Brain circuits and mechanisms for social learning: from emotion to cognition

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The brain's high energy demands reflect the complexity of its networks and the metabolic cost of sustaining synaptic plasticity and cognition. While neuronal activity has been extensively studied, the specific metabolic pathways underlying learning and memory remain less well understood especially in the context of neurodegenerative diseases.

In this project, we aim to identify the key metabolic substrates and pathways engaged during fear learning, using both self-experienced and observational learning paradigms in mice. Observational fear learning, in which a mouse acquires fear by witnessing a conspecific being conditioned, allows us to investigate how socially transmitted information impacts brain metabolism compared to direct experience. We further examine how contextual cues (social vs. non-social) regulate such processes.
To characterize the coupled metabolic profiles, we used liquid chromatography and tandem mass spectrometry (LC-MS/MS) to perform targeted metabolomic analysis on brain tissue collected after the fear conditioning. This allows for high-resolution mapping of metabolite distribution in brain regions implicated in fear memory, the amygdala, hippocampus, and prefrontal cortex.

Importantly, we extend our analysis to aged mice and a mouse model of Alzheimer's disease to assess how age and pathology alter metabolic engagement during learning. We hypothesize that specific disruptions in these pathways may underlie the cognitive deficits seen in neurodegenerative conditions.

This study integrates behavioral neuroscience with high-throughput metabolomics to offer new insights into how memory formation use energy. Our findings could help redefine the role of metabolism in learning and pave the way for metabolically targeted interventions for cognitive dysfunctions in both aging and disease.