CSE P 590

Building Data Analysis Pipelines

Fall 2024

Data visualization and reporting

tidyverse

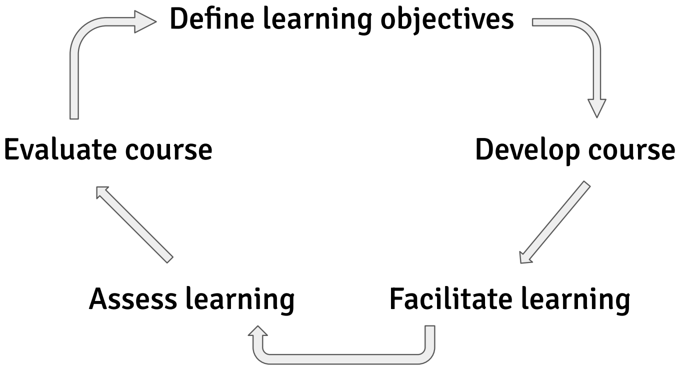
Today

- Logistics and reflection
- Effective tables and visualizations
    - Tables vs. graphs
    - Effective tables
    - Effective visualizations (ggplot2)
- HW2: Overview
- Tutorial: Quarto

Logistics and reflection

Reflections on HW1

HW1 in the teaching, learning, assessment cycle



Define learning objectives

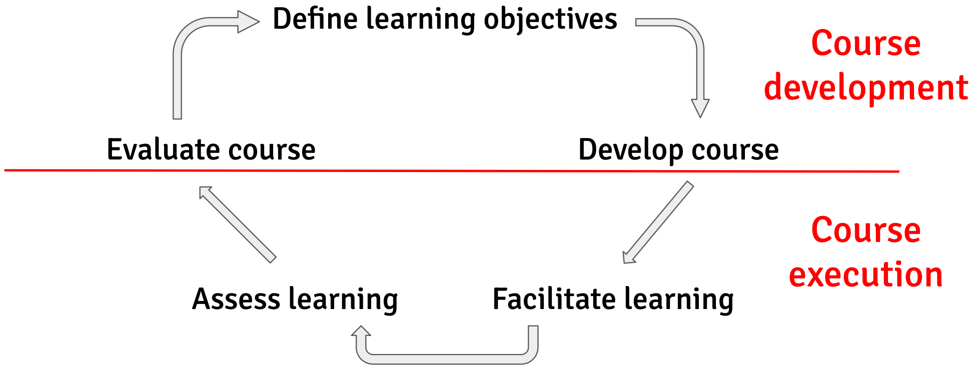
Evaluate course

Develop course

Assess learning

Facilitate learning

HW1 in the teaching, learning, assessment cycle



Define learning objectives

Course development

Evaluate course

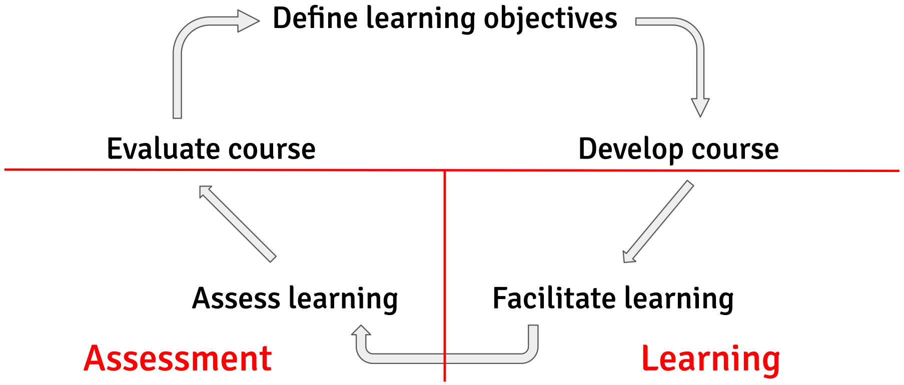
Develop course

Course execution

Assess learning

Facilitate learning

HW1 in the teaching, learning, assessment cycle



Define learning objectives

Evaluate course

Develop course

Assess learning

Facilitate learning

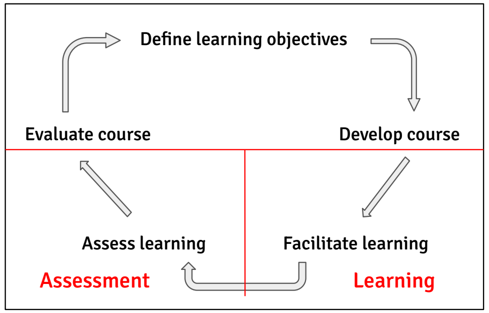
Assessment

Learning

HW1 in the teaching, learning, assessment cycle

HW 1

- Designed to facilitate learning
- Two key focus areas:
  - Analysis design and validity
  - Reasoning under uncertainty
- Primer for HW2
- Address HW1 grading feedback (and get HW1 points back)



Define learning objectives

Evaluate course

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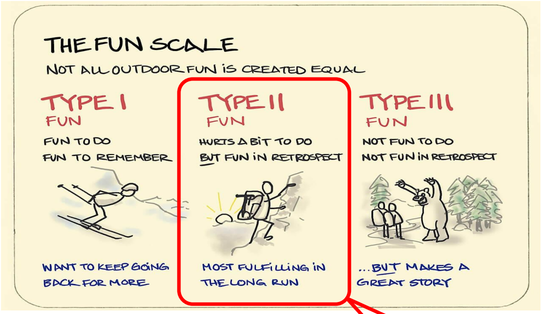
Assessment

Learning

HW1 in one picture: mostly type II fun



Sweet spot for teaching

Course overview: the big picture

- **09/30:** Course introduction
- **10/07:** Analysis design and validity
- **10/14:** Data wrangling
- **10/21:** Statistical modeling
- **10/28:** Statistical significance and power
- **11/04:** Advanced statistical modeling
- **11/11:** *No class*
- **11/18:** Data visualization and reporting
- **11/25:** Big data
- **12/02:** Big data

Course overview: the big picture

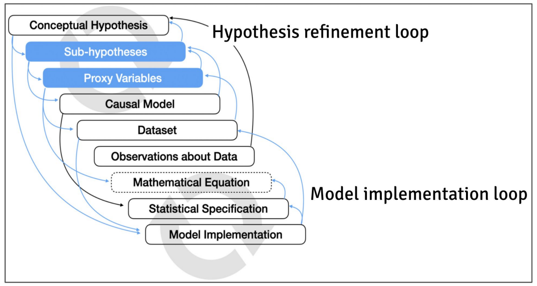
09/30: Course introduction	
10/07: Analysis design and validity	In-class exercise
10/14: Data wrangling	In-class exercise
10/21: Statistical modeling	In-class exercise
10/28: Statistical significance and power	In-class exercise
11/04: Advanced statistical modeling	HW 1
11/11: *No class*	
11/18: Data visualization and reporting	**HW 2**
11/25: Big data	**In-class exercise**
12/02: Big data	

Extended due date for HW2 (12/04) and more time for in-class 5!

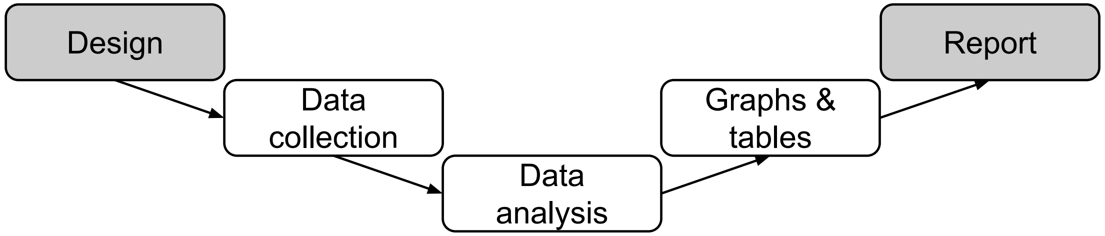
Tables vs. graphs

From analysis design to report

Design
How do we get here?
Report

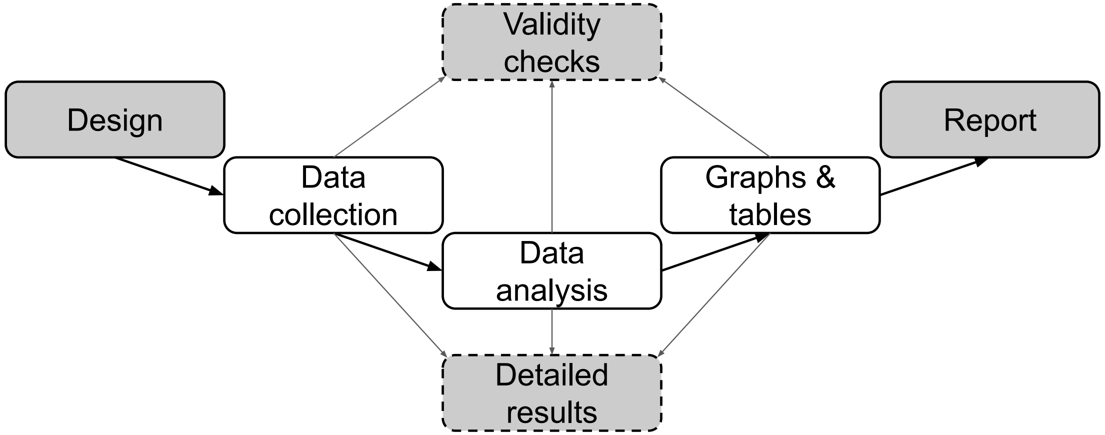


From analysis design to report



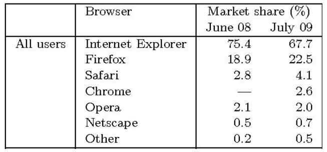
Do all analysis results go into the final report?

From analysis design to report



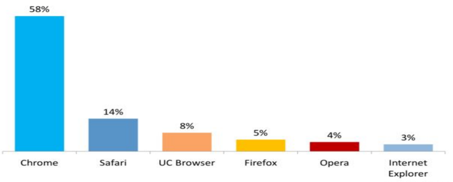
Tables vs. graphs

- When are tables useful?
  - Compare individual values
  - Values involve multiple units
  - Precise values are important



	Browser	Market share (%)	
		June 08	July 09
All users	Internet Explorer	75.4	67.7
	Firefox	18.9	22.5
	Safari	2.8	4.1
	Chrome	—	2.6
	Opera	2.1	2.0
	Netscape	0.5	0.7
	Other	0.2	0.5

- When are graphs useful?
  - Consider an entire set of values
  - Visualize trends and patterns
  - Relationships are more important than precise values



Market share 2018

Effective tables

Effective tables: the run-time data set

```
variant,naive,caching,forking,run,subject
11,      309.8,157.6,  144.8,   1,   "tax"
12,      379.5,237.4,  254.5,   1,   "tax"
13,      415.9,225.9,  225.9,   1,   "tax"
...
```

- Recall the run-time data set
  - 3 subjects (tax, tictactoe, triangle)
  - 3 strategies (naive, caching, forking)
  - 5 runs to account for the variation in run time

Goal: show run times and relative improvements in a table

Effective tables: layout

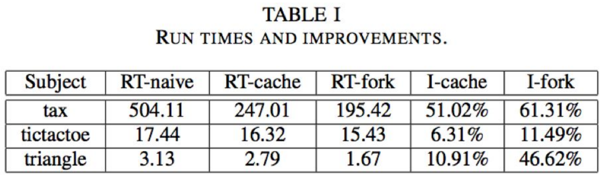


TABLE I
RUN TIMES AND IMPROVEMENTS.

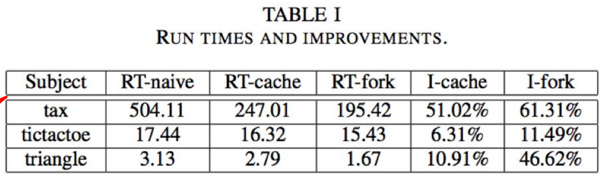
Subject	RT-naive	RT-cache	RT-fork	I-cache	I-fork
tax	504.11	247.01	195.42	51.02%	61.31%
tictactoe	17.44	16.32	15.43	6.31%	11.49%
triangle	3.13	2.79	1.67	10.91%	46.62%

- Recall the run-time data set
  - 3 subjects (tax, tictactoe, triangle)
  - 3 strategies (naive, caching, forking)
  - 5 runs to account for the variation in run time

What are the pros/cons of Table I?

How would you improve it?

Effective tables: layout



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Compare the two w.r.t. readability, clarity, and interpretability

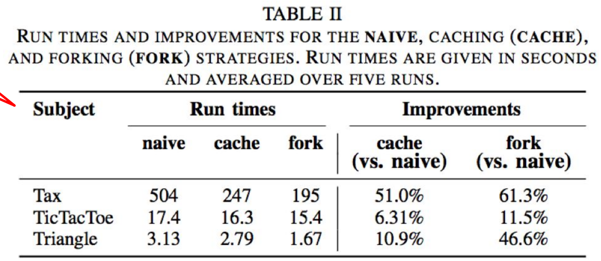


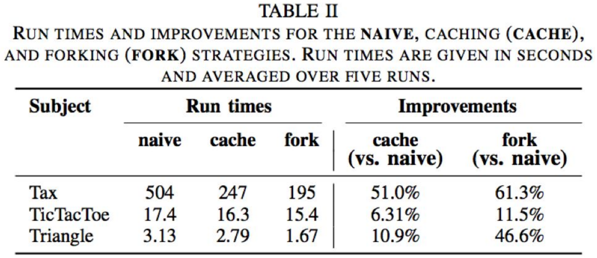
TABLE II
RUN TIMES AND IMPROVEMENTS FOR THE **NAIVE**, CACHING (**CACHE**), AND FORKING (**FORK**) STRATEGIES. RUN TIMES ARE GIVEN IN SECONDS AND AVERAGED OVER FIVE RUNS.

Subject	**Run times**			**Improvements**	
	naive	**cache**	**fork**	**cache (vs. naive)**	**fork (vs. naive)**
Tax	504	247	195	51.0%	61.3%
TicTacToe	17.4	16.3	15.4	6.31%	11.5%
Triangle	3.13	2.79	1.67	10.9%	46.6%

Effective tables: content

Keep it simple

- Avoid mixing higher-is-better and lower-is-better numbers
- Allow for easy comparisons, primarily by row
- Be consistent about precision vs. significant digits
- Summarize the table (what is the bottom line?)



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Subject	Run times			Improvements	
	naive	cache	fork	cache (vs. naive)	fork (vs. naive)
Tax	504	247	195	51.0%	61.3%
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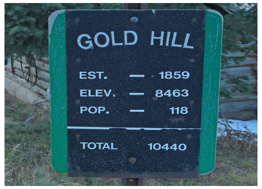
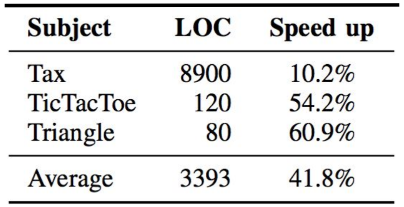
Effective tables: summaries





Subject	LOC	Speed up
Tax	8900	10.2%
TicTacToe	120	54.2%
Triangle	80	60.9%
Average	3393	41.8%

Total vs. **Average**

What are the downsides of these summaries?

Effective tables: best practices

Do

- Make each table self-contained (content and caption)
- Use descriptive (hierarchical) headers
- Right align numbers
- Use meaningful totals or weighted averages
- Be consistent about precision vs. significant digits

Don’t

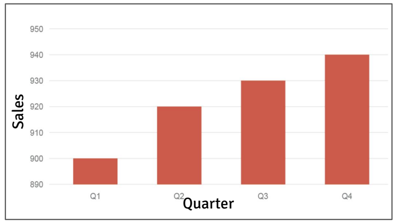
- Don’t use horizontal lines between related rows
- Don’t use vertical lines between related columns

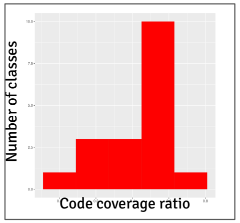
Effective graphs

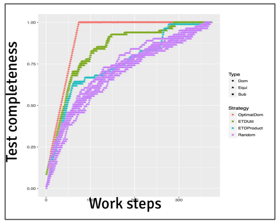
4 beautiful graphs

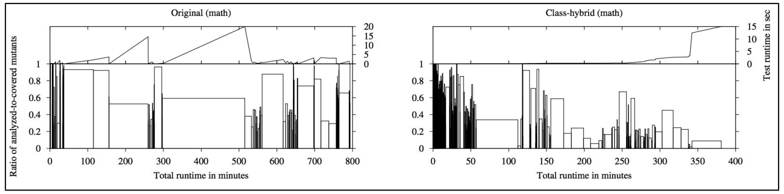
- Small groups of 4-6 students
- 4 example graphs
- For each graph
  - Discuss pros and cons
  - Propose improvements

4 beautiful graphs

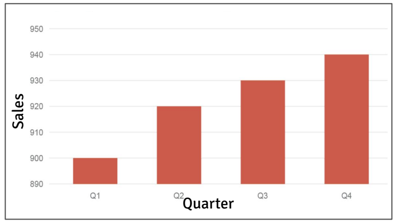






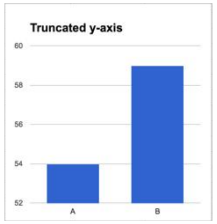


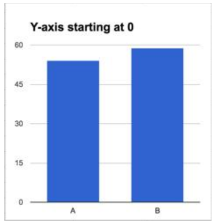
Example 1: bar charts



Truncated axes are misleading and
not a proper way to “demonstrate” effect size!

Example 1: bar charts





Truncated axes are misleading and
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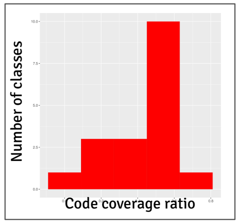
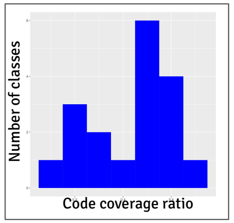
Example 2: histogram



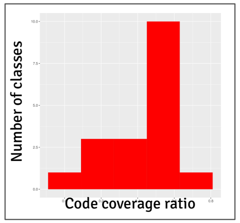
Good visual summary of count data, but binning may be misleading.

Kernel density overlay can provide information about adequate binning.

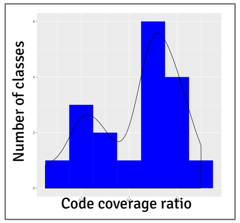
Example 2: histogram vs. density plot



Adequate binning



Changed binning



Kernel density overlay

Good visual summary of count data, but binning may be misleading.

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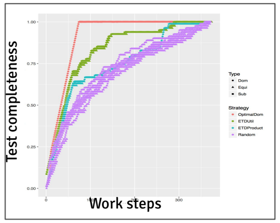
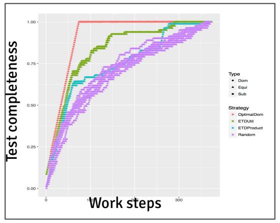
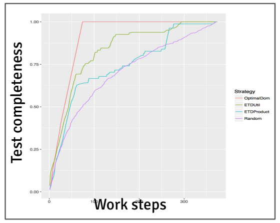
Example 3: scatter plot



Good visual summary of point clouds, trends, and relationships.
May obscure relevant trends (overlapping points).
Hard to reason about density (without adding transparency).

Example 3: scatter plot vs. line plot





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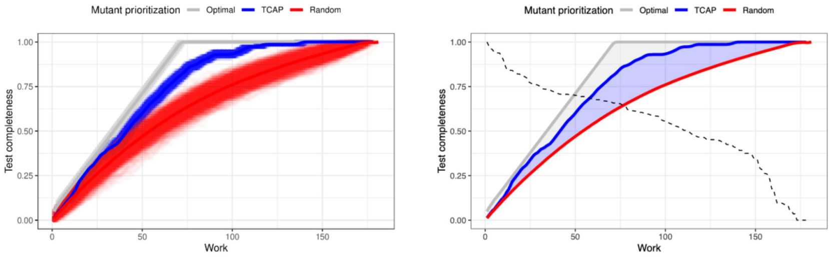
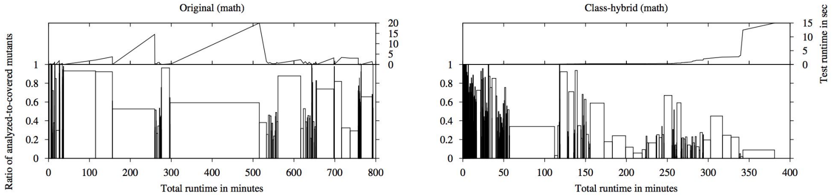


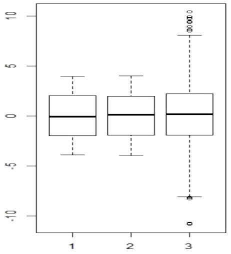
Good visual summary of point clouds, trends, and relationships.
May obscure relevant trends (overlapping points).
Hard to reason about density (without adding transparency).

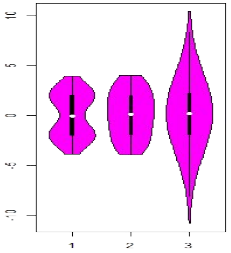
Example 4: multi-plot visualization



Way too many details!
The key trends and takeaways are obscured.
Good for detailed results but not a final report.

Effective graphs: box plots vs. violin plots

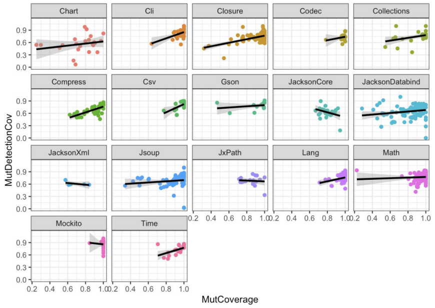




Box plots:

- Good visual data summary
- Nicely complements hypothesis tests
- May be misleading for multimodal data
- May be misleading for small samples

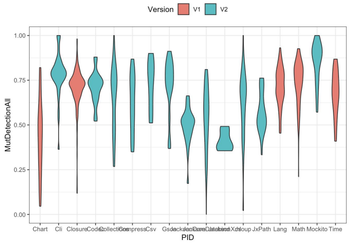
Effective graphs: facet plots

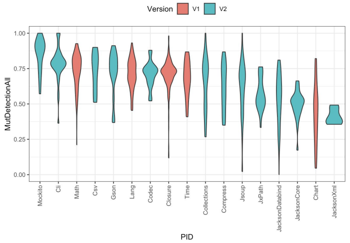


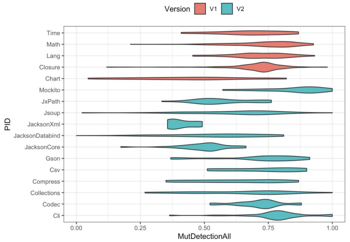
Facet plots:

- Clean visualizations across multiple dimensions of interest
- Allows for comparisons within groups and across groups
- Complementary to other ggplot2 aesthetics (color, shape, etc.)
- Use ggplot's `facet_grid` for cross-product visualizations (formula syntax)

Effective graphs: reorder and/or flip axes







Reorder and/or flip axes:

- Reorder by mean/median or by groups of interest etc.
- Flip axes for readability if appropriate
- Favor short labels over rotated labels

Effective graphs: best practices

Do

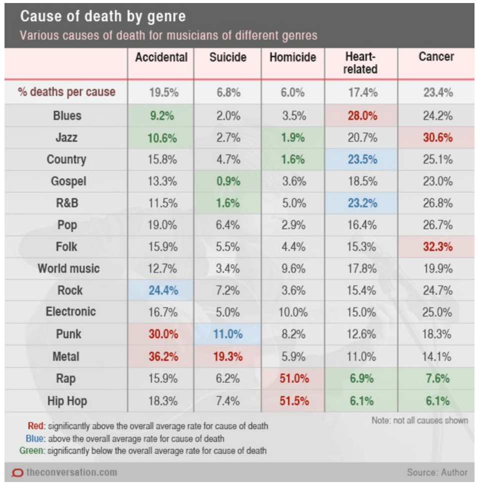
- **Use ggplot2!**
- Make each plot self-contained (content and caption)
- Relate tables and graphs to tell a consistent story
- By default put the DV on the vertical axis
- Reduce complexity with facet plots

Don't

- Don't use multiple, unrelated axes
- Don't connect unrelated data points
  (choose an appropriate graph instead)

A real-world example

Let's consider the following reporting



Cause of death by genre

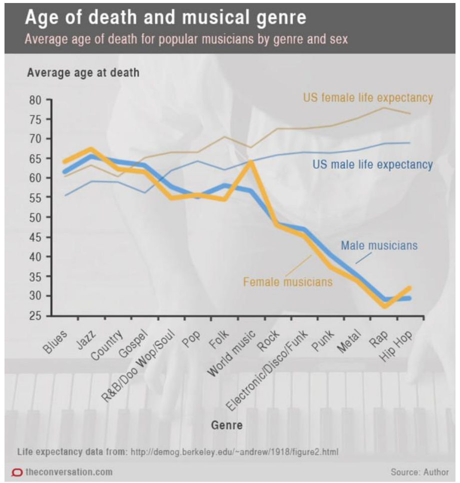
Various causes of death for musicians of different genres

	Accidental	Suicide	Homicide	Heart-related	Cancer
% deaths per cause	19.5%	6.8%	6.0%	17.4%	23.4%
Blues	9.2%	2.0%	3.5%	28.0%	24.2%
Jazz	10.6%	2.7%	1.9%	20.7%	30.6%
Country	15.8%	4.7%	1.6%	23.5%	25.1%
Gospel	13.3%	0.9%	3.6%	18.5%	23.0%
R&B	11.5%	1.6%	5.0%	23.2%	26.8%
Pop	19.0%	6.4%	2.9%	16.4%	26.7%
Folk	15.9%	5.5%	4.4%	15.3%	32.3%
World music	12.7%	3.4%	9.6%	17.8%	19.9%
Rock	24.4%	7.2%	3.6%	15.4%	24.7%
Electronic	16.7%	5.0%	10.0%	15.0%	25.0%
Punk	30.0%	11.0%	8.2%	12.6%	18.3%
Metal	36.2%	19.3%	5.9%	11.0%	14.1%
Rap	15.9%	6.2%	51.0%	6.9%	7.6%
Hip Hop	18.3%	7.4%	51.5%	6.1%	6.1%

Note: not all causes shown

Red: significantly above the overall average rate for cause of death
Blue: above the overall average rate for cause of death
Green: significantly below the overall average rate for cause of death

theconversation.com Source: Author



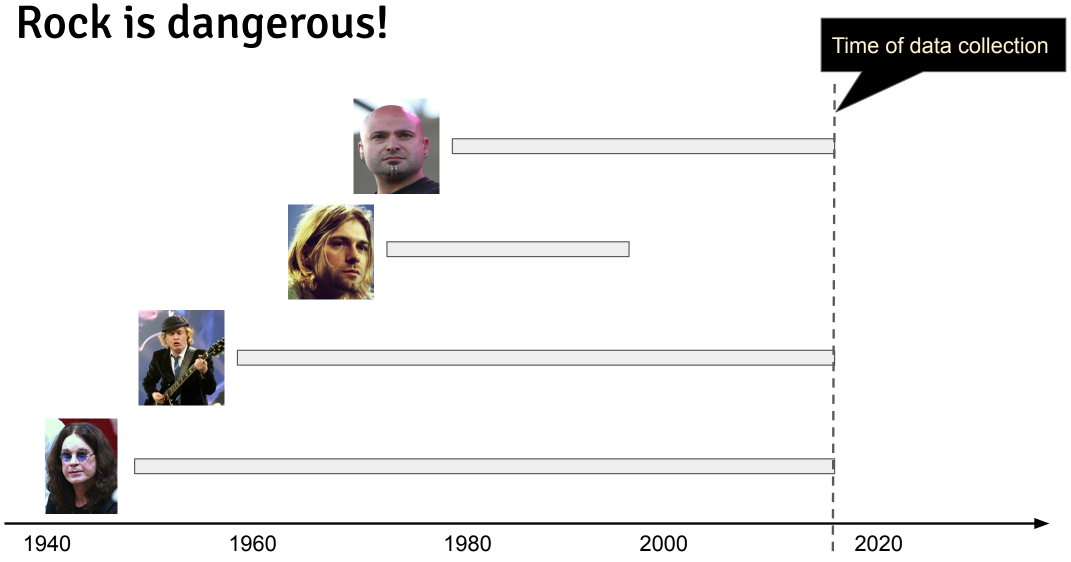
Age of death and musical genre

Average age of death for popular musicians by genre and sex

Life expectancy data from: http://demog.berkeley.edu/~andrew/1918/figure2.html

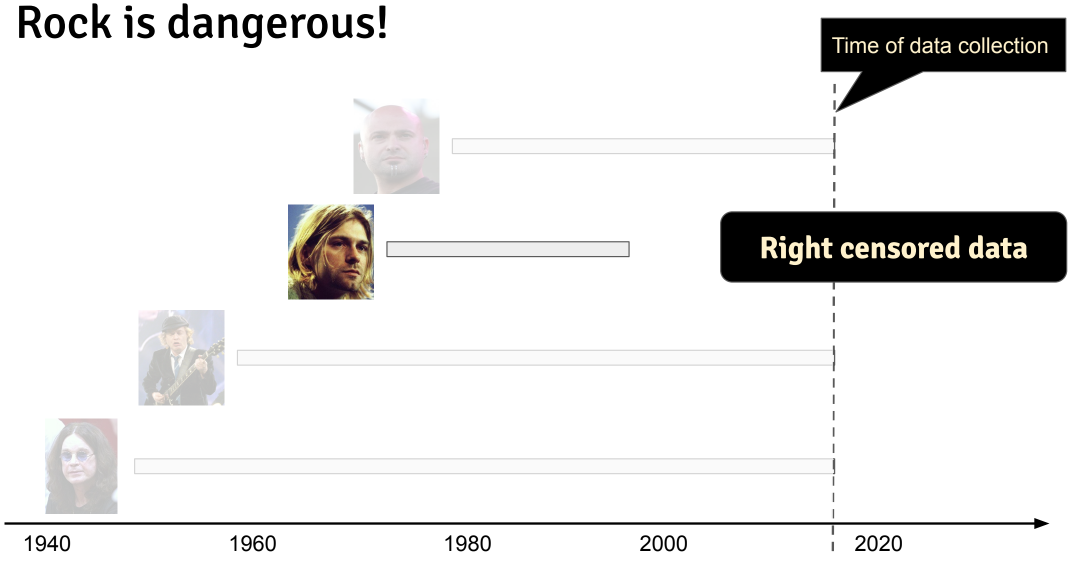
theconversation.com Source: Author

Rock is dangerous!



Time of data collection

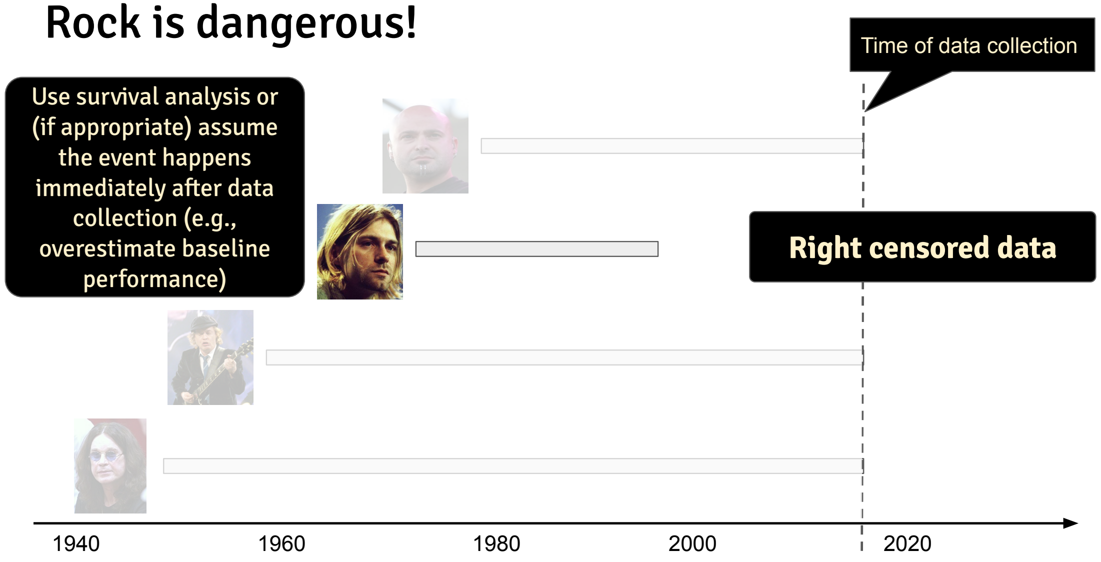
Rock is dangerous!



Time of data collection

Right censored data

Rock is dangerous!



Time of data collection

Use survival analysis or (if appropriate) assume the event happens immediately after data collection (e.g., overestimate baseline performance)

Right censored data

HW2: Overview

HW2: Revisit and extend your HW1 solution

4 Parts

1. Produce two Quarto reports
   a. Detailed analysis report
   b. Summary report or presentation
2. Use different visualizations
3. Address grading feedback from HW1
4. Use distributed computing with Spark(lyr)
   a. Distributed data consolidation
   b. Distributed computation

Today

- Render your HW1 notebook with Quarto

Tutorial: Quarto