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SELECTIVELY REINFORCING THE SPEED-ACCURACY TRADE-OFF IN DECISION MAKING

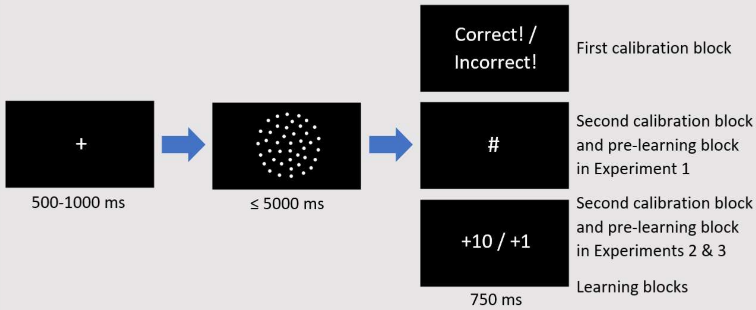
Introduction

- Recent theories suggest that cognitive control functions are subject to the same reinforcement learning principles as 'lower-level' behaviours (Abrahamse et al., 2016).
- In three experiments, we tested this notion on a well-studied cognitive control function: the regulation of one's speed-accuracy trade-off (SAT; i.e., caution) in decision making.
- Previous studies have demonstrated that the SAT can be modulated indirectly by differentially rewarding fast and slow correct and error responses (Heitz, 2014).
- However, we aimed to modulate the SAT more directly by quantifying the SAT by the drift diffusion model parameter 'boundary separation' and estimating and selectively reinforcing the boundary separation on a trial-by-trial basis.

Methods

- **Random dot motion task**
- Experiment 1: 27 participants (± 14 in each group)
- Experiment 2: 54 participants (± 27 in each group)
- Experiment 3: 77 participants (± 39 in each group)

➔ **Total sample size: 158 participants** (± 79 in each group)

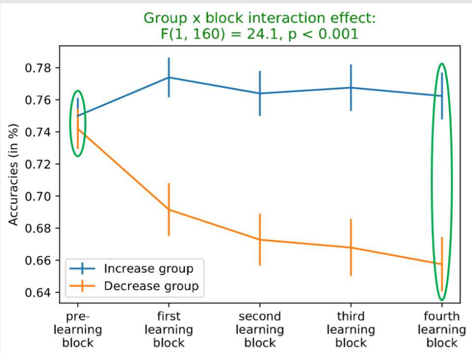


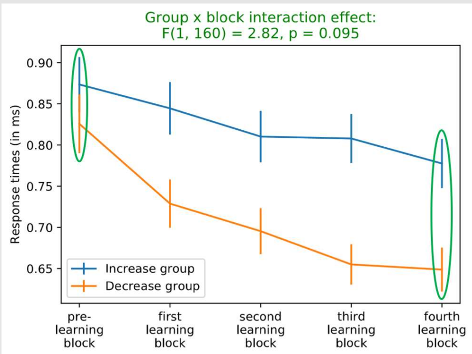
Experimental procedure (only comparable experimental blocks):

- Calibration phase: task difficulty calibrated on individual level
  - 2 x 120 trials (100 trials in Experiment 3)
- **Pre-learning phase:** pre-learning boundary separation estimations
  - 1 x 120 trials (100 trials in Experiment 3)
- **Learning phase**: boundary separations estimated twice after each response, using the (fast) EZ diffusion model (Wagenmakers et al., 2007): once based on previous 120 trials (100 trials in Experiment 3) and once based on previous 120 trials (100 trials in Experiment 3) + current trial
  - **Increase group**: high reward each time boundary separations evolved towards value 25% higher than pre-learning value
  - **Decrease group:** high reward each time boundary separations decreased towards value 25% lower than pre-learning value
  - 4 x 120 trials (100 trials in experiment 3)

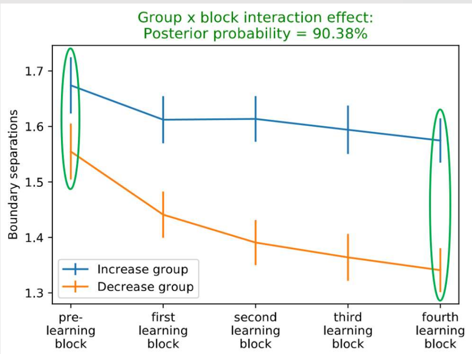
Data Analysis: boundary separations, as well as nondecision times and drift rates, re-estimated using the (robust) hierarchical drift diffusion model (HDDM; Wiecki et al, 2013)

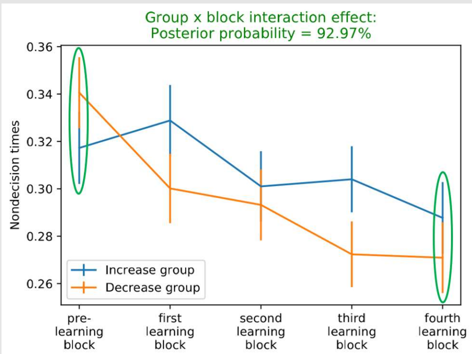
Behavioural Results

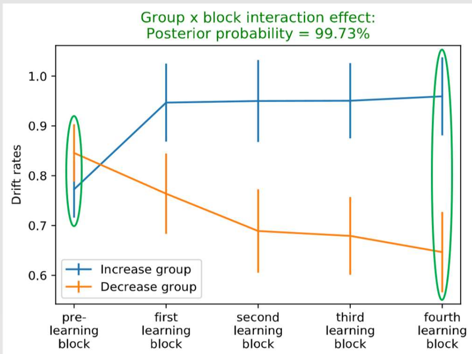




Drift Diffusion Model Decomposition







Discussion

- The selective reinforcement procedure indeed modulated behaviour, however, not entirely as expected.
- Accuracies and drift rates were affected more than response times and boundary separations.
- This could be due to the reinforcement procedure not being consciously experienced.
- Post-experiment questionnaires indeed indicate participants were unaware of the reinforcement procedure.
- Future research should investigate whether boundary separations can be more selectively modulated by consciously experienced reinforcement procedures.

References

Abrahamse, E. L., Braem, S., Notebaert, W., & Verguts, T. (2016). Grounding cognitive control in associative learning. *Psychological Bulletin*, 142(7), 693-728.

Heitz, R. P. (2014). The speed-accuracy tradeoff: history, physiology, methodology, and behavior. *Frontiers in neuroscience*, *8*, 150.

Wagenmakers, E. J., Van Der Maas, H. L., & Grasman, R. P. (2007). An EZ-diffusion model for response time and accuracy. *Psychonomic bulletin & review*, *14*(1), 3-22.

Wiecki, T. V., Sofer, I., & Frank, M. J. (2013). HDDM: hierarchical Bayesian estimation of the drift-diffusion model in python. Frontiers in neuroinformatics, 7, 14.