The Maximum Information Principle of Place Cell Activity

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Abstract Spatial cognitive function is crucial for the animal's survival. However, the formation of place codes in different dimensional spaces cannot be uniformly explained. In this paper, a constrained optimization model based on information theory is constructed to explain the formation of place cell activity in different dimensional spaces across species. The question is proposed as, using limited amount of neural energy, how to design the place field to obtain the most efficient spatial information representation? Variational techniques are applied and the results suggest that the place field will comply with a certain centralized distribution (normally is Gaussian form) automatically to convey the largest amount spatial information per spike, under the constraint of limited neural energy. The animal's natural habitat property and locomotion experience statistics also affected the spatial codes. These findings not only answer whether the spatial codes of place cell are isotropic in different dimensional spaces, but also provide an insight about the maximum information principle of the place cell activity.

Acknowledgements Supported by the National Natural Science Foundation of China (No. 11702096, 11802095), Natural Science Foundation of Shanghai (No. 19zr1473100) and Fundamental Research Funds for the Central Universities (No. 222201714020, 222201814025).

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A. Lintas et al. (eds.), *Advances in Cognitive Neurodynamics (VII)*, Advances in Cognitive Neurodynamics,
https://doi.org/10.1007/978-981-16-0317-4_32