A Rational Model of Prioritized Experience Replay

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Presentation Abstract Summary Psychologists have long argued that animals use maps or models to plan actions, typically viewed as forward simulation at choice time. However, recent experiments suggest that many flexible choice phenomena previously considered to support such planning actually depend on computations occurring earlier, during encoding or offline rest. Analogously, position representations in rodent hippocampus run ahead of the animal at choice points, suggesting a substrate for forward evaluation. However, these events are only one instance of a heterogeneous family of nonlocal sequences which include forward and backward replay, during behavior and rest. Thus, theories of model-based evaluation must be generalized to explain offline computation. We propose a rational model that prioritizes memory retrieval for action evaluation according to expected utility. Utility is approximated as the product of two terms whose balance produces a heterogeneous pattern of experience replay that resembles sequential place cell activity. In particular, a prediction error such as an unexpected reward drives reverse replay to propagate its gain; at other times, a need term drives forward sweeps ahead of the agent. Our model accounts for many empirical findings in humans and rodents and suggests that memory access reflects rational investment of limited computational resources.

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