Project Details	
Project Code	NMH27Ex YZhang
Title	How sights become signals for learning
Research Theme	Neuroscience & Mental Health
Project Type	Wet lab
Summary	How does the brain discover that a sight predicts something important? This project will uncover the neural circuits that transform visual information into dopamine signals that teach the brain about motivation, action and decision-making. The student will use state-of-the-art in vivo electrophysiology, fibre photometry, fast-scan cyclic voltammetry, targeted optogenetic stimulation, behavioural tasks and computational modelling to record, control and predict learning in real time. This project addresses a fundamental question in neuroscience and provides advanced training in technologies relevant to Parkinson's disease and psychiatric disorders.
Description	Learning allows the brain to identify which sights, sounds or events predict something important. A previously meaningless visual cue can, through experience, become a powerful signal that guides attention, motivation and action. Dopamine is central to this process. It acts as a teaching signal in the brain and is strongly implicated in neurological and psychiatric disorders, including Parkinson's disease and psychiatric conditions. However, we still do not fully understand how sensory information is transformed into dopamine signals during learning. Our recent work suggests that the superior colliculus, a midbrain structure involved in visual salience and orienting behaviour, plays an unexpected role in this process (Zhang† et al., 2026, Nature Communications). We found that activity in the superior colliculus is required for dopamine responses to learned visual cues. This raises a key question: how does visual information gain access to dopamine learning systems? This PhD project will investigate how superior colliculus activity contributes to the emergence of dopamine responses during visual cue-reward learning. The project is designed around three focused aims, allowing the student to build a coherent body of work within a three-year studentship. In Aim 1, the student will determine how behavioural learning develops during a visual cue-reward task. Mice will learn that a visual cue predicts reward, while the student measures cue-evoked behaviour such as orienting, licking and movement. This aim will establish a clear behavioural framework and define different stages of learning. The student will be able to take ownership by refining the behavioural task, choosing the most informative behavioural readouts, and developing analysis approaches to quantify learning across trials and sessions. In Aim 2, the student will test how superior colliculus activity relates to dopamine signals during learning. The student will record neural activity and dopamine signals during the same visual learning task, using approaches such as in vivo electrophysiology, fibre photometry with neurotransmitter sensors, or fast-scan cyclic voltammetry. The exact experimental emphasis will be shaped by the student's interests and the direction of the project. The goal will be to determine whether changes in superior colliculus activity occur before, alongside or after the

	emergence of dopamine responses to learned cues. This aim will also include targeted optogenetic manipulation in selected experiments to test whether visual inputs and local circuits in the superior colliculus are required for cue-evoked dopamine signalling. The student will have scope to steer this aim towards circuit recording, dopamine measurement or causal manipulation. In Aim 3, the student will develop computational models to explain how visual cue information is transformed into dopamine learning signals. These models will use the behavioural and neural data generated in Aims 1 and 2 to test how sensory activity, learning stage and dopamine responses interact over time. The modelling work will help identify which features of the circuit best predict behavioural learning and dopamine signalling. This aim will give the student the opportunity to develop an independent analytical direction and to generate predictions for future experiments. The project will provide training in modern systems neuroscience, including behavioural analysis, in vivo recording methods, genetically encoded neurotransmitter sensors, optogenetics and computational modelling. Importantly, the project is structured so that the student can make meaningful progress by focusing deeply on one main experimental approach while gaining broader exposure to complementary techniques. The student will be encouraged to develop their own hypotheses, select key analyses, and shape the final direction of the project based on early findings. By revealing how visual information becomes linked to dopamine signalling, this project will address a fundamental question in neuroscience: how does the brain learn which sensory cues matter? The findings may also provide insight into disorders in which dopamine signalling, learning and motivation are disrupted.
Can be completed part time?	Yes
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