Cognitive Science and AI

Visual Perception: Eye, Brain, and Low-level Processing

Presentation from: PNS (6 Ed) Ch 21 Constructive Nature of Visual Processing

Eye and Brain

We are so familiar with seeing, that it takes a **leap of imagination** to realize that there are **problems to be solved**. But consider it. We are given tiny distorted upside-down images in the eyes and we see separate solid objects in surrounding space. From the patterns of stimulation on the retina we percieve the worlds of objects and this is nothing short of a miracle.

Richard L. Gregory, Eye and Brain, 1966

Visual Perception is a constructive process

- Vision is used not only for object recognition but also for guiding our movements => mediated by two parallel and interacting pathways.
- Visual Perception is a constructive process
  - Quite unlike a camera!!
  - Creates 3D representation of the world from 2D images on the retina
  - Recognition is Invariant to disparate visual conditions
- Early atomistic theories posited simple sensory elements processing color, shape, and brightness, are assembled in an additive way.

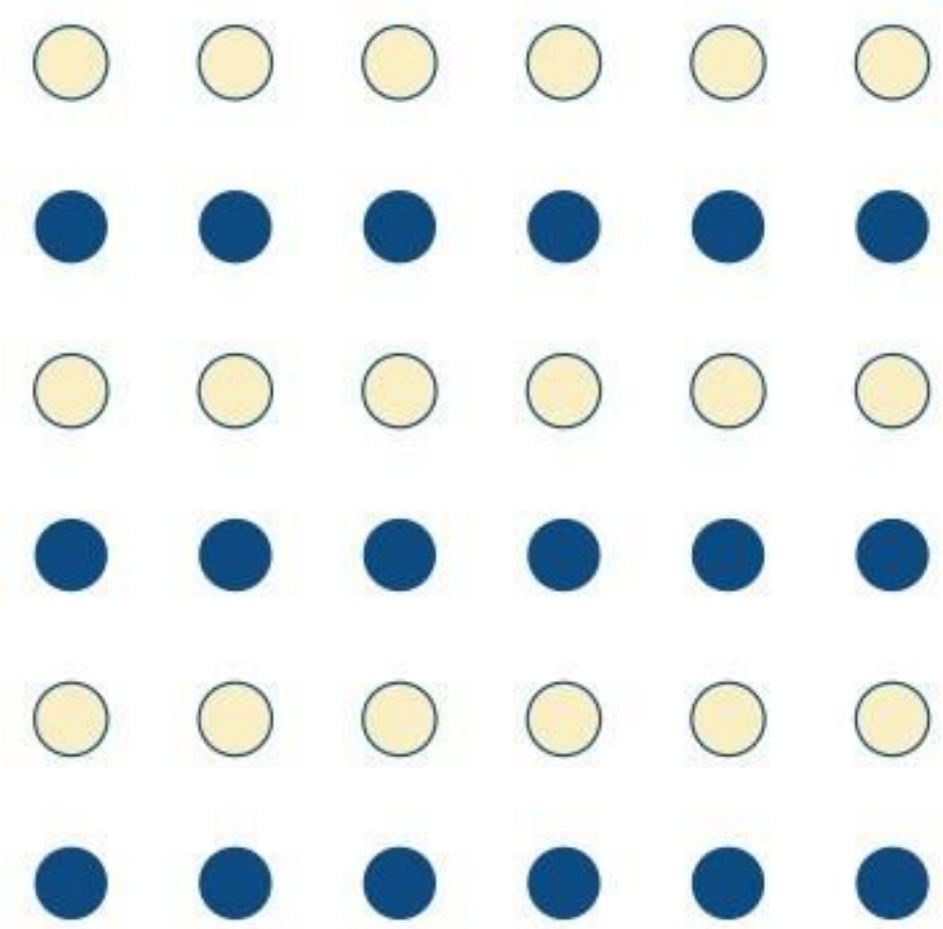
Visual Perception is a constructive process

- Gestalt Psychologists (Wertheimer, Koffka, Kohler) suggested that stimulus properties and context around the stimulus influence perception / perceptual interpretation
  - *Gestalt*: configuration or form
  - Expectations derived from experience and built-in neural wiring/rules influence what is perceived

Max Wertheimer: "There are entities where the behavior of the whole cannot be derived from its individual elements nor from the way these elements fit together; rather the opposite is true: the properties of any of the parts are determined by the intrinsic structural laws of the whole."

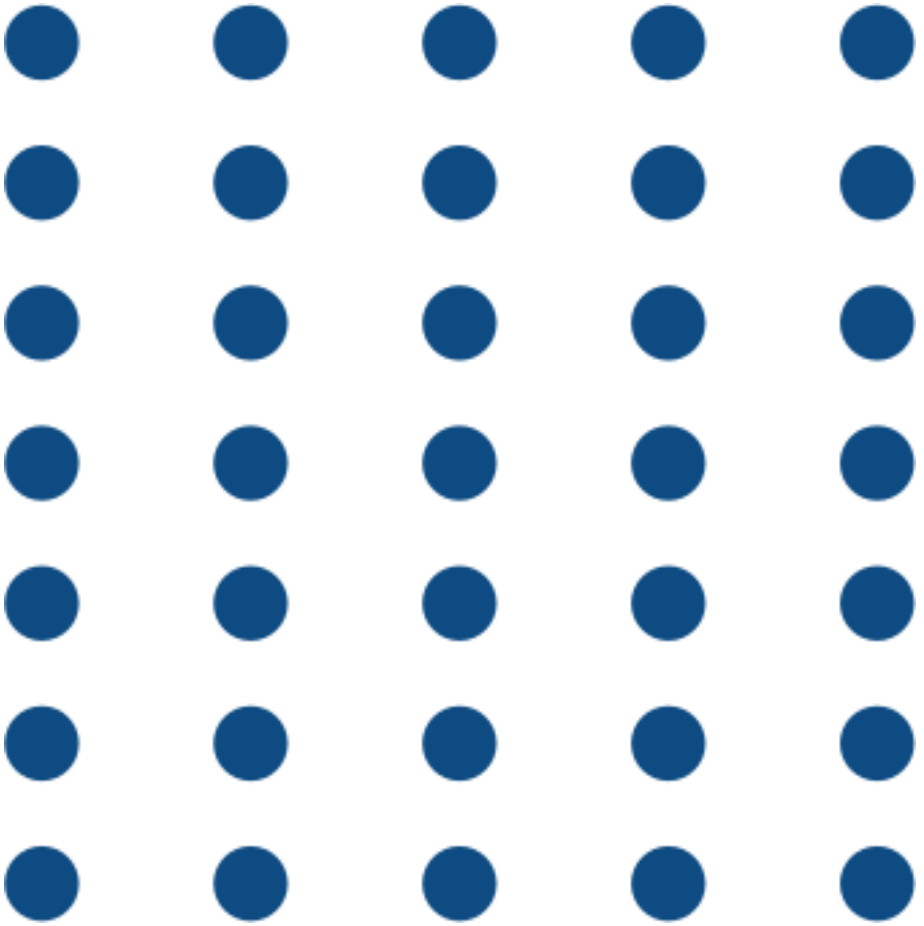
Organizational Rules of Visual Perception[2]

- Similarity



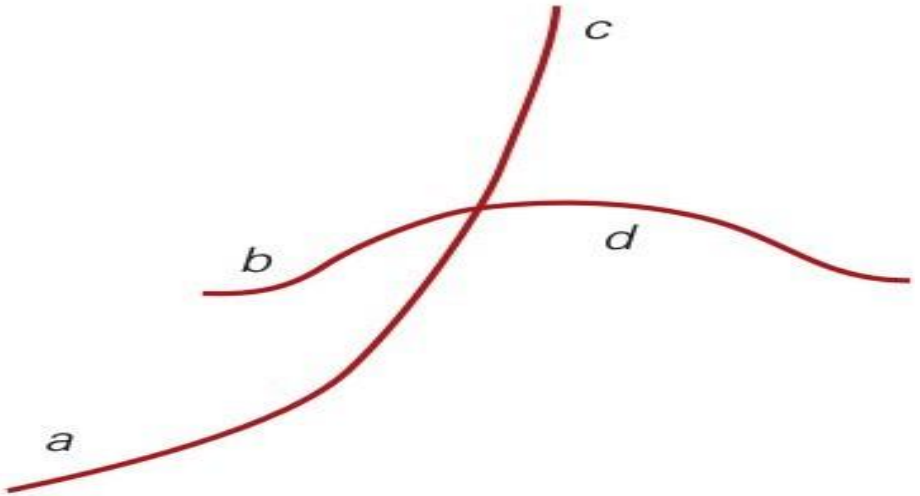
Organizational Rules of Visual Perception[2]

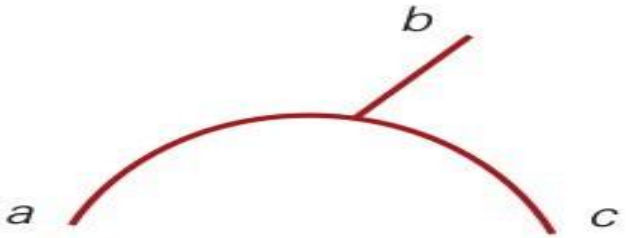
- Proximity



Organizational Rules of Visual Perception[2]

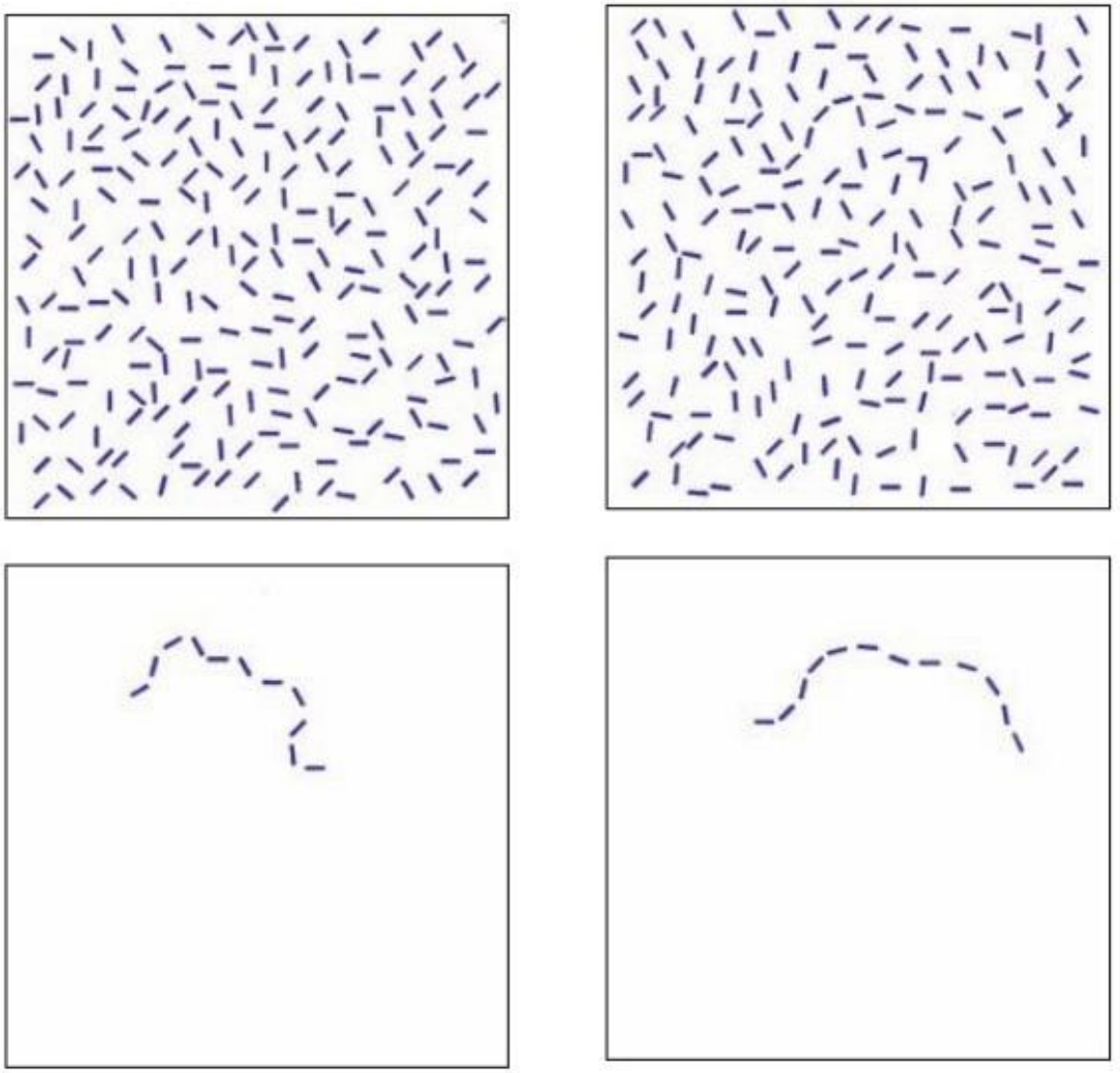
- Continuation





Organizational Rules of Visual Perception[2]

- Contour Saliency



Object Recognition depends on the separation of foreground and background in a scene[2]

Three level Processing of a Visual Scene[2]

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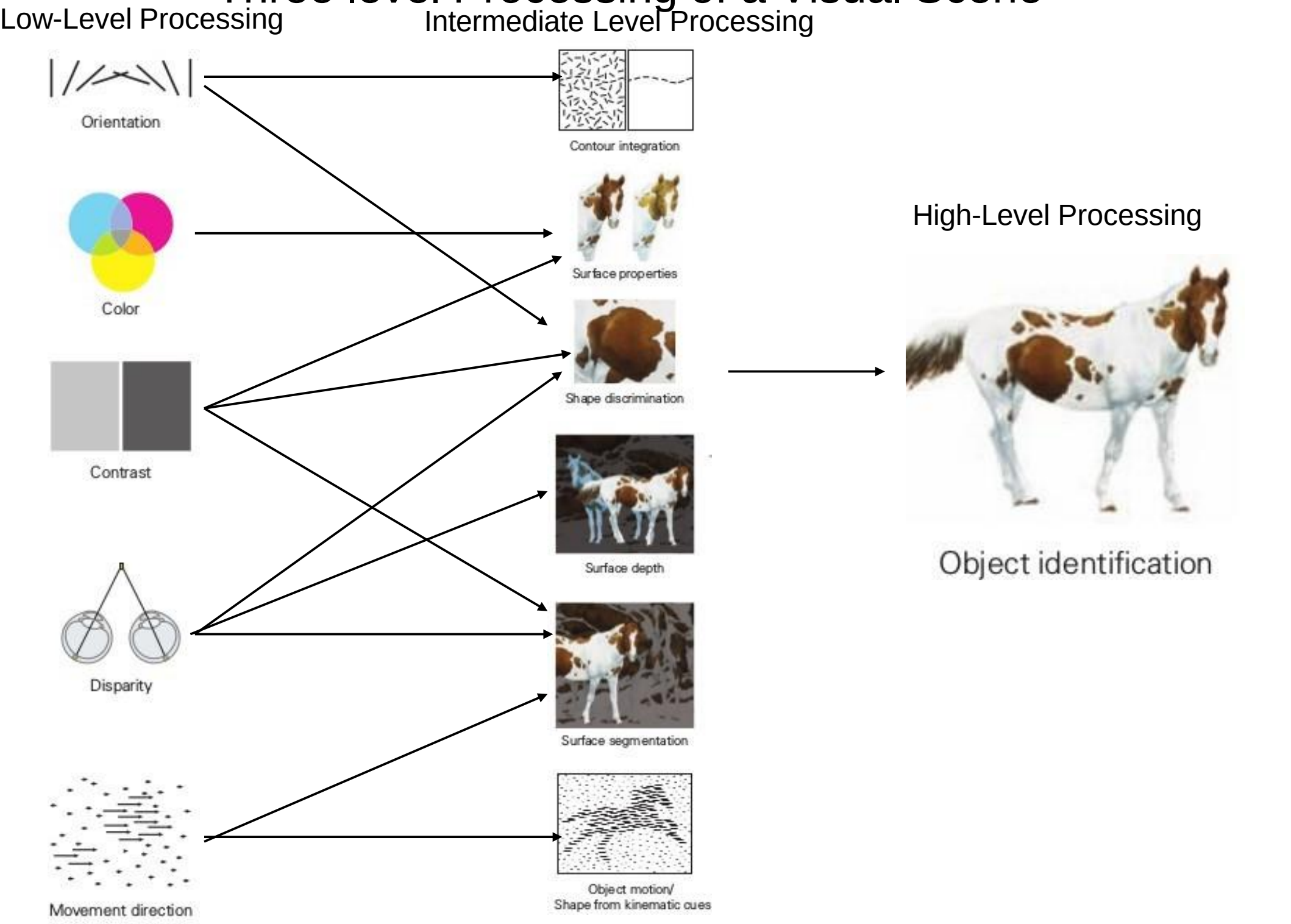

How does the Vision Process or Interpretation of the world in front of us happen?

Vision Processing

- Constructive Nature
- Low-level Visual Processing
- Intermediate-level Visual Processing
- High-level Visual Processing

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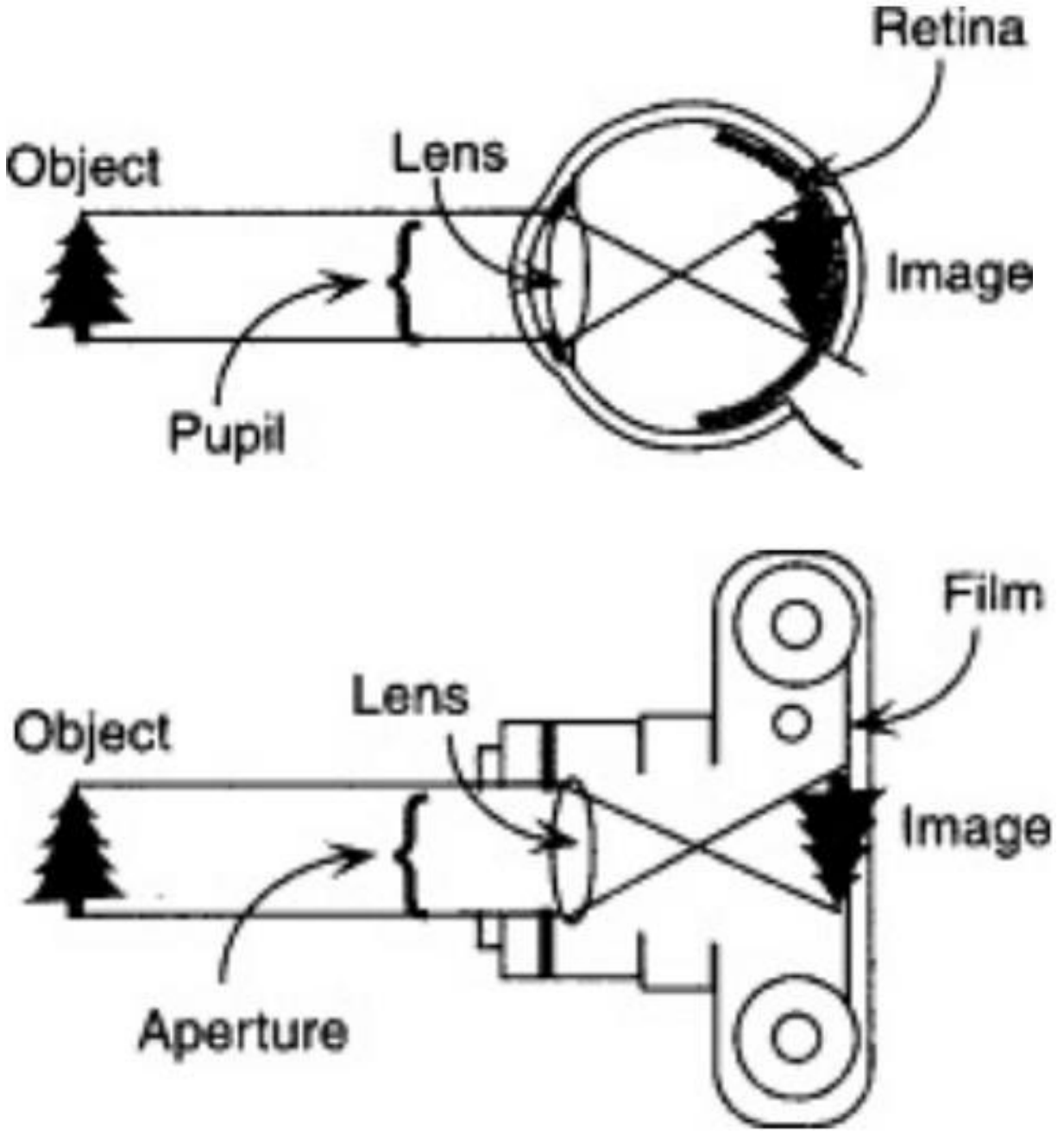
Eye-Camera Analogy [1]



Expectation and Perceptual task play a critical role in what is seen[2]

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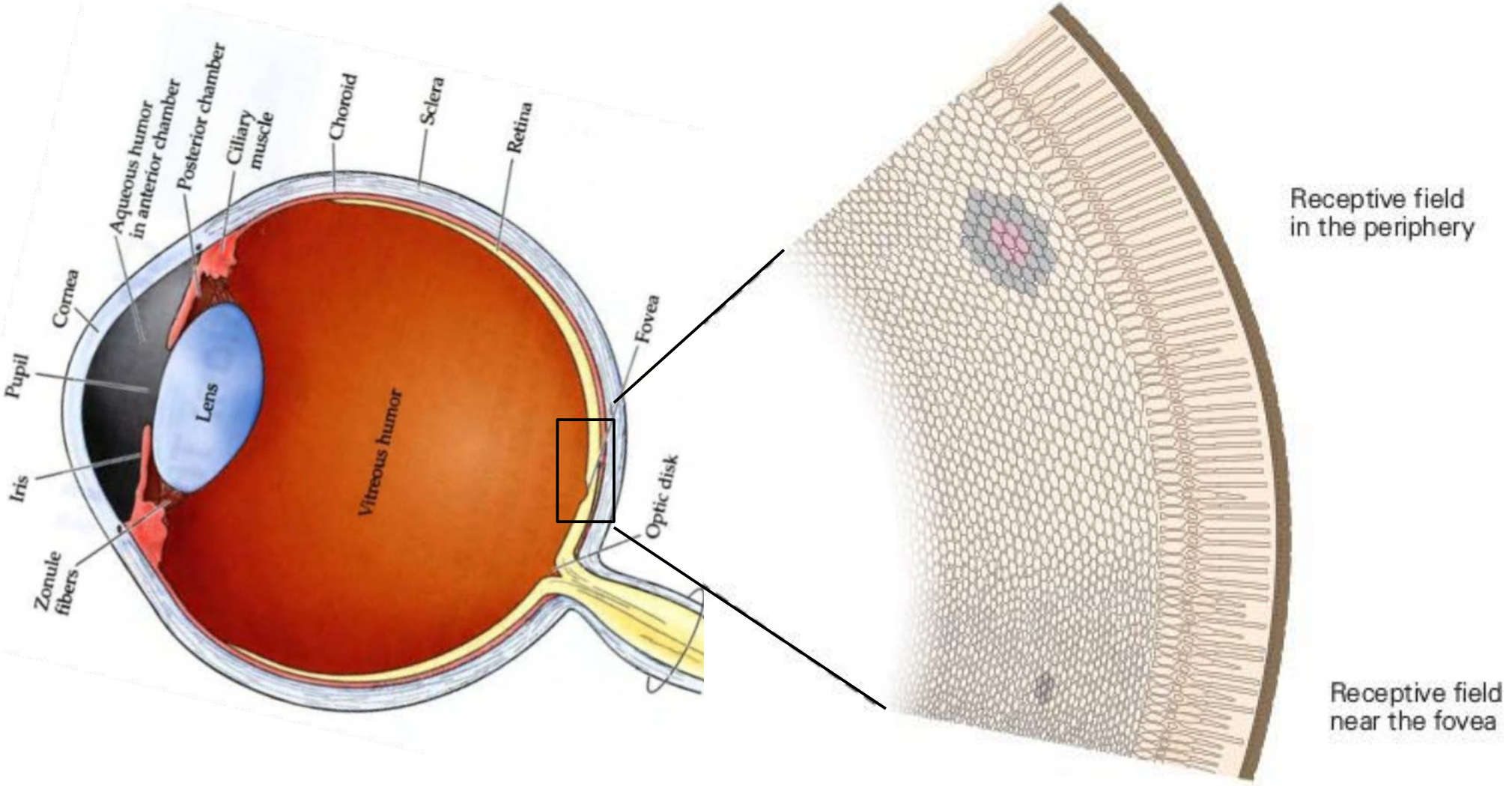
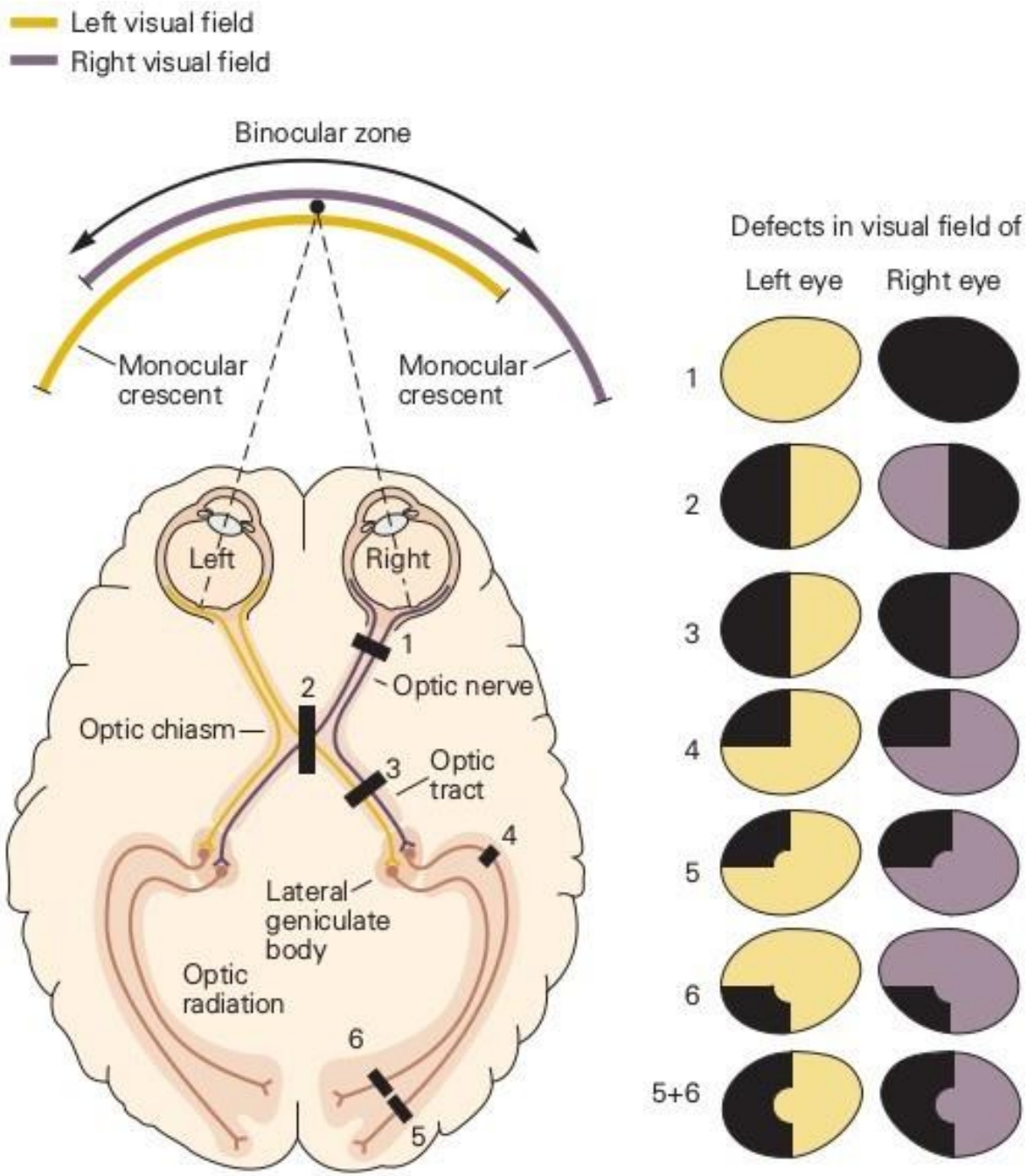
How does the constructive process take place?

Structure of the Human Eye[2,3]



Visual Pathway

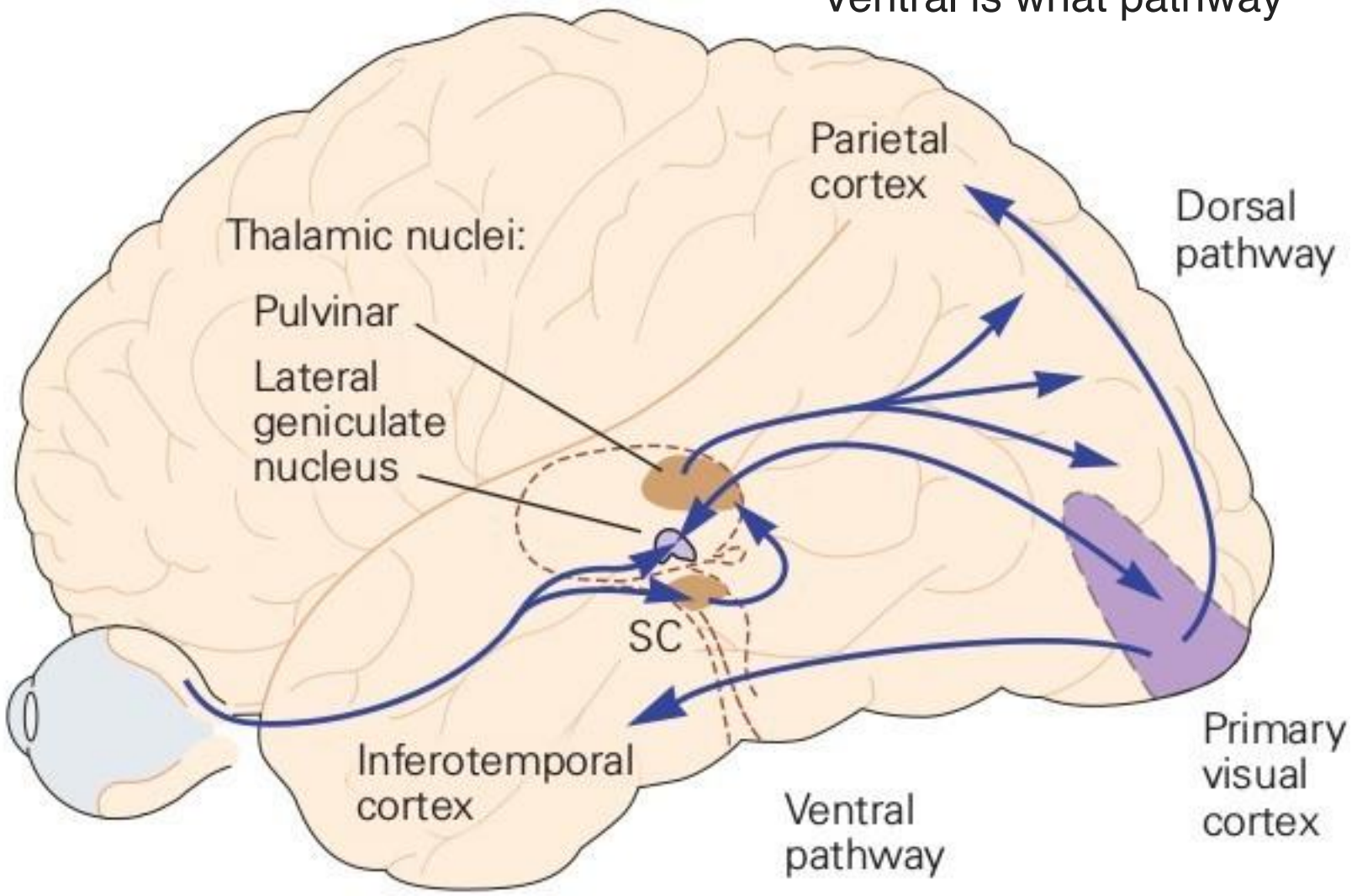
Visual Field along the Visual Pathway[2]



Three Visual Pathway from retina[2]

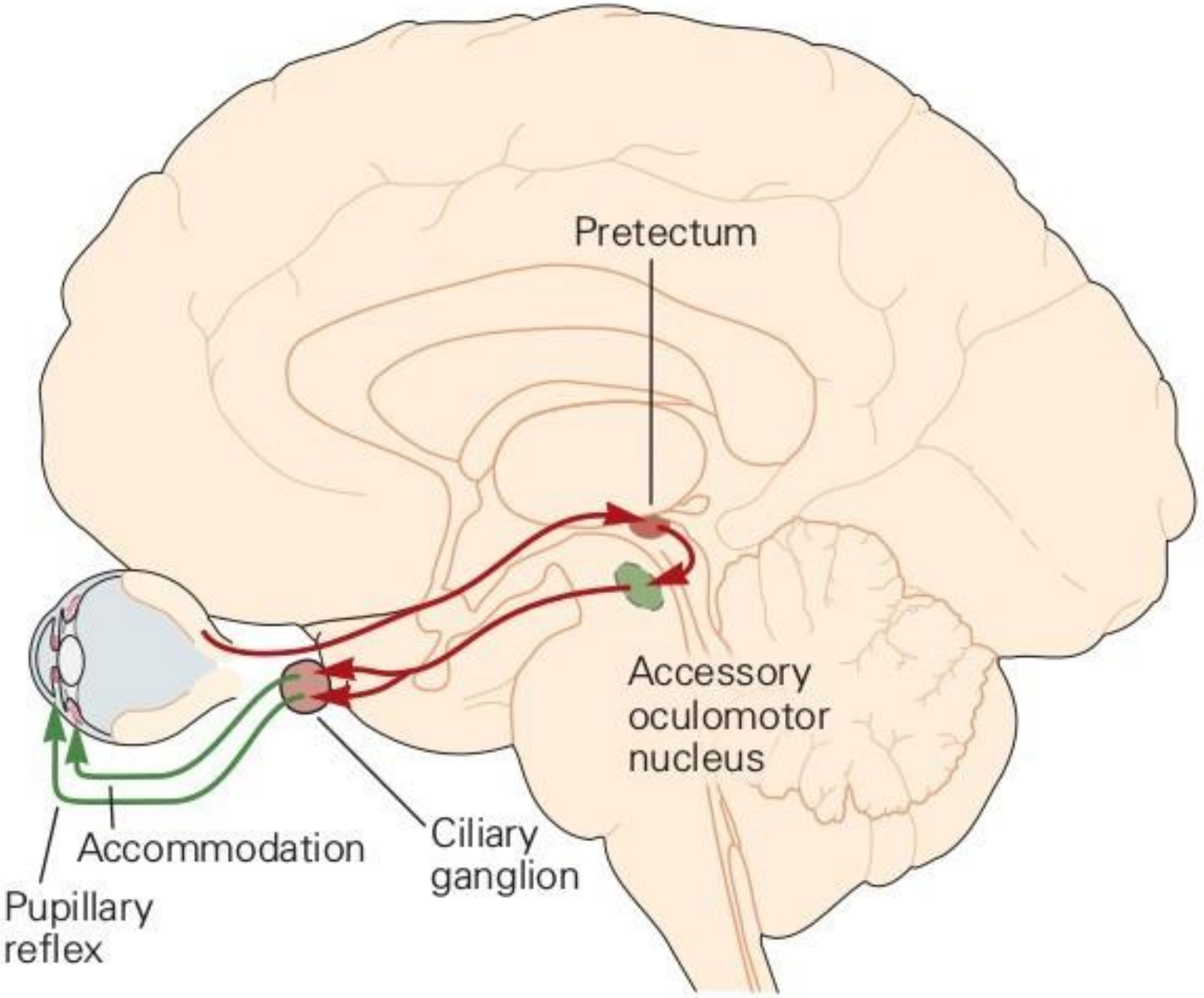
- Visual Processing

Doral is where path way ,
Ventral is what pathway



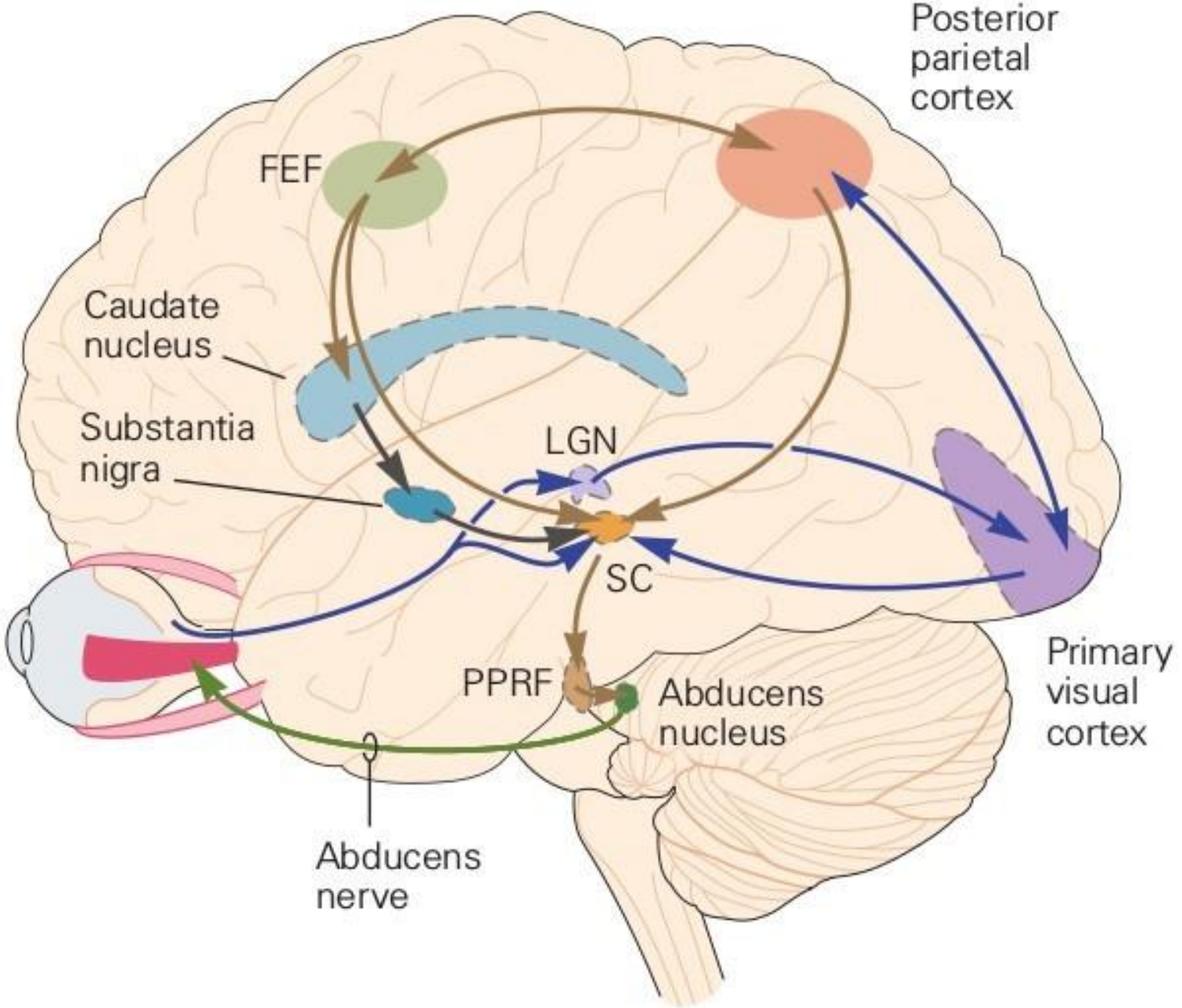
Three Visual Pathway from retina[2]

- Pupilary Reflex and Accommodation

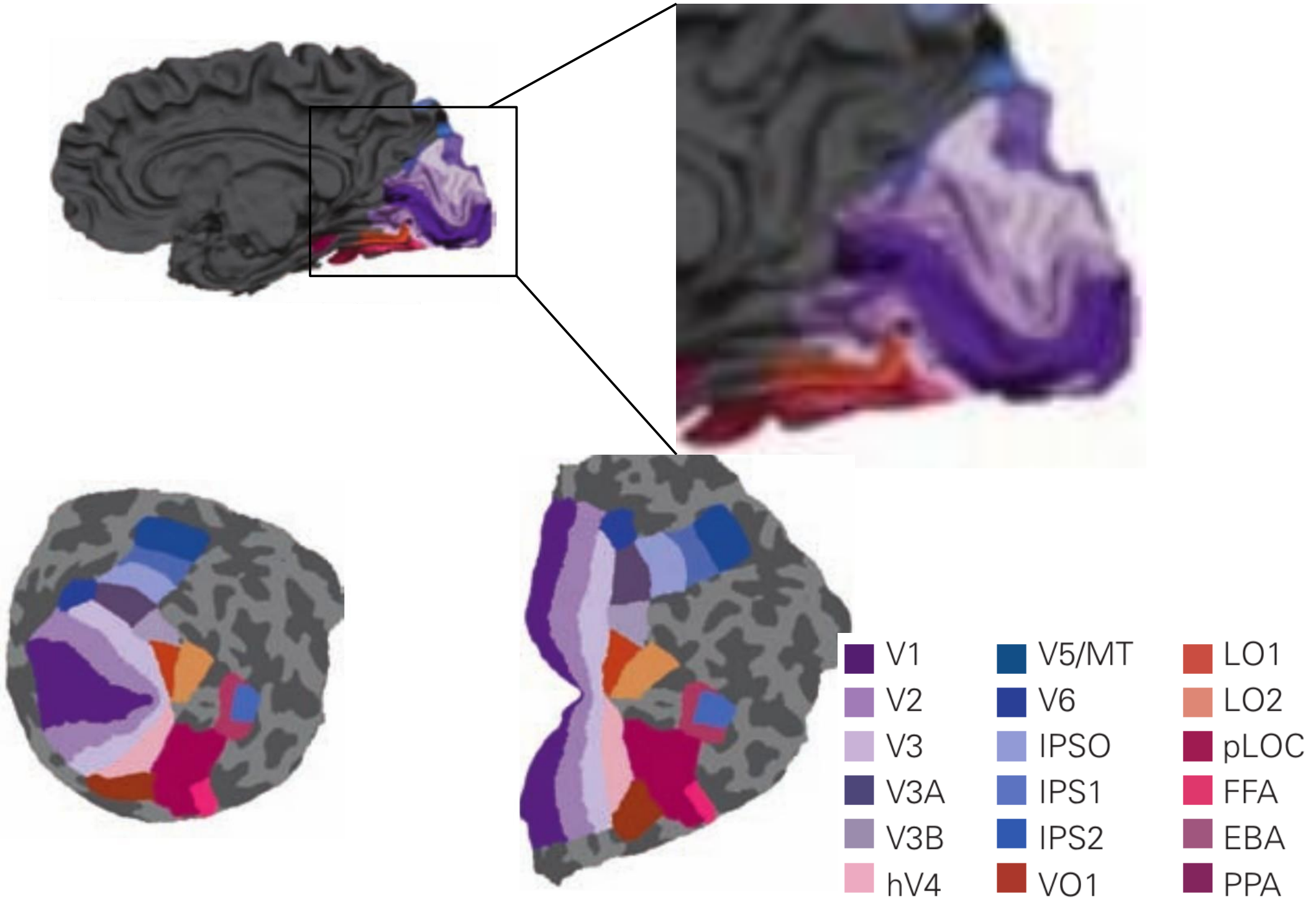


Three Visual Pathway from retina[2]

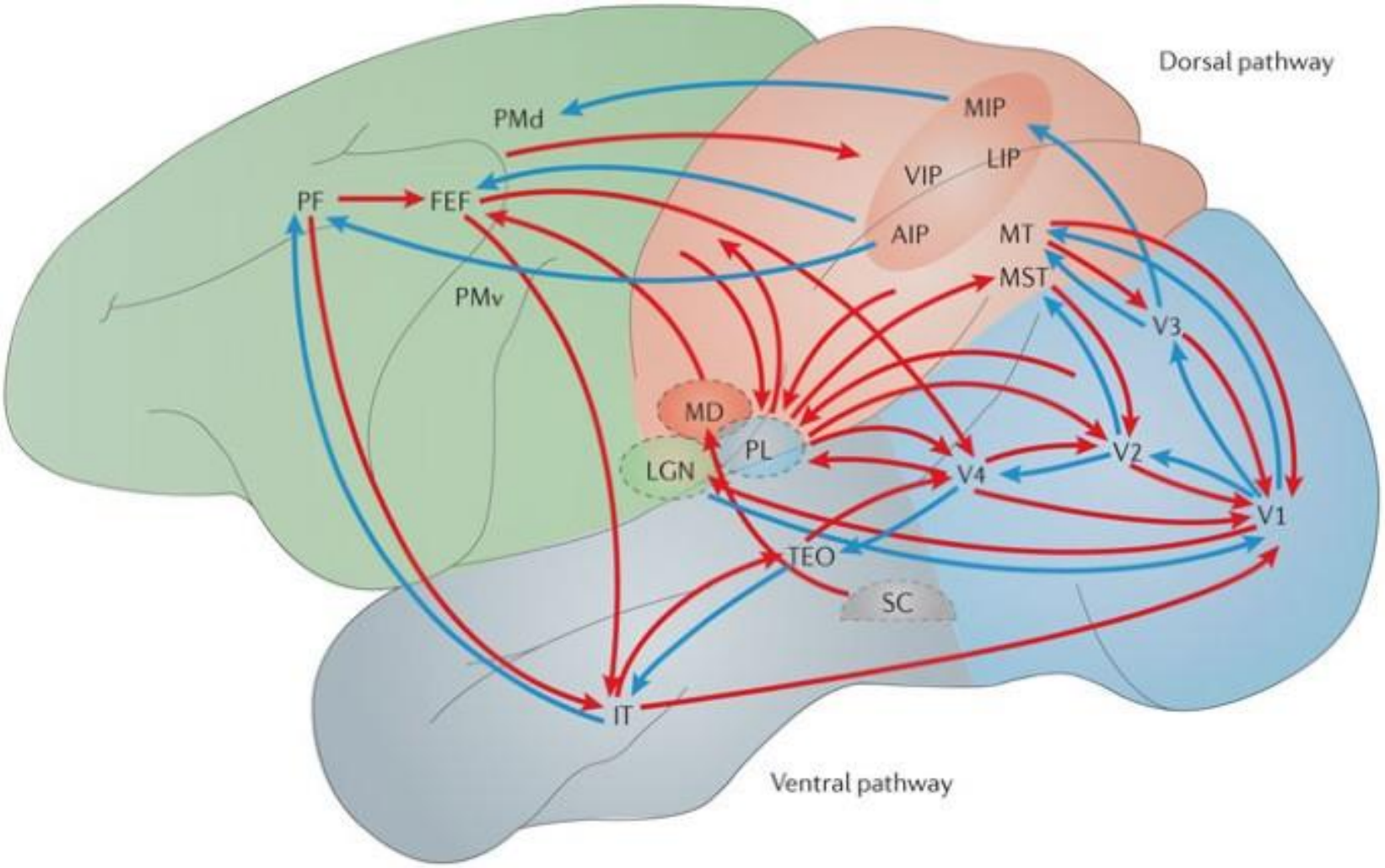
- Eye Movement (Horizontal)



Visual Pathways in the Cerebral Cortex[2]



Visual pathways in the macaque monkey



Nature Reviews | Neuroscience

Summary

- Visual perception is a constructive process
- Visual perception is mediated by the Geniculostriate pathway
- Form, Color, Motion, and Depth are processed in Discrete Areas of the Cerebral Cortex

References

1. Palmer, Stephen E. Vision science: Photons to phenomenology. MIT press, 1999.
2. Siegelbaum, Steven A., and A. J. Hudspeth. Principles of neural science. Eds. Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell. Vol. 4. New York: McGraw-hill, 2000.
3. Purves, D. et al (2008) Neuroscience 4th edition. Sinauer Associates, Sunderland, MA

Course Logistics [Paper Presentations]

- Presentations: 5% (In-classs Presentation + PPT)
  - 2 Presentations per class (starting from 3rd March, every Monday!)
  - 45 mins each presentation. [30-35 mins presentation + 10-15 min Q&A]
  - Groups of 2 per presentation.
- Guidelines:
  - Organization:
    - Problem statement
    - Motivation & Background
    - Methods
    - Results (Main Expts, Baselines, Ablations)
    - Discussion
    - Novelty of the idea
    - Limitations & Future scope.
  - Presentation will be graded for
    - Clarity,
    - Understanding of the main essence and details,
    - Quality of slides and Creativity in Presenting the ideas, and
    - Handling of Q&A.

Course Logistics [Paper Presentations]

- **Do's** and **Don'ts**
- Summarize in bullets, more visual presentation.
- You can use Graphs, Diagrams, Sketches from the original paper.
- Submit ppt to be put on Moodle [Quiz questions on these].

- No cut-paste of long text from paper!
- No wordy slides!