

Computational Cognitive Neuroscience ISM

Module 1 - Cognition and Computation: How different are they?

1. Philosophy of Mind

Readings:

- [Puzzle of Conscious Experience](#)
- [Searle](#) (417 - 424)

2. Reverse engineering the brain / Comp Model of Mind

Readings

- [Turing](#)
- [Nilsson - Human-Level AI?](#)

[Lecture Slides](#)

3. Theory of Mind

- [Minsky's Society of Mind](#)
- Our [ToM of ChatGPT](#)

4. Later: Subsumption (Perception of Mind)

- Minsky, [Braitenberg's vehicles](#)
- [Cheating Robot](#)
- [Intelligence without reason](#) by Rod Brooks
- Joanna Joy Bryson's [old PhD thesis](#) since it talks super clearly about BoD (Behaviour Oriented Design) and POSH (Parallel-rooted, Ordered, Slip-stack Hierarchical)

Module 2 - Deeper into the Brain

1. Synaptic plasticity (Learning)

Readings:

- [Synaptic plasticity: taming the beast](#)- slightly outdated
- [Neuroscience of learning](#)
- Prof. Bittu recommended: [Beyond STDP-towards diverse and functionally relevant plasticity rules](#)

2. Time and space

Readings:

- Space: [A manifold of spatial maps in the brain](#)
(8 pages, quite neuro heavy, talks about the role of interconnectedness of hippocampal and entorhinal spatial maps in reflecting the complexity of natural environments in dynamic time frames)
- Time: [What makes us tick? Functional and neural mechanisms of interval timing](#)
(9 pages, vv neuro heavy)
(Suggests that brain represents time in a distributed manner and tells time by detecting the coincidental activation of different neural populations)

Module 3 - Rationality and Decision Making

1. Neuroeconomics

Readings:

- [Neuroeconomic foundations of economic choice- Recent advances](#)
(23 pages, long but does not seem difficult, gives a good overview of the field)
- <https://www.hse.ru/data/2011/12/09/1259101786/Neuroeconomics.pdf> (Could possibly do some topics like perceptual vs value-based decision making, social decision making etc.) - **Chapters 3, Estimation and testing of computational psych models (computation stuff), Chapter 7**
- **Monkey Economy** -
https://www.ted.com/talks/laurie_santos_a_monkey_economy_as_irrational_as_ours?language=en

2. Probabilistic Inference Neuroeconomics

Readings:

- [Basic probability theory](#) (Sections 1 through 4)
- **TO DO BAYESIAN INFERENCE basics**
- [Generalisation, similarity and Bayesian inference](#) (Griffiths & Tenenbaum) (Read Pages 629-634) (11 pages, seems a bit complex but super interesting, talks about generalization from multiple consequential stimuli and draws parallels between set-theoretic and spatial approaches)
- [Probabilistic brains: Knowns and Unknowns](#) - Difficult, Medium (probabilistic learning, structural learning and approximate inference)
- [Predicting pragmatic reasoning in language games](#)
(one page, seems nice n fun)

3. Reinforcement learning Readings:

- [Introduction to reinforcement learning: Sutton and Barton](#) (Chp 1 & 14)
- [A neural substrate of prediction and reward](#)
- [Reinforcement learning in the brain](#)

Module 4 - Vision and Language

1. Vision across modeling approaches (lab)

Readings:

- [frisby_stone_2010_seeing.pdf \(tallinzen.net\)](#) - Medium, Lengthy (lots of neuro, super interesting)
- [1332_1332..1338 \(tallinzen.net\)](#) - Doable (CS), Small (concept learning, computational)
- [Deep Neural Networks: A New Framework for Modeling Biological Vision and Brain Information Processing \(tallinzen.net\)](#) - Doable (CS), Lengthy (neural networks psychologically)

2. Language acquisition across modeling approaches

- [alishahi_2010.pdf \(tallinzen.net\)](#) - Medium-Difficult, Lengthy (whole book) (covers everything - psych + math in language learning and acquisition)
- [PLI: S1364-6613\(02\)01990-3 \(tallinzen.net\)](#) - Medium-Difficult, Small (theories of language acquisition)

Module 5 - Putting everything together!

1. Contemporary AI and cognitive science

Readings:

- [lecun_bengio_hinton_2015.pdf \(tallinzen.net\)](#) - Easy, Small (review of key architectures in Deep Learning)
- [Why deep-learning AIs are so easy to fool \(tallinzen.net\)](#) - Easy, Small (delves into drawbacks of DL)
- [Has AI surpassed humans at translation? – Skynet Today \(tallinzen.net\)](#) - Easy, Small (delves into a human/AI comparison in the context of translation)

2. Modeling Human Cognition

Lectures:

- <http://www.infocobuild.com/education/audio-video-courses/psychology/res-9-003-summer2015-mitocw.html> MIT - Tenenbaum 3 part talk

Readings:

- Computational Models as Aids to Better Reasoning in Psychology - Medium, Small (talks about modeling cog stuff in general + introduces random walk)
- The Place of Modeling in Cognitive Science - Medium, Medium (similar but more detailed than above)
- [computing machinery and intelligence - a.m. turing, 1950 \(abelard.org\)](#) - Easy, Small (cool intro type material)

- [10.1.1.83.5248.pdf \(southampton.ac.uk\)](#) (similar^)
 - [The New Turing Omnibus: 66 Excursions In Computer Science - PDF Drive](#) (similar^)
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Cool readings

- Where cognitive science went wrong - <http://www.naturalthinker.net/trl/texts/Fodor,%20Jerry/Fodor%20-%20Concepts%20-%20Where%20cognitive%20science%20went%20wrong.pdf>
- [Word learning as Bayesian inference](#) (Tenenbaum and Xu) (Pages 245-253) (Three experiments with adults and children test the Bayesian account's predictions in the context of learning words for object categories at multiple levels of a taxonomic hierarchy)
- Modeling random firing of neurons - [pcbi.1002211 1..22 \(ucl.ac.uk\)](#) - Difficult, Lengthy (lots of probability math)
- [Analogues of mental simulation and imagination in deep learning](#)

Course Structure

- 2 Discussion / work sessions per week for students
- 1 Review session per week with Professors

Grading

1. Projects
 - a. 3 implementation projects derived from syllabus; computational emphasis
 - b. Projects due on on weeks 5, 8, 11
2. Final Presentation - an in-depth review of a topic from the syllabus
3. Course Engagement ?

All Resources

Courses & Lectures:

1. CCN - Harvard- Taught by Sam Gershman (need Harvard ID for lectures)
https://cbmm.mit.edu/sites/default/files/courses/syllabus/CCN2016_syllabus_0.pdf
2. Projects to implement in Gershman course
<https://cbmm.mit.edu/learning-hub/course/residential/computational-cognitive-neuroscience-building-models-brain>
3. Hopkins- Taught by Tal Linzen
https://tallinzen.net/media/teaching/intro_ccs_fall_2019.html
4. Intro to Cogsci - Stanford- Taught by Dan Jurafsky (Introduction to CogSci) but in 2005
<https://web.stanford.edu/~jurafsky/symbsys100.2005/>
2008 link: SYMBSYS 100 / LING 144 / PSYCH 130 / PHIL 190 (Stanford University)
5. BMM - MIT OCW (all lectures available)
<http://www.infocobuild.com/education/audio-video-courses/psychology/res-9-003-summer-2015-mitocw.html>
6. MIT- Infant and Early Childhood Cognition taught by Laura Scultz (can incorporate some topics)
<https://ocw.mit.edu/courses/9-85-infant-and-early-childhood-cognition-fall-2012/pages/syllabus/>

Topics & Readings:

Gershman (Harvard):

- Reverse engineering the brain
- Principles of perceptual representation
- Object recognition
- Perceptual decision-making
- Neuroeconomics
- Reinforcement learning
- Computational neuromodulation
- Synaptic plasticity
- Complementing learning systems
- Working memory
- Time and space
- Probabilistic inference in neural circuits
- Computational Psychiatry
- Cognitive control and metareasoning

Linzen (Hopkins):

- Probabilistic inference
- Formal grammars
- Reinforcement learning
- Artificial neural networks
- Language acquisition across modeling approaches
- Vision across modeling approaches
- Contemporary AI and cognitive science

Jurafsky (Stanford) *NOTE: It is old*

- Turing Test - [PPT – SYMBOLIC SYSTEMS 100 Introduction to Cognitive Science PowerPoint presentation | free to download - id: 59ea81-ZTE5M \(powershow.com\)](#)
- Computational Model of the Mind
- Philosophy of Mind
- Bridging Mind and Brain
- Language and Thought
- Vision and Colour Perception
- Perceptual Illusions
- Neuroscience of Awareness
- The Goal of Perception
- Active Vision and Artificial Life
- Language Processing

- Metaphor
- Conversation
- Reasoning and Decision Making - [PPT - SYMBOLIC SYSTEMS 100: Introduction to Cognitive Science Dan Jurafsky and Daniel Richardson Stanford University Spring 20 PowerPoint Presentation - ID:1401685 \(slideserve.com\)](#)
- Cognitive Development
- Machine Learning and Neural Networks- [PPT – SYMBOLIC SYSTEMS 100: Introduction to Cognitive Science Dan Jurafsky and Daniel Richardson Stanford University Spring 2005 PowerPoint presentation | free to view - id: 25132f-ZDc1Z \(powershow.com\)](#)
- Nativism vs Empiricism and Language Learning
- The Evolution of the Mind

Schulz (MIT OCW)