

# CNV Semester Review

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# CNV Overview

In this lecture we review the topics we have covered this semester, focusing on what I consider the most important points to review.

The lecture slides on each topic, coupled with the required readings listed on the lecture notes web page, contain all of the basic material required to prepare for the exam.

Other background readings, particularly material that is not in the book, plus experience gained during the practical assignments, will help you improve your mark beyond the minimum standard.

## Introduction

**Visual system:** Should be able to discuss what the visual system does and what types of scientific questions can be asked about it.

**Models:** Should be able to discuss how models are useful, what they can contribute to science, how to choose the right level, what makes a model good or bad for investigating particular questions, etc.

## Vision background (1)

Should be able to demonstrate that you know and understand the basic organization and properties of the visual system in carnivores, primates, and rodents, including:

- The different types of experimental techniques used to study the visual system
- How images are formed on the retina
- The organization of the early visual system into visual areas

## Vision background (2)

- The large-scale arrangement of neurons in the retina, LGN, and V1 (as thin sheets with multiple layers)
- The response properties of neurons in each of the early areas
- The main circuitry involved in generating those properties
- How neurons interact during visual stimulation
- How feature maps are measured, and their main properties
- Some of the main aspects of how maps develop

## Modeling background (1)

**Types of models:** Should be able to discuss what types and levels of models can be used for what purposes

**Adult cell models:** Should be able to describe the basic properties of the standard models of retinal ganglion cells, LGN neurons, and V1 simple cells

**Kohonen SOM:** Should be able to describe and analyze in some detail how a SOM works, what it is doing, how that relates to biological systems, and how it differs from other models

## Modeling background (2)

**Retinotopy:** Should be able to discuss what the SOM model of retinotopy is achieving, and specifically how the model maps the high-dimensional input space into the 2D model network surface.

## LISSOM intro

**SOM limitations:** Should be able to explain and analyze the limitations of a SOM as a cortical model

**LISSOM algorithm:** Should be able to describe and analyze in some detail how LISSOM works, what it is doing, how that relates to biological systems, and how it differs from other models

## LISSOM orientation maps (1)

**Multiple maps:** Should be able to discuss how adding orientation maps changes the retinotopy results

**Analysis:** Should be able to describe how maps are measured and analyzed

**Lateral connections:** Should be able to discuss the lateral connection patterns that are predicted by the model, and why

**Scaling:** Should be able to describe what it means to scale the area or density

## LISSOM orientation maps (2)

**Contrast gain control:** Should be able to discuss why contrast gain control is needed, and how it can be achieved

**Training patterns:** Should be able to discuss how the results relate to properties of the training patterns that were used

**Pre/post natal:** Should be able to discuss why multiple learning phases are necessary, and possible roles of each phase

## LISSOM OR/OD/DR/etc. (1)

**Features:** Should be able to discuss the features that could be detected in principle by V1 neurons

**Ocular dominance:** Should be able to explain how neurons can develop ocular dominance, and how and why maps change with strabismus

**Direction:** Should be able to explain how neurons can develop spatiotemporal receptive fields, and what determines the relative importance of orientation and direction maps

## LISSOM OR/OD/DR/etc. (2)

**Disparity, Color, SF, etc.:** Should be able to explain what these maps represent and how they could develop.

**Joint maps:** Should be able to explain how multiple features can be mapped smoothly across the same cortical area, and in what ways they interact

## Adult function

**Surround modulation:** Should be able to give a very basic summary of the source of surround modulation and types of interactions, including what circuit(s) could underlie the phenomena

**Aftereffects:** Should understand and be able to explain how and why aftereffects occur in LISSOM, and how that relates to the mechanisms underlying development

## Higher levels (1)

**Pathways:** Should be able to describe the high-level organization into dorsal and ventral streams, and describe how such separation could occur in principle, based on relatively low-level differences

**Form processing:** Should be able to describe the basic properties of the form processing pathway, such as how RF size and invariance increase away from V1 along the ventral pathway

## Higher levels (2)

**Measurement:** Should be able to discuss why it is difficult to make clear conclusions about the properties of neurons beyond V1 simple cells, and what approaches can be used to measure them

**Selectivity:** Should be able to give examples of what types of stimuli have been shown to give strong responses in IT neurons, and how these are measured

## Higher levels (3)

Not covered in much detail in 2012.

**Trace learning:** Should be able to describe briefly how trace learning works, and what it achieves

**Saliency maps:** Should be able to describe briefly how the Itti and Koch saliency maps work

**Complexities:** Should be able to discuss future directions for computational models of the visual system, and the complications that will be involved

## Recommended reading

**Blasdel (1992):** Extremely detailed reference for how cortical maps are measured and analyzed

**Any neuroscience textbook chapter on vision:**

Background on terms and concepts used in this course

**Any of the papers cited in the lecture notes:** More information about topics that interest you

## Summary

- The exam covers the material from the lectures
- The focus is on having a solid, well-grounded understanding of the early visual system, of modeling in general, and of the specific models studied in this course, **not** on memorizing a list of facts
- The CMVC book has much extra background and explanation
- You should follow up on individual topics you are interested in by doing further reading

## References

Blasdel, G. G. (1992). Orientation selectivity, preference, and continuity in monkey striate cortex. *The Journal of Neuroscience*, 12, 3139–3161.