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The spatial information content of DG inputs

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Background

In the mammalian hippocampus, the dentate gyrus (DG) is characterized by sparse and powerful projections to CA3 cells, the so-called mossy fibers. These projections appear to duplicate, in terms of the information they convey, what CA3 cells already receive from entorhinal cortex layer II cells (ECII). It has been hypothesized that the function of the mossy fibers is to enforce a new pattern of activity onto CA3 cells, which has to represent a new memory, prevailing over the interference produced by the traces of older memories already stored on CA3.

Such an hypothesis is supported by a mathematical model which compares the amount of information carried by both inputs to CA3 [1] and it seems to be supported also by experimental studies with rodents. A recent experimental study has clarified the nature of the spatial representations in the DG [2]. This allows us to study the information flow from DG to CA3 in a more detailed and quantitative way and, moreover, to apply that to 2-D spatial representations.

Methods and results

This paper reports the analysis of a simplified mathematical model, performed through simulations and analytical calculations. We simulated the formation of spatial maps in a CA3 network under the influence of EC layer II and DG inputs, modelled as units with multiple place field. The number of fields being given by a Poisson or by an exponential distribution, we calculate the information carried by the DG input and associated to a spatial representation. We studied how the information content depends on the parameters of the DG code. We observed, moreover, that the information is strongly dependent on the method used to build the "confusion matrix" (the conditional probability to have a response r to a stimulus s) and that these differences are quite significant when the external correlates of neuronal activity form a continuous set, as it is the case with position in the environment (see figure 1). These findings imply that a substantial fraction, often over half, of the information content of a spatial

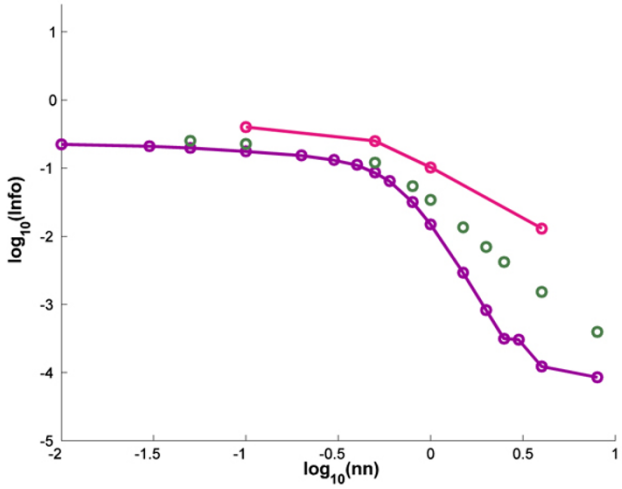

Figure 1

CA3 representation can neither be extracted through the simplified method that assumes translation nor assessed through the analytical method. This large fraction of the information content is only extracted through the time-consuming construction of the full confusion matrix. We hence refer to this large fraction as "dark information," which requires a special effort to reveal.

References

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