Bertin's Visual Variables

Location variables (position, relative to a coordinate frame)
- e.g. horizonal and vertical axes on a scatterplot; longitude and latitude on a map
- (so fundamental to presenting map information that these variables are often ignored in cartography)

Retinal variables (perceptual properties)
- ways of representing differences between objects
- size, shape, colour (hue), colour (value), texture, orientation

pop-out: variables recognized immediately ("seen" not "understood")

hue is not for order, but for categorical data

Associative variables (Bertin)

All variations are perceived equally

(location, shape, orientation, colour hue, texture)

No colour is seen as more prominent than another

No shape is seen as more prominent than another

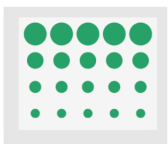
Allows for other variations to be noticed (e.g. different colour values)

Dissociative variables (Bertin)

One variation dominates (size, colour value)

The eye is drawn to the darker colour values

Larger sizes are seen as more dominant than smaller ones



Variation in other variables is likely to be overlooked (e.g. different colours)

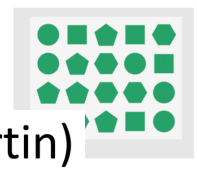
Selective variables (Bertin)

It is possible to focus on the variations of the variable, despite variations in other variables

(only shape is not selective)

Easy to see the distribution of red circles, despite location changes

Not so easy to see the distribution of hexagons, even though they are distributed in the same way as the red circles above



Ordered perception (Bertin)

Variations are perceived as being ranked in order

(location, size, colour value)

Green is not seen as 'more' than purple or red

Darker circles are seen as 'more' than the lighter ones

Quantitative perception (Bertin)

(an extension of ordered perception)

The variation can be quantitatively estimated

(location, size)

Darker circles are seen as 'more' than the lighter ones, but it is difficult to estimate 'how much' more

It is possible to estimate 'how much' more the larger circles represent in comparison with the smaller ones

Unordered (*colour hue, orientation, shape, texture*)

for nominal information: apples, oranges, pears

Ordered, non-quantitative (*colour value*)

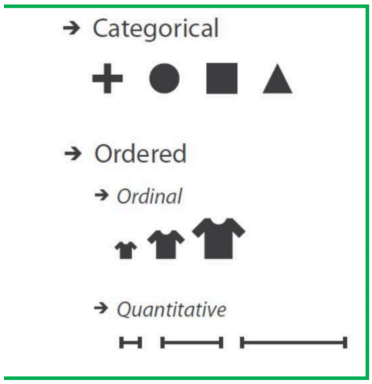
for ordinal information: rainfall map of low/medium/high

Ordered, quantitative (*location, size*)

for numerical information: electricity usage

(also good for non-quantitative and nominal information given their visual dominance)

Data attributes

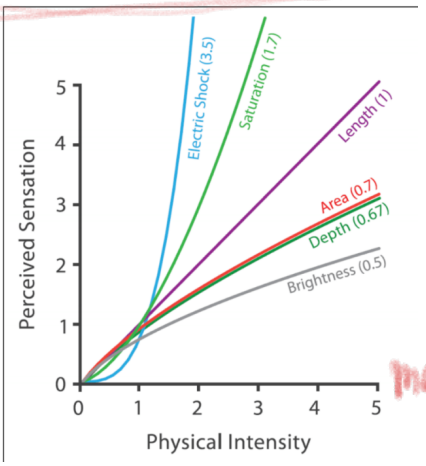


- Categorical/ "nominal"
  - no implicit order
  - Names of fruit
- Ordinal
  - implicit order
  - non-numerical
  - Low/medium/high rainfall
- Quantitative
  - implicit order
  - numerical
  - Electricity usage 10 cm, 17 cm

Steven's Psychophysical Power Law (1957)

perception(stimulus) = constant x (strength of stimulus) power

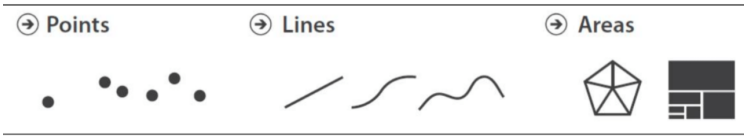
The strength of perceived sensation
is proportional to
the measurement of physical intensity
raised to a **power**



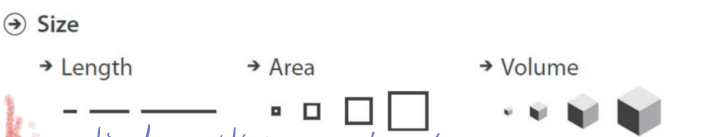
Perceived sensation is subjective
Physical intensity is objective

Data Marks

The basic graphical element of an image
Can be 0D, 1D, 2D, 3D



Volumes



mark: vertical position line/area
vertical, horizontal point
Volume

Perceptual model

Three levels to preceiving a scene:

Level 1: processing low-level properties (parallel) colour, texture etc

Level 2: pattern recognition (sequential) recognition of patterns, contours regions etc.

Level 3: target-oriented search (sequential) identification of objects

Topics:

Level 1: (bottom-up) pre-attention

- rapid, parallel extraction of features
- *e.g. edges, orientation, colour, texture, movement*
- bottom-up, data-driven
- pre-attentive, held very briefly

color

Level 2: (bottom-up & top-down)

- slow, serial detection of patterns
- *e.g. contours, regions*
- combination of bottom-up and top-down
- needs attention, uses memory (working and long-term)

pattern identification

Level 3: (top-down)

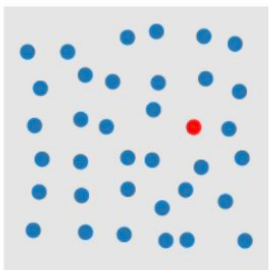
- slow, serial identification of objects
- *e.g. a handle to turn, a data point to focus o*
- related to action, purpose, concentration
- uses memory

object identification

Top-down identification of objects

Often led by a query, task or intention

Supported by memory and context



Interference between levels

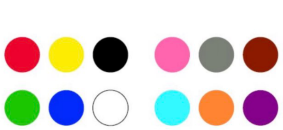
Red Green Purple
Brown Blue Red

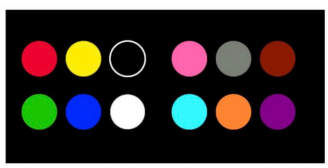
Purple Red Brown
Red Green Blue

The top-down processing (reading the words)interferes with the bottom-up processing(identifying the colours)...

so the second row of words is usually read more slowly

colours level 1





Set 1 (left): red, green, yellow, blue, black, white
(the unique colors that mark the ends of the opponent color axes)

Set 2 (right): pink, cyan, gray, orange, brown, purple

Most common colour names in cross-cultural study (+cyan)
[Berlin&Kay, 1969]

Use all the colours in Set 1 before choosing any in Set 2

Gestalt laws (level 2):

Proximity 接近

see visual objects form groups

Elements that are physically close together are perceptually grouped together

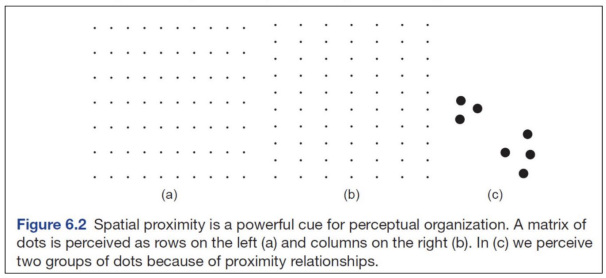


Figure 6.2 Spatial proximity is a powerful cue for perceptual organization. A matrix of dots is perceived as rows on the left (a) and columns on the right (b). In (c) we perceive two groups of dots because of proximity relationships.

So: symbols representing related information should be placed together

Similarity

Similar elements tend be to be grouped together

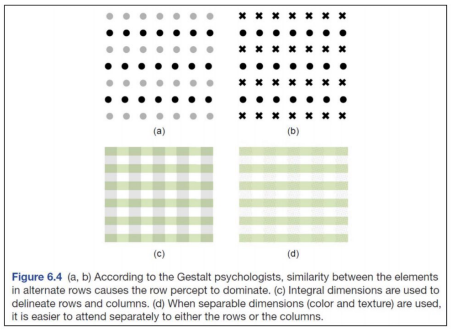


Figure 6.4 (a, b) According to the Gestalt psychologists, similarity between the elements in alternate rows causes the row percept to dominate. (c) Integral dimensions are used to delineate rows and columns. (d) When separable dimensions (color and texture) are used, it is easier to attend separately to either the rows or the columns.

So: use different colours to encode rows/columns in a grid data set

Connectedness

Elements connected by lines form groups

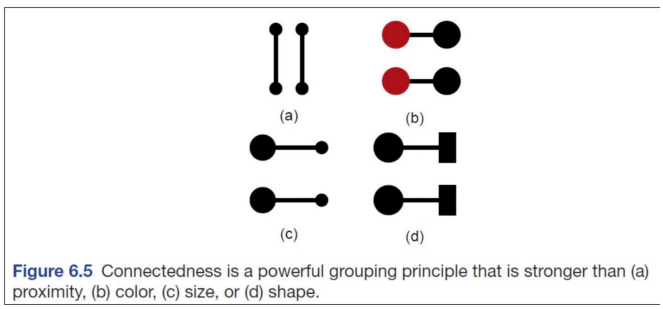


Figure 6.5 Connectedness is a powerful grouping principle that is stronger than (a) proximity, (b) color, (c) size, or (d) shape.

So: use lines to show relationships between objects

Continuity

We perceive elements as smooth and continuous (rather than with abrupt change in direction)

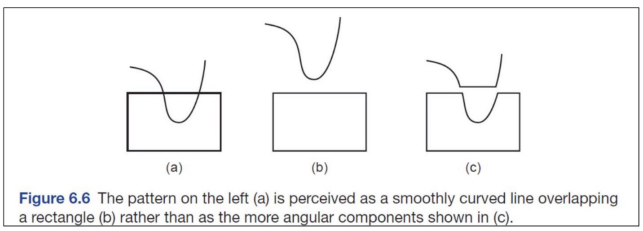
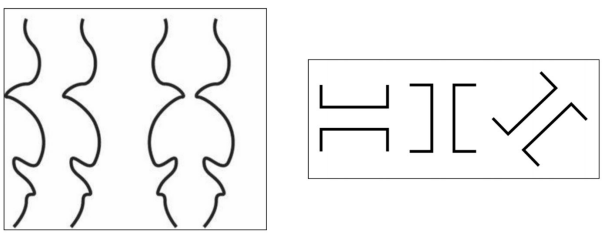


Figure 6.6 The pattern on the left (a) is perceived as a smoothly curved line overlapping a rectangle (b) rather than as the more angular components shown in (c).

Consider continuity when showing overlapping objects

Symmetry

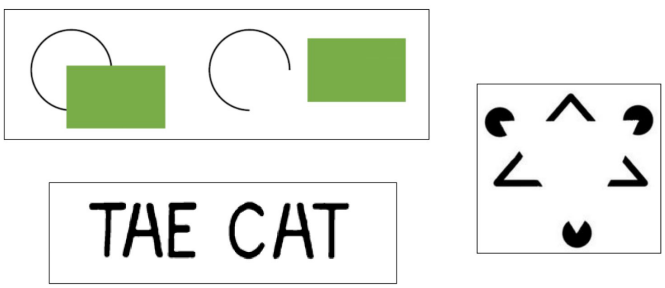
Symmetric elements tend to be grouped together



So: use symmetry to make pattern comparisons easier

Closure

Contours with gaps tend to be perceptually 'closed'



So: put related information in a closed contour – defined by line, colour or texture

Figure and Ground

don't move things together unless they're related

Small areas tend to be seen as 'figure'

Context may affect figure/ground interpretation

Common Fate

Things that move together are grouped together

So: Use closure, symmetry, layout etc. to ensure objects will be perceived as figures, not ground.