Learning to cope with uncertainty without knowing it: A role for the hippocampus and a Bayesian model of belief update.

Appraising beforehand the optimal course of actions in dynamic and unforeseeable environments becomes difficult since it is hard to identify the influence variables and their functional relationship. Adapting behavior under uncertainty typically implies varying strategies over trials on the basis of previous outcomes. This trial and error learning involves a flexible and often implicit (unplanned) adjustment of our internal beliefs and considered actions in the measure that new information about the relevant environment is revealed by the outcomes of our own actions or that of others.

According to prevalent learning theories the update in our internal beliefs and the subsequent behavioral adjustments depend on neural signals coding a reward prediction error, i.e., the mismatch between reward prediction and reward occurrence. According to these models learning takes place when rewards are different than predicted, ensues while outcomes occur that are not fully predicted and ends when outcomes are fully predicted. A prediction derived from these models is that learning, and behavioral adjustments, should occur in an unpredictable environment even if subjects are not explicitly trying to extract general inferences about the environment. This form of implicit learning remains poorly understood despite its importance for autonomous systems.

To investigate the neural mechanisms of implicit learning we recorded intracranial EEG from three epileptic patients playing a single-shot variant of the Trust Game. Following trials where their gains were smaller than expected, all participants reduced their beliefs and expectancies about following and yet unknown players. Behavior after unexpected gains considerably varied across subjects. Hippocampal/peri-hipocampal contacts showed the largest responses at the stage of outcome evaluation and were significantly modulated by the mismatch between the expected and received gains, i.e., by the reward prediction error. Hippocampal theta oscillations recorded at the stage of evaluating the outcomes were a consistent predictor of behavioral adjustments in subsequent trials. A bayesian model was created to describe the subjects behavior providing an excellent prediction of how did subjects modify beliefs on the basis of current information and learned experience.