Summary

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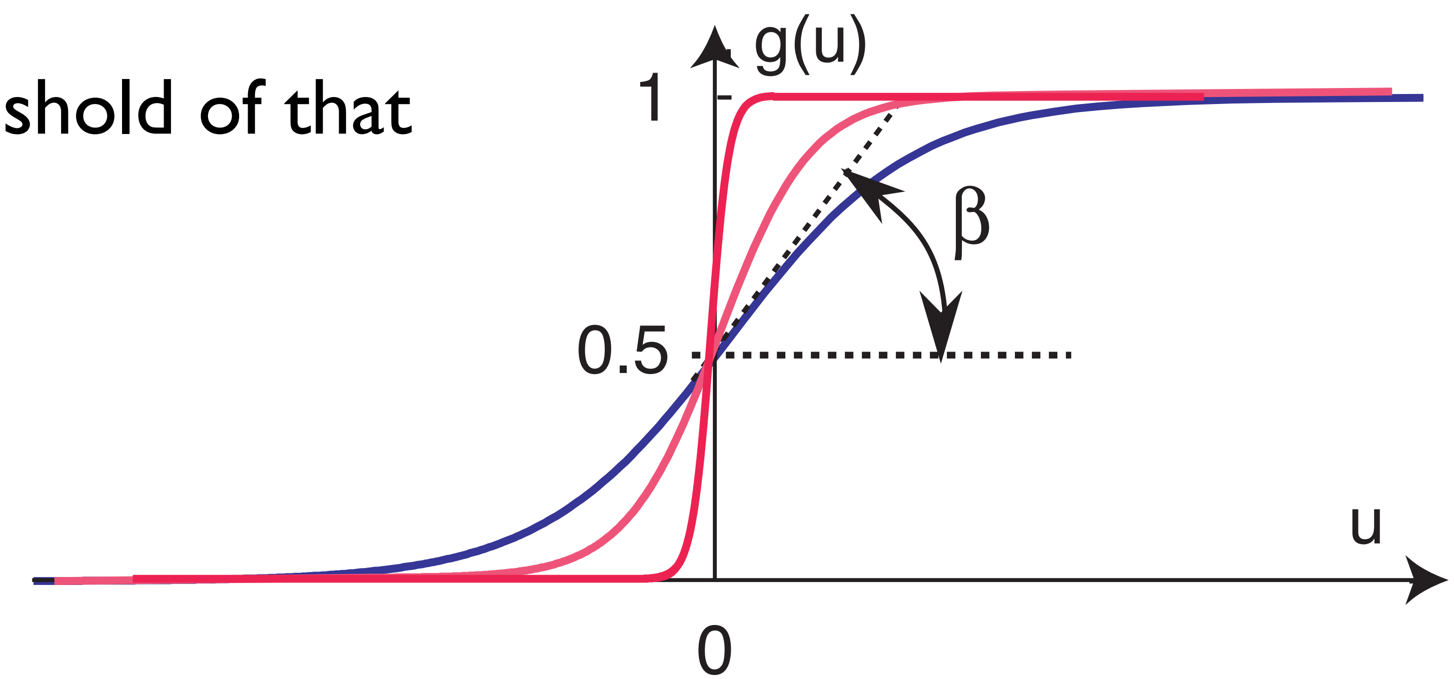
Activation

- neural state variable activation
  - linked to membrane potential of neurons in some accounts
  - linked to spiking rate in our account
  - through: population activation... (later)

Activation

- activation as a real number, abstracting from biophysical details
  - low levels of activation: not transmitted to other systems (e.g., to motor systems)
  - high levels of activation: transmitted to other systems
  - as described by sigmoidal threshold function
  - zero activation defined as threshold of that function

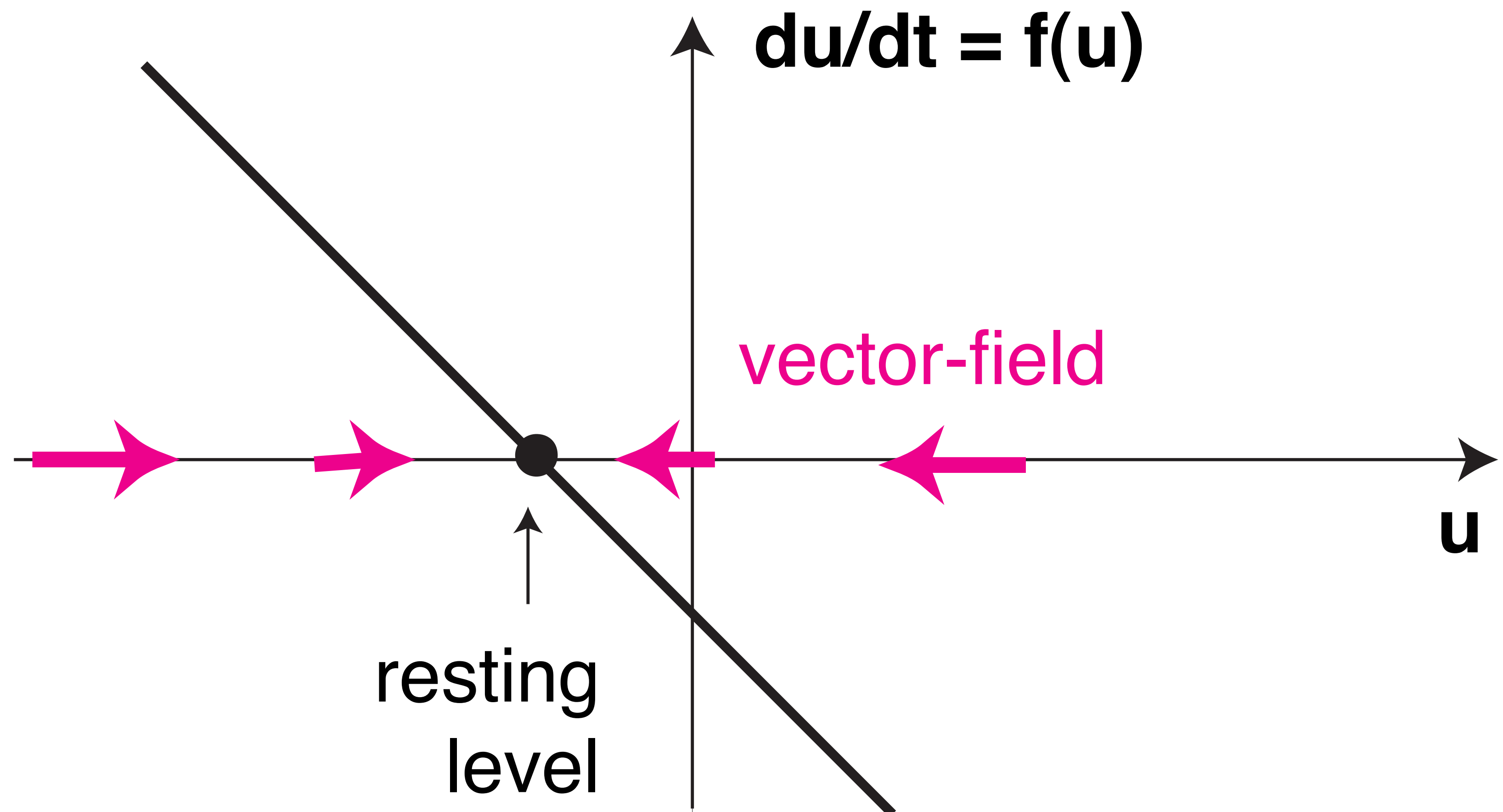


Activation dynamics

- activation evolves in continuous time
  - no evidence for a discretization of time, for spike timing to matter for behavior

Neural dynamics

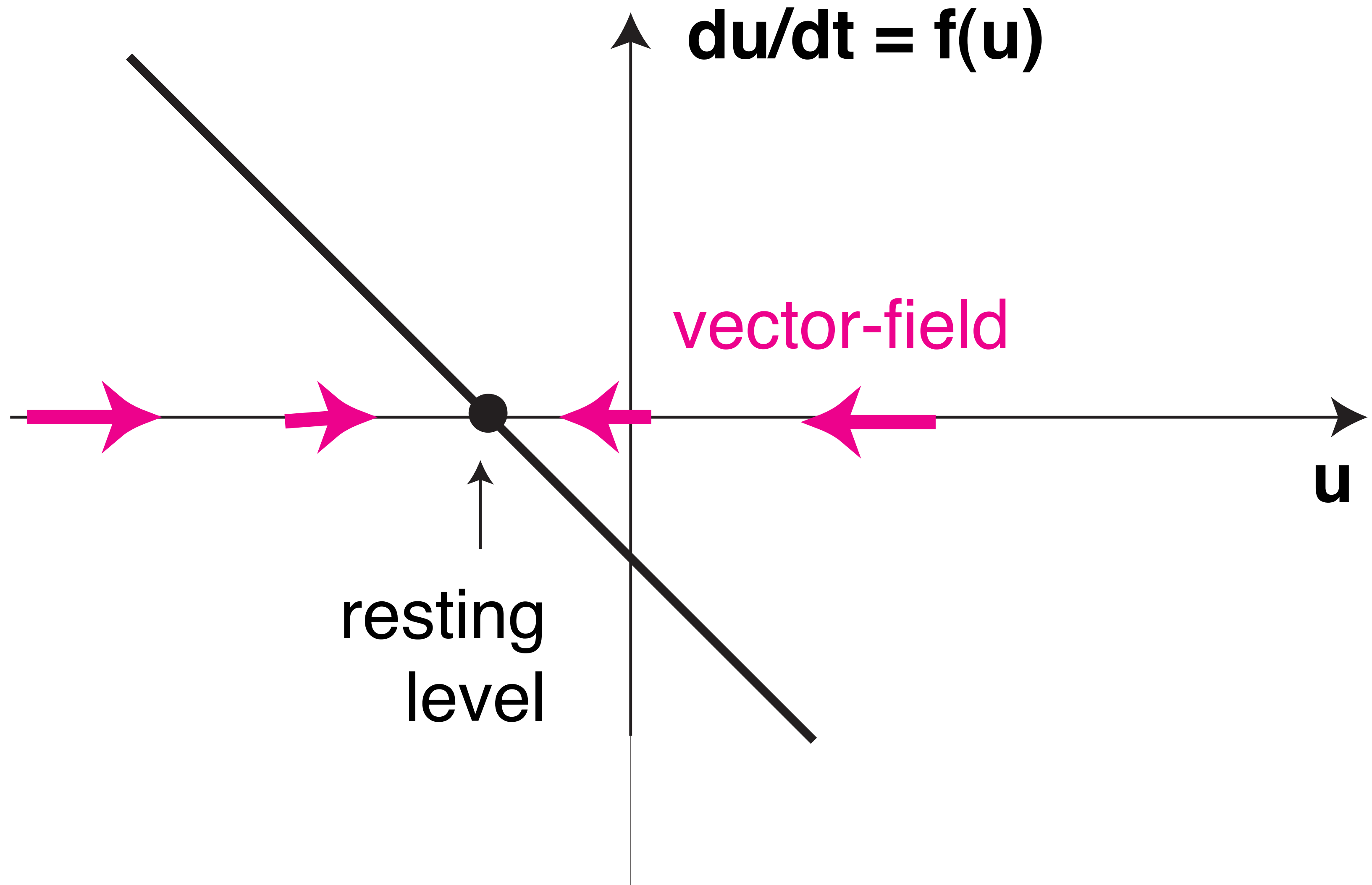
- In a dynamical system, the present predicts the future: given the initial level of activation u(0), the activation at time t: u(t) is uniquely determined



$$\frac{du(t)}{dt} = \dot{u}(t) = -u(t) + h \qquad (h < 0)$$

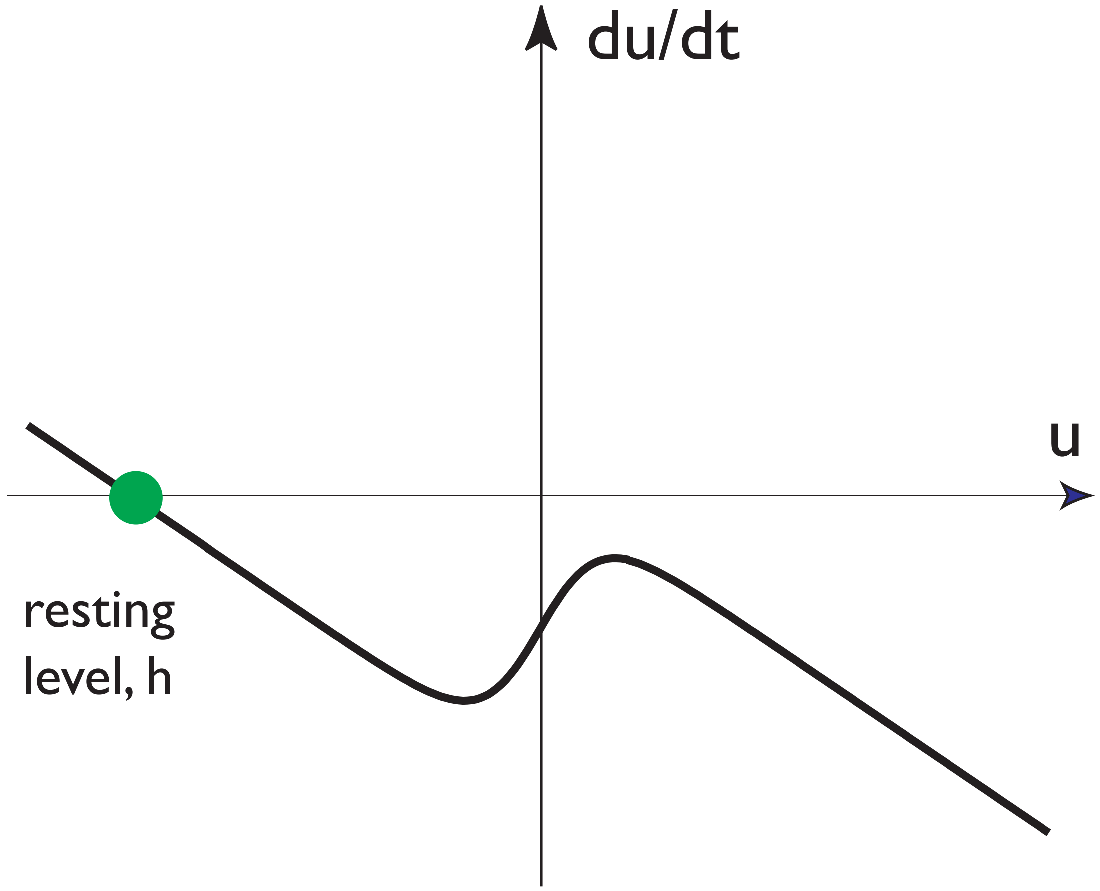
Neural dynamics

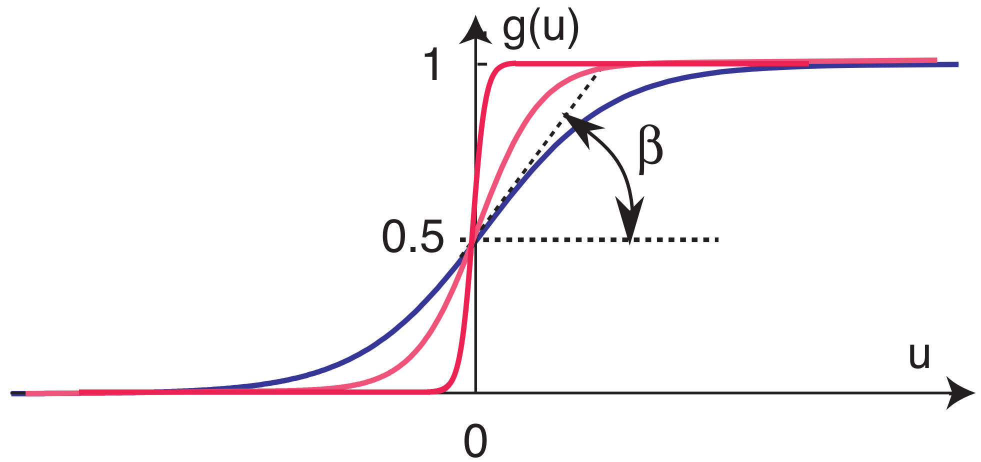
- stationary state=fixed point= constant solution
- stable fixed point: nearby solutions converge to the fixed point=attractor



$$\frac{du(t)}{dt} = \dot{u}(t) = -u(t) + h \qquad (h < 0)$$

Neuronal dynamics with self-excitation

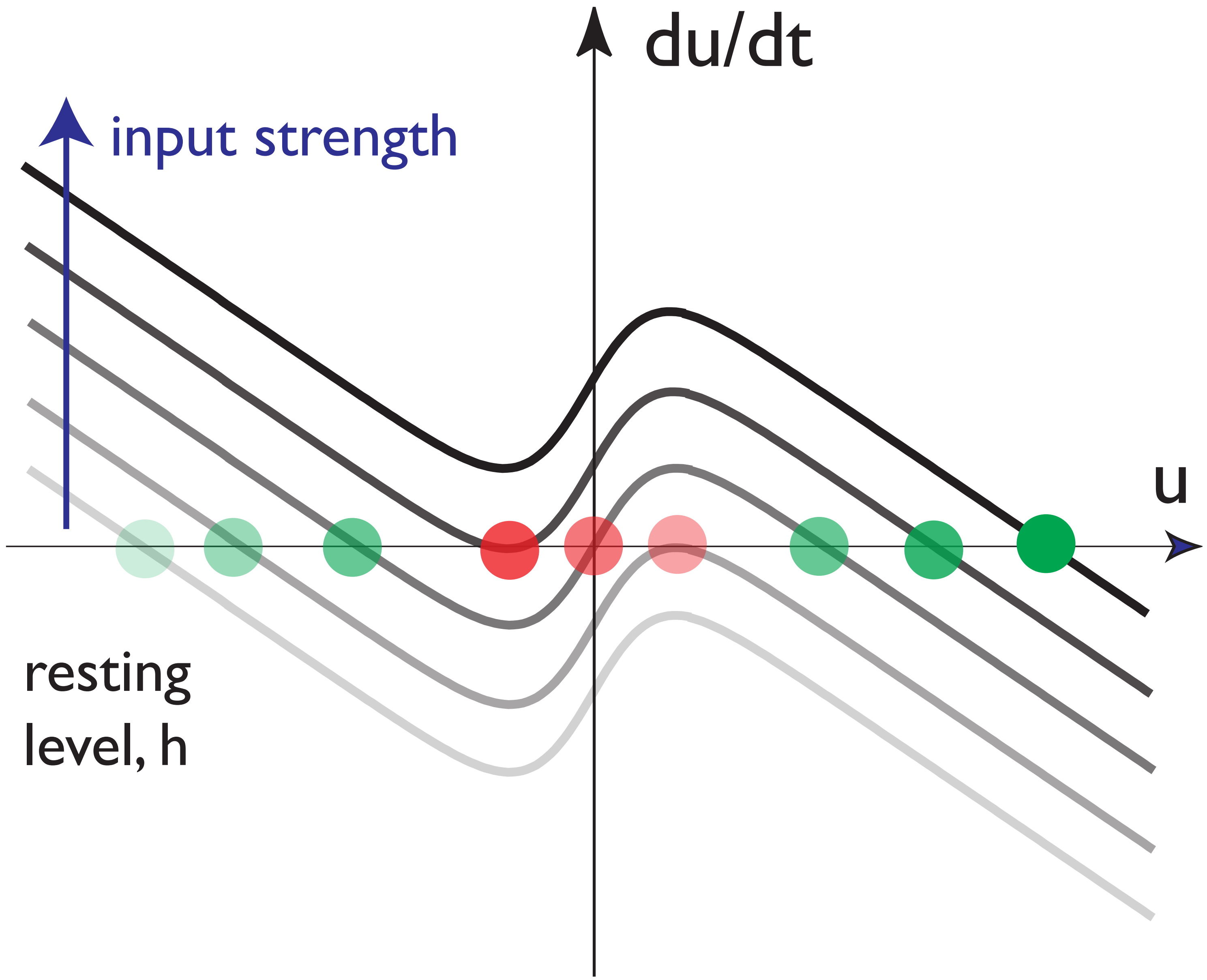




$$\tau \dot{u}(t) = -u(t) + h + S(t) + c\sigma(u(t))$$

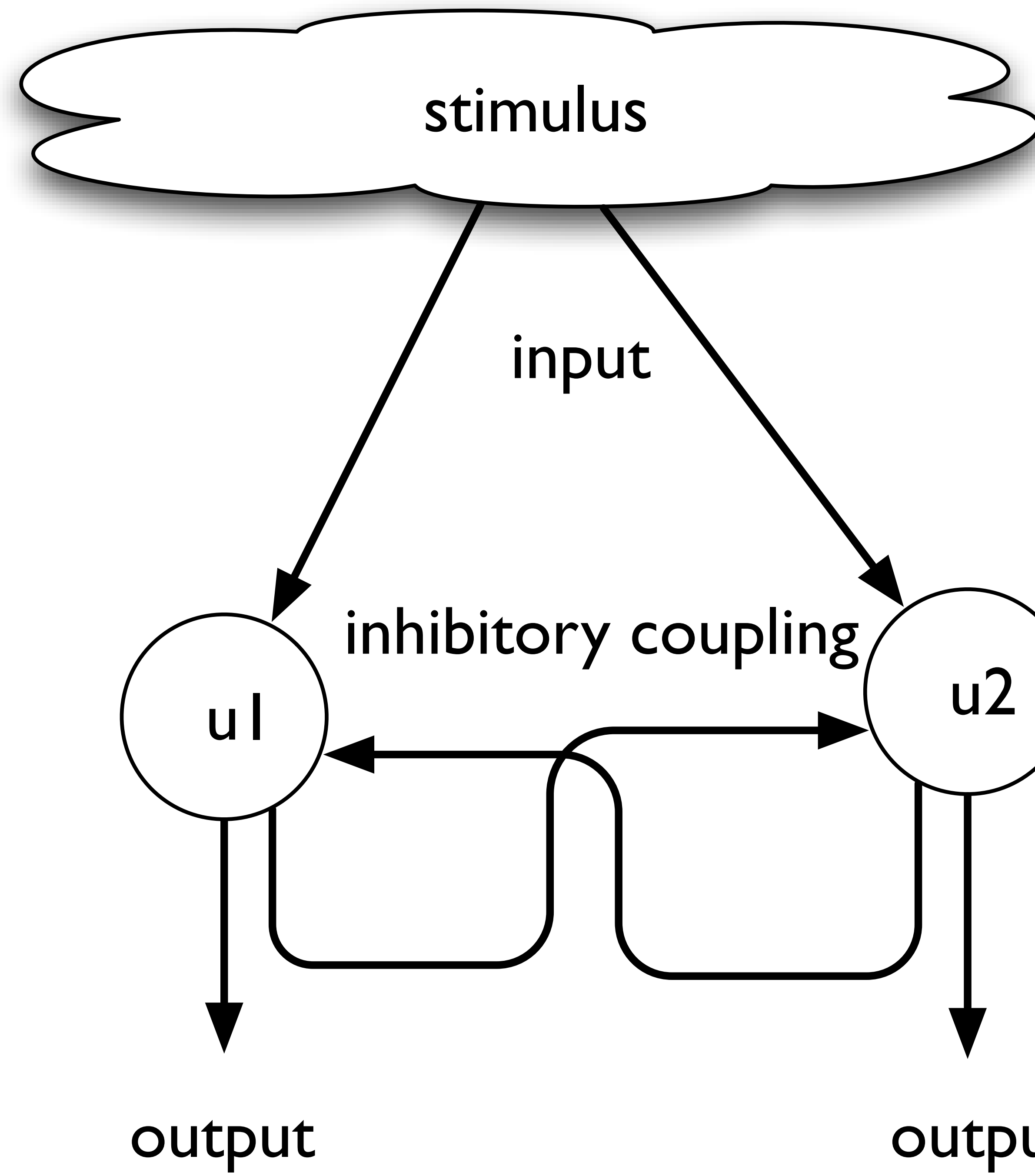
Neuronal dynamics with self-excitation

- stimulus input



$$\tau \dot{u}(t) = -u(t) + h + S(t) + c\sigma(u(t))$$

Neuronal dynamics with competition

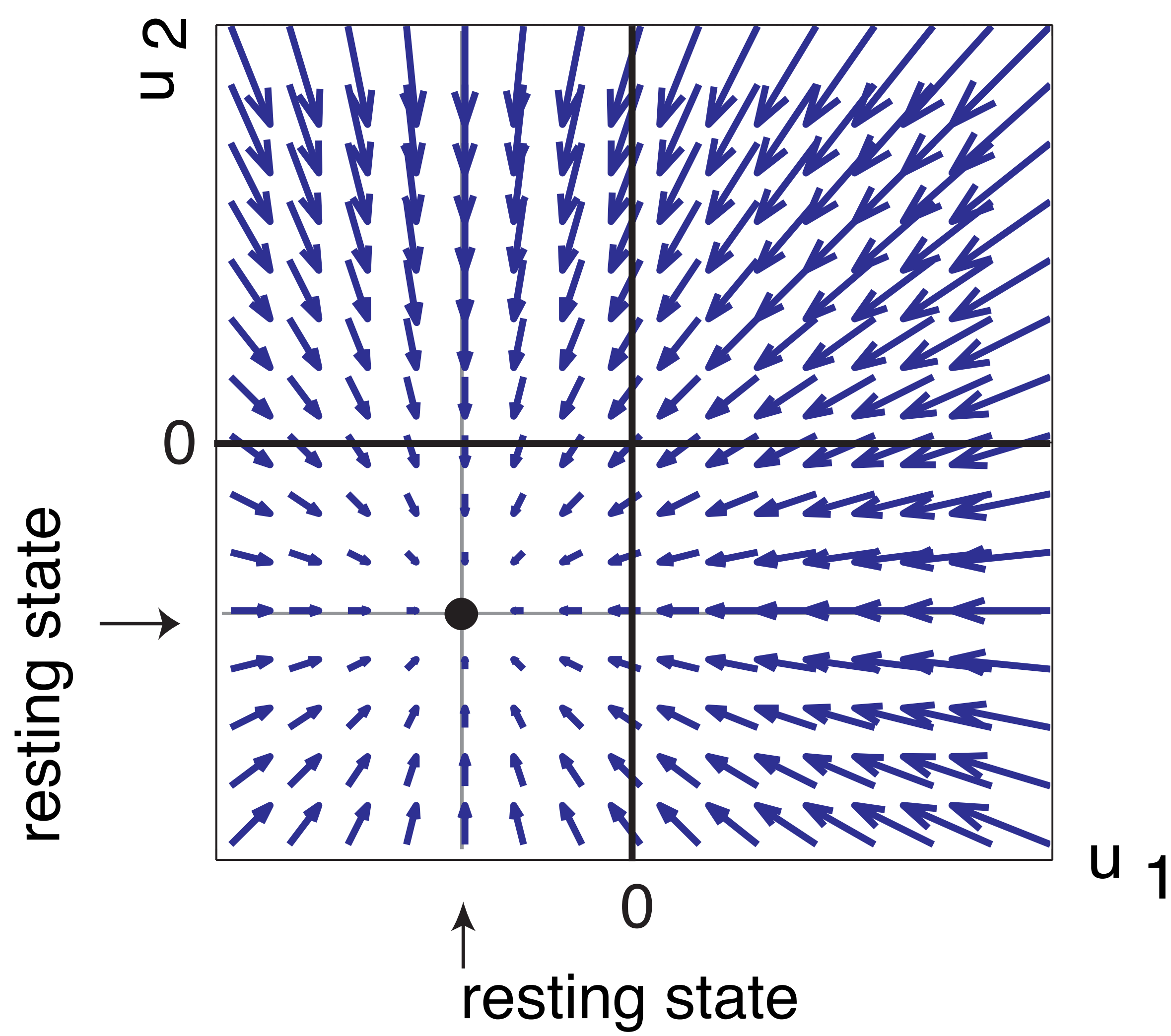


$$\tau \dot{u}_1(t) = -u_1(t) + h - \sigma(u_2(t)) + S_1$$
$$\tau \dot{u}_2(t) = -u_2(t) + h - \sigma(u_1(t)) + S_2$$

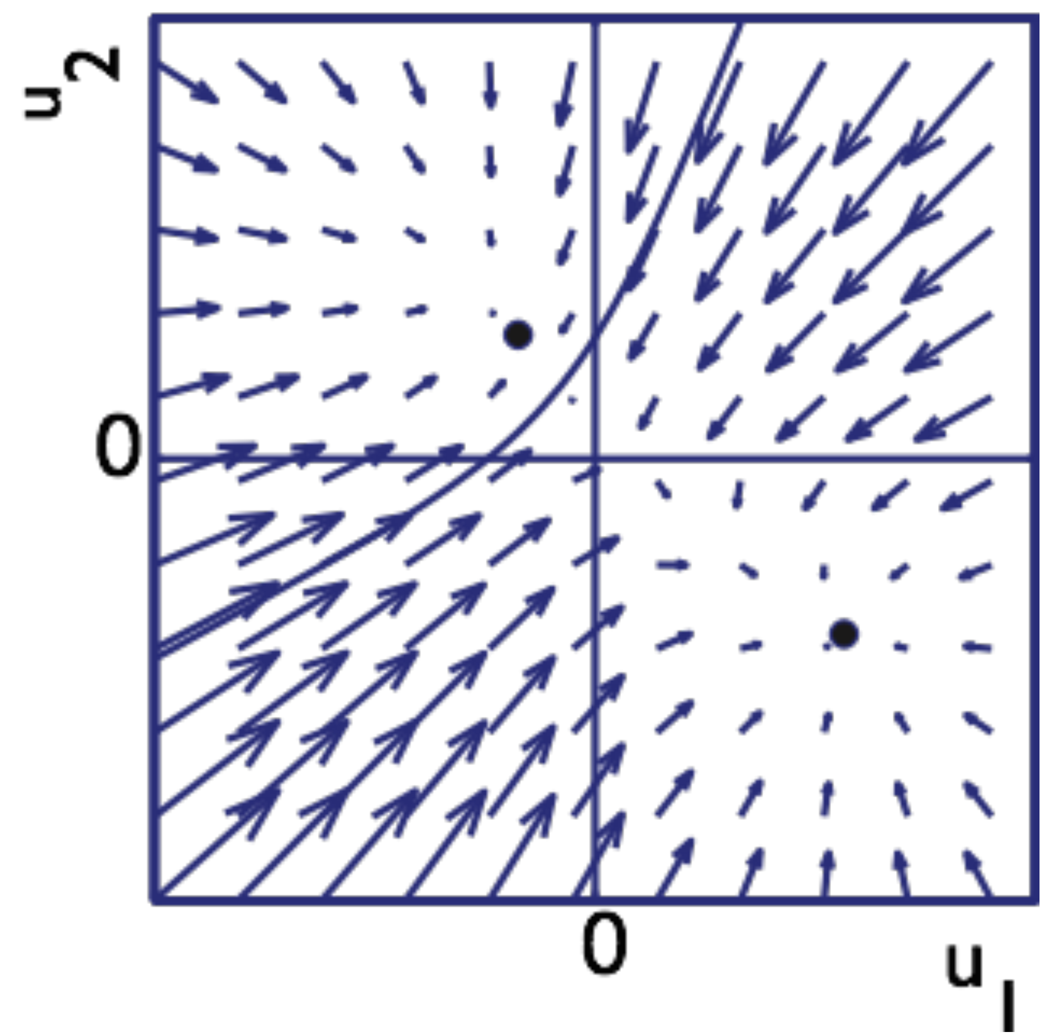
Neuronal dynamics with competition

=>biased competition

before input is presented

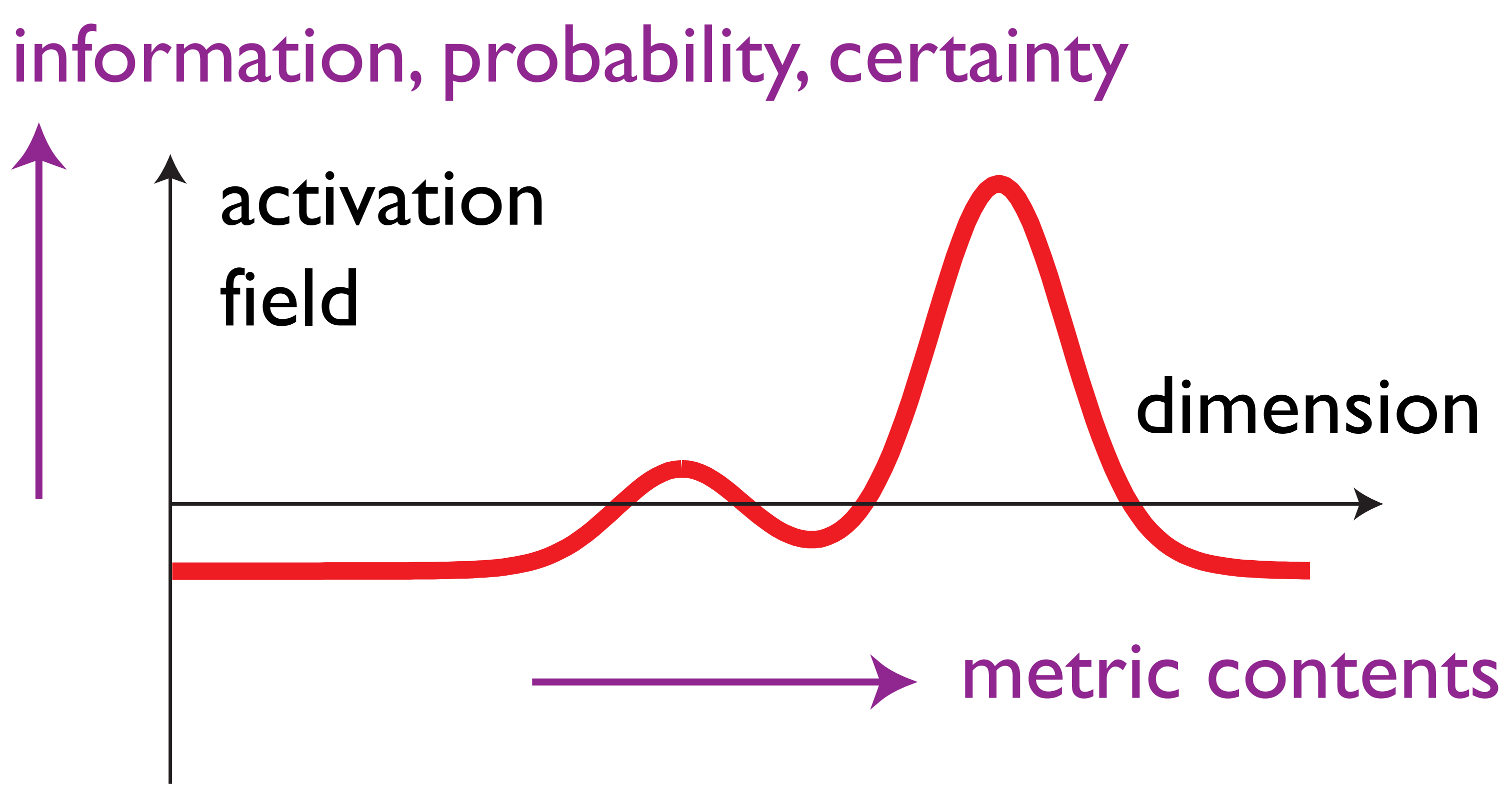


after input is presented



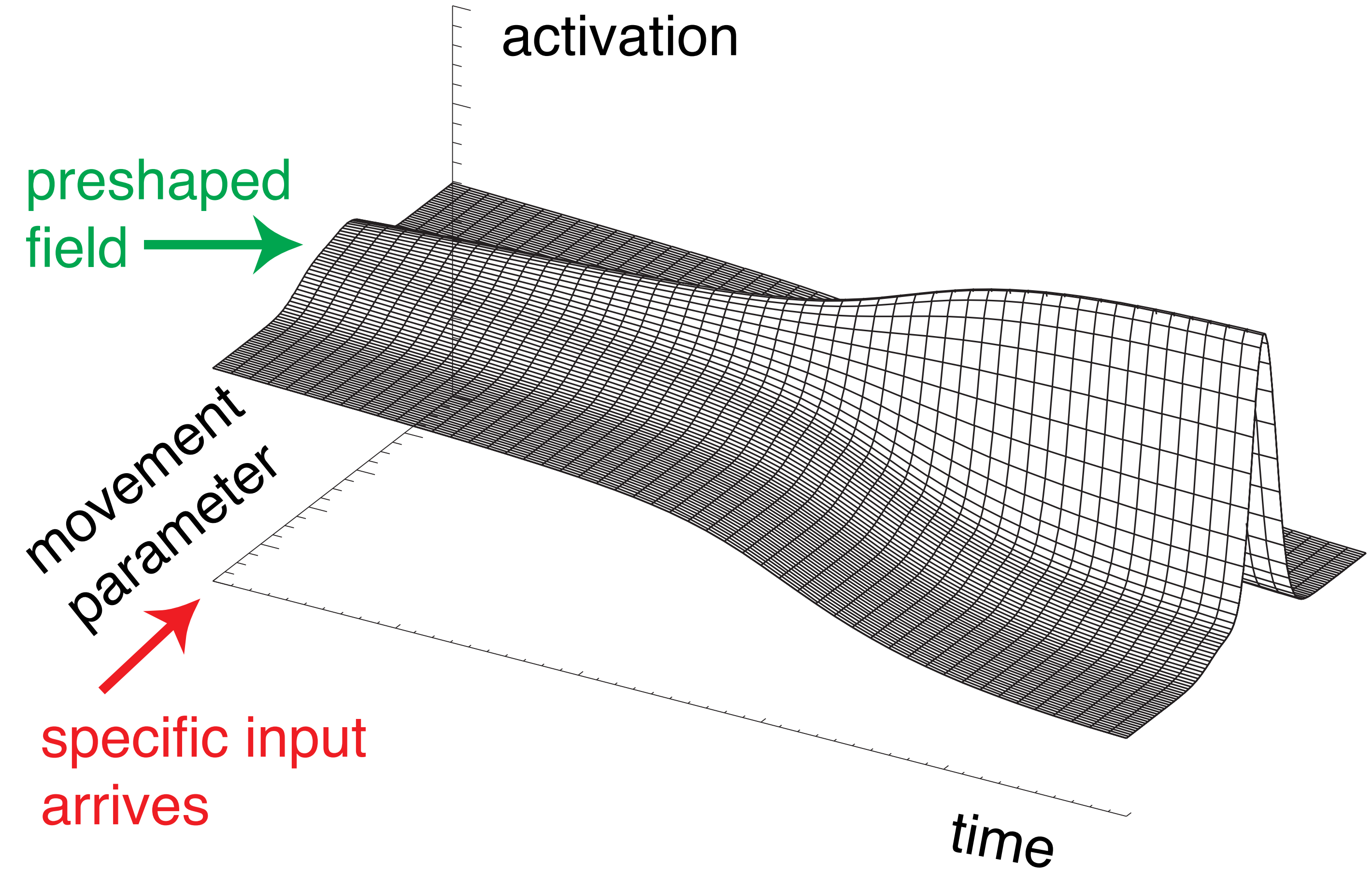
Dynamical Field Theory: space

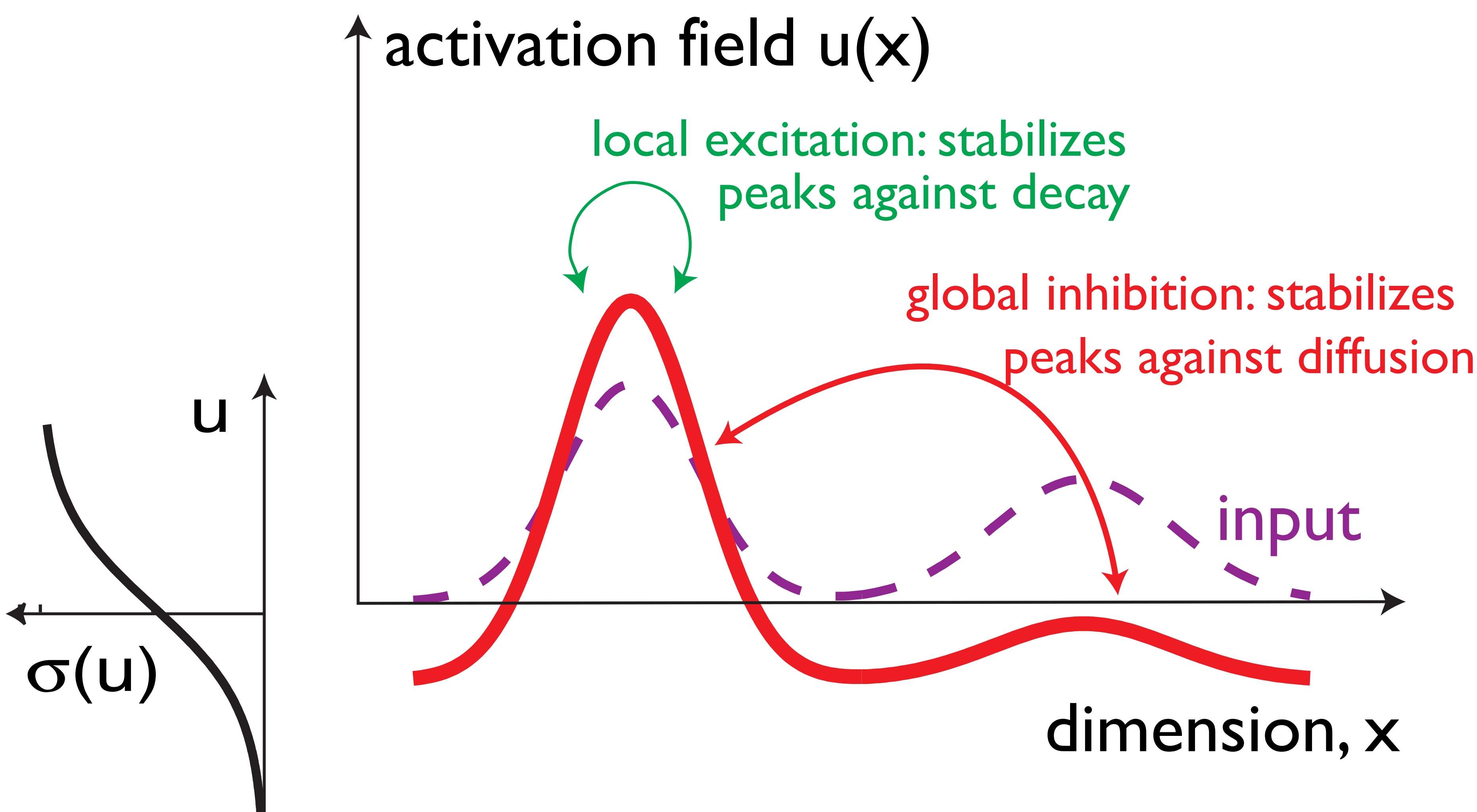
- fields: continuous activation variables defined over continuous spaces



e.g., retinal space, movement parameters, feature dimensions, viewing parameters, ...

the dynamics such activation fields is structured so that localized peaks emerge as attractor solutions





mathematical formalization

Amari equation

$$\tau \dot{u}(x,t) = -u(x,t) + h + S(x,t) + \int w(x-x')\sigma(u(x',t))\ dx'$$

where

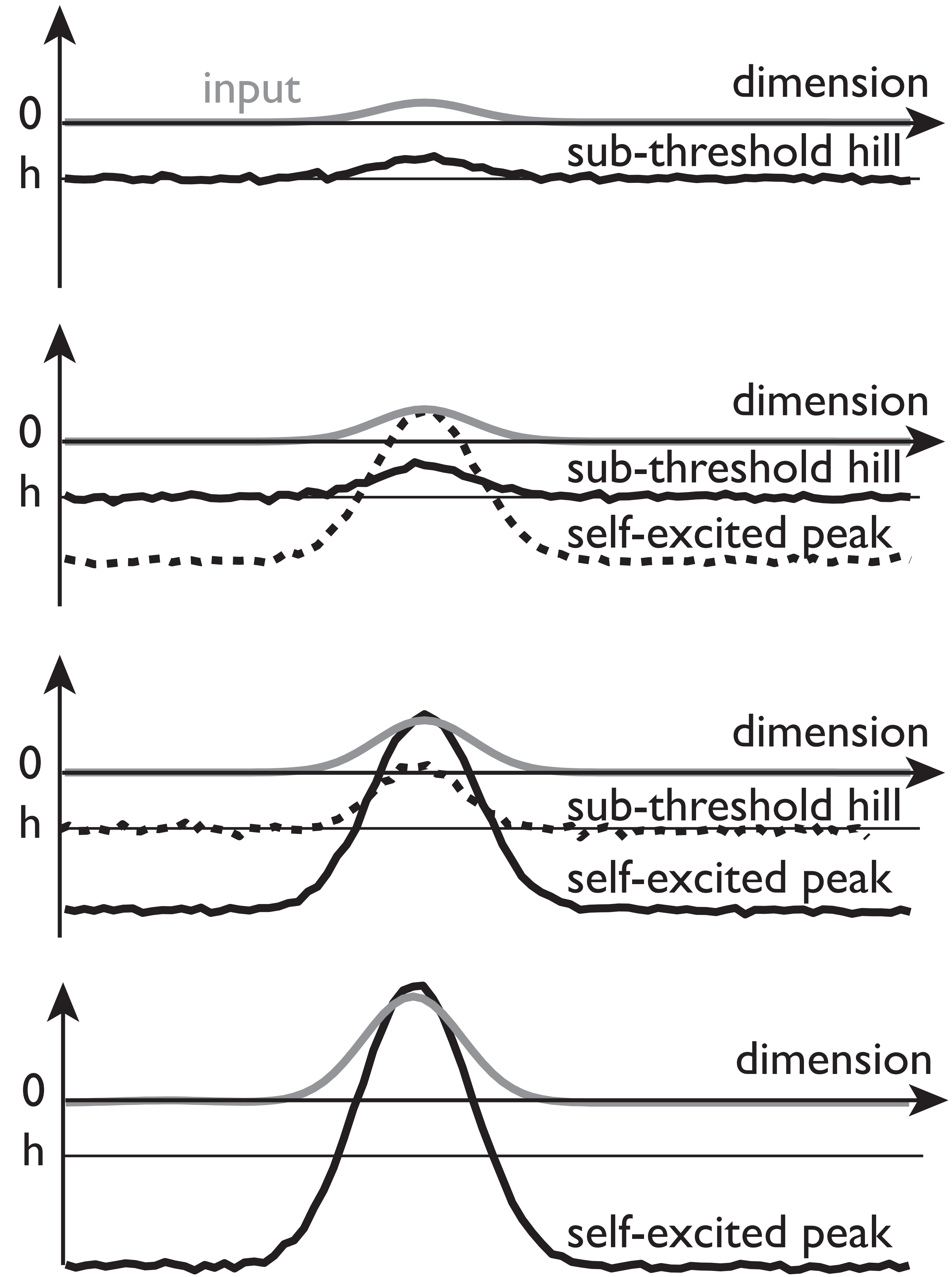
- time scale is τ
- resting level is $h < 0$
- input is $S(x,t)$
- interaction kernel is

$$w(x-x') = w_i + w_e \exp\left[-\frac{(x-x')^2}{2\sigma_i^2}\right]$$

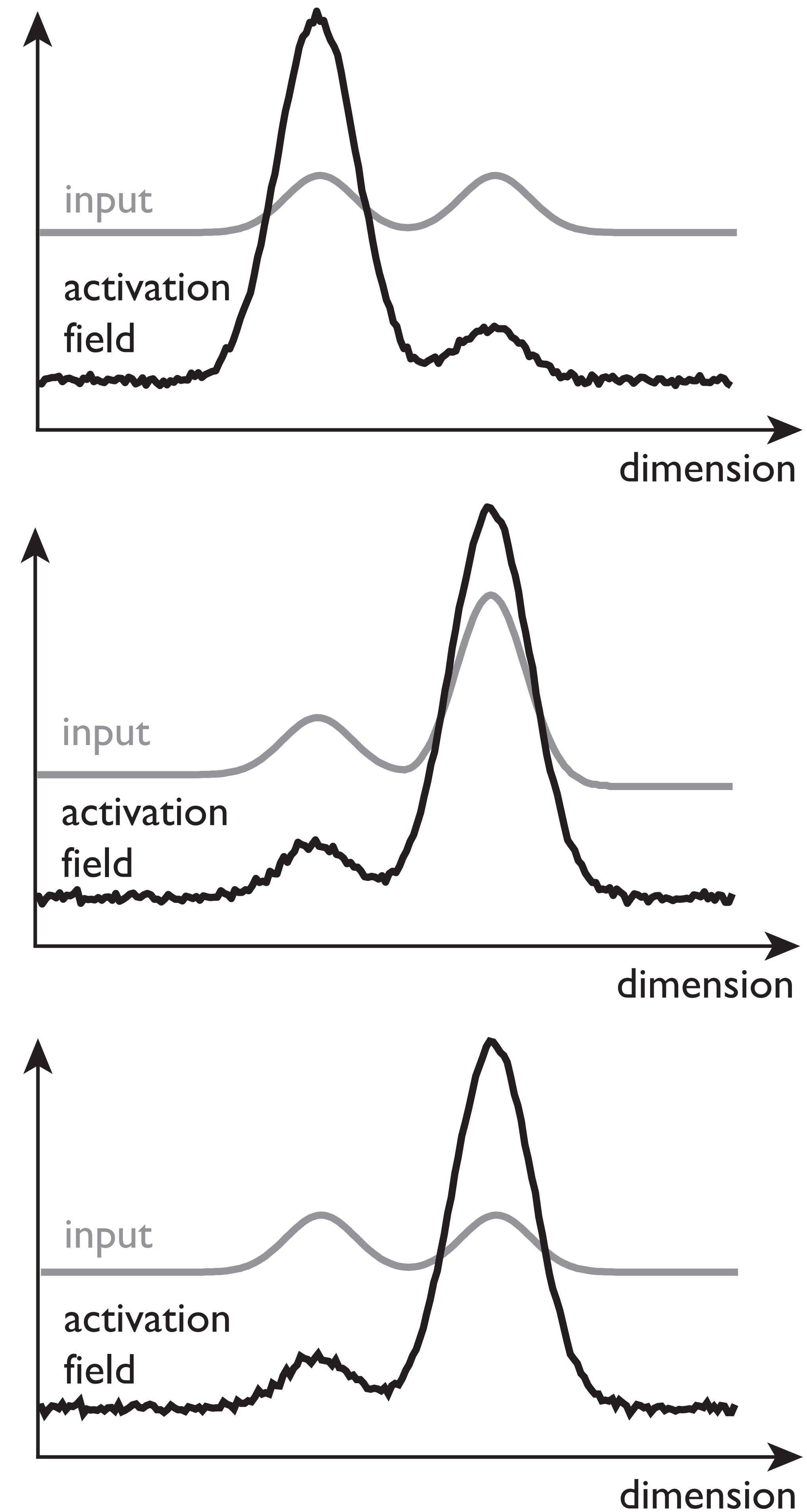
- sigmoidal nonlinearity is

$$\sigma(u) = \frac{1}{1+\exp[-\beta(u-u_0)]}$$

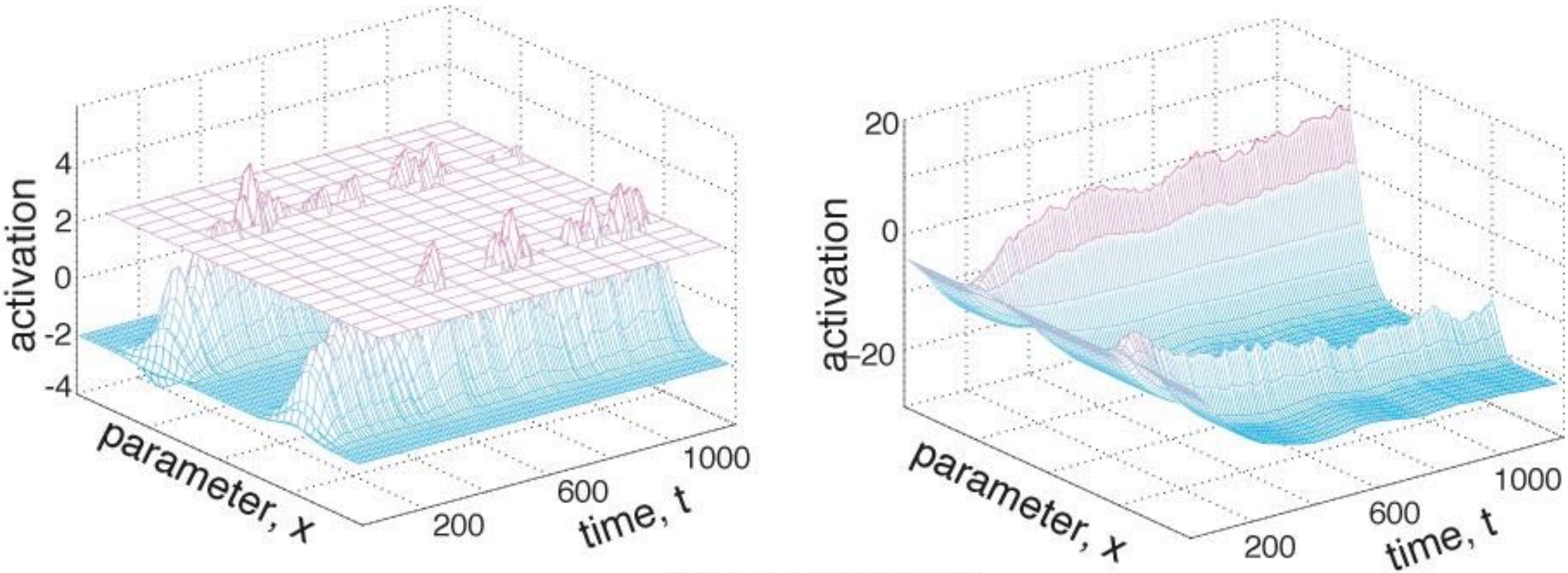
Detection instability



selection instability



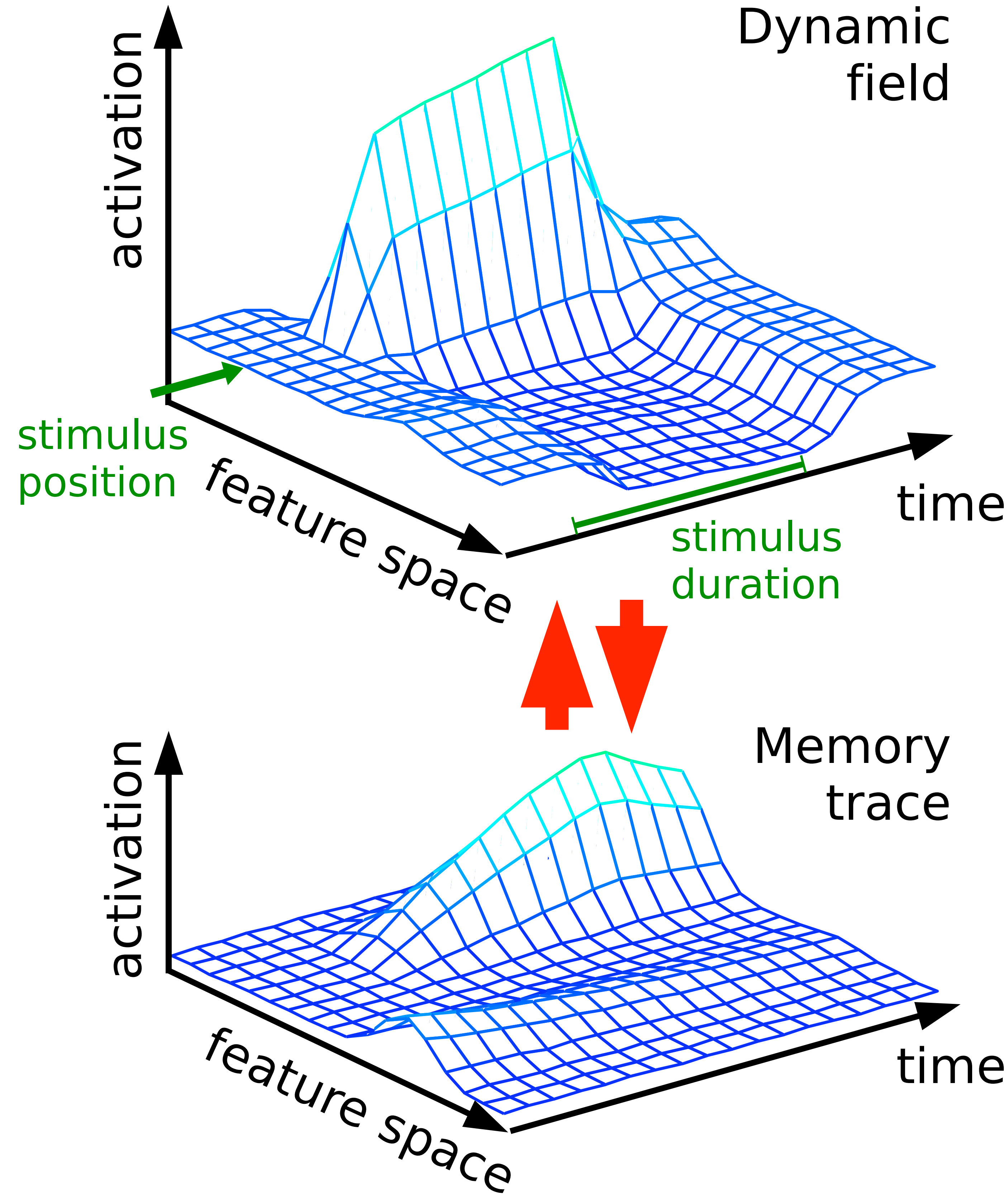
stabilizing selection decisions

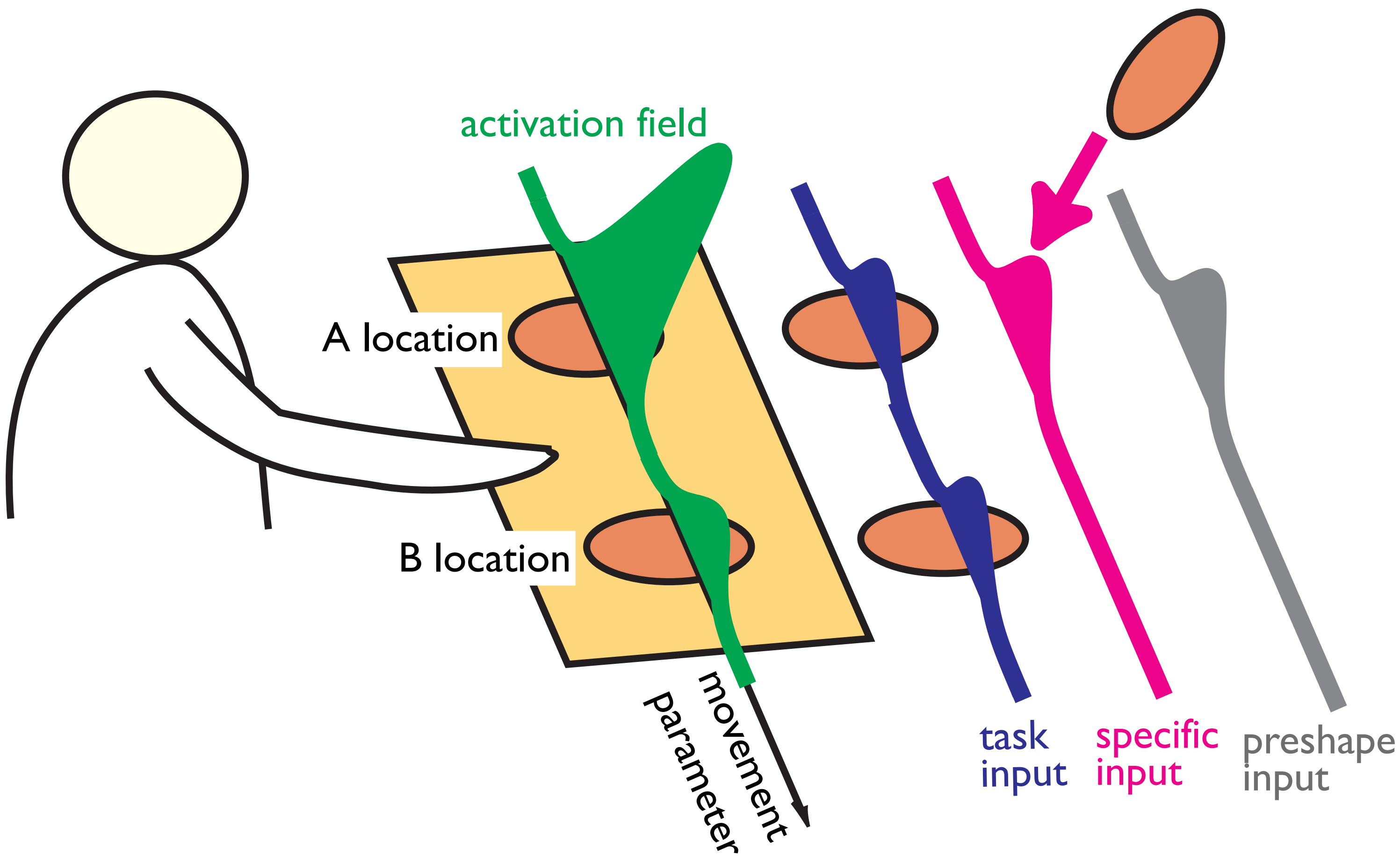


[Wilimzig, Schöner, 2006]

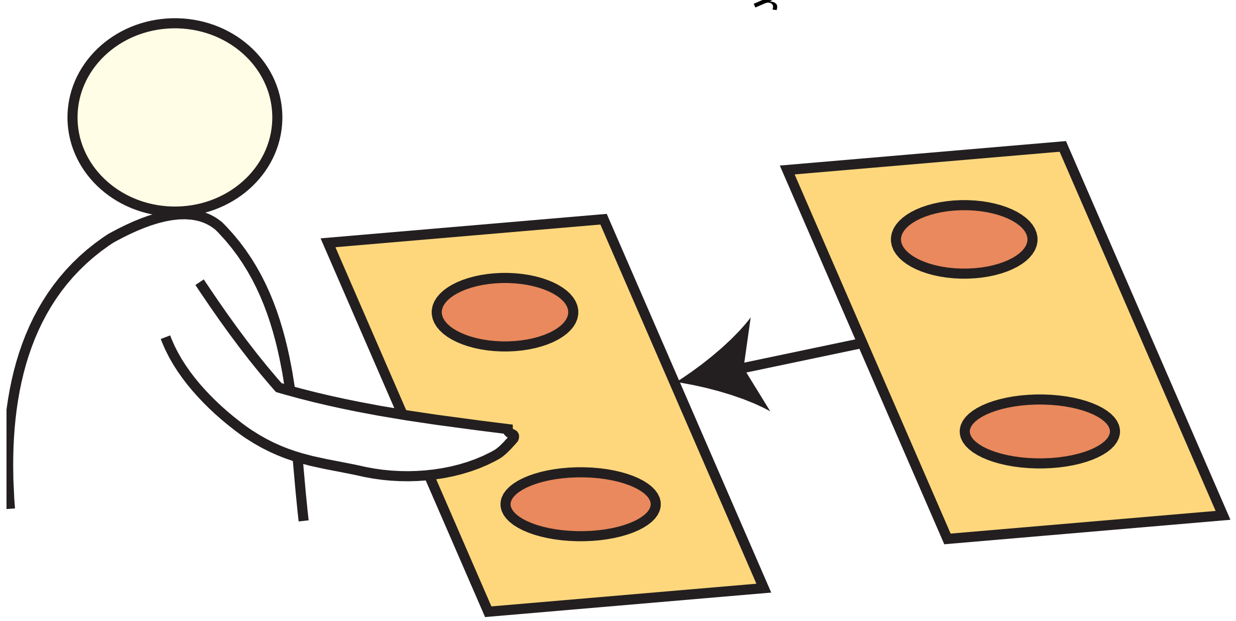
the memory trace

- inhomogeneities from simplest from the memory trace
- ~ habit formation (?) William James: habit formation as the simplest form of learning
- habituation: the memory trace for inhibition..





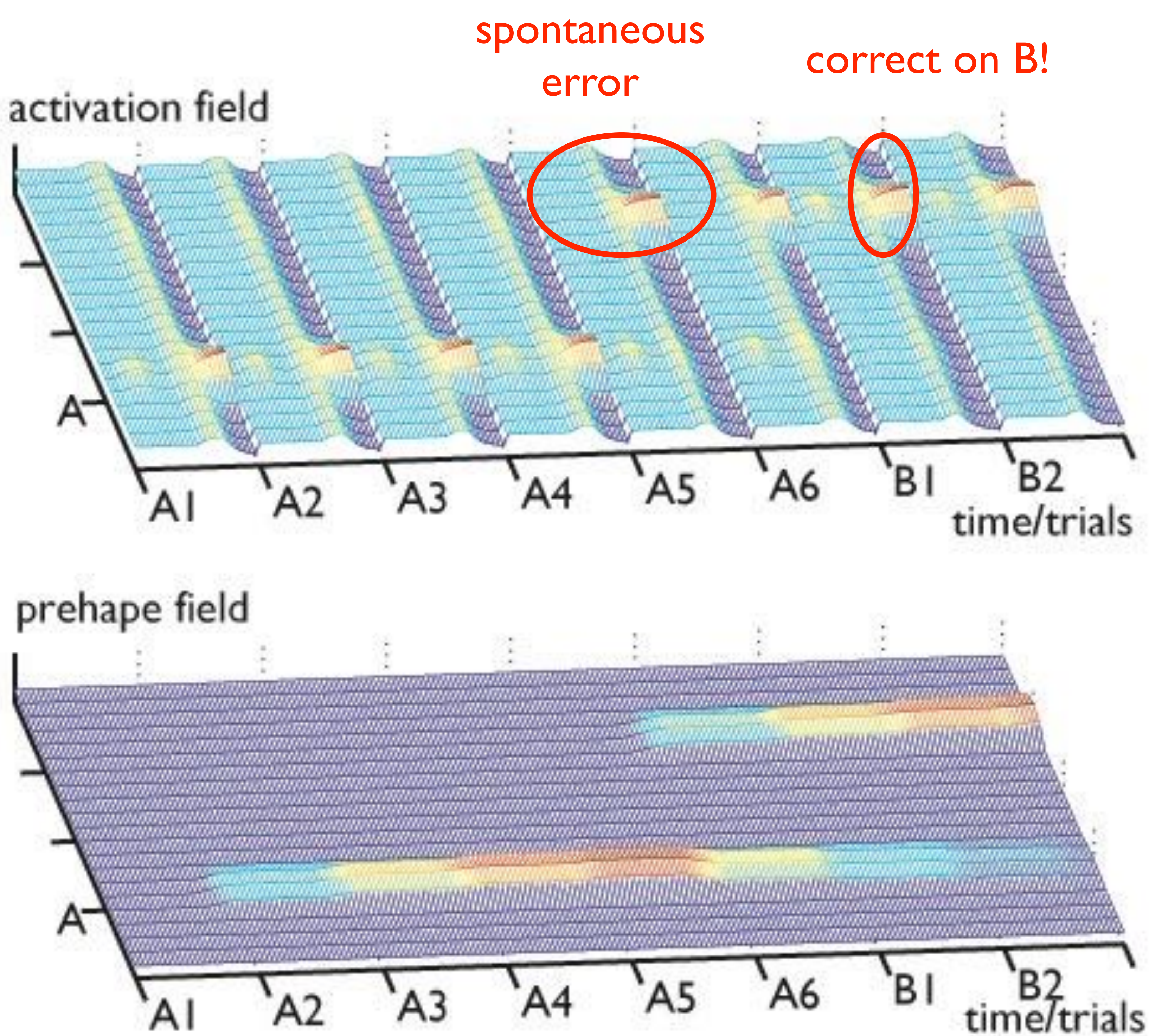
[Thelen, et al., BBS (2001)]



[Dinveva, Schöner, Dev. Science 2007]

DFT of infant perseverative reaching

- that is because reaches to B on A trials leave memory trace at B



[Dinveva, Schöner, Dev. Science 2007]