SCHOOL OF MEDICINE & DENTISTRY
UNIVERSITY of ROCHESTER

Neuroscience Graduate Program

Feb. 28th, 2022 at 1:00 pm
Advisor: Krishnan Padmanabhan, PhD

Presents
In a PhD Thesis Defense:

Emily Crosier

Investigating the Link Between Locomotion and Olfaction in Rodents: Utilizing Behavioral, Physiological, and Anatomical Approaches

SENSORY INPUTS INTEGRATE MOVEMENT RELATED SIGNALS TO CONTROL BEHAVIOR IN THE BRAIN. RECENT WORK SUGGESTS THAT EVEN IN PRIMARY SENSORY AREAS, NEURAL ACTIVITY CAN OFTEN REFLECT THESE MOVEMENT RELATED SIGNALS. PREVIOUS STUDIES HAVE SHOWN THAT LOCOMOTION, ONE OF THE GENERATORS OF MOVEMENT RELATED SIGNALS, CAN BE FOUND IN THE VISUAL AND SOMATOSENSORY SYSTEMS OF RODENTS. INTERESTINGLY, ALTHOUGH OLFACTION IS A MAJOR SENSORY MODALITY FOR RODENTS, THE EXTENT TO WHICH LOCOMOTION RELATED SIGNALS ARE FOUND IN EARLY OLFACTORY AREAS REMAINS UNKNOWN. THIS DISSERTATION DISSECTS COMPONENTS OF THE LOCOMOTION SIGNAL, INCLUDING HOW LOCOMOTION IS REPRESENTED IN THE NEURAL ACTIVITY OF EARLY OLFACTORY CIRCUITS IN THE MOUSE.

LOCOMOTOR BEHAVIOR IS INHERENTLY COMPLEX, VARYING DEPENDING ON A NUMBER OF FACTORS INCLUDING THE GOAL OF THE MOTOR COMMAND (FOR EXAMPLE FLEEING A PREDATOR VS TRACKING AN ODOR) AND THE SEX OF THE ANIMAL. LOCOMOTOR BEHAVIORS IN MICE ARE DIMORPHIC IN THE WILD, AND SOME EVIDENCE SUGGESTS THAT THESE BEHAVIORS ALSO SHOW SEX SPECIFIC DIFFERENCES IN VARIOUS LAB SETTINGS. TO EXTEND THIS LINE OF RESEARCH, IN CHAPTER 1, WE ASKED WHETHER DIFFERENCES IN MOUSE LOCOMOTION BEHAVIORS WERE PRESENT IN A HEAD-FIXED PARADIGM; AN EXPERIMENTAL SETUP COMMONLY USED IN THE LABORATORY. WE FOUND THAT SEX DIFFERENCES WERE PRESENT ON EARLY DAYS OF HABITUATION BUT BY DAY 4, THE SEX DIFFERENCES WERE DIMINISHED AND BOTH MALE AND FEMALE MICE WERE RUNNING A SIGNIFICANT AMOUNT OF TIME IN THE FORWARD DIRECTION. IN CHAPTER 2, WE NEXT ASKED IF THESE MOTOR SIGNATURES COULD BE FOUND IN THE ACTIVITY OF THE PRIMARY CELLS OF THE MAIN OLFACTORY BULB (MOB), THE MITRAL AND TUFTED CELLS. WE FOUND THAT THE OVERALL POPULATION OF MITRAL AND TUFTED CELLS HAD AN INCREASE IN FIRING RATE WHEN THE ANIMALS WERE RUNNING AS OPPOSED TO REMAINING STATIONARY. FURTHERMORE, WE FOUND THAT THERE WERE CELLS THAT WERE BOTH CORRELATED AND ANTICORRELATED WITH THE VELOCITY OF THE ANIMAL, SUGGESTING THAT PRINCIPAL CELLS IN THE MOB DIRECTLY RESPOND TO THE RUNNING BEHAVIOR OF THE MOUSE. FINALLY, IN CHAPTER 3, WE WISHED TO IDENTIFY THE ANATOMICAL CIRCUITY THAT LINKS THE BEHAVIOR OF LOCOMOTION TO THE PHYSIOLOGY OF LOCOMOTION-RESPONSIVE CELLS IN THE MOB. USING RETROGRADE TRACING TECHNIQUES, WE CHARACTERIZED THE CONNECTIVITY BETWEEN AREAS IN THE PRIMARY OLFACTORY CIRCUIT (MOB AND OLFACTORY CORTEX) AND AREAS SUCH AS THE VENTRAL CA1 REGION OF THE HIPPOCAMPUS, THE AMYGDALA, AND THE NUCLEUS ACCUMBENS. ALL OF THESE AREAS HAVE PREVIOUSLY BEEN SHOWN TO BE INVOLVED IN VARIOUS FEATURES OF LOCOMOTOR AND AFFECTIVE BEHAVIORS.

OUR WORK SUGGESTS THAT THE EARLY OLFACTORY CIRCUITS ENCODE MORE THAN JUST OLFACTORY INFORMATION AND THAT FEEDBACK FROM HIGHER ORDER BRAIN AREAS, INCLUDING VCA1, MAY BE RESPONSIBLE FOR ALTERING THE NEURAL RESPONSES IN THESE EARLY SENSORY REGIONS TO INFLUENCE THE ENCODING OF ODORS.

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