Memory for temporal information during spatial navigation
Iva Brunec¹,², Jason Ozubko¹,², Morris Moscovitch¹,², Morgan Barense¹,²
(1) Department of Psychology, University of Toronto; (2) Rotman Research Institute, Baycrest Centre

Introduction
- Damage to the hippocampus results in profound episodic memory impairments and disorientation in space and time¹,²
- The hippocampus is crucial for creating unique, non-overlapping memory representations by the mechanism of pattern separation³. We appear to use spatiotemporal contextual information to construct unique memory representations for individual events.
- Traditionally, hippocampal function has been studied in the spatial domain. However, recent research points to the existence of ‘time cells’ which track successively elapsed moments during an empty temporal gap⁴.
- Space and time are inextricably linked and understanding the complex interplay of memory for space and time may offer insight into the principles of hippocampal function.

Aims & Questions
- Explore participants’ memory for time in a spatial navigation task with closely controlled spatial and temporal parameters.
- How good is our capacity for temporal pattern separation?
- What is the relationship between memory for temporal duration and spatial location?
- Is information about time encoded automatically or does it require a rich sense of re-experiencing an event?

Participants
- 14 participants (6 female)
- Average age 19.2 (SD = 2.5) years
- Average Santa Barbara Sense of Direction Scale score 4.2 (SD = 2.0)

Design and Stimuli
- 7 repetitions of time-constrained passively guided navigation in a virtual rendering of the city of Chicago, USA.
- Stops in 12 intersections, each associated with a different temporal duration (range 1-12 seconds).

Task and Procedure
- Participants complete 7 repetitions of the same route where each of the 12 intersections is associated with a unique temporal duration. The temporal durations of different intersections are randomized across participants.

Temporal Duration Discrimination
- Overall proportion correct: 0.6 (SD = 0.48)

Distance Discrimination
- Overall proportion correct: 0.84 (SD = 0.34)

Results
- Significantly greater overall accuracy on distance discrimination relative to temporal discrimination judgments.
- No significant correlation between distance and temporal judgments.
- Sign. greater proportion of accurate temporal judgments when both intersections were ‘re-experienced’ rather than ‘known’.

Summary and Conclusions
- Spatial information is encoded much more readily than temporal duration information. Memory for time appears to be more sensitive to interference and requires a greater degree of separation. This suggests that temporal deficits might precede spatial deficits in disorders such as dementia.
- Reliable temporal duration discrimination requires a rich sense of re-experiencing and is significantly lower when participants report ‘knowing’ an intersection with little associated perceptual and spatial detail.
- While hippocampal time cells may track time continuously, this information may only be available to conscious evaluation when the memory trace for the spatiotemporal context is strong and the subjective experience is vivid.

Future Directions
- Passive experience of navigation could have contributed to low performance – active navigation with slightly less constrained timing might yield different results.
- A different pattern of results might be observed in a familiar environment where participants would not need to encode the spatial features of the route.
- Comparison of each individual duration with a pre-learned duration.
- Elapsed time during motion vs. pause.

References