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# Data Analytics
# SET10109

Understanding Data Using Visualisation

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# Gestalt: Form from patterns

The visual system will attempt to find structure in the pattern of visual data.

Individual elements will be combined into a meaningful '**whole**', known as **binding**.

"The whole is 'other' than the sum of its parts." –Kurt Koffka

The laws of Gestalt attempt understand this process.

Gestalt Laws/Principles: proximity, similarity, connectedness, continuity, symmetry, closure, relative size, common fate.

**Law of Parsimony:** Simplest explanation 'wins'

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# Gestalt Principals/Laws.

- Simplicity: every pattern is seen such that the resulting structure is as simple as possible
- Proximity: Things that are near to each other appear to be grouped together
- Similarity: Similar things appear to be grouped together
- Closure: We perceptually close up, or complete, objects that are not, in fact, complete
- Connectedness: things that are physically connected are perceived as a unit
- Continuity: points connected in a straight or smoothly curving line are seen as belonging together
- Common fate: things that are moving in the same direction appear to be grouped together

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# Gestalt Principals/Laws.

- Figure-ground articulation: smaller areas seen as figures against larger background
- Symmetry: the symmetrical areas tend to be seen as figures against the asymmetrical background.
- Past experience: context affects perceptual task
  - Familiarity: things are more likely to form groups if the groups appear familiar or meaningful.

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# Common Theme

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

—Stephen Palmer

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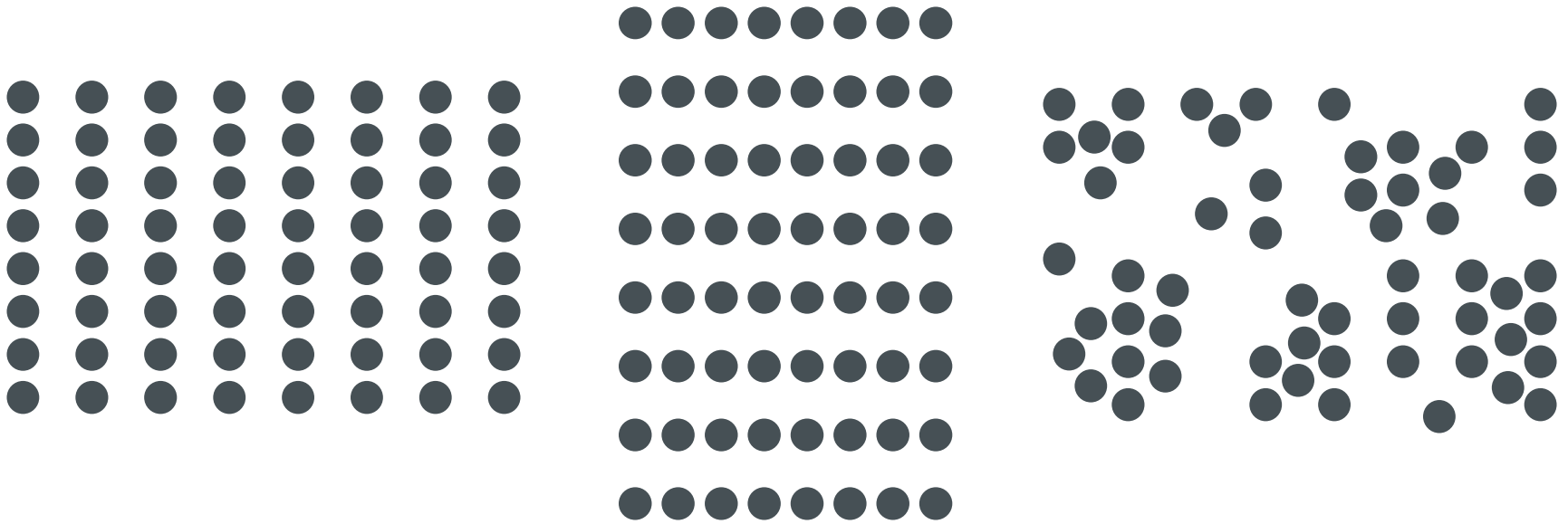
# Common Theme

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

—David Hunter

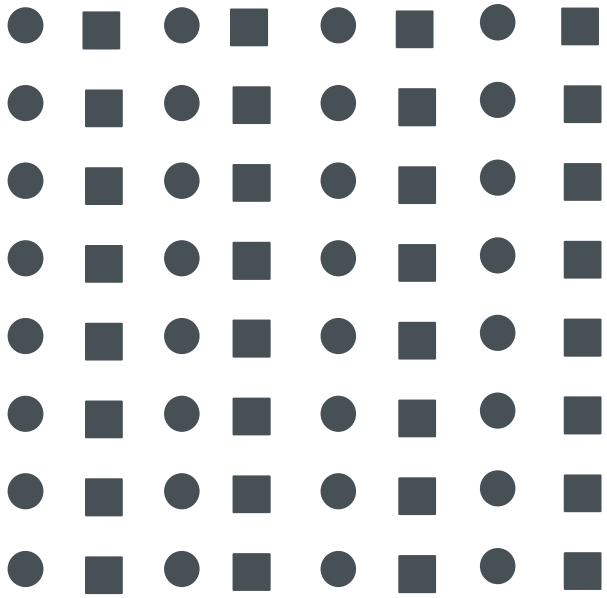
# Principle of Proximity

- Things that are near to each other appear to be grouped together



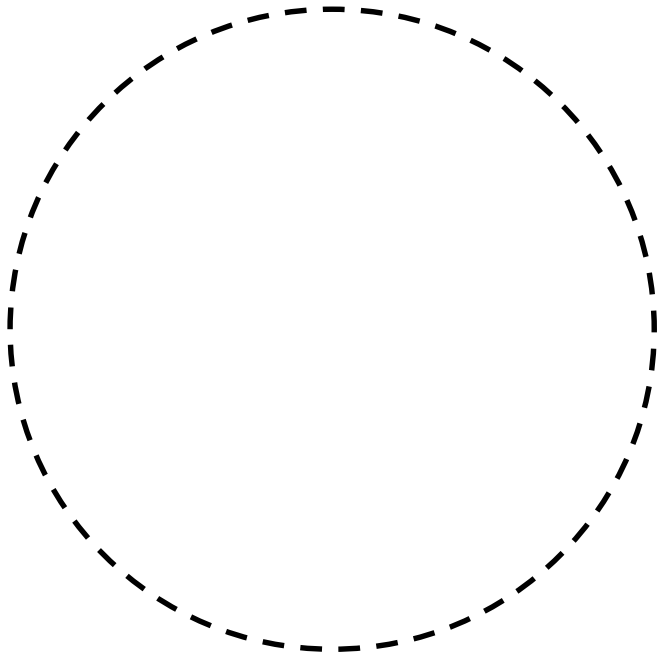
# Principle of Similarity

- Similar things appear to be grouped together



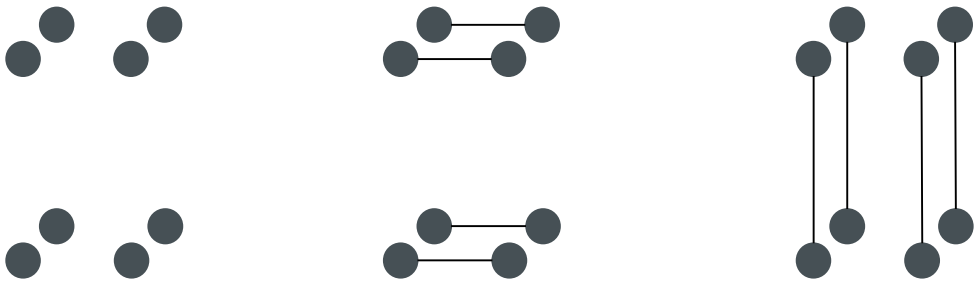
# Principle of Closure

- The law of closure posits that we perceptually close up, or complete, objects that are not, in fact, complete



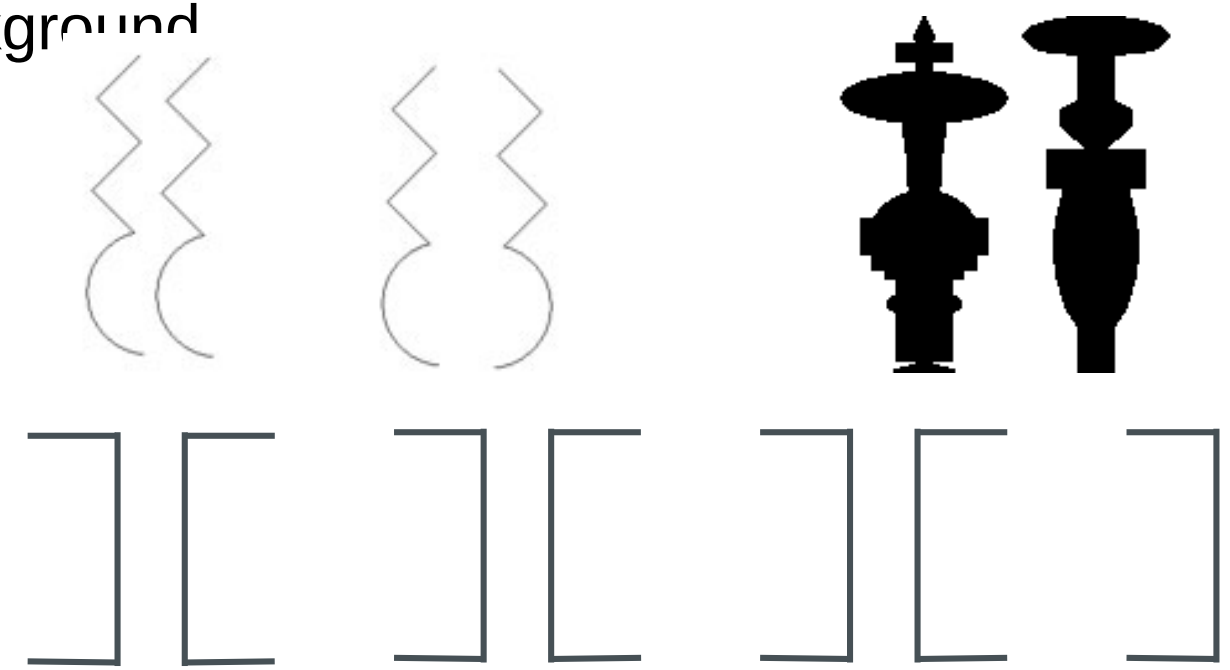
# Principle of Connectedness

- Things that are physically connected are perceived as a unit
- Stronger than colour, shape, proximity, size



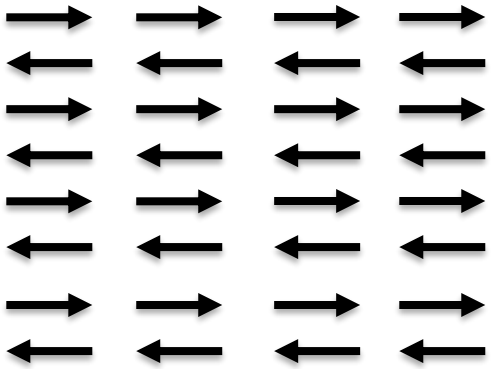
# Principle of Symmetry

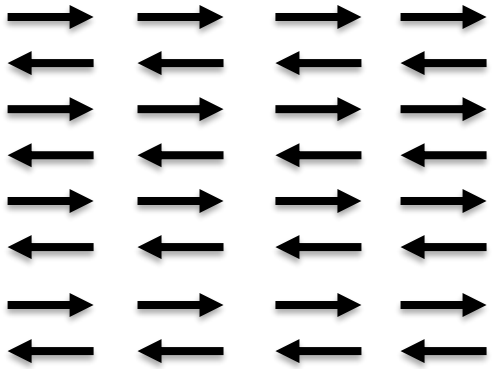
- The principle of symmetry is that, the symmetrical areas tend to be seen as figures against the asymmetrical background



# Principle of Common Fate

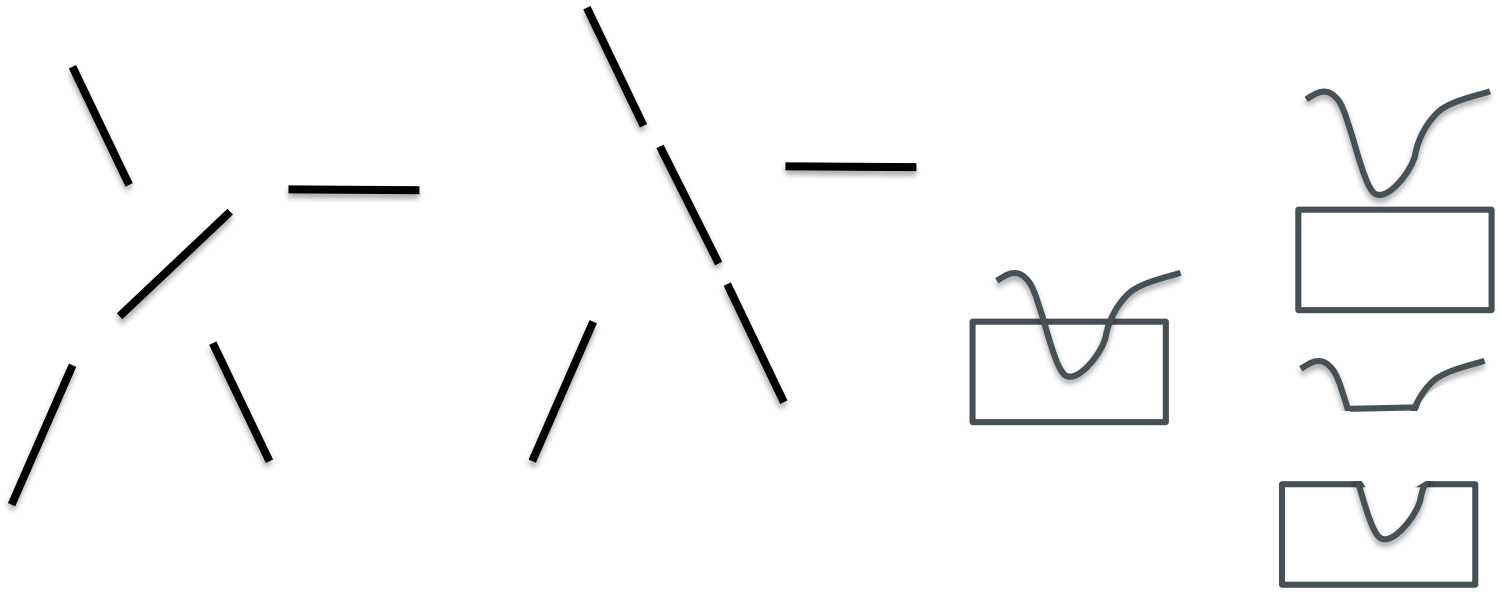
- Things that are moving in the same direction appear to be grouped together





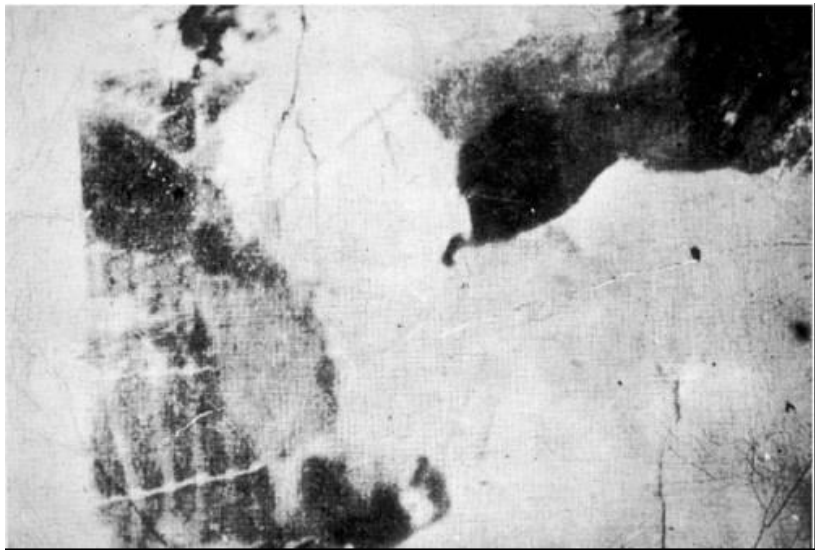
# Principle of Good Continuation

- Points connected in a straight or smoothly curving line are seen as belonging together
  - lines tend to be seen as to follow the smoothest path



# Principle of Familiarity

- Things are more likely to form groups if the groups appear familiar or meaningful



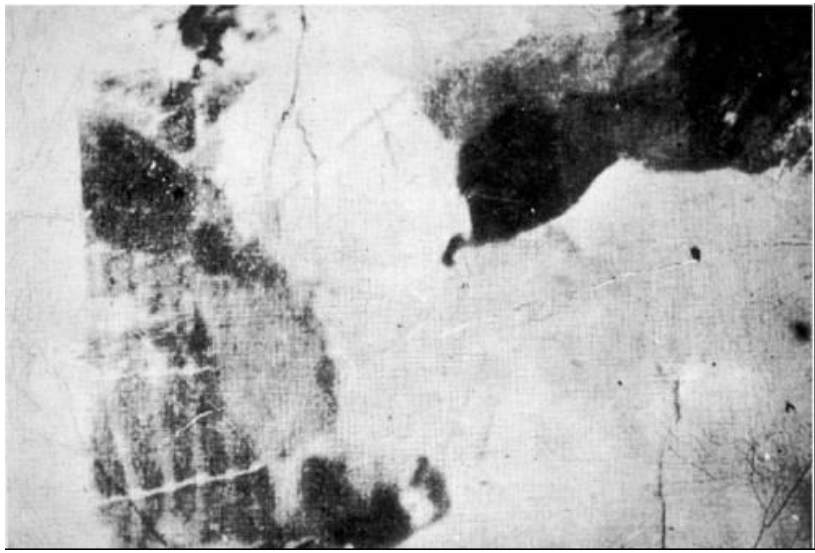
# Principle of Familiarity

- Things are more likely to form groups if the groups appear familiar or meaningful

World Map
Rabbit
Cow

# Principle of Familiarity (Expectations)

- Things are more likely to form groups if the groups appear familiar or meaningful



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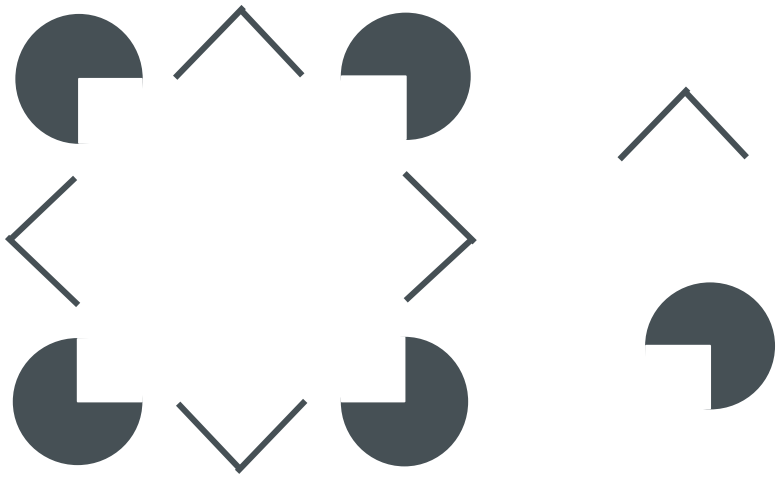
# Reification

- Imagined or illusory shapes.
- Perception is *constructed* from smaller components



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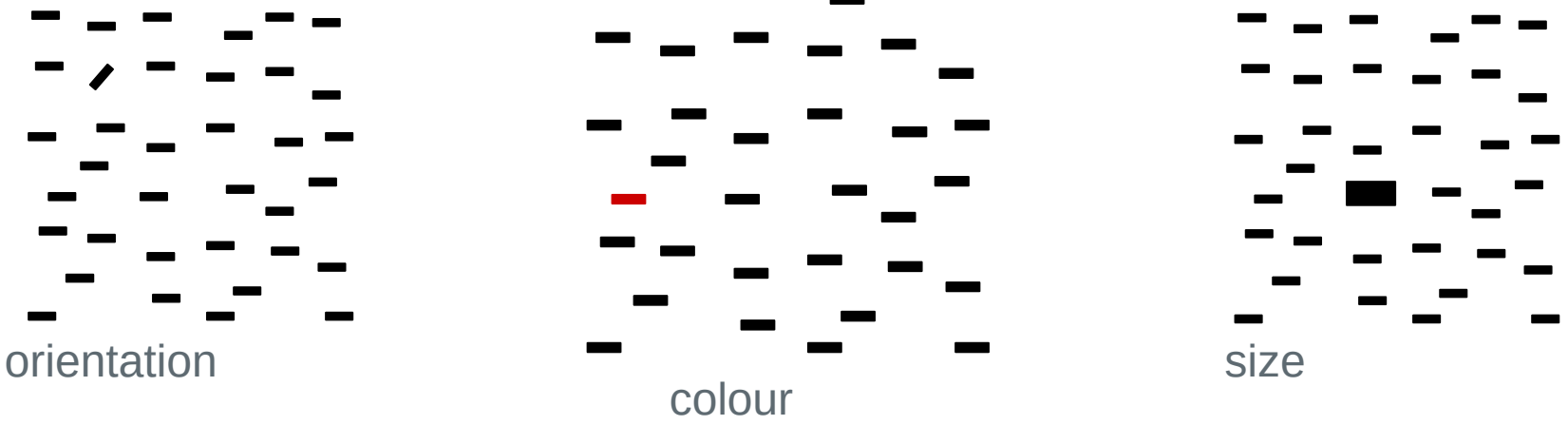
# How Gestalt affects in practice

- Grouping features -
  - Assigning sets of feature to a category for interpretation.
- Visual Search
  - Finding features we are interested in.
- Salience
  - Drawing attention to features the creator is interested in presenting.
- Context
  - Expectations impose a cost on switching ‘modes’

# Preattentive Visual Features

- the ability of the low-level human visual system to rapidly identify certain basic visual properties
- a unique visual property e.g., colour red allows it to "pop out”
- aids visual searching



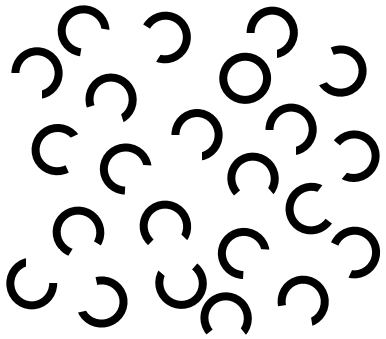
orientation

colour

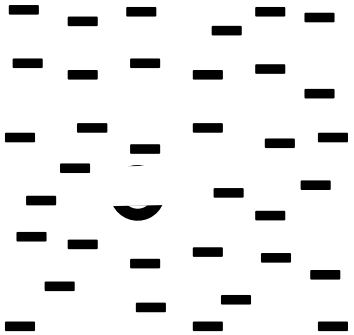
size

# Preattentive Visual Features

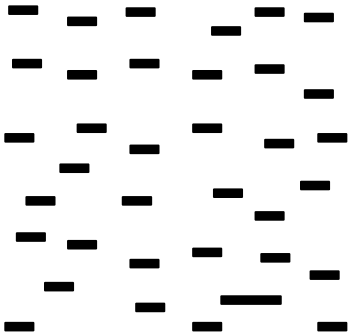
- Some more effective than others



closure

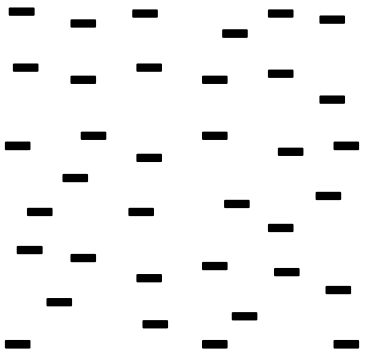


curvature

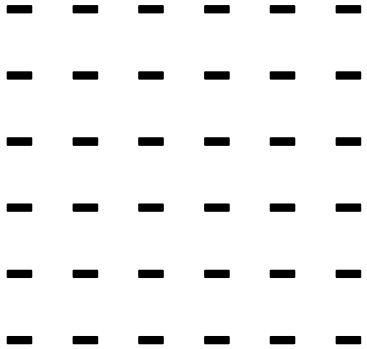


length

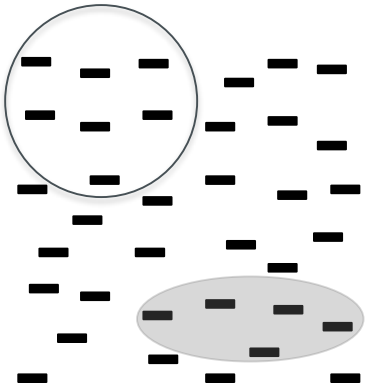
# Preattentive Visual Features



flicker



direction of movement

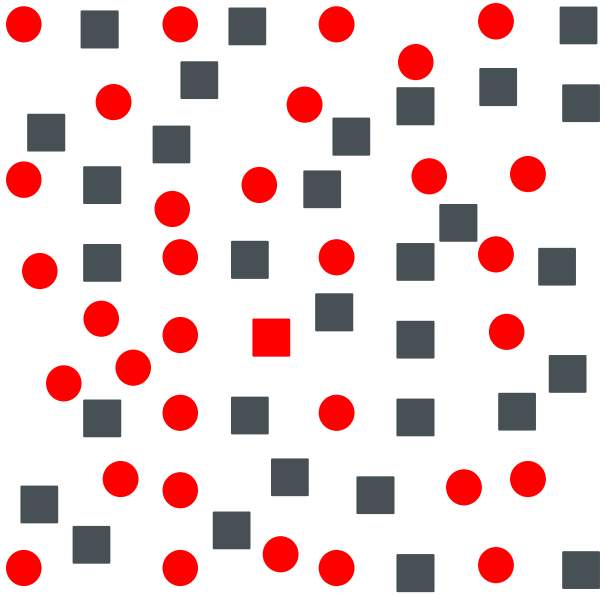


enclosure/containment

Adapted from Perception in visualization C. Healey, : http://www.csc.ncsu.edu/faculty/healey/PP/

# More than 2 Preattentive visual features

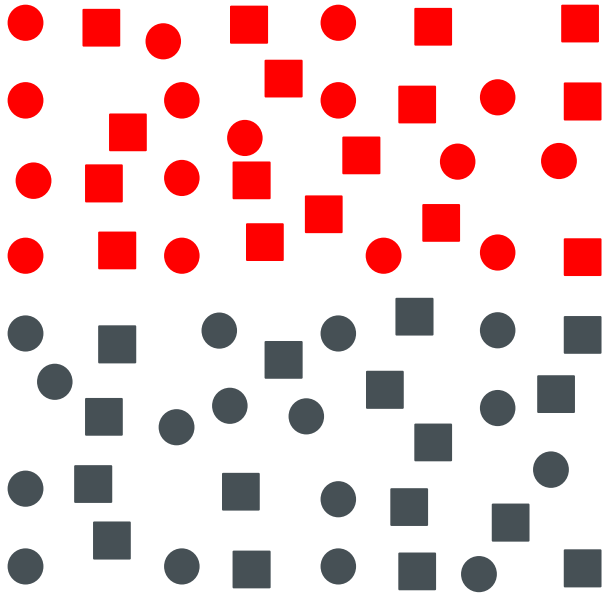
- A target made up of a combination of non-unique features normally cannot be detected preattentively



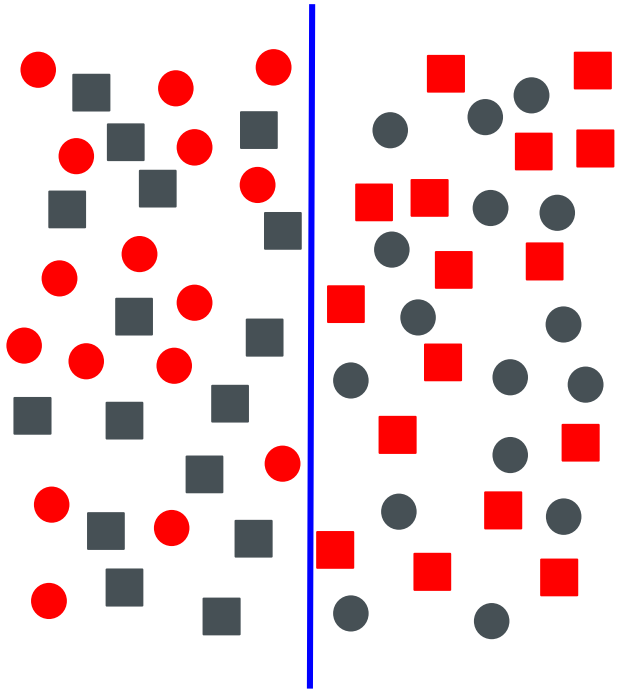
- spot the red square
- difficult to detect
- serial search required

Adapted from Perception in visualization C. Healey, : http://www.csc.ncsu.edu/faculty/healey/PP/

# Boundary detection



Horizontal boundary



Vertical boundary

Adapted from Perception in visualization C. Healey, : http://www.csc.ncsu.edu/faculty/healey/PP/

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# Salience

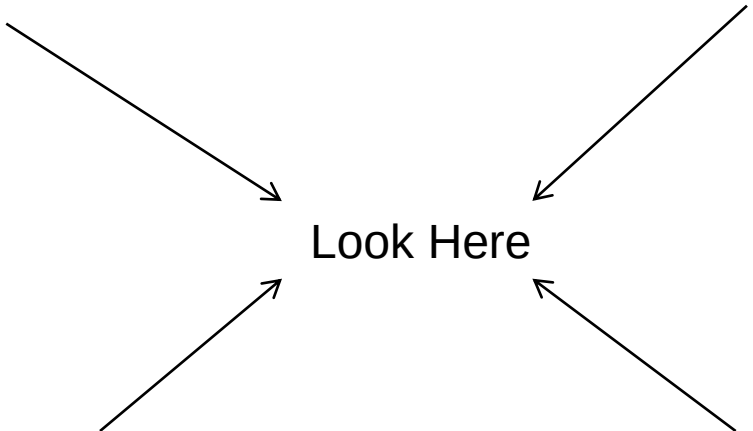
Areas of the image that attract our attention are known as salient.

Examples of highly salient information, includes

- Text, Faces
- Intersections (e.g. of lines)
- An odd-one-out stimulus (failures of Gestalt)

# Salience

- In general we want information to be salient within a figure.
- However this more a guideline than an actual rule.
- Salient features can be used to guide attention to we want it



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# Mixed messages (Stroop effect)

- Red
- Green
- Blue
- Yellow
- Black

- Red
- Green
- Shit
- Yellow
- Black

# Switching Context

Visual search tasks are fastest if we are looking for the same ‘thing’ in the same channel.

Context switch: Change of mode/channel

Change from red-squares to green-squares.

Context switching takes effort, cognitive load.

Load varies depending on .

Red-squares to green-squares to green-circles.

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# Some other considerations.

- Peripheral vs foveal vision.
- Texture and randomness.

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# Peripheral Vision

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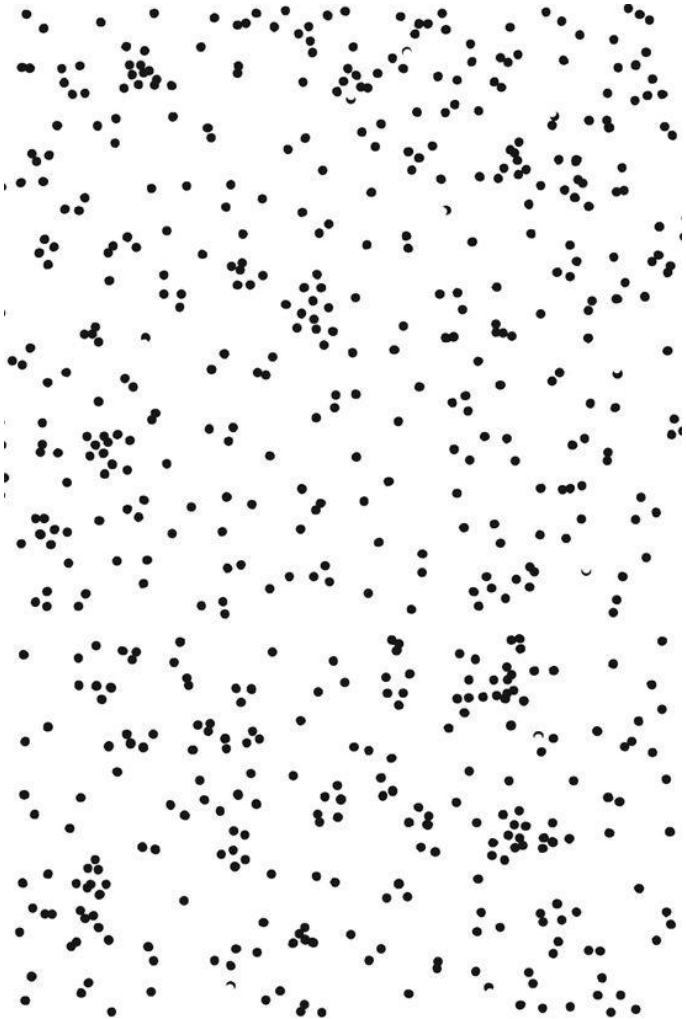
# Visual search video

# Texture vs Randomness

## Texture

- Random Dot



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# Effectiveness

# Effectiveness

- **Effectiveness Principle**: Encode the most important information in the most “effective” way.
  - **Accuracy**: how close is human perceptual judgement to some objective measurement of the stimulus?
  - **Discriminability**: what is the Just Noticeable Difference the visual channel?
  - **Separability**: can the visual channel be judged independently of other visual channels?
  - **Importance Ordering:** the importance of the attribute should match the salience of the visual channel.

| Attribute importance | Salience of visual channel |
|---|---|
| Most important | Most salient |
| ↓ | ↓ |
| Least important | Least salient |

# Types of channel and ranks (Munzner)

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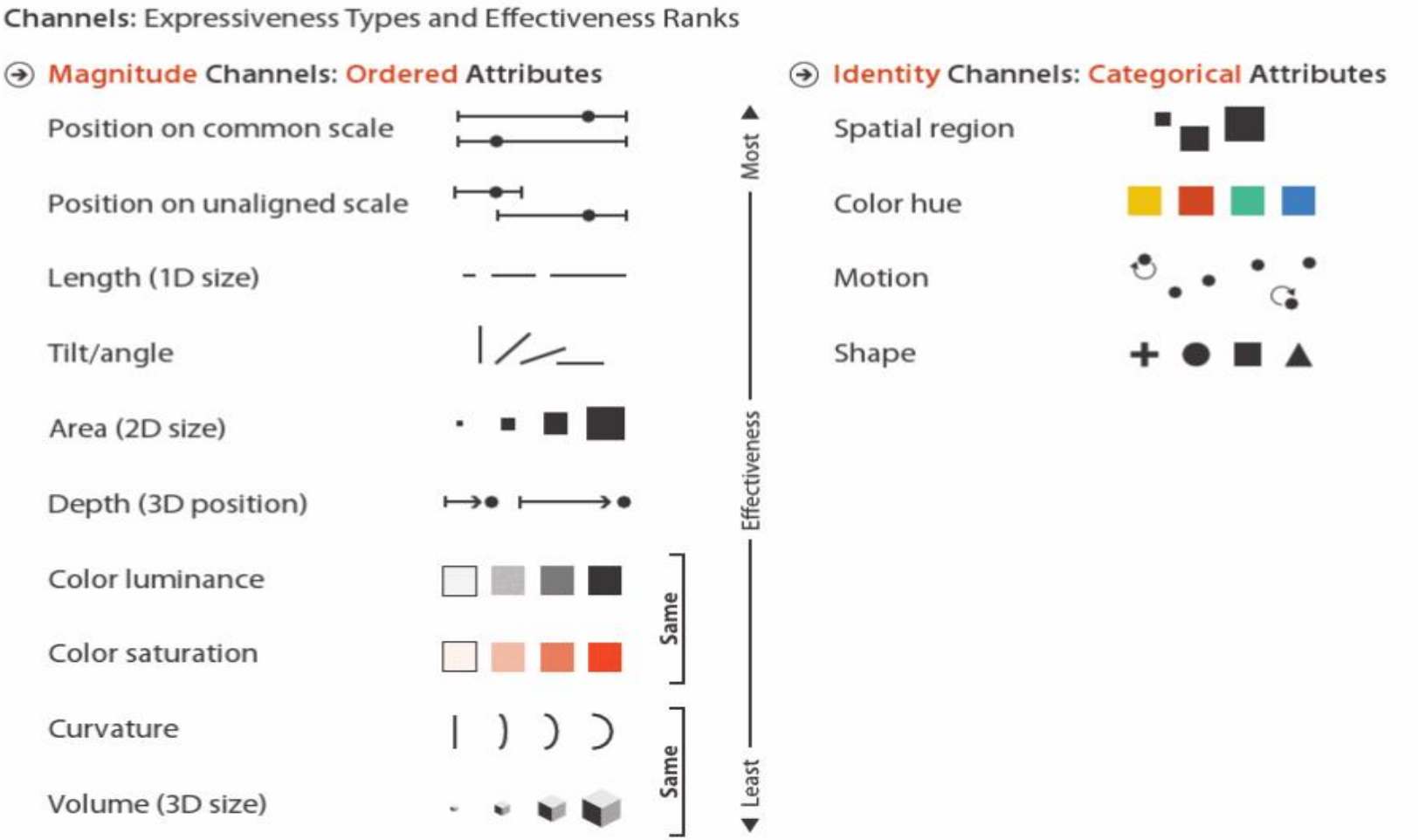



**Figure 5.6.** Channels ranked by effectiveness according to data and channel type. Ordered data should be shown with the magnitude channels, and categorical data with the identity channels.

Munzner, Tamara. Visualization Analysis and Design. CRC Press, 2014. Harvard press

# How were these rankings determined?

- Recap.

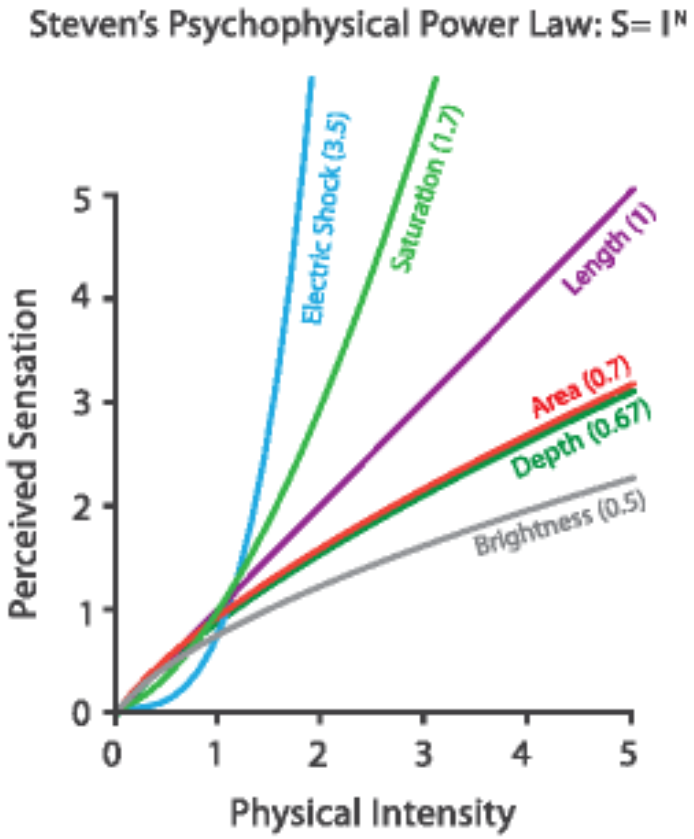
Just Noticeable Differences

What is the smallest change we can detect.

Depends on stimuli

# How were these rankings determined?

- **Accuracy**: how close is human perceptual judgement to some objective measurement of the stimulus?




Steven's power law: $S=I^n$

Perception of sensation:

**Magnified** (n>1):
- Greyscale lightness
- Red-grey saturation

**Compressed** (n<1):
- Area
- brightness

**Accurate** (n=1):
- Length

Figure from Munzner (2014) p104; based on original from Stevens, S.S. (1975). Psychophysics: introduction to its perceptual, neural, and social prospects, Transaction Publishers. Page 17.

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# Steven Few's Graph Design IQ Test

- http://www.perceptualedge.com/files/GraphDesignIQ.html

# Study guide for this lecture

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Required Reading:

Munzner, T. (2014). *Visualization Analysis and Design*.

Chapter 5 - Marks and Channels

Chapter 10 - Map Colour and Other Channels.

Reflective Questions:

- Discuss the properties of data that need to be considered when designing a visualisation, and give examples of how they might influence your design choices.
- Discuss the different properties of an image that are available to us when designing a visual representation and the factors that need to be taken into consideration when making our design choices.
- Illustrating with examples, explain the rules which help us select the best visual encodings for our data.

# References


- Anderson, E. W., Potter, K. C., Matzen, L. E., Shepherd, J. F., Preston, G. a., & Silva, C. T. (2011). A User Study of Visualization Effectiveness Using EEG and Cognitive Load. *Computer Graphics Forum*, *30*(3), 791-800. doi:10.1111/j.1467-8659.2011.01928.x
- Bresciani, S., & Eppler, M. J. (2008). The Risks of Visualization A Classification of Disadvantages Associated with Graphic Representations of Information.
- Cleveland, W., & McGill, R. (1984). Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American Statistical …*, *79*(387), 531-554.
- Ellis, G., & Dix, A. (2007). A taxonomy of clutter reduction for information visualisation. *IEEE transactions on visualization and computer graphics*, *13*(6), 1216-23. doi:10.1109/TVCG.2007.70535
- Fekete, J.-daniel, & Plaisant, C. (2002). Interactive Information Visualization of a Million Items. *Information Visualization, 2002. INFOVIS 2002. IEEE Symposium on*, 117-124. doi:10.1109/INFVIS.2002.1173156
- Stephen Few (2005). Effectively Communicating Numbers: Selecting the Best Means and Manner of Display. http://www.perceptualedge.com/articles/Whitepapers/Communicating_Numbers.pdf
- Hall, J. (2002). Animation : can it facilitate ?, 247-262. doi:10.1006/ijhc.1017
- Heer, J., & Bostock, M. (2010). Crowdsourcing Graphical Perception : Using Mechanical Turk to Assess Visualization Design. *CHI 2010*. Atlanta, Georgia, USA. Retrieved from http://vis.stanford.edu/files/2010-MTurk-CHI.pdf
- Heer, J., & Robertson, G. (2007). Animated transitions in statistical data graphics. *IEEE transactions on visualization and computer graphics*, *13*(6), 1240-7. doi:10.1109/TVCG.2007.70539
- Inbar, O., Tractinsky, N., & Meyer, J. (2007, August). Minimalism in information visualization: attitudes towards maximizing the data-ink ratio. In *Proceedings of the 14th European conference on Cognitive ergonomics: invent! explore!* (pp. 185-188). ACM.
- Mackinlay, J. (1987). Automating the Design of Graphical Presentations of Relational Information. *ACM Transactions on Graphics (TOG)*, *5*(April 1986), 110-141.
- Meyer, M., Sedlmair, M., & Munzner, T. (2012). The Four-Level Nested Model Revisited : Blocks and Guidelines.
- Munzner, T. (2009). A Nested Model for Visualization Design and Validation. *Visualization and Computer Graphics, IEEE Transactions on*, *15*(6), 921-928. doi:10.1109/TVCG.2009.111
- Robertson, G., Fernandez, R., Fisher, D., Lee, B., & Stasko, J. (2008). Effectiveness of animation in trend visualization. *IEEE transactions on visualization and computer graphics*, *14*(6), 1325-32. doi:10.1109/TVCG.2008.125
- Tufte, E. R. (1983). *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press.
- Tufte, E. R. (1990). *Envisioning Information*. Cheshire, CT: Graphics Press.

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# Further reading

- behind every great visualization is a design principle: MARTIN KRZYWINSKI -2012 http://mkweb.bcgsc.ca/vizbi/2012/