SUBCORTICAL PROCESSING

Retina and thalamic circuits

Valentin Dragoi
Department of Neurobiology and Anatomy
Local intracortical circuits

Feedforward input

Excitatory

Inhibitory

LOCAL CIRCUIT
Parallel streams of visual processing

Spatial vision

Object vision

Dorsal (parietal) pathway

A1T
CIT
PIT
V4
7a
MST
LIP
MT
VIP

Ventral (temporal) pathway

V1
V2

Retina

LGN
VISUAL FIELD:

area in space when the eyes are in a fixed position
COMPONENTS OF THE RETINA

- Rod
- Cone
- Horizontal cell
- Bipolar cell
- Amacrine cell
- Ganglion cell
Retinal ganglion cell axons leave the eye at the optic disc
**OPTIC DISC**

- area where the RGC axons exit the eye
- only optic nerve fibers in this area of the retina
- area free of receptor cells
- corresponds to blind spot in visual field
FOVEA

- area of specialization of retina, where only receptor cells (cones) found
- a depression in the center of the macula
- area where central visual field projected
PHOTORECEPTORS: RODS & CONES

Neurons specialized to convert (transduce) light energy into a neural (electrochemical) response.

OUTER SEGMENT:
Specialized to respond to light.

Photoreceptors do not generate action potentials

SYNAPTIC TERMINAL:
Glutamate is released when the receptor is DEPOLARIZED
**PHOTORECEPTORS: RODS & CONES**

In the human eye, there are four different types of photoreceptors based on the photopigments they contain.

However all of the photoreceptors, rods & cones, respond to light in a similar fashion.
CONVERGENCE and VISUAL ACUITY

Cones concentrated in the fovea, whereas the rods predominate in the periphery.

Low convergence of cones on cone bipolar cells within the fovea (as low as 1:1).
BIPOLAR CELLS SYNAPSE WITH PHOTORECEPTORS
BIPOLAR CELLS ARE “NAMED” ON THE BASIS OF THE STIMULUS CONDITION THAT PRODUCES DEPOLARIZATION

- OFF-BIPOLARS ARE DEPOLARIZED IN DARK, i.e., when the light is OFF

IN THE DARK
ON-BIPOLARS ARE DEPOLARIZED IN LIGHT, i.e., when the light is ON.
Physiologically, the receptive fields of bipolar cell are concentric, opponent type. Light on the receptor cells in the center and surround of a bipolar cell receptive field produces a reduced “center-type” response.
HORIZONTAL CELLS PRODUCE THE SURROUND RESPONSE

HORIZONTAL CELL CONNECTS THE CENTER RECEPTORS WITH THE SURROUNDING RECEPTORS

HORIZONTAL CELLS PRODUCE THE BIPOLAR CELL SURROUND RESPONSE
RETINAL GANGLION CELLS

Generate action potentials that travel to the diencephalon & midbrain

Receptive field determined by bipolar cells with which they synapse
RETINAL GANGLION CELLS ARE OF 2 MAJOR TYPES

**TYPE P GANGLION CELL**
- is small in size
- has a small dendritic arbor
- synapses with few bipolars
- has a small concentric field
- is less sensitive to small brightness contrasts
- can be ON or OFF type
- is color sensitive
- responds strongly to static stimuli
RETINAL GANGLION CELLS ARE OF 2 MAJOR TYPES

**TYPE P GANGLION CELL**
- is small in size
- has a small dendritic arbor
- synapses with few bipolars
- **has a small concentric field**
- is less sensitive to small brightness contrasts
- can be ON or OFF type
- **is color sensitive**
- responds strongly to static stimuli
- responds poorly to moving stimuli

> **COLOR SENSITIVE**
> **STIMULUS SHAPE/FORM**
RETINAL GANGLION CELLS ARE OF 2 MAJOR TYPES

TYPE M GANGLION CELL
- is large in size
- has a large dendritic arbor
- synapses with many bipolars
- has a large concentric field
- is sensitive to small brightness contrasts
- can be ON or OFF type
- is color insensitive
- responds poorly to static stimuli
RETINAL GANGLION CELLS ARE OF 2 MAJOR TYPES

TYPE M GANGLION CELL
- is large in size
- has a large dendritic arbor
- synapses with many bipolars
- has a large concentric field
- is sensitive to small brightness contrasts
- can be ON or OFF type
- is color insensitive
- responds poorly to static stimuli
- responds strongly to moving stimuli

> COLOR INSENSITIVE
> SIGNALS MOVEMENT
AMACRINE CELLS
**OPTIC NERVE**
Consists of 3° afferent axons
Axons of retinal ganglion cells

**OPTIC CHIASM**
Optic nerve fibers originating from the nasal retina that decussate in the optic chiasm
Optic nerve fibers originating from the temporal retina do not decussate in the optic chiasm

**OPTIC TRACT**
Consists of 3° afferent axons from the nasal half of the contralateral eye & the temporal half of the ipsilateral eye
Optic nerve

Optic chiasm

Lateral geniculate nucleus

Optic radiation

Hypothalamus: regulation of circadian rhythms

Pretectum: reflex control of pupil and lens

Superior colliculus: orienting the movements of head and eyes

Striate cortex
LATERAL GENICULATE NUCLEUS OF THE THALAMUS
The visual system thalamic nucleus

Lateral Geniculate Nucleus of the Thalamus

LGN organized into 6 cell layers
  2 Magnocellular layers
  4 Parvocellular layers
  with thin layers of kinocellular (dust-like) neurons interposed
**All LGN neurons**
- are monocular - respond to stimulation of one eye only
- have concentric (ON/OFF or OFF/ON) receptive fields

**Type mLGN neurons in LGN magnocellular layers**
- synapse with Type M retinal ganglion axons
- have large concentric receptive fields
- are insensitive to color
- sensitive to small changes in brightness levels (*scotopic vision*)
- are rapidly-adapting (*motion sensitive*)

**Type pLGN neurons in LGN parvocellular layers**
- synapse with Type P retinal ganglion axons
- have small concentric receptive fields (*high acuity*)
- are sensitive to color (*color sensitivity*)
- are not sensitive to small changes in brightness levels
- are slowly-adapting (indicate duration stimulus is “on”*)
Suggested readings

‘Neuroscience’ book: Chapters 11 & 12