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Exploring the Neural Basis of Internal Environment Dependent Salt Preference from Imaging and Theory

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Summary

Animals prefer low concentrations of salt and dislike high concentrations of salt. However, it is known that extreme salt reduction leads to a preference for high salt concentrations. The brain basis for these salt concentration-dependent changes in preference has not been clarified. The basal ganglia control not only motor balance but also reward and aversive behavior, and decision-making. In particular, dopamine cells in the ventral tegmental area of the midbrain are known to code value information and release dopamine into the nucleus accumbens, the projection target. In the present study, to investigate the brain basis of concentration-dependent preference for salt, we recorded neuronal activity of dopaminergic neurons in the ventral tegmental area of mice by calcium imaging and dopamine imaging of the nucleus accumbens using fiber photometry.

In this study, we attempted to measure the aversive and rewarding effects of saline solution, which has been difficult to measure, by using a task in which normal water and saline solution are presented randomly. The results showed that under water restriction, the number of licking reactions to the high-concentration saline solution decreased compared to that to the normal water, while under salt restriction, licking reactions to the high-concentration saline solution increased compared to that to the normal water. This result indicates that both aversive and rewarding effects of salt can be measured using this task.

Fiber photometry recordings revealed that dopamine neurons in the ventral tegmental area and the dopamine release in the nucleus accumbens flexibly showed bidirectional excitatory and inhibitory response to water and salt intake in a state-dependent manner. These results indicate that fluctuations in dopamine released by dopaminergic neurons in the ventral tegmental area to the nucleus accumbens are associated with changes in salt preference that are dependent on the environment in the body.

The present results can be regarded as a homeostatic mechanism that attempts to maintain a constant internal environment. In the future, we will analyze the results using a mathematical model based on homeostatic machine learning and aim to theoretically reconstruct the concentration-dependent preference for salt.