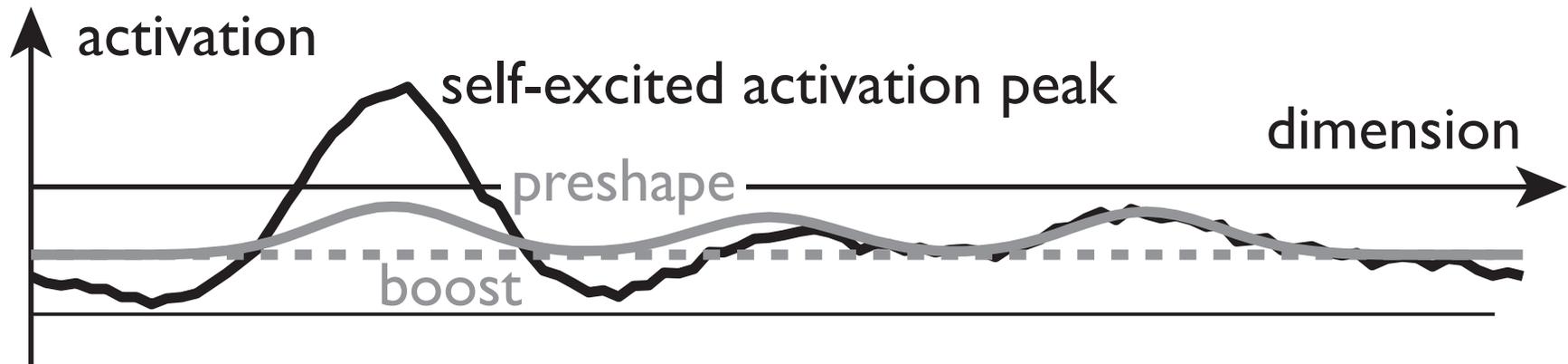
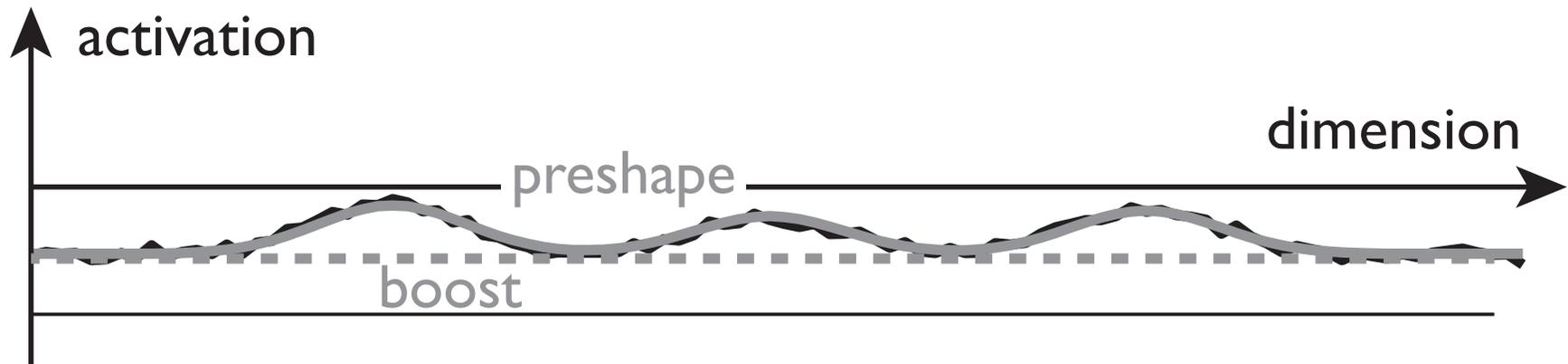
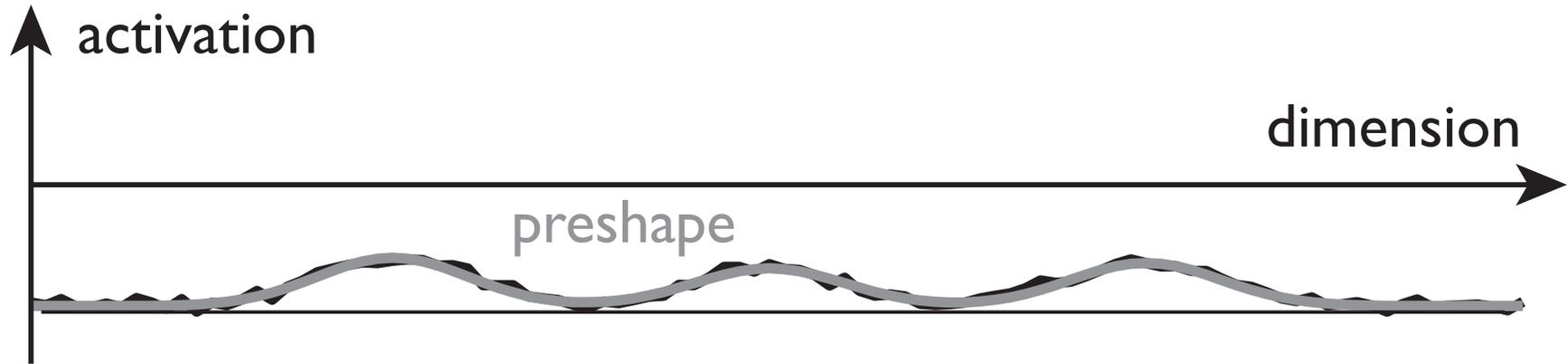


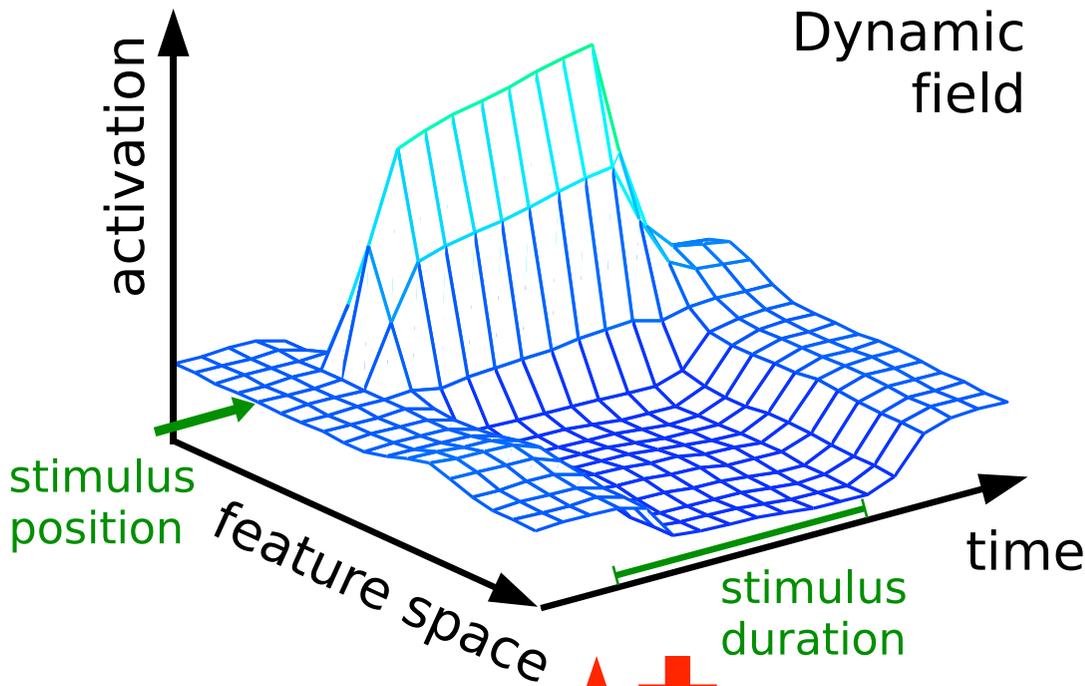
Dynamic Field Theory: Part 4:

Gregor Schöner
gregor.schoener@ini.rub.de

boost-induced detection instability

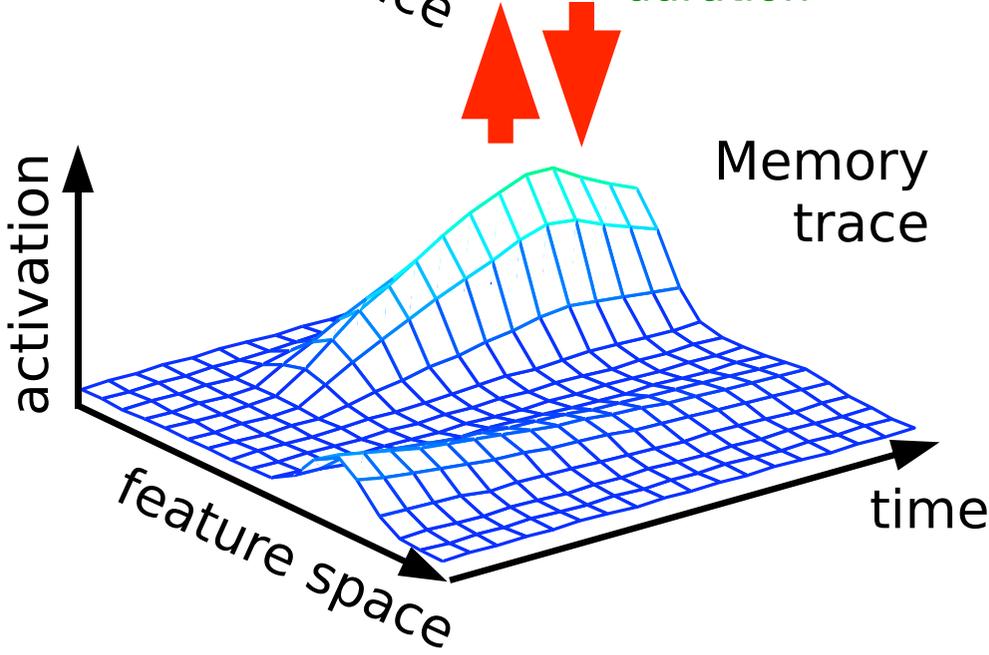


simplest form of learning: the memory trace



■ William James: habit formation as the simplest form of learning

■ (habituation: same for inhibition)



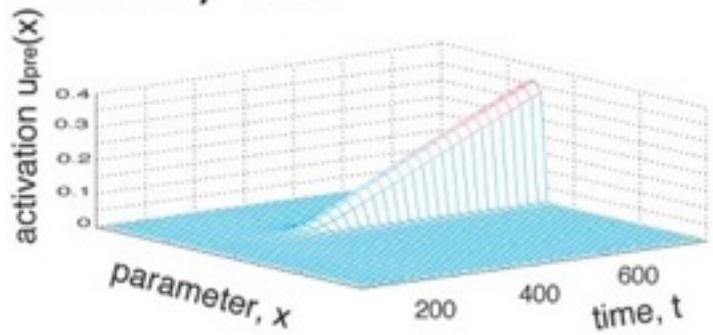
mathematics of the memory trace

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

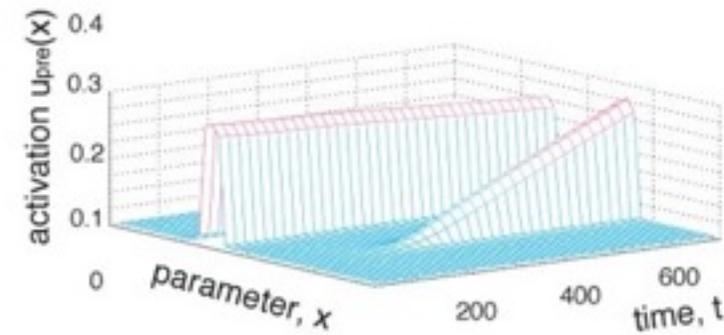
$$\tau_{\text{mem}} \dot{u}_{\text{mem}}(x, t) = -u_{\text{mem}}(x, t) + \int dx' w_{\text{mem}}(x - x') \sigma(u(x', t))$$

- memory trace only evolves while activation is excited
- potentially different growth and decay rates

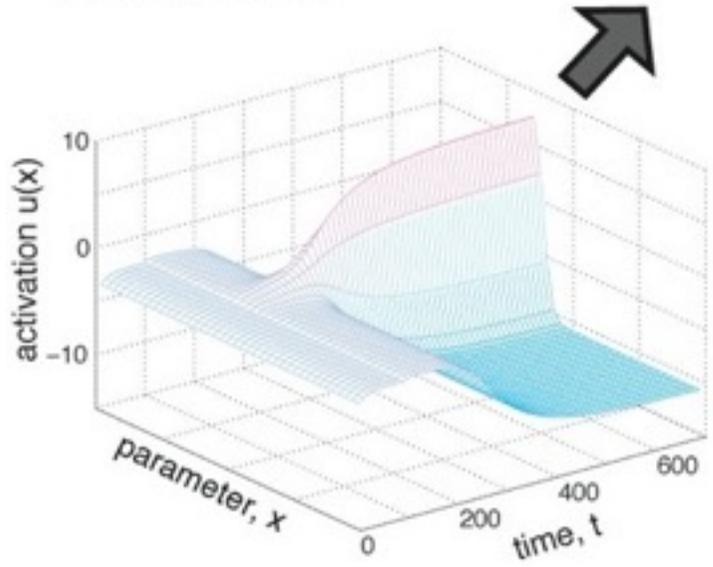
slow memory trace



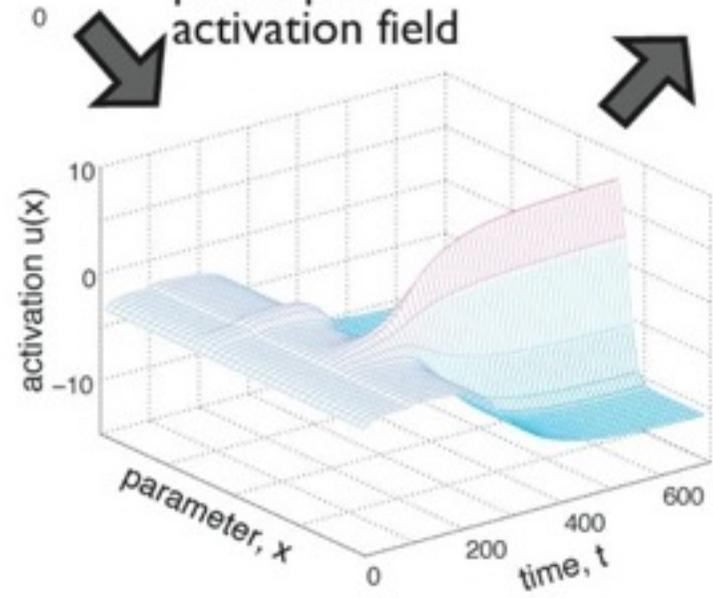
memory trace



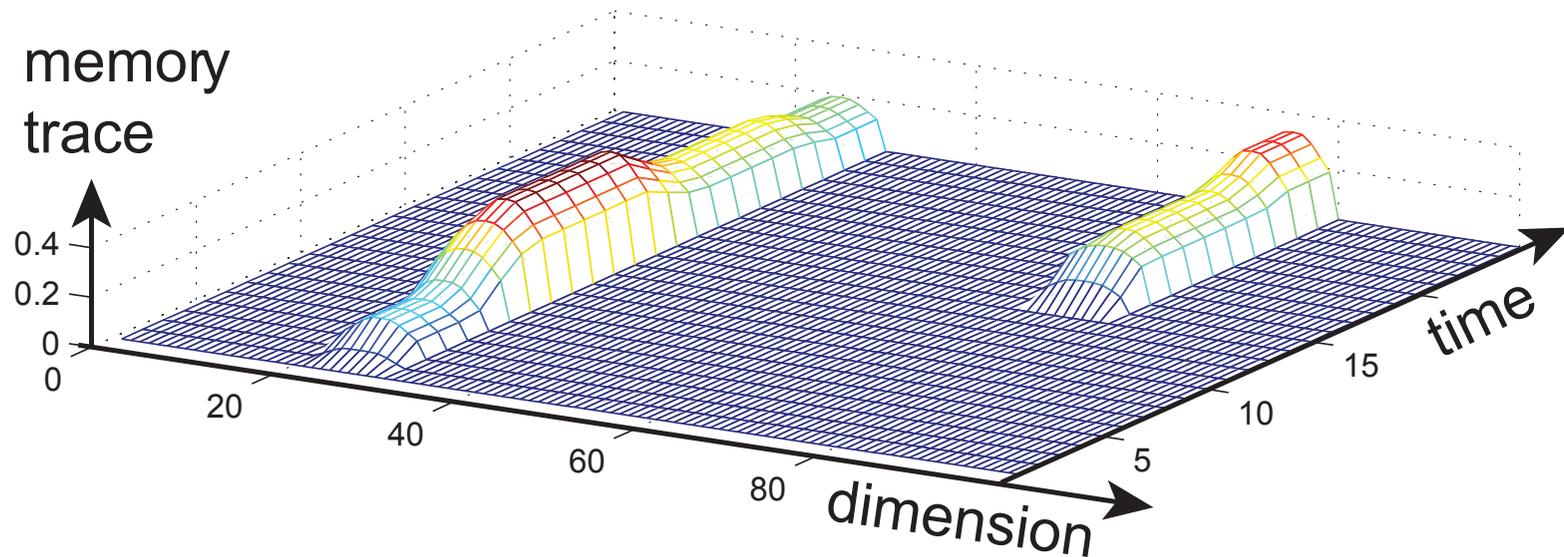
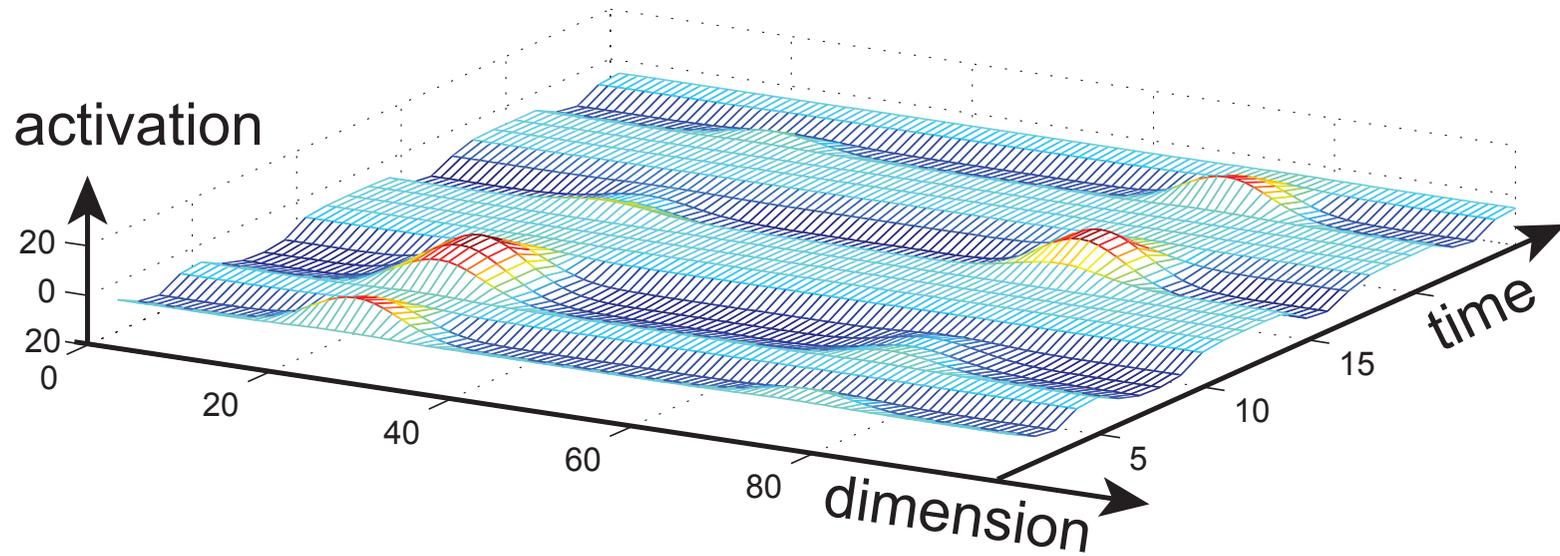
fast activation field



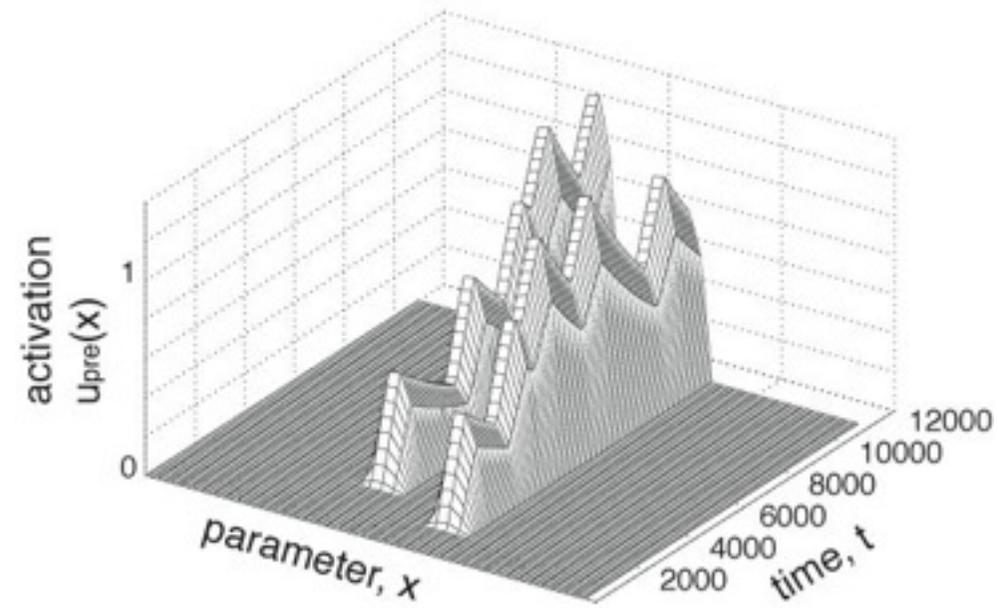
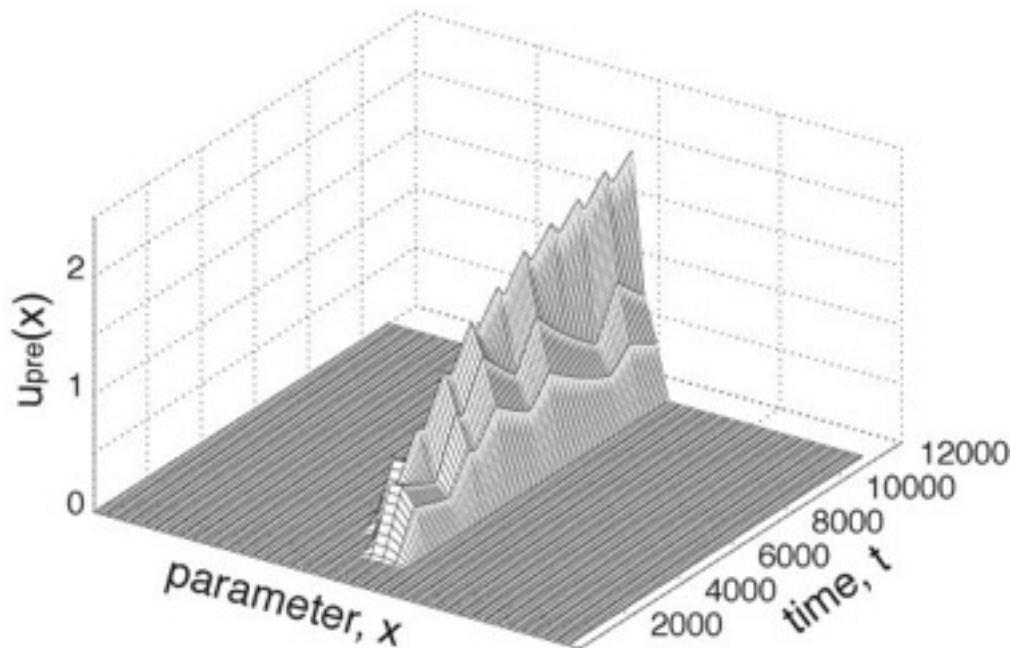
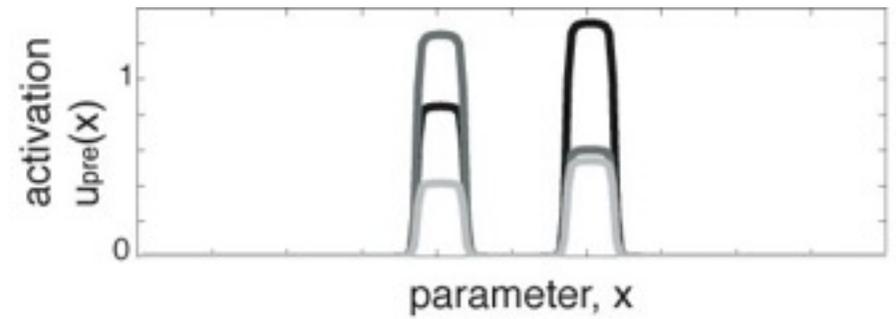
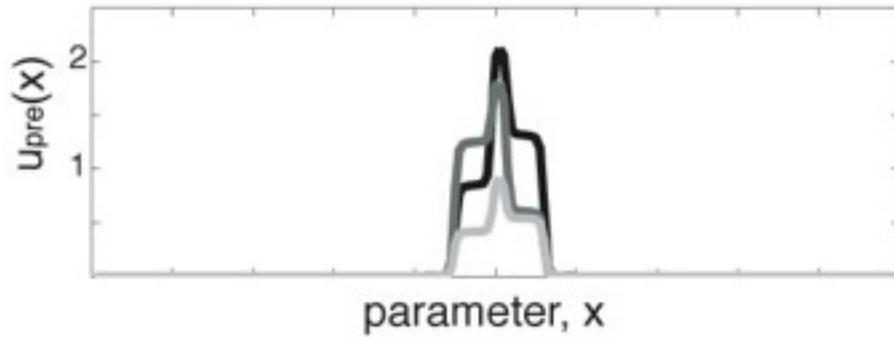
preshapes activation field



memory trace reflects history of decisions formation



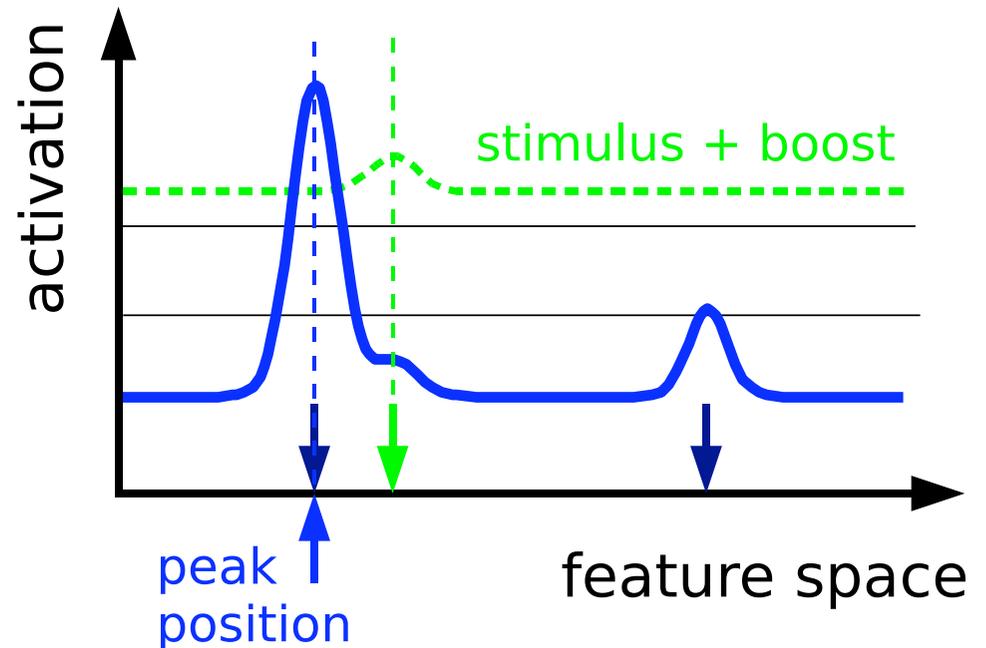
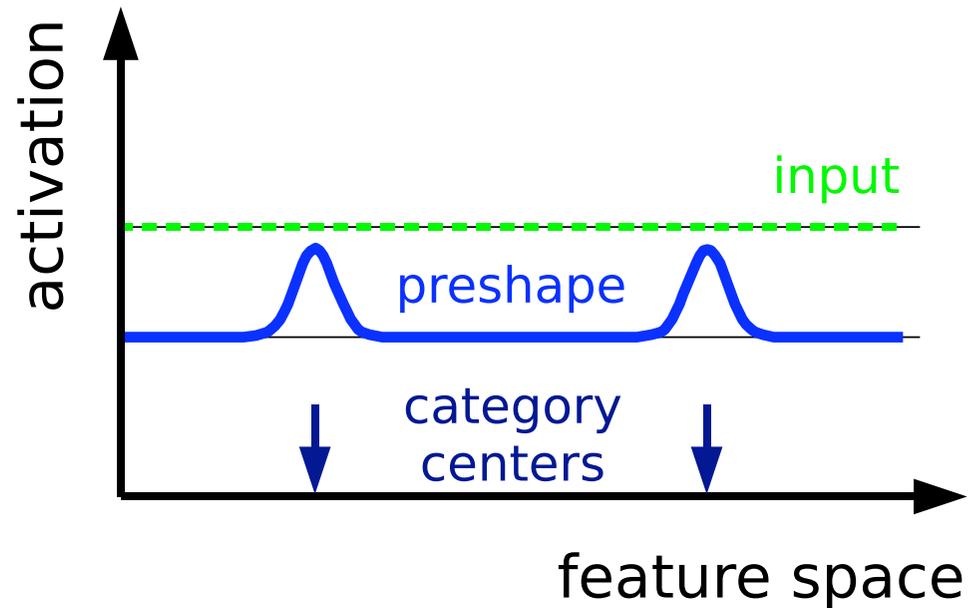
categories may emerge ...



categories emerge ...

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

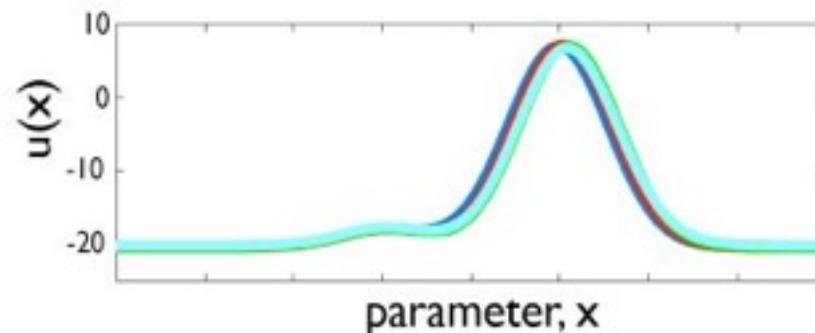
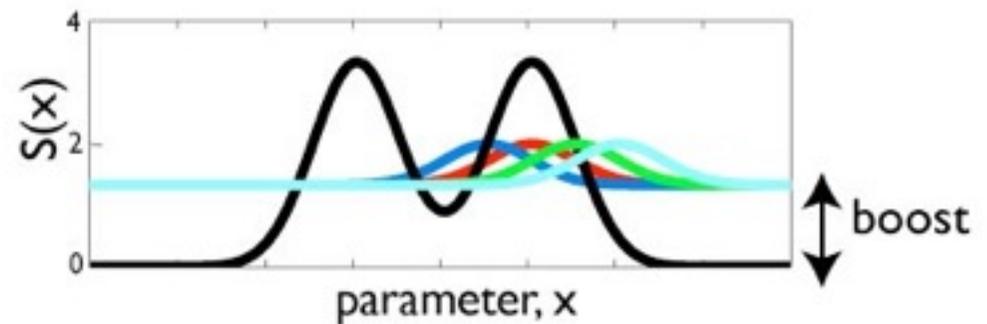
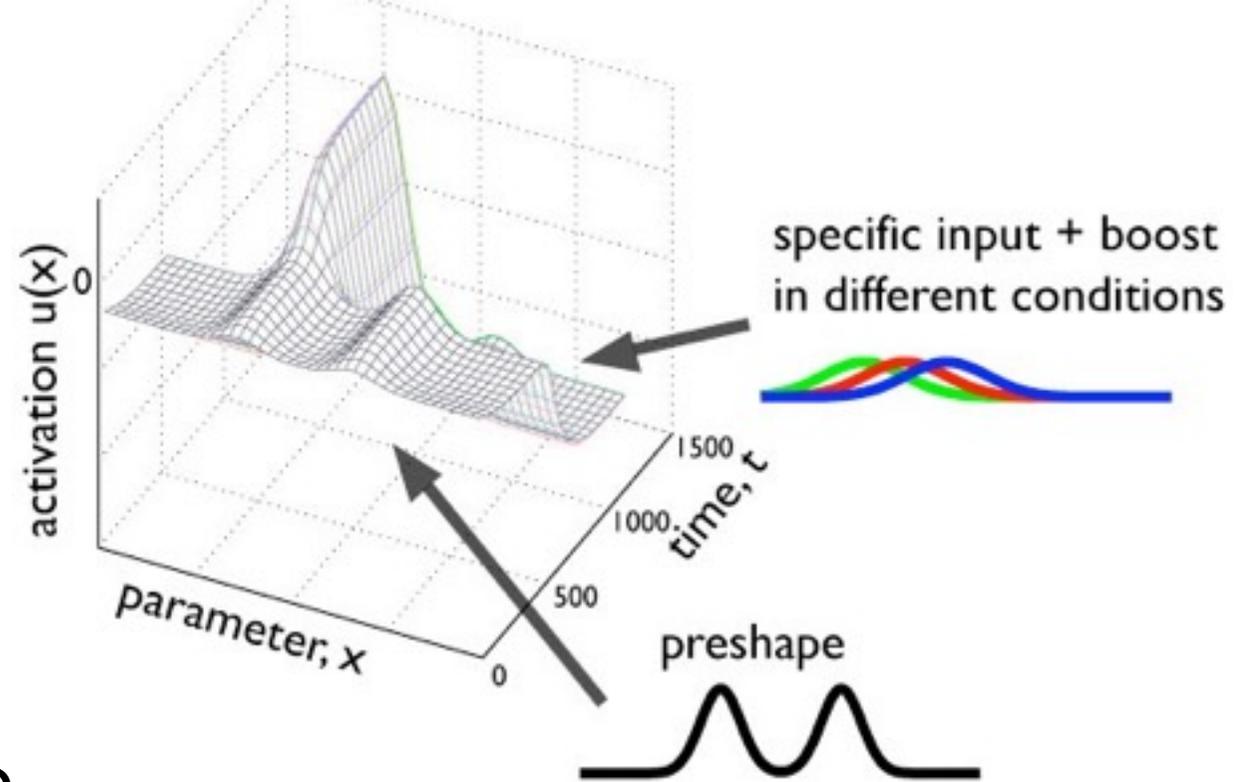
■ => field responds categorically



categories emerge ...

■ based on categorical
memory trace and
boost-driven detectio
instability

■ => field responds
categorically



studying selection decisions in the laboratory

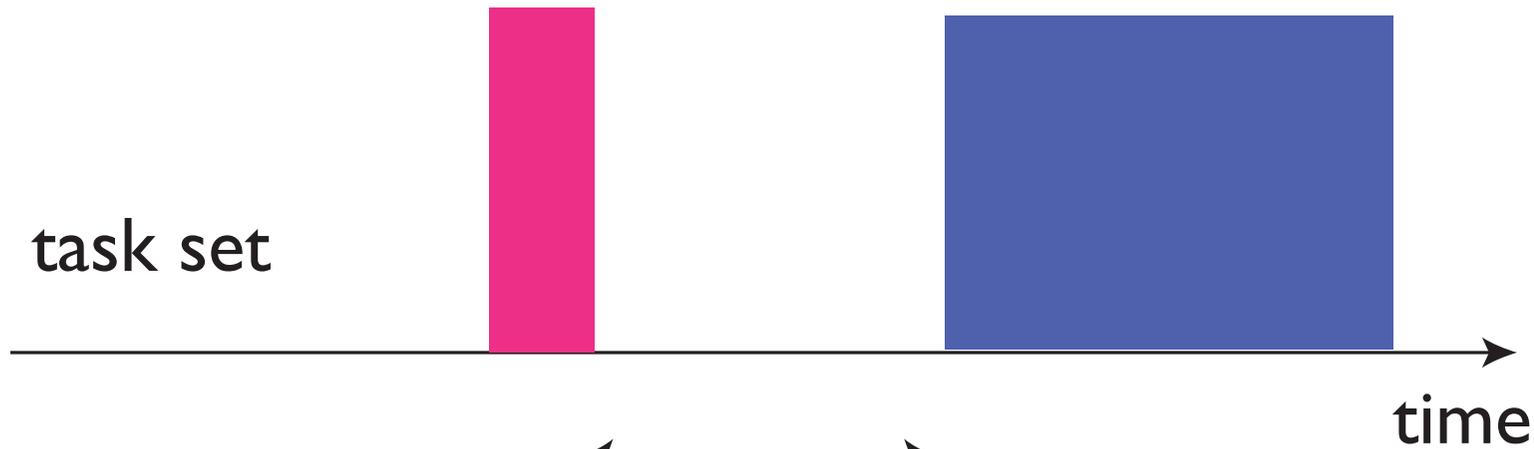
- using an imperative signal...

reaction time (RT) paradigm

imperative
signal=
go signal

response

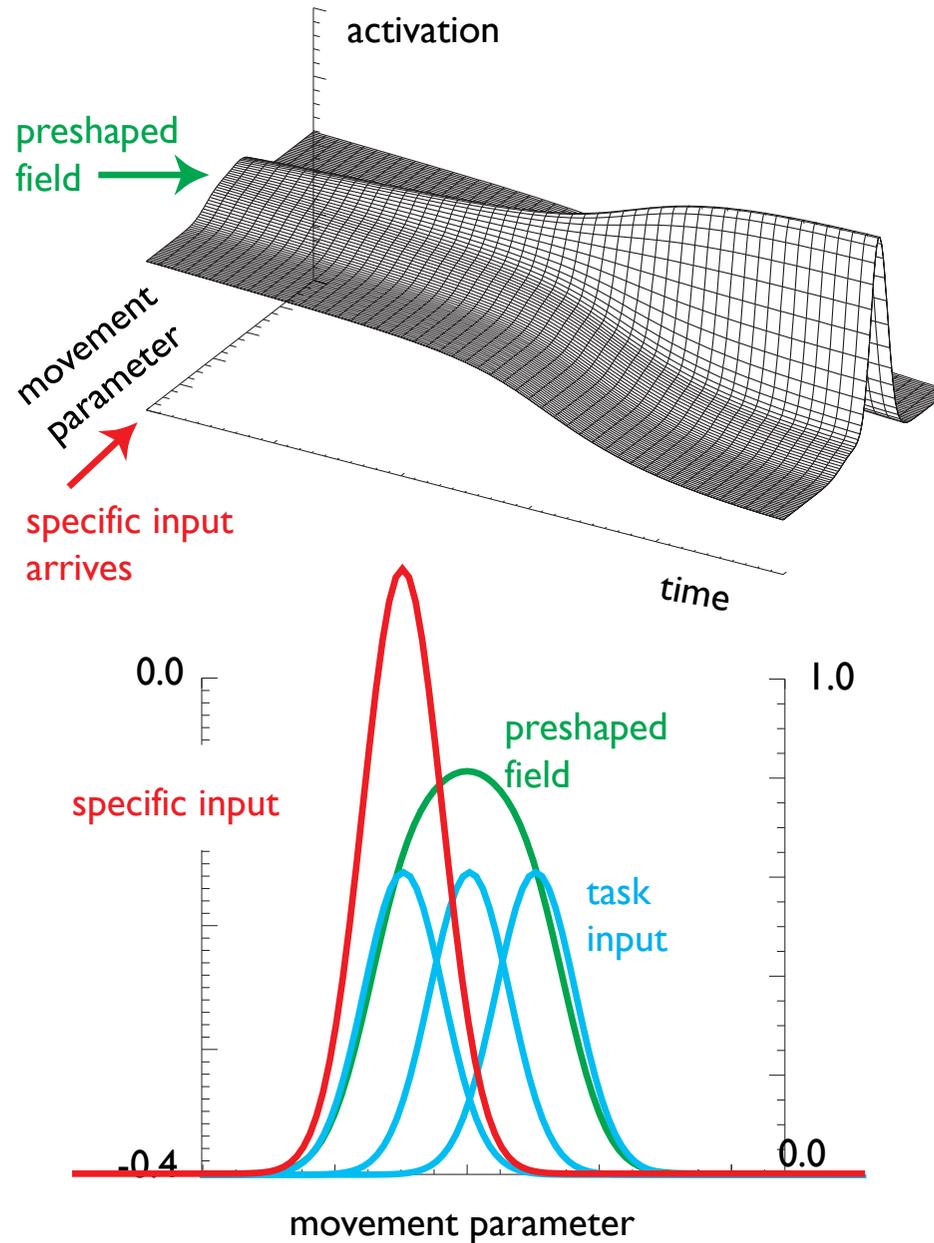
task set



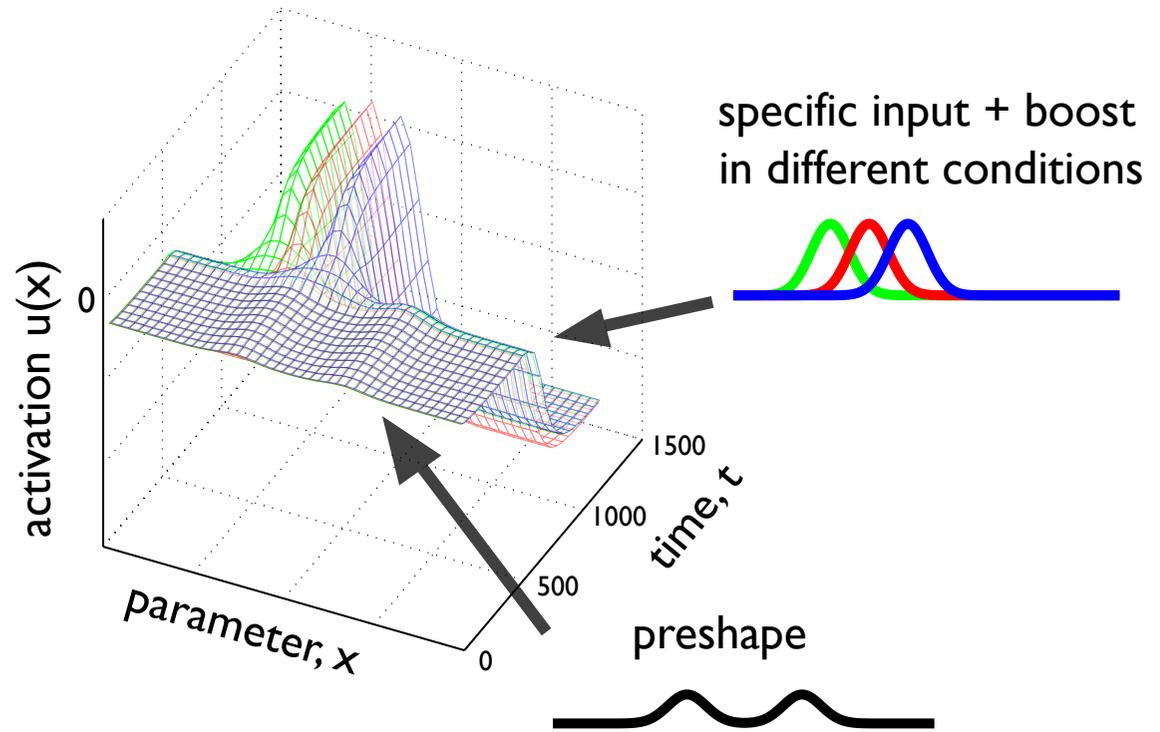
task set

- that is the critical factor in most studies of selection!
 - for example, the classical Hick law, that the number of choices affects RT, is based on the task set specifying a number of choices
- (although the form in which the imperative signal is given is varied as well...)
- how do neuronal representations reflect the task set?

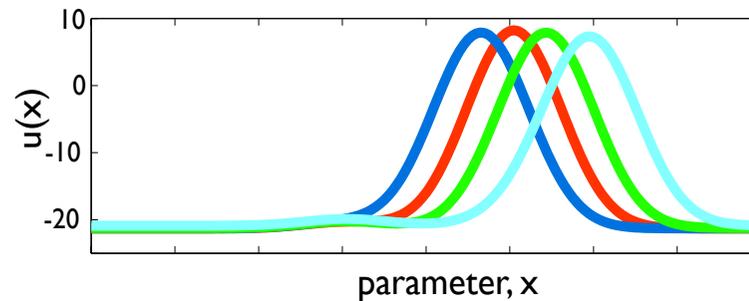
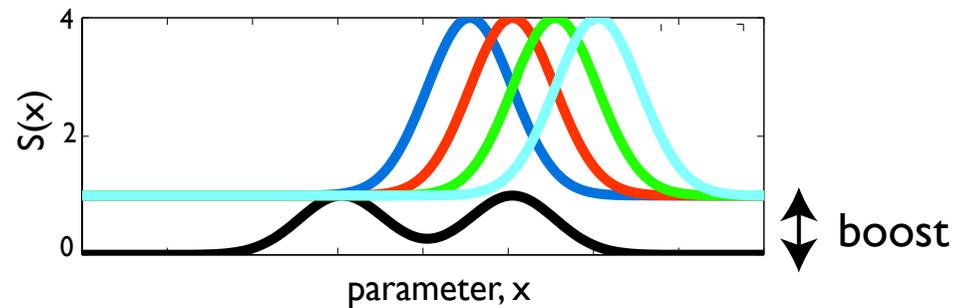
notion of preshape



weak preshape in selection

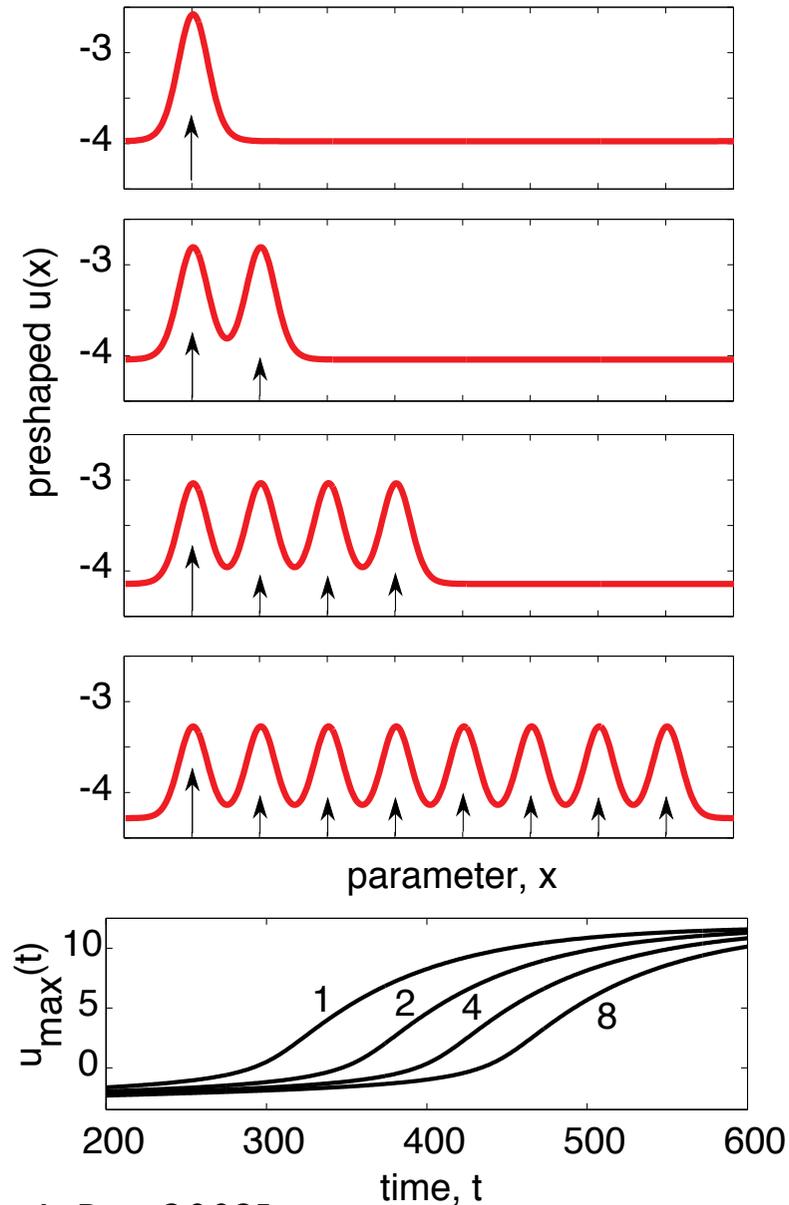
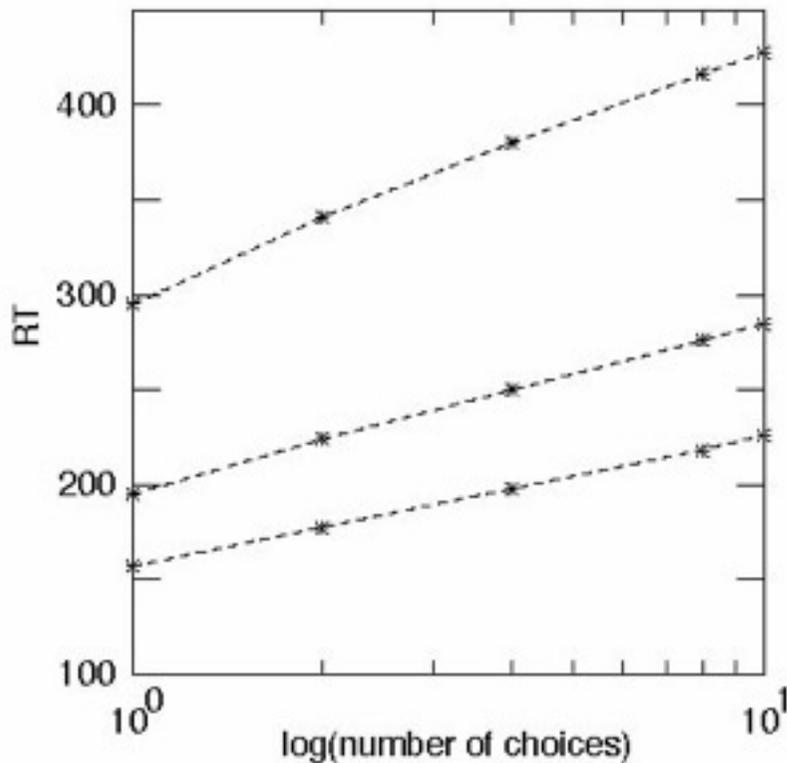


- specific (imperative) input dominates and drives detection instability



using preshape to account for classical RT data

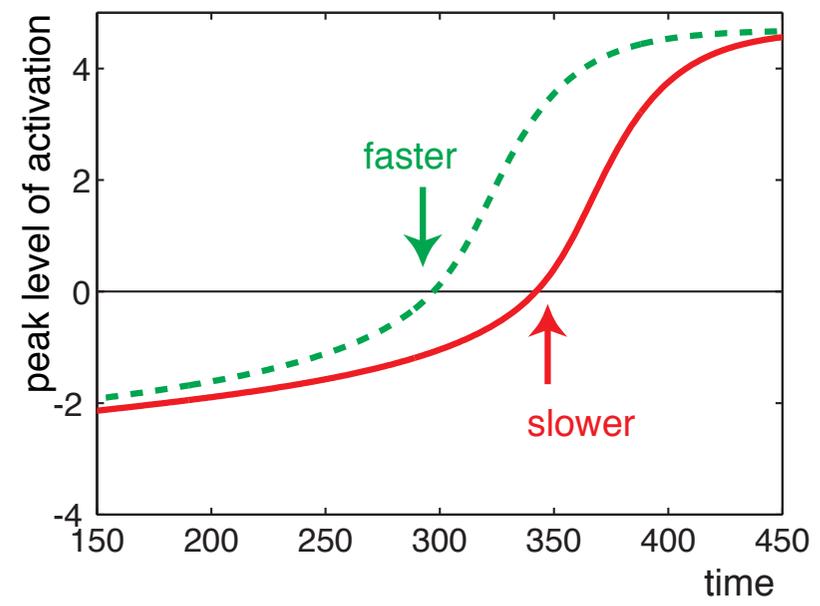
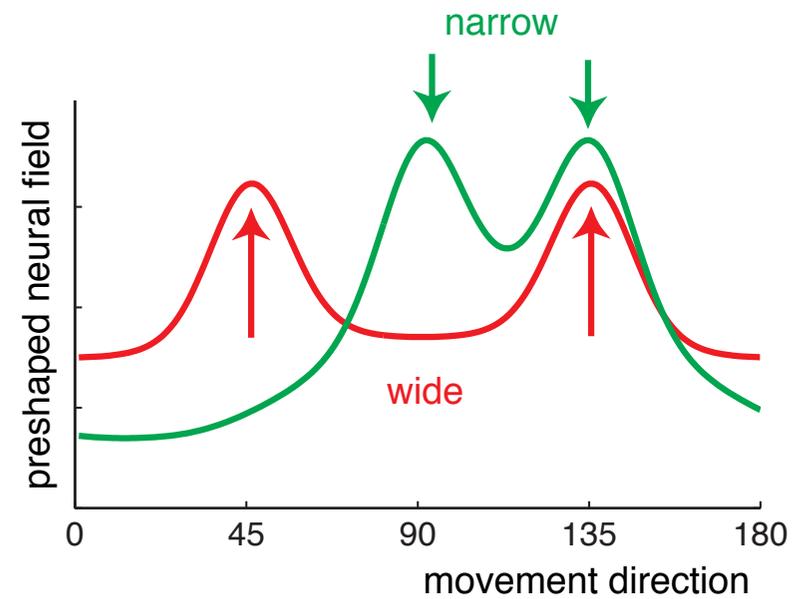
- Hick's law: RT increases with the number of choices



[Erlhagen, Schöner, Psych Rev 2002]

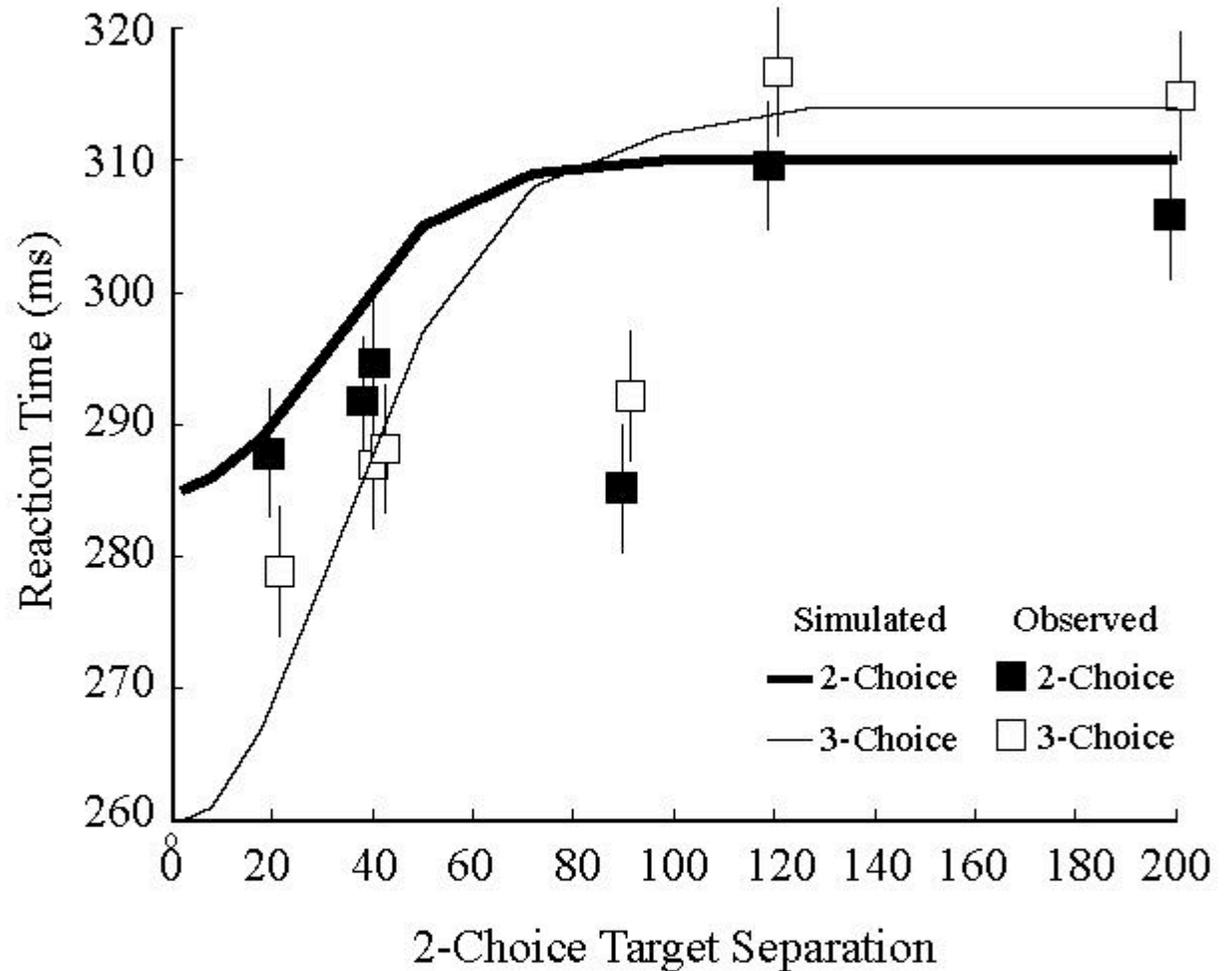
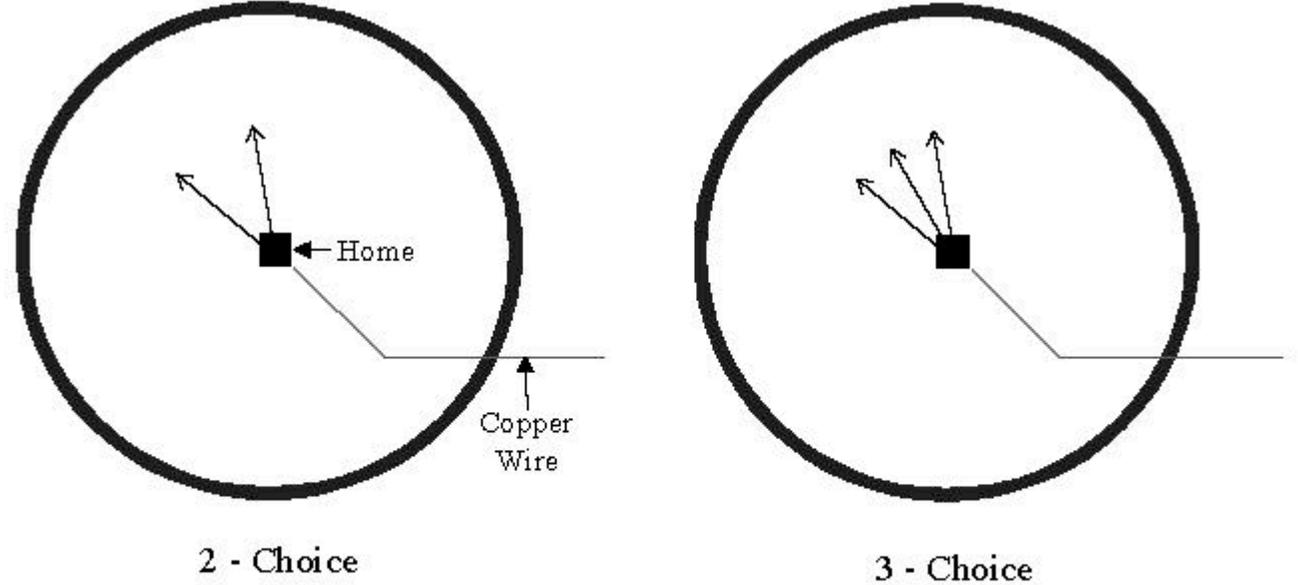
metric effect

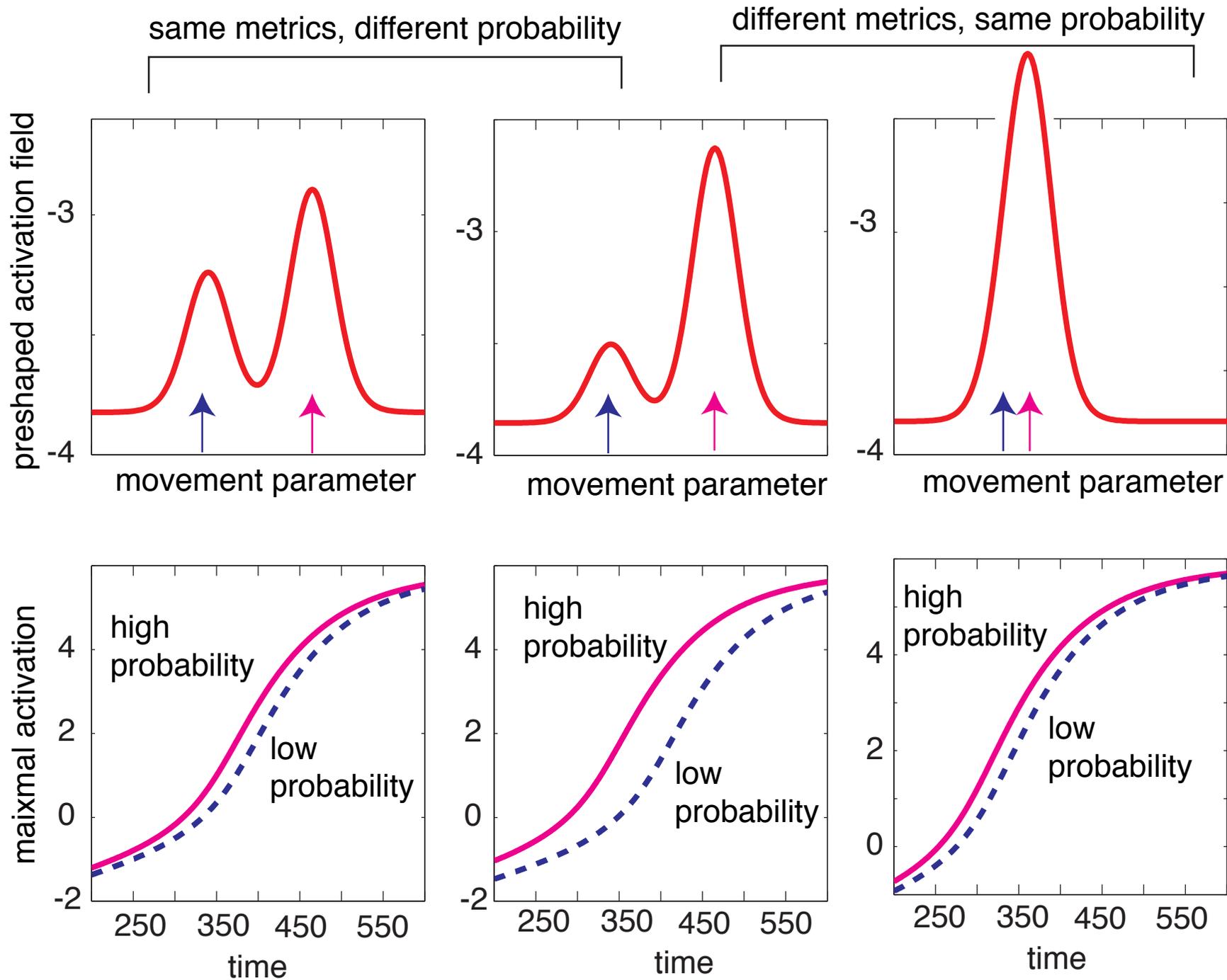
- predict faster response times for metrically close than for metrically far choices



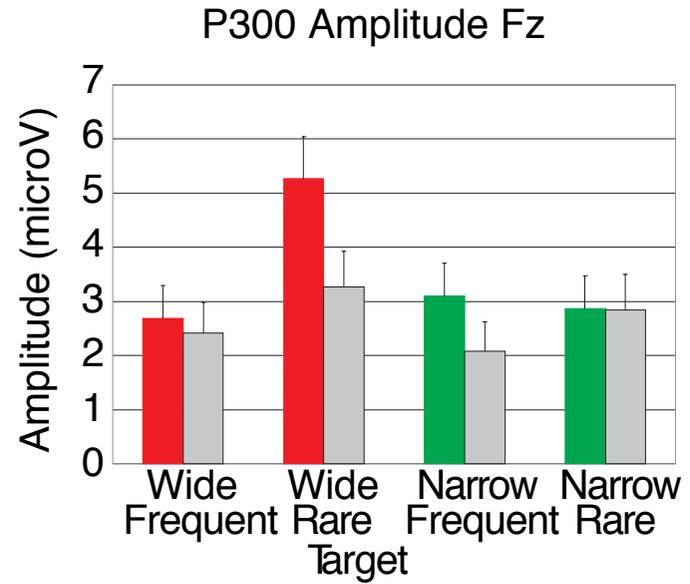
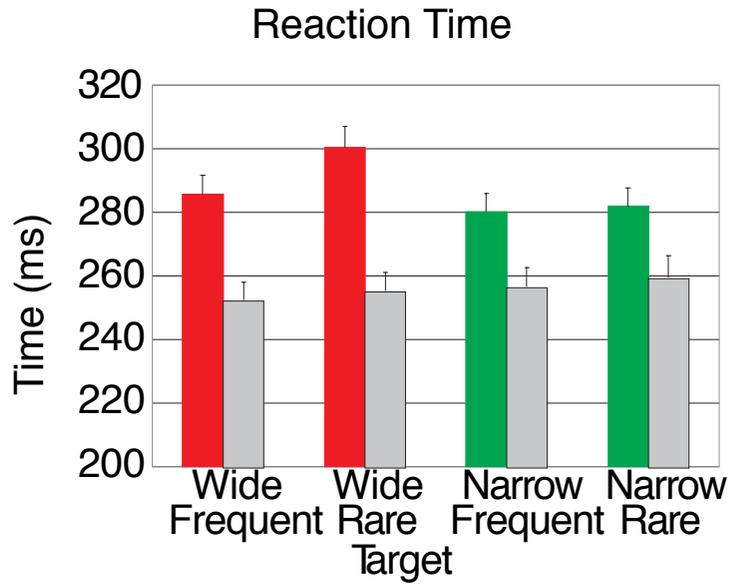
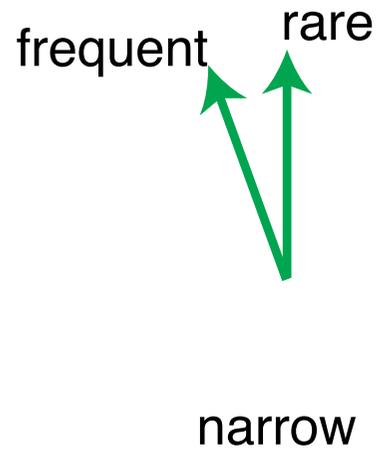
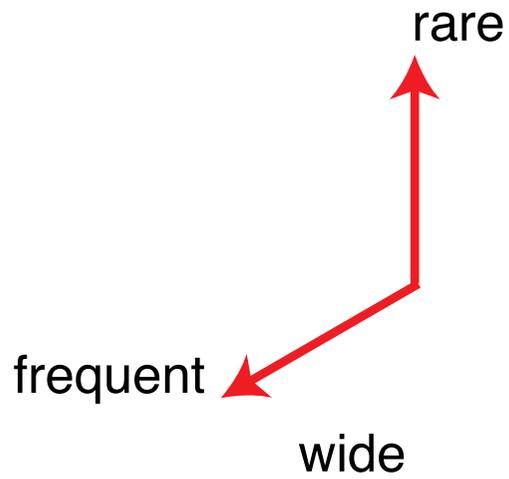
[from Schöner, Kopecz, Erlhagen, 1997]

experiment: metric effect



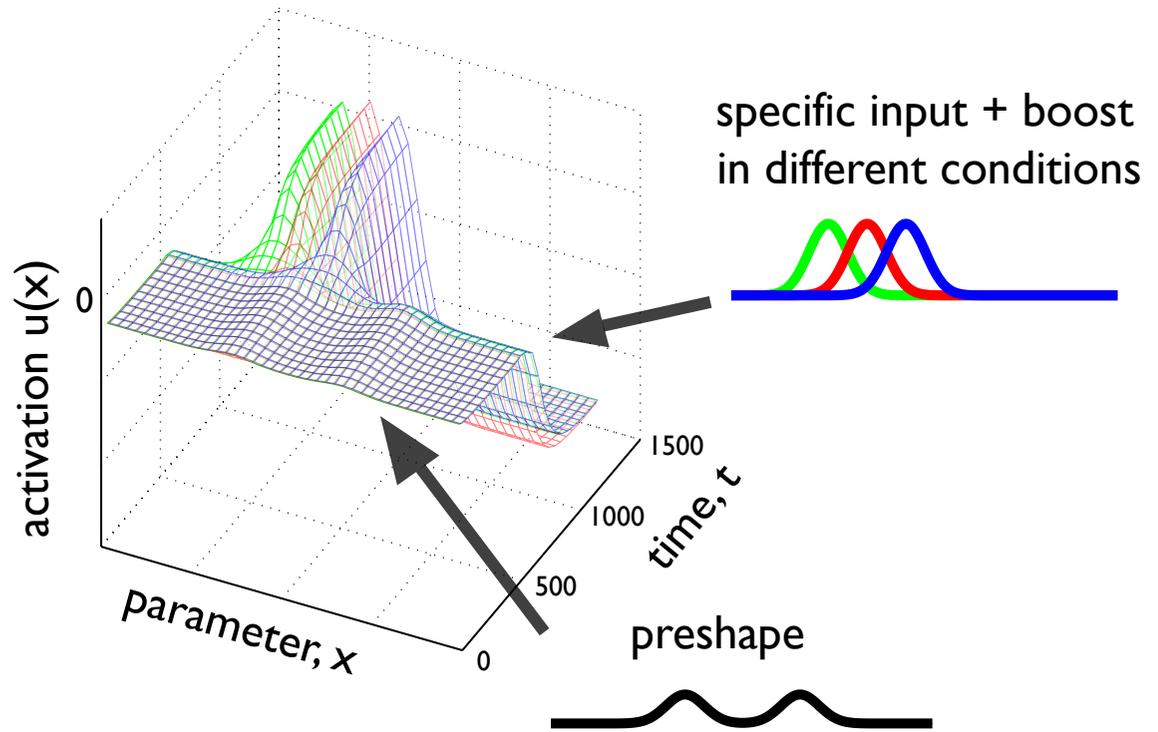


[from Erlhagen, Schöner: Psych. Rev. 2002]

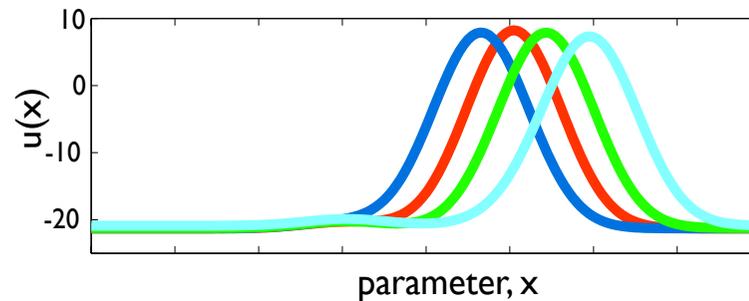
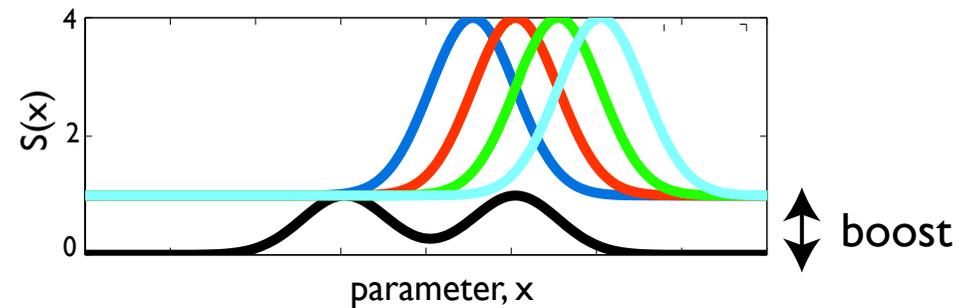


[from McDowell, Jeka, Schöner, Hatfield, 2002]

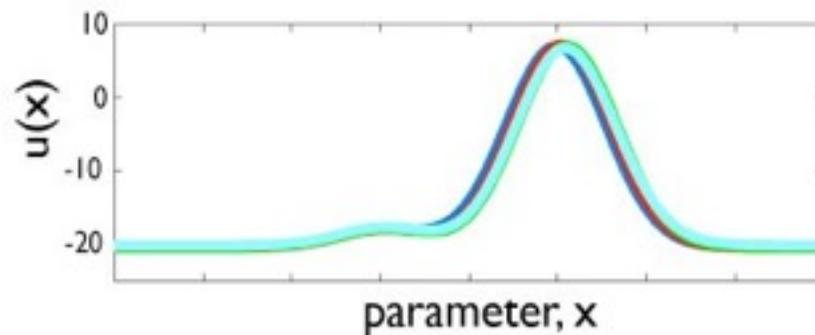
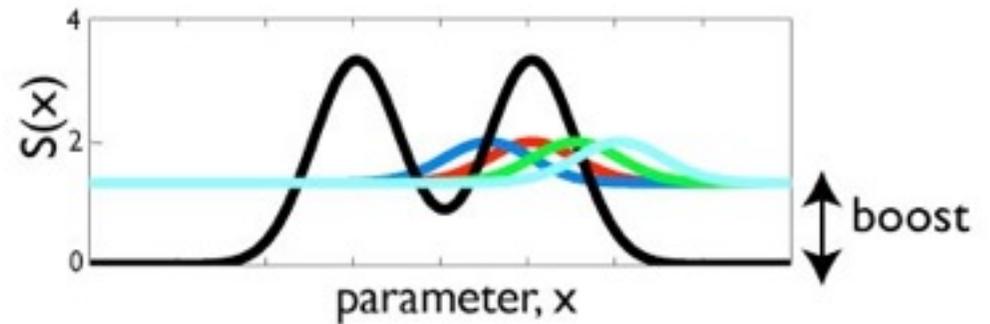
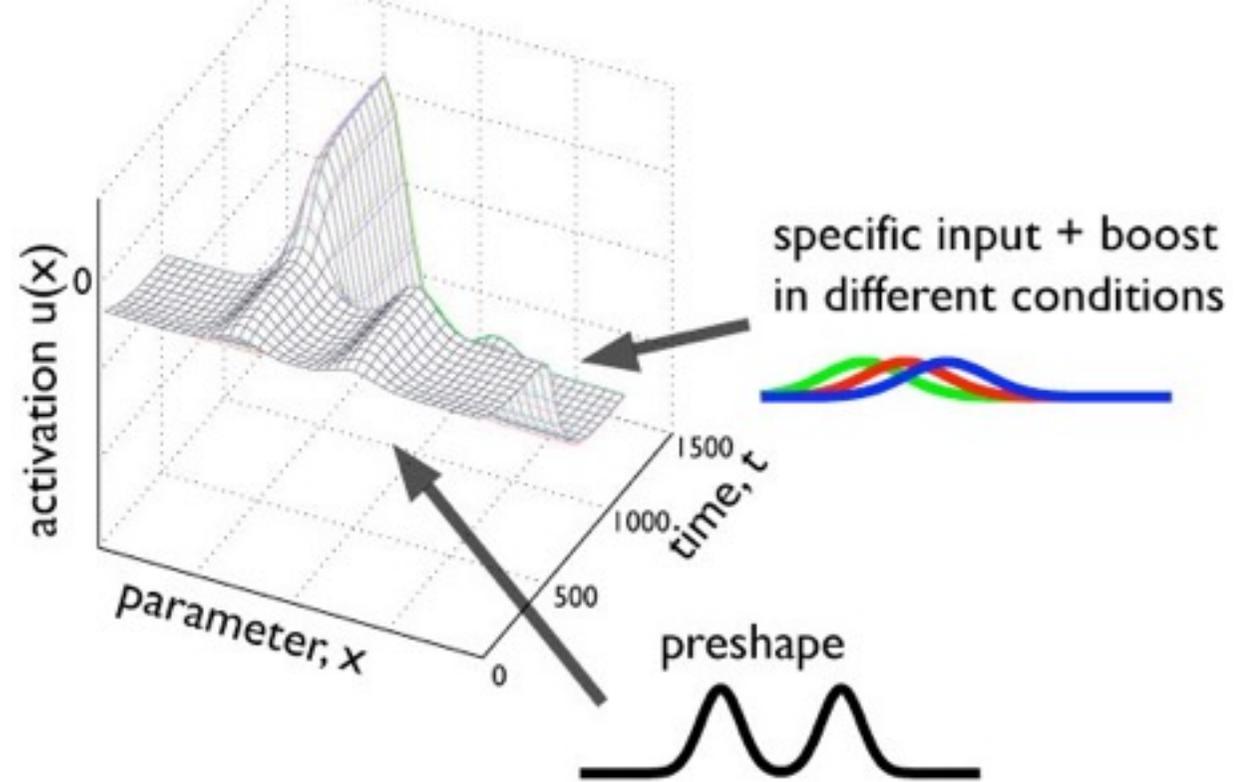
weak preshape in selection



- specific (imperative) input dominates and drives detection instability



strong
preshape
dominates
selection



[Wilimzig, Schöner, 2006]

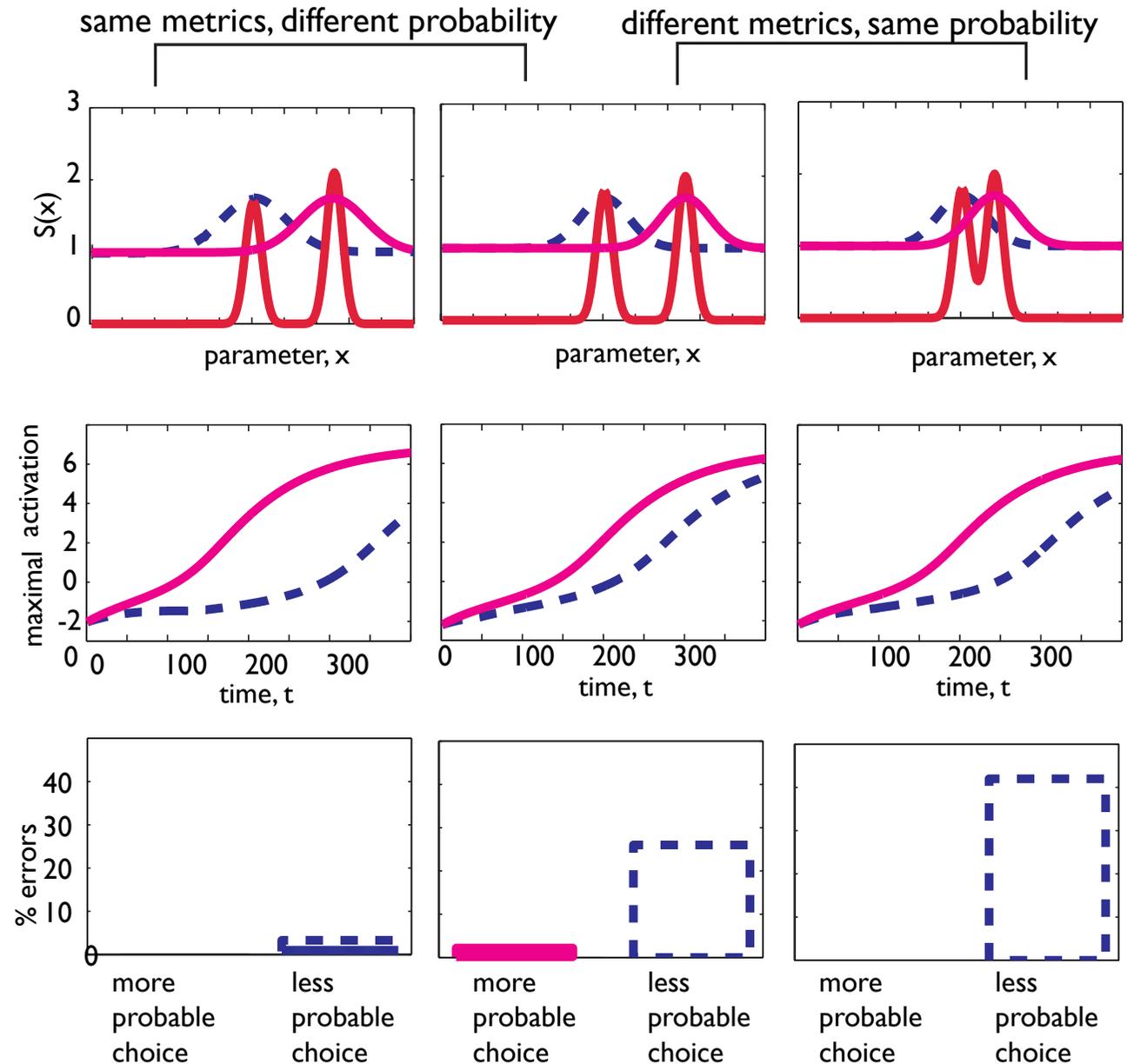
distance effect

- common in categorical tasks

- e.g., decide which of two sticks is longer... RT is larger when sticks are more similar in length

interaction metrics-probability

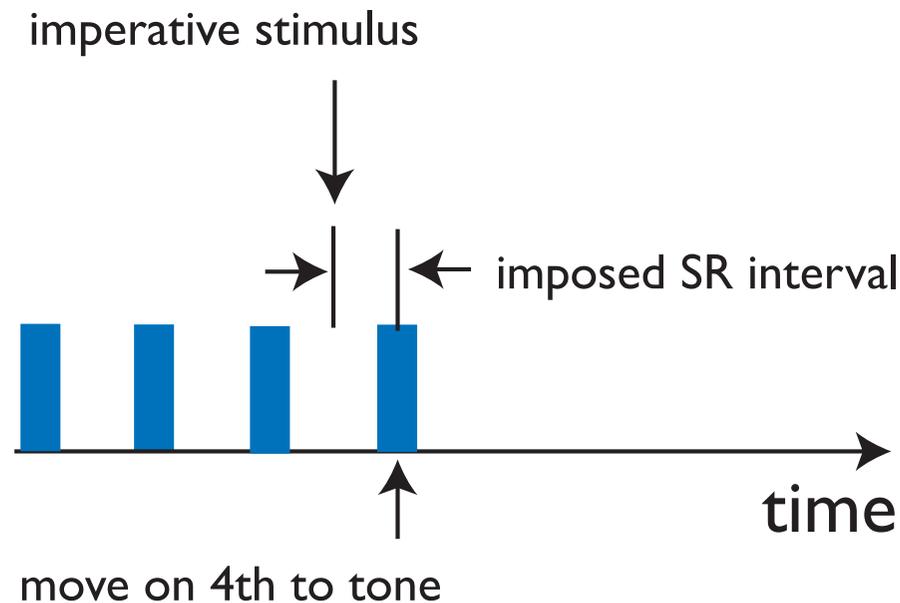
- opposite to that predicted for input-driven detection instabilities:
- metrically close choices show larger effect of probability



Behavioral evidence for preshape

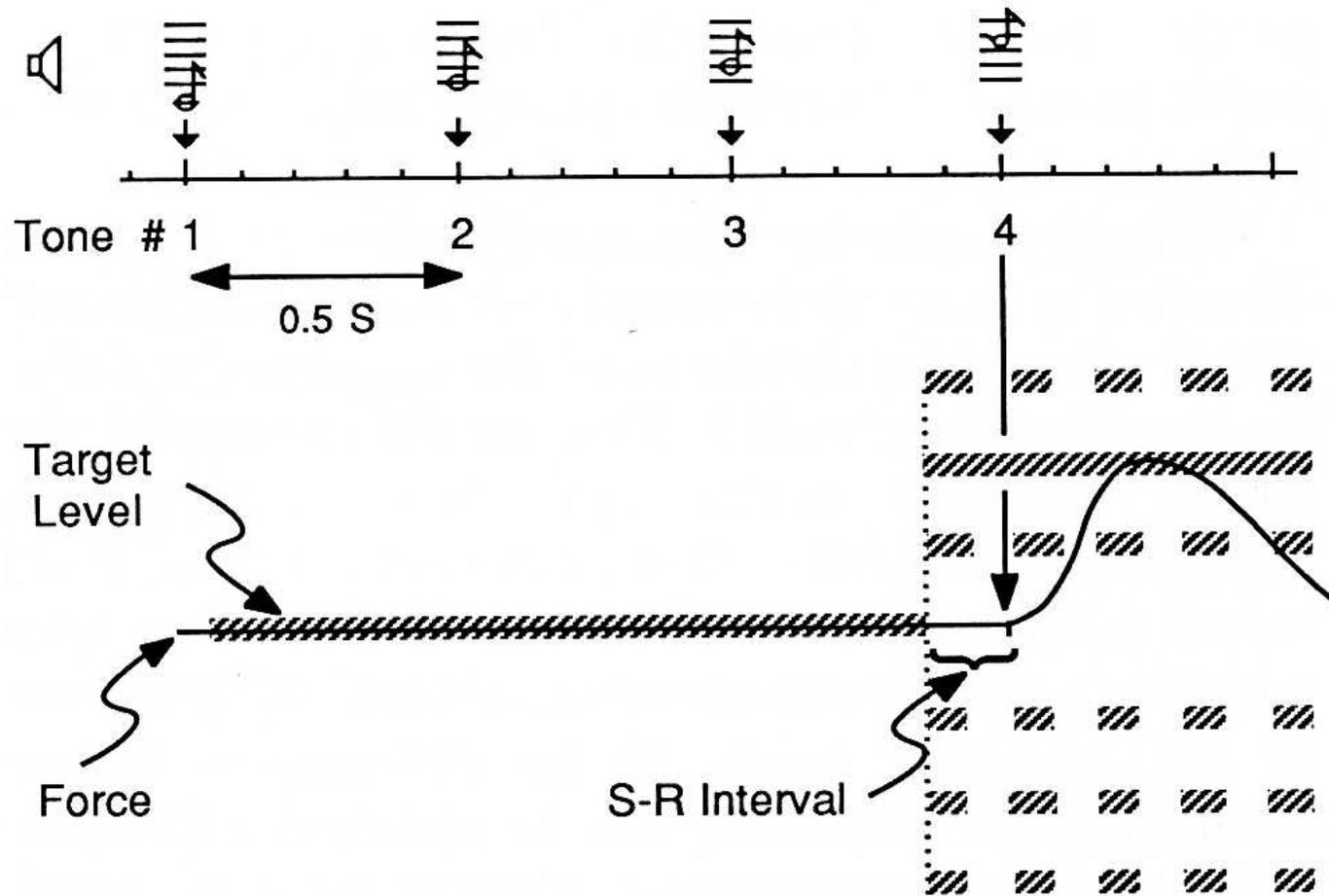
- movement preparation is graded and continuous in time starting out from preshaped representations

timed movement initiation paradigm



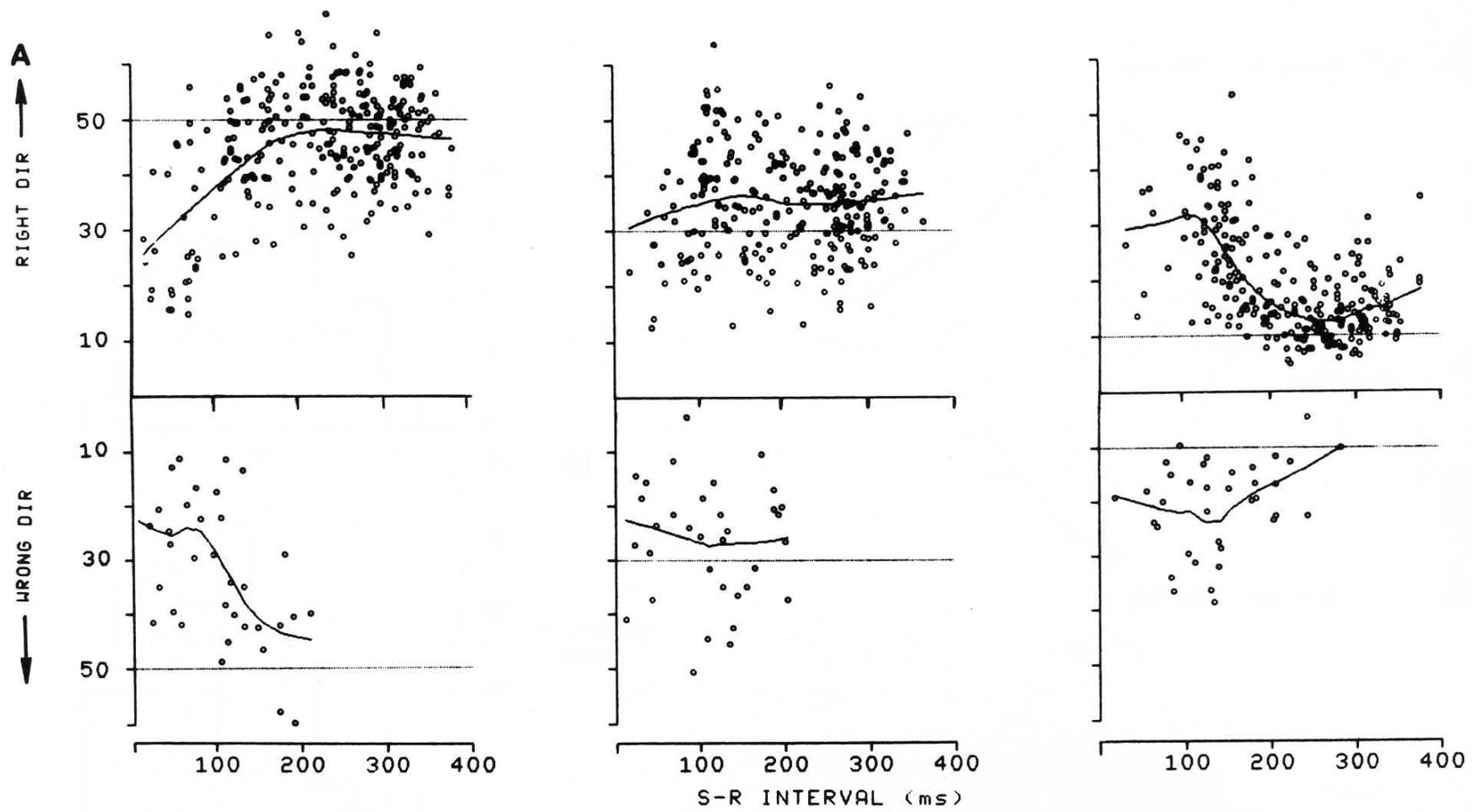
[Ghez and colleagues, 1988 to 1990's]

Behavioral evidence for preshape

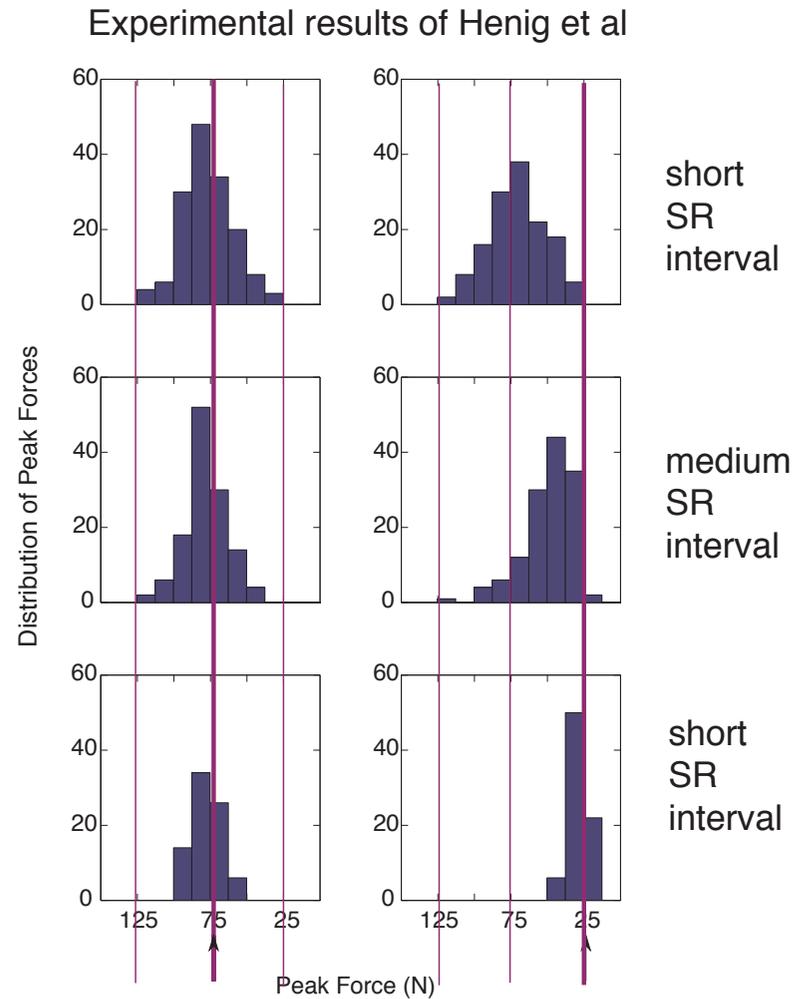


[Favilla et al. 1989]

1



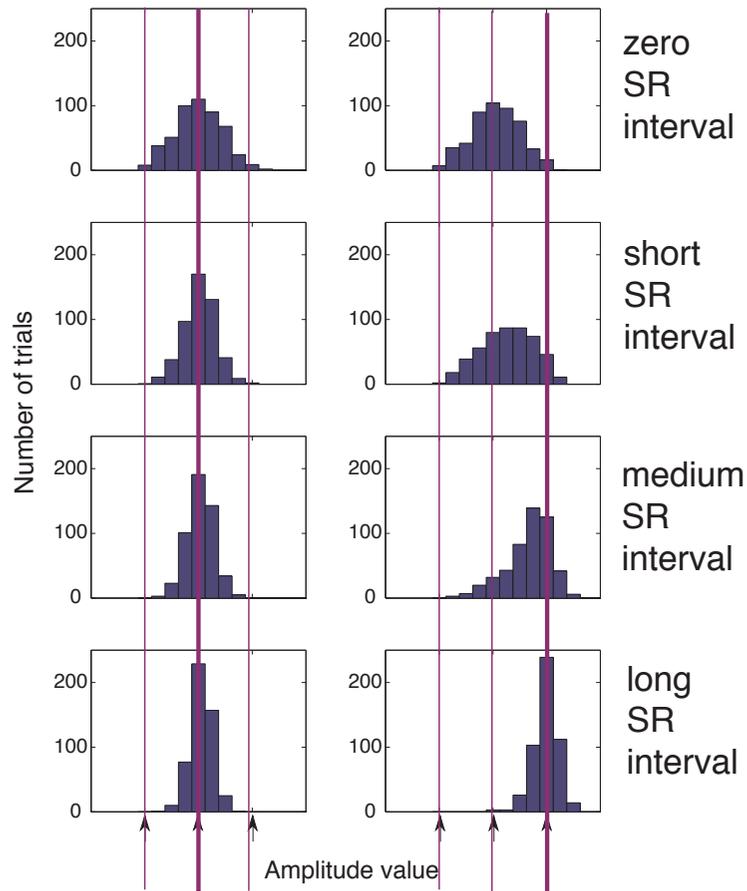
Behavioral evidence for preshape



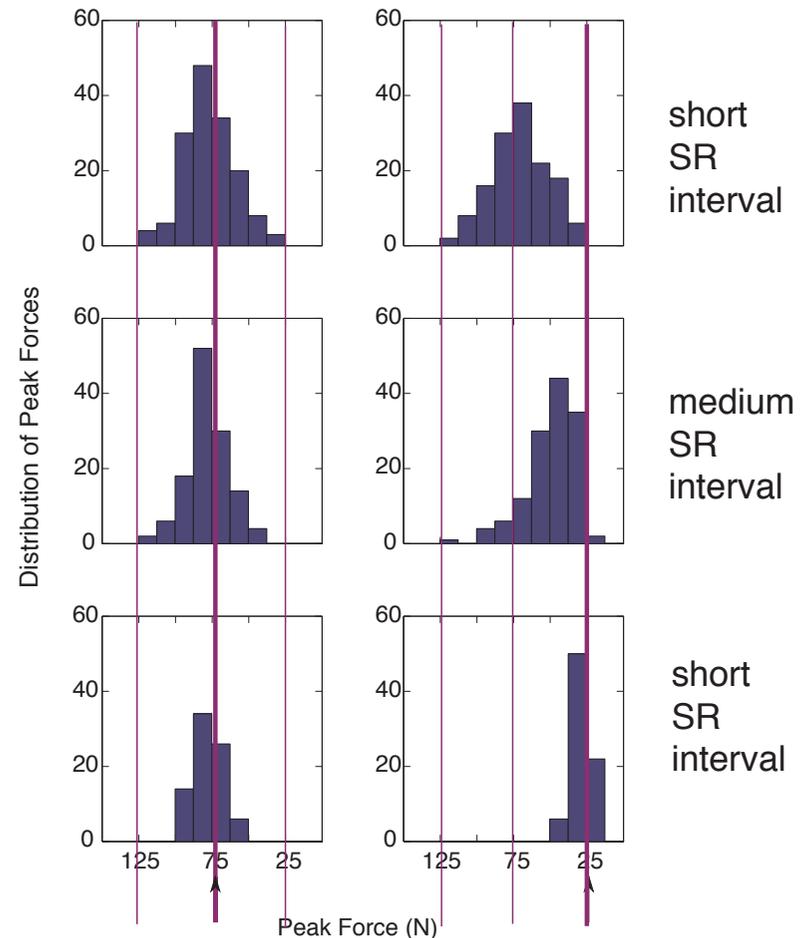
Dynamic Field Theory (DFT)

■ theoretical account: movement parameters are represented in dynamic neural activation fields

theoretical account for Henig et al.

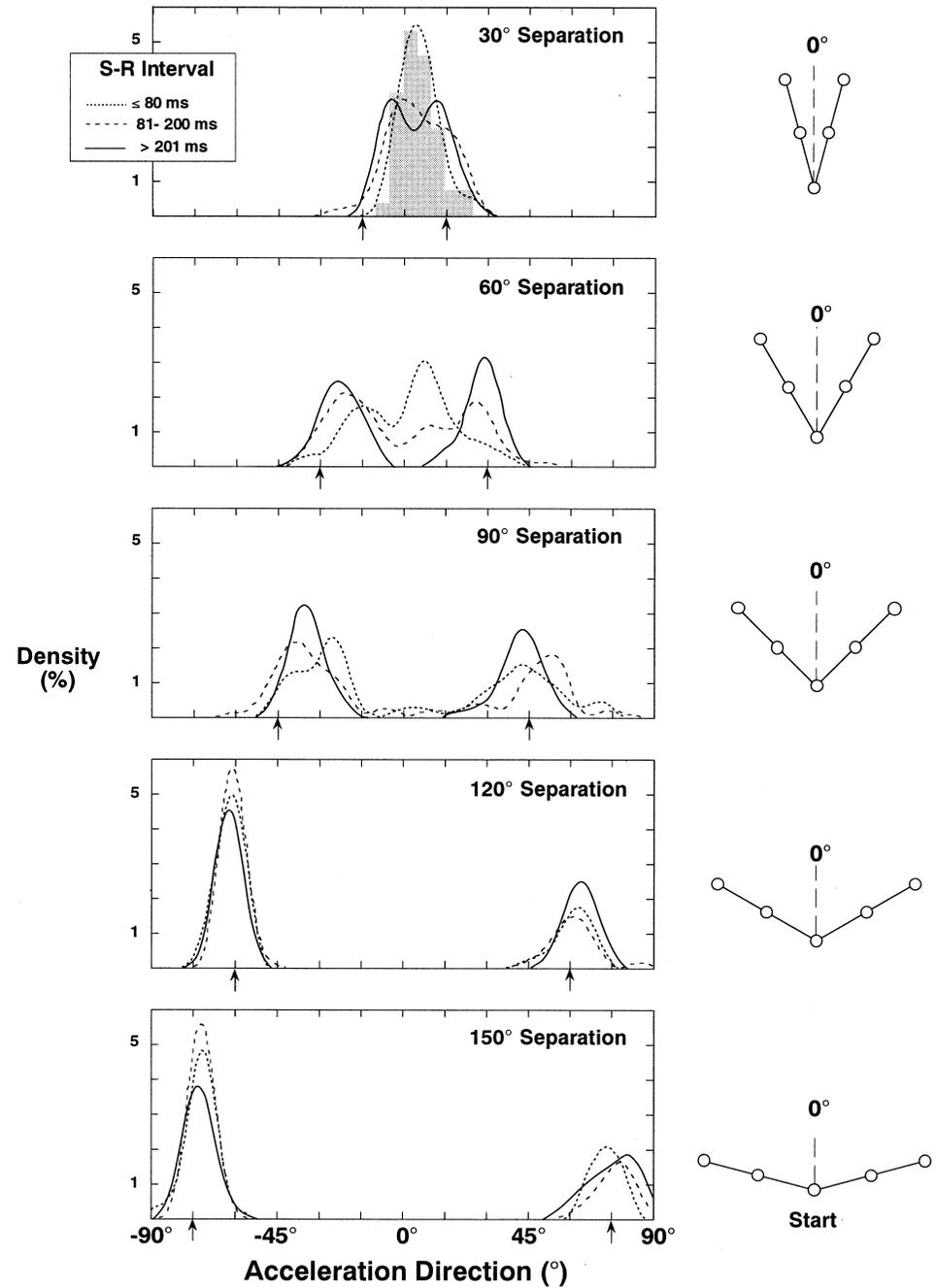


Experimental results of Henig et al



behavioral evidence for preshape

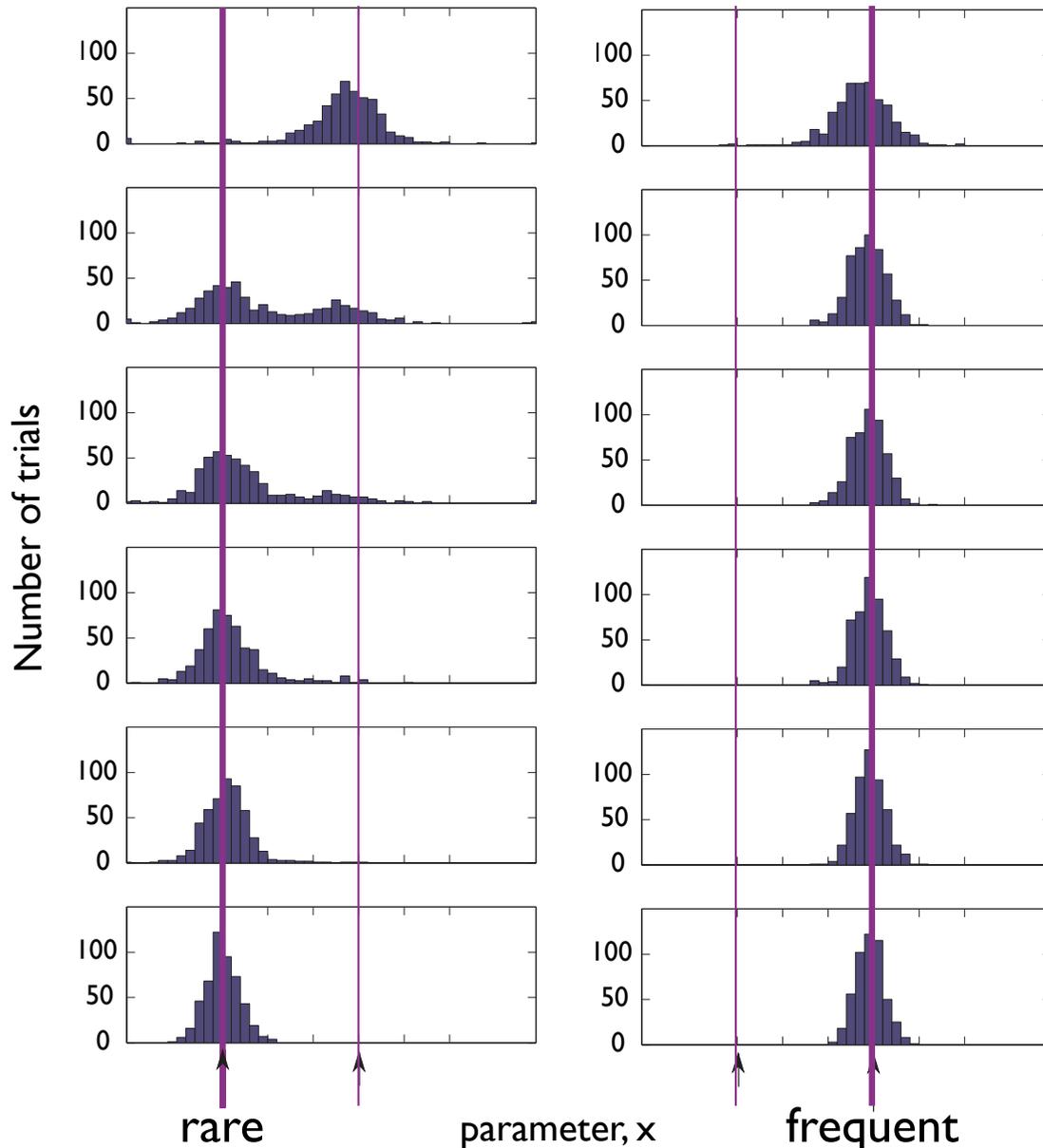
■ infer width of preshape peaks in field



[Ghez et al 1997]

behavioral evidence for preshape

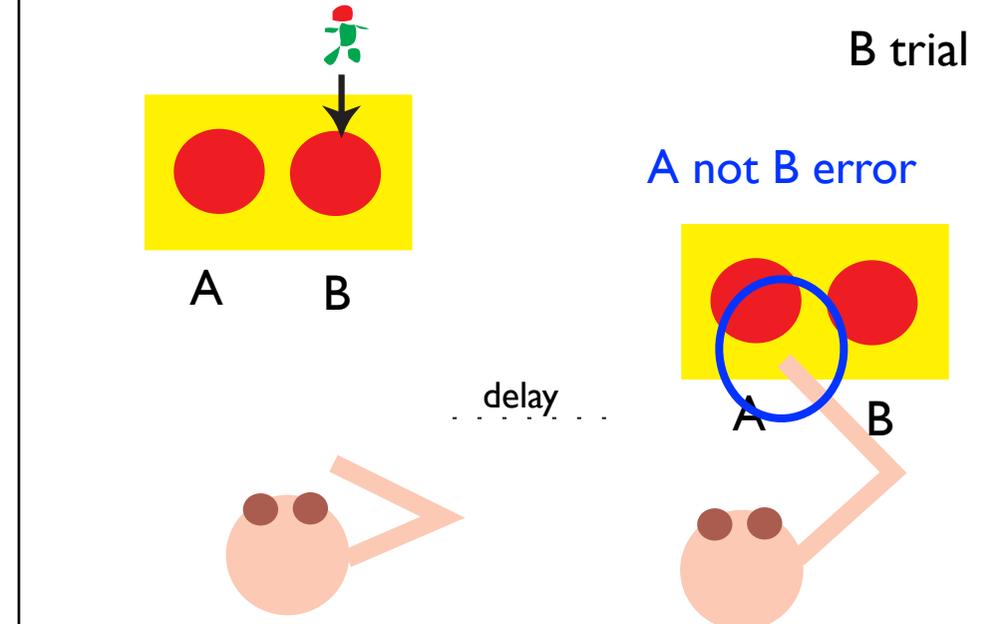
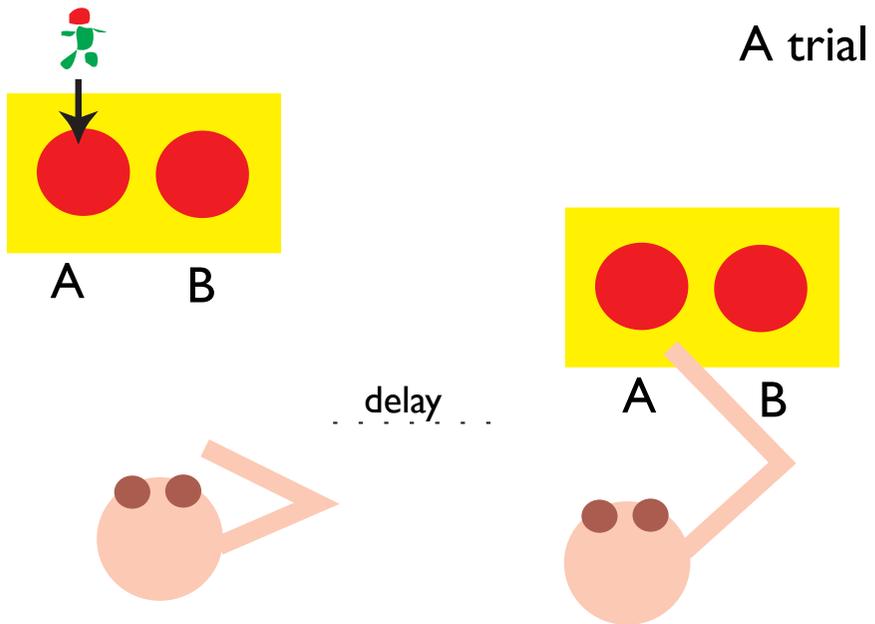
probability in timed movement initiation
rare frequent



short SR interval:
observe preshape

long SR interval:
observe stimulus-defined
movement plan

Piaget's A not B paradigm: "out-of-sight -- out of mind"

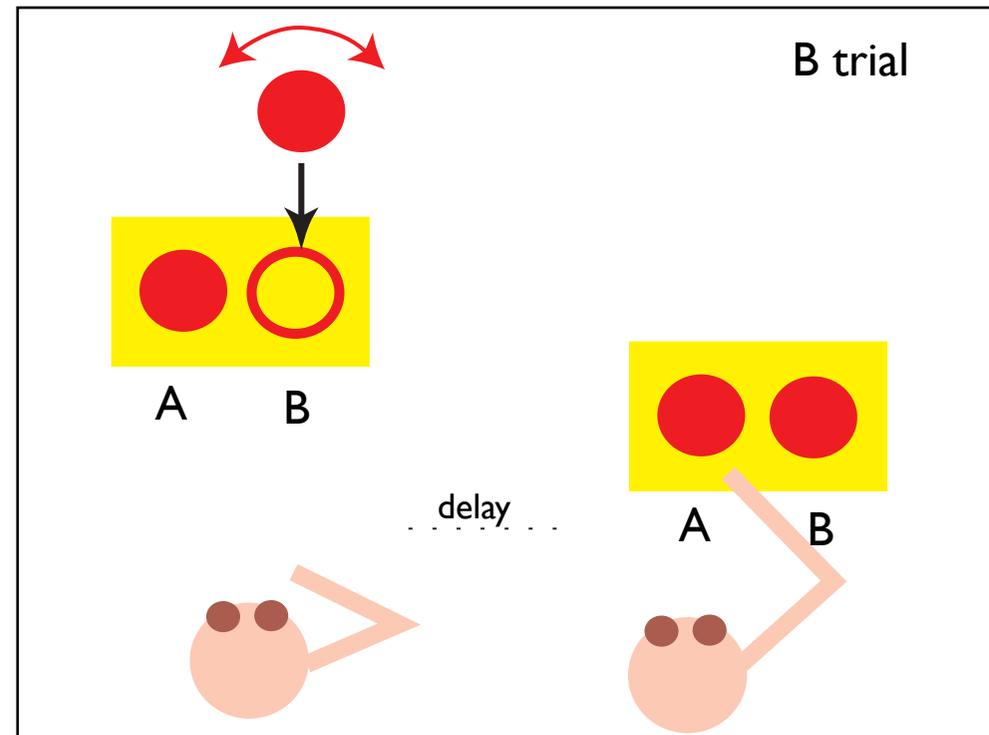
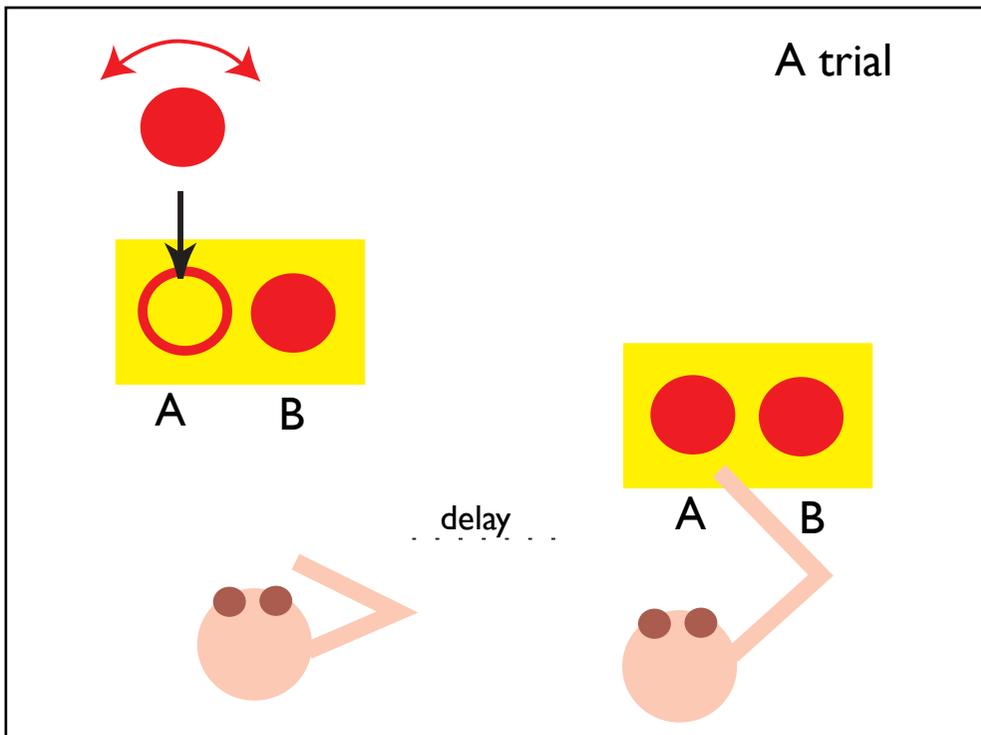


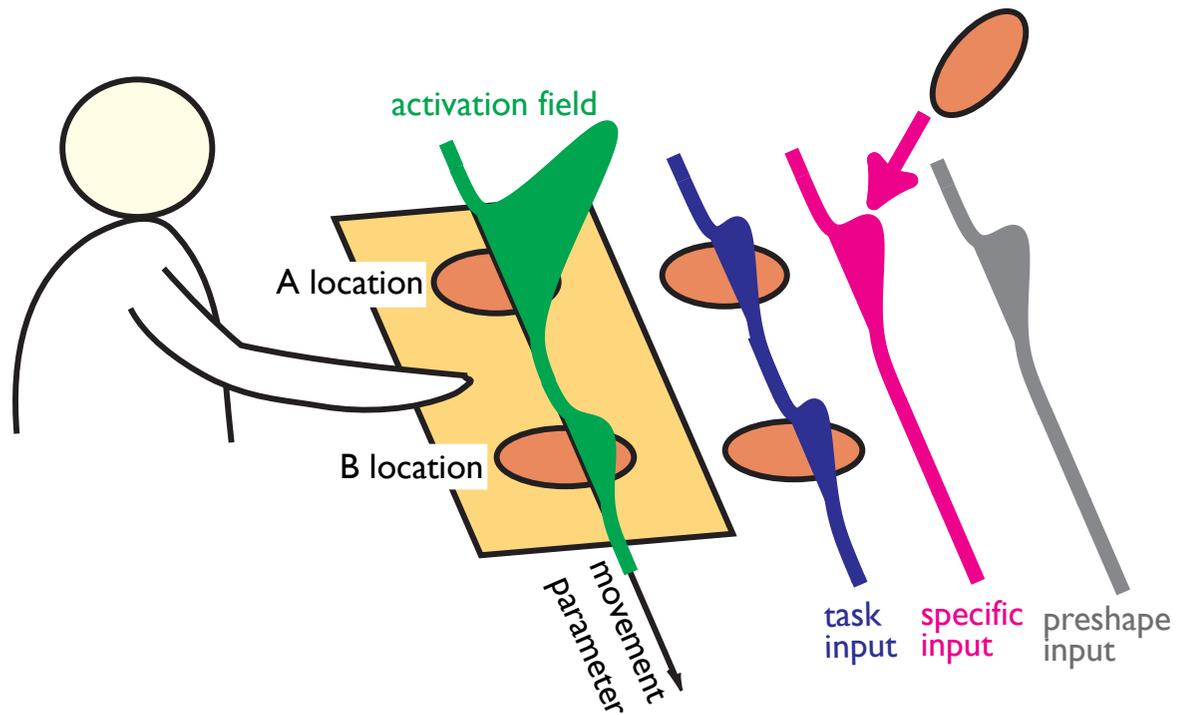
Toyleless variant of A not B task



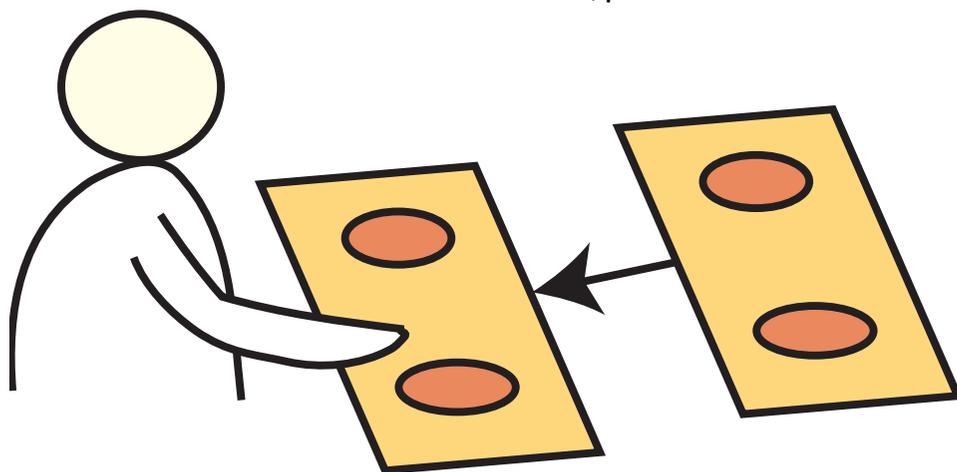
[Smith, Thelen et al.: Psychological Review (1999)]

Toyleless variant of A not B task reveals that A not B is essentially a decision task!





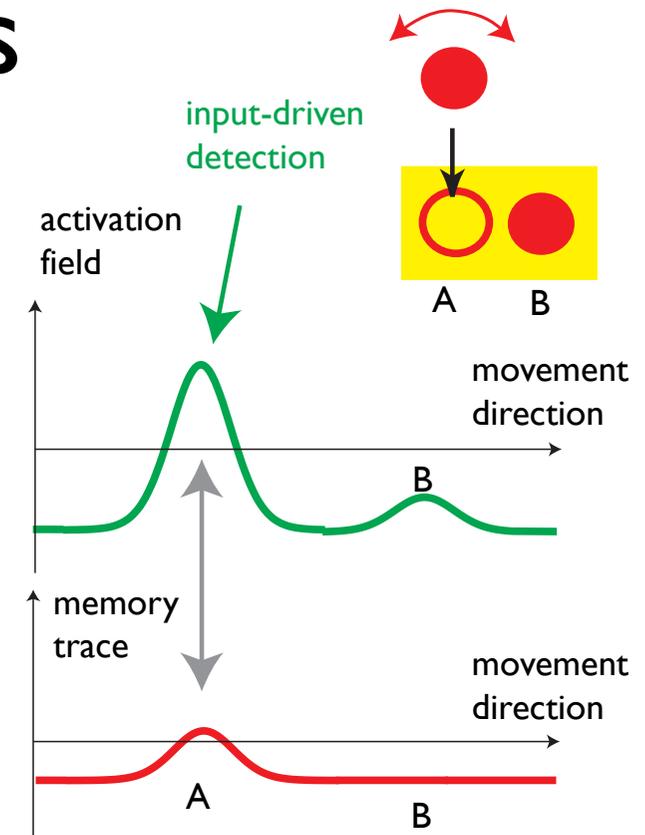
[Thelen, et al., BBS (2001)]



[Dinveva, Schöner, Dev. Science 2007]

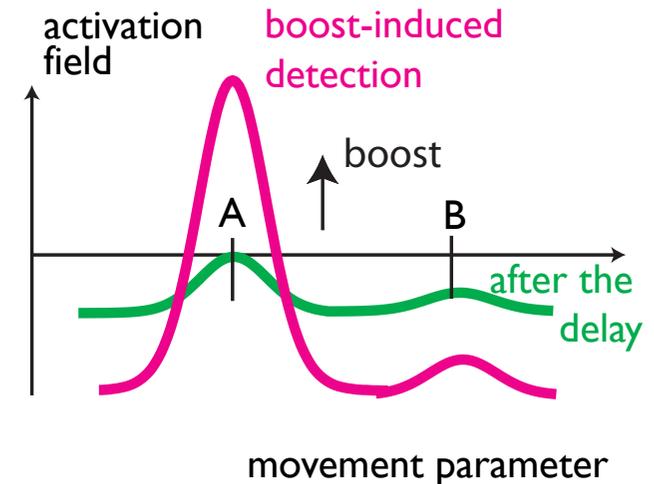
Instabilities

- detection: forming and initiating a movement goal
- selection: making sensori-motor decisions
- (learning: memory trace)
- boost-driven detection: initiating the action
- memory instability: old infants sustain during the delay, young



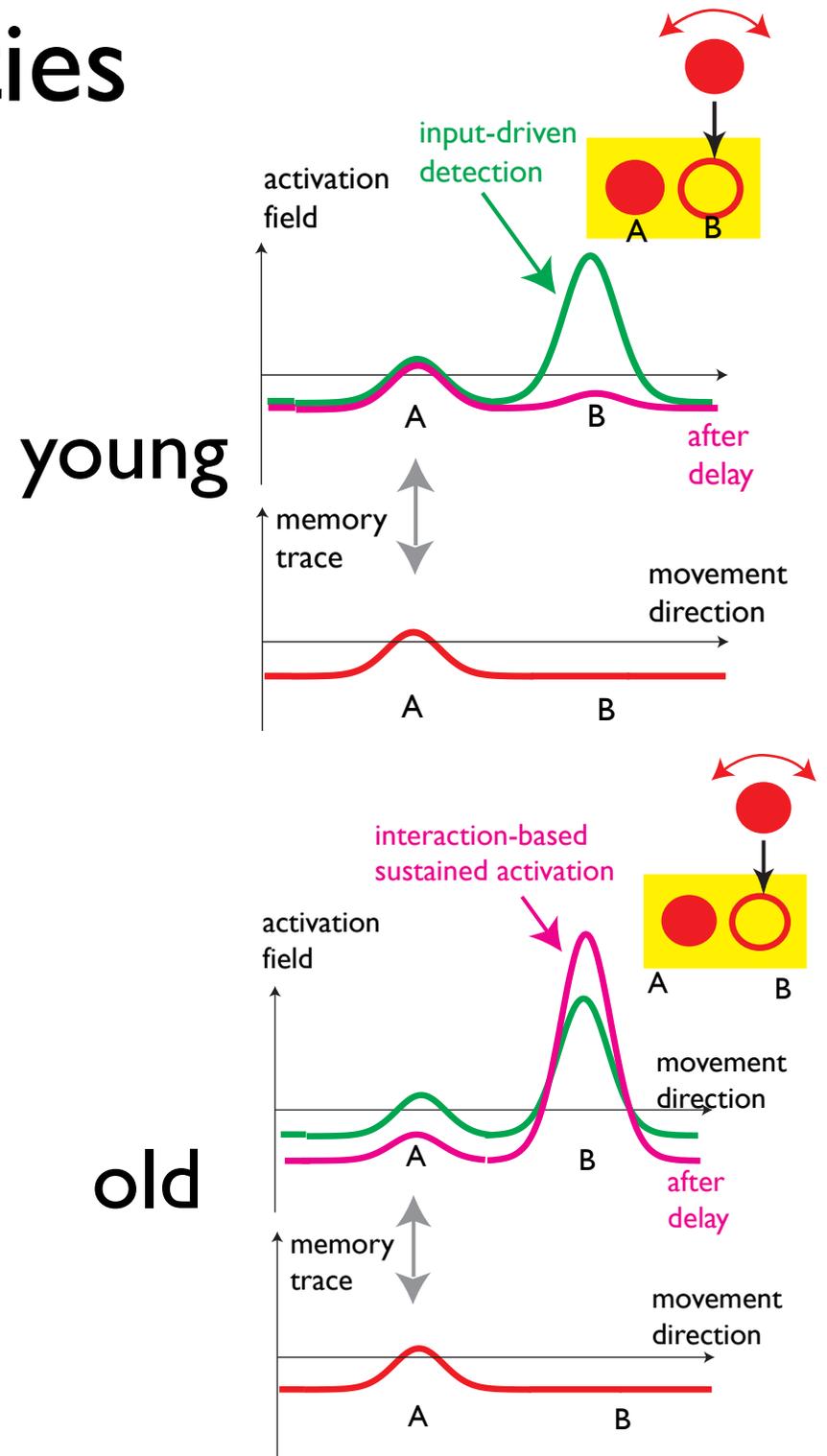
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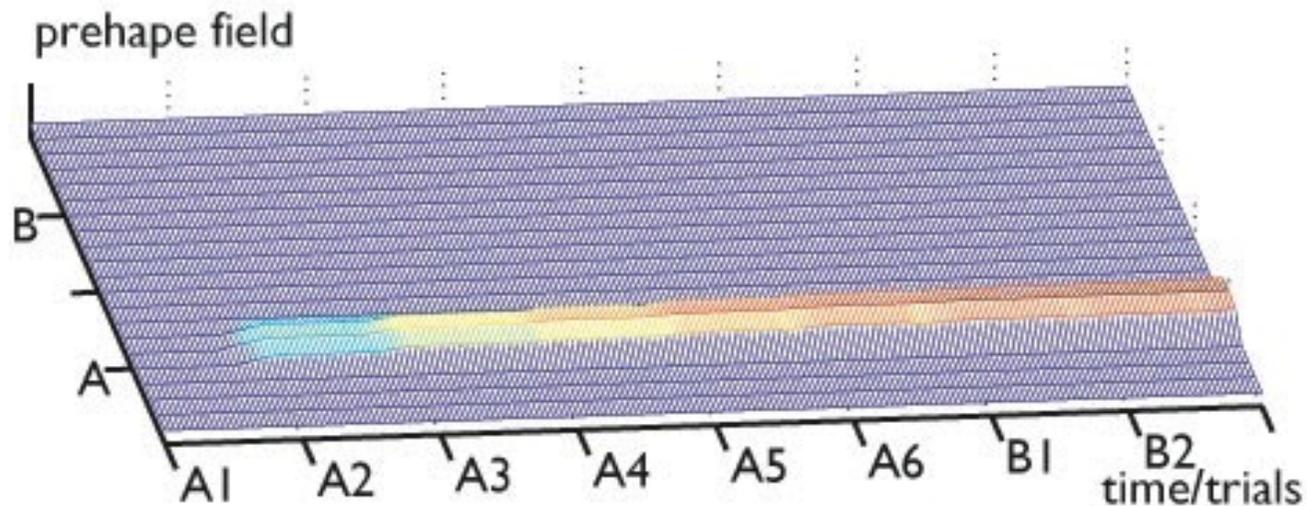
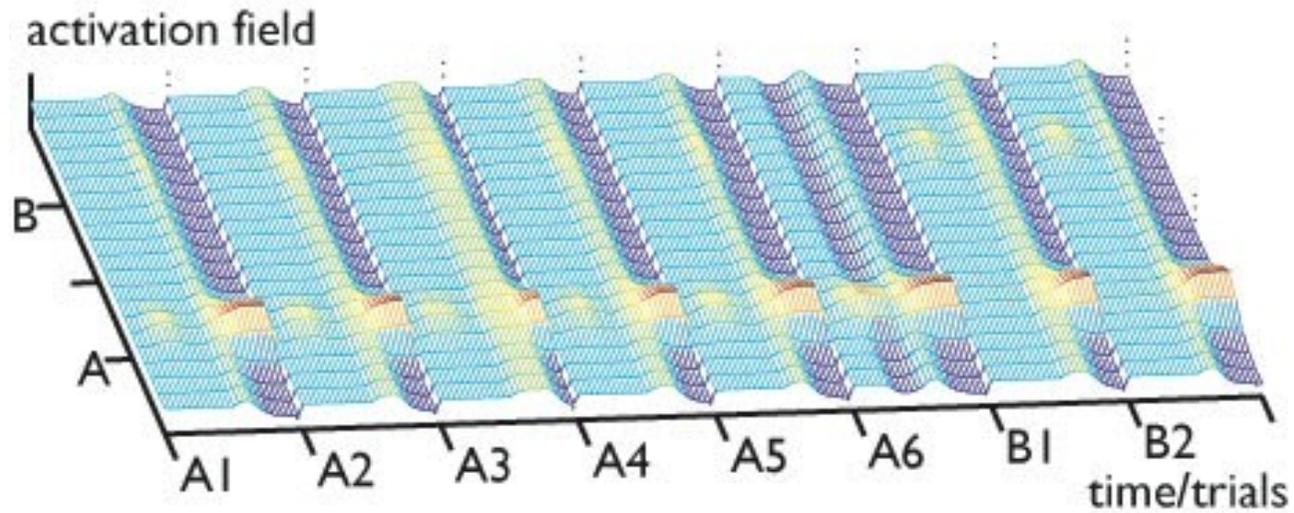


Instabilities

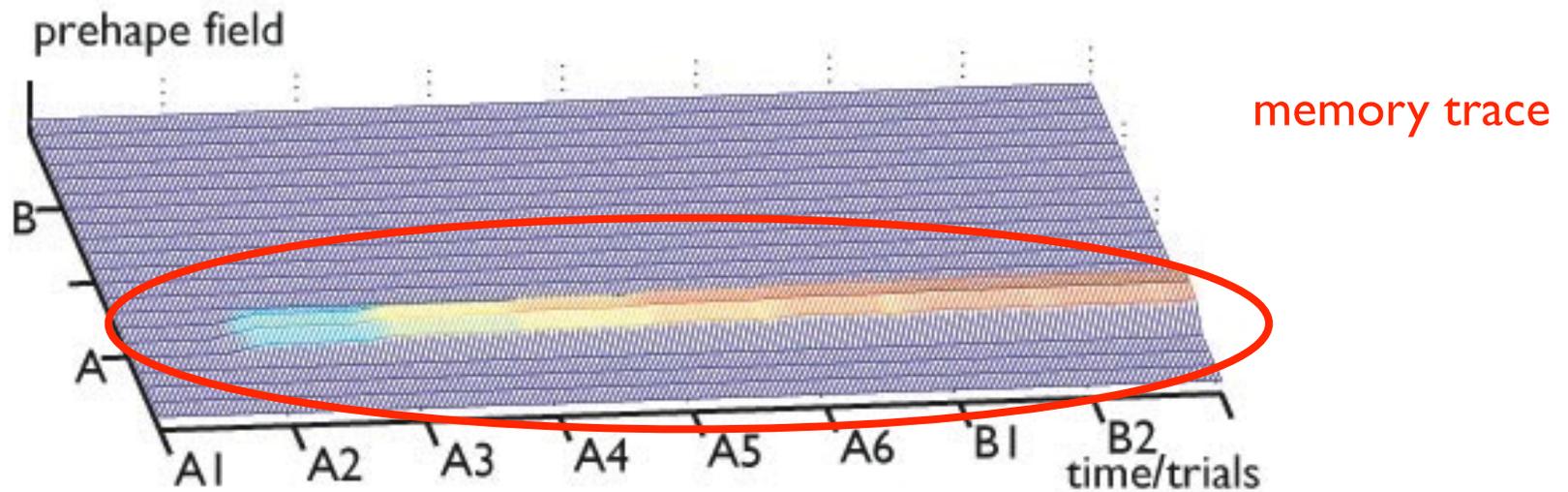
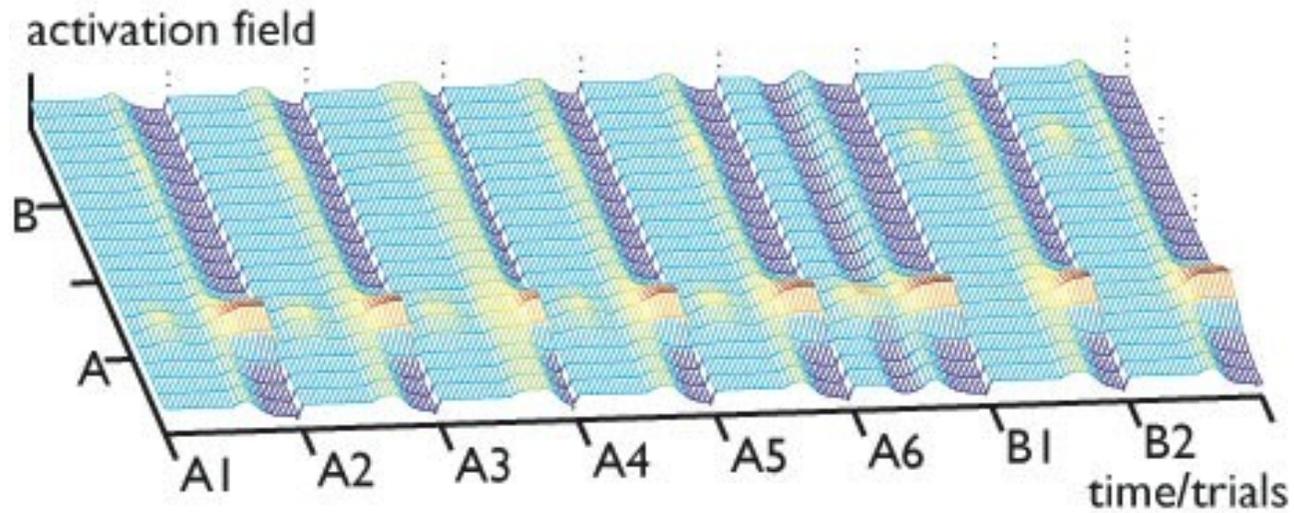
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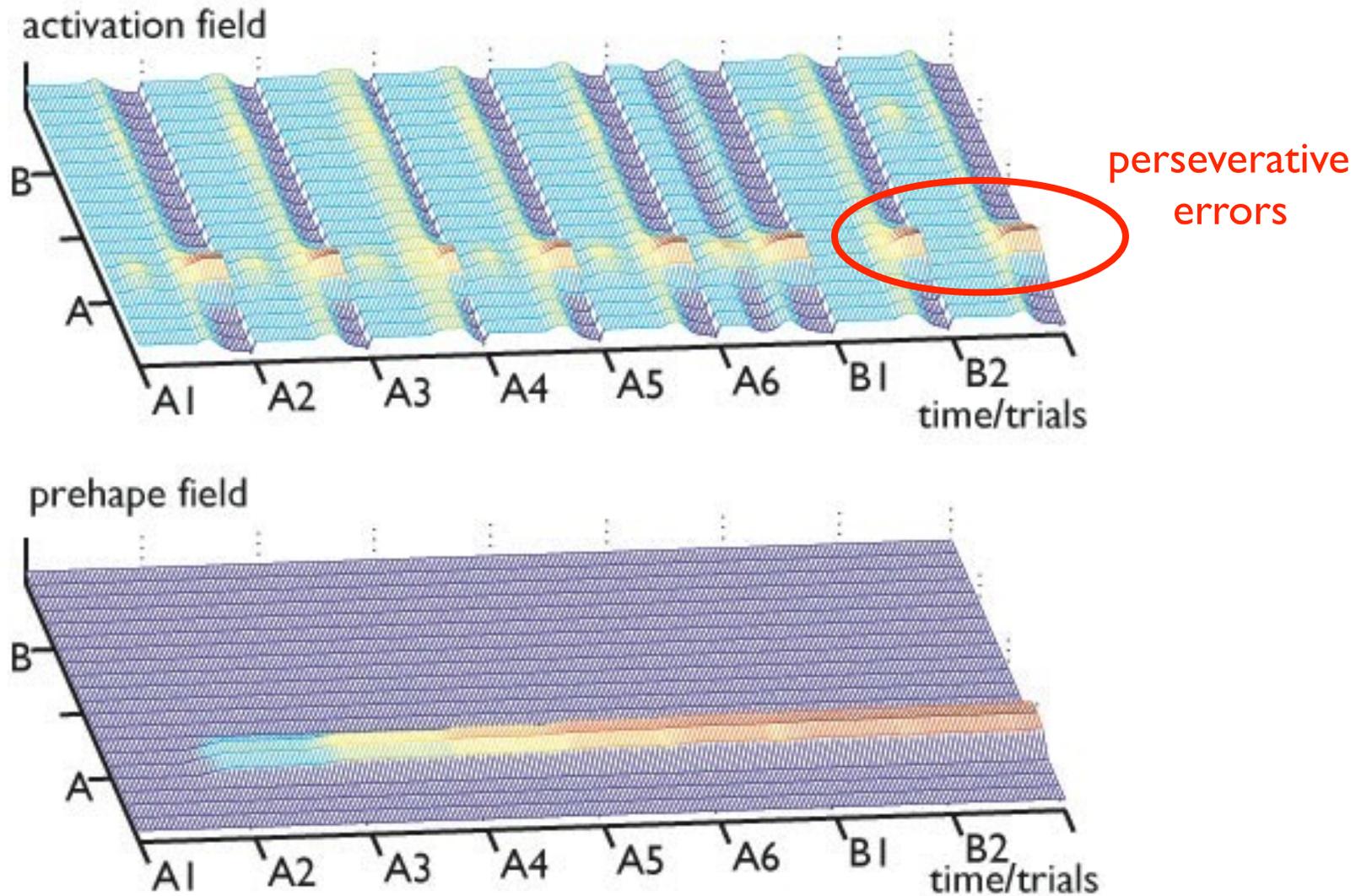
DFT of infant perseverative reaching



DFT of infant perseverative reaching



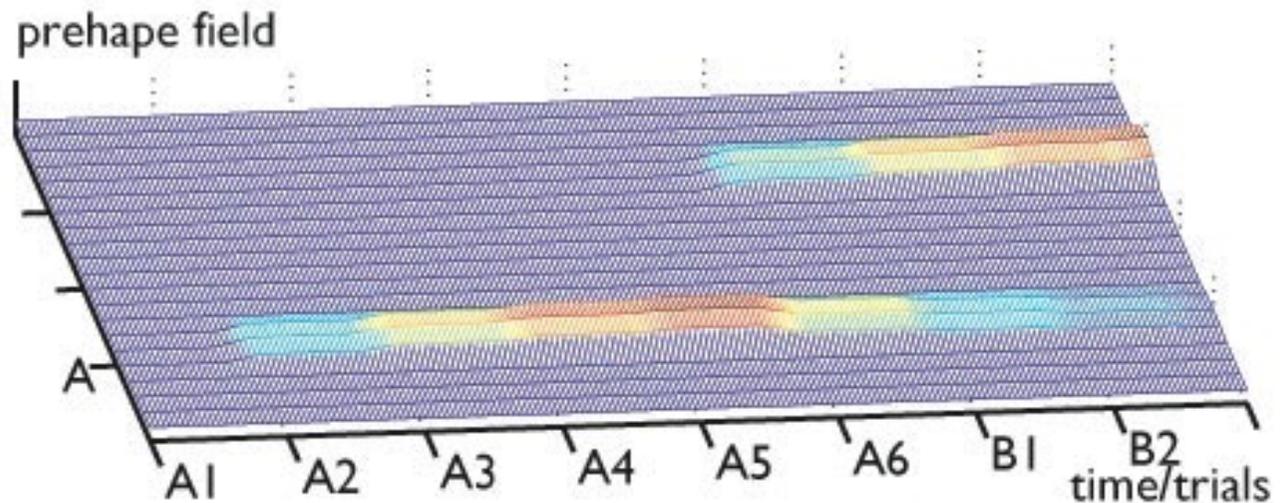
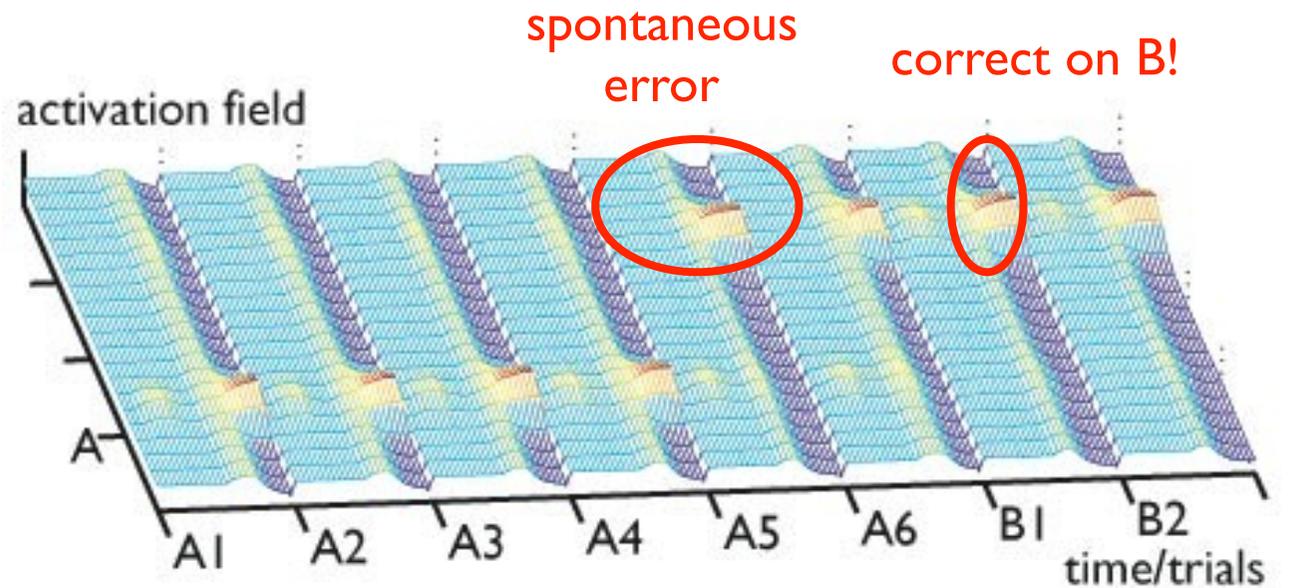
DFT of infant perseverative reaching



DFT of infant perseverative reaching

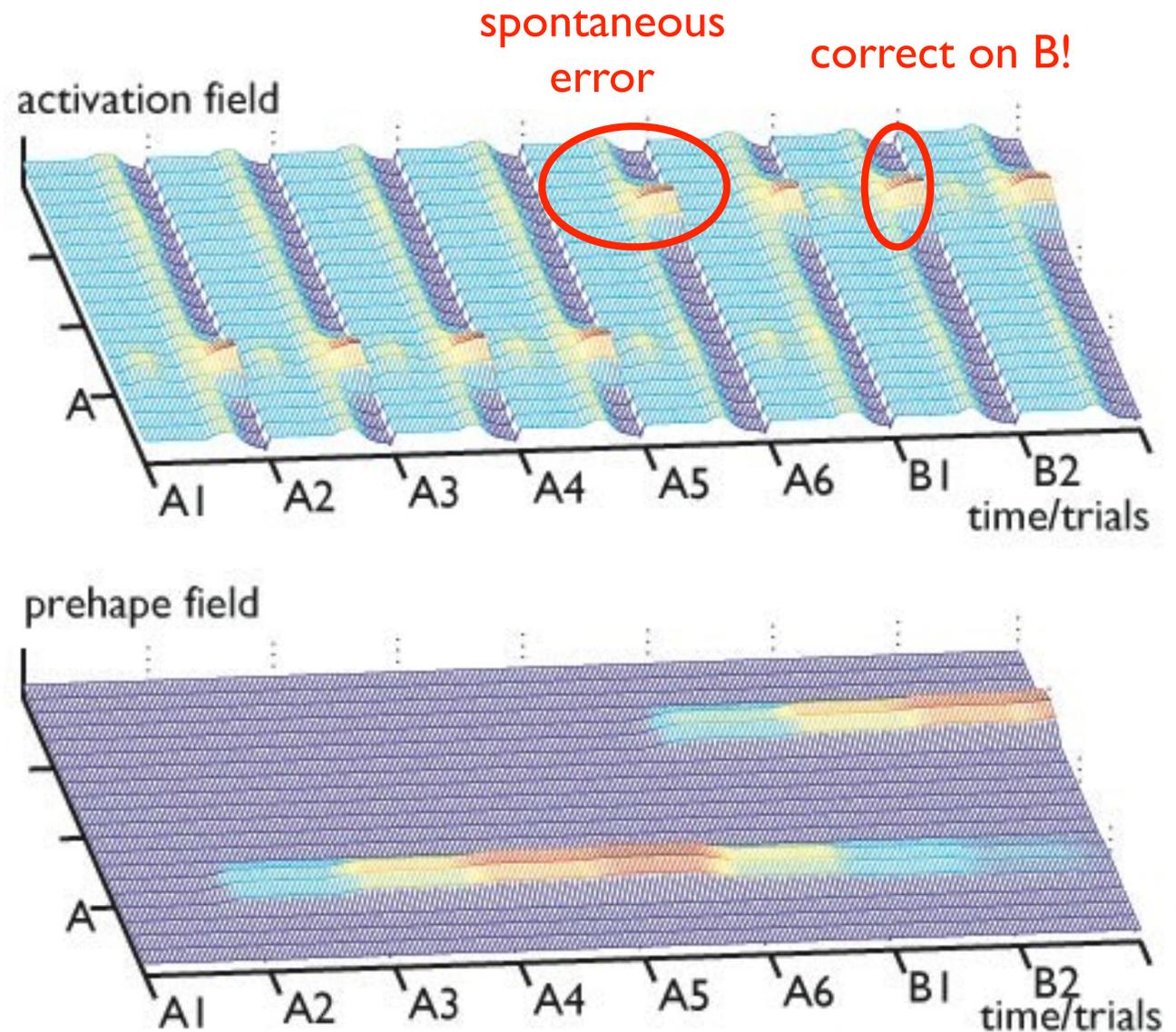
- in spontaneous errors, activation arises at B on an A trial

- which leads to correct reaching on B trial



DFT of infant perseverative reaching

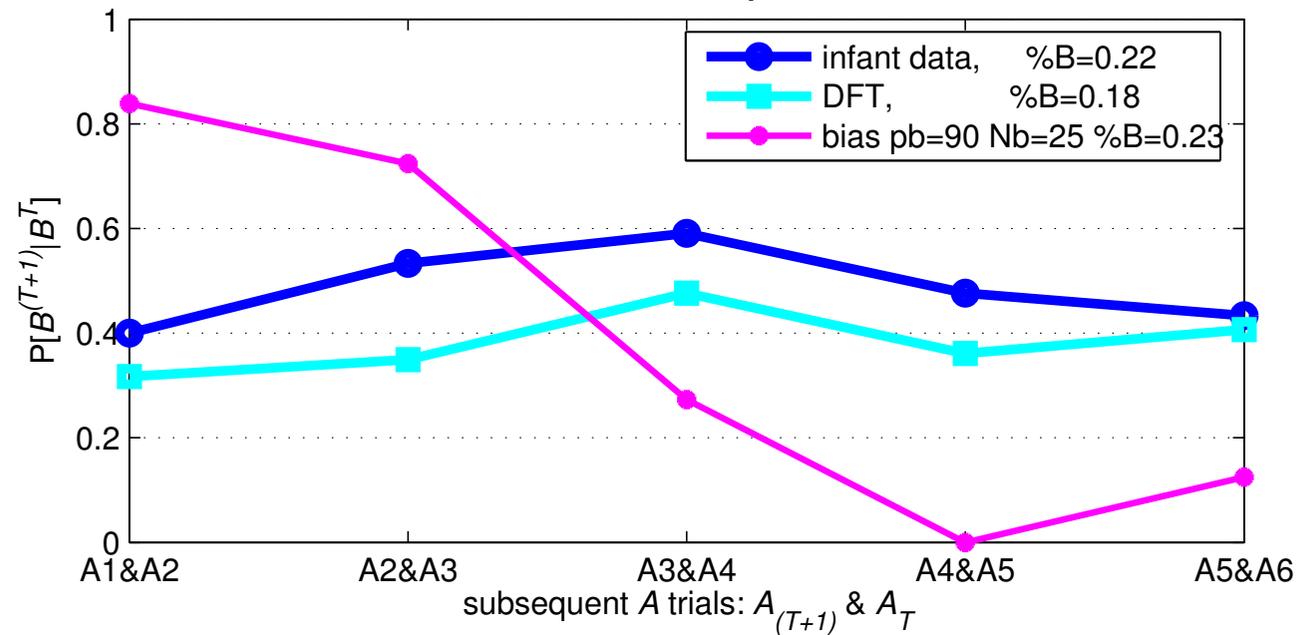
- that is because reaches to B on A trials leave memory trace at B



DFT of infant perseverative reaching

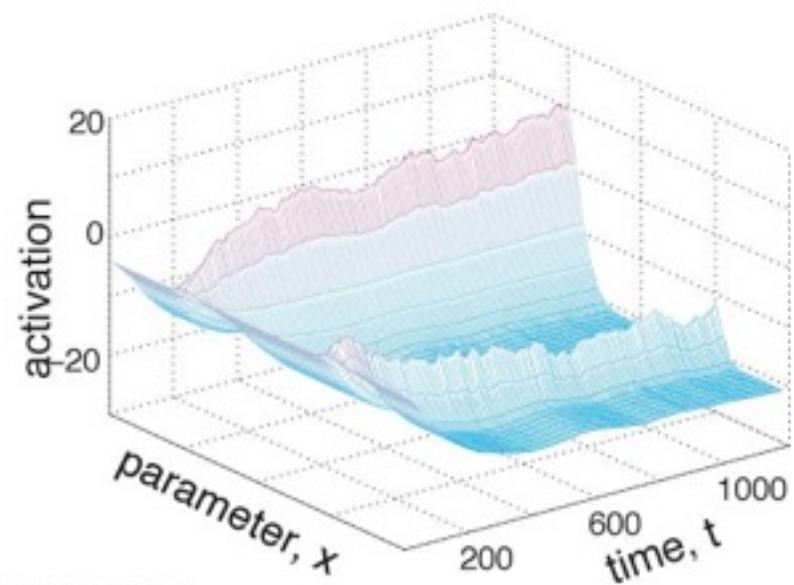
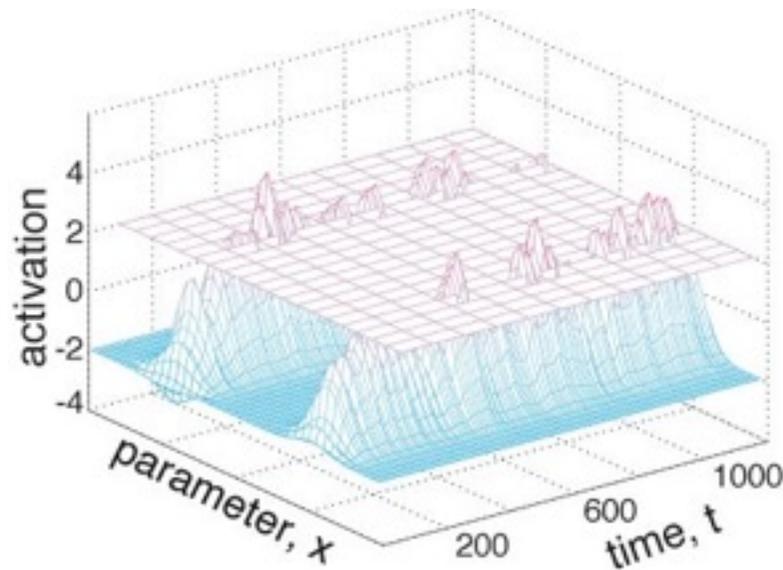
■ spontaneous errors promote spontaneous errors

first and second reaches to B are on two subsequent A trials



DFT is a neural process model

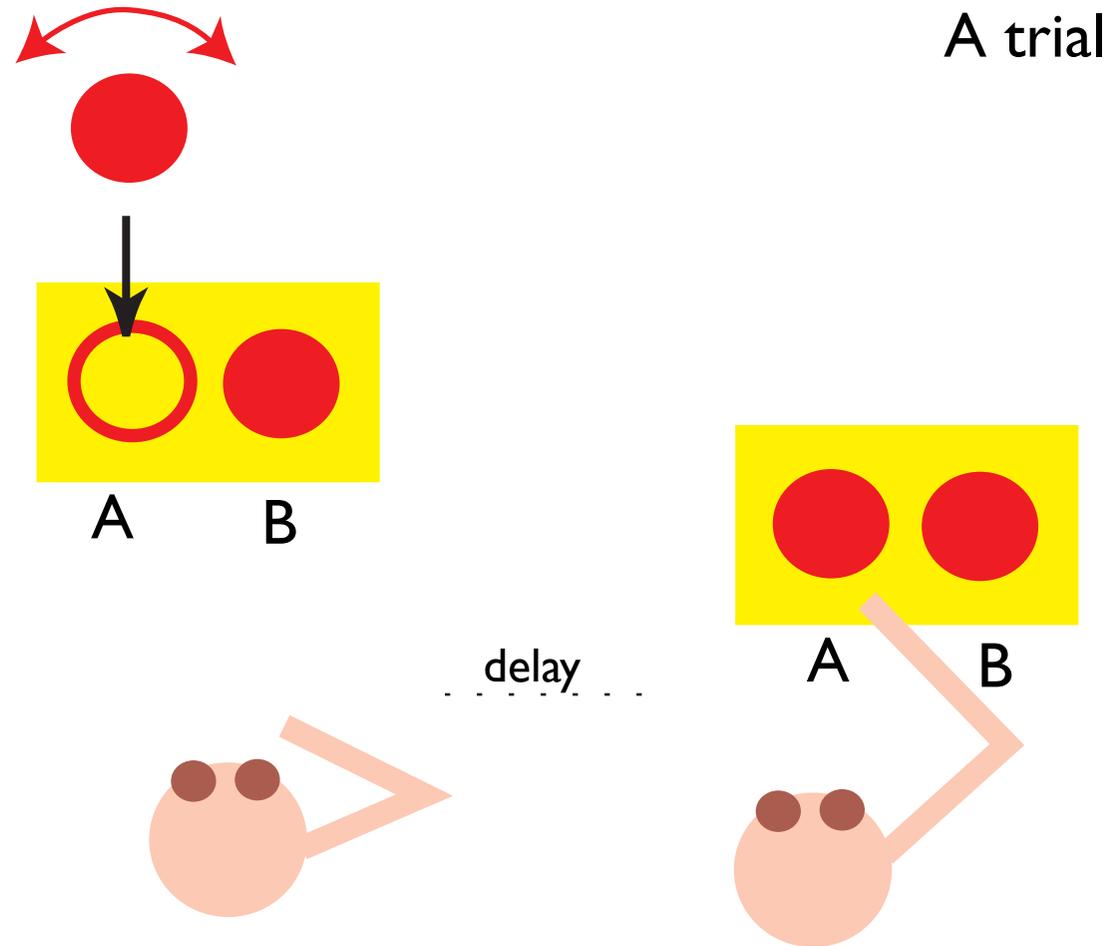
- that makes the decisions in each individual trial, by amplifying small differences into a macroscopic stable state
- and that's how decisions leave traces, have consequences



[Wilimzig, Schöner, 2006]

summary: instabilities

- detection: forming and initiating a movement goal
- selection: making sensori-motor decisions
- boost-driven detection: initiating the the action
- learning: memory trace
- working memory: sustaining a delay



Toyless version of A not B
(Smith, Thelen, et al., 1999)

Conclusions

- action, perception, and embodied cognition takes place in continuous spaces. peaks = units of representation are attractors of the neural dynamics
- neural fields link neural representations to these continua
- stable activation peaks are the units of neural representation
- peaks arise and disappear through instabilities through which elementary cognitive functions (e.g. detection, selection, memory) emerge

The conceptual framework of DFT

