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INFORMATION
TECHNOLOGY

FIT3179 Data Visualisation

Week 02: What, why, marks and channels

GROUP OF EIGHT AUSTRALIA

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Lecture Overview

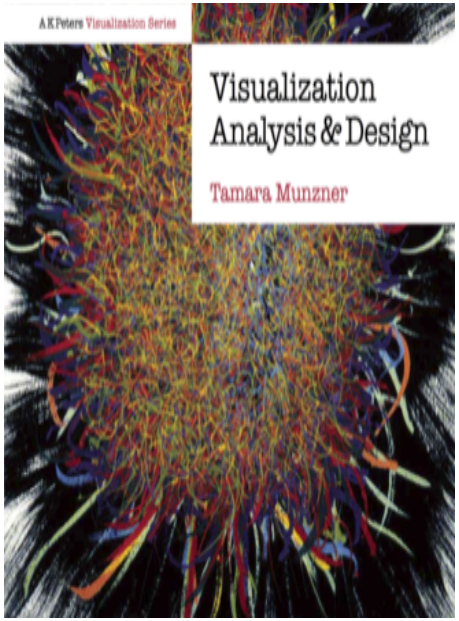
- Student presentations
- Analysis framework (Textbook chapter 4)
  - What? – data abstraction
  - Why? – task abstraction
  - (How? – Week 3)
- Marks and channels (Textbook chapter 5)

Student Presentations

- Choropleth maps presentations

Textbook

- For the next four lectures we will be focusing on the early chapters from the text:
  Visualization Analysis & Design
  by Tamara Munzner
- Available to read electronically for *free* from the Monash Library



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Analysis framework:
Four levels: domain, abstraction, idiom, algorithm
Three questions: What? Why? How?

Textbook chapter 4

Analysis framework: Four levels, three questions

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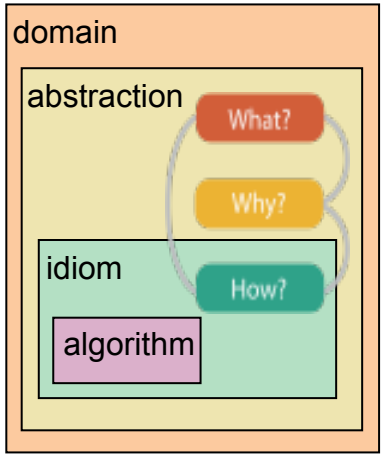
- *Domain: a field of interest of the users*
  - *domain-specific vocabulary, data and workflows*
  - who are the target users?
- *Task and data abstraction*
  - translate from domain to vocabulary of visualisation
  - **what** is shown? **Data abstraction**
    - often don't just draw what you're given: transform to new form
  - **why** is the user looking at it? **Task abstraction** from domain-specific to generic task
- *Idiom for visual encoding and interaction*
  - **how** is it shown?
    - **visual encoding idiom**: how to draw
    - **interaction idiom**: how to manipulate
- *Algorithm*
  - efficient computation



A Multi-Level Typology of Abstract Visualization Tasks
Brehmer and Munzner. IEEE TVCG 19(12):2376–2385, 2013.

Textbook chapter 2

Data Attributes

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Attribute Types

- Categorical
- Ordered
  - *Ordinal*
  - *Quantitative*

Ordering Direction

- Sequential

- Diverging

- Cyclic

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Dataset Types

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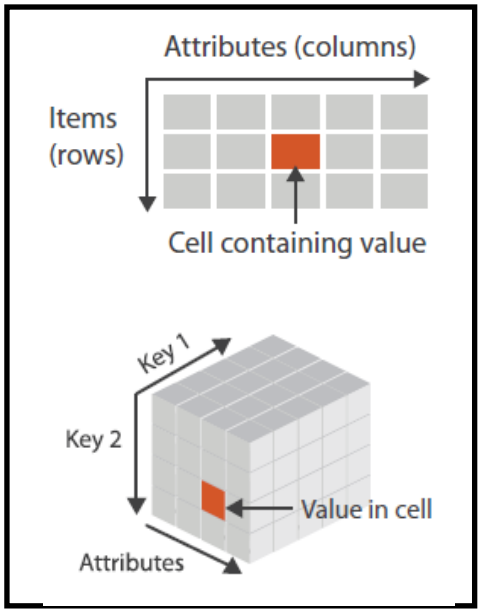
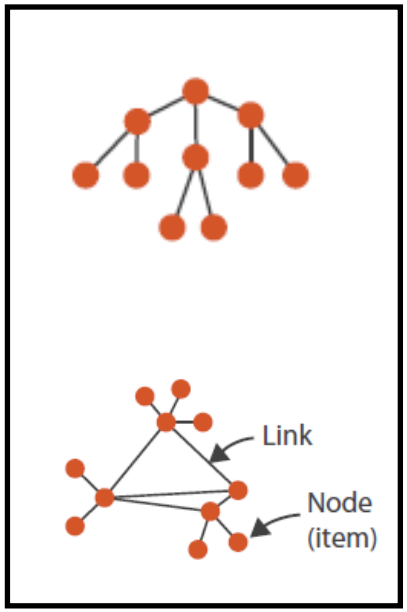
Tables

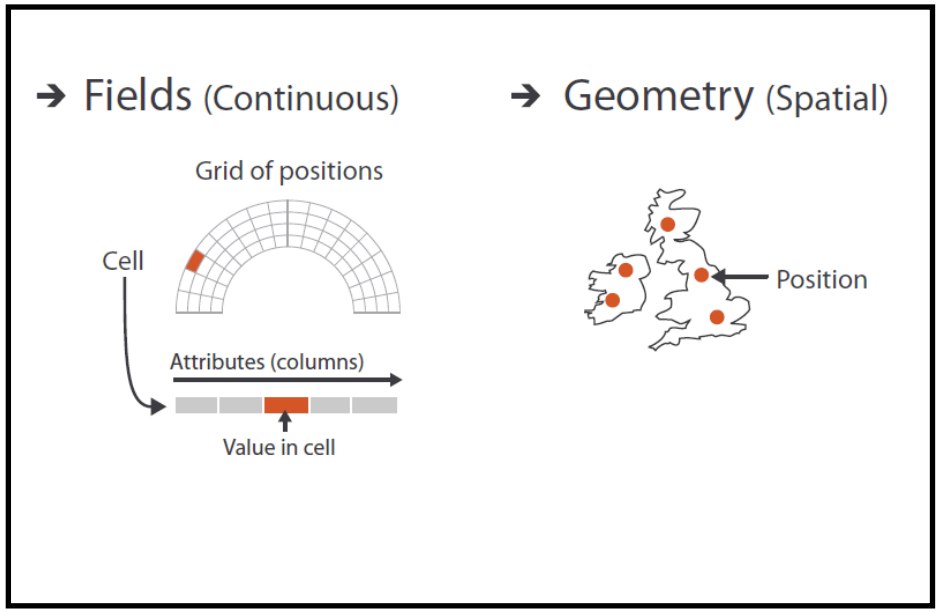


Trees & Networks



Network synonyms
network = graph
node = vertex
link = edge

Spatial



Uniform grid: implicit geometry and topology
A grid cell can have one or more attributes.
Scalar field: 1 attribute per cell.
Vector field: 2 or more attributes with a direction
Tensor field: many attributes per cell.
A field consists of samples of infinitely many values.

A geometry item (point, line or area) can have attributes.

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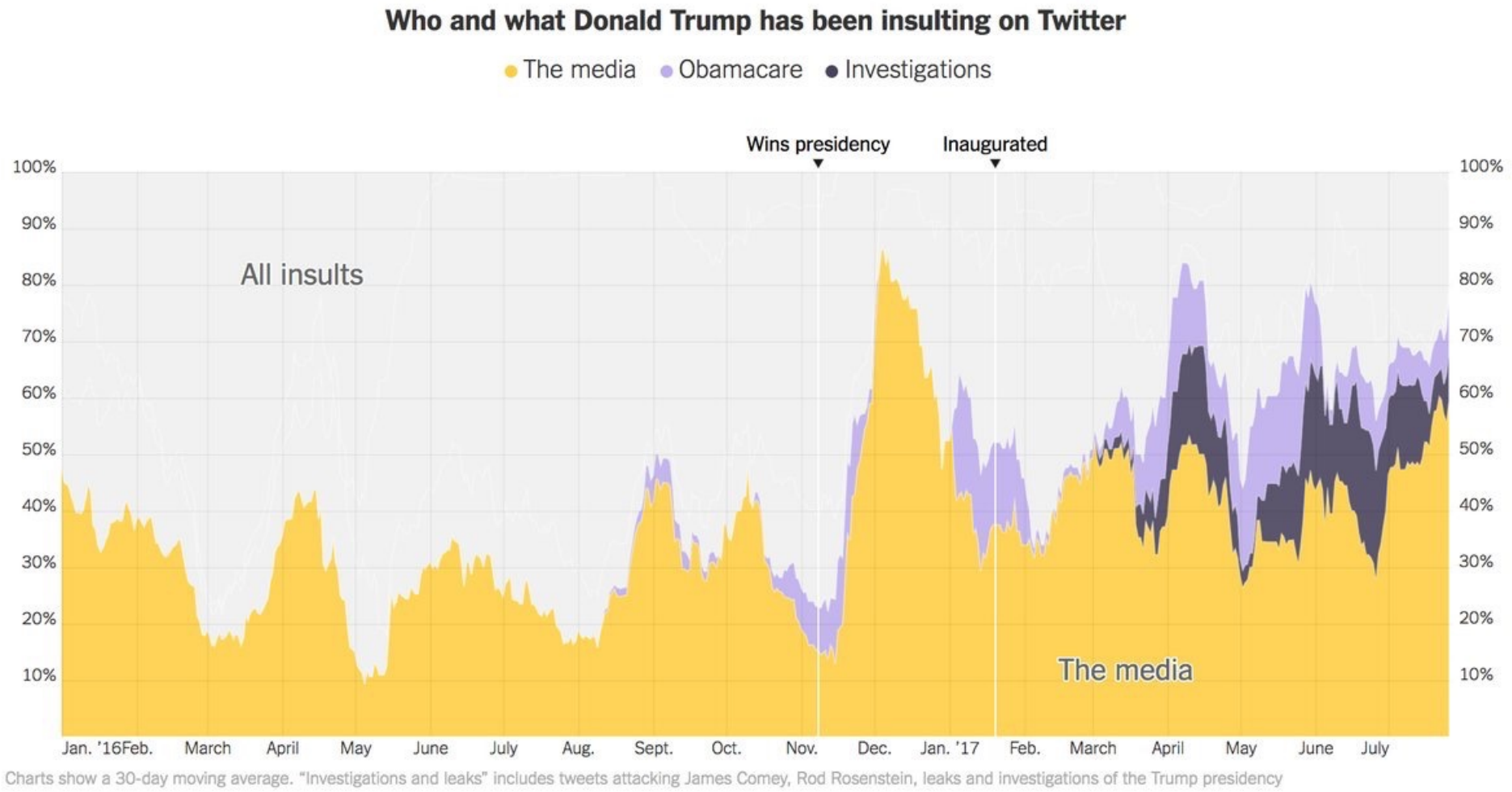
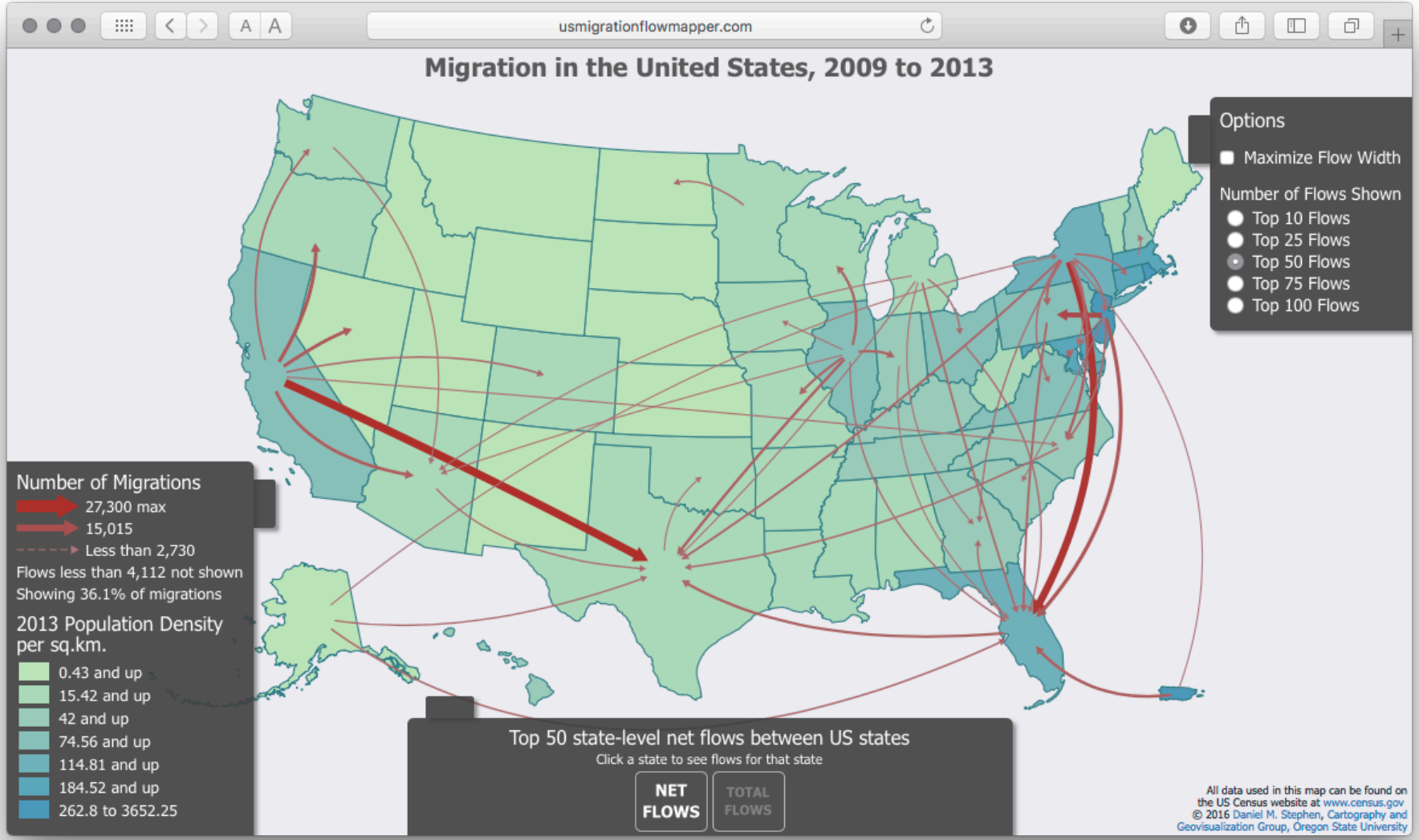
Dataset type? Attribute type?



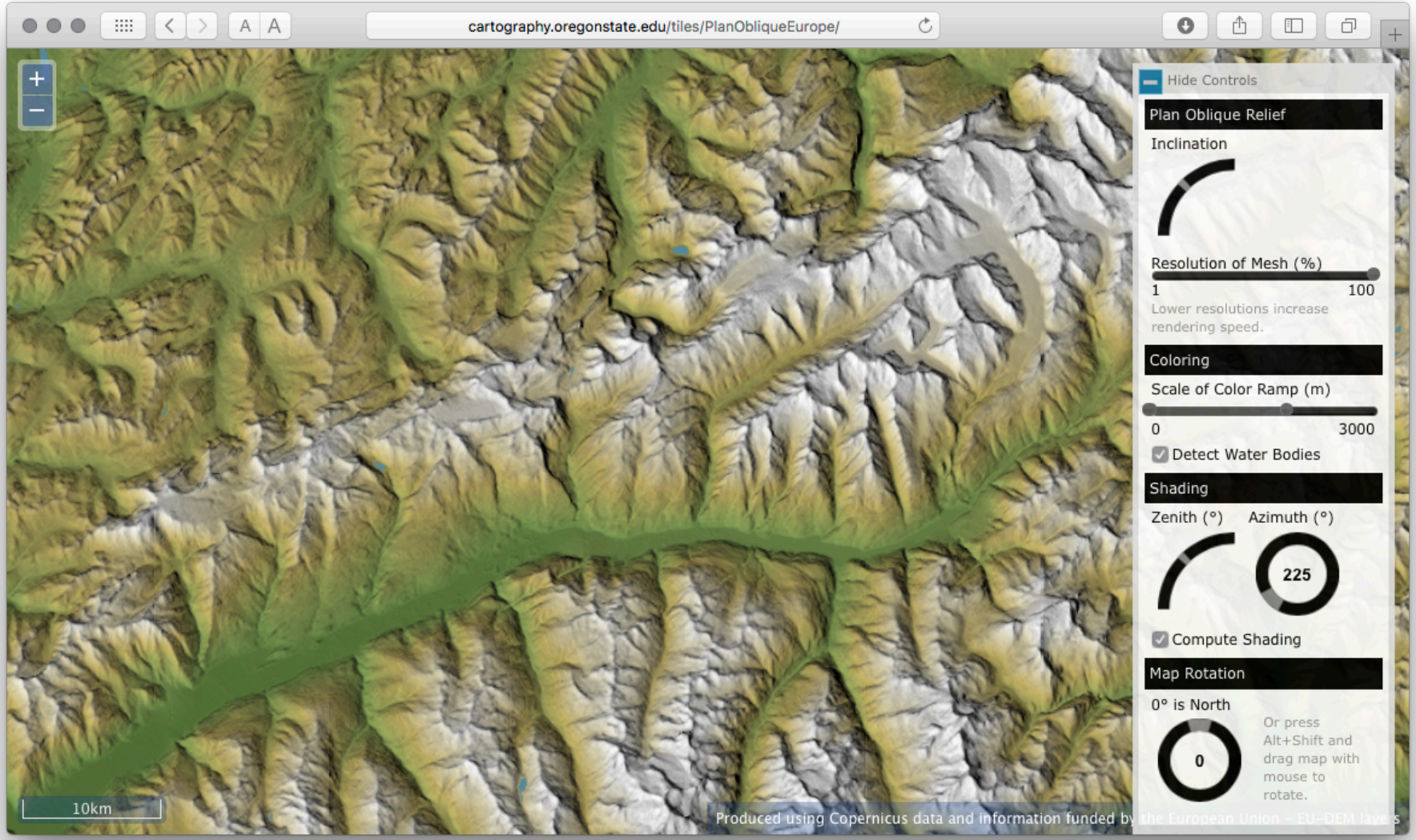
Source: New York Times, 26 July 2017
https://www.nytimes.com/interactive/2017/07/26/upshot/president-trumps-newest-focus-discrediting-the-news-media-obamacare.html

Dataset type? Attribute type?



Source: http://usmigrationflowmapper.com

Dataset type? Attribute type?



Source: http://cartography.oregonstate.edu/tiles/PlanObliqueEurope/

Dataset type? Attribute type?

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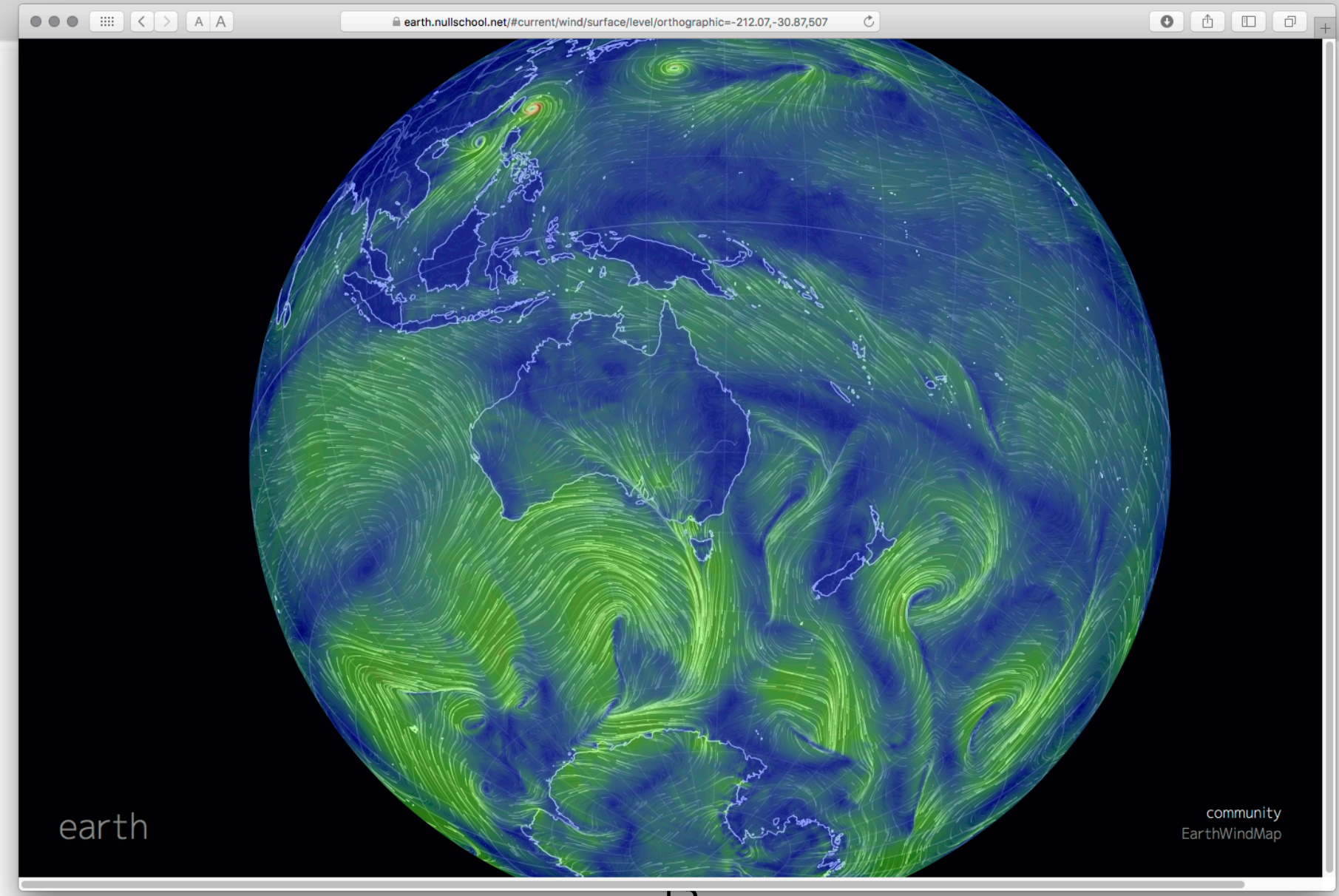
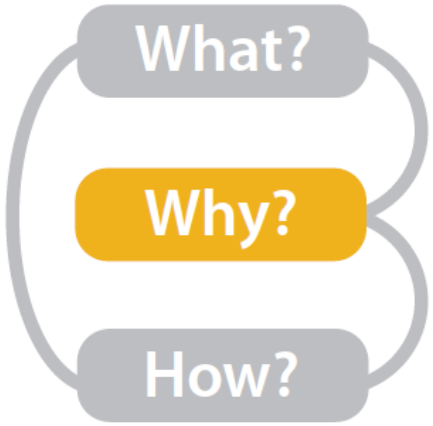


Source: https://earth.nullschool.net

Why?



Textbook chapter 3

Why?

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Actions

Analyze

- Consume
  - Discover
  - Present
  - Enjoy
- Produce
  - Annotate
  - Record
  - Derive

Search

	Target known	Target unknown
Location known	Lookup	Browse
Location unknown	Locate	Explore

Query

- Identify
- Compare
- Summarize

Targets

All Data

- Trends
- Outliers
- Features

Attributes

- One
  - Distribution
  - Extremes
- Many
  - Dependency
  - Correlation
  - Similarity

Network Data

- Topology
- Paths

Spatial Data

- Shape

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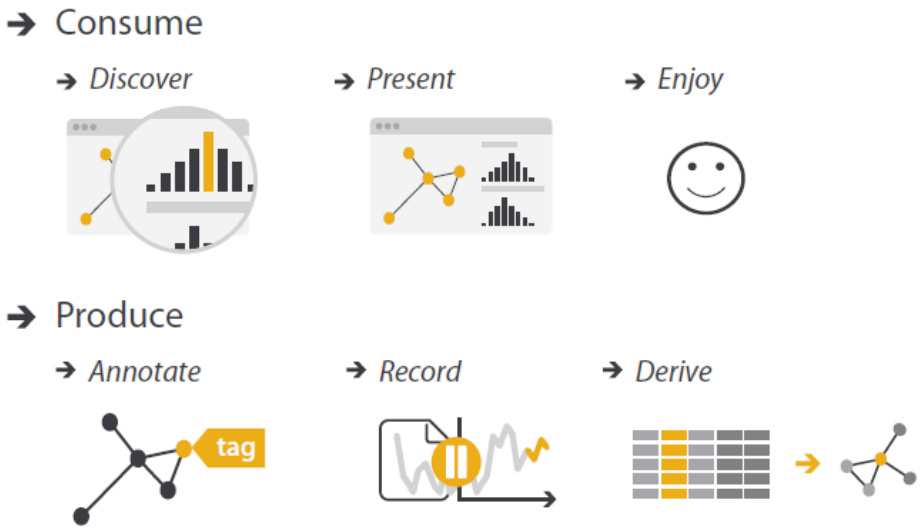
Why? Actions > Analyse

- Analyse > Consume
  - Discover vs. present
    AKA: explore vs. explain
  - Enjoy
    - AKA casual, social
    - AKA storytelling
- Analyse > Produce
  - Annotate, record
  - Derive/transform
    - Crucial design choice



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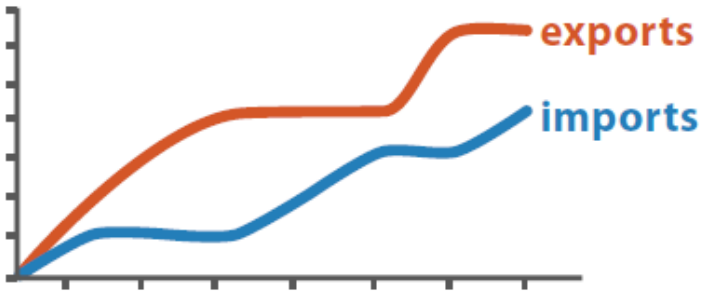
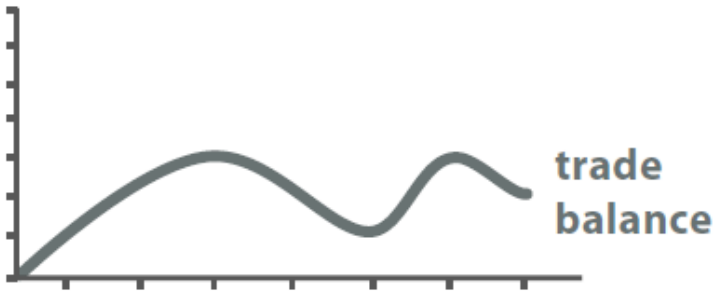
- Don't just draw what you are given
  - Decide what is the right thing to show
  - Create it with a series of transformations from the original dataset
  - Draw that
- One of the main strategies for handling complexity



Original Data



trade balance = exports – imports

Derived Data

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- Lookup = location and target are known
- Browse = location is known, target is unknown
- Locate = location is unknown, target is known
- Explore = location and target are unknown

Search

	Target known	Target unknown
Location known	 *Lookup*	 *Browse*
Location unknown	 *Locate*	 *Explore*

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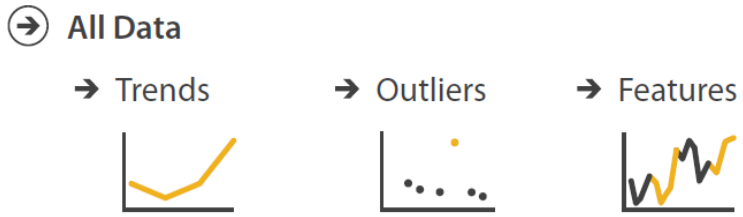
Why? Targets



Trend: increases, decreases, peaks, etc.

Outlier: data not aligning with trend

Feature: task dependent

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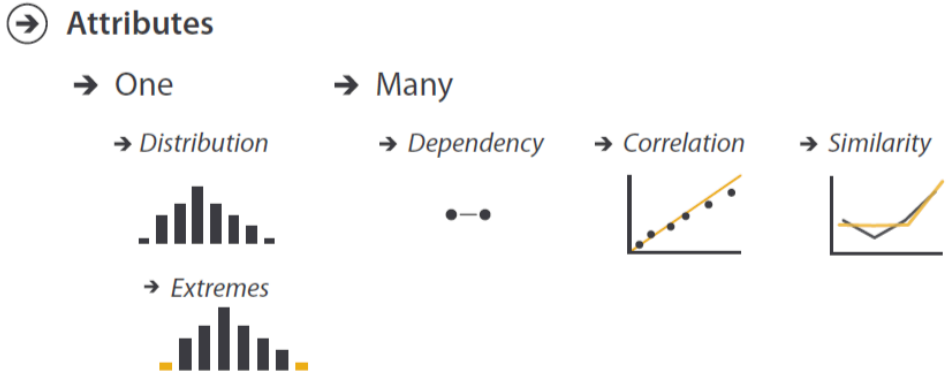
Why? Targets



Attribute = property that can be visually encoded.

Dependency: values of first attribute directly depend on second attribute.

Correlation: tendency of first attribute to be tied to second attribute.

Similarity: quantitative measure of all values of two attributes.

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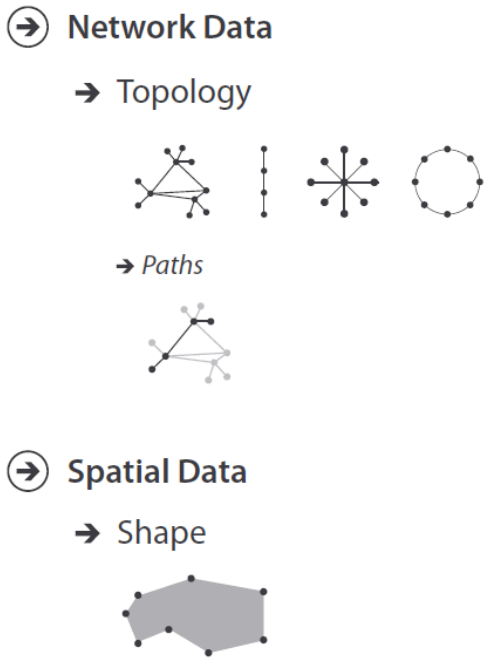
Why? Targets

Topology examples: adjacency of two nodes, shortest path between two nodes, number of connected edges, etc.



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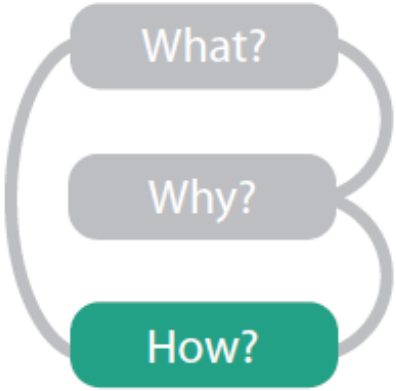
How?



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VAD chapter 5

Marks and Channels

How? Marks and Channels

- Marks
  - Geometric primitives
- Channels
  - Control appearance of marks
  - Can redundantly code with multiple channels

Marks

Points Lines Areas

Channels

?

Group work:
How can we vary the appearance of marks to encode quantitative and qualitative data? Compile a list of channels.

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Definitions: Marks and Channels

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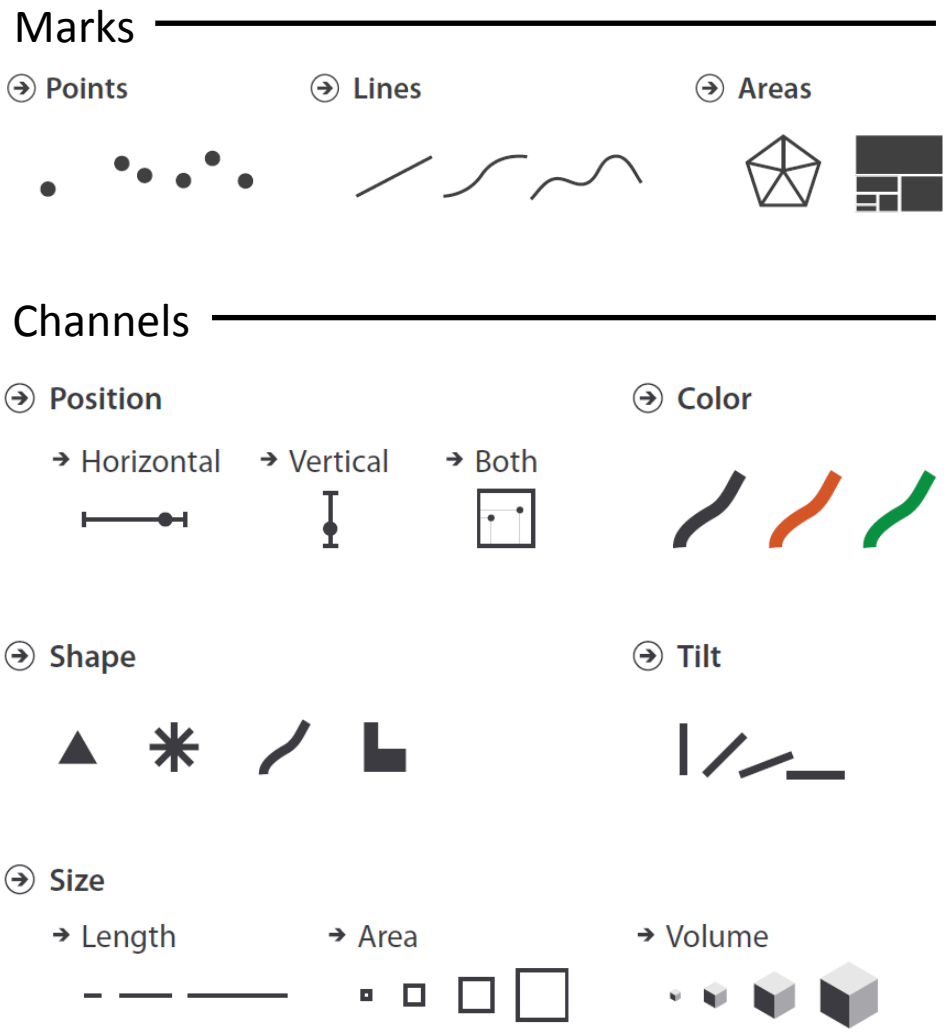
- Marks
  - Geometric primitives
- Channels
  - Control appearance of marks
  - Can redundantly code with multiple channels
- Combinations
  - 2D position of points can represent 2 data attributes
    - Use size/shape/area for additional attributes
  - Example: Line marks encode quantity with width (size) and quality with hue.



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Channels applied to point, line and area marks

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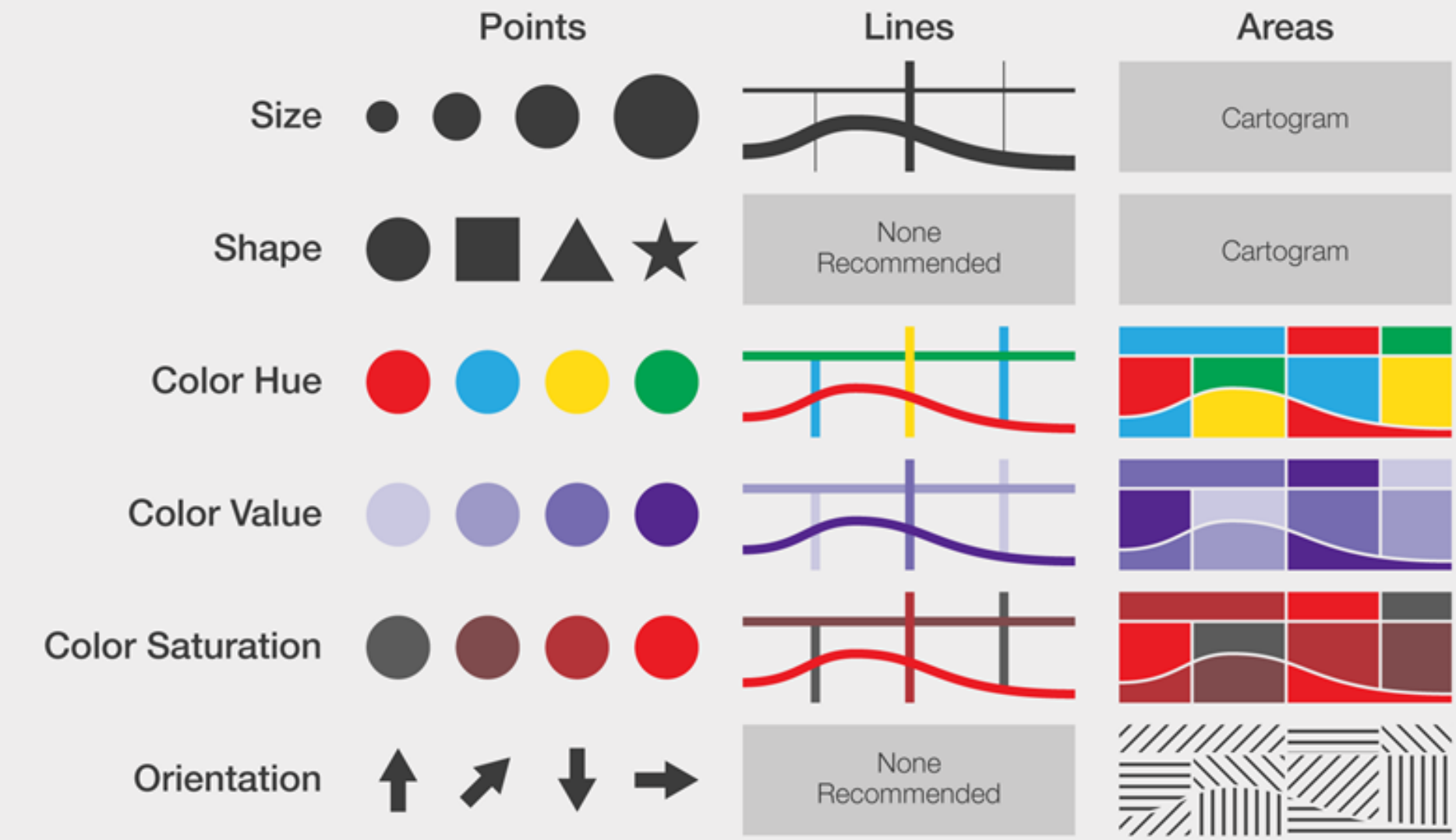
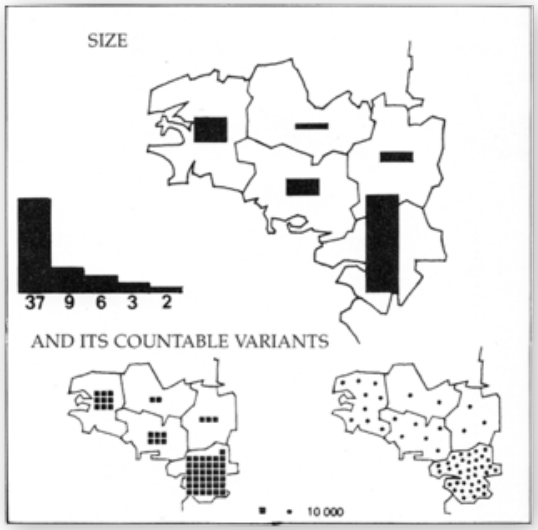
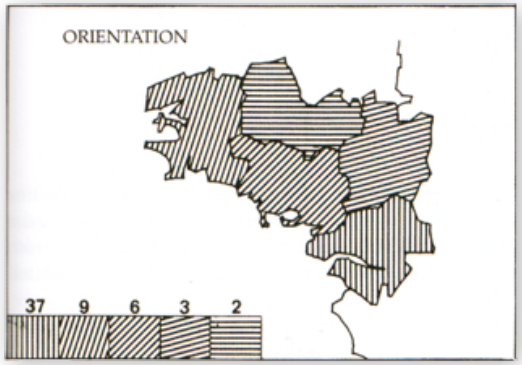
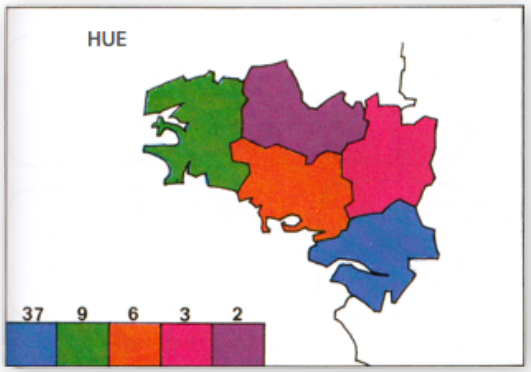


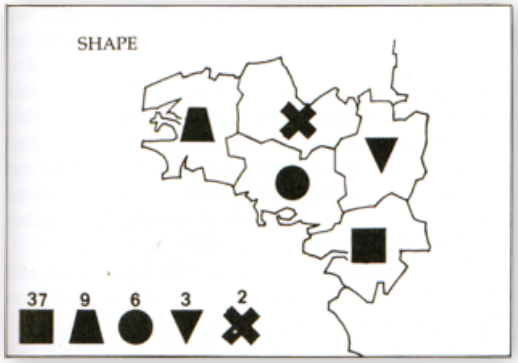
https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables

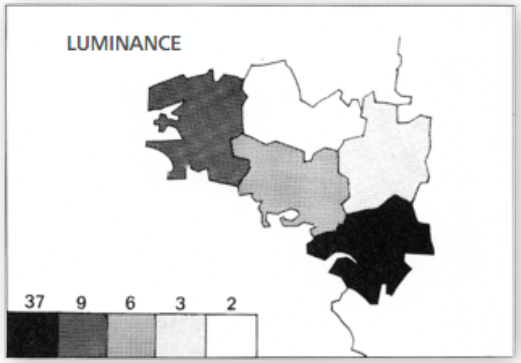
Channels: What works for quantitative data?







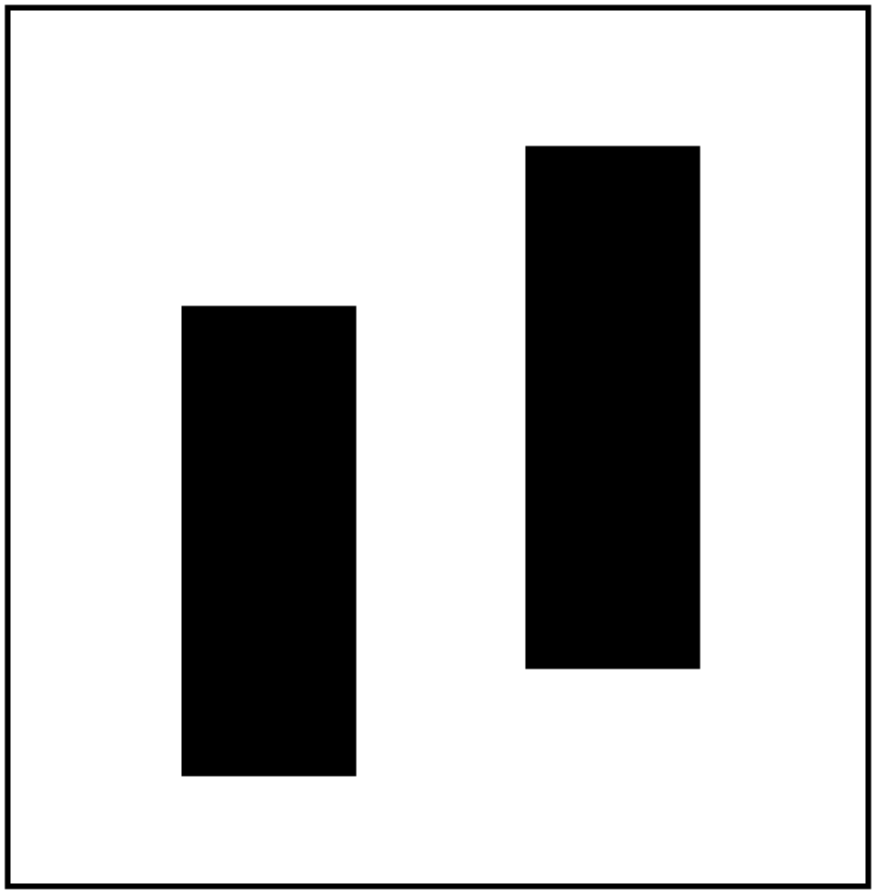




Bertin, J. 1983. Semiology of Graphics, p. 60–61

Note: For Bertin and generally in cartography *channels* are *visual variables.*

Accuracy: Relative vs. Absolute Judgements



Bar Chart

Which bar chart is longer? And how much?

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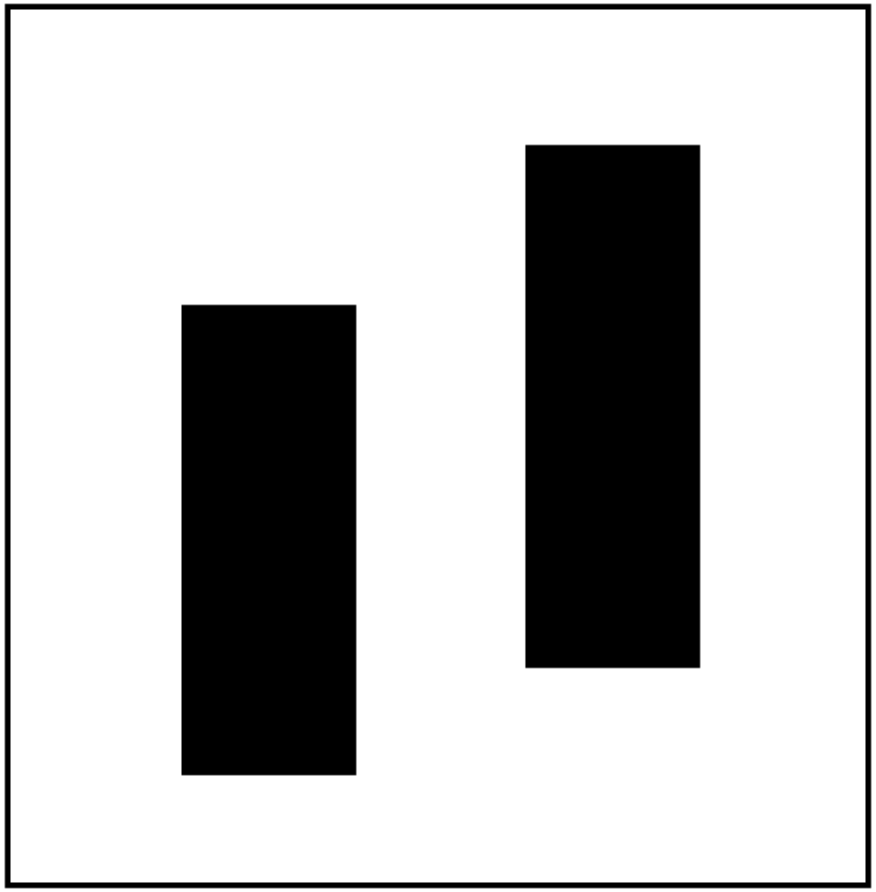
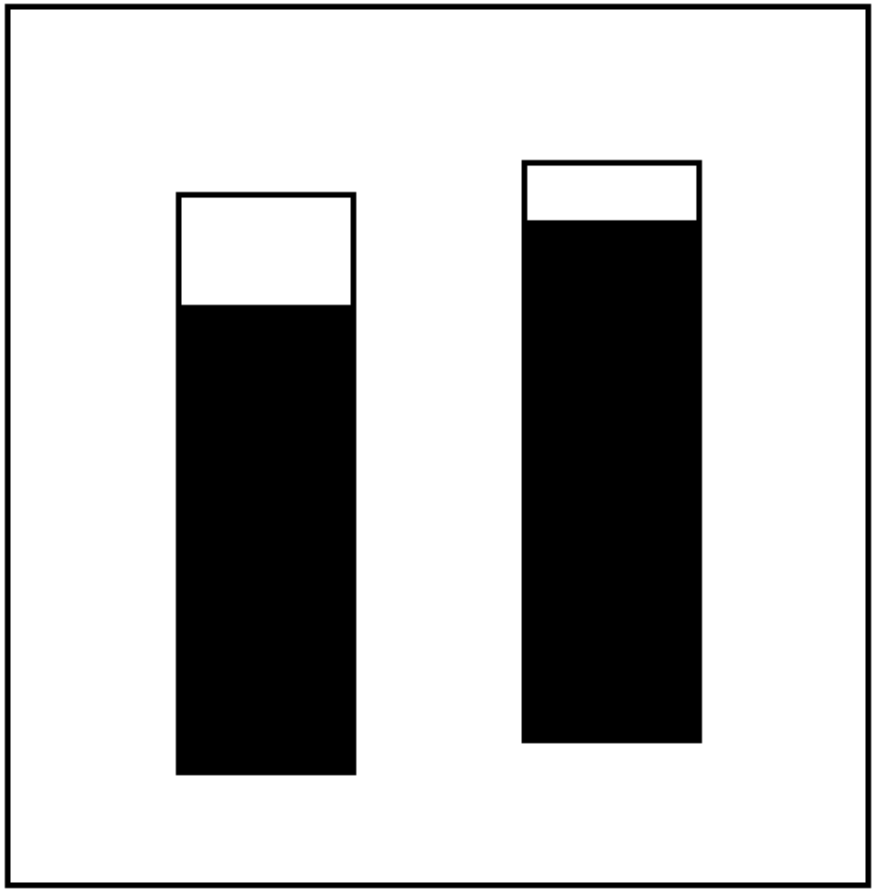
Accuracy: Relative vs. Absolute Judgements



Bar Chart



Framed Rectangle

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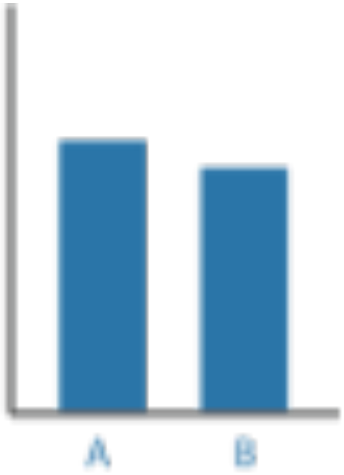
Relative vs. Absolute Judgements

- Perceptual system mostly operates with relative judgements, not absolute - Weber's Law (roughly)

Unframed
Unaligned

Framed
Unaligned



Unframed
Aligned

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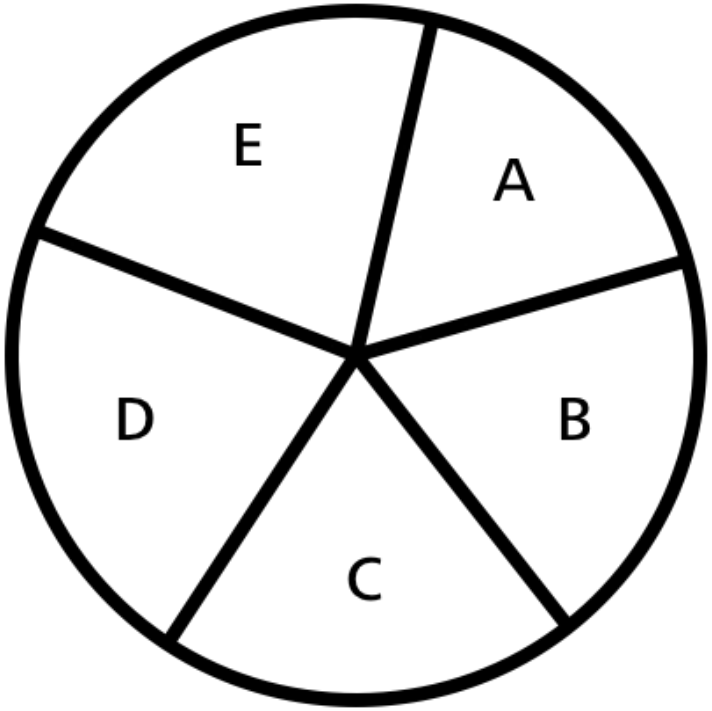
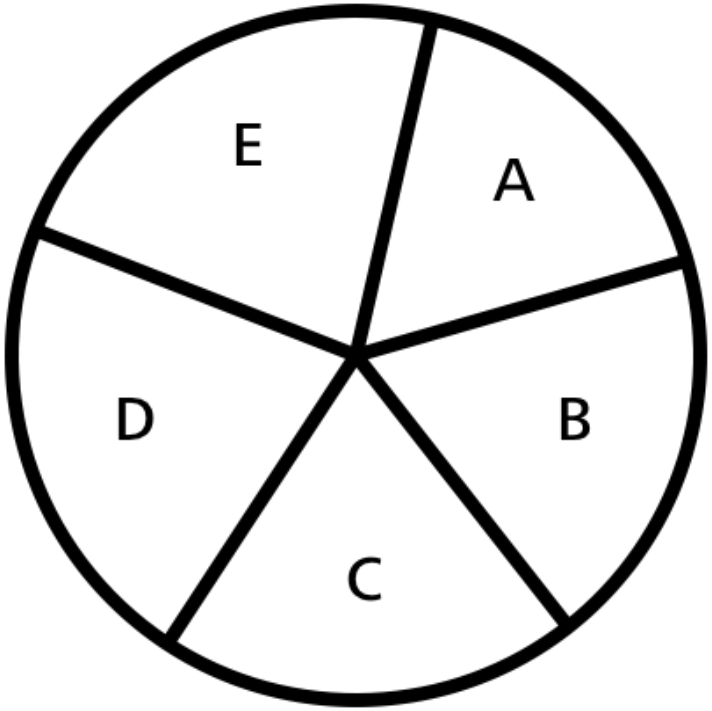
Accuracy: Angles vs. Length



Is C larger than B?

Accuracy: Angles vs. Length

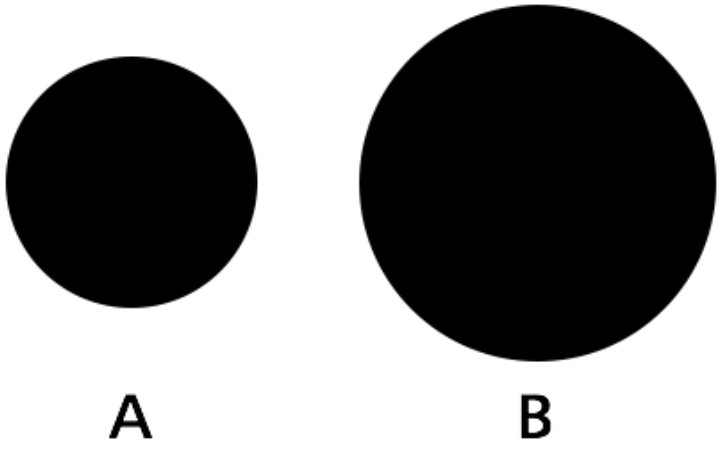


Pie Chart (angle)

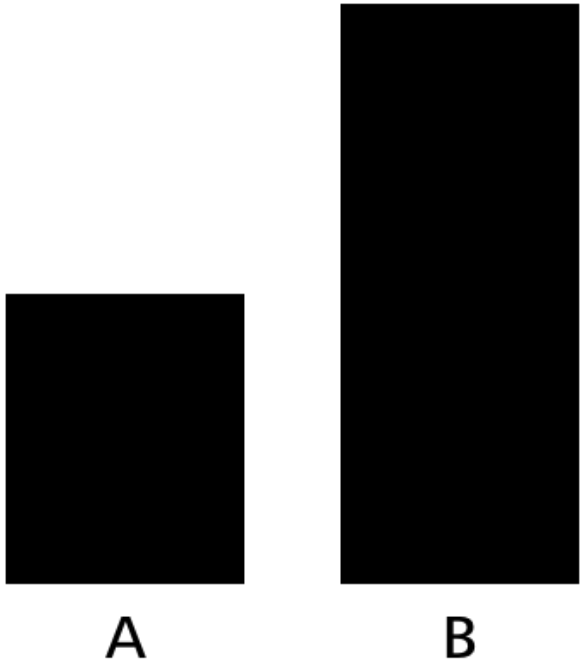
Bar Chart (length)

Accuracy: Area vs. Length

How much larger is B than A?



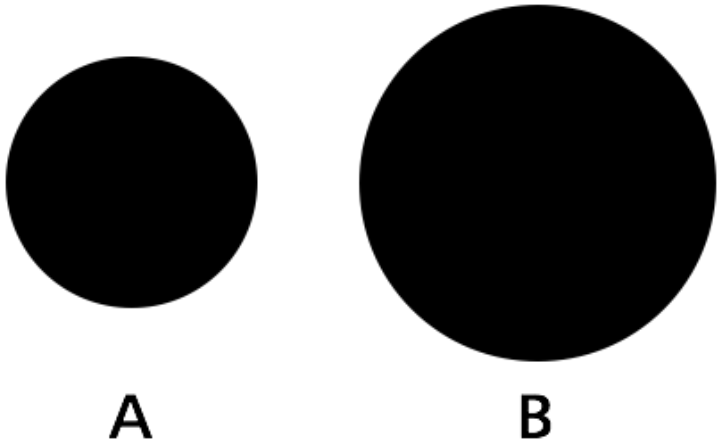
Area-proportional Symbols



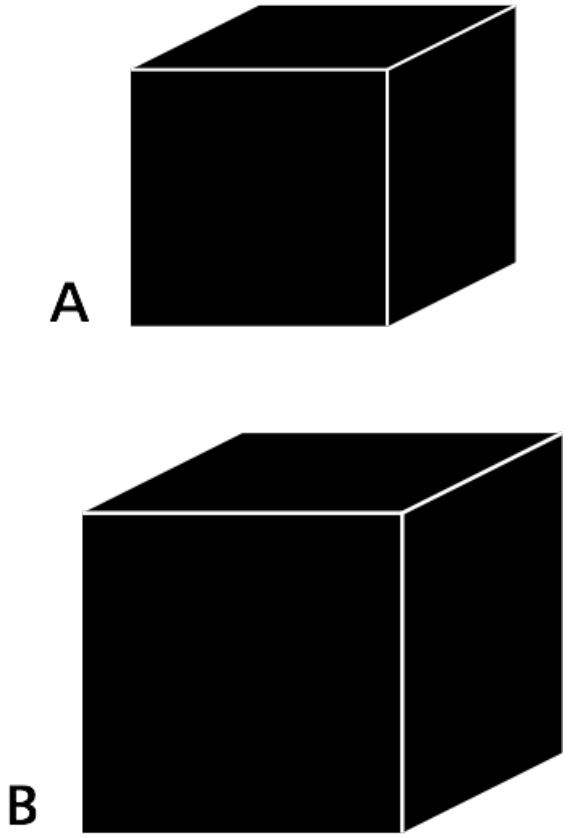
Bar Chart (length)

Accuracy: Area vs. Volume

How much larger is B than A?



Area-proportional Symbols



Volume-proportional Symbols

Accuracy: Luminance

How much larger is B than A?

Accuracy: Ranking of Channels

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1. Position along a common scale

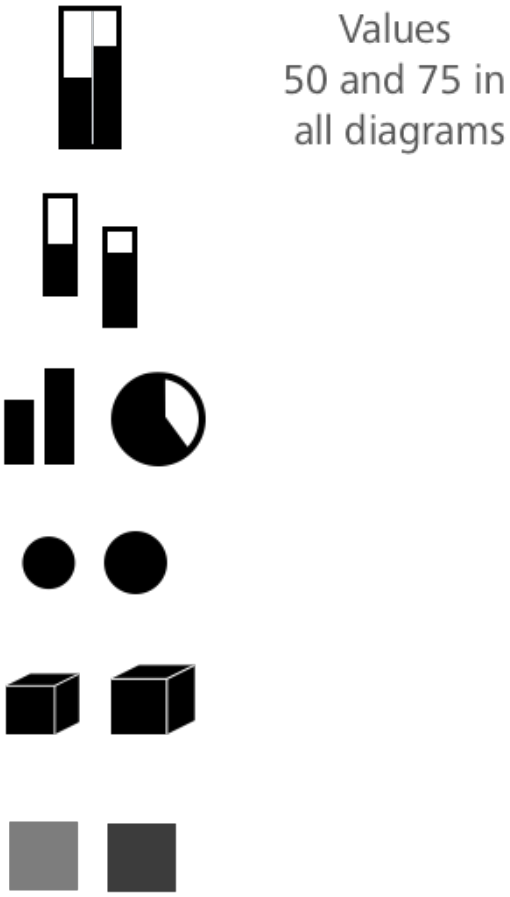
2. Position along nonaligned scales (multiple diagrams)

3. Length, direction, angle

4. Area

5. Volume, curvature

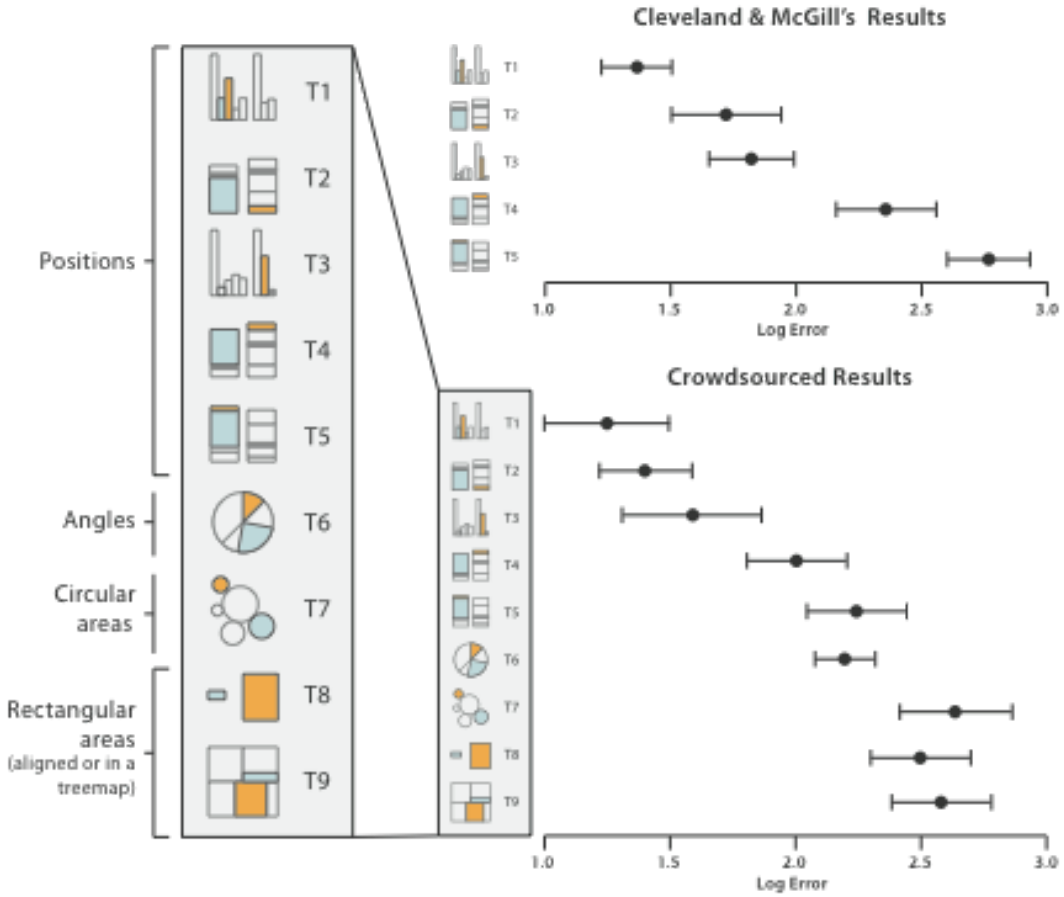
6. Luminance, saturation



Values
50 and 75 in
all diagrams

Cleveland and McGill 1984.
Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods

Accuracy: Vis experiments



Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.

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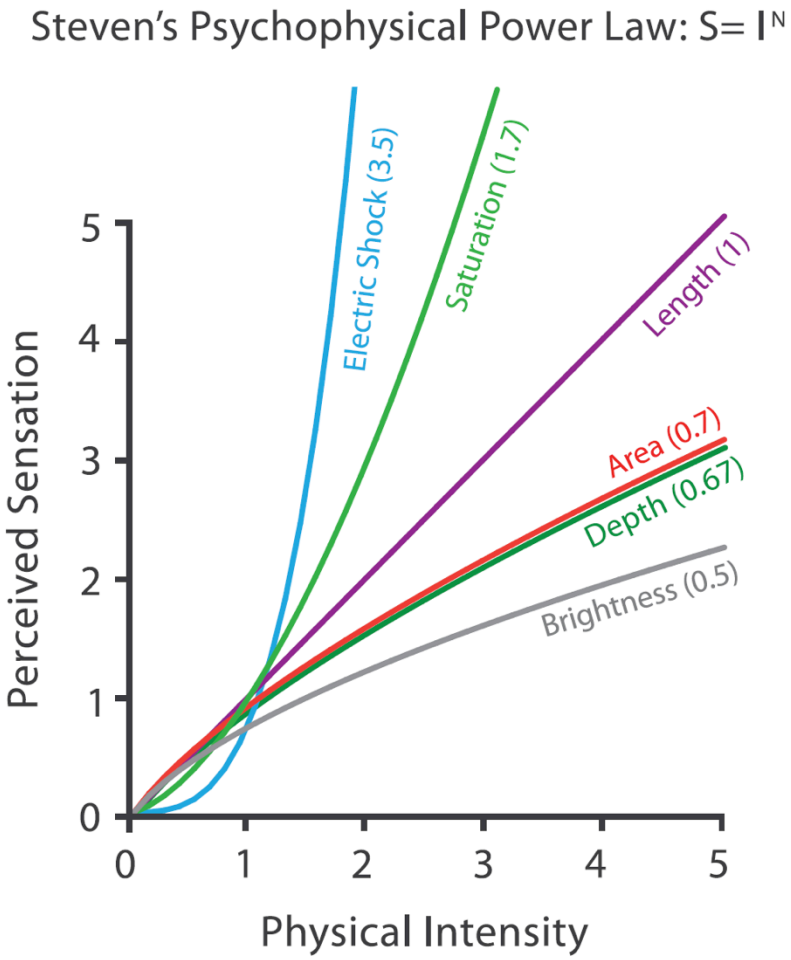
Accuracy: Physical intensity vs. perceived sensation



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Channels: Expressiveness types

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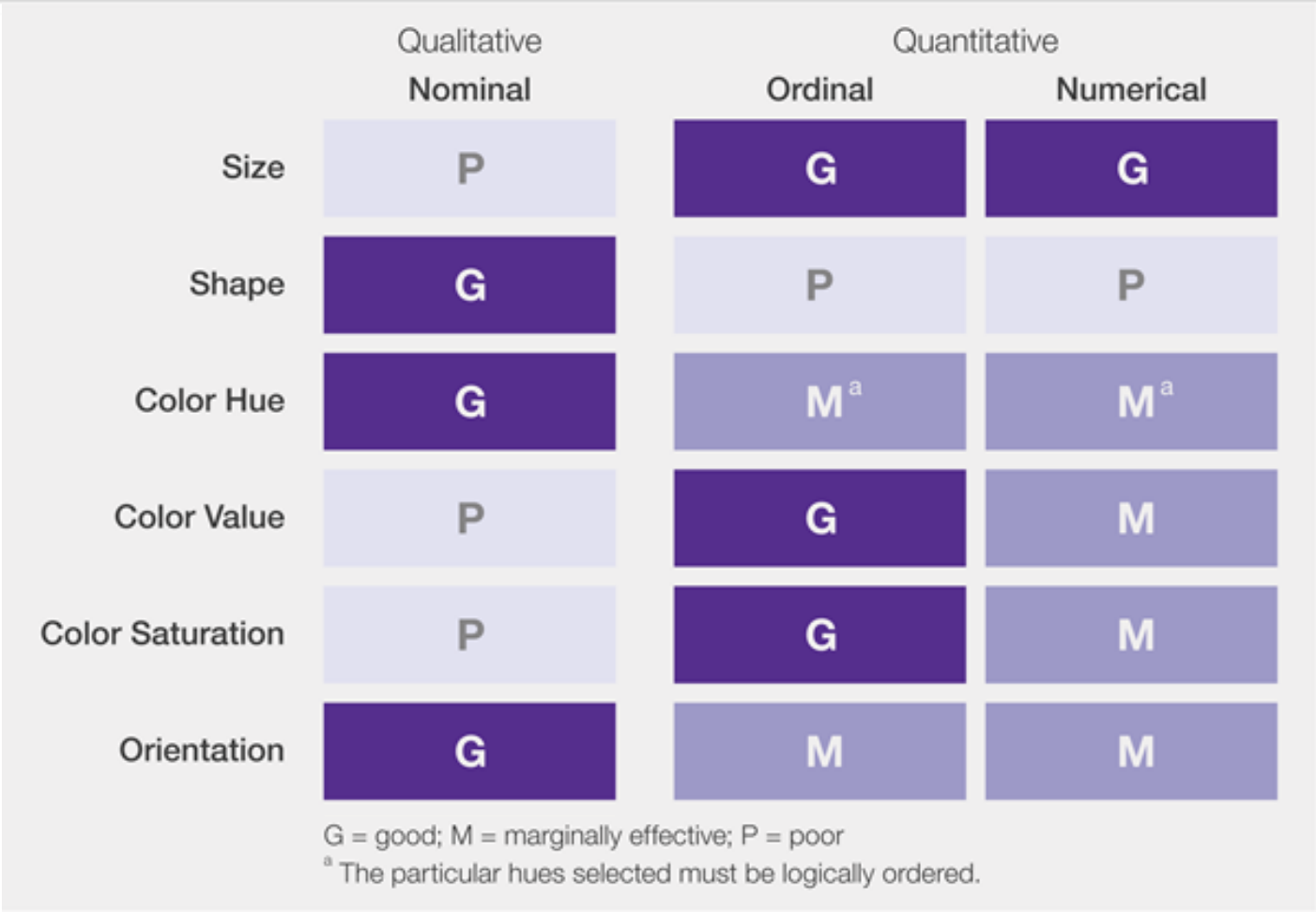

	Qualitative	Quantitative	
	Nominal	Ordinal	Numerical
Size	P	G	G
Shape	G	P	P
Color Hue	G	M[a]	M[a]
Color Value	P	G	M
Color Saturation	P	G	M
Orientation	G	M	M

G = good; M = marginally effective; P = poor

[a] The particular hues selected must be logically ordered.

https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables

Channels: Expressiveness types and effectiveness rankings

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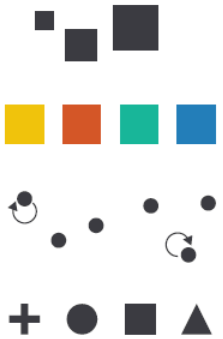
Magnitude Channels: Ordered Attributes

- Position on common scale
- Position on unaligned scale
- Length (1D size)
- Tilt/angle
- Area (2D size)
- Depth (3D position)
- Color luminance
- Color saturation
- Curvature
- Volume (3D size)

Identity Channels: Categorical Attributes

- Spatial region
- Color hue
- Motion
- Shape



Note: Cleveland & McGill invert order of luminance/saturation and curvature/volume.

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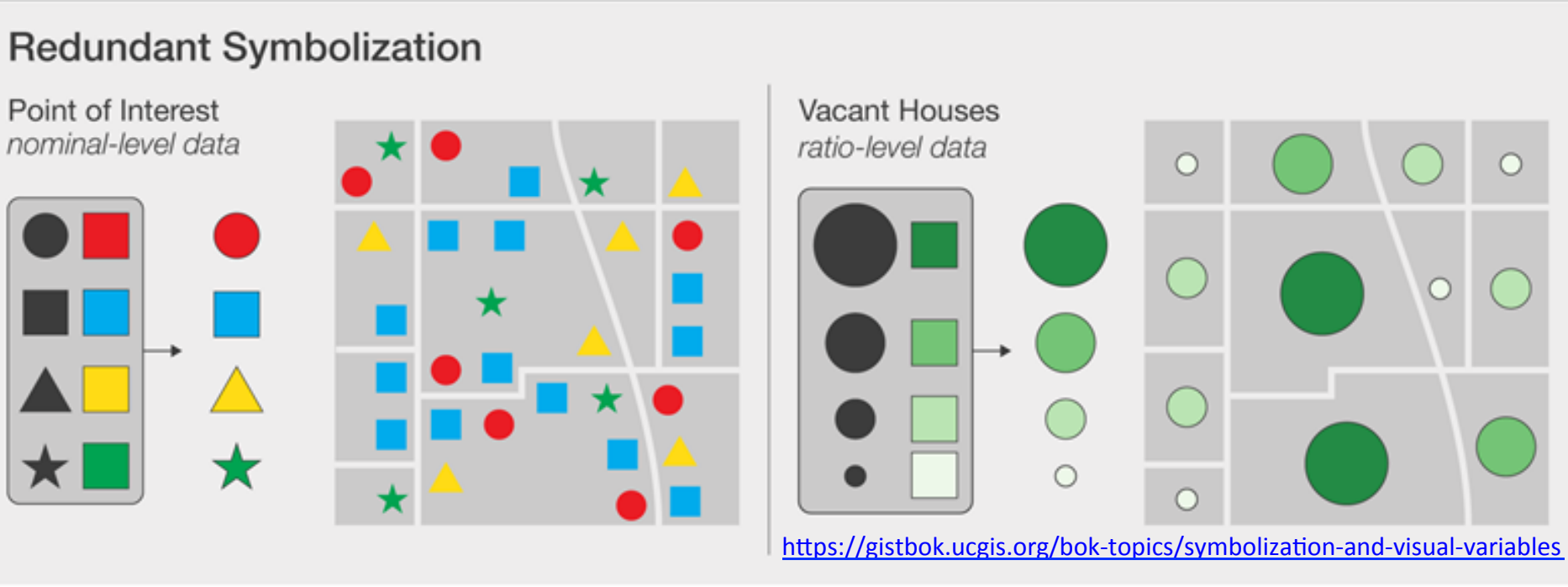
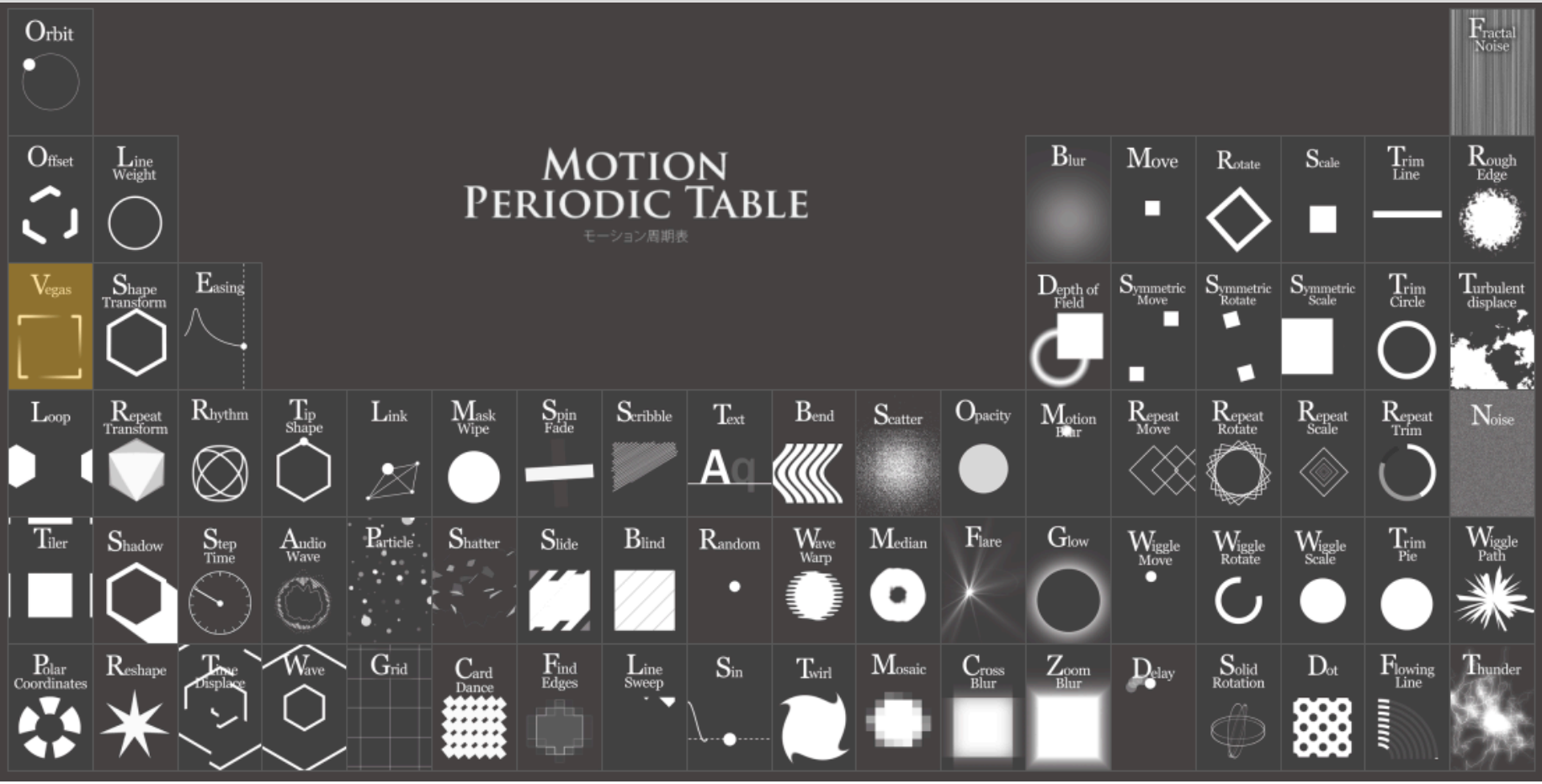
Redundant and multivariate encoding



Redundant = two or more channels express the same attribute
Bivariate or multivariate encoding = two ore more channels express different attributes

Motion channels



(Note: this material is not part of the final exam or any quiz.)

http://foxcodex.html.xdomain.jp

Motion Channels: Expressiveness types

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Variable	Definition	Nominal	Ordinal
Duration	The length of time between changes in the display.	P	G
Order	The sequencing of changes in the display.	P	G
Rate of Change	The speed at which the display changes over time.	M	G
Display Date	The time at which a display change is initiated.	G	M
Frequency	The number of identifiable states per unit time.	M	G
Synchronization	The temporal correspondence of two or more time series.	G	P

G = good; M = marginally effective; P = poor

https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables

(Note: this material is not part of the final exam or any quiz.)

Sound Channels: Expressiveness types

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Variable	Definition	Nominal	Ordinal
Location	The location of a sound in 2D or 3D space.	M	G
Loudness	The magnitude of a sound.	P	G
Pitch	The frequency (highness or lowness) of a sound.	P	G
Register	The location of a pitch within a given range of pitches.	P	G
Timbre	The prevailing quality or characteristic of a sound.	G	P
Duration	The length of time a sound (or silence) is heard.	P	G
Rate of Change	Changes in the duration of sound or silence over time.	P	G
Order	The sequence of sounds over time.	P	G
Attack / Decay	The time it takes for a sound to reach its maximum/minimum.	P	G

G = good; M = marginally effective; P = poor

https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables

(Note: this material is not part of the final exam or any quiz.)

MONASH University

Presentations next Week!

Presentation Theme

MONASH University

Based on the Allocate+ tutorial class list, the students in the CLAYTON Lab 3 (Tuesday 8 am – 10 am) and Lab 5 (Tuesday 2 pm – 4 pm) will present in Week 3.

All students: Please read the instructions on the weekly forum and post your visualisation research and analysis there.

- Find a visualisation in a domain of your choice
- Discuss in a few words each the What / Why / How of your chosen Vis following Munzner's framework

Further reading

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- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, Nov 2014.
  - *Chap 1-5: Marks and Channels*
- *On the Theory of Scales of Measurement.* Stevens. Science 103:2684 (1946), 677–680.
- Psychophysics: Introduction to its Perceptual, Neural, and Social Prospects. Stevens. Wiley, 1975.
- *Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods.* Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.
- *Perception in Vision*. Healey. http://www.csc.ncsu.edu/faculty/healey/PP
- Visual Thinking for Design. Ware. Morgan Kaufmann, 2008.
- Information Visualization: Perception for Design, 3rd edition. Ware. Morgan Kaufmann /Academic Press, 2004.