Perceptual Grouping

- Reading:
  - Chapter from Palmer
  - Article by Julesz
  - Optional: look up article by Kanizsa

Perceptual Grouping

- Perceptual grouping is about putting parts together into a whole:
  - Finding regions with a uniform property
  - Linking edges into object boundaries

  Surfaces and objects are critical.

  Also, simpler ``objects'' such as lines

Human perceptual grouping

- This has been significant inspiration to computer vision.
- Why?
  - Perceptual grouping seems to rely partly on the nature of objects in the world.
  - This is hard to quantify, we hypothesize that human vision encodes the necessary knowledge.

Gestalt Principles of Grouping: some history

- Behaviorists were dominant psychological theorists in early 20th century.
  - To make psych scientific, wanted to view it as rules describing relation between stimulus and response, described as atomic elements.
  - No role for “mind”.
    - This meant no role for internal processing/inference/algorithms.
  - Influential early behaviorist was Pavlov

- Gestalt movement claimed atomic stimulus and response don't exist.

  -The mind perceives world as objects, as wholes, not as atomic primitives.

  - Can't understand psych without understanding how we perceive the world.

I stand at the window and see a house, trees, sky.

Theoretically I might say there were 327 brightnesses and nuances of colour. Do I *have* "327"? No. I have sky, house, and trees. It is impossible to achieve "327 " as such. And yet even though such droll calculation were possible and implied, say, for the house 120, the trees 90, the sky 117 -- I should at least have *this* arrangement and division of the total, and not, say, 127 and 100 and 100; or 150 and 177.

Max Wertheimer, 1923

I. A row of dots is presented upon a homogeneous ground. The alternate intervals are 3 mm. and 12 mm.

Normally this row will be seen as *ab/cd,* not as *a/bc/de.* As a matter of fact it is for most people impossible to see the whole series simultaneously in the latter grouping.

Max Wertheimer

Gestalt Movement

- Perceptual organization was a big issue.
  - How we perceive the world in terms of things/objects, not pixels.
- This was part of broader attack on behaviorism.
  - Gestalt viewed mind as constructing *representations* of the world, no learning/behavior could be understood without understanding this.
  - These representations were constructing by inferences of the mind.

Issues in Perceptual Organization

- What is the role of an edge in an image? To what object (if any) does it belong?

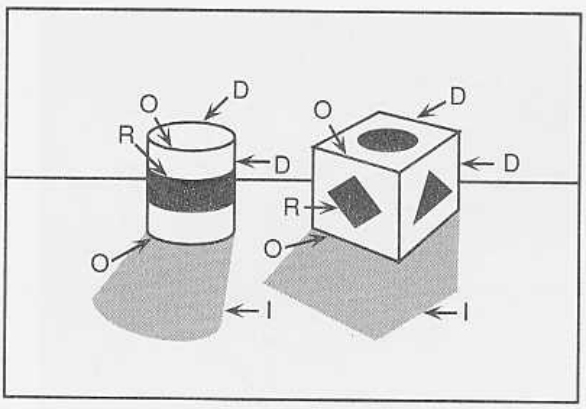
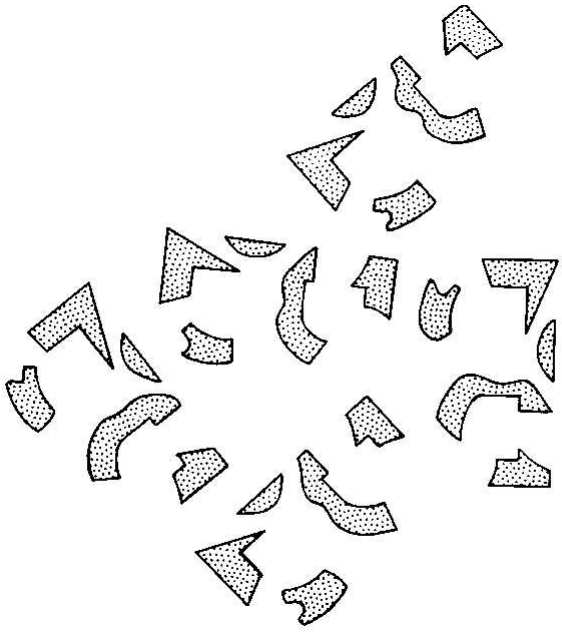
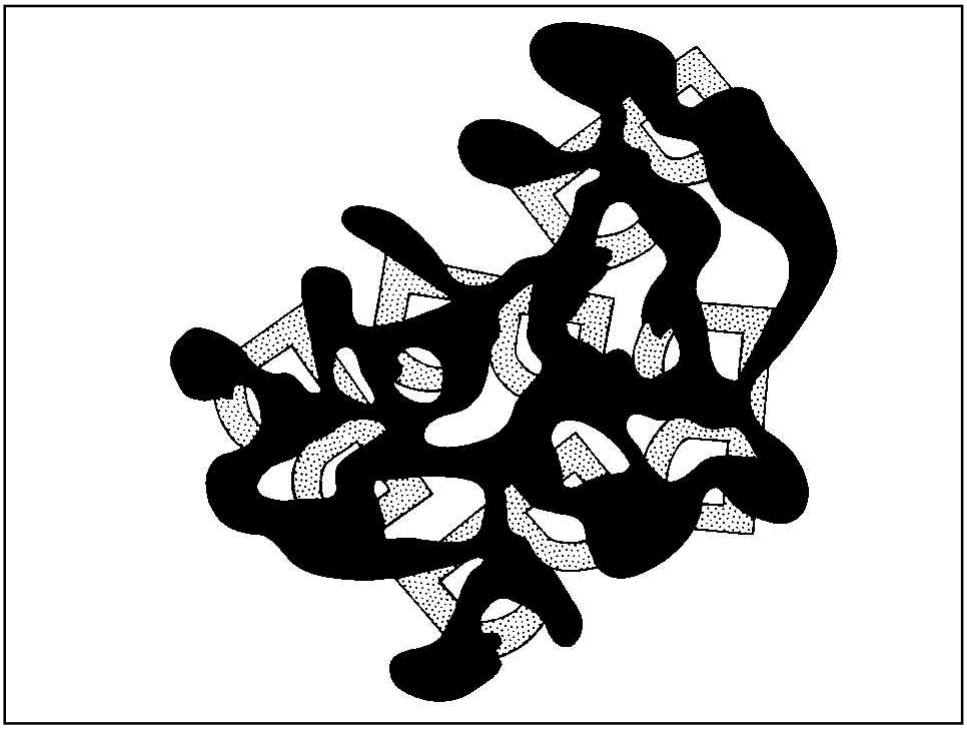


Figure 5.5.16 Four kinds of edges. This scene contains four different kinds of luminance edges: orientation edges (O) due to abrupt changes in surface orientation, depth edges (D) due to gaps between surfaces at different distances, reflectance edges (R) due to different surface pigments or materials, and illumination edges (I) due to shadows.

If you know what is in the next image, silently raise your hand. Don't call out.



(Bregman)

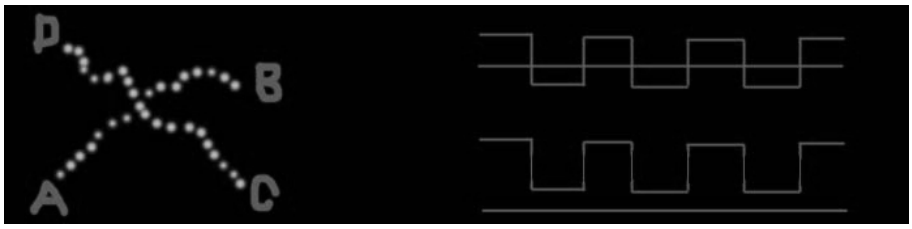


Issues in Perceptual Organization

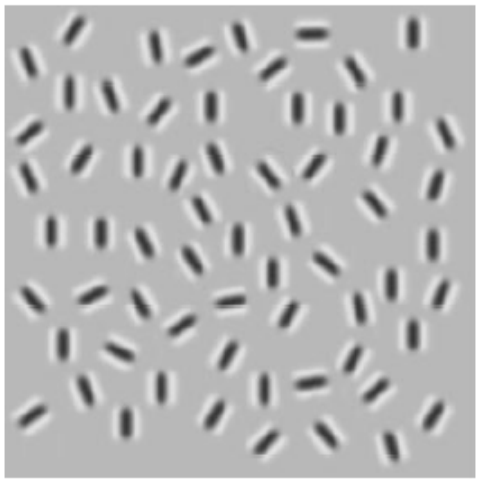
- What factors determine which parts of an image are combined in the same object?

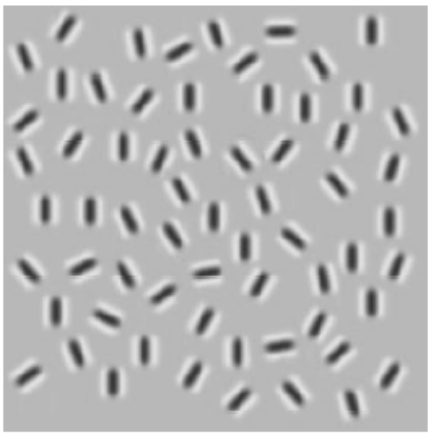
Proximity

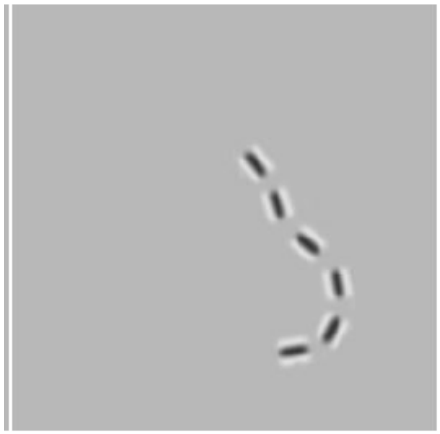
Good Continuation



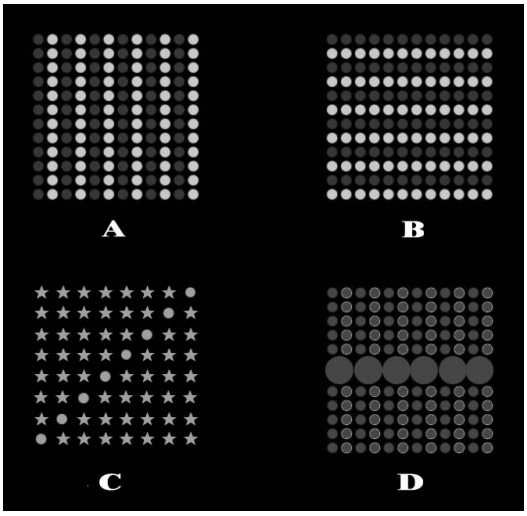
Good Continuation



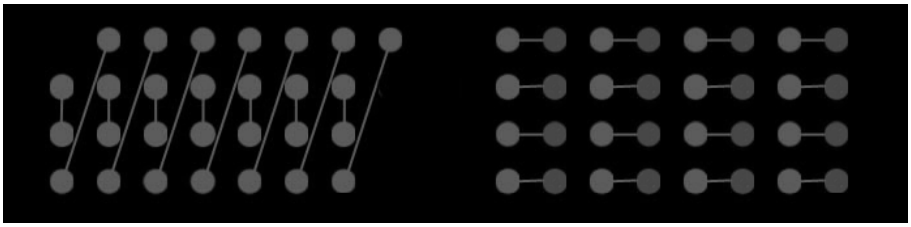




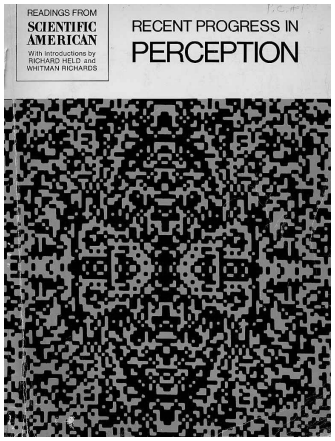
Common Form: (includes color and texture)



Connectivity



Symmetry



Symmetry

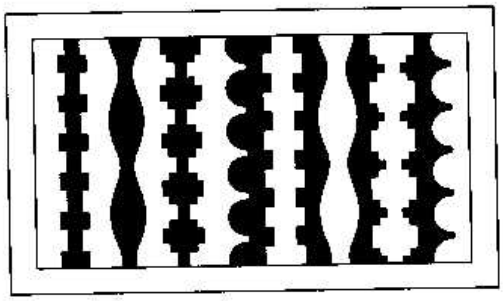
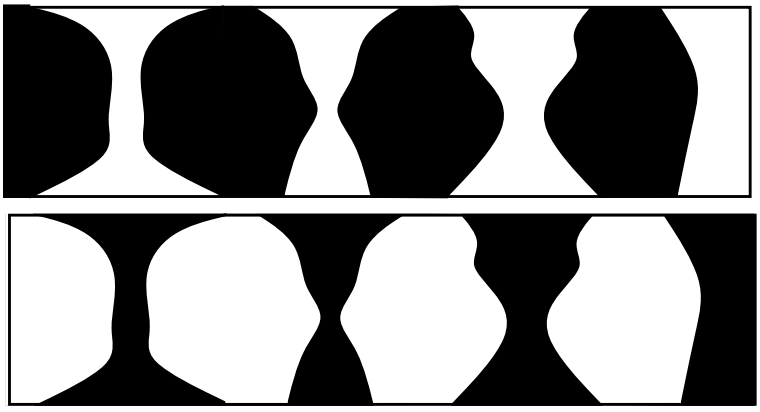


Figure 7.25
Symmetry and figure ground. Look to the left and to the right, and observe which colors become figure and which become ground. (Adapted from Hochberg, 1971.)

Convexity (stronger than symmetry?)



Good continuation also stronger than symmetry?

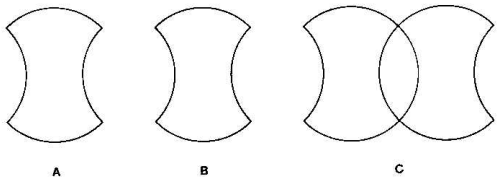


Figure 5.8 Not two symmetrical figures juxtaposed, but two overlapping less regular figures.

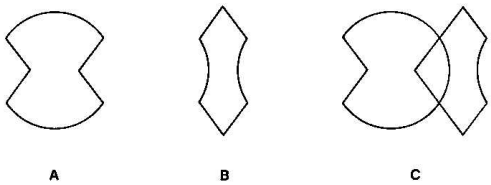
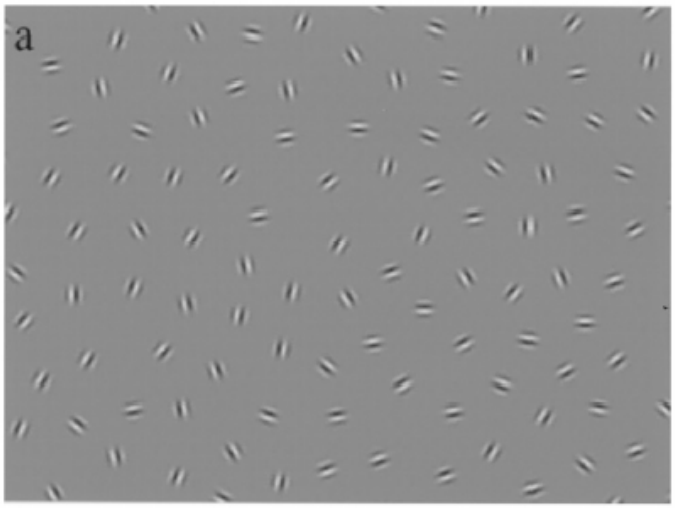


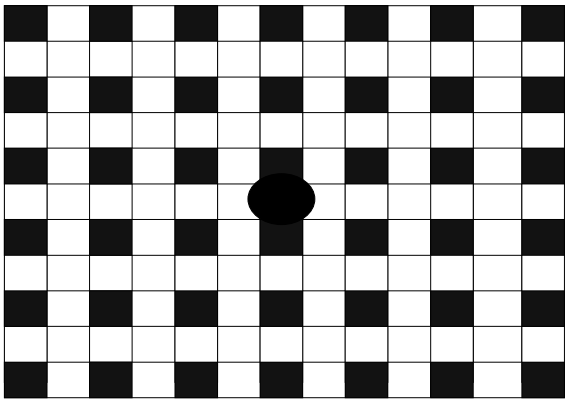
Figure 5.9 Continuity of direction prevails over maximal symmetry.

Closure

Closure



Higher Level Knowledge



Sometimes, it doesn't play seem to play such a big role.

Higher level Knowledge

and sometimes it does. If you know what is in the next image, silently raise your hand. Don't call out.

Other Factors

- Common fate (ie., common motion).
- Good continuation in time.
- Parallelism
- Collinearity

Theories of P.O.

- Gestalt psychologists: “good form”.
  - We perceive shapes that are “good” or “simple”.
  - Example: smooth curves simpler than ones with discontinuities.
  - Drawbacks: vague and not quantitative
    - eg., how do we predict which of two cues will “win”.

Theories of P.O.

- Information theory
  - This is one way of making good form concrete.
  - Prefer organization that entails shortest code.
  - Related to ideas (eg. Barlow) that low-level vision is doing efficient coding.
  - Drawbacks: What is the right code?

Theories of P.O.

- Bayesian inference (Helmholtz)
  - Pick organization that is most likely to be true.
  - Explain "Suspicious Coincidences"
    - Eg., good continuation powerful because otherwise two different objects are accidentally aligned.
  - Drawback: Very hard to fully specify this.

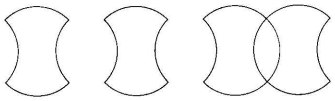


Figure 5.8 Not two symmetrical figures juxtaposed, but two overlapping less regular figures.

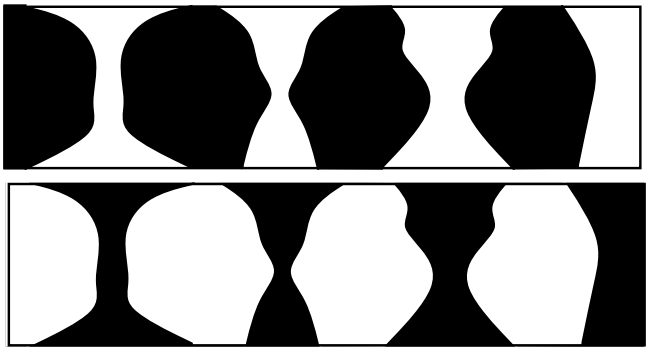
Theories of P.O.

- Computational Considerations
  - Bayesian inference, but done with a tractable algorithm.
  - Eg., some suspicious coincidences too hard to find.
  - May explain prevalence of local cues.
  - Drawback: even more vague and hard to specify.

How well do these theories explain the data?

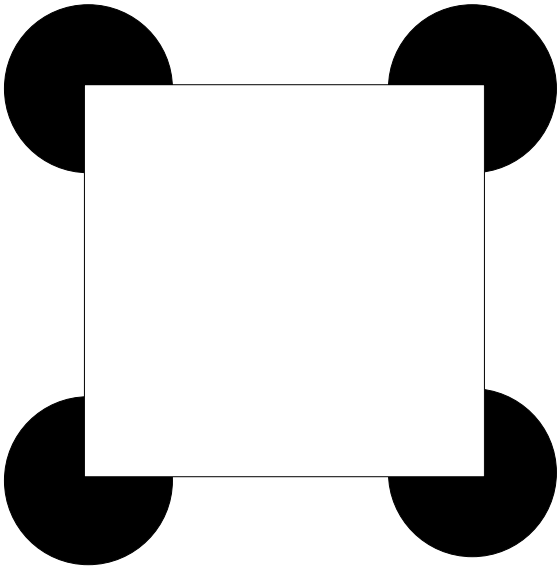
- They can handle a lot.
  - Good continuation, symmetry, closure, common motion.
  - But there are some problems.

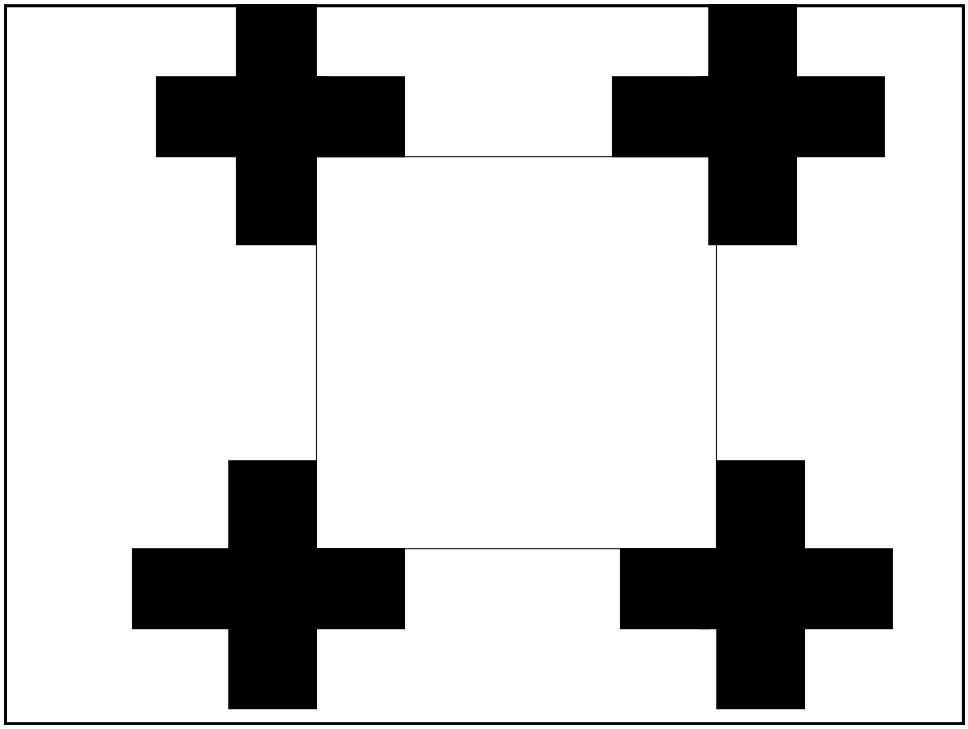
Example: Convexity vs. symmetry



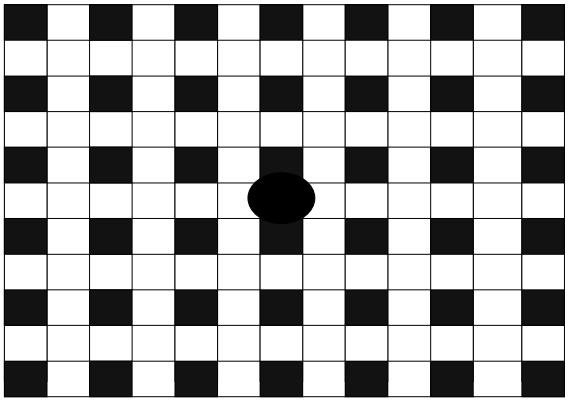
- Hard to explain this with good form.
- But could say convex shapes are more likely.

Example





- This seems to demonstrate good form.
  - The *Pac-men* need to be completed.
  - The crosses are already symmetric
- Less natural for Bayesian inference.



• If you see the cross, this seems a failure of Bayesian inference.

• Also doesn't seem to have much to do with good form.

•Maybe shows computational considerations – locality.

Take Home Message

- We perceive the world in terms of objects, not pixels.
- What forms an object is determined by regularities and non-trivial inference.

Gestalt Psychologists showed the importance of representation and inference.