Brain systems for action sequences

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Movement, language, and thought occur in streams of complex sequential patterns, a shared feature that has been called action syntax. Instinctive behavior of animals such as natural rodent grooming can be particularly useful for studying sequential patterns of behavior, due to its rich array of complex but predictable movement sequences, with features of action syntax. Rodent grooming has syntactic (rule-driven) sequences with holistic patterns of serial structure [1].

Evidence indicates that brain circuits containing the striatum and substantia nigra causally implement the syntactic sequence, and also code its serial organization in neuronal firing patterns [2;3]. Brain structures such as neostriatum and substantia nigra similarly help control the sequential pattern of normal human action, language and thought, and nigrostriatal dysfunction is linked to human disorders including obsessive-compulsive disorder, Tourette's syndrome, and Parkinson's disease. Indeed it has been suggested that sequencing functions of the striatum in human language/thought may derive from its evolutionary 'action syntax' role in sequencing instinctive actions, including rodent grooming. Our studies aim to clarify how brain systems carry out action syntax functions.

The syntactic behavior during grooming in rats is used to study the role of the basal ganglia in such natural sequential behaviors. Learning more about how neurons code sequential movement may have important implications for treatment and understanding of Parkinson's disease. Our research involves studies of neuronal activity in the basal ganglia. There is evidence that these regions play a role in controlling movement, as well as reward learning and interval timing. Our long-term goal is to understand how individual neurons and neuronal circuits in the basal ganglia might be contributing and processing information related to these processes. We evaluate movements in both normal states and in animal models that simulate human movement disorders. Our principal method is to record electrical activity of individual nerve cells while animals execute either instinctive movements or learned movements in response to sensory cues. From this information, we study the computational properties of neuronal networks activated during our experiments. In these experiments we also activate neural systems by the application of dopaminergic drugs that are known to affect behavior. Currently, our efforts are directed toward examining neuronal mechanisms related to sequences of grooming movements [4], reward learning [5], and the effects of dopaminergic manipulations [5-7]. Also we have studied how excessively rigid behavioral patterns can be caused, in mutant mouse and related models of obsessive compulsive disorder and Tourette syndrome [8]. Our goal is to better understand the brain link that connects animal instinctive actions to human language and thought.

Finally, we are also exploring the relation between action and emotion and motivation, including hedonic impact of sensory pleasures, in striatal processing. One interesting recent finding from our lab is that one region of the basal ganglia, the ventral pallidum, seems to have neural activity that especially represents things that taste "pleasant" or "good" [5;9;10].

Results in our studies indicate show that the brain neostriatum controls the sequential pattern of instinctive grooming behaviors by making action syntax patterns stronger. They also suggest that neostriatum roles in action syntax and patterning behavior may related in some ways to its roles in psychological functions involving emotion and motivation.

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