Embodied nervous systems

Gregor Schöner

Braitenberg vehicles

■ =embodied nervous systems with:

■ effectors
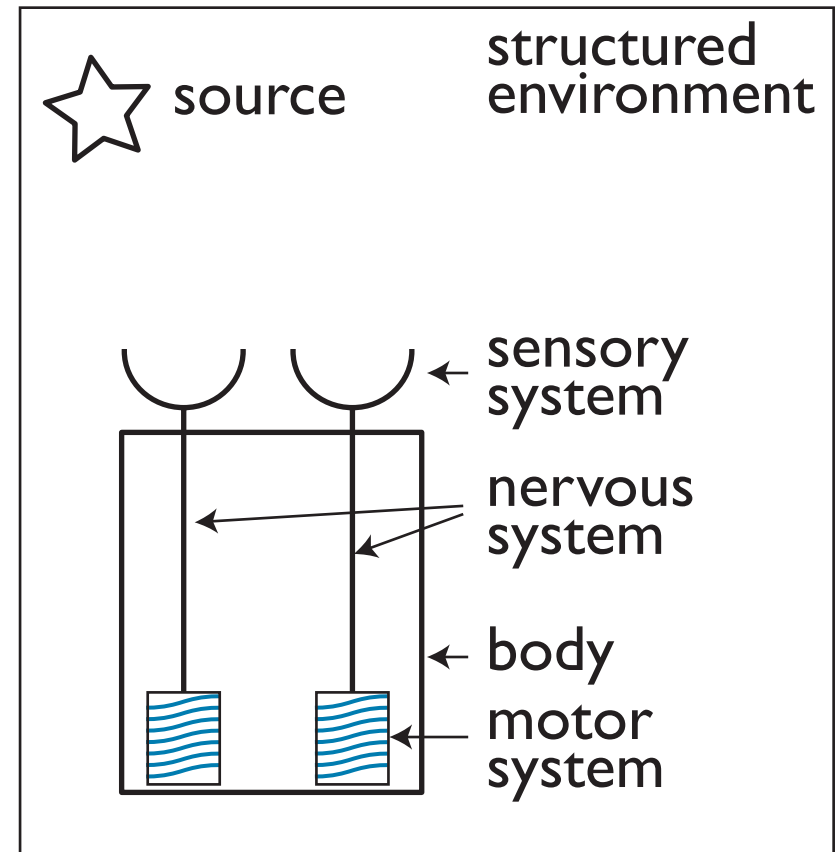
■ sensors

■ a nervous system

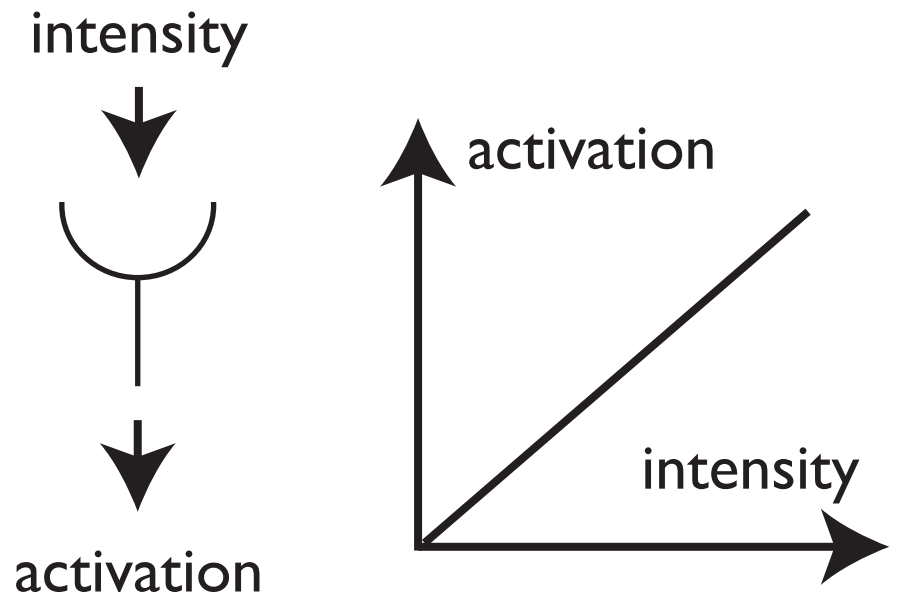■ a body

■ + situated in a structured environment

■ = emergent function

Sensors

- defined by sensor characteristic =relationship between

- the physical stimulus intensity

  - e.g., sound, luminance, chemical concentration, mechanical pressure....

- and an activation variable
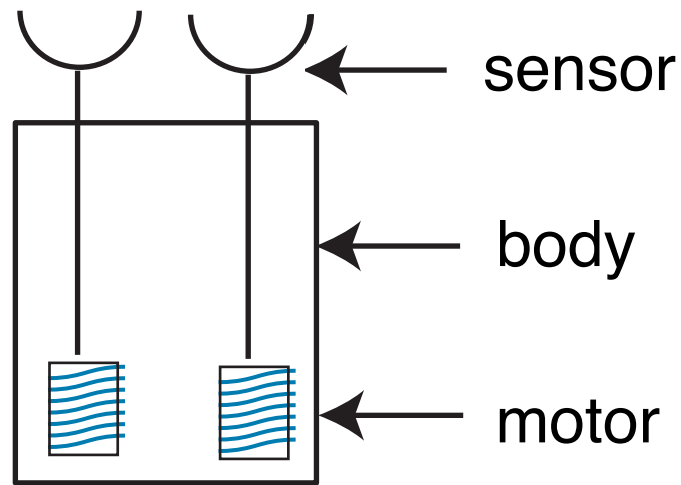
intensity

activation

activation

intensity

Effectors

- defined by the motor characteristic =functional relationship between

- an activation level

- and a physical effect generated

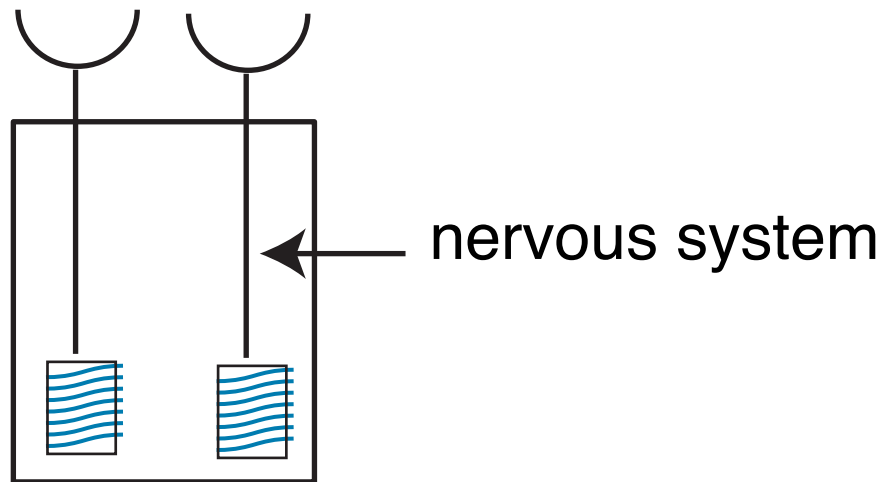 - for example: turning rate (rotations per minute rmp), force level, stiffness, ...)

activation

movement

movement

activation
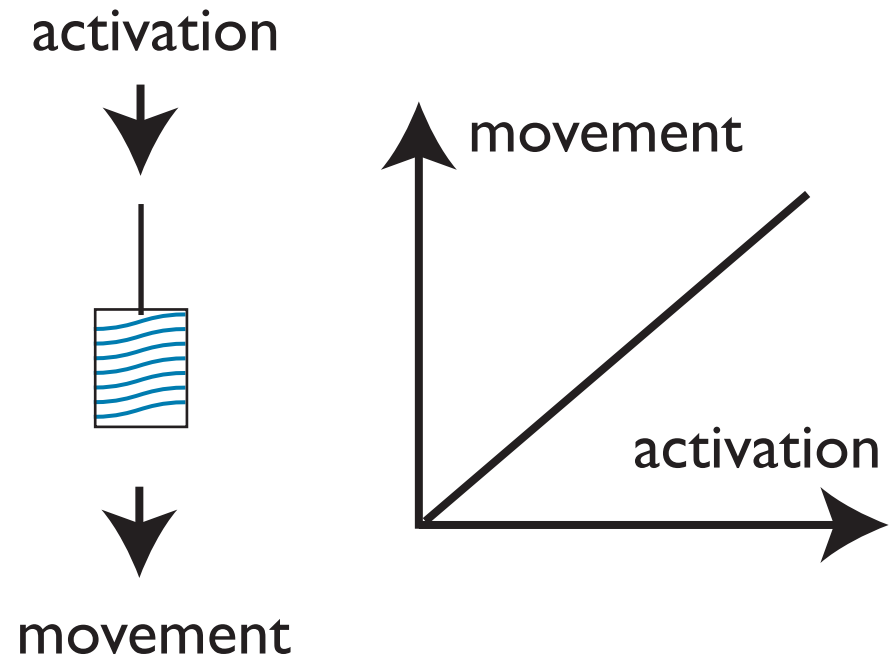
Body

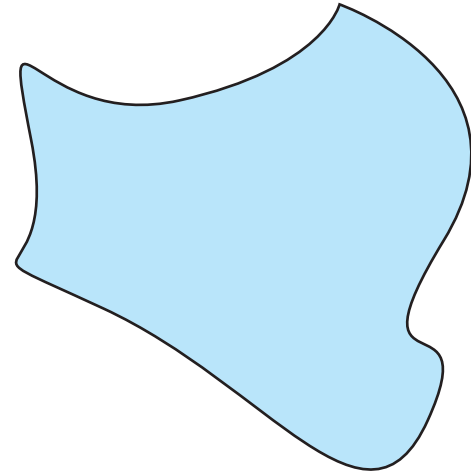- the body links the sensors and effectors mechanically

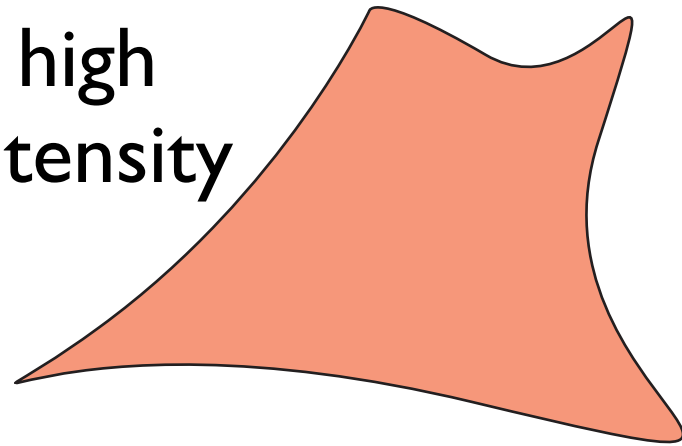# Nervous system

- links sensors to effectors
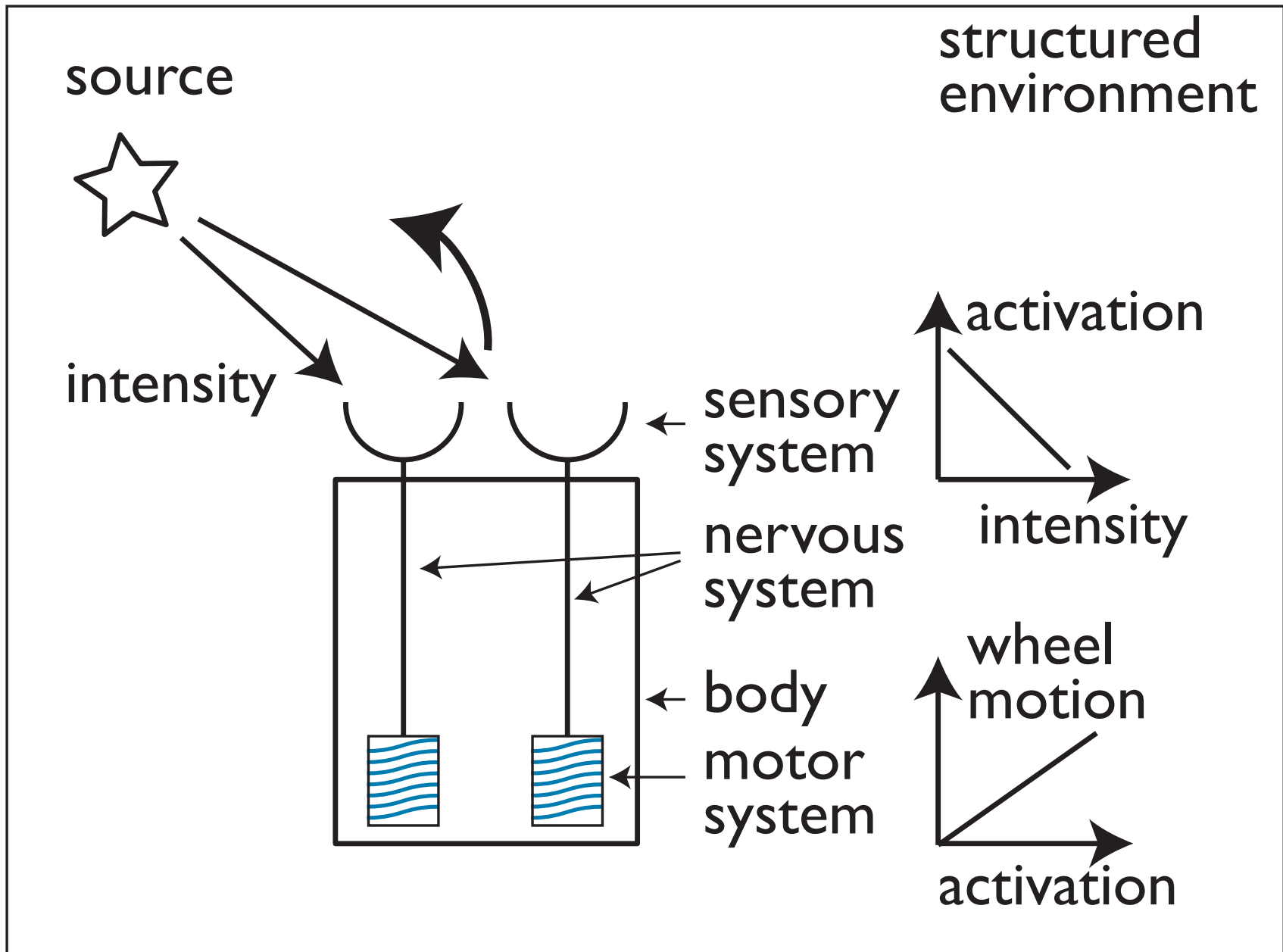
nervous system

Environment

low
intensity

non-homogeneous with
respect to the physical
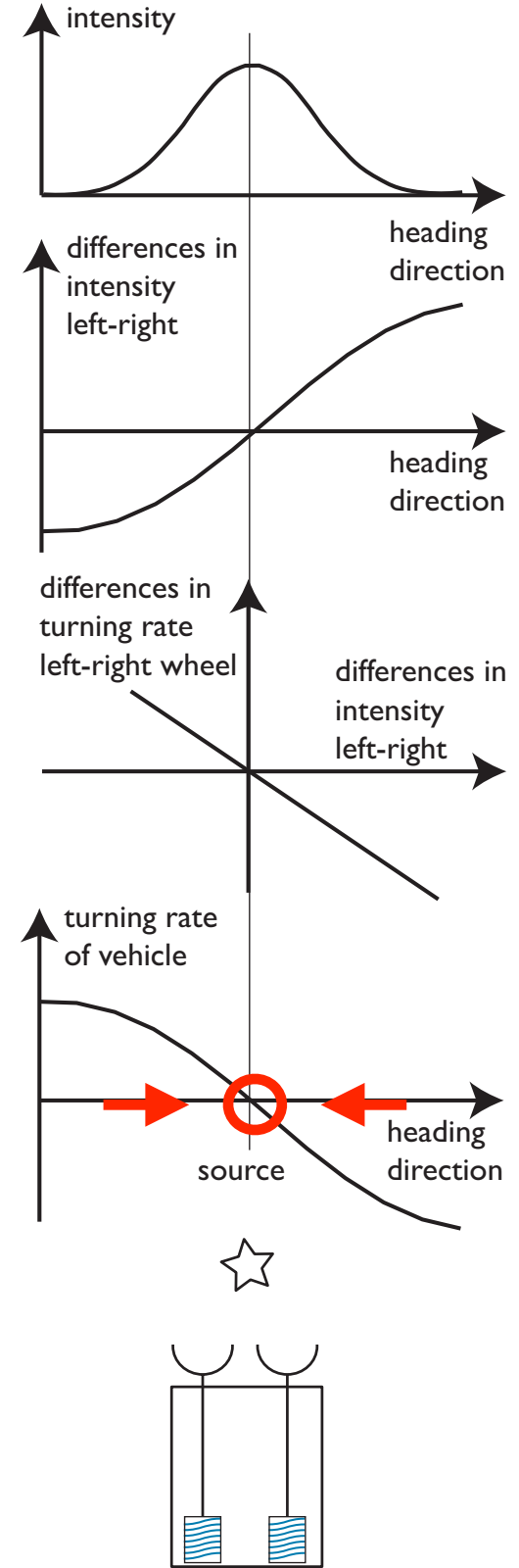intensity sensed

high
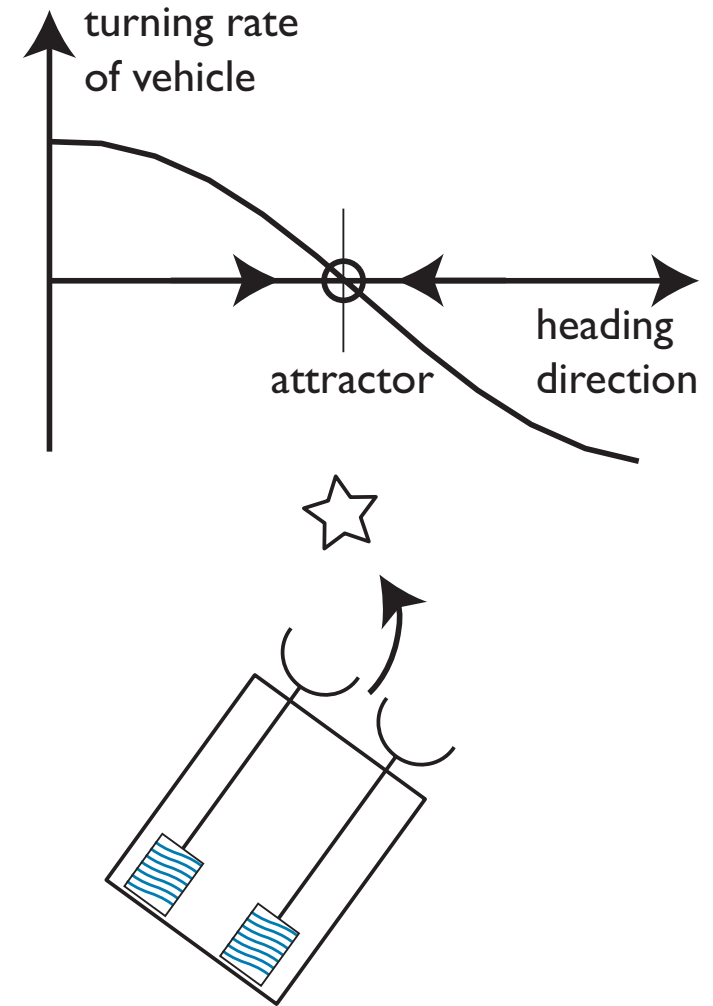intensity

Emergent behavior: taxis

Emergent behavior: this is a dynamics

- feedforward nervous system

- + closed loop through environment
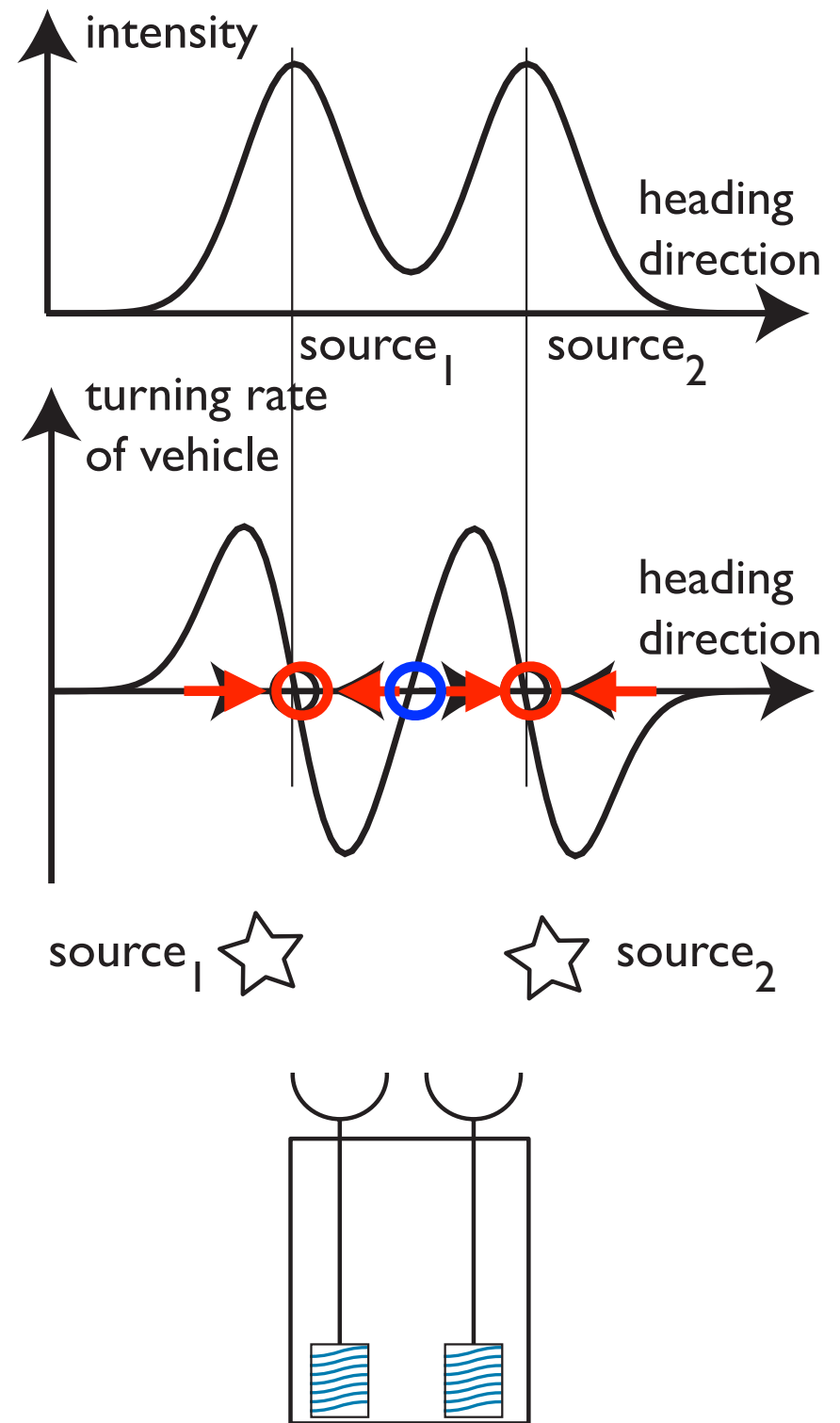
- => (behavioral) dynamics

Emergent behavior: this is a dynamics

turning rate of vehicle

heading direction

attractor

- feedforward nervous system

- + closed loop through environment

- => (behavioral) dynamics

Complex environment => complex dynamics

- bistable dynamics for bimodal intensity distribution

- => nonlinear dynamics makes selection decision

Complex environment => complex dynamics

■ transition to monostable for mono-modal distribution

■ => instabilities lead to qualitative change of behavior
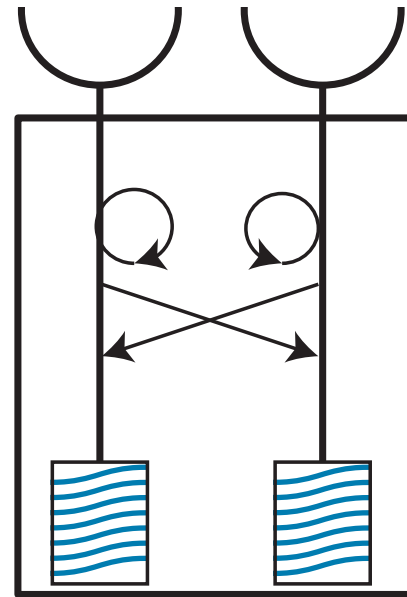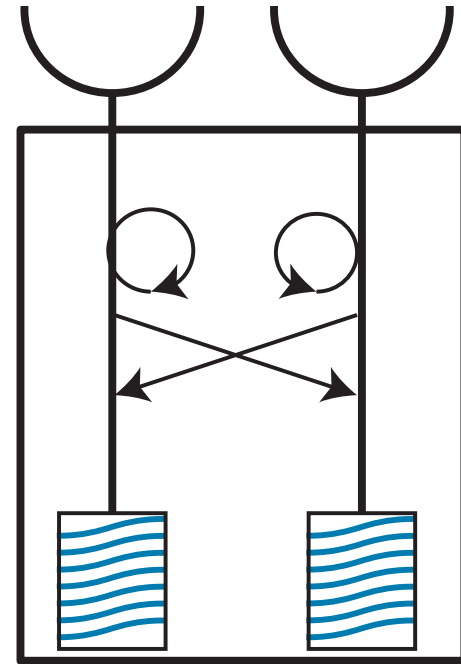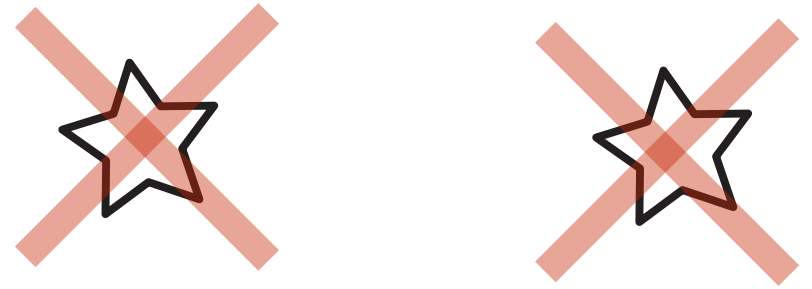
Complex environment => complex dynamics

■ transition to monostable for mono-modal distribution

■ => instabilities lead to qualitative change of behavior

heading direction, ϕ

attractor

attractor

repellor

attractor

distance between sources
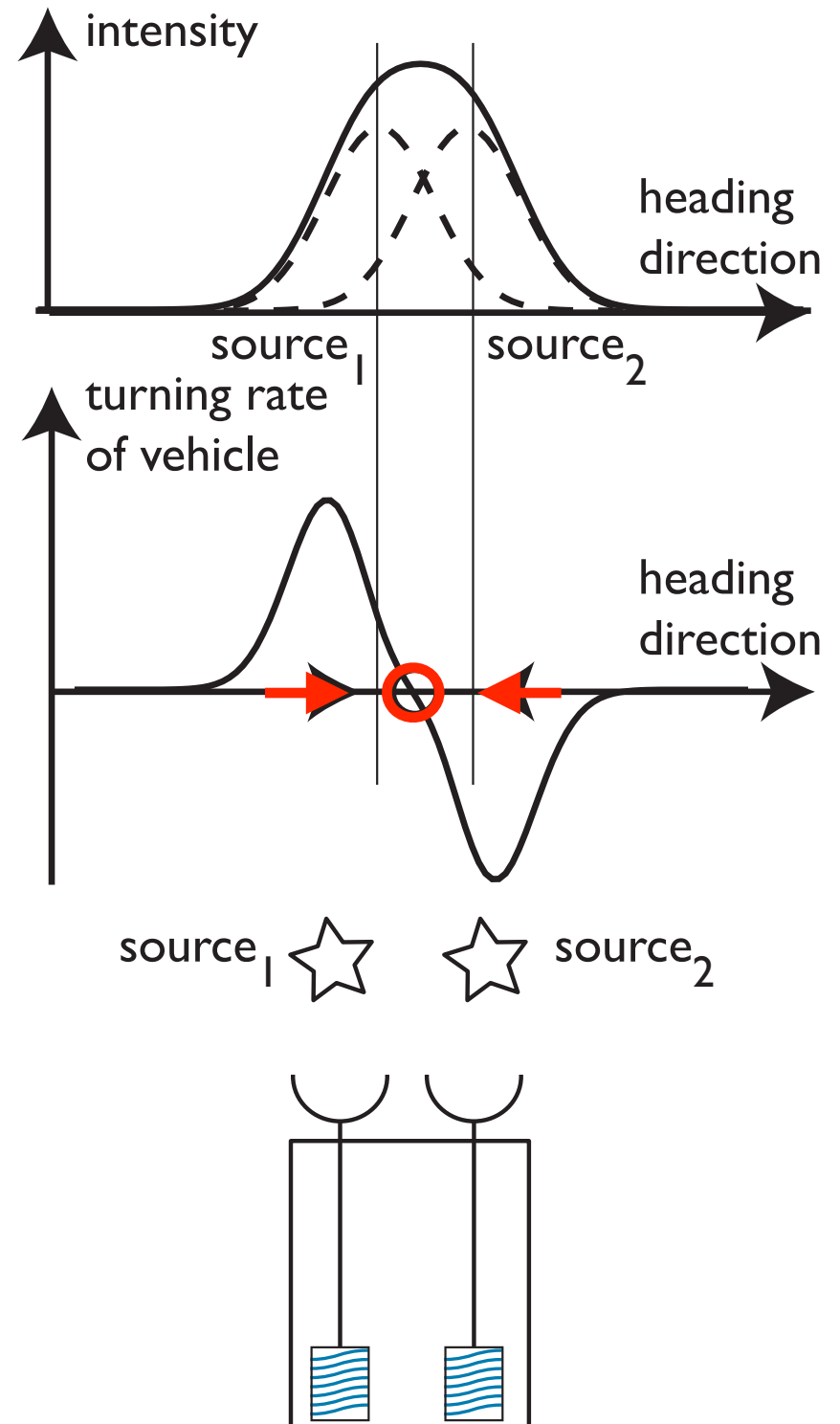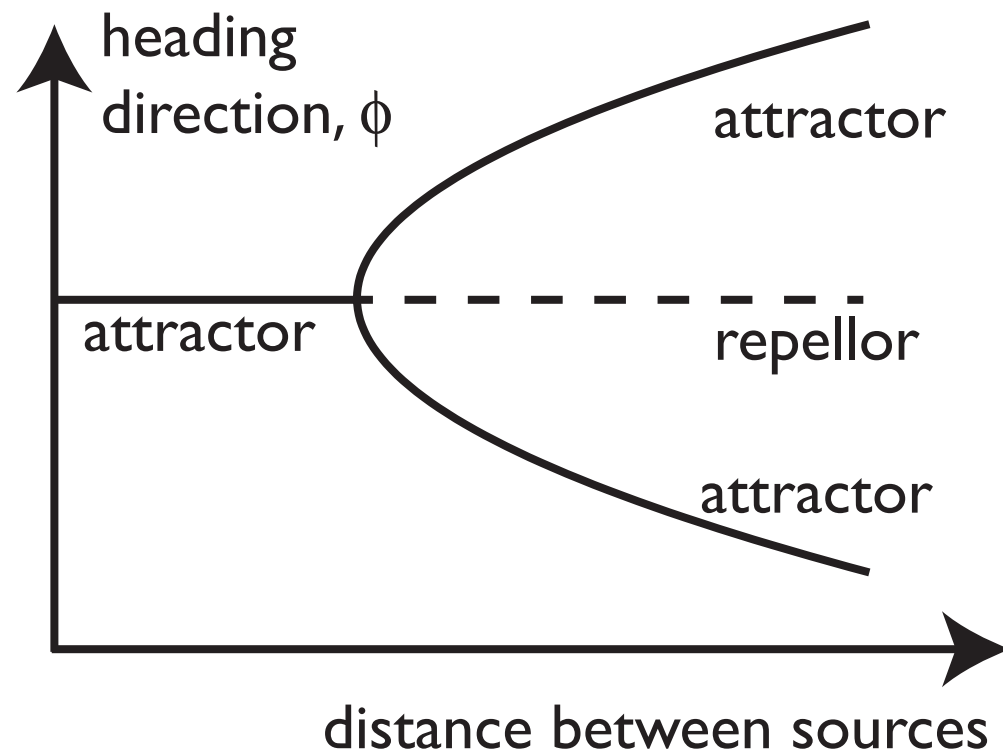
Beyond sensory-motor cognition…

source₁ ⭐   ⭐ source₂

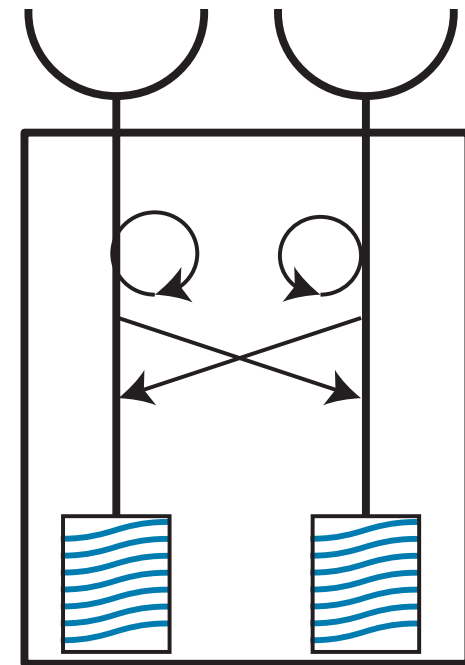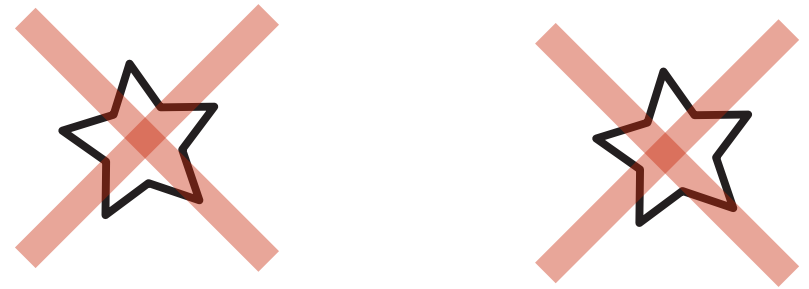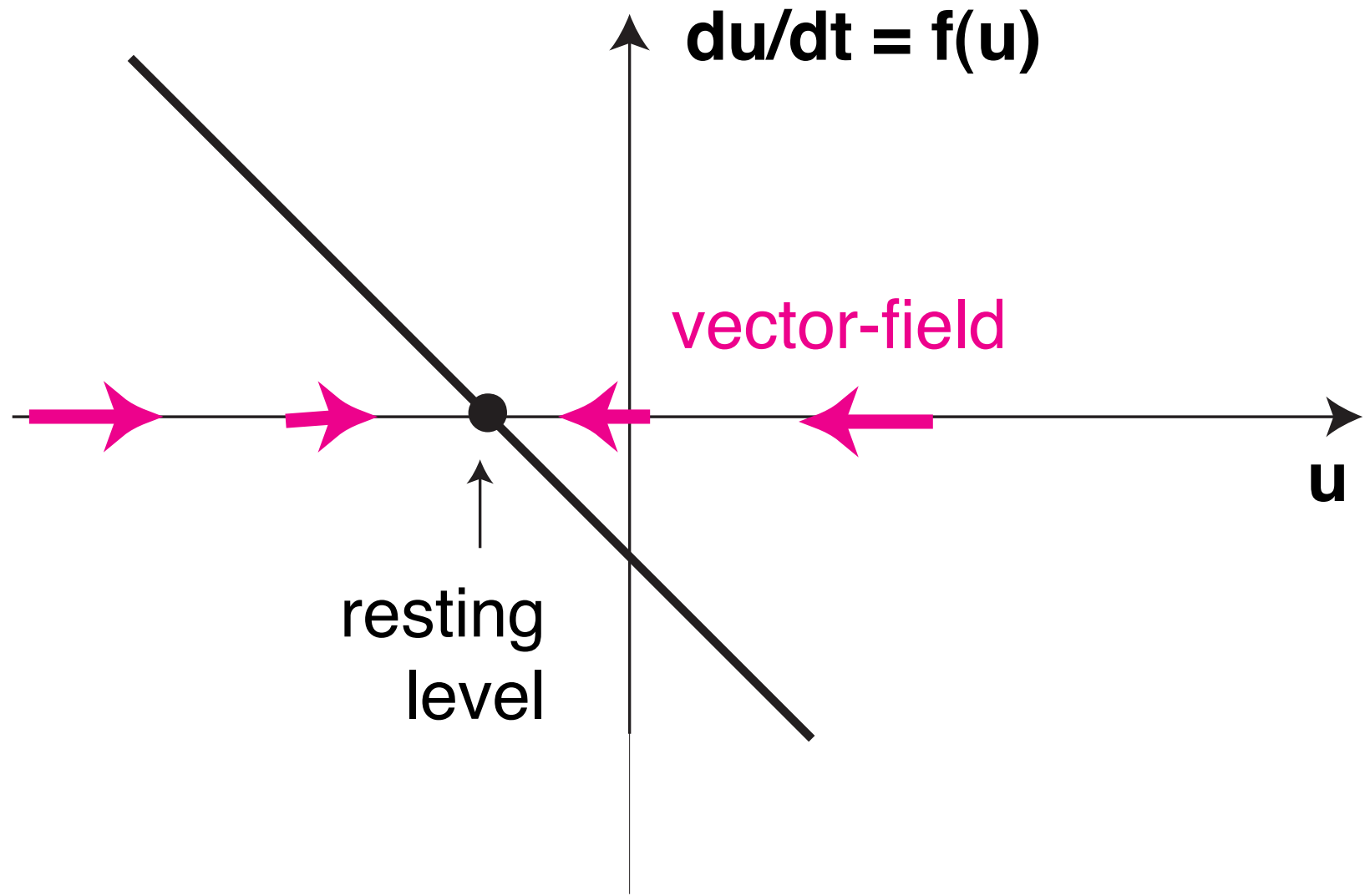# Beyond sensory-motor cognition…

Beyond sensory-motor cognition...

- if sensory information about source not always available on the sensory surface

- => working memory

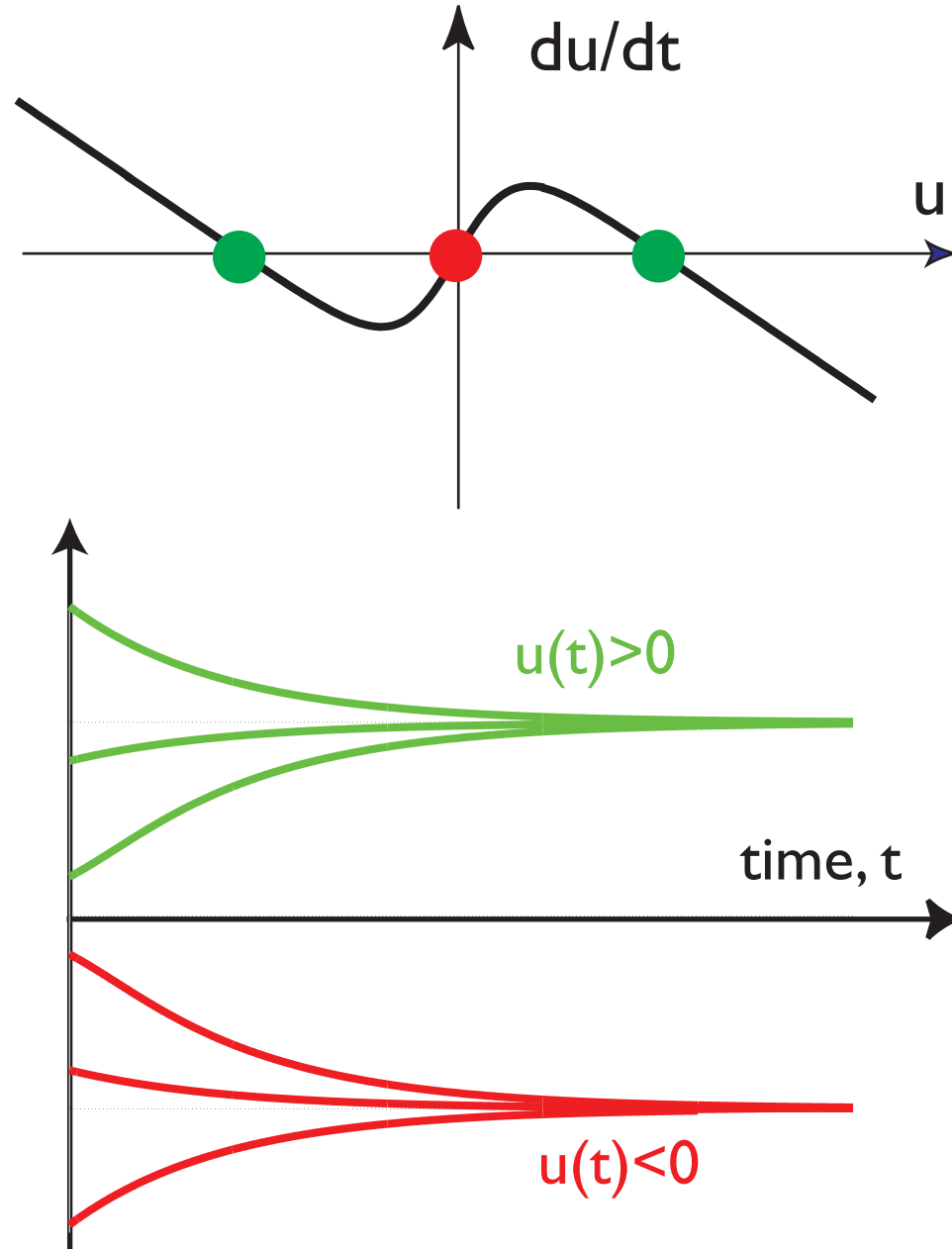- need "inner state" that is independent of body or sensors:

- => activation

Internal loops generate neural dynamics

Internal loops generate neural dynamics

Outlook

■ neural dynamics

■ DFT