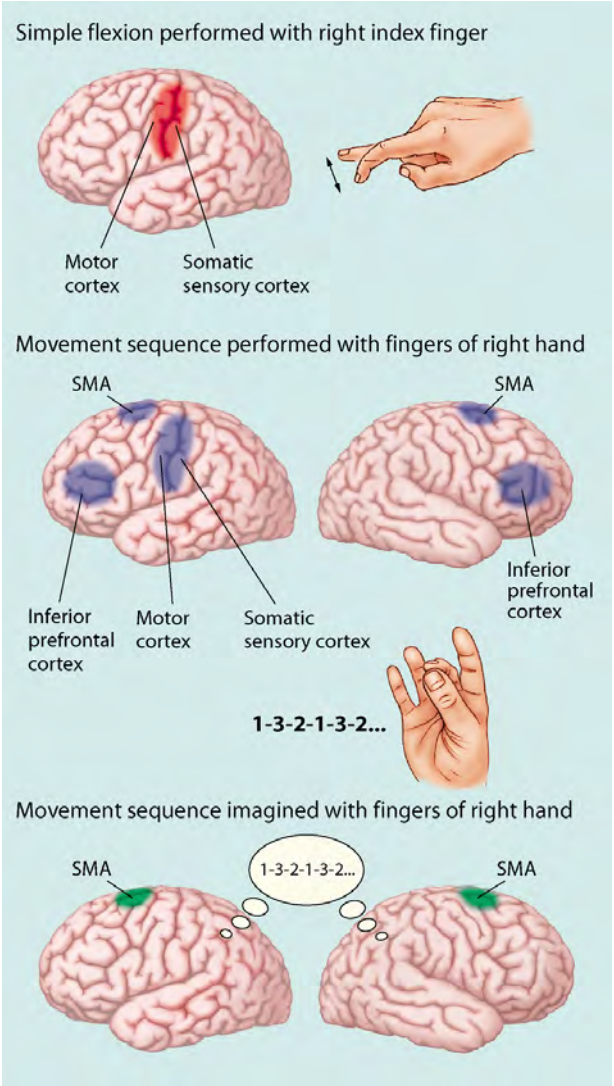
10/18

**Population vector is responsible for direction of motion**

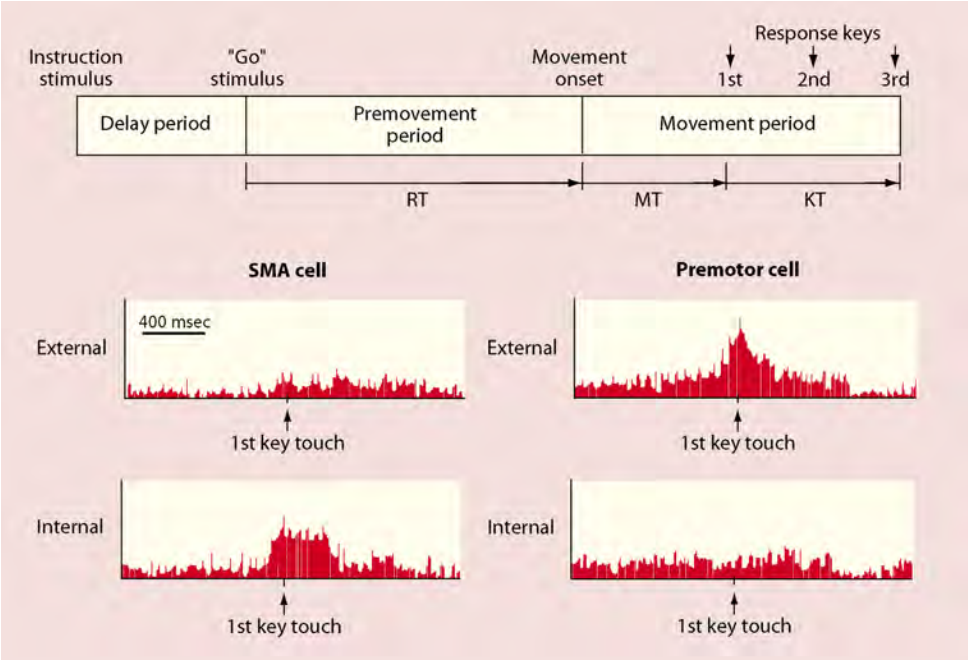
- Population vector: action or intention?
- One is the time to the exactly the action happening or the intention of the movement
- Subsequent direction of the monkey
    - Money was given cue signal, light going on, monkey trained to withhold movement until signal was given, moved joystick once go signal (beep) is given
    - Recording from neurons and then getting response to calculate population vector of that region of the cortex → which way its pointing and the length of the response
    - During delay period, close to go signal, population vector is already computed → it is intention during the delay period
    - INTENTION
    - Before go signal, neurons are still active in that direction → intention
    - There is variability → the movement is result of population vector
    - Taks about 100 mm for neurons to compute the motor plan

**Motor Planning vs Execution**

- Execution of any movement depends on motor plan being executed and existing moto cortex
- Hierarchical ideas
    - Primary and somatosensory activated for simple movements
    - Complex: supplementary motor and prefrontal cortex
    - Imaging movements: only SMA (abstract motor plan)
- Evidence from TMS study
    - Over motor cortex: movement halted or wrong key pressed
    - Over SMA: delayed movement
- Lying in fMRI asked to flex fingers of right hand, activities recorded over cortex → cortex highlighted is what is being activated
    - Precentral and postcentral gyrus, motor cortex in the left hemisphere and somatosensory cortex (bc stretch receptor is activated whenever you move)
    - When you move your body, it starts with the idea to move a part of the body, then motor and somatosensory cortex is activated
    - When move your arms, you know what it is moving bc of the stretch receptor

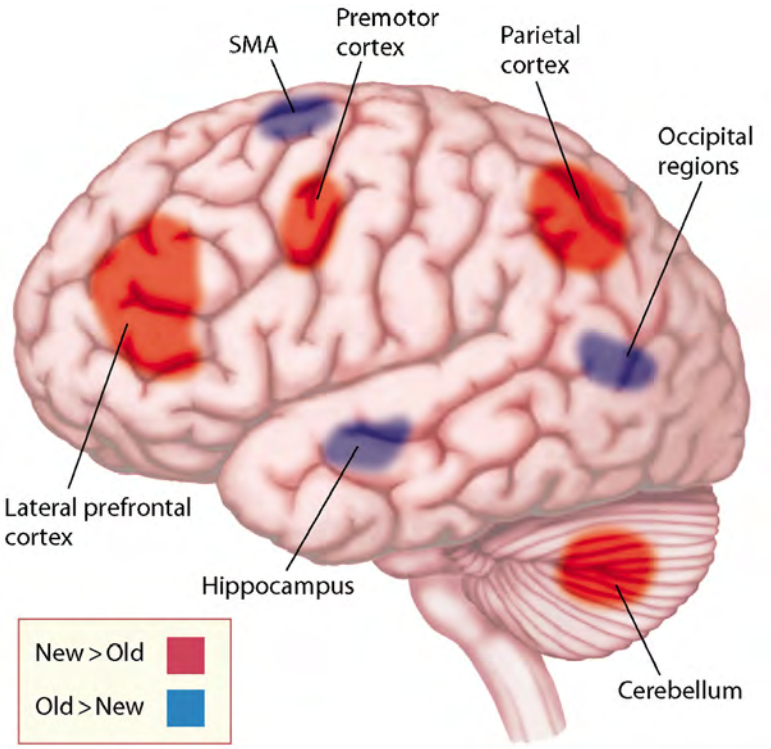


- In scanner, given sequence of particular motions to execute (pinky, ring, index ect)
    - More complex
    - Prefrontal gyrus, contralateral hemisphere, motor and somatosensory cortex, primary motor function, area SMA that lies anterior to primary motor region (not tied to particular part of the body, contributed to motor plan)
- In scanner, asked to withhold any movement, imagine performing movements
    - SMA activated, supplementary motor area
    - Why is there no action in the motor and somatosensory cortex? → bc there is no physical movements
    - Vortexes are responsible for actual movement
    - SMA is responsible for idea of movement , planning
- Internal vs External Guidance
    - Internal → SMA, internal factors
        - Internalized movements, no reliance on external information, know where cup it = no longer externally guided
        - SMA cell →
    - External → PMC (visually guided), heavily dependent on external movement
        - To execute movement, need to know where the item is to grab it, sports
        - Premotor cell →
    - Contribute different computations to movements




    - Measured SMA cell and premotor cell
    - Give monkey something to do, monkey responds when there is a beep
    - Externally guided movement, three buttons, press lit up button
    - Internally guided movement, monkey taught a sequence in which the buttons need to pressed in a specific way

    - SMA cell during externally guided continues to fire at baseline through delay, premovement, movement
        - Modulated activity for the internally guided movement
        - Fires vigorously for internal movement
    - Premotor cell → opposite than SMA
    - SMA is involved in internally guided movement, premotor cells are involved in external movement
    - This is double association experiment → strong inference in different movements
- Effects of learning
    - New sequences: lateral premotor and prefrontal cortex
    - Previously learned sequences: activate SMA and hippocampus
    - Parallel circuits contributing in the brain
    - When participants lying in scanner, learning particular motor task (sequence)
    - Researchers divided experiment into new part (just learning to execute sequence) and old (learned info), conducted subtraction method in comparison
    - Red → regions activated when new, blue → regions activated when old
    - Turning from external guidance to internal guidance
    - SMA = old info, premotor = new info




- Parallel Circuits
    - Parietal, lateral premotor (and cerebellar) → spatially directed or guided movement

        - Dominate in early acquisition
    - SMA (and basal ganglia) → when skills is learned and driven by internal representation
- Functional analysis
    - What contribution a particular region has through brain function and behavior
    - Lesion method
- Movement disorders
    - Hemiplegia → loss of voluntary movement, reflexes return (hyper), spasticity (increased muscle tone)
        - No primary motor cortex, computer program written but no signal given to muscles from PMC, not receiving muscle
    - Apraxia (left hemi, parietal) → loss of motor skill (not muscle related)
        - Inconsistent movement with planned action
    - Parietal cortex → related to execution of the movement more than computation of the plan,
- Cerebellum
    - Packs insane amount of neurons, contributed to motor control
    - Vestibulocerebellum → balance, VOR
    - Spinocerebellum
        - Just above the spine
        - Sensory info from spinal cord
        - Receives info where muscles are, the muscles state
        - Also from auditory/visual
            - Polysensory
        - Output to spinal cord and motor cortex
    - Neocerebellum
        - Innervated by cerebral cortex and goes back to the cortex  via thalamus
        - Newer part of cerebellum
    - Cerebellar lesions
        - Vestibulocerebellum → affects balance
        - Spinocerebellum
            - Smooth control of action (especially axial muscles, body and trunk), alcohol
            - Hypermetria → good initiation, but clumsy, irregular erratic
            - Effects execution of movement
        - Neocerebellum → similar to spinocerebellum but with prolonged initiation (planning role)
    - Cerebellar function
        - Not clear! It receives a lot of inputs
        - TIMING HYPOTHESIS (conductor) → goal of function is to send out outputs to cortex and muscles and finetune the timing of that, activate muscle at just the right time for the movement to be smooth and accurate
            - When we make movement, we ordershoot a little and then correct
        - Coordinate timing, conductor, make things happen just at the right time