Decision-making under uncertainty: Probing the neural basis of mental models

Alla Karpova

The overall interest of my lab is to understand how model-based inference is accomplished by neural circuits. Over the past few years we have focused on the role that the rodent medial prefrontal cortex (mPFC), an area homologous to primate anterior cingulate cortex (ACC), plays in encoding the internal representation of the rules of the environment. We have designed behavioral tasks in which these rules change suddenly or evolve in a very complex manner—in some cases eliciting abrupt changes in the workings of the internal model and in others leading to the abandonment of attempts at model construction. Recordings of the activity of neuronal ensembles in mPFC revealed that moments of abrupt change in behavioral strategy are associated with sudden transitions in the pattern of neural activity across the mPFC, one interpretation of which is that such changes signify a reset of prior expectations. In addition, inactivation of mPFC by local muscimol administration revealed that the influence of mPFC on behavior is suppressed when attempts to build an internal model are unsuccessful. Finally, selective enhancement or suppression of Locus Coeruleus input into the ACC, respectively, abolished or restored model-based control of behavior. In combination, our observations argue in favor of the idea—that mPFC represents an animal’s beliefs about the environment’s governing rules.