

# G53FIV: Fundamentals of Information Visualization

## Lecture 8: Visual Perception

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<https://moodle.nottingham.ac.uk/course/view.php?id=96914>

# Visual Perception

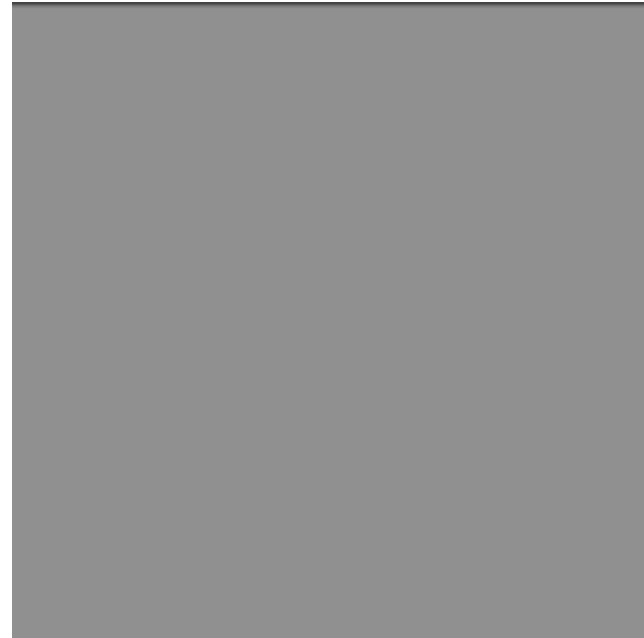
The ability of viewers to interpret visual encodings of information and thereby decode information in graphs.

# Related Disciplines

- Psychophysics
  - Applying methods of physics to measuring human perceptual systems
    - How fast must light flicker until we perceive it as constant?
    - What change in brightness can we perceive?
- Cognitive psychology
  - Understanding how people think, here, how it relates to perception

# Effectiveness Ranking

# Detecting Brightness



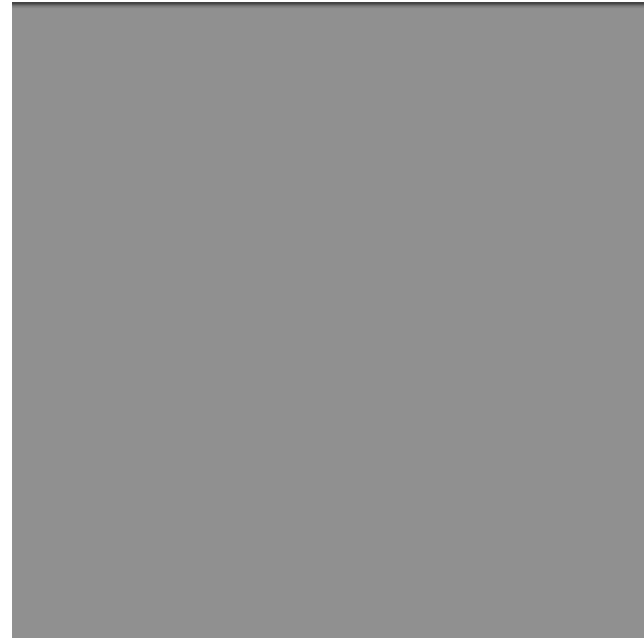
Which one is brighter?

# Detecting Brightness

(128,128,128)

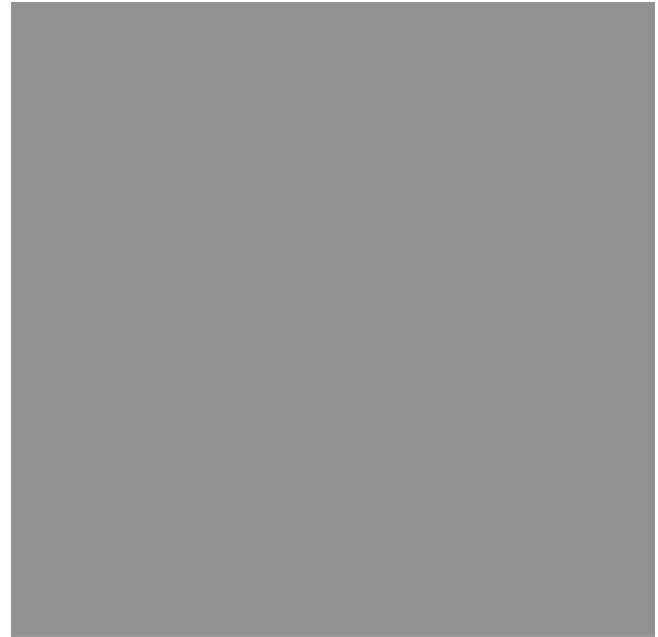


(144,144,144)



Which one is brighter?

# Detecting Brightness



Which one is brighter?

# Detecting Brightness

(134,134,134)



(128,128,128)

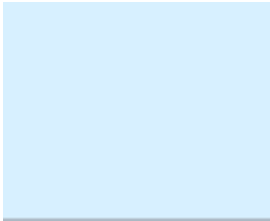
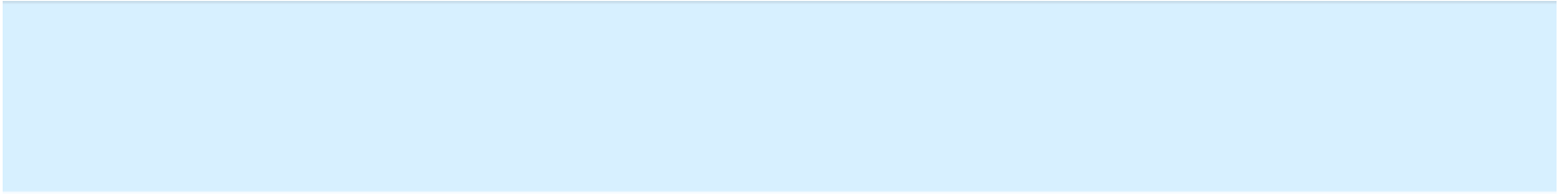


- Ratios more important than magnitude
- Most continuous variation in stimuli are perceived in discrete steps



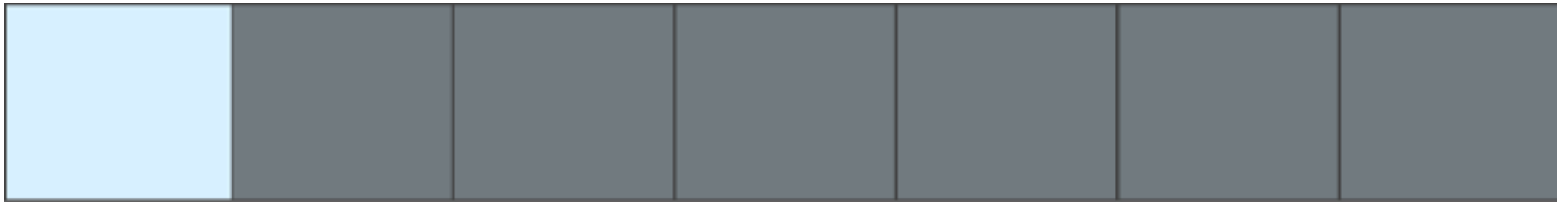
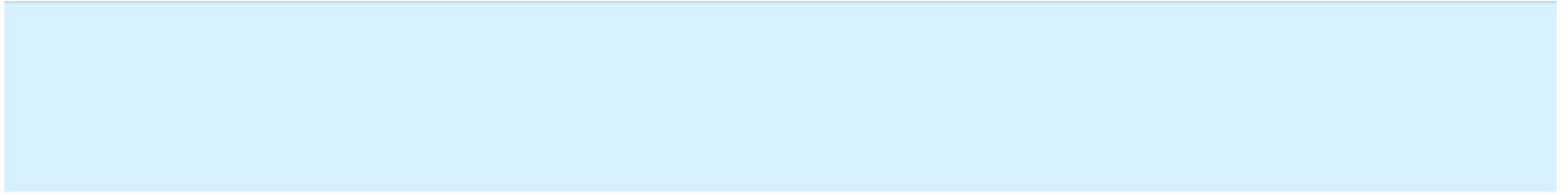


# Estimating Magnitude



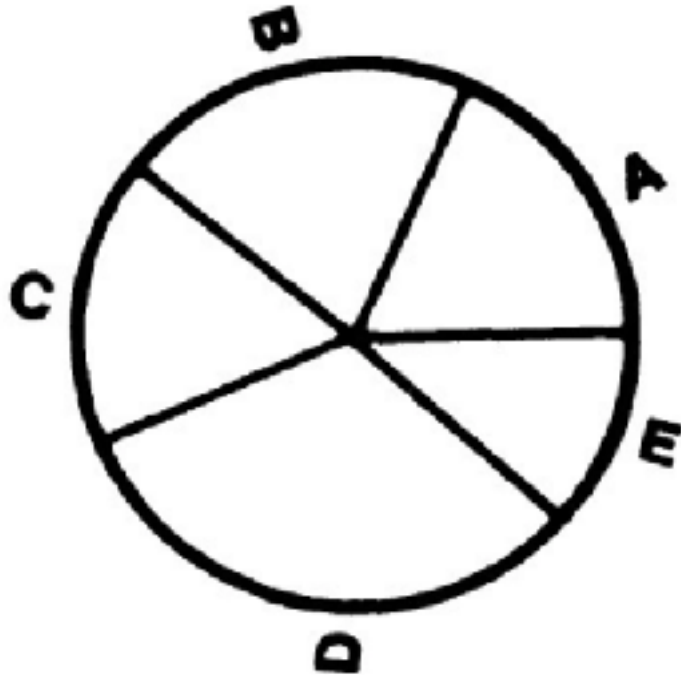
Compare length of bars

# Estimating Magnitude



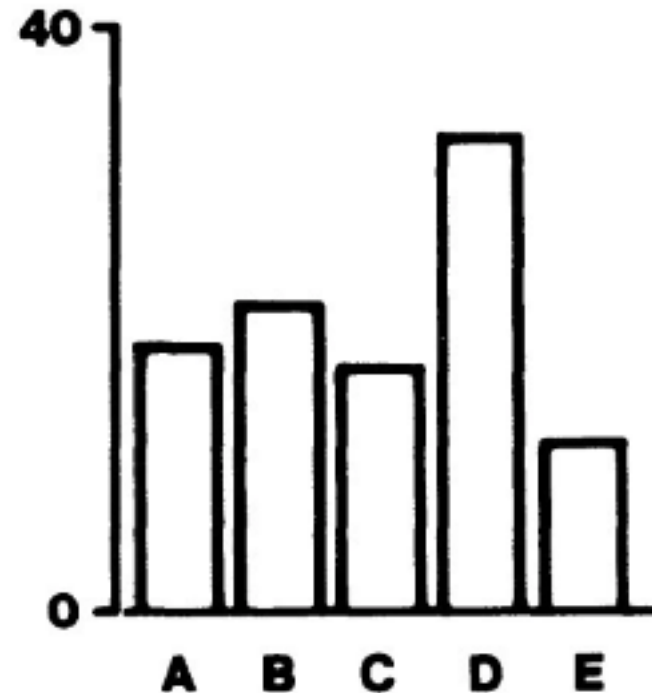
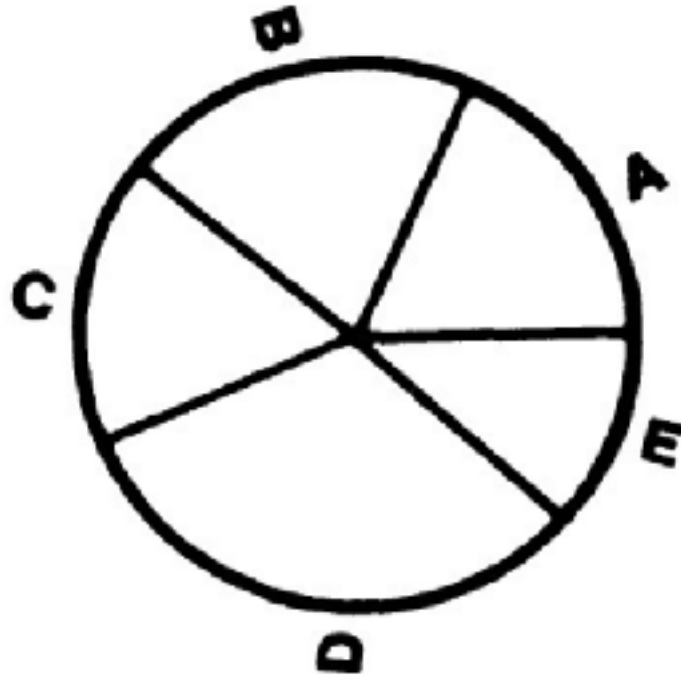
Compare length of bars

# Estimating Magnitude



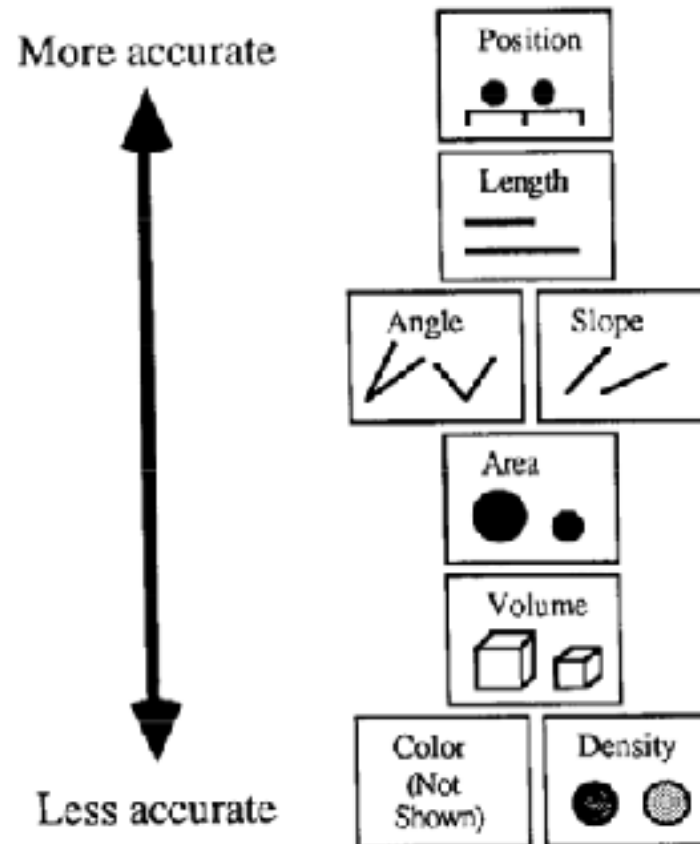
Which section is bigger? A or C?

# Estimating Magnitude



Which section is bigger? A or C?

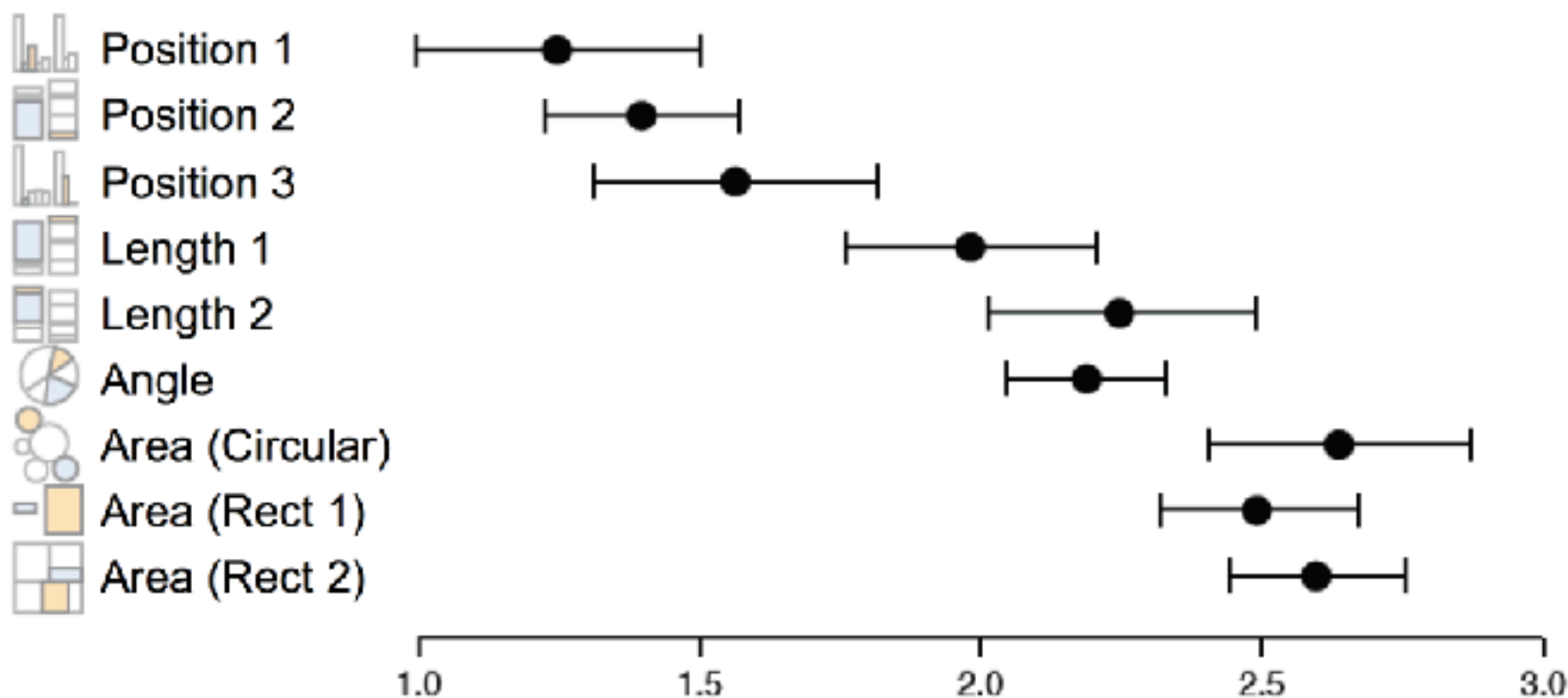
# Effectiveness: Accuracy Ranking



Mackinlay, Automating the design of graphical presentations of relational information, 1986.

# Graphical Perception Experiments

- Empirical estimates of encoding

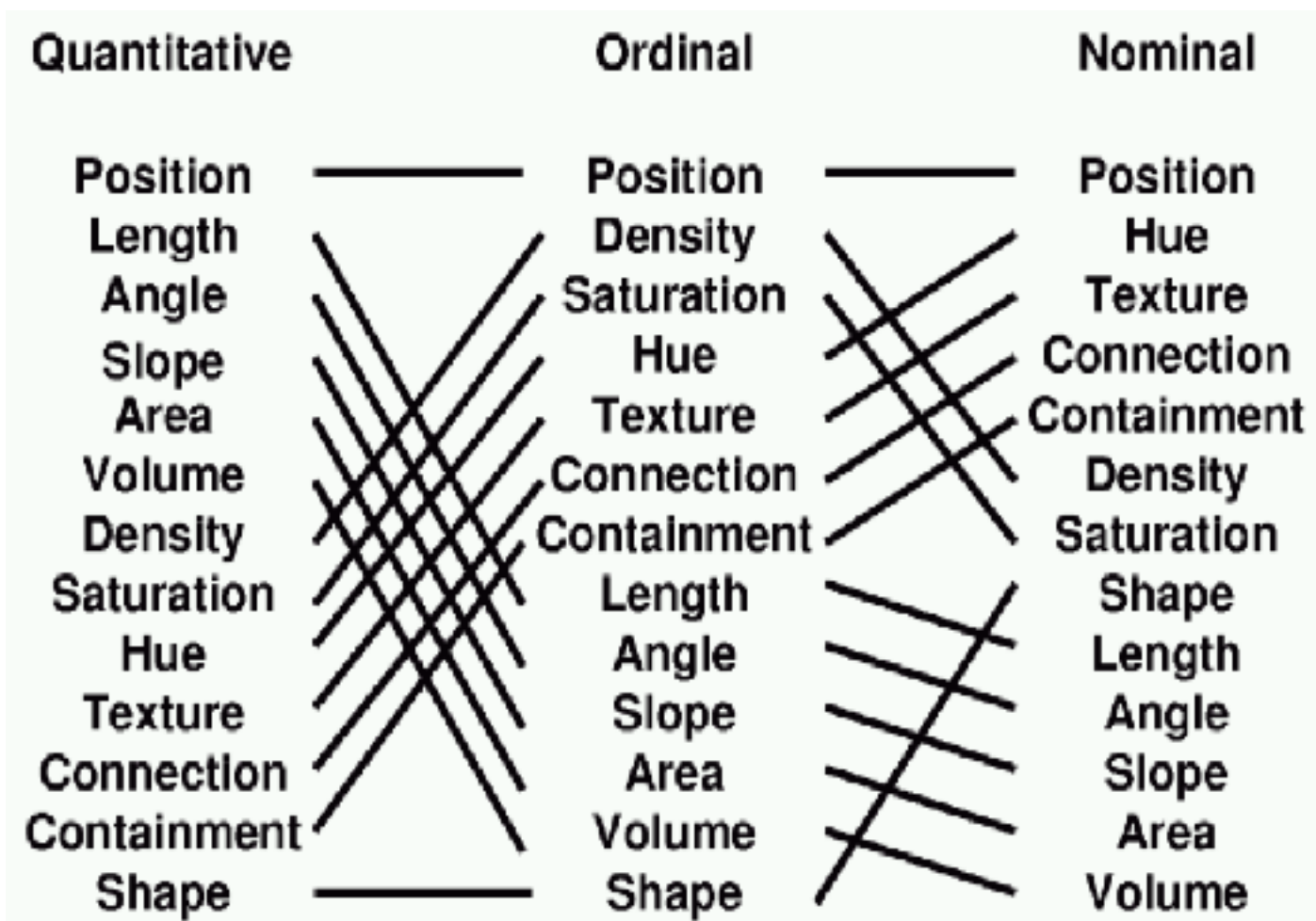


Heer & Bostock '10

(Optional Reading) Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess

Log Absolute Estimation Error

# Conjectured Effectiveness of Encodings by Data Type

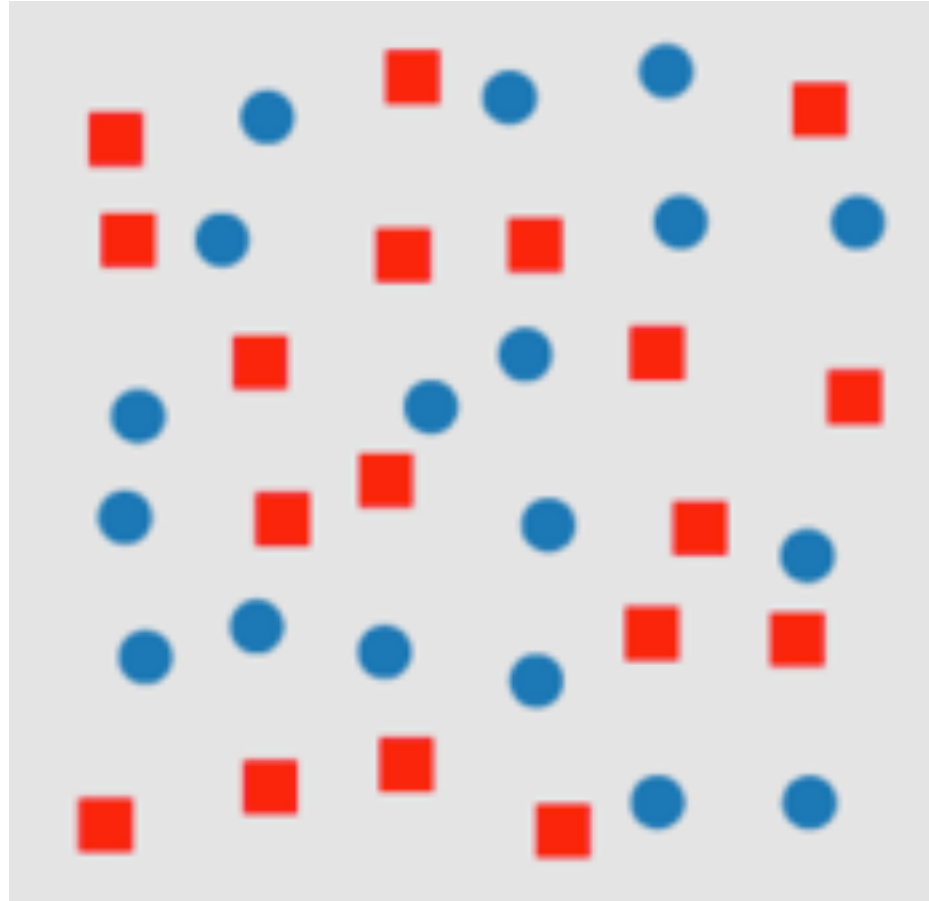


Mackinlay, Automating the design of graphical presentations of relational information, 1986.

# Perceptual Processing

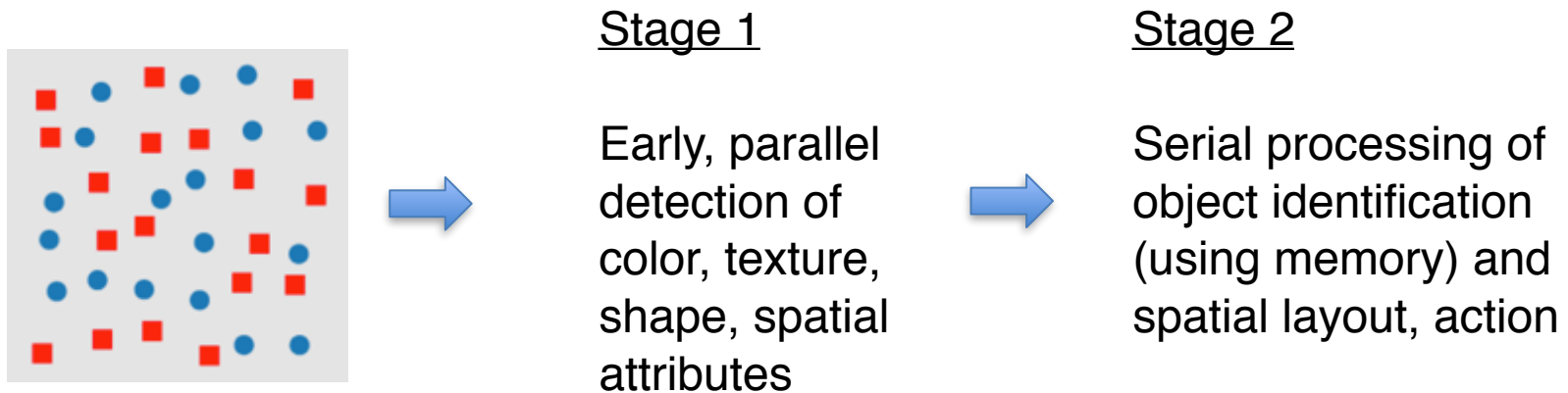


# Perceptual Processing Model



# Perceptual Processing Model

- Two stage process
  - Parallel extraction of low-level properties of scene
  - Sequential goal-directed processing



# Stage 1: Pre-attentive Processing

## - Low-level, Parallel

- Neurons in eye & brain responsible for different kinds of information
  - Orientation, color, texture, movement, etc.
- Arrays of neurons work in parallel, occurs “automatically” and rapidly
  - Generally less than 200-250 msec
- Information is transitory, briefly held in iconic store
- Bottom-up data-driven model of processing
- Often called “pre-attentive” processing, i.e. without the need for focused attention



# Stage 2 - Sequential, Goal-Directed

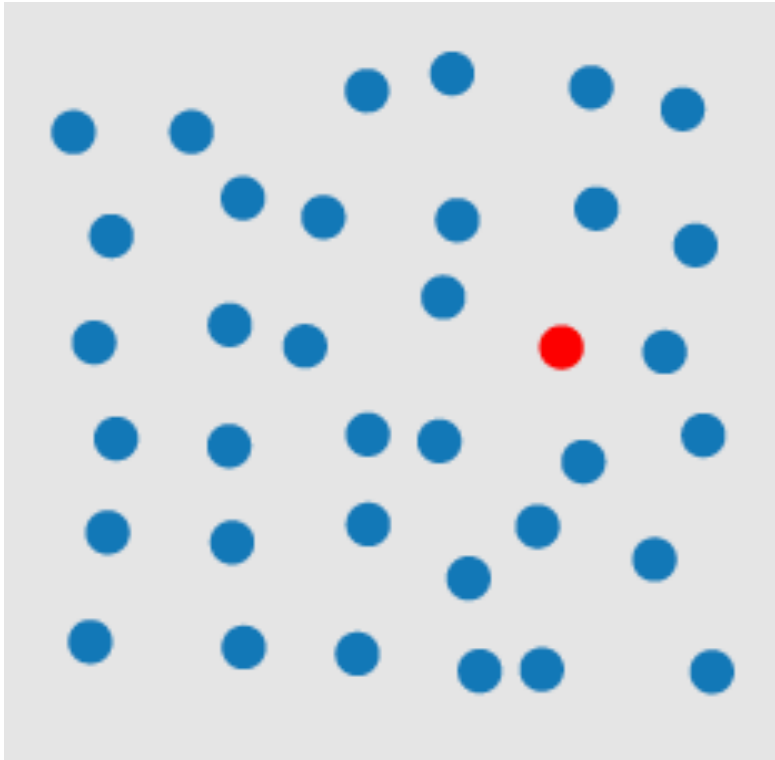
- Splits into subsystems for object recognition and for interacting with environment
- Increasing evidence supports independence of systems for symbolic object manipulation and for locomotion & action
- First subsystem then interfaces to verbal linguistic portion of brain, second interfaces to motor systems that control muscle movements
- Slow serial processing
- Involves working and long-term memory

# Pre-attentive Processing

How many 3's?

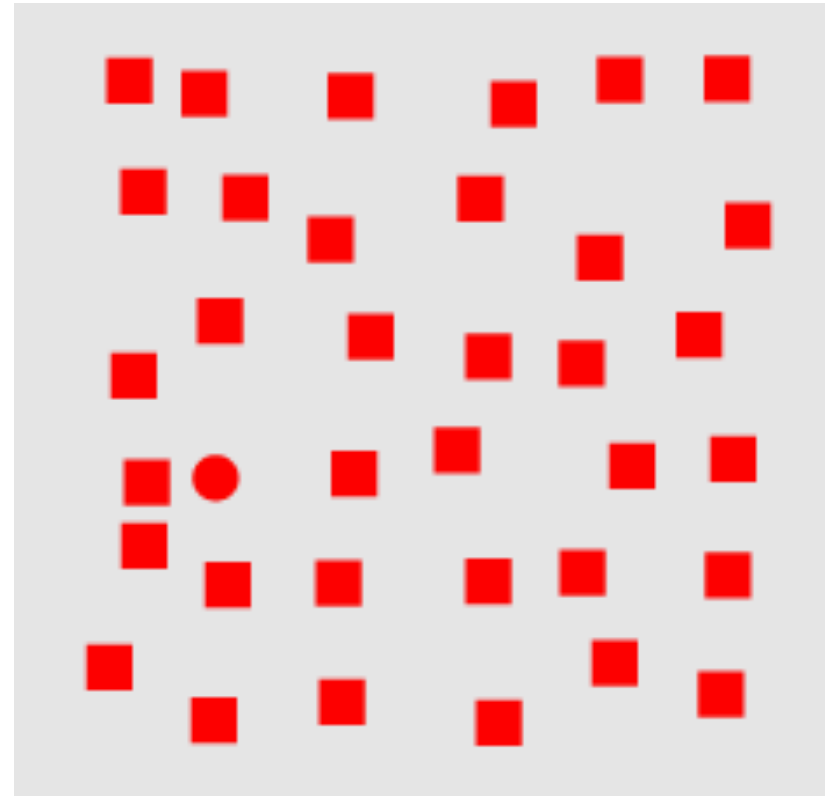
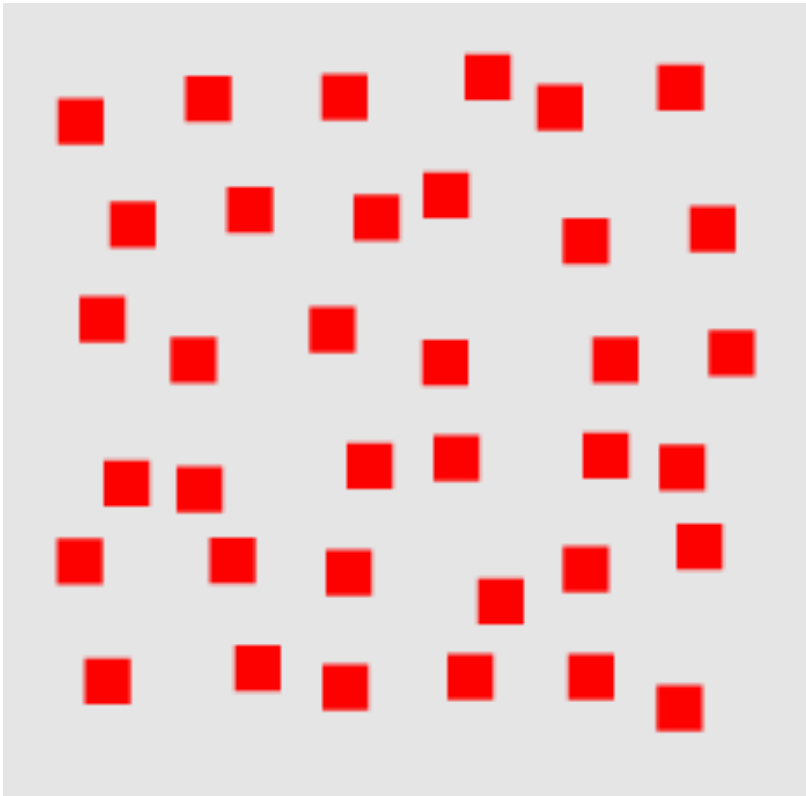
12817687561**3**8976546984506985604982826762  
980985845822450985645894509845098094**3**585  
90910**3**0209905959595772564675050678904567  
8845789809821677654876**3**64908560912949686

# Visual Pop-Out: Color (Hue)



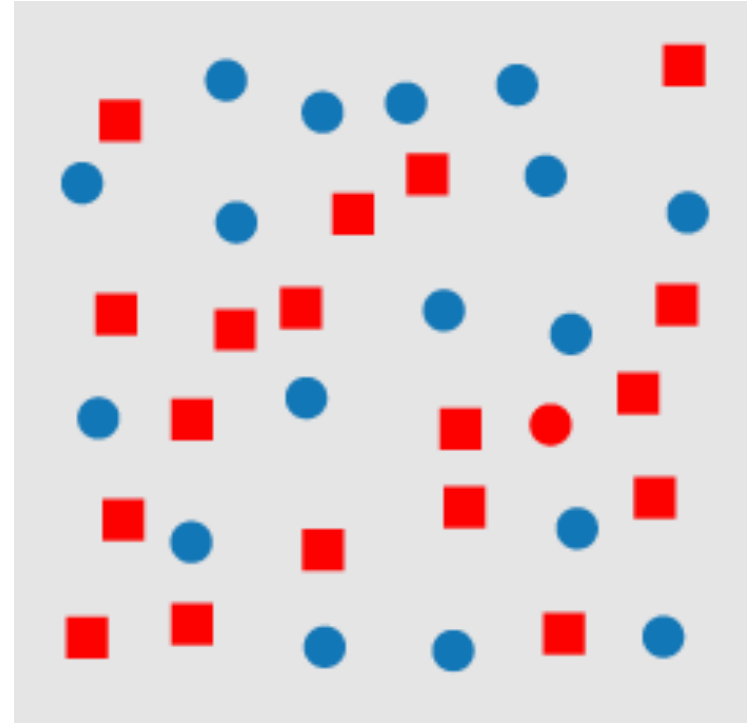
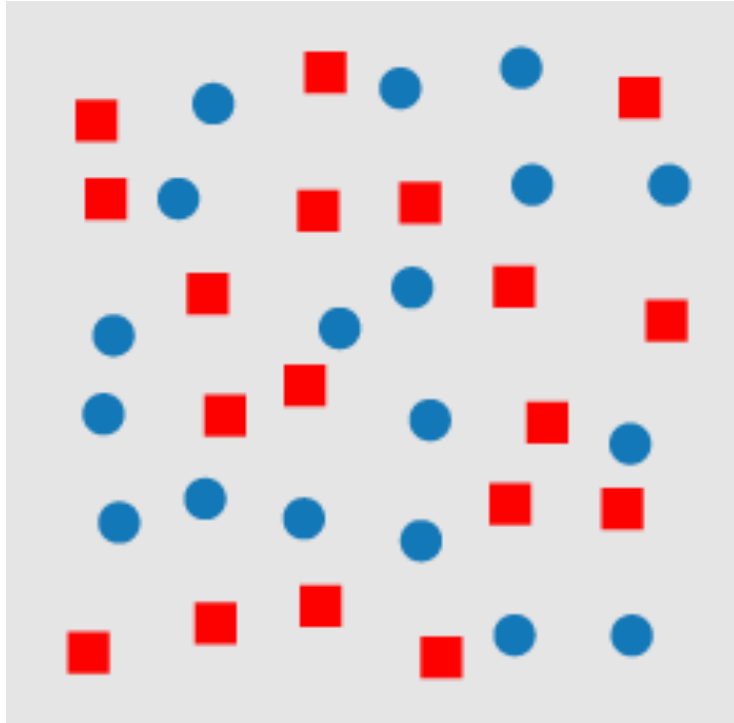
Can be done rapidly (preattentively) by people  
Surrounding objects called “distractors”

# Visual Pop-Out: Shape



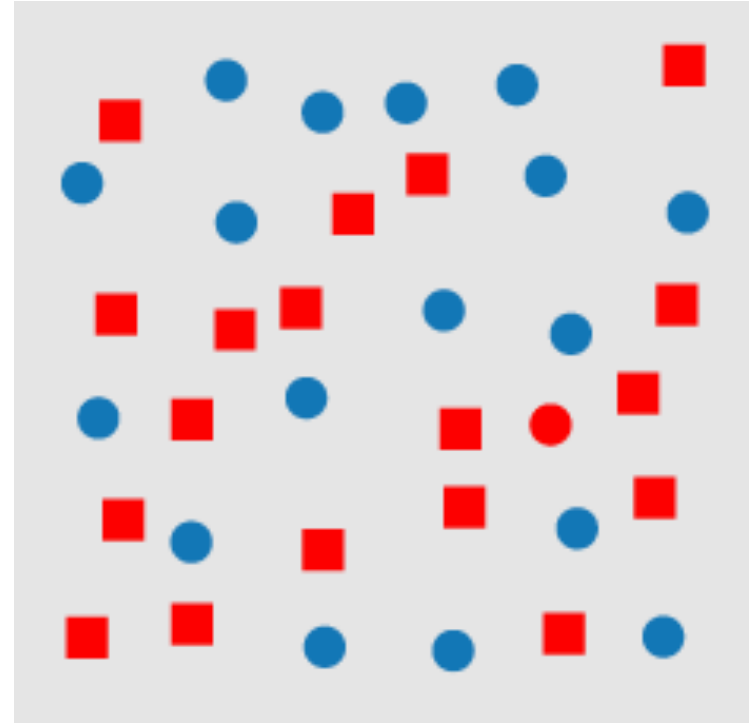
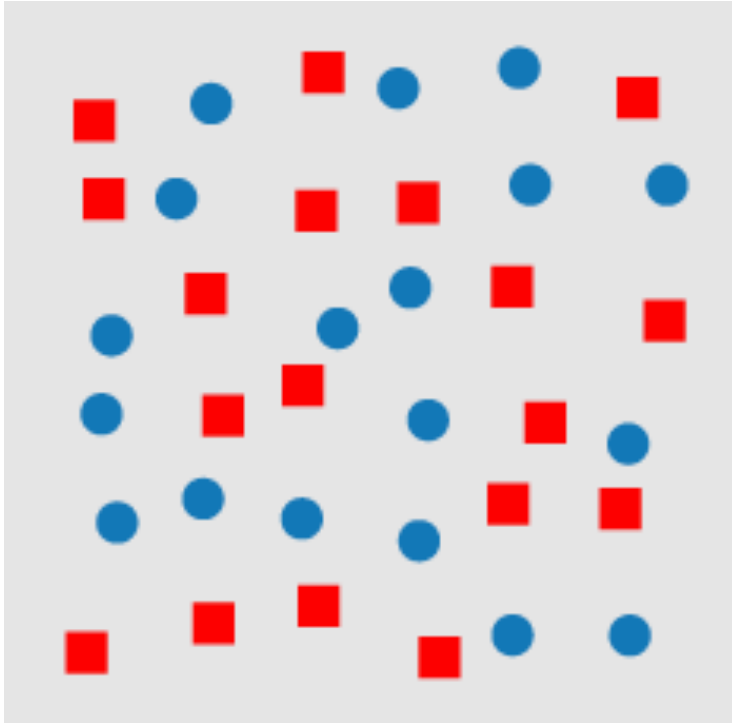
Can be done preattentively by people

# Feature Conjunctions: Color and Shape





# Feature Conjunctions: Color and Shape



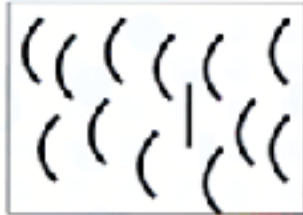
- Cannot be done preattentively
- Must perform a sequential search
- Conjunction of features (shape and hue) causes it

# Pre-Attentive Features

Orientation



Curved/straight



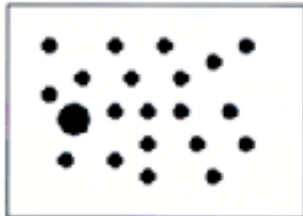
Shape



Shape



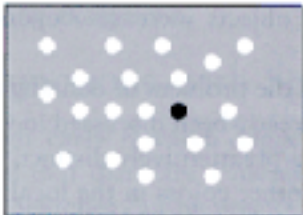
Size



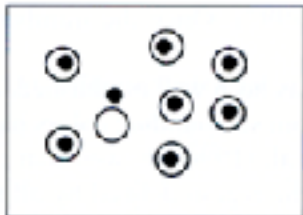
Number



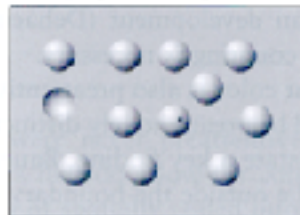
Gray/value



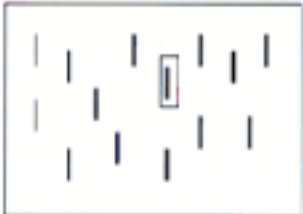
Enclosure



Convexity/concavity



Addition



Juncture



Parallelism



- length
- width
- size
- curvature
- number
- terminators
- intersection
- closure
- hue
- intensity
- flicker
- direction of motion
- binocular lustre
- stereoscopic depth
- 3-D depth cues
- lighting direction

# Pre-Attentive Feature Conjunctions

- Spatial conjunctions are often pre-attentive
  - Motion and 3D disparity
  - Motion and color
  - Motion and shape
  - 3D disparity and color
  - 3D disparity and shape
- 
- Most conjunctions are not pre-attentive

# Gestalt Grouping Principles

“All else being equal, elements that are related by X tend to be grouped perceptually into higher-order units.”

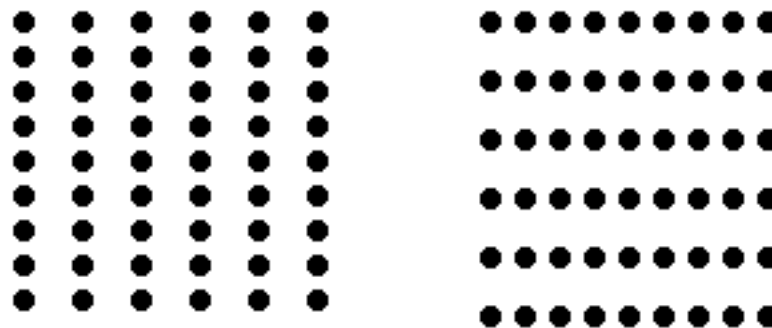
— Stephen Palmer

- Proximity
- Similarity
- Connectedness
- Continuity
- Symmetry
- Closure
- Figure/Ground
- Common Fate

# Gestalt Grouping Principles

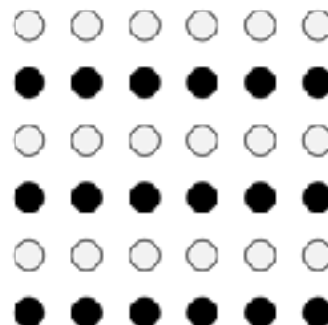
- Proximity

- Things close together are perceptually grouped together



- Similarity

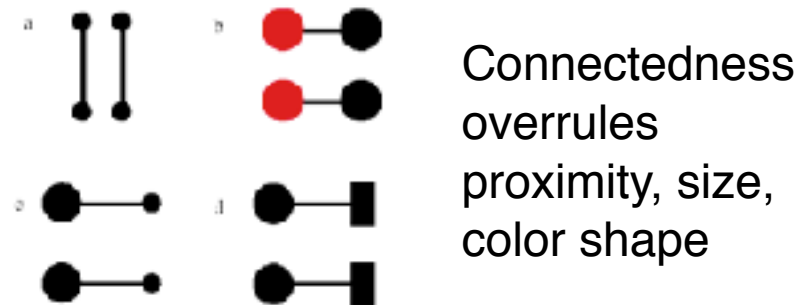
- Similar elements get grouped together



Rows dominate  
due to similarity

# Gestalt Grouping Principles

- Connectedness
  - Connecting different objects by lines unifies them



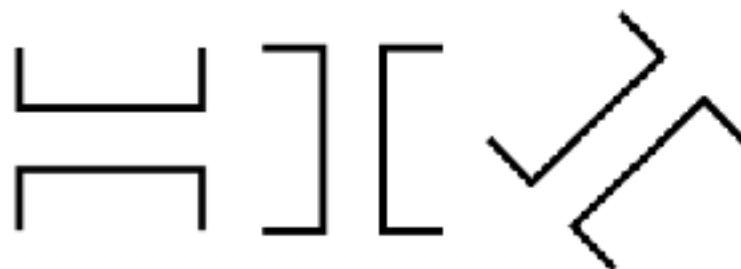
- Continuity
  - More likely to construct visual entities out of smooth, continuous visual elements



# Gestalt Grouping Principles

- Symmetry

- Symmetrical patterns are perceived more as a whole



- Closure

- A closed contour is seen as an object



# Gestalt Grouping Principles

- Figure/Ground
  - Figure is foreground, ground is behind
- Common Fate (Synchrony)
  - Elements that move in the same direction are perceived as more related



ambiguous



Relative  
size

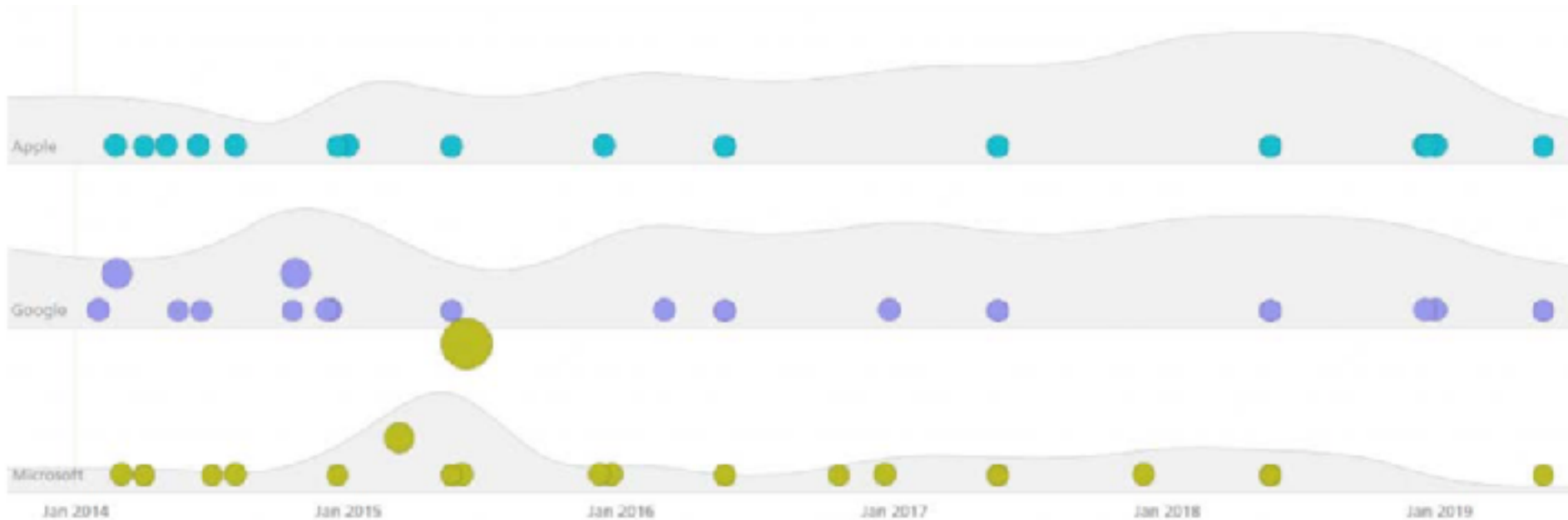


surroundedness





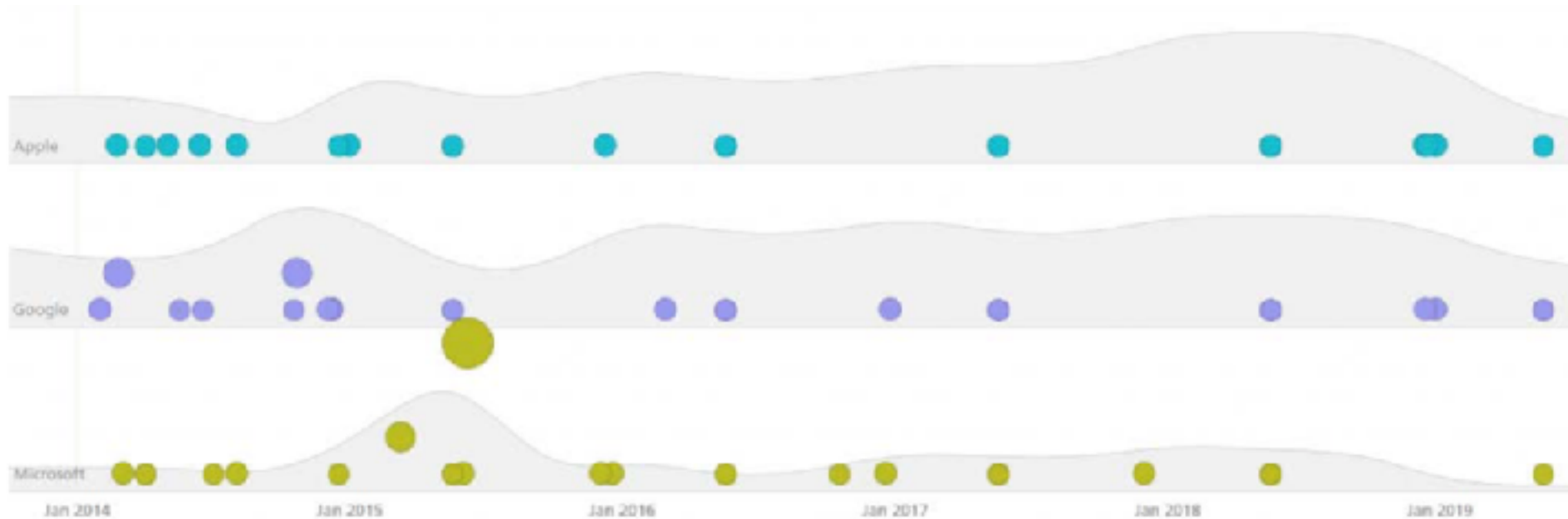
# An Example



Visualisation based on total number of mentions (Source: Recorded Future)

What important Gestalt principles of visual organization are used in this visualisation?

# An Example



Visualisation based on total number of mentions (Source: Recorded Future)

Figure & ground  
Proximity  
Similarity

# Change Blindness

- We don't always see everything that is there!
- Is the viewer able to perceive changes between two scenes?
  - If so, may be distracting
  - Can do things to minimize noticing changes
- Video: <http://www.simonslab.com/videos.html>

# Next Lecture

- Topic:
  - Interaction
- Next Friday (6 March)
  - 13:00 - 15:00
  - A25, Business South, Jubilee Campus

