



# XXIX CONGRESSO NAZIONALE UNIVERSITA DEGLI STUDI DI PALERMO BEYOND THE LOCKDOWN OF THE BRAIN

## Respiratory phases shape electrophysiological and behavioural correlates of cardiac interoception

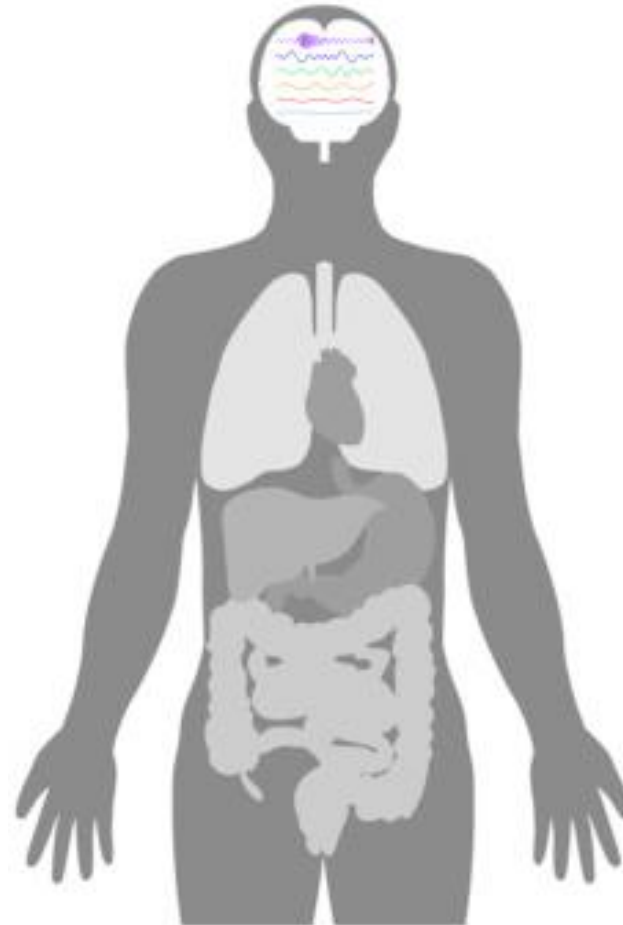
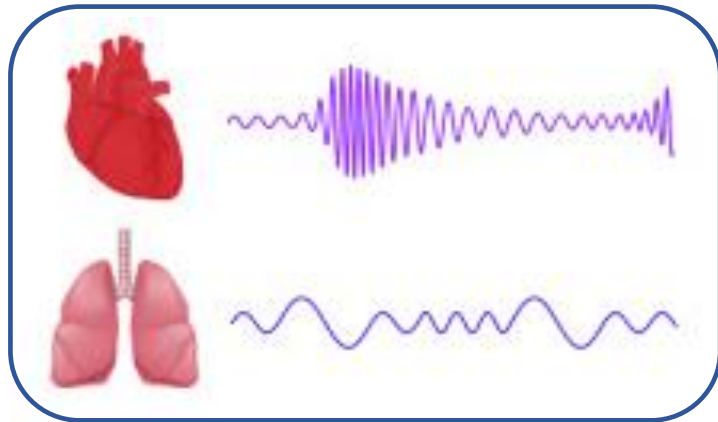
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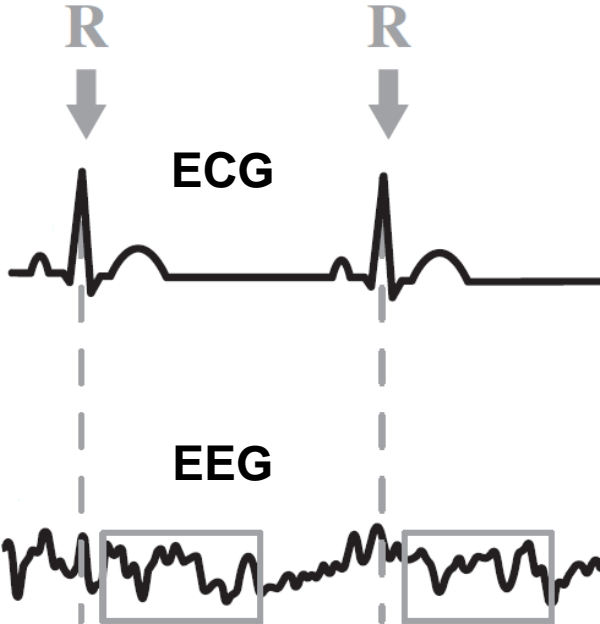
# Interoception

*“Interoception is the representation of the internal states of the organism, and includes the processes by which it senses, interprets, integrates, and regulates signals from within itself”*

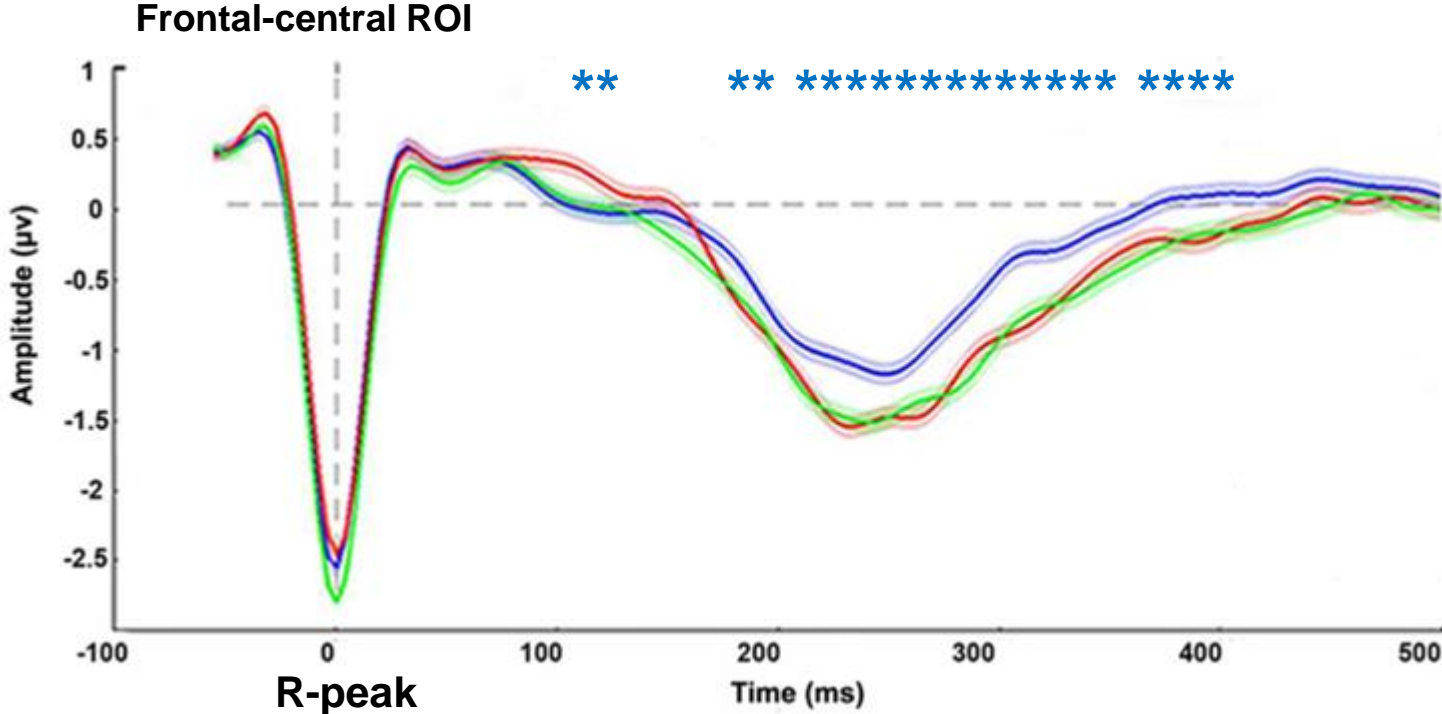


# Heartbeat-evoked potentials (HEP) are linked to interoception

R-peak time-locking and epochs averaging

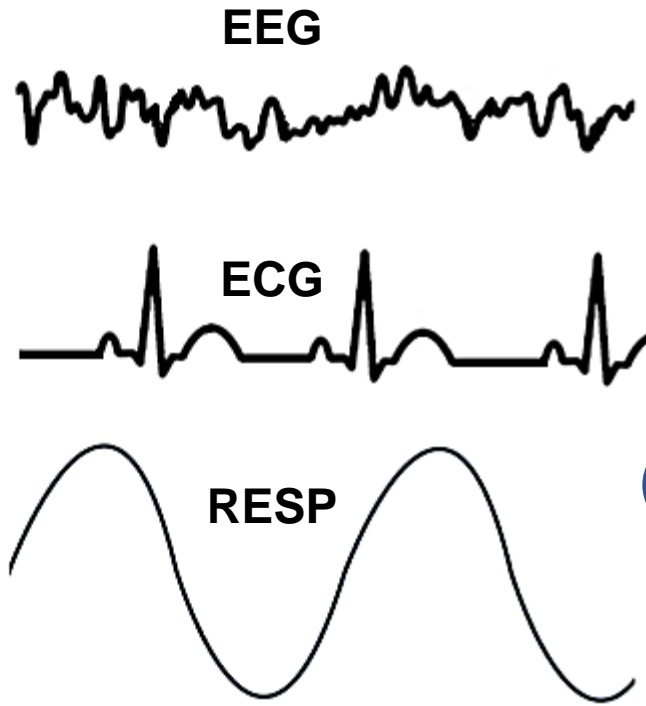


HEP waveform during interoceptive tasks

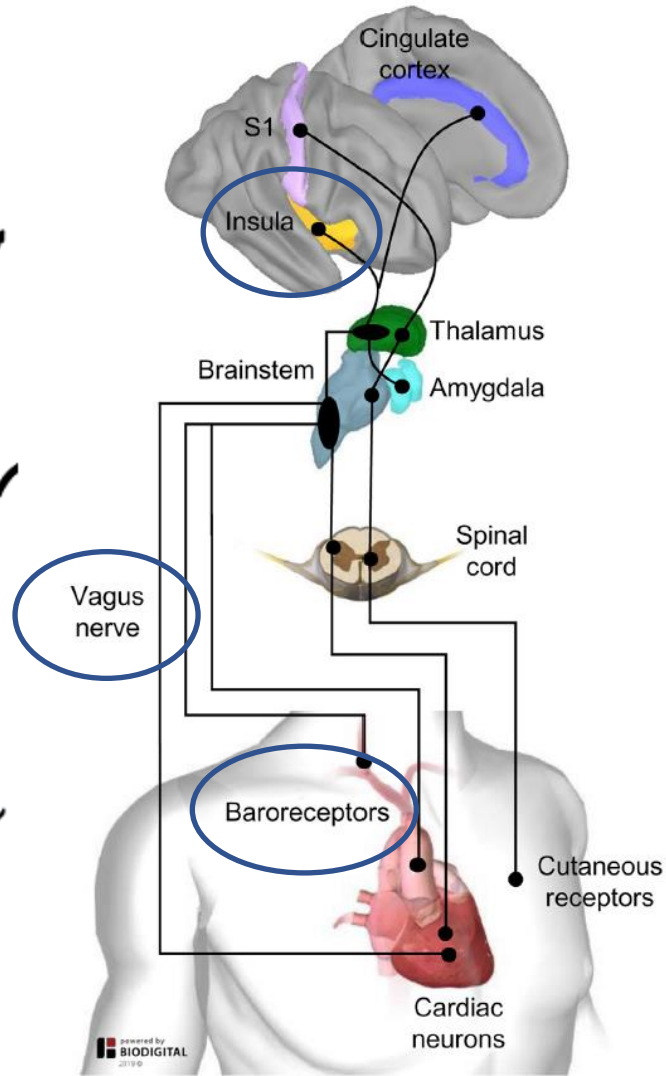


- Exteroception
- Basal interoception
- Post-feedback interoception
- \* Exteroception vs basal interoception

# The heartbeat and respiration share similar interoceptive pathways



## Cardiac interoceptive pathways



## Pulmonary interoceptive pathways

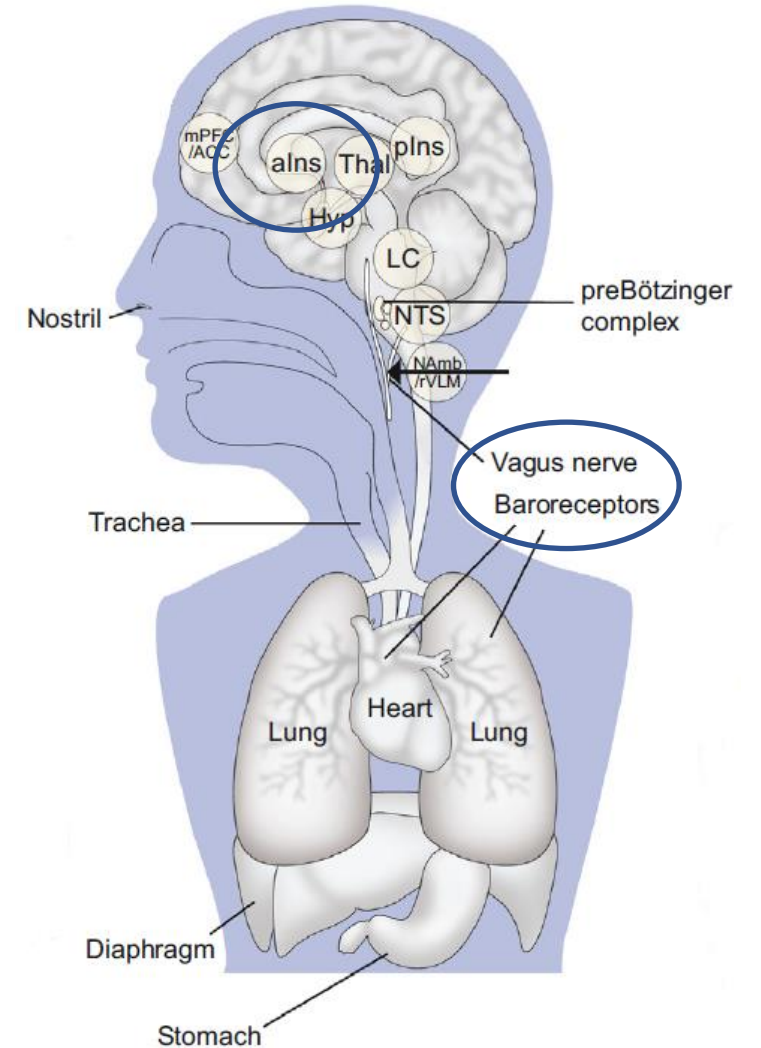


Figure adapted from Babo-Rebelo et al., 2016

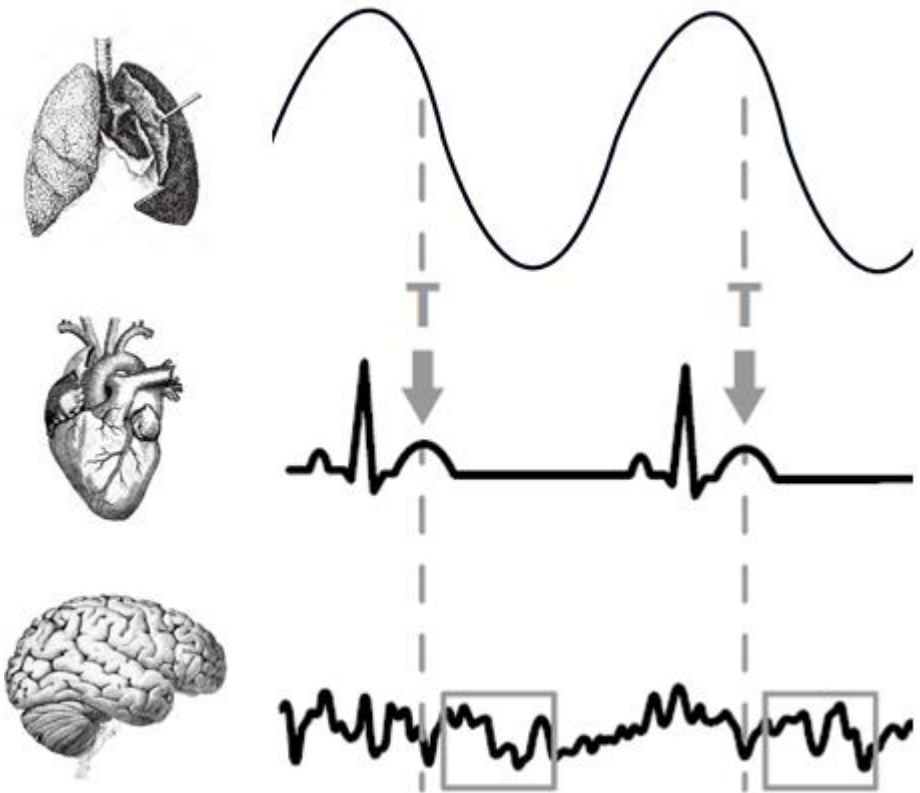
Park and Blanke, 2019; Weng et al., 2021

# Main research questions and methods

1) *Does respiratory phases modulate the HEP?*

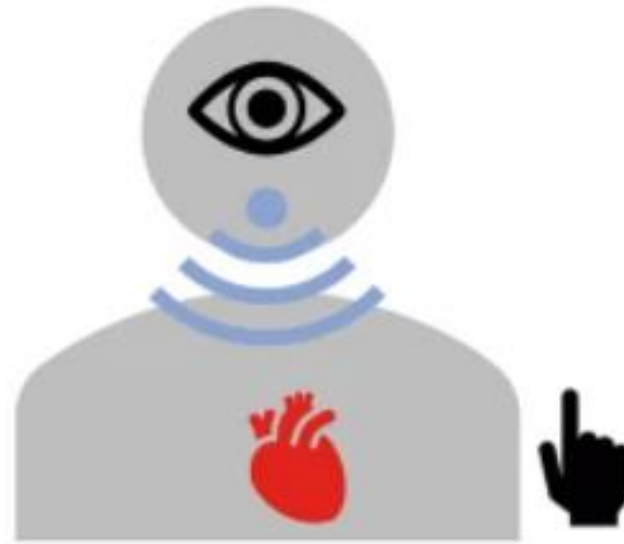
2) *Does respiratory phases modulate cardiac interoceptive accuracy?*

HEP detection on T-peak



Heartbeat Detection Task  
(HBD) - Interoception

*"Focus on your heartbeat and press the button for every beat you feel"*



Heartbeat Detection Task  
(HBD) - Exteroception

*"Focus on the sounds and press the button for every sound you feel"*

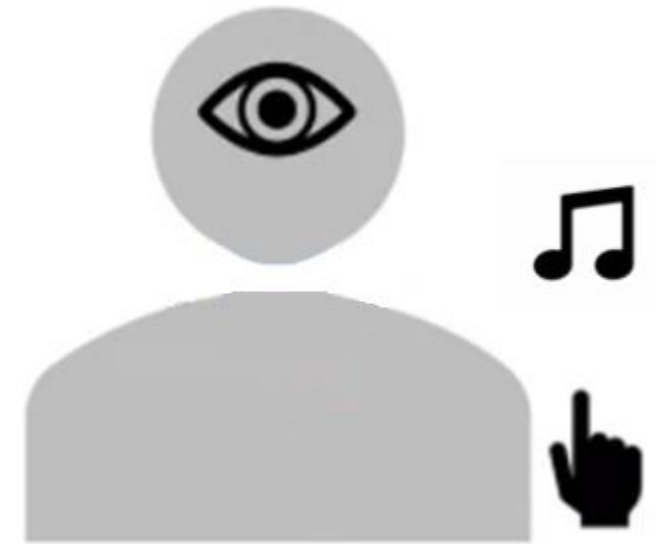


Figure adapted from Babo-Rebelo et al., 2016

Figures adapted from Yoris et al., 2002

# Methods

Simultaneous recording of 64-channel EEG, single-lead ECG, and respiration

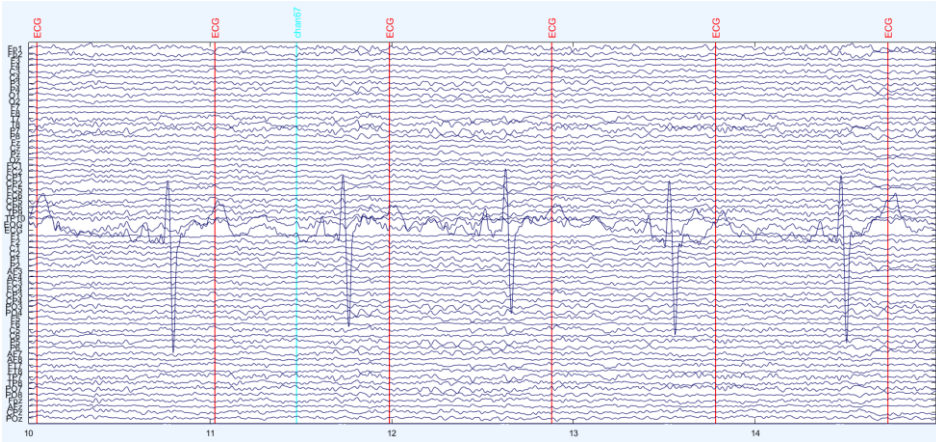
## Study 1 – Resting state

- 12 healthy subjects
- Resting-state condition (8 minutes):
  - Open eyes
  - Spontaneous breathing
- HEP during inhalation vs exhalation

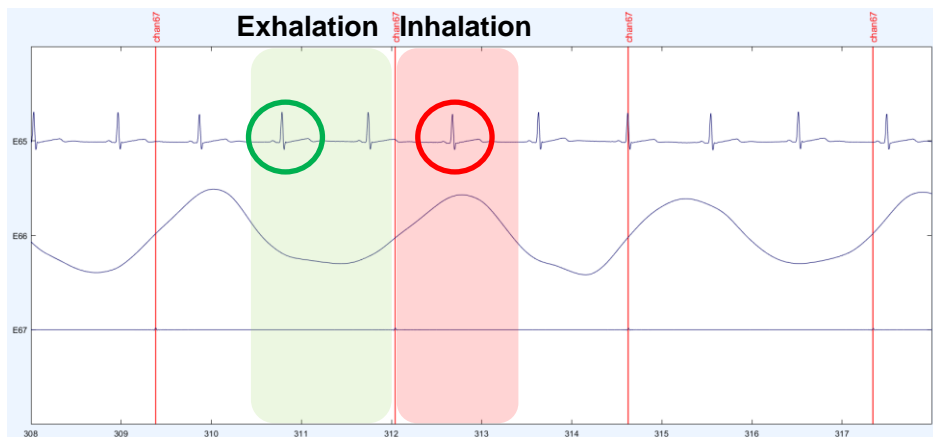
## Study 2 – HBD Task

- 20 healthy subjects
- Interoceptive (10 min) and exteroceptive (10 min) conditions of the Heartbeat Detection Task:
  - Open eyes
  - Spontaneous breathing
- HEP during inhalation vs exhalation in both conditions
- HBD performance during inhalation vs exhalation in both conditions

# Data analysis

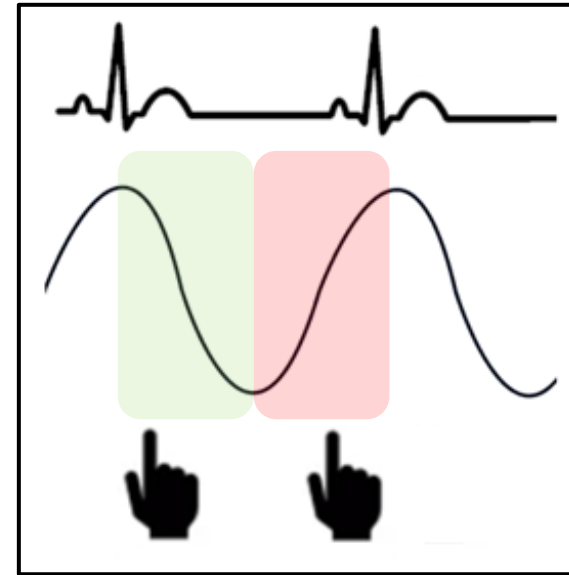


EEG epoching on T-peak (-100 + 350 ms)

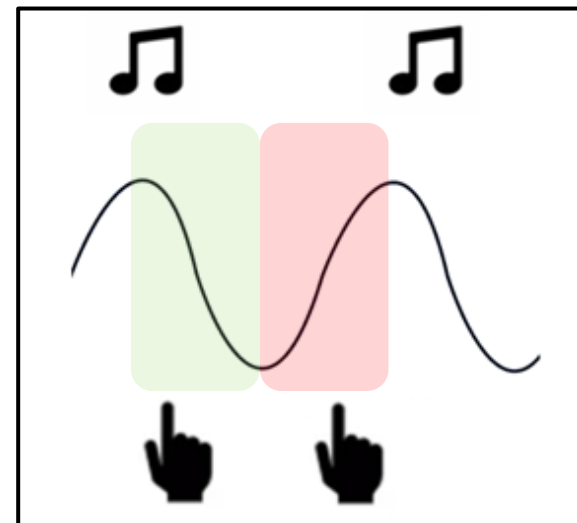


Inhale/exhale segmentation and epochs averaging

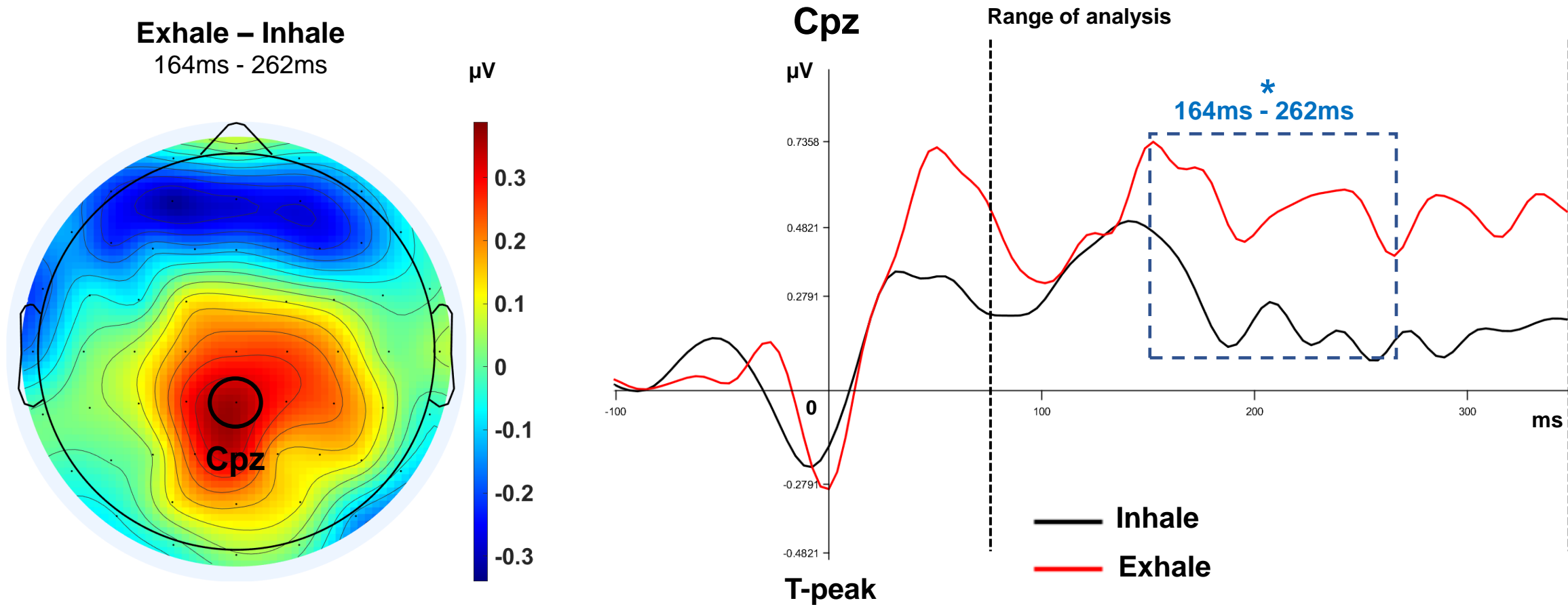
## Interoceptive Accuracy (Inhale VS Exhale)



## Exteroceptive Accuracy (Inhale VS Exhale)



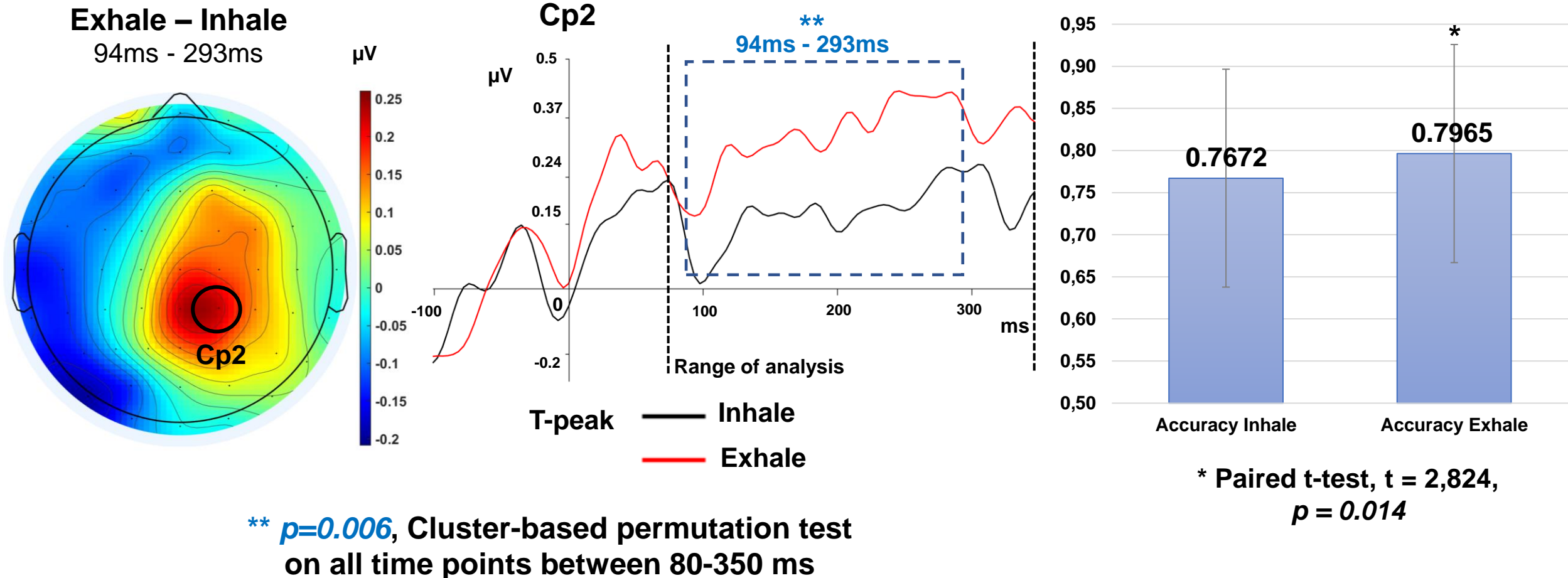
# Resting-state results: HEP mean amplitude increases during exhalation at rest



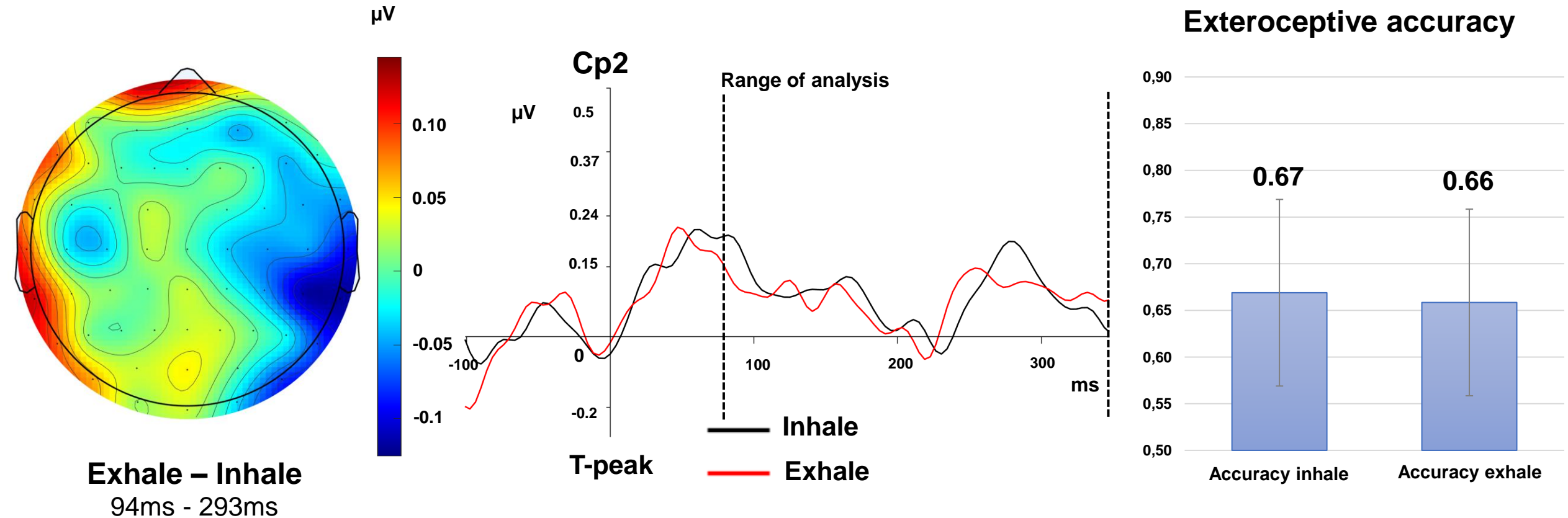
\*  $p = 0.025$ , Cluster-based permutation test on all time points between 80-350 ms



# HBD task results: during **interoception**, HEP mean amplitude increases and is associated to **higher interoceptive accuracy** during exhalation



# HBD task results: during **exteroception**, HEP is not modulated by respiratory phases, and is **not** associated to **exteroceptive accuracy** during exhalation



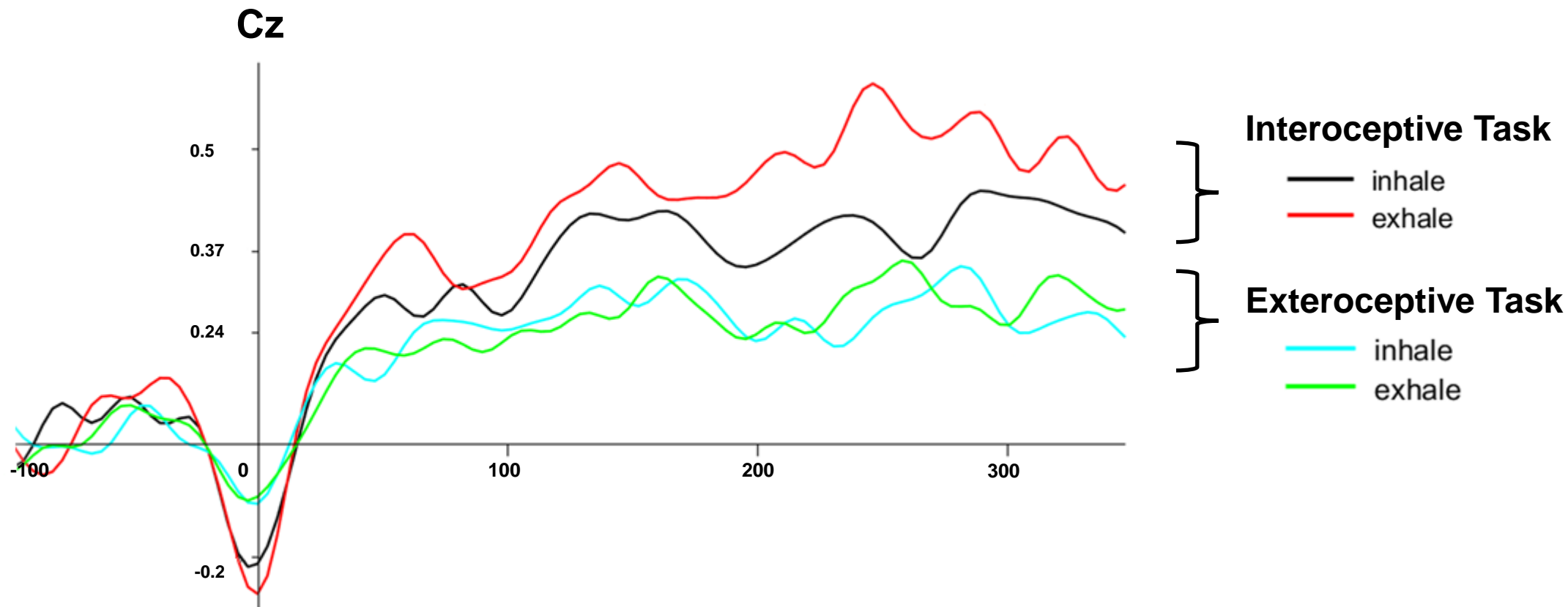
**Exhale – Inhale**  
94ms - 293ms

**NS, Cluster-based permutation test**  
on all time points between 80-350 ms

**NS, Paired t-test**

# To sum up

- HEP mean amplitude increases during exhalation, both during resting-state and in the interoceptive condition of the Heartbeat Detection Task, together with increased interoceptive accuracy during exhalation, as compared to inhalation
- This effect is specific to interoception, being absent during the exteroceptive condition of the Heartbeat Detection Task



# Discussion and future perspectives

- Present findings indicate an often-unnoticed influence of respiratory phases on cardiac interoception, as shown by increased processing of the heartbeat, probably due to reduced neural outflow from the pulmonary afferents, during exhalation
- They also suggest that respiration may tune our brain to switch to a more general mode of higher perception and processing of interoceptive signals during exhalation
- Differences in the amplitude of the HEP between respiratory phases can represent a reliable index of interoceptive attention
- Future studies should assess the presence of this “respiratory-related HEP effect” in different clinical populations with altered interoceptive abilities

# Acknowledgements

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