Beyond the Receptive Field:
Neuroscientific and computational approaches

Course leaders

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ECTS: 2.5; Fridays, 2-4pm starting 24.02.2023

(hybrid format; in-person locale Av. de Provence 82, Lausanne, ground floor conference room)

Course description

The notion of the receptive field is a cornerstone of neuroscientific theory and modes of inquiry. An operational definition of a neuron's receptive field is the part of the sensory epithelia whose stimulation affects its discharge. On the one hand, the receptive field has been a very practical concept that allows for characterization of the topology of sensory systems (e.g. retinotopy, tonotopy, somatotopy). On the other hand, the notion falls short of characterizing the plastic and dynamic features of neural functioning as well as ensemble coding and ultimately perceptual outcomes. Receptive fields can change their properties as a function of time, task, and sensory input. This course will challenge students in reconciling these two general aspects of receptive fields. To do so, students will particularly consider the phenomenon of illusory contours as studied across species as well as neuroscientific and computational methodologies. Through journal-club style discussions, students will also improve their abilities for critical analysis as well as data presentation. Students will also learn fundamentals of computational modelling methods. Finally, the course evaluation will provide students with the opportunity to hone their skills in experimental design and scientific writing.

Participation is limited to maximally 25 (12 students for in-person attendance and another 13-15 for online attendees). Please register by sending an e-mail (with course name as subject and your supervisor in copy) to lndscourses@gmail.com. Places will be given on a first come – first served basis.

The course grade will be based on 3 parts:

1. **In-class participation (30%).** In-class participation refers to both to the student's ability to present one of the papers from the syllabus and to lead a discussion of it as well as to the student's active participation in the discussion of the articles of the remainder of the syllabus. On the first day of the class, each student will be assigned one of the papers from the syllabus.
2. **Oral presentation of research question for written report (20%).** Each student will give a maximally 10 minute oral presentation of their research question that they will be addressing in their written report. Students should use slides to communicate the essential background, research question and hypothesis, method and analysis design, anticipated results, and implications.
3. **Written Report (50%).** The written report will require students to write a fictitious manuscript and is intended to challenge students' abilities to think critically and to write concisely and clearly in English. Each student will be free to choose the specific research question of their choice and the best suited technique for the question, but it should nonetheless pertain to the general topic of the receptive field. Each student will write a scientific manuscript with formatting and length constraints taken from the instructions for authors at The Journal of Neuroscience (Abstract 250 words, Introduction

650 words, Methods and Results no limits, Discussion 1500 words). The Results section will clearly be fictitious. However, students are expected to write this section as if they were presenting actual results. They are encouraged to be creative and even to generate illustrations, tables, and figures with fictitious data as warranted.

Course Schedule & Syllabus:

Date	Topic(s)	Readings
24.02.2023	Overview of course objectives Introduction to the receptive field concept	Spillmann et al 2015 Journal of Vision Hubel and Wiesel 1959 J Physiology
03.03.2023	The dynamic receptive field and the example of illusory contours	Gilbert & Li (2013) Nat Rev Neurosci Lesher GW (1995) Psychon Bull Rev 2: 279-321. Von der Heydt et al (1989) Science 224:1260-1262.
10.03.2023	Psychophysics in humans	Ringach & Shapley (1996) Vision Res 36: 3037-3050. McKyton et al. (2015) C Biol 25 : 2373-2378. Vuilleumier et al 2001
17.03.2023	Introduction to computational modelling of receptive fields (part 1)	DeAngelis, G.C., Ohzawa, I., Freeman, R.D.: Receptive-field dynamics in the central visual pathways. Trends Neurosci. **18**(10), 451–458 (1995) Hubel, D.H., Wiesel, T.N.: Ferrier lecture: functional architecture of macaque monkey visual cortex. Proc. R. Soc. Lond. B Biol. Sci. 198(1130), 1–59 (1977)
24.03.2023	Introduction to computational modelling of receptive fields (part 2)	Daugman,J.G.:Uncertainty relation for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters. JOSA A **2**(7), 1160–1169 (1985) Jones, J.P., Palmer, L.A.: An evaluation of the two-dimensional gabor filter model of simple receptive fields in cat striate cortex. J. Neurophysiol. **58**(6), 1233–1258 (1987)
31.03.2023	Circuit approaches	Gold et al. (2000) Curr Biol 10: 663-666. Dura-Bernal et al. (2011) Adv Exp Med Biol Perspective on Wilson-Cowan equations (large brain connectivity) Franceschiello et al. (2017), JMIV
28.04.2023	Practical course on computational modelling	
05.05.2023	Animal electrophysiology studies of illusory contours	Redies et al. (1986) Exp Brain Res 61: 469-481. Neider & Wagner (1999) Nat Neurosci 2: 660-663. Lee & Nguyen (2001) PNAS 98: 1907-1911.
12.05.2023	fMRI in humans	Mendola et al. (1999) J Neurosci 19: 8560-8572. Stanley & Rubin (2003) Neuron 37: 323-331. Kok et al. (2016) C Biol 26: 371-376.
26.05.2023	EEG in humans	Tallon-Baudry et al. (1996) J Neurosci 16: 4240-4249. Murray et al. (2002) J Neurosci 22 : 5055-5073. Altschuler et al. (2014) Neuroimage
02.06.2023	Student presentations	
15.07.2023	Exams due	