CDL PS2011/16

Lecture 3
Perceptual Grouping

Reading

Essential
- Bruce, Green & Georgeson (2003), Chapter 6, pp. 119-136
- Gordon (2004), Chapter 2 or Gordon, (1997), Chapter 3
- Eysenck & Keane (2000), Chapter 2, pp. 25-30

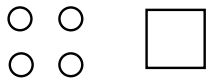
Highly Recommended
-Quinlan & Dyson (2008). Cognitive Psychology. Harlow, Pearson Education. Pp. 166-183; 186-195.

How is grouping achieved?
How do we know which parts belong together?

Associationism
complex forms originate from associative links between perceptual units

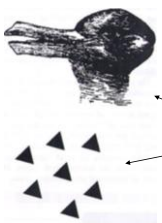
Gestalt (e.g. Koffka, 1935; Koheler, 1947; Werteimer, 1923)
perception of complex forms requires organisational principles that go beyond summation or juxtaposition of elementary units

e.g.
Different elementary units can be perceived as descriptions of the same shape



Ambiguous figures
the same perceptual input (i.e. the same physical display) can produce different perceptions

e.g.
displays where figure and background can be inverted

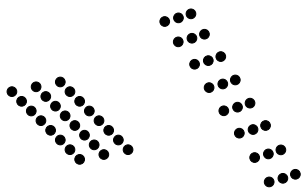


or
figures in the foreground that offer ambiguous interpretations

In figures that are artificially constructed to offer equally plausible interpretations, typically people spontaneously alternate from one interpretation to the other

Normally the organisation of more elementary units into larger perceptual groups follows specific rules which have been identified by gestalt psychologists:

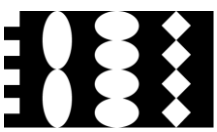
- proximity



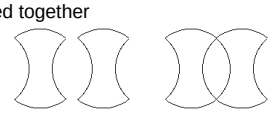
- similarity
similar elements are grouped together

- symmetry

e.g. the white patterns are normally perceived as figures against a black background because they are symmetric

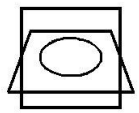


- good continuation
elements forming smooth continuous lines or curves are grouped together



- common fate
things that move together are grouped together

commonFateDepth.gif



commonFateUpright.gif

The law of Pragnanz or "Goodness" of shape

"Of several possible geometric organisations, the one will actually occur which possesses the best, simplest and most stable shape" (Koffka, 1935).

- Simplicity and goodness of shape not well defined by gestaltists

- Assumption of innate isomorphic relationship between sensory experience and brain states

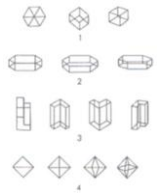
Can simplicity be formalised ?

Hochberg & Brooks (1960)

Method
correlations between different measures and rating of threedimensionality of line drawings
Rationale
the more "complex" a figure is, the more likely that a simpler three-dimensional interpretation will be perceived

Critical measures
- number of angles
  general complexity
-number of angles of different size
  asymmetry
-number of continuous lines
  discontinuity

Results replicated with new figures



What variables determine grouping by similarity ?

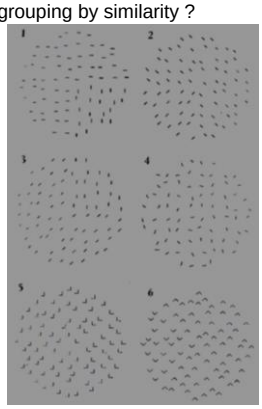
High level conceptual similarity?
More basic properties that can be processed pre-attentively?

e.g. Olson & Attneave (1970)
subjects required to identify odd quadrant within display

- Quadrant easily spotted when elements differ in slope e.g. **V** v.s. **>** (fig 1-3)

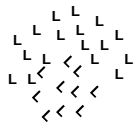
- Most difficult when elements differ in configuration e.g. < vs. > (fig 5-6)

- Even identity can be difficult to spot e.g. curves vs. lines (fig 4)

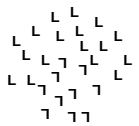


These results indicate that variables that affect grouping by similarity might not be the same that affect conceptual similarity

e.g. small variations in slope do not affect your ability to classify all the elements as Ls but they are a powerful grouping cue



By contrast, upside-down Ls is not perceived as Ls but are still difficult to group together



Julesz (1965)
Similarity grouping is pre-attentive and precedes the identification of patterns and objects

De Yoe, Knierem, Sagi, Juslez & Van Essen (1986)
cells within primary visual cortex (and V2) respond to changes in orientation of elements presented to centre and periphery of receptive fields

Do Gestalt principles of perceptual organisation work because they enable the organisms to derive realistic interpretations of the environment (likelihood principle)?

- a particular surface reflects light in uniform ways so portions of the same surface are similar (similarity)

- parts of the same objects are close together (proximity)

- shapes of natural objects vary smoothly (good continuation)

- living organisms are symmetric (symmetry)

- parts of the same object move together (common fate)

Do Gestalt principles of perceptual organisation work because they enable the organisms to encode the external world using the simplest description (simplicity principle)?

Approaches to simplicity based on "algorithmic information theory"

- complexity defined in terms of length of program code necessary to reproduce a stimulus.

E.g. 1212121212121212

Can be generated by simple program:

for i = 1 to 8 do print {print (1), print (2)}

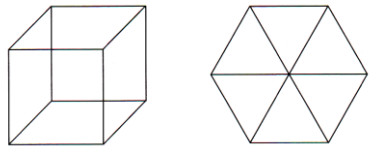
By contrast, a random sequence: 01834862

Would require more programming code and as such can be considered more complex:

For i = 1 to 8 do print { print (0), print (1), print (8), print (3)…print (2)}

The left figure requires a shorter description as a symmetrical three dimensional cube

The right figure requires a shorter description as a symmetrical 2D pattern would be more economically described



Simplicity would predict a tendency to perceive the figure on the left as 3D and the figure on the right as 2D

Artificial Intelligence (AI) approaches to grouping

Although A.I. models do not tell us what biological systems do, they:

- highlight task difficulty
- test internal consistency of theoretical models
- require identification of relevant variables
- mostly implemented using "toy" worlds

Scene analysis programs

- segmentation problem
- how are elementary features (e.g. lines) grouped together to form surfaces?
- which surfaces belong to the same object?

Guzman (1968)

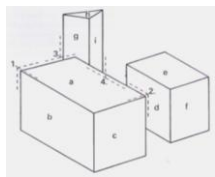
junctions (points where lines meet)

arrow junctions

same body

T junctions

different bodies



Summary

- Associationism vs. Gestalt
- Gestalt perceptual organisation principles
- Pragnanz
- The simplicity principle
- More recent experimental approaches to grouping
- Early AI approaches to scene analysis