CS49000-VIZ - Fall 2020

Introduction to Data Visualization

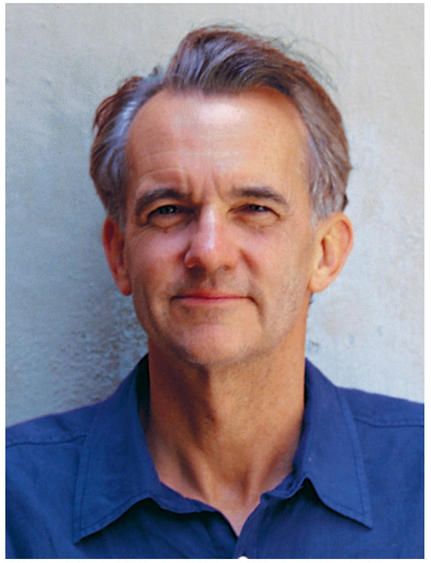
Design Guidelines

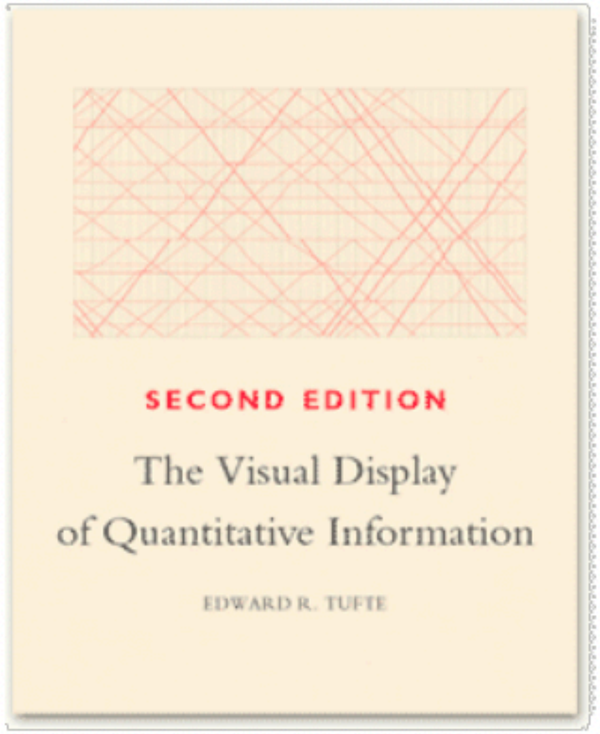
Lecture 8

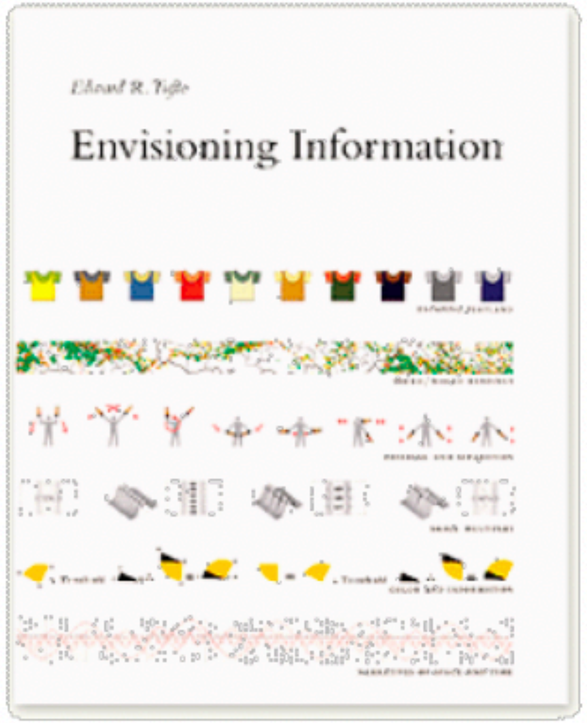
Slides credits: T. Munzner (UBC) and A. Lex (Utah)

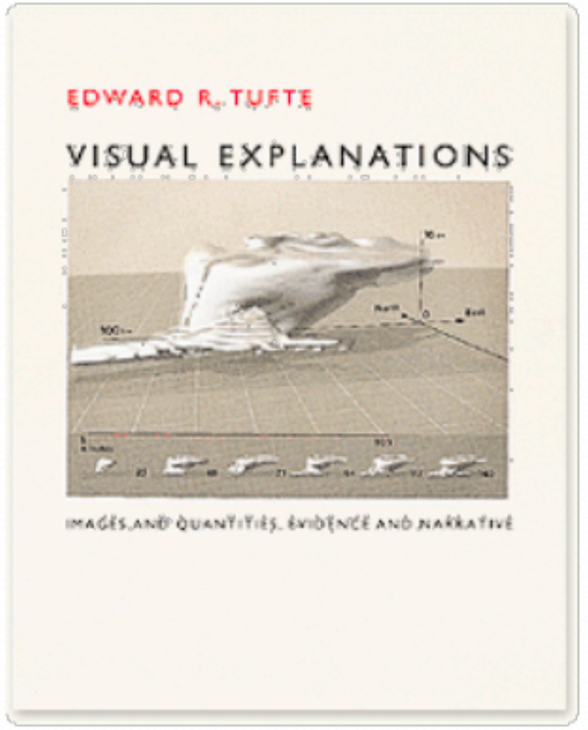
September 17, 2020

Edward Tufte

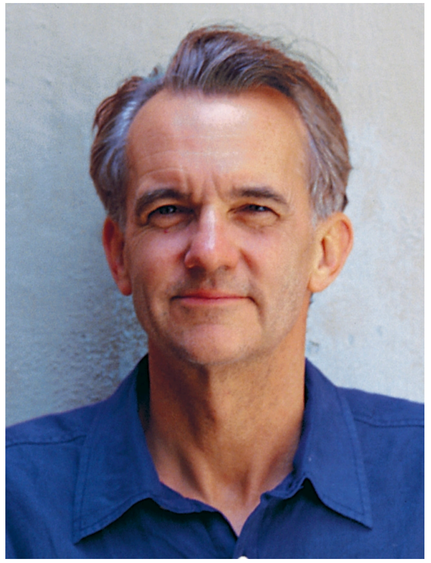




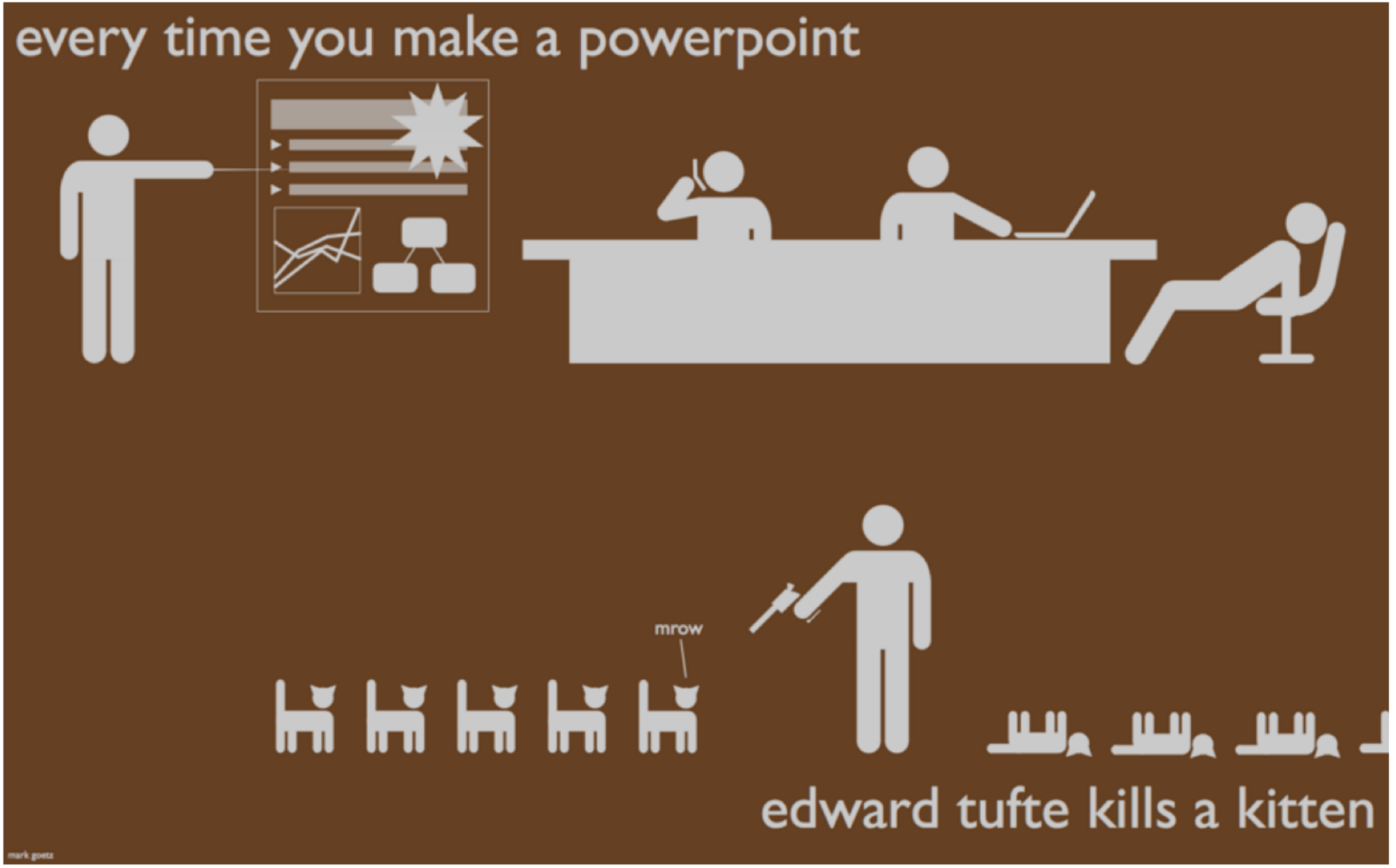




Edward Tufte



"Well-designed presentations of interesting data are a matter of substance, of statistics, and of design."


every time you make a powerpoint
mrow
edward tufte kills a kitten
mark goetz

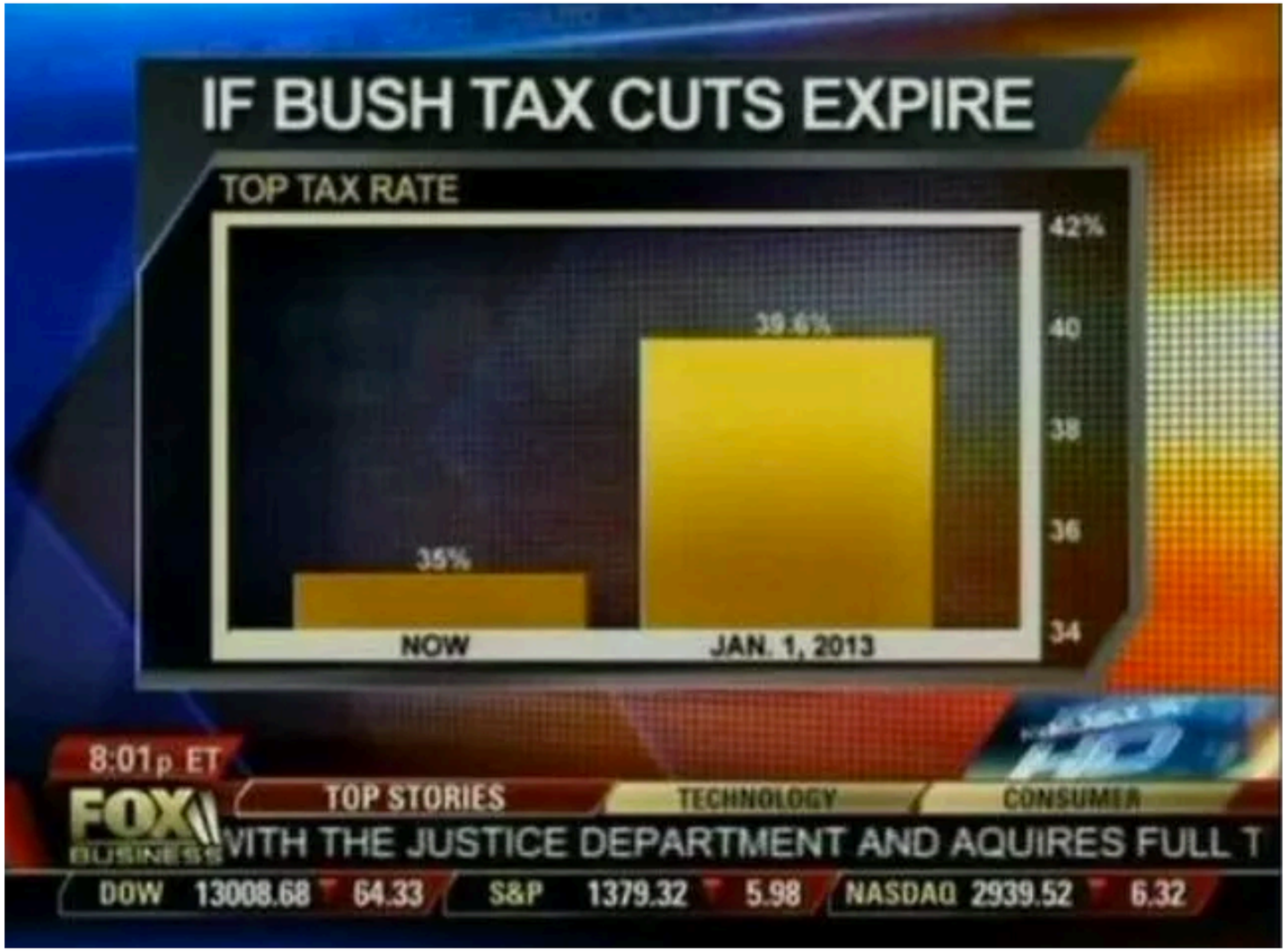
Edward Tufte

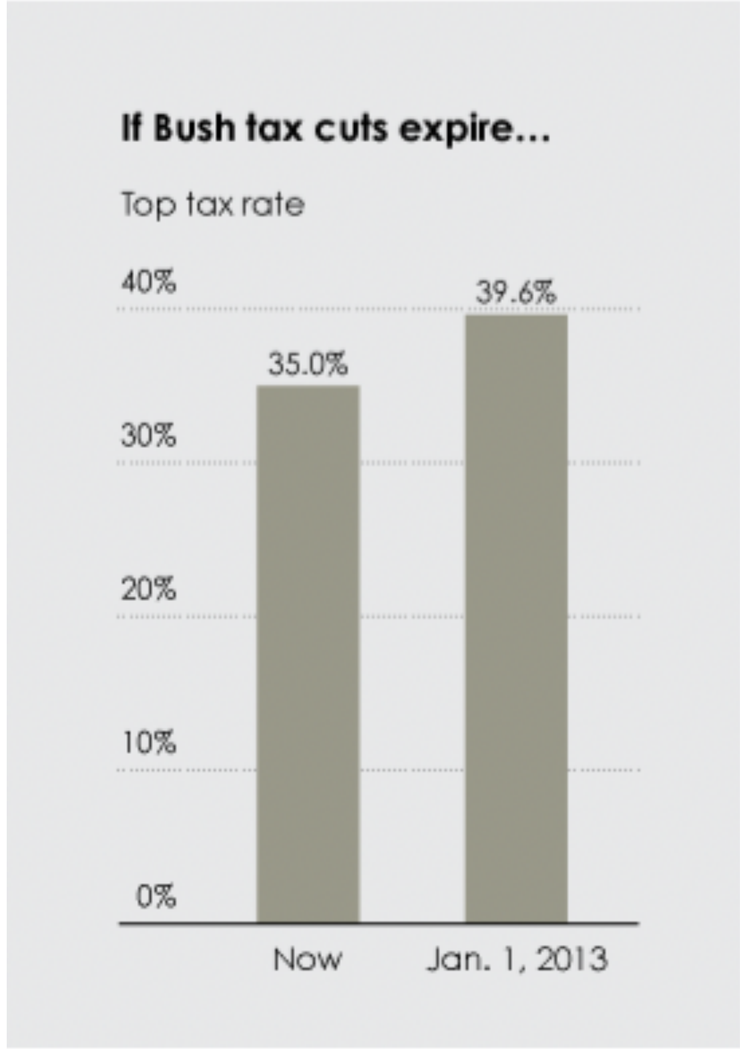
Practice: graphical integrity and excellence

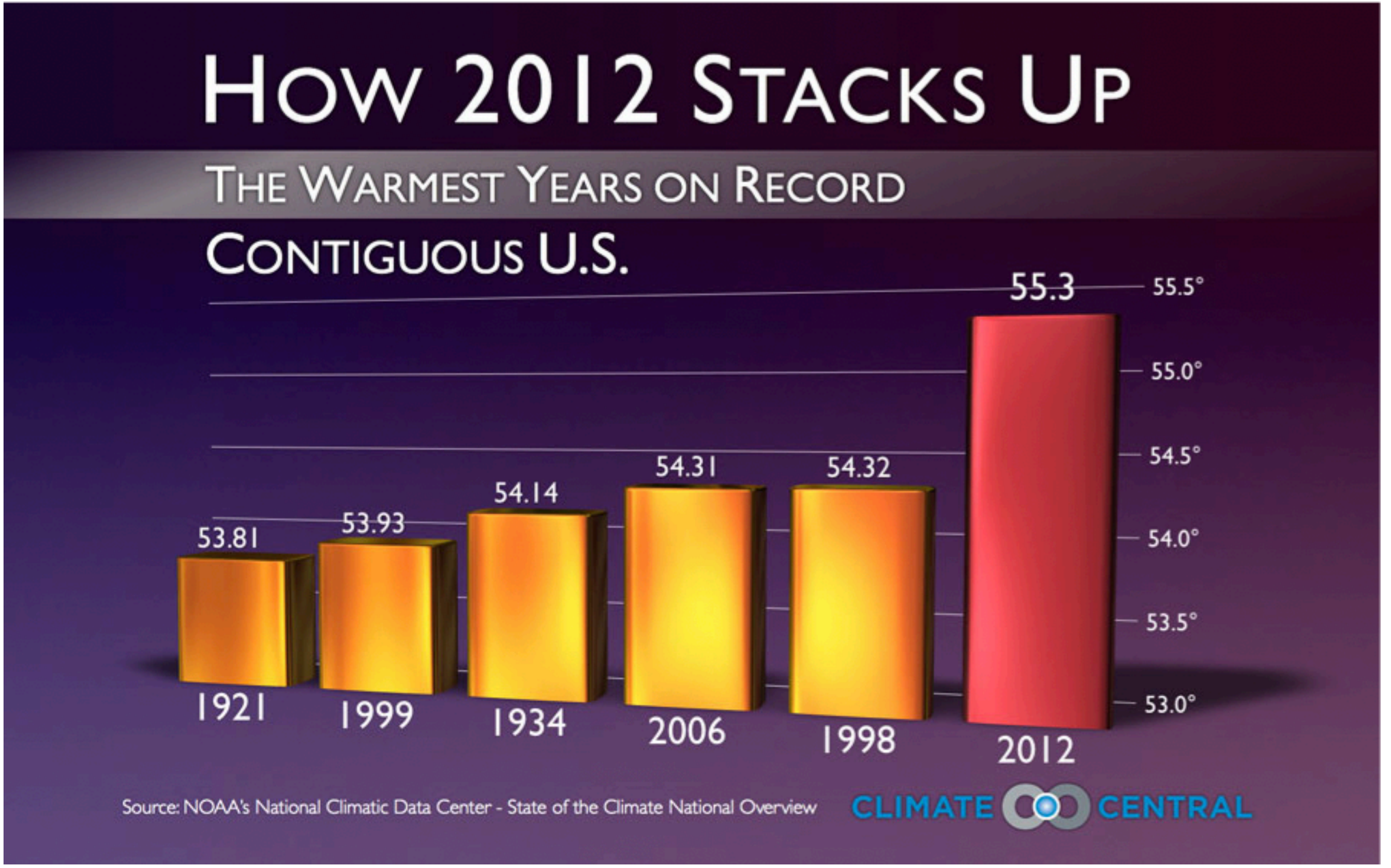
Theory: design principles for data graphics

Graphical Integrity

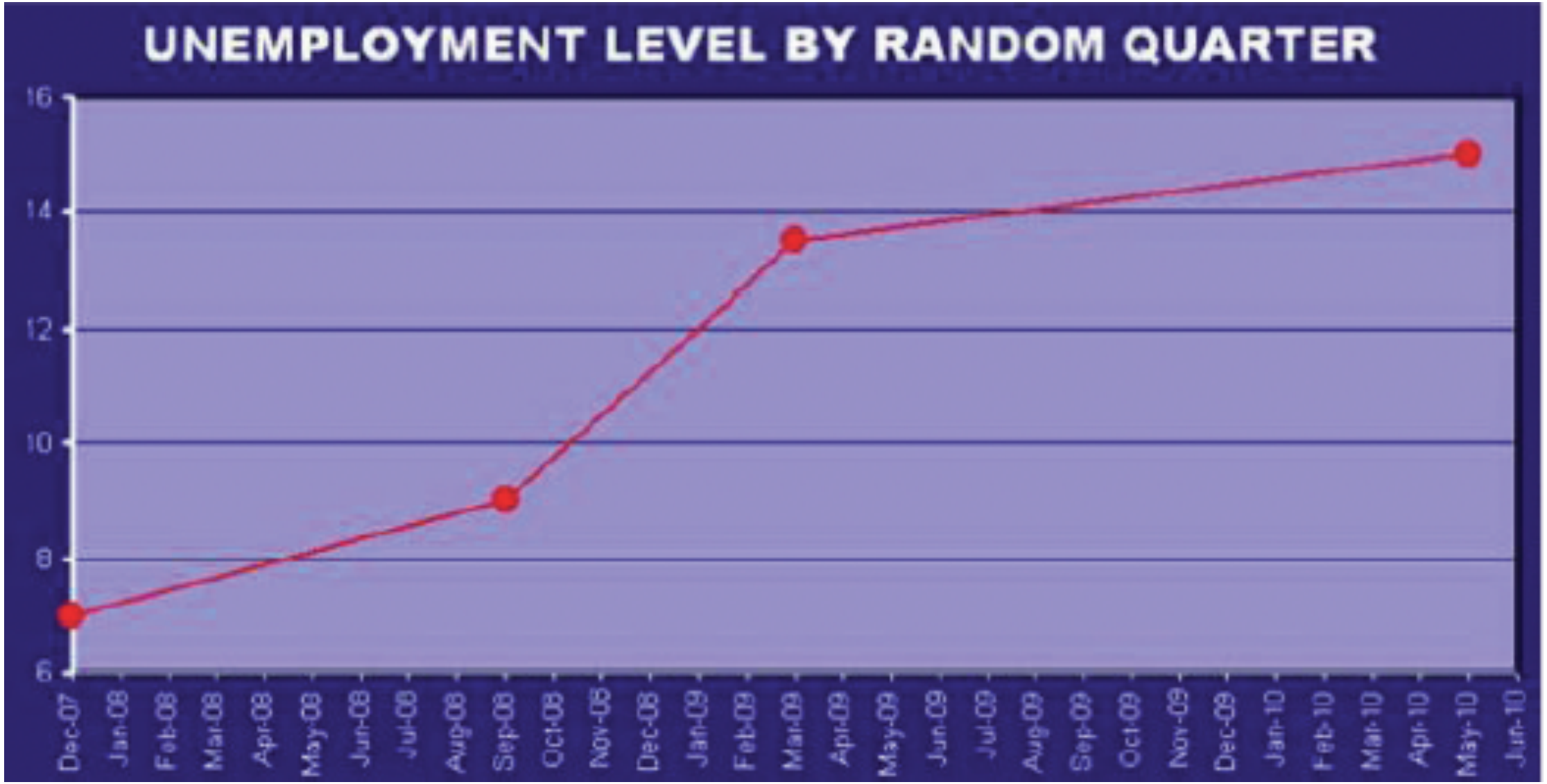
Scale Distortions



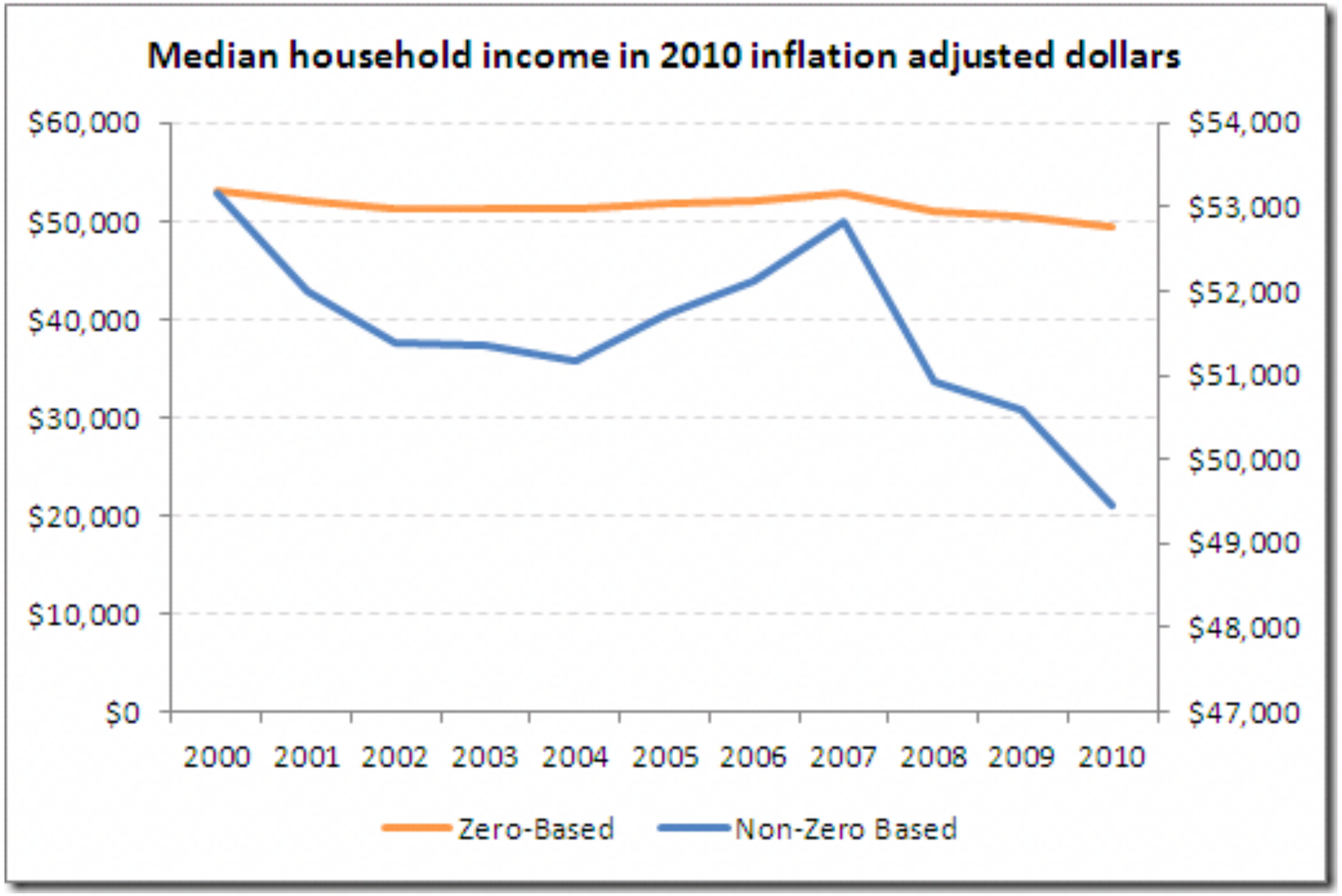



How 2012 Stacks Up
The Warmest Years on Record
Contiguous U.S.
53.81
53.93
54.14
54.31
54.32
55.3
55.5°
55.0°
54.5°
54.0°
53.5°
53.0°
1921
1999
1934
2006
1998
2012
Source: NOAA's National Climatic Data Center - State of the Climate National Overview
CLIMATE CENTRAL

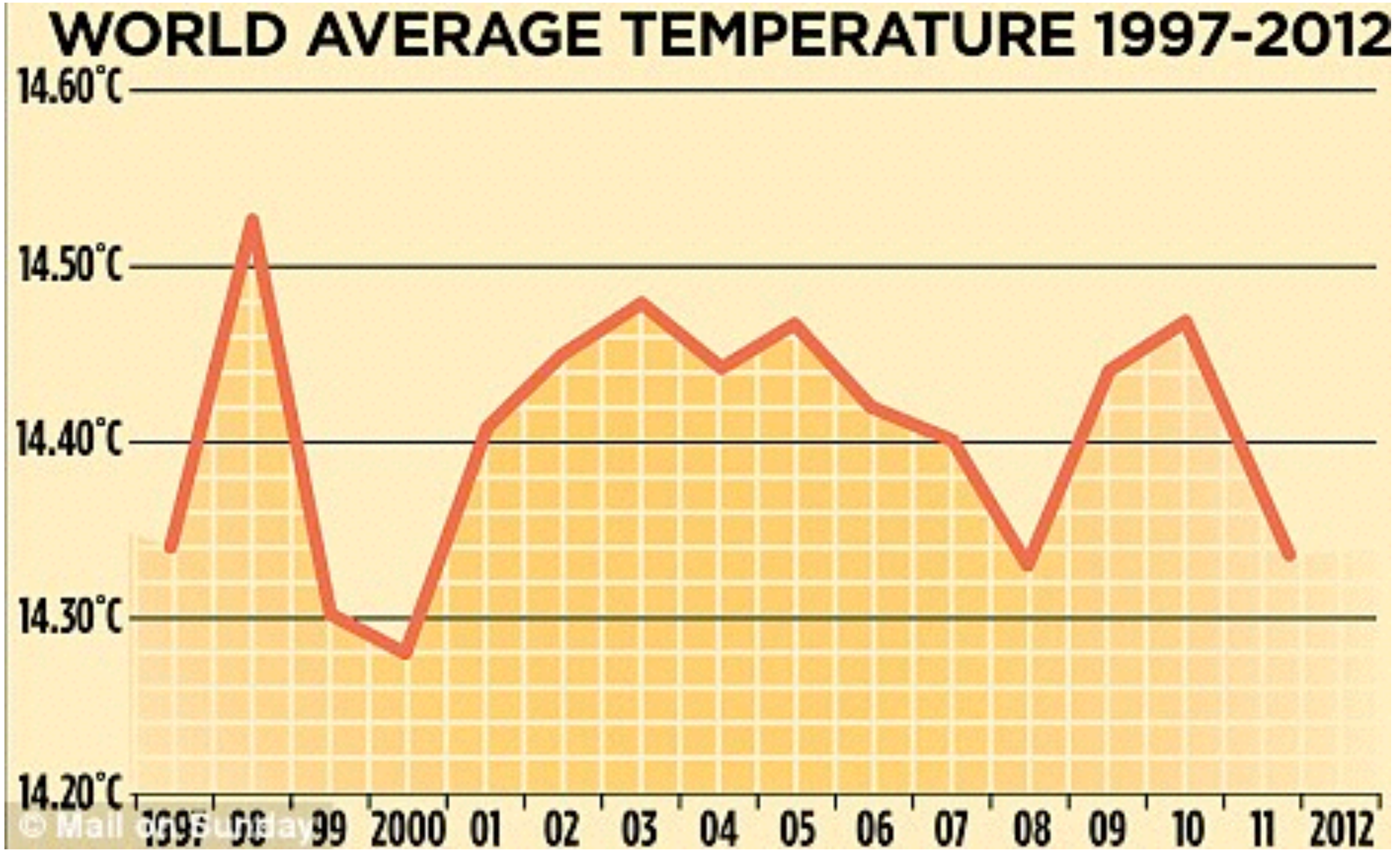
JOB LOSS BY QUARTER
15 MIL
13.5 MIL
9 MIL
7 MIL
DEC '07
SEPT '08
MARCH '09
JUNE '10
FOX NEWS .COM
SOURCE: BLS
AMERICA'S NEWSROOM


UNEMPLOYMENT LEVEL BY RANDOM QUARTER
16
14
12
10
8
6
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10

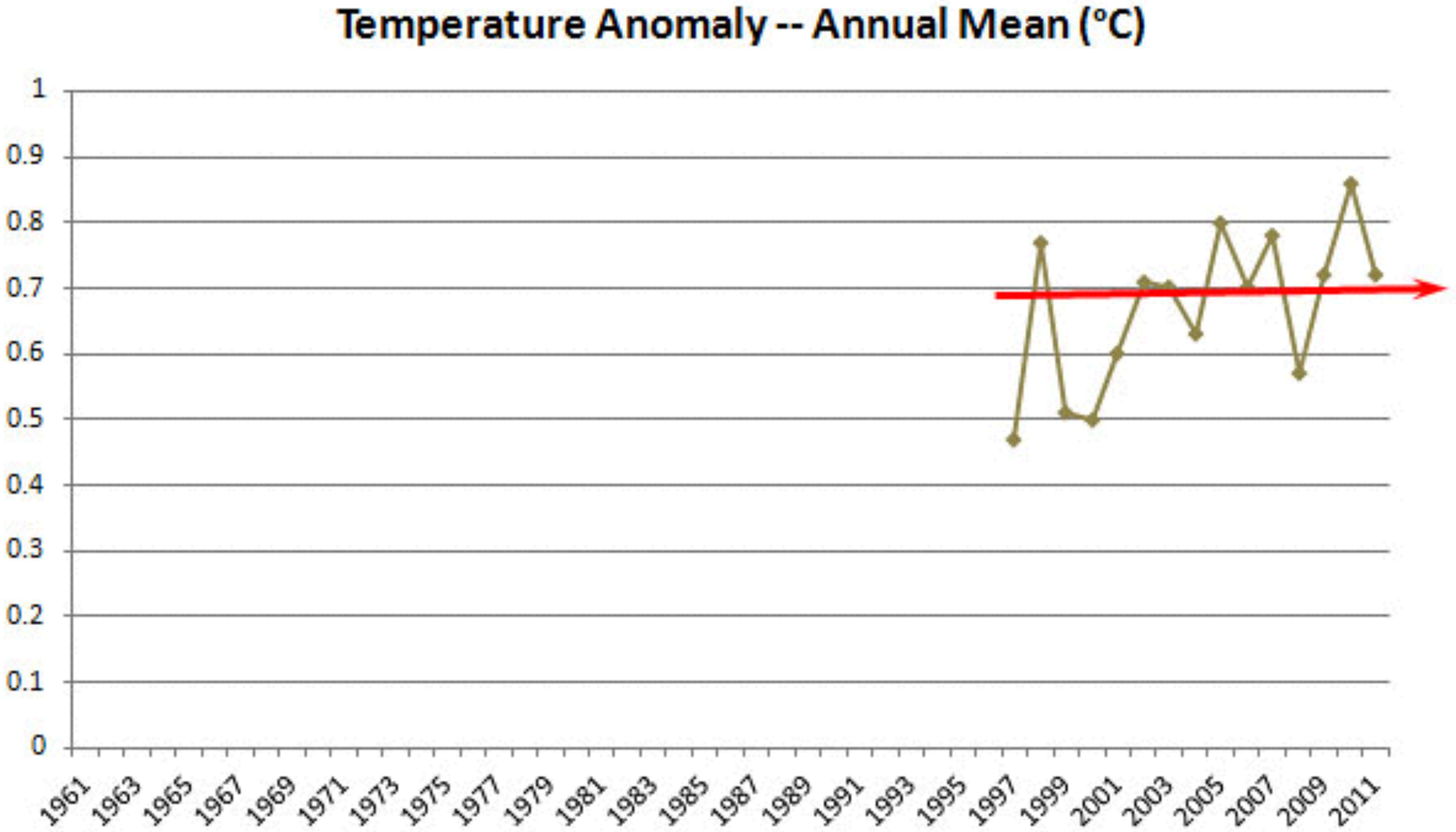
Zero-based Scale?



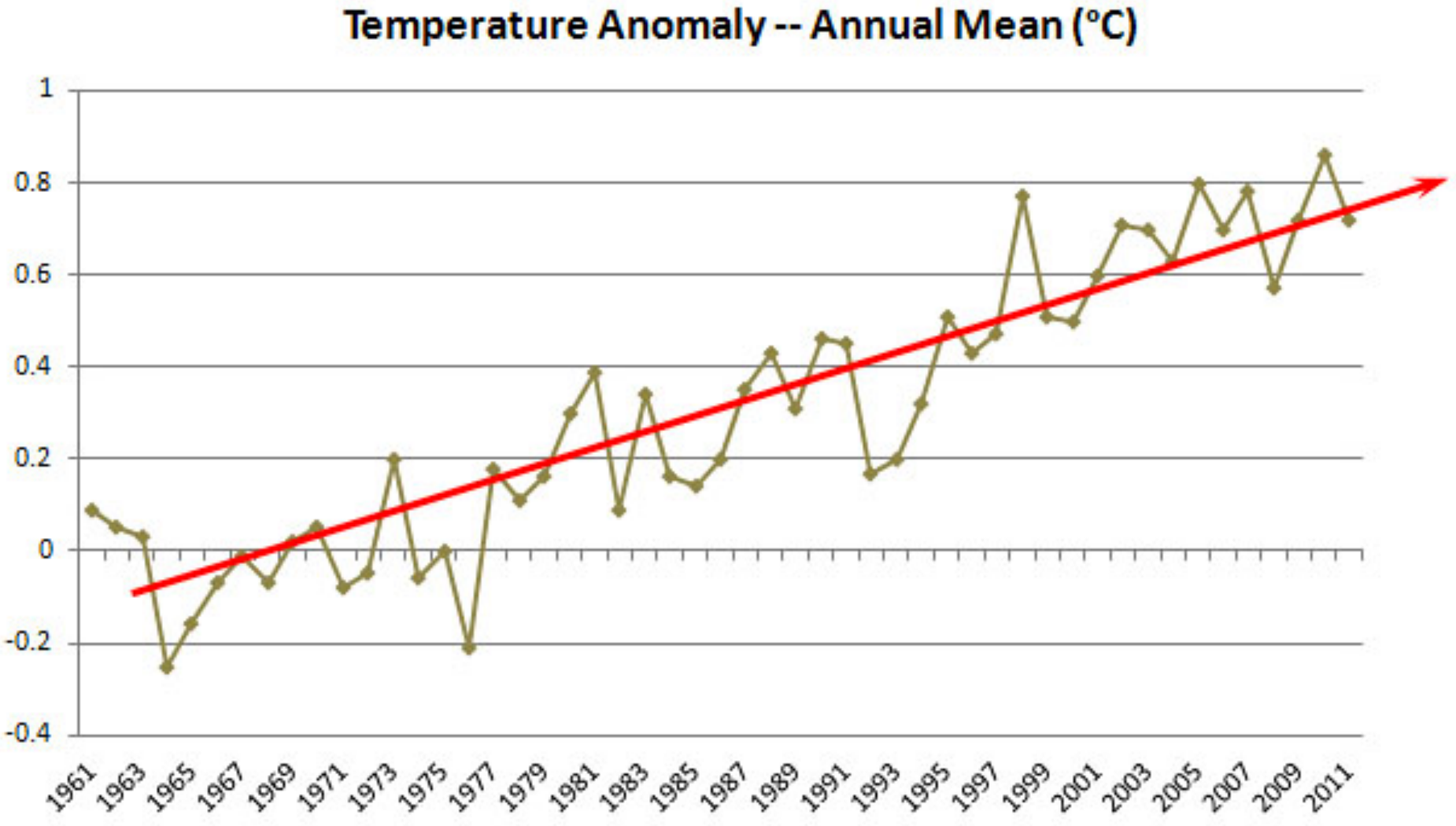
Global Warming??



Global Warming?

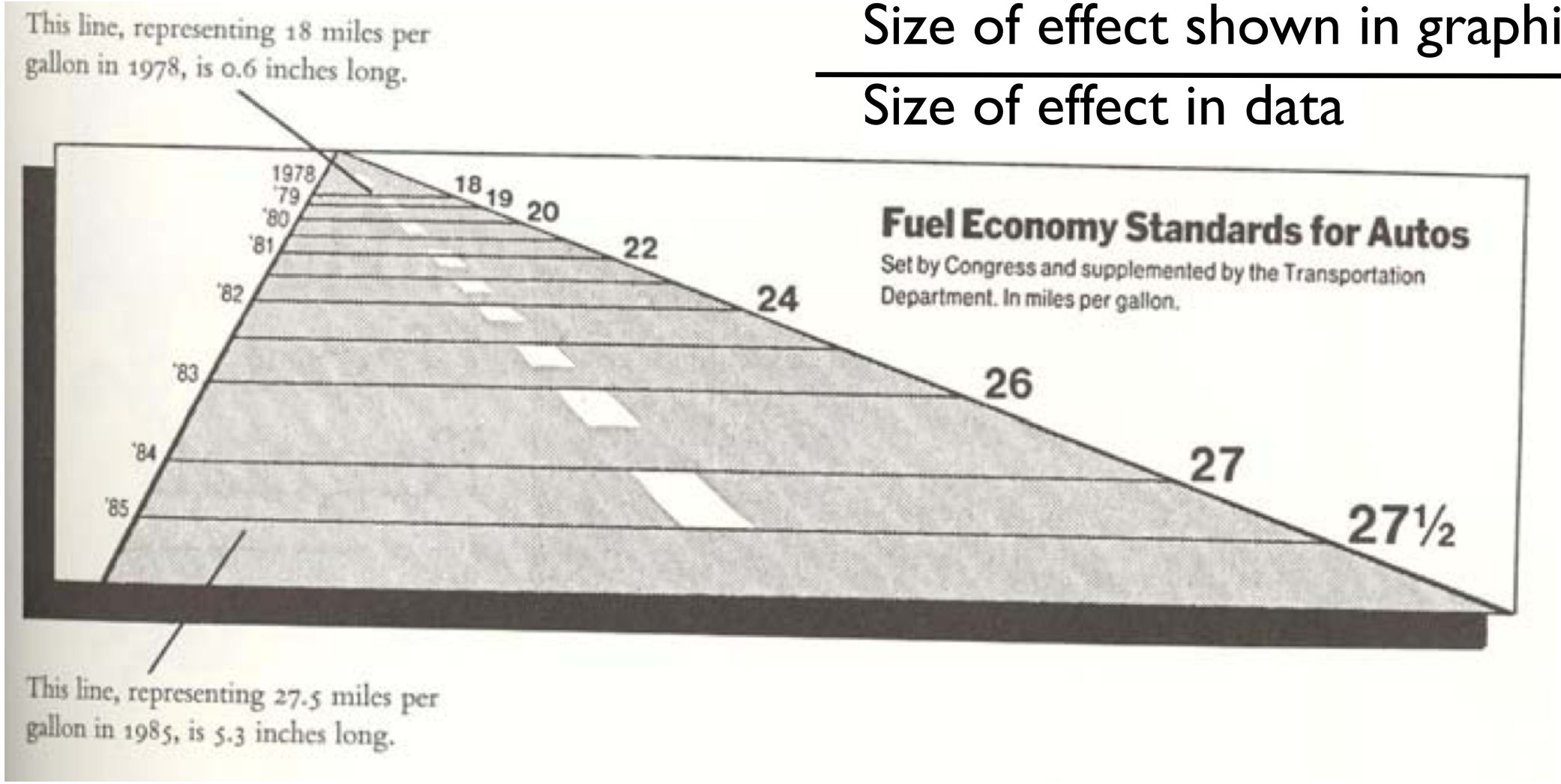


Global Warming

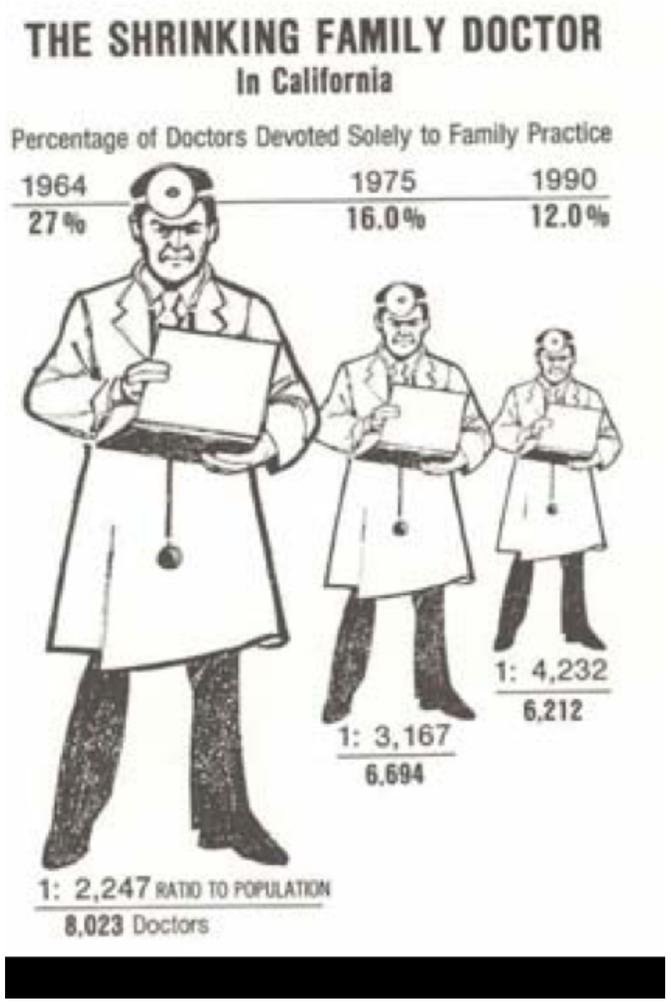


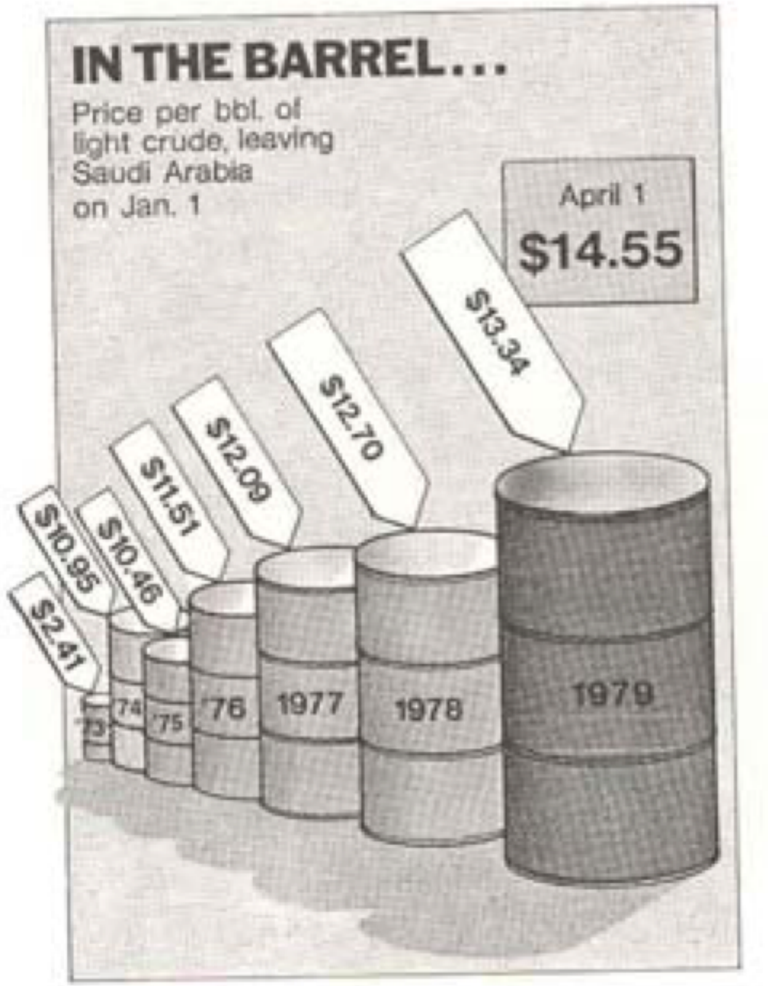
Tufte's Lie Factor

$$\frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}$$



Tufte's Lie Factor





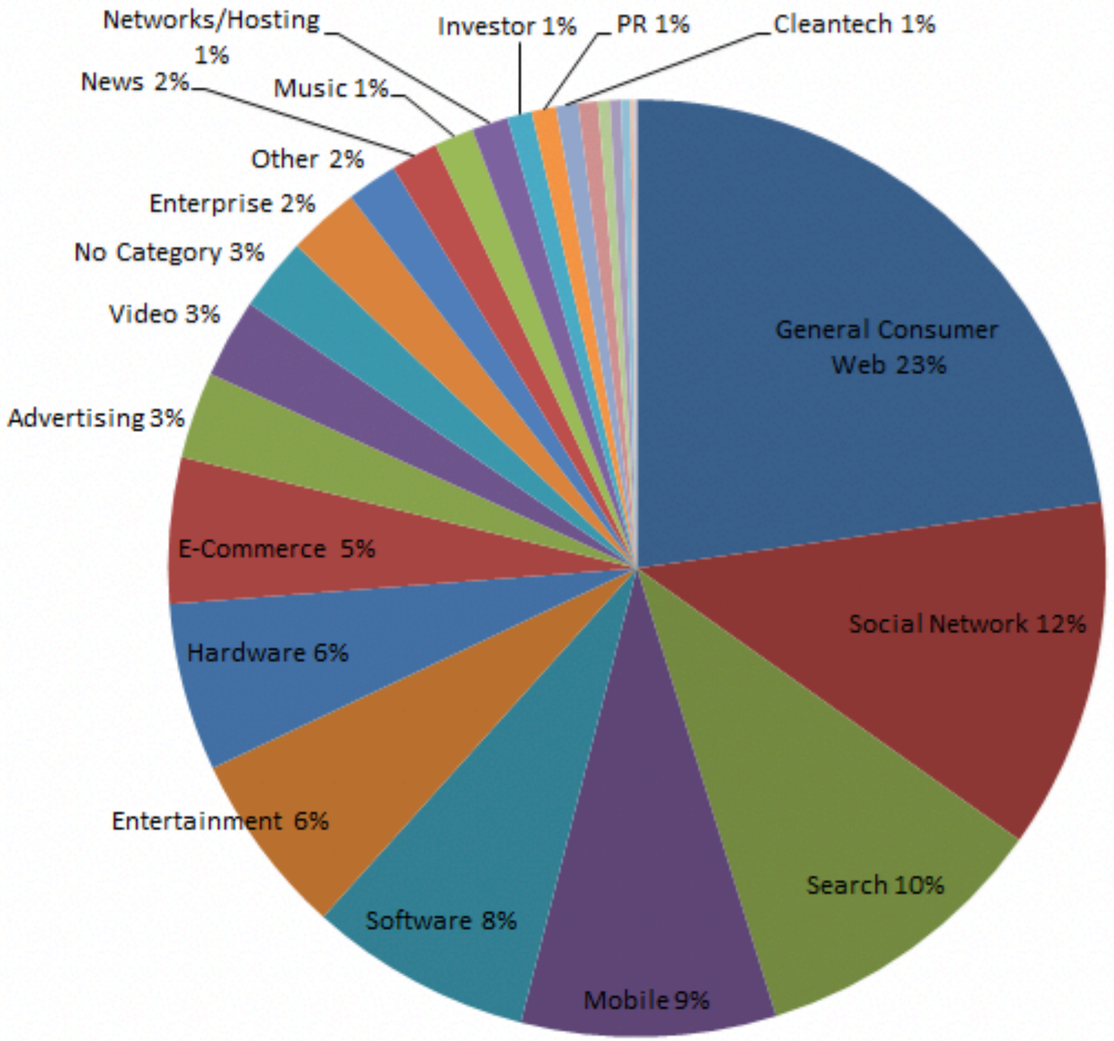
Tufte's Integrity Principles

Show **data variation**, not design variation
Clear, detailed, and thorough **labeling** and **appropriate scales**

Size of the **graphic effect** should be **directly proportional to the numerical quantities** ("lie factor")

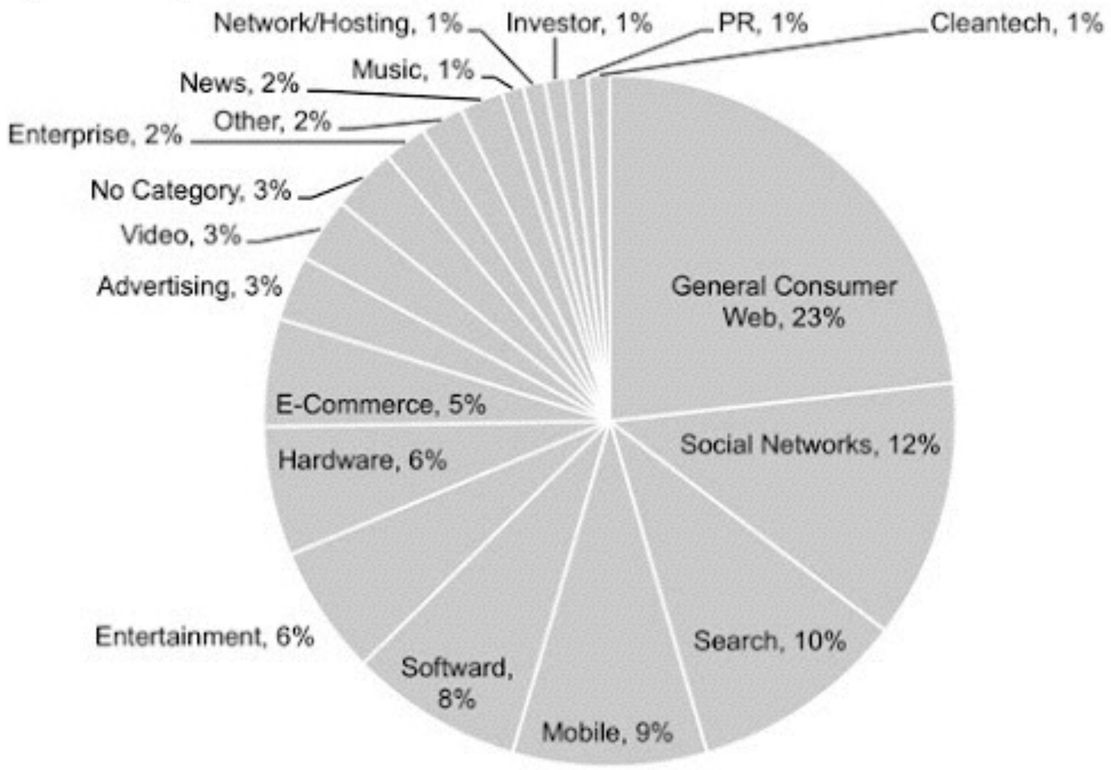
The Horrible Truth About Pie Charts

Share of coverage on TechCrunch

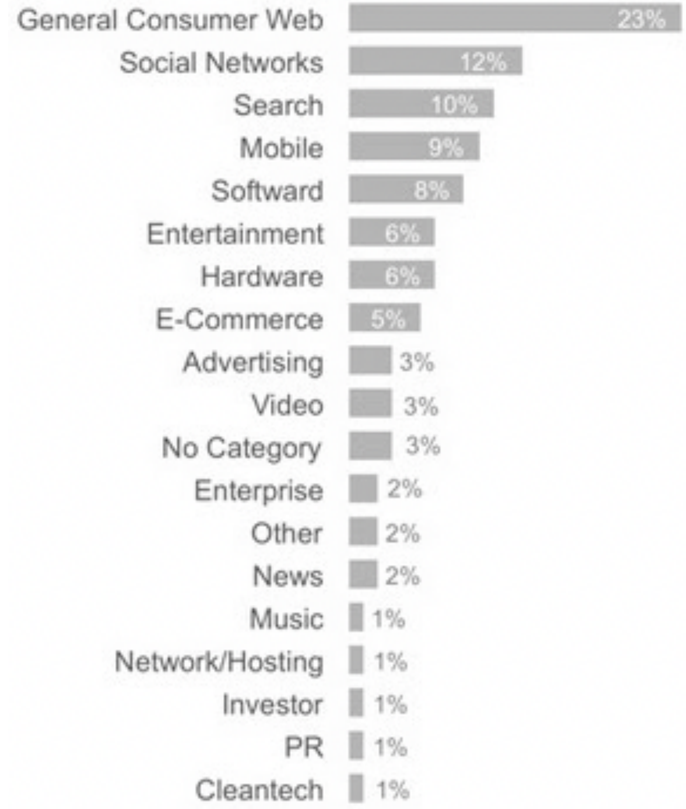


How to Fix?

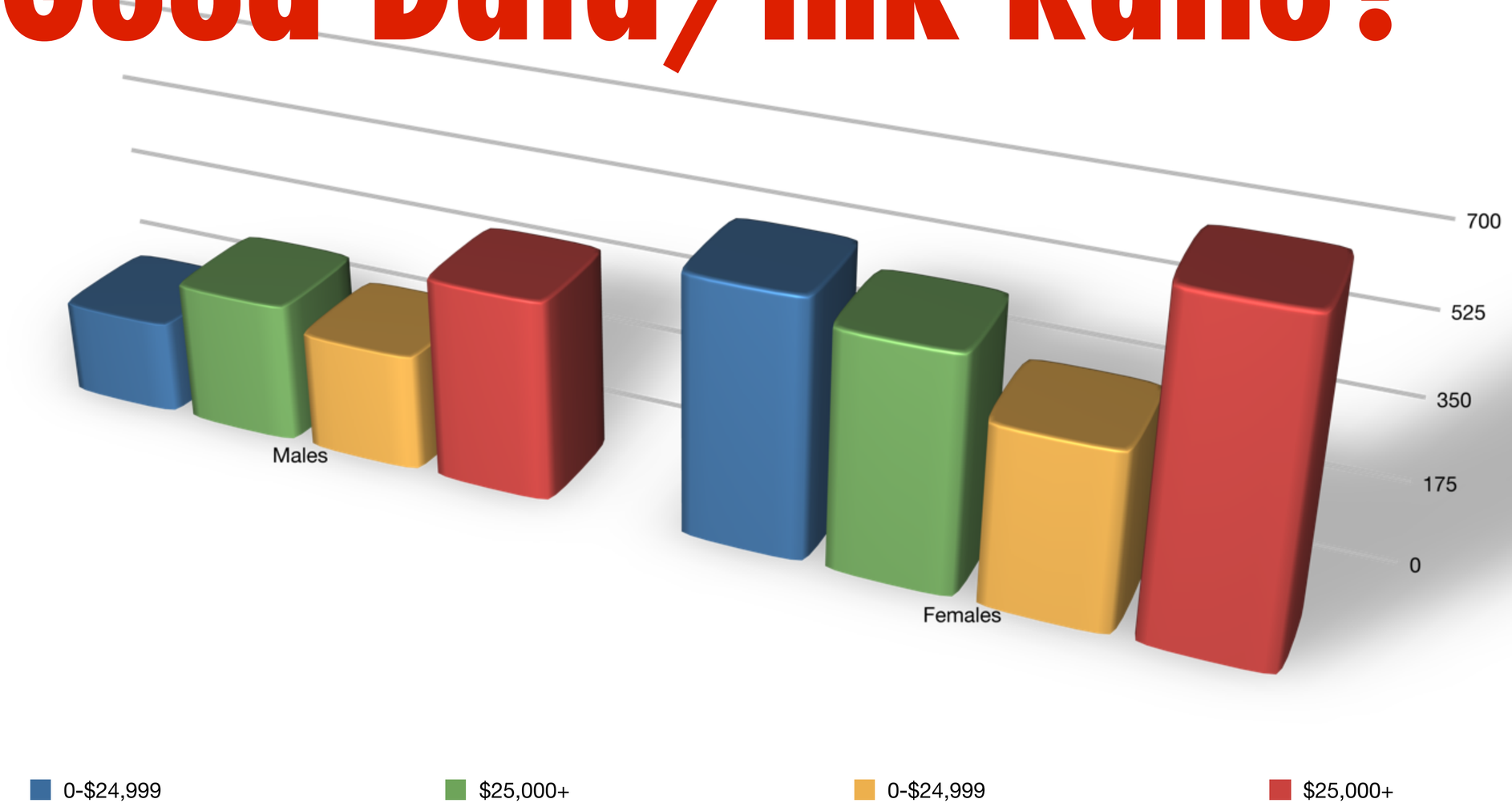
TechCrunch Coverage: 2005 - 2011
A slightly better pie?



TechCrunch Coverage: 2005 - 2011
Bars are best!



Good Data/Ink Ratio?



Better Data/Ink

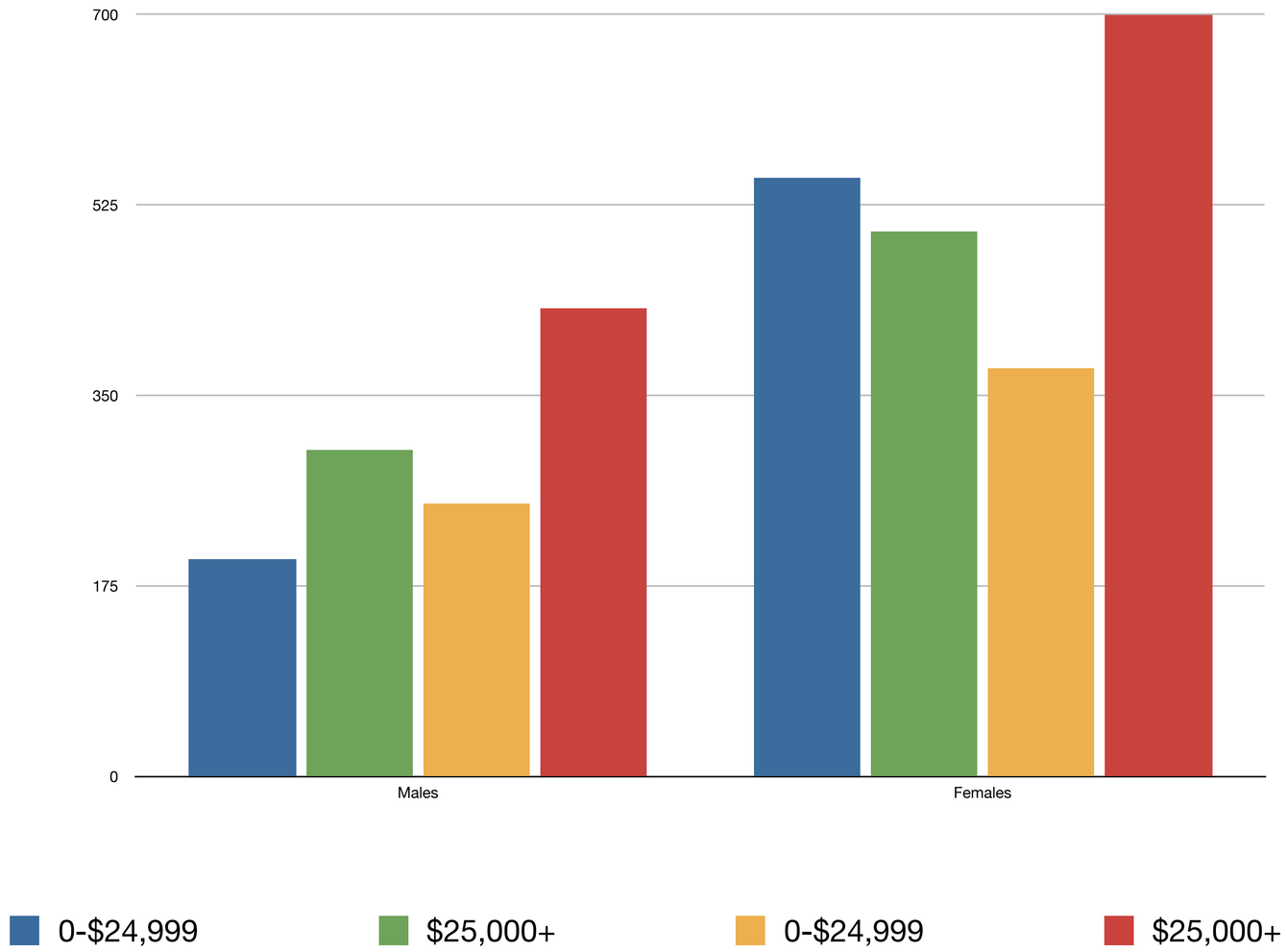
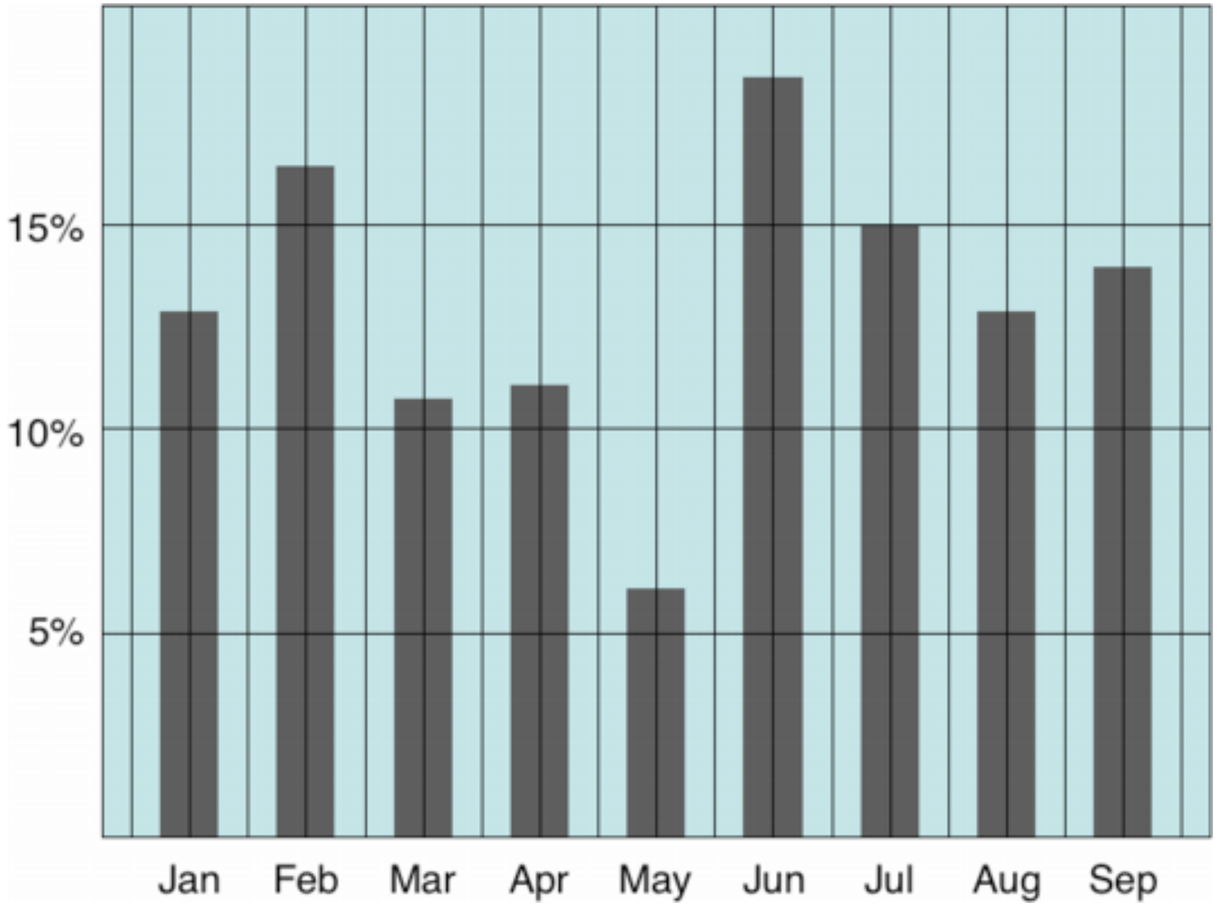
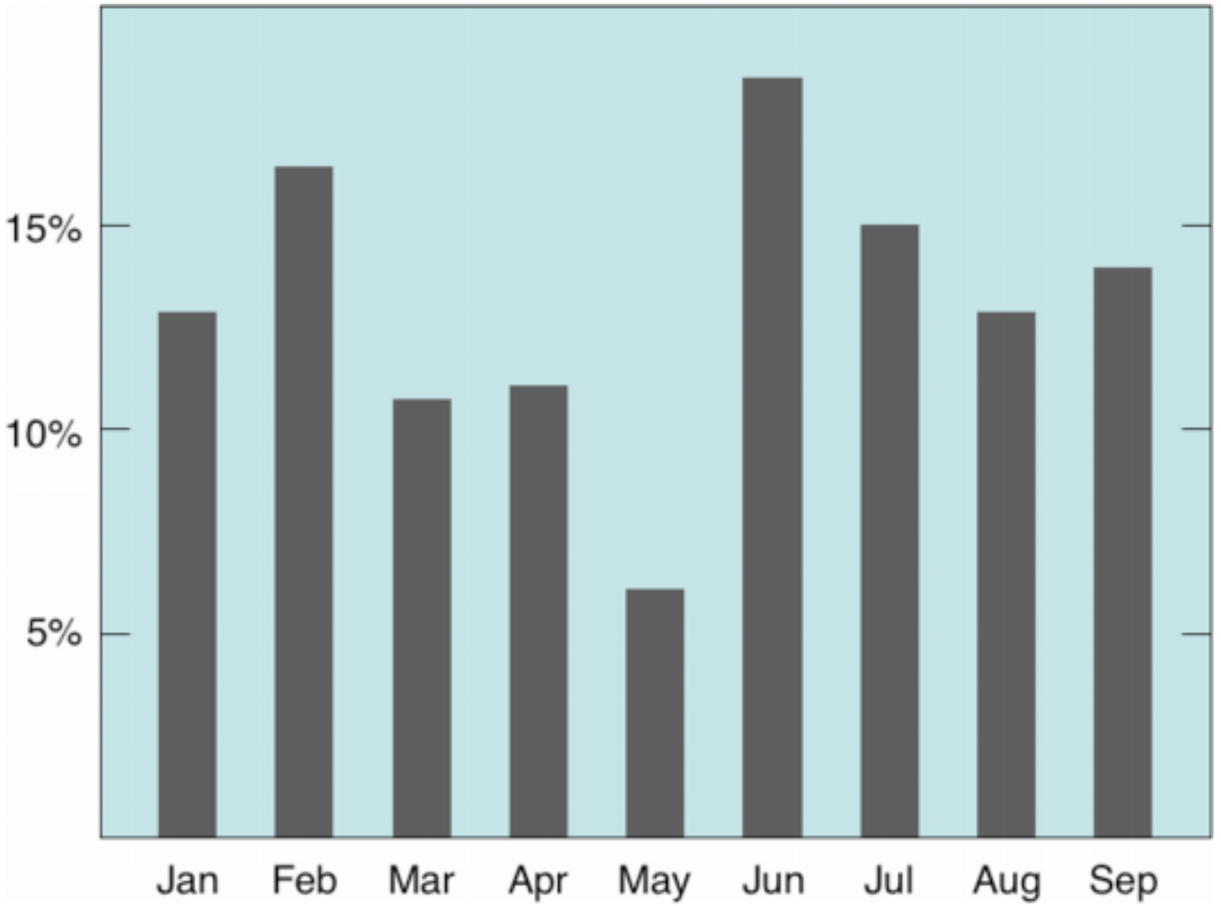


Chart Junk

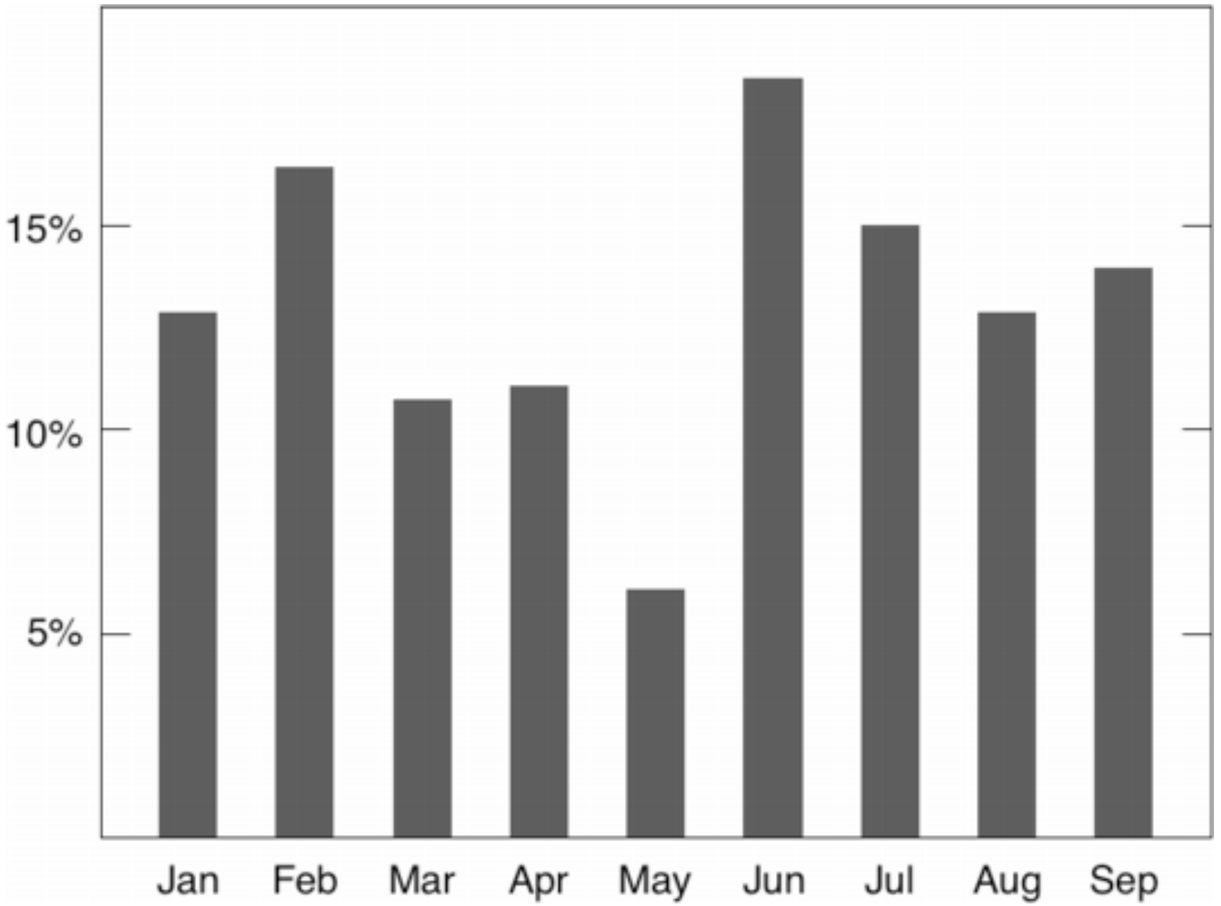
Unnecessary visual contents that distract from the message



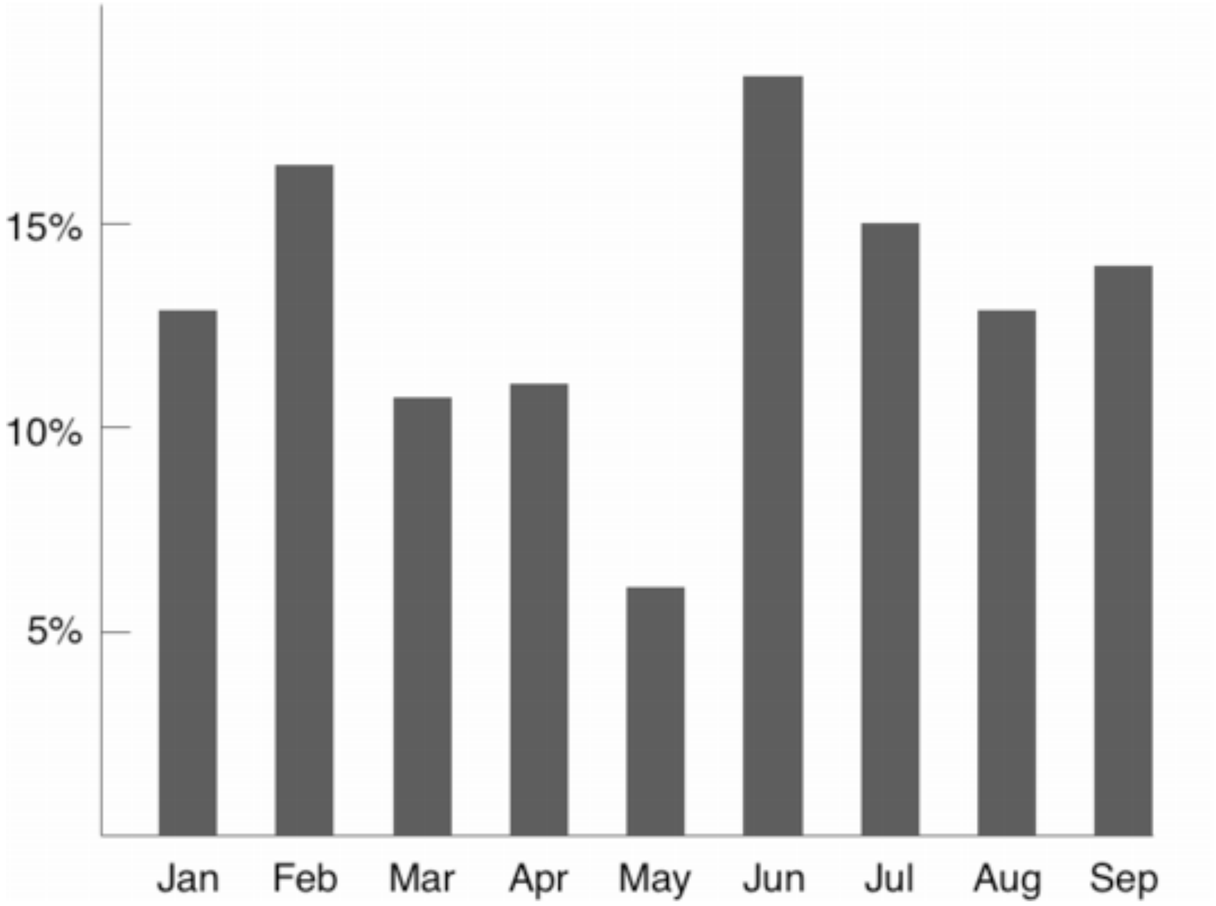
Avoid Chart Junk



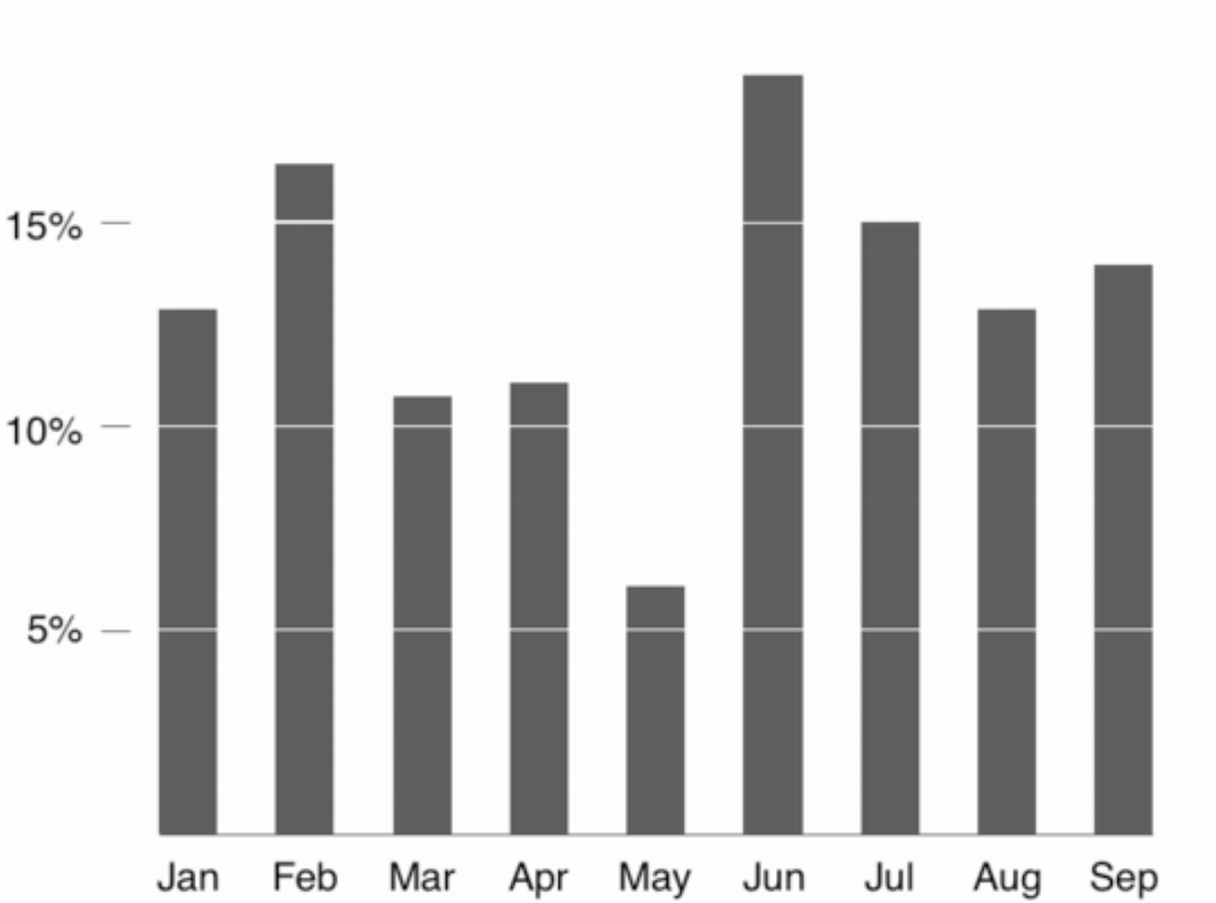
Avoid Chart Junk



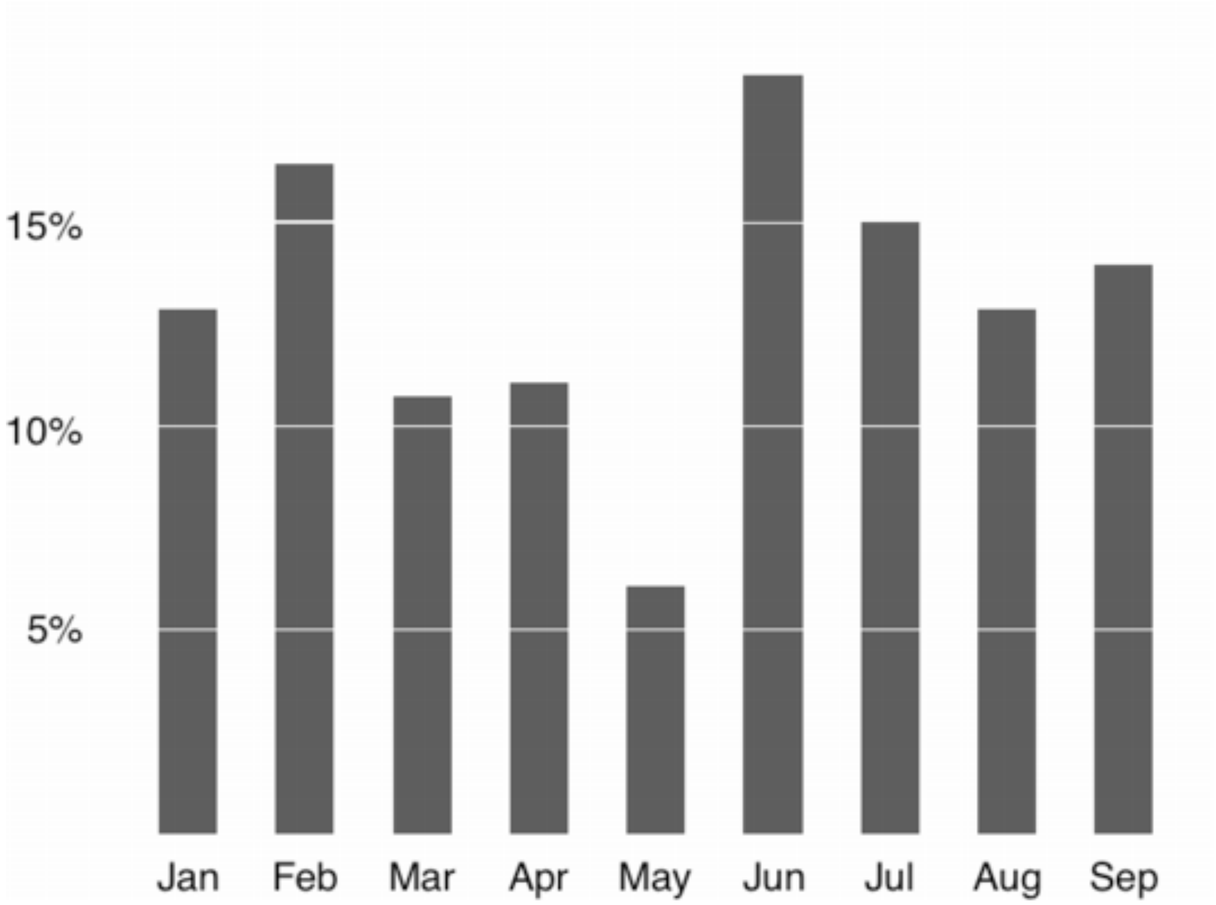
Avoid Chart Junk

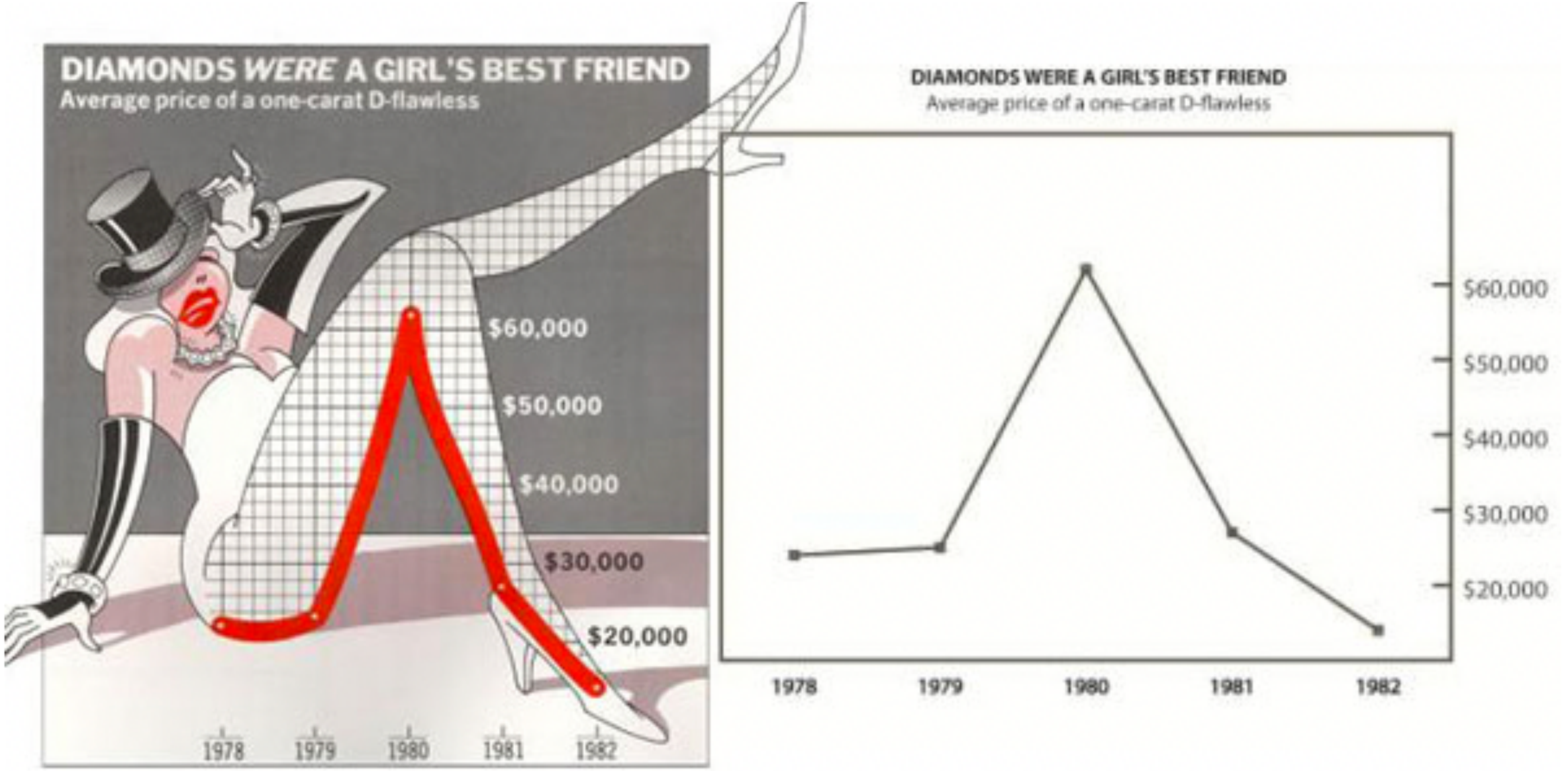


Avoid Chart Junk

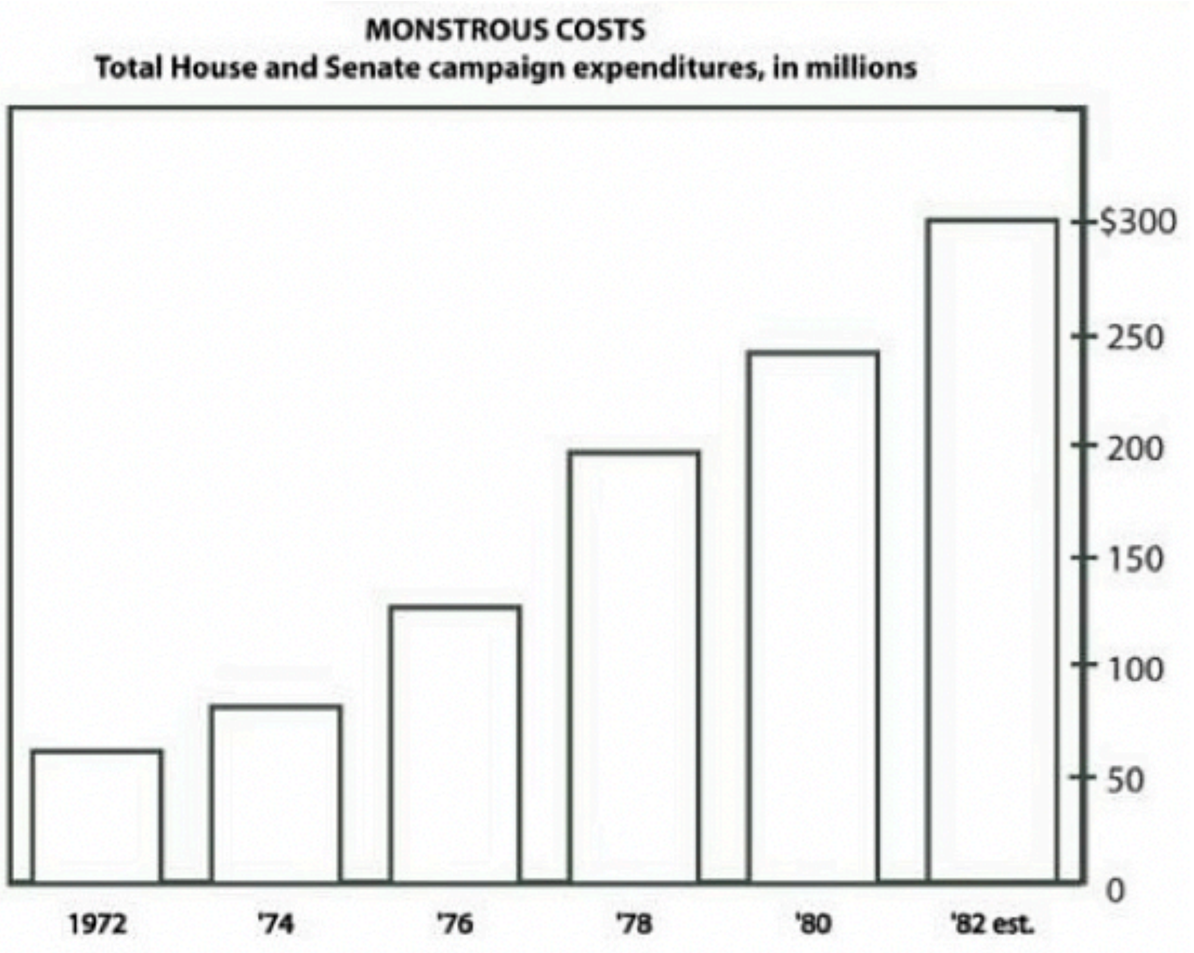


Avoid Chart Junk




DIAMONDS *WERE* A GIRL'S BEST FRIEND
Average price of a one-carat D-flawless
$60,000
$50,000
$40,000
$30,000
$20,000
1978
1979
1980
1981
1982
DIAMONDS WERE A GIRL'S BEST FRIEND
Average price of a one-carat D-flawless
$60,000
$50,000
$40,000
$30,000
$20,000
1978
1979
1980
1981
1982

MONSTROUS COSTS
Total House and Senate campaign expenditures, in millions
$300
250
200
150
100
50
1972
'74
'76
'78
'80
'82 est.
VOTE


MONSTROUS COSTS
Total House and Senate campaign expenditures, in millions
$300
250
200
150
100
50
0
1972
'74
'76
'78
'80
'82 est.

Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts

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Aaron Genest, David McDine, Christopher Brooks
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ABSTRACT
Guidelines for designing information charts often state that the presentation should reduce 'chart junk' – visual embellishments that are not essential to understanding the data. In contrast, some popular chart designers wrap the presented data in detailed and elaborate imagery, raising the questions of whether this imagery is really as detrimental to understanding as has been proposed, and whether the visual embellishment may have other benefits. To investigate these issues, we conducted an experiment that compared embellished charts with plain ones, and measured both interpretation accuracy and long-term recall. We found that people's accuracy in describing the embellished charts was no worse than for plain charts, and that their recall after a two-to-three-week gap was significantly better. Although we are cautious about recommending that all charts be produced in this style, our results question some of the premises of the minimalist approach to chart design.

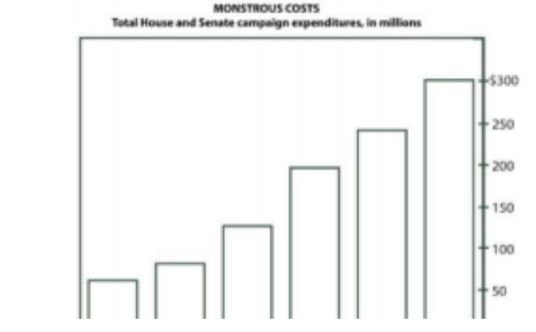
Author Keywords
Charts, information visualization, imagery, memorability.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

INTRODUCTION
Many experts in the area of chart design, such as Edward Tufte, criticize the inclusion of visual embellishment in charts and graphs; their guidelines for good chart design often suggest that the addition of *chart junk,* decorations and other kinds of non-essential imagery, to a chart can make interpretation more difficult and can distract readers from the data [22]. This *minimalist* perspective advocates *data-ink* – or the ink in the chart used to represent data.

Despite these minimalist guidelines, many designers include a wide variety of visual embellishments in their charts, from small decorations to large images and visual backgrounds. One well-known proponent of visual embellishment in charts is the graphic artist Nigel Holmes, whose work regularly incorporates strong visual imagery into the fabric of the chart [7] (e.g., Figure 1).



A Case for Chart Junk?

PROS

- persuasion
- memorability
- engagement

CONS

- unbiased analysis
- trustworthiness
- interpretability
- space efficiency

VAD Rules of Thumb

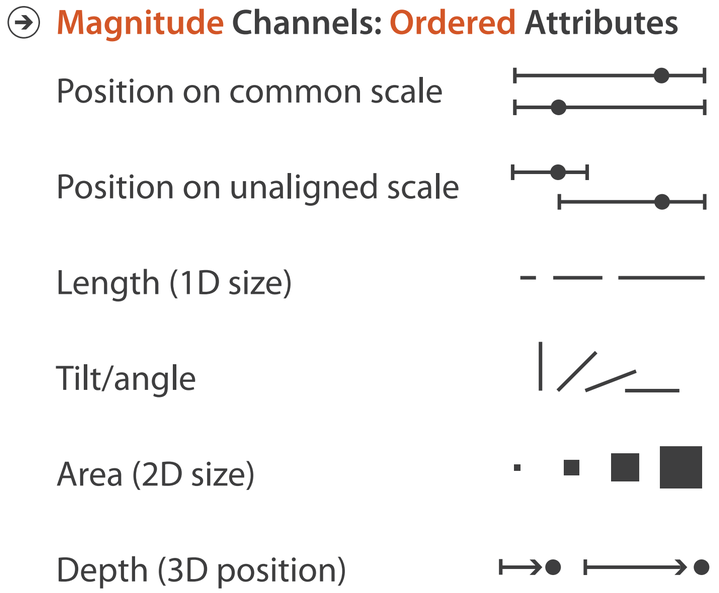
- No unjustified 3D
- No unjustified 2D
- Eyes beat memory
- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Function first, form next

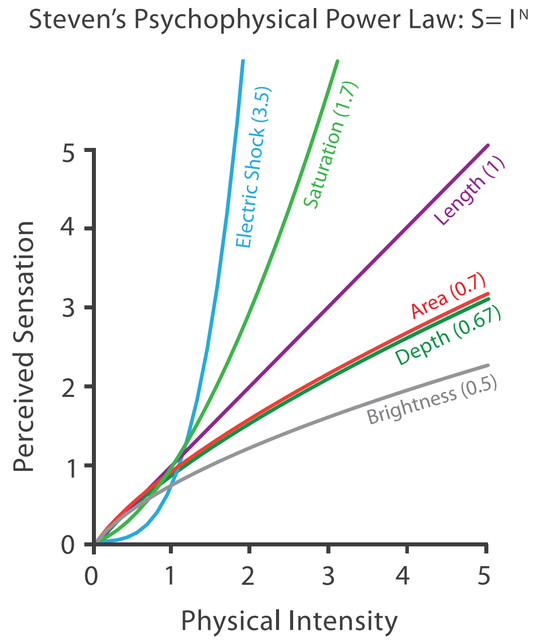
(Get it right in black and white)

Power of the plane

No Unjustified 3D

high-ranked spatial position channels: **planar** spatial position, not depth!

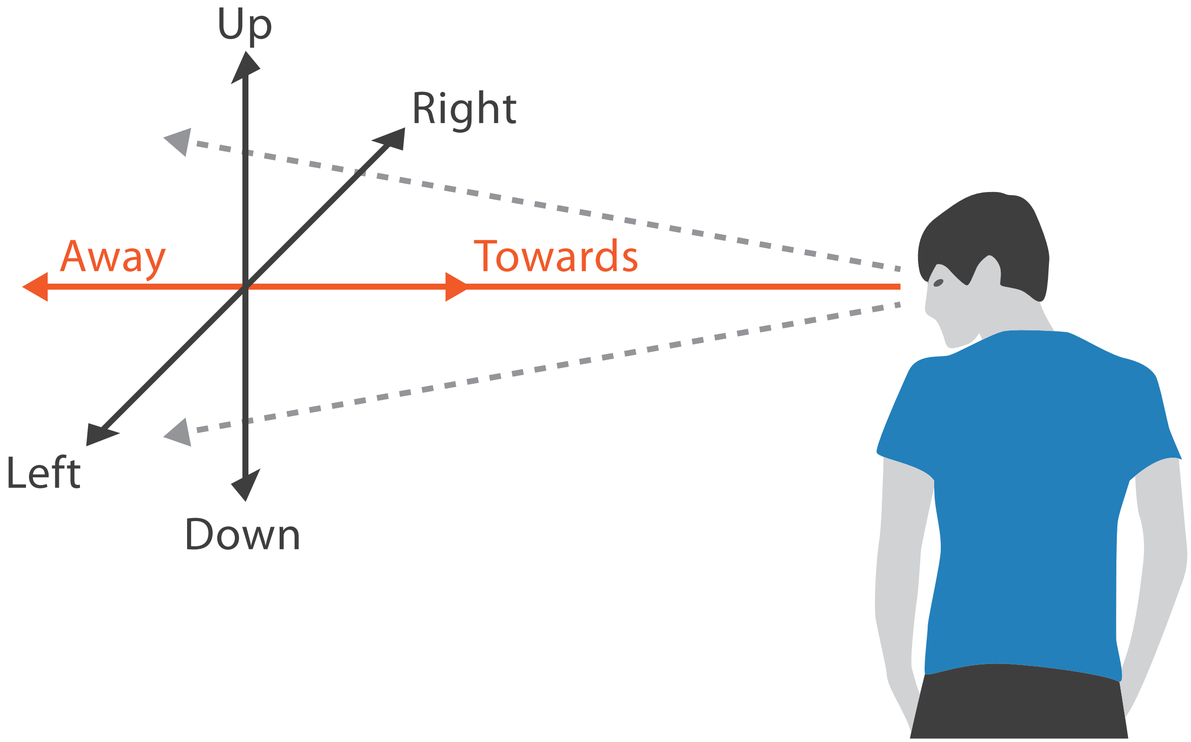


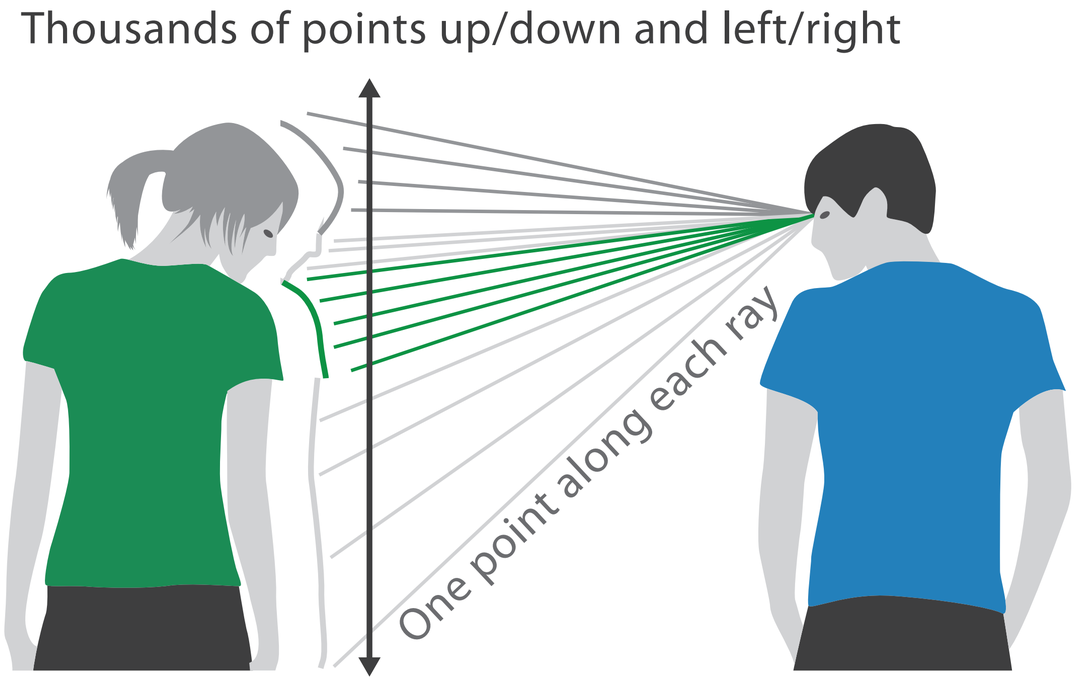


Danger of depth

No Unjustified 3D

We don’t really live in 3D:
we ***see*** in 2.05D



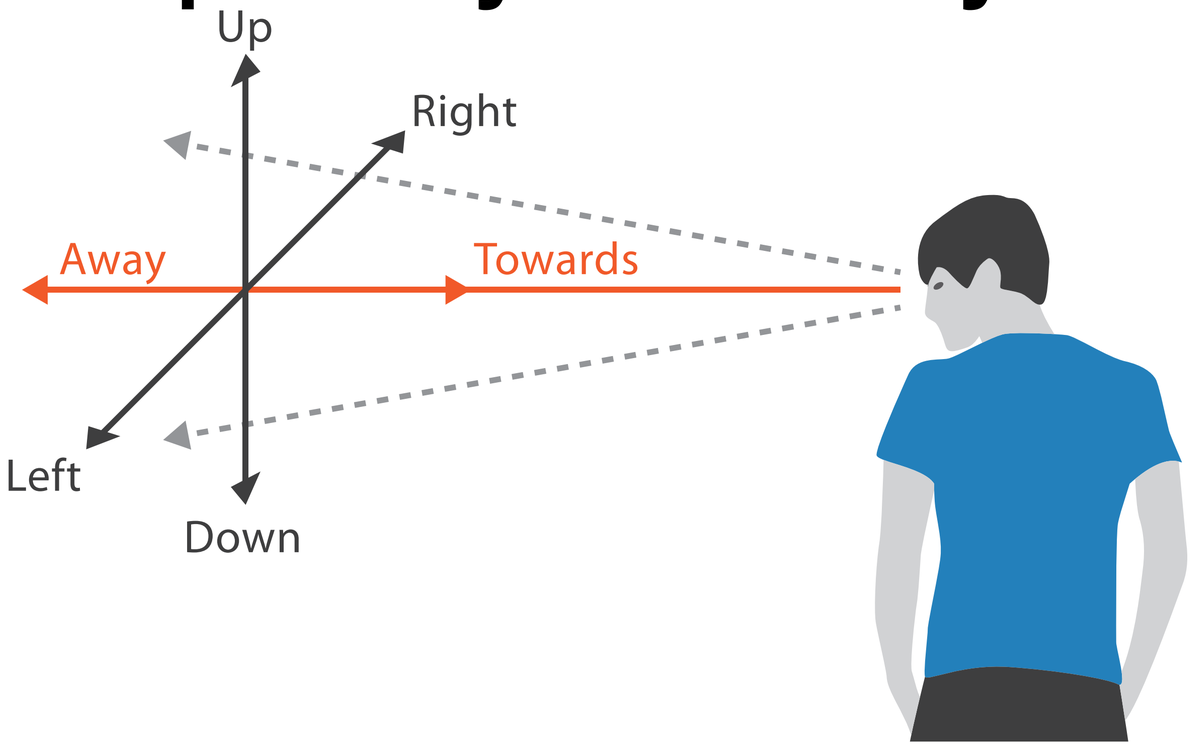


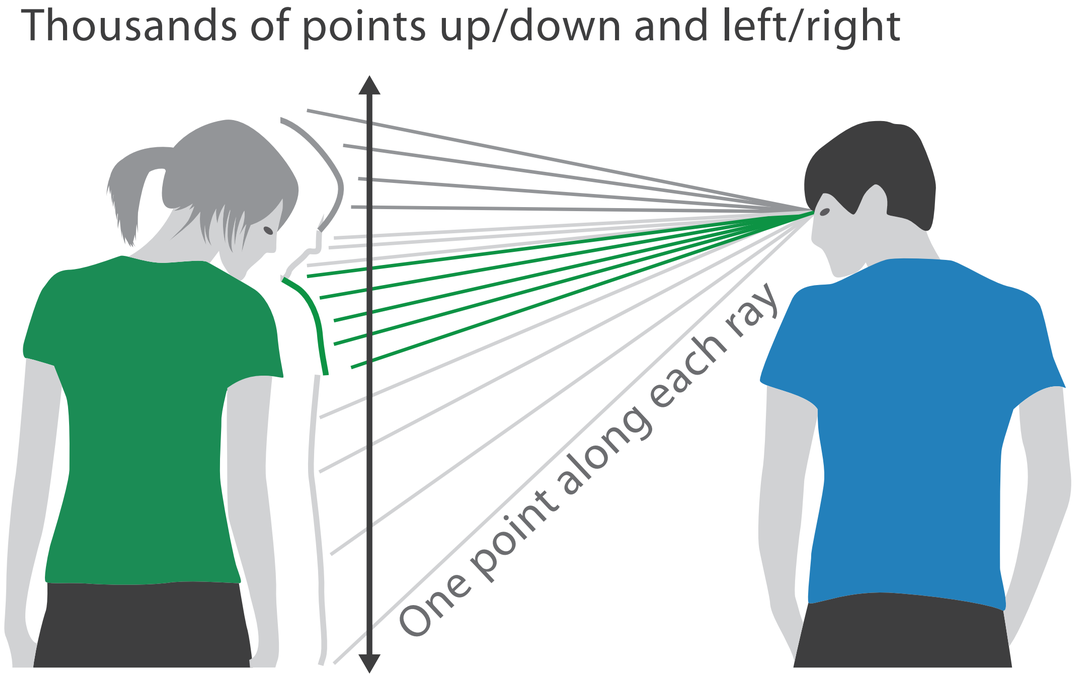
We can only see the outside shell of the world

Danger of depth

No Unjustified 3D

acquire more info on image plane quickly from eye movements



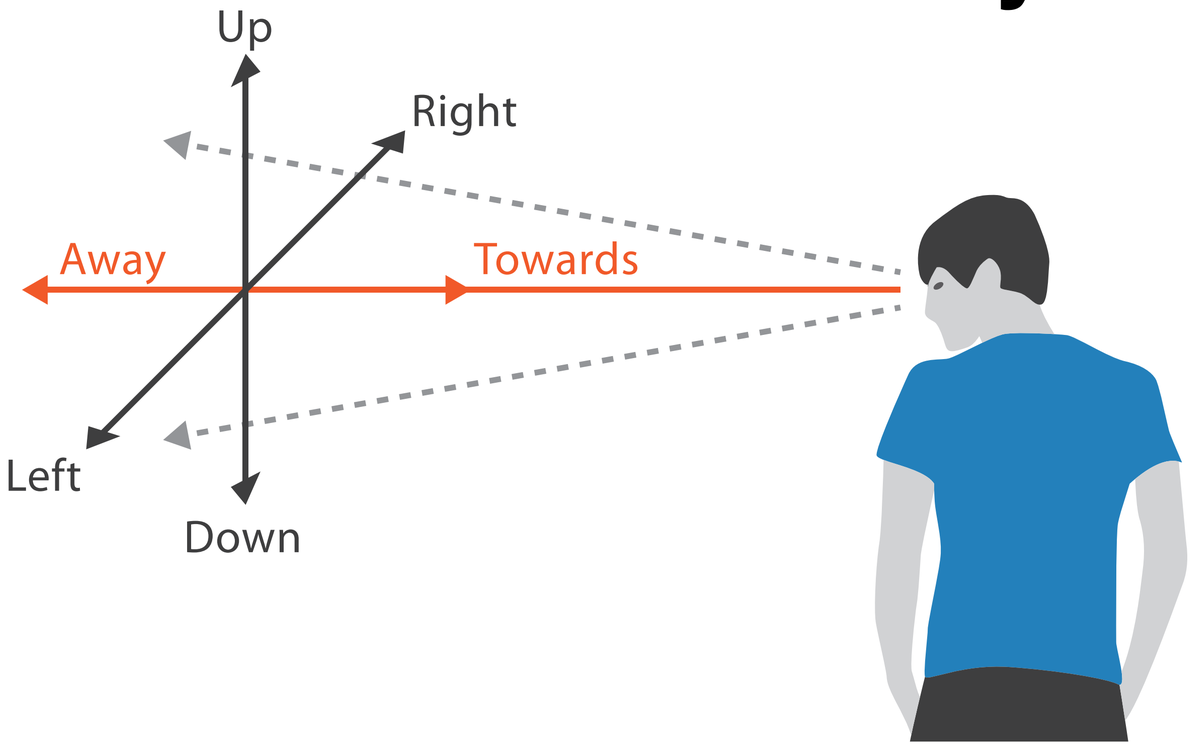


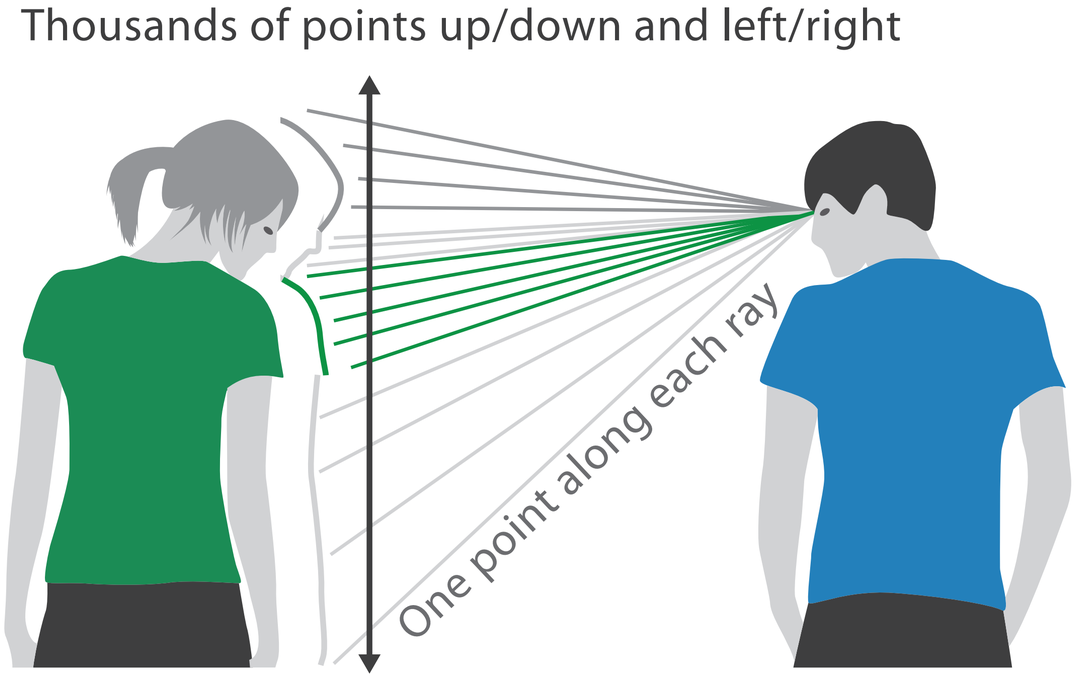
We can only see the outside shell of the world

Danger of depth

No Unjustified 3D

acquire more info for depth slower, from head/body motion





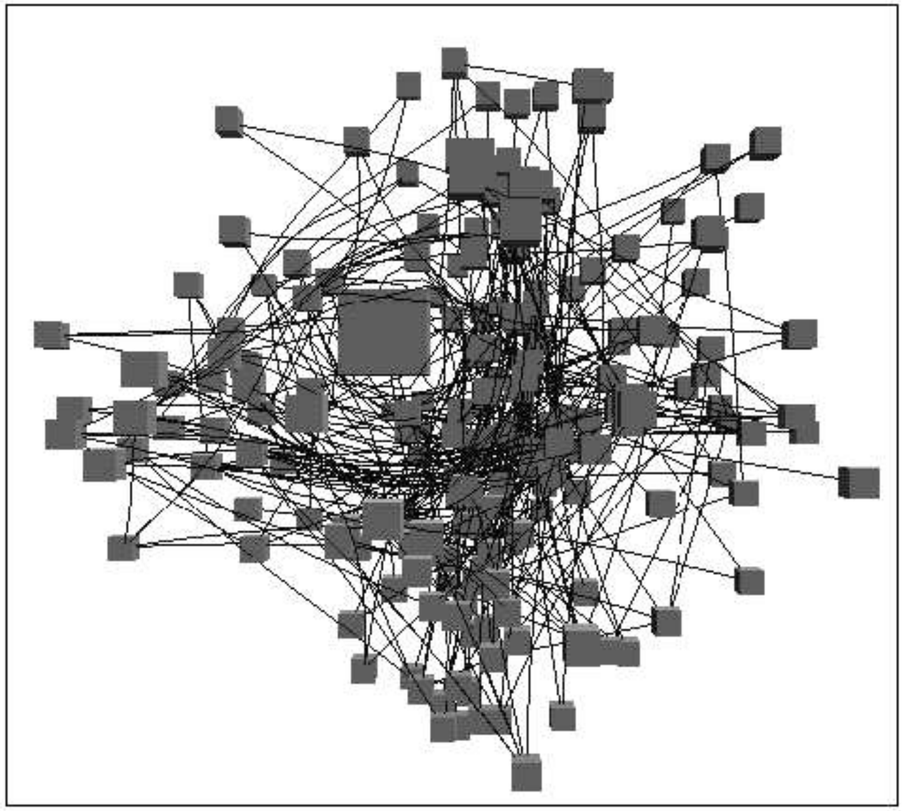
We can only see the outside shell of the world

Occlusion hides information

No Unjustified 3D

occlusion

interaction complexity



[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis1996.]

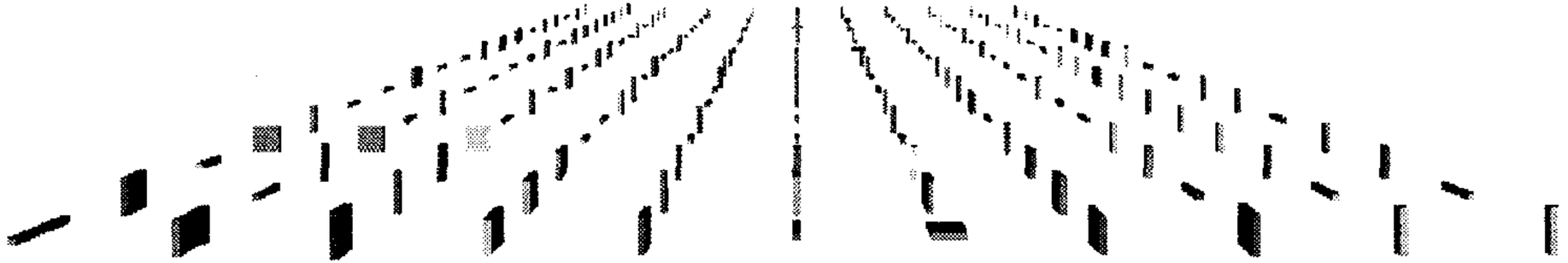
Perspective distortion loses information

No Unjustified 3D

perspective distortion

interferes with all size channel encodings

power of the plane is lost!



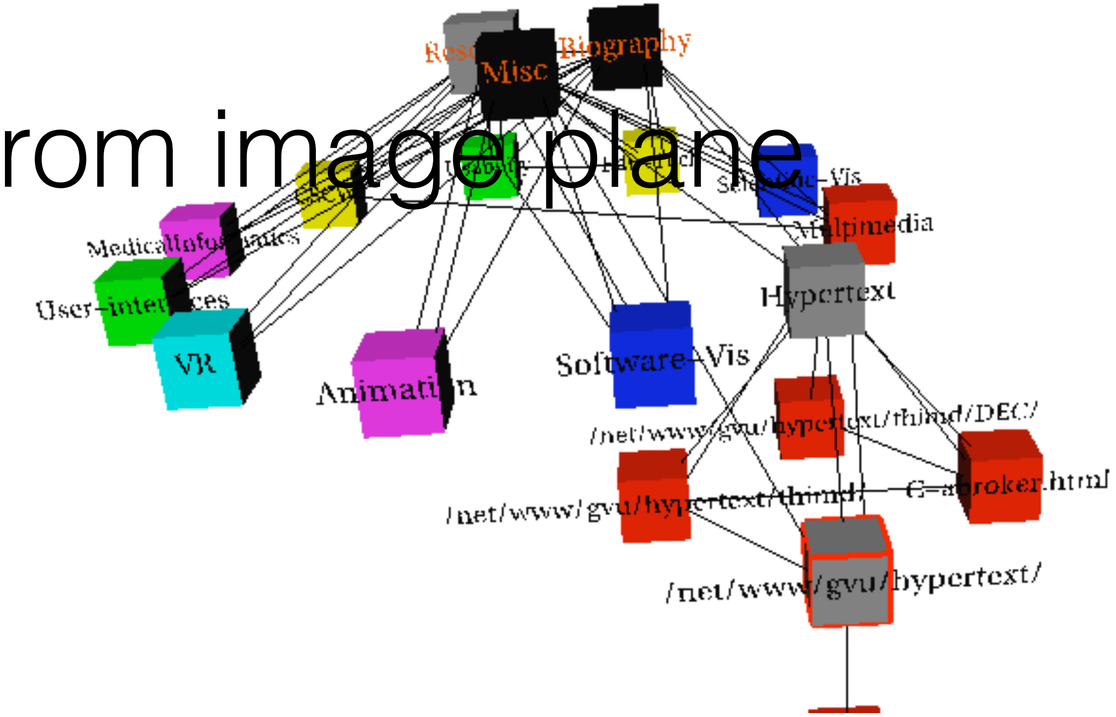
[Visualizing the Results of Multimedia Web Search Engines. Mukherjea, Hirata, and Hara. InfoVis 96]

Tilted text isn't legible

No Unjustified 3D

text legibility

far worse when tilted from image plane



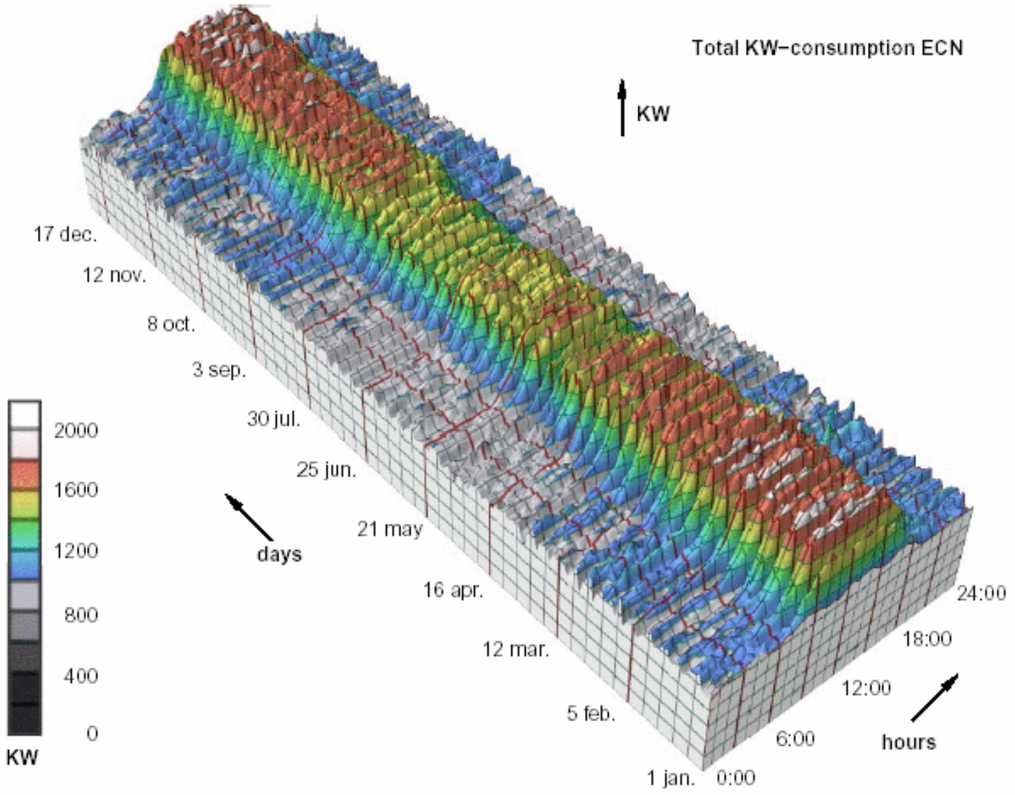
[Visualizing the World-Wide Web with the Navigational View Builder. Mukherjea and Foley. Computer Networks and ISDN Systems, 1995.]]

Example: Time-series data

No Unjustified 3D

extruded curves: detailed comparisons impossible

[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

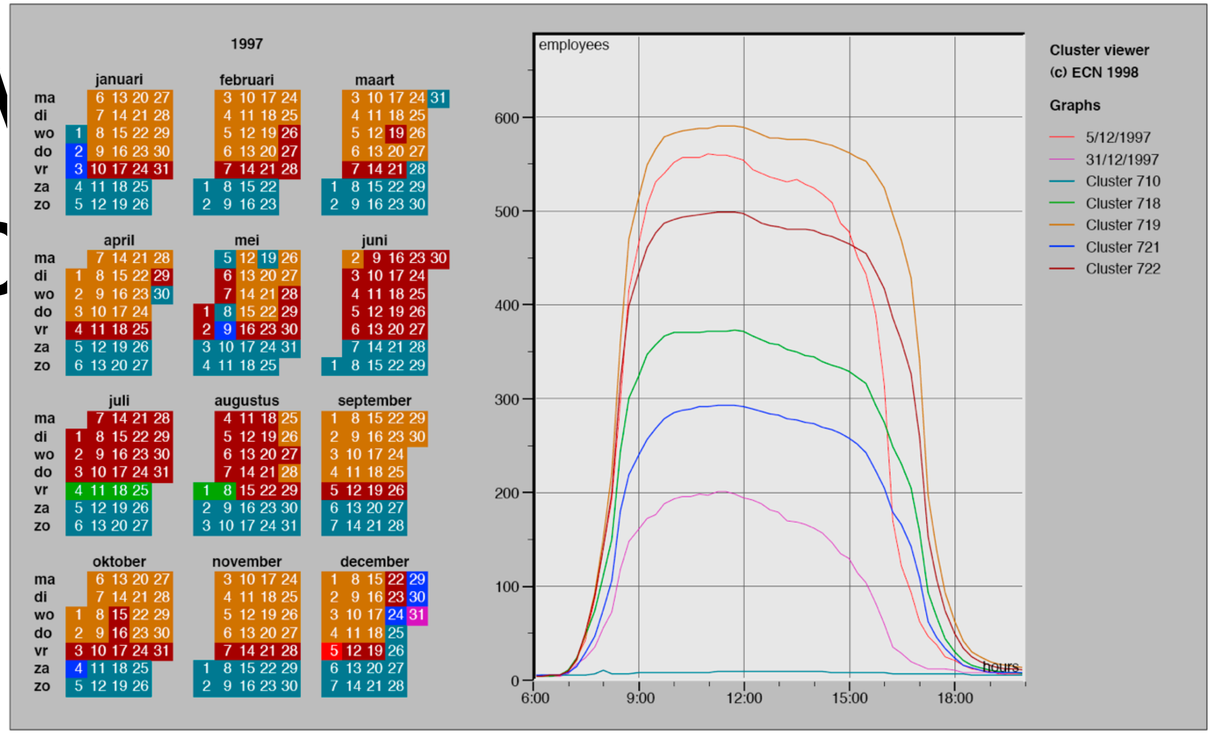


Transform for new data abstraction

No Unjustified 3D

derived data: cluster hierarchy

juxtapose multiple v
superimposed 2D c



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

No unjustified 3D

3D legitimate for true 3D spatial data

3D needs very careful justification

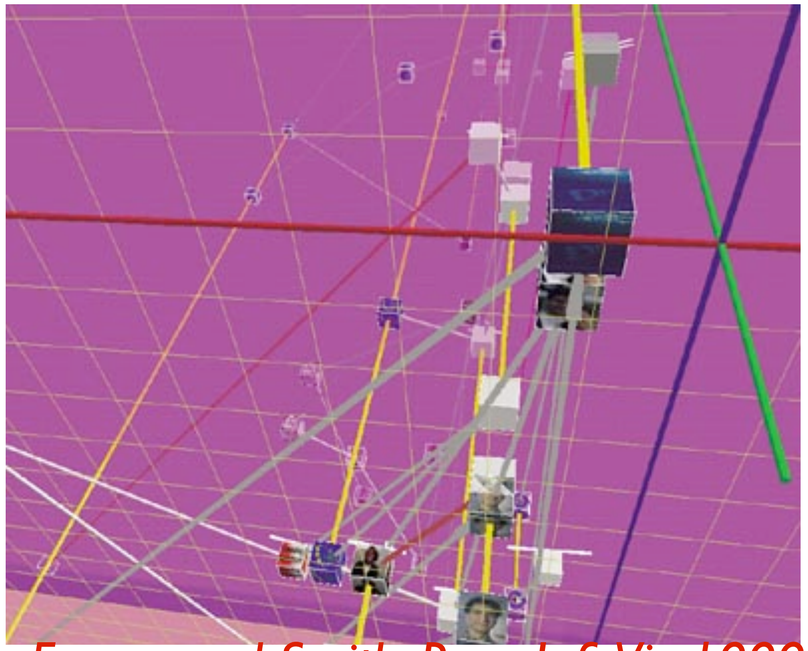
for abstract data

enthusiasm in 1990s, but

now skepticism

be especially careful with 3D

for point clouds or networks



[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

No unjustified 2D

consider whether network data requires 2D spatial layout

- especially if reading text is central to task!
- arranging as network means lower information density and harder label lookup compared to text lists

No unjustified 2D

benefits outweigh costs when topological structure/context important for task

be especially careful for search results, document collections, ontologies

Eyes beat memory

principle: external cognition vs. internal memory

- easy to compare by moving eyes between side-by-side views
- harder to compare visible item to memory of what you saw

Eyes beat memory

implications for animation

- great for choreographed storytelling
- great for transitions between two states
- poor for many states with changes everywhere

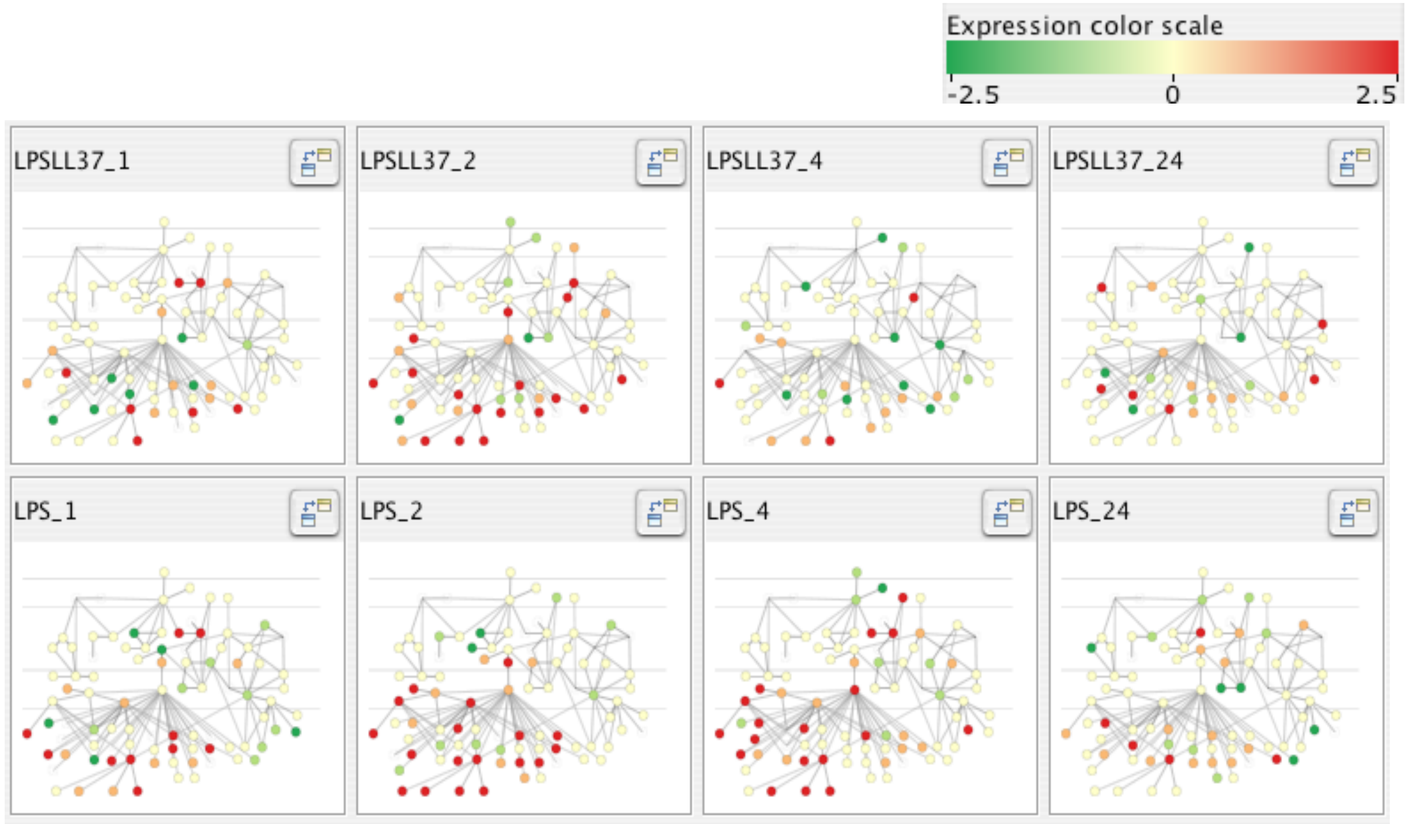
consider small multiples instead

Example: Cerebral

small multiples: one graph instance per experimental condition

same spatial layout

color differently, by condition



[Cerebral:Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

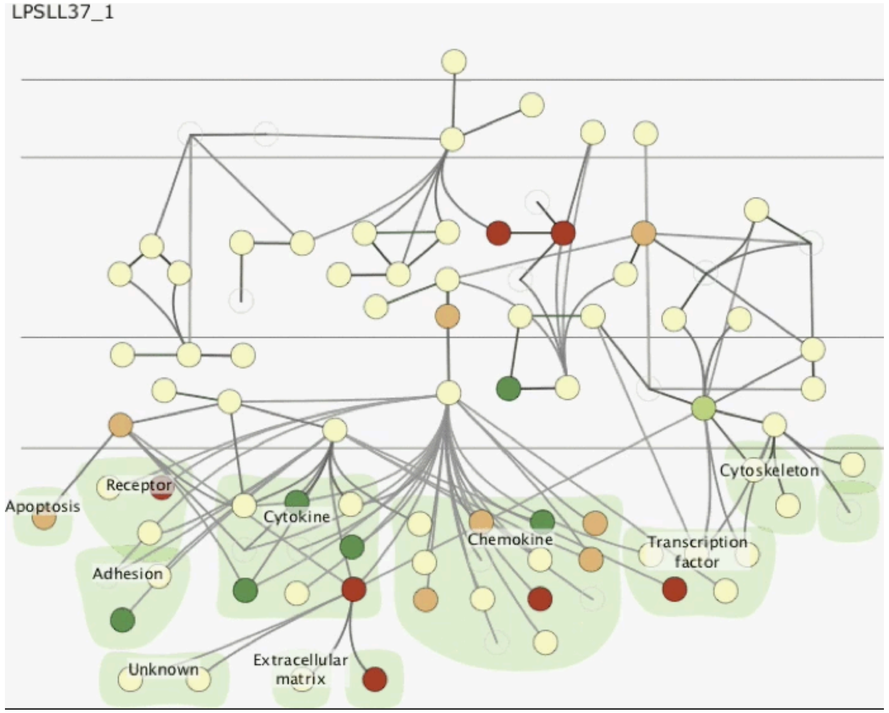
Why not animation?

disparate frames and regions: comparison difficult

vs contiguous frames

vs small region

vs coherent motion of group



change blindness

even major changes difficult to notice if mental buffer wiped

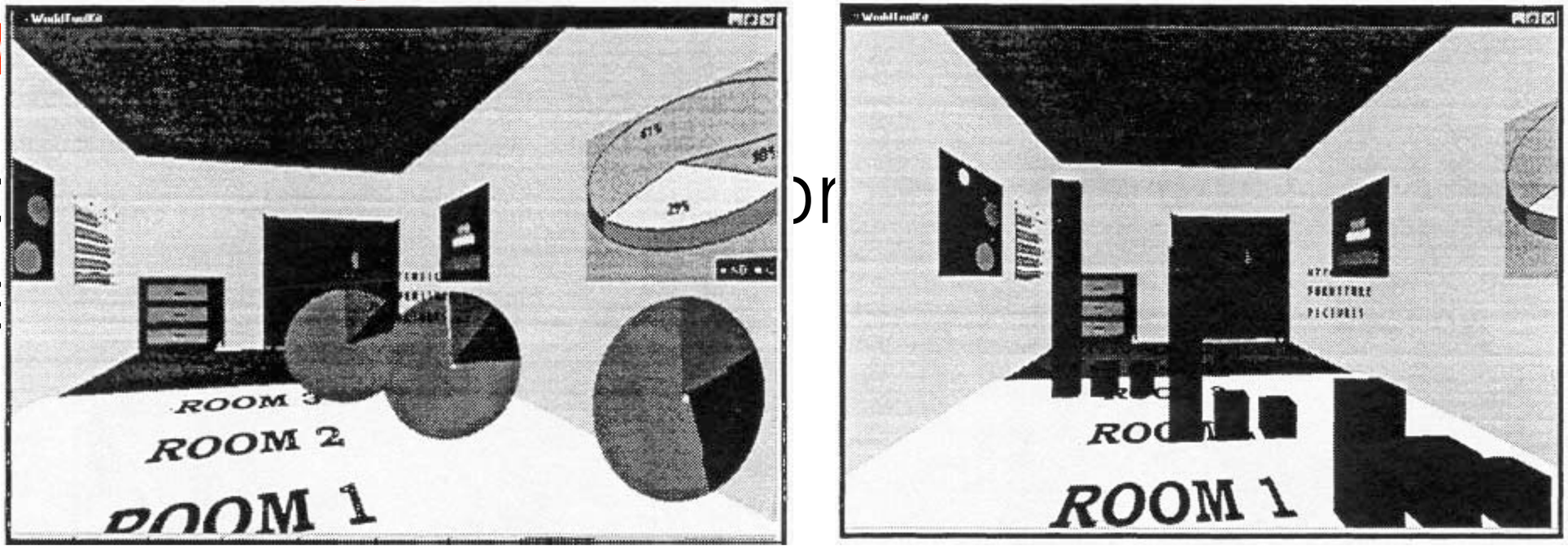
Resolution beats immersion

immersion typically not helpful for

ab

dc or

ste



[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

Resolution beats immersion

immersion typically not helpful for abstract data

resolution much more important

- pixels are the scarcest resource
- desktop also better for workflow integration

Resolution beats immersion

immersion typically not helpful for abstract data

resolution much more important

virtual reality for abstract data very difficult to justify

Overview first, zoom and filter, details on demand

influential mantra from Shneiderman

[The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Shneiderman. Proc. IEEE Visual Languages, pp. 336–343, 1996.]

Overview first, zoom and filter, details on demand

overview = summary

microcosm of full vis design problem

[Search, Show Context, Expand on Demand: Supporting Large Graph Exploration with Degree-of-Interest. van Ham and Perer. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 953–960.]

Overview first, zoom and filter, details on demand

nuances

beyond just two levels: multi-scale structure

difficult when scale huge: give up on overview and browse local neighborhoods?

Function first, form next

start with focus on functionality

straightforward to improve aesthetics later on, as refinement

if no expertise in-house, find good graphic designer to work with

Function first, form next

start with focus on functionality

dangerous to start with aesthetics

usually impossible to add function retroactively

Further reading: Books

VAD Book: Chap 6: Rules of Thumb

The Non-Designer's Design Book. Williams. Peachpit Press, 2008.

Visual Thinking for Design, Colin Ware, Morgan Kaufmann 2008.

Information Visualization: Perception for Design, 3rd edition, Colin Ware, Morgan Kaufmann, 2013.