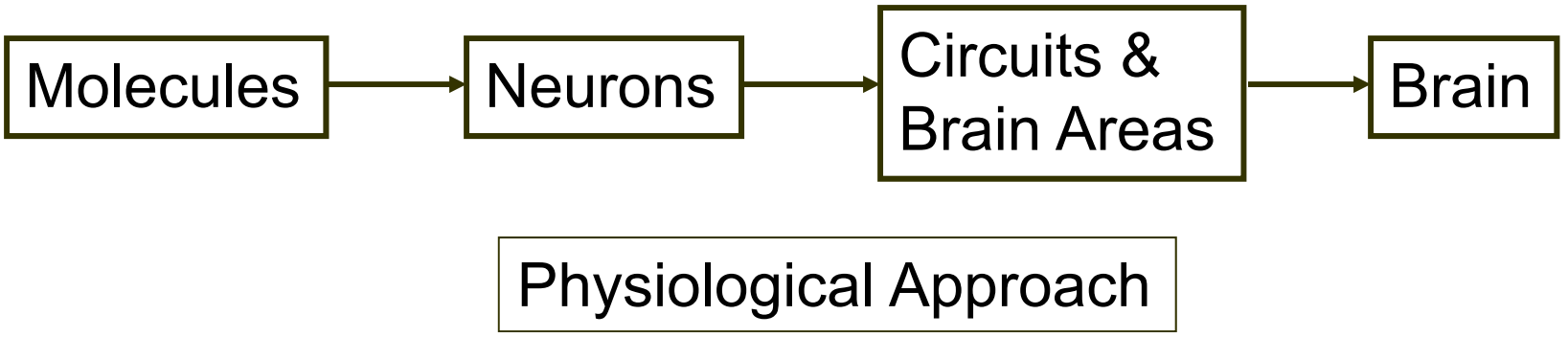
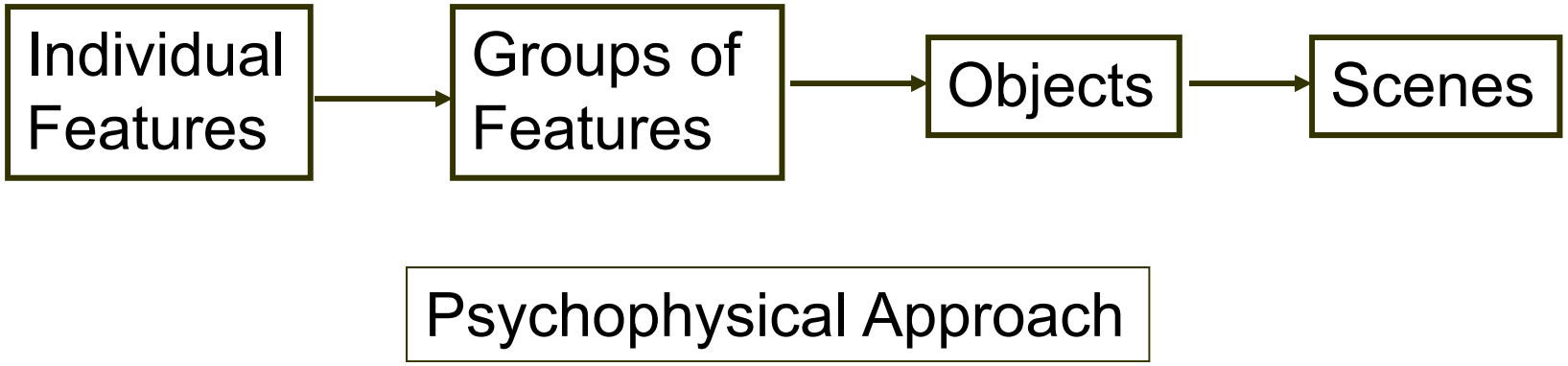
PERCEIVING OBJECTS

Visual Perception

Different Approaches

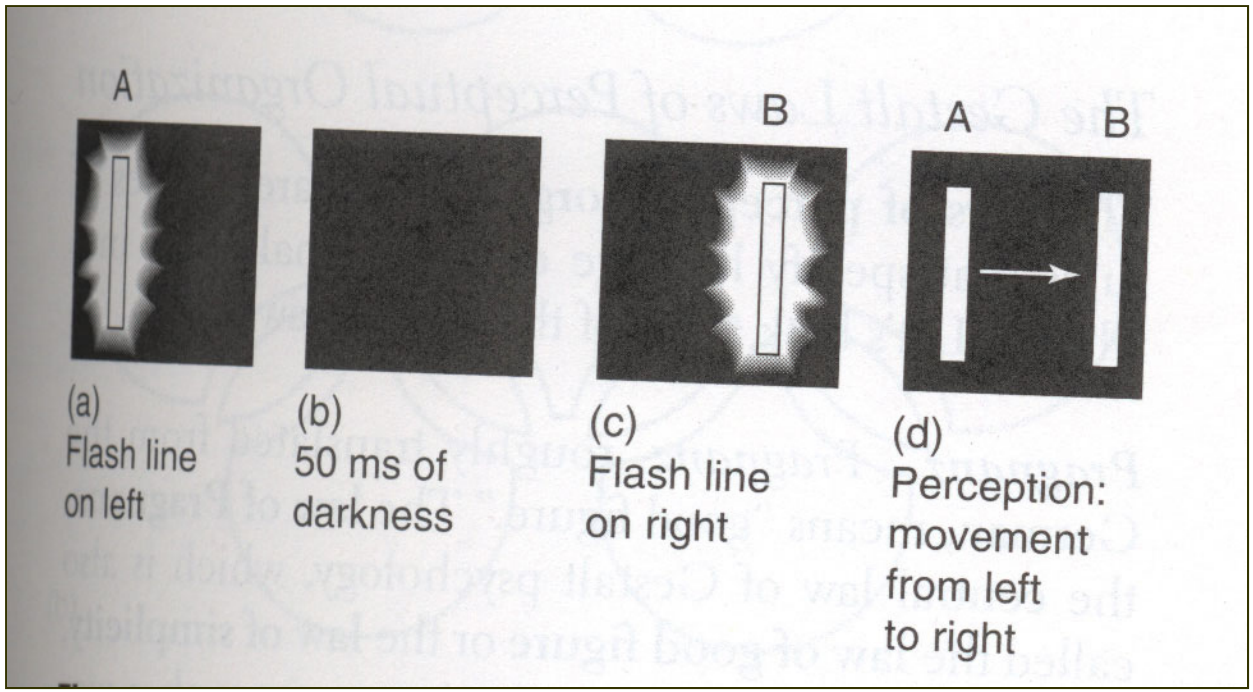




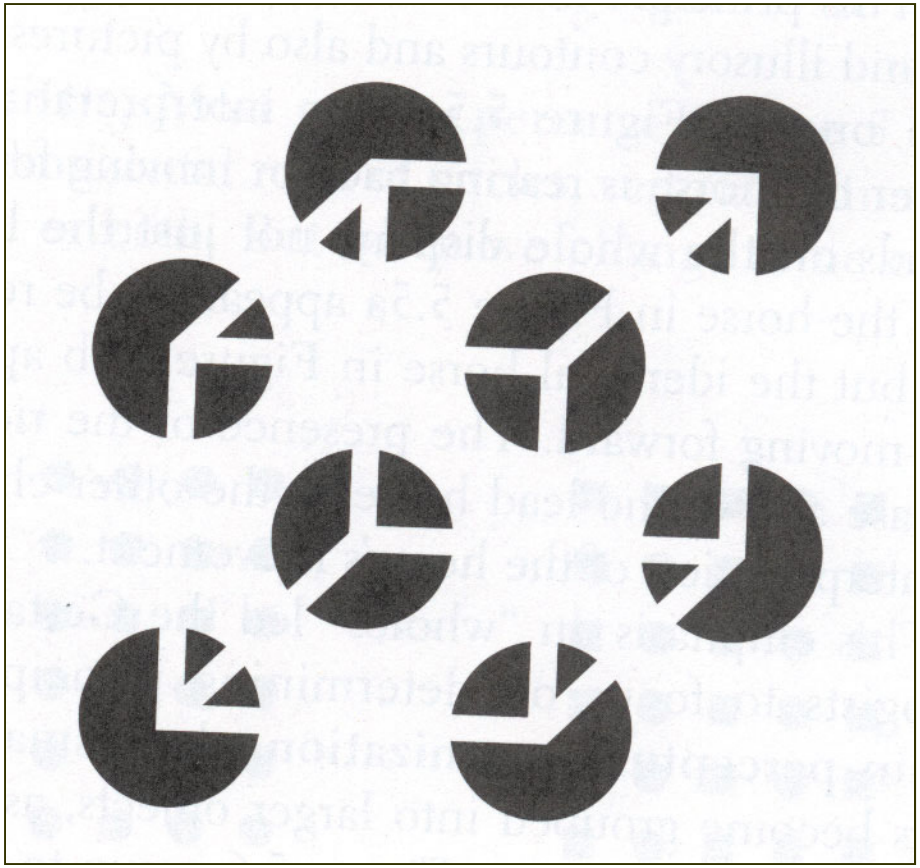
Gestalt Approach

- Gestalt psychology
  - Structuralism : Perception is created by combining elements called *sensation*
- But this cannot explain
  - Apparent Movement
  - Illusory Contours

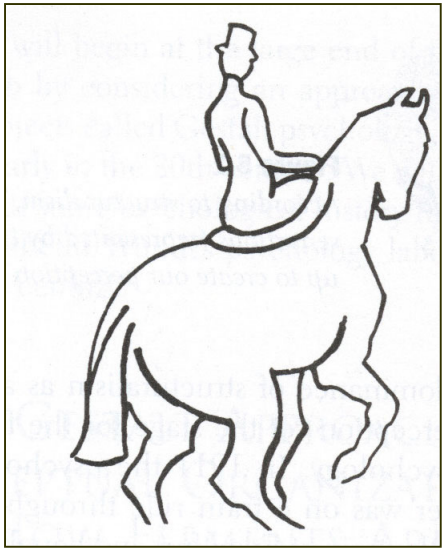
Apparent Movement

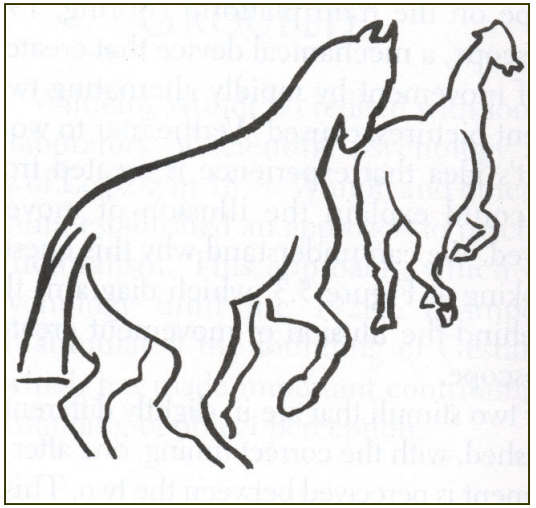


Illusory Contours



Whole is different from the sum of its parts





Basic Philosophy

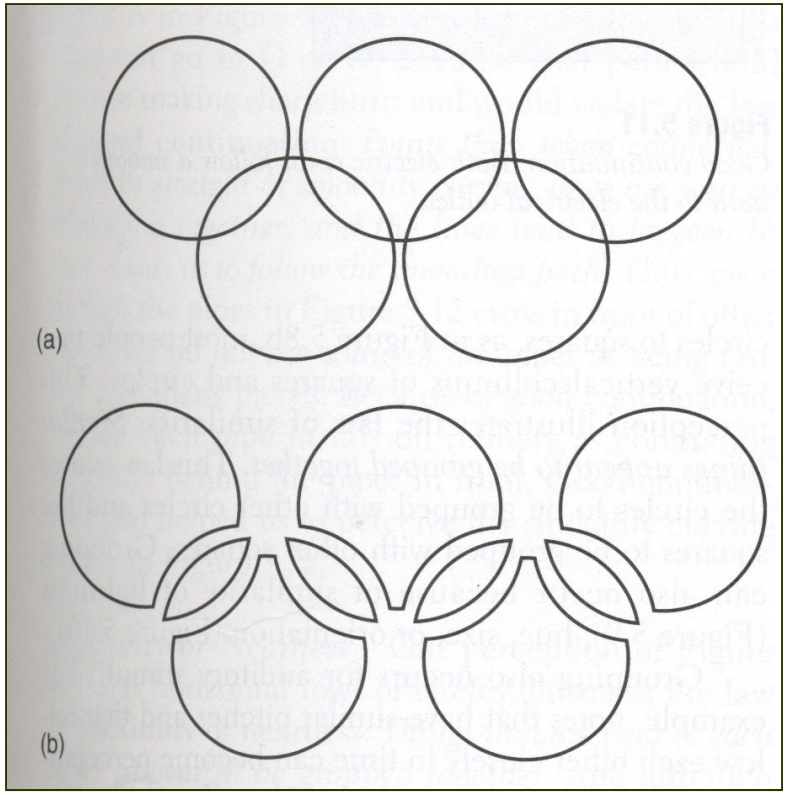
- The whole is different than the sum of its parts
- Six principles defining perceptual organization
  - How do we combine components to perceive the whole?
  - Is their any basic rules that we use?

Gestalt Principles of Perceptual Organization

- Law of Simplicity
- Law of Similarity
- Law of Good Continuation
- Law of Proximity
- Law of Common Fate
- Law of Familiarity

Law of Simplicity

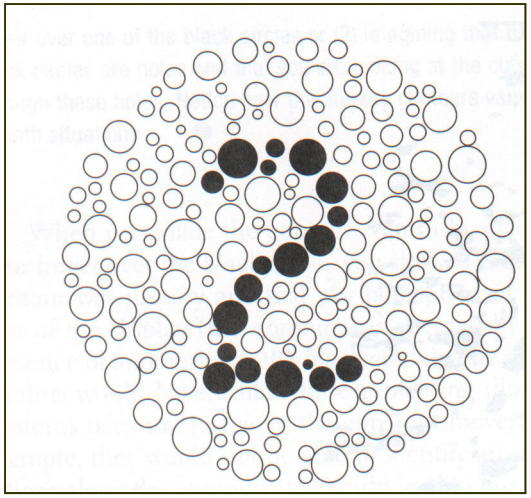
- Every stimulus pattern is seen in a way that is as simple as possible.

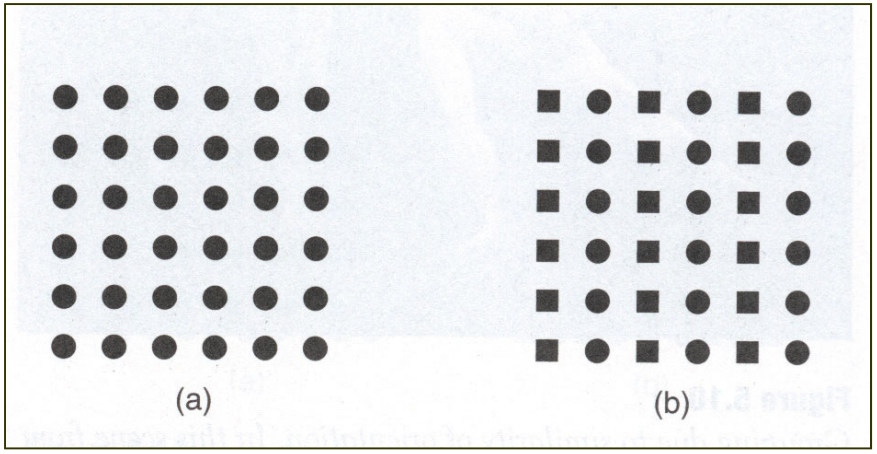


Law of Similarity

- Similar things appear to be grouped together

Lightness



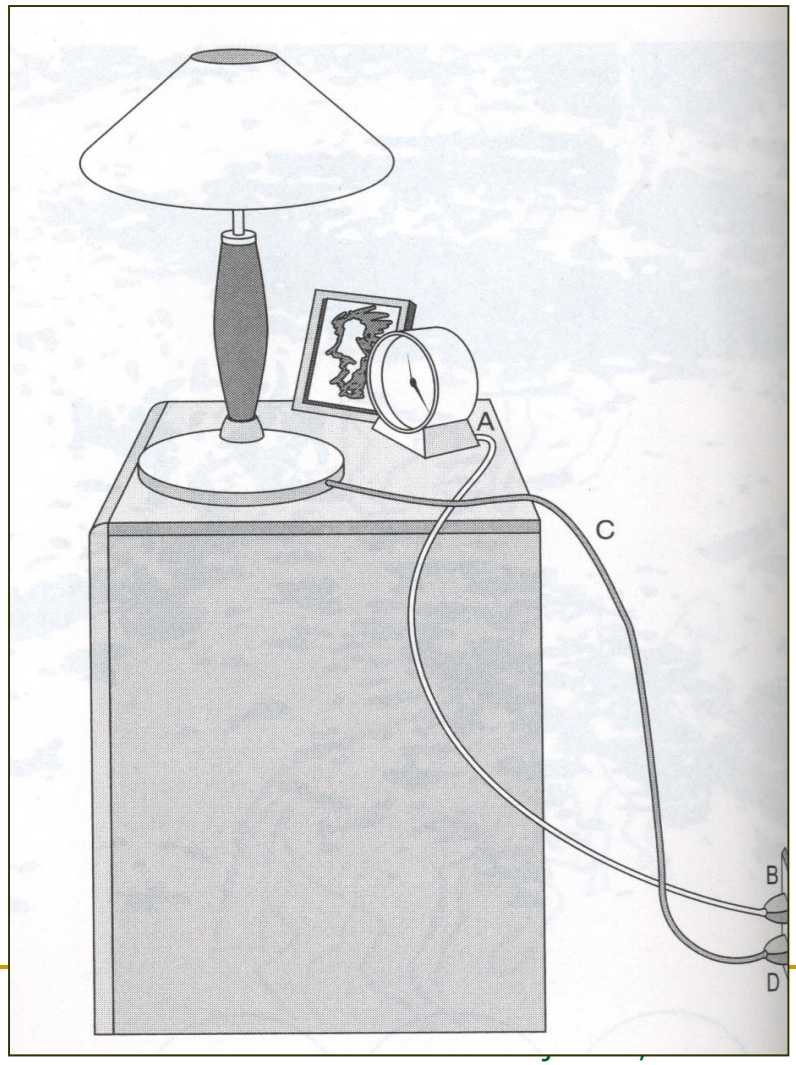


Shape

Orientation

Law of Good Continuation

- Points that when connected are seen as straight or smoothly curving lines tend to be seen as belonging together, and the lines tend to be seen in such a way that they follow the smoothest path.



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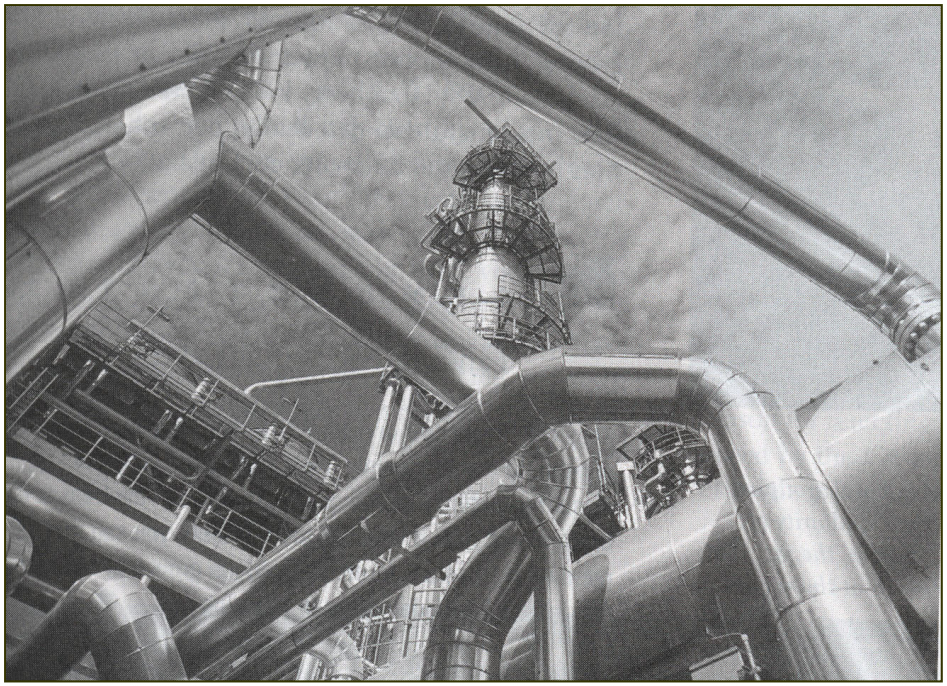
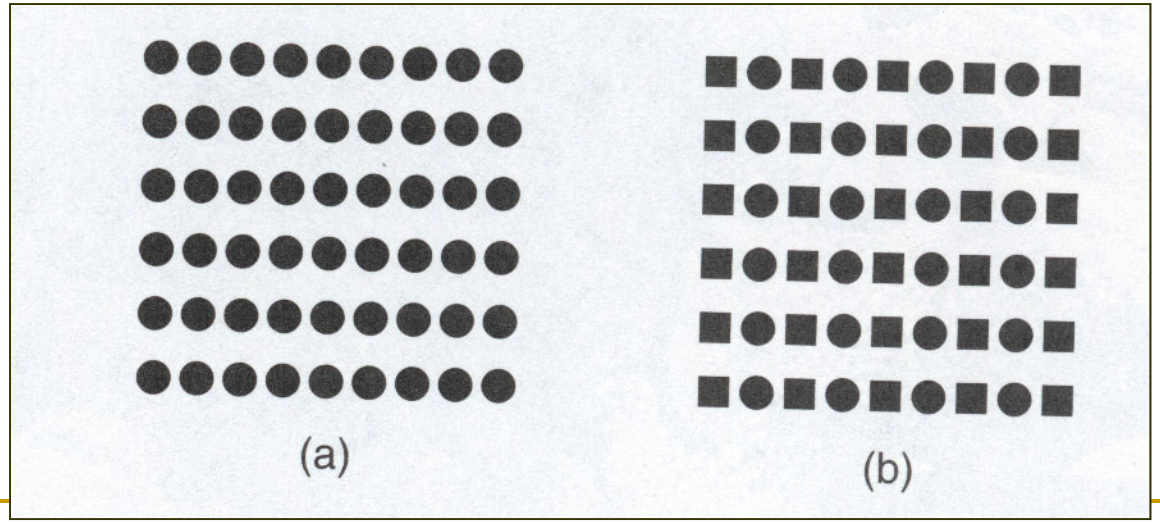


Law of Proximity or Nearness

- Things close together appear to be grouped together
- Overcomes law of similarity in this example



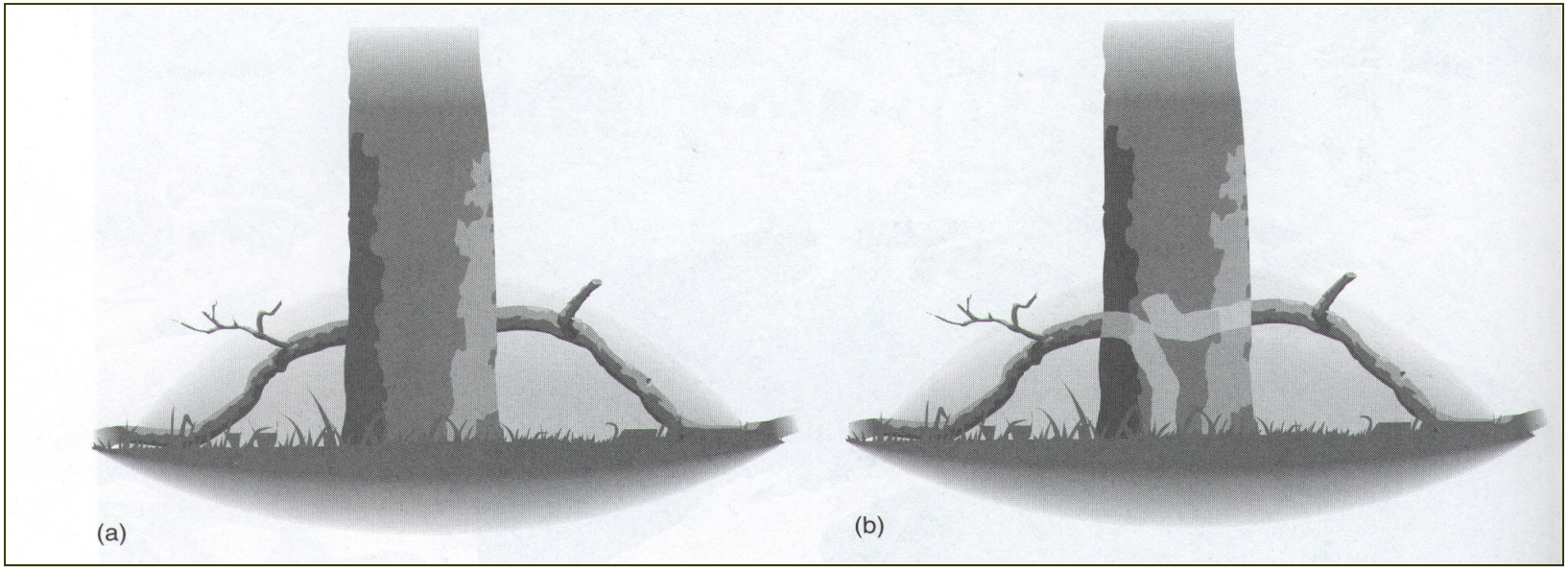
Law of Common Fate

- Objects moving in the same direction appear to be grouped together

Law of Familiarity

- Objects appear to be grouped if the groups appear to be familiar or meaningful.

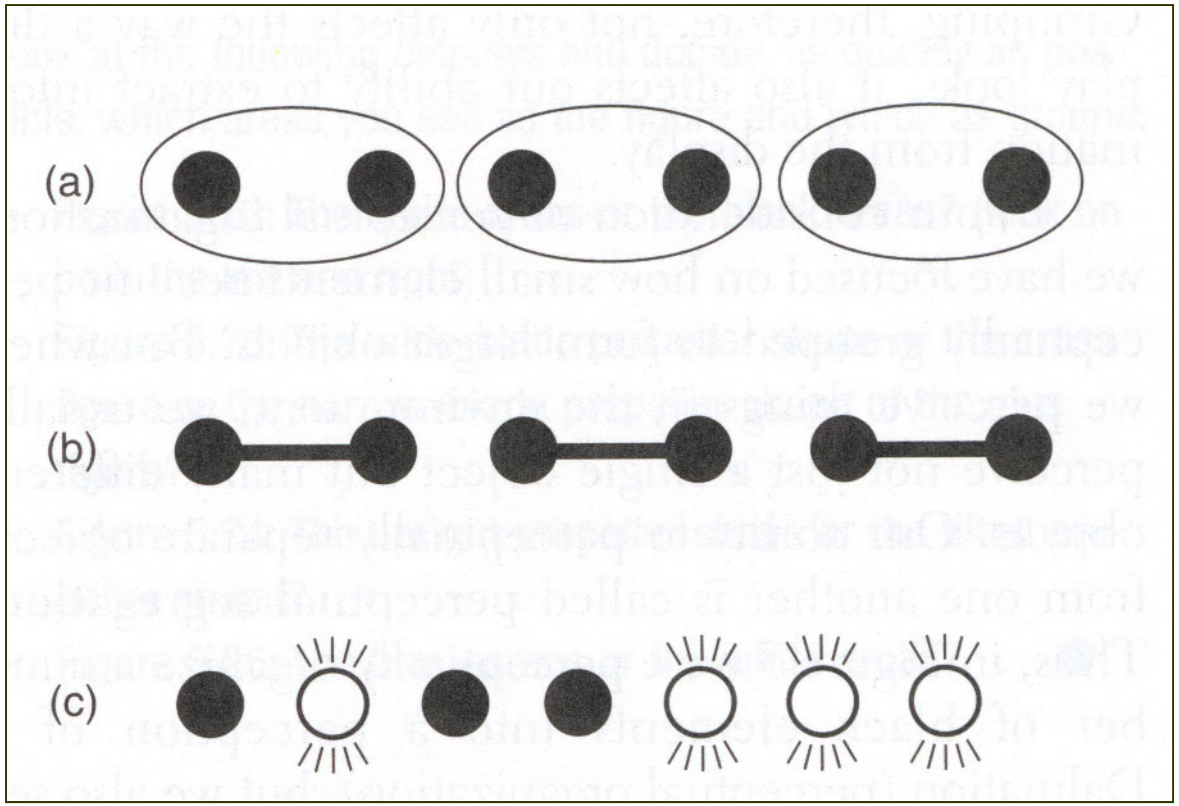
Heuristic and not Algorithm



Where does the heuristics come from?

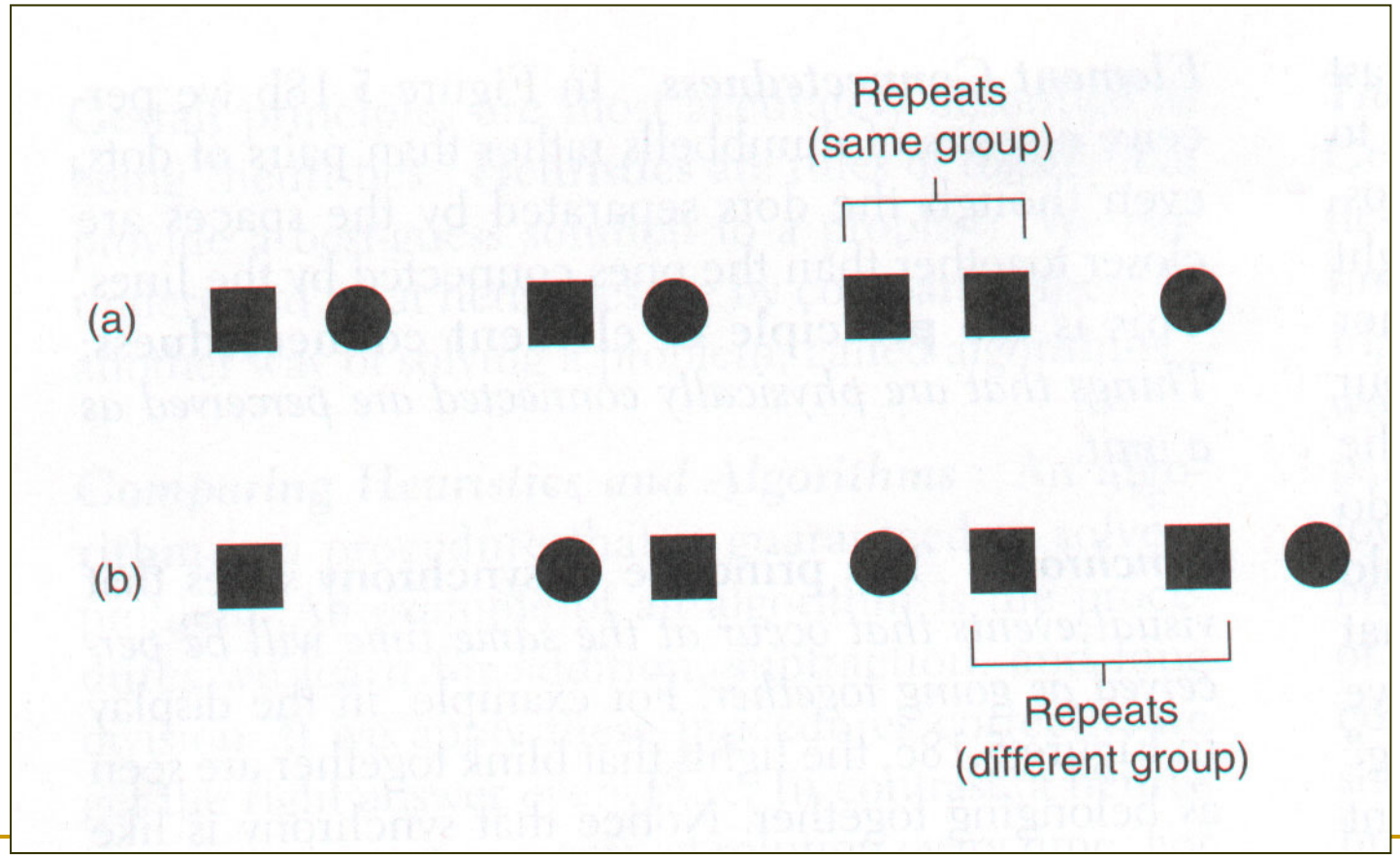
Palmer-Irvine Principles of Perceptual Organization

- Common Region
- Element Connectivity
- Synchrony



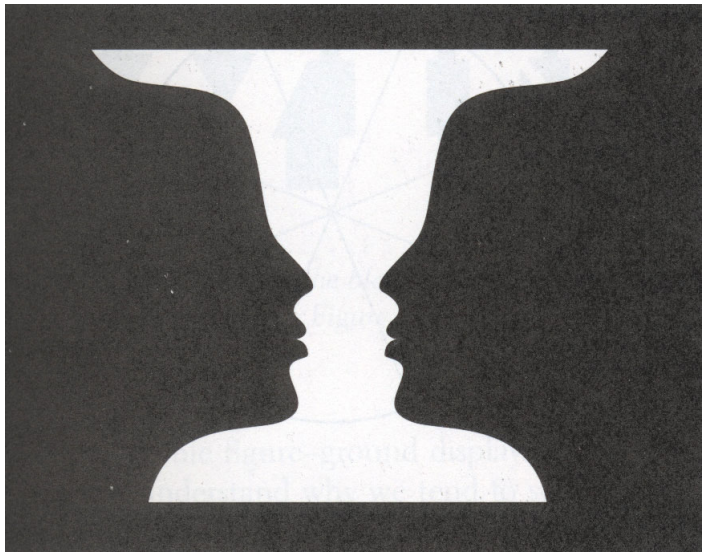
Quantitative Measure of Grouping Effects

- Repetition Discrimination Task



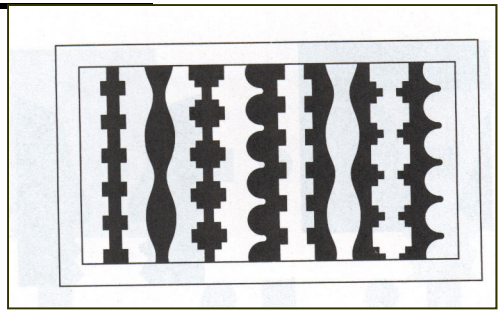
Perceptual Segregation

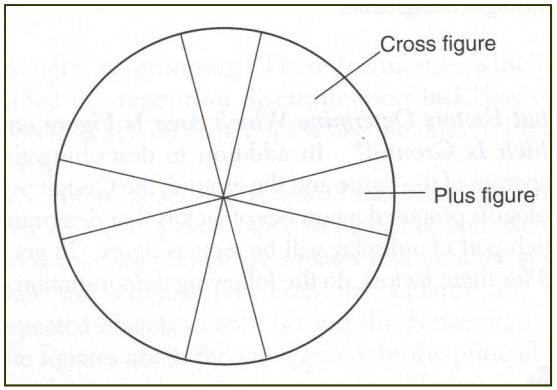
- Gestalt Theory
- Reversible figure ground
  - Figure more object like
  - Figure seen as being in front of ground
  - Ground is uniform region behind figure
  - Separating contours appear to belong to figure

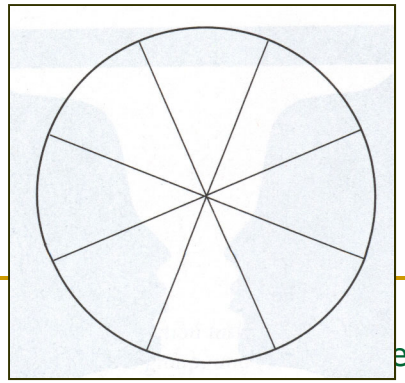


Factors Determining Figure and Ground

- Figure
  - Symmetry
  - Smaller Areas
  - Horizontal or Vertical

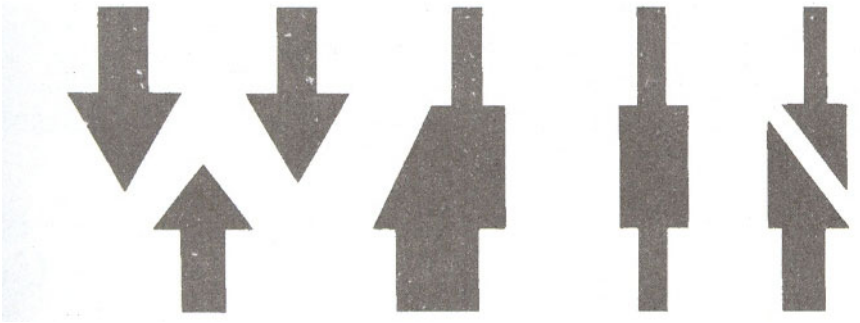


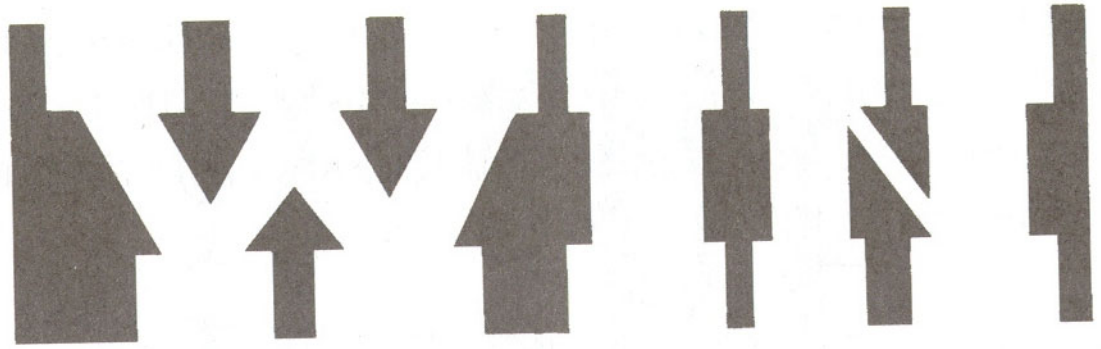




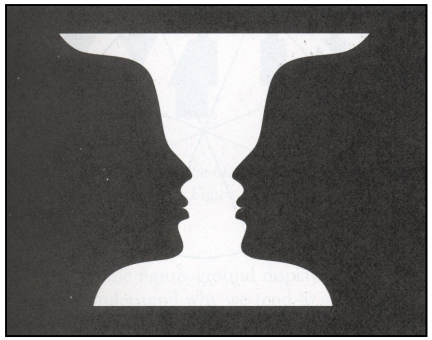
Factors Determining Figure and Ground

- Figure
  - Familiarity



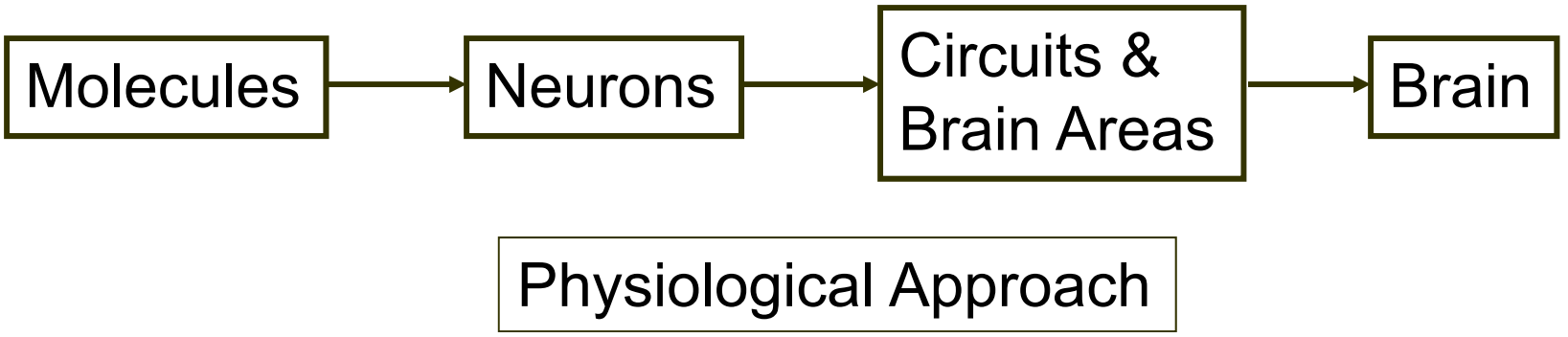


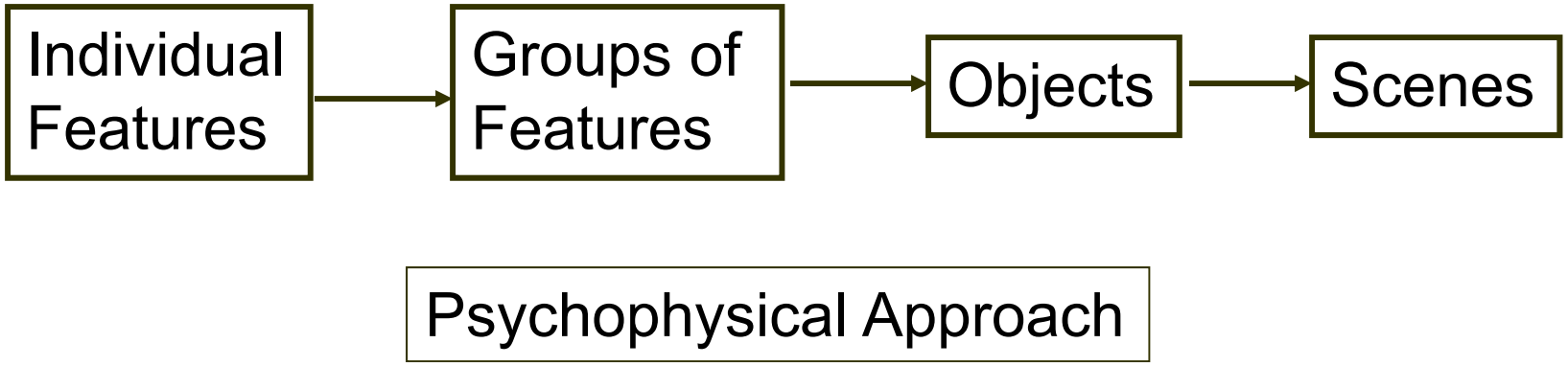
Modern Research



- Role of Contours
  - Likeliness of Occurance
- When does segregation occur?
  - Popular belief
    - First segregation, then recognition
  - Later proved
    - Recognition and segregation may happen in parallel

Perceiving Objects



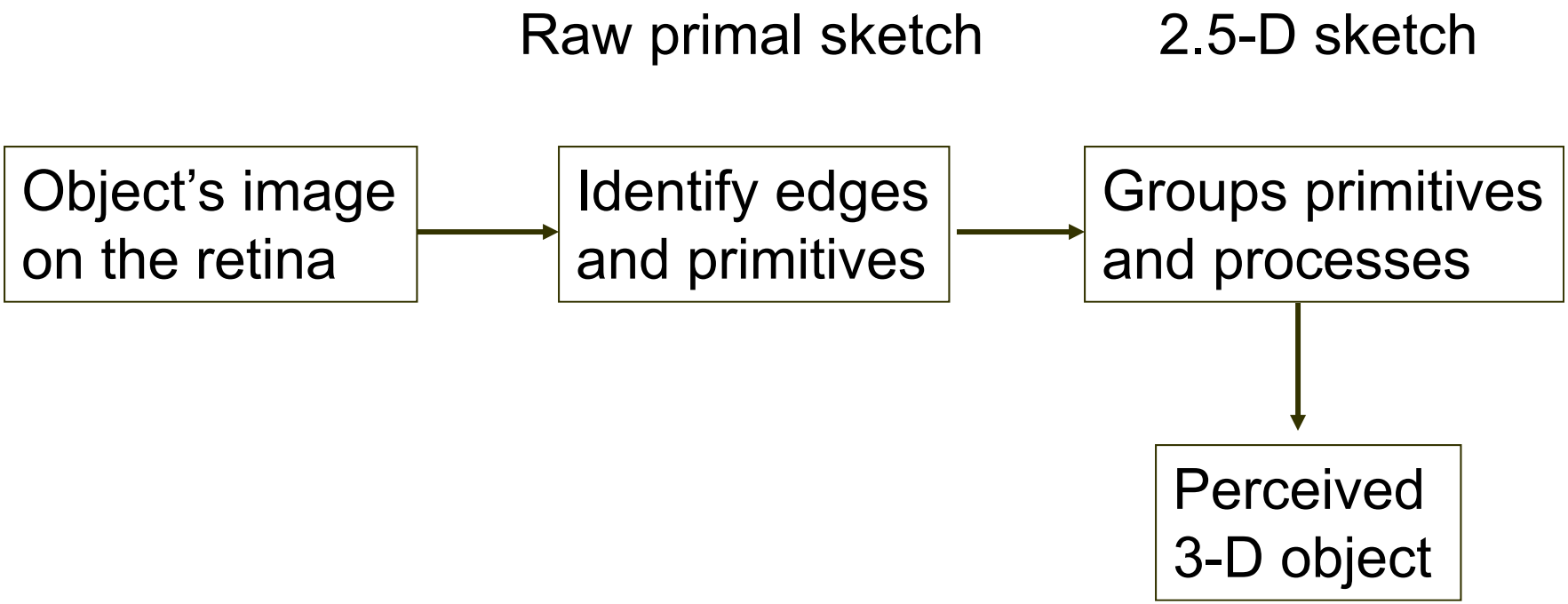


How Objects are Constructed?

- Marr's computational Model
- Feature Integration Theory (FIT)
- Recognition-by-Components Theory (RBC)

Marr's Theory of Object Construction

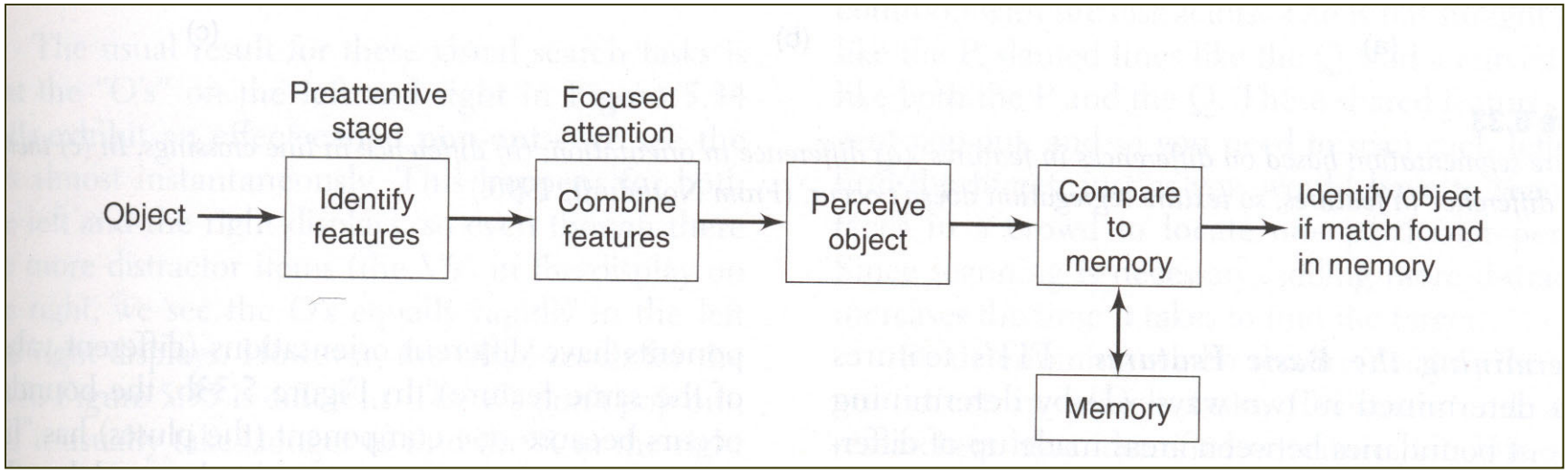
- Computational Approach



Marr's Theory

- Computational Approach
  - Creation of *raw primal sketch*
    - Analysis of light and dark region of retinal image
    - Using natural constraints
      - E.g. Illumination edge vs. geometric edge
    - Do not see this
  - Processed to develop a 2.5D sketch

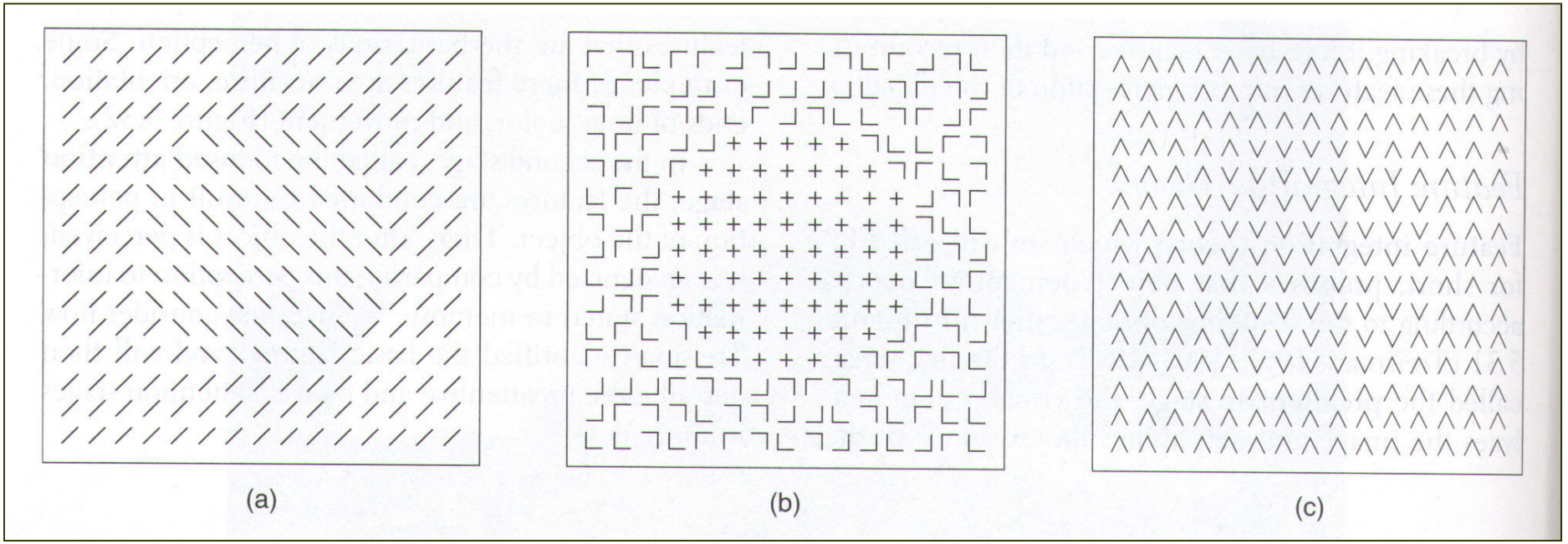
Feature Integration Theory (FIT)



- Preattentive Stage
  - Detects features
- Focused Attention Stage
  - Features are combined to perceive the object

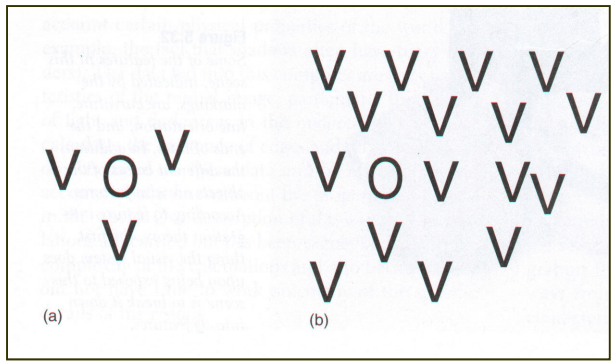
FIT : Preattentive Stage

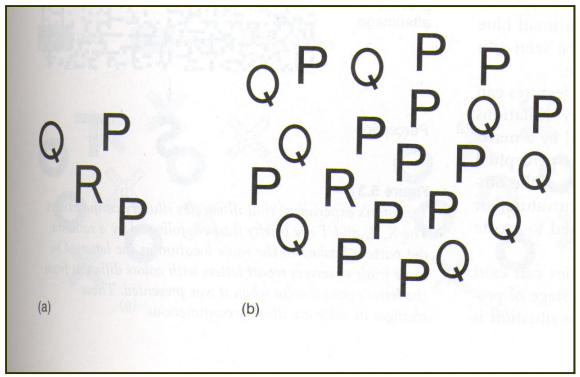
- Pop-out boundary for detecting features
  - Different Orientation
  - Different Value

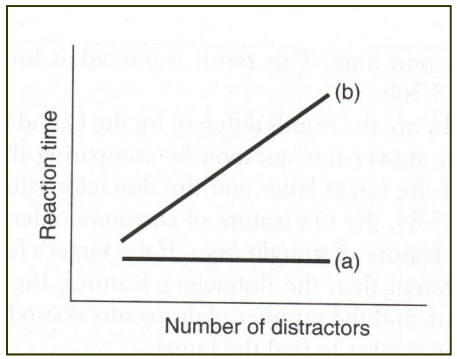


FIT : Preattentive Stage

- Visual Search Detection Time
  - Constant with increase in number of distractors if target has pop-out features
  - Increases with increase in number of distractors if target has no pop-out features
    - Have to scan each distractor and eliminate







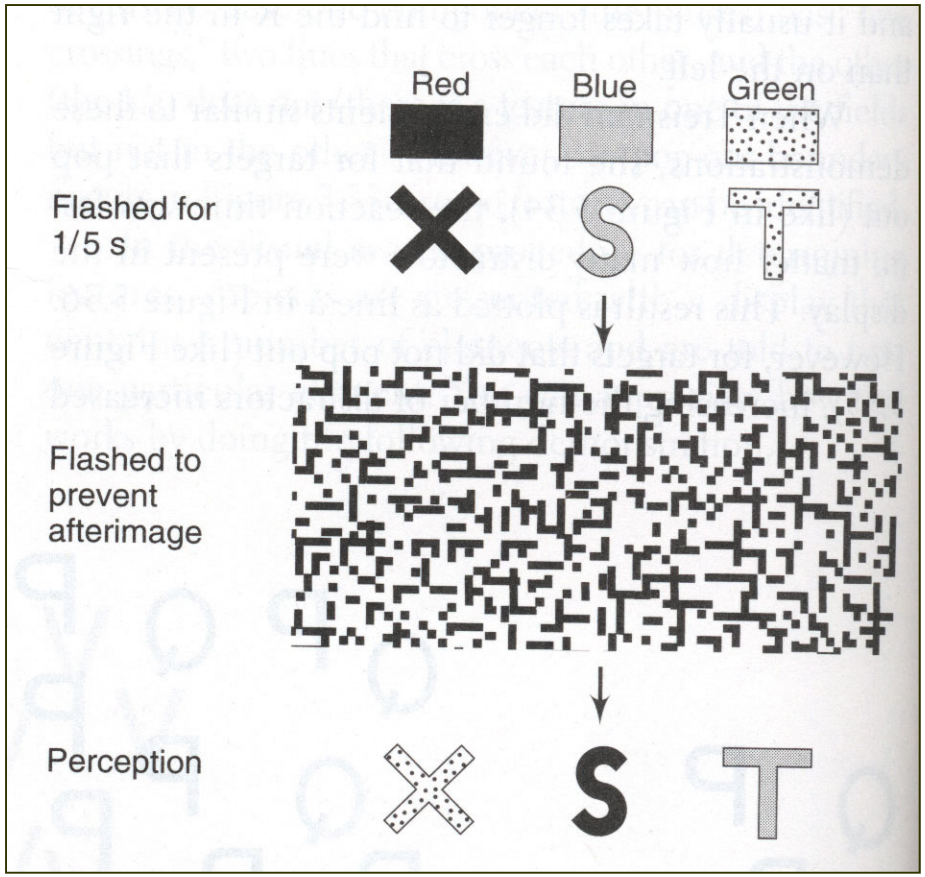
Similar to Salience

FIT: What makes things pop out?

- Curvature
- Tilt
- Line ends
- Movements
- Color
- Brightness
- Direction of Illumination

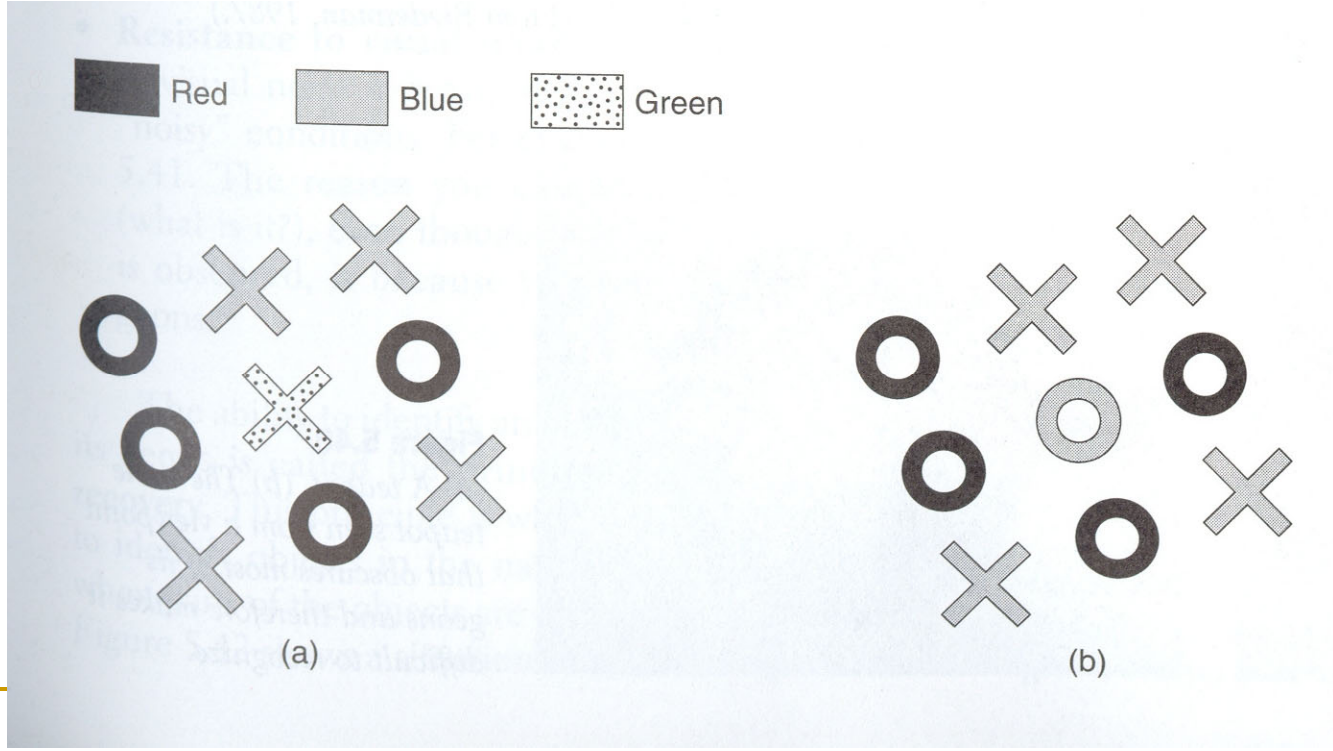
FIT : Preattentive Stage

- Independent features
- No association with objects
- Same observation from physiology



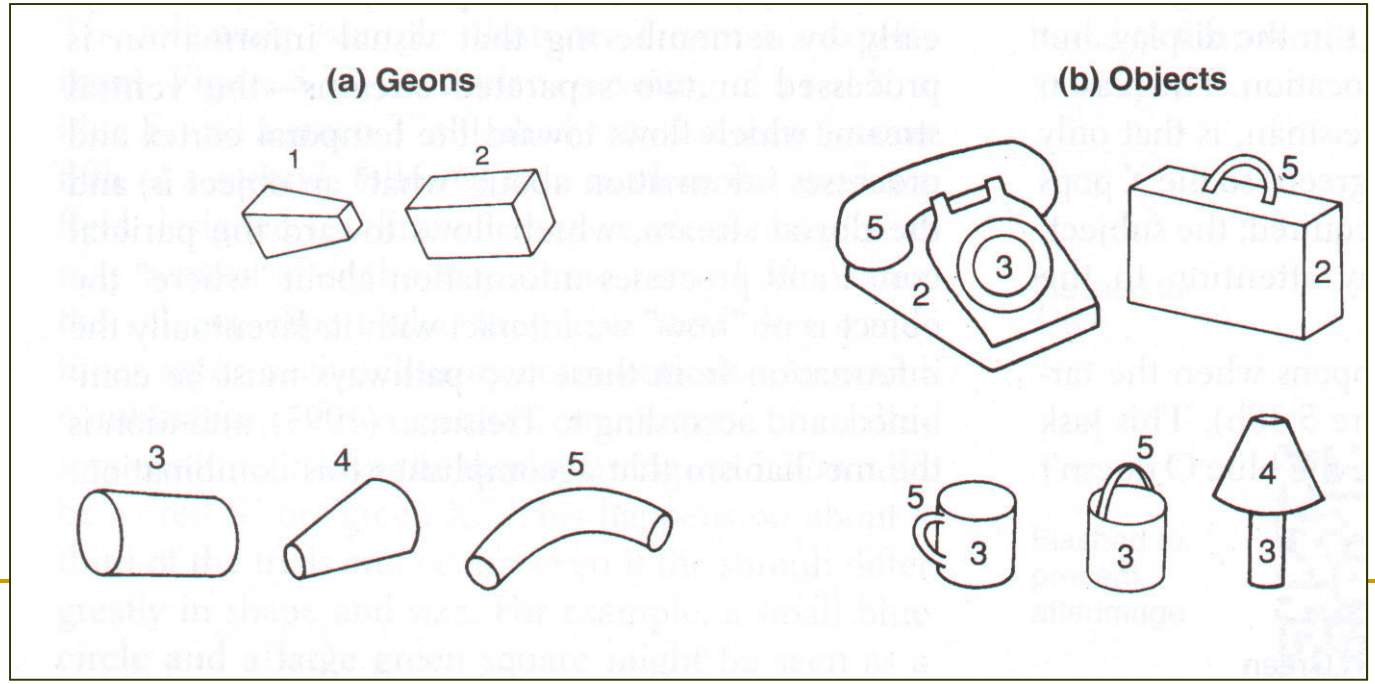
FIT : Focused Attention Stage

- Attention is essential for combining features
- Same result from physiology



Recognition-by-Components (RBC)

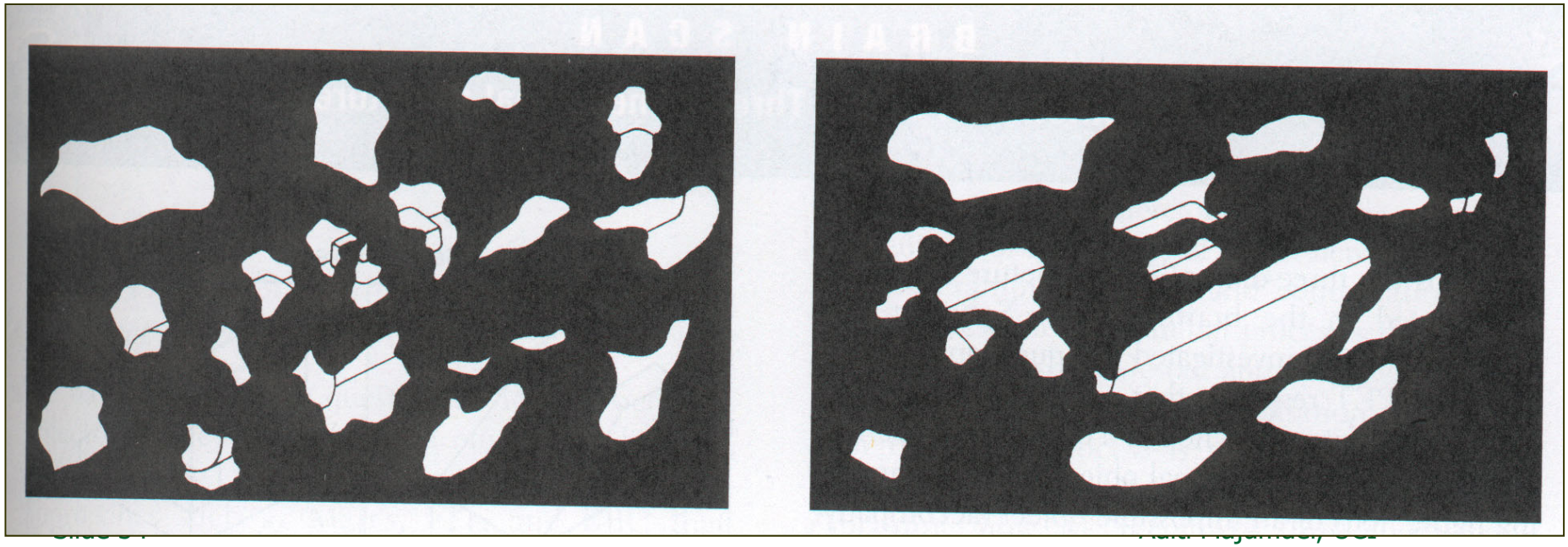
- Volumetric Primitives
  - Geons
- Principle of componential recovery



Properties of Geons

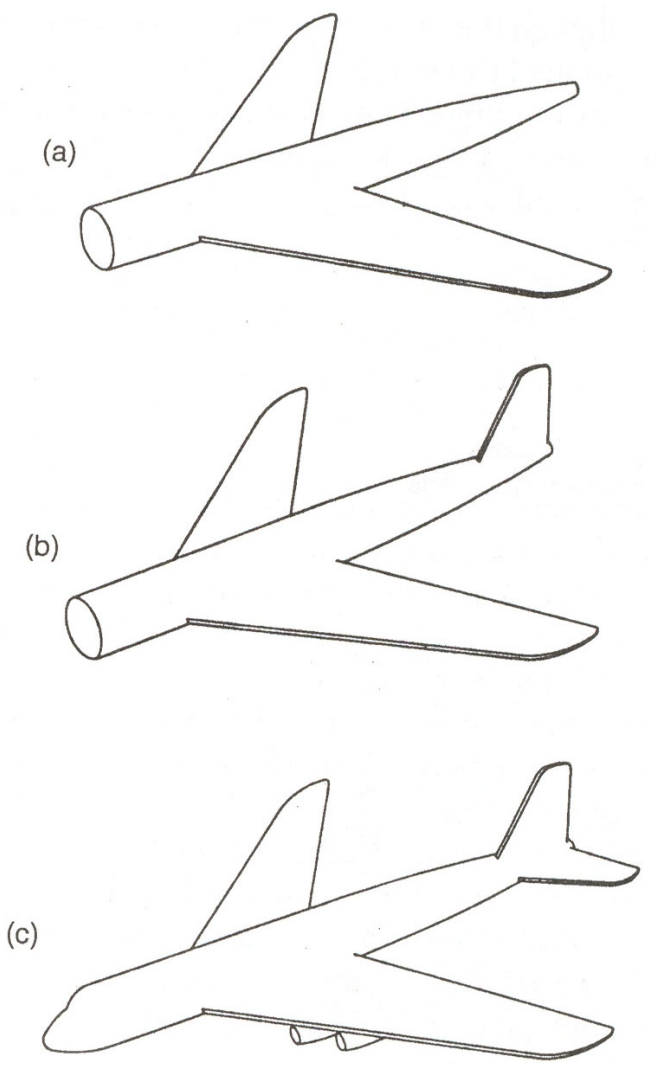
- View invariance
- Discriminability
- Resistance to visual noise

Cannot be mathematically enforced. Not very formal. Limitation of many psychophysical model. No hard quantification.



RBC theory

- + Can identify objects based on a few basic shapes
- - Cannot help us detect the finer details which causes difference



Comprehensive Model

- Image Based Stage
- Surface Based Stage
- Object Based Stage
- Category Based Stage

Image Based Stage

- Retinal Image
- Local feature detection

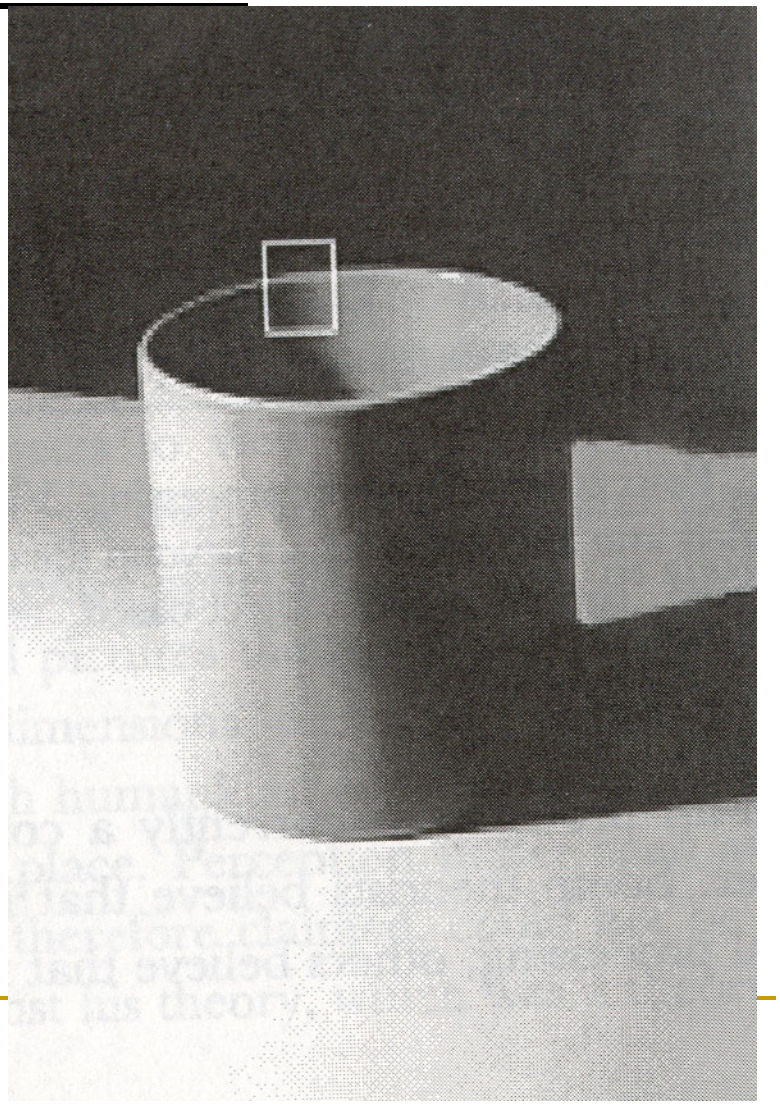
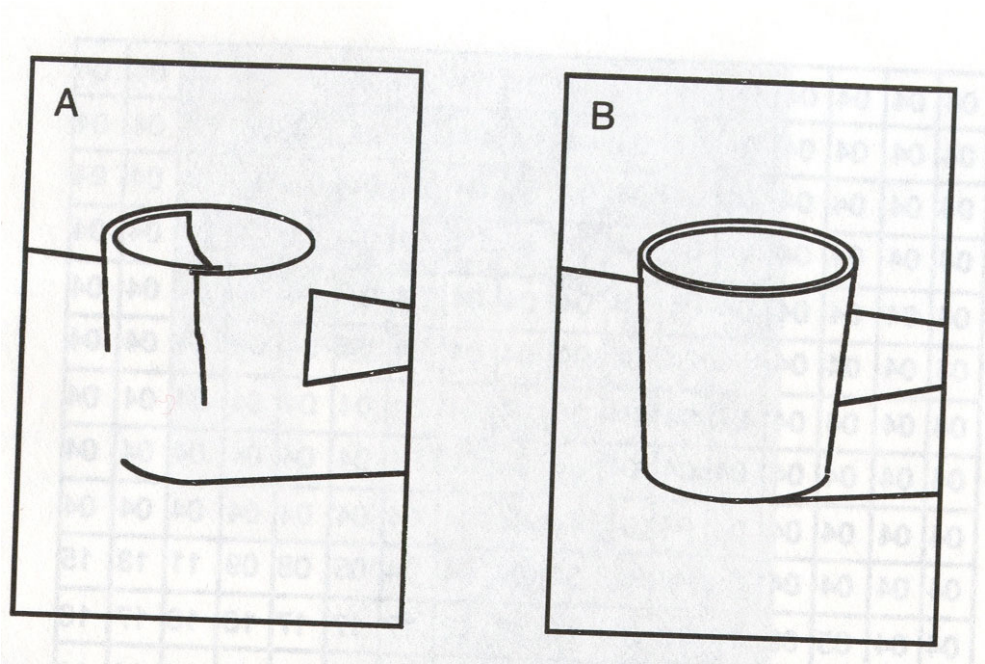


Image Based Stage

- Retinal Image
- Local feature detection
  - Edges, Corners, blobs
  - Raw primal sketch
- Global relationship between them
  - Full primal sketch
  - Difficult



Similarity with Marr's Primal Sketch

Image Based Stage

- *Primitives*
  - 2D structure of image intensities
    - Features like edges, blobs, corners etc
- *Geometry*
  - Two dimensional
- *Reference Frame*
  - Retinal

Surface Based Stage

- Find intrinsic property of surfaces in the real world
- Surfaces in 3D world as opposed to 2D primitives
- Visible surfaces from which light reflect to our eye
- *Intrinsic Images*

Surface Based Stage

- Represented by 2D planar elements in 3D
  - 3D surface can be represented by infinite 2D planar elements
  - Properties
    - Distance from viewer
    - Slant
    - Shading (as color or texture)
  - Like a 2D rubber sheet wrapped on the face of the visible surfaces.

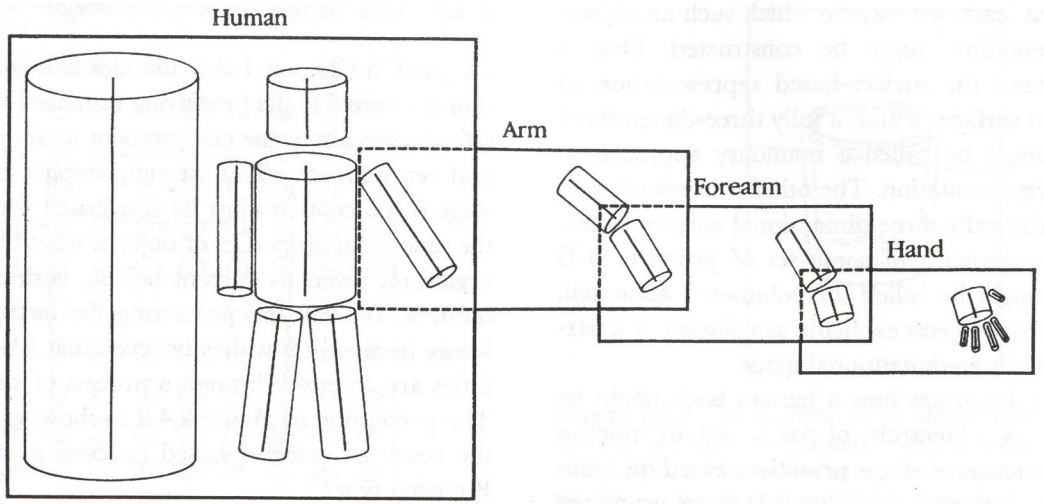
Similarity with Marr's 2.5D representation

Surface Based Stage

- *Primitives*
  - 2D planes embedded in 3D
- *Geometry*
  - Three dimensional
- *Reference Frame*
  - Viewer dependent

Object Based Stage

- We have some 3D definition
  - Otherwise, surprised when hidden surfaces got exposed
- Two types of representation
  - 2D patched in 3D
  - 3D volume elements
    - Hierarchical



Similarity with Recognition by Components

Object Based Stage

- *Primitives*
  - 2D planes embedded in 3D
  - Volumes
- *Geometry*
  - Three dimensional
- *Reference Frame*
  - Object dependent

Category Based Stage

- Categorization
- Identification
- Cognitive Science
- Deals with knowledge in perception
- How it helps us survive
- What about more frames? The temporal domain is not explored that much

Relationship to Graphics

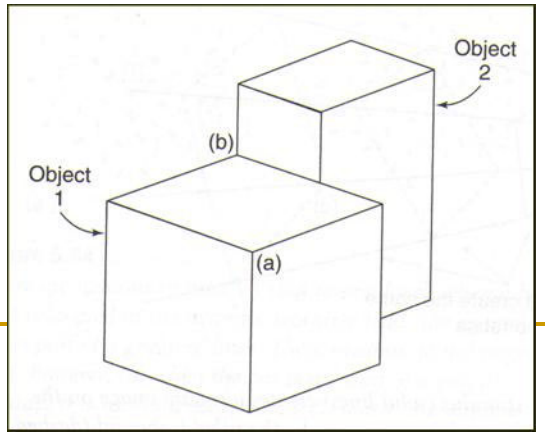
- OpenGL triangular rendering
  - 2D triangle mesh embedded in 3D
  - Triangle is smallest planar 2D elements
- Volume Rendering
  - Uses volumes as primitives
- Image based Rendering
  - Depth Images analogous to surface based representation
  - That is why a view dependent rendering scheme is adopted
  - Since no object based information, difficulty in handling occlusion

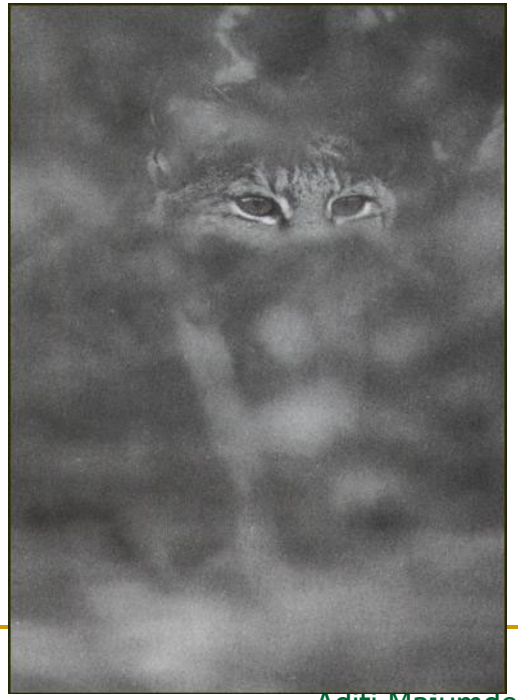
Role of Intelligence in Object Perception

- Ambiguous Stimulus
  - Inverse Projection Problem

Role of Intelligence in Object Perception

- Ambiguous Stimulus
  - Inverse Projection Problem
- Objects not separated
- Occlusion
- Ambiguity in lightness





Intelligence Heuristics

- Occlusion
- Light from above