Cognition

<Still tentative syllabus>

CNS/Bi/SS/Psy 176

2017 Spring

Shinsuke Shimojo

12 Units (6-0-6)

TIME: Monday/Wednesday 2:00 PM - 3:55PM
LOCATION: Broad 300

The cornerstone of current progress in understanding the mind, the brain, and the relationship between the two is the study of human and animal cognition. This course will provide an in-depth survey and analysis of behavioral observations, theoretical accounts, computational models, patient data, electrophysiological studies, and imaging results on mental capacities such as attention, object representation and recognition, memory, cognitive development, and language.

Undergraduates CAN take the course with an instructor's permission. Prerequisite (or preferred background) includes an introduction to experimental psychology, neuroscience, cognitive science, computational vision, biomedical engineering, etc.

General Information

Time and Location

Monday	2:00 – 3:55 pm Broad 300
Wednesday	2:00 – 3:55 pm Broad 300

Instructor
Shin Shimojo: sshimojo@its.caltech.edu
x3324

Teaching Assistants
Connie Wang: cxw@caltech.edu
Office Hours: TBA

Class wiki (contains latest announcements and downloadable readings, accessible only to Caltech IPs):
http://wiki.cns.caltech.edu/wiki/index.php/CNS176_Spring_2015 <Need to be updated for 2017>

Textbooks & Readings

No particular textbooks will be assigned, but particular chapters will be listed in the reading **list (and provided as pdfs). Each student has to choose a chapter or a paper from the reading list, ahead of time, to present in the subsequent weeks. Each may be asked to present several times / term, depending on the number of participants.**

Course Requirements

A. Class Format:

Each class is either a lecture with student presentations or a tutorial / discussion section. The former is devoted to a single topic (with few exceptions). Class will begin with a 30-40 minute lecture from one of the instructors. The rest of the class will consist of student presentations (typically two) and discussion. The latter comprises tutorials, student project presentation, or TA hour.

B. Class Presentations and Attendance:

Each participant will be responsible for presenting and leading the discussion on material in a topic of their choice from the offered topics. Materials will be one or more of the papers listed as that topic's readings. The organizational meeting (the first class on 3/30) will include a survey of individual preferences for class presentations and every effort will be made to allot participants their top choice. Student presentations will count toward 25% of the final grade. These presentations will be peer evaluated with an evaluation sheet. Presenters' score will be based on the mean of these peer evaluations. To ensure attendance, 5% of your grade will be based on attendance, participation in discussions, and the peer evaluations you fill out.

C. Homework:

Each participant should choose one of the two topics for each two-week period, read relevant papers (starting from the reading list), and write three new experimental questions that would be interesting to investigate and why (2-3 pages). Thus all together, three review papers are required (the deadline will be in 1 week after the two weeks). 10% x 3 = 30% of the final grade will be based on these review papers. Please make sure that you come to class on time.

D. Presentation on Tentative Project Idea (April 27)

Short presentation in discussion section on the topic (and type) of term paper will occur on April 27th. Please generate two slides and email them to the TA by April 26th at 5 pm. Slide 1 should include a summary of the type of project you choose and the topic it will be on (*i.e.* if the project is an experiment, discuss the problem you are working on and previous work). Slide 2 should contain an outline of your plan (*i.e.* if you choose to review papers, outline the debate you are going to investigate *etc.*). The presentation should give the class a general idea of your term paper topic, type, and goals. This presentation counts 10% toward the final grade.

E. Term Paper: 30% of the final grade will be based on the term paper, which is due on June 1st. Please select ONE of the options below for your term project; the details of each type will be reviewed during the discussion section.

1) Review Paper

Each student should select one topic covered in class and review this scientific field in depth. The student should, in particular, outline one key debate within the scientific field, not only arguing each side but also choosing which option fits the data the best. The student should write up this analysis in 10-15 page paper (including figures and references).

2) Meta-Analysis Paper

Each student should select one topic covered in class and review this scientific field in depth. The student should draw data from multiple papers within the field and use it to justify or disprove theories about the cognition in the field. The student should write up this analysis in 10-15 page paper (including figures and references).

3) Proposal

Each participant should select one of the questions they posed in their homework and write 5-10 page grant "proposal" (including figures and references). Students should propose in their proposal an explicit and detailed method to investigate the proposed question, provide background about the state of the art, and make an argument about how answering this question will advance the field. Proposals will be reviewed according to NSF's Merit Review Criteria.

4) Project/Experiment

Each student should select one topic covered in class and conceive a new idea for a novel and scientifically interesting psychophysical experiment or neural model. The student will generate the experimental concept, the code or experimental design to carry it out, and finally analyze data (from running several subjects or simulating several cases). The student will write up the project details in a final report that is 5-10 pages (including figures and references).

No midterm or final exam.

Grading Scheme

Point Distribution:

Class presentations (25%)
Attendance and participation (5%)
Homework (3*10% = 30%)
Tentative project idea presentation (10%)
Term paper (30%)

Policy:

Faculty members and postdoctoral fellows are welcome to participate in the class discussions and presentations. Undergraduate and graduate students who are taking the class for credit should keep in mind the following exercises upon which their final grade will be determined.

Course Schedule **<Very tentative; susceptible to changes>**

Date	Week day	Type	Description	Due
4/3	Mon	Lecture Meeting	Class Introduction, Organizational Meeting (Shimojo)	First class
4/5	Wed	Tutorial	How to give a scientific presentation (Wang) Basics in MATLAB programming (Wang)	
4/10	Mon	Lecture Presentation	Visual Representation and Recognition (Shimojo)	
4/12	Wed	Lecture Presentation	Postdiction / Hindsight (Shimojo/Wu)	
4/17	Mon	Tutorial	Psychtoolbox (Wang) Experimental Design (Wang)	
4/19	Wed	Lecture Presentation	Development and Evolution of Cognition (Shimojo)	HW1
4/21	Fri			Last add day
4/24	Mon	Tutorial TA hour	Tutorial on term project types Review and discussion of homework questions (please bring 1 question to discuss)	
4/26	Wed	Lecture Presentation	Face and Expression (Shimojo)	
5/1	Mon	Presentation	Presentation of Tentative Term Project Plan	Project plan due
5/3	Wed	Lecture Presentation	Attention and Memory (Shimojo)	HW2
5/8	Mon	Lecture Presentation	Visual Awareness (Shimojo)	
5/10	Wed	TA hour	Review and discussion of homework questions	
5/15	Mon	Lecture Presentation	Time Perception (Guest: Yong-Jun Lin)	
5/17	Wed	Lecture Presentation	Human magnetoreception? (Connie Wang)	HW3
5/22	Mon		No class due to Vision Sciences Society conference	
5/24	Wed	Lecture Presentation	Developmental disorder (Wang) / VSS conference	Last drop day
5/29	Mon	Holiday	Memorial Day (Institute Holiday)	
5/31	Wed	Lecture Presentation	Retinal Prostheses and Sensory Substitution for the Blind (Guest: Dr. Noelle Stiles)	Last class
6/??	??			Term paper due
6/12	Mon			Grade reports for seniors and graduates
6/21	Wed			Grade reports for undergraduates

List of topics and reading list

Readings may be downloaded from the CNS wiki (only accessible from Caltech IP addresses) at this address: http://wiki.cns.caltech.edu/wiki/index.php/CNS176_Spring_2015
See the latest reading list online.

Visual Representation and Recognition (Lecture by Shimojo)

- Marr, D. *Vision*. (1982). Chapter 1.2 Understanding complex information processing systems (19-31), 1.3 A representational framework for vision (31-39).
- Pinto N, Cox DD, DiCarlo JJ. (2008). Why is Real-World Visual Object Recognition Hard? *PLoS Comput Biol*., 4(1): e27. doi:10.1371/journal.pcbi.0040027
- von der Heydt, R., Peterhans, E., and Baumgartner, G. (1984). Illusory contours and cortical neuron responses. *Science*, 224, 1260-1262.
- Tanaka, K. (1993). Neuronal mechanisms of object recognition. *Science*, 262, 685-688.
- Biederman, I. (1995). Visual object recognition. *Visual Cognition,* Chapter 4.
- Goodale, M. and Milner, A. D. (1992). Separate visual pathways for perception and action. T*rends in Neuroscience,* 15, 20-25.
- Epstein R, and Kanwisher N. (1998). A cortical representation of the local visual environment, *Nature*, 392, 598-601.
- Rao, R. P. N. and Ballard, D.H. (1999). Predictive coding in the visual cortex: a functional interpretation of some extra-classical receptive-field effects *Nature Neuroscience* 2, 79-87 (1999)
- Koch, C. & Poggio, T. (1999). Predicting the visual world: silence is golden. *Nature Neuroscience* 2, 9-10.

Postdiction/Hindsight (Lecture by Shimojo)

- Shimojo, S. (2014). Postdiction: its implications on visual awareness, hindsight, and sense of agency. *Frontiers in Psychology***,** 196, 1-19
- Wu, D-A., Shimojo, S., Wang, S. W. & Camerer, C. F. (2012) Shared visual attention reduces hindsight bias, *Psychol. Sci*., 1-10
- Kamitani, Y. and Shimojo, S. (1999) Manifestation of scotomas created by transcranial magnetic stimulation of human visual cortex. *Nature Neuroscience*, 2, 767-771.
- Kolers,P.A., and von Grunau,M.(1976). Shape and color in apparent motion. *VisionRes.* 16, 329–335.
- Choi, H., and Scholl,B.J.(2006). Perceiving causality after the fact: postdiction in the temporal dynamics of causal perception. *Perception* 35, 385–399
- Eagleman,D.M., and Sejnowski,T.J.(2000).Motion integration and postdiction in visual awareness. *Science* 287, 2036–2038
- Goldreich,D., and Tong,J.(2013). Prediction, postdiction, and perceptual length contraction: a Bayesian low-speed prior captures the cutaneous rabbit and related illusions. *Front.Psychol.* 4:221
- Fischhoff B. (1975). I knew it would happen, Remembered probabilities of once-future things, O*rganziational Behavior and Human Performance*, 13, 1 - 16
- Bruner J. S., and Potter M. C. (1964). Interference in Visual Recognition, *Science*, 144, 3617, 424-425
- Harely E. M., Carlsen K. A., Loftus G. R. (2004). The “Saw-It-All-Along” Effect: Demonstrations of Visual Hindsight Bias. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 30, 5, 960-968

Development and Evolution of Cognition (Lecture by Shimojo)

- Taylor Parker, S. & McKinney, M. L. *Origins of intelligence*. Chapter 8. Development and evolution: a primer, 235-258.
- Taylor Parker, S. & McKinney, M. L. *Origins of intelligence*. Chapter 9. The evolution of human mental development, 235-258.
- Taylor Parker, S. & McKinney, M. L. *Origins of intelligence*. Chapter 4. Development of social cognition in children, apes and monkeys, 107-161.
- Spelke, E. S., Gutheil, G., & Van de Walle, G. (1995). The development of object perception. *Visual Cognition Vol.2*, Chapter 8 (pp. 297-330).
- Meltzoff, A. N. & Borton, R. W. (1979). Intermodal matching by human neonates. *Nature*, 282, 403-404.
- Lockman, J. J. & Thelen, E. (1993). Developmental biodynamics: Brain, body, behavior connections. *Child Development*, 64, 953-959.
- Wimmer, H. & Perner, J. (1983). Beliefs about beliefs: representation and constraining function of wrong beliefs in young children's understanding deception. *Cognition*, 13, 103-128.
- Scheier, C., Lewkowicz, D. & Shimojo, S. (2003). Sound induces perceptual reorganization of an ambiguous motion display in human infants. *Developmental Science*, 6, 233-241.
- Robinson, G. E., Fernald, R. D. & Clayton. (2008). Genes and social behavior. *Science*, 322, 896-899.
- Miller, G. (2011). The seductive allure of behavioral epigenetics. Science, 329, 24-27.

Face and Expression (Lecture by Shimojo)

- Kosslyn & Osherson (textbook): Chapter 3. M. Farah, M.J. Dissociable systems for recognition: a cognitive neuropsychology approach, 101-119.
- Goffaux, V. & Rossion, B. (2006). Faces Are “Spatial”—Holistic Face Perception Is Supported by Low Spatial Frequencies. *Journal of Experimental Psychology: Human Perception and Performance,* 32-4, 1023-1039.
- Adolphs, R. (2001). The neurobiology of social cognition. *Curr. Opin. Neurobiol,* 11, 231-239.
- Adolphs, R. (2002). Neural systems for recognizing emotion. *Curr. Opin. Neurobiol,* 12, 169-177.
- Kanwisher N., McDermott J., and Chun, M.M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience,* 17, 4302-4311.
- Haxby, J V. Hoffman, E A. Gobbini, M I. (2000). The distributed human neural system for face perception. *Trends Cogn. Sci.,* 4, 223-233.
- Shimojo, S, Simion C, Shimojo E, Scheier C. (2003). Gaze bias both reflects and influences preference. *Nature Neuroscience*, 6, 1317-1322.
- Simion, C, Shimojo, S. (2006). Early interactions between orienting, visual sampling and decision making in facial preference. *Vision Research*, 46, 3331-3335.

Attention and Memory (Lecture by Shimojo)

- Palmer, S. E. (1999). *Vision Science – Photons to Phenomenology*. Chapter 11. Visual selection: eye movements and attention. 519-571.
- Rensink, R.A. (2002). Change detection. *Annu Rev Psychol*., 53, 245-277.
- O'Regan, J.K. *et al.* (1999). Change-blindness as a result of 'mudsplashes'. *Nature* 398, 34 Scientific Correspondence.
- Taatgen, N. A., Juvina, I., Schipper, M., Borst, J. P., Martens, S. (2009). Too much control can hurt: A threaded cognition model of the attentional blink. *Cognitive Psychology,* 59, 1–29

- Mack, A., Pappas, Z. Silverman, M., et al. (2002). What we see: Inattention and the capture of attention by meaning. *Conscious Cogn*. 11(4), 488-506.
- Hikosaka, O., Miyauchi, S. and Shimojo, S. (1993). Voluntary and stimulus-induced attention detected as motion sensation. *Perception*, 22, 517-526.
- Posner, M. I., and Cohen, Y. (1984). Components of visual orienting. In Bouma, H. and Bouwhuis, D. J. (eds.), *Attention and Performance X: Control of Language Processes,* 531-556. Laurence Erlbaum, Hillsdale.
- Tipper, S. (1985). The negative priming effect: inhibitory priming by ignored objects. *The Quarterly Journal of Experimental Psychology*, 37, 571-590.
- Watanabe, K., and Shimojo, S. (1998). Attentional modulation in perception of visual motion events. *Perception*, 27, 1041-1054.
- Gabrieli, J. D. E. (1998). Cognitive neuroscience of human memory. *Annual Review of Psychology,* 49, 87-115.
- Graf, P. L. R., Squire, L. R., and Mandler, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 10, 164-178.

Visual Awareness (Lecture by Shimojo)

- Palmer, S. E. (1999). *Vision Science – Photons to Phenomenology*. Chapter 13. Visual awareness. 615-663.
- Tong, F., Meng M. & Blake, R. (2006). Neural bases of binocular rivalry. *Trends in Cognitive Sciences*, 10—11, 5-23.
- Goodale, M. A. & Milner, A. D. (1992). Separate visual pathways for perception and action. *Trends in Neuroscience*, 15, 20-25.
- Kunst-Wilson, W. R. & Zajonc, R. B. (1980). Affective discrimination of stimuli that cannot be recognized. *Science*, 207, 557-558.
- Marcel, A. J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. Cognitive Psychology, 15, 197-237.
- Bonneh, Y. S., Cooperman, A. & Sagi, D. (2001). Motion-induced blindness in normal observers. *Nature,* 411, 798-801.
- Silvanto, J., Cowey, A., Lavie, N., Walsh, V. (2005). Striate cortex (V1) activity gates awareness of motion. *Nature Neuroscience*, 8 (2), 143-144.
- Tsuchiya, N. (2005). Continuous flash suppression reduces negative afterimages. *Nature Neuroscience* 8, 1096 – 1101.
- Koch, C. & Tsuchiya, N. (2007). Attention and consciousness: two distinct brain processes. *Trends in Cognitive Sciences,* 11, 16-22.

Time Perception (Lecture by Yong-Jun Lin)

- Buhusi, C. V., Meck, W. H. (2005). What makes us tick? Functional and neural mechanisms of interval timing. *Nature Reviews Neuroscience, 6* (10), 755-765.
- Eagleman, D. M., Tse, P. U., Buonomano, D., Janssen, P., Nobre, A. C., Holcombe, A. O. (2005). Time and the brain: How subjective time relates to neural time. *The Journal of Neuroscience, 25* (45), 10369-10371.
- Stetson, C., Fiesta, M. P., Eagleman, D. M. (2007). Does time really slow down during a frightening event? *PLoS ONE, 2* (12), e1295: 1-3.
- Tse, P. U., Intriligator, J., Rivest, J., Cavanagh, P. (2004). Attention and the subjective expansion of time. *Perception & Psychophysics, 66* (7), 1171-1189.
- Grondin, S. (2010). Timing and time perception: A review of recent behavioral and neuroscience findings and theoretical directions. *Attention, Perception, & Psychophysics, 72* (3), 561-582.

- Yarrow, K., Haggard, P., Heal, R., Brown, P., Rothwell, J. C. (2001). Illusory perceptions of space and time preserve cross-saccadic perceptual continuity. Nature, 414 (6861), 302-305.
- Johnston, A., Arnold, D. H., Nishida, S. (2006). Spatially localized distortions of event time. Current Biology, 16 (5), 472-479.

Different modes of learning and the brain (Lecture by Dr. Sangwan Lee)

- Daw, N. D., Niv, Y. & Dayan, P. (2005). Uncertainty-based competition between prefrontal and dorsolateral striatal systems for behavioral control. *Nat. Neurosci*. 8, 1704–1711
- Gläscher, J., Daw, N. D., Dayan, P. & O'Doherty, J. P. (2010). States versus rewards: dissociable neural prediction error signals underlying model-based and model-free reinforcement learning. *Neuron* 66, 585–595
- Dobbins, I. G., Foley, H., Schacter, D. L. & Wagner, A. D. (2002). Executive Control during Episodic Retrieval: Multiple Prefrontal Processes Subserve Source Memory. *Neuron* 35, 989–996
- Moutoussis, M., Bentall, R. P., El-Deredy, W. & Dayan, P. (2011). Bayesian modelling of Jumping-to- Conclusions bias in delusional patients. *Cogn. Neuropsychiatry* 16, 422–447
- Rescorla, R.A. & Wagner, A.R. (1972) A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement, Classical Conditioning II, A.H. Black & W.F. Prokasy, Eds., pp. 64–99. Appleton-Century-Crofts.
- Daw, N., O'doherty, J. P. (2014) Multiple Systems for Value Learning. Neuroeconomics: decision making and the brain, 2nd edition

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Neural Networks (Lecture by Yazan Billeh)

- Cheng B. and Titterington D. M. (1994). Neural Networks: A Review from a Statistical Perspective. *Statistical Science*, 9(1), 2 – 54
- Eliasmith, C., Stewart, T. C., Choo X., Bekolay T., DeWolf T., Tang Y., Rasmussen D. (2012). A Large-Scale Model of the Functioning Brain, *Science*, 338 (6111), 1202-1205
- Hunsberger E., Blouw P., Bergstra J., Eliasmith C. (2013). A Neural Model of Human Image Categorization, *35th Annual Conference of the Cognitive Science Society*, 633 – 638
- Laughlin S. B., Sejnowski T. J. (2003). Communication in Neuronal Networks, *Science*, 301, 1870-1874
- Liu Y. Y., Slotine J-J., Barabási A-L, (2011). Controllability of complex networks, *Nature*, 473 (7346), 197-173
- Minsky M. L, and Papert S. A. (1969). Perceptrons. 1 – 20, Cambridge, MA: MIT Press
- Rumelhart, D.E., & McClelland, J.L. (1986) Eds. Parallel Distributed Processing: Explorations in the Microstructure of Cognition. 3 – 44 Volume 1: Foundations. MIT Press: Cambridge, MA.

Retinal Prostheses and Sensory Substitution for the Blind (Lecture by Dr. Noelle Stiles)

- Amedi A, Stern WM, Camprodon JA, Bermpohl F, Merabet L, Rotman S, Hemond C, Meijer P, Pascual-Leone A. (2007). Shape Conveyed by visual-to-auditory sensory substitution activates the lateral occipital complex. *Nat Neurosci,* 10(6), 687-689
- Saenz M, Lewis LB, Huth AG, Fine I, Koch C. Visual motion area MT+/V5 responds to auditory motion in human sight-recovery subjects (2008). *The Journal of Neuroscience*, 28 (20),5141-5148
- Stronks HC, Dagnelie G (2014), The functional performance of the Argus II retinal prosthesis, *Expert review of medical devices,* 11 (1), 23-30

- Renier L, Laloyaux C, Collignon O, Tranduy D, Vanlierde A, Bruyer R, De Volder AG. (2005). The Ponzo Illusion with Auditory Substitution of Vision in Sighted and Early-Blind Subjects. *Perception*, 34, 857-867.
- Collignon O, Voss P, Lassonde M, Lepore F. (2009). Cross-modal plasticity for spatial processing of sounds in visually deprived subjects. *Exp. Brain Res*., 192, 343-358.
- Araque NO, Dunai L, Rossetti F, Listl L, Mirmehdi M et al. (2008). Sound Map Generation for a Prototype Blind Mobility System Using Multiple Sensors. *Service Robotics & Smart Homes: How a gracefully adaptive integration of both environments can be envisaged?*
- Margalit E, Maia M, Weiland J, Greenberg RJ, Fujii GY, Torres G et al. (2002). Retinal Prosthesis for the Blind. *Survey of Ophthalmology*, 47 (4) 335-356.
- Weiland JD, Yanai D, Mahadevappa M, Williamson R, Mech BV, Fujii GY, Little GY, Greenberg RJ, de Juan Jr. E, Humayun MS. (2004). Visual Task Performance in Blind Humans with Retina Prosthetic Implants. *Proceedings of the 26th Annual International Conference of IEEE EMBS*, 4172-4173.
- Nasiatka PJ, Hauer MC, Stiles NRB, Lue JC, Takahashi S, Weiland JD, Humayun MS, Tanguay AR. (2007). An Intraocular Camera for Retinal Prostheses. *Proceedings of BioMed2007*