The neural basis for object recognition

Lesson II: Perception module 11
The two cortical pathways

- Early processing of visual information in the visual (occipital) cortex (V1, V2, V3)
  - After pre-processing visual stimuli in the retina and the LGN, information is relayed to the striate cortex in the occipital lobe
  - Increasingly complex processing from V1 through V3 and later in the processing stream

- The two main visual pathways
  - Dorsal pathway:
    the **where** system (renamed **how**: vision for action)
    Through MT and MST to the parietal lobe
  - Ventral pathway:
    the **what** system (object recognition)
    Through V4 to the temporal lobe
The two cortical pathways

"Where?" system

"What?" system

dorsal path

ventral path
Two different tasks:
A. The landmark discrimination task
   - Monkey sees food hidden in container close to a landmark
   - The position of landmark varies randomly between the food containers
   - Monkey has to learn the contingency between food and the distance to the landmark
   - Unable to learn with bilateral lesions in parietal cortex
Two different tasks:
B. The object discrimination task
- Monkey is familiarized with one particular object
- Monkey is presented two objects - only one contains food
- Spatial arrangement is randomized
- Monkey has to learn contingency between object & food
- Unable to learn with bilateral lesions in infero-temporal cortex
A closer look at the ventral system

- **Response characteristics of neurons moving from V1 up to areas in the temporal lobe**
  - Receptive field sizes tend to get larger with increasing processing level (anterior regions)
  - Optimal stimuli increase in complexity and specificity with increasing processing level (e.g., hand, face)
  - Neurons tend to become less sensitive to 3D object orientation of stimulus

- **Computational analysis**
  - Neurons early in the visual processing stream process specific information in a small receptive field
  - Neurons late in the visual processing stream integrate across a large portion of the visual field
Animal models of human vision

- **Studies with non-human primates**
  - Many studies use non-human primates and other animals as a model for the human visual system
  - Single-cell recordings show the responses of a single cell to a visual stimulus
  - Changing responses of a neuron indicate which stimulus it is sensitive to
  - The area of the visual field that the neuron responds to is called its receptive field

- **How can we generalize from monkey to human**
  - Many early areas of monkey visual cortex are homologous in both species
  - Higher cortical processing is not as easy to map between the two species
The role of the temporal lobe
- Functional imaging studies imply cortical areas within the temporal lobe in object recognition
- Lesions (stroke, tumor) within the temporal lobe lead to specific object recognition deficits

Specialized temporal object recognition areas are sensitive for ...
- Faces (fusiform face area)
- Human body and body parts
- Familiar places

Viewpoint invariance vs. dependence
- Some neurons in the temporal lobe are insensitive to object orientation, some respond differently
- Temporal neurons often insensitive to size changes
Idealized responses of a single cell

This might be the behavior of a highly specialized cell in temporal cortex, a.k.a “the Lena-cell”
Patient studies: Agnosia

**Agnosia**
- Inability to recognize objects with intact basic perceptual processing and memory
- Modality specific: Objects can be recognized through another perceptual channel

**Different types of agnosia (there are more...)**
- Visual agnosia
  Patient can still distinguish light from dark and basic shapes, but cannot identify complex objects
- Tactile agnosia
  Patient cannot identify an object from touch, even though the patient can still feel the presence of it
- Simult(an)agnosia
  Patient can only “see” one object at a time
Apperceptive vs. associative visual agnosia

- **Apperceptive visual agnosia**
  - Inability to identify objects from visual information
  - Inability to reproduce simple drawings
  - Diffuse occipital lesions

- **Associative visual agnosia**
  - Inability to identify objects from visual information
  - Patients are able to reproduce drawings
  - Patients can describe parts of images but not the whole
  - Specific, bilateral occipito-temporal lesions