

Neurocomputational mechanisms underlying subjective reward devaluation by cognitive and physical effort

Matt Apps^{1,*}, Trevor T-J Chong^{1,2*}, Kathrin Giehl¹, Annie Blake¹, Laura Grima¹ & Masud Husain¹

*equal contributors
1 Experimental Psychology, University of Oxford
2 Macquarie University



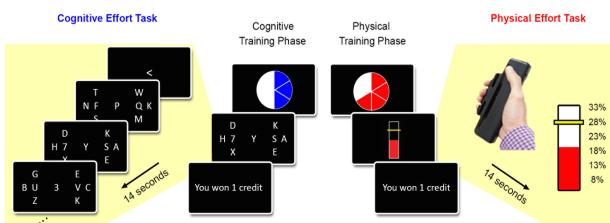
Domain-specific or Domain-general subjective cost-benefit valuation?

- In the real world, rewards are devalued by both cognitive and physical demands¹
- Such valuations are highly subjective¹⁻⁵
- Previous studies have implicated the amygdala, anterior cingulate cortex, anterior insula and dorsolateral prefrontal cortex separately in processing cognitive and physical effort⁵⁻¹².
- No previous study has examined the subjective valuation of rewards associated with both cognitive and physical effort.

Are the mechanisms that underpin the subjective valuation of cognitive and physical effort domain-specific or general?

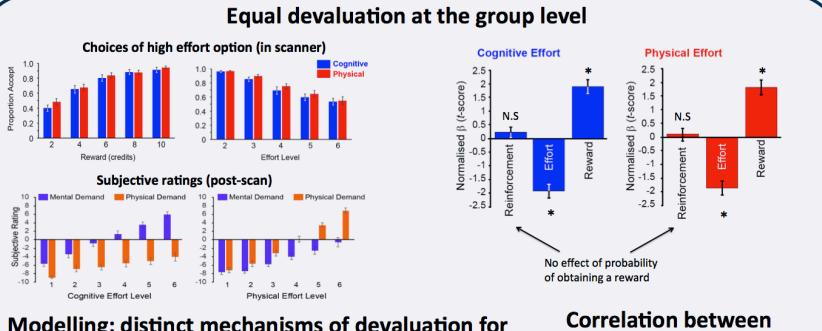
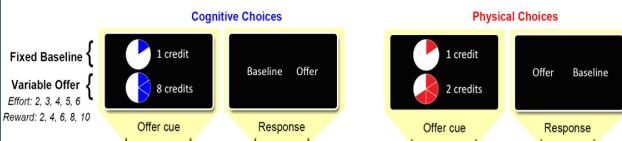
Training - Two tasks parametrically varying in cognitive or physical effort (n = 34)

- 60 training trials for each task prior to fMRI (6 levels of effort for each task)
- Each effort level associated with one of six blue (Cognitive²) or red (Physical) pie charts

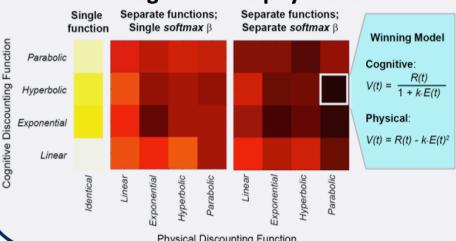


fMRI task - Subjective cost-benefit decision-making

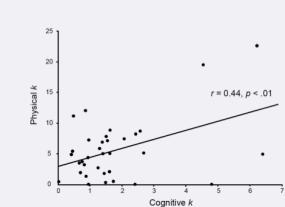
- Choose: low effort, low reward "baseline" (1 credit/effort level 1) vs variable higher effort (2-6 switches/13%-33% MVC), higher reward "offer" (2-10 credits)
- Decisions made during fMRI – Effort (10 trials randomly selected) performed after scanning
- Activity covarying with the subjective value of the chosen option at the time of the option cues examined



Modelling: distinct mechanisms of devaluation for cognitive and physical effort



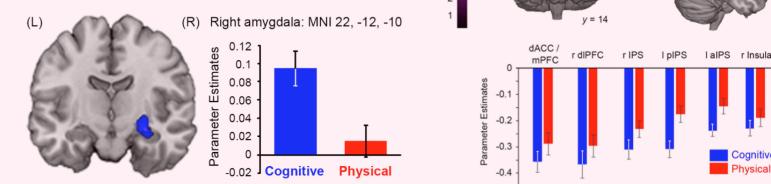
Correlation between motivation across domains



Overlapping responses to the subjective value of cognitive and physical effort

- Activity covarying with subjective value from the winning model examined
- Conjunction and overlap between domains in the ACC/pre-SMA, DLPFC, anterior insula and IPS ($p < 0.05$ FWE corrected)
- Amygdala the only region to show a significant difference between domains.

Amygdala activity covaries only with the subjective value of cognitive effort



A domain-general circuit for cost-benefit evaluation

- Effects cannot not be explained by temporal discounting, differences in reward probability or choice difficulty
- Most regions that code subjective value do so regardless of the nature of the cost.
- The ACC, DLPFC and Insula are strongly interconnected and have previously been implicated in both human and rodent studies of effort processing⁵⁻¹³

This circuit may be important for evaluating the costs and benefits of different types of behaviour.

- Many previous studies have implicated the basolateral amygdala in effort based decision-making^{11,13}
- Recent studies suggested it may be important for evaluating cognitive effort and may underlie individual differences¹¹

The amygdala may play a key role in calculating the value of exerting cognitive, rather than physical, effort

References

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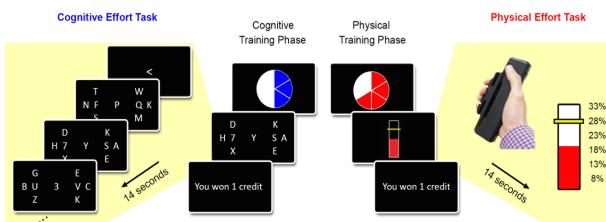
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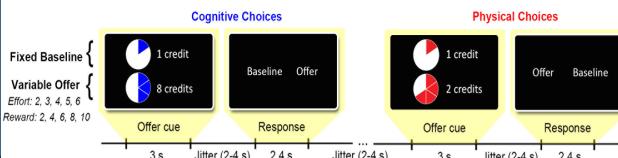
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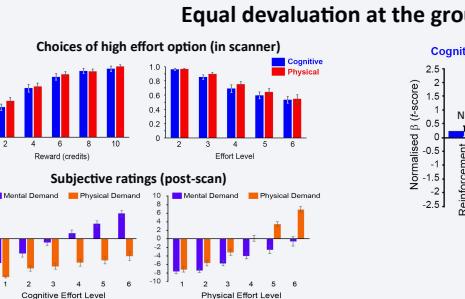


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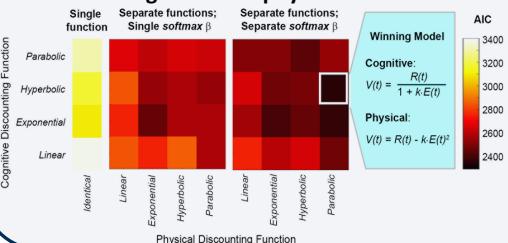
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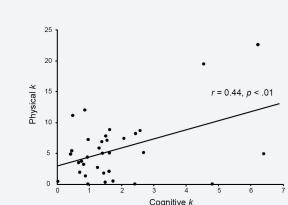
Equal valuation at the group level



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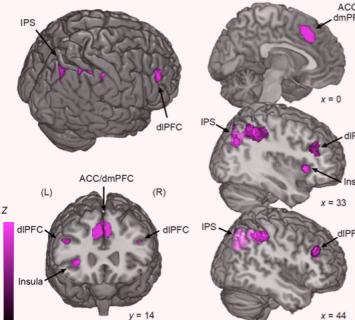
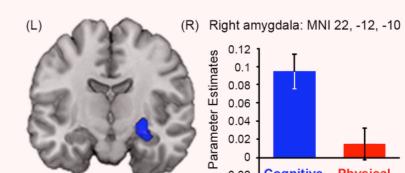
Correlation between motivation across domains



Overlapping responses to the subjective value of cognitive and physical effort

- Parametric analysis examining activity at the time of the effortful offers covarying with the subjective value according to the winning model.
- Conjunction and overlap between domains analysis reveal activity in the ACC/pre-SMA, DLPFC, anterior insula and IPS ($p < 0.05$ FWE corrected)
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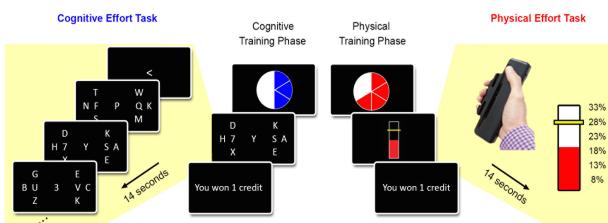
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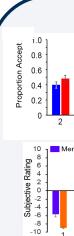
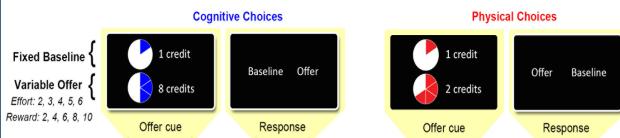
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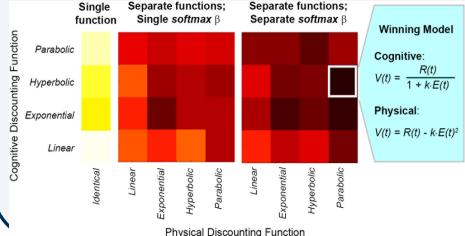
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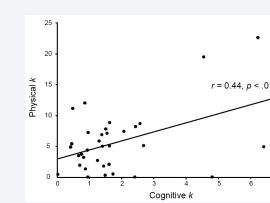
Equal devaluation at the group level

No across subject differences in devaluation by cognitive or physical effort during scanner choices (above). The physical task rated as more physically demanding. The cognitive task more mentally demanding.

Modelling: distinct mechanisms of devaluation for cognitive and physical effort



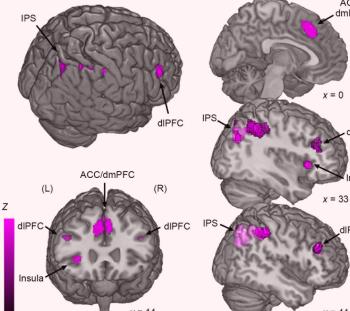
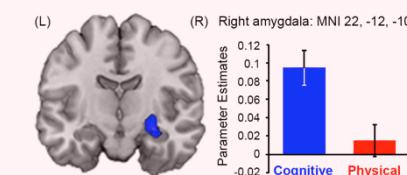
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