GBE5063-41
Neurophysiology Seminar

Instructors: Hansem Sohn (hansem.sohn@gmail.com)
Time & Location: Wednesday 12-3PM (N center, 86102)

Goal
The goal of this course is to introduce seminal research papers in neurophysiology for graduate students majoring in brain and cognitive science, and to provide insights into ongoing research conducted by students through a deep understanding of the seminal work. In particular, focusing on papers that used non-human primates as animal models, it will cover a wide range of papers from the time when neuroscience is born to the latest.

Format
This course will be conducted in the form of a seminar in which students read papers in advance, present key contents, and discuss the historical contributions and limitations of research papers. Through such a seminar format, students will learn and simulate how to present their research in academic environment and how to communicate through the question-and-answer process. Another expected effect of this course is to understand how the seminal studies in neurophysiology have created new scientific ideas and made discoveries given technical limitations and theoretical backgrounds. Through this, the ultimate goal is to creatively establish theories and models in real-world research and design new analysis methods or experiments.

Assessment
Students are expected to 1) submit summary and discussion points of the assigned paper before the class – **Tuesday midnight** - every week (30%), 2) actively participate in the discussion during the class (30%), 3) present one of the papers in an academic presentation format (30%), and 4) attend every class (10%).

Prerequisite
Basic knowledge in neurobiology

Office hour
Monday 10-12AM

Course outline

Weeks	*Topics*
1	Introduction/ Organizational meeting
2	Retina/LGN
3	Primary visual cortex (V1)
4	V2/V4
5	Middle temporal cortex (MT)
6	Posterior parietal cortex - I
7	Posterior parietal cortex – II
8	Posterior parietal cortex - III
9	Superior colliculus
10	Inferotemporal cortex (IT)
11	Motor cortex - I

12	Motor cortex - II
13	Frontal eye field (FEF)
14	Prefrontal cortex (PFC) - I
15	Prefrontal cortex (PFC) - II
16	Multiple areas

Reading list (only 1st paper in the list will be read; the rest are just for references)

2. Retina/LGN

Kuffler SW (1953) Discharge patterns and functional organization of mammalian retina. J Neurophysiol 16:37-68.

Enroth-Cugell C, Robson JG (1966) The contrast sensitivity of retinal ganglion cells of the cat. J Physiol 187: 517-552.

Schiller PH, Malpelig JG (1977) Properties and tectal projections of monkey retinal ganglion cells. J Neurophysiol 40: 428-445.

Schiller PH, Malpeli JG (1978) Functional specificity of lateral geniculate nucleus laminae of the rhesus monkey. J Neurophysiol 41: 788-297.

3. Primary visual cortex (V1)

Hubel DH, Wiesel TN (1962) Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. J Physiol 160:106-154.

Field DJ. Relations between the statistics of natural images and the response properties of cortical cells. J Opt Soc Am A. 1987 Dec;4(12):2379-94.

Olshausen BA, Field DJ (1996) Emergence of simple-cell receptive field properties by learning a sparse code for natural images. Nature 381: 607-609.

Nealey TA, Maunsell JHR (1994) Magnocellular and parvocellular contributions to the responses of neurons in macaque striate cortex. J Neurosci 14: 2069-2079.

Movshon JA, Thompson ID, Tolhurst DJ. Spatial summation in the receptive fields of simple cells in the cat's striate cortex. J Physiol. 1978 Oct;283:53-77.

Movshon JA, Thompson ID, Tolhurst DJ. Receptive field organization of complex cells in the cat's striate cortex. J. Physiol. 1978 Oct;283:79-99.

Ohzawa I, DeAngelis GC, Freeman RD. Encoding of binocular disparity by simple cells in the cat's visual cortex. J Neurophysiol. 1996 May;75(5):1779-805.

Adelson EH, Bergen JR. Spatiotemporal energy models for the perception of motion. J Opt Soc Am A. 1985 Feb;2(2):284-99.

4. V2/V4

Levitt JB, Kiper DC, Movshon JA. Receptive fields and functional architecture of macaque V2. Journal of neurophysiology. 1994 Jun 1;71(6):2517-42.

Gallant JL, Connor CE, Rakshit S, Lewis JW, Van Essen DC. Neural responses to polar, hyperbolic, and Cartesian gratings in area V4 of the macaque monkey. Journal of neurophysiology. 1996 Oct 1;76(4):2718-39.

Freeman J, Simoncelli EP. Metamers of the ventral stream. Nature neuroscience. 2011 Sep;14(9):1195-201.

Roe AW, Chelazzi L, Connor CE, Conway BR, Fujita I, Gallant JL, Lu H, Vanduffel W. Toward a unified theory of visual area V4. Neuron. 2012 Apr 12;74(1):12-29.

Bashivan P, Kar K, DiCarlo JJ. Neural population control via deep image synthesis. Science. 2019 May 3;364(6439):eaav9436.

5. Middle temporal cortex (MT)

Britten KH, Shadlen MN, Newsome WT, Movshon JA (1992) The analysis of visual motion: a comparison of neuronal and psychophysical performance. J Neurosci 12: 4745-4765.

Movshon JA, Adelson EH, Gizzi MS, Newsome WT (1985) The analysis of moving visual patterns. In: Pattern recognition mechanisms (Chagas, C, Gattass, R, Gross, C, eds) , p. 117. New York: Springer.

Salzman CD, Newsome WT (1994) Neural mechanisms for forming a perceptual decision. Science 264: 231-237.

Gu Y, Angelaki DE, DeAngelis GC (2008) Neural correlates of multisensory cue integration in macaque MSTd. Nat Neurosci 11, 1201-1210.

6. Posterior parietal cortex - I

Mountcastle VB, Lynch JC, Georgopoulos A, Sakata H, Acuna C (1975) Posterior parietal association cortex of the monkey: command functions for operations within extrapersonal space. J Neurophysiol 38: 871-908.

Robinson DL, Goldberg ME, Stanton GB (1978) Parietal association cortex in the primate: sensory mechanisms and behavioral modulations. J Neurophsyiol 41: 910-932.

Snyder LH, Batista AP, Andersen RA (1997) Coding of intention in the posterior parietal cortex. Nature 386: 167-170.

7. Posterior parietal cortex - II

Zipser D, Andersen RA (1988) A back-propagation programmed network that simulates response properties of a subset of posterior parietal neurons. Nature 331: 679-684.

Snyder LH, Grieve KL, Brotchie P, Andersen RA (1998) Separate body- and world-referenced representation of visual space in parietal cortex. Nature 394: 887-891.

Bisley JW, Goldberg ME (2003) Neuronal activity in the lateral intraparietal area and spatial attention. Science 299: 81-86

Swaminathan SK, Freedman DJ (2012) Preferential encoding of visual categories in parietal cortex compared with prefrontal cortex. Nat Neurosci 15: 315-320.

8. Posterior parietal cortex - III

Roitman, J. D., & Shadlen, M. N. (2002). Response of neurons in the lateral intraparietal area during a combined visual discrimination reaction time task. Journal of neuroscience, 22(21), 9475-9489.

Kiani, R., & Shadlen, M. N. (2009). Representation of confidence associated with a decision by neurons in the parietal cortex. science, 324(5928), 759-764.

9. Superior colliculus

Schiller PH, Stryker M (1972) Single-unit recording and stimulation in superior colliculus of the alert rhesus monkey. J Neurophysiol 35: 915-924.

Robinson DA (1972) Eye movements evoked by collicular stimulation in the alert monkey. Vision Res 12: 1795-1808.

Mays LE, Sparks DL (1980) Dissociation of visual and saccade-related responses in superior colliculus neurons. J Neurophysiol 43: 207-232.

Sparks DL, Mays LE (1983) Spatial localization of saccade targets. I. Compensation for stimulation-induced perturbations in eye position. J Neurophysiol 49:45-63.

Sparks DL, Porter JD (1983) Spatial localization of saccade targets. II. Activity of

superior colliculus neurons preceding compensatory saccades. J Neurophysiol 49: 64-74.

Schiller PH, Sandell JH, Maunsell JH (1987) The effect of frontal eye field and superior colliculus lesions on saccadic latencies in the rhesus monkey. J Neurophysiol 57: 1033-1049.

10. Inferotemporal cortex (IT)

Desimone R, Albright TD, Gross CG, Bruce C. Stimulus-selective properties of inferior temporal neurons in the macaque. J Neurosci. 1984 Aug;4(8):2051-62.

Fujita I, Tanaka K, Ito M, Cheng K. Columns for visual features of objects in monkey inferotemporal cortex. Nature. 1992 Nov 26;360(6402):343-6.

Tsao DY, Freiwald WA, Tootell RB, Livingstone MS. A cortical region consisting entirely of face-selective cells. Science. 2006 Feb 3;311(5761):670-4.

Sheinberg DL, Logothetis NK. Noticing familiar objects in real world scenes: the role of temporal cortical neurons in natural vision. J Neurosci. 2001 Feb 15;21(4):1340-50.

11. Motor cortex - I

Georgopoulos AP, Kalaska JF, Caminiti R, Massey JT (1982) On the relations between the direction of two-dimensional arm movements and cell discharge in primate motor cortex. J Neurosci 2: 1527-1537.

Schwartz AB, Kettner RE, Georgopoulos AP (1988) Primate motor cortex and free arm movements to visual targets in three-dimensional space. I. Relations between single cell discharge and direction of movement. J Neurosci 8: 2913-2927.

Georgopoulos AP, Kettner RE, Schwartz AB (1988) Primate motor cortex and free arm movements to visual targets in three-dimensional space. II. Coding of the direction of movement by a neuronal population. J Neurosci 8: 2928-2937.

Kalaska JF et al. (1989) A comparison of movement direction-related versus load direction-related activity in primate motor cortex, using a two-dimensional reaching task. J Neurosci 9: 2080-2102.

12. Motor cortex – II

Churchland, M. M., Cunningham, J. P., Kaufman, M. T., Foster, J. D., Nuyujukian, P., Ryu, S. I., & Shenoy, K. V. (2012). Neural population dynamics during reaching. Nature, 487(7405), 51-56.

Sadtler, P. T., Quick, K. M., Golub, M. D., Chase, S. M., Ryu, S. I., Tyler-Kabara, E. C., ... & Batista, A. P. (2014). Neural constraints on learning. Nature, 512(7515), 423-426.

13. Frontal eye field (FEF)

Bruce CJ, Goldberg ME (1985) Primate frontal eye fields. I. Single neurons discharging before saccades. J Neurophysiol 53: 603-635.

Hanes DP, Patterson WF, Schall JD (1998) Role of frontal eye fields in countermanding saccades: visual, movement, and fixation activity. J Neurophysiol 79: 817-834.

Thompson KG, Schall JD (1999) The detection of visual signals by macaque frontal eye field during masking. Nature Neurosci 2: 283-288.

Moore T, Armstrong KM (2003) Selective gating of visual signals by microstimulation of frontal cortex. Nature 421: 370- 373.

14. Prefrontal cortex (PFC) - I

Mante, V., Sussillo, D., Shenoy, K. V., & Newsome, W. T. (2013). Context-dependent computation by recurrent dynamics in prefrontal cortex. nature, 503(7474), 78-84.
Barraclough, D. J., Conroy, M. L., & Lee, D. (2004). Prefrontal cortex and decision making in a mixed-strategy game. Nature neuroscience, 7(4), 404-410.

15. Prefrontal cortex (PFC) - II

Nieder, A., Freedman, D. J., & Miller, E. K. (2002). Representation of the quantity of visual items in the primate prefrontal cortex. Science, 297(5587), 1708-1711.
Freedman, D. J., Riesenhuber, M., Poggio, T., & Miller, E. K. (2001). Categorical representation of visual stimuli in the primate prefrontal cortex. Science, 291(5502), 312-316.

16. Multiple areas

Murray, J. D., Bernacchia, A., Freedman, D. J., Romo, R., Wallis, J. D., Cai, X., ... & Wang, X. J. (2014). A hierarchy of intrinsic timescales across primate cortex. Nature neuroscience, 17(12), 1661-1663.
Schmolesky, M. T., Wang, Y., Hanes, D. P., Thompson, K. G., Leutgeb, S., Schall, J. D., & Leventhal, A. G. (1998). Signal timing across the macaque visual system. Journal of neurophysiology, 79(6), 3272-3278.
Seo H, Cai X, Donahue CH, Lee D. Neural correlates of strategic reasoning during competitive games. Science. 2014 Oct 17;346(6207):340-3.