Cortical networks guiding hunger-dependent attention to real and imagined food cues

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The goal of my laboratory is to understand how the needs of the body determine which sensory cues are attended to, learned, and imagined. In particular, we are investigating how natural and experimentally induced states of hunger modulate neural representations of sensory food-associated cues, and the consequences for obesity, binge eating, and other eating disorders. Previous studies support a simple model for hunger-dependent processing of food cues: During states of satiety, food cue information enters sensory neocortex but may not be relayed by cortical areas involved in selective processing of motivationally salient food cues, such as postrhinal cortex (POR). By contrast, during states of hunger, area POR may be attentionally 'primed' such that food cue information spreads from visual cortex through POR to subcortical areas that orchestrate food-seeking behavior. Such motivation-specific priming of cortical sensory representations may be caused by hunger-induced activation of hypothalamic AgRP neurons which, in turn, stimulate reward-related subcortical inputs to cortex.

Consistent with this model, human neuroimaging studies have identified temporal lobe cortical brain areas that respond more strongly to food-associated images than to other images during states of hunger. We are characterizing the influence of hunger on cortical area POR and other homologous brain regions in behaving mice, using novel tools for mapping and manipulating brain activity in identified neurons. We are assessing visual responses to food-associated, aversive, and neutral cues, in the same neurons across multiple daily sessions, each preceded by 24 hours of fasting or of free-feeding. We predict that states of hunger will selectively bias the evoked and ongoing activity of neural representations of food cues but not of other, non-food cues. We are visualizing the activity of hundreds of neurons in early visual cortex and in area POR, using novel methods for long-term, simultaneous two-photon calcium imaging across all cortical layers. We have established methods that will allow us to test whether the effects of fasting and refeeding on cortical activity can be mimicked by (1) rapid and reversible optogenetic activation of hypothalamic AgRP neurons, a manipulation known to trigger rapid food-seeking, and (2) by natural elevations in AgRP neuron activity (using optetrode recordings).

Together, these experiments will provide a novel conceptual and technical framework for investigating the neural pathways that underlie hunger-dependent processing of food-associated cues – a critical step towards novel, cell-type specific therapies targeting excess imagery of, and attention to, foods and food cues.