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Dear Editor,

We hereby submit our manuscript, '*Exploring Replay*', to Nature Communications.

Our work addresses a critical facet of hippocampal replay – a phenomenon that is under intense investigation in animals and humans alike: we suggest that it is involved in efficient exploration, which is one of the most important aspects of learning in artificial and biological agents.

In seminal work reported recently, *Mattar & Daw (2018)* suggested a normative account of replay that successfully explained many observations and made now-confirmed predictions. However, their theory assumes that the environment the subject occupies is known - something that is rarely true, at the beginning of learning owing to ignorance, during learning owing to environmental change, and throughout owing to forgetting. When the environment is imperfectly known, exploration is required, and must be balanced against exploitation.

We therefore extend the theory of replay substantially, postulating an algorithmic structure of approximately optimal exploratory choices in the animal brain and providing concrete, theoretically grounded predictions for future experiments.

We use simulations to highlight the implications of our theory. We predict the exploratory replay choices one should expect given a subject's uncertainty about its environment in a paradigmatic spatial navigation task (patterned after a venerable suggestion from Tolman). We also successfully model the available (albeit limited) experimental data suggestive of exploratory replay, and illuminate the importance of sequence replay, something to which *Mattar & Daw (2018)* is agnostic.

Our results inspire questions relating to individual differences in replay, something that has raised great interest in computational psychiatry and risk-sensitive decision-making, by theoretically anchoring replay choices to subjective beliefs about a task. We also make a number of testable predictions.

We suggest that our work has important implications for computational cognitive science and decision-neuroscience across a diverse range of task paradigms. We think it will be of great interest to a wide range of your readership.

We would like to recommend the following experts as potential reviewers:

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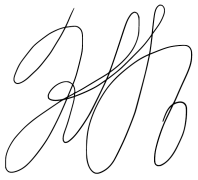

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