

Telling Compelling Stories with Numbers



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ActuateOne Live

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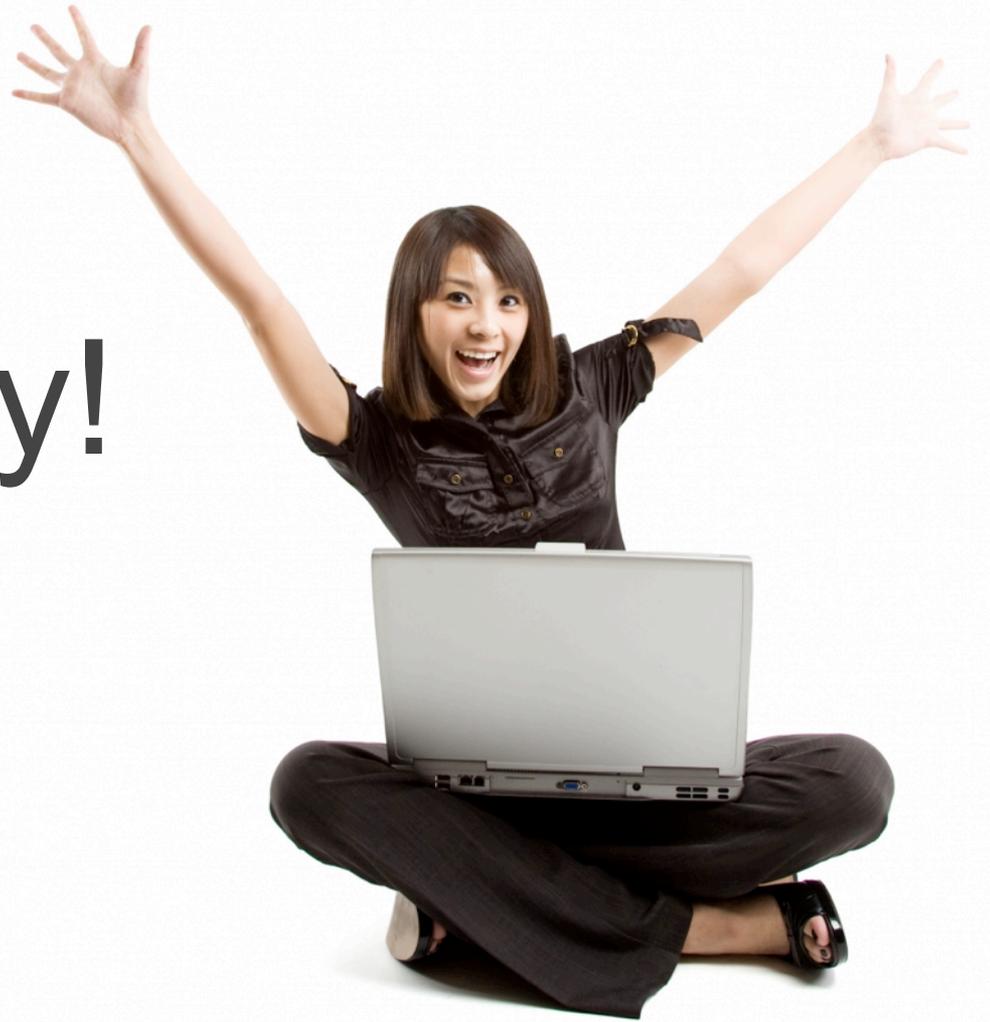


21st Century Fluency Project

The world is not yet prepared for a true information age. Most people lack the basic skills and the good tools that are required to use information in effective ways. I recently discovered an organization named the 21st Century Fluency Project that is trying to help people develop the skills that are needed to survive and thrive in a true information age.

Hurray data!

Hurray technology!



We celebrate technology. We live for the latest gadgets.

Big Data



But the amount of data that is available has grown much faster than our ability to make use of it. Most organizations lack both the skills in data analysis and the tools that are required to support the process. Most people who actually rely on data to do their jobs are not comforted by the thought of Big Data. Until they can use what they have, more data is overwhelming.

Opportunity

Crisis



Big Data, Little Information

We live in a time of Big Data, but little information. The state of data sensemaking today is one of crisis. Most people find themselves buried in data with nary a clue how to use it. Those of us who have developed basic sensemaking skills and have experienced useful sensemaking tools, however, know that we have a great opportunity to make better decisions and greater progress than ever before. We must get a handle on sensemaking.

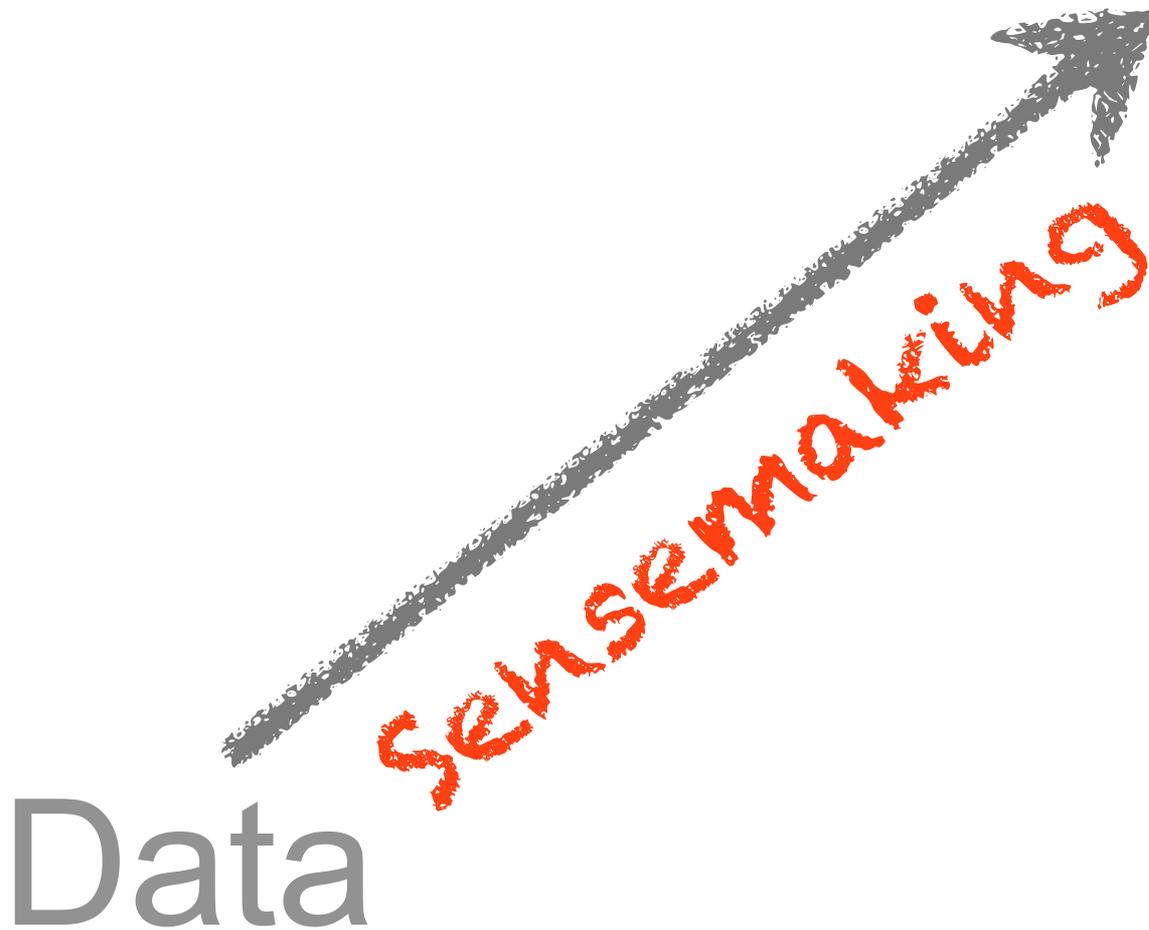


We must learn to tap into the steady stream of data in ways that allows us to make sense of it and then use what we learn to do good in the world.



We must find ways to turn on the light bulbs of understanding, to separate the signals from the noise. Most data is noise.

Information



Data

Sensemaking

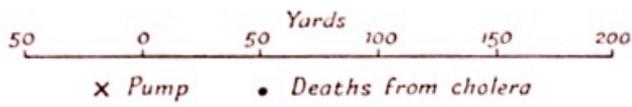
Data – all those facts that we’ve accumulated – do not qualify as information until they inform. To use data effectively, we first make sense of them. Today, sensemaking is our primary task.

A picture is worth a thousand words.



Data visualization is one of the tools that we can use to make sense of data. When words and numbers fail, we need pictures to coax the stories that live in our data from the shadows into the light. The right picture can sometimes tell a story in a way that no amount of words could ever match. To take advantage of visualization's great potential, we first must know when pictures rather than words are needed.

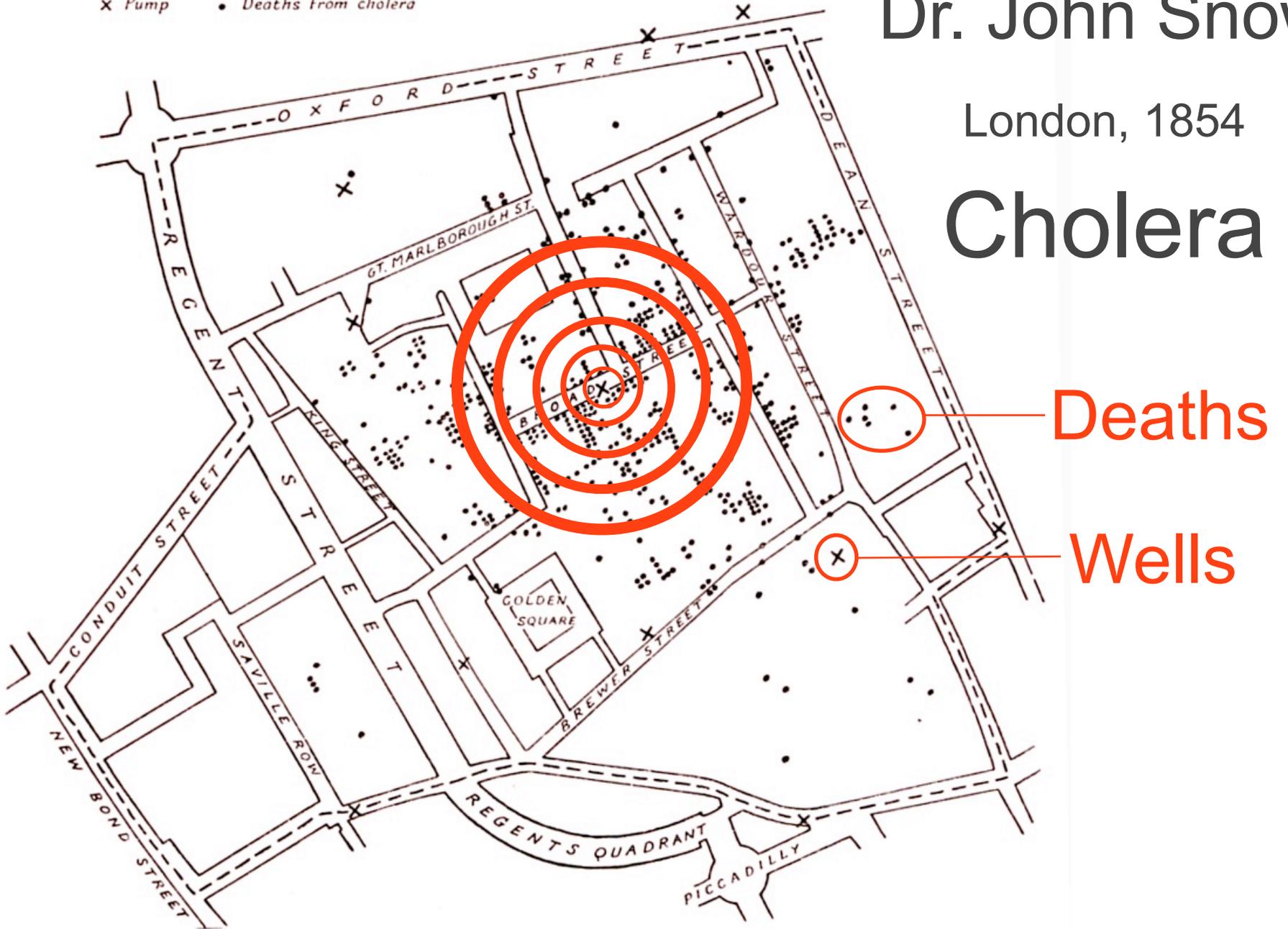
Not just any picture will do. We must craft pictures that clarify and enlighten.



Dr. John Snow

London, 1854

Cholera



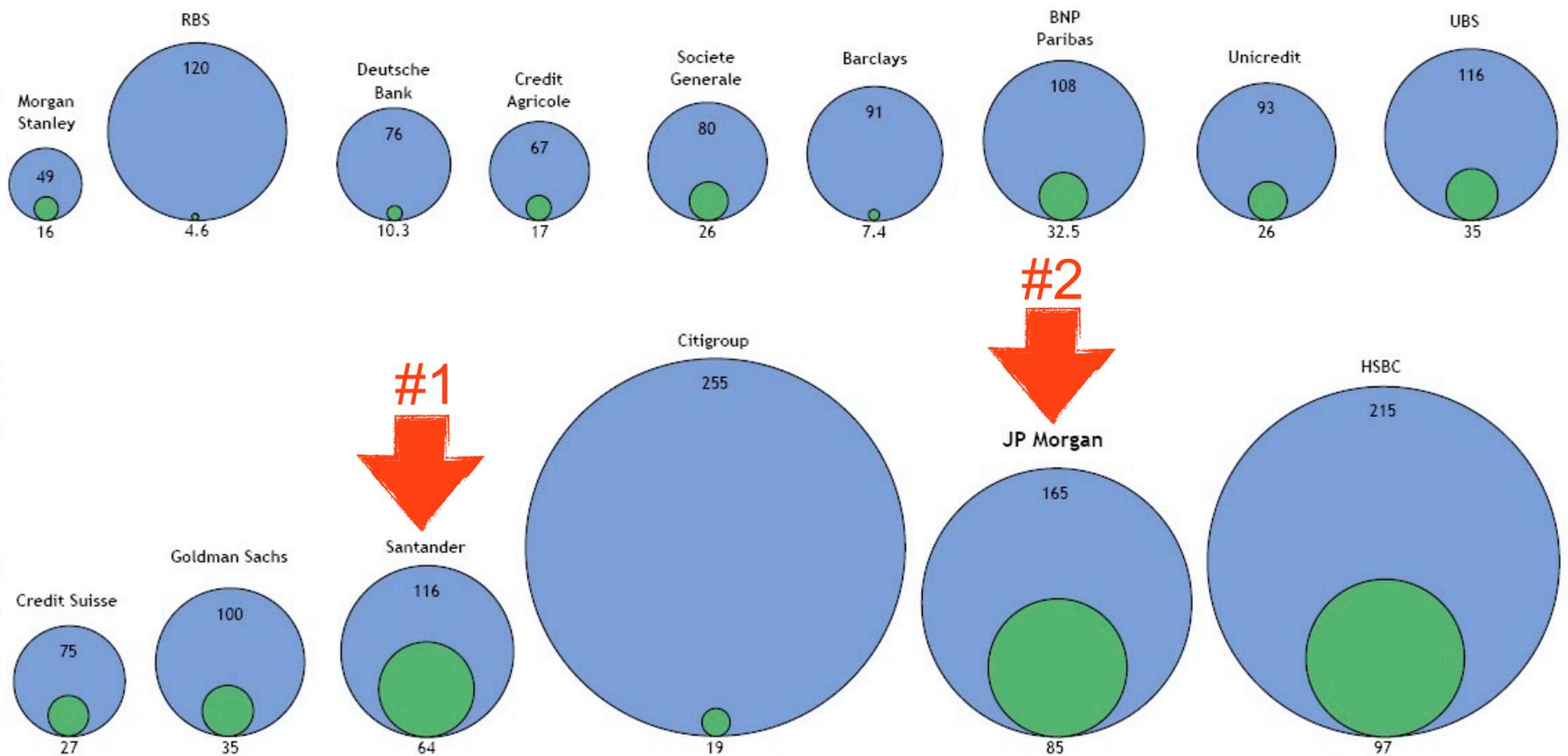
Deaths

Wells

Here's a data visualization that was needed, for it told an enlightening story that saved hundreds of lives. This map was researched and drawn by Dr. John Snow in the mid-19th century during cholera epidemic in London. He was trying to determine how cholera was spread so he could figure out how to stop it. Contrary to the current miasma theory, that cholera was spread by noxious fumes in the air, Snow suspected that it was spread in the water supply. By marking the location of each death, shown here as the black dots, and the location of each well from which water was drawn, the connection between the disease and the city's water supply became visible as emanating from the Broad Street well. Snow used this evidence to persuade the city fathers to remove the handle from the Broad Street pump. Within a short time the epidemic ceased.

Banks: Market Cap

- Market Value as of January 20th 2009, \$Bn
- Market Value as of Q2 2007, \$Bn



J.P.Morgan

While JPMorgan considers this information to be reliable, we cannot guarantee its accuracy or completeness

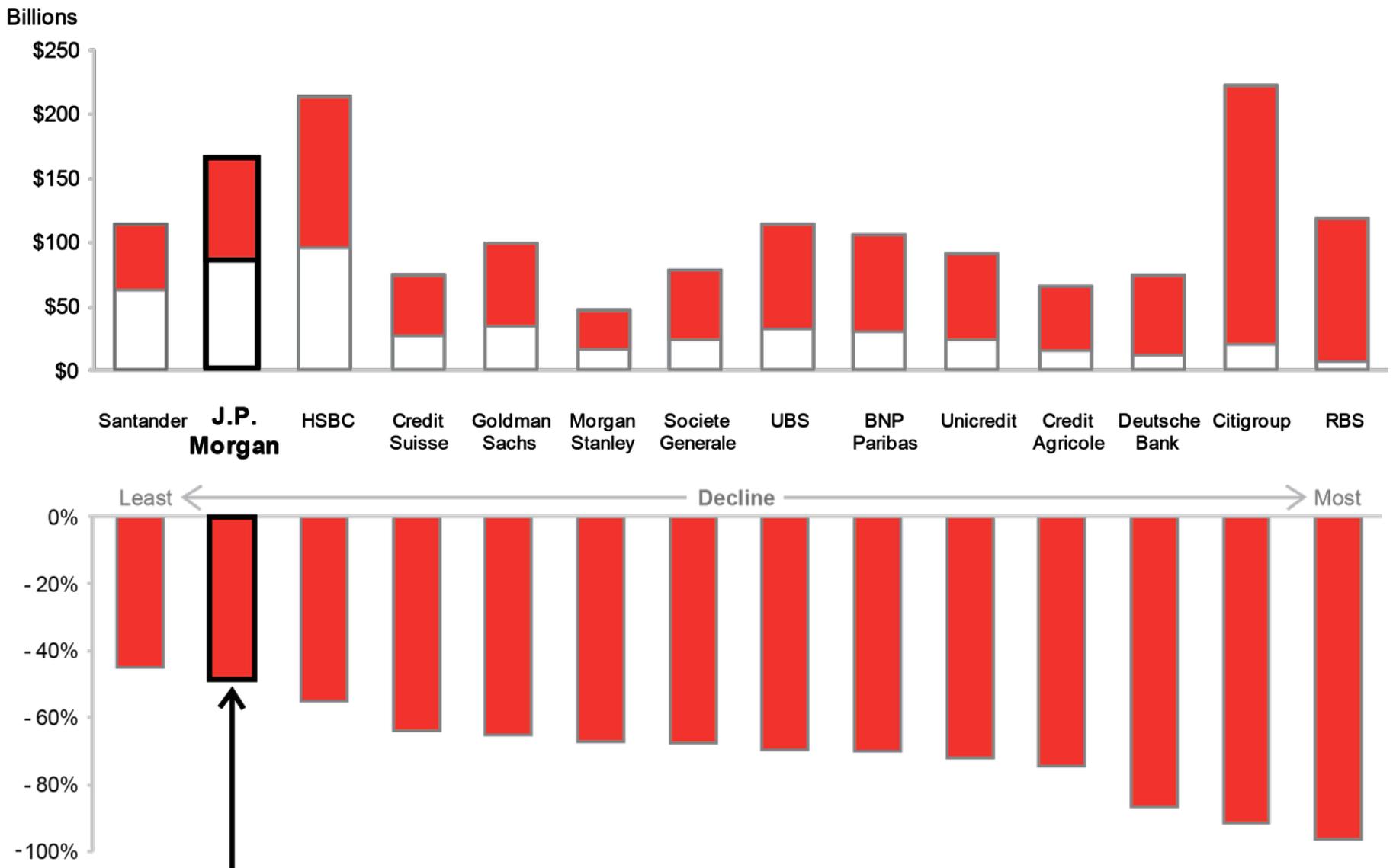
Source: Bloomberg, Jan 20th 2009

We must not only know when to use pictures of data, but also how to design them to tell stories clearly, accurately, and compellingly.

This recent visualization fails to do this. This series of circles within circles--blue for the market values of banks in quarter 2 of 2007, before the recent financial meltdown, and green for declined values as of January of 2009--was published by Bloomberg. You would never guess its purpose, however, which was to show that J. P. Morgan's decline in market value was less severe than all other major banks except one: Santander.

This picture of the data doesn't tell the story clearly, simply, or accurately. The comparative sizes of the circles are far from the comparative market values. Even if the sizes of the circles were accurate, we would still struggle with this chart because visual perception isn't well-tuned to handle size comparisons, but it is tuned to handle length comparisons,...

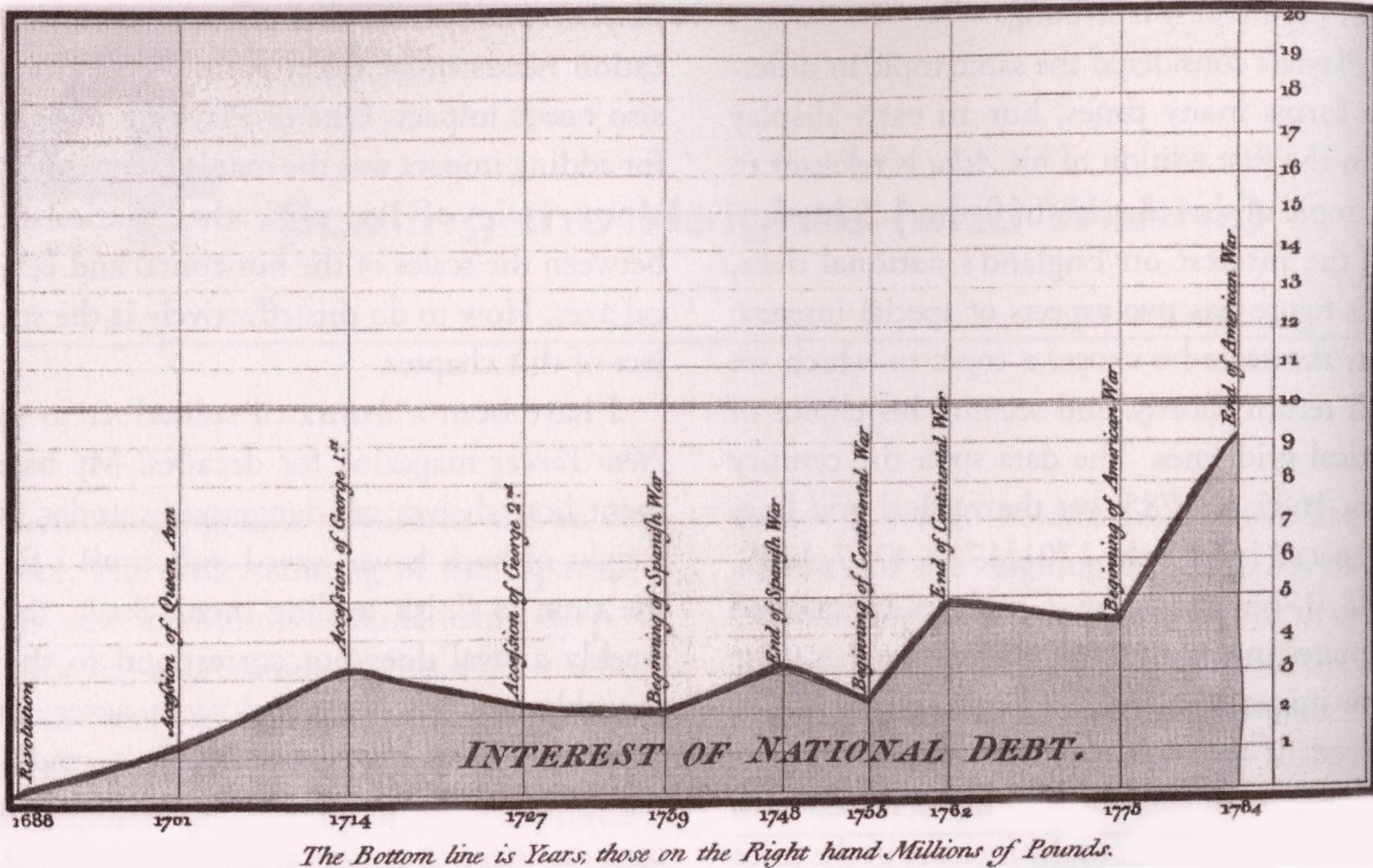
Bank Market Values Prior to the Financial Crisis



Among major banks, J.P. Morgan had the second least percentage decline in market value.

...such as the lengths of these bars in my redesign of the chart. We can now easily see that J. P. Morgan lost roughly half of its market value during this period, but the fact that its losses were less severe than all by one bank—Santander—still isn't obvious. The right addition to the picture, however, such as this one in the bottom half that displays the losses directly, can make this part of the story clear as well.

Interest of the NATIONAL DEBT from the Revolution.



William Playfair – 1786

We've been telling them with graphs for quite awhile. In 1786, a roguish Scot – William Playfair – published a small atlas that introduced or greatly improved most of the quantitative graphs that we use today. Prior to this, graphs of quantitative data were little known. (Source: This graph was included in Playfair's *The Commercial and Political Atlas* in 1786 to make a case against England's policy of financing colonial wars through national debt.)

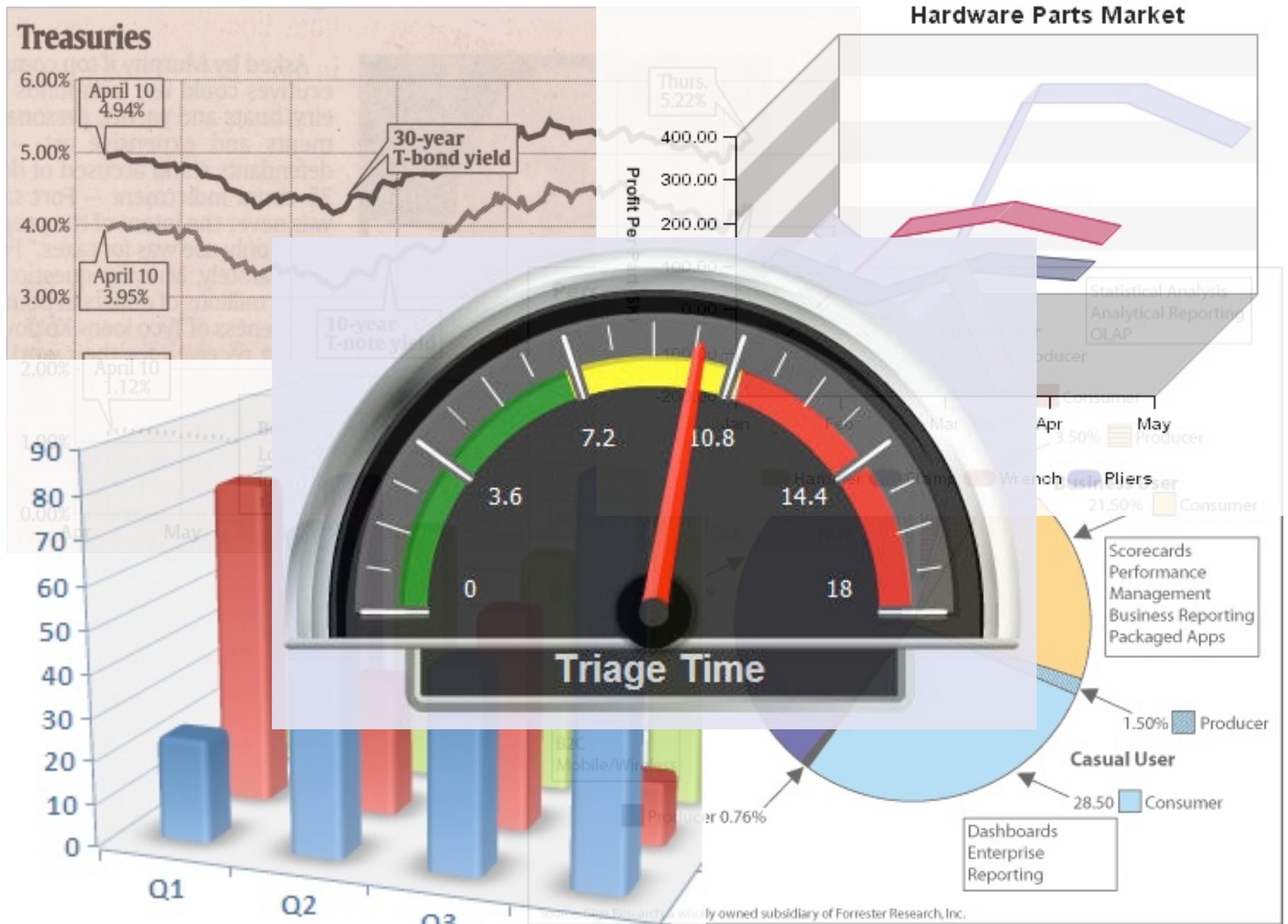


Figure 2: Analytic End-User Spectrum of Usage

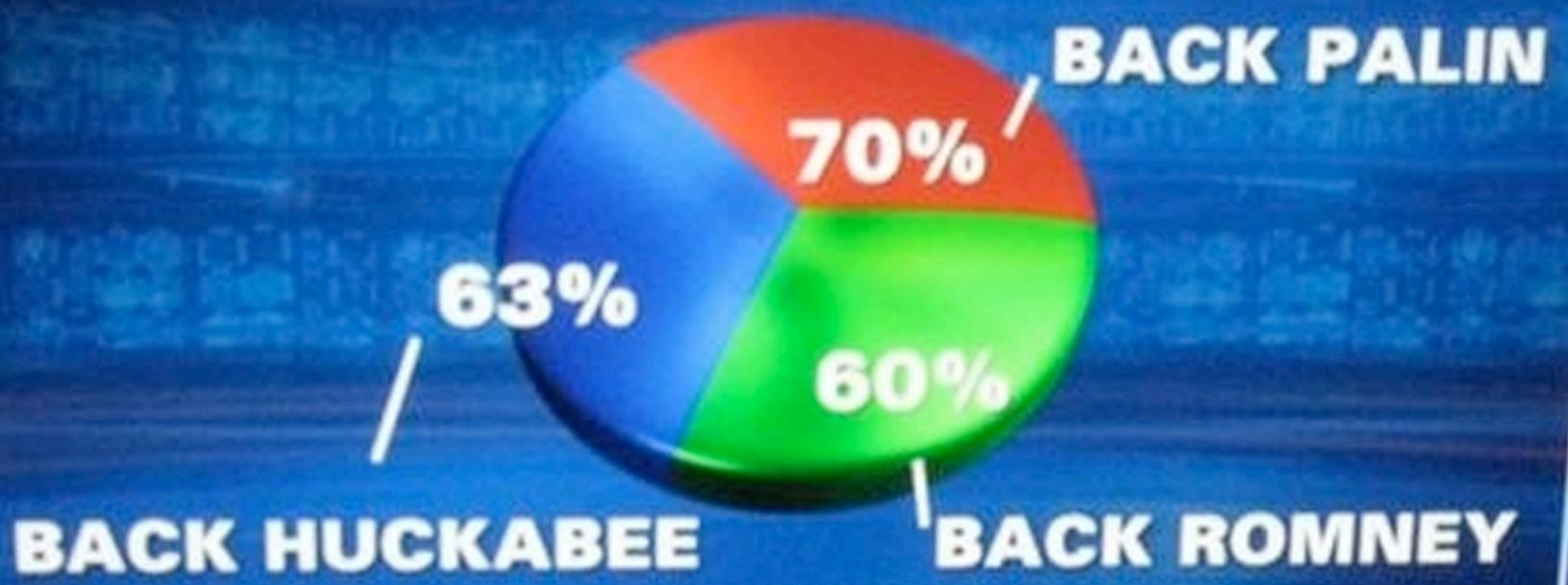
Graphs are now commonplace. Today, 220 years later, partly due to the arrival of the PC, graphs are commonplace, fully integrated into the fabric of modern communication. Surprisingly, however, Playfair's innovative efforts – sprung from meager precedent – are still superior to most of the graphs produced today.



But most graphs today communicate poorly. This spoof of a newscast, created by *The Onion*, hilariously illustrates the graphical incompetence that plagues our world.

2012 PRESIDENTIAL RUN

GOP CANDIDATES



FOX

47'

SOURCE: OPINIONS

DYNAMIC

Problems like this silly pie chart on Fox News, which adds up to 193%, are far too common.

Most software vendors aren't helping matters

Most of the software vendors that provide data visualization tools encourage poor design

- providing useless features and gizmos
- providing formatting defaults that undermine a clear display of the data
- producing documentation that demonstrates poor design
- marketing flash and dazzle, rather than good design

As an independent analyst and educator who focuses on uses of data visualization for business, it is my role to be the voice of reason, constantly asking the question: “But does it work?” No matter how cool it looks or how much it dazzles the eyes, does it help you discover, make sense of, or communicate what’s meaningful in the data? A great deal of what is being marketed by software vendors and even what appeals to buyers simply doesn’t work. This is especially true of the big software companies, with few exceptions. The best data visualization products by and large are being offered today by relatively small software companies that have close ties to the academic research community.

Let’s take a quick tour of several graph examples from the user documentation and Web sites of several software vendors to illustrate my point.

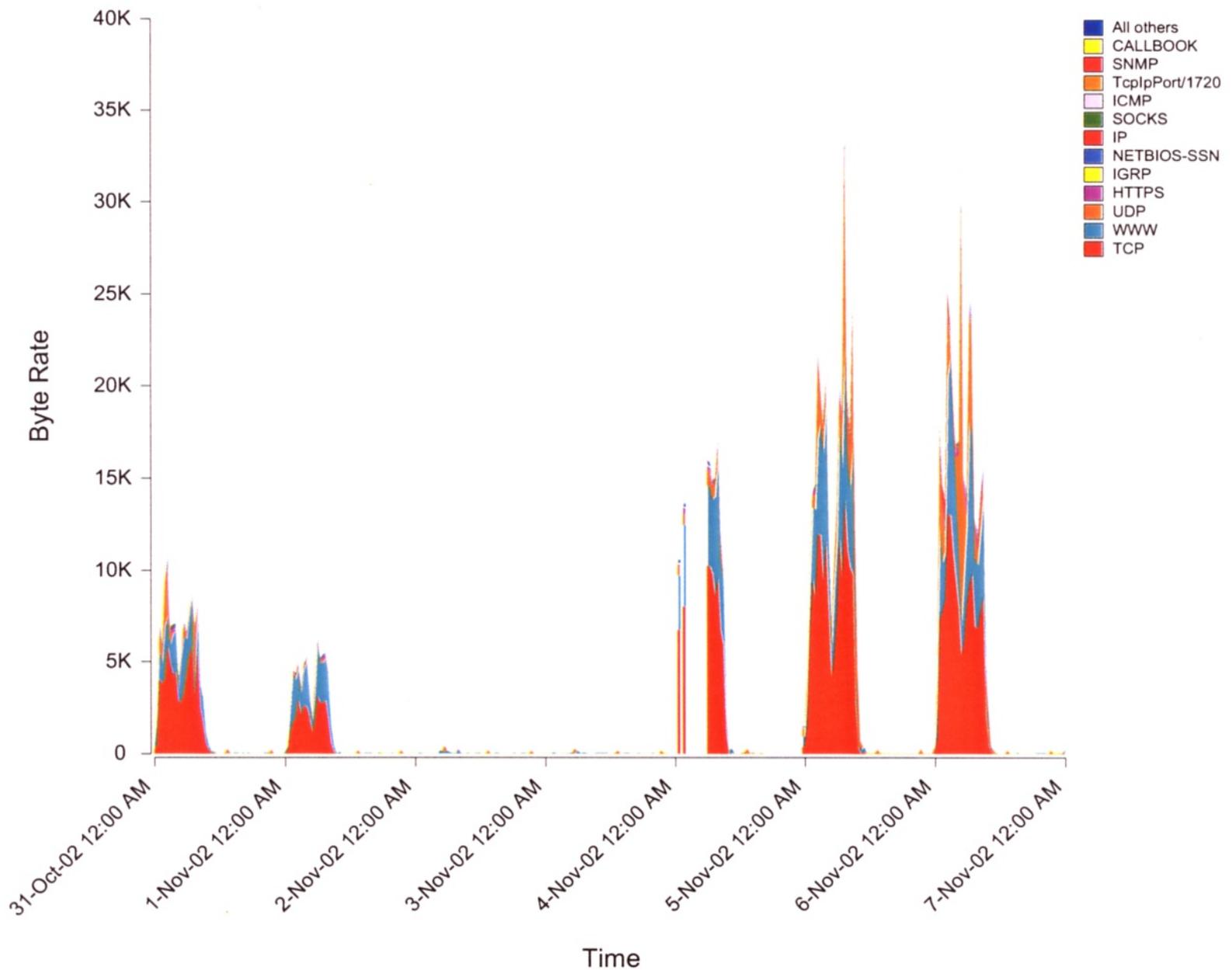
Finally...

Effective network monitoring has arrived!

- Near real-time
- Phenomenally user-friendly
- Instant insight→effective response

Imagine that you've been invited to another of those many meetings that you're required to attend. You're one of several managers in the IT department. Like most meetings, this one begins with the light of a projector suddenly illuminating a screen. Bursting with excitement, a young fellow at the front of the room announces that you will now receive a daily report that will inform you how the network is being utilized, and then the graph on the next slide appears.

Network Volume by Application

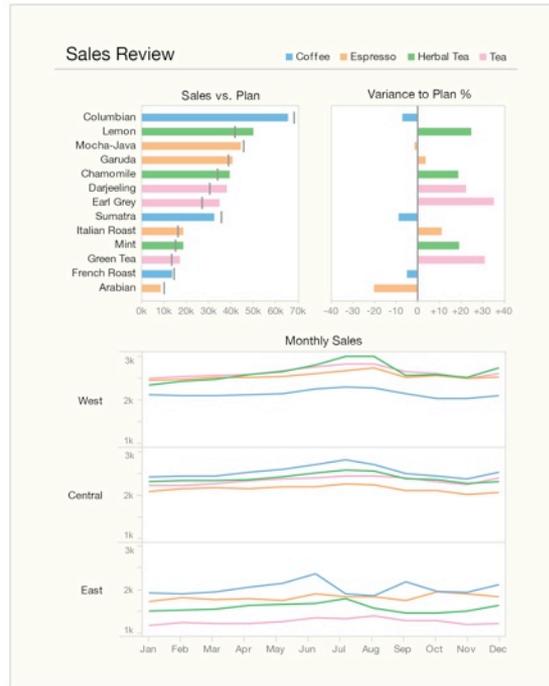


You stare at this graph intently, trying your best to keep any hint of confusion from showing on your face. From your peripheral vision you can see that the CIO (Chief Information Officer) is smiling broadly and nodding with obvious understanding. You and everyone else in the room begin to nod enthusiastically as well. You feel dumb, because you have no idea what this graph is trying to say. What you don't realize is that you are not alone.

Second Edition

Show Me the Numbers

Designing Tables and Graphs to Enlighten



Stephen Few

I wrote the book *Show Me the Numbers: Designing Tables and Graphs to Enlighten* in 2004 to help business people like you respond to the challenges that you face every day when presenting quantitative information. The second edition of *Show Me the Numbers*, published in 2012, is now available.

Fundamental challenges of data presentation

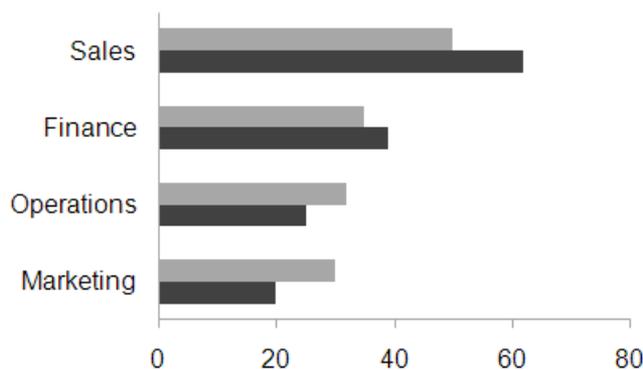
1. Determine the medium that tells the story best.

2. Design the components to tell the story clearly.

Either

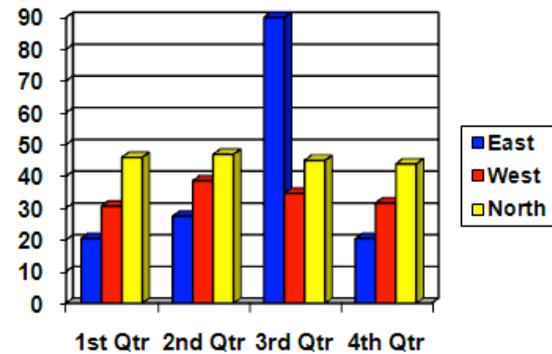
Product	Units Sold	Revenue
Food	34,837	746,383
Beverage	42,374	845,984
Total	77,211	1,592,367

or

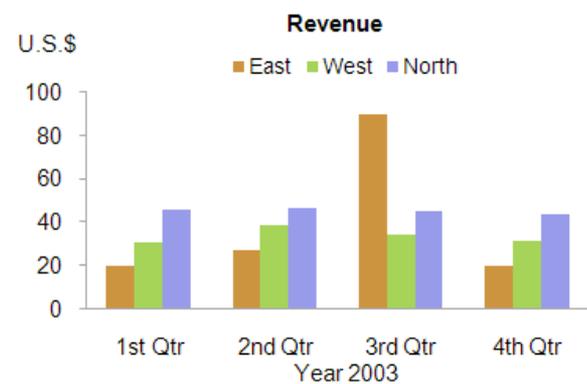


and which kind?

From



to



Displaying quantitative data effectively involves two fundamental challenges.

1. You begin by determining the best medium for your data and the message you wish to emphasize. Does it require a table or a graph? Which kind of table or graph?
2. Once you've decided, you must then design the individual components of that display to present the data and your message as clearly and efficiently as possible.

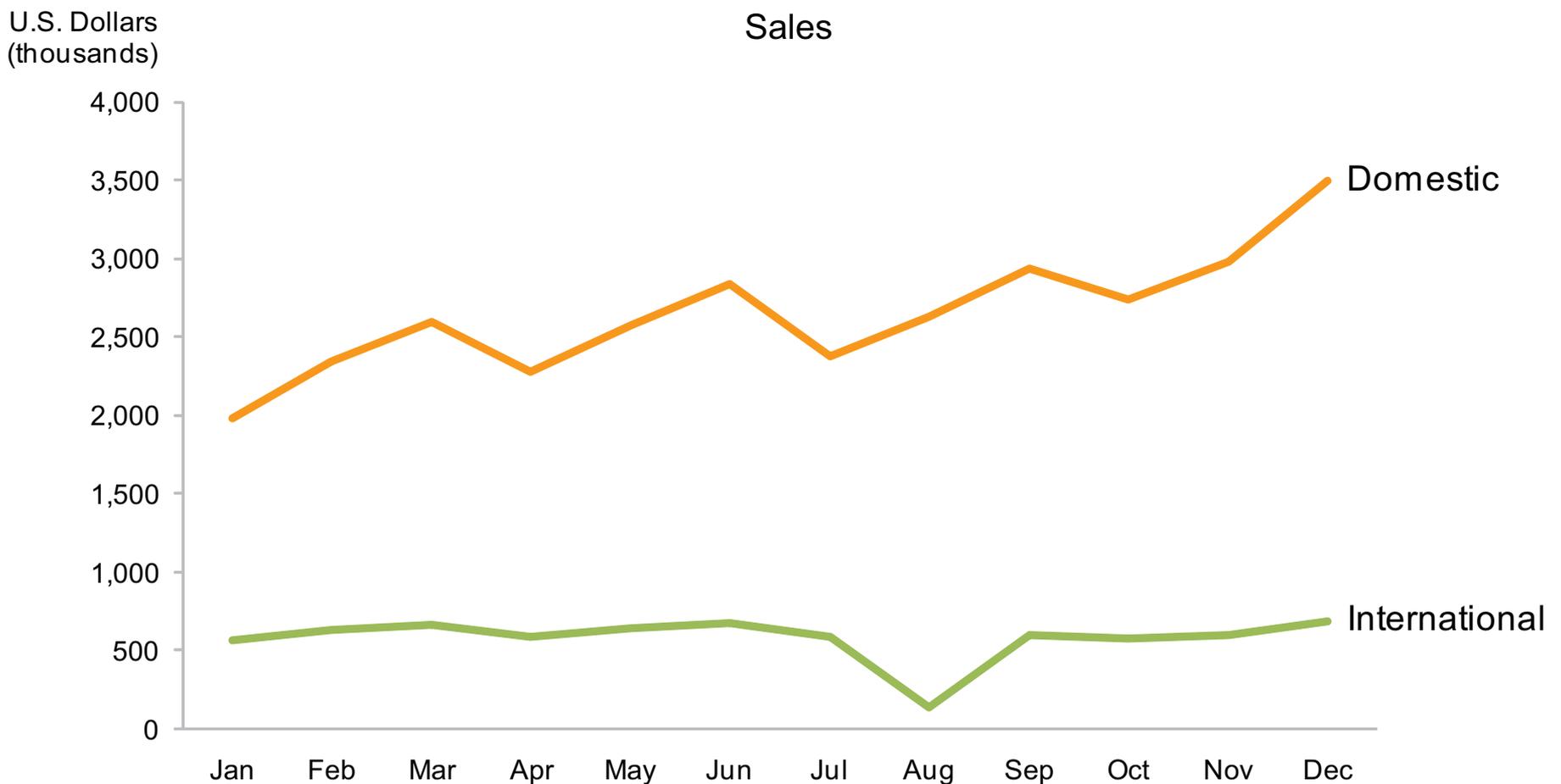
The solutions to both of these challenges are rooted in an understanding of visual perception.

Tables work best when...

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
2000	138.1	138.6	139.3	139.5	139.7	140.2	140.5	140.9	141.3	141.8	142.0	141.9	140.3
2001	142.6	143.1	143.6	144.0	144.2	144.4	144.4	144.8	145.1	145.7	145.8	145.8	144.5
2002	146.2	146.7	147.2	147.4	147.5	148.0	148.4	149.0	149.4	149.5	149.7	149.7	148.2
2003	150.3	150.9	151.4	151.9	152.2	152.5	152.5	152.9	153.2	153.7	153.6	153.5	152.4
2004	154.4	154.9	155.7	156.3	156.6	156.7	157.0	157.3	157.8	158.3	158.6	158.6	156.9
2005	159.1	159.6	160.0	160.2	160.1	160.3	160.5	160.8	161.2	161.6	161.5	161.3	160.5
2006	161.6	161.9	162.2	162.5	162.8	163.0	163.2	163.4	163.6	164.0	164.0	163.9	163.0
2007	164.3	164.5	165.0	166.2	166.2	166.2	166.7	167.1	167.9	168.2	168.3	168.3	166.6
2008	168.8	169.8	171.2	171.3	171.5	172.4	172.8	172.8	173.7	174.0	174.1	174.0	172.2
2009	175.1	175.8	176.2	176.9	177.7	178.0	177.5	177.5	178.3	177.7	177.4	176.7	177.1
2010	177.1	177.8	178.8	179.8	179.8	179.9	180.1	180.7	181.0	181.3	181.3	180.9	179.9

- Used to look up individual values
- Data must be precise

Graphs feature patterns, trends, exceptions, and entire series of values at once.

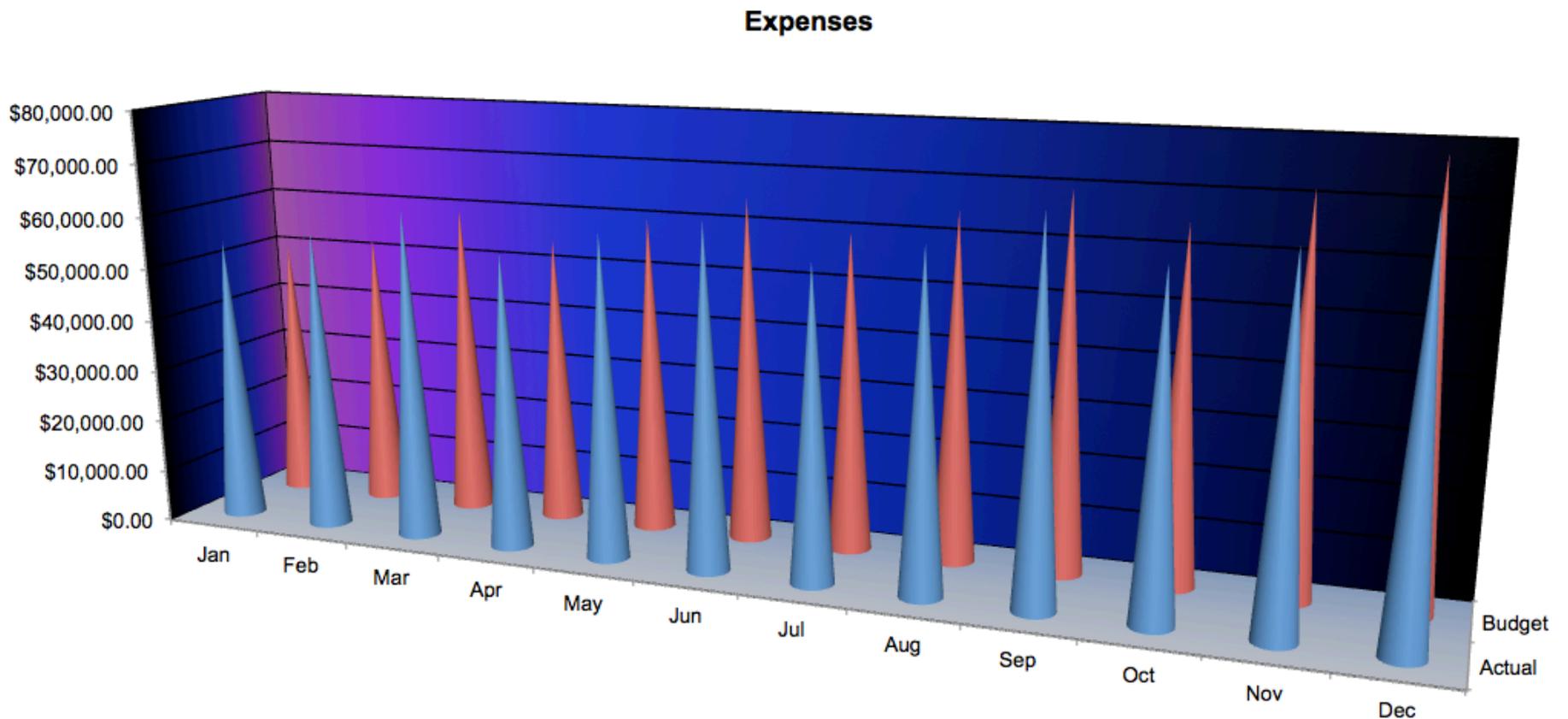


By displaying quantitative information in visual form, graphs efficiently reveal information that would otherwise require a thousand words or more to adequately describe.

In this example of purely manufactured data to illustrate my point...

Joseph Berkson once stated what happens quite powerfully: When we visualize the data effectively and suddenly, we experience “interocular traumatic impact”—a conclusion that hits us between the eyes.

Design choices matter.

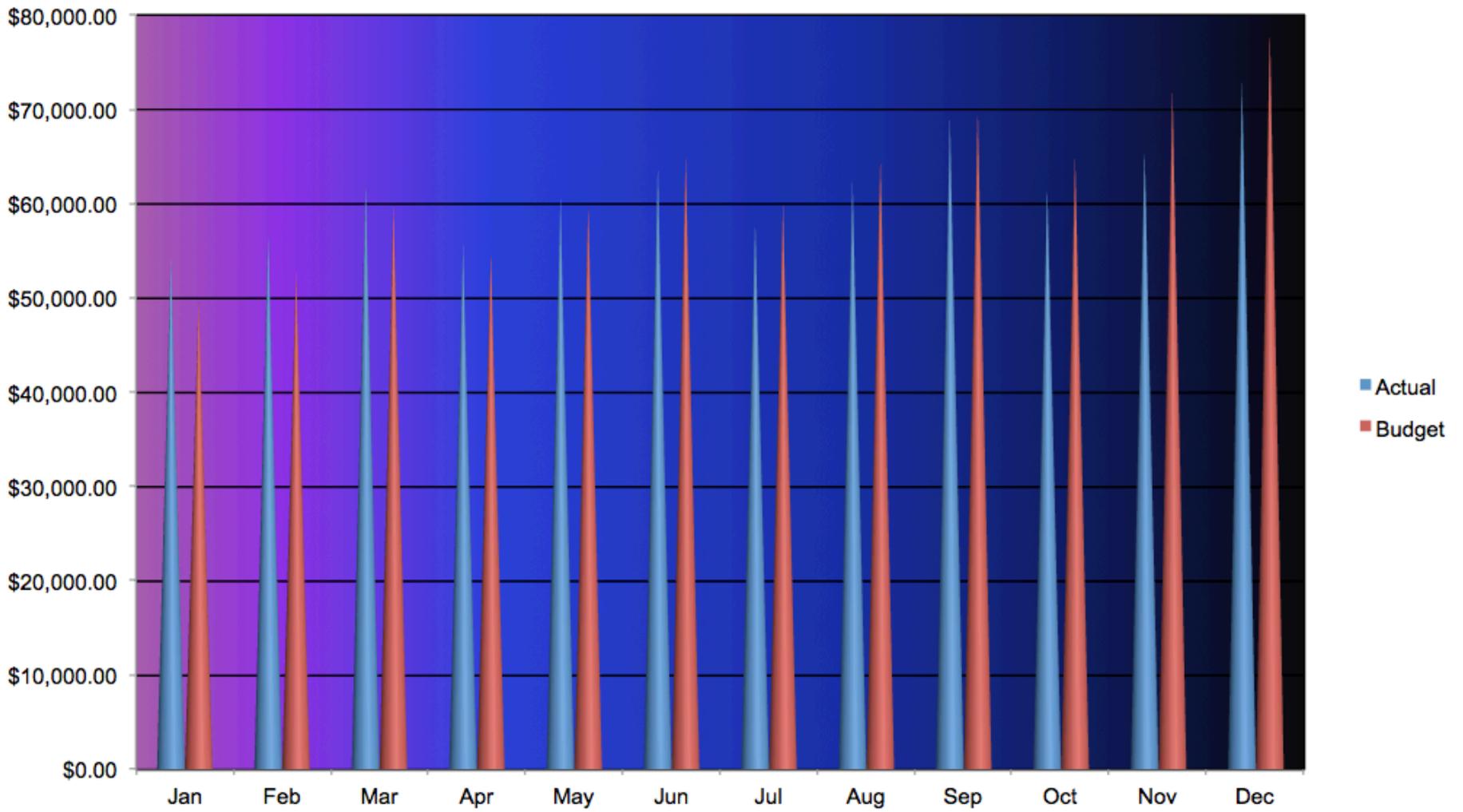


This is the kind of graph that software products, including Excel, encourage us to create. They give us an infinite selection of poorly-designed graphs from which to choose. What we really need, however, is a small selection of graphs that really work.

Using this graph, try to see the pattern of change across the months in actual expenses. Try to determine one of the actual values. Try to compare actual expenses to the budget across time.

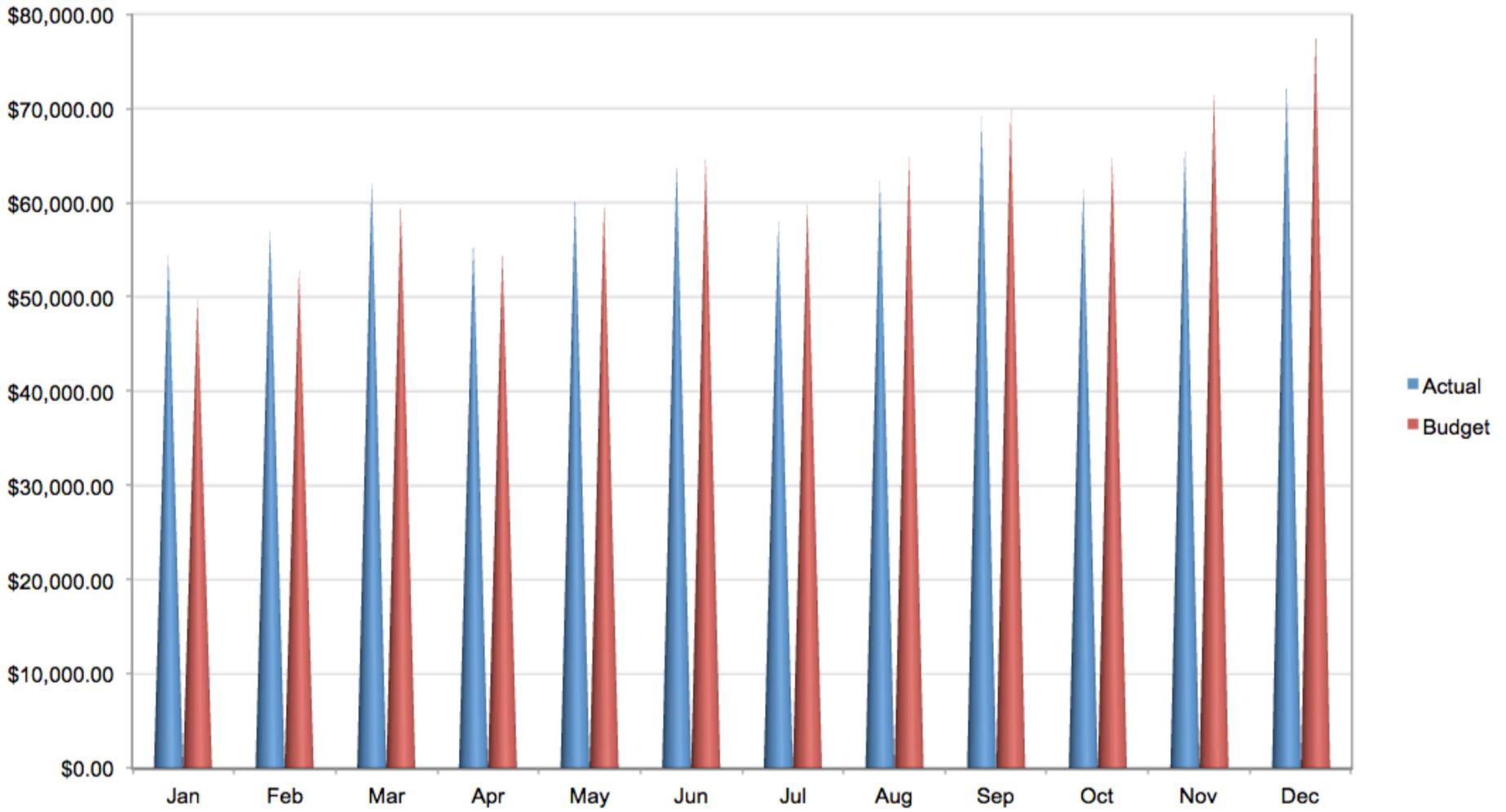
Let's transform this graph into one that communicates.

Expenses



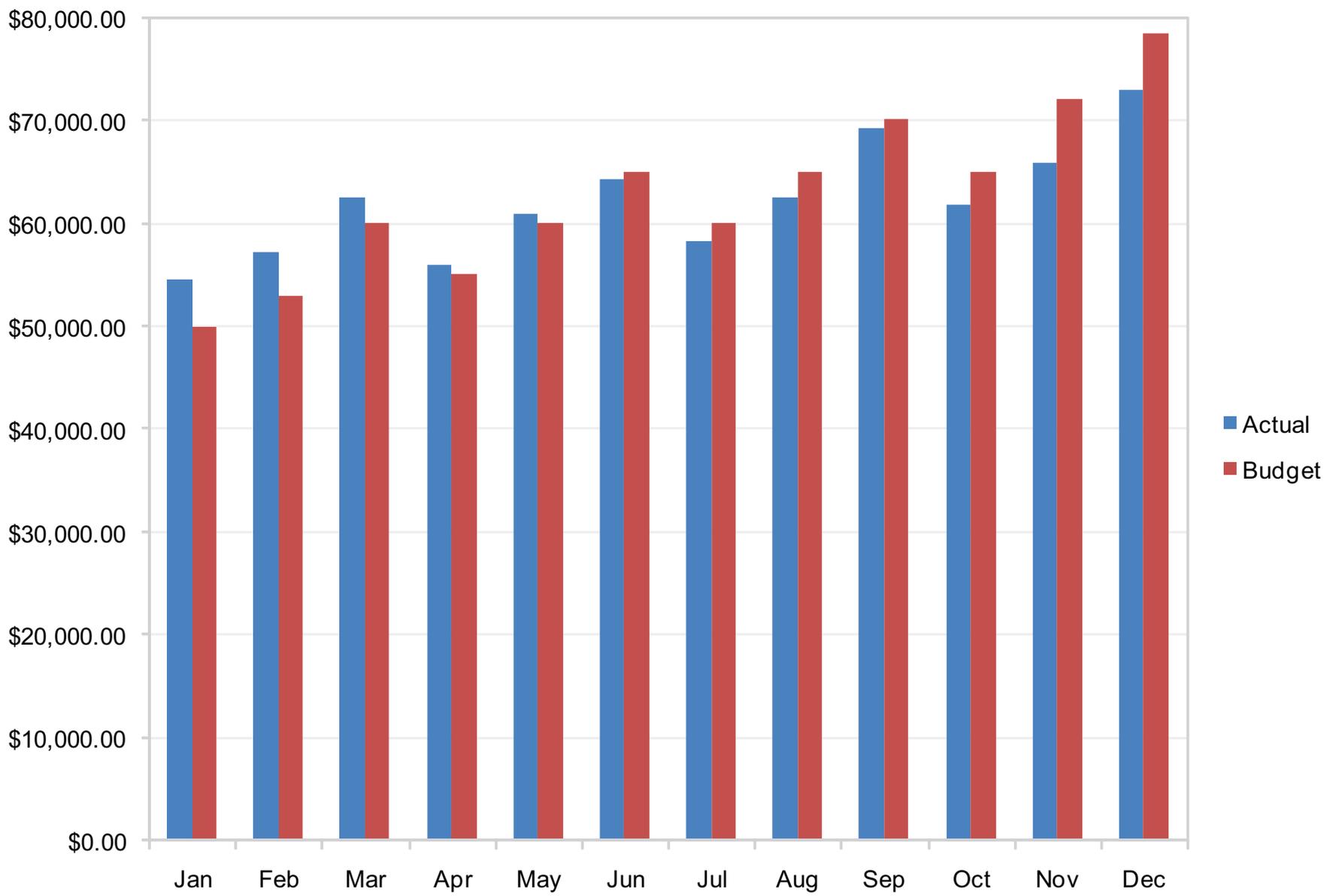
We have now removed the useless 3-D effects and angle, which makes the data easier to read.

Expenses



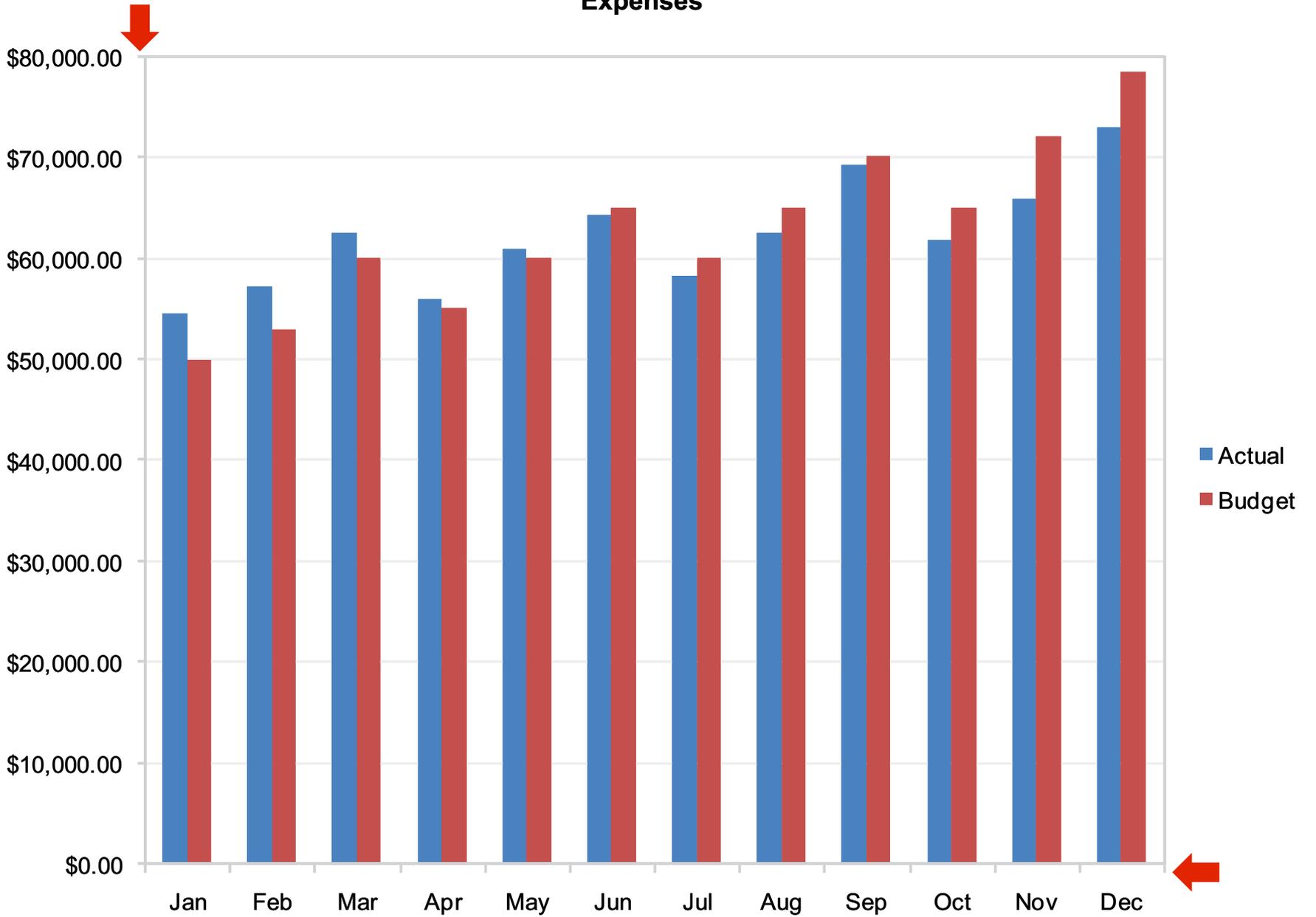
We have now removed the background fill color.

Expenses



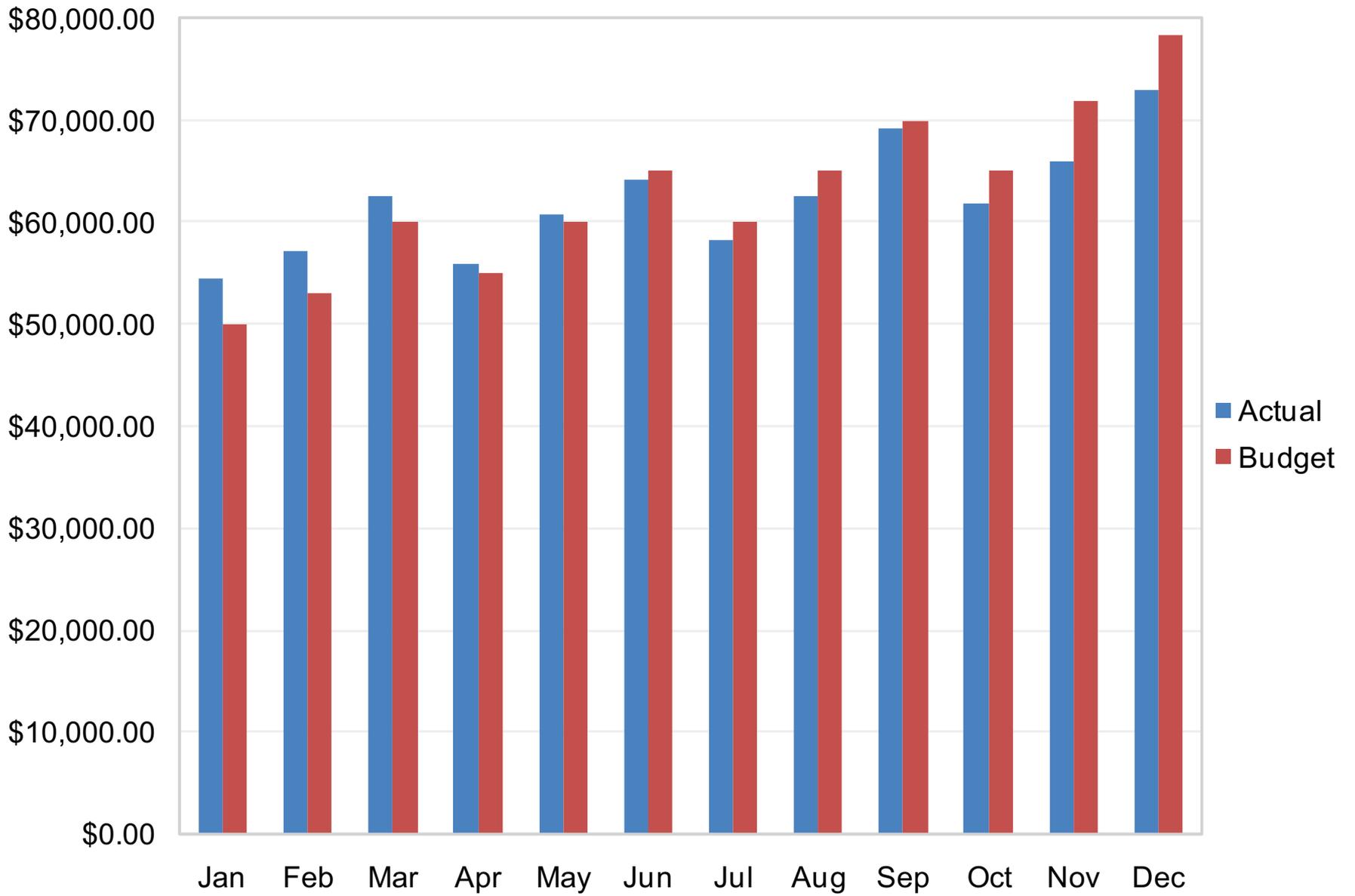
We have now replaced the silly cones with regular bars.

Expenses



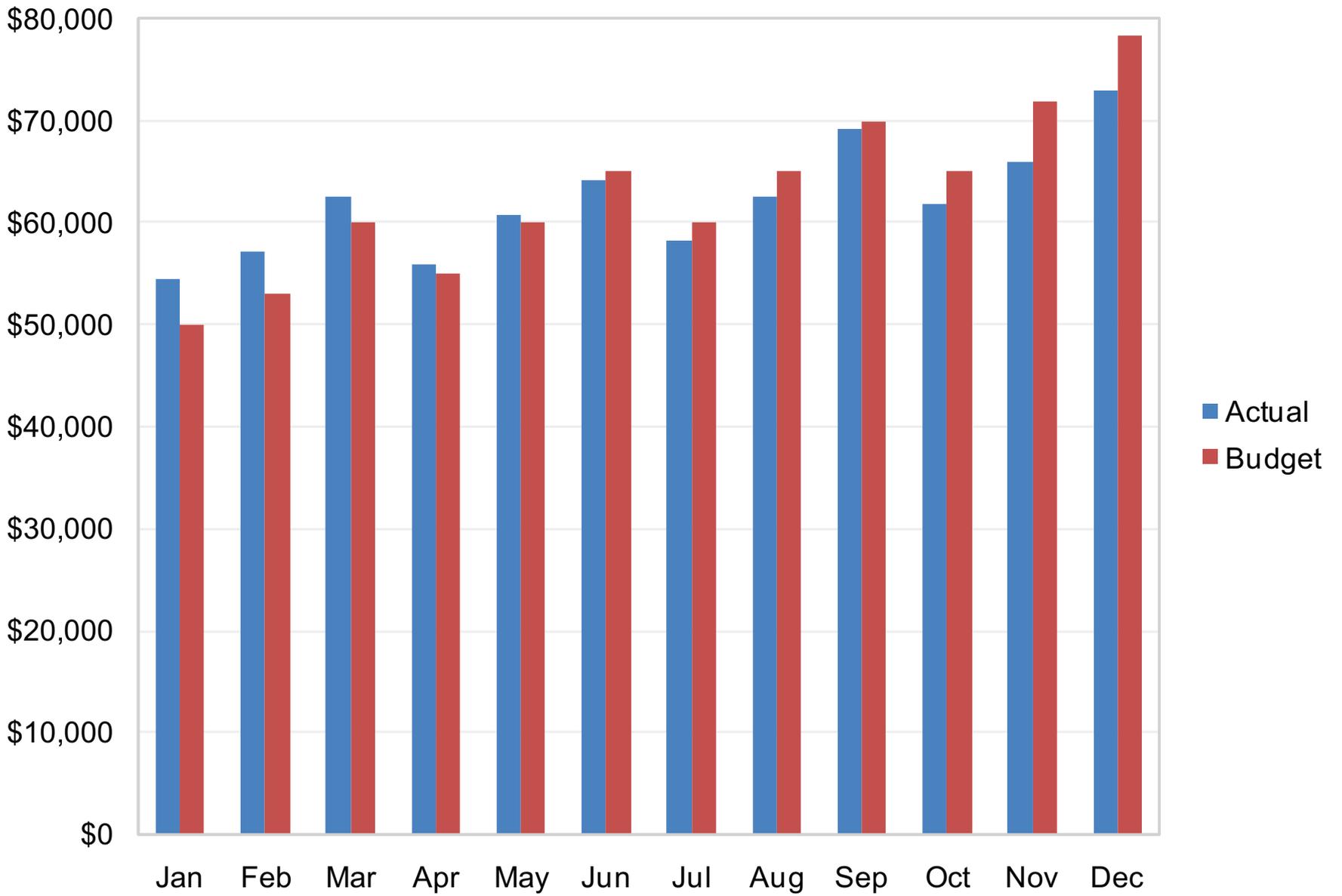
We have now removed the tick marks, which aren't necessary. Tick marks are not needed to separate the months along the X-axis and because horizontal grid lines are being displayed, there is no need for tick marks on the Y-axis either.

Expenses



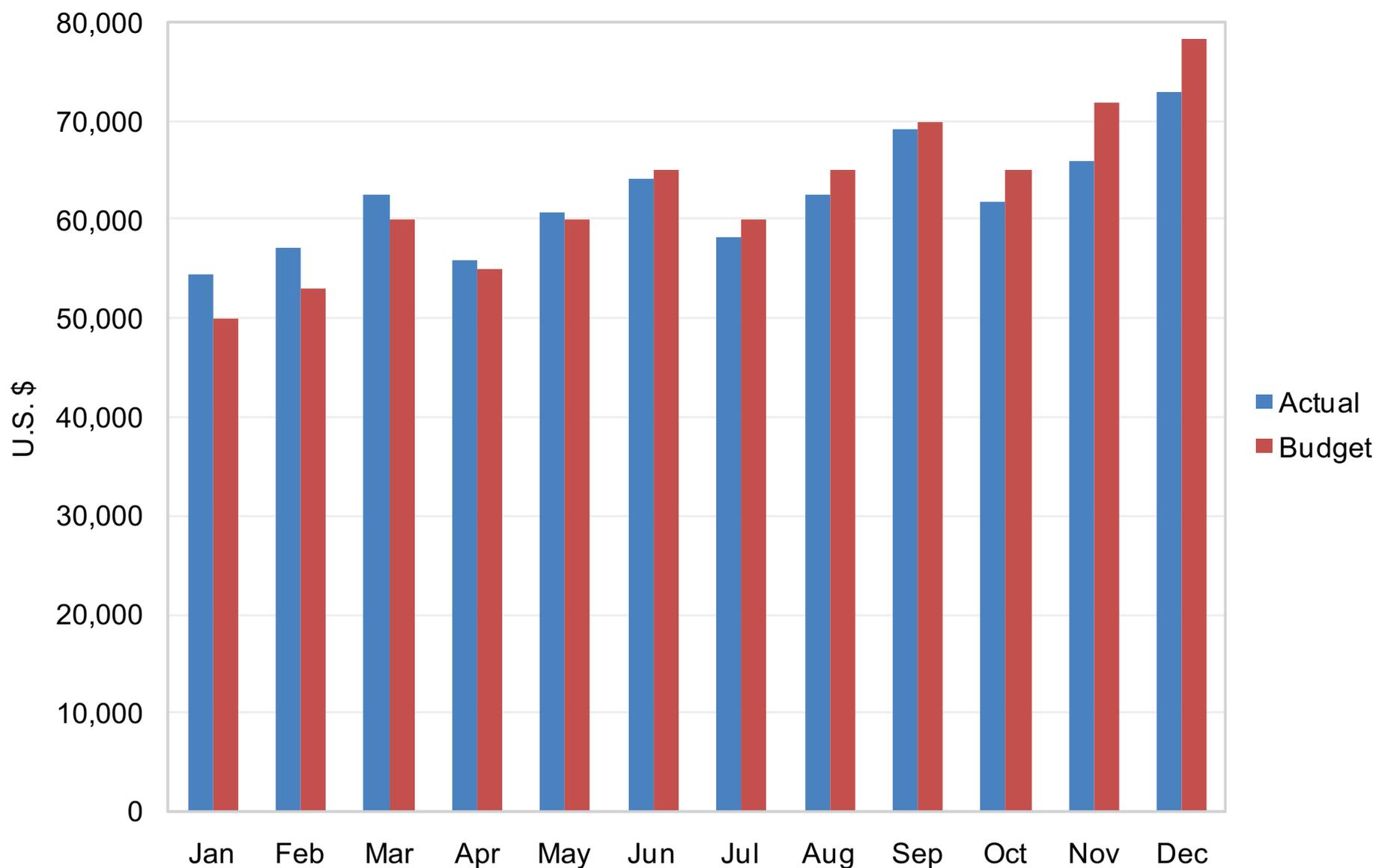
We have now enlarged the text, making it easier to read.

Expenses

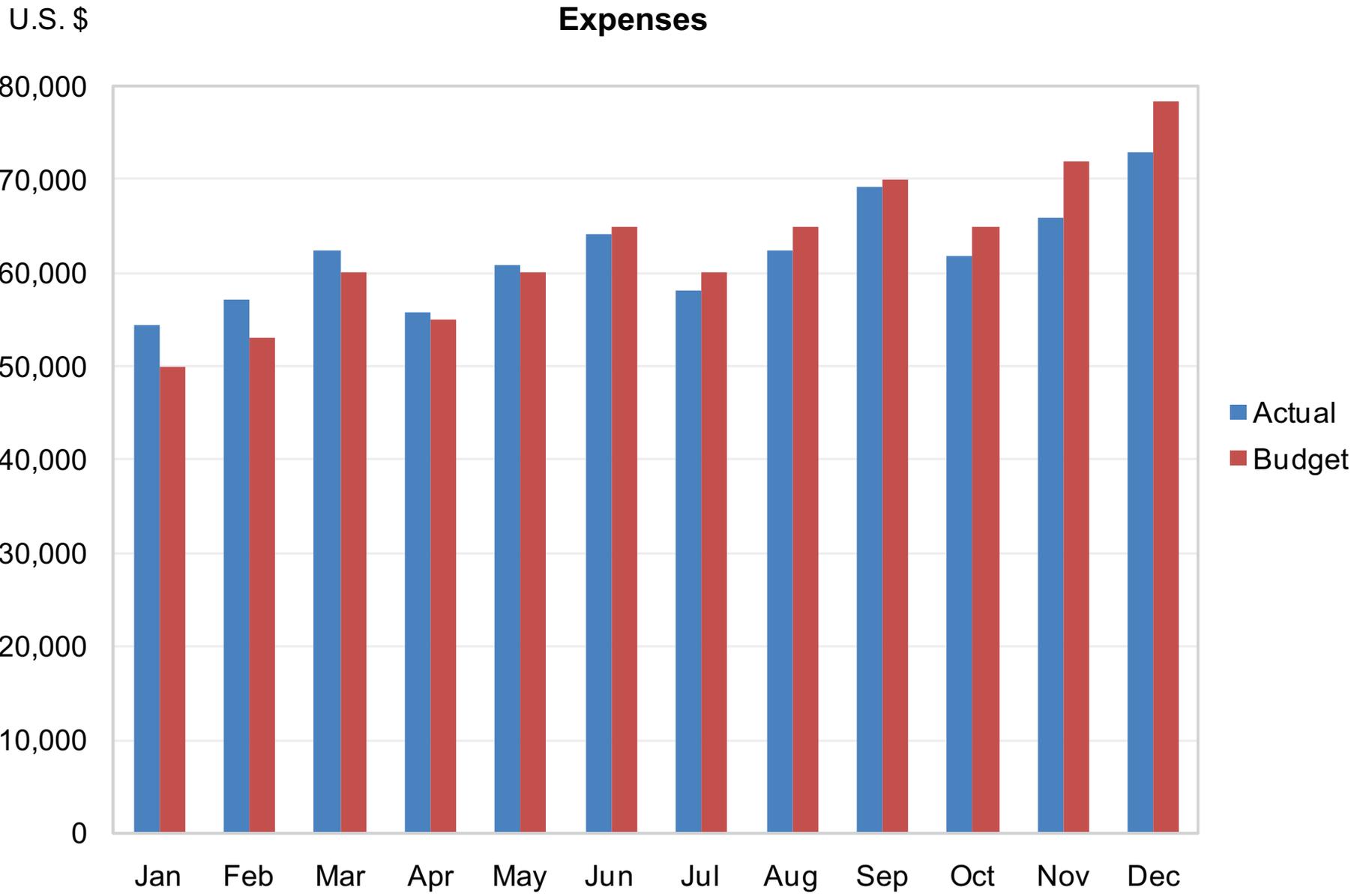


We have now removed the unnecessary decimal places in the dollar amounts along the Y-axis.

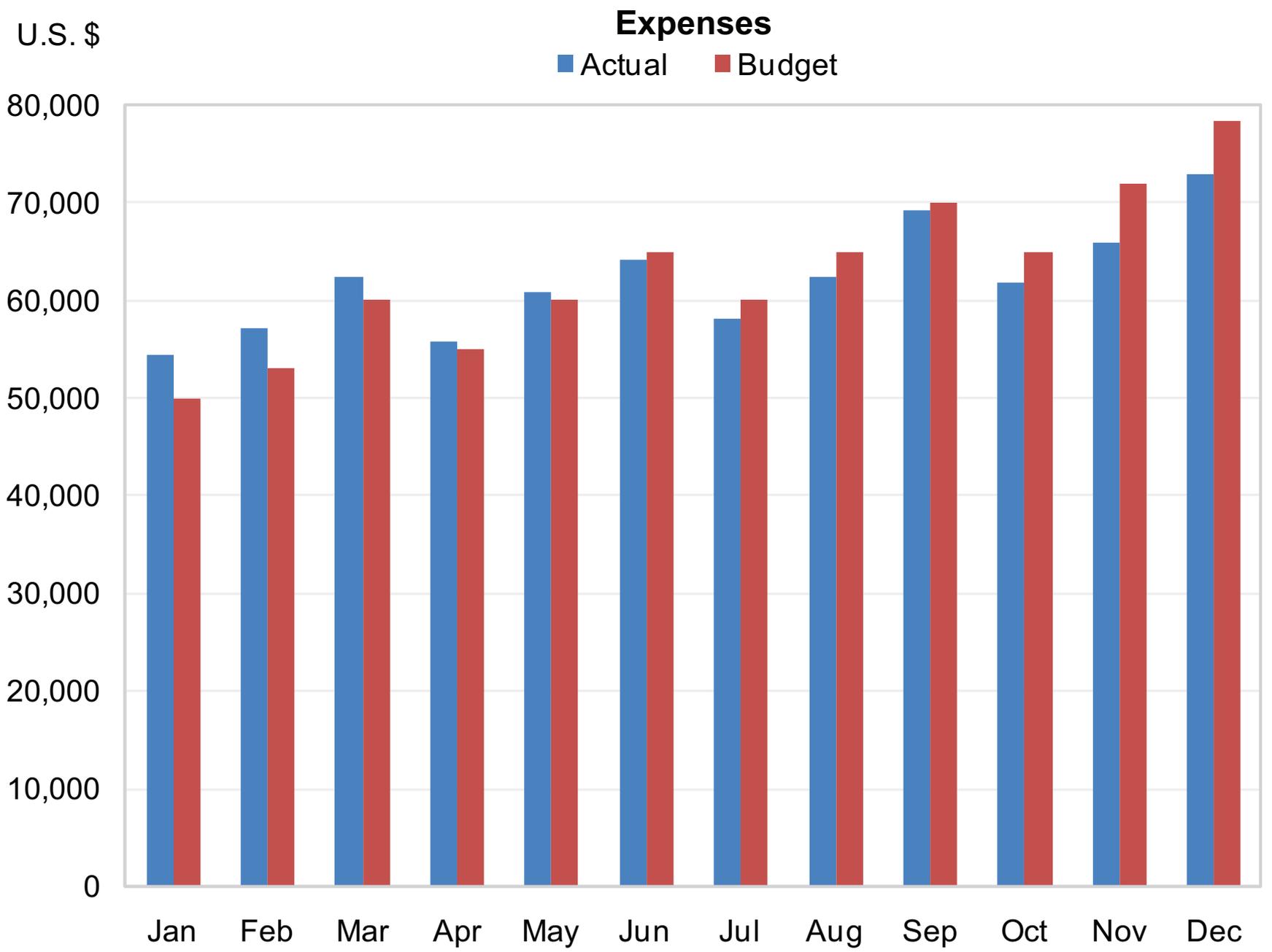
Expenses



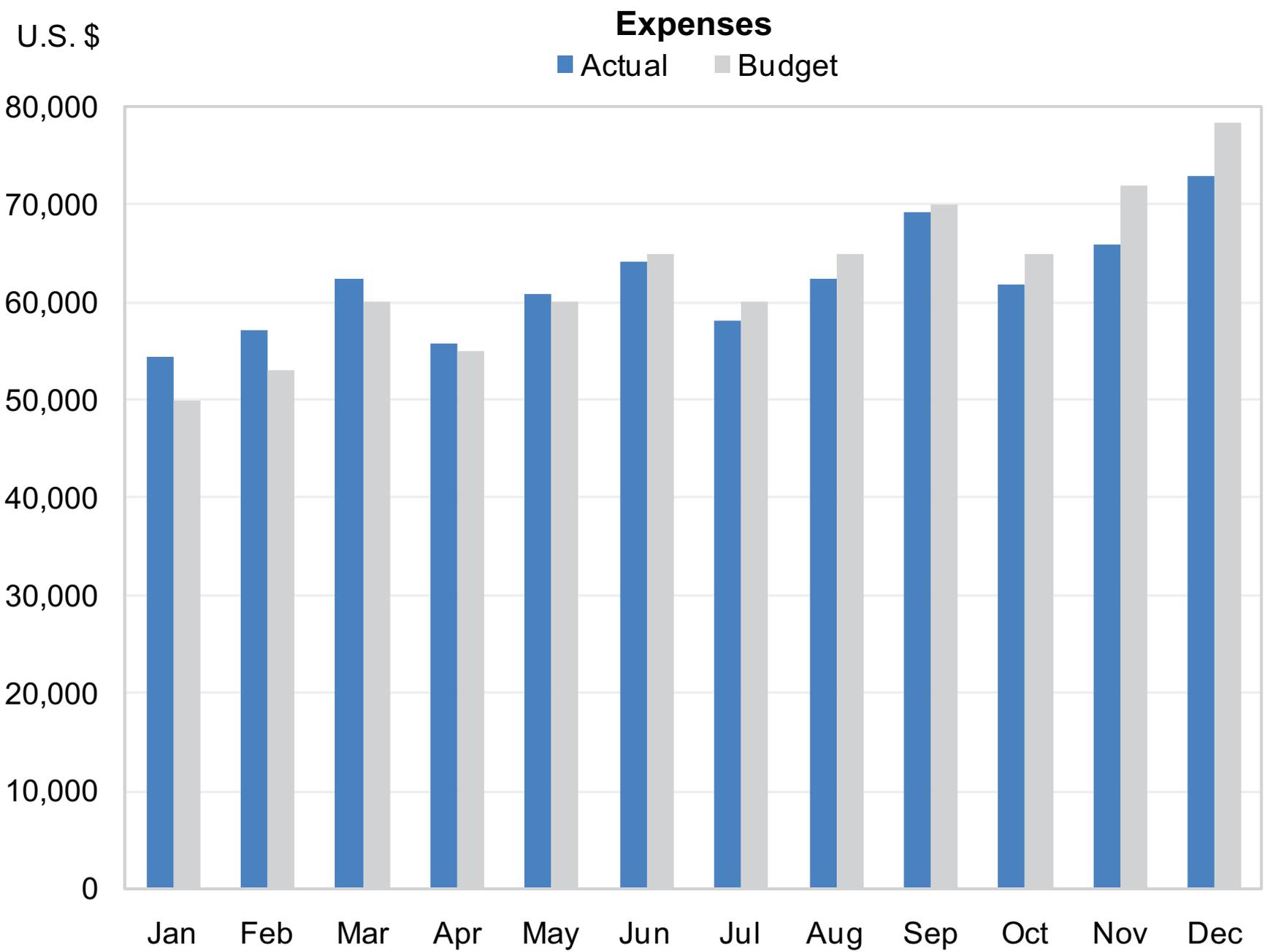
We have now removed the redundant dollar signs and labeled the unit of measure (U.S. \$) clearly.



We have now reoriented the Y-axis label to the horizontal and placed it above the axis to make it easier to read.



We have now reoriented and repositioned the legend to make it easier to associate it with the data bars.



We have now changed the color of the Budget bar to be more visually pleasing in relation to the blue Actual bars. Changing from the color red also removed the possibility people interpreting the data as something bad or a warning, which red is often used to represent.

Expenses

Actual Budget

U.S. \$

80,000

70,000

60,000

50,000

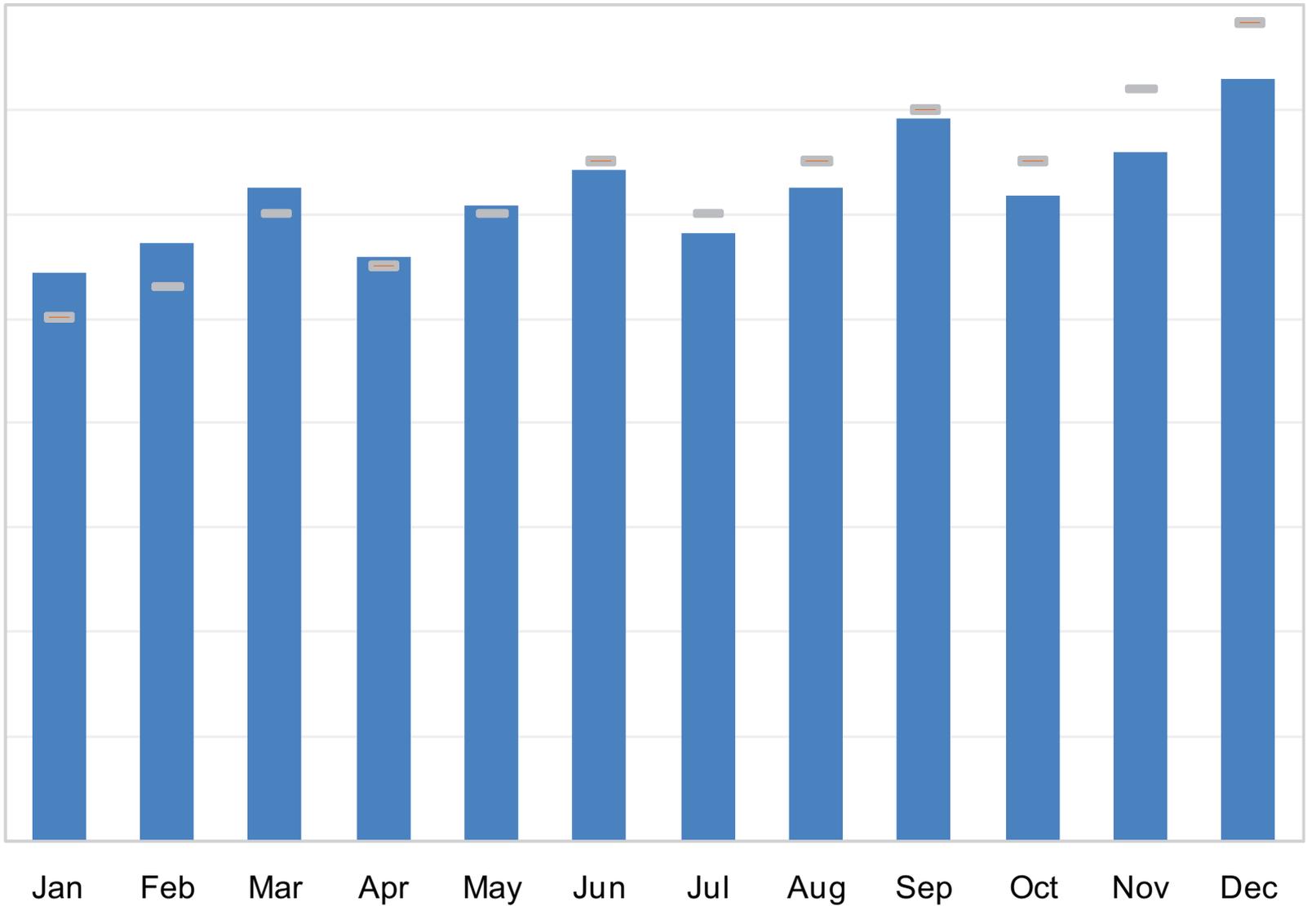
40,000

30,000

20,000

10,000

0



We have now reduced the visual salience of the Budget values, because they are less important than the Actual values, and have done so in a way that reduced clutter.

Expenses

Actual Budget

U.S. \$

80,000

70,000

60,000

50,000

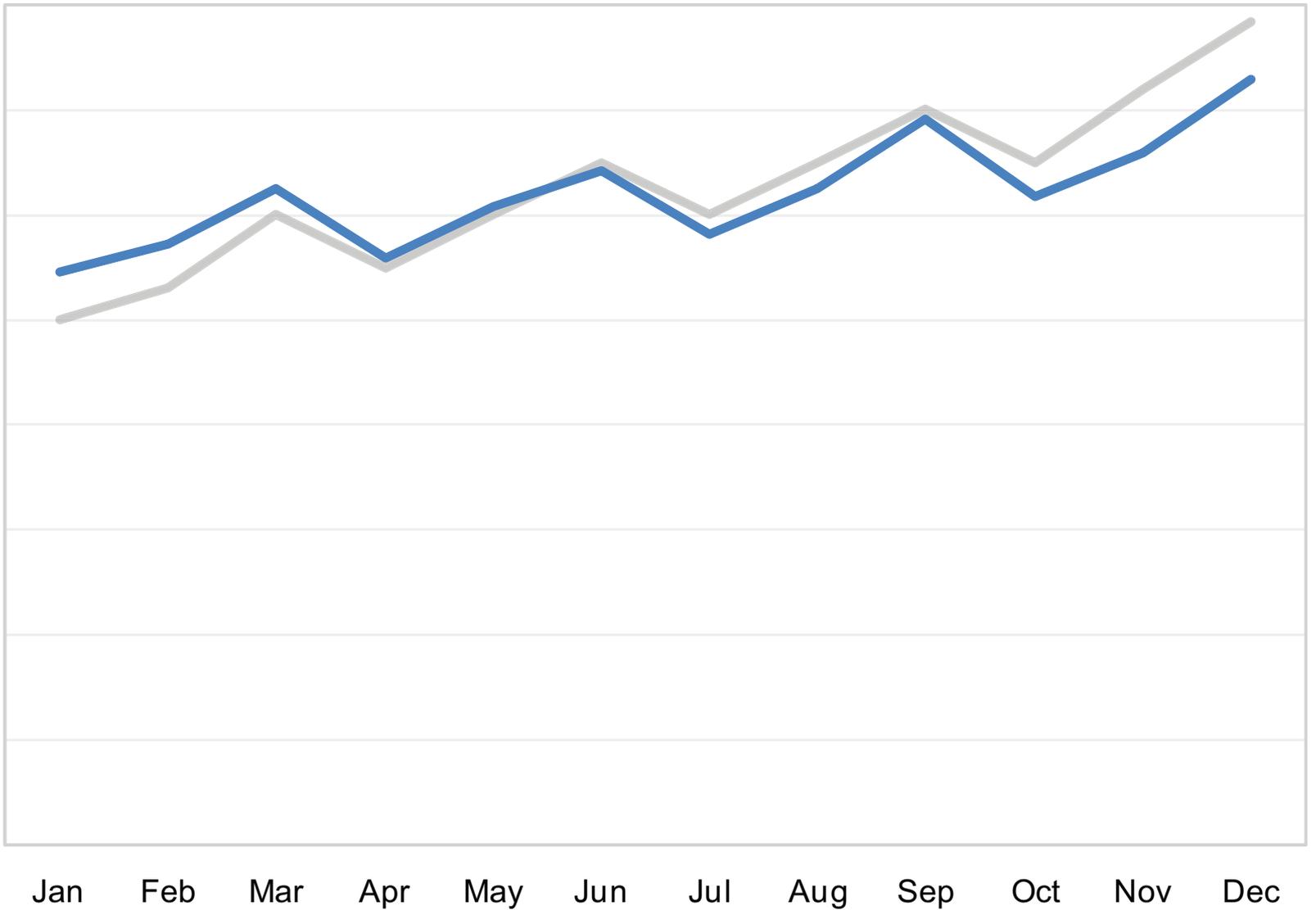
40,000

30,000

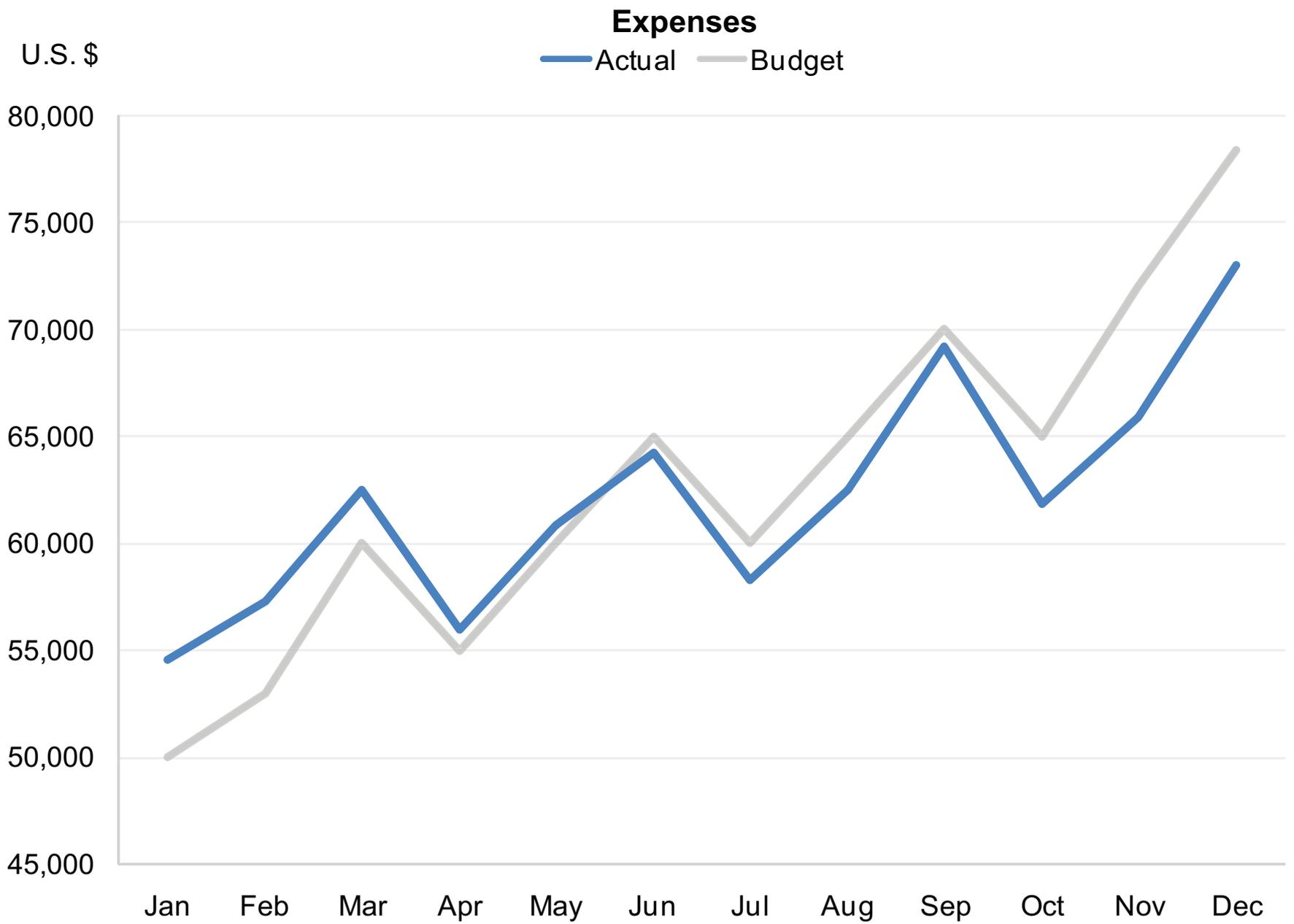
20,000

10,000

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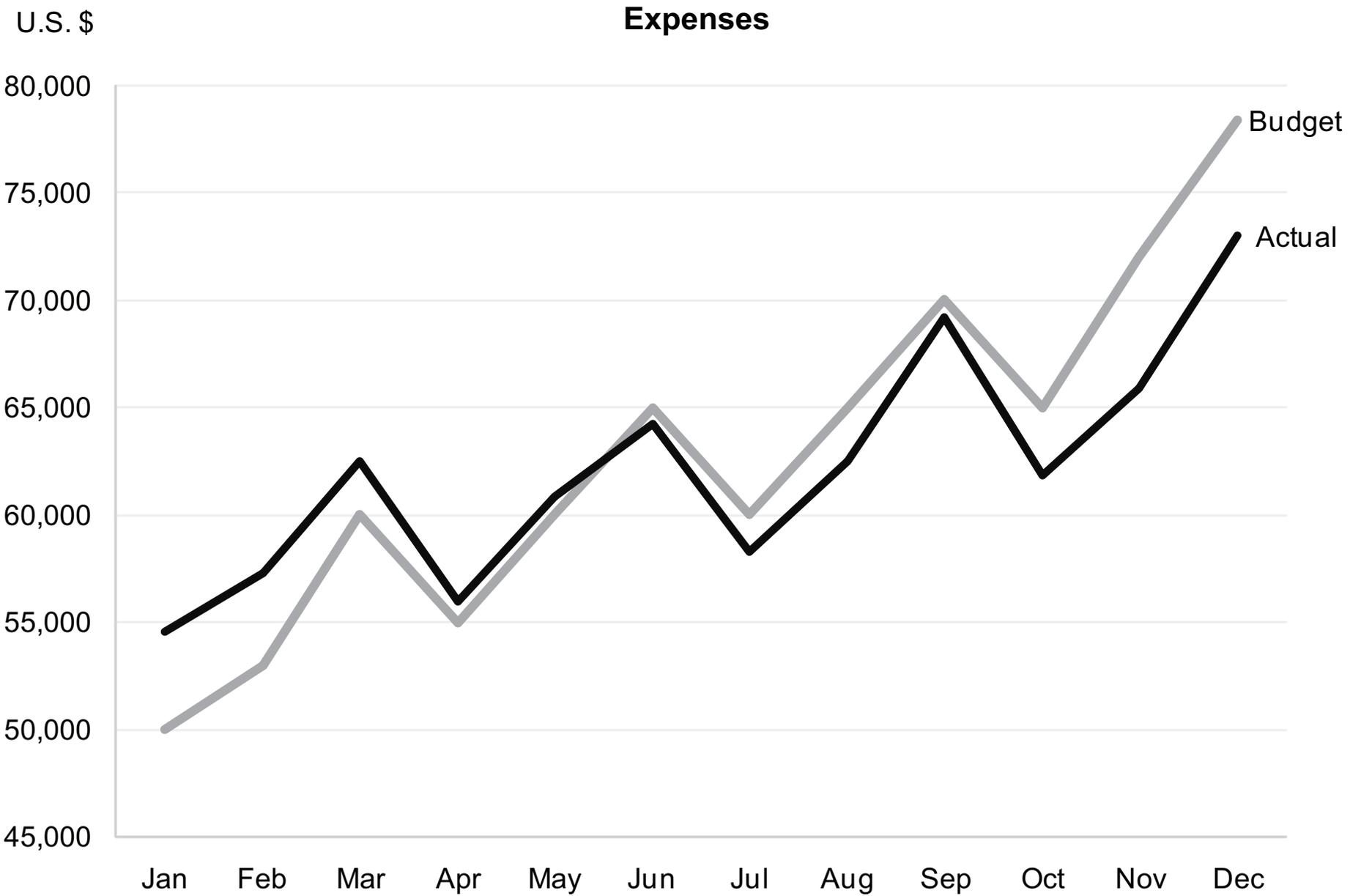
We have now made it much easier to see the pattern of change through time by using lines rather than bars to represent the data.



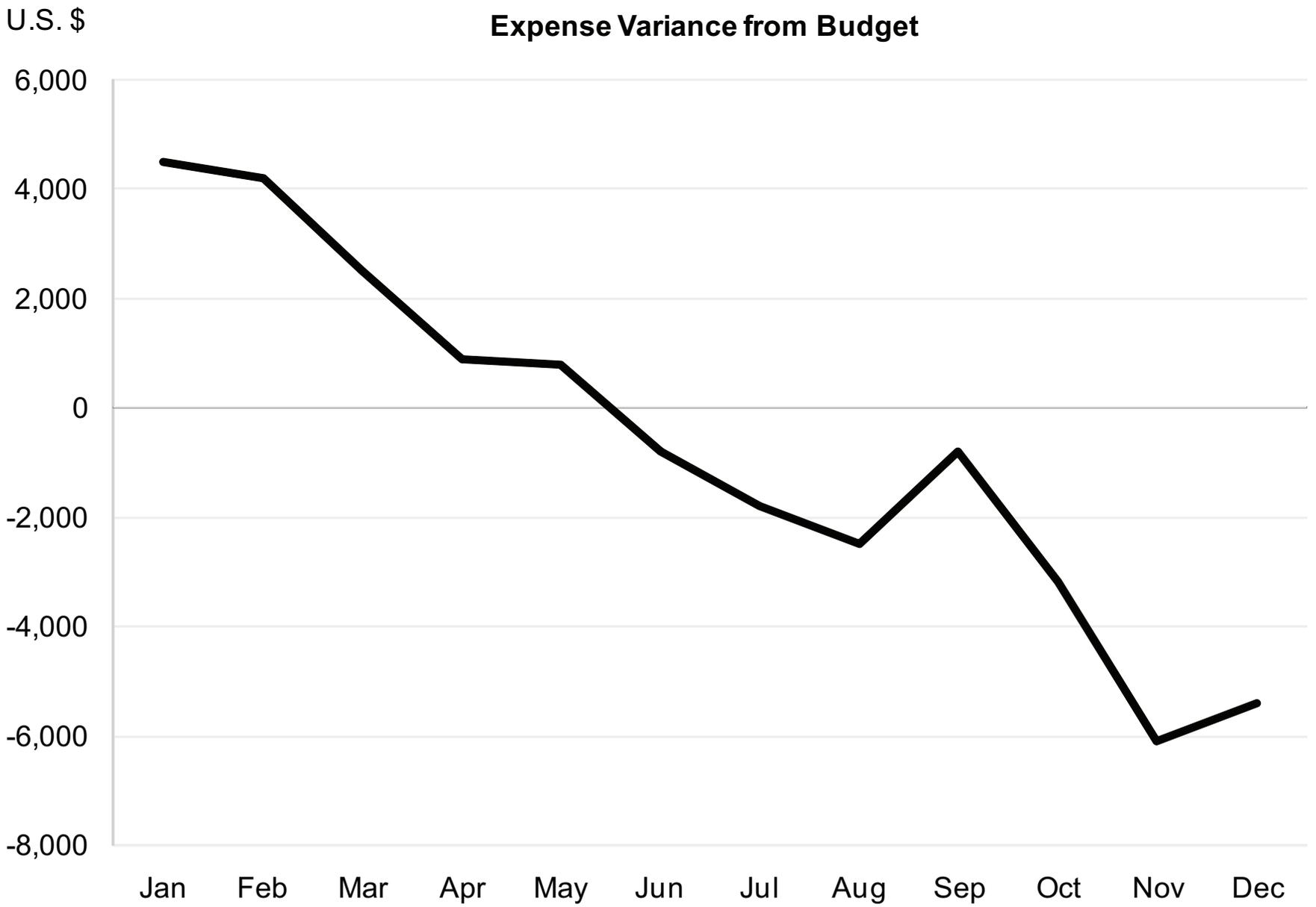
We have now made it much easier to examine the differences between actual expenses and the budget by spreading them across more space.



We have now labeled the lines directly, removing the need for a legend.

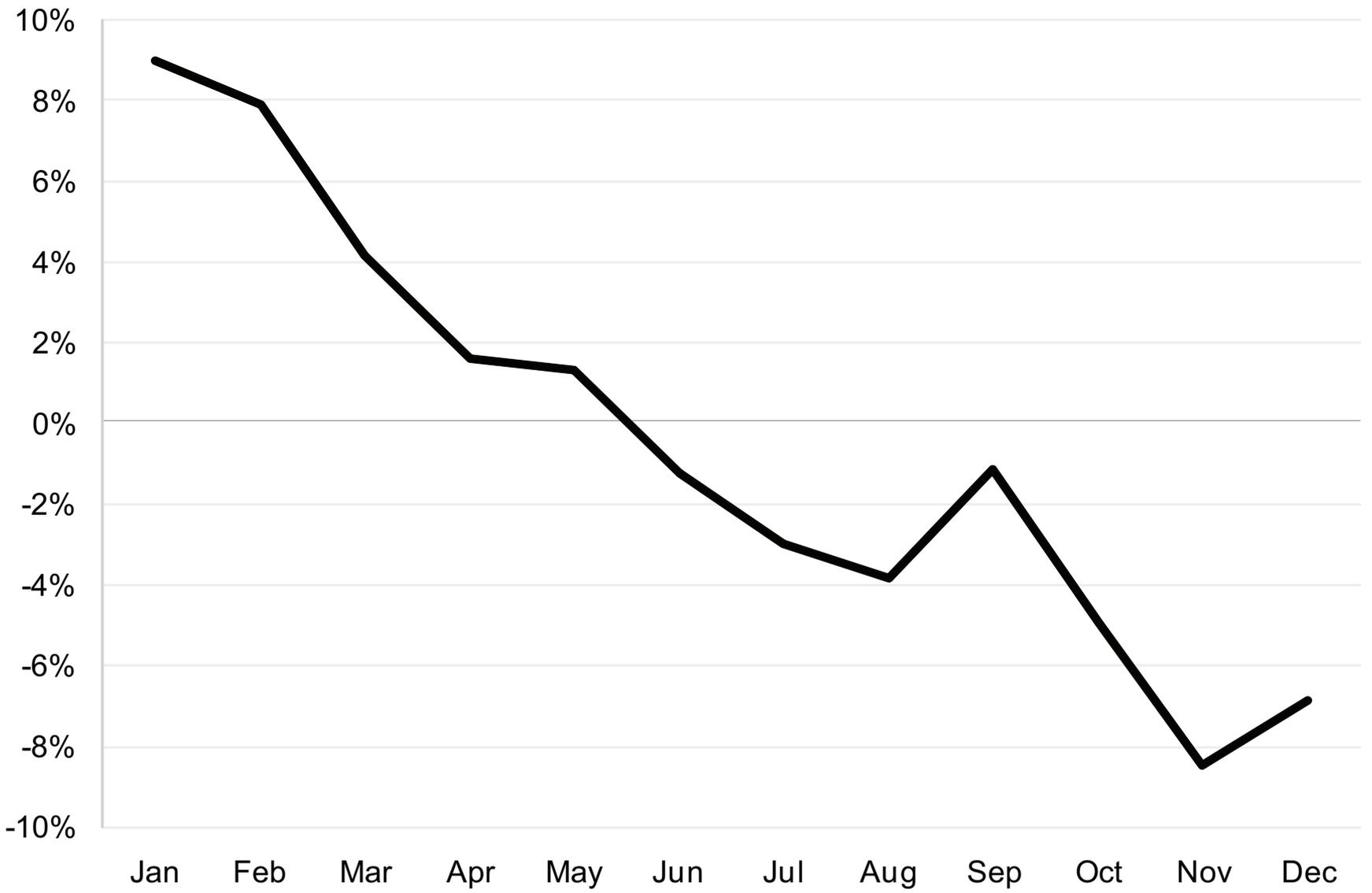


We have now changed the lines to two shades of gray to guaranty that even if the graph is printed on a black-and-white printer or photocopier, they will still look distinctly different from one another.



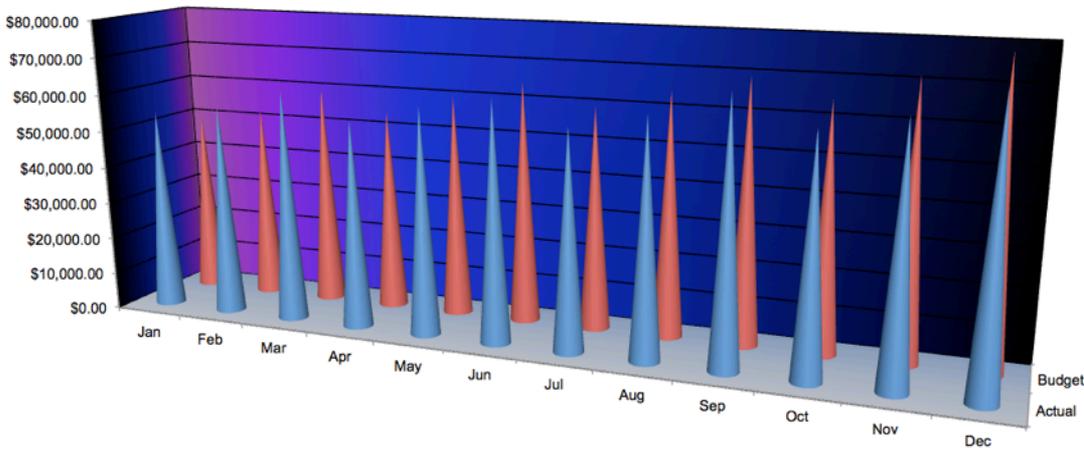
We have now represented the variance of actual expenses from the budget directly, as a single line.

Expense Percentage Variance from Budget



As our final step, we have expressed variance as a percentage, to provide a better measure of performance.

Expenses



Expenses Percentage Variance from Budget



Our final solution, which we produced in sixteen steps, could have easily been our original solution. It usually takes no longer to design effective graphs than those that communicate poorly, if at all.

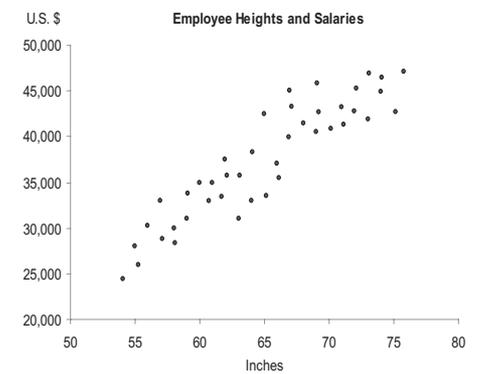
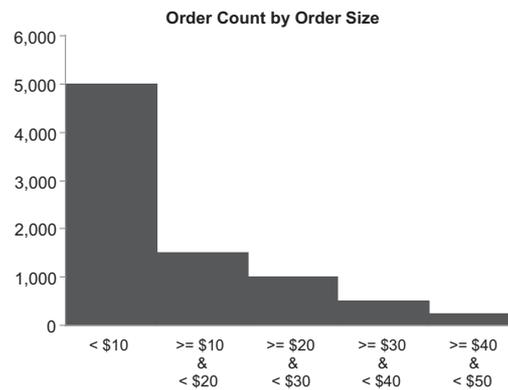
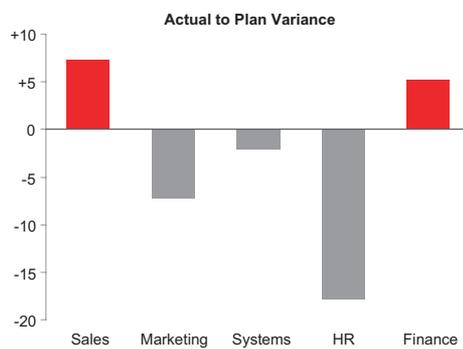
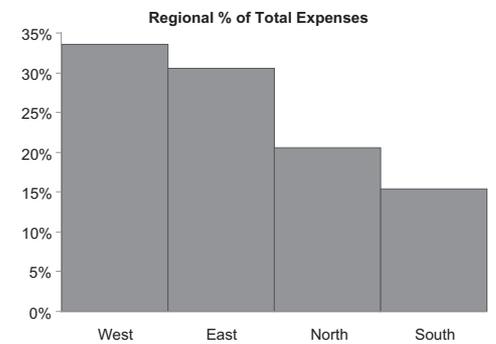
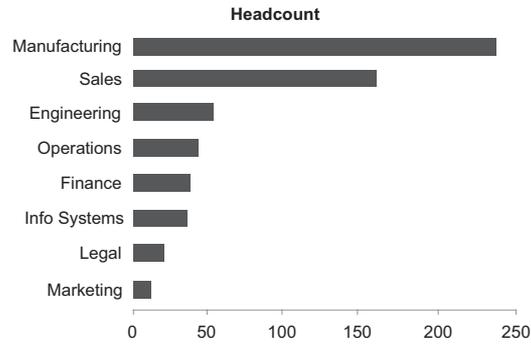
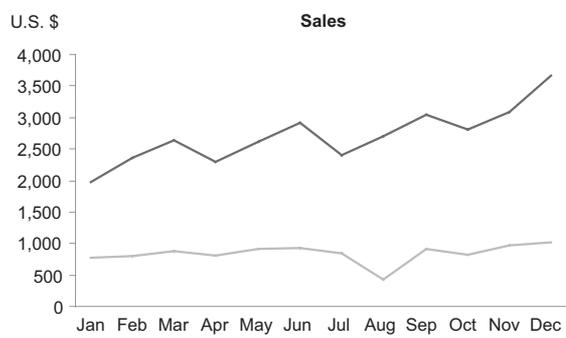
Eloquence through Simplicity

Eloquence of communication is often achieved through simplicity of design. We accomplish this by paring the story down to its essence and presenting that in the simplest possible way.

Simple, but not obvious

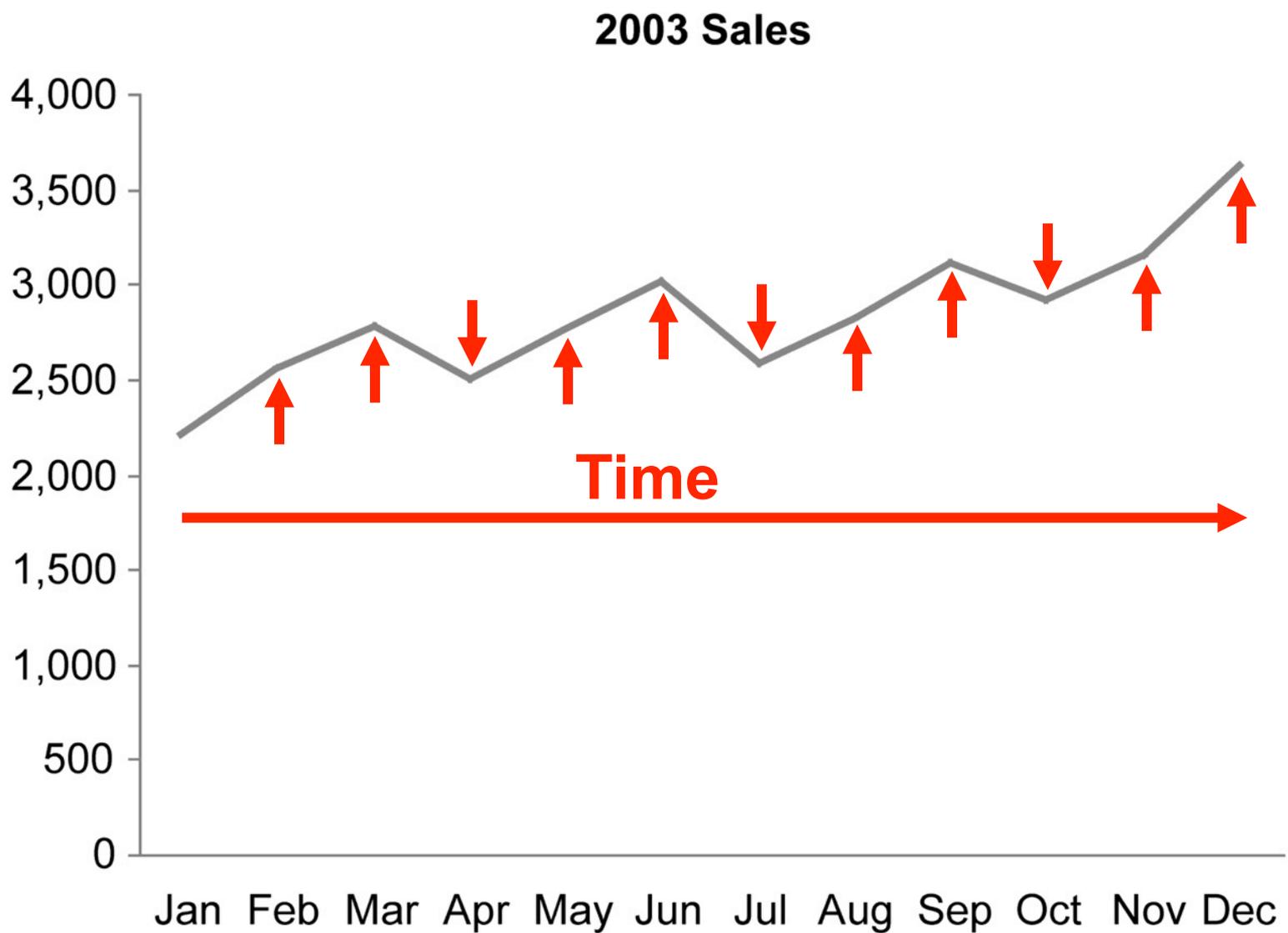
The best practices of graph design are simple -- easy to learn, understand, and use -- but not obvious.

Seven common quantitative relationships

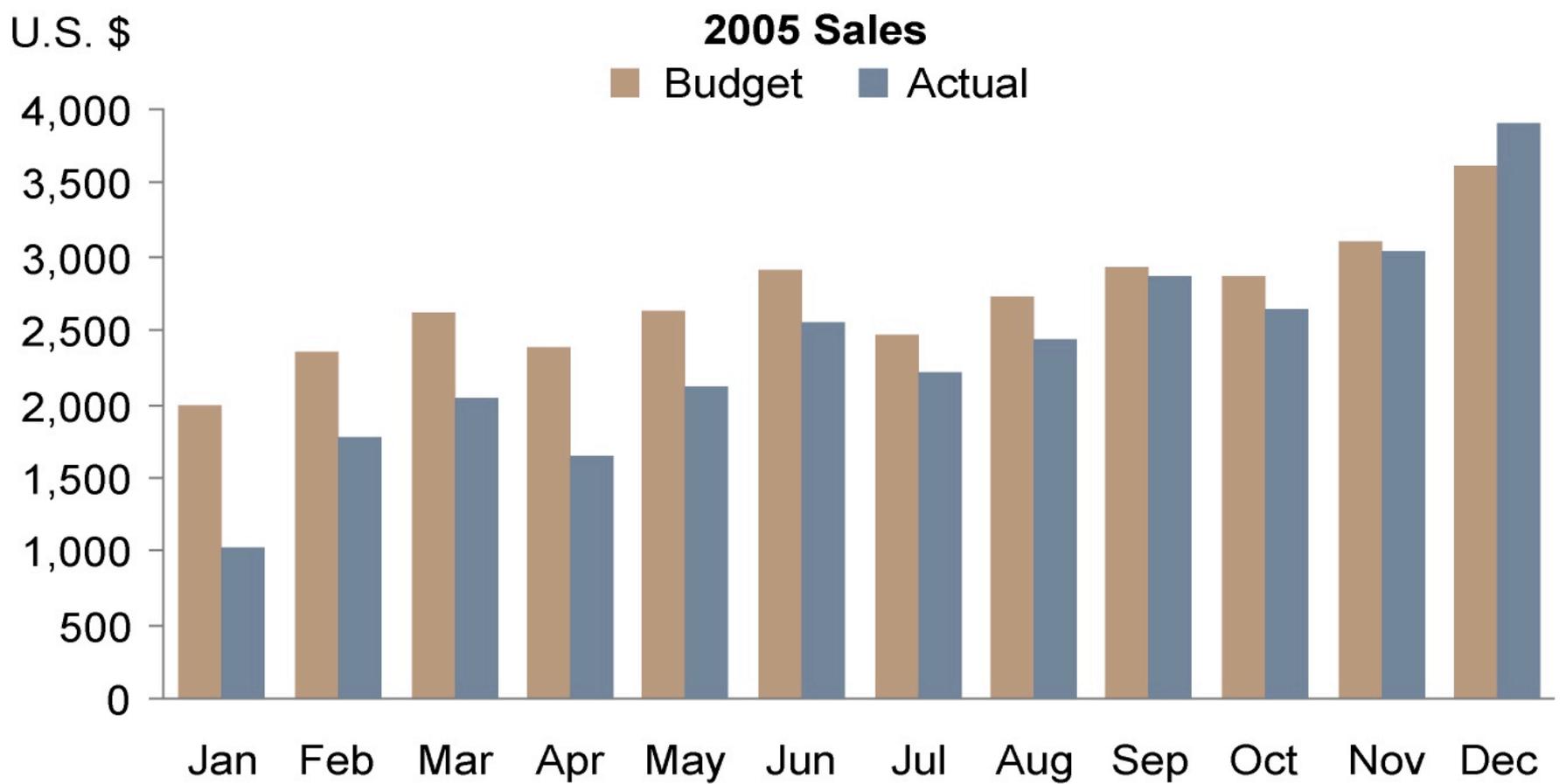


Quantitative messages always feature relationships. Each of these graphs illustrates a different type of quantitative relationship. Just as in life in general, the interesting and important content of a graph always involves relationships.

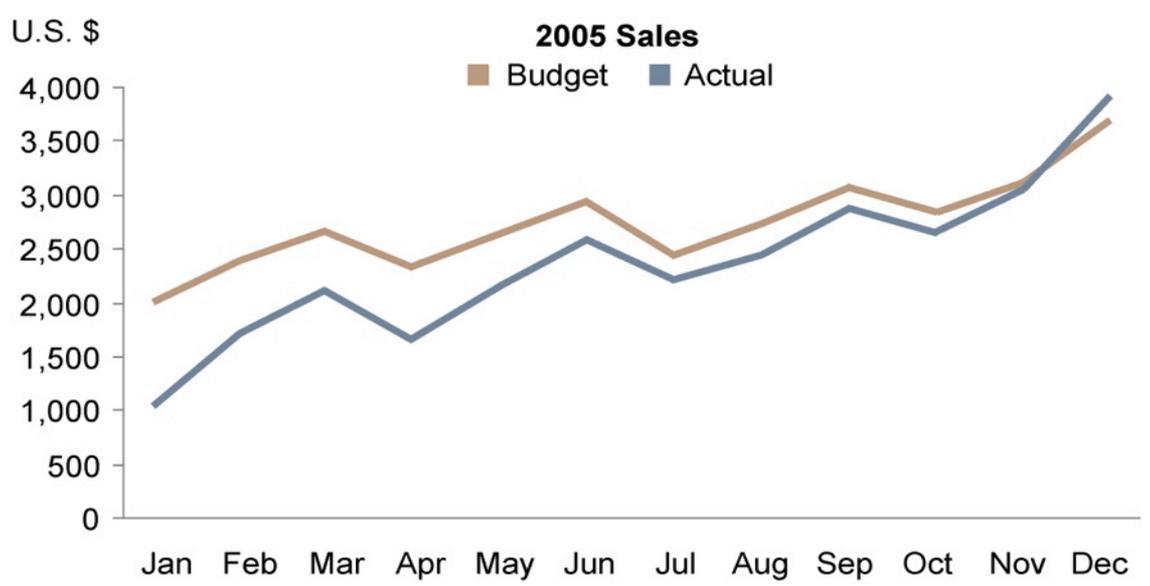
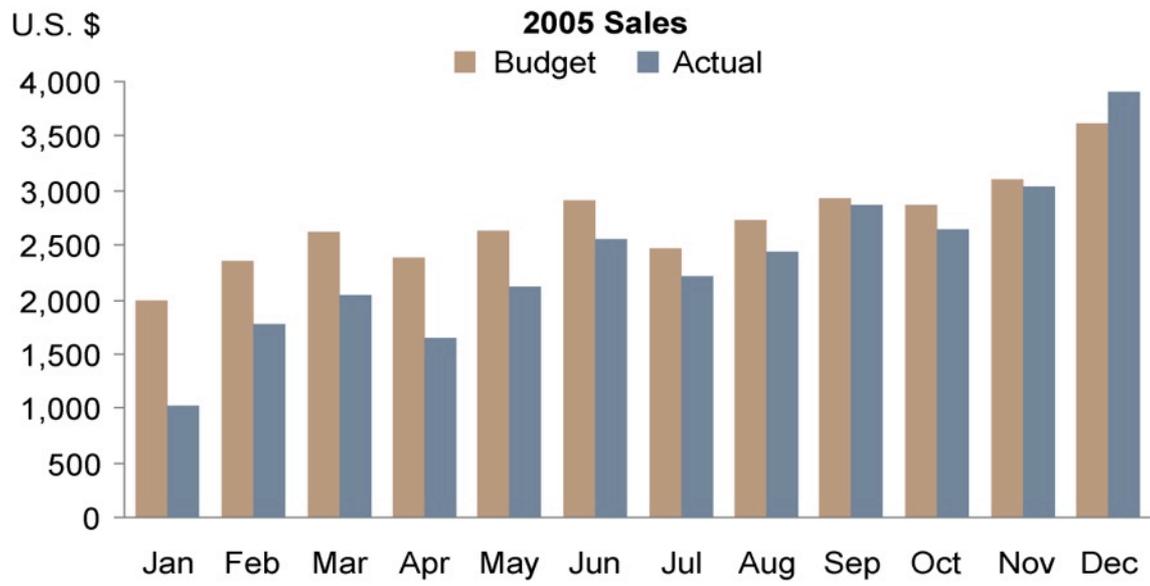
Time Series



A time-series graph has a categorical scale that represents time, subdivided into a particular unit of time, such as years, quarters, months, days, or even hours. These graphs provide a powerful means to see patterns in the values as they march through time.



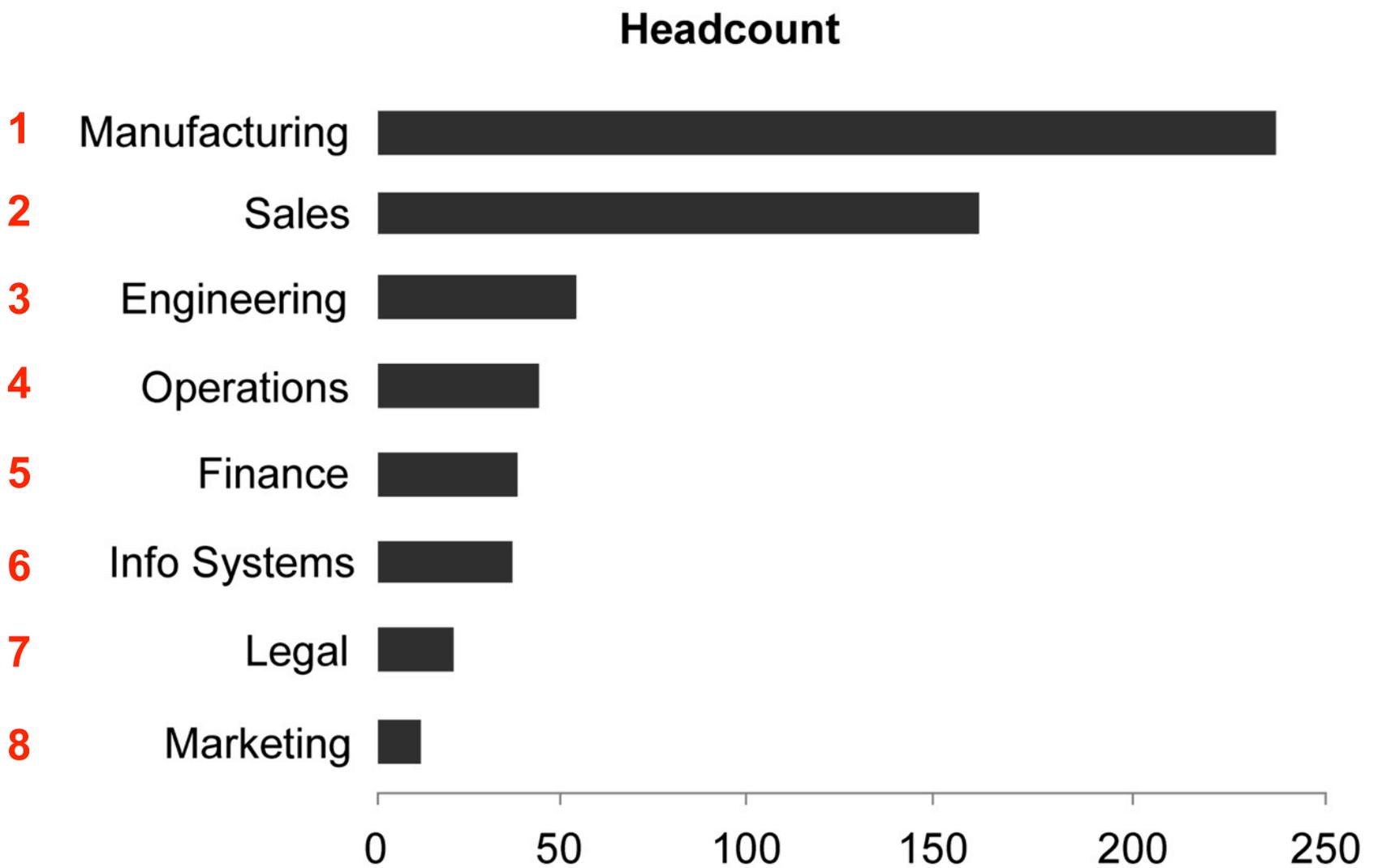
Could this pattern of change be displayed more clearly? Here's an attempt to display a time-series relationship regarding HIV diagnoses, which works, but the trend and patterns could be much more clearly displayed.



Bars and lines tell time differently. Here's the same exact data presented in two ways: to top graph uses bars and the bottom graph uses a line. Which displays the shape of change through time more clearly?

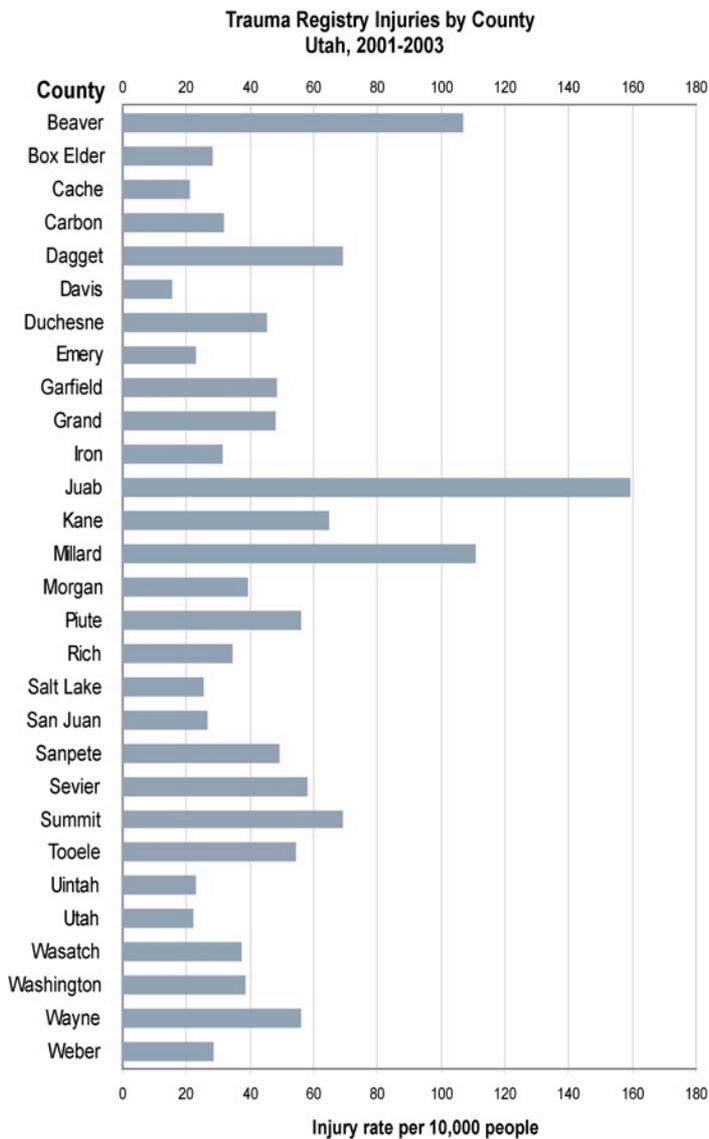
Bars work well for comparing individual values to one another, but lines show the shape of change through time much more clearly.

Ranking

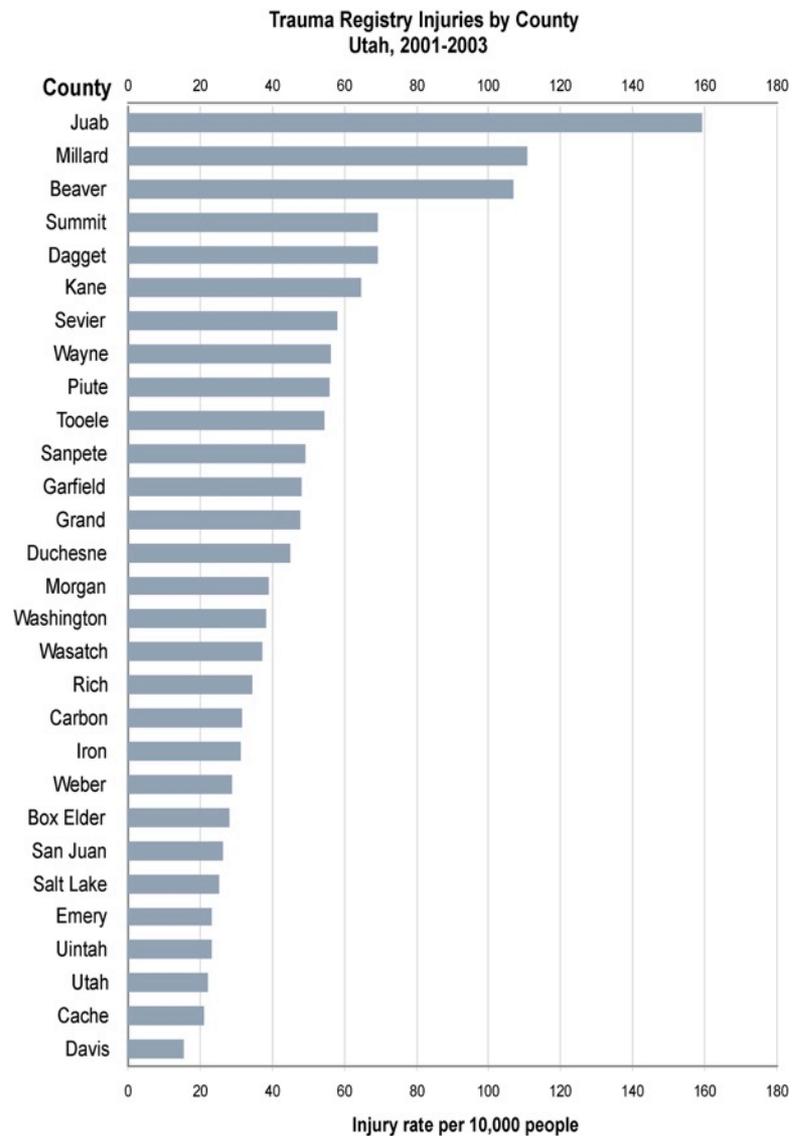


Ranking graphs show the sequence of a series of categorical subdivisions, based on the measures associated with them.

Unsorted



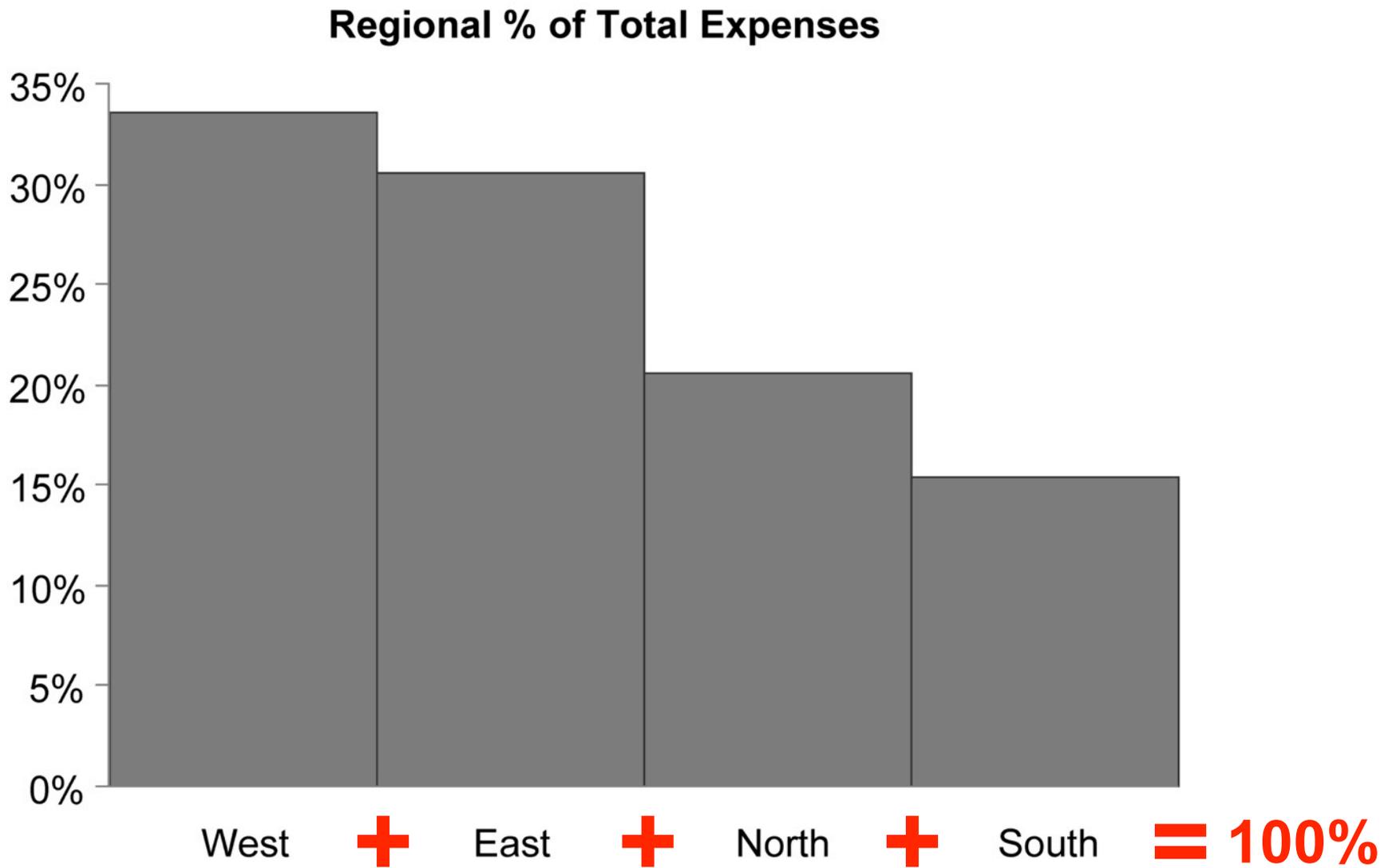
Sorted



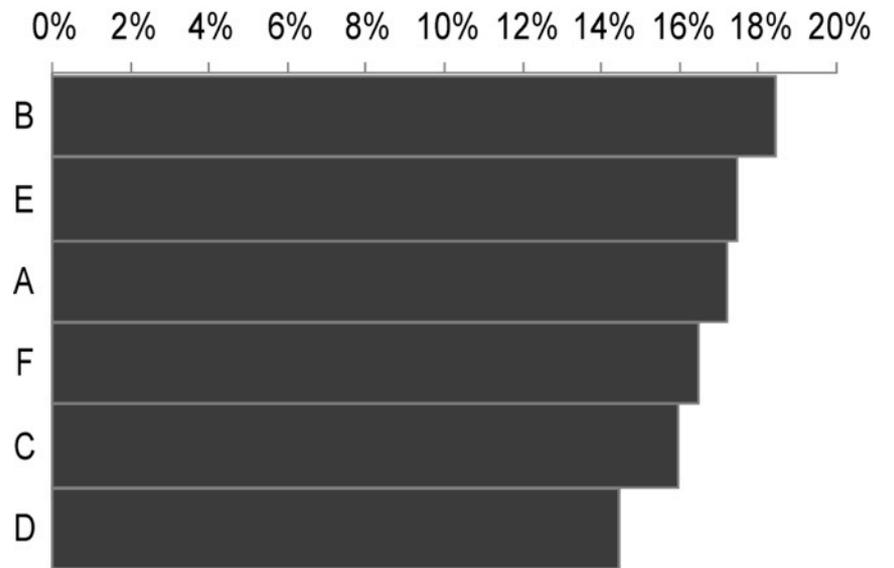
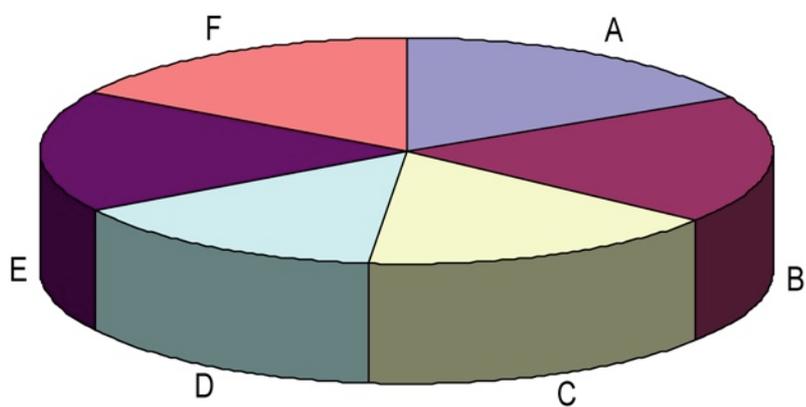
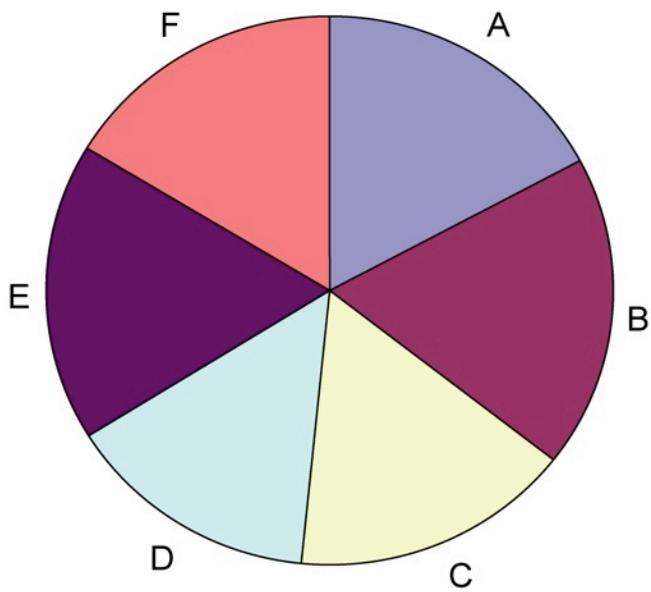
A simple sort adds meaning and clarity. In the display of trauma registry injuries by county on the left, notice how difficult it is to compare the values and to get a sense of rank when they aren't sequenced by size.

The same information is displayed on the right, this time with the counties arranged by the number of injuries. If the purpose of the display is to look up individual values, which is the only thing that alphabetical order supports, a table would work much better. The ranking display on the right, however, tells a useful story.

Part-to-Whole



A part-to-whole graph shows how the measures associated with the individual categorical subdivisions of a full set relate to the whole and to one another.



Pie charts use 2-D areas and the angles formed by slices to encode quantitative values. Unfortunately, our perception of 2-D areas and angles as measures of quantity is poor.

Since all graphs have one or more axes with scales, there must be one on a pie chart, but where is it? The circumference of the circle is where its quantitative scale would appear, but is rarely shown.

Try using either one of the pie graphs to put the slices in order by size. Can't do it, can you? Now see how easy this is to do when the same data is encoded in a bar graph.

Save the pies for dessert!



Coda Hale once expressed his opinion of pie charts quite colorfully:

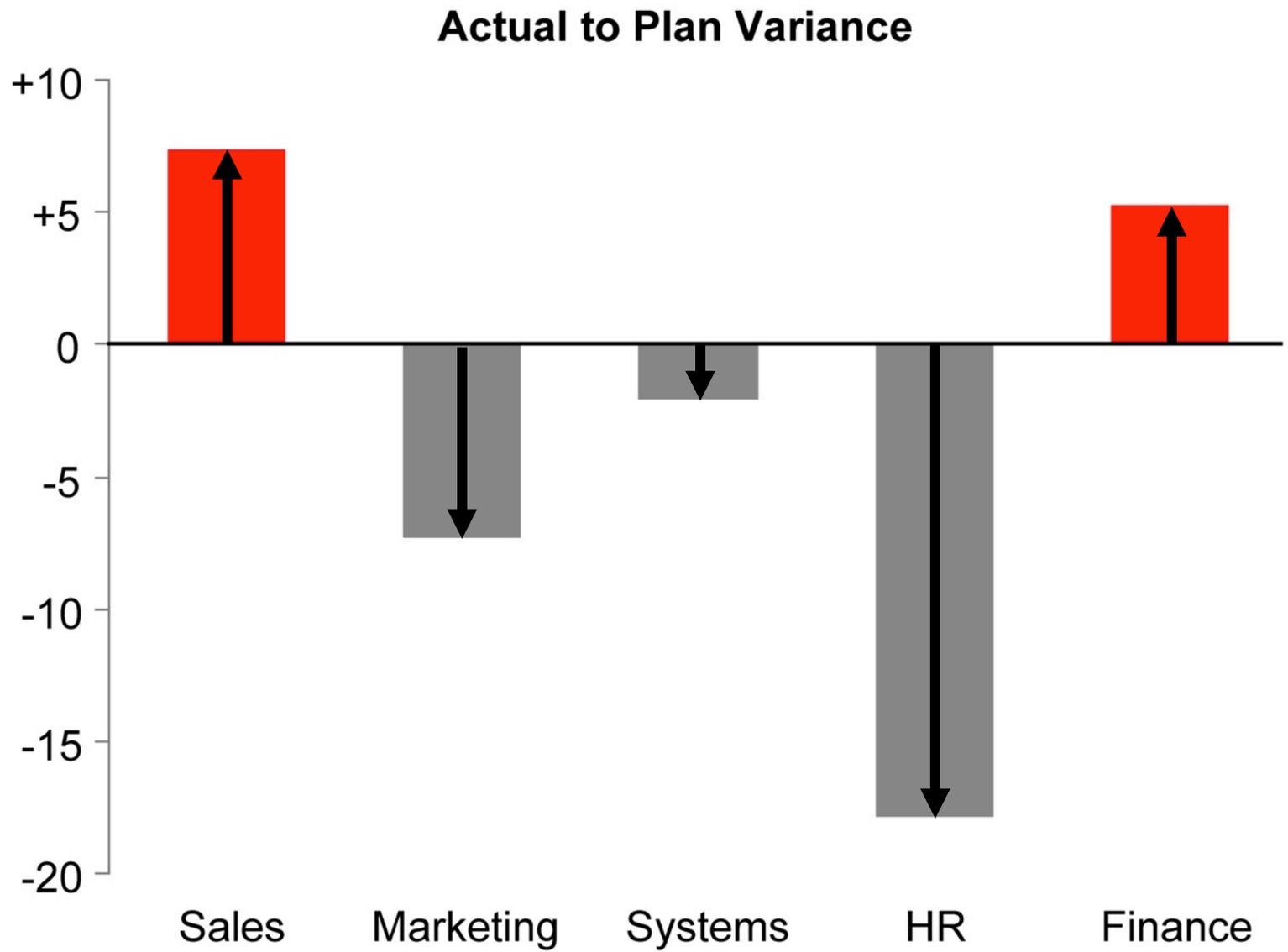
Pie charts are the information visualization equivalent of a roofing hammer to the frontal lobe...[Piecharts] have no place in the world of grownups, and occupy the same semiotic space as short pants, a runny nose, and chocolate smeared on one's face. They are as professional as a pair of assless chaps. Anyone who suggests their use should be instinctively slapped.

For more information about pie charts, read my article "Save the Pies for Dessert."

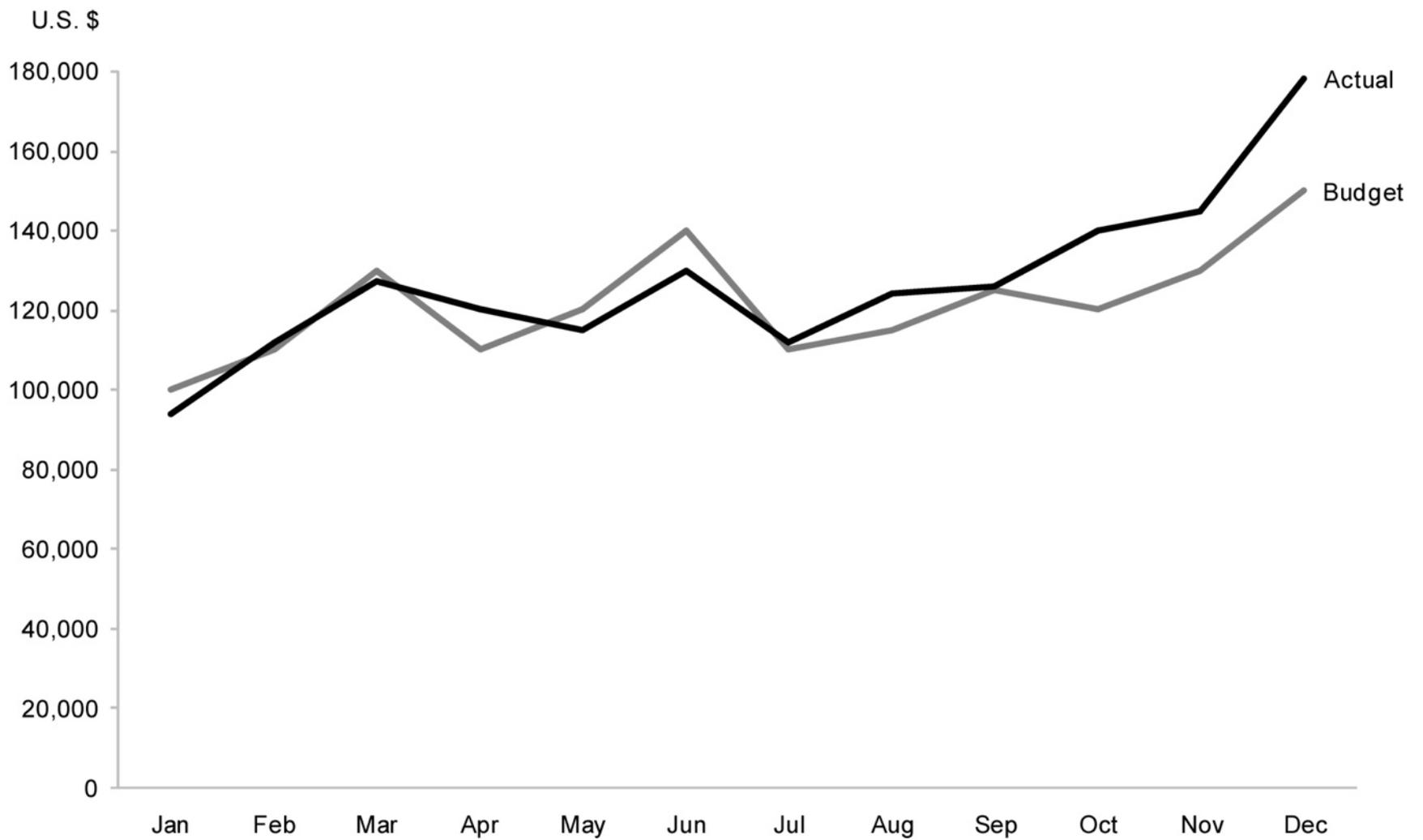


And just in case you're wondering, donut charts aren't any better than pies. Both are high in calories but low in nutrition.

Deviation



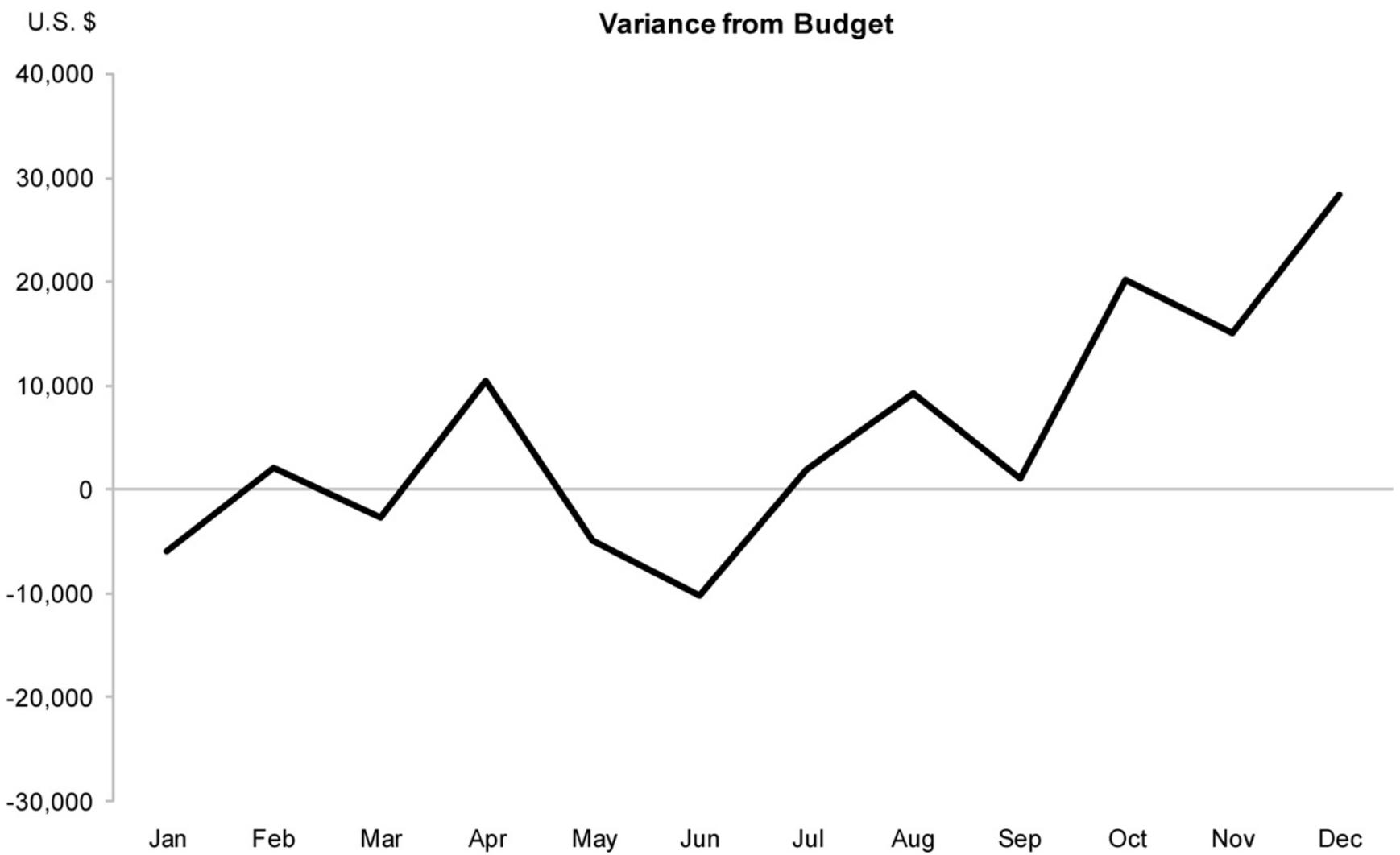
A deviation graph shows how one or more sets of values differ from a reference set of values.



Don't force people to calculate difference in their heads.

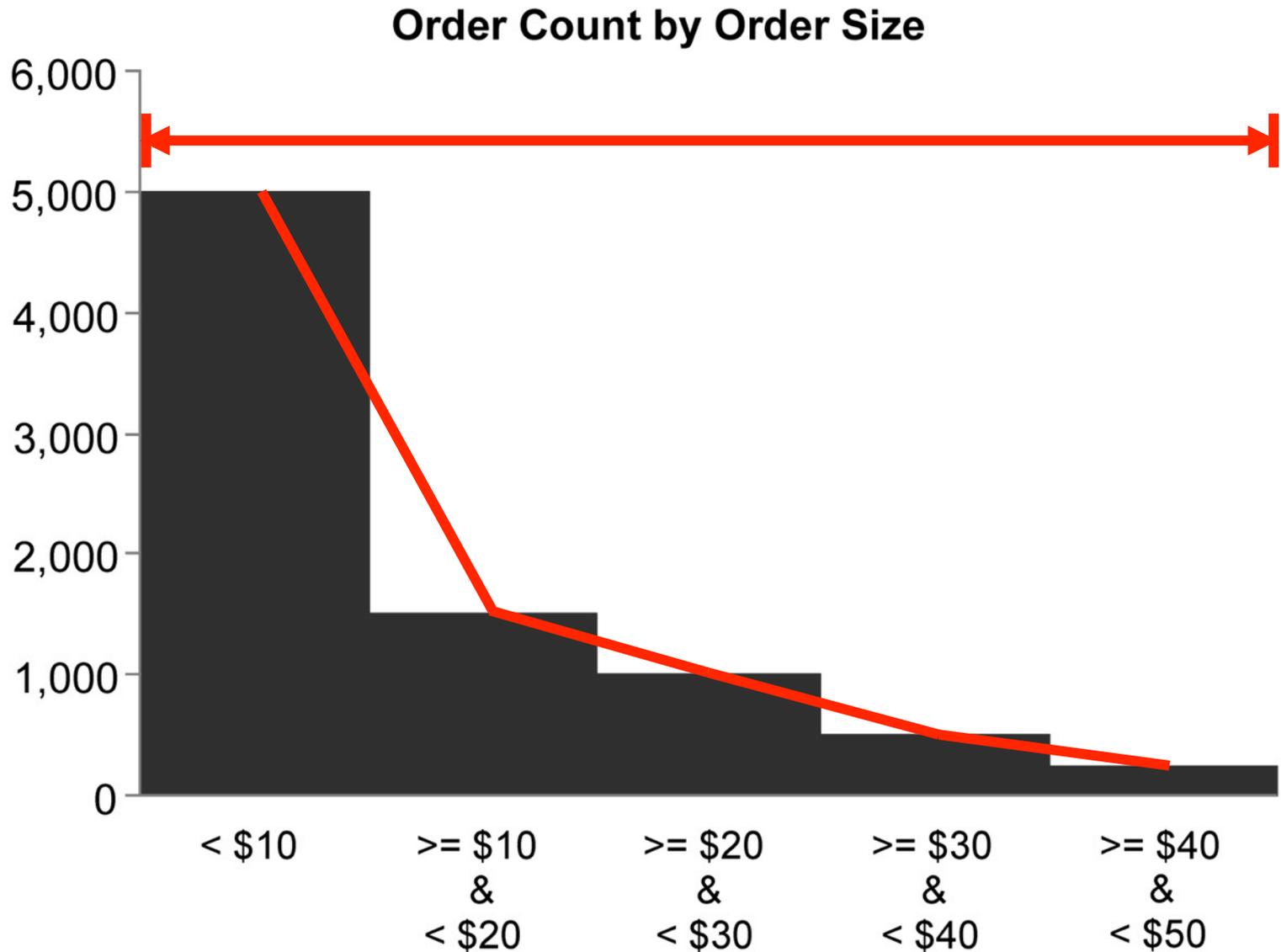
When people primarily need to see the differences between things, show them the difference directly, rather than showing them the two sets of values and forcing them to construct a new picture in their heads of how they differ.

The differences between the actual and budgeted expenses in this graph aren't shown directly in this graph,...



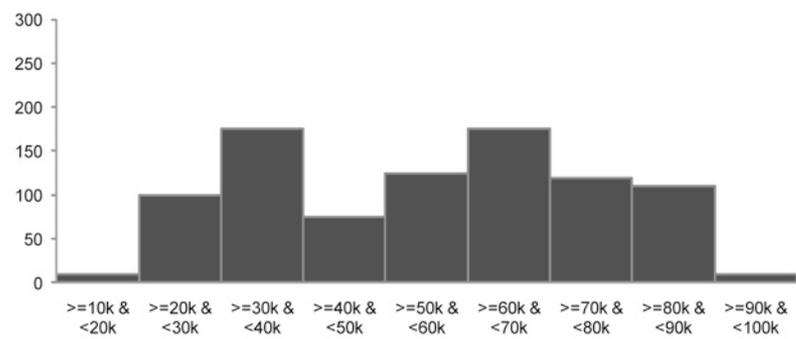
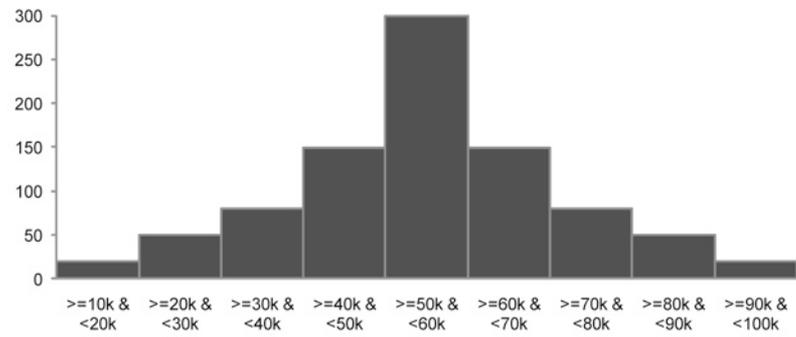
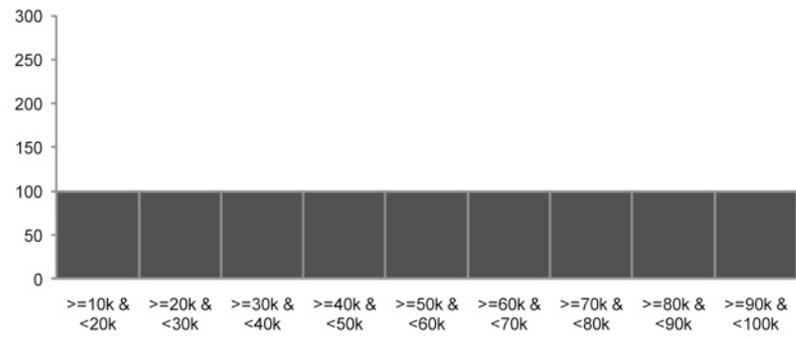
...but this graph directly expresses how actual expenses varied from the budget in positive and negative dollars.

Distribution



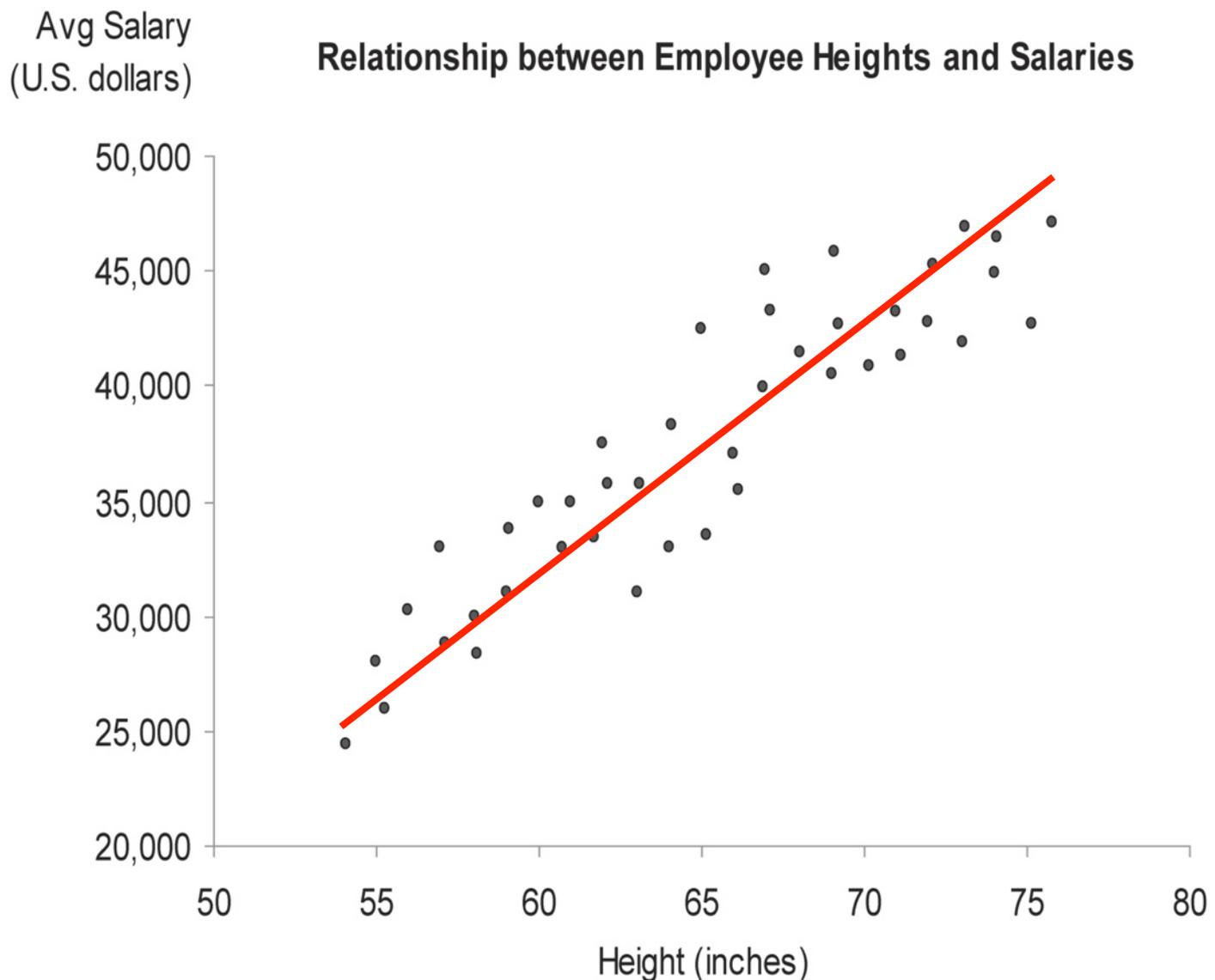
This type of distribution graph, called a frequency distribution, shows the number of times something occurs across consecutive intervals of a larger quantitative range. In a frequency distribution, a quantitative scale (in this case the range of dollar values of orders) is converted to a categorical scale by subdividing the range and giving each of the subdivisions a categorical label (“< \$10”, and so on).

Average Salary = \$55,000

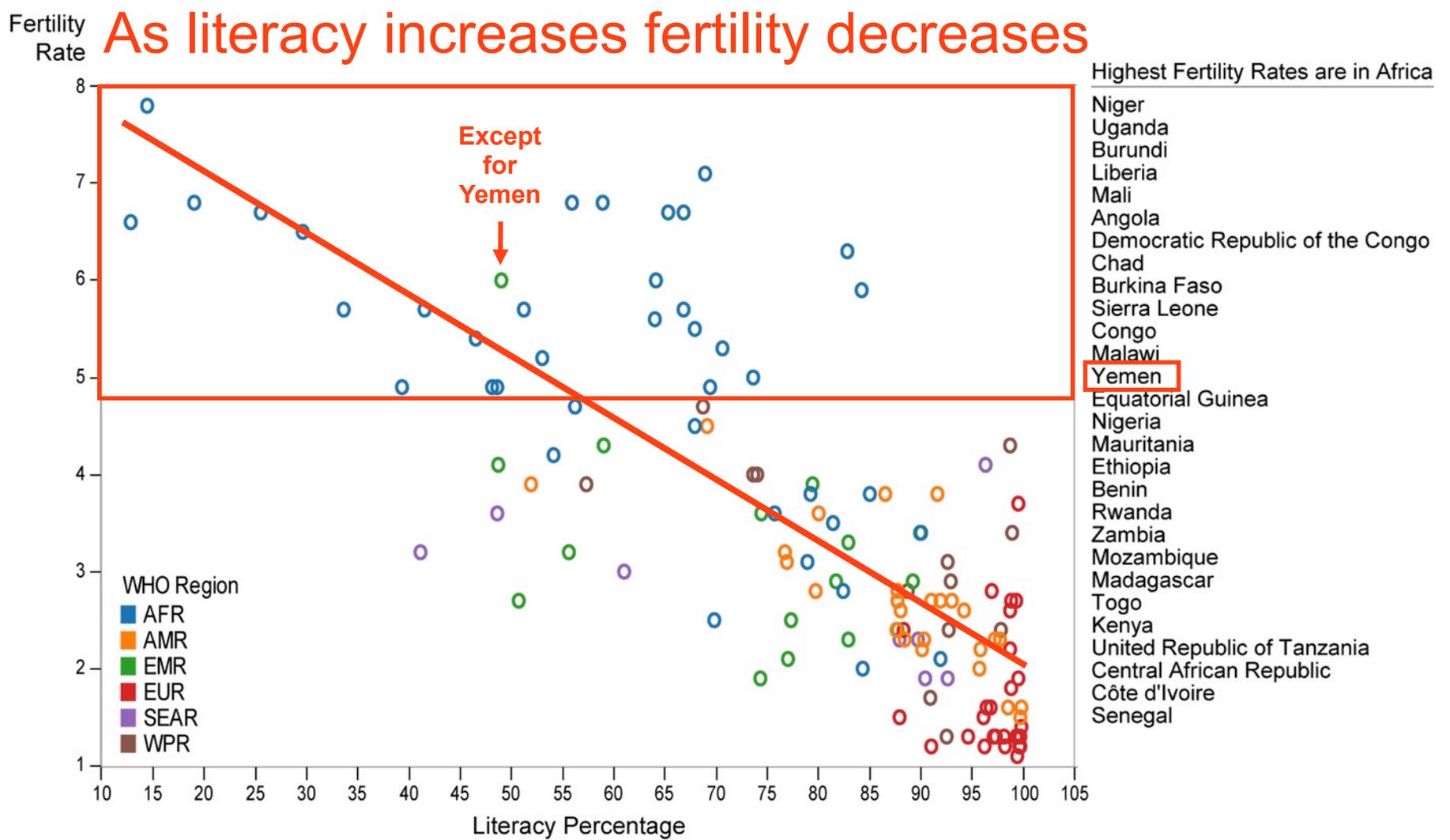


If you only examine and present distributions as a measure of average (mean or median), you're missing much of the story. Notice here that an average salary in this company of 900 employees can be distributed across the salary range in many ways.

Correlation



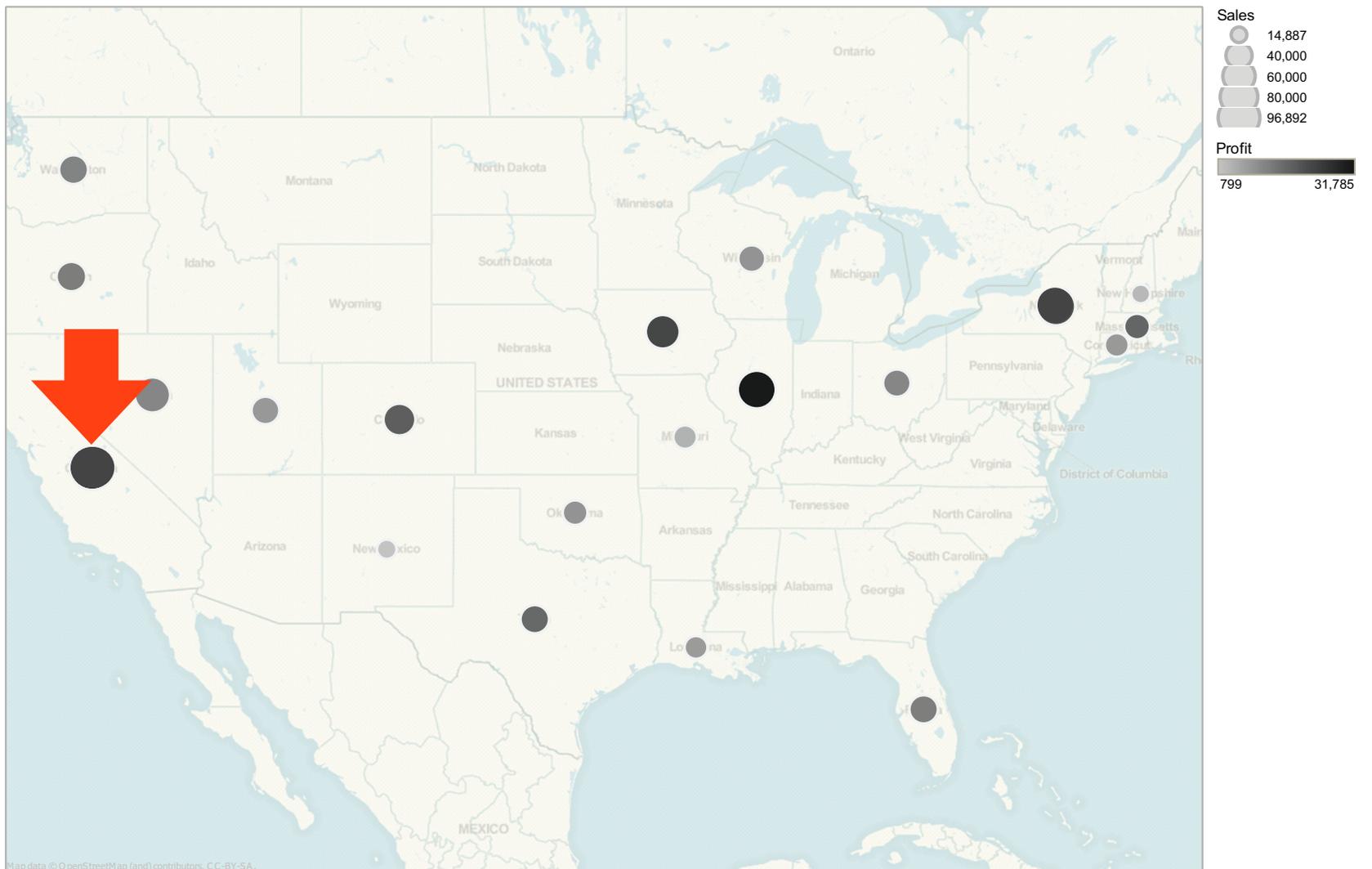
A correlation graph shows whether two paired sets of measures vary in relation to one another, and if so, in which direction (positive or negative) and to what degree (strong or weak). If the trend line moves upwards, the correlation is positive; if it moves downwards, it is negative. A positive correlation indicates that as the values in one data set increase, so do the values in the other data set. A negative correlation indicates that as the values in one data set increase, the values in the other data set decrease. In a scatter plot like this, the more tightly the data points are grouped around the trend line, the stronger the correlation.



I don't run across many correlation displays that are used for business analysis. This is a shame, because correlations can reveal important information about the causes of things. Unless we understand causation, we can't change what's happening.

This example, based on WHO data, explores the correlation between adult literacy and fertility rate by country. A correlation clearly exists: higher literacy corresponds to lower rates of fertility. It is also clear from this display that the highest rates of fertility all occur in Africa (the blue circles), with the one exception of Yemen (the one green circle at the high end of fertility).

Geospatial



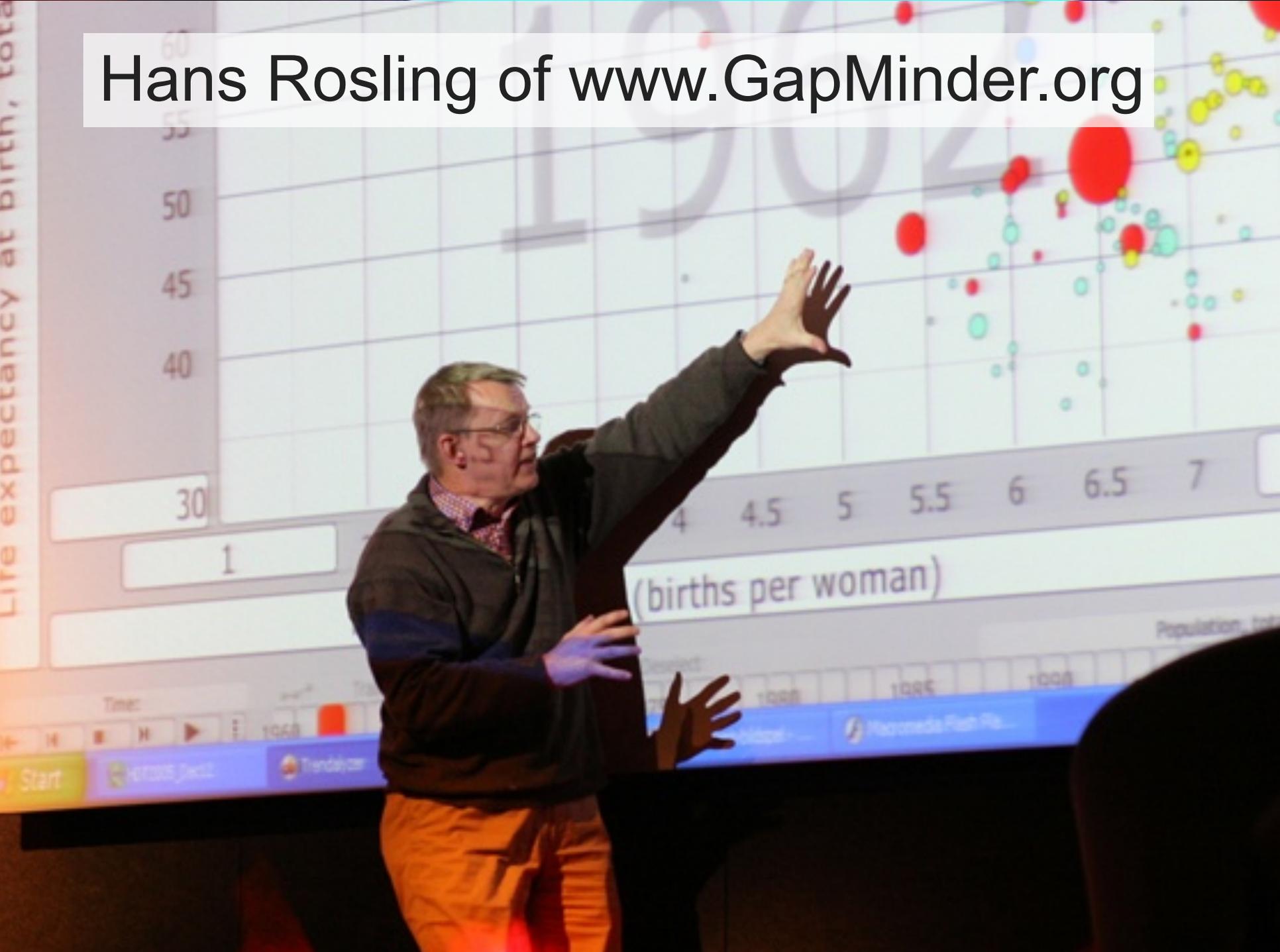
A geospatial display shows the locations of values, which is useful when geography is relevant to the story that you're telling.

Seven common relationships in graphs

- Time-series
- Ranking
- Part-to-whole
- Deviation
- Distribution
- Correlation
- Geospatial

Every quantitative story involves one or more of these fundamental relationships, these comparisons between numbers. Fortunately, the skills required to tell these stories clearly are easy to learn.

Hans Rosling of www.GapMinder.org



Few people tell quantitative stories as compellingly as Hans Rosling. When he spoke at the TED Conference (Technology, Entertainment, and Design) for he first time in 2006, it was perhaps the first time in history that a large audience of people found themselves on the edge of their seats watching a bubble plot.

Wisdom

Knowledge

Information

Information cannot speak for itself. It needs our help. It relies on us to give it a voice. When we do, information can tell its story, and will thus become knowledge. The ultimate goal, however, isn't knowledge; it is wisdom. Knowledge becomes wisdom when it is used to do something good. Only when we use what we know to make the world a better place has information served its purpose and we have done our job.

Our networks are awash in data. A little of it is information. A smidgen of this shows up as knowledge. Combined with ideas, some of that is actually useful. Mix in experience, context, compassion, discipline, humor, tolerance, and humility, and perhaps knowledge becomes wisdom.

Turning Numbers into Knowledge, Jonathan G. Koomey, 2001, Analytics Press: Oakland, CA page 5, quoting Clifford Stoll.



***O perpetual revolution of configured stars,
O perpetual recurrence of determined seasons,
O world of spring and autumn, birth and dying!
The endless cycle of idea and action,
Endless invention, endless experiment,
Brings knowledge of motion, but not of stillness;
Knowledge of speech, but not of silence;
Knowledge of words, and ignorance of The Word.
All our knowledge brings us nearer to our ignorance,
All our ignorance brings us nearer to death,
But nearness to death no nearer to God.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?***

Excerpt from *The Rock*, 1934, T.S. Elliot

[Image source: www.irishastronomy.org]



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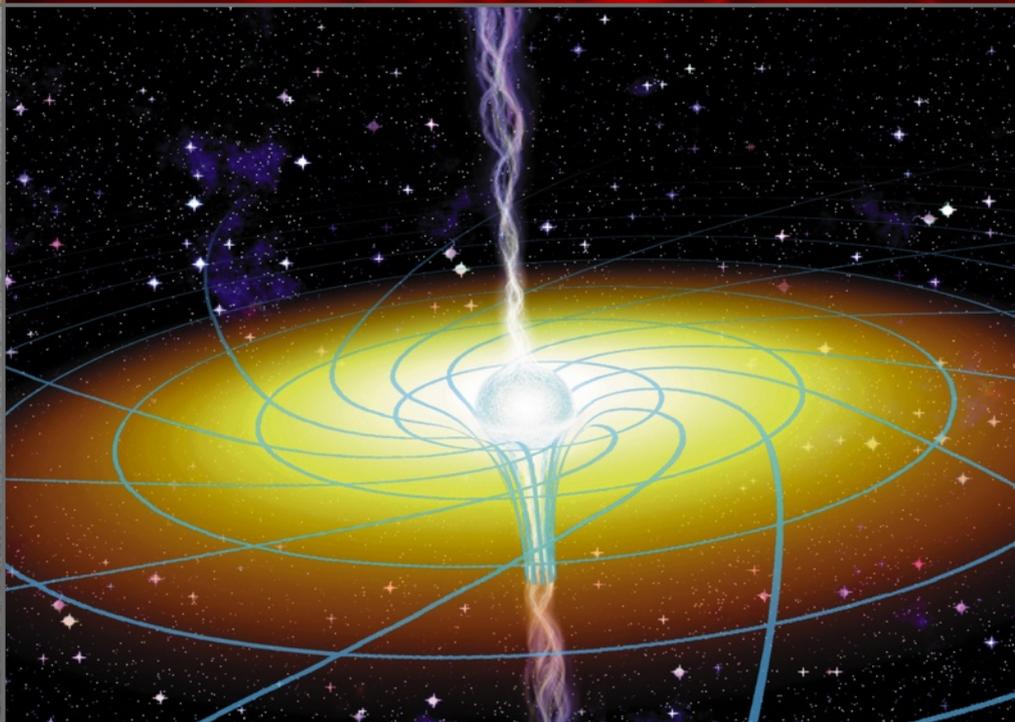
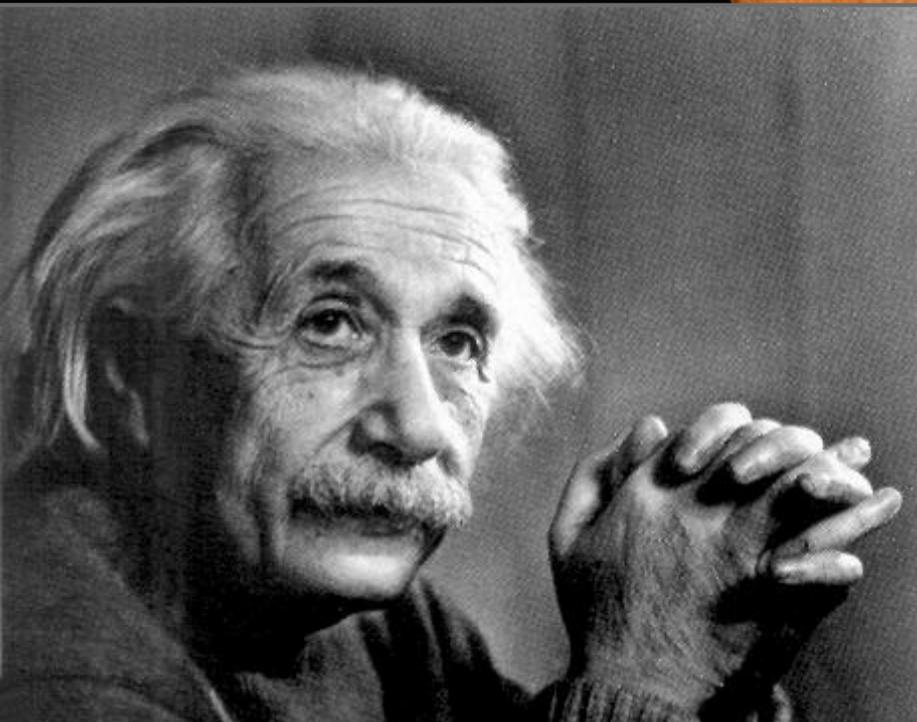
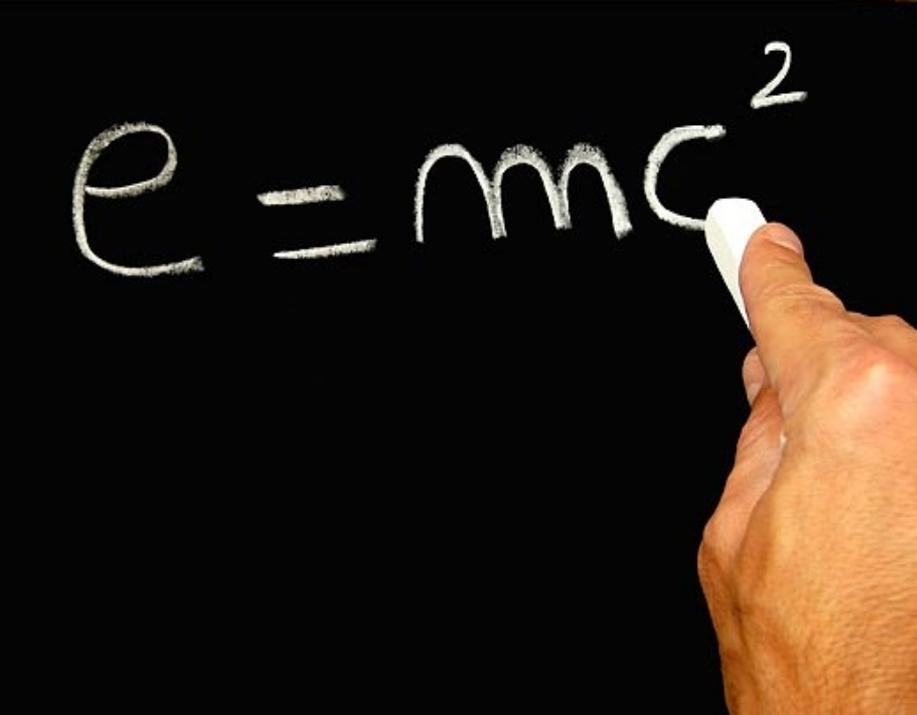
[Image source: www.trekvisual.com]



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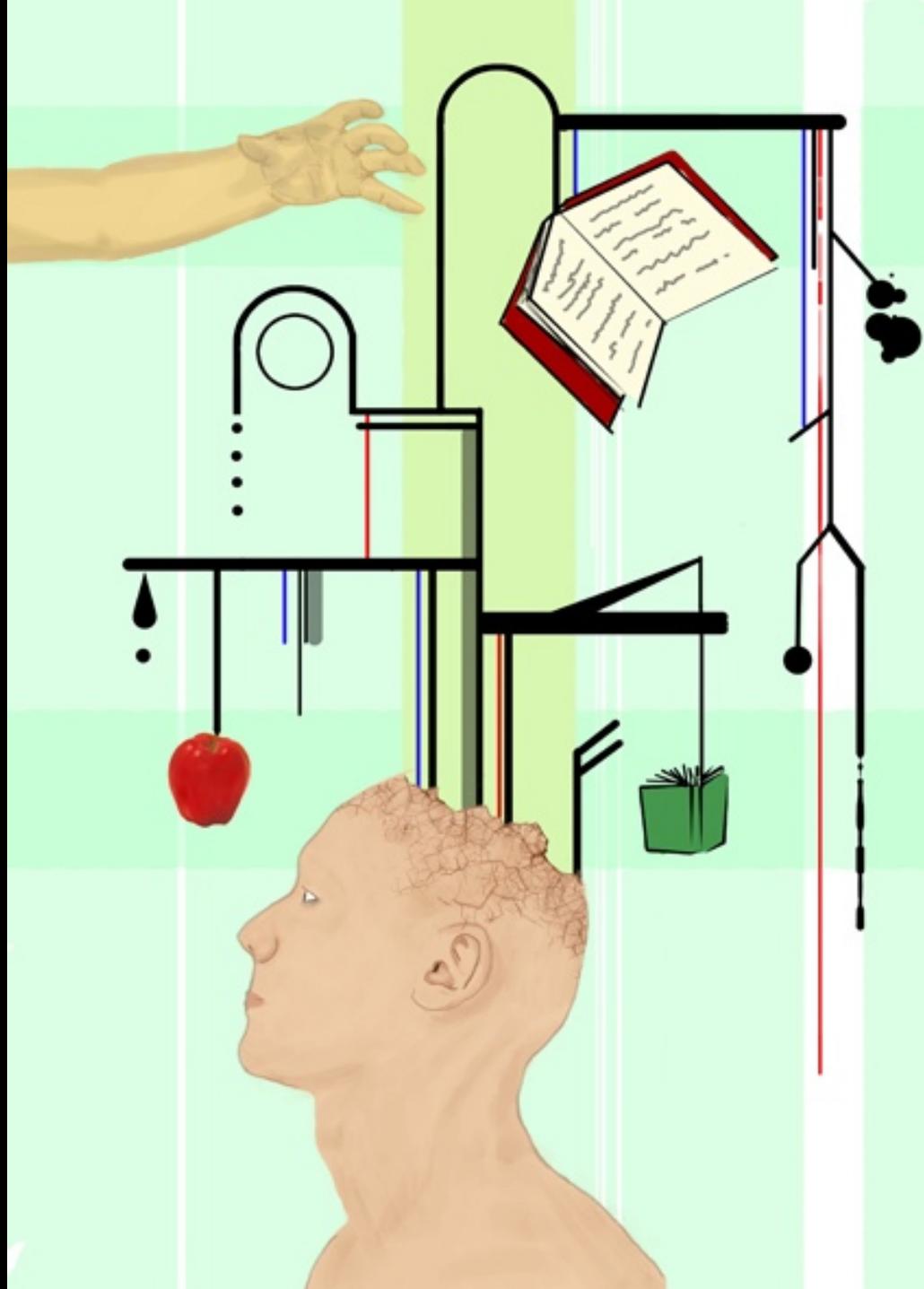
Truth



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[Image source: www.shepherdpics.com]



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[Image source: www.i163.photobucket.com]

The value of information depends on how it's used.



Use it wisely.

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[Image source: www.jamin.org]