Impact of nasal breathing on somatosensory detection: experimental design and pilot results

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES

brighton and sussex medical school

MAX PLANCK SCHOOL of cognition

Enk, L.[1,2,3], Patchitt, J.[2], Tertikas, G.[2], Grund, M.[1], Villringer, A.[1,4,5,6], & Critchley, H.[2]

1 Department of Neurology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
2 Brighton and Sussex Medical School, University of Sussex, Brighton, United Kingdom
3 Max Planck School of Cognition, Leipzig, Germany
4 Department of Cognitive Neurology, Leipzig University Hospital, Leipzig Universität, Leipzig, Germany
5 MindBrainBody Institute, Berlin School of Mind and Brain, Humboldt-Universität zu Berlin, Berlin, Germany
6 Charité - Universitätsmedizin Berlin, Berlin, Germany

INTRODUCTION

- Evidence exists that breathing influences rhythmic brain activity and cognitive function. A central role has been attributed to the **nasal pathway**. Here, (rhythmic) sensory input in the nasal cavity (1) modulates neural activity at breathing rate and has been shown to (2) entrain faster oscillations [1, for review].
- In fact, agents adjust their breathing to task demands [2], and perceptual thresholds vary across the respiratory cycle with beneficial effects during late inspiration [3] to early expiration [2]. Similarly, it has been shown that alpha power fluctuates across the cycle [3], a proxy for cortical excitability, that was found to predict perceptual performance prior to stimulus presentation [3,4,5,6].
- Similar to breathing, perceptual sensitivity varies across the cardiac cycle, namely being improved during late cycle, i.e. diastole [2,6].

Research questions

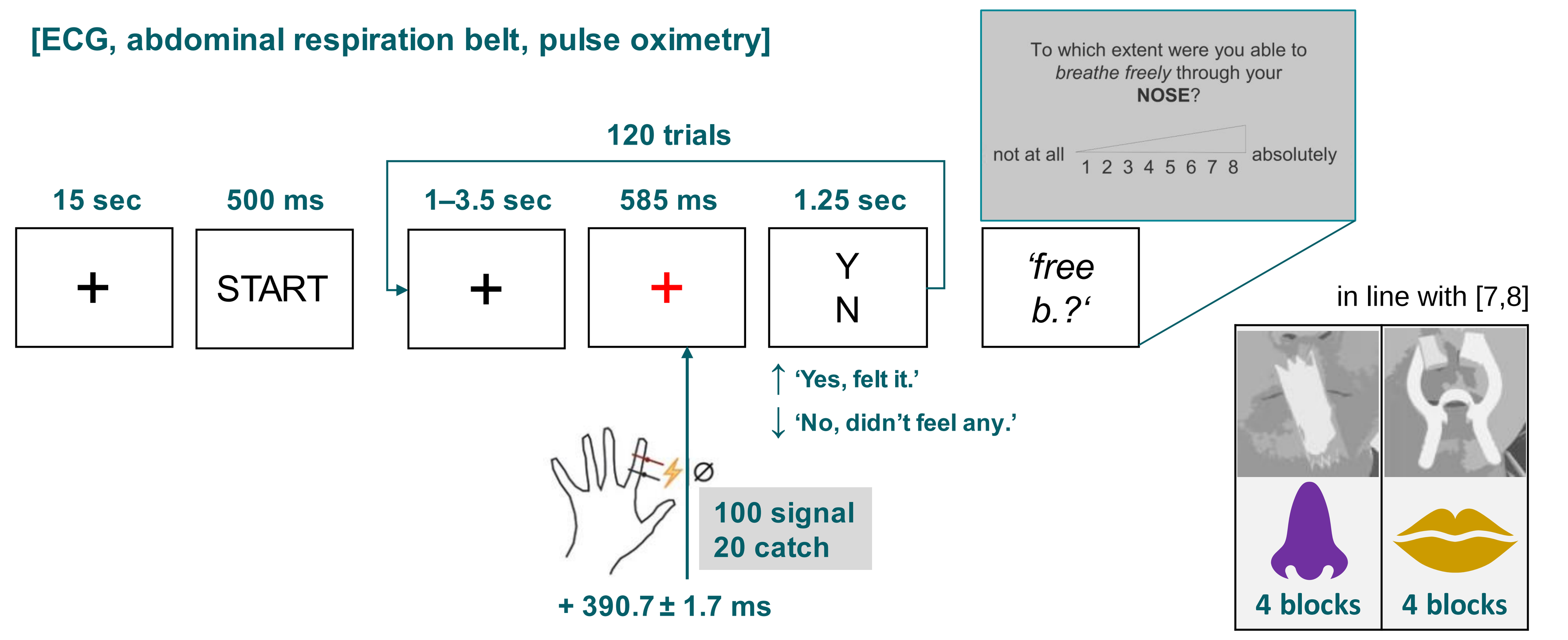
- Are we more sensitive to weak somatosensory stimuli during nose (compared to mouth) breathing, i.e. better in detecting them?
- Does detection performance vary across the respiratory cycle? If so, differentially by breathing route?
- Is our perceptual sensitivity indeed improved during cardiac diastole? If so, is this effect altered by respiratory fluctuations?

Hypotheses

- Better performance* under nose breathing
- Better performance* during late nasal inspiration/ early expiration
- Better performance* at stimulation during cardiac diastole
- No change in response criterion

* Higher hit rate and perceptual sensitivity (dprime)

DESIGN & DEMOGRAPHICS

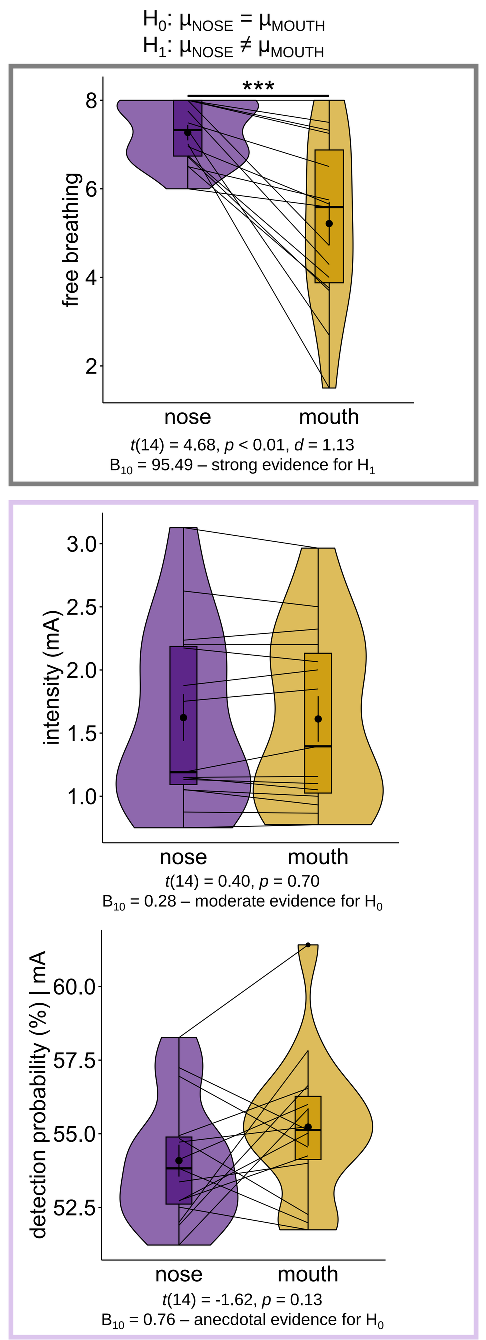


Offline threshold assessment
0.1 mA ↓↑ & always nose breathing
→ 50% detection probability

N = 21 (14 female, 7 male, 0 diverse)
- 23.5 ± 3.09 years of age
- Ø neurological, psychiatric, respiratory or cardiac disease
- non-smoking & low consumption profile

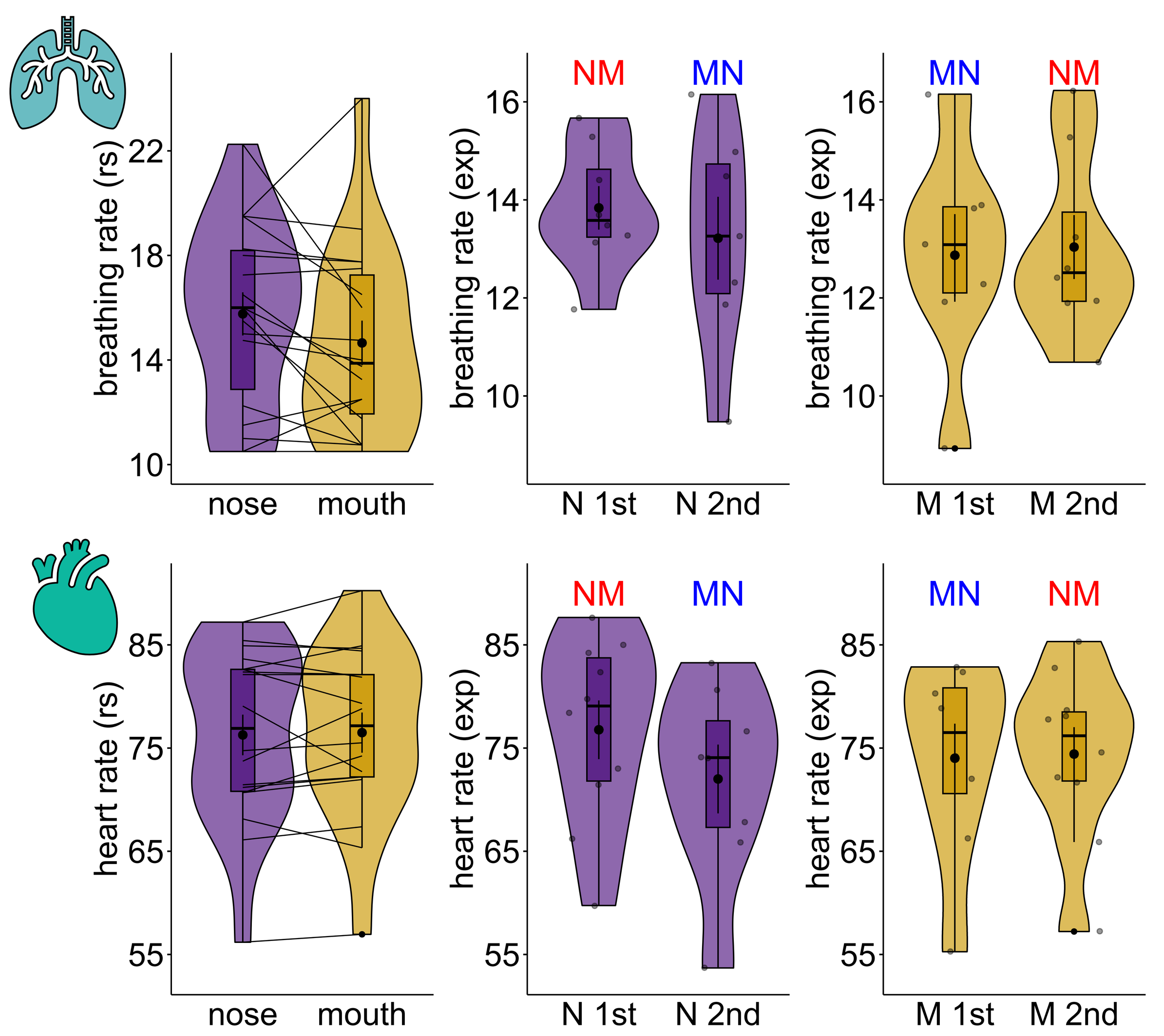
Criteria (behavioural analysis)
- Detection RT > 100 ms
- 10 % < Hit rate < 90%
Hit rate > FA rate
FA rate < 40%
diff (Hit rate – FA rate) > 5%

N = 15
- 11 female, 4 male
- 23.4 ± 2.69 years of age

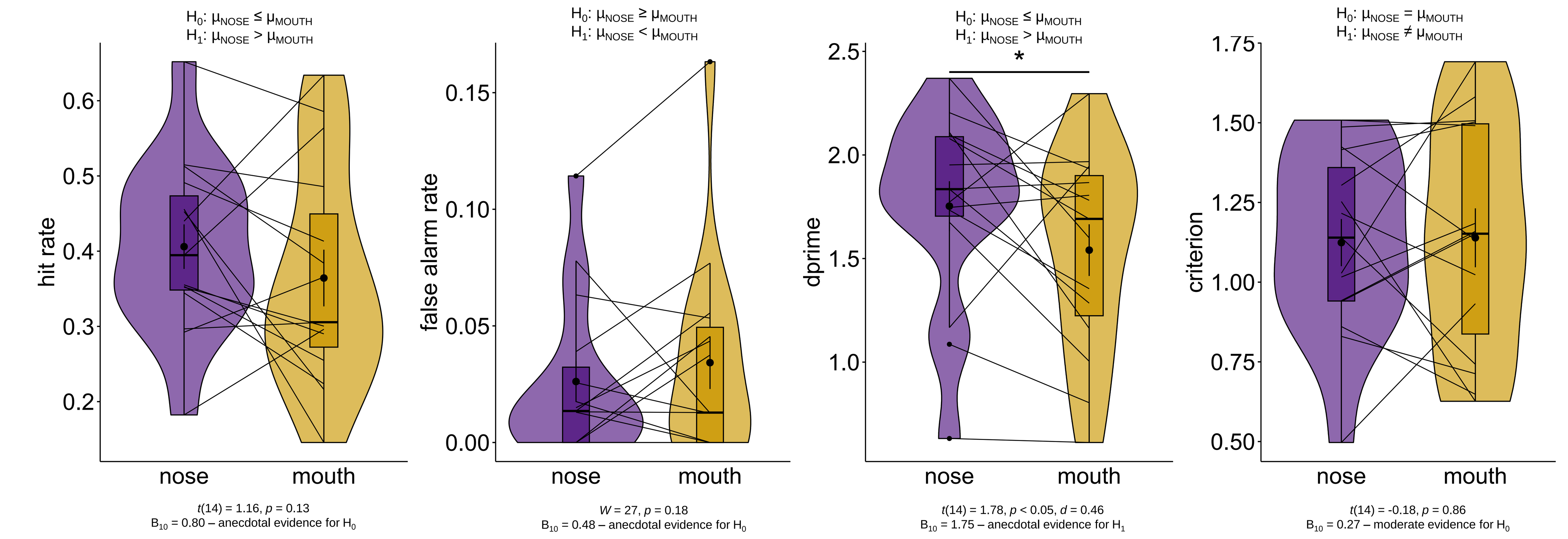


RESULTS

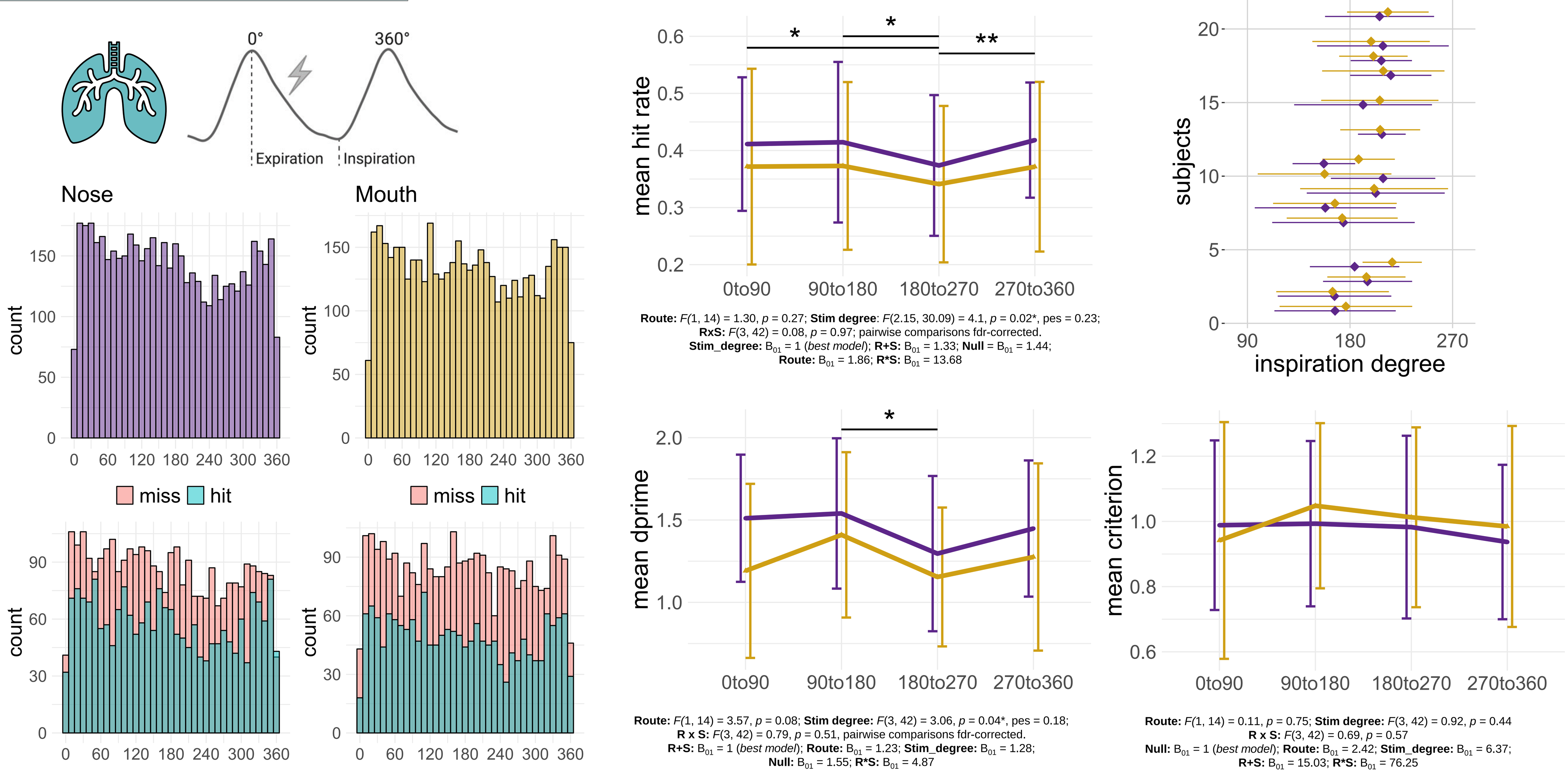
Resting state (4 min) vs. Task



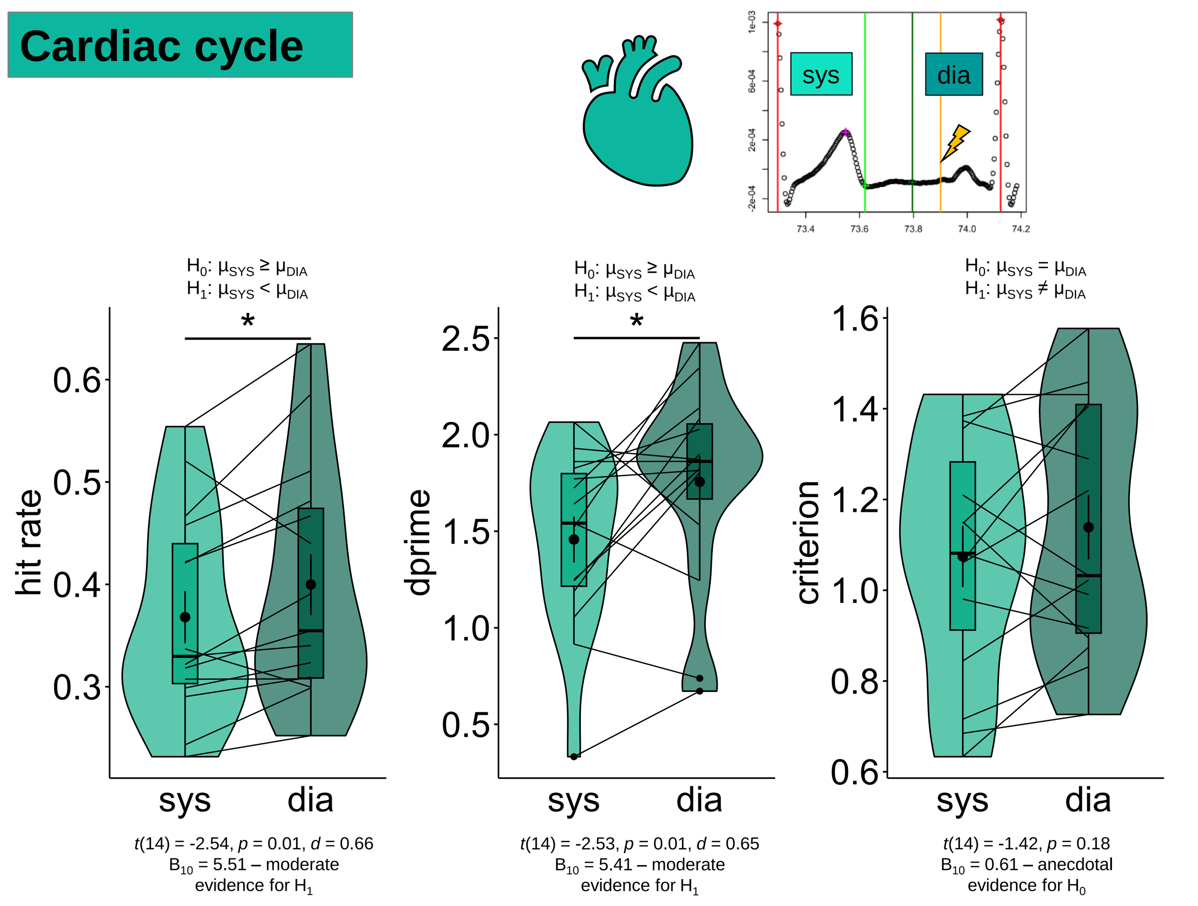
Respiratory route



Respiratory route x cycle



Cardiac cycle



CONCLUSION

- **Perceptual sensitivity improved during nose breathing**
- However, **hit rates** were not higher during late inspiration and early expiration
  - Instead **decreased at expiration-to-inspiration transition**
- **Perceptual sensitivity improved during cardiac diastole**

!
- Subjective reports of **disturbed mouth breathing flow**
- Task allowed **less** for **breathing alignment to trial sequence**
- **Hardware less precise** (0.1 mA)

→ Future improvements
- Block order & length: alternating conditions; shorter in length
- Threshold: online staircase, detection probability ↑,
- N (catch trials) ↑
- Refinement of breathing control
- Electroencephalography

REFERENCES

[1] Tort, A. B., Brankačk, J., & Draguhn, A. (2018). Respiration-entrained brain rhythms are global but often overlooked. Trends in Neurosciences, 41(4), 186-197.
[2] Grund, M., Al, E., Pabst, M., Dabbagh, A., Stephani, T., Nierhaus, T., ... & Villringer, A. (2022). Respiration, heartbeat, and conscious tactile perception. Journal of Neuroscience, 42(4), 643-656.
[3] Kluger, D. S., Balestrieri, E., Busch, N. A., & Gross, J. (2021). Respiration aligns perception with neural excitability. eLife, 10, e70907.
[4] Samaha, J., Iemi, L., Haegens, S., & Busch, N. A. (2020). Spontaneous brain oscillations and perceptual decision-making. Trends in Cognitive Sciences, 24(8), 639-653.
[5] Stephani, T., Hodapp, A., Idaji, M. J., Villringer, A., & Nikulin, V. V. (2021). Neural excitability and sensory input determine intensity perception with opposing directions in initial cortical responses. eLife, 10, e67838.
[6] Al, E., Iliopoulos, F., Forschack, N., Nierhaus, T., Grund, M., Motyka, P., ... & Villringer, A. (2020). Heart–brain interactions shape somatosensory perception and evoked potentials. Proceedings of the National Academy of Sciences, 117(19), 10575-10584.
[7] Arshamian, A., Iravani, B., Majid, A., & Lundström, J. N. (2018). Respiration modulates olfactory memory consolidation in humans. Journal of Neuroscience, 38(48), 10286-10294.
[8] Zelano, C., Jiang, H., Zhou, G., Arora, N., Schuele, S., Rosenow, J., & Gottfried, J. A. (2016). Nasal respiration entrains human limbic oscillations and modulates cognitive function. Journal of Neuroscience, 36(49), 12448-12467.

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung