

# Dynamic Field Theory

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# Recall from last lecture ...

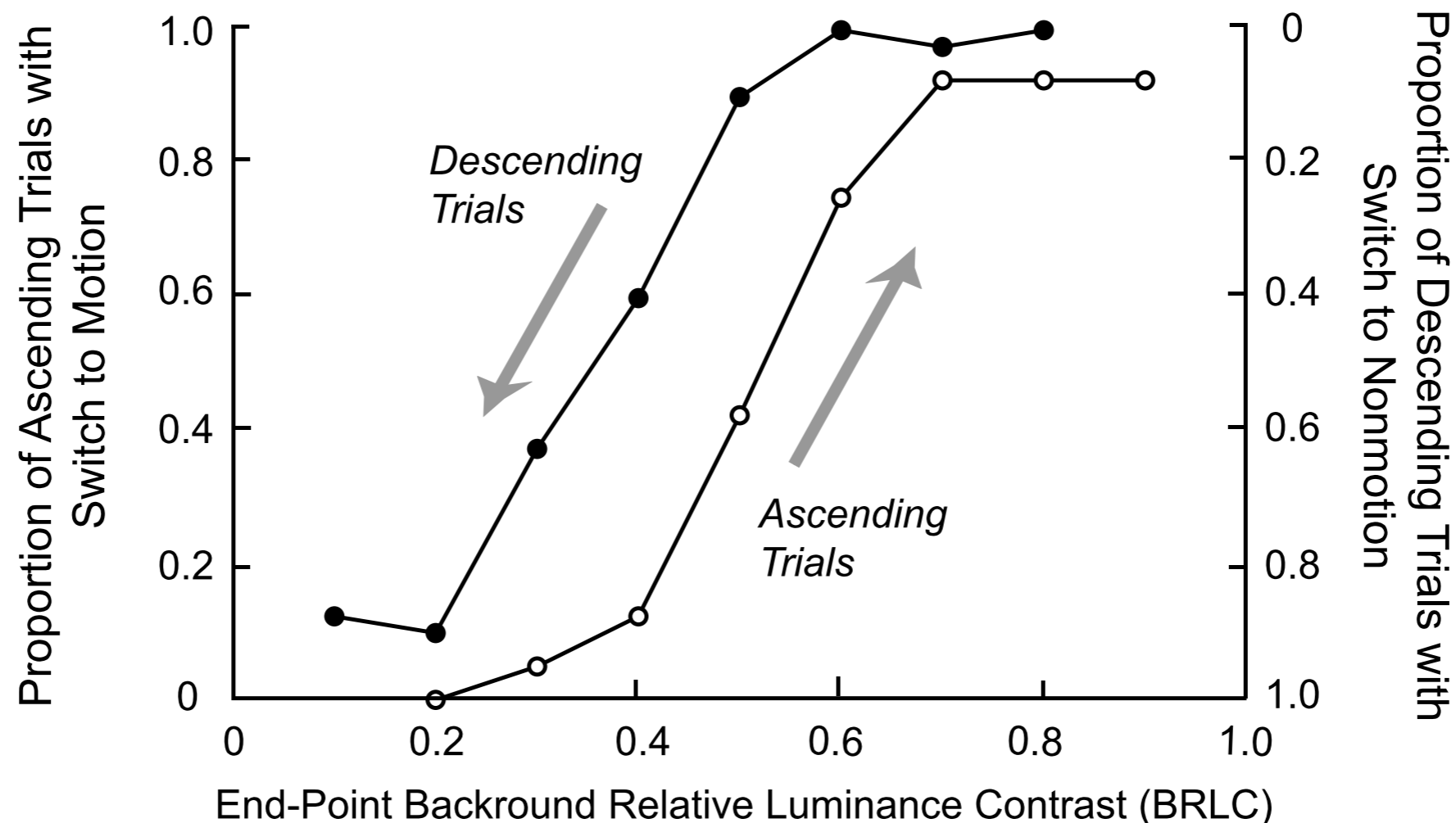
# Solutions and instabilities

- 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

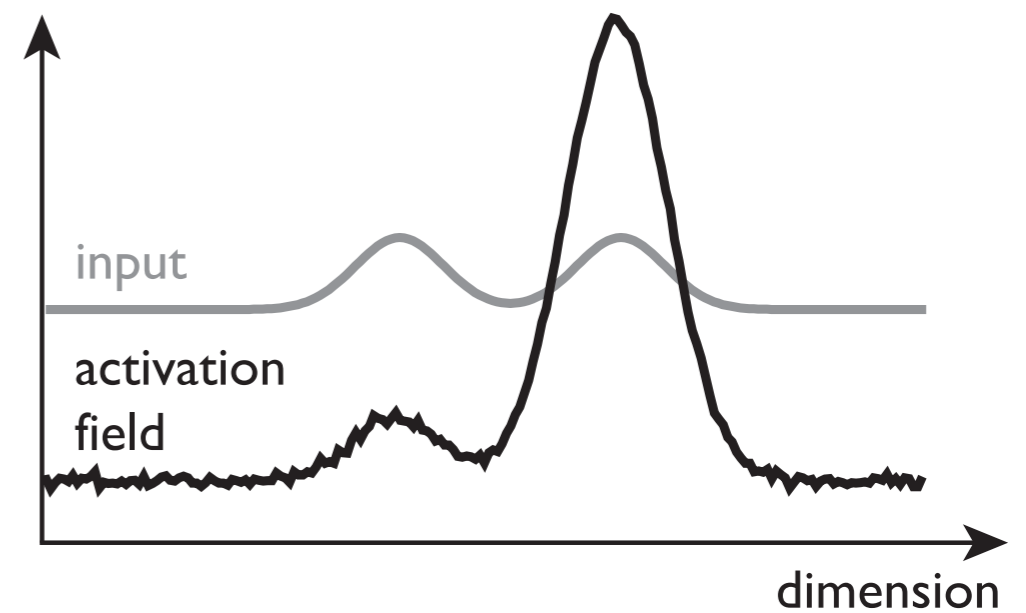
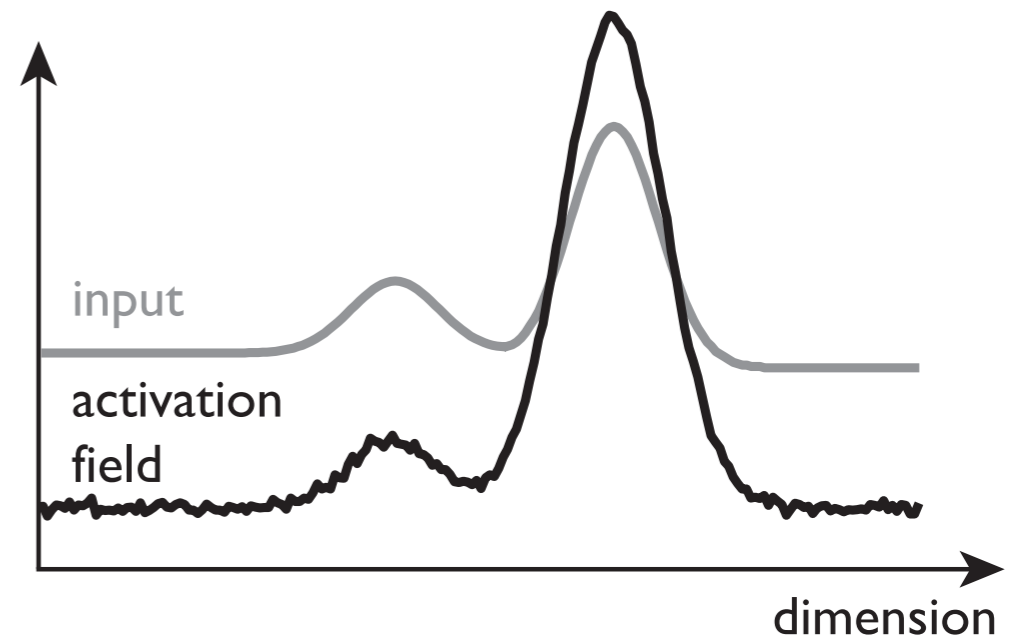
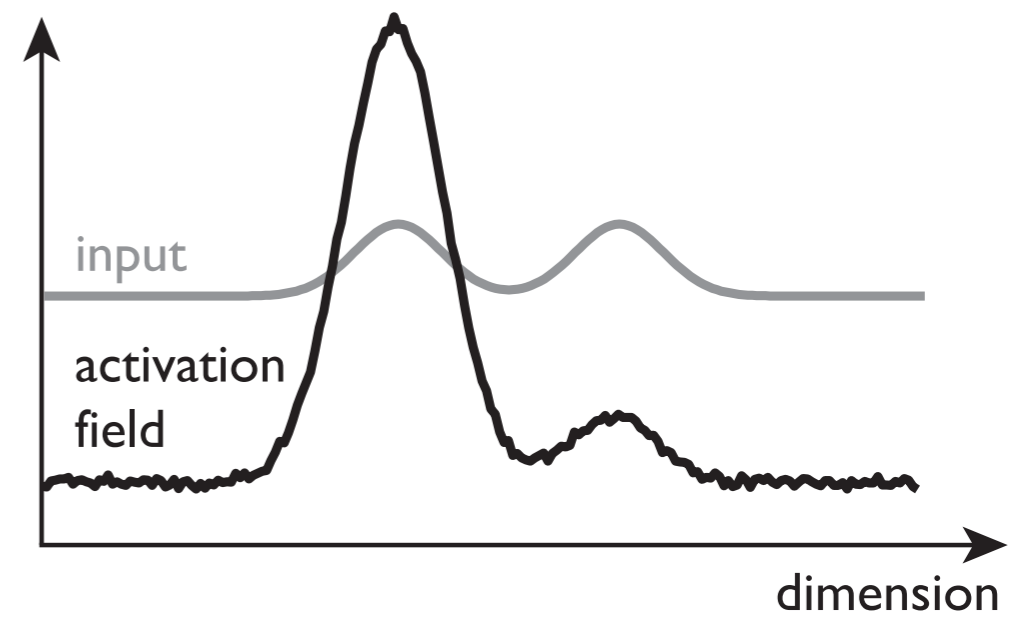
# Psychophysical evidence for the detection instability

## ■ perceptual hysteresis of motion detection

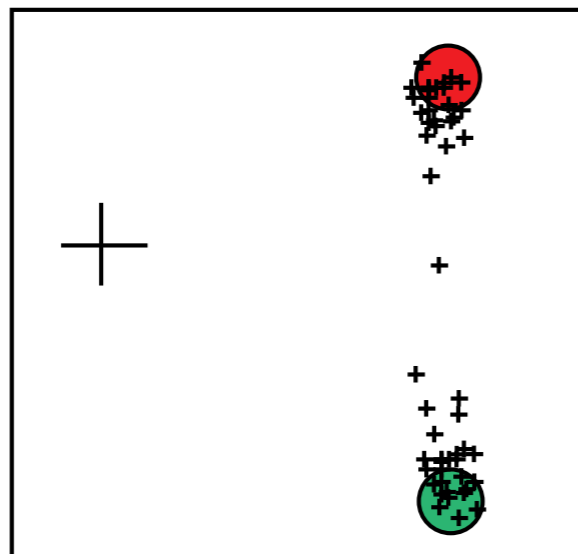
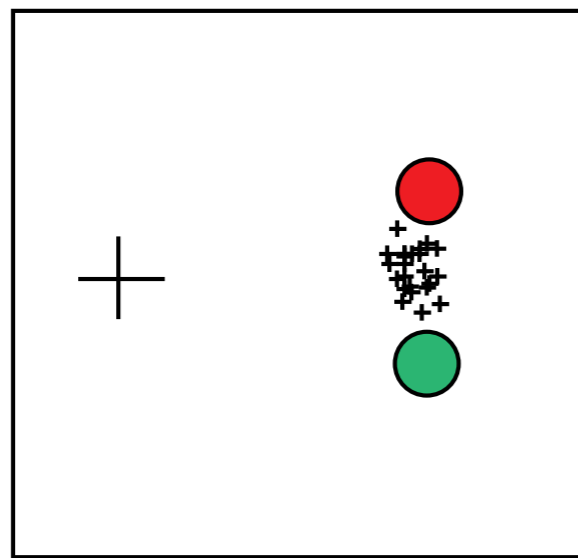
*H. S. Hock, G. Schöner / Seeing and Perceiving 23 (2010) 173–195*



# selection instability

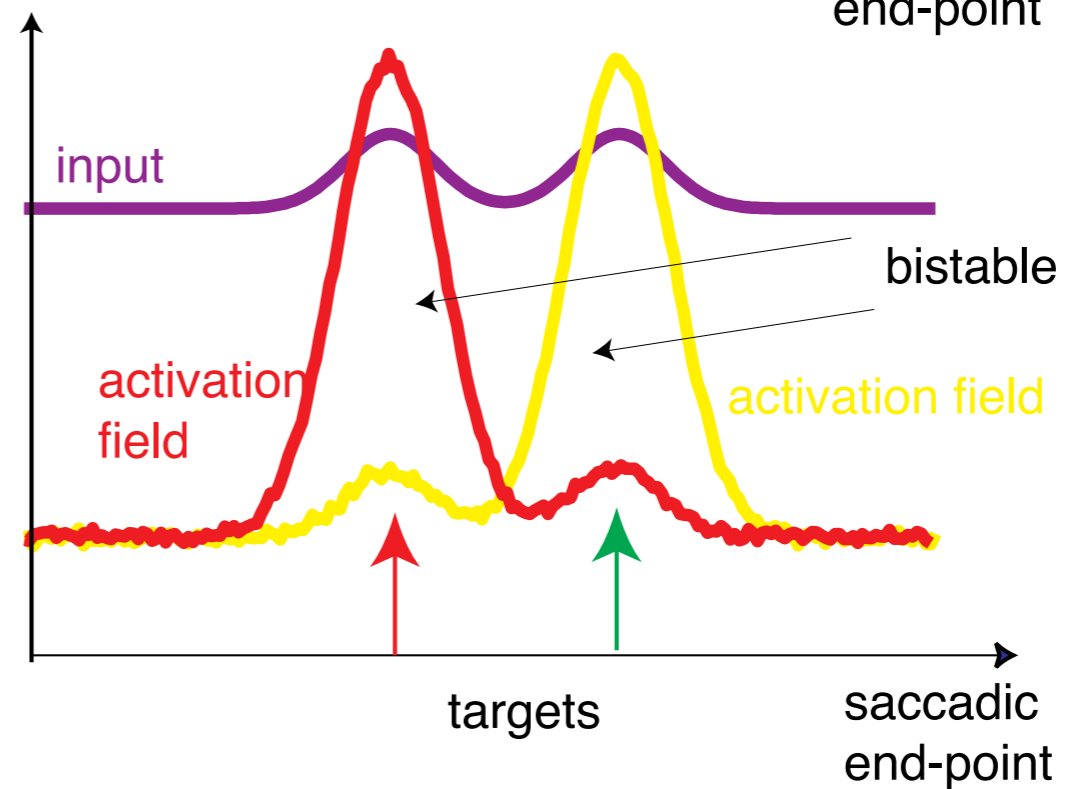
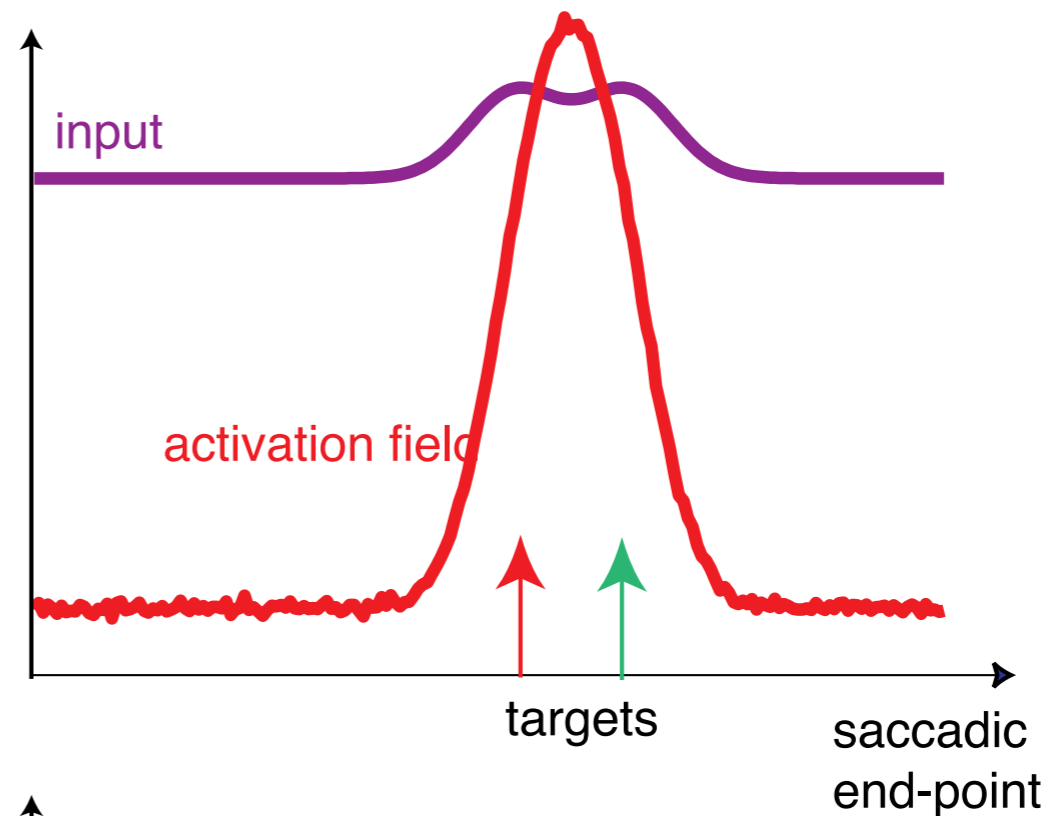


# saccade generation



initial  
fixation

visual  
targets

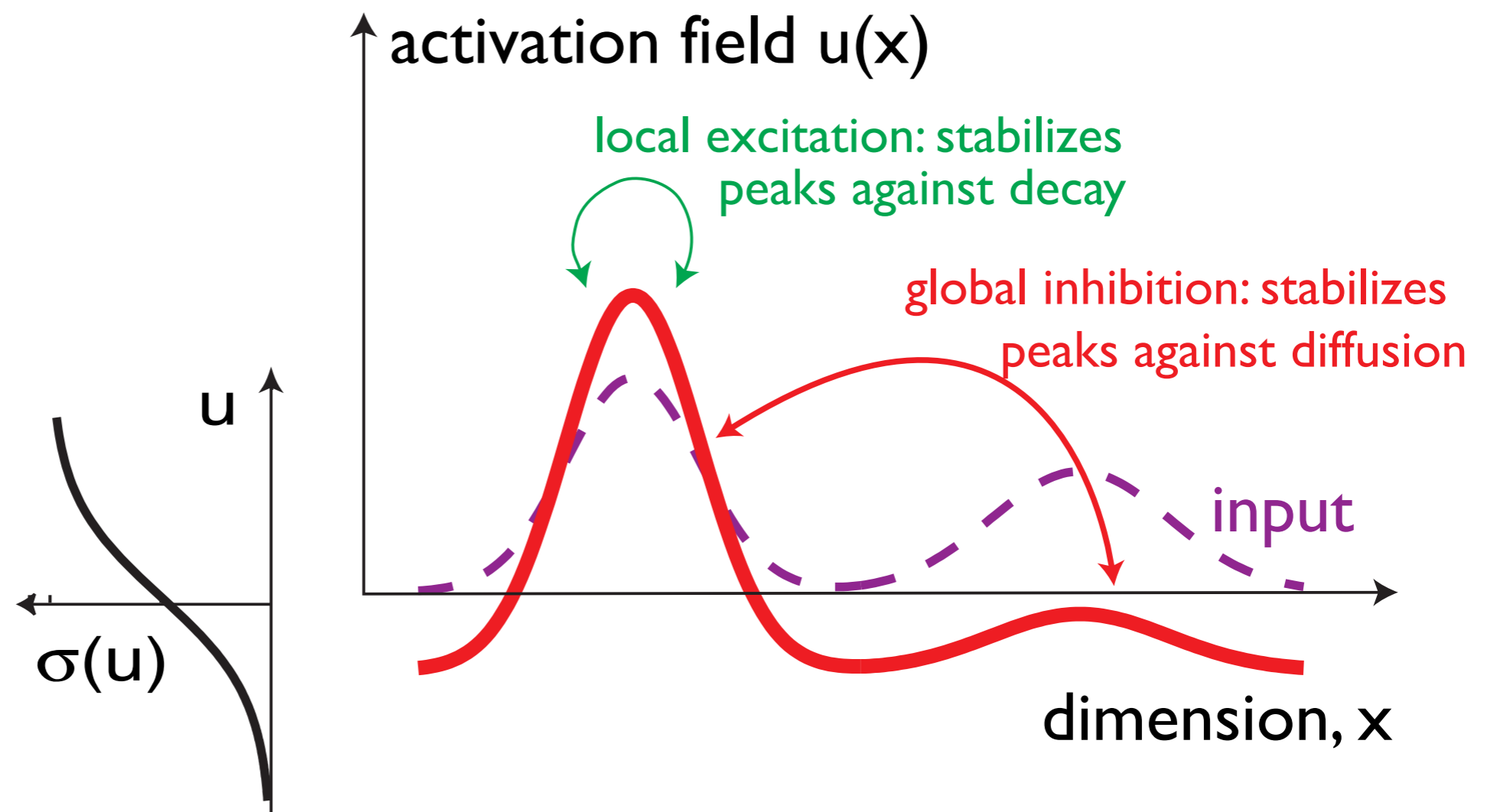


[after: Ottes et al., Vis. Res. 25:825 (85)]

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

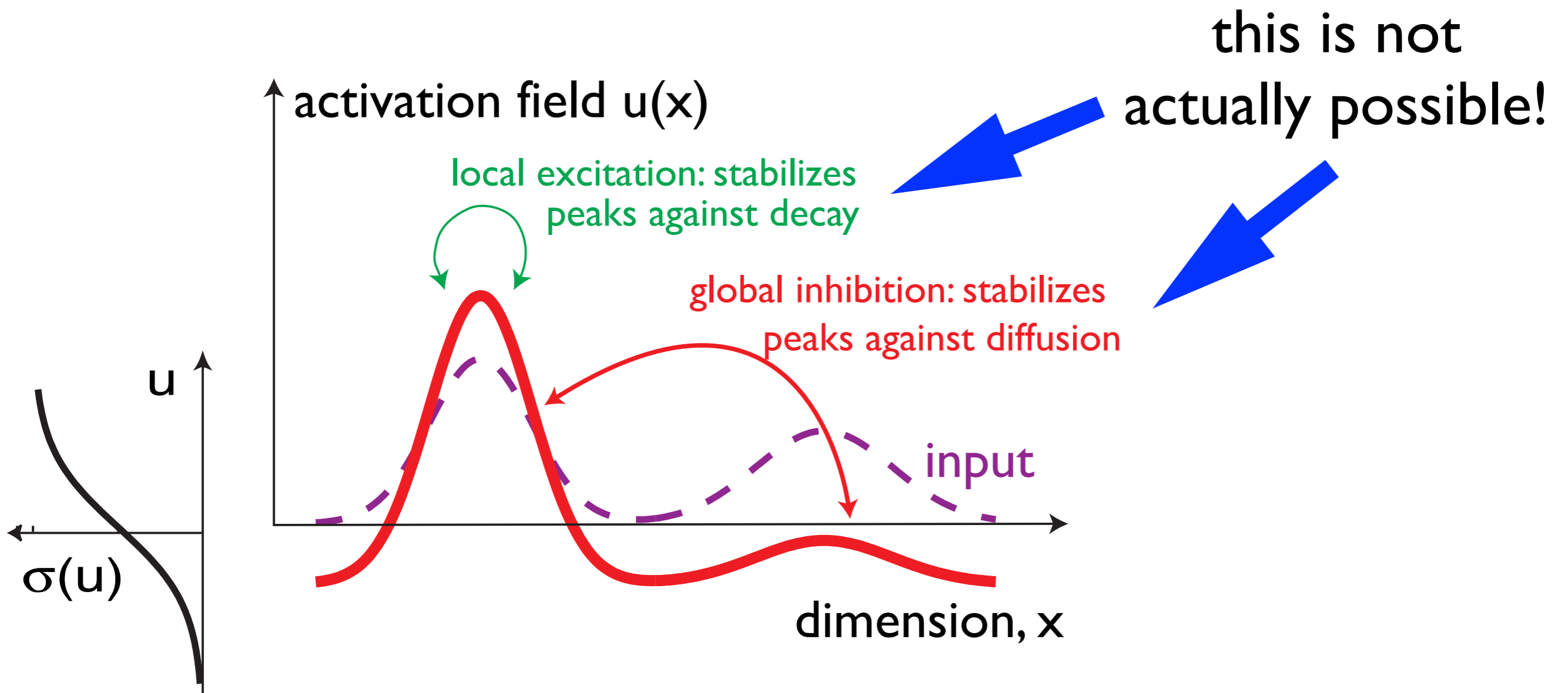
... so far we assumed

- that a single population of activation variable mediates both the excitatory and the inhibitory coupling required to make peaks attractors



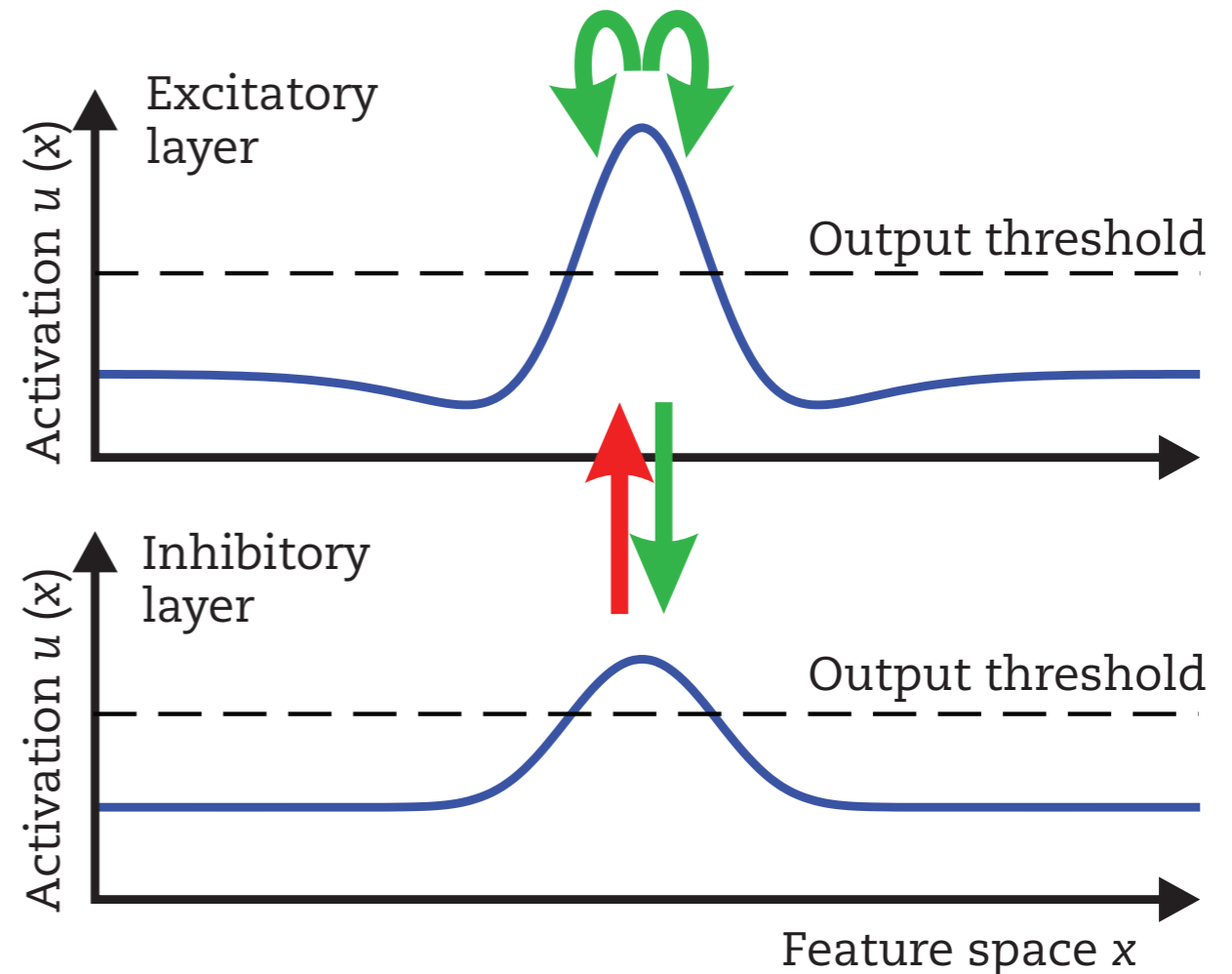
# But: Dale's law

- says: every neuron forms with its axon only one type of synapse on the neurons it projects onto
- and that is either excitatory or inhibitory



# 2 layer neural fields

- inhibitory coupling is mediated by inhibitory interneurons that
- are excited by the excitatory layer
- and in turn inhibit the inhibitory layer



[chapter 3 of the book]

# 2 layer Amari fields

$$\tau_u \dot{u}(x, t) = -u(x, t) + h_u + s(x, t) + \int k_{uu}(x - x') g(u(x', t)) dx' - \int k_{uv}(x - x') g(v(x', t)) dx'$$

$$\tau_v \dot{v}(x, t) = -v(x, t) + h_v + \int k_{vu}(x - x') g(u(x', t)) dx'$$

with projection kernels

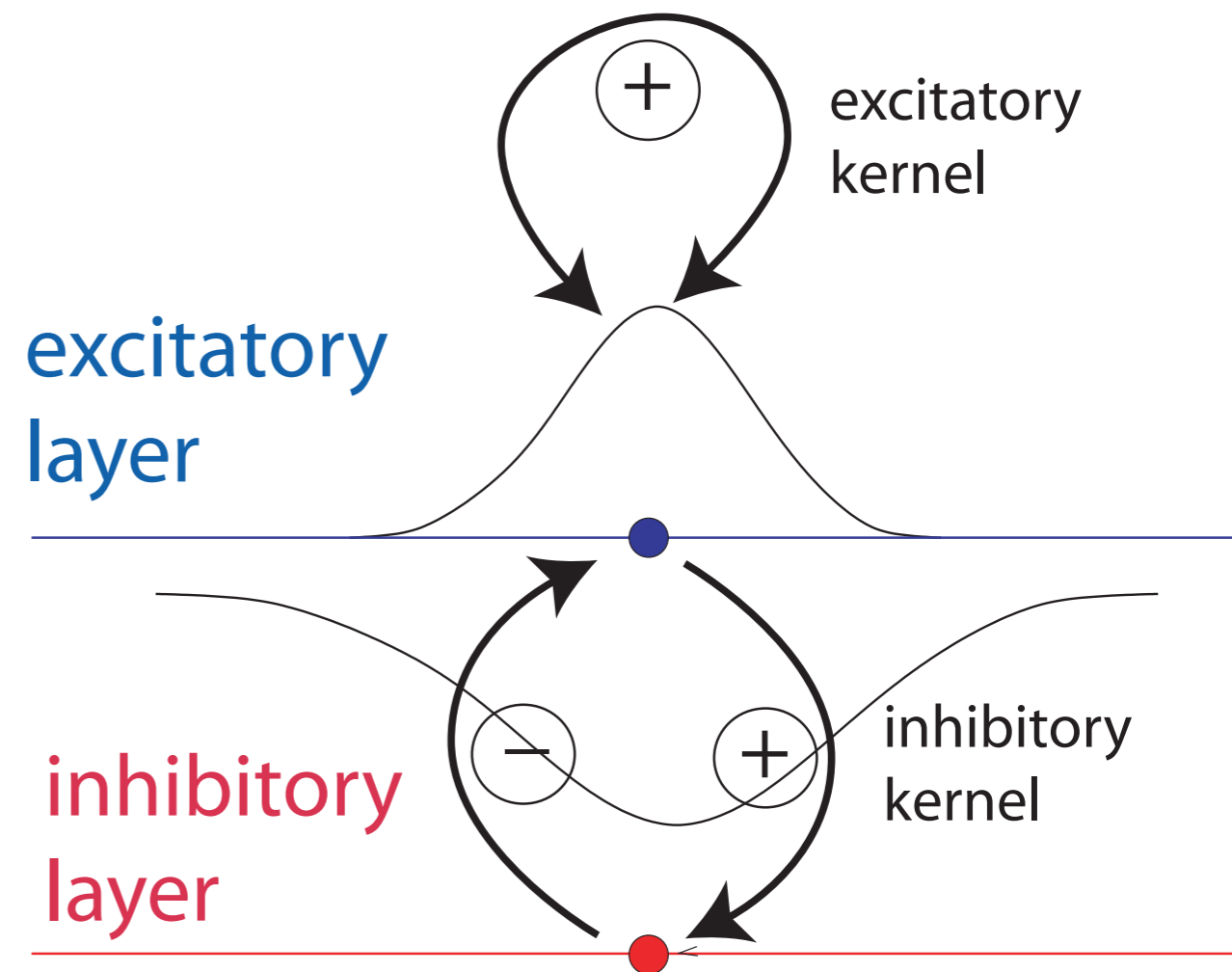
$$k_{uu}(x - x') = c_{uu} \cdot \exp\left(-\frac{(x - x')^2}{2\sigma_{uu}^2}\right)$$

# simulation

# Implications

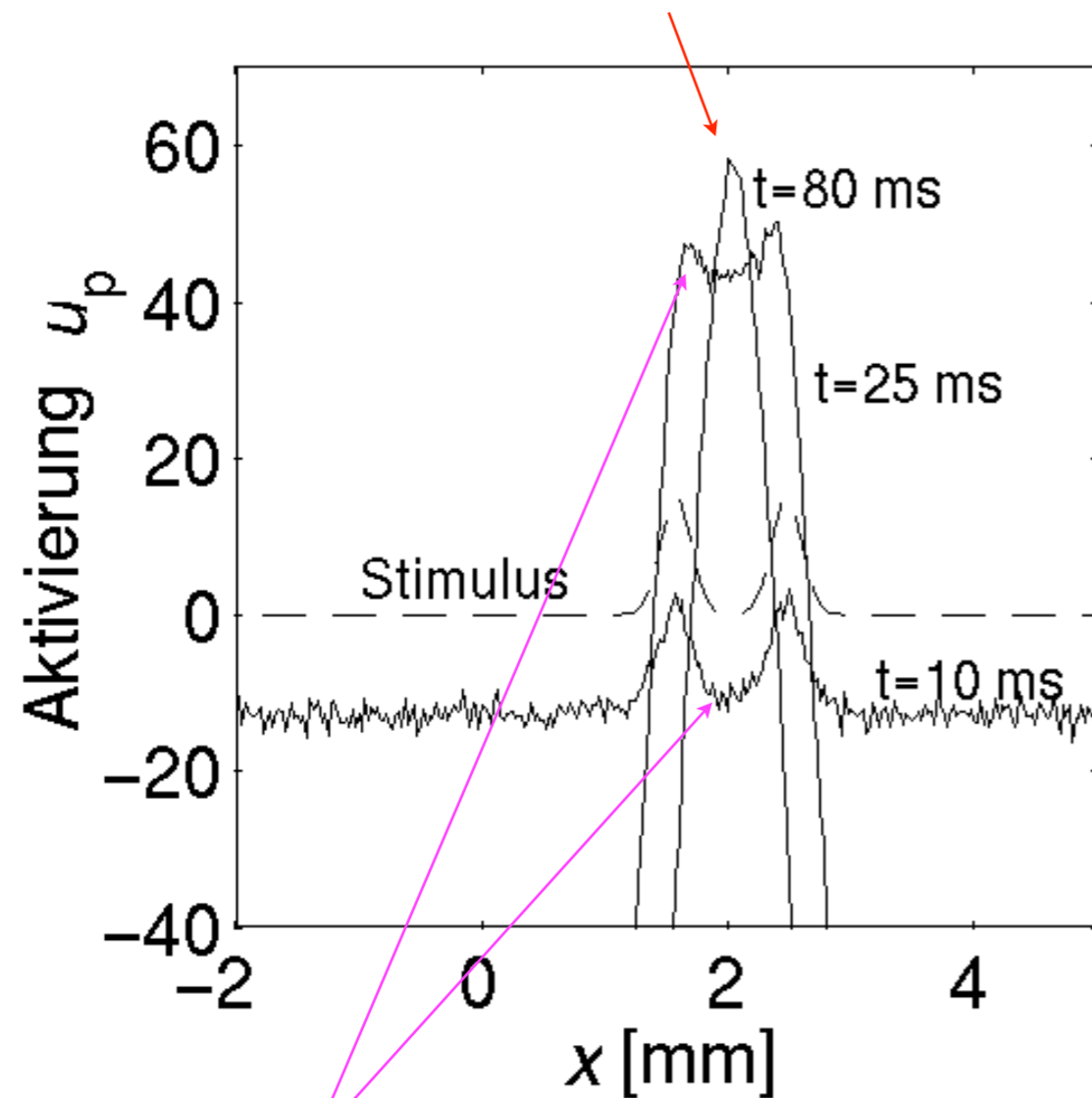
■ the fact that inhibition arises only after excitation has been induced has observable consequences in the time course of decision making:

- initially input-dominated
- early excitatory interaction
- late inhibitory interaction

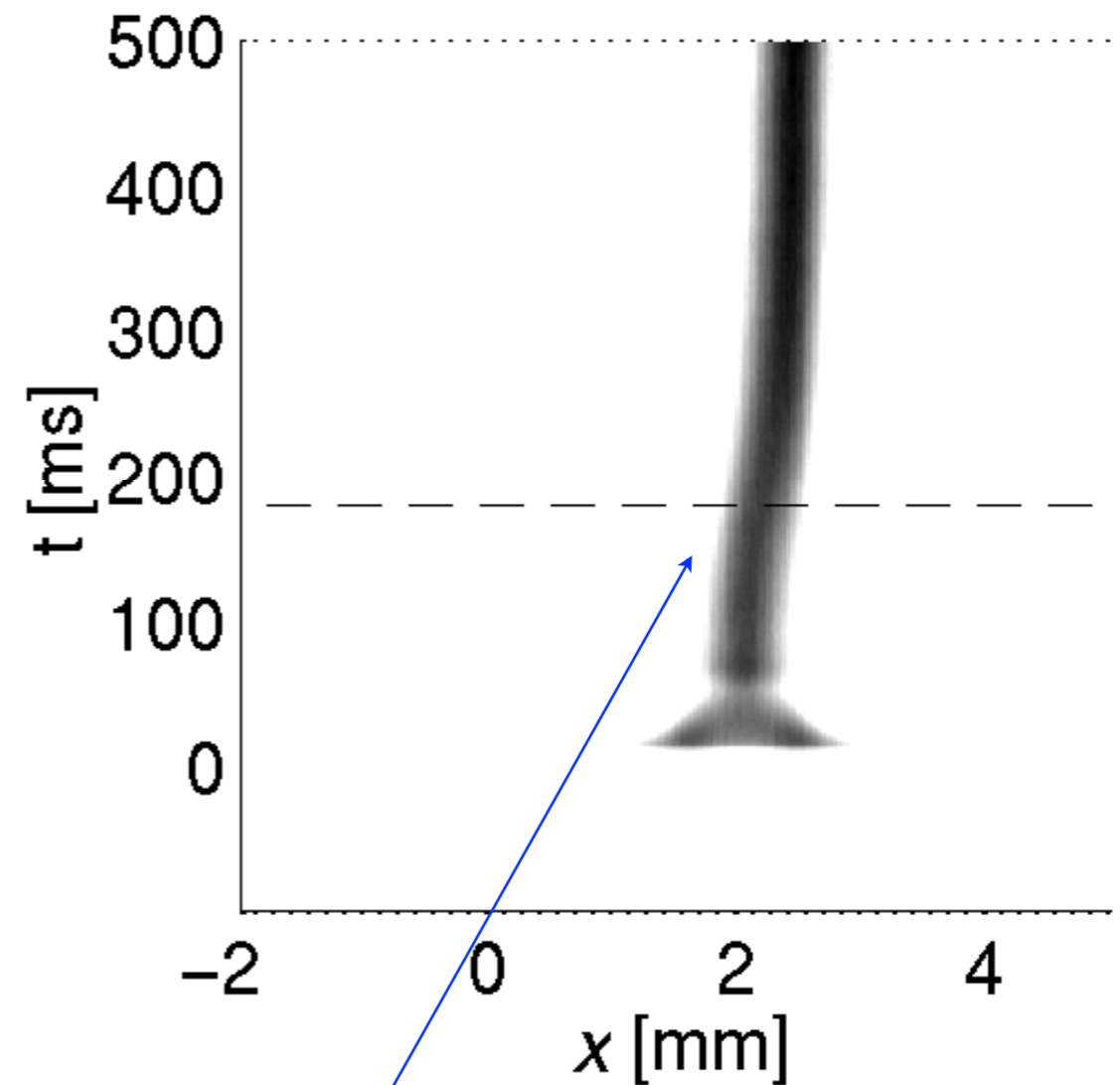


# time course of selection

intermediate: dominated by excitatory interaction

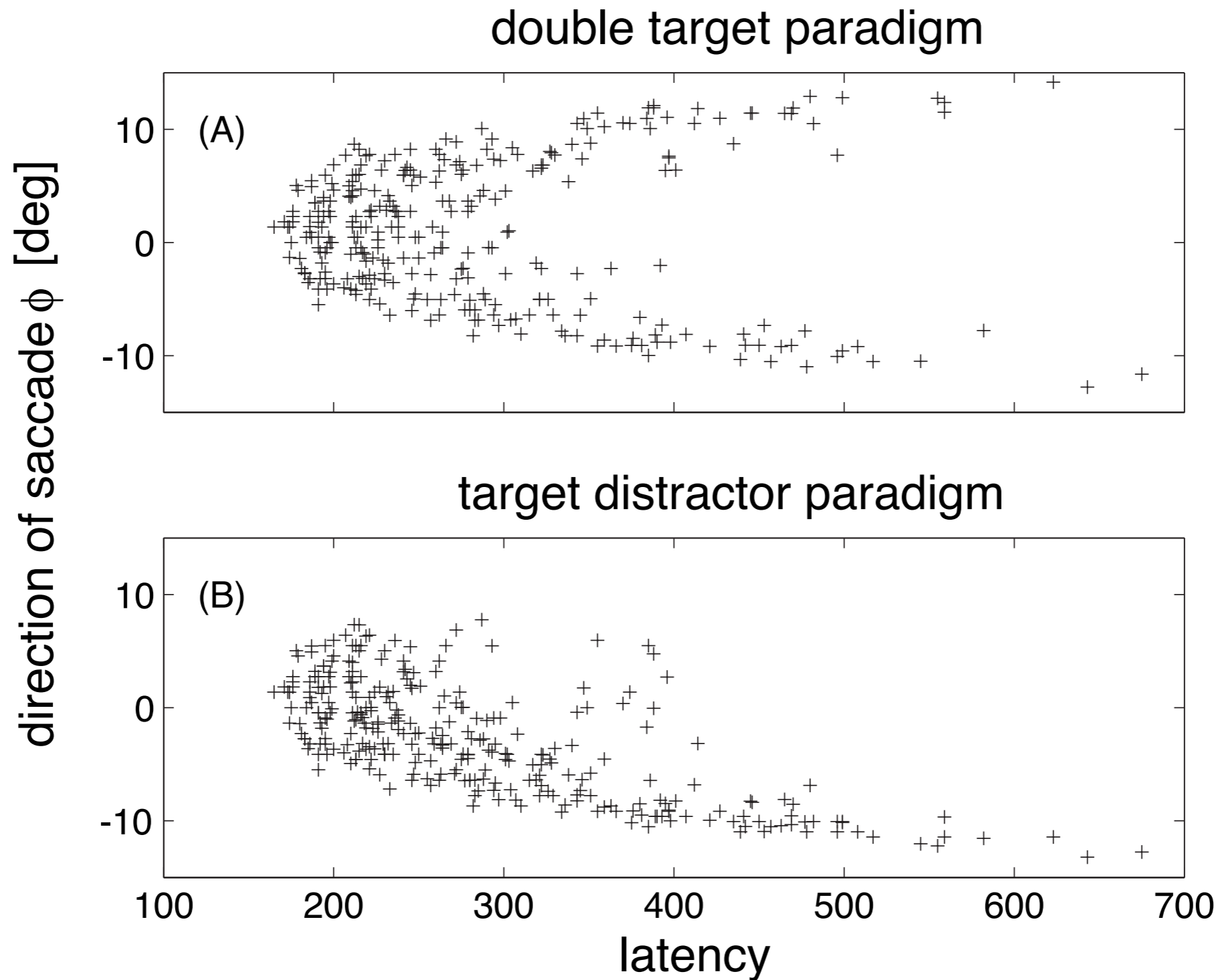


early: input driven



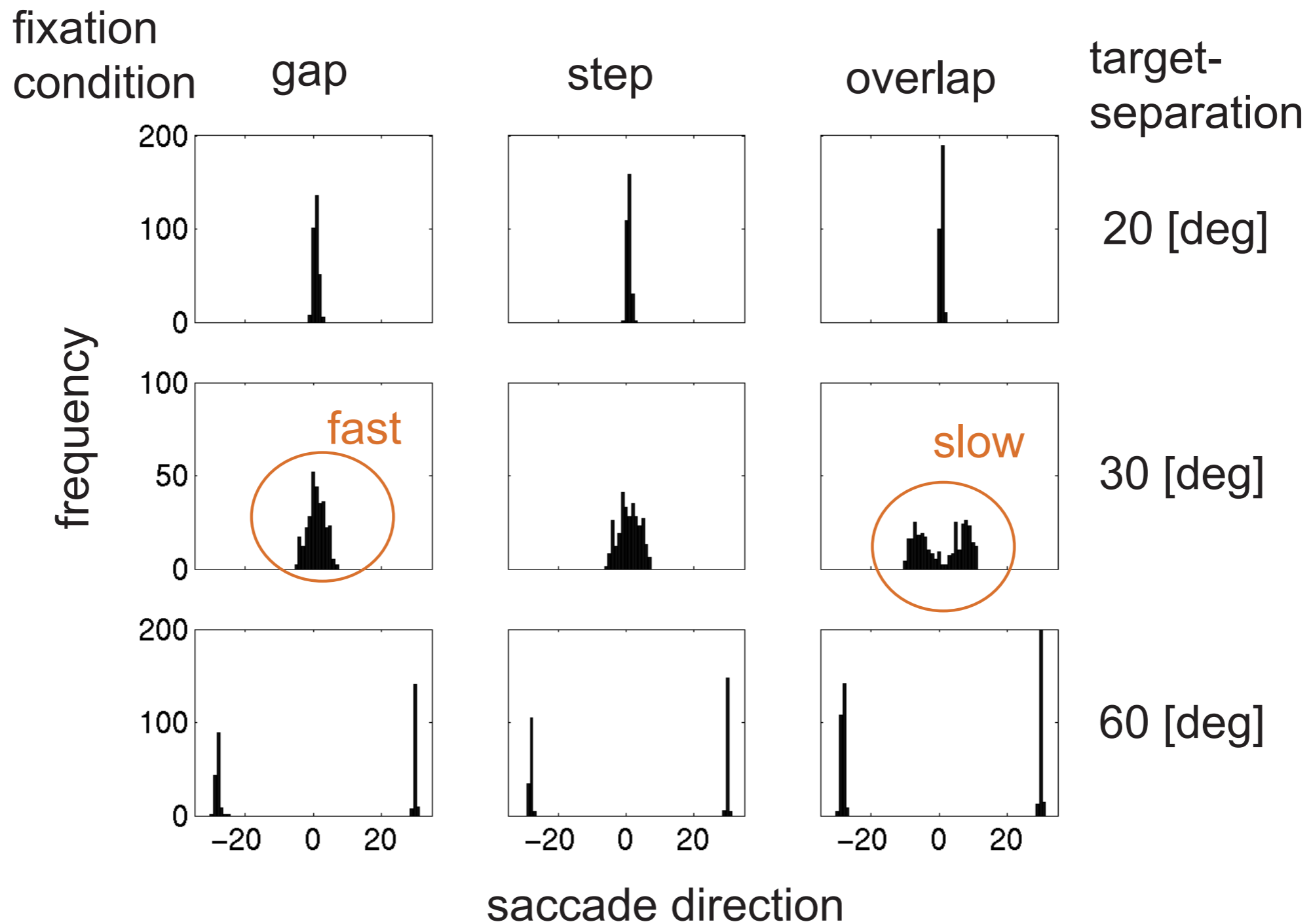
late: inhibitory interaction drives selection

=> early fusion, late selection



[figure: Wilimzig, Schneider, Schöner, Neural Networks, 2006]

# fixation and selection



[figure: Wilimzig, Schneider, Schöner, Neural Networks, 2006]

# 2 layer fields afford oscillations

- => simulation
- (oscillatory states for enhanced coupling among fields)
- (generic nature of oscillations)

# studying selection decisions in the laboratory

- using an imperative signal...

# reaction time (RT) paradigm

imperative  
signal=  
go signal

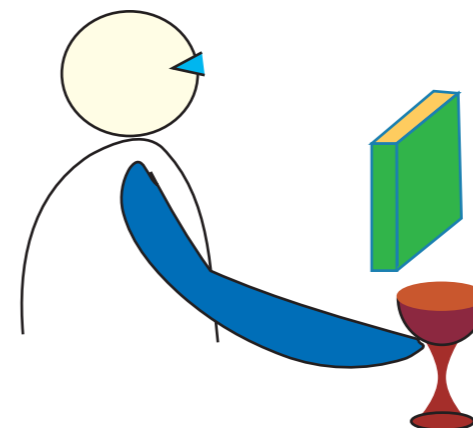
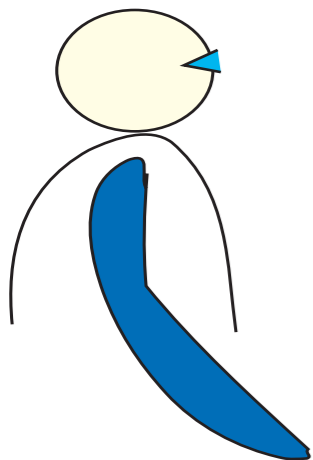
response

task set

time



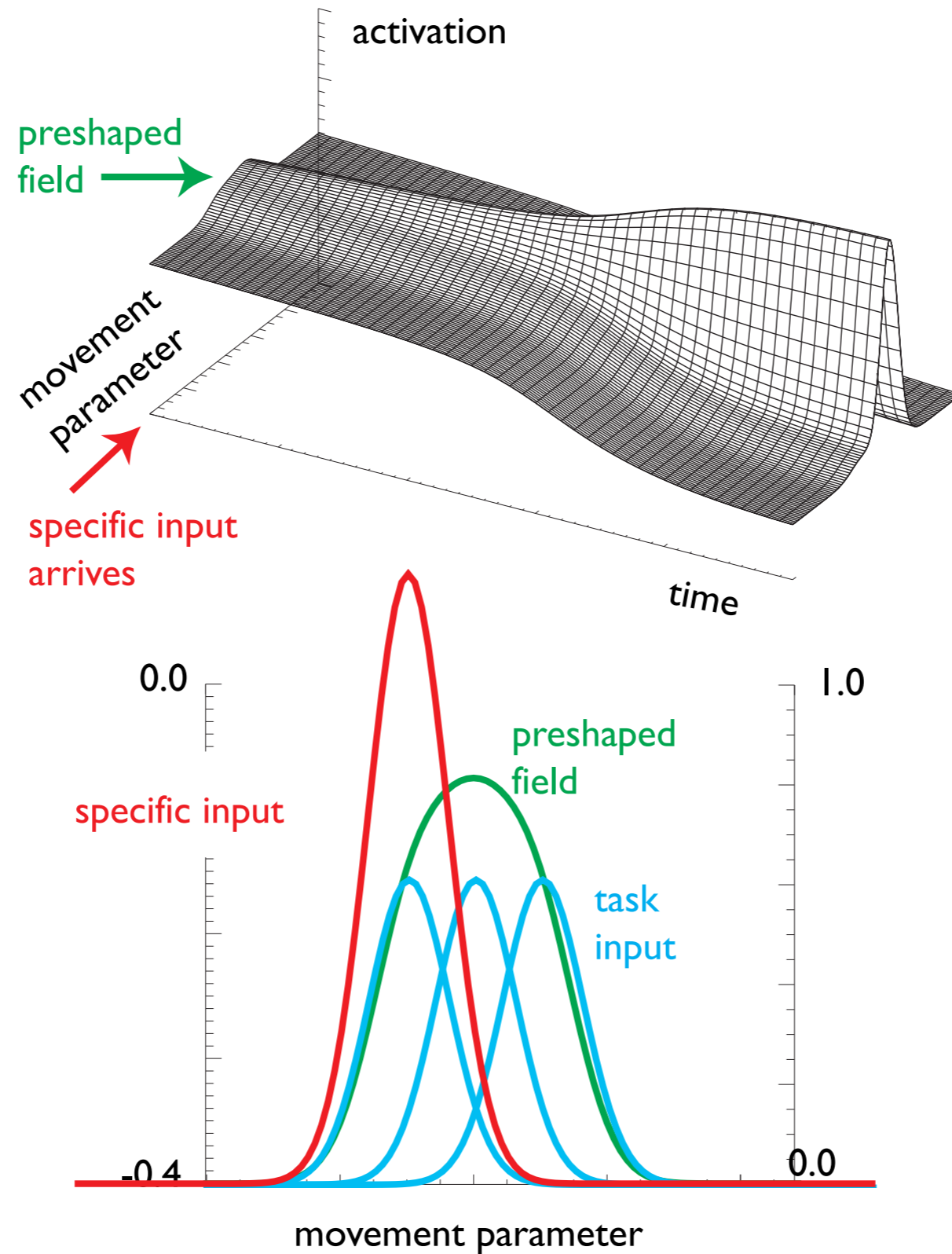
RT



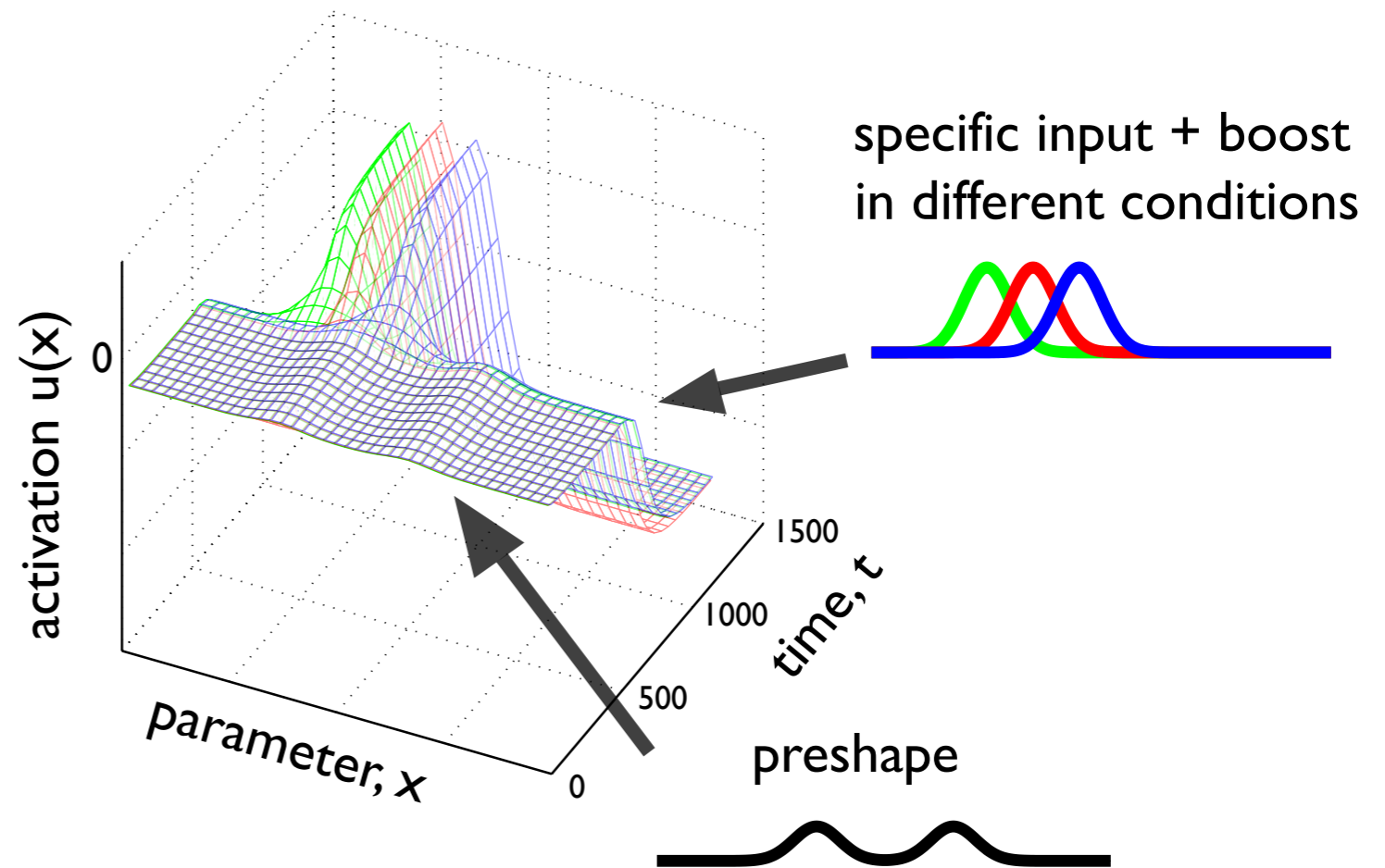
# the task set

- is the critical factor in such studies of selection: which perceptual/action alternative/choices are available...
  - e.g., how many choices
  - e.g., how likely is each choice
  - e.g., how “easy” are the choices to recognize/perform
- because the task set is known to the participant prior to the presentation of the imperative signal, one may think of the task set as a “preshaping” of the underlying representation (pre=before the decision)

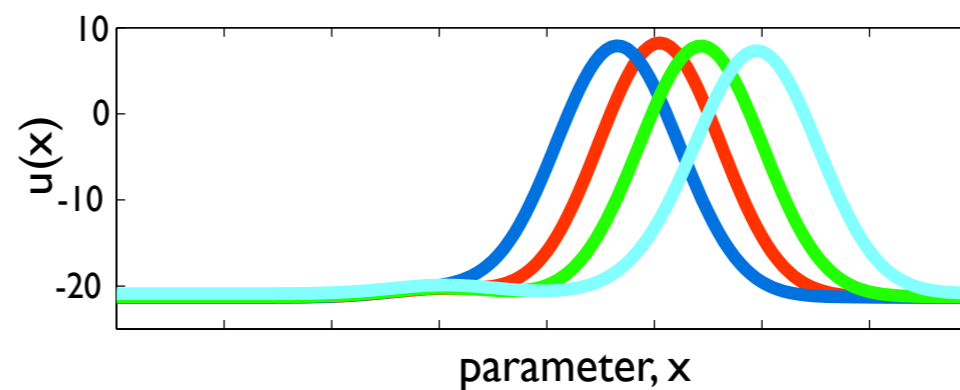
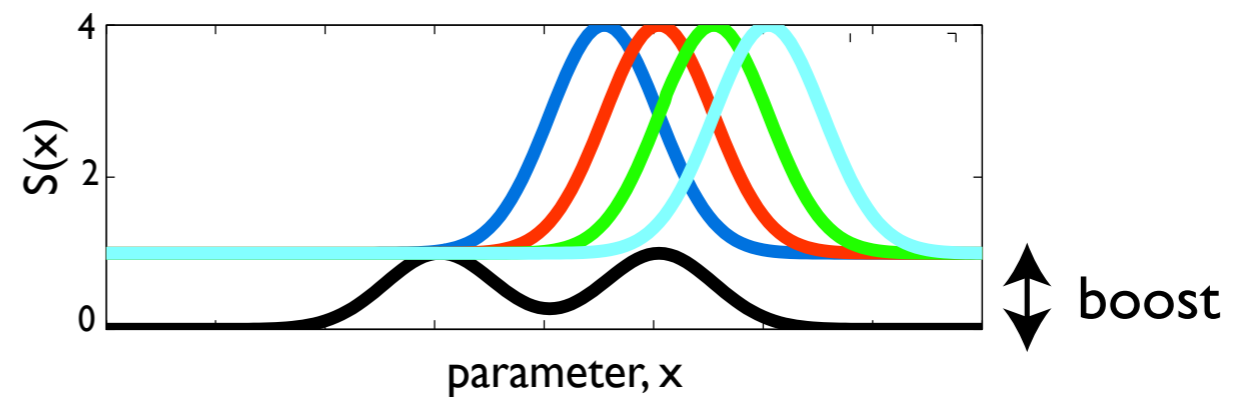
# notion of preshape



# weak preshape in selection

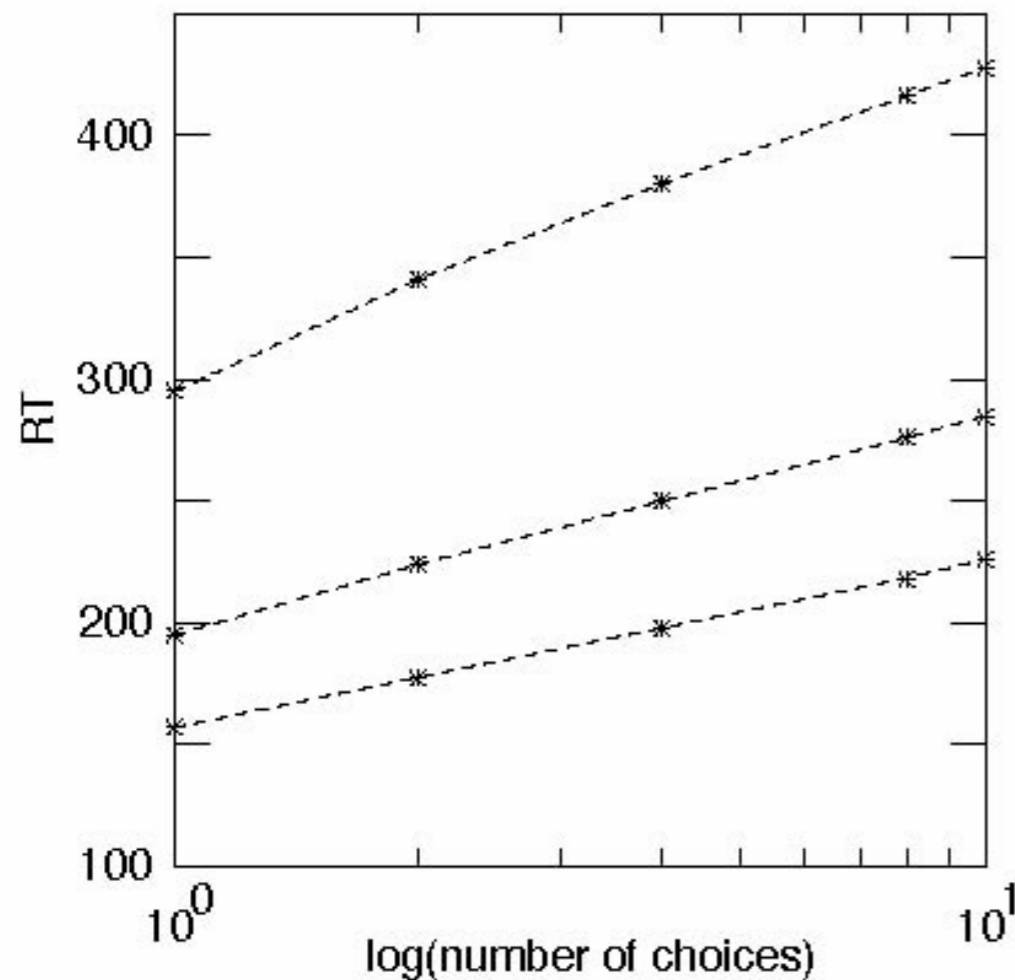


- specific (imperative) input dominates and drives detection instability

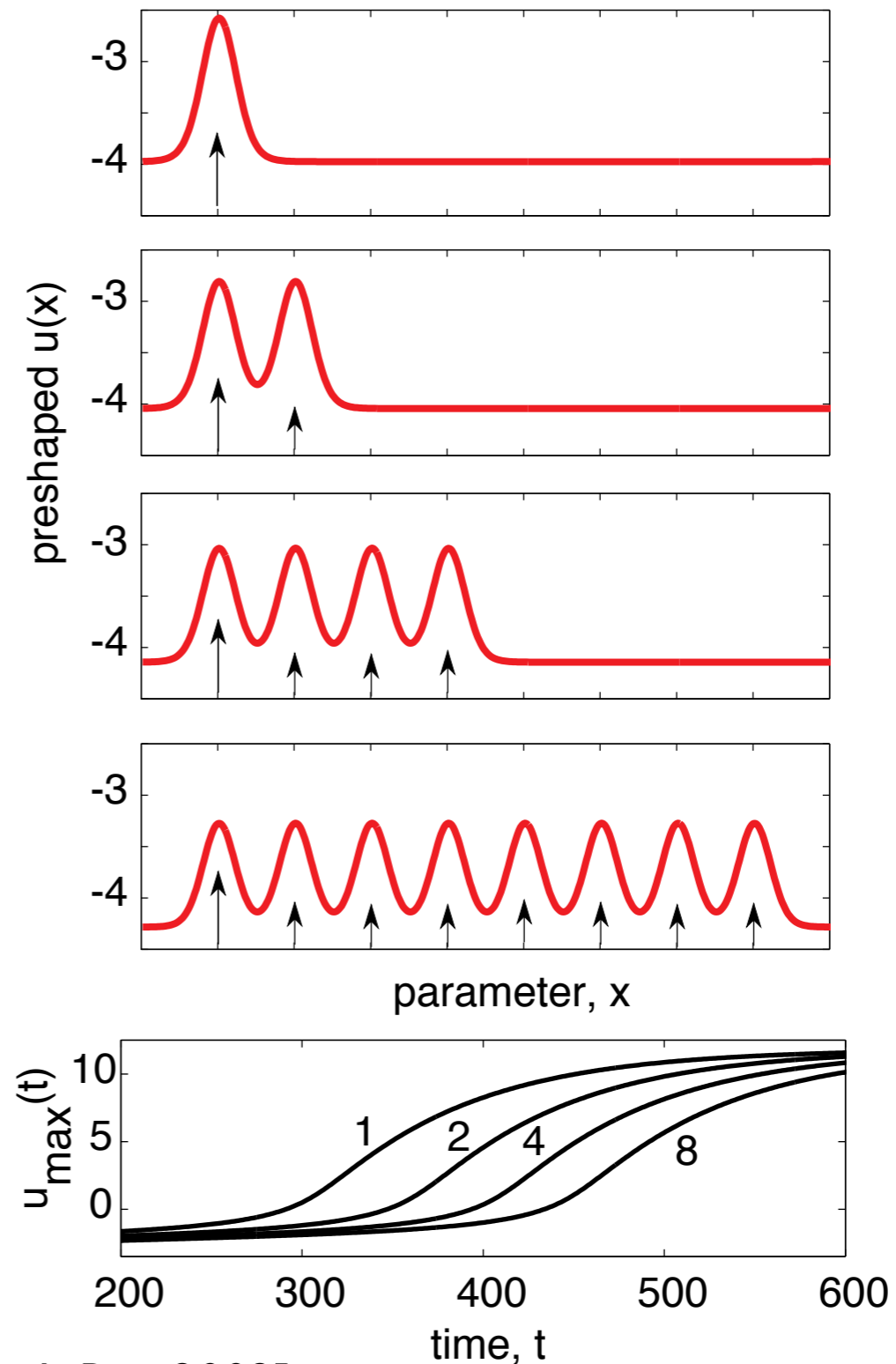


# using preshape to account for classical RT data

- Hick's law: RT increases with the number of choices

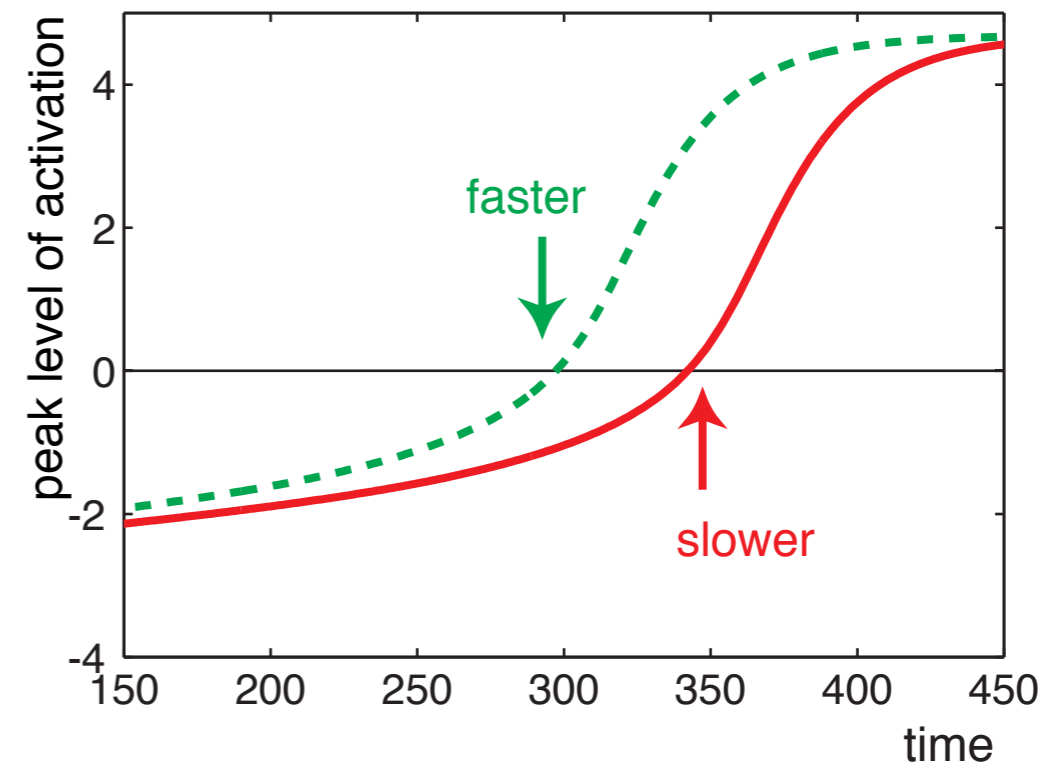
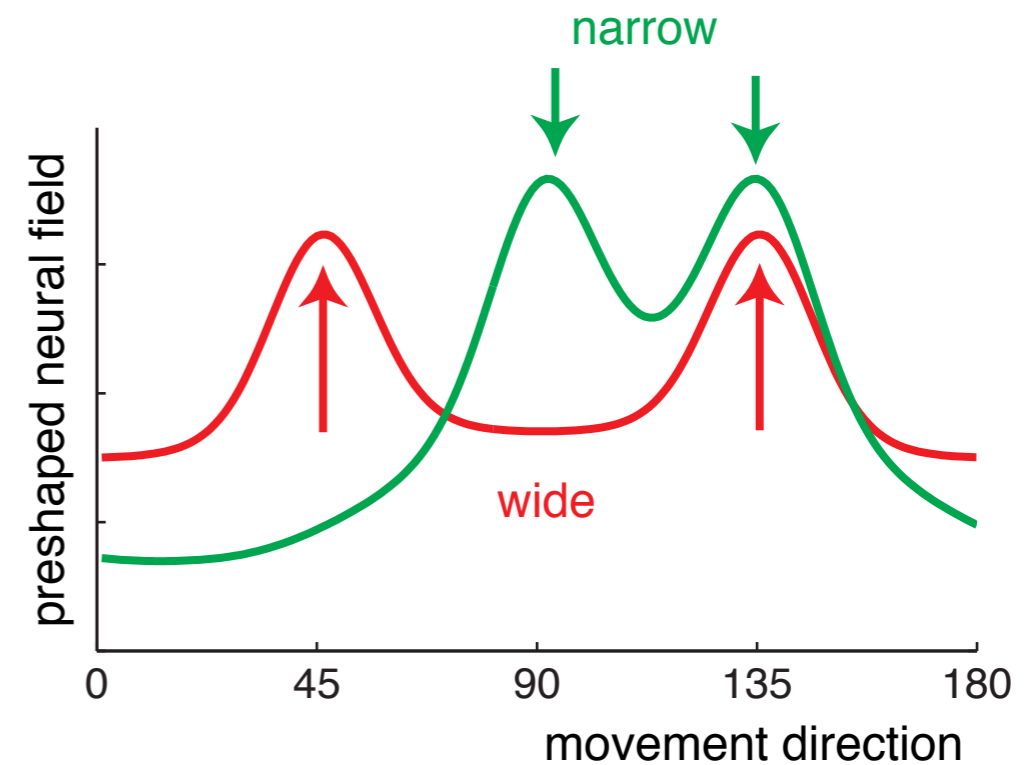


[Erlhagen, Schöner, Psych Rev 2002]



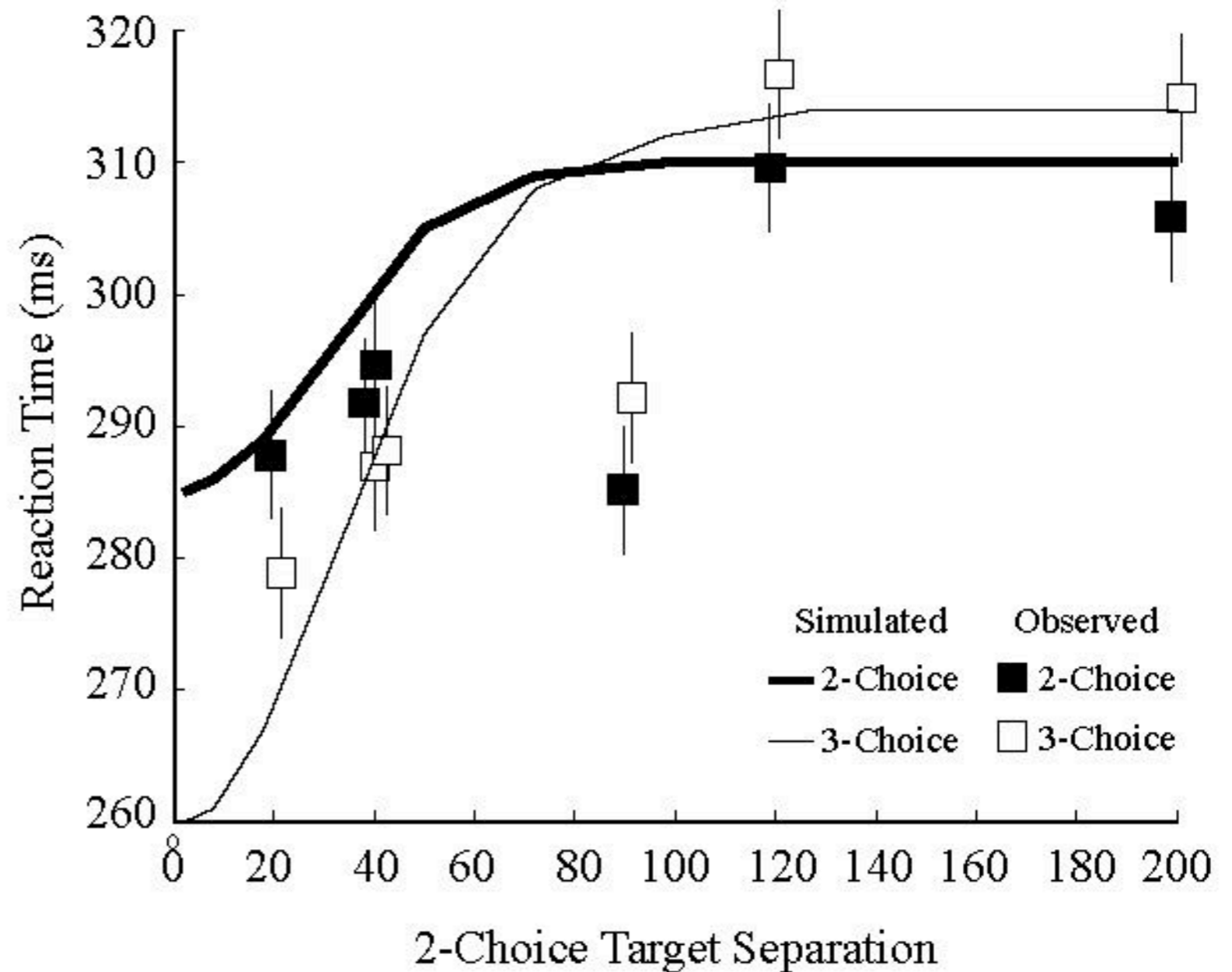
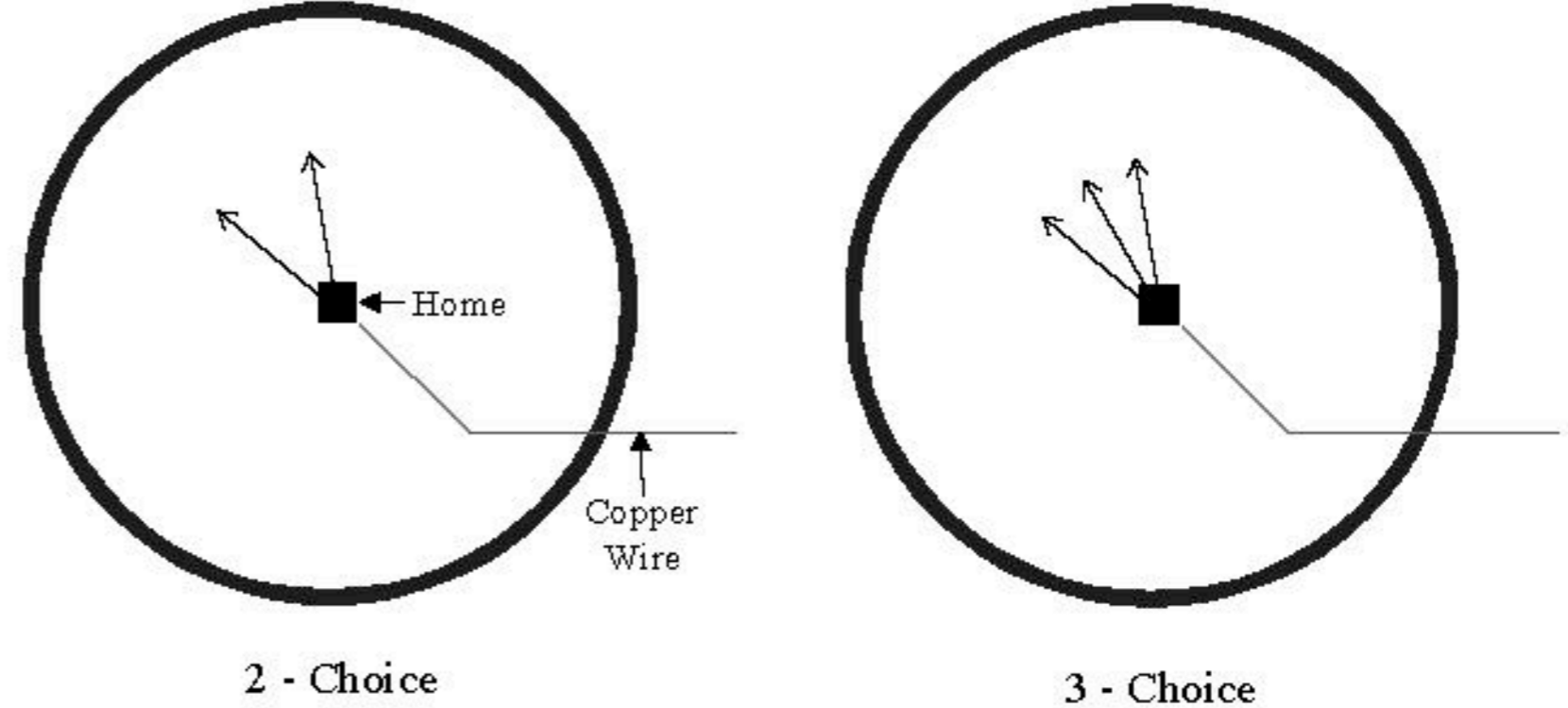
# metric effect

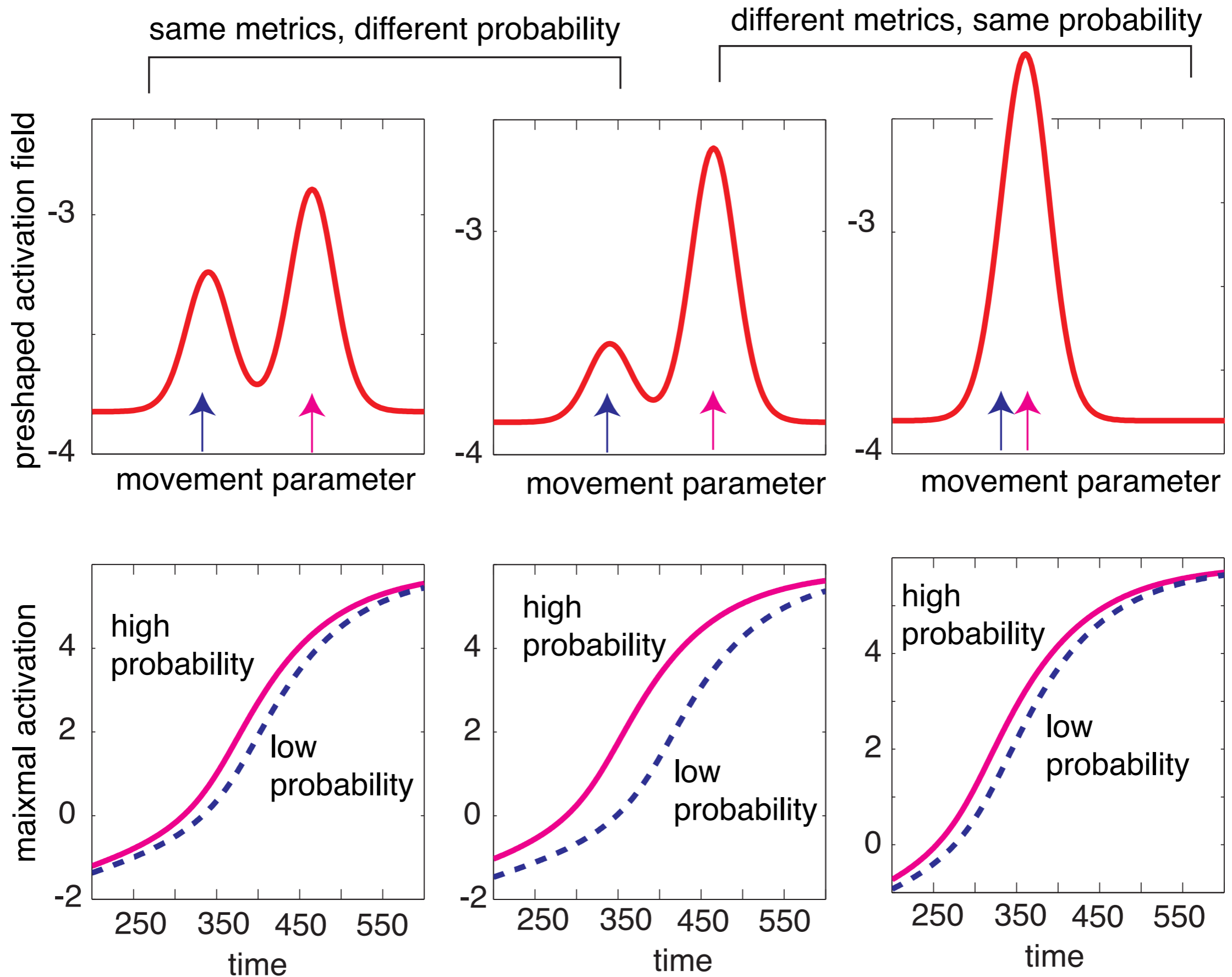
- predict faster response times for metrically close than for metrically far choices



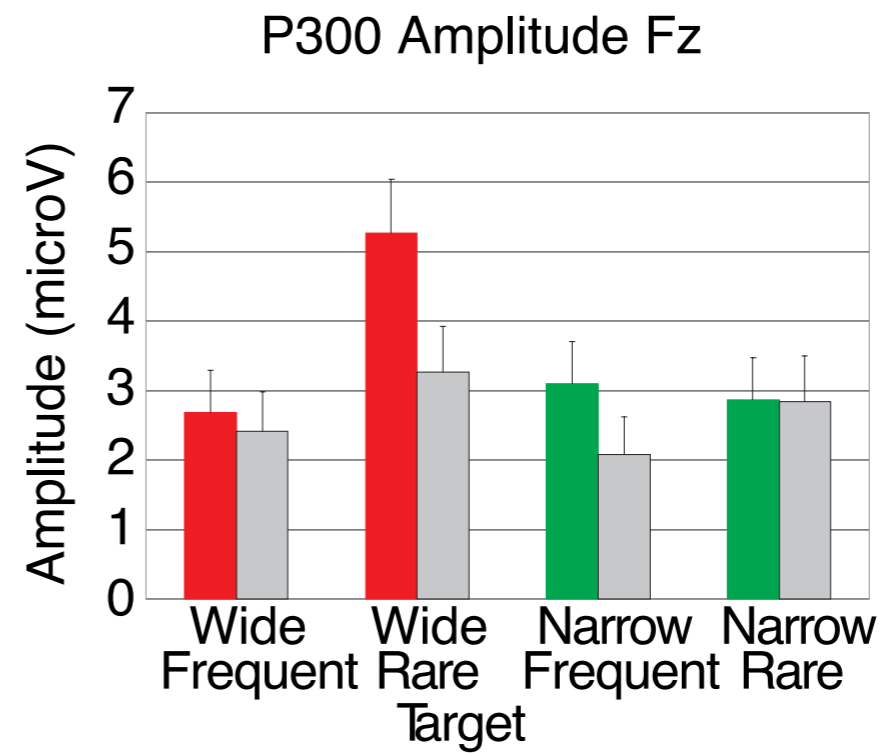
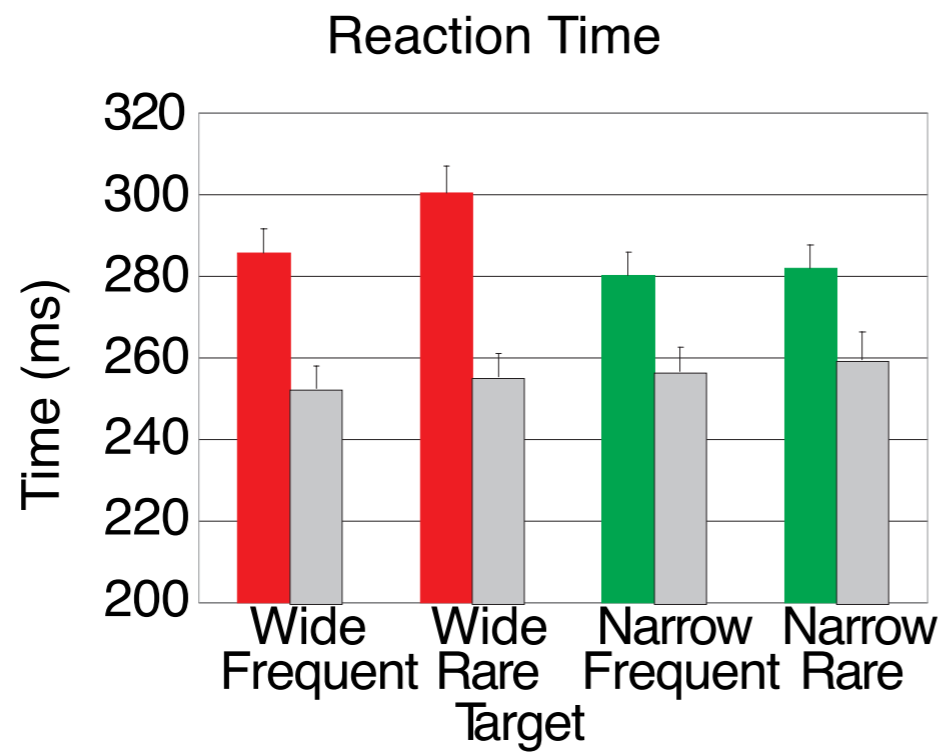
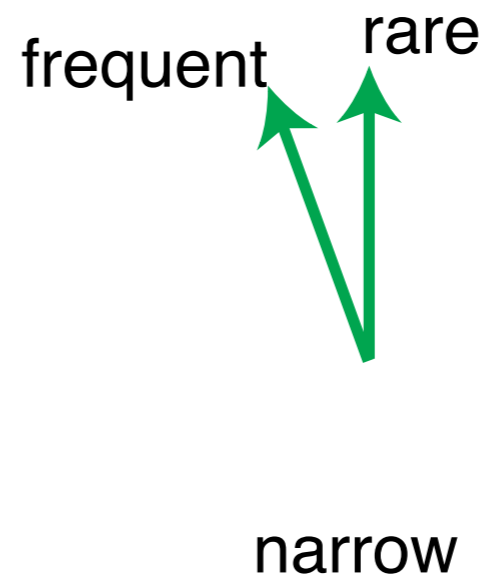
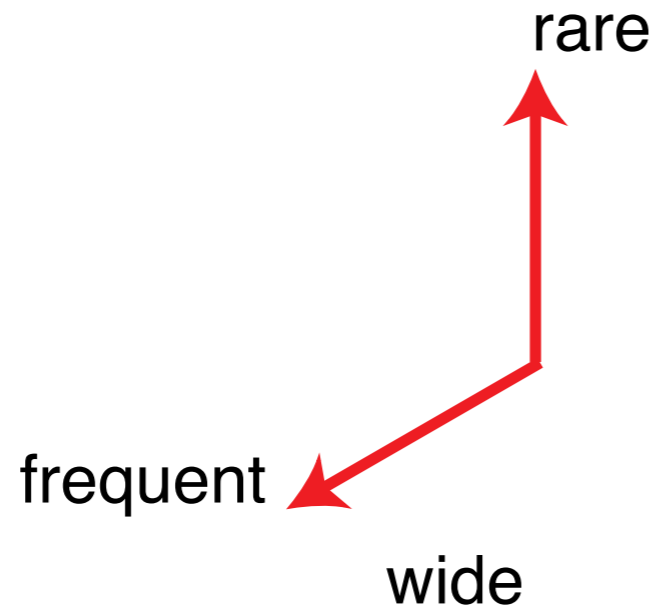
[from Schöner, Kopecz, Erlhagen, 1997]

# experiment: metric effect





[from Erlhagen, Schöner: Psych. Rev. 2002]

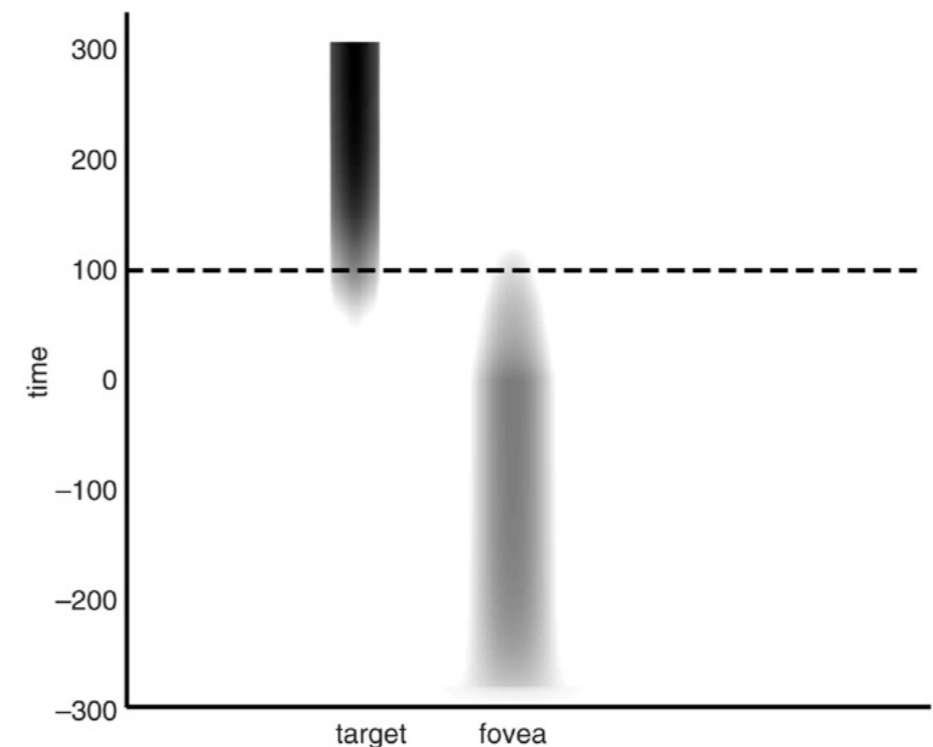
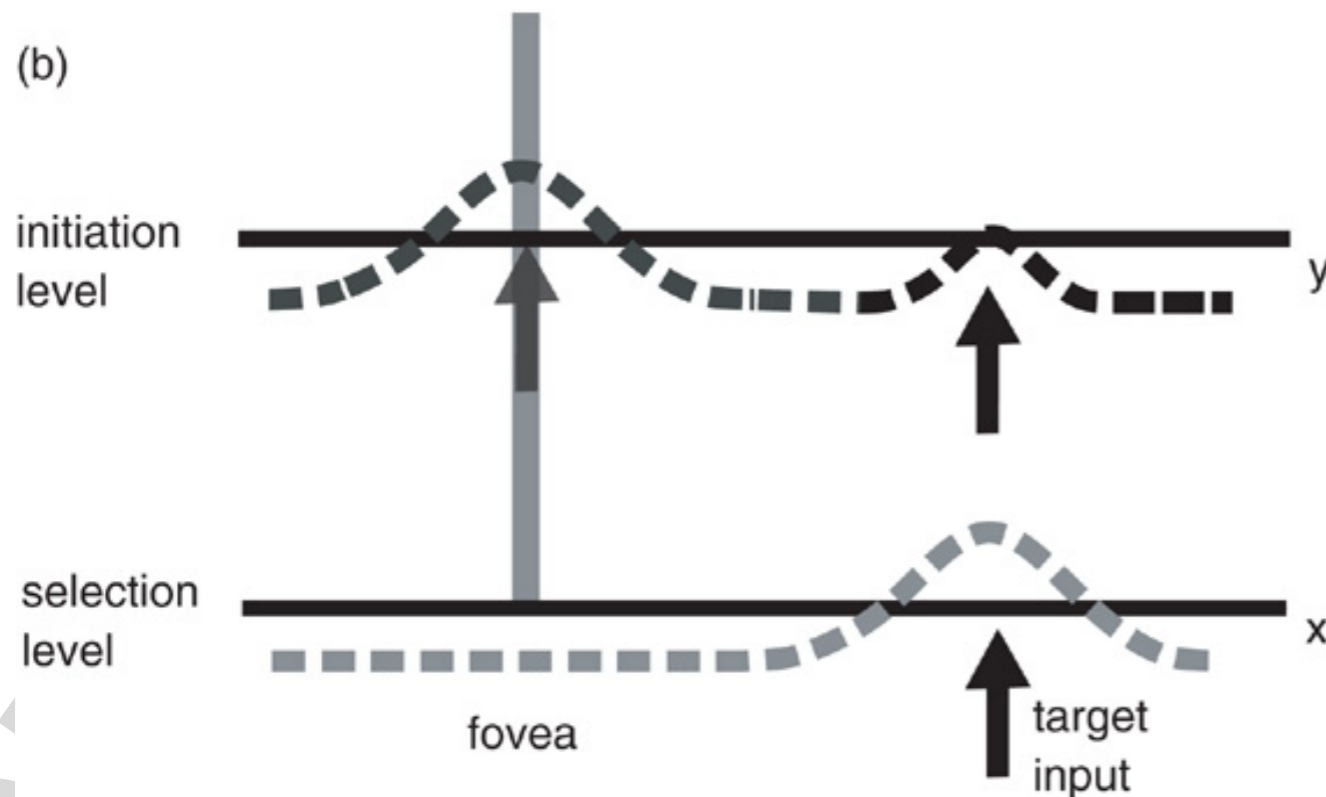


[from McDowell, Jeka, Schöner, Hatfield, 2002]

# detection-selection: overcoming fixation

■ detection can be like selection: initiating an action means terminating the non-action=fixation or posture

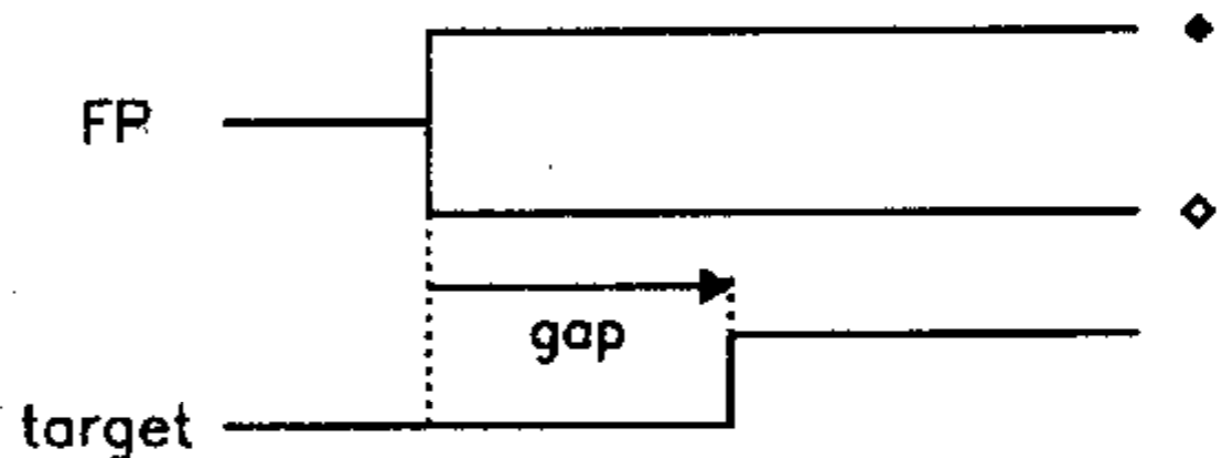
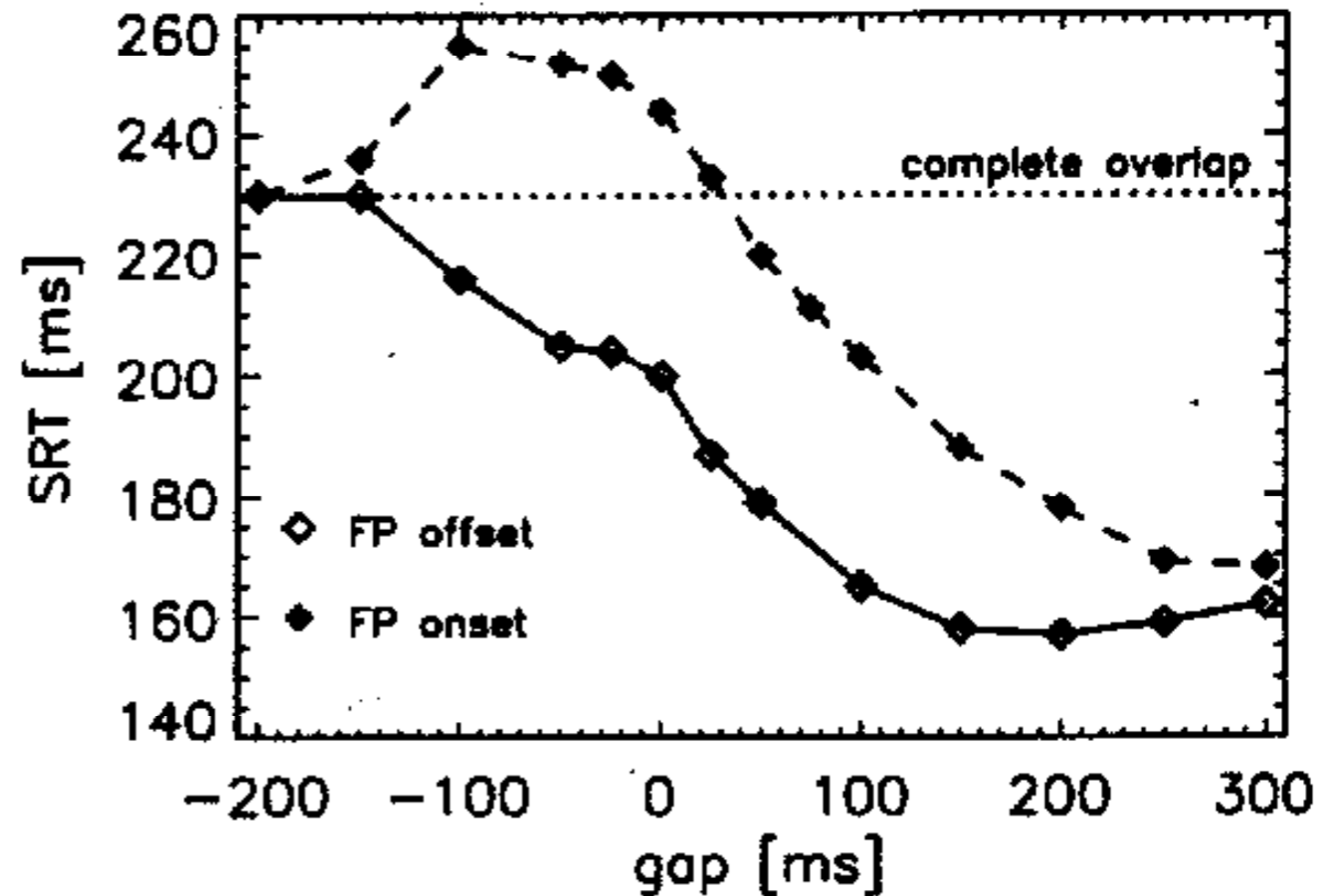
■ example: saccade initiation



[Wilimzig, Schneider, Schöner, 2006]

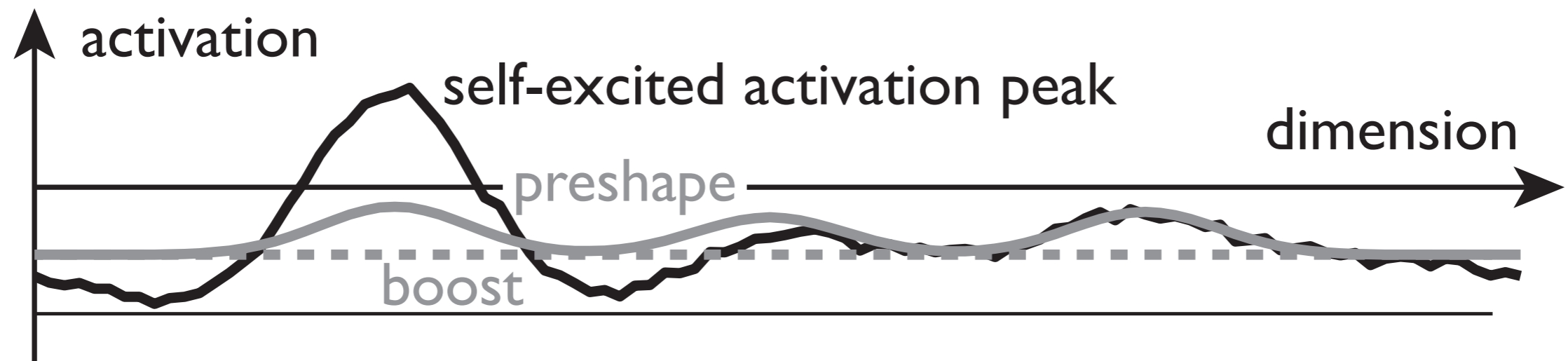
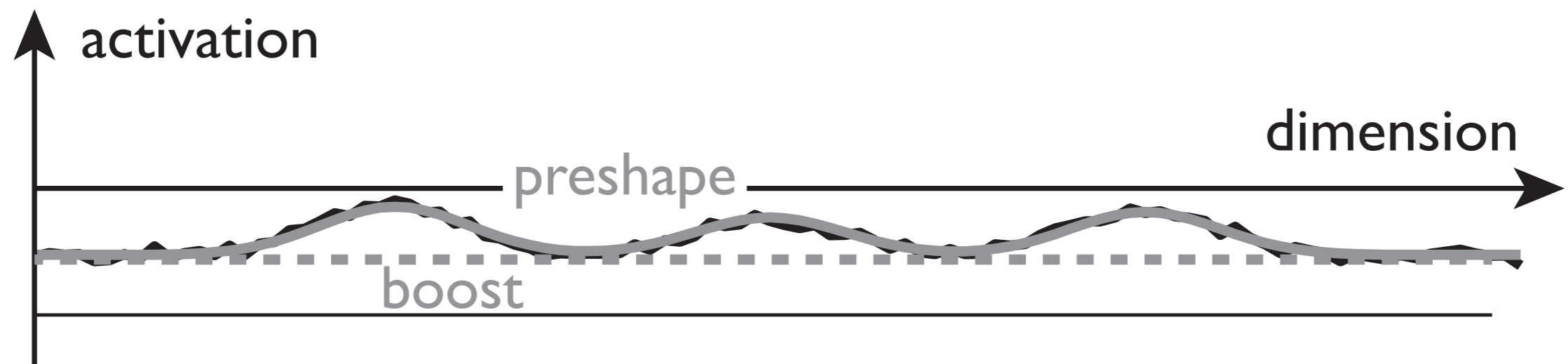
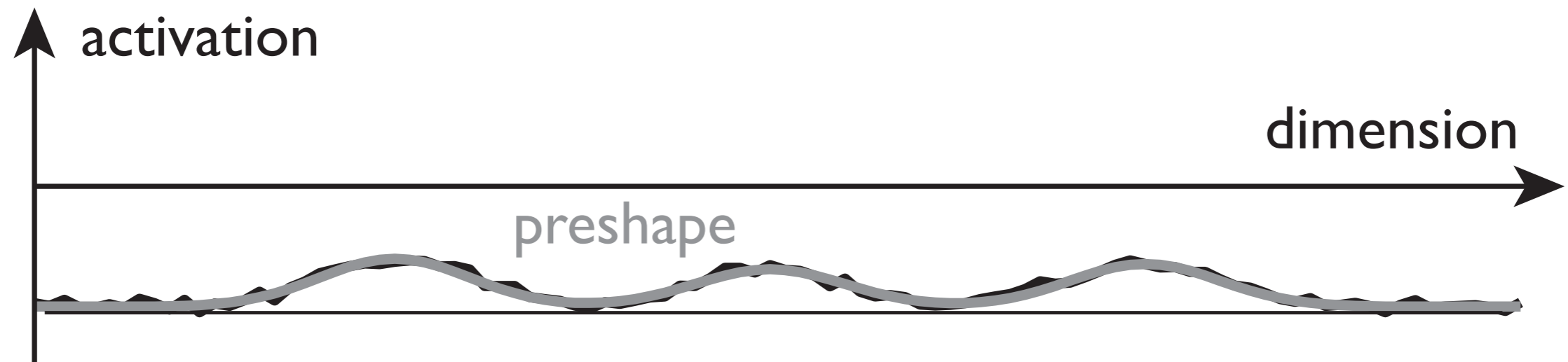
# initiation vs. fixation

- such models account for the gap-step-overlap effect



[Kopecz, 95]

# boost-induced detection instability



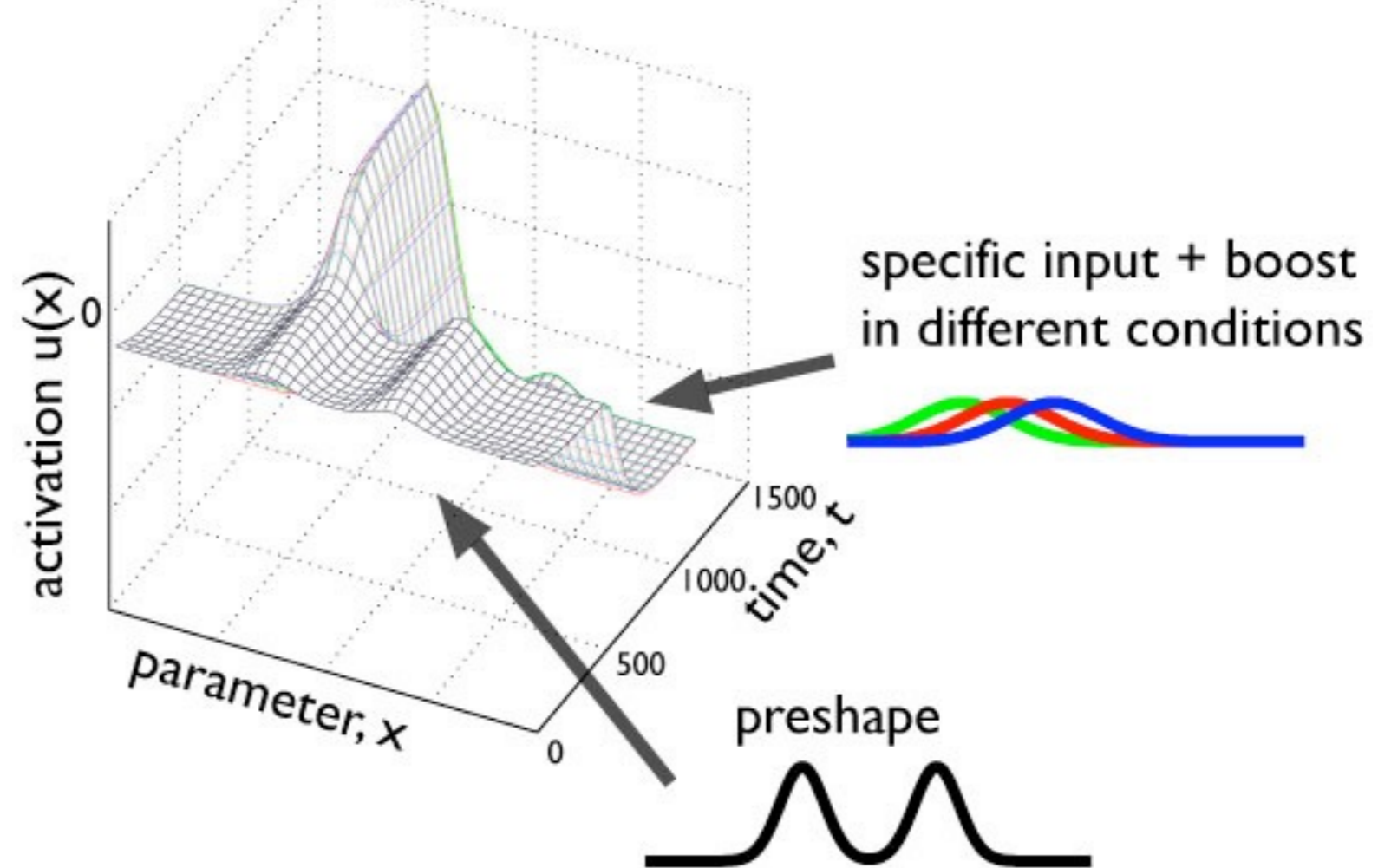
# boost-driven detection instability

- inhomogeneities in the field existing prior to a signal/stimulus that leads to a macroscopic response=“preshape”
- the boost-driven detection instability amplifies preshape into macroscopic selection decisions

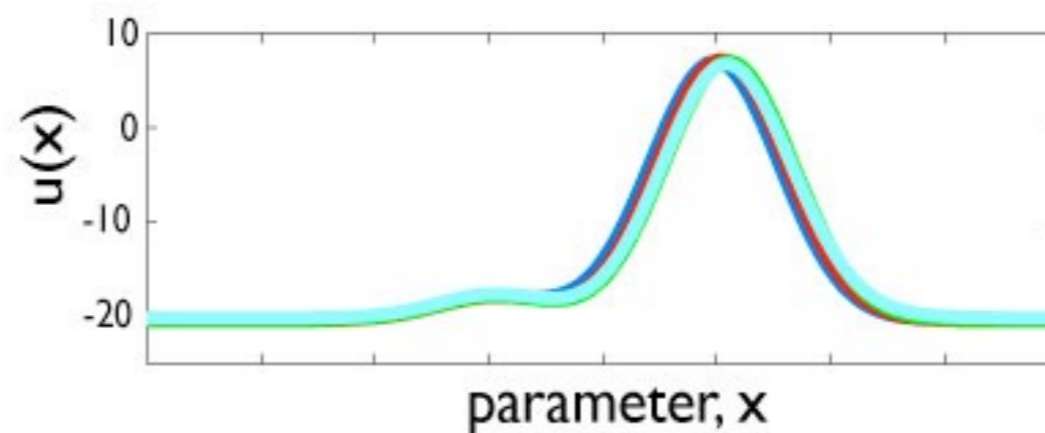
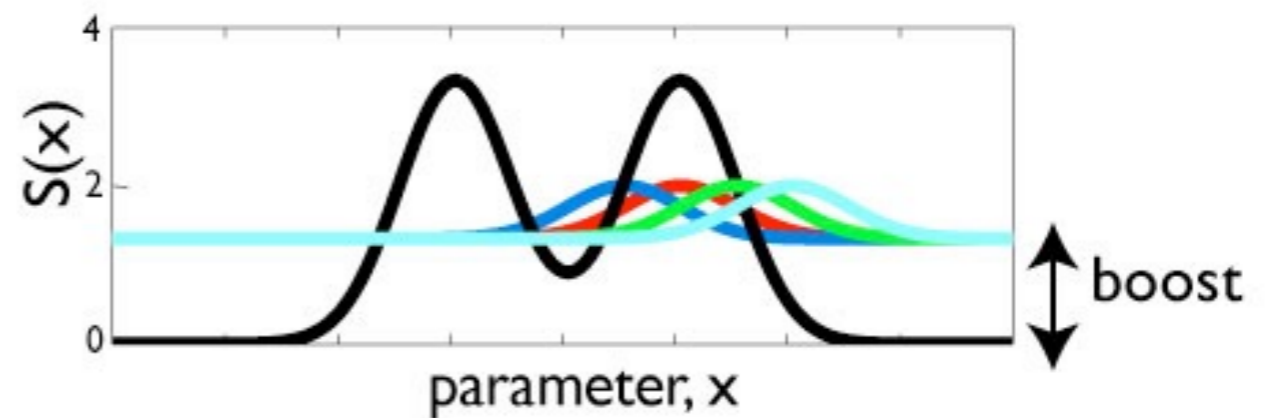
# ... emergence of categories?

- if we understand, how such inhomogeneities come about, we understand the emergence of categories...

this supports  
categorical  
behavior



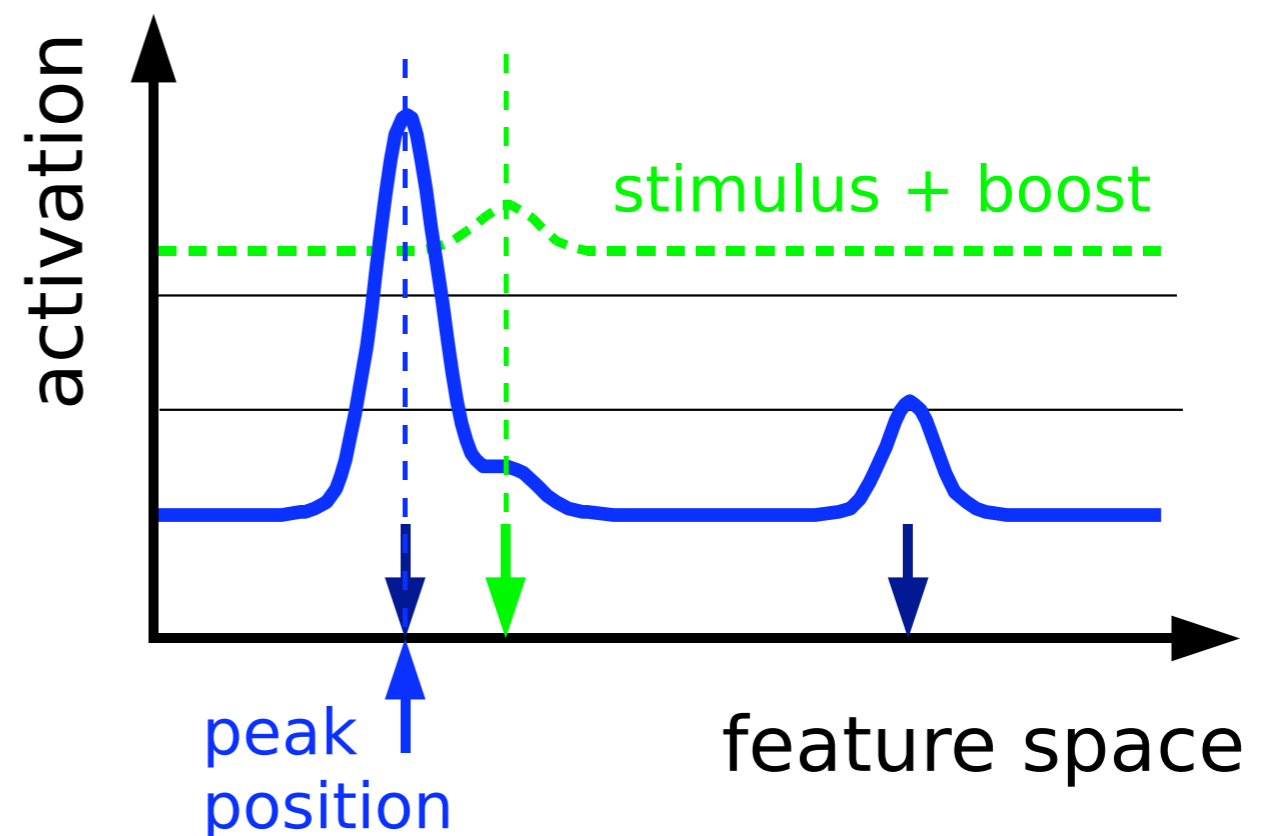
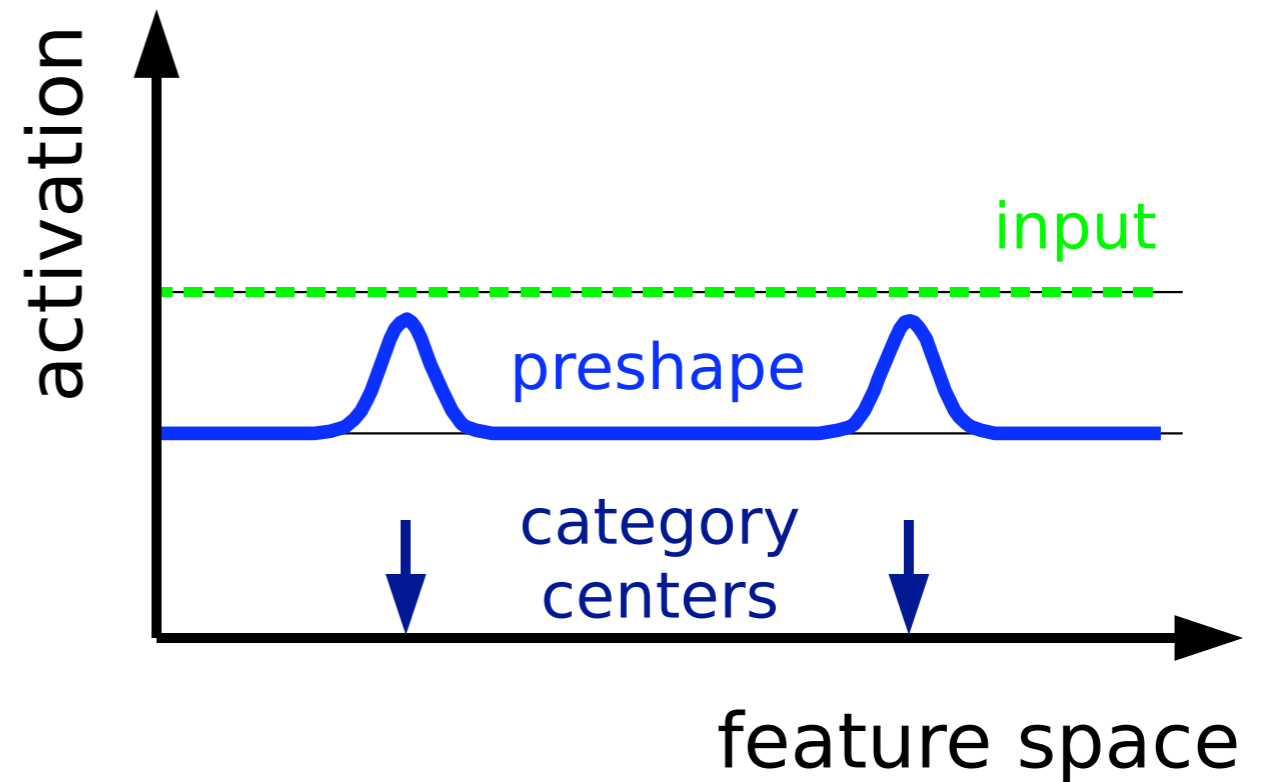
■ when preshape  
dominates



[Wilimzig, Schöner, 2006]

# categorical responding

- based on categorical memory trace and boost-driven detection instability

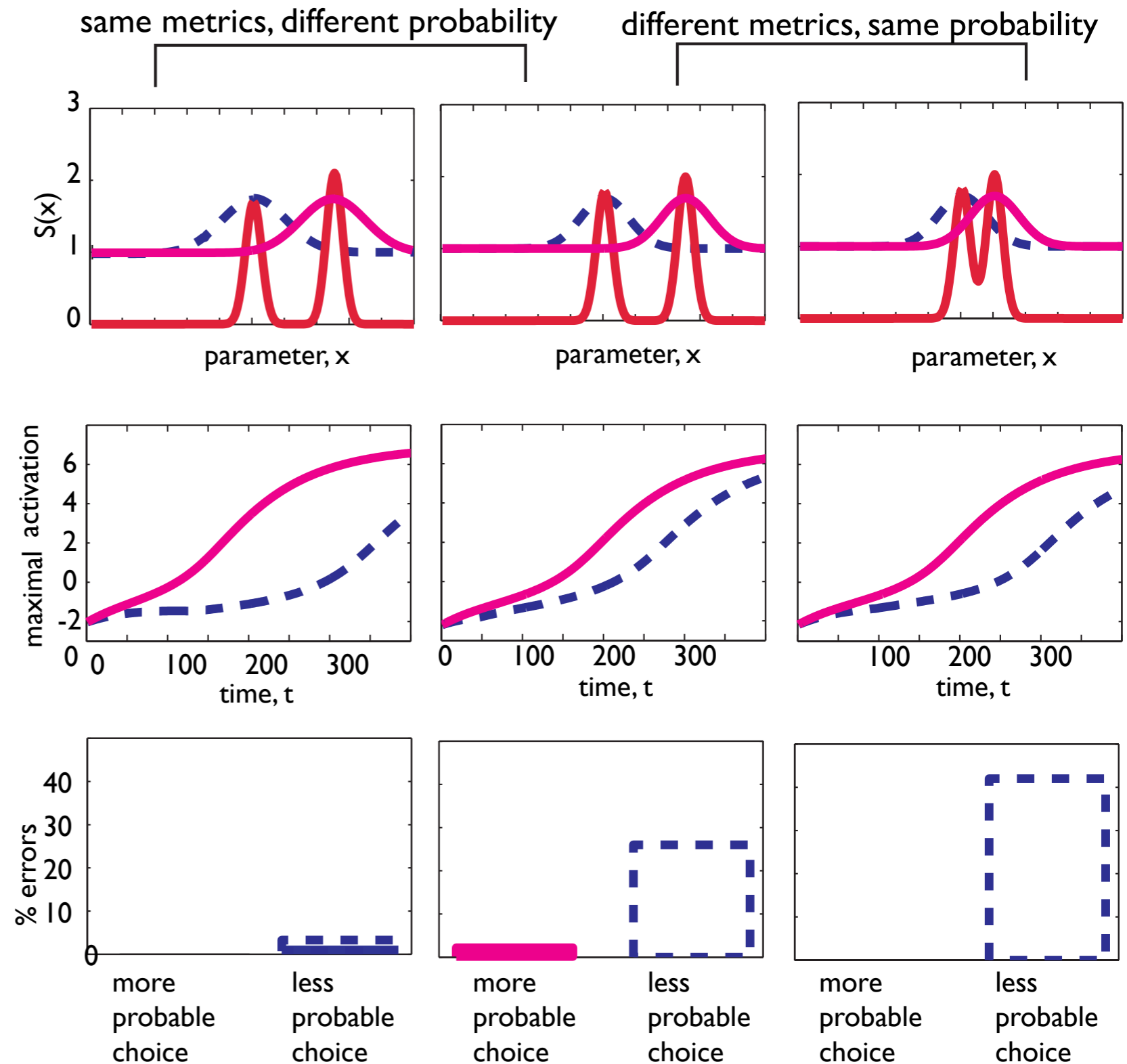


# distance effect

- common in categorical tasks... e.g., decide which of two sticks is longer => RT is larger when sticks are more similar in length (1930s')

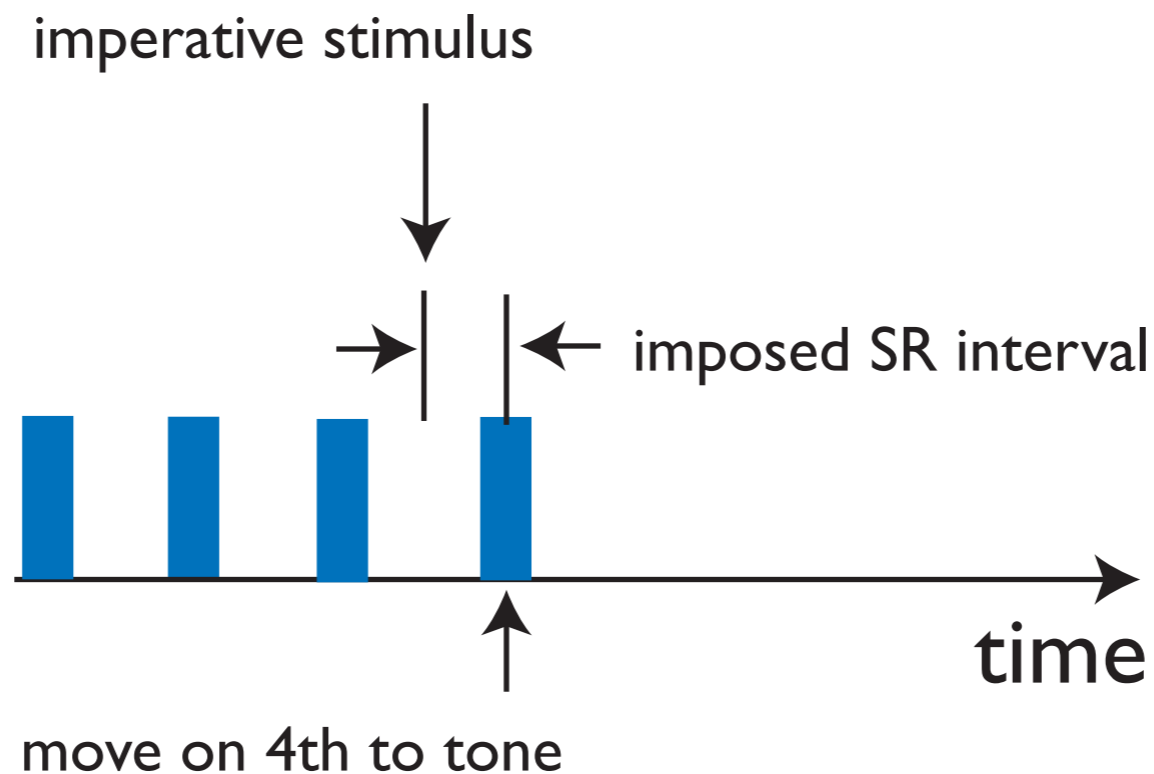
# interaction metrics-probability

- opposite to that predicted for input-driven detection instabilities:
- metrically close choices show larger effect of probability

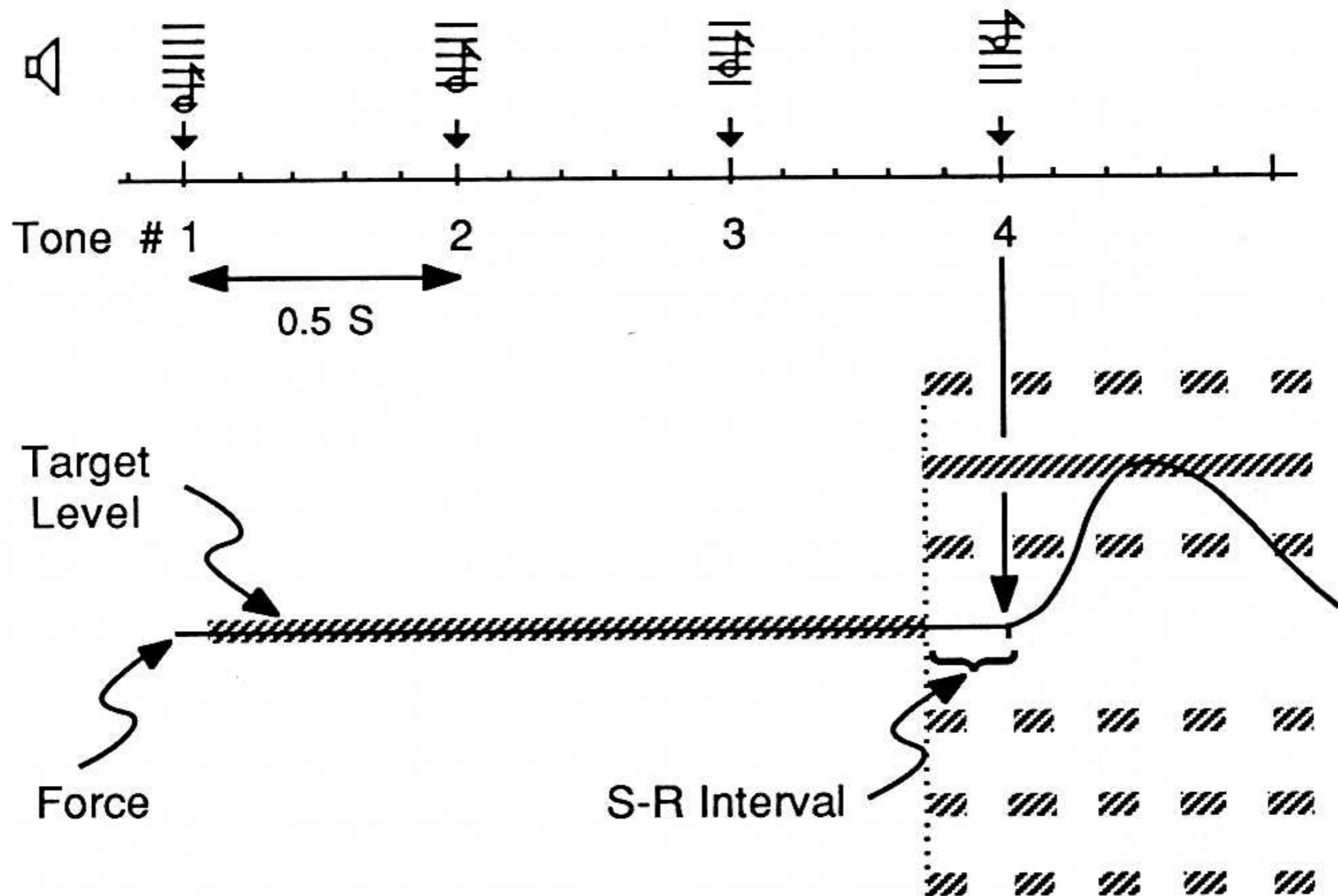


# Behavioral evidence for the graded and continuous evolution of decision

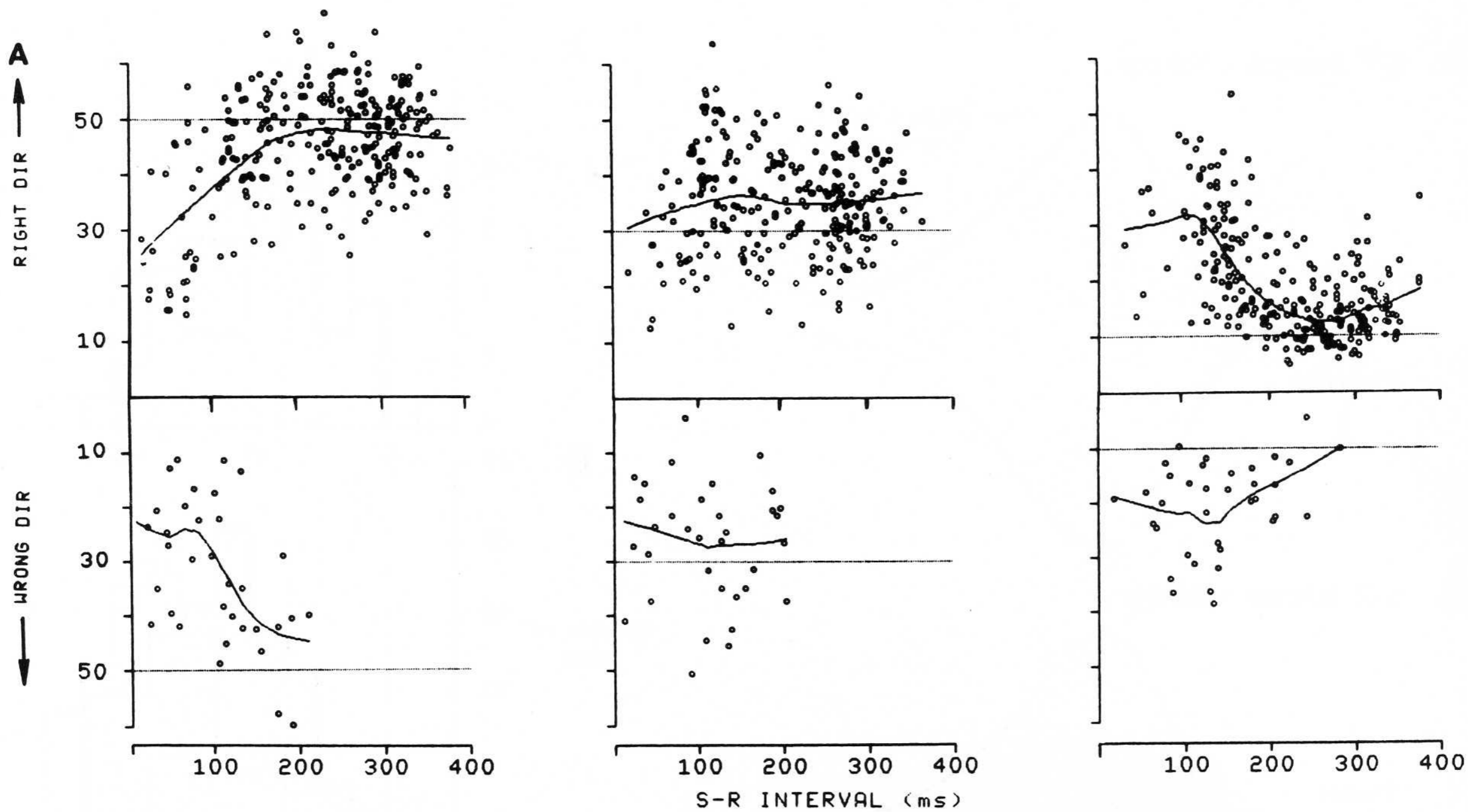
timed movement  
initiation paradigm



[Ghez and colleagues, 1988 to 1990's]

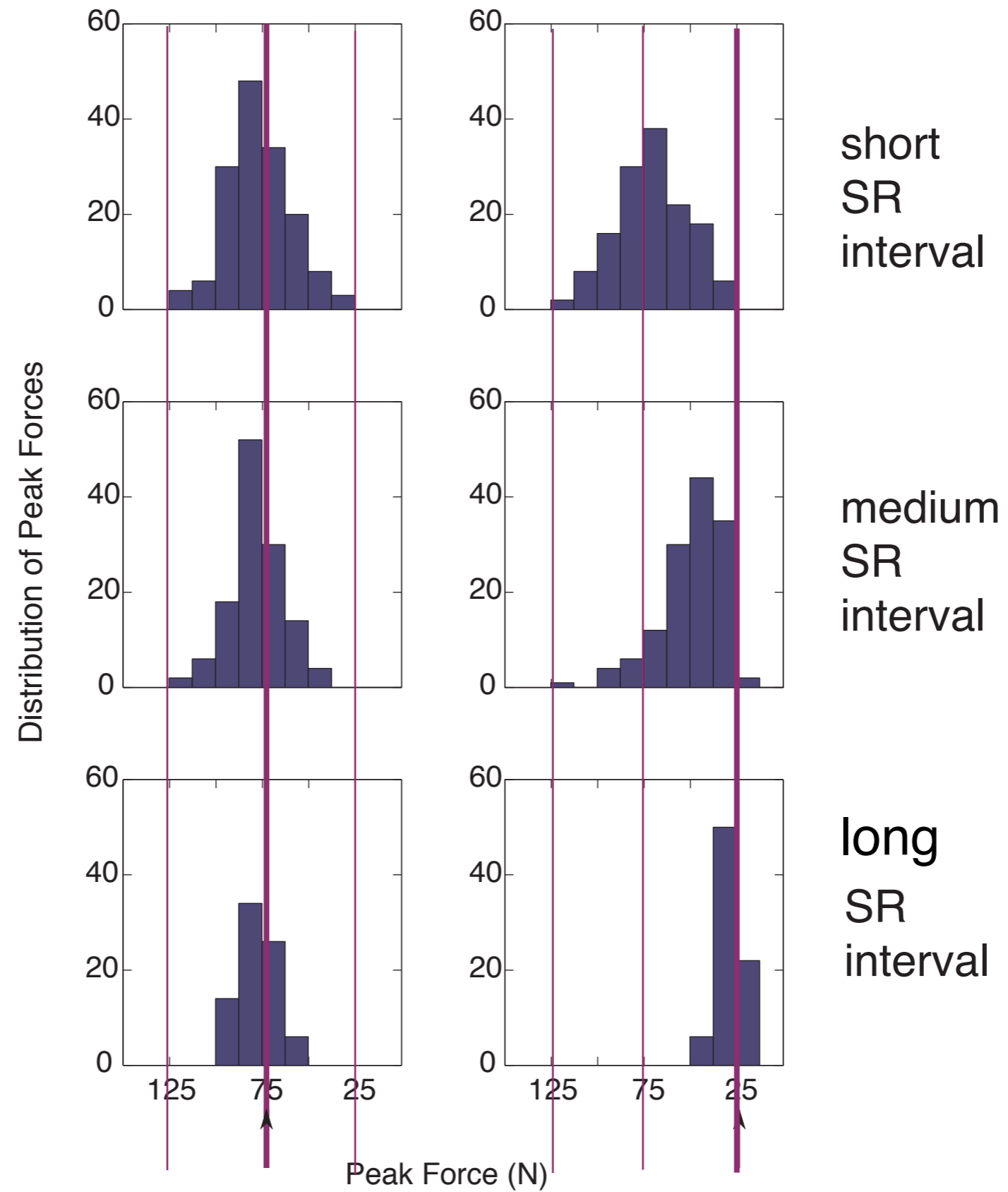


[Favilla et al. 1989]

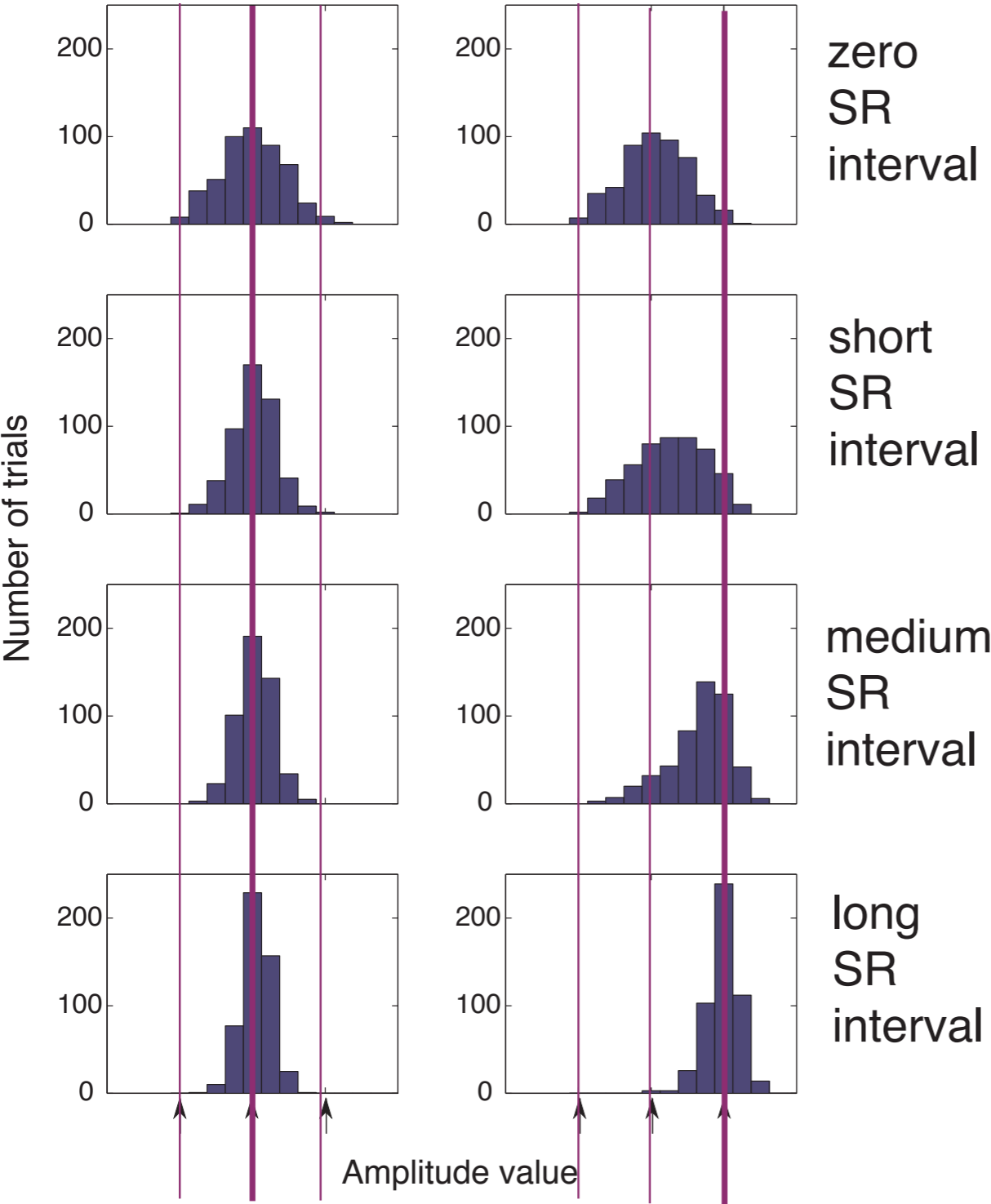


[Favilla et al. 1989]

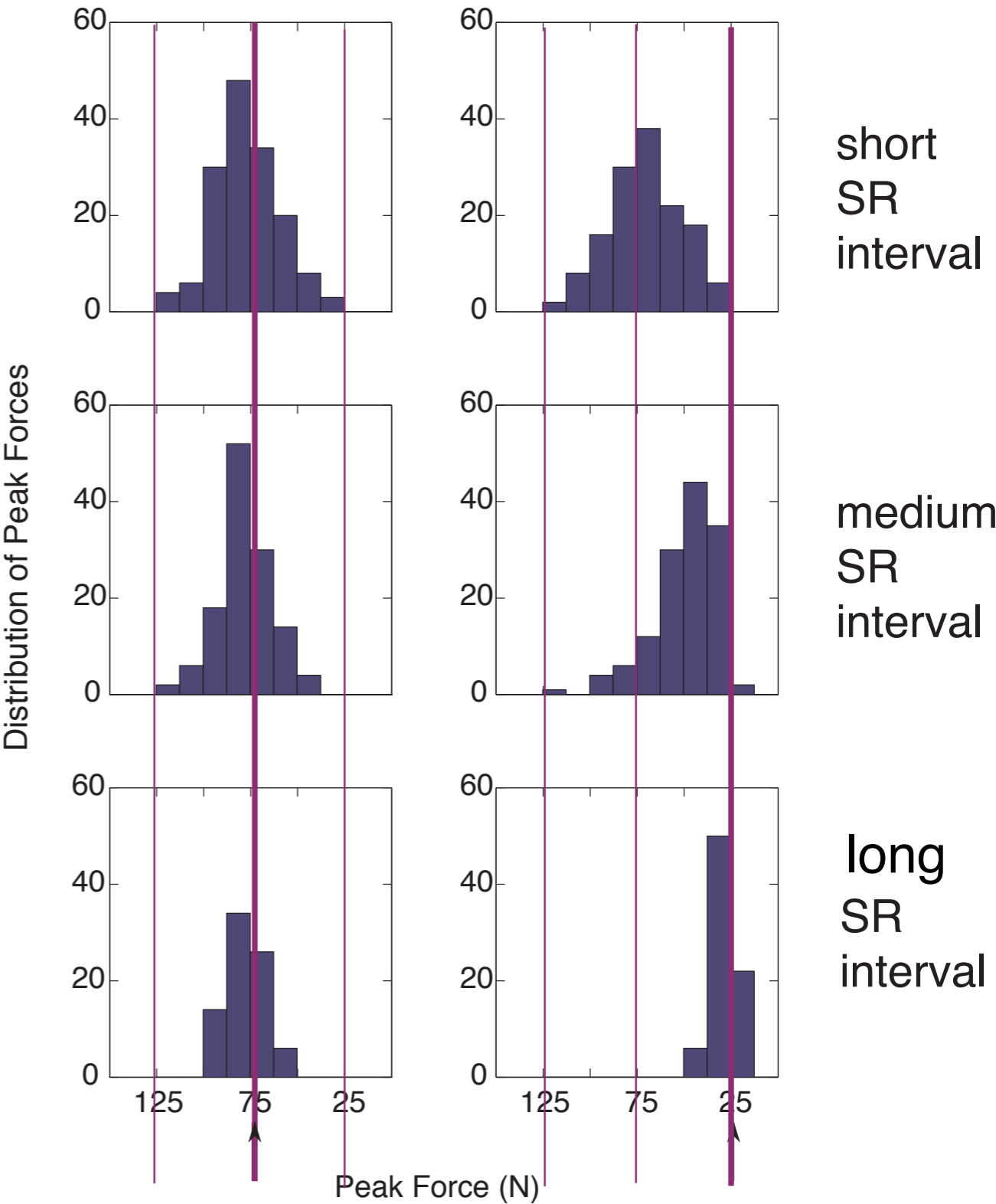
# Experimental results of Henig et al



theoretical account for Henig et al.

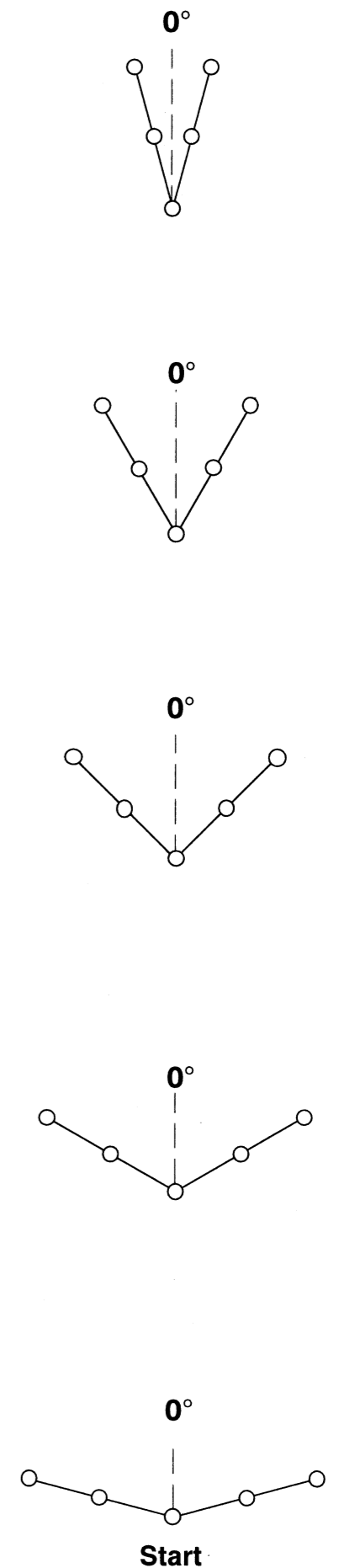
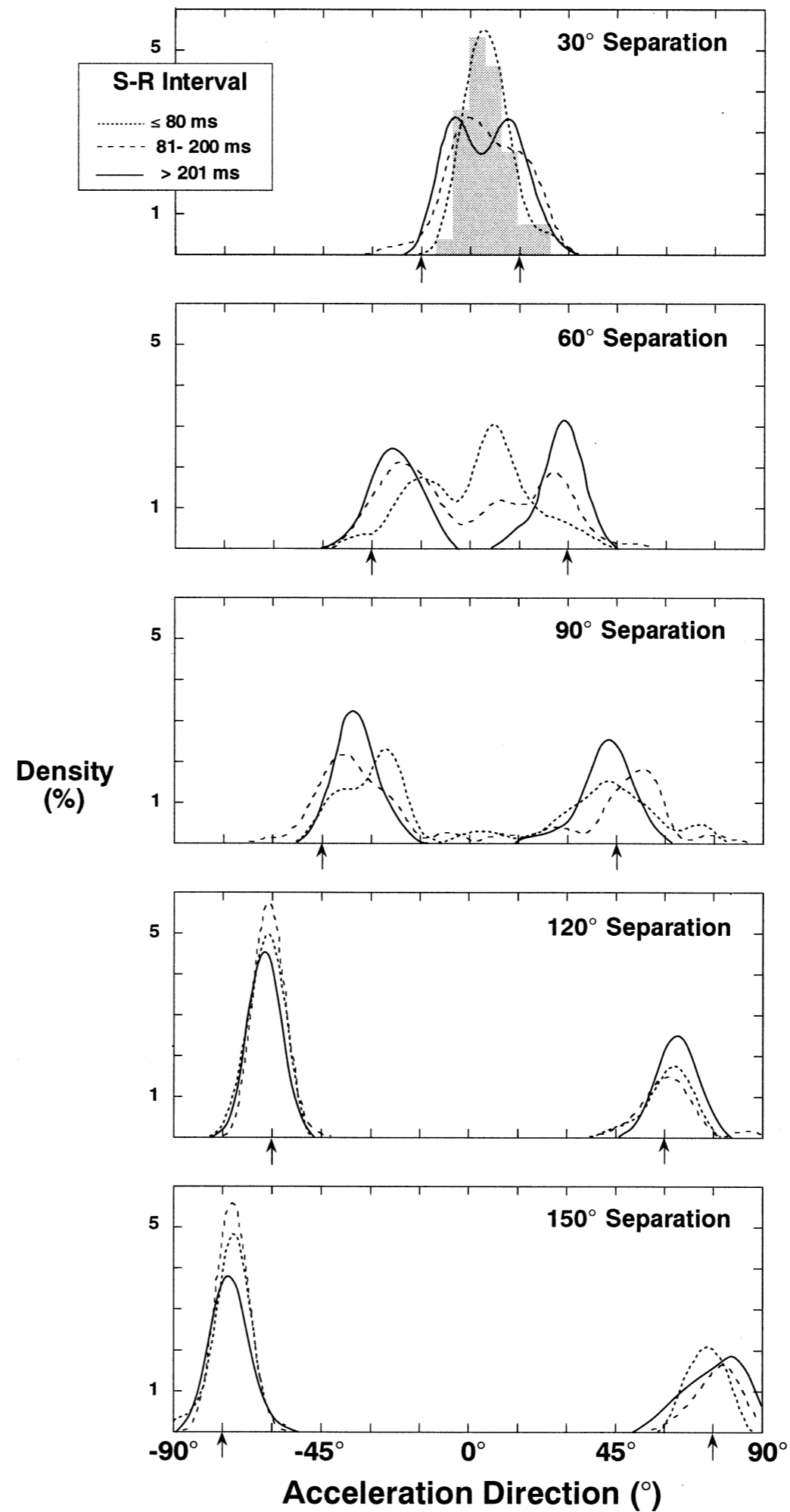


Experimental results of Henig et al

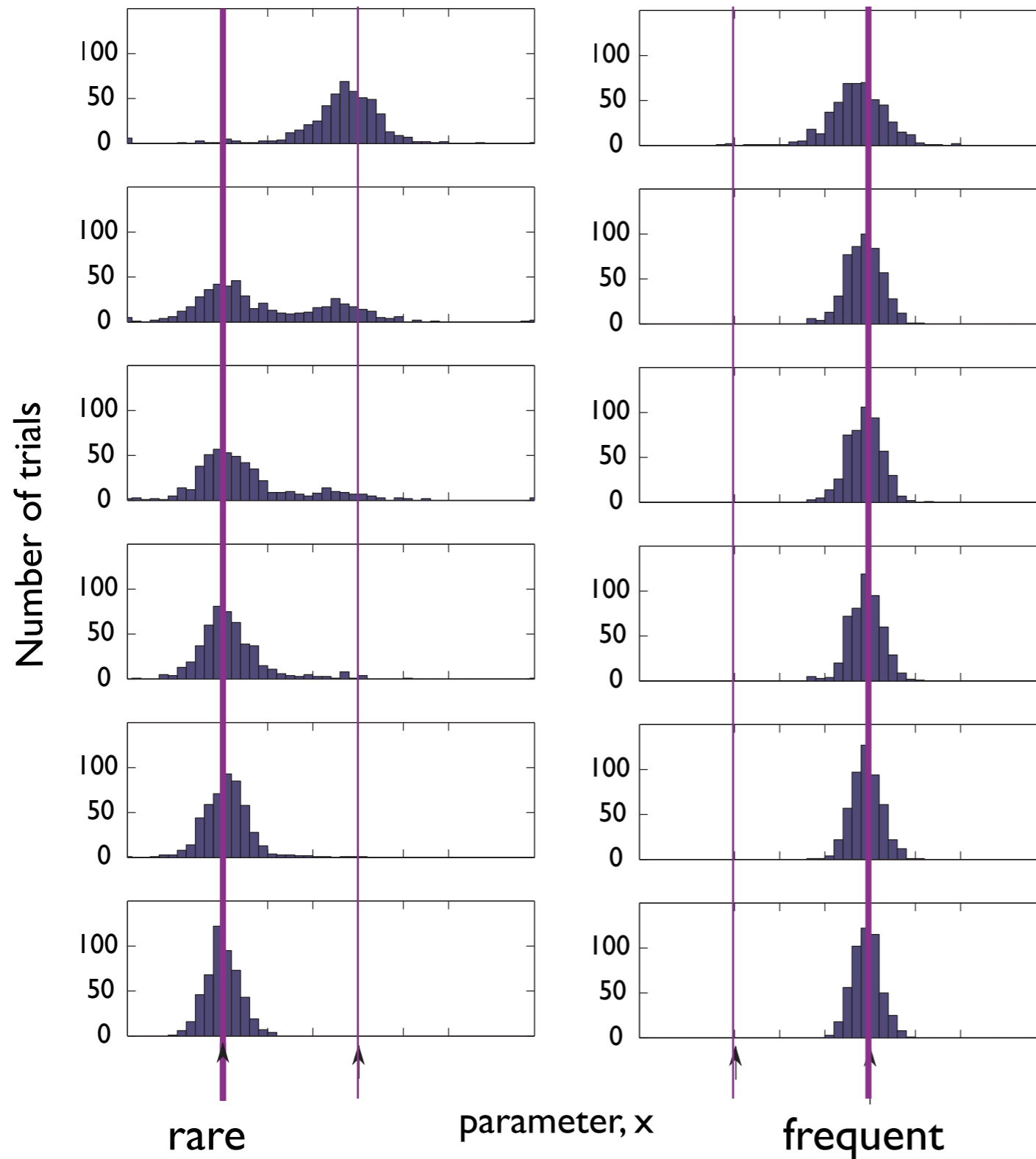


■ infer width of  
preshape peaks  
in field

[Ghez et al 1997]



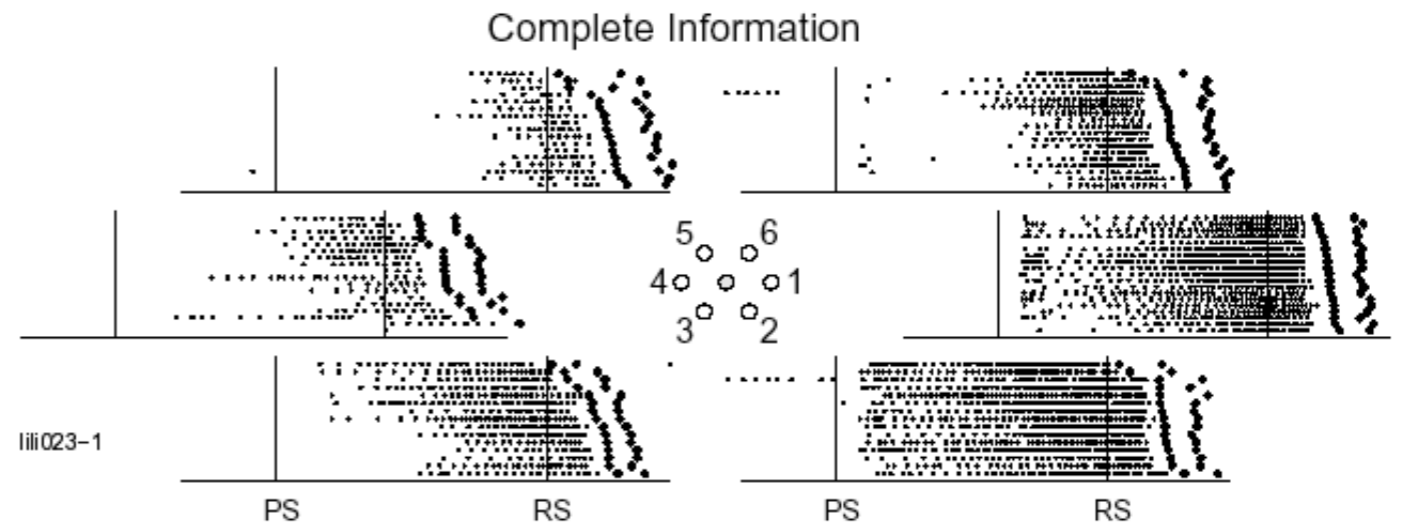
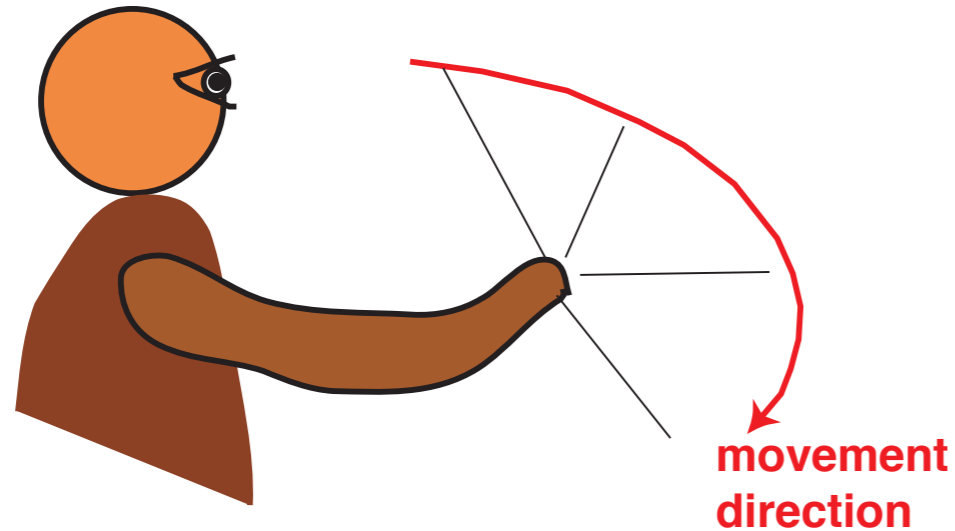
probability in timed movement initiation  
rare frequent



short SR interval:  
observe preshape

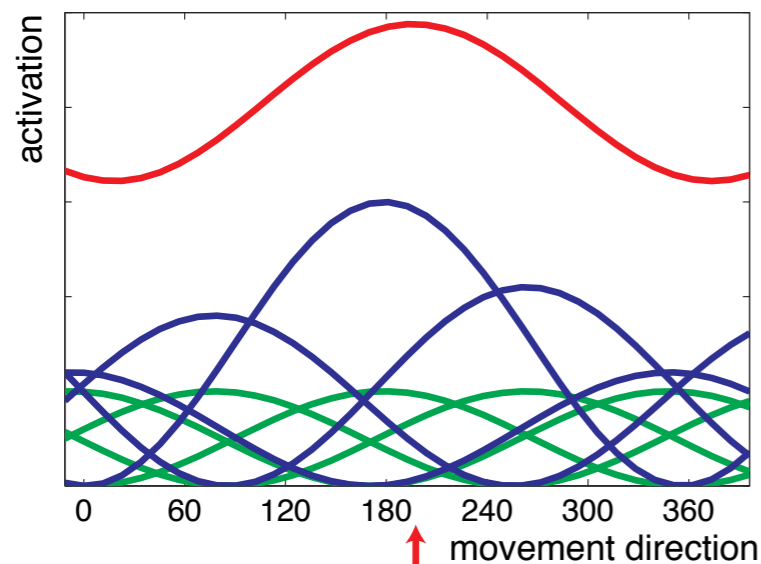
long SR interval:  
observe stimulus-defined  
movement plan

# Neural evidence for preshape



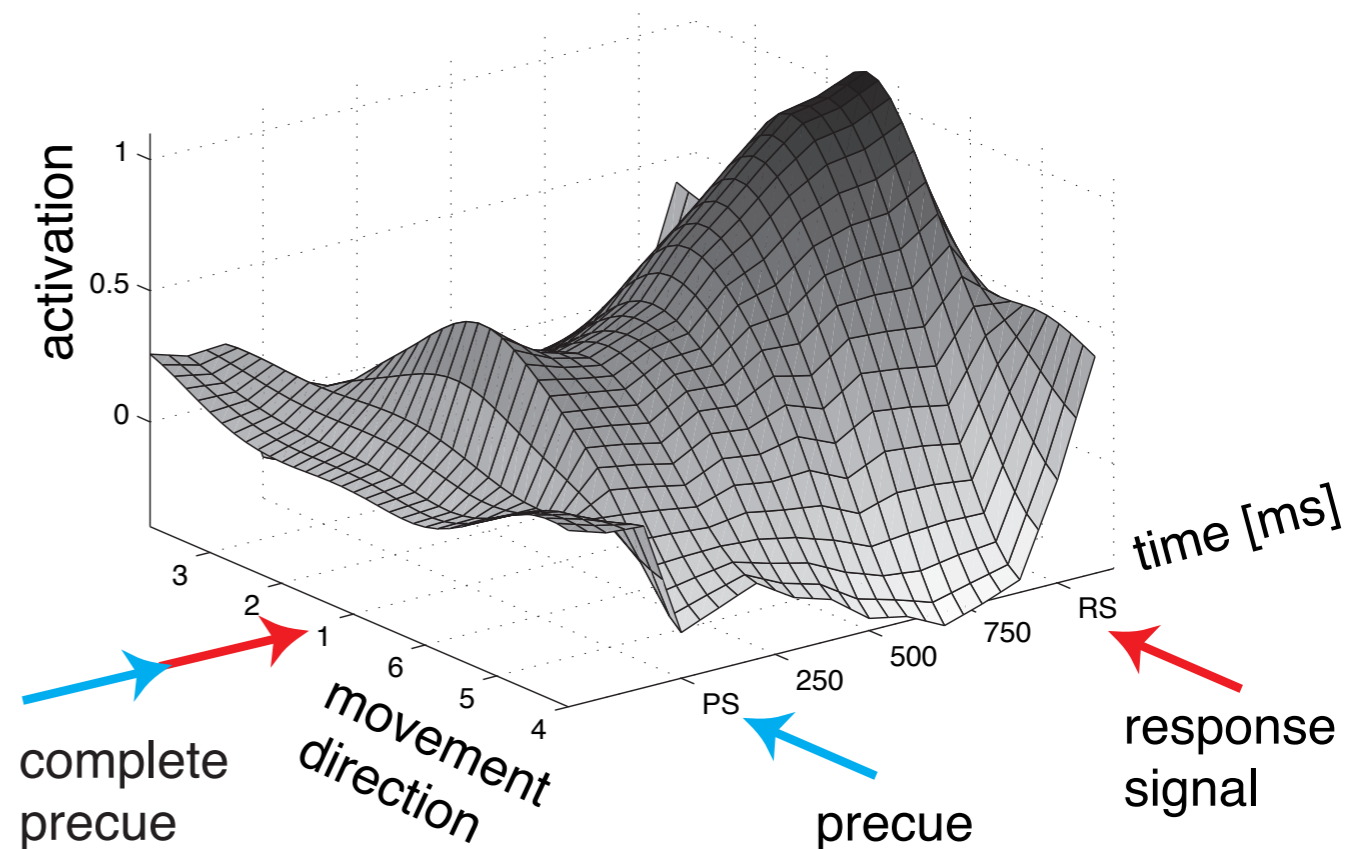
Distribution of population activation =

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



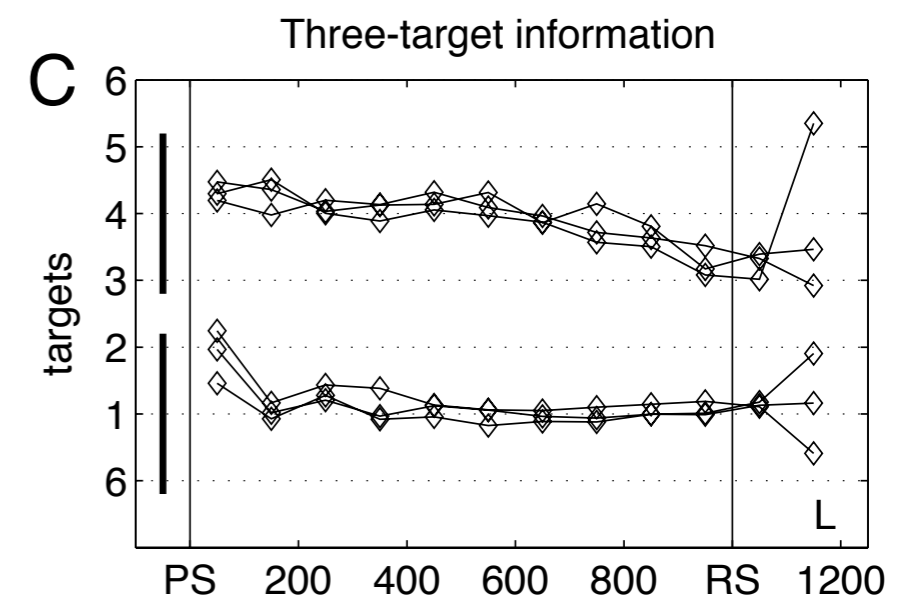
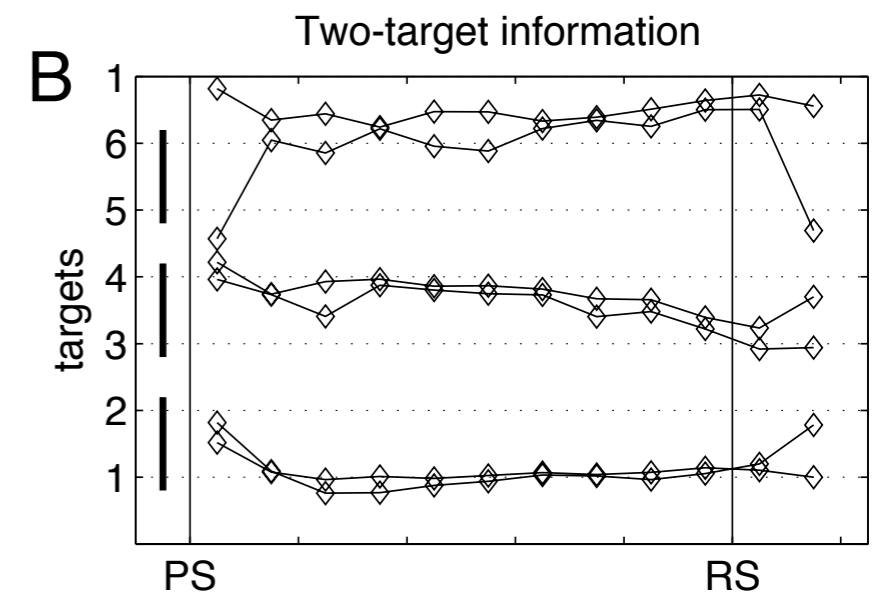
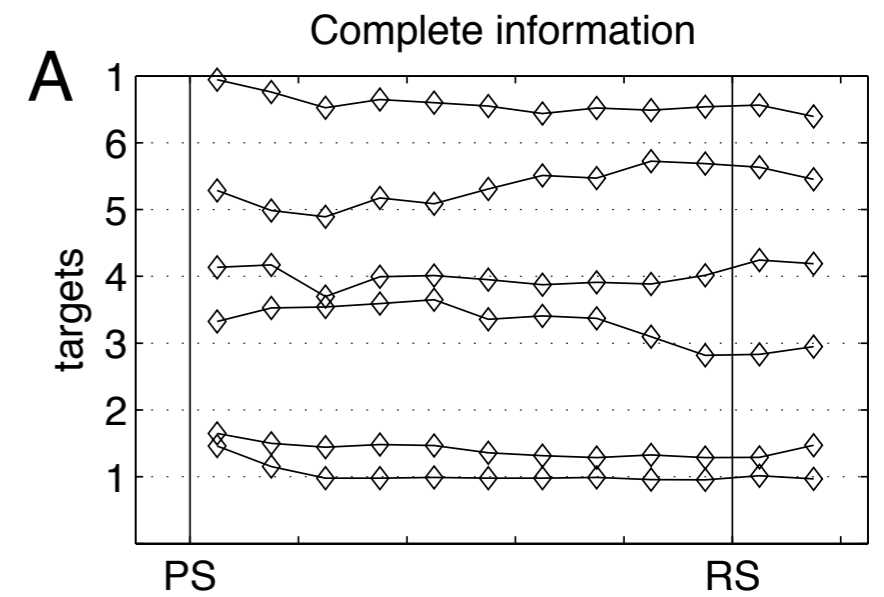
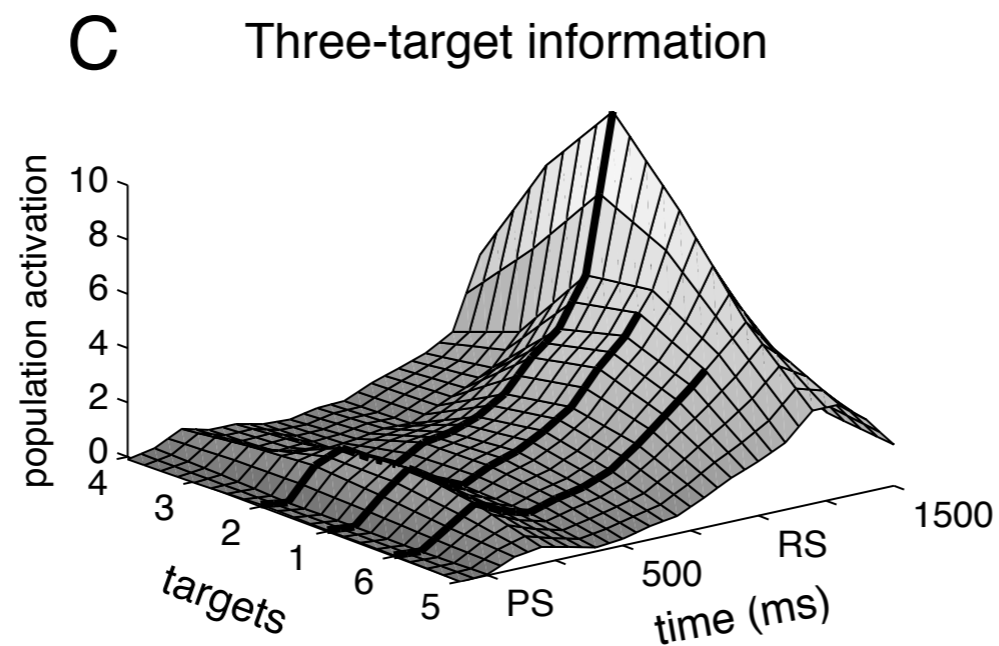
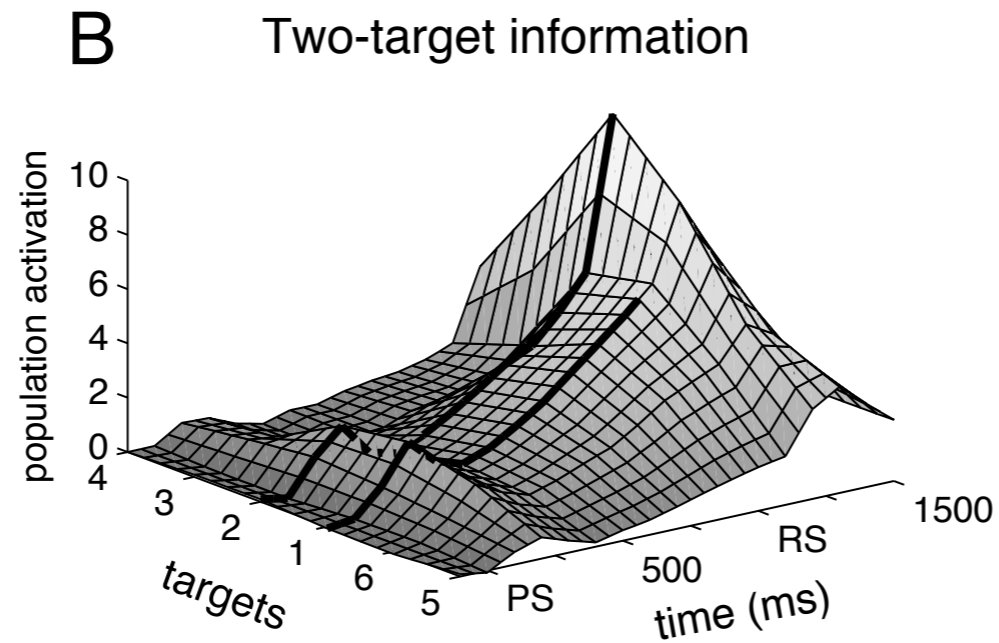
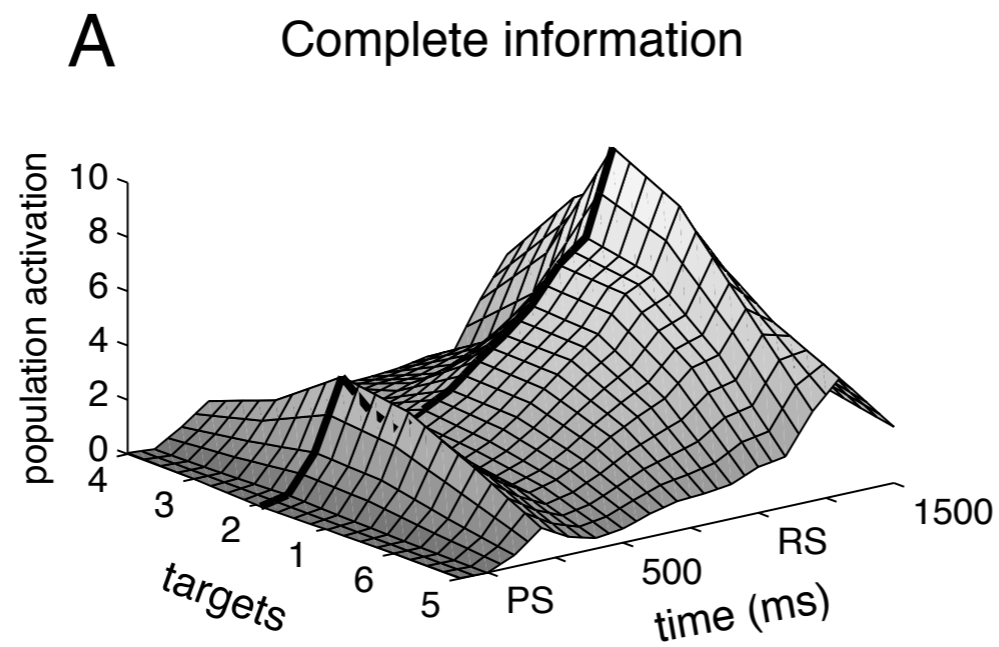
movement direction  
required in this trial

[after Bastian, Riehle, Schöner, submitted]



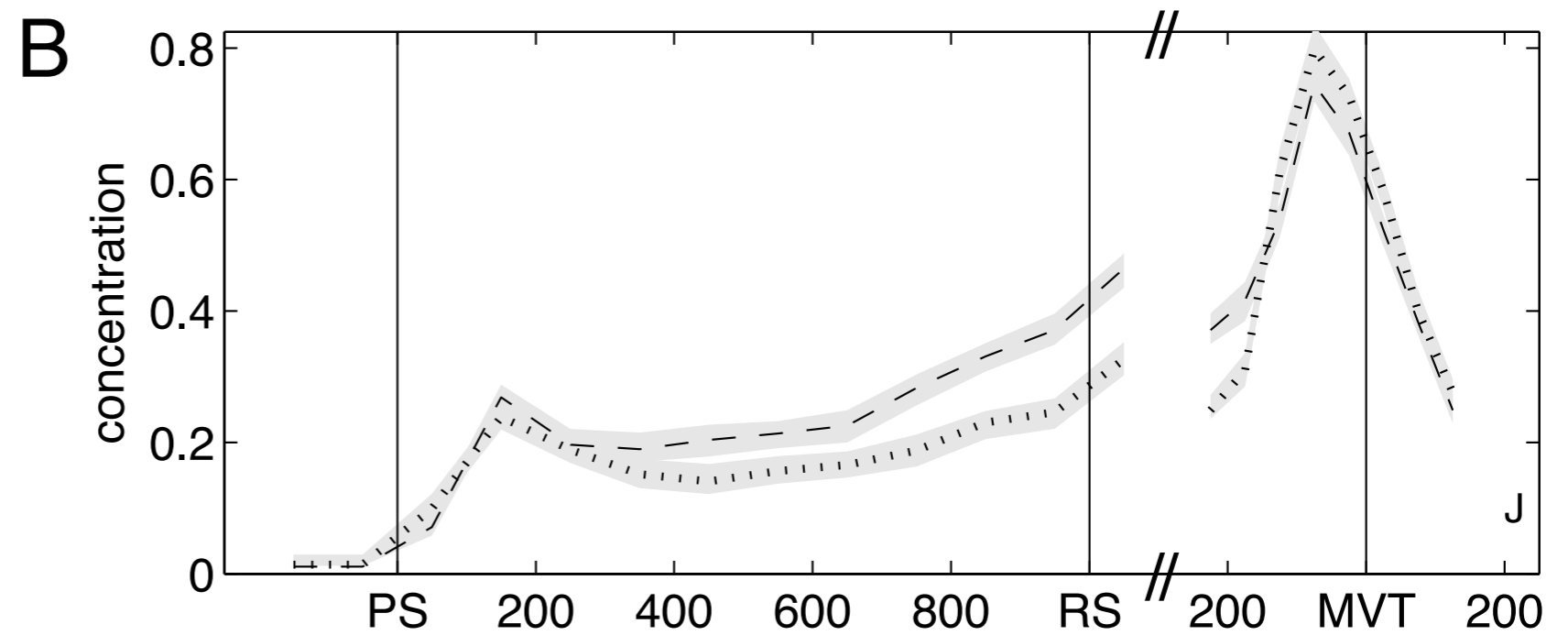
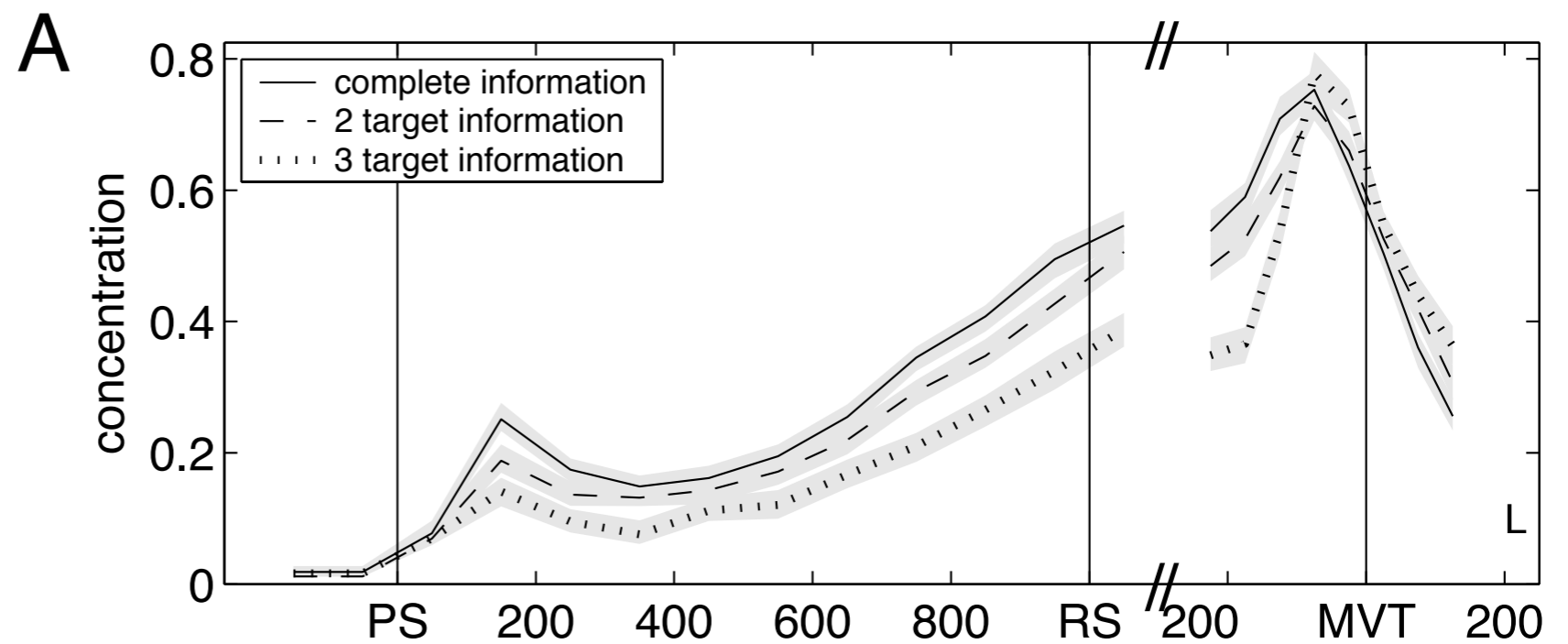
[Bastian, Riehle, Schöner: Europ J Neurosci 18: 2047 (2003)]

■ DPA reflects  
prior  
information



[Bastian, Schöner, Riehle 2003]

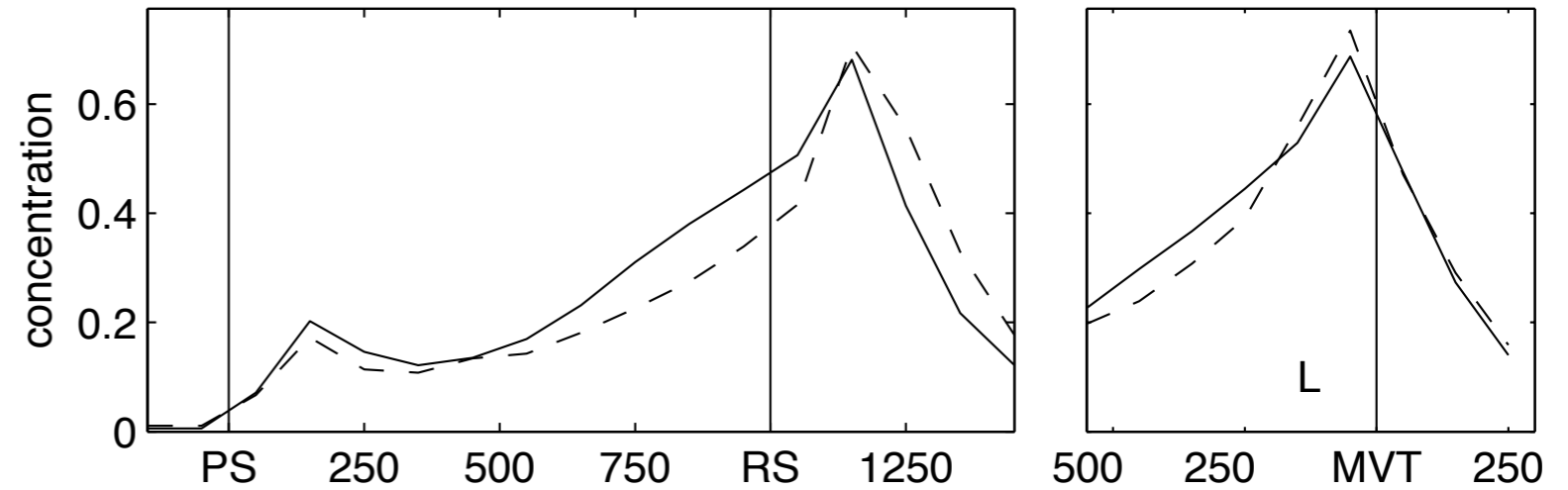
■ DPA reflects prior information



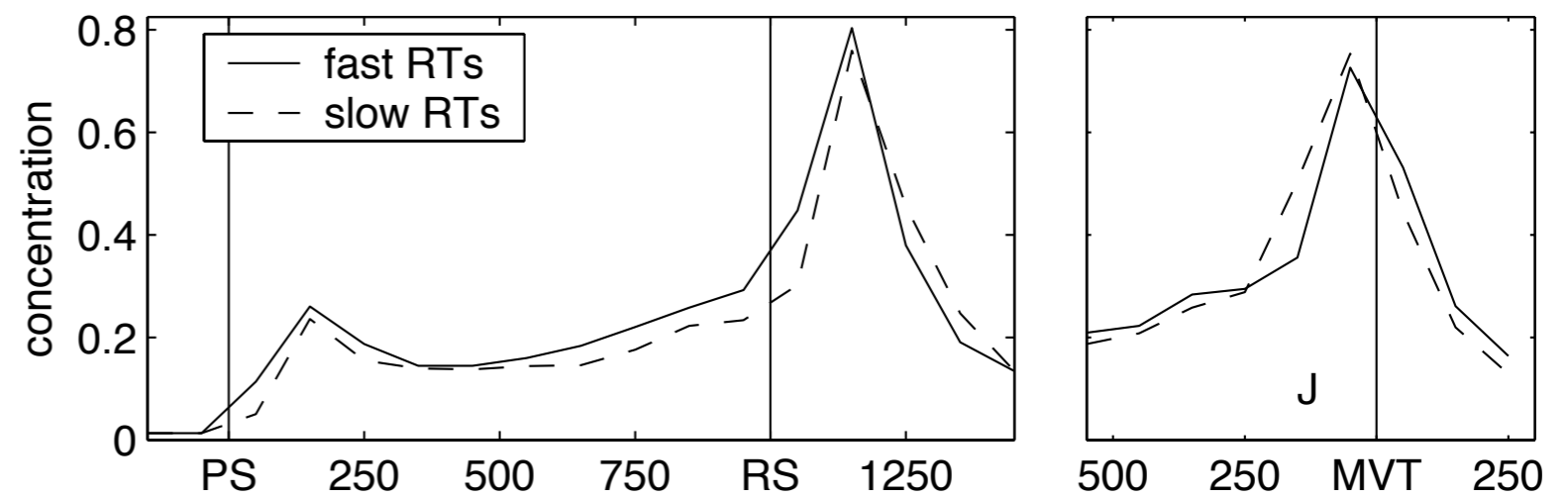
[Bastian, Schöner, Riehle 2003]

■ preshape correlates  
with RT

A



B



[Bastian, Schöner, Riehle 2003]