Visual Analytics

Communicating data-driven insights through data visualization techniques and useful dashboards

Mikel Madina &
Miren Berasategi

0. Introduction

0.1 Key points

- **Data driven**: as seen in previous sessions with Professors Onieva and Lorenzo
- **Insights**: the capacity to gain an accurate and deep understanding of something *through*
- **Data visualization techniques**: to take the user from data to insight
- **Dashboards**: as *situation awareness* tools

Tableau Desktop to practice

Section outline

0. Introduction: the *why* and the *what for* of visualization
1. Graphs: some reminders, idioms to map variables to graphs
2. Promote insight: by adding meaningful modifications to graphs
3. Dashboards: situation awareness, dos and don'ts
4. Epilogue

Practice: build a simple dashboard with online marketing campaign data

0.2 Why use visualization

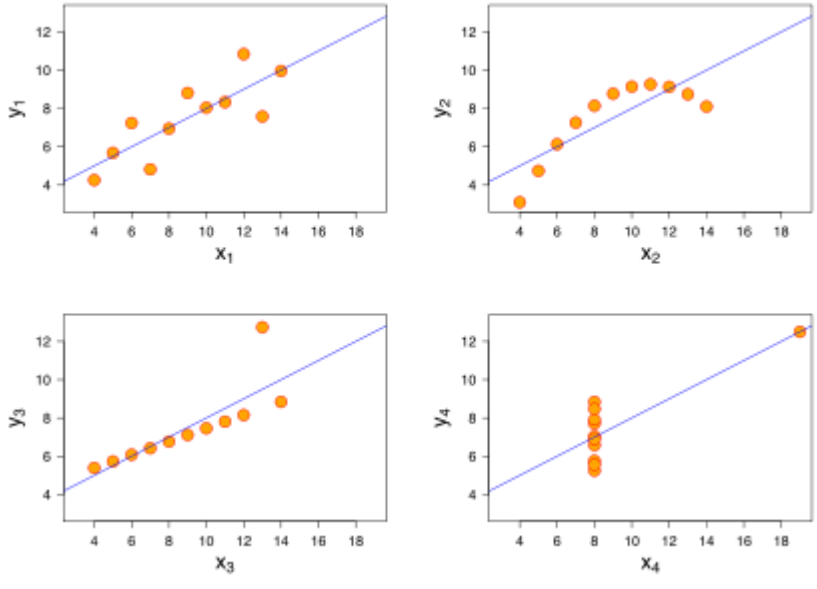
- Sight is our most developed sense
- The visual system provides a very high-bandwidth channel to our brains
- A significant amount of visual information processing occurs in parallel at the preconscious level
- The human brain is *trained* to identify visual patterns
- Summary statistics have the intrinsic limitation of data loss

0.2 Why use visualization

Anscombe's quartet

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Property	Value	Accuracy
Mean of *x*	9	exact
Sample variance of *x*	11	exact
Mean of *y*	7.50	to 2 decimal places
Sample variance of *y*	4.125	plus/minus 0.003
Correlation between *x* and *y*	0.816	to 3 decimal places
Linear regression line	$y = 3.00 + 0.500x$	to 2 and 3 decimal places, respectively

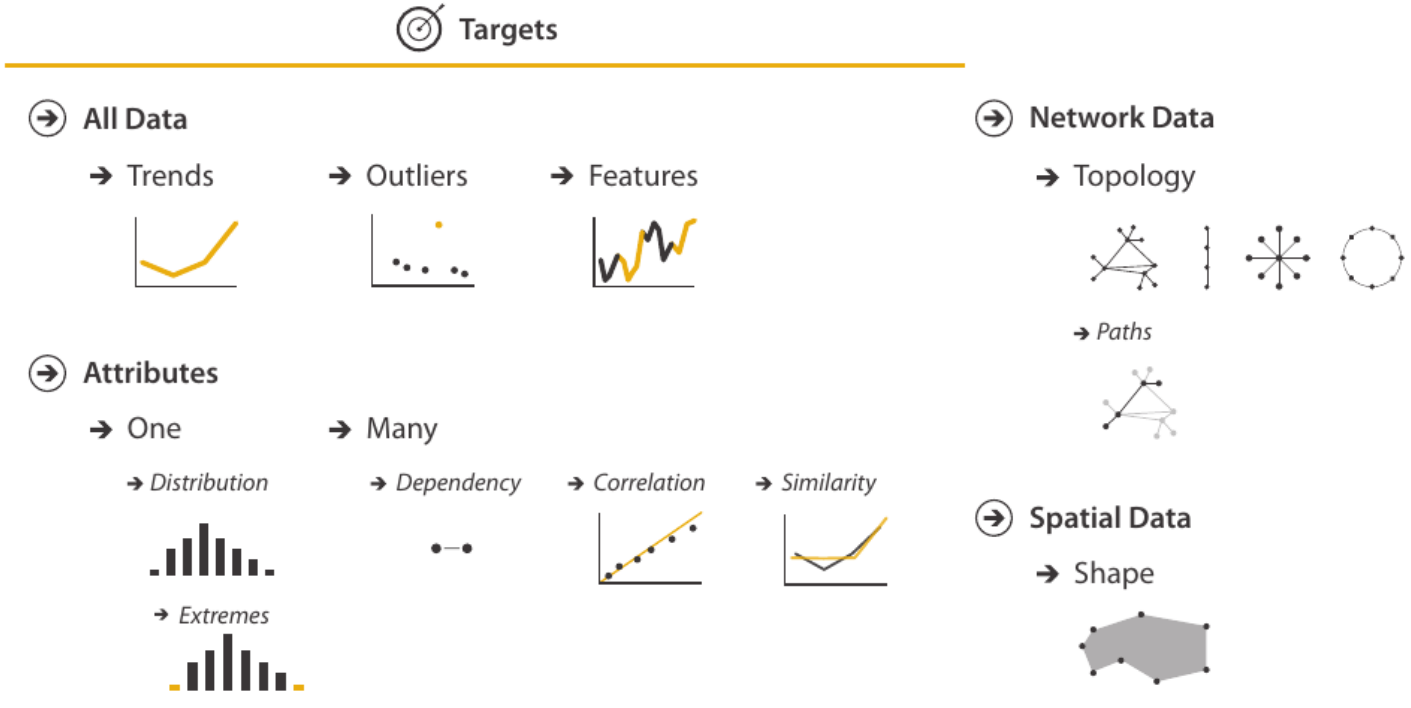


Anscombe's Quartet

0.3 What to use visualization for

Munzner 2014, p.42

0.3 What to use visualization for



Munzner 2014, p.56

0.3 What to use visualization for

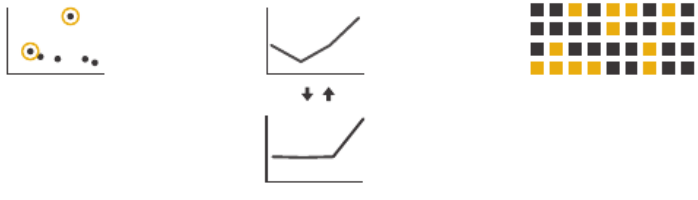
Actions

Search

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

Query

- Identify
- Compare
- Summarize



Analyze

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

Munzner 2014, p.46

0.3 What to use visualization for

> *There is a **strong relationship** between the form of the data (the attribute/variable and dataset types) and what kinds of vis[ualization] idioms are effective at displaying it. (…) Don't just draw what you are given; decide what the right thing to show is, create it with a series of **transformations** from the original database, and draw that!*

Munzner 2014, p.50

0.3 What to use visualization for

Derived attributes can be directly visually encoded. Munzner 2014, p.52

Practice: meet our sample data

Download and open `data.xls`: fake data for online marketing goals and tools

from Google Drive or

http://mrn.bz/MUMA2018data

	A	B	C	D	E	F
1	source	quarter	spent	visits	income	goal
2	Adwords	20160101	1000	50000	900	1500
3	Twitter	20160101	200	8500	1300	1000
4	Facebook	20160101	500	20000	800	1500
5	Adwords	20160401	1000	48000	1200	1500
6	Twitter	20160401	300	9000	1400	1000
7	Facebook	20160401	750	21500	1400	1500
8	Adwords	20160701	1000	50000	1500	1500
9	Twitter	20160701	400	10000	1000	1000
10	Facebook	20160701	750	23000	200	1500
11	Adwords	20161001	1000	45000	1250	1500
12	Twitter	20161001	500	11000	1000	1000
13	Facebook	20161001	1000	25000	2000	1500
14	Adwords	20170101	1000	50000	1100	1500
15	Twitter	20170101	500	8500	1300	1000
16	Facebook	20170101	1000	20000	800	1500
17	Adwords	20170401	1000	48000	1500	1500
18	Twitter	20170401	500	9000	1400	1000
19	Facebook	20170401	1000	21500	1400	1500
20	Adwords	20170701	1000	50000	1500	1500
21	Twitter	20170701	500	10000	1000	1000
22	Facebook	20170701	1000	23000	200	1500
23	Adwords	20171001	1000	45000	1250	1500
24	Twitter	20171001	400	11000	1000	1000
25	Facebook	20171001	1000	25000	2000	1500

Tableau Software

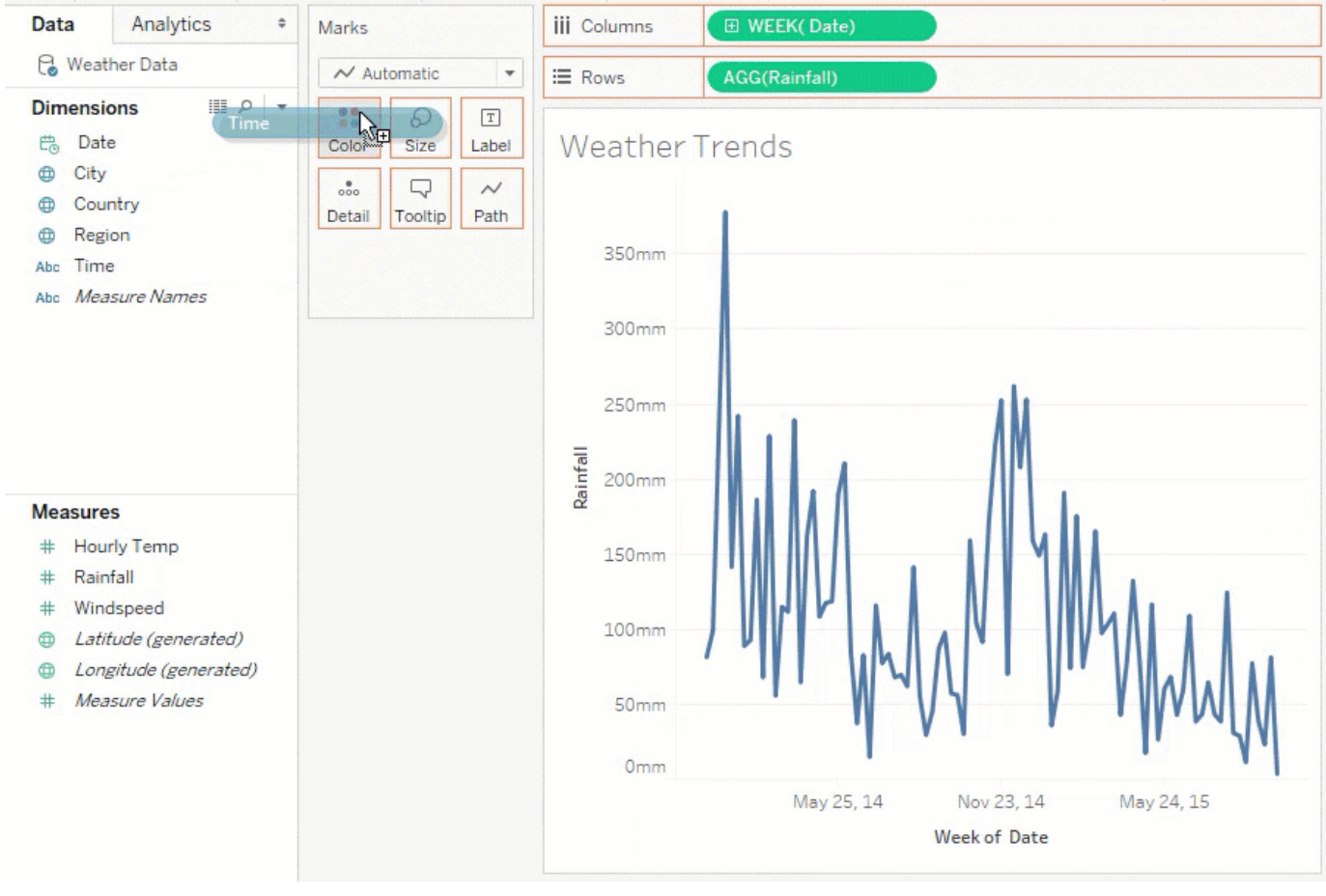


Tableau Software

Tableau

1. Load data
2. Explore the `Data Source` tab

See the subtle blue/green colour of the variable type icon? Take notice, it is important:

> *Understanding the difference between the blue and green items in Tableau is (IMHO) the single most important piece of understanding necessary to make Tableau function well.*

Tom Brown, Blue things and Green things

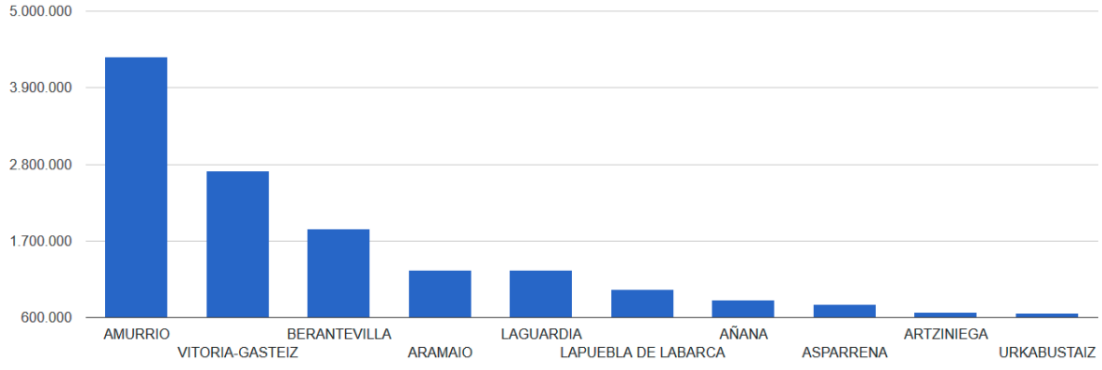
1. Graphs

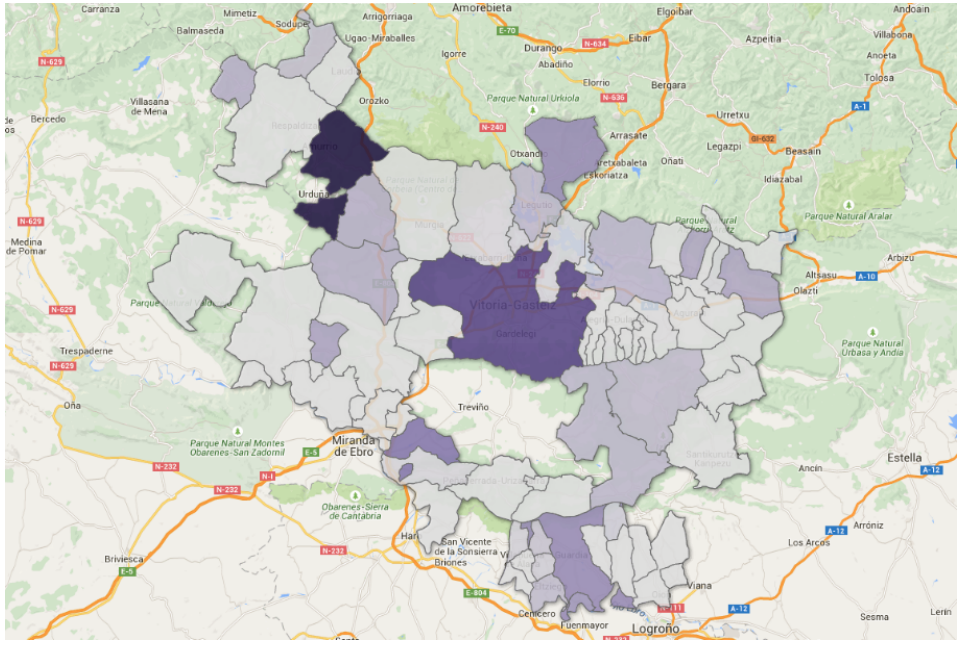
Section outline

1. Reminder: variable types
2. Mapping variables to graphs
   - Marks
   - Channels, channel types
   - Using marks and channels 3. So, which graph?

Practice: explore dimensions, measures and graph types in Tableau

```
ABERASTURI;1025880,88
ABETXUKO;1626,20
ABEZIA;183184,81
ABORNIKANO;54530,28
ACEBEDO;13519,09
ACOSTA;64930,00
ADANA;53139,42
AGIÑAGA;314344,94
ALAITZA;75534,95
ALBENIZ;61152,16
ALCEDO;21313,54
ALDA;27922,86
ALEGRIA-DULANTZI;142607
3,93
ALORIA;5211,22
AMARITA;174311,53
AMETZAGA
ASPARRENA;41376,28
AMETZAGA ZUIA;233555,14
AMURRIO;4348908,77
ANDA;477,65
ANDOIN;21622,76
ANDOLLU;6532,92
ANGOSTINA;65719,04
ANTEZANA;23135,10
...
```





?

1.1 Reminder: variable types

- Quantitative
  - Continuous
  - Discrete
- Qualitative
  - Categorical
  - Ordinal
- Special types
  - time
  - space
  - …

A question of time

Spatial and time/hour variables are special variable types. **Time variables** are specially complex:

- are there 365 days in every year? 30 days in every month? 24 hours in every day?
- *timezones* make it even more complex to use hours or time of day

Time may be used as a continuous or as a qualitative variable.

- as a qualitative variable, it has a hierarchy: year > month > (week >) day > hour > minute
- but different hierarchies may be necessary: bimonthly publications, multiple work shifts in a day…

1.2 Mapping variables to graphs

Understanding **marks and channels** provides the building blocks for analyzing visual encodings (Munzner 2014, p.95)

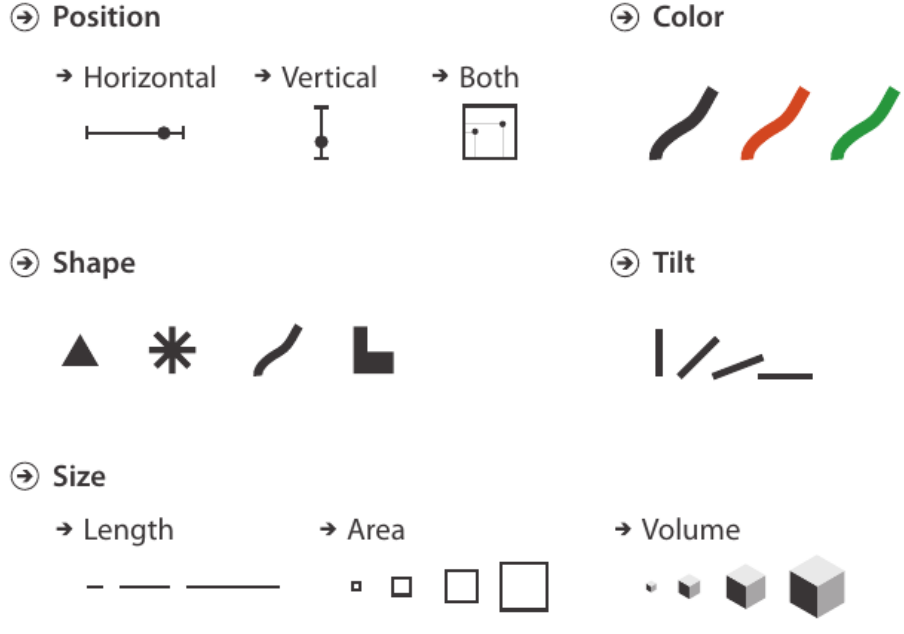
1.2.1 Marks

A **mark** is a basic graphical element in an image

Marks are geometric primitives (Munzner 2014, p.96)

1.2.2 Channels

A visual **channel** is a way to control the appearance of marks



Visual channels control the appearance of marks (Munzner 2014, p.96)

1.2.2 Channels

One and only one attribute/variable should be used per channel.

Multiple channels per attribute are possible (**redundant encoding**), but this approach has limitations.

1.2.2 Channels

The **size** and **shape** channels cannot be used on all types of marks, but most combinations are still possible:

- lines have two *size channels*: length + width
- points refer to location but can be *size* and *shape* coded

1.2.3 Channel types

Two kinds of sensory modalities:

1. **Identity**: what, where
2. **Magnitude**: how much

It does not make sense to ask magnitude questions for shape, color hue. We can ask about magnitudes with length, area or volume; color luminance or saturation; and angle/tilt/slope.

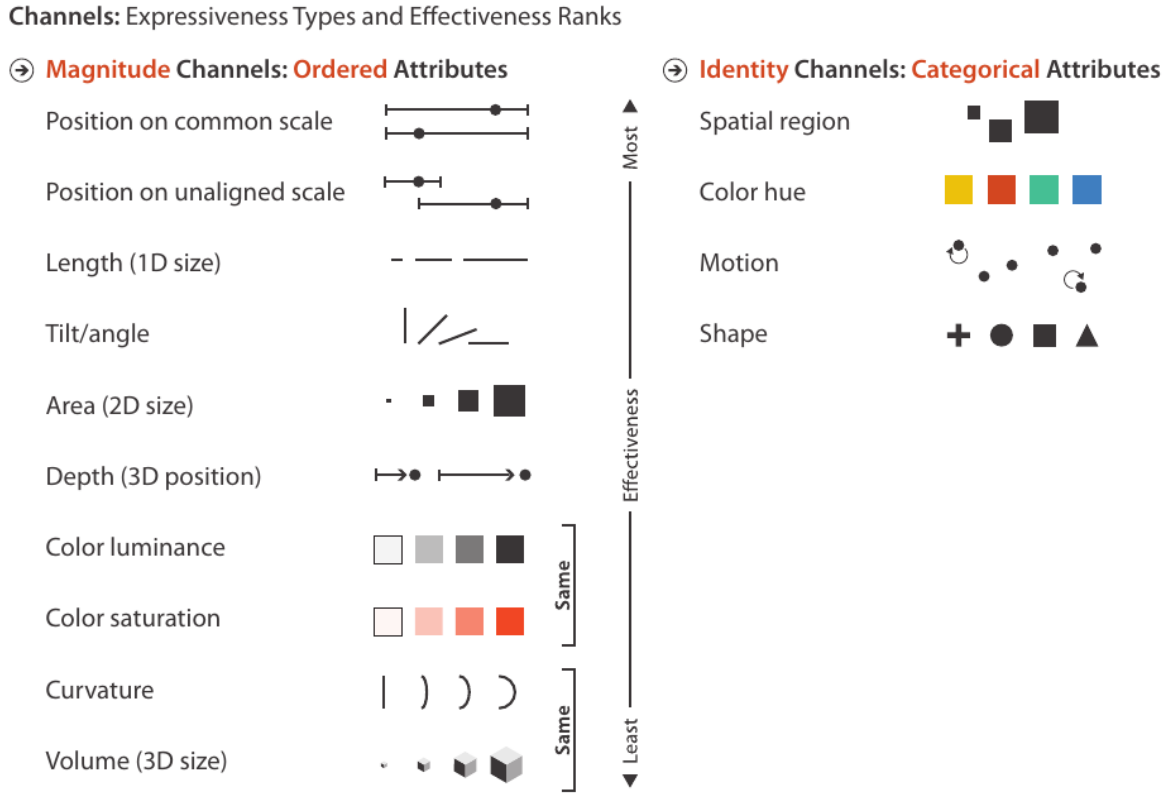
1.2.4 Using marks and channels

All channels are not equal.

The selection of marks and channels should be guided by the principles of **expressivenes** and **effectiveness**.

Once the most important attributes/variables for the desired insight have been identified, the selection of marks and channels should ensure that they are **encoded with the highest ranked**.

1.2.4 Using marks and channels

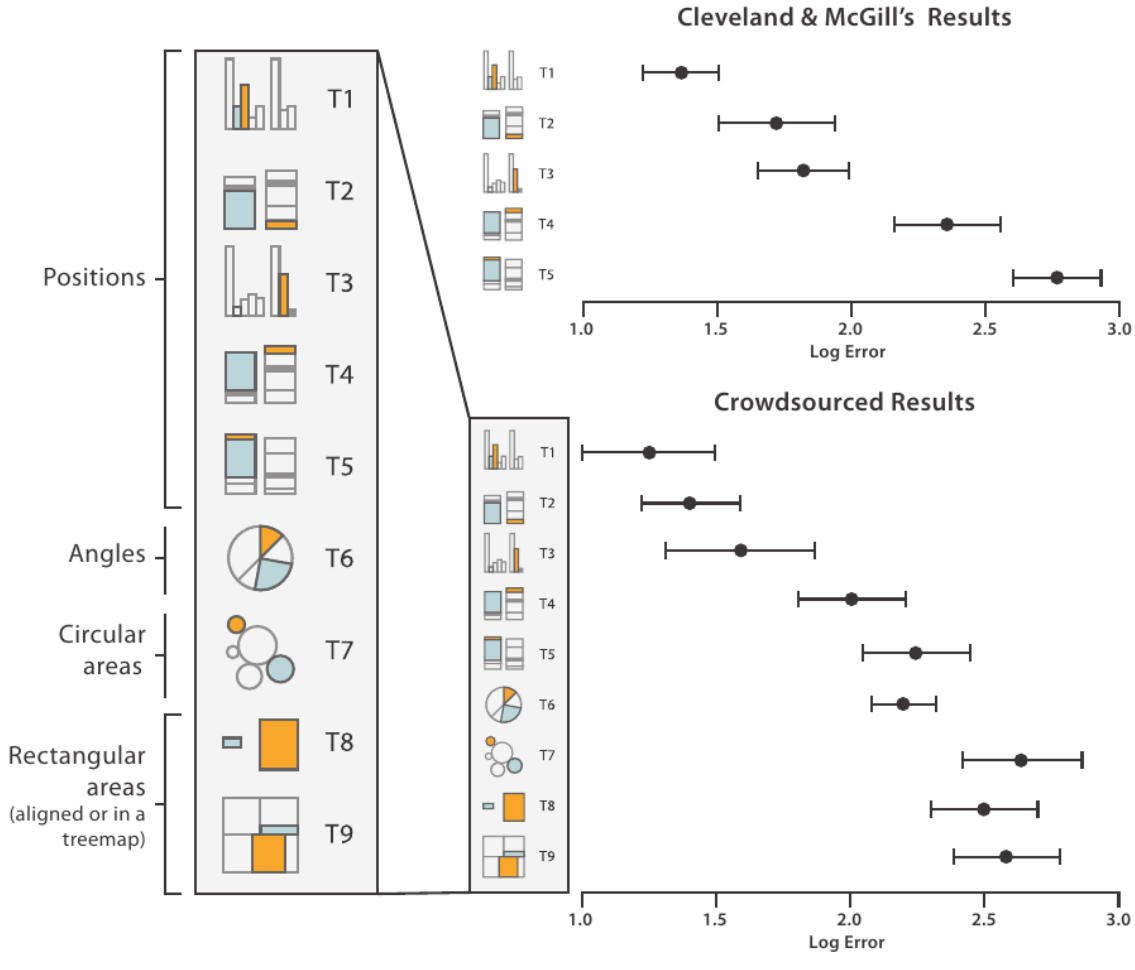


Channels ranked by effectiveness according to data and channel type. Ordered data should be shown with the magnitude channels, and categorical data with the identity channels (Munzner 2014, p.102)

1.2.4 Using marks and channels

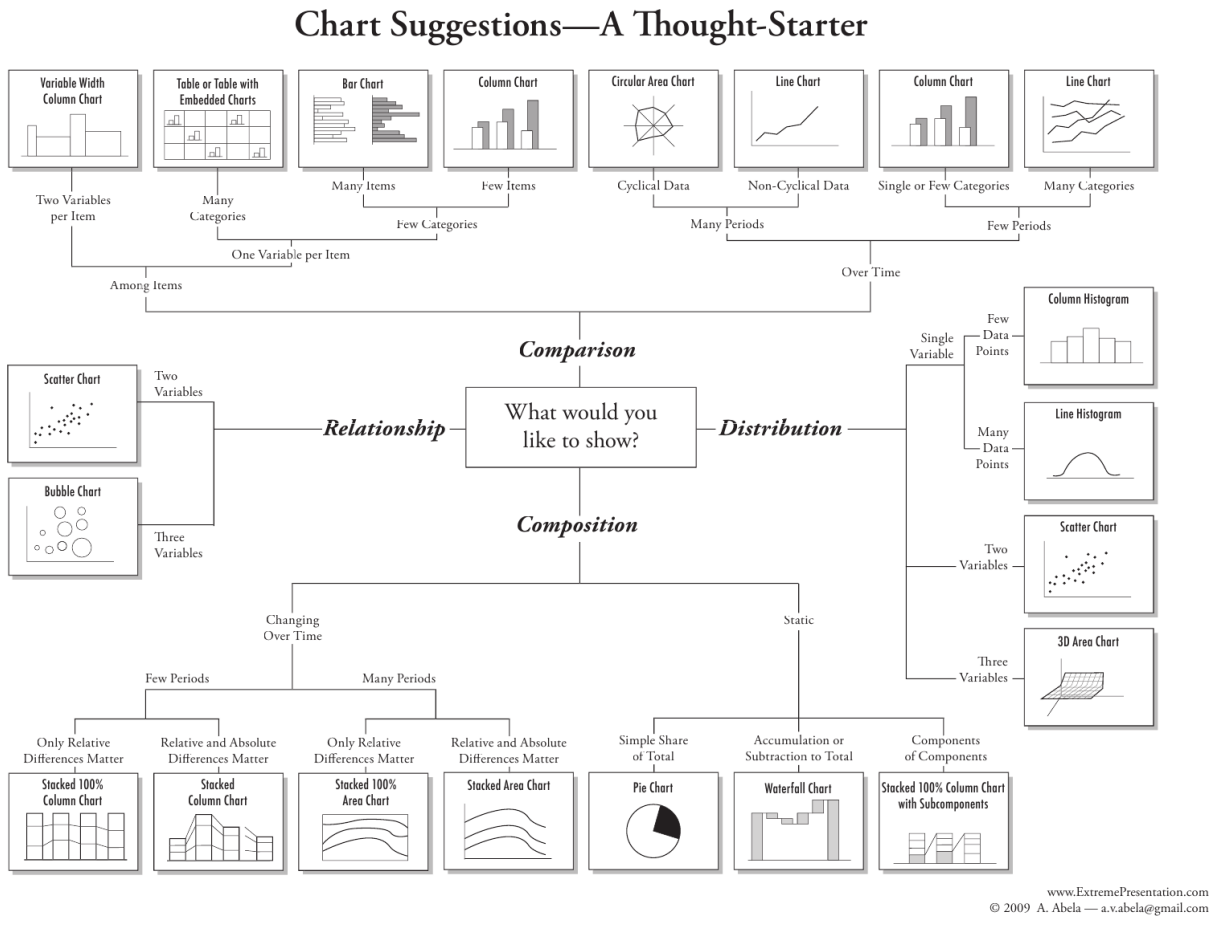
The choice of **which attributes/variables to encode with position** is the most central choice in visual encoding.

1.2.4 Using marks and channels



Error rates accross visual channels (Munzner 2014, p.105)

1.3 So, which graph?



A. Abela (2006), Choosing the right chart. Interactive version: Chart chooser

Tableau: let's explore

- Dimensions and measures (remember also blue *vs.* green)
- Encode = drag
- `Show me` tab

2. Promote insight

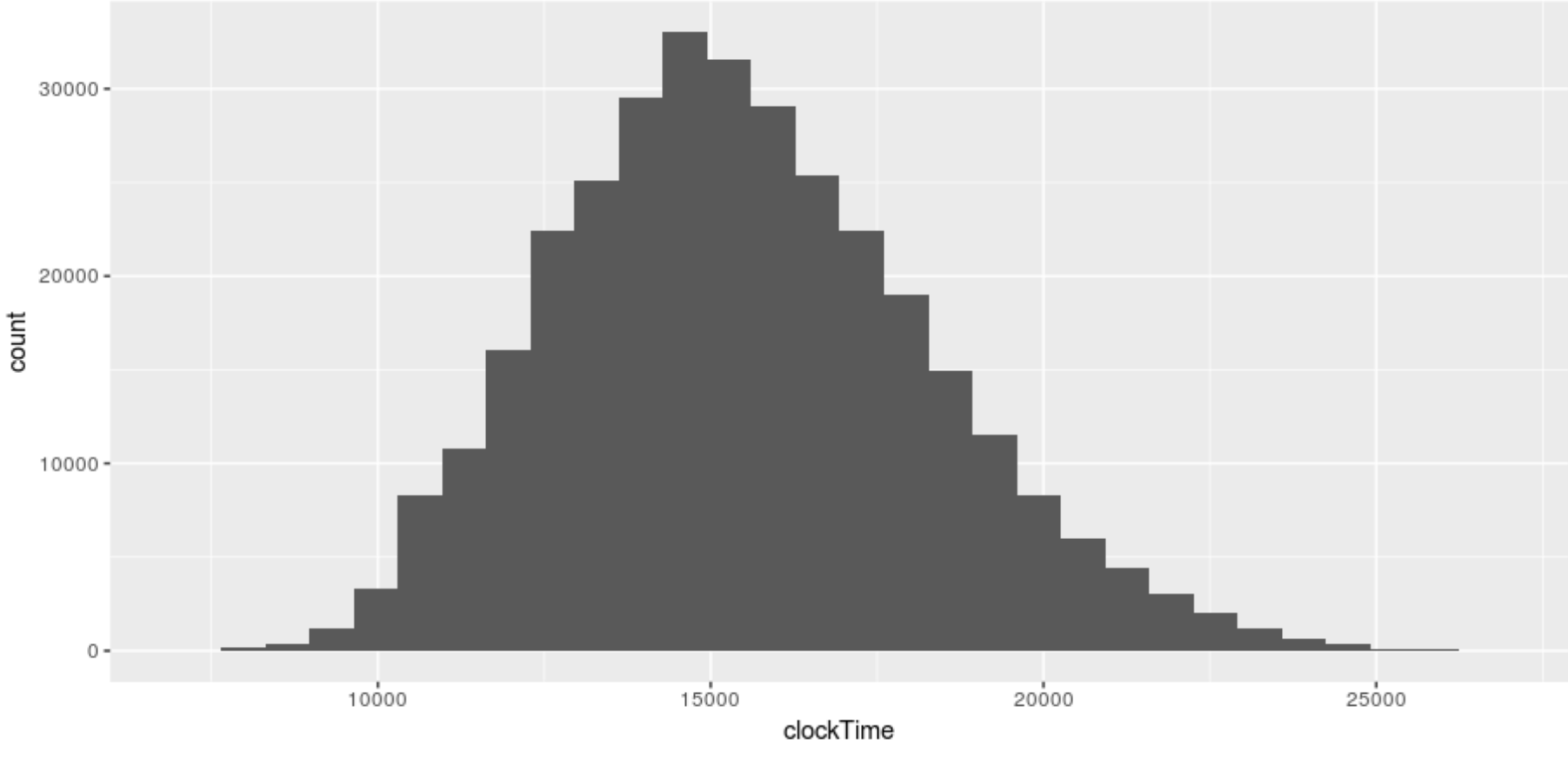
Section outline

How can we enable easier insight through data visualization?

1. Change default settings
2. Make simpler graphs
3. Highlight observations
4. Add attributes as context
5. Add statistical information

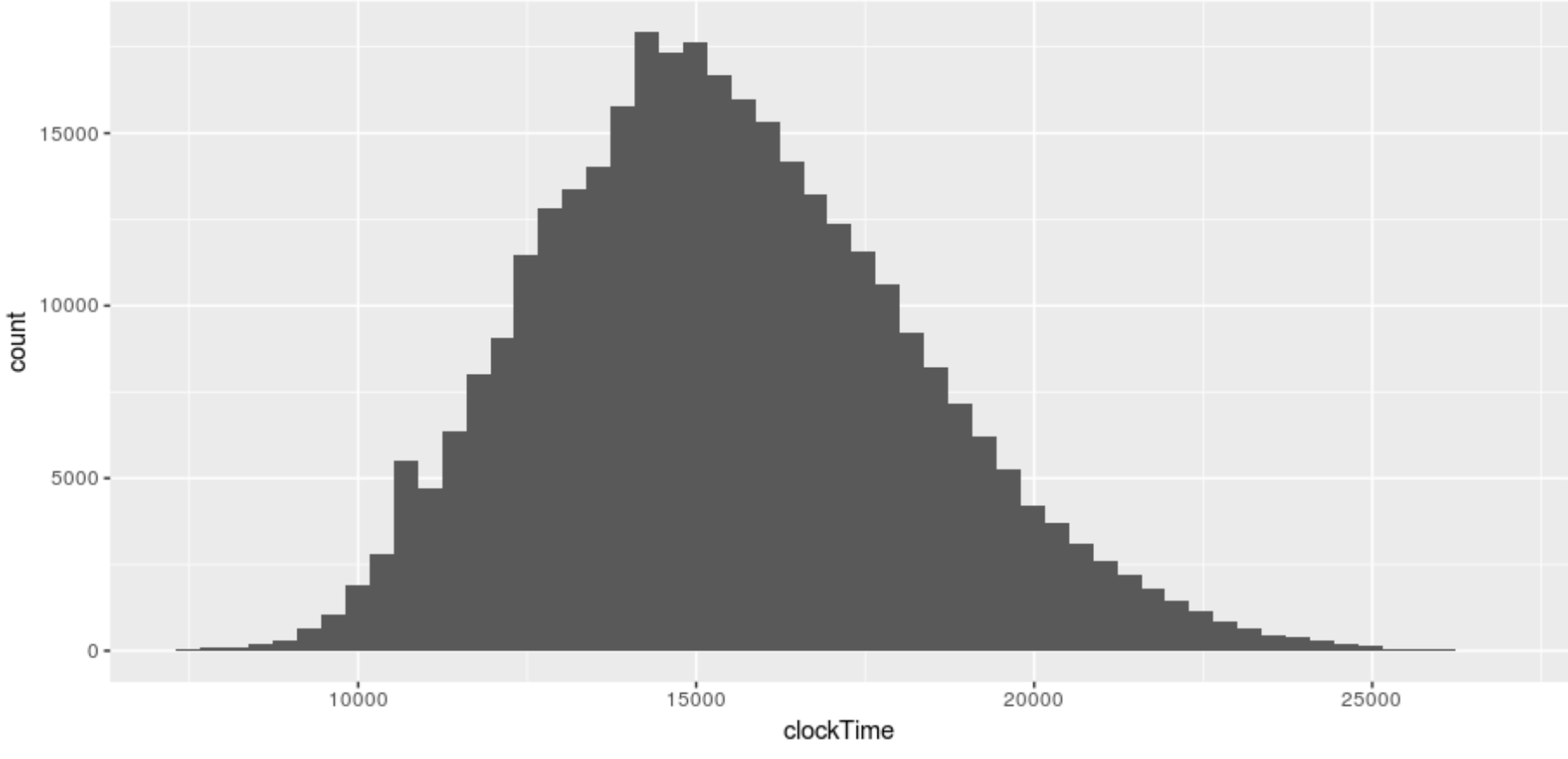
Practice: build (not so) basic graphs

2.1 Change default settings



Data source: Berlin marathon times

2.1 Change default settings



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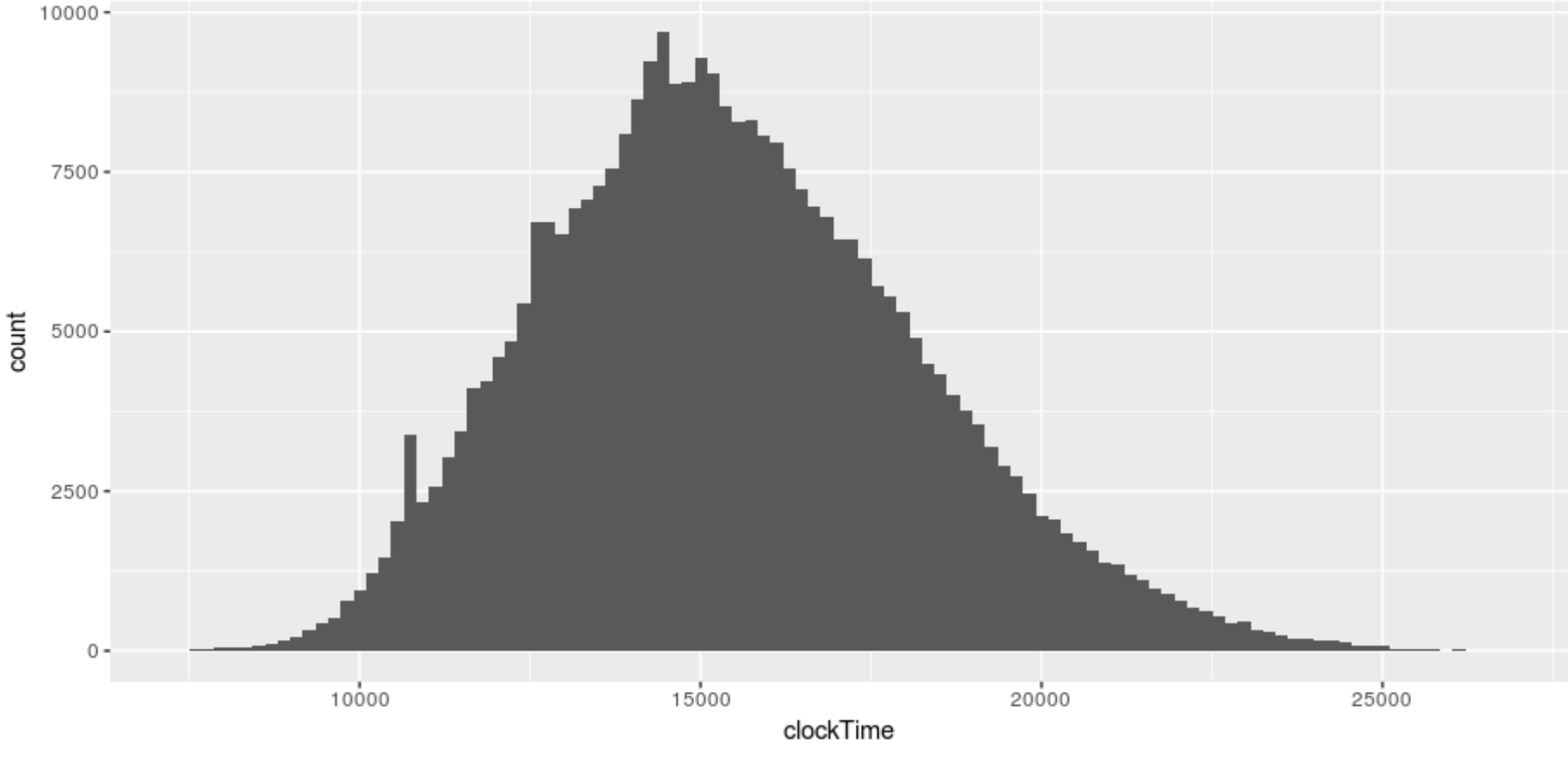
2.1 Change default settings



Data source: Berlin marathon times

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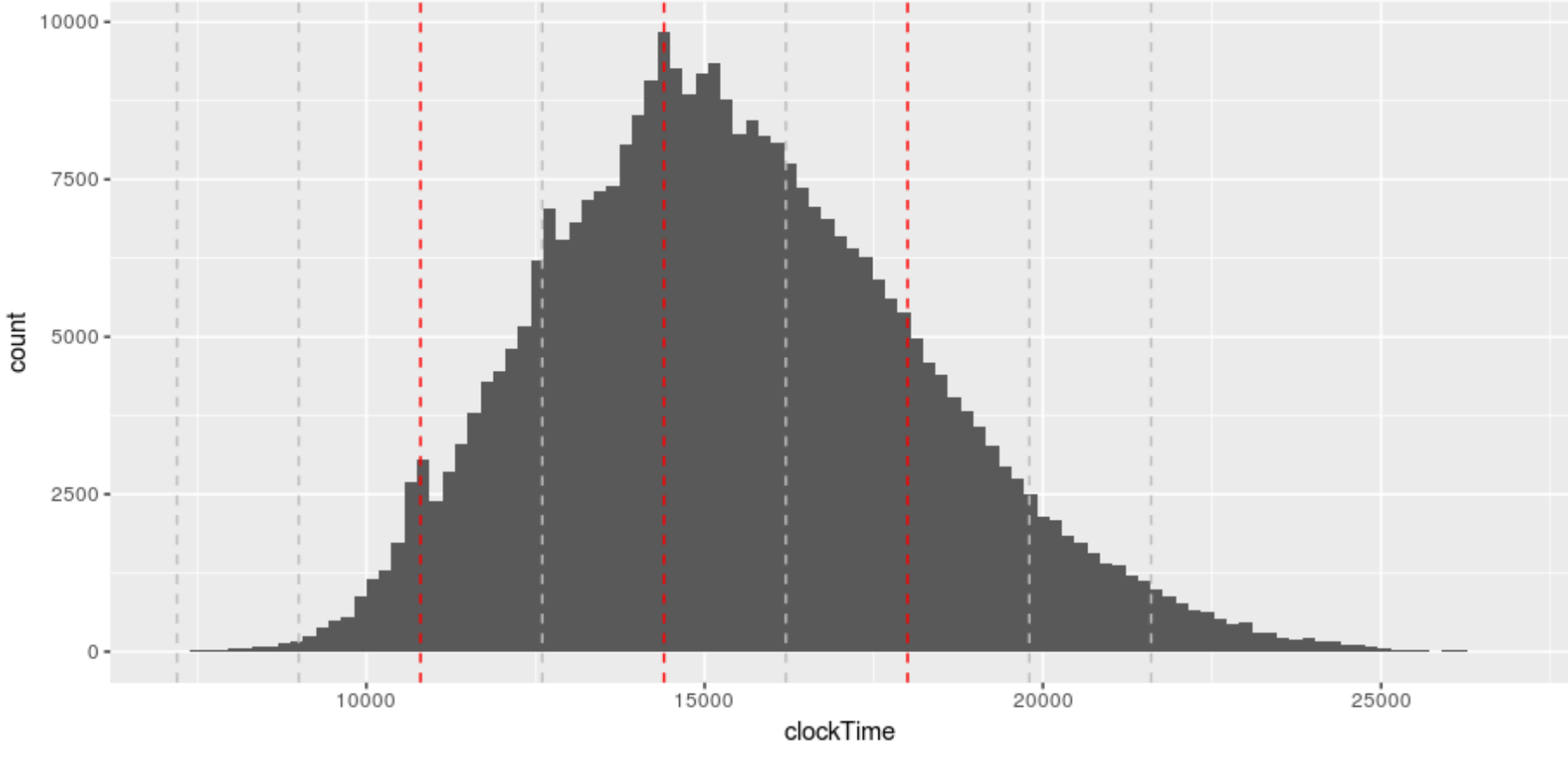


Data source: Berlin marathon times

2.2 Make simpler graphs

> *Data-ink is the non-erasable core of the graphic, the non-redundant ink arranged in response to variation in the numbers represented.*

Tufte 1983

2.2 Make simpler graphs

Speaker Deck

Talk by Joey Cherdarchuk

Full Screen

A step-by-step example: Data looks better naked

2.2 Make simpler graphs

More on decluttering:

Nussbaumer, Declutter Your Data Visualizations

2.3 Highlight observations

Through preattentive attributes:

- they are processed in spatial memory without our conscious action
- make it easier to understand what is represented through a design: saves from consciously processing data

2.3 Highlight observations

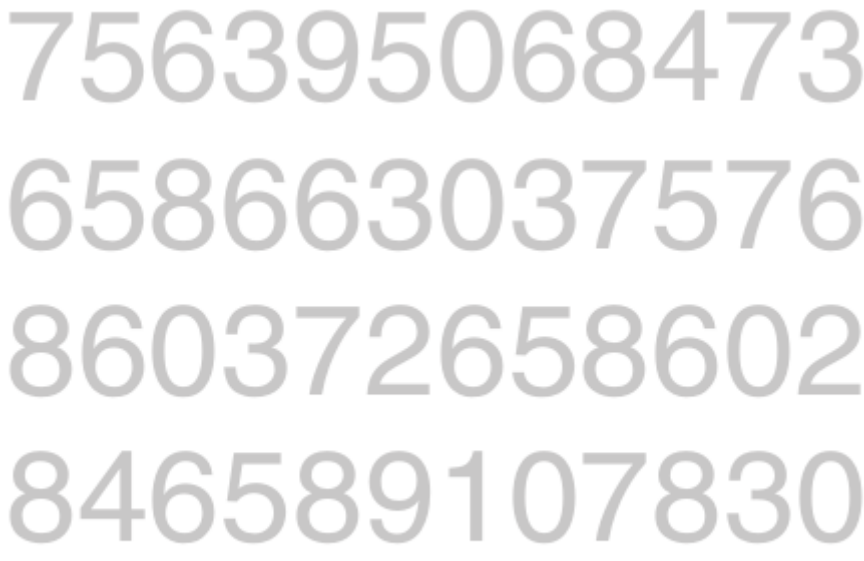


FIGURE 4.2 Count the 3s example

Nussbaumer 2015, p.103

2.3 Highlight observations

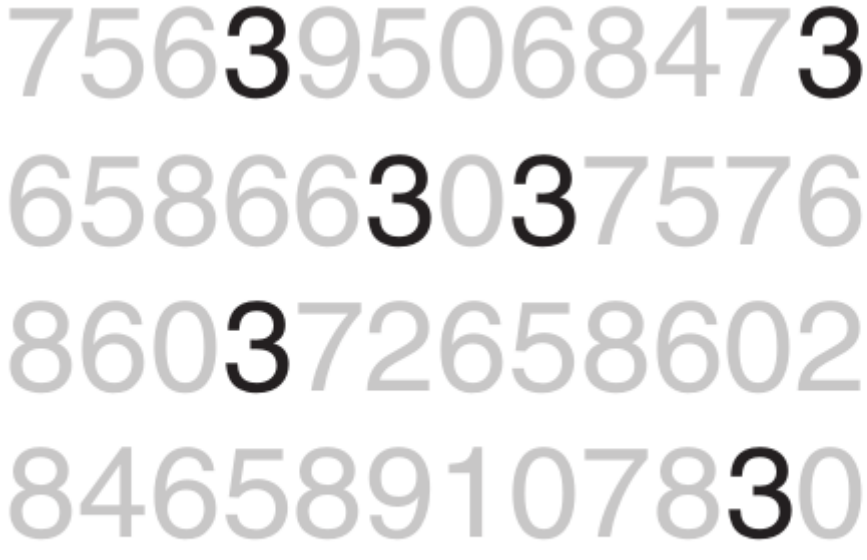


FIGURE 4.3 Count the 3s example with preattentive attributes

Nussbaumer 2015, p.104

2.3 Highlight observations

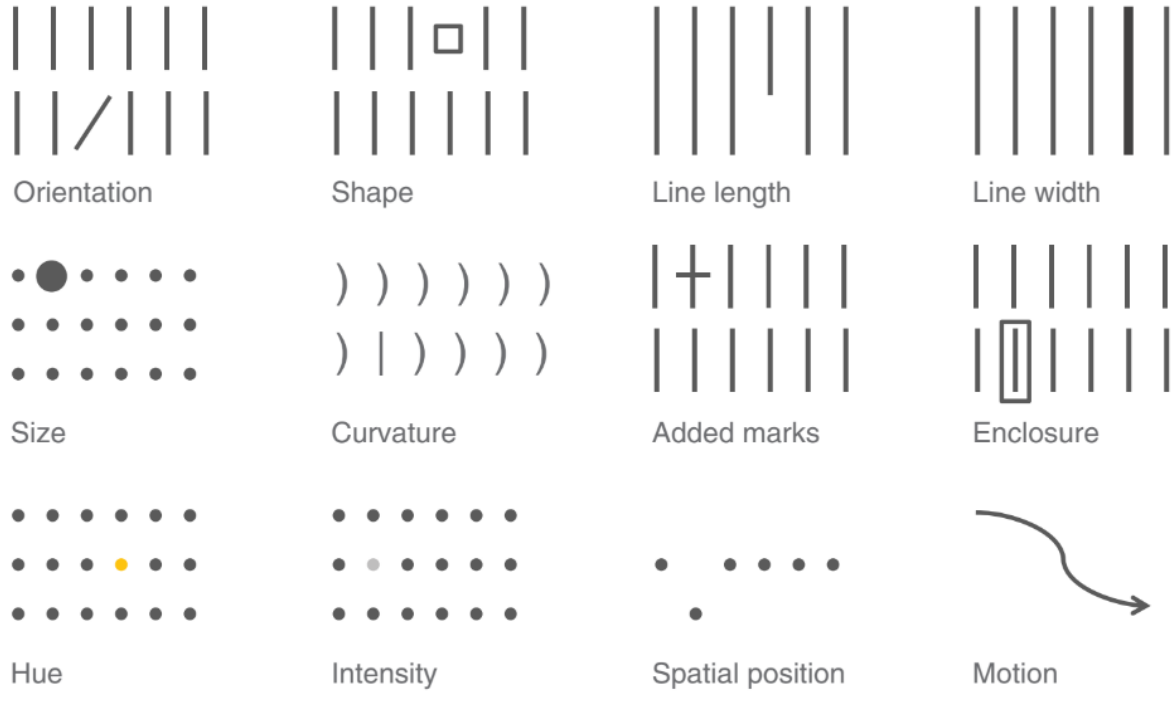


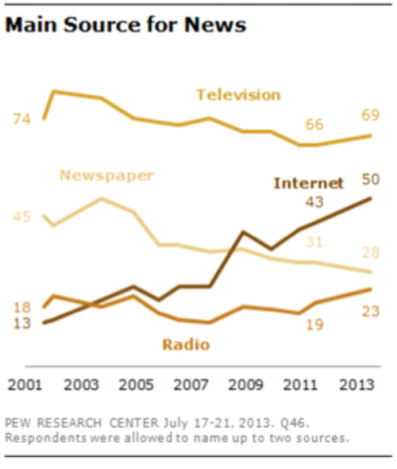
FIGURE 4.4 Preattentive attributes

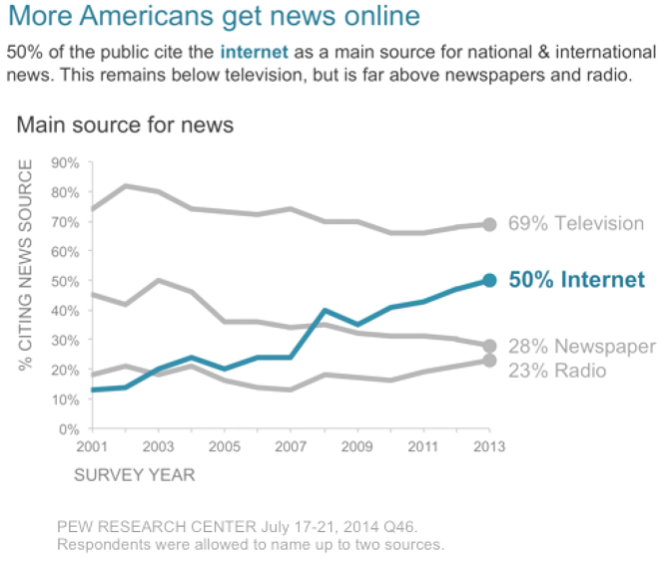
Source: Adapted from Stephen Few's *Show Me the Numbers*, 2004.

Nussbaumber 2015, p.105

2.3 Highlight observations

1. More Americans get news online... 50% of the public now cites source for national and international news, still below television, newspapers and radio. (Report)





Source: http://www.pewresearch.org/fact-tank/2013/10/16/12-trends-shaping-digital-news/

storytelling with data

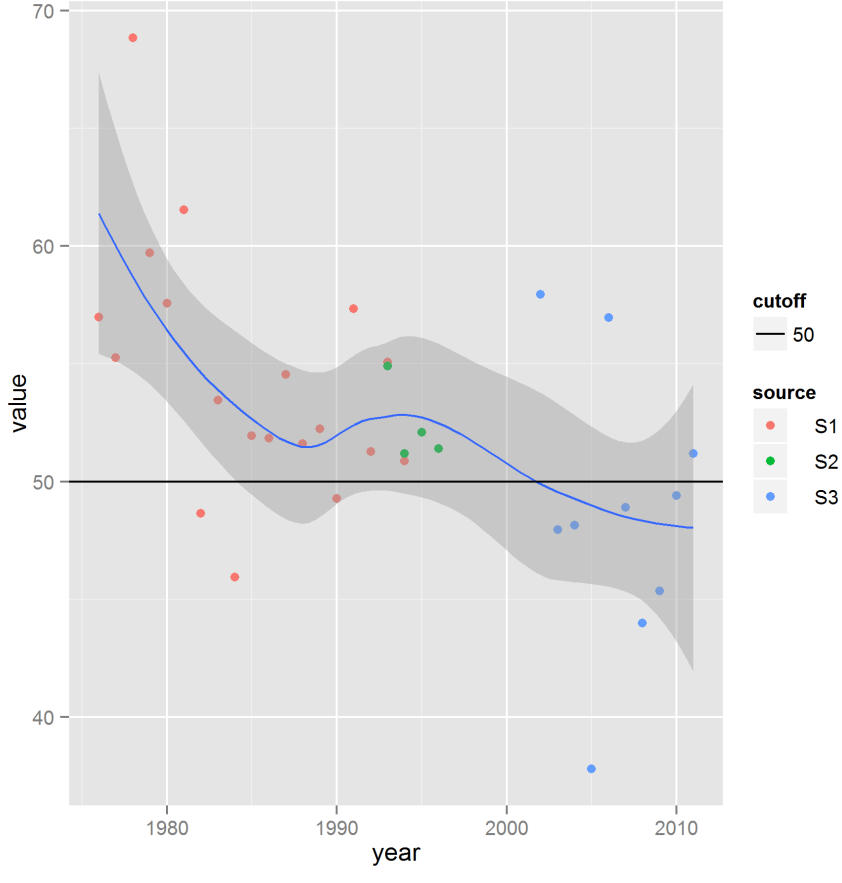
Nussbaumber, Do you see it? The importance of contrast when communicating with data [video]

2.4 Add variables (as context)

- Adding preexisting variables (in moderation)
- Creating conditional variables from preexisting variables
  - binaries or with few levels are best
  - example of calculated field or variable: weekend date

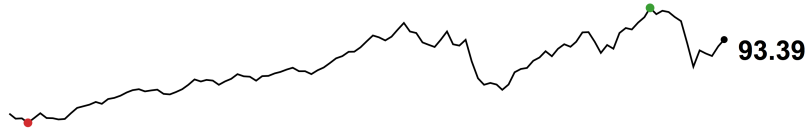
2.5 Add statistical information

- statistical summaries (mean, variance)
- models



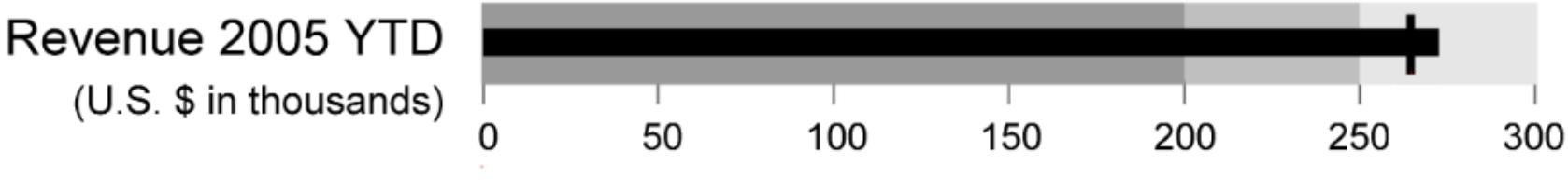
source

Tableau: (not so) basic graphs



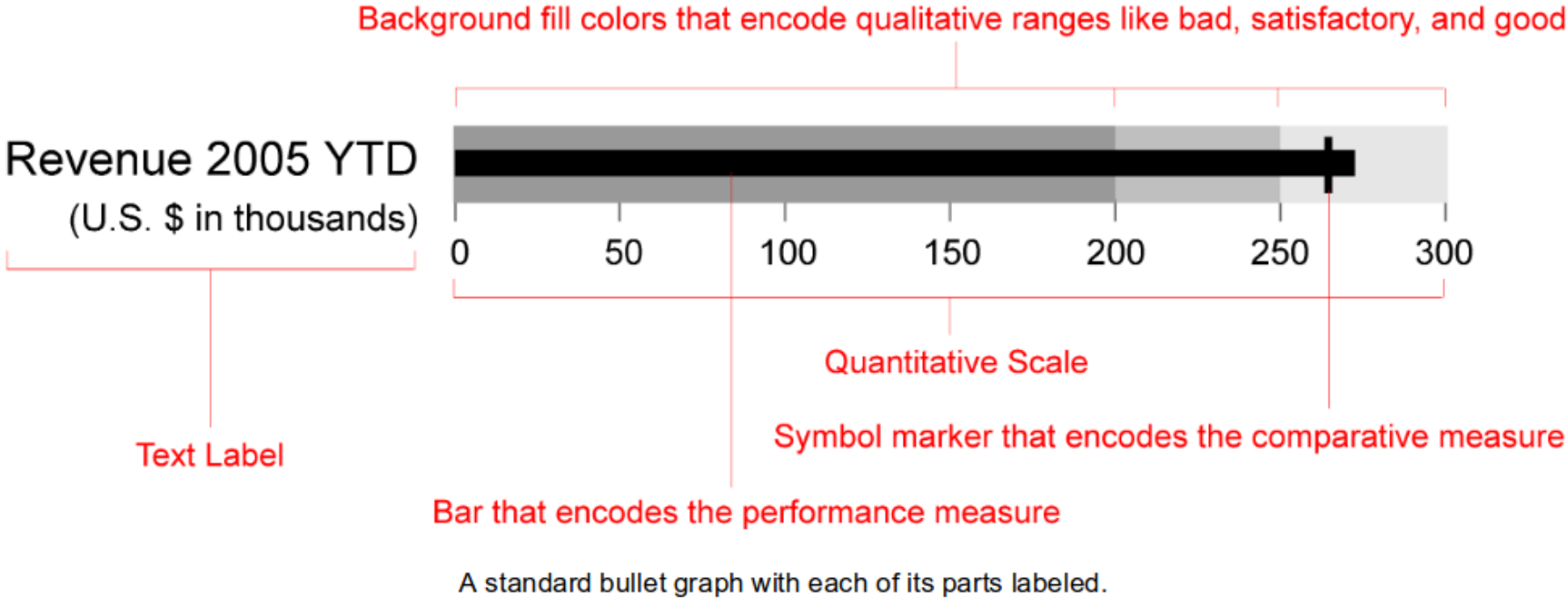
Sparklines (Tufte 2006)

Tableau: (not so) basic graphs



Bulletgraphs (Few 2007)

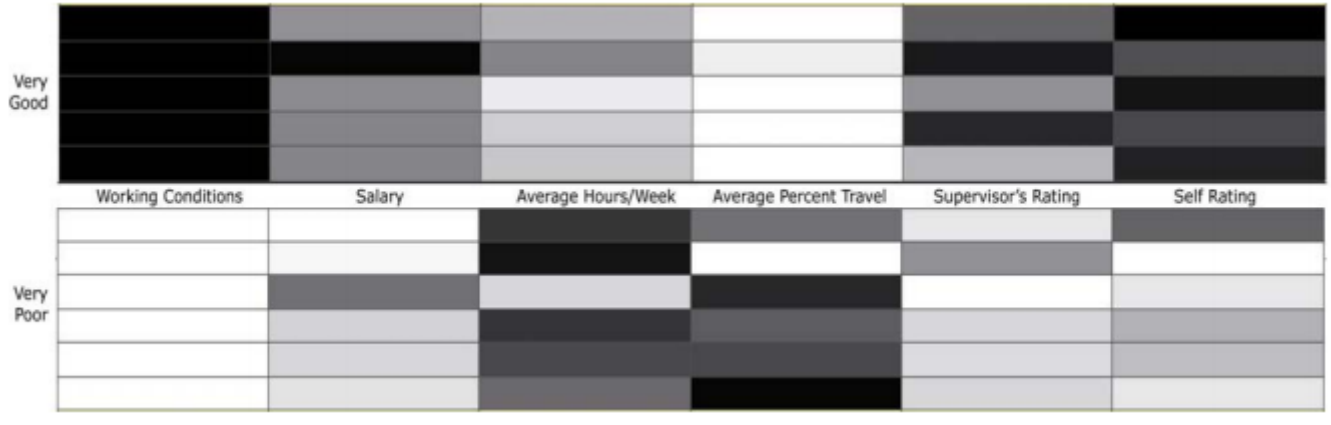
Tableau: (not so) basic graphs



A standard bullet graph with each of its parts labeled.

Bulletgraphs (Few 2007)

Tableau: (not so) basic graphs



Heatmaps (Few 2006)

3. Dashboards

Section outline

1. What is a dashboard?
2. Common design mistakes
3. Key goals in the visual design process
4. Example

Practice: layout and format graphs into a dashboard

3.1 What is a dashboard?

> *Visual display of the most information needed to achieve one or more objectives which fits entirely on a single computer screen so it can be monitored at a glance.*

Few 2013

3.1 What is a dashboard?

- **Visual display**: *I see = I understand → insight* **to achieve specific objectives**: may require gathering information that is otherwise unrelated or disperse
- **fits in a single computer screen**: it must all be seen at once (short-term memory effect)
- **monitored at a glance**: doesn't need to provide all the details, but if it doesn't, it should make it as easy and seamless as possible to get to that information

3.2 Common design mistakes

- Exceeding the boundaries of a single screen
- Supplying inadequate context for the data
- Displaying excessive detail or precision
- Choosing a deficient measure
- Choosing inappropriate display media
- Introducing meaningless variety
- Using poorly designed display media

continues…

3.2 Common design mistakes

…continued

- Encoding quantitative data inaccurately
- Arranging the data poorly
- Highlighting important data ineffectively or not at all
- Cluttering the display with useless decoration
- Misusing or overusing color
- Designing an unattractive visual display

3.3 Key goals in the visual design process

From previous section:

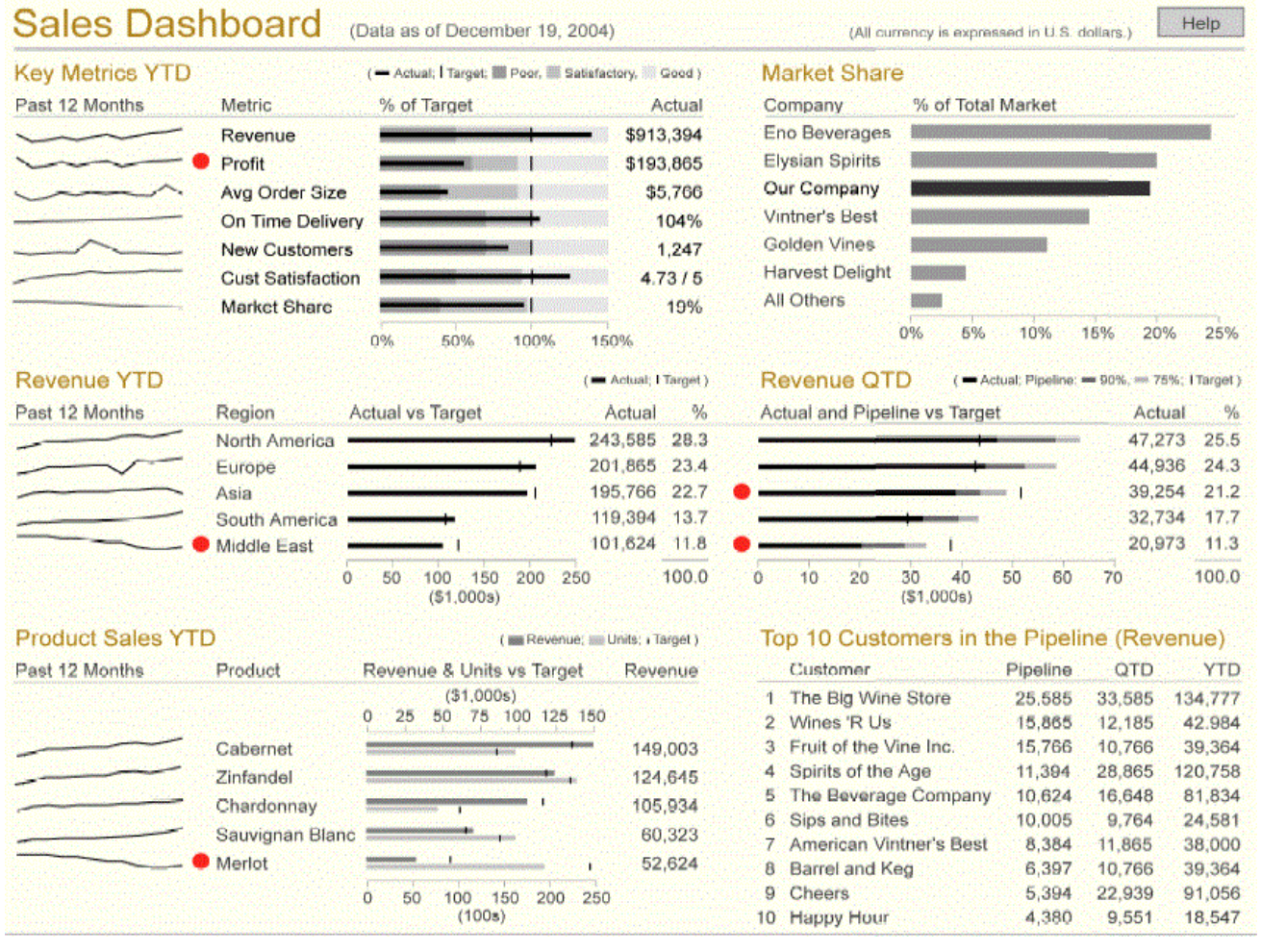
- make simpler graphs (declutter)
- highlight observations
- add attributes/variables as context or statistical information

3.3 Key goals in the visual design process

In other words:

1. Reduce non-data pixels
   - eliminate all unnecessary non-data pixels
   - de-emphasize and regularize the non-data pixels that remain
2. Enhance data pixels
   - eliminate all unnecessary data pixels
   - highlight the most important data-pixels that remain

3.4 Example



Few 2013

Dashboards in Tableau

Dashboards in Tableau are containers of *sheets* of graphs.

Allow for quite basic but functional formatting.

Tableau: Actions

Some degree of interactivity with `Actions`: highlight and filter

Tableau: What else?

Calculated fields

…

Epilogue

References

Abela, Andrew (2006). Choosing a good chart.

Few, Stephen (2009). Dashboard Design for Real-Time Situation Awareness [White Paper]

— (2013). *Information Dashboard Design*. Analytics Press: 316.763 F 44 s

Kirk, Andy (2016). *Data Visualisation: A Handbook for Data Driven Design*. SAGE: London 316.763 K 63 a

Munzner, Tamara (2015). *Visualization Analysis and Design*. CRC Press: Boca Raton, Florida 316.763 M 92 t

Tufte, Edward R. (1983). *The Visual Display of Quantitative Information*. Graphics Press: California 316.763 T 87 e

Thank you!

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Miren Berasategi

miren.berasategi@deusto.es

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