HOW TO DRAW AND RECOGNIZE MISREADING GRAPHS PART I

Aniekan Asukwo Ebiefung

University of Tennessee at Chattanooga

Department of Mathematics, 615 McCallie Ave, Chattanooga, TN 37403

Aniekan-ebiefung@utc.edu

Introduction

We can use statistics to lie by drawing misleading graphs. In this paper, I will share with you some of the ways you can draw or recognize misleading graphs. The examples are not exhaustive. However, they should assist you in becoming a cautious user of graphical information.

Drawing and Recognizing Misleading graphs

In this paper, we discuss six ways that misleading graphs could be drawn. As we pointed out in the introduction, there is no reason to assume that the list is complete. We plan to update this list in the future.

1. A bar graph with a vertical scale that does not start at zero

When the vertical scale does not start at zero, the heights of the bars will give an exaggerated picture of the relationship among the data categories.

Distribution of car colors at UTC parking Lots 12 and 13 on a winter semester is given in Figure 1.

The graph in Figure 1 is misleading because the vertical scale starts at 15.5 and not zero. This causes the graph to over exaggerate the differences between the car colors. The graph in Figure 2 is not misleading since the vertical scale starts at zero. Notice that the differences between the bar heights in Figure 2 are not as pronounced as those in Figure 1.

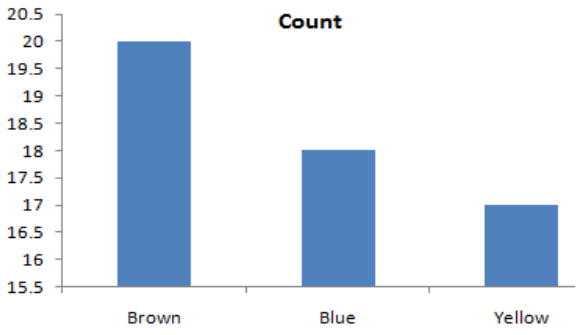

Figure 1: Misleading graph for numbers of car colors

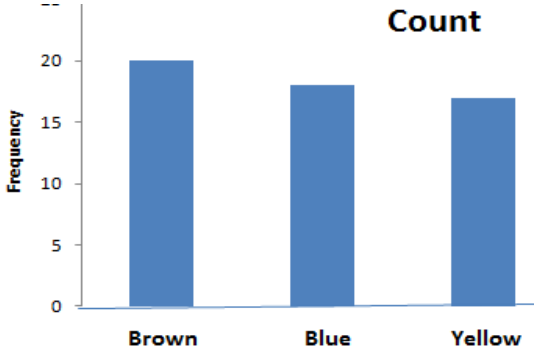

Figure 2: Non-misleading graph for numbers of car colors

There is nothing wrong or unethical about starting the vertical scale at any point, but the reader needs to be careful in interpreting the bar heights. The following are real life examples of misleading bar graphs.

Example 1: Expiration of Bush Tax Cuts

Figure 3 shows a bar graph that FOX news used to illustrate what will happen if the tax rate is changed from 35% of President Bush era to the 39.6% of President Clinton era. The graph is misleading because the scale does not start at zero. The non-misleading graph is given in Figure 4. Observe that the difference between the two bars' heights in Figure 4 is not as big as that in Figure 3.

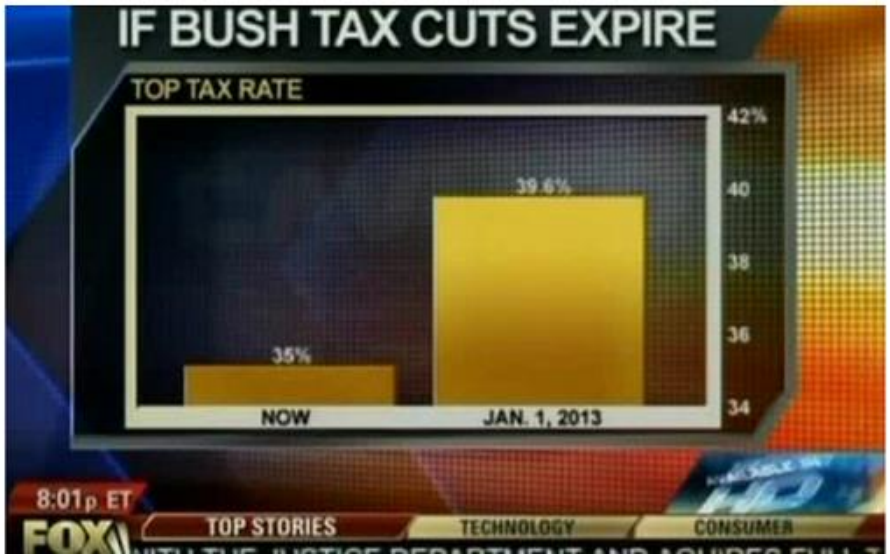

Figure 3: Misleading graph of Bush tax cut vs. Clinton tax cut

http://mediamatters.org/blog/2012/07/31/dishonest-fox-chart-bush-tax-cut-edition/189046; **July 25, 2015**

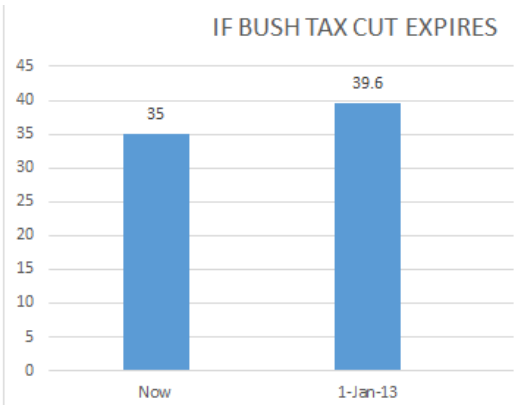

Figure 4: Non-leading graph for Fox graph in Figure 3

Example 2: Terri Schiavo's Life Support Case

Source: https://en.wikipedia.org/wiki/Terri_Schiavo_case

Theresa Marie Schiavo, aka Terri, was comatose for about 15 years, 1990—2005. This case became a national issue when the husband wanted her taken off life-support but the parents said no. Eventually, the case was decided in favor of the husband by the Courts.

The media giant CNN conducted a survey to determine how adult Americans agreed with the courts on taking her off life support on the basis of party affiliations. According to CNN, 62 % of Democrats, 54% of Republicans, and 54% of independents agreed with the courts. Figure 5 is the bar graph that CNN drew to visually represent the results of the surveys. This graph is misleading as the vertical scale does not start at zero. Notice the exaggerated differences among the bars' heights. CNN did redraw a non-leading graph after Mediamatters.org pointed out the leading nature of the graph. An accurate and non-misleading graph is given in Figure 6. Again compare the differences in the

heights of the bars in both figures. The over exaggerated nature of the misleading graph is certainly of concern to all who want fairness.

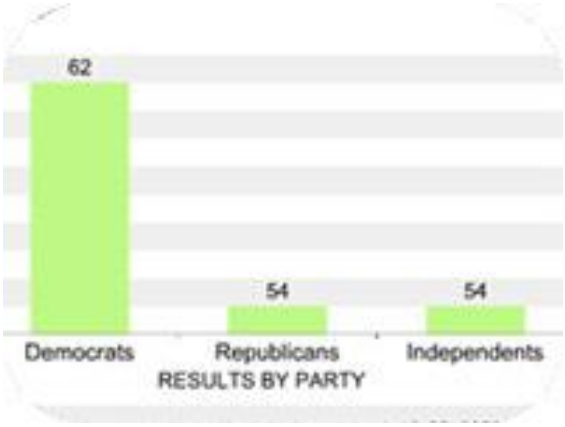

Figure 5: CN misleading graph
http://www.adweek.com/tvnewser/schiavo-cnns-absurd-misleading-graph/5724; July 25, 2015

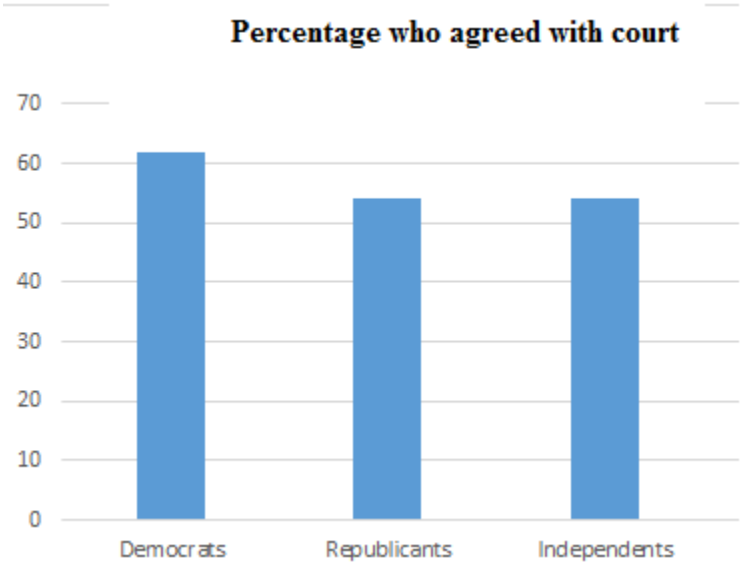

Figure 6: Non-misleading graph for CNN survey

Example 3: Obamacare Enrollment

The Obama administration had predicted enrollment figure of 7 million by the end of March 31, 2014, for the Obamacare. According to Fox, the enrollment figure by March

27, 2014, four days to the end of March, was 6 million. Figure 7 is how Fox graphically represented the two numbers. After much outpouring of anger on the Internet, Fox shamefully accepted making a mistake and drew the correct non-misleading graph giving in Figure 8.

Figure 7: Fox misleading graph.

Figure 8: Fox non-misleading graph

http://www.huffingtonpost.com/2014/04/01/fox-news-corrects-obamacare-graphic_n_5069764.html; July 25, 2015

2. Changing the length of the unit on the vertical scale

If the length of the unit on the vertical scale is increased or decreased, the resulting graph exaggerates or suppresses the true relationship between the variables.

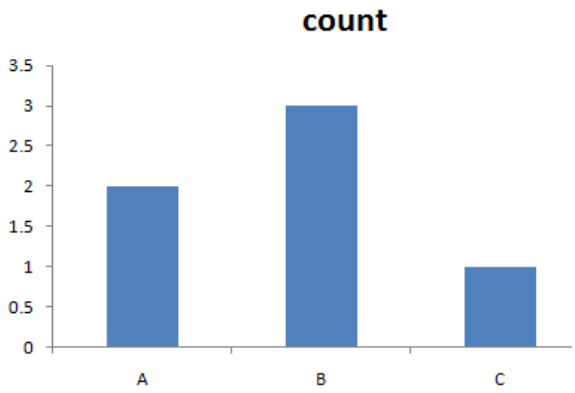

Figure 9: Counting absences; longer bar heights

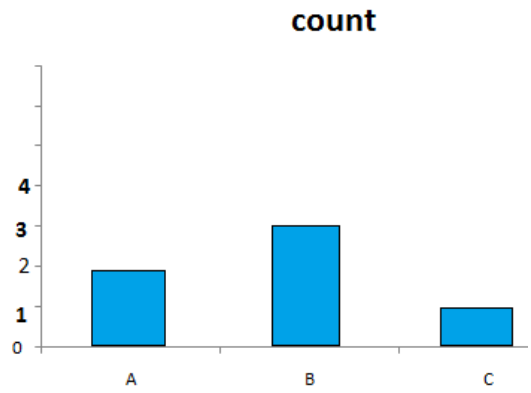

Figure 10: Counting absences shorter bar heights

Figures 9 and 10 show the numbers of times high school students skip classes. The length of 1 unit in Figure 9 is twice that of Figure 10. Consequently, the bar heights in Figure 9 are twice those of Figure 10, even though both graphs are drawn using the same data. An instructor would likely show Figure 9 to parents, while the students would prefer Figure 10. It is ethical to graph as in Figure 9 or Figure 10, but the reader needs to be careful in interpreting the bar heights.

3. Using a 2– or 3—dimensional diagram to represent a 1—dimensional change.

The parking rate at the XYZ University was $1.00 per month in 1999. In 2005, it was raised to $2.00. The Student Voice, the SGA newspaper, graphically represented the differences between the amounts using boxes as in Figure 11.

The increase of $1 is a 1-dimentional change. The value of $1 in 1999 is represented by a box of sides 1 unit. The value of $2 in 2005 is represented by a box of sides 2 units. The volume of the box with $1 is 1 cubic unit, while the volume of the box with $2 is 8 cubic units. Hence, a change that is in the ratio of 1: 2 is represented by a diagram that is in the ratio of 1:8. The box in Figure 11 over exaggerates the true nature of the change in

the parking fees. This is because a reader looking at the graphs is likely to compare the volumes of the two boxes and not the lengths of the sides.

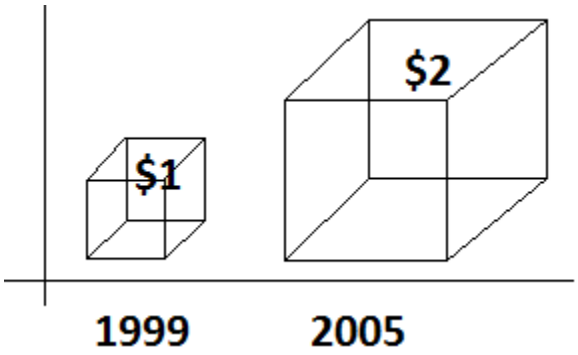

Figure 11: Boxes in the ratio of 1:8

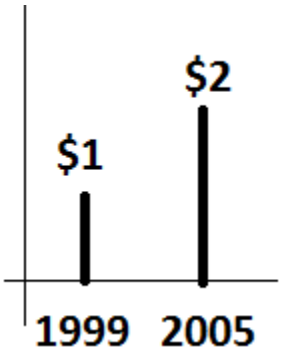

Figure 12: Lines in the ratio of 1:2

The most appropriate way to represent a 1-dimensional change is to use a vertical or horizontal line. The non-misleading graph is shown in Figure 12.

4. Graphing the wrong data

Table 1 represents the numbers of homicides in two cities. A city newspaper represents the information on the bar graph given in Figure 13. The bar heights are equal to the number of homicides in a given city.

Table 1

City	Population	# of Homicide
A	50,000	500
B	500	10

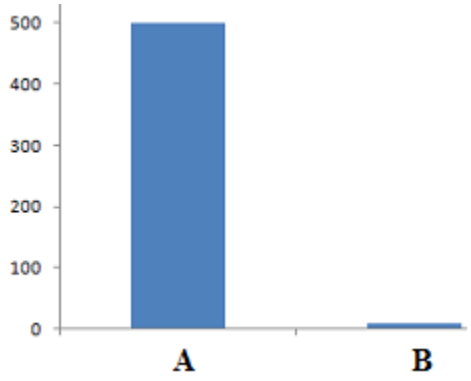

Figure 13: Number of homicides in cities A and B.

The graph is misleading because it does not take into account the number of people in each city. City A has more people than city B. Comparing the actual homicide numbers

without taking into account the population is using the wrong data to graph. It gives a graph that is not fair to city A.

The appropriate data for the graph should take into account the number of residents in the two cities. Examples of such data include the number of homicides divided by the population i.e. the per capita, the homicide rate per 1000 residents, or the homicide rate per 100 residents. Table 2 gives the homicide rate per 1000 residents.

An appropriate bar graph is given in Fig. 14. From Figure 14, we see that the number of homicides per 1000 residents in city B is twice that of city A. This gives a better explanation of the relationship between the numbers of homicides in the two cities.

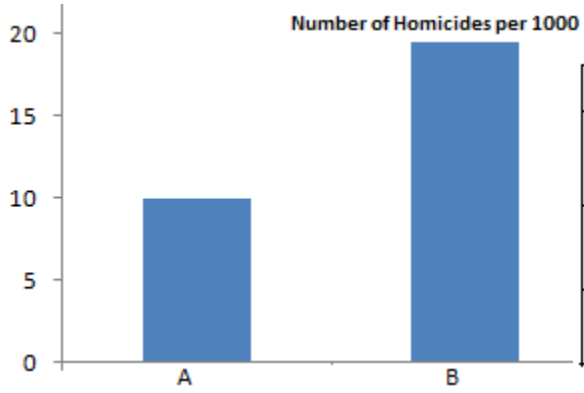

Table 2

City	Population	Homicide rate per 1000
A	50,000	$\frac{500}{50000} \times 1000 = 10$
B	500	$\frac{10}{500} \times 1000 = 20$

Figure 14: Bar graph of the numbers of homicides per 1000 residents.

5. A bar graph in which bar heights are not proportional to frequencies

A bar graph in which bar heights are not proportional to frequencies is very common in newspapers. The obvious reason for this is probably space constraints and not a desire to mislead. In any case, such graphs distort the true nature of the relationship among variables. It is the responsibility of the reader to use critical thinking when making judgment about the heights of the bars. Figure 15 is an example of such a bar graph.

In Figure 15, observe that the difference between 61% and 44% is 17%; while the difference between 75% and 66% is 9%. However, the differences in the bar heights between 61% and 44% and that of between 75% and 66% are about the same.

Fig. 15: Does made in US boost Sales?
Source: USA Today

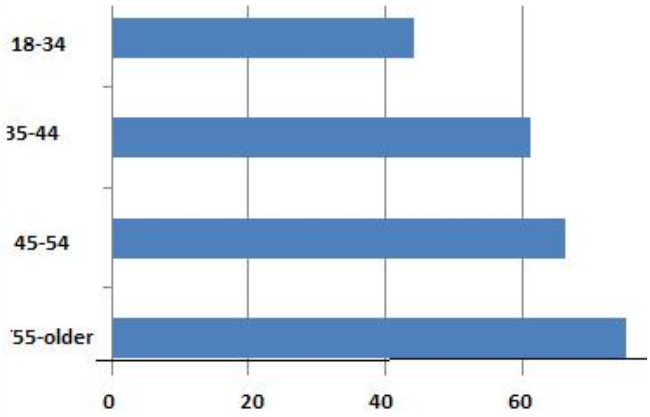

Figure 16: Non-misleading graph

The non-misleading graph is given in Figure 16. Notice that the vertical scale starts at zero and that the bar heights are proportional to the frequencies of the categories they represent.

6. A pie graph in which sectors' percentages/degrees do not add up properly

In a pie graph, the sectors' degrees should add to 360°, and the sectors' angles should add to 100%. The pie graph in Figure 17 gives the percentages of people who backed Palin, Huckabee, and Romney during the 2012 presidential run. Why is this graph misleading?

The sum of the sectors' percentages is not 100%. The sum is 193%. It is likely that Fox combined different opinion polls' results. This is wrong as the categories in a pie graph should come from the same population.

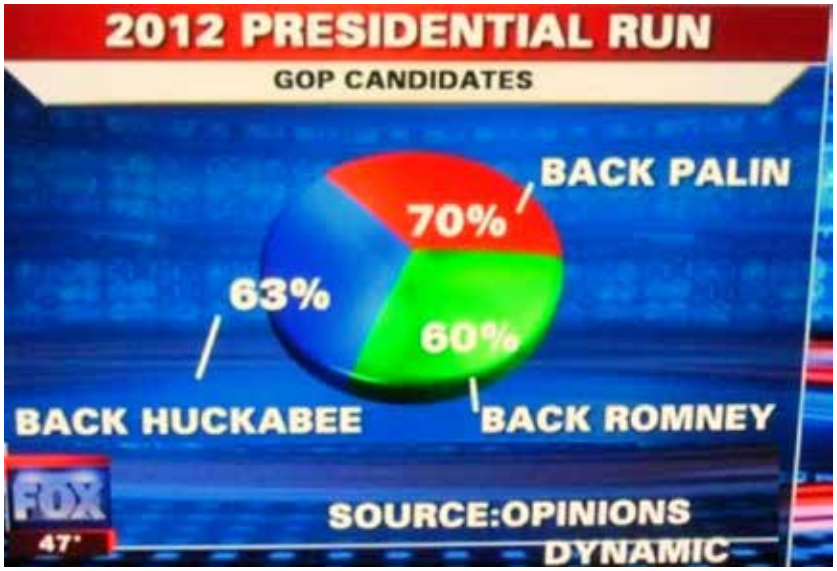

Figure 17: 2012 Presidential Run

Source: http://media.nbcchicago.com/images/1200*900/Fox%27s+Pie+Chart.jpg; July 26, 2015

Conclusion

In this paper, we discussed how to draw and recognize misleading graphs. It is ethical to draw theses graphs. However, it is the responsibility of the reader to give an appropriate interpretation to the graph before him or her.