Modeling cognitive parsimony with a demand selection task

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Cognitive parsimony is our tendency to favour low-effort strategies that help us to efficiently approach a complex problem.

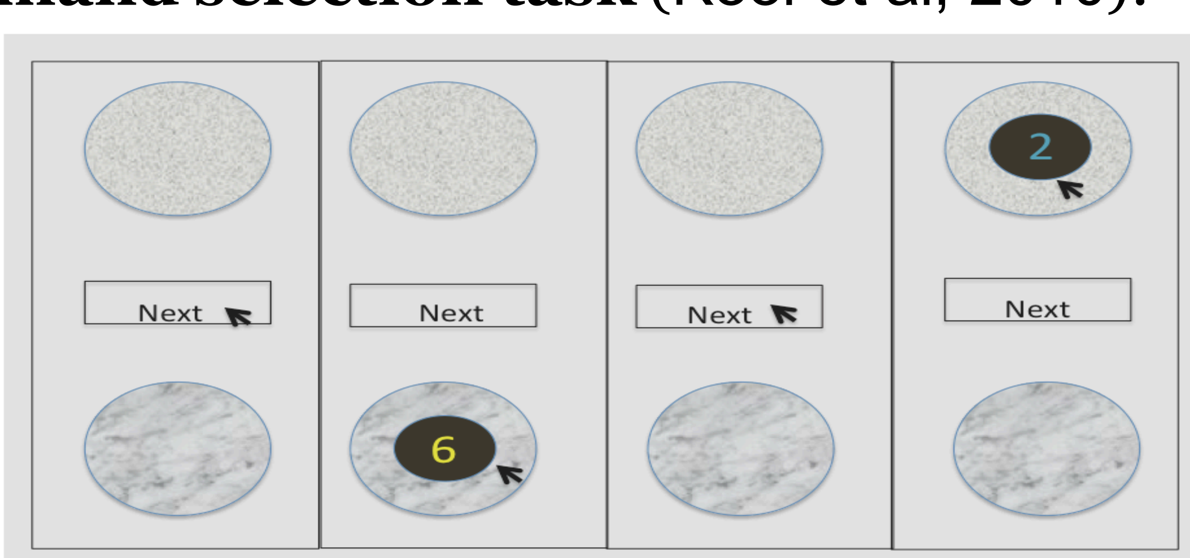
The demand selection task (DST; Kool, McGuire, Rosen, and Botvinick, 2010) is aimed at evaluating the tendency to avoid cognitively demanding tasks.

Hypothesis

Performance at DST relies mainly on implicit cognitive mechanisms, in accordance with experimental results showing that the participants were not always aware of the demand manipulation (low or high demand) when the demand avoidance effect was observed.

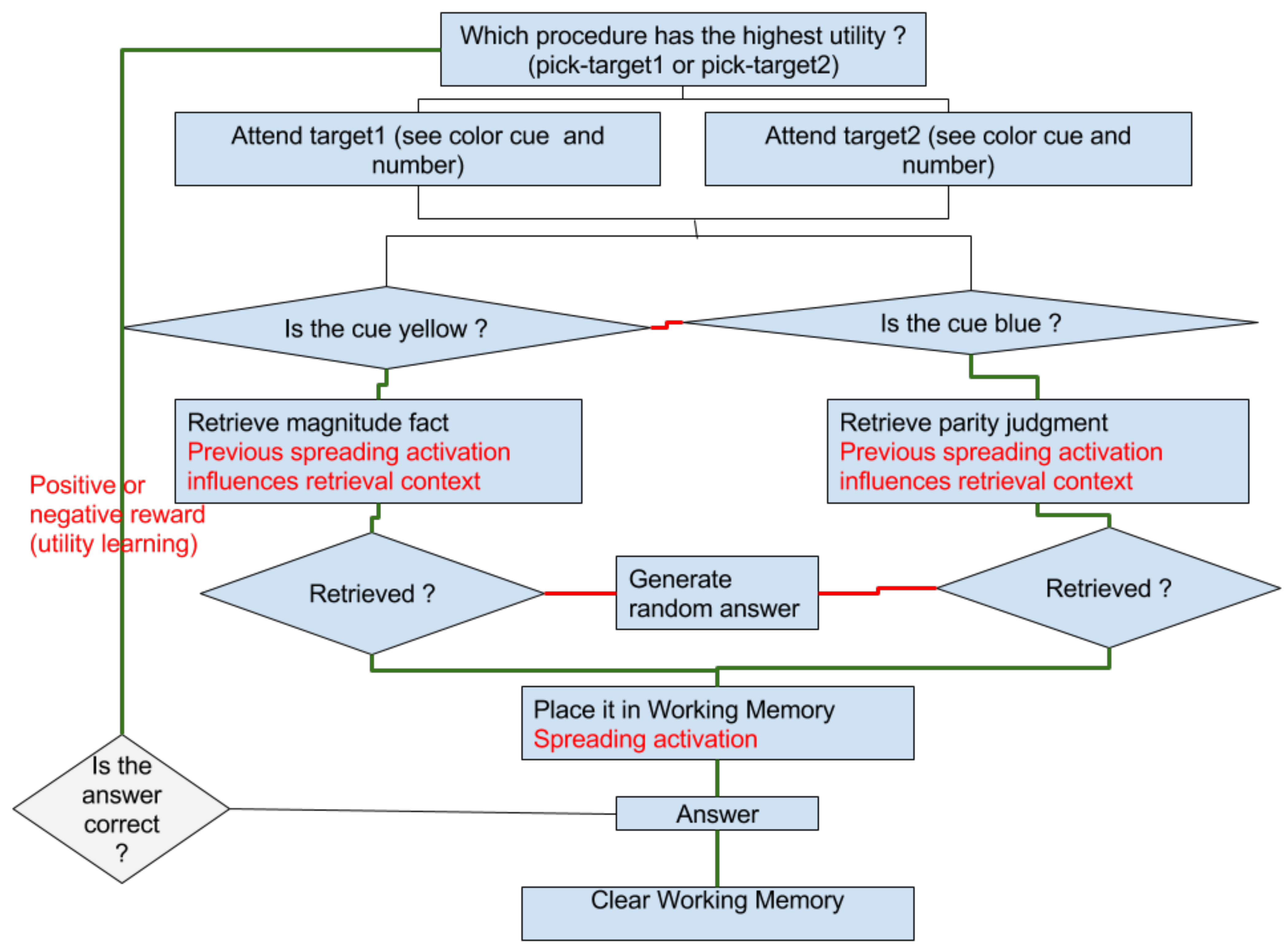
Experiment Overview

- Investigate the role of implicit cognitive processes (utility, base-level learning, and spreading activation) in avoidance of cognitive effort by employing a computational cognitive model.
- **Demand selection task** (Kool et al, 2010):



  - Deck 1: task switched with a probability of 0.9
  - Deck 2: task switched with a probability 0.1
- **ACT–R computational cognitive architecture** (Anderson, 2007):
  - Interacting modules support implementation of a theory of human cognition
  - Declarative memory (know what) and procedural memory (know how)
  - Symbolic structures and sub-symbolic quantities

Cognitive Model



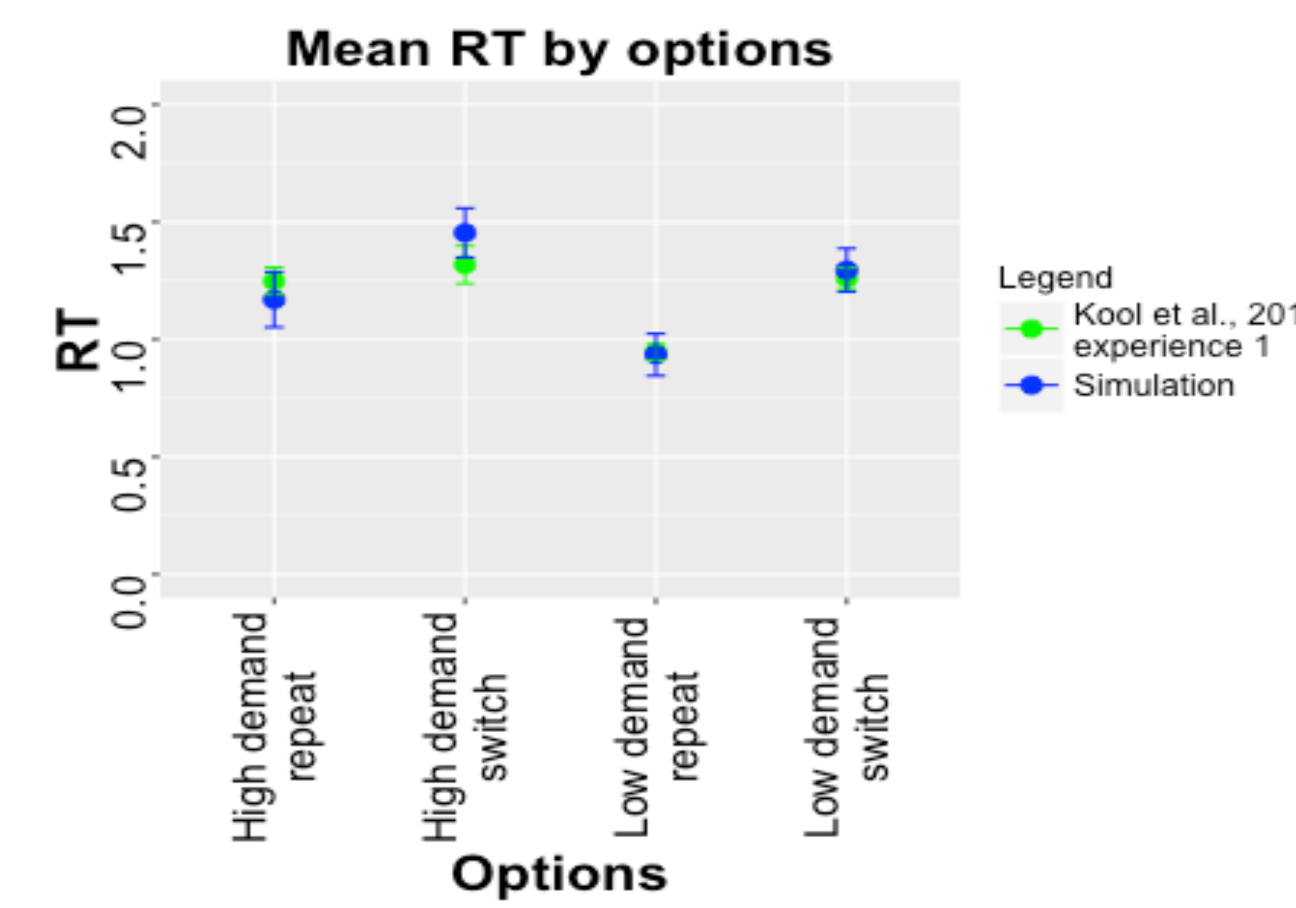
- Preference for a deck over another relies on implicit mechanisms: base-level, spreading activation, and utility learning.
- Base-level learning determines how patterns of use affect chunk activation and decay.
  - Chunks encode cue, task, and response ('yellow' = 'magnitude', 'blue' = 'parity'). A judgment is produced based on the retrieved chunk.
- Spreading activation provides context to retrieval.
  - Retrieved chunk placed in the imaginal module spreads activation and influences next retrieval.
- Choice between the two decks = two procedures
  - A reward is back propagated after the answer has been produced.
- Gradual selection of the lower demanding deck due to:
  - When probability of switch is high, retrieval is slower due to less spreading of activation from the previous trial.
  - The longer this process takes, the less reward gets back-propagated to the selection of this deck.
  - Errors encountered due to the failure of retrieval of judgment chunks.

Results

- Simulation parameters:

Parameters	Value
:rt	-1.0
:alpha	0.1
:lf	1.5
:mas	3.0
:imaginal-activation	0.41
:ans	0.1
:bll	0.21

- As in the empirical study, significant effects for trial types ($F(1,50) = 9.940$; $p < 0.002$) and deck types ($F(1,50) = 3.691$; $p < 0.05$).
- Selection of the low demand deck is 63% in our simulation and 68% in the original study.



Conclusions

- Simple ACT-R model using mainly implicit mechanisms.
- To be improved by adding explicit strategies and accounting for more error types.

Acknowledgements

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References

- Anderson, J. R. (2007). *How can the human mind occur in the physical universe?* New York: Oxford University Press.
- Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. Journal of Experimental Psychology: General, 139(4), 665-682.