Spatiotemporal analyses of interactions between entorhinal and CA1 projections to the subiculum of the rat

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Question

How do projections from the CA1 region and the entorhinal cortex interact in the subiculum?

Introduction

The subiculum (Sub) and the medial entorhinal cortex (MEC) are key structures of the neocortical-hippocampal network. The distal subiculum receives information from the MEC layer III by way of two pathways:

1) a direct projection from MEC III to the subiculum
2) an indirect polysynaptic connection via CA1 to the subiculum. Several routes converge from MEC to the CA1 region

DG = Dentate Gyrus; LEC = Lateral Entorhinal Cortex
d = distal; p = proximal.

Materials & Method

All recordings were done in in vitro horizontal brain slices (400 µm) of the rat, containing the hippocampus and MEC. The slices were stained with a voltage sensitive dye (absorption dye NK3630/RH482, 0.005-0.02 mg/ml in ACSF for 60 minutes). Relative changes in membrane potential, exhibited as changes in absorption, were recorded with an optical imaging system.

Optical imaging set up (WuTech): A tungsten lamp illuminates the slice. The photodiodes record the local changes in light intensity related to membrane voltage.

Recording electrode 464 element photodiode array

ACSF in Stimulating electrodes

ACSF out

Hippocampal-entorhinal cortex slice and hexagonal shaped 464-channel photodiode array (red overlay). Indicated is the position of an exemplary channel in Sub (see Results).

Stimulation electrodes were placed in layer III of MEC (direct; blue) and in the CA1 area (indirect; red)

Stimulation was either in the CA1, or in the MEC or in both. We investigated whether linear addition existed in the subicular response:

\[ \text{CA1} \text{(alone)} + \text{MECIII} \text{(alone)} = (\text{CA1} + \text{MECIII}) \text{(together)} \]

Results

Consecutive timeframes (5 ms interval) of the spatial voltage pattern after stimulation at t=0 for conditions:

a) MEC layer III stimulation alone (MECIII): activation in the superficial molecular layer of the subiculum;

b) CA1 stimulation alone (CA1): activation in the distal part of the subiculum, which involved the whole radial extent of the subiculum;

c) simultaneous stimulation of MEC III and CA1 (MECIII + CA1): stimulation of the distal part of the subiculum comparable with individual stimulation of MEC or CA1

d) the algebraic sum of a and b

e) the difference between c and d

Conclusion

The data strongly suggests that in the subiculum input of the direct and the indirect pathways from the entorhinal cortex add linearly.

The hypothesis that the direct and the indirect pathways from EC to subiculum act as a comparator between “old” (indirect) and “new” (direct) information seems unlikely. We found no interaction between these two pathways. Our data support a contrasting view: the direct and indirect pathway transfer their information to the subiculum independently of each other.