Computational Neuroscience: Neural Dynamics

What is this course about?

- Theoretical tools/concepts
  - Dynamical systems theory (attractor dynamics approach)
  - in which stability is central
  - as is the analysis of instabilities

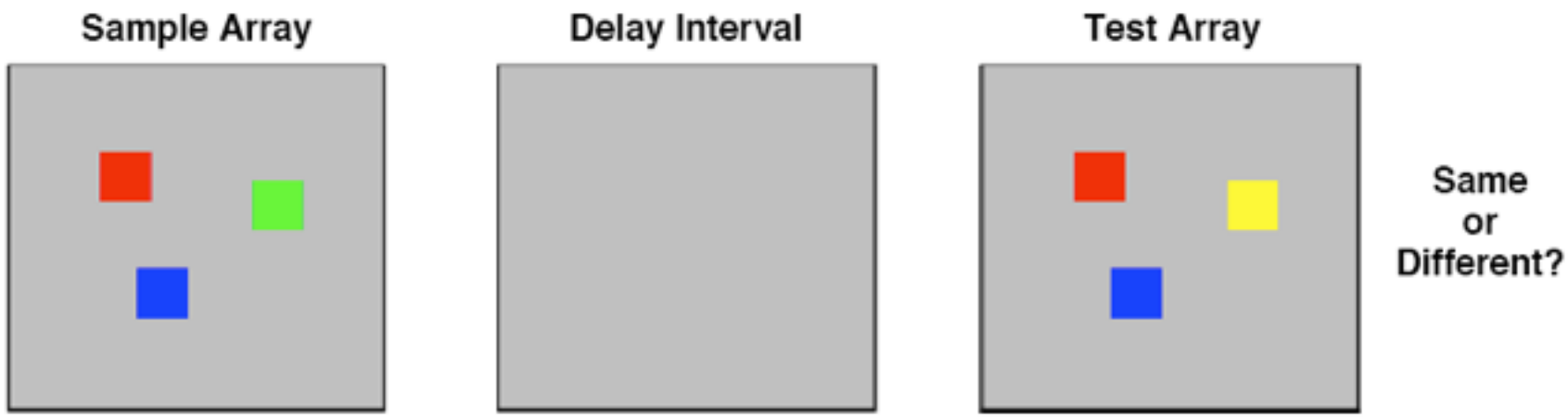
=> we'll have math tutorials

- about the foundations of dynamical systems, attractors, stability, bifurcations
- making use of interactive simulators
- having you use simulators in your home/work or in life sessions

Why learn theory?

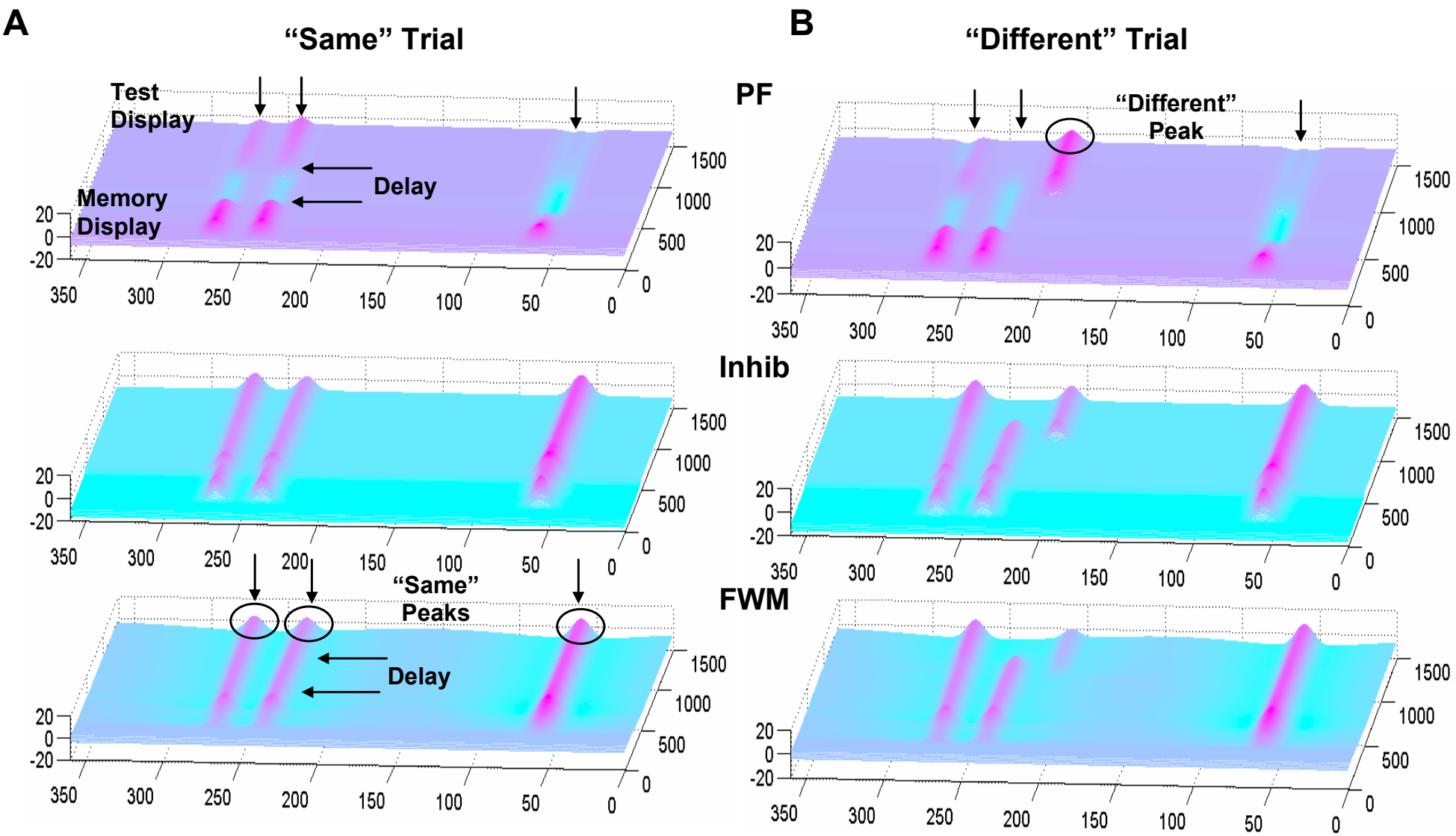
- Understand concepts
  - e.g., what does it mean that a particular brain area is responsible for a particular function?
- Test understanding by making predictions
  - example: change detection

Change detection for color



Johnson, Spencer, Luck, Schöner, 2008

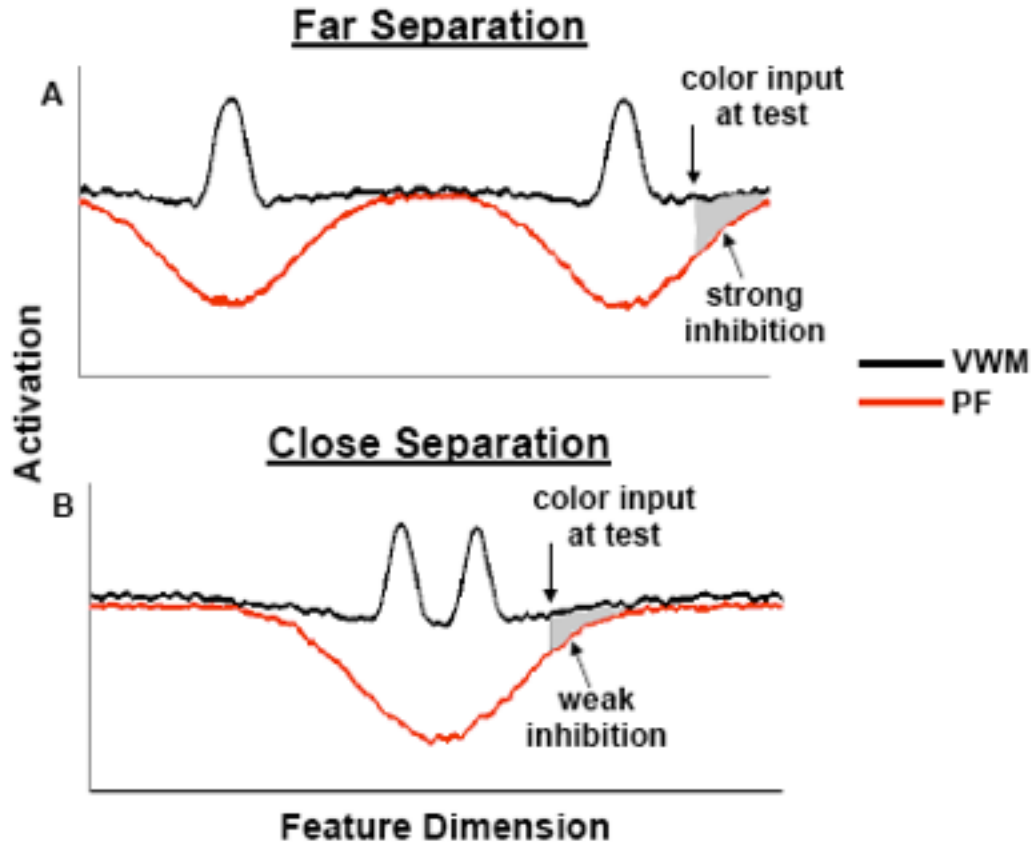
DFT model of change detection



Johnson, Spencer, Schöner, 2007

behavioral signatures of DFT

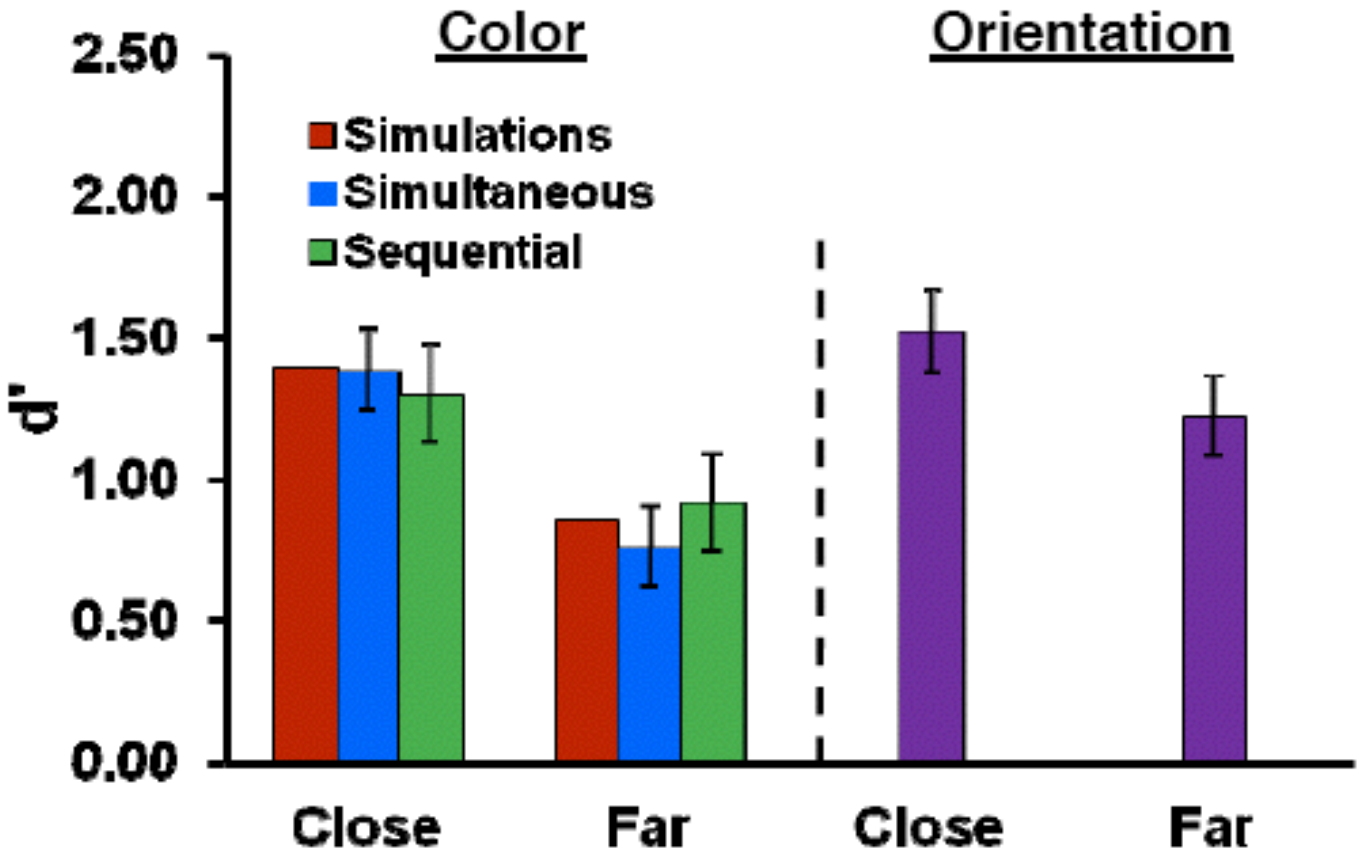
- at close metric separation, there is less inhibition in perceptual layer, leading to reduced threshold for change detection for metrically close items!



Johnson, Spencer, Luck, Schöner, 2008

Experimental confirmation

- better change detection when items are metrically close!
- true also for orientation discrimination

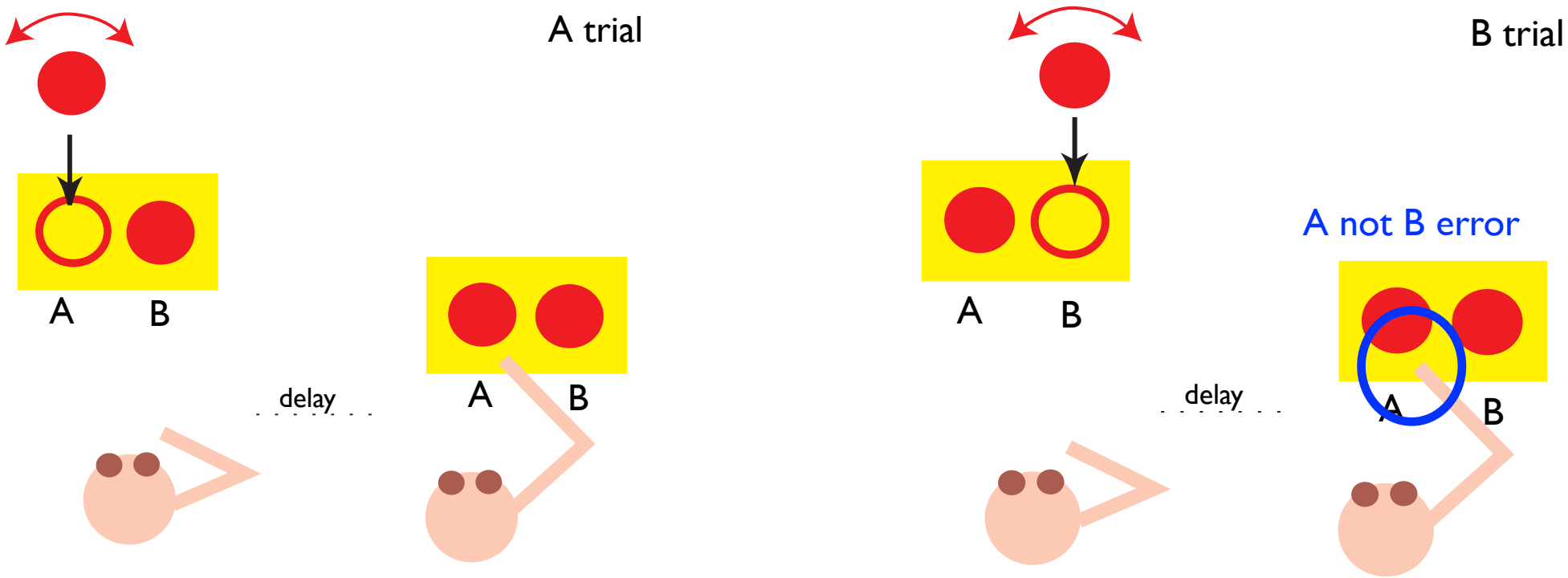


Johnson, Spencer, Luck, Schöner, 2008

Why learn theory?

- Test understanding by demonstrating functions

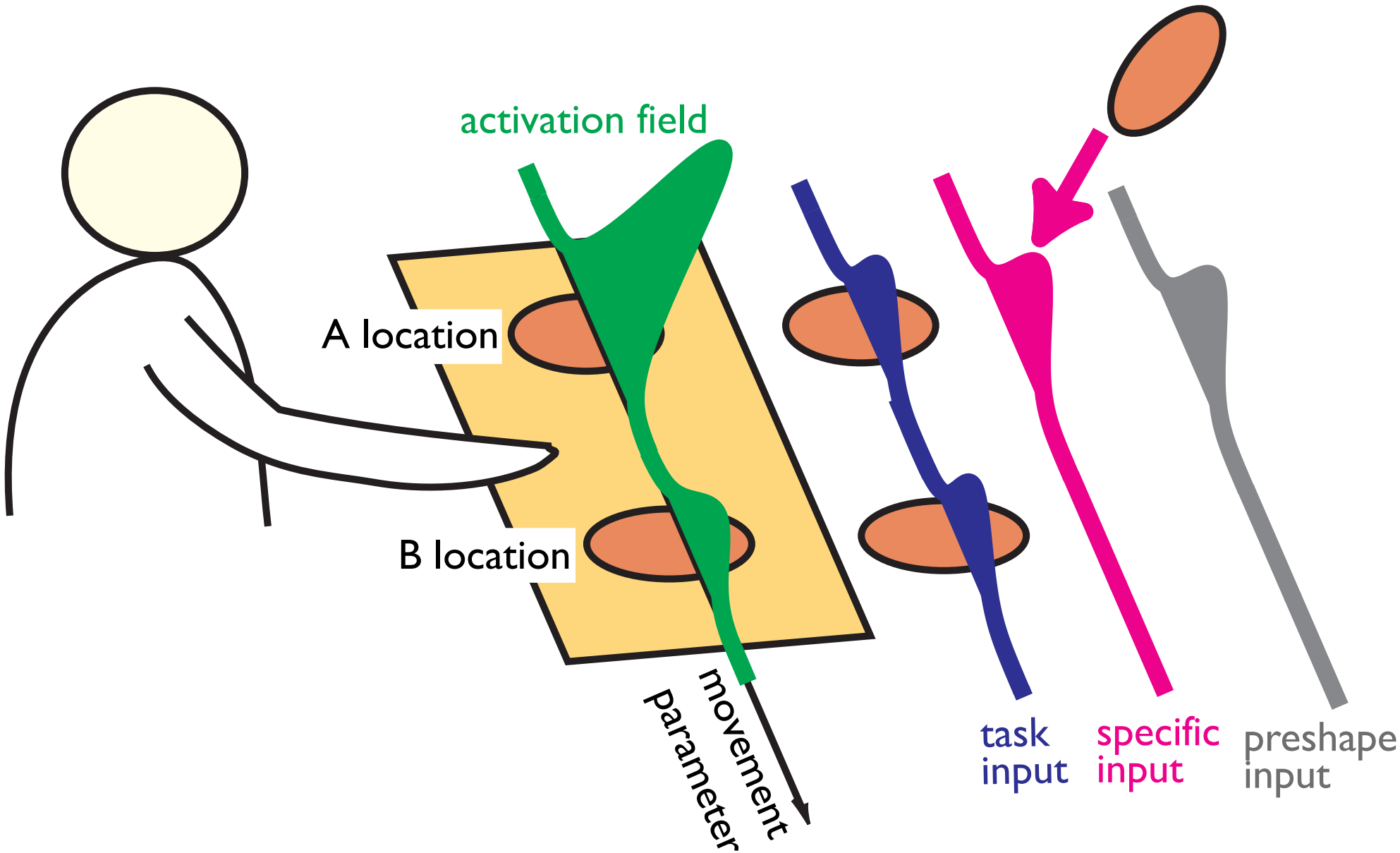
Example: selection decisions in Piaget's A not B paradigm



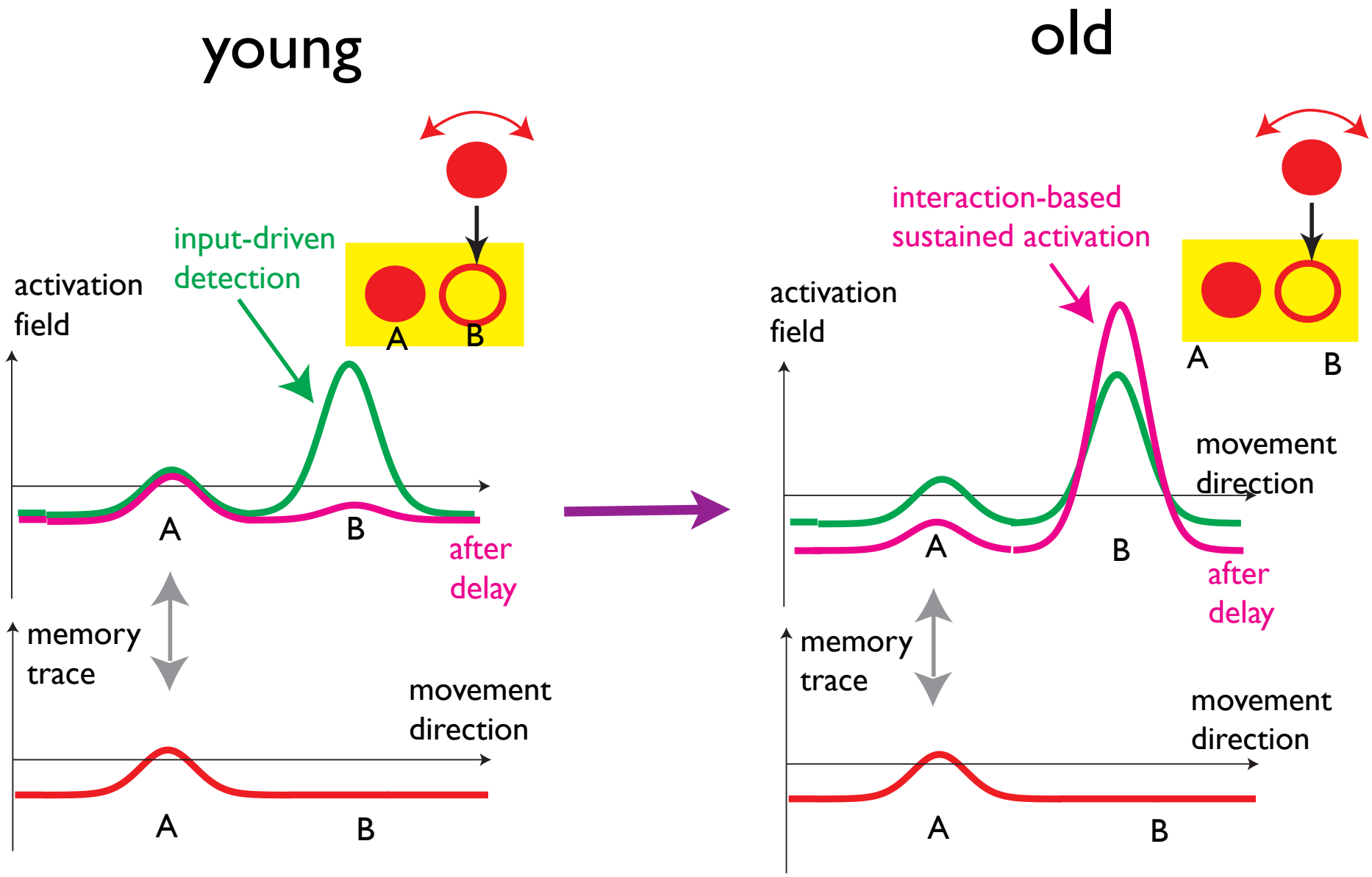
Toyless variant of A not B task

Linda Smith & Esther Thelen

Dynamic Field Theory of A not B

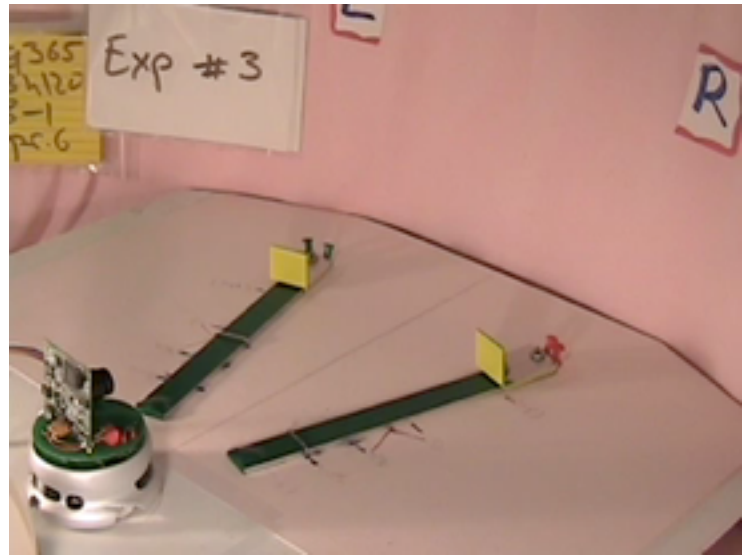


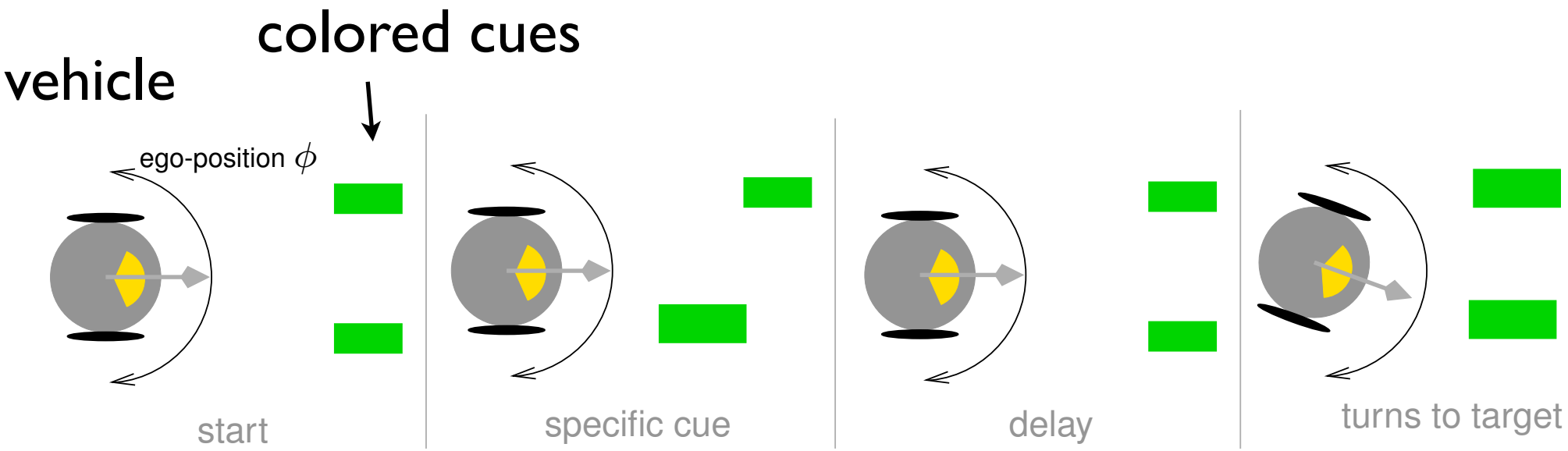
B trial

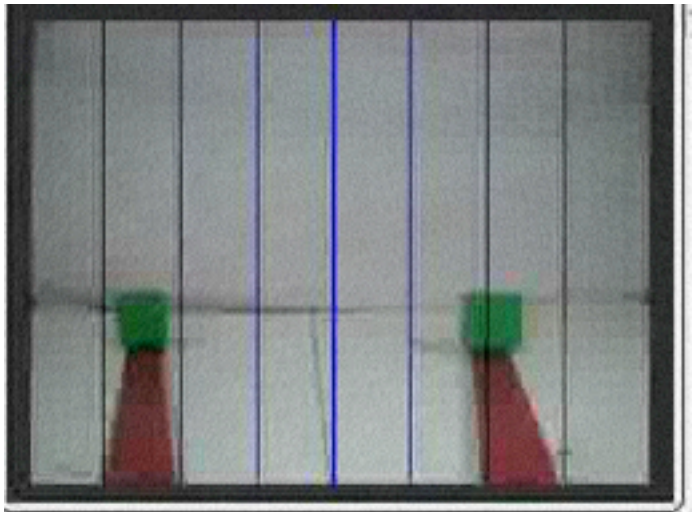

young
old
input-driven
detection
activation
field
A
B
after
delay
memory
trace
movement
direction
interaction-based
sustained activation

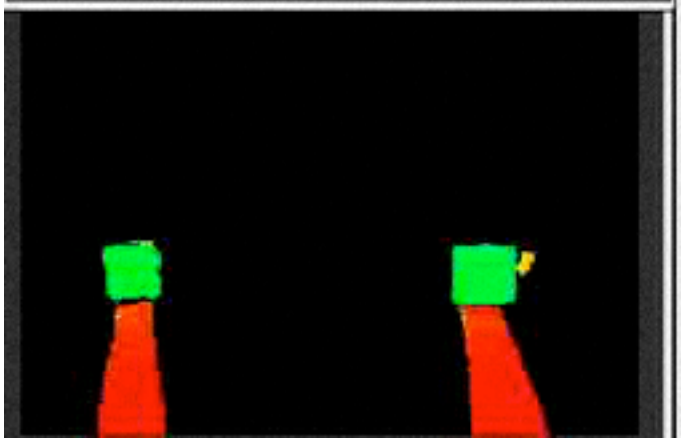
implementing DFT on robot

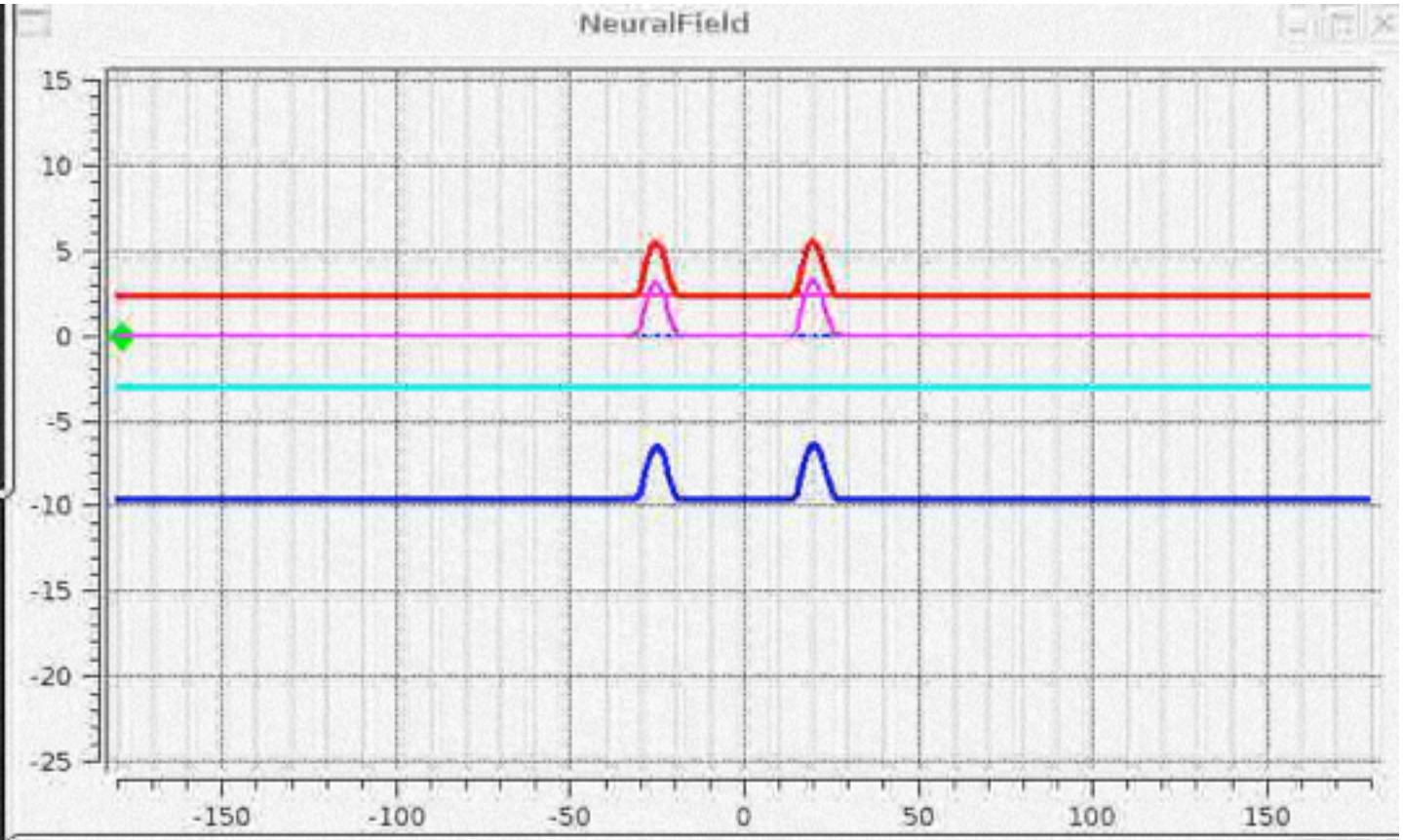
- Rather than "read out" peak state by finding the "argmax" in "disembodied models", generate continuous motor output
- reveals problems of stabilization

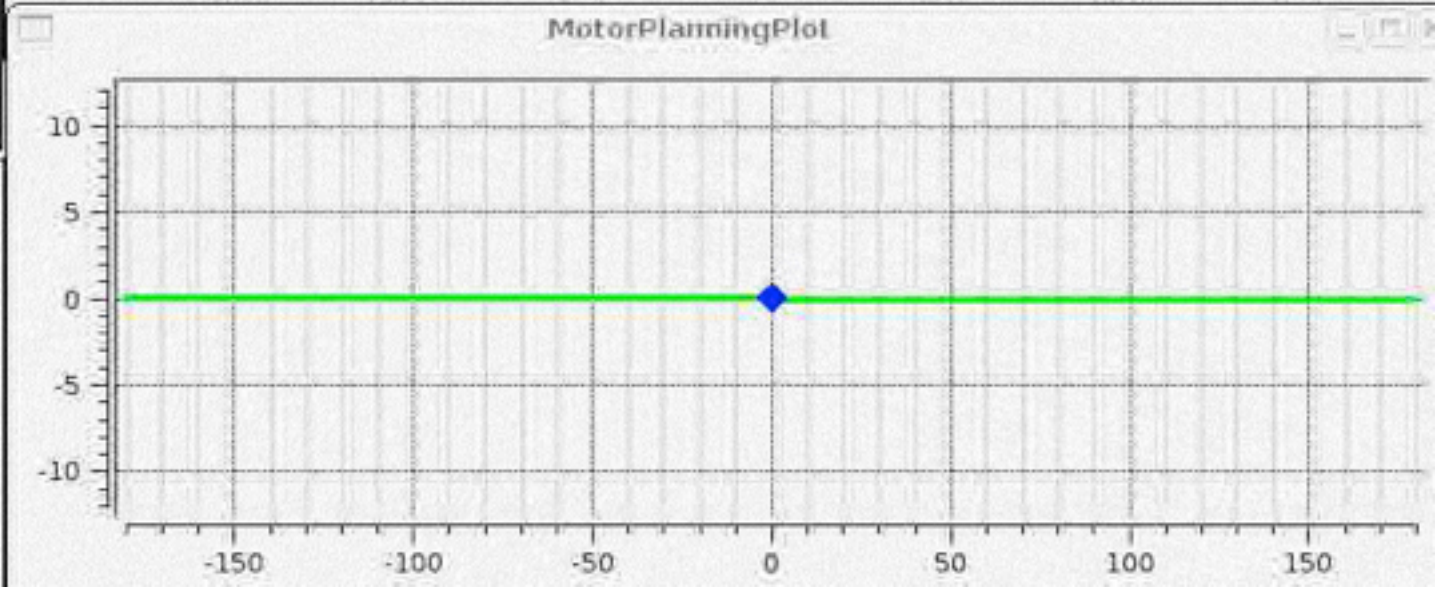




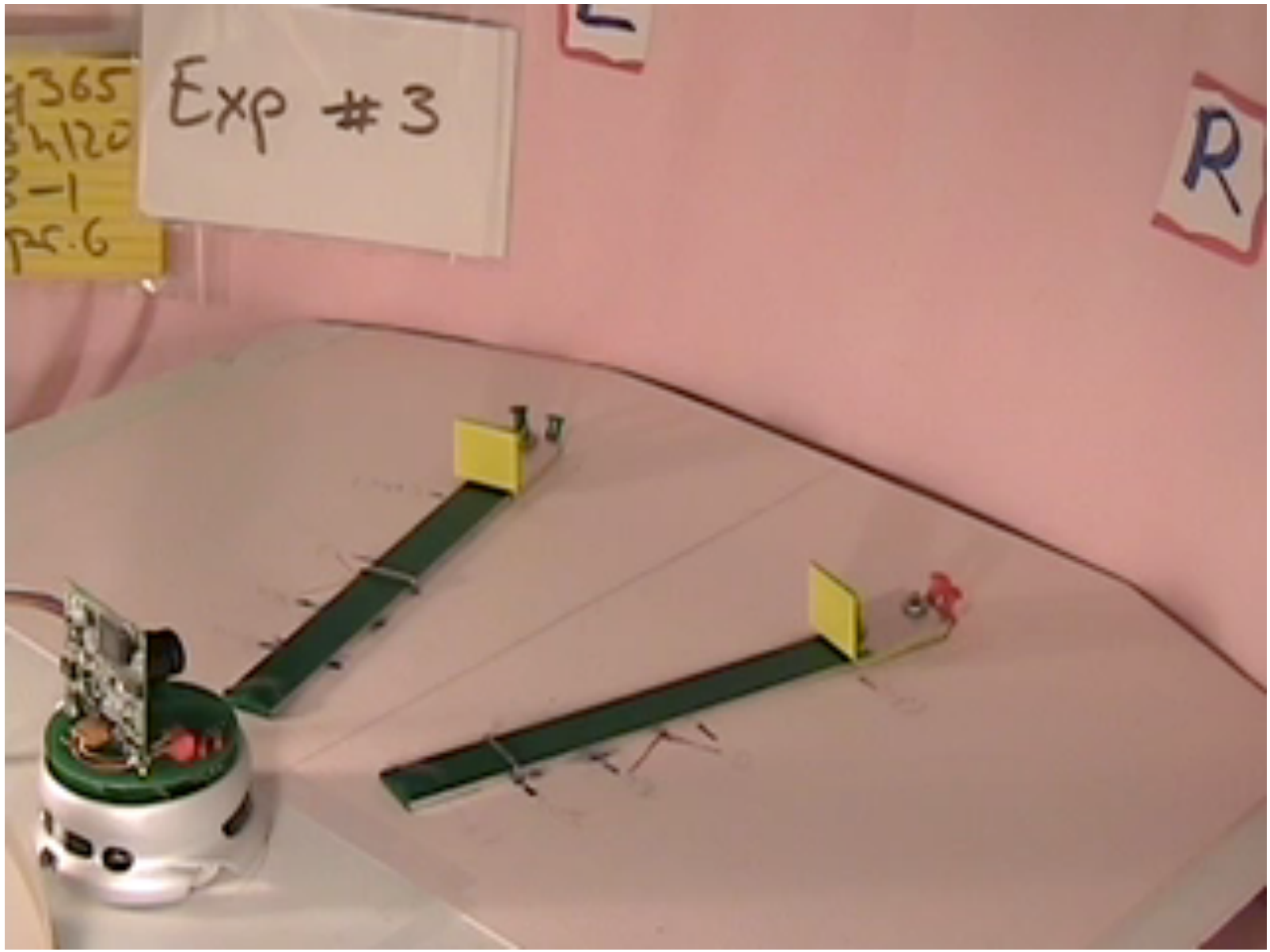


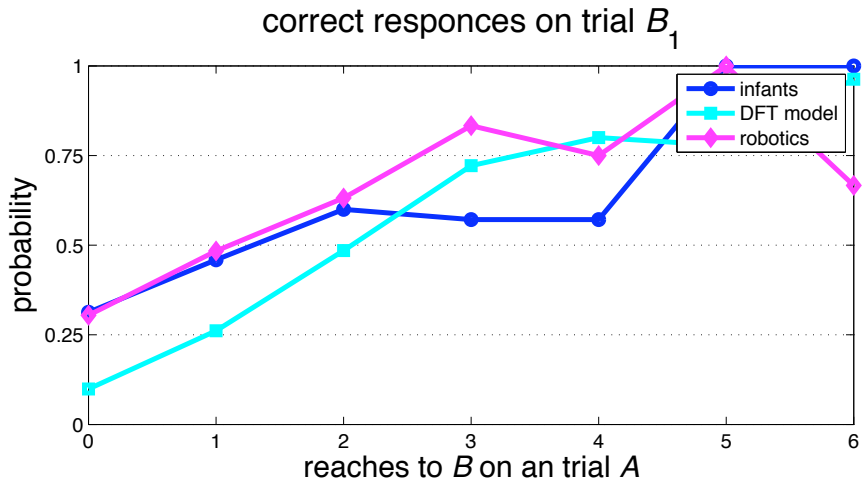


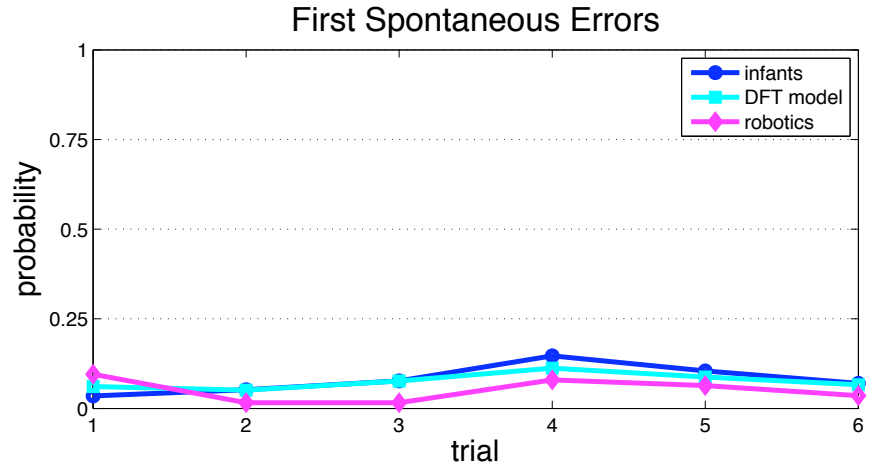

NeuralField
15
10
5
0
-5
-10
-15
-20
-25
-150
-100
-50
0
50
100
150

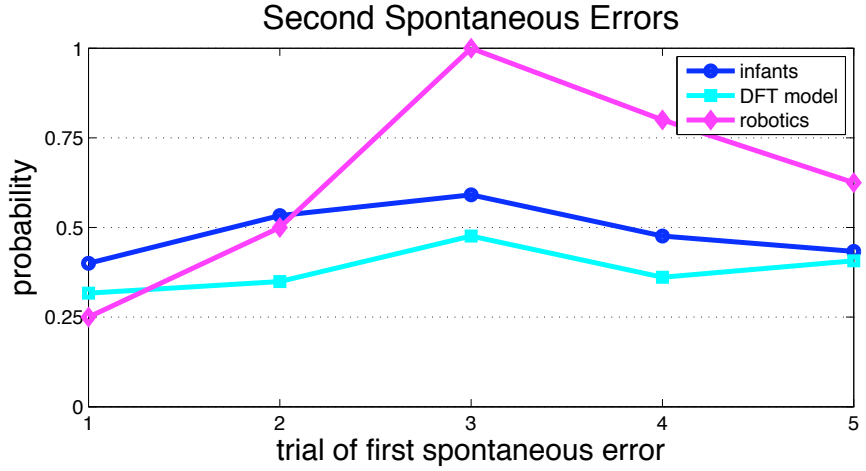

MotorPlanningPlot
10
5
0
-5
-10
-150
-100
-50
0
50
100
150

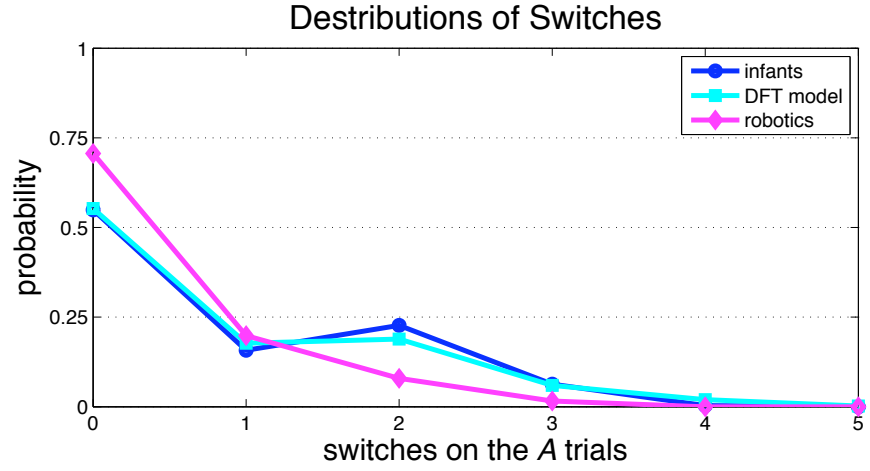
A not B robot

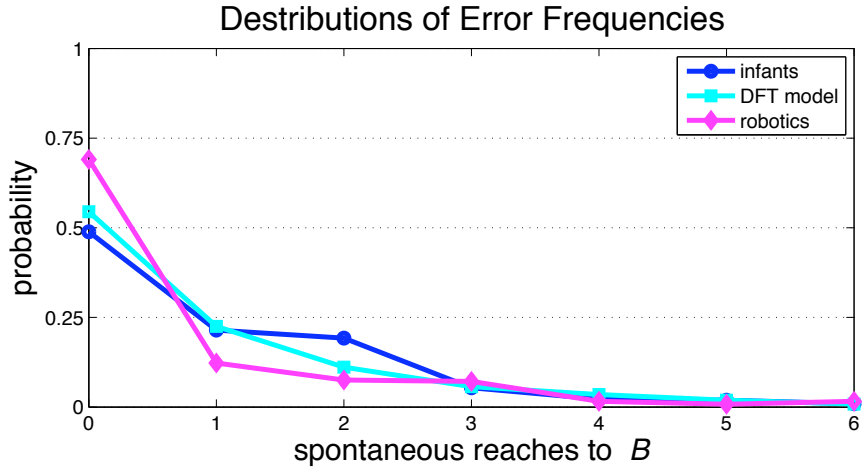



correct responces on trial B_1
probability
reaches to B on an trial A
infants
DFT model
robotics


First Spontaneous Errors
probability
trial
infants
DFT model
robotics

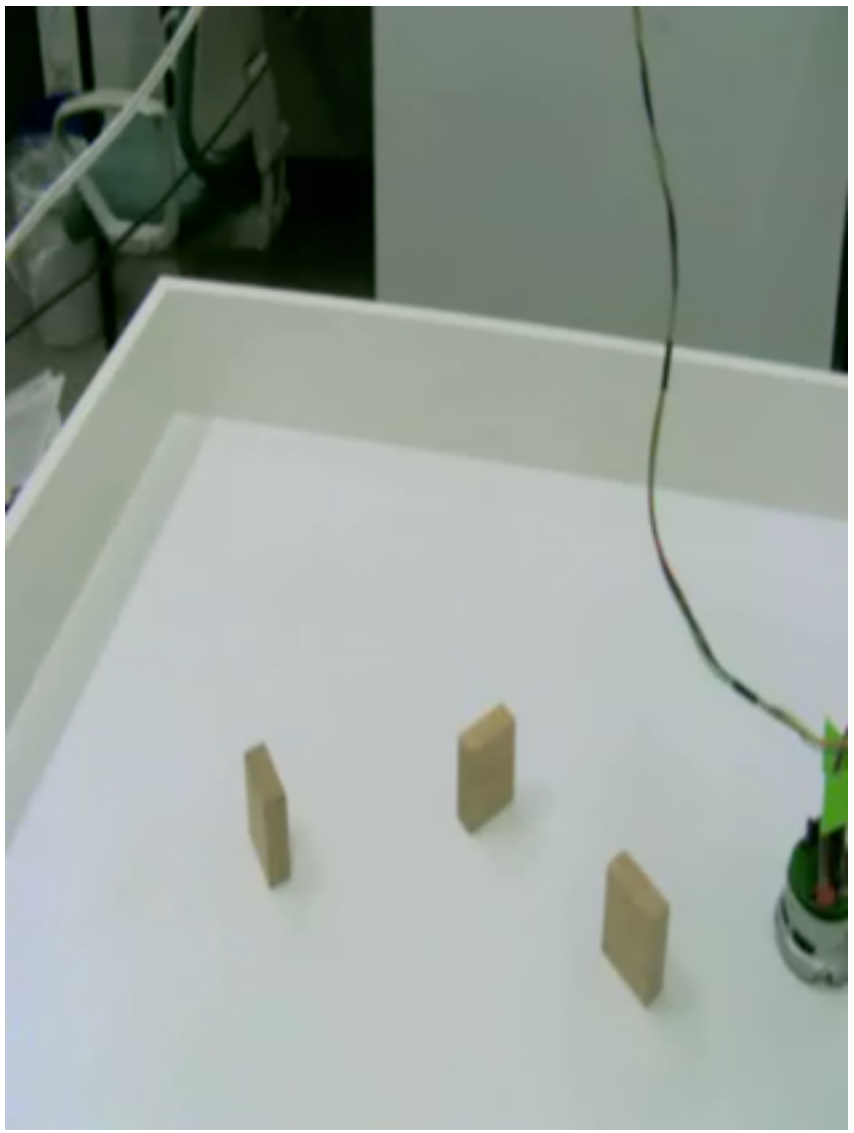

Second Spontaneous Errors
probability
trial of first spontaneous error
infants
DFT model
robotics


Destributions of Switches
probability
switches on the A trials
infants
DFT model
robotics

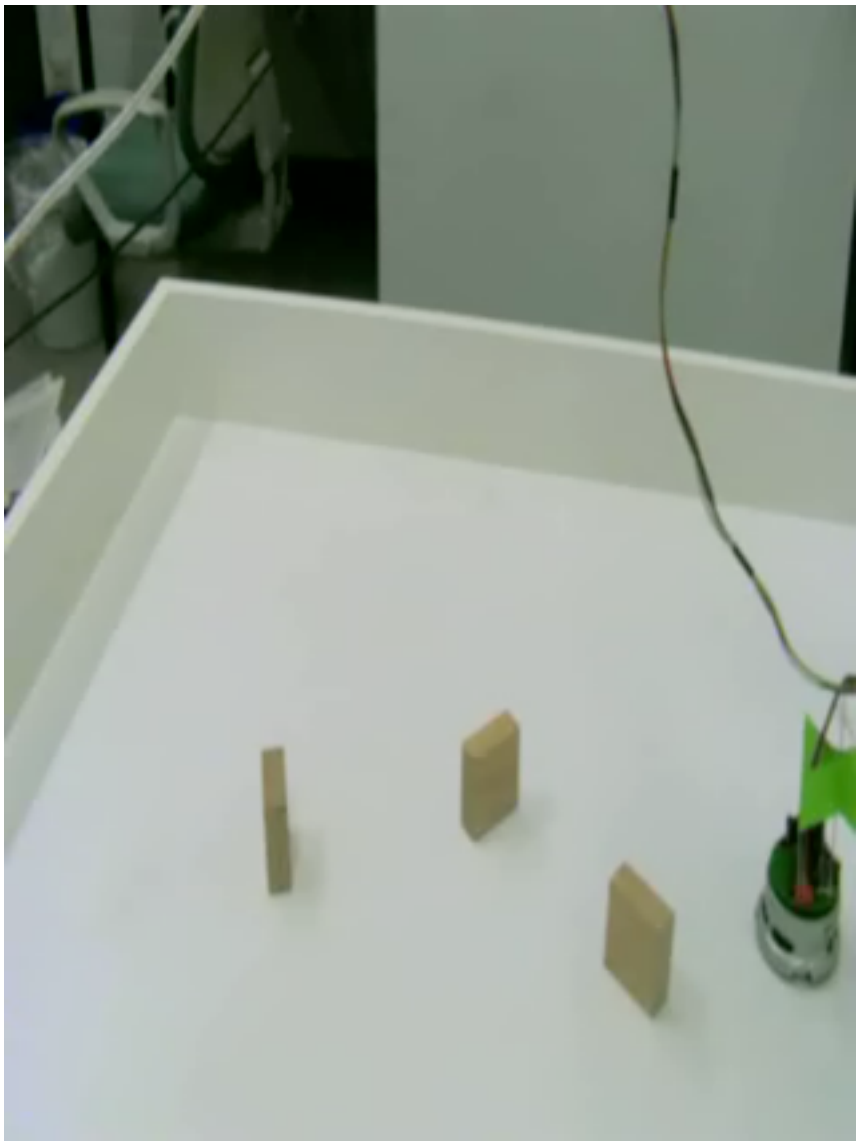

Destributions of Error Frequencies
probability
spontaneous reaches to B
infants
DFT model
robotics

Robotic model shows functional value of "mature" dynamics

"young" robot



"old" robot



When we're done you will:

- theoretical language
  - understand the concepts of the dynamical systems approach and some of the mathematical foundations
  - understand how theory can be linked to experiment
- substance matter
  - learn something about embodied cognition along the way
- skills
  - have learned to do math-type exercises, to write small essays, to read research publications

An experience in interdisciplinarity

- many of you have very limited knowledge of the subject matter...
- ... we'll have to open a number of parenthesis...
- and you have to learn to deal with only understanding parts of a story