# Journal Club

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# What I have done by now

- **Paper Reading**

  - Robust, automated sleep scoring by a compact neural network with distributional shift correction.

  - SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

- **Software & Hardware Coding**

  - Matlab codes for automated real-time sleep scoring

  - Arduino codes for controlling the singlechips to manipulate stimulus signal

- **Background**
- **Distributional shift correction**
- **Automated sleep scoring by neural network**
- **AccuSleep interface for sleep scoring**

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ Background

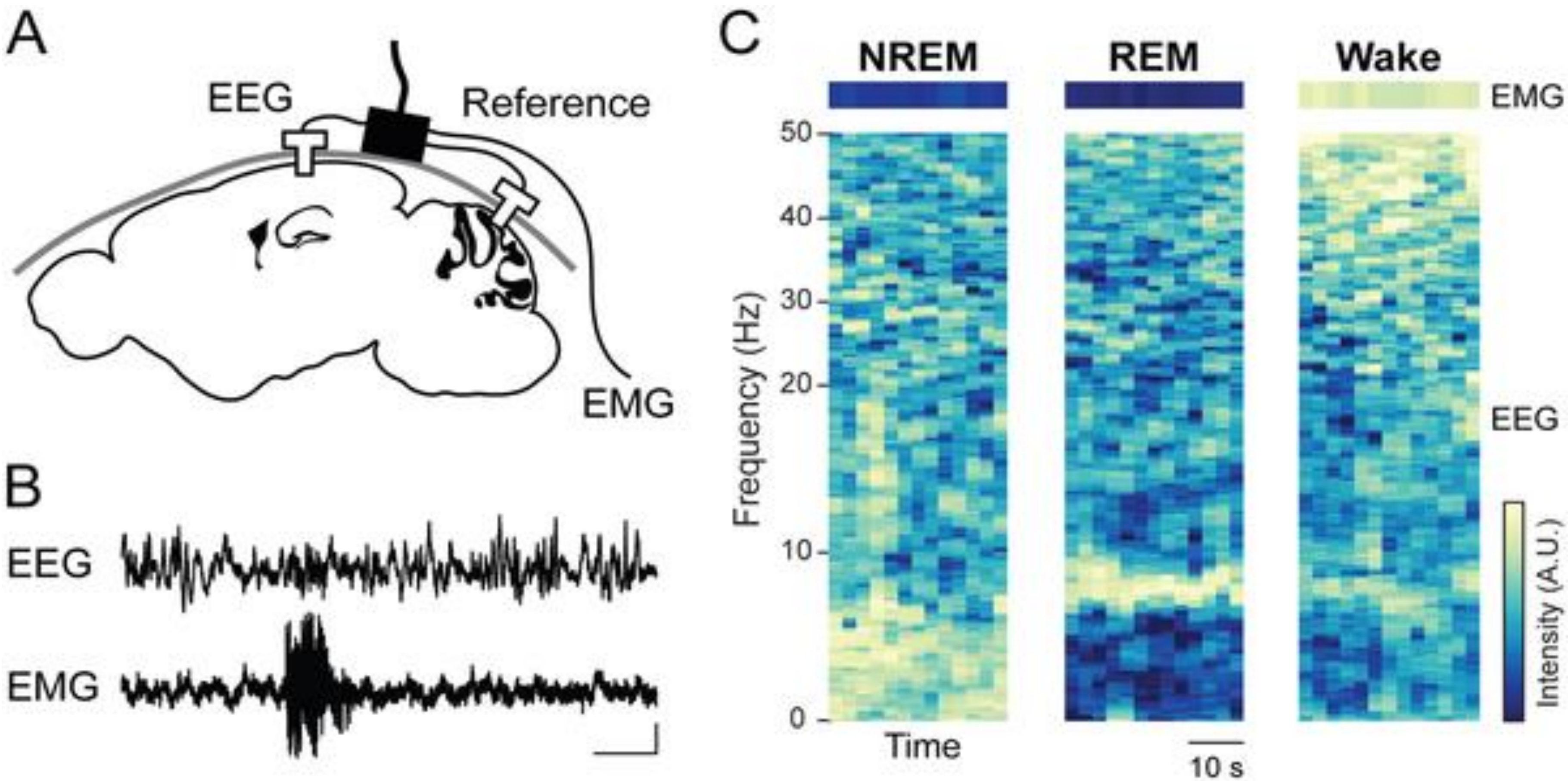



**Fig 1. Overview of the signal collection process for sleep scoring in mice.**

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ Distributional shift correction

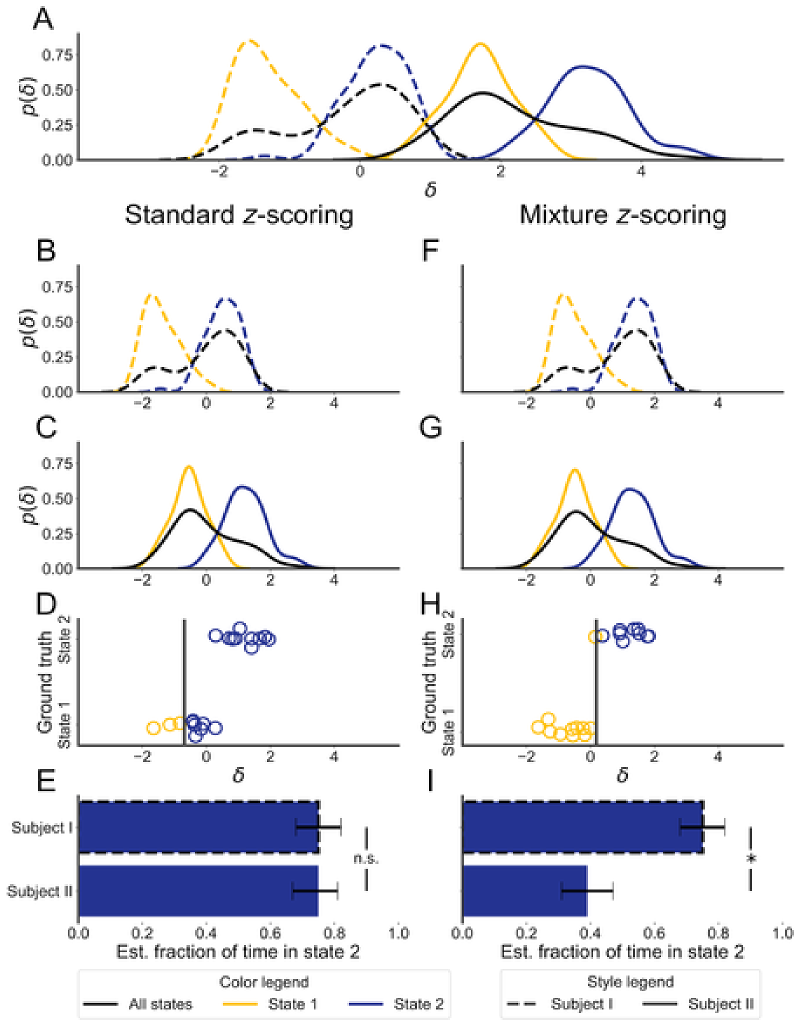



**Fig 2. Correcting for distributional shift prevents a false negative in a simple model.**

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

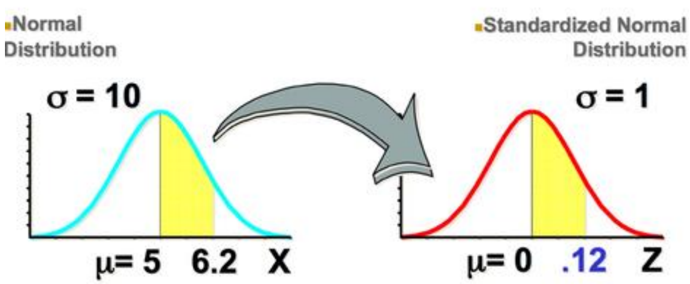
## ❖ Distributional shift correction

*z*-scores

$$Z = \frac{\Phi - \mu}{\sigma}$$

**Example**

$$Z = \frac{X - \mu}{\sigma} = \frac{6.2 - 5}{10} = .12$$




**Mixture *z*-scoring**

$$Z_M = \frac{\Phi - w^\top \hat{\mu}}{\sqrt{w^\top\left(\hat{\sigma}^2 + (\hat{\mu} - w^\top \hat{\mu})^2\right)}}$$

$$\phi_Z = \frac{\phi - \mu_G}{\sigma_G} = \frac{\phi - w^\top \mu}{\sqrt{w^\top(\sigma^2 + s)}} \qquad \mu_G := \mathbb{E}[\phi] = w^\top \mu$$

$$w_i := P(Y = i) \qquad \sigma_G^2 := \mathbb{V}[\phi] = w^\top(\sigma^2 + s)$$

$$\mathbb{E}[\phi|Y = i] := \mu_i \qquad \mathbb{V}[\phi] = w^\top \sigma^2 + w^\top(\mu - w^\top \mu)^2$$

$$\sigma_i^2 := \mathbb{V}[\phi|Y = i] \qquad s := (\mu - w^\top \mu)^2$$

$\sigma_G^2$ comes from the law of total variance:

$$\mathbb{V}[\phi] = \mathbb{E}[\mathbb{V}[\phi|Y]] + \mathbb{V}[\mathbb{E}[\phi|Y]]$$

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ Distributional shift correction

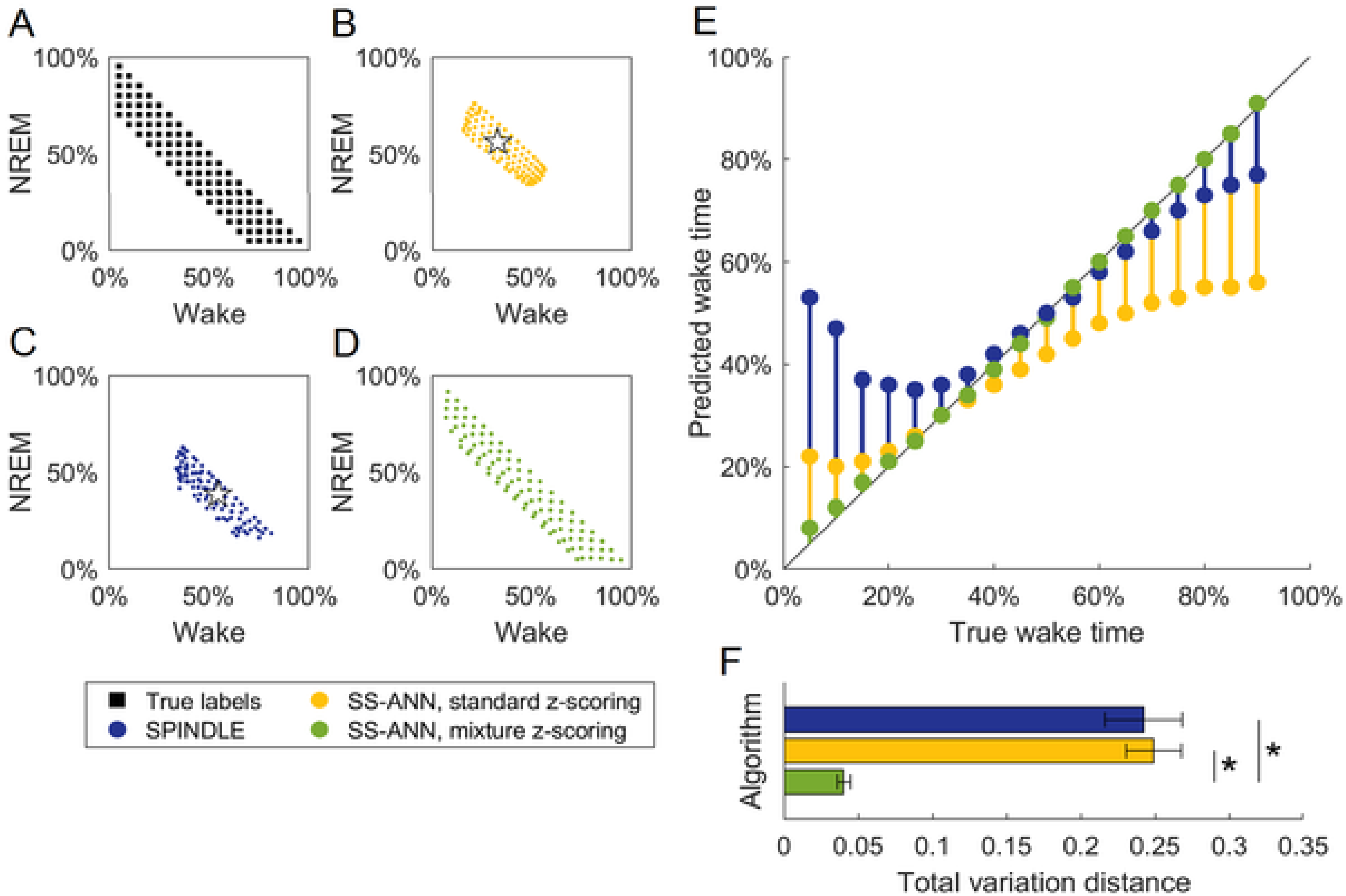



**Fig 3. Comparison of sleep scoring algorithms on recordings with programmatically varied class balances.**

# SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

## ❖ Automated sleep scoring by neural network

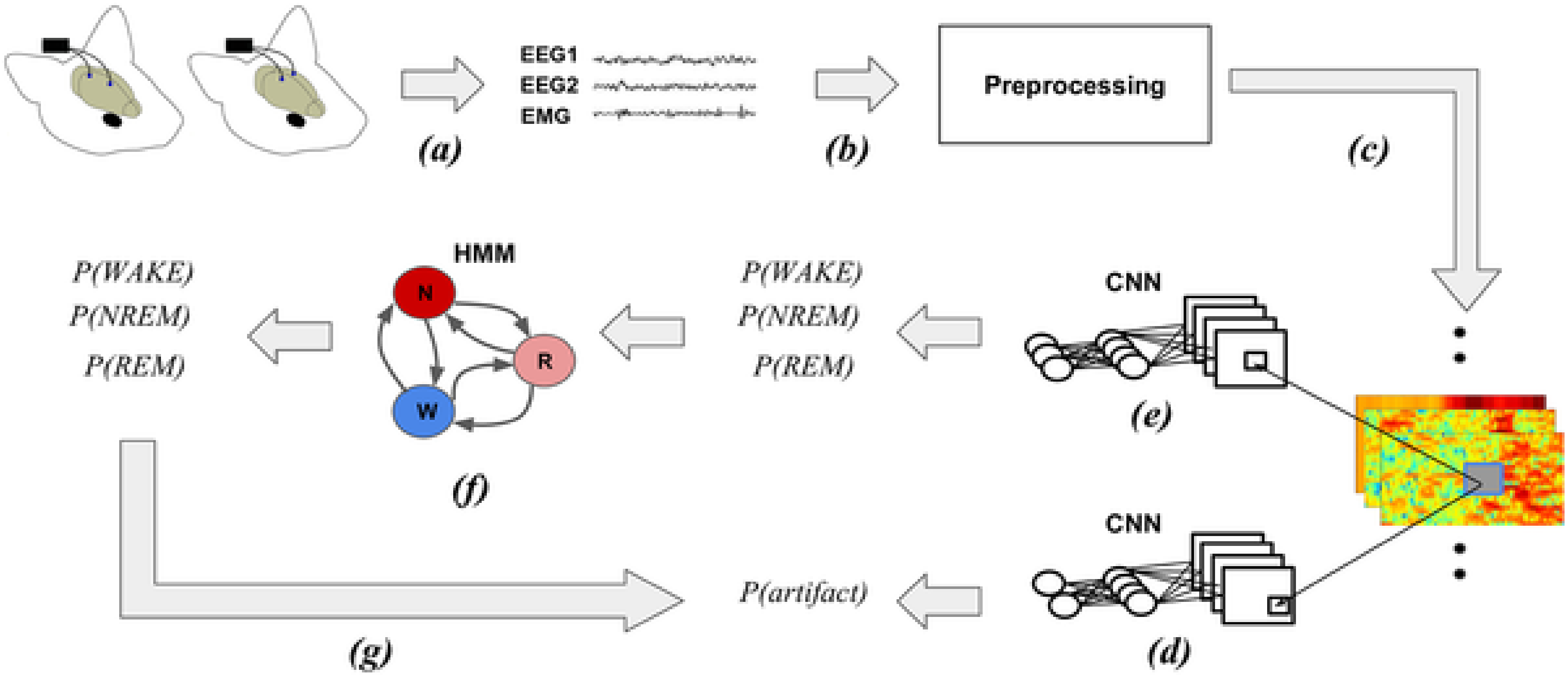



**Fig 4. Conceptual overview of the SPINDLE framework.**

# SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

## ❖ Automated sleep scoring by neural network

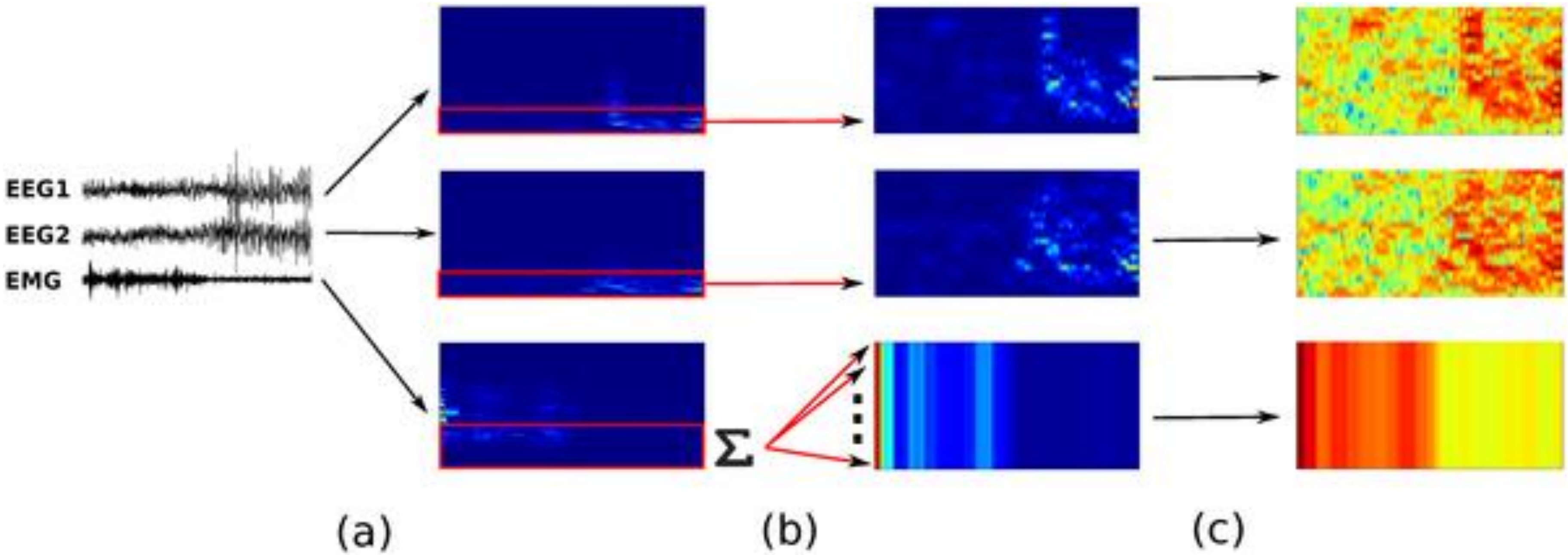



**Fig 5. Data preprocessing and CNN input preparation.**

## SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

### ❖ Automated sleep scoring by neural network

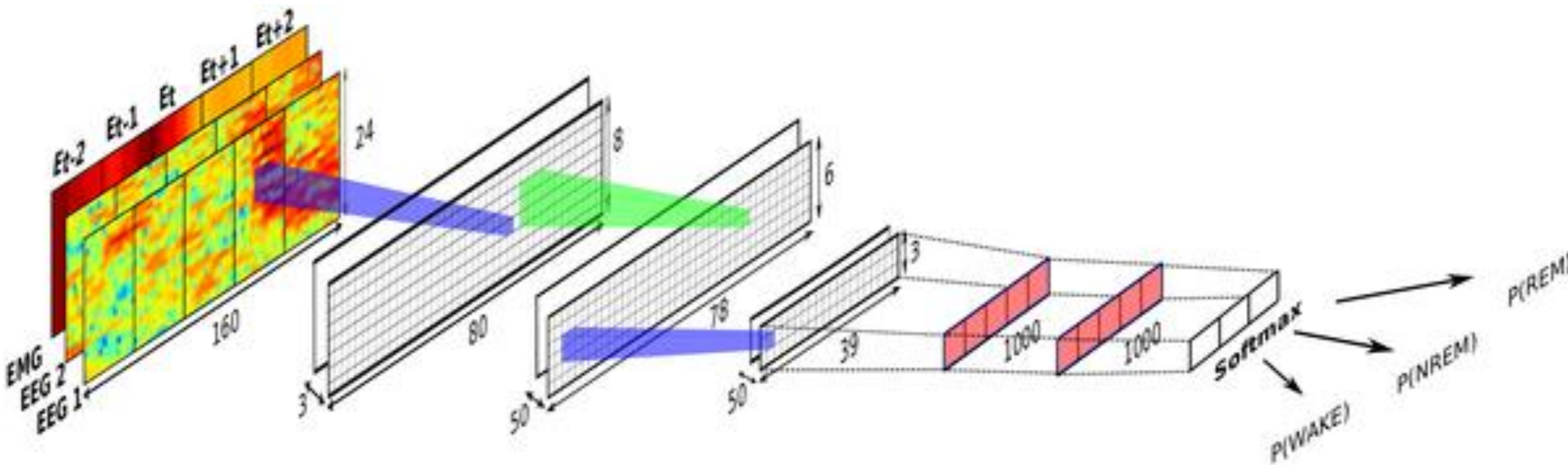



**Fig 6. Sleep scoring CNN architecture.**

# SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

## ❖ Automated sleep scoring by neural network

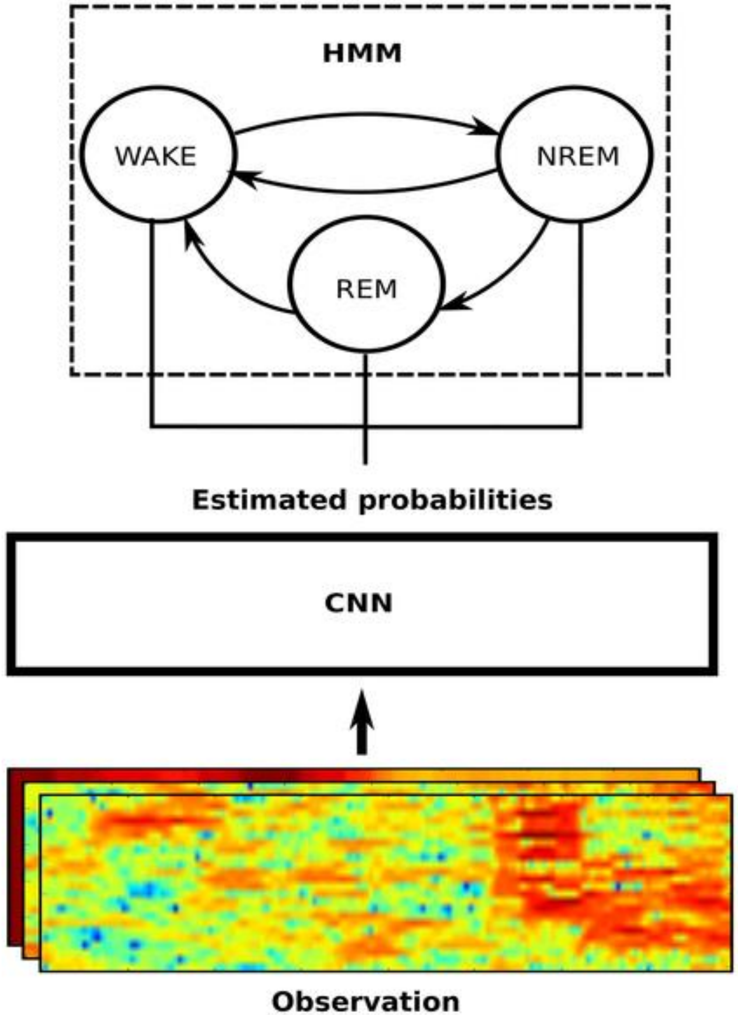



Fig 7. CNN-HMM for constraining state transitions.

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ Automated sleep scoring by neural network

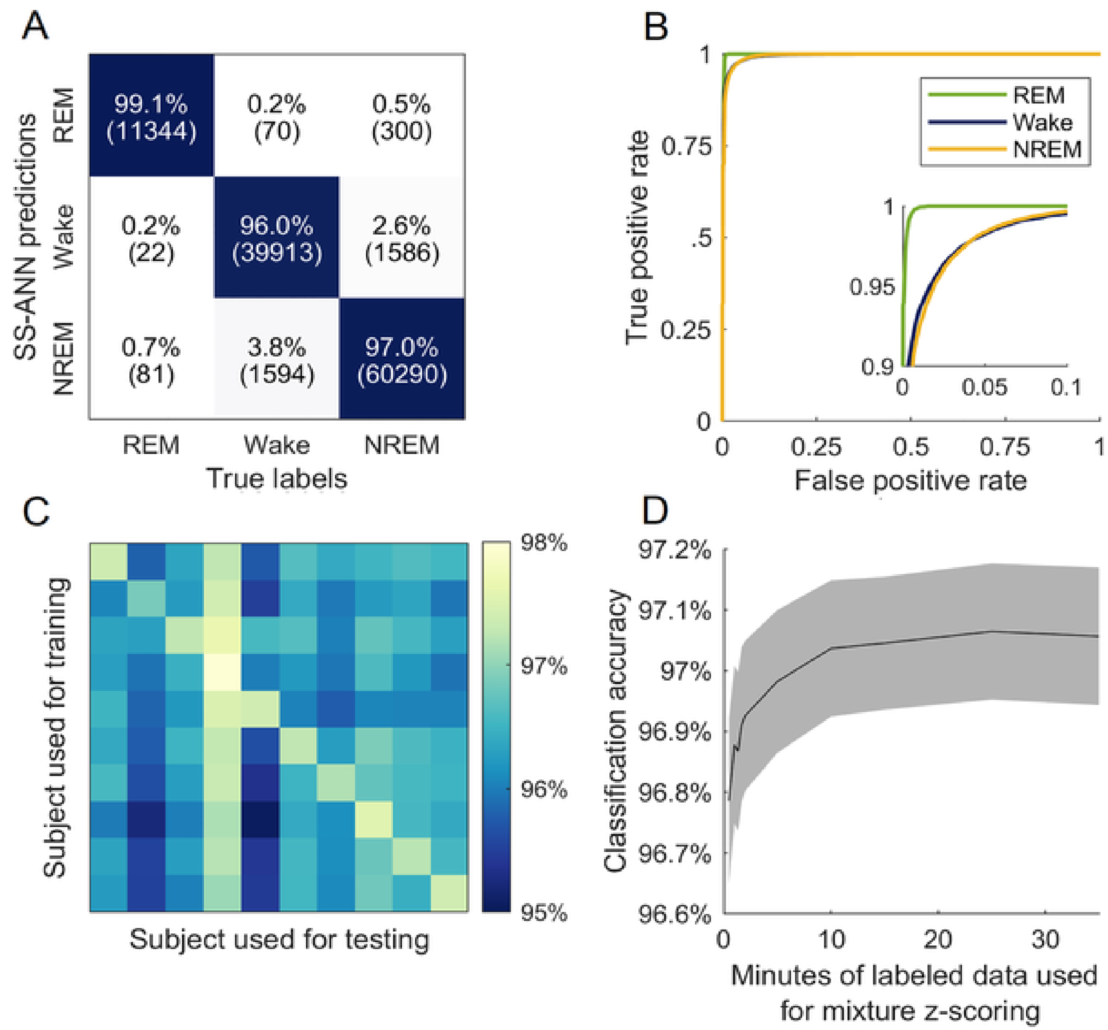



**Fig 8. Validation of SS-ANN.**

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ AccuSleep interface for sleep scoring

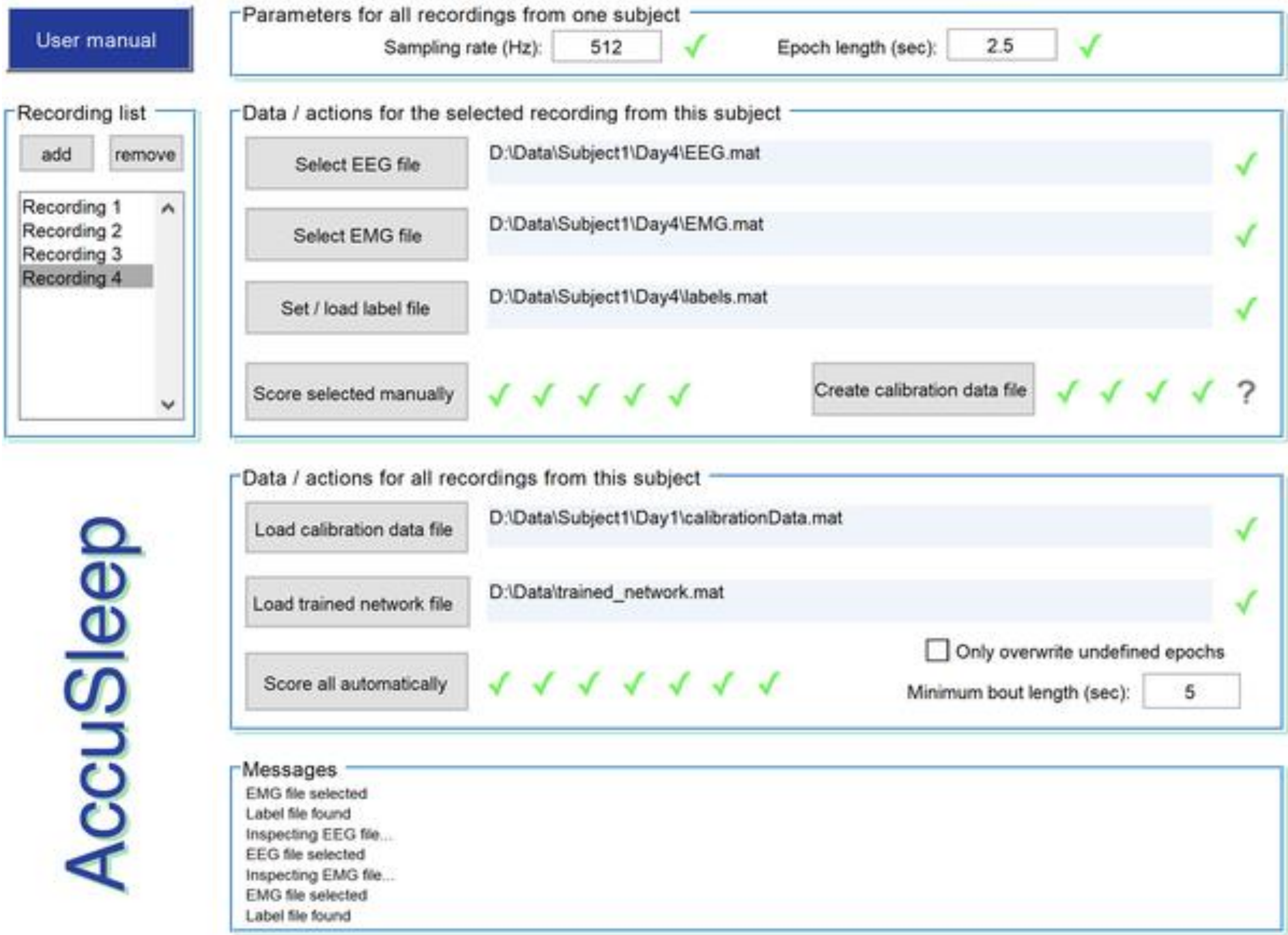



**Fig 9. AccuSleep interface for automated sleep scoring.**

# Robust, automated sleep scoring by a compact neural network with distributional shift correction.

## ❖ AccuSleep interface for sleep scoring

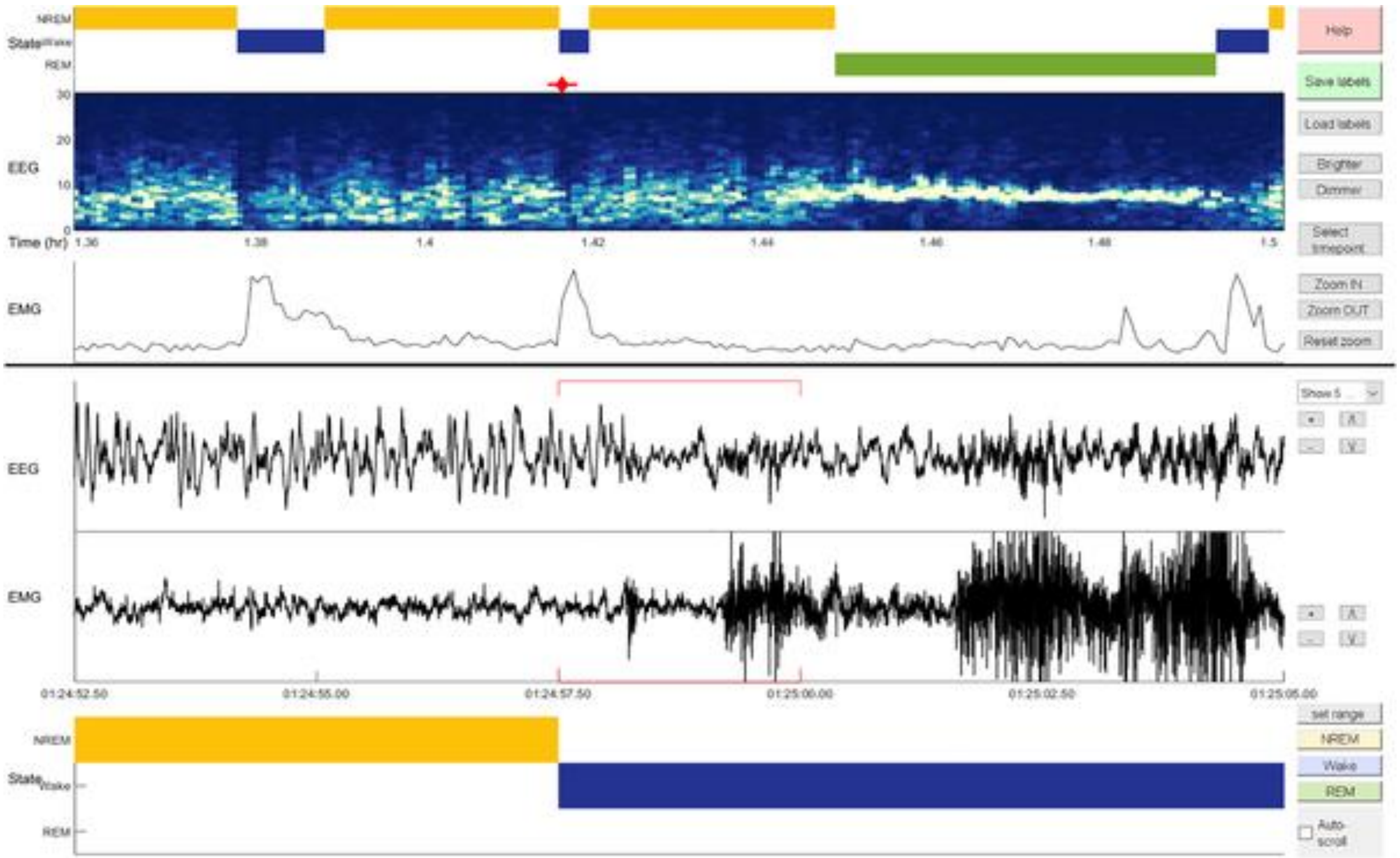



Fig 10. AccuSleep interface for manual sleep scoring.

# ❖ Our sesults

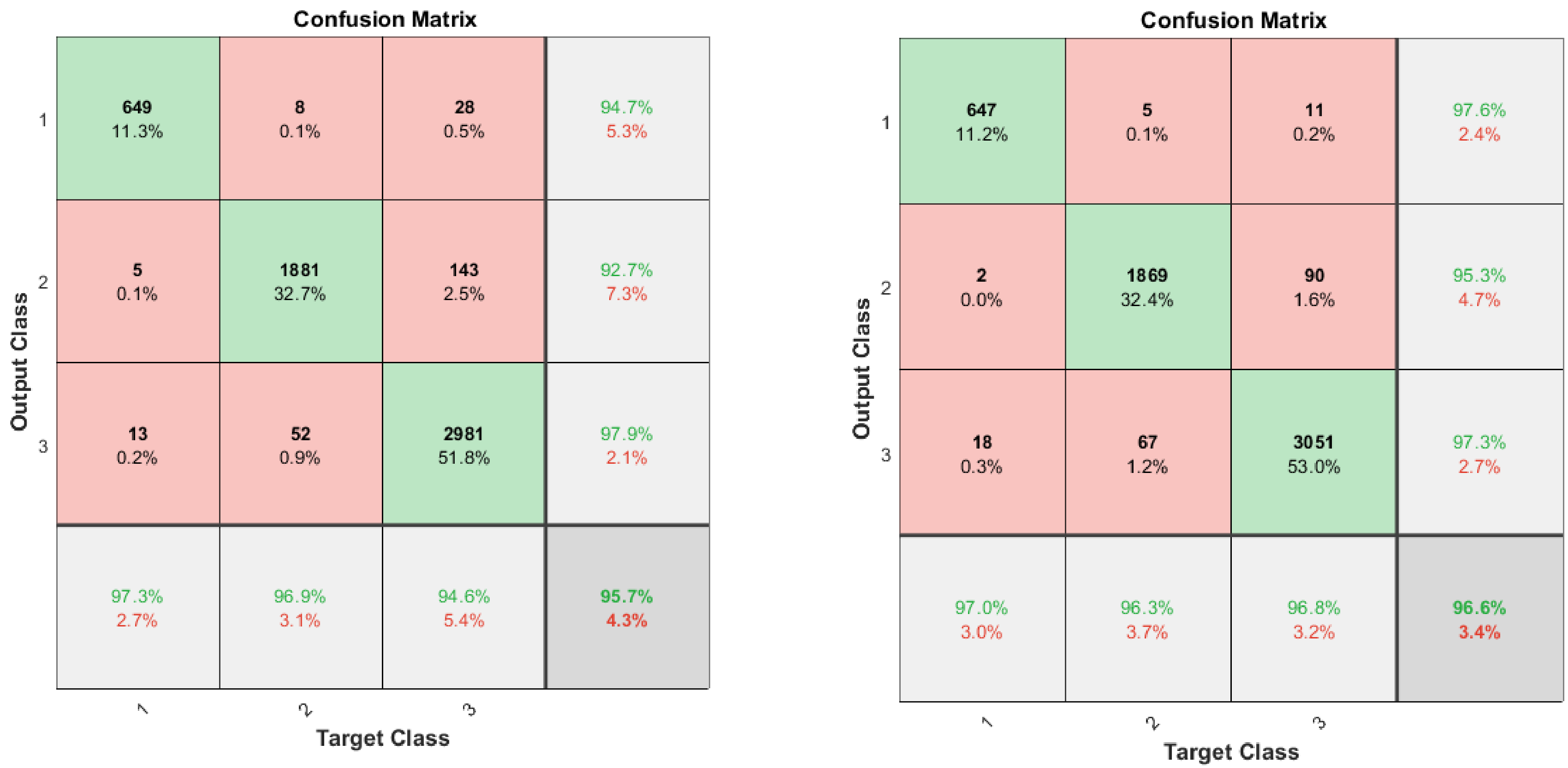
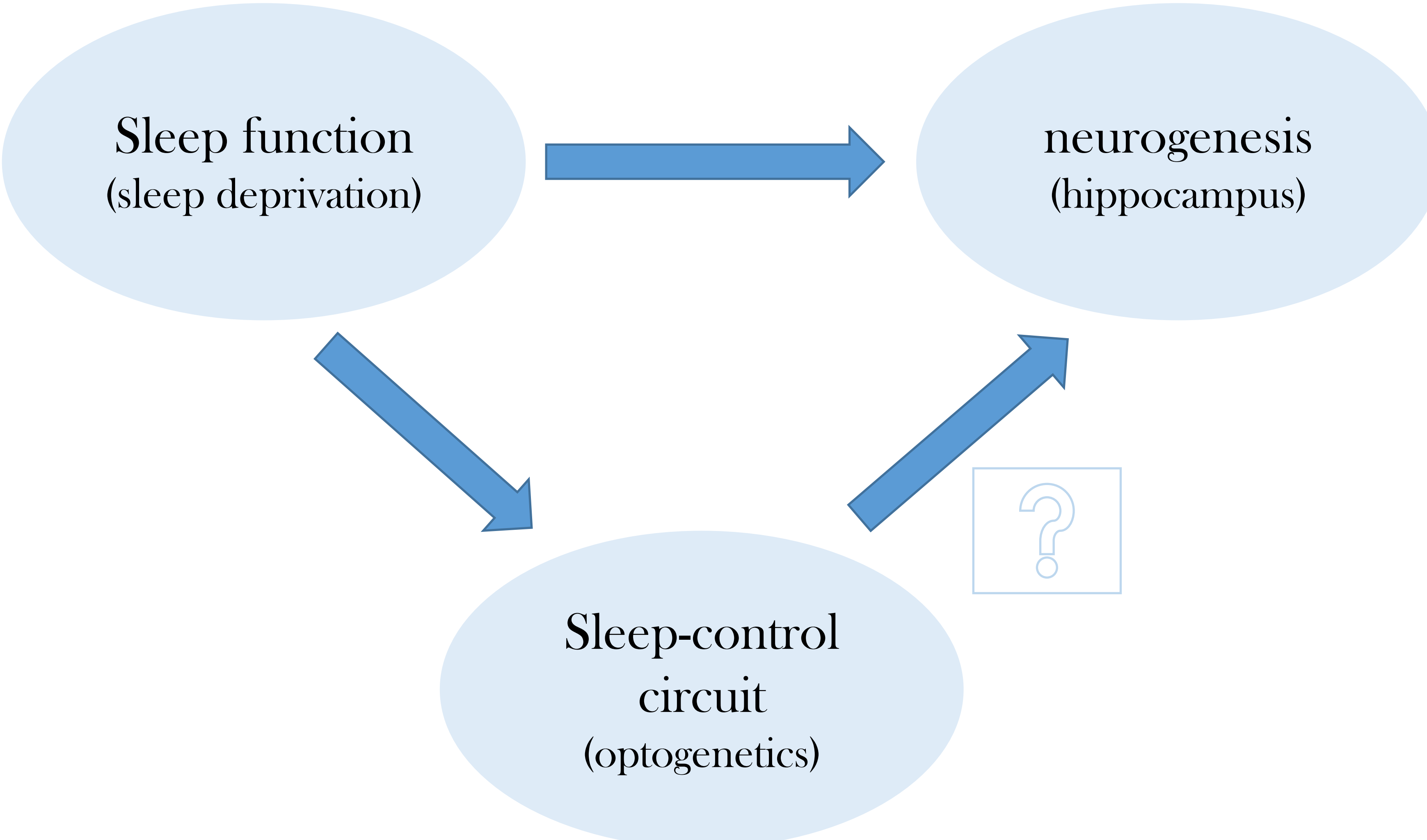



**Fig 11. confusion matrix of auto-mated sleep scoring at different parameters.**

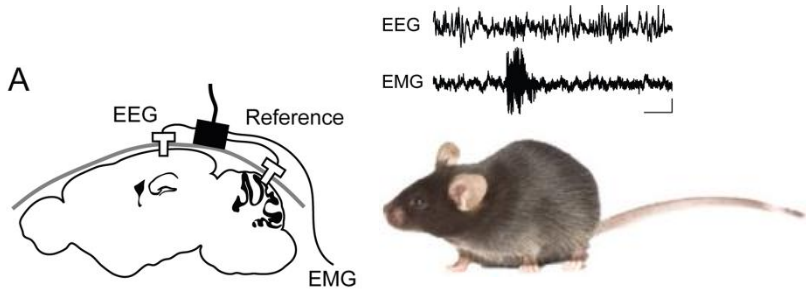
# Project Plan

## ❖ Project purpose

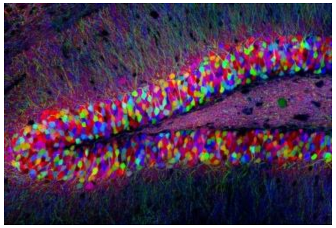


# Project Plan

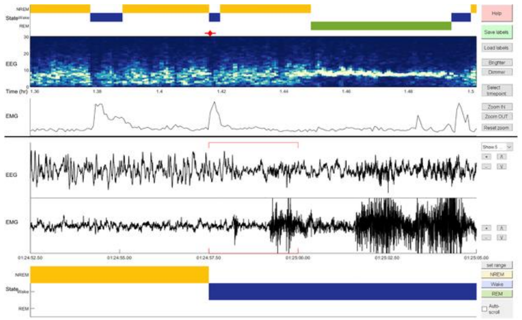
## ❖ Project design: close-loop



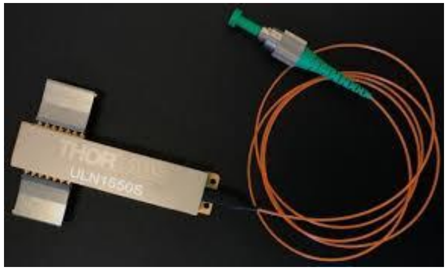

EEG,EMG signals

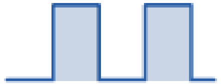


neurogenesis



MATLAB:
Sleep stage classification





Laser optical stimulus

Single-chip (Arduino)

# References

Barger Z, Frye CG, Liu D, Dan Y, Bouchard KE (2019) **Robust, automated sleep scoring by a compact neural network with distributional shift correction.** PLOS ONE 14(12): e0224642. https://doi.org/10.1371/journal.pone.0224642
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0224642

Miladinović Đ, Muheim C, Bauer S, Spinnler A, Noain D, et al. (2019) **SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.** PLOS Computational Biology 15(4): e1006968. https://doi.org/10.1371/journal.pcbi.1006968
https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1006968