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Human-Computer Interaction: 2B. Visual Perception

16 October 2024

Visual Perception

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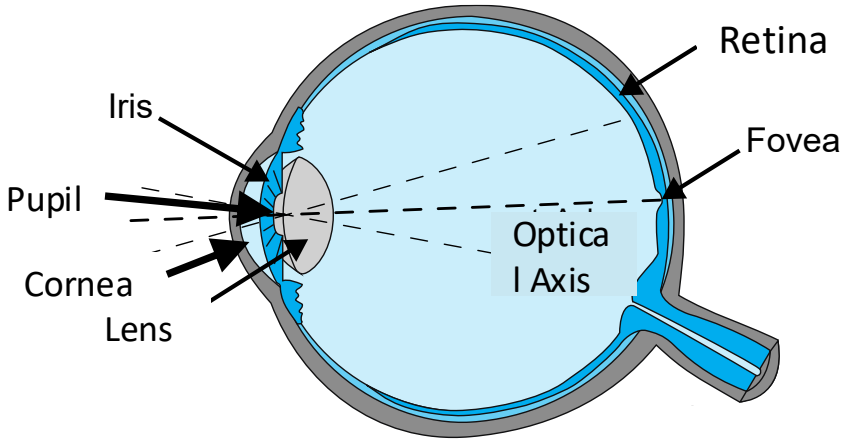
- Gestalt – Perception of Form
- Visual Search
- Preattentive Processing
- Visual encoding of data

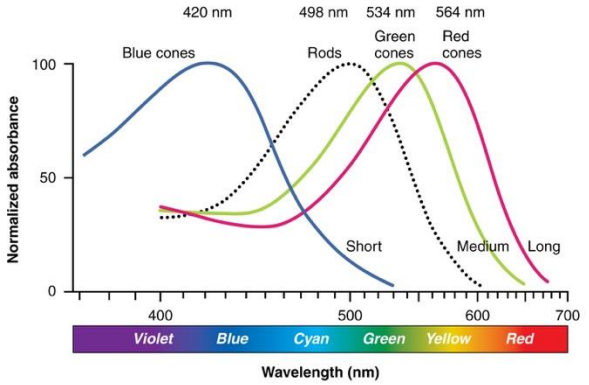
Learning Objectives: be able to …

- Analyse visual designs in terms of Gestalt
- Identify effects of relevance to visual search and perception of objects
- Describe pop-out features and their relevance to interface design
- Use visual features to communicate data effectively and efficiently

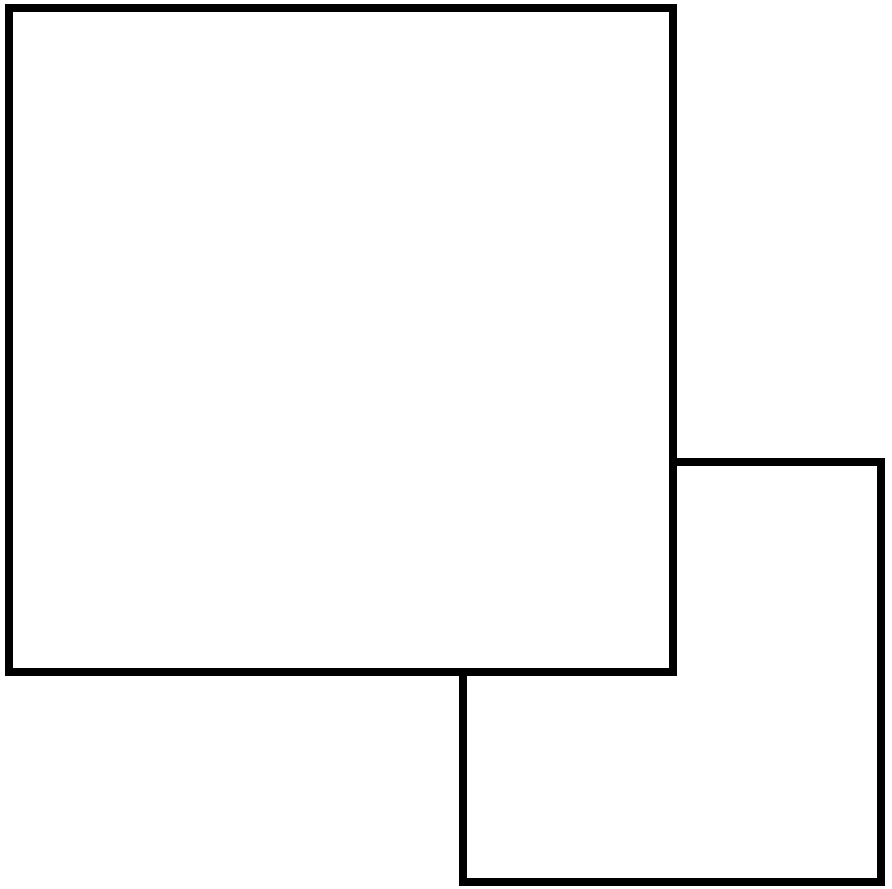
Human Vision Recap

- Light shines into our eyes, all the time
- Photoreceptors sense intensity and frequency, as basis for colour perception
- Images from both eyes are fused into a single field-of-view
- We move eyes (and head) to obtain detail from objects of interest with foveal vision
- … while keeping track of changes in the bigger picture with peripheral vision



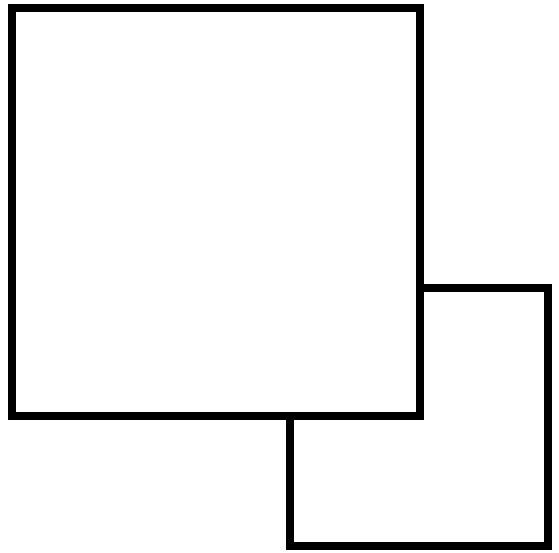


What do you see?



Gestalt Perception

- **Human vision is biased to perceive structure**
  - Whole shapes, figures and objects
- *Gestalt*
  - German for “unified whole”
  - Essence or shape of an entity's complete form
  - Pattern, configuration
- Given a visual image, the human brain chooses the simplest interpretation



Gestalt Principles

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- Gestalt principles are laws of human perception
  - How we find order in what we see
  - How we recognize groups, relationships and patterns
  - How we see individual elements as a whole
  - How we simplify complex images when we perceive objects
- Background in “Laws of Gestalt” in psychology
- Applied as principles in visual design and information visualization
- What follows are examples (not complete)

Perception of Objects: Emergence

- “Seeing the big picture”
- Perceiving the whole without having to analyse the individual parts

Gestalt Rule: **Emergence**

Interaction Design Foundation
interaction-design.org

Perception of Objects: Closure

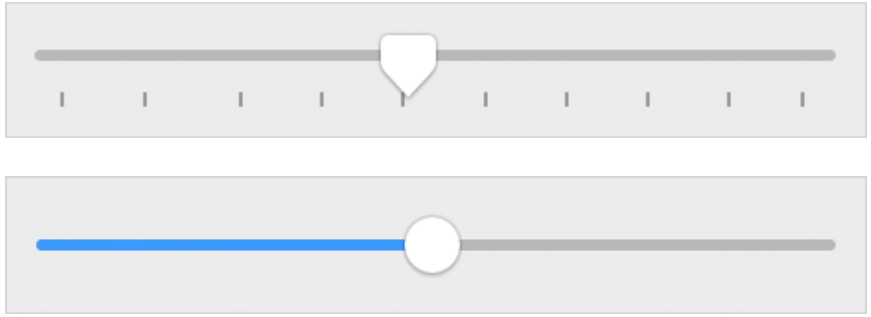
- Seeing the complete shape even when only parts are visible
- The mind fills in the gaps

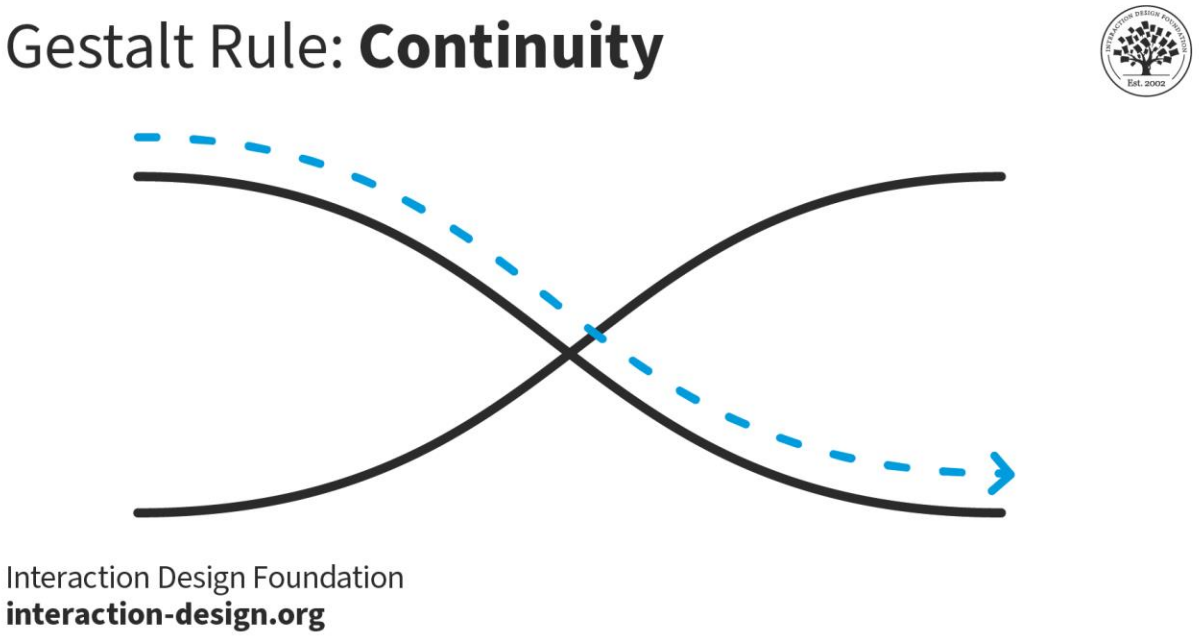
Gestalt Rule: **Closure**

Interaction Design Foundation
interaction-design.org

Perception of Objects: Continuity

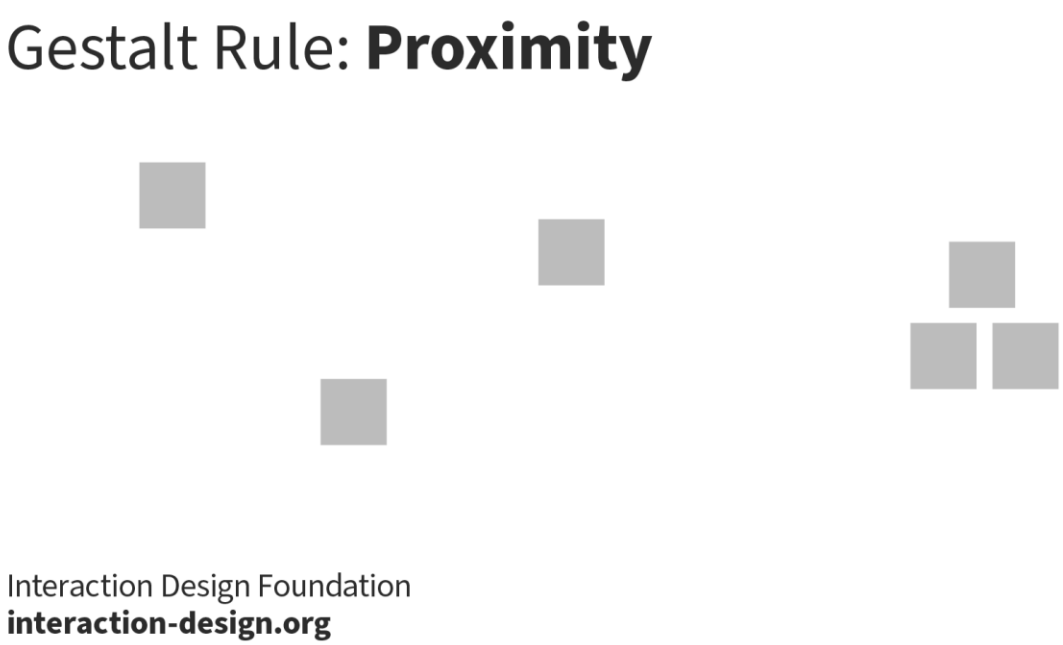
- Grouping elements that follow the same path
- Seeing a continuous shape even if partly occluded





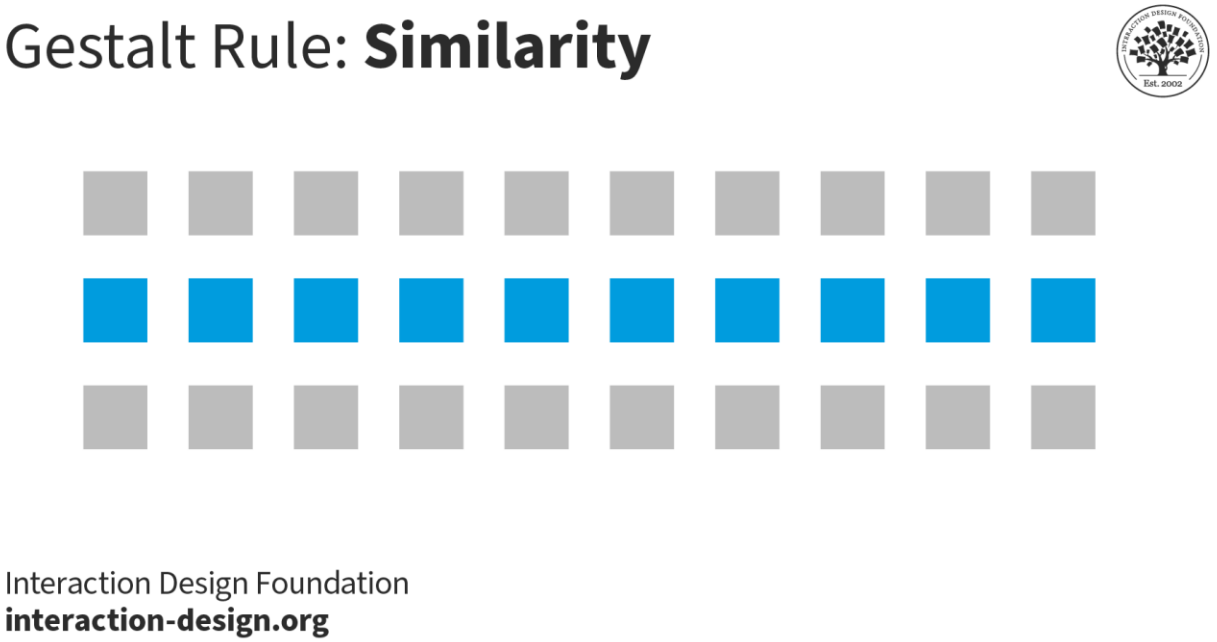
Perception of Groups: Proximity

- Objects that are closer together are perceived as a group



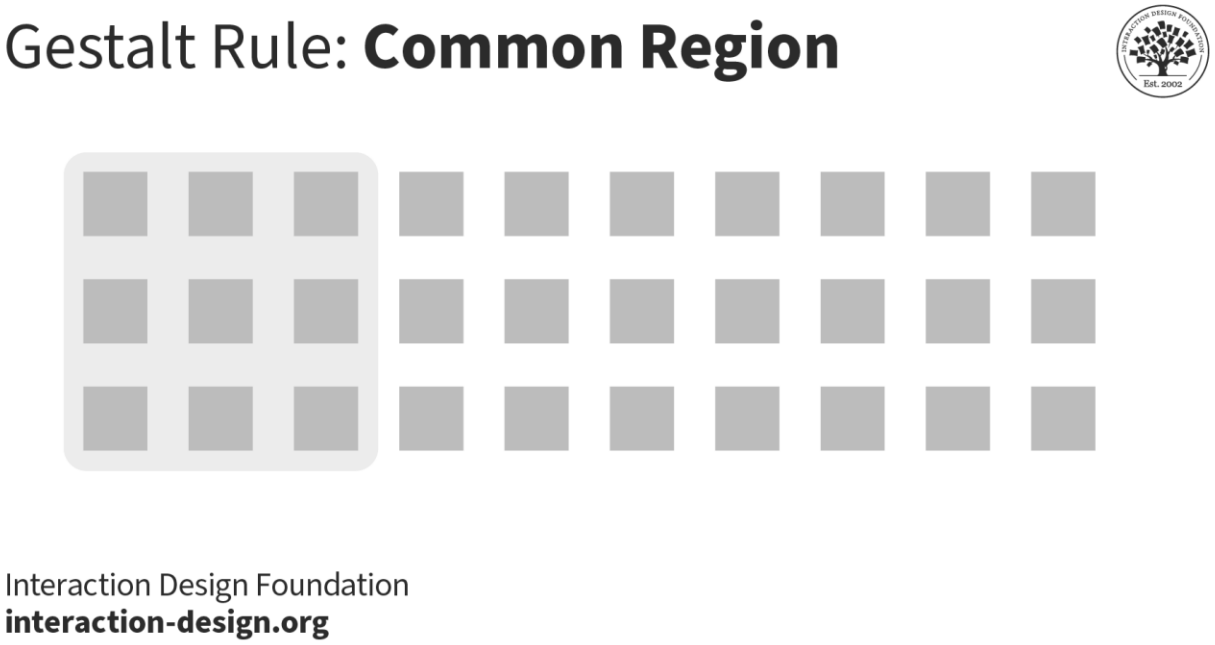
Perception of Groups: Similarity

- Objects that share visual characteristics are perceived as grouped



Perception of Groups: Common Region

- Objects that are within the same region are perceived as one group
- In many guidelines, this principle is called “Enclosure”



Perception of Image Structure: Figure/Ground

- To simplify an image, the brain separates foreground (“figure”) from background (“ground”)
- Important, as more attention is given to the foreground
- In visual design, separation is supported by contrast
- Smaller, brighter, crisper objects are perceived as in front

Gestalt Rule: **Figure/Ground**

Rubin’s Vase

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interaction-design.org

Rubin’s Vase is an example where figure/ground separation is ambiguous (not stable).

Gestalt Principles in Design

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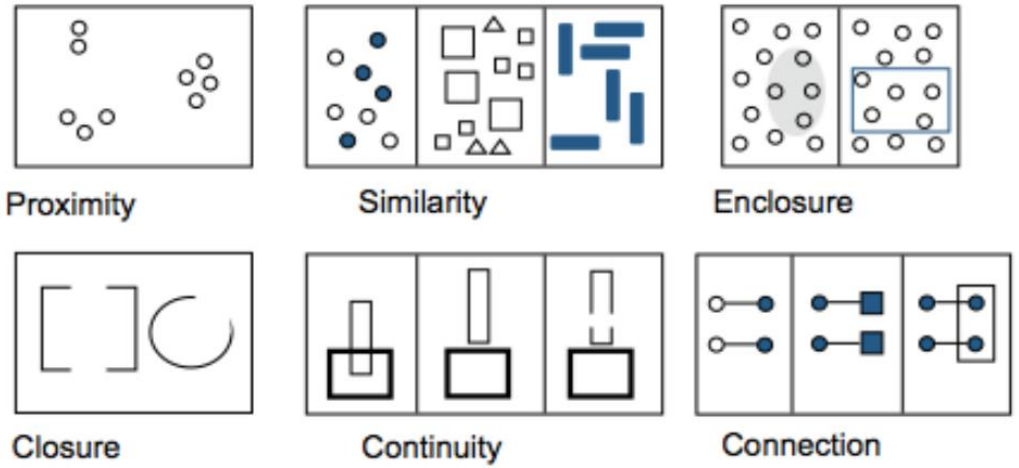
- Read article on Gestalt Principles on interaction-design.org
  - Covers further principles and examples
  - Exercise sheet E2
- In design guidelines, you will often find shorter lists of Gestalt principles
  - Focused on direct application to visual design and visualization



Cole Nussbaumer Knaflic. Storytelling with Data, 2015, Wiley

Gestalt and Structure – Key Points

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- Gestalt principles describe how we see structure in all of the visual stimuli that we receive
- Perception of
  - the whole even if not complete
  - groups and relationships
  - foreground versus background
- In design, Gestalt principles guide the layout of user interfaces and information, to effectively communicate structure

Visual Perception

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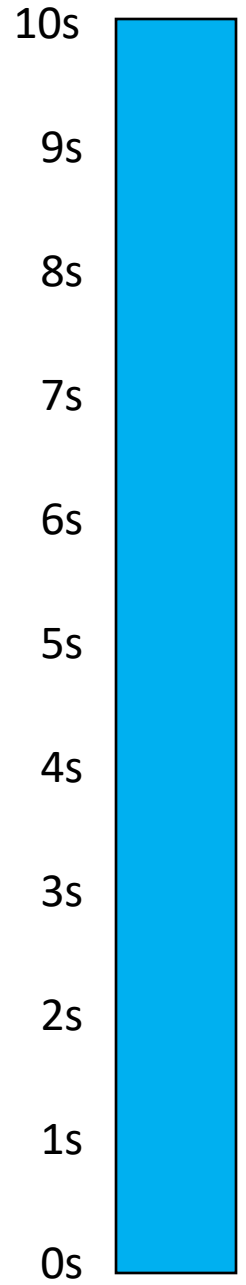
- Gestalt – Perception of Form
- **Visual Search**
- **Preattentive Processing**
- Visual encoding of data

Visual Search: Experiment

- Task: find specific information on a display
- Task will be timed
- Be as fast as possible
- When you found the answer, check the timer
- Note how long it took



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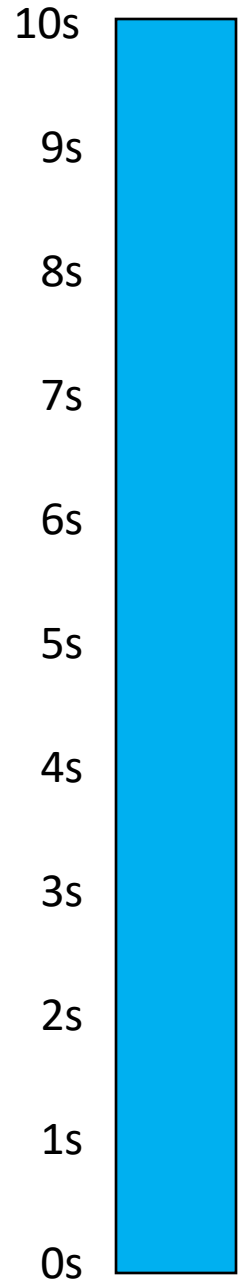
Find the price of …

Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $18 D: $20
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $29 D: $36
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $21 D: $26
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $19 D: $25
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $23 D: $28
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $22 D: $24
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $20 D: $24
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $22 D: $25
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $32 D: $40
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $20 D: $27
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $16 D: $18



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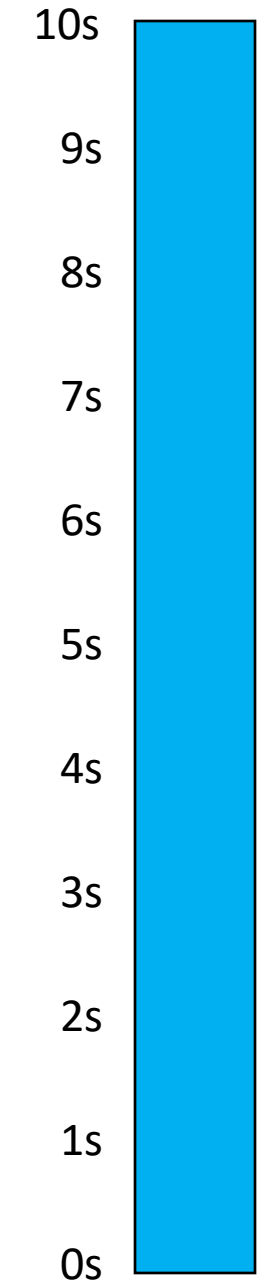
Find the price of …

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada Inn	803	774-8281	$33	$40
Charleston	Sheraton Inn	803	744-2401	$34	$42
Columbia	Best Western	803	796-9400	$29	$34
Columbia	Carolina Inn	803	799-8200	$42	$48
Columbia	Days Inn	803	736-0000	$23	$27
Columbia	Holiday Inn NW	803	794-9440	$32	$39
Columbia	Howard Johnsons	803	772-7200	$25	$27
Columbia	Quality Inn	803	772-0270	$34	$41
Columbia	Ramada Inn	803	796-2700	$36	$44
Columbia	Vagabond Inn	803	796-6240	$27	$30



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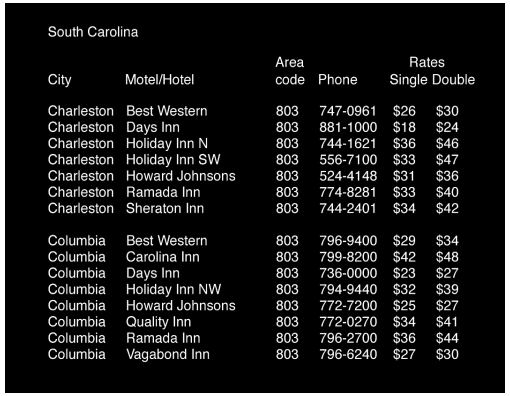
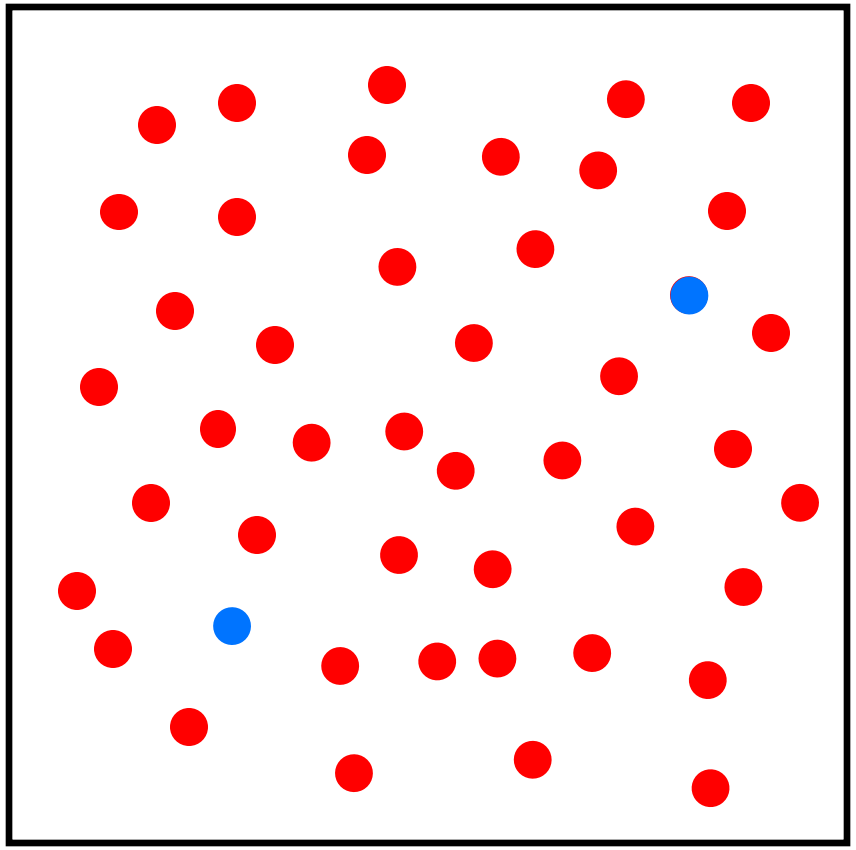
Visual Structure

- Visual structure helps us scan and understand information more quickly
- The two screens have the same amount of information, and same number characters and white pixels
- Spacing, grouping and alignment reduces search time



- Original experiment:
  - Preece et al., Human-Computer Interaction, 1994
  - mean of 5.5 sec for first screen, 3.2 sec for second

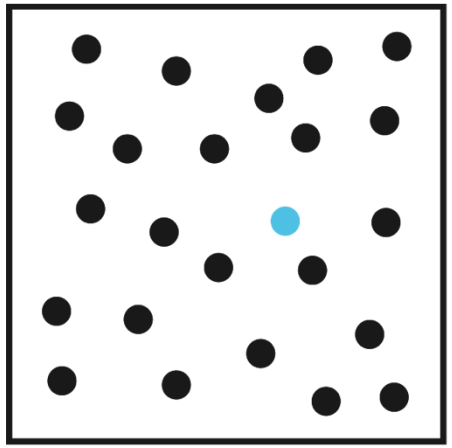
Another Experiment!



- Task: Detect whether a blue dot is present, among all the red dots

Preattentive processing

- Preattentive processing of visual information is performed automatically on the entire visual field
  - quickly, effortlessly and in parallel
  - without focussing visual attention
- Visual information processing is called *preattentive*, when information is gained in less than 200-250ms
  - Less time than would be needed to move the eyes
  - Relying on peripheral vision



Attention guidance

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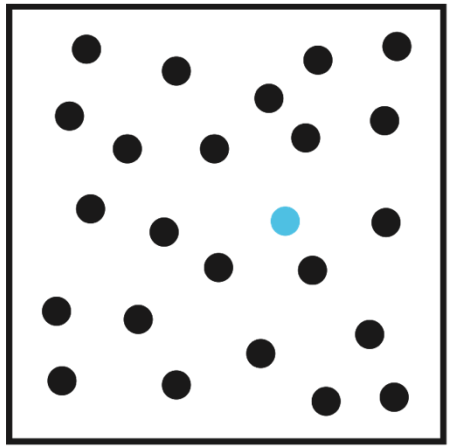
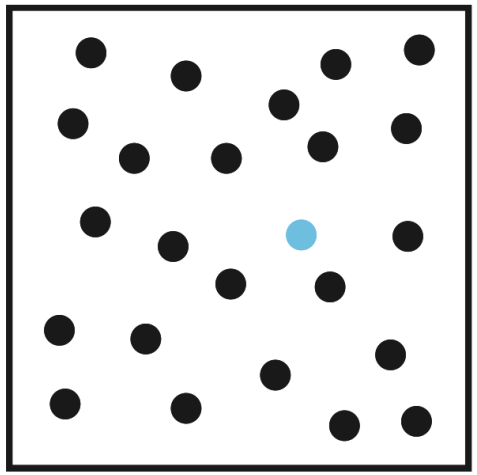
- In human vision, preattentive processing is the mechanism that lets us notice events in the visual periphery
  - Drawing our attention
  - Directing foveal vision
- In visual design, we can apply knowledge of preattentive processing
  - to direct attention to critical information
  - to convey information “at a glance”

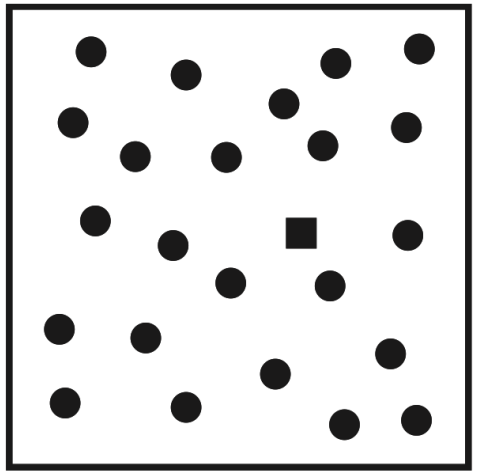


Pop-out features

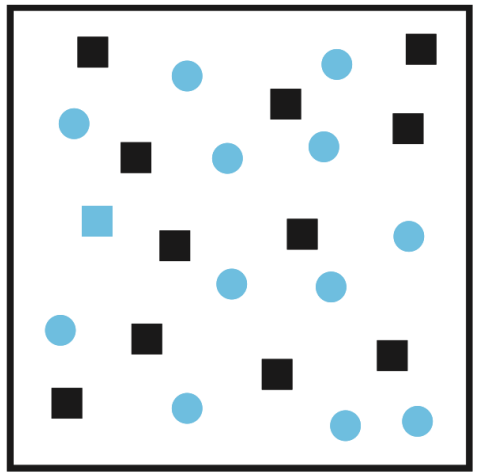
- Pop-out features (also called out preattentive features) are visual properties that can be perceived without focussed attention



Colour pops out (blue circle)



Shape pops out (square)



Combined features (blue square) need more search time

Pop-out features for data visualisation

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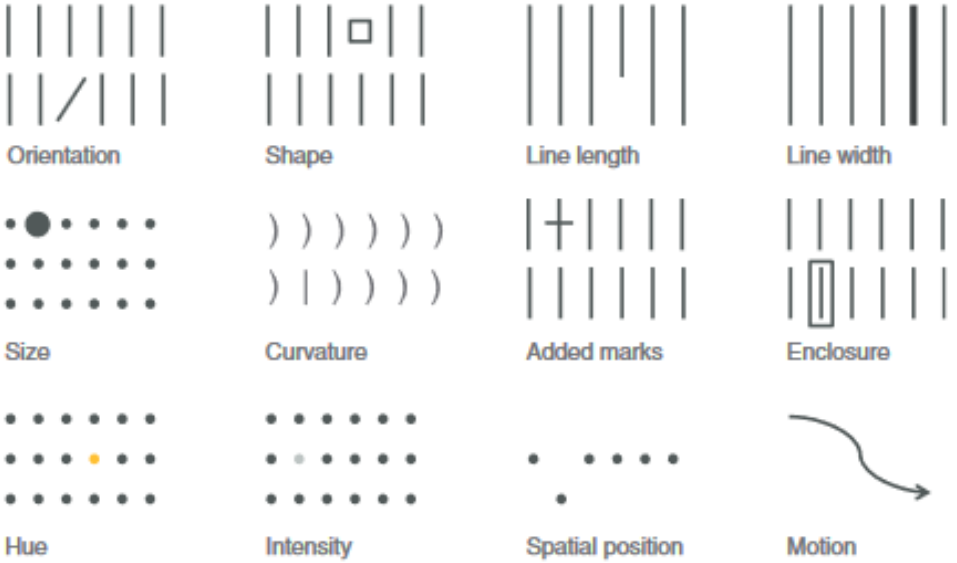
- Pop-out features help communicate information efficiently
- Some features pop out more than others
  - Colour is stronger than shape
  - Motion is effective
    (but can be annoying)
- Some features convey quantitative information “at a glance”:
  - Length, size, position
  - Orientation



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Visual Search – Key Points

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- Visual structure and representation matter: we find information faster when it is presented with a clear visual structure
- We can accomplish basic visual tasks without moving our eyes
  - Seeing whether an object is present or not … if it is visually distinct
- Pop-out features draw our attention and can guide us to relevant information (e.g., highlighting)
- Pop-out features can communicate information efficiently, including quantitative data (e.g., bar charts)

Visual Perception

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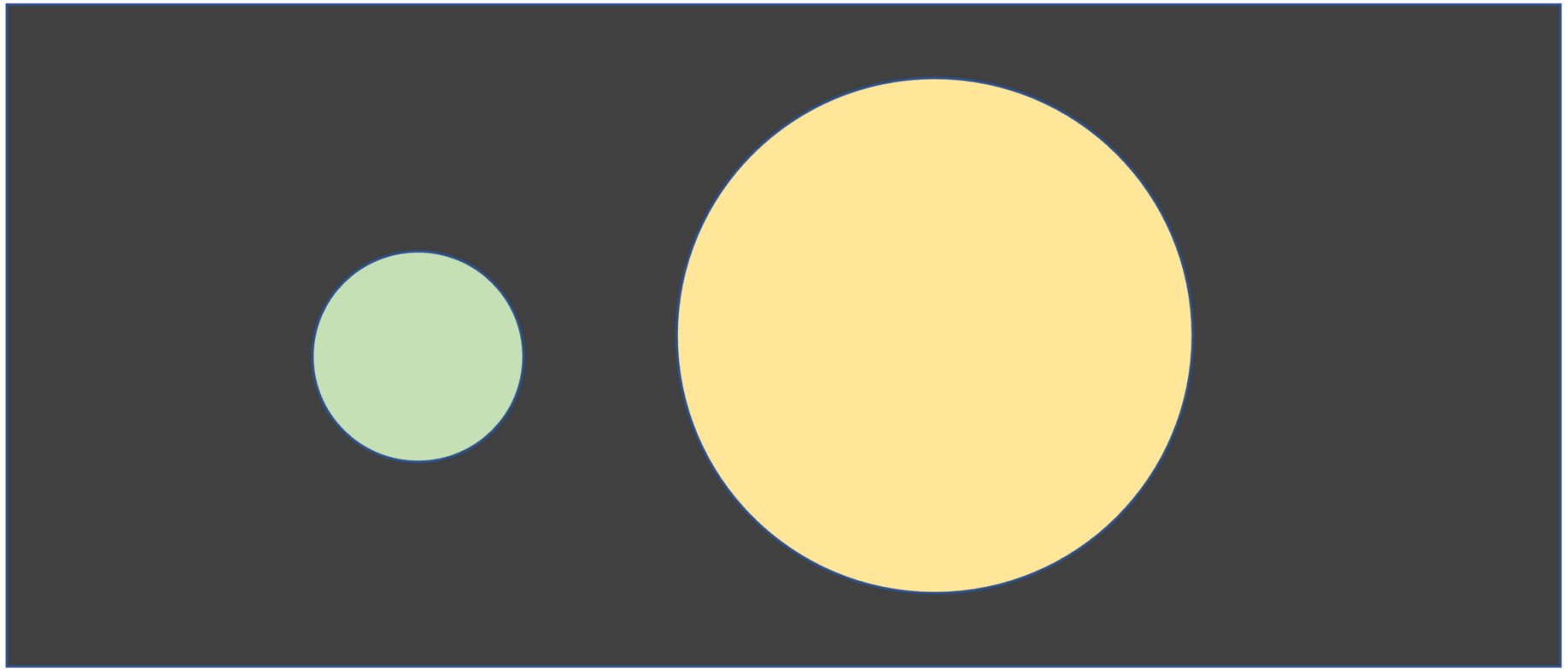
- Gestalt – Perception of Form
- Visual Search
- Preattentive Processing
- **Visual encoding of data**

Mentimeter



Visualisation: Basics

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- In visualisation, we deal with different *types of data*
  - Categorical (also called nominal): Variables that just have named attributes
  - Ordinal: variables, where the possible values have a logical order
  - Quantitative: variables have a magnitude
- We use *perceptual channels* for representing data visually
  - Position (on a scale, or in a 2D plot or image)
  - Size (area), length
  - Colour, brightness
  - Shape, etc

Visual encoding: Position

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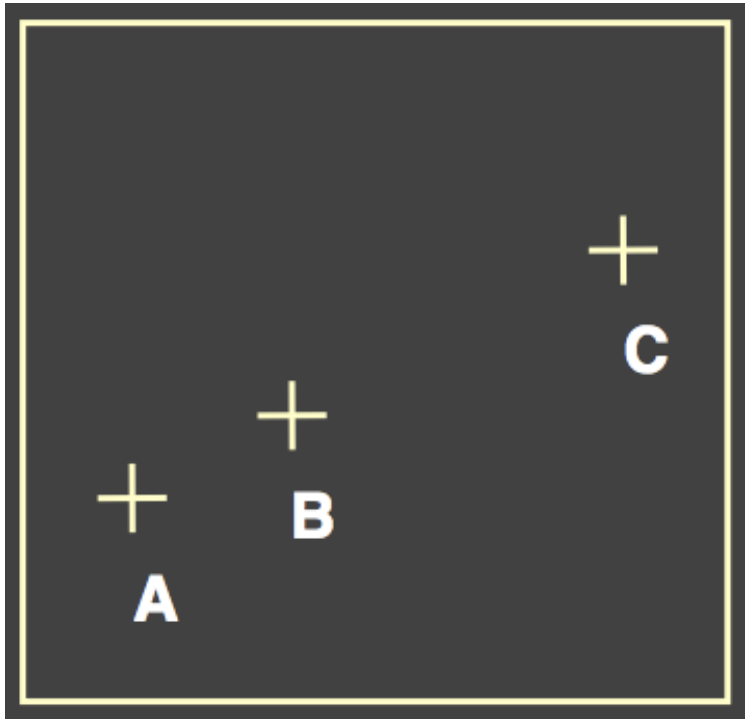
- Position in an image is a highly expressive channel
- Encoding quantitative variables
- Example
  - A, B, C are distinguished by position
  - We can see at a glance that B is between A and C
  - BC is about twice as long as AB



Visual Encoding: Colour Hue and Value

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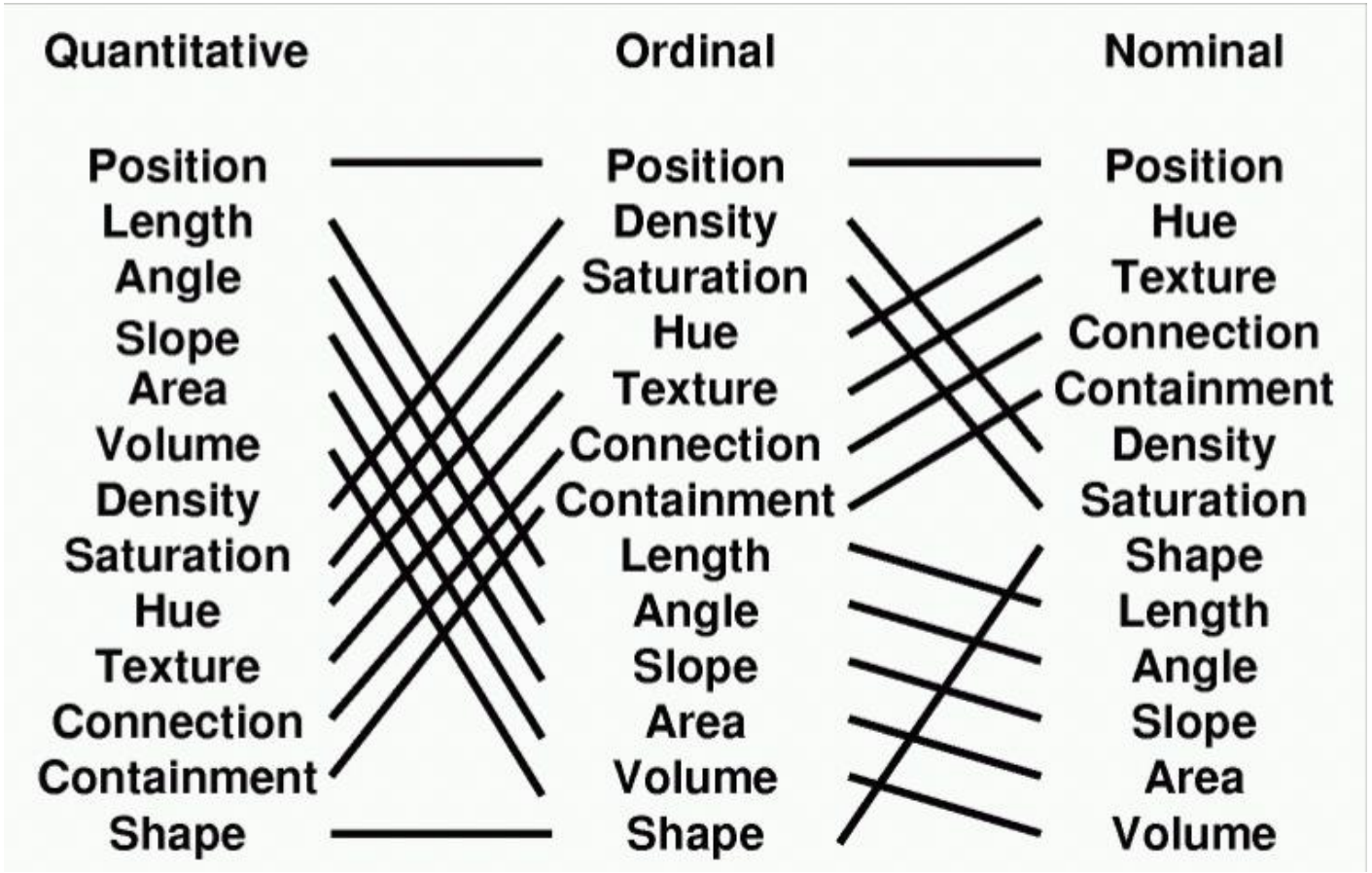
- Value (lightness) is perceived as ordered
  - Encoding ordinal variables
- Less good for continuous variables
  - We are better at seeing contrast than absolute value
- Colour (hue) is perceived as unordered
  - Encode nominal variables (categories)
  - Rainbow scales are popular but not a great idea

Effectiveness Ranking by Data Type



Mackinlay, J. (1986). Automating the design of graphical presentations of relational information. *ACM Transactions On Graphics (Tog)*, *5*(2), 110-141.

Visual Encoding – Key Points

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- How we perceive data depends on how the data is visually encoded
- Visualisations make use of different perceptual channels to represent data
  - Visual properties that support perception of magnitudes or categories
- Visual encodings vary in their effectiveness (and expressiveness)
  - How quickly information can be perceived
  - How accurately
  - How much effort / thinking

Next Lecture: Movement and Fitts' Law

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- Fitts' Law – modelling human performance
- Speed-accuracy trade-off – in pointing and other aimed movements
- Index of Difficulty – what makes a task easier or harder?
- Throughput – efficiency in conveying information with a pointing device

Lecture Revision

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- Look up further Gestalt principles. What is the principle of Symmetry?
- Floating action buttons have become popular in user interfaces. Which Gestalt principle explains our perception of these buttons as in front of the content over which they are displayed?
- On which part of the visual system does preattentive processing rely?
- Why is it not a good idea to use a rainbow scale for data visualization?