Dynamic Field Theory

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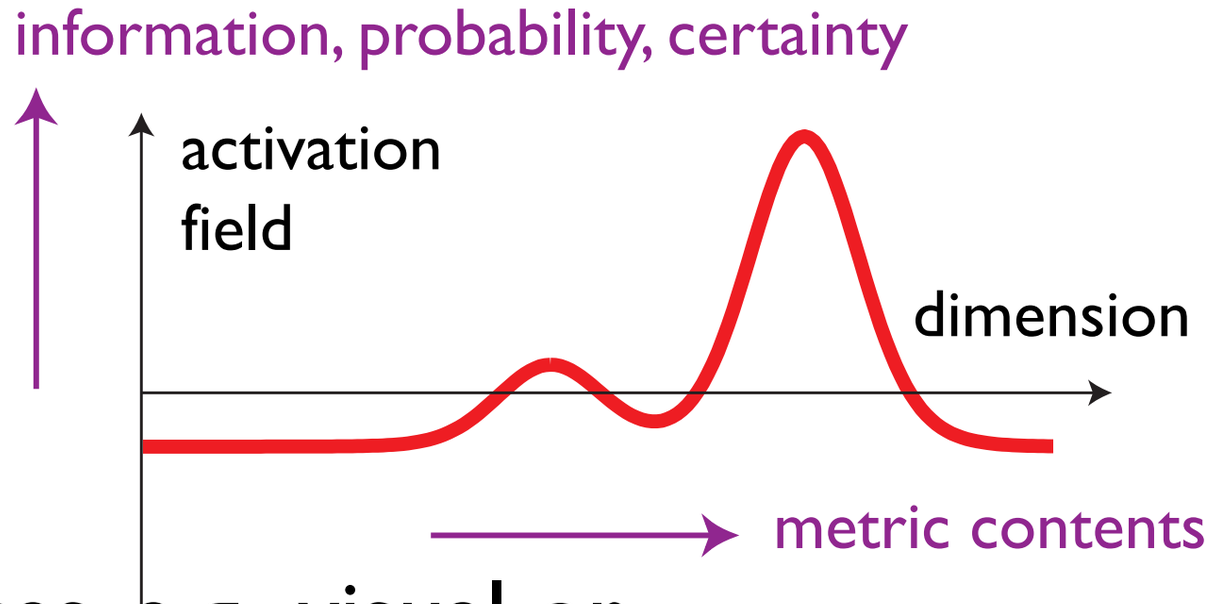
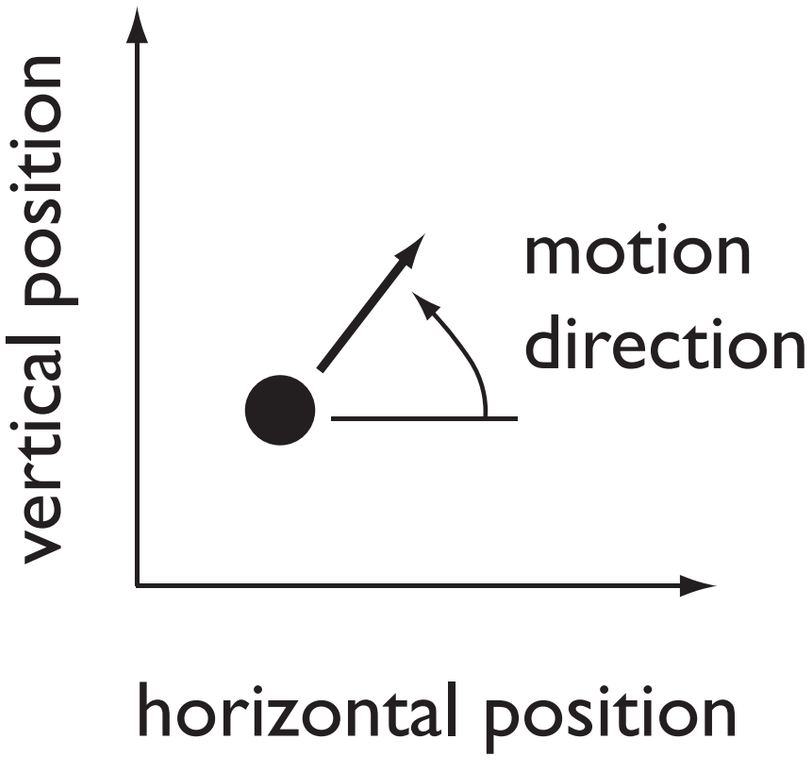
Recall from last lecture …

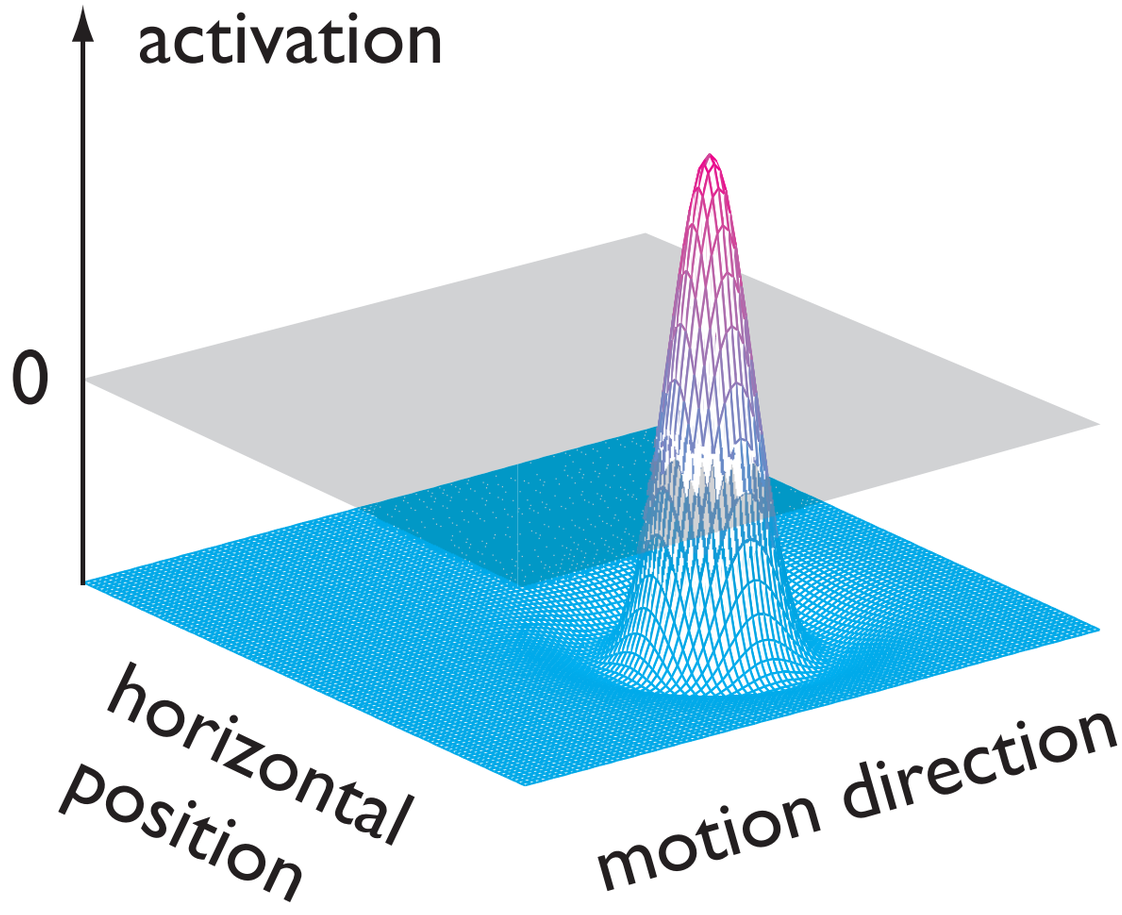
Activation fields over continuous spaces



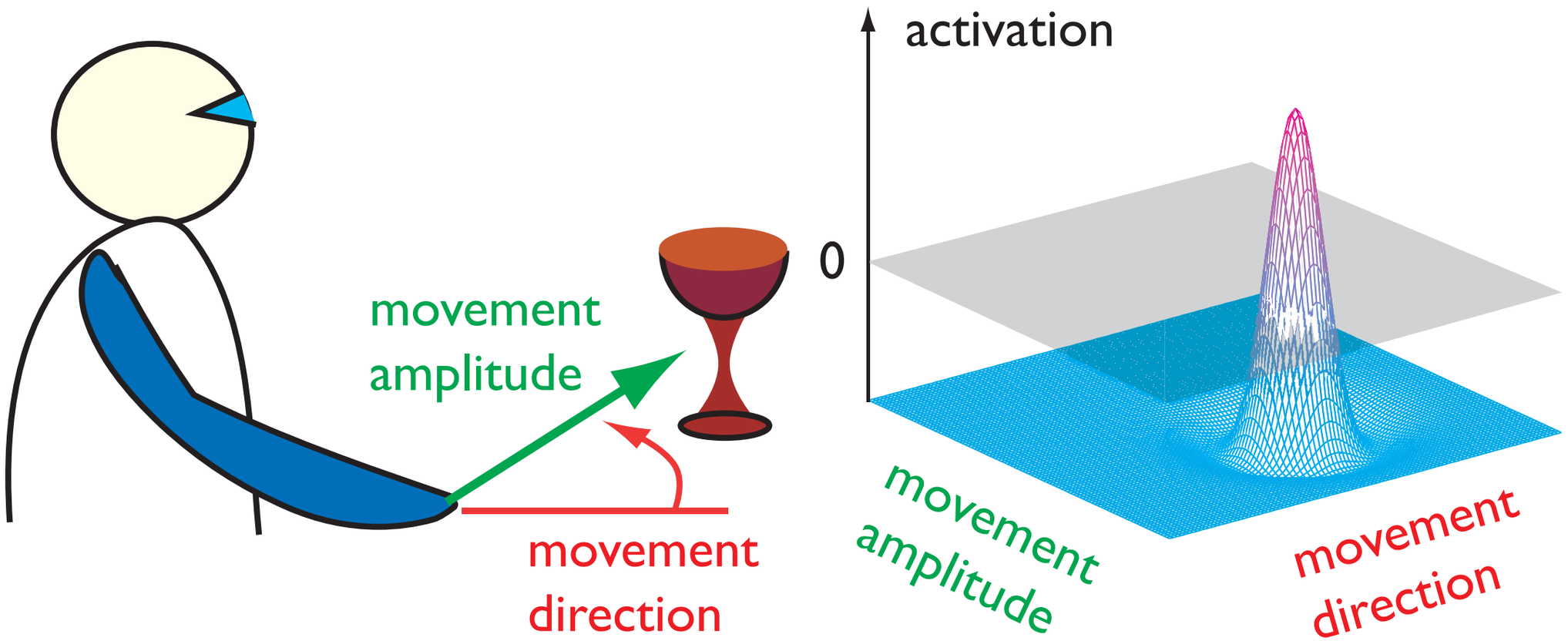
- homologous to sensory surfaces, e.g., visual or auditory space (retinal, allocentric, ...)
- homologous to motor surfaces, e.g., saccadic end-points or direction of movement of the end-effector in outer space
- feature spaces, e.g., localized visual orientations, color, impedance, ...
- abstract spaces,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

Example motion perception: space of possible percepts





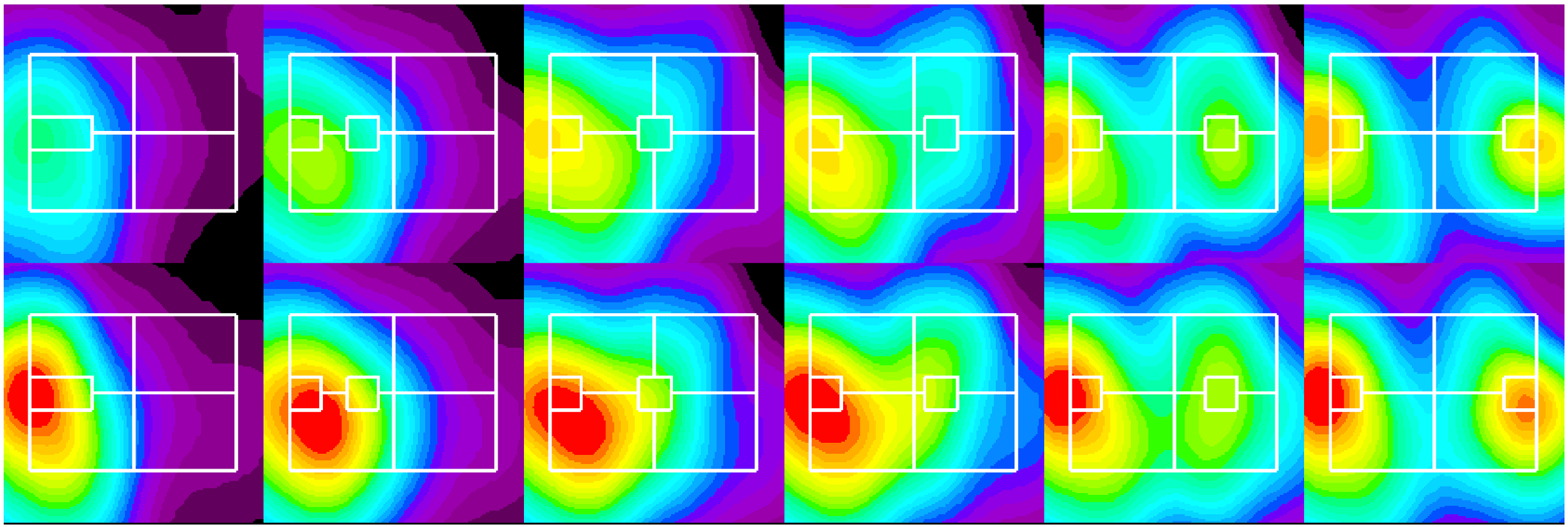
Example: movement planning: space of possible actions



Distribution of Population Activation (DPA)

response to composite stimuli

increasing distance between the two squares of light



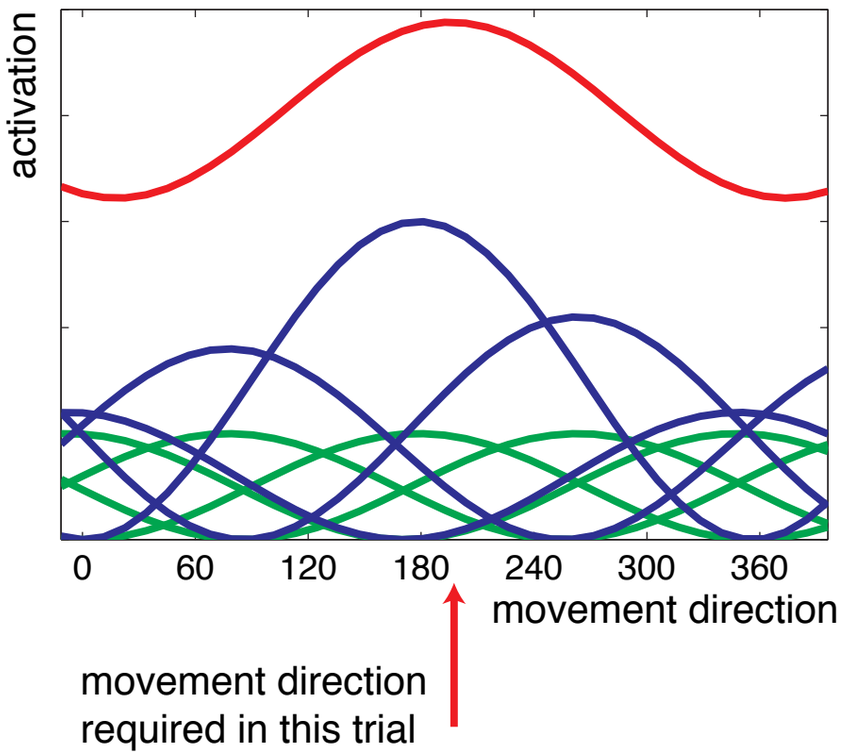
superposition of responses to each elemental stimulus

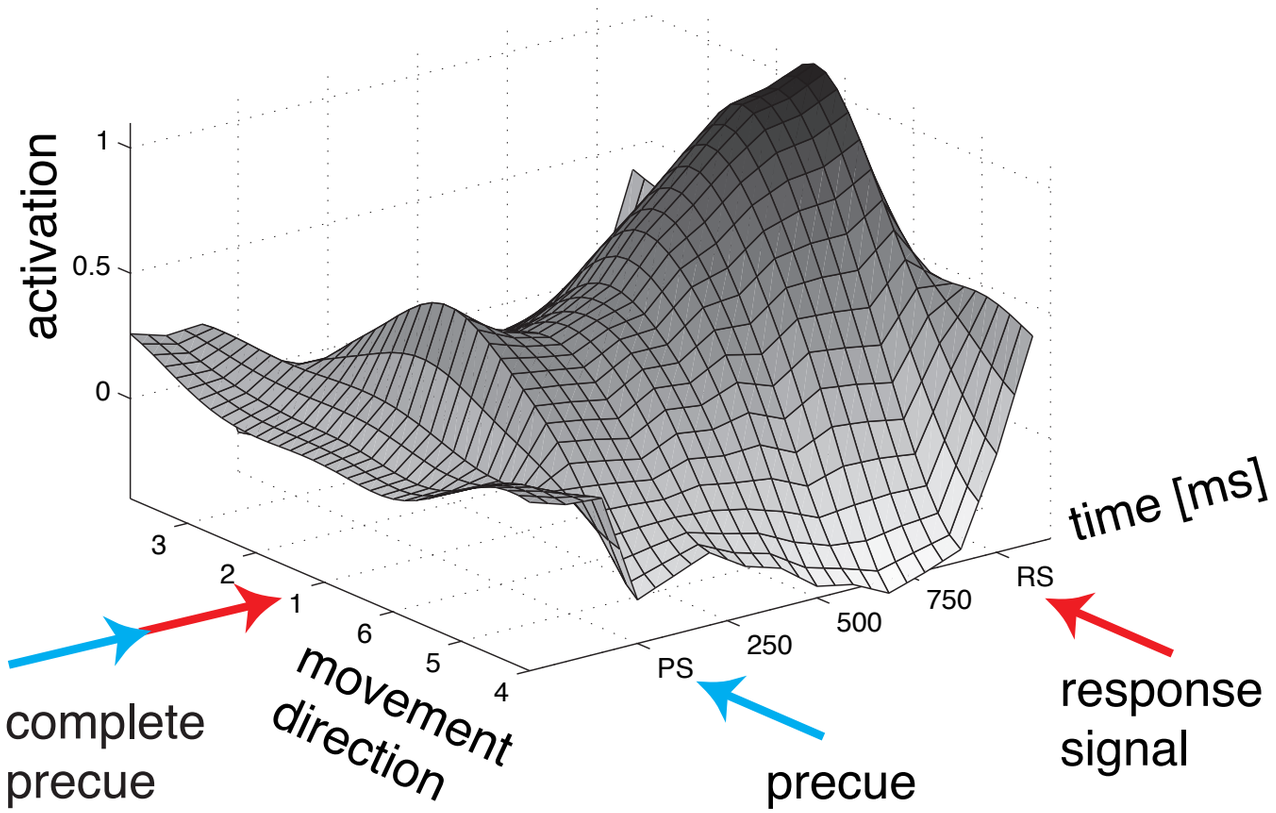
0.4°

Distribution of Population Activation (DPA)

Distribution of population activation =

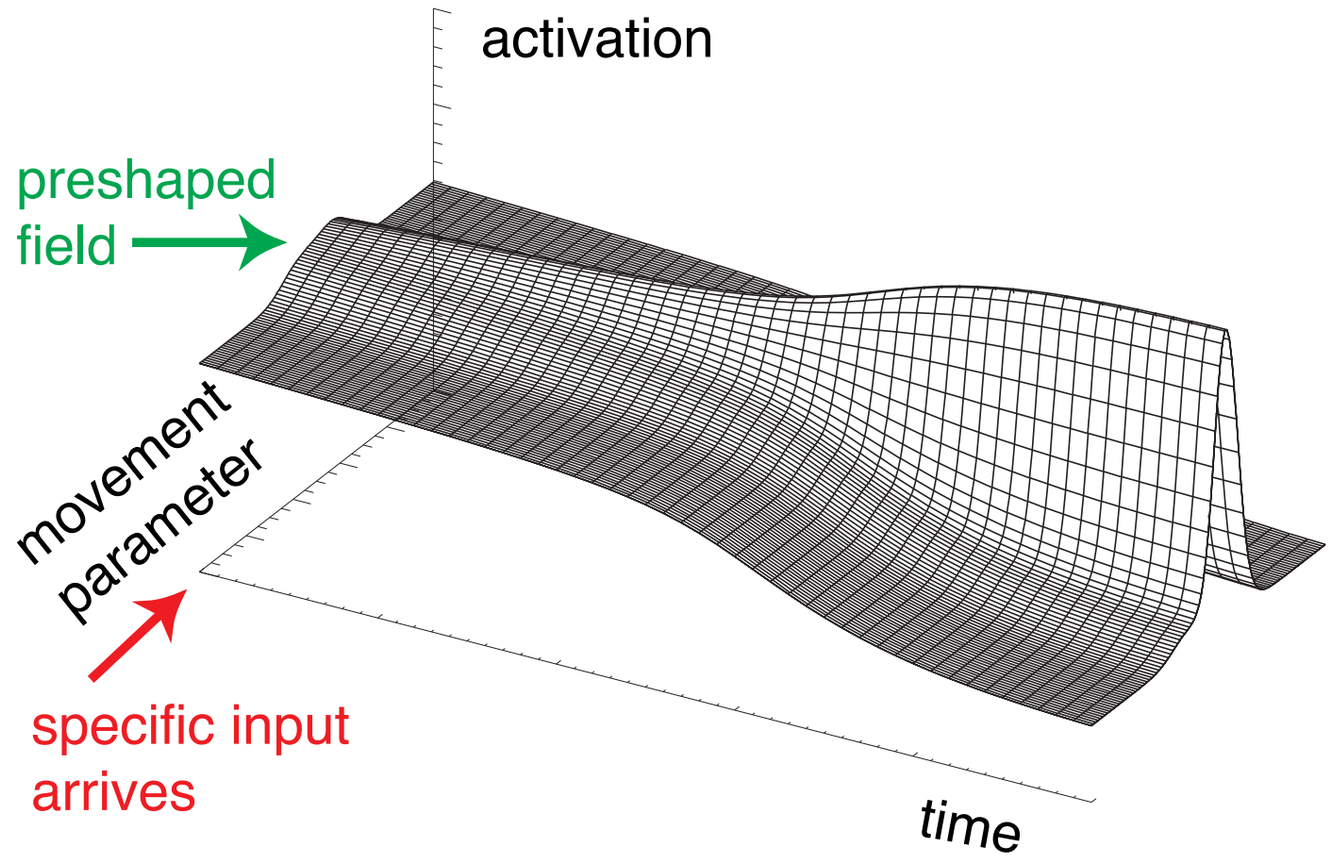
$\sum_{\text{neurons}}$ tuning curve * current firing rate

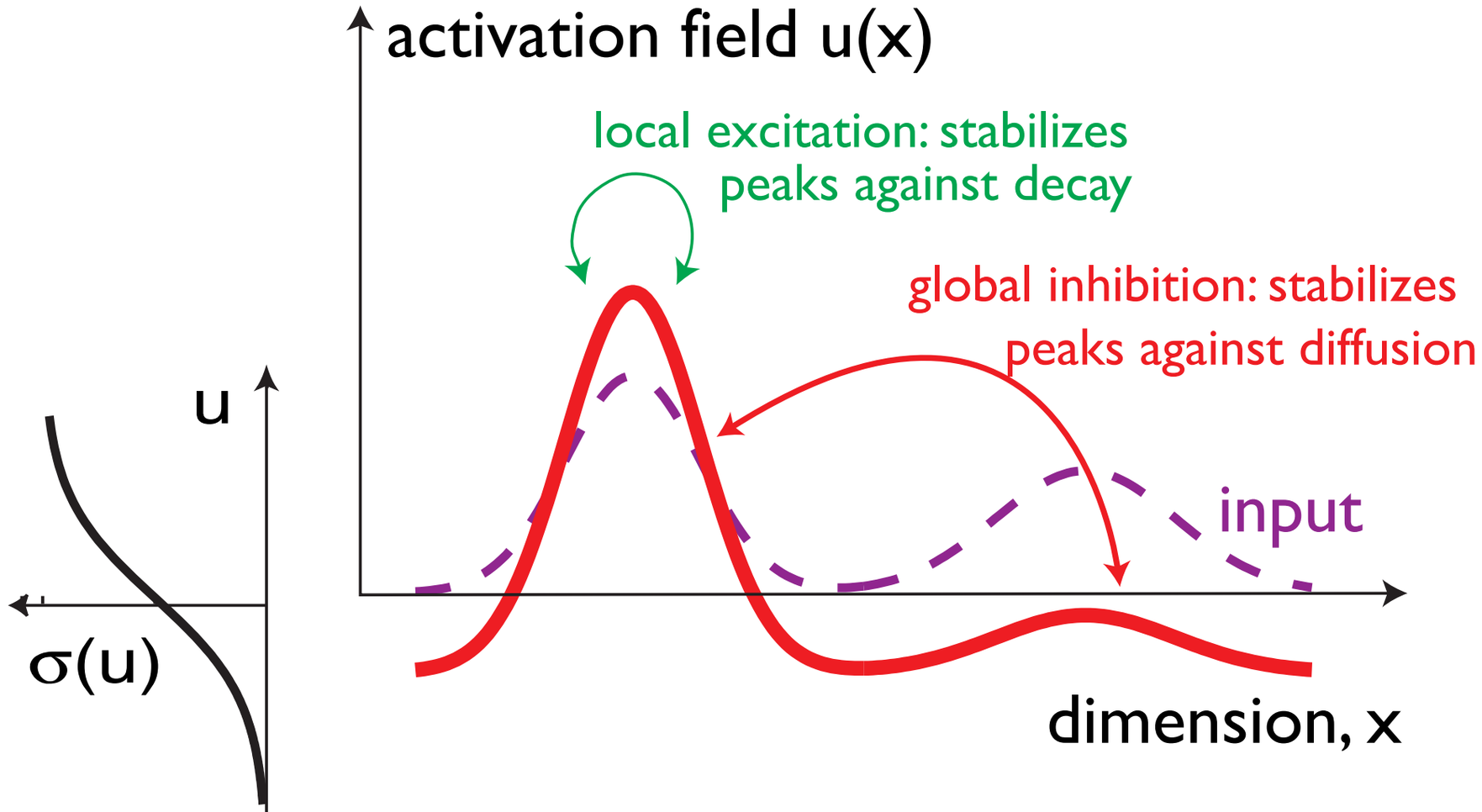




[Bastian, Riehle, Schöner, 2003]

Neural dynamics of activation fields is structured so that localized peaks are attractors





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

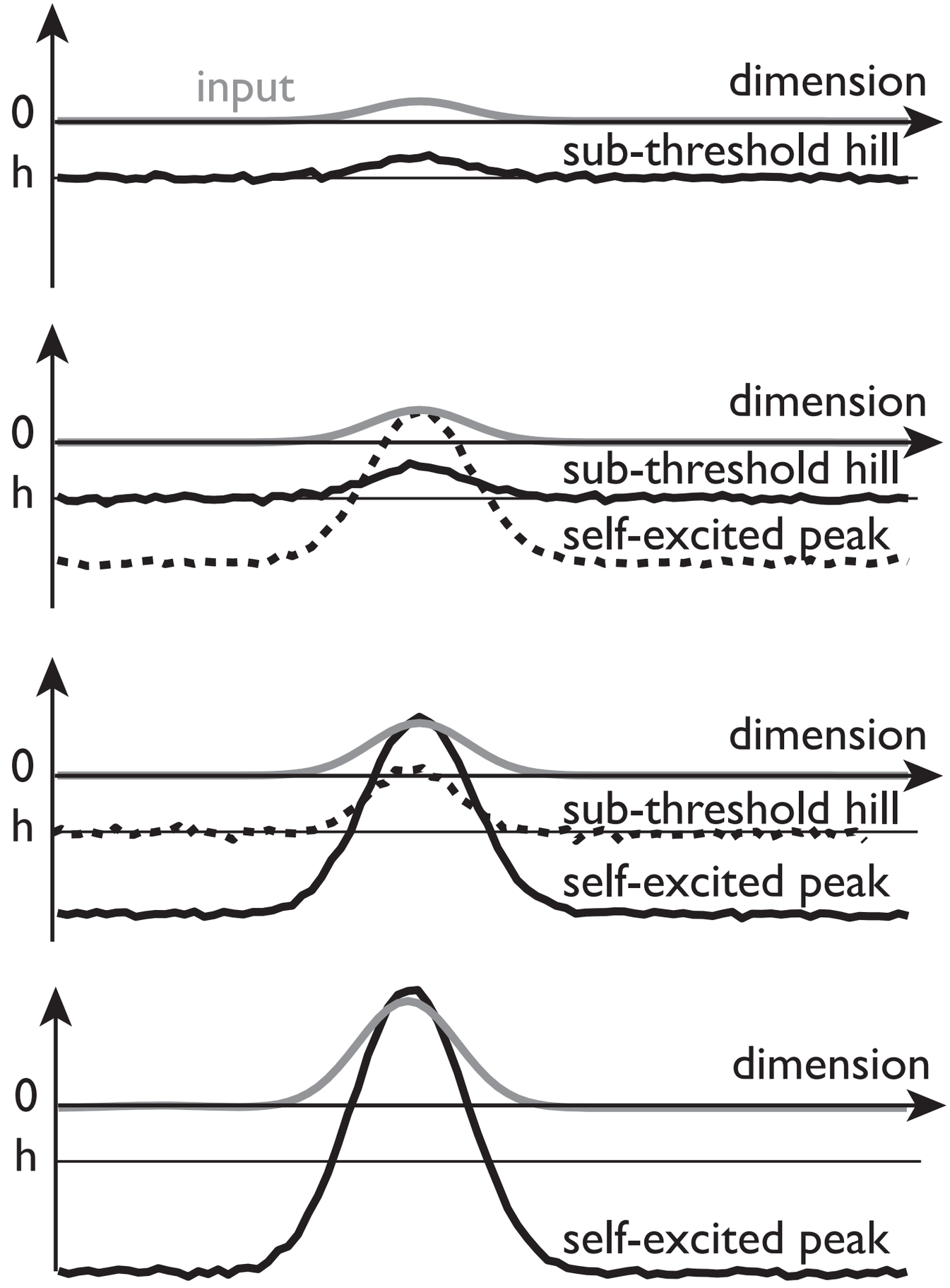
$$\sigma(u) = \frac{1}{1+\exp[-\beta(u-u_0)]}$$

=> simulations

Solutions and instabilities

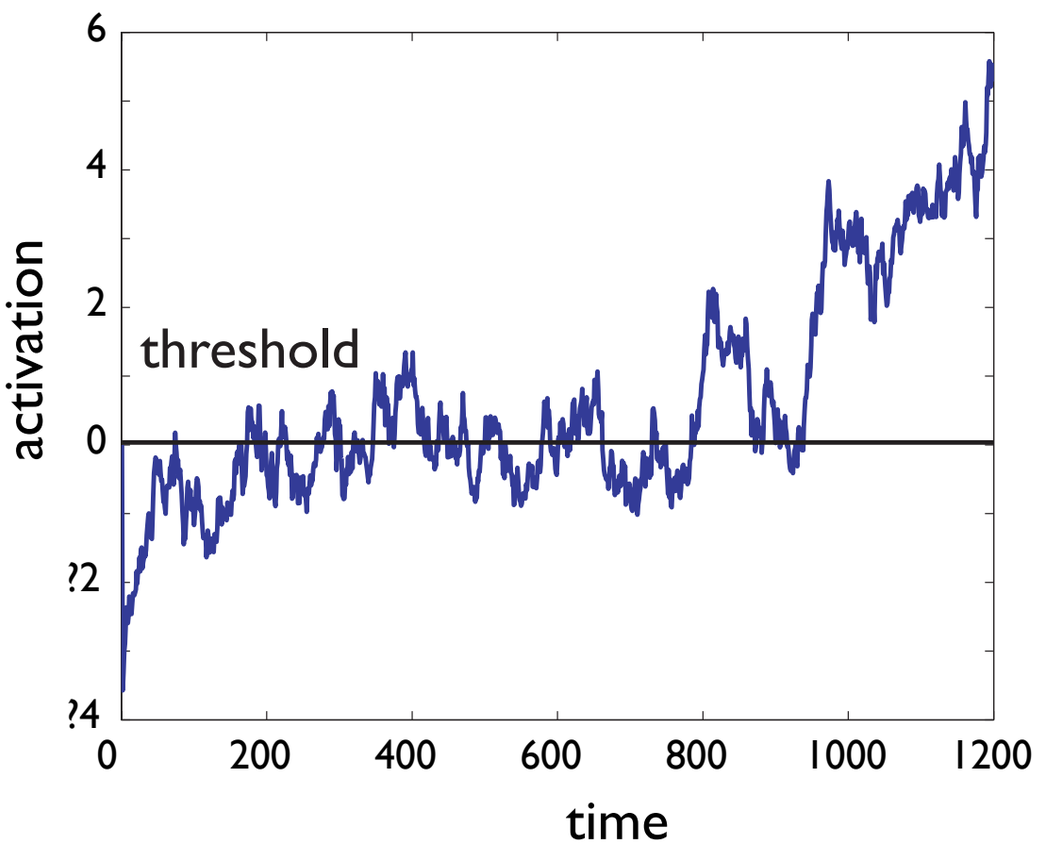
- input driven solution (sub-threshold) vs. self-stabilized solution (peak, supra-threshold)
- detection instability
- reverse detection instability
- selection
- selection instability
- memory instability
- detection instability from boost

Detection instability

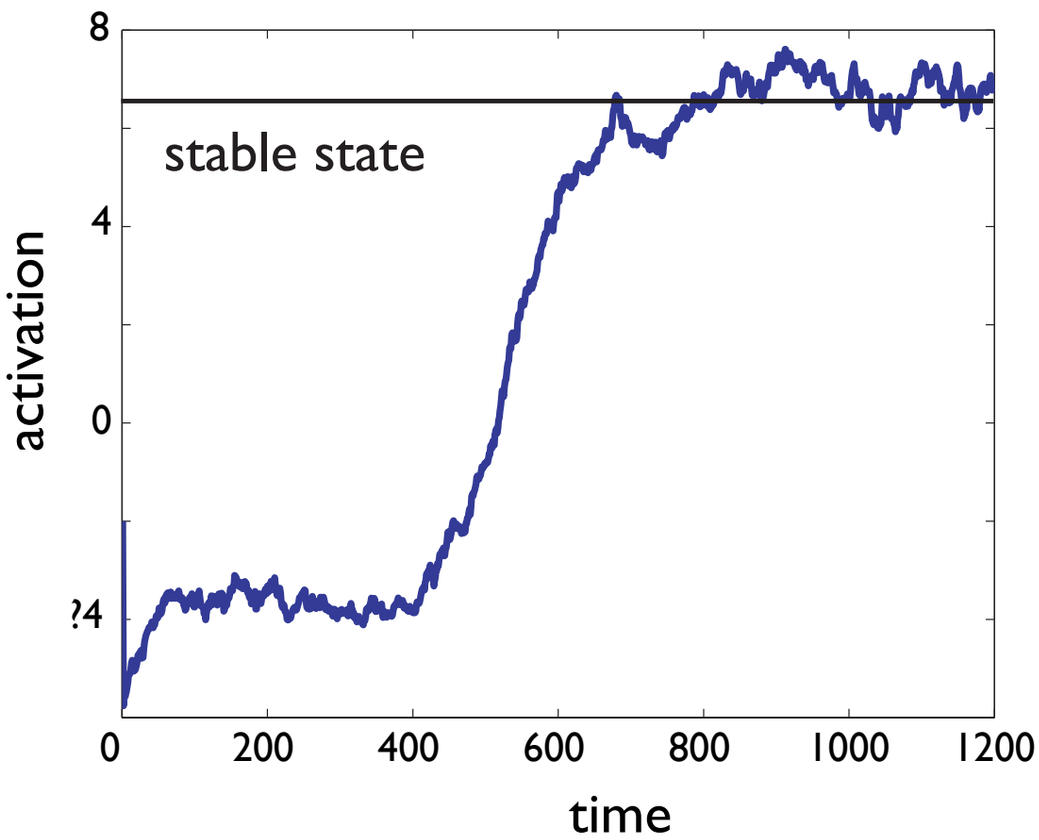


the detection instability helps stabilize decisions

threshold piercing



detection instability



the detection instability helps stabilize decisions

- self-stabilized peaks are macroscopic neuronal states, capable of impacting on down-stream neuronal systems
- (unlike the microscopic neuronal activation that just exceeds a threshold)

emergence of time-discrete events

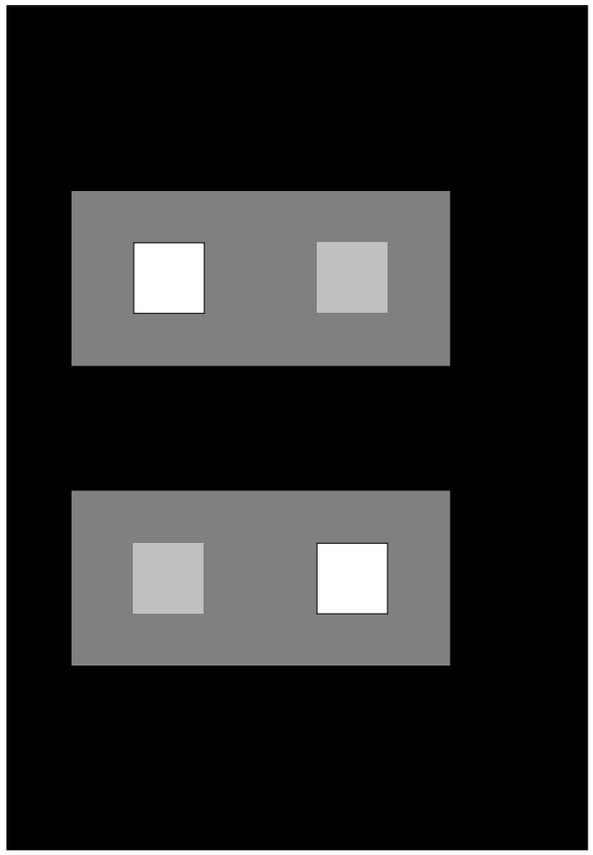
- the detection instability also explains how a time-continuous neuronal dynamics may create macroscopic, time-discrete events

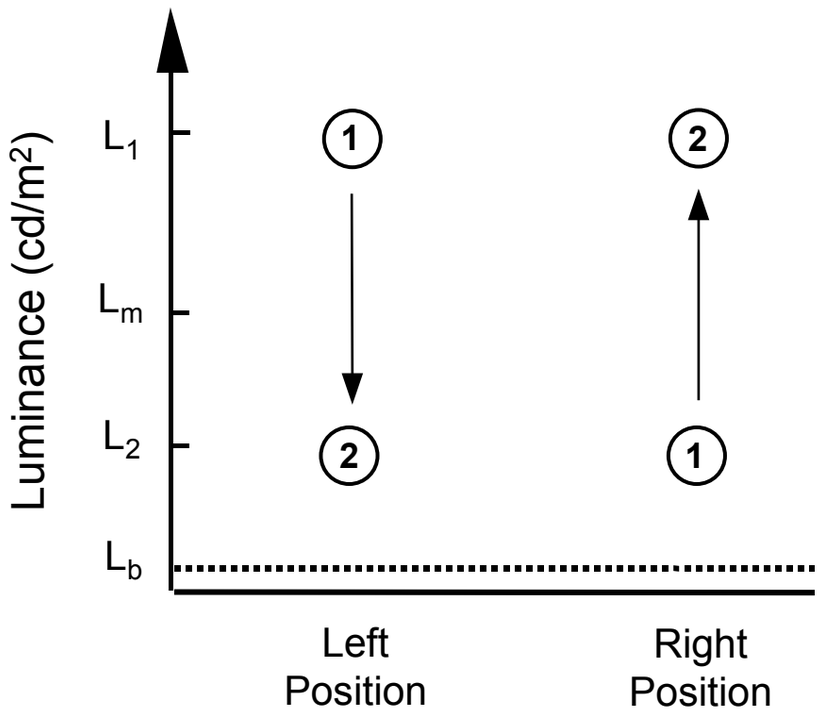
behavioral signatures of detection decisions

- detection in psychophysical paradigms is rife with hysteresis
- but: minimize response bias

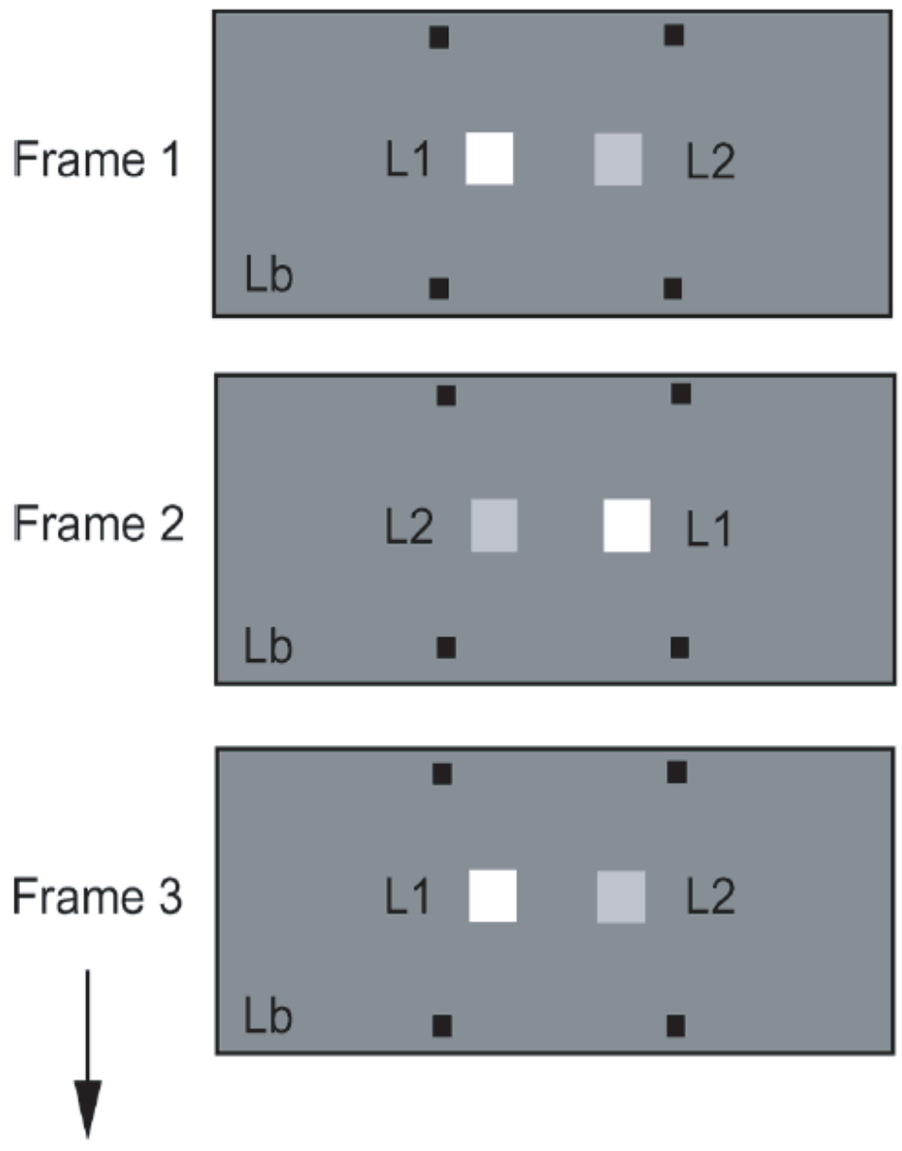
Detection instability

- in the detection of Generalized Apparent Motion





Detection instability



$$Lm = \frac{L1 + L2}{2}$$

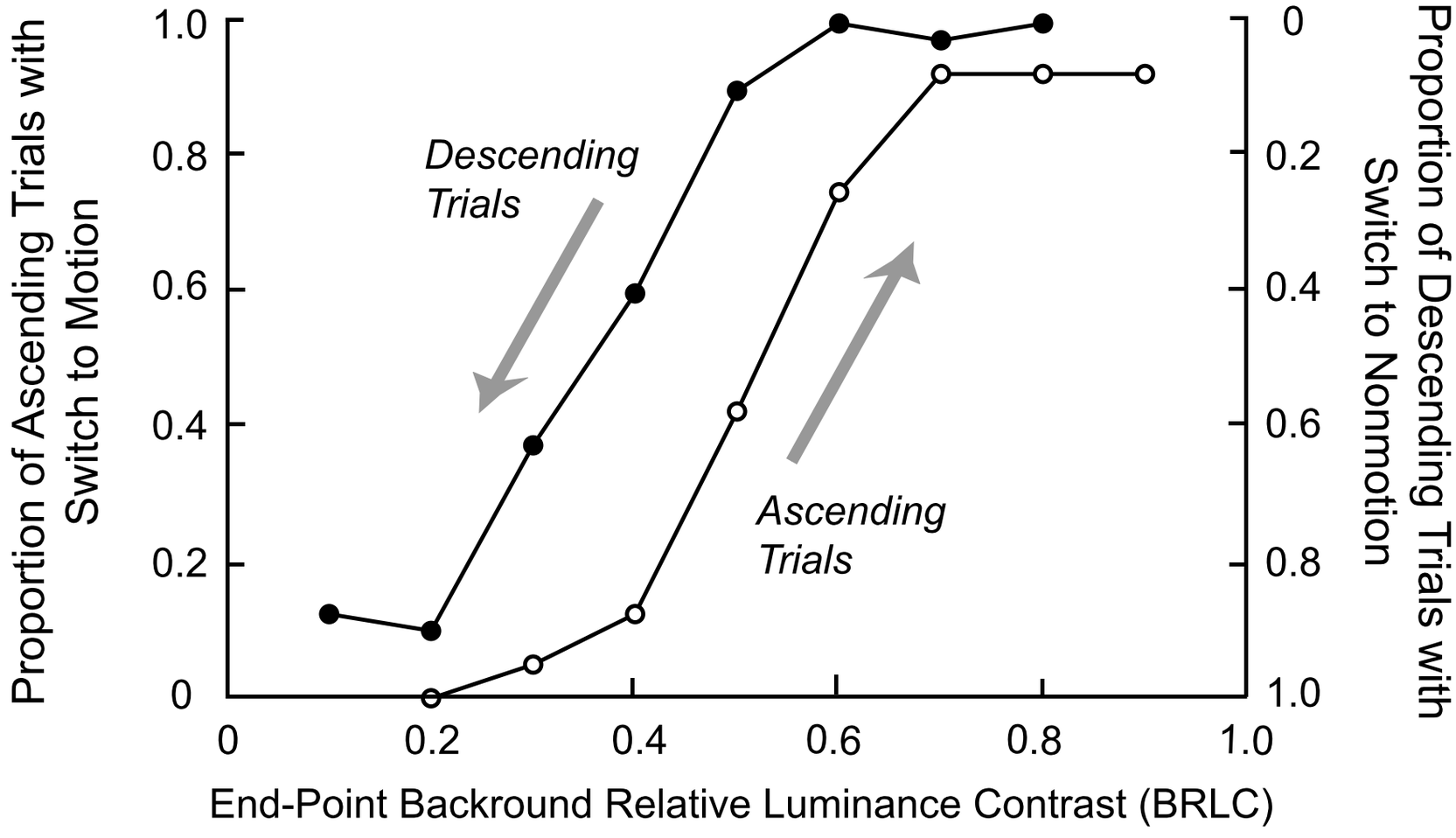
- varying BRLC

$$\text{Background-Relative Luminance Change (BRLC)} = \frac{L1 - L2}{Lm - Lb}$$

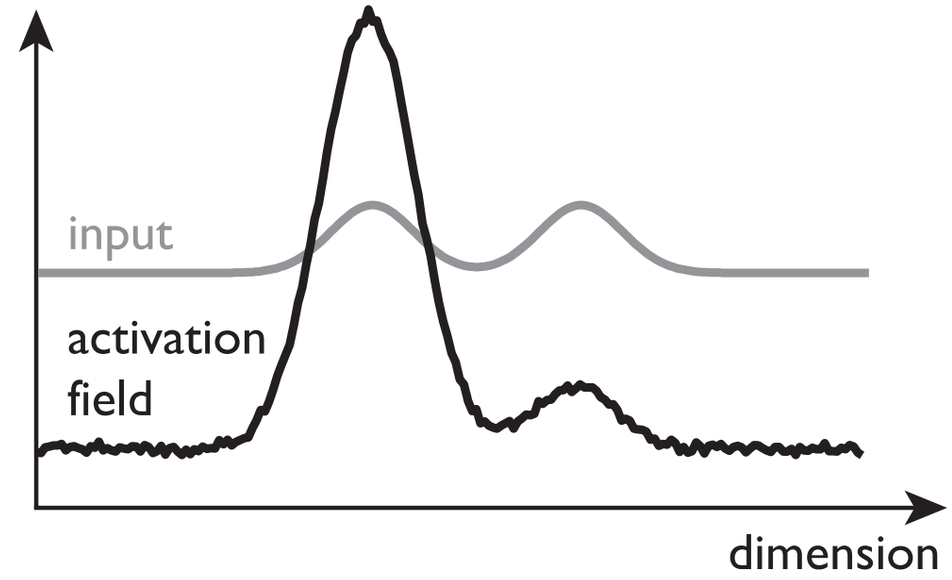
Detection instability

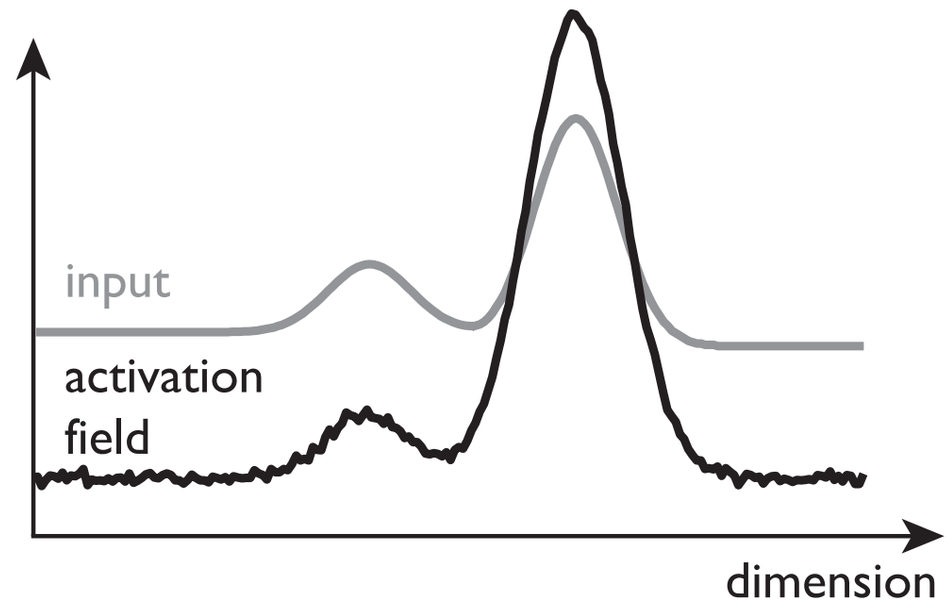
- hysteresis of motion detection as BRLC is varied
- (while response bias is minimized)

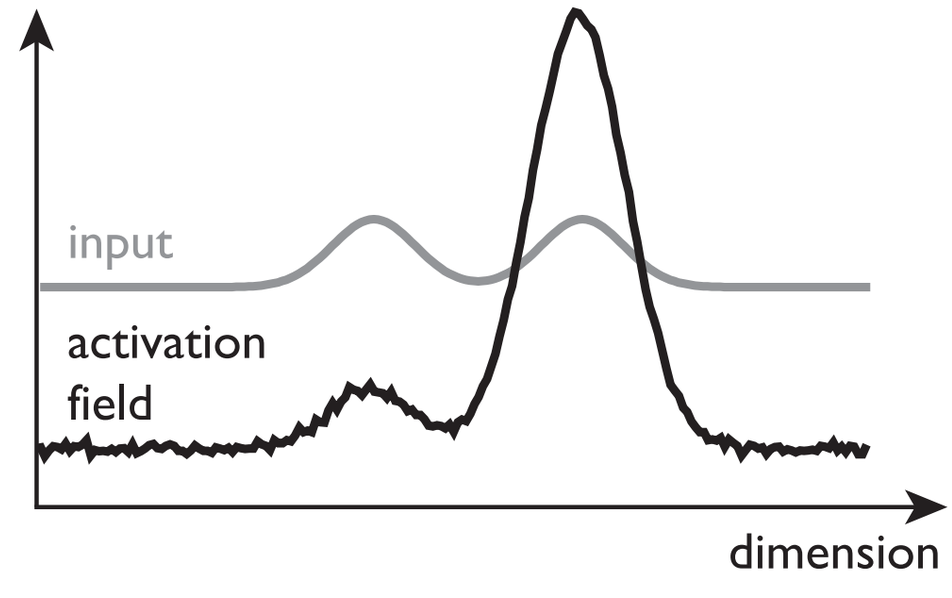
H. S. Hock, G. Schöner / Seeing and Perceiving 23 (2010) 173–195



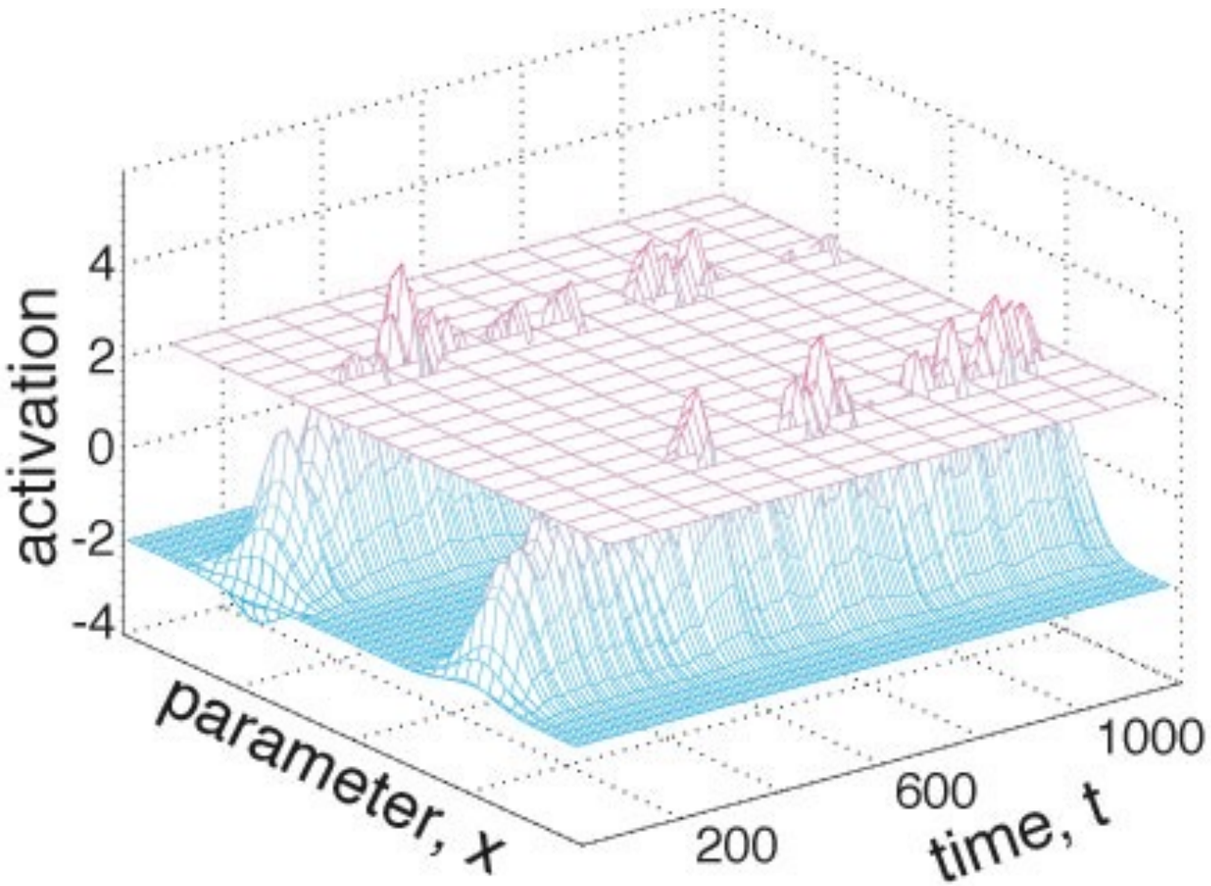
selection instability

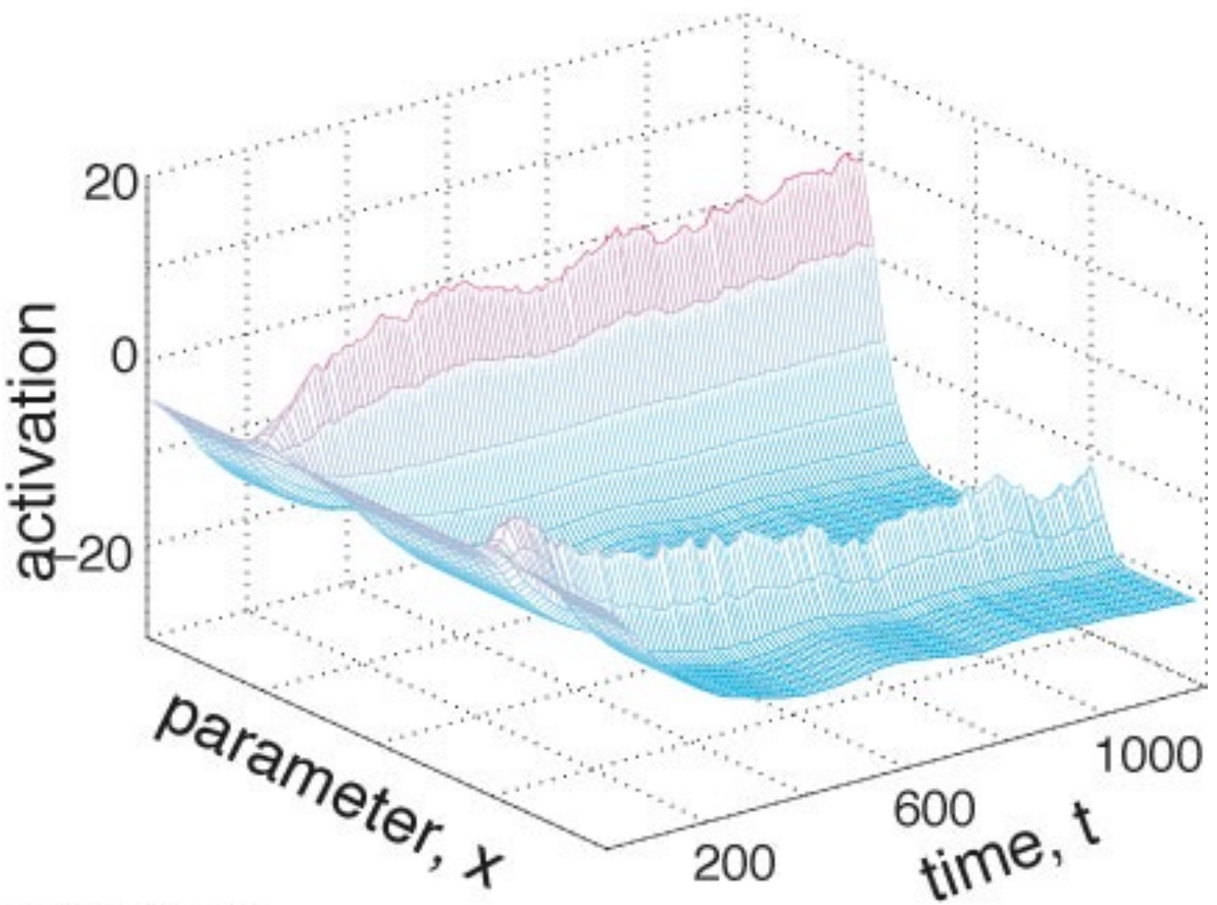






stabilizing selection decisions





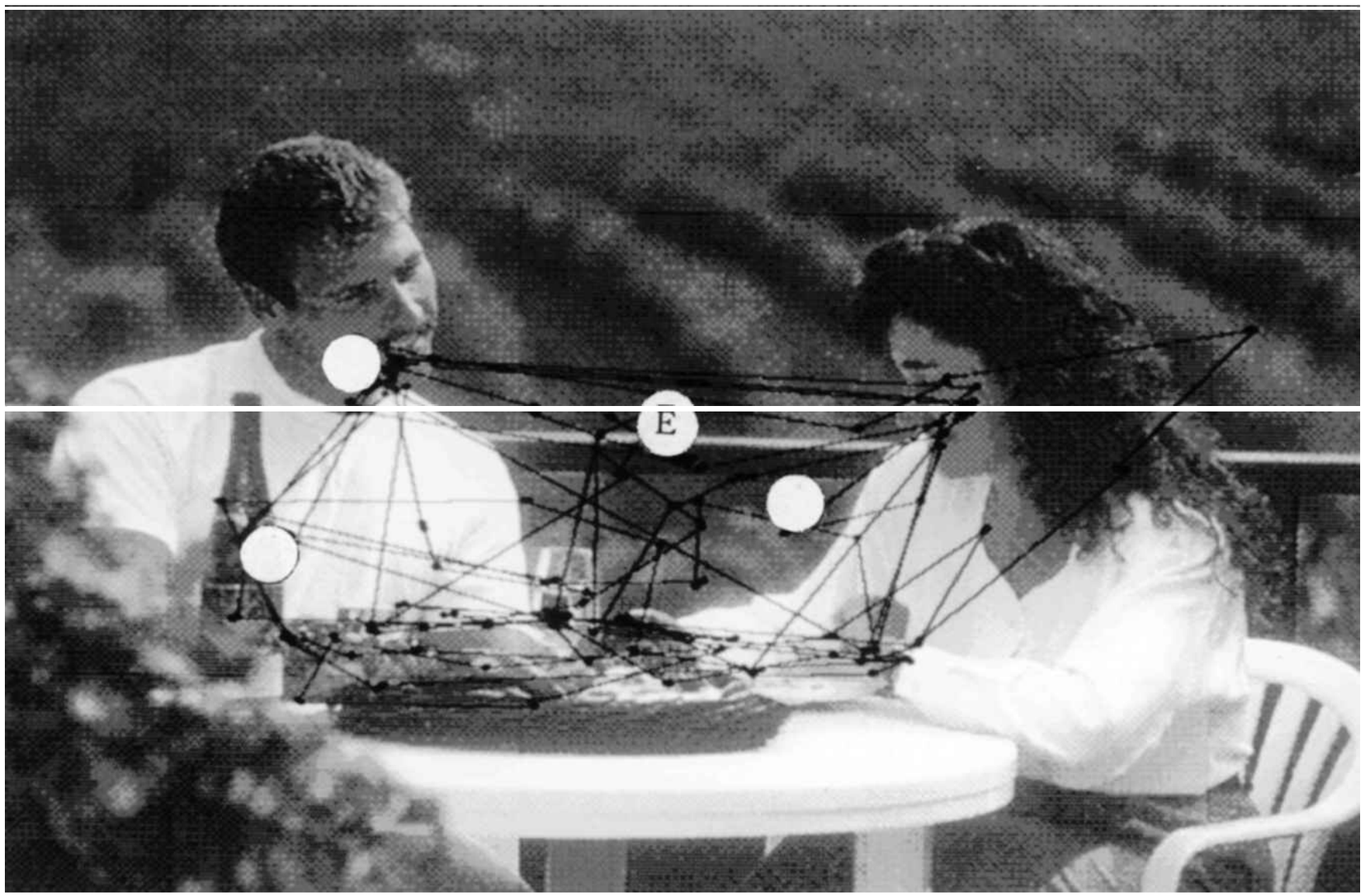
[Wilimzig, Schöner, 2006]

behavioral signatures of selection decisions

- in most experimental situations, the correct selection decision is cued by an "imperative signal" leaving no actual freedom of "choice" to the participant (only the freedom of "error")
- reasons are experimental
- when performance approaches chance level, then close to "free choice"
- because task set plays a major role in such tasks, I will discuss these only a little later

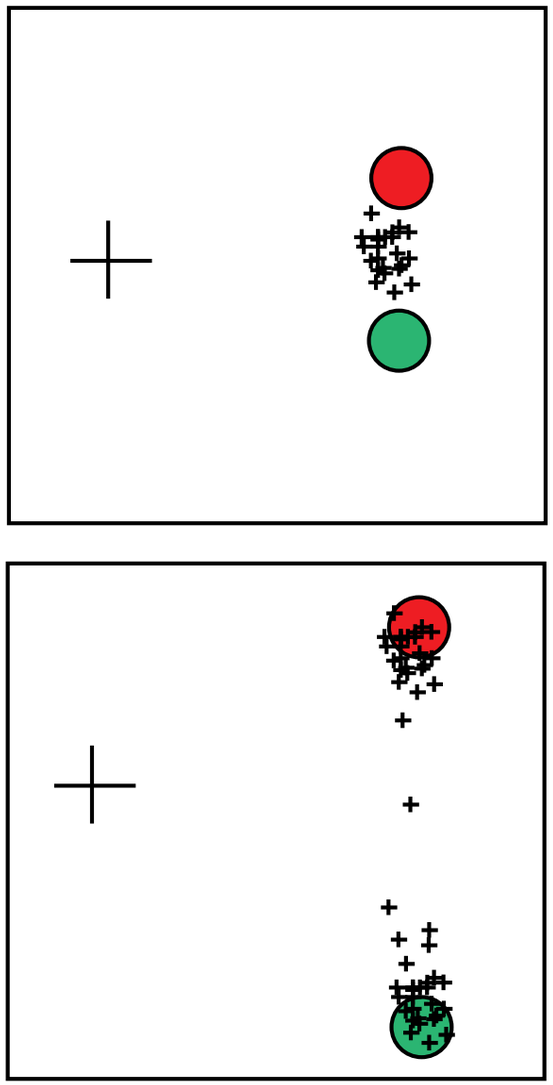
one system of "free choice"

- selecting a new saccadic location

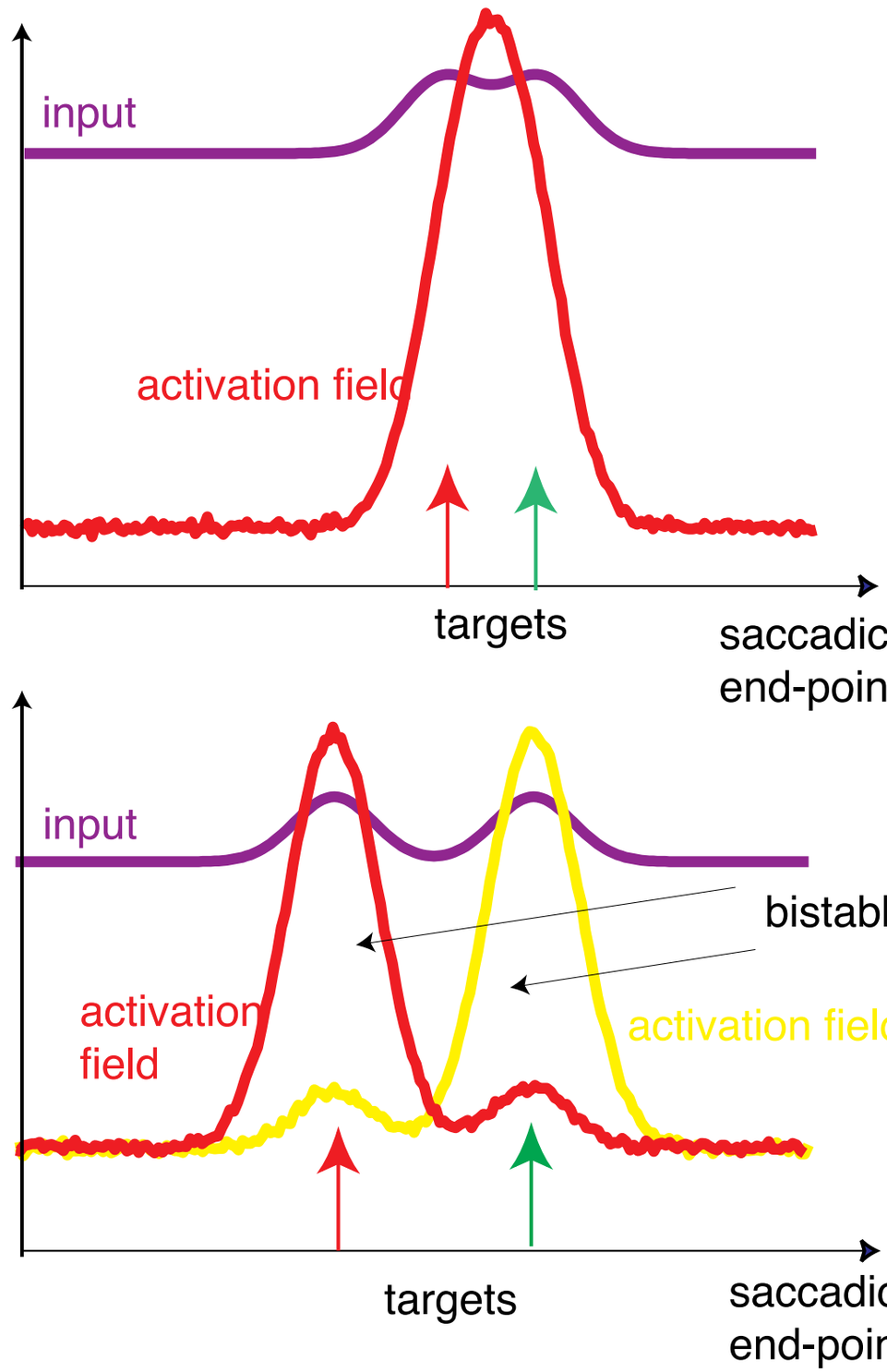


[O'Reagan et al., 2000]

saccade generation



[after: Ottes et al., Vis. Res. 25:825 (85)]



[after Kopecz, Schöner: Biol Cybern 73:49 (95)]

… next

- how decisions are normally observed in the lab
- detections and decisions
- boost driven detections…
- evidence for time continuous decisions