Experience related changes in dog (*Canis familiaris*) sleep EEG

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Introduction

Information processing and **memory consolidation** have been the focus of **sleep** research for a long time, thus these phenomena are widely studied both in humans and model systems (Klimesch 1996, Stickgold et al. 2001). **Dogs** have become a primary model of **social cognition research**, however these have almost exclusively focused on **awake functioning**. Furthermore, apart from a few exceptions (e.g. Törnqvist et al. 2013) **EEG** data on **animal models** is gathered with **invasive** techniques.

AIM

To **adapt** the human (non-invasive) **polysomnographic** technique to **dogs**.

QUESTIONS

STUDY 1: Is the **sleep** pattern of dogs different following a behaviourally **active** versus **passive day?** (method **validation**)
STUDY 2: Is memory consolidation after a **learning** task reflected in dog **sleep EEG**?

Methods

Data recording

Dog-owner co-sleep on three occasions (3hours each)
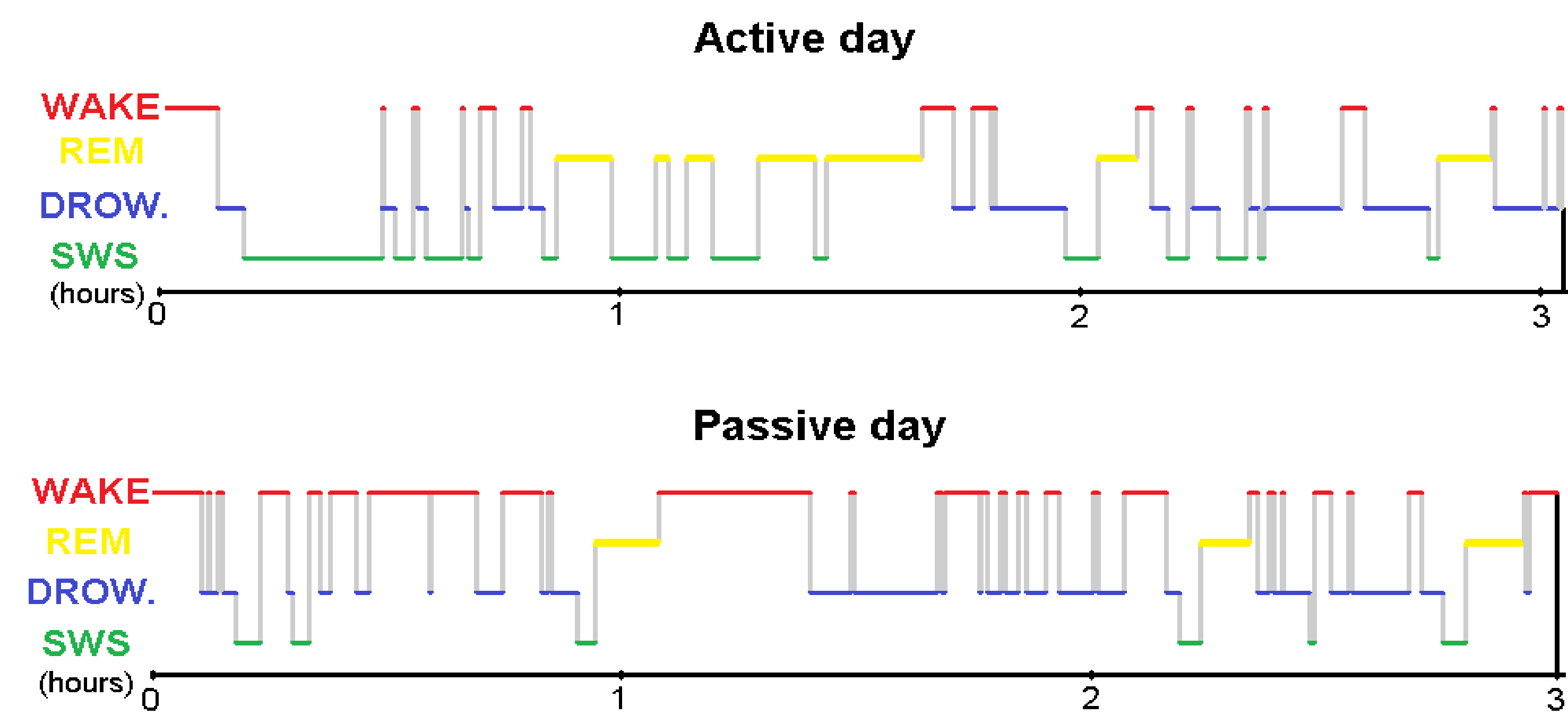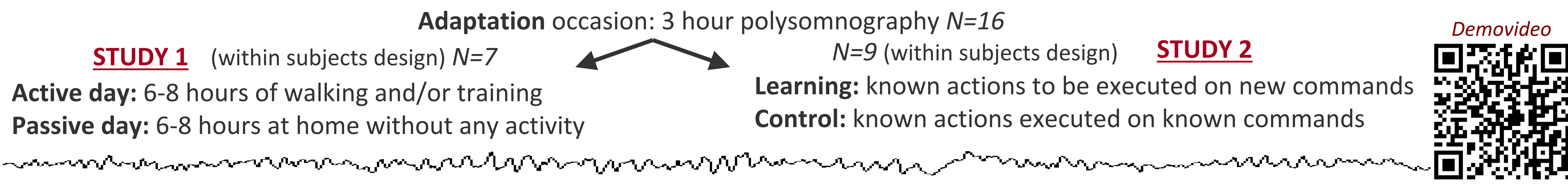Fully non-invasive **polysomnography** (EEG, EOG, ECG, EMG) technique

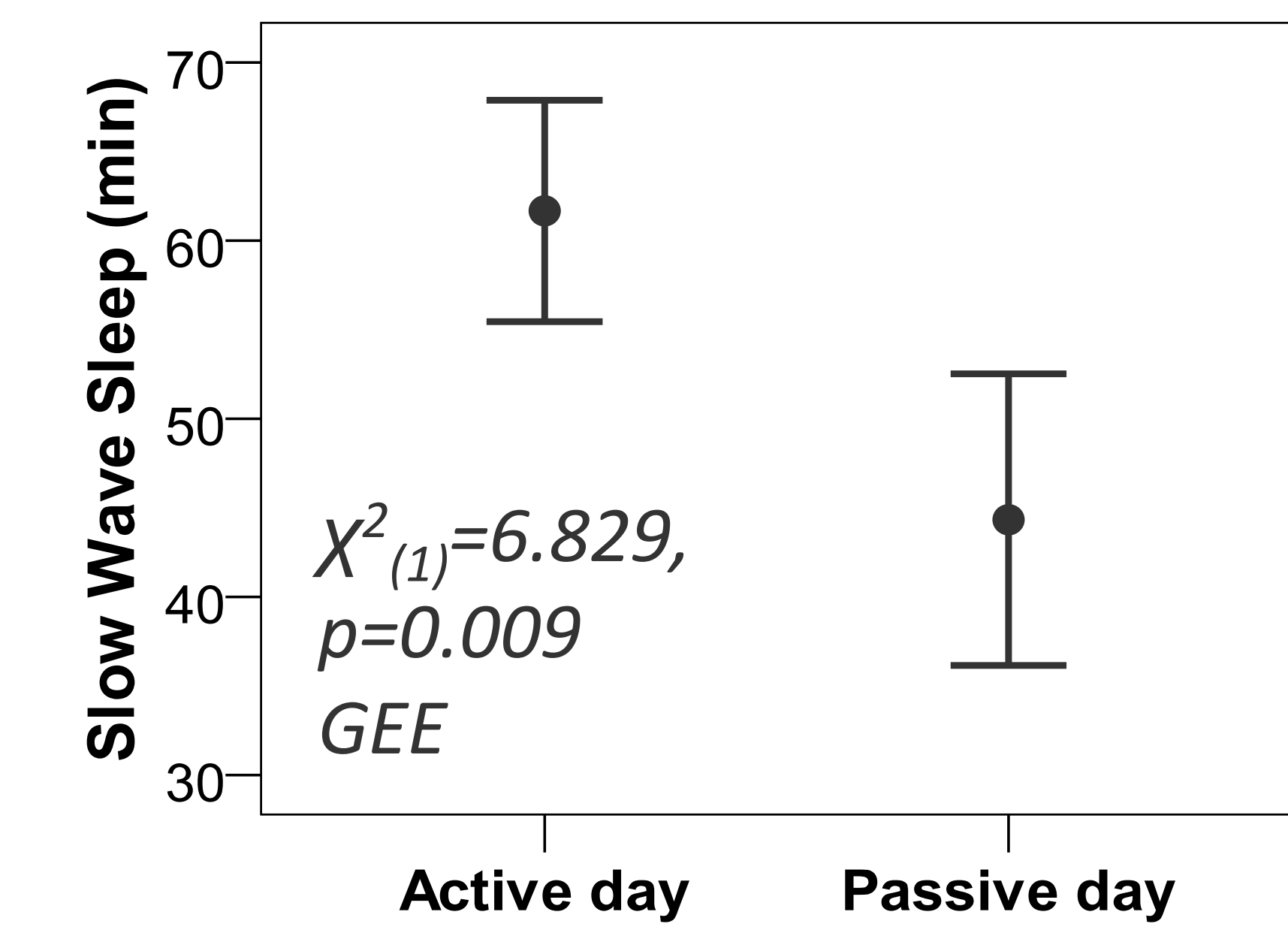*Electrode placement*
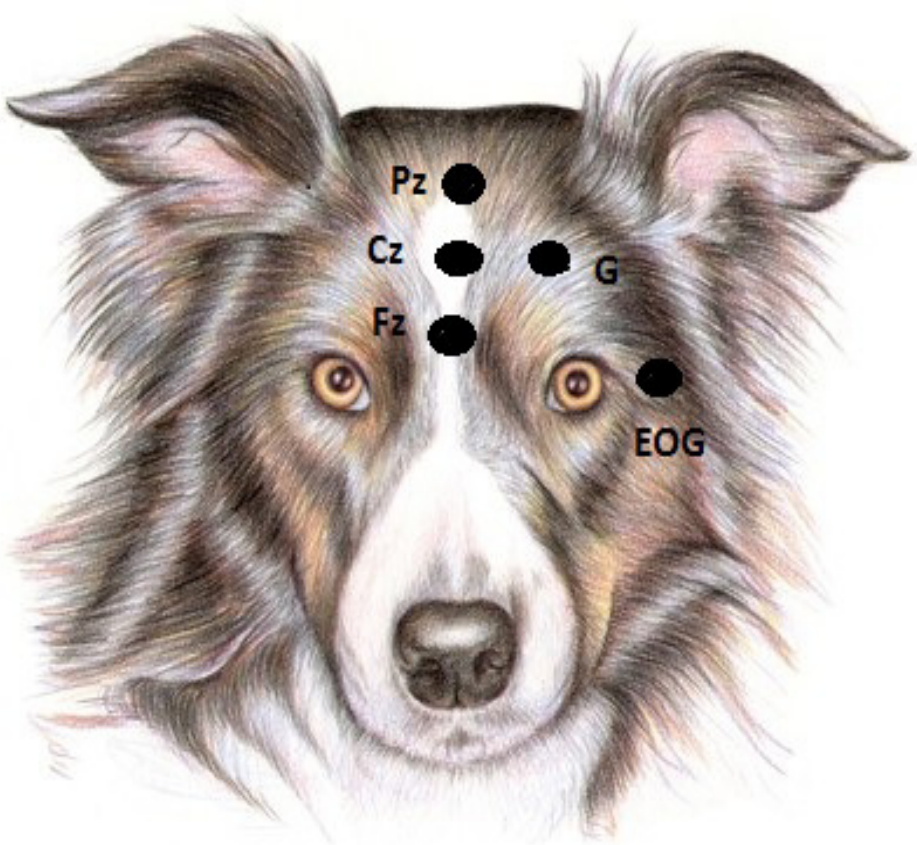
Experimental setup

Data analysis

Hypnogram scoring → **macrostructural** variables
EEG analysis: **relative power** (4 sec FFT Hanning window)

Adaptation occasion: 3 hour polysomnography *N=16*

STUDY 1 (within subjects design) *N=7*
Active day: 6-8 hours of walking and/or training
Passive day: 6-8 hours at home without any activity

N=9 (within subjects design) **STUDY 2**
Learning: known actions to be executed on new commands
Control: known actions executed on known commands

Demovideo

Results

Active day

Passive day

Relative spectrum
- Increased **delta**, decreased **theta** and **alpha** in Drowsiness
- Decreased **delta**, increased **alpha** and **beta** in REM sleep

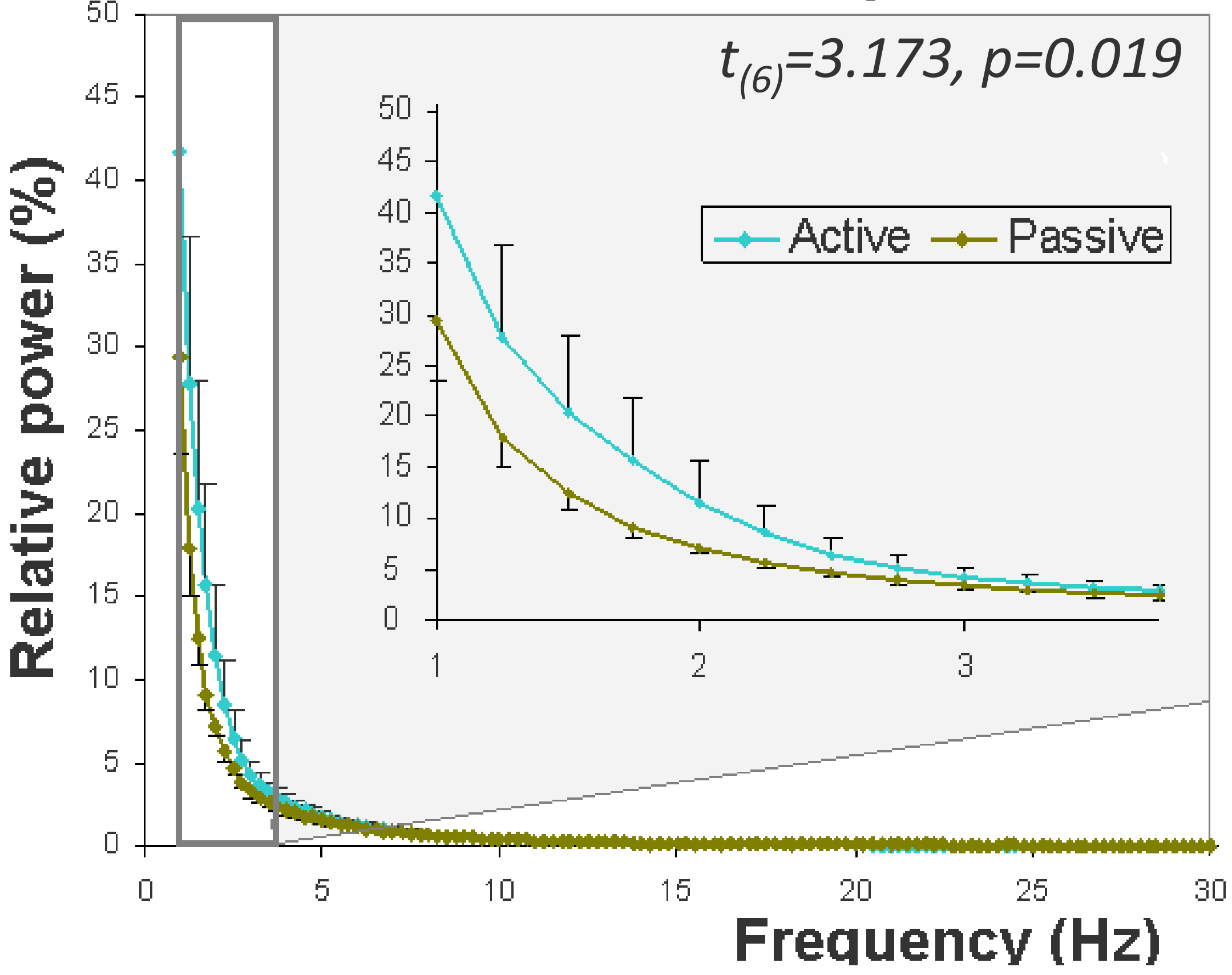### Drowsiness

$t_{(8)}=2.457, p=0.039$

Control — Learning

Macrostructure
- Shortened **sleep latency** and increased **SWS duration** after the **active** day
- No effect on sleep efficiency and sleep cycle duration

$\chi^2_{(1)}=6.829, p=0.009$ GEE

Active day **Passive day**
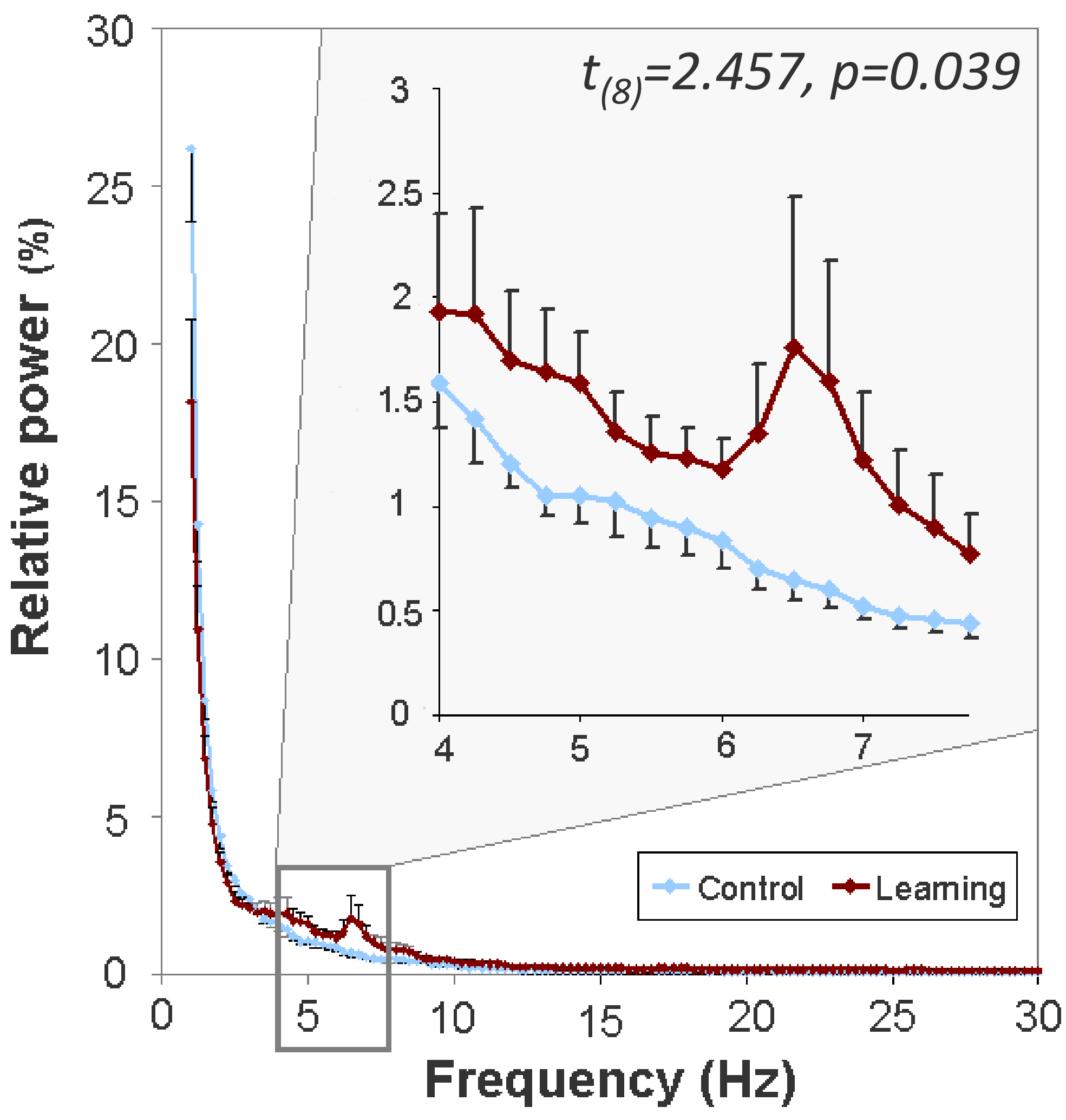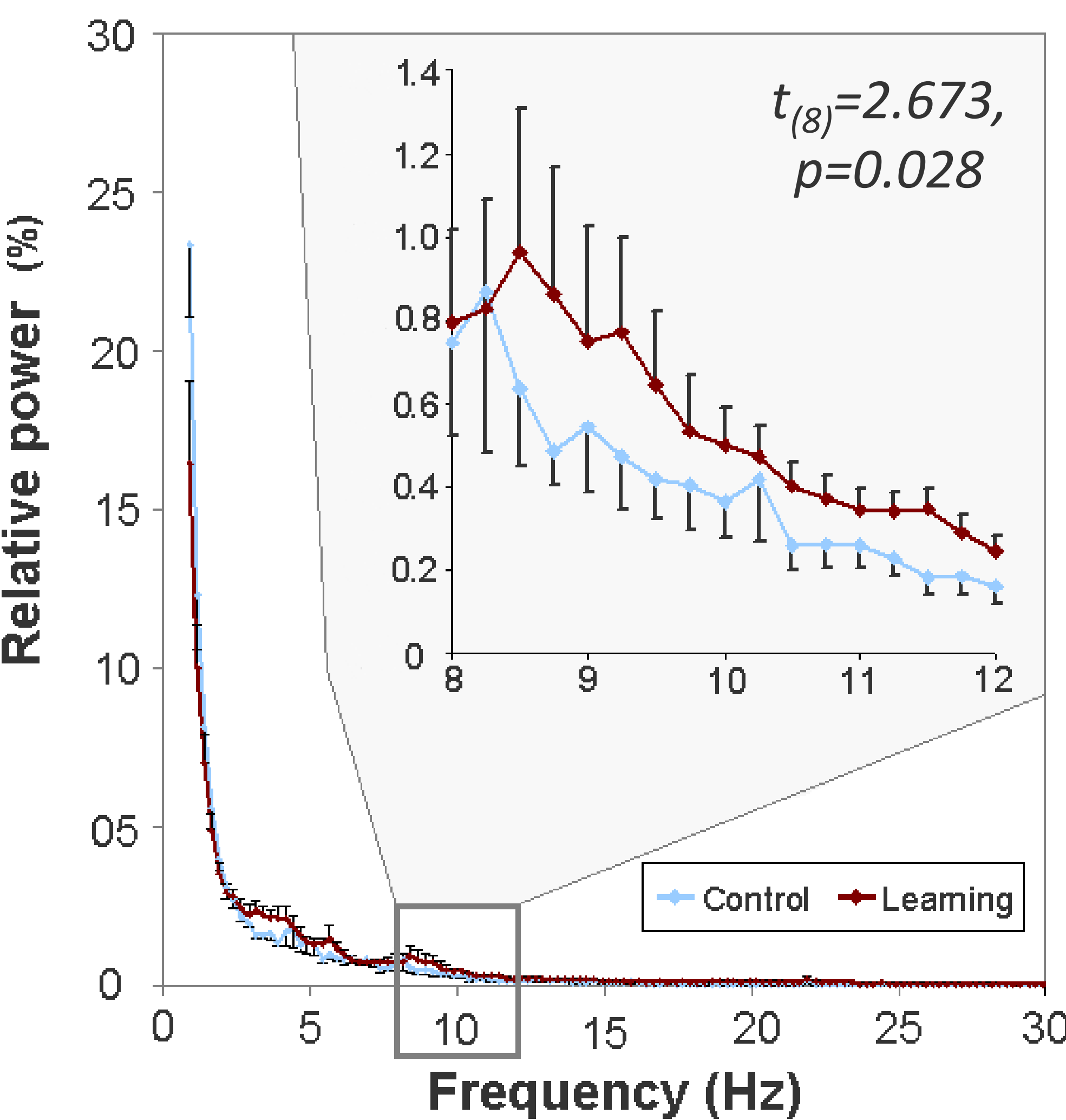
Slow wave sleep

$t_{(6)}=3.173, p=0.019$

Active — Passive

Relative spectrum
- increased **delta** power
- decreased **alpha** and **beta** power after **active** day (drowsiness, SWS)

REM sleep

$t_{(8)}=2.673, p=0.028$

Control — Learning

Conclusions

o **Human** non-invasive **polysomnography** can be applied to dogs.

o **Experiences** influence both the **macrostructure** (active/passive day) and the **relative EEG spectrum** (active/passive day; learning) of **sleep** in dogs – similarly to humans.

o These results validate the **family dog** as a **model** species for studying the effect of **pre-sleep activities** on **EEG pattern** under **natural** (non-laboratory) conditions.

References

Klimesch, W. (1996). Memory processes, brain oscillations and EEG synchronization. *International Journal of Psychophysiology, 24(1-2),* 61–100.
Stickgold, R., Hobson, J. a, Fosse, R., & Fosse, M. (2001). Sleep, learning, and dreams: off-line memory reprocessing. *Science, 294(5544),* 1052–7.
Törnqvist, H., Kujala, M. V, Somppi, S., Hänninen, L., Pastell, M., Krause, C. M., Kujala, J., et al. (2013). Visual event-related potentials of dogs: a non-invasive electroencephalography study. *Animal Cognition,* in press.