Experimental Design and Data Analysis

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Scientific Method

1. Idea - Question - Something to test.
2. Review previous work.
3. Articulate that.
4. Design an experiment
5. Report and Analyze results

Method types

1. Quantitative research.
   a. Numbers.
   b. Large size (increases representation).
   c. Error range.

2. Qualitative research.
   a. Ideas and words.
   b. Small size (time constraint)
   c. Biases.

Experiment Design

1. Baseline experiment
2. Change exactly one variable.
3. Record new results.
4. Repeat runs
    a. Reduce error.

Be careful !!!!

Do

- Try different approaches.
- Repeat experiments
- Compare your results with others
- Analyze results
- Control for different sources of variability.
- Plan for repeatability by outsiders.

Don't

- Ignore controlled variables effect
- make large approximations
- Claim first to result unless really sure
- Compare different metrics

Experiments Discussion

- What do you think is most important in designing an experiment?

- What do you try to avoid?

Data Collection

1. What types of data?
2. Data size?
3. Sampling?
4. Method limitations?
5. Collection design.
6. How to keep the data?
7. Reporting and representation?

Avoid bias

- Researchers bias
- Participants bias
  - Different genders.
  - Different cultures.
- Methodology bias
- Interpretation bias
  - Income increase: people surviving inflation - luxury

Ethical Considerations

1. Validity.
2. Accurate reporting.
3. Human involved?
4. Confidentiality?
5. Voluntary Participation and Consent?
6. No harm to volunteers.
7. Institutional Review Board (IRB)

Ethical Considerations Discussion

- How do you collect data? avoid bias?
- How to avoid unethical issues?

Data Analysis

- One of the more important parts of presenting your work; it conveys empirical validation of your hypothesis.
- Both a messaging component and a technical component
- Reproducibility just as important as in experiments
- Also an integrity component

Data Analysis: Technical

- Use enough data samples
  - Try to make sure data isn't biased somehow
  - Make sure analysis supports usefulness of method in the real world.
  - Verify correctness
- Use correct metrics*
- Version control + config files*

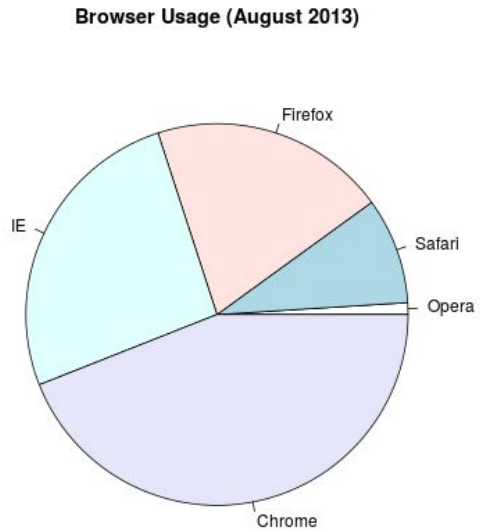
* Credit to Arsenii, Feyza, & Samarth (https://cs-people.bu.edu/mathan/classes/CS697/slides/cs697_week8.pdf)

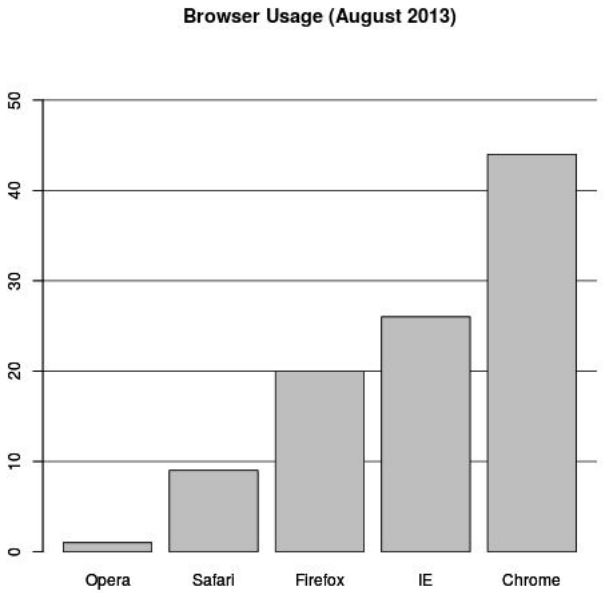
Data Analysis: Messaging

- Use clear description of methodology; reproducibility in analysis is important too.
- Make clear figures

Data Analysis: Messaging

- Which figure is better for describing browser usage?





Credit to https://genomicsclass.github.io/book/pages/plots_to_avoid.html

Data Analysis: Integrity

- Highlighting strong results or withholding poor results?
  - Example: Models which generate high-quality images. Show random selection or all?
- Discuss with your advisor about this
- Discussion question: Is cherry-picking results acceptable if you don't claim they are randomly sampled? Everyone else does it. What if you're asked to cherry pick by collaborators?

Reproducibility in Data Analysis

- How can you set up analysis to make it easy to reproduce?
  - Version control + configs!!!
- How do community expectations differ around reproducibility? Are they changing?
  - For ML; papers with code webpage!
- Discussion question: Problems in reproducing analysis?