MSc in Computational Cognitive Neuroscience

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Heart-brain interactions: Interoceptive awareness in anxiety and its influence on Bayesian inference and decision-making

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Background

- Interoception represents the sense of the internal physiological state of the body. Interoceptive information modulates brain-to-body control of physiology and behaviour and it is important for the maintenance and recovery of homeostasis [1].
- Aberrant processing of interoceptive signals is implicated in the emergence of psychiatric disorders such as anxiety. It has been shown that anxious individuals often exhibit both increased sensitivity to and decreased accuracy of interoceptive signals [2].
- Anxiety is typically characterized by enhanced expectation of negative possibilities in addition to altered experience with respect to self, indicating dependence on both interoceptive processing and belief-based processes [2, 3].
- Bayesian predictive coding is used to explain the belief-based processing in the brain where top-down prior beliefs (predictions) are contrasted to bottom-up sensory input and the resulting prediction errors (PEs) are weighted on their precision. Beliefs are then updated to minimize PE signals across different levels of the brain [4].

Aim

The main aim of the project is to assess heart-brain interactions and their influence of decision-making and learning as a function of anxiety using the Bayesian hierarchical Gaussian Filter (HGF) computational model.

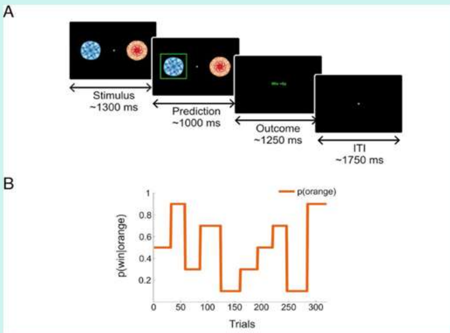
Hypotheses

- Subclinical anxiety impairs learning and decision making.
- Any changes in neural representation of precision-weighted prediction errors and uncertainty estimation will be mediated by cardiovascular interoceptive signals represented by the heartbeat evoked potential.

Experimental Design and Methods

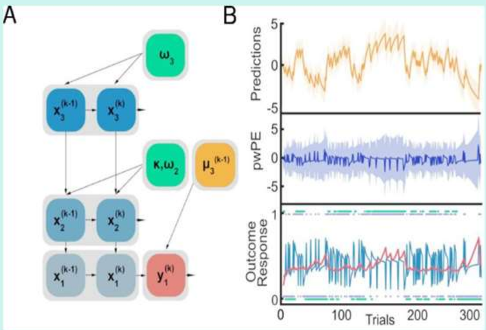
Task and participants

- 39 participants (24 female, 15 male) underwent MEG while completing a probabilistic binary reward-based learning task under volatility setting.
- Spielberger's State-Trait Anxiety Inventory used to divide participants into low trait anxiety and high trait anxiety groups.
- Between-subject experimental design
- Two blocks of 160 trials; blue or orange image rewarding at any trial
- Possible stimulus-outcome contingencies (0.9/0.1; 0.3/0.7; 0.5/0.5) change across trials



Behaviour modelling and analysis

- Behaviour was modelled using the HGF available in TAPAS and implemented in Matlab [5].
- 3-level HGF for binary outcomes was used as the perceptual model
- Input to model are observed outcomes and participant responses
- Outputs of model are precision-weighted Prediction Errors and parameters determining uncertainty estimation trajectories
- HGF model was paired with different response models and the winning pair was chosen for each participant



MEG and ECG data analysis

- Pre-processing with MNE-Python toolbox and Fieldtrip toolbox for MATLAB.
- Cardiac events (R-peaks and T-waves) extracted from ECG signal and used to obtain the Heart Evoked Potential.

Statistical analysis

- Model comparison and selection with random-effects Bayesian model selection (BMS)
- Bayesian Linear Mixed Models to assess influence of HEP on uncertainty estimation and pwPEs

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