Action prediction error: a value-free dopaminergic teaching signal that drives stable learning

Animals' choice behavior is characterized by two main tendencies: taking actions that led to rewards and repeating past actions. Theory suggests these strategies may be reinforced by different types of dopaminergic teaching signals: reward prediction error (RPE) to reinforce value-based associations and movement-based action prediction errors to reinforce value-free repetitive associations. We use an auditory-discrimination task in mice to show that dopamine activity in the tail of the striatum encodes the hypothesized action prediction error signal. We show that dopaminergic input to this region is important for learning, and that dopaminergic activity during the task is movement-related. We go on to show that this movement-related dopaminergic activity encodes an action prediction error. Causal manipulations show that this value-free teaching signal can reinforce state-action associations, essentially biasing mice to repeat the actions that they have taken in the past. We propose a model where this movement-based teaching signal works in conjunction with canonical RPE signaling to boost and stabilize learning about consistent state-action associations.