Hybrid Intelligent Systems
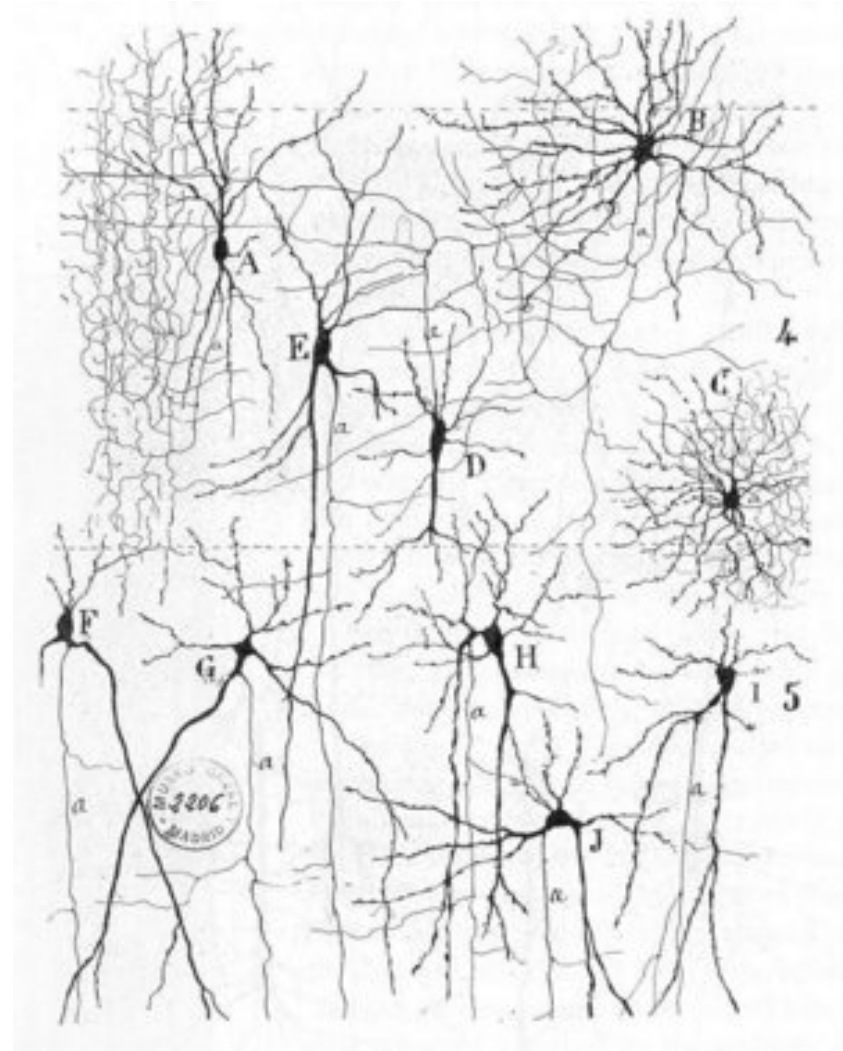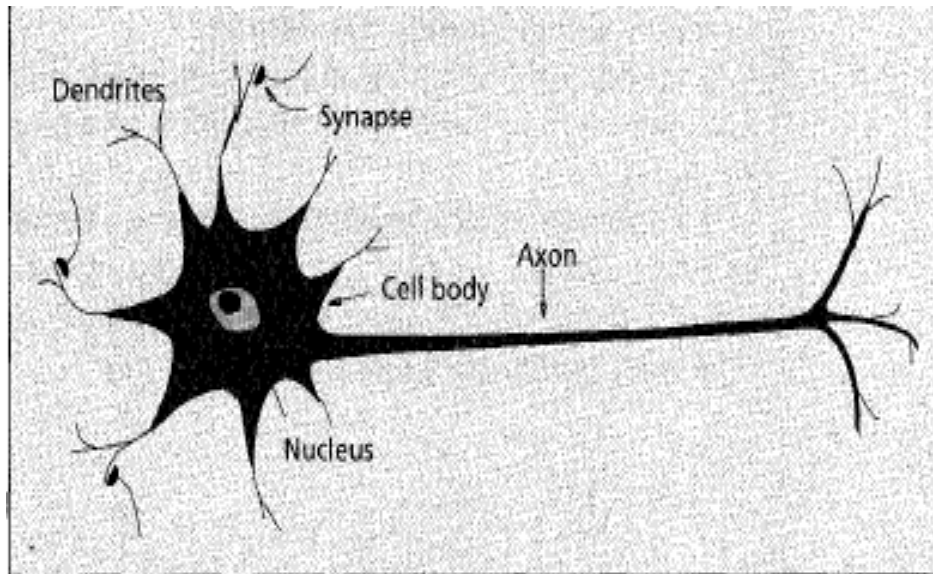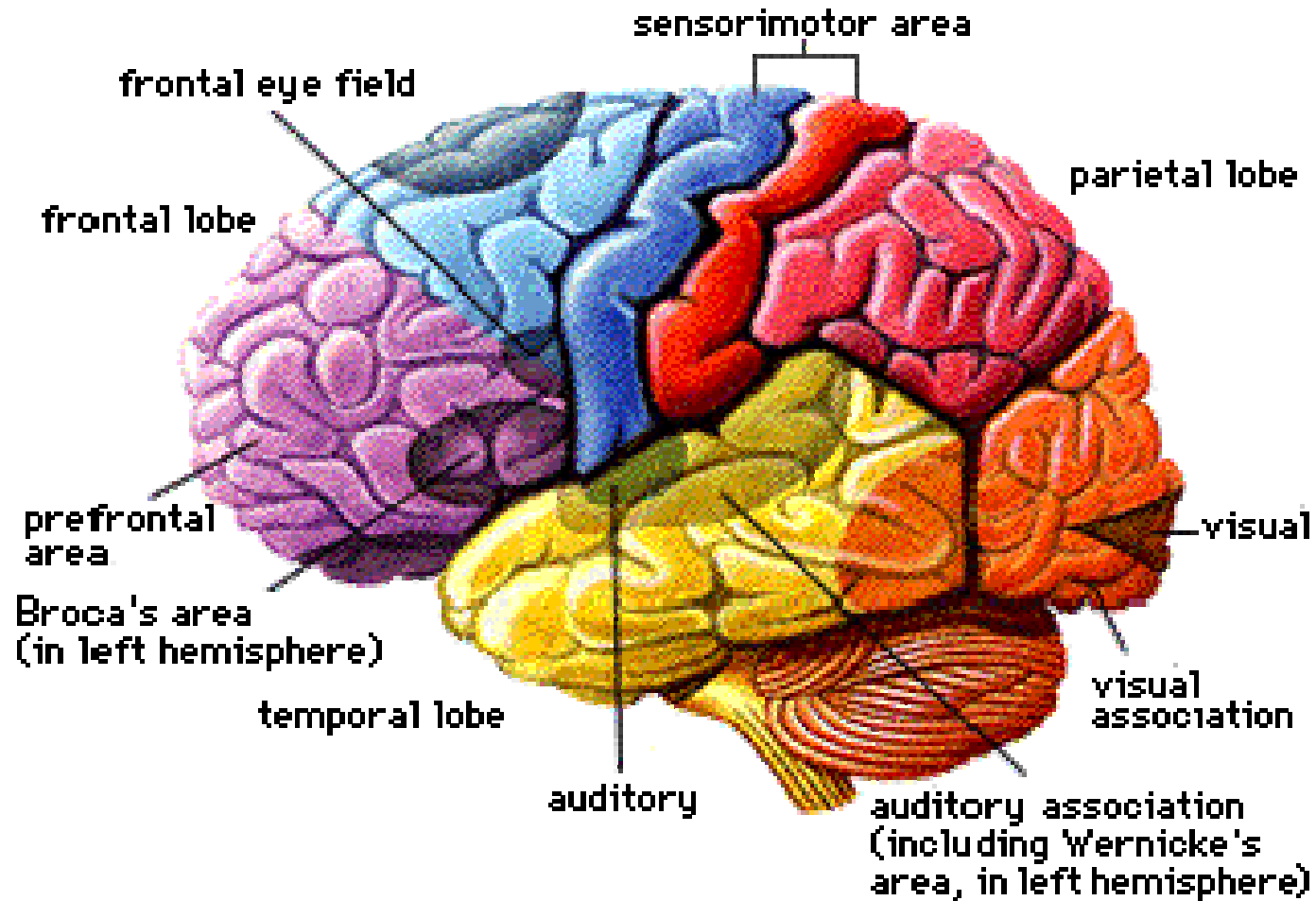
Lecture 2

Difficulties and features of simulation of mind and brain

Human brain

The areas of brain

sensorimotor area

frontal eye field

frontal lobe

parietal lobe

prefrontal area

visual

Broca's area (in left hemisphere)

visual association

temporal lobe

auditory

auditory association (including Wernicke's area, in left hemisphere)

Criterions of Jeff Hawkins (in book "On Intelligence") for model of mind

- The inclusion of time in brain function
- The importance of feedback
- Any theory or model of the brain should account for the physical architecture of the brain

Senses

- We teach our children that humans have five senses: sight, hearing, touch, smell, and taste.
- We really have more.
- Vision is more like three senses— motion, color, and luminance (black-and-white contrast).
- Touch has pressure, temperature, pain, and vibration.
- We also have an entire system of sensors that tell us about our joint angles and bodily position. It is called the proprioceptive system (*proprio-* has the same Latin root as *proprietary* and *property*). You couldn't move without it.
- We also have the vestibular system in the inner ear, which gives us our sense of balance.
- Some of these senses are richer and more apparent to us than others, but they all enter our brain as streams of spatial patterns flowing through time on axons.

Neocortical memory

- The neocortex stores sequences of patterns
- The neocortex recalls patterns auto-associatively
- The neocortex stores patterns in an invariant form
- The neocortex stores patterns in a hierarchy
- Neocortex consists of 6 layers of neurons identical for different regions of one

Hierarchy in mind

Classification (rocognition) of situation (task)

Associative links

Forming of reaction on situation (solving)

Neocortex

Prediction

Old brain

Basic behaviors
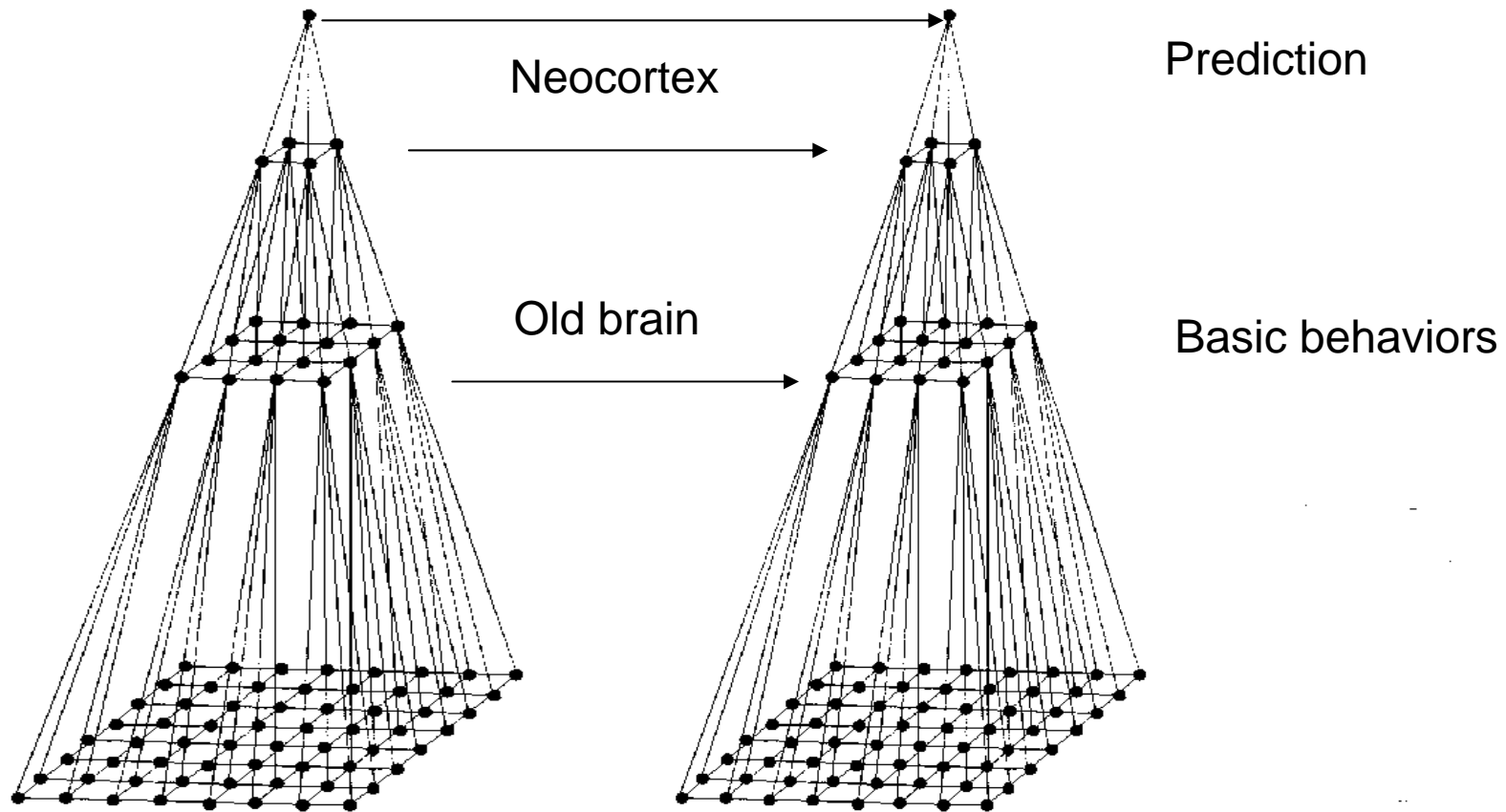
Essential features of action of brain

- Recognition of invariant patterns received from the world
  - Sufficient features of the environment
- Capability to predict
  - For avoidance of negative situations and for aspiration for positive ones

The understanding is prediction.

What we perceive is a combination of what we sense and of our brains' memory-derived predictions.

Instead of just making predictions based on the behavior of the old brain, the human neocortex directs behavior to satisfy its predictions.

# The first four visual regions in the recognition of objects
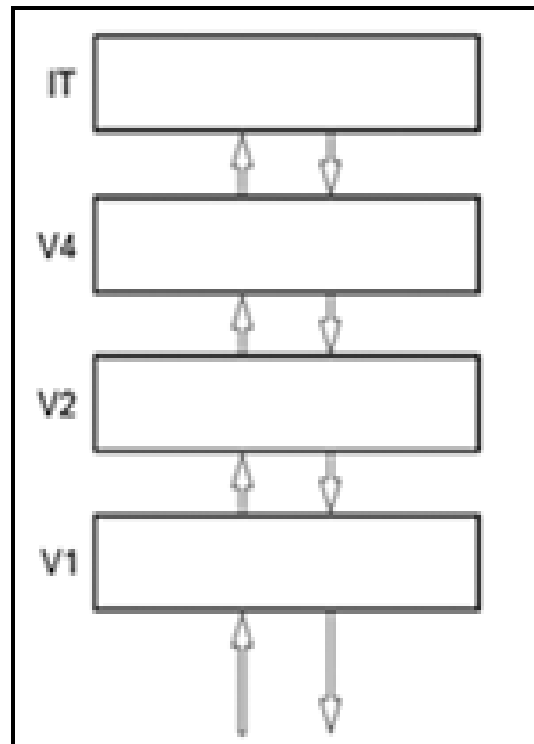
Vx – layers of visual region
of neocortex

In the course of spanning four cortical stages
from retina to IT, cells have changed from being
rapidly changing, spatially specific, tiny-feature
recognition cells, to being constantly firing,
spatially nonspecific, object recognition cells.
The IT cell tells us we are seeing a face
somewhere in our field of view. This cell,
commonly called a face cell, will fire no matter
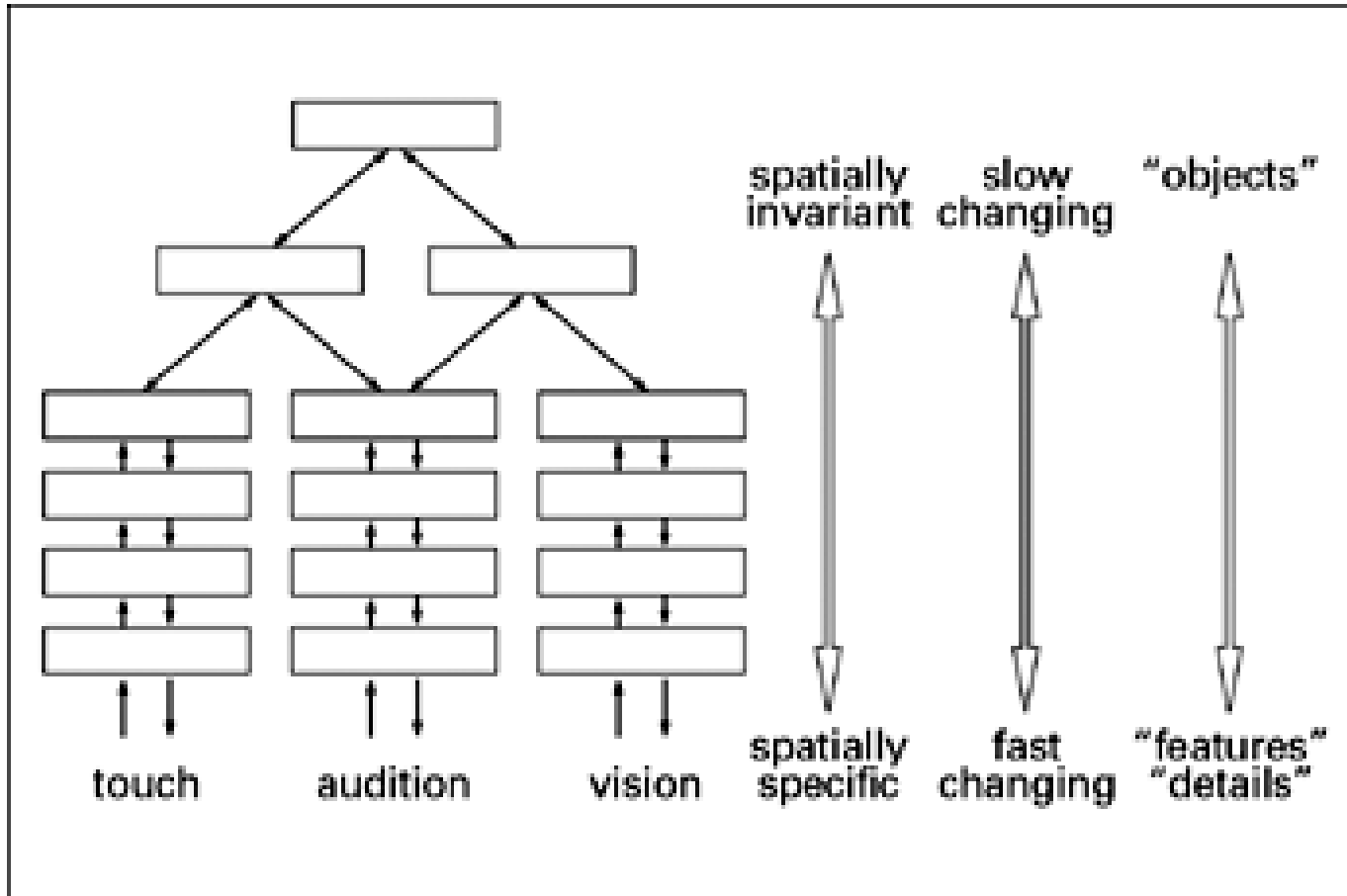whether the face is tilted, rotated, or partially
occluded.
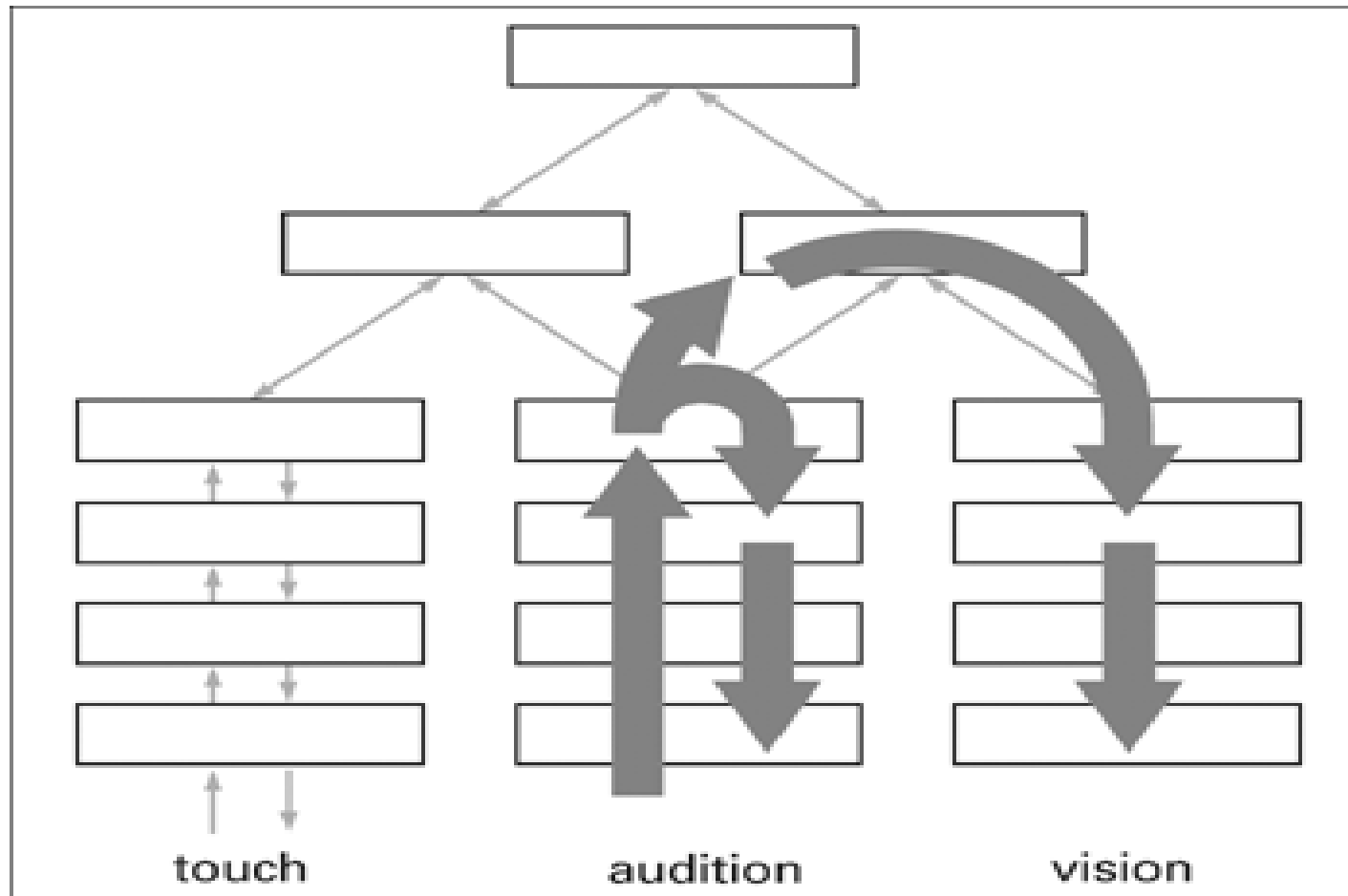It is part of an invariant representation for "face".

From retina
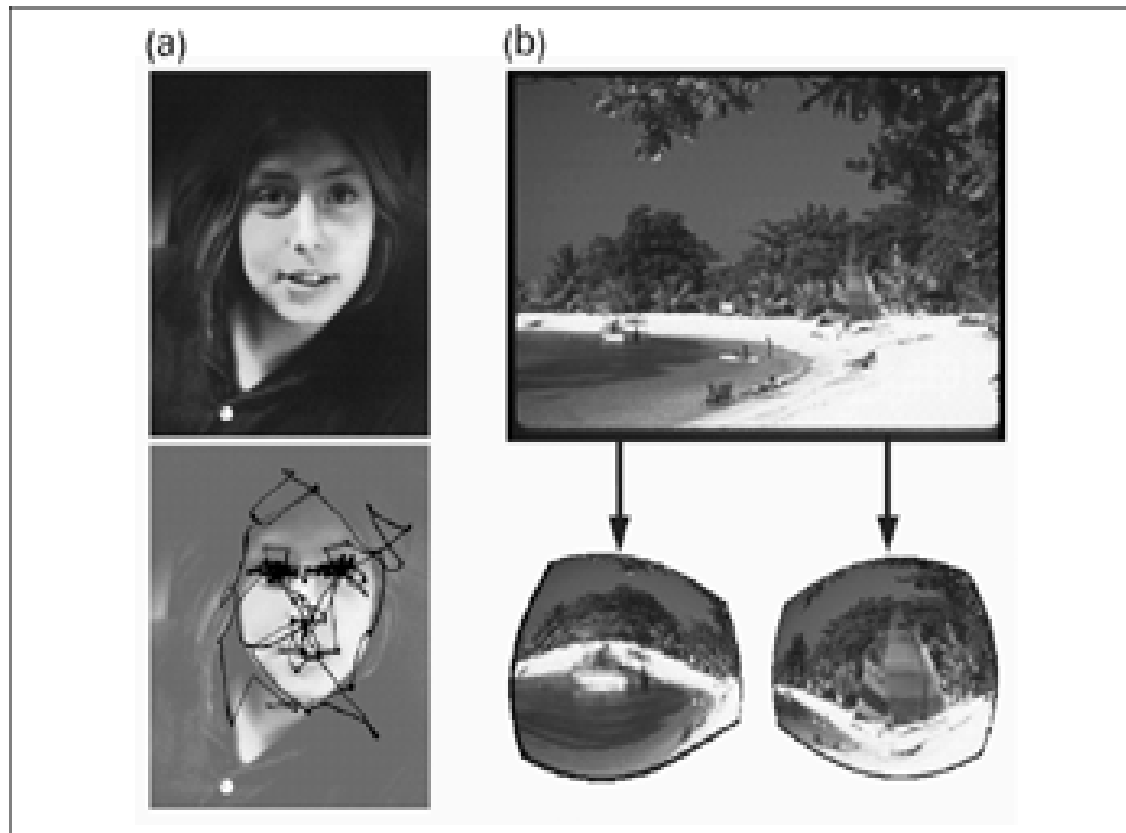
How the eye makes saccades across a human face

Distortion caused by the uneven distribution of receptors in the retina.
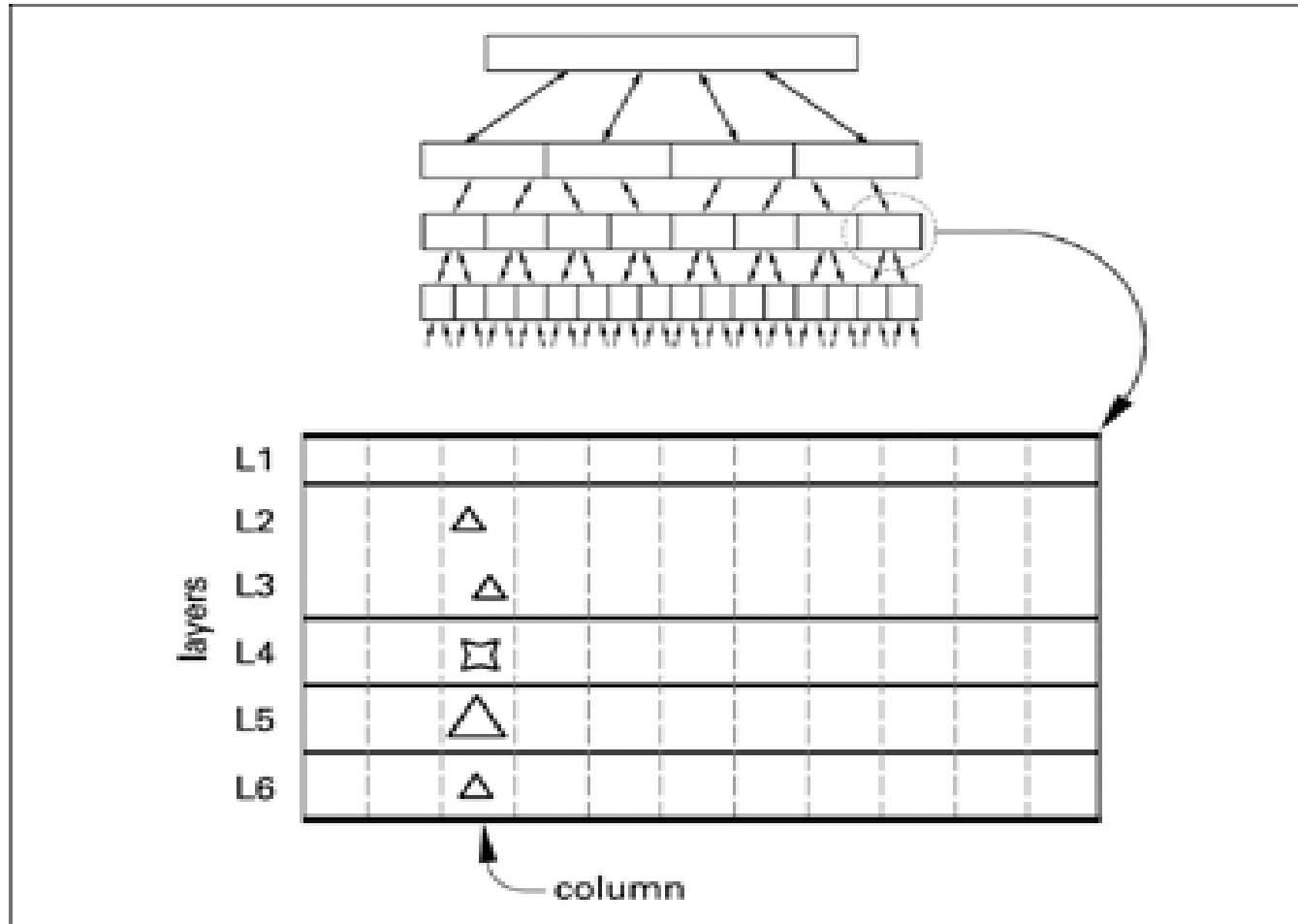
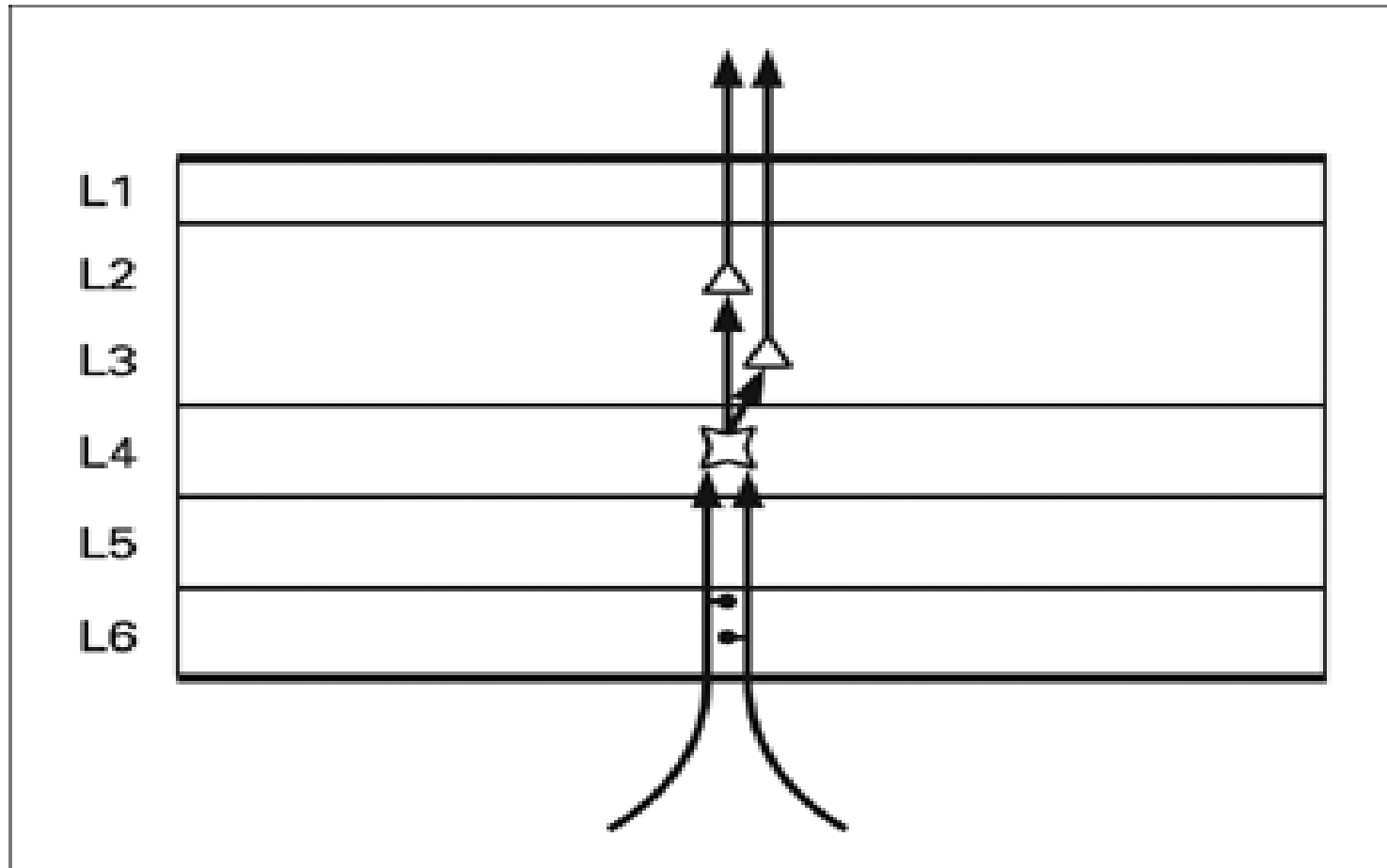# Forming invariant representations in hearing, vision, and touch

Information flows up and down sensory hierarchies to form predictions and create a unified sensory experience
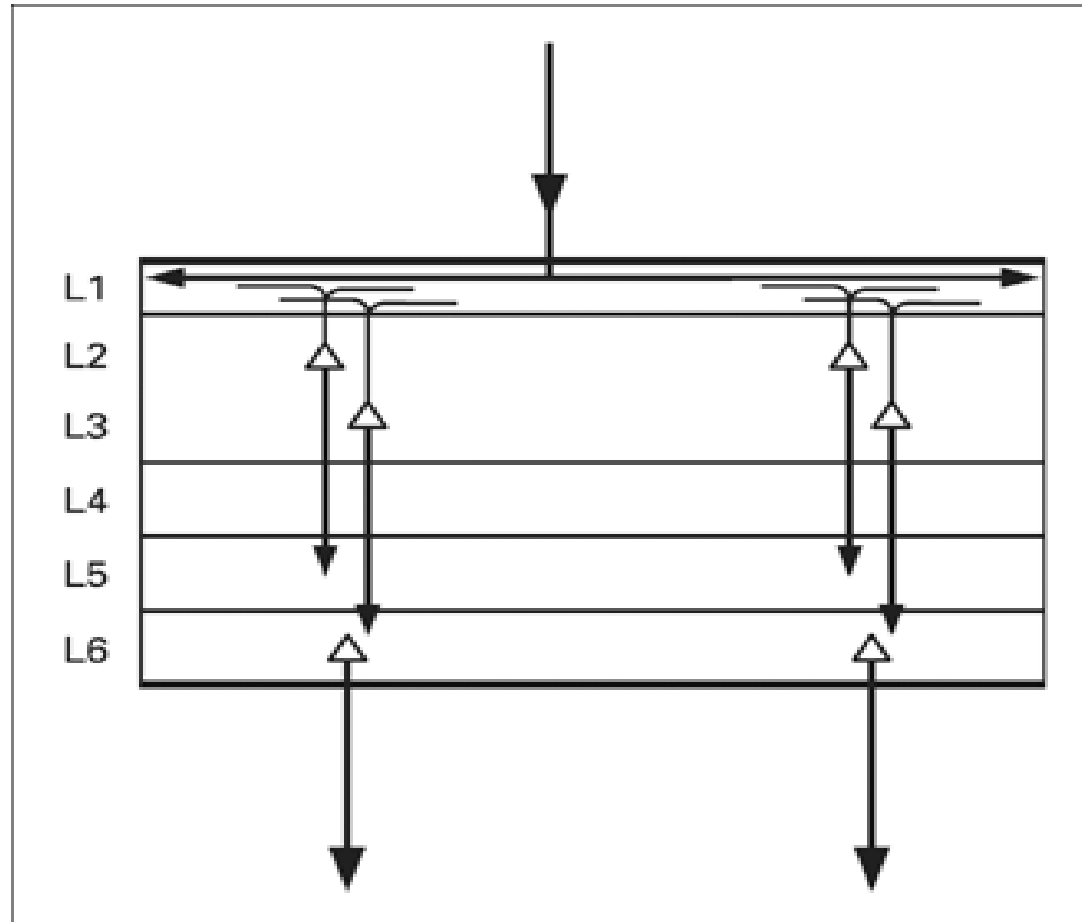
Alternate view of the cortical hierarchy taking into account left and right hemisphere

touch   audition   vision

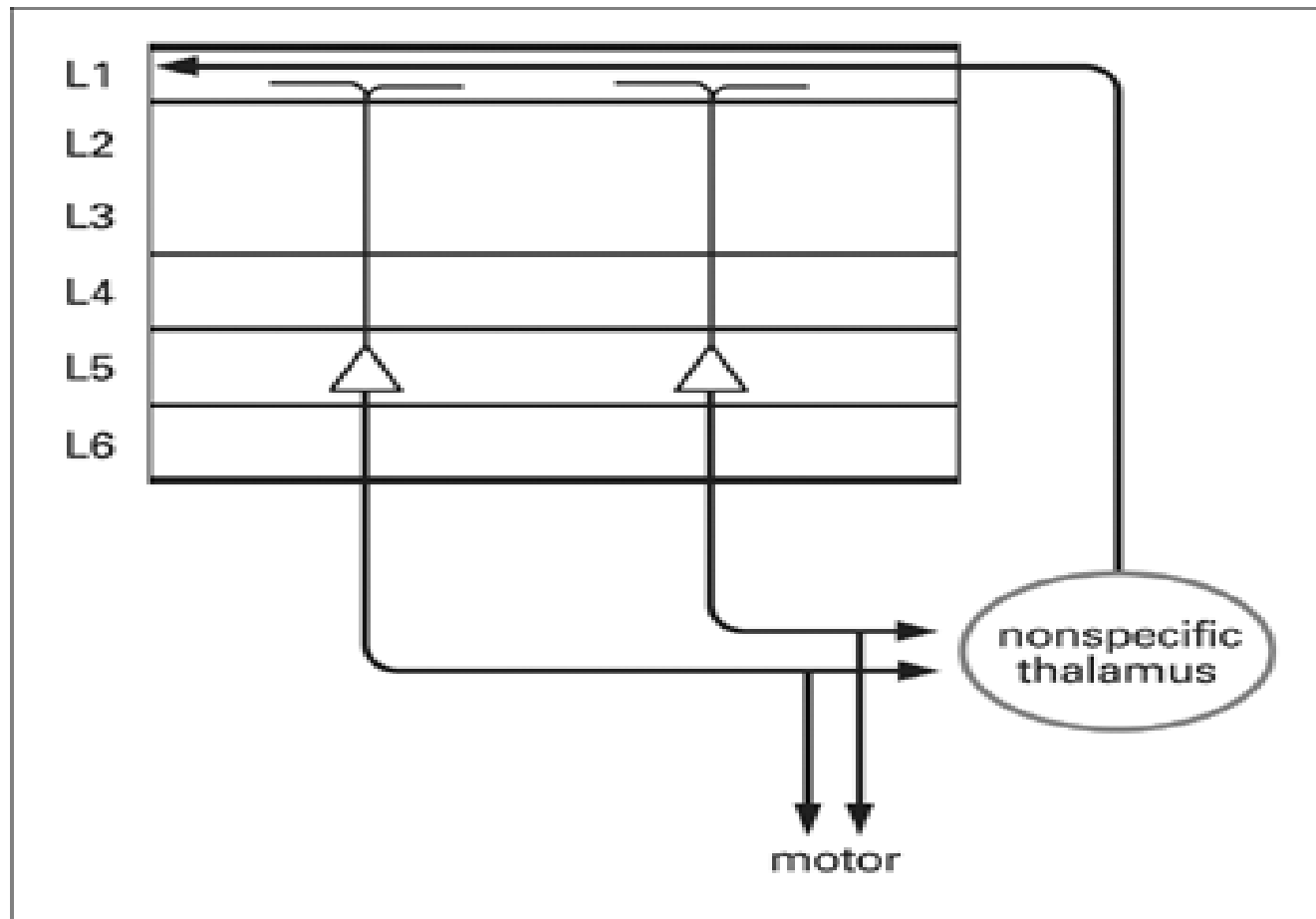# Layers and columns in a region of cortex

Upward flow of information through a region of cortex

Downward flow of information through a region of cortex

How current state and current motor behavior is communicated broadly via the thalamus

Three main circuits in mind

- Converging patterns going up the cortical hierarchy

- Diverging patterns going down the cortical hierarchy

- Delayed feedback through the thalamus

Hebbian learning

- When two neurons fire at the same time, the synapses between them get strengthened

Evolution of mind (or brain)

- Prediction of simple changes in environment (in protozoa, unicellular) and simple behavior based on it (tropism and avoidance)

- Prediction of simple changes in environment based on associative links between events (conditioned reflex) – appearance of sequences of signals

- Appearance of senses as fields of same sensors for more reliable recognition of events – appearance of associative memory of sequences of patterns (in reptiles)

- Invariant recognition of input patterns based on generalization – appearance of associative memory of sequences of preprocessed (generalized) patterns (prediction of generalized patterns), appearance of neocortex (in mammals)

- Increasing of role of neocortex on motor activity; Invariant recognition of sequences of generalized patterns – appearance of signs and manipulation of ones (in humans)

Reference

- J. Hawkins and S. Blakeslee,

  On Intelligence, Times Books, 2004.
  (**Electronic book is available**)