Dynamics of Goldfish Subregional Hippocampal Pallium Activity throughout Spatial Memory Formation

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The teleost fish hippocampal pallium, like the hippocampus of tetrapods, is essential for relational map-like spatial memories. In mammals, these relational memories involve the dynamic interactions among different hippocampal subregions and between the hippocampus-neocortex network, which performs specialized operations such as memory encoding and retrieval. However, how the teleost hippocampal homologue operates to achieve comparably sophisticated spatial cognition capabilities is largely unknown. In the present study, the progressive changes in the metabolic activity of the pallial regions that have been proposed as possible homologues of the mammalian hippocampus were monitored in goldfish. Quantitative cytochrome oxidase histochemistry was used to measure the level of activation along the rostrocaudal axis of the ventral (Dlv) and dorsal parts of the dorsolateral division (Dld) and in the dorsoposterior division (Dp) of the goldfish telencephalic pallium throughout the time course of the learning process of a spatial memory task. The results revealed a significant increase in spatial memory-related metabolic activity in the Dlv, but not in the Dld, suggesting that the Dlv, but not the Dld, is comparable to the amniote hippocampus. Regarding the Dlv, the level of activation of the precommissural Dlv significantly increased at training onset but progressively declined to finally return to the basal pretraining level when the animals mastered the spatial task. In contrast, the commissural Dlv activation persisted even when the acquisition phase was completed and the animal's performance reached an asymptotic level. These results suggest that, like the dentate gyrus of mammals, the goldfish precommissural Dlv seems to respond nonlinearly to increments of change in sensory input, performing pattern separation under highly

dissimilar input patterns. In addition, like the CA3 of mammals, the commissural Dlv likely operates in a continuum between two modes, a pattern separation or storage operation mode at early acquisition when the change in the sensory input is high, probably driven by the precommissural Dlv output, and a pattern completion or recall operation mode when the animals have mastered the task and the change in sensory input is small. Finally, an unexpected result of the present study is the persistent activation of the area Dp throughout the complete spatial task training period, which suggests that the Dp could be an important component of the pallial network involved in spatial memory in goldfish, and supports the hypothesis proposing that the Dp is a specialized part of the hippocampal pallium network.

Cytochrome oxidase histochemistry

Dentate gyrus/CA3 network

Forebrain evolution

Hippocampal neural network

Hippocampal pallium

Parahippocampal region

Spatial memory

Teleost fish

cytochrome c oxidase

analysis of variance

anatomy and histology

animal

cytology

depth perception

goldfish

hippocampus

metabolism

neuropsychological test

physiology

randomization

spatial learning

spatial memory

Analysis of Variance

Animals

Electron Transport Complex IV

Goldfish

Hippocampus

Neuropsychological Tests

Random Allocation

Space Perception

Spatial Learning

Spatial Memory