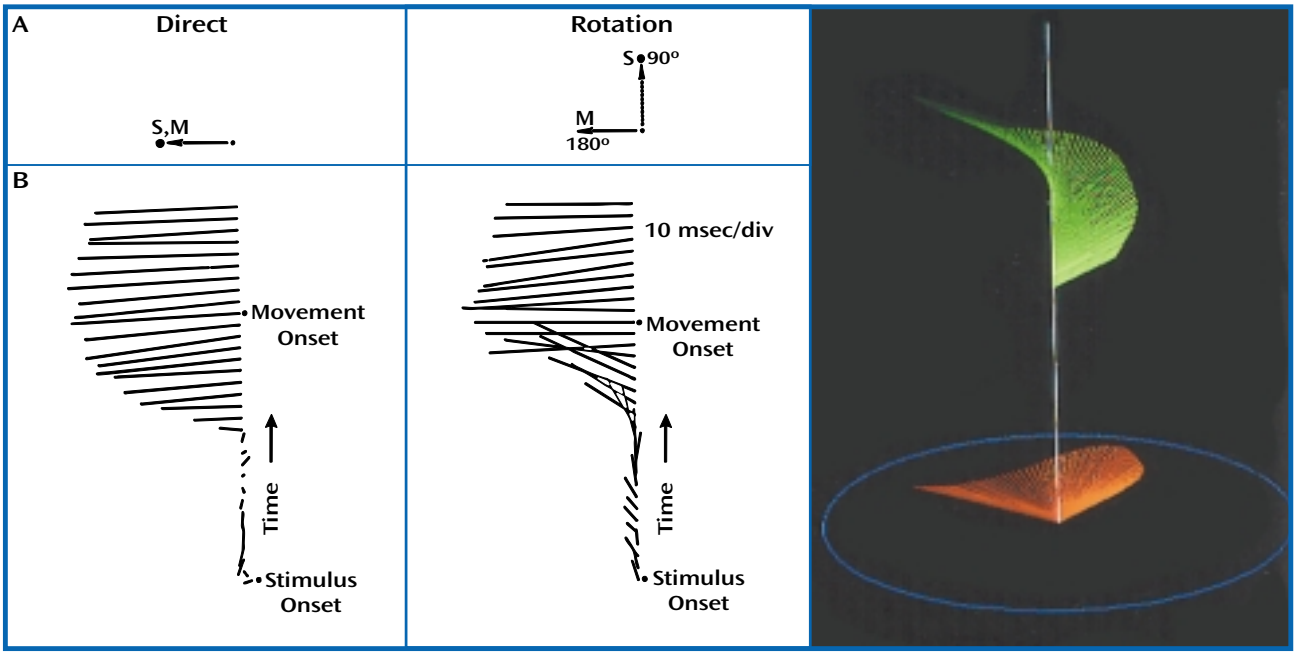
Carol A. Tamminga, M.D., Editor

Cognition



Results from a direct movement (left panel) and a rotation movement (middle panel). S is the location of the stimulus and M the direction of the movement in row "A". Row "B" shows representations of neuronal population vectors calculated every 10 msec from the onset of the stimulus until after the onset of the movement. When the population vector lengthens, for the direct movement (left panel) it points in the direction of the movement, and for the rotation movement (middle panel) it points initially in the direction of the stimulus and then rotates counterclockwise and points in the direction of the movement. The right panel illustrates brain activity during mental rotation; the neuronal population vector (green) rotated gradually counterclockwise as the monkey was thinking (the white line upward represents the progression of time).

Mental Rotation

Cognitive neuroscience seeks to identify brain events underlying cognitive operations. Scientists already know that the activity of single cells in specific areas of the cerebral cortex changes during the performance of particular tasks, presumably in association with the task. The figures above represent neuronal vector firing changes in the motor cortex of a monkey that are associated with the cognitive operation of mental rotation (moving a handle in a direction at an angle to the stimulus). The direction of a movement in space can be represented in the motor cortex as a "neuronal population vector"; a population vector is the weighted vector sum of contributions of directionally tuned neurons. In the example represented above, a monkey was trained to move a freely movable handle either toward a light stimulus (left panel) or at a 90° angle away from the stimulus (middle panel). Individual recordings from neurons in the motor cortex are consistent with the idea that the directional transformation required by the task was achieved by a counter-clockwise rotation of an imagined movement vector (right panel). This process is reflected in the gradual change of activity of motor cortical cells, which leads to a gradual rotation of the vectorial distribution of the neuronal ensemble and population vector. These changes in cortical neuronal firing subserve the cognitive task required of the monkey.

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