Hybrid artificial neural network modelling predicts behaviour and neural activity in a solution for Buridan's ass.

Simone D'Ambrogio
University of Oxford

Jan Grohn
University of Oxford

Laurence Hunt
University of Oxford

Matthew Rushworth
University of Oxford

UNIVERSITY OF OXFORD

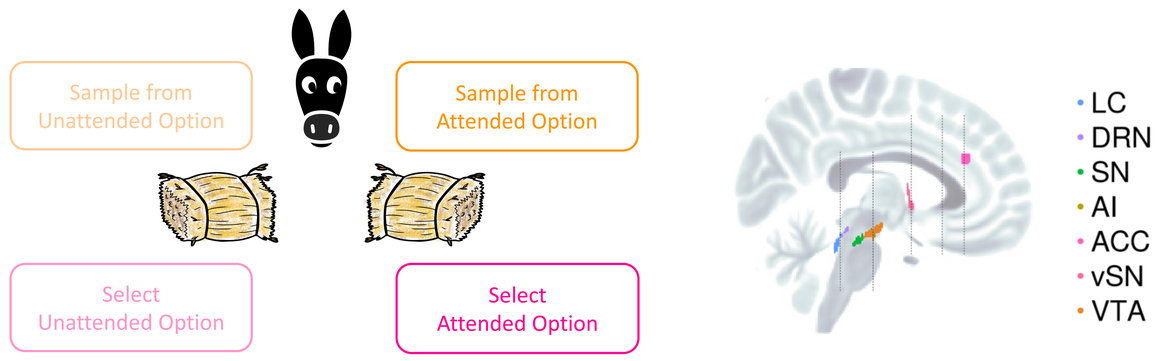
wellcome centre integrative neuroimaging

Experimental Psychology

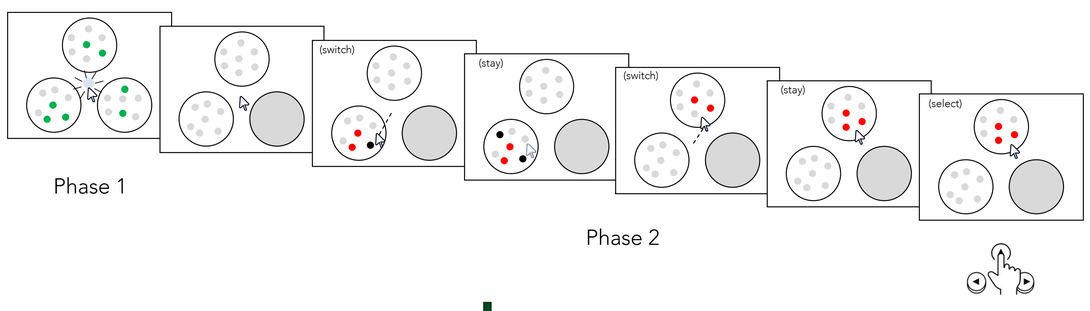
Introduction

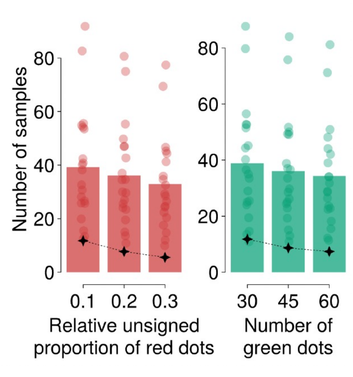
Navigating uncertain environments demands a delicate balance between the collection of information and making decisions. Additionally, uncertainty originating from external, independent factors (background uncertainty) may play a role in this decision-making process. The goal of this project is to understand the neurocognitive mechanisms behind information seeking and decision-making under uncertainty. To this end, we used 7T fMRI and a new modelling approach that integrates deep learning with traditional cognitive models to identify complex strategies and their neural underpinnings.

Problem

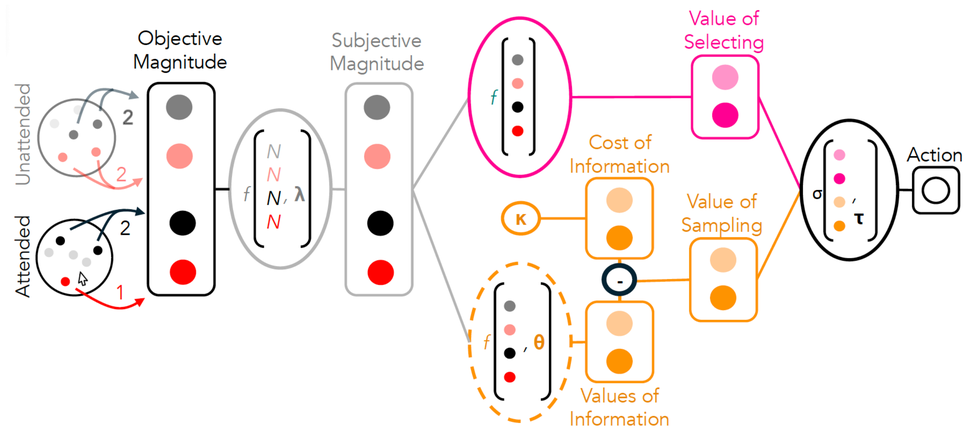


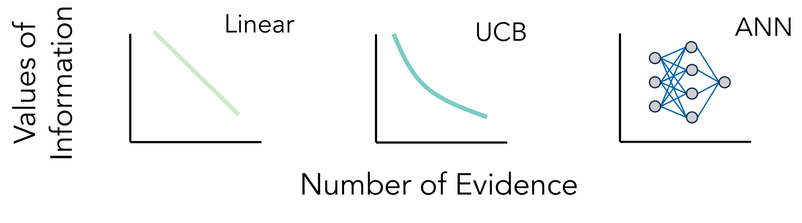
Task & Behaviour



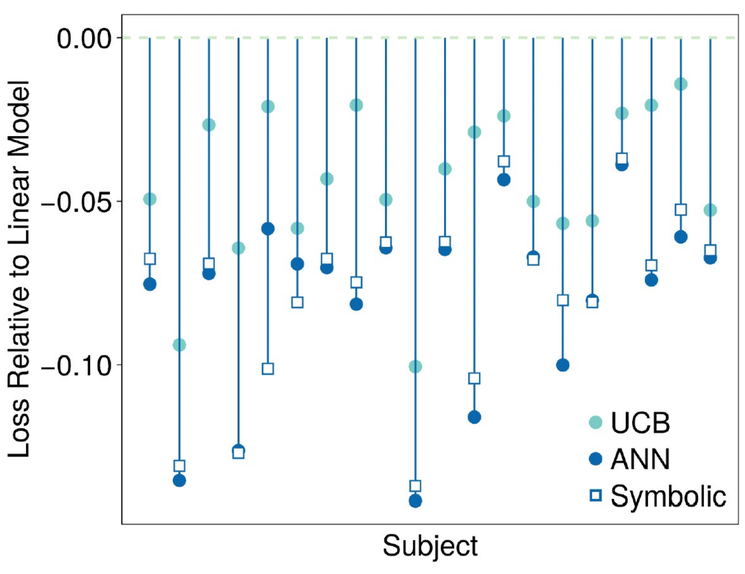


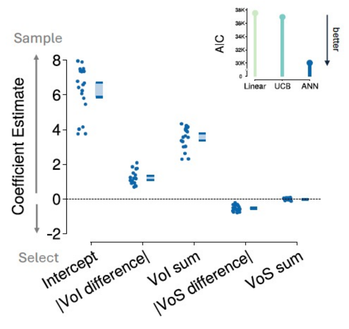
Computational Model

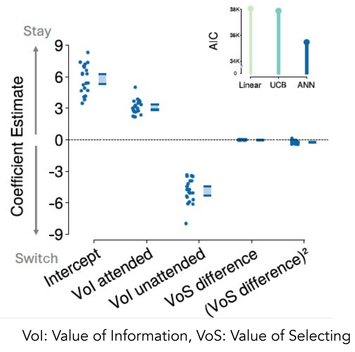




Model's Performance

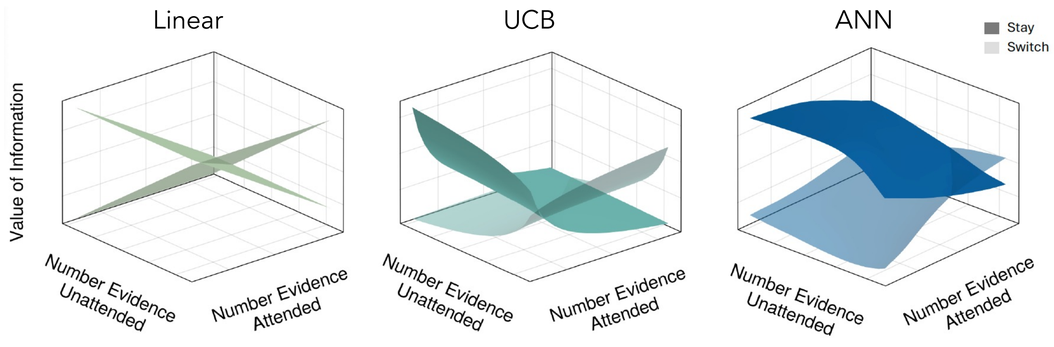


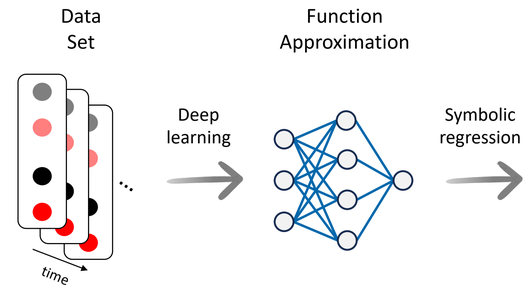




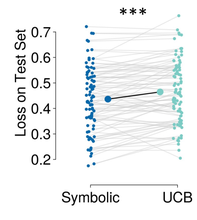
VoI: Value of Information, VoS: Value of Selecting

Interpret Neural Network

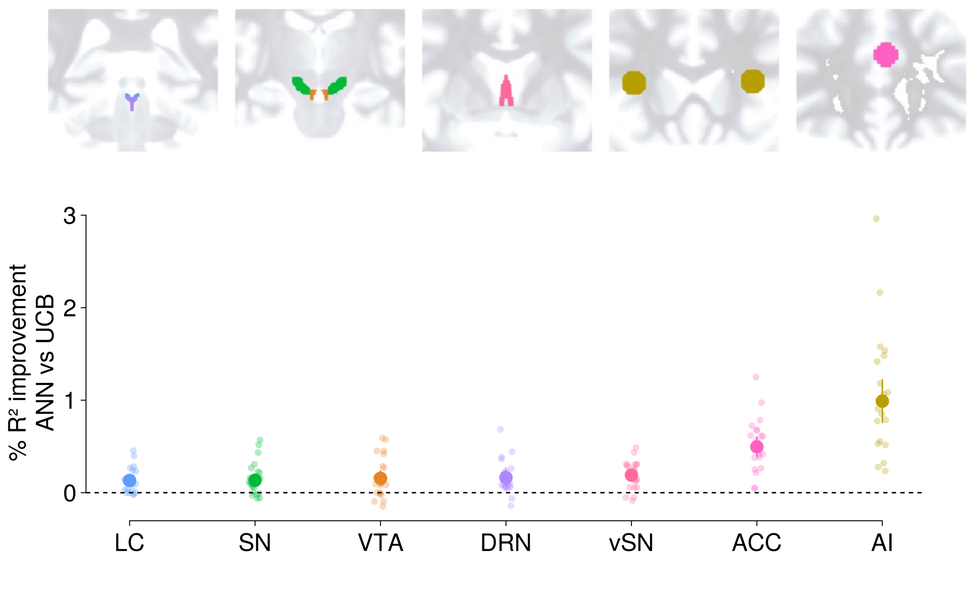


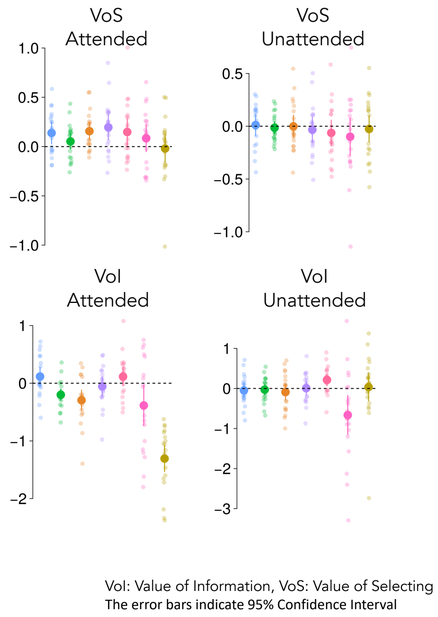


Two-armed bandit task
Gershman, 2018



Predict BOLD





VoI: Value of Information, VoS: Value of Selecting
The error bars indicate 95% Confidence Interval

Conclusion

We developed a hybrid artificial neural network model that combined traditional cognitive principles with data-driven machine learning to better understand how people evaluate the value of additional information. Our model outperformed conventional approaches in predicting participants' sampling behavior. Using high-resolution fMRI, we simultaneously recorded activity from various neuromodulatory systems, including as well as cortical regions. Our findings indicate that brain activity is better explained using the ANN-derived value of information. This work provides new insights into the neural mechanisms underlying how humans resolve the exploration-exploitation dilemma, particularly in situations requiring active information sampling.

simone.dambrogio@psy.ox.ac.uk