Training curriculum matters for cognitive map acquisition

Leonie Glitz[1], Helen C. Barron[2] & Christopher Summerfield[1]

[1]Department of Experimental Psychology; [2]MRC Brain Networks Dynamics Unit; University of Oxford

Question: How can we teach people a cognitive map most efficiently?

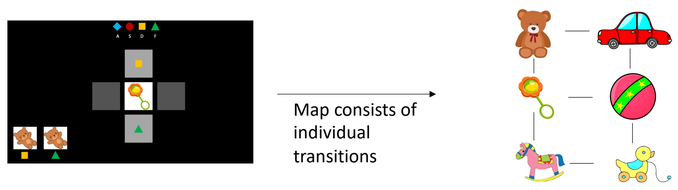
Short answer: Experiencing spatially disjointed transitions in temporal proximity results in more accurate and flexible map representations than random walk type training

Background

- Accurate spatial and non-spatial cognitive maps of our environment are crucial for our ability to plan flexibly and in line with goal demands
- We don't know how we can learn new maps in the most efficient way

Aim: find the best one-step curriculum for flexible multi-step planning

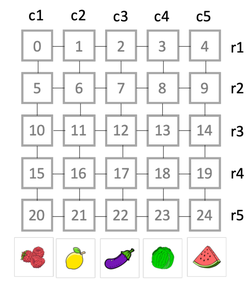
Approach: manipulate the order in which participants experience the paired associates making up the map (curriculum)



Experimental manipulations and design

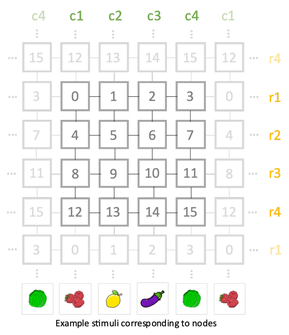
1. Map shape

5 x 5 grid



Example stimuli corresponding to nodes

4 x 4 torus



Example stimuli corresponding to nodes

2. Training: temporal spacing manipulation

LOCAL: which transitions are **within a block**

1. Row/column: random walk along 1 row/col (8 transitions)
2. Random: set of 8 randomly sampled transitions

GLOBAL: **across block** spacing of transitions

Fixed half 

Interleaved 

DESIGN

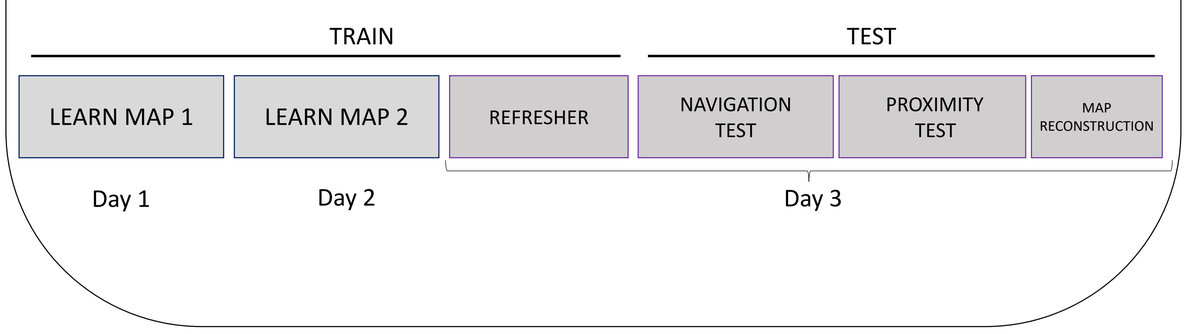
Between subjects factor (GLOBAL)

Fixed half row/column	**Fixed half random**
Interleaved row/column	**Interleaved random**

Within subjects factor (LOCAL)
(one random and one row/column map per participant)

$N_{GRID,\ FIXED\ HALF}$ = 49
$N_{GRID,\ INTERLEAVED}$ = 43
$N_{TORUS,\ FIXED\ HALF}$ = 46
$N_{TORUS,\ INTERLEAVED}$ = 44

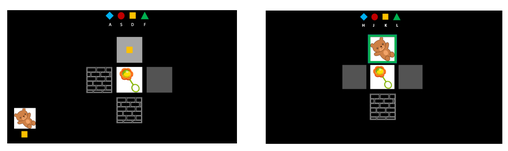
Prolific



Results I: training

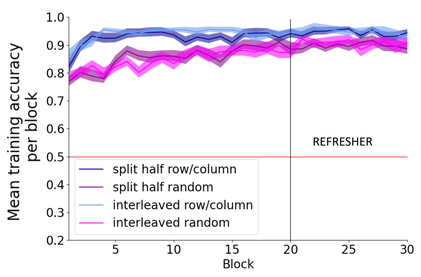
First day of training: all blocks experienced *twice*; 4 repeats per transition per block
Refresher: all blocks experienced *once*; 4 repeats per transition per block

5 x 5 GRID

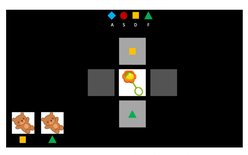


Response indication

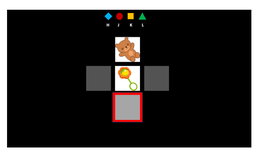
Feedback



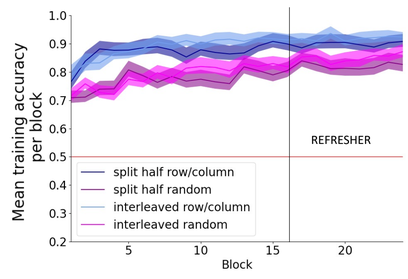
4 x 4 TORUS



Response indication

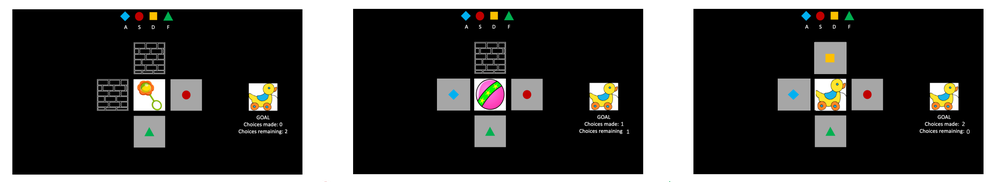


Feedback

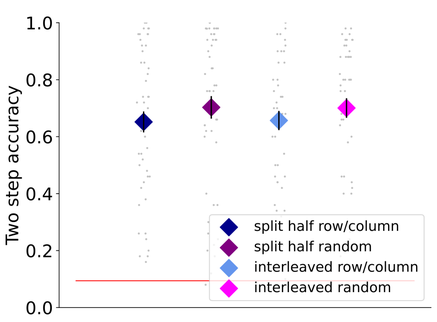


➡ **Row/column > random during training** in grid ($F(1,90) = 108.20$, $p < .001$) and torus ($F(1,88) = 77.92$, $p < .001$)

Results II: two-step navigation and proximity

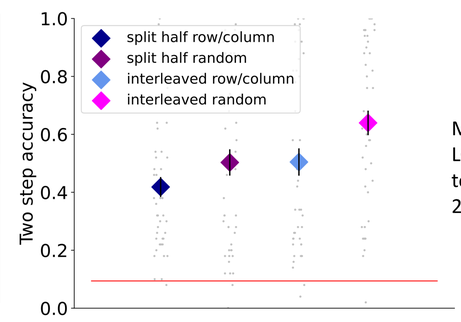


5 x 5 GRID



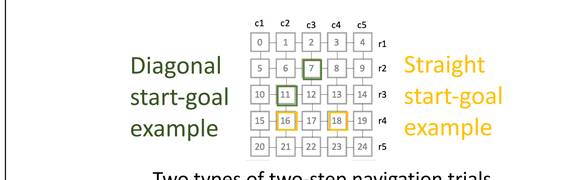
Main effect of LOCAL spacing: $F(1,90) = 9.66$, $p = .003$

4 x 4 TORUS

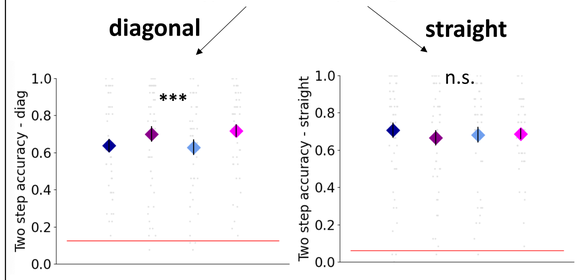


Main effect of LOCAL spacing: torus $F(1,88) = 21.53$, $p < .001$

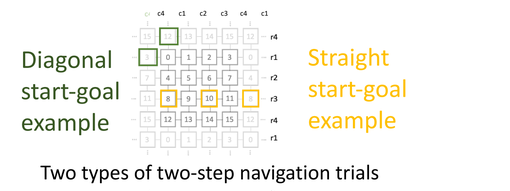
➡ **Random training associated with better 2-step navigation performance**



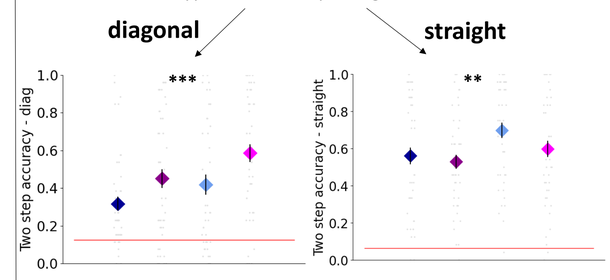
Two types of two-step navigation trials



Random better than row/column (LOCAL spacing) on diagonal ($F(1,90) = 14.14$, $p < .001$) but not straight 2-steps

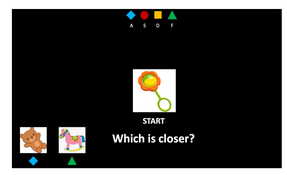


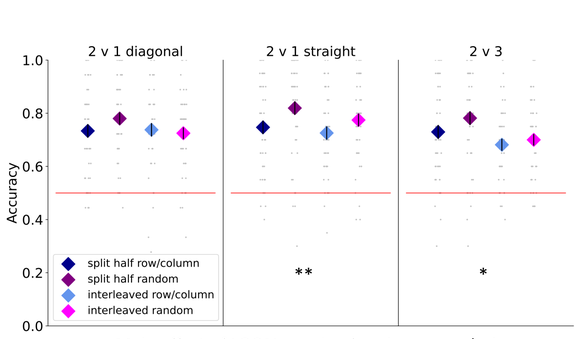
Two types of two-step navigation trials



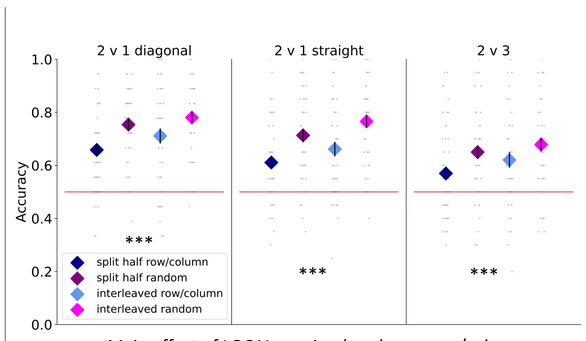
Random better than row/column (LOCAL spacing) on both straight ($F(1,88) = 27.60$, $p < .001$) and diagonal ($F(1,88) = 8.00$, $p = .006$)

Proximity judgements: 2AFC
a) 1 step away vs 2 steps straight
b) 1 steps vs 2 steps diagonal
c) 2 steps diagonal vs 3 steps diagonal





Main effect of LOCAL spacing (random > row/column in 2/3 comparisons; effect of GLOBAL spacing (split half > interleaved in 2v3; $p = .04$)



Main effect of LOCAL spacing (random > row/column; all $p < .001$) but not of GLOBAL spacing

➡ **random training is associated with better map integration and more flexible deployment of learned information than row/column training across tasks and map shapes**

Summary

- We manipulated both the content of a training block (LOCAL) and the order of training blocks (GLOBAL) when teaching people novel (spatial) cognitive maps
- The content of training blocks (LOCAL) had the biggest effect on learning
- Participants were better during training on the map where they were trained in a row/column (random walk) fashion in each block
- In contrast, navigation performance and proximity judgements were better in map with randomly sampled transitions in each training block
- This suggests that experiencing spatially disjointed transitions in temporal proximity results in more accurate and flexible map representations than random walk type training

Future directions

- Explain why learning disjointed transitions during training helps with flexible and robust cognitive map acquisition
- Use a neuroimaging version of the task (grid, fixed half) to help constrain the hypothesis space of what might underlie this effect and where in the brain it is implemented (presumably medial temporal lobe; N = 24/48 collected)

Acknowledgements

This work was supported by a Waverley Scholarship (The Queen's College) in collaboration with the Clarendon Fund to L.G., ERC award no. 725937 to C.S. and a UKRI Future Leaders Fellowship (MR/W008939/1) to H.C.B.

European Research Council
Established by the European Commission

Follow me on twitter for updates

Find our **abstracts** here https://github.com/summerfieldlab/CCN_papers_2023

Find all lab **posters** here! https://github.com/summerfieldlab/CCN_2023_posters

MRC Brain Network Dynamics Unit

If you have any questions, please contact: leonie.glitz@psy.ox.ac.uk or christopher.summerfield@psy.ox.ac.uk; or find us on twitter @GlitzLeonie or @summerfieldlab