Replay induced representation changes

Fabian M. Renz[1,2,3], Shany Grossman[2], Peter Dayan[4,5], Christian F. Doeller[1,6,7] and Nicolas W. Schuck[2,8,9]

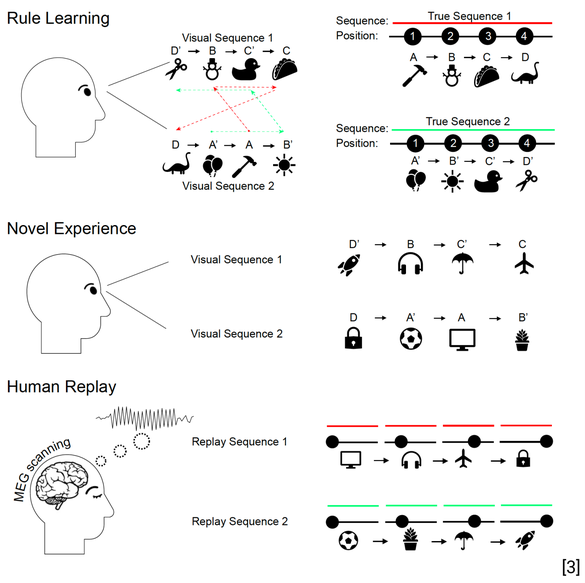
1 Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
2 Max Planck Research Group NeuroCode, Max Planck Institute for Human Development, Berlin, Germany
3 Max Planck School of Cognition, Leipzig, Germany
4 Max Planck Institute for Biological Cybernetics, Tübingen, Germany
5 Eberhard-Karls-Universität Tübingen, Germany
6 Kavli Institute for Systems Neuroscience, NTNU, Trondheim, Norway
7 Universität Leipzig, Germany.
8 Max Planck UCL Centre for Computational Psychiatry and Ageing Research, Berlin, Germany
9 Universität Hamburg, Germany

MAX PLANCK INSTITUTE
FOR HUMAN COGNITIVE AND BRAIN SCIENCES

Introduction

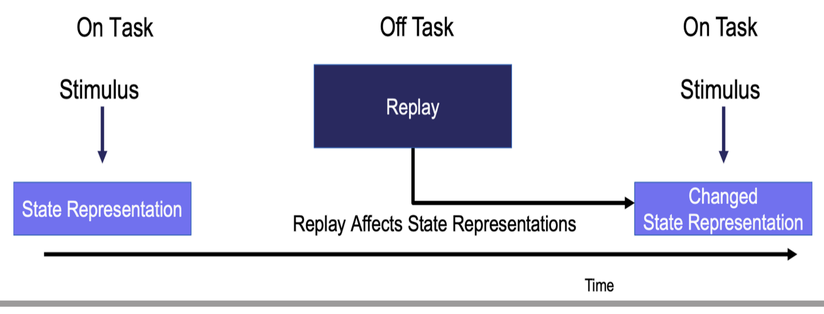
Previous work

- Rodent replay research has been shown to go beyond past experiences, representing inferred trajectories [1][2].
- Recent work demonstrated that replay-like MEG signals reflect the application of structural knowledge [3].
- We hypothesize replay to go beyond the application of structural knowledge, taking an active role in establishing and shaping such knowledge.
- We devised a new graph-structured sequence task to investigate value generalization.



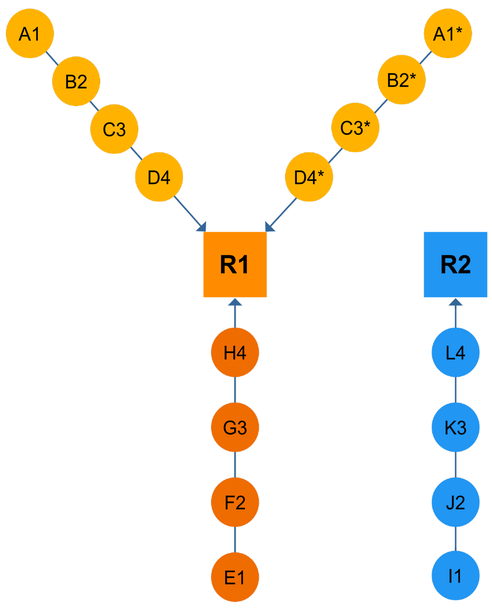
[3]

Does replay contribute to learning state representations?

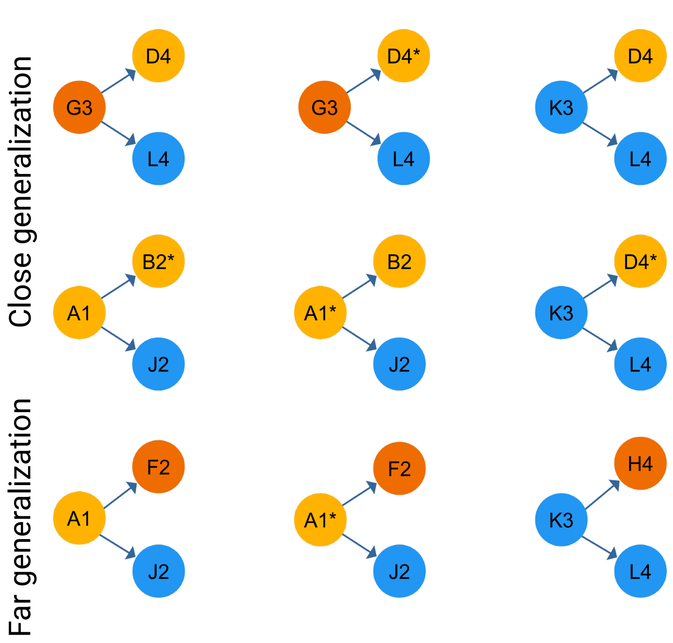


Design

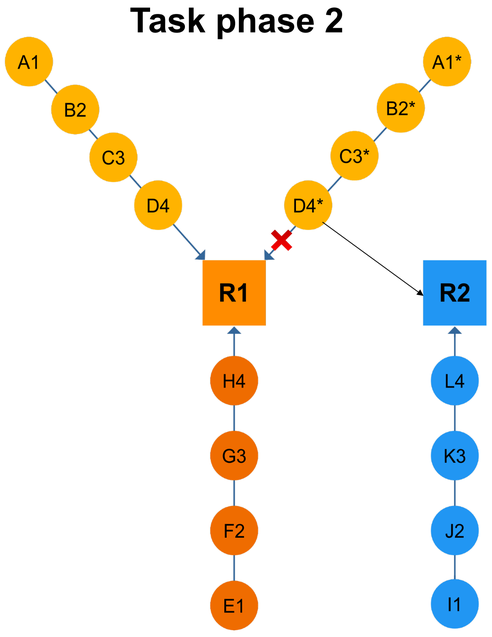
Task phase 1



Available transitions

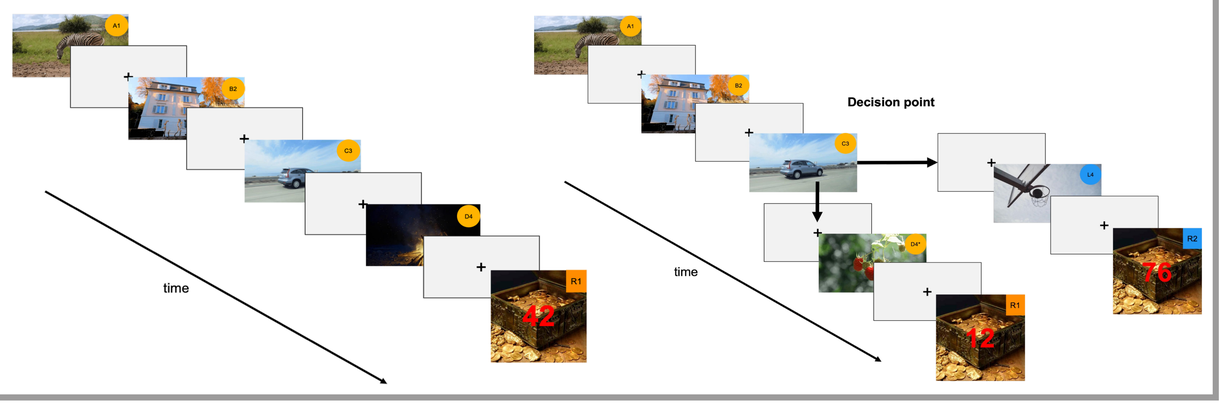


Task phase 2

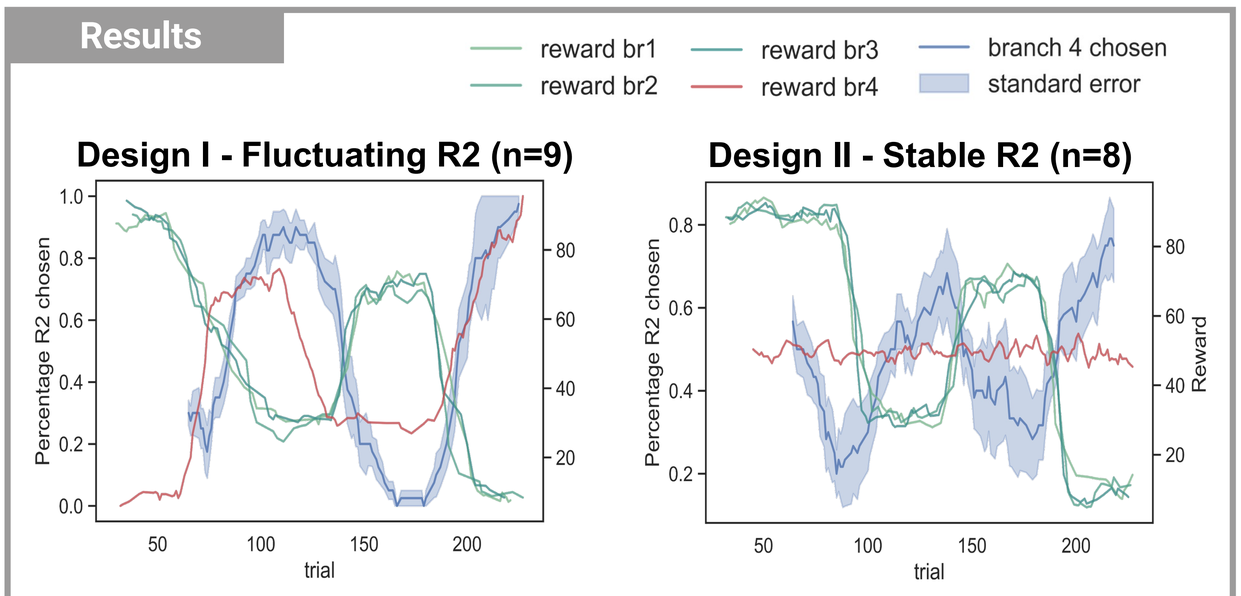


- Four unique 4-step paths leading to 2 fluctuating rewards (R1 & R2).
- Latent graph structure needs to be inferred by transitions and paid rewards.
- Shared reward structure allows for value generalization.
- 2 shared reward paths additionally share category structure (light orange).
- Afforded generalization (task phase 1) becomes maladaptive (task phase 2).

Trial structure

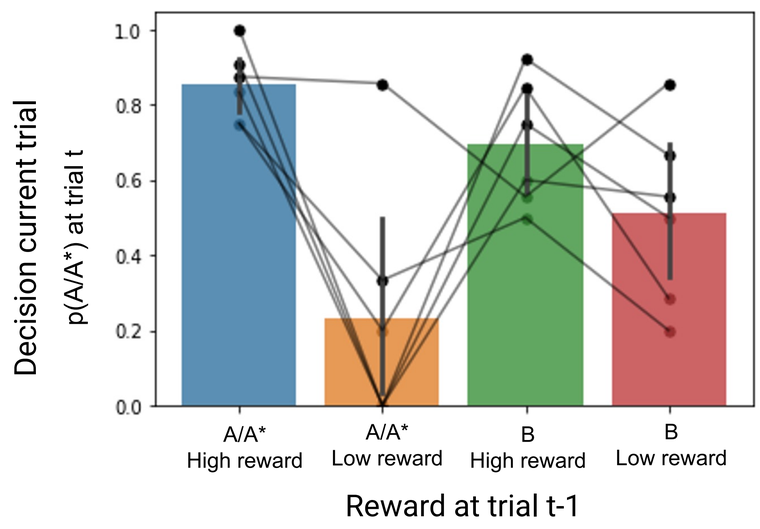


Results



- Participants successfully choose the more rewarding path across conditions.
- Participants reliably adapt their behavior following reward reversals.

Reward generalization (n=6)

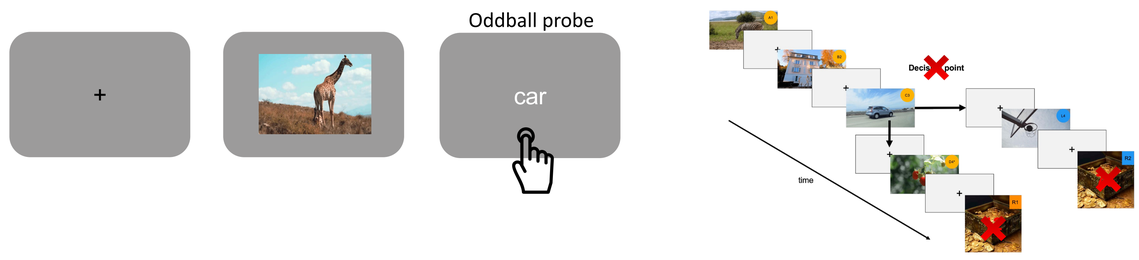


- Shared category structure leveraged to generalize rewards.
- Shared category option will be more often chosen / avoided compared to different category option.

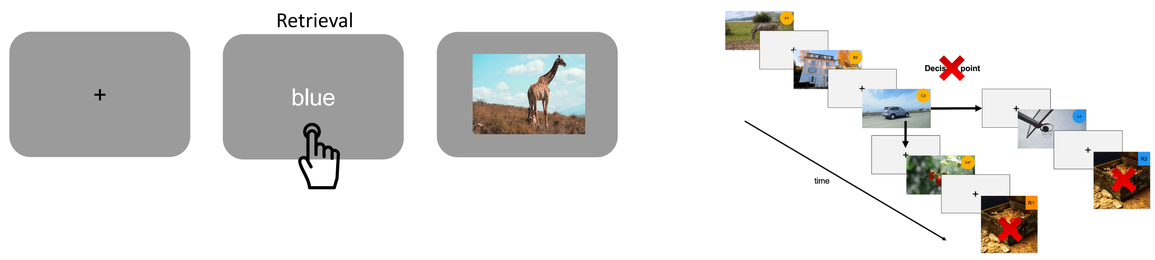
Interim conclusion & Outlook

- Behavioral piloting demonstrates learning of reward structure and successful value generalization.
- A planned fMRI study will investigate the along going representational changes and replay dynamics during learning.
- Replay analysis based on independently trained classifiers applied to every TR. Probability of classifiers allow to infer sequentiality of neural reactivation [4][5].

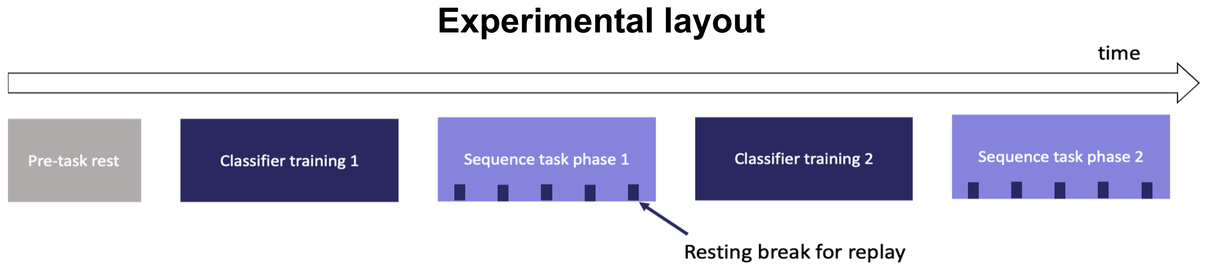
Localizer option 1 - Sequential



Localizer option 2 - Association



Experimental layout



References

[1] A. S. Gupta, M. A. A. van der Meer, D. S. Touretzky, and A. D. Redish, "Hippocampal replay is not a simple function of experience," (2010).
[2] L. Wittkuhn, S. Chien, S. Hall-McMaster, and N. W. Schuck, "Replay in minds and machines," (2021).
[3] Y. Liu, R. J. Dolan, Z. Kurth-Nelson, and T. E. J. Behrens, "Human Replay Spontaneously Reorganizes Experience," (2019).
[4] N. W. Schuck and Y. Niv, "Sequential replay of nonspatial task states in the human hippocampus," (2019).
[5] L. Wittkuhn and N. W. Schuck, "Dynamics of fMRI patterns reflect sub-second activation sequences and reveal replay in human visual cortex," (2021)

DOELLERLAB
renz@cbs.mpg.de | doeller@cbs.mpg.de
www.cbs.mpg.de
doellerlab.com
@doellerlab