



# **MECC 2021:**

# **Data Viz Workshop**

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**Oct 24, 2021**

# Questions from audience + schedule

- Challenges of virtual/zoom presentation
- If you have any questions, please ask in chat and I'll get to it as soon as I can (I'll be keeping an eye on chat)
- If you'd like me to slow down, speed up, or repeat myself also let me know in chat
- Slides can be made available afterwards
- **Schedule:**
  - 1-3pm - presentation (I'll try to break for 10 min between sections)
  - 3-4pm - breakout into groups, share your own viz, get some feedback

# Agenda

## 1) Intro to Data Viz (25 min)

- Explain what a data viz is and show ex
- Look at the components that make up a viz
- Explain what a good viz does and how to think about your own work
- Share some resources for choosing viz type

## 2) Data Viz Checklist (40 min)

- Introduce the data viz checklist created by Sanjines, Evergreen, and Lyons
- Discuss all 24 items on the checklist and how it helps you to rate, evaluate, and improve your visualizations
- Try it out on some examples

## 3) Figures + Diagrams (15 min)

## 4) Tables (15 min)

## 5) Exporting / Outputting (5 min)

## 6) Breakout (50 min)

- Bring a viz (your own or one you've found), and break into groups
- Use the data viz checklist and graphic design concepts to rate, evaluate, and improve your viz
- Get feedback from the colleagues in your group

# What is data visualization (data viz)?

91%

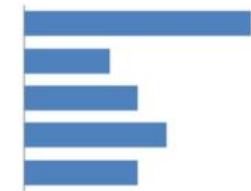
Simple text



Scatterplot



Vertical bar



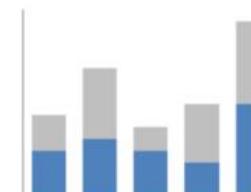
Horizontal bar

	A	B	C
Category 1	15%	22%	42%
Category 2	40%	36%	20%
Category 3	35%	17%	34%
Category 4	30%	29%	26%
Category 5	55%	30%	58%
Category 6	11%	25%	49%

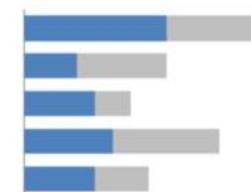
Table



Line



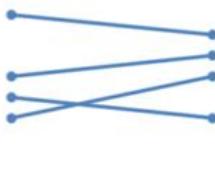
Stacked vertical bar



Stacked horizontal bar

	A	B	C
Category 1	15%	22%	42%
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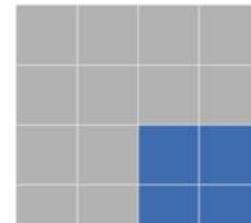
Heatmap



Slopegraph



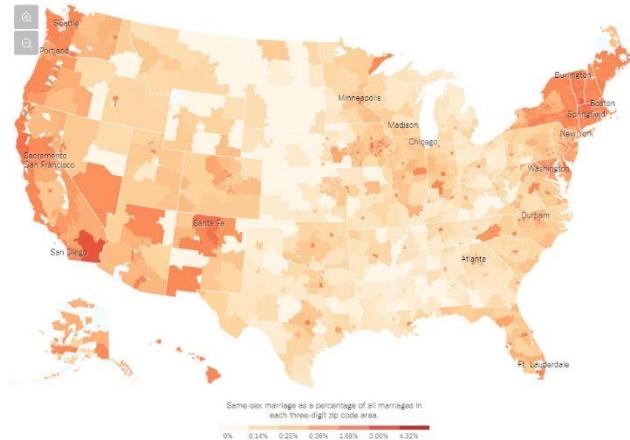
Waterfall



Square area



Same-sex marriage as a percentage of all marriages in each 3-digit zip code



<https://www.nytimes.com/2016/10/19/upshot/what-this-2012-map-can-tell-us-about-the-2016-election.html>

## STATE OF THE UNION 2014

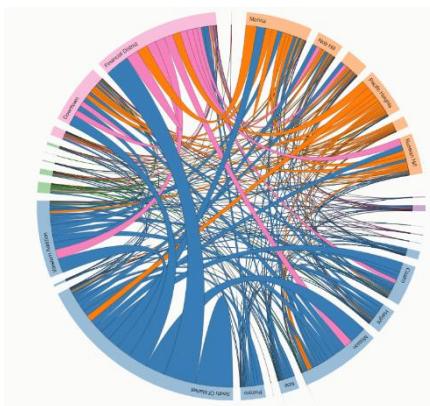
KEY TERMS FROM PRESIDENT OBAMA'S SPEECH



<http://abcnews.go.com/Politics/fullpage/state-union-address-word-cloud-infographic-22273151>

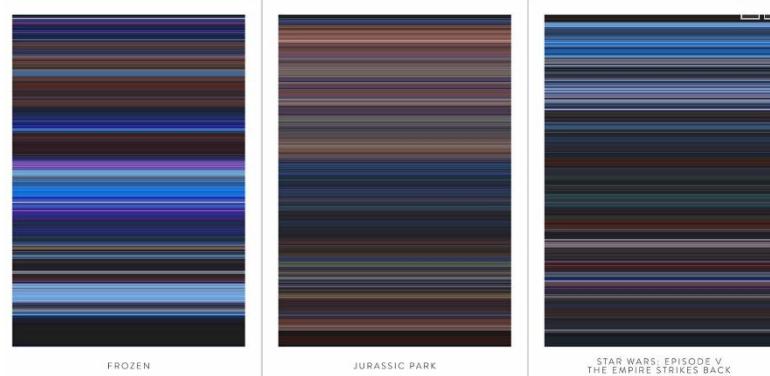


Uber Ride Frequency in San Francisco Neighborhoods



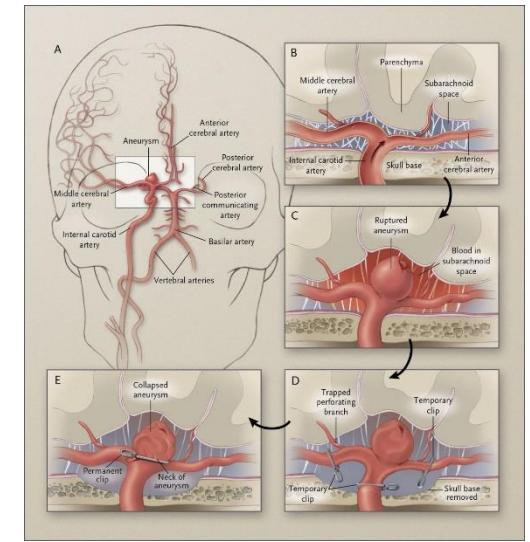
<https://bost.ocks.org/mike/uberdata/>

The Colors of Motion



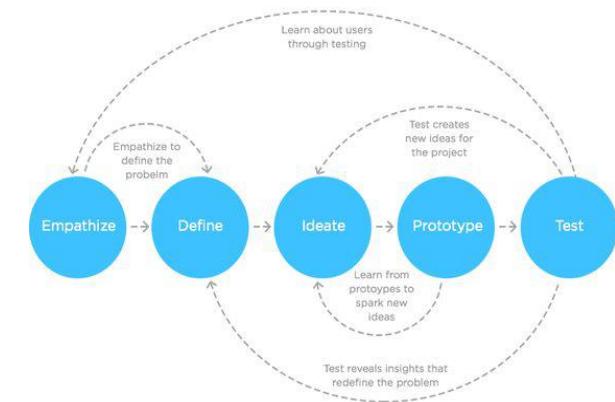
<http://thecolorsofmotion.com/films>

Aneurysms



<https://www.northeastern.edu/visualization/events/daniel-muller-visualization-and-illustration-for-the-medical-audience/>

Design Thinking: A Non-Linear Process

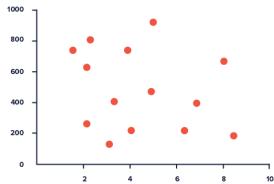


# Data visualization

- Means different things to different people.
- Definition - Way of presenting **data** in a **visual context**.
- **Data** – Numbers, words, letters, location, time, money, colors, basically any piece of information.
- **Visual context** – How you design the data visually using visual properties/cues (position, length, angle, direction, shape, area, volume, color saturation) and other elements (coordinate system, scale, annotation).

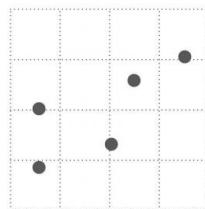
# Visual properties / cues

## Scatter Plot



### Position

Where in space the data is



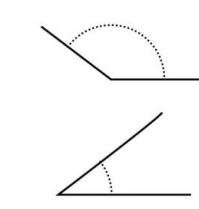
### Length

How long the shapes are

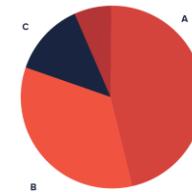


### Angle

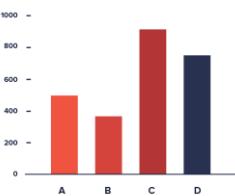
Rotation between vectors



## Pie Chart

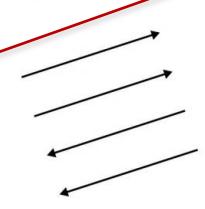


## Bar Graph



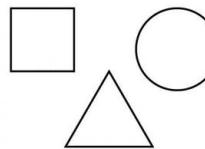
### Direction

Slope of a vector in space



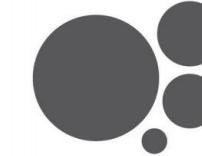
### Shapes

Symbols as categories

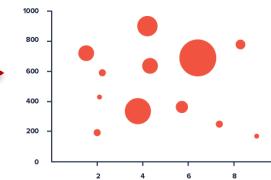


### Area

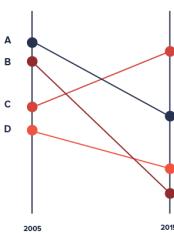
How much 2-D space



## Bubble Chart



## Slope Graph



### Volume

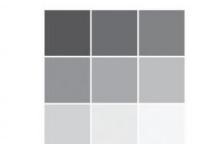
How much 3-D space



FIGURE 3-3 Visual cues

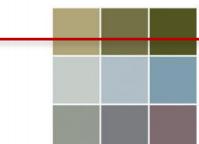
### Color saturation

Intensity of a color hue

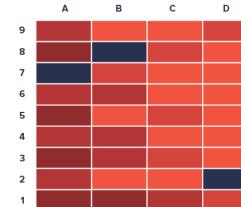


### Color hue

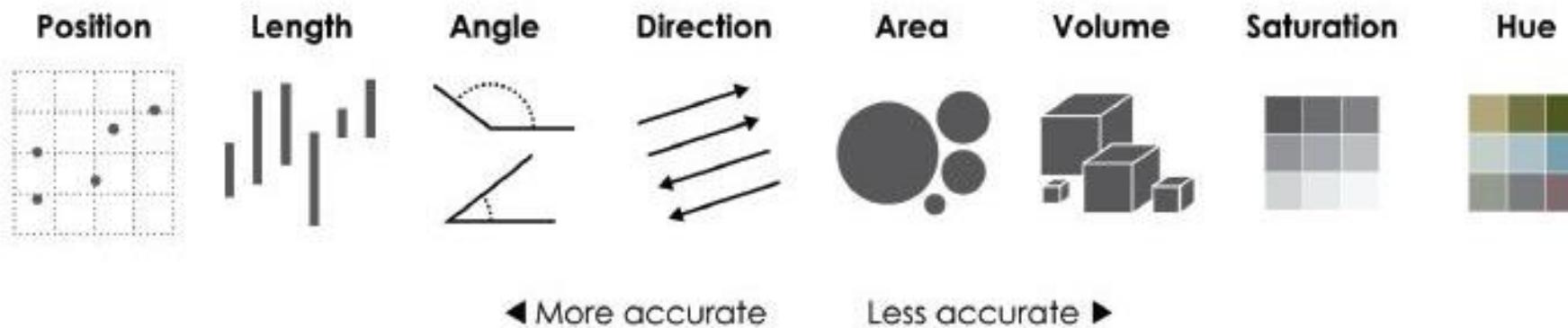
Usually referred to as color



## Heat Map



# Perception of visual properties / cues



Data Points - Nathan Yau, pg 104

In 1985, Cleveland and McGill published a paper on graphical perception and methods.

Determine how accurately people read visual cues and ranked them from most accurate to least accurate.

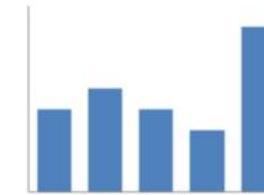
There is a reason why these are easy to understand and very popular types of visualizations to use!

91%

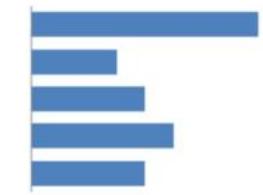
Simple text



Scatterplot



Vertical bar



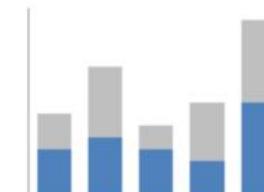
Horizontal bar

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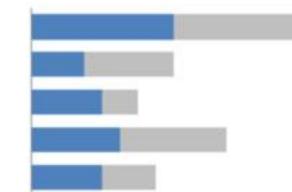
Table



Line



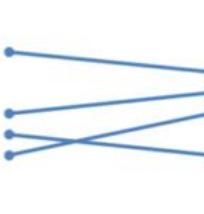
Stacked vertical bar



Stacked horizontal bar

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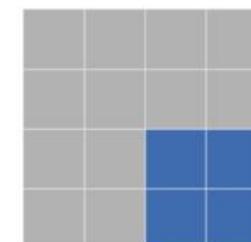
Heatmap



Slopegraph



Waterfall

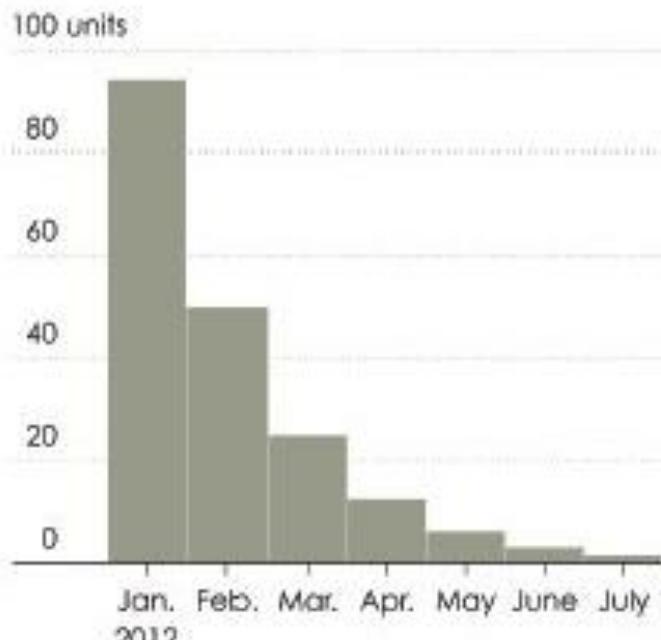


Square area

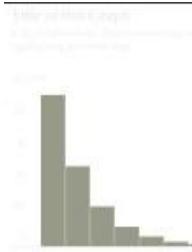
# Other elements

## Title of this Graph

A description of the data or something worth highlighting to set the stage.



Data Points - Nathan Yau, pg 95



## Visual Cues

Visualization involves encoding data with shapes, colors, and sizes. Which cues you choose depends on your data and your goals.

## Coordinate System

You map data differently with a scatterplot than you do with a pie chart. It's x- and y-coordinates in one and angles with the other; it's cartesian versus polar.

## Scale

Increments that make sense can increase readability, as well as shift focus.

## Context

If your audience is unfamiliar with the data, it's your job to clarify what values represent and explain how people should read your visualization.

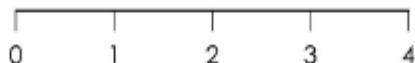
	Position	Length	Angle	Direction	Shapes	Area or Volume	Color
Coordinate systems							
Cartesian							
Polar							
Geographic							

## Scales

Along with coordinate systems, they dictate where the shapes are placed and how objects are shaded.

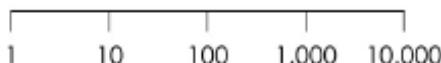
### Linear

Values are evenly spaced



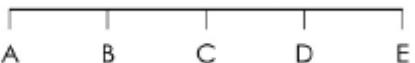
### Logarithmic

Focus on percent change



### Categorical

Discrete placement in bins



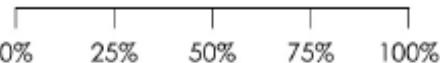
### Ordinal

Categories where order matters



### Percent

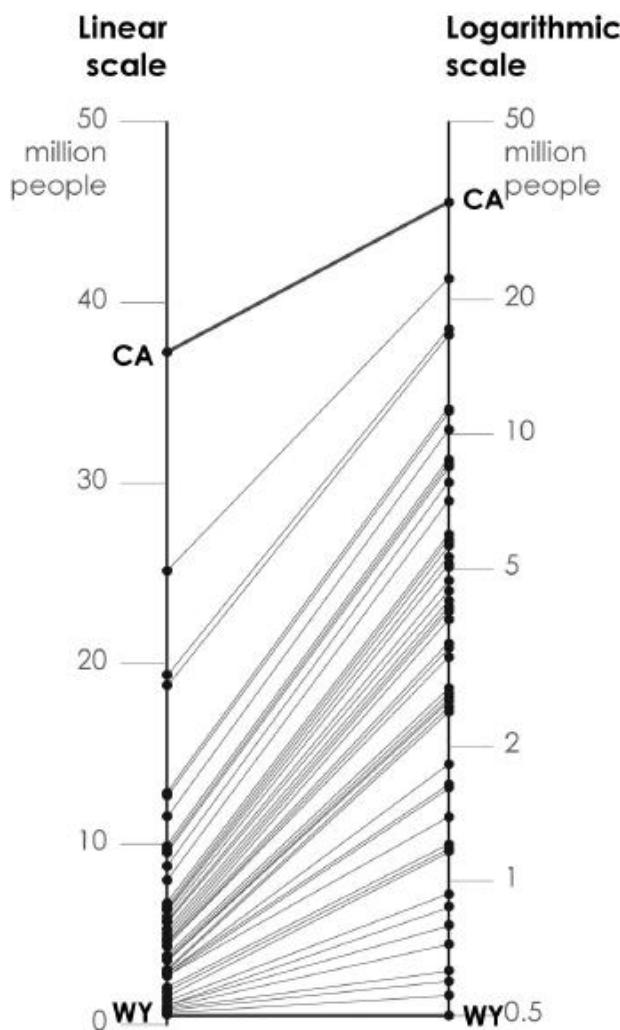
Representing parts of a whole



### Time

Units of months, days, or hours



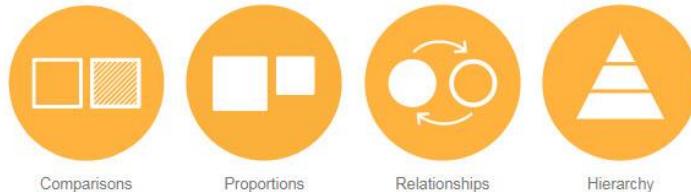


# Choosing viz types

[datavizcatalogue.com](http://datavizcatalogue.com)

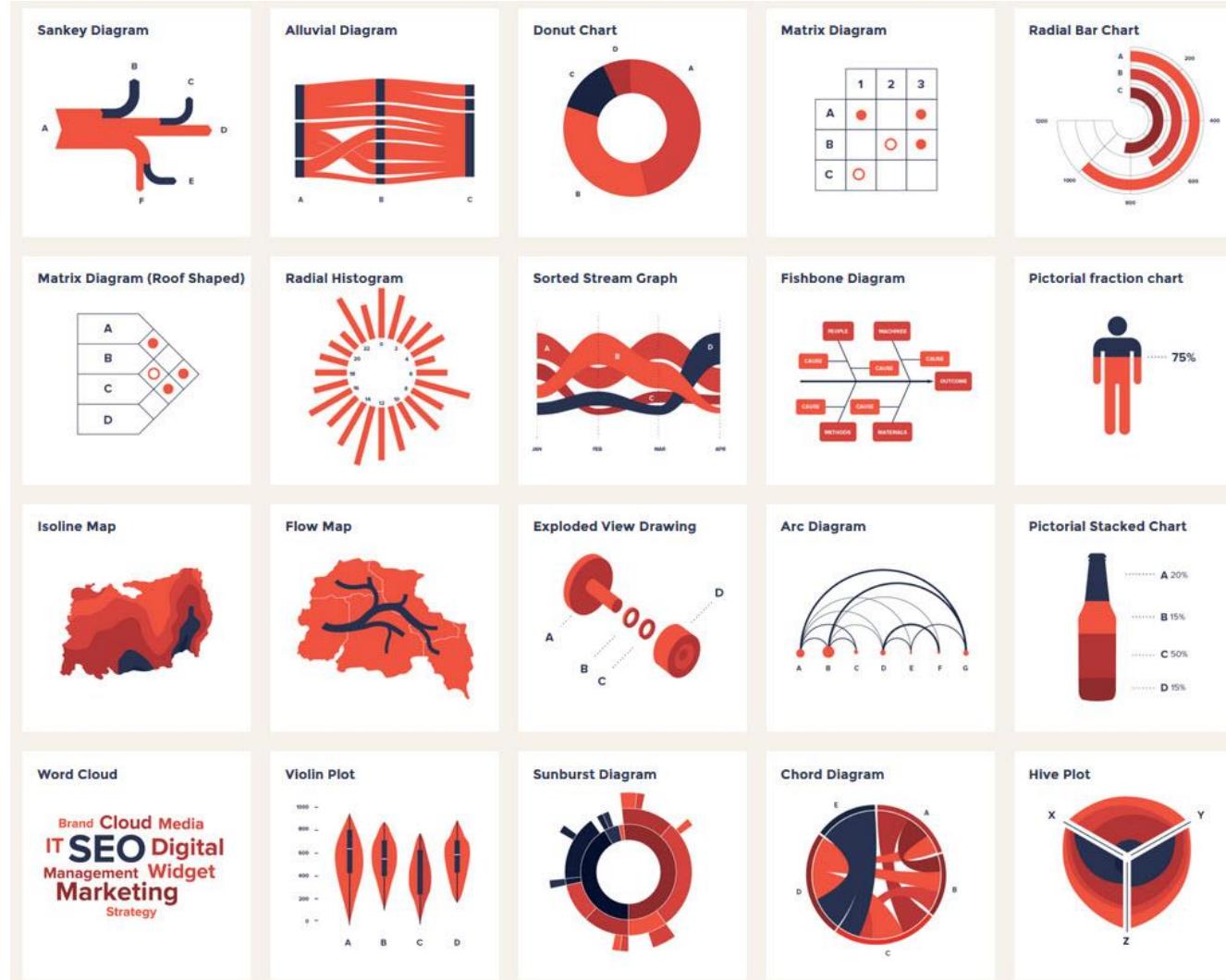
## What do you want to show?

Here you can find a list of charts categorised by their data visualization functions or by what you want a chart to communicate to an audience. While the allocation of each chart into specific functions isn't a perfect system, it still works as a useful guide for selecting chart based on your analysis or communication needs.



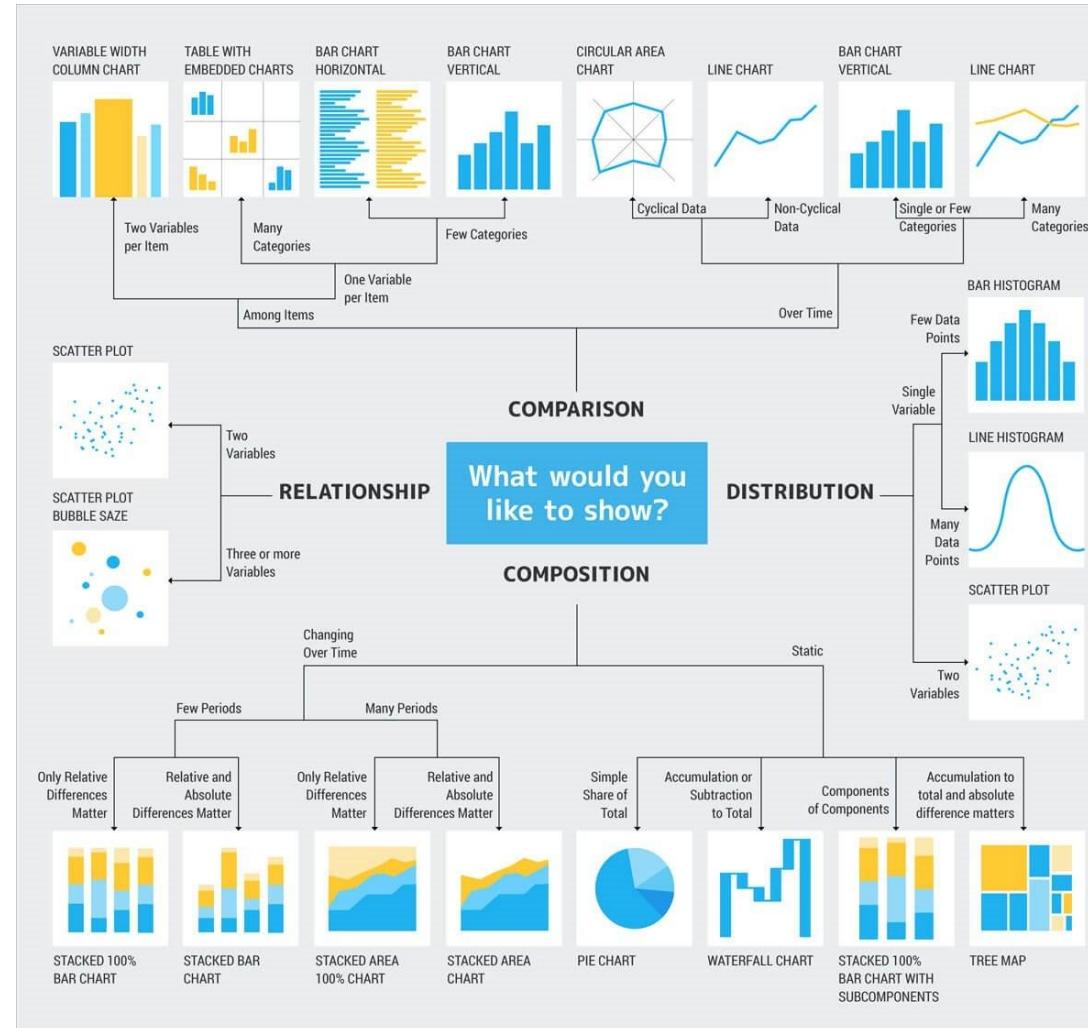
# Choosing viz types

[datavizproject.com](http://datavizproject.com)



# Choosing viz types

# Chart Suggestions – A Thought Starter



# A good data viz...

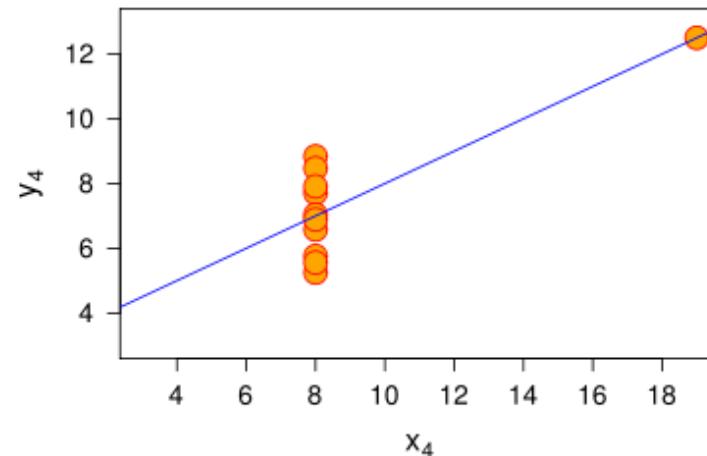
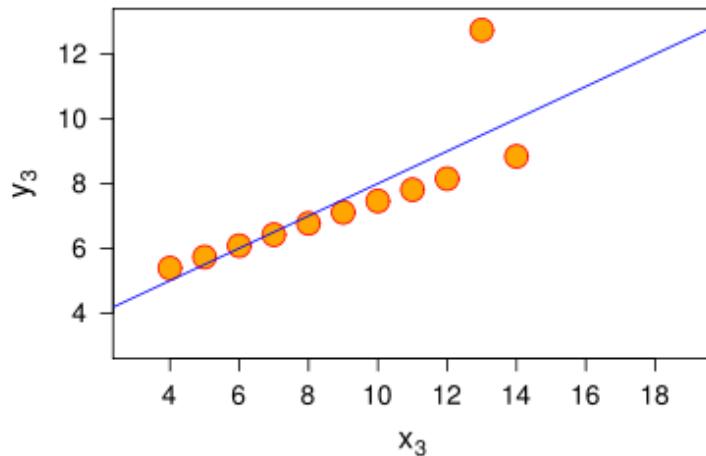
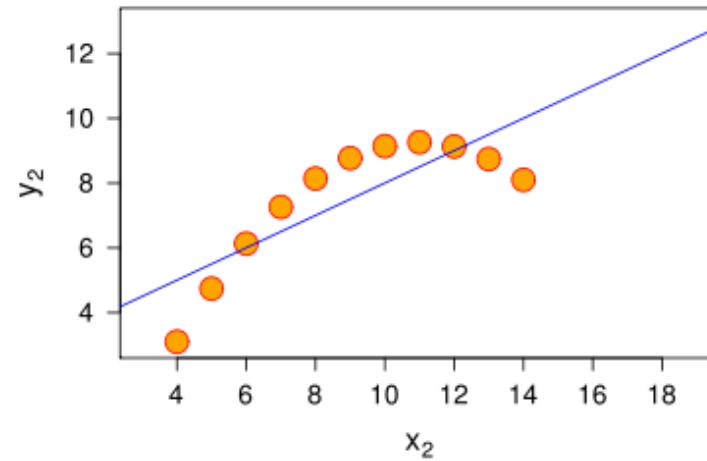
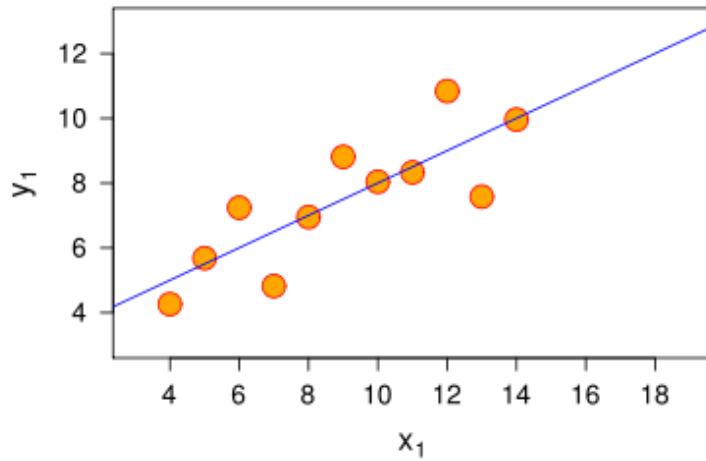
1. Helps us detect patterns, trends, and correlations, as well as make comparisons
2. Engages the audience – make enjoyable, accessible, and fun

# Anscombe's Quartet

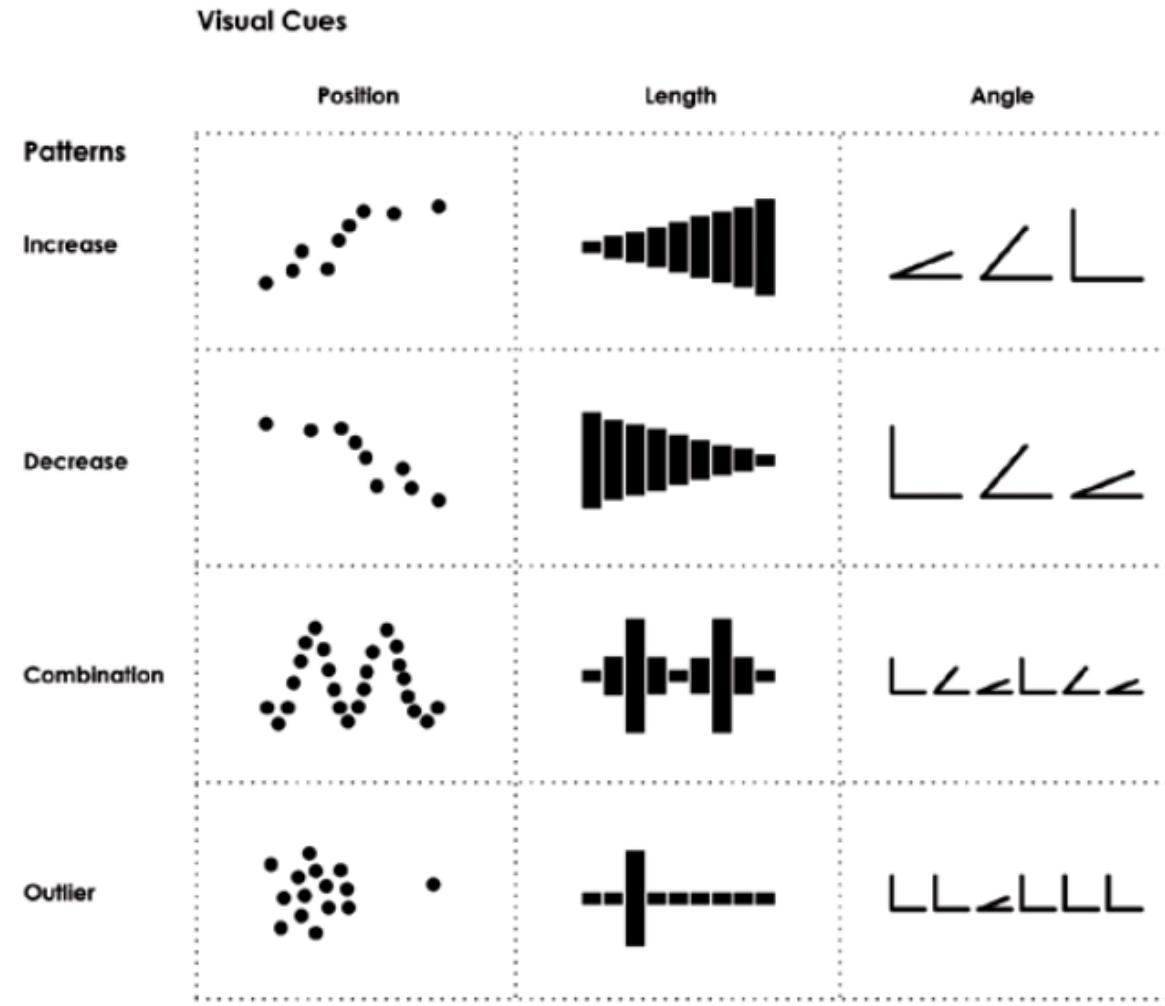
I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Property	Value	Accuracy
Mean of $x$	9	exact
Sample variance of $x$	11	exact
Mean of $y$	7.50	to 2 decimal places
Sample variance of $y$	4.125	plus/minus 0.003
Correlation between $x$ and $y$	0.816	to 3 decimal places
Linear regression line	$y = 3.00 + 0.500x$	to 2 and 3 decimal places, respectively
Coefficient of determination of the linear regression	0.67	to 2 decimal places

# Anscombe's Quartet



# How visual properties/cues help us find patterns



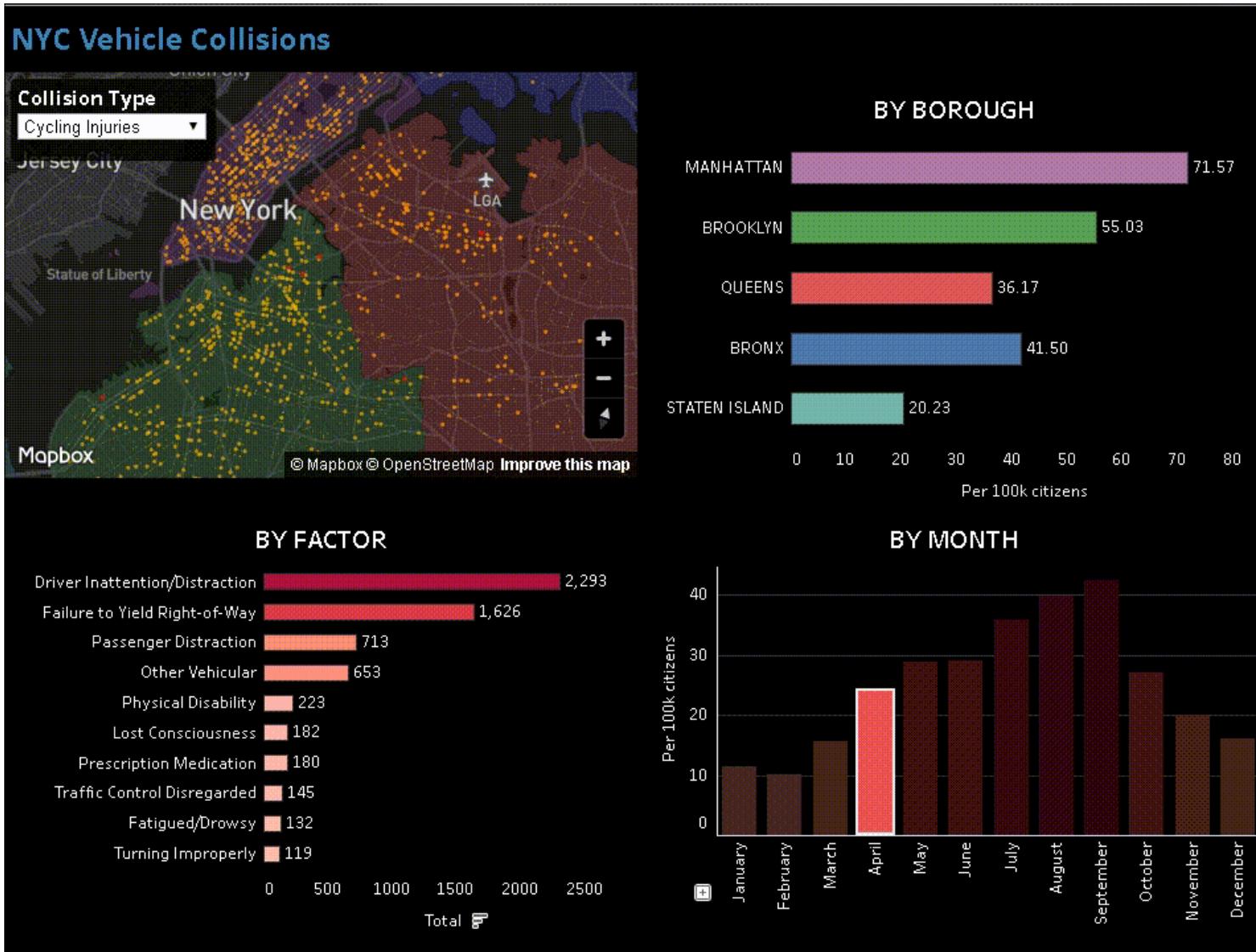
# A good data viz...

1. Helps us detect patterns, trends, and correlations, as well as make comparisons
2. Engages the audience – make enjoyable, accessible, and fun

# Peak Break-Up Times

According to Facebook status updates

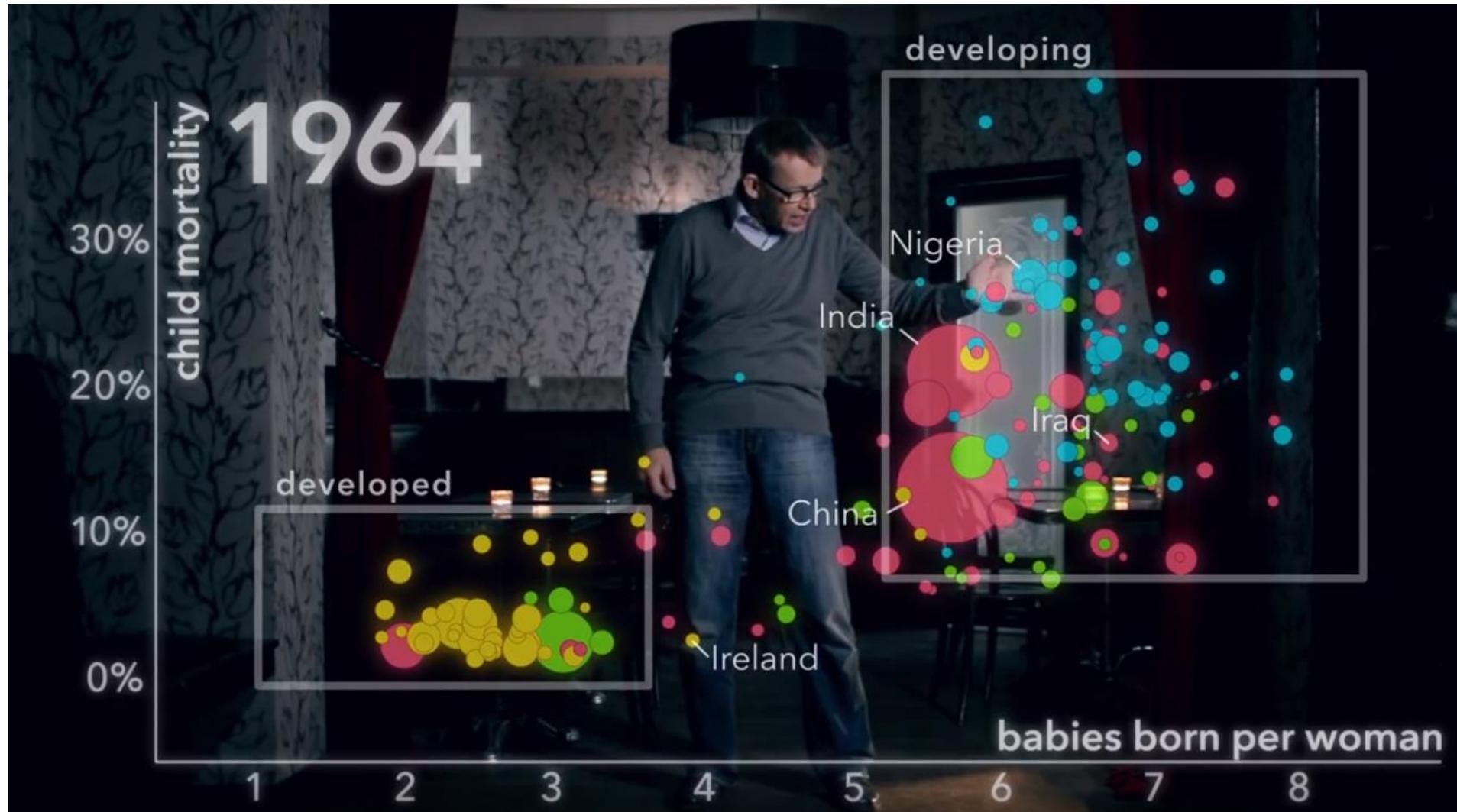




# **Watch: The River of Myths**

## **- Hans Rosling**

## The River of Myths - Hans Rosling - <https://www.youtube.com/watch?v=OwII-dwh-bk>



# 5 min break

Data viz checklist is next



# **How to Rate (+ eval + improve)**

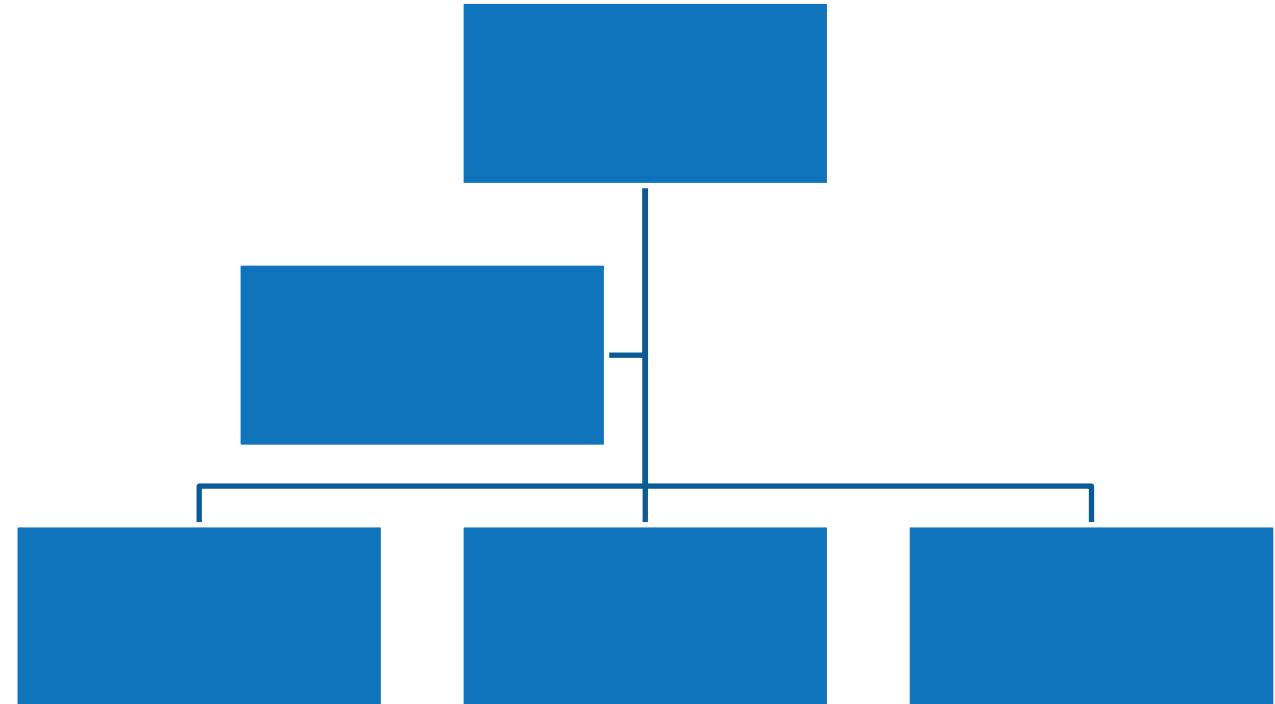
# **Data visualizations**

**Sena Pierce Sanjines, Stephanie  
Evergreen, & Jennifer Lyons**

# What is & isn't a data visualization? (in our specific context)

This checklist focuses on  
**quantitative** data visualization.

This diagram would not work  
well with the checklist – it is not  
representing underlying  
quantitative data.

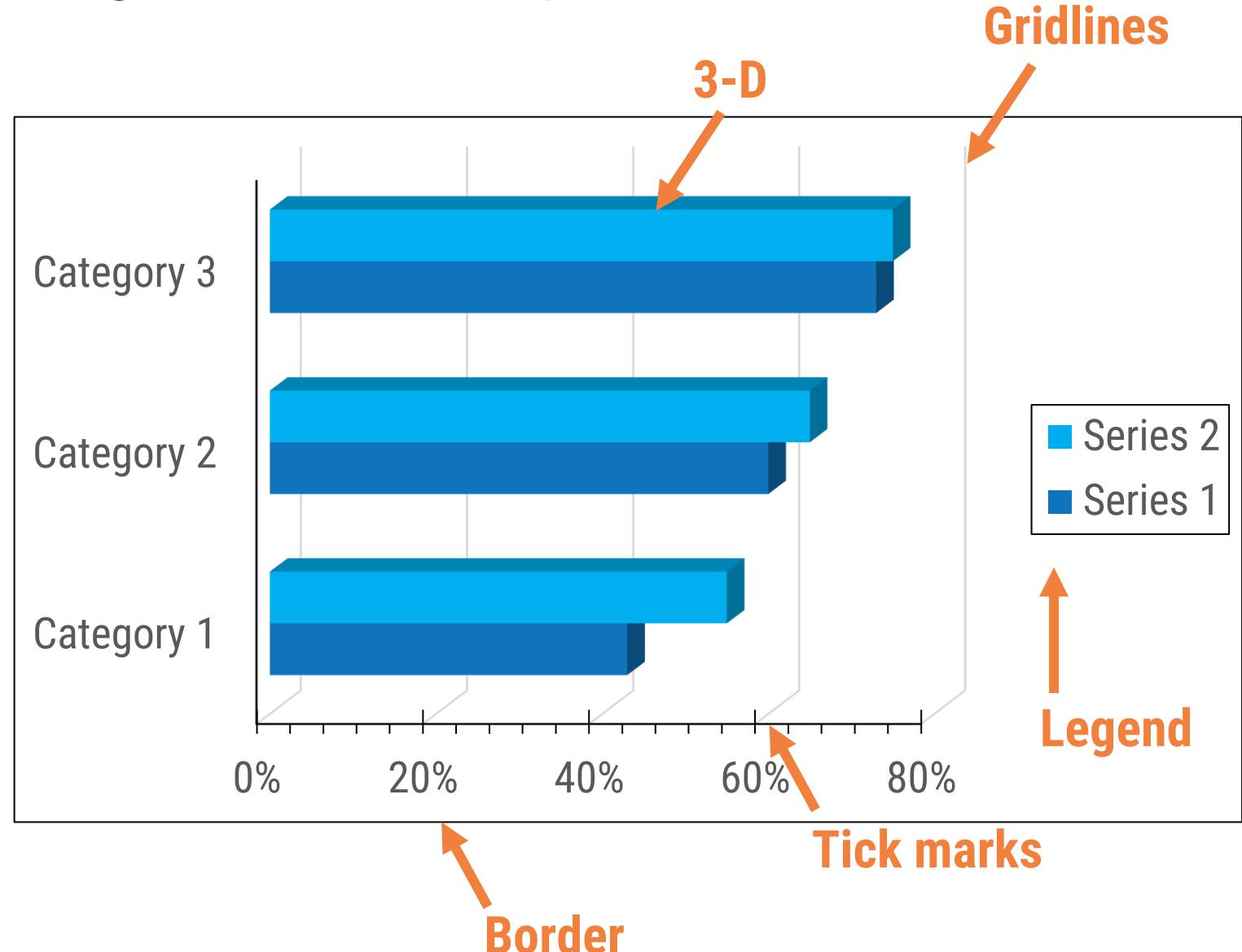


Also not well-suited:  
Logic models, Illustrations, Maps

# What's included in your rating?

## All graph/chart elements

- Title
- Axis
- Data labels
- Legend
- Border
- Etc...



# What's not included in your ratings?

Anything that's not a part of the graph/chart...

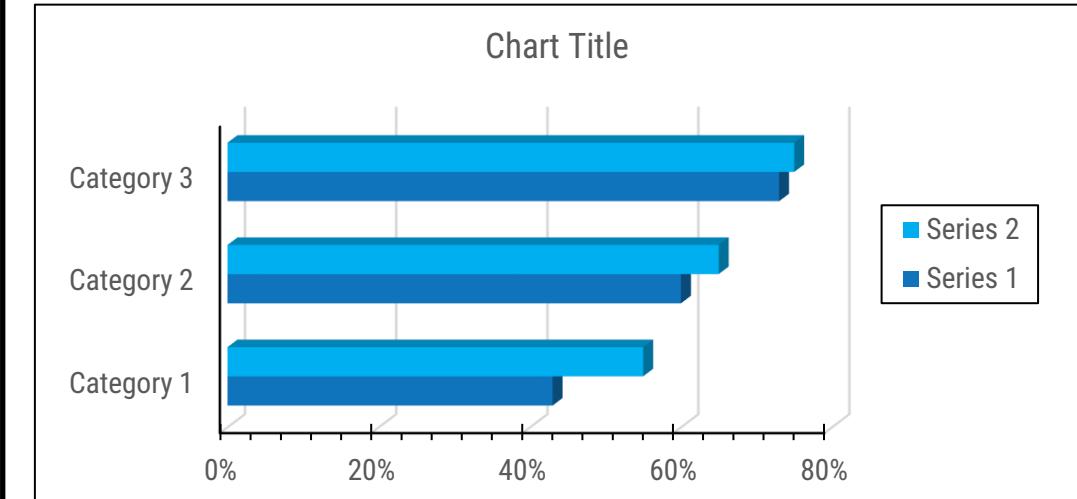
- **Section headings**
- **Narrative text**, etc.

Nope!

Only this stuff

Some interesting header.

Narrative text here. Narrative text here. Narrative text here.  
Narrative text here. Narrative text here. Narrative text here.  
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# The Checklist

A set of 24 checkpoints  
grouped into 5 sections: Text, Alignment, Color, Lines, & Overall  
developed by **Dr. Stephanie Evergreen** and **Ann Emery**  
based in research and best practice  
to guide chart formatting so the story in the data is clear.

[https://stephanieevergreen.com/wp-  
content/uploads/2020/12/EvergreenDataVizChecklist.pdf](https://stephanieevergreen.com/wp-content/uploads/2020/12/EvergreenDataVizChecklist.pdf)

# The Checklist

## was originally published on 4 pages

### Data Visualization Checklist

by Stephanie Evergreen & Ann K. Emery

May 2016

This checklist is meant to be used as a guide for the development of high impact data visualizations. Rate each aspect of the data visualization by circling the most appropriate number, where 2 points means the guideline was fully met, 1 means it was partially met, and 0 means it was not met at all. n/a should not be used frequently, but reserved for when the guideline truly does not apply. For example, a pie chart has no axes lines or tick marks to rate. If the guidelines has been broken intentionally to make a point, rate it n/a and deduct those points from the total possible. Refer to the Data Visualization Anatomy Chart on the last page for guidance on vocabulary and the Resources at the end for more details.

	Guideline	Rating
<b>Text</b>	<b>6-12 word descriptive title is left-justified in upper left corner</b> Short titles enable readers to comprehend takeaway messages even while quickly skimming the graph. Rather than a generic phrase, use a descriptive sentence that encapsulates the graph's finding or "so what?" Western cultures start reading in the upper left, so locate the title there.	2 1 0 n/a
	<b>Subtitle and/or annotations provide additional information</b> Subtitles and annotations (call-out text within the graph) can add explanatory and interpretive power to a graph. Use them to answer questions a viewer might have or to highlight specific data points.	2 1 0 n/a
	<b>Text size is hierarchical and readable</b> Titles are in a larger size than subtitles or annotations, which are larger than labels, which are larger than axis labels, which are larger than source information. The smallest text - axis labels - are at least 9 point font size on paper, at least 20 on screen.	2 1 0 n/a
	<b>Text is horizontal</b> Titles, subtitles, annotations, and data labels are horizontal (not vertical or diagonal). Line labels and axis labels can deviate from this rule and still receive full points. Consider switching graph orientation (e.g., from column to bar chart) to make text horizontal.	2 1 0 n/a
	<b>Data are labeled directly</b> Position data labels near the data rather than in a separate legend (e.g., on top of or next to bars and next to lines). Eliminate/embed legends when possible because eye movement back and forth between the legend and the data can interrupt the brain's attempts to interpret the graph.	2 1 0 n/a

# The Checklist

## is now available as an interactive website.



Data Visualization Checklist

Rate your visualization

## Rate your visualization

Upload an image of your visual into the space below (jpg, gif, png). When your image uploads, you'll see the first checkpoint from the checklist and you'll be asked to choose whether, based on your graphic, the checkpoint is Fully Met, Partially Met, or Not Met. If you need an example of the checkpoint, click the Show Me button.

After you score the first checkpoint, you'll be taken to the next checkpoint and so on, through the Text, Arrangement, Color, Lines, and Overall section of the checklist. At the end, you'll see how you scored (2 points for Fully Met, 1 point for Partially Met, 0 points for Not Met).

Drag a file here or [browse](#) to upload.

# The Checklist Ratings

2 = checkpoint is fully met in the visual

1 = partially met

0 = not met

N/A

N/A is rare.

Example – three of the four guidelines in the “Lines” section are not applicable for pie charts because they do not have x and y-axes. These would be rated as N/A.

# Checklist Guideline

## Guideline



### 6-12 word descriptive title is left-justified in upper left corner

Short titles enable readers to comprehend takeaway messages even while quickly skimming the graph. Rather than a generic phrase, use a descriptive sentence that encapsulates the graph's finding or "so what?" Western cultures start reading in the upper left, so locate the title there.

# Checklist Guideline

## Checklist Guideline



6-12 word descriptive title is left-justified in upper left corner

Short titles enable readers to comprehend takeaway messages even while quickly skimming the graph. Rather than a generic phrase, use a descriptive sentence that encapsulates the graph's finding or "so what?" Western cultures start reading in the upper left, so locate the title there.



Explanation Text

# What not to do...

“I think they could have done it better...” aka the graph should get a fully met but you don’t like it.

“I think they meant to do this...” aka giving benefit of the doubt.

**Both should be avoided.**

When in doubt, use the explanations and example visuals and stick to what is in the graph to make your rating.



**Let's walk through the  
checkpoints in**

**Text**

# **Text:**

## **6-12 word descriptive title is left-justified in upper left corner**

Short titles enable readers to comprehend takeaway messages even while quickly skimming the graph. Rather than a generic phrase, use a descriptive sentence that encapsulates the graph's finding or "so what?" Western cultures start reading in the upper left, so locate the title there.

**Fully met** = Title is 6-12 words, left-aligned in the upper left corner, and describes a finding or takeaway message.

**Partially met** = One of the "fully met" criteria below is met, but not all three.

**Not met** = None of the "fully met" criteria below is met.

# Text:

**6-12 word descriptive title is left-justified in upper left corner**

NOTE – I realize that not all titles are put in the left upper hand corner of a viz and in research papers they may be elsewhere.

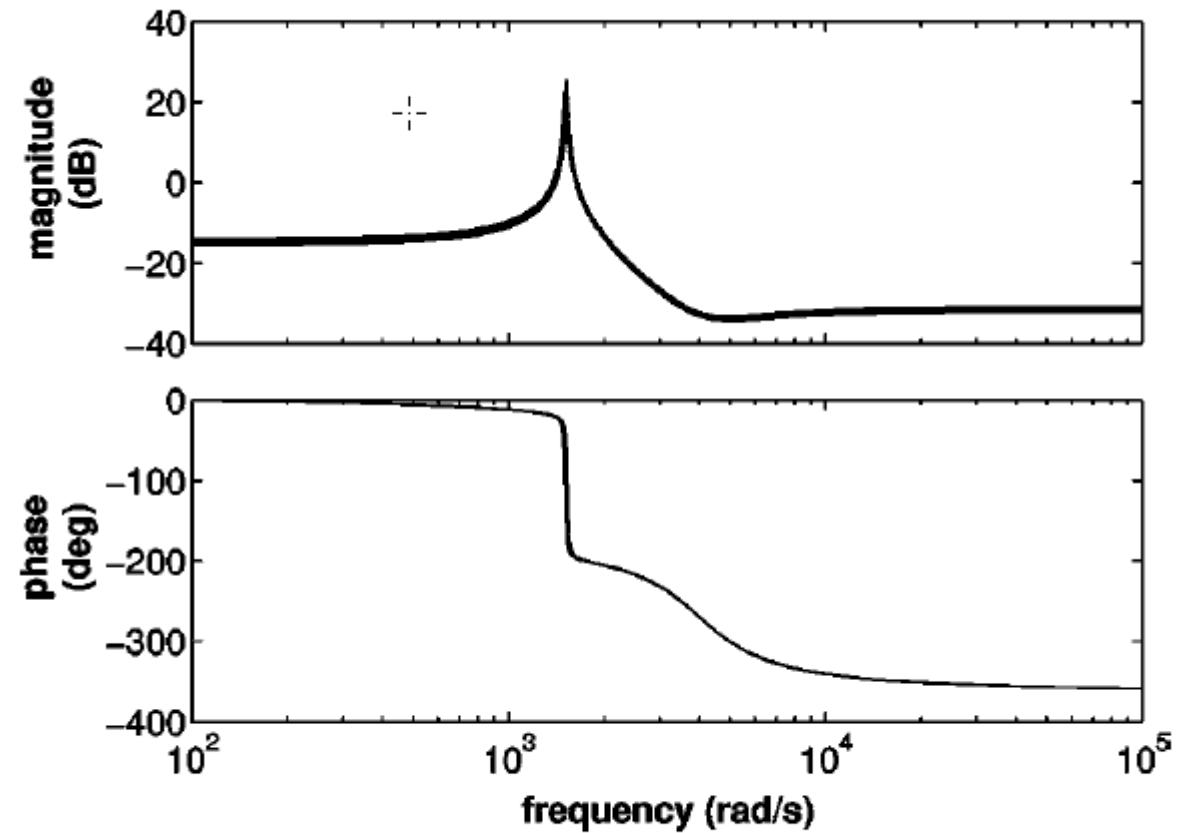
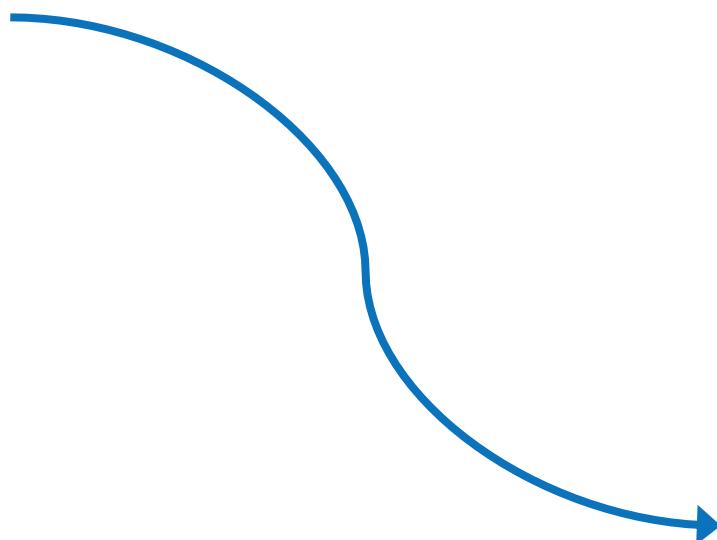


FIG. 10. Frequency responses of the plant  $G$  at different operating points.

From "High bandwidth nano-positioner: A robust control approach"

# Text:

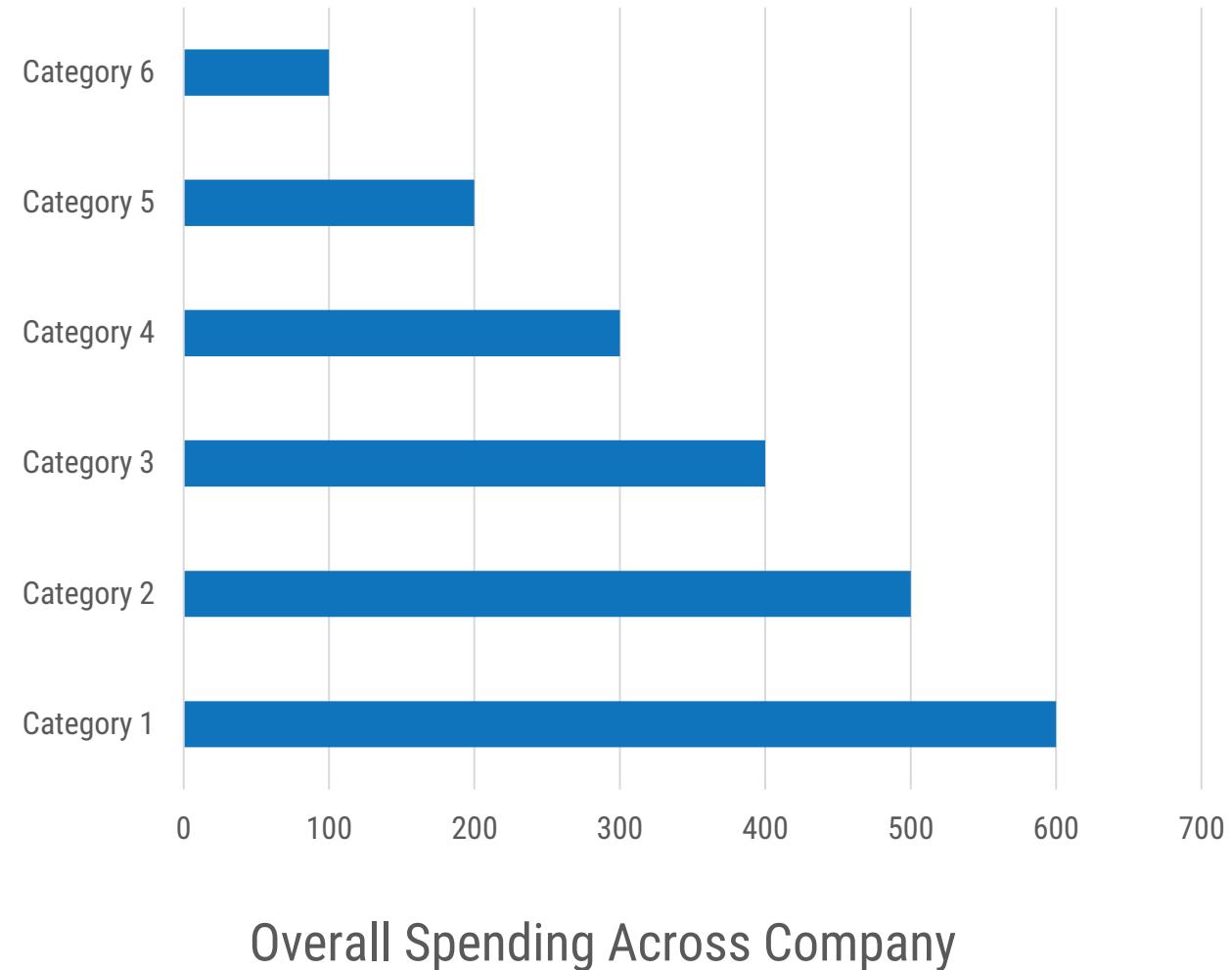
**6-12 word descriptive title is left-justified in upper left corner**

## Example:

Title is less than 6 words **and** is not left-aligned in the upper left hand corner **and** does not describe a finding.

None of three criteria were met.

**Rating = 0**



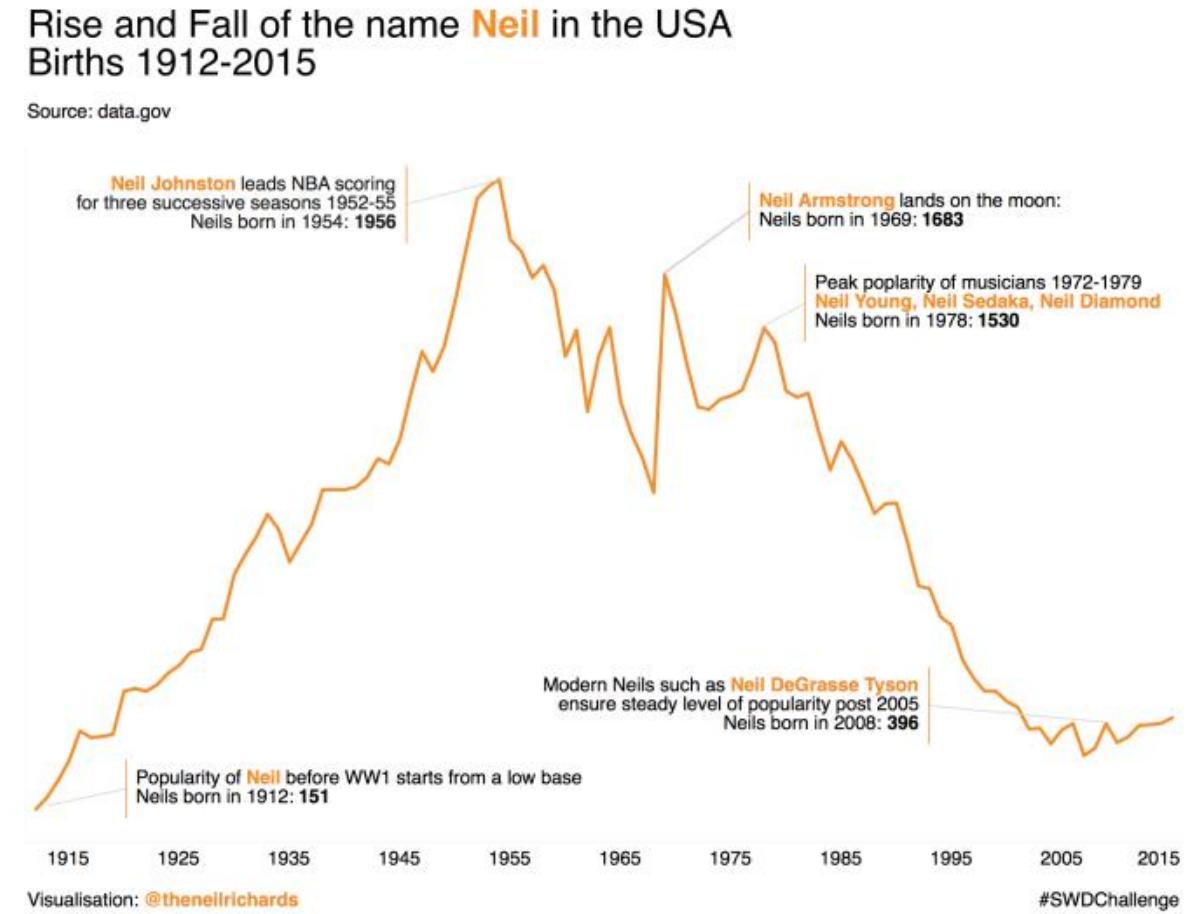
# Text: 6-12 word descriptive title is left-justified in upper left corner

## Example:

Title is between 6-12 words **and**  
is left-aligned in the upper left  
hand corner **and** describes a  
finding.

All three criteria were met.

Rating = 2



<https://questionsindataviz.com/2018/01/06/is-white-space-always-your-friend/>

# **Text:**

## **Subtitle and/or annotations provide additional information**

Subtitles and annotations (call-out text within the graph) can add explanatory and interpretive power to a graph. Use them to answer questions a viewer might have or to **highlight specific data points.**

**Fully met** = Subtitles and/or annotations provide useful information about the data.

**Partially met** = This is often either not met or fully met.

**Not met** = There are no sub-titles or annotations and/or they do not provide useful information about the data, i.e. citations or data sources.

\* Note legends are a part of the graph and are not considered annotations.  
Annotations are usually text boxes on or near the graph.

# Text:

## Subtitle and/or annotations provide additional information

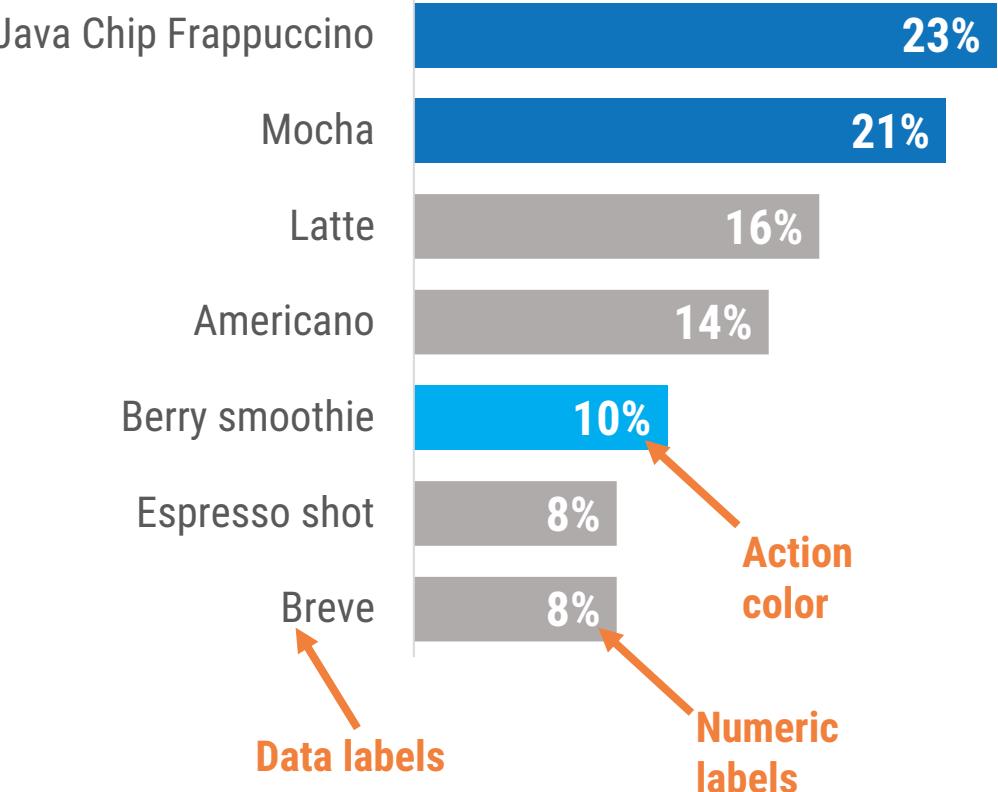
### Example:

Subtitle adds more information about the graph (often this is about the graph population).

Rating = 2

Notes about the data within the graph area or below axis labels, etc. are considered annotations and coded as 2, fully met.

**title**  
**subtitle**  
Coffee preferences focus on chocolate-based drinks.  
One in ten fellow attendees do not consume caffeine in their preferred morning drinks.



# **Text:**

## **Text size is hierarchical and readable**

Titles are in a larger size than subtitles or annotations, which are larger than labels, which are larger than axis labels, which are larger than source information. The smallest text - axis labels - are at least 9 point font size on paper, at least 20 on screen.

**Fully met** = Titles are larger than subtitles are larger than axis labels **and** all text is readable.

**Partially met** = Text is readable **and** title is larger **but** all other text in the graph (subtitles, axis labels, etc.) is the same size.

**Not met** = Text is not readable **and/or** all text is the same size.

**NOTE – For printed materials (poster presentations and handouts), make sure to print out to really see if text is readable! Readable on the computer doesn't mean readable when printed.**

# Text:

## Text size is hierarchical and readable

### Example:

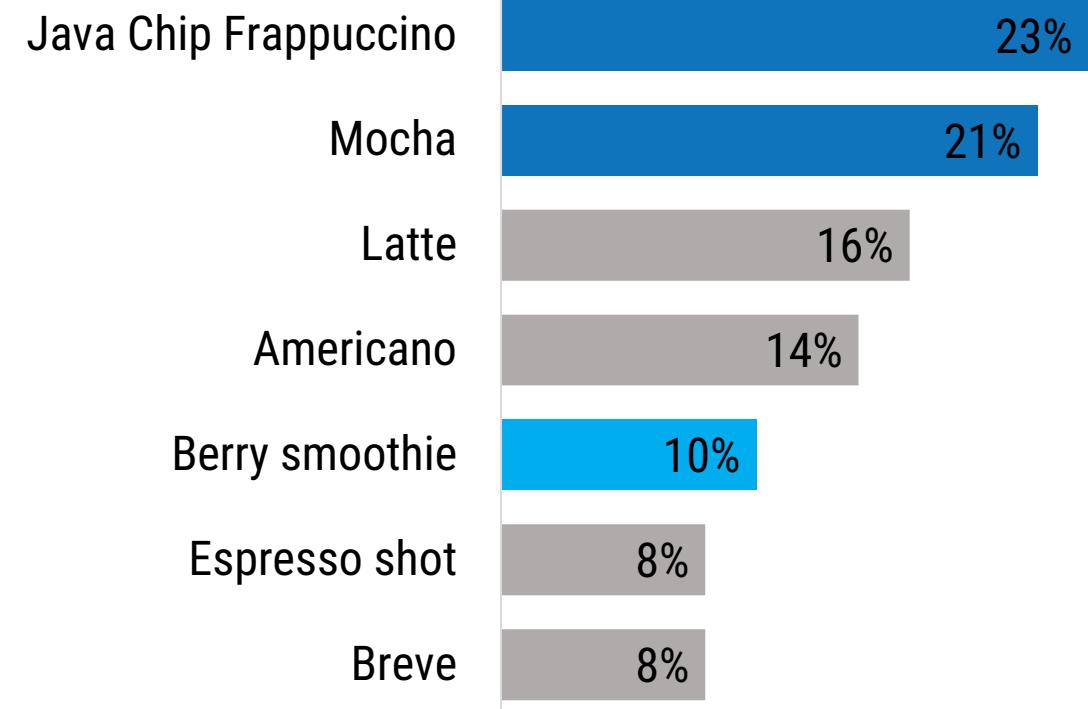
Text is readable and bold  
but title, subtitle and axis  
labels are the same size.

Rating = 1

**NOTE – I'm more lenient because hierarchy isn't only determined by font size but also adjusting (bold, italicize, color, highlight, proximity, etc).**

**Coffee preferences focus on chocolate-based drinks.**

*One in ten fellow attendees do not consume caffeine in their preferred morning drinks.*



# **Text:**

## **Text is horizontal**

Titles, subtitles, annotations, and data labels are horizontal (not vertical or diagonal). Line labels and axis labels can deviate from this rule and still receive full points. Consider switching graph orientation (e.g., from column to bar chart) to make text horizontal.

**Fully met** = Labels are horizontal.

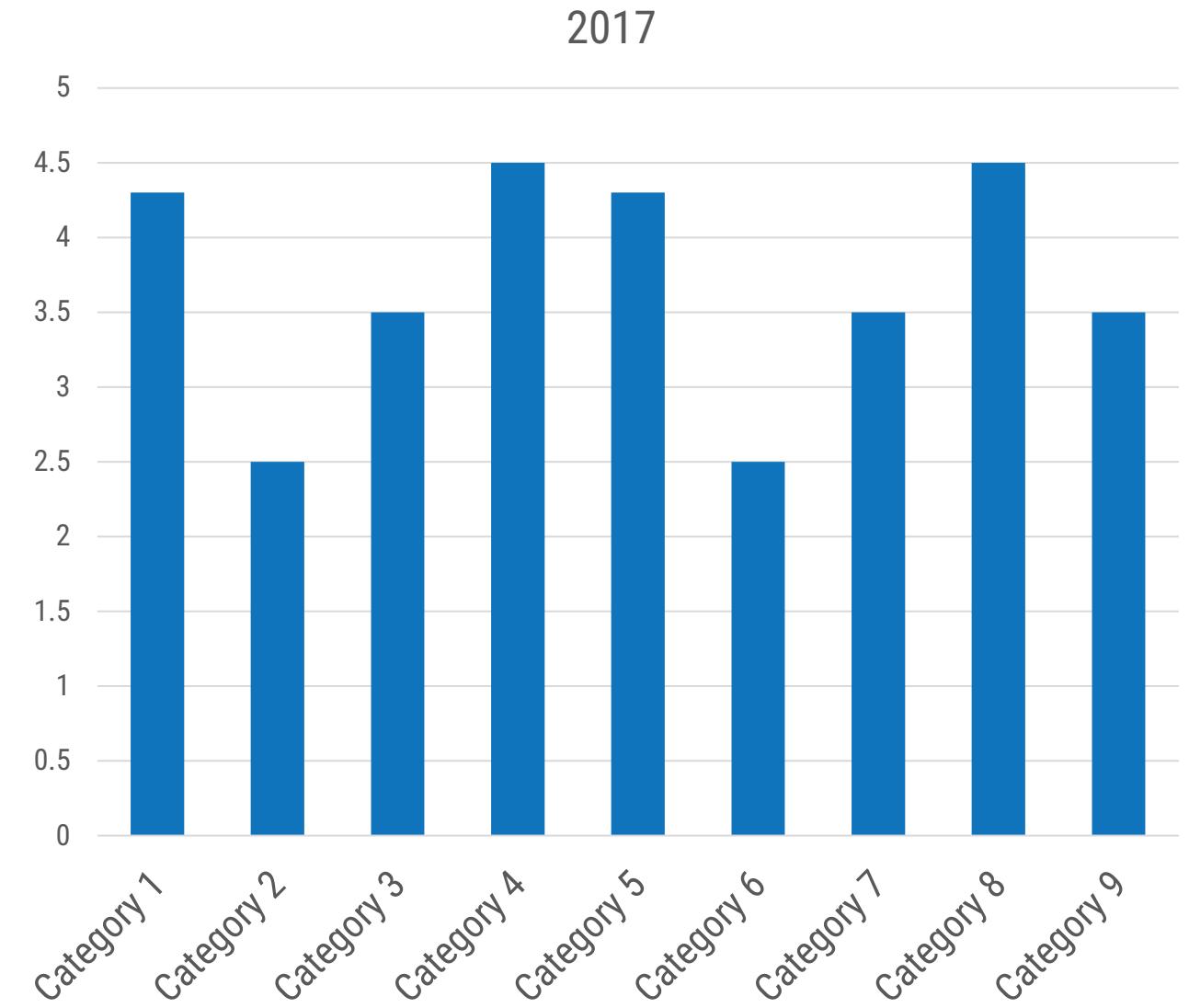
**Partially met** = This is often either not met or fully met.

**Not met** = Labels (usually category labels on the horizontal axis) are vertical or diagonal.

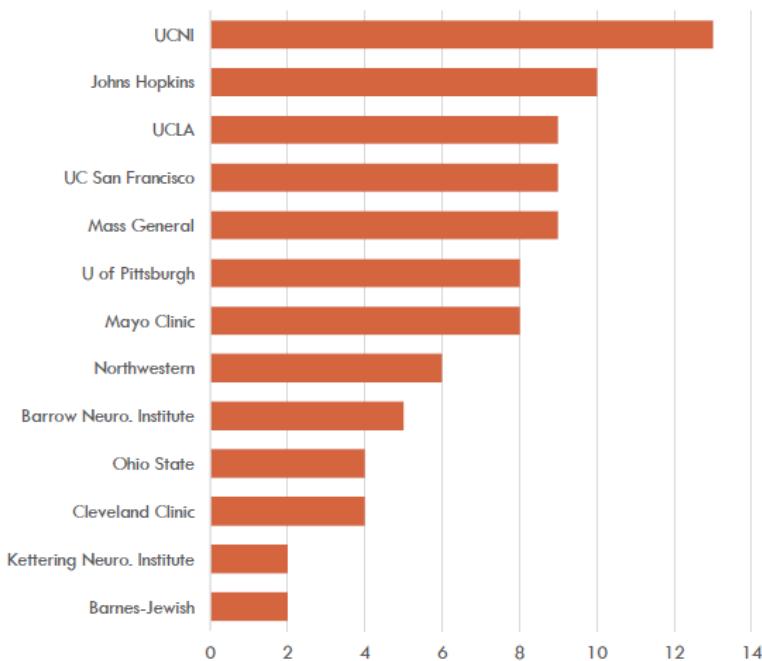
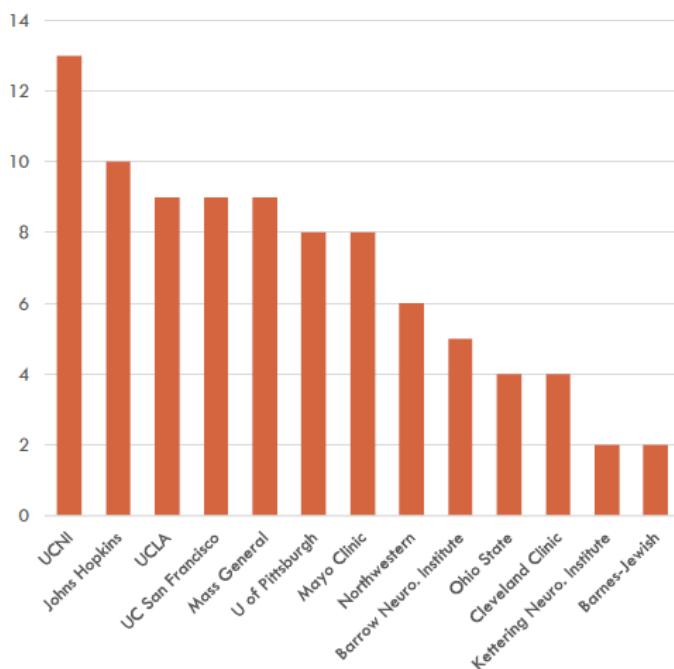
**Text:  
Text is horizontal**

**Example:  
X-axis labels are diagonal.**

**Rating = 0**



# Keep text horizontal



<http://www.storytellingwithdata.com/2012/09/some-finer-points-of-data-visualization.html>

# **Text:**

## **Data are labeled directly**

Position data labels near the data rather than in a separate legend (e.g., on top of or next to bars and next to lines). Eliminate/embed legends when possible because eye movement back and forth between the legend and the data can interrupt the brain's attempts to interpret the graph.

**Fully met** = Data are directly labeled so you don't have to go back and forth between the data and a legend.

**Partially met** = Data are labeled directly but additional info appears in the legend.

**Not met** = Labels appear separate from the data, i.e. only in the legend.

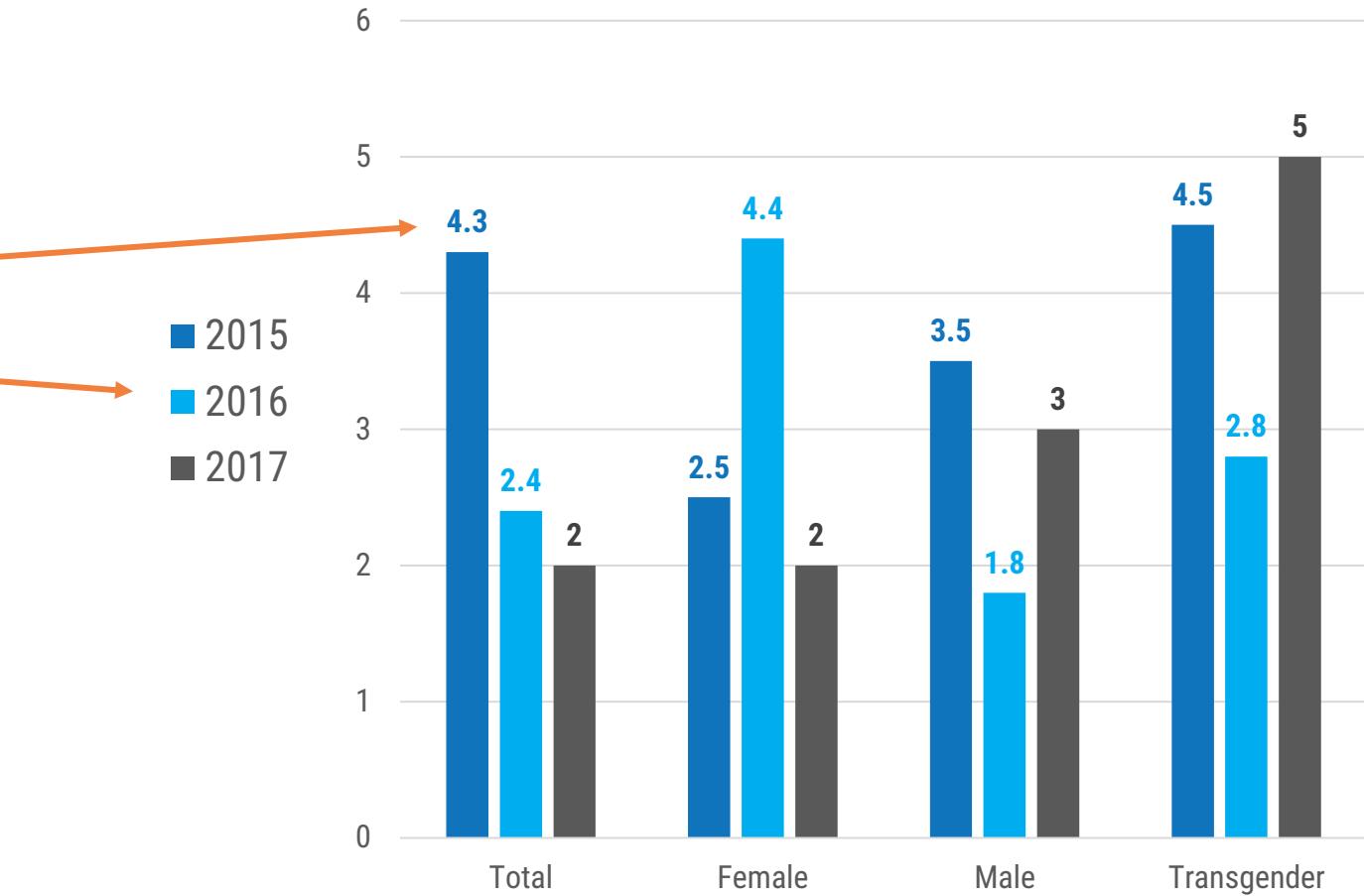
# **Text:**

**Data are labeled directly (proximity graphic design concept)**

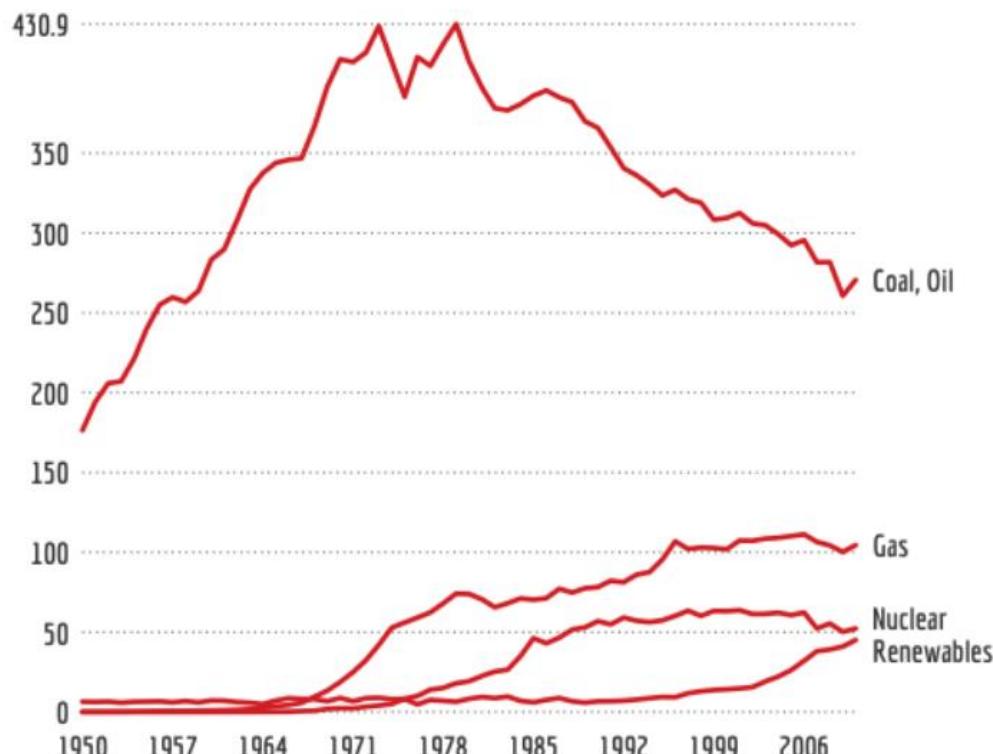
## **Example:**

Data are labeled directly  
but additional info  
appears in the legend.

**Rating = 1**



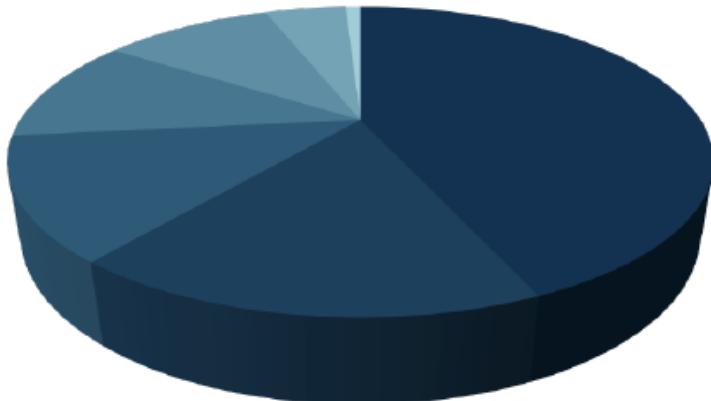
# Label directly



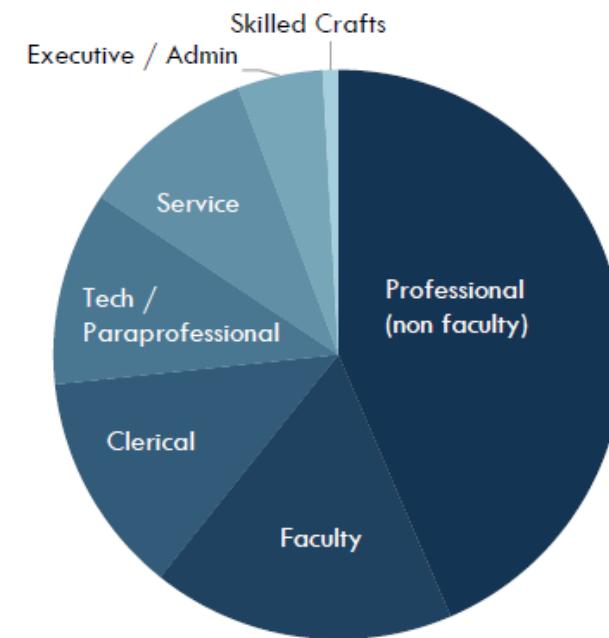
<http://bit.ly/M70xek>

From Duke University's Angela Zoss

# 3D distorts area (we'll talk about soon) + label directly



- Professional (non faculty)
- Faculty
- Clerical
- Tech / Paraprofessional
- Service
- Executive / Admin
- Skilled Crafts



Duke Job Categories

# **Text:**

## **Labels are used sparingly**

Focus attention by removing the redundancy. For example, in line charts, label every other year on an axis. Do not add numeric labels **and** use a y-axis scale, since this is redundant.

**Fully met** = Labels are not redundant.

**Partially met** = Some redundancy has been removed, but not all.

**Not met** = Labels are redundant and make it difficult to read the graph.

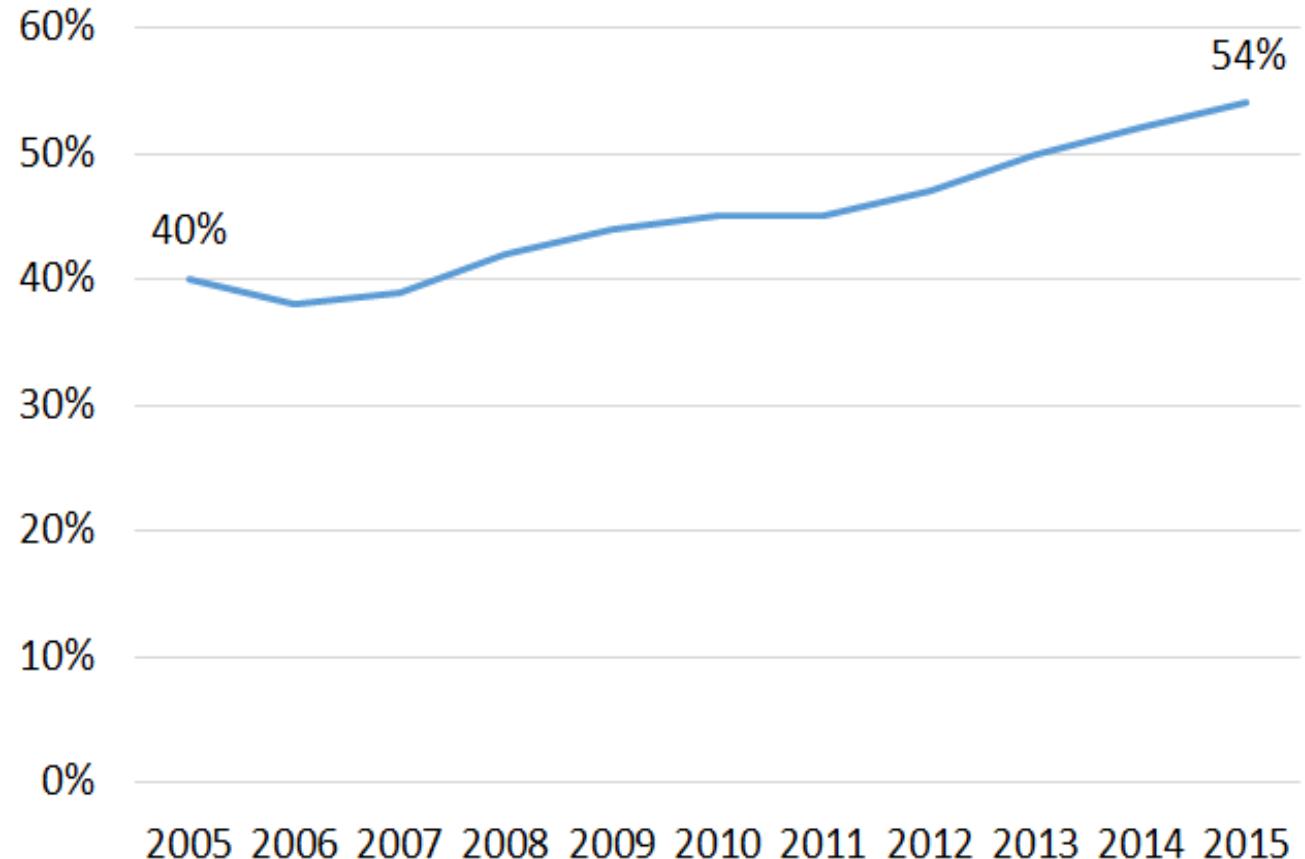
\* Warning - This is one that people commonly rate higher because they don't mind the redundancy. Don't do this.

# Text: Labels are used sparingly

**Example:**  
Some redundancy has  
been removed but x-axis  
includes every year.

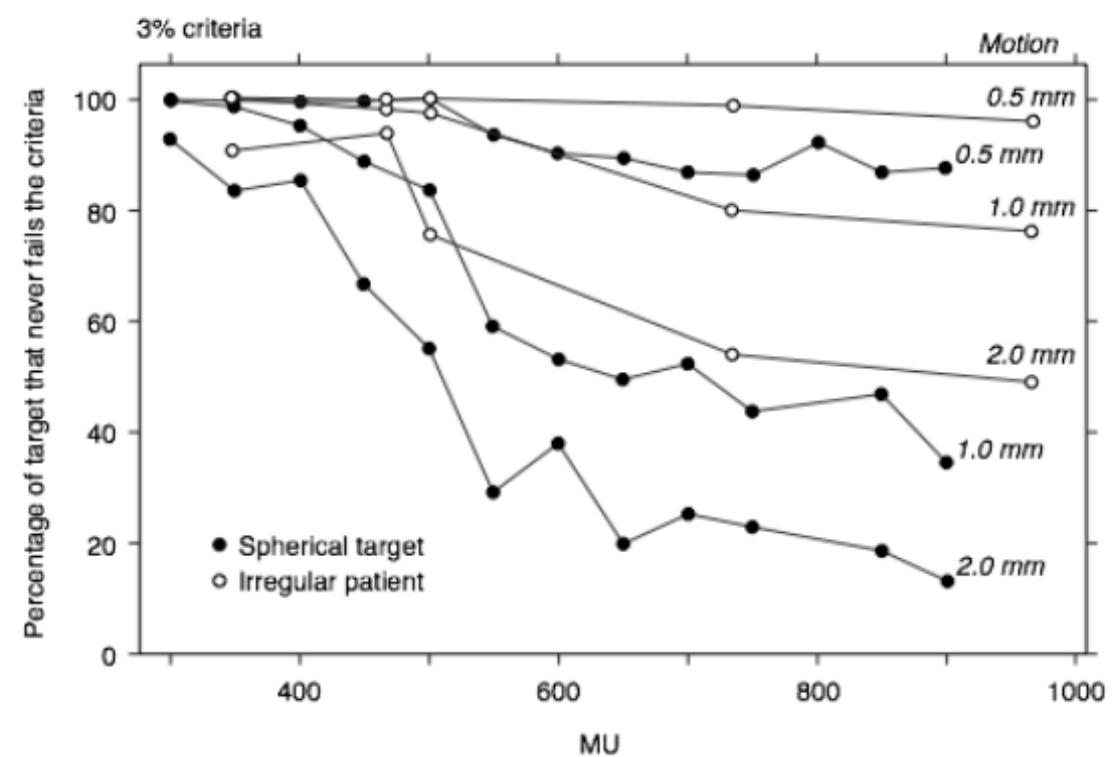
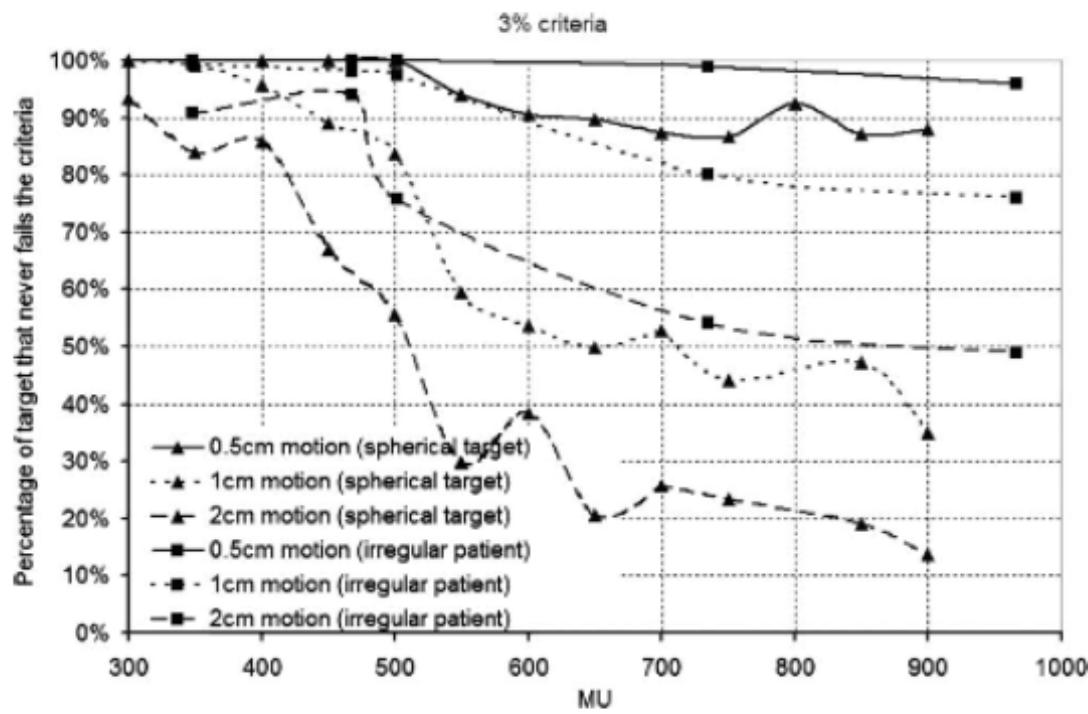
Rating = 1

**More parents drink coffee.**  
Percent of parents who report drinking coffee every morning.



# Exercise

Can you identify all the changes that were made to improve the readability of this viz? Were they effective?





**Let's walk through the  
checkpoints in**

**Arrangement**

# Arrangement:

**Proportions are accurate (avoid distortion) ... also called proportional ink**

A viewer should be able measure the length or area of the graph with a ruler and find that it matches the relationship in the underlying data.

Y-axis scales should be appropriate. Bar charts start axes at 0. Other graphs can have a minimum and maximum scale that reflects what should be an accurate interpretation of the data (e.g., the stock market ticker should not start at 0 or we won't see a meaningful pattern).

**Example: a bar  
that's 40%  
should be about  
half the size of a  
bar that's 80%...**

**Fully met** = Bar chart axes start at 0 **and/or** graph lengths or area match the relationships in the data.

**Partially met** = This is often either not met or fully met.

**Not met** = Bar chart axes don't start at 0 **or** the proportions don't match the data.

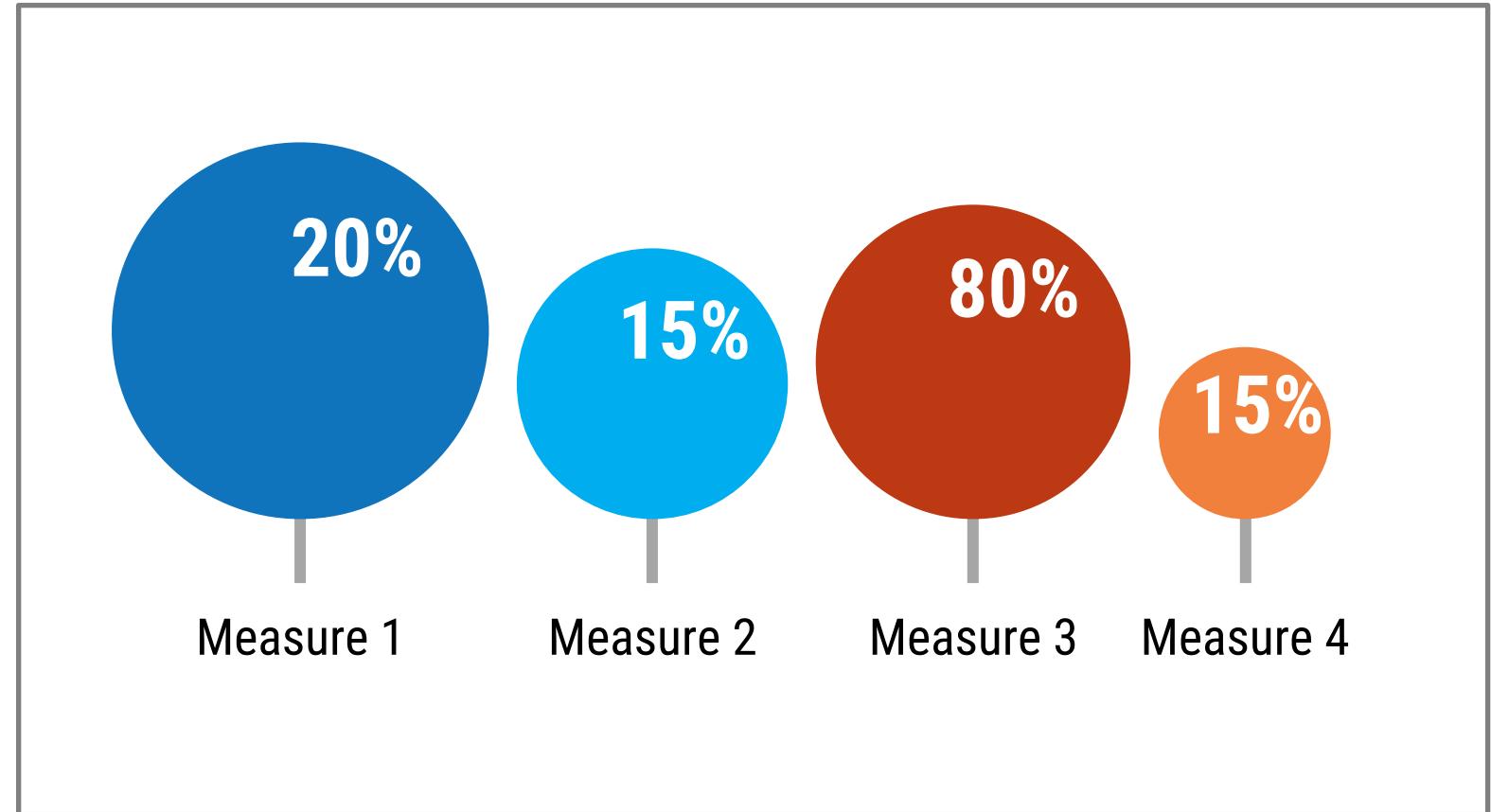
# Arrangement:

## Proportions are accurate (avoid distortion)

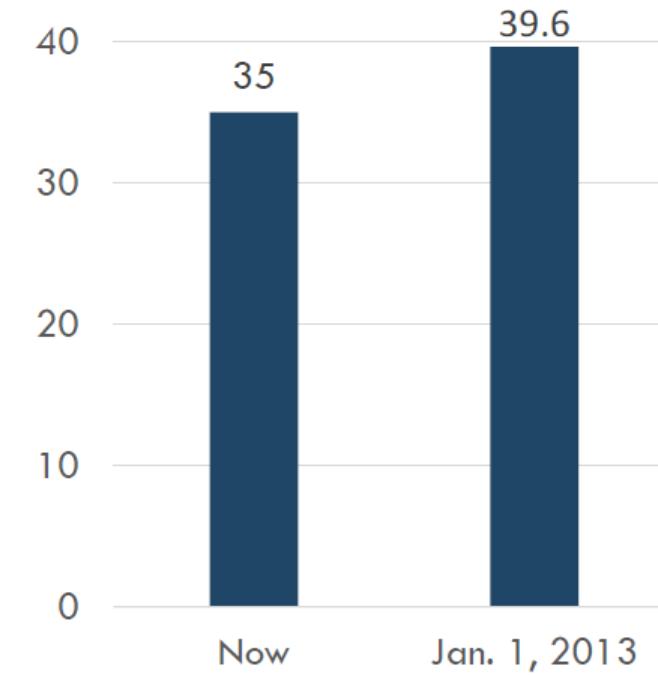
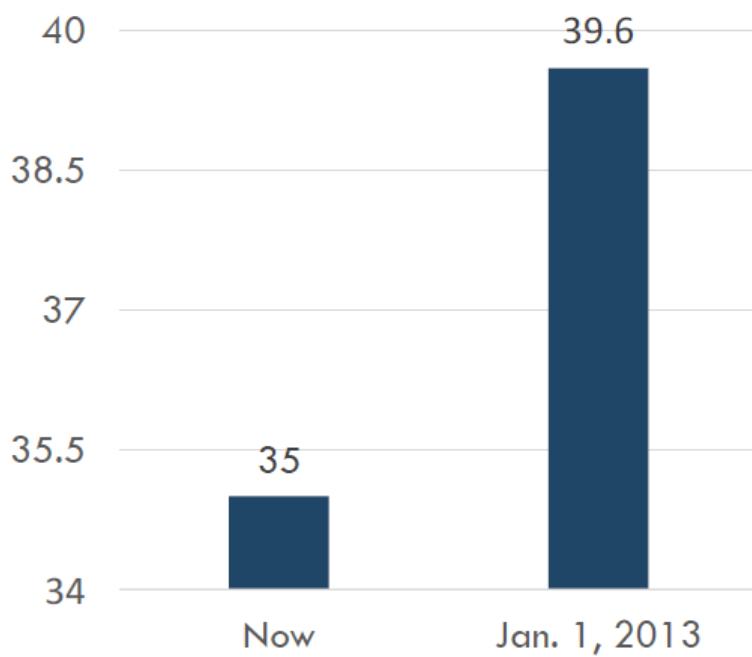
### Example:

The proportions don't match the underlying data, i.e. 15% are two different sizes, 20% is giant...

Rating = 0



# Axis should start at zero



<http://flowingdata.com/2012/08/06/fox-news-continues-charting-excellence/>

## THE BLOG

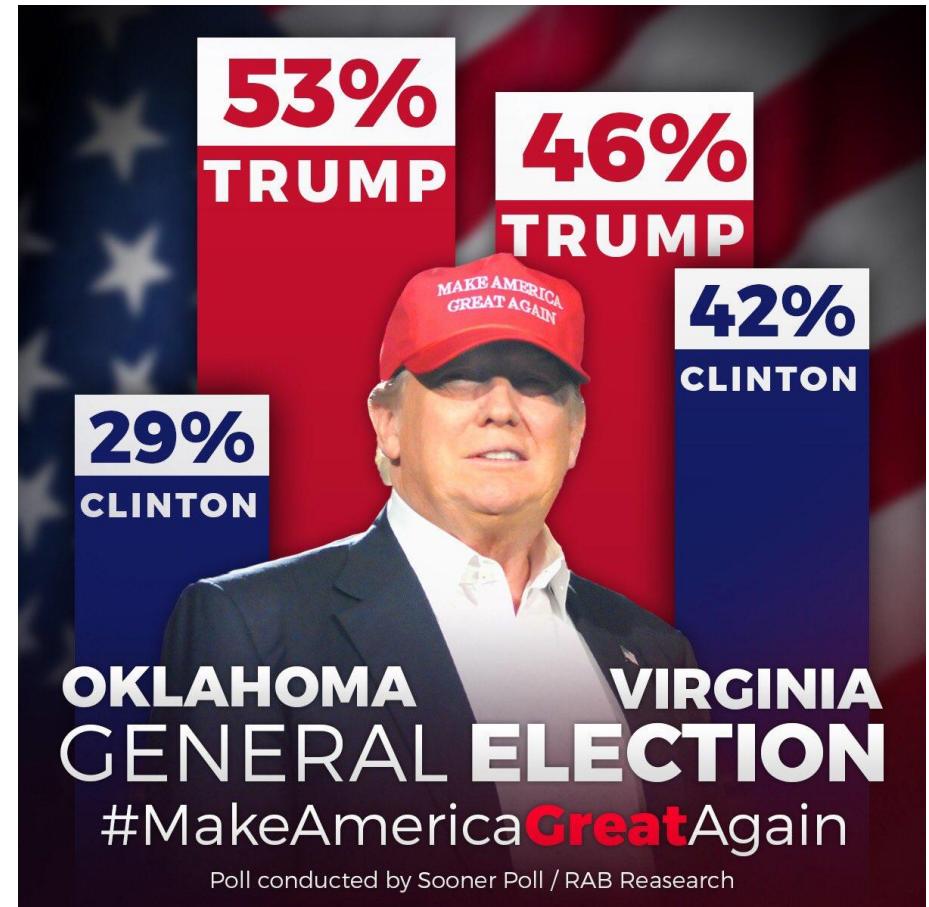
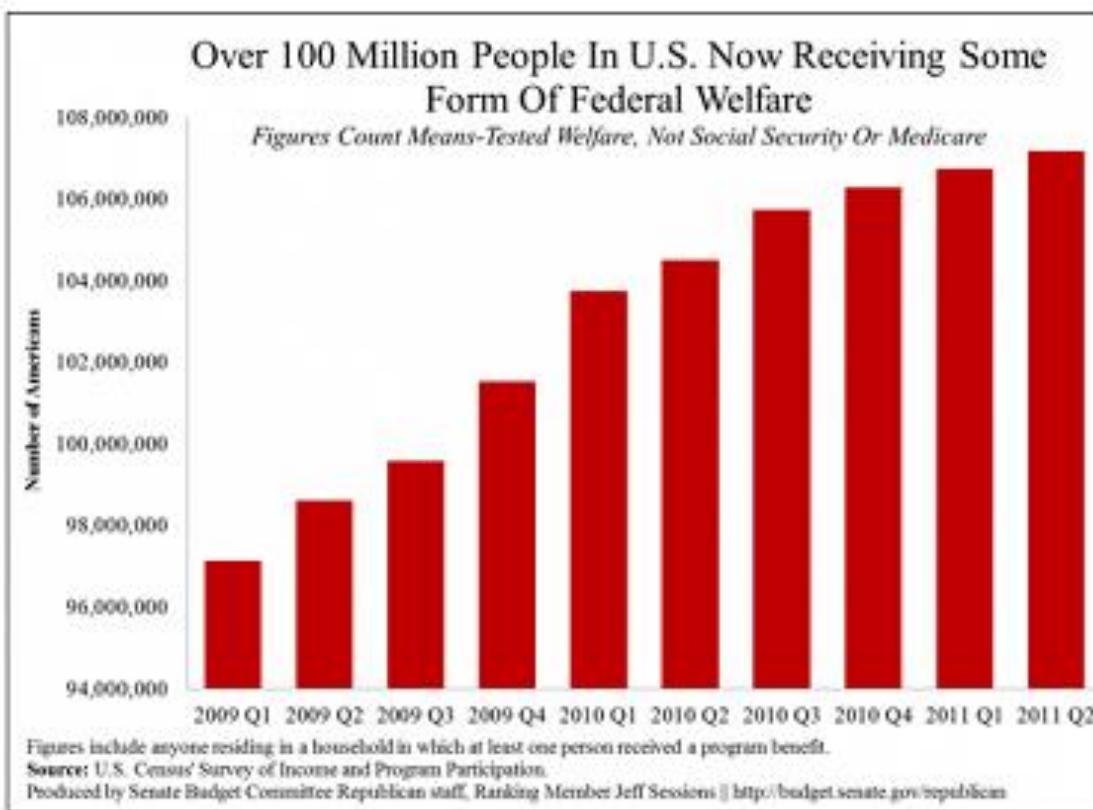
# Over 100 Million Now Receiving Federal Welfare

2:40 PM, AUG 6, 2012 • BY DANIEL HALPER 

[EDITORIAL PAGE](#) [PRINT](#) [LARGER TEXT](#) [SMALLER TEXT](#) [REPORT](#)

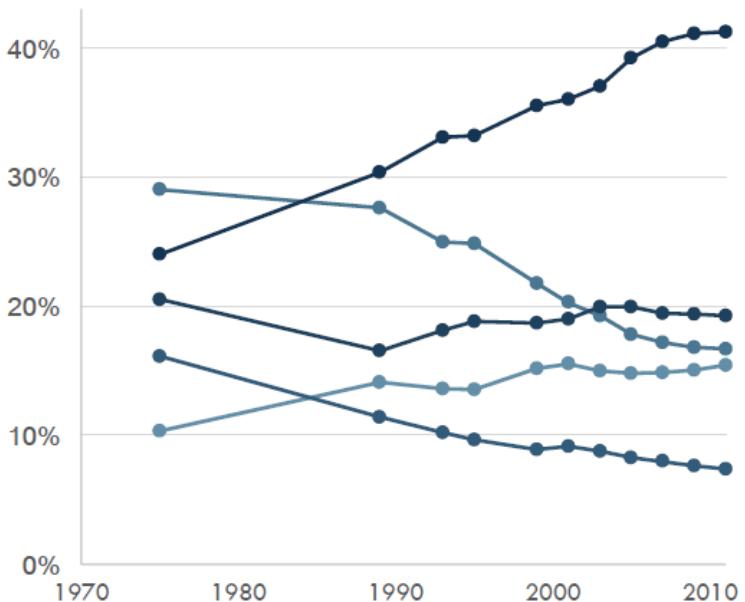
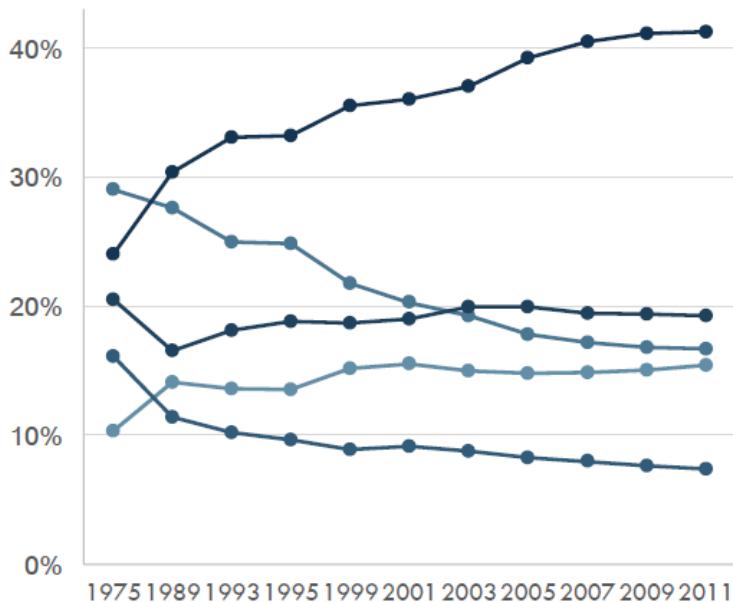


A new chart set to be released later today by the Republican side of the Senate Budget Committee details a startling statistic: "Over 100 Million People in U.S. Now Receiving Some Form Of Federal Welfare."



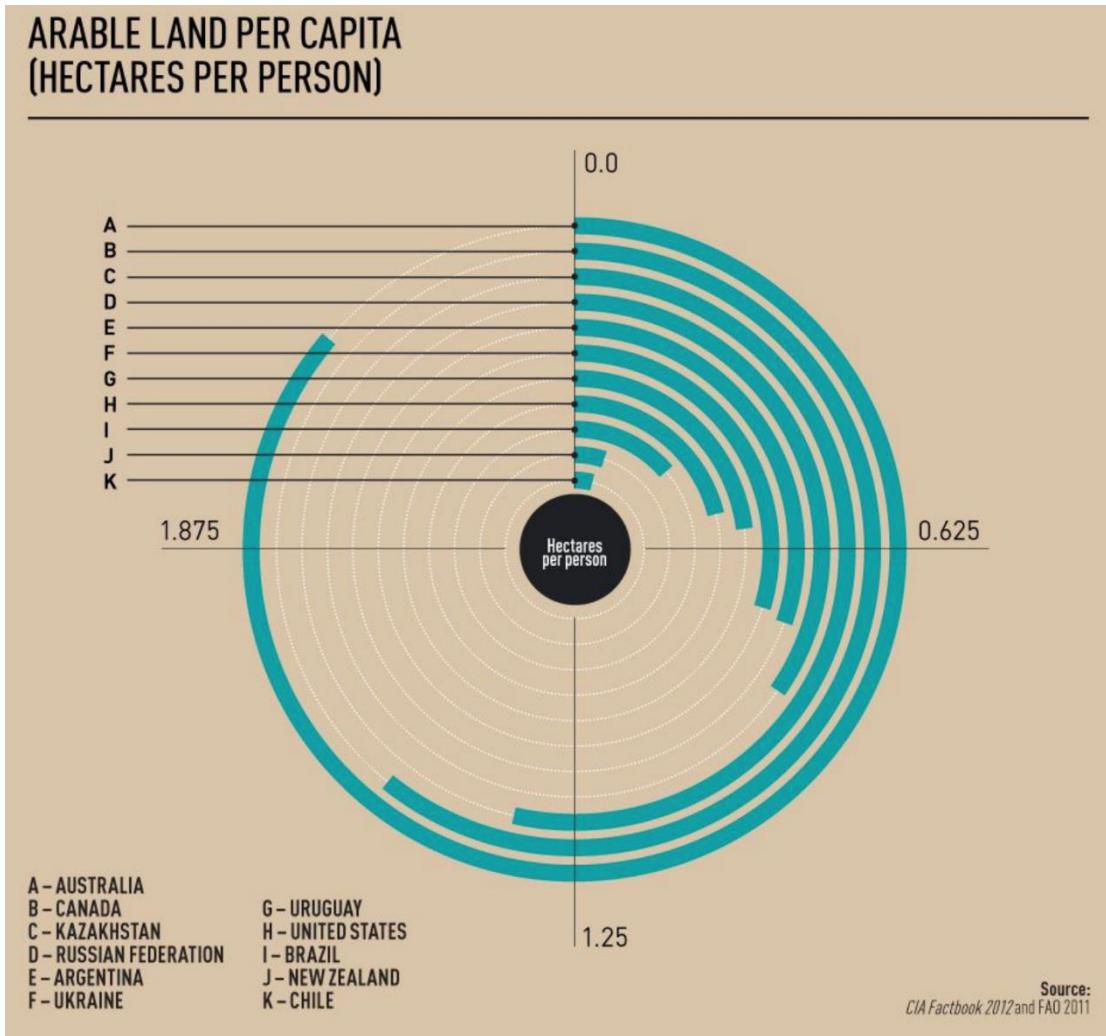
<https://twitter.com/realdonaldtrump/status/760213628926779392>

# Mind the gaps



[http://www.aaup.org/sites/default/files/files/AAUP\\_Report\\_InstrStaff-75-11\\_apr2013.pdf](http://www.aaup.org/sites/default/files/files/AAUP_Report_InstrStaff-75-11_apr2013.pdf)

## ARABLE LAND PER CAPITA (HECTARES PER PERSON)

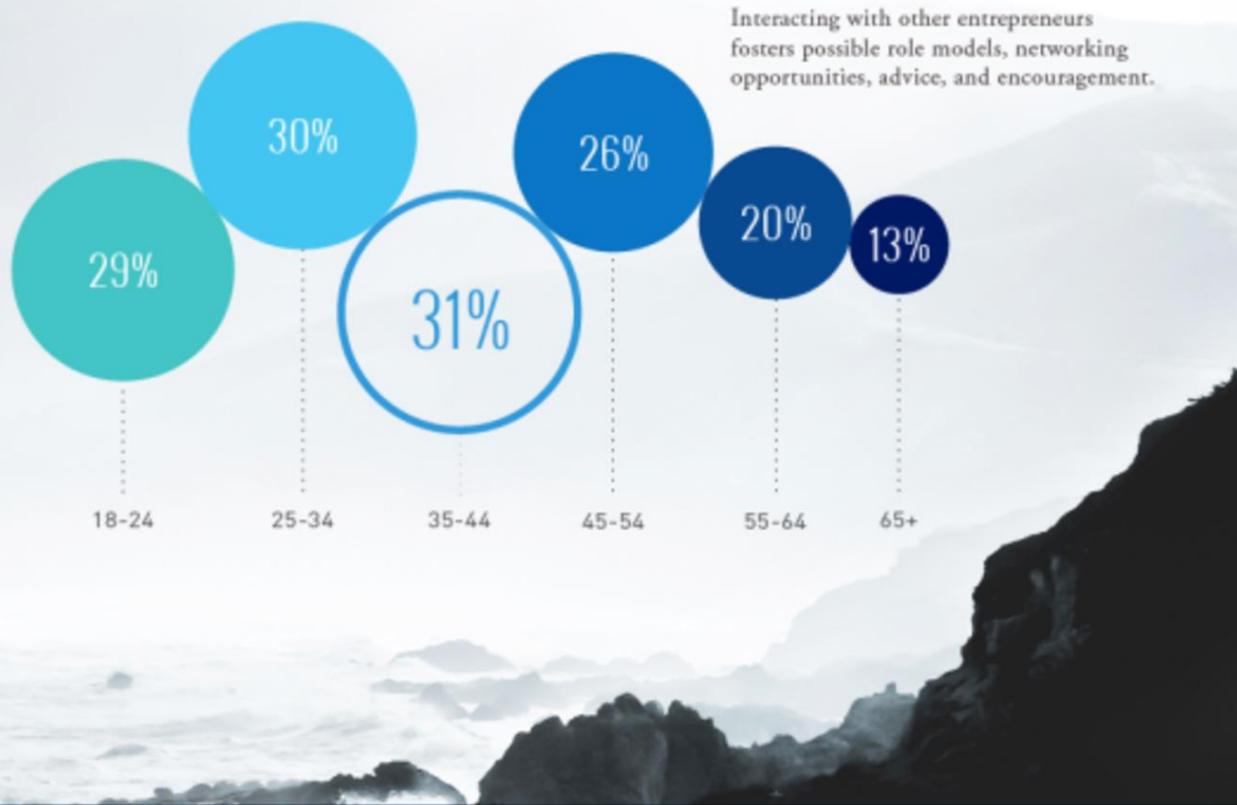


In this donut bar chart, the US (H) has about 1/3 the arable land per capita of Canada (B), but almost 6x the area/ink on the viz.

Intention is to encode via angle but we can easily visually misinterpret it by area.

## It's Who You Know

By ages 35–44, people are likely to have the strongest network of fellow entrepreneurs, but these personal social networks begin to decline over time.



**Bubble charts using radius rather than area to encode data also run into distortion.**

**Take a look at the 45-54 bubble and 65+ bubble.  
13% is half of 26%, but the area is  $\frac{1}{4}$ .**

# **Arrangement:**

## **Data are intentionally ordered**

Data should be displayed in an order that makes logical sense to the viewer. Data may be ordered by frequency counts (e.g., from greatest to least for nominal categories), by groupings or bins (e.g., histograms), by time period (e.g., line charts), alphabetically, etc. Use an order that supports interpretation of the data.

**Fully met** = There's an intentional order that aligns with the takeaway message.

**Partially met** = There's an intentional order but doesn't align with takeaway message.

**Not met** = No discernable order.

# Arrangement:

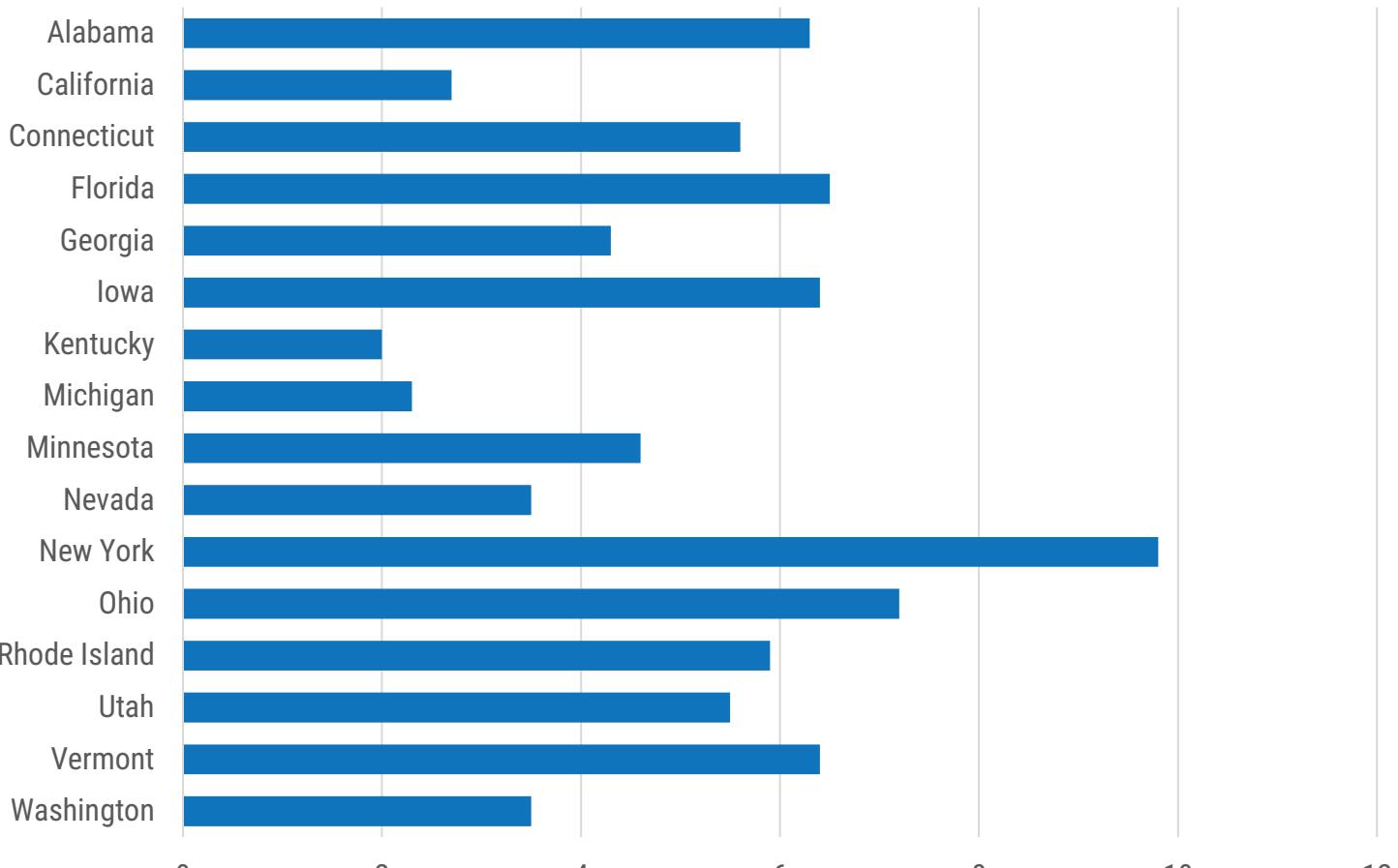
## Data are intentionally ordered

### Example:

Ordered alphabetically  
but doesn't align with  
overall message.

Rating = 1

Overall Kentucky, Michigan, and California had least amount of top soil erosion.



# **Arrangement:**

## **Axis intervals are equidistant**

The spaces between axis intervals should be the same unit, even if every axis interval isn't labeled. Irregular data collection periods can be noted with markers on a line graph, for example.

**Fully met** = Space between axis intervals are equal.

**Partially met** = This is often either not met or fully met.

**Not met** = Spaces between axis intervals are **not** equal.

# Arrangement:

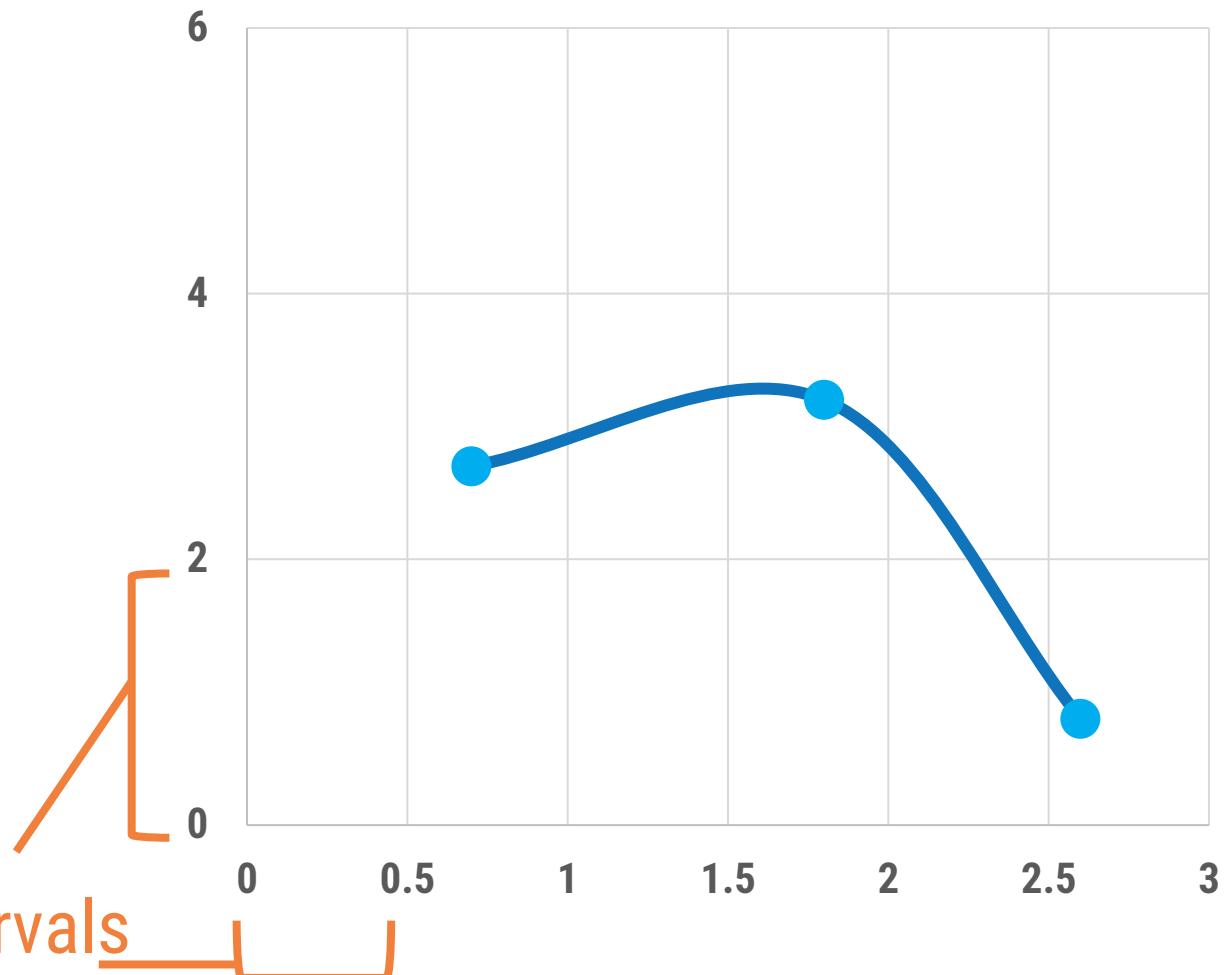
## Axis intervals are equidistant

### Example:

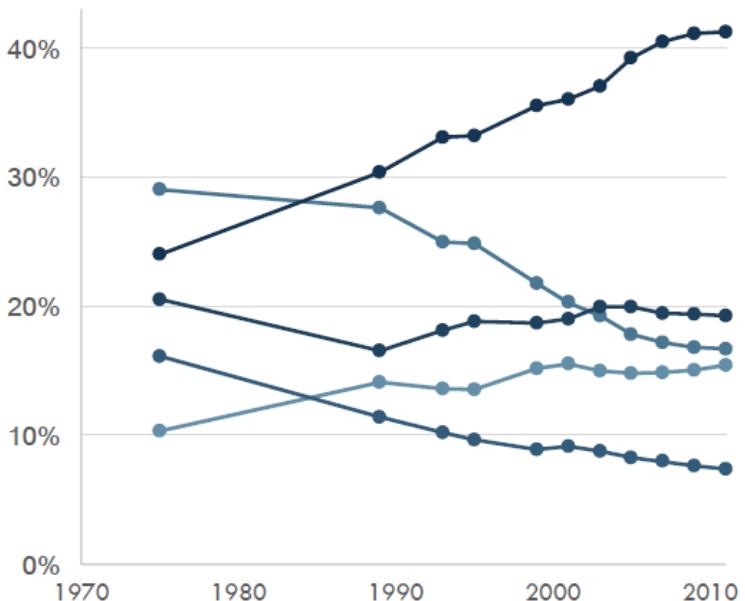
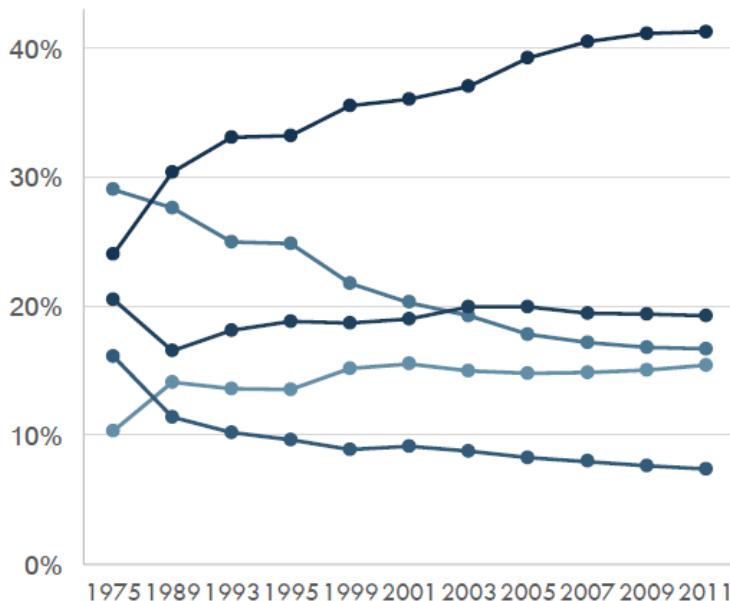
Axis intervals on both the x and y-axes are equal.

Rating = 2

These are axis intervals



# Mind the gaps



[http://www.aaup.org/sites/default/files/files/AAUP\\_Report\\_InstrStaff-75-11\\_apr2013.pdf](http://www.aaup.org/sites/default/files/files/AAUP_Report_InstrStaff-75-11_apr2013.pdf)

# **Arrangement:**

## **Graph is two-dimensional**

Avoid three-dimensional displays, bevels, and other distortions.

**Fully met** = It's a flat, 2D design.

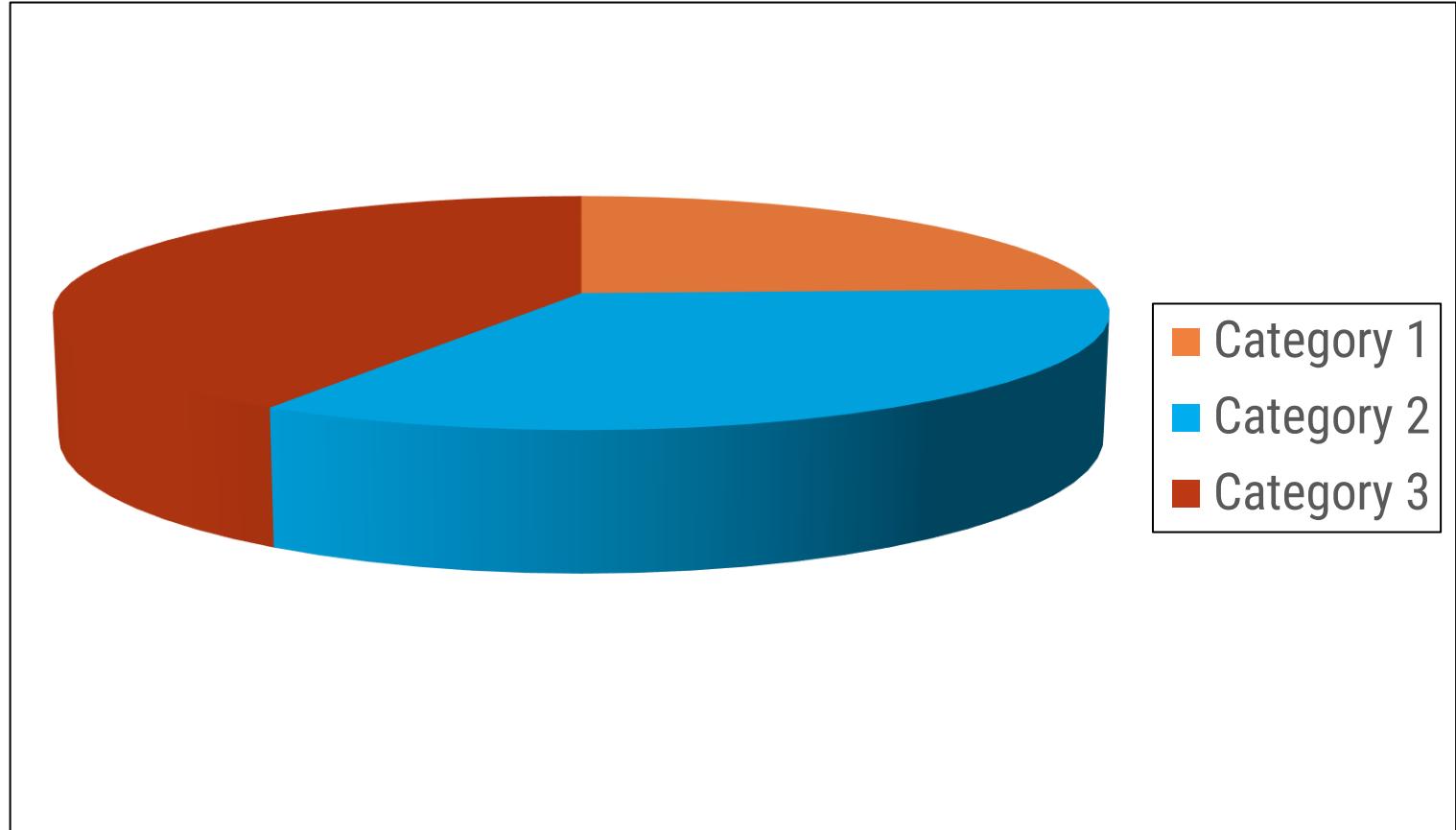
**Partially met** = This one will usually be “Not met” or “Fully met.”

**Not met** = It's an exploding pie-chart, a similar 3D design, or uses bevels.

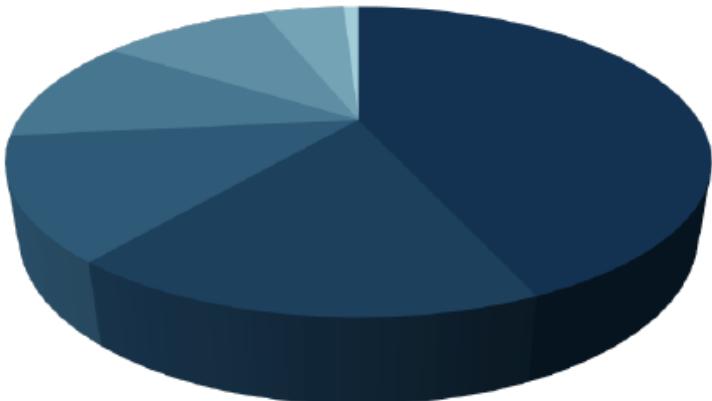
# Arrangement: Graph is two-dimensional

**Example:**  
Graph has a 3D design.

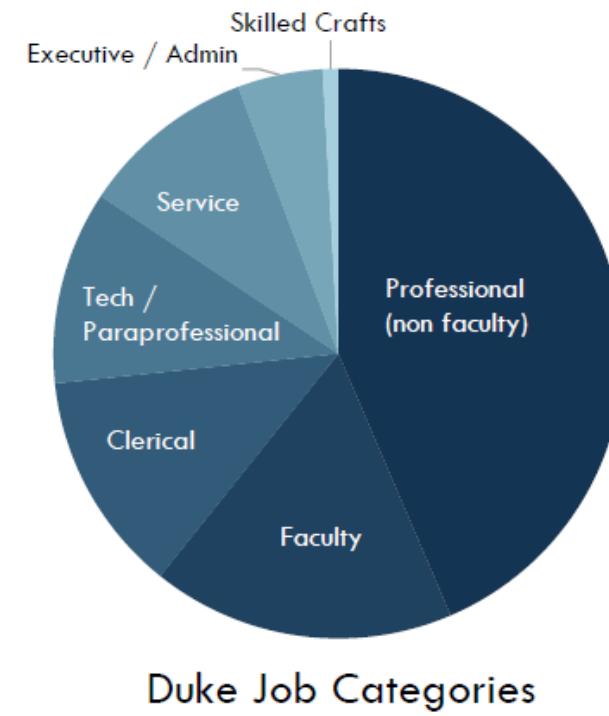
Rating = 0



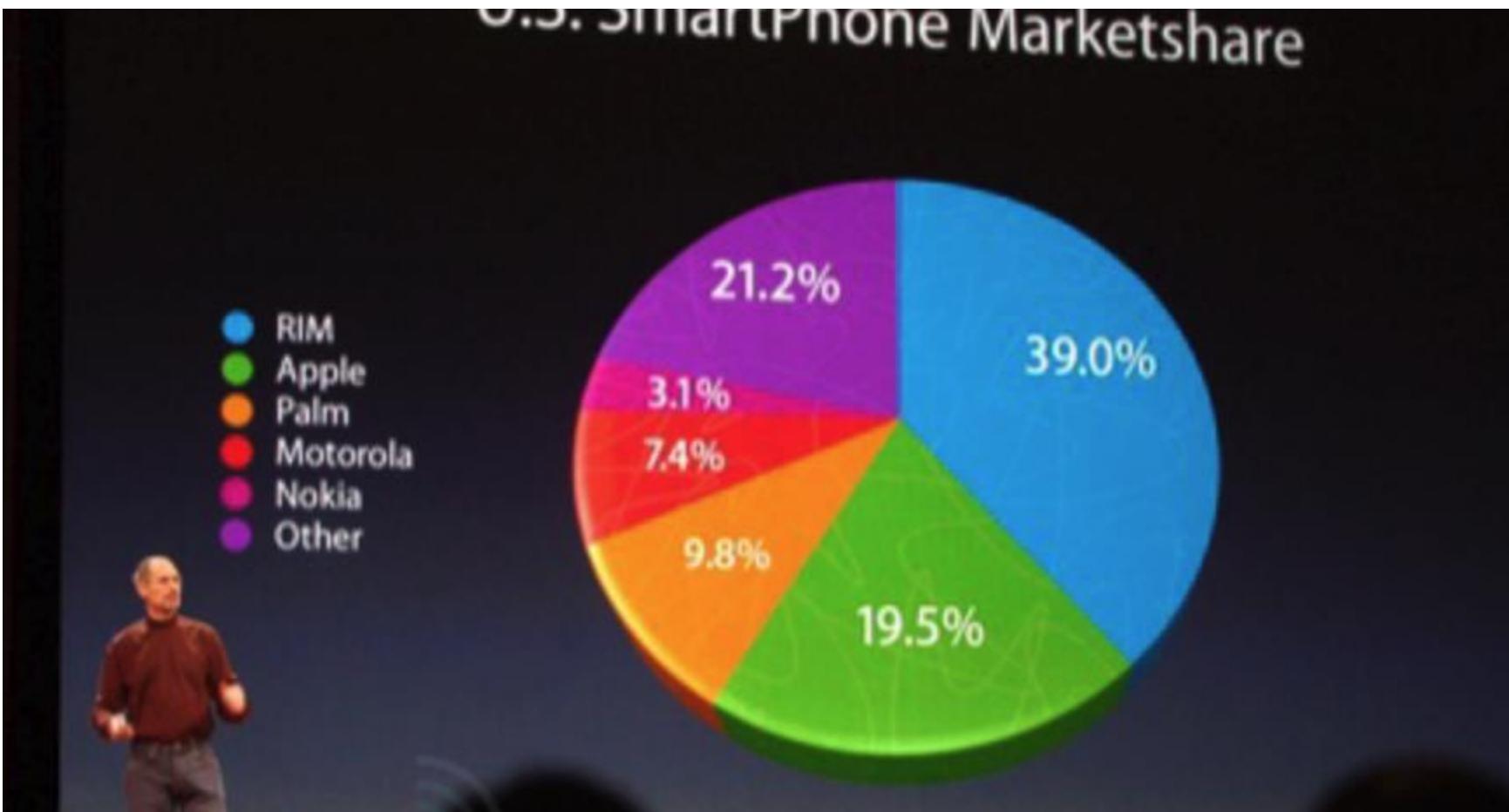
# 3D distorts area + Label directly



- Professional (non faculty)
- Faculty
- Clerical
- Tech / Paraprofessional
- Service
- Executive / Admin
- Skilled Crafts



# Real-life example - 3D pie chart distorts area



# **Arrangement:**

## **Display is free from decoration**

Graph is free from clipart or other illustrations used solely for decoration. Some graphics, like icons, can support interpretation.

**Fully met** = Graph does not have decoration **OR** decoration supports interpretation (rare).

**Partially met** = This one will usually be “Not met” or “Fully met.”

**Not met** = Graph has decorative clipart, illustrations, etc.

# Arrangement:

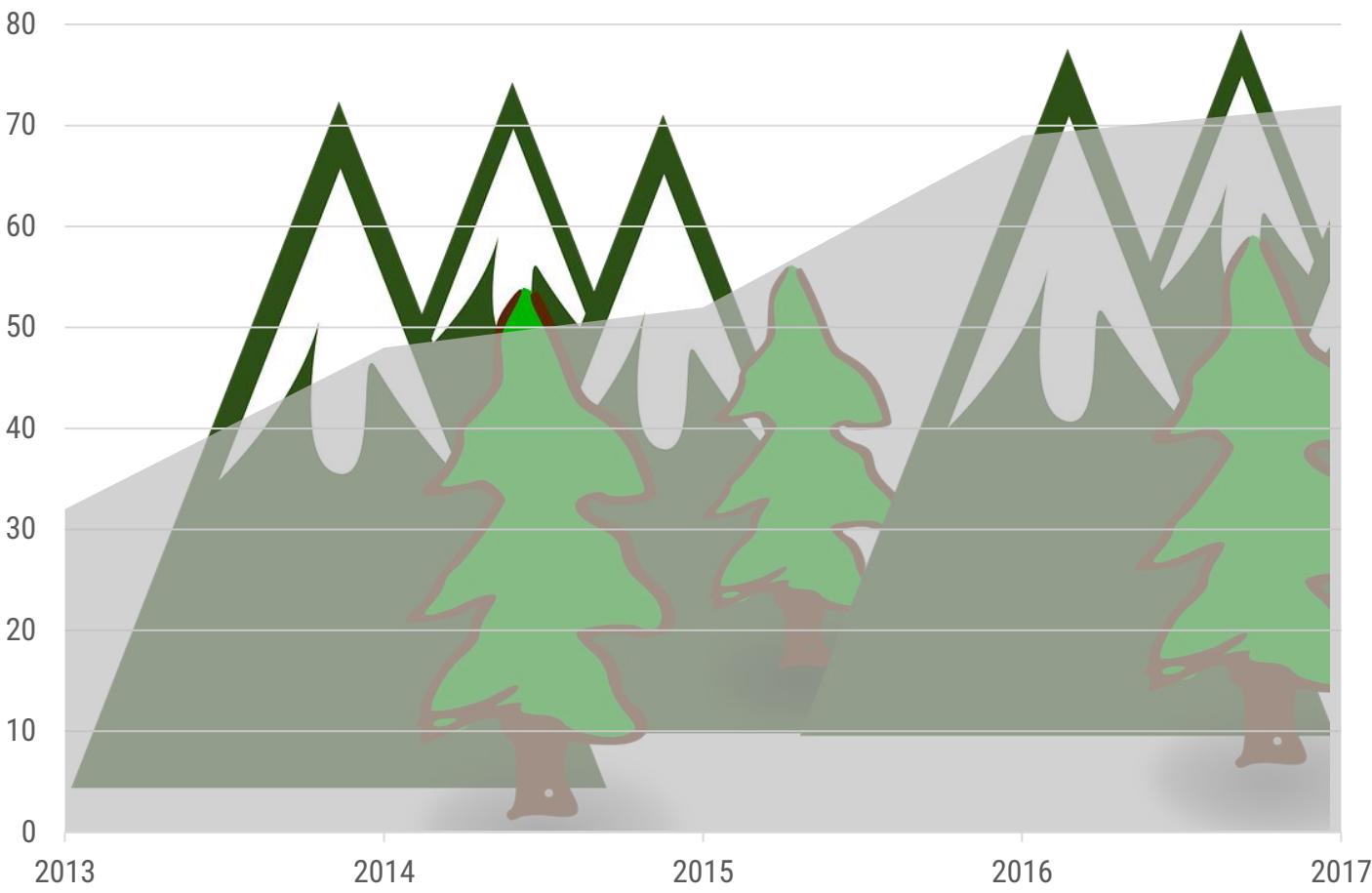
## Display is free from decoration

### Example:

There's a lot going on with this visualization. The mountain image is decorative and does not support interpretation.

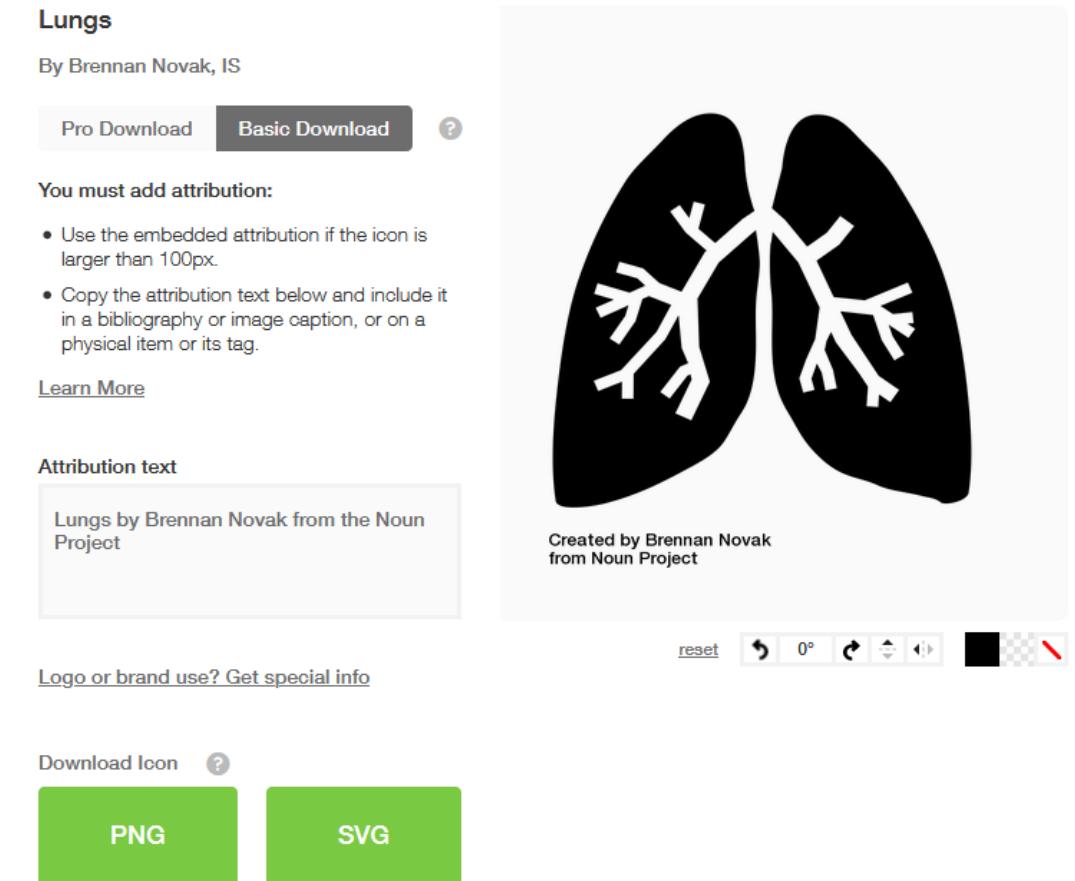
Rating = 0

Overall sales are increasing.



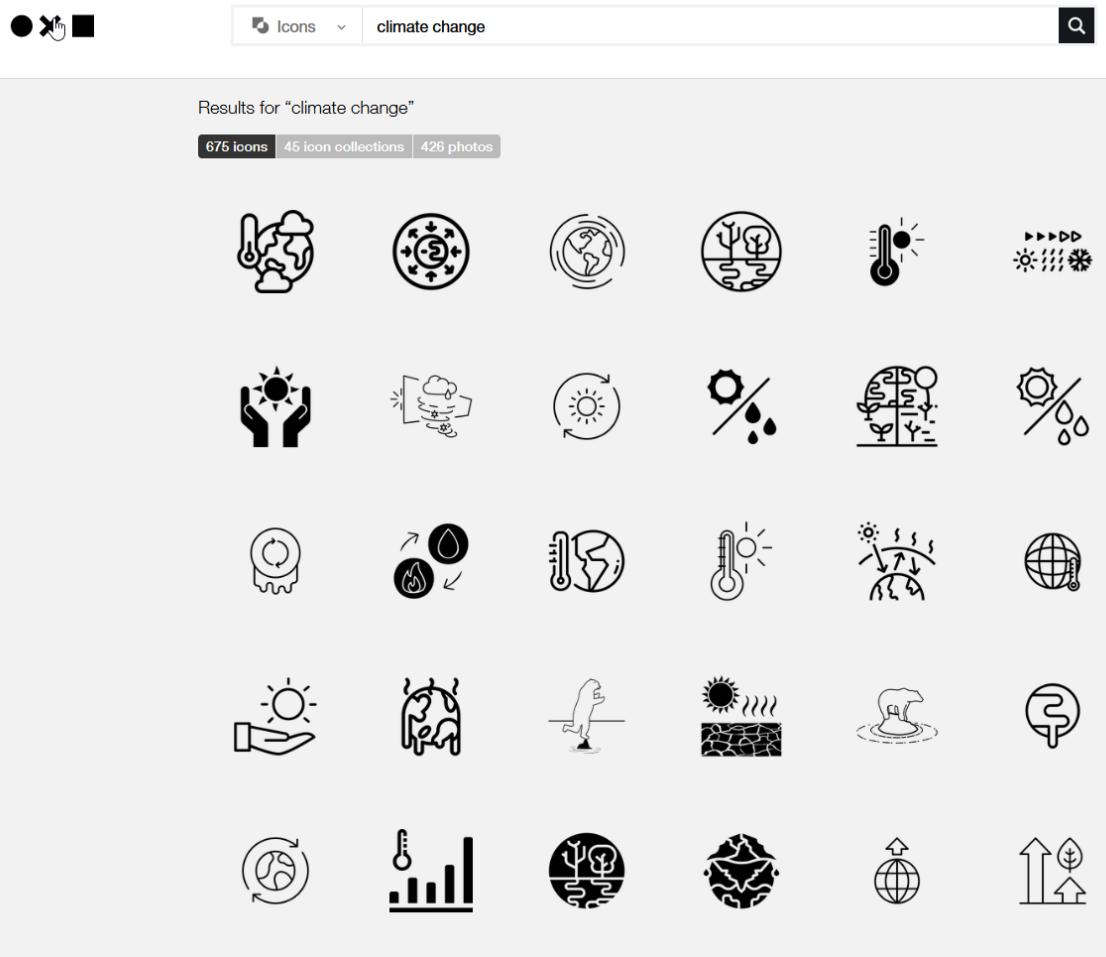
# Arrangement: Display is free from decoration (some exceptions)

- While stripping away decoration is a good rule of thumb, make sure to utilize visuals (ex. icons, illustrations, photos) when appropriate like in an infographic, flowchart, or schematic.
- <https://thenounproject.com/> is a good site to use at a very low cost or free if you cite their image - You can use the CC license, or pay for a royalty free license that won't require citation.



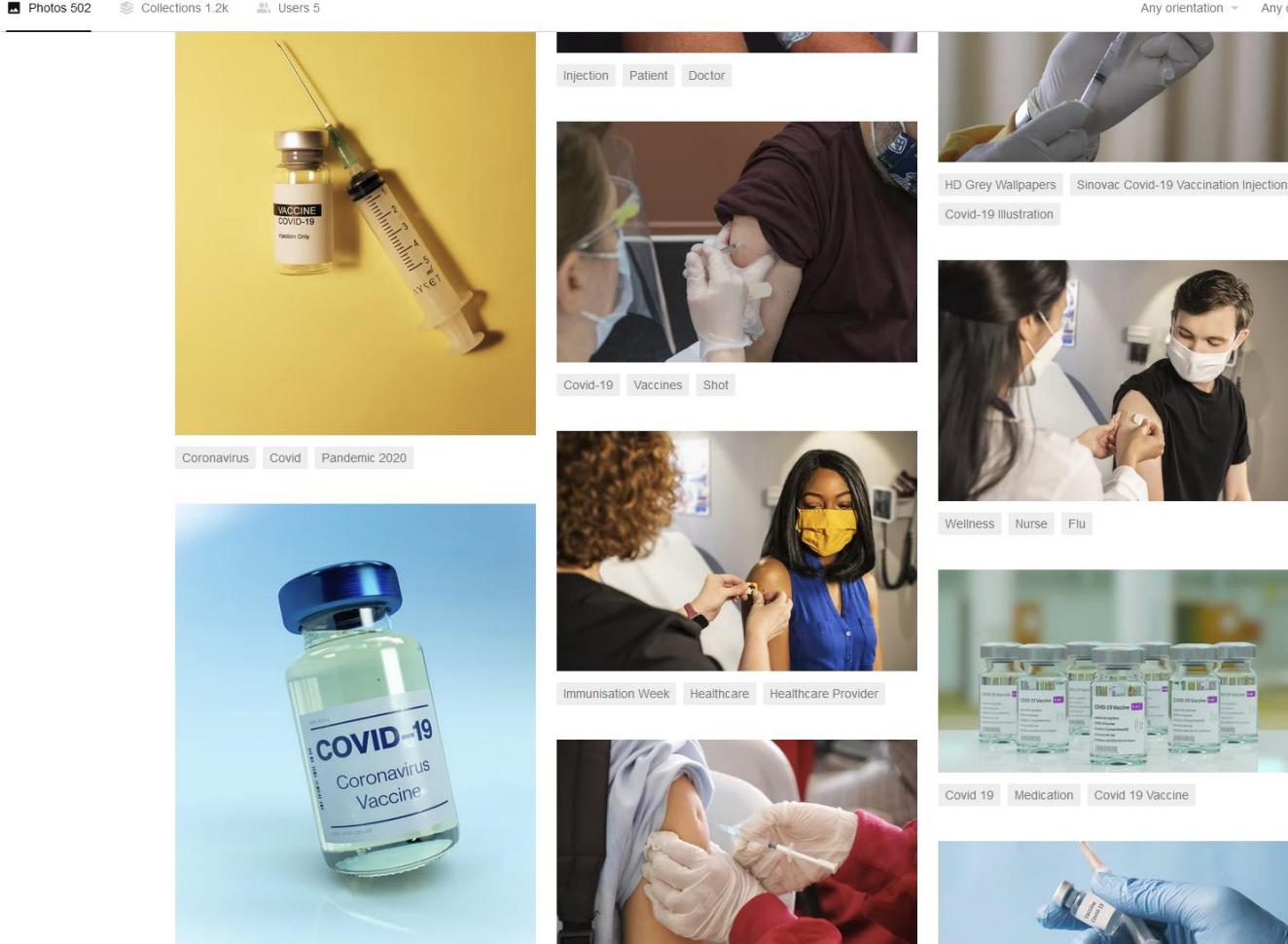
# Arrangement: Display is free from decoration (some exceptions)

Home Icons Photos Pricing Apps & Plugins API Lingo ...



675 icons just by searching  
the term “climate change”

# Arrangement: Display is free from decoration (some exceptions)



<https://unsplash.com/>

502 large, high-quality stock photos just by searching the term “vaccine”



**Let's walk through the  
checkpoints in  
Color**

# **Color:**

## **Color scheme is intentional**

Colors should represent brand or other intentional choice, not default color schemes. Use your organization's colors or your client's colors. Work with online tools to identify brand colors and others that are compatible.

Note – Your university most likely has a brand guide that may even include a data visualization color guide you can use.

**Fully met** = Appears that colors were changed from the default.

**Partially met** = This one will usually be “Not met” or “Fully met.”

**Not met** = Appears to be default Excel or Tableau coloring.

# Color: Color scheme is intentional

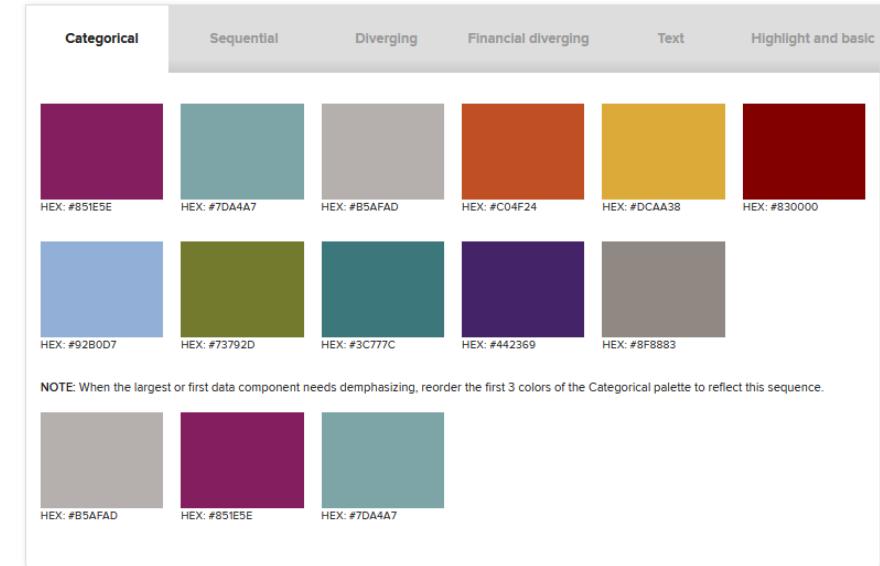
Note – Your university most likely has a brand guide that may even include a data visualization color guide you can use. Ex. <https://brand.osu.edu/data-visualization/>

Sequential palettes are appropriate when data ranges from relatively low or uninteresting values to relatively high or interesting values. For sequential data, it's better to use a palette that has a relatively subtle shift in hue accompanied by a substantial change in brightness and saturation.

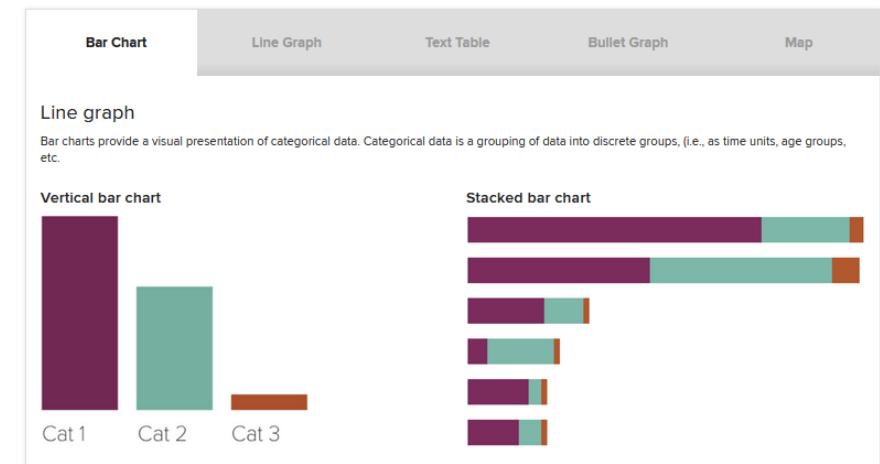
Diverging palettes work well when the values are ordered and there is a critical mid-point (e.g. an average or zero).

Tableau after editing your Preferences.tps to apply the palettes.

[Download color palette codes PDF](#)



## Basic Charts

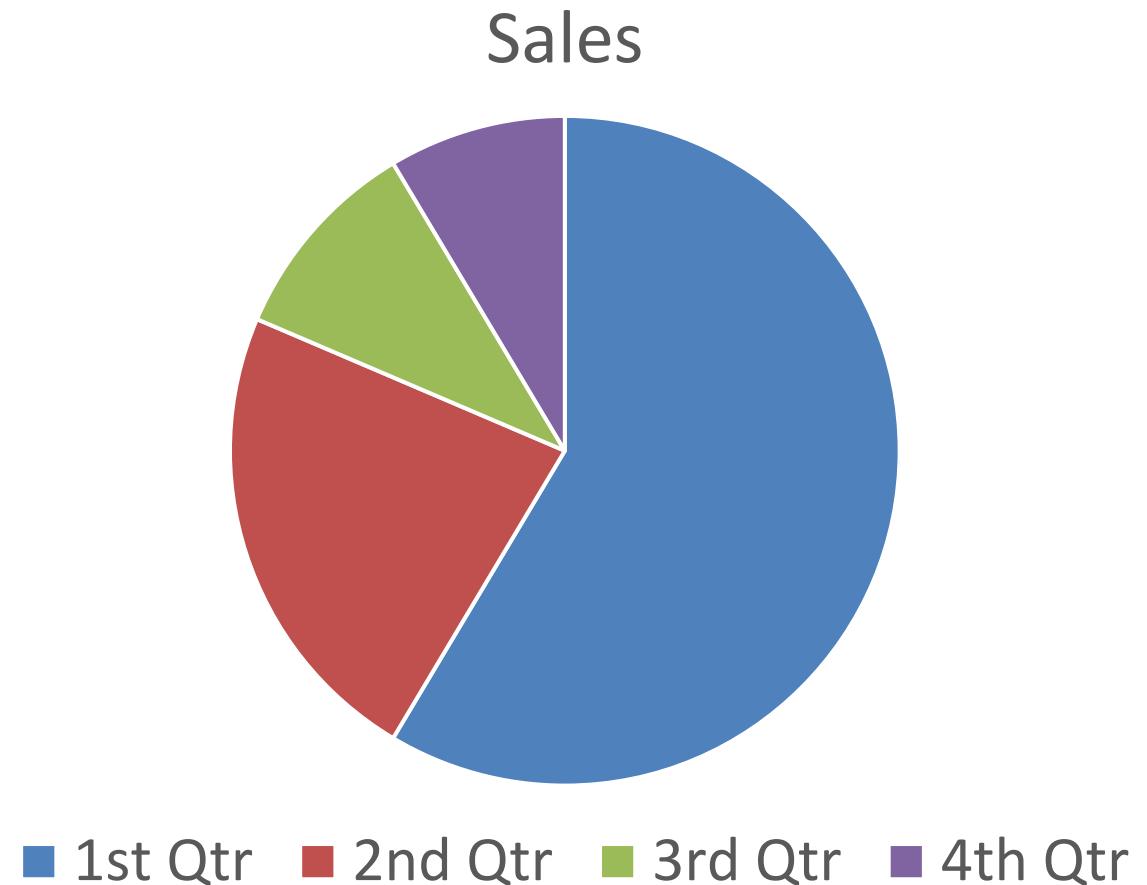


# Color: Color scheme is intentional

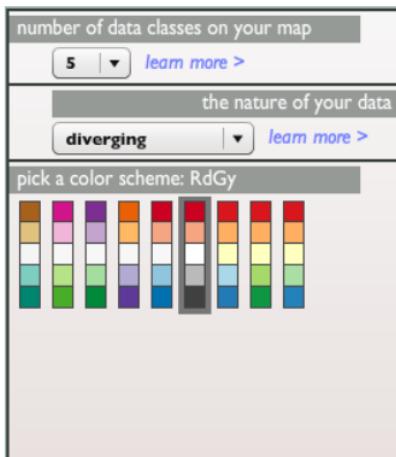
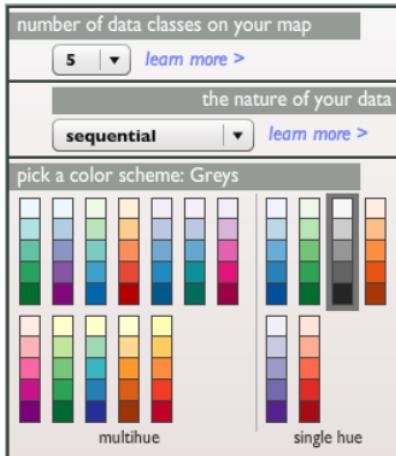
## Example:

Graph appears to follow  
default Excel color scheme

Rating = 0



# Color: Color scheme is intentional



## ColorBrewer

Cynthia Brewer, PhD – Penn State

The screenshot shows the ColorBrewer website for a 5-class Red-Grey diverging color scheme. It features sections for 'ArcGIS User!', 'Adobe User!', 'Excel spreadsheet', and 'or just copy-n-paste'. Each section includes a brief description and a 'DOWNLOAD' or 'COPY-N-PASTE' link. The 'Excel spreadsheet' section also has an 'EXPORT YOUR COLORS >>' button. A preview of the color scheme is shown at the top right.

<http://colorbrewer2.org/>

# **Color:**

## **Color is used to highlight key patterns**

Action colors should guide the viewer to key parts of the display. Less important, supporting, or comparison data should be a muted color, like gray.

**Fully met** = There's an action color **and** comparison data is in a muted color.

**Partially met** = There's an action color but other colors for comparison/less important data are not muted.

**Not met** = No discernable action color/too many colors.

# Color:

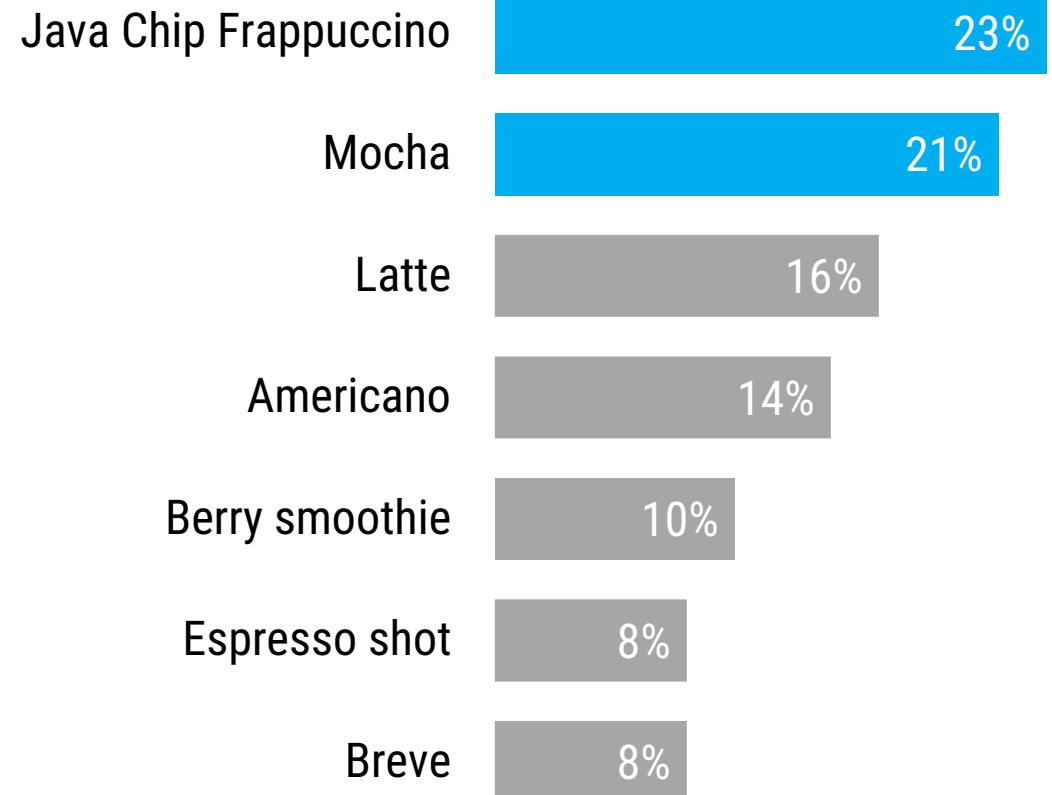
Color is used to highlight key patterns

## Example:

Blue highlights finding, all other bars are gray.

Rating = 2

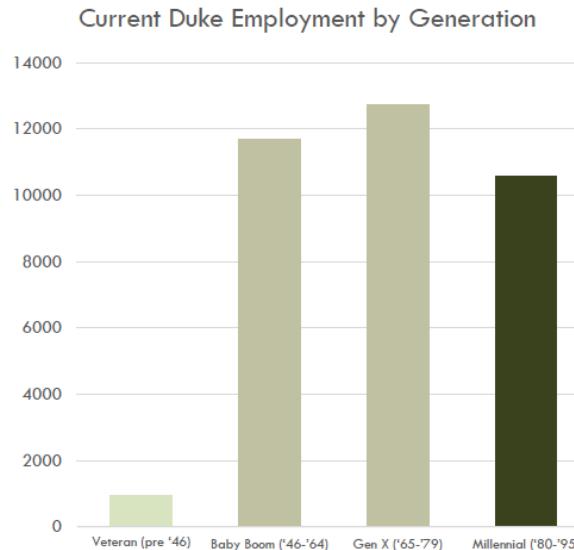
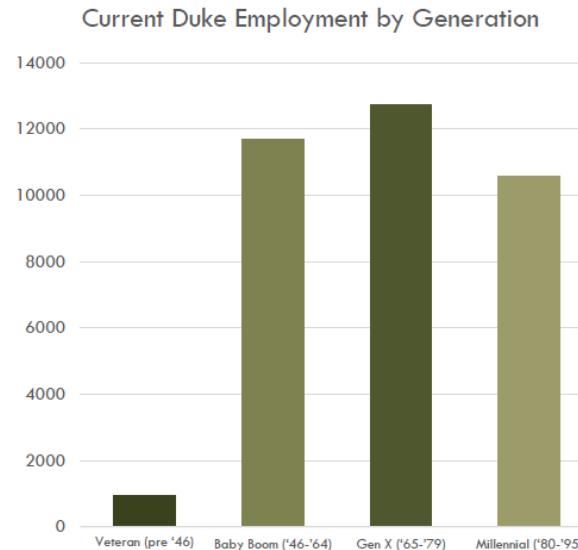
Coffee preferences focus on chocolate-based drinks.



# Color:

## Color is used to highlight key patterns

Use color to draw attention



From Duke University's Angela Zoss

# **Color:**

## **Color is legible when printed in black and white**

When printed or photocopied in black and white, the viewer should still be able to see patterns in the data.

**Fully met** = Patterns are equally clear in color and black and white.

**Partially met** = Patterns are harder to see in black and white than in color.

**Not met** = Different colors look the same or similar when printed in B&W.

\* Tip: Use print preview on your computer and select black and white or grayscale to quickly see what will happen to the colors when printed.

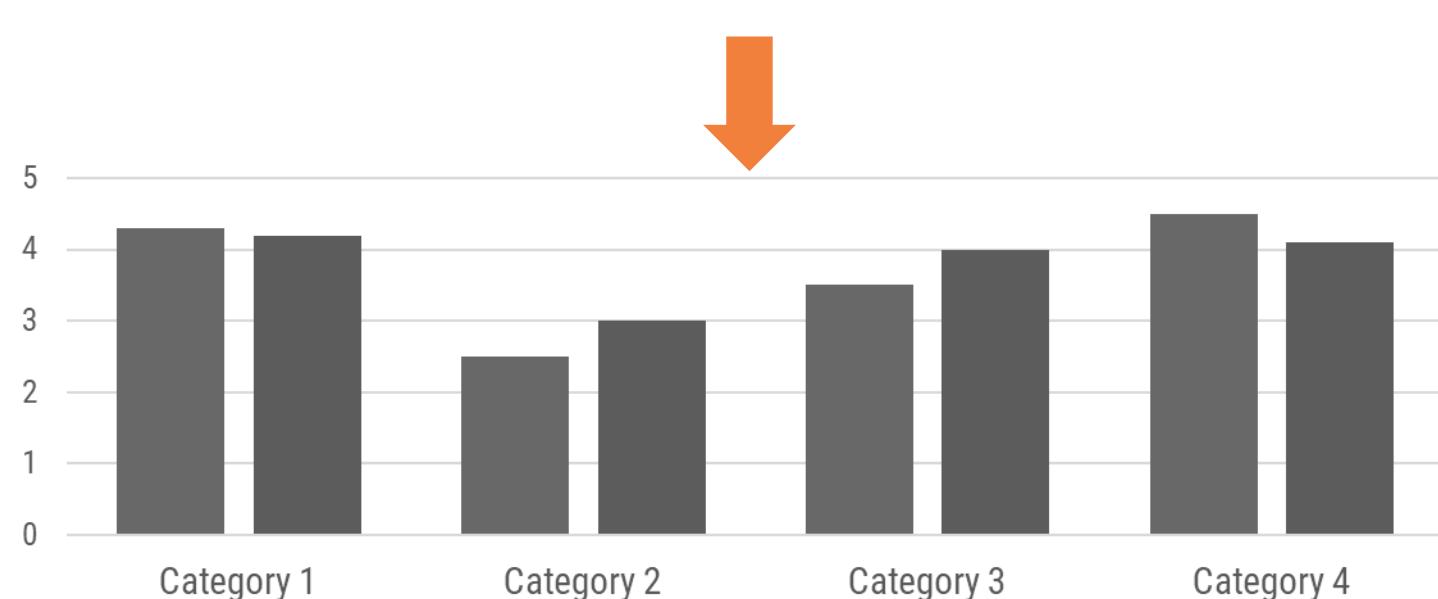
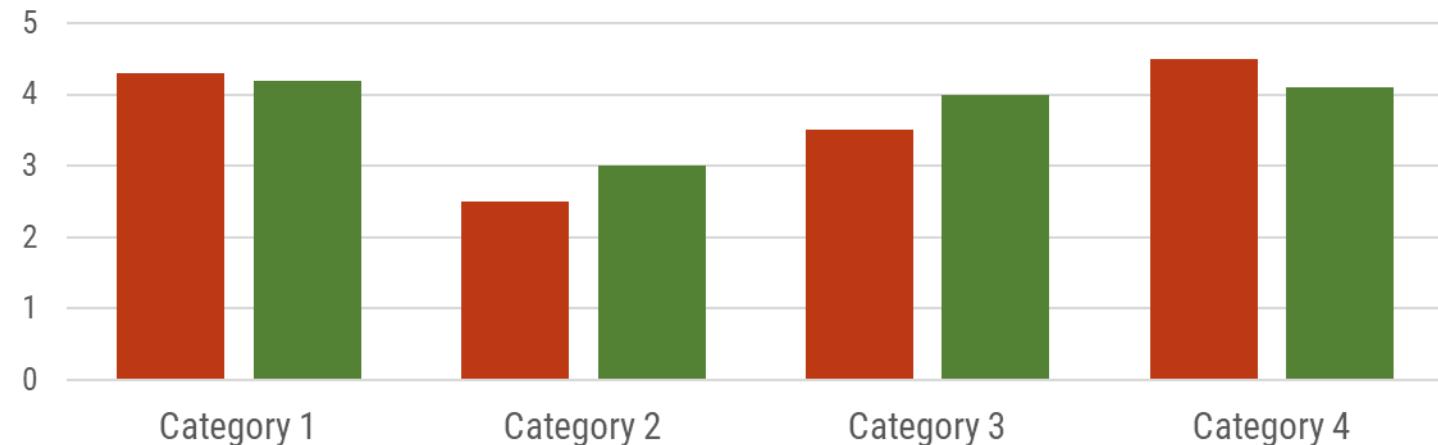
# Color:

## Color is legible when printed in black and white

### Example:

In the before and after example, you can see it is hard to tell the difference between the colors when printed in black and white.

Rating = 0



# **Color:**

## **Color is legible for people with colorblindness**

Avoid red-green and yellow-blue combinations, especially when those colors touch one another. Avoid using red to mean bad and green to mean good in the same chart.

**Fully met** = There are no red/green, yellow/blue combinations.

**Partially met** = This is usually either “Not Met” or “Fully Met.”

**Not met** = Red/green or yellow/blue are used.

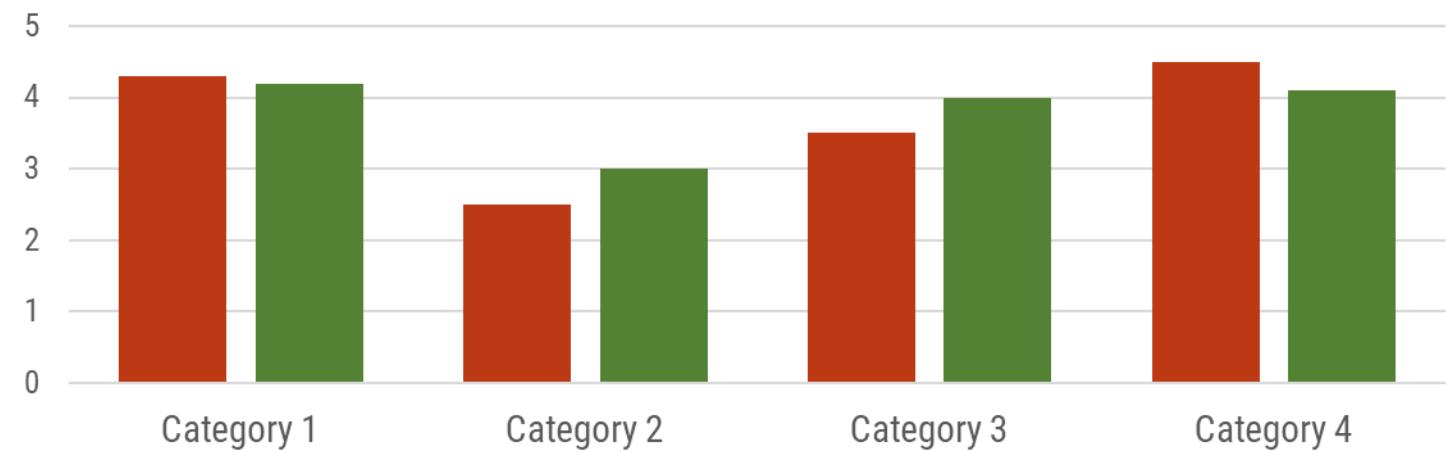
# Color:

## Color is legible for people with colorblindness

### Example:

Red and green are used in the graph, which isn't colorblind safe.

Rating = 0



# **Color:**

## **Text sufficiently contrasts background**

Black/very dark text against a white/transparent background is easiest to read.

**Fully met** = Black, or very dark color (i.e. dark grey, dark blue, etc. on white).

**Partially met** = White text on black or very dark background – still readable, but less so than black on white.

**Not met** = Dark text on colored background or light text on white background.

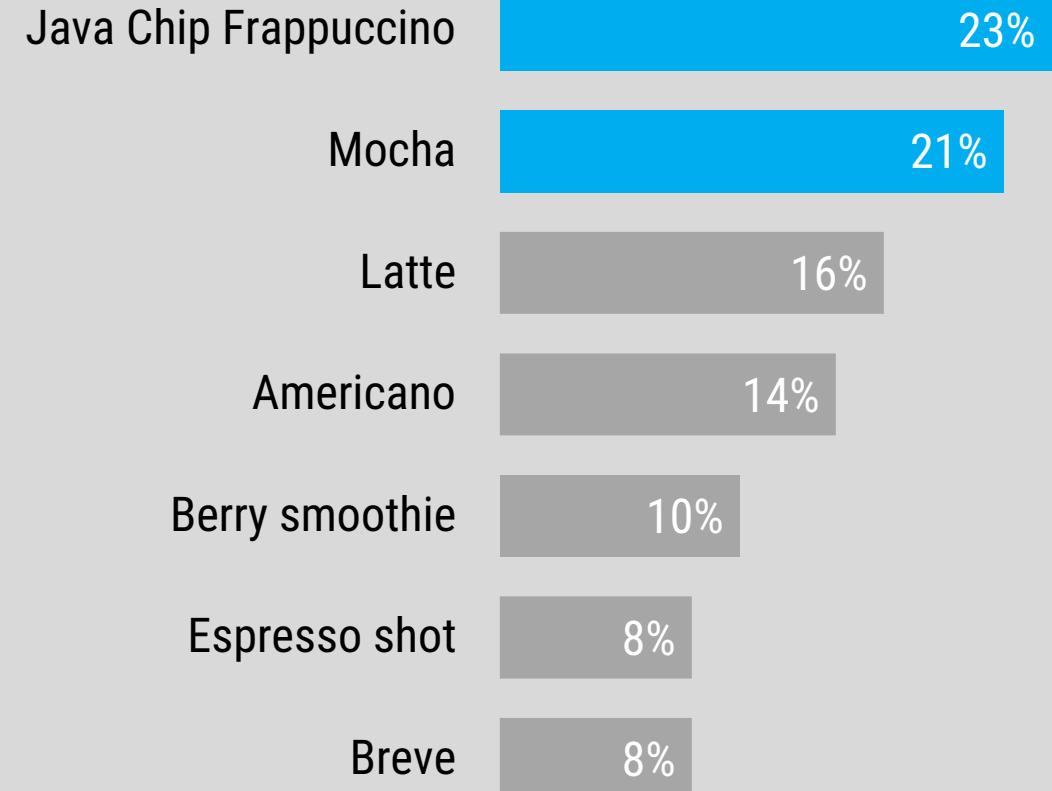
# Color: Text sufficiently contrasts background

## Example:

Color text no longer contrasts well on a gray background. Even legibility of black text on a gray background is impaired.

Rating = 0

Coffee preferences focus on chocolate-based drinks.





**Let's walk through the  
checkpoints in**

**Lines**

# **Lines:**

## **Gridlines, if present, are muted**

Color should be faint gray, not black. Full points if no gridlines are used and data labels are used instead. Gridlines, even muted, should not be used when the graph includes numeric labels on each data point.

**Fully met** = There are no gridlines and the data are directly labeled.

**Partially met** = Data are not directly labeled but gridlines are gray or a lighter color than the other lines in the graph.

**Not met** = The graph includes gridlines though the data are directly labeled **OR** data are not directly labeled but gridlines are as dark as other lines in the graph.

\* Warning – This is one people commonly rate higher because they don't mind gridlines. Don't do this.

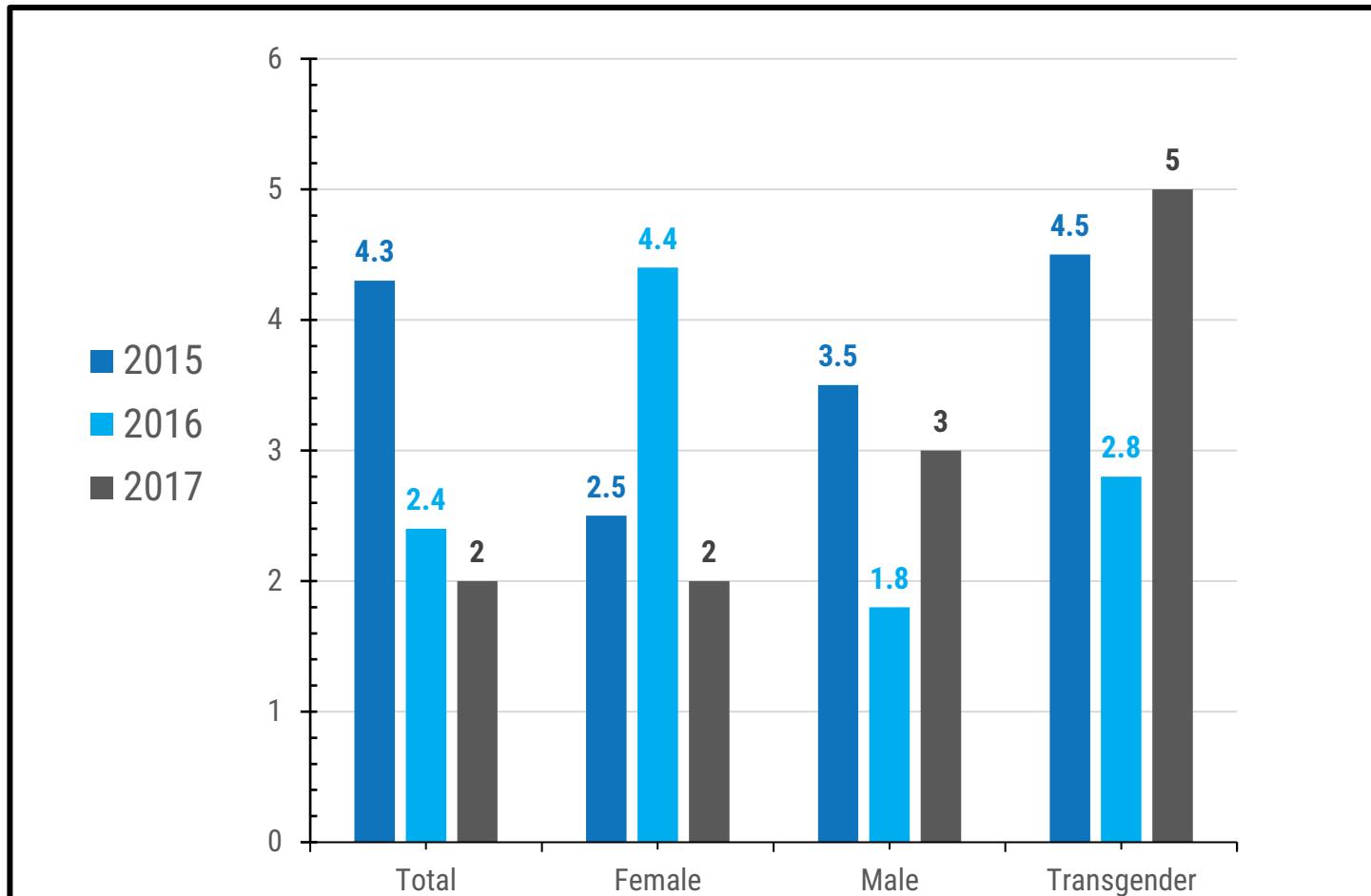
# Lines:

## Gridlines, if present, are muted

### Example:

Though gridlines are muted, they should not be included because data are directly labeled.

Rating = 0



# **Lines:**

## **Graph does not have border line**

Graph should bleed into the surrounding page or slide rather than being contained by a border.

Note – Utilize whitespace and proximity/grouping (instead of lines/borders) to contain and structure different viz and groups of elements (provide hierarchy and flow).

**Fully met** = The graph doesn't have a border.

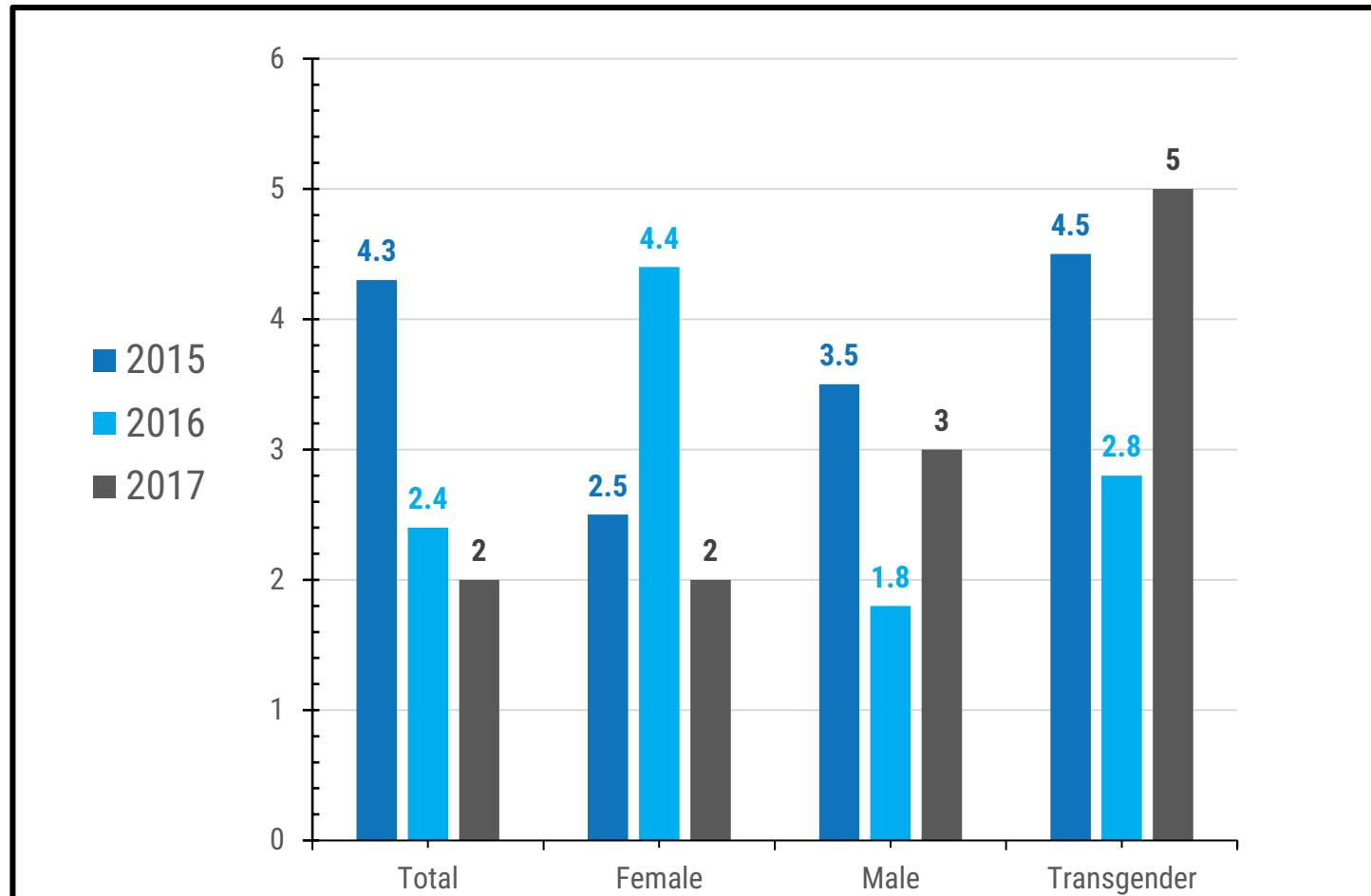
**Partially met** = This one will usually be “Not met” or “Fully met.”

**Not met** = The graph has a border.

# Lines: Graph does not have border line

**Example:**  
Graph has a border.

Rating = 0



# Lines:

## Axes do not have unnecessary tick marks or axis lines

Tick marks can be useful in line graphs (to demarcate each point in time along the y-axis) but are unnecessary in most other graph types. Remove axes lines whenever possible.

**Fully met** = The graph does not have tick marks or axes lines.

**Partially met** = The graph has ticks but no axes lines or vice versa.

**Not met** = The graph has tick marks and axes lines.

\* Warning – This is one people commonly rate higher because they don't mind tick marks. Don't do this.

# Lines:

Axes do not have unnecessary tick marks or axis lines

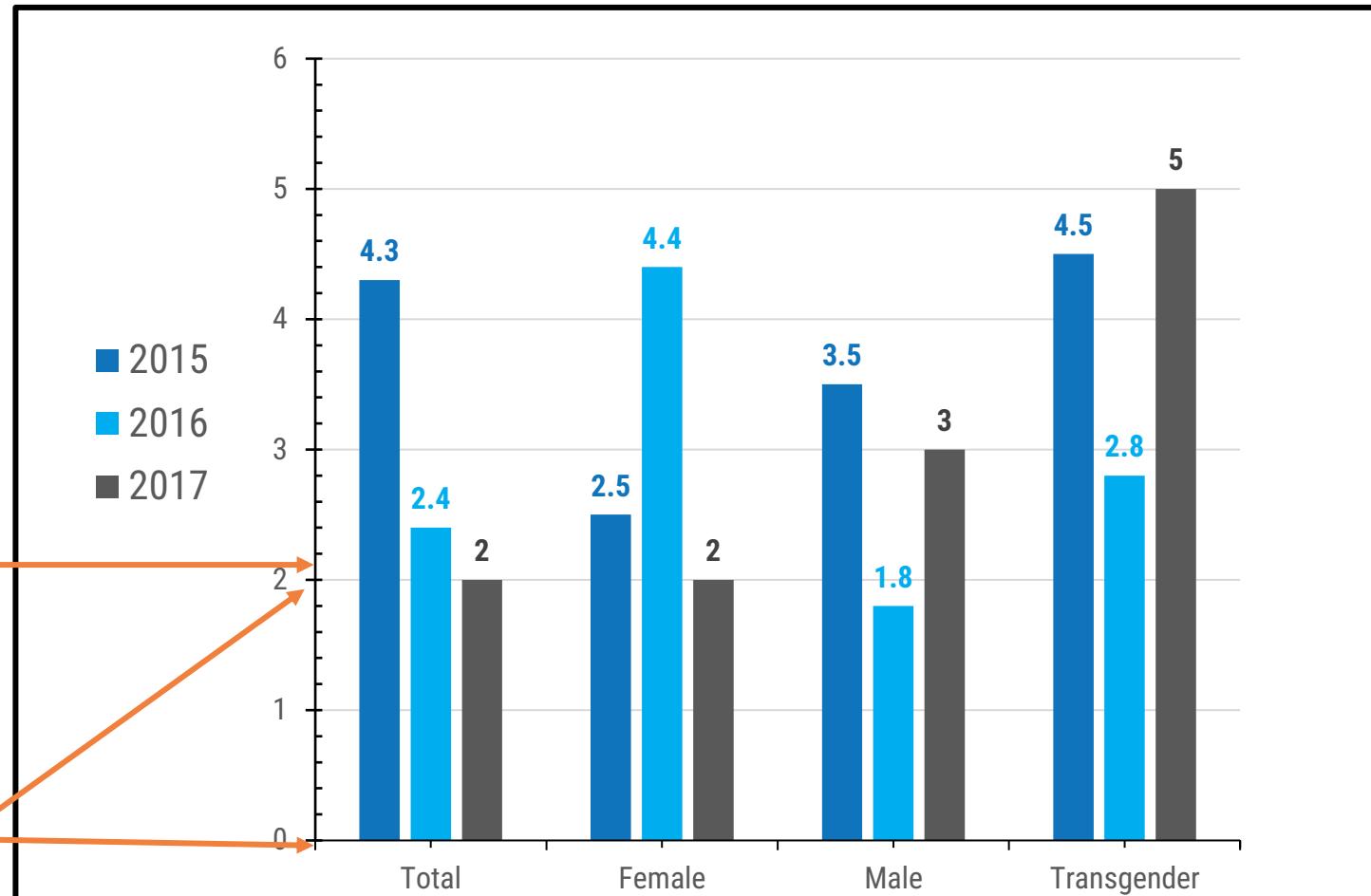
## Example:

There are tick marks  
and axes lines.

Rating = 0

Axis line

Tick marks



# **Lines:**

## **Graph has one horizontal and one vertical axis**

Viewers can best interpret one x- and one y-axis. Don't add a second y-axis. Try a connected scatter plot or two graphs, side by side, instead. (A secondary axis used to hack new graph types is ok, so long as viewers aren't being asked to interpret a second y-axis.)

**Fully met** = The graph only has one visible y-axis.

**Partially met** = This one will usually be “Not met” or “Fully met.”

**Not met** = The graph has two y-axes, one on the left and one on the right.

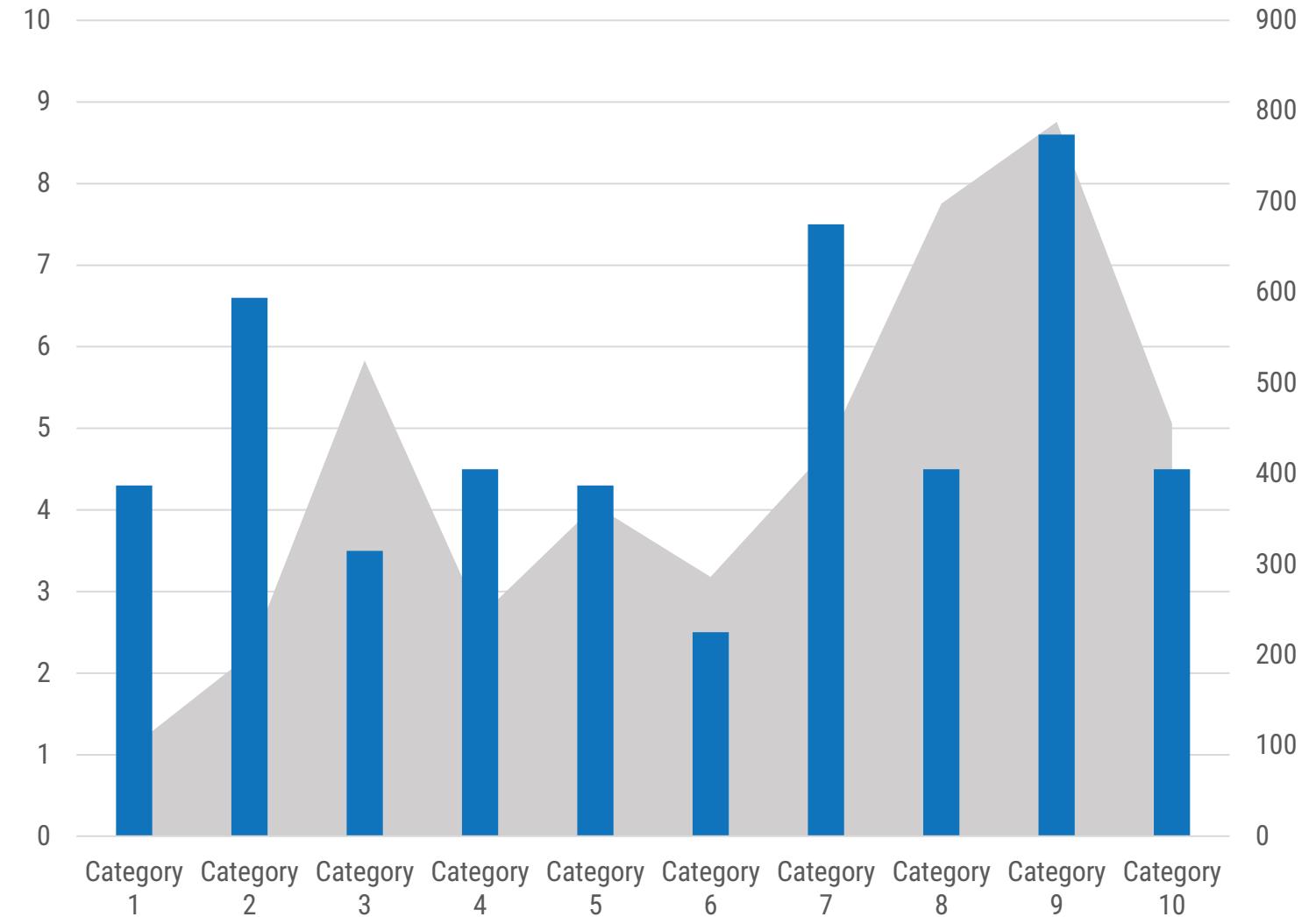
# Lines:

**Graph has one horizontal and one vertical axis**

## Example:

There are two y-axes,  
one on the left for the  
bar graph and one on the  
right for the area graph.

Rating = 0





**Let's walk through the  
checkpoints in  
Overall**

# Overall: Graph highlights significant finding or conclusion

Graphs should have a "so what?" – either a practical or statistical significance (or both) to warrant their presence. For example, contextualized or comparison data help the viewer understand the significance of the data and give the graph more interpretive power.

Not everything  
needs to be  
graphed.

**Fully met** = There is a point to the graph that you can figure out (via graph title, colors, etc).

**Partially met** = There may be a point to showing the graph but you have to dig for it.

**Not met** = There is no point to the graph, i.e. demographic data, or there's no way to tell if there's a practical or significant finding.

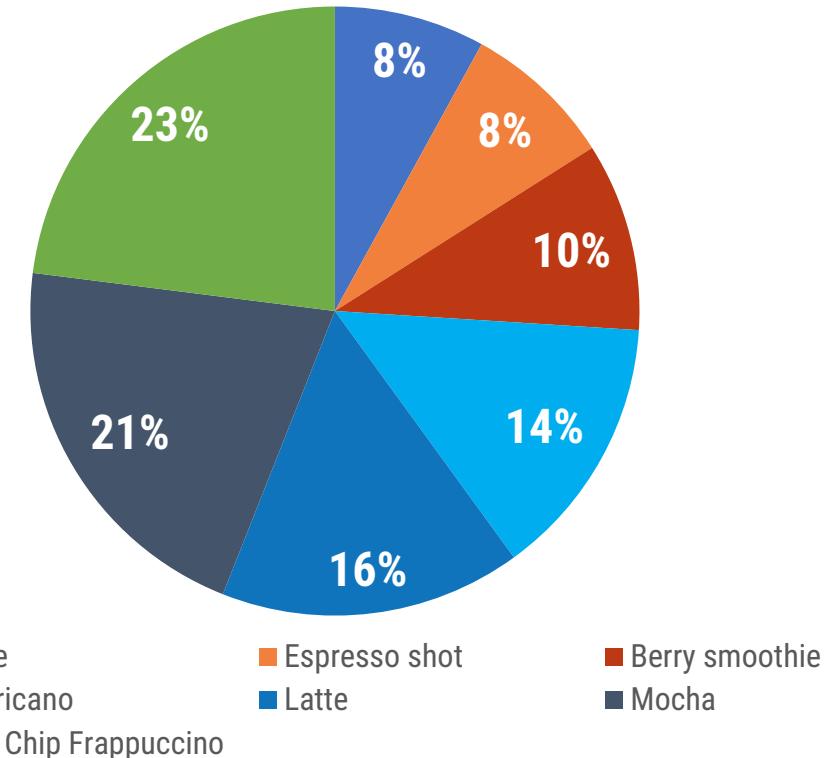
# Overall: Graph highlights significant finding or conclusion

## Example:

No clear point. Cannot easily see if there's a practical or significant finding.

Rating = 0

**Coffee Preferences**



# **Overall:**

## **The type of graph is appropriate for data**

Data are displayed using a graph type appropriate for the relationship within the data. For example, change over time is displayed as a line graph, area chart, slope graph, or dot plot.

**Fully met** = The graph type matches the data.

**Partially met** = The graph type is ok for the data, but not the best it could be.

**Not met** = The graph type doesn't match the data.

\* Warning – This is one people commonly rate lower because they think the graph selection could be better. Don't do this.

# Overall:

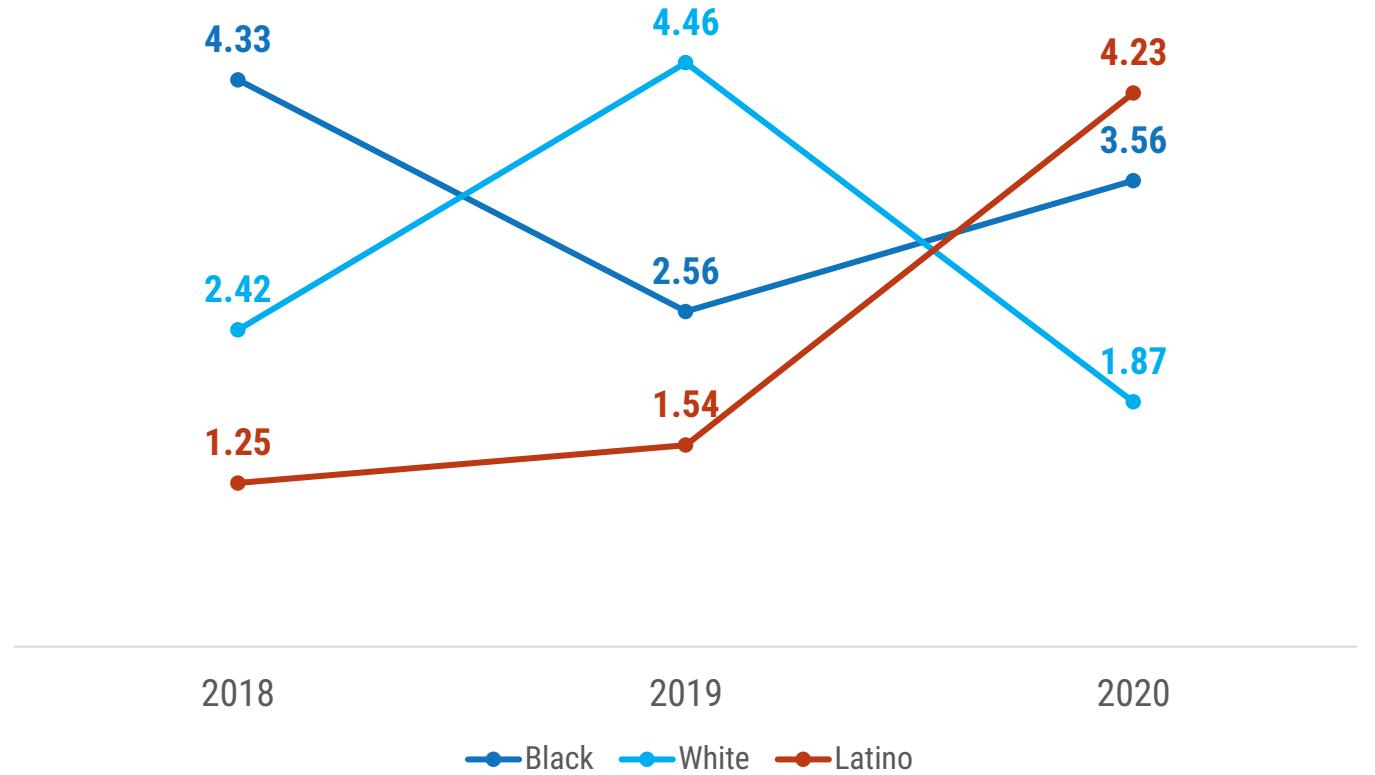
## The type of graph is appropriate for data

**Latino enrollment has dramatically increased since 2018.**

### Example:

A line graph is an appropriate way to show change over time.

Rating = 2

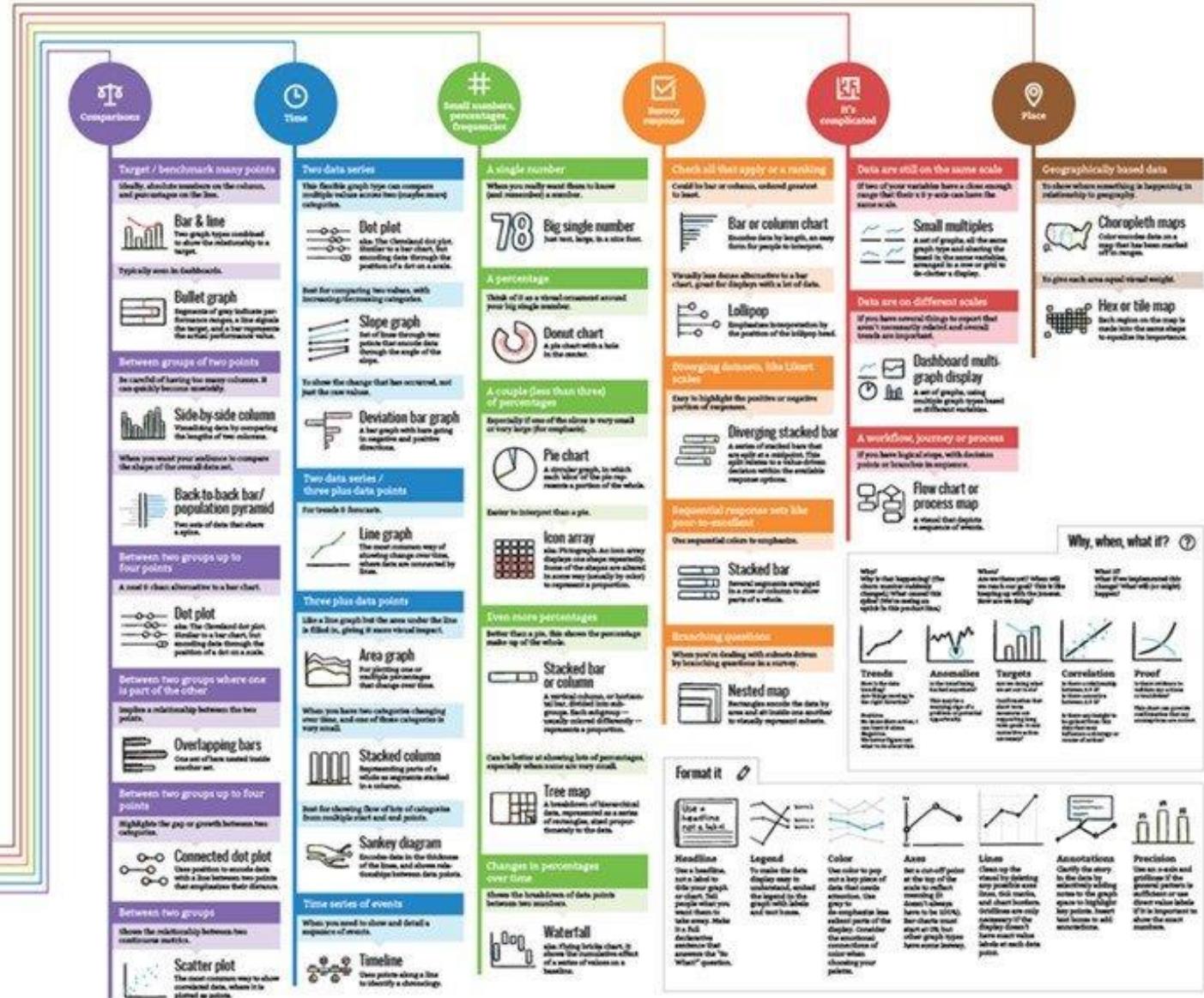


# Need help? Consult this chart chooser infographic.

What data  
are you using  
to tell your  
visual story?

Half the battle in presenting data effectively is to quickly figure out what visual form will make your point. Usually that involves a lot of playing around in Excel, or worse, not even trying and leaving it as a default column chart.

What type of chart will show your insight, and what chart will obscure it? Once you know what people are looking for, and the key piece of information you have, use the chart chooser on the right to pick out your graph.



# **Overall:**

## **Graph has appropriate level of precision**

Use a level of precision that meets your audiences' needs. Few numeric labels need decimal places, unless you are speaking with academic peers. Charts intended for public consumption rarely need p values listed.

**Fully met** = Graph is precise enough for primary audience.

**Partially met** = A mix, such as p-values but rounded percentages.

**Not met** = Graph includes unnecessary precision (i.e. percentages include too many decimals [16.712% instead of 16.7%] and/or the graph uses technical statistical language) for primary audience.

\* Warning – This is one people commonly rate higher because they don't mind more precision. Don't do this.

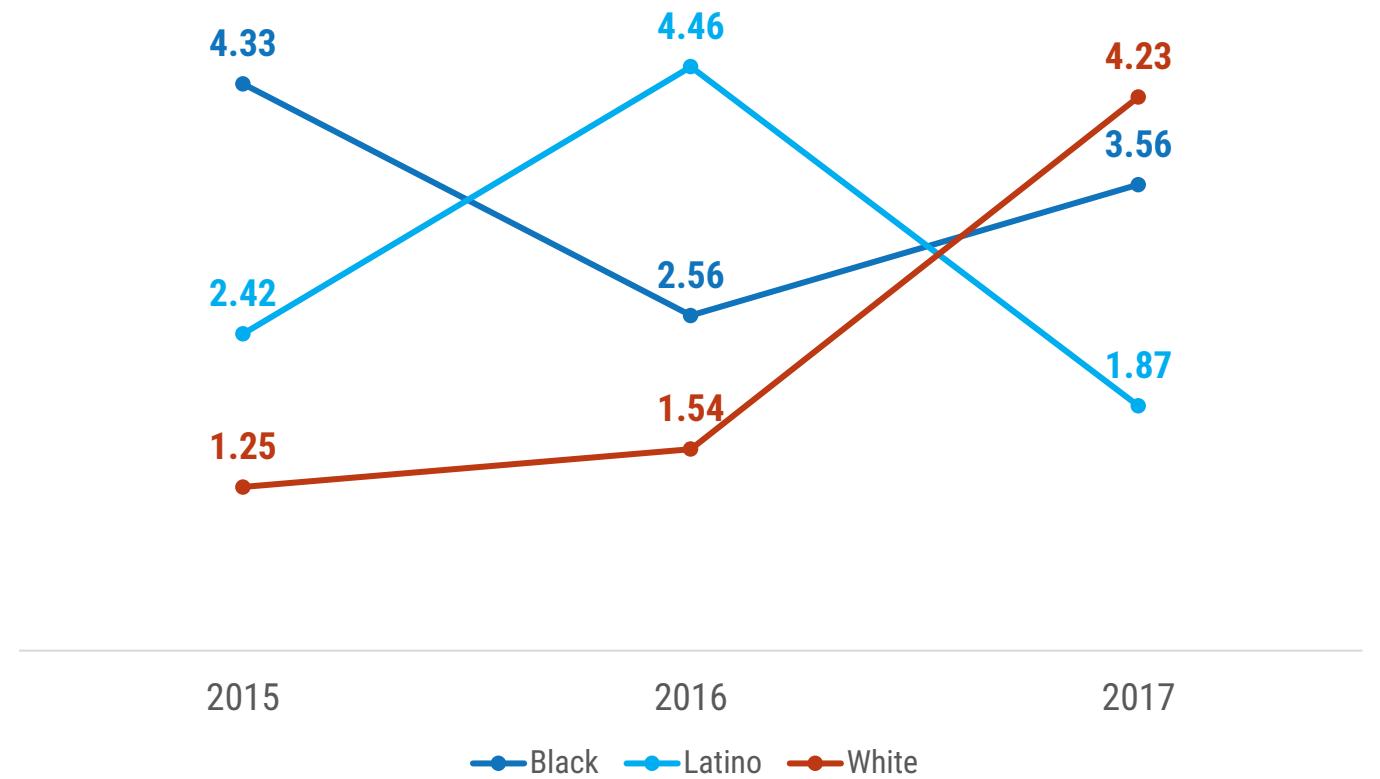
# Overall: Graph has appropriate level of precision

**Latino enrollment has dramatically increased since 2016.**

## Example:

Graph is for a public audience and uses two decimal points in the data labels.

Rating = 0



# **Overall:**

**Individual chart elements work together to reinforce the overarching takeaway message**

Choices about graph type, text, arrangement, color, and lines should reinforce the same takeaway message.

**Fully met** = The title and graph elements (order, color, etc.) point to a takeaway message.

**Partially met** = Graph has a takeaway message in the title but the graph doesn't highlight the takeaway message or vice versa.

**Not met** = There is no clear takeaway message or you have to work hard work hard to dig one out.

# Overall:

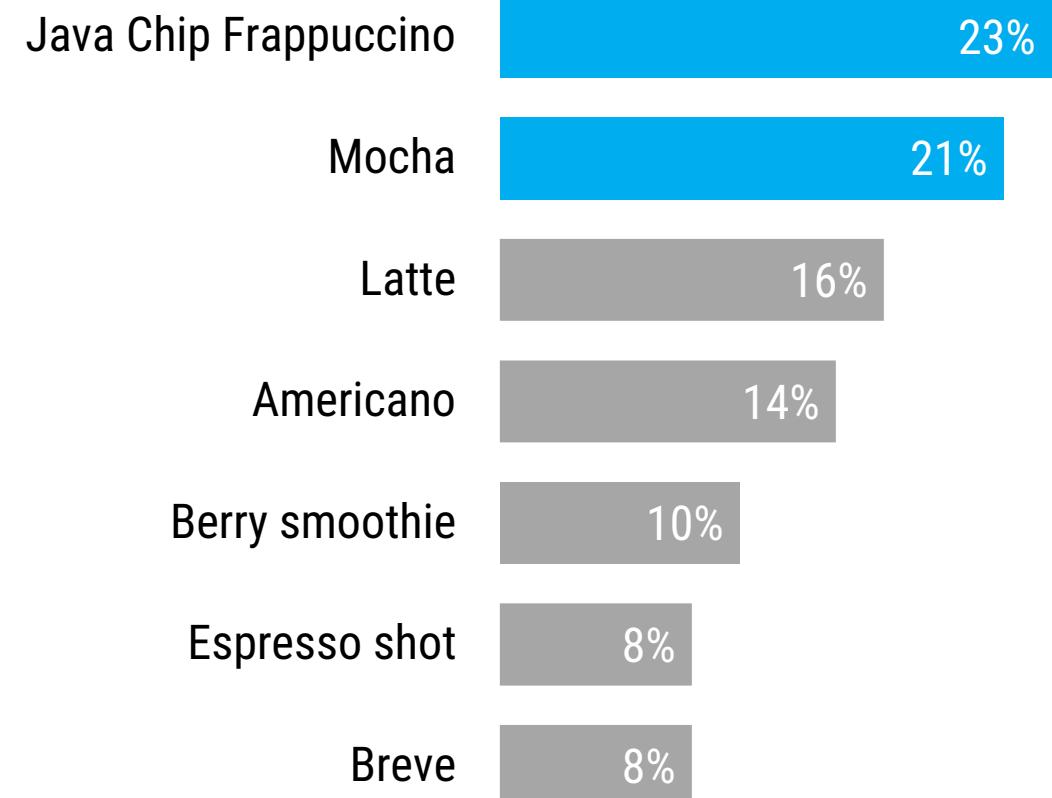
**Individual chart elements work together to reinforce the overarching takeaway message**

## Example:

The title and colors work together to reinforce the takeaway message.

Rating = 2

**Coffee preferences focus on chocolate-based drinks.**



# Scoring

**Possible points total to 48 (minus any N/A checkpoints).**

**Great graphs should aim for 80-90% of that total (38-43 points).**

Note – So this might be a stretch for this particular audience because of how rigid the guidelines are in this checklist so I think it's more important to follow the spirit of the guidelines.

# Real-life example

JOM, Vol. 68, No. 3, 2016

DOI: 10.1007/s11837-016-1812-6

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CrossMark

## Microstructure Development in Electron Beam-Melted Inconel 718 and Associated Tensile Properties

M.M. KIRKA,<sup>1,2,7</sup> K.A. UNOCIC,<sup>2</sup> N. RAGHAVAN,<sup>3</sup> F. MEDINA,<sup>4</sup>  
R.R. DEHOFF,<sup>1,2</sup> and S.S. BABU<sup>1,5,6</sup>

1.—Manufacturing Demonstration Facility, Oak Ridge National Laboratory, Knoxville, TN 37932, USA. 2.—Materials Science & Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA. 3.—Bredesen Center for Interdisciplinary Research, The University of Tennessee, Knoxville, TN 37996, USA. 4.—Arcam AB, 431 37 Molndal, Sweden. 5.—Energy and Transportation Science Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA. 6.—Department of Mechanical, Aerospace and Biomedical Engineering, The University of Tennessee, Knoxville, TN 37996, USA. 7.—e-mail: kirkamm@ornl.gov

During the electron beam melting (EBM) process, builds occur at temperatures in excess of 800°C for nickel-base superalloys such as Inconel 718. When coupled with the temporal differences between the start and end of a build, a top-to-bottom microstructure gradient forms. Characterized in this study is a microstructure gradient and associated tensile property gradient common to all EBM Inconel 718 builds, the extent of which is dependent on build geometry and the specifics of a build's processing history. From the characteristic

# Can you apply what we learned?

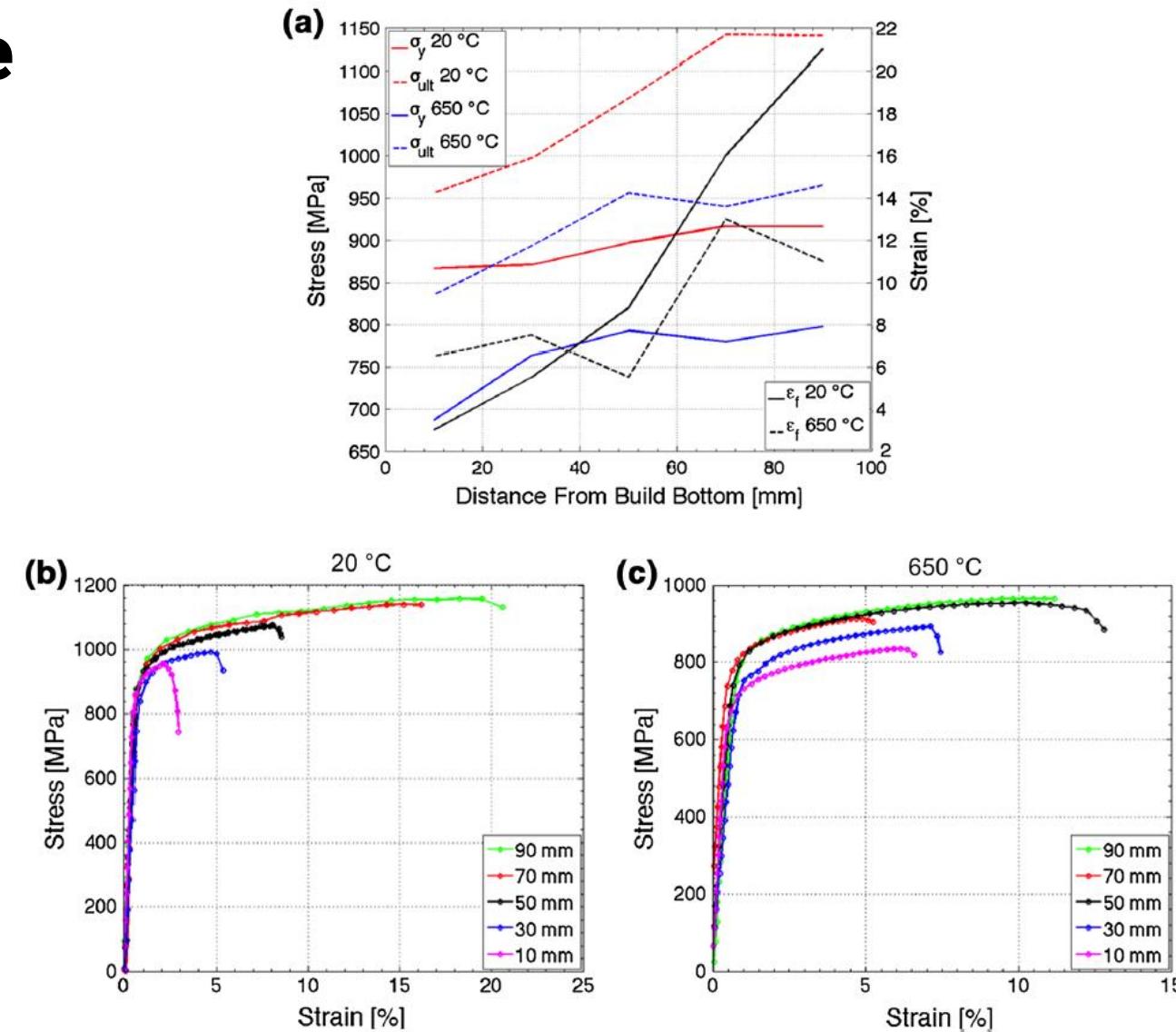


Fig. 11. Monotonic mechanical properties of EBM Inconel 718: (a) as function of build height measured at 20°C and 650°C, (b) engineering stress-strain response at 20°C, (c) engineering stress-strain response at 650°C.

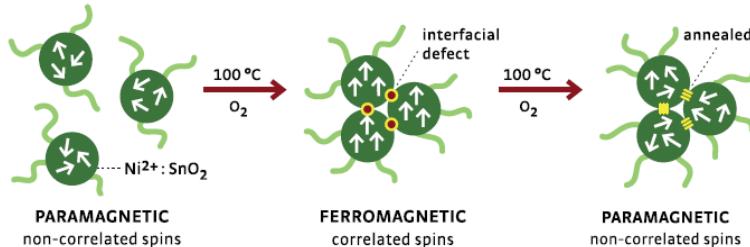
# 10 min break

Figures and diagrams is next.



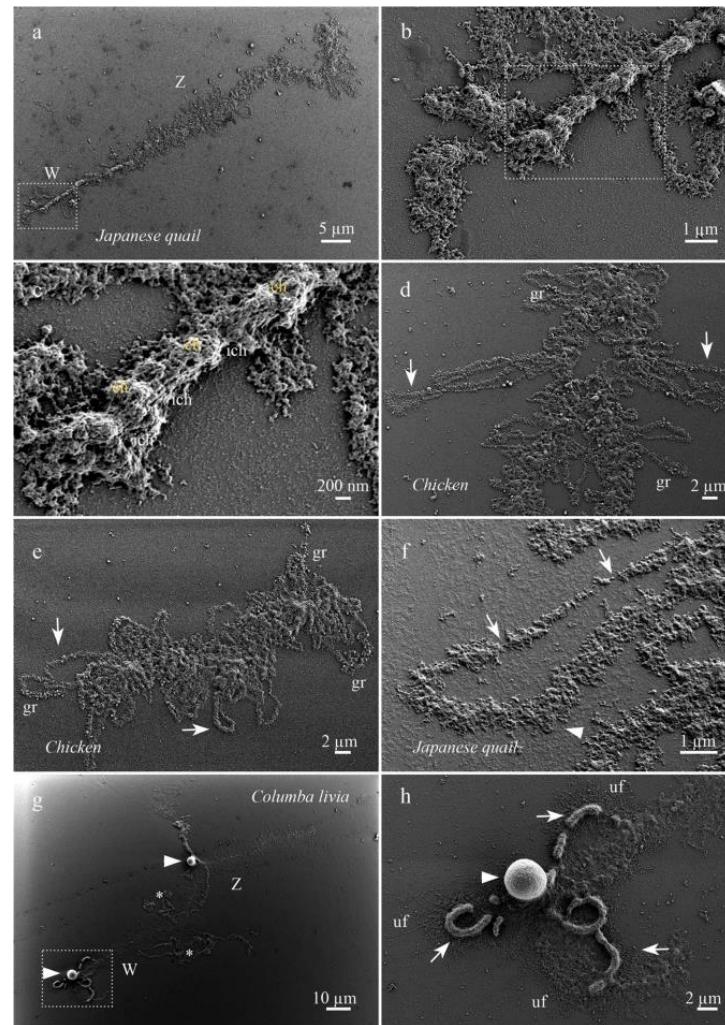
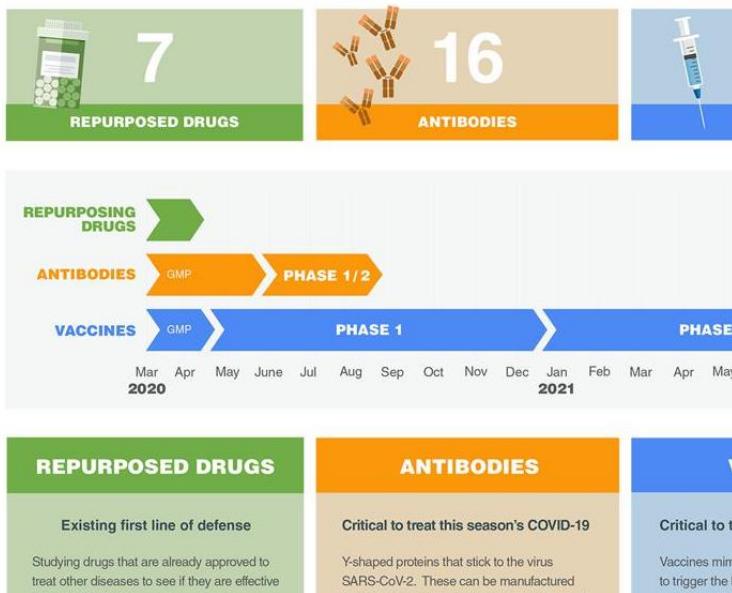
# Figures and Diagrams

# Figures, diagrams, schematics, flowcharts, illustrations ...



Cheng, K., & Rolandi, M. (2015). Graphic design for scientists. *Nature nanotechnology*, 10(12), 1084-1084.

There are **66 programs** working on **3 different approaches**:



## Airborne imaging spectroscopy

Finding spectral indices for hydrothermal processes by study of rock samples

Chapter 2:  
Tracing fluid pathways with near-infrared spectroscopy

Mapping spectral indices from airborne hyperspectral imagery

Chapter 3:  
Mapping white micas and their absorption wavelengths using hyperspectral band ratios

Segmentation and classification of spectral indices images

Chapter 4:  
Detection of pre-defined boundaries between hydrothermal alteration zones using rotation-variant template matching

Integrated interpretation of segmented imagery and field data

Chapter 5:  
Hydrothermal processes in the Archean -- new insights from airborne imaging spectroscopy

New information of hydrothermal processes

# Figures + Diagrams

- While the authors of the data viz checklist (Evergreen, Emery, and Sanjines) might not agree, I do think that a lot of ideas and rules of thumb from the checklist apply to figures and diagrams.
- Here are a few other principles we can use from graphic design and apply to figures and diagrams.

# Borrowing from graphic design ...

- Hierarchy
- Contrast
- Proximity
- Color
- Repetition
- White space
- Flow

# Hierarchy

- (visual) hierarchy – arrangement or organization of visual elements to imply importance
- Used as a design principle to:
  - Add structure
  - Create visual organization
  - Create direction
  - Add emphasis
  - Help a viewer navigate and digest information easily

# Contrast

Contrast of size



Contrast of color



# Proximity

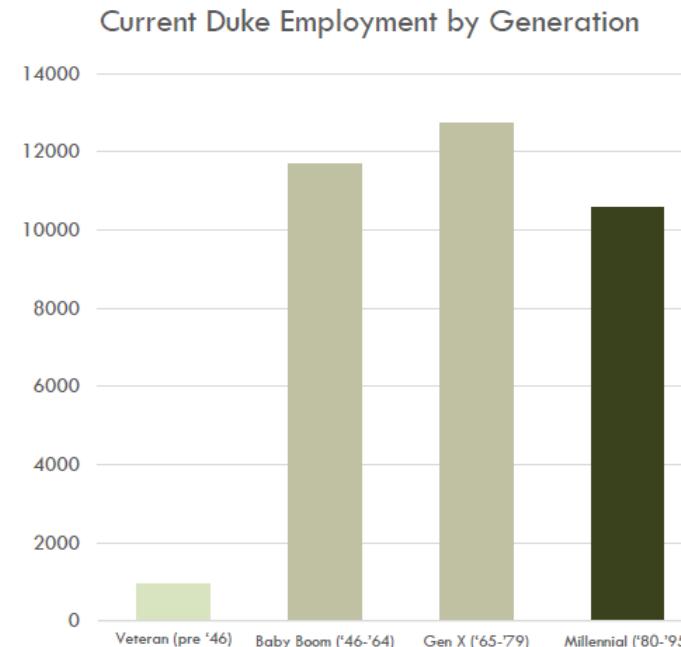
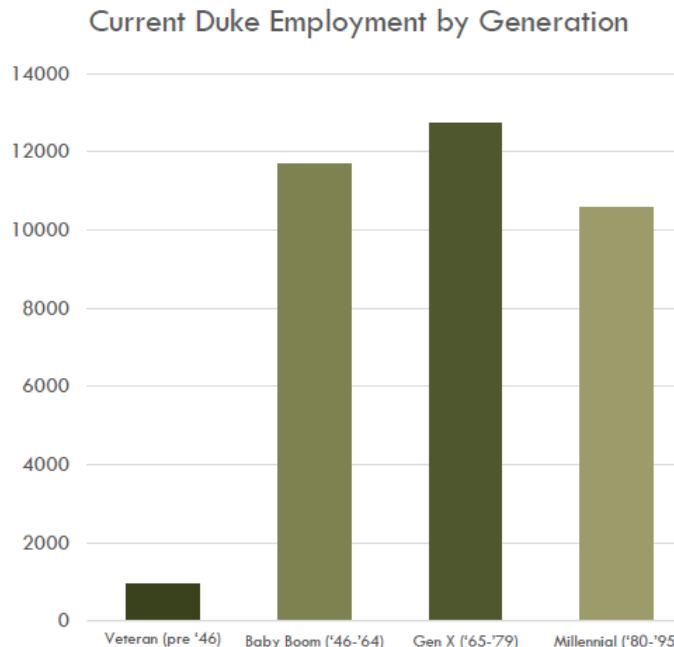
- Proximity suggests relationships ... closely related to negative space, spacing, and grouping like with like.



# Color

- Use color purposefully ... like to highlight the message you're trying to convey.

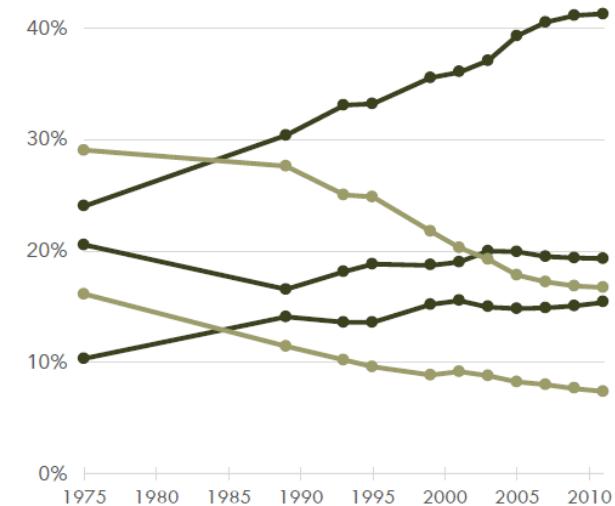
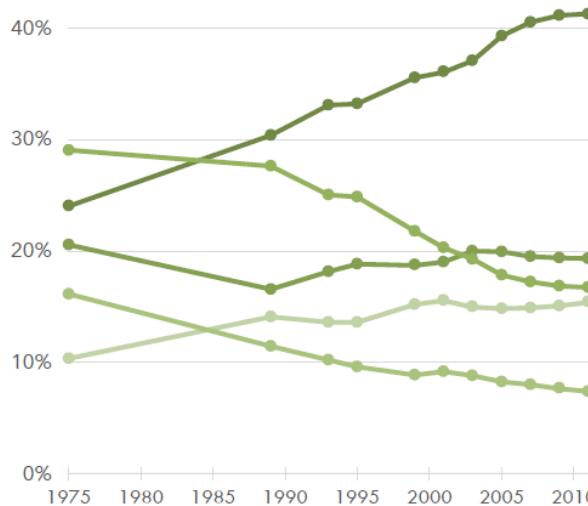
## Use color to draw attention



# Color

- Use color purposefully ... like to group things together.

## Use color to group



# White space / negative space

- White space / negative space – space between visual elements (not always white but is a space free from text, photos, logos, etc)
- Used as a design principle to:
  - Improve legibility
  - Create direction, flow, order, and organization
  - Create emphasis or attention
  - Help a viewer navigate and digest information easily

# Improves legibility

## The Death And Life Of Atlantic City

Mike Hauke opened a pizza and sub shop in Atlantic City in 2009, but only after he had failed in nine tries to rent the space to somebody else. He had bought the building three years earlier on the advice of his father, an accountant who considered distressed real estate a smart long-term bet.

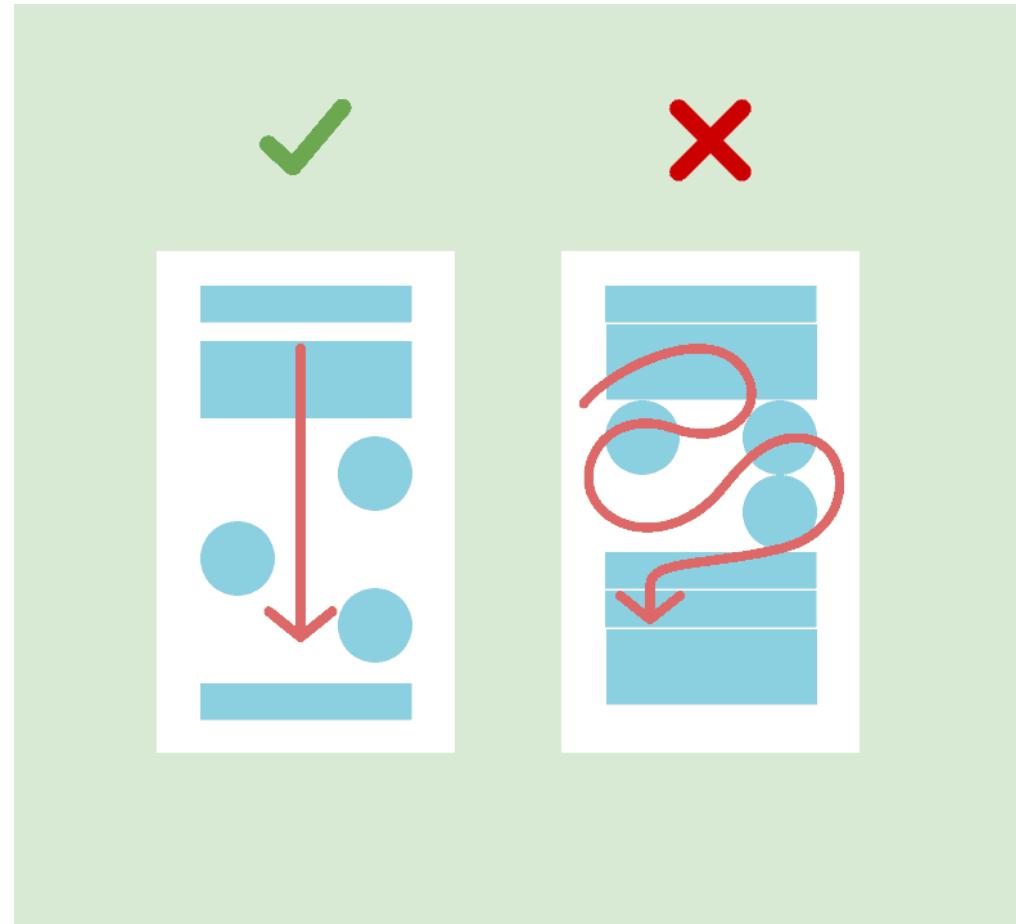
This piece of real estate seemed to test the proposition. It was a bedraggled three-story clapboard house that years of neighborhood demolition and neglect had stranded at the edge of several mostly vacant blocks, which together formed an urban badlands reaching all the way to the dunes.

## The Death And Life Of Atlantic City

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This piece of real estate seemed to test the proposition. It was a bedraggled three-story clapboard house that years of neighborhood demolition and neglect had stranded at the edge of several mostly vacant blocks, which together formed an urban badlands reaching all the way to the dunes.

# Create flow, order, and organization



# Diagram Example

REVIEW OF SCIENTIFIC INSTRUMENTS

VOLUME 73, NUMBER 9

SEPTEMBER 2002

## High bandwidth nano-positioner: A robust control approach

S. Salapaka

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J. P. Cleveland

*Asylum Research, 601-C Pine Avenue, Goleta, California 93117*

M. V. Salapaka

*Department of Electrical and Computer Engineering, Iowa State University, Ames, Iowa 50010*

(Received 20 March 2002; accepted for publication 10 June 2002)

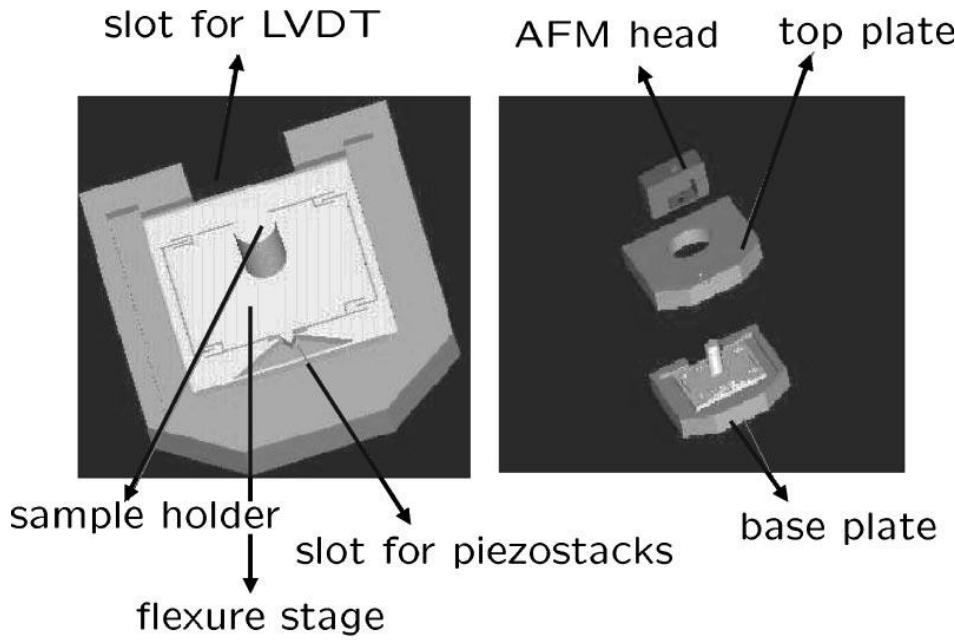
This article presents the design, identification, and control of a nano-positioning device suited to image biological samples as part of an atomic force microscope. The device is actuated by a piezoelectric stack and its motion is sensed by a linear variable differential transformer. It is demonstrated that the conventional proportional-integral control architecture does not meet the bandwidth requirements for positioning. The design and implementation of an  $H_{\infty}$  controller demonstrates substantial improvements in the positioning speed and precision, while eliminating the undesirable nonlinear effects of the actuator. The characterization of the resulting device in terms of bandwidth, resolution, and repeatability provided illustrates the effectiveness of the modern robust control paradigm. © 2002 American Institute of Physics. [DOI: 10.1063/1.1499533]

### I. INTRODUCTION

The advent of new techniques to explore properties of near atomic-scale structures has led to the development of the new field of nanotechnology. In the past decade, it has become evident that nanotechnology will make fundamental contributions to science and technology. Inevitably, most schemes of nanotechnology impose severe specifications on positioning. As is evident in scanning probe microscopy

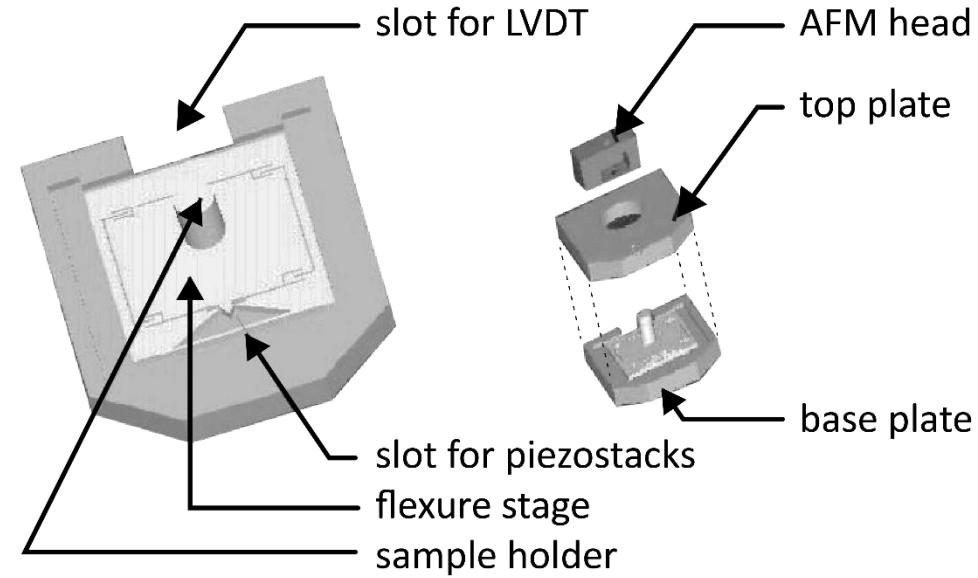
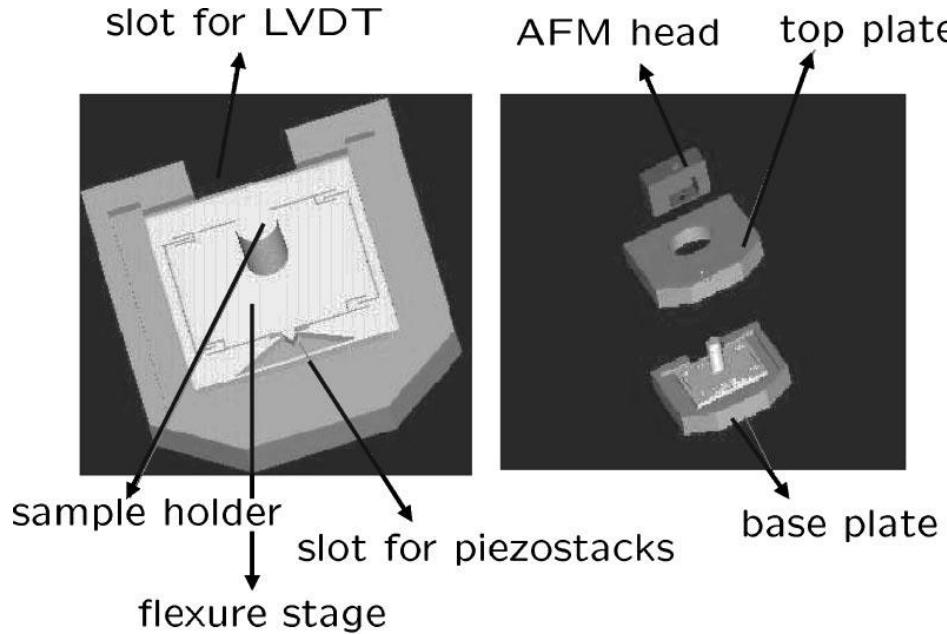
positioning with high accuracy. They achieve repeatable nanometer and subnanometer resolution at relatively high bandwidth since they have no sliding parts and thereby preclude undesirable effects such as backlash and stick-slip motions. Also, they can generate large forces (as high as few tens of kN), have very fast response times (acceleration rates of  $10^4$  g can be obtained), are not affected by magnetic fields, and are operable at wide ranges of temperatures (they are functional even at near zero Kelvin temperatures albeit

# Diagram Example



- Hierarchy
- Contrast
- Proximity
- Color
- Repetition
- White space
- Flow

# Diagram Example



- Hierarchy
- Contrast – biggest issue, black bg hides arrows
- Proximity – my “slot for piezostacks” label and “base plate” label might be too close together, need more white space between them
- Color
- Repetition – consistent arrow types (even angles), not

- sure where this goes but arrow should follow convention of text pointing to actual area of interest
- White space – labels and arrows need some room to breathe
- Flow – not sure where this goes but consistent alignment of text labels (can easily count how many labels for each diagram at a glance)

# Schematic / Flowchart Example

Mechatronics 56 (2018) 268–276



Contents lists available at ScienceDirect

Mechatronics

journal homepage: [www.elsevier.com/locate/mechatronics](http://www.elsevier.com/locate/mechatronics)



## An electrohydrodynamic jet printer with integrated metrology<sup>☆</sup>

Christopher P. Pannier<sup>\*a</sup>, Lauro Ojeda<sup>a</sup>, Zhi Wang<sup>b</sup>, David Hoelzle<sup>c</sup>, Kira Barton<sup>a</sup>



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<sup>b</sup> Department of Aerospace and Mechanical Engineering, University of Notre Dame, 225 Multidisciplinary Research Building, Notre Dame, 46556, IN, United States

<sup>c</sup> Department of Mechanical and Aerospace Engineering, The Ohio State University, 201 West 19th Avenue, Columbus, 43210, OH, United States

### ARTICLE INFO

#### Keywords:

Electrohydrodynamic jet printing  
Micro-scale additive manufacturing  
Integrated metrology  
Atomic force microscopy

### ABSTRACT

Integrated metrology is critical for quality control and validation of micro-scale additive and subtractive manufacturing processes. However, the current practice in micro-scale additive manufacturing is to manufacture a component on a die and then transfer the die to a separate metrology tool, losing the datum, increasing production time, and also risking contamination. This paper presents a new system that integrates electrohydrodynamic jet printing, an emerging micro-scale additive manufacturing technique, with inline atomic force microscopy for rapid, die-by-die in-line metrology and quality monitoring. The system performs automatic registration of datums and is self-contained for minimal contamination. To validate the effectiveness of the integrated system, performance metrics such as position precision and accuracy and drop volume precision are derived from 50 samples of a 122-drop pattern. These experimental results provide a demonstration of electrohydrodynamic jet printed patterns with completely automated, *in situ* quality monitoring.

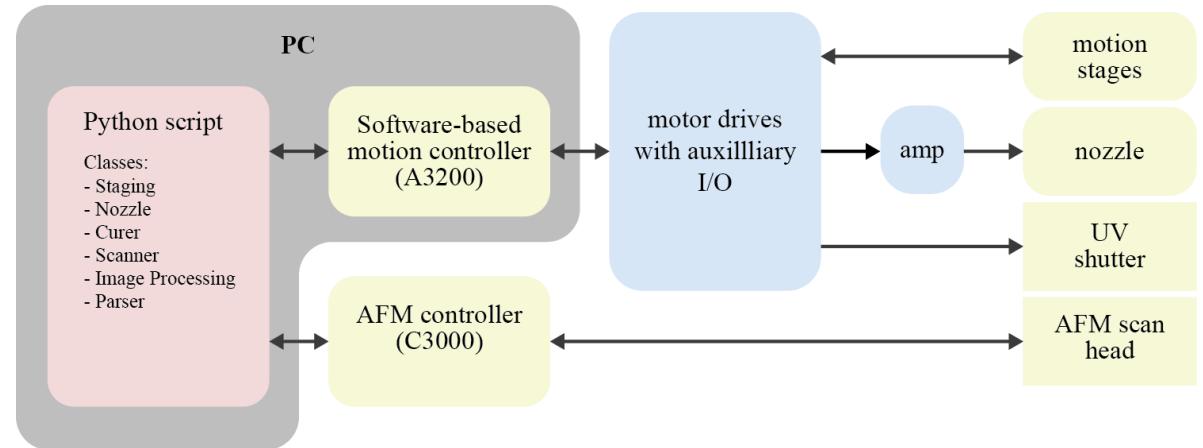
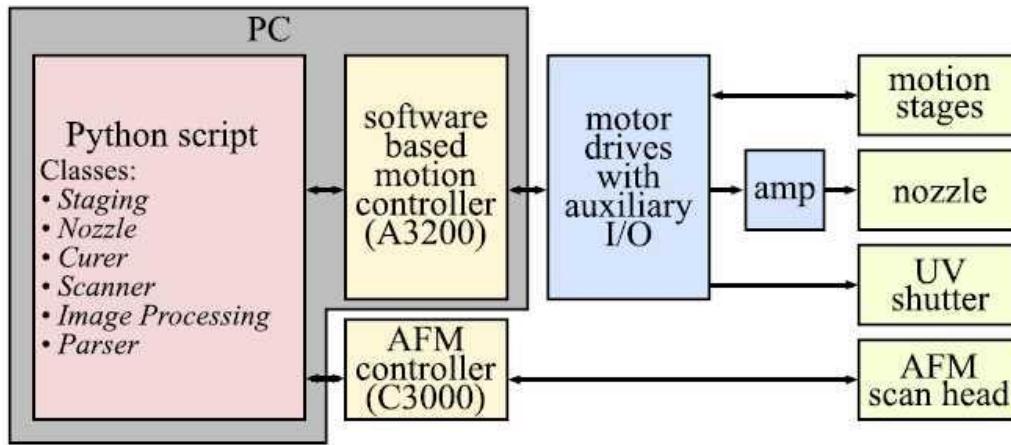
### 1. Introduction

The definition of micro-scale additive manufacturing ( $\mu$ -AM) has yet to be agreed upon. For simplicity, we will use a definition often employed in ‘direct write’ printing as demonstrated by Lewis in [1] in which the term refers to the ability to print parts directly without the need for a secondary process.

work flow will enable build quality statistics to inform critical process challenges in  $\mu$ -AM.

In-line metrology is used in many high-value manufacturing fields. The high-volume semiconductor industry uses metrology for statistical process control, with an emphasis on cycle time savings and improved

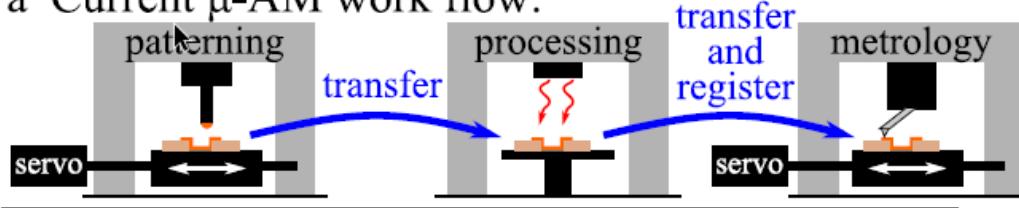
# Schematic / Flowchart Example



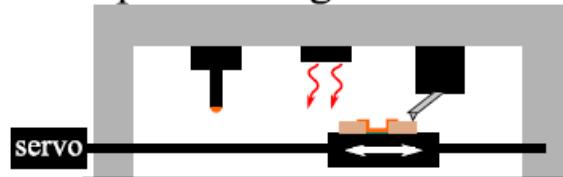
- Hierarchy – colors rep diff categories/types?
- Contrast – got rid of black border, size of arrows more legible
- Proximity
- Color – probably still need to adjust the yellow as not enough contrast between yellow and white background
- Repetition – consistency with rounded rectangles
- White space – gave more breathing room aka margin to the text and gave up some text size as a result
- Flow – Would need to read more on the paper to make judgement call on changing flow
- Note – potential for use of icons?

# Other Figures and Diagrams Examples

a Current  $\mu$ -AM work flow:

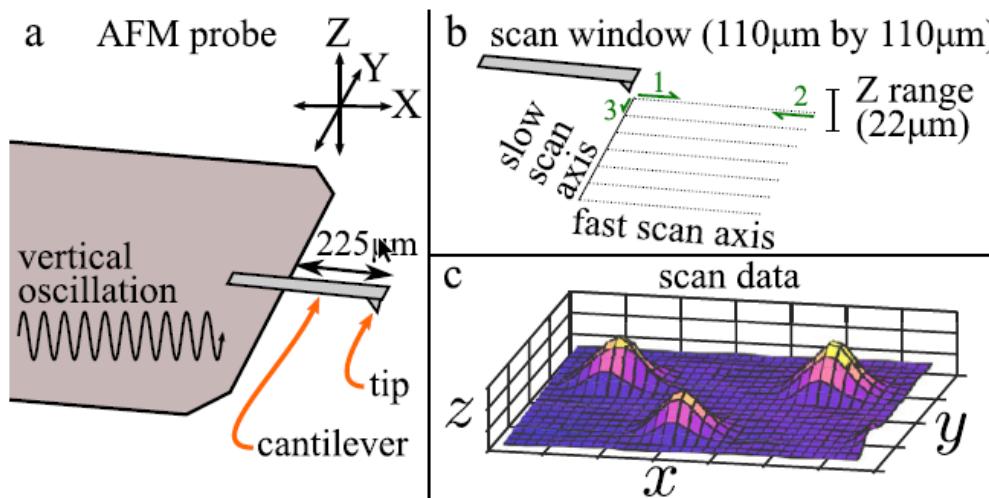


b Proposed integrated work flow:

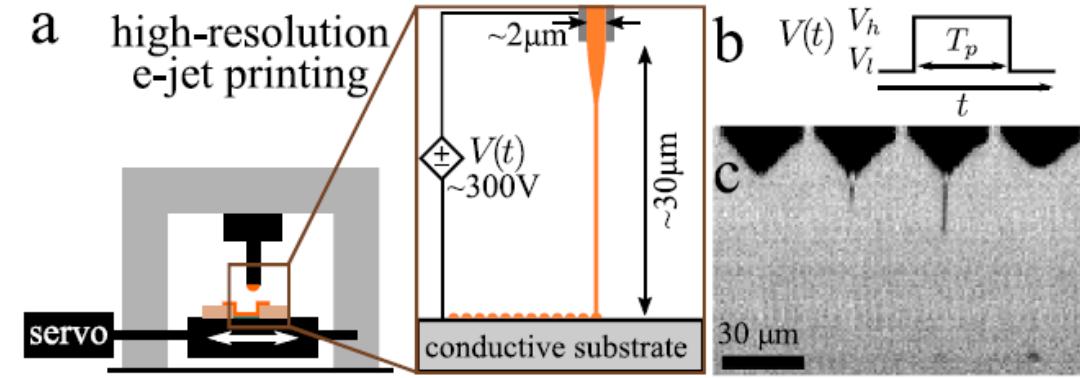


- no substrate transfer
- automated registration
- rapid data collection

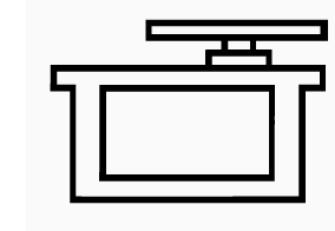
a AFM probe



a high-resolution e-jet printing



Whitespace, hierarchy, flow, and consistency are the biggest areas to improve for the other viz in the paper. Potential to replace some of these diagrams with more interesting and visually representative icons like this servo icon from [thenounproject](https://thenounproject.com).



# 10 min break

Formatting and designing tables is next.

# Tables

Remove *and move*  
to improve  
the **data tables** edition

# Start here ... what would you change?

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	61.978
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.29
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4332
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.7689
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	37.99
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.316
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.61
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0196

- In this example ... we will strip away anything unnecessary leaving the “data ink” (non-erasable core of a graphic) and then add things back on if they contribute



# Before

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	61.978
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.29
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4332
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.7689
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	37.99
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.316
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.61
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0196

# After

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	<b>Macho Man Randy Savage</b>	<b>Monkey</b>	<b>Feb-2008</b>	<b>157.6</b>	<b>59.3</b>
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0



## Remove the Colors

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	61.978
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.29
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4332
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.7689
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38
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Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	37.99
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.316
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.61
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0196

# Left Align Text

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	61.978
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.29
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4332
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.7689
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Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0196



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Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0



## Round the Numbers

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0

## Round the Numbers

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5	21.0



## Round the Numbers More

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5	21.0

## Round the Numbers More

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	0.2	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0



# Remove Repetition

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	0.2	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

# Remove Repetition

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	0.2	33.6
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0



## Please, No More Calibri

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

## Please, No More Calibri

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

- I disagree with this suggestion. Use what is most appropriate to your specific medium and style.



## Add Back the Emphasis

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	Macho Man Randy Savage	Monkey	Feb-2008	157.6	59.3
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

## Add Back the Emphasis

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	<b>Macho Man Randy Savage</b>	<b>Monkey</b>	<b>Feb-2008</b>	<b>157.6</b>	<b>59.3</b>
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

# Review

Before

Role	Name	Year of the...	Debut	Number of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97320.00	86.2
Face (The Hero)	Hulk Hogan	Oxen	Jan-2008	988551.00	61.978
Face (The Hero)	Macho Man Randy Savage	Monkey	Feb-2008	157618.00	59.29
Face (The Hero)	Hacksaw Jim Duggan	Pig	Mar-2008	30300.00	53.4332
Face (The Hero)	Superfly Jimmy Snuka	Dragon	Mar-2008	12341.00	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71645.00	45.4
Heel (The Bad Guy)	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449342.00	43.7689
Heel (The Bad Guy)	Mr. Perfect Curt Henning	Rat	May-1980	13773.00	38
Heel (The Bad Guy)	Jake the Snake Roberts	Snake	Jul-1975	5609.00	37.99
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1103.00	36.316
Jobber (The Unknown)	Ted Duncan	Sheep	Aug-2008	200.00	33.61
Jobber (The Unknown)	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	5.00	21.0196

After

Role	Name	Year of the...	Debut	Thousands of Fans	Takedown Rate
Face (The Hero)	The Ultimate Warrior	Tiger	May-2011	97.3	86.2
	Hulk Hogan	Oxen	Jan-2008	988.6	62.0
	<b>Macho Man Randy Savage</b>	<b>Monkey</b>	<b>Feb-2008</b>	<b>157.6</b>	<b>59.3</b>
	Hacksaw Jim Duggan	Pig	Mar-2008	30.3	53.4
	Superfly Jimmy Snuka	Dragon	Mar-2008	12.3	52.7
Heel (The Bad Guy)	Rowdy Roddy Piper	Rooster	Jun-1968	71.6	45.4
	The Million Dollar Man Ted DiBiase	Rat	Apr-1975	449.3	43.8
	Mr. Perfect Curt Henning	Rat	May-1980	13.8	38.0
	Jake the Snake Roberts	Snake	Jul-1975	5.6	38.0
Jobber (The Unknown)	Brad Smith	Sheep	Aug-2008	1.1	36.3
	Ted Duncan	Sheep	Aug-2008	0.2	33.6
	Joey the Uber Nerd Cherdarchuk	Snake	Aug-2008	0.0	21.0

# Real-life example

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## Microstructure Development in Electron Beam-Melted Inconel 718 and Associated Tensile Properties

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During the electron beam melting (EBM) process, builds occur at temperatures in excess of 800°C for nickel-base superalloys such as Inconel 718. When coupled with the temporal differences between the start and end of a build, a top-to-bottom microstructure gradient forms. Characterized in this study is a microstructure gradient and associated tensile property gradient common to all EBM Inconel 718 builds, the extent of which is dependent on build geometry and the specifics of a build's processing history. From the characteristic

# Real-life example

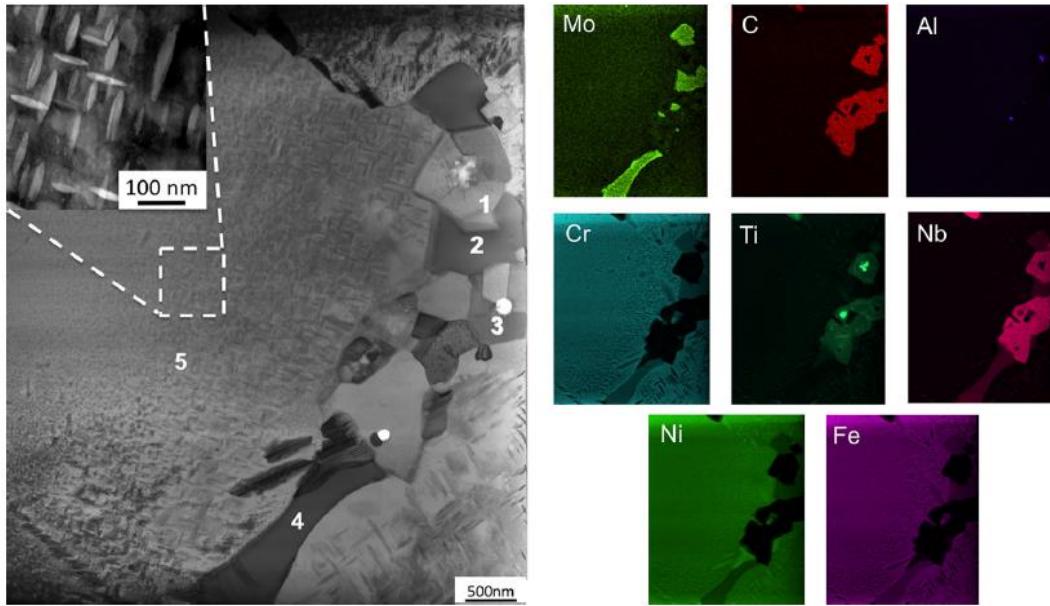


Fig. 3. TEM micrograph of the matrix and interdenritic regions as viewed within the plane of the build in the second to last layer.

Table II. Chemical compositions of the phases observed in Fig. 3 as determined through TEM EDS listed in wt.%

	<u>Phase</u>	<u>Ni</u>	<u>Nb</u>	<u>Ti</u>	<u>Fe</u>	<u>Cr</u>	<u>Mo</u>	<u>Si</u>	<u>C</u>
1	MC	0.43	89.91	6.01	0.15	0.62	—	—	2.73
2	Laves	42.20	22.87	0.11	13.54	11.24	9.53	0.5	—
3	MC	0.4	90.38	6.31	0.17	0.7	0.71	—	0.99
4	Laves	38.8	28.55	0.23	11.70	9.40	11.19	0.77	—
5	$\gamma$ matrix	56.19	4.14	0.68	18.99	15.91	3.80	0.04	—

# Can you apply what we learned about formatting tables?

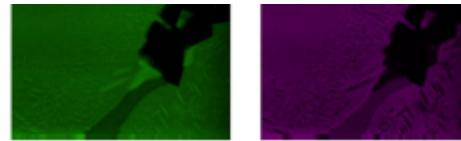
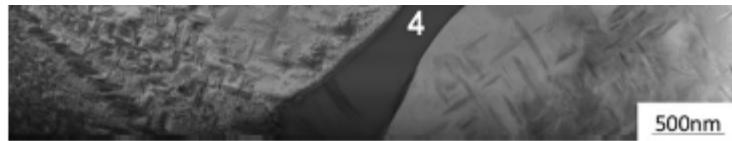


Fig. 3. TEM micrograph of the matrix and interdenritic regions as viewed within the plane of the build in the second to last layer.

**Table II. Chemical compositions of the phases observed in Fig. 3 as determined through TEM EDS listed in wt.%**

	<b>Phase</b>	<b>Ni</b>	<b>Nb</b>	<b>Ti</b>	<b>Fe</b>	<b>Cr</b>	<b>Mo</b>	<b>Si</b>	<b>C</b>
1	MC	0.43	89.91	6.01	0.15	0.62	–	–	2.73
2	Laves	42.20	22.87	0.11	13.54	11.24	9.53	0.5	–
3	MC	0.4	90.38	6.31	0.17	0.7	0.71	–	0.99
4	Laves	38.8	28.55	0.23	11.70	9.40	11.19	0.77	–
5	$\gamma$ matrix	56.19	4.14	0.68	18.99	15.91	3.80	0.04	–

# Can you apply what we learned about formatting tables?

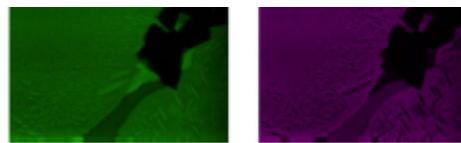


Fig. 3. TEM micrograph of the matrix and interdenritic regions as viewed within the plane of the build in the second to last layer.

Remove borders but allow whitespace (left the other longer horiz lines alone bc not sure if formatting standard for paper)

\*Does the order of the columns matter?

Align column headers accordingly (left align text, right align numbers)

Table II. Chemical compositions of the phases observed in Fig. 3 as determined through TEM EDS listed in wt.%

	Phase	Ni	Nb	Ti	Fe	Cr	Mo	Si	C
1	MC	0.43	89.91	6.01	0.15	0.62	—	—	2.73
2	Laves	42.20	22.87	0.11	13.54	11.24	9.53	0.5	—
3	MC	0.4	90.38	6.31	0.17	0.7	0.71	—	0.99
4	Laves	38.8	28.55	0.23	11.70	9.40	11.19	0.77	—
5	$\gamma$ matrix	56.19	4.14	0.68	18.99	15.91	3.80	0.04	—

Left align text

Right align numbers

Use consistent precision

Resize columns ... too much white space  
(don't feel forced to use entire width)

# Review

## Before

**Table II.** Chemical compositions of the phases observed in Fig. 3 as determined through TEM EDS listed in wt.%

	<b>Phase</b>	<b>Ni</b>	<b>Nb</b>	<b>Ti</b>	<b>Fe</b>	<b>Cr</b>	<b>Mo</b>	<b>Si</b>	<b>C</b>
1	MC	0.43	89.91	6.01	0.15	0.62	—	—	2.73
2	Laves	42.20	22.87	0.11	13.54	11.24	9.53	0.5	—
3	MC	0.4	90.38	6.31	0.17	0.7	0.71	—	0.99
4	Laves	38.8	28.55	0.23	11.70	9.40	11.19	0.77	—
5	$\gamma$ matrix	56.19	4.14	0.68	18.99	15.91	3.80	0.04	—

## After

	<b>Phase</b>	<b>Ni</b>	<b>Nb</b>	<b>Ti</b>	<b>Fe</b>	<b>Cr</b>	<b>Mo</b>	<b>Si</b>	<b>C</b>
1	MC	0.43	89.91	6.01	0.15	0.62	-	-	2.73
2	Laves	42.20	22.87	0.11	13.54	11.24	9.53	0.50	-
3	MC	0.40	90.38	6.31	0.17	0.70	0.71	-	0.99
4	Laves	38.80	28.55	0.23	11.70	9.40	11.19	0.77	-
5	$\gamma$ matrix	56.19	4.14	0.68	18.99	15.91	3.80	0.04	-

# Reminder ... there are other kinds of tables



This **highlight table** looks at the # of patients admitted in a hospital and their wait times.

Darker color = more patients in waiting room at that time

Note data is spread evenly. Easily see when patients have to wait. Elective and emergency wait times are split into 2 tables but use same colors.

# Graphs + tables = graphical tables, taphs, grables

Trust rank	Index rank	Borough	Amount approved (£)	Number of grants
1	3	Tower Hamlets	£9,692,642	269
2	2	Hackney	£7,809,608	225
3	12	Southwark	£7,266,118	232
4	14	Camden	£6,140,419	136
5	4	Islington	£5,424,137	156
6	8	Lambeth	£5,257,941	156
7	2	Newham	£5,217,075	154
8	13	Hammersmith and Fulham	£4,085,708	109
9	29	Merton	£3,656,112	113
10	20	Croydon	£3,629,066	127
11	9	Lewisham	£3,537,049	144
12	17	Westminster	£3,357,911	100
13	15	Ealing	£3,057,709	84
14	30	Bromley	£3,038,621	131
15	19	Kensington and Chelsea	£2,979,468	74
16	11	Brent	£2,898,224	85
17	10	Greenwich	£2,837,658	87
18	24	Barnet	£2,796,587	99
19	21	Wandsworth	£2,592,453	89
20	5	Waltham Forest	£2,505,730	131
21	28	Sutton	£2,468,511	87
22	18	Hounslow	£2,383,393	75
23	7	Haringey	£2,360,290	101
24	22	Redbridge	£2,285,173	75
25	33	Rechmond upon Thames	£2,249,983	133

Borough	Trust rank	Index rank	Number of grants	Amount approved (£)
Tower Hamlets	1	3	269	£9,692,642
Hackney	2	2	225	£7,809,608
Southwark	3	12	232	£7,266,118
Camden	4	14	136	£6,140,419
Islington	5	4	156	£5,244,137
Lambeth	6	8	156	£5,257,941
Newham	7	2	154	£5,217,075
Hammersmith and Fulham	8	13	109	£4,085,708
Merton	9	29	113	£3,656,112
Croydon	10	20	127	£3,629,066
Lewisham	11	9	144	£3,537,049
Westminster	12	17	100	£3,357,911
Ealing	13	15	84	£3,057,709
Bromley	14	30	131	£3,038,621
Kensington and Chelsea	15	19	74	£2,979,468
Brent	16	11	85	£2,898,224
Greenwich	17	10	87	£2,837,658
Barnet	18	24	99	£2,796,587
Wandsworth	19	21	89	£2,592,453
Waltham Forest	20	5	131	£2,505,730
Sutton	21	28	87	£2,468,511
Hounslow	22	18	75	£2,383,393
Haringey	23	7	101	£2,360,290
Redbridge	24	22	75	£2,285,173
Rechmond upon Thames	25	33	133	£2,249,983
Hillingdon	26	23	103	£2,181,566
Enfield	27	16	86	£2,145,800
Barking and Dagenham	28	6	68	£1,943,59
Havering	29	25	95	£1,934,42
Bexley	30	26	103	£1,631,4
Harrow	31	27	62	£1,516,
Kingston upon Thames	32	31	55	£1,353
City of London	33	32	11	£

Life expectancy at birth by nation, 1960-2018



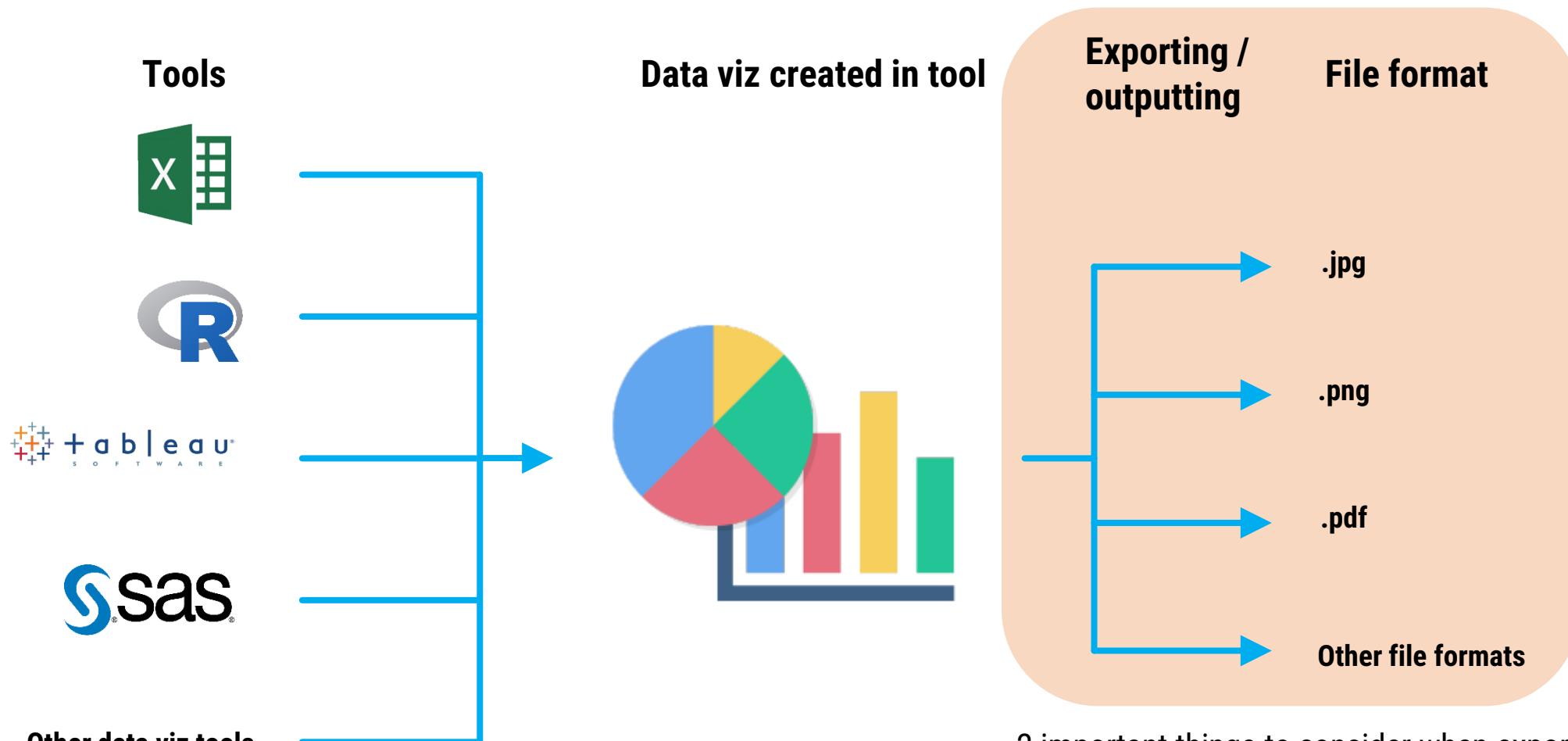
# 10 min break

Exporting / outputting visualizations is next.



# **Exporting / Outputting Visualizations**

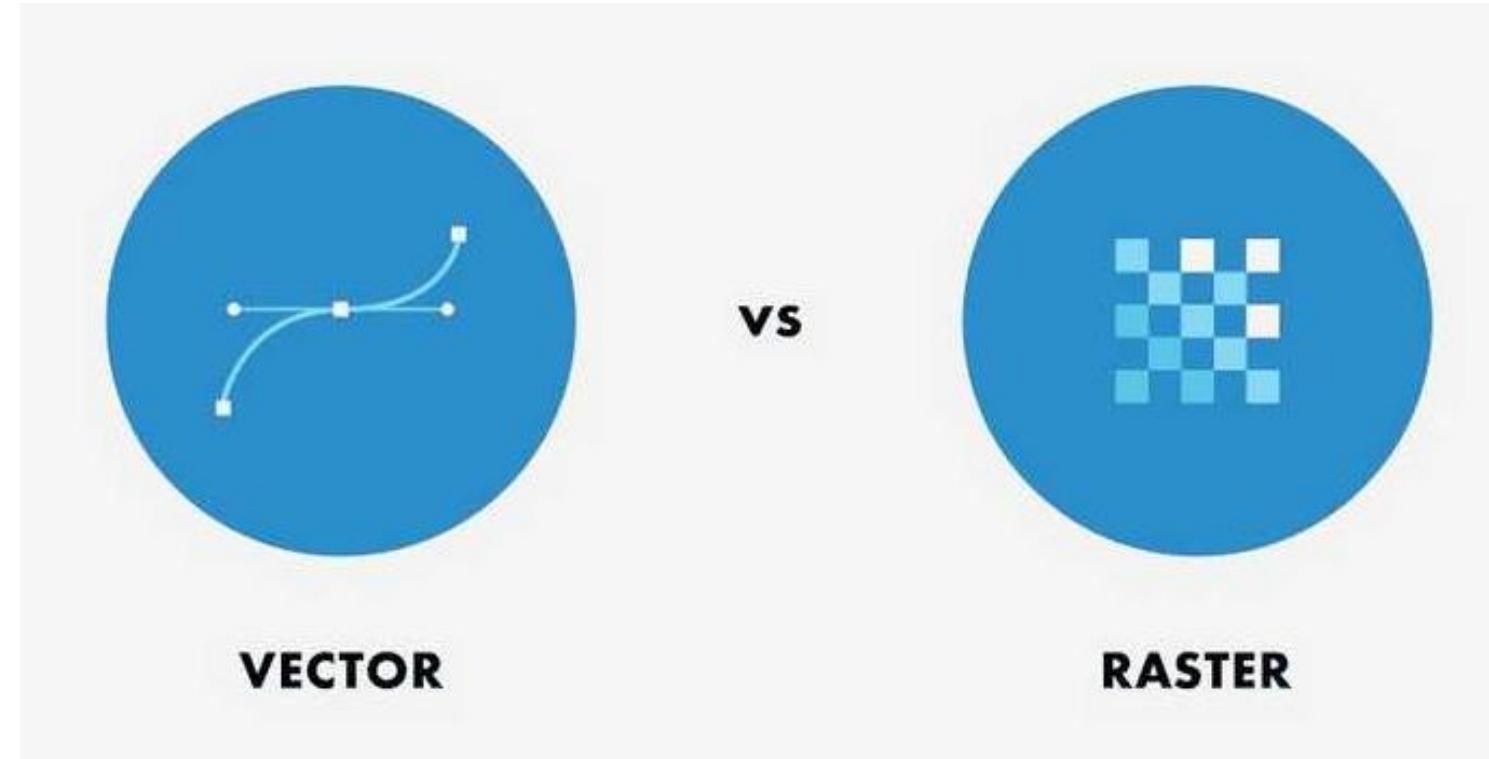
# Exporting / Outputting Visualizations



2 important things to consider when exporting and choosing a file format for your viz:

- 1) Image quality / scalability
- 2) Transparency

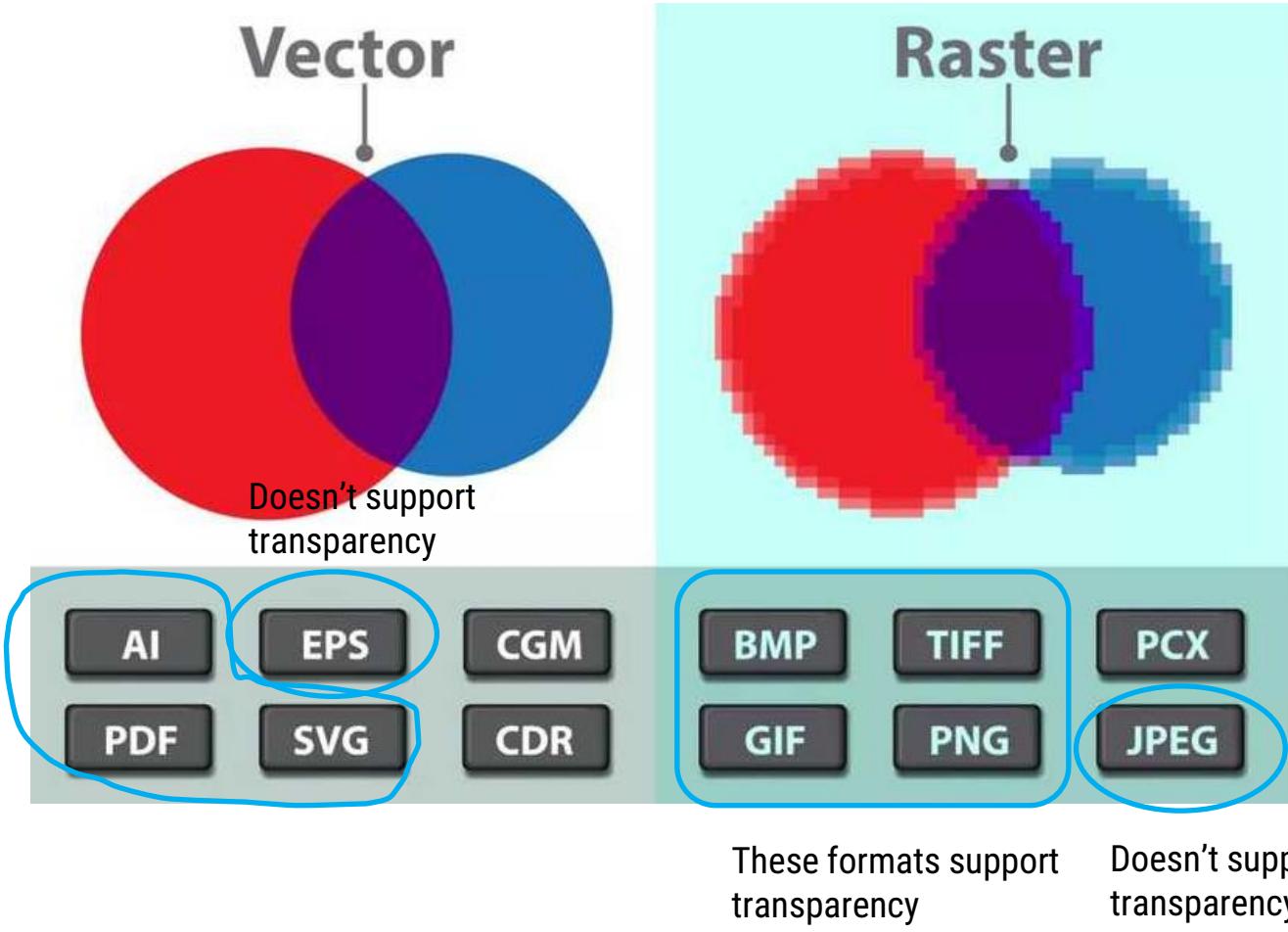
# Image quality / scalability: Vector vs Raster



Made out of paths.  
Infinitely scalable.

Made out of pixels. Scalable depending on pixel density (aka detail, ppi = pixels per inch must be specified). Quality degrades if scaled up too much.

# Check to see if your file format supports transparency

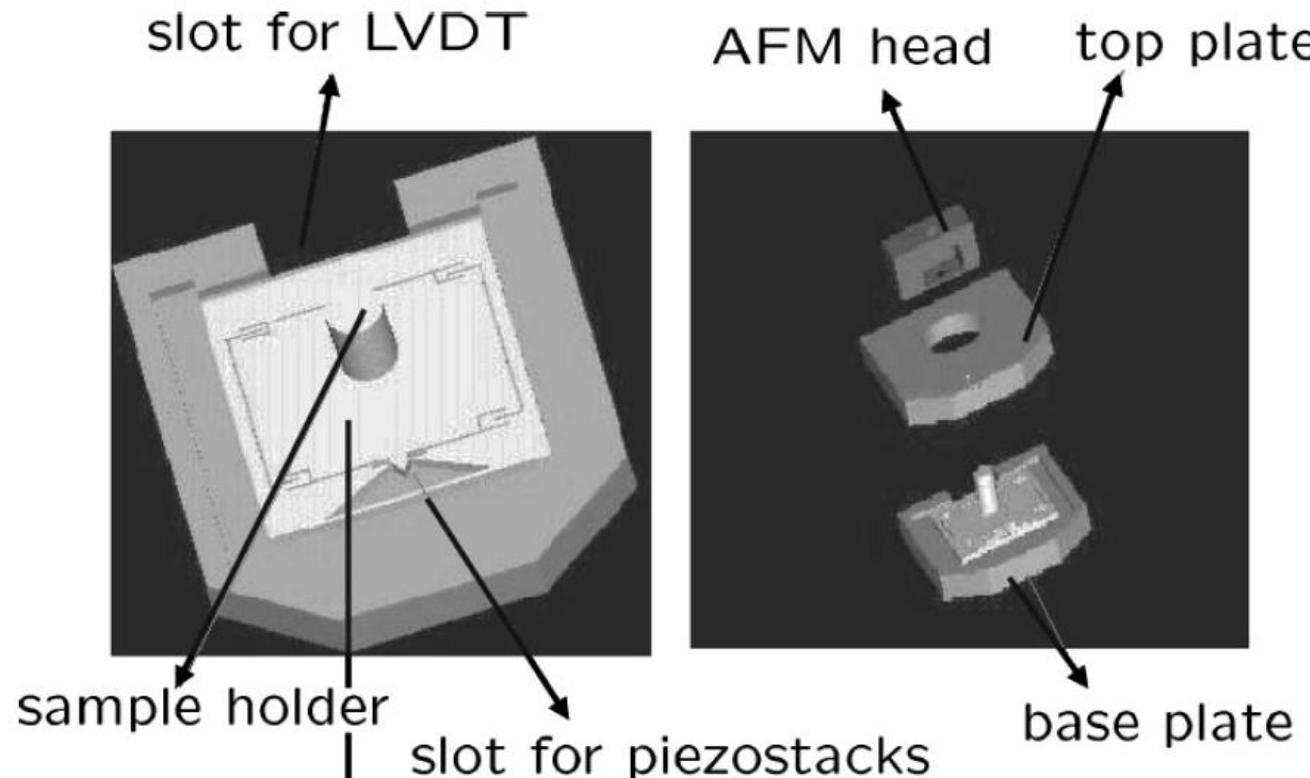


## Real-life example of low-quality export (not the best example)

accuracy,  
the piezo

robust-  
performance  
dynamics  
devices.  
2 where  
are com-  
ditional  
perfor-  
s where  
sociated  
itioning  
functions

plate and is of similar dimensions as the base plate. It provides support for the AFM head above the sample [see Fig. 2(b)].



# Real-life example of low-quality export (not the best example)

. 73, No. 9, September 2002

High bandwidth nano-positioner 3233

ations (such as cell biological studies) in compensation is needed. In Ref. 12, the de-controller using an optical sensor attached to an atomic force microscope (AFM) to compensate for the nonlinearity has been described. Another method used by several commercial manufacturers is to restrict the movement to non-overlapping trajectories (e.g., raster scans). These effects can be compensated. In Ref. 13, the effect of nonlinearities has been addressed by a combined modeling and control approach based on modeling of these nonlinearities and a model-based inversion approach to compensate for them. The efficacy of this approach depends on the modeling of the nonlinearities. However, this approach can be used in conjunction with the

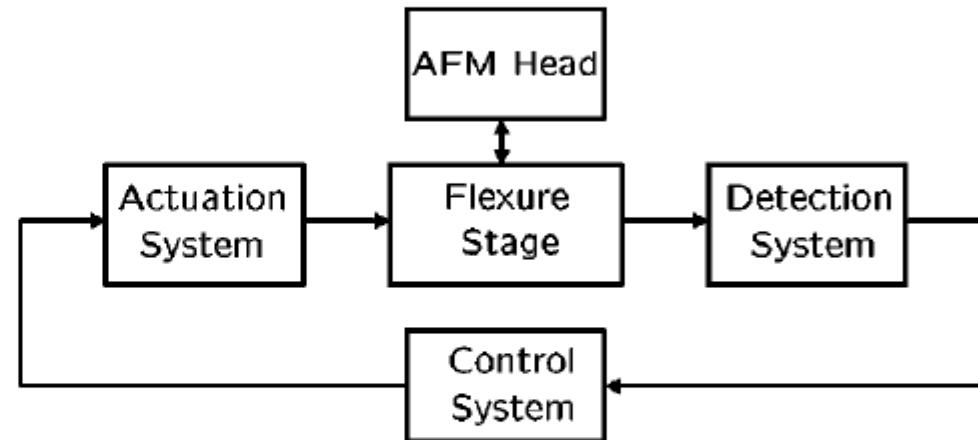
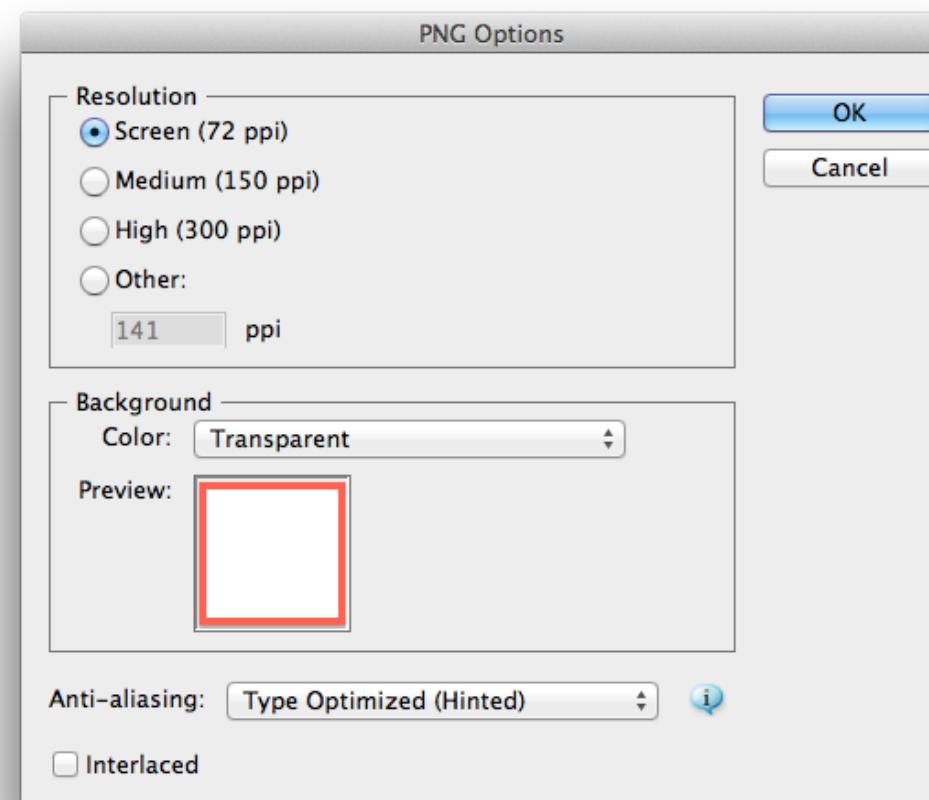


FIG. 1. Schematic block diagram of the device.

formance specifications (high bandwidth tracking, noise rejection) into an optimization problem that can be solved to obtain a controller meeting the specifications (if such a con-

# Set 300 ppi when exporting as a raster file, especially for print / publication



# 10 min break

Breakout into groups is next, find and bring your own visualizations (or any visualizations of interest).

# Breakout

# Breakout directions

- We will be breaking out into **groups of 3-5 people**.
- Take **15 min to rate, evaluate, and think of improvements** you can make to your own (or any other viz you've chosen).
- Afterward, take another **15 min to share with each other** what you've discovered after doing the data viz checklist and/or applying the design concepts to your viz. Help each other by giving some **constructive feedback**.
- Make sure to **keep track of questions** you might have as I'll be dropping by the groups to answer questions and provide feedback.
- If we happen to have time left, I'll ask maybe a few of you to **present your own viz** and talk a bit about what areas can be improved and what ideas you might have to make your viz communicate more clearly and effectively.