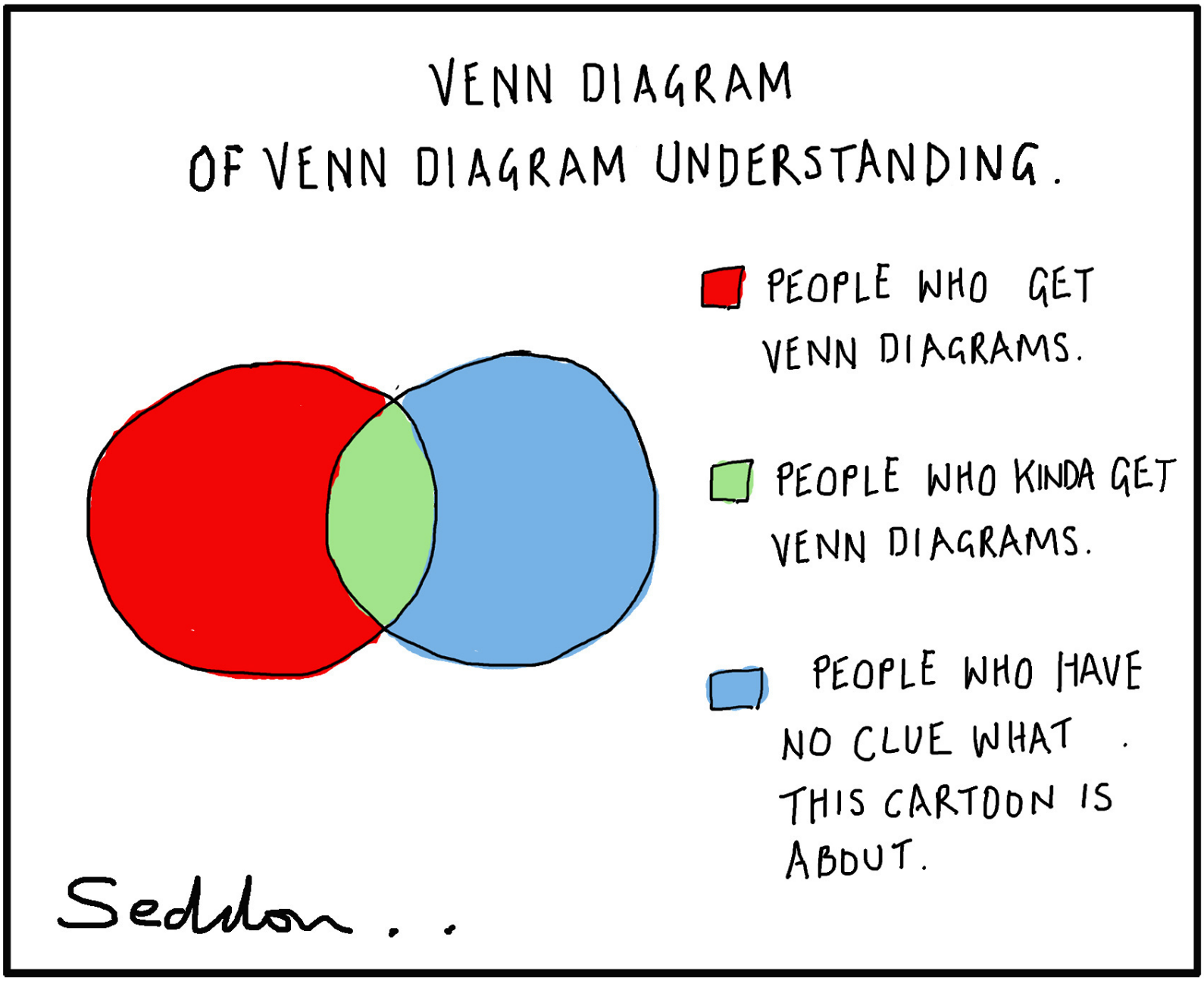


A Guide to Reading Charts

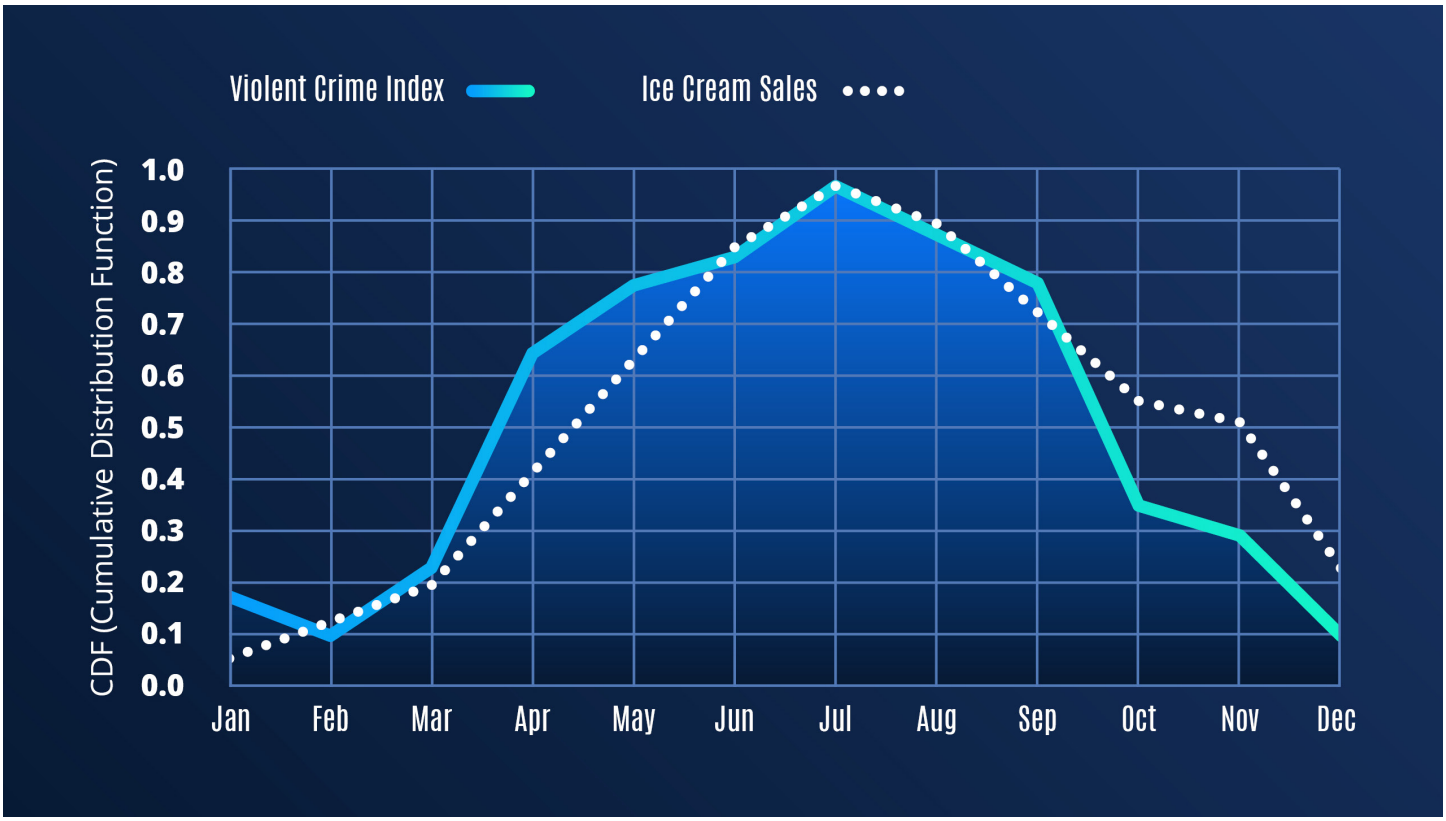
By Marissa Major

Learning to read and evaluate charts is an important skill. This guide will be a useful reference as you encounter different charts in this course.

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Lies and ice cream

There's a common saying in the English language: "There are three kinds of lies: lies, damned lies, and statistics." People have a lot of trust in numbers, but numbers lie — or rather, people can use numbers to lie. They use charts to tell stories that support their point of view. For an example, look at the chart below.



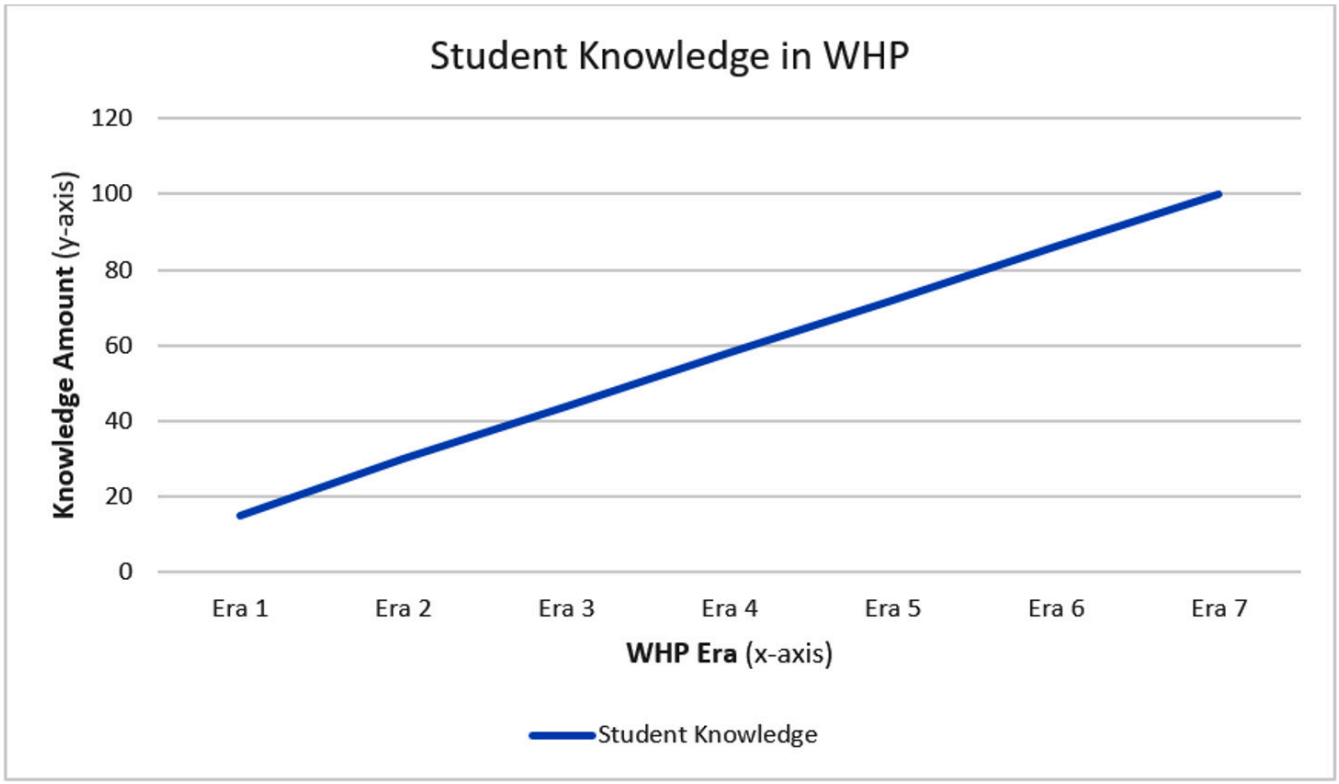
Correlation does not equal causation: violent crime index vs ice cream sales. By WHP, CC BY-NC 4.0.

This chart makes it seem like eating ice cream causes violent crime. But the chart leaves out something important: weather. When it's sunny, people eat more ice cream. And when the nights get warmer, people stay out later and commit more crimes.

A lot of charts are misleading in this way. That's why it's important to learn the difference between the good use of information, and the use of information to support a faulty assertion. This article will guide you through how to start reading and evaluating charts.

The basics

Let's start with the basics: What is a chart? A chart is a way to show data visually. Data refers to pieces of information collected together, such as statistics or facts. Charts use data to illustrate two things. The first is change over time. The second is how two or more "things," or variables, are related to each other. Let's look at an example:

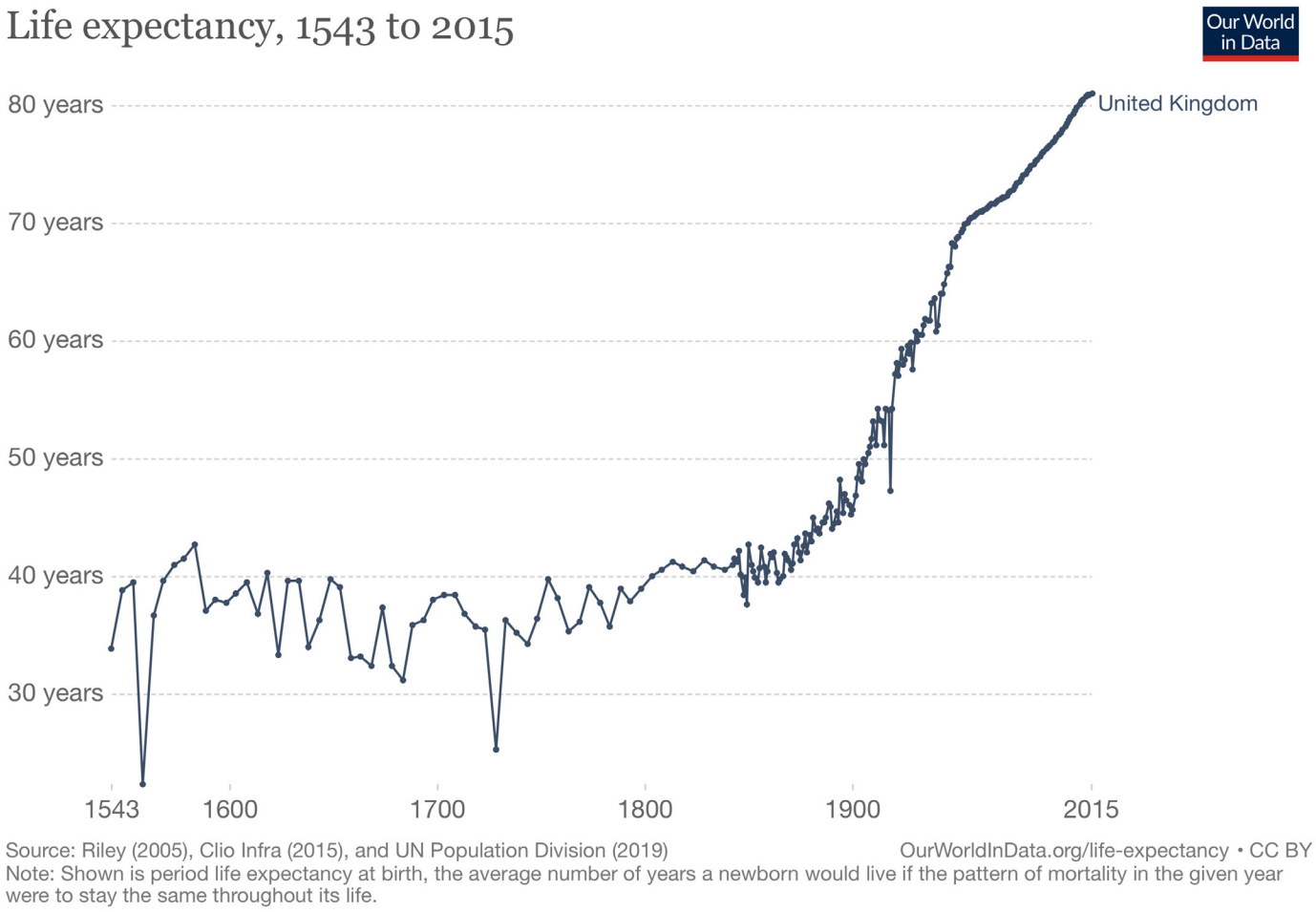


Student knowledge in WHP. By WHP, CC BY-NC 4.0.

This is a line graph. It shows how student knowledge changes as WHP students progress through the course. To start reading a chart, you should first look for a title and any captions that might provide clues. Next, identify what the chart is measuring by looking at the x-axis and y-axis. Both are labeled above. In this chart, the blue line represents the relationship between time (x-axis) and student knowledge (y-axis). The relationship between these two things is measured by a blue line. This chart is arguing that as students move through the course, they gain more knowledge. Do you trust this chart? Where do you think the data came from? (Hint: we totally made it up.)

Variables and scale

The most important part of reading a chart is identifying the variables. Variables are the information in the chart that can change, depending on where you're looking. Look at the line graph on the next page, which is titled "Life Expectancy, 1543 to 2015."



Life expectancy, 1543 to 2015. Explore an interactive version of this chart here: https://ourworldindata.org/grapher/life-expectancy?country=~GBR

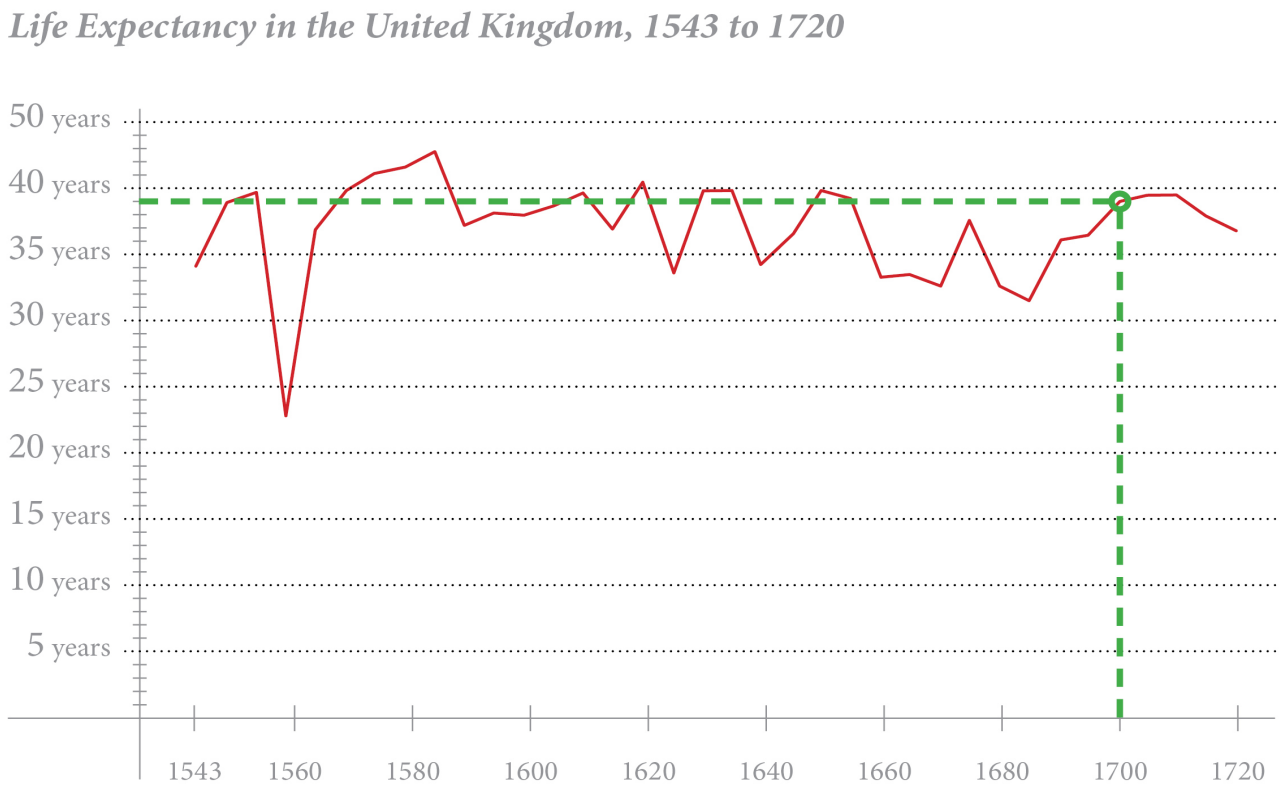
In this chart, there are three variables: life expectancy (y-axis), years (x-axis), and country (the line labeled "United Kingdom"). If you move from left to right in the chart, the year increases. If you move from bottom to top, the life expectancy increases. The jagged line shows the relationship between life expectancy and dates. This line specifically represents changes in life expectancy in the United Kingdom over 500 years. If you view this chart online, you'll see that it is interactive. Click on the link above to add more countries and regions.

We talk about *scale* a lot in WHP. Scale is also an important part of charts. In charts, scale means the range of numbers on either axis. For example, the dates in this chart are provided in years ranging from 1543 to 2015. Changing the scale of a chart can transform its meaning. If you click the link above, you can change the scale of this chart by sliding the range of the blue line. How does this chart look different if you switch scales? Try switching to a 25-year period from 1703 to 1728. How does it look now?

When looking at a chart, you should always begin by identifying titles, variables, and scale. Then, you can start to examine the details.

Points on the graph

The line in the graph above shows how life expectancy changed in the United Kingdom. How do you find what life expectancy was in a specific year? Easy!



Detail from the Life expectancy, 1543 to 2015 chart. By WHP, CC BY-NC 4.0.

If I'm interested in the year 1700, I find that value on the x-axis. Then I follow it straight up (green dotted line) until I hit the line representing the United Kingdom. Next, I determine how high up on the y-axis it lands. I can see it lands at 39 years. So, in the year 1700, the life expectancy in the United Kingdom was 39 years.

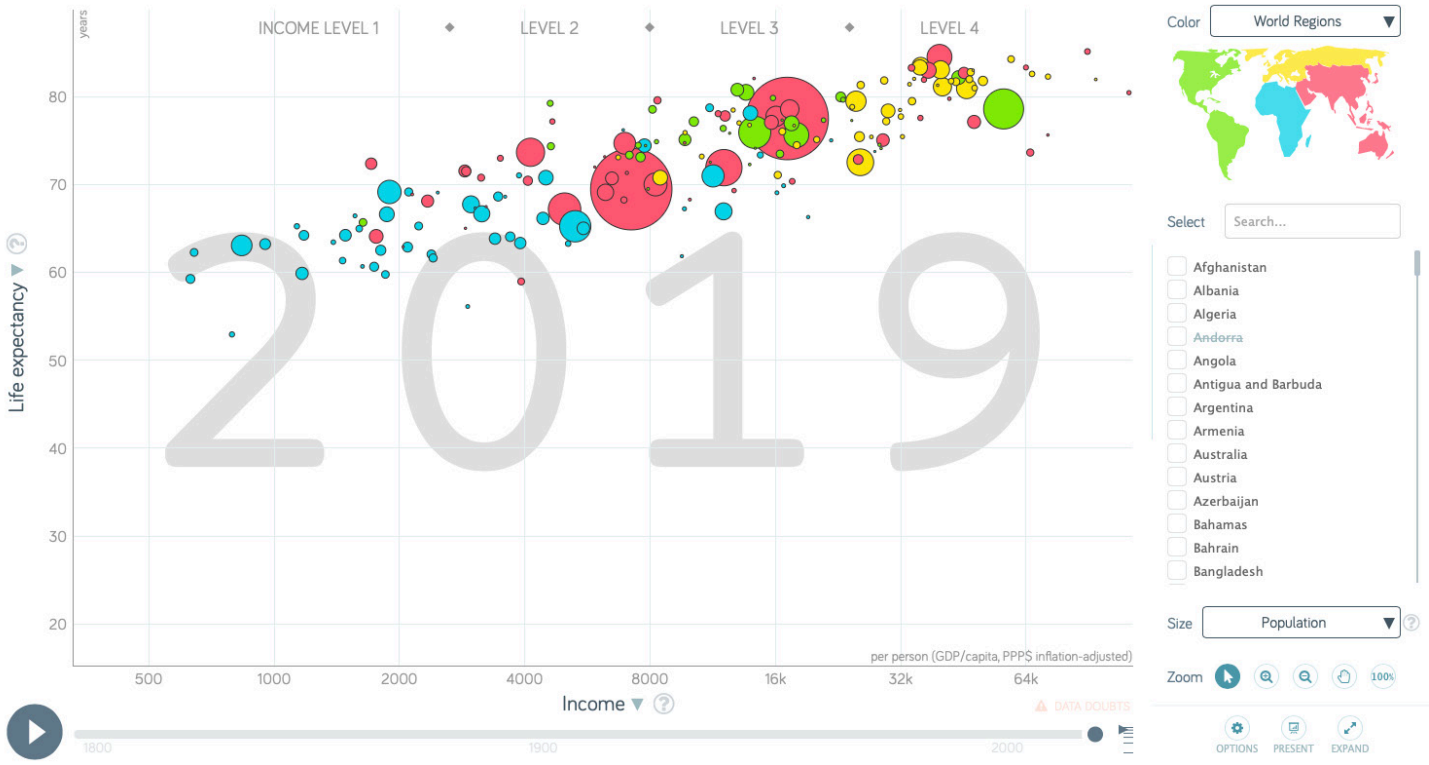
Evaluating charts and data

Often, what's missing from the data is just as important as what's included. The graph above consists of points connected by a line. The points represent the years when data was collected. There are fewer points in the first couple of centuries. What was happening in those years where no data was collected? Was that steep drop around 1550 because of a war or famine? Or was the data collected only from certain regions, where people tended to die younger? We don't have the answers to these questions. So we're missing parts of the story.

Very few societies kept detailed records before the 1800s. When you see charts that go back hundreds or thousands of years, you should always ask where that data came from. Even when looking at very recent data, it's important to ask this question.

Bubble charts

Let's examine two other types of charts that you'll encounter in the course: bubble charts and maps. The bubble chart below also displays data on life expectancy. However, it uses bubbles instead of lines. Bubble charts can include more variables than line charts.



Bubble chart. Explore an interactive version of this chart here: https://www.gapminder.org/tools/#$chart-type=bubbles. By Gapminder, CC BY 4.0

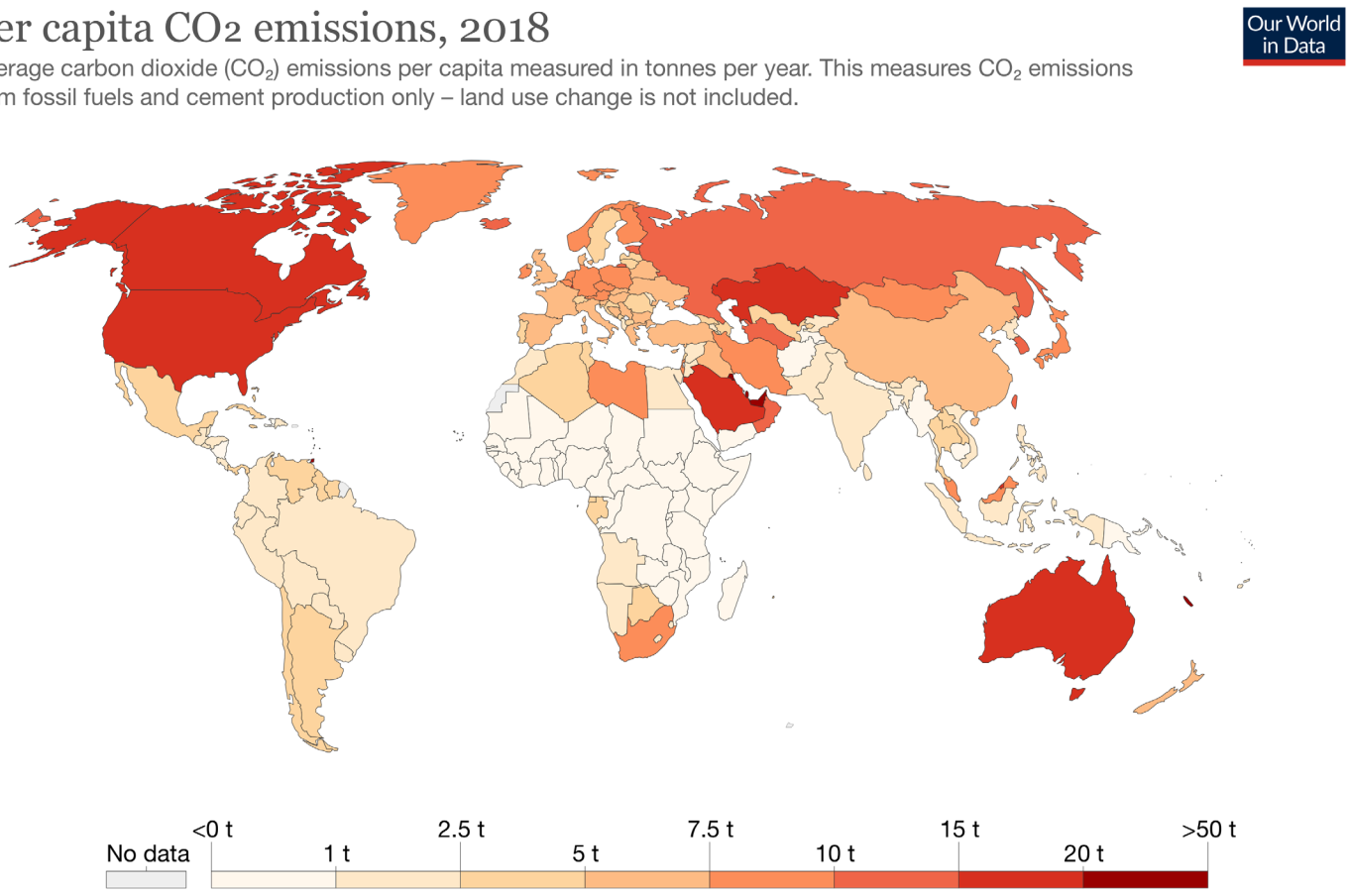
In this chart each bubble represents a country. The bigger the bubble, the larger the country's population. In this image, the chart is paused in the year 2019. There's a "play" button at the bottom that allows you to move through the years from 1800 to 2019. When you press play, the chart changes each year. The bubbles bounce up and down and slowly move toward the upper right corner as life expectancy and national incomes increase. Click the link above and experiment. In addition to changing the year, you can add or remove countries and regions. You can even change the variable that's represented by the bubbles.

In total, the chart has six variables. These are: life expectancy (y-axis), income (x-axis), country (bubbles), population (bubble size), year, and geographic region (bubble color).

Map charts

Now, let's take a look at a different kind of chart: maps. Unlike other charts, maps don't have axes. The principles of reading them are the same, though. You should begin by identifying titles, variables, and scale.

In the chart below, we have three variables: CO2 emissions per capita (represented by color), country, and year. There's a play button and slider on the bottom that lets you adjust the year.



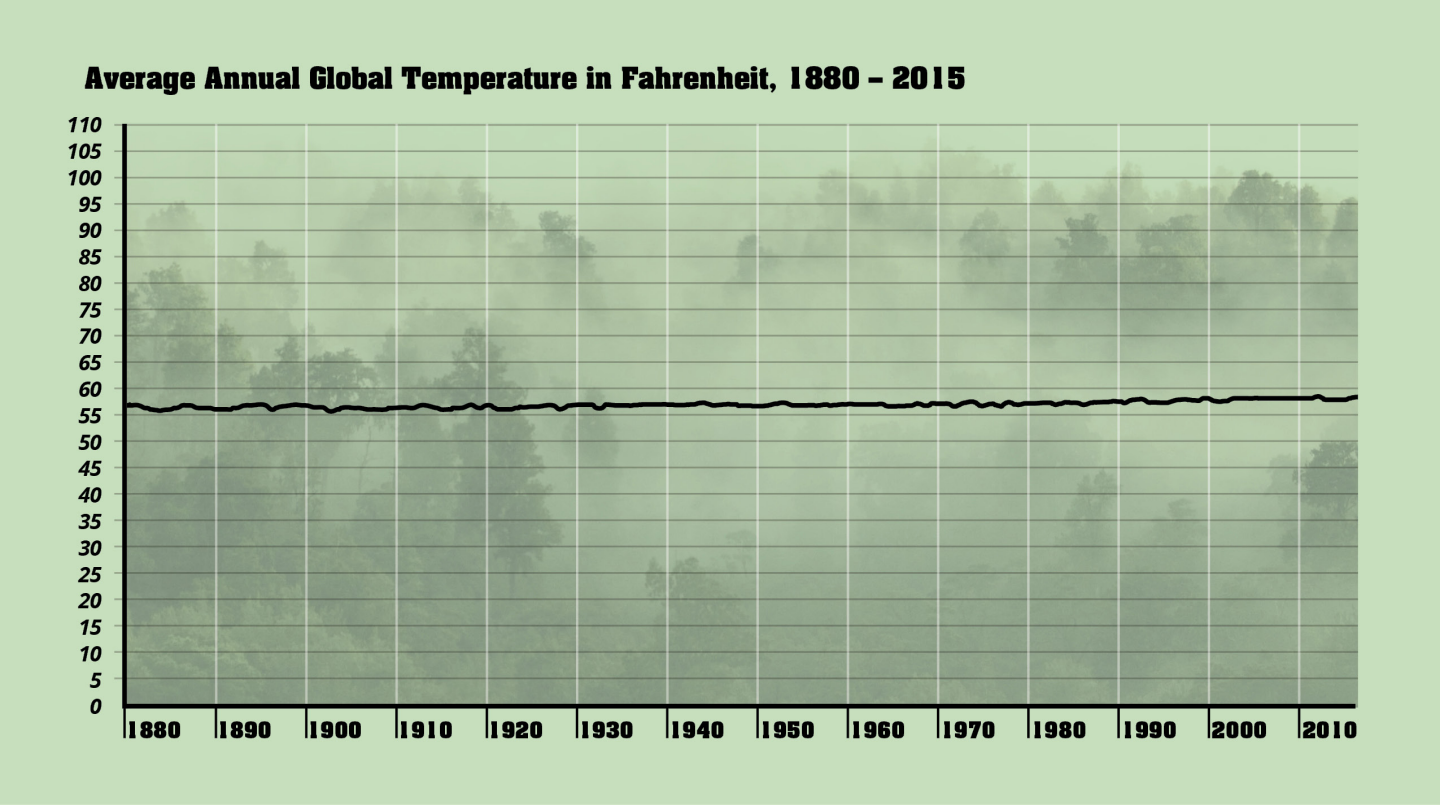
Per capita CO2 emissions, 2018 Explore an interactive version of this chart here: https://ourworldindata.org/grapher/co-emissions-per-capita. By Our World in Data, CC BY 4.0.

Click on the link above to explore this chart. What are some conclusions you can draw by watching the chart change from 1800 to 2017? What parts of the world turn red, and when? You can click on individual countries to display the data as a line graph for that country.

The main takeaway from this map is that global CO2 emissions have risen since 1800, but changes differ between regions. What part of the world produces the most emissions?

Lies and the lying charts that tell them

Charts can be a useful tool for making sense of data. But they can also be misleading. Remember, we started with a chart that seemed to argue that eating ice cream causes crime. Yet really it is warmer weather that leads to an increase in both ice-cream-eating and crime. In that example, a missing variable (weather) caused the confusion. Now, you're going to see an example of how scale can change our understanding of charts.

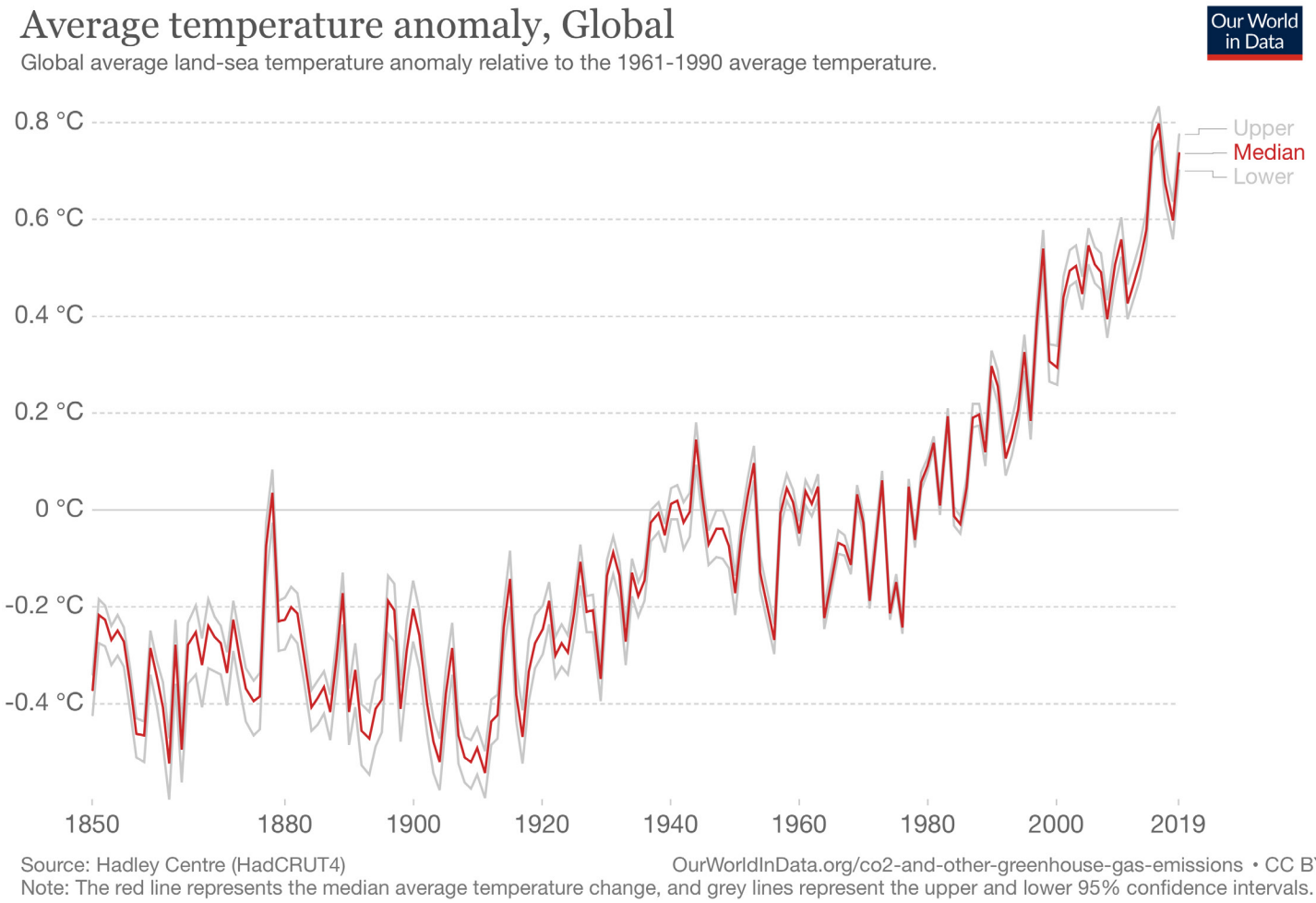


Average annual global temperature in Fahrenheit, 1880-2015. By WHP, CC BY-NC 4.0.

This chart is a line graph. It shows how the global average temperature has changed over time. There are two variables: year and global temperature. Reading this chart might lead you to think that the average global temperature has stayed about the same for the last 150 years. It makes it look like climate change isn't happening. Climate change is the significant change in the climate of Earth over a long period of time.

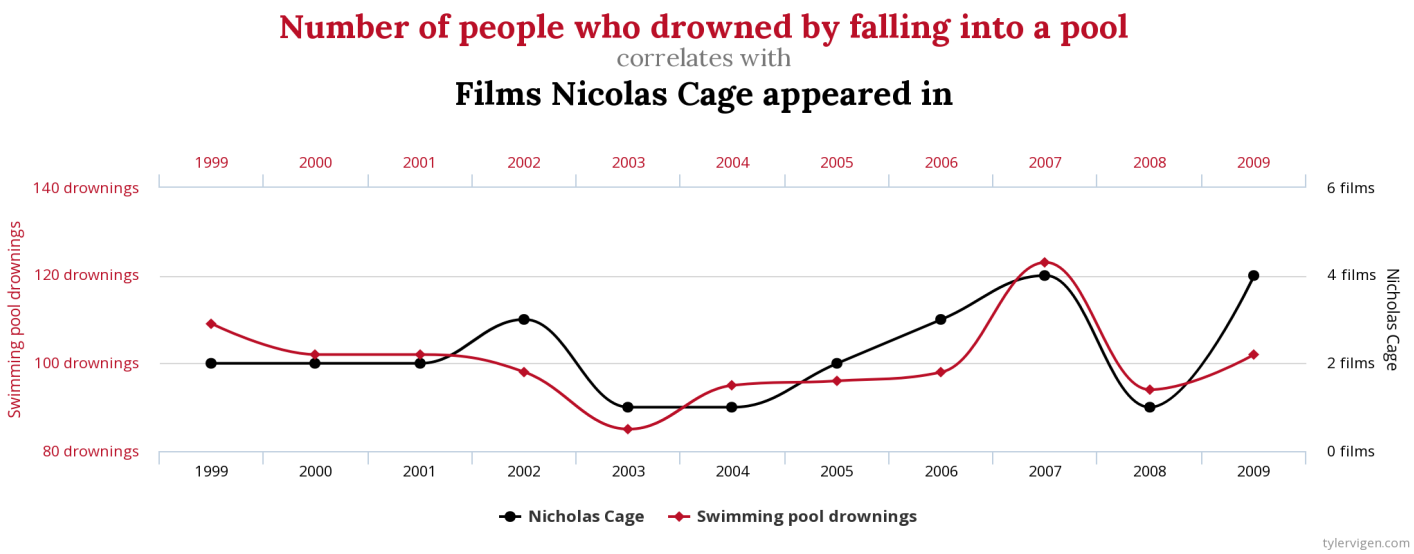
But look, now, at that scale on the y-axis! Those are some big numbers. Climate scientists claim that an increase of only 1 degree on the global average can have catastrophic impacts on weather, sea levels, and ecosystems. The temperature scale on the chart above is so large that we can't really see a change of 1 degree.

Now check out the chart below, which displays almost the same information at a different scale.



Average temperature anomaly, Global. Explore an interactive version of this chart here: https://ourworldindata.org/grapher/temperature-anomaly. By Our World in Data, CC BY 4.0.

The only difference between these two charts is the scale used on the y-axis. The second chart uses a scale that provides a more accurate picture of climate change. This is just one example of how charts can be used to mislead the viewer.

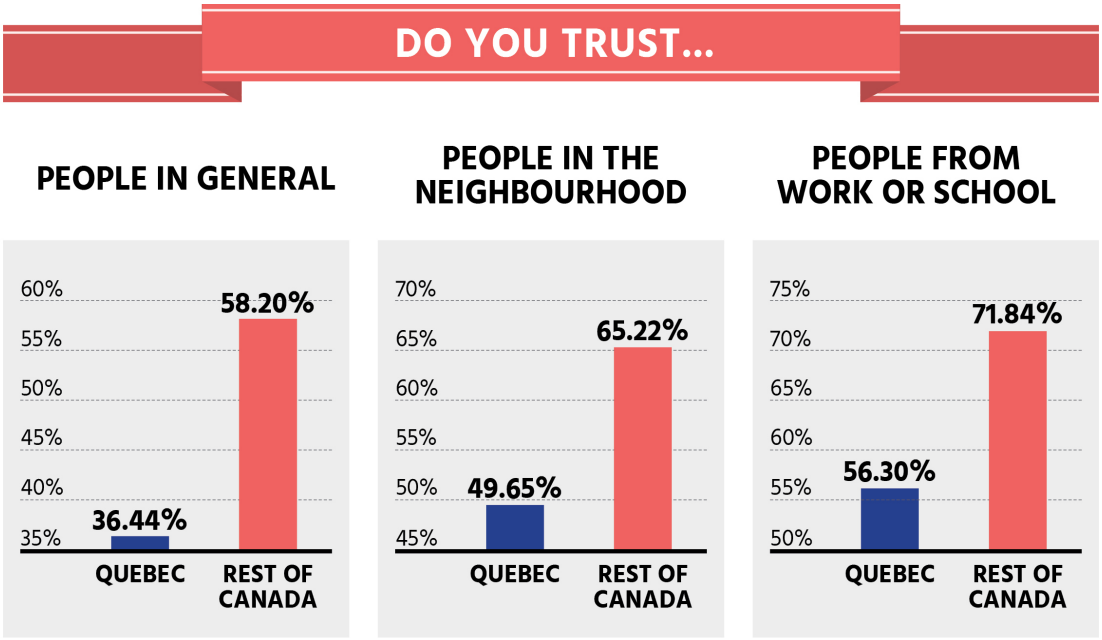


Spurious correlations, by Tyler Vigen, CC BY 4.0 http://tylervigen.com/spurious-correlations

In the chart above, the black line represents the number of films the actor Nicholas Cage appears in each year. The red line represents the number of drownings in swimming pools each year. As one line goes up or down, so does the other (roughly). Two bogus conclusions can be drawn here. One is that Nicholas Cage films cause people to drown in pools. The other is that people drowning in pools cause Nicholas Cage to make more films. Either way, it seems that Nicholas Cage should stop acting! However, there is no actual proof here that one thing causes the other. It is probably a complete coincidence.

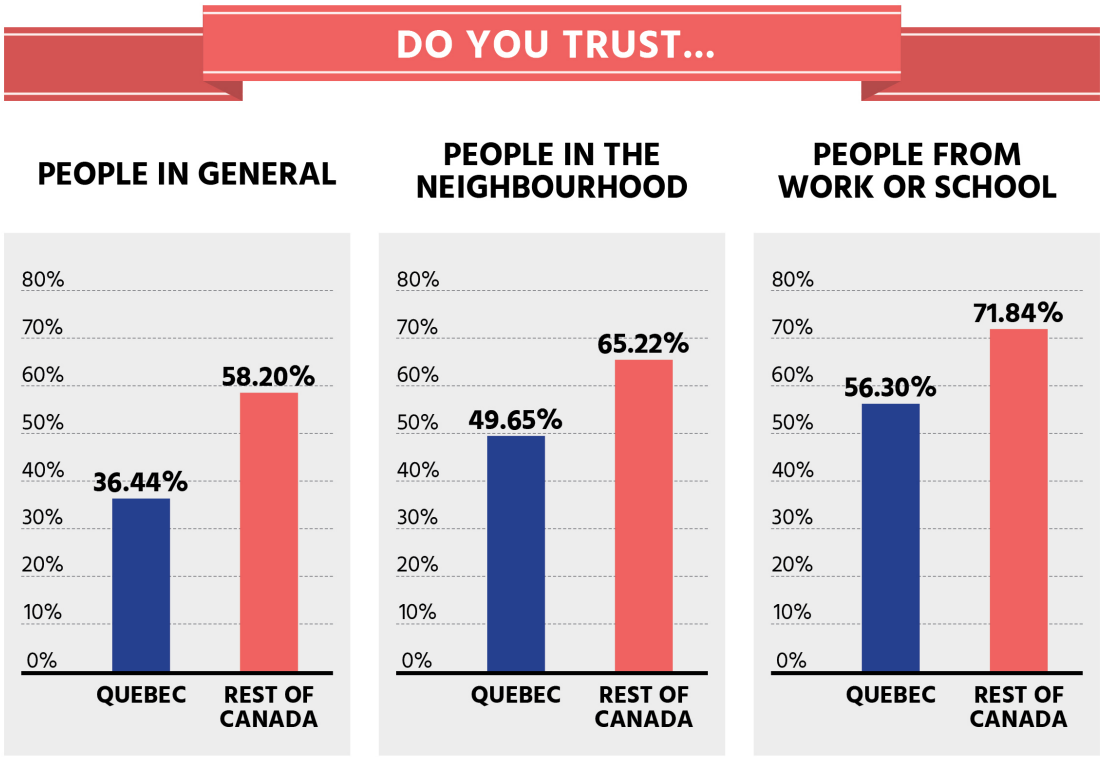
Beware scales without zero

Let's look at a final example. The first graph on the next page seems to suggest that people in Quebec are much more suspicious than people from the rest of Canada.



Do you trust... graphic adapted from an article in Maclean's. By WHP, CC BY-NC 4.0.

Now compare the chart above with the one below. They represent the same data. In the first one, the disparity in trust between Quebec and the rest of Canada is much more pronounced.



Do you trust... graphic adapted from an article in Maclean's. By WHP, CC BY-NC 4.0.

The only difference between the charts is their scale on the y-axis. The y-axis in the top chart starts between 35 and 50. In the bottom chart it starts at 0. The top chart is misleading because it exaggerates the differences. With charts misusing scale, it's no surprise that Quebec is less trusting!

As you can see, learning to read and evaluate charts is important. They can be used or misused to support arguments on subjects both serious and silly. You will encounter many charts in this course. When you do, look back at this article as a guide.

Marissa Major

Marissa Major holds a master's degree in pure mathematics from Portland State University and has taught all levels of undergraduate mathematics for the past five years. Her current goal, using writing, research, and curriculum development, is to promote mathematical thinking as a tool to gain more knowledge about the world and improve the lives of those in it.

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