

Visualizations are an effective way to communicate a story about a group of data or an analysis. Visualizations, when done effectively, not only display data but also assist the audience in digesting crucial information. However, if done carelessly, visualization has the ability to mislead and, in the worst-case scenario, deceive the audience.

In 2007, Purdue Pharma, the maker of OxyContin, pled guilty and agreed to pay \$600 million in fines for misleading doctors and patients about the addictive power of its pain medication.^{1, 2} The case centered around a data visualization² promoted by Purdue that showed OxyContin levels remain stable in patients' blood over time.

This information was used to convince physicians that OxyContin does not lead to symptoms withdrawal or addiction, which are often caused by sharp drops in drug concentration in a patient's blood. The figure plotted the data on the logarithmic scale instead of a linear scale; when plotted on a linear scale, it becomes clear that there is, in fact, a sharp drop in OxyContin levels over time.

This article attempts to present a set of rules that will assist you in creating the most useful data displays possible.

THE FIRST PRINCIPLE IS TO FOCUS ON THE MESSAGE.

The goal of a graph is to make someone go "a-ha" and see something in the same manner you do. It is vital that the objective of each figure be to use the data gathered to support the story you are attempting to tell. Choosing the right plot type is the most difficult part of ensuring that your figure sends the desired message.

PRINCIPLE 2: DISPLAYS SHOULD BE SUITABLE FOR THEIR PURPOSE.

The message, as well as the audience and forum, influence the type of graphical display that should be employed. Due to journal regulations, graphical displays for journal papers are sometimes the least inventive. It's vital that as many graphical components as possible are consistent among figures.

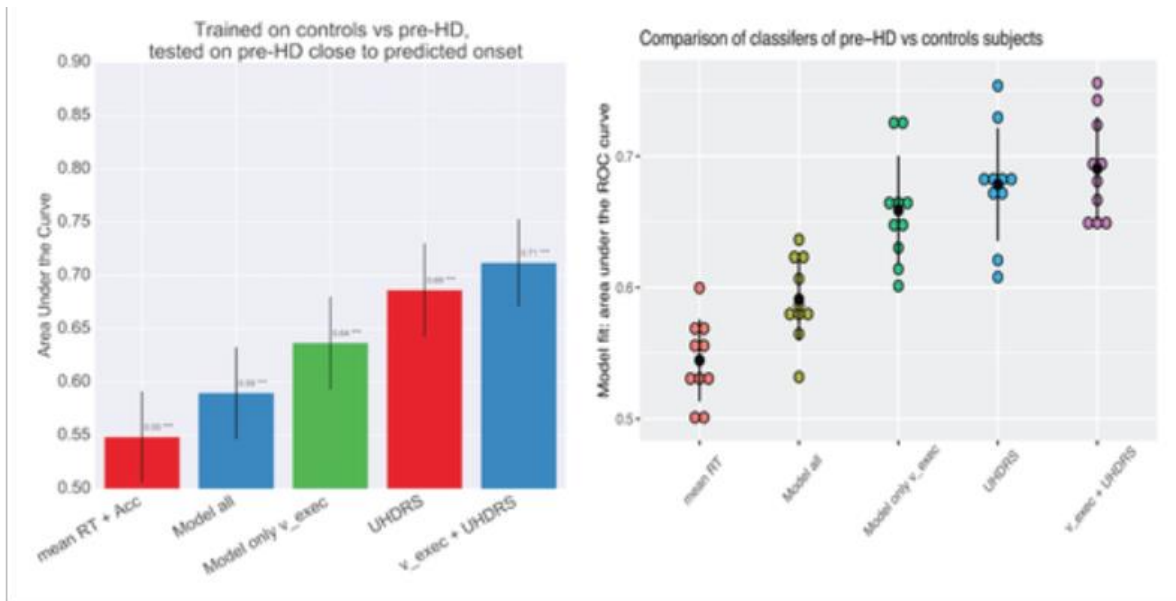
SIMPLIFY IS THE THIRD PRINCIPLE.

There is an increasing trend toward requiring more experimental data and meta-analyses in order to publish a journal paper. The presentation of a clear and focused message is sometimes sacrificed in favor of complex and dense representations. Use the simplest plot that will effectively communicate your message. It's crucial to consider whether all of the display's features are necessary.

PRINCIPLE 4: EVERY GRAPH SHOULD BE ABLE TO STAND Independent.

Figure below is an example of one of the most common plots used in publications today. The problem with this story is that it's impossible to draw any conclusions without more information. The ink used for the bars in this (albeit very typical) display attracts your attention away from the

actual data.



AVOID DECEPTION, PRINCIPLE 5

Plots can be utilized in a variety of ways to fool an audience, whether intentionally or unintentionally. This is especially critical if you're merely showing summary statistics without the raw data, or if you're transforming the data or axes. Time should be expressed on a continuous scale rather than a category scale for longitudinal data.