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

A

“Same” Trial

Test Display

Memory Display

Delay

B

“Different” Trial

PF

Inhib

“Different” Peak

FWM

“Same” Peaks

Delay

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

A trial

B trial

A not B error
Toyless variant of A not B task

Linda Smith & Esther Thelen
Dynamic Field Theory of A not B

- Activation field
- A location
- B location
- Movement parameter
- Task input
- Specific input
- Preshape input
B trial

young

old

interaction-based
sustained activation

activation field

input-driven detection

after delay

memory trace

movement direction

A B

A B

A B

A B

A B

A B
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

vehicle colored cues

green arrows indicate motor commands

green square indicates target

green diamond indicates cue

ego-position $\phi$

start specific cue delay turns to target

star specific cue
delay
turns to target
A not B robot
correct responses on trial $B_1$

First Spontaneous Errors

Second Spontaneous Errors

Destributions of Switches

Destributions of Error Frequencies
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