Heart-evoked potentials reflect interoceptive-exteroceptive predictions, during a paradigm with individual adjustment of cardio-audio delays

INTRODUCTION

Integration of internal and external signals important for a unified interactive experience of the body in the external world.

Predictive coding models describe these integrated mechanisms as predictive and precision-weighted. Our previous study found heartbeat-driven expectations of sounds and attentional-precision modulation of predictive mechanisms, reflected in heartbeat-evoked potentials (HEPs). However, no trait-precision modulation by interoceptive performance was found.

In this study, we individually tailored the cardio-audio delays to more accurately test precision modulations of cross-modal predictive mechanisms, determining if HEPs operate under a predictive coding framework.

METHOD

1. Multi-interval heartbeat discrimination (120 trials): 5-7 Sounds at 1 of 6 delays from heartbeat.
   - Judge synchronicity of tones with heartbeat.

2. Determine perceived synchronous delay
   - median of linearly interpolated cumulative distribution of choices from multi-interval task.

3. Individually-adjusted two-forced choice task
   - 168 trials: 7-10 sounds at perceived synchronous delay or 300ms perceived asynchronous delay from heartbeat.
   - 50% include an omission (missing sound).
   - Attention (internal/external) manipulated and interoceptive ability measured.

RESULTS

- Behavioural results
  - Perceived synchrony preference for cardio-audio delays closer to heartbeat (R+113 & R+213ms), than further delays (R+414ms & R+510ms) (Figure 1A).
  - Preference effect more pronounced in high heartbeat perceivers, determined by individual Chi2 tests (Figure 1B).

Cardio-audio expectation

Replicated pre-omission main effect of cardio-audio delay (79-128ms, p = .024), reflecting cardio-audio expectation differences.

Post-omission main effect of cardio-audio delay (94-137ms, p = .022), thus perceived cardio-audio synchrony influences prediction error.

Prediction error

No state-precision modulation of cross-modal predictive mechanisms by attention.
No trait-precision modulation of cross-modal predictive mechanisms by interoceptive ability.

DISCUSSION

- No evidence of precision-modulation of integrated cross-modal predictive mechanisms, despite using a more sensitive individually-adjusted task – thus HEPs may not reflect precision-weighted predictive responses.

- However, using tailored delays may have enhanced the perception of cardio-audio synchrony, resulting in less reliance on attentional precision to boost predictions.

- Also, measuring interoceptive ability is challenging, thus interoceptive performance variations may not reflect variations in trait-precision.

- Nonetheless, the robust delay effects observed in both studies support intero-extero integration in HEPs – providing a useful tool for assessing the relationship with cognition and clinical groups.

Interoceptive awareness and attention interaction

Post-omission awareness and attention interaction during perceived synchronous trials (96-139ms, p = .014), driven by a attention difference in high heartbeat awareness participants only (105-131ms, p = .019).

REFERENCES


Link to preregistration: https://osf.io/ptbzf/