Asymmetric theta activity in the hippocampus of freely flying homing pigeons as revealed by combined EEG and GPS tracking

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Lesion studies have shown that the pigeon hippocampus is a critical structure for spatial orientation. In addition, there is evidence for hemispheric specialization of homing mechanisms. Likewise, studies in caged migratory birds have suggested a left-hemispheric predominance in magnetoperception. Since the occurrence of theta oscillations in the EEG has been associated with navigational behavior also in humans, we analyzed the EEG of freely flying homing pigeons in relation to their position as recorded by GPS.

Pigeons were implanted bilaterally with 4 electrodes per hippocampus. These were connected by fine wires to a backpack of 40 g consisting of a micro-GPS recorder storing flight positions with an accuracy of ± 6 m and an 8-channel EEG-logger storing the raw data in flash memory. Off-line analysis determined the proportion of theta oscillations in the EEG during bins of 2 sec of flight which were matched to GPS coordinates. The proportion of bilateral theta activity was larger in pigeons far from the loft, theta being significantly stronger in the left hemisphere. After release and upon approaching the home loft area, the right hemisphere showed increased bursts of desynchronization (non-theta), possibly indicating the perception of familiar landmarks by the left eye. These findings corroborate functional lateralization of homing in the pigeon brain, and promise new approaches to analyze brain mechanisms underlying homing and navigation.

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