



**Please sit in the
center in row
A, B, C, D or E**



**Sit near people for
discussion**



CSE 216 / COGS 230

Visualization

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10/24/2024



Before We Start

What's your understanding of visualization?

Charts, Plots, Large data...

Using Vision to Think in Information Visualization

(Ch. 1)

Stuart K. Card

Jock D. Mackinlay

Xerox Palo Alto Research Center

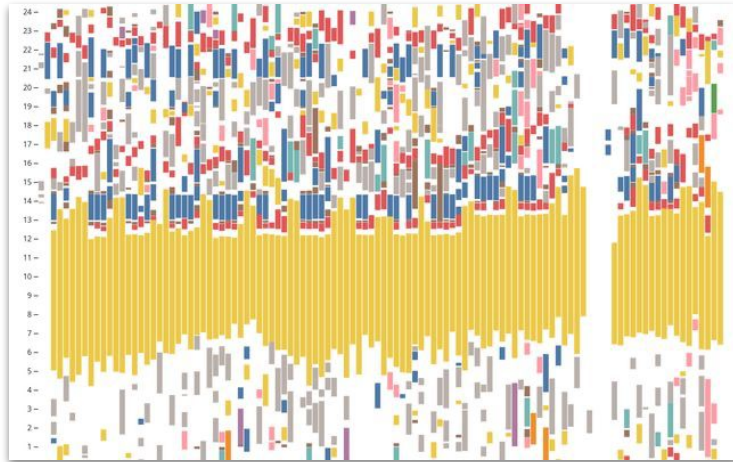
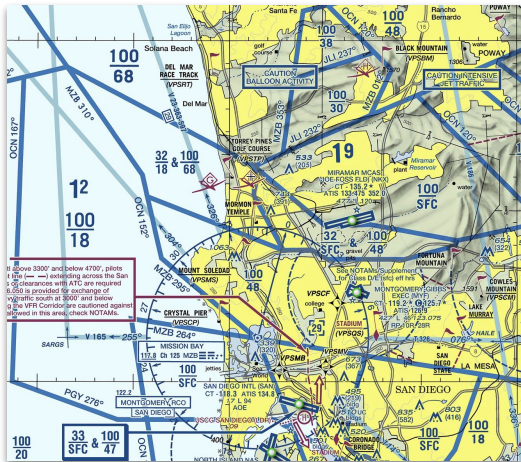
Ben Shneiderman

University of Maryland

Visualization amplifies cognition.

External cognition: Extending working memory and supporting computation

Diagrams: *“The right representation of a problem, often the right visual representation, can make a problematic decision obvious.”*



Visualization is interactive.

Visualization

Computer-based, interactive visual representations

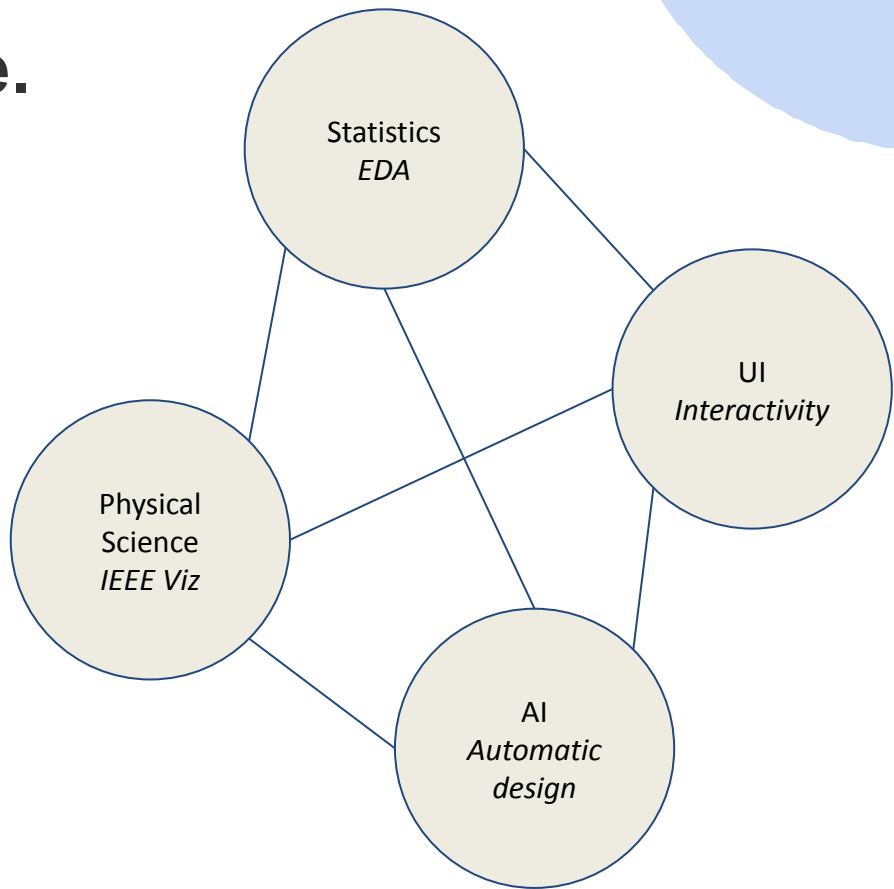
Scientific visualization

Scientific, mostly spatial data

Information visualization

Abstract, non-physically based data

Tufte's theory of data graphics (1983)

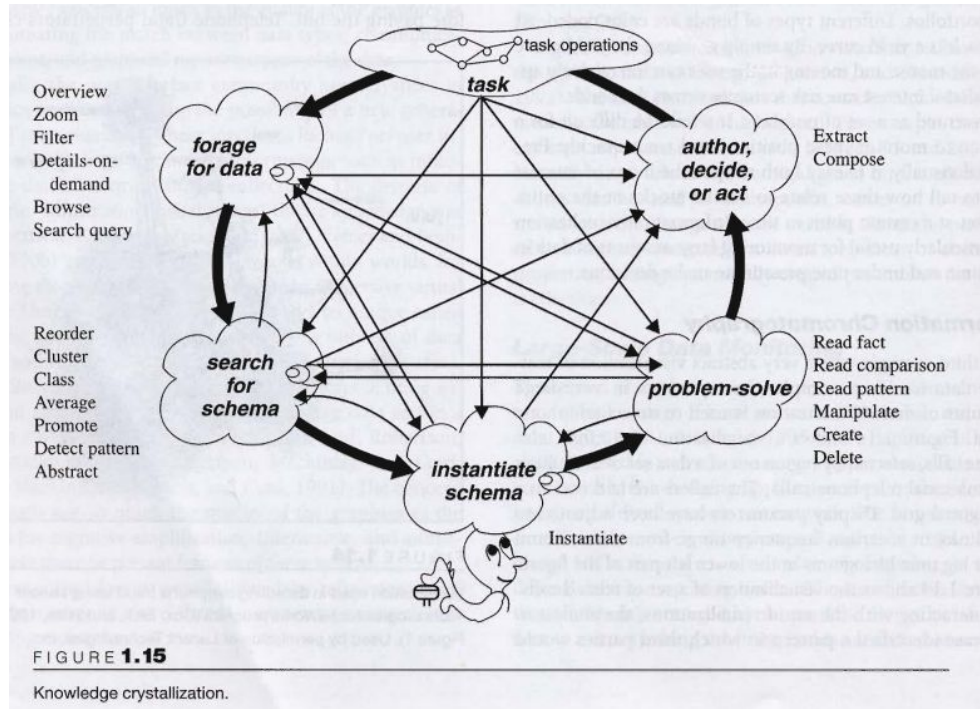


Discussion Questions (1/3)

05:00

1. Daniel Fallman (from 10/03's reading) views **sketching** as the way designers “work” and “think”. How might the mechanisms of external cognition explain the role of sketching for designers?
2. For what kinds of problems do you find diagrams most or least helpful? Why?
3. Tufte's theory of data graphics from 1983 emphasizes maximizing the density of useful information. Support and/or refute this emphasis.

Knowledge crystallization



Example task
Literature search

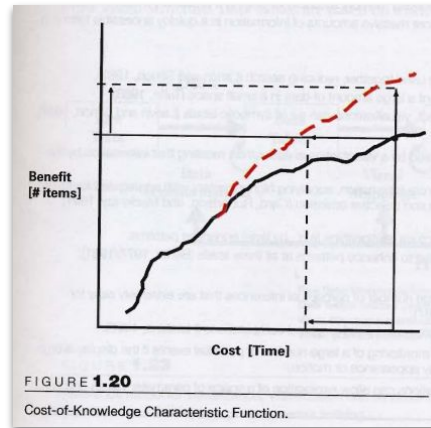
Example visualization
Zillow

Cost structure contributes to visualization effectiveness

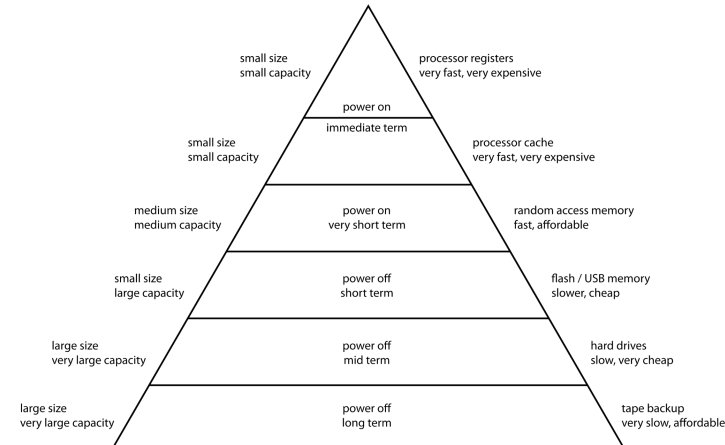
Costs associated with each step in knowledge crystallization

Representations induce different cost structures

Visualize the *Cost-of-Knowledge Characteristic Function*



Computer Memory Hierarchy



Visualization leverages visual processing strengths to lower information cost

- Increased resources Offload, parallelize, and expand cognitive work and memory
- Reduced search Clustering information used together
- Enhanced pattern recognition
- Perceptual inference Physics diagrams
- Perceptual monitoring Strength at detecting change
- Manipulable medium Interaction enables exploration

Discussion Questions (2/3)

1. What challenges did you encounter when attempting a literature review? How might/did information visualization help you overcome them?
2. How feasible is it to measure the Cost-of-Knowledge Characteristic Function in a controlled environment? How might a researcher do this?
3. How might evolutionary biology explain the ways in which visualization amplifies cognition?

05:00

“Recognition over recall” corner

Increased resources
Reduced search
Enhanced pattern recognition
Perceptual inference
Perceptual monitoring
Manipulable medium

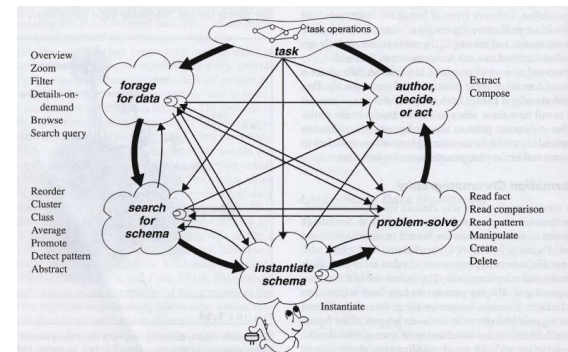


FIGURE 1.15
Knowledge crystallization.

Visualizations turn *Raw Data* into *Views*

or, the conceptual fundamentals of data science

Raw Data → Data Tables → Visual Structures → Views

Variable types

Nominal (Eq)

Ordinal (<, >)

Quantitative (arithmetic)

Data Transformations

Statistical operations on data tables

	Case _i	Case _j	Case _k	
Variable _x	Value _{ix}	Value _{jx}	Value _{kx}	...
Variable _y	Value _{iy}	Value _{iy}	Value _{ky}	...
...	...	...	...	...

Derived values / structure
Hierarchical representation

Visual structures are designed for human eyes

“The visual system does not work like a photograph developing in a camera but like a flying-spot scanner.”

Controlled processing

Conscious, serial, low-capacity, foveal
Can be inhibited

Automatic processing

Parallel, high-capacity, non-foveal
Cannot be inhibited

Cones

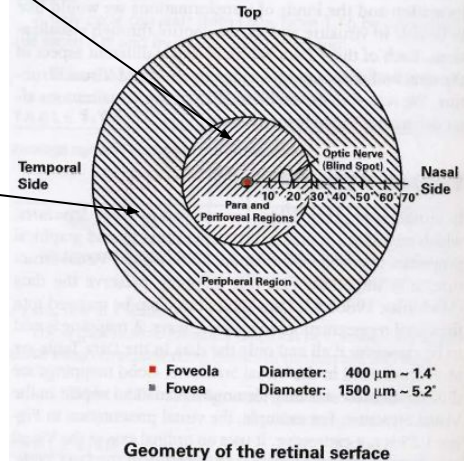
For colorful
detail and
focus

Rods

For movement and
spatial awareness

FIGURE 1.28

Distribution of photoreceptors in the human eye. By permission of Resnikoff (1987, Figure 5.3.3).



Visual structures: marks on a spatial substrate

Spatial encoding gets first priority in visualization design

Axes: None, Nominal, Ordinal, Quantitative
Composition, alignment, folding, recursion

Marks: Points, Lines, Areas, Volumes

Connections: Graphs (with proximity and enclosure)

Retinal properties: Size, orientation, color, texture, shape

Time as animation

TABLE 1.22

Visual features that can be automatically processed (Healy, Booth, and Enns, 1995).

Number	Terminators	Direction of motion
Line orientation	Intersection	Binocular luster
Length	Closure	Stereoscopic depth
Width	Color	3D depth cues
Size	Intensity	Lighting direction
Curvature	Flicker	

TABLE 1.23

Relative effectiveness of different retinal properties. Data based on MacEachren (1995, Figure 6.30). Q = Quantitative data, O = Ordinal data, N = Nominal data. Filled circle indicates the property is good for that type of data. Half-filled circle indicates the property is marginally effective, and open circle indicates it is poor.

		Spatial	Q	O	N	Object	Q	O	N
Extent	(Position)	●	●	●	Grayscale	○	●	○	
	Size	●	●	●					
Differential		○	○	●	Color	○	○	●	
	Orientation				Texture	○	○	●	
					Shape	○	○	●	

Discussion Questions (3/3)

05:00

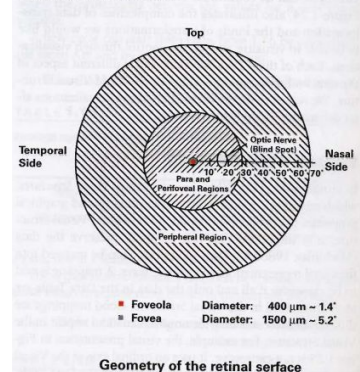
1. How does our *Data Table* definition compare with relational databases in terms of information organization and cost structure?
2. Many previous presentations used **word clouds**. Analyze word clouds in terms of controlled processing vs automatic processing as well as cones vs rods.
3. Why are “walls of text” discouraged in presentation visuals?

“Recognition over recall” corner

	Case _i	Case _j	Case _k	
Variable _x	Value _{ix}	Value _{jx}	Value _{kx}	...
Variable _y	Value _{iy}	Value _{iy}	Value _{ky}	...
...	...	...	...	...

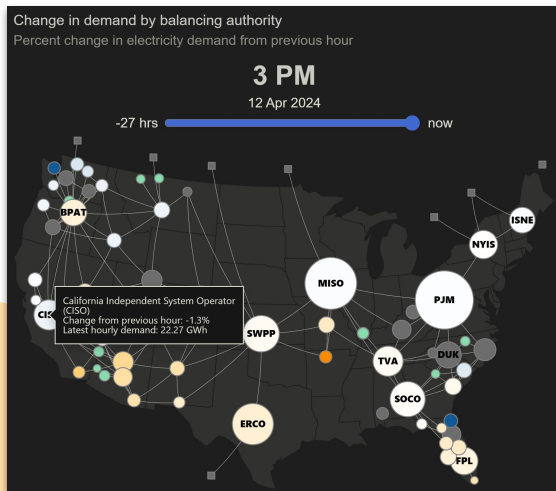
FIGURE 1.28

Distribution of photoreceptors in the human eye. By permission of Resnikoff (1987, Figure 5.3.3).

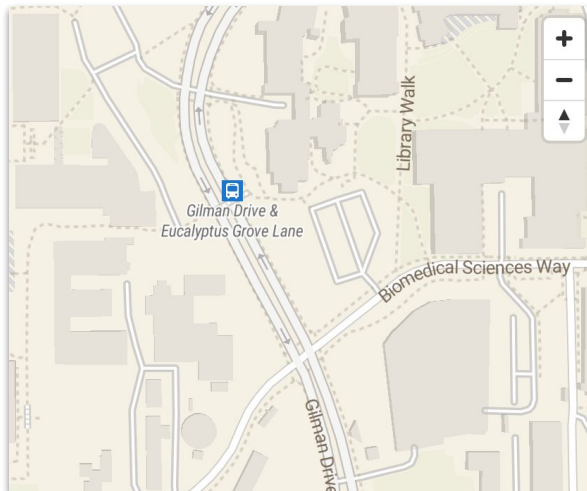


Interactions enable more information extraction

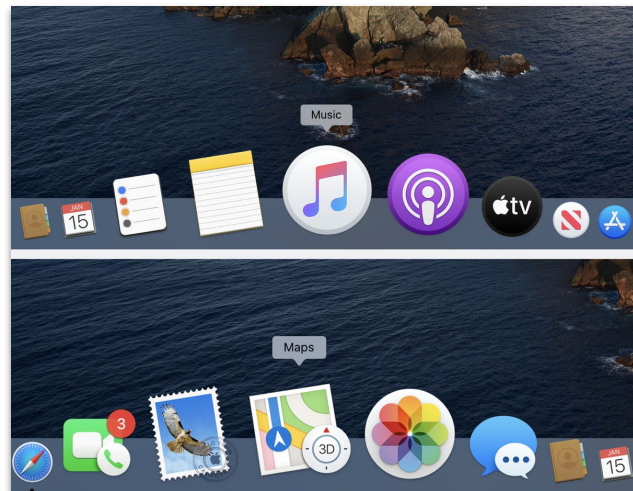
Location Probes



Viewpoint controls



Distortion



Takeaways

External cognition: The external world is important in thought and reasoning

Extension of working memory, clarification of patterns, leveraging senses

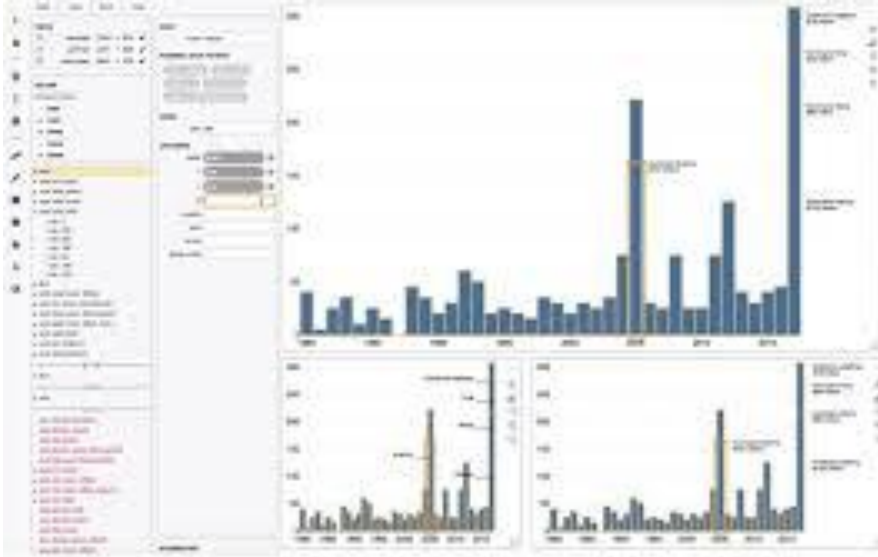
Visualization amplifies cognition, exploiting automatic processing

Knowledge crystallization: Forage, organize, filter, and present information

Cost structure: Cost of information retrieval, reduced with visualization

Crafting visualizations: Raw Data → Data Tables → Visual Structures → Views

What's Next?



How many of you tried to rotate your screen?

Techniques for Flexible Responsive Visualization Design

Hoffswell et al, 2020

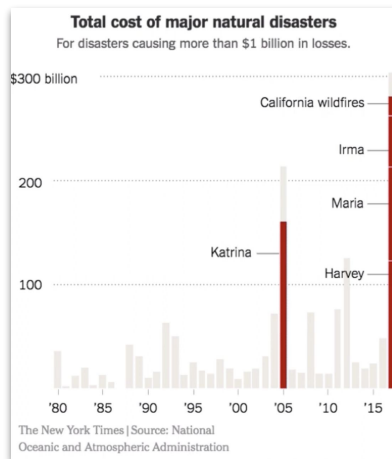
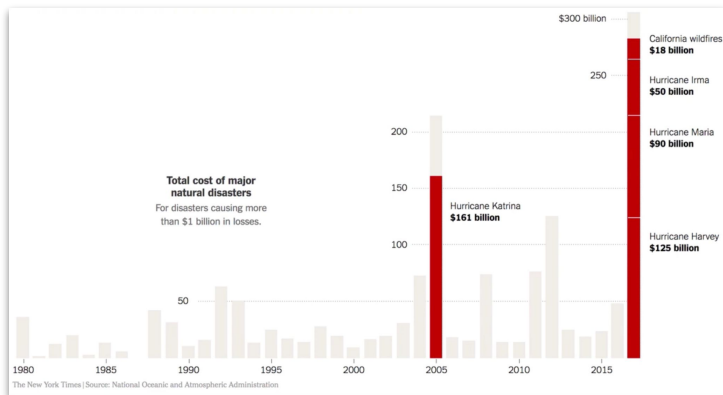
Introduction

- **Responsive Visualizations:** Adapt visual content based on device context, crucial for mobile consumption.
- **Challenges:** Current tools provide limited support for responsive visualization design.
- **Contributions:** Analysis of 231 responsive news visualizations, design guidelines, and a prototype system for editing visualizations across devices.

Background

Importance of Mobile Devices: Increasing use for consuming news articles.

Responsive Design Needs: Visuals must remain informative and legible on different devices and orientations.



Discussion Questions (1/3)

05:00

1. How do current visualization tools limit the design of responsive visualizations?
2. Why is it crucial for visualizations to be responsive in today's mobile-first world?

Methodology & Design Guidelines

Analysis of News Articles: Examination of visualization techniques across 12 sources.

Formative Interviews: Insights from journalists on responsive design needs and challenges.

- **Simultaneous Cross-Device Edits**
- **Device-Specific Customizations**
- **Cross-Device Previews**
- **Propagation of Edits**

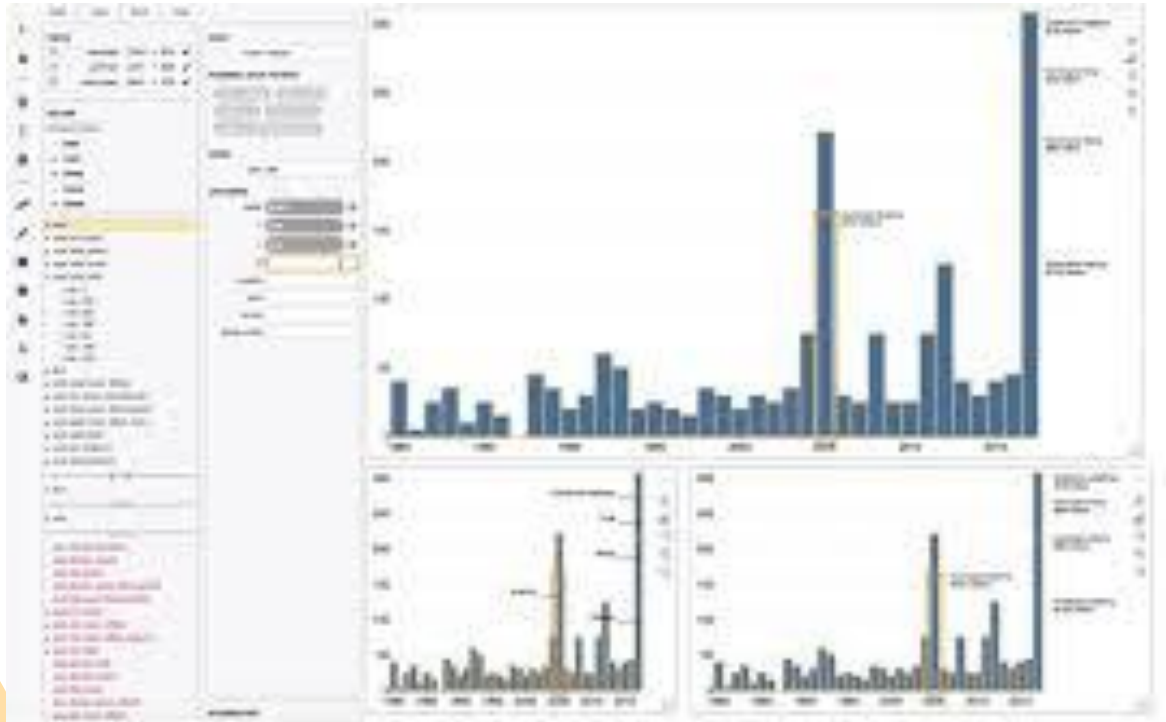
Discussion Questions (2/3)

05:00

1. What are the potential impacts of these guidelines on the workflow of visualization designers?
2. How could these guidelines influence the adoption of responsive visualization tools?

4

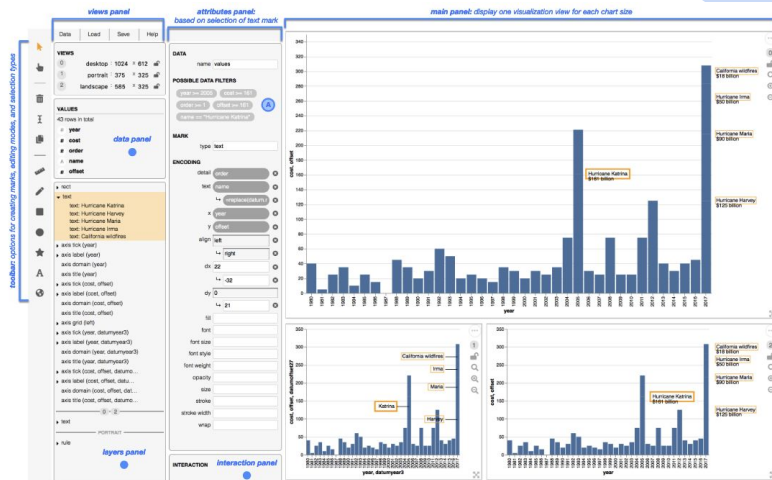
Prototype System



Prototype System (Cont.)

Demonstration of System Features:
Showcasing the ability to edit and preview responsive visualizations effectively.

Real-world Application: Recreating responsive designs from the analyzed corpus to validate the system.

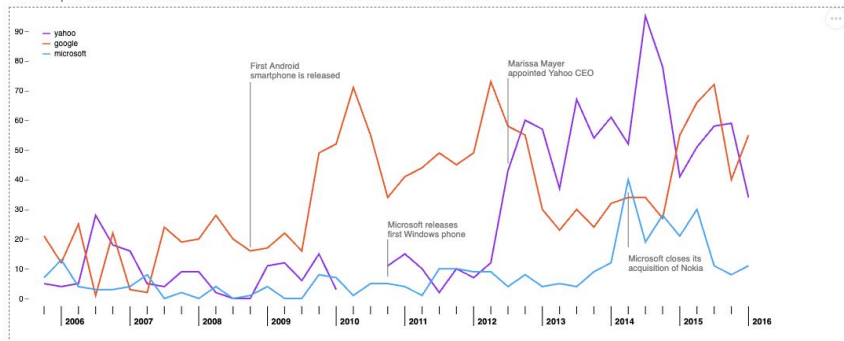


Case Studies & Demonstrations

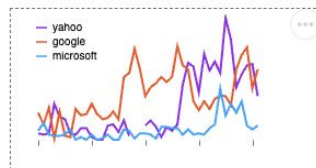
Examples: Detailed walk-throughs of responsive design adjustments made in real-world scenarios.

Desktop Visualization (1024x400 px)

The desktop visualization uses a multi-series line chart with annotations that fits well on standard screen sizes.

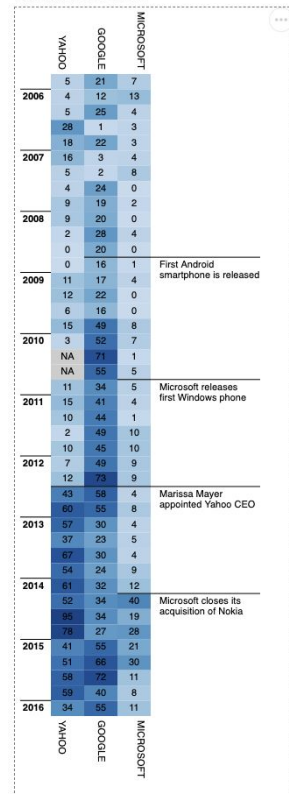


Thumbnail Visualization (240x120 px)



Phone Visualization - Portrait (275x875 px)

The phone visualization uses a heatmap that fits the portrait orientation better. Interestingly, this visualization also requires users to scroll on the phone to see all the visualization content.



How the system addresses the need for responsive design flexibility...

Discussion Questions (3/3)

05:00

1. What's the potential challenges or limitations of the proposed system?
2. How might these tools evolve with the increasing complexity of visualization needs?

Takeaways

- Visualizations need to be **responsive** due to the increase in mobile device usage. This shift necessitates tools and techniques that cater specifically to diverse environments.
- There is a notable gap in existing visualization tools regarding their support for creating responsive designs.
- Future tools are likely to incorporate AI and machine learning to further enhance responsiveness without manual adjustments, making the design process more efficient and less error-prone.

Before We Start

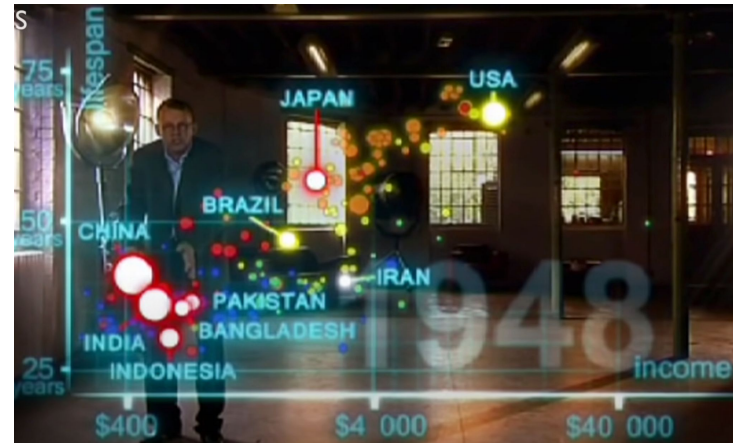


Before We Start Next Paper

05:00

What's your current understanding of visualization?

Charts, Plots, Large data...



What the difference between these two visualization?

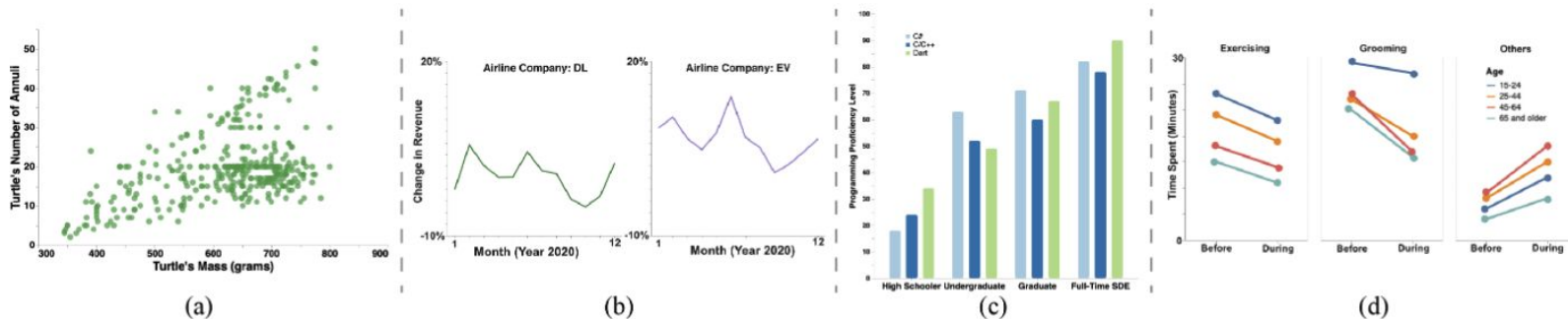
Can you learn what the author want you to learn without explanation?

Do You See What I See? A Qualitative Study Eliciting High-Level Visualization Comprehension

Quadri et al, 2024

Introduction

- The study investigates high-level visualization comprehension.
- Focuses on how people interpret visualizations without explicit cues.
- Aims to align design intentions with audience understanding.



Can you get author's' idea without any text hint?

Background

Previous studies focused on **low-level tasks**
The study emphasizes the importance of **natural, intuitive comprehension**.

Uses **three kinds of visualization** to analyze comprehension patterns with different **data type** and **juxtaposition**.

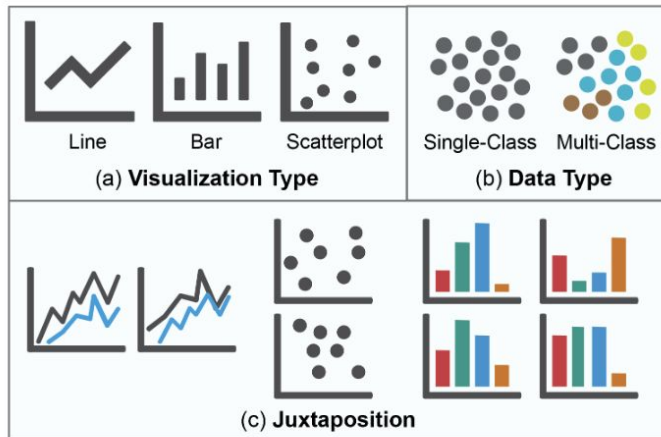


Figure 2: The design dimensions (see section 3.2.1) used in our study: (a) visualization types, (b) data types, and (c) composition type (juxtaposed).

Study Design

- Qualitative study conducted with participants describing various graph types.
- Data collected through think-aloud protocols and written responses.
- Graphs were chosen to reflect common designs in real-world scenarios.

Key Findings - Part 1

Intention does not always align with comprehension.

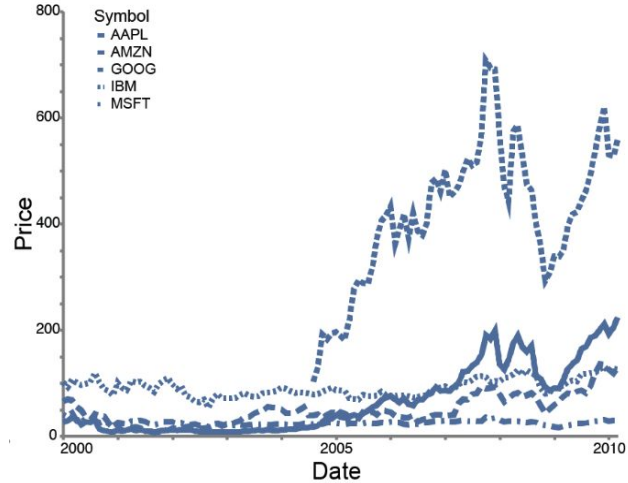
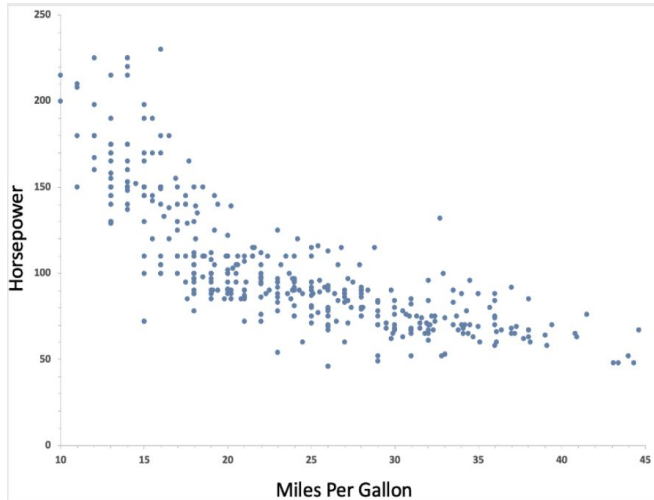
- 41% of responses matched the visualization intended goals.
- Mismatch signals the need for better design guidelines.

Discussion Questions (1/3)

05:00

1. What factors could cause a mismatch between design intentions and audience comprehension?
2. How can designers improve alignment between visualization goals and audience understanding?

What Do You Get From The Following Visualizations?



5

Discussion Questions (1/3)

05:00

1. What factors likely cause a mismatch between design intentions and audience comprehension?
2. How can designers avoid this problem?

Key Findings - Part 2

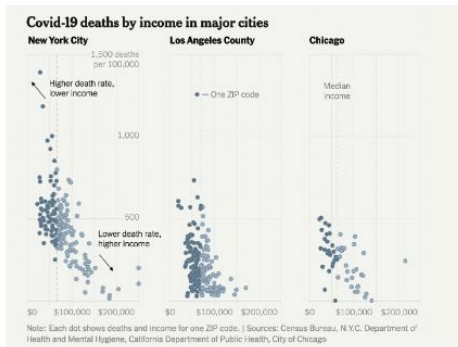
**Results from cued tasks alone
may not predict knowledge people build in a graph.**

- People often missed patterns without explicit guidance, showing the need for holistic design approaches.
- Chart type alone is insufficient to predict comprehension.

Discussion Questions (2/3)

05:00

1. Why might traditional cued tasks fail to predict natural comprehension?



(a) One million Covid-19 deaths.



(b) Covid-19 deaths by income



2. What role does chart complexity play in influencing user understanding?

Key Findings - Part 3

**Chart type alone is not sufficient
to predict the information people extract from a graph**

- Participants' comprehension varied significantly based on graph type and complexity. Juxtaposed and multiclass graphs often led to more misalignments.
- Annotations and design elements like color and legend helped improve comprehension.

Discussion Questions (3/3)

05:00

1. How can designers effectively use annotations and visual cues to enhance comprehension?
2. What are some challenges in designing effective multiclass or juxtaposed visualizations?

Takeaways

When creating visualization, what you want the audience to learn may not align what they actually learn.

So when you try to design a visualization, consider:

- How can you effectively convey your idea with multiple media.
 - visualization, text, animation, etc
- Who is the consumer and what are their comprehension styles?