



# DATA VISUALIZATION



# UNIT - I



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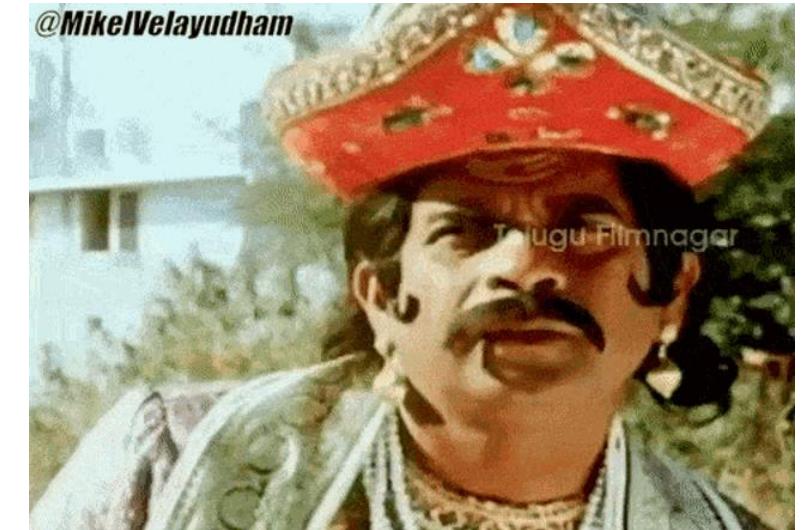
Choosing the Effective Visual



# Introduction

## Example:

- In the IPL 2023, In the Chennai Super Kings vs Lucknow Super Giants match the Chennai team player Ruturaj Gaikwad scores 57 runs in 31 balls, Convey scores 47 runs in 29 balls and in Lucknow team the player KL Rahul scored 20 runs in 18 balls, The other player Mayers scored 53 runs in just 22 balls. The result of the match was Chennai super kings won by 12 runs.





# Introduction

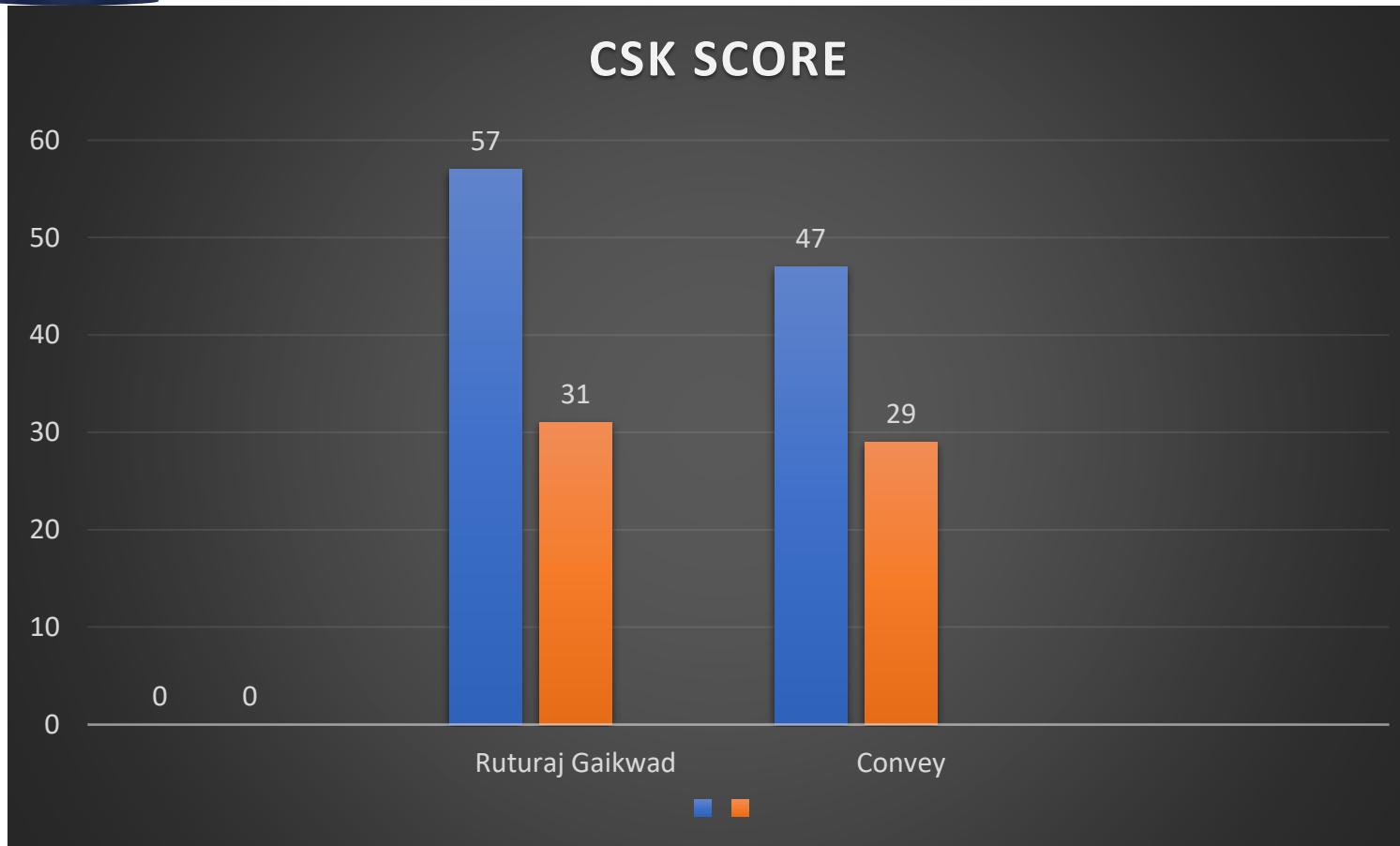
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# Introduction





# Introduction

- Data visualization is a powerful and essential tool in the field of data analysis and communication.
- It involves the representation of data through visual elements such as charts, graphs, maps, and other visual aids to help people understand complex information, patterns, and trends.

## Applications:

- Exploration and Discovery
- Communication
- Decision-Making
- Storytelling



# Introduction

## Storytelling

- Storytelling in the context of data visualization refers to the practice of using data and visual elements to convey a narrative or message that engages and informs the audience.





# Introduction

- It's about turning raw data into a compelling story that makes complex information more relatable, understandable, and memorable.
- Effective data storytelling goes beyond just presenting numbers and facts; it aims to create an emotional connection and help the audience grasp the significance of the data.

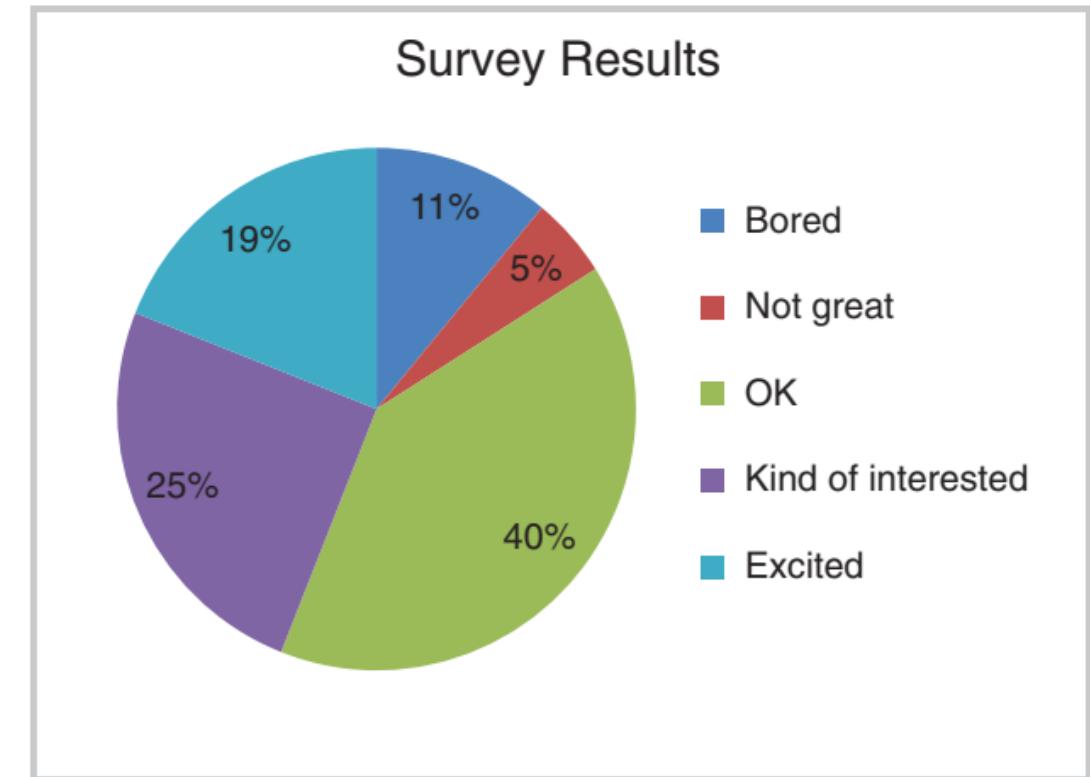




# Introduction

Bad graphs are everywhere:

- Nobody sets out to make a bad graph. But it happens. Again, and again.
- At every company throughout all industries and by all types of people.

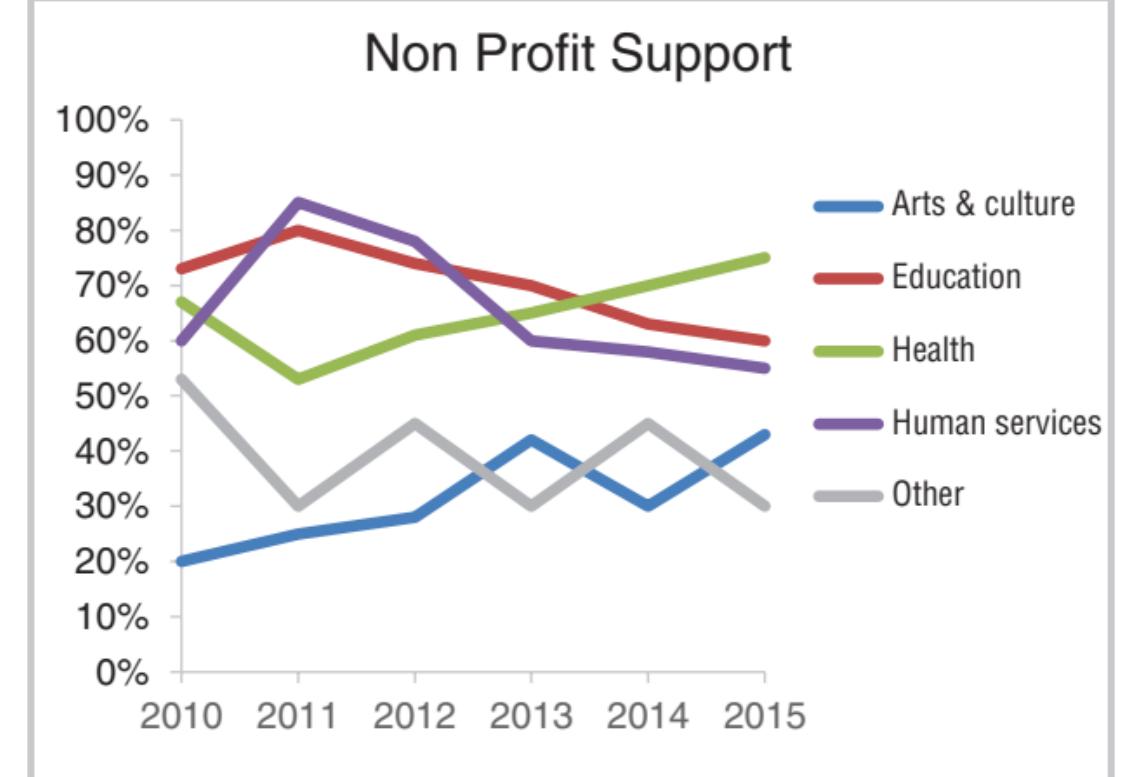




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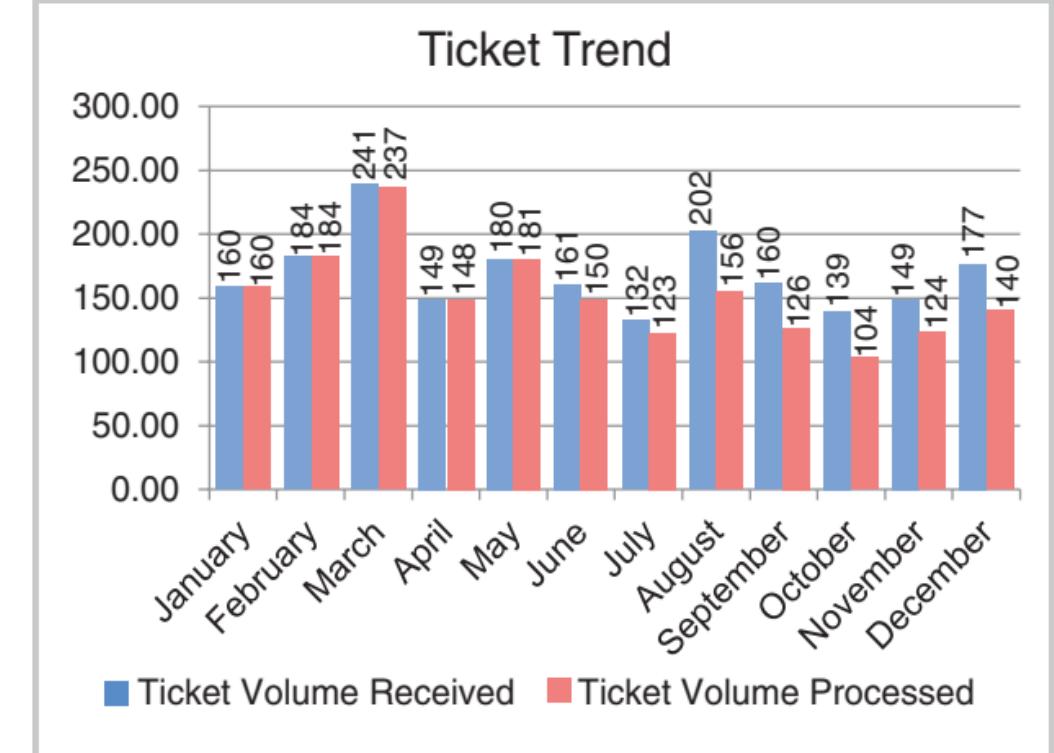




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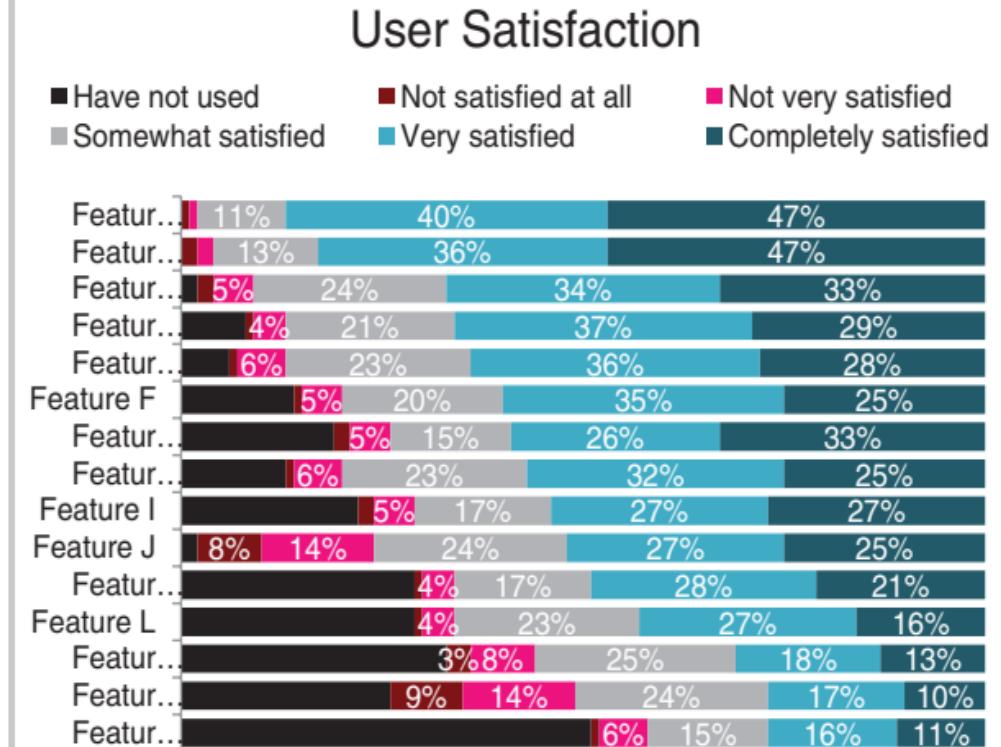




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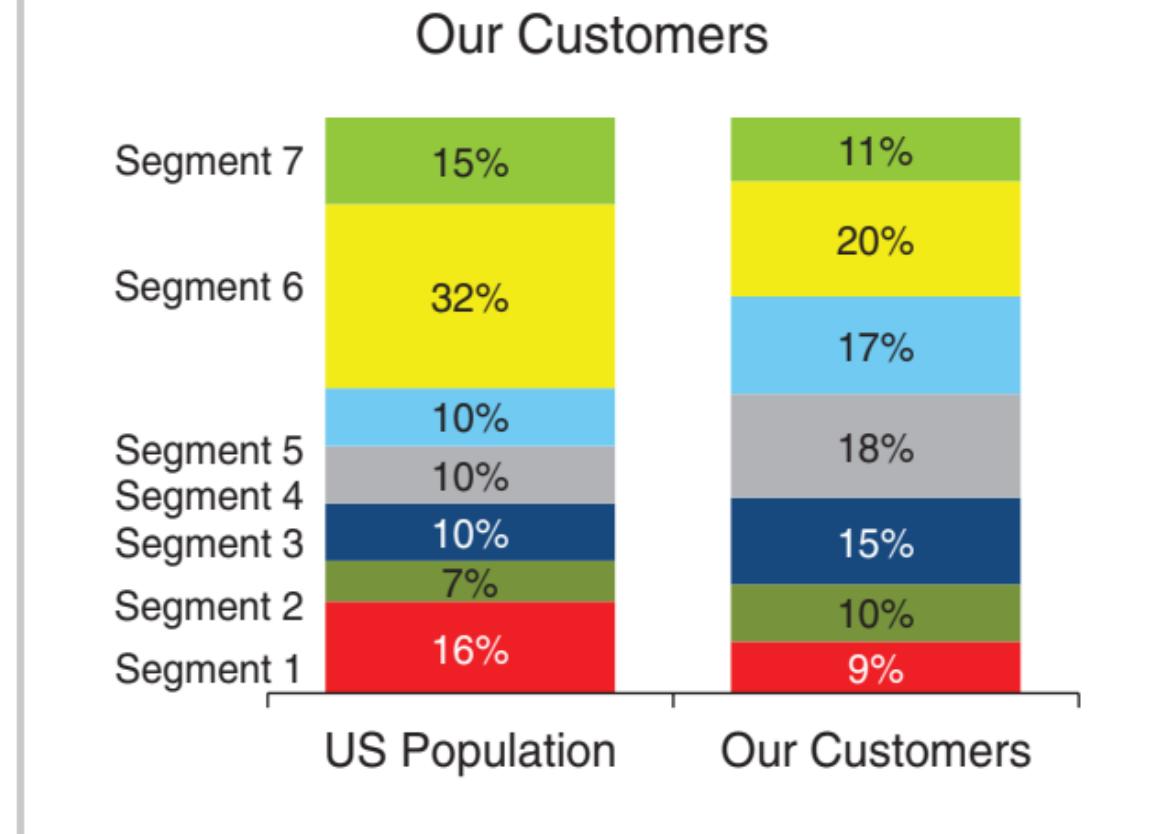




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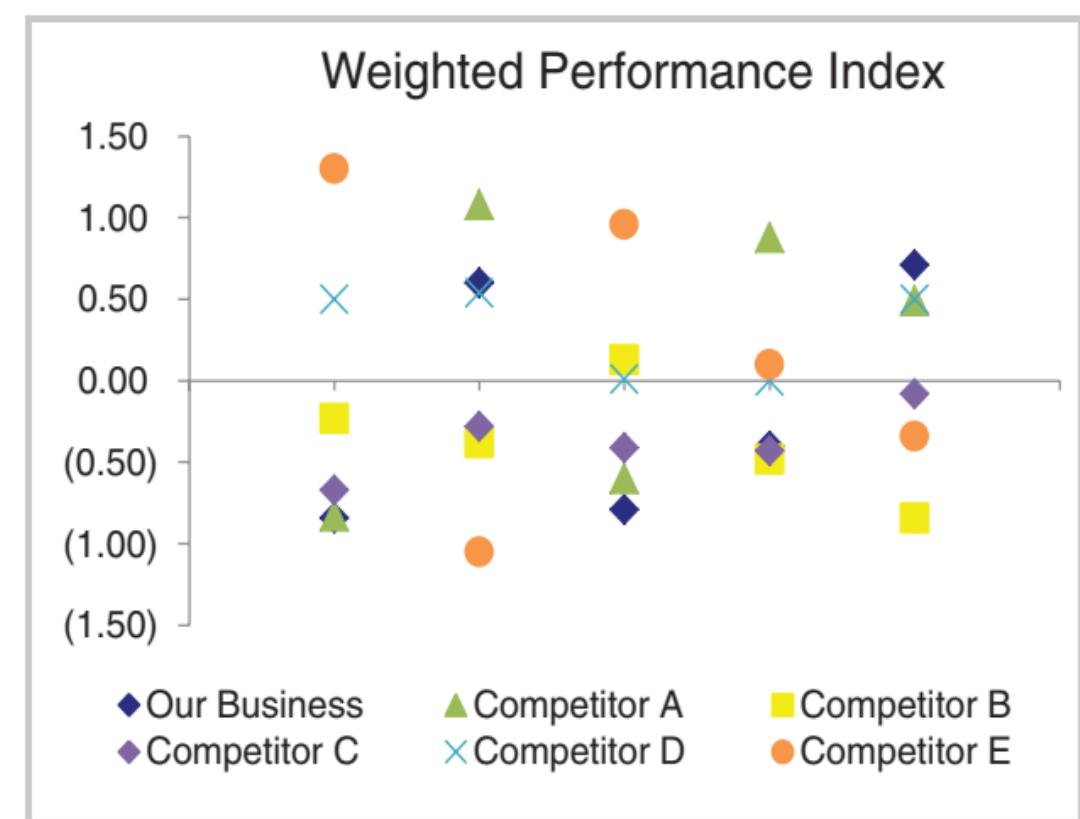




# Introduction

Bad graphs are everywhere:

- Nobody sets out to make a bad graph. But it happens. Again, and again.
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# Introduction

- We aren't naturally good at storytelling with data



## Ticket Trend

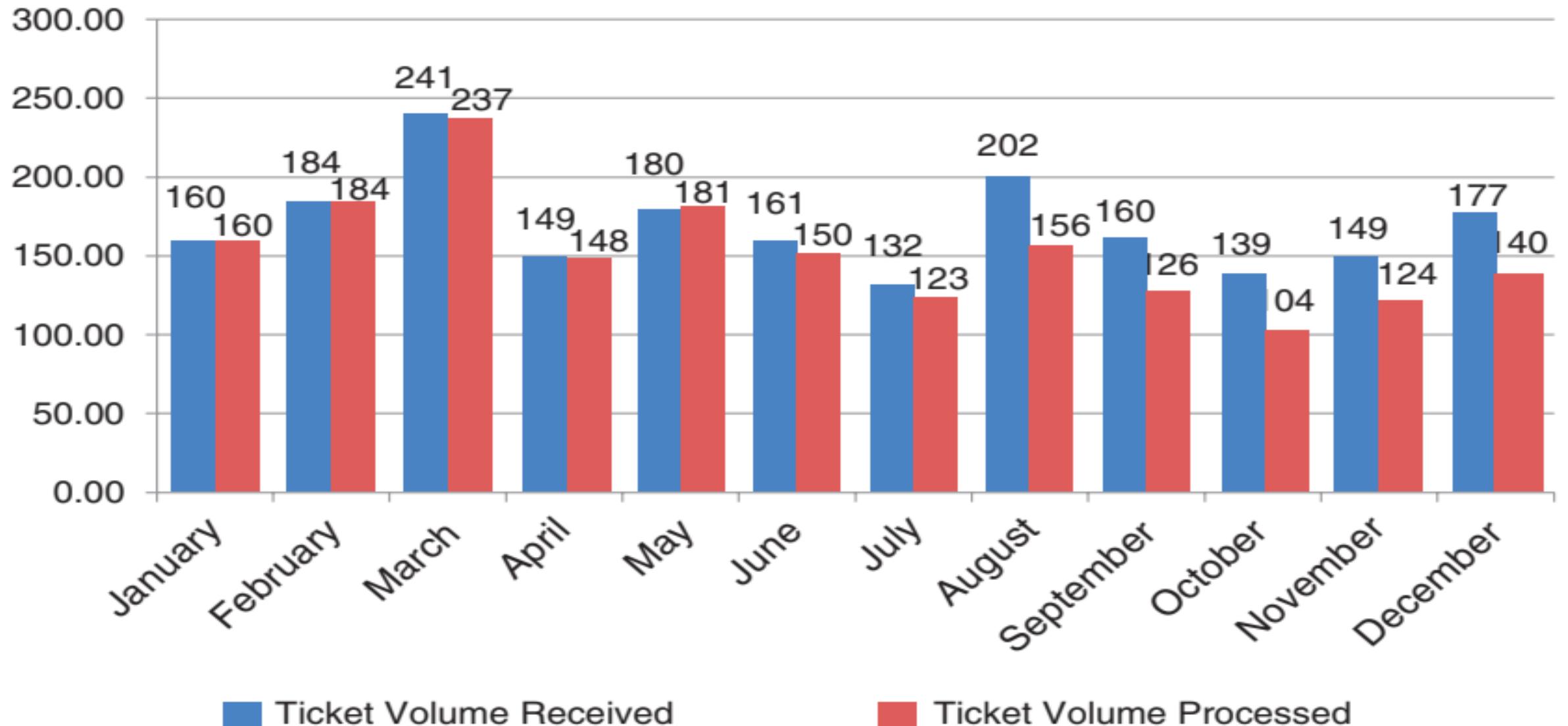


FIGURE 0.2 Example 1 (before): showing data

# Please approve the hire of 2 FTEs

to backfill those who quit in the past year

## Ticket volume over time



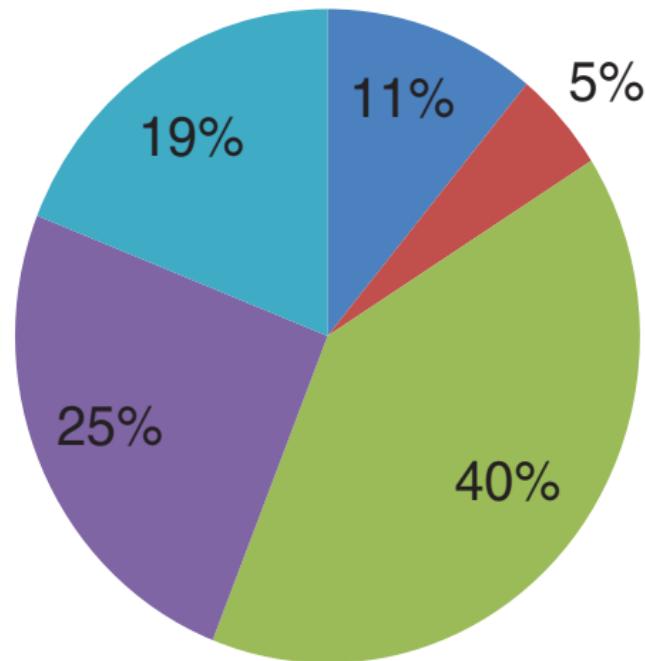
Data source: XYZ Dashboard, as of 12/31/2014 | A detailed analysis on tickets processed per person and time to resolve issues was undertaken to inform this request and can be provided if needed.

**FIGURE 0.3** Example 1 (after): storytelling with data

# Survey Results

PRE: How do you feel about doing science?

■ Bored ■ Not great ■ OK ■ Kind of interested ■ Excited



POST: How do you feel about doing science?

■ Bored ■ Not great ■ OK ■ Kind of interested ■ Excited

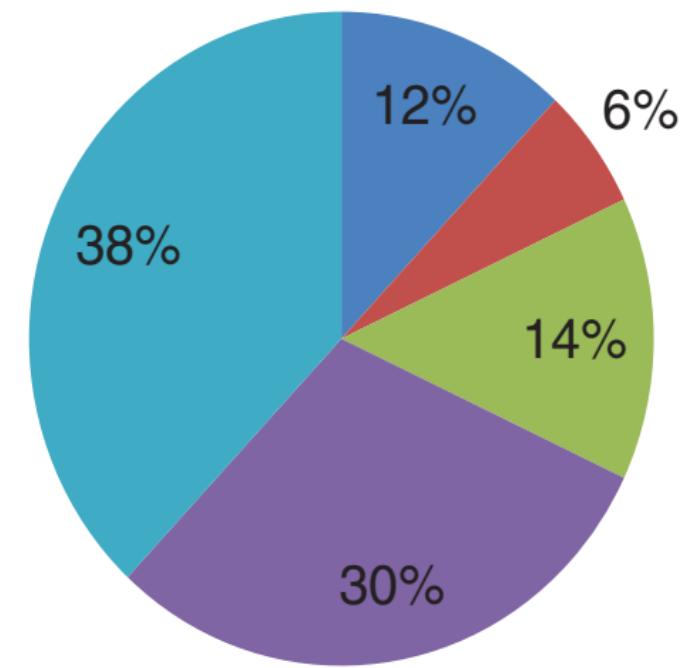
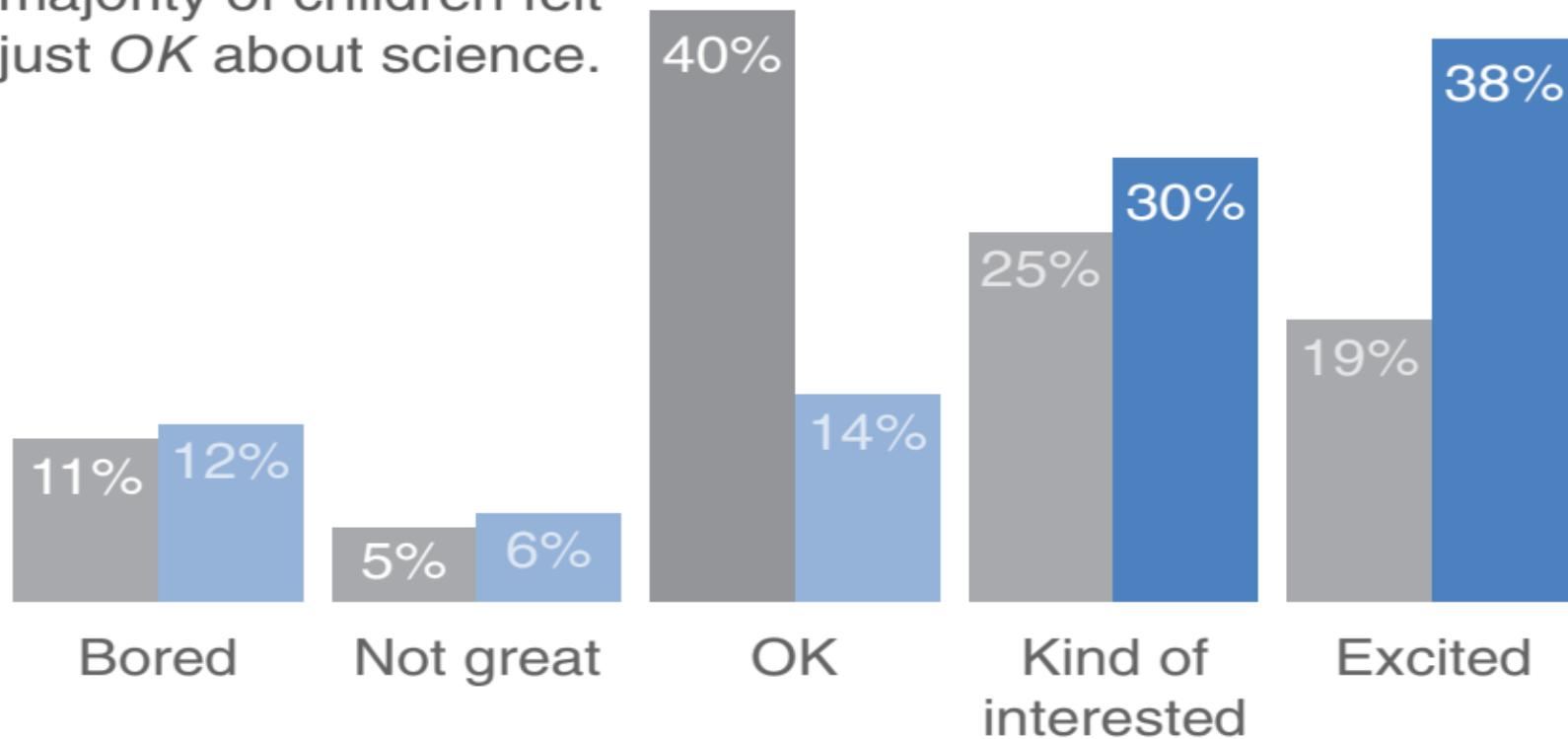


FIGURE 0.4 Example 2 (before): showing data

# Pilot program was a success

How do you feel about science?

**BEFORE** program, the majority of children felt just *OK* about science.



**AFTER** program,  
more children  
were *Kind of  
interested &  
Excited* about  
science.

Based on survey of 100 students conducted before and after pilot program (100% response rate on both surveys).

**FIGURE 0.5** Example 2 (after): storytelling with data

## Average Retail Product Price per Year

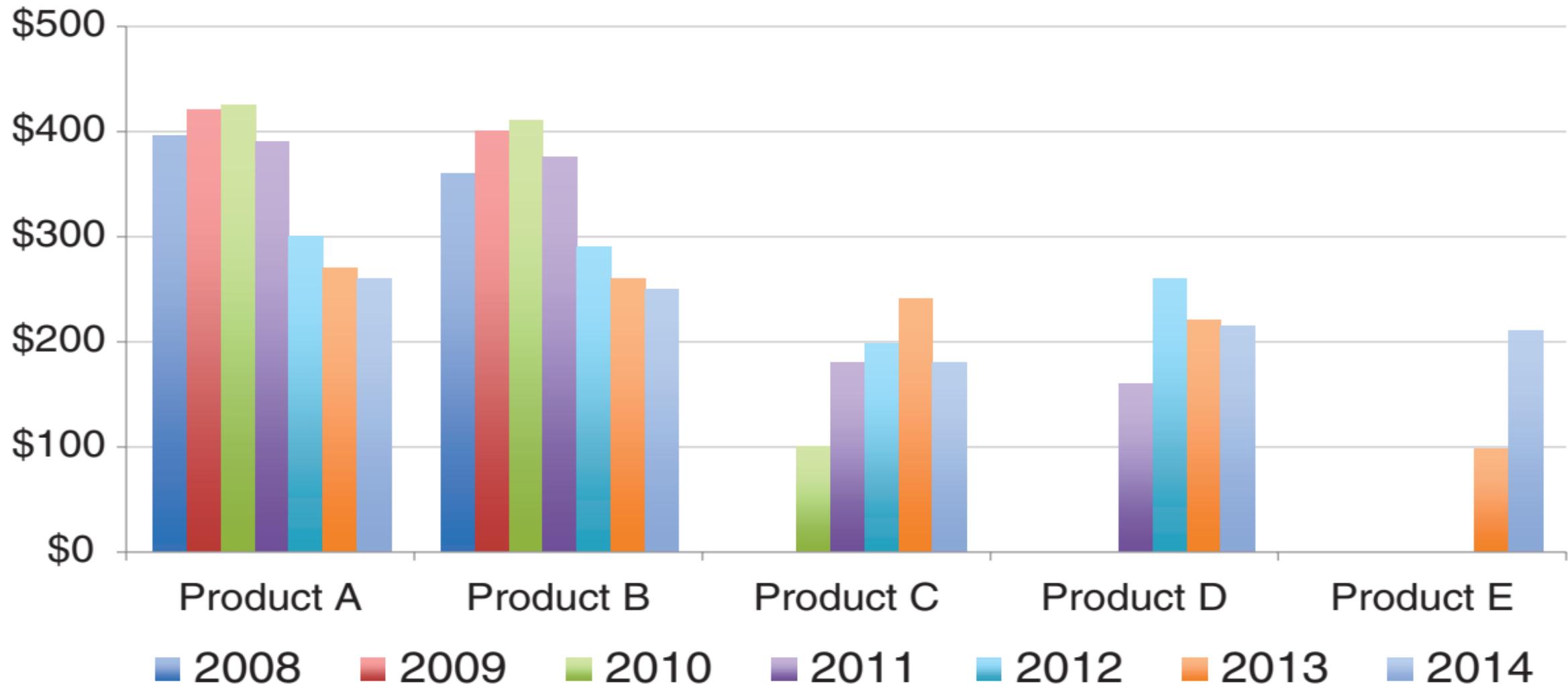


FIGURE 0.6 Example 3 (before): showing data

To be competitive, we recommend introducing our product *below* the \$223 average price point in the \$150–\$200 range

Retail price over time by product

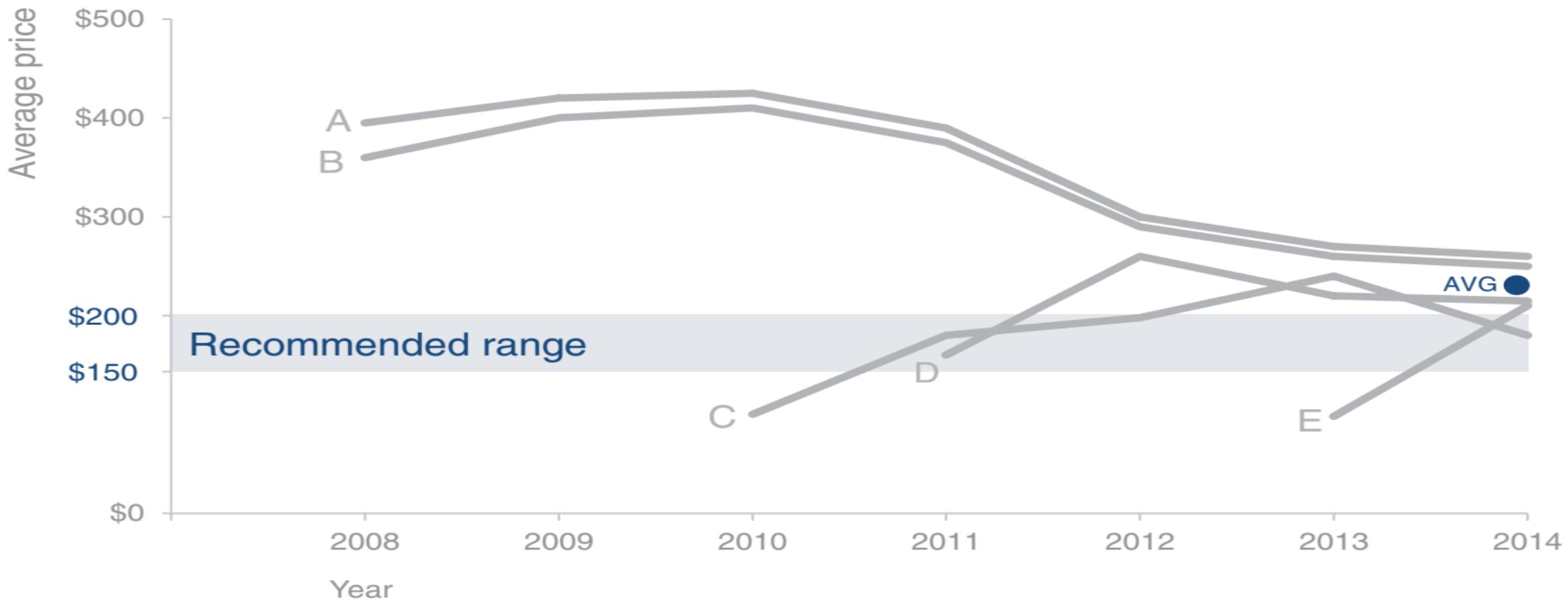


FIGURE 0.7 Example 3 (after): storytelling with data

# CORONAVIRUS

## STATS

As declared by WHO on March 11, 2020,  
COVID-19 has become a Pandemic



COUNTRY/REGION:



CONFIRMED



RECOVERED



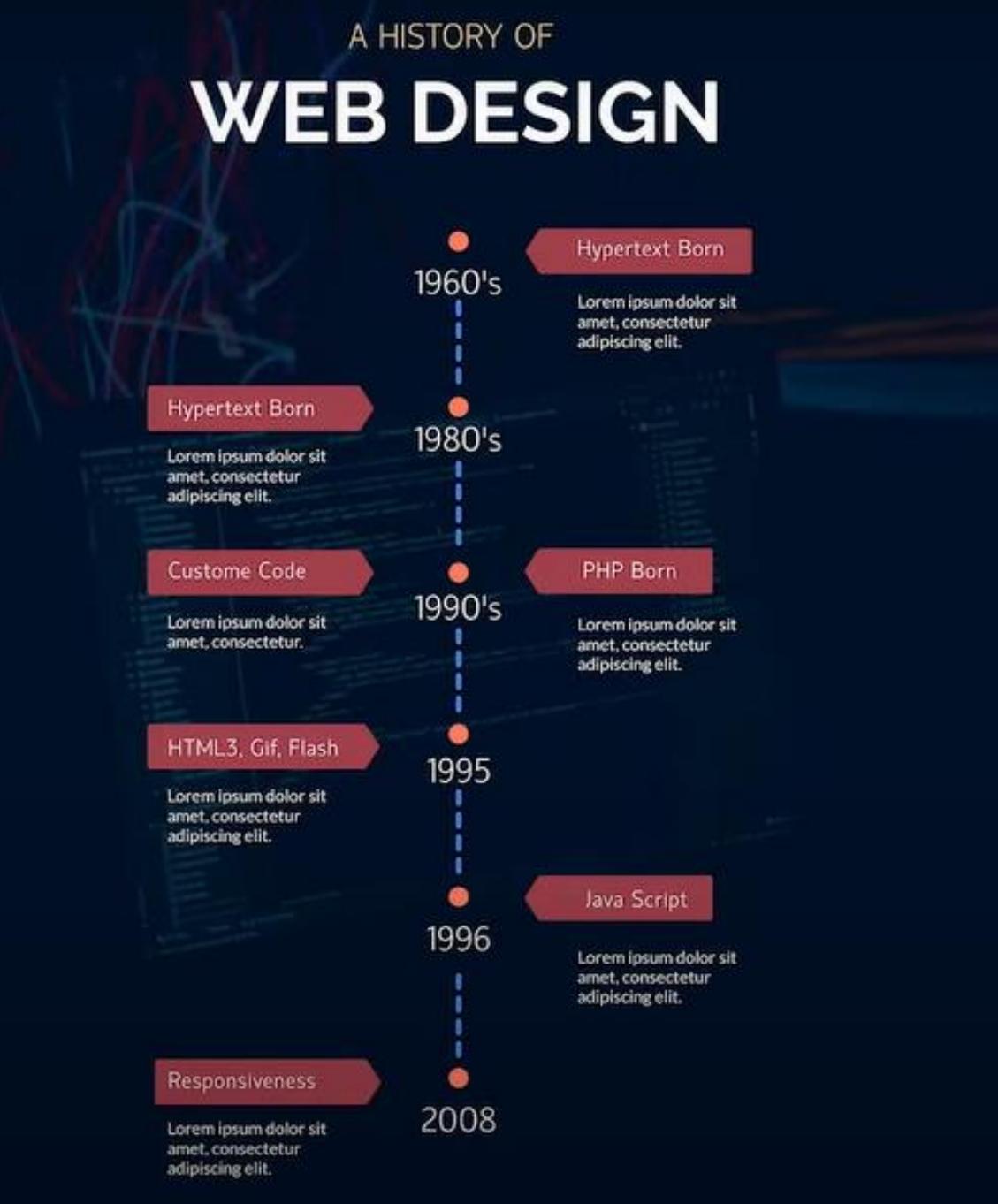
22,837

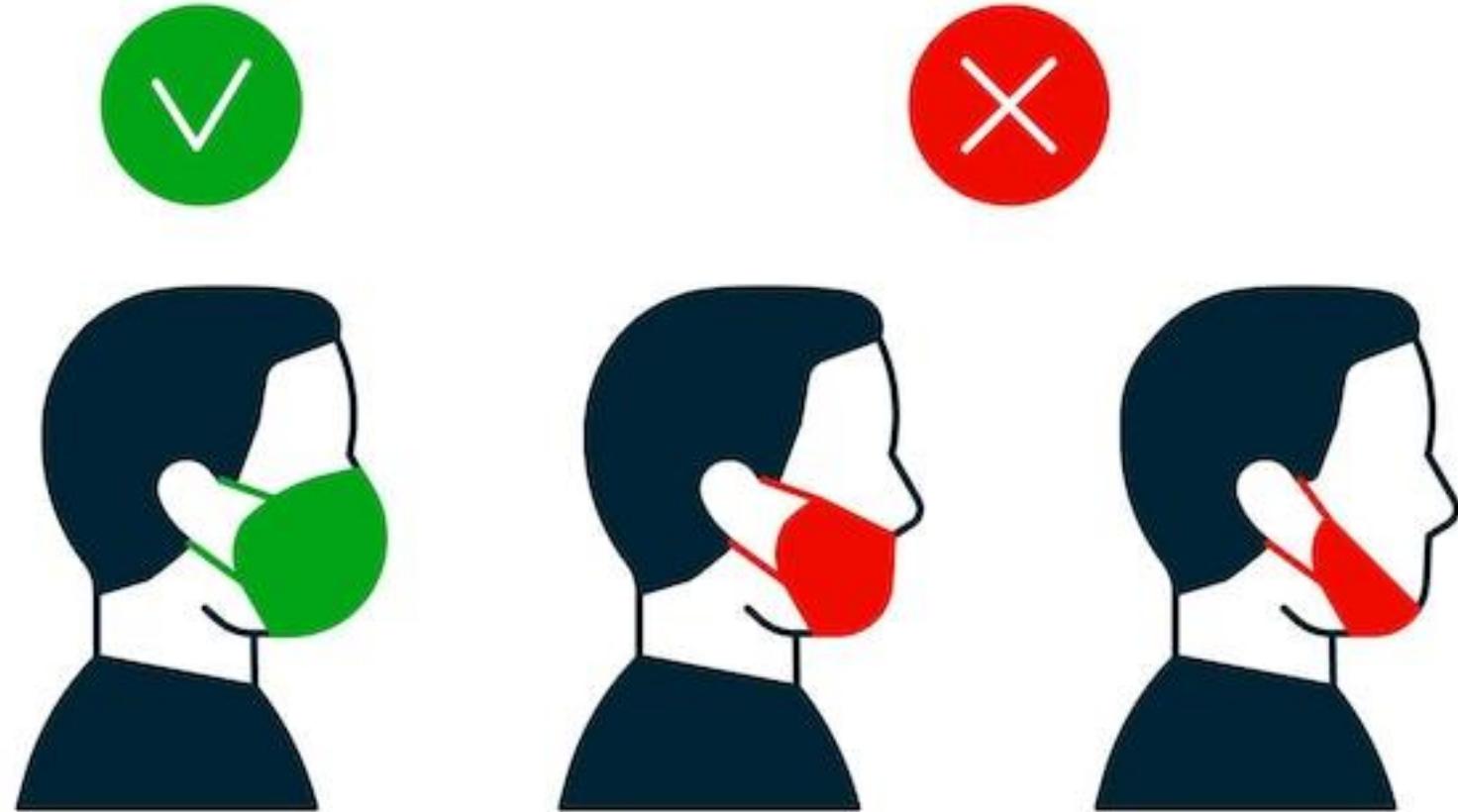
DEATHS



16,523

132,547







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# DATA VISUALIZATION



# UNIT - I

# How you'll learn to tell stories with data



## STEP 1

### CONTEXT

Understand the Context



## STEP 2

### DISPLAY

Choose an appropriate visual display



## STEP 3

### CLUTTER

Eliminate Clutter



## STEP 4

### ATTENTION

Focus attention where you want it



## STEP 5

### THINKING

Think like a designer



## STEP 6

### TELL A STORY

Tell a story to audience





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# The Importance of Context

- Success in data visualization does not start with data visualization.
- Rather, before you begin down the path of creating a data visualization or communication, attention and time should be paid to **understanding the context** for the need to communicate.





# The Importance of Context

## Exploratory vs. explanatory analysis:

- **Exploratory** analysis is what you do to understand the data and figure out what might be noteworthy or interesting to highlight to others.
- When we do exploratory analysis, it's like hunting for pearls in oysters.
- We might have to open 100 oysters to find perhaps two pearls.
- When we're at the point of communicating our analysis to our audience, we really want to be in the **explanatory** space, meaning you have a specific thing you want to explain, a specific story you want to tell—probably about those two pearls.



# The Importance of Context

## Exploratory analysis:

- Suppose researchers want to explore a new, mysterious disease that has recently emerged. They don't have much prior information about this disease. In this case, they might conduct exploratory research.





# The Importance of Context

- They could start by collecting data from affected patients, conducting interviews with them, and reviewing existing medical records.
- The goal here is to gain a better understanding of the disease, its symptoms, potential causes, and any patterns that might emerge.

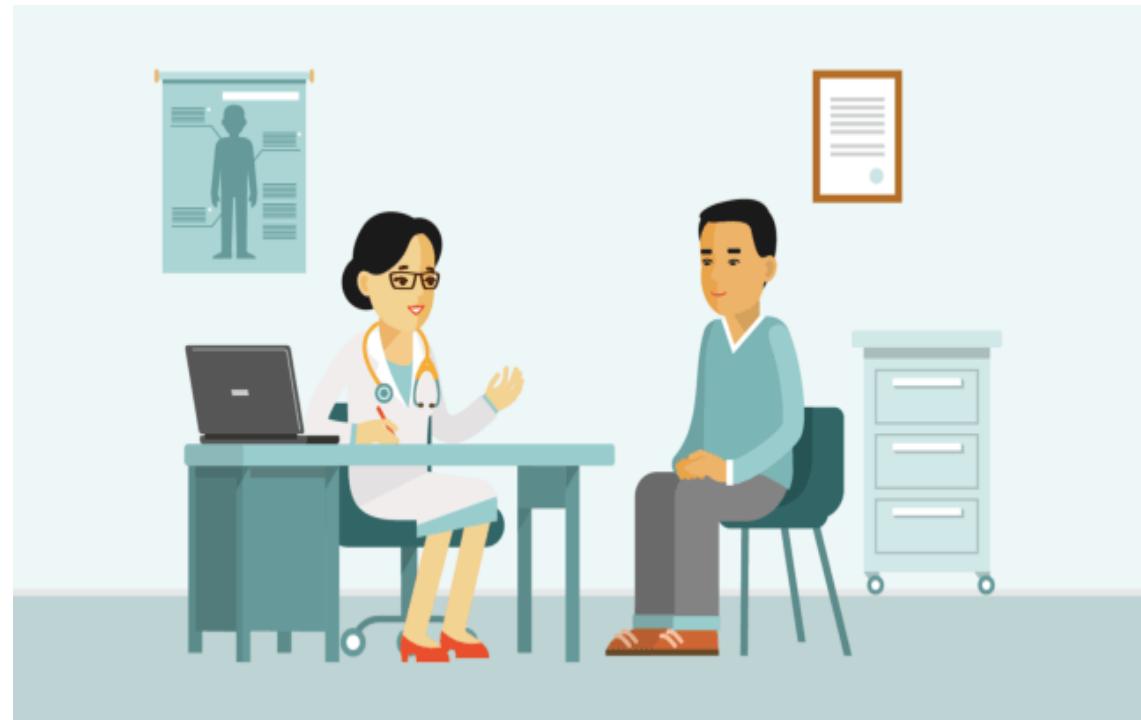




# The Importance of Context

## Explanatory analysis:

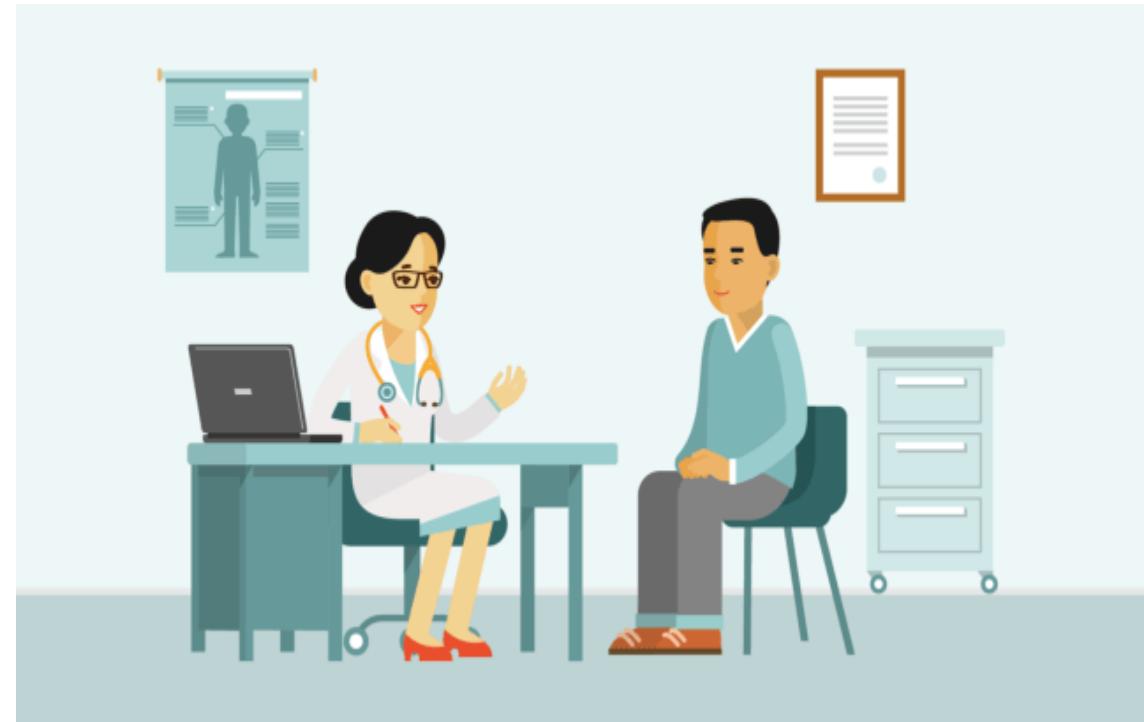
- The researchers have identified a potential cause for the disease, such as exposure to a certain environmental toxin. They now want to establish a causal relationship and explain how this toxin leads to the disease.





# The Importance of Context

- To do this, they design a controlled experiment, exposing laboratory animals to the toxin and monitoring their health over time. This explanatory research aims to provide clear evidence of causation by controlling variables and using statistical analysis to establish a cause-and-effect relationship.





# The Importance of Context

Who, what, and how:

- When it comes to explanatory analysis, there are a few things to think about and be extremely clear on before visualizing any data or creating content.
- To whom are you communicating? It is important to have a good understanding of who your audience is and how they perceive you.





# The Importance of Context

- What do you want your audience to know or do?
- You should be clear how you want your audience to act and consider how you will communicate to them and the overall tone that you want to set for your communication.
- It's only after you can concisely answer these first two questions that you're ready to move forward with How can you use data to help make your point?

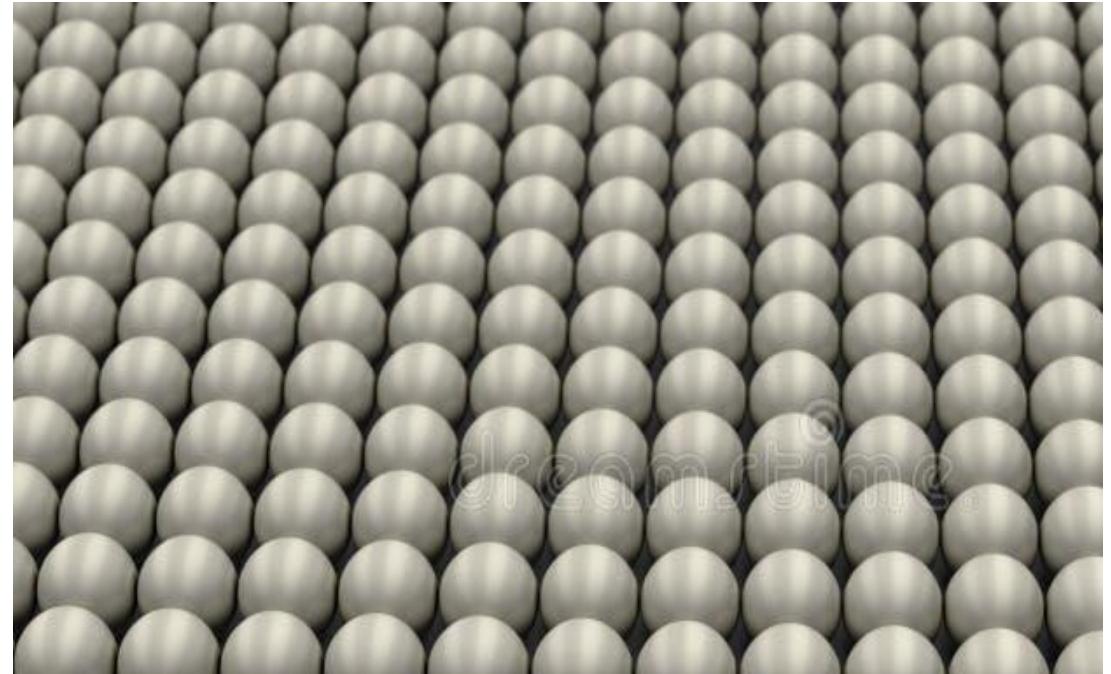


# The Importance of Context

Who:

Your audience:

- The **more specific** you can be about who your audience is, the better position you will be in for successful communication.





# The Importance of Context

Who:

Your audience:

- Avoid general audiences, such as “internal and external stakeholders” by trying to communicate to too many different people with disparate needs at once, you put yourself in a position where you can’t communicate to any one of them.

## Stakeholders





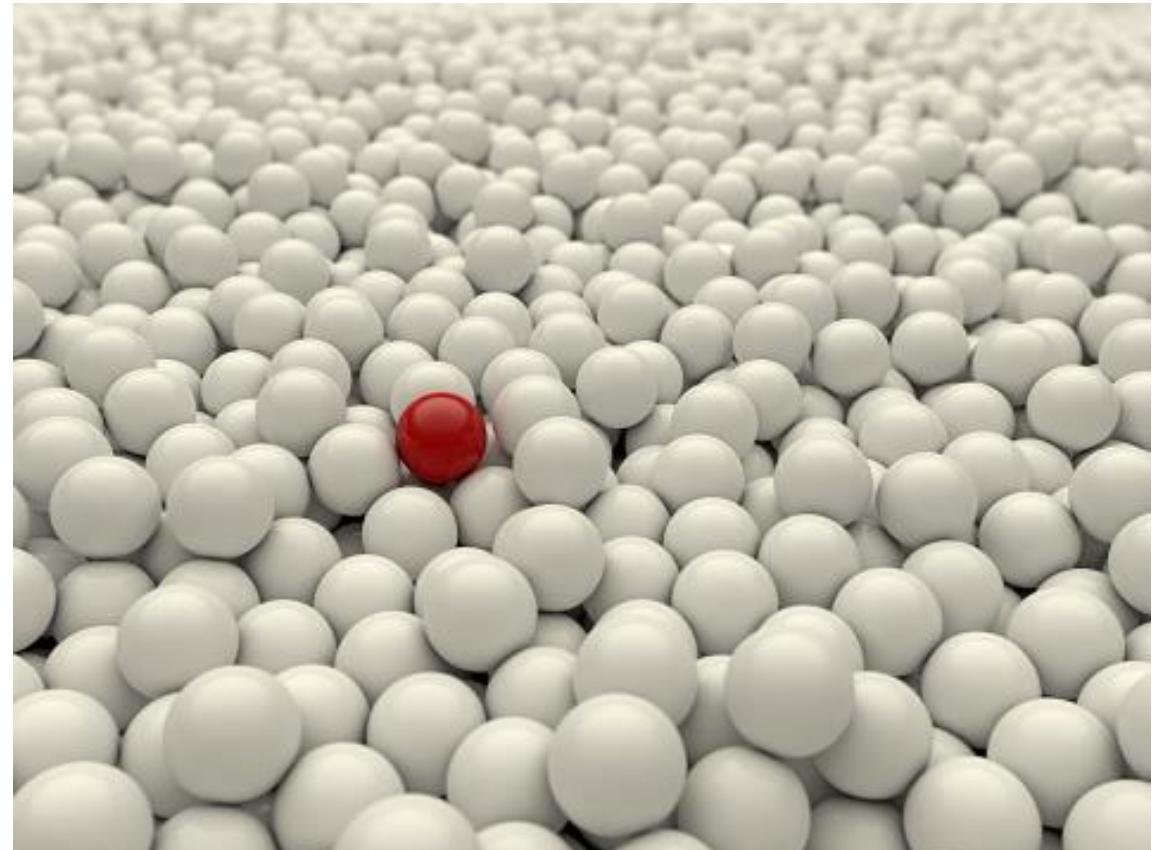
# The Importance of Context

Who:

Your audience:

- Sometimes this means creating different communications for different audiences.

Identifying the **decision maker** is one way of narrowing your audience





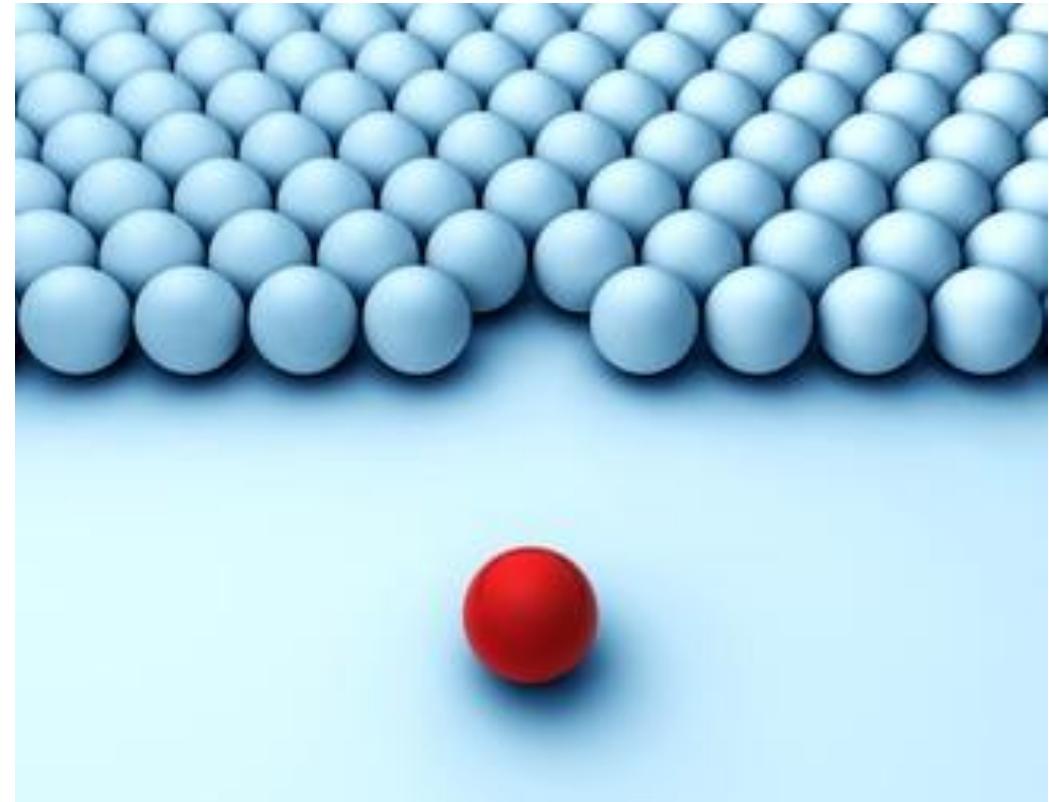
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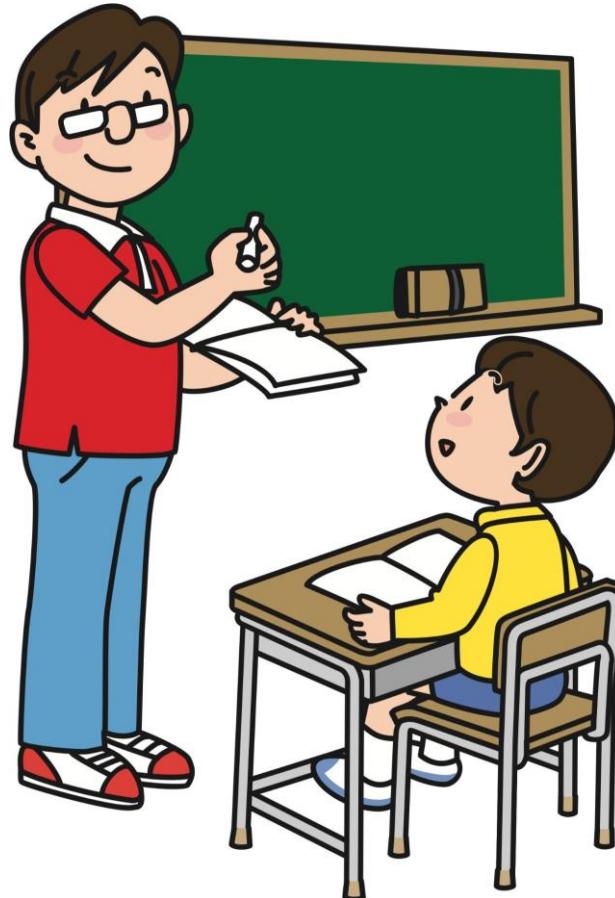


# The Importance of Context

Who:

You:

- It's also helpful to think about the relationship that you have with your audience and how you expect that they will perceive you.





# The Importance of Context

Who:

You:

- Will you be encountering each other for the first time through this communication, or do you have an established relationship? Do they already trust you as an expert, or do you need to work to establish credibility?





# The Importance of Context

What:

Action:

- What do you need your audience to know or do? This is the point where you think through how to make what you communicate relevant for your audience and form a clear understanding of why they should care about what you say.



# The Importance of Context

What:

Mechanism:

- How will you communicate to your audience?
- We can think of the communication mechanism along a continuum, with live presentation at the left and a written document or email at the right, as shown in Figure.

LIVE PRESENTATION ..... WRITTEN DOC OR EMAIL

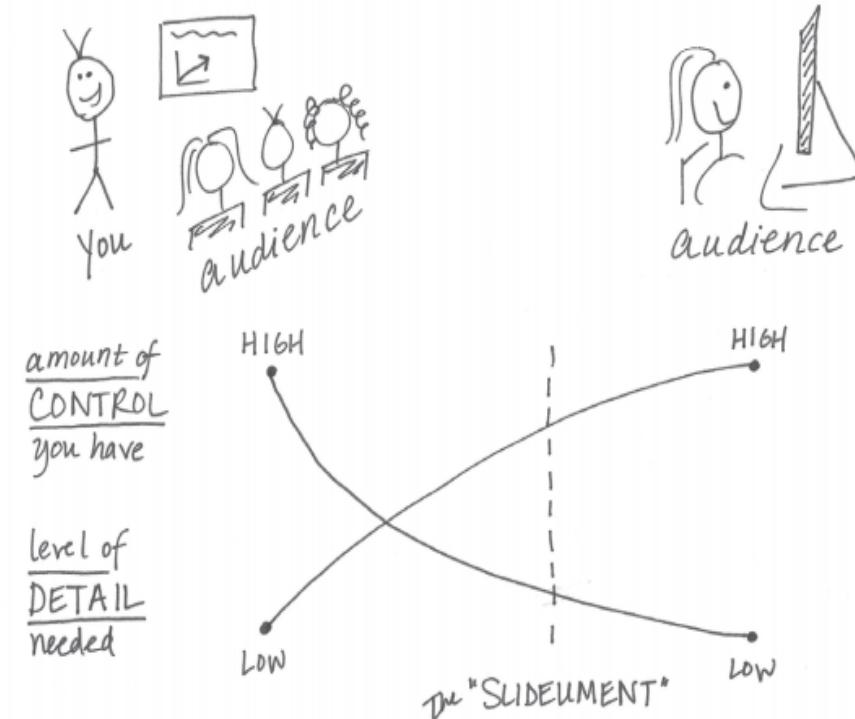


FIGURE 1.1 Communication mechanism continuum



# The Importance of Context

What:

Mechanism:

- At the left, with a live presentation, you (the presenter) are in full control. You determine what the audience sees and when they see it. You can respond to visual cues to speed up, slow down, or go into a particular point in detail.

LIVE PRESENTATION ..... WRITTEN DOC OR EMAIL

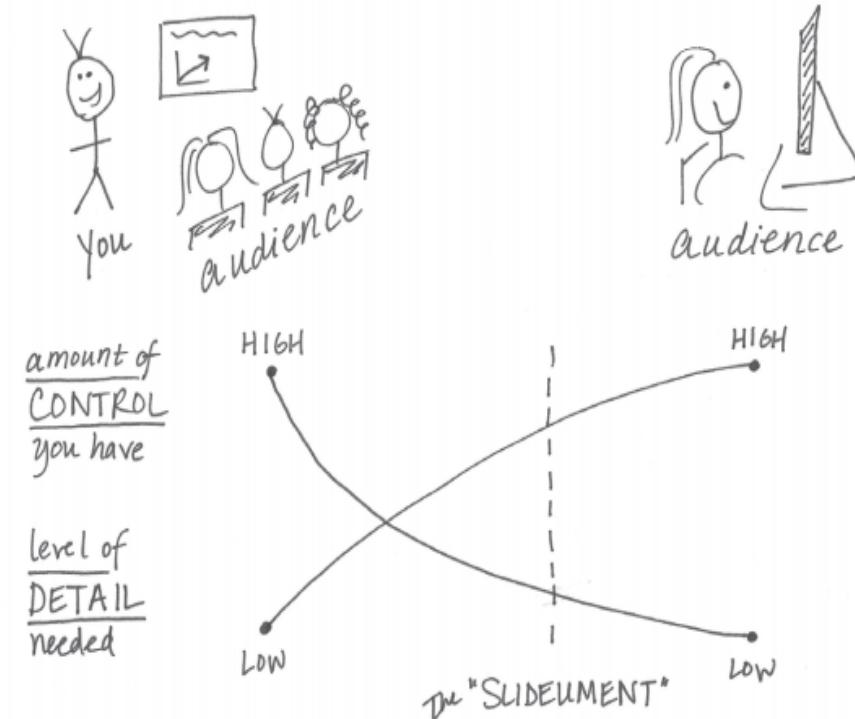


FIGURE 1.1 Communication mechanism continuum



# The Importance of Context

What:

Mechanism:

- At the right side of the spectrum, with a written document or email, you have less control. In this case, the audience is in control of how they consume the information.

LIVE PRESENTATION ..... WRITTEN DOC OR EMAIL

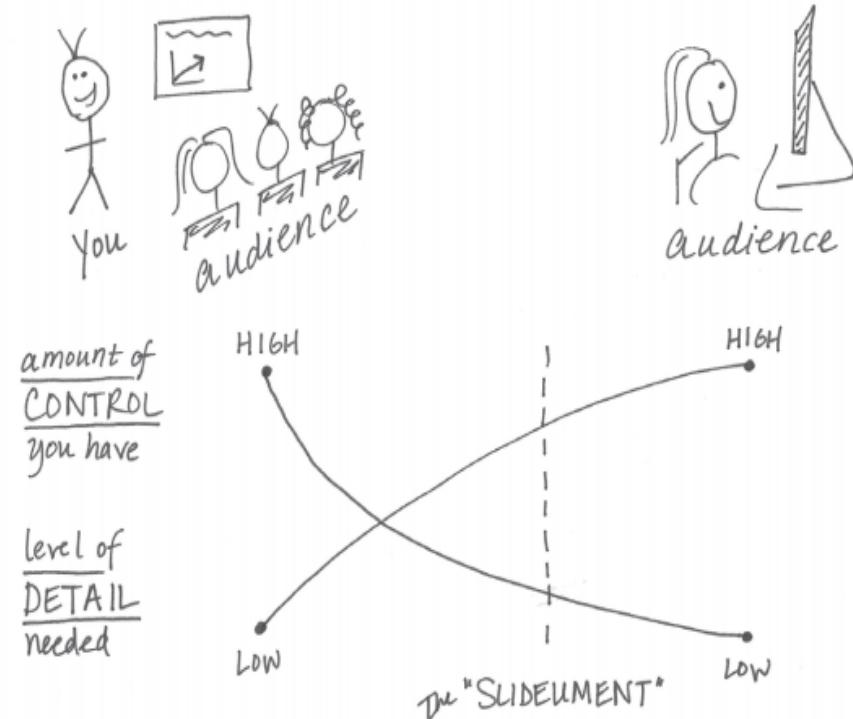


FIGURE 1.1 Communication mechanism continuum



# The Importance of Context

What:

Mechanism:

- This gives rise to the slideument, a single document that's meant to solve both needs.

**SLIDES ARE  
NOT  
DOCUMENTS**



# The Importance of Context

What:

Tone:

- What tone do you want your communication to set?
- Are you celebrating a success?
- Trying to light a fire to drive action?
- Is the topic lighthearted or serious?

How:

- What data is available that will help make my point?
- Data becomes supporting evidence of the story you will build and tell.



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# DATA VISUALIZATION



# UNIT - I

# How you'll learn to tell stories with data



## STEP 1

### CONTEXT

Understand the Context



## STEP 2

### DISPLAY

Choose an appropriate visual display



## STEP 3

### CLUTTER

Eliminate Clutter



## STEP 4

### ATTENTION

Focus attention where you want it



## STEP 5

### THINKING

Think like a designer



## STEP 6

### TELL A STORY

Tell a story to audience





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Choosing the Effective Visual



# Choosing the Effective Visual

- There are many different graphs and other types of visual displays of information.
- Choosing an effective visual, whether it's for a presentation, marketing campaign, website, or any other purpose, is crucial for conveying your message and engaging your audience.

**So Many  
Graphs & Displays**



# Choosing the Effective Visual



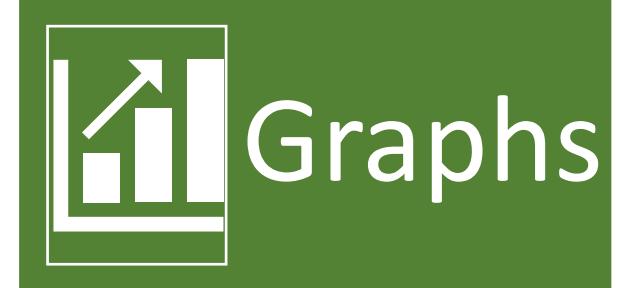
# Choosing the Effective Visual

- Column
- Line
- Pie
- Bar
- Area
- X Y (Scatter)
- Map
- Stock
- Surface
- Radar
- Treemap
- Sunburst
- Histogram
- Box & Whisker
- Waterfall
- Funnel
- Combo

- List
- Process
- Cycle
- Hierarchy
- Relationship
- Matrix
- Pyramid
- Picture



## Visual Types





- Simple Text
- Tables
- Graphs



- When you have just a number or two to share, simple text can be a great way to communicate.

**91%**

Simple text

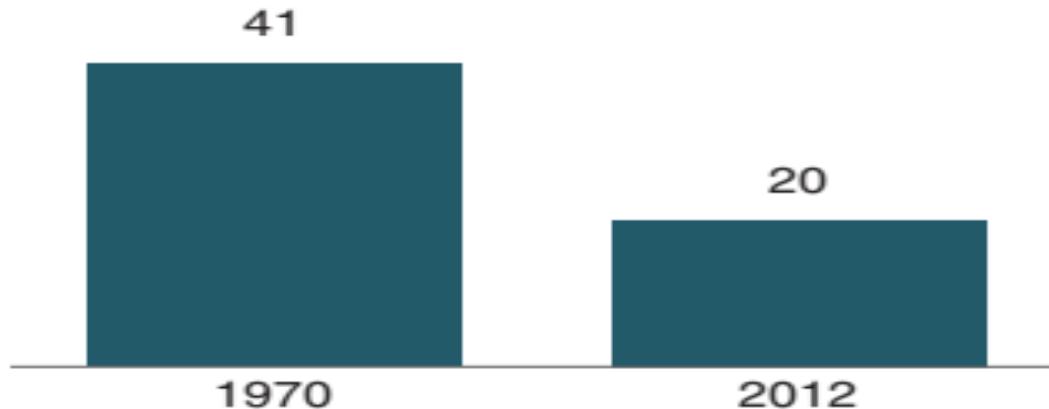


- Simple Text
- Tables
- Graphs



## Children with a "Traditional" Stay-at-Home Mother

*% of children with a married stay-at-home mother with a working husband*



Note: Based on children younger than 18. Their mothers are categorized based on employment status in 1970 and 2012.

Source: Pew Research Center analysis of March Current Population Surveys Integrated Public Use Microdata Series (IPUMS-CPS), 1971 and 2013

Adapted from **PEW RESEARCH CENTER**

**FIGURE 2.2** Stay-at-home moms original graph



- Simple Text
- Tables
- Graphs



20%

of children had a  
**traditional stay-at-home mom**  
in 2012, compared to 41% in 1970

FIGURE 2.3 Stay-at-home moms simple text makeover



- Simple Text
- Tables →
- Graphs

- Tables interact with our verbal system, which means that we read them.
- When I have a table in front of me, I typically have my index finger out: I'm reading across rows and down columns or I'm comparing values.

### Heavy borders

Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ



- Simple Text
- Tables →
- Graphs

- Tables interact with our verbal system, which means that we read them.
- When I have a table in front of me, I typically have my index finger out: I'm reading across rows and down columns or I'm comparing values.

### Light borders

Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ



- Simple Text
- Tables
- Graphs



- Tables interact with our verbal system, which means that we read them.
- When I have a table in front of me, I typically have my index finger out: I'm reading across rows and down columns or I'm comparing values.

### Minimal borders

Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ



- Simple Text
- Tables
- Graphs



- Borders should be used to improve the legibility of your table.
- Think about pushing them to the background by making them grey or getting rid of them altogether.
- The data should be what stands out, not the borders.



- Simple Text
- Tables
- Graphs



- let's shift our focus to a special case of tables:

Heatmap.

Table

	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%

Heatmap

LOW-HIGH

	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%



- Simple Text
- Tables →
- Graphs

- In the left table, I find myself scanning across rows and down columns to get a sense of what I'm looking at, where numbers are higher or lower.

	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%



- Simple Text
- Tables →
- Graphs

- We can use color saturation to provide visual cues, helping our eyes and brains more quickly target the potential points of interest. In the second iteration of the table on the right entitled “Heatmap,” the higher saturation of blue, the higher the number.

Heatmap

LOW-HIGH

	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%



- Simple Text
- Tables
- Graphs

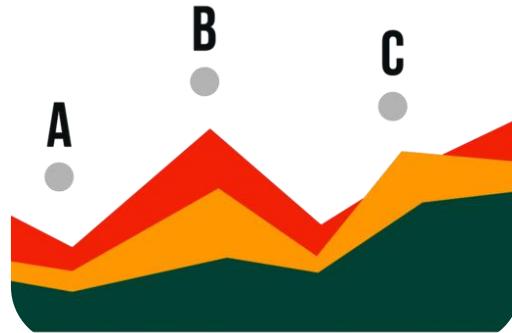


- Graphs interact with our visual system, which is faster at processing information. This means that a well-designed graph will typically get the information across more quickly than a well-designed table.





- Simple Text
- Tables
- **Graphs**



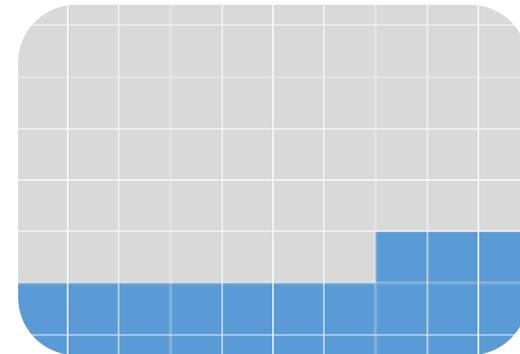
Points



Lines



Bars



Area



- Points
- Lines
- Bars
- Area



### Scatterplot:

- Scatterplots can be useful for showing the relationship between two things, because they allow you to encode data simultaneously on a horizontal x-axis and vertical y-axis to see whether and what relationship exists.
- For example, let's say that we manage a bus fleet and want to understand the relationship between miles driven and cost per mile.



- Points
- Lines
- Bars
- Area

Cost per mile by miles driven

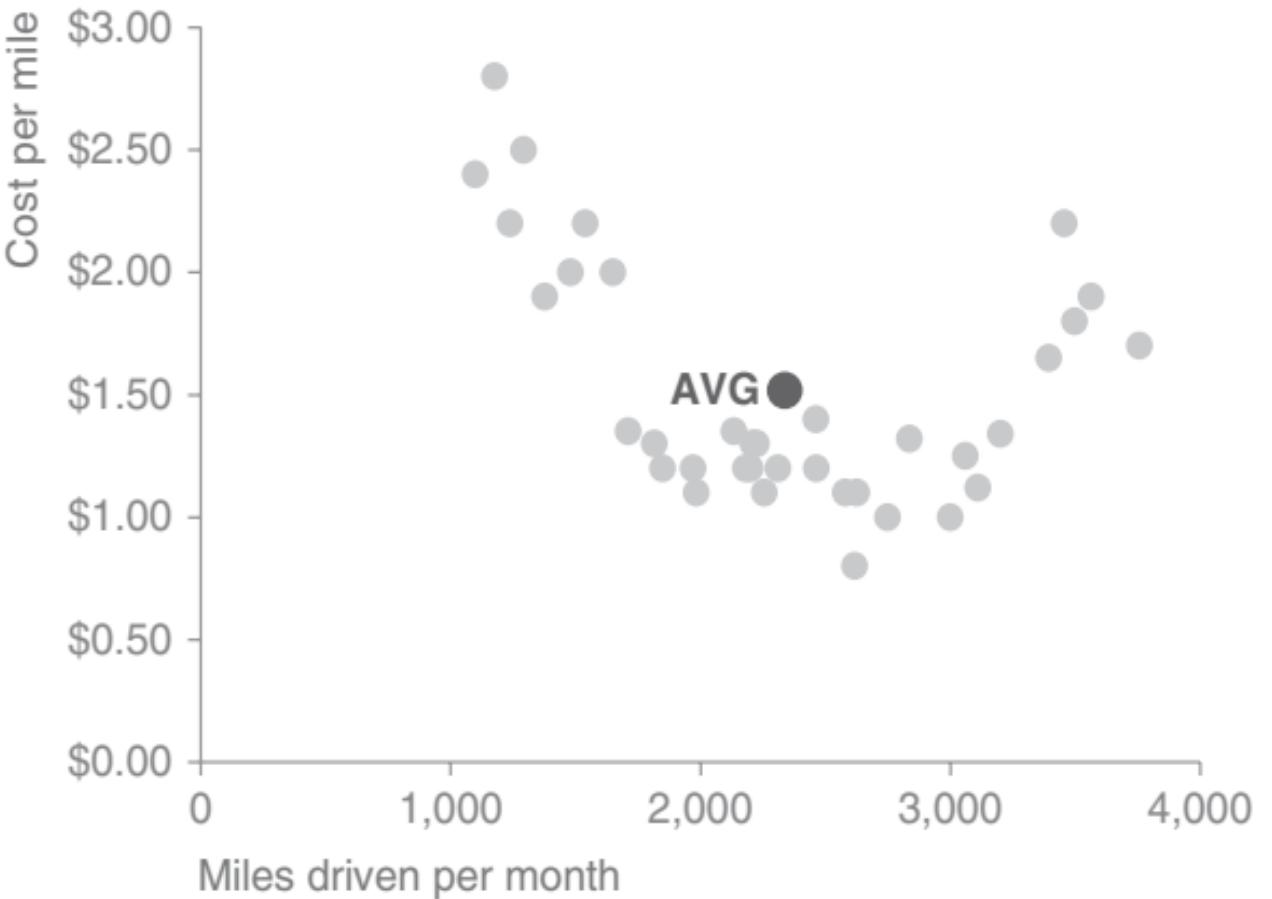


FIGURE 2.6 Scatterplot



- Points
- Lines
- Bars
- Area



Cost per mile by miles driven

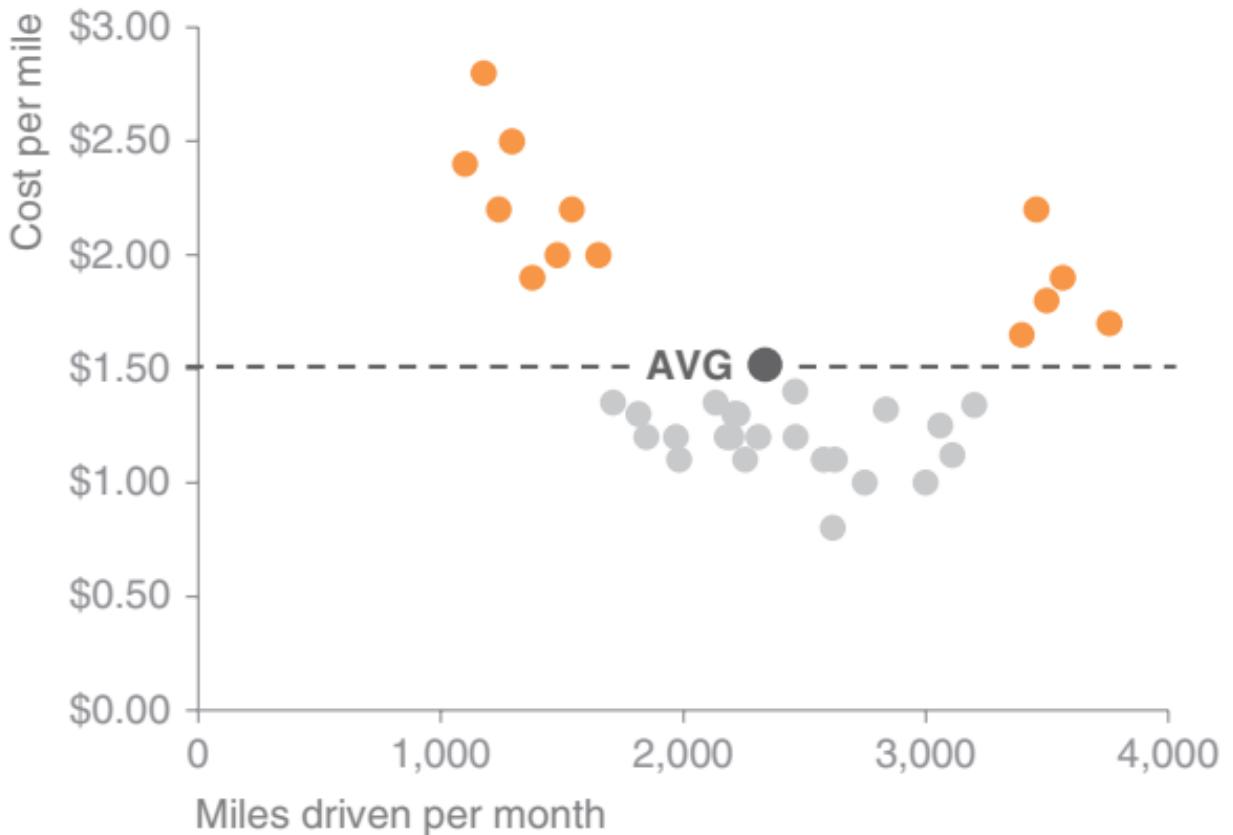


FIGURE 2.7 Modified scatterplot



- Points
- Lines
- Bars
- Area



Cost per mile by miles driven

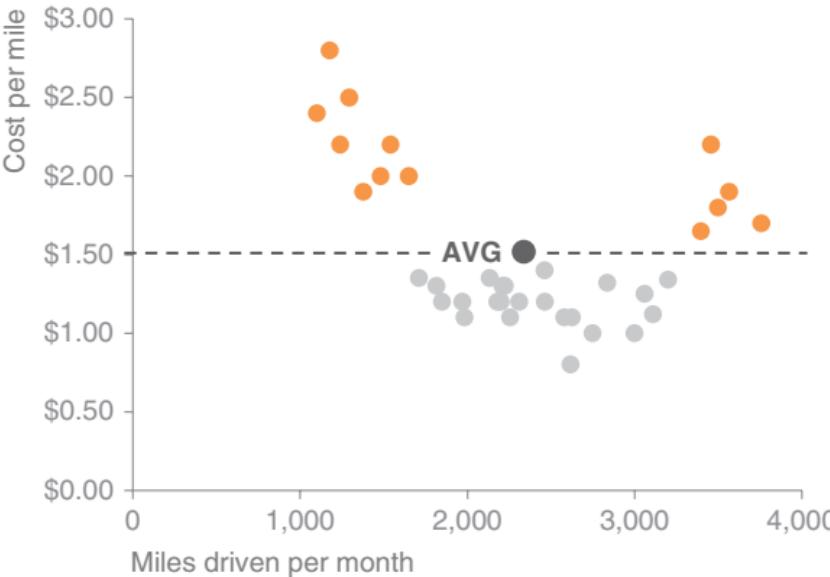


FIGURE 2.7 Modified scatterplot

- Observations such as cost per mile is higher than average when less than about 1,700 miles or more than about 3,300 miles were driven for the sample observed.



- Points
- Lines
- Bars
- Area



- Line graphs are most commonly used to plot continuous data.
- Because the points are physically connected via the line, it implies a connection between the points.
- There are two types:
  1. The standard line graph
  2. The slope graph.

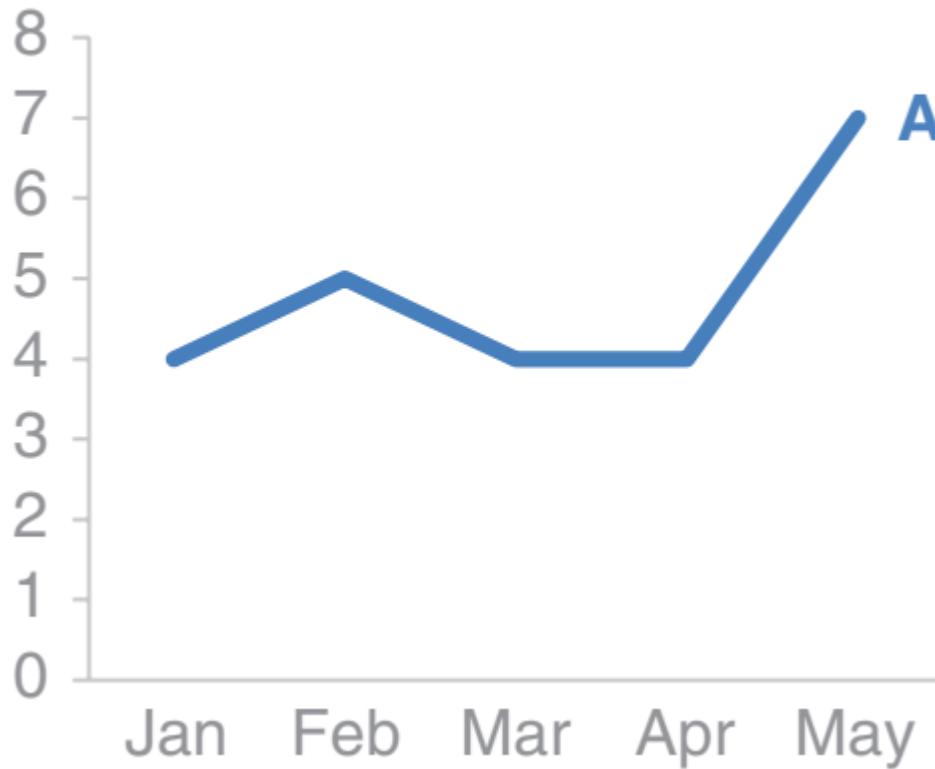


- Points
- Lines
- Bars
- Area



Line graph:

Single series



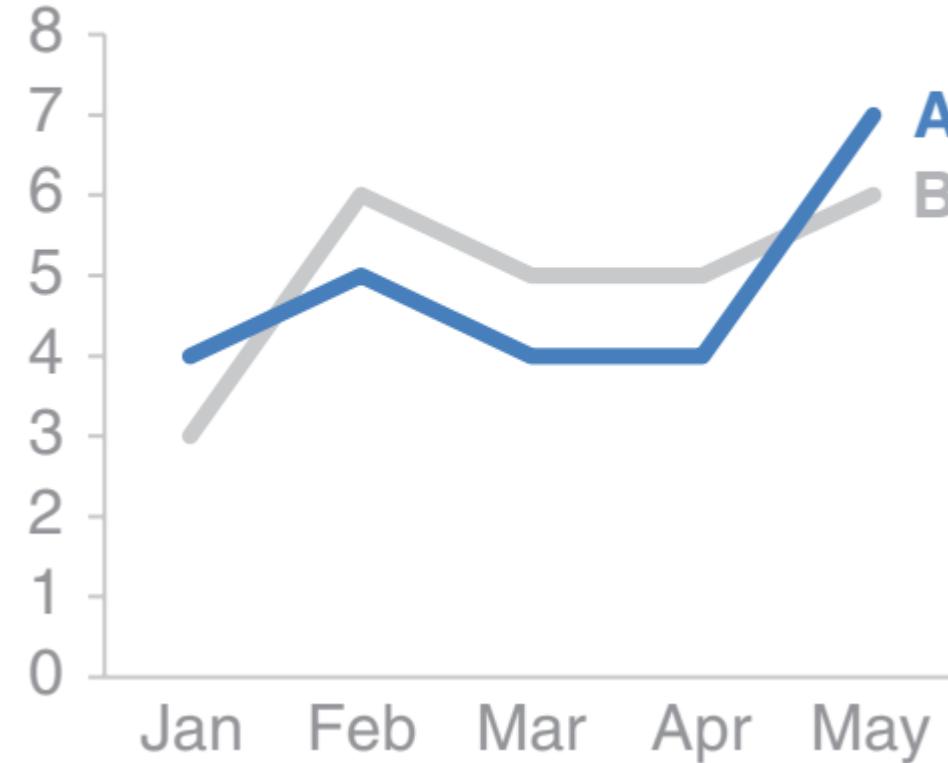


- Points
- Lines
- Bars
- Area



Line graph:

Two series



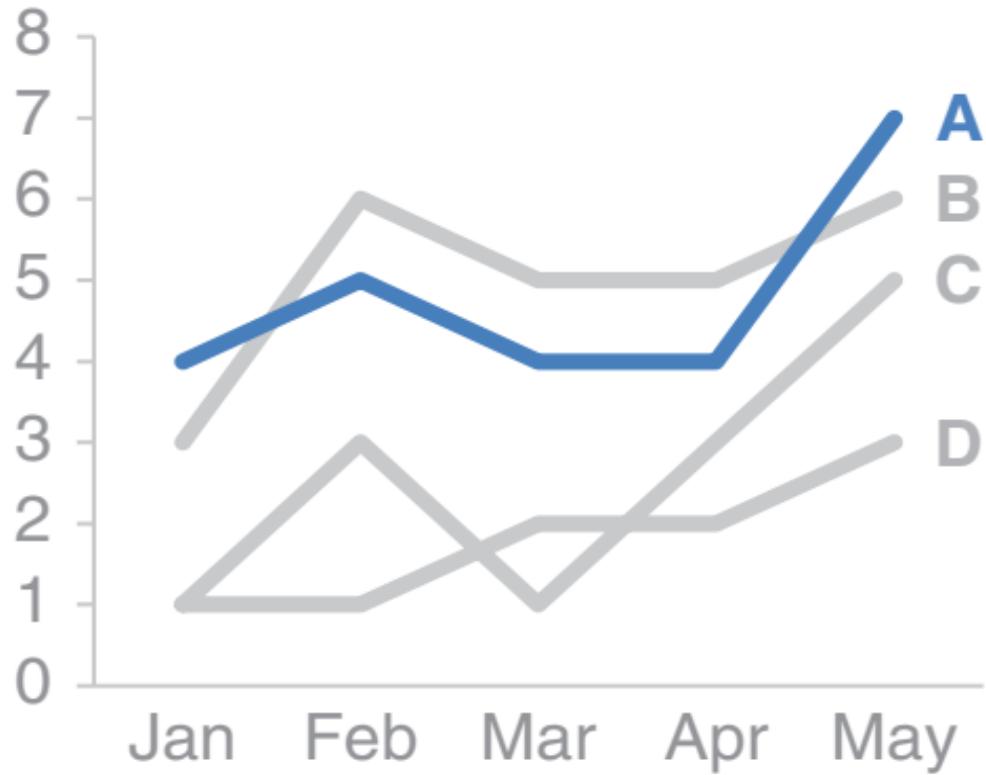


- Points
- Lines
- Bars
- Area



Line graph:

Multiple series





- Points
- Lines
- Bars
- Area



Passport control wait time  
Past 13 months

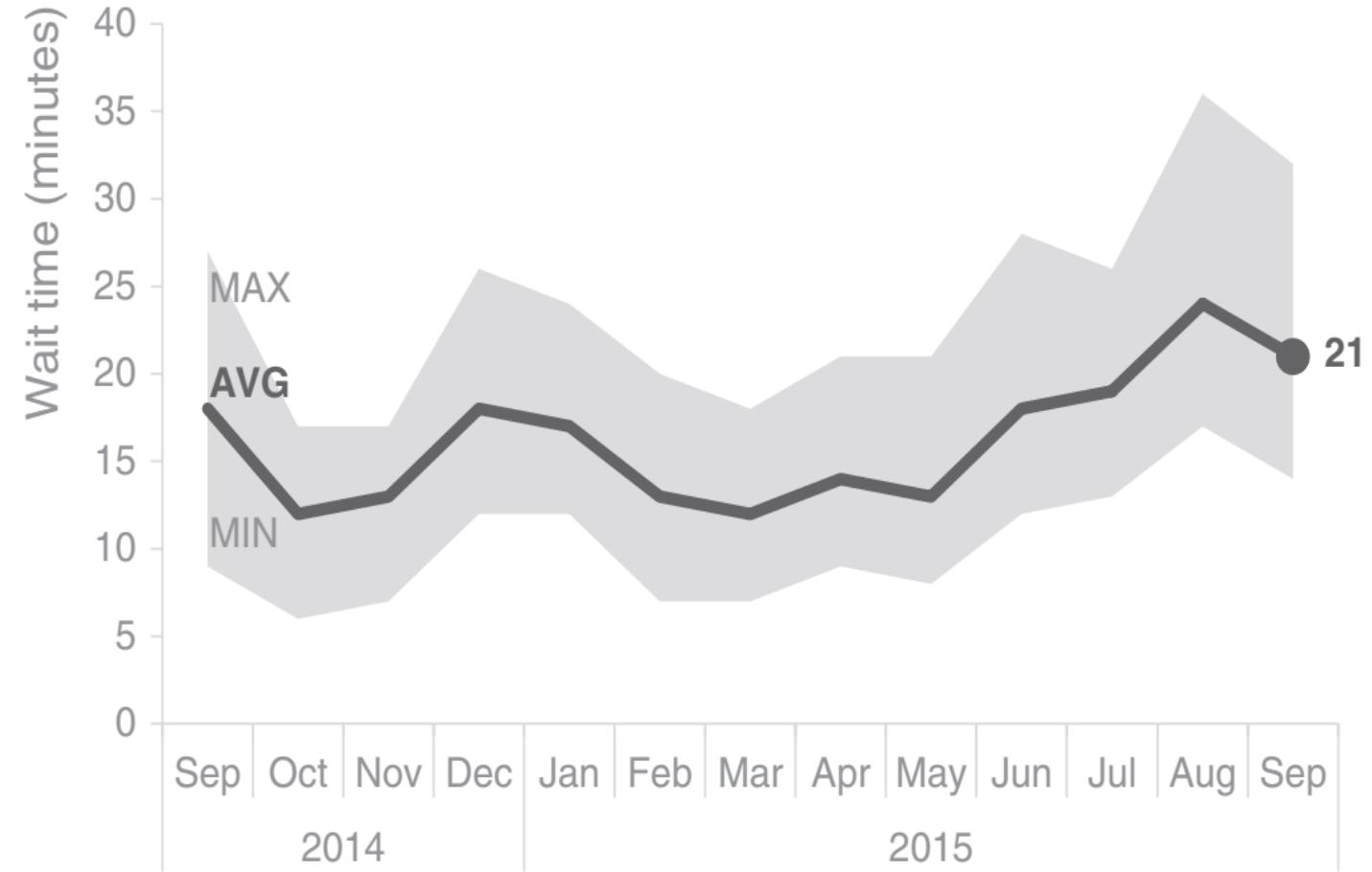


FIGURE 2.9 Showing average within a range in a line graph



- Points
- Lines
- Bars
- Area



### Slope graph:

- Slope graphs can be useful when you have two time periods.
- Points of comparison and want to quickly show relative increases and decreases.
- Differences across various categories between the two data points.



- Points
- Lines
- Bars
- Area



## Employee feedback over time

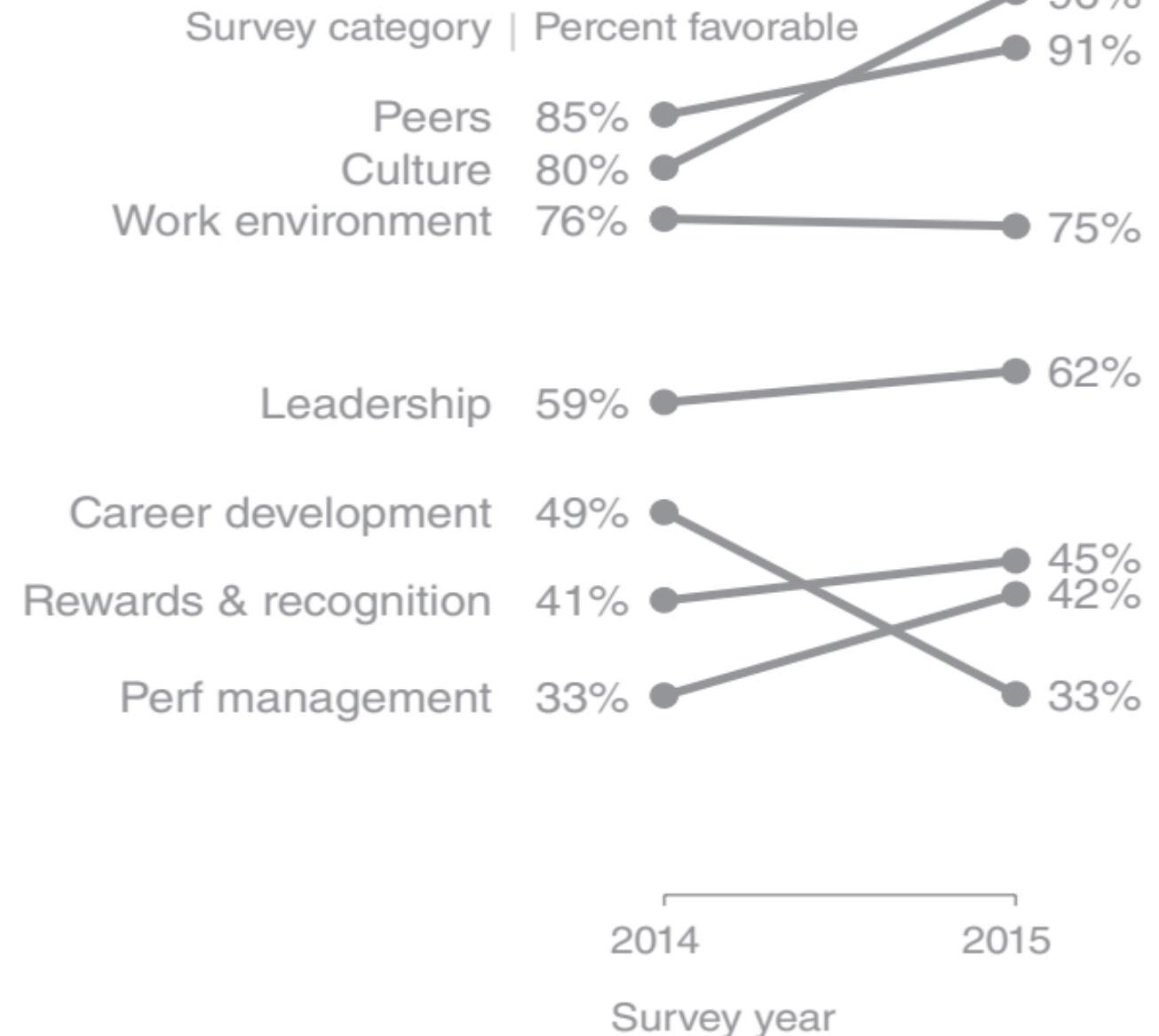


FIGURE 2.10 Slopegraph



- Points
- Lines
- Bars
- Area



## Employee feedback over time

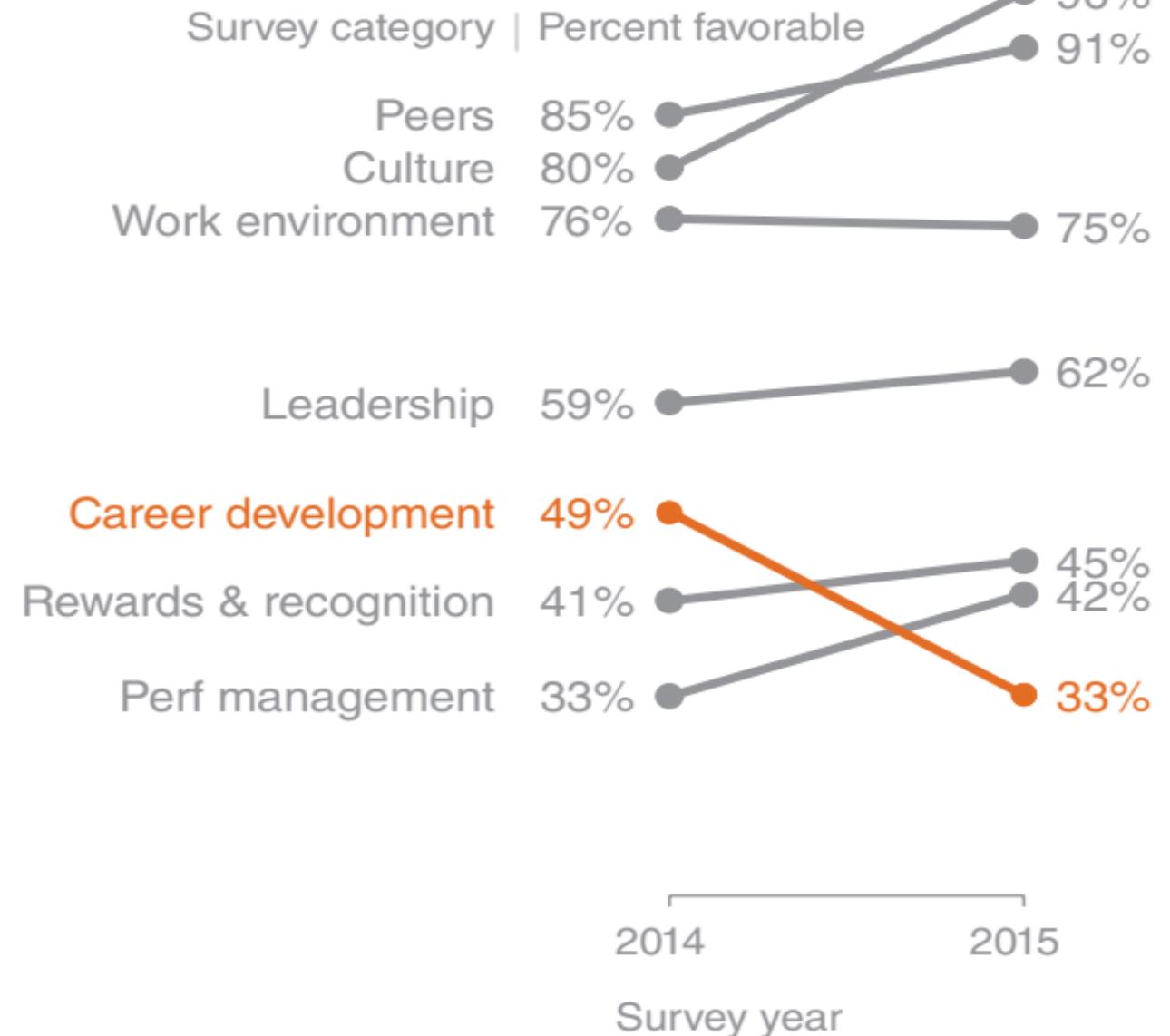


FIGURE 2.11 Modified slopegraph



- Points
- Lines
- Bars
- Area



- Bar charts are easy for our eyes to read. Our eyes compare the end points of the bars, so it is easy to see quickly which category is the biggest, which is the smallest, and the incremental difference between categories.
- It is important that bar charts always have a zero baseline (where the x-axis crosses the y-axis at zero), otherwise you get a false visual comparison.



- Points
- Lines
- Bars
- Area

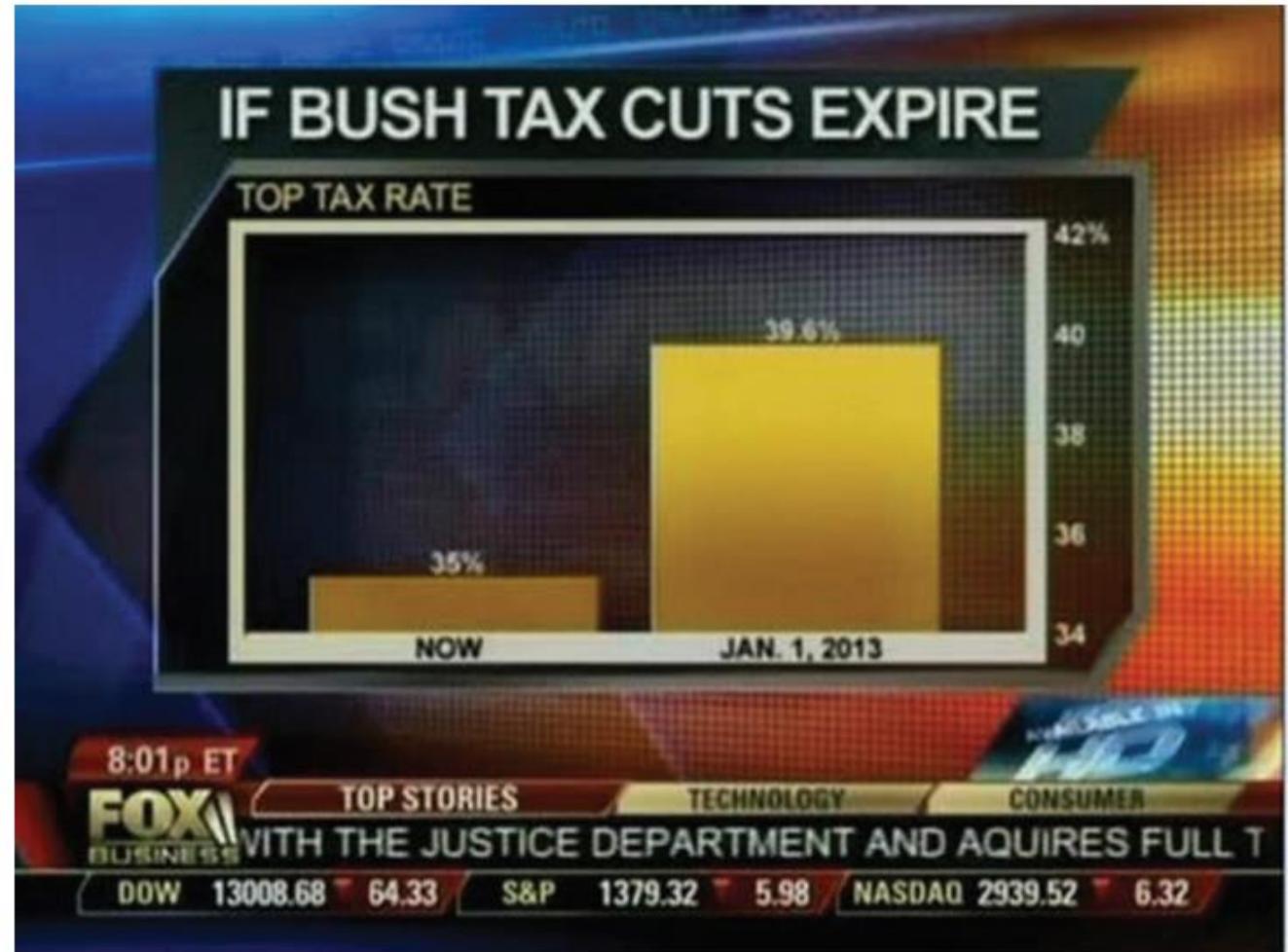


FIGURE 2.12 Fox News bar chart



- Points
- Lines
- Bars
- Area



- For this example, let's imagine we are back in the fall of 2012.
- We are wondering what will happen if the Bush tax cuts expire. On the left-hand side, we have what the top tax rate is currently, 35%, and on the right-hand side what it will be as of January 1, at 39.6%



- Points
- Lines
- Bars
- Area



- Note that the bottom number on the vertical axis (shown at the far right) is not zero, but rather 34.
- This means that the bars, in theory, should continue down through the bottom of the page. In fact, the way this is graphed, the visual increase is 460% (the heights of the bars are  $35 - 34 = 1$  and  $39.6 - 34 = 5.6$ , so  $(5.6 - 1) / 1 = 460\%$ ).

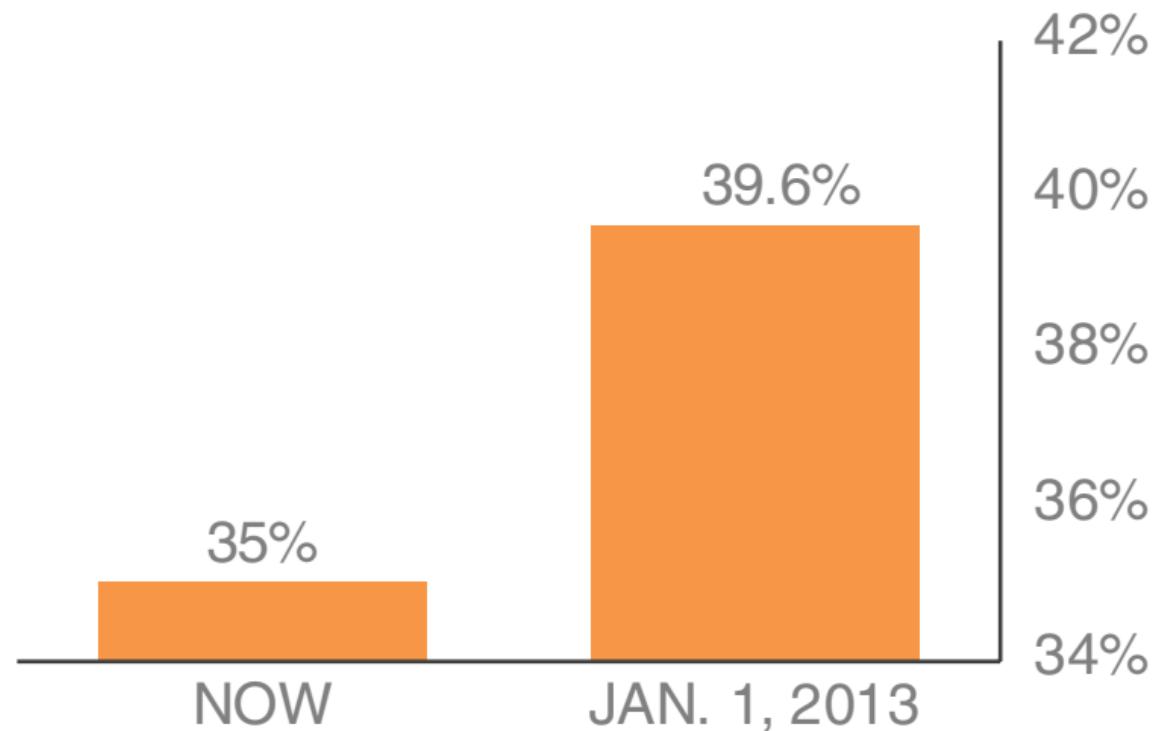


- Points
- Lines
- Bars
- Area



**Non-zero baseline:** as originally graphed

IF BUSH TAX CUTS EXPIRE  
TOP TAX RATE





- Points
- Lines
- Bars
- Area



- If we graph the bars with a zero baseline so that the heights are accurately represented (35 and 39.6), we get an actual visual increase of 13%  $((39.6 - 35) / 35)$ .

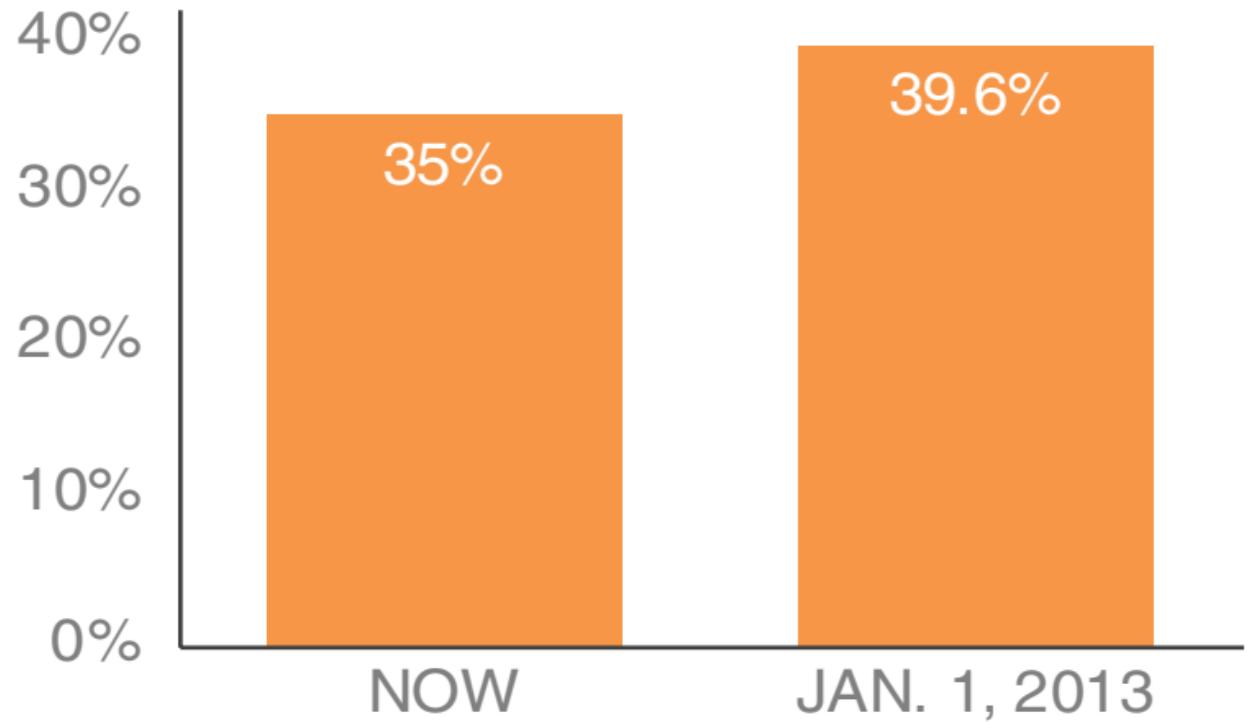


- Points
- Lines
- Bars
- Area



**Zero baseline:** as it should be graphed

IF BUSH TAX CUTS EXPIRE  
TOP TAX RATE



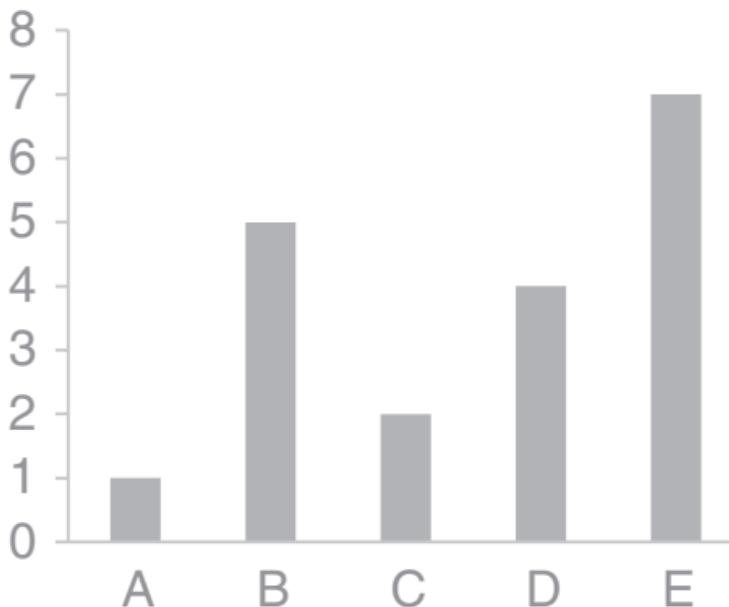


- Points
- Lines
- Bars
- Area



- While we're considering lengths of bars, let's also spend a moment on the width of bars.
- Consider the following “Goldilocks” of bar charts: too thin, too thick, and just right.

Too thin



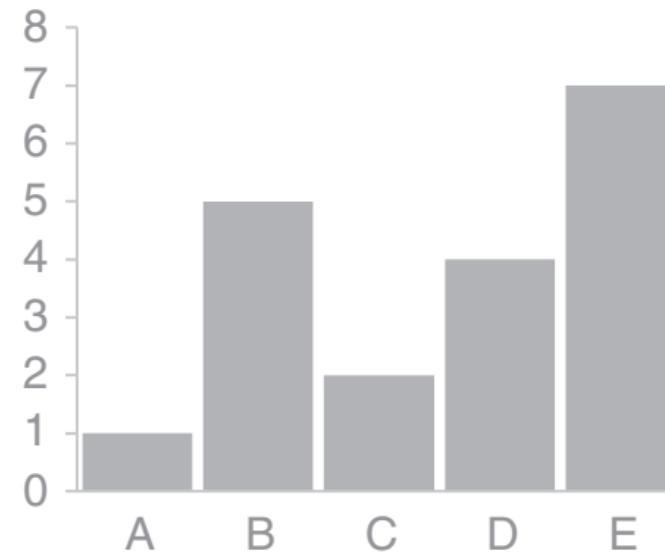


- Points
- Lines
- Bars
- Area



- While we're considering lengths of bars, let's also spend a moment on the width of bars.
- Consider the following “Goldilocks” of bar charts: too thin, too thick, and just right.

Too thick



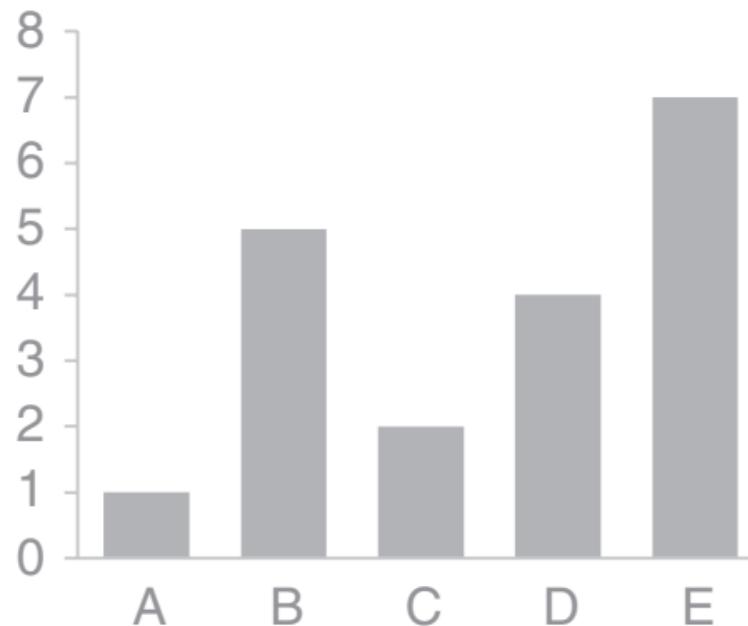


- Points
- Lines
- Bars
- Area



- While we're considering lengths of bars, let's also spend a moment on the width of bars.
- Consider the following “Goldilocks” of bar charts: too thin, too thick, and just right.

Just right





- Points
- Lines
- Bars
- Area



let's look at some different varieties.

- Vertical bar chart
- Stacked vertical bar chart
- Waterfall chart
- Horizontal bar chart
- Stacked horizontal bar chart



- Points
- Lines
- Bars
- Area



## Vertical bar chart

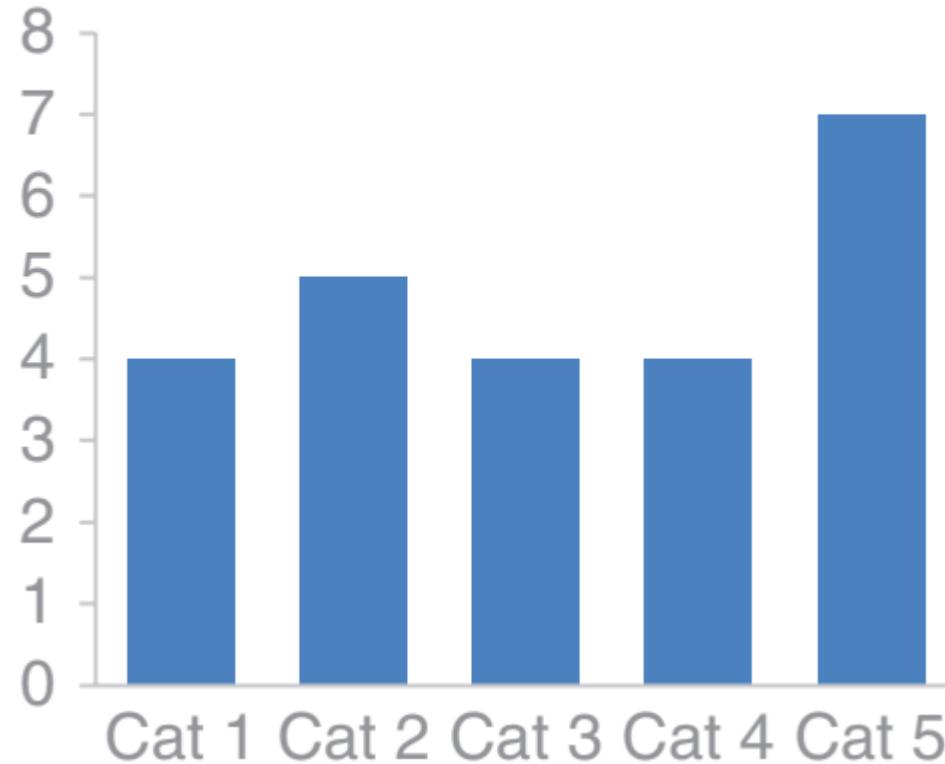
- The plain ordinary bar chart is the vertical bar chart, or column chart.
- Like line graphs, vertical bar charts can be single series, two series, or multiple series. Note that as you add more series of data, it becomes more difficult to focus on one at a time~ and pull~out insight, so use multiple series bar charts with caution.



- Points
- Lines
- Bars
- Area



Single series

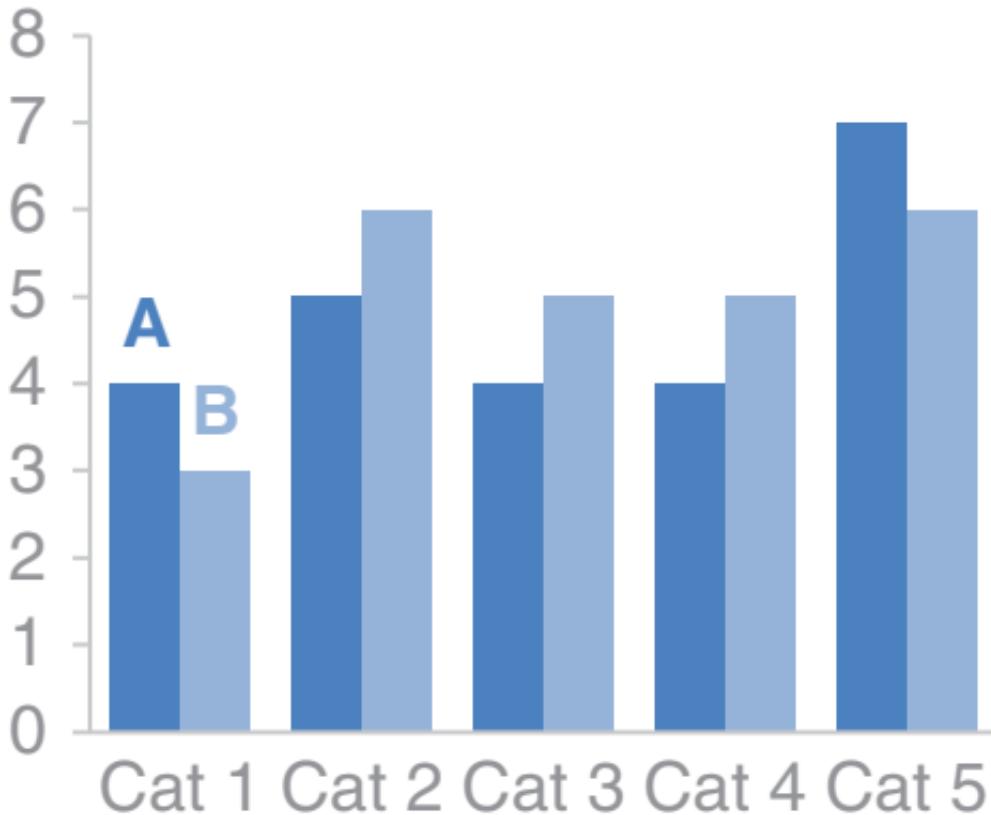




- Points
- Lines
- Bars
- Area



## Two series

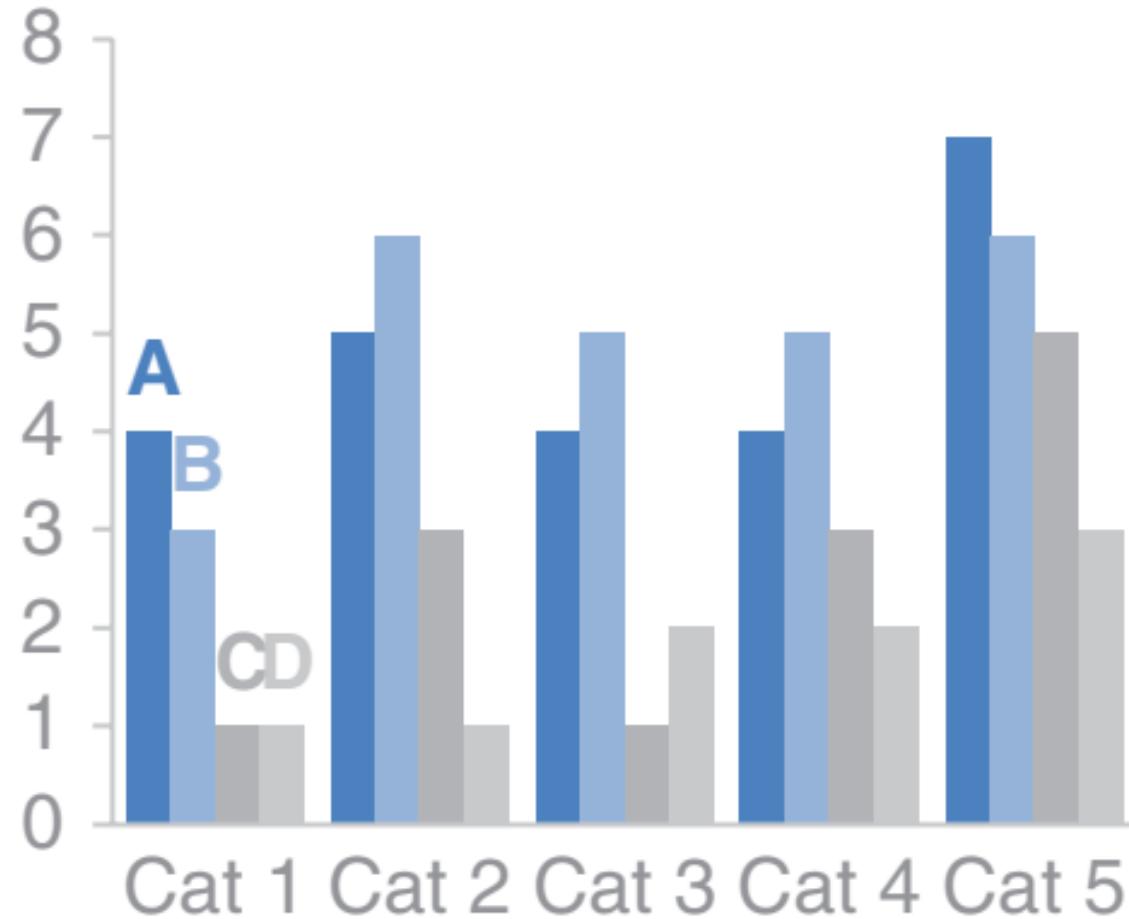




- Points
- Lines
- Bars
- Area



## Multiple series





- Points
- Lines
- Bars
- Area



## Stacked Vertical bar chart

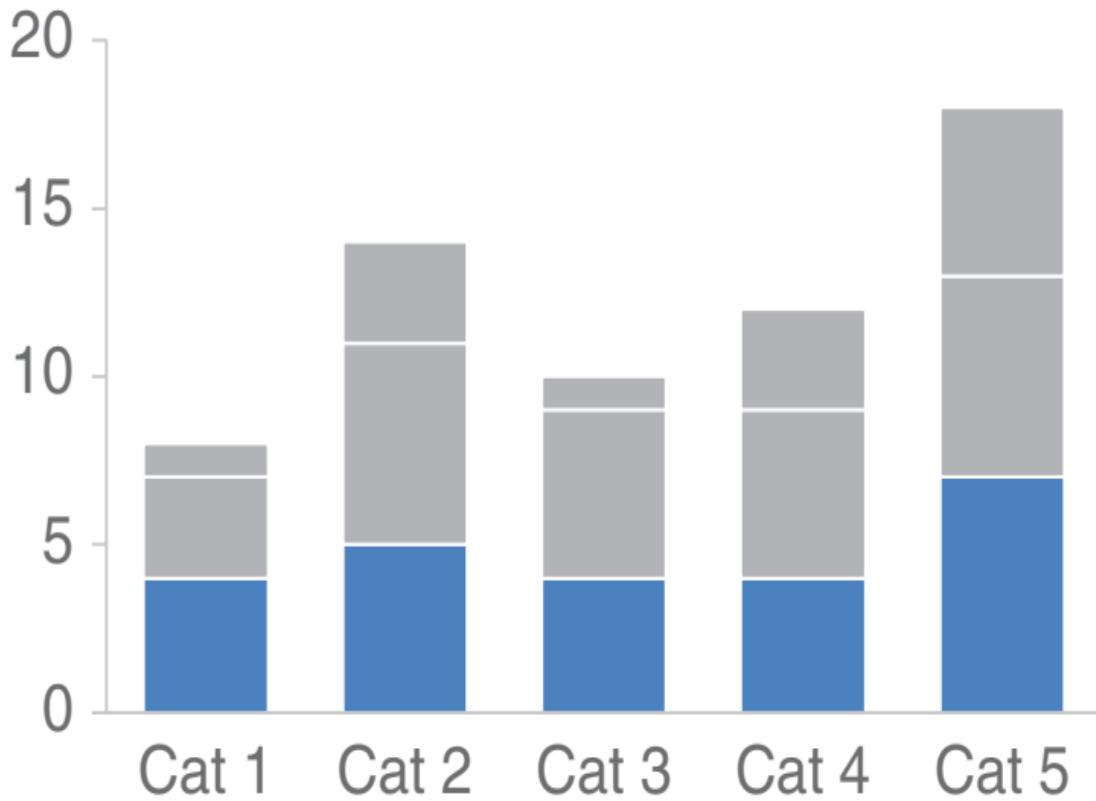
- Use cases for stacked vertical bar charts are more limited. They are meant to allow you to compare totals across categories and see the subcomponent pieces within a given category.



- Points
- Lines
- Bars
- Area



Comparing **these** is easy

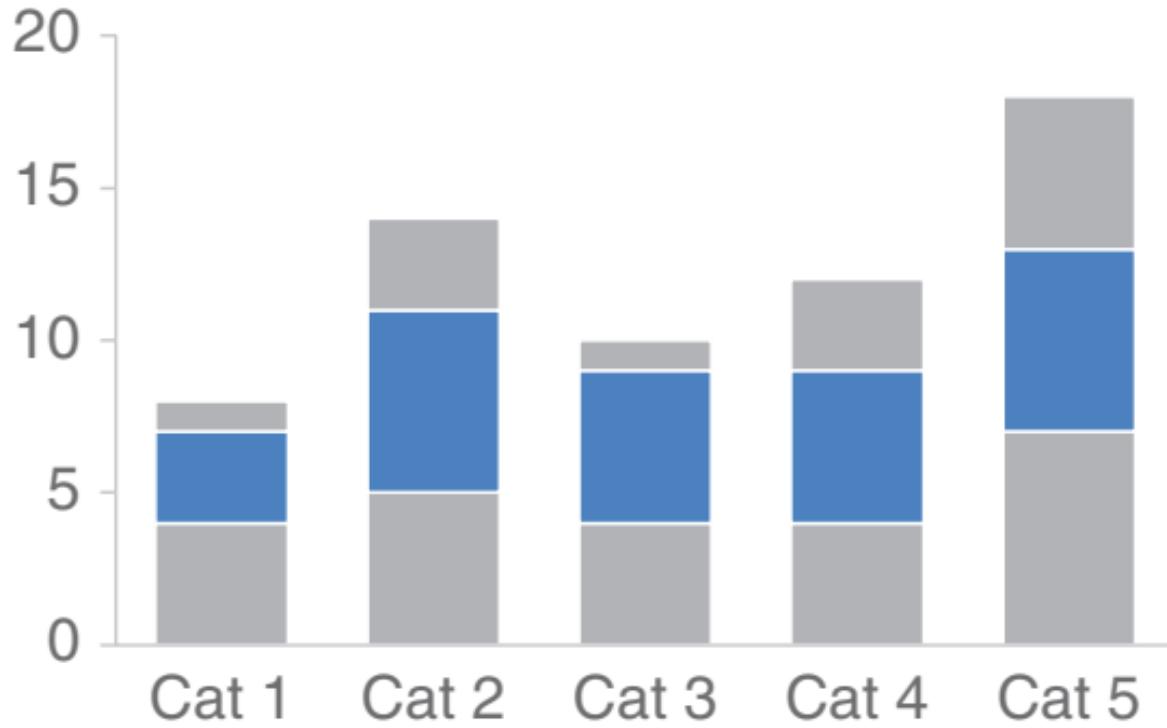




- Points
- Lines
- Bars
- Area



Comparing **these** is hard





- Points
- Lines
- Bars
- Area



## Waterfall chart

- The waterfall chart can be used to pull apart the pieces of a stacked bar chart to focus on one at a time, or to show a starting point, increases and decreases, and the resulting ending point.



- Points
- Lines
- Bars
- Area



### 2014 Headcount math

Though more employees transferred out of the team than transferred in, aggressive hiring means overall headcount (HC) increased 16% over the course of the year.

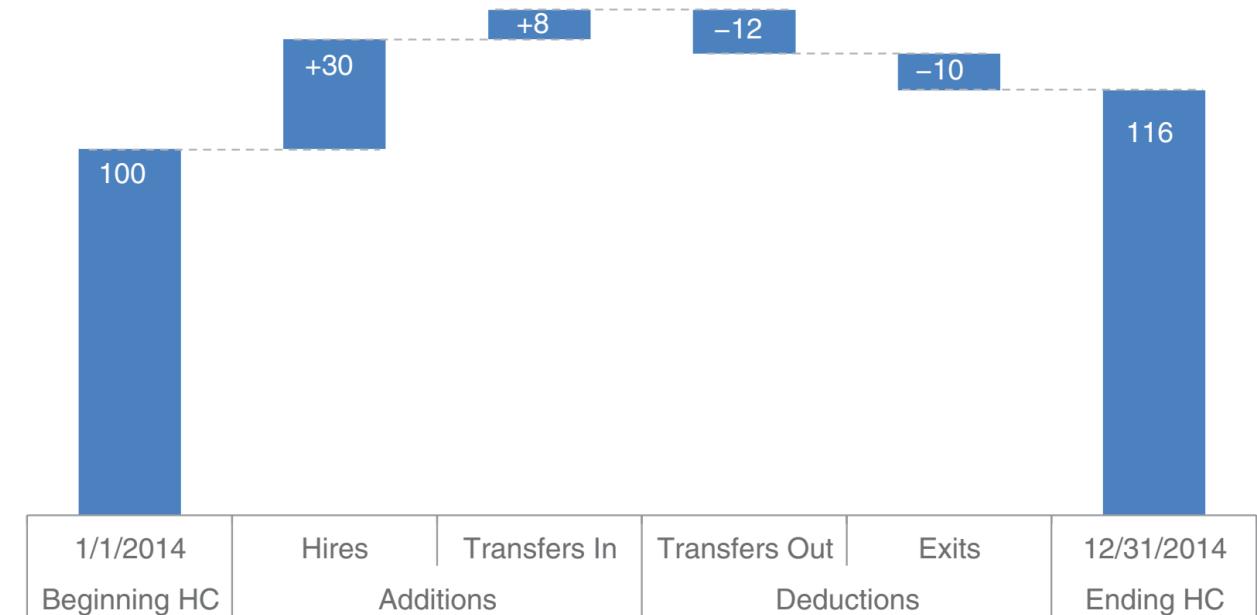
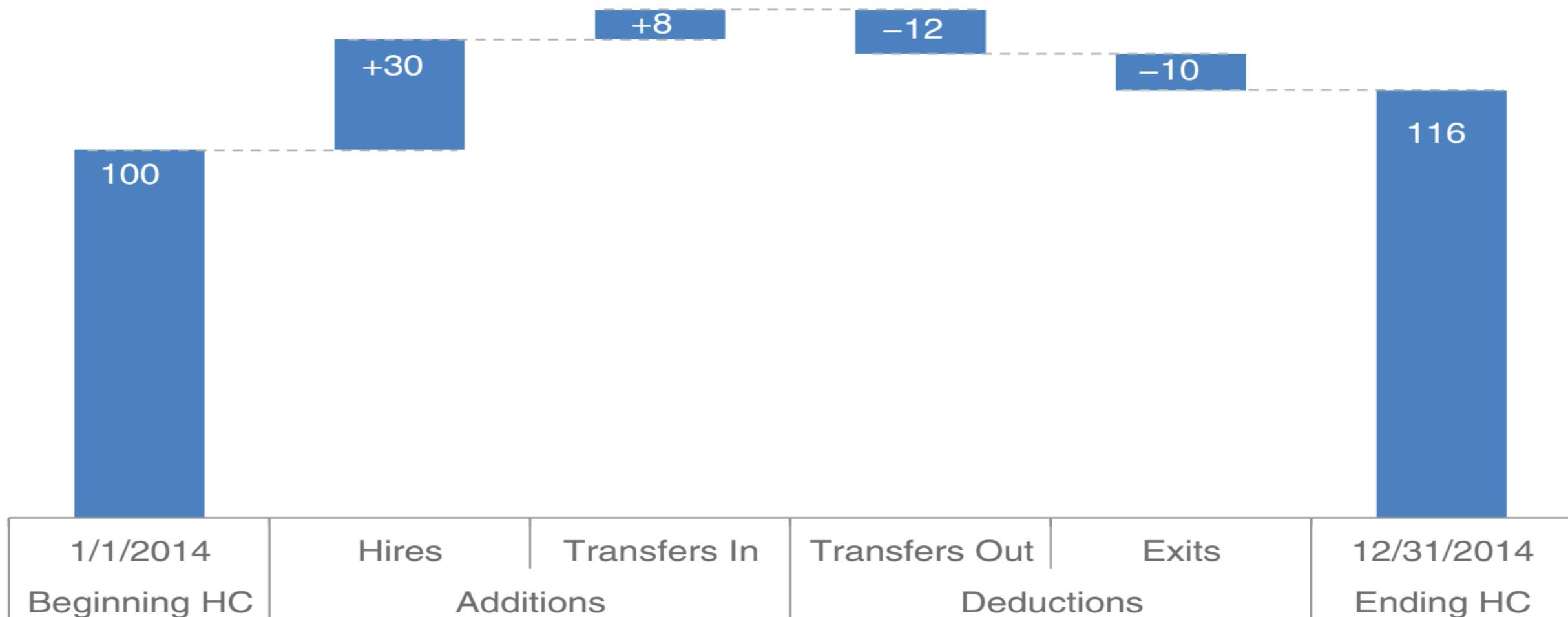


FIGURE 2.17 Waterfall chart

## 2014 Headcount math

Though more employees transferred out of the team than transferred in, aggressive hiring means overall headcount (HC) increased 16% over the course of the year.



**FIGURE 2.17** Waterfall chart



- Points
- Lines
- Bars
- Area



### 2014 Headcount math

Though more employees transferred out of the team than transferred in, aggressive hiring means overall headcount (HC) increased 16% over the course of the year.

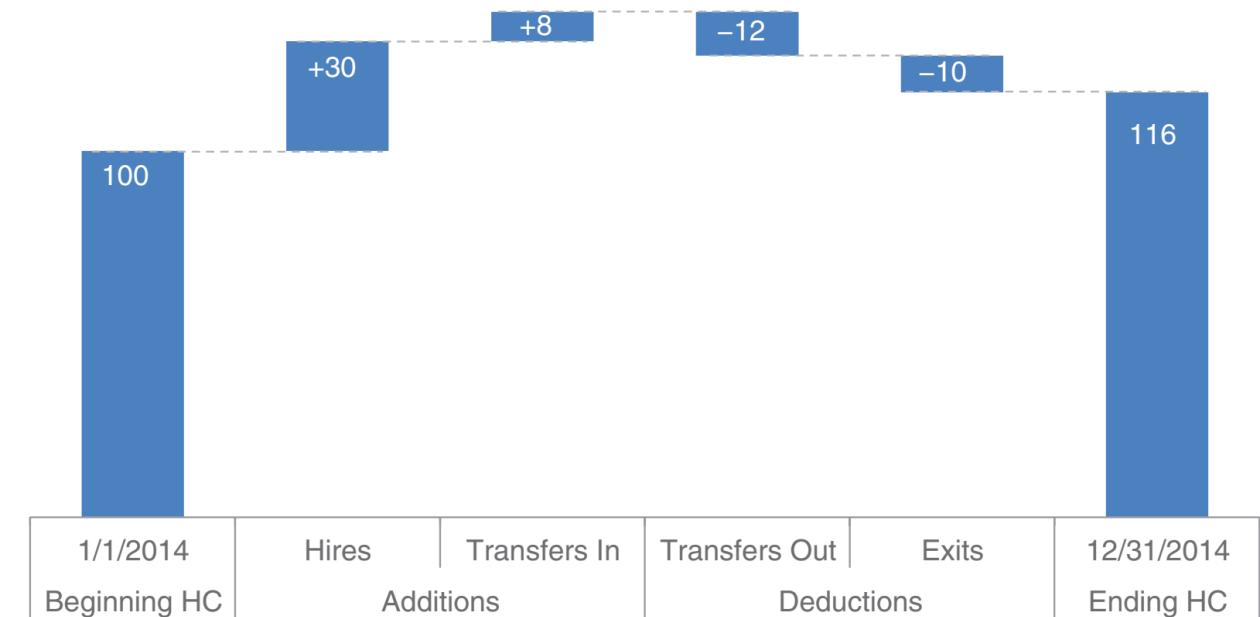


FIGURE 2.17 Waterfall chart



- Points
- Lines
- Bars
- Area



## Horizontal bar chart

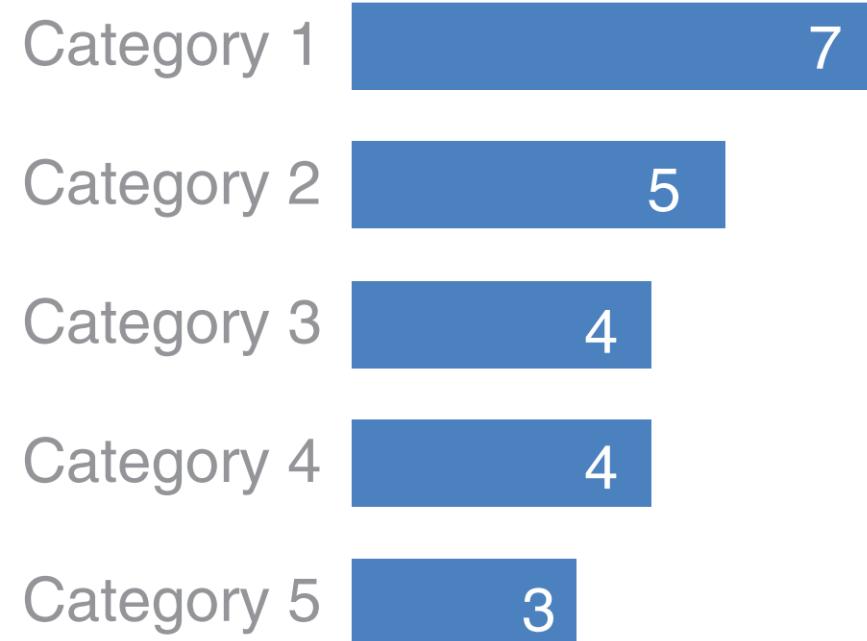
- The horizontal bar chart is especially useful if your category names are long, as the text is written from left to right, as most audiences read, making your graph legible for your audience.
- Like the vertical bar chart, the horizontal bar chart can be single series, two series, or multiple series



- Points
- Lines
- Bars
- Area



## Single series

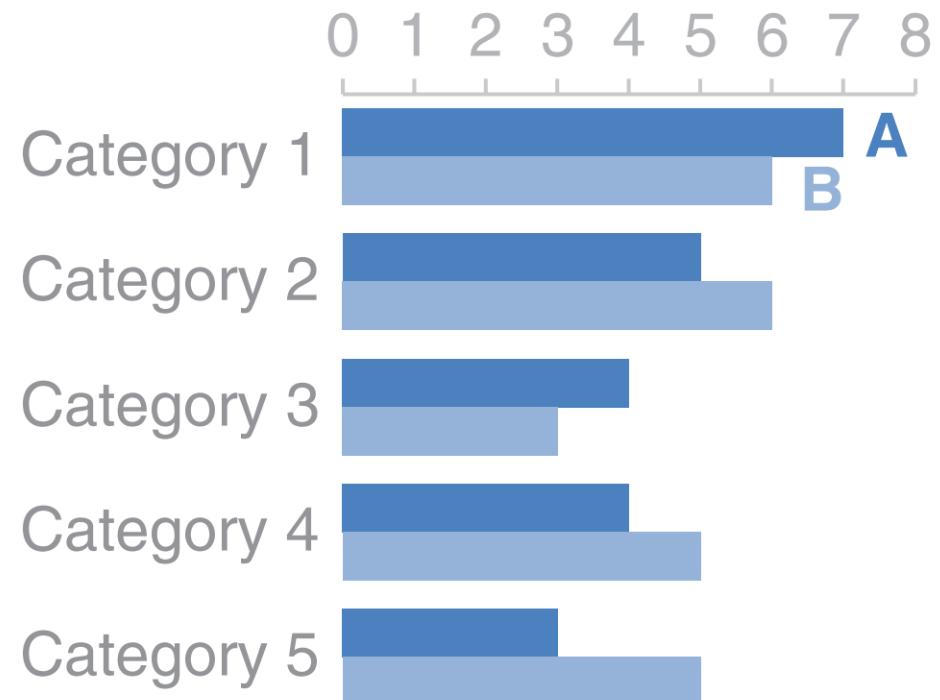




- Points
- Lines
- Bars
- Area



## Two series

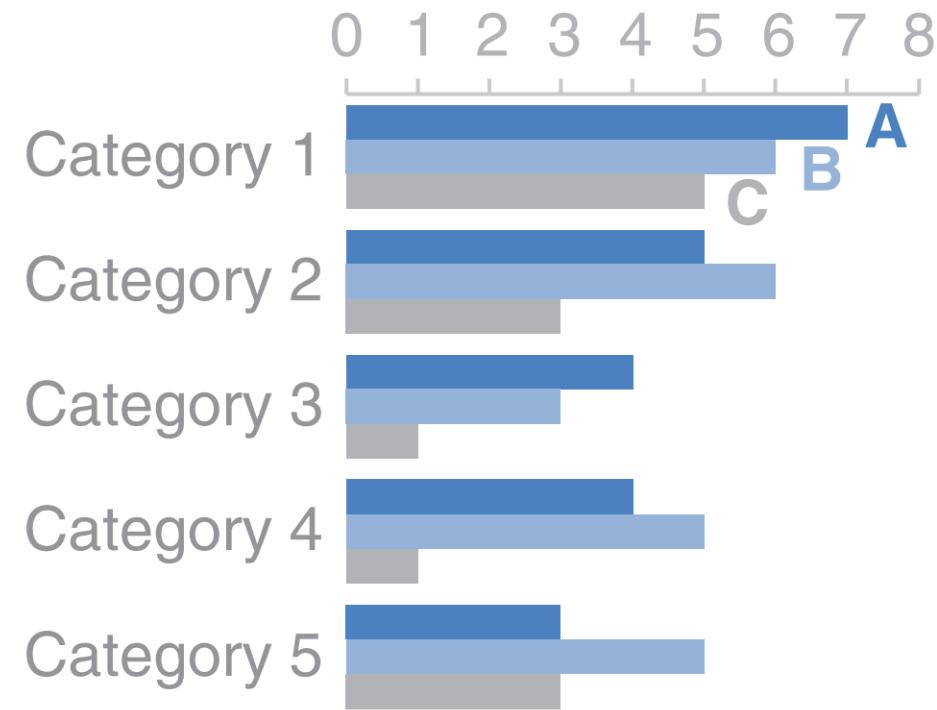




- Points
- Lines
- Bars
- Area



## Multiple series





- Points
- Lines
- Bars
- Area



### Stacked Horizontal bar chart

- Like the stacked vertical bar chart, stacked horizontal bar charts can be used to show the totals across different categories but also give a sense of the subcomponent pieces.



- Points
- Lines
- Bars
- Area



## Survey results

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

Percent of total

0% 20% 40% 60% 80% 100%



FIGURE 2.19 100% stacked horizontal bar chart



- Points
- Lines
- Bars
- Area



### Area:

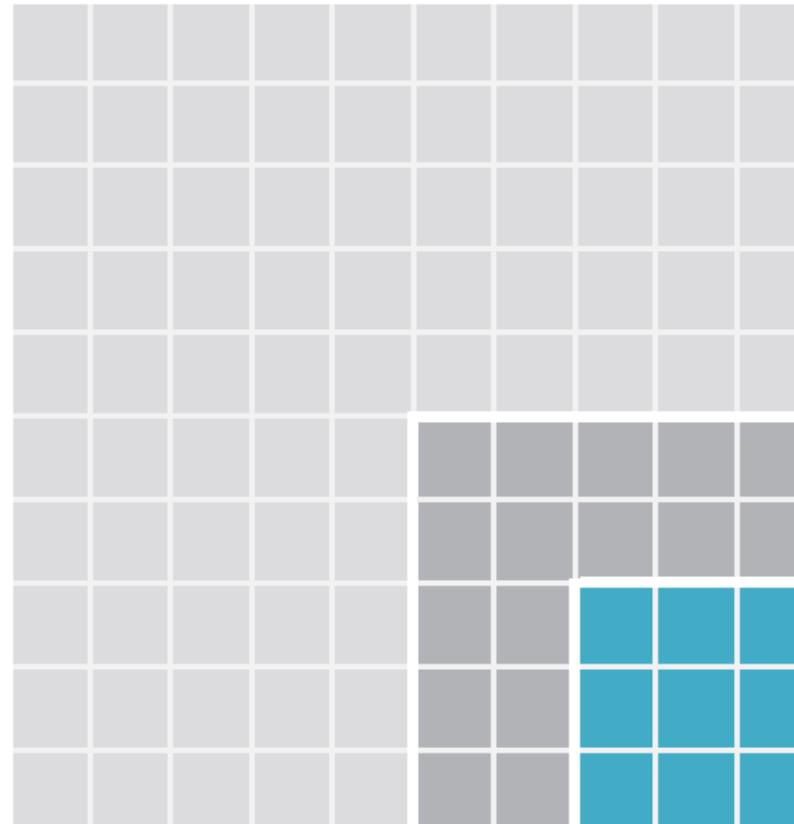
- Avoid most area graphs. Humans' eyes don't do a great job of attributing quantitative value to two-dimensional space, which can render area graphs harder to read.



- Points
- Lines
- Bars
- Area



## Interview breakdown



Out of every 100 phone screens...

we bring **25 candidates onsite** for interviews...

and **extend 9 offers.**

**FIGURE 2.20** Square area graph



## To be avoided:

- There are also some specific graph types and elements that you should avoid: pie charts, donut charts, 3D, and secondary y-axes.

Supplier Market Share

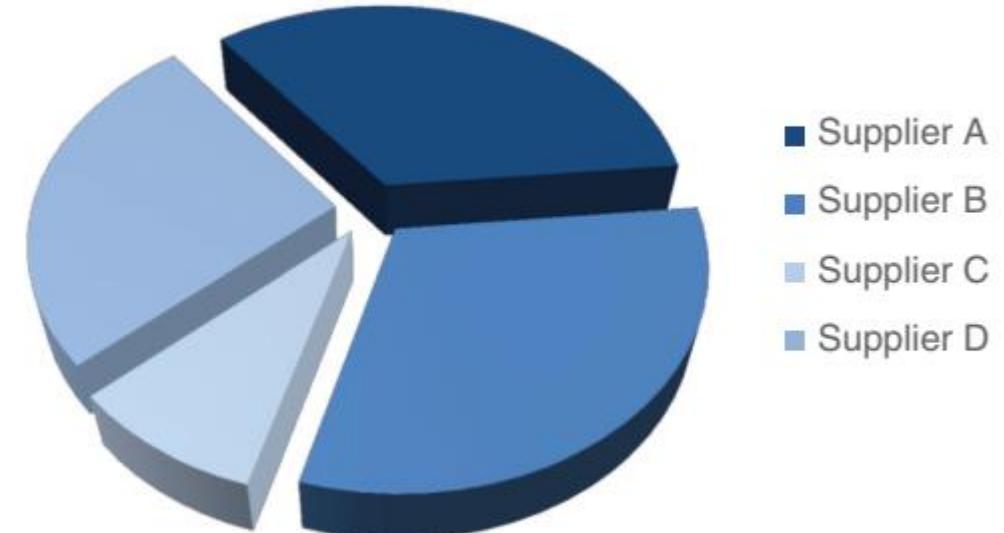


FIGURE 2.21 Pie chart



## To be avoided:

- There are also some specific graph types and elements that you should avoid: pie charts, donut charts, 3D, and secondary y-axes.

The donut chart

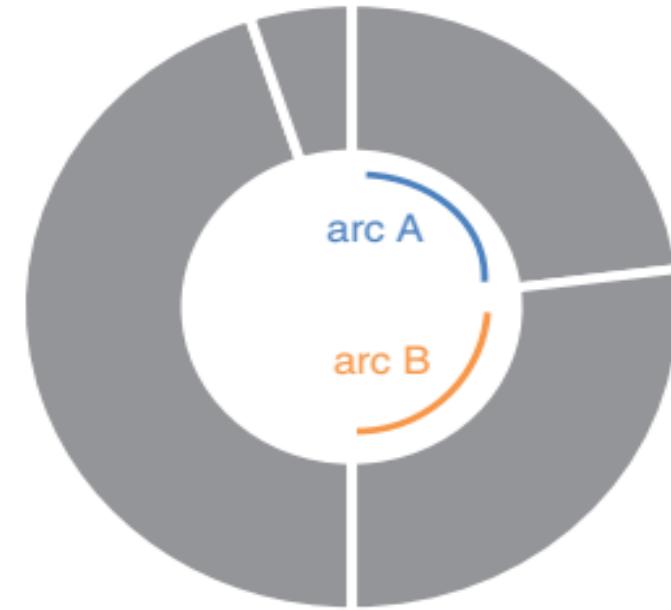


FIGURE 2.24 Donut chart



## To be avoided:

- There are also some specific graph types and elements that you should avoid: pie charts, donut charts, 3D, and secondary y-axes.

Number of issues

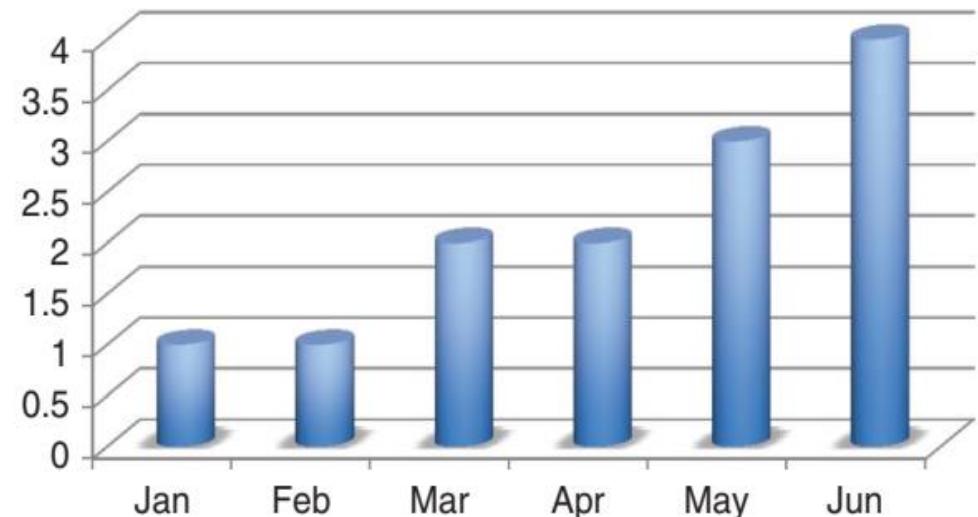


FIGURE 2.25 3D column chart



### To be avoided:

- There are also some specific graph types and elements that you should avoid: pie charts, donut charts, 3D, and secondary y-axes.

Secondary y-axis

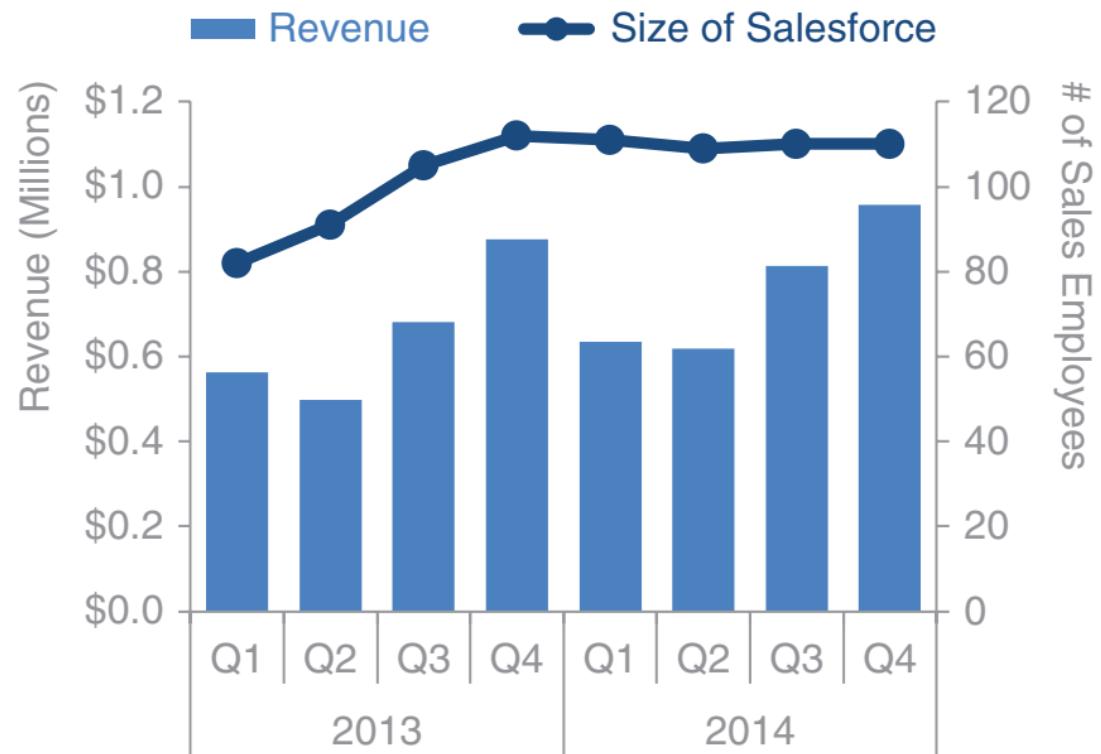


FIGURE 2.26 Secondary y-axis



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