



A unifying theory for hippocampal remapping through the lens of contextual inference

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Hippocampal remapping describes the phenomenon of substantial reshuffling of the spatial preferences of hippocampal place cells in response to environmental changes. Disparate neural representations in different environments could reduce interference between competing memories, hence functionally supporting robust context-dependent spatial cognition. Experimental data on existing remapping studies exhibit a diverse range of physiological properties, sometimes with seemingly conflicting results. In particular, subtle changes in experimental conditions lead to qualitatively different results. Despite previous attempts, no existing models provide a coherent normative explanation for these mixed remapping responses reported in the literature. Here, we interpret remapping through the lens of probabilistic inference over ongoing task context, instead of being based solely on environmental changes. This subtle but important difference allows us to probe how remapping profiles change as a function of a multitude of task-dependent features. Through performing Bayesian inference over the latent contextual variable, we derive precise mathematical identities showing that remapping exhibits explicit dependence on the degree of environmental difference during pre-training and the amount of pre-training experience. Moreover, we numerically show that remapping is implicitly dependent on the order of presentation during probing trials. We model three influential experimental studies that lead to different remapping profiles under similar experimental conditions [1, 2], and that previous theoretical accounts were not able to reconcile. We show that our theory captures the qualitative features of remapping in all three studies. Our work suggests that the computations underlying spatial remapping generalise beyond spatial context, and support a more general role of the hippocampal formation in computations centering around contextual inference.

normative modelling, hippocampal remapping, Bayesian nonparametrics, contextual inference