Designing Effective Visualizations

Yasmin AlNoamany

L&S 88-2

University of California, Berkeley

Announcements

- Extra credit:
  - Find and critique existing visualization
  - Getting familiar with D3

- Submitting your projects
  - Presentations on Nov. 28
  - Do you have something after the class?
  - Put all related files (e.g., code, data, presentation, report, all project milestones, and any other related files) to the project in a shareable place such as the university Box, Dropbox, bDrive, or Github (1 extra point).
  - One member of the group emails me a link to the shared folder that contains all the related files to the project.

Resources

1. Effectively Communicating Numbers, S. Few
2. Table and Graph Design for Enlightening Communication, S. Few
3. Data Visualization Principles: Lessons from Tufte

- Optional:
  - The Seven Stages of Visualizing Data
  - In Defense of Simplicity, A Data Visualization Journey – blog
  - 6 charts you will see in hell
  - A Tour through the Visualization Zoo, Heers

Outlines

- Data Visualization Process
- What makes a good visualization
  - Choosing the right graph
  - Data visualization best practices
- What you should NOT do
- Poor graphs can be transformed

Objectives

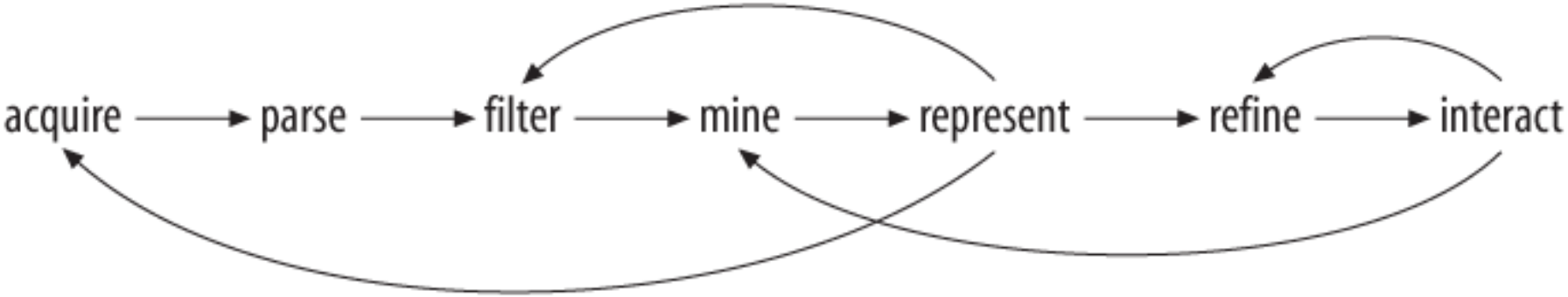
- Identify the basic steps of data visualization process
- Distinguish among the different types of datasets
- Distinguish among different types of relationships among data values
- Identify multiple data visualization principles
- Determine how to use colors wisely
- Know what not to do in designing effective visualizations
- Turn bad visualizations into good visualizations

Visualization process 7 stages

Provide some structure for the data's meaning, and order it into categories

Apply methods from statistics or data mining as a way to discern patterns or place the data in mathematical context

Improve the basic representation to make it clearer and more visually engaging



Obtain the data, whether from a file on a disk or a source over a network

Remove all but the data of interest

Choose a basic visual model, such as a bar graph, list, or tree

Add methods for manipulating the data or controlling what features are visible

https://www.safaribooksonline.com/library/view/visualizing-data/9780596514556/ch01.html

What makes a visualization good?

Designing a graph

- Must keep the task in mind
  - why do you need a graph?
  - what questions are being answered?
  - what data is needed to answer those questions?
  - who is the audience?

Questions to assess the quality of visualization

Welcome to **Visual Trumpery**. Thanks so much for being here. I foresee that, depending on your political leanings, your expectations for this talk are diametrically opposed.

If you are a liberal, you're likely prepared to enjoy a tirade against right-wing politicians. If you are a conservative, I bet you came here ready to get outraged by an unhinged leftist ranter.

I am indeed a ranter, and I love a good tirade, but I'm also going to disappoint you. The very title of this talk is an example of its content. It's intended to prime you and trick you into believing what is not so.

The English word "**trumpery**" means worthless nonsense, something that is showy and deceitful at the same time. Trumpery can occur in text, verbally, or visually. This non-partisan talk focuses on the visual, examining misleading charts, graphs, and data maps designed by individuals and organizations from all over the political spectrum.

I'll use these examples to equip you with a solid understanding of "**graphicacy**," the word I use to refer to visual literacy. I believe a literate, numerate, and graphicate citizenry is the best antidote for a world where trumpery runs rampant.

Join me in the fight against it.

SUMMARY OF THE TALK

Here are the four questions I'll mention during the talk to assess the quality of any data visualization:

1. Is the graphic based on reliable sources and data?
Any document or news story that uses data and graphics ought to clearly identify its sources and link to them. You, the reader, must be able to check whether they are trustworthy, and whether writers and designers handled the data properly.

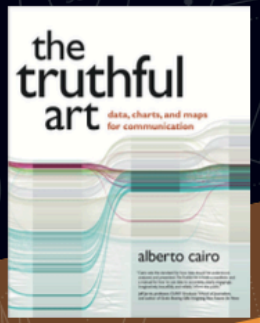
2. Does the graphic include enough information to be truthful?
Visualizations should never *simplify* information. They ought to *clarify* it. You'll soon understand the difference, thanks to the examples I'll share with you.

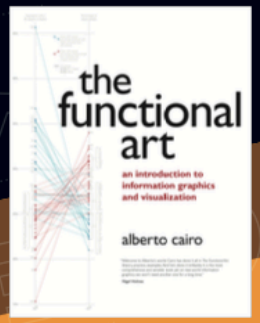
3. Is the data correctly represented?
Data visualization is based on visual encoding. Numbers are mapped onto spatial properties of objects, like their height, length, size, color, etc. When seeing a chart, graph, or map, always ask yourself: Are the properties representing the data proportional to the data itself?

4. Did the journalist or designer take uncertainty into account?
Data is hardly ever precise or certain, regardless of what visualizations and news stories often suggest. A good understanding of uncertainty and elementary probability can help you decide what to think or how to act based on what you read.

ADDITIONAL READINGS

It's impossible to teach all about graphicacy in just 90 minutes. That's why I created a repository of readings: **http://goo.gl/JwmUcW**
Finally, if you're interested in my books, I recommend that you first read *The Truthful Art*. A good part of it is related to the Visual Trumpery talk:





Initial steps for generating good visualizations

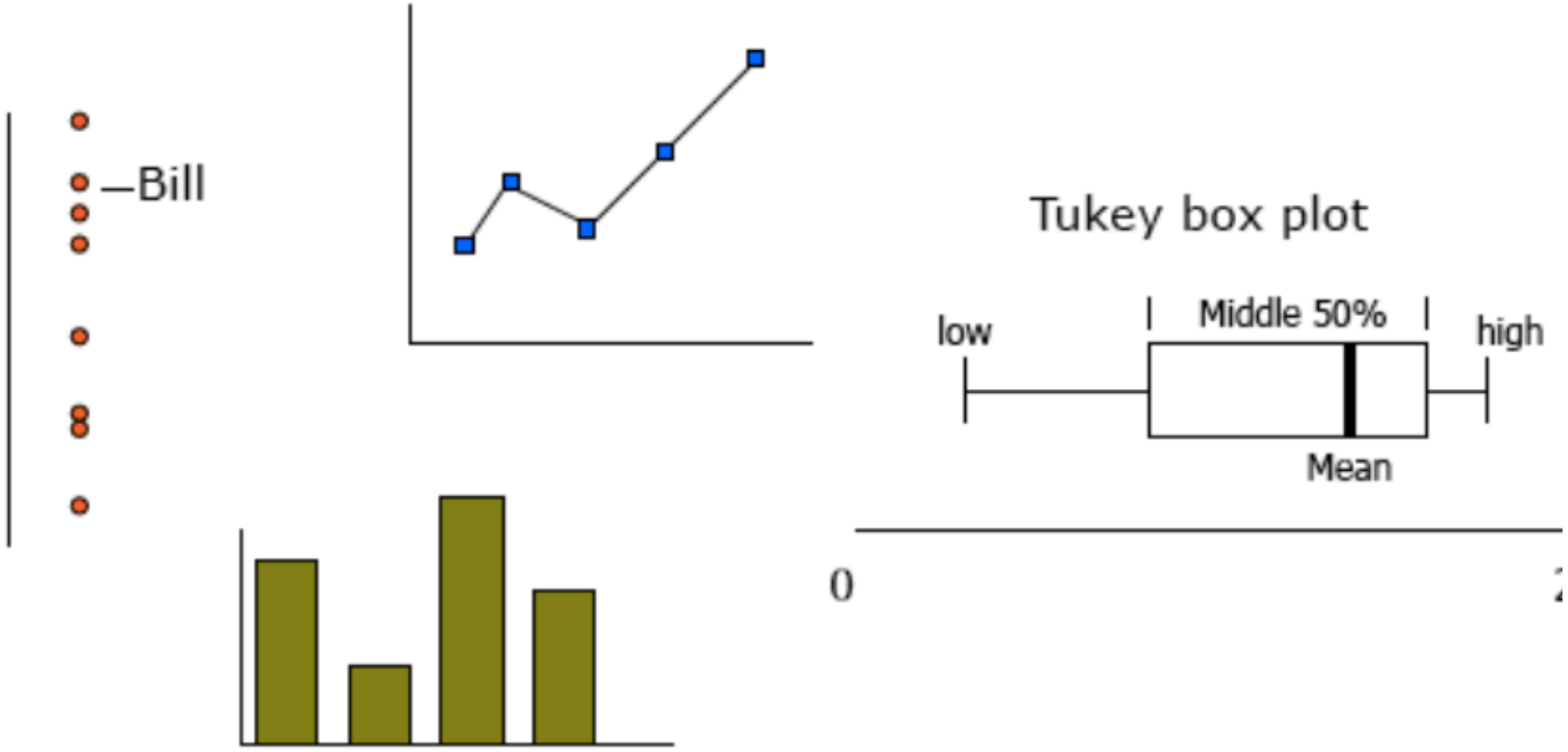
- Choosing the right graph
  - Identify your data
  - Determine the best means to encode the values

- Design your visualization to tell a story clearly

Types of datasets

- Univariate data
- Bivariate data
- Trivariate data
- Hypervariate data

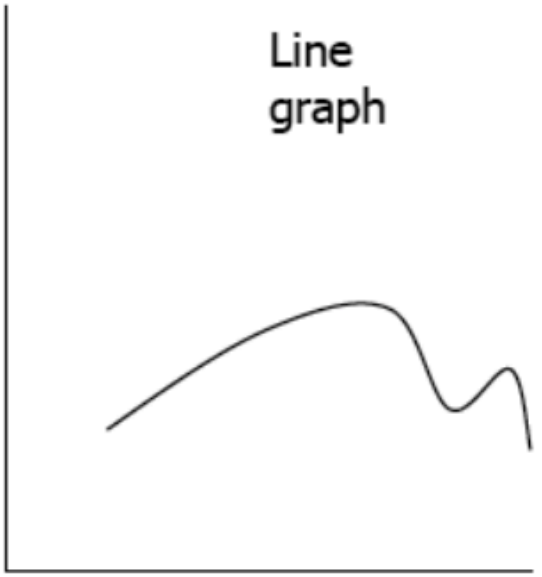
Univariate data



Univariate data
What Goes Where

In univariate representations, we often think of the data *case* as being shown along one dimension, and the *value* in another

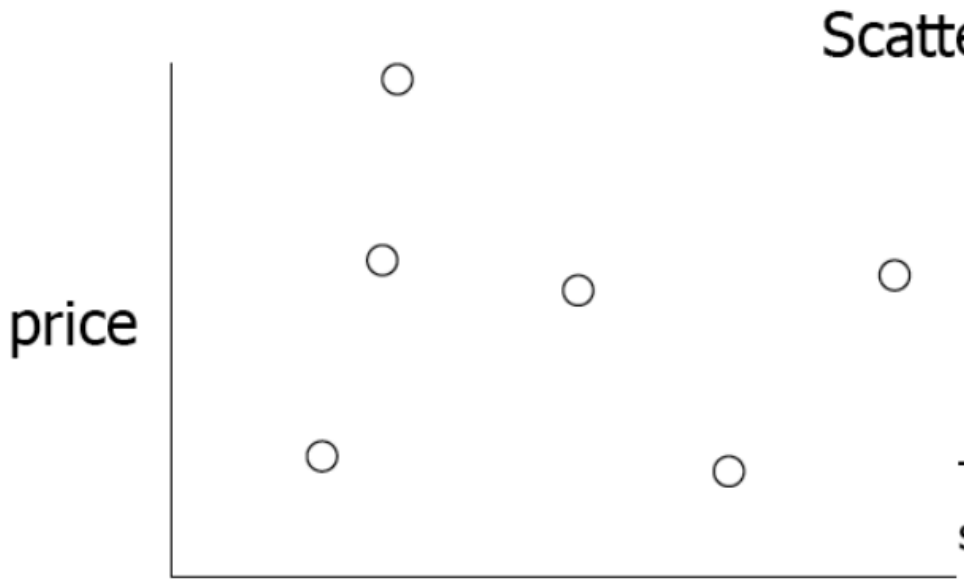
	$Case_1$	$Case_2$	$Case_3$ ...
$Variable_1$	$Value_{11}$	$Value_{21}$	$Value_{31}$
$Variable_2$	$Value_{12}$	$Value_{22}$	$Value_{32}$
$Variable_3$	$Value_{13}$	$Value_{23}$	$Value_{33}$
...			



Y-axis is quantitative variable

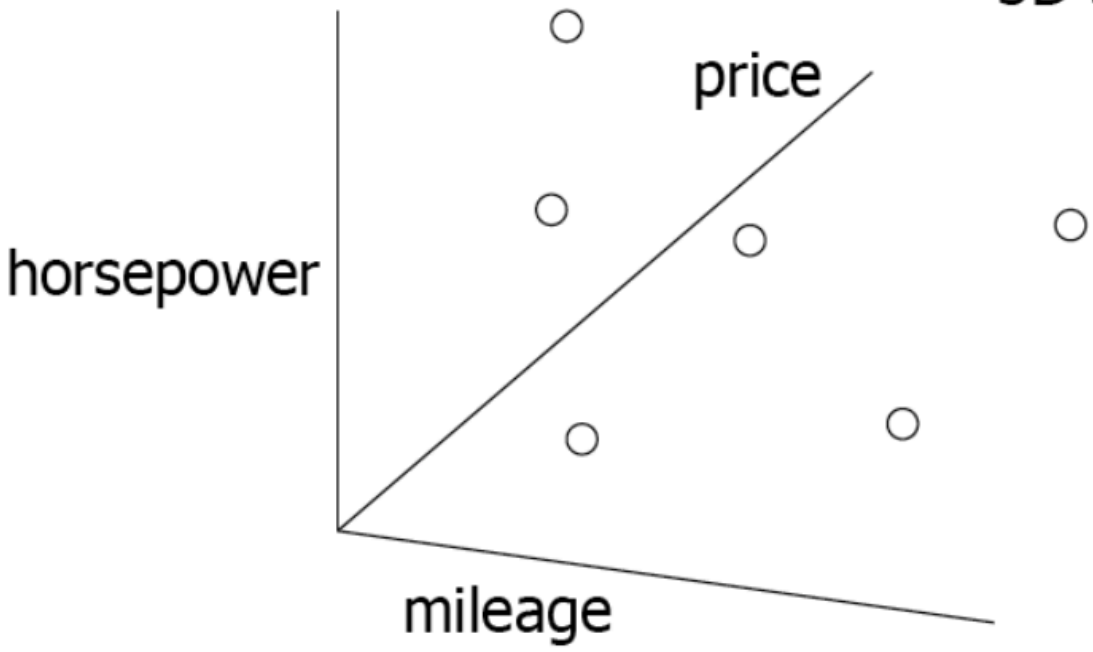
See changes over consecutive values

Bivariate data



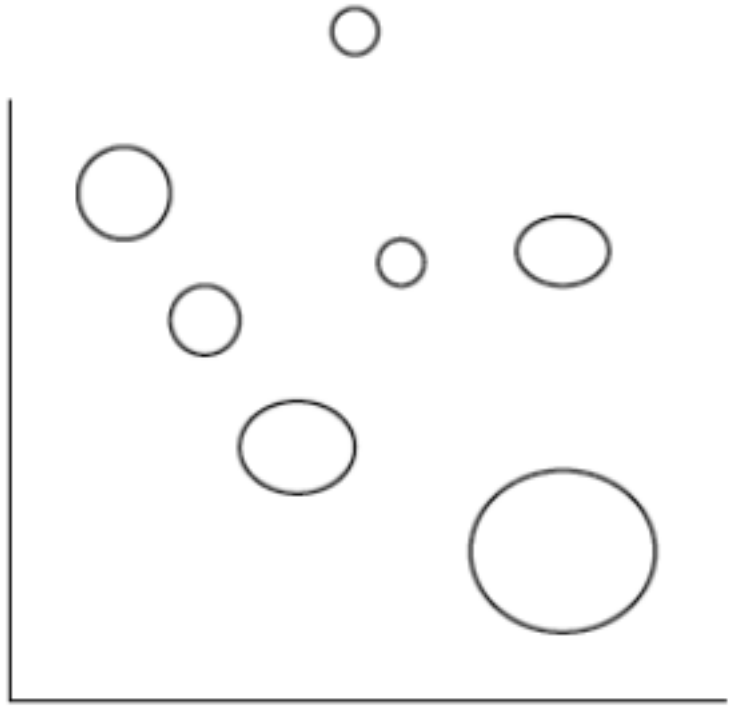
Trivariate data

3D scatter plot is possible



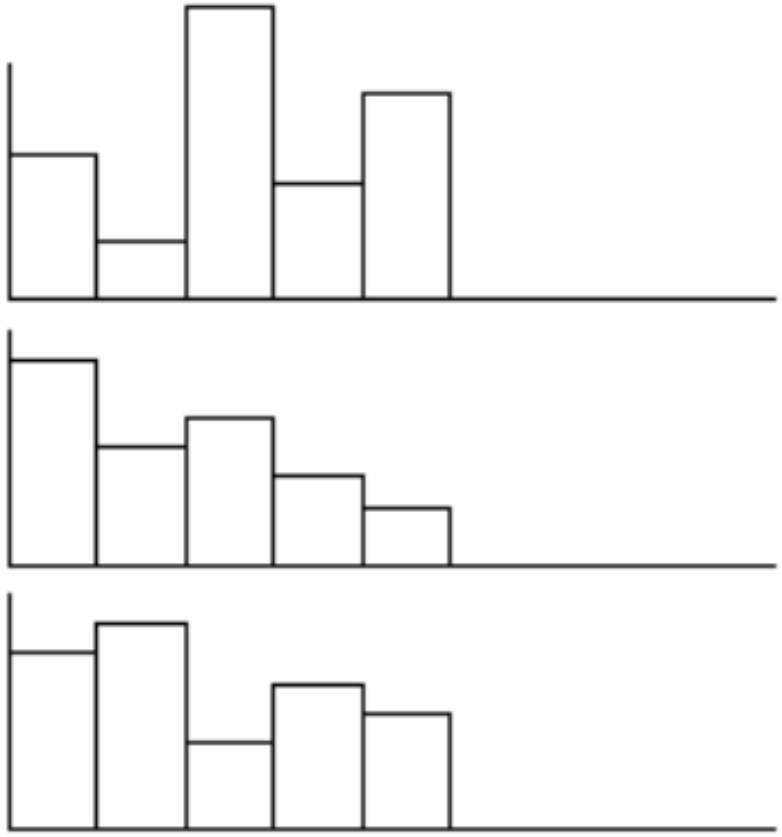
Trivariate data
Alternative Representation

Still use 2D but have mark property (size, color, etc.) represent third variable



Trivariate data
Alternative Representation

- Represent each variable in its own explicit way



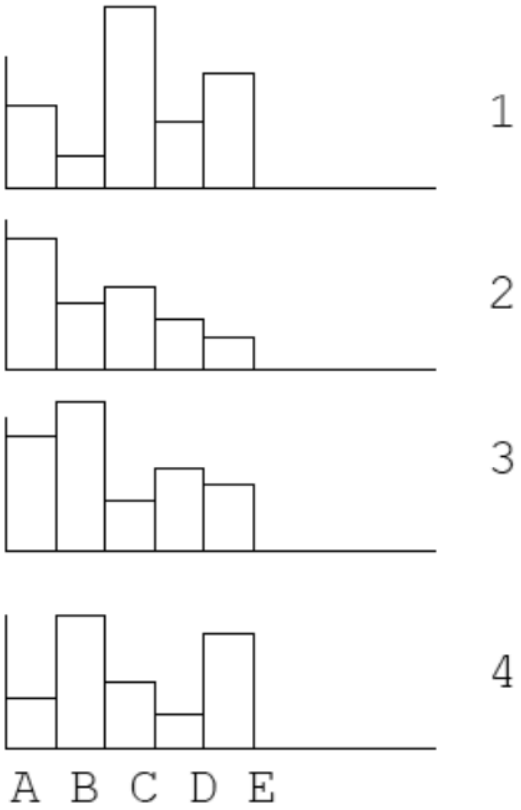
Hypervariate Data

- What about data sets with more than 3 variables?
  - Often the interesting, challenging ones
  - line graphs, bar graphs, scatter plots
  - small multiples

Hypervariate Data

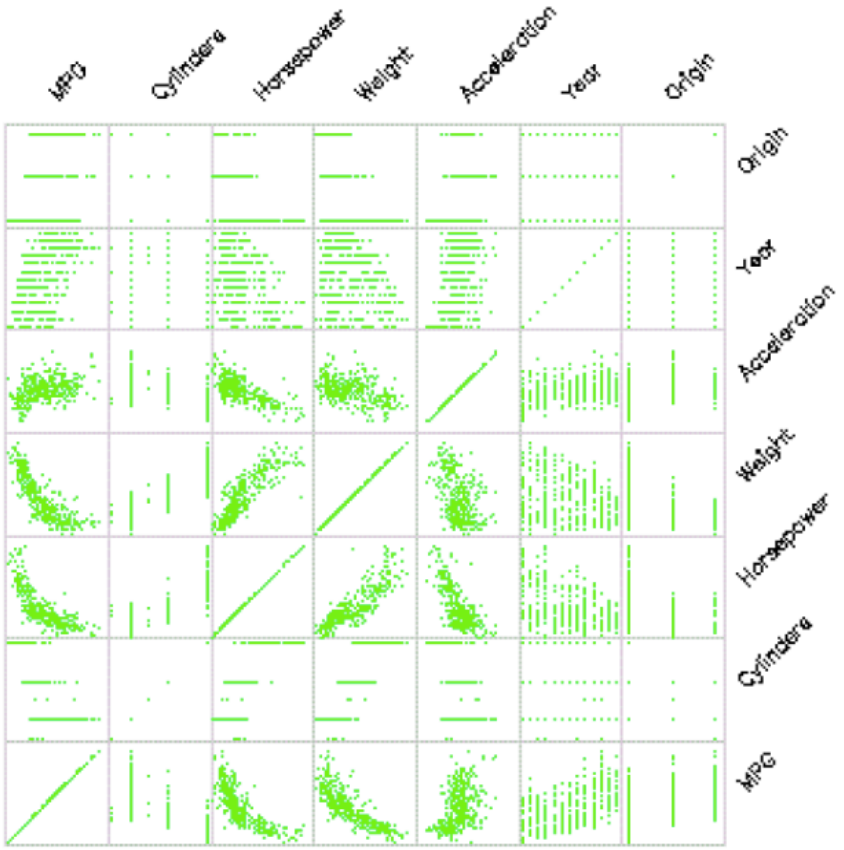
- Multiple Views
  - Give each variable its own display

	A	B	C	D	E
1	4	1	8	3	5
2	6	3	4	2	1
3	5	7	2	4	3
4	2	6	3	1	5

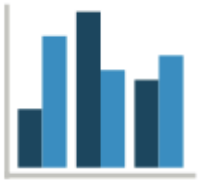


Hypervariate Data
Scatterplot Matrix

Represent each possible pair of variables in their own 2D scatterplot



Determine the best means to encode the values



COMPARE ITEMS

Compare values across different categories.

STATIC COMPOSITION

Part-to-whole relationship.

CORRELATION

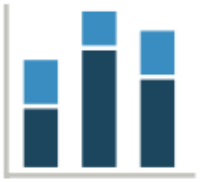
Relationship between two or more variables.

LOCATION

Show where things happen.

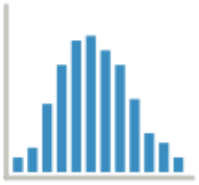
TIME COMPARISON

Compare changes over a period of time.



NON-STATIC COMPOSITION

Part-to-whole relationship over time.



DISTRIBUTION

Frequency of values in a data set.

KPIs

Key Performance Indicators.

https://portal.yellowfinbi.com

Seven relationships between values

Nominal comparison

Time-series

Ranking

Part-to-whole

Deviation

Frequency distribution

Correlation

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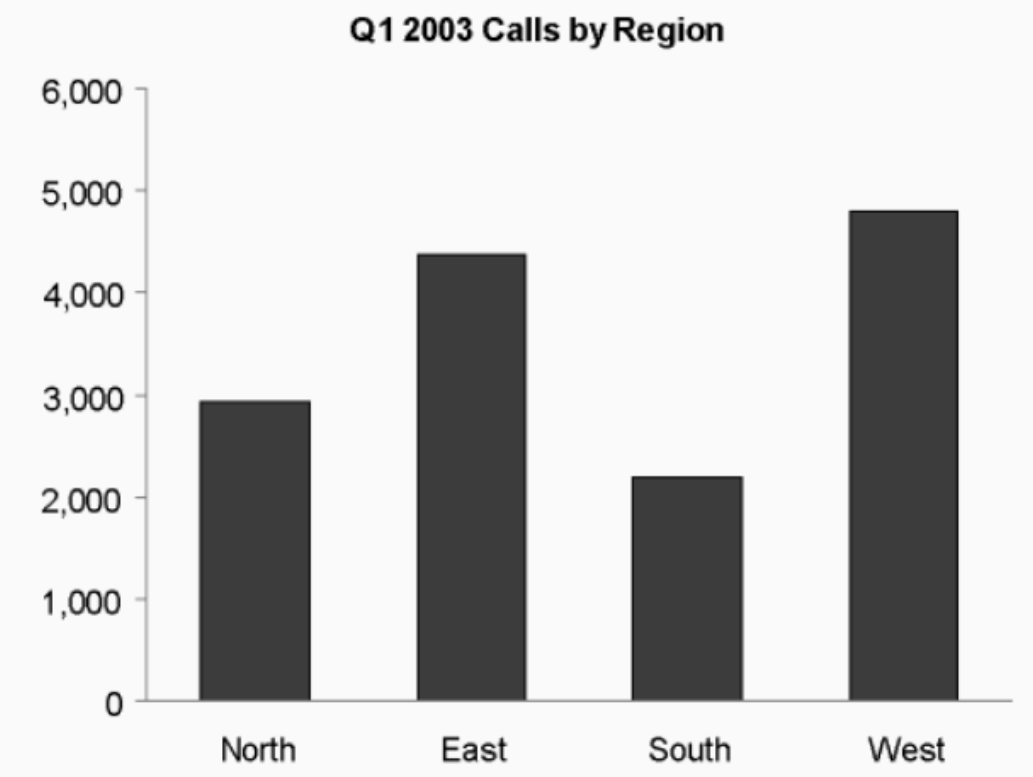

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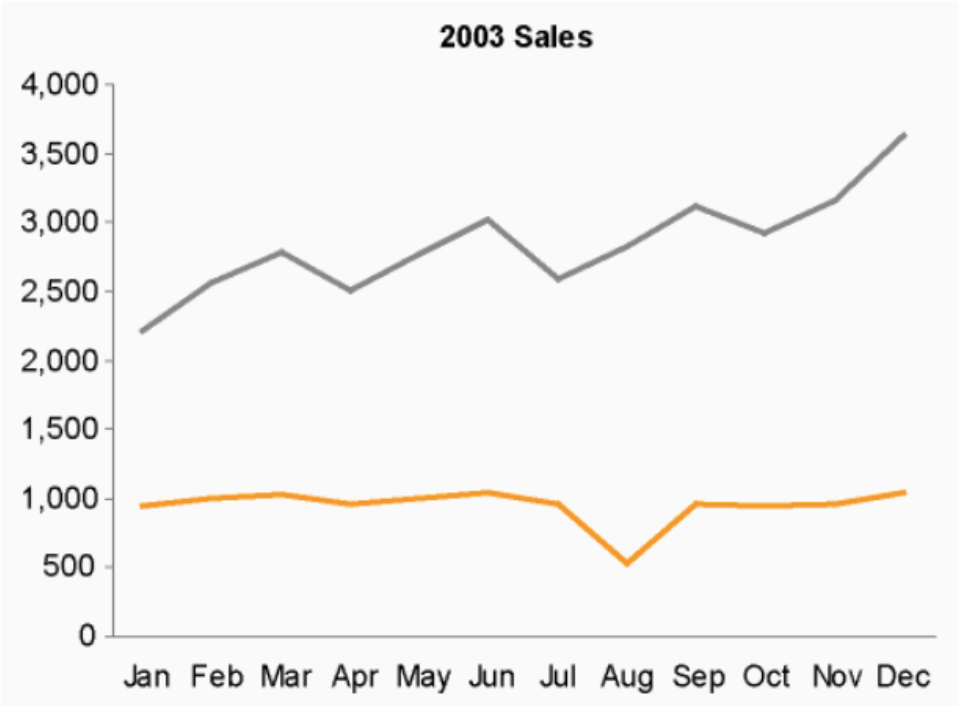

Few, Selecting the Right Graph for Your Message

Seven relationships between values

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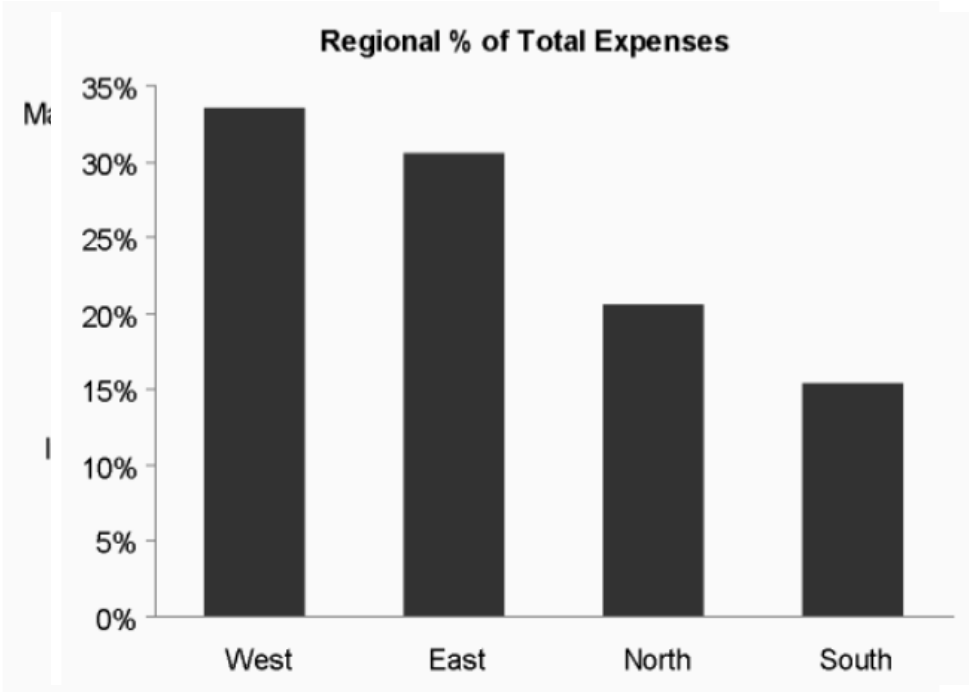

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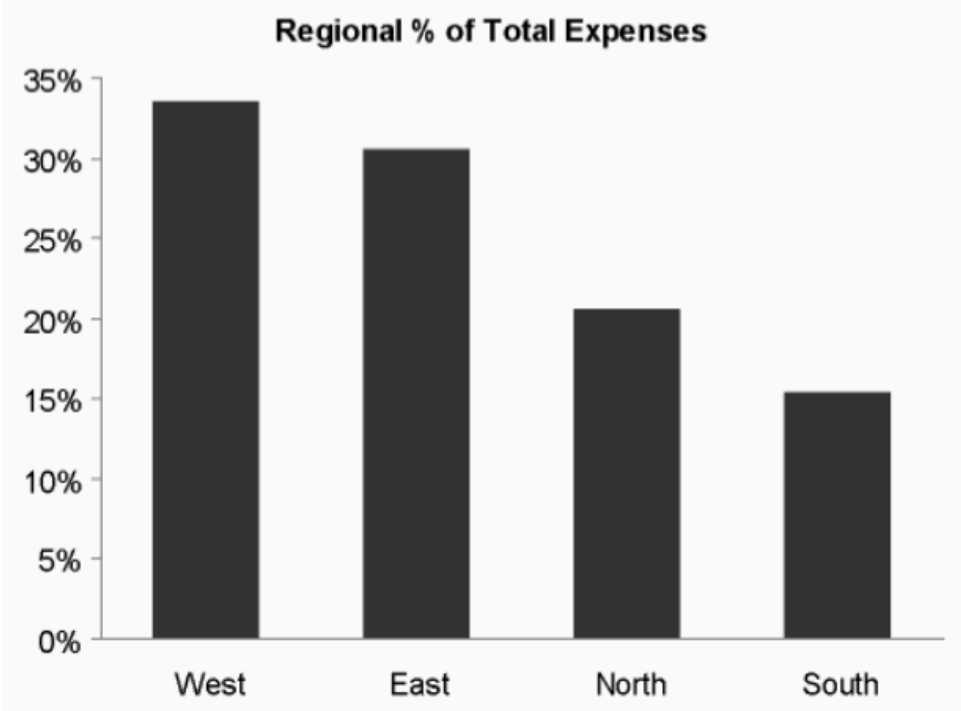

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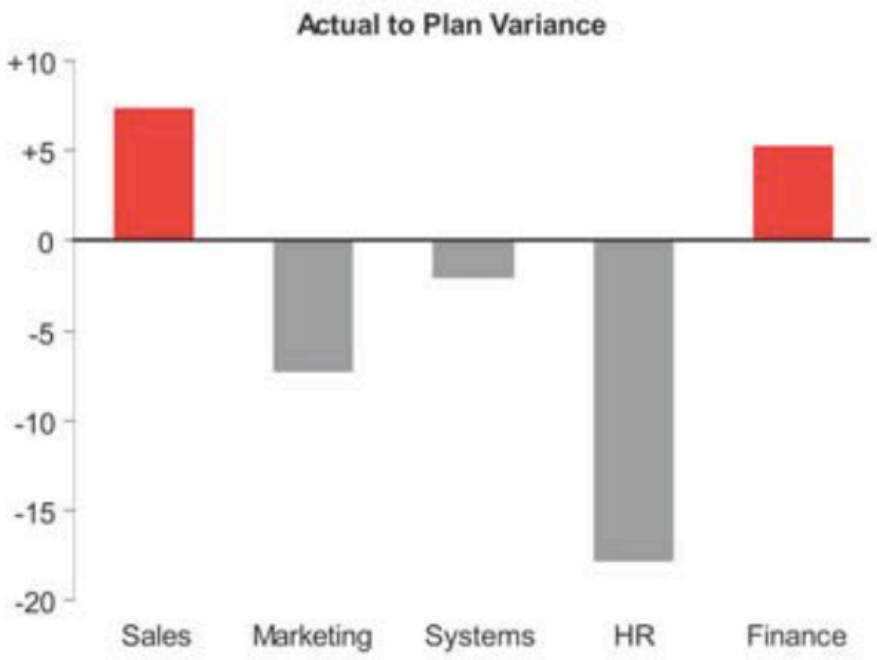

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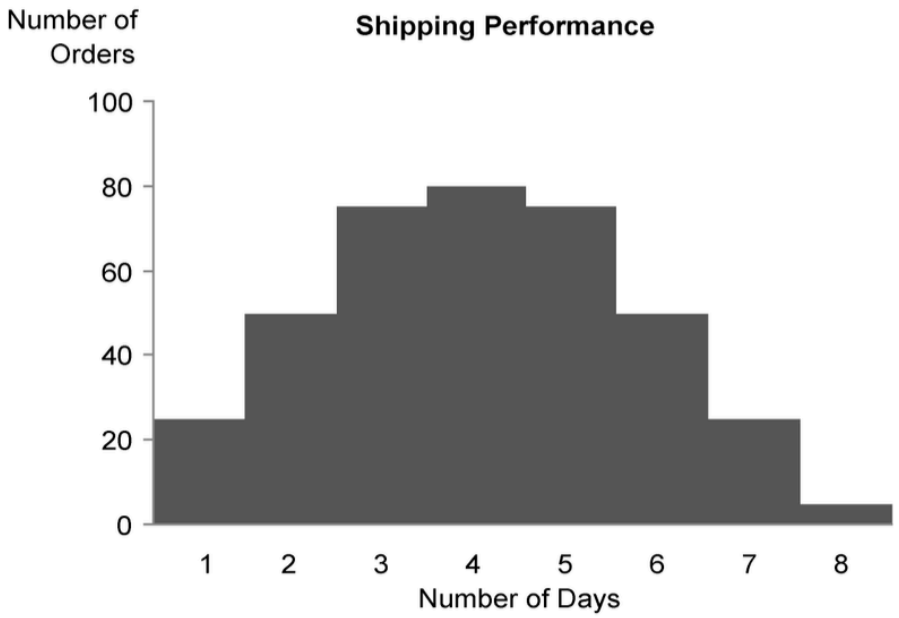

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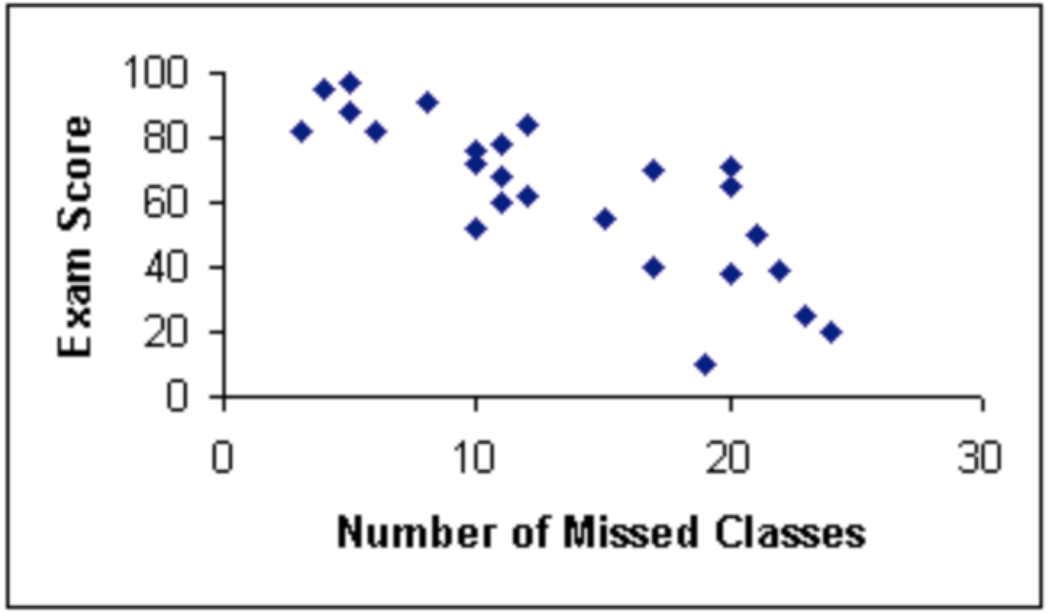

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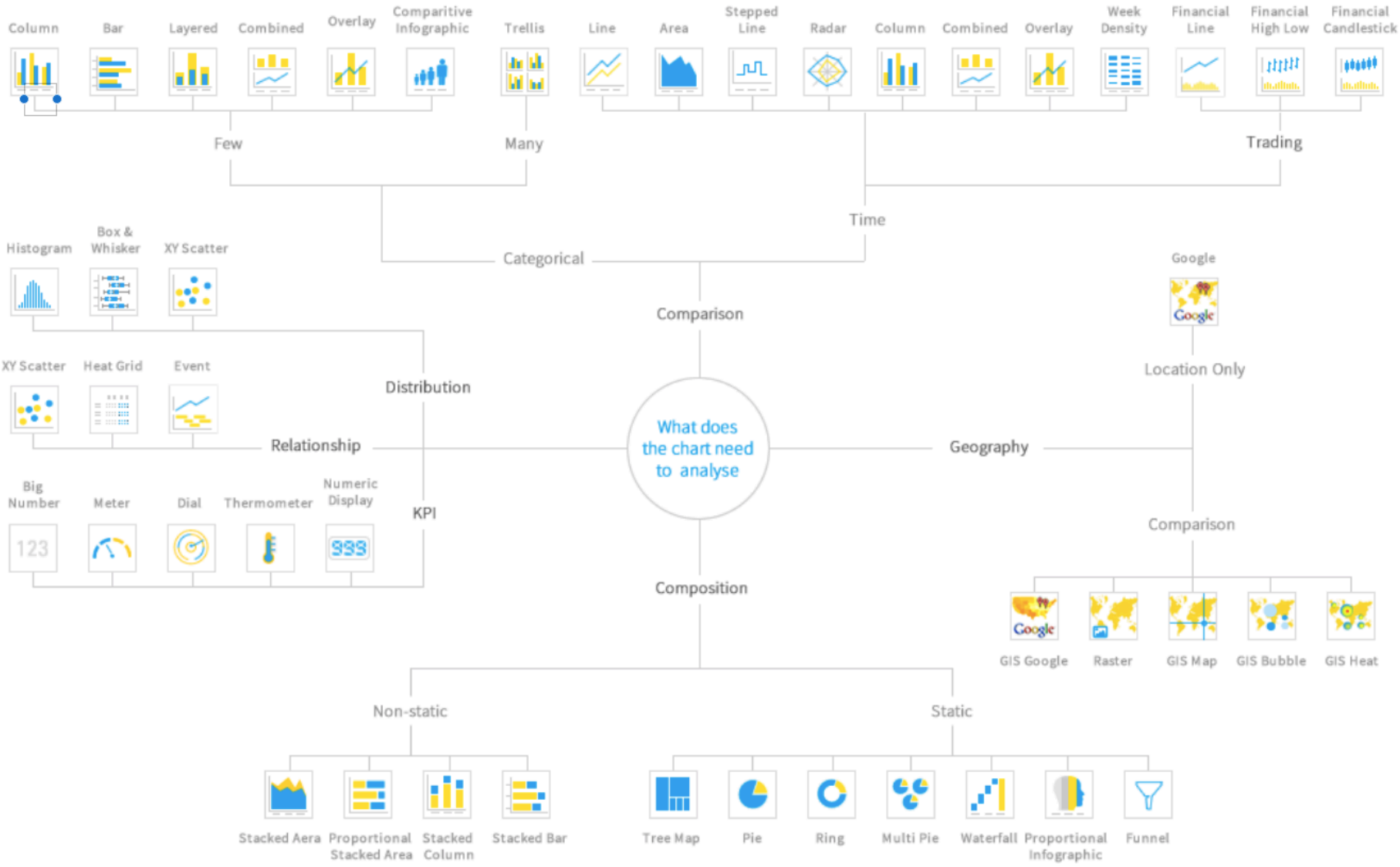
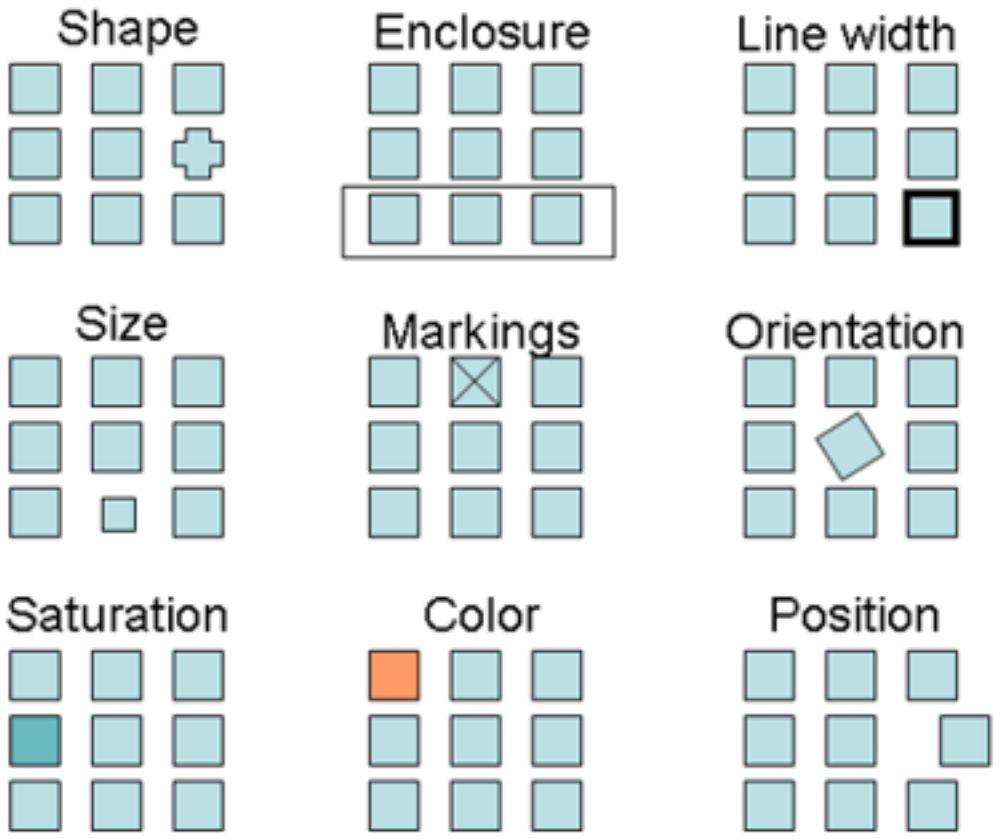


https://portal.yellowfinbi.com

Data Visualization Best Practices

Use visual variables for pre-attentive processing

1. Shape
2. Size
3. Saturation
4. Enclosure
5. Marking
6. Color
7. Line Width
8. Orientation
9. Position



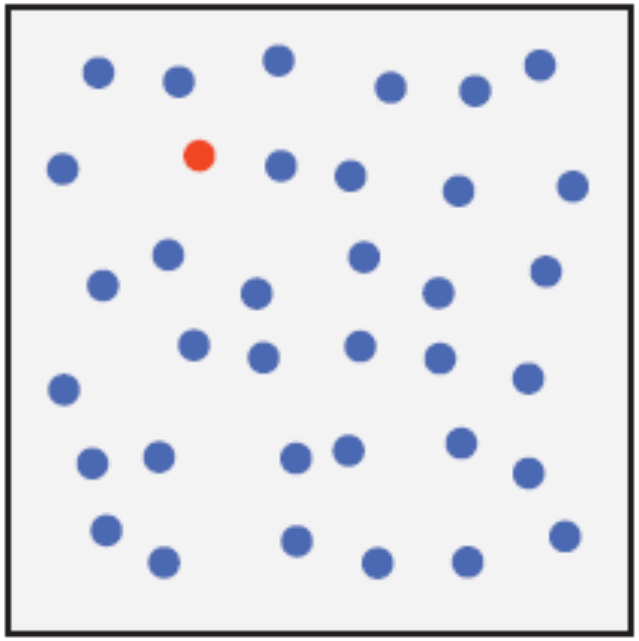
How many 3s?

128176875613897654698450698560498282676
298098584582245098564589450984509809435
859091030209905959595772564675050678904
567884578980982167765487636490856091294
9686

How many 3s?

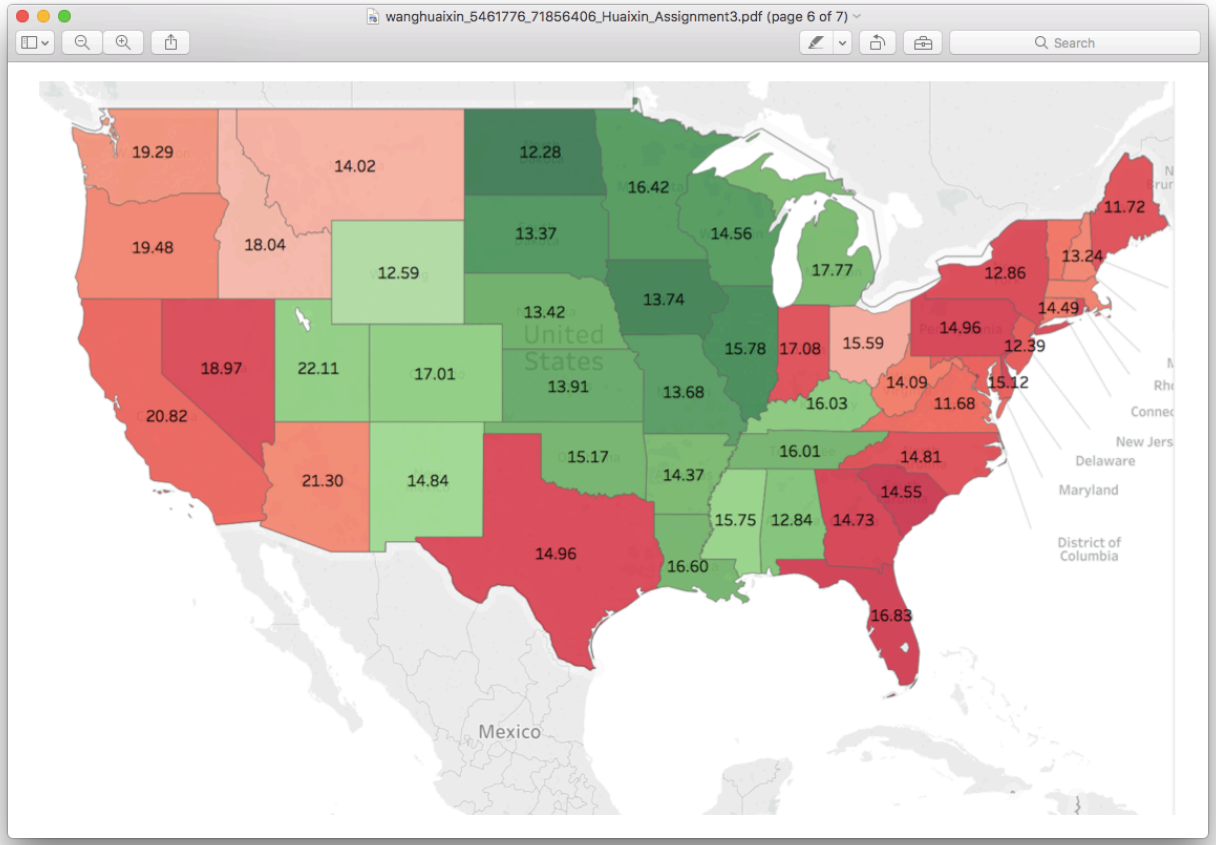
1281768756138976546984506985604982826762980985845822450985645894509845098093585909103020990595959577256467505067890456788457898098216776548763649085609129496 86

Can you find the red dot?



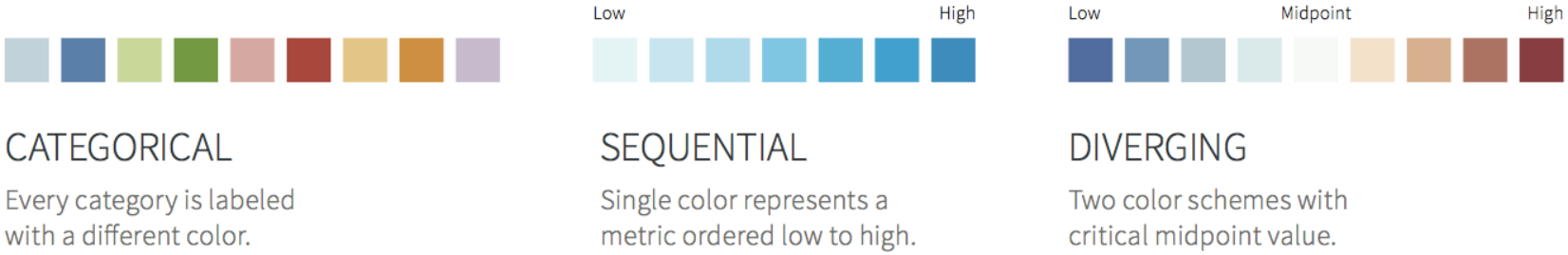
Source: https://www.csc2.ncsu.edu/faculty/healey/PP/index.html

Do you remember Assignment 3?



Format your charts

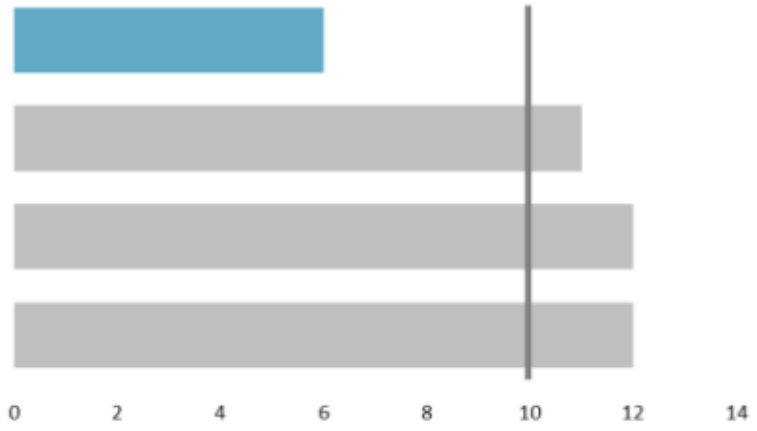
Colors can give your charts more meaning



- Use colors to highlight different categories or metrics
- Design a chart with a color blind friendly palette

https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

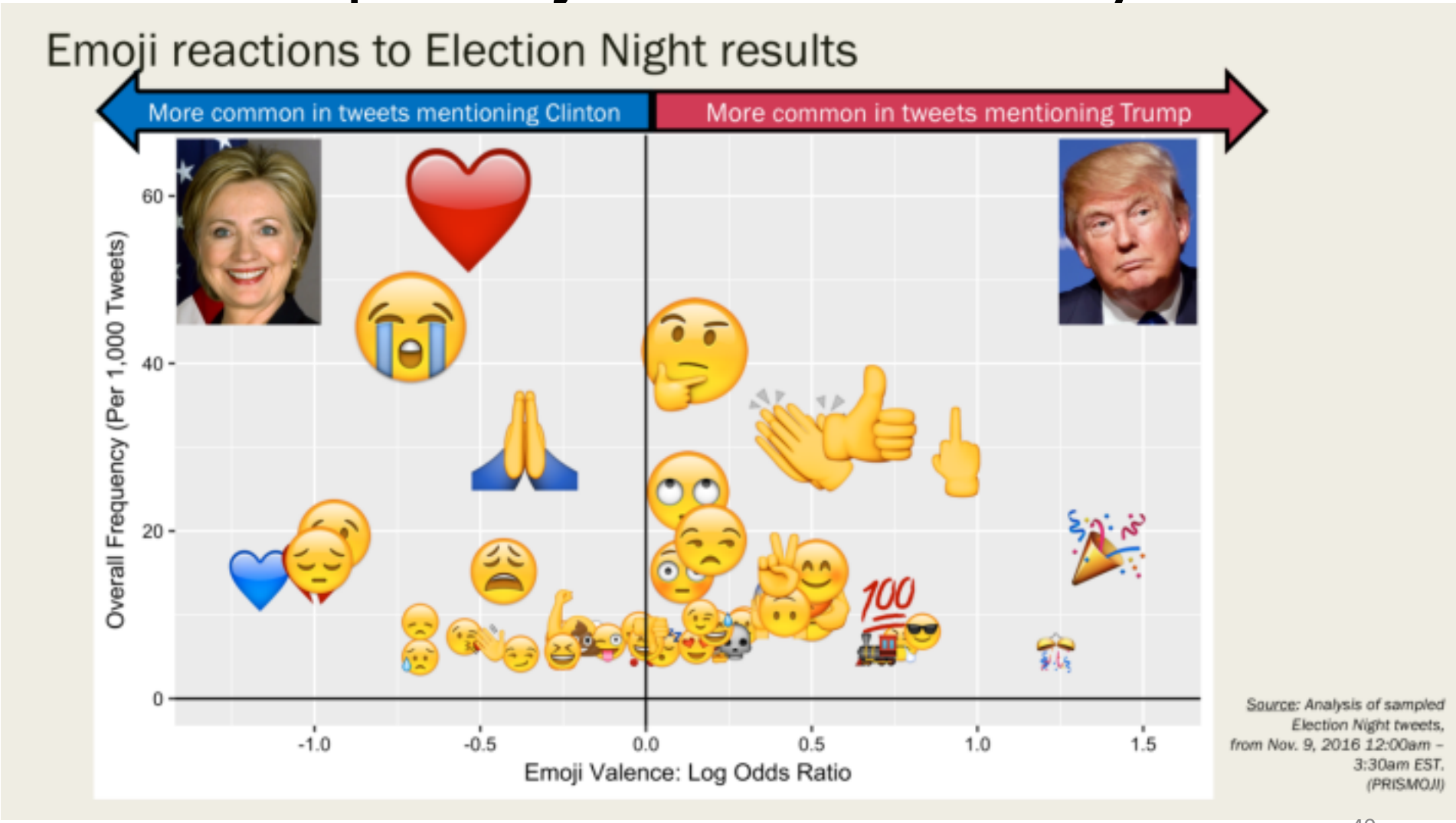
Use color meaningfully and with restraint



Add emphasis

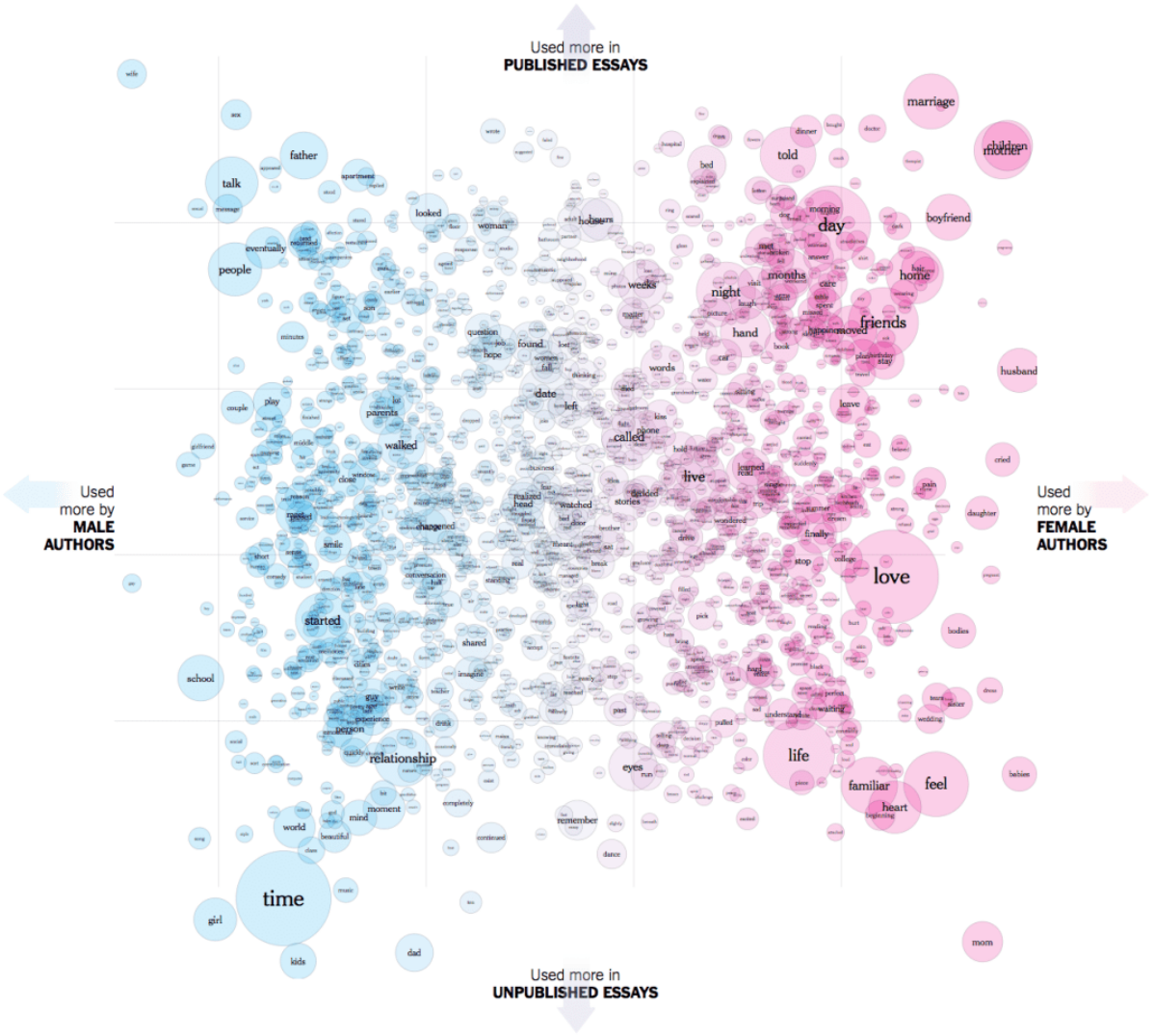
Create the confusing effect of Skittles on a page

Good use of color
The top emojis of Election Day 2016



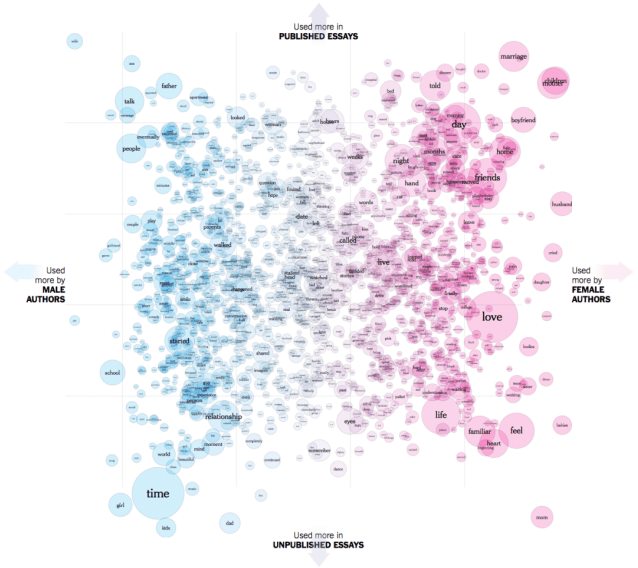
For more information on how to generate emojis from tweets, check our this site: https://prismoji.com

Words men and women use when they write about love



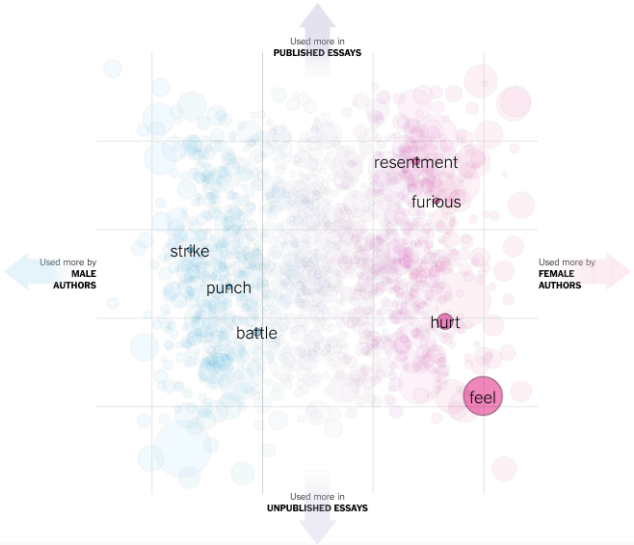
https://www.nytimes.com/interactive/2017/11/07/upshot/modern-love-what-we-write-when-we-write-about-love.html

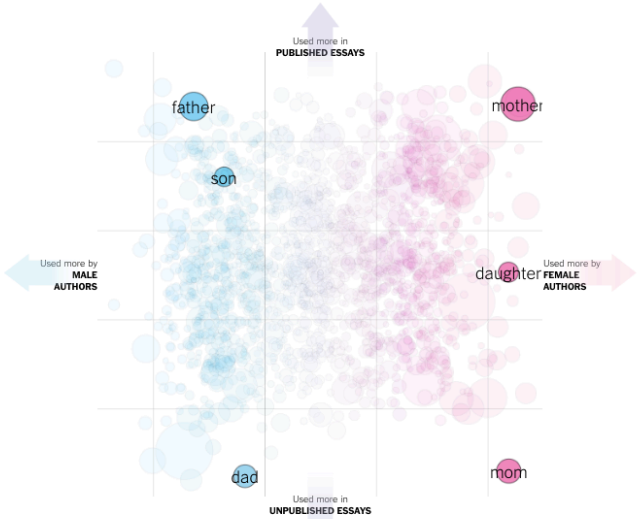
Always be consistent

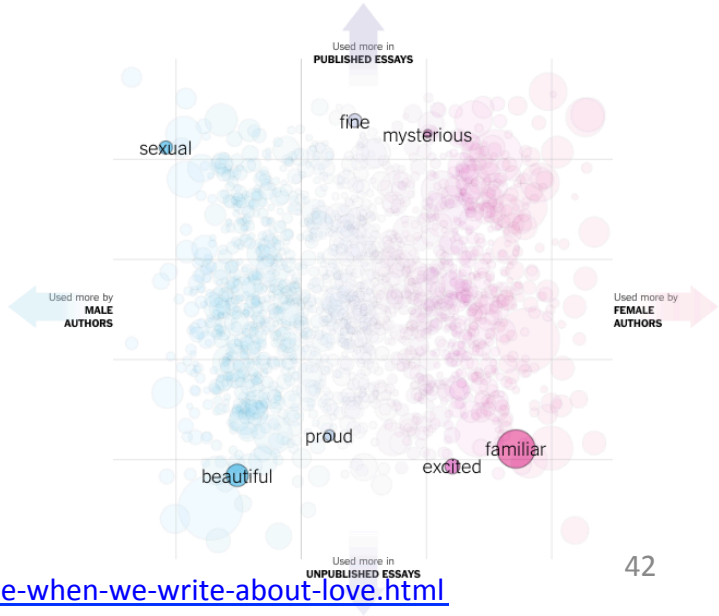


men versus

women







https://www.nytimes.com/interactive/2017/11/07/upshot/modern-love-what-we-write-when-we-write-about-love.html

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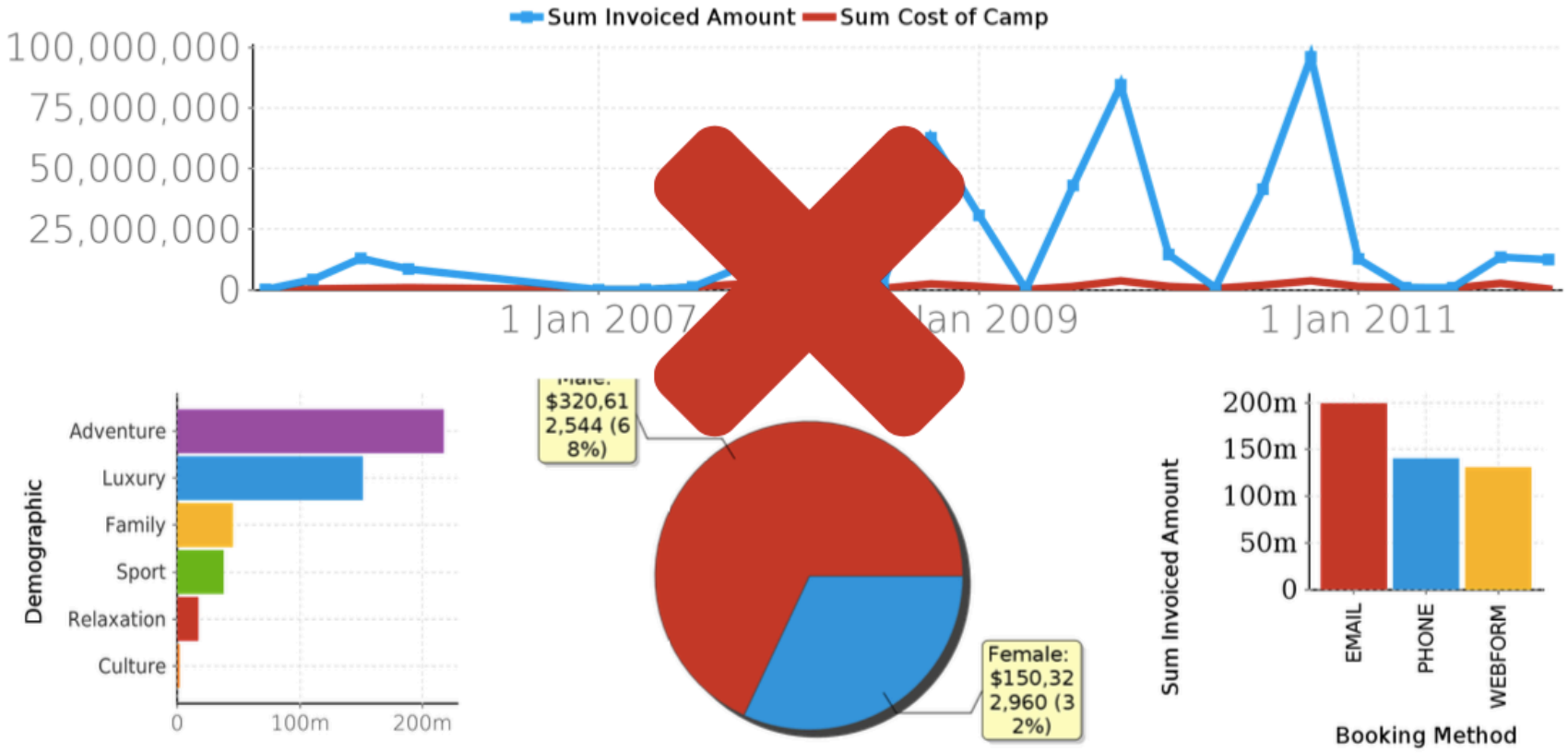

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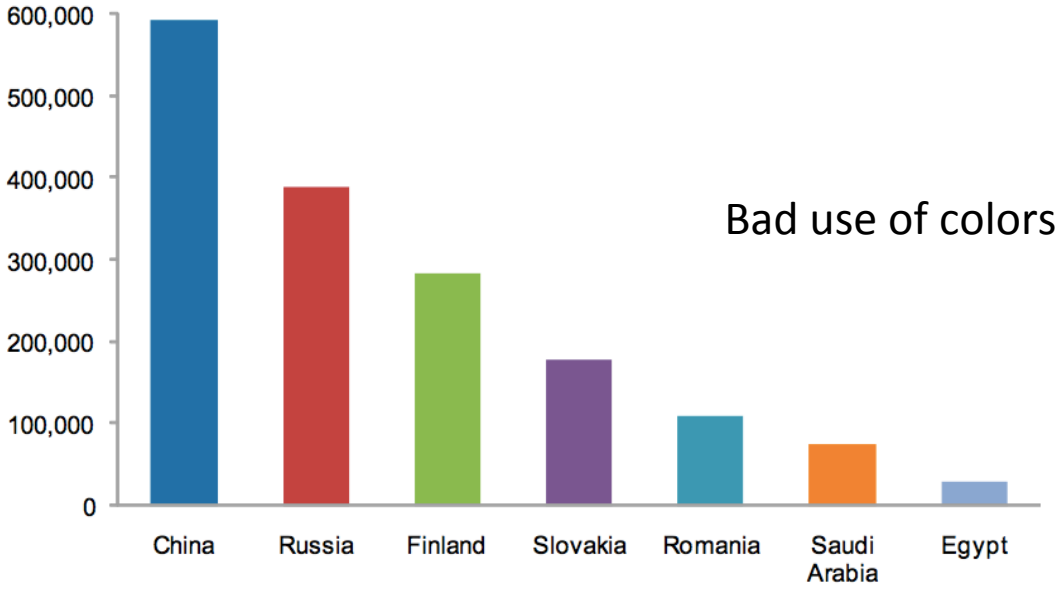
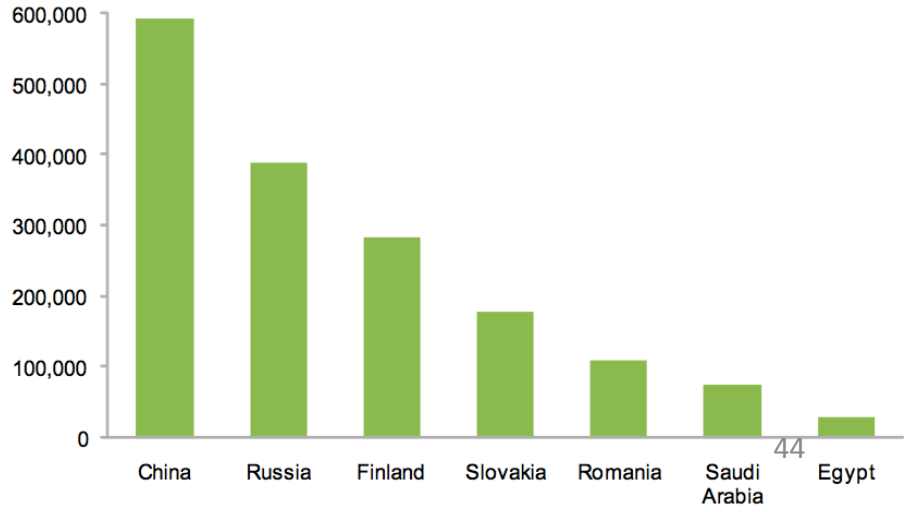
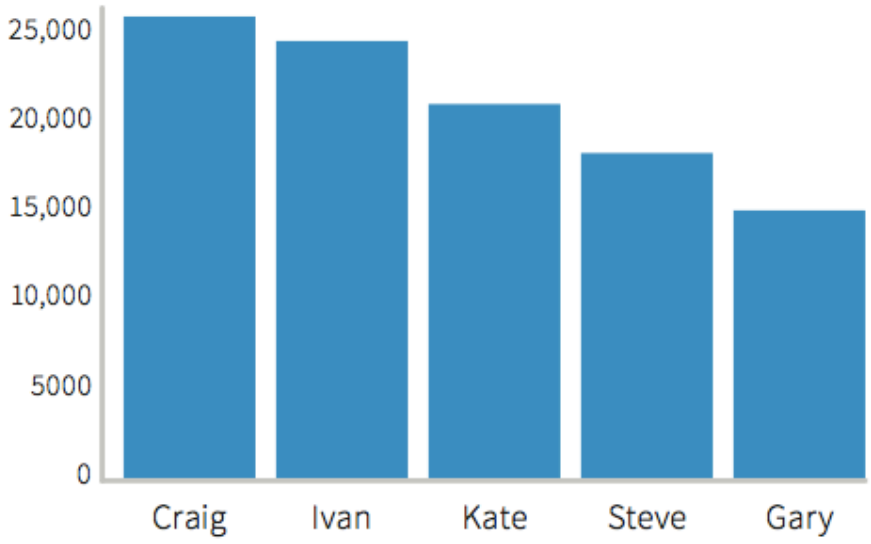


Bad use of colors

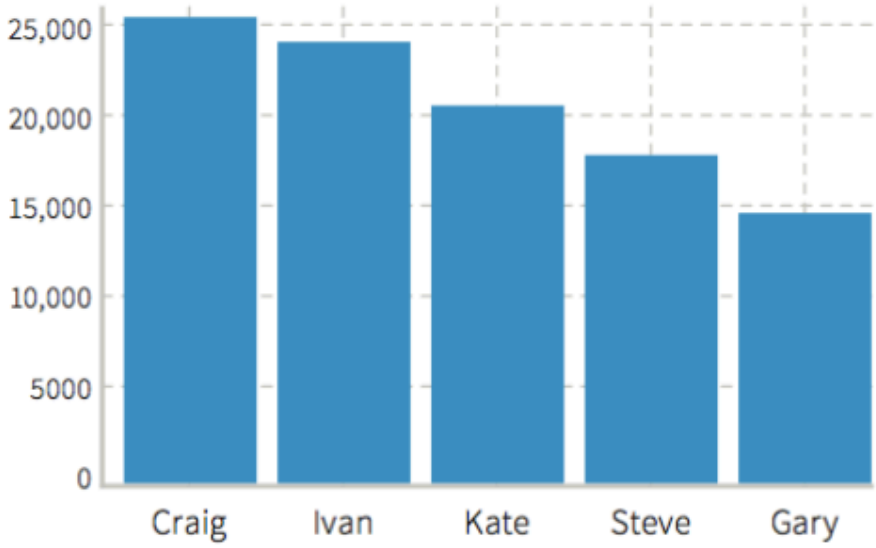


Add context
Grid lines communicate key thresholds

NO GRID LINES



GRID LINES



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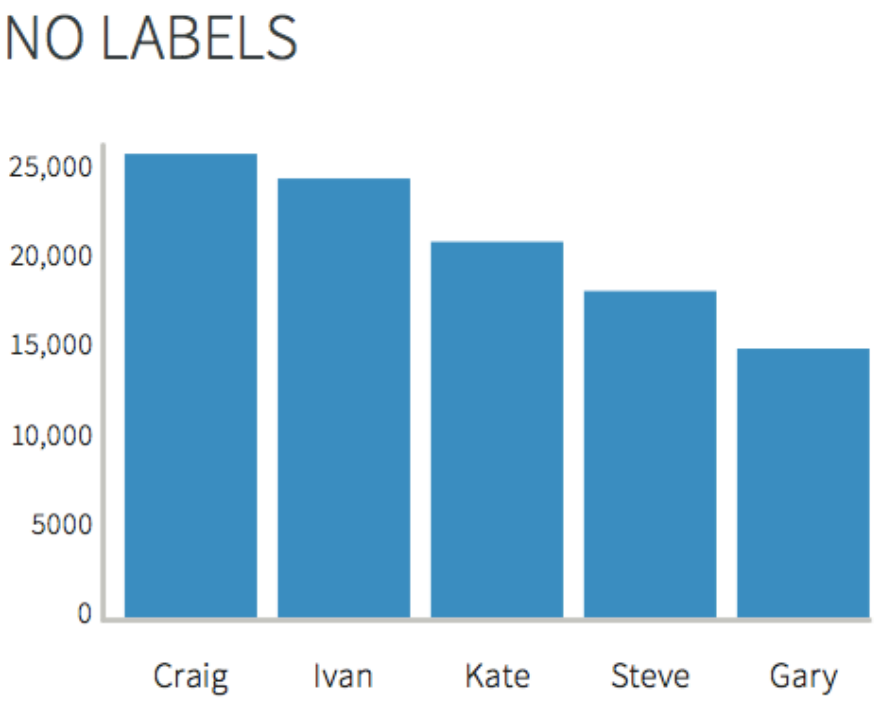
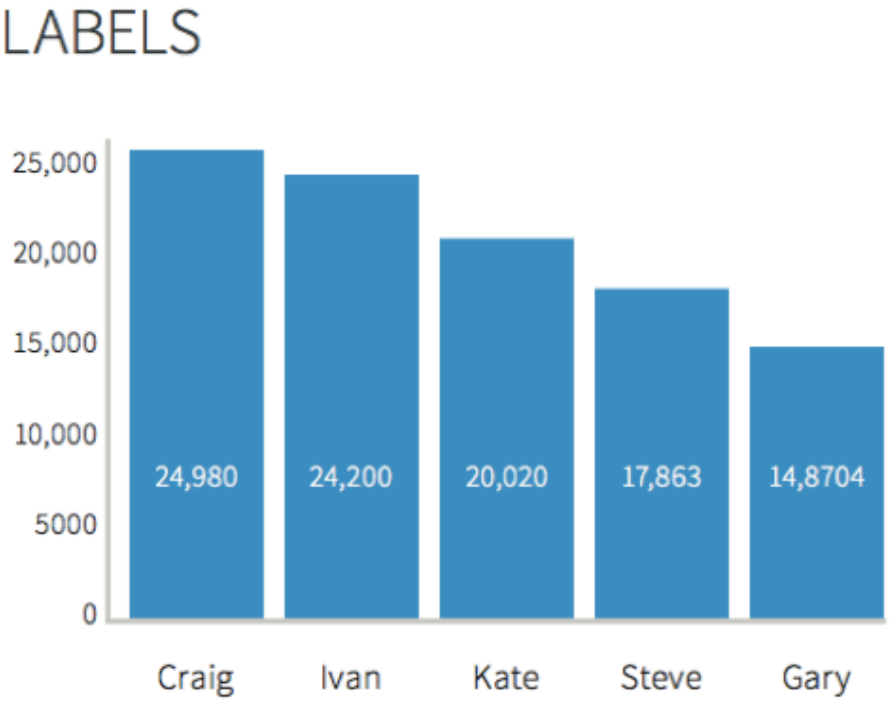
Add context
Labels reveal exact values



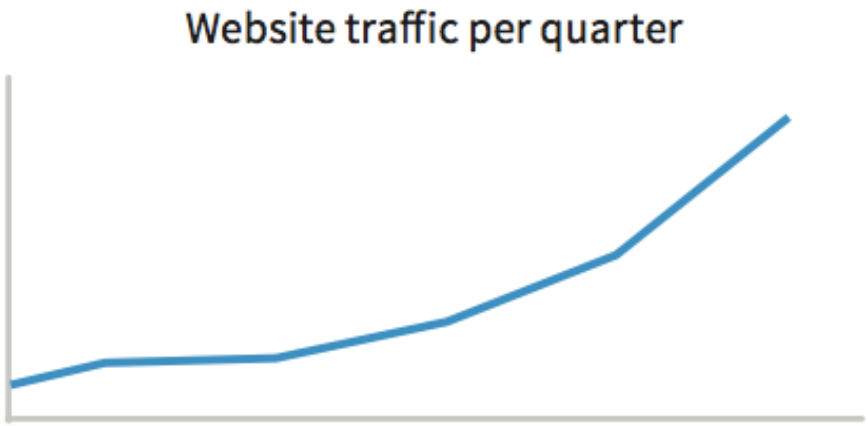


https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

Add context
Chart titles frame the story in your data

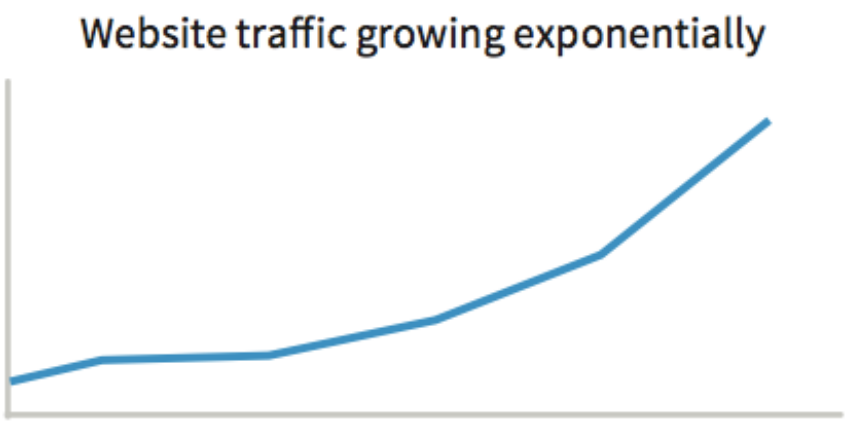
DESCRIBE THE QUERY

For monitoring data without bias.



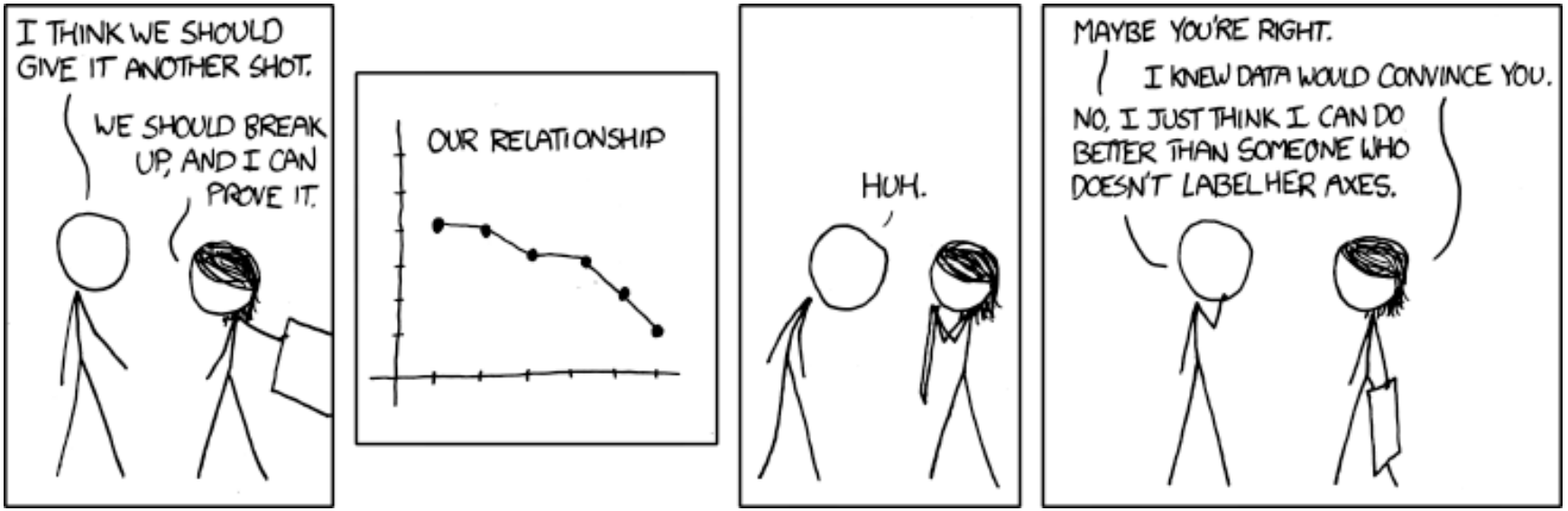
EXPLAIN THE INSIGHT

Use data to tell a story.



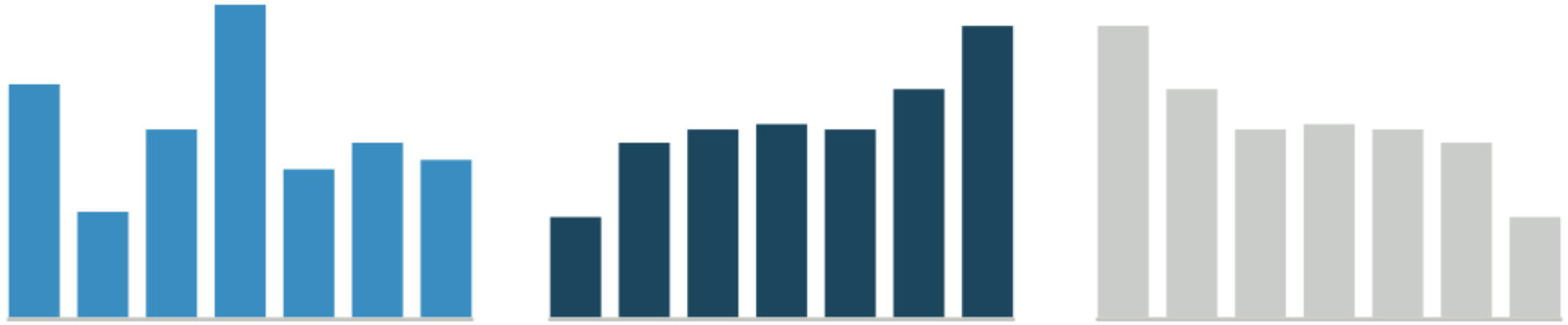
https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

Axis Labels



https://xkcd.com/833/

Sort your data to make finding insights easier



ALPHABETICAL

Quickly find a category.

ASCENDING

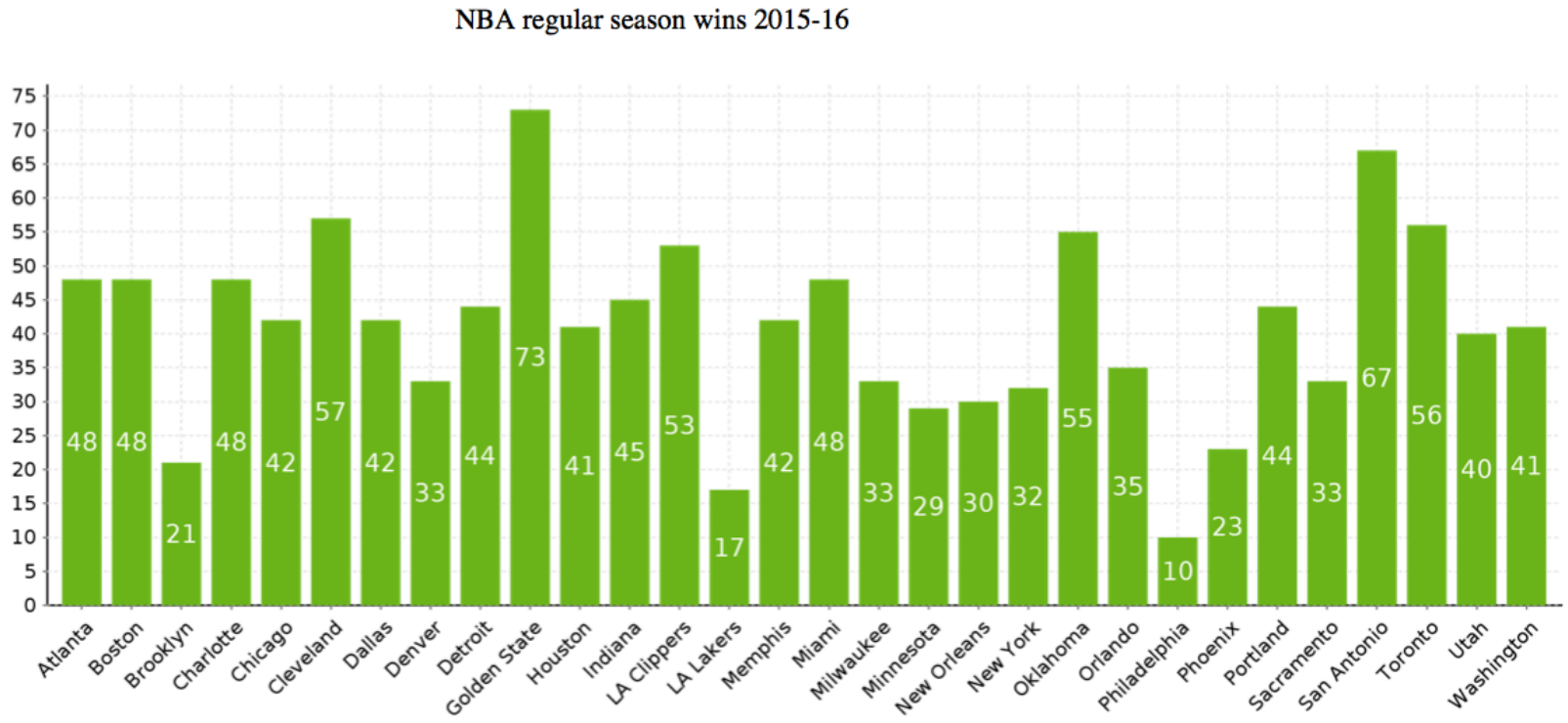
Tell a story in order.

DESCENDING

Compare categories.

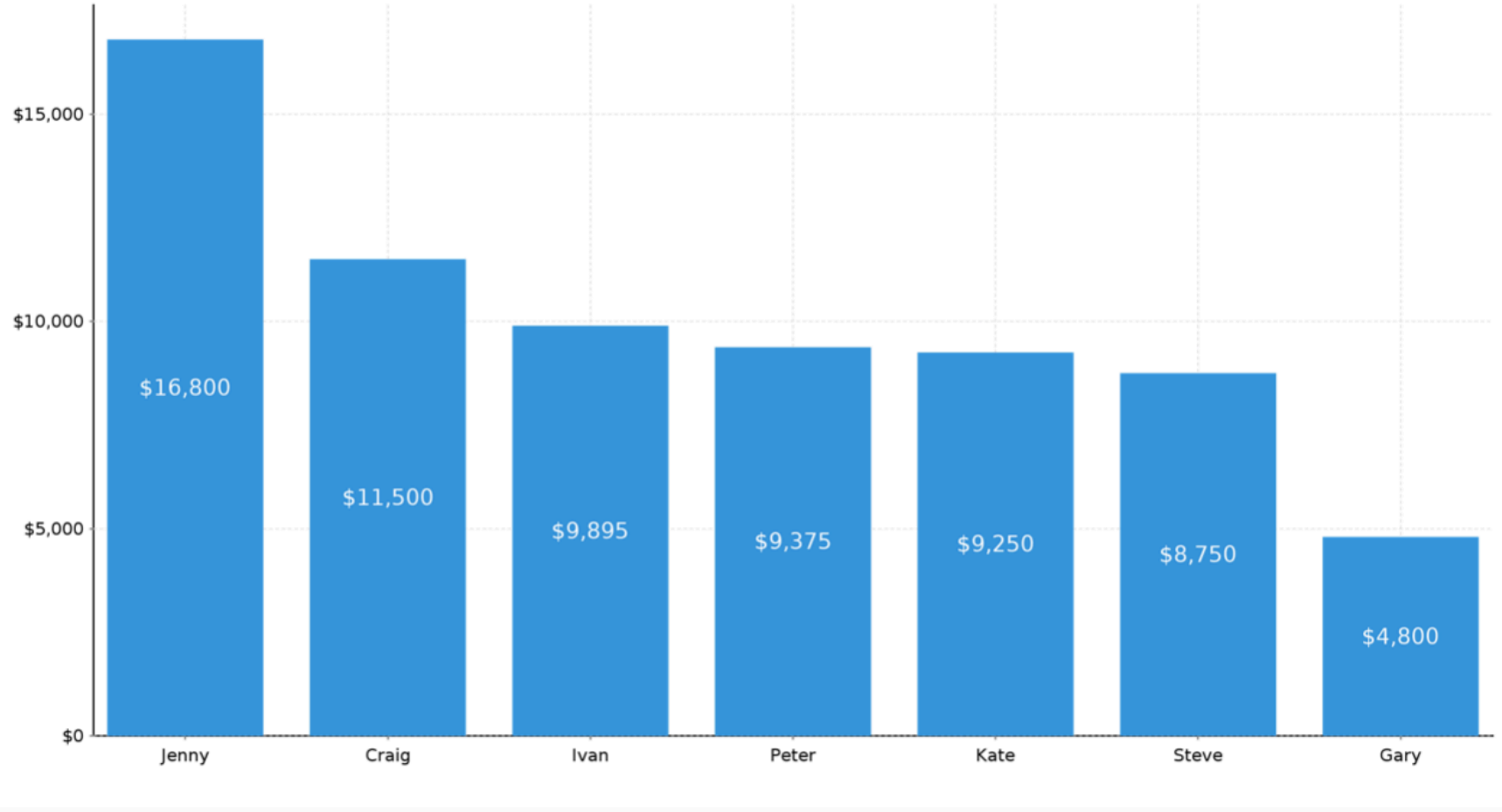
https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

Sorting Alphabetical helps people find what they are looking for



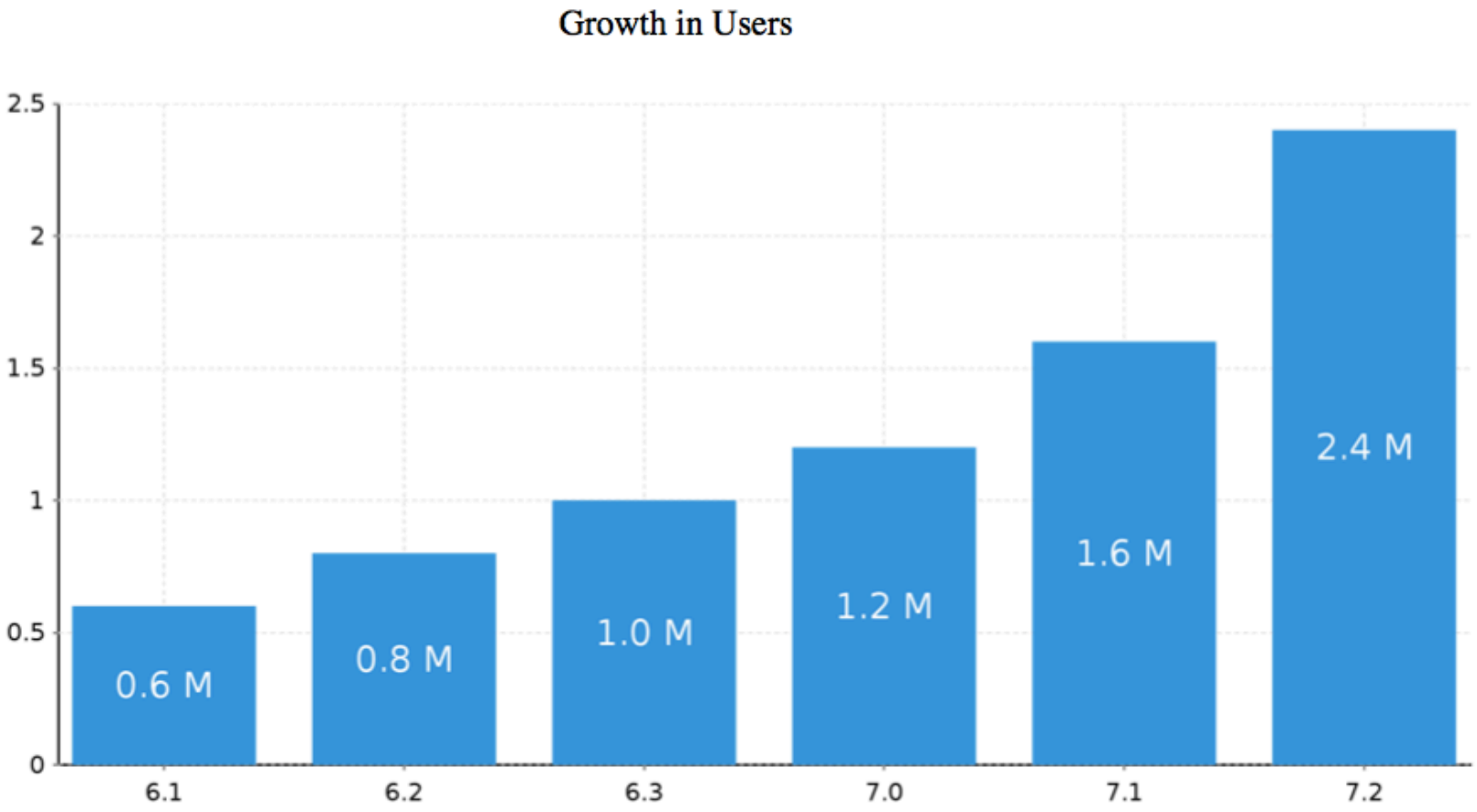
https://portal.yellowfinbi.com/

Sort by descending - helps compare largest to smallest



https://portal.yellowfinbi.com/

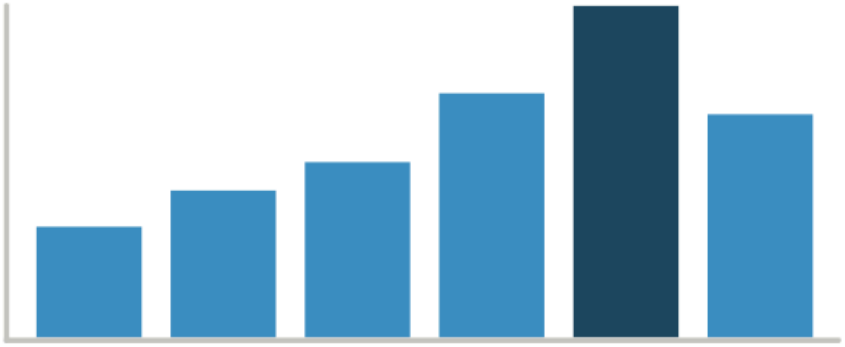
Sort by ascending - tells a story of growth



https://portal.yellowfinbi.com/

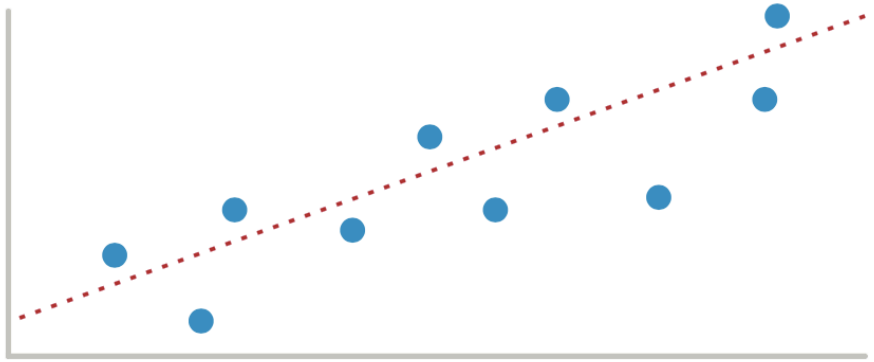
Highlight what's important

- Draw people's eye to what's important.



CONDITIONAL FORMATTING

Colors data that is above or below defined thresholds.

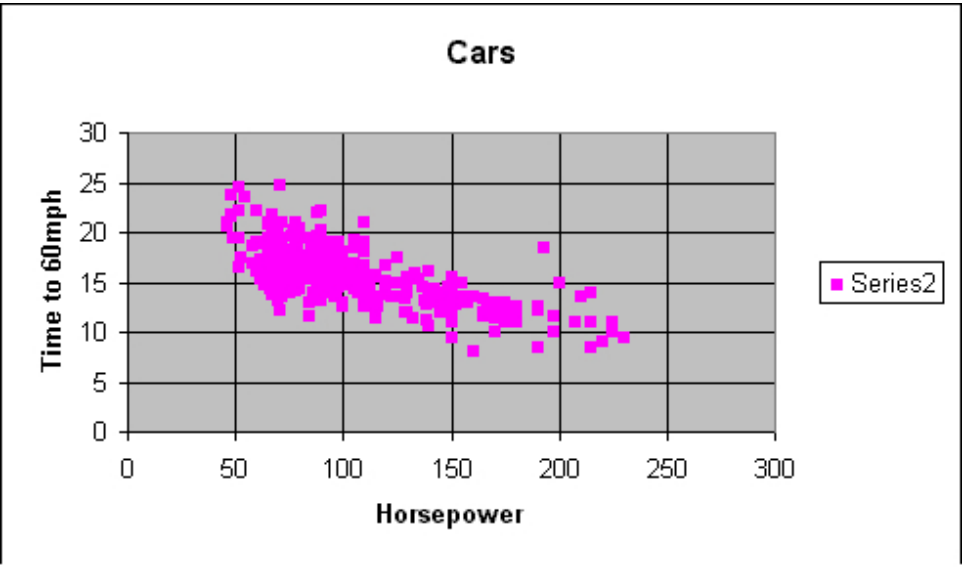


HIGHLIGHT TRENDS

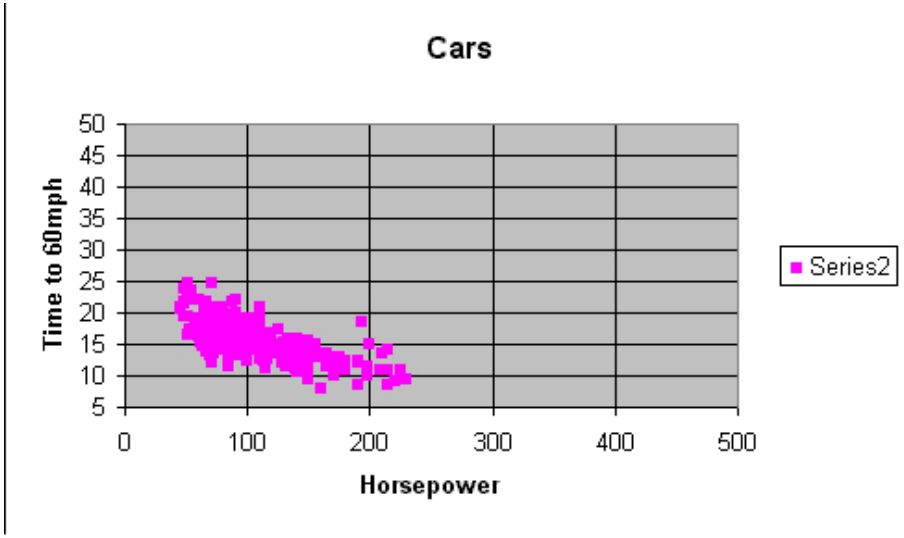
Uncover patterns in your data.

https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

Give your chart reasonable data range



illogical

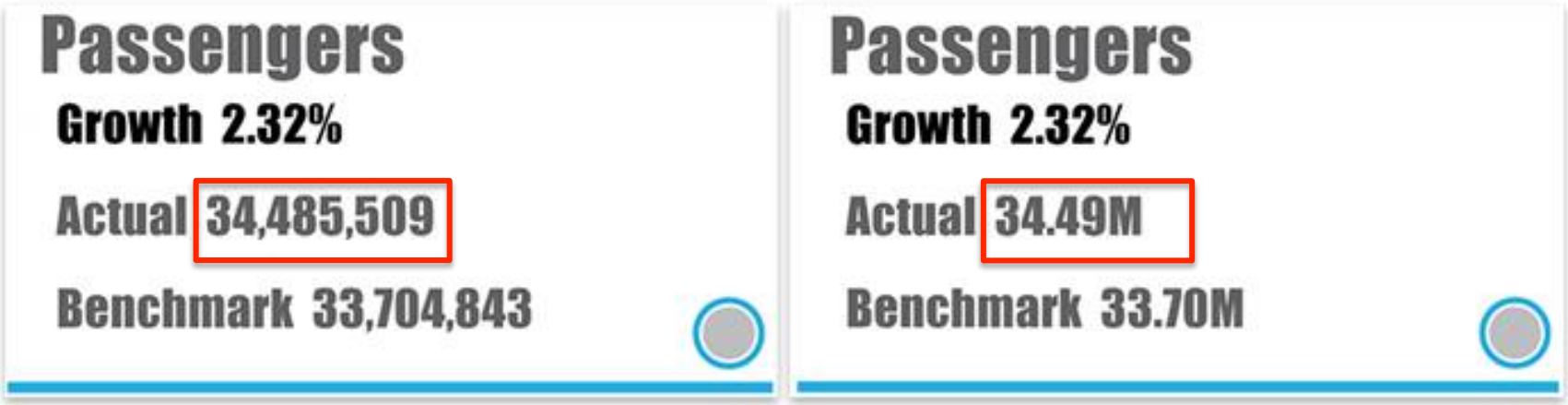


logical

Limit numbers

https://www.targit.com/en/blog/2016/01/data-visualization-best-practices-part-2

Limit numbers



https://www.targit.com/en/blog/2016/01/data-visualization-best-practices-part-2

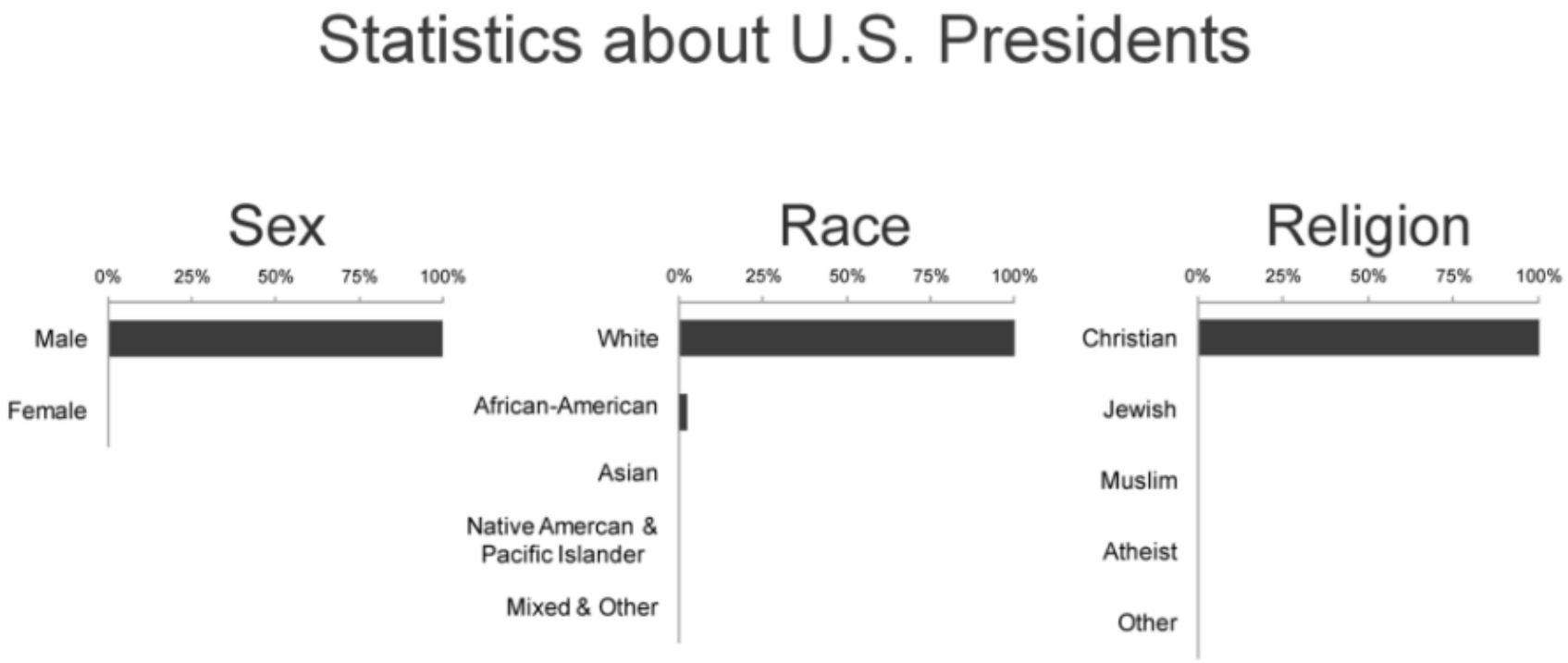
Less is More

- Focus on what is most important and guide the user through the dashboard

- So you need your dashboard (or report) to be
  - Clear
  - Concise
  - not overly stuffed with charts and objects

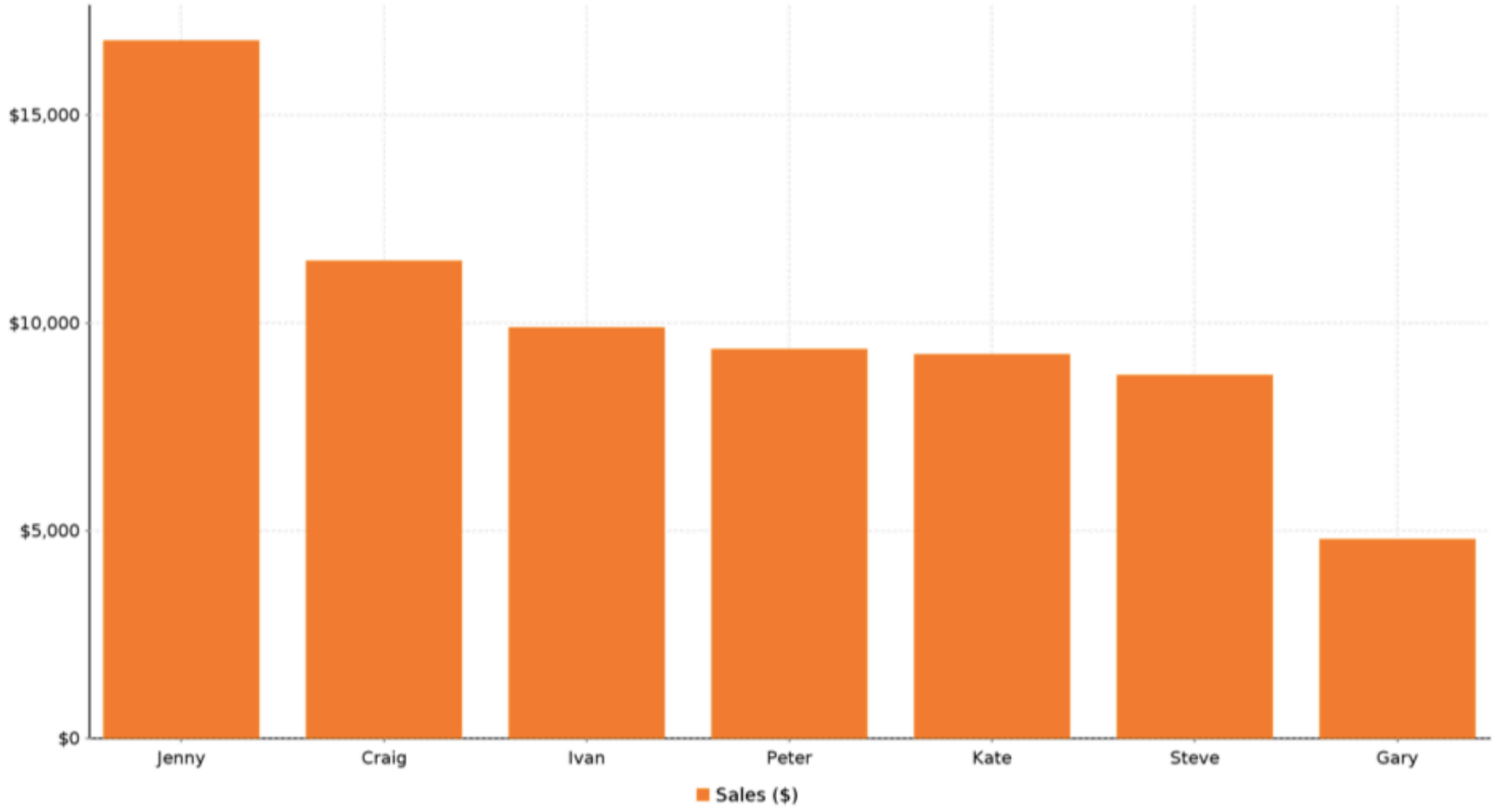
https://www.targit.com/en/blog/2016/01/data-visualization-best-practices-part-2

Simple is powerful!



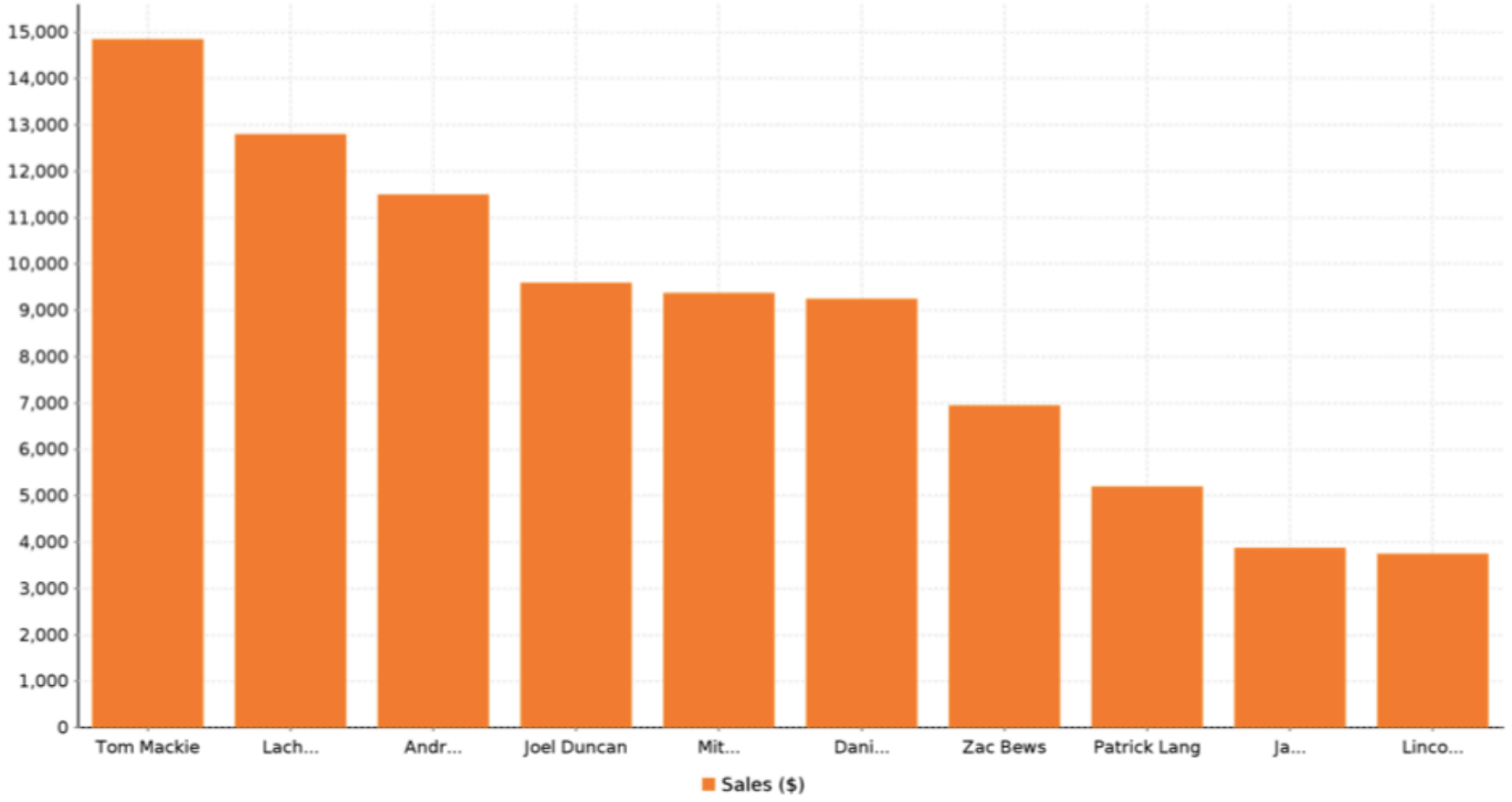
Few, Perceptual Edge

Column charts are simple and easy to understand...



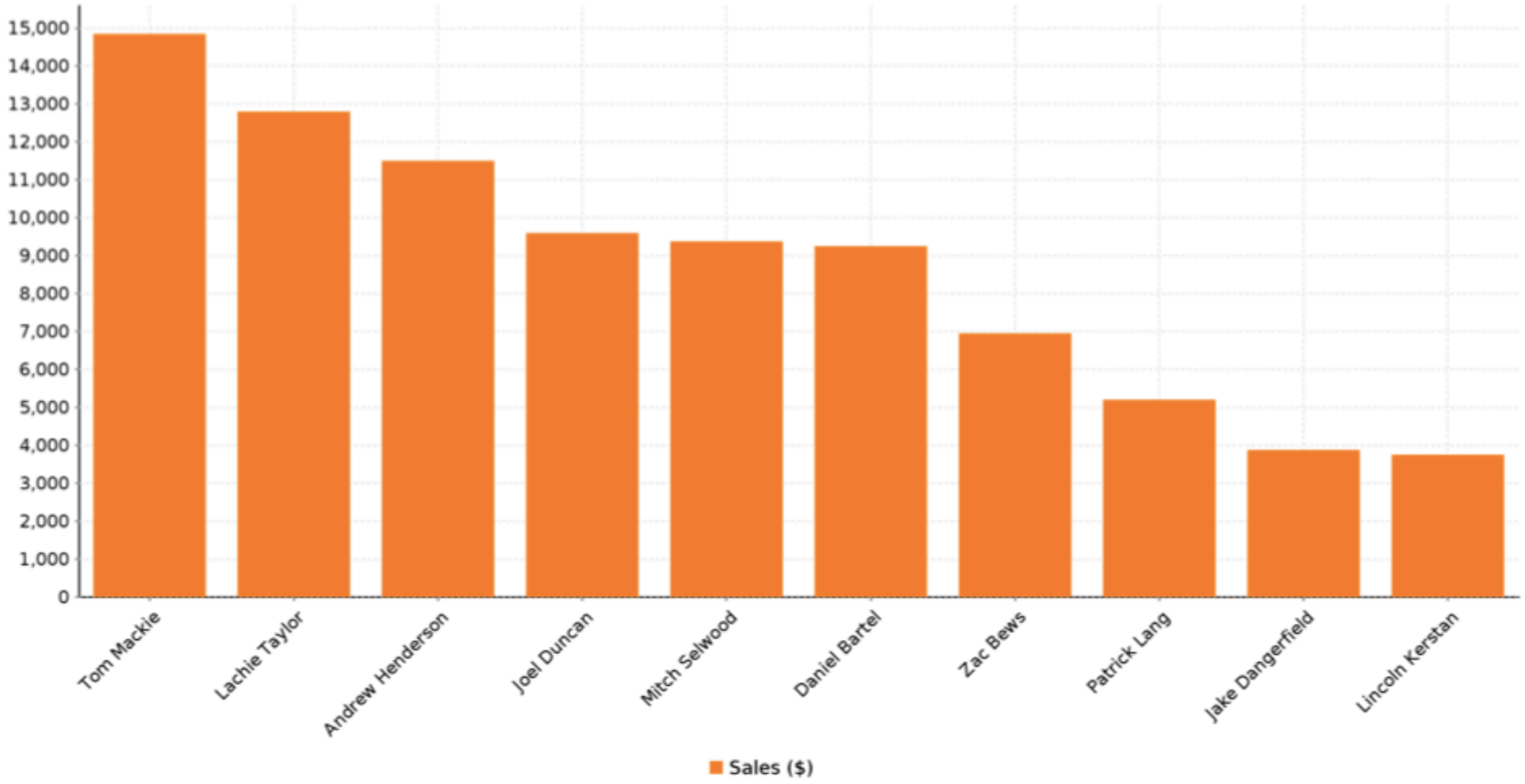
https://portal.yellowfinbi.com/

...but become difficult to compare with too many categories.



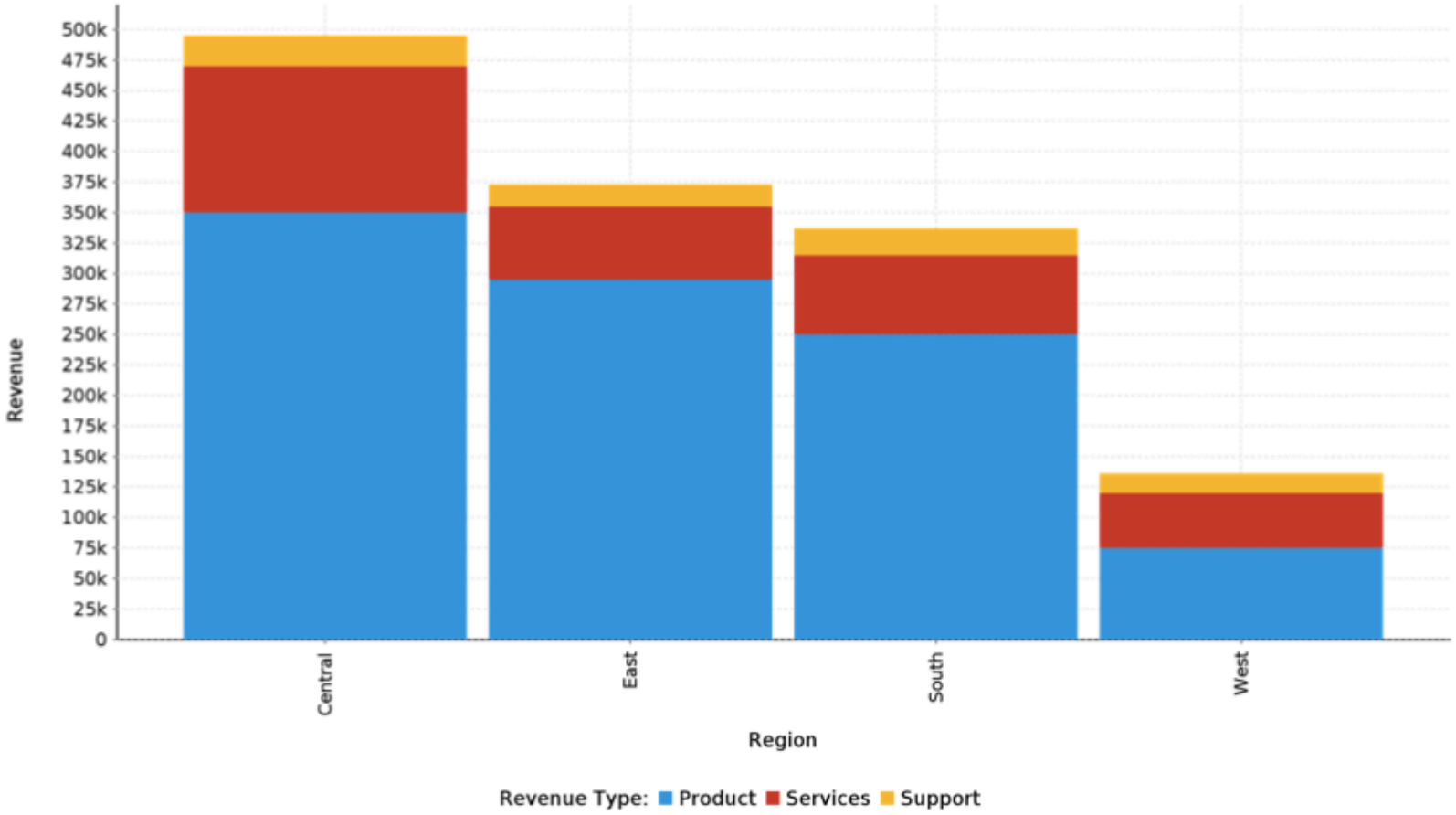
https://portal.yellowfinbi.com/

One solution is to rotate the horizontal font...



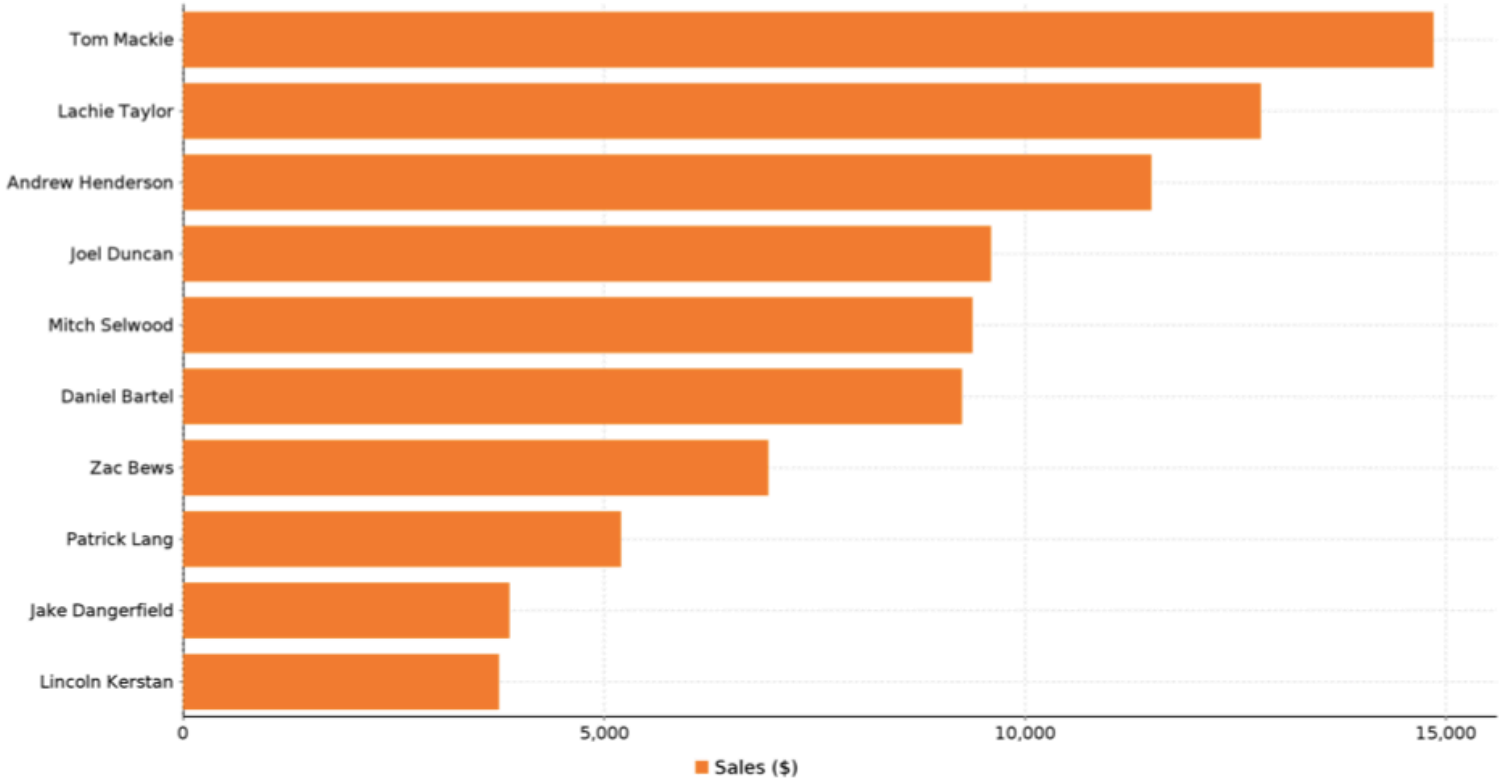
https://portal.yellowfinbi.com/

Try to avoid vertical labels as possible



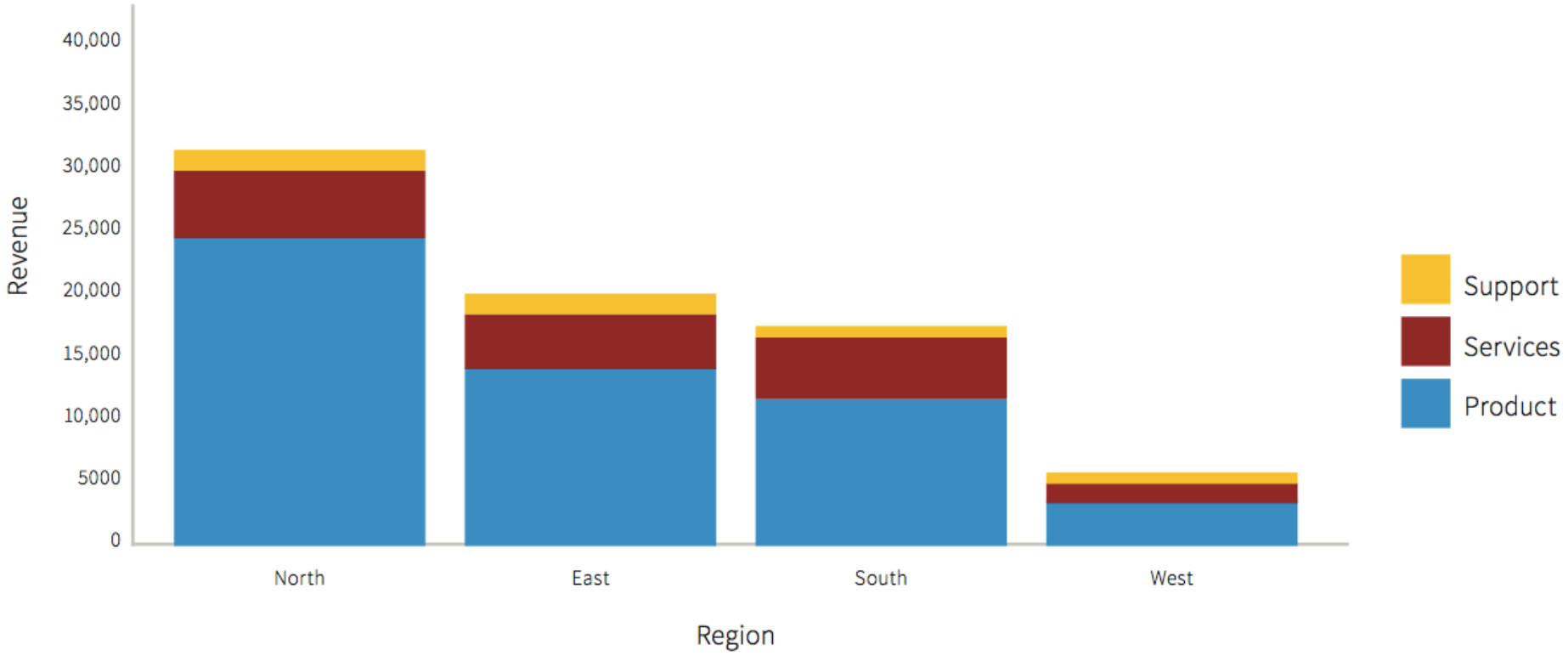
...Bar chart best if more than 10 categories

- Horizontal can be good if long text labels or many items



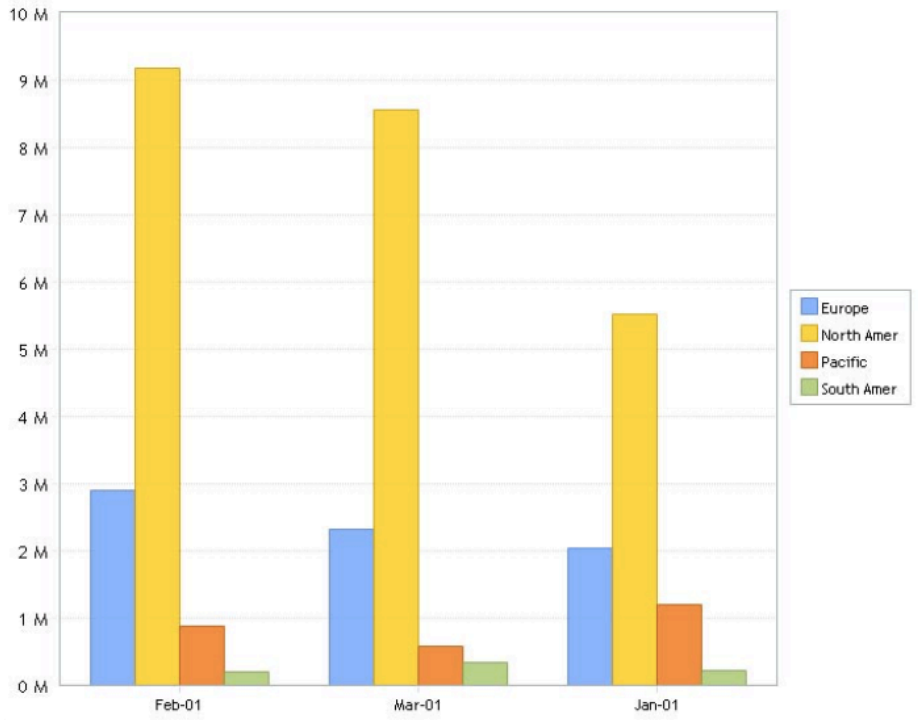
https://portal.yellowfinbi.com/

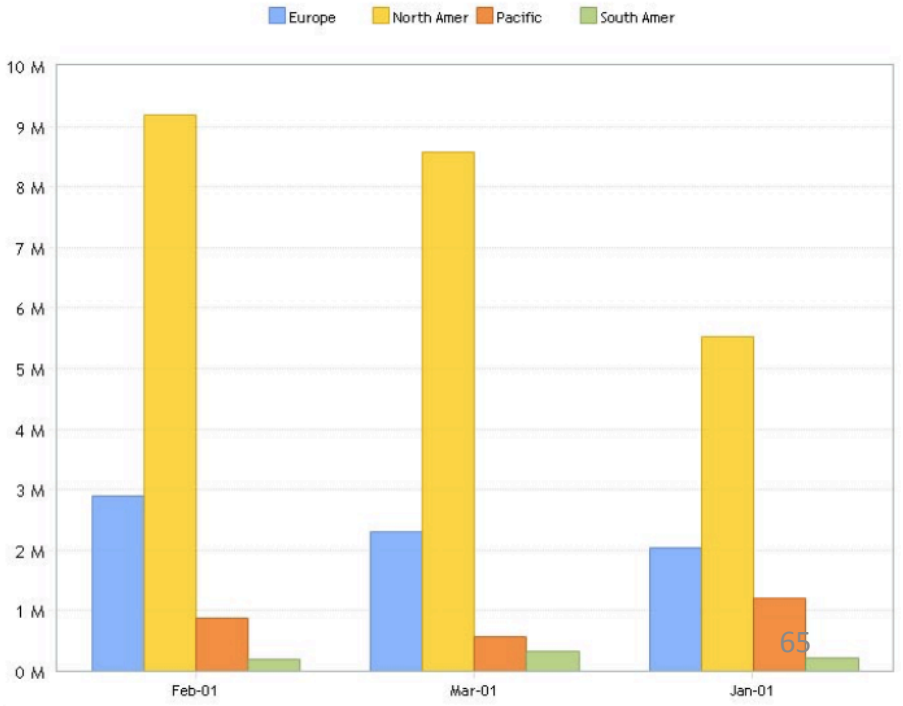
Use legends as your key



https://portal.yellowfinbi.com/Document.i4?DocumentId=1009768

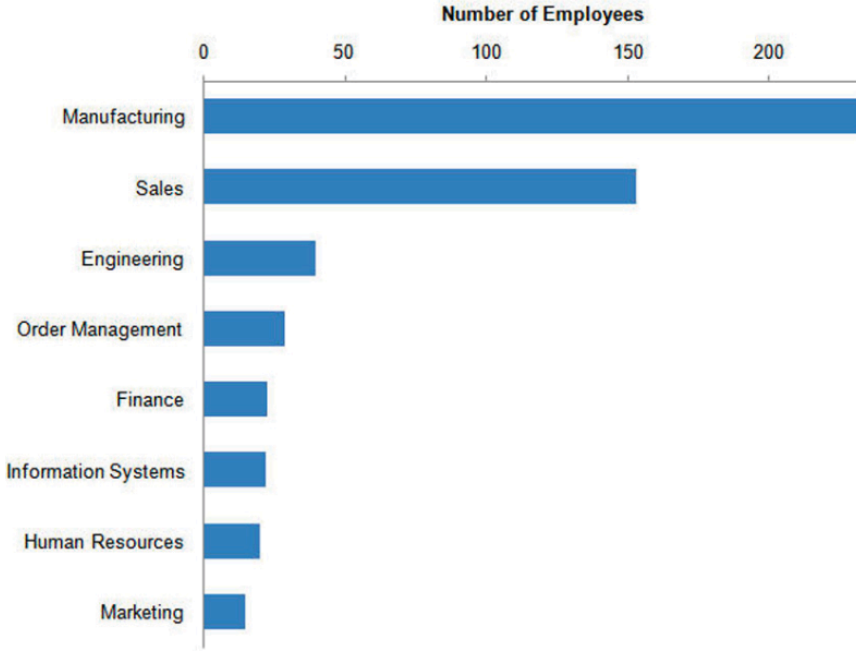
Legend placement

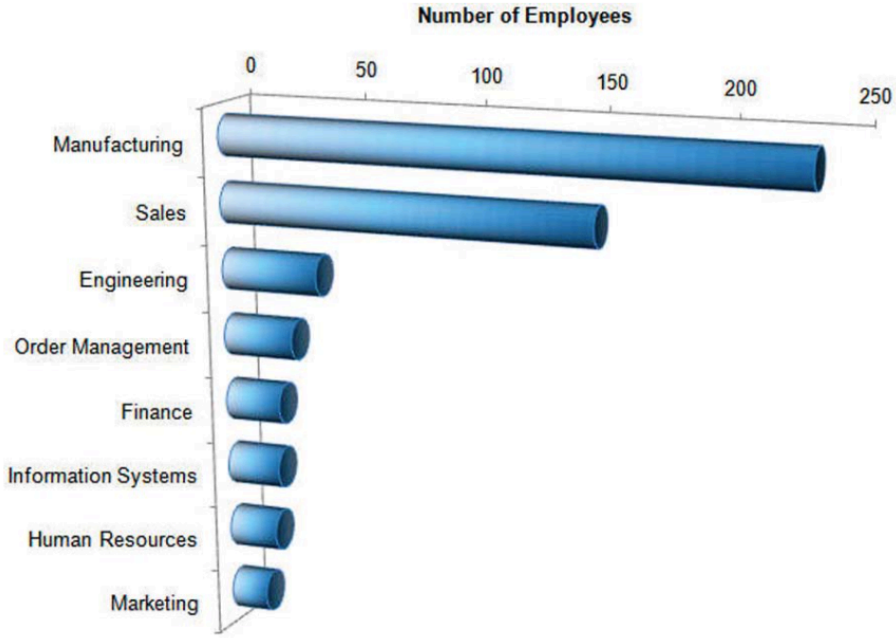




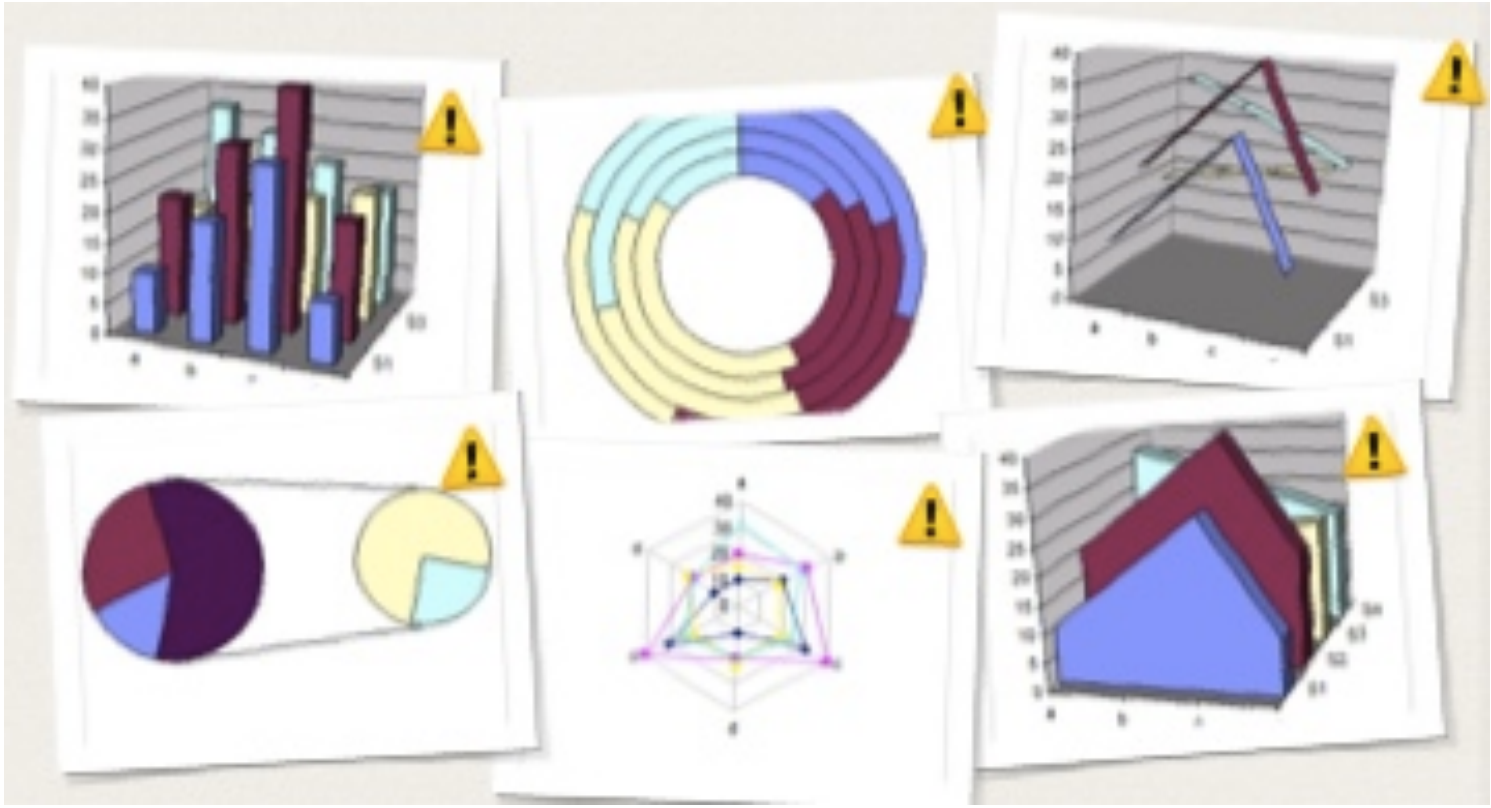
What not to do!

Which of the following two graphs is easier to read?

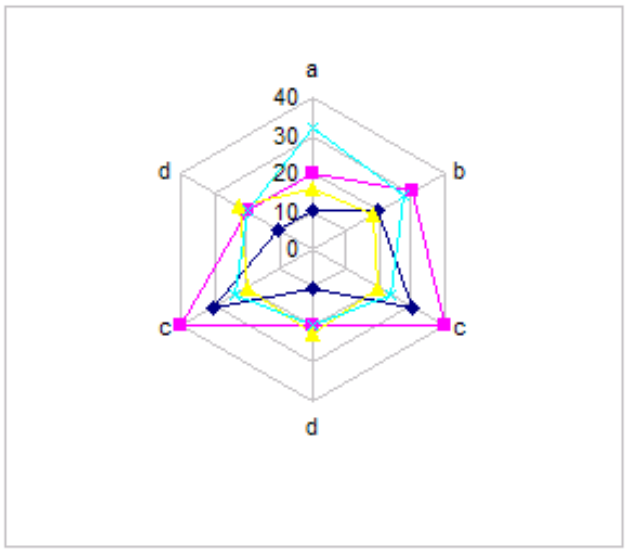




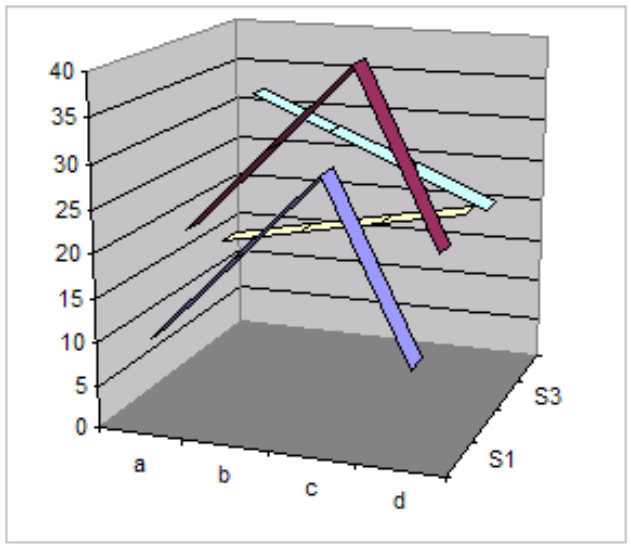
6 charts you will see in hell



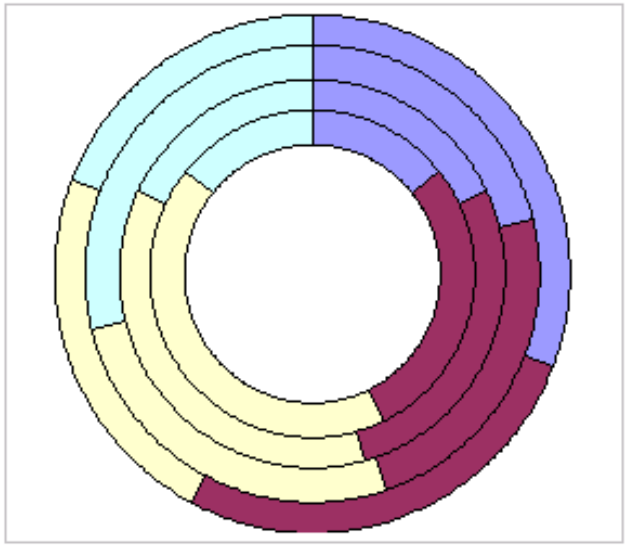
https://chandoo.org/wp/2008/09/03/6-charts-to-never-use/



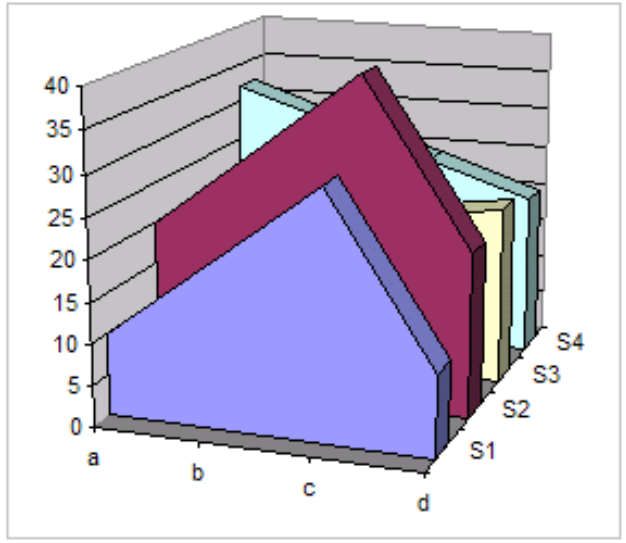
Leave the radar charts for Spidermen



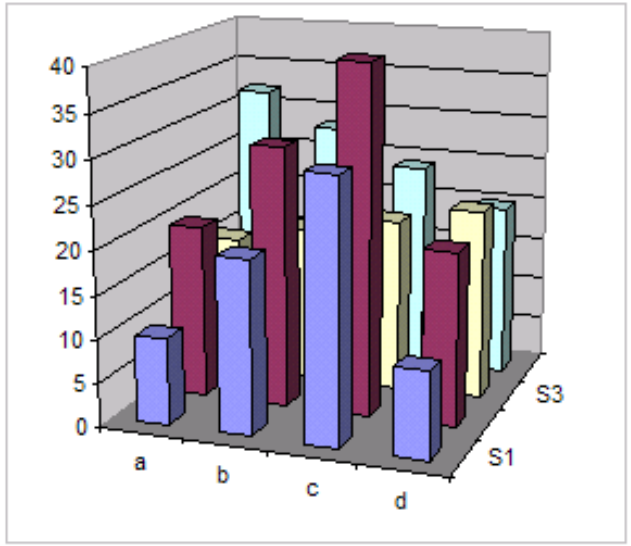
Don’t add dimensions to your lines



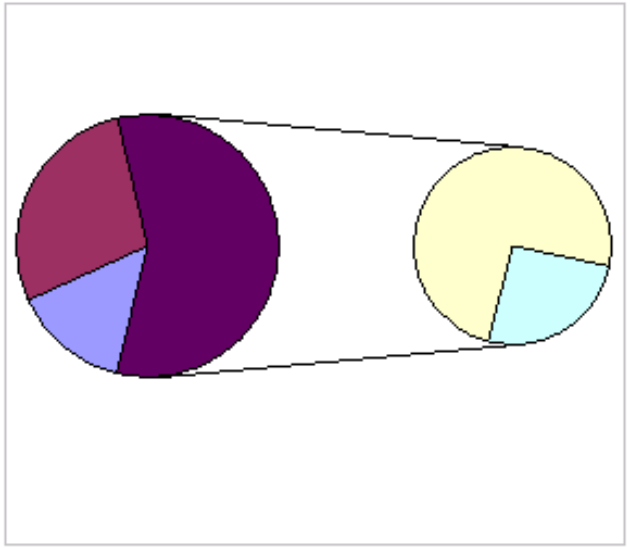
Don’t show, just eat your donuts



Save the unstacked area charts till we have x-ray vision

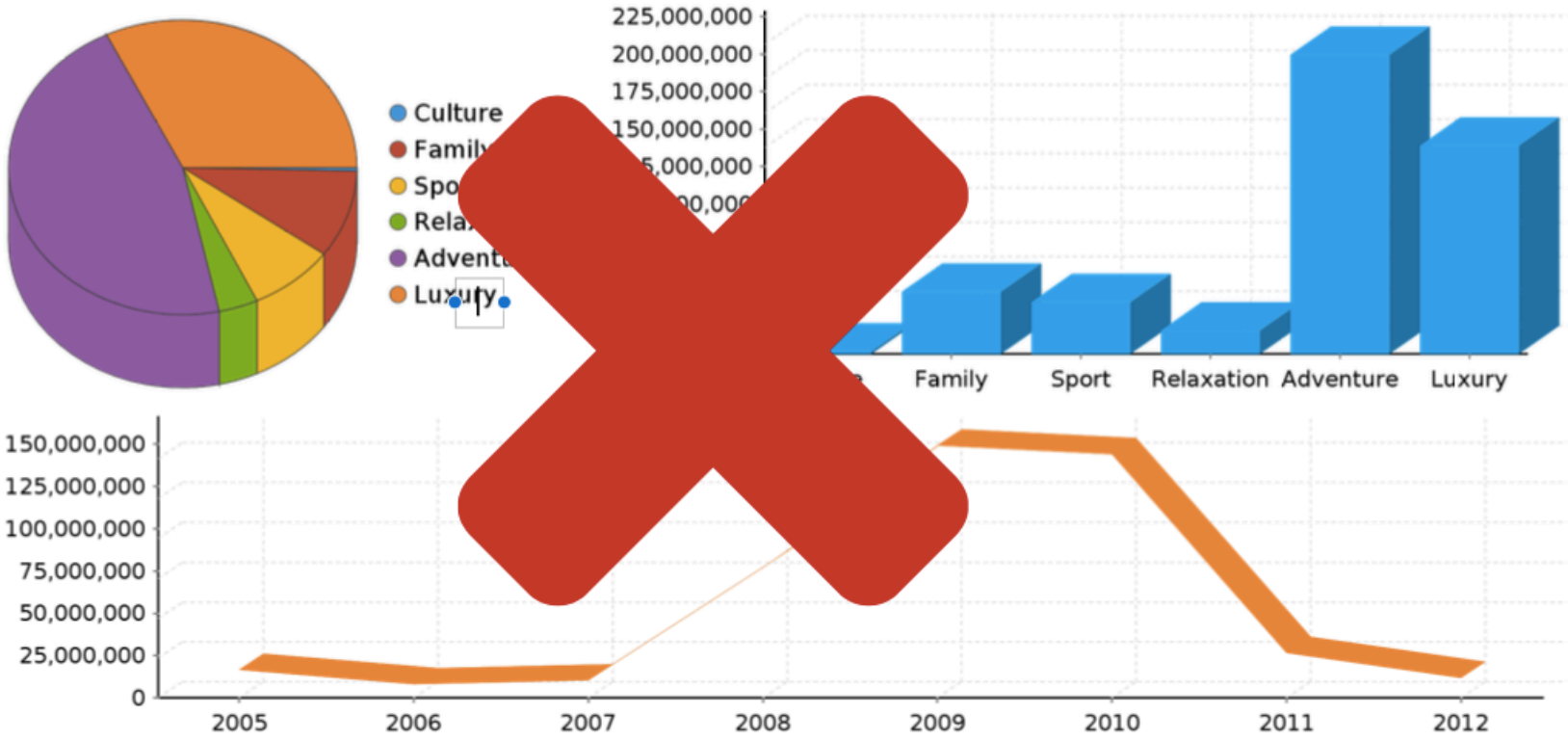


Don’t make your charts look like downtown



If one Pie is bad, two of them is worst

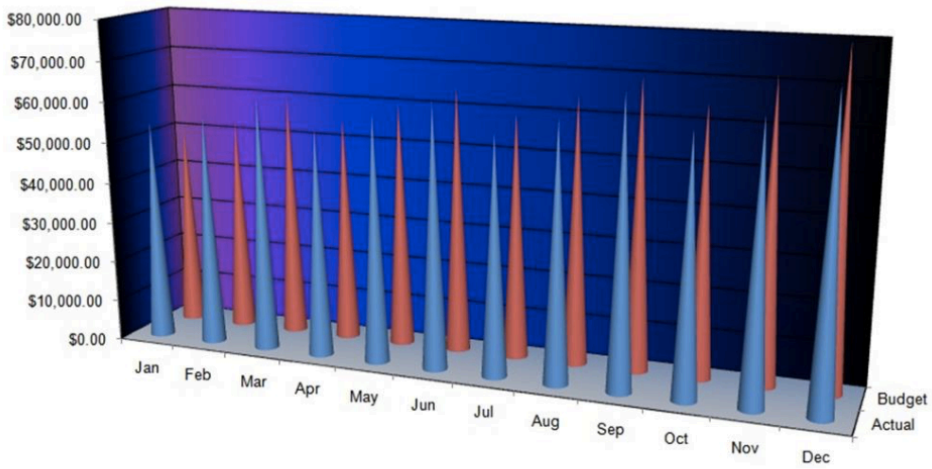
3D is not best practice

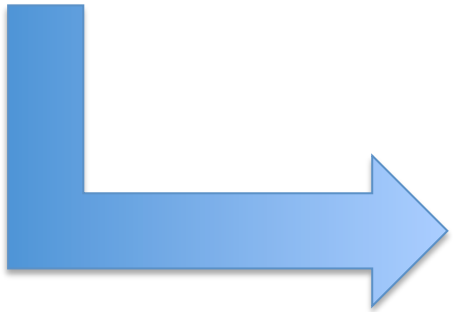


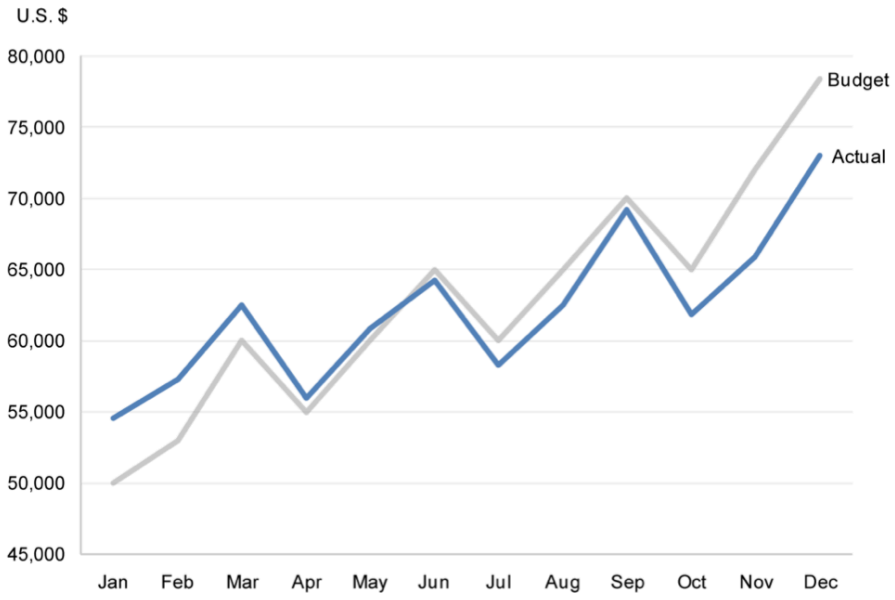
https://portal.yellowfinbi.com

Poor graphs can be transformed

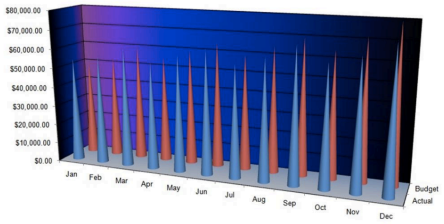
Try to compare actual expenses to the budget across time



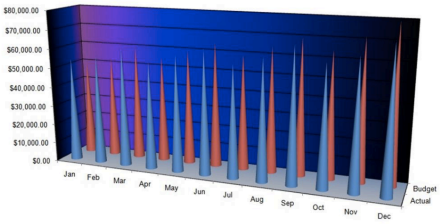


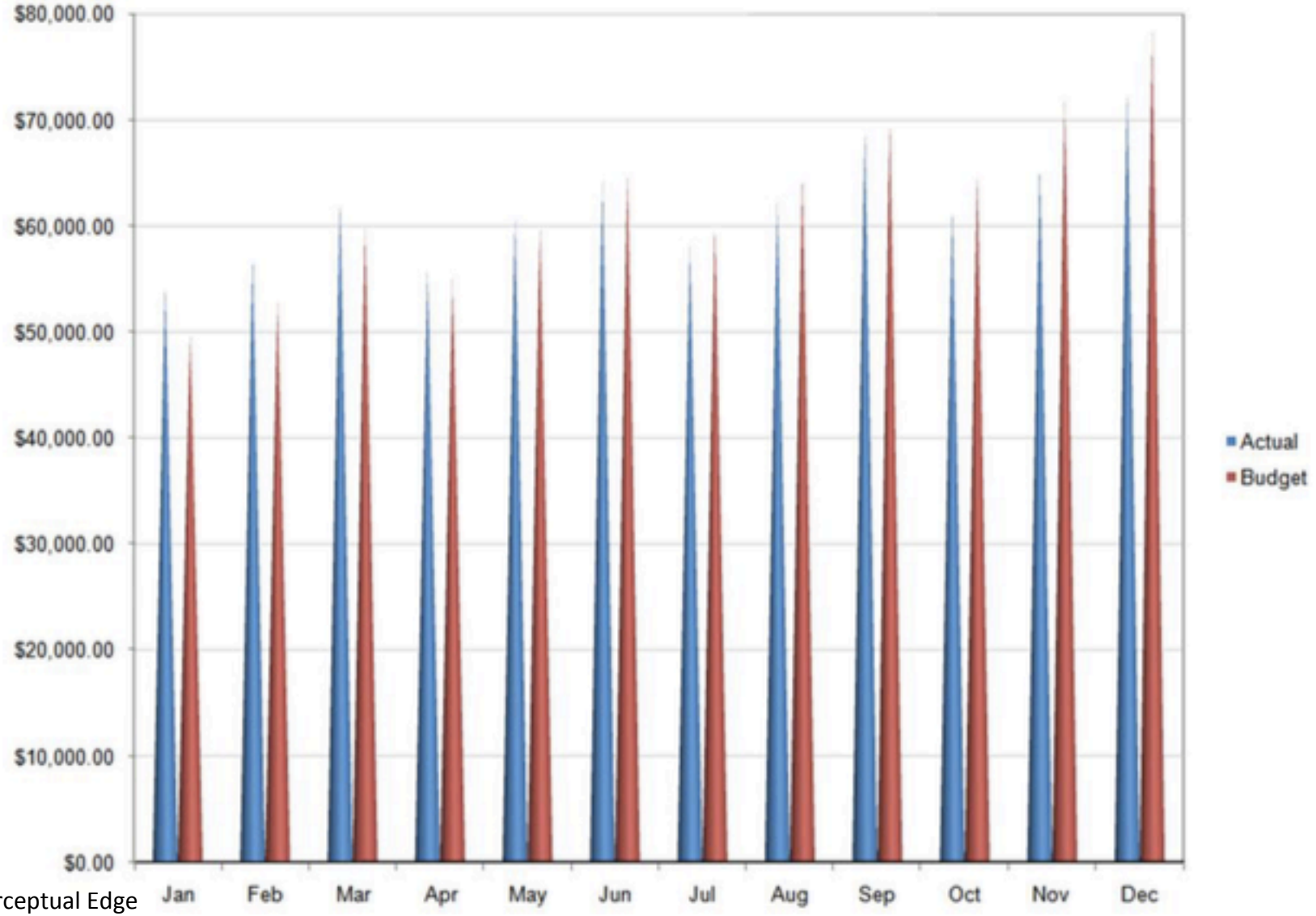


Few, Perceptual Edge

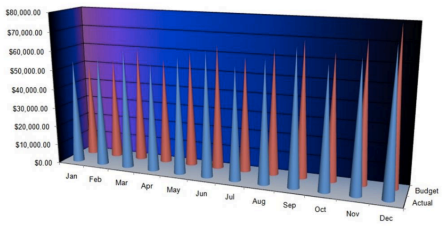


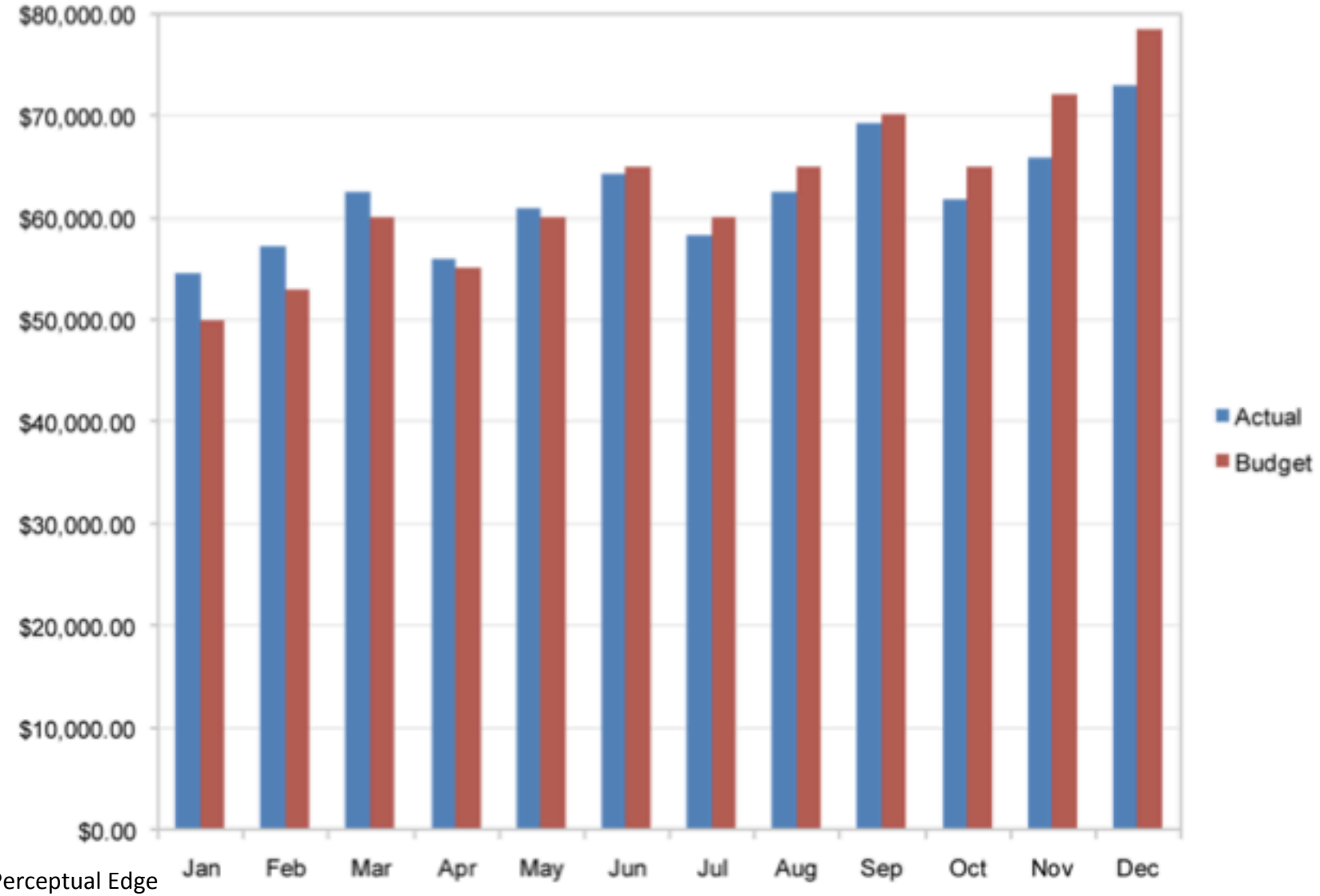
Few, Perceptual Edge



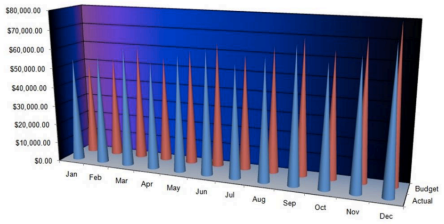


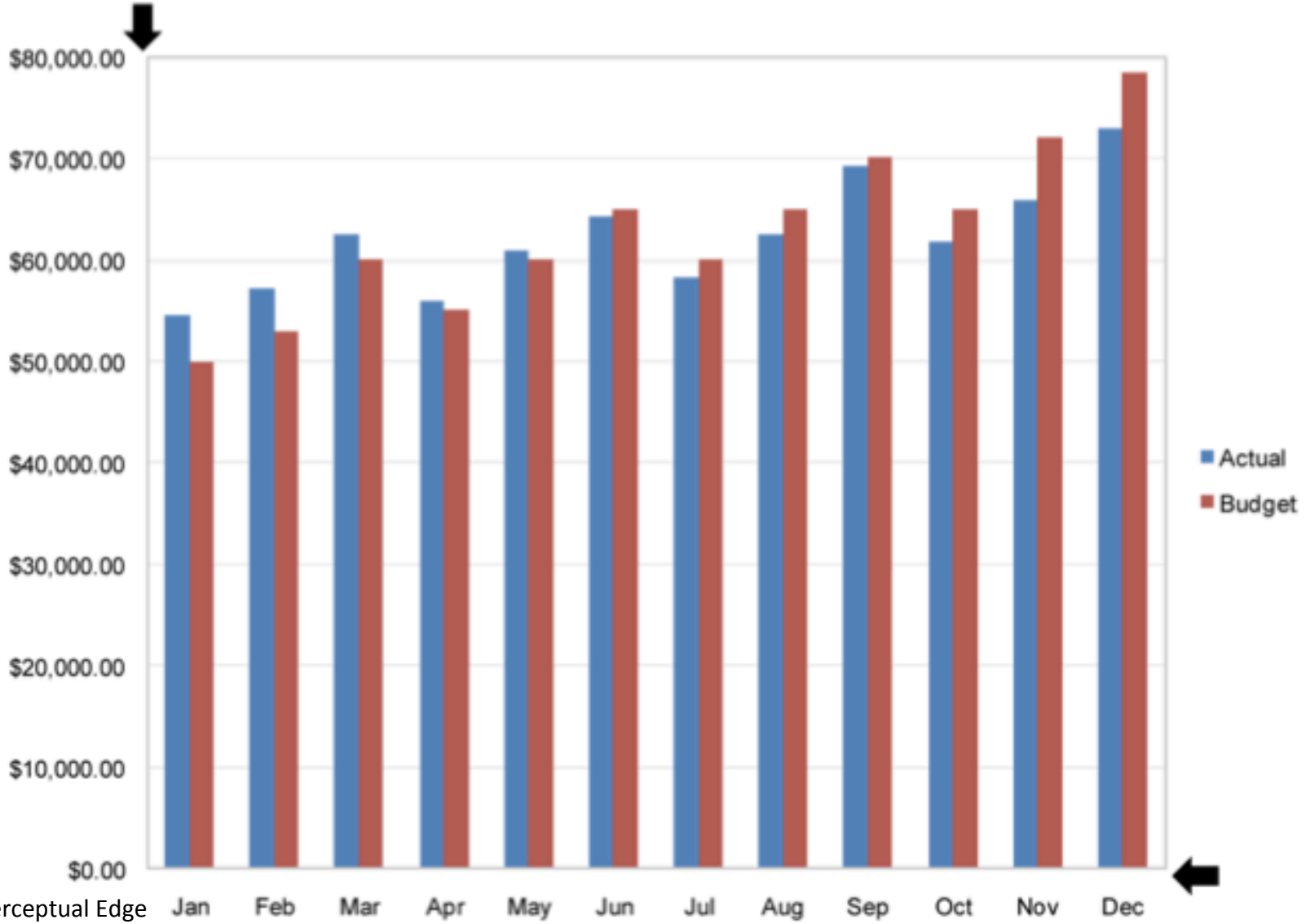
Few, Perceptual Edge





Few, Perceptual Edge


$80,000.00
$70,000.00
$60,000.00
$50,000.00
$40,000.00
$30,000.00
$20,000.00
$10,000.00
$0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Budget
Actual


$80,000.00
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$60,000.00
$50,000.00
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$20,000.00
$10,000.00
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Jan
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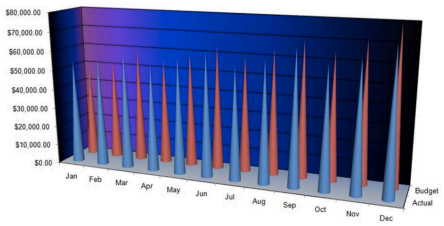
Actual
Budget

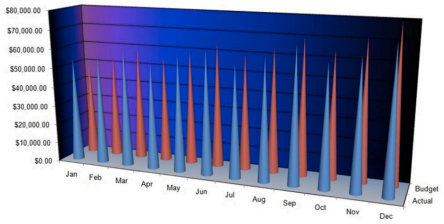


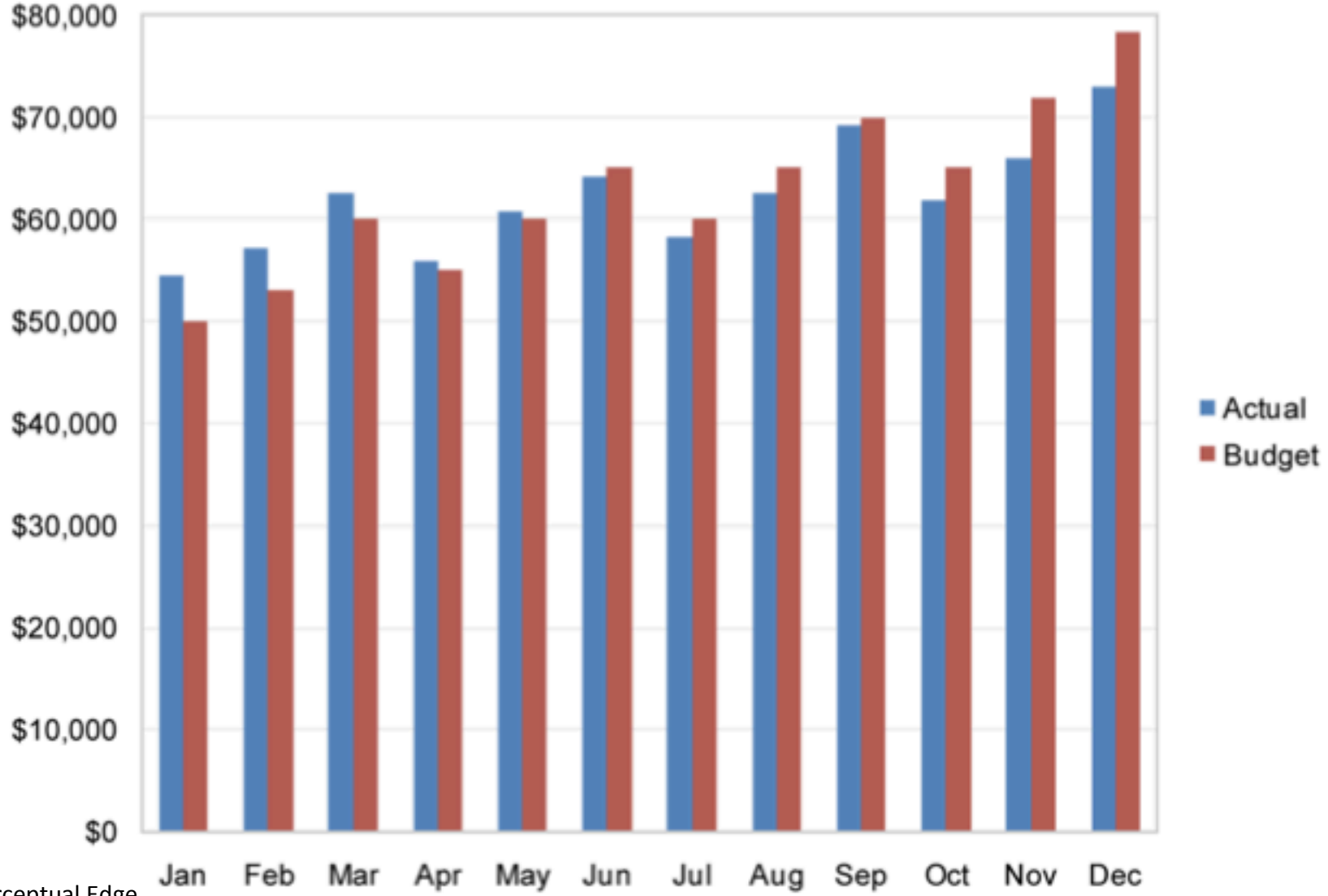
$80,000.00
$70,000.00
$60,000.00
$50,000.00
$40,000.00
$30,000.00
$20,000.00
$10,000.00
$0.00

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

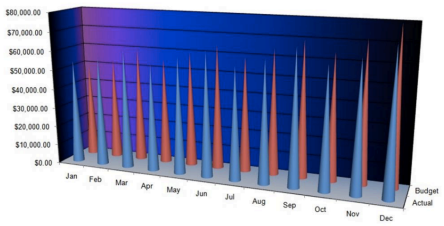
Actual
Budget

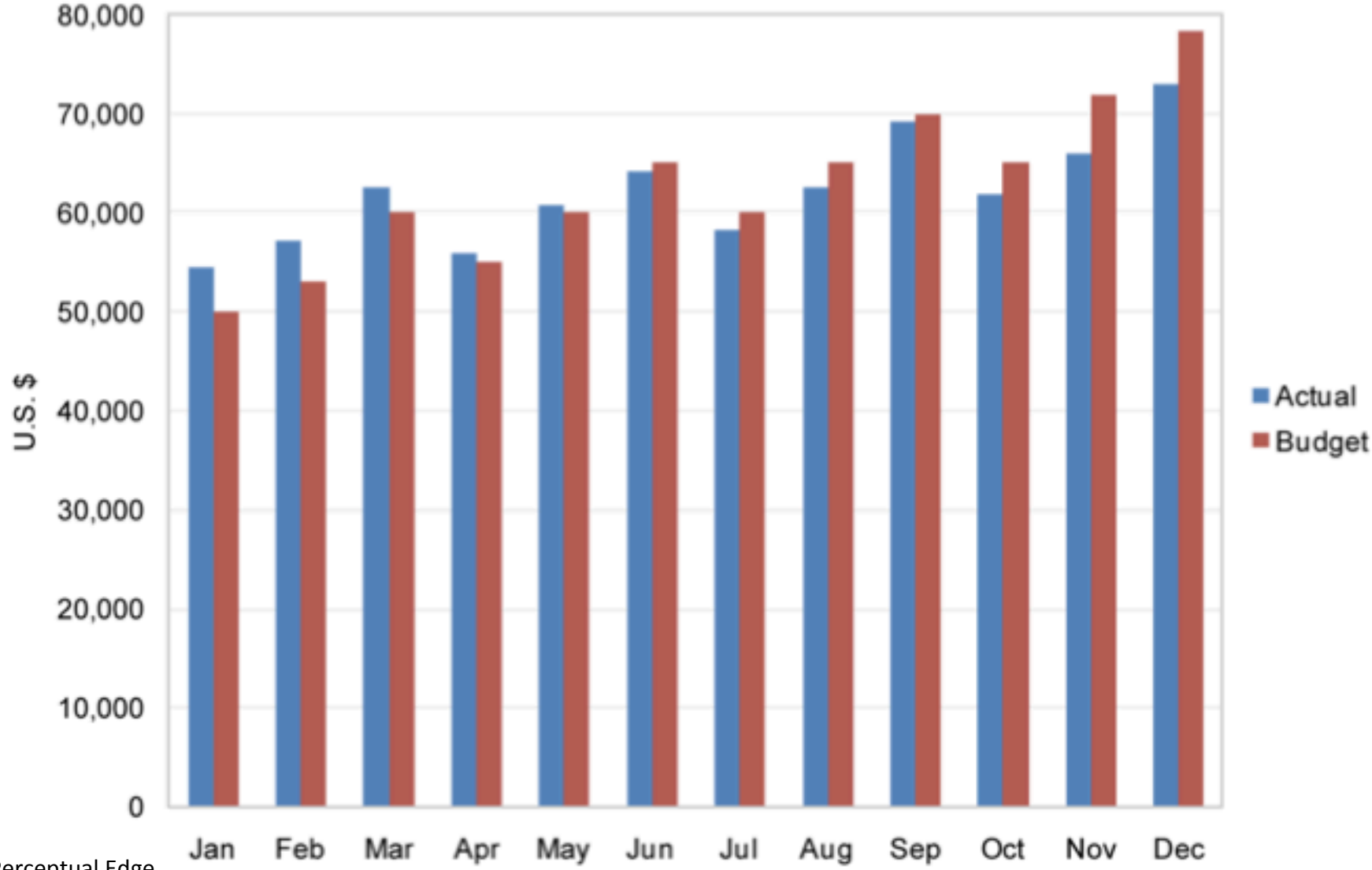
Few, Perceptual Edge



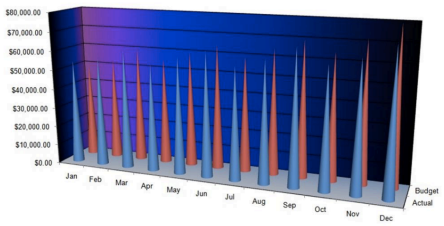


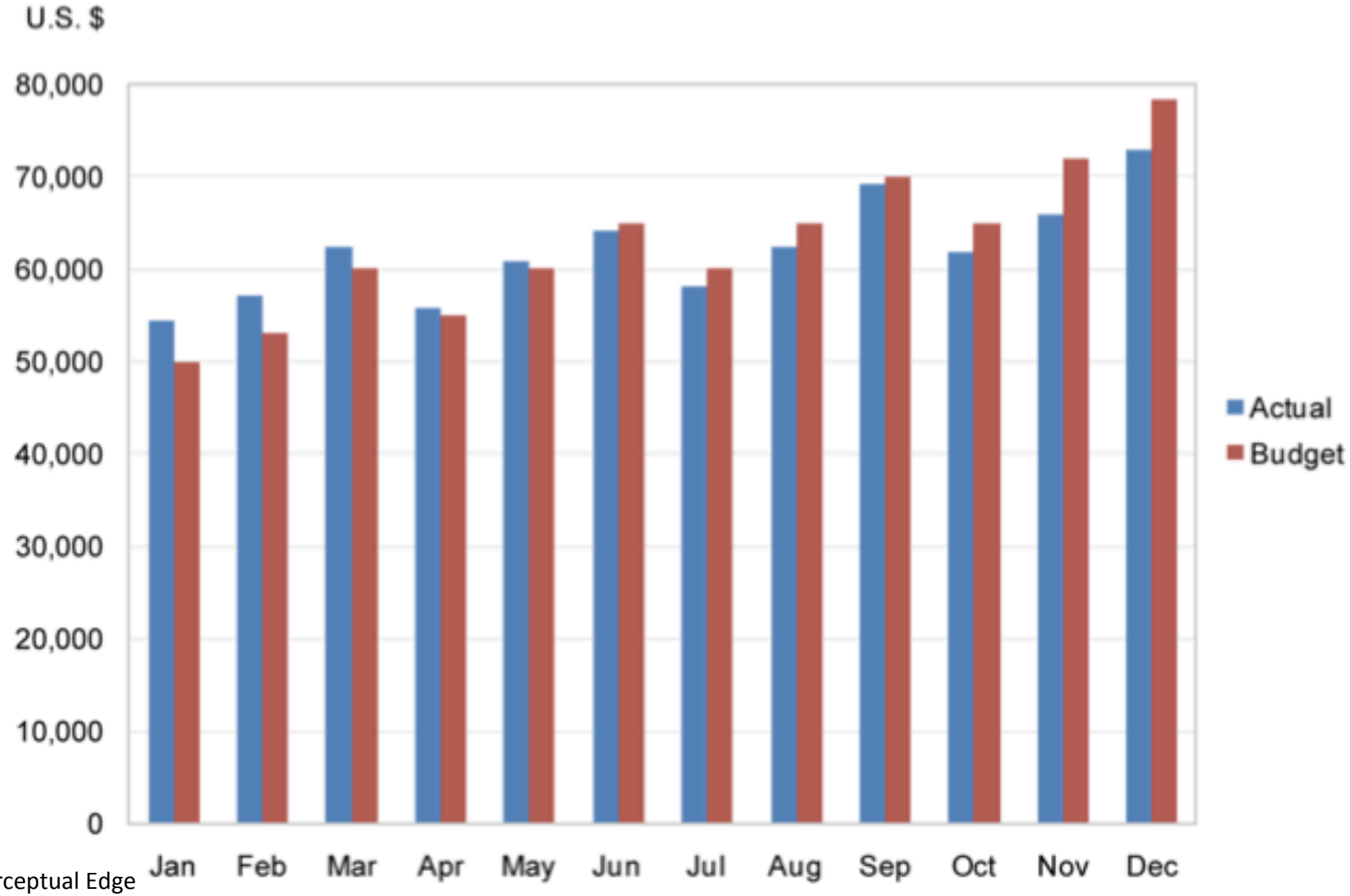
Few, Perceptual Edge



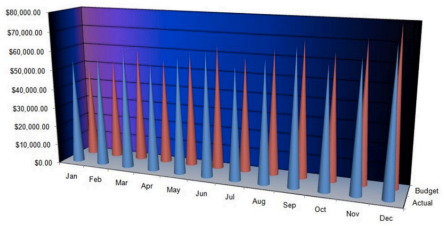


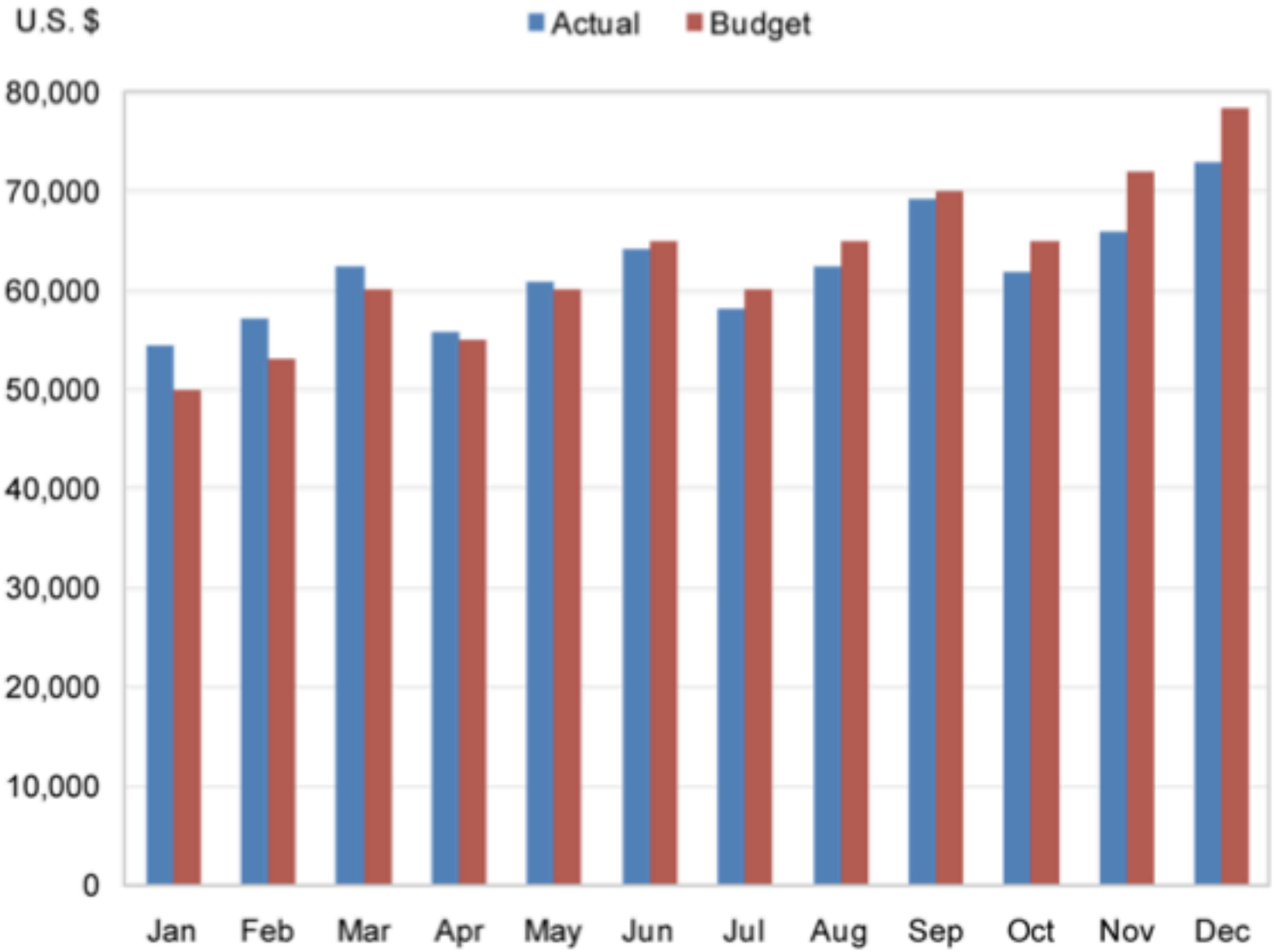
Few, Perceptual Edge



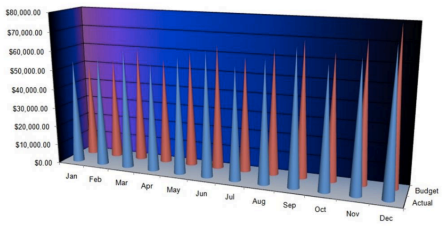


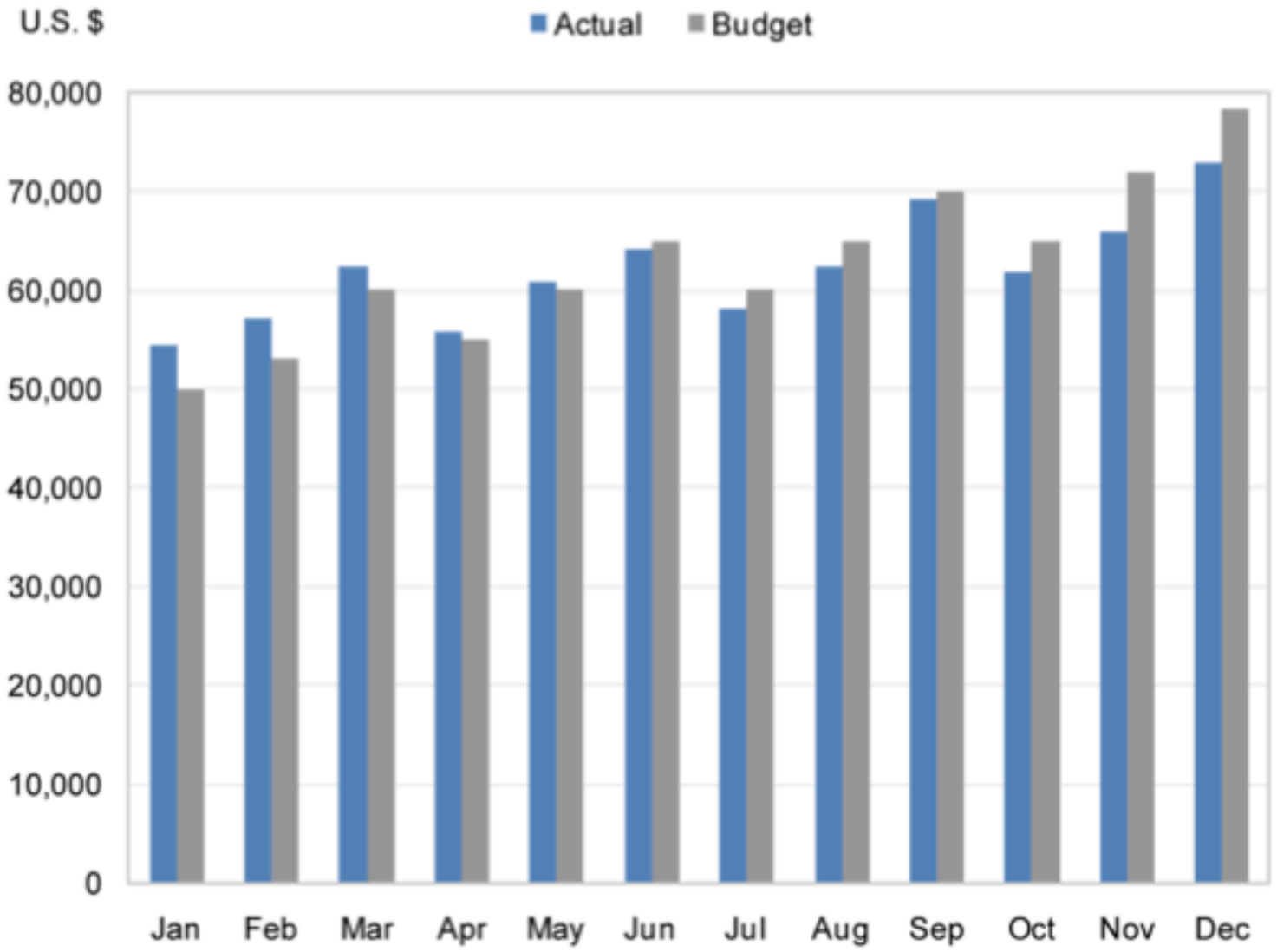
Few, Perceptual Edge



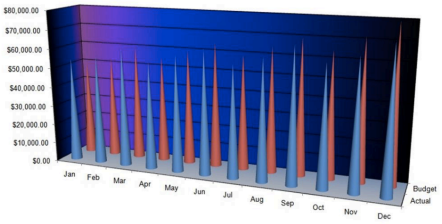


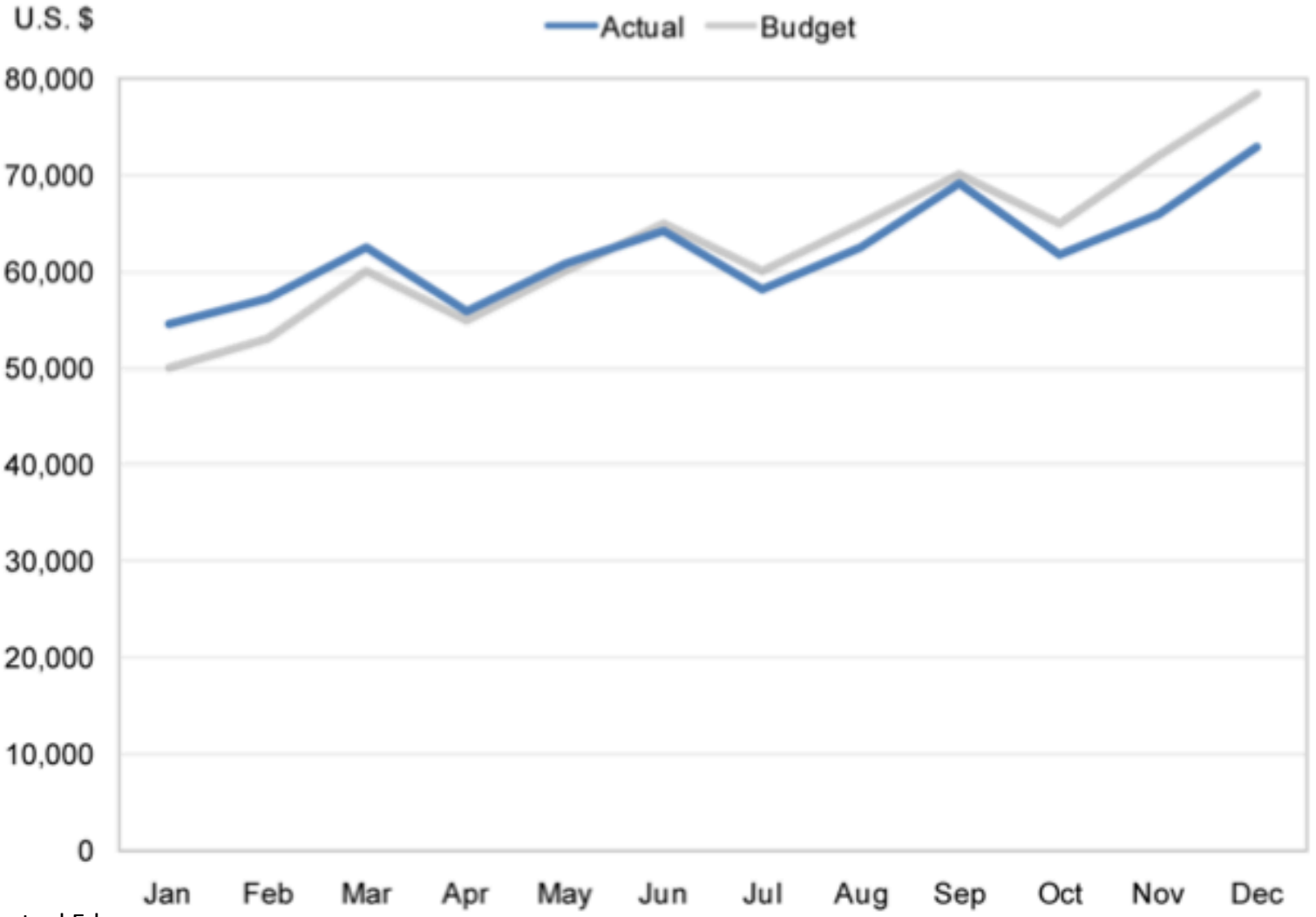
Few, Perceptual Edge



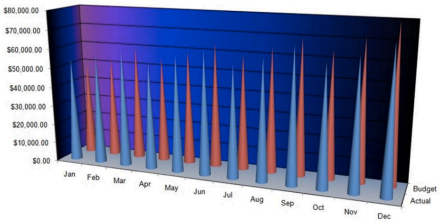


Few, Perceptual Edge





Few, Perceptual Edge



U.S. $

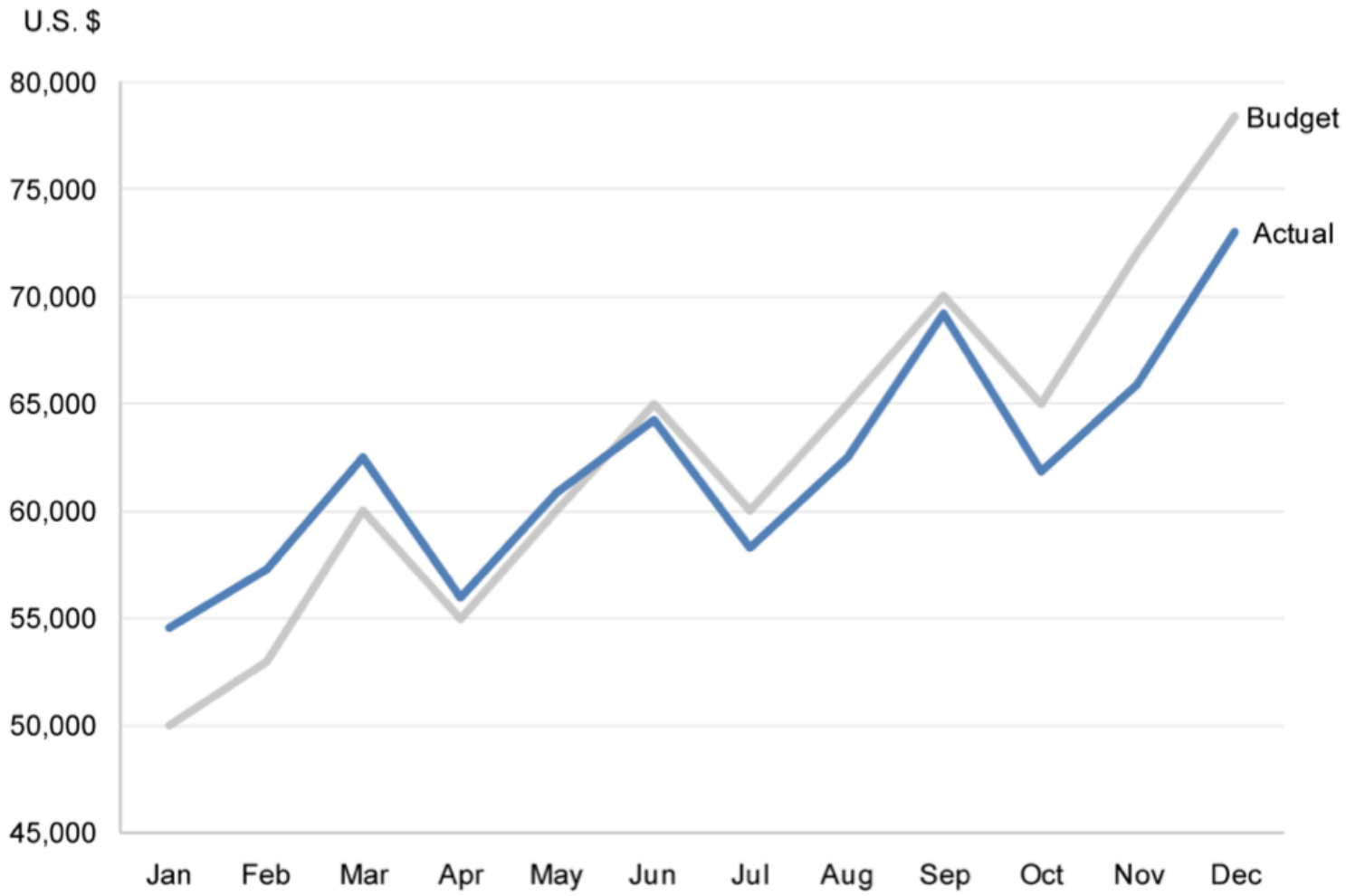
Actual Budget

80,000
75,000
70,000
65,000
60,000
55,000
50,000
45,000

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

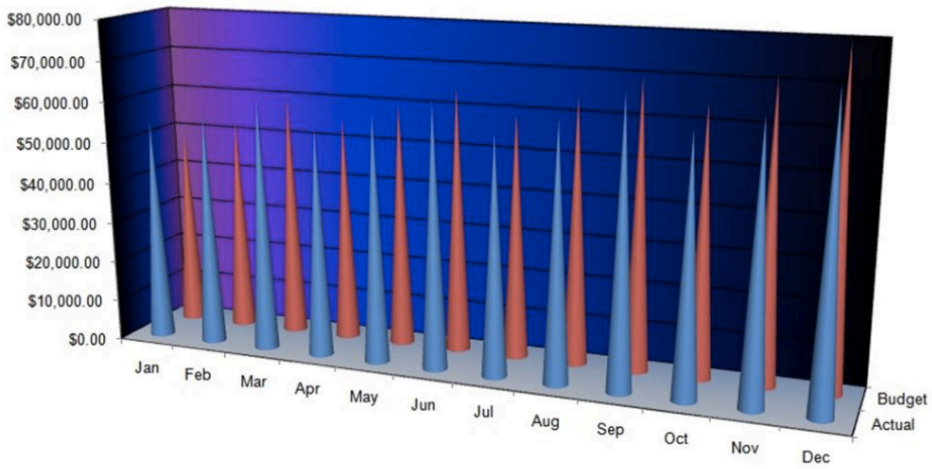
Few, Perceptual Edge

Is it easier to compare them now?

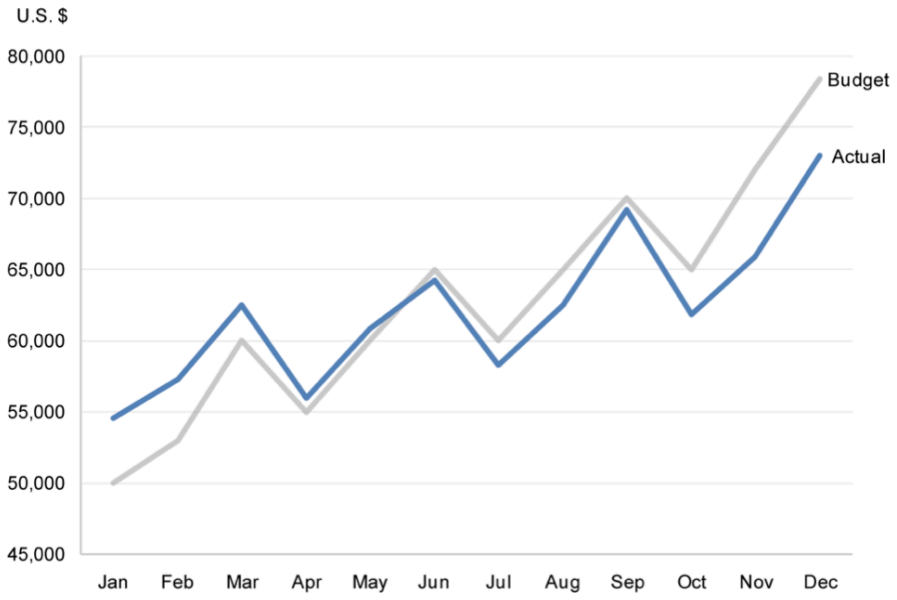


Few, Perceptual Edge

Try to compare actual expenses to the budget across time



13 steps



Few, Perceptual Edge

Now it is your turn…

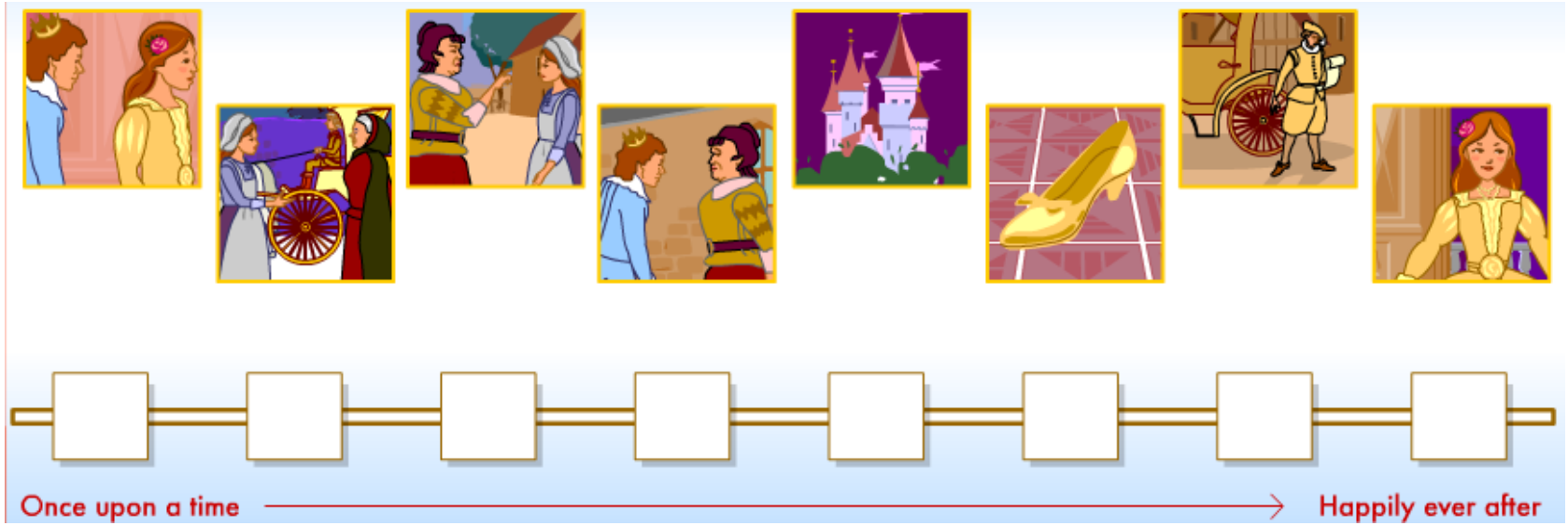
- Draw a chart that reflect your actual learning curve from this lecture versus your expected learning curve ☺

In order to communicate your information effectively

- Determine your message and identify your data
- Determine if a table, graph, or combination of both is needed to communicate your message
- Determine the best means to encode the values
- Determine where to display each variable
- Determine if particular data should be featured, and if so, how

Next

Once upon a time



http://www.learner.org/interactives/story/

Extra slides

Graphs should

- Show the data
- Avoid distorting what the data have to say
- Present many numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- Be closely integrated with statistical and verbal descriptions of a data set

Few's selection and design process

- Should particular data be featured, and if so, how?
  - use bright or dark colors (when using soft colors for everything else)
  - bars - place borders around only those bars that should be highlighted
  - lines - make lines to be highlighted thicker
  - points - make featured points larger or include fill color in them alone

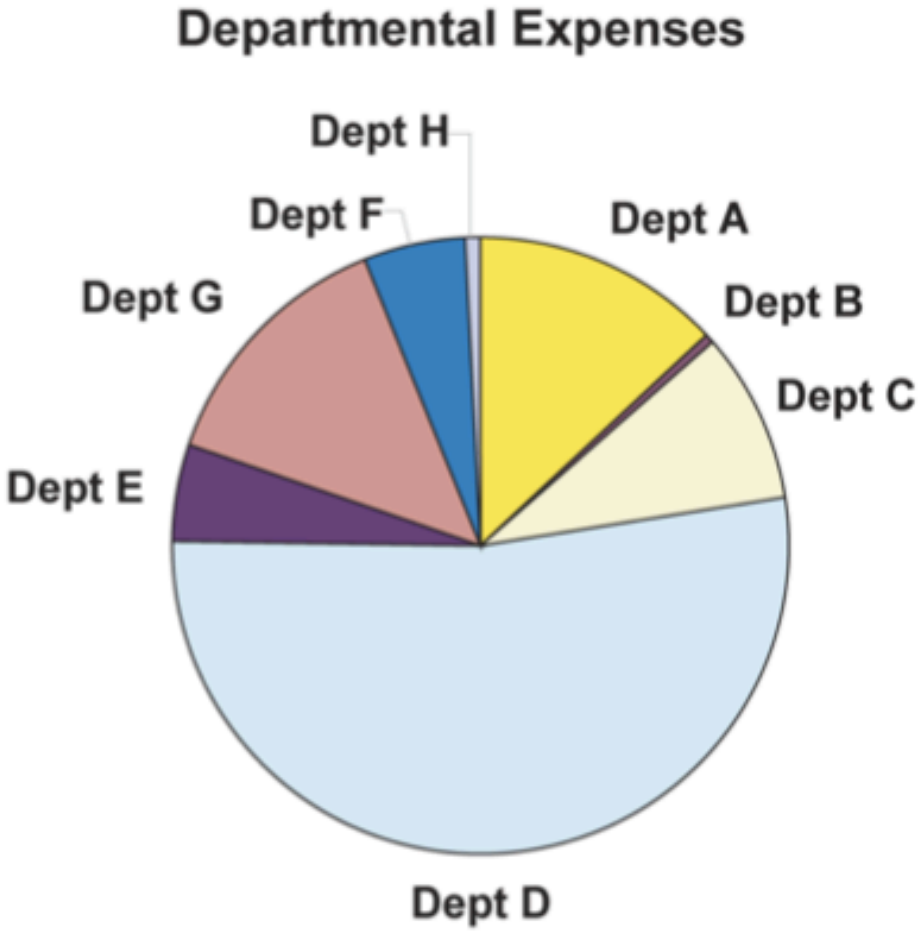
Few's selection and design process

- Range of the quantitative scale?
  - bars - start from 0
  - lines, points - adjust scale so that it extends a little below the lowest data value and a little above the highest
  - bars - if you want to narrow the scale, switch from bars to points
- If a legend is required, where to place it?
  - the more directly you label the data, the better
  - bar - arrange labels to match the arrangement of bars
- Tick marks required for axis?
  - only necessary on quantitative scales
  - only major tick marks are necessary (5-10 usually enough)

Few's selection and design process

- Best location for the quantitative scale?
  - avoid placing scale on right side unless necessary
  - if quantitative scale ranges between positive and negative, place axis at 0 (but don't let labels interfere with data)
- Grid lines required?
  - values cannot be interpreted with the necessary degree of accuracy
  - subset of points in multiple related scatter plots must be compared
  - if used, make them barely visible
- What descriptive text is needed?
  - title
  - axes titles

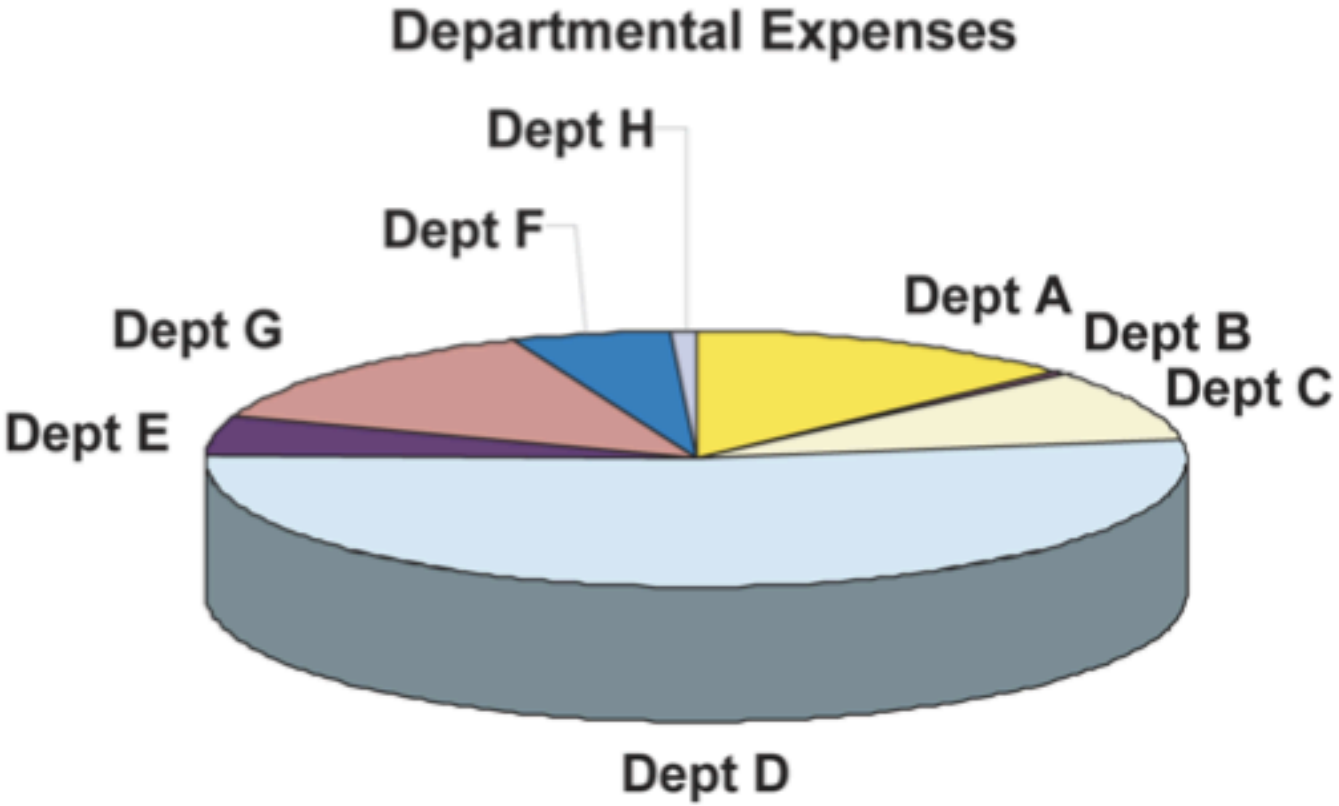
Is the message clear?



how Department G is doing regarding expenses compared to the other departments

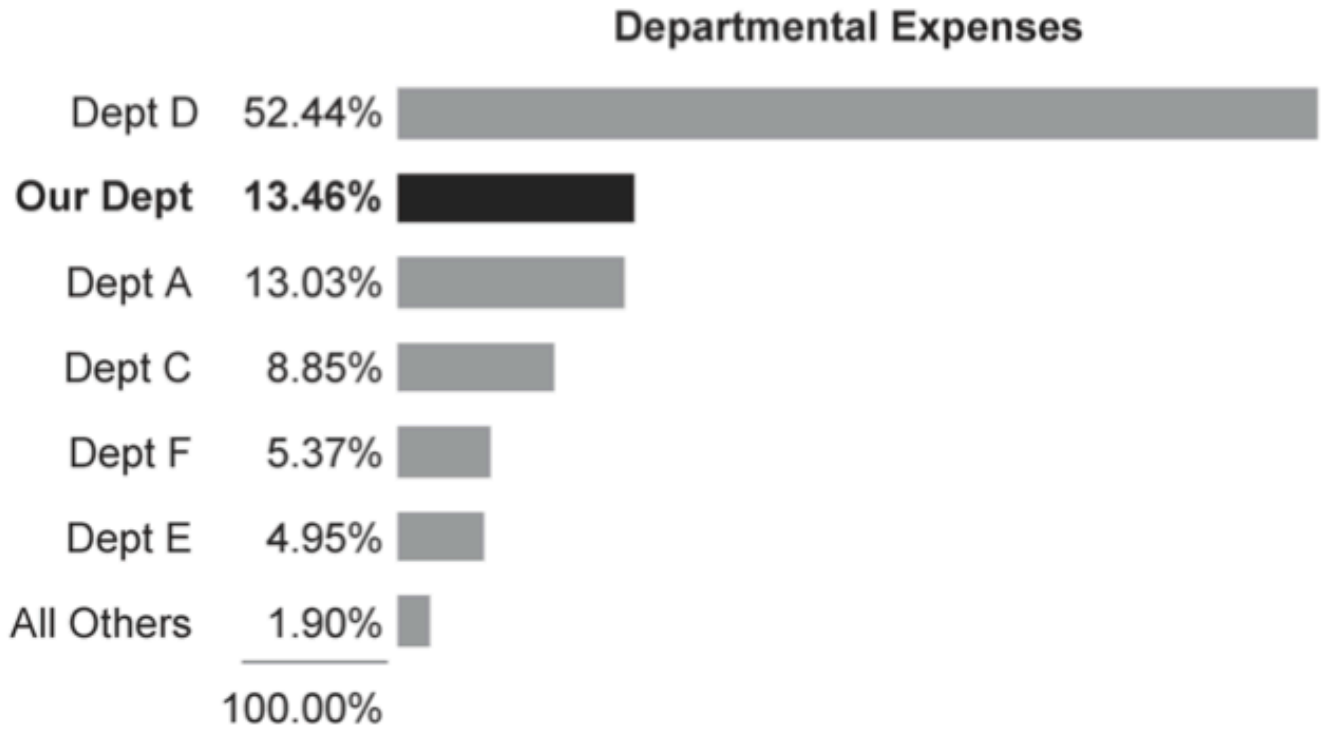
Few, Perceptual Edge

Does the addition of 3D improve this pie chart?



Few, Perceptual Edge

This chart convey the message simply and elegantly



Few, Perceptual Edge

ICA12