Spatial Memory in Rats under non Life-Threatening Conditions

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The *Morris water navigation task*, also known as the *Morris water maze*, is a commonly used behavioral procedure for studying spatial learning and memory in rodents. In this experiment, a rat is placed in a large circular pool and must find an invisible platform to escape the water. However, this situation puts the rats under high stress, which can be perceived as life-threatening by them. Our goal is to evaluate spatial memory formation in a setting closer to the rat's daily life (a circular arena in the ground) with a softer, more natural reward: switching off the lights when the target is found. Since rats prefer dark environments, it has the potential to motivate rats to complete the task, without causing too much anxiety. Specifically, we measure memory formation within a single day of experimentation (*short-term memory*) and between two consecutive days (*long-term memory*), as well as analyze the relation between both.

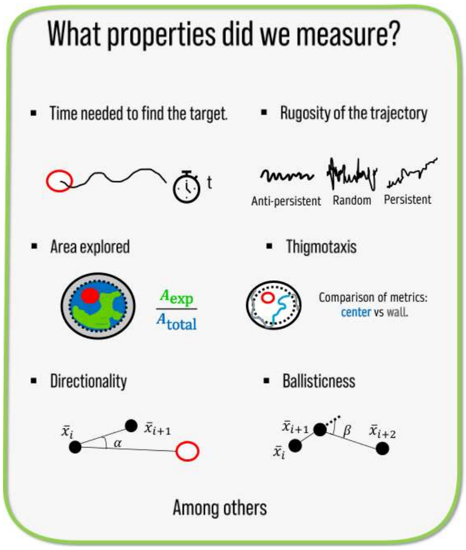

Fig. 1. **Measured properties for spatial memory analysis.**

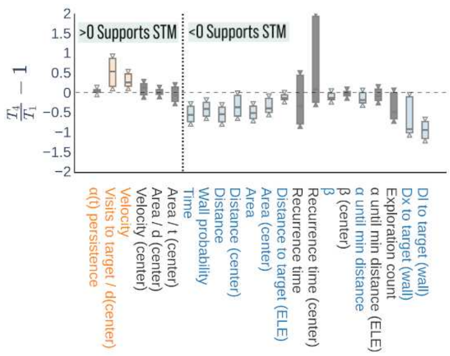

Fig. 2. **Strong evidence of STM.** Equally tailed, 95% C.I. for the median ratio change between trial 1 and trial 4. Metrics expected to increase (decrease) in the presence of STM are located at the left (right) of the dashed line. Statistically significant results are plotted in blue (decrease) and orange (increase).

During an experiment, the rat tries to find the (initially unknown) target for four trials, and is expected to learn its location. By comparing the metrics (Fig. 1) between the first and last trial, we can estimate the existence of memory. Our findings provide strong evidence of STM formation, as the metrics that are expected to increase or decrease in the presence of memory align with the expected patterns (Fig. 2).

Moreover, we observe strong indications of LTM formation. Our main test relies on a *decision model*. If a rat shows LTM, it tends to prioritize visiting the target from the previous day ("preROI") during T1 of any given day. This behavior is statistically significant and not merely influenced by chance or the proximity of preROI to the rat's initial position compared to the current day's target ("ROI"). To assess the absence of LTM, we establish a *null model*: a binary classifier predicting whether the rat finds the target (ROI or preROI) closer to its initial location within the crop. The null model is evaluated against the actual outcomes (preROI or ROI found first at each T1) across rats and days. If a *blind classifier*, predicting the majority class without using any data, outperforms the null model with 95% confidence based on the F1 score, we reject the null model and conclude the *detection* of LTM.

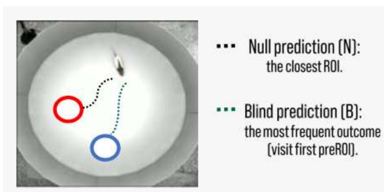

Fig. 3. **Null model scheme for the LTM decision model.**

The rat consistently reaches the previous day's target with 95% confidence, ruling out proximity as the sole explanation. The blind classifier's F1 score outperforms the null model with 99% confidence. Additionally, LTM is quantified using the same metrics as STM (Fig. 1).

[1] R. Morris, *Developments of a Water-Maze Procedure for Studying Spatial Learning in the Rat*, J. Neurosci. Methods **11**, 1984.

[2] J. Bergstra, D. Yamins, and D.D. Cox. *Making a Science of Model Search: Hyperparameter Optimization in Hundreds of Dimensions for Vision Architectures*, 30th International Conference on Machine Learning, 2013.