Psych 210B Introduction II: Cognition

Instructor Information

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Class webpage: https://eee.uci.edu/17s/68730

In this course, we will be discussing evidence linking cognition and the brain. We will focus on higher-level cognition including theory, decision-making, memory, and learning. We will try to understand how the brain is organized and functions to support these cognitive abilities.

Course Assignments:

Readings
We will assign a selection of readings for each week highlighting interesting and current issues from within the domains. Everyone will be responsible for reading all of the material prior to the class period in which it is discussed.

Signup sheet:

https://docs.google.com/spreadsheets/d/1dX5cCDg9tLoG3iZLrIuCLUVidiiTu3IxxFrg9hTgSlw/edit?usp=sharing

Weekly comments
All students are required to submit comments and questions on each reading prior to class. The goal of this assignment is to promote critical thinking on the topic prior to class, so that our discussion in class is most fruitful. Comments should be posted via an EEE MessageBoard associated with the class. Comments must be posted by **Monday evening (midnight) prior to class**.

Presentations
Each week student presenters will present the readings for the week. In your presentations, you should discuss the rationale behind the work as well as to highlight the most interesting or controversial aspects of the research. Your goal is to generate discussion of the research, its contributions to the literature, as well as the major issues or questions it raises.

Discussants
Each week student discussants will guide the class discussion of that week's readings. Discussants are expected to organize the comments submitted prior to class and moderate the discussion. Discussants are also responsible for posting a summary of the discussion and any follow-up comments by **Friday evening (midnight) following the class**. Discussant summaries should be uploaded to the EEE DropBox associated with the class.

Students not leading the discussion should come to class prepared to discuss the readings selected for that week. Class participation is expected from all students. Failure to participate in class discussion will adversely affect your course grade.

Papers
There will be a final paper. You will select one of the topics discussed in class and explore it further. You will write a paper reviewing the literature you have read. Papers should be about 10-15 pages in length (double spaced). Papers should include recent work in the area you've selected (i.e., publications within the last five years).

Final papers are due **Wednesday, June 14th** by midnight. All papers should be submitted using the DropBox on the EEE website. All papers should be in PDF format.

GRADING:
Grades will be determined as follows:
40% final paper
20% presentations
20% discussant
10% weekly comments
10% class participation

SCHEDULE

April 12 - Bayesian modeling & Deep Learning

April 19 – Brain and Behavior

April 26 – Human Cognition and Big Data (Brain Initiatives)

May 3 – Information Theory and Efficient Coding

May 10 – Exploration vs. Exploitation

May 17 – Memory Consolidation

May 24 – Decision-Making

May 31 – Cognitive Effort and Resource Rational Models

June 7 – Self-Directed Learning & Embodiment

June 14 – Final Papers due

READING LIST (Subject to Change)

Bayesian modeling & Deep Learning

- Lake, B. M., Ullman, T. D., Tenenbaum, J. B., and Gershman, S. J. (in press). Building machines that learn and think like people. *Behavioral and Brain Sciences*. Target Article.

- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature, 521*, 436-444.

  Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A.A., Veness, J., Bellemare, M.G., Graves, A., Riedmiller, M., Fidjeland, A.K., Ostrovski, G., et al. (2015). Human-level control through deep reinforcement learning. *Nature, 518*, 529-533.

Further Reading:

- Lake, B. M., Salakhutdinov, R., and Tenenbaum, J. B. (2015). Human-level concept learning through probabilistic program induction. *Science, 350*(6266), 1332-1338.

- C. Kemp, A. Perfors, J. B. Tenenbaum, Dev. Sci. 10, 307–321. (2007).

- Kriegeskorte, N. (2015). Deep Neural Networks: A New Framework for Modeling Biological Vision and Brain Information Processing. Annual Review of Vision Science, 1, 417-446.

Brain and Behavior

- Jonas, E., and Kording, K.P. (2017). Could a Neuroscientist Understand a Microprocessor? PLoS Comput Biol *13*, e1005268

  Krakauer, J.W., Ghazanfar, A.A., Gomez-Marin, A., MacIver, M.A., and Poeppel, D. Neuroscience Needs Behavior: Correcting a Reductionist Bias. Neuron 93, 480-490

- Turner, B. M., Forstmann, B. U., Love, B. C., Palmeri, T. J., and Van Maanen, L. (2017). Approaches to analysis in model-based cognitive neuroscience. *Journal of Mathematical Psychology, 76*, 65-79.

Human Cognition and Big Data (Brain Initiatives)

- Griffiths, T. L. (2015). Manifesto for a new (computational) cognitive revolution. *Cognition, 135*, 21-23.

  Griffiths, T. L., Abbott, J. T., & Hsu, A. S. (2016). Exploring human cognition using large image databases. *Topics in Cognitive Science, 8*(3), 569-588

- Alivisatos, A.P., Chun, M., Church, George M., Greenspan, Ralph J., Roukes, Michael L., and Yuste, R. (2015). A National Network of Neurotechnology Centers for the BRAIN Initiative. Neuron 88, 445-448.

  Bota, M., Sporns, O., and Swanson, L.W. (2015). Architecture of the cerebral cortical association connectome underlying cognition. Proceedings of the National Academy of Sciences of the United States of America 112, E2093-2101.

  Sporns, O. (2013). The human connectome: origins and challenges. NeuroImage 80, 53-61.

Information Theory and Efficient Coding

- Friston, K. (2010). The free-energy principle: a unified brain theory? Nature reviews Neuroscience *11*, 127-138.

- Louie, K., and Glimcher, P.W. (2012). Efficient coding and the neural representation of value. Annals of the New York Academy of Sciences *1251*, 13-32.

Exploration vs. Exploitation

- Barto, A.G. (2013). Intrinsic Motivation and Reinforcement Learning. In: G. Baldassarre and M. Mirolli (Eds), Intrinsically Motivated Learning in Natural and Artificial Systems. Springer Berlin Heidelberg, Berlin, Heidelberg, 17-47.

- Solway, A., & Botvinick, M. M. (2012). Goal-directed decision making as probabilistic inference: a computational framework and potential neural correlates. Psychological Review, 119(1), 120-154. doi:10.1037/a0026435

  OR

  Rich, A.S. and Gureckis, T.M. (in press, 2017). Exploratory choice reflects the future value of information. Decision.

Further Reading:

- Lee, M.D., Zhang, S., Munro, M., & Steyvers, M. (2011). Psychological models of human and optimal performance in bandit problems. Cognitive Systems Research 12, 164-174.

- Krichmar, J.L. (2008). The Neuromodulatory System – A Framework for Survival and Adaptive Behavior in a Challenging World. Adaptive Behavior, 16, 385-399.

Memory Consolidation

- McClelland, J.L., McNaughton, B.L., and O'Reilly, R.C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory. Psychological review 102, 419-457.

- Kumaran, D., Hassabis, D., and McClelland, J.L. (2016). What Learning Systems do Intelligent Agents Need? Complementary Learning Systems Theory Updated. Trends Cogn Sci 20, 512-534.

- Kappel, D., Habenschuss, S., Legenstein, R., and Maass, W. (2015). Network Plasticity as Bayesian Inference. PLOS Computational Biology 11, e1004485.

Decision-Making

- Daw, N.D., Gershman, S.J., Seymour, B., Dayan, P., and Dolan, R.J. (2011). Model-based influences on humans' choices and striatal prediction errors. Neuron *69*, 1204-1215.

- Hayden, B.Y., Pearson, J.M., and Platt, M.L. (2011). Neuronal basis of sequential foraging decisions in a patchy environment. Nature neuroscience *14*, 933-939.

Further Reading:

- Gold, J.I., and Shadlen, M.N. (2007). The neural basis of decision making. Annu Rev Neurosci *30*, 535-574.

- Gershman, S. J., Horvitz, E. J., & Tenenbaum, J. B. (2015). Computational rationality: A converging paradigm for intelligence in brains, minds, and machines. *Science, 349*, 273-278.

Cognitive Effort and Resource Rational Models

- Vul E., Goodman N., Griffiths T.L. & Tenenbaum J.B. (2014) One and Done? Optimal decisions from very few samples, *Cognitive Science, 38*(4), 599-637

- Shenhav, A., Musslick, S., Lieder, F., Kool, W., Griffiths, T.L., Cohen, J.D., & Botvinick, M.M. (2017). Toward a rational and mechanistic account of mental effort. *Annual Review of Neuroscience*.

Further Reading:

- Griffiths, T. L., Lieder, F., & Goodman, N. D. (2015). Rational use of cognitive resources: Levels of analysis between the computational and the algorithmic. *Topics in Cognitive Science, 7*, 217-229.

- Griffiths, T. L., Vul, E., & Sanborn, A. N. (2012). Bridging levels of analysis for probabilistic models of cognition. *Current Directions in Psychological Science, 21*, 263-268.

- Computational rationality: A converging paradigm for intelligence in brains, minds and machines..Gershman, S. J., Horvitz, E. J., and Tenenbaum, J. B. (2015). *Science 349*(6245), 273-278

Self-Directed Learning & Embodiment

- Krichmar, J.L. (2012). Design principles for biologically inspired cognitive robotics. Biologically Inspired Cognitive Architectures 1, 73-81.

  Pfeifer, R., Iida, F., and Lungarella, M. Cognition from the bottom up: on biological inspiration, body morphology, and soft materials. Trends in cognitive sciences 18, 404-413

- Gureckis, T.M. and Markant, D.B. (2012) Self-directed learning: A cognitive and computational perspective. Perspectives in Psychological Science, 7, 464-481.

  Markant, D.B. and Gureckis, T.M. (2014). Is it better to select or to receive? Learning via active and passive hypothesis testing. Journal of Experimental Psychology: General, 143(1), 94-122.