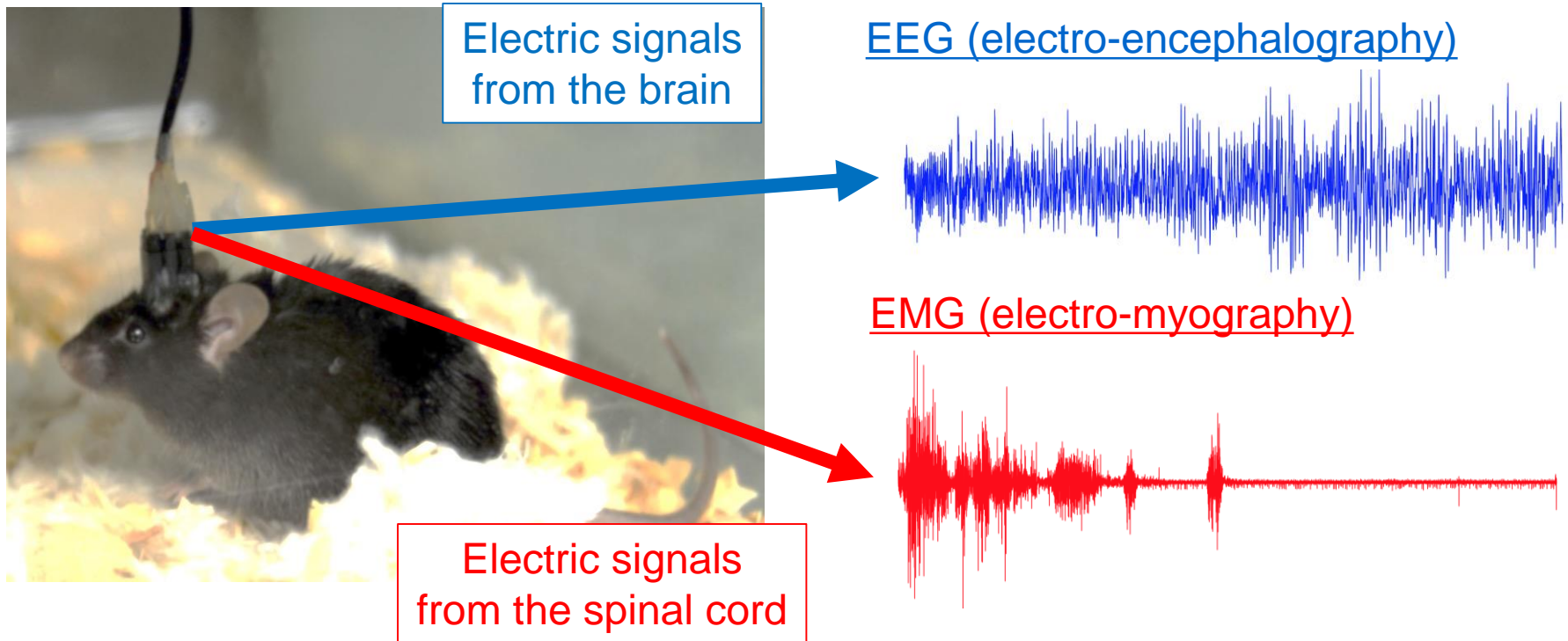
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Automatic Sleep Stage Scoring

- Joint project with IIIS (International Institute for Integrative Sleep Medicine, Prof. Yanagisawa), Univ. of Tsukuba

- Sleep stage analysis is crucial in sleep research

  - Reference data for sleep analysis

  - Sleep disorder can be identified by abnormal stage transition.

- Sleep generally consists of different stages.

  - REM (Rapid Eye Movement) sleep, Non-REM sleep, Wake…

  - Sleep stage scoring is the base for sleep disorder diagnoses and researches.
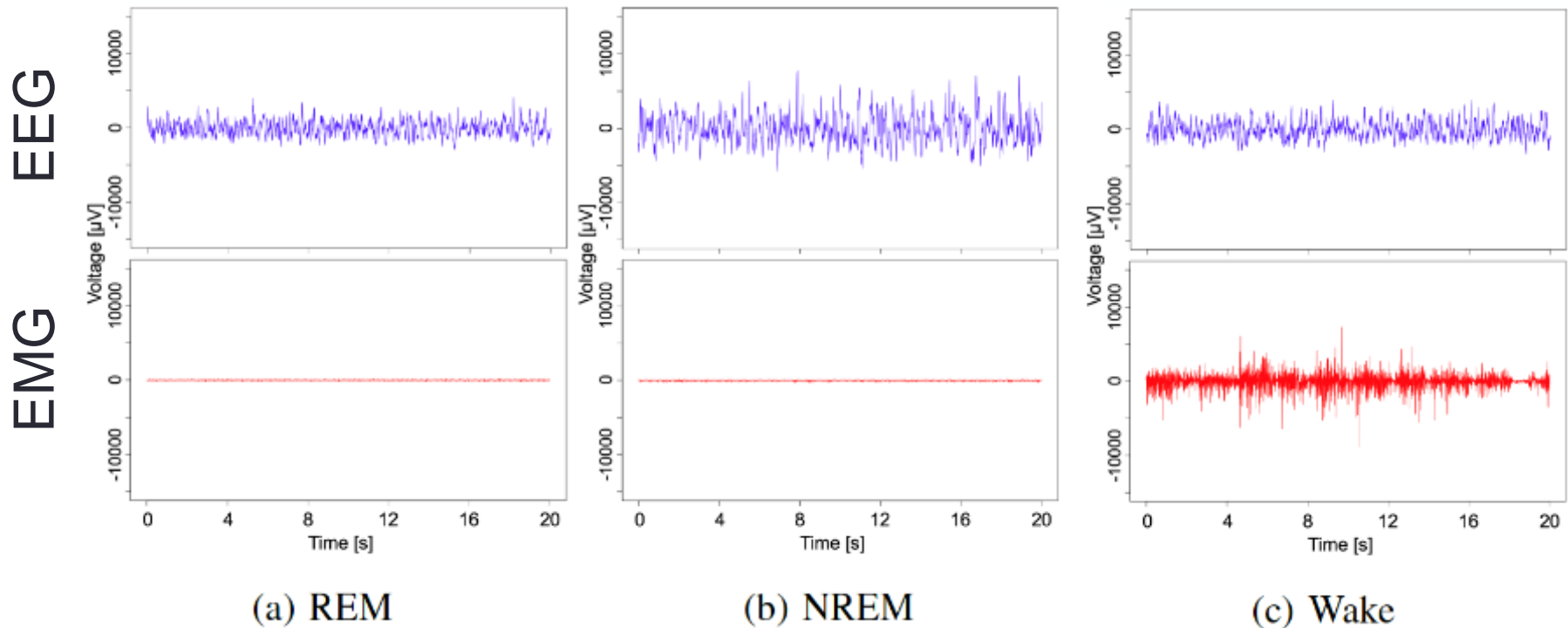
Sleep Stage Scoring for Mice

- Clinical experts often analyze sleep stages of mice for different purposes, say to check effectiveness of mediations for the sleep disorder.

- Abundant mice data sets.

Electric signals from the brain

EEG (electro-encephalography)

EMG (electro-myography)

Electric signals from the spinal cord

Sleep Stages

- Mice generally take three sleep stages:
  - REM, Non-REM, and Wake
  - They have different amplitudes in EEG and EMG signals.

(a) REM   (b) NREM   (c) Wake

How is sleep state scoring done?

- Human experts *visually inspect signals* for sleep stage scoring.

  - Split EEG/EMG signals into fixed size of subsequences, called *epochs*, and score them.

    - Epoch length: ~20 seconds.

- Time-consuming and needs much labor.

 - *An expert needs to spend more than 24 hours* to classify EEG/EMG signals whose length is 8 hours.
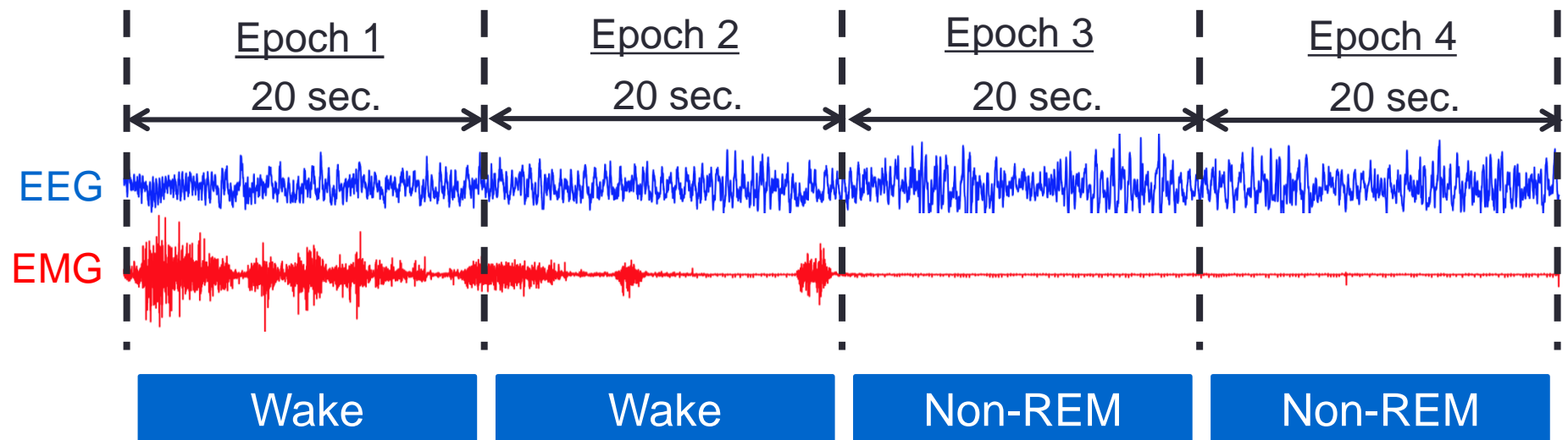
Existing works

- Clinical researchers require **more than 95% accuracy!**

- Existing works:
  - Neural network based method [Yokoyama et al., 1993]
  - Decision tree based method [Hanaoka et al., 2001]
  - LDA + Decision tree [Brankack et al., 2010]
  - Naïve Bayes classifier [Rempe et al., 2015]
  - FASTER [Sunagawa et al., 2013], exFASTER：[Suzuki et al., 2015]

  They have not yet achieved 95% accuracy.

Overview of MASC

- MASC: a supervised sleep stage classification method
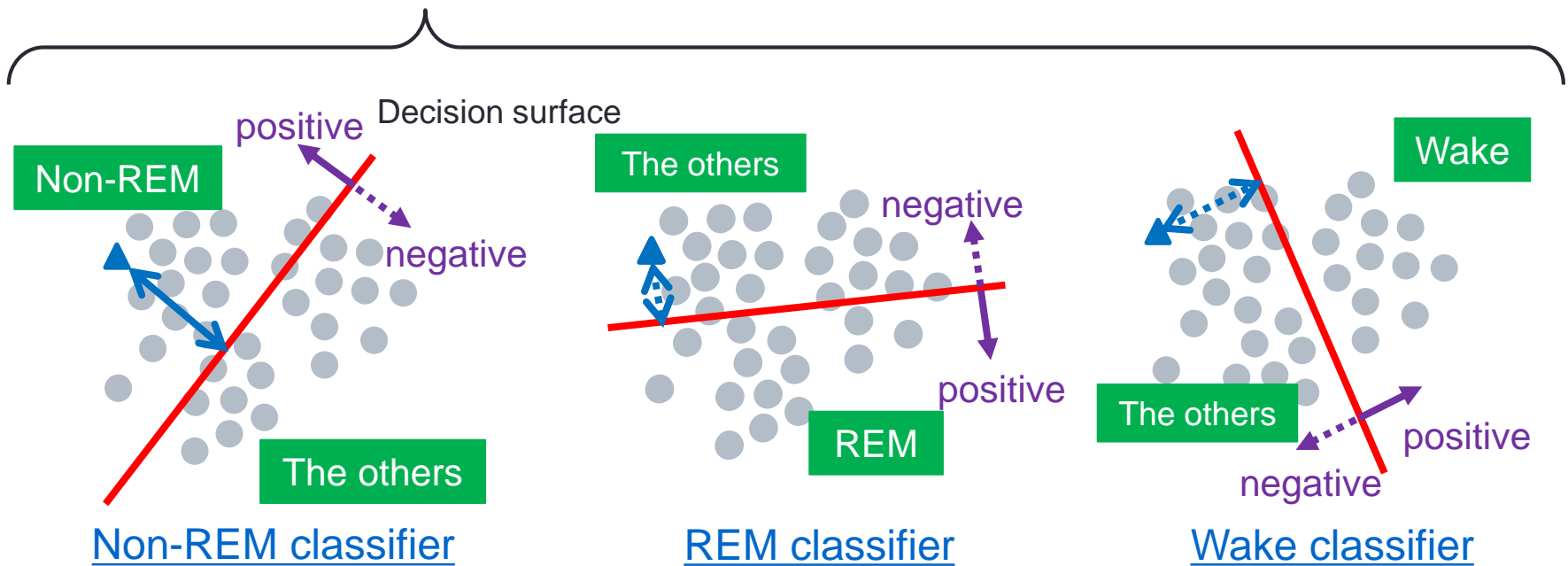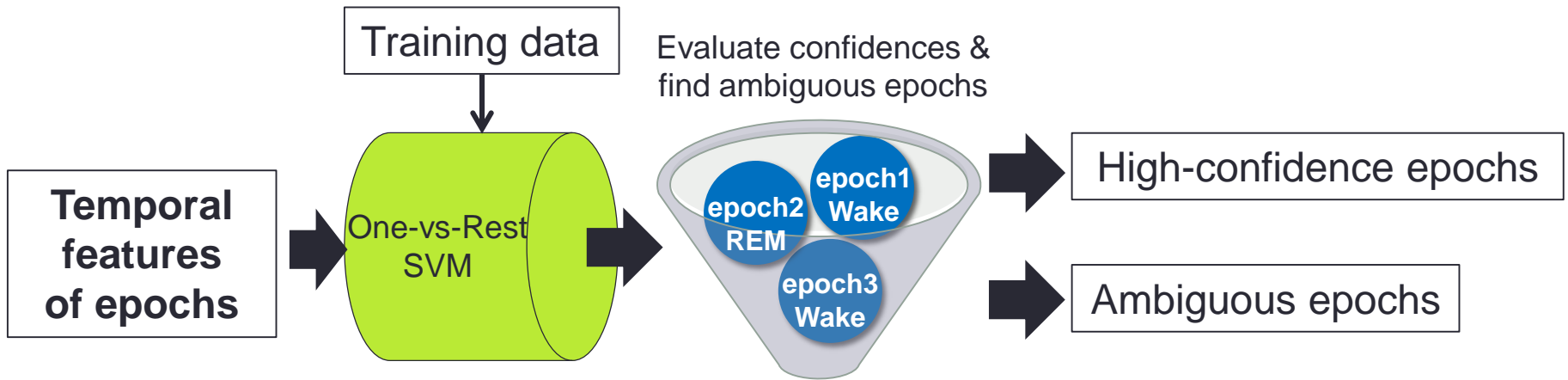 - MASC consists of the following three steps.
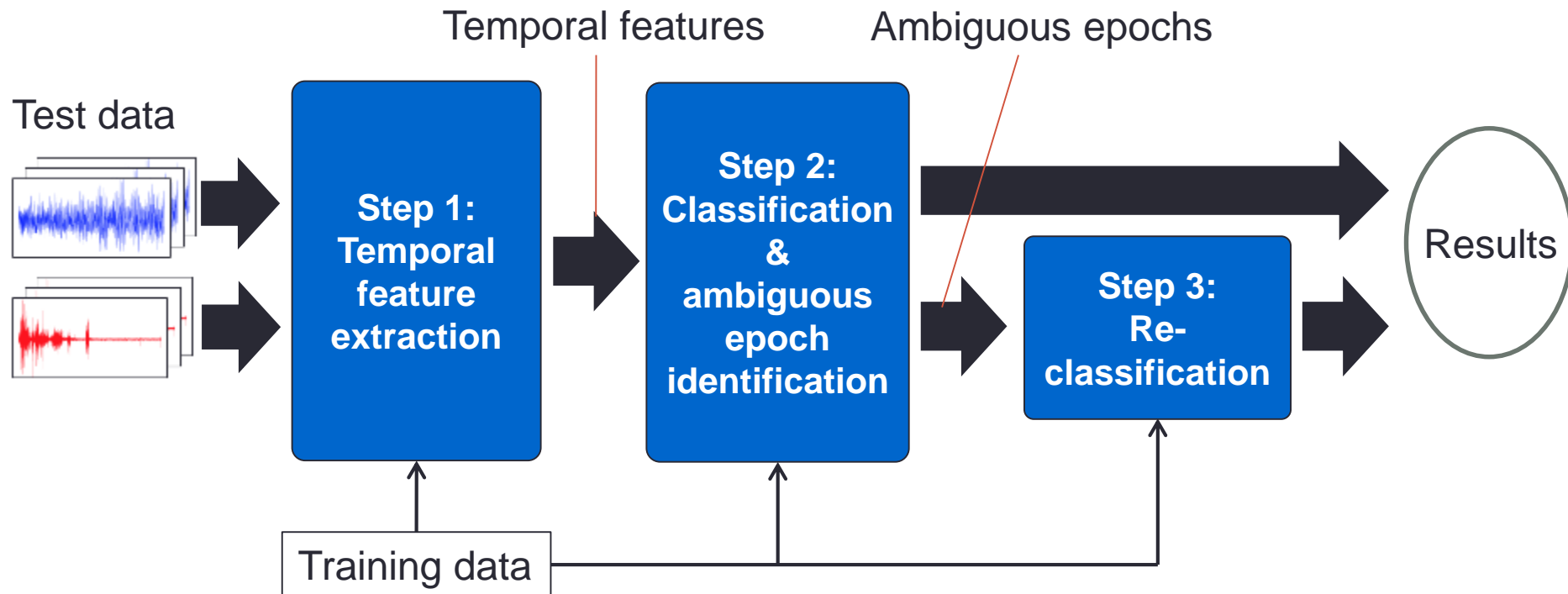
1. Temporal feature extraction

- FFT spectrum: the main feature
- Careful dimension reduction so as not to drop components important for sleep stage scoring.
- Include class labels tentatively given to epochs before and after the target epoch into its feature.
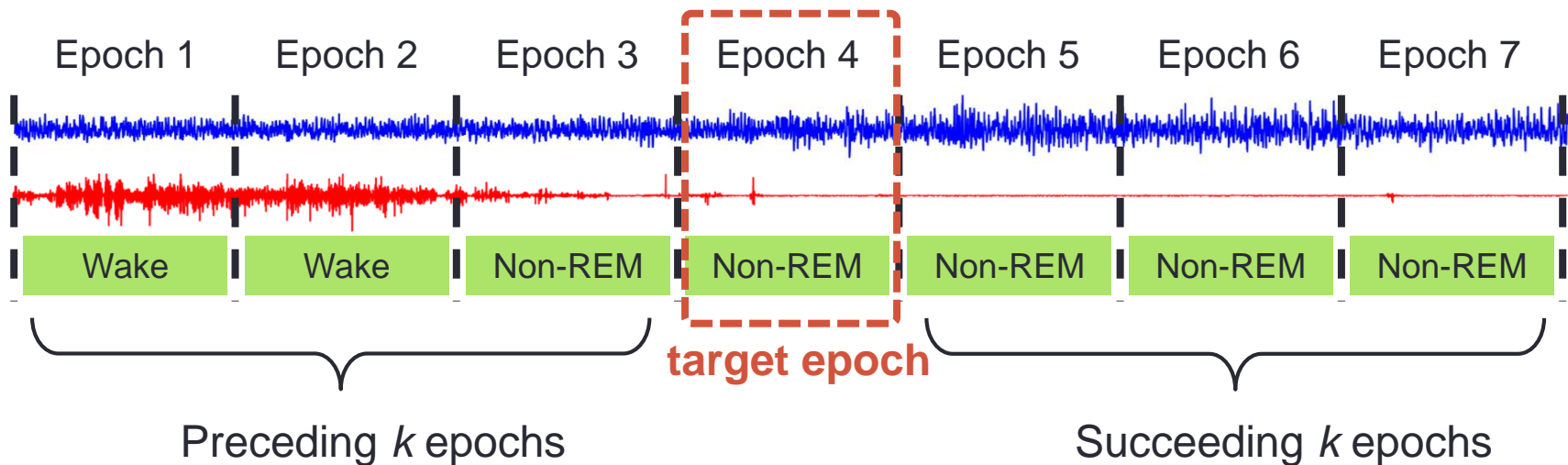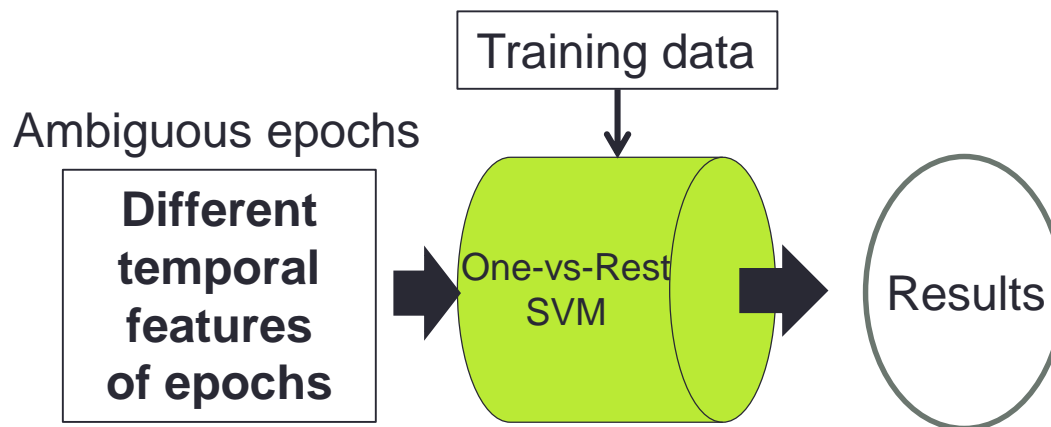
# 2. Classification & ambiguous epochs identification

3. Re-classification

- MASC re-classifies ambiguous epochs by using **different types features and a classifier**.
  - The misclassification ratio for REM is high compared with other stages.
  - Misclassified epochs are often Non-REM rather than REM.
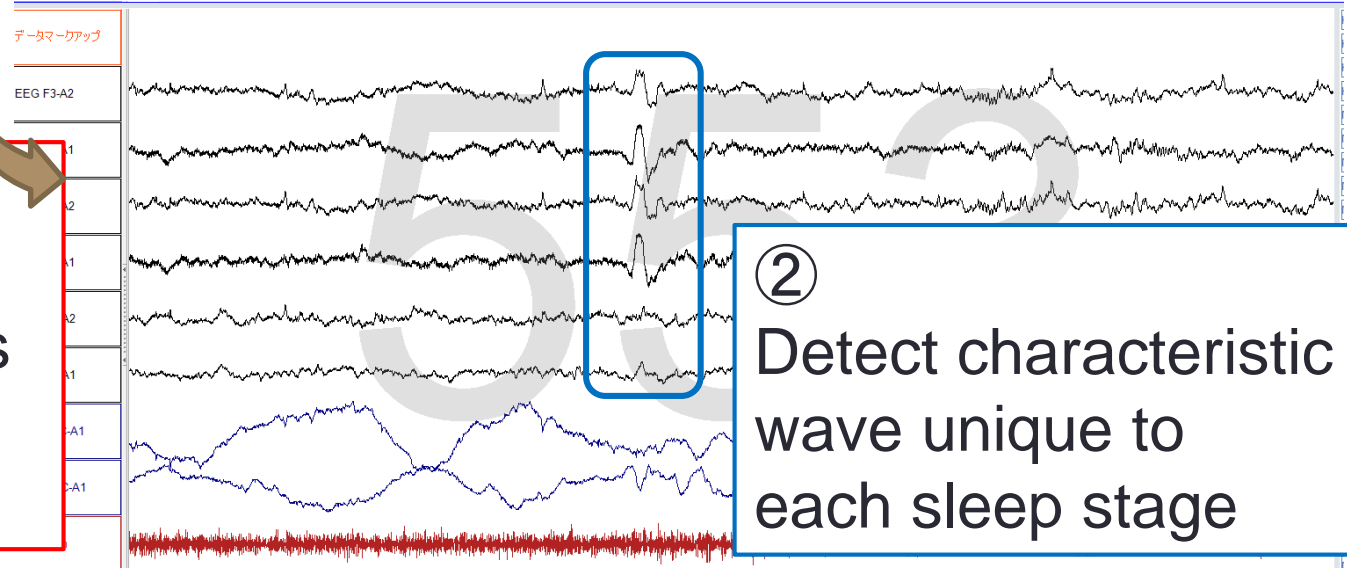 - We use different features and a classifier which are good at identifying the REM stage.

Training data

Ambiguous epochs

Different temporal features of epochs → One-vs-Rest SVM → Results

The procedure of
sleep stage scoring for humans
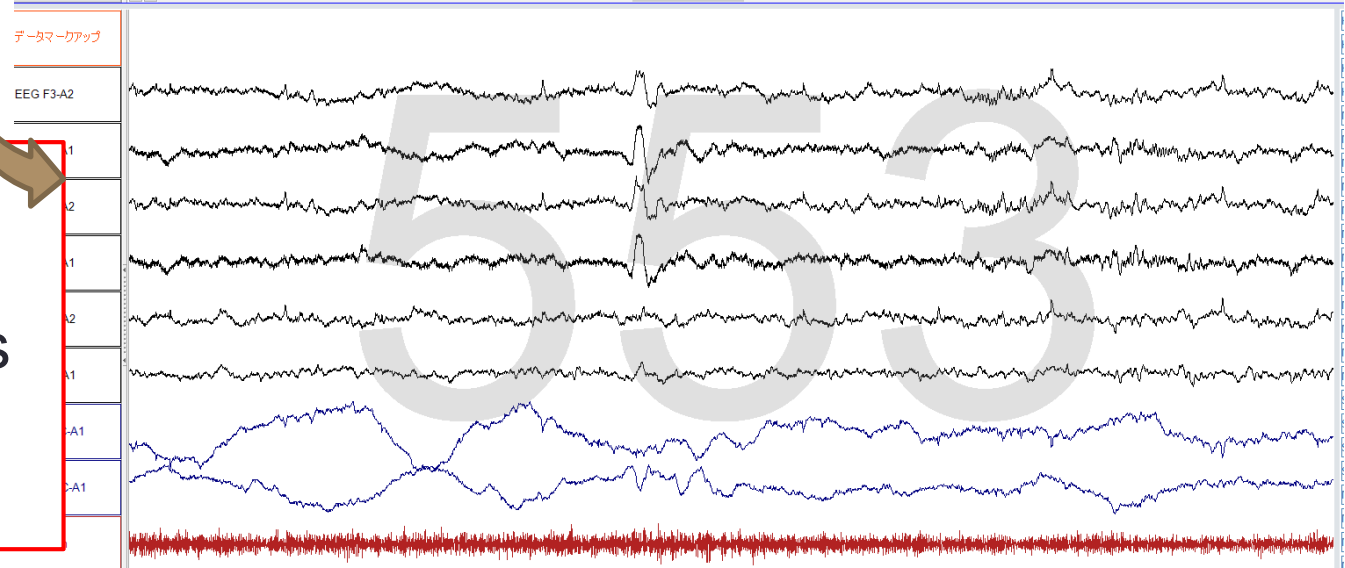
① Measure biological signals & split them into epochs

The procedure of
sleep stage scoring for humans

① Measure biological signals & split them into epochs
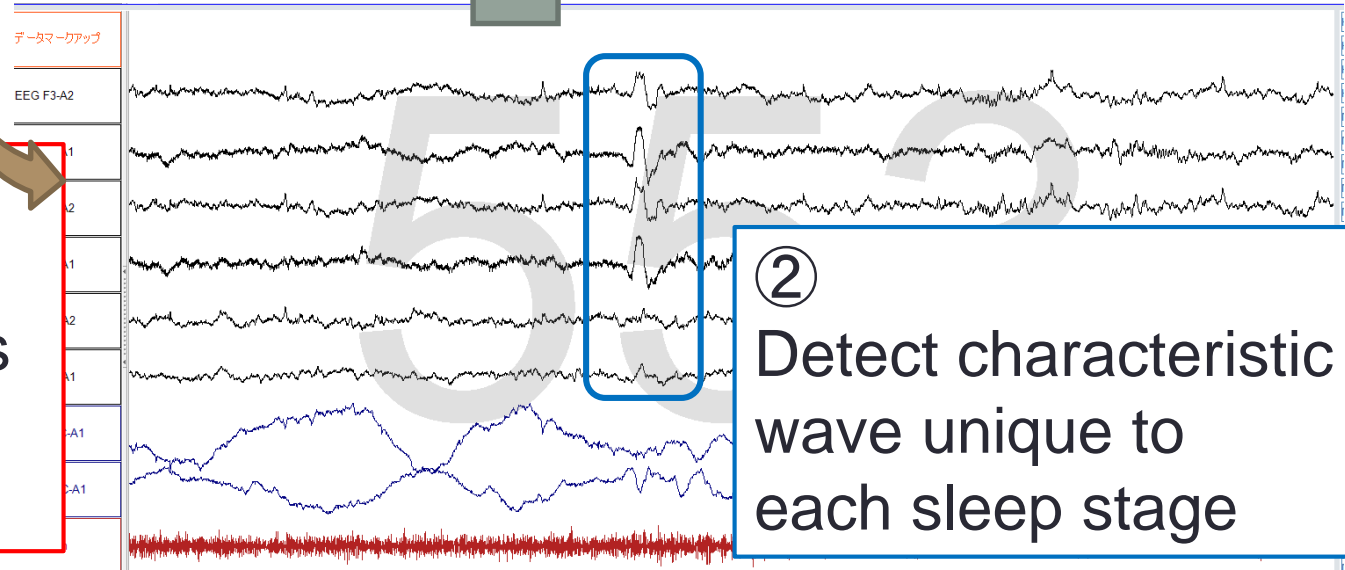
② Detect characteristic wave unique to each sleep stage

The procedure of sleep stage scoring for humans

③ Decide sleep stage

①
Measure biological signals & split them into epochs

②
Detect characteristic wave unique to each sleep stage

Conclusion

We have developed automated sleep stage scoring methods for mice and humans.

Experimental results show that the proposed methods are promising.