

Sequential processing in DFT

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Sequences

- all actions in real life consist of sequences of movements, perceptual acts, inferences
 - often fixed by the logic of action
 - often highly automated: routines
- but also flexible:
 - serial order: arbitrary sequences

Challenge in DFT

- behaviors/representations are stable states
- in sequence: need to switch out of one behavior to the next. How to do that?
- answer: induce an instability

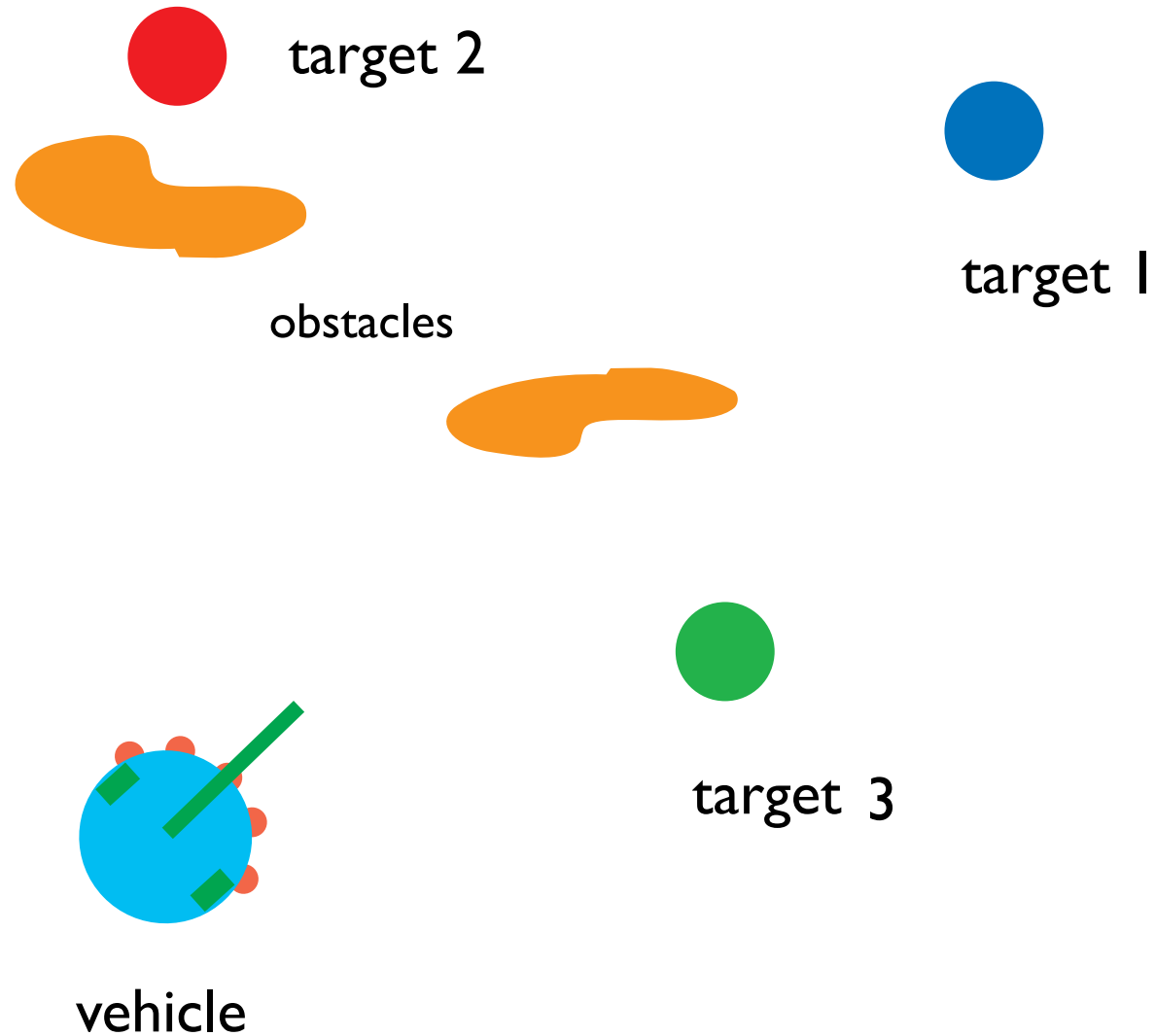
Illustration

■ search for objects
of a given color in
order

■ 1 blue

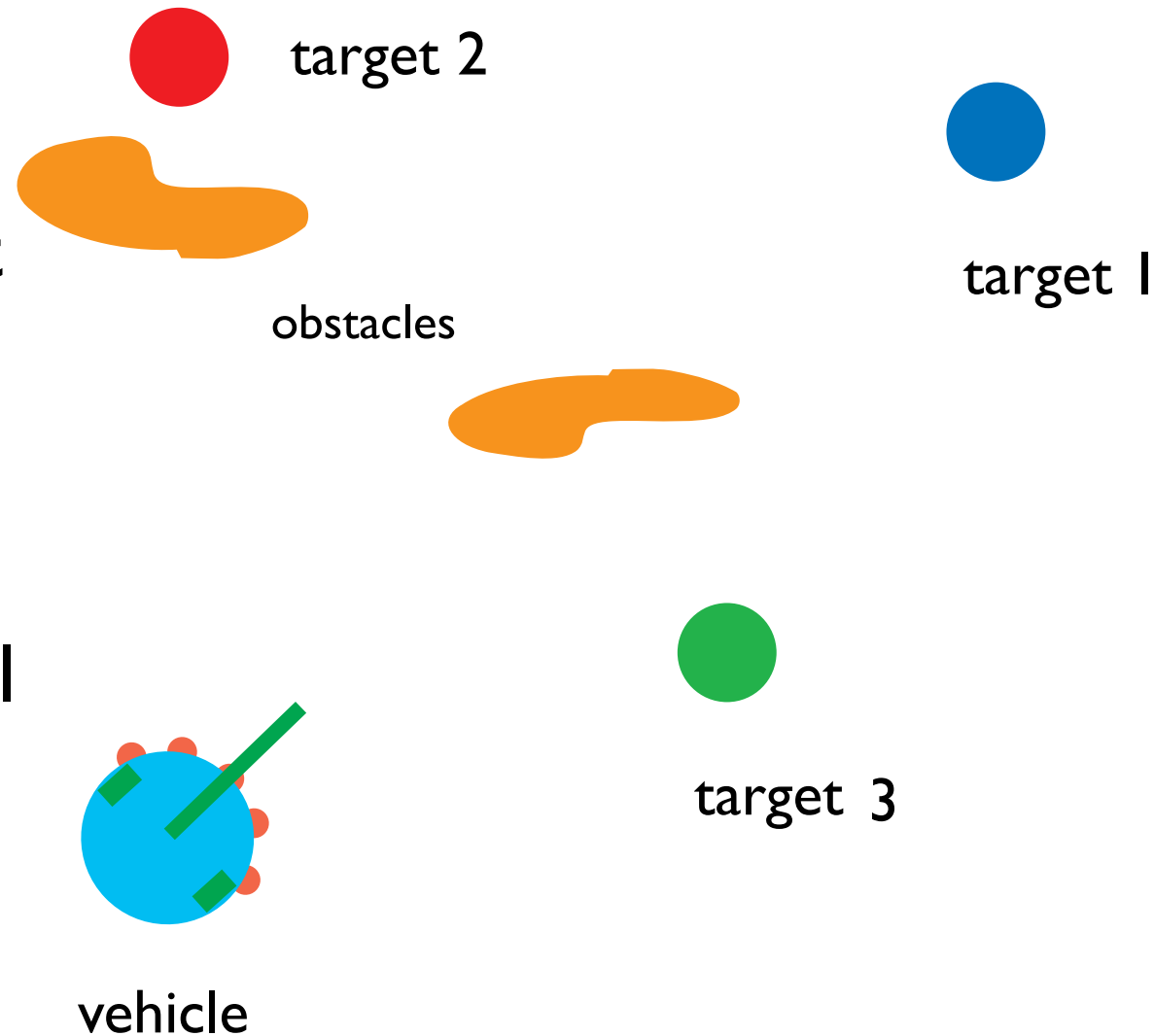
■ 2 red

■ green



The problem of sequential processing

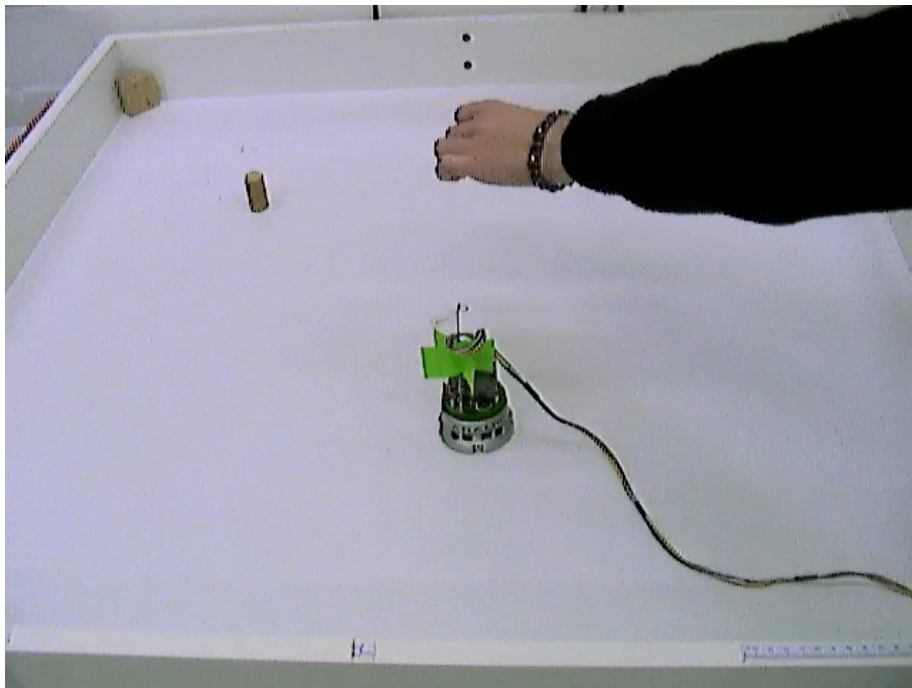
- each step in the sequence is a visual search, which takes a variable (here: unpredictable) amount of time
- so stabilize the goal of the visual search until the search is successful
- only then switch to the next element of the sequence



Implementation as an imitation task

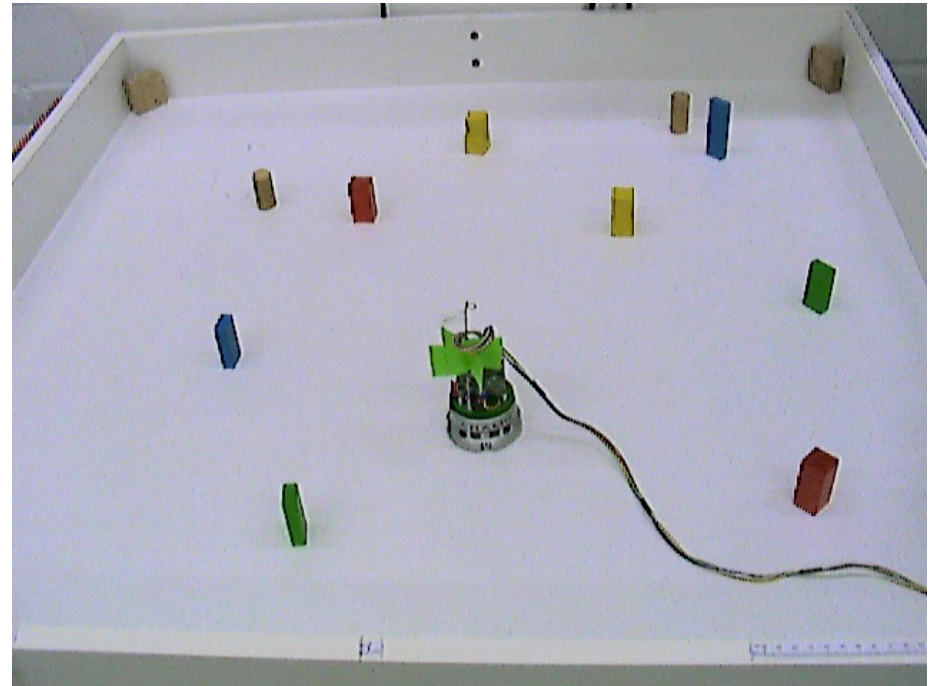
- learn a serially ordered sequence from a single demonstration

yellow-red-green-blue-red

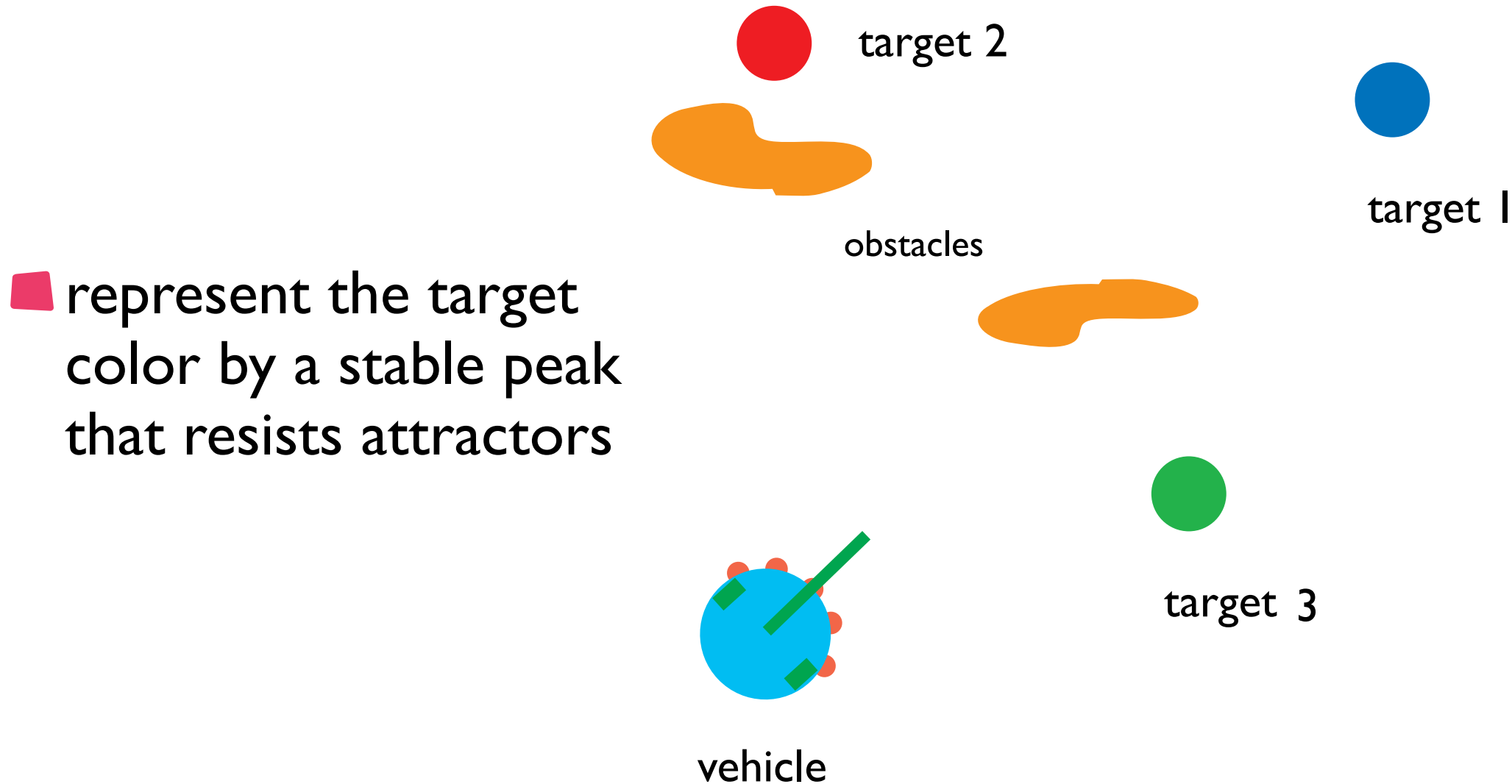


- perform a serially ordered sequence with new timing

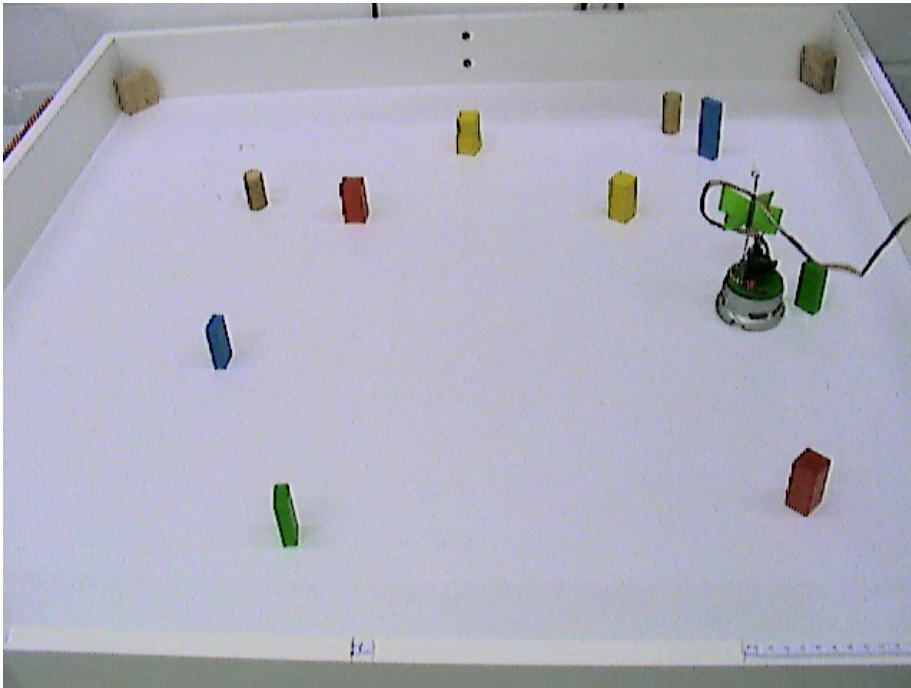
yellow-red-green-blue-red



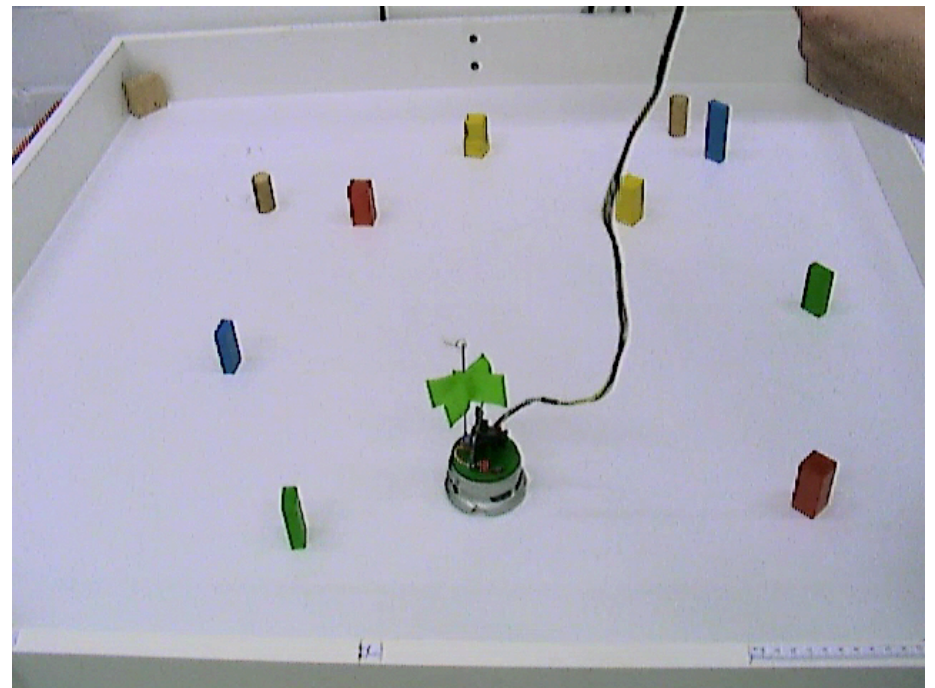
Neural dynamics of sequence generation



red a distractor

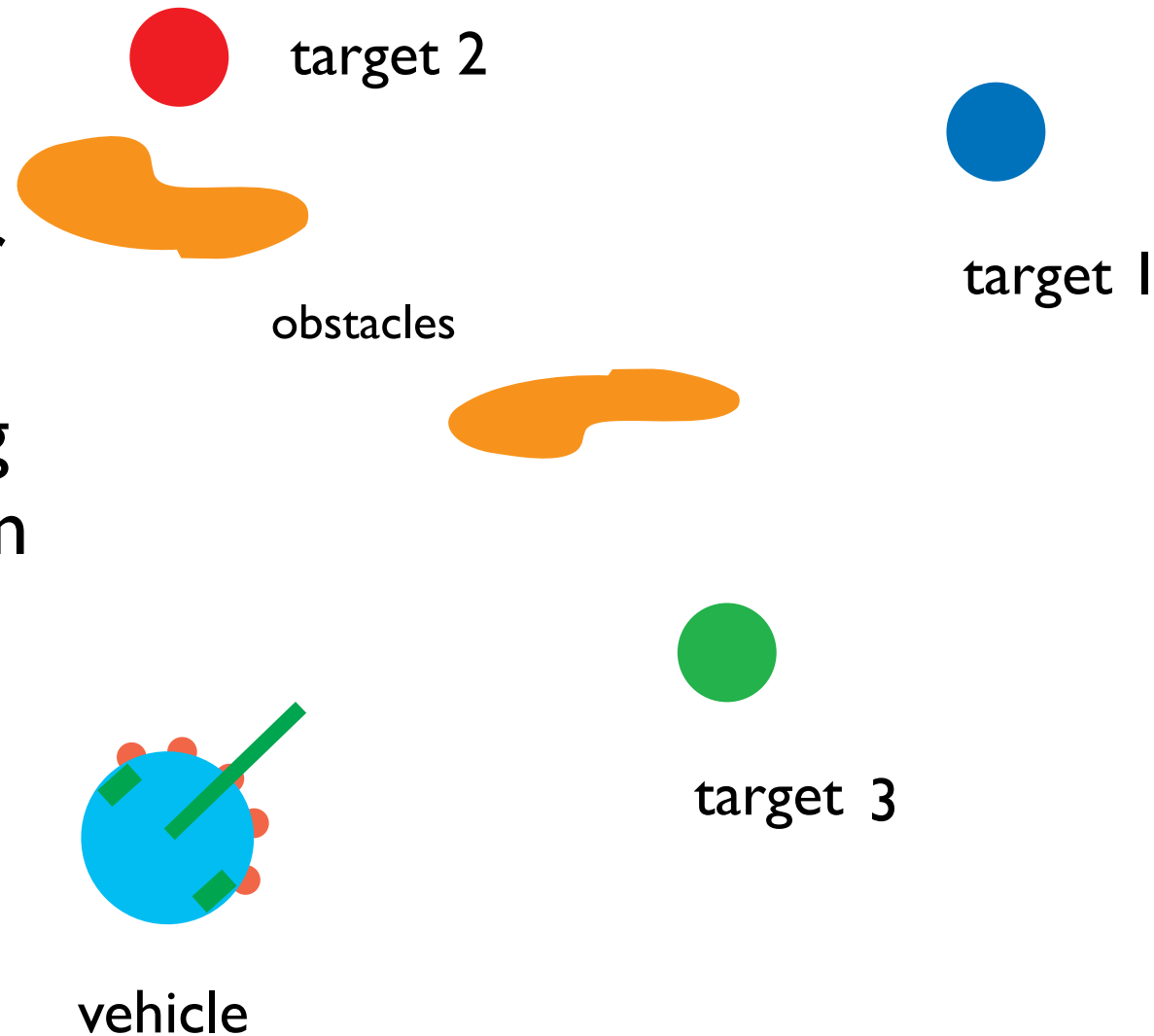


red a target

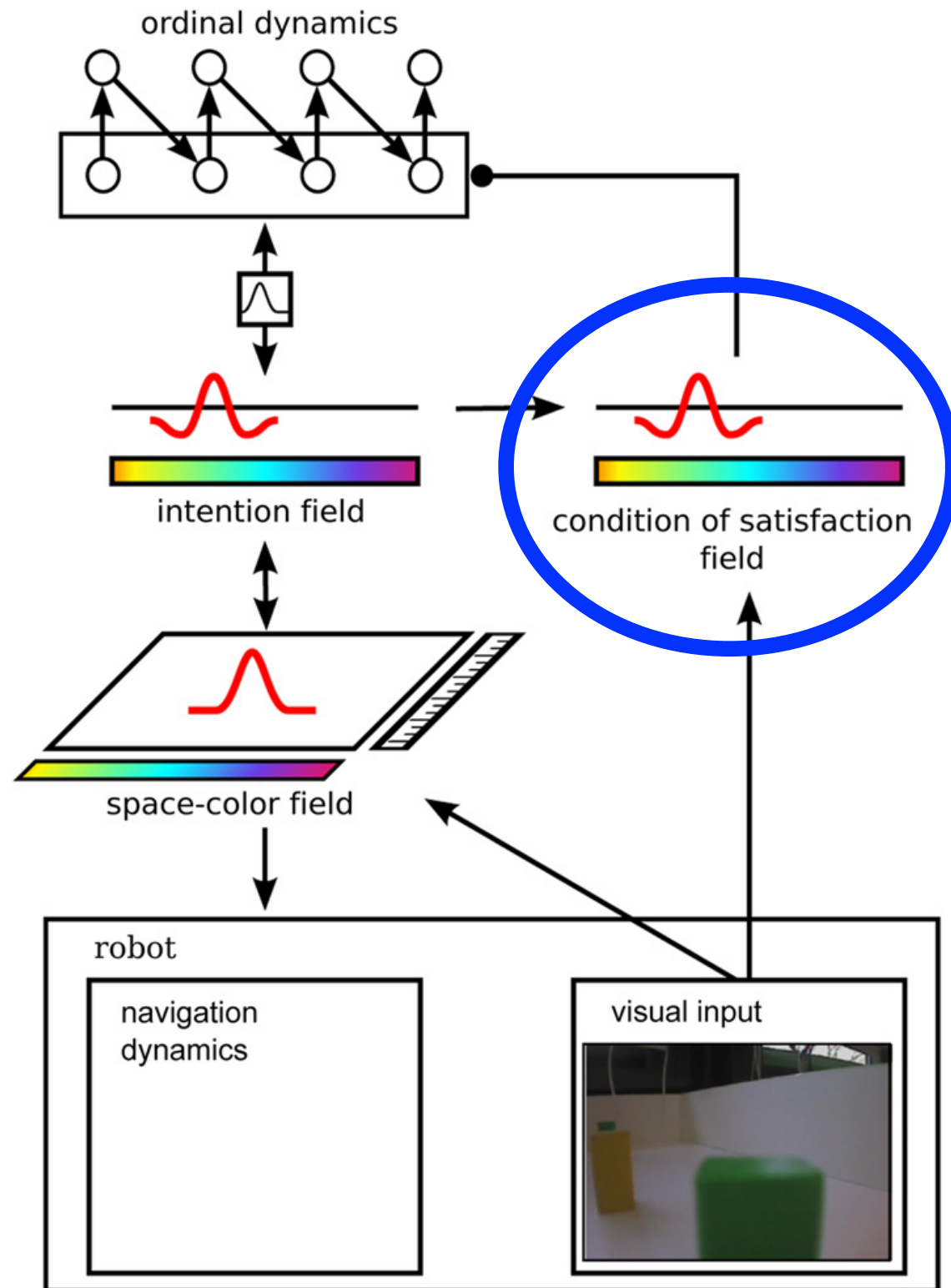


Neural dynamics of sequential processing

- when the sought color is found, switch to the next color by releasing the previous state from stability...through an instability



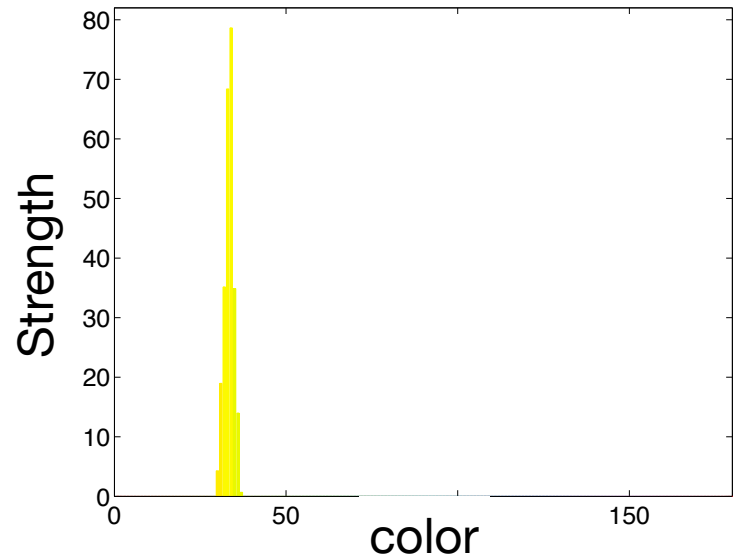
“Condition of Satisfaction” (CoS)



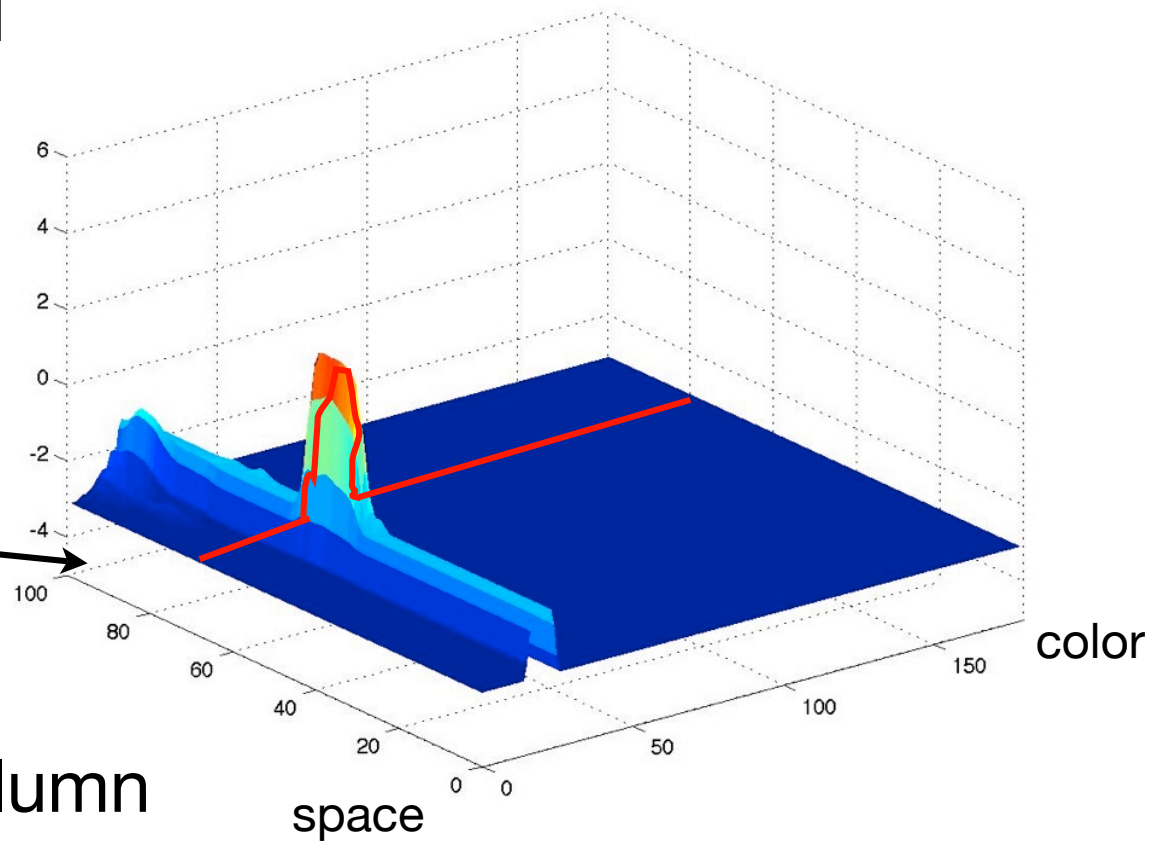
Camera image



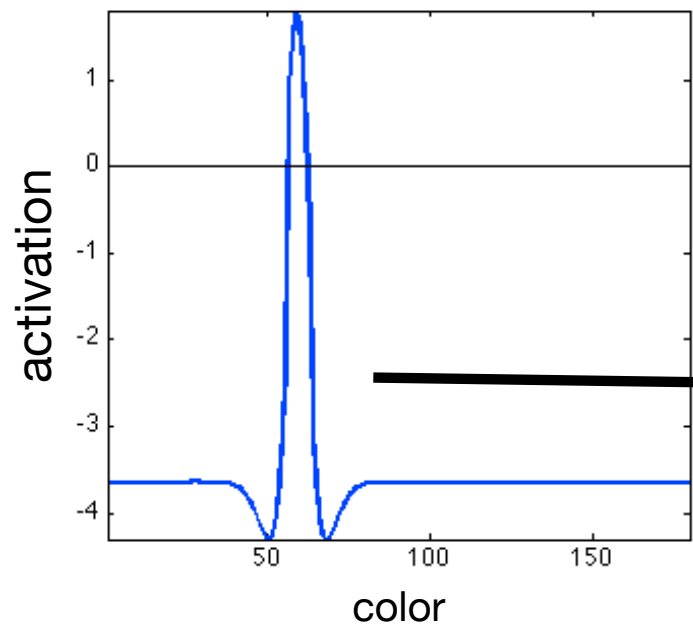
Color-space DF



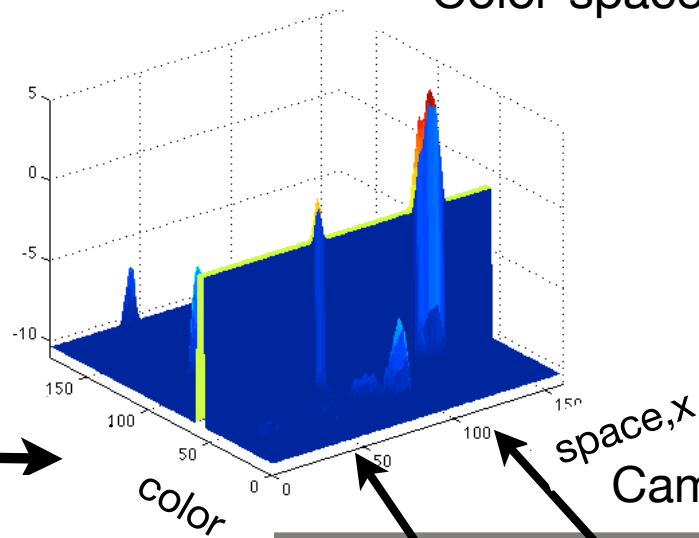
Color histogram of the column



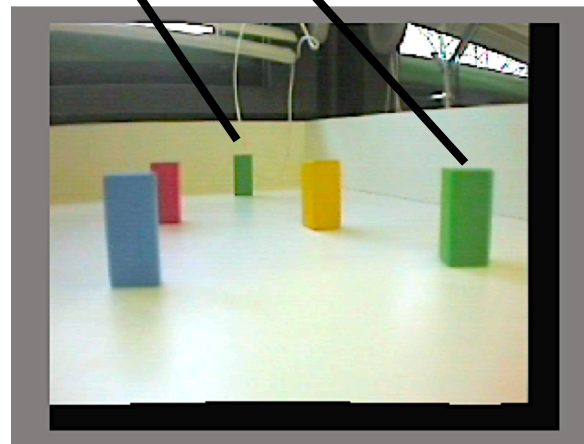
Intention DF



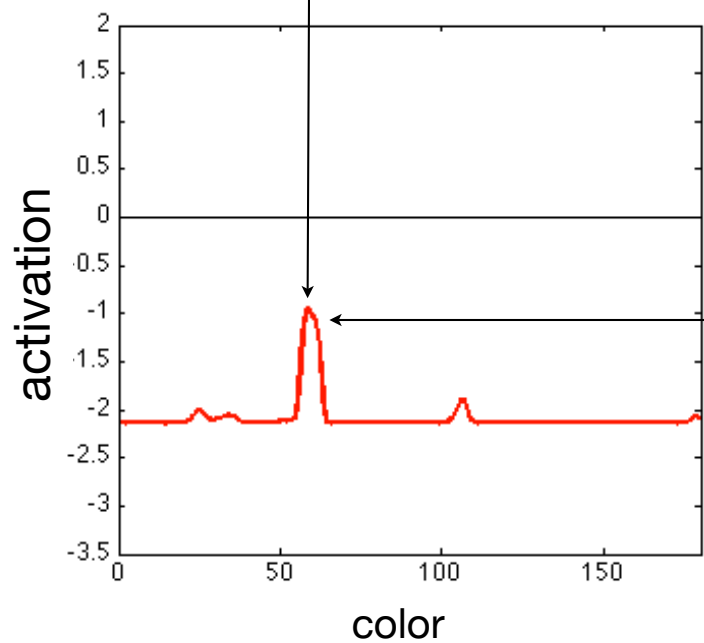
Color-space DF



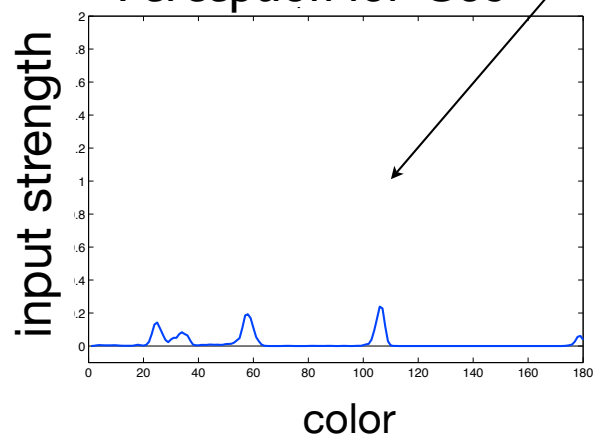
Camera image



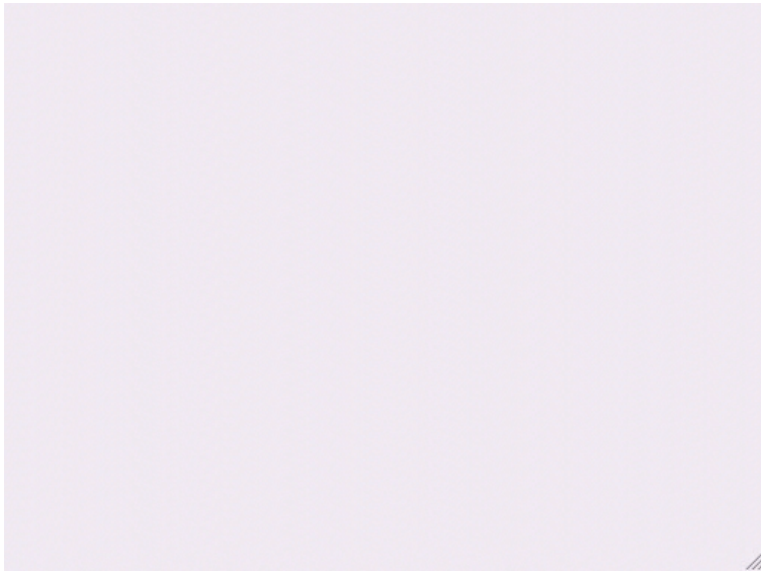
CoS DF



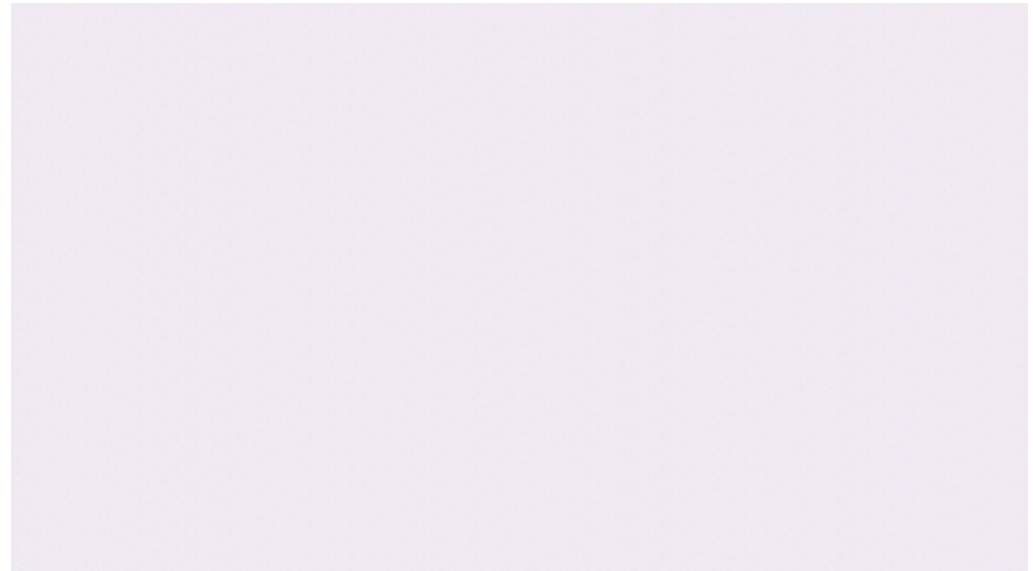
Perception for CoS



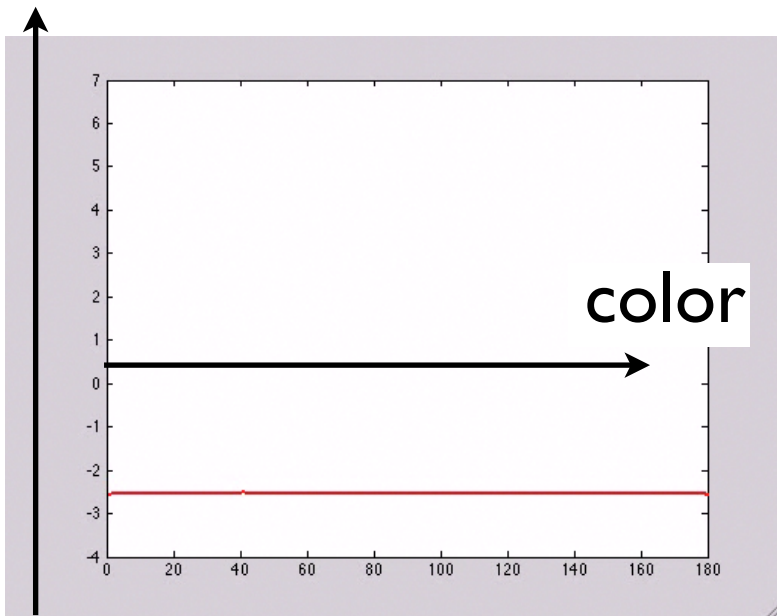
ordinal stack



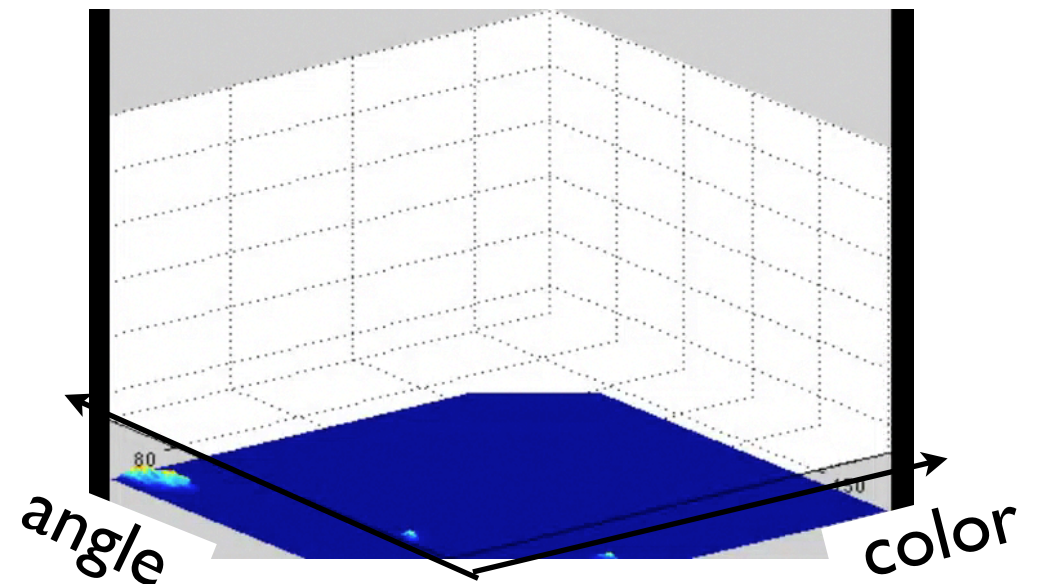
condition of satisfaction (CoS)



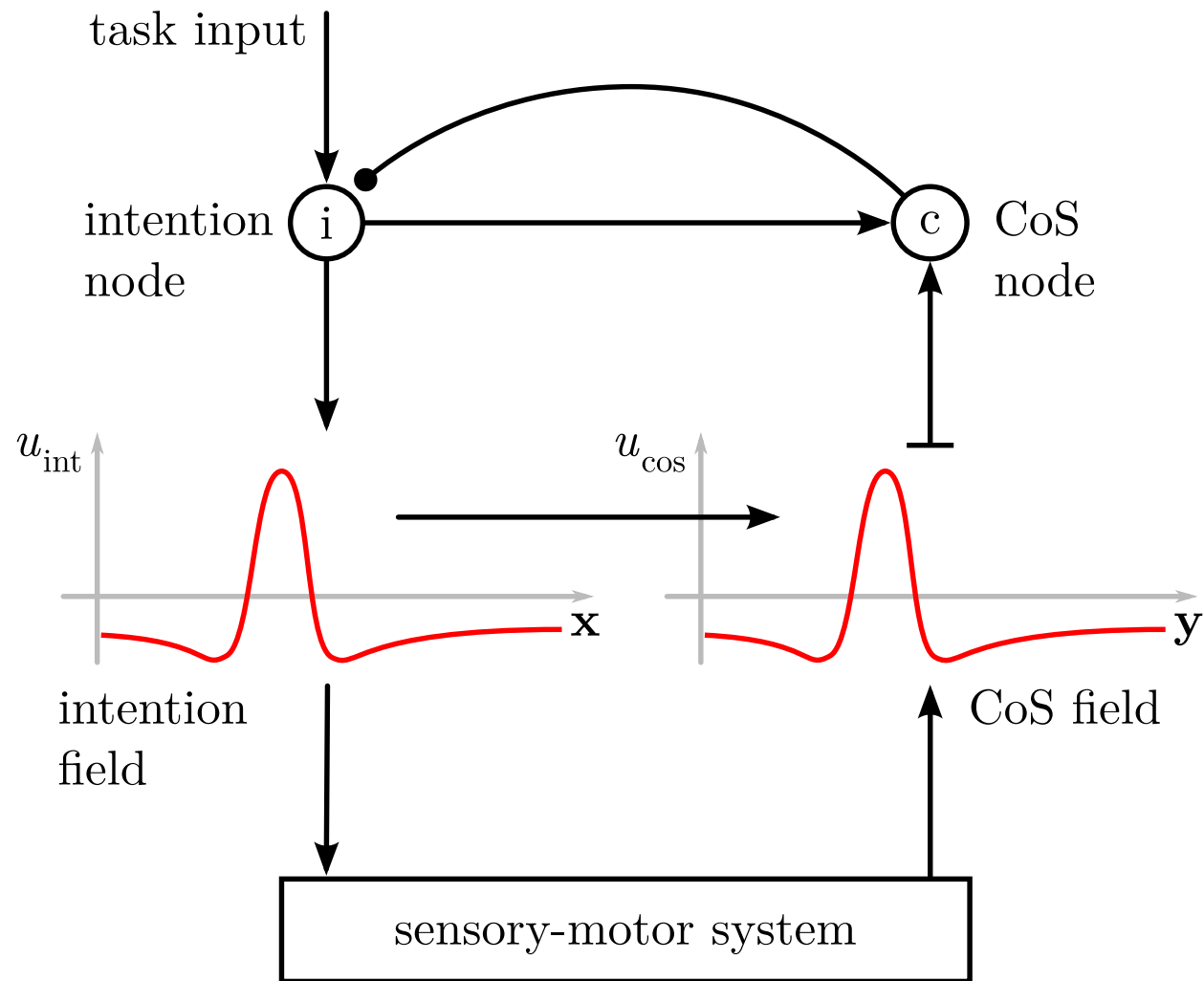
intentional state



2D feature-space field

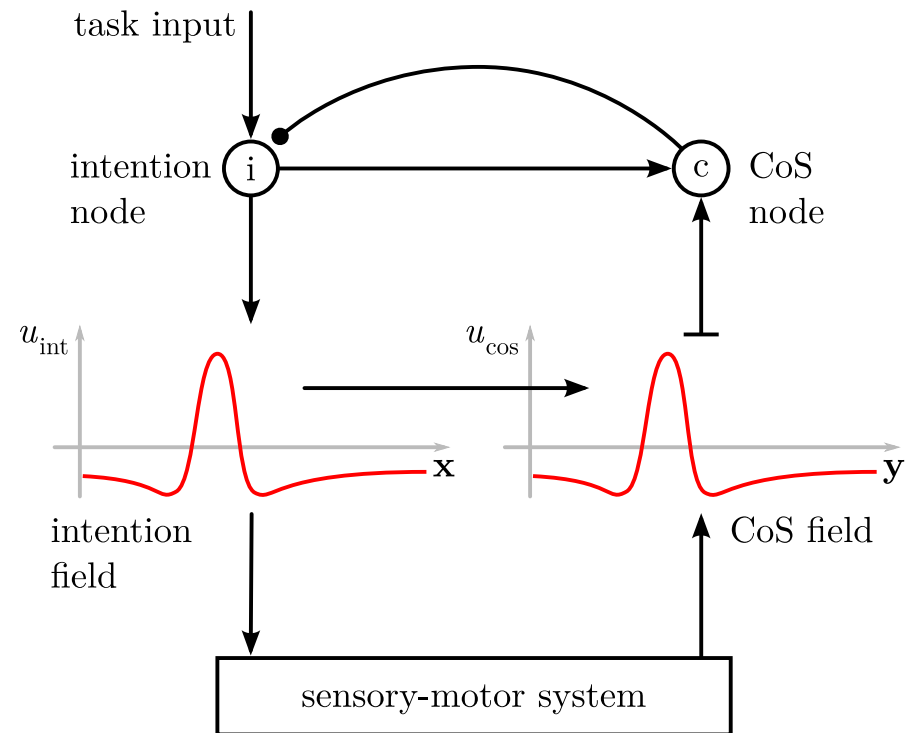


Generalization



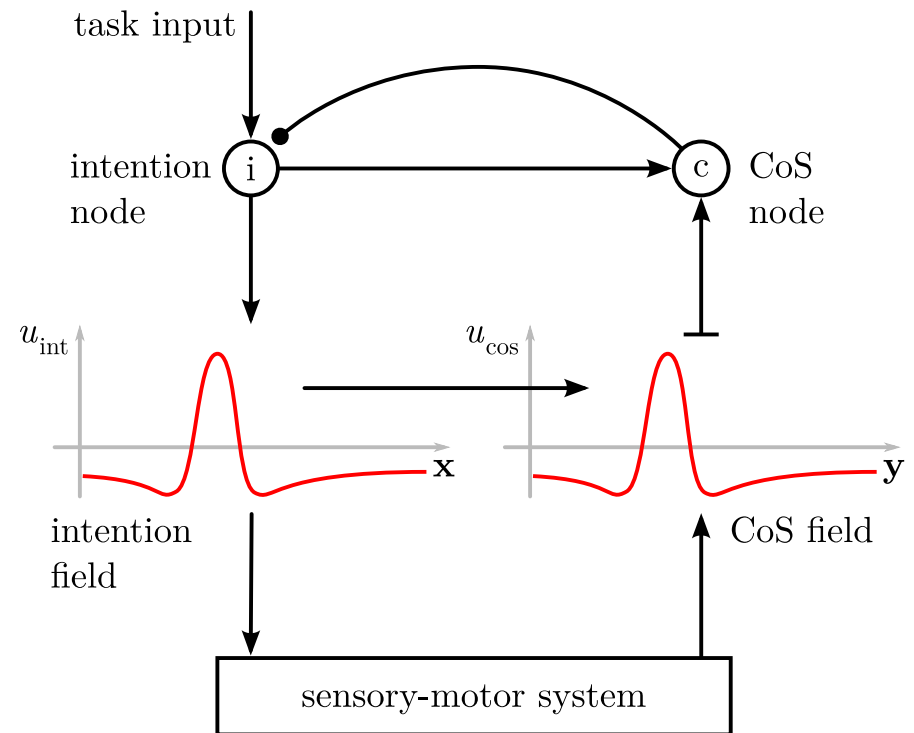
A DFT cognitive architecture for sequence generation

- every action is represented by an “intentional” node
- an an “intentional field” that represents the specific action (parameter value) that is to be enacted



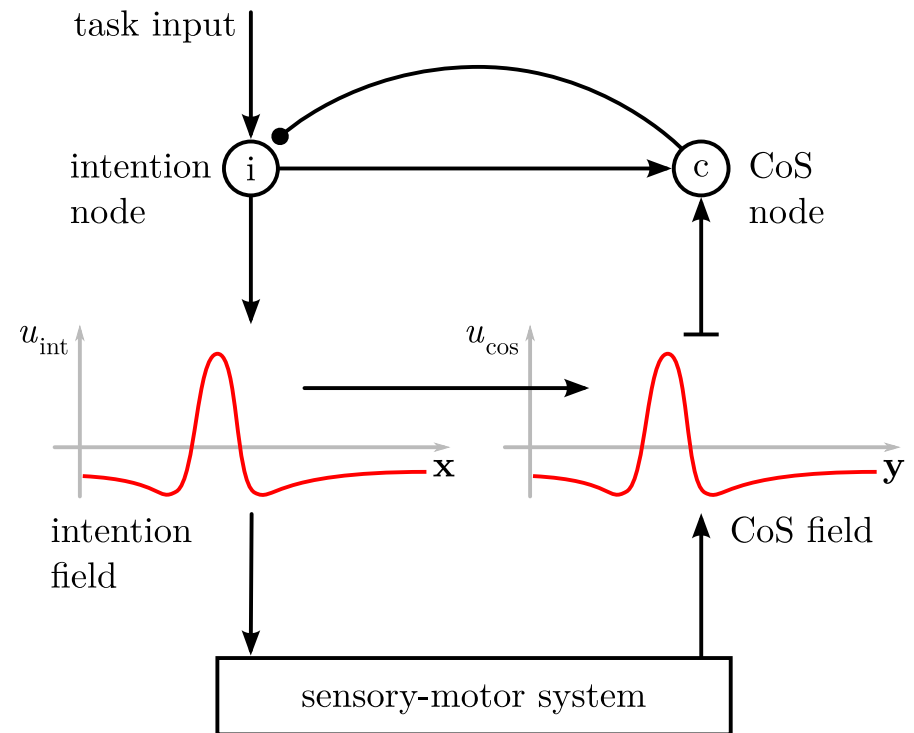
A DFT cognitive architecture for sequence generation

- the intention pre-activates a “condition of satisfaction” field with the predicted sensory information
- the CoS field goes through a detection instability as sensory input matches the prediction

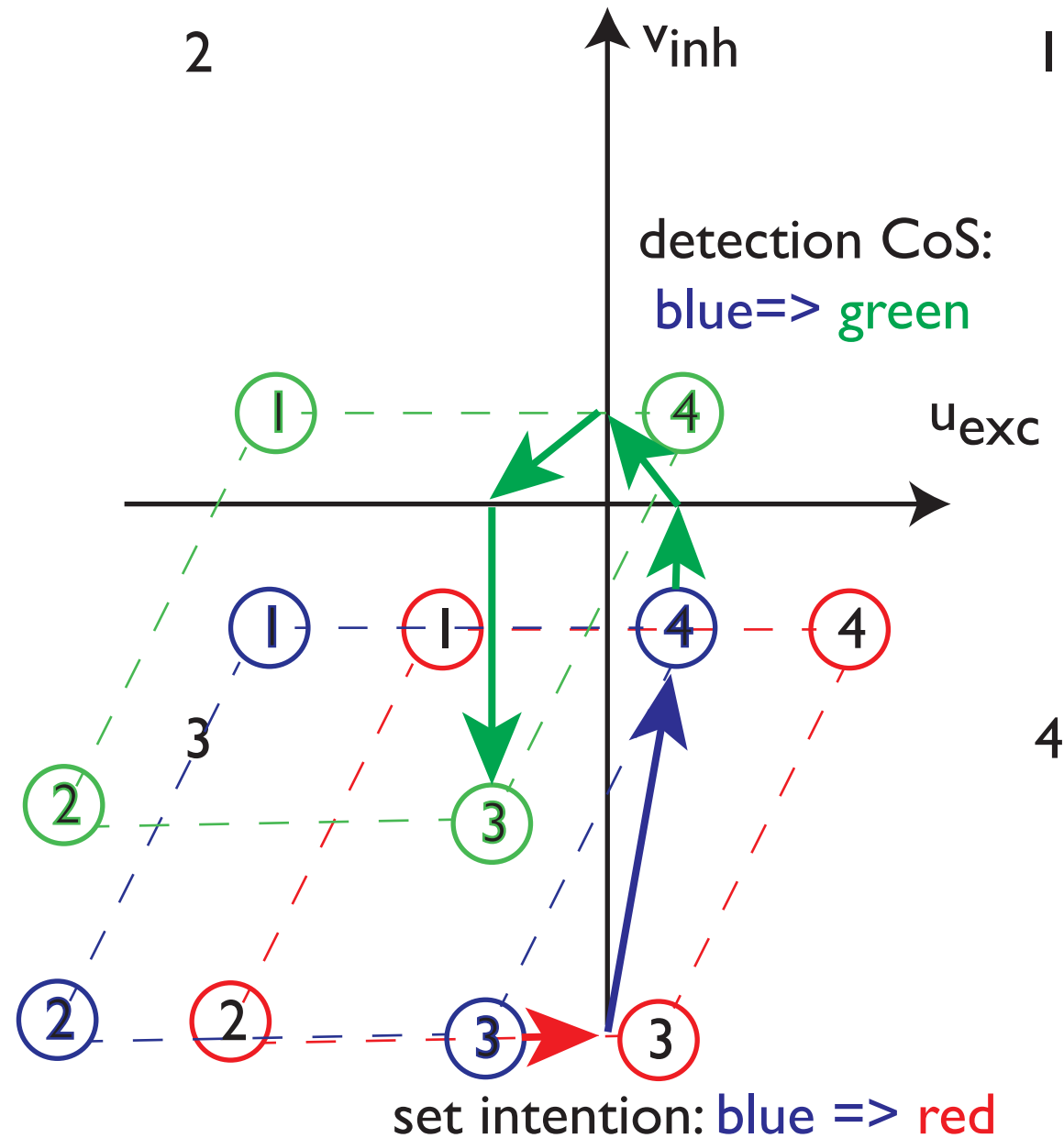


A DFT cognitive architecture for sequence generation

- this detection instability in CoS triggers the sequential transition by inhibiting the intention

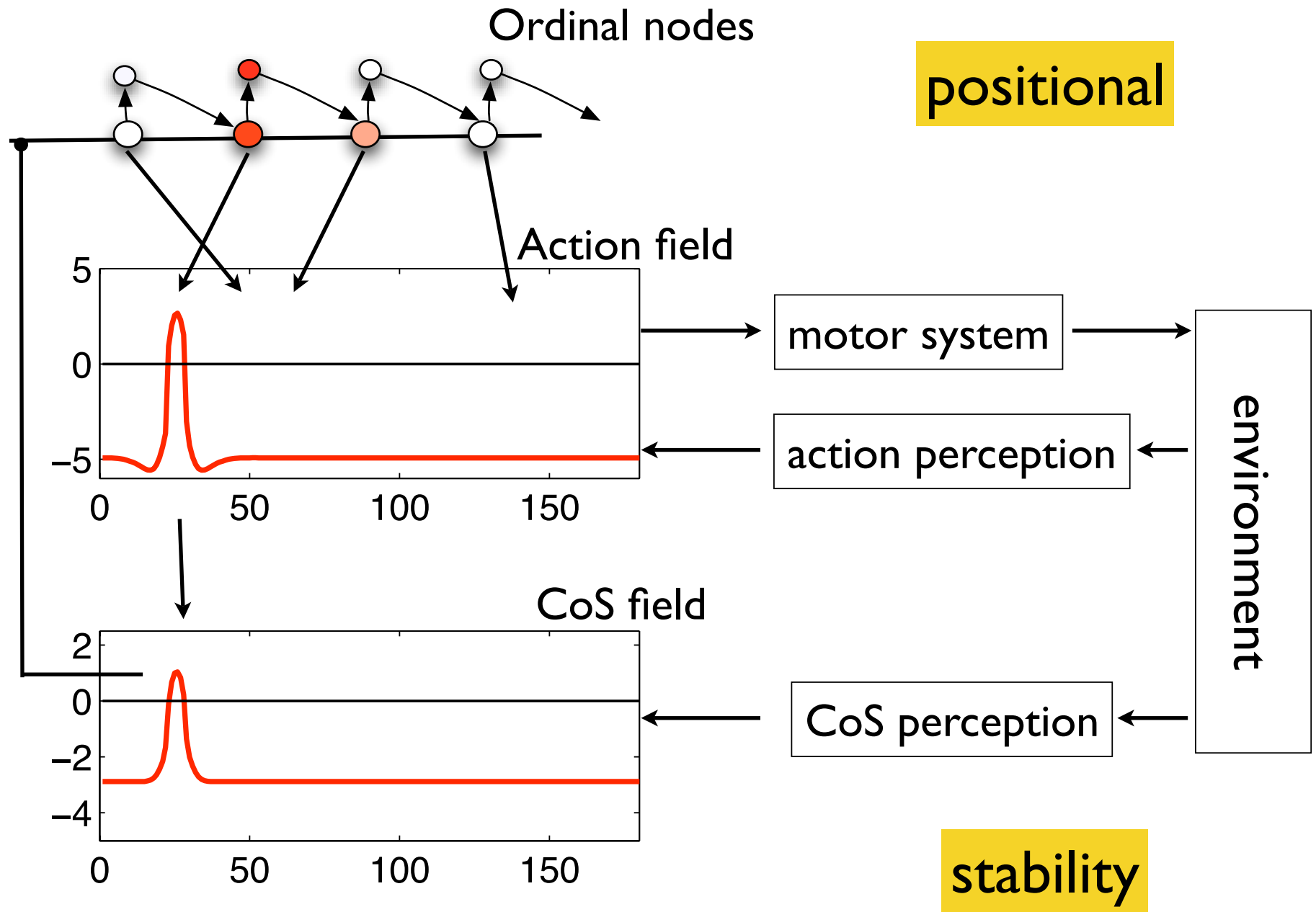


active transient of the CoS

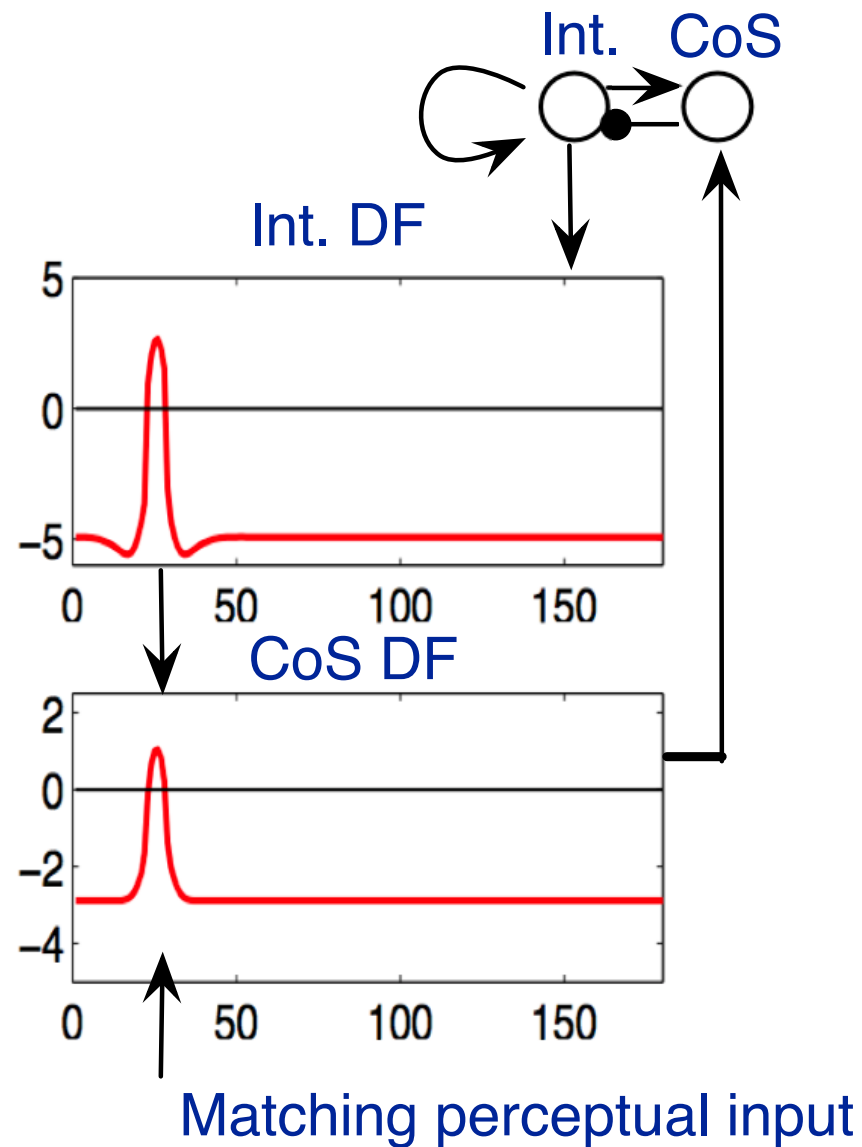


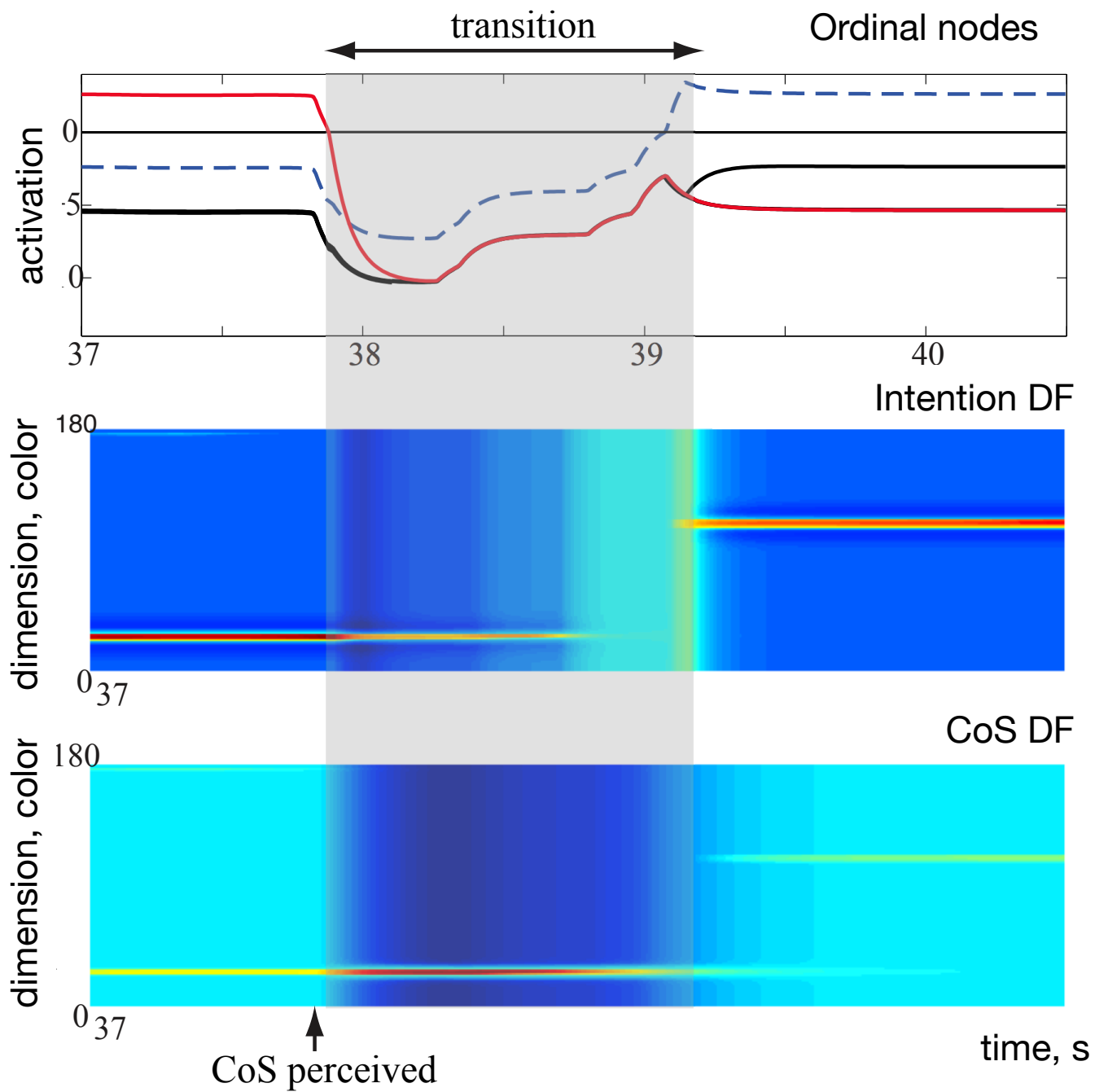
back to the DFT model

- the DFT model we have so far clearly is an instance of the positional model
- in which a positional context (ordinal node) is associated with the contents of an item
- the generic mechanism makes this link more explicitly as a neural (synaptic) association



mechanism for transition





Learning first item
("green")

Transition

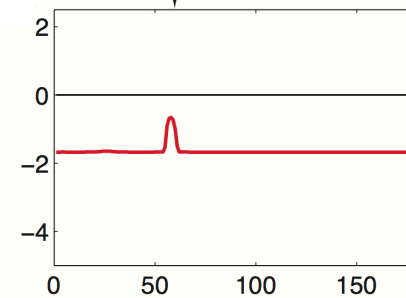
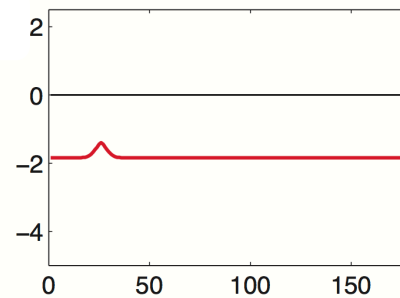
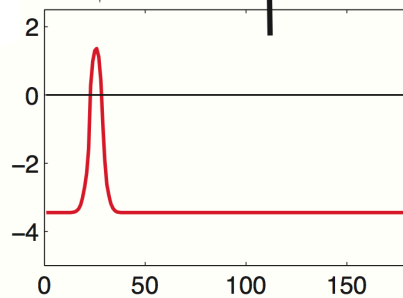
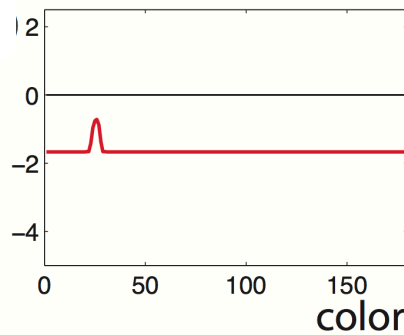
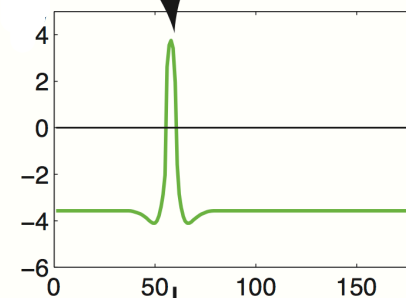
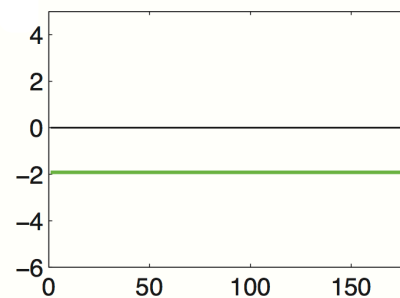
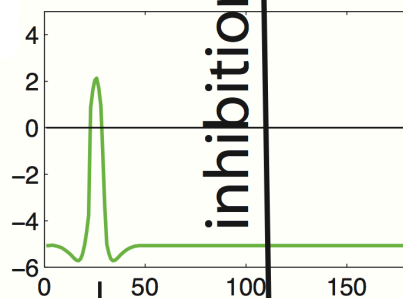
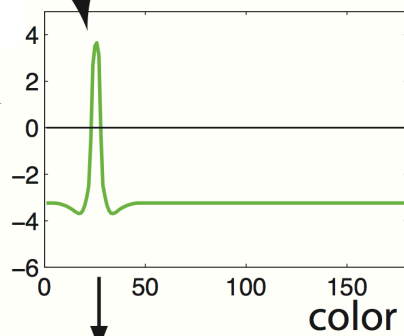
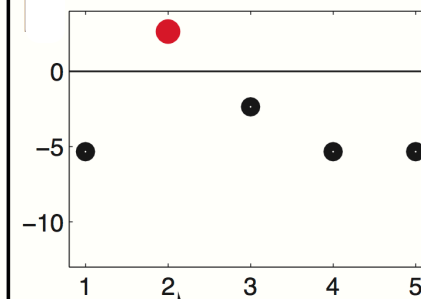
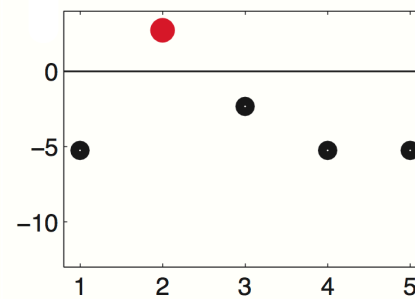
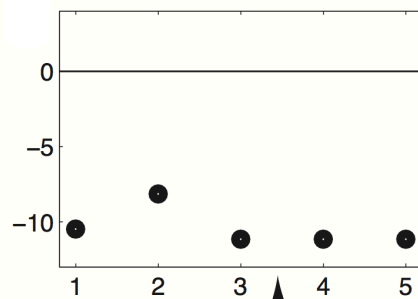
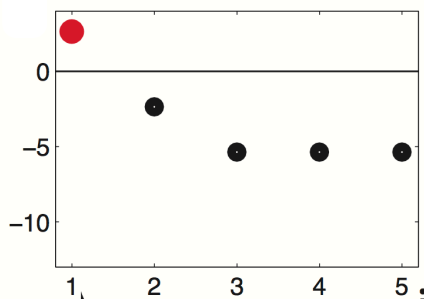
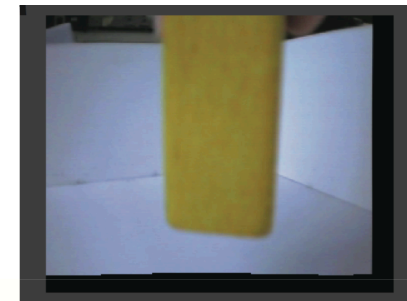
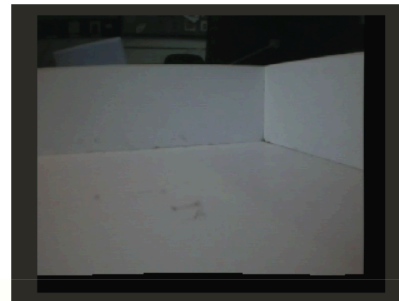
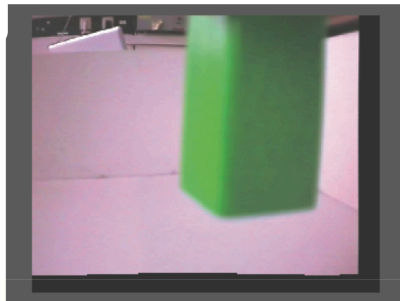
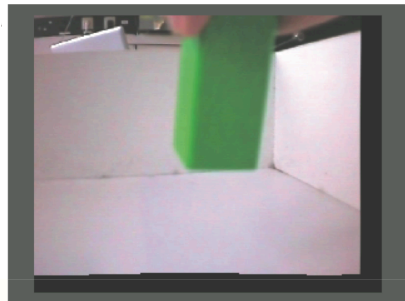
Learning second item
("yellow")

Camera image

Ordinal nodes

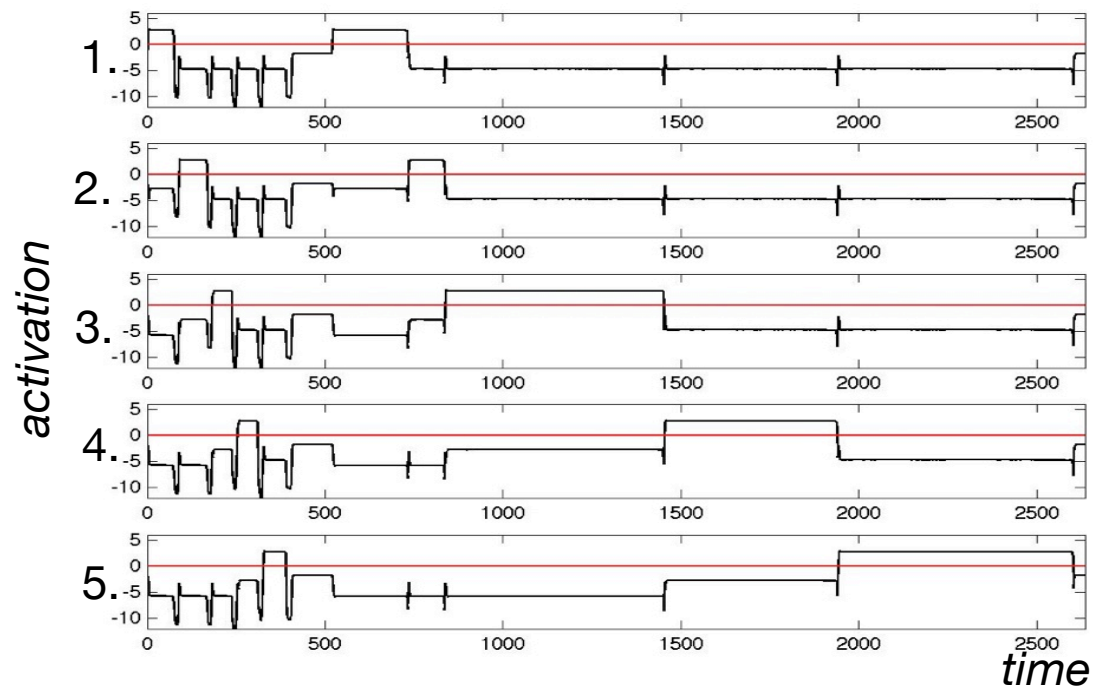
Intention DF

CoS DF

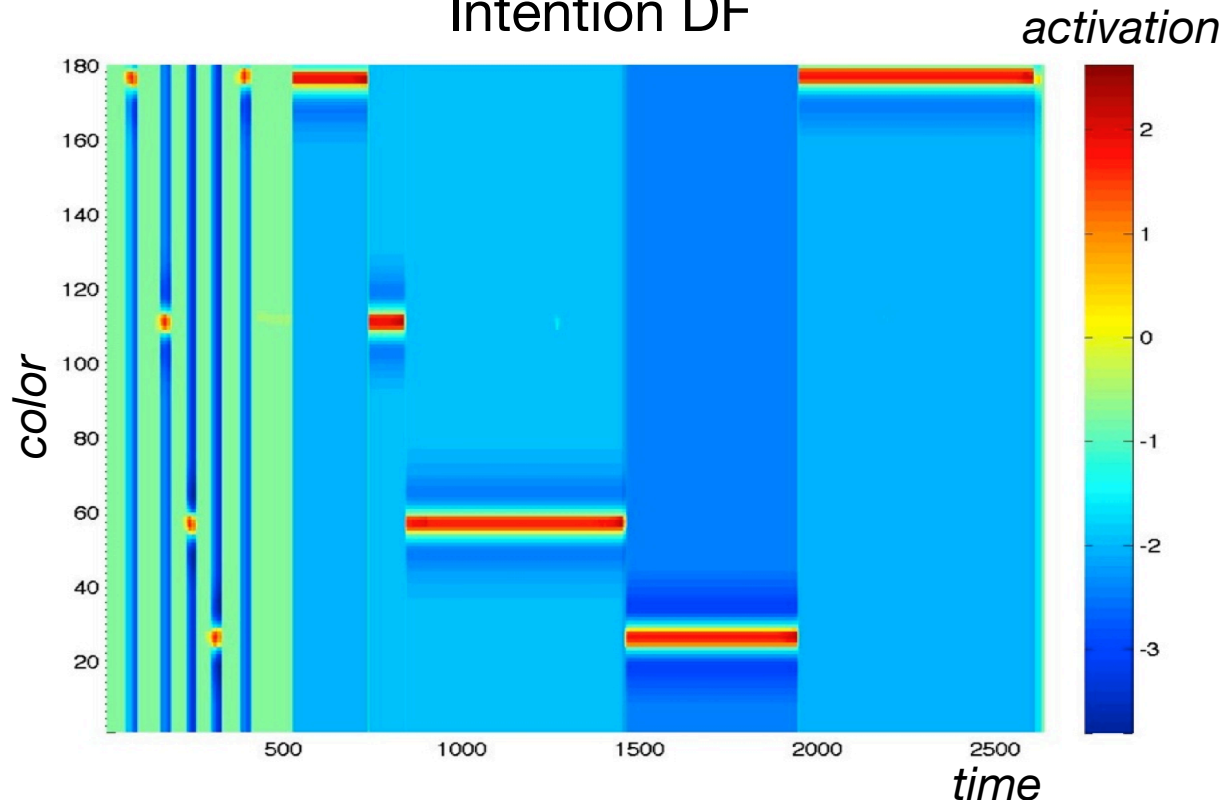


inhibition

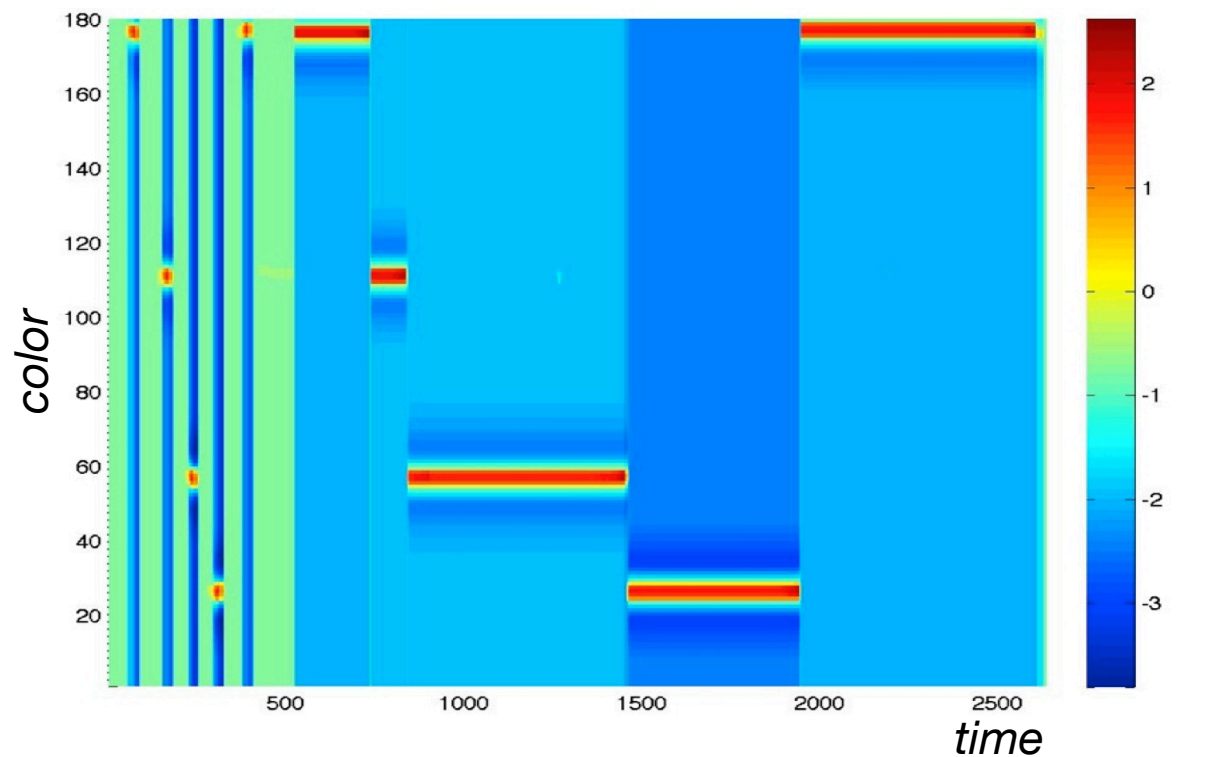
Ordinal nodes



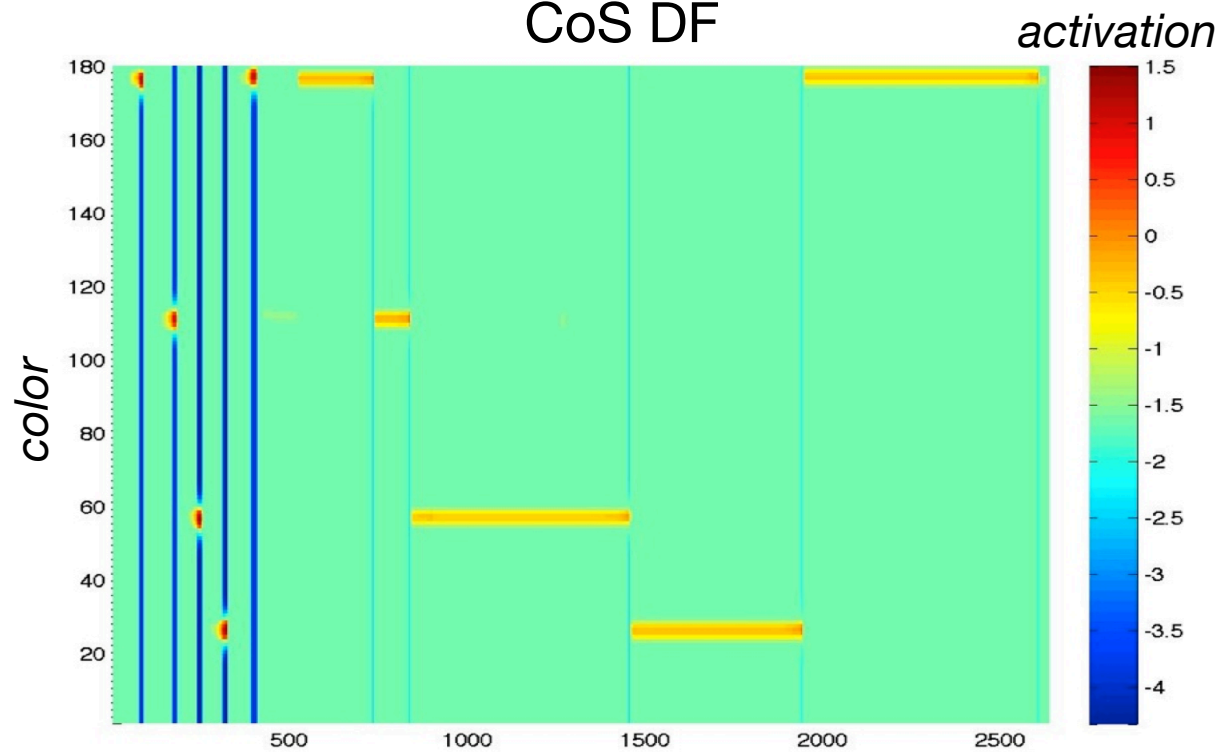
Intention DF



Intention DF

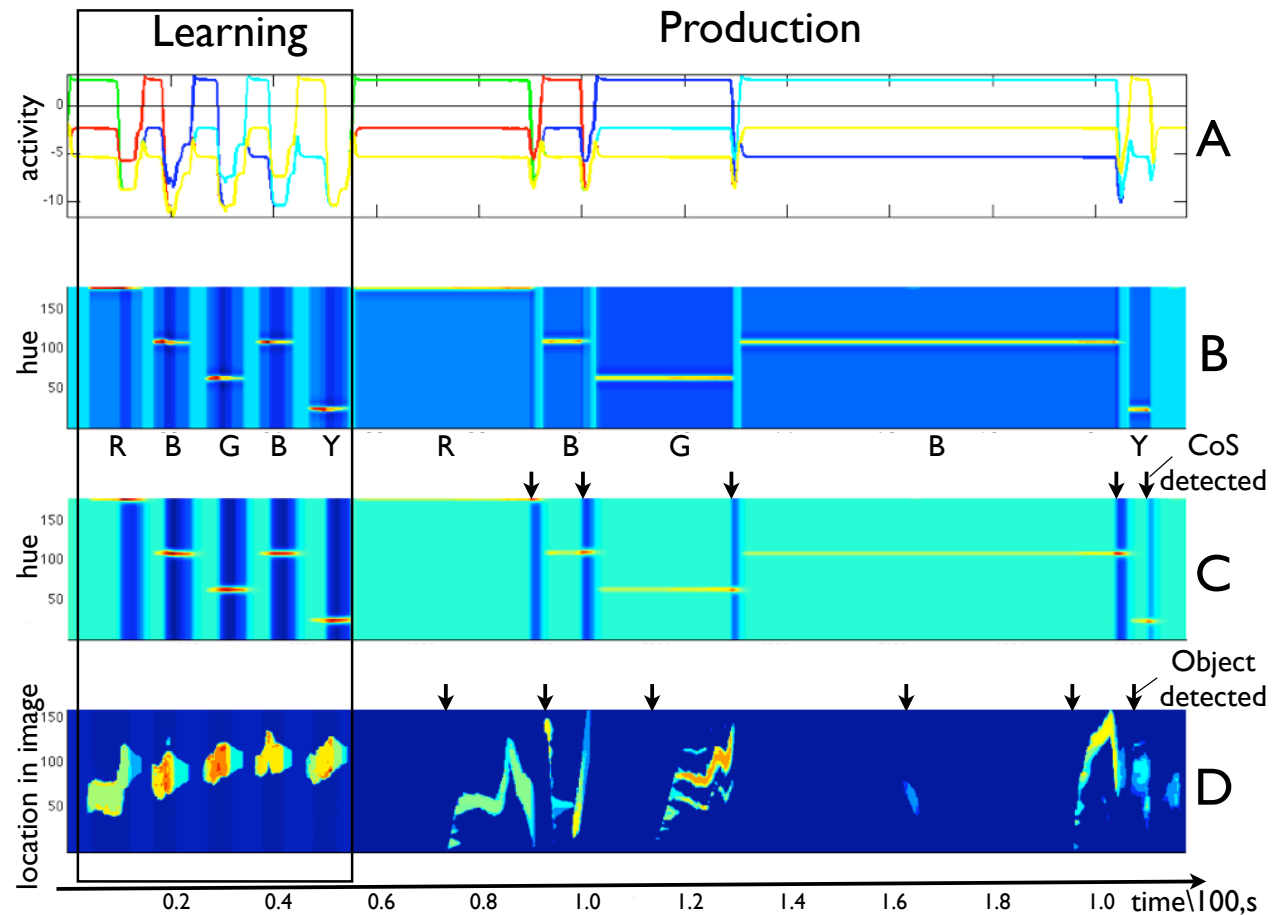


CoS DF

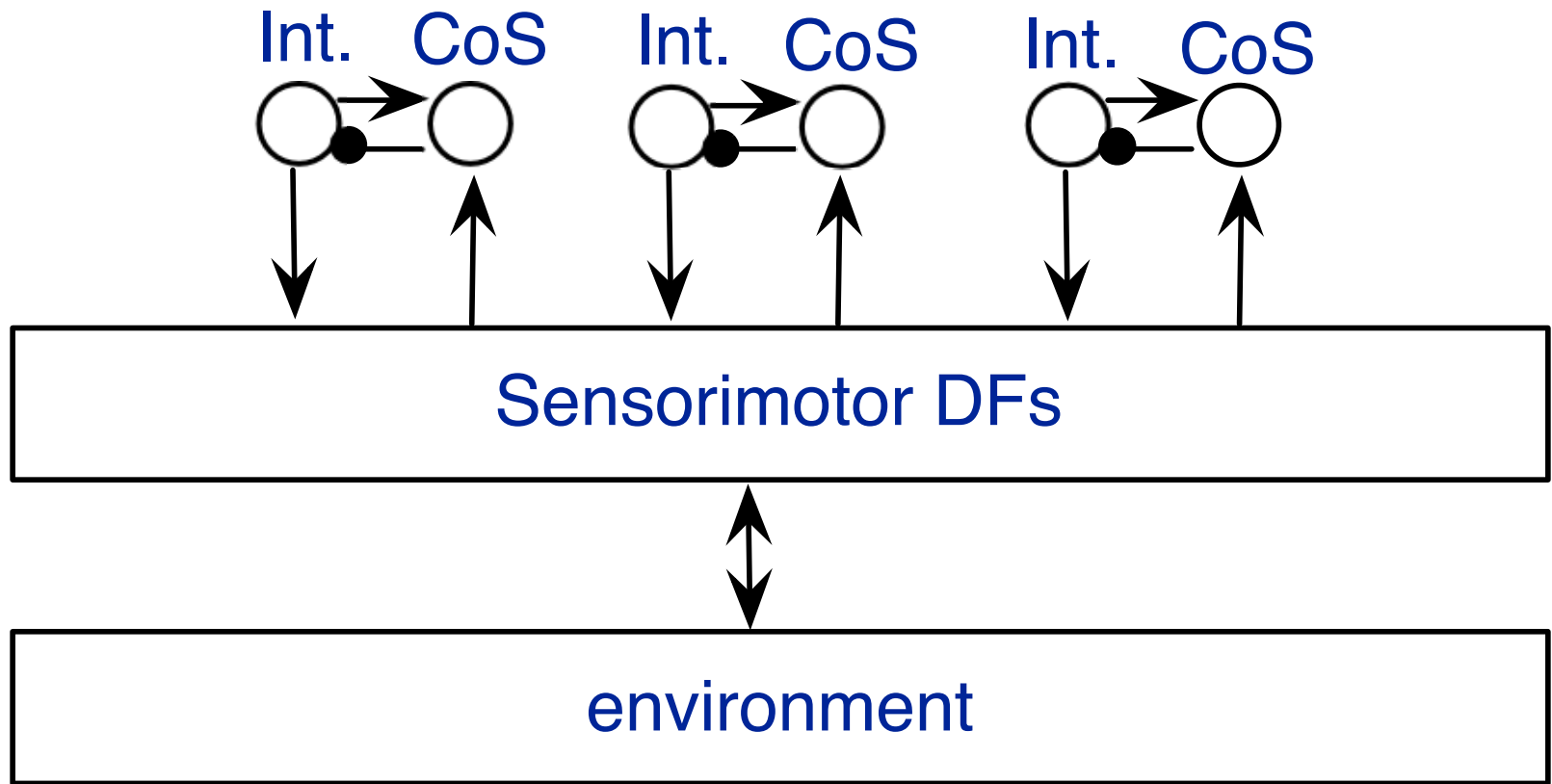


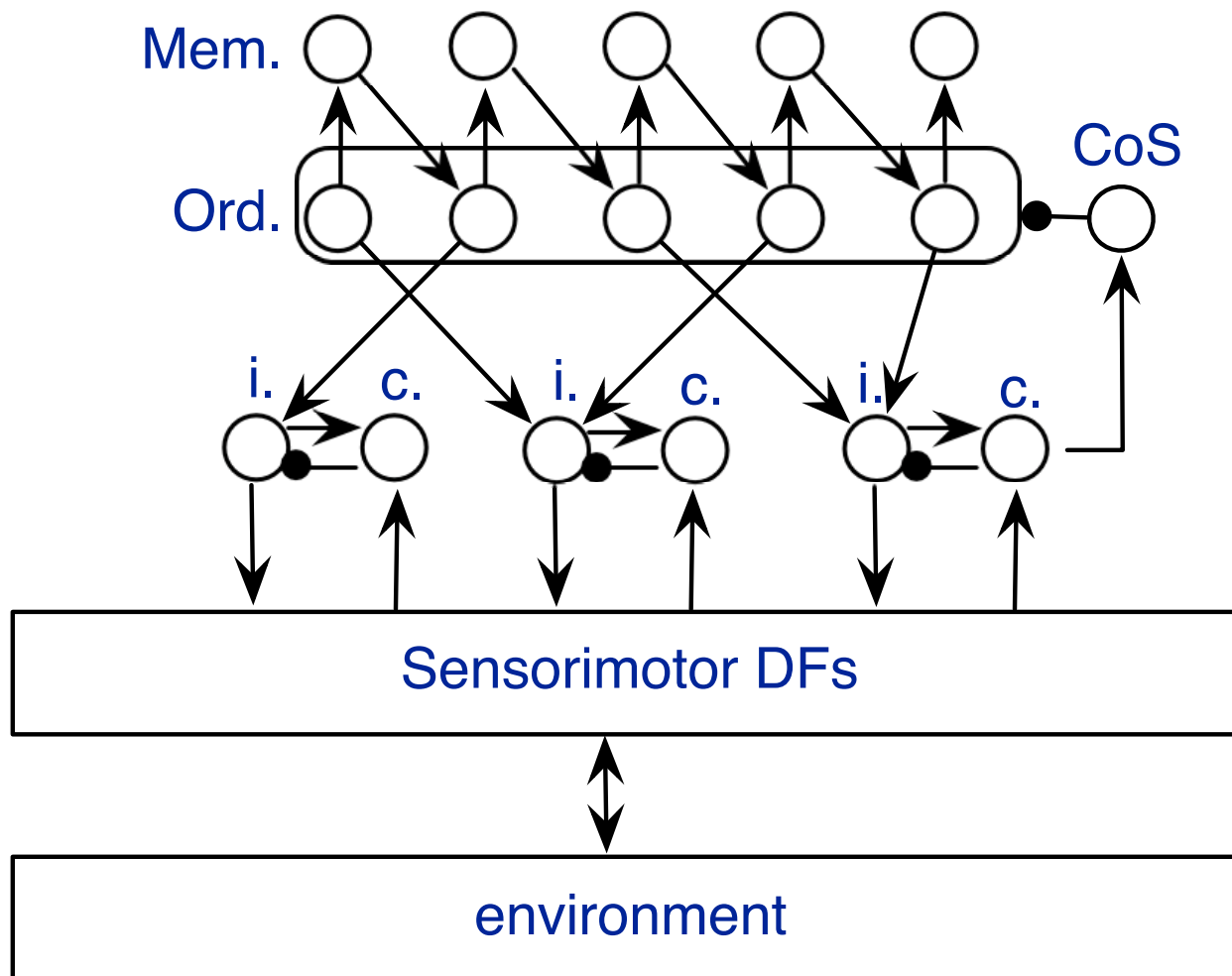
Autonomous sequence generation

- discrete events in time are autonomously generated
- when the world matches the intention: condition of satisfaction

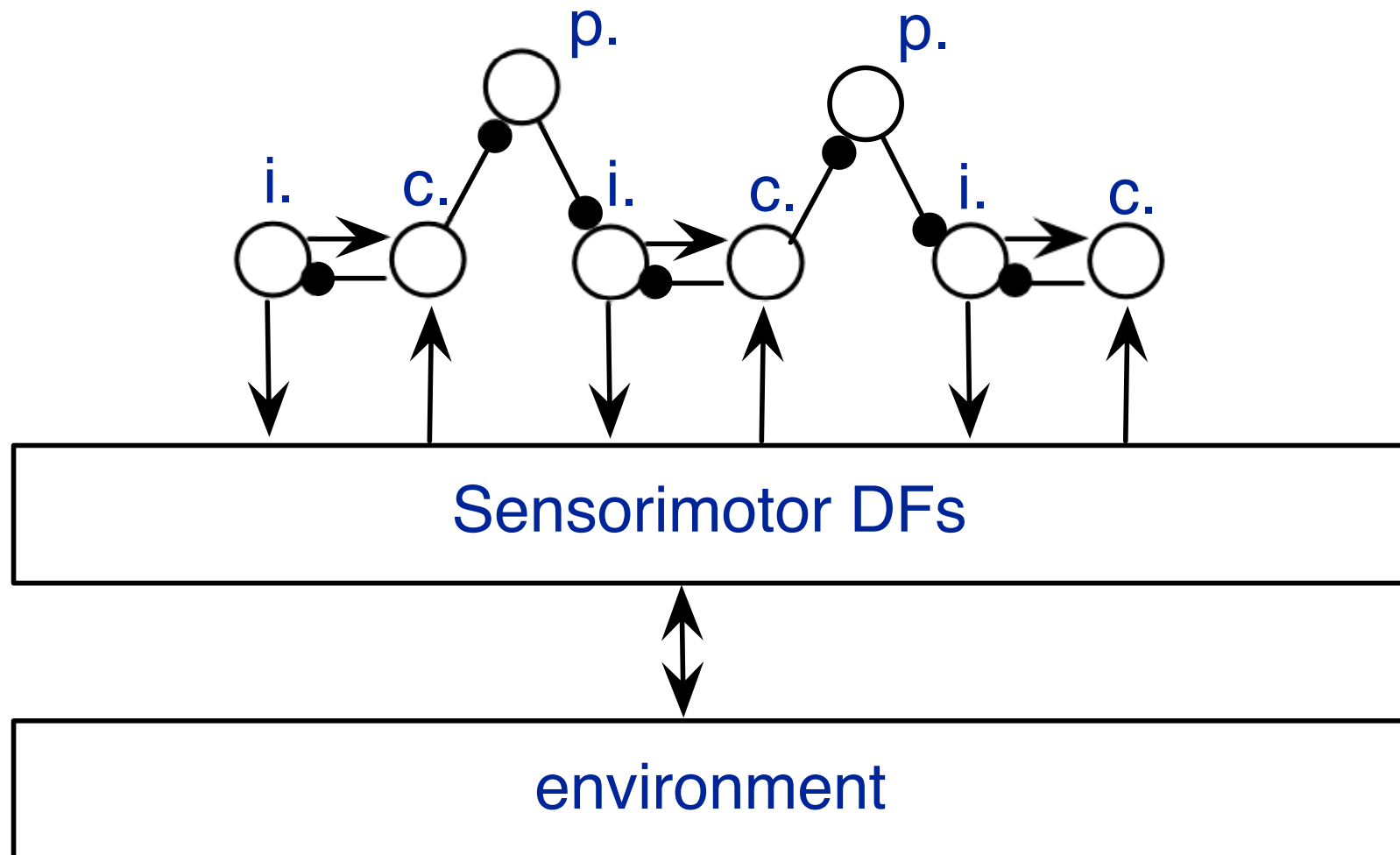


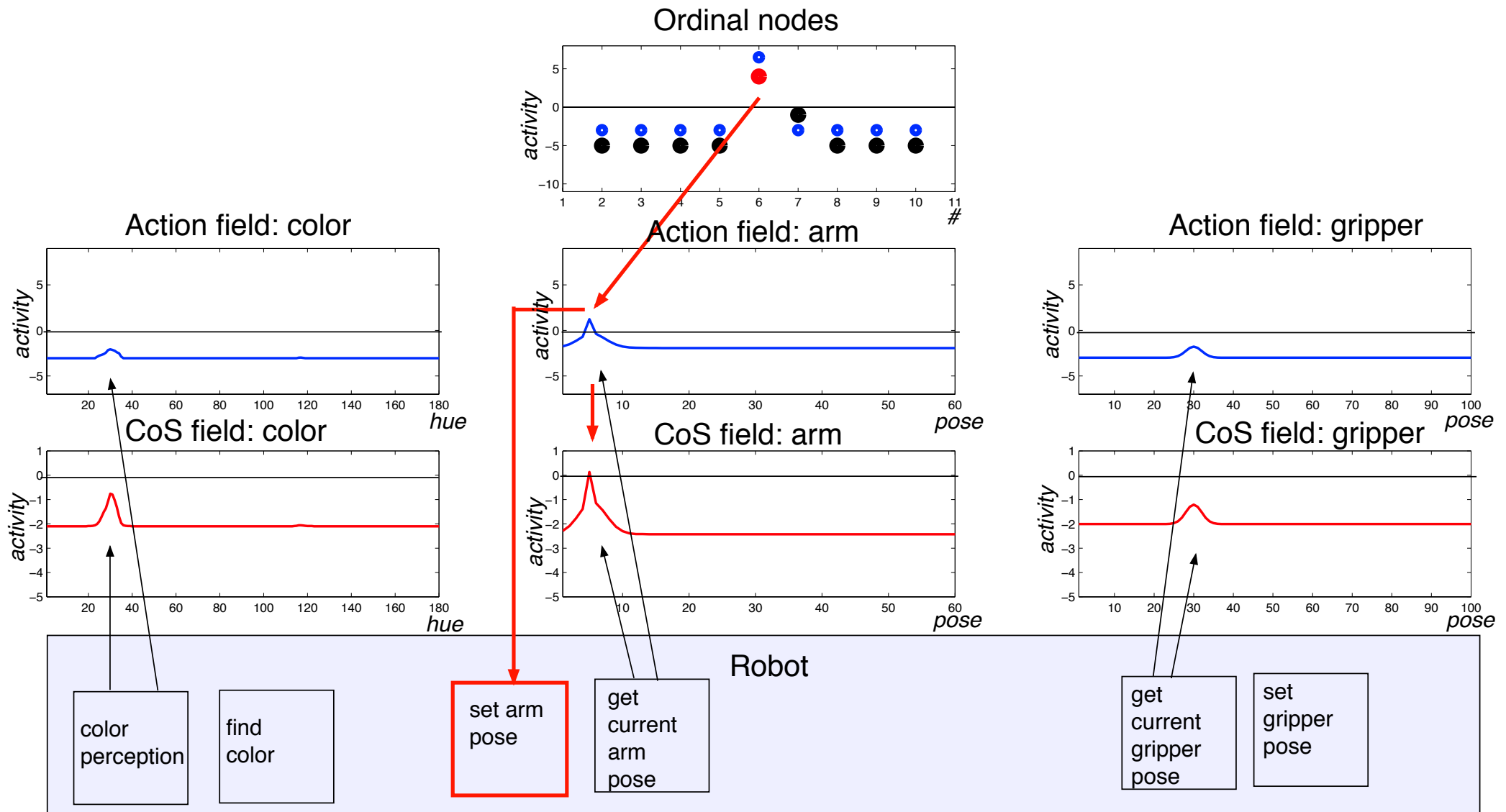
Generalization



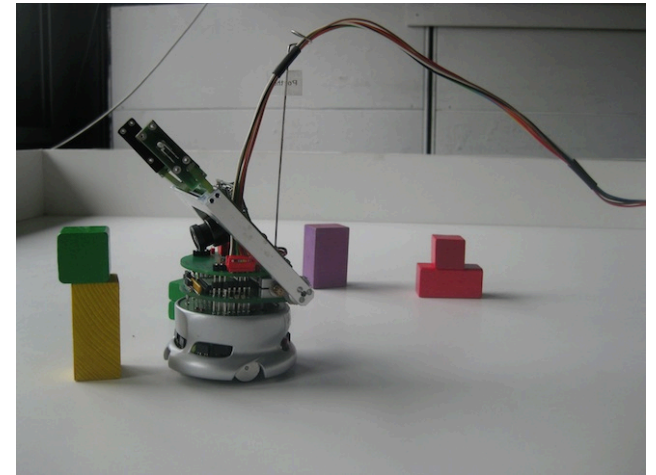
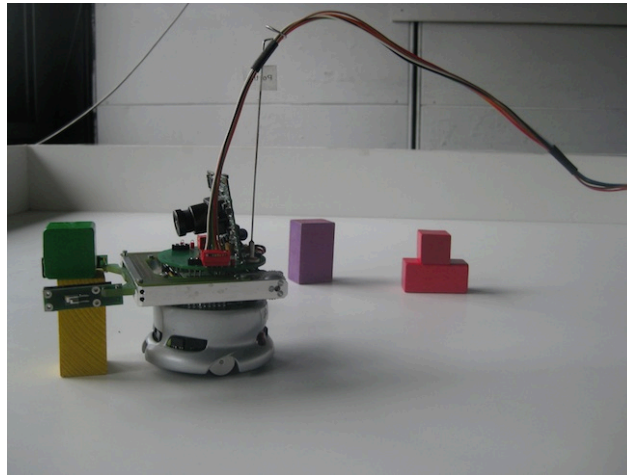
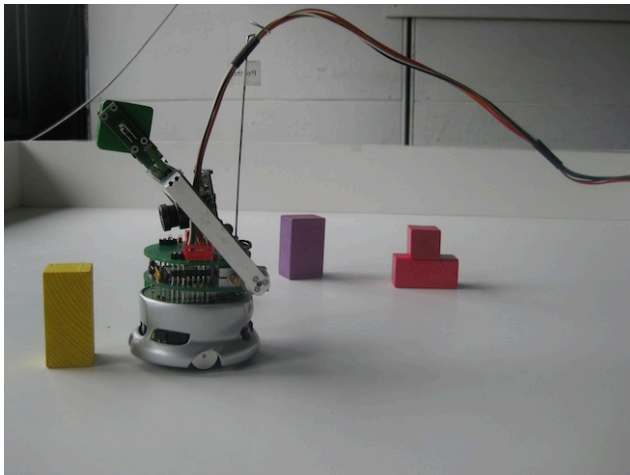
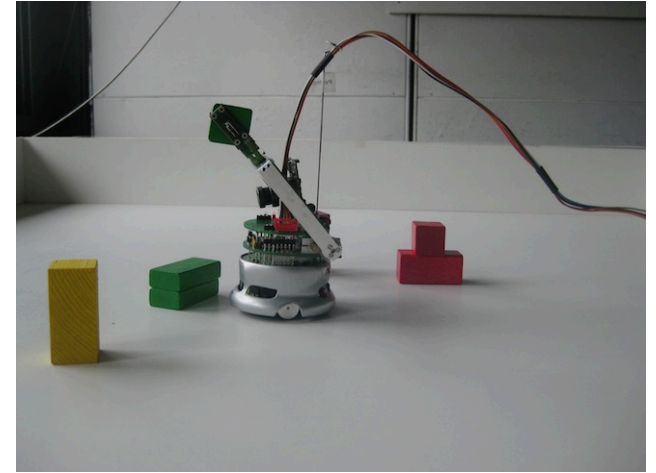
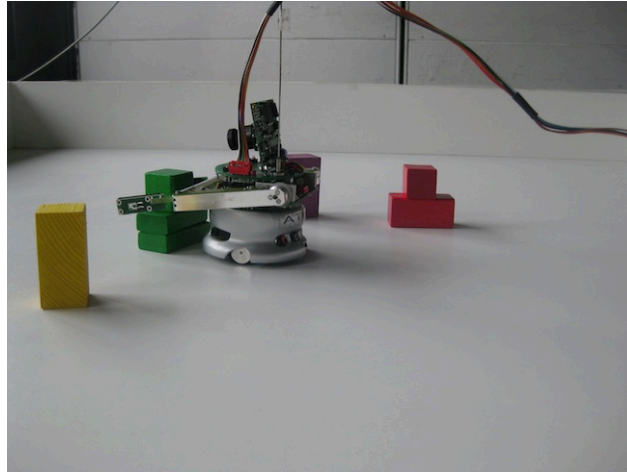
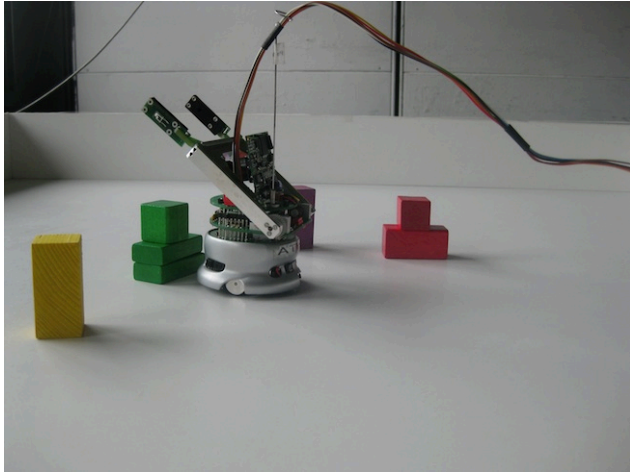


chaining



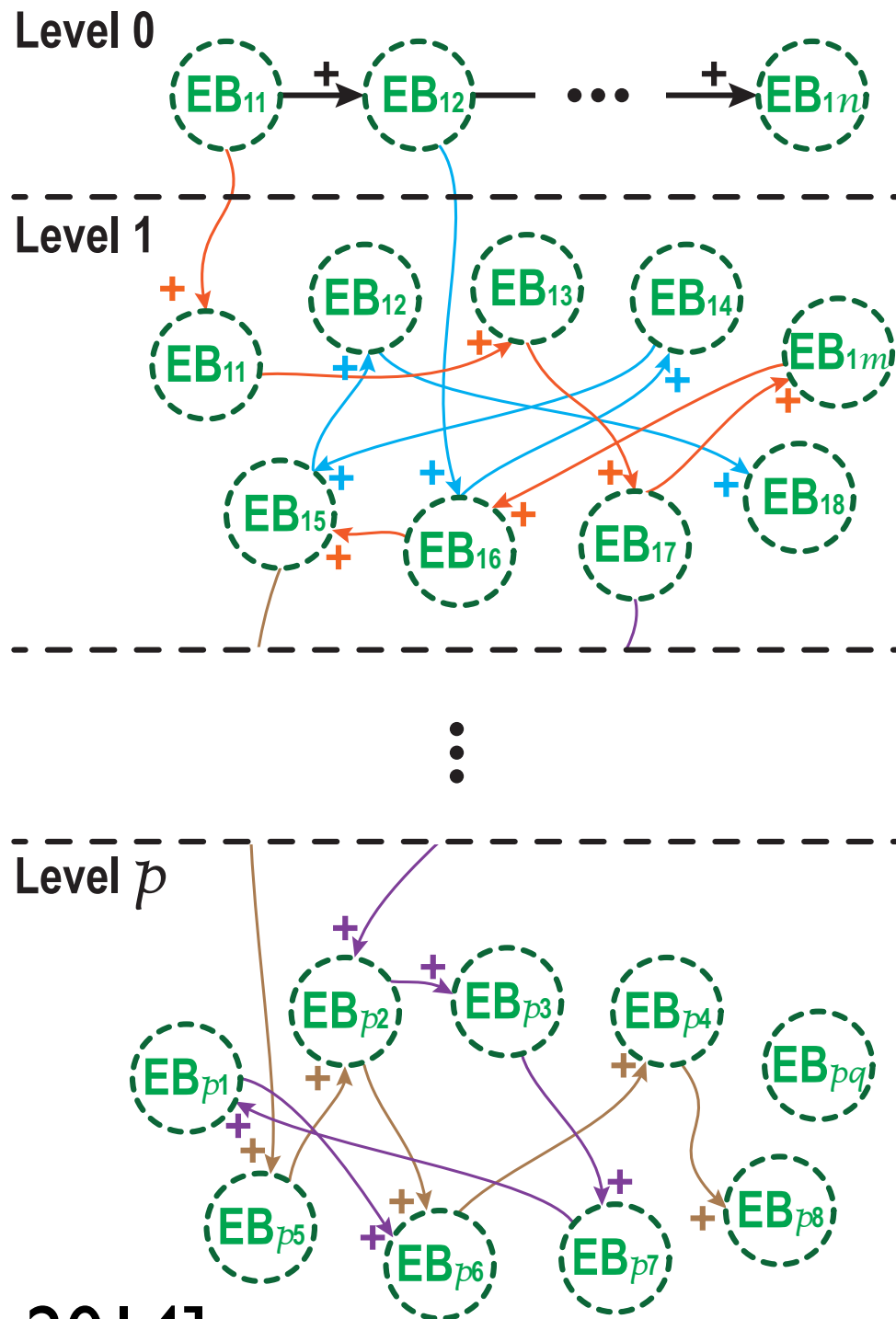


[Sandamirskaya, 2011]



[Sandamirskaya, 2011]

hierarchy



[Duran, Sandamirskaya, 2014]

Conclusions

- I reviewed the mechanism of transitions between stable (intentional) state by the condition of satisfaction and its underlying dynamical mechanism of active transient generation
- This is a critical element that enables DFT to account for complex sequential behaviors and autonomous cognitive processes
- This key mechanism sets apart DFT architectures from almost all other neural processing accounts