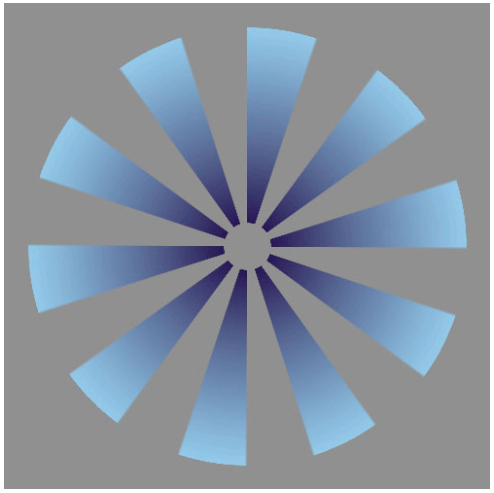
IAT 355
Perception



(Or… What You See is Maybe Not What You Were Supposed to Get)

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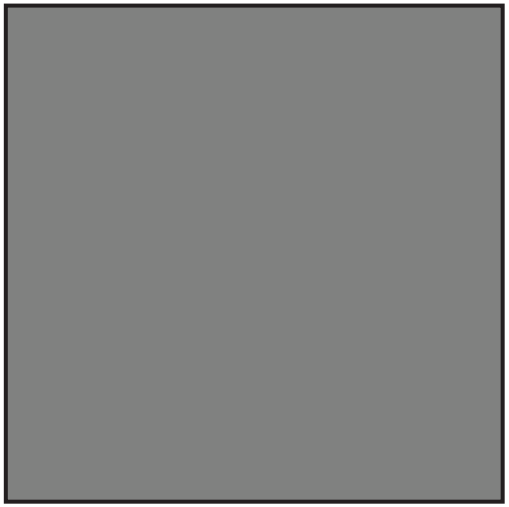
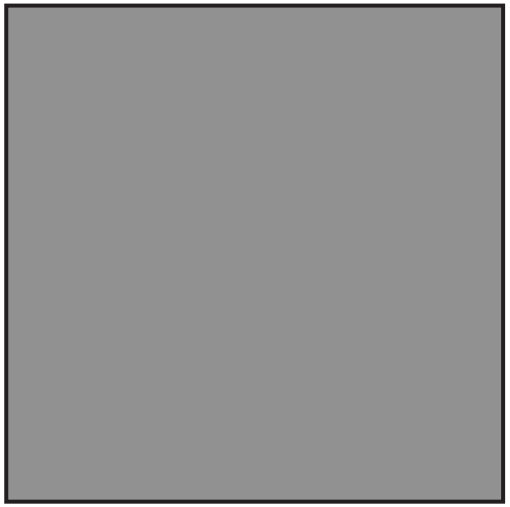
Detecting differences

- Is one brighter?



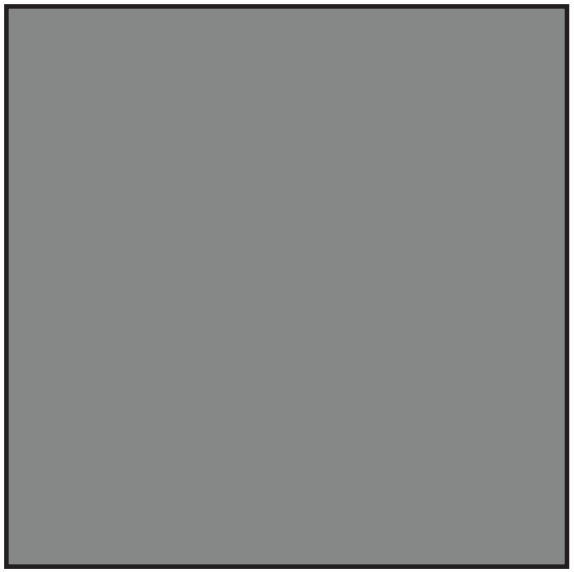
128, 128, 128



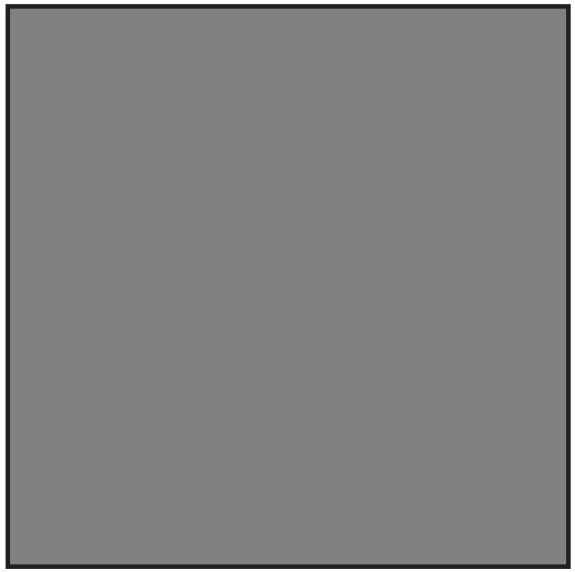
144, 144, 144

Detecting differences

- Is one brighter?



134, 134, 134

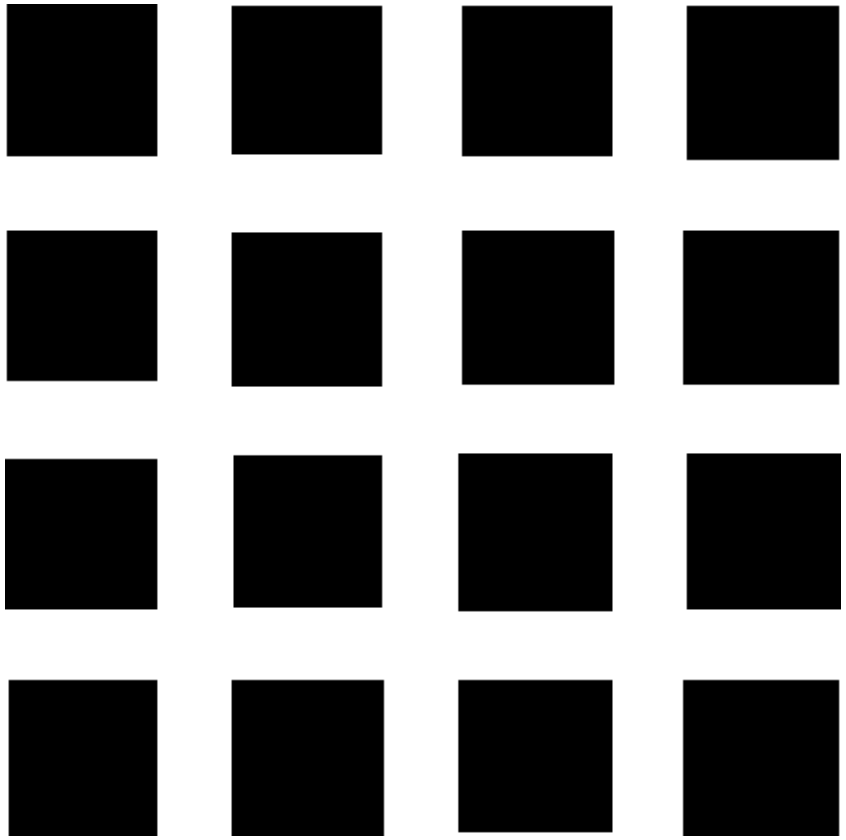


128, 128, 128

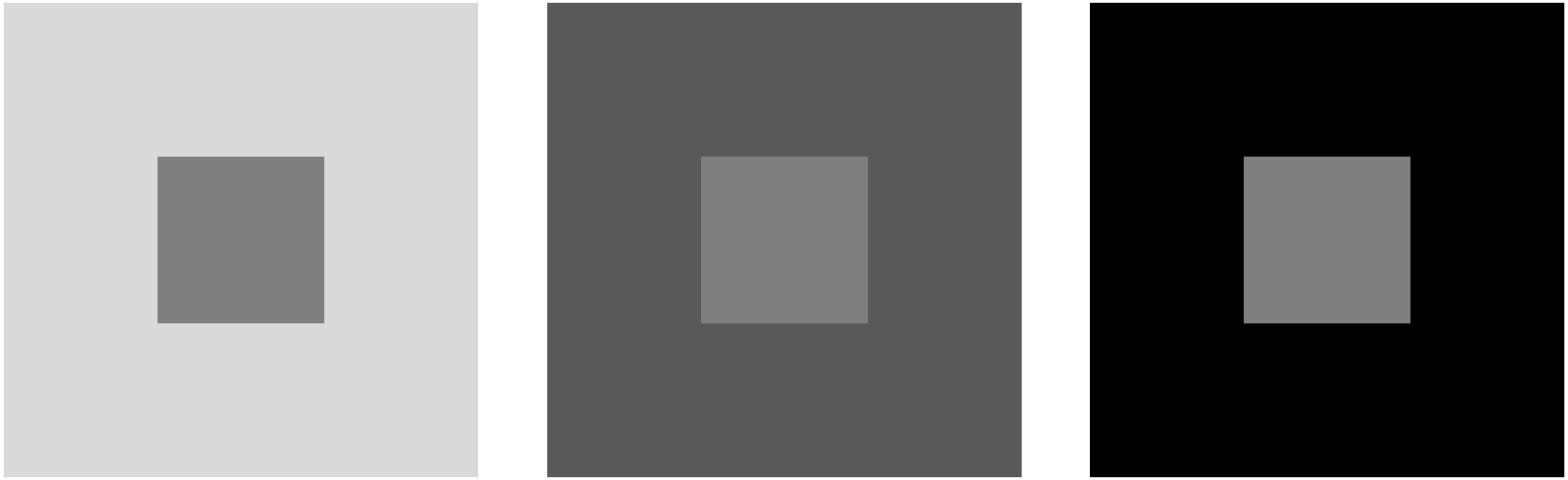
Just Noticeable Difference

- JND (Weber's Law)
- The smallest detectable difference between equally spaced levels of a stimulus
- Relative difference is important
- Most continuous variation perceived in distinct steps

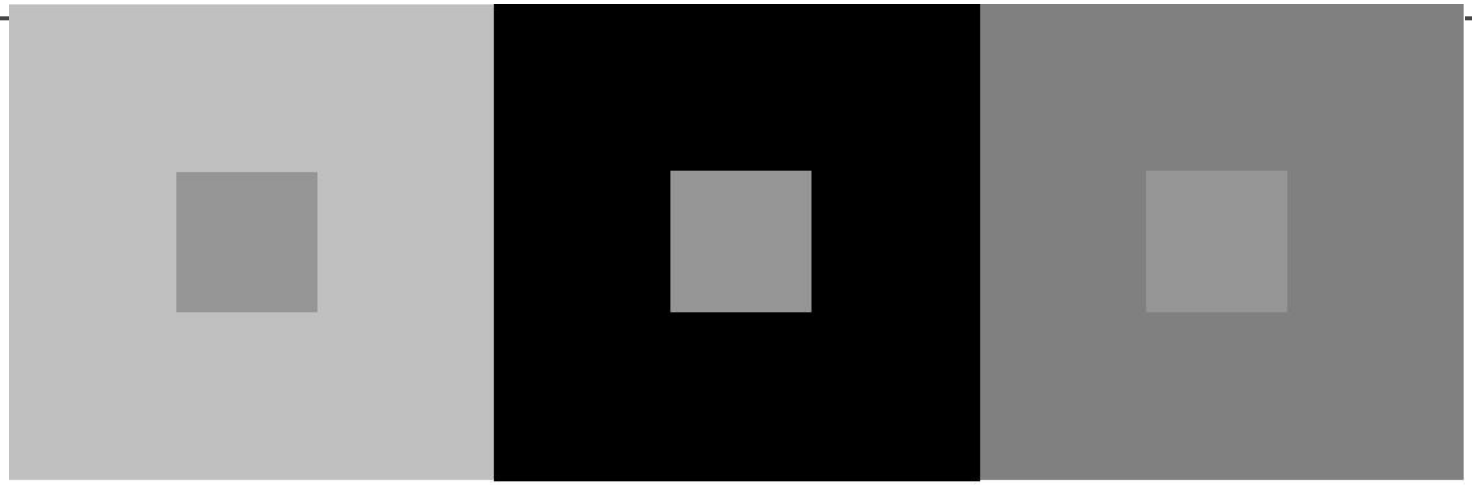
We see things that aren't there ….




Humans see relatively – related to surroundings

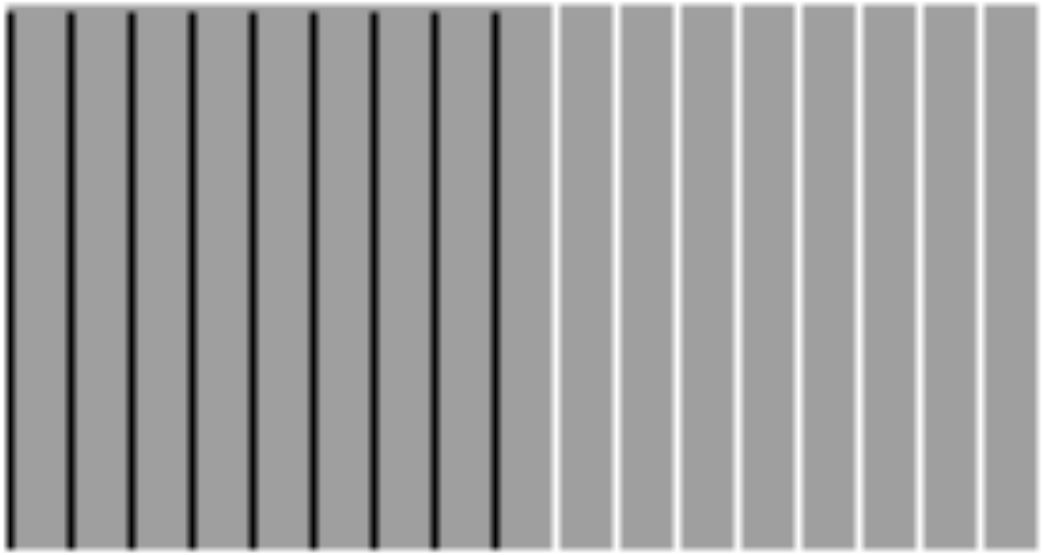


Simultaneous contrast effects



- a gray patch on a dark background looks lighter than the same gray patch on a light background.
- http://www.michaelbach.de/ot/lum_dynsimcontrast/index.html

Assimilation of lightness



- The gray background with black lines appears to be darker while the gray background with white lines appears to be lighter.

Dynamic Luminance

- Changes in apparent brightness with quick changes in viewing distance

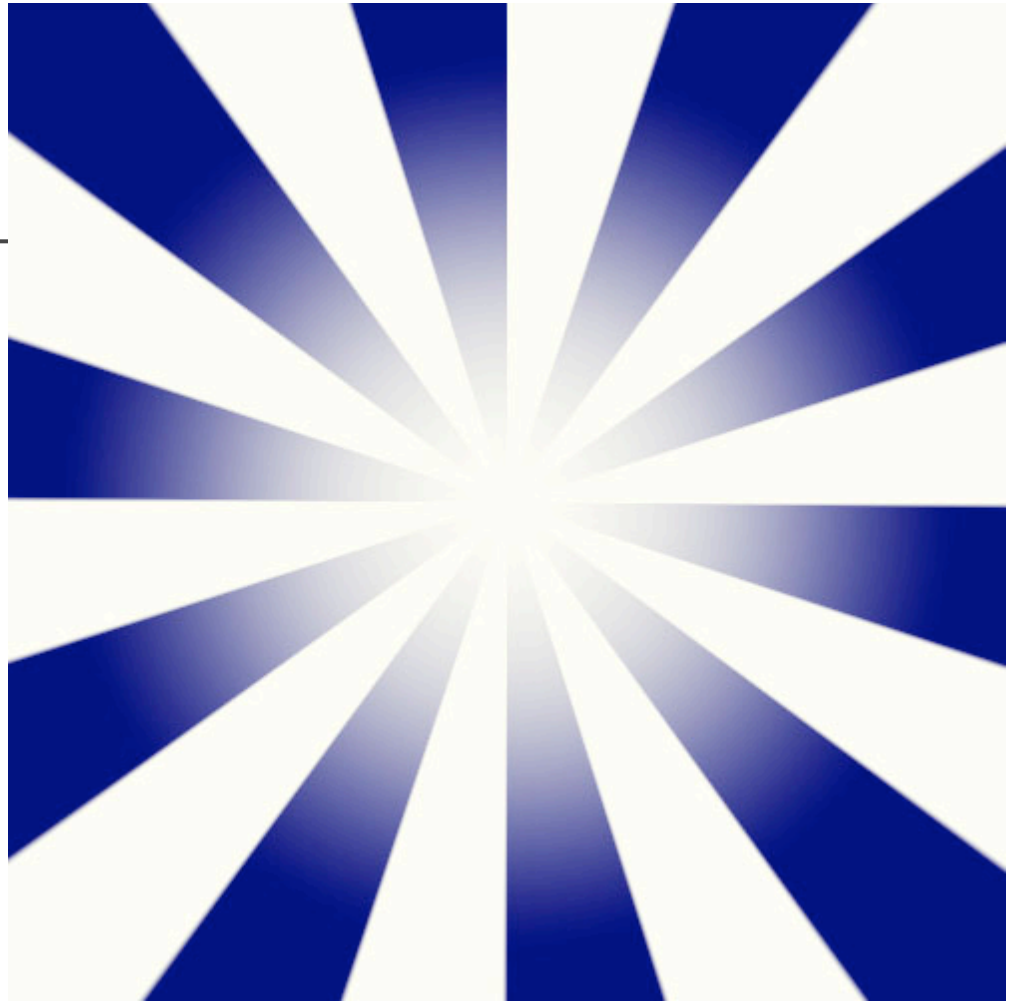


Image from perceptualstuff.org

The Breathing Light Illusion

- Change in apparent brightness as you move closer in and farther away quickly

- Gori, S. & Stubbs, D. A. (2006). A new set of illusions - The Dynamic Luminance-Gradient Illusion and the Breathing Light Illusion. Perception. 35, 1573-15771.

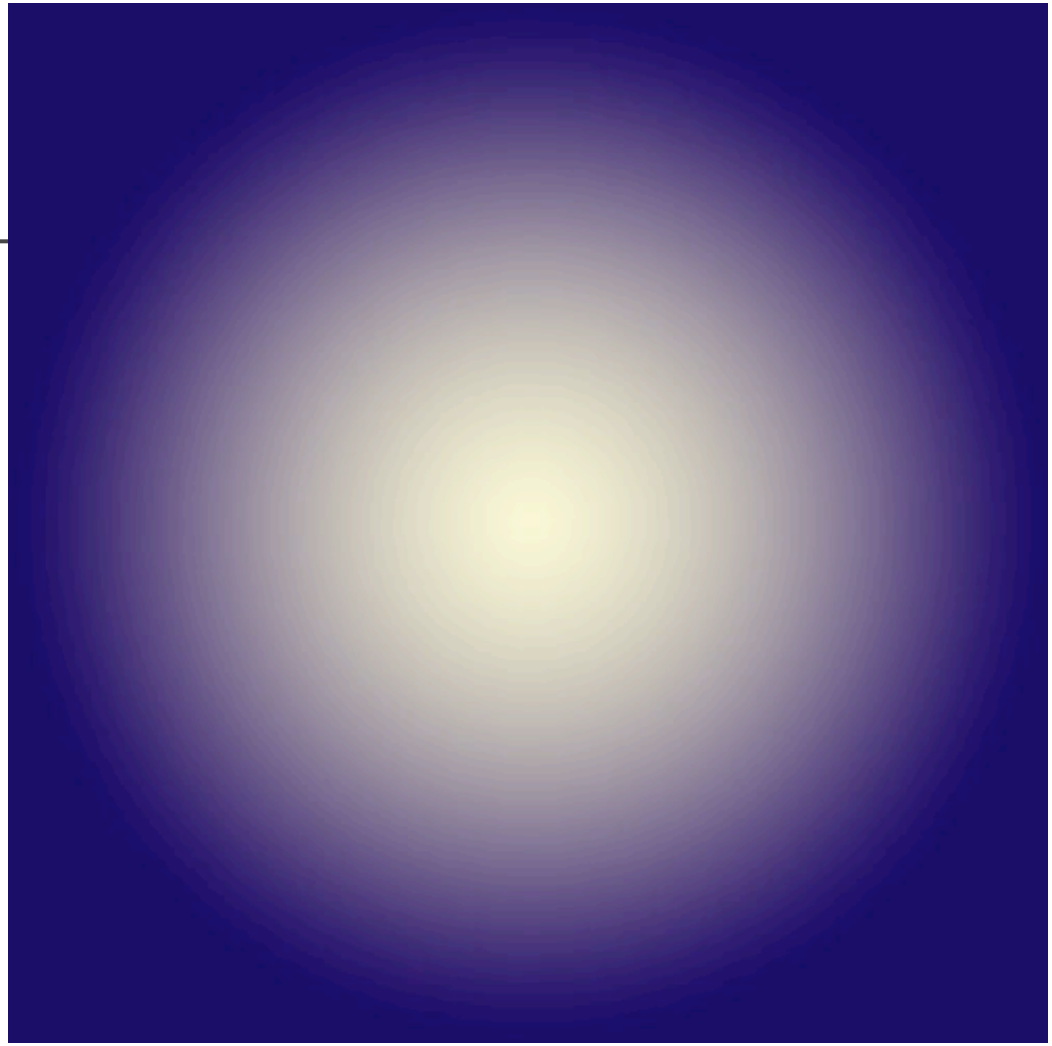
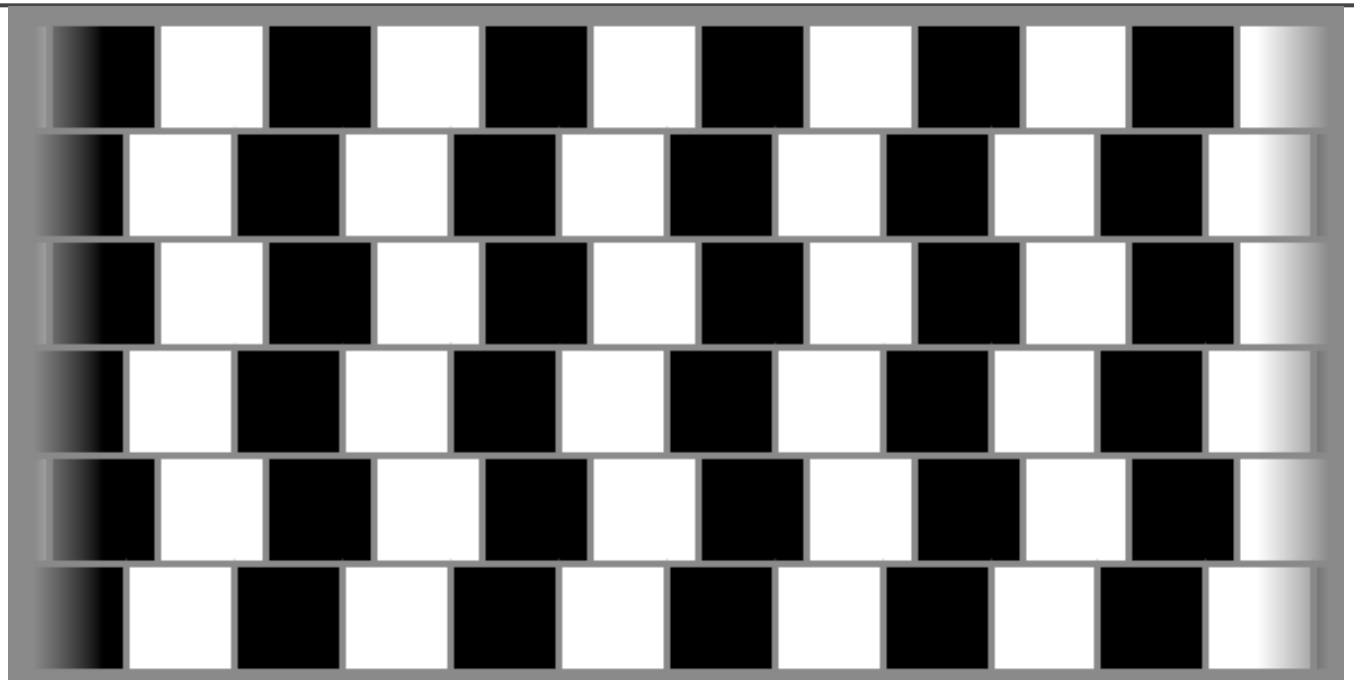


Image from perceptualstuff.org

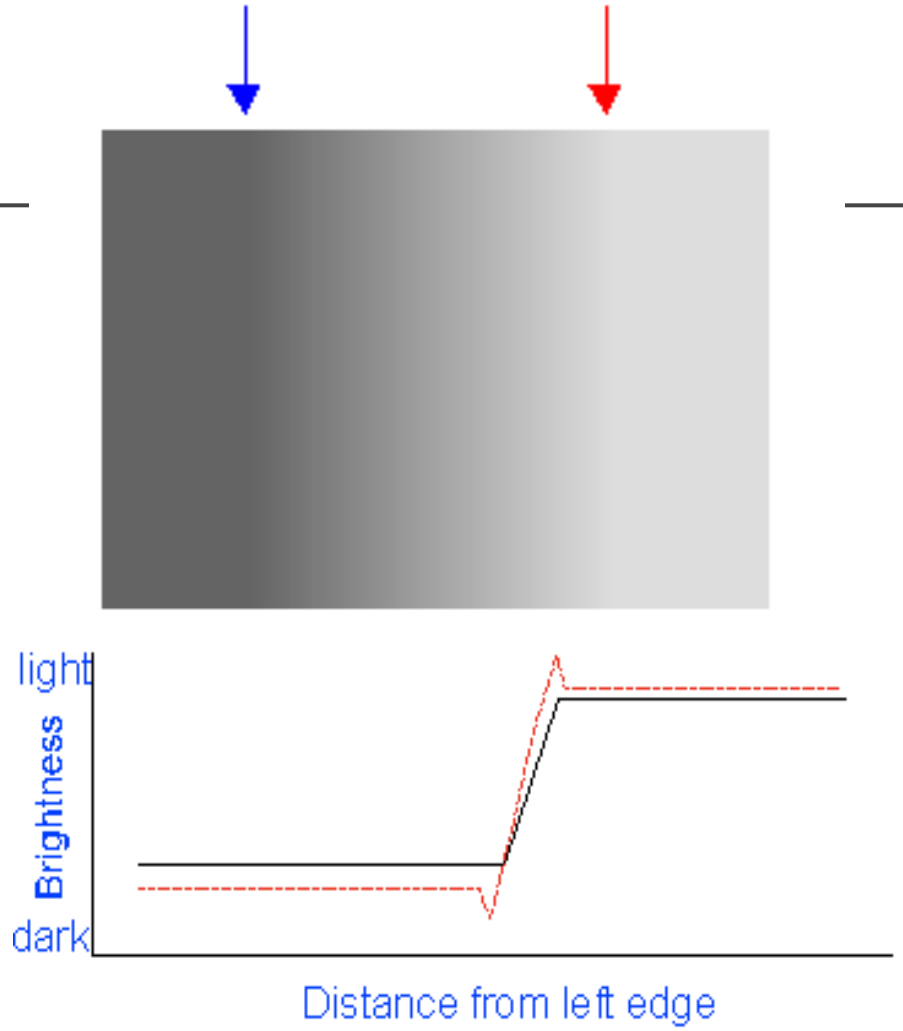
The Café Wall Illusion



- The tiles are actually evenly rectangular

Mach bands

- Illusory Mach bands appear when gradients from darker to lighter shades are created



Mach bands

- The effect is robust with different shapes and numbers of gradients

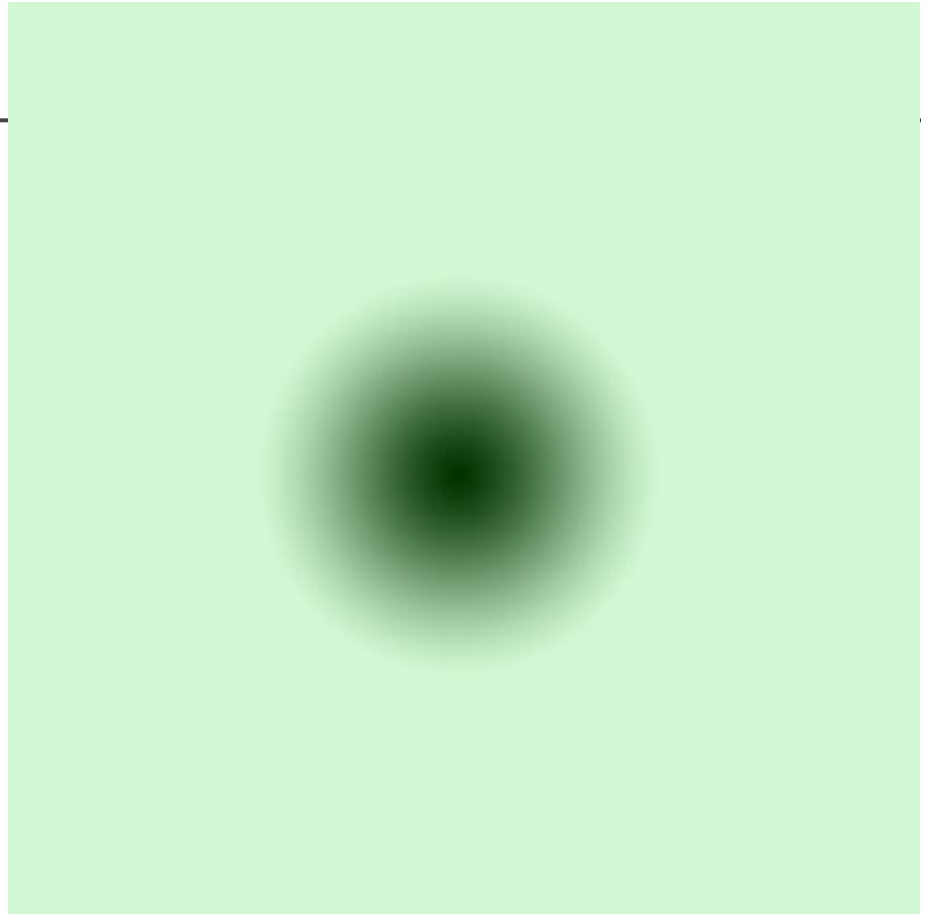
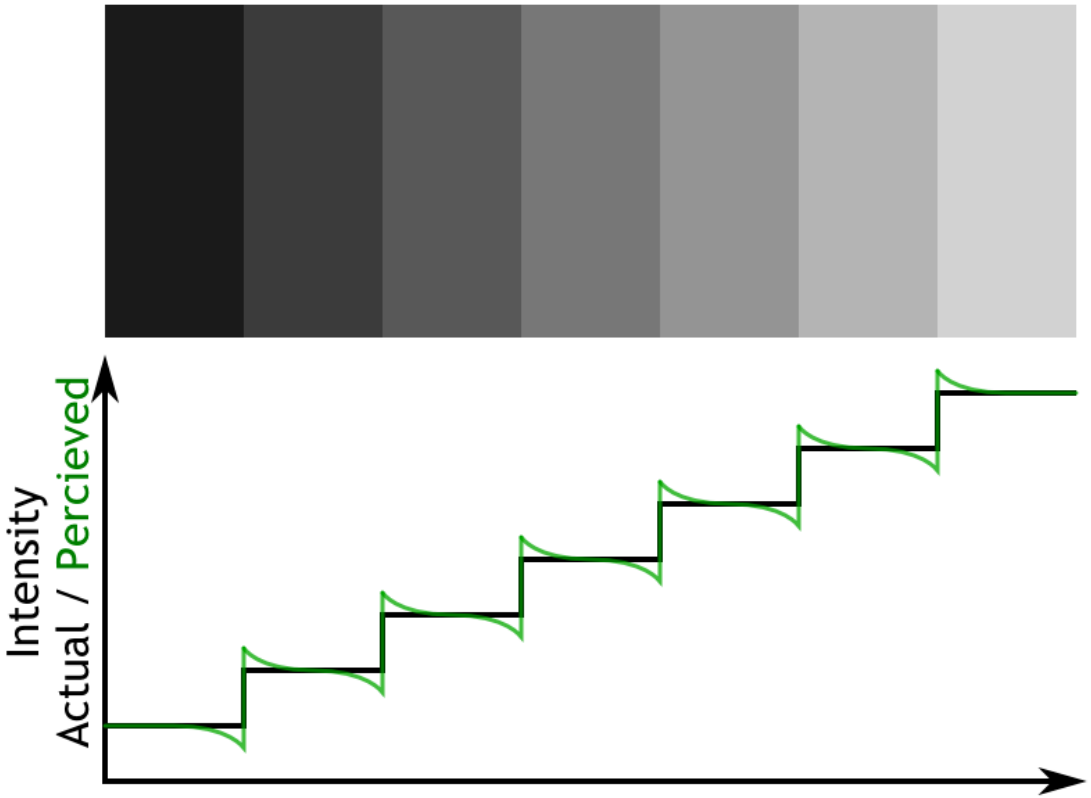


Image from perceptualstuff.org


Intensity
Actual / Percieved

Mach bands

- The effect is robust with different shapes and numbers of gradients

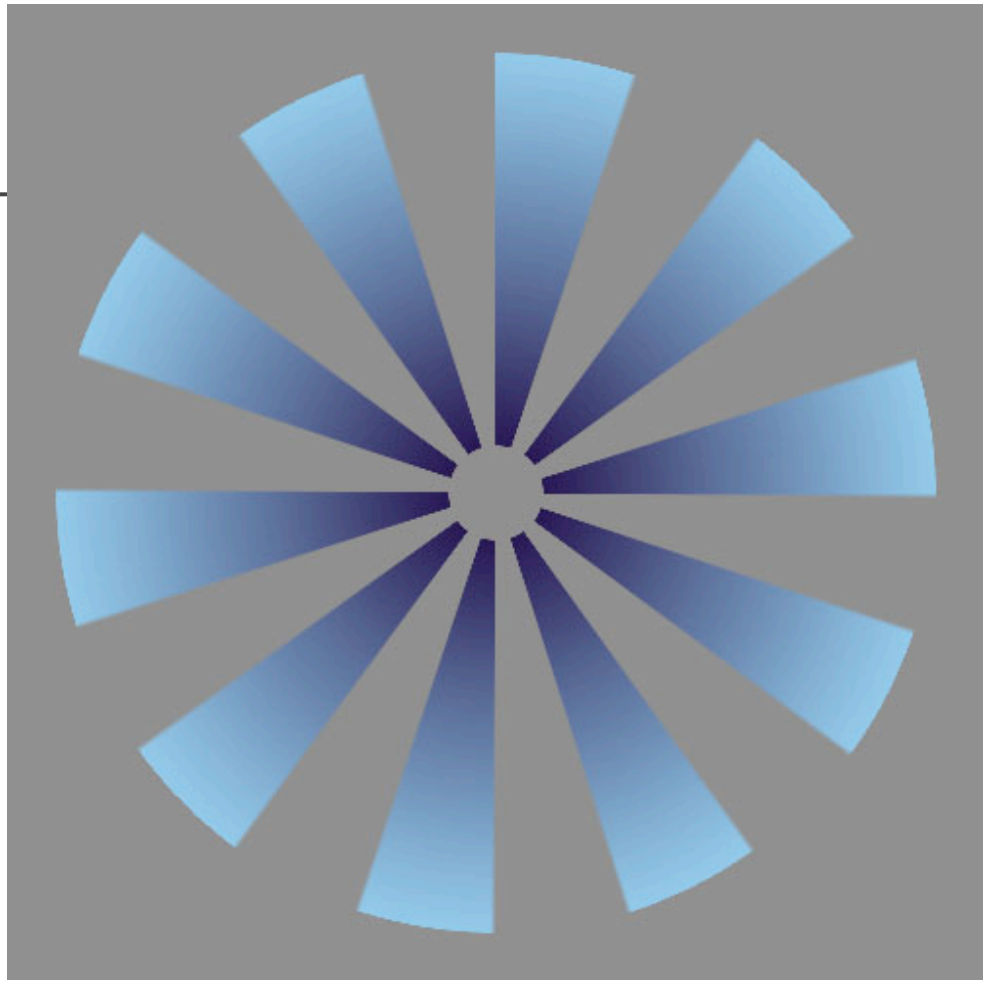
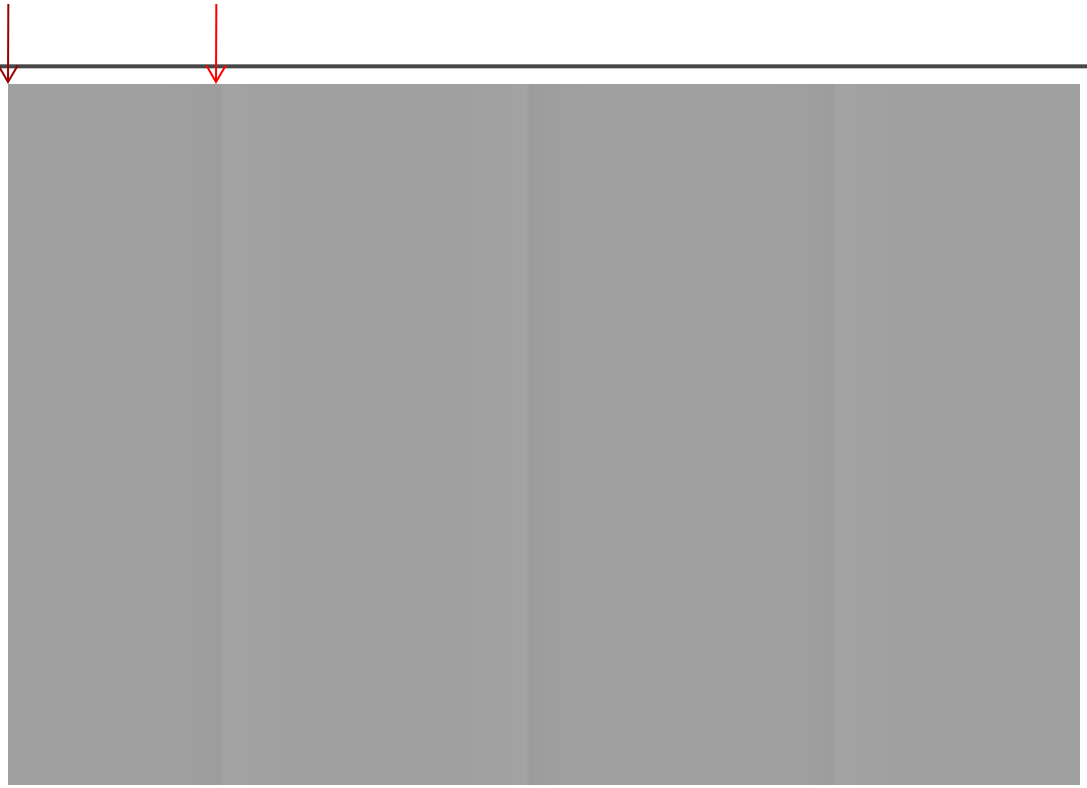


Image from perceptualstuff.org

Chevreuil Illusion



- When a sequence of gray bands is generated , the bands appear darker at one edge than at the other, even though they are uniform

Light does not equal Bright

- What defines white, black,gray?
- Receptor signals do not tell us **absolute** values
  - amount of light on the retina - the light meter
- They tell us **relative** values
  - change of amounts of light
  - Change meter
- Contrast illusions
- Non-linear perception

GRAY SCALES CAN BE MISLEADING

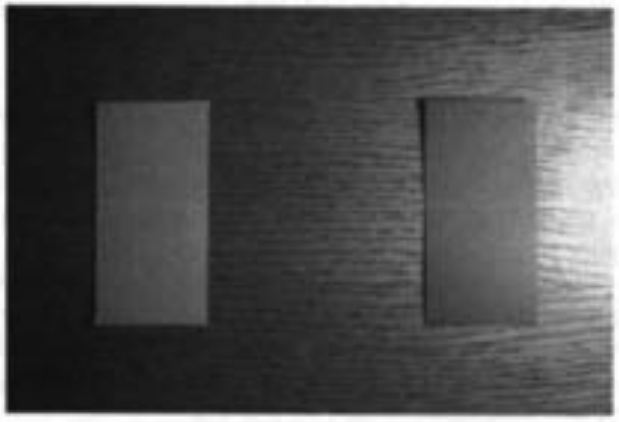
Luminance, Brightness and Lightness

- Luminance is completely unrelated to perceived brightness or lightness
- Luminance is completely unrelated to perceived brightness or lightness
- Luminance is completely unrelated to perceived brightness or lightness
- Luminance is completely unrelated to perceived brightness or lightness
- Luminance is completely unrelated to perceived brightness or lightness

Contrast and constancy

- Concentric opponent receptive fields react most strongly to differences in light levels
  - Edges of objects

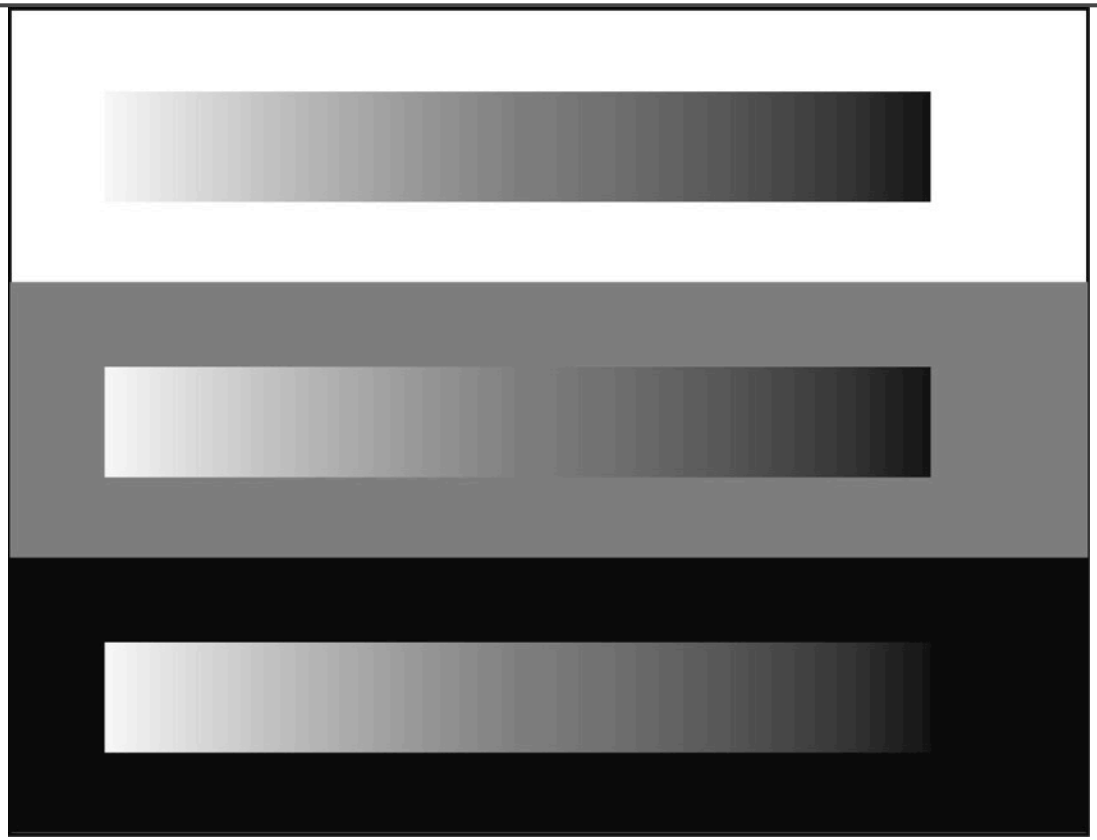
- Simultaneous contrast mechanism: item relative to surround
- We judge by the lightest object in the scene



- Corrects for background intensity differences

Simultaneous contrast

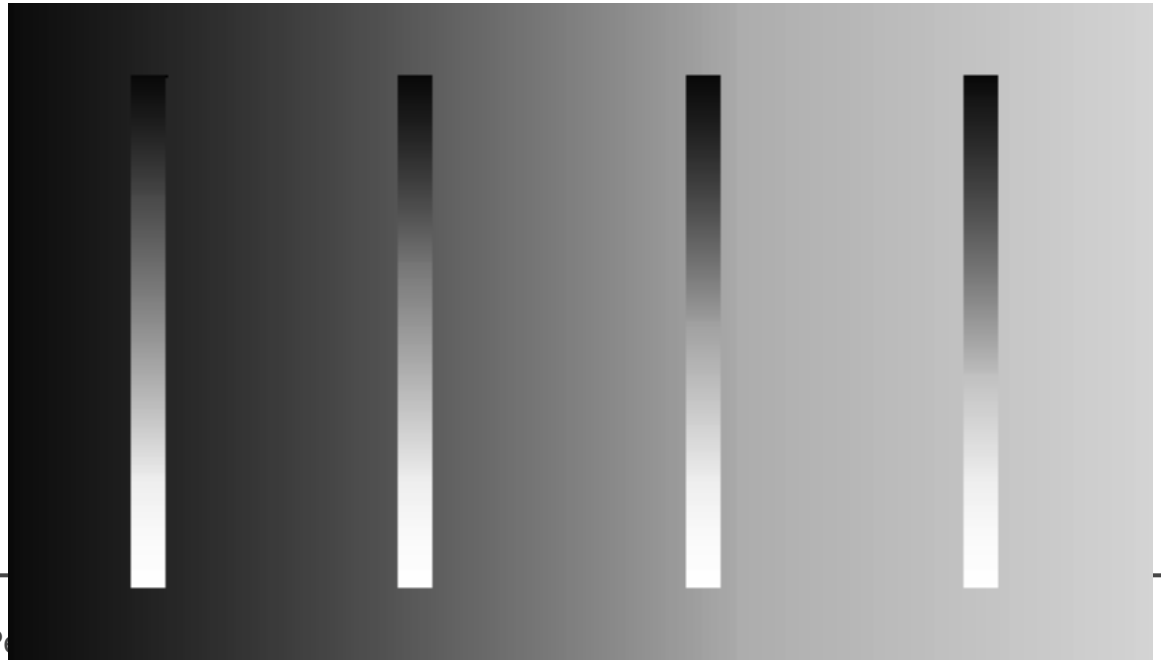
Affects Lightness Scale



It's about relative **contrast** and **constancy**

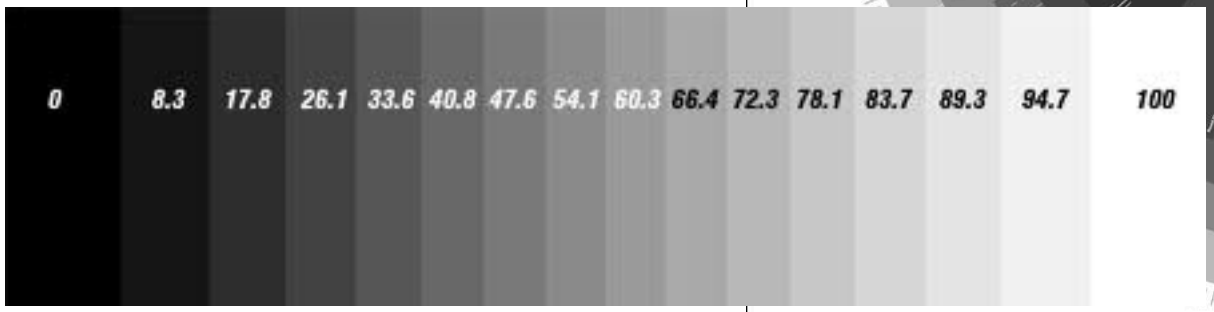
Contrast **crispening:**

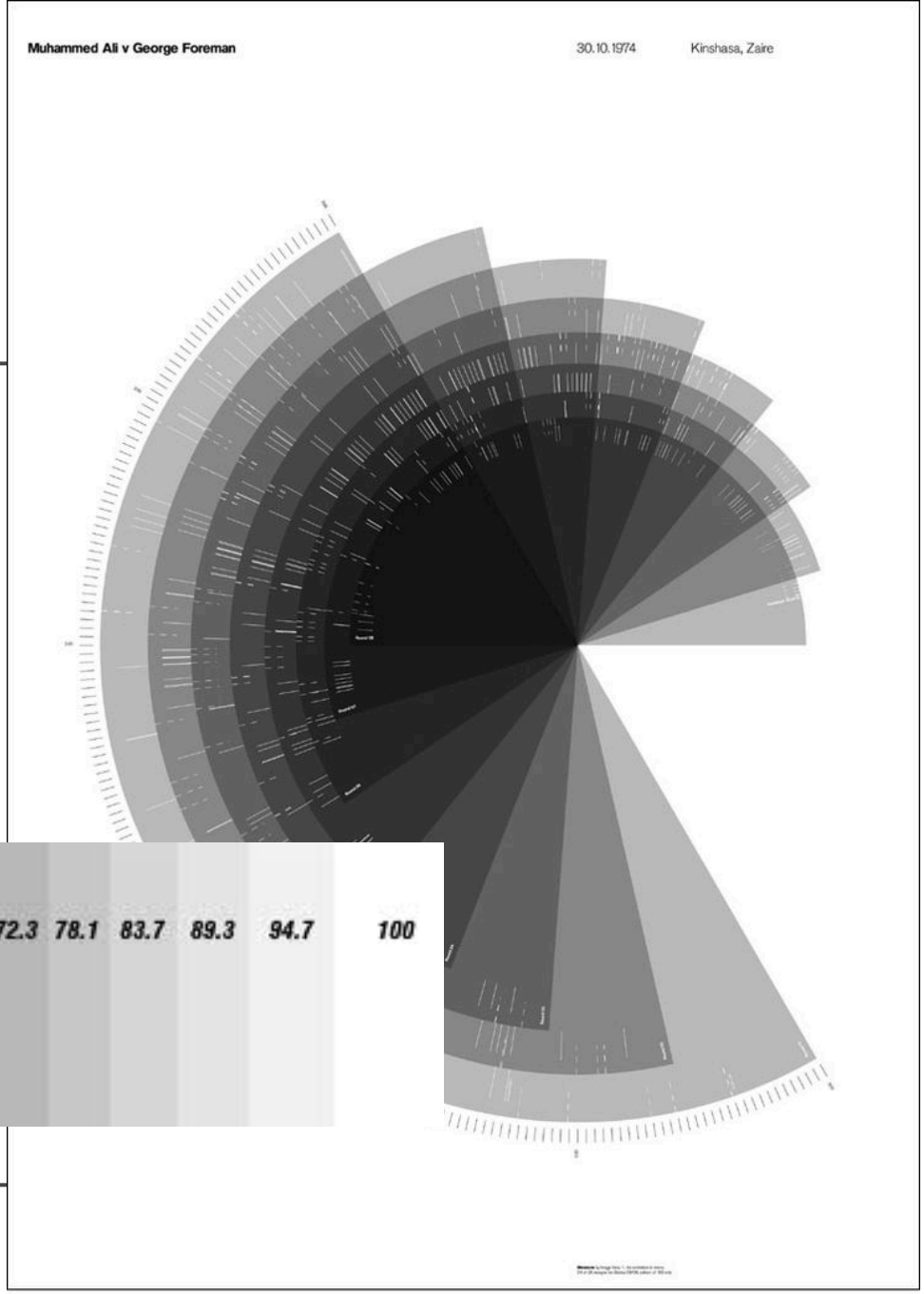
- Differences are perceived as larger when objects are similar to background colour



We care because?

- Effects cause error
- average error **of 20% with 16 gray levels**





The enhancement of edges is also an important part of artists' techniques

Chevreuil Illusion

- Colour
- Irregular boundaries.

- Luminance not hue

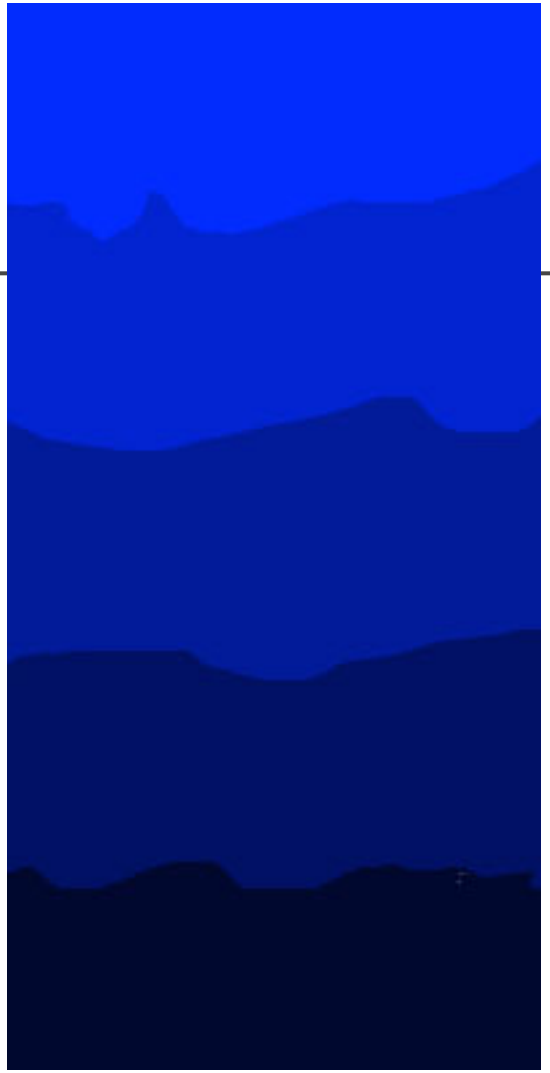
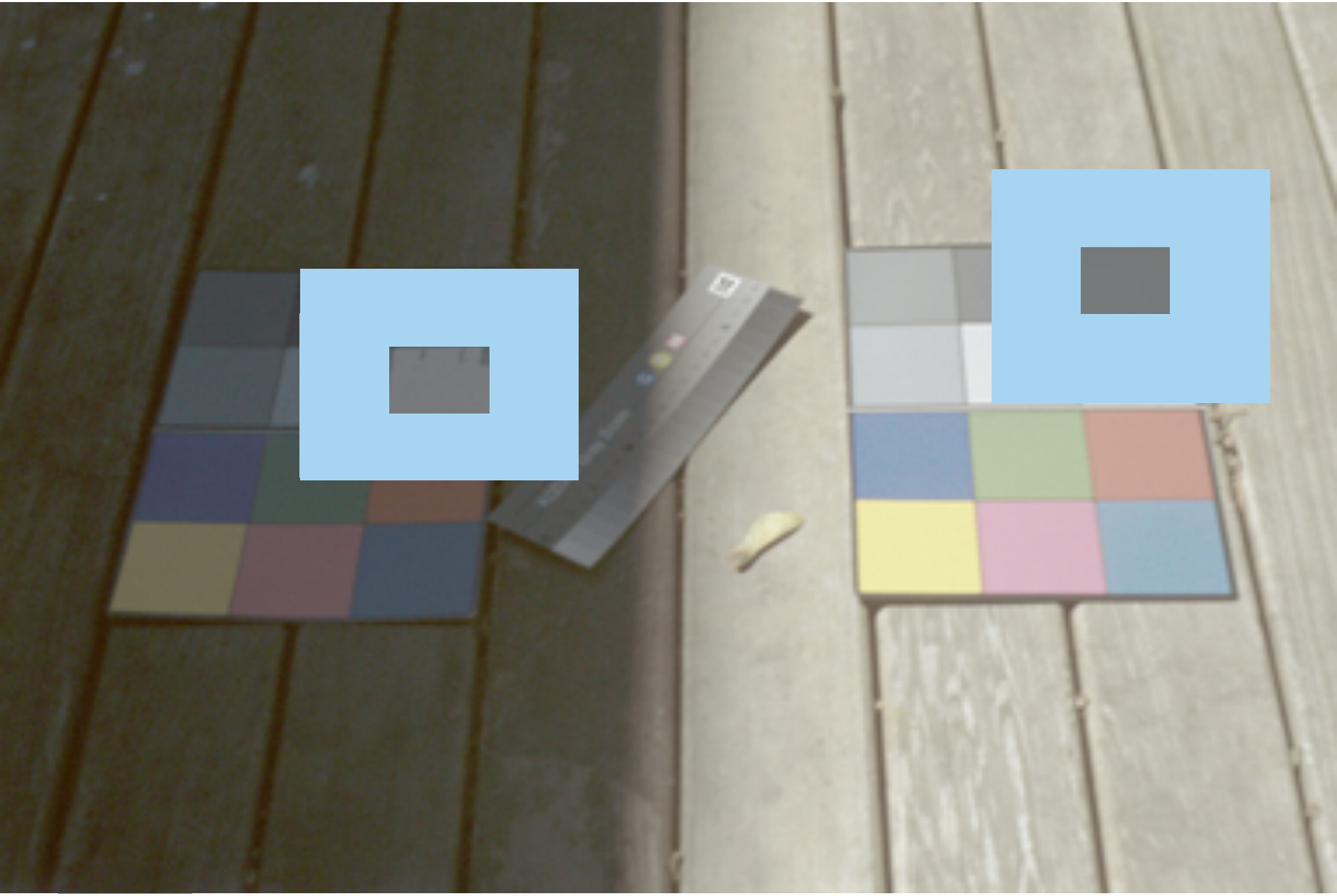


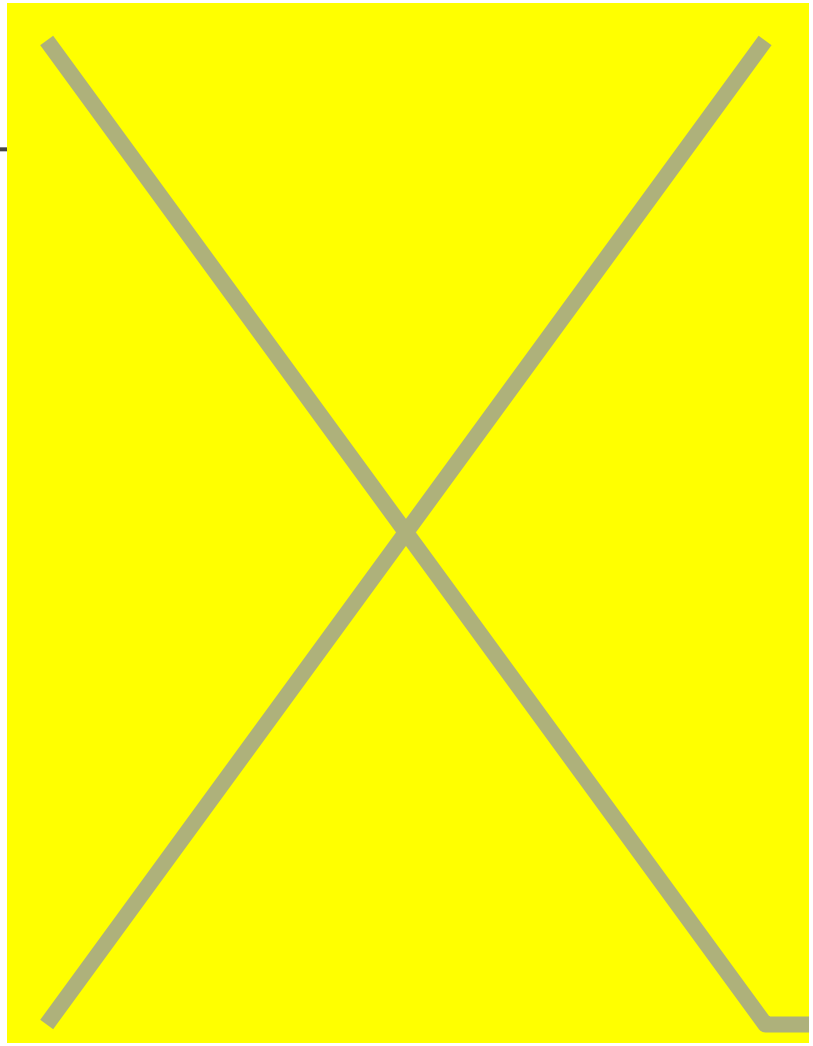
Image from perceptualstuff.org

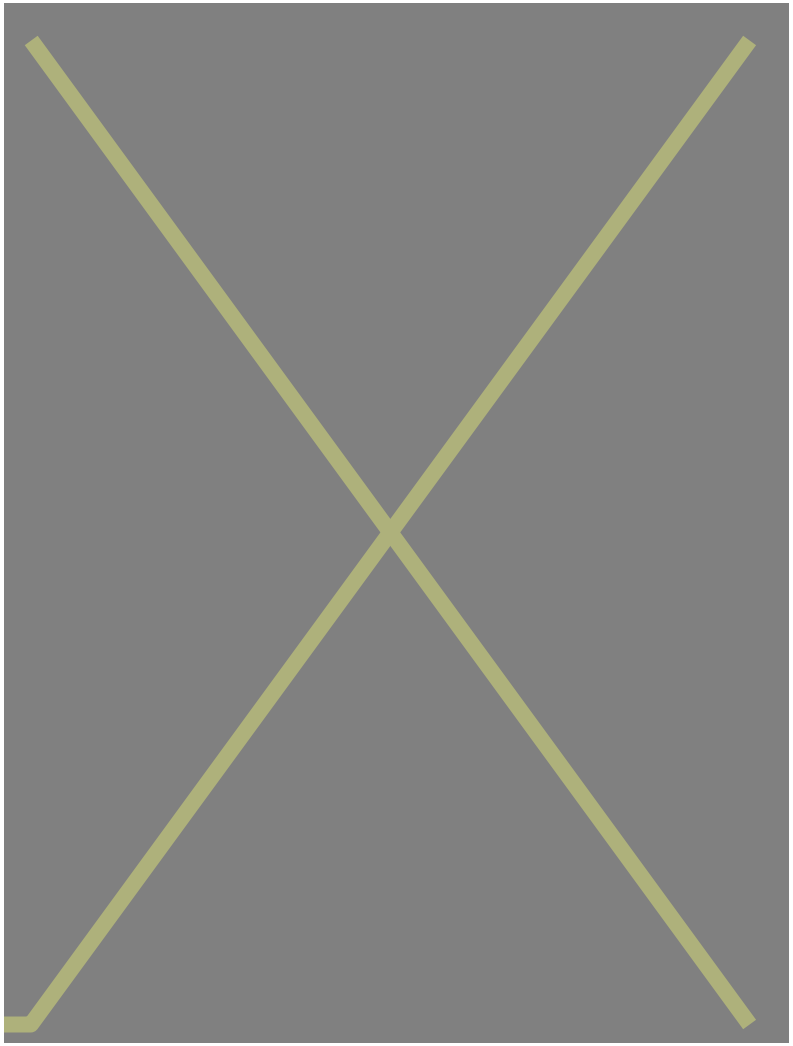
Image courtesy of John MCann

Image courtesy of John MCann

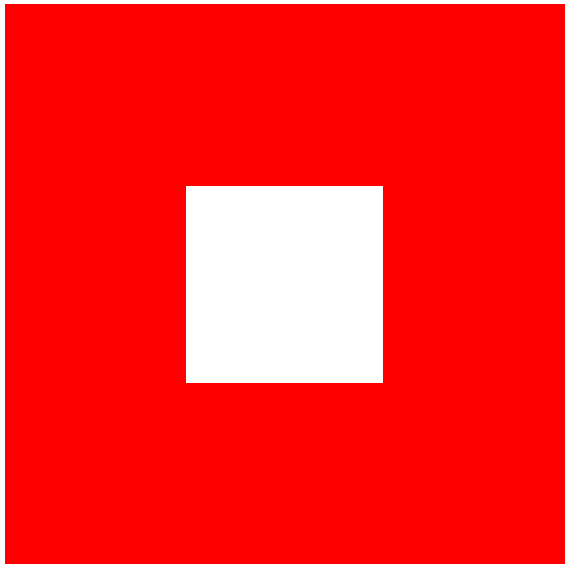


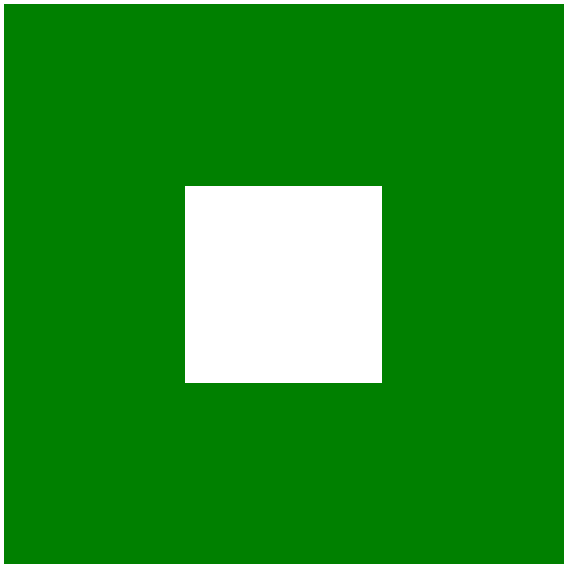
Color Appearance



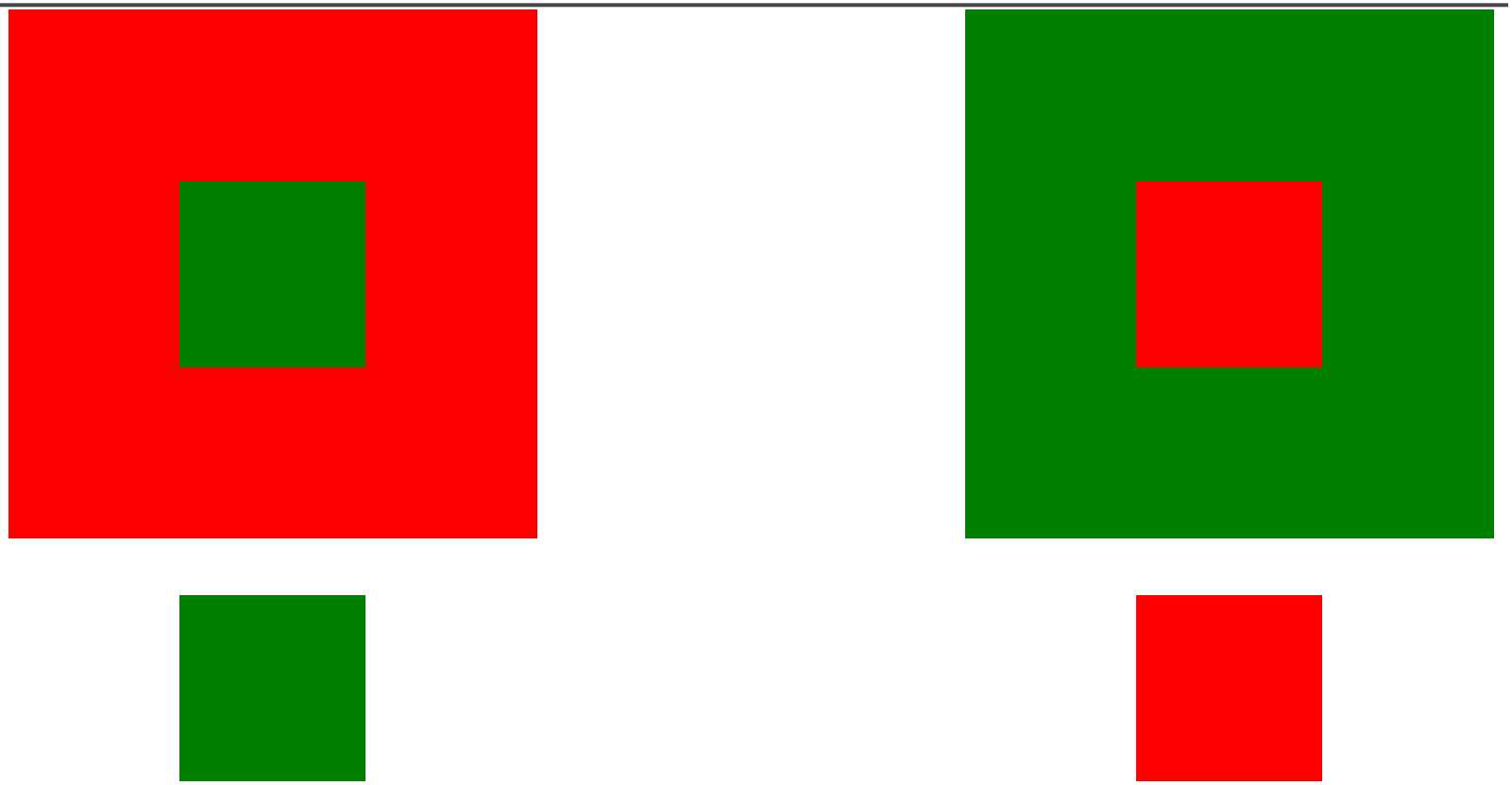


Chevreuiil colour

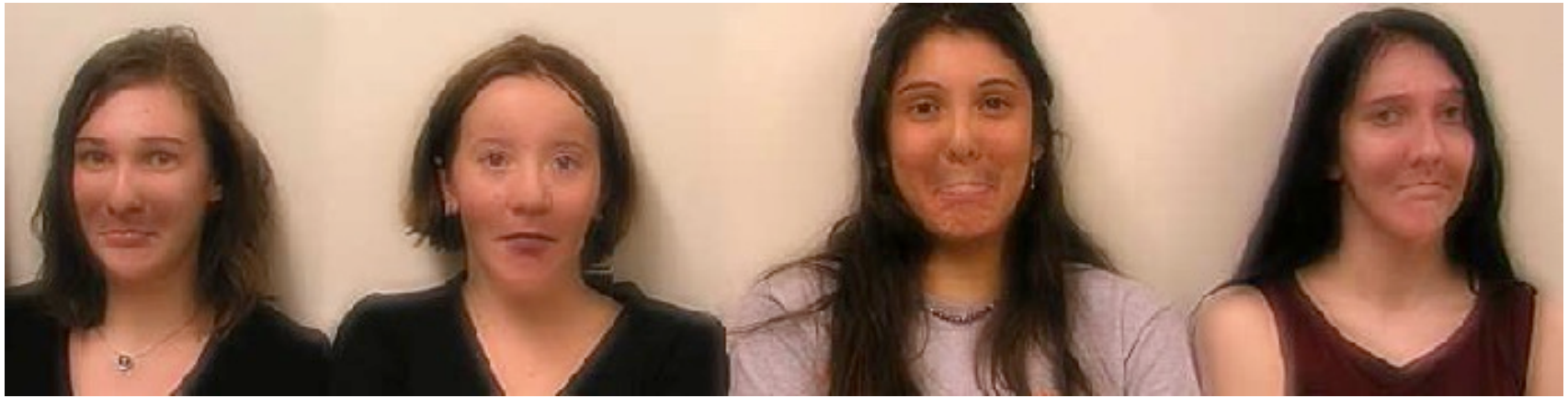




Chevreuil complementary contrast



And different things depending on how we look at them



Oliva, Torralba and Schyns. Hybrid images. Siggraph 2006.

Icon Analysis: Evaluating Low Spatial Frequency Compositions, Mat Queen

What's the good news???

What we do really well.

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Preattentive processing

- A limited set of visual properties are processed preattentively (without need for focusing attention).
  - **Visual features: Marks and Channels**

- This is important for the design of visualizations
  - what can be perceived immediately
  - what properties are good discriminators
  - what can mislead viewers
  - Differentiate items “at a glance”

How Many 3's?

128176875613897654698450698560498282676 2
980985845822450985645894509845098094358 5
909103020990595959577256467505067890456 7
884578980982167765487636490856091294968 6

How Many 3's?

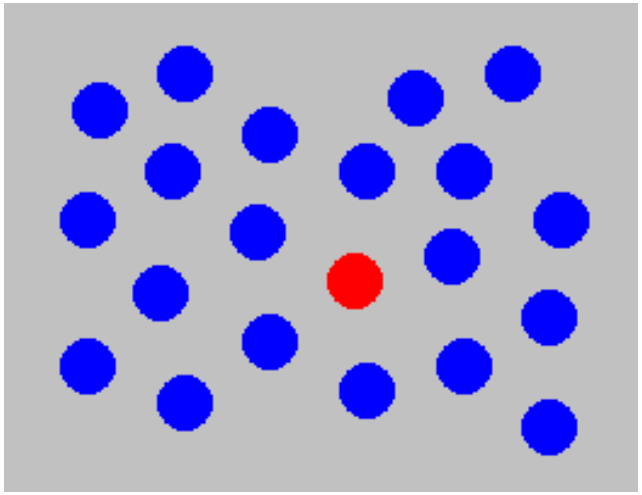
1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

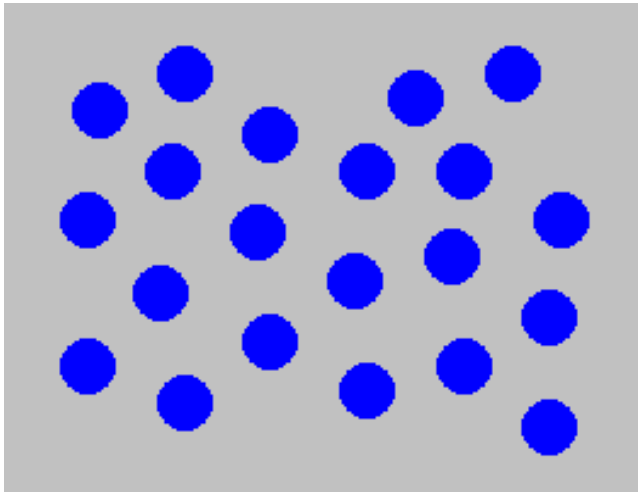
What Kinds of Tasks?

- Target detection
  - Is something there?
- Boundary detection
  - Can the elements be grouped?
  - What associates them?
- Counting
  - How many elements of a certain type are present?

Example:
Where is the red circle?
Left or right?
Put your hand up as soon as you see it.

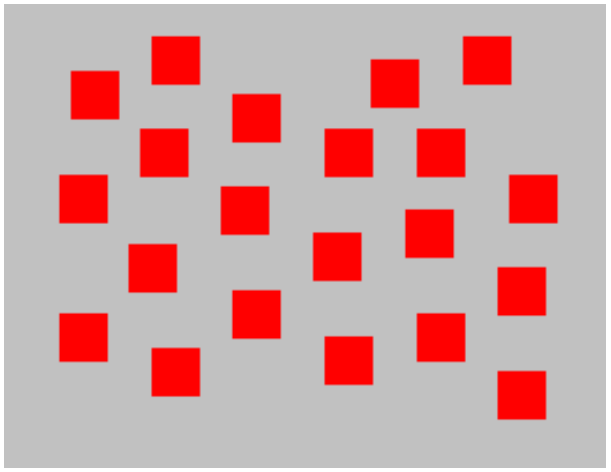
Example: Colour selection

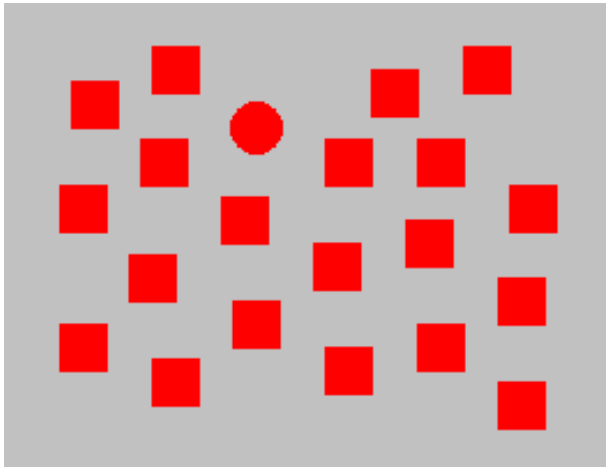




Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in **hue**.

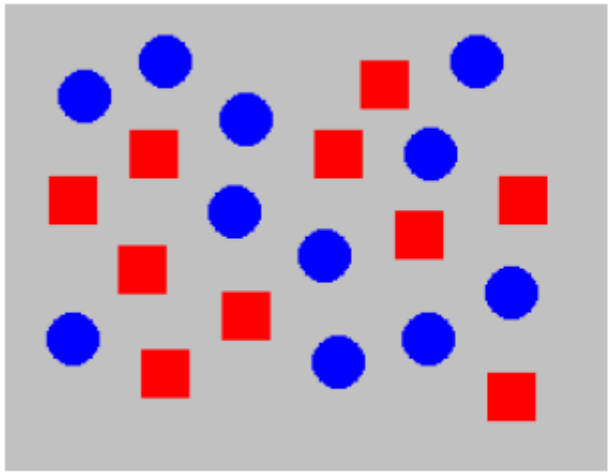
Example: shape selection

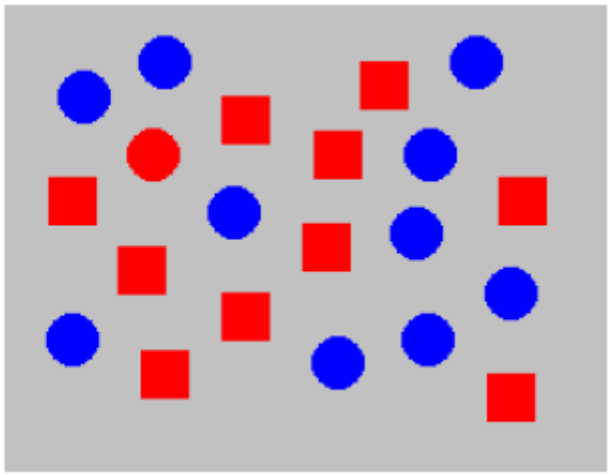




Viewer can rapidly and accurately determine whether the target (red circle) is present or absent.
Difference detected in **form** (curvature)

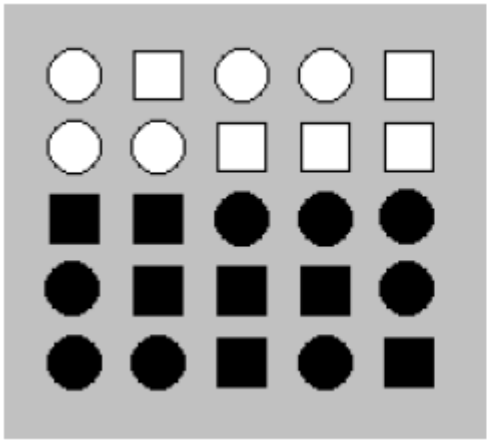
Hue and Shape

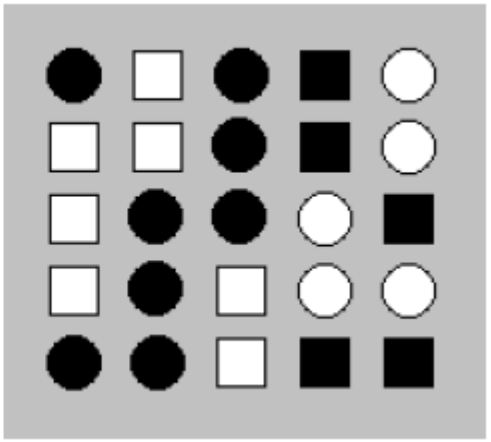




- Cannot be done preattentively
- Must perform a sequential search
- Conjunction of features (shape and hue) causes it

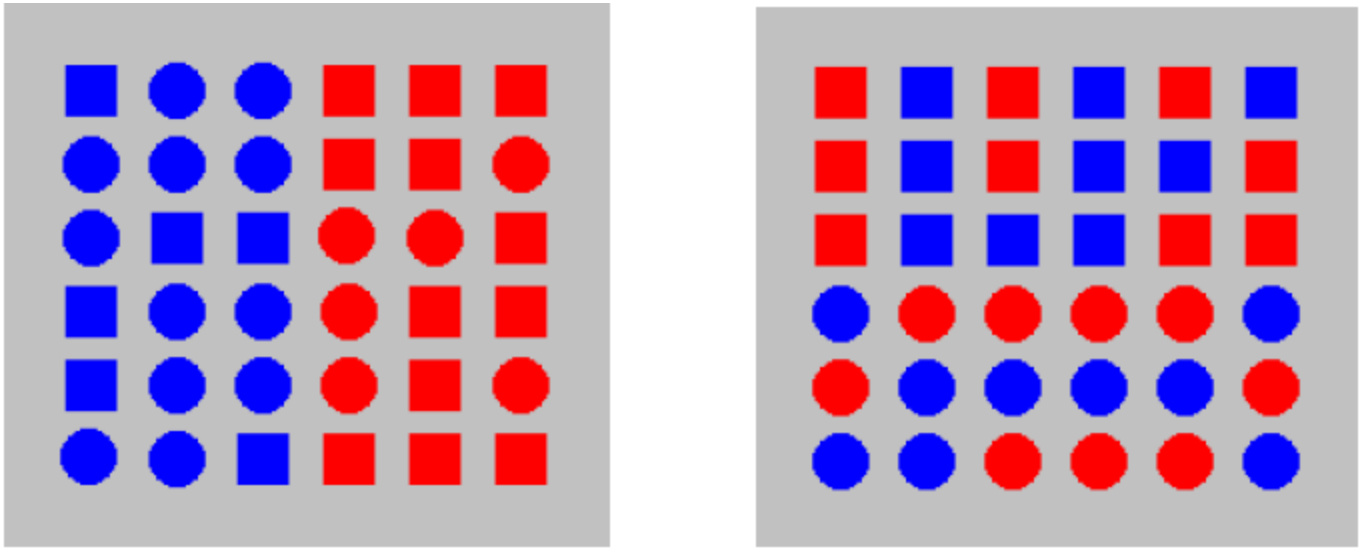
Boundaries make groups





- Left can be done preattentively since each group contains one unique feature
- Right cannot (crosses boundary) since the two features are mixed (fill and shape)

Hue versus Shape



- Left: Boundary detected preattentively based on hue regardless of shape
- Right: Cannot do mixed color shapes preattentively

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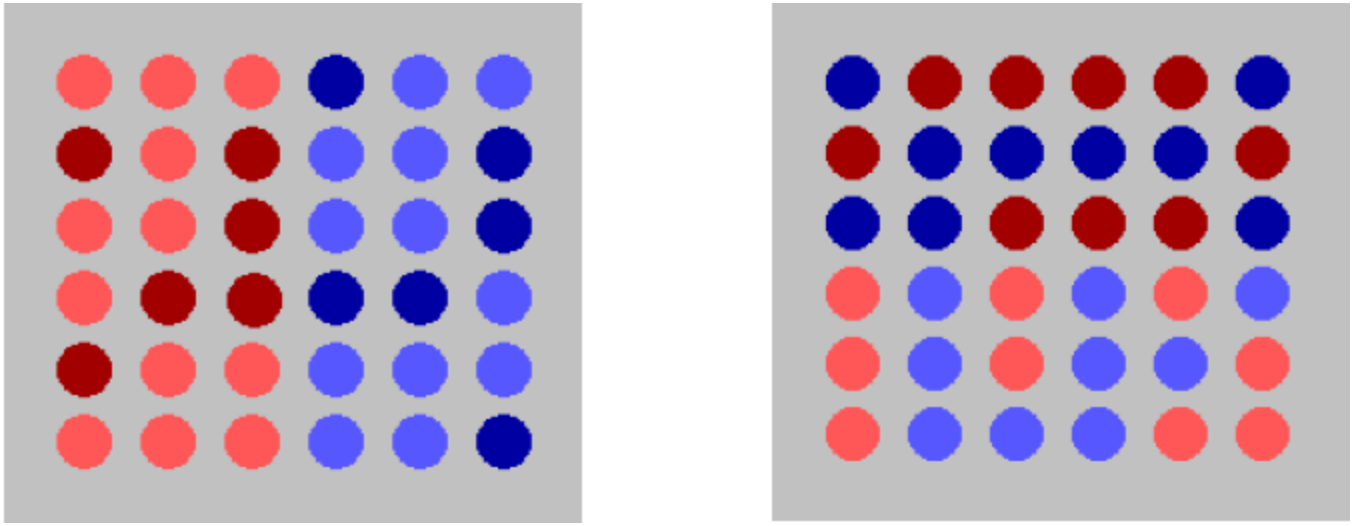
Hue vs. Brightness



- Left: Varying brightness seems to interfere
- Right: Boundary based on brightness can be done preattentively

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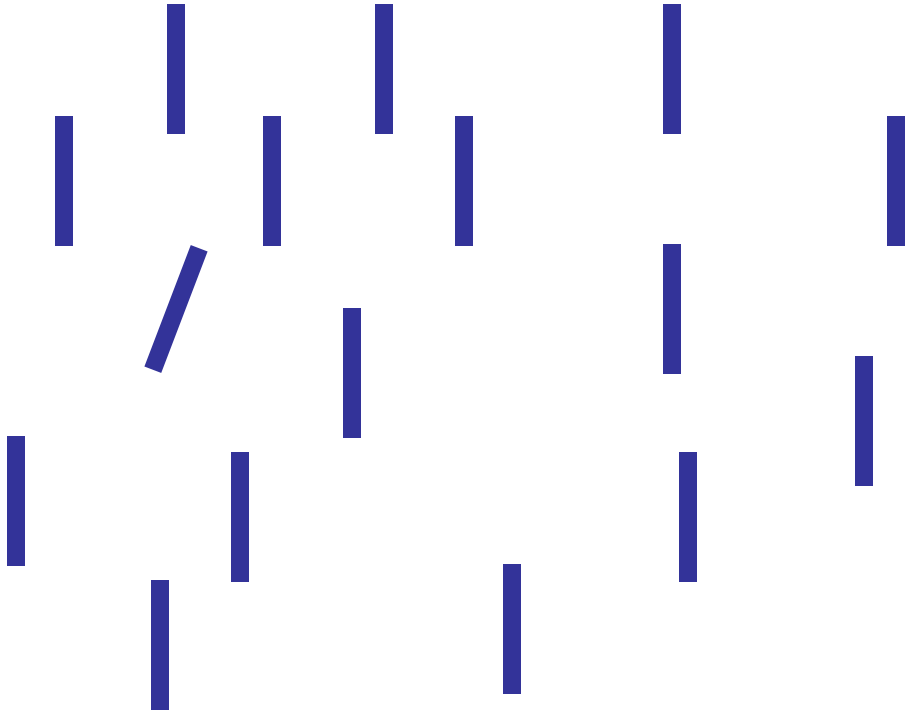
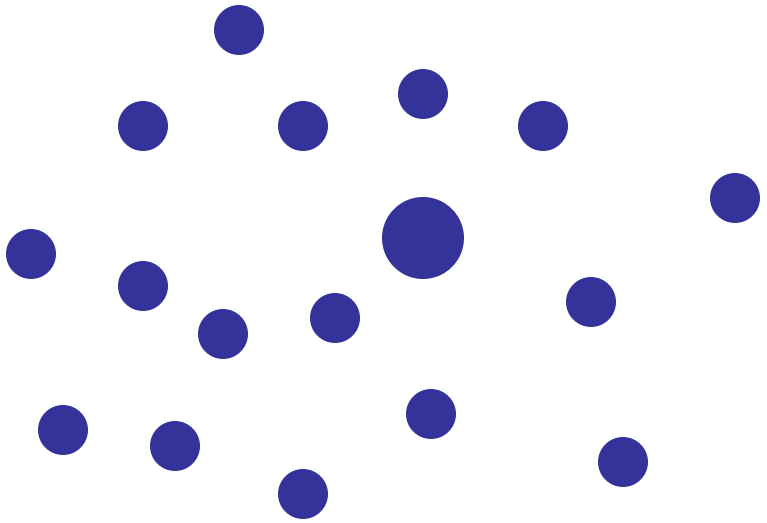
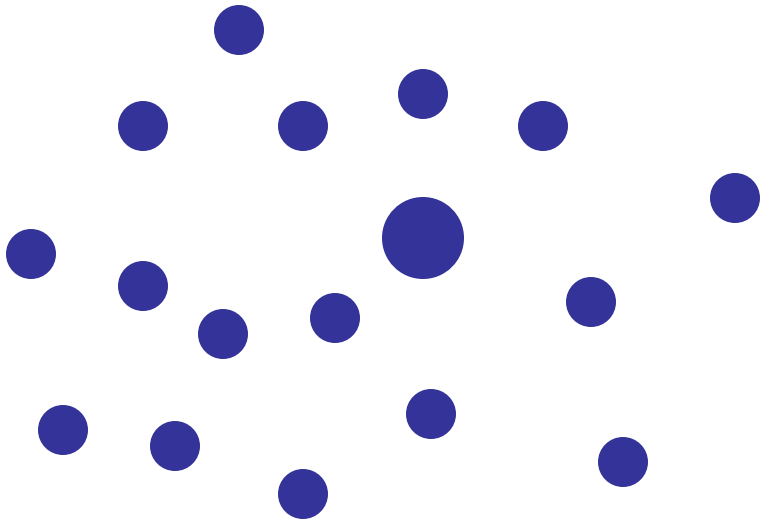
Example: orientation



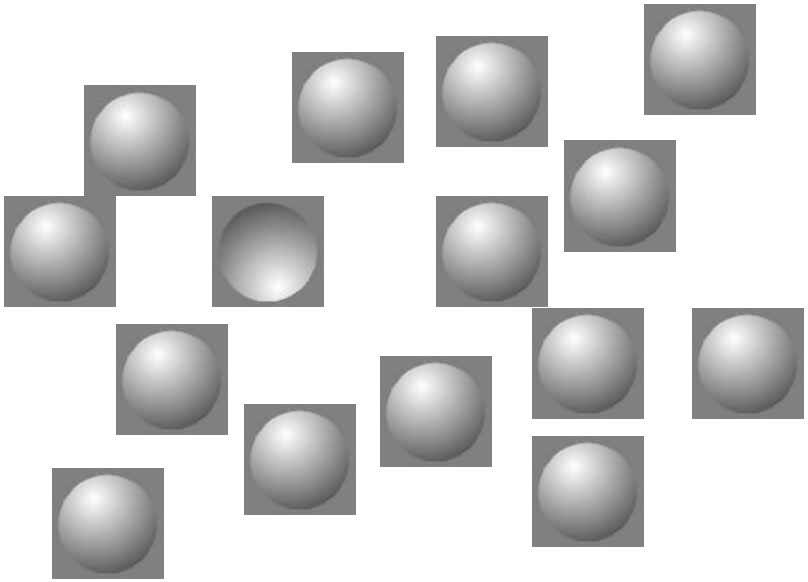
Example: size



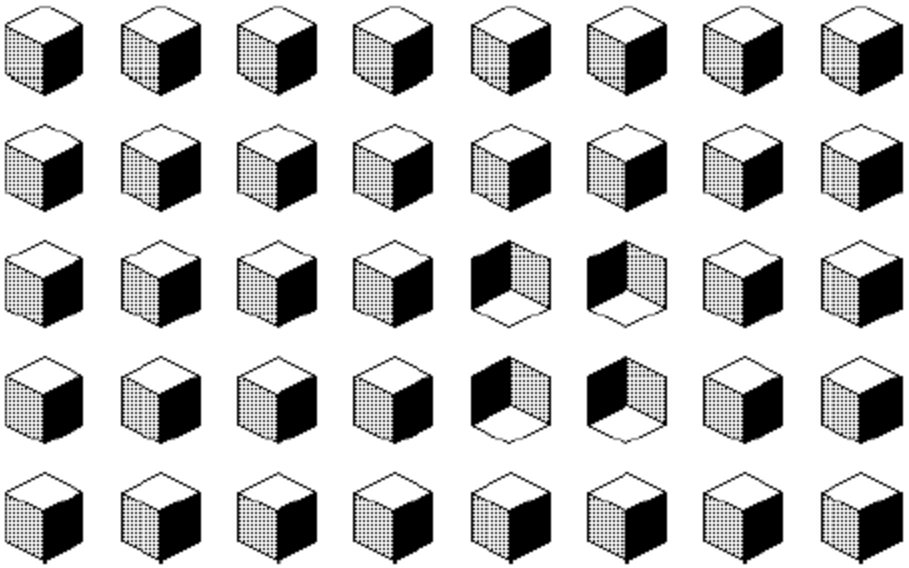
Example: motion



Example: simple shading

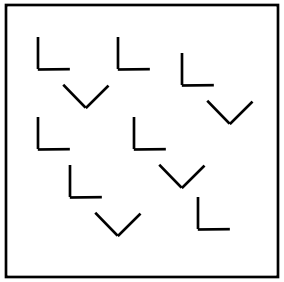


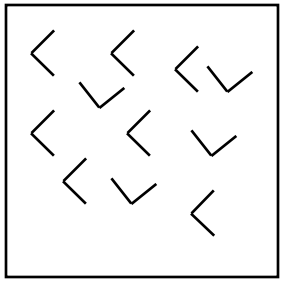
3-D Figures



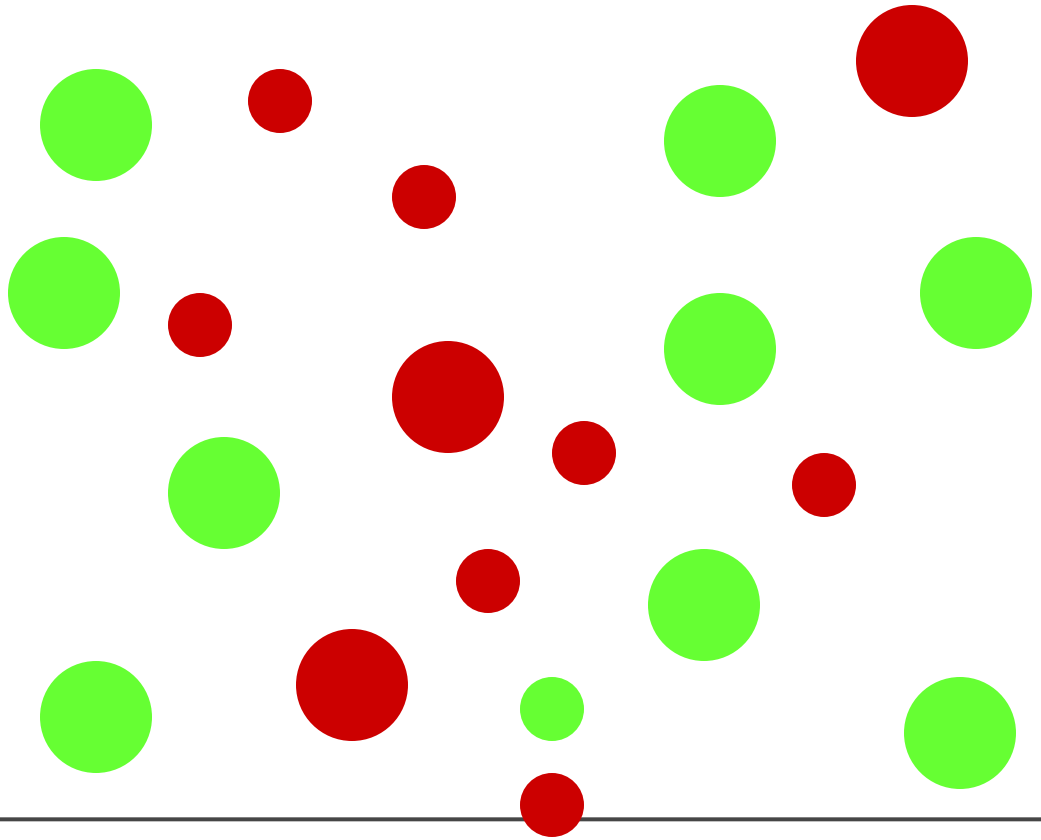
Asymmetric and graded preattentive properties

- Some properties are asymmetric
  - a sloped line among vertical lines is preattentive
  - a vertical line among sloped ones is not
- Some properties have a gradation
  - some more easily discriminated among than others

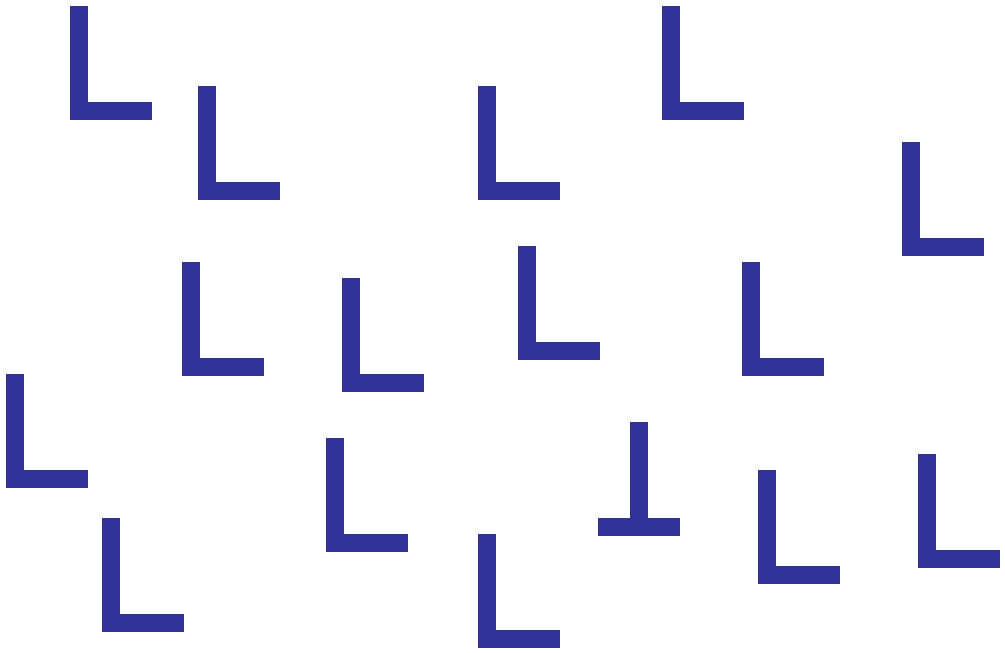




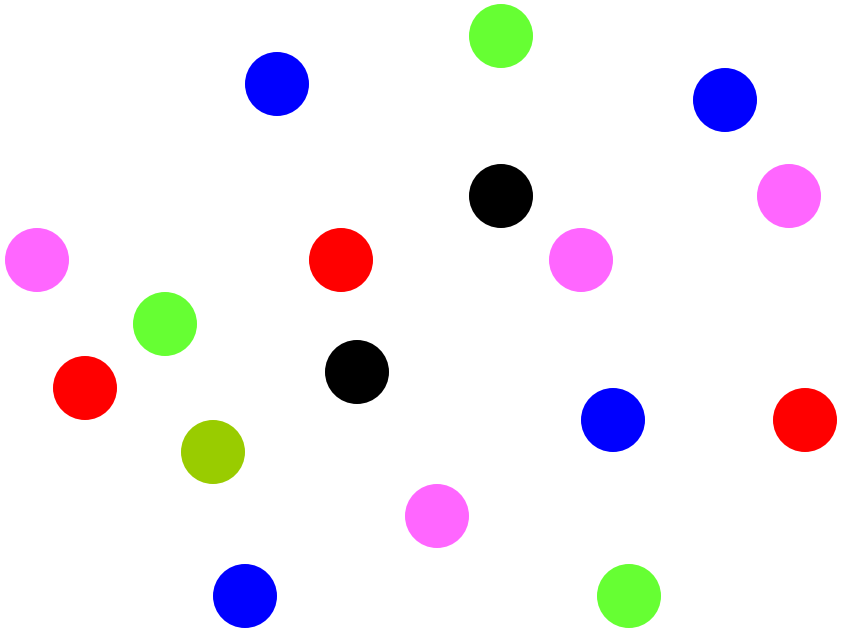
Combinations don’t pop out



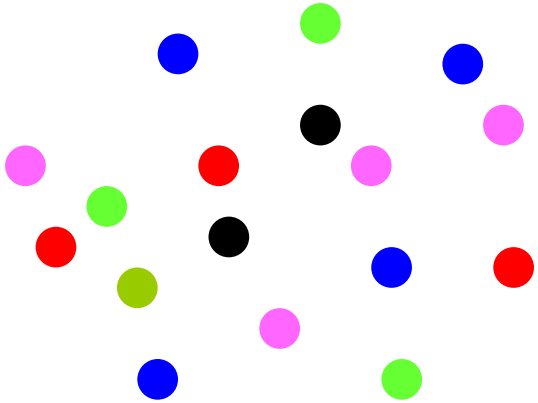
Compound features do not pop out



Surrounded colours do not pop out



Distraction and clutter



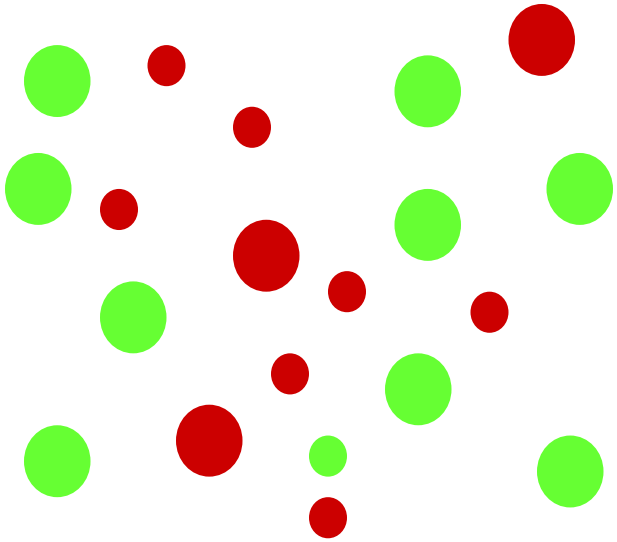
- pre-attentive symbols become less distinctive as the variety of distractors increases.

- two factors are important in determining whether something stands out preattentively:
  - the **degree of difference** of the **target** from the **non-targets** (distractors), and
  - the **degree of difference** of the **non-targets** from **each other**.

Distractors

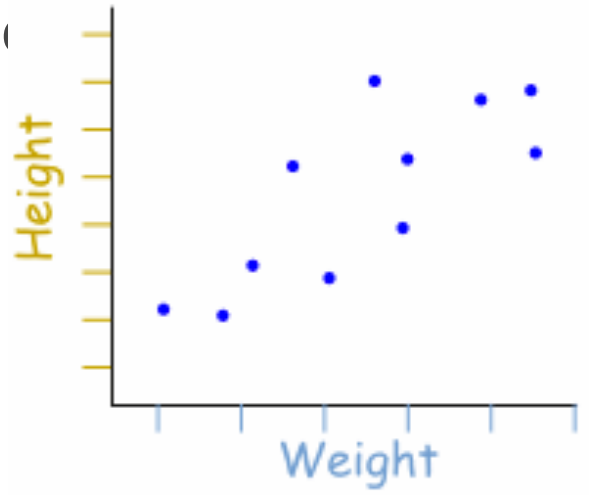
- For example, yellow highlighting of text works well if yellow is the only color in the display besides black and white, but if there are many colors the highlighting will be less effective.

Coding with several features: *conjunction*



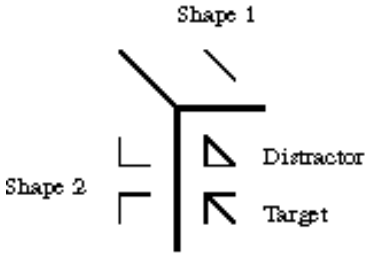
Conjunctions that pop out

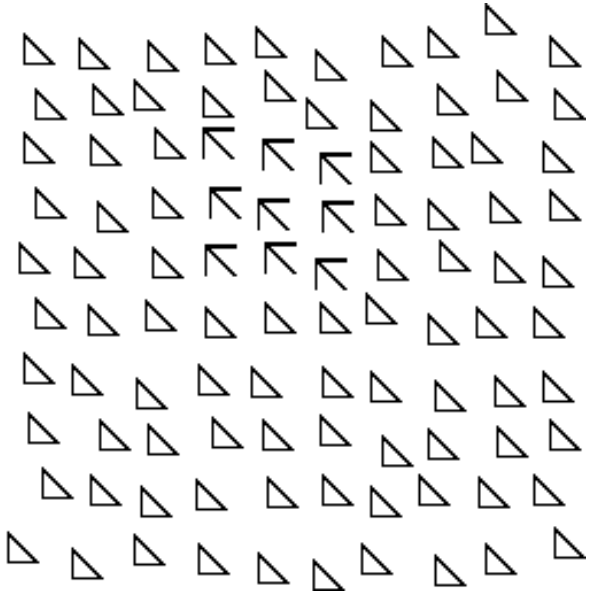
1. Spatial grouping on the XY plan



emergent features

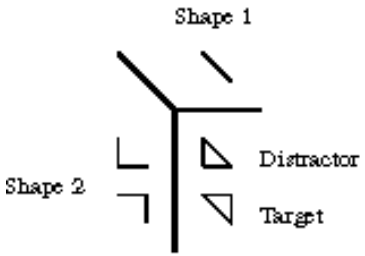
- **Target** has a unique feature with respect to **distractors** (open sides)
- group can be detected preattentively.

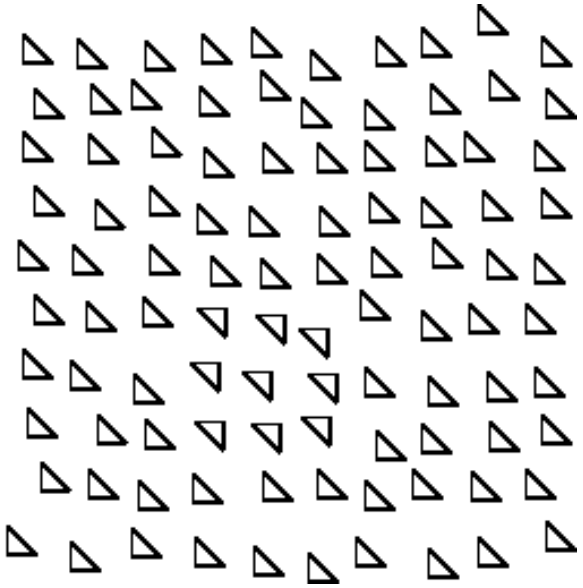




Example: emergent features

- **Target** does not have a unique feature with respect to **distractors**
- group cannot be detected preattentively.





Preattentive processing features

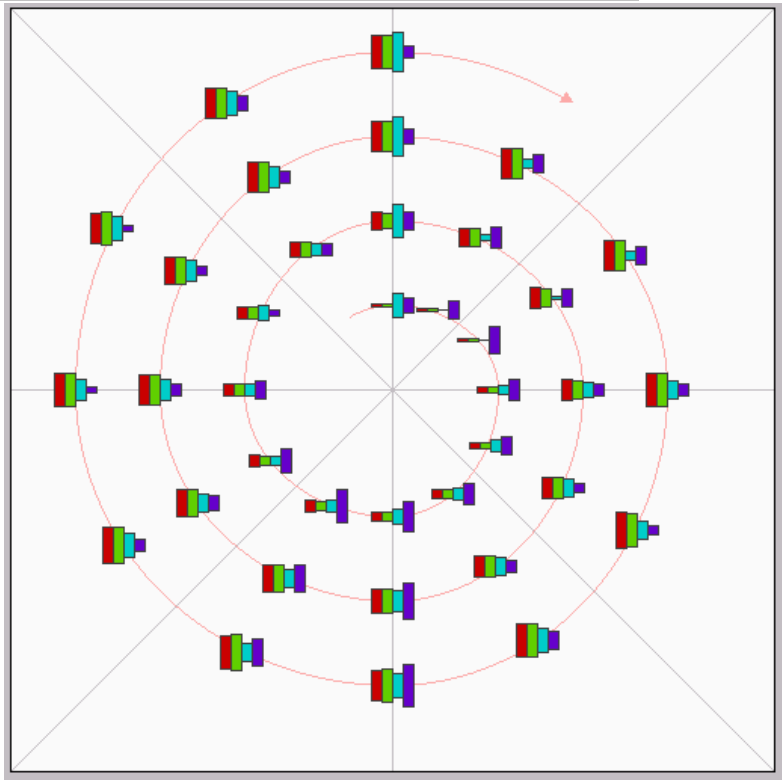
- Form
  - Line orientation
  - Line length
  - line width
  - Size
  - Curvature
  - Spatial grouping
  - Blur
  - numerosity
- Colour
  - Hue
  - Intensity
- Motion
  - Flicker
  - Direction of motion
- Spatial position
  - 2D position
  - Stereo depth
  - Concavity/convexity shape from shading

Chris Healey's table of visual features shown to be preattentively processed

Combiningvisual properties

- different visual properties encode different variables
  color, size, shape, position

- Interaction: more/less difficult to untangle?



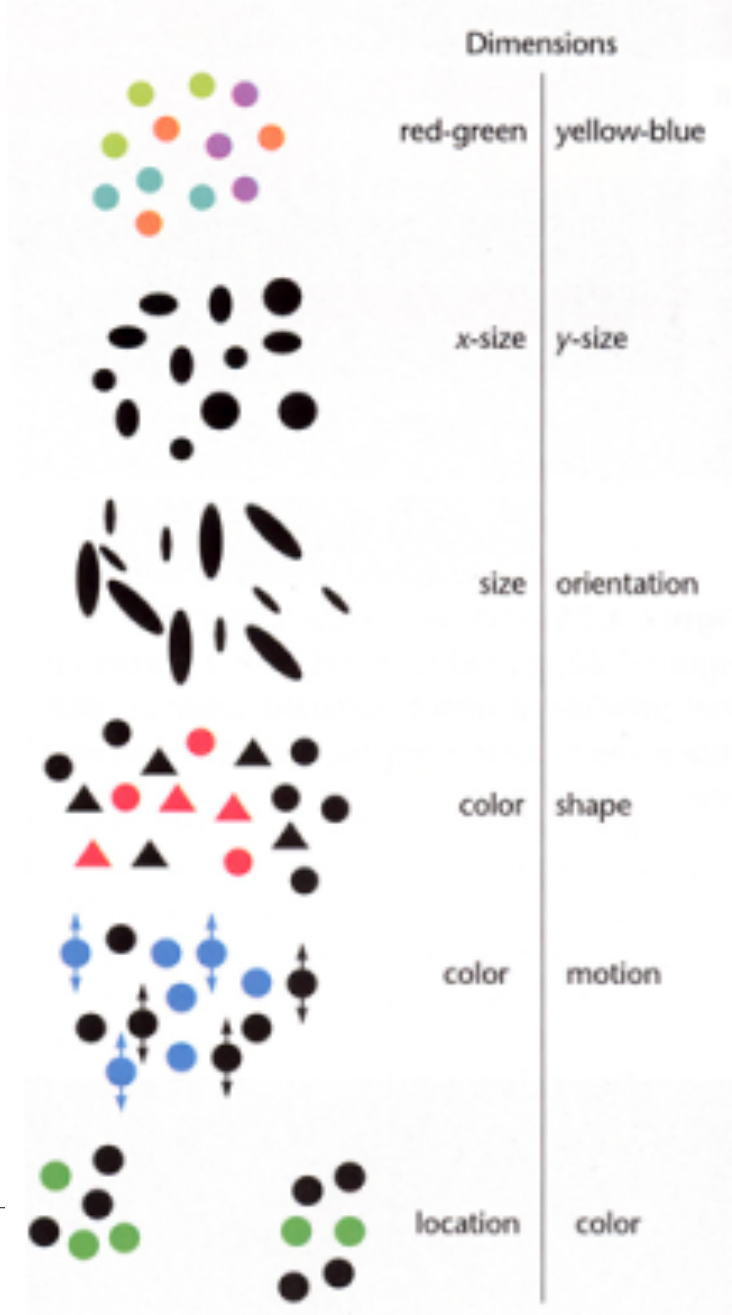
http://davis.wpi.edu/~matt/projects/SpiralGlyphics/overview.html

Integral vs separable

- Integral:
  - Properties are viewed holistically
- Separable
  - Judge each dimension independently

Integral

Separable



[Ware 2000]

IAT 355
Visual Analytics

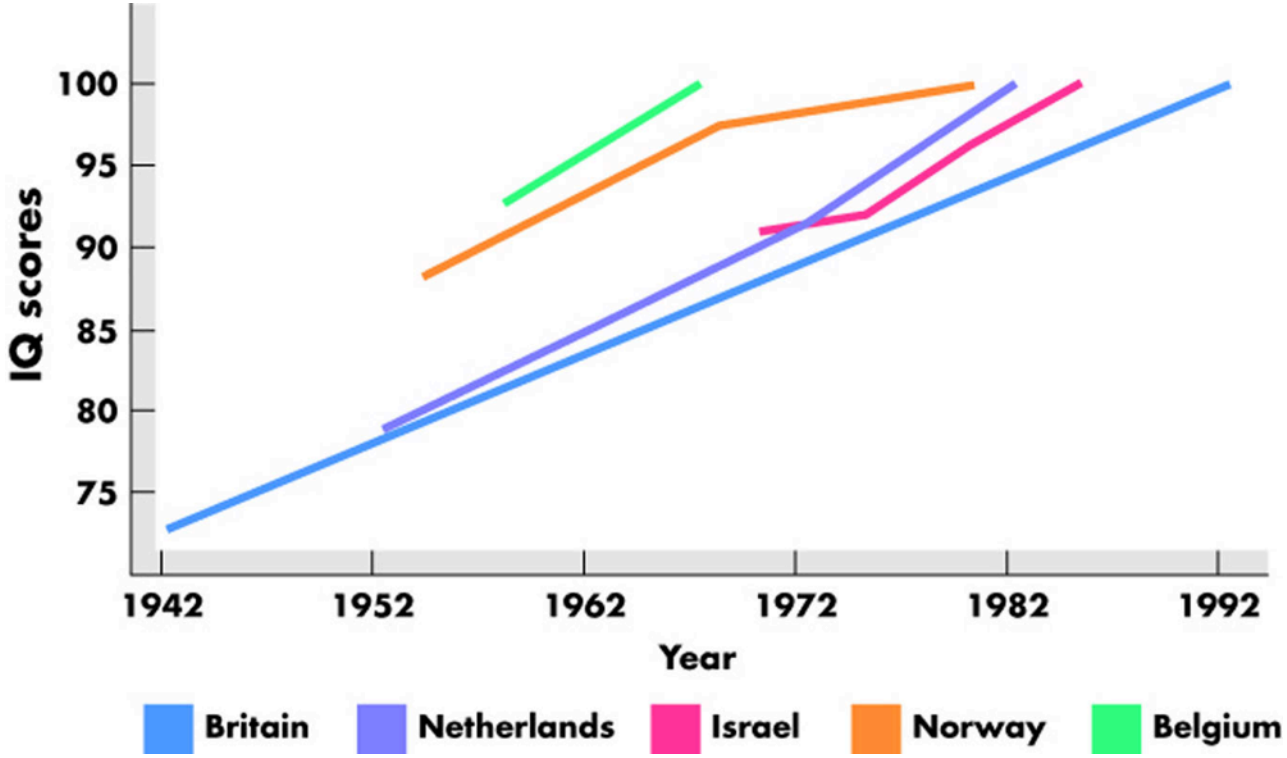
Perception: Patterns and Structure

Lyn Bartram

SFU

SCHOOL OF INTERACTIVE ARTS + TECHNOLOGY

(Why) are people getting smarter?



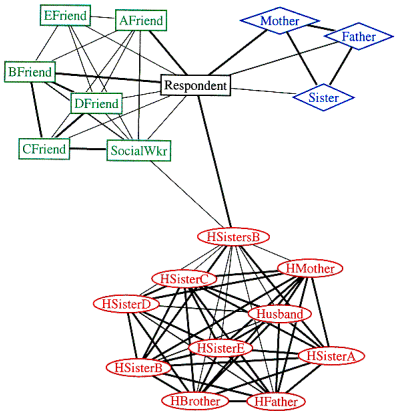
Expert knowledge is about understanding patterns (Flynn effect)

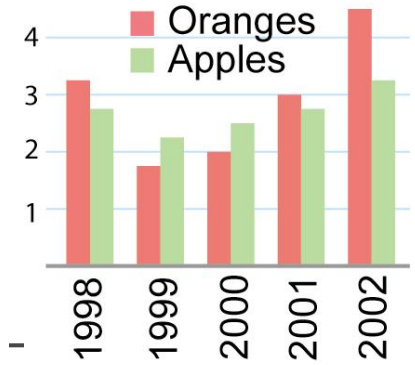
Finding patterns is key to problem solving

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


EFriend
AFriend
Mother
Father
BFriend
Respondent
DFriend
Sister
CFriend
SocialWkr
HSistersB
HMother
HSisterC
HSisterD
Husband
HSisterE
HSisterA
HSisterB
HBrother
HFather


Oranges
Apples
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3
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1
-
1998
1999
2000
2001
2002


Alma
Fergus
Salem
Elora
Glen Allan
Floradale
Yatton
Macton
Elmira
Wallenstein
West Montrose
Linwood
Hawkesville
Arlss
Winterbourne
Conestogo
Crosshill
St. Jacobs
Maryhill
St. Clements
Heidelberg
Bloomingdale
Guelph
Bamberg
Waterloo
Wellesley
St. Agatha
Breslau
KITCHENER
Phillipsburg
Baden
Petersburg
Hamburg
Mannheim
New Dundee
Haysville
Roseville
Plattsville
Bright
Ayr
Drumbo


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Languages
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Last Updated: Wednesday, 26 April 2006, 18:54 GMT 19:54 UK
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West Bank jail raid sparks chaos
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First Zarqawi video 'significant'
Air strike kills 'Iraq militants'
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Security failures
Egypt struggles to stop those behind Sinai attacks
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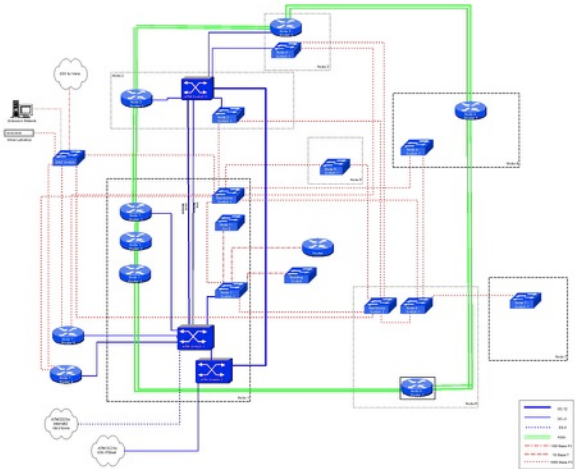
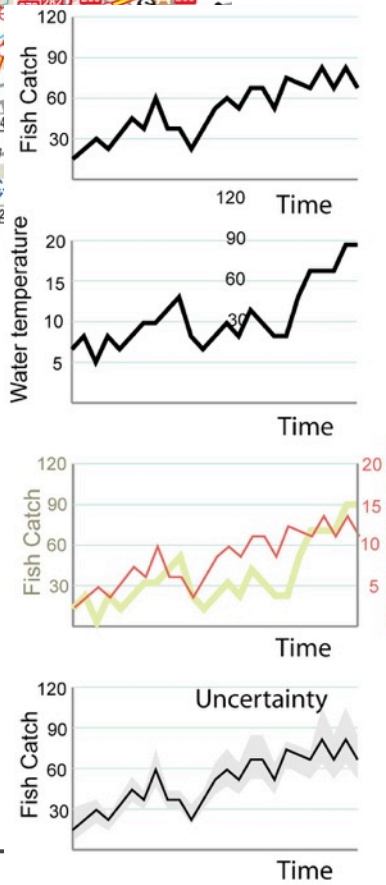
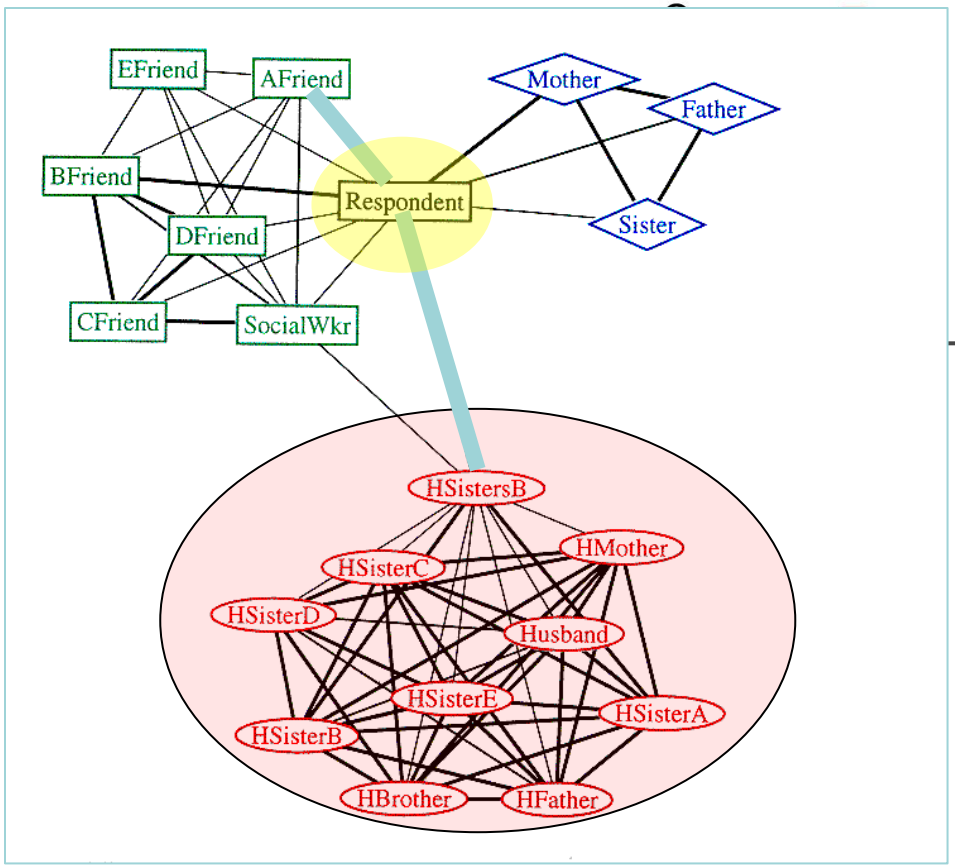
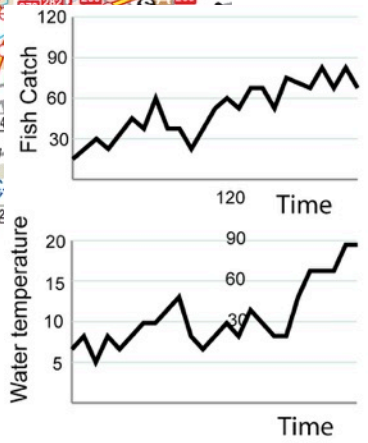
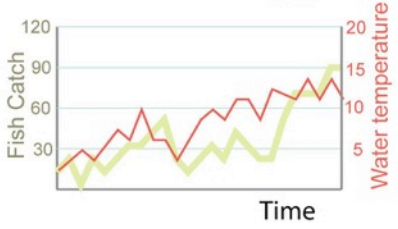
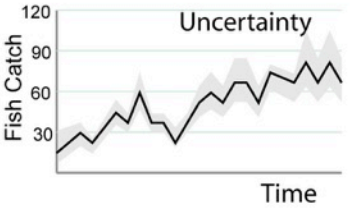



Fish Catch
120
90
60
30
Time
Water temperature
20
15
10
5
Time
Fish Catch
Water temperature
Time
Uncertainty
Fish Catch
Time









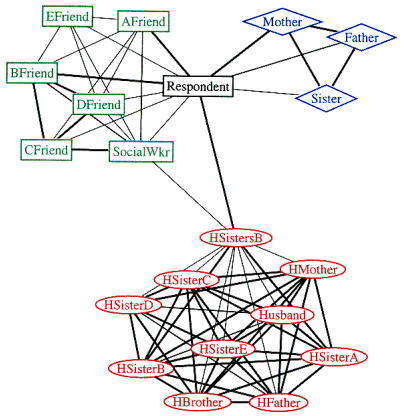
If we can map **information** structures to **readily perceived patterns** then those structures will be more easily interpreted

Gestalt laws

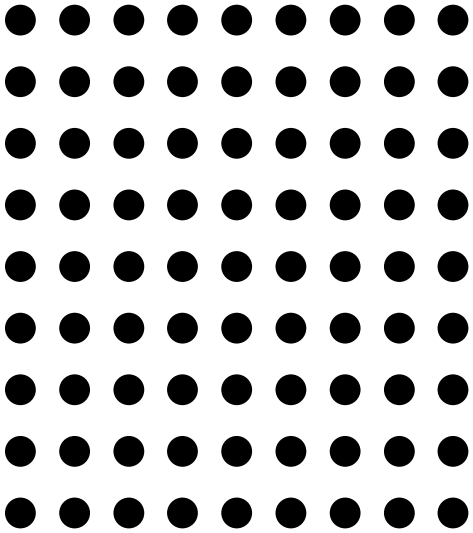
- Idea: forms or patterns transcend the stimuli used to create them.
  - Why do patterns emerge?
  - Under what circumstances?
- .

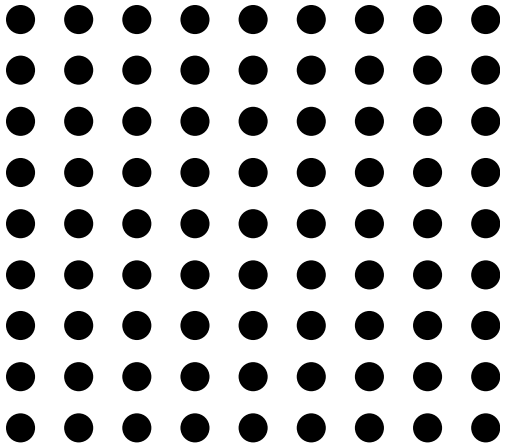
- **The Gestalt laws easily translate into a set of design principles for information displays.**

Proximity : objects



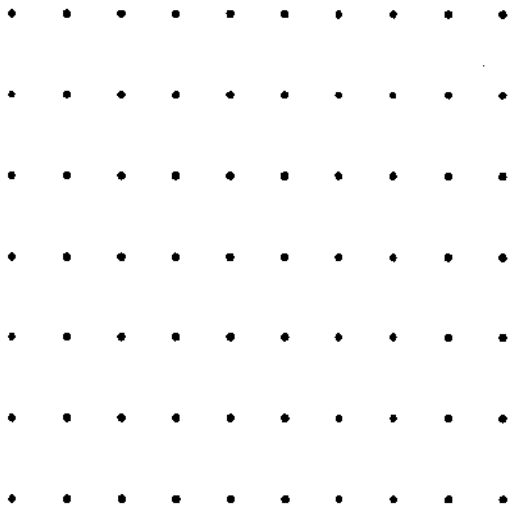
- Things that are close together are perceptually grouped together



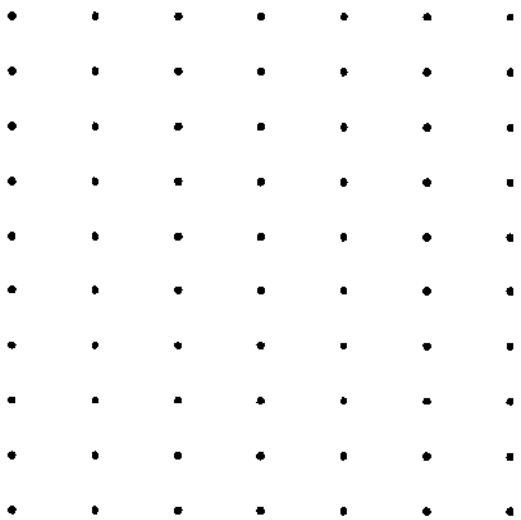


- the simplest and most powerful way **to emphasize the relationships** between different data entities is to place them in **proximity** in display.

Proximity: elements within groups

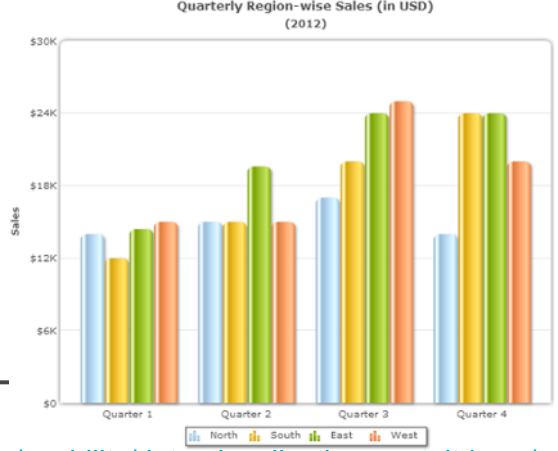


rows



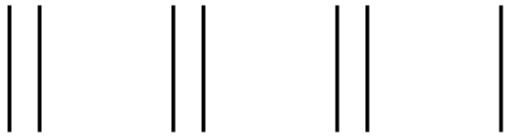
columns

Proximity



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

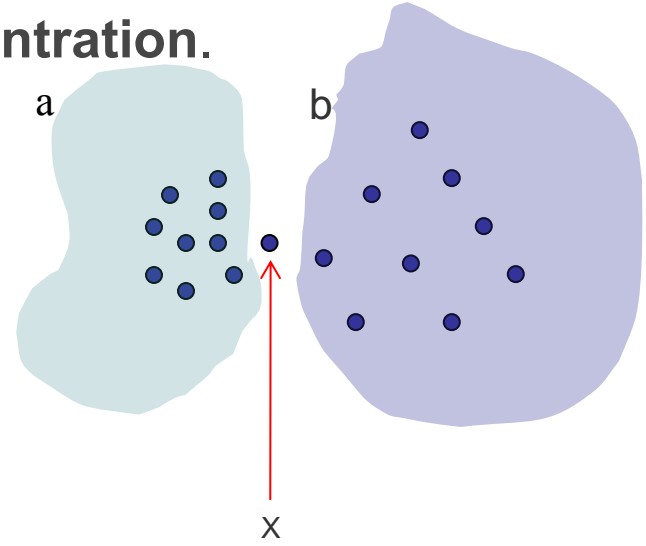
- We associate the lines which are close together than those which are further apart.
- three pairs of lines which are fairly close together (and a lonely line on the far right) rather than three pairs of lines which are further apart (and a lonely line on the far left).



Proximity and density

- **Principle of spatial concentration.**

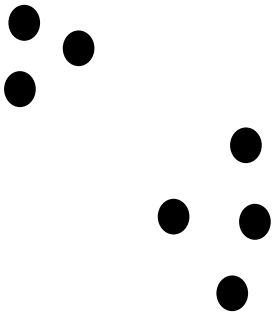
- We perceptually group **regions of similar density**

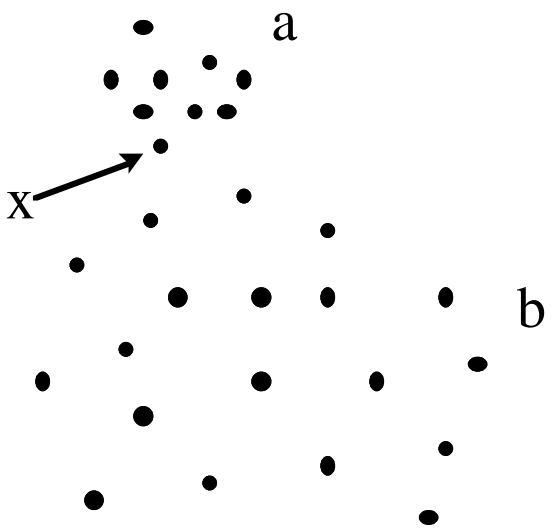


Dot **x** is perceived as part of group **a** rather than group **b** although it is equidistant

Proximity: design implications

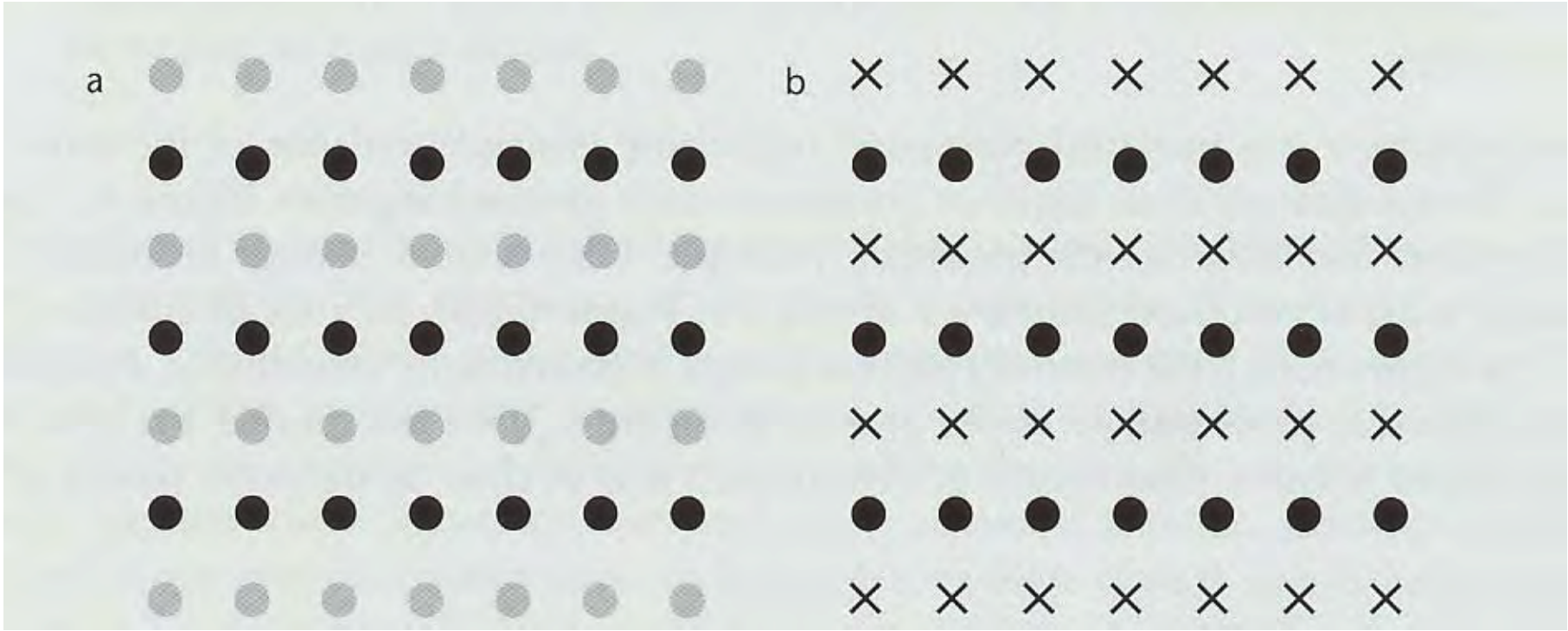
- Emphasize relationship by proximity





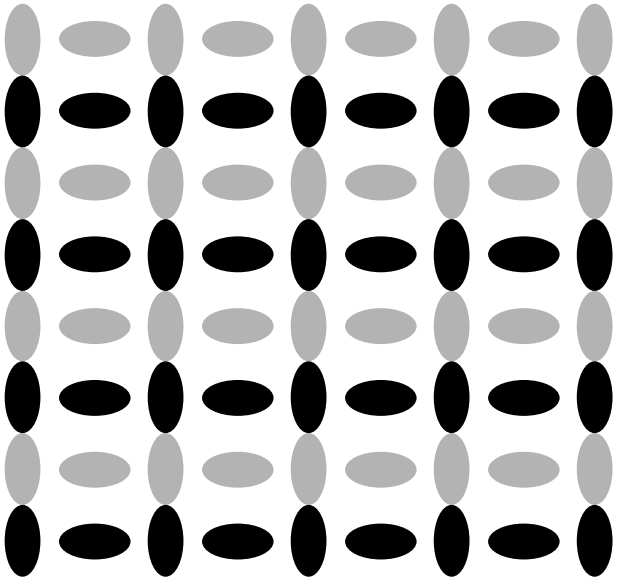
- Emphasize relationship by spatial density

Similarity



Similarity and integral dimensions

a

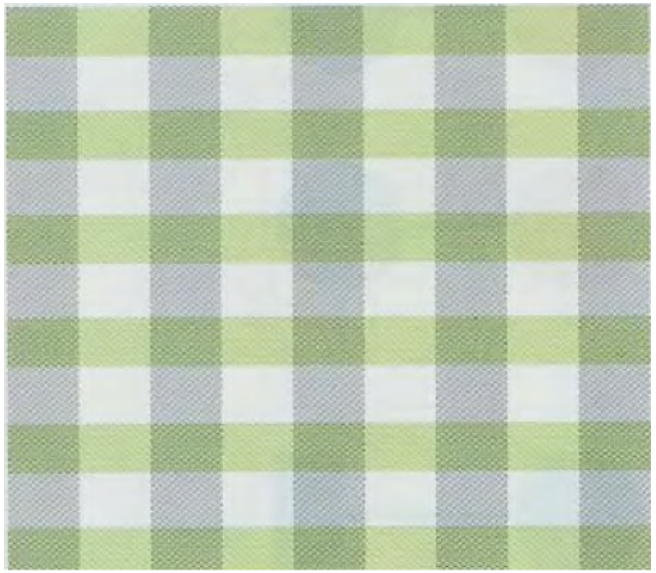


separable

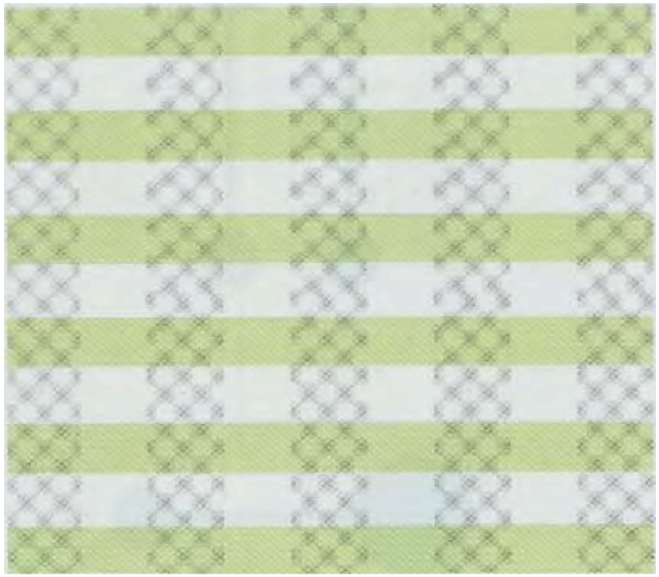
integral

- 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

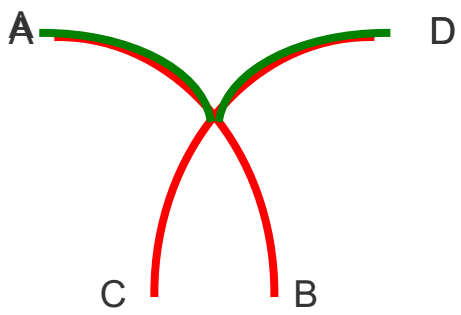


Separable dimensions (colour and texture) make it easier to attend separately to either the rows or the columns

Continuity

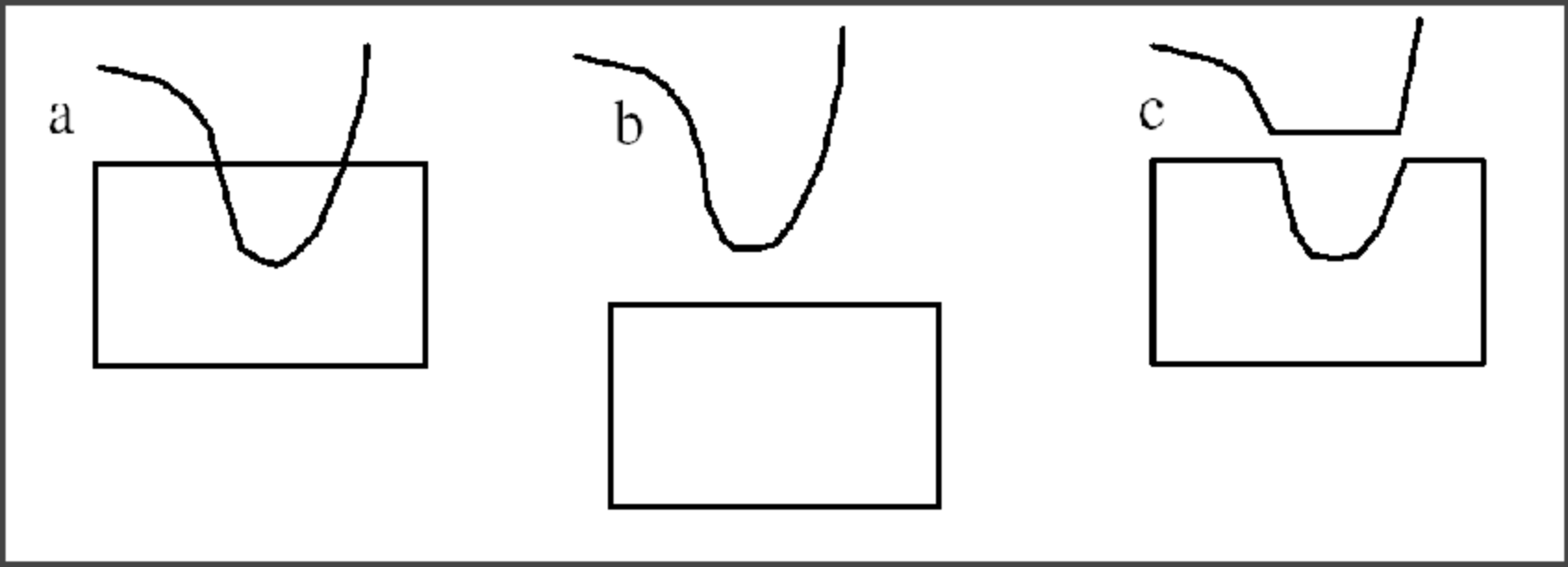
- we are more likely to construct visual entities out of objects that are smooth and continuous.

- We see a-b crossing c-d
- not a-d or b-c



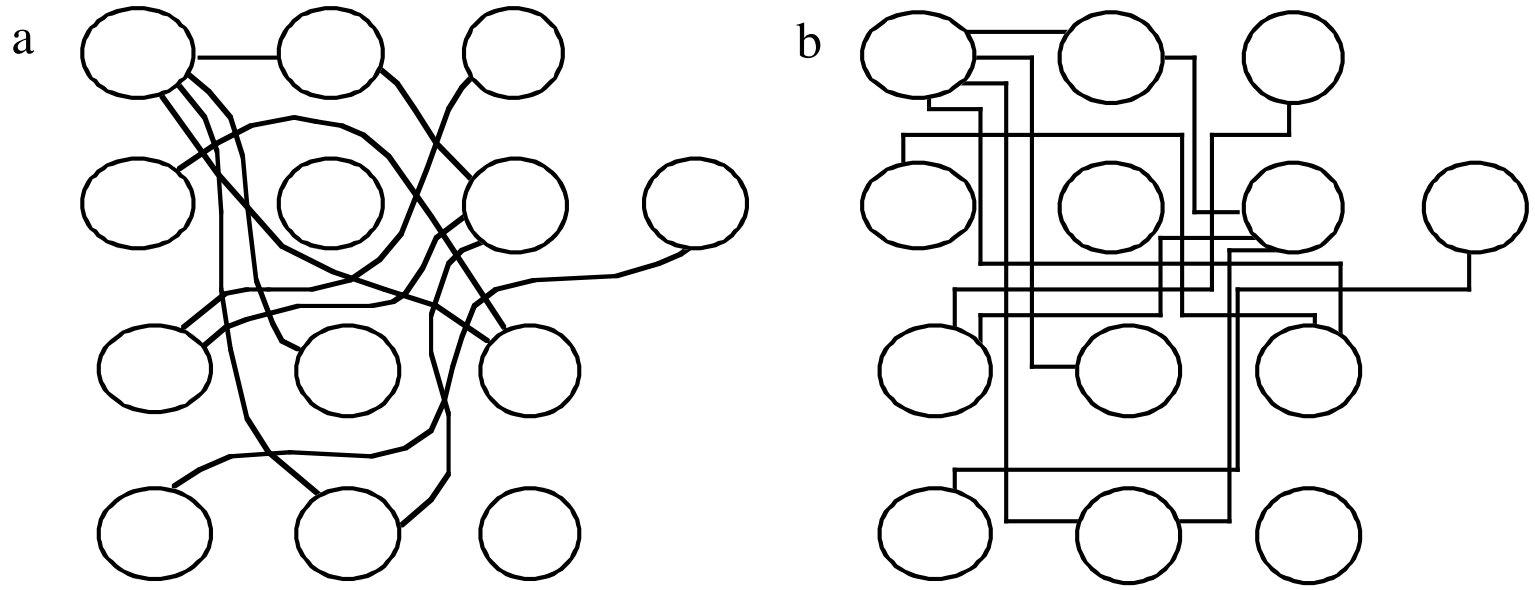
Continuity

smooth not abrupt change
overrules proximity



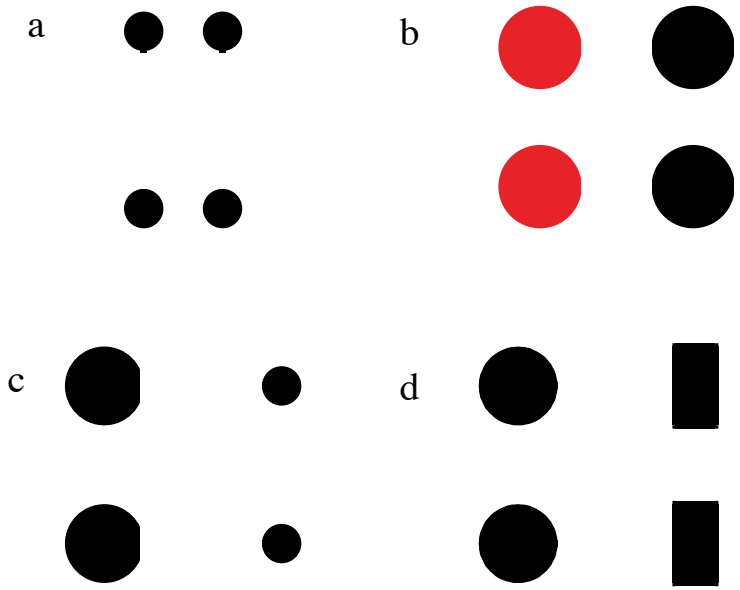
Continuity in Diagrams

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



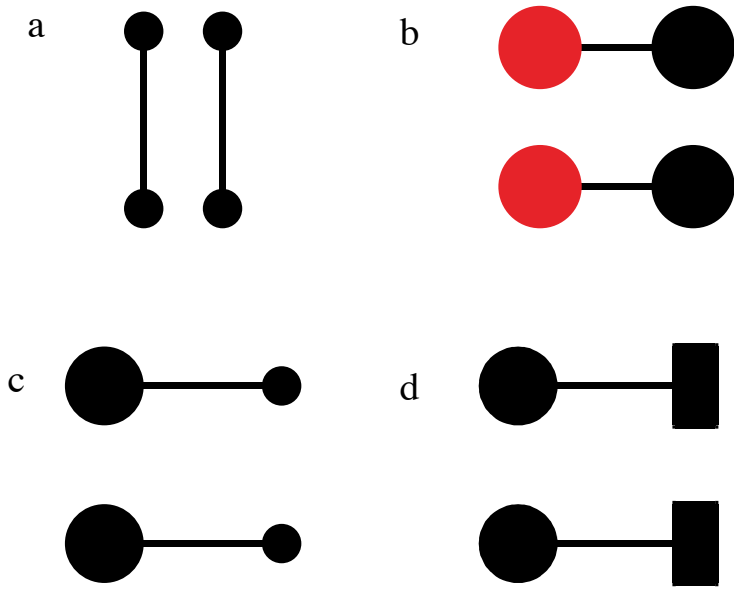
Connectedness

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



Connectedness

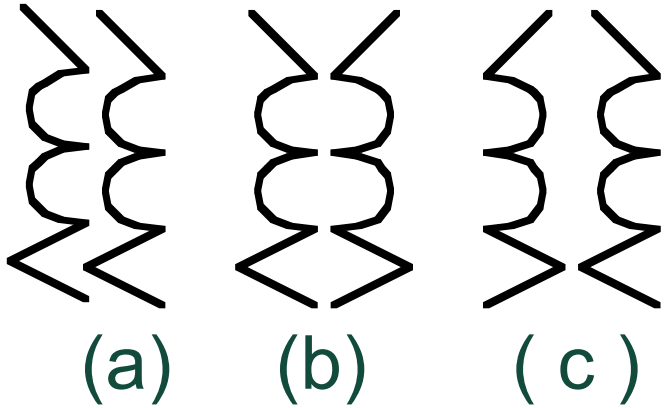
- Connecting graphical objects by a line is a very powerful way of expressing that there is a relationship between them



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

Symmetry

- Symmetry creates **visual whole**
- Powerful organising principle

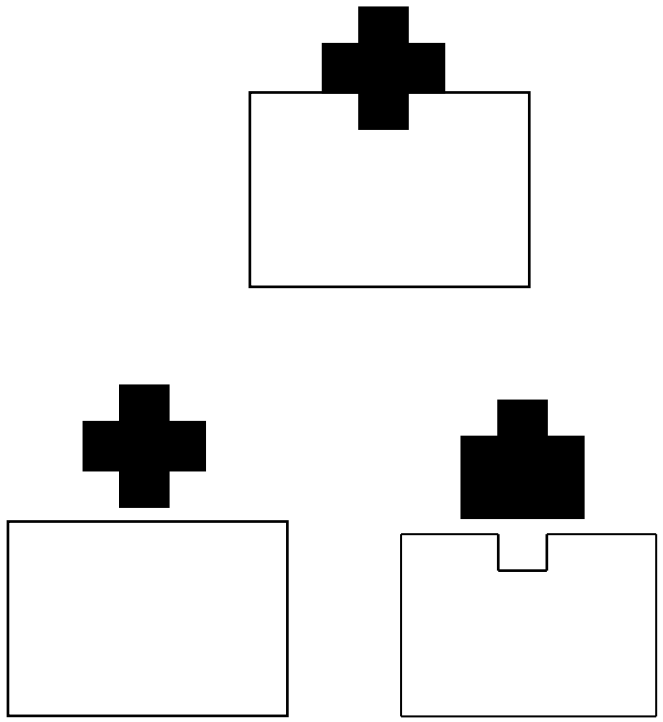


- b and c are seen as figures/objects, where a is a pair of parallel lines

Symmetry

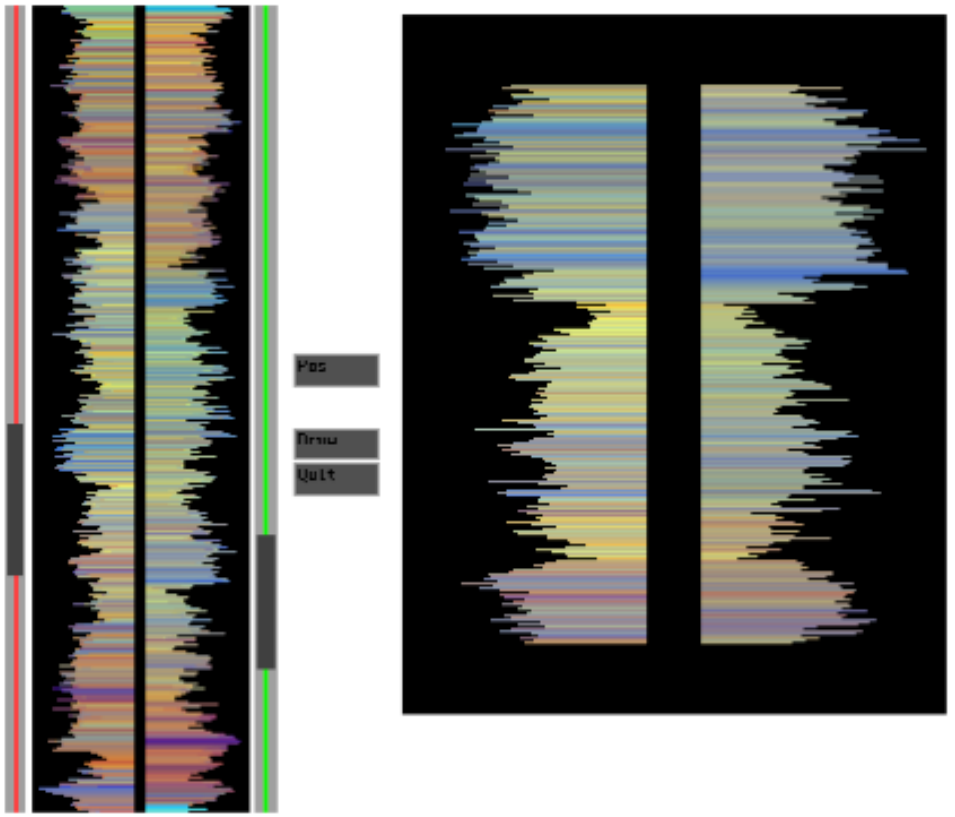
- Symmetry creates visual whole
- Powerful organising principle

- Outlines and filled shapes



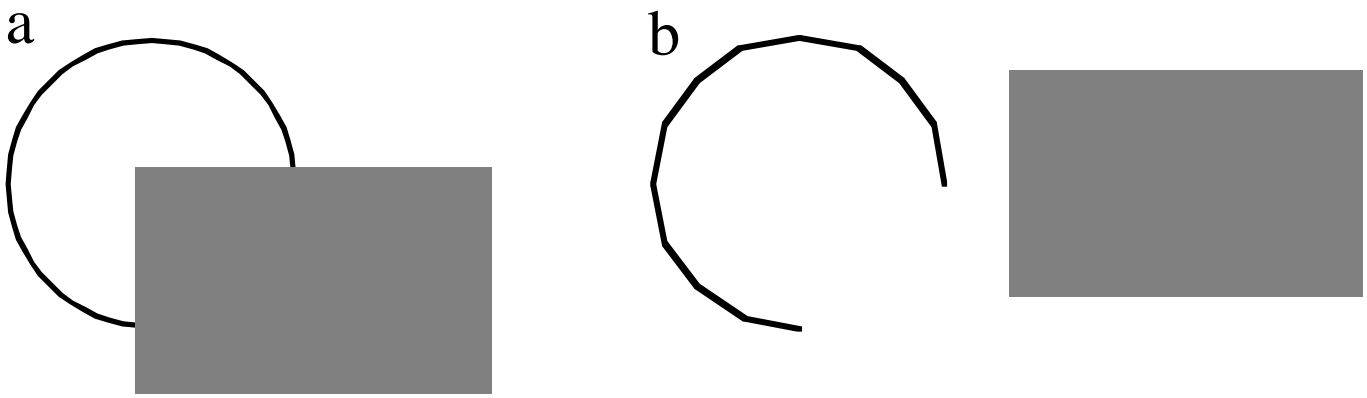
Symmetry

- We detect **asymmetries** effectively



Closure

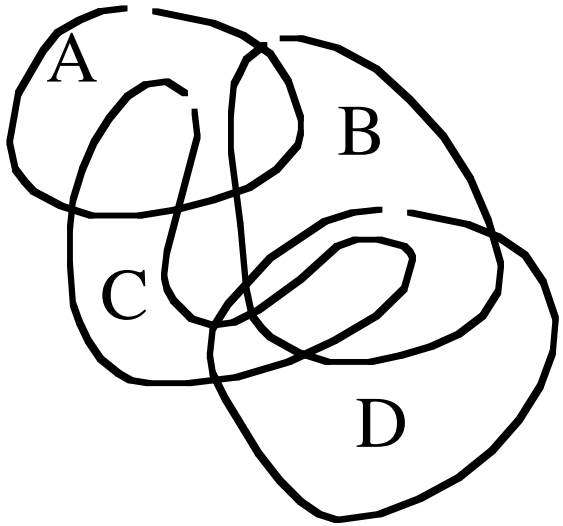
- **Over-rules proximity** !
- A closed contour tends to be seen as an object
- perceptual tendency to close contours that have gaps



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

Closure (cont.)

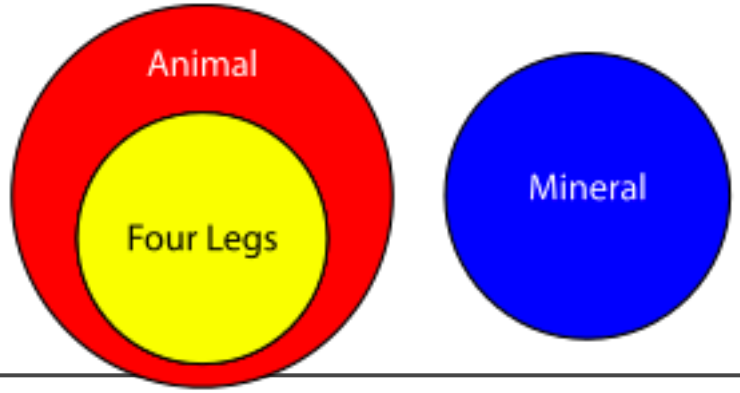
- Closed contours show **inclusion**
- Consider a set of entities where things can:
  - be members of sets A and C but not of A, B, and C.
  - anything that is a member of both B and C is also a member of D.
- How would you do this?



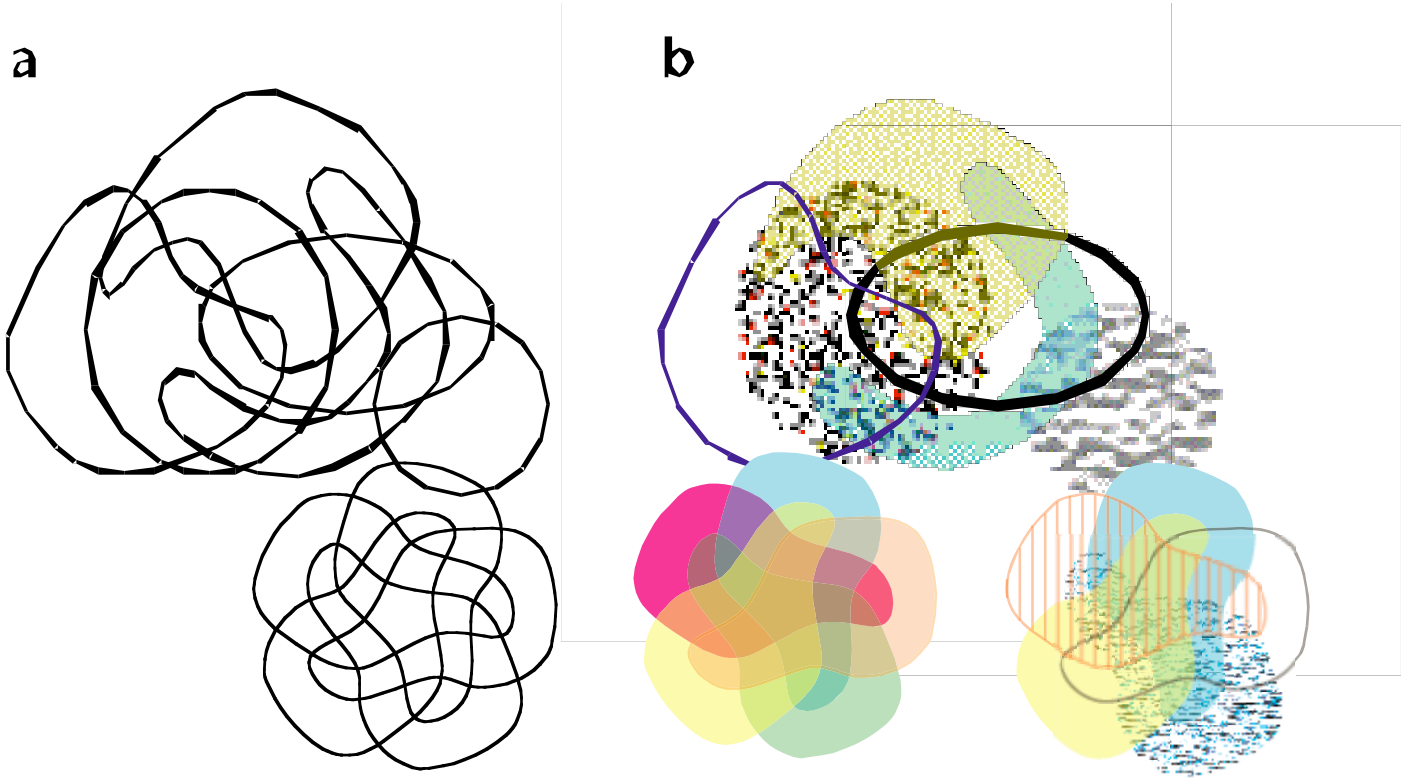
Common region

strong perceptual tendency to divide regions of space into “inside” or “outside” a contour.

- **Common region :** stronger organising principle than simple proximity

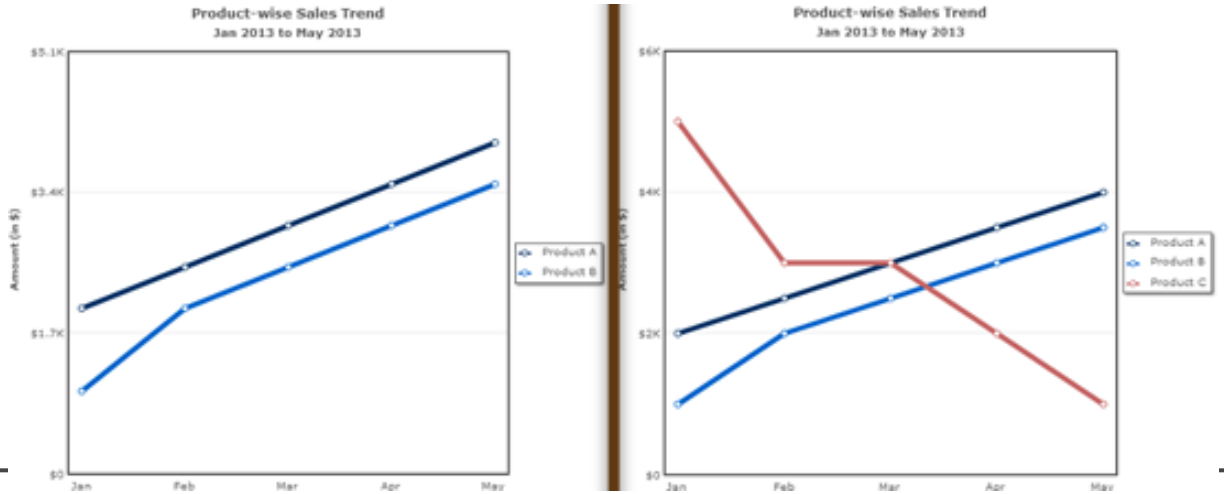


Closure and common region =



Common fate

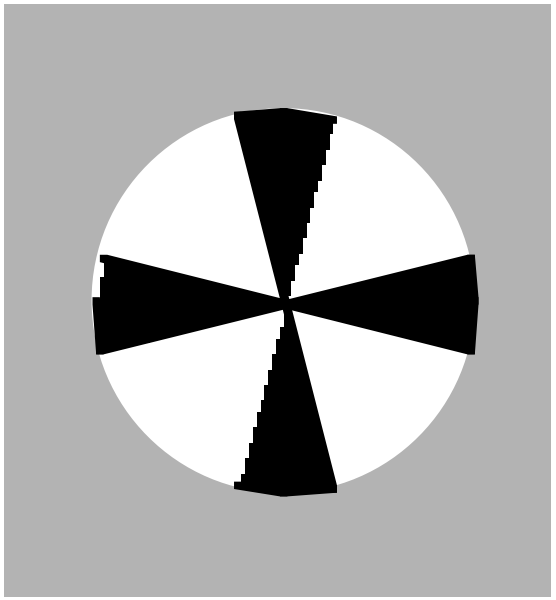
- When lines or shapes “move” in the same direction, they are perceived to be in some relationship
  - Share a “common fate”



Relative Size

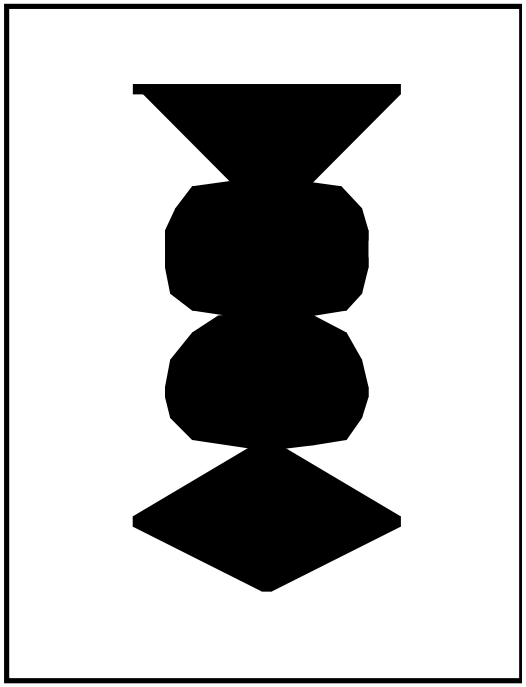
- Smaller components tend to be perceived as objects

- prefer horizontal and vertical orientations



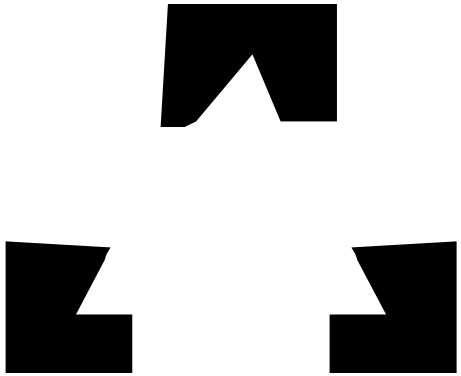
Gestalt organising principles

- Figure and ground
  - Symmetry, white space, and closed contour contribute to perception of figure.
- Subjective contour
- Prägnanz

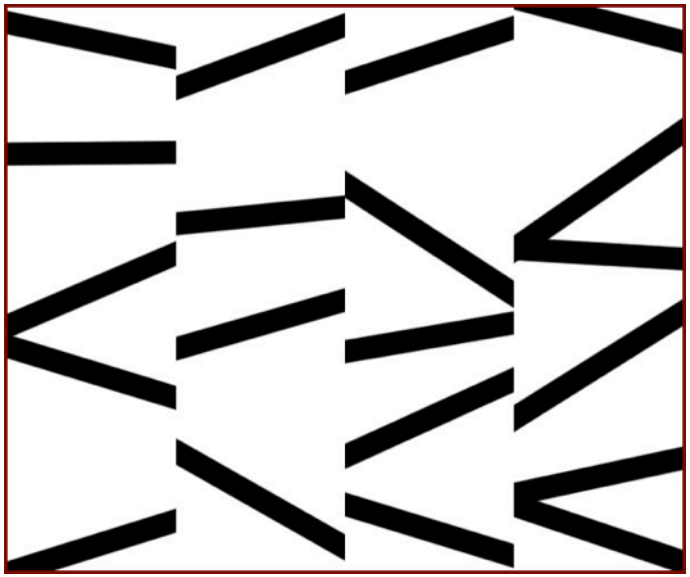


Gestalt organising principles

- Figure and ground.
- Subjective contour
  - We construct objects from pieces
- Prägnanz



Illusory Contours

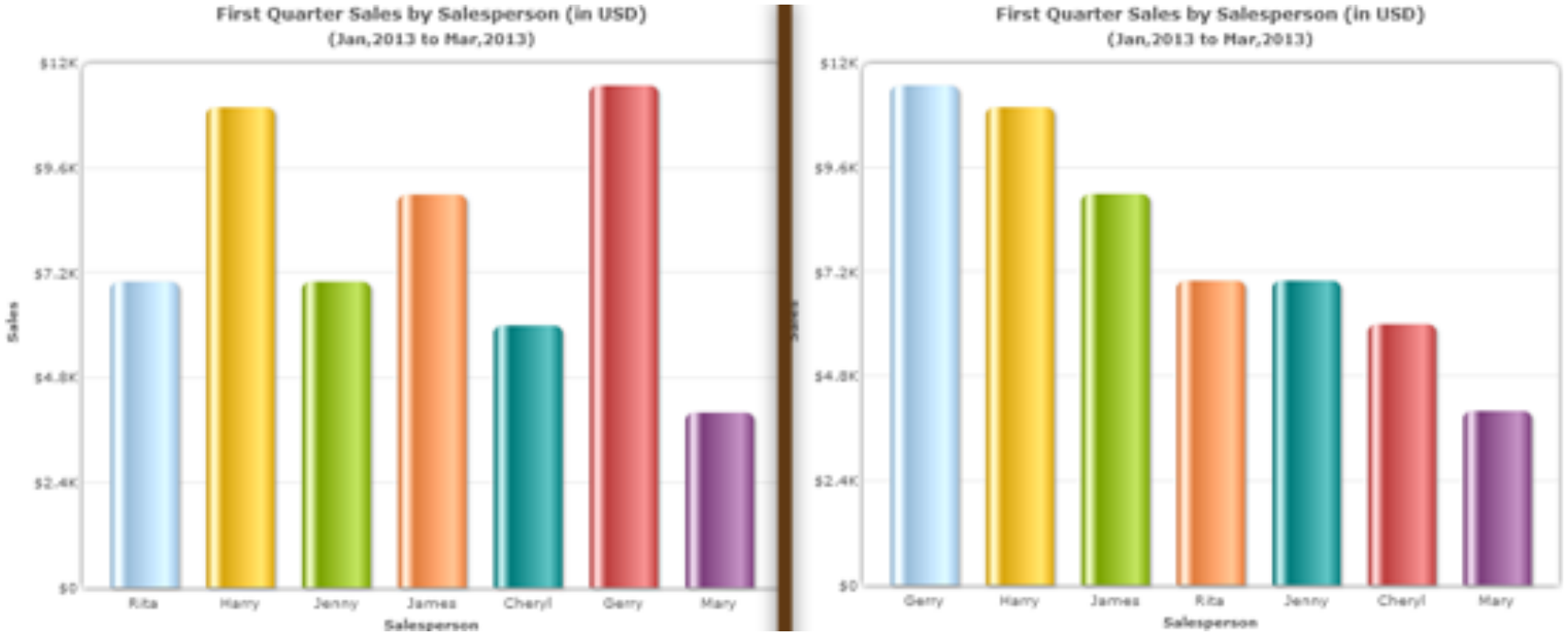


www.perceptualstuff.org

Gestalt organising principles

- Figure and ground.
- Subjective contour
- Prägnanz
  - Keep it simple

Design example



(In)Attention and Visual Awareness
IAT355

SFU

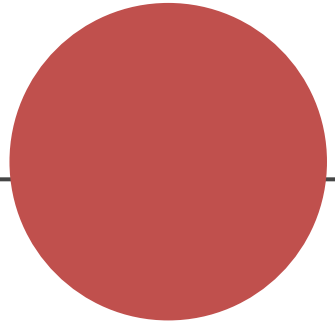
SCHOOL OF INTERACTIVE
ARTS + TECHNOLOGY

What is Attention ?

- "Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought...It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state."

  William James (1890, p. 403)

Pop-up: bottom-up attention



- Pre-attentive features.
  - color, orientation, shapes, motion.
- Search for items based on single features leads to efficient search.
  - "pop out" from surrounding distractors.

- Things that “grab” our attention cannot be ignored!

WE do not see everything at once!

- Attention dictates what we see.
- Bottom-up: grab me
- Top-down: decide what to look at/for
- ATTENTION IS LIMITED

a game

- Focus and attention

- Discussion: what are the practical implications of this for everyday life?

And just in case you are not convinced ….

- Here are some more examples!

Main models in top-down attention research

- Selective attention (focused):
  - Whether we become aware of sensory information
  - Non-random selection
  - Stream/bottleneck model

- Divided Attention (multitasking)
  - Attention can be split between multiple tasks
  - Allocation approach
  - Is what some of you are doing right now

- Control and Automaticity

Divided attention

- More recent models of attention as a resource that is allocated between processes
- Top-down, consciously driven “spotlight” set: focus of attention
  - How many foci can we maintain?
  - What kinds of tasks demand more resources than others?
- Bottom-up, stimulus driven “demand” events
  - Involuntary response to perceptual cue
  - Flashing light or alarm bell
- How much can we attend to? No established capacity

Conscious attention and restricted awareness

- Can we be conscious of things without attending to them?
- Are there only some kinds of things we see when we are not attending?
- If we don't have a highly salient cue of some kind, we will miss changes in the world
  - Motion
  - Sound
  - sensation

Change blindness (Rensink)

We are constantly making rapid eye movements, known as saccades, as we scan a scene.

- Vision is suppressed during saccades.
- People fail to notice large changes in the scene if the change occurs during a saccade. (McConkie, Grimes, Ballard and others).

Different from inattentional blindness

- you don't notice when things around you are altered to be drastically different than they were a moment ago.

Change blindness

- A cut between scenes can induce change blindness.
  - http://viscog.beckman.uiuc.edu/grafs/demos/11.html
- even for objects that are the center of attention:
  - http://viscog.beckman.uiuc.edu/grafs/demos/23.html
- Disruptions in real life can also lead to change blindness:
  - https://www.youtube.com/watch?time_continue=87&v=FWSxSQsspiQ

Automatic processing

- Highly familiar and learned
- Do not require conscious attention
- Occur without intention
- Well practiced responses
- Unaffected by capacity
- Fast
- Difficult to modify

- Driving a car and listening to the radio
- Reading and (not) listening to your partner

Controlled processing

- Require conscious attention
- Takes resources
- Limited capacity
- Not well practiced
- Slow

- Driving on the other side of the road
- Reading unfamiliar/rare words
- Listening to lyn lecture

Automaticity vs control : the Stroop Effect

- blue green red yellow

Designing for attention

Two basic goals

1. Provide relevant information without overloading the user

2. Attract and engage the user's attention appropriately
   - Situation awareness