The Brain's Executive Is An 'Event Planner'

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Studies in which monkeys were asked to manipulate computer cursors for fruit juice rewards have revealed that the brain's "executive" center plans behaviors not by specifying movements required for given actions, but rather the events that will result from those actions.

The distinction is significant, said the researchers, because it yields new basic insight into a central function of behavioral planning in this higher brain region, called the lateral prefrontal cortex (PFC).

The researchers, led by Hajime Mushiake of Tohoku University School of Medicine, reported their findings in the May 18, 2006, issue of Neuron. They concentrated on a brain region called the lateral prefrontal cortex (PFC), which many studies have shown to be involved in such higher brain functions as planning. However, noted the researchers, few studies have analyzed the specific nature of the behaviors that are planned.

"To achieve a behavioral goal in daily life, we often need to plan multiple steps of motor behavior that involve selection of a series of actions," wrote the researchers. "The question arises: how are individual neurons within the PFC involved in the planning of multistep behaviors? More specifically, does the activity of PFC neurons during the process of planning reflect the multiple movements required during future actions or the individual future events that occur as a result of the actions?"

To study the detailed activity of neurons in the lateral PFC during

planning, the researchers fitted monkeys with recording electrodes that could measure activity in the region's neurons.

They then taught the monkeys to perform a complex task in which the animals were required to manipulate joysticks to move a cursor on a computer screen from a starting point to a goal. Importantly, the researchers required the monkeys to maneuver the cursor within a maze to reach the goal and to perform those maneuvers in a discrete stepwise fashion with pauses in between. This stepwise approach enabled the researchers to distinguish whether the lateral PFC neurons were active during planning the movements or planning the events that would result from those movements.

"We found that neurons in the lateral PFC exhibited substantial changes in activity during a preparatory period in which monkeys were required to plan multiple steps of motor behavior," concluded the researchers. "Neuronal activity during the preparatory period predominantly reflected intended (future) movements of a cursor along a particular path within a maze to reach an intended goal. All cursor movements that had to be prepared . . . to reach the goal were reflected by the activity of the PFC neurons. In contrast, very few PFC neurons (9%) reflected the intended arm movements during the preparatory period," they concluded.

"When we plan multiple steps of actions in daily life, we usually do so by consciously arranging future events that we expect to occur as the consequence of actions in a particular temporal order; we rarely consider the temporal sequence of motor actions themselves," wrote Mushiake and colleagues. "The properties of PFC neurons that we observed in the present study are compatible with behavioral planning based on future events.

"If we assume that planning for multiple movements in monkeys is analogous to that in humans, it follows that PFC neurons in the monkey

brain process information for future events in a prospective manner to generate action plans based on a series of events during the course of reaching a behavioral goal," they wrote.