Dynamic Field Theory

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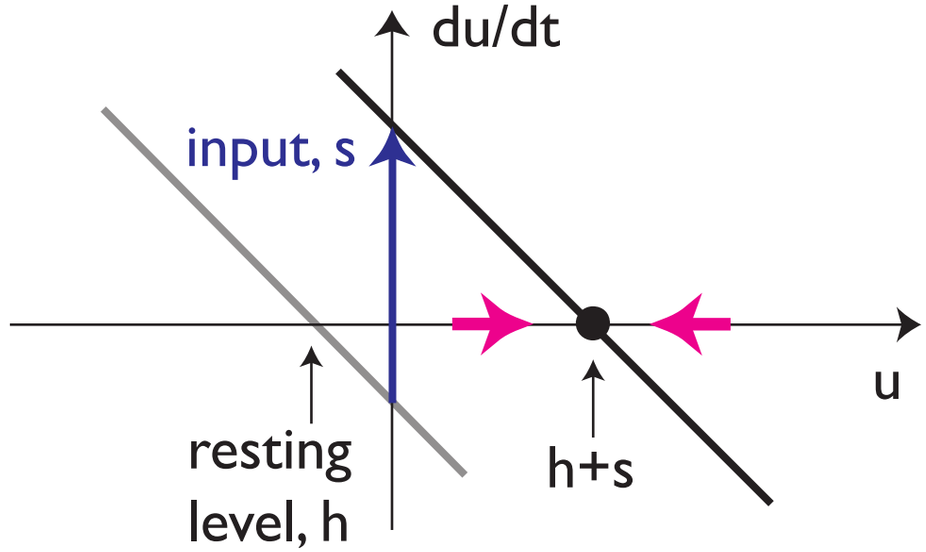
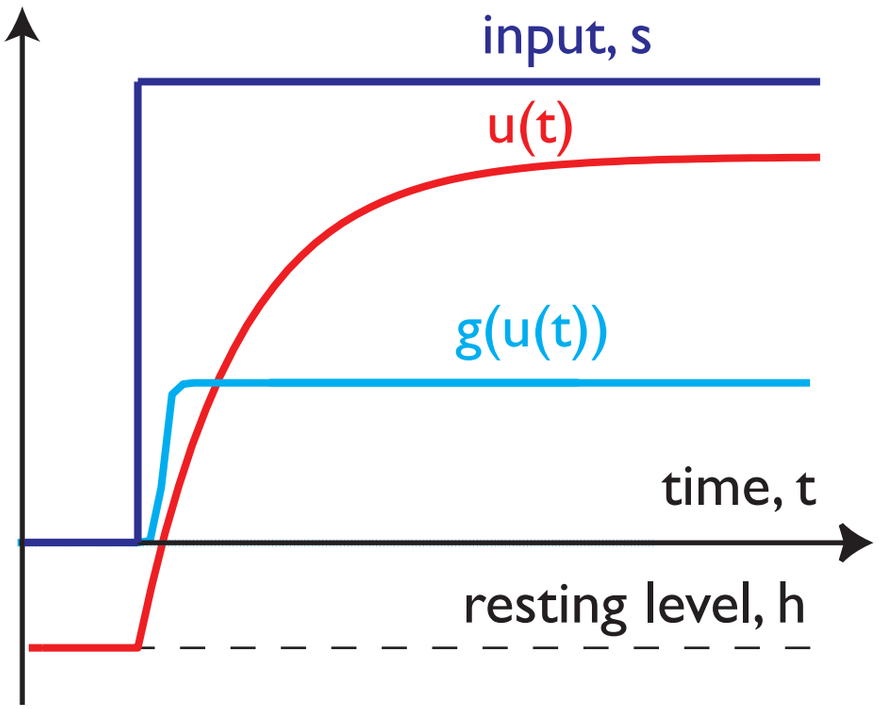
Neural dynamics



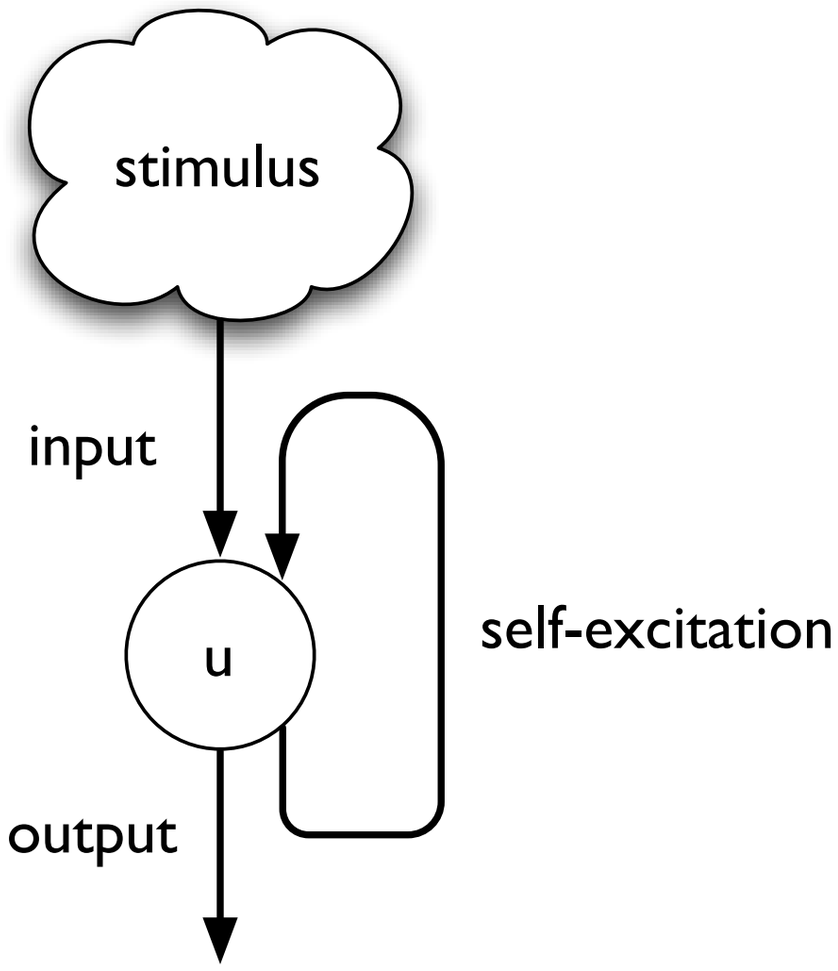
- activation dynamics of individual "neurons"

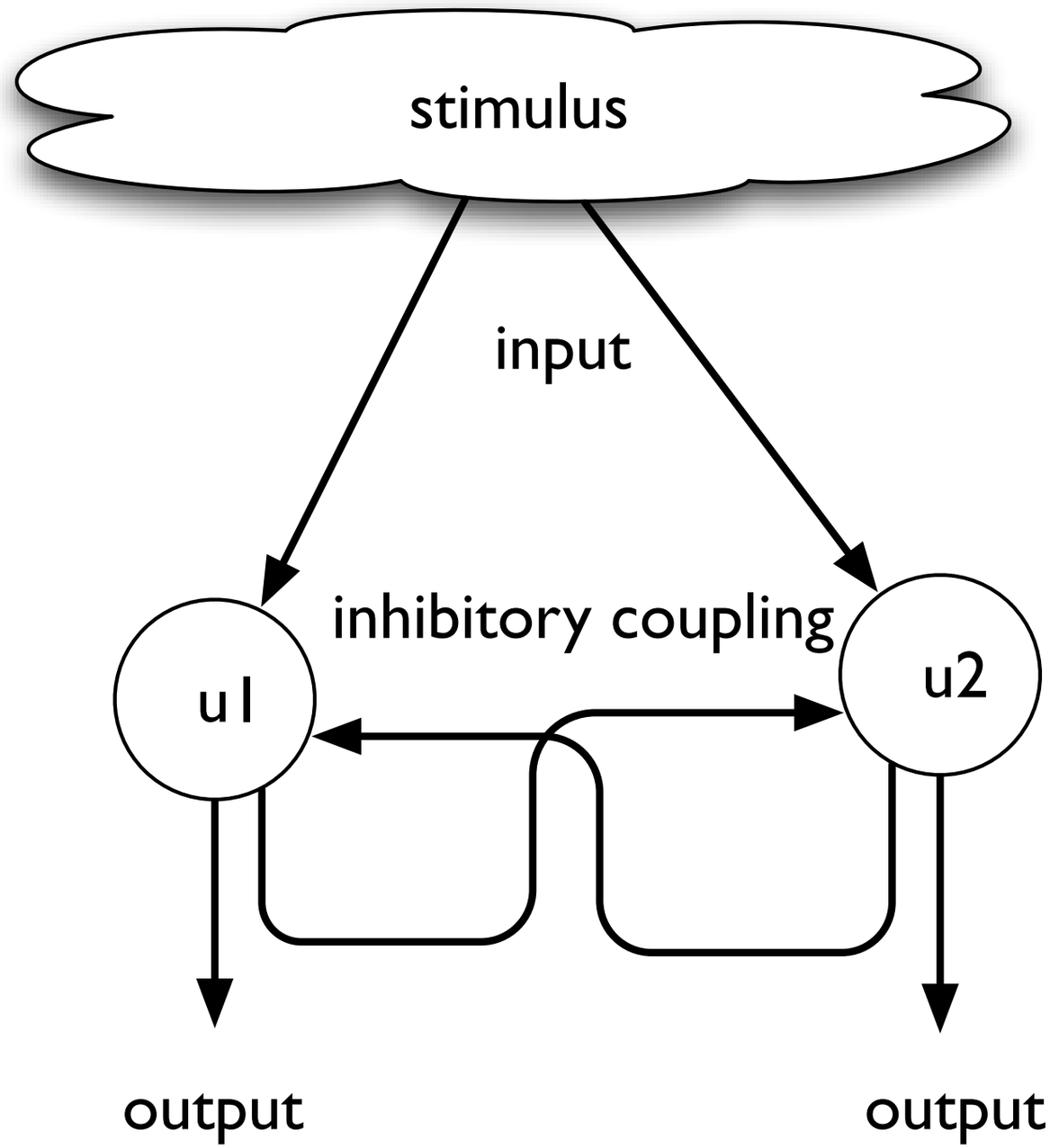


$$\tau \dot{u}(t) = -u(t) + h + \text{ inputs(t)}$$

Neural Dynamics

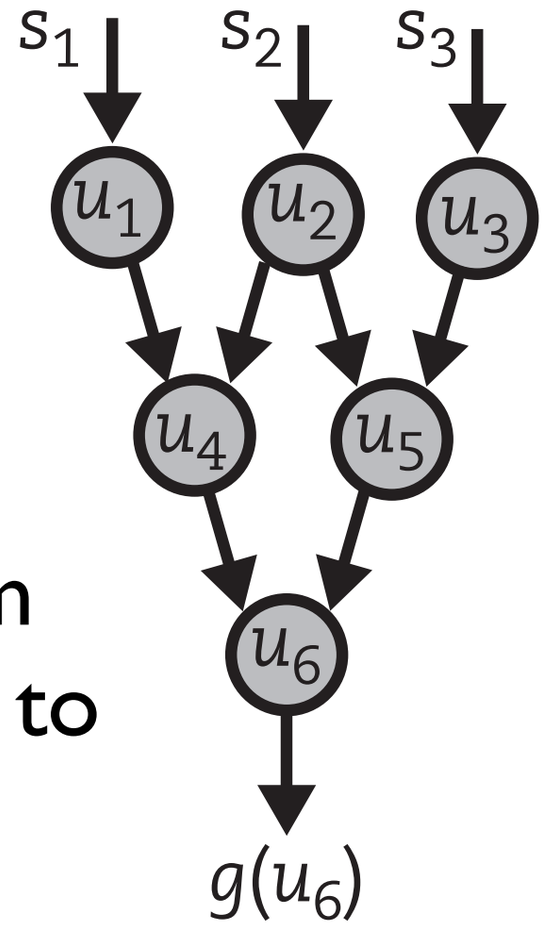
- dynamic neural "networks" consisting of one or two neurons





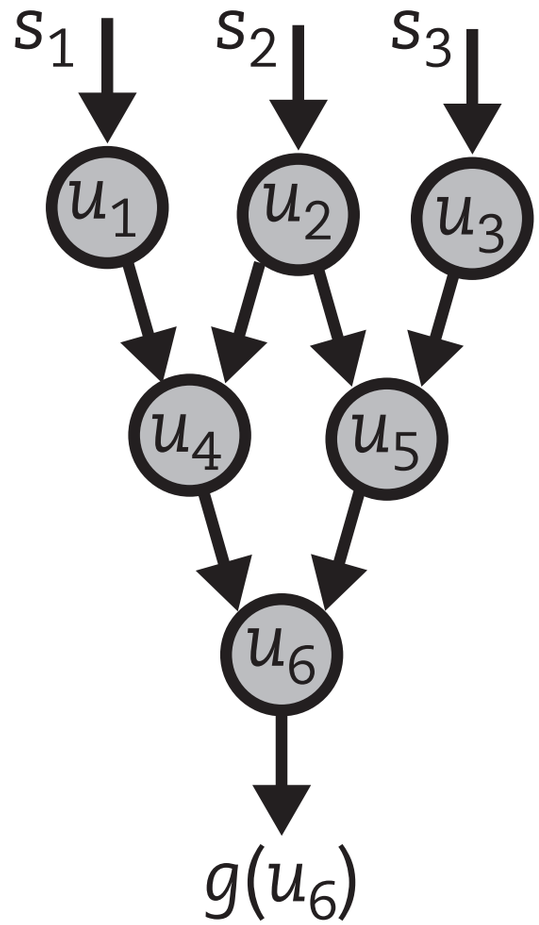
… toward fields

- where do "inputs" come from…?
  - from sensory systems
  - from other neurons
- => activation variables gain their meaning from the connections from the sensory surfaces or to the motor surfaces



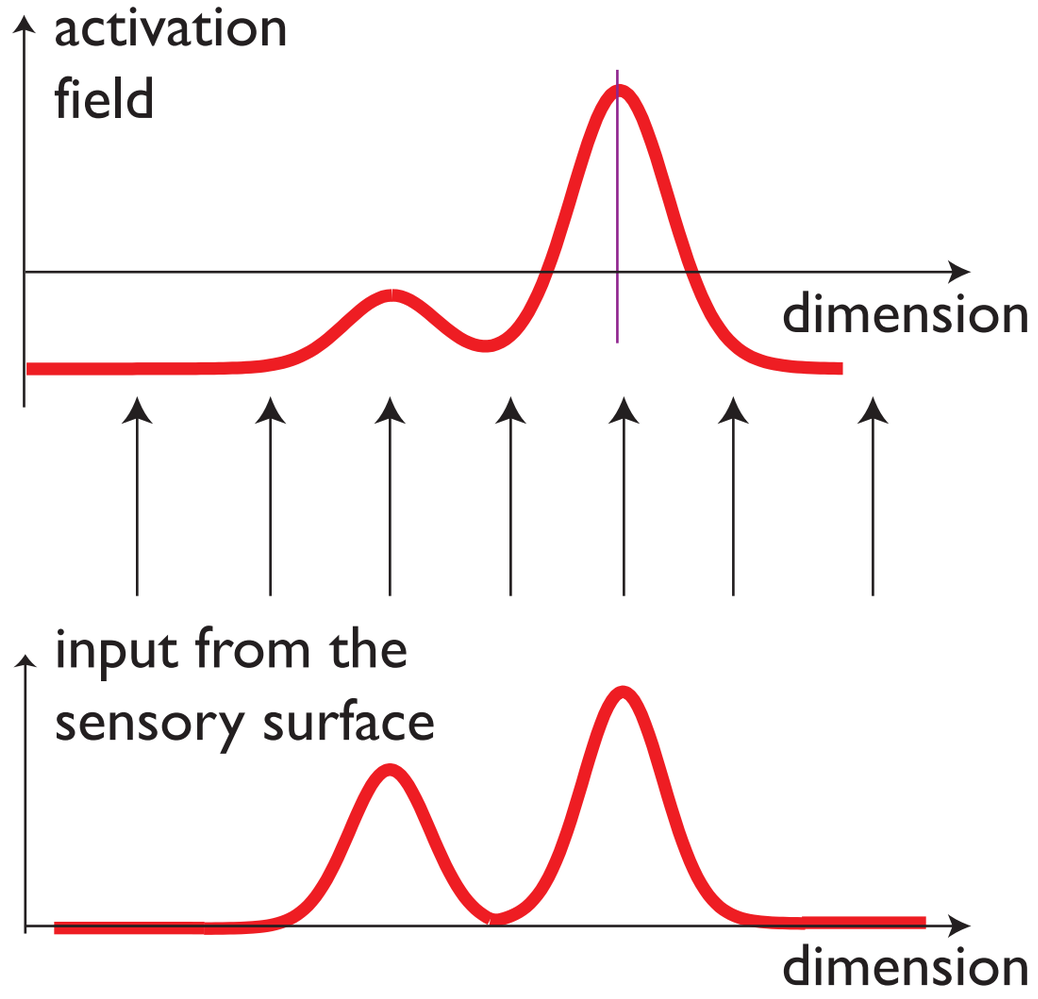
… toward fields

- there is no behavioral evidence for discrete sampling…
- => abstract from discrete sampling…



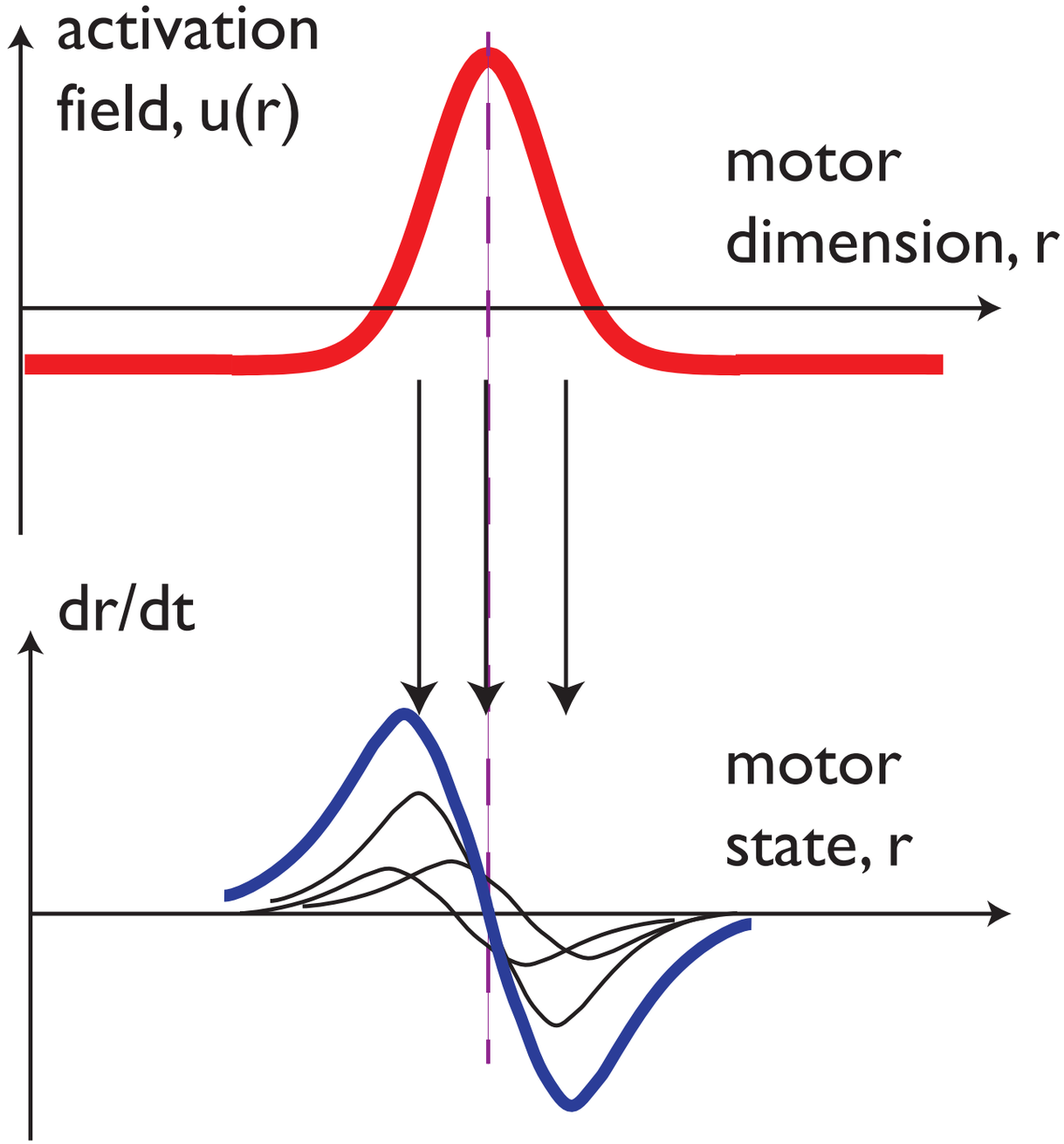
… toward fields

- define field is over the continuous stimulus dimension
- … as dictated by input/output connectivity…

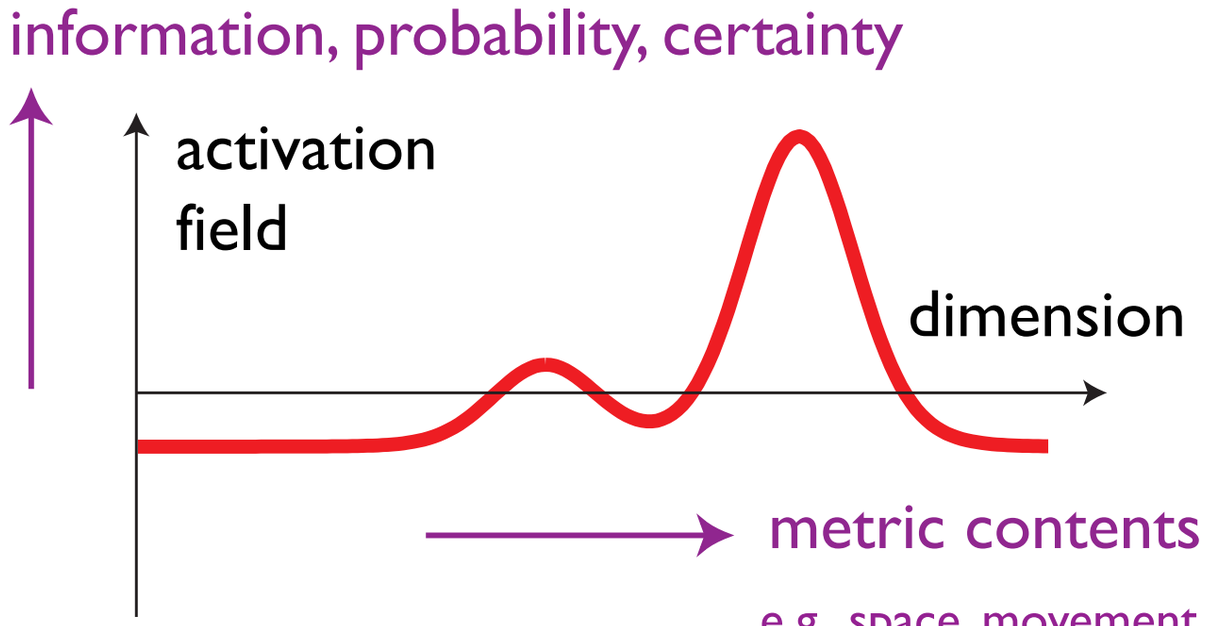


… toward fields

- or by forward projections onto motor surfaces…
- => behavioral dynamics
- e.g., through peripheral reflex loops

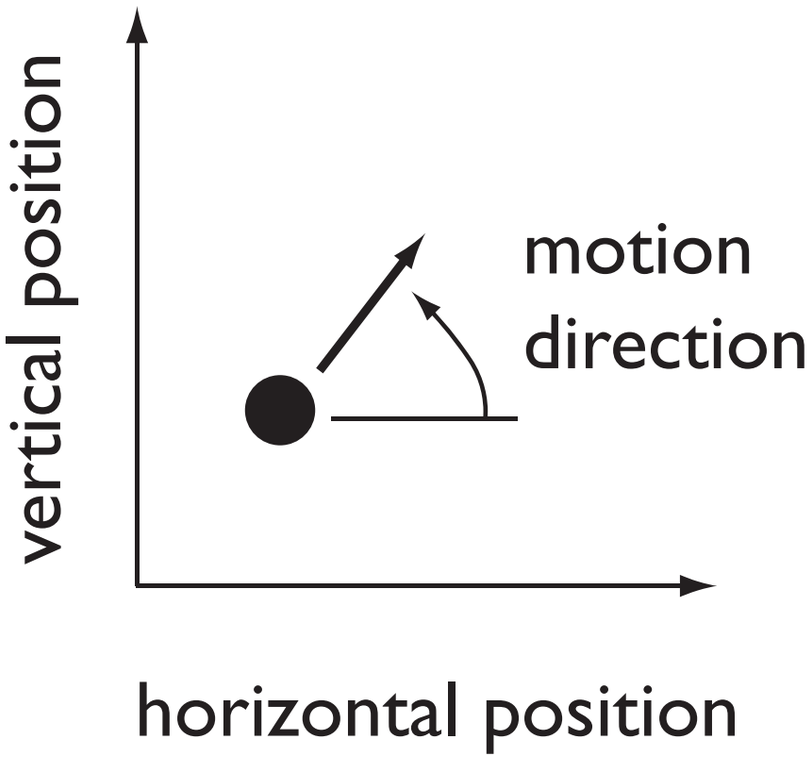


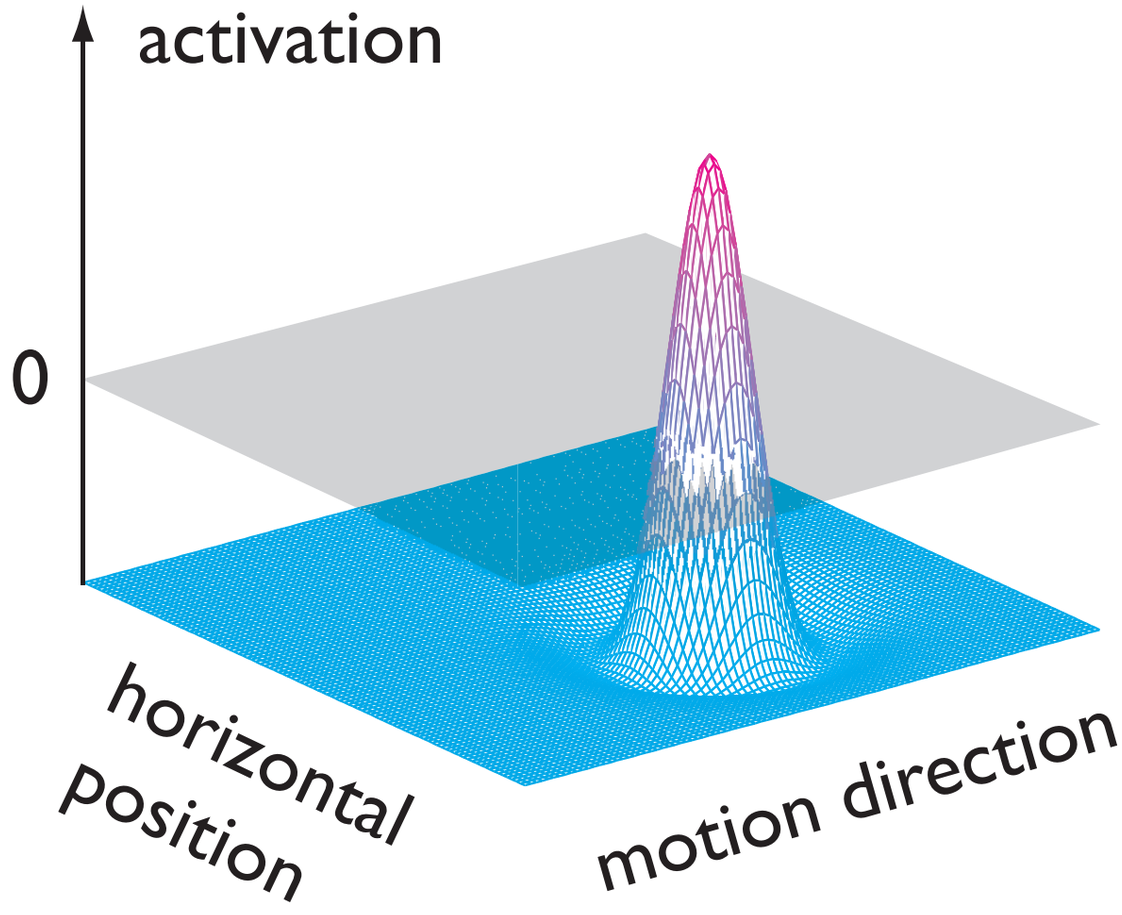
activation fields



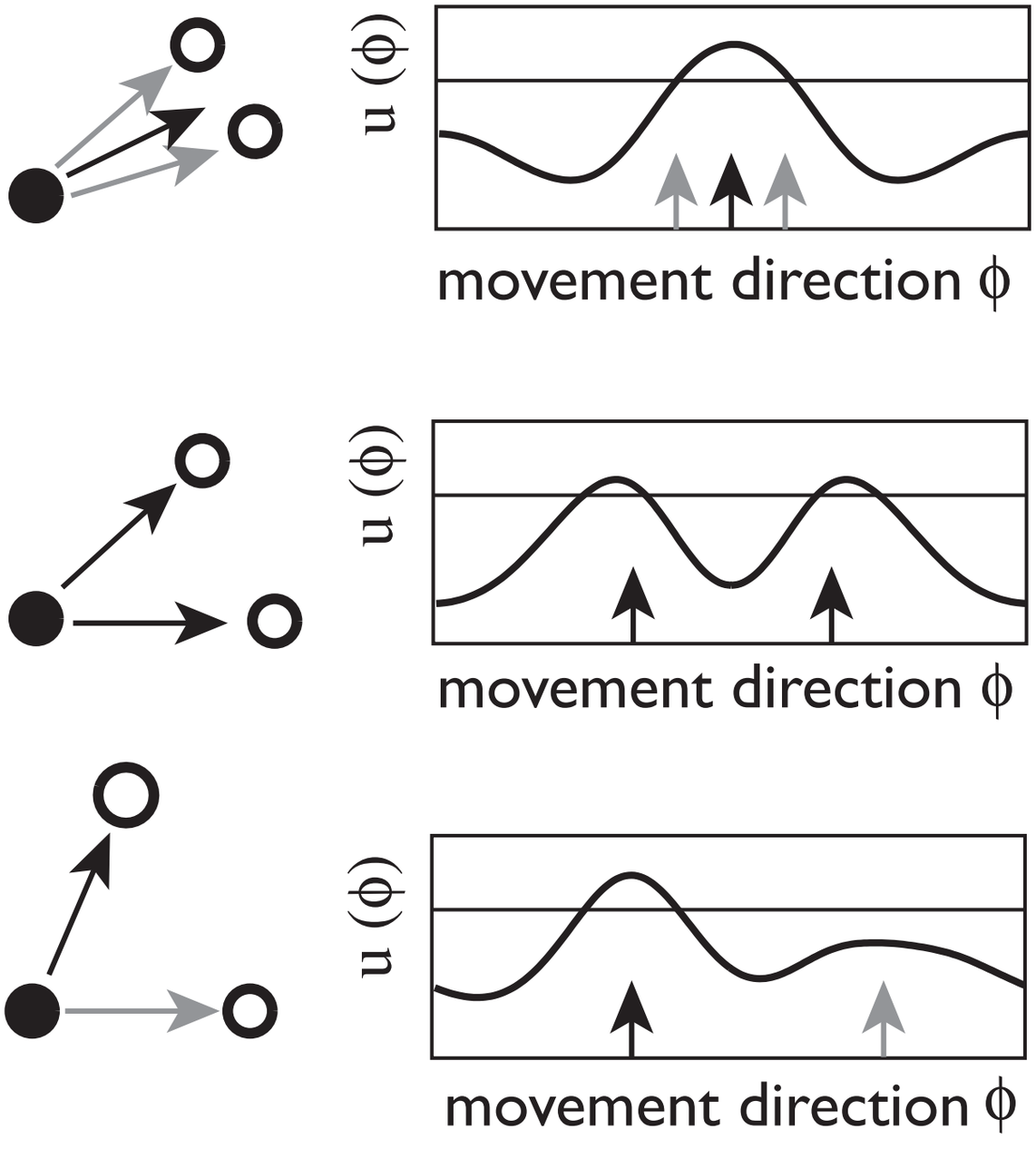
- define activation fields over continuous spaces
  - homologous to sensory surfaces, e.g., visual or auditory space (retinal, allocentric, ...)
  - homologous to motor surfaces, e.g., saccadic end-points or direction of movement of the end-effector in outer space
  - feature spaces, e.g., localized visual orientations, color, impedance, ...
  - abstract spaces, e.g., ordinal space, along which serial order is represented

Example motion perception: space of possible percepts

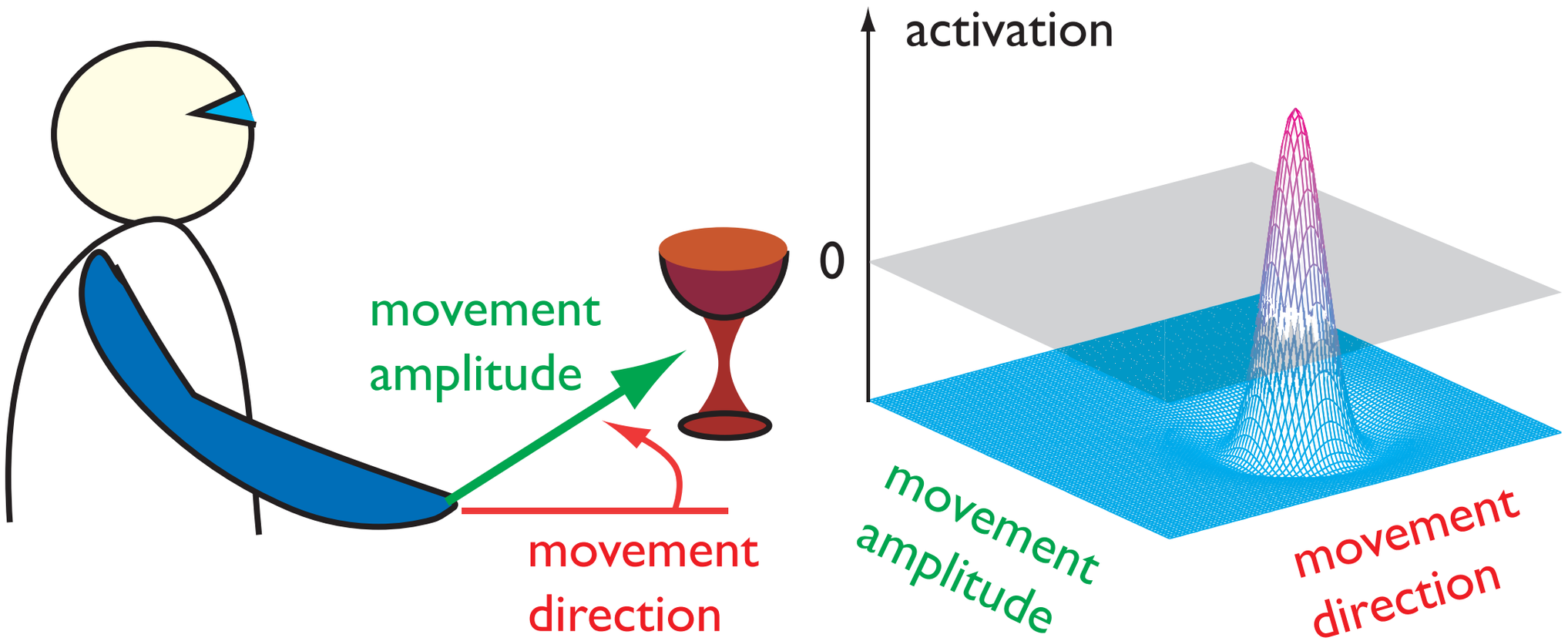




Activation patterns representing different percepts

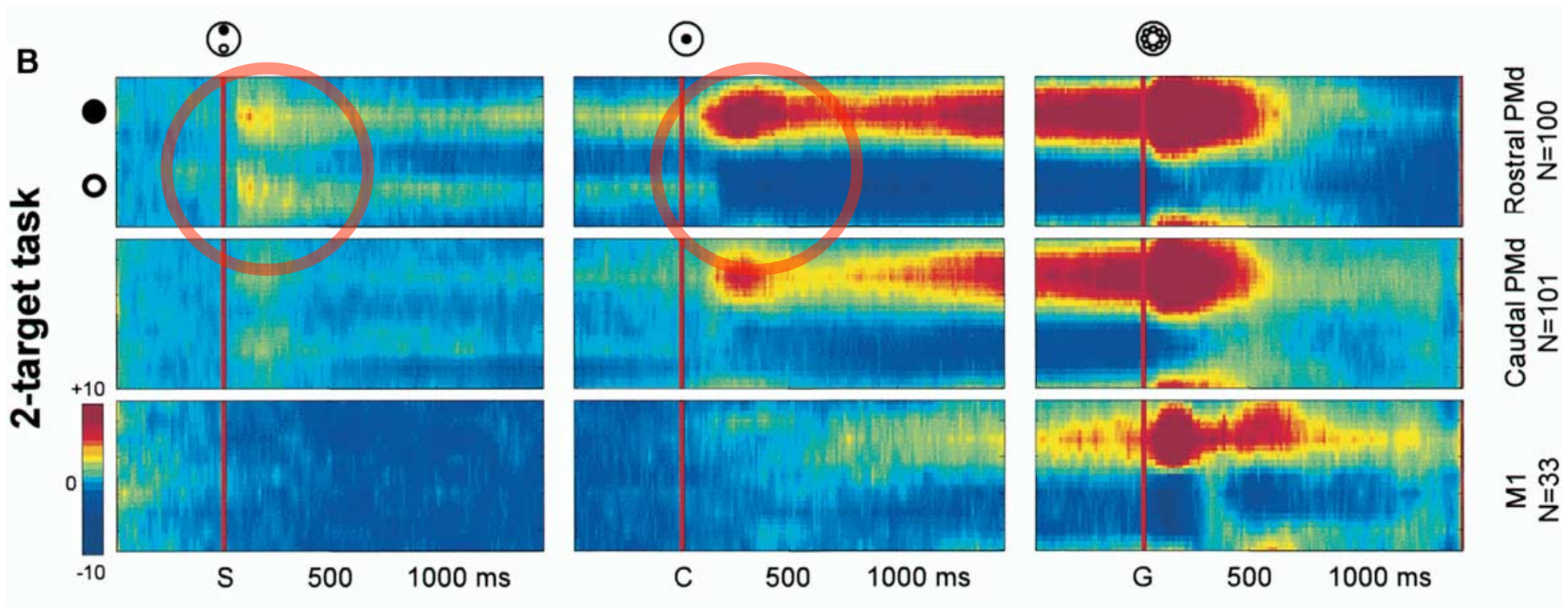


Example: movement planning: space of possible actions



Activation patterns representing states of motor decision making

- bi-modal distribution of activation over movement direction in pre-motor cortex before a selection decision is made
- mono-modal distribution once the decision is made



[Cisek, Kalaska: Neuron 2005]

Summary: activation fields