Contribution of Cardiac Interoception to Motor Preparation and Volition

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Introduction

The Somatic Marker Hypothesis, introduced by Antonio Damasio in 1994, underscores the essential role of perceiving 'body states' in decision-making processes.

This theory links interoceptive processing to specific brain areas, such as the insula and somatosensory cortex, and suggests their primary function to be the emotional evaluation of action outcomes.

Decision-making manifests in movements. Therefore, perceiving 'body states' may have an effect on motor output.

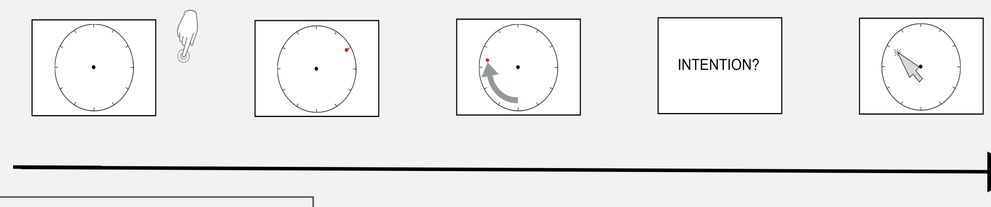
Indeed, movement initiation was shown to be influenced by the phases of the cardiac cycle [Palser et al., 2021; Al et al., 2023], and motor agency was suggested to depend on cardiac input [Herman & Tsakiris, 2020].

Here, we assess the question of if, during movement preparation in Libet's task, 'body states' are taken into account.

We particularly focus on the perception of the W-time, defined as reporting the conscious intention to move.

Methods

Experimental design: 40 self-paced movements per each of the two conditions in the classical Libet's paradigm [Libet et al., 1983; Bredikhin et al., 2023].



M-condition

- M-time — movement time
- Button press

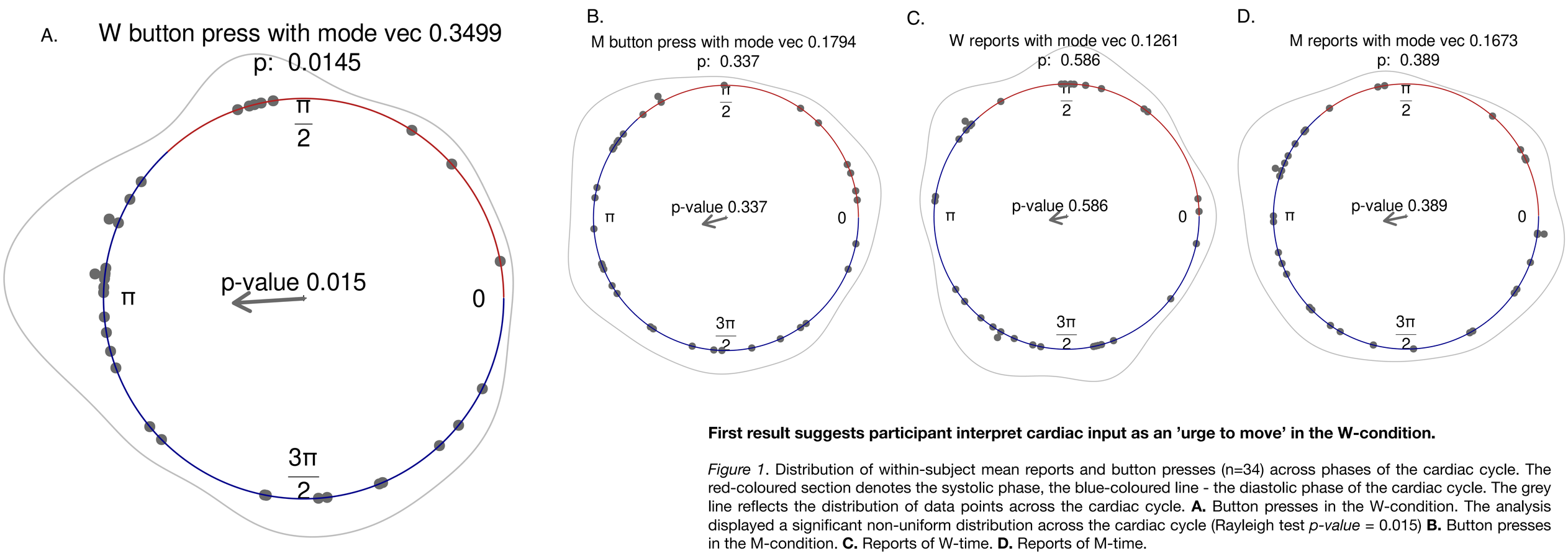
W-condition

- W-time — intention to move
- Button press

In participants (n = 34, mean age 25) Heartbeat evoked potential (HEP) was obtained by averaging epochs from trial start to the button press for all trials.
Behavioral data were aligned with the cardiac cycle using $\phi(b)=2\pi((b-t_1)/(t_2-t_1))$ formula.

Results

1 The W-condition button presses were aligned with the diastolic phase of the cardiac cycle



First result suggests participant interpret cardiac input as an 'urge to move' in the W-condition.

Figure 1. Distribution of within-subject mean reports and button presses (n=34) across phases of the cardiac cycle. The red-coloured section denotes the systolic phase, the blue-coloured line - the diastolic phase of the cardiac cycle. The grey line reflects the distribution of data points across the cardiac cycle. **A.** Button presses in the W-condition. The analysis displayed a significant non-uniform distribution across the cardiac cycle (Rayleigh test *p-value* = 0.015) **B.** Button presses in the M-condition. **C.** Reports of W-time. **D.** Reports of M-time.

2 No difference in HEP amplitude between the conditions of Libet's task

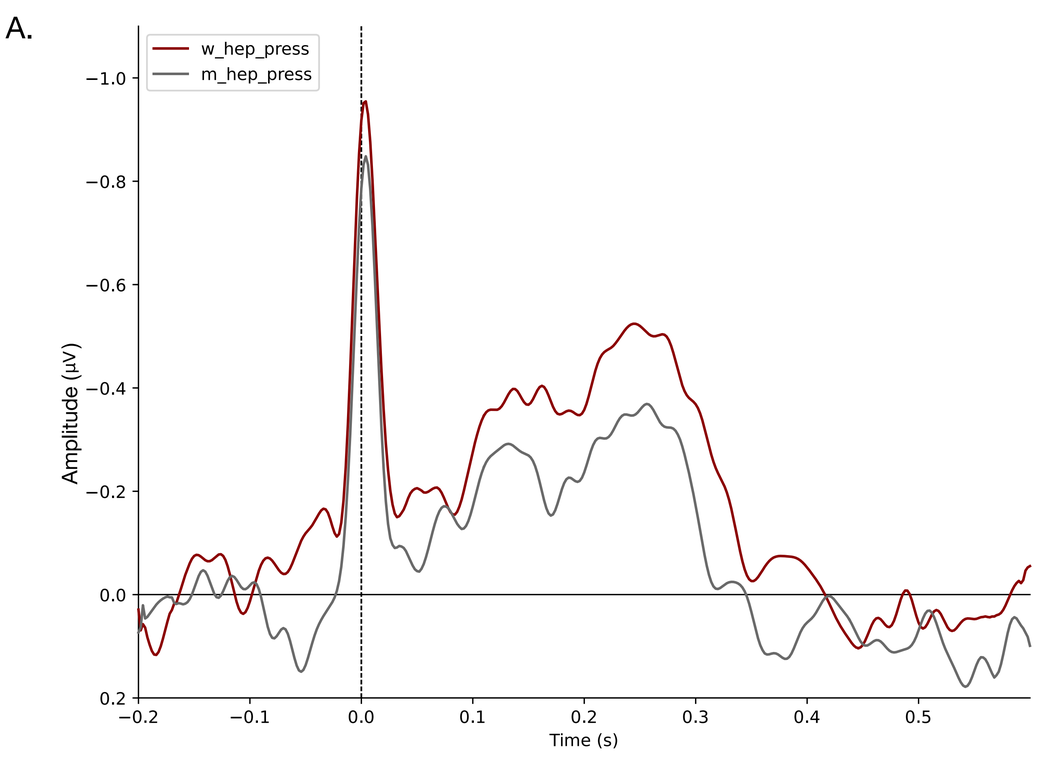


Figure 2. **A.** We found no clusters of heart evoked potential amplitude differences between W- and M-conditions (with M subtracted from W, using unrectified data). The R-peak corresponds to 0.0 s. **B.** Descriptive topographical plots (n=34) for W-condition, M-condition and between condition difference (W-M).

Discussion

The observed non-uniform distribution of button presses, predominantly during the diastolic phase of the cardiac cycle, underscores a link between cardiac input and motor control in Libet's task.

We did not observe any between-condition HEP difference, which could be due to the low signal-to-noise ratio or insufficient number of epochs.

These findings suggest that cardiac interoception could play a role in motor preparation in Libet's task.

Our results reinforce the association between cardiac input and the experience of volition in tasks that involve self-paced movements. This challenges traditional interpretations of the W-condition and presents an alternative perspective on the 'urge to move' phenomenon.

References

[1] Palser et al., *Cognition* 217 (2021).
[2] Al et al., *PLoS Biology* (2023).
[3] Herman & Tsakiris., *Affective Science* (2020).
[4] Libet et al., *Brain* (1983).
[5] Bredikhin et al., *Neuropsychologia* (2023).