Dynamic Field Theory

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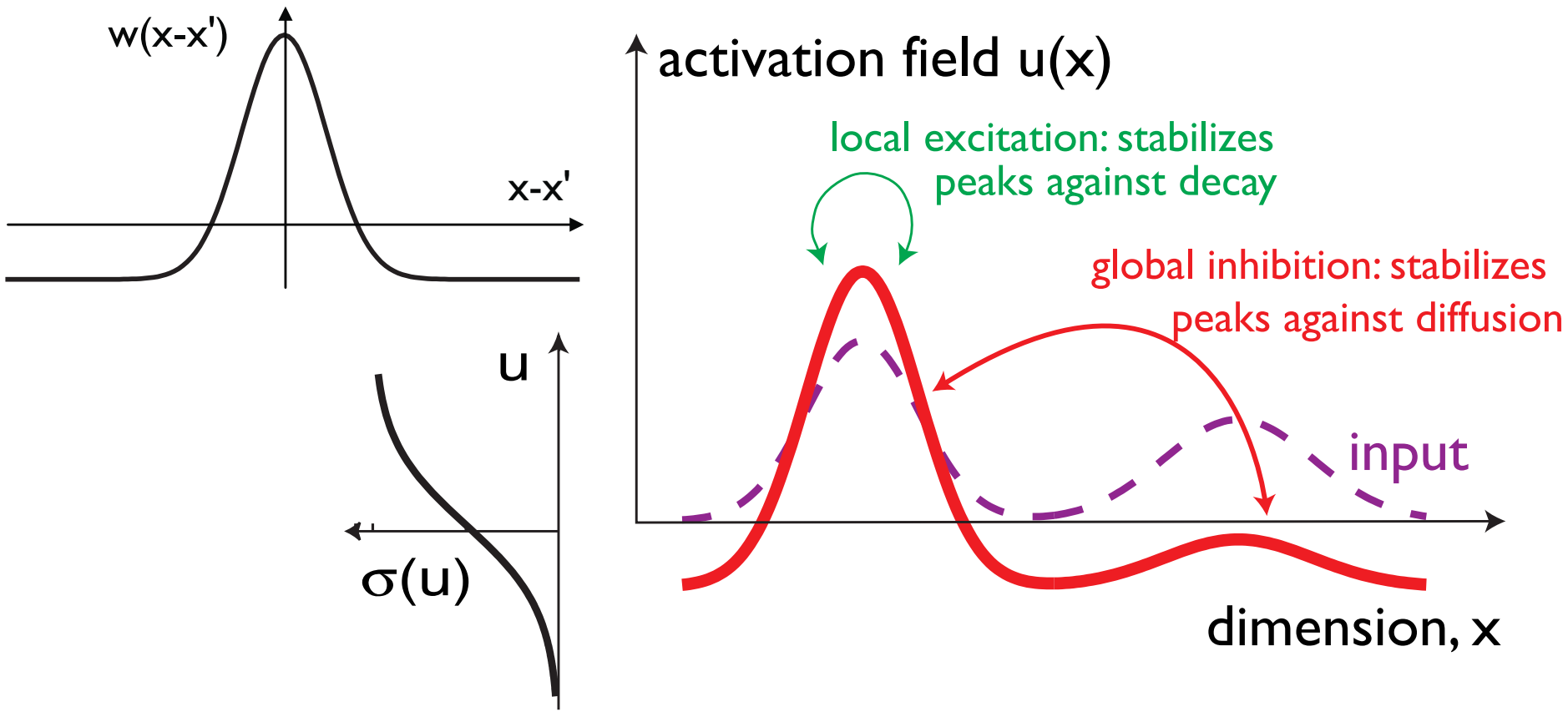
Neural dynamics of fields

- Peaks as stable states from intra-field interaction
- = local excitation/global inhibition



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

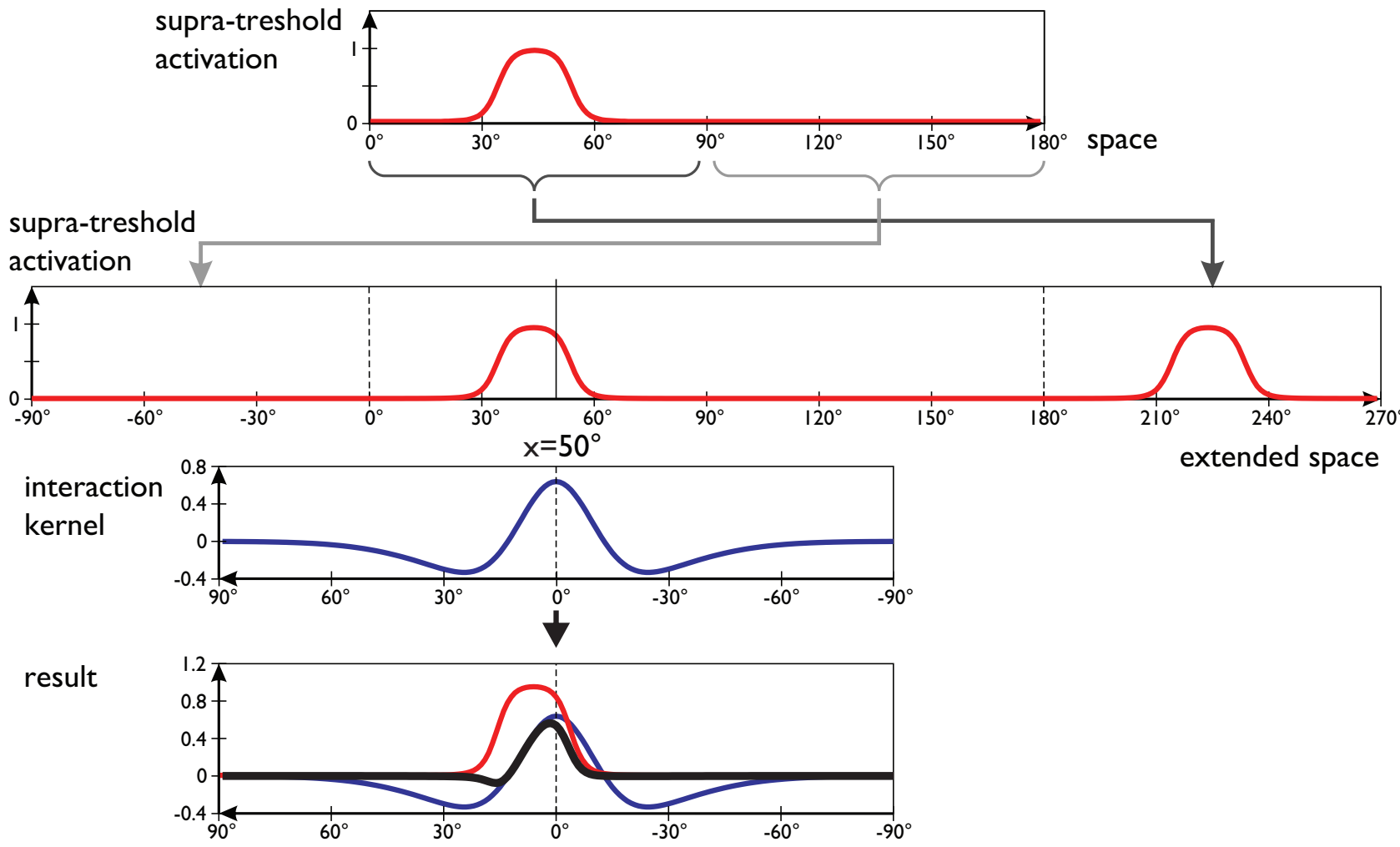
- time scale is τ
- resting level is $h < 0$
- input is $S(x,t)$
- interaction kernel is

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

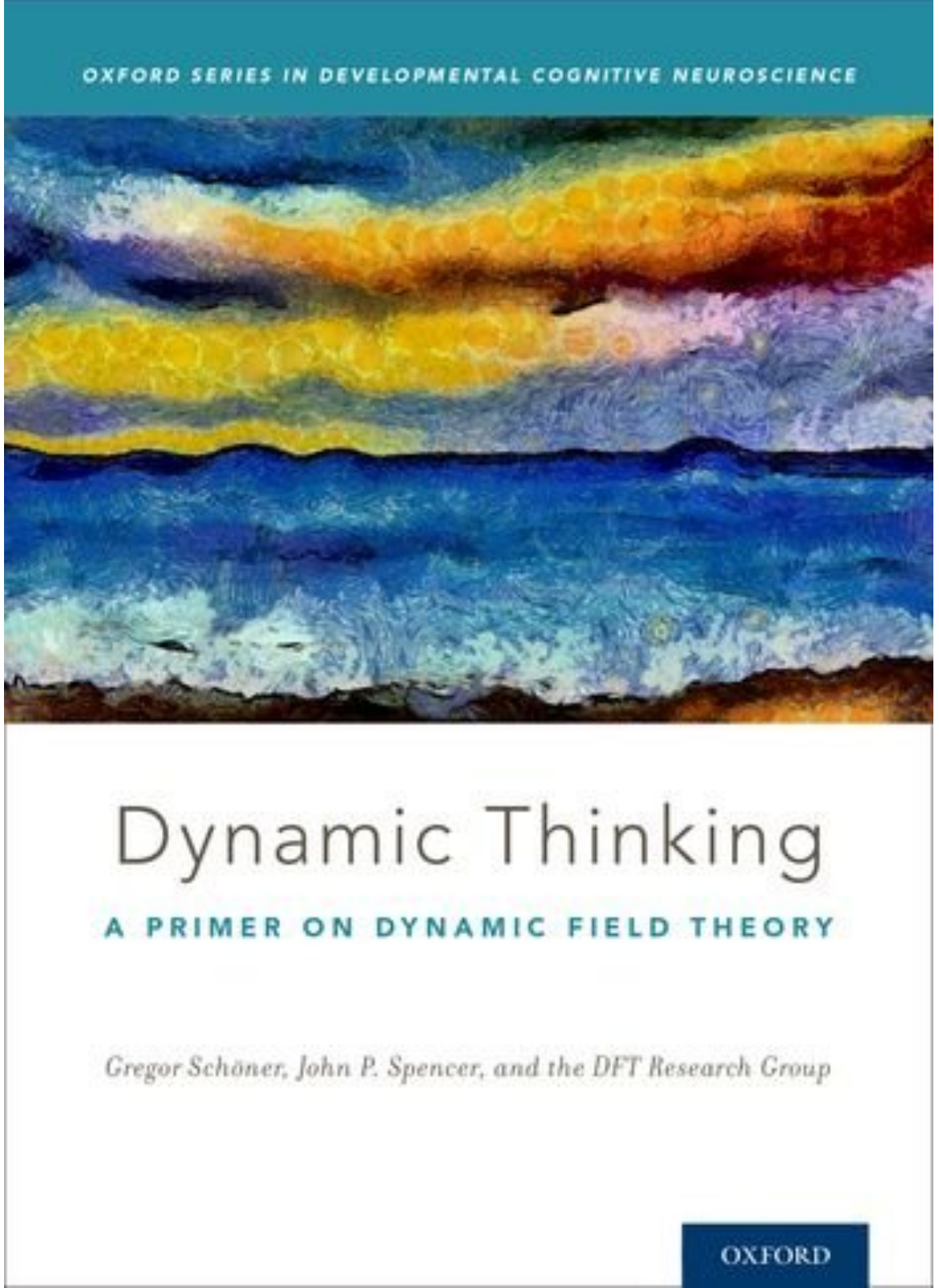
- sigmoidal nonlinearity is

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

Interaction: convolution



dynamicfieldtheory.org



=> simulation

Attractors and their instabilities

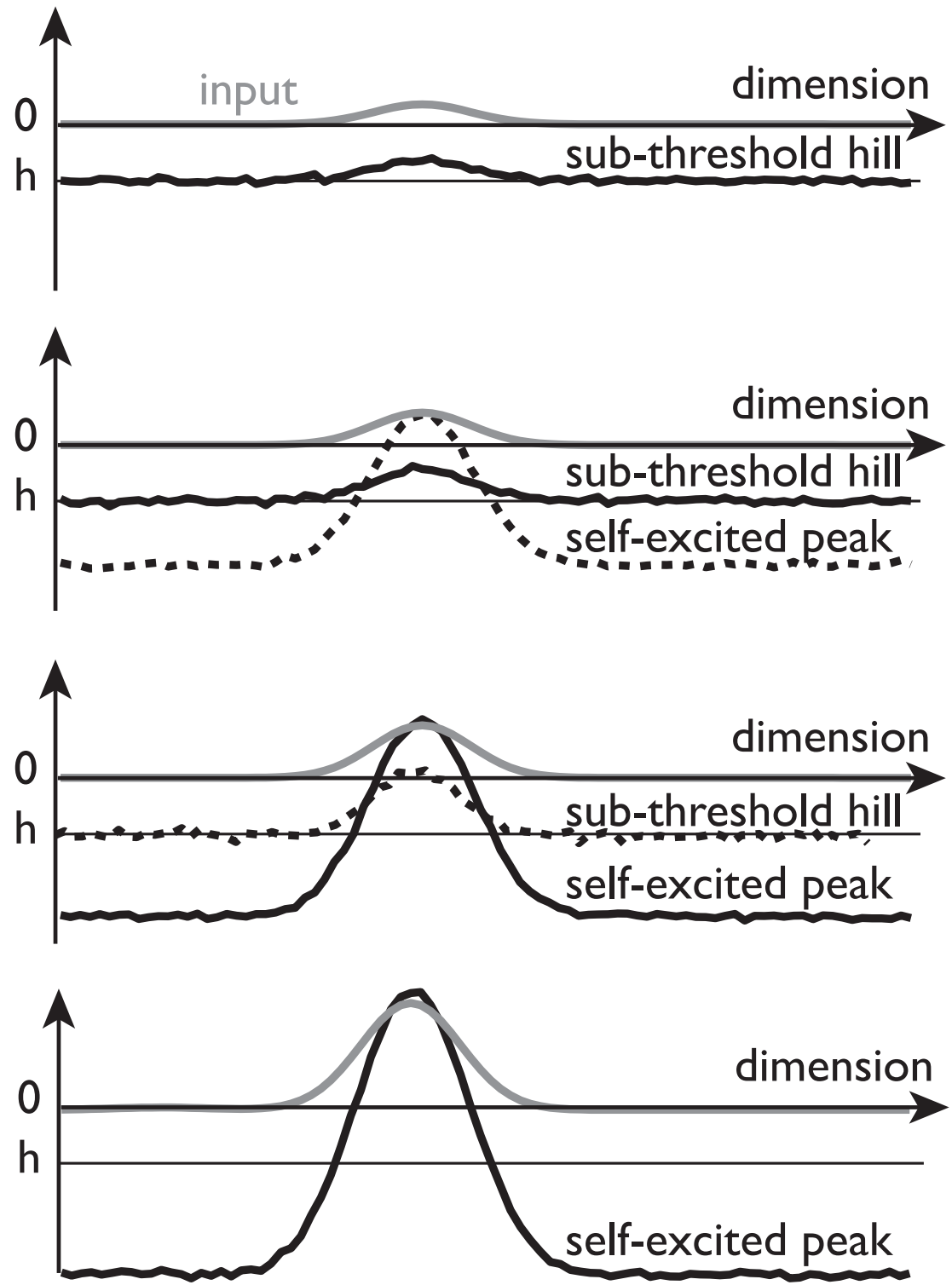
- input driven solution (sub-threshold)
- self-stabilized solution (peak, supra-threshold)
- selection / selection instability
- working memory / memory instability
- boost-driven detection instability

detection instability

reverse detection instability

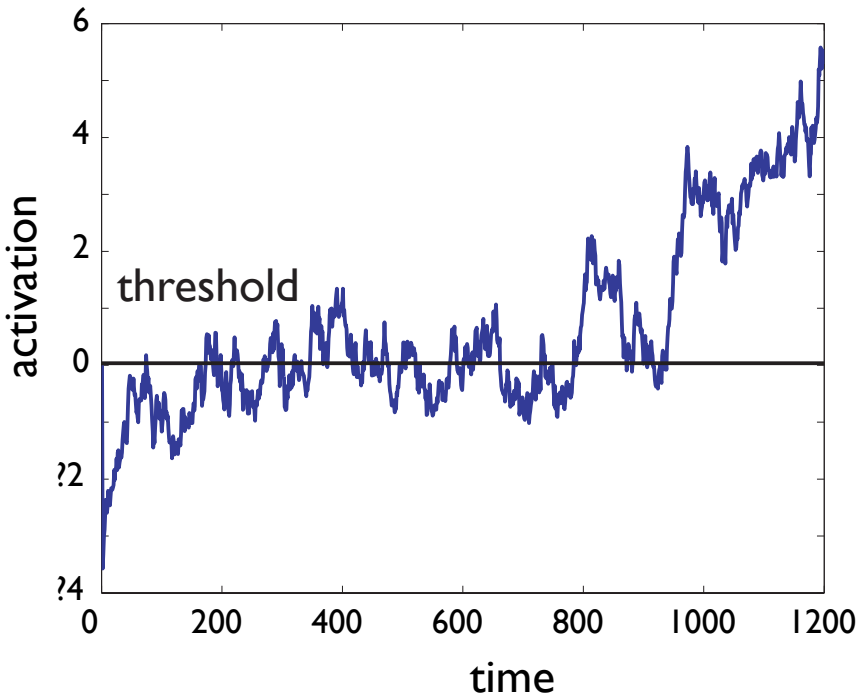
Noise is critical near instabilities

Detection instability

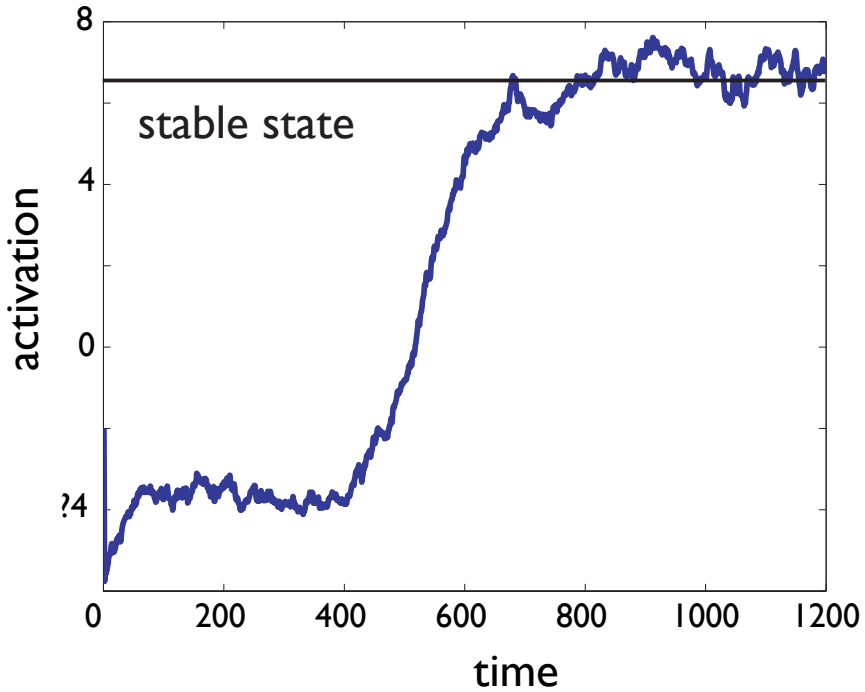


The detection instability stabilizes decisions

threshold piercing



detection instability

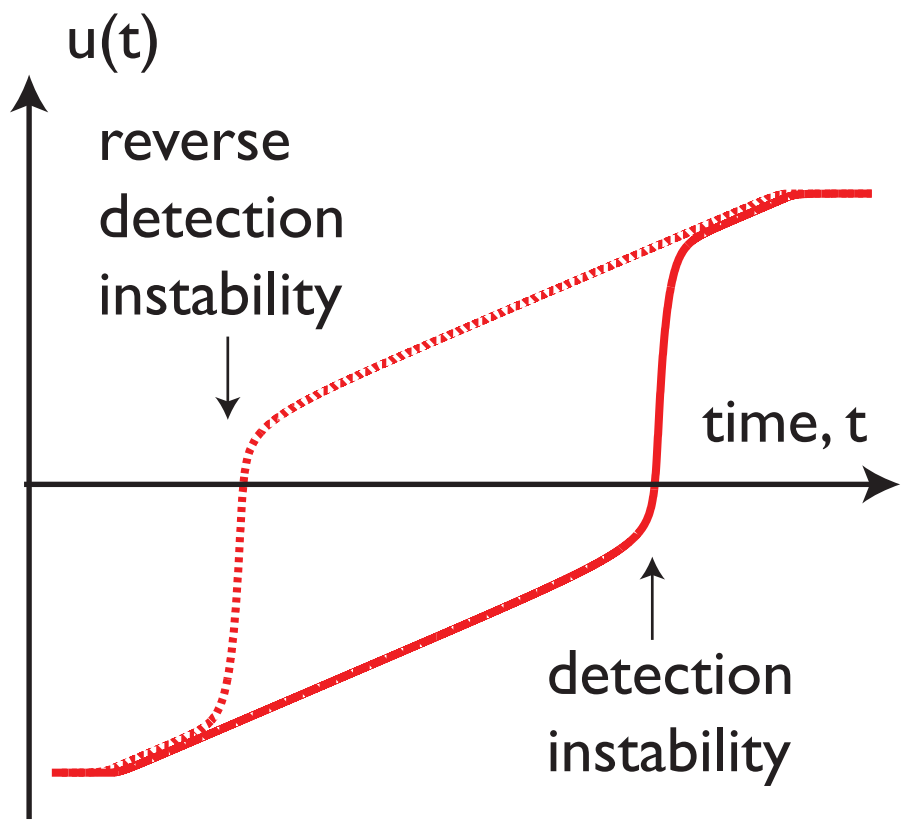


The detection instability stabilizes detection decisions

- 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)

The detection instability leads to the emergence of events

- the detection instability explains how a time-continuous neuronal dynamics may create macroscopic events at discrete moments in time

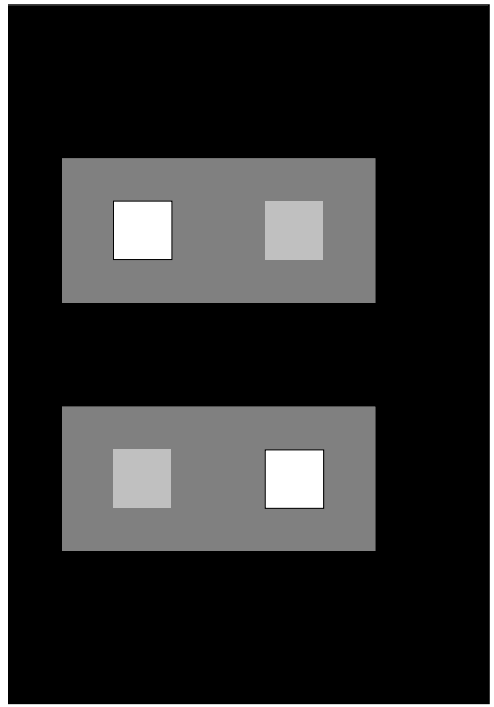


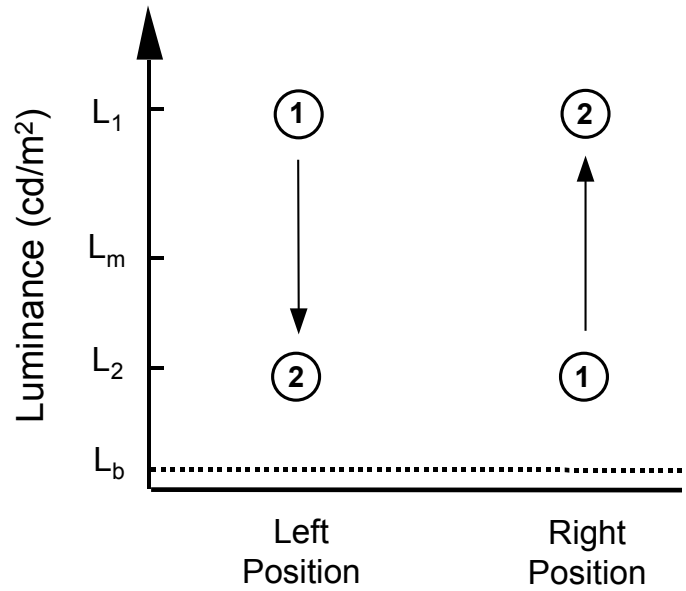
behavioral signatures of detection decisions

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

Detection instability

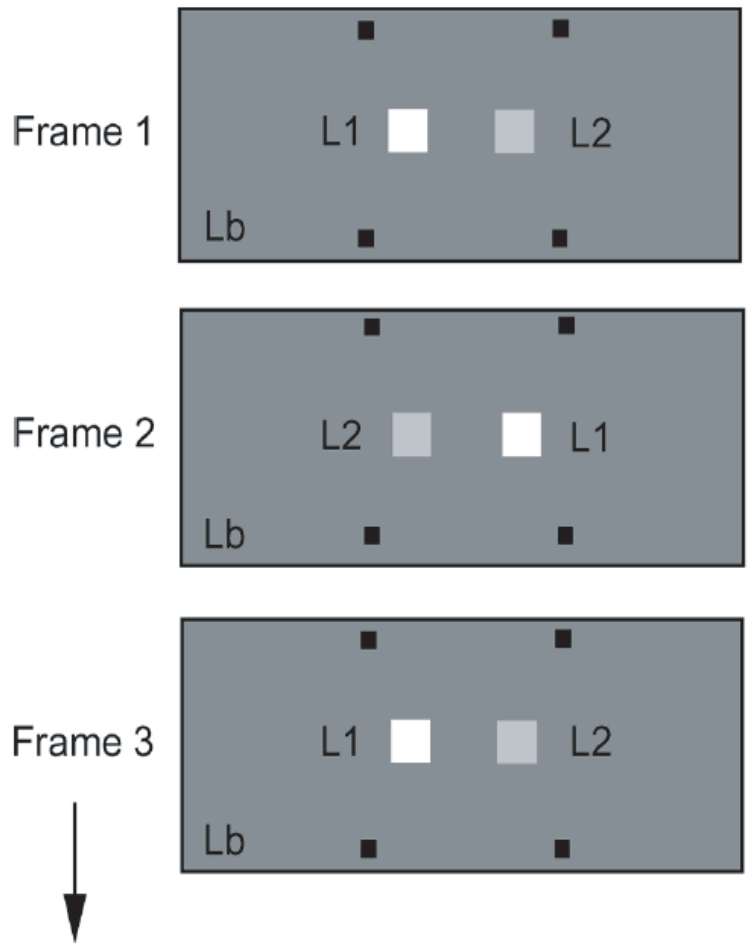
- in the detection of Generalized Apparent Motion





Detection instability

- varying BRLC



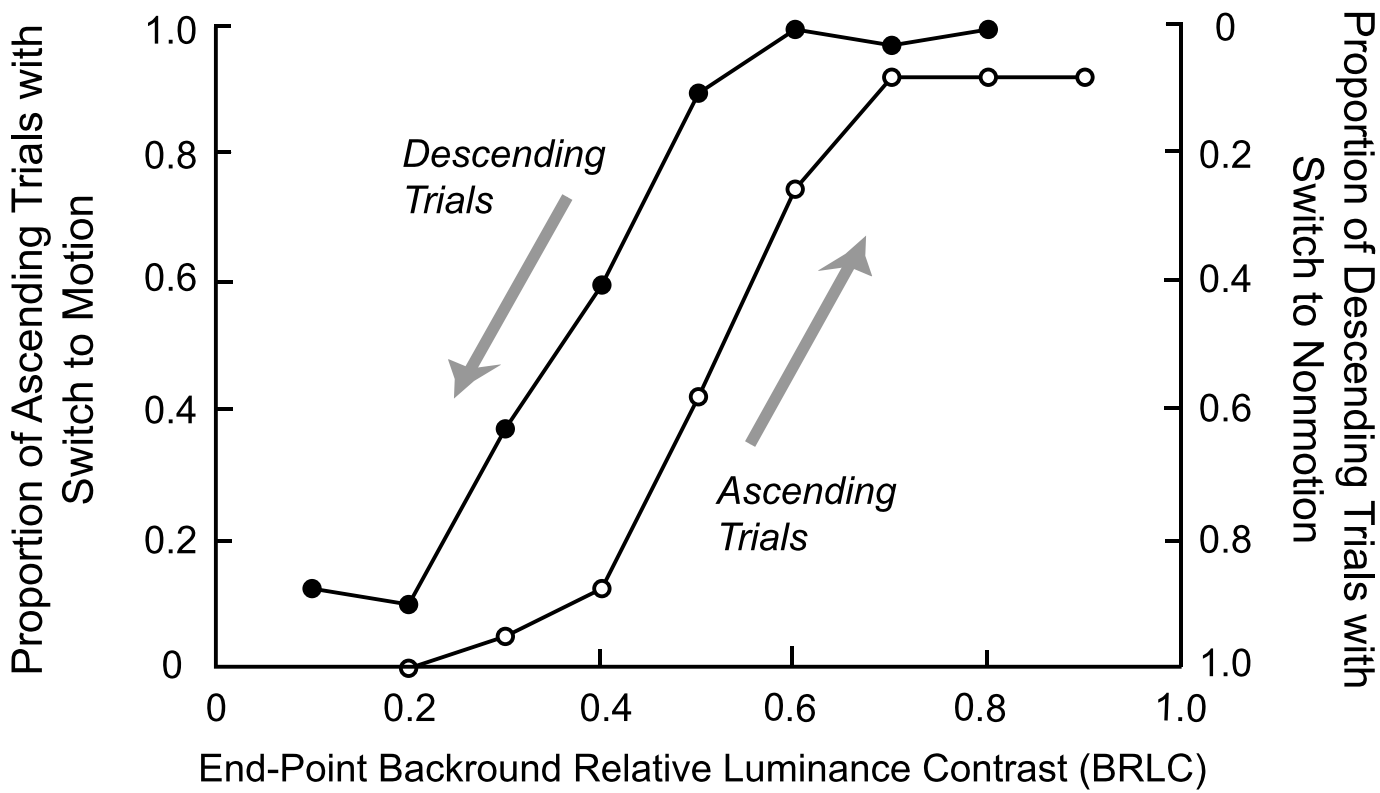
$$Lm = \frac{L1 + L2}{2}$$

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

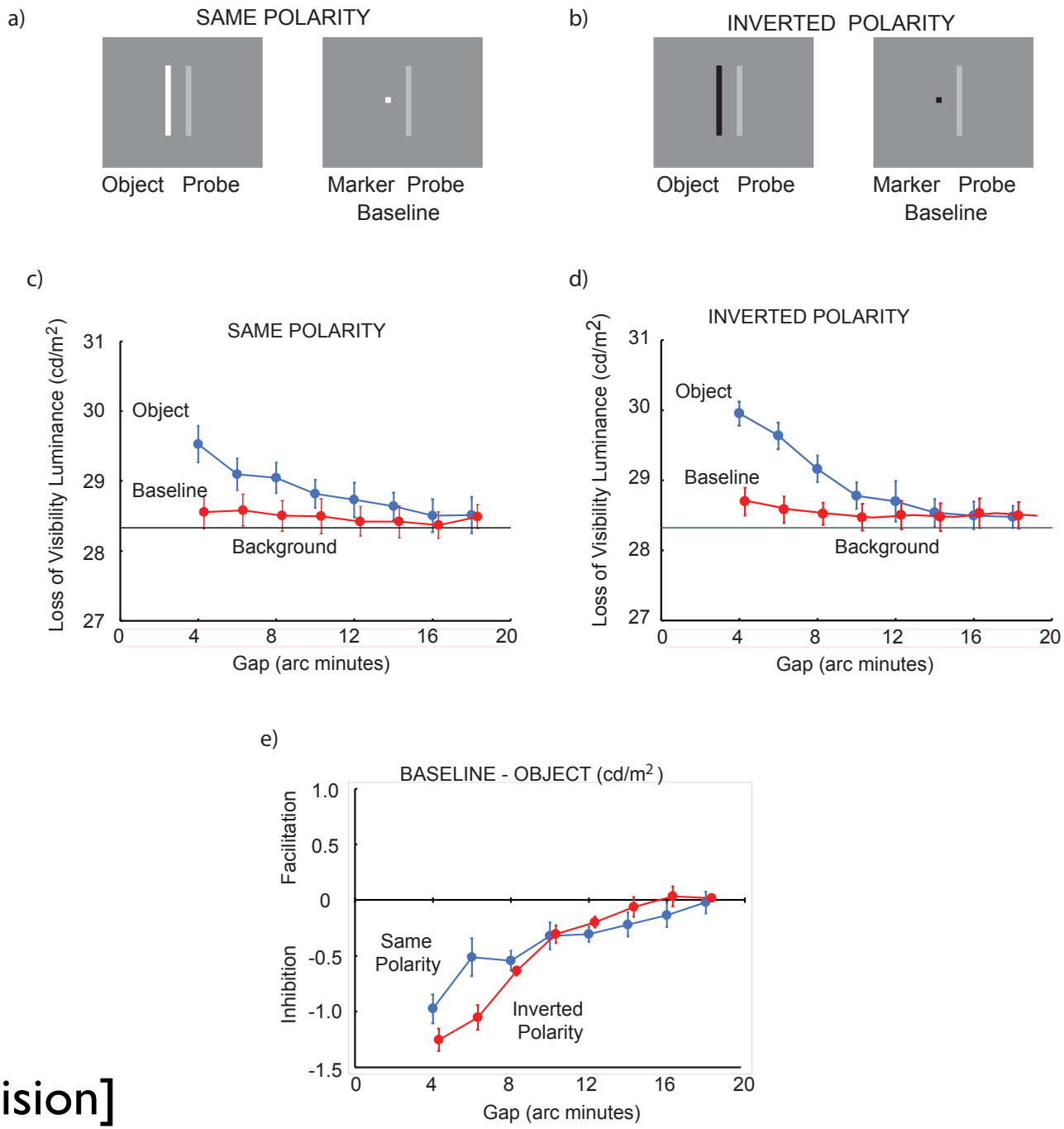
Detection instability

- 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



Contrast detection



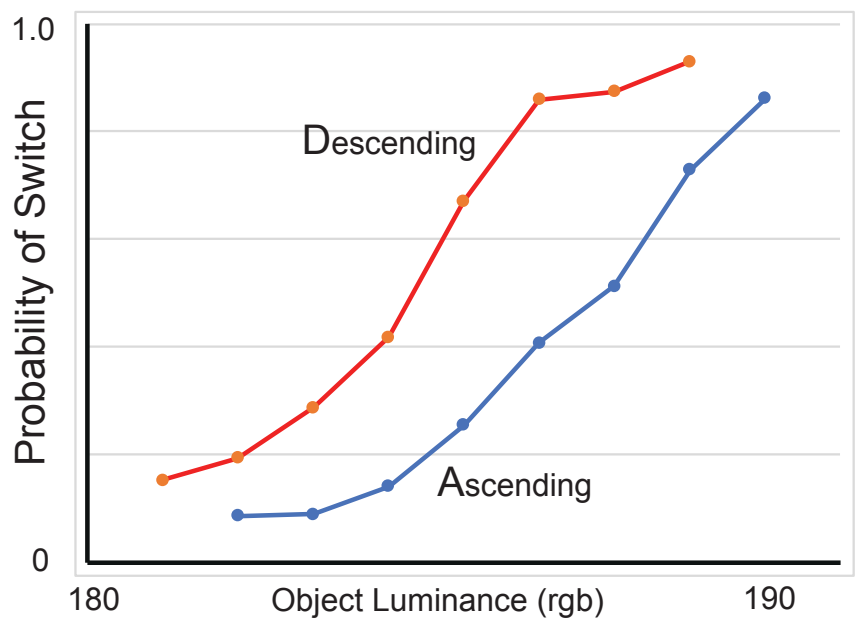
[Hock, Schöner, under revision]

Hysteresis in contrast detection

- ascending trials: increase luminance in steps, ending unpredictably… report contrast or not
- descending trials: decrease luminance in steps, ending unpredictably
- report change over initial percept (modified method of limits)

- object a 4 minutes distance suppresses probe detection at lowest luminance
- also helps to localize attention!
- between presentations, the object/ probe pair jumps around on the screen unpredictably by < 1 deg

[Hock, Schöner, under revision]



Conclusion

- even the simplest of decisions=detection in the simplest settings (contrast) is state dependent…
- consistent with the notion of a detection instability at the basis of perception