

Assessing the impact of endogenous BOLD fluctuations in the locus coeruleus on decision-making and metacognition

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Background

Human perceptual decisions and confidence ratings therein vary considerably even under identical conditions, yet the neural mechanisms driving this variability remain unclear. The locus coeruleus–noradrenergic (LC-NE) system has been proposed to regulate decision making and metacognition, making it a strong candidate for modulating variability in both decision making and confidence. However, prior work has relied on indirect proxies like pupillometry or exogenous manipulations, leaving the role of endogenous LC-NE dynamics in human perceptual confidence uncharacterized. Using real-time fMRI, this study directly probes how naturally occurring LC states shape perceptual decisions and subjective confidence.

Methods

Participants performed a perceptual decision-making task (random dot motion with counterfactual evidence manipulation) inside an MR scanner. Using a real-time framework, dot-motion trials were triggered by endogenous LC BOLD activity reflecting background activation states, defined by a moving-average signal exceeding participant-specific 15th or 85th percentile thresholds to index low and high LC states respectively. This enabled direct comparison of behaviour during high- and low-LC states. Confidence ratings were collected trial-by-trial alongside accuracy and response times. Drift diffusion models (DDMs) were applied to dissociate the contributions of decision boundary and drift rate to LC state-dependent behavioural changes. Eye-tracking data were additionally acquired to provide complementary information of potential LC states.

Results

LC state fluctuations were associated with differences in subjective confidence, with trials occurring across distinct LC states showing a tendency toward greater dispersion in confidence ratings, alongside a similar pattern in response time variability. Computational modelling indicated possible differences in decision boundary between LC states, with considerable inter-individual variability. Eye-tracking analyses supported the validity of the real-time LC-state detection approach.

Discussion

The observed variation in confidence and response times across LC states is consistent with LC-NE-mediated modulation of evidence accumulation thresholds, suggesting a link between endogenous arousal states and decision boundary dynamics during decision-making. Future work should examine how LC-NE dynamics are transmitted across brain regions linked to metacognition using multivariate decoding approaches.