Electroencephalographic evidence for the sparsity heuristic

C.D. Hassall[1], P.C. Connor[2], T.P. Trappenberg[2], and O.E. Krigolson[1]

1. The Neuroeconomics Laboratory, University of Victoria, 2. Computer Science, Dalhousie University

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INTRODUCTION

- Learning about high-dimensional stimuli is challenging due to the many states that must be represented.
- The world is often sparse – that is, only a subset of dimensions/ properties are relevant for predicting reward.
- The sparsity heuristic aids learning in sparse environments by focusing learning on a subset of features (Gershman et al., 2010).
- In particular, it is proposed that humans employ both reinforcement learning (RL) and selective attention when learning about high-dimensional stimuli.
- Our goal here was to find EEG evidence for the sparsity heuristic.
- We focused on two event-related brain potentials: the feedback-related negativity (FRN) and the N2pc

The FRN is thought to index an RL prediction error (Holroyd and Coles, 2002).

The N2pc is thought to reflect selective attention (Eimer, 1996).

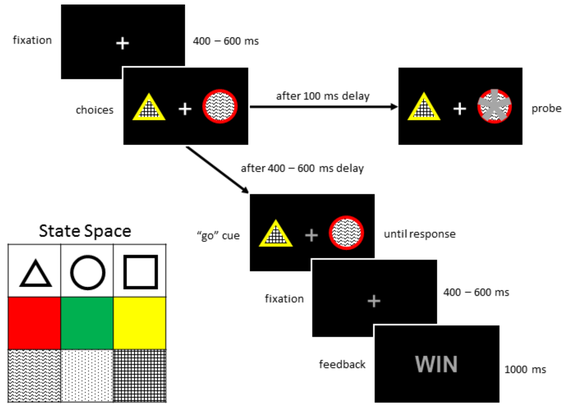
DESIGN

n = 20; 25 blocks of 20 trials each

target dimension/properties chosen randomly for each block

figures randomly generated on each trial

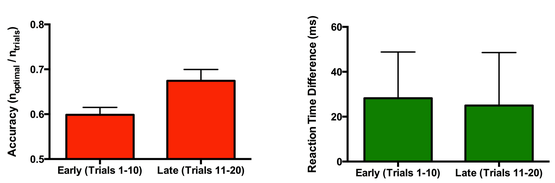
attentional probes on randomly-chosen trials



e.g. target dimension = SHAPE; triangle > circle > square

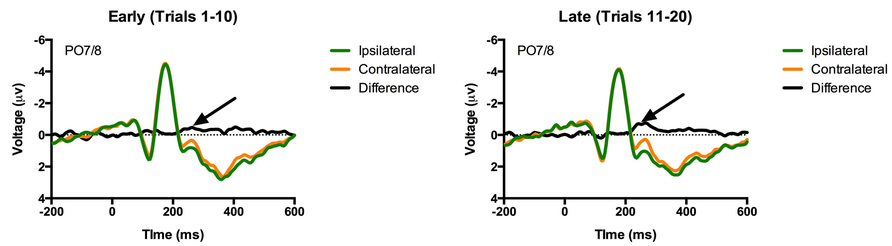
p(win, triangle) = .95, p(win, circle) = .5, p(win, square) = .05

BEHAVIORAL RESULTS

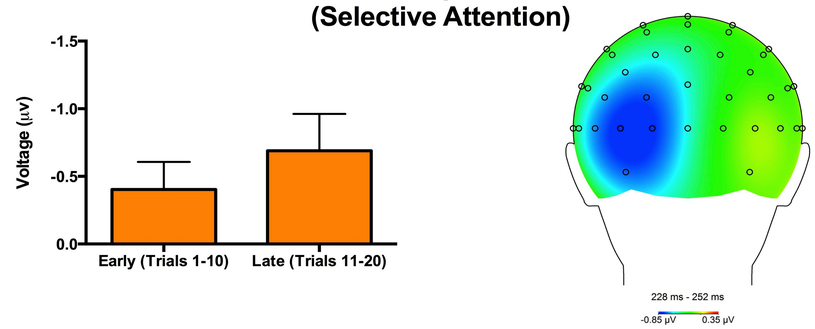


Right: Difference in reaction time to attentional probes appearing unexpectedly within choice stimuli (lower value – higher value)

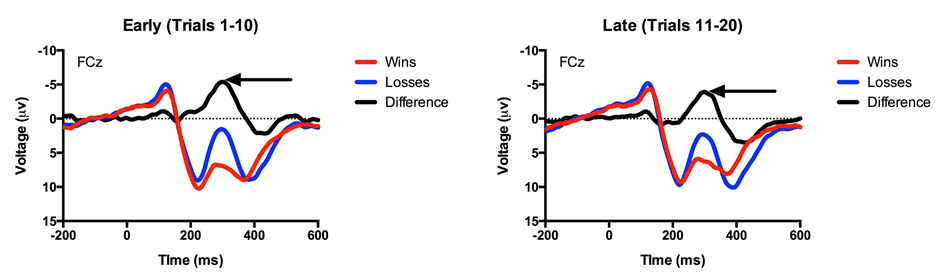
EEG RESULTS



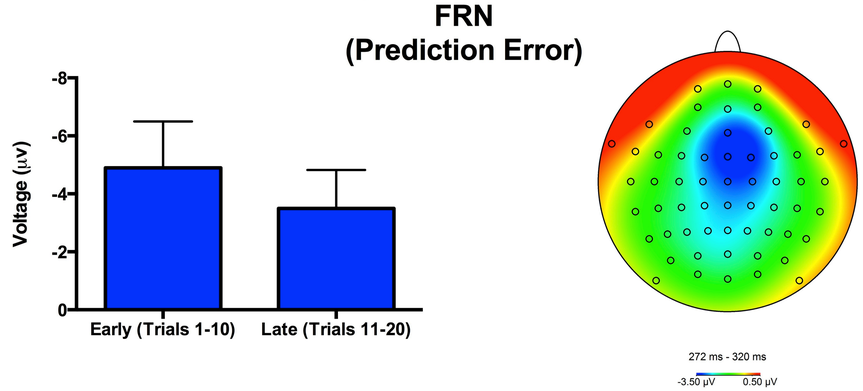
Ipsi/Contra Response to Higher-Valued Stimuli
N2pc
(Selective Attention)



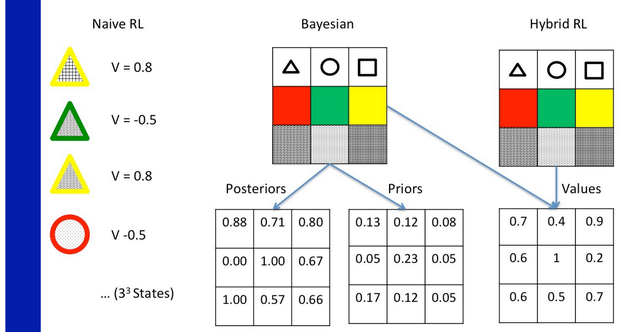
e.g. "high right"

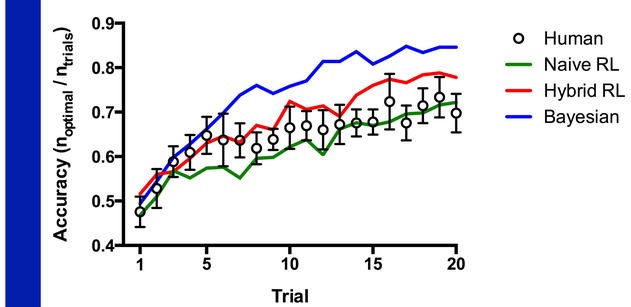


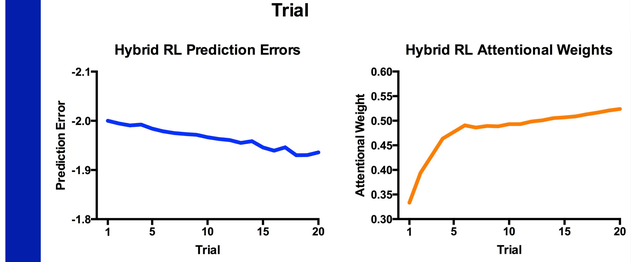
Response to Feedback
FRN
(Prediction Error)



MODELS







CONCLUSIONS

- The FRN behaved like a prediction error (as predicted by an RL model), suggesting the involvement of an RL system.
- The N2pc in response to higher-valued stimuli increased over time, suggesting the involvement of selective attention.
- Human performance in a sparse environment is best explained by a combined RL/Bayesian model than by either an RL or a Bayesian model alone.

CONTACT

Cameron Hassall

The Neuroeconomics Laboratory at the University of Victoria

www.neuroeconlab.com

chassall@uvic.ca

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