

IAT 814

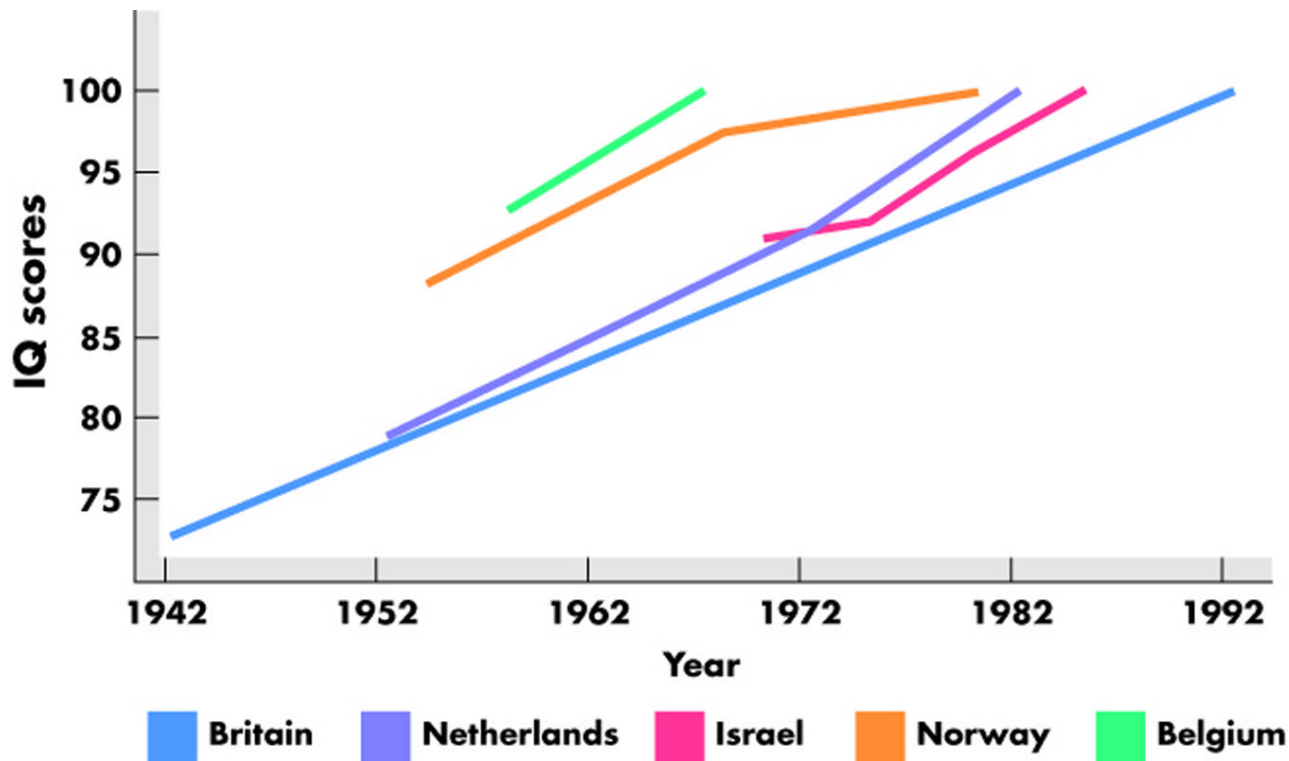
Visual Analytics

Perception 2: Patterns and Structure

Lyn Bartram



(Why) are people getting smarter?



Expert knowledge is about understanding patterns (Flynn effect)

Finding patterns is key to problem solving

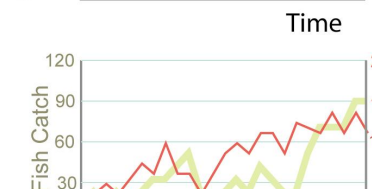
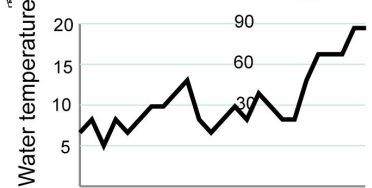
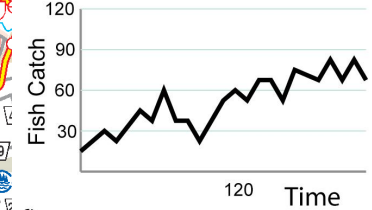
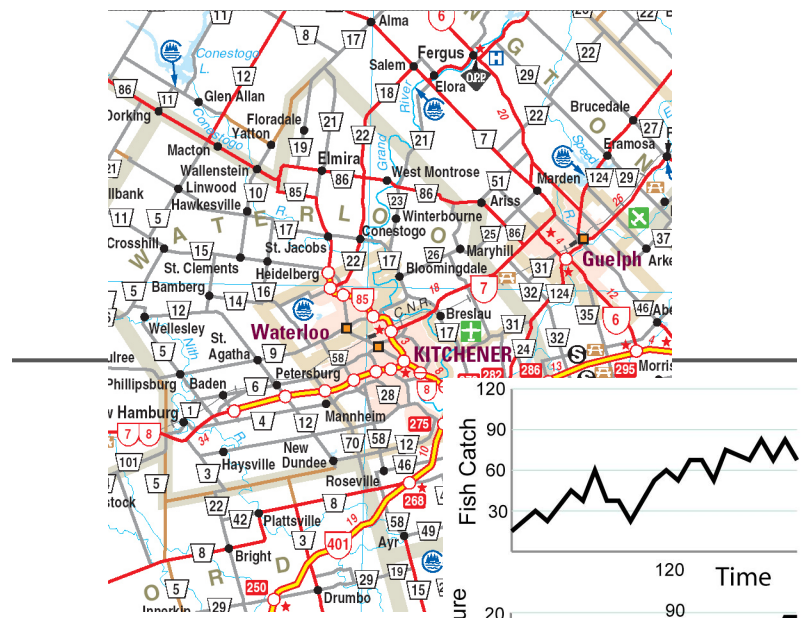
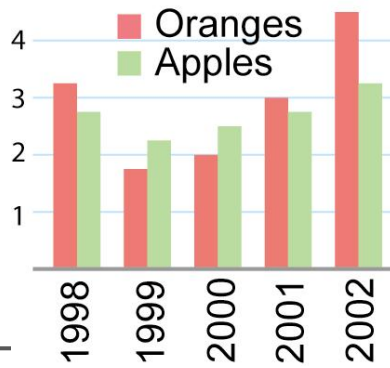
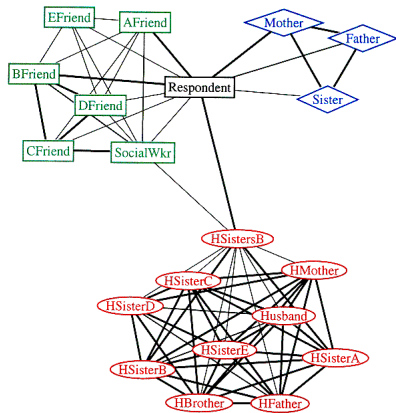
We think by making pattern queries on the world (visual thinking)

- Example Queries
 - Patterns showing groups?
 - Patterns showing structure?
 - When are patterns similar?
 - How should we organize information on the screen?

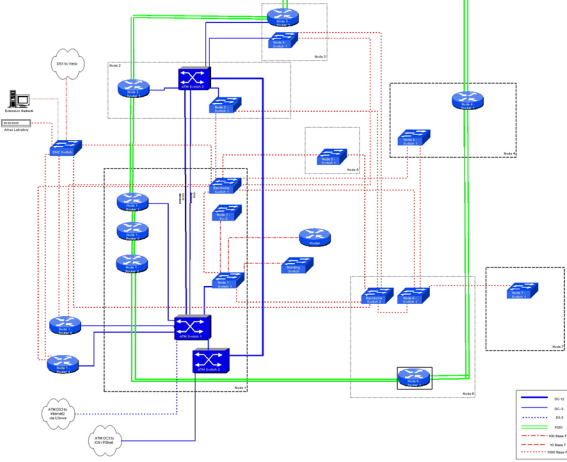
- Critical to information visualization design

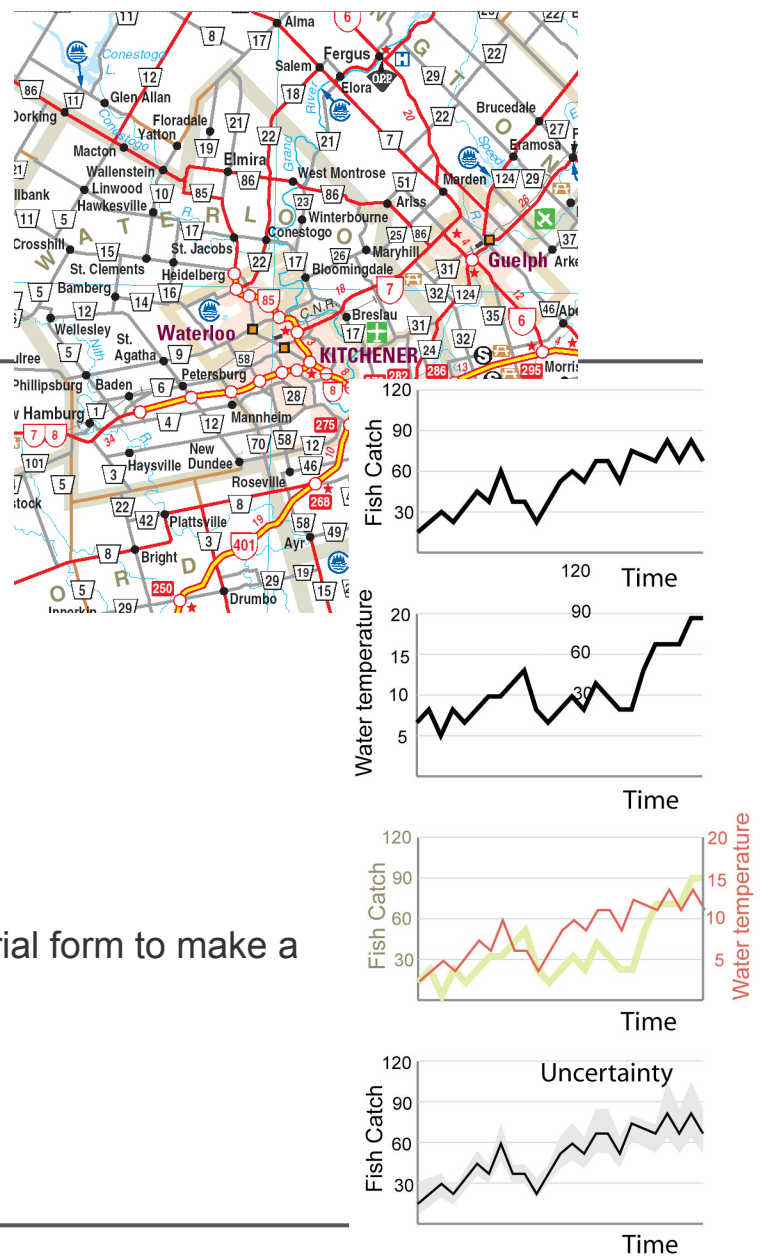
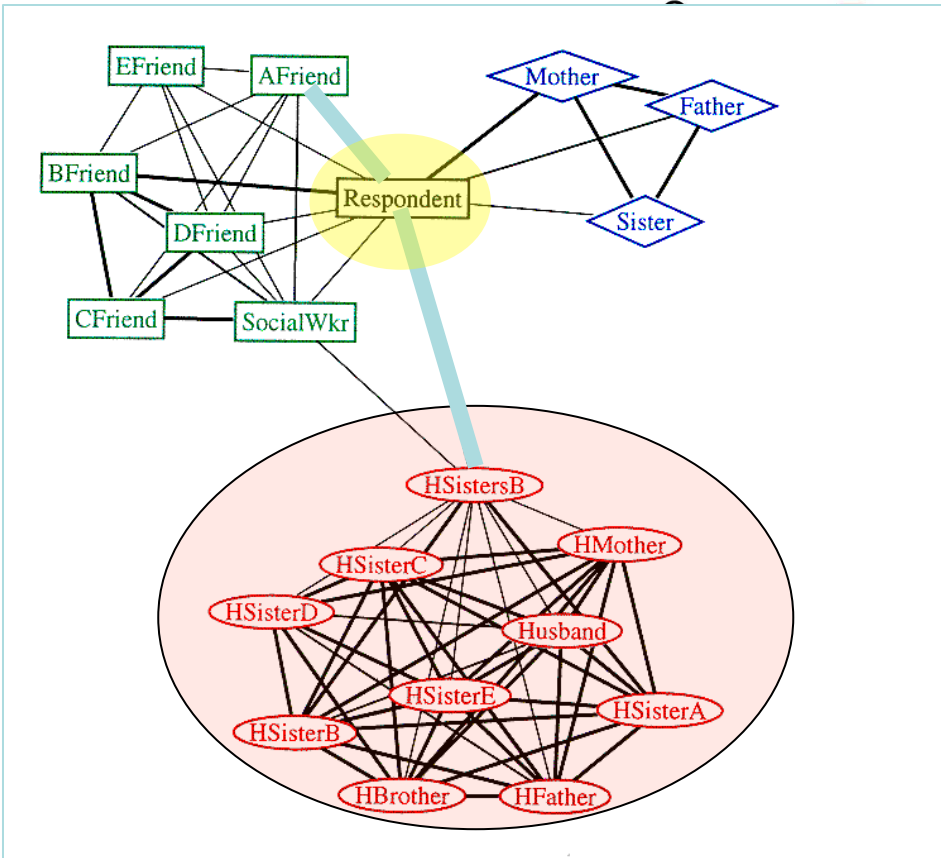
Static and moving patterns

- ***Data mining*** is about finding patterns that were previously unknown or that depart from the norm.
 - *visual analytics*
- When we look for patterns, we are making ***visual queries*** that are key to visual thinking.
- In data exploration, seeing a pattern can often lead to a key insight, and this is the most compelling reason for visualization.



Water temperature

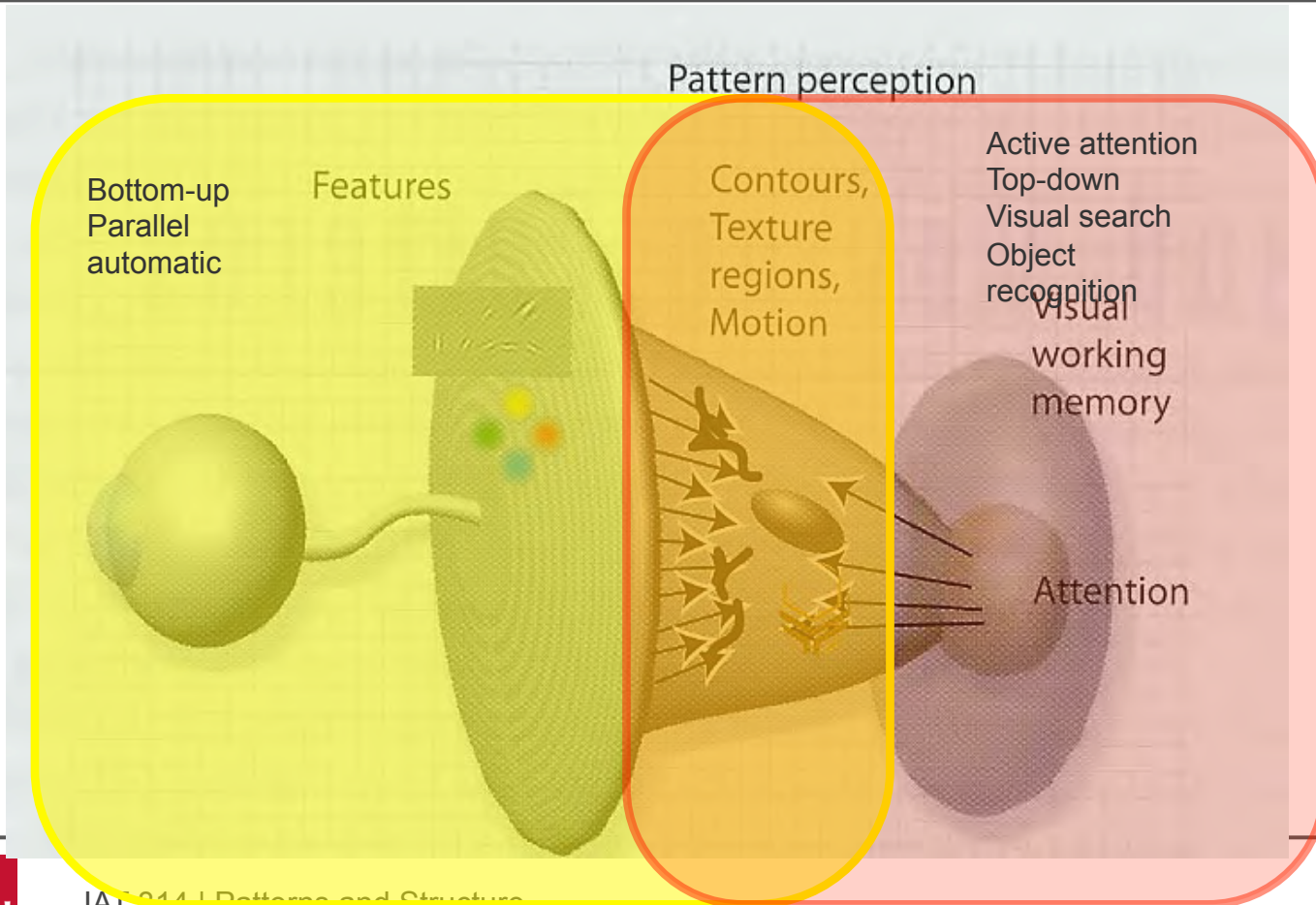




The arrangement of elements into regular, repeated or serial form to make a larger perceptual structure

Not only elements but the spaces between them

Pattern perception is the flexible middle ground where objects are extracted from sets of features



Pattern perception

- Understanding pattern perception provides abstract design rules on how to organise data so important structures are perceived
 - If we can map **information** structures to **readily perceived patterns** then those structures will be more easily interpreted
- Learning is important
 - **Priming:** once we have seen a pattern we identify it much more easily
 - **Long-term learning:** takes place over thousands of occurrences, but some patterns are much easier to learn (quicker) than others

Gestalt laws

- Idea: forms or patterns transcend the stimuli used to create them.
 - Why do patterns emerge?
 - Under what circumstances?
- robust rules that describe the way we set patterns in visual displays, and although the neural mechanisms proposed by these researchers to explain the laws have not withstood the test of time, the laws themselves have proved to be of enduring value.
- **The Gestalt laws easily translate into a set of design principles for information displays.**

The Gestalt laws

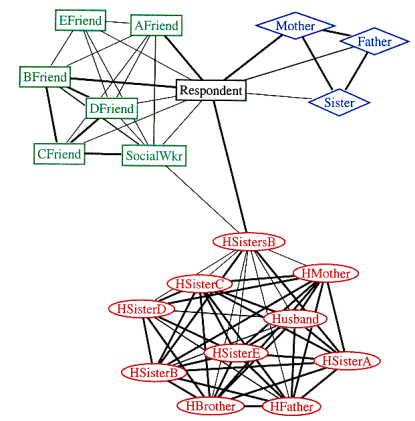
The core laws

1. Proximity
2. Similarity
3. connectedness
4. Continuity
5. Symmetry
6. Closure
7. Relative Size
8. Common fate

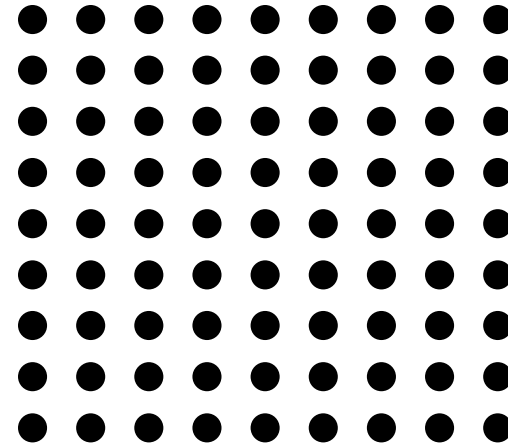
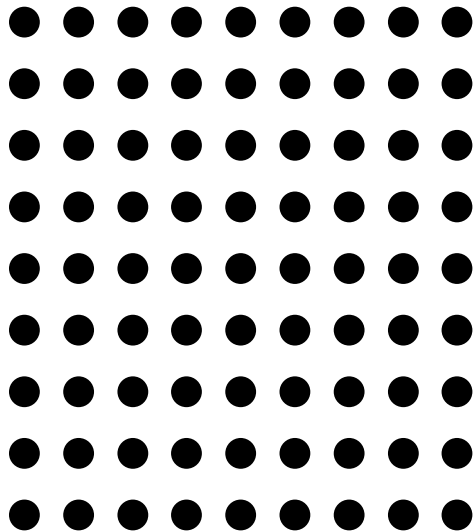
Principal effects

9. Figure - ground
10. Prägnanz : the “organising principle”

Proximity

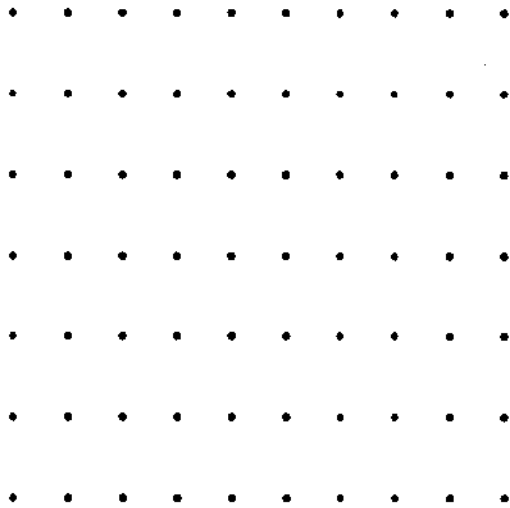


- Things that are close together are perceptually grouped together



- the simplest and most powerful way to **emphasize the relationships** between different data entities is to place them in **proximity** in display.

Proximity

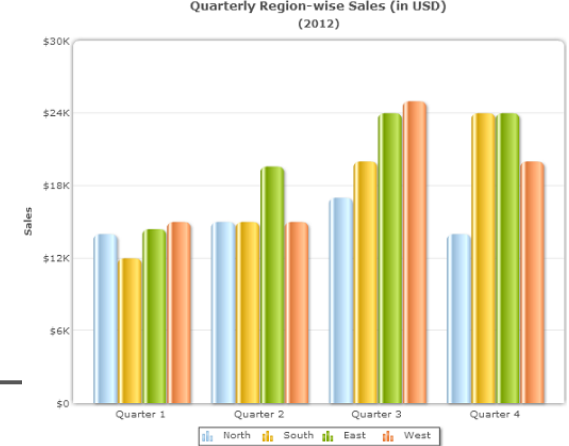


rows



columns

Proximity



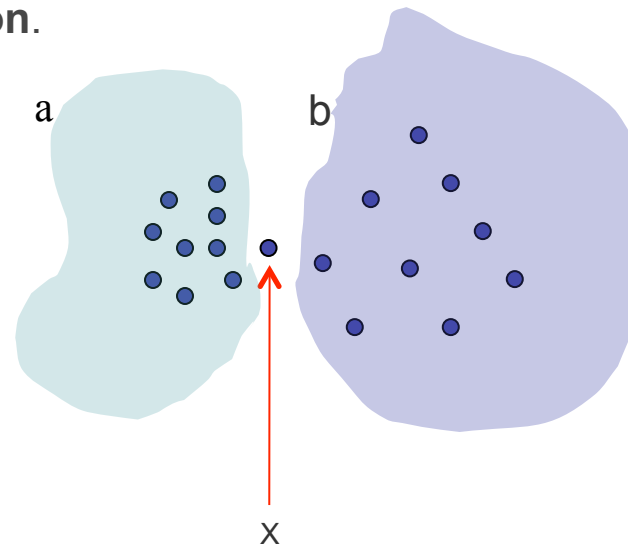
<http://sixrevisions.com/usability/data-visualization-gestalt-laws/>

- We associate the lines which are close together than those which are further apart.
- three pairs of lines which are fairly close together (and a lonely line on the far right) rather than three pairs of lines which are further apart (and a lonely line on the far left).



Proximity and density

- **Principle of spatial concentration.**

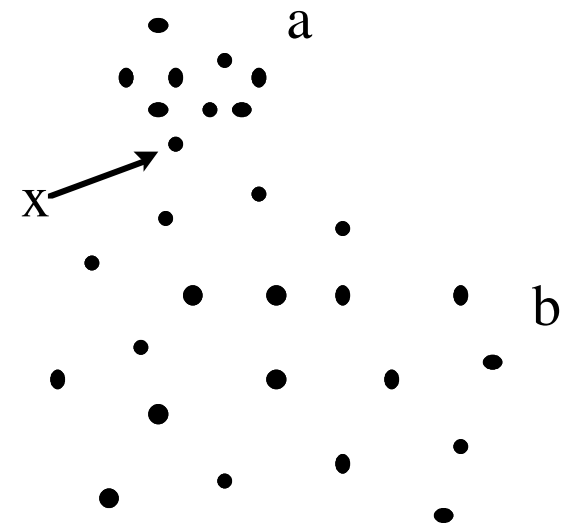
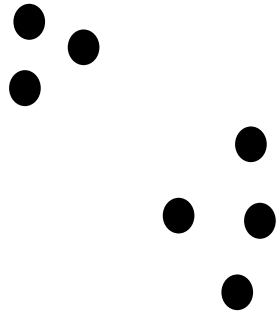


- We perceptually group **regions of similar density**

Dot **x** is perceived as part of group **a** rather than group **b** although it is equidistant

Proximity: design implications

- Emphasize relationship by proximity

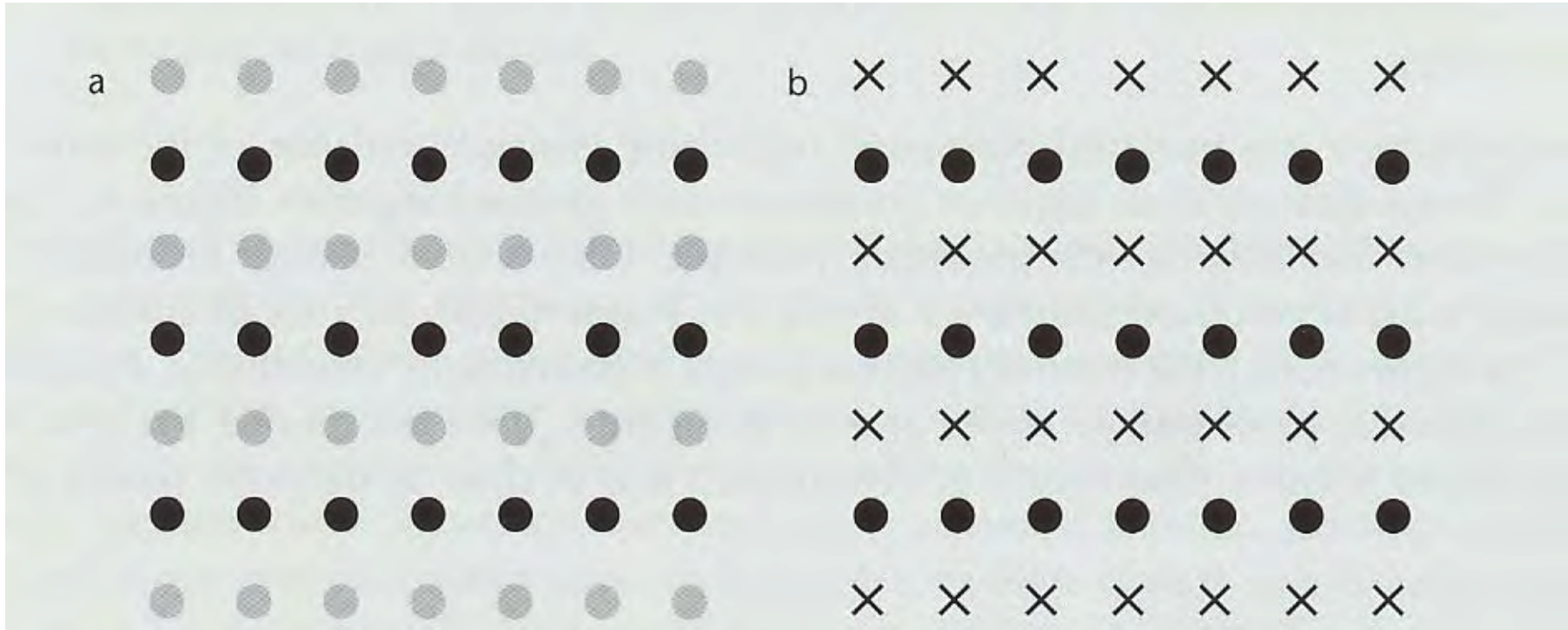


- Emphasize relationship by spatial density

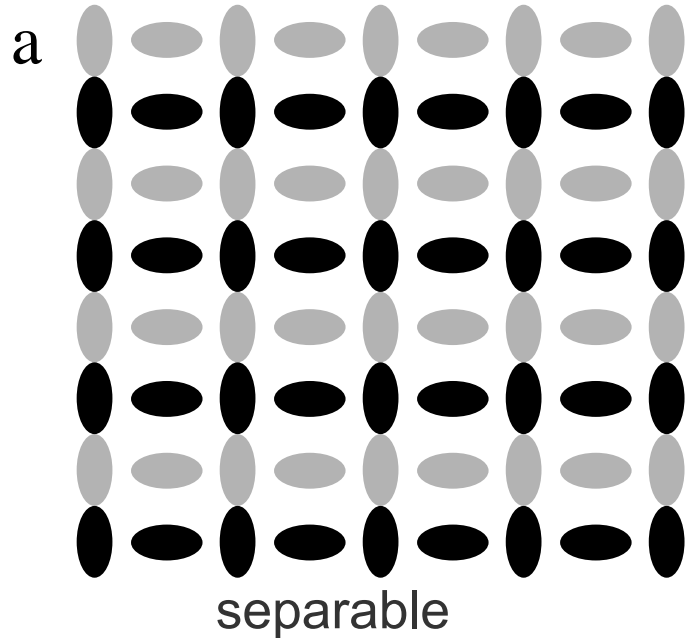
Similarity

- The shapes of individual pattern elements can also determine how they are grouped
- Similar elements tend to be grouped together

Similarity



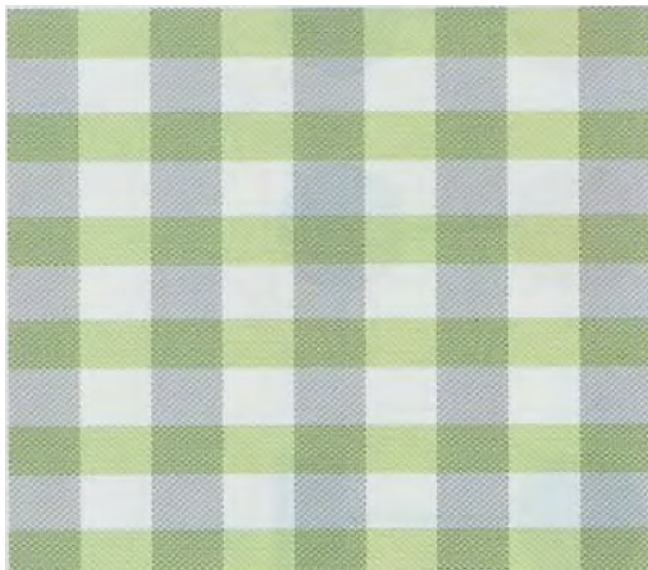
Similarity and integral dimensions



integral

- A: separable dimensions allow both groupings to be perceived – but not simultaneously

Similarity and the separability of dimensions



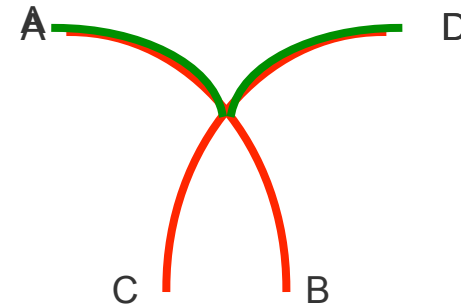
Integral dimensions (colour and grayscale) are used to delineate rows and columns



Separable dimensions (colour and texture) make it easier to attend separately to either the rows or the columns

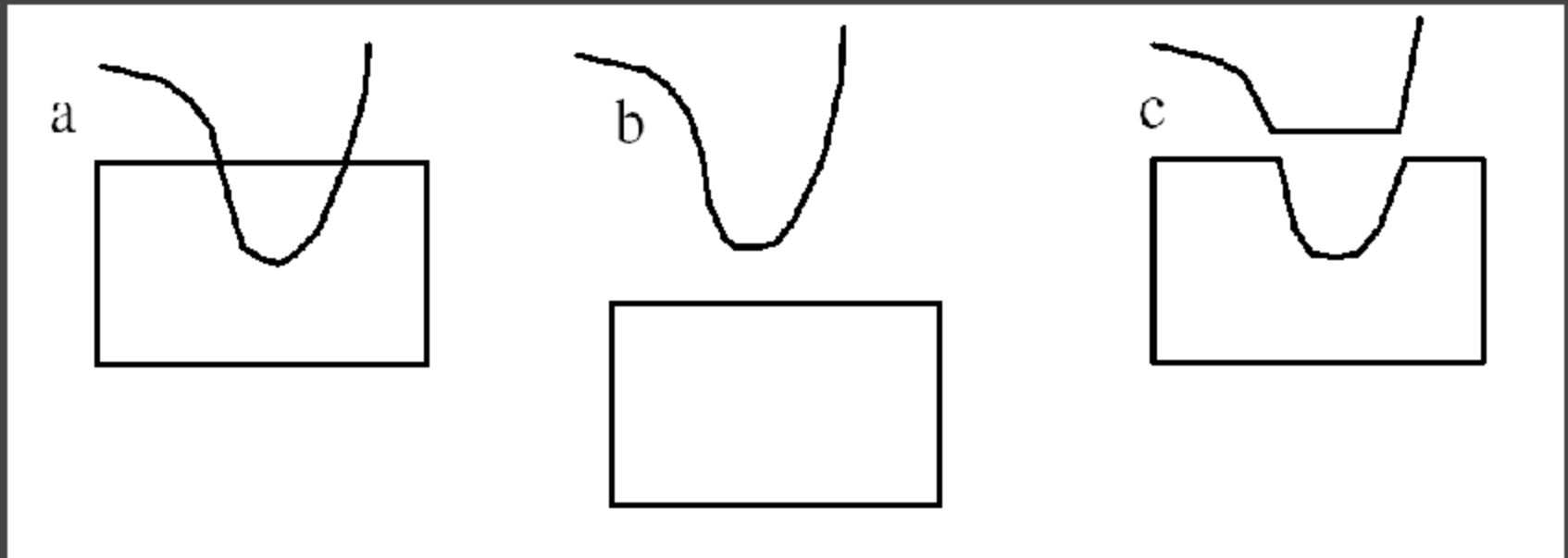
Continuity

- The Gestalt principle of continuity states that we are more likely to construct visual entities out of objects that are smooth and continuous, rather than those that contain abrupt changes in direction.
- We see a-b crossing c-d
- not a-d or b-c



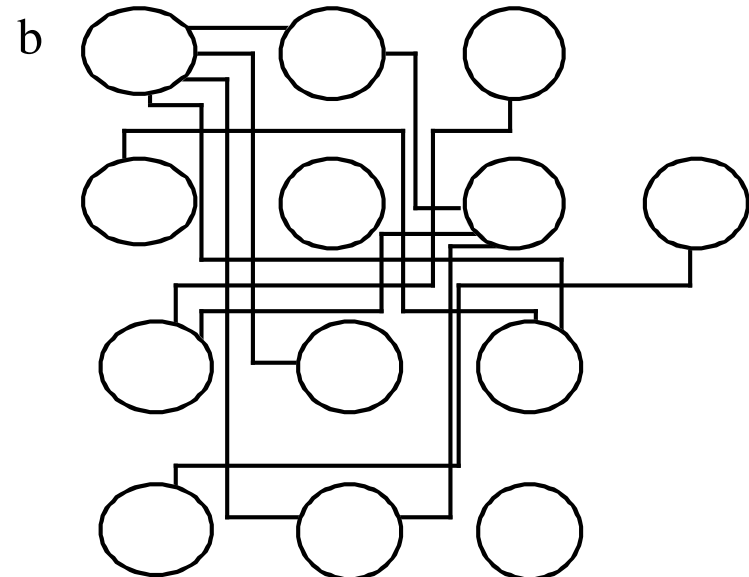
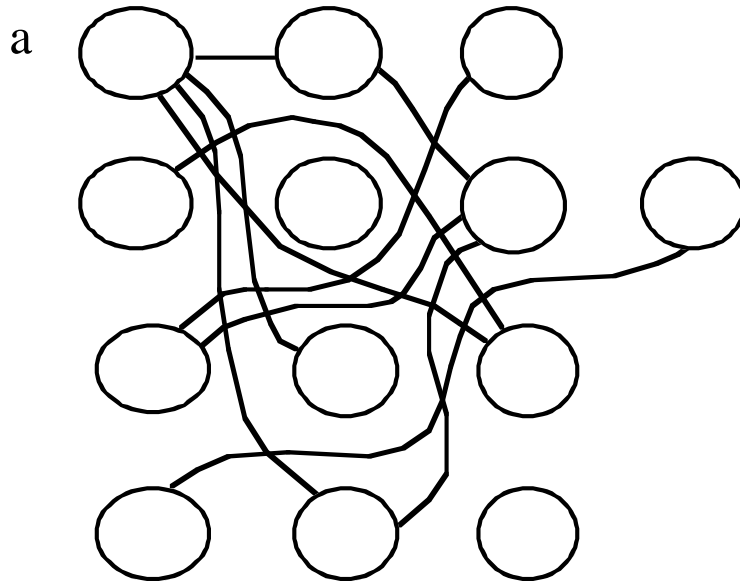
Continuity

smooth not abrupt change
overrules proximity



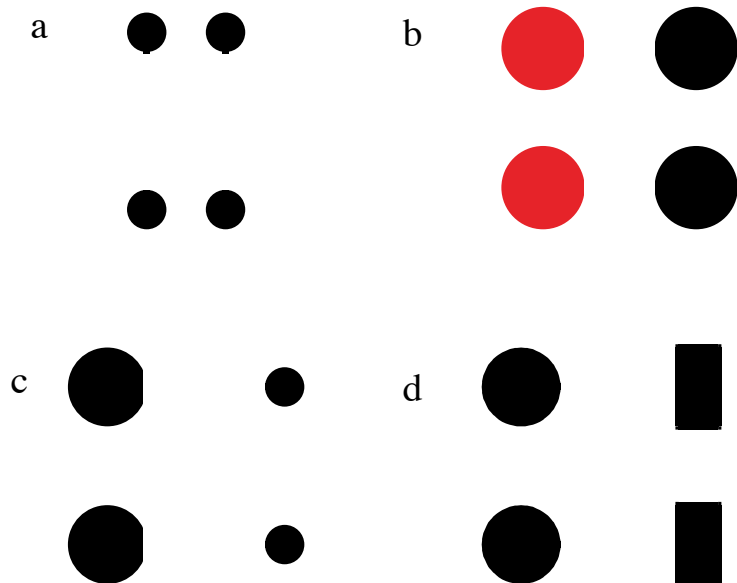
Continuity in Diagrams

- Connections using smooth or abrupt lines
- Which is easier to follow?



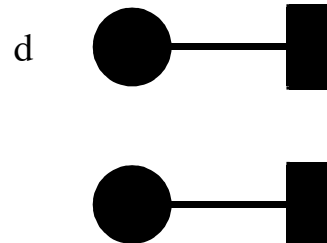
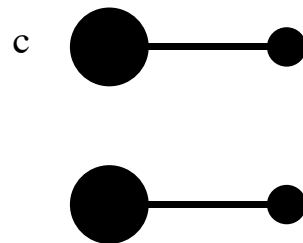
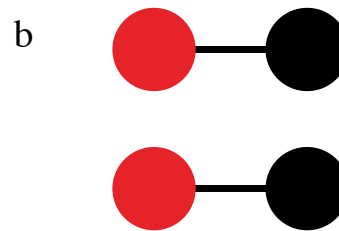
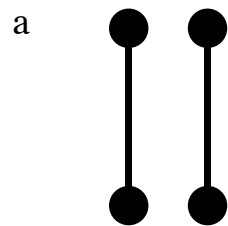
Connectedness

- Connectedness can over-rule **proximity**, colour, size or shape



Connectedness

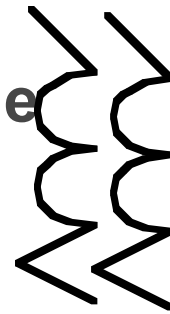
- Connecting graphical objects by a line is a very powerful way of expressing that there is a relationship between them



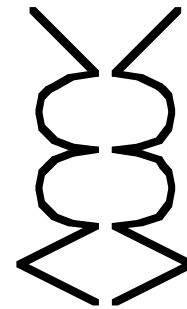
- Basis of node-link diagrams
- Most common method of indicating relationships

Symmetry

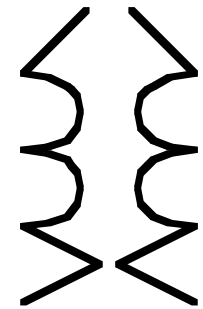
- Symmetry creates **visual whole**



(a)



(b)



(c)

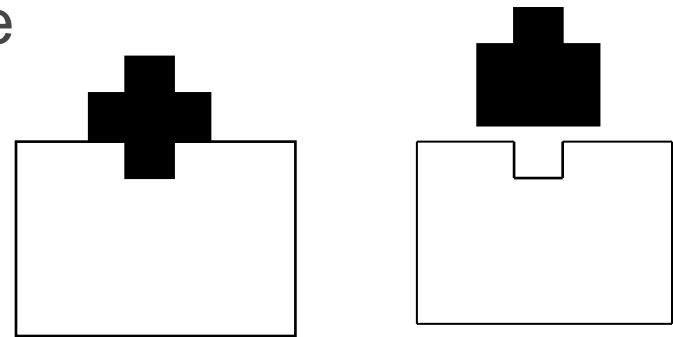
- Powerful organising principle

- b and c are seen as figures/objects, where a is a pair of parallel lines

- We construct objects in the world

Symmetry

- Symmetry creates visual whole
- Powerful organising principle

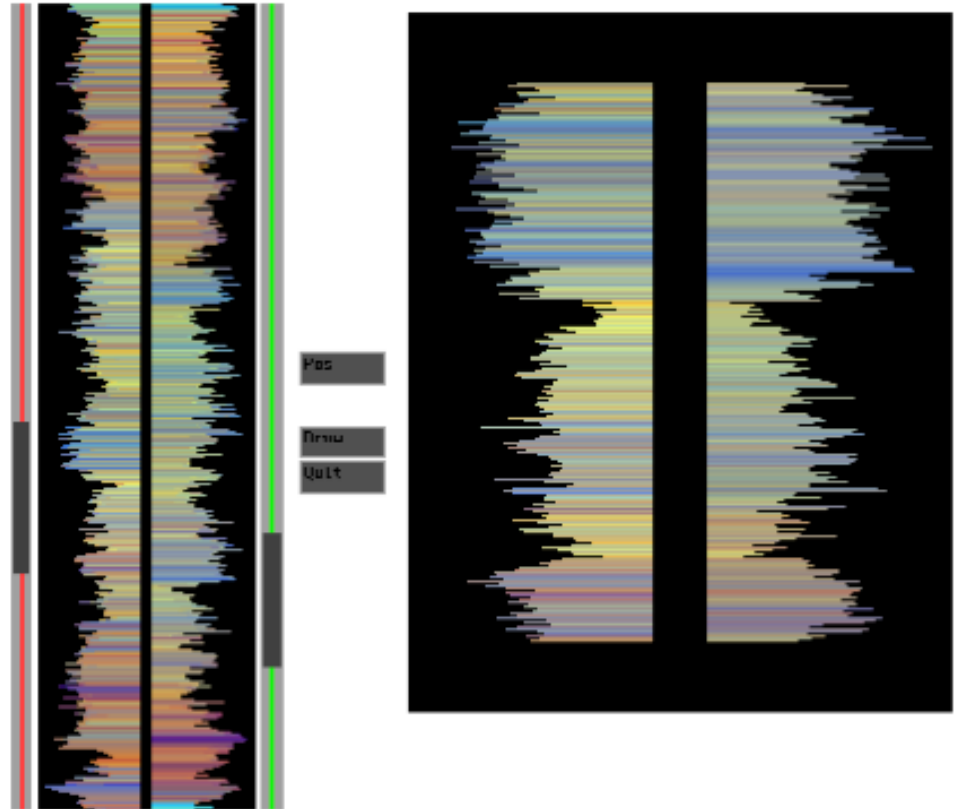


- Outlines and filled shapes

- We see a cross in front of a rectangle not the second option

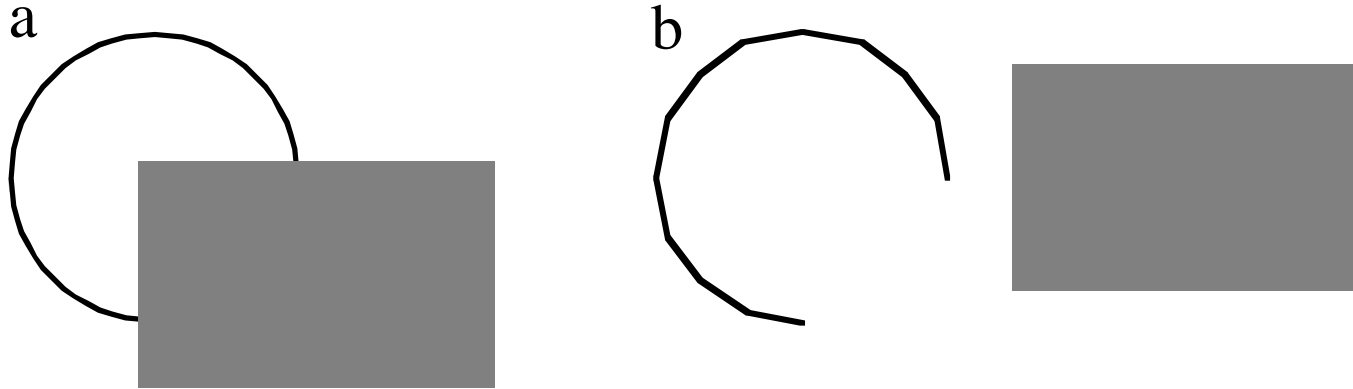
Symmetry

- One application is in tasks where data analysts are looking for similar patterns (e.g. in time-series data).
 - Detect **asymmetries** effectively



Closure

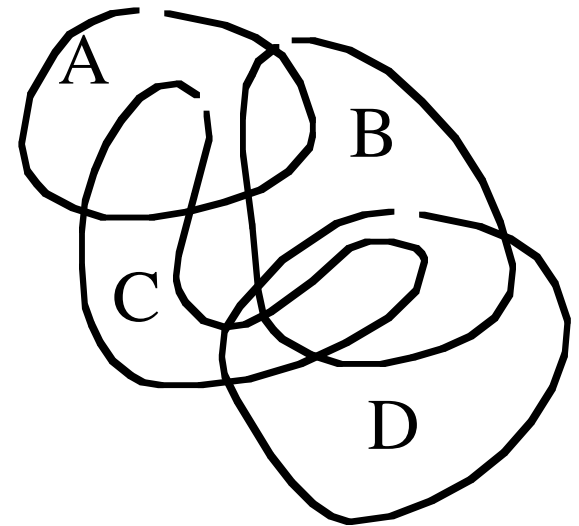
- **Over-rules proximity !**
- A closed contour tends to be seen as an object
- The Gestalt psychologists argued that there is a perceptual tendency to close contours that have gaps



a circle behind a rectangle as in (a), not a broken ring as in (b).

Closure (cont.)

- Closed contours to show set relationship
- An Euler diagram. This diagram tells us (among other things) that entities can simultaneously be members of sets A and C but not of A, B, and C.
- Also, anything that is a member of both B and C is also a member of D.
- These rather difficult concepts are clearly expressed and understood by means of closed contours.



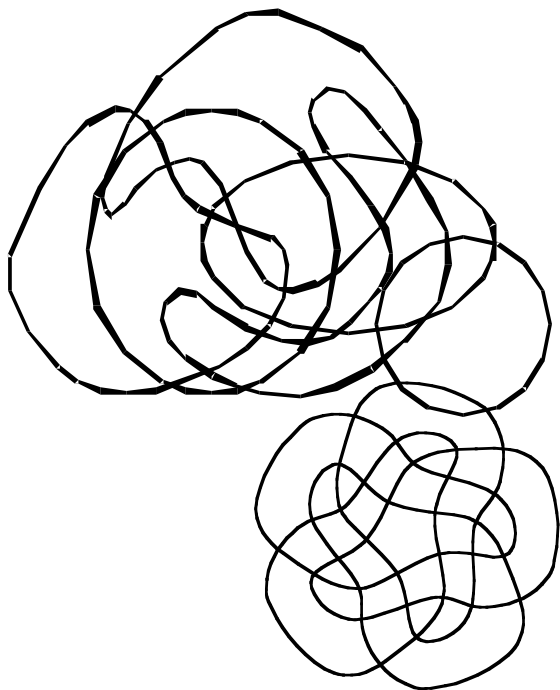
Common region

Wherever a closed contour is seen, there is a very strong perceptual tendency to divide regions of space into “inside” or “outside” the contour.

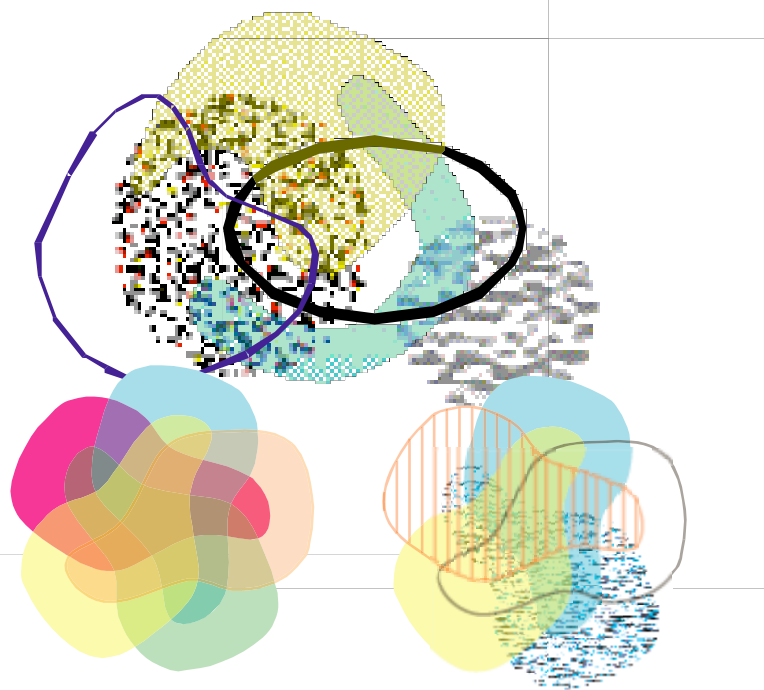
- common region [Palmer (1992)].
- **Common region is a much stronger organising principle than simple proximity**
- This is presumably the reason why Venn-Euler diagrams are such a powerful device for displaying associations among sets of data.

Extending the Euler diagram

a

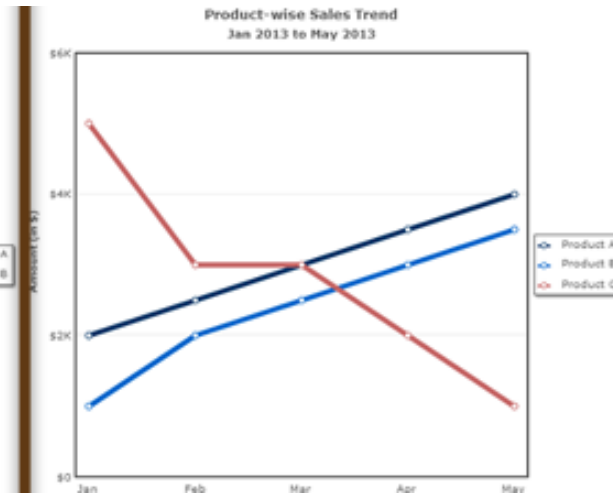
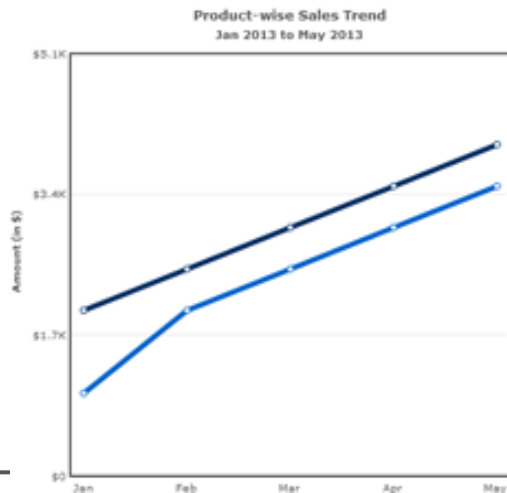


b



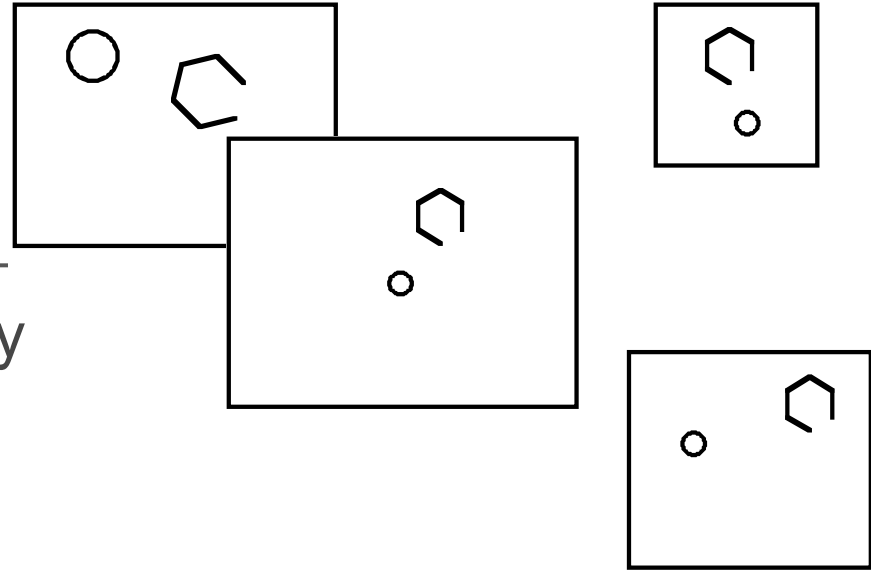
Common fate

- When lines or shapes “move” in the same direction, they are perceived to be in some relationship
 - Share a “common fate”
 - Lack of common fate negates a relationship ? Or negative relationship ?



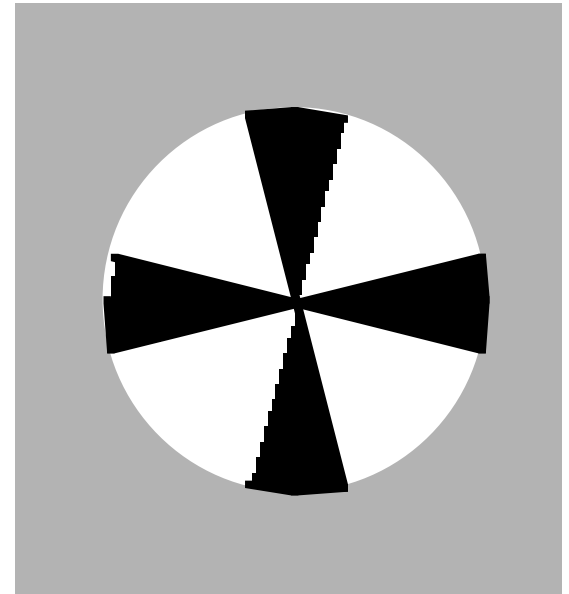
Closure

- Rectangular contours strongly segment the visual field.
 - Creating frame of reference
- Position of objects judged based on enclosing frame
- Where is this critical?



Relative Size

- Smaller components tend to be perceived as objects
- prefer horizontal and vertical orientations

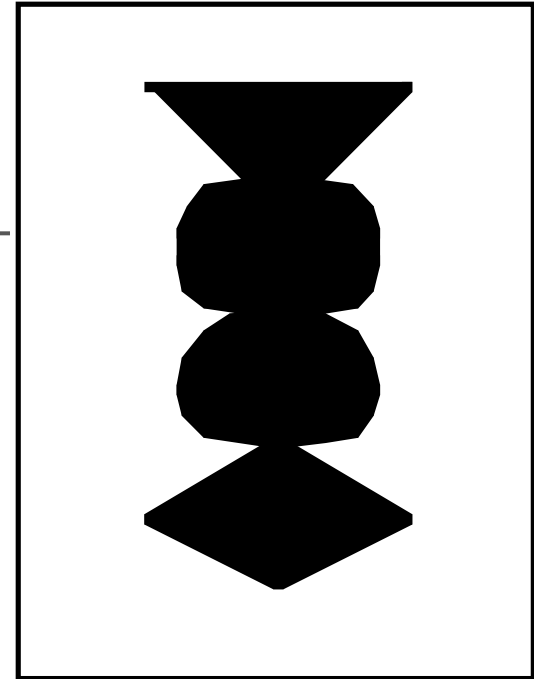


Gestalt organising principles

- Figure and ground
- Subjective contour
- Prägnanz

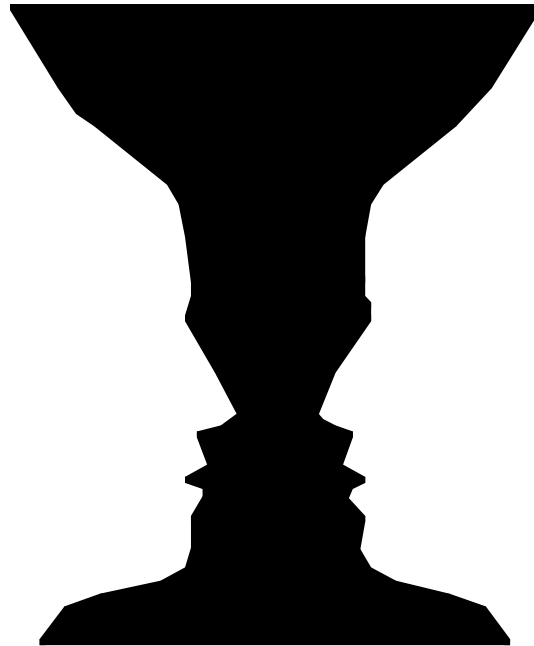
Figure and Ground

- we to separate a dominant shape (a 'figure' with a definite contour) from what our current concerns relegate to 'background' (or 'ground')
- Symmetry, white space, and closed contour contribute to perception of figure.
- **The perception of figure as opposed to ground can be thought of as the fundamental perceptual act of identifying objects.**



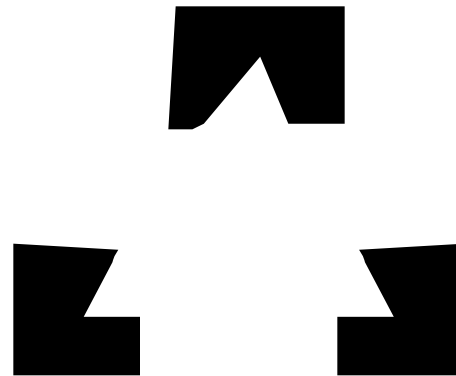
Figures and Grounds

Rubin's Vase



Subjective Contour

- We construct an object from pieces



Emergence

- (Kosara)
- Holistic perception of image



Prägnanz

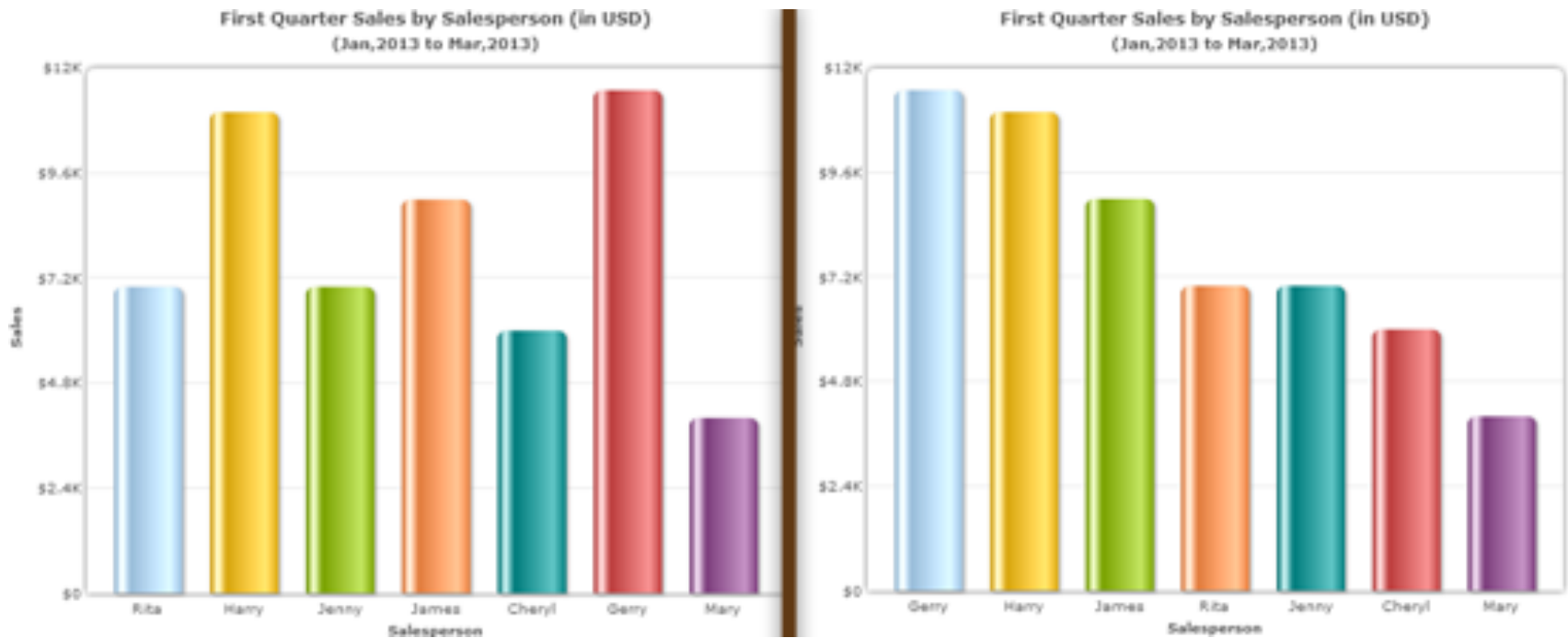
- The law of “good form” – Keep it simple
- Overarching principle that the simplest and most stable interpretations are preferred
- “What the Gestalt principles of perceptual organization suggest is that we may be predisposed towards interpreting ambiguous images in one way rather than another by universal principles...The Gestalt principles can be seen as reinforcing the notion that the world is not simply and objectively 'out there' but is constructed in the process of perception.”
 - --Daniel Chandler
- <http://www.aber.ac.uk/media/Modules/MC10220/visper07.html>

Prägnanz

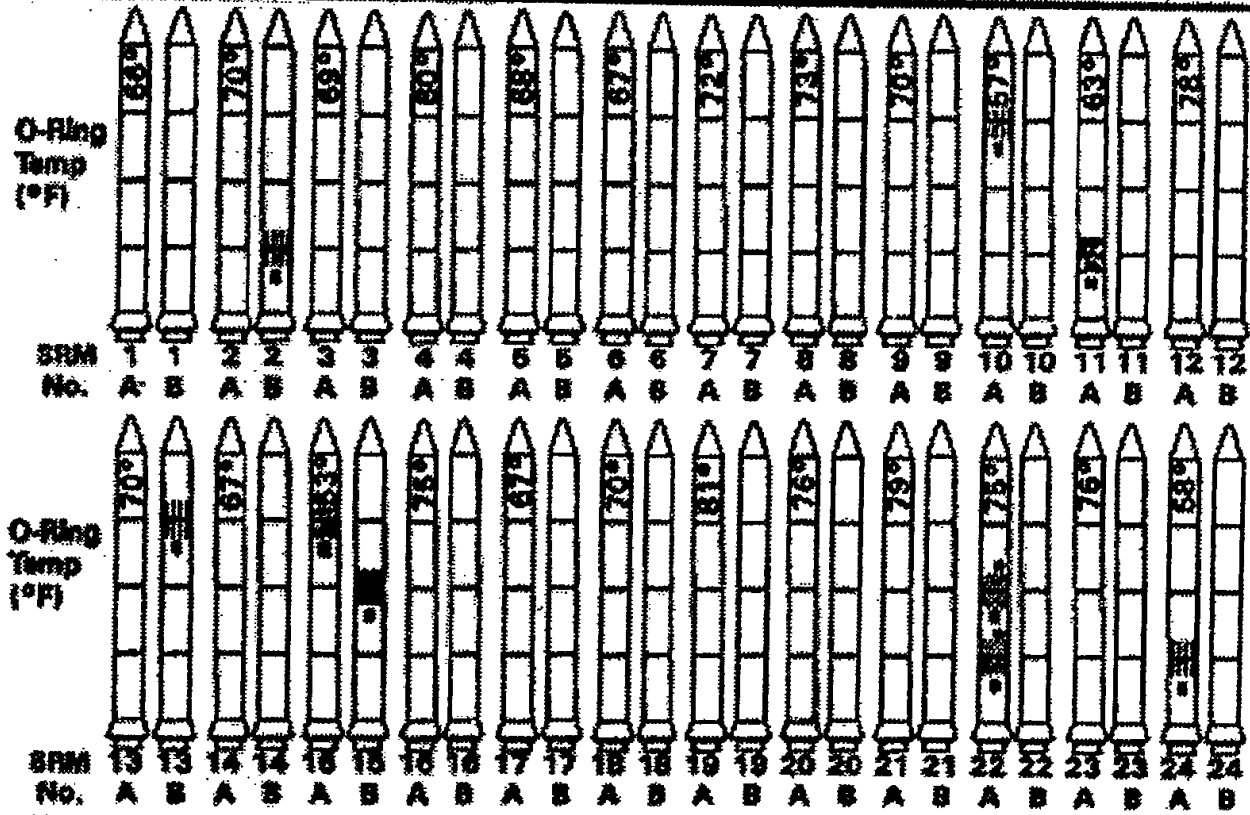
- A stimulus will be organized into as good a figure as possible. Here, good means symmetrical, simple, and regular.
- here we see a square overlapping a triangle, not a combination of several complicated shapes.



Design example



History of O-Ring Damage in Field Joints (Cont)



Monroe Power, Inc.
 Newark, Delaware

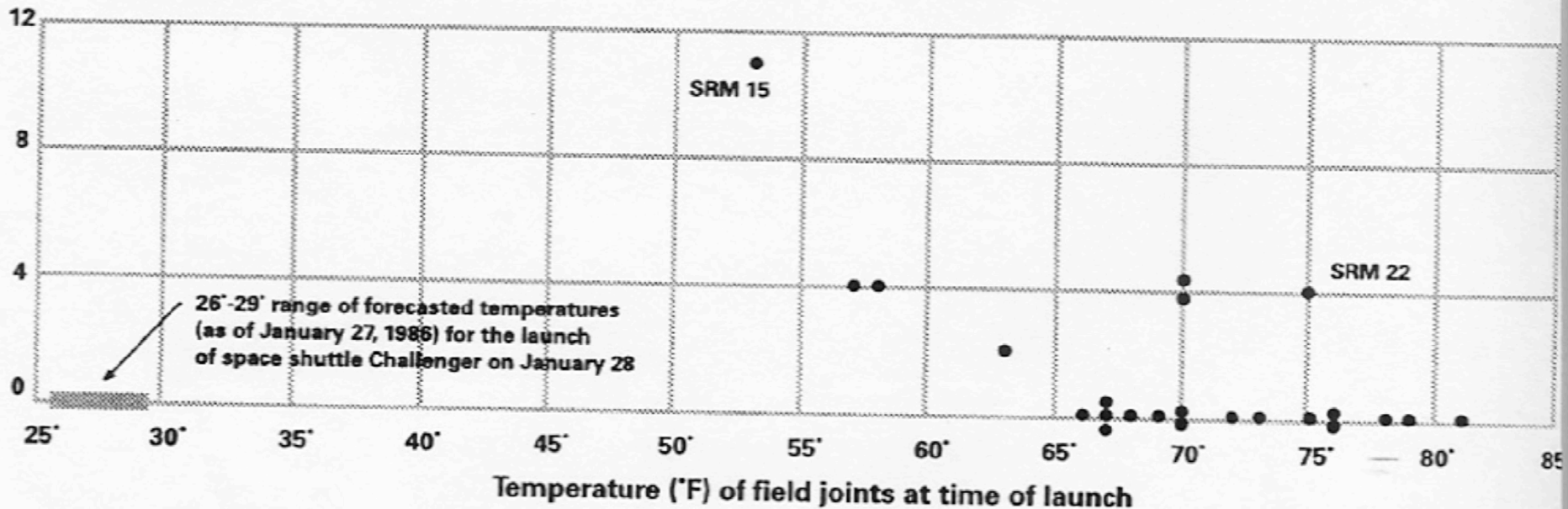
* No Erosion

NO WARRANTY OR ENDORSEMENT IS MADE BY MONROE TO SUPPORT OR ENDORSE ANY PRODUCT OR SERVICE, AND NO WARRANTY OR ENDORSEMENT IS MADE BY MONROE TO SUPPORT OR ENDORSE ANY PRODUCT OR SERVICE.

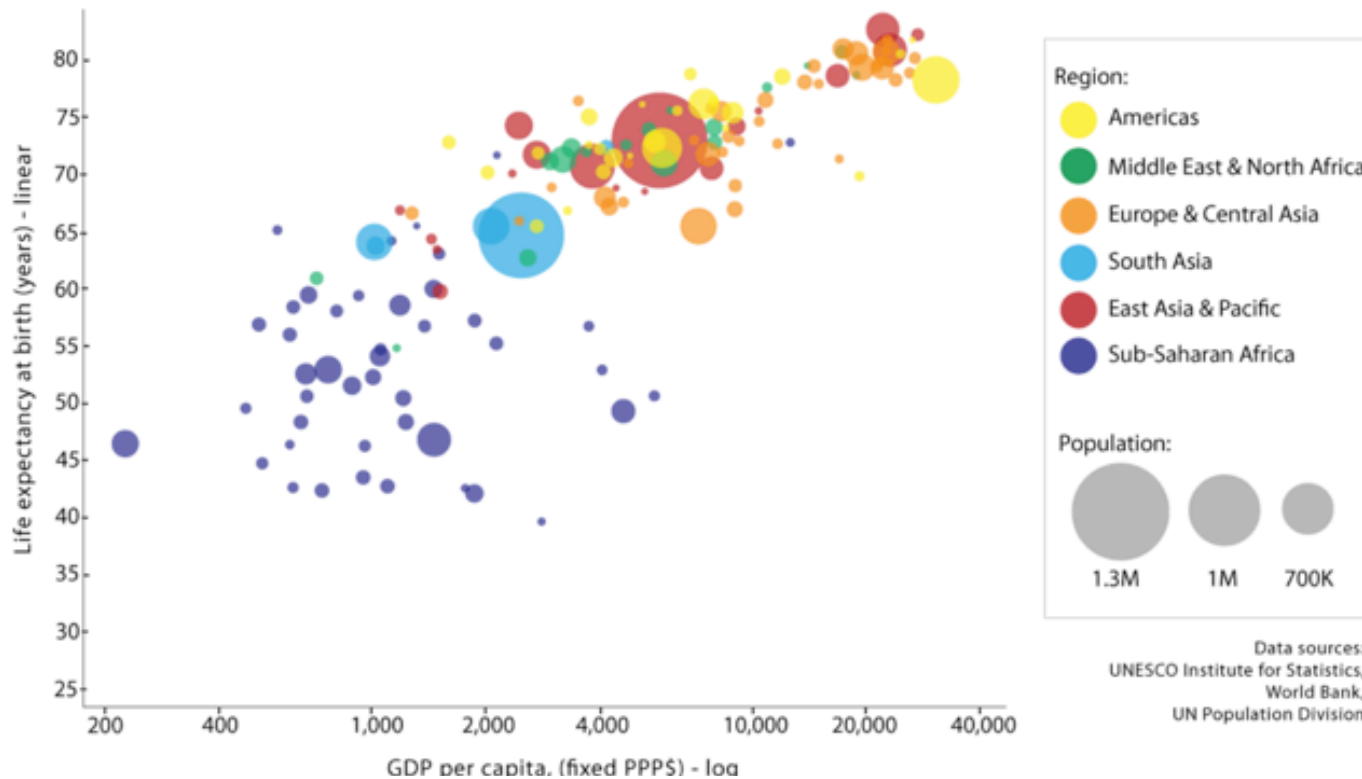


Same Data – Different Plot

O-ring damage index, each launch

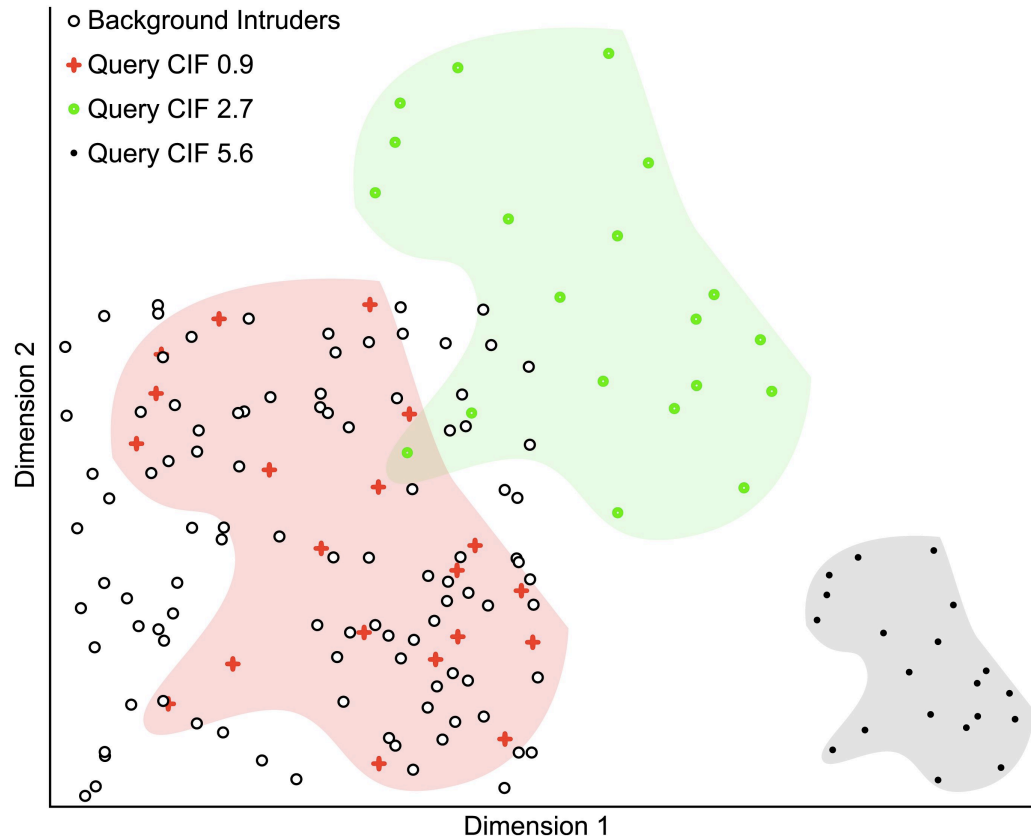


Proximity, continuity, similarity



<http://www.softviscollection.org/intro/a-thousand-words/>

Common region



Pattern learning: can we practice?

- People who work with visualizations must learn the skill of seeing patterns in data.
- In terms of making visualizations that contain easily identified patterns, one strategy is to rely on pattern-finding skills that are common to everyone.
- Good idea to use *priming* to enhance perceptual receptivity