

VISUAL ENCODING AND PRESENTATION

Bùi Tiến Lên

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KHOA CÔNG NGHỆ THÔNG TIN
TRƯỜNG ĐẠI HỌC KHOA HỌC TỰ NHIÊN

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Marks And Visual Variables



Marks

Expressiveness
and
Effectiveness

Evaluation

Data
Visualization
Gallery

Concept 1

Marks are basic *geometric elements* that serve as the carriers of information. They are distinguished by their dimensionality. There are 0D points, 1D lines, 2D areas, and 3D bodies.

Marks as Items/Nodes

④ Points



④ Lines



④ Areas



Marks as Links

④ Containment



④ Connection





Visual Variables

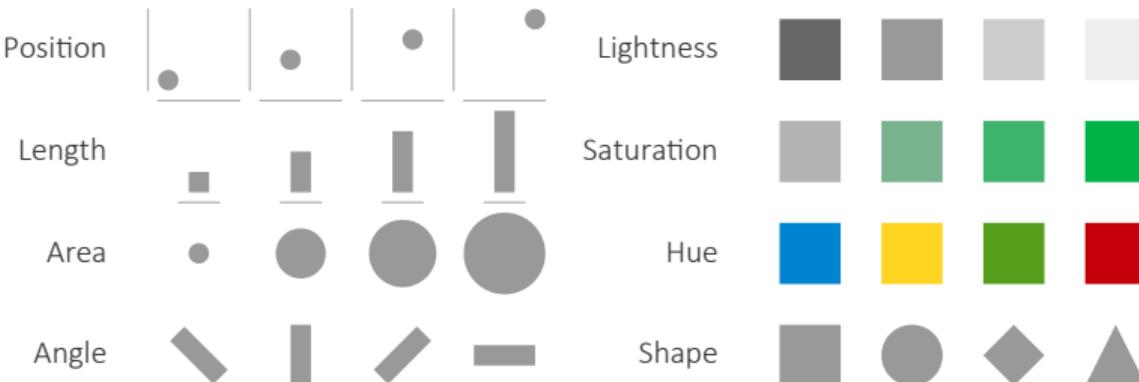
Expressiveness
and
Effectiveness

Evaluation

Data
Visualization
Gallery

Concept 2

Visual variables (aesthetics, channels) such as position, shape, or hue, which control appearance of marks.





Types of Data Variables

Type of variable	Examples
continuous	$1.3, 5.7, 83, 1.5 \times 10^{-2}$
discrete	1, 2, 3, 4
categorical unordered	dog, cat, fish
categorical ordered	good, fair, poor
Date or time	Jan. 5 2018, 8:03am
Text	The quick brown fox jumps over the lazy dog.



Mapping Data onto Aesthetics

Concept 3

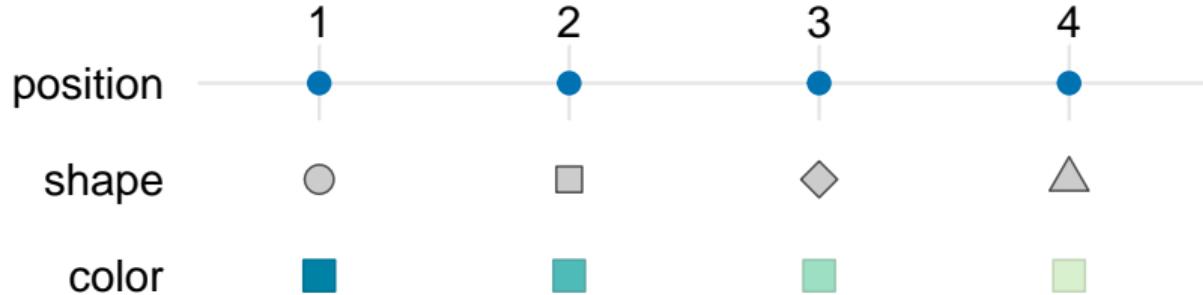
Mapping or **encoding** is a process that converts data values in a systematic and logical way into the visual elements that make up the final graphic.

- A 1-to-1 visual mapping is the standard approach to visual encoding: A single data variable is mapped onto a single visual variable.
- A 1-to- n visual mapping takes advantage of the combined power of n visual variables for the encoding a single data variable.



Mapping Data onto Aesthetics (cont.)

- To map data values onto aesthetics, we need to specify which data values correspond to which specific aesthetics values.
- This mapping between data values and aesthetics values is created via **scales**, a scale must be one-to-one.





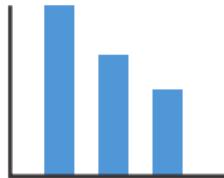
Example

Expressiveness
and
Effectiveness

Evaluation

Data
Visualization
Gallery

- (a) **Bar chart** encode two attributes using a line mark with the vertical spatial position channel for the quantitative attribute, and the horizontal spatial position channel for the categorical attribute.
- (b) **Scatterplot** encode two quantitative attributes using point marks and both vertical and horizontal spatial position.
- (c) A third categorical attribute is encoded by adding color to the scatterplot.
- (d) Adding the visual channel of size encodes a fourth quantitative attribute as well.



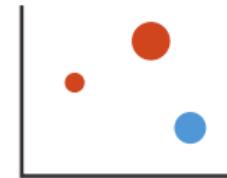
(a)



(b)



(c)



(d)



Expressiveness and Effectiveness



Expressiveness And Effectiveness

Two principles guide the use of visual channels in visual encoding:

- **Expressiveness** principle dictates that the visual encoding should express all of, and only, the information in the dataset attributes.
 - match channel and data characteristics
- **Effectiveness** principle dictates that the importance of the attribute should match the **salience** of the channel; that is, its noticeability.
 - encode most important attributes with highest ranked channels



Effectiveness Ranking Of Visual Variables

Quantitative Data

Position
Length
Angle
Area
Lightness
Saturation
Hue
Shape

Ordinal Data

Position
Lightness
Saturation
Hue
Length
Angle
Area
Shape

Nominal Data

Position
Shape
Hue
Lightness
Saturation
Length
Angle
Area



Evaluation



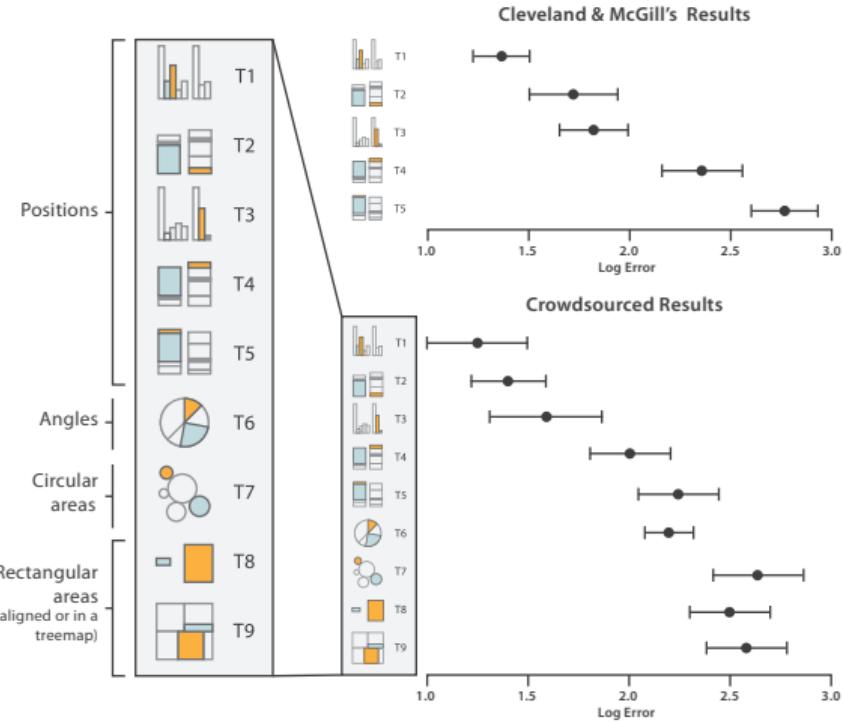
Accuracy

- The obvious way to quantify effectiveness is **accuracy**.
- We perceive different visual channels with different levels of accuracy.



Accuracy: Vis experiments

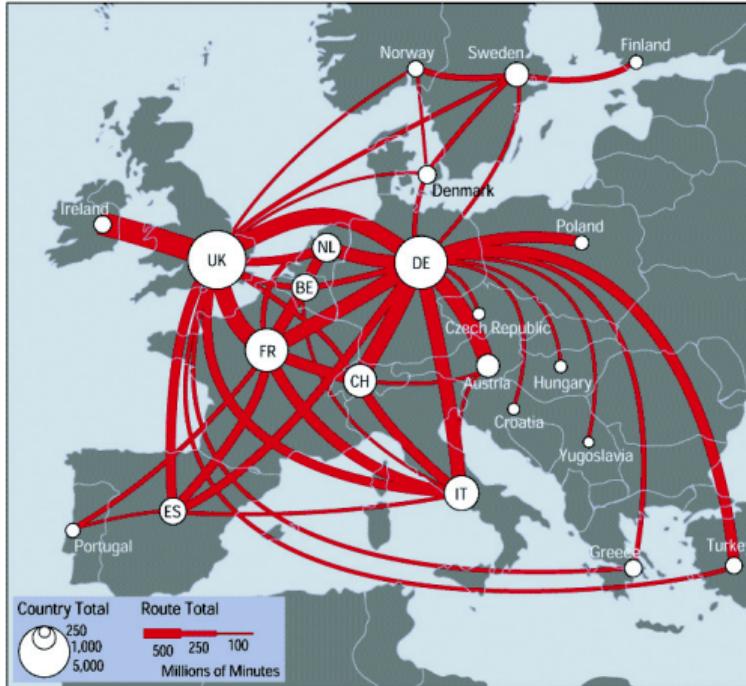
Error rates across visual channels, with recent crowdsourced results replicating and extending seminal work from Cleveland and McGill





Discriminability

- Linewidth has a limited number of discriminable bins.



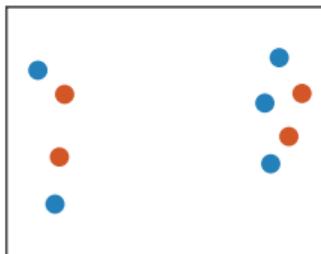


Separability vs. Integrality

- We cannot treat all visual channels as **completely independent** from each other, because some have **dependencies** and **interactions** with others

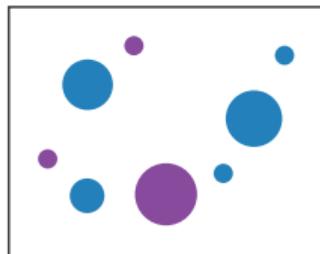
Position

+ Hue (Color)



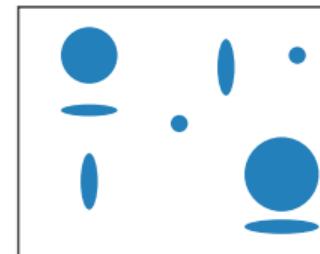
Size

+ Hue (Color)



Width

+ Height



Red

+ Green



Fully separable

Some interference

Some/significant
interference

Major interference



Popout

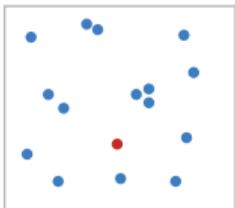
Many visual channels provide visual **popout**, where a distinct item stands out from many others immediately

- Task: Find the **red** dot
- Question: how long does it take?
- *Parallel processing* on many individual channels
 - speed independent of distractor count
 - speed depends on channel and amount of difference from distractors
- *Serial search* for (almost all) combinations
 - speed depends on number of distractors

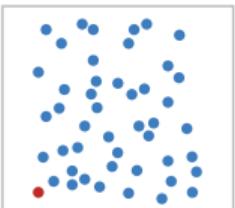


Popout (cont.)

- Visual popout. (a) The red circle pops out from a small set of blue circles. (b) The red circle pops out from a large set of blue circles just as quickly. (c) The red circle also pops out from a small set of square shapes, although a bit slower than with color. (d) The red circle also pops out of a large set of red squares. (e) The red circle does not take long to find from a small set of mixed shapes and colors. (f) The red circle does not pop out from a large set of red squares and blue circles, and it can only be found by searching one by one through all the objects



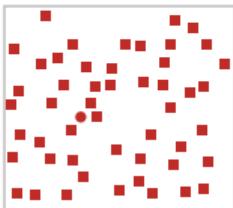
(a)



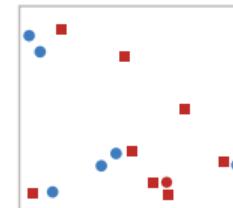
(b)



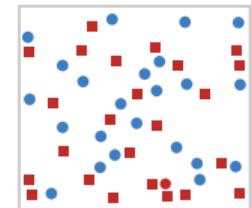
(c)



(d)



(e)



(f)



Popout (cont.)

- Many channels support visual popout



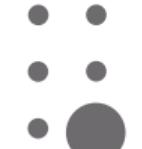
Orientation



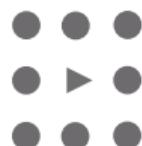
Length



Width



Size



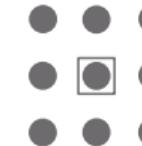
Shape



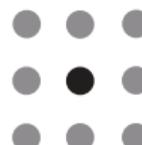
Curvature



Added Marks



Enclosure



Color Value



Color Hue



Position



Spatial Grouping



Example

- How many 9s are there?

2	2	5	6	7	1	1	6	9	1
9	1	7	5	5	5	6	2	5	9
4	5	2	9	6	9	7	6	4	6
8	1	5	7	8	5	6	6	6	7
7	2	3	6	8	9	1	7	9	1
3	8	6	8	4	5	6	9	4	5
4	9	9	2	3	7	1	9	1	2
3	7	8	1	6	1	5	6	1	6
5	6	6	8	6	6	9	1	2	6
3	2	4	2	6	9	4	2	7	1



Example (cont.)

- It's easy to count the 9s.

2	2	5	6	7	1	1	6	9	1
9	1	7	5	5	5	6	2	5	9
4	5	2	9	6	9	7	6	4	6
8	1	5	7	8	5	6	6	6	7
7	2	3	6	8	9	1	7	9	1
3	8	6	8	4	5	6	9	4	5
4	9	9	2	3	7	1	9	1	2
3	7	8	1	6	1	5	6	1	6
5	6	6	8	6	6	9	1	2	6
3	2	4	2	6	9	4	2	7	1



Example (cont.)

- Can you see the 9?

6	4	5	5	1	3	7	8	4	4	1	2	3	2	8	2	2	7	6	6	1	8	7	2	4	8	4	1	7	2	4	1	7	5	1	3	3	8	8	4	7	3	2	6	8	3	8	7	2	8
8	7	3	1	4	8	8	8	2	2	7	1	4	1	3	1	7	8	6	1	3	1	8	8	7	2	4	8	5	2	5	7	2	3	4	1	6	8	7	8	2	8								
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4	8	4	2	8	2	2	5	0	8	1	6	5	4	2	5	1	3	1	7	4	2	5	1	3	1	2	4	5	1	6	8	7	2	4	8	5	1	6	8	7	2	4							
6	7	7	2	1	3	8	5	1	4	2	5	7	4	2	5	1	3	1	7	4	2	5	1	3	1	2	4	5	1	6	8	7	2	4	8	5	1	6	8	7	2	4							
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7	6	3	7	1	4	6	2	3	5	0	8	1	6	5	4	2	5	1	3	1	7	4	2	5	1	3	1	2	4	5	1	6	8	7	2	4	8	5	1	6	8	7	2	4					
3	6	2	6	5	3	7	1	4	2	5	7	4	2	5	1	3	1	7	4	2	5	1	3	1	2	4	5	1	6	8	7	2	4	8	5	1	6	8	7	2	4								
1	7	5																																															



Example (cont.)

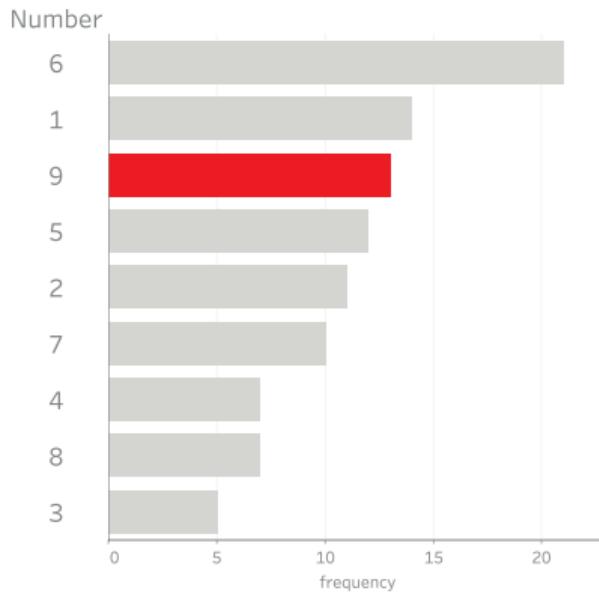
- Differences in size are easy to see too.

2	2	5	6	7	1	1	6	9	1
9	1	7	5	5	5	6	2	5	9
4	5	2	9	6	9	7	6	4	6
8	1	5	7	8	5	6	6	6	7
7	2	3	6	8	9	1	7	9	1
3	8	6	8	4	5	6	9	4	5
4	9	9	2	3	7	1	9	1	2
3	7	8	1	6	1	5	6	1	6
5	6	6	8	6	6	9	1	2	6
3	2	4	2	6	9	4	2	7	1



Example (cont.)

- Sorted bar chart using color and length to show how many 9s are in our table.



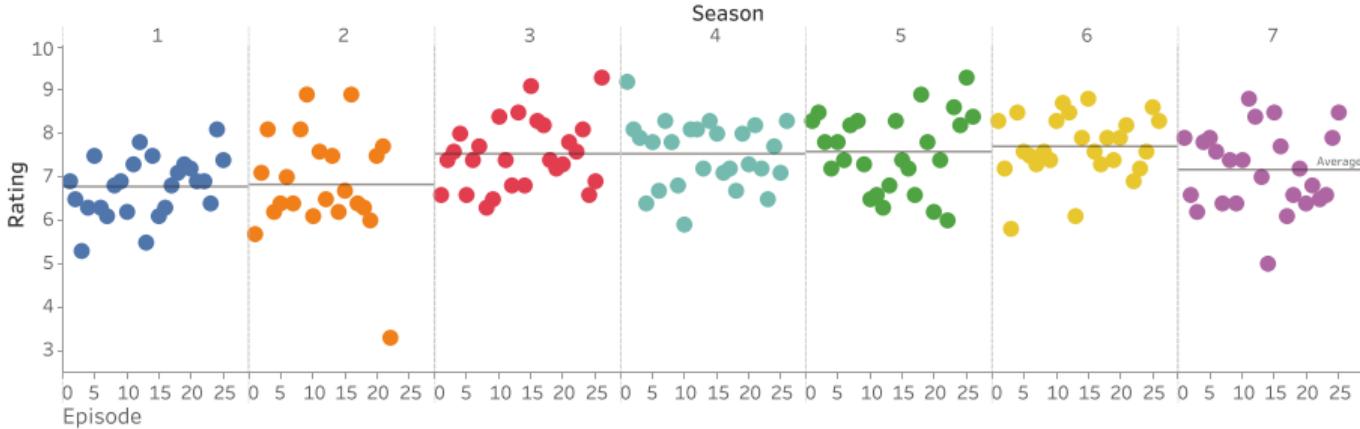


Data Visualization Gallery



Star Trek: The Next Generation

Star Trek: The Next Generation
Episode ratings from IMDB.com



Data	Data Type	Encoding	Note
Episode	Categorical	Position	Each episode is represented by a dot. Each dot has its own position on the canvas.
Episode Number	Ordinal	Position	The x-axis shows the number of each episode in each season.
Season	Ordinal	Color	Each season is represented by a different color (hue).
		Position	Each season also has its own section on the chart.
IMDB rating	Ordinal	Position	The better the episode, the higher it is on the y-axis.
Average season rating	Quantitative	Position	The horizontal bar in each pane shows the average rating of the episodes in each season. There is some controversy over whether you should average ordinal ratings. We believe that the practice is so common with ratings it is acceptable.

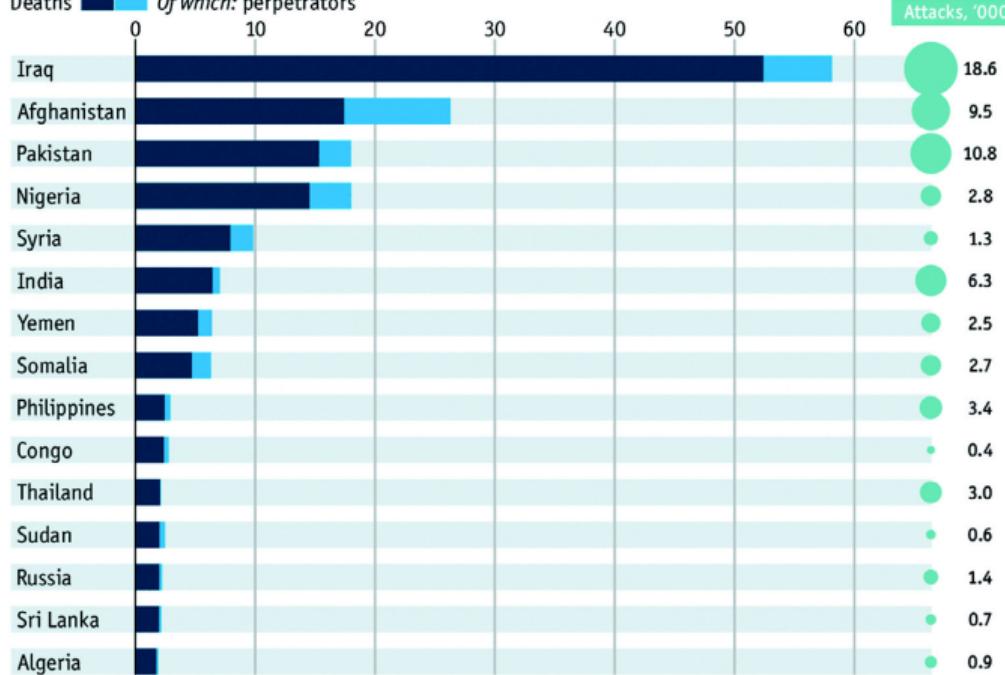


A terrible record

A terrible record

Countries with highest number of deaths from terrorism, 2003-15, '000

Deaths █ Of which: perpetrators



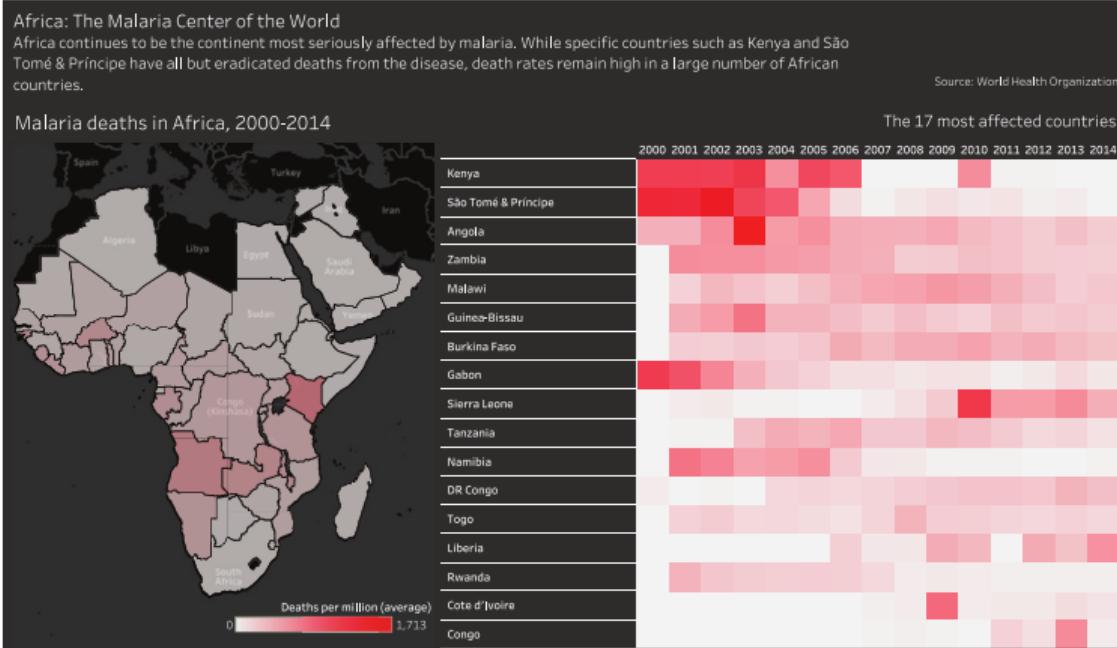


A terrible record (cont.)

Data	Data Type	Encoding	Note
Country	Categorical	Position	Each country is on its own row (sorted by total deaths).
Deaths	Quantitative	Length	The length of the bar shows the number of deaths.
Death type	Categorical	Color	Dark blue shows deaths of victims, light blue shows deaths of the perpetrators.
Attacks	Quantitative	Size	Circles on the right are sized according to the number of attacks.



Deaths from malaria, 2000–2014



Data	Data Type	Encoding	Note
Country	Categorical	Position	The map shows the position of each country. In the highlight table, each country has its own row.
Deaths per million	Quantitative	Color	The map and table use the same color legend to show deaths per million people.
Year	Ordinal	Position	Each year is a discrete column in the table.

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