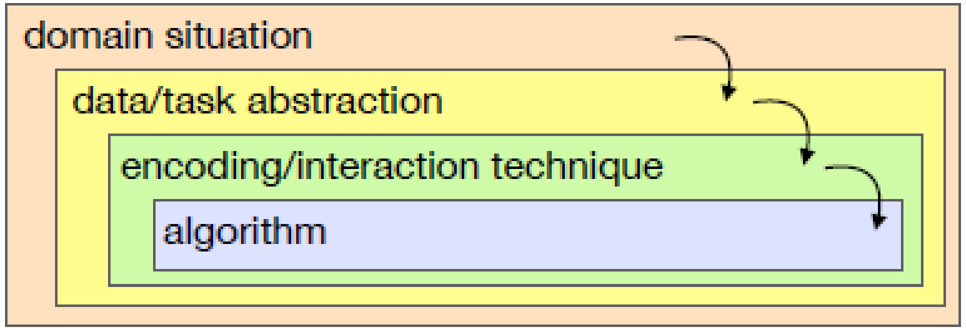
Lecture 4

9/15/2020

Analysis: Four Levels for Validation

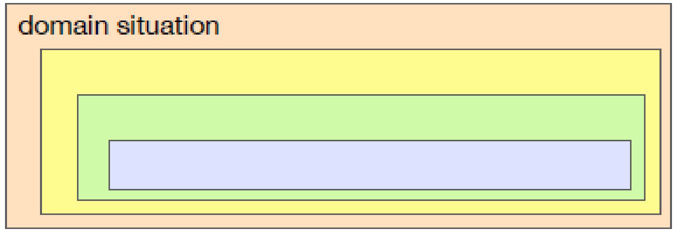
Four Nested Levels of Vis Design

- Design model: describes levels of design inherent to, and that should be considered in, the creation of a visualization.
- Four cascading levels are nested;
  - Output from an upstream level above is input to the downstream level below
- Block
  - Outcome of the design process at that level
  - Choosing a wrong block at an upstream level inevitably cascades to all downstream levels
    - Abstracting the wrong data will not solve the intended problem even if the idiom and algorithm levels are perfect
- Highly iterative refinement process
  - Principles of design as redesign



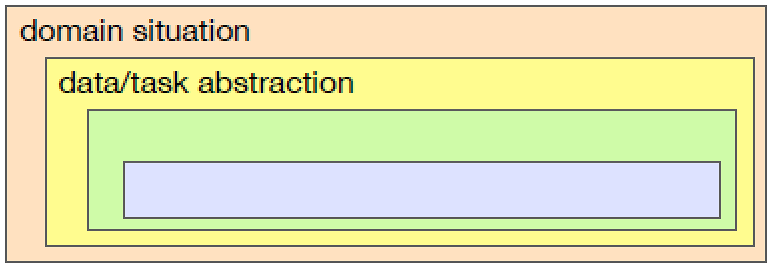
Domain Situation

- Describing a group of target users, their domain of interest, their questions, and their data
- Domain
  - particular field of interest of the target users of a vis tool
  - Has own vocabulary for describing its data and problems
  - Users: as small as 5 people of a department to as big as the general public (ex scientific community)…
- At this level, **situation blocks are identified**
  - **Outcome** of the design process is an understanding that the designer reaches about the needs of the user
  - **Methods** typically used to identify domain situation blocks: interviews, observations, careful research about target users within a specific domain
  - Common pitfall: designers cut corners by making assumptions and not engaging with target users
- User-centered design or human-centered design
  - Working closely with a specific target audience to iteratively refine a design



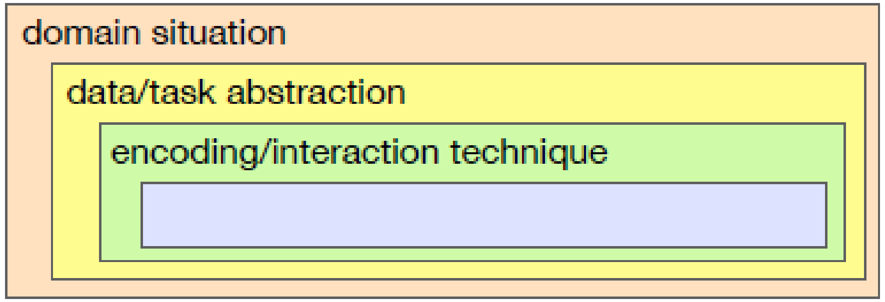
Data/Task Abstraction

- Abstracting the specific domain questions and data from the domain-specific form into a generic, computational form
- Questions from very different domain situations can map to the same abstract vis tasks
  - Ex: browsing, comparing, summarizing
- **Abstract data blocks are designed**
  - Selecting a data block is a creative design step
  - Original data may work in some cases
  - More often, designer chooses to transform the original data from its upstream form to something quite different
  - Many vis idioms are specific to a particular data type
  - Goal: determine which data type would support a visual representation of it that addresses the user's problem



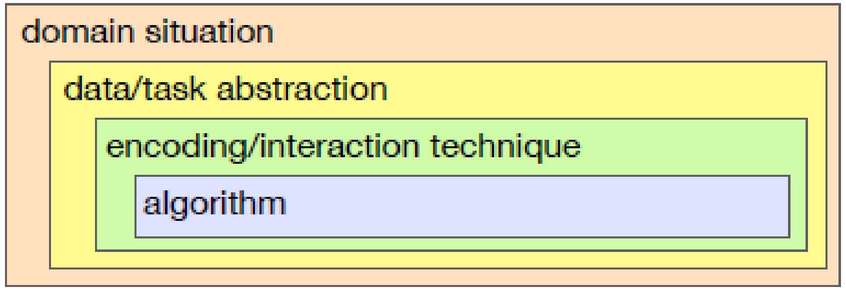
Encoding/Interaction Technique

- Decide on the specific way to create and manipulate the visual representation of the abstraction
- Idiom – each distinct possible approach
- Two concerns:
  - How to **create** a single picture of the data
    - **Visual encoding** idiom controls exactly what users see
  - How to **manipulate** that representation **dynamically**
    - **Interaction** idiom controls how users change what they see
- Good and bad matches
  - Human abilities: visual perception and memory



Algorithm

- Crafting a detailed procedure that allows a computer to automatically and efficiently carry out the desired visualization goal
- Efficiently handle the visual encoding and the interaction idioms chosen in the previous level
- **Algorithm blocks are designed**
- Different algorithms to achieve an idiom
  - Speed of computation, computer memory required, is resulting image an exact match or an approximation of specified visual encoding idiom
- Nested model emphasized separating algorithm design from idiom design
  - Algorithm design concerns are primarily about computational issues
  - Idiom design concerns are more about human perception issues



Angles of Attack

Problem-driven work	Technique-driven work

• Start at top domain situation level and work down through abstraction, idiom, and algorithm decisions	• Bottom two levels: idiom or algorithm design
	• Goal:
	  • Invent new idioms that better support existing abstractions
	  • New algorithms that better support existing idioms

Problem-Driven Work

- Address problems of real-world users and attempt to design a solution that helps them work more effectively
  - Aka design study
- Usually existing visual encoding and interaction idioms solve the problem
- Challenge usually lies at the abstraction level
- Sometimes, the problem motivates the design of new idioms (if existing ones don’t adequately solve the abstracted design problem)
- Design process for problem-driven work
  - Almost never strictly linear
  - Involves iterative refinement at all of the levels

Technique-Drive Work

- Starting point
  - New visual encoding or interaction idiom
  - New algorithm

Threats to Validity

- Fundamental reasons why you might have made the wrong choices
- Different set of threats for each of the four levels
- “they” = target users
- “you” = vis designer

Validation Approaches

- Immediate
- Downstream
- Nested levels
  - Most kinds of validation for outer levels are not immediate because they require results from the downstream levels nested within them
- Examples:
  - poor algorithm design may cast doubt when testing an interaction technique
  - Poor visual encoding choice may cast doubt when testing a legitimate abstraction choice
- Get feedback from target users about abstraction and encoding designs before diving into designing or implementing any algorithms

Validation Approaches: Domain

- Primary threat
  - problem is mischaracterized; target users do not in fact have these problems
- Validation
  - Immediate
    - Interview and observe the target audience to verify the characterization (don't rely on assumptions)
    - Common approach: field study
      - Investigate people in real world settings (not laboratory)
      - Gathering qualitative data from semi-structured interviews
  - Downstream
    - Report rate at which the tool has been adopted by the target audience, but this does not always tell the whole story!
    - A tool that is actually used by its intended users has reached a different level of success than one that has only been used by its designers

Validation Approaches: Abstraction

- Threat
  - identified task abstraction blocks and designed data abstraction blocks do not solve the characterized problems of the target audience
- Key aspect of validation:
  - System must be tested by target users doing their own work (not an abstract task specified by the designers of the vis system)
  - Downstream approach:
    - Have a member of the target user community try the tool
    - Hopes to collect anecdotal evidence (insights found, hypotheses confirmed) that the tool is in fact useful
    - All three of the other levels have to be fully addressed first
    - Usually qualitative, but quantitative methods have been developed
    - Important to distinguish between discovery made by target user vs designer; former is compelling argument for utility of the vis tool
  - Rigorous validation approach: field study
    - Observe and document how target audience uses the deployed system as part of their real-world work-flow
    - ** Field study difference for abstraction vs domain:
      - Domain field study – documents existing work practices
      - Abstraction field study – observing how behavior changes after intervening with the deployment of a vis tool

Validation Approaches: Idiom

- Threat
  - Chosen idioms are not effective at communicating the desired abstraction
- Immediate validation approach:
  - Justify the design of the idiom with respect to known perceptual and cognitive principles
  - Evaluation methods to systematically ensure that no known guidelines are being violated by the design
    - Heuristic evaluation
    - Expert review
- Downstream approach
  - Lab study
    - Quantitative, qualitative, objective measurements by carrying out tasks, subjective measurements such as preferences, mouse clicks, eye movement
  - Presentation of and qualitative discussion of results in the form of still images or video
    - Why is this considered downstream?
  - Quality metrics - quantitative measurements of results images created by the implemented system
    - Ex: measurable layout metrics such as # of edge crossings and edge bends used to assess drawings of node-link networks

Validation Approaches: Algorithm

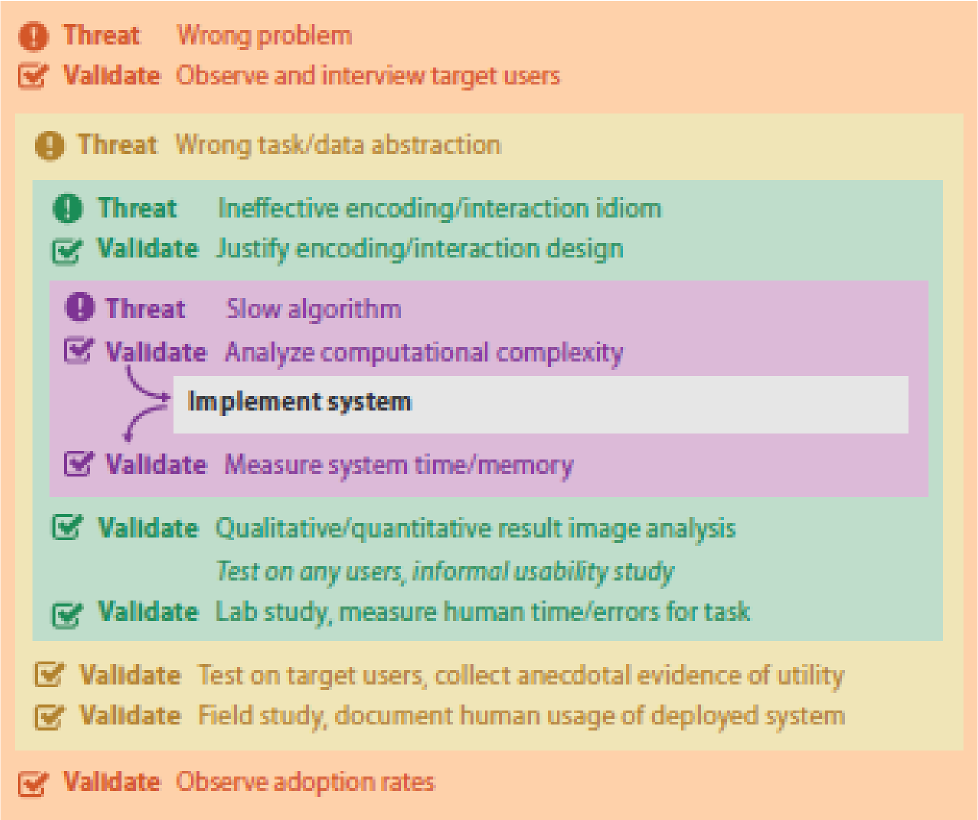
- Threat
  - Algorithm is suboptimal in terms of time or memory performance (theoretically or compared to a previously proposed algorithm)
- Immediate validation approach
  - Analyze the computational complexity of the algorithm (# of items in dataset, # of pixels in the display)
- Downstream validation approach
  - Measure the wall-clock time and memory performance of the implemented algorithm
    - Scalability (how dataset size affects algorithm speed, datasets to use – benchmark and broad set)

Validation Approaches: Algorithm

- Threat
  - Incorrectness at algorithm level where implementation does not meet the specification from the idiom level above (poor algorithm design or bugs)
- Implicit validation approach
  - Presenting still images/videos created by the implemented algorithm, where the reader of a paper can directly see that the algorithm correctness objectives have been met
- Explicit validation approach
  - Qualitative discussion of why these images show that the algorithm is in fact correct

Nested Model: Threats and Validations

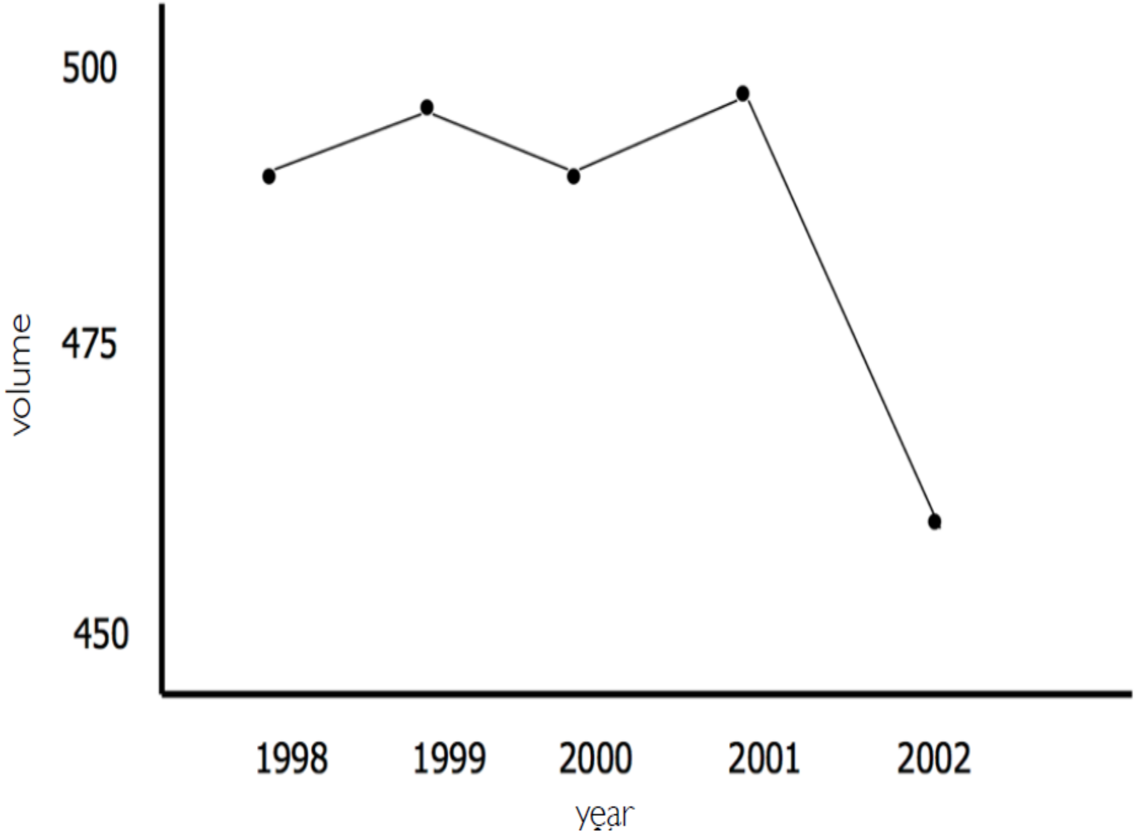
The nested model explicitly separates the vis design problem into levels in order to guide validation according to the unique threats at each level.



Tufte: Graphical Integrity

- Clear, detailed, and thorough labeling should be used to defeat graphical distortion and ambiguity.

SCALE DISTORTION



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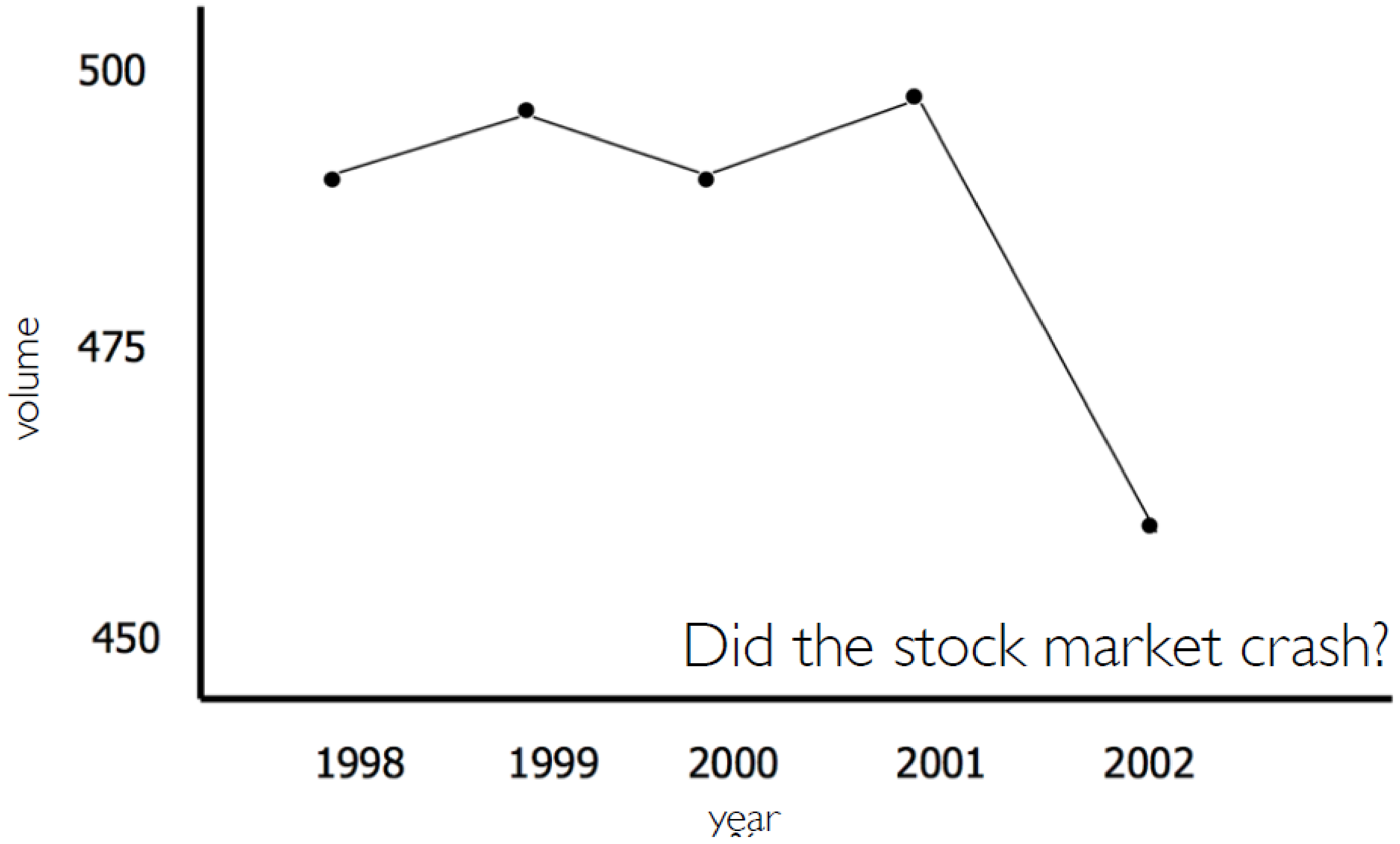

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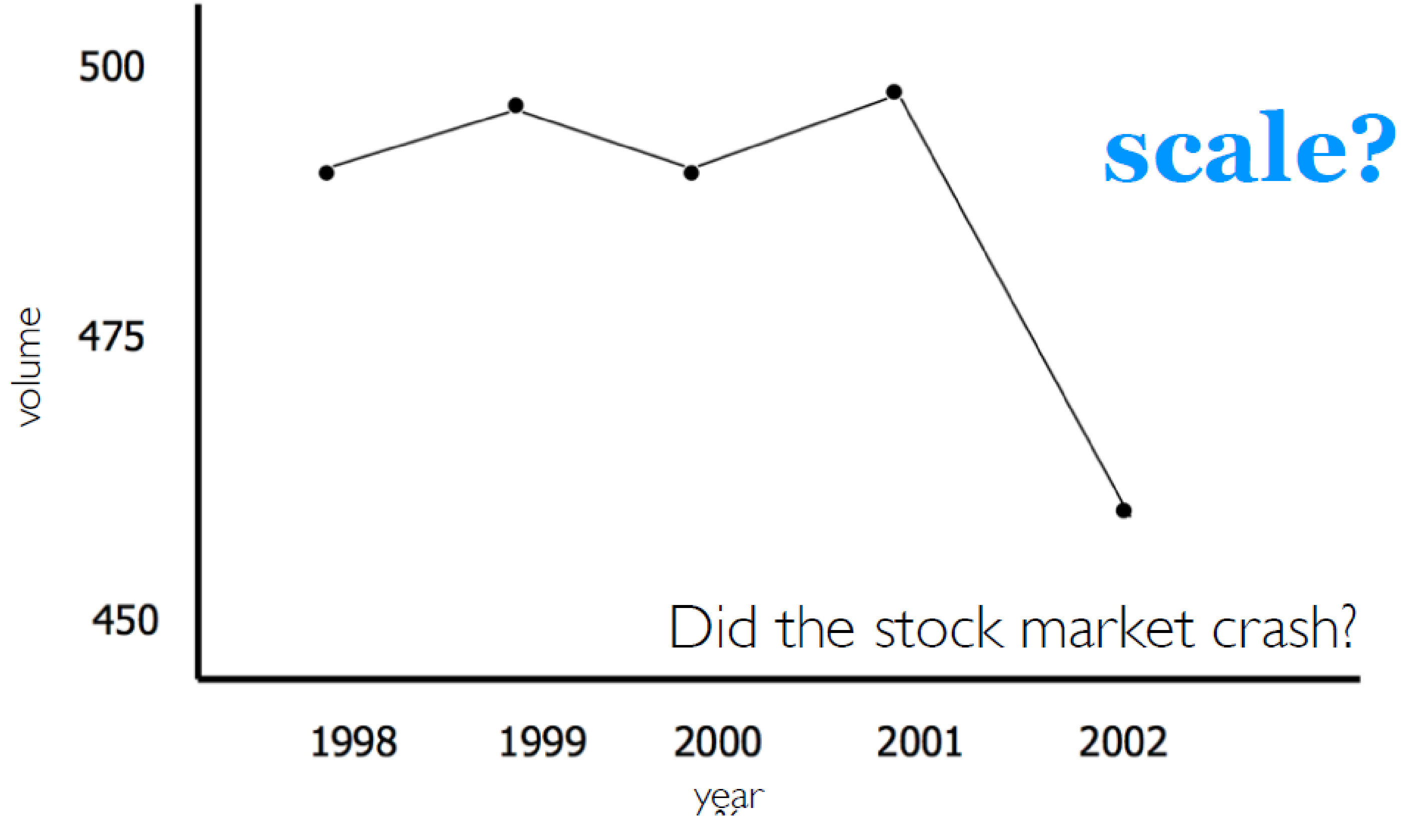

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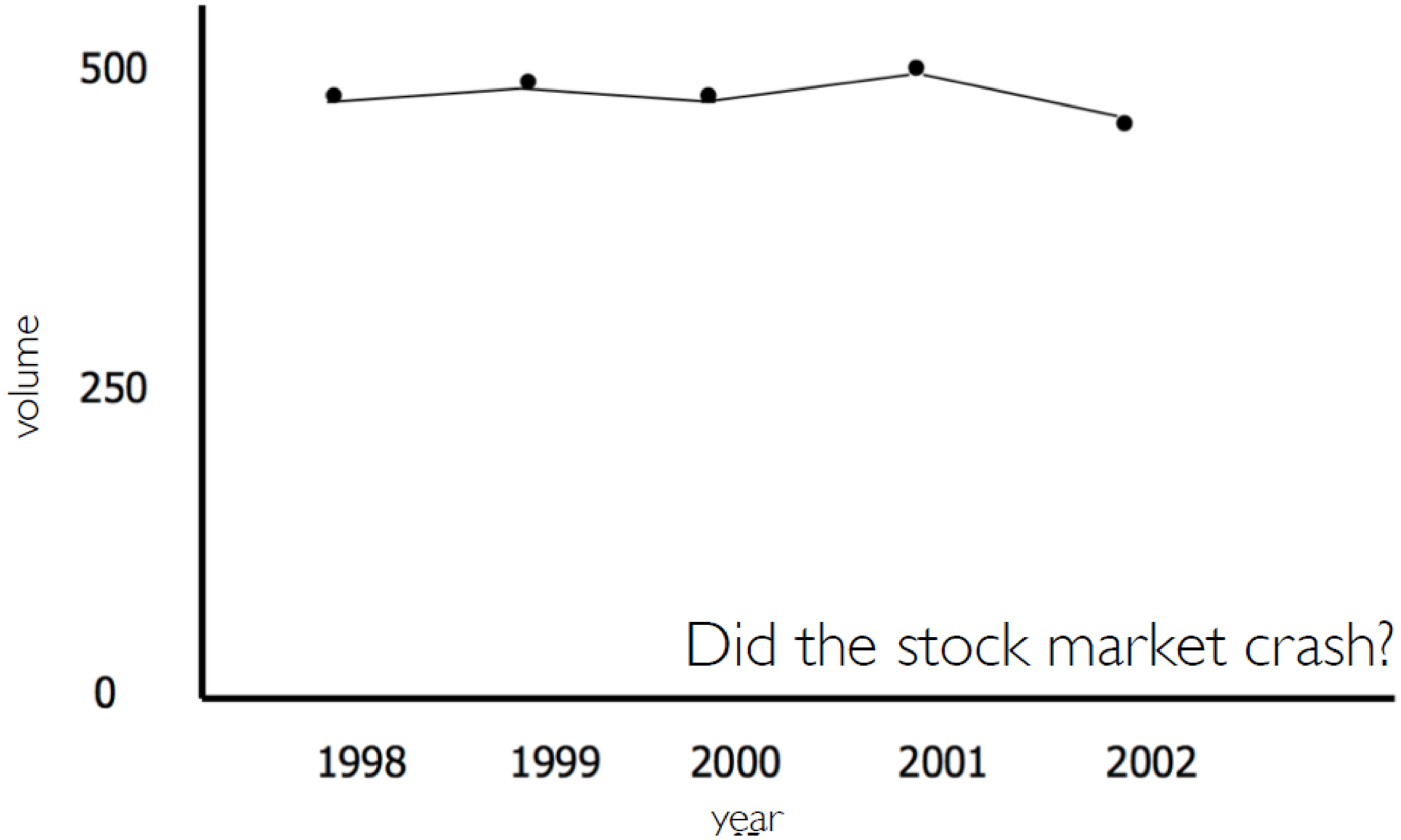

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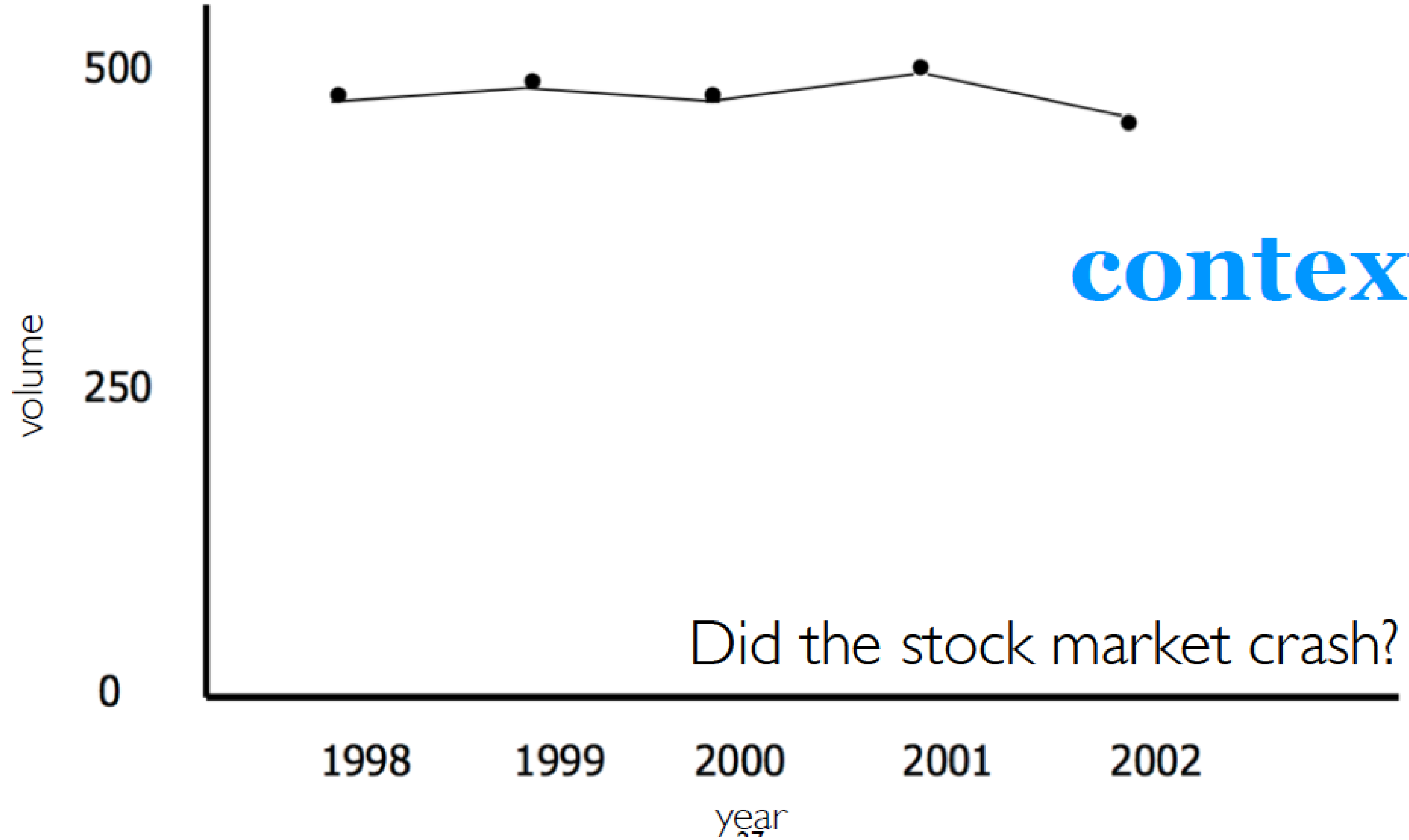

context?

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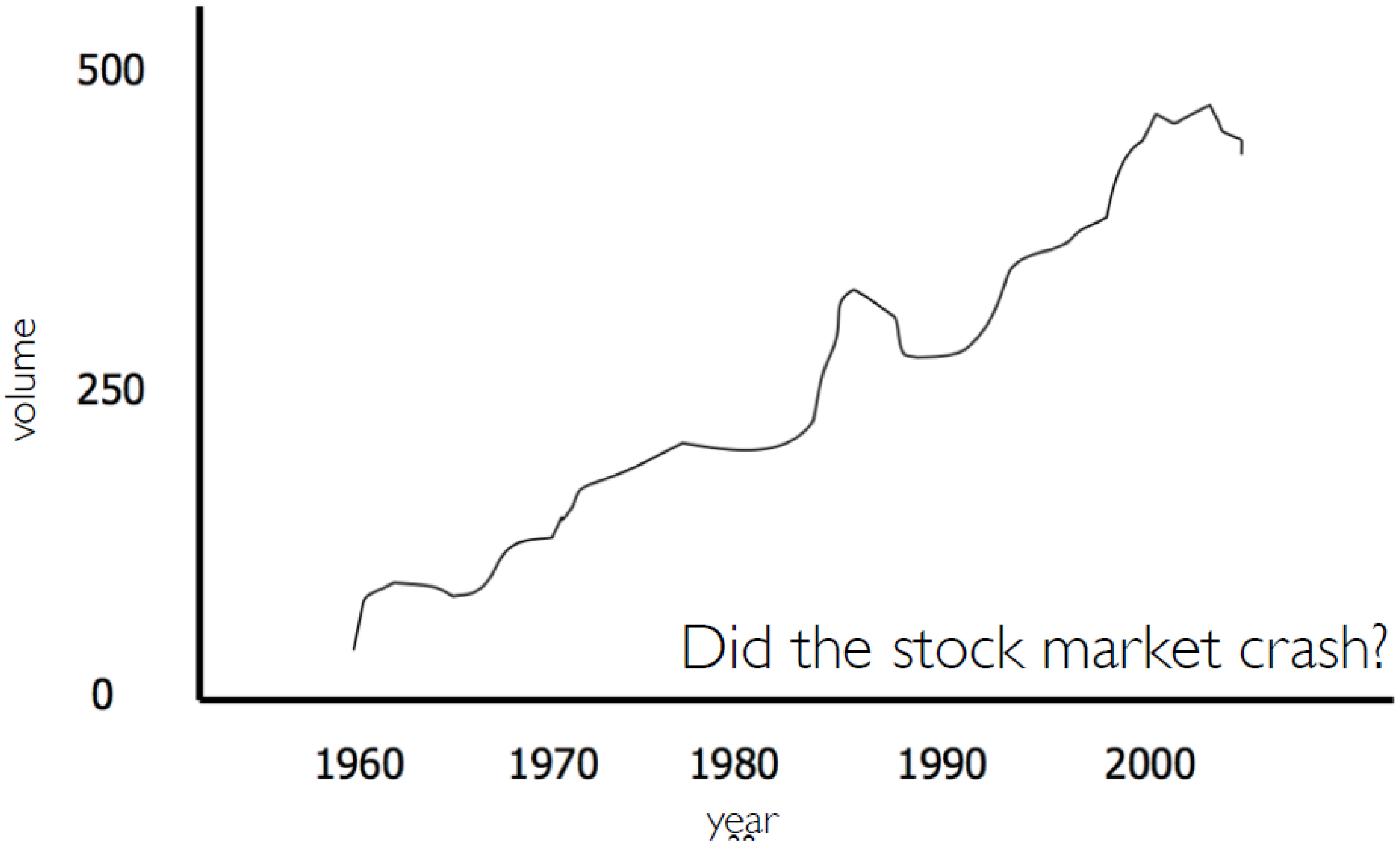

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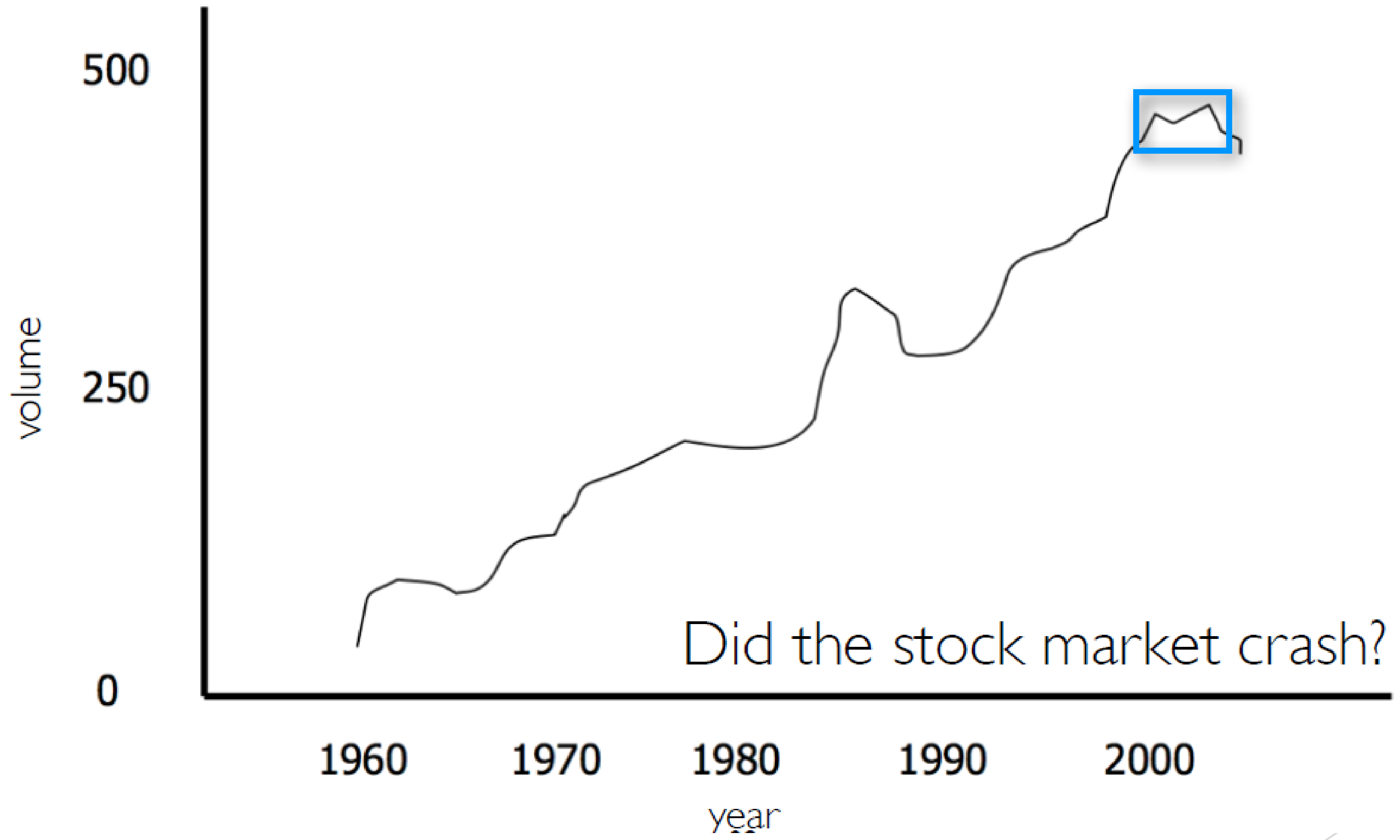
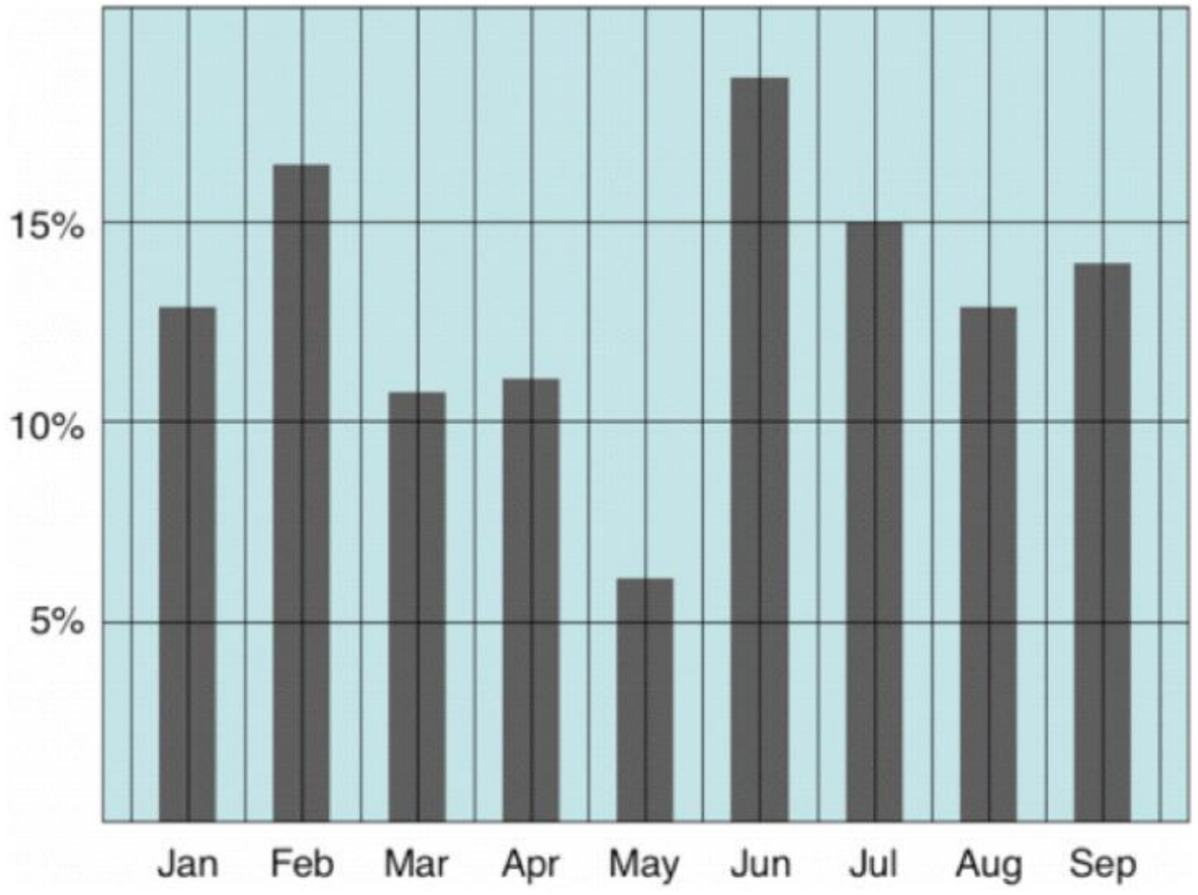


Avoid Chart Junk



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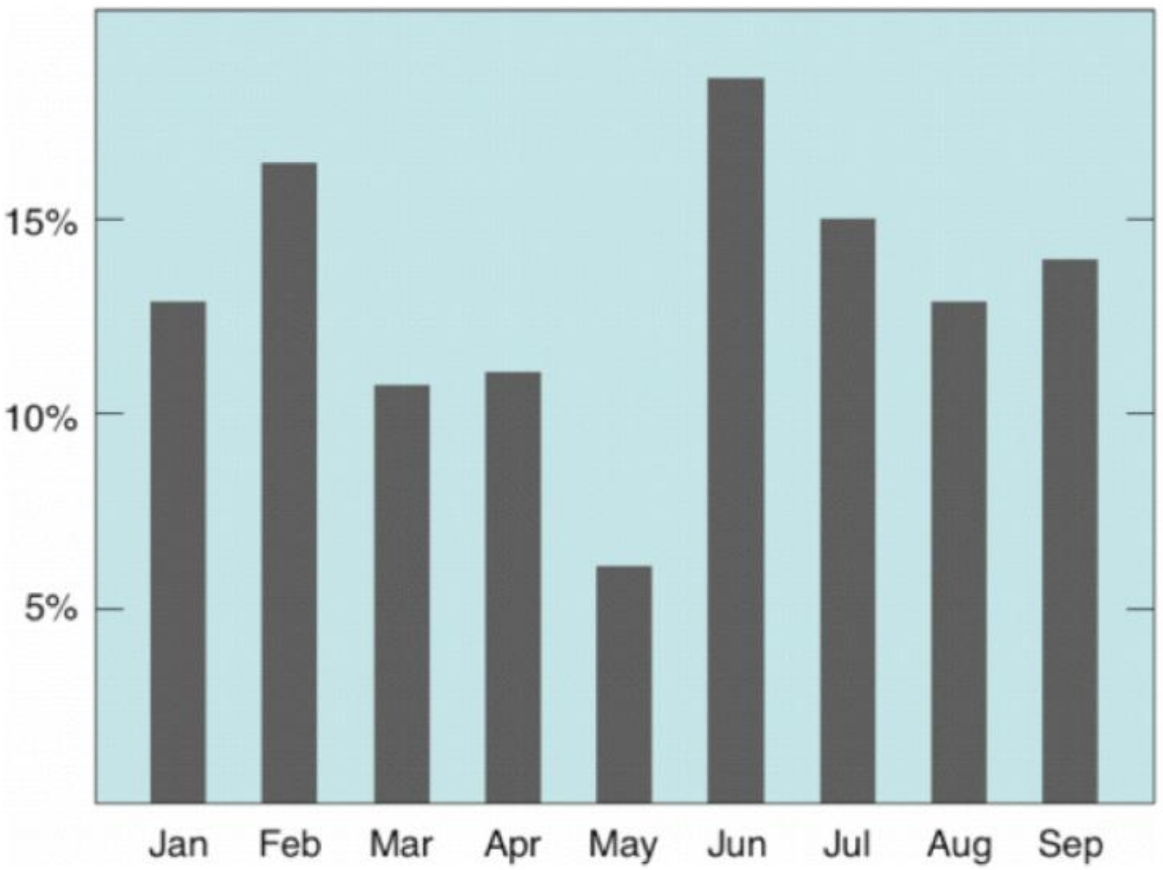

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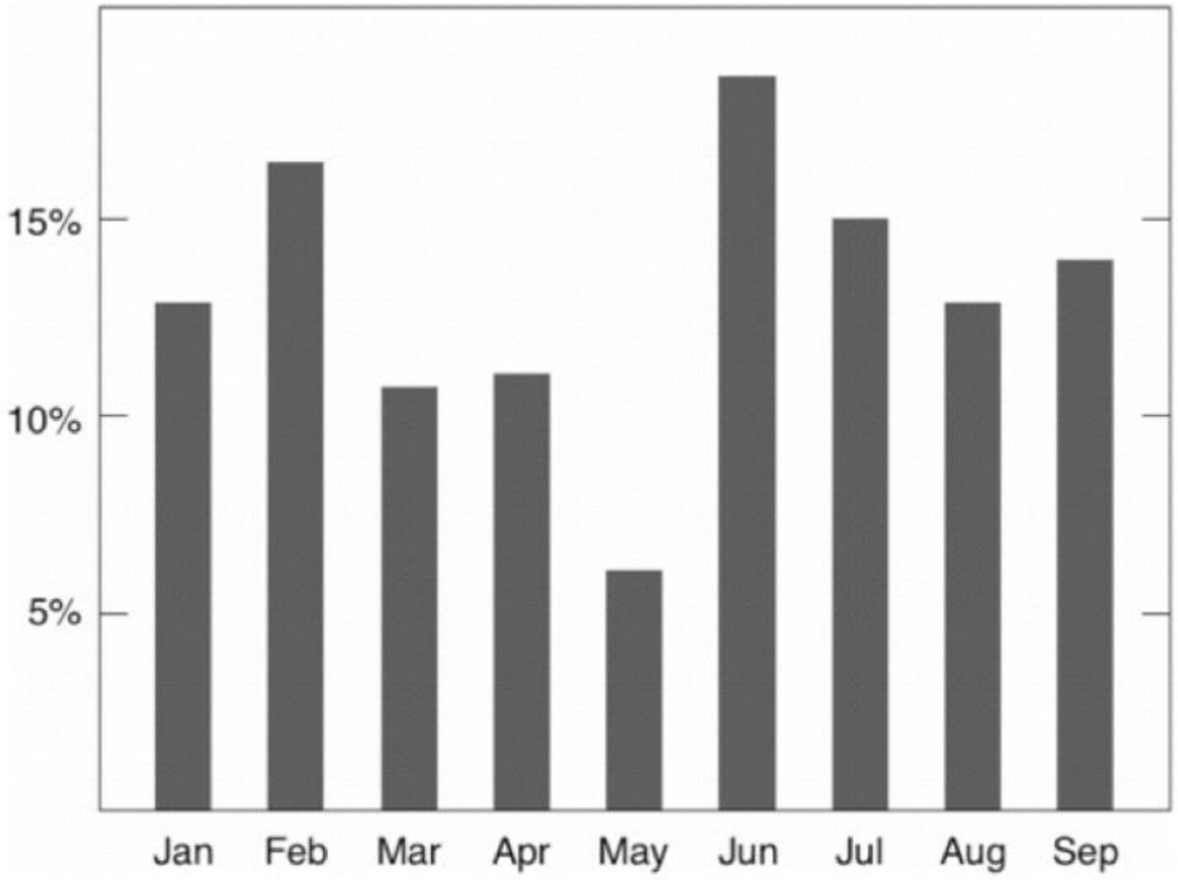

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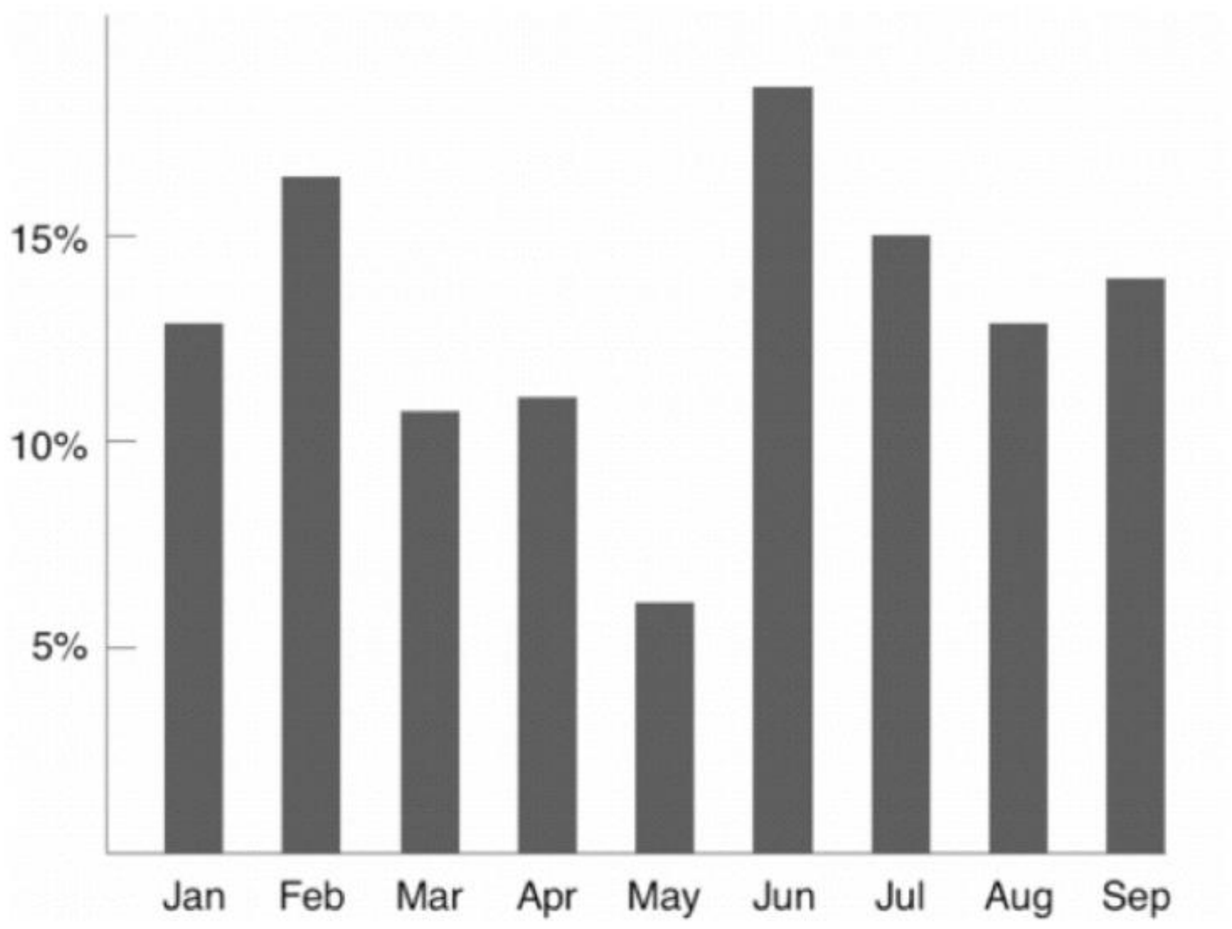

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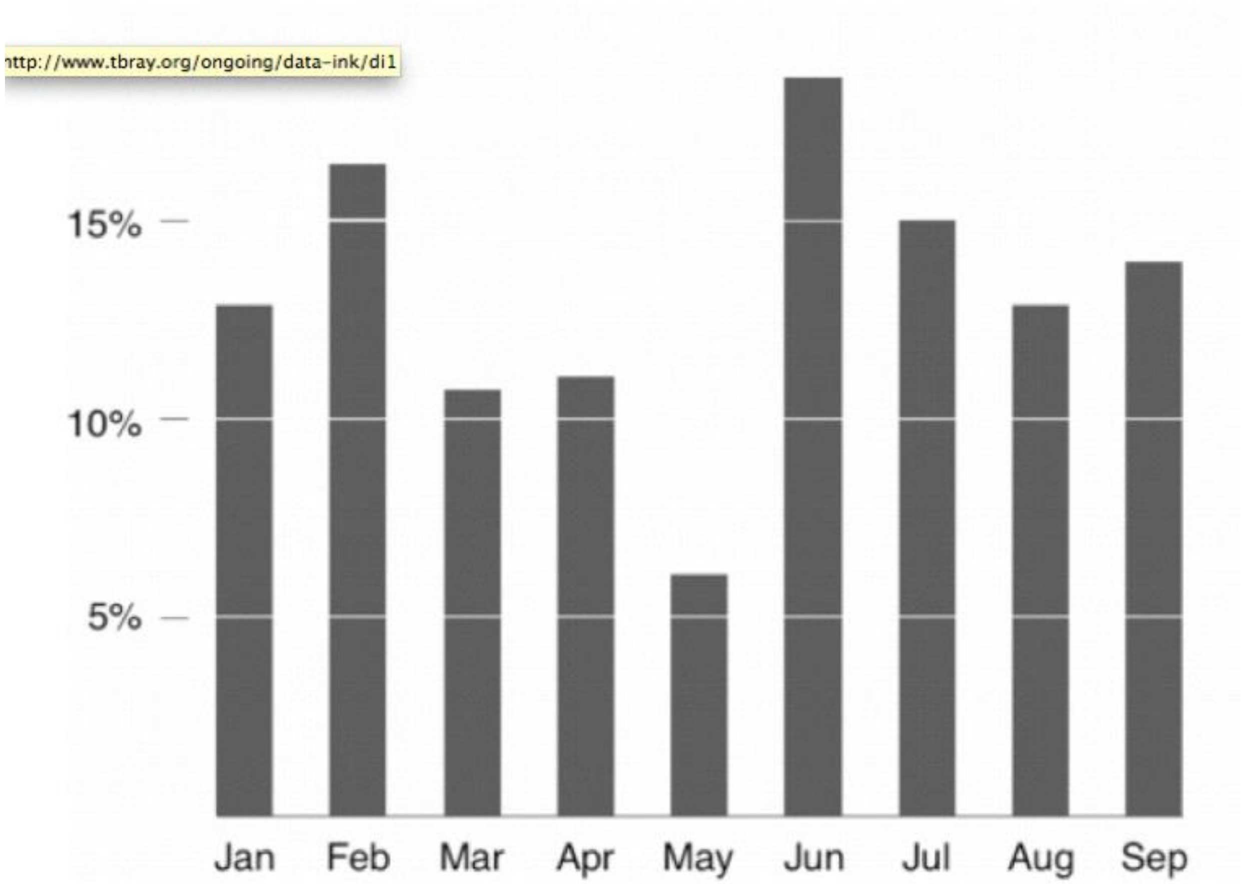

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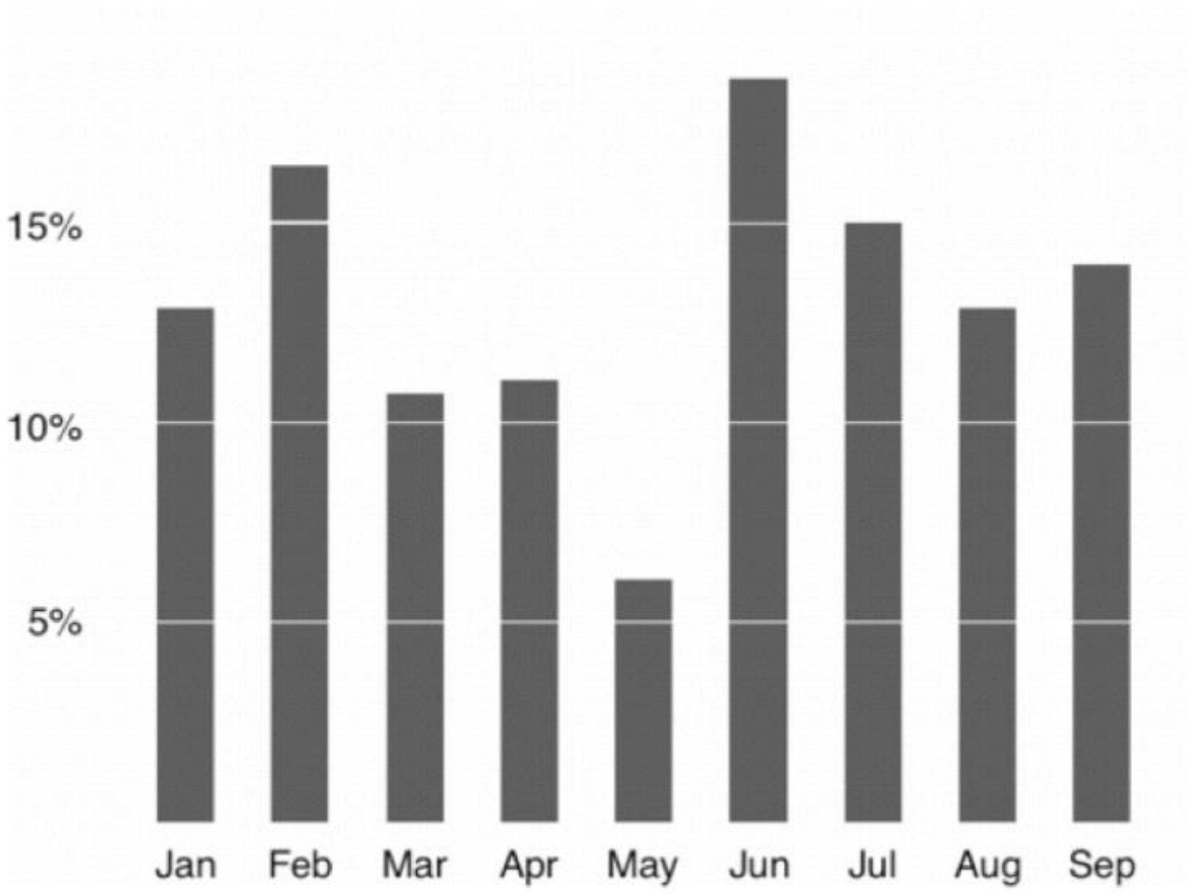

Sources/Credits

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- Utah, Miriah Meyer, Visualization (2014).
- UMass Dartmouth, David Koop, Data Visualization (2015).