Ready, set, explore! Event-related potentials reveal the time-course of exploratory decisions

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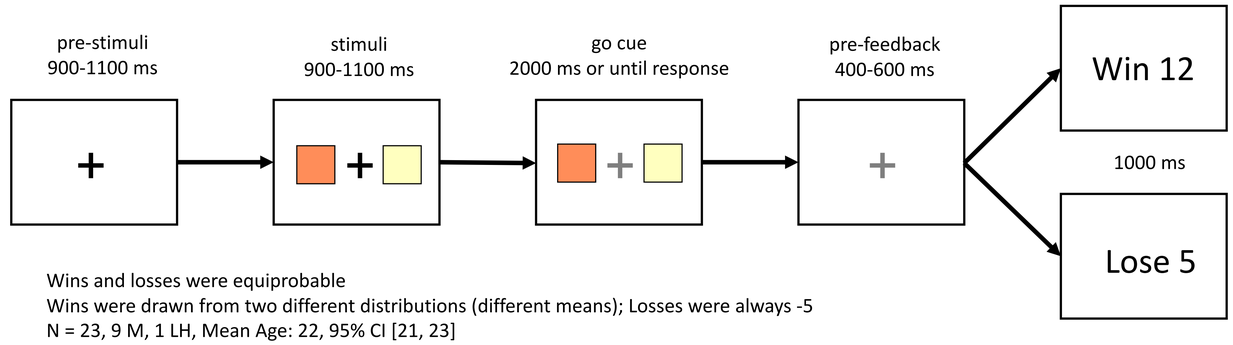
INTRODUCTION

When do we *exploit* previous learning, and when do we *explore*?
Which neural systems are involved?

Neurotransmitter	Source	Target	Event-Related Potential	Function
Dopamine	Basal Ganglia	ACC	reward positivity[1]	reinforcement learning[1]
Norepinephrine	Locus Coeruleus	Various	P300[2], N200[3]	neural interrupt[4], response conflict[5]

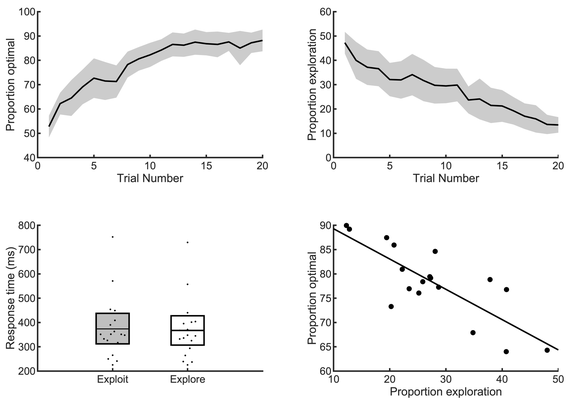
Decision making and EEG data → Computational modelling → Trial classification (explore/exploit) → Event-related potentials
- pre-explore
- pre-exploit

METHODS

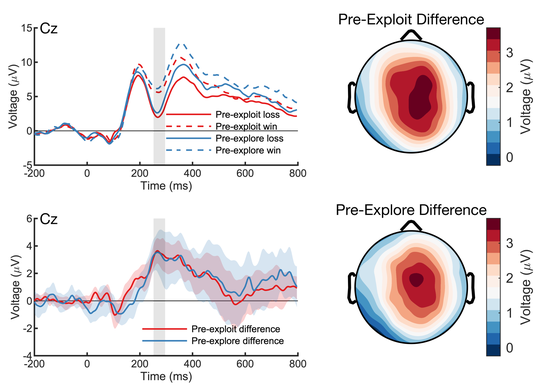


Wins and losses were equiprobable
Wins were drawn from two different distributions (different means); Losses were always -5
N = 23, 9 M, 1 LH, Mean Age: 22, 95% CI [21, 23]

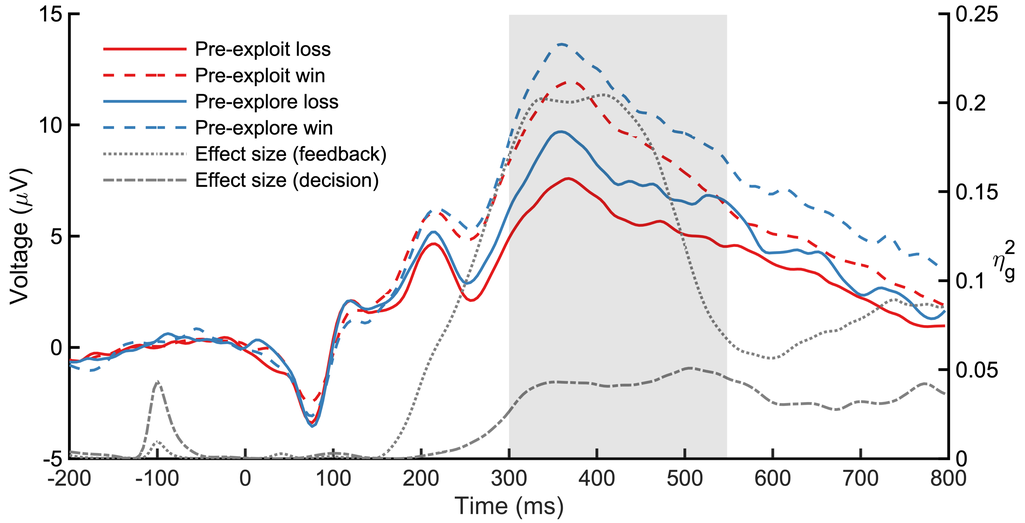
RESULTS

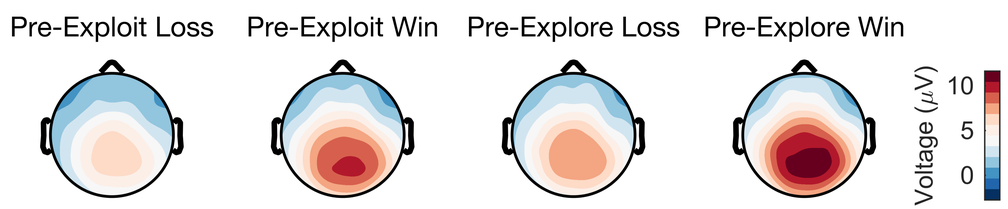


Behavioural data

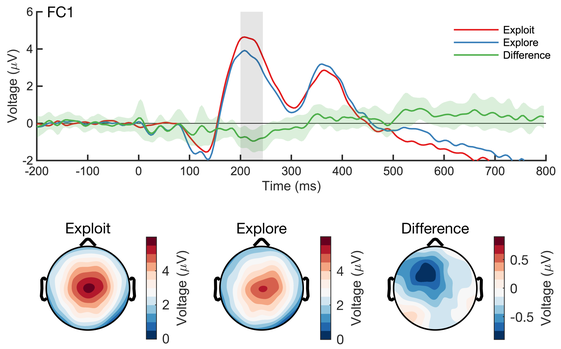


Reward positivity (no effect of decision type)





P300 (main effect of decision type)



Stimulus-locked N200

Conclusions

- Phasic activity of the LC-NE system, as indexed by a feedback-locked P300, plays a critical role in triggering a switch from exploitative to explorative decision making
- Phasic midbrain dopamine does not appear to play this same role
- The period just prior to a decision to explore involves response conflict

1. Holroyd, C. B., & Coles, M. G. (2002). The neural basis of human error processing: reinforcement learning, dopamine, and the error-related negativity. *Psychological Review*, *109*(4), 679.
2. Nieuwenhuis, S., Aston-Jones, G., & Cohen, J. D. (2005). Decision making, the P3, and the locus coeruleus--norepinephrine system. *Psychological Bulletin*, *131*(4), 510–532.
3. Warren, C. M., & Holroyd, C. B. (2012). The Impact of Deliberative Strategy Dissociates ERP Components Related to Conflict Processing vs. Reinforcement Learning. *Frontiers in Neuroscience*, *6*.
4. Dayan, P., & Yu, A. J. (2006). Phasic norepinephrine: A neural interrupt signal for unexpected events. *Network: Computation in Neural Systems*, *17*(4), 335–350.
5. Yeung, N., Botvinick, M. M., & Cohen, J. D. (2004). The Neural Basis of Error Detection: Conflict Monitoring and the Error-Related Negativity. *Psychological Review, 111*(4), 931–959.

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