Visual Analytics– Evaluation Techniques

Dr. Ab Mosca (they/them)

Slides based off slides courtesy of Jordan Crouser (https://jcrouser.github.io/)

Plan for Today

- Final Project Check-in
- Evaluation of visual analytic systems

Final Project

- What ideas did you come up with?
- Any questions?

Discussion

How do we measure the **effectiveness** of a visualization system?

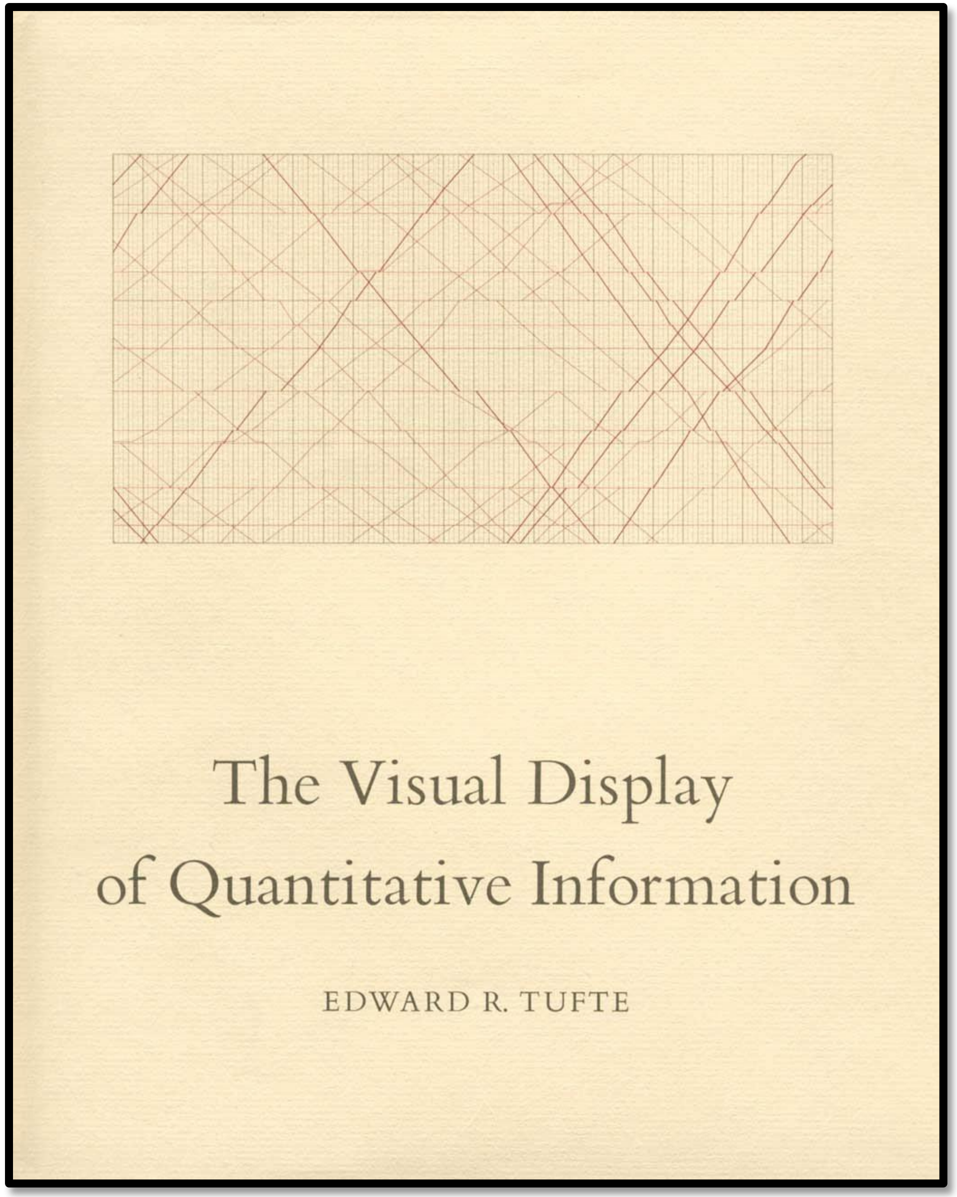
Example Visual Analysis Tool

data**voyager**: https://vega.github.io/voyager/

- Pair up and toy around with datavoyager to get a sense of the tool
- Try to do a mini exploratory data analysis with it

Evaluation via Design Guidelines

- “Above all else, show the data.”



The Visual Display of Quantitative Information

EDWARD R. TUFTE

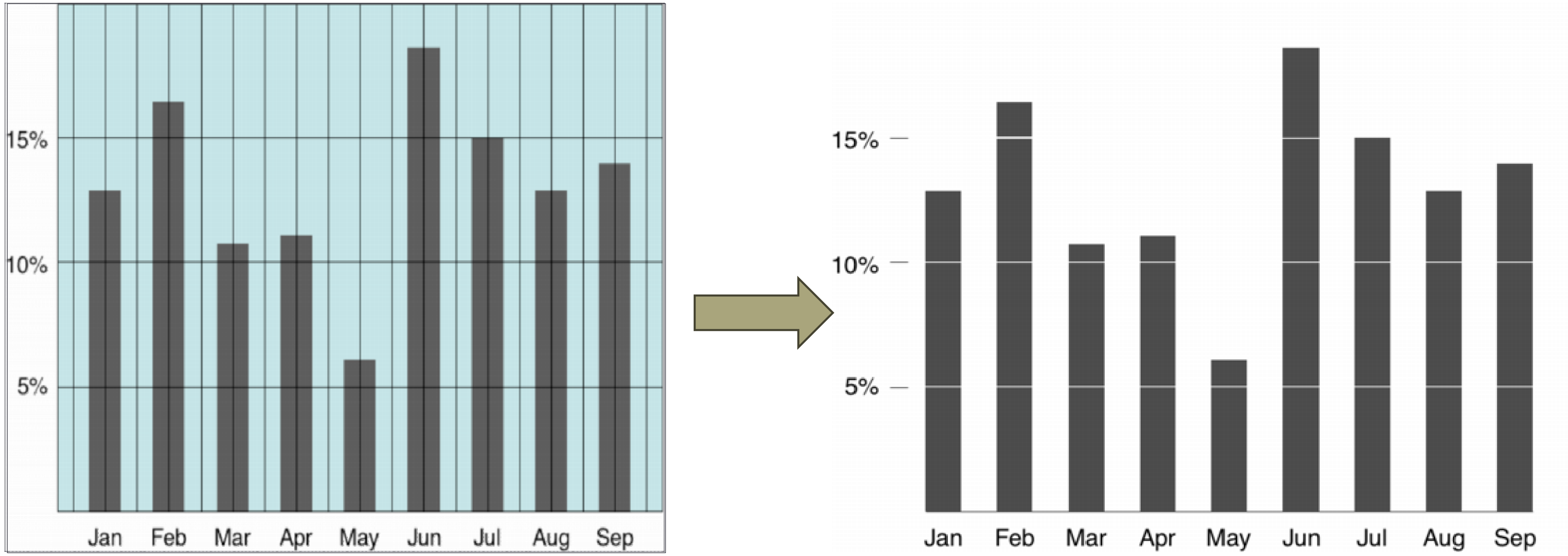
Tufte, 1983

$$\text{Data-ink ratio} = \frac{\text{Data-ink}}{\text{Total ink used to print the graphic}}$$

= proportion of a graphic's ink devoted to the non-redundant display of data-information

= 1 - proportion of a graphic that can be erased

Tufte: maximize the data-ink ratio

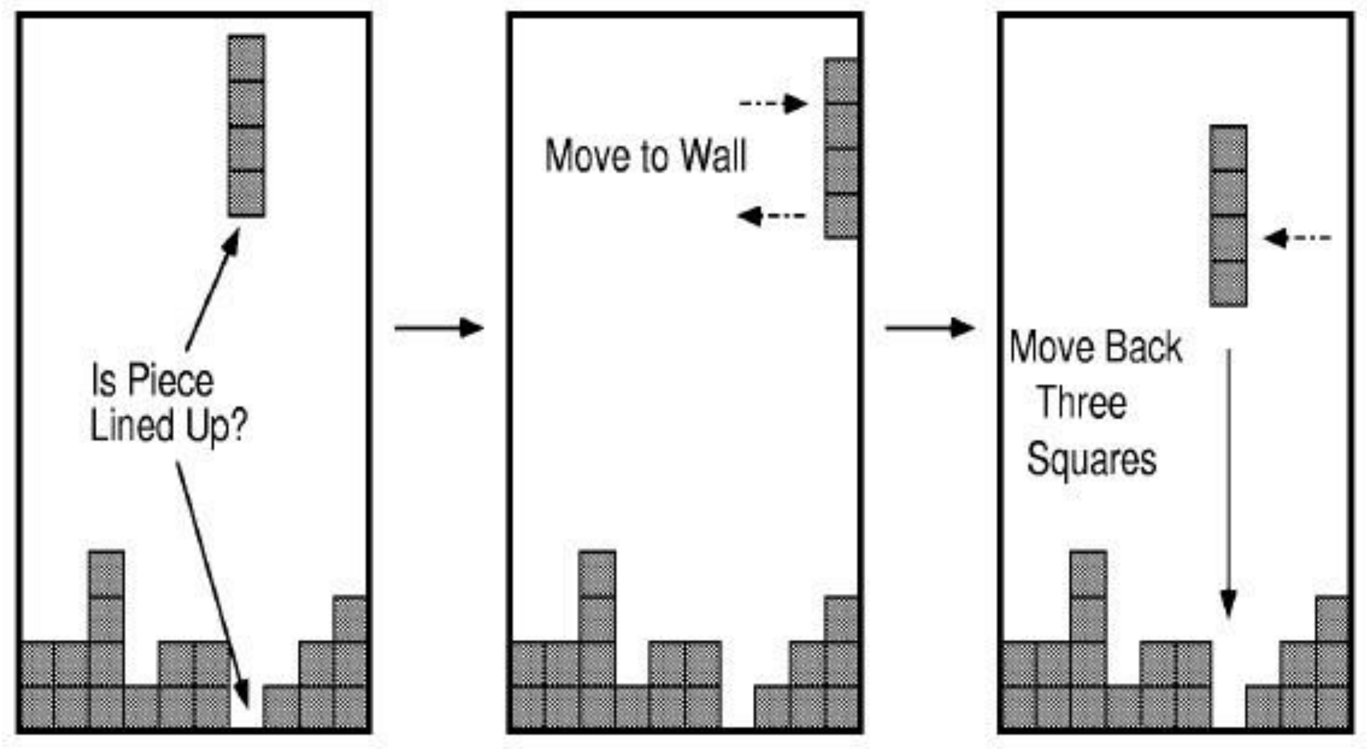


Discussion

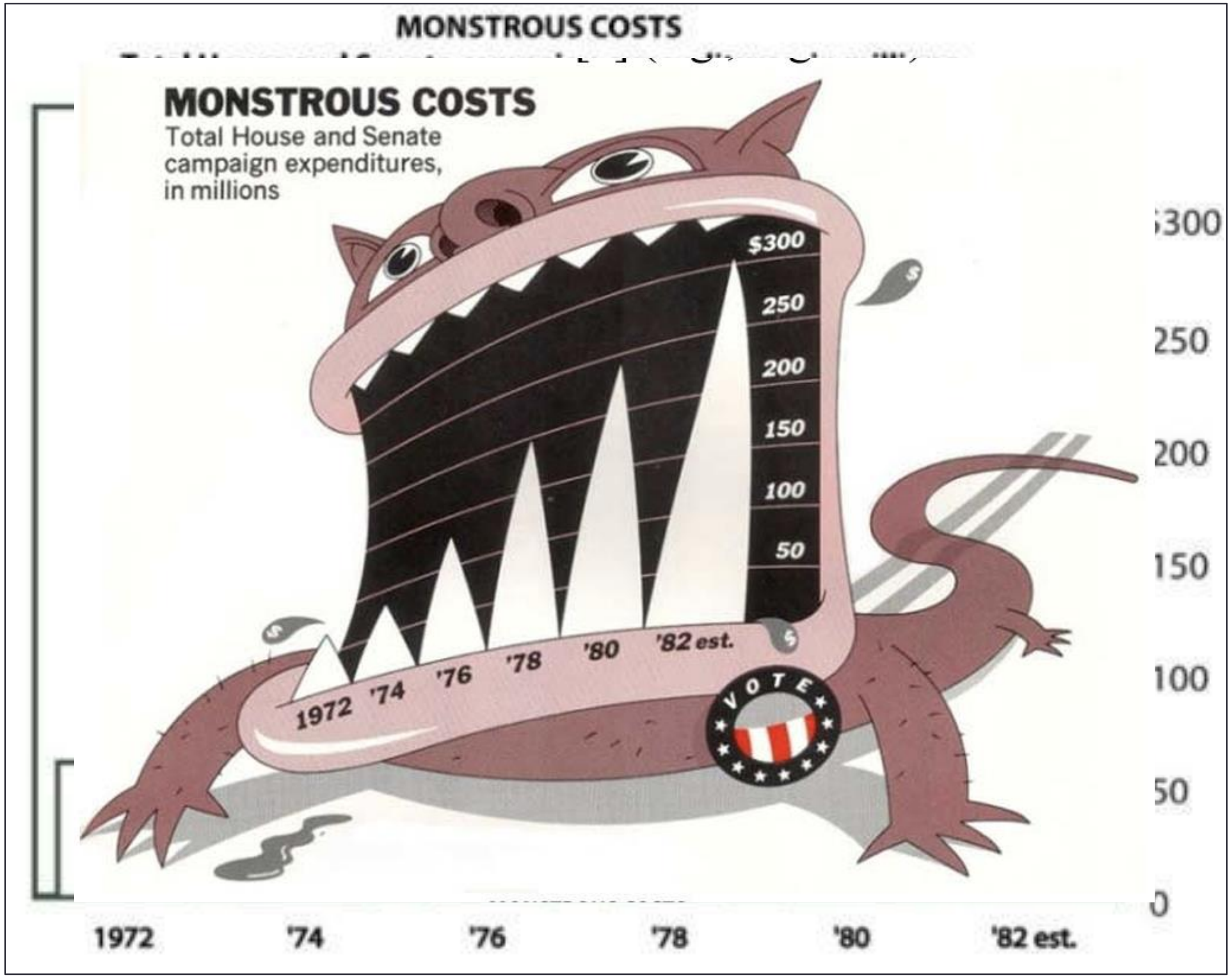
- Evaluate data**voyager** in terms of data-ink ratio
- What are the pros and cons of using data-ink ratio to evaluate visual analytic tools?

Flashback: Epistemic Action

The purpose of some actions is not the effect they have on the environment but **the effect they have on the humans**.



A caveat to Tufte: "chart junk" and recall



Bateman et al. "Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts", CHI 2010

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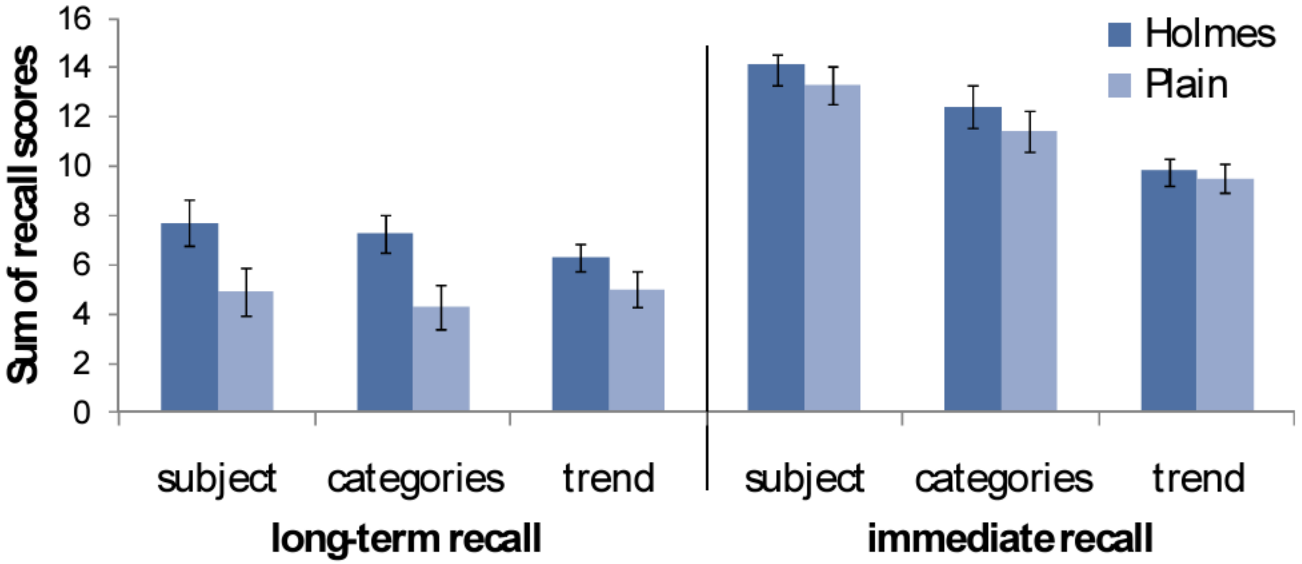

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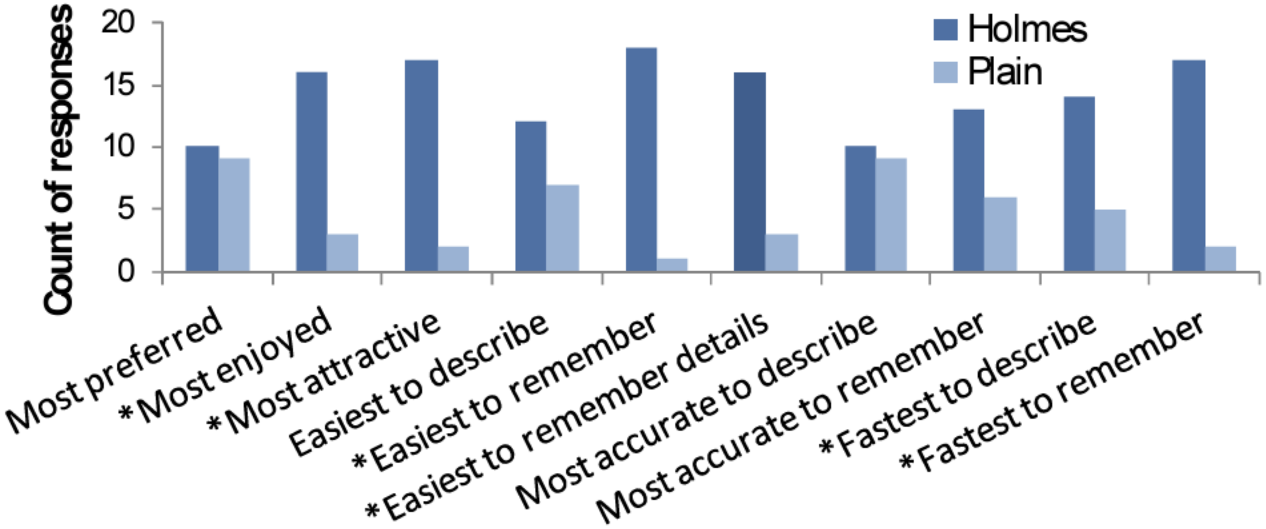
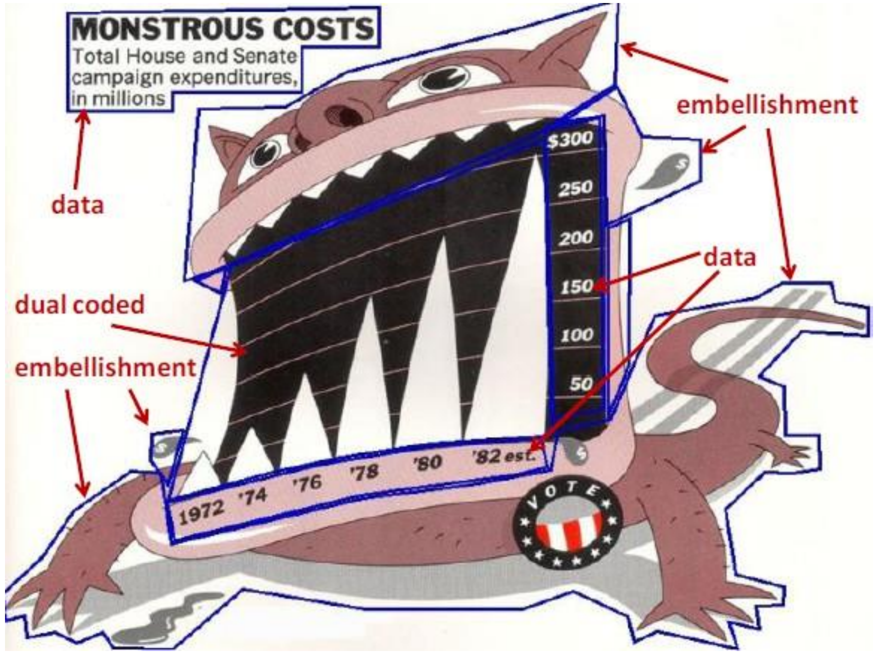


Figure 8. Count of user responses: *indicates significant difference between chart types from chi-squared test at α=0.05

Bateman et al. “Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts”, CHI 2010

Chart junk and eye gaze



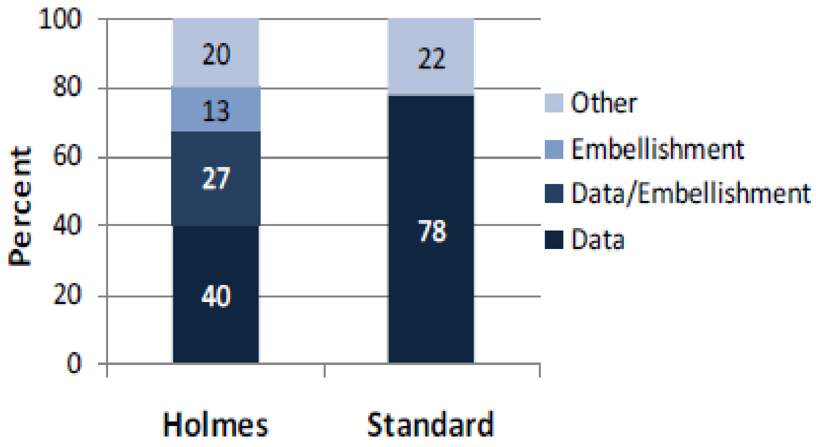
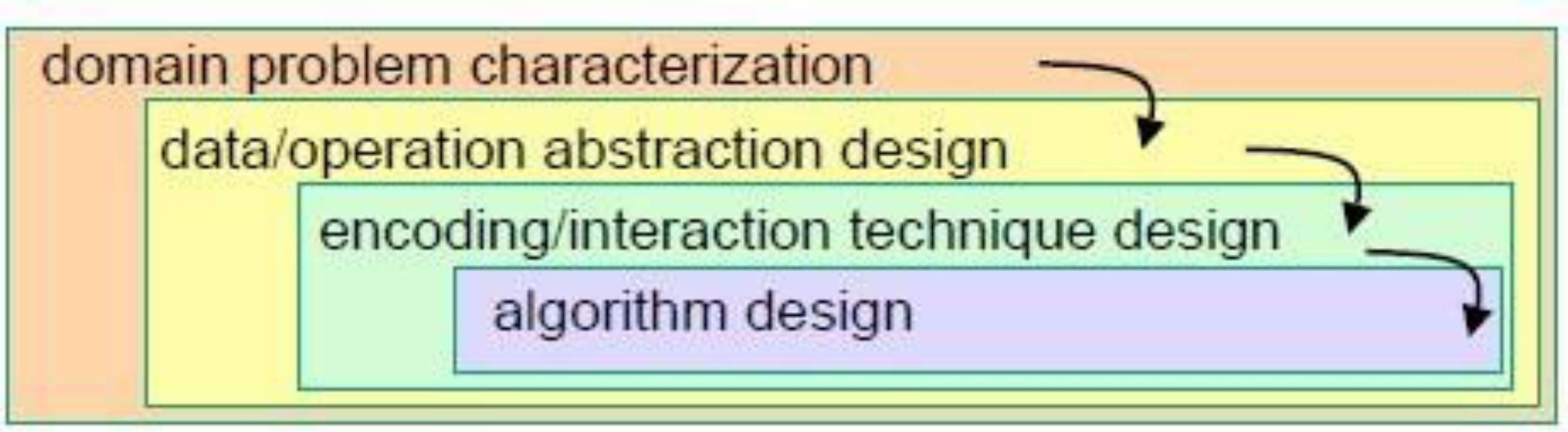


Figure 9. Percentage of on-screen time spent looking at different chart elements for Holmes and Plain charts.

Discussion

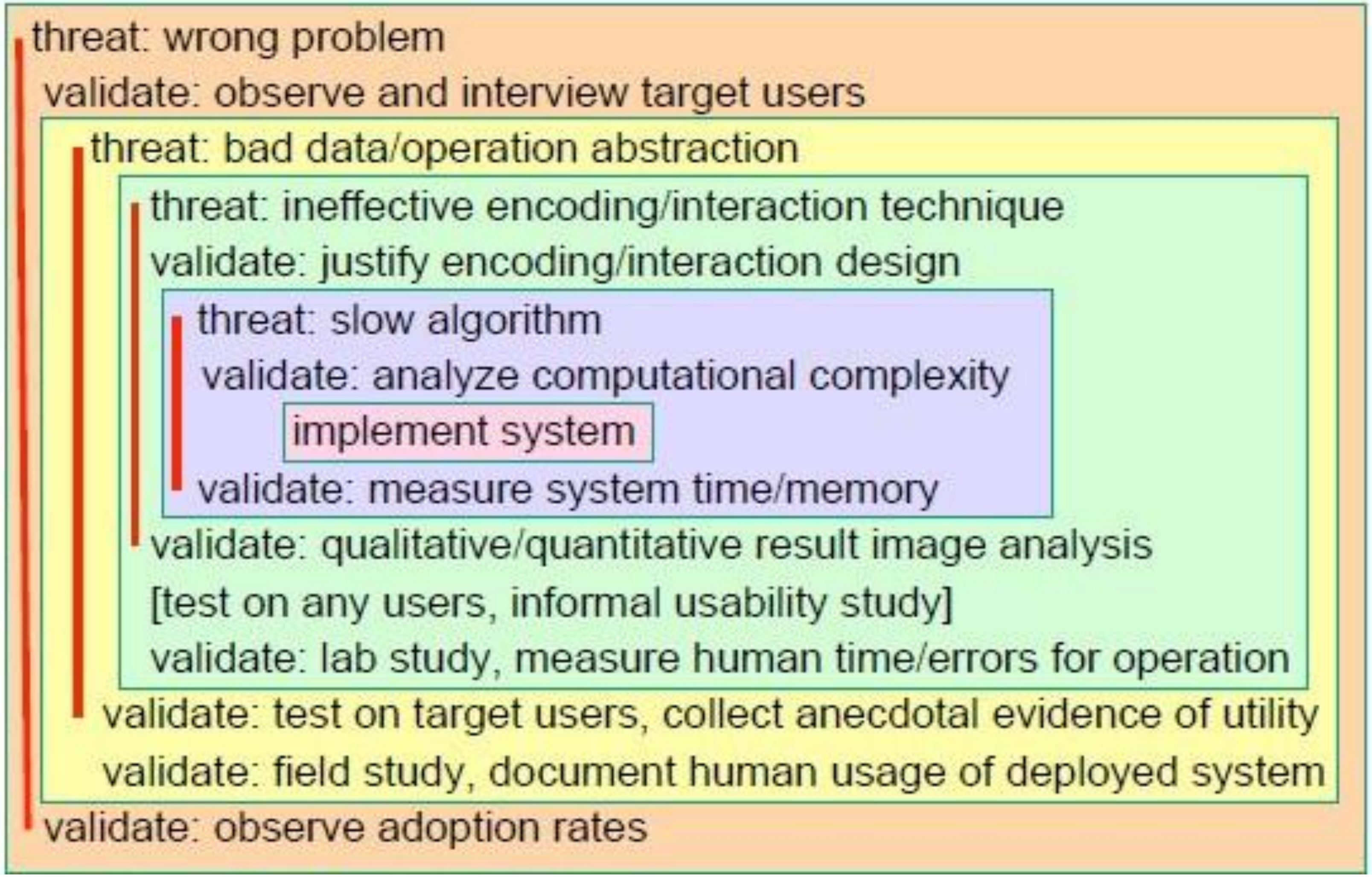
- Know any **compelling** examples of visual embellishment?
- **Tragic** ones?
- What's the right balance between Tufte and ChartJunk?

Evaluation Via Design Guidelines: Nested Model of VIS Design, Munzner


domain problem characterization
data/operation abstraction design
encoding/interaction technique design
algorithm design

Munzner, Tamara. "A nested model for visualization design and validation." Visualization and Computer Graphics, IEEE Transactions on 15.6 (2009): 921-928.

Nested Model of VIS Design, Munzner



threat: wrong problem

validate: observe and interview target users

threat: bad data/operation abstraction

threat: ineffective encoding/interaction technique

validate: justify encoding/interaction design

threat: slow algorithm

validate: analyze computational complexity

implement system

validate: measure system time/memory

validate: qualitative/quantitative result image analysis

[test on any users, informal usability study]

validate: lab study, measure human time/errors for operation

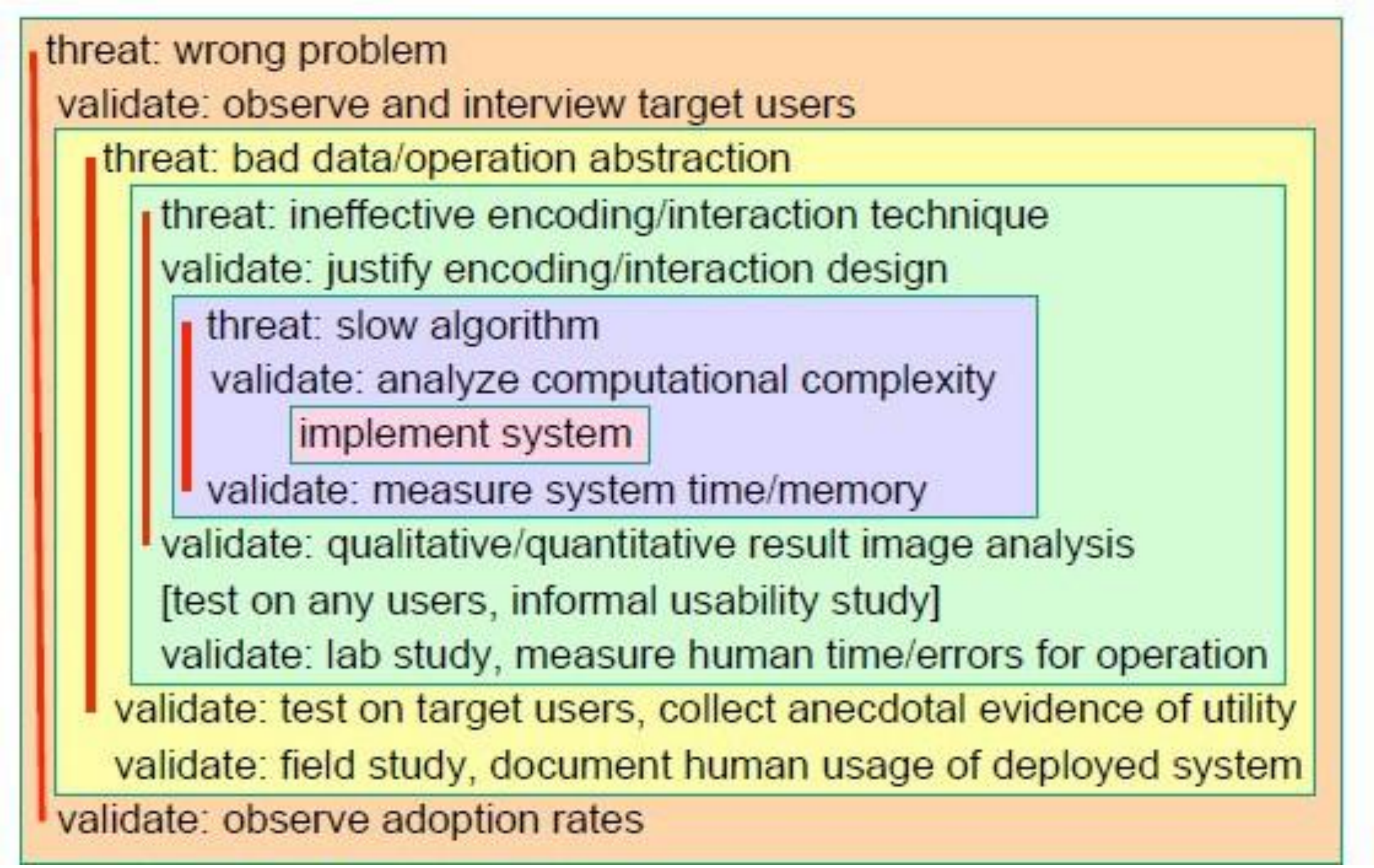
validate: test on target users, collect anecdotal evidence of utility

validate: field study, document human usage of deployed system

validate: observe adoption rates

Discussion

- How would you evaluate data**voyager** following Munzner's Nested Model?



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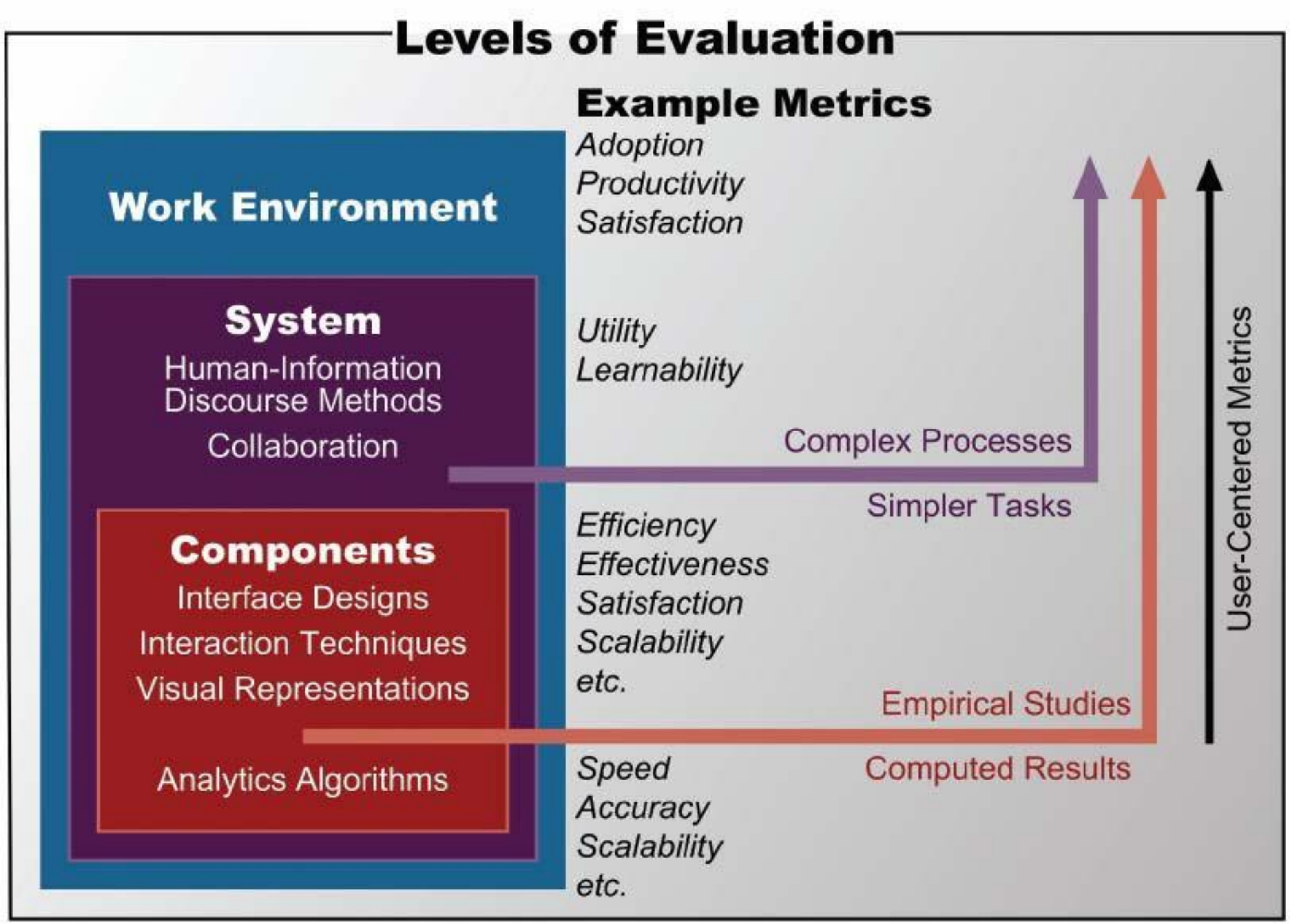
Nested Model of VIS Design, Munzner

- **Mismatch**: a common problem in evaluating VIS systems
- Examples:
  - the value of a new visual encoding can't be measured using a quantitative timing of the algorithm
  - mischaracterized task can't be addressed in a formal lab study

Matching **methods** and **metrics**



Evaluation Via Insights: Insight-based evaluation, North et. al

Measure the usefulness of a visualization by counting the **number of insights** a person generated while using it

Insight-Based Evaluation Method

- No “benchmark tasks”
- Training on data and visualization for 15 minutes
- Participants list **questions** that they would like to pursue
- Asked to examine the data for as long as necessary until **no new insights** can be gained
- During analysis, participants are **asked to comment** on their observations, inferences, and conclusions

Evaluating the Results

- Tally up the number of insights:

  Insights: distinct observations about the data

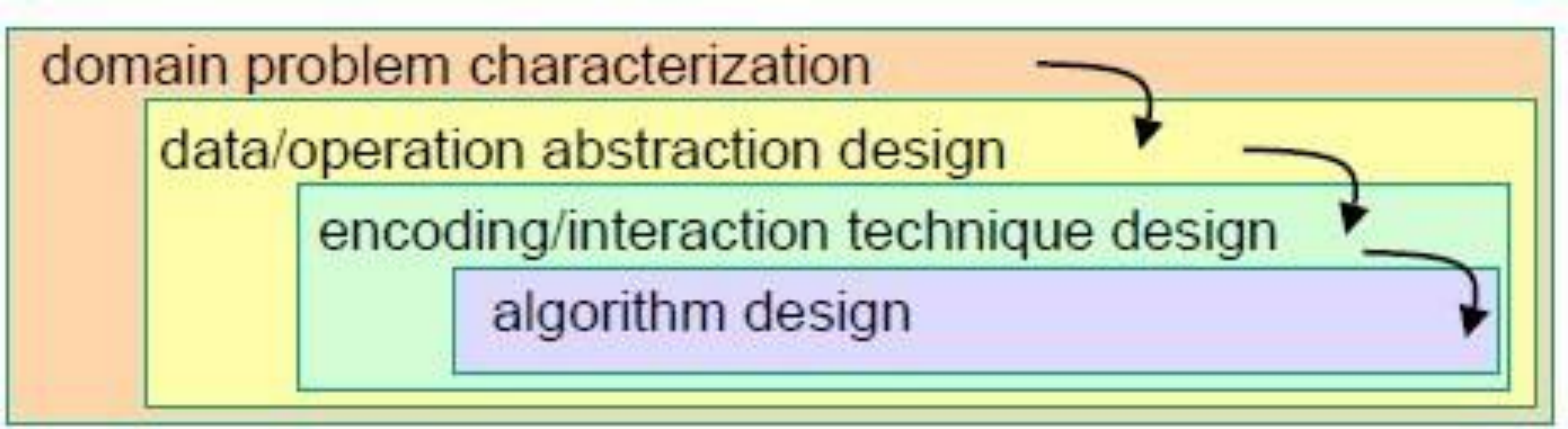
  Baseline: all insights generated by all participants

- Various quantitative statistics on insight generation

  (time spent, time to first insight, etc.)

Discussion

What does insight-based evaluation address?



domain problem characterization

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Discussion

- Design an insight-based evaluation of data**voyager.** Be sure to include a data collection and analysis plan.

- What is challenging about this type of evaluation?

Problem: defining “insight”

North’s definition:

> “[Insight is] an individual observation about the data by the participant, a **unit of discovery**. It is straightforward to recognize insight occurrences in a think-aloud protocol as any data observation that the user mentions is considered an insight.”

Example 1

“Our tool allows the biologists to interactively visualize and explore the whole set of trees, providing **insight** into the overall distribution and possible conflicting hypothesis”

Insight = knowledge about the overall distribution

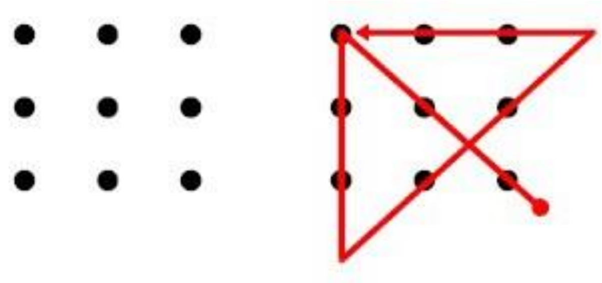
Example 2

"The analyst determined the answers to these questions, but also came up with further **insights** that she shared with people from other administrative units. She used the discovered information to advise other administrators of **certain previously unknown relationships in their data**"

Insight = information about previously unknown relationships

Cognitive science definition

- Something measurable in the frontal and temporal lobes (superior temporal gyrus).
- Spontaneous insight vs. model-building insight



boot	boot camp
summer	summer camp
ground	campground

Disambiguating "Insight"

- Knowledge-building insight:

  Discovering insight, gaining insight, and providing insight

  Insight as a substance, that accumulates over time and could be measured/quantified

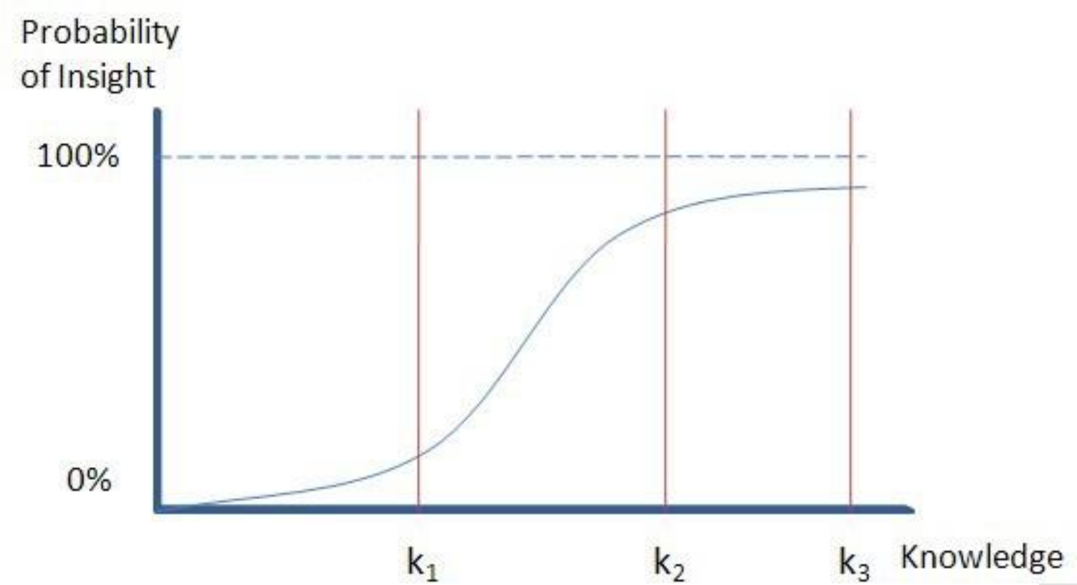
- Spontaneous insight:

  Experiencing insight, having an insight, or a moment of insight

  Insight as a discrete event, that occurs at a specific moment in time and could be observed

Discussion

- Can we measure knowledge-building insight?
- Can we measure spontaneous insight?
- Are they related?



Evaluation Via Case Studies: MILCs – Shneiderman and Plaisant (2006)

- Multi-dimensional In-depth Long-term Case studies
- Hypothesis: the efficacy of tools can be assessed by documenting:

  Usage (observations, interviews, surveys, logging, etc.)

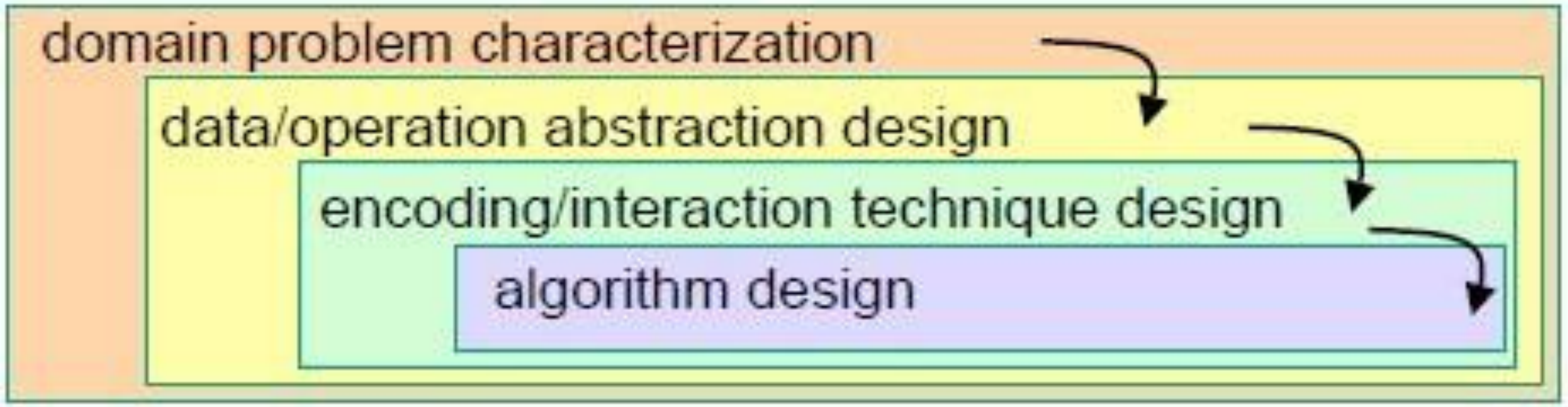
  How successful the users are in achieving their professional goals

Definition

- Multi-dimensional: using observations, interviews, surveys, and loggers
- In-Depth: intense engagement of the researchers with the expert users to the point of becoming a partner or assistant
- Long-term: longitudinal studies that begin with training in use of a specific tool through proficient usage that leads to strategy changes for the expert users.
- Case studies: detailed reporting about a small number of individuals working on their own problems, in their own environment

Discussion

What do MILCs address?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Discussion

- Design an MILC evaluation of data**voyager.** Be sure to include a data collection and analysis plan.
- What is challenging about this type of evaluation?

Challenges

- MILCs have been embraced by a small community of researchers interested in studying creativity support
- Challenges:

  Cannot control for the users

  Cannot control for the tasks

  Toy problems in laboratories are not indicative of real-world problems and environments

Execution issues with MILCs

- Duration is always a problem
- Number of participants has to be small
- Formalities are difficult

  Understand organization policies and work culture

  Gain access and permission to observe or interview

  Observe users in their workplace, and collect subjective and objective quantitative and qualitative data.

  Compile data of all types in all dimensions

  Interpret the results

  Isolate factors

  Need to repeat the process

Evaluation Via Learning: Learning-based evaluation (Chang, 2010)

- Working assumption: “the goal of visualization is to gain insight and knowledge”
- Big idea: maybe we should evaluate a visualization based on whether or not the user actually gains insight or knowledge after using a visualization

Much like learning in education…

- How would an instructor choose between two textbooks for a course?
- We could:

  Ask the students which book they prefer

  Issue: they might like a book because its cover is pretty

  Ask colleagues what book they prefer

  Issue: different students in different environments

  Ask the students to find some information in the book and measure how quickly they can perform the task

  Issue: this only demonstrates how well the book is organized

Metaphor for visualization evaluation

- In a best case scenario, we would:
  - Ask half of the class to use book one to learn a subject
  - Ask the other half to use another book to learn the same subject
- Then we give the two groups the same test, and whichever scores higher “wins”

Traditional LBE

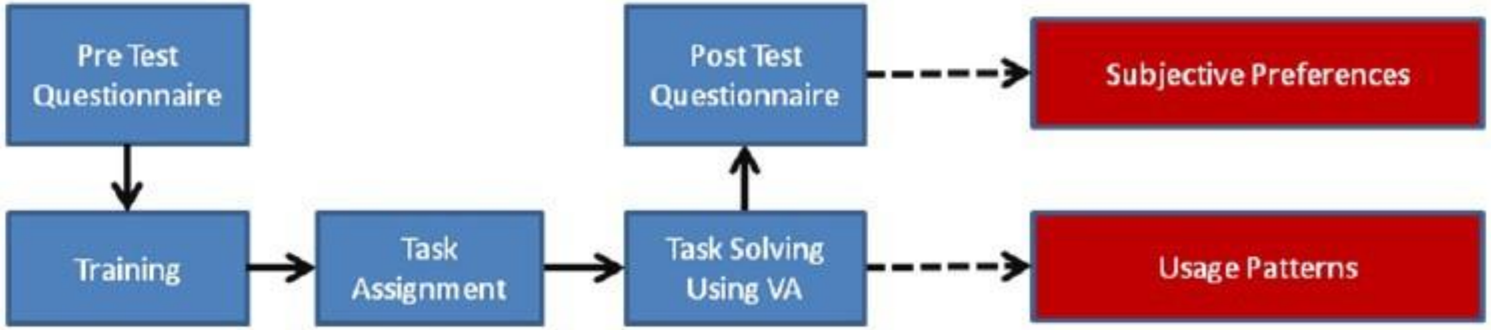


Figure 1. A pipeline for typical visualization evaluations

Single-system LBE

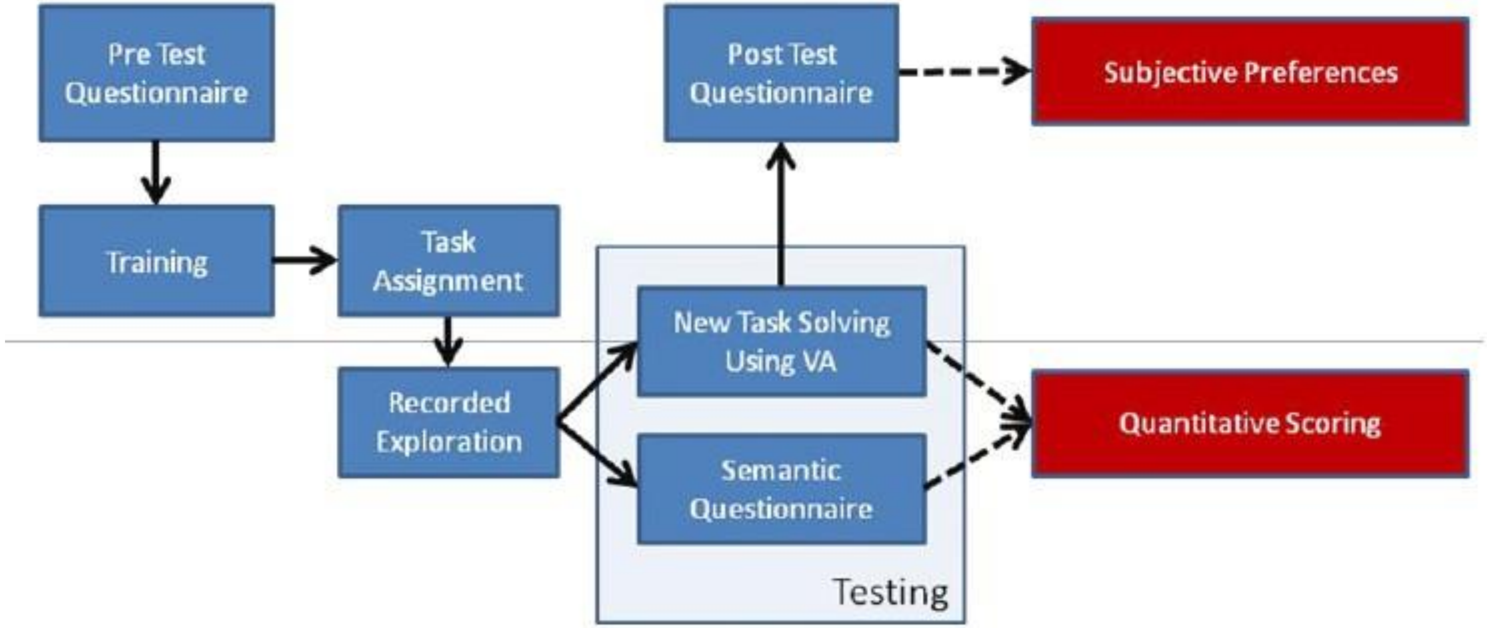
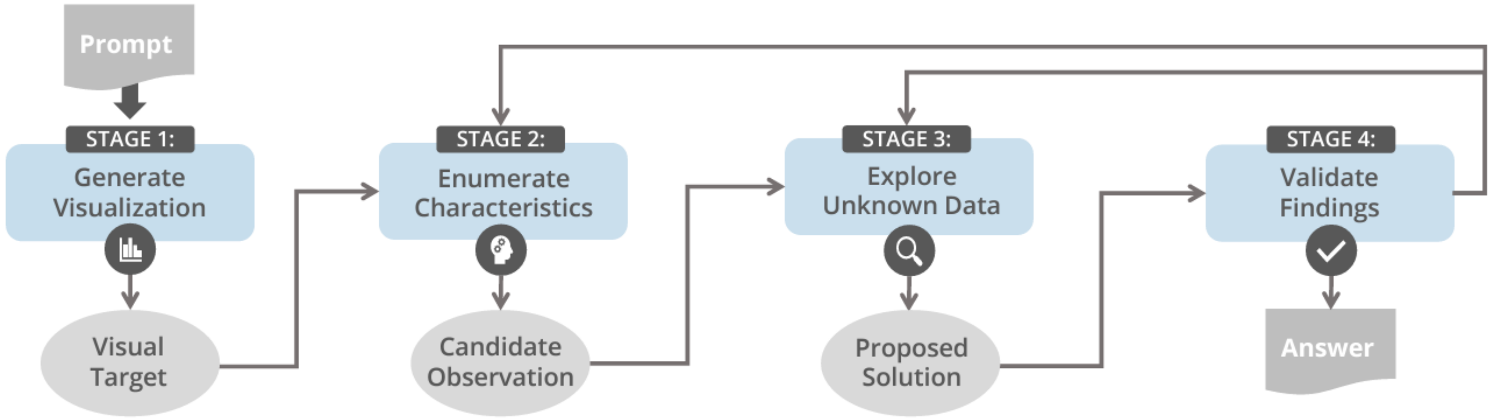


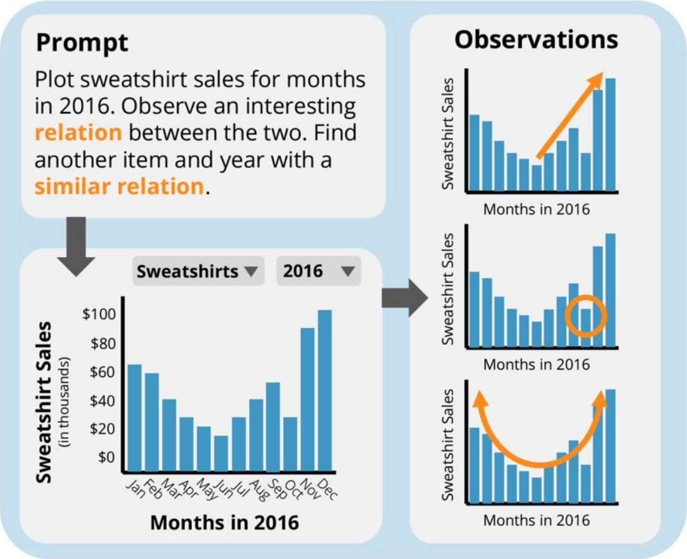
Figure 2. A pipeline for knowledge-based visualization evaluations

Evaluation Via Inferential Tasks Suh et al. 2022

Inferential tasks require evaluation participants to construct knowledge by inferring relations between learned concepts and new observations



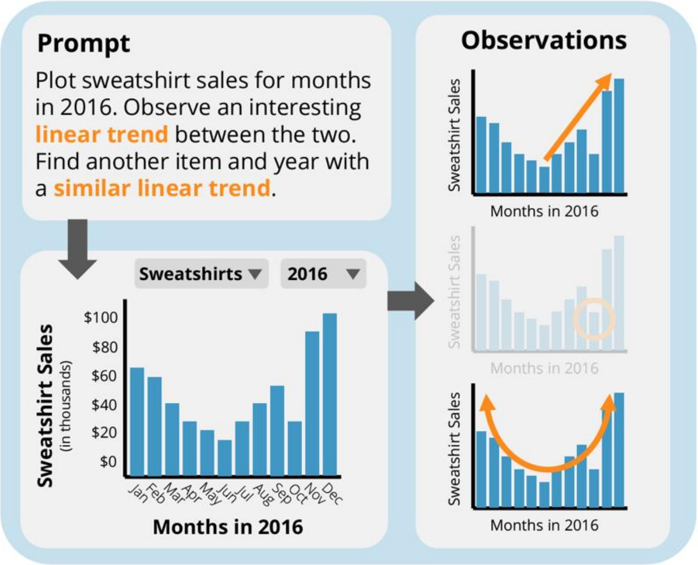
Evaluation Via Inferential Tasks Suh et al. 2022



Prompt

Plot sweatshirt sales for months in 2016. Observe an interesting **relation** between the two. Find another item and year with a **similar relation**.

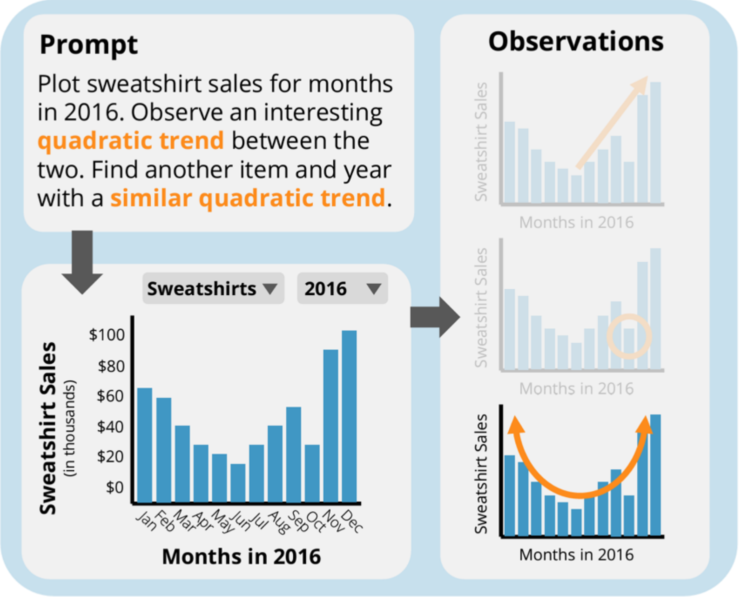
(a) Many observations due to a vague prompt



Prompt

Plot sweatshirt sales for months in 2016. Observe an interesting **linear trend** between the two. Find another item and year with a **similar linear trend**.

(b) Fewer observations due to a less vague prompt



Prompt

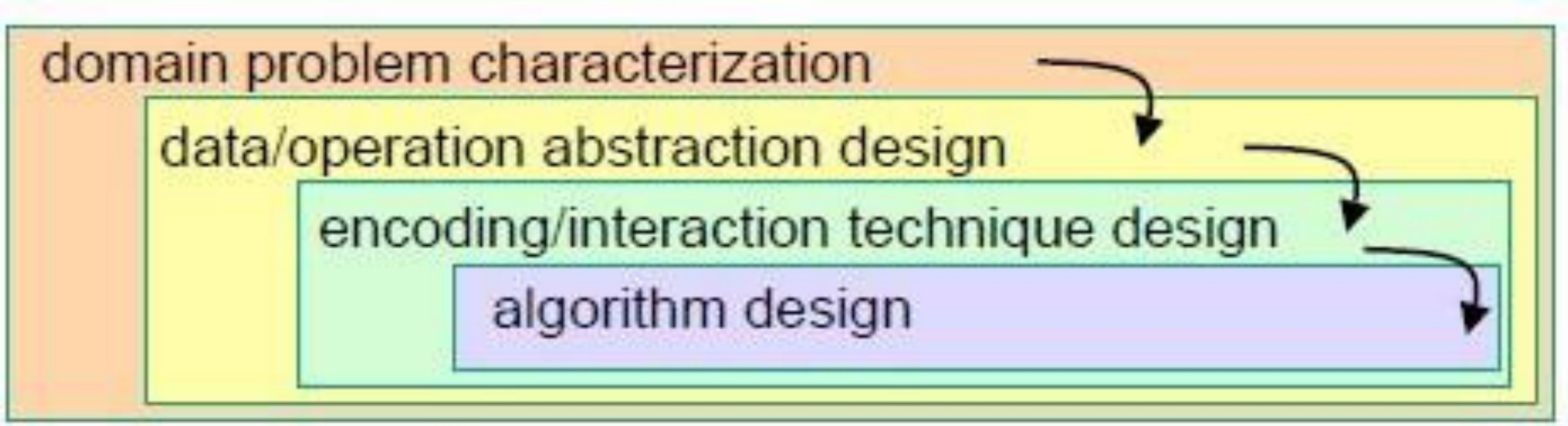
Plot sweatshirt sales for months in 2016. Observe an interesting **quadratic trend** between the two. Find another item and year with a **similar quadratic trend**.

(c) Least observations due to a specific prompt

Discussion

- Design an LBE evaluation of data**voyager.** Be sure to include a data collection and analysis plan.

- What part of Munzner's Nested Model does this evaluate?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Takeaways

- Evaluation is complex and requires creativity
- The best method depends on which part of the tool you want to evaluate, and resources available