How to Produce Excellent Graphs in SAS

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Abstract

Presenting data through graphs is a powerful, efficient method to convey information. This is only effective, though, if it is done well. Edward Tufte states, “Graphical excellence consists of complex ideas communicated with clarity, precision, and efficiency.” The goal, then, of data graphics is to tell a story as clearly as possible.

This paper presents a set of principles gleaned from Tufte as well as Stephen Few that encourages quality graphical design and provides examples from SAS that follow these principles. SAS/Graph and its many options are used.

Introduction

Edward Tufte states, “Graphical excellence consists of complex ideas communicated with clarity, precision, and efficiency.” Achieving this goal of graphical excellence takes forethought and planning, along with an awareness of what story you are trying to tell with the graph. Tufte presents five principles in the theory of data graphics which help direct graph design.

While these high level principles should guide you in graph design, more practical guidance is needed in the details. Stephen Few has provided very practical advice in this area. He takes Tufte’s principles and applies them in practical situations. In particular, Few addresses the elements of graphical design by giving particular guidance in that helps direct the design of the whole graph. This approach provides the user with an easier way to follow Tufte’s more general principles.

This paper presents Edward Tufte’s principles and supplements these with Stephen Few’s sage advice. First, the general principles are given along with a simple example. This is followed by a detailed discussion of the elements of graph design with numerous examples taken from Few's book, Show Me the Numbers. SAS/Graph is used throughout to produce all of the examples, and the code for these examples is included in an appendix.

Additionally, a short section is included on what not to use in data graphics.

General Principles

Edward Tufte speaks of five principles in the theory of data graphics. These are

- Above all else show the data
- Maximize the data-ink ratio
- Erase non-data-ink
- Erase redundant data-ink
- Revise and edit

These principles help guide the development of any graph used to display data. By following these principles the story that is being told becomes clearer and easier to tell.

Stephen Few restates the first principle as “Show me the numbers.” This implies that the overarching concern should be how to convey the message in the data.

Data-ink is the part of the graph that display's data information. This could include data points, value labels, and lines connecting points. Non-data-ink includes axes lines, tick marks, non-relevant labels or headings. Tufte defines the data-ink ratio as

$$\text{Data-ink-ratio} = \frac{\text{data-ink}}{\text{Total ink used to print the graph}}$$

$$= \text{Proportion of a graphic's ink devoted to the non-redundant display of data information}$$

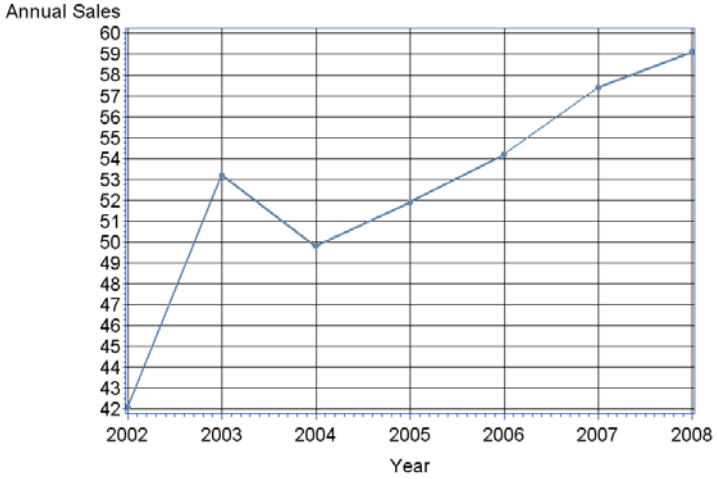
$$= \text{1 - proportion of a graphic that can be erased without loss of data information}$$

The data-ink ratio is maximized by applying the third and fourth principles, erasing non-data-ink and erasing redundant data-ink.

As with most endeavors, creating excellent graphs is an iterative process. Graphs should be revised and then checked for additional changes.

Let's apply these principles to a simple example of line plot of annual sales from 2002 - 2008. A starting point is shown in Figure 1.

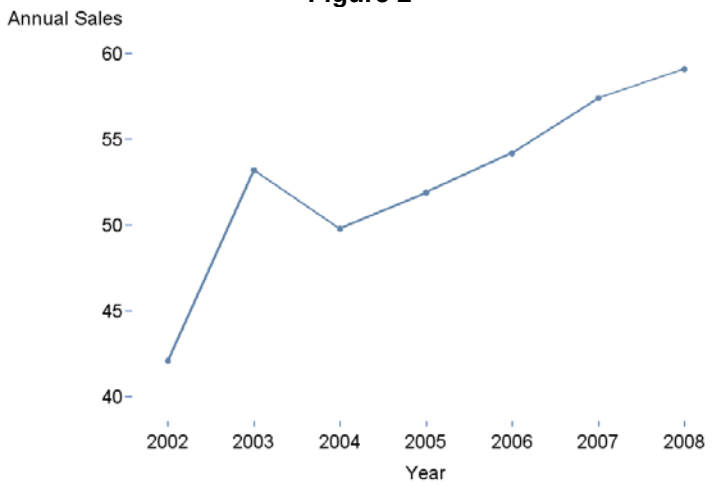
Figure 1



This example does show the data. You can identify the annual sales values for each of the years. However, there is a lot of non-data-ink, especially with the vertical and horizontal reference lines.

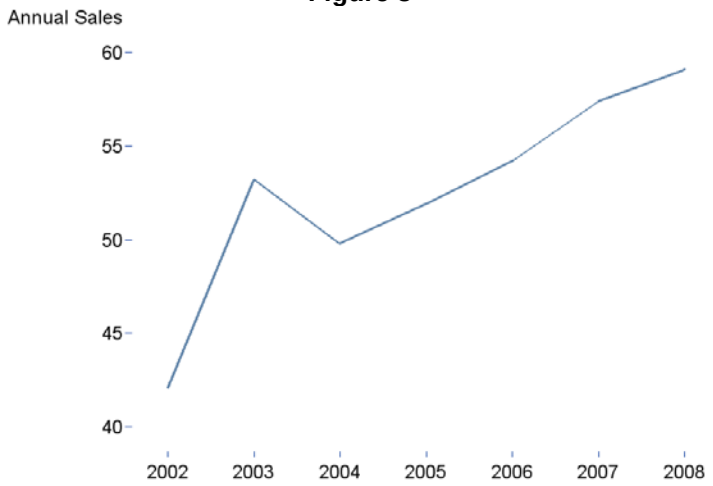
Erasing the reference lines along with minor tick marks, the frame around the graph, and the horizontal and vertical axes produces the following cleaner graph (Figure 2).

Figure 2



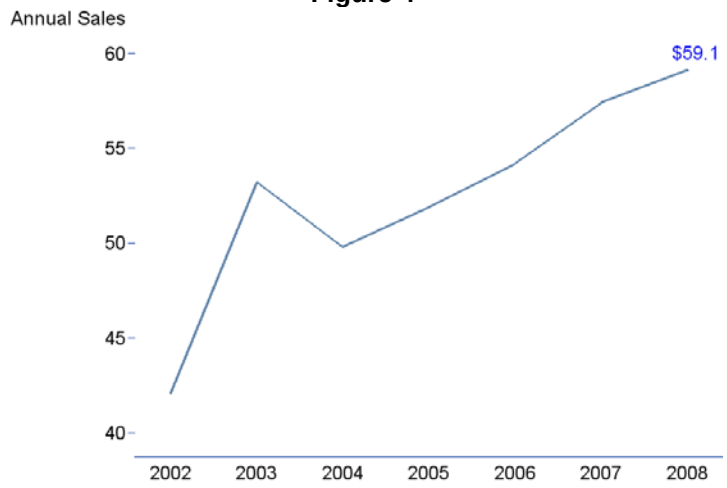
The data points could be considered redundant data-ink. The annual sales values can be determined fairly easily from the inflection points on the line. Also, the label “Year” is not necessary, since this would be implied from the label “Annual Sales.” Erasing these points and label produces an even cleaner graph (Graph 3).

Figure 3



Of course, this may be going too far. This is where the principle of “Revise and edit” comes in. You may want to put back in the axis lines or, at least, the horizontal axis, for example. Also, concerning the first principle, you might want to provide the value of annual sales for 2008. These revisions produce the final graph in Figure 4.

Figure 4



This process produces a graph that certainly maximizes the data-ink ratio. Hopefully, the "story" told by the graph is clear as well.

This quick example illustrates Tufte's principles very simply. Of course, the devil is in the details. The next section will discuss the elements of graph design without mention of SAS. An appendix provides detail on the SAS/Graph options that were used to create the examples in the graph design section.

Elements of Graph Design

Stephen Few in Show Me the Numbers applies these principles to the elements of graphical design. This section summarizes his ideas and illustrates these with examples drawn primarily from Chapter 10 of his book. Both data component and support component design will be addressed.

Data Component Design

First, consider the parts of the graph pertaining to the data:

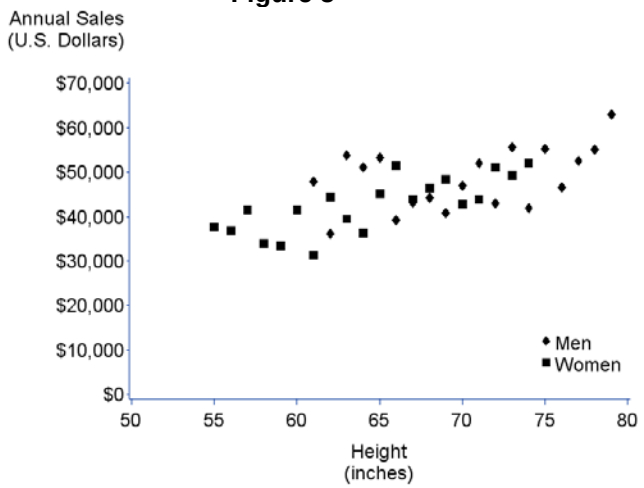
- Points
- Bars
- Lines
- Scale lines
- Legends
- Other text

We will consider each of these elements in turn.

Points

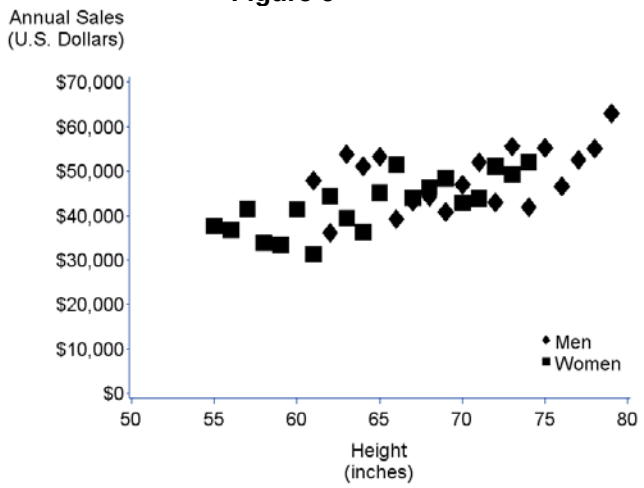
Stephen Few indicates the primary objective with points is to "keep each of the points distinctly visible." Consider the graph of average salary by height by gender in Figure 5.

Figure 5



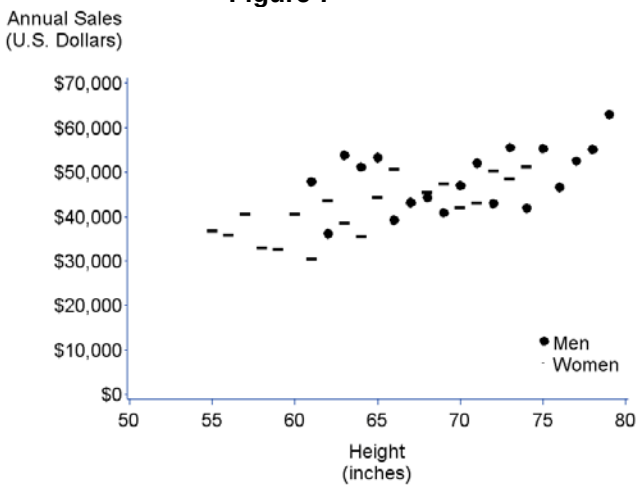
It is a bit difficult to distinguish the symbol between Men and Women in this graph. One solution is to enlarge the points (Figure 6).

Figure 6



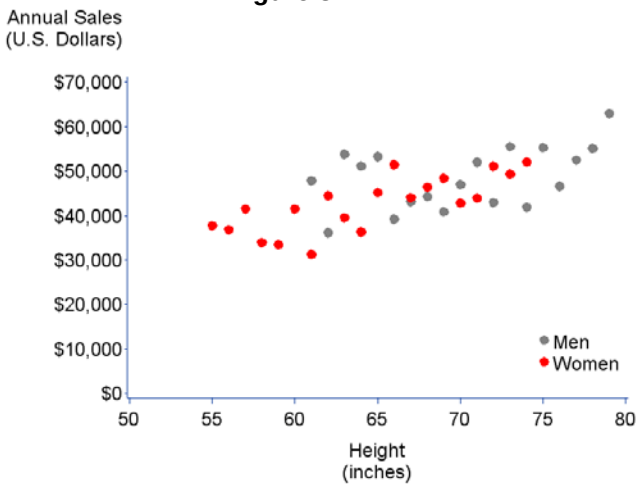
Another method is to use symbols that are more visually distinct (Figure 7),

Figure 7



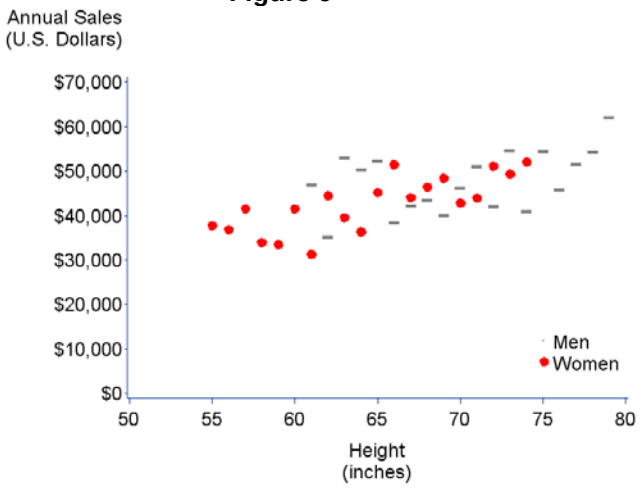
or use different hues (Figure 8),

Figure 8



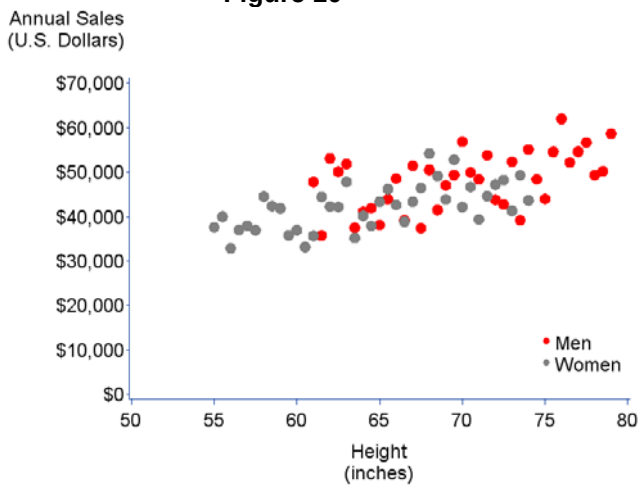
or both (Figure 9).

Figure 9



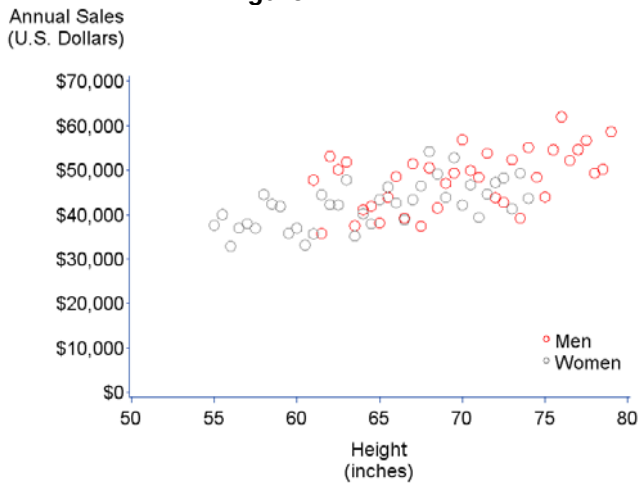
Another issue that arises with points is the overlapping of points. This may obscure some points behind others as can be seen in Figure 10.

Figure 10



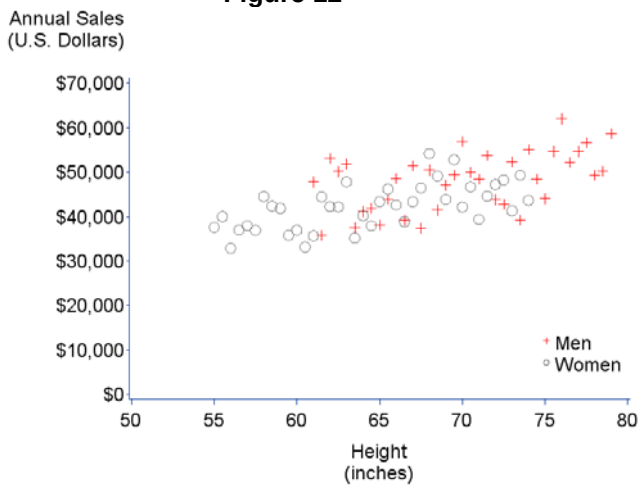
You can enlarge the graph or reduce the size of the points, or both. Other options are to make the point symbols transparent (Figure 11).

Figure 11



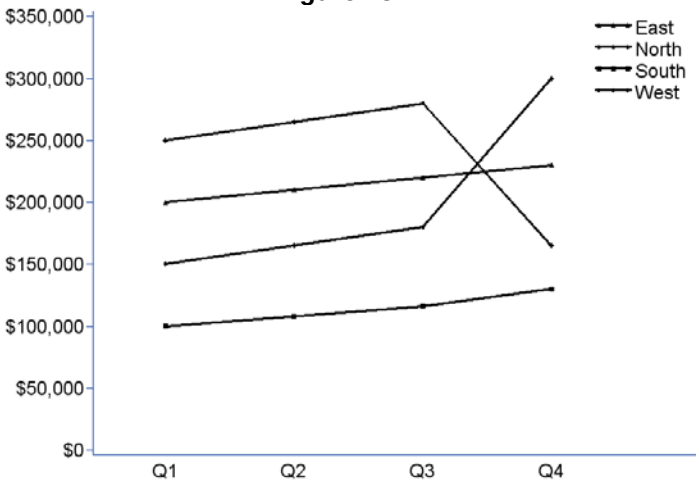
Or use different shapes (Figure 12).

Figure 12



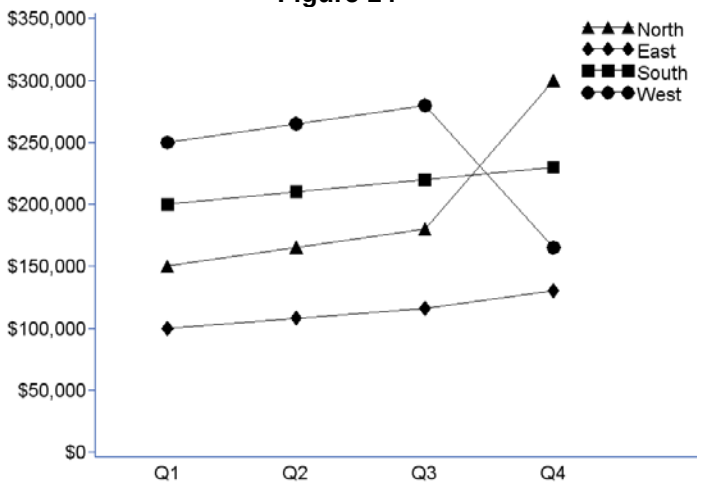
When using lines in conjunction with points, there is the potential for the lines to obscure the points as shown in Figure 13.

Figure 13



Reducing the width of the lines and increasing the size of the points resolves this problem (Figure 14).

Figure 14



The key when determining what symbols to use for points, is to remember to keep each point distinctly visible. What to use may depend on the number and density of the points.

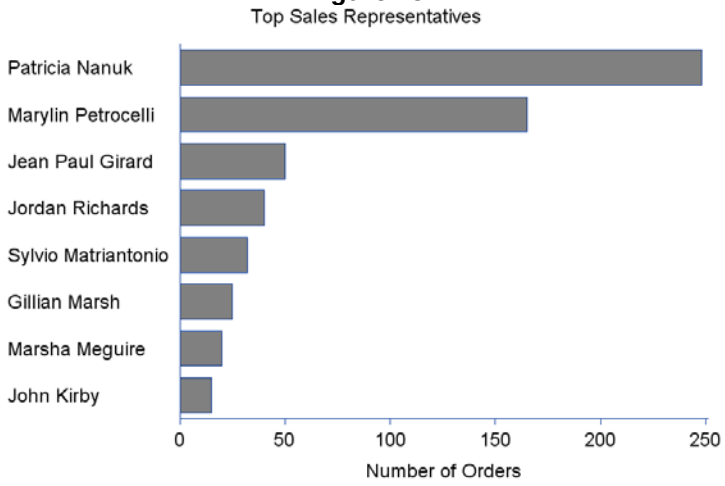
Bars

The bars in bar charts play a similar role to points in a scatter or line graph. However, additional questions need answers.

What orientation should be used? Few suggests two reasons to use horizontal bars: (1) the graph displays a ranking relationship in descending order, and/or (2) the categorical labels on the bars won't fit side by side. Otherwise, a vertical bar is preferable.

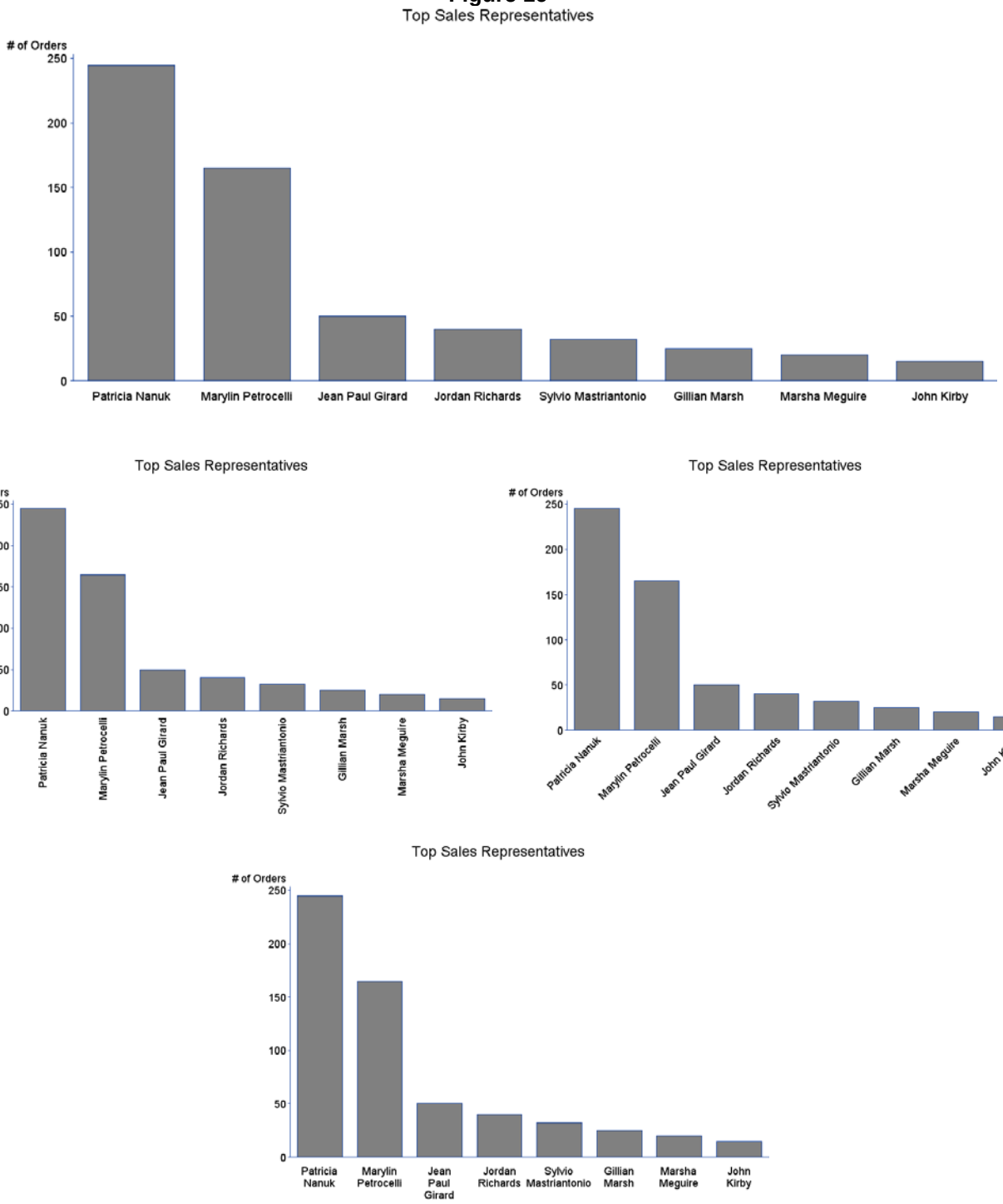
Both of these reasons apply to the example in Figure 15.

Figure 15



This works much better than the following alternatives.

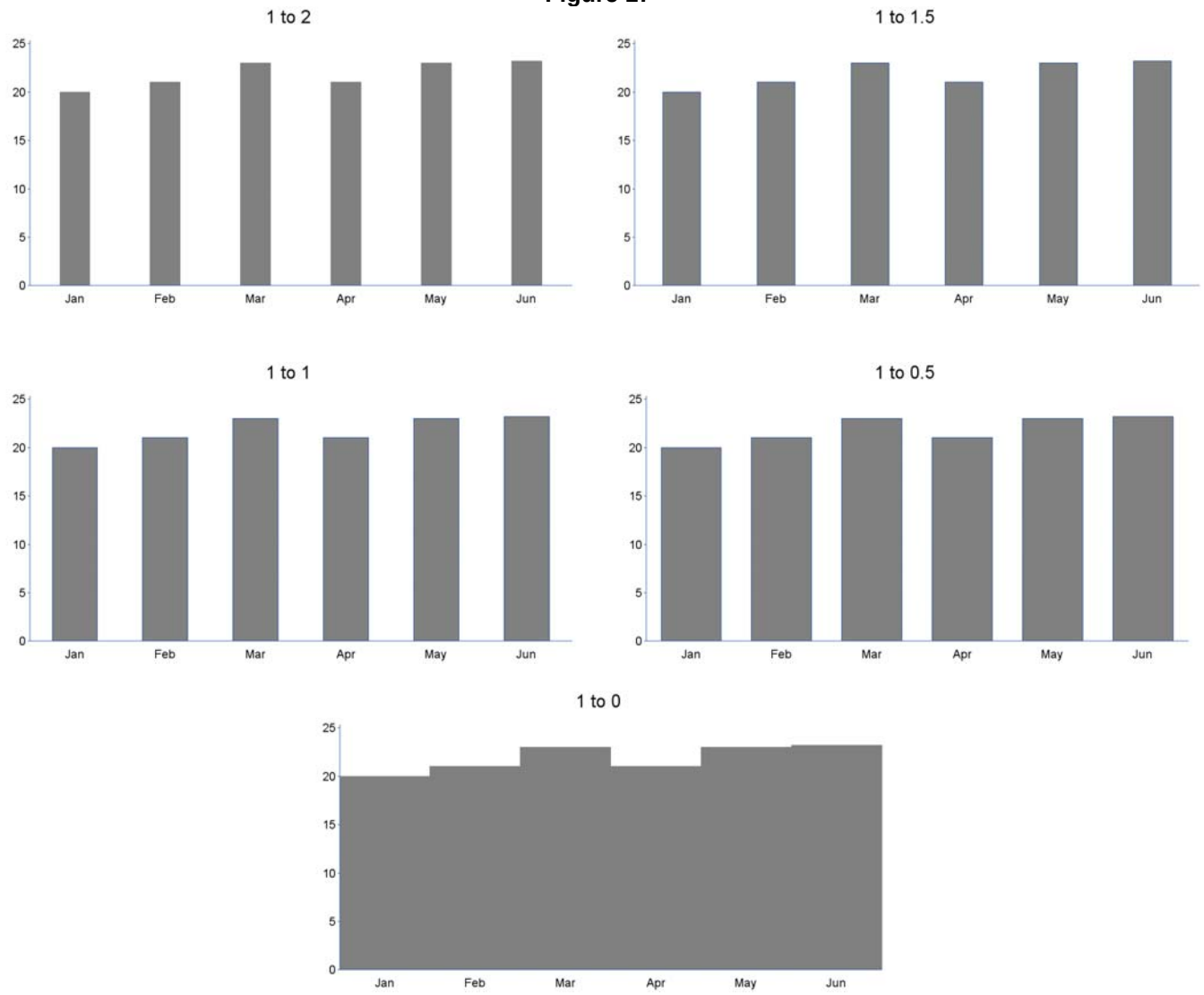
Figure 16



The first of these is very wide and could not accommodate many more salespersons. The second is not as wide, but it is not good design to angle text vertically since it makes it difficult to read. The third and fourth are the best of the alternatives and would probably work in a pinch.

How close should the bars be to one another? The following show various ratios of bar width to spacing.

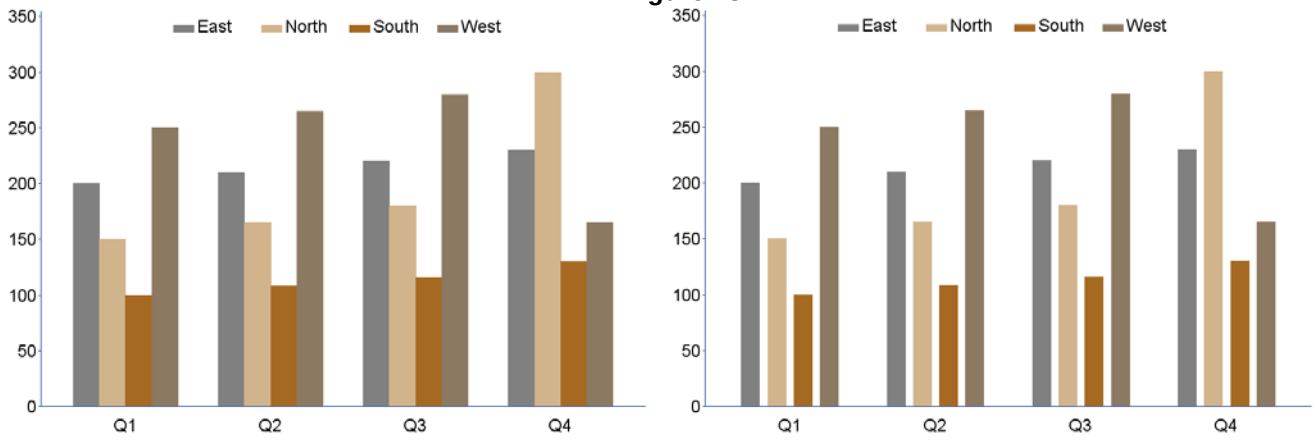
Figure 17



From these examples, a ratio of 1:1.5 to 1:0.5 appears to work best. There is too much white space in the first example, and the bars become indistinct in the last. Of course, the best ratio for a particular chart may require a bit of trial-and-error (or “revise and edit”) to get it just right.

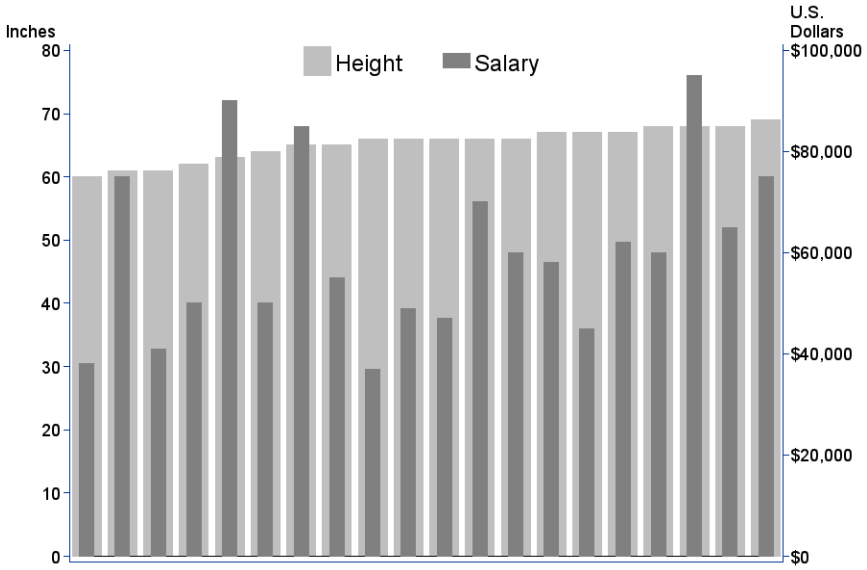
No space between bars does work well in a graph that displays groups of bars. In this case, setting bars side by side in a group helps to more easily differentiate the groups. In the first graph the grouping by quarters is much clearer, compared to the second graph which contains spacing between the regional bars.

Figure 18



In general there is no reason to overlap bars, and fortunately SAS does not have an option to do this. However, one situation that Few discusses is the correlation bar graph, where one bar completely overlaps another. This allows a direct comparison of two bars. This would work especially well with actual to target comparisons. The example in Figure 19 is one similar to that presented by Few.

Figure 19

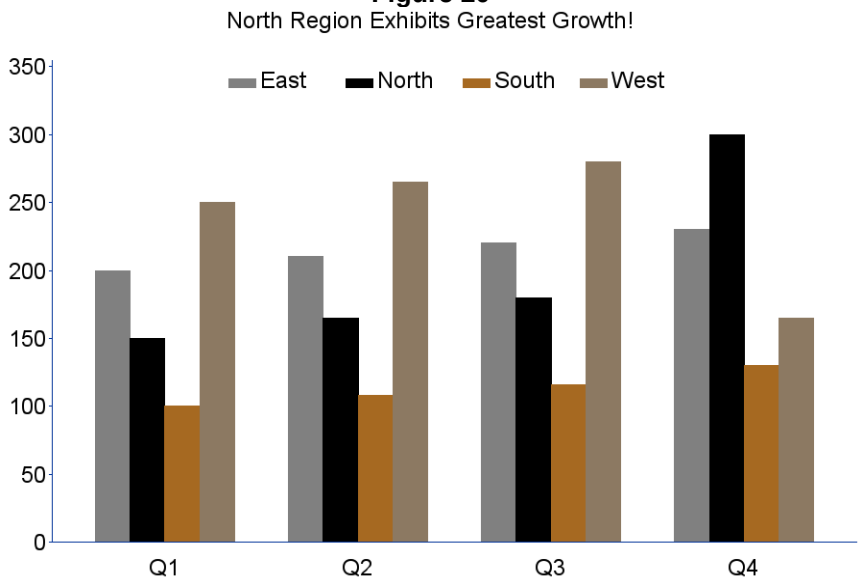


What kind of fills should be used? These should follow the design practices laid out by Stephen Few:

- Avoid use of fill patterns, because they create disorienting visual effects
- Use fill colors that are clearly distinct
- Use fill colors that are fairly balanced in intensity for data that are equal in importance
- Use fill colors that are more intense than others when you wish to highlight particular values above others

The following graph illustrates the use of the last point, where North is highlighted.

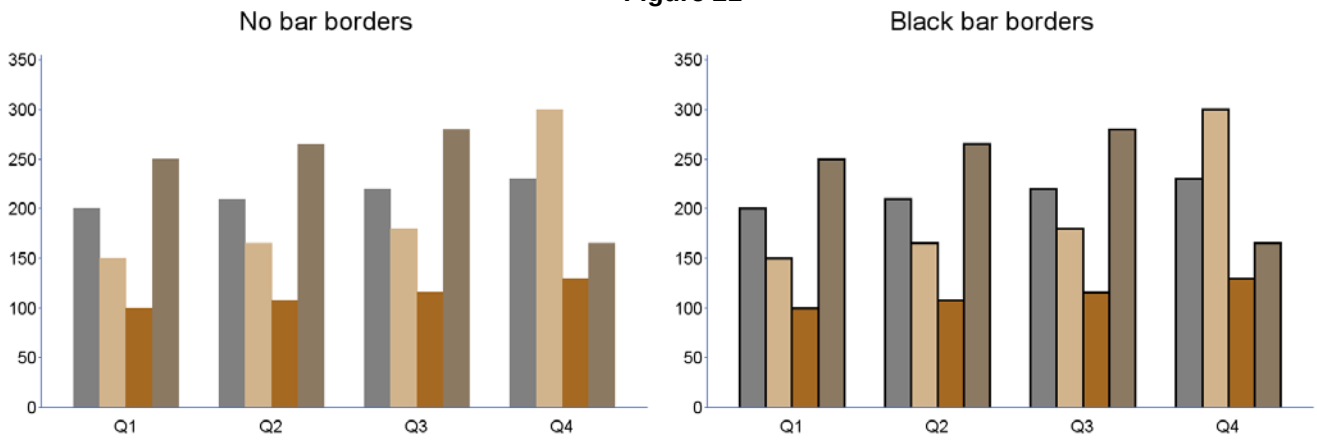
Figure 20

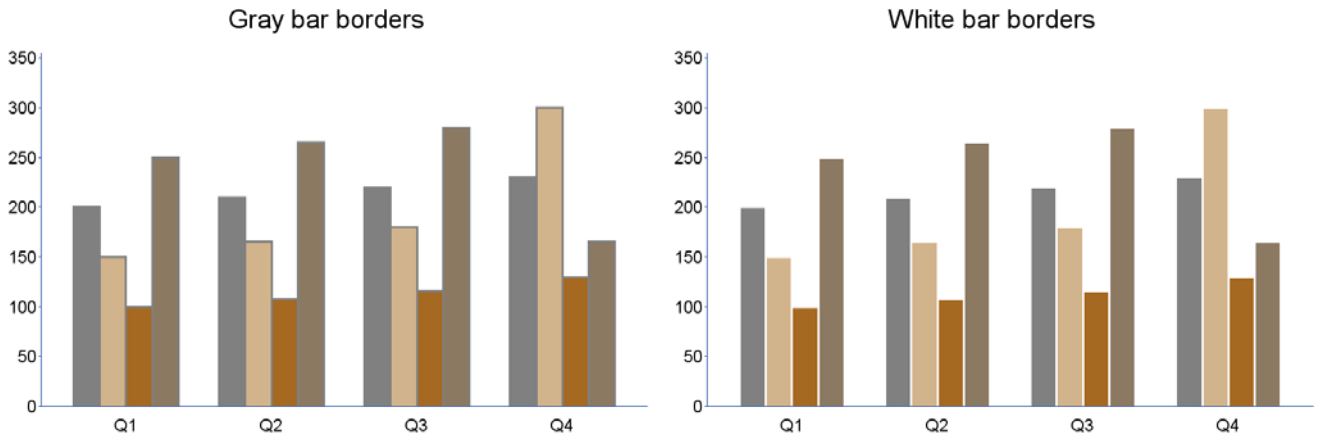


Also, consider the use of grayscale if the graphs are to be printed in black & white. In a seminar, Stephen Few also suggested using earth tones, instead of primary colors, because they are more pleasing.

Should borders be used on the bars? In most cases borders are not needed, except when the color of the bar does not stand out from the background. This latter case can be avoided by a better choice of color, of course. The graphs in Figure 21 show examples of various borders.

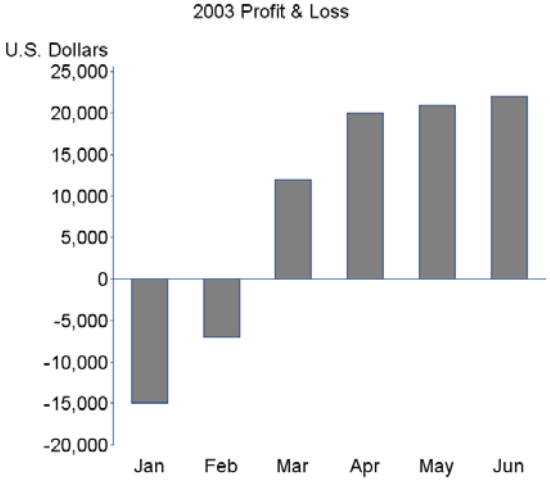
Figure 21





Should the base of the bars always be at zero? Bars should almost always start at zero with very few exceptions. This is true even if the bars may have negative values as in Figure 22.

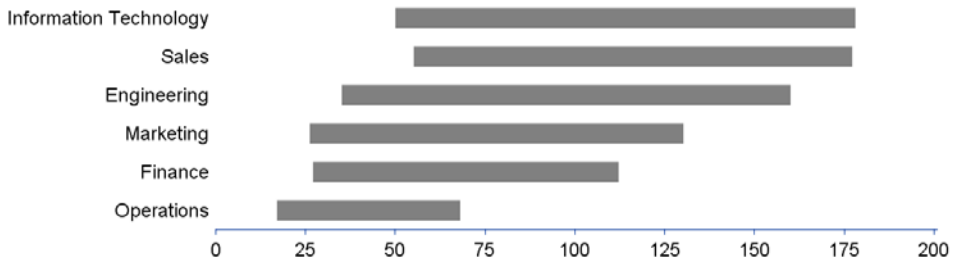
Figure 22



This provides a clearer picture than starting at a value below the lowest value, which would distort the story.

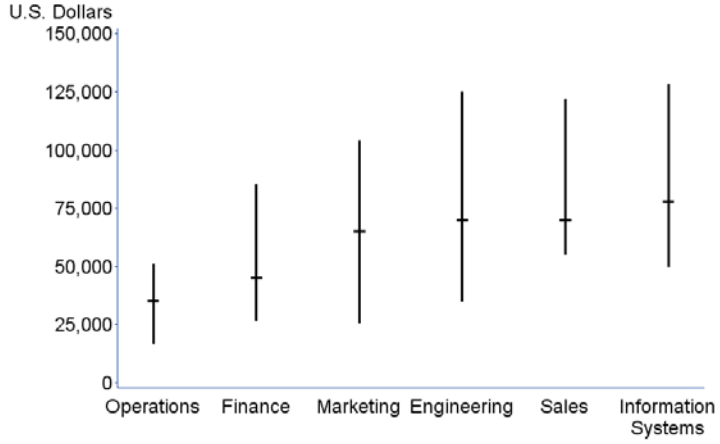
The only situation where a bar may not start at zero is when the bars indicate a range of values (Figure 23).

Figure 23
Salary Ranges by Department



This could be thought of a variation on box plots. Making the bars vertical and including an indicator of the mean or median illustrates the similarity (Figure 24).

Figure 24
Minimum, Maximum, and Median Salaries by Department

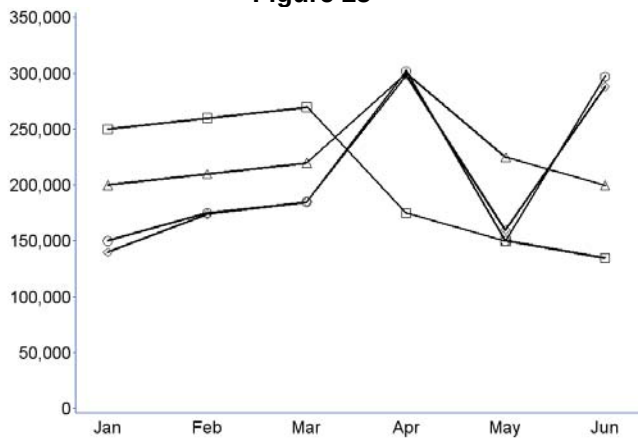


Lines

Lines on a graph can add valuable interpretability. However, there are things to consider, just as with bars, to make them more useful.

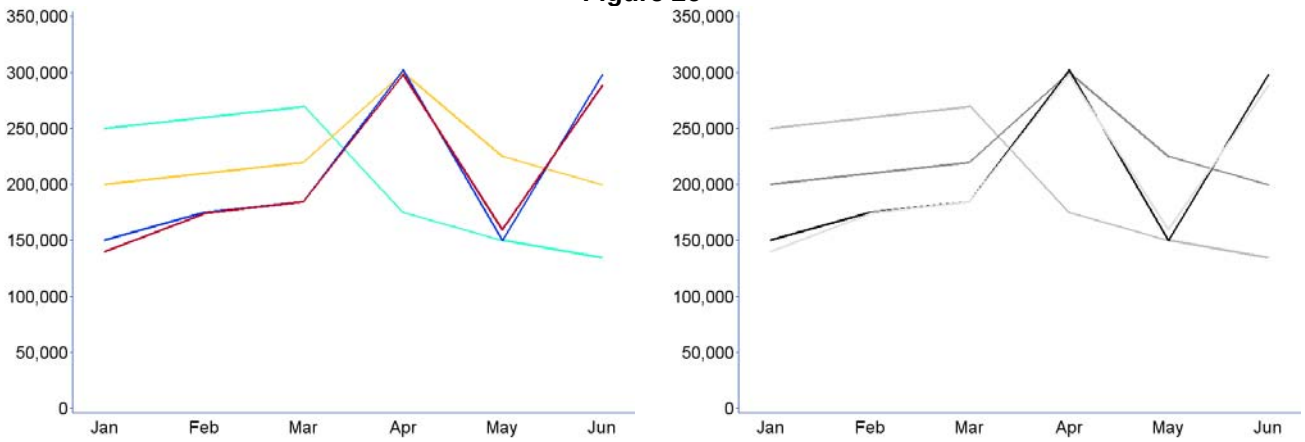
Lines can be used to connect points and show the continuity of the points. Just as with points, lines should be distinct, especially if they lay close to one another. In the graph in Figure 25 the lines are not distinct enough.

Figure 25



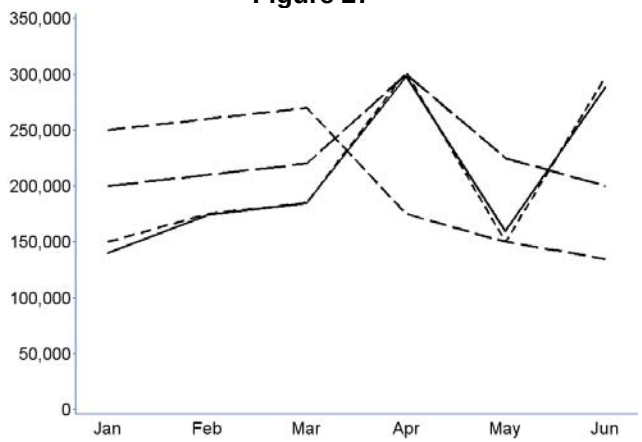
Again, similar to points we can use hue to distinguish among lines. This can be done with different colors or with different intensities. The two graphs in Figure 26 show using color and various intensities of gray for the lines.

Figure 26



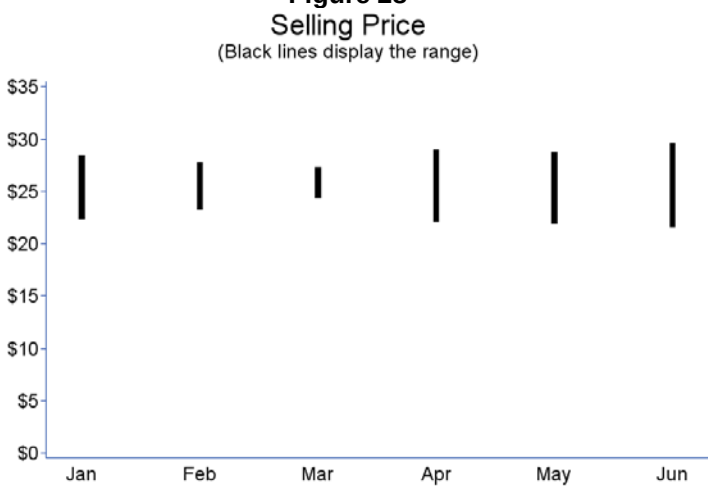
Another method would be to use different line styles (Figure 27). This is not preferable due to the break in flow of the lines, but can be useful when other methods cannot be used.

Figure 27



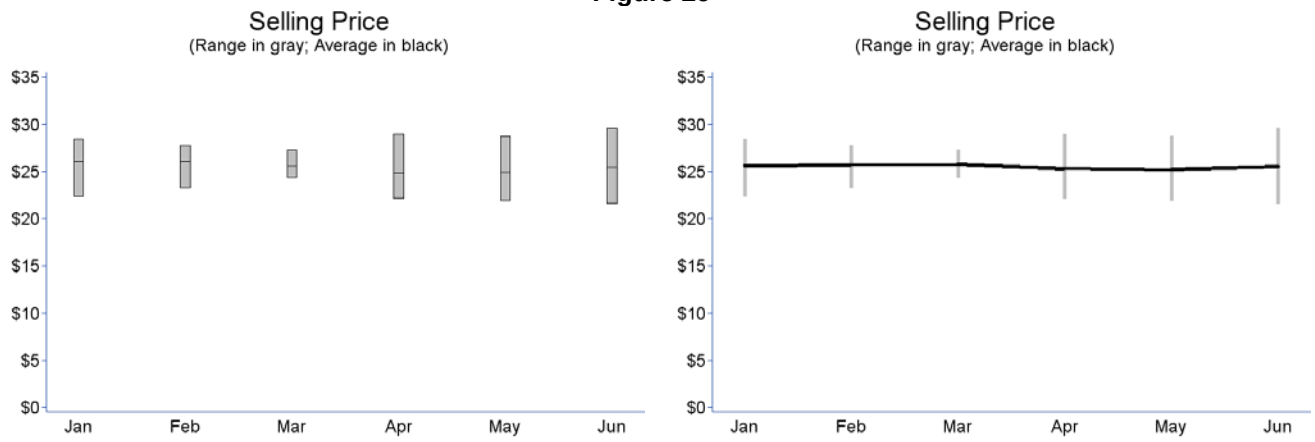
High-low lines are another common use of lines in graphs. These indicate the maximum and minimum values for each set of data grouped by a categorical variable. This is essentially the range plot previously discussed and is illustrated in Figure 28.

Figure 28



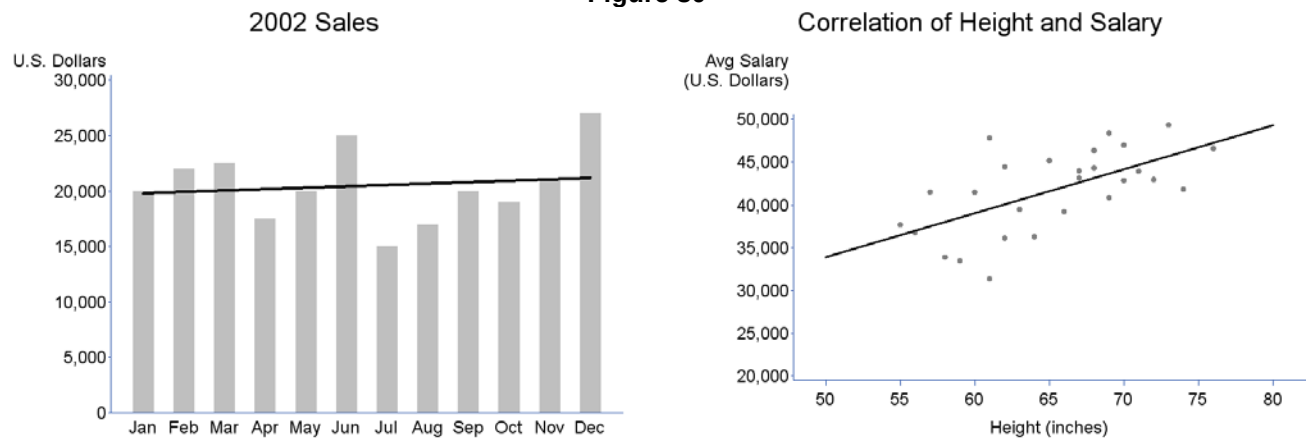
High-low lines can also include additional information, such as the mean or median values. The following graphs illustrate two ways for displaying this.

Figure 29



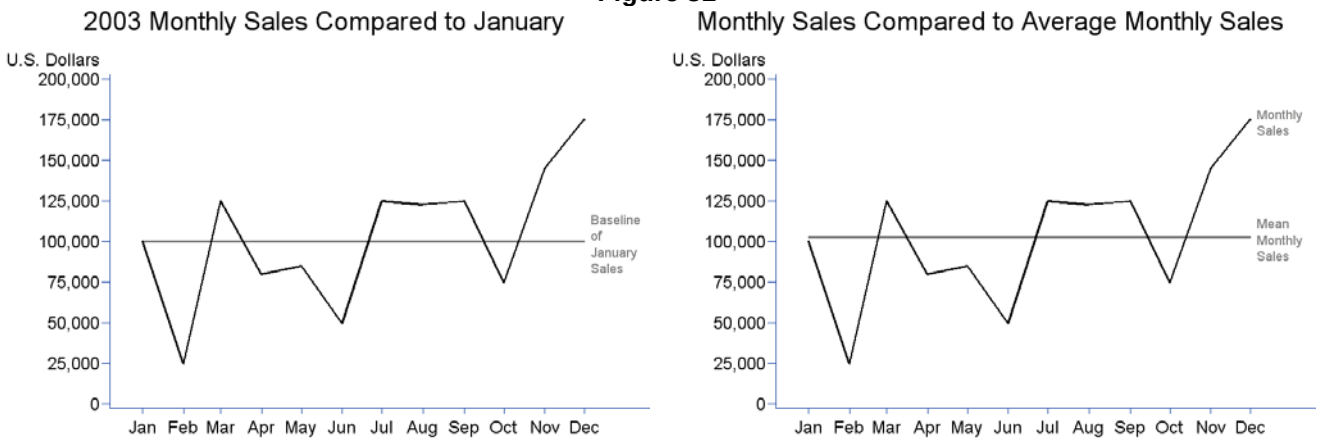
Trend lines provide a visual of relationships in the data. Two common uses of trend lines are in time series and correlation as seen in the examples in Figure 30.

Figure 30



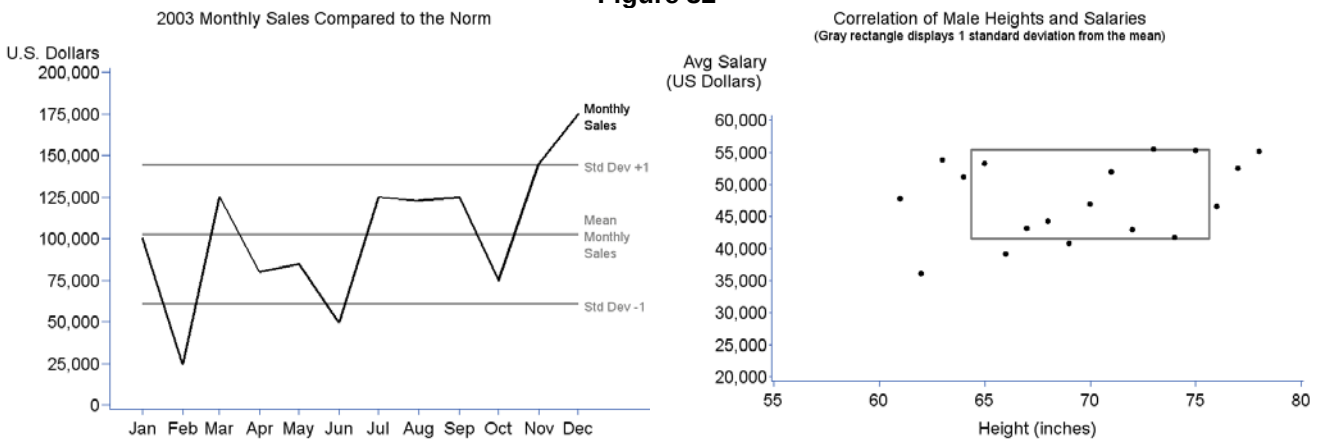
Finally, reference lines are used to provide a comparison to some standard or another point of interest. This might be a baseline value as in the following examples (Figure 31),

Figure 31



or a range of values as in the two graphs in Figure 32.

Figure 32

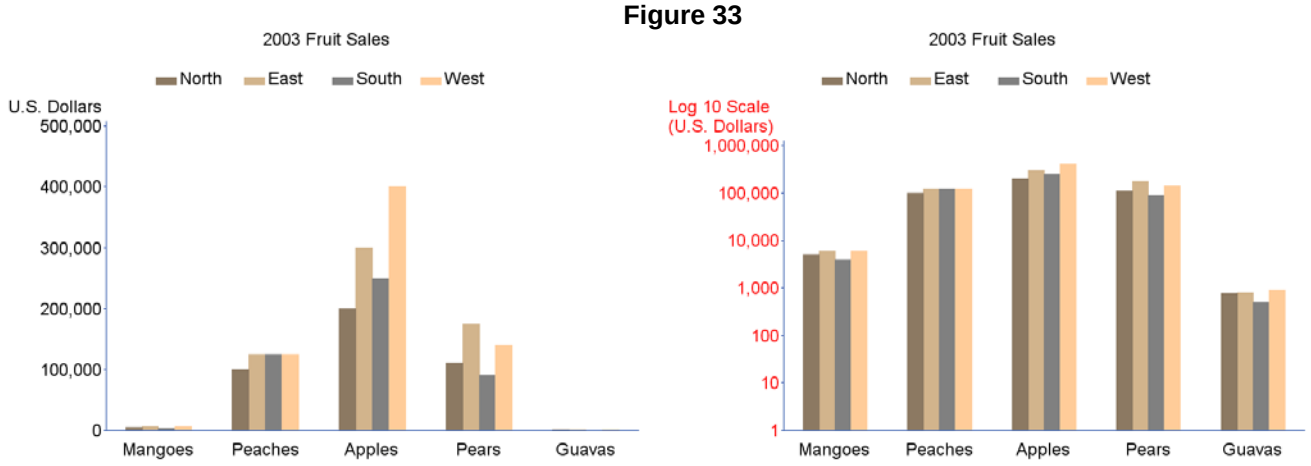


Scale Lines

Sometimes a linear scale may hide data if some of the data values are very small and some very large. A logarithm scale may help to “show the data” better. However, the scales must be clearly visible for the user to properly read the graph. This is an instance where minor tick marks may be useful.

Consider the pair of graphs in Figure 33.

Figure 33

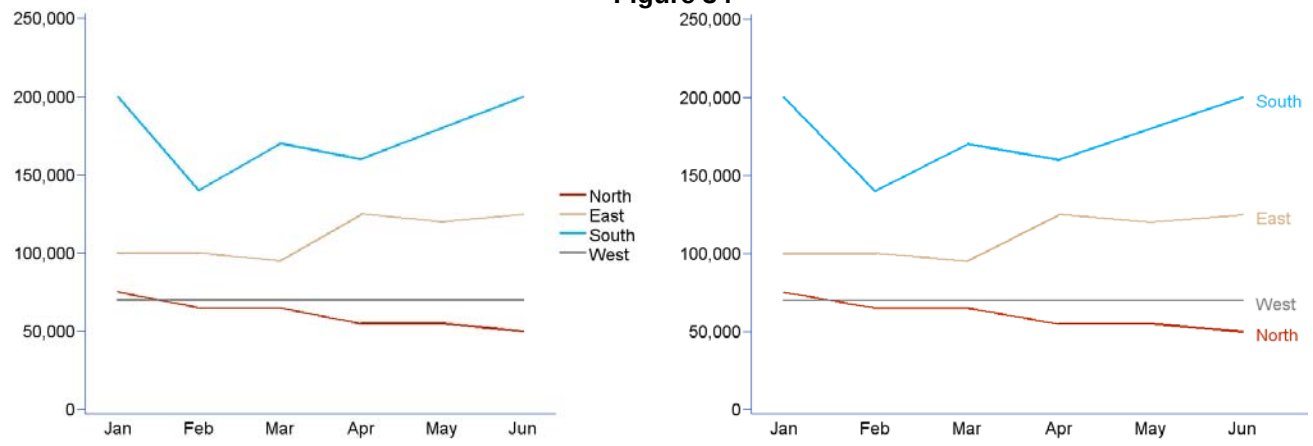


Using the log scale shows more clearly the values of Mangoes and Guavas. Of course, the reading of the log scale is different. Same distances along the logarithm scale equal the same percentages or ratios. This takes a bit of an adjustment, but provides the viewer with more meaningful data.

Legends

Legends provide the viewer with important additional information to distinguish between various points, lines, or bars. First, legends should only be used if it there is not another way to distinguish these elements more directly. Placing labels near the lines, for example, makes it easier to identify the associated category. Compare the two graphs in Figure 34. It is easier to identify the lines with the region for the graph on the right.

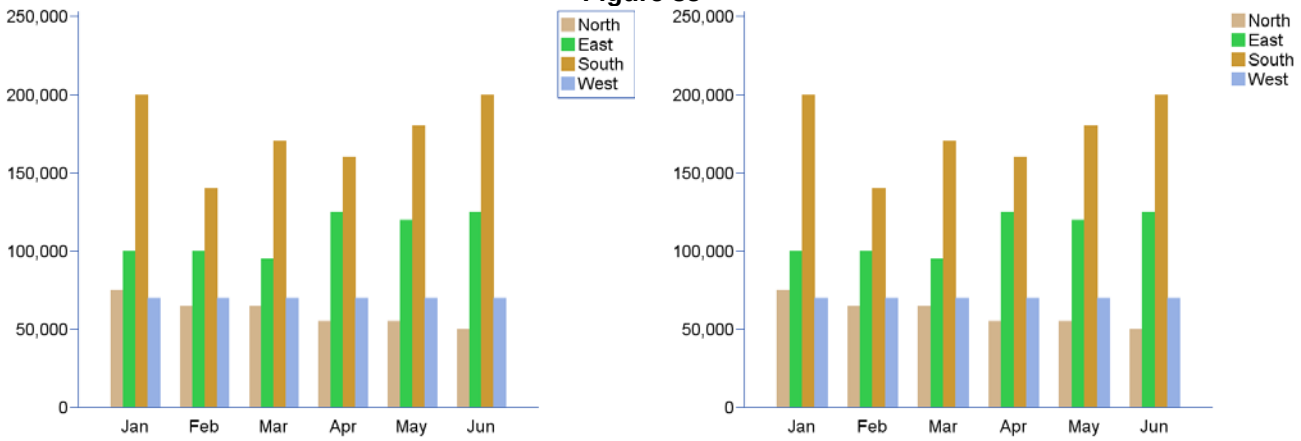
Figure 34



However, this only works when there is some separation between lines. Also, the use of this technique with bar charts generally becomes too busy. In these situations separate legends would be preferable.

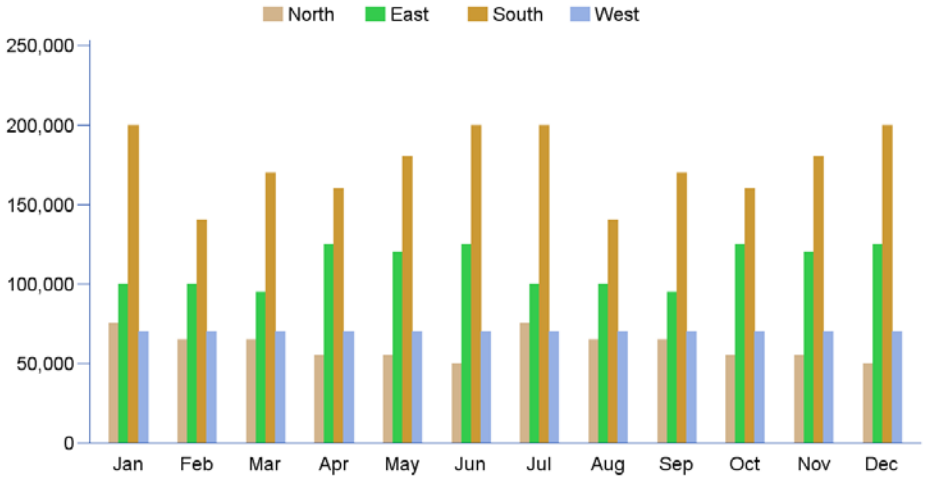
Where should you place legends? The closer the legend can be to the data the better. If it does not interfere with the data itself, put the legend in the data area. Otherwise, place the legend in a reasonable place that does not interfere with the graph components and is easy to find. The legend should be clearly visible, but not distracting to the main story, the graph. Subtleness should be the overriding rule. A good example of this is the use of borders. There are few reasons that borders should ever be used, since this draws too much attention to the legend – also remember the data-ink ratio! Figure 35 illustrates this difference.

Figure 35



The arrangement of labels in the legends depends on the space available. Generally, if the graph is wide and the labels are not too long, the labels are best arranged horizontally at the top as shown in Figure 36. Including the label near the top of the chart puts it closer to the data. If the graph is not as wide or the labels are too long, the labels are best arranged vertically on right.

Figure 36



Other Text

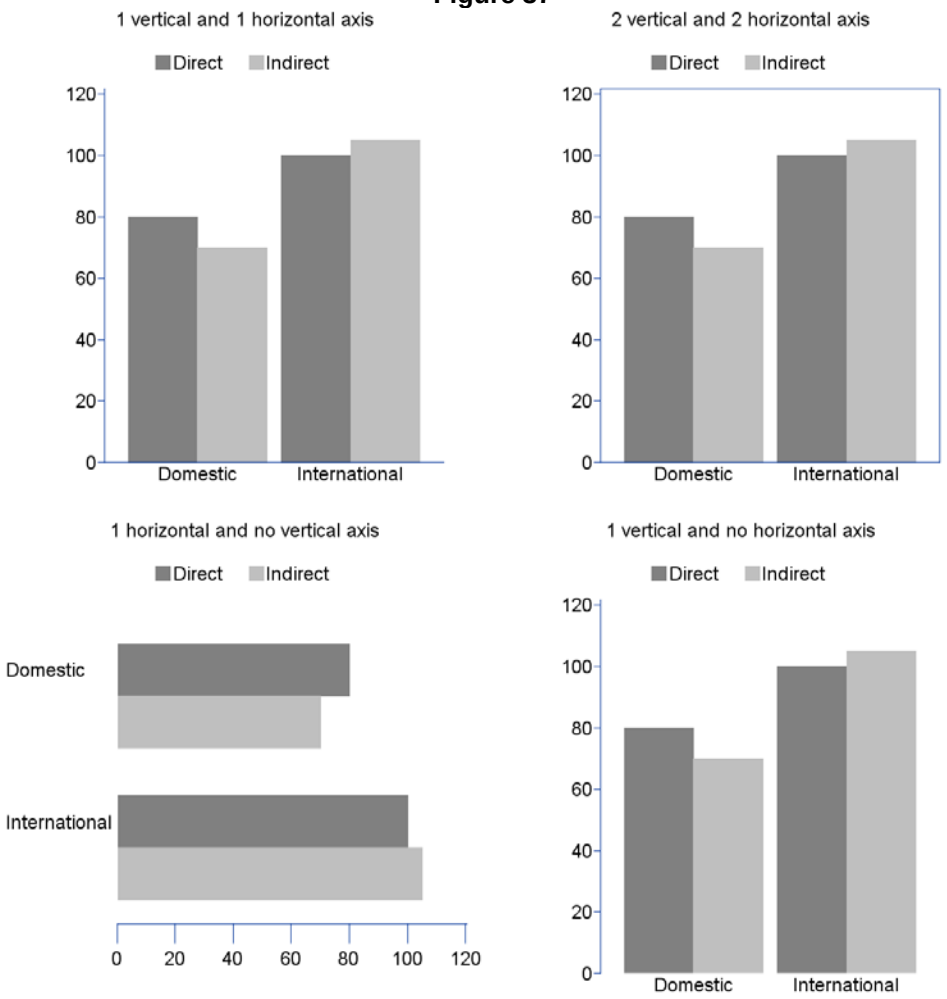
Other text included in the graph should appear as close to the data it is describing without interfering with any other data. This would include any annotation that might be included in the graph.

Support Component Design

There are many support components that also contribute to graph design. These include axes, tick marks, and backgrounds. Some of these aspects will be covered here.

Axes are important, since they provide a boundary of the data area and provide definition of scale and categories for the data. The first question is how many axes to include. Figure 37 illustrates four possibilities.

Figure 37



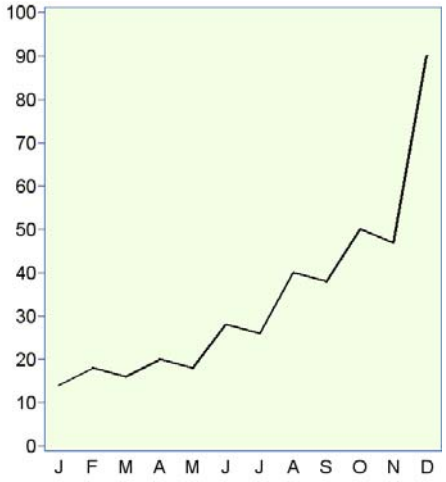
As was previously mentioned in the general principles, to minimize data-ink you would only want to include the axes that are necessary. This immediately eliminates putting a full frame around the data area. The decision on whether to include a base axis, whether vertical or horizontal, depends on the context of the data. If it is interval data an axis is necessary; however, if it categorical, as in the example above, it would be user preference. Few prefers to have an axis, because he says that the “bars appear to float in space,” but Tufte would probably say that they are not necessary so should be eliminated. In fact, Tufte might recommend eliminate the axis lines altogether (but not the tick marks) since they constitute non-data-ink.

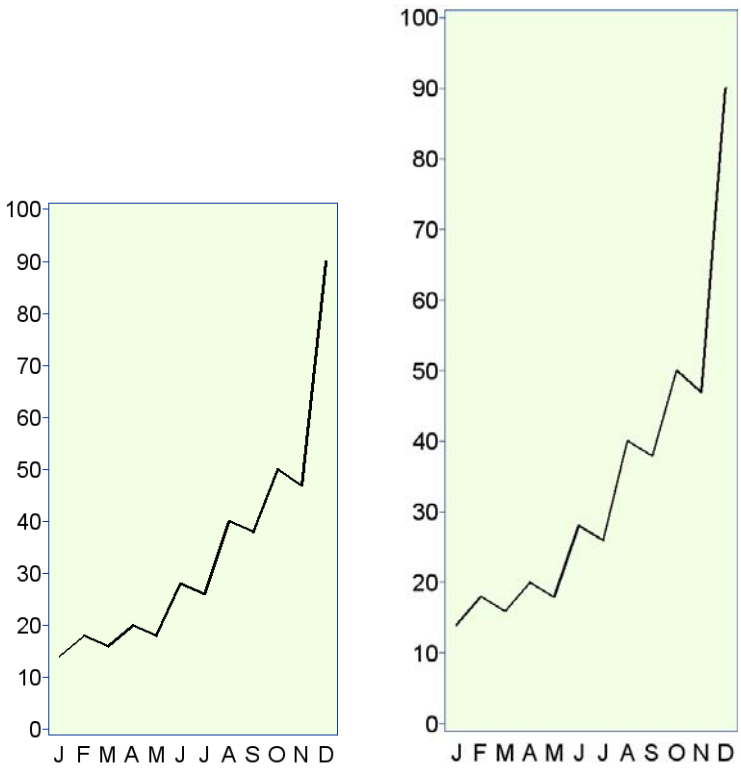
The relative lengths of the axes are dependent on the data, but both Tufte and Few provide guidance. Except for unique circumstances, graphs should be wider than they are tall. Tufte suggests a range for the ration of length to height from 1.2 to 2.2, while mentioning the Golden Rectangle, which has an aspect ratio of about 1.67, as being optimal. Few says about the same thing, mentioning an exception of a scatter plot, where a square data area works well. Figure 38 illustrates compares different aspect ratios from 2 to 0.5.

Figure 38


100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D


100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D


100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D

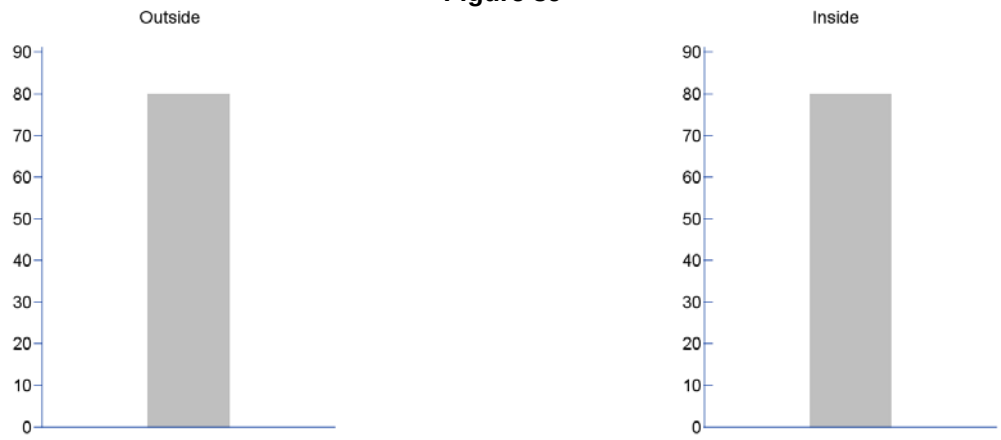


As can be seen from these examples, the story of the data can be distorted by changing the aspect ratio. However, by sticking with the suggestions made by Tufte and Few, a truer picture is revealed.

Tick marks are an integral part of the axis. Several aspects of tick marks should be taken into consideration.

First, tick marks should be visually muted but still be read easily. Primarily, this is done by varying the length of the mark. They may appear either outside the axis, inside the axis, or across the axis. Examples of the first two of these are shown in Figure 39 (SAS/Graph does not provide for tick marks across the axis.)

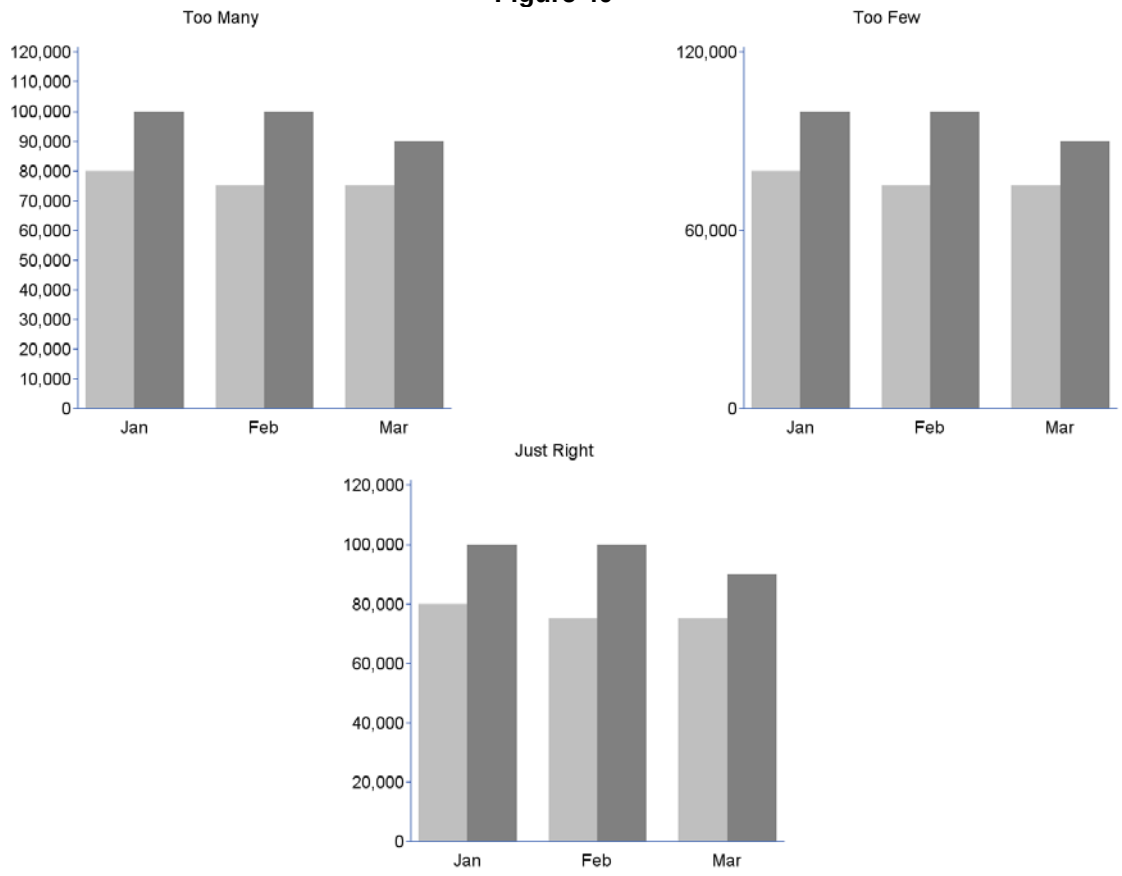
Figure 39



Tick marks are always needed on a quantitative scale, but many times can be eliminated for categorical data. Also, minor tick marks are almost always unnecessary. The only exception may be on a logarithmic scale where the minor tick marks make it easier to determine intermediate values.

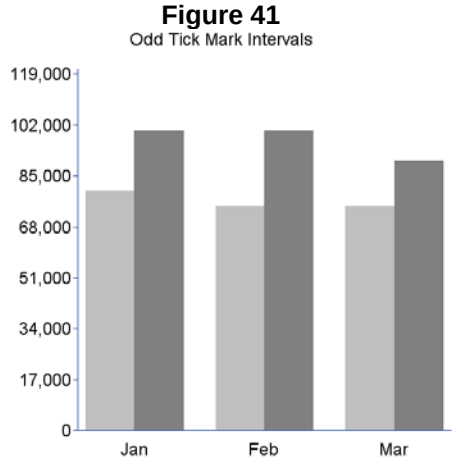
The graph should include a sufficient number of tick marks to determine the data values at any point without cluttering up the axis. The length of the axis will generally determine how many this should be. Figure 40 illustrates when there are too many, too few, and just about the right number of tick marks.

Figure 40



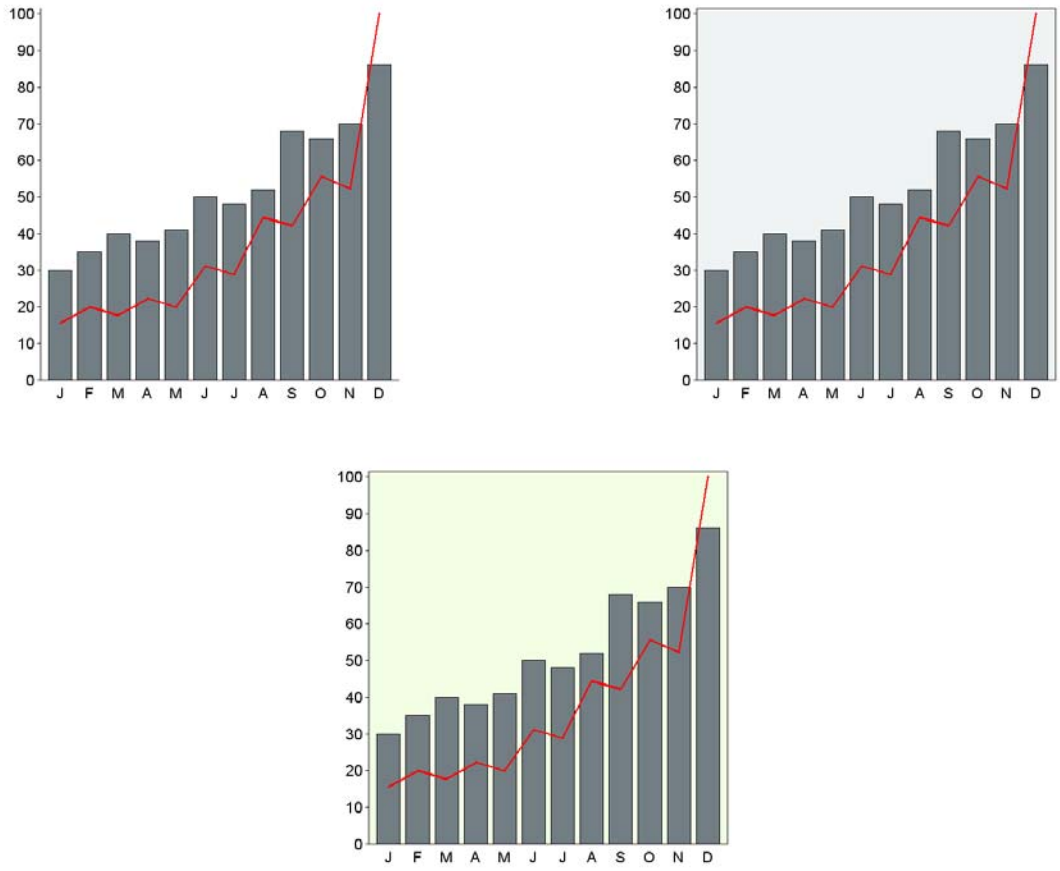
Also, the values should be nice, round numbers. Odd intervals make the values more difficult to determine. Figure 41 shows this difficulty.

Figure 41



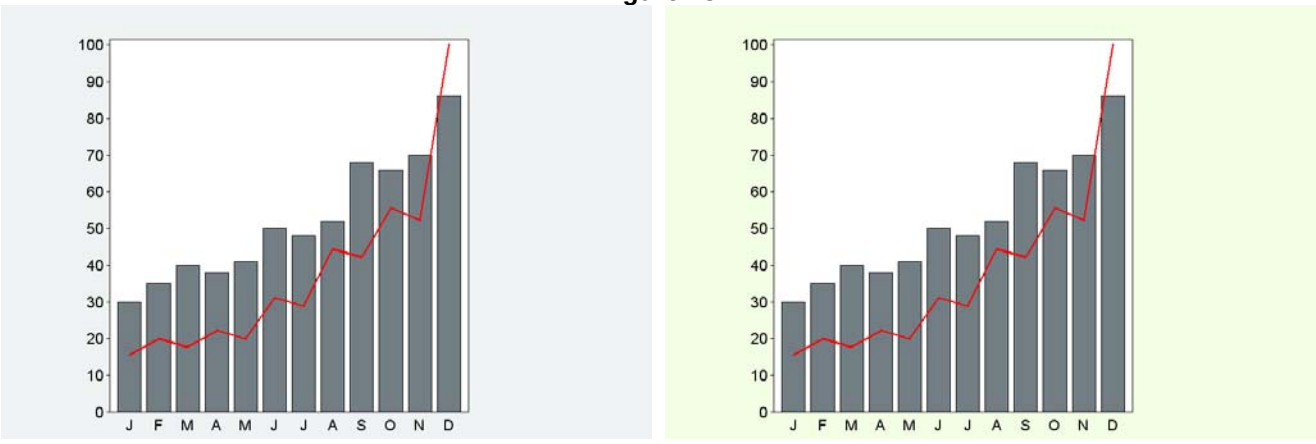
Fill color can be used to enhance a graph. Providing a background color to the data area can help to draw a viewer's eye to the data. However, care must be used to not distract as well. Although Tufte would probably say never use a background color, a subtle color may be an aid. Compare the graphs in Figure 42.

Figure 42



A similar approach could be taken by filling the surrounding area with a fill color while leaving the data area with a white background. This is shown in Figure 43.

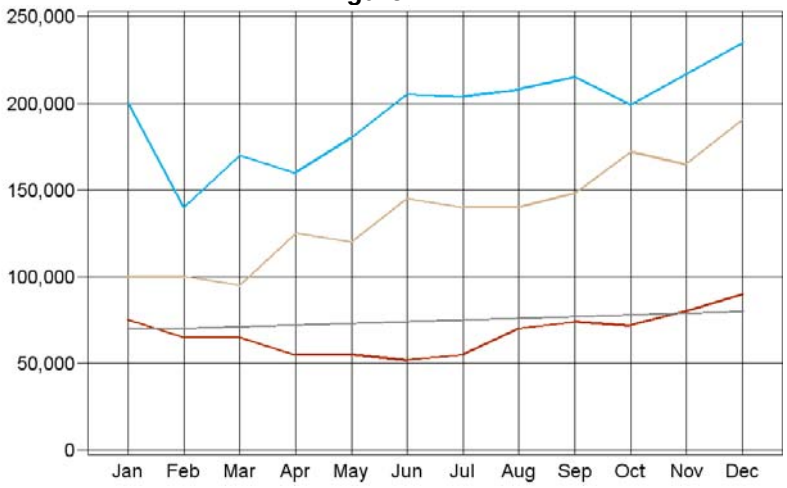
Figure 43



Judgment should be used in determining which of these might work best in different situations.

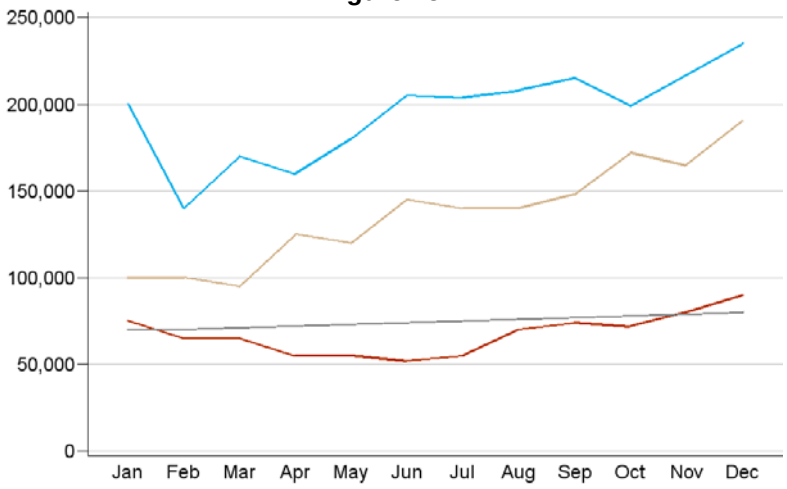
Grid lines to better determine data values can be useful, if used properly. As with most of what has been presented here, the grid lines should be subtle, but readable. The earlier discussion of Tufte would discourage the use of grid lines, and, certainly, heavy lines as shown in Figure 44 should not be used.

Figure 44



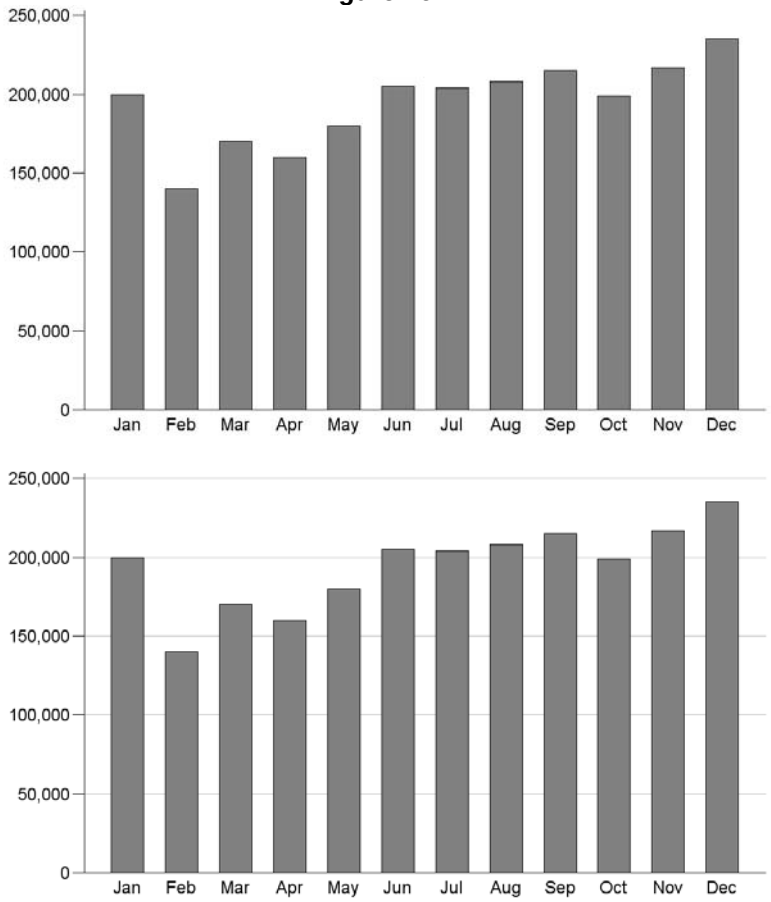
However, if used properly grid lines can aid in the determining data values from a graph, without distracting from the data. Compare the graph in Figure 45 to the previous graph.

Figure 45



Reference lines can also be added to enhance comparisons in bar charts. Compare the graphs in Figure 46.

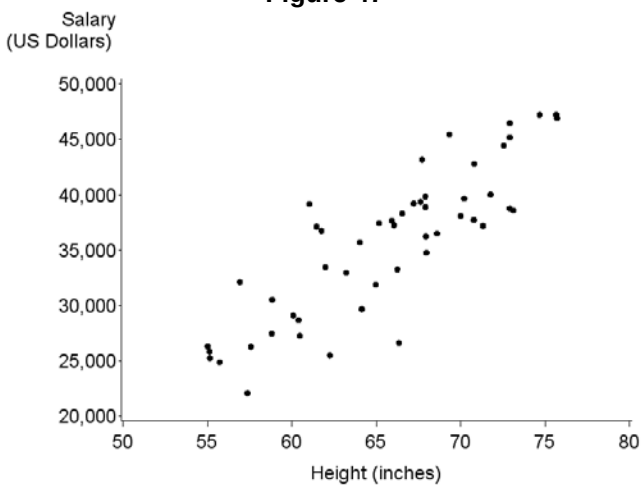
Figure 46



It is easier to compare bars that are close to the same height, such as June to August, with the aid of the reference line. However, the reference lines should be subtle and appear behind the bars, so not to distract from the bars.

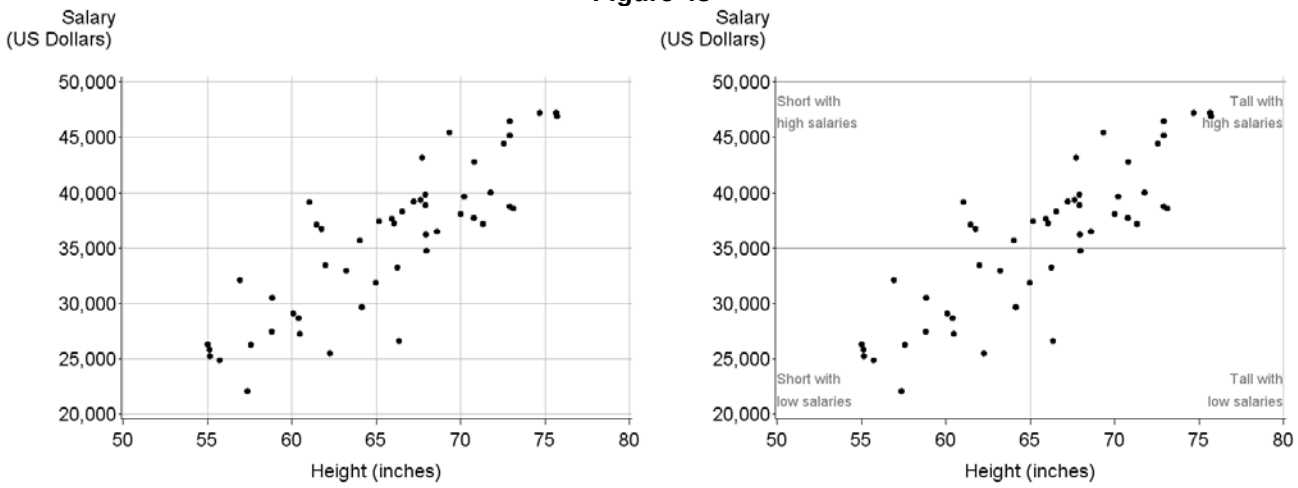
Reference lines can be useful in scatter plots as well. Consider the scatter plot in Figure 47.

Figure 47



The addition of grid lines allows the viewer to focus on a part of the graph. These may be divided into several lines on each axis as in the graph on the left in Figure 48, or just a few as in the graph on the right.

Figure 48



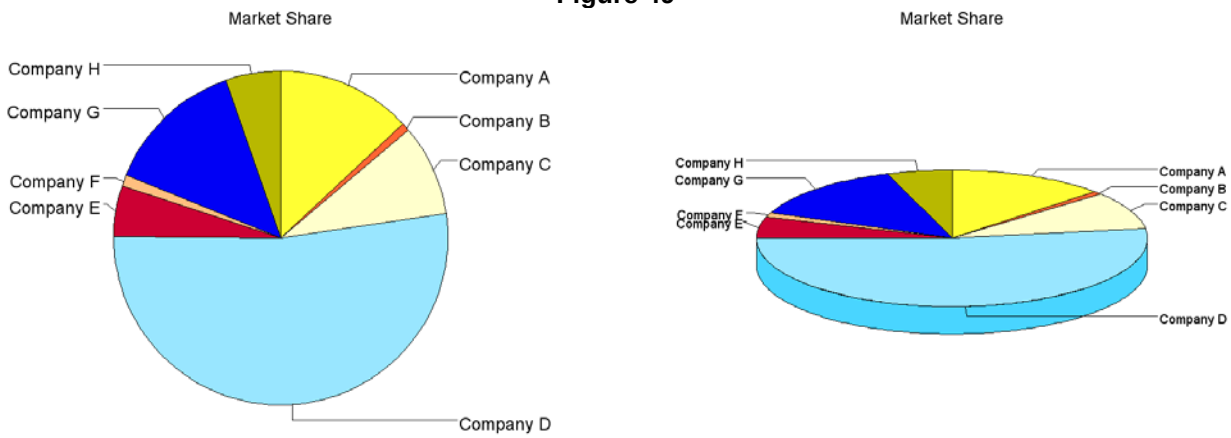
What Was Left Out?

You may have noticed that two subjects were left out of this presentation, namely 3-D graphics and pie charts. This was intentional.

First, there is really no place where a third dimension enhances graphics, except for the "cool" factor. Most graphics are inherently two dimensional, so why add a third. Or, if the data is truly three (or more) dimensional, it is difficult to display in a 2-dimensional medium. In that situation, it is better to display a series of 2-dimensional graphs that contain the data in higher dimensional space. A good example of this is what Tufte calls small multiples.

What about pie charts? Both Tufte and Few are adamant about this. Stephen Few likes to say, "Save the pies for dessert." Few points out that the information in a pie chart can almost always be displayed more clearly with a bar chart. The bar chart allows easier comparison of categories, since we can compare lengths much easier than we can compare area. Notice how in Figure 49 it is difficult to tell whether company A or company G has a larger share.

Figure 49



Notice also that using a 3-D effect only makes it worse. The use of a bar chart makes these comparisons much easier, as can be seen in Figure 50.

Figure 50
Market Share

Conclusion

Graphs can help tell the story of the data, but only if care is taken in the design. Through presenting Edward Tufte's principles and Stephen Few's examples, this paper has provided a framework that could be used to produce excellent graphs that tell the story clearly. This constitutes a very abbreviated version of this topic, and it is advised that additional reading of the references be pursued to see the subject in all its glory.

However, the key may truly be in "Revise and edit"!

Contact Information

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Appendix: SAS/Graph Code for Examples

As mentioned previously all the examples in this paper were done with SAS/Graph. This section provides the code along with highlights on what options produced the various effects. This will allow you to use these examples to produce similar graphs. The code is arranged by figure numbers and includes only the SAS/Graph code.

Figure 1

```
symbol i=join value=dot width=2 ;
proc gplot data=test1 ;
   plot sales * year /
      autohref cautohref=black
      autovref cautovref=black ;
   label sales = 'Annual Sales'
         year = 'Year' ;
run ;
quit ;
```

Figure 2

```
axis1 label=('Year') minor=none
   offset=(5 pct, 5 pct) style=0 ;
axis2 label=('Annual Sales')
   minor=none major=(height=1.5)
   order=(40 to 60 by 5)
   offset=(5 pct,) style=0  ;
proc gplot data=test1 ;
   plot sales * year /
      noframe
      haxis=axis1 vaxis=axis2;
run ;
quit ;
```

Figure 3

```
goptions reset=symbol ;
symbol i=join value=none width=2 ;
axis1 label=none minor=none
   offset=(5 pct, 5 pct) style=0 ;
axis2 label=('Annual Sales')
   minor=none major=(height=1.5)
   order=(40 to 60 by 5)
   offset=(5 pct,) style=0  ;
proc gplot data=test1 ;
   plot sales * year /
      noframe
      haxis=axis1 vaxis=axis2;
run ;
quit ;
```

Figure 4

```
%annomac
data point ;
   set test1 end=last ;
   if last ;
   retain xsys '2' ysys '2' ;
   length text $30 ;
   %label(year, sales,
          put(sales,dollar8.1),
          blue,0,0,1.5,'Arial',2) ;
run ;

axis1 label=none minor=none major=none
   offset=(5 pct, 5 pct) ;
axis2 label=('Annual Sales')
   minor=none major=(height=1.5)
   order=(40 to 60 by 5) offset=(5 pct,)
   style=0  ;
proc gplot data=test1 anno=point ;
   plot sales * year /
      noframe
      haxis=axis1 vaxis=axis2;
run ;
quit ;
```

Figure 5

```
axis1 minor=none value=(height=2)
   label=(height=2 j=r 'Annual Sales'
   j=r '(U.S. Dollars)' j=r ' ')
   order=(0 to 70000 by 10000) ;
axis2 minor=none value=(height=2)
   label=(height=2 'Height'
   j=c '(inches)')
   order=(50 to 80 by 5) ;
legend1 across=1 label=none repeat=1
   position=(bottom right inside)
   offset=(,5 pct)
   value=(height=2 'Men' 'Women') ;
symbol1 i=none font=marker v=P c=black
   height=1 ;
symbol2 i=none font=marker v=U c=black
   height=1 ;
title;
proc gplot data=test2 ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 6

```
symbol1 i=none font=marker v=P c=black
   height=2 ;
symbol2 i=none font=marker v=U c=black
   height=2 ;
proc gplot data=test2 ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 7

```
symbol1 i=none f=marker v=W c=black h=1;
symbol2 i=none f='Arial' v=- c=black h=4;
proc gplot data=test2 ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 8

```
symbol1 i=none f=marker v=W c=gray h=1 ;
symbol2 i=none f=marker v=W c=red h=1 ;
proc gplot data=test2 ;
proc gplot data=test2 ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 9

```
symbol1 i=none f='Arial' v=- c=gray h=4 ;
symbol2 i=none f=marker v=W c=red h=1 ;
proc gplot data=test2 ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 10

```
goptions reset=symbol ;
symbol1 i=none v=dot c=red height=2 ;
symbol2 i=none v=dot c=gray height=2 ;
proc gplot data=test2a ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 11

```
symbol1 i=none v=circle c=red height=2 ;
symbol2 i=none v=circle c=gray height=2 ;
proc gplot data=test2a ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 12

```
symbol1 i=none v=plus c=red height=2 ;
symbol2 i=none v=circle c=gray height=2 ;
proc gplot data=test2a ;
   plot salary * height = gender /
      noframe
      legend=legend1
      vaxis=axis1 haxis=axis2;
   format salary dollar10. ;
run ;
quit ;
```

Figure 13

```
axis1 minor=none major=(height=1.5)
   label=none value=(height=2)
   order=(0 to 350000 by 50000);
axis2 minor=none major=none label=none
   offset=(10, 20) pct value=(height=2);
legend1 across=1 label=none
   position=(top right inside)
   shape=symbol(5 pct,.5)
   value=('North' 'East' 'South' 'West');
symbol i=join f=marker v=C c=black
   height=.5 width=2 ;
symbol2 i=join f=marker v=P c=black
   height=.5 width=2 ;
symbol3 i=join f=marker v=U c=black
   height=.5 width=2 ;
```

```
symbol4 i=join f=marker v=W c=black
   height=.5 width=2 ;
proc gplot data=test3 ;
   plot sales * qtr = region  /
      noframe
      vaxis=axis1 haxis=axis2
      legend=legend1 ;
   format sales dollar12.0;
run ;
quit ;
```

Figure 14

```
legend1 across=1 label=none
   position=(top right inside)
   shape=symbol(7 pct,1.5)
   value=('North' 'East' 'South' 'West');
symbol i=join font=marker v=C  c=black
   height=1.5 width=1 ;
symbol2 i=join font=marker v=P c=black
   height=1.5 width=1 ;
symbol3 i=join font=marker v=U c=black
   height=1.5 width=1 ;
symbol4 i=join font=marker v=W c=black
   height=1.5 width=1 ;
proc gplot data=test3 ;
   plot sales * qtr = region  /
      noframe
      vaxis=axis1 haxis=axis2
      legend=legend1 ;
   format sales dollar12.0 ;
run ;
quit ;
```

Figure 15

```
axis1 label=(height=2 'Number of Orders')
   value=(height=2) minor=none
   order=(0 to 250 by 50) ;
axis2 label=none ;
pattern c=gray coutline=gray ;
title 'Top Sales Representatives' ;
proc gchart data=test4 ;
   hbar name /
      noframe
      sumvar=orders descending nostats
      raxis=axis1
      maxis=axis2 ;
run ;
quit ;
```

Figure 16

```
axis3 label=none
   value=(height=1.5 angle=0 rotate=360);
proc gchart data=test4 ;
   vbar name /
      noframe
      sumvar=orders descending
      raxis=axis1 maxis=axis3 ;
run ;
quit ;

axis1 label=(height=1.5 '# of Orders')
   value=(height=1.5) minor=none
   order=(0 to 250 by 50) ;
axis2 label=none
   value=(height=1.5 angle=90) ;
proc gchart data=test4 ;
   vbar name /
      noframe
      sumvar=orders descending
      raxis=axis1 maxis=axis2 ;
run ;
quit ;

axis3 label=none
  value=(height=1.5 angle=45 rotate=360);
proc gchart data=test4 ;
   vbar name /
      noframe
      sumvar=orders descending
      raxis=axis1 maxis=axis3 ;
run ;
quit ;

axis3 label=none value=(height=1.5)
   split='~' ;
proc gchart data=test4 ;
   vbar name2 /
      noframe
      sumvar=orders descending
      raxis=axis1 maxis=axis3 ;
run ;
quit ;
```

Figure 17

```
title ;
axis1 label=none value=(height=2)
   minor=none order=(0 to 25 by 5) ;
axis2 label=none value=(height=2) ;
pattern c=gray  ;
proc gchart data=test5 ;
   title h=3 '1 to 2' ;
   vbar date /
      noframe discrete
      sumvar=freq
      raxis=axis1 maxis=axis2
      width=8 space=16
      coutline=gray ;
   format date monname3. ;
run ;
   title h=3 '1 to 1.5' ;
```

```
   vbar date /
      noframe discrete
      sumvar=freq
      raxis=axis1 maxis=axis2
      width=10 space=15 ;
   format date monname3. ;
run ;
   title h=3 '1 to 1' ;
   vbar date /
      noframe discrete
      sumvar=freq
      raxis=axis1 maxis=axis2
      width=12 space=12 ;
   format date monname3. ;
run ;
   title h=3 '1 to 0.5' ;
   vbar date /
      noframe discrete
      sumvar=freq
      raxis=axis1 maxis=axis2
      width=16 space=8 ;
   format date monname3. ;
run ;
   title h=3 '1 to 0' ;
   vbar date /
      noframe discrete
      sumvar=freq
      raxis=axis1 maxis=axis2
      width=24 space=0
      coutline=same ;
   format date monname3. ;
run ;
quit ;
```

Figure 18

```
axis1 label=none value=(height=2)
   minor=none order=(0 to 350 by 50) ;
axis2 label=none value=none ;
axis3 label=none
   offset=(5 pct, 5 pct) nobrackets ;
legend1 down=1 label=none
   position=(top center inside) ;
pattern1 c=gray ;
pattern2 c=tan ;
pattern3 c=sto ;
pattern4 c=libr ;
proc gchart data=test6 ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      legend = legend1
      coutline=same ;
run ;
```

```
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=2 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      legend = legend1
      coutline=same ;
run ;
quit ;
```

Figure 19

```
axis1 value=(height=1.5) major=(height=1)
  label=(height=1.5 j=l ' ' j=l 'Inches')
  minor=none order=(0 to 80 by 10) ;
axis2
   label=(height=1.5 j=l 'U.S.'
   j=l 'Dollars') value=(height=1.5)
   major=(height=1) minor=none
   order=(0 to 100000 by 20000) ;
axis3 label=none value=none major=none
   minor=none offset=(2 pct, 2 pct)
   nobrackets ;
legend1 label=none value=('Height')
   position=(top center inside)
   offset=(-8 pct,);
legend2 label=none value=('Salary')
   position=(top center inside)
   offset=(8 pct,);
symbol1 i=needle width=30 c=ligr ;
symbol2 i=needle width=15 c=gray ;
proc gplot data=test6a ;
   plot height * order /
      noframe
      vaxis=axis1 haxis=axis3
      legend=legend1 ;
   plot2 salary * order /
      noframe
      vaxis=axis2 haxis=axis3
      legend=legend2 ;
   format salary dollar10. ;
run ;
quit ;
```

Figure 20

```
axis1 label=none value=(height=2)
   minor=none order=(0 to 350 by 50) ;
axis2 label=none value=none ;
axis3 label=none offset=(5 pct, 5 pct)
   nobrackets ;
legend1 down=1 label=none
   position=(top center inside) ;
pattern1 c=gray ;
pattern2 c=black ;
pattern3 c=sto ;
```

```
pattern4 c=libr ;
title 'North Region Exhibits Greatest
Growth!' ;
proc gchart data=test6 ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      legend = legend1
      coutline=same ;
run ;
quit ;
```

Figure 21

```
pattern1 c=gray ;
pattern2 c=tan ;
pattern3 c=sto ;
pattern4 c=libr ;
proc gchart data=test6 ;
   title h=3 'No bar borders' ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      nolegend
      coutline=same ;
run ;
   title h=3 'Black bar borders' ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      nolegend
      coutline=black
      woutline=2 ;
run ;
   title h=3 'Gray bar borders' ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      nolegend
      coutline=gray
      woutline=2 ;
run ;
   title h=3 'White bar borders' ;
   vbar region /
      noframe
      sumvar=sales group=qtr
      subgroup=region
      space=0 gspace=10
      raxis=axis1 maxis=axis2 gaxis=axis3
      nolegend
      coutline=white
      woutline=2 ;
run ;
quit ;
```

Figure 22

```
axis1 label=('U.S. Dollars')
   value=(height=2) minor=none
   order=(-20000 to 25000 by 5000) ;
axis2 label=none style=0 ;
title '2003 Profit & Loss' ;
proc gchart data=test7 ;
   vbar date /
      noframe discrete
      sumvar=profit
      width=8 space=8
      raxis=axis1 maxis=axis2 ;
   format date monname3. profit comma10.;
run ;
quit ;
```

Figure 23

```
axis1 label=none value=(height=2)
   minor=none order=(0 to 200 by 25) ;
axis2 label=none style=0
   value=(height=2 justify=right) ;
pattern1 c=white ;
pattern2 c=gray ;
title 'Salary Ranges by Department' ;
proc gchart data=test8 ;
   hbar dept /
      noframe descending nostats
      sumvar=value subgroup=type
      raxis=axis1 maxis=axis2
      width=2 space=2
    coutline=same nolegend ;
run ;
quit ;
```

Figure 24

```
axis1 label=('U.S. Dollars')
   value=(height=2) minor=none
   order=(0 to 150000 by 25000) ;
axis2 label=none value=(height=2)
   major=none offset=(5 pct, 5 pct)
   split='~'
   order=('Operations' 'Finance'
   'Marketing' 'Engineering' 'Sales'
   'Information~Systems');
```

```
symbol i=hiloc value=none ;
title 'Minimum, Maximum, and Median
Salaries by Department' ;
proc gplot data=test8a ;
   plot value * dept /
      noframe
      vaxis=axis1 haxis=axis2;
   format value comma10. ;
run ;
quit ;
```

Figure 25

```
axis1 minor=none label=none
   order=(0 to 350000 by 50000)
   value=(height=2) ;
axis2 minor=none major=none label=none
   offset=(5 pct, 5 pct)
   value=(height=2) ;
symbol1 i=join c=black height=2 width=2
   v=square ;
symbol2 i=join c=black height=2 width=2
   v=triangle ;
symbol3 i=join c=black height=2 width=2
   v=circle ;
symbol4 i=join c=black height=2 width=2
   v=diamond ;
proc gplot data=test9 ;
   plot freq * month = region /
      noframe nolegend
      vaxis=axis1 haxis=axis2 ;
   format month $mon. freq comma10. ;
run ;
quit ;
```

Figure 26

```
symbol1 i=join c=cx33FFCC width=2 v=none;
symbol2 i=join c=cxFFCC33 width=2 v=none;
symbol3 i=join c=cx0039E6 width=2 v=none;
symbol4 i=join c=cxB8002E width=2 v=none;
proc gplot data=test9 ;
   plot freq * month = region /
      noframe nolegend
      vaxis=axis1 haxis=axis2 ;
   format month $mon. freq comma10. ;
run ;
quit ;

symbol1 i=join c=cxBDBDBD width=2 v=none;
symbol2 i=join c=cx8A8A8A width=2 v=none;
symbol3 i=join c=cx000000 width=2 v=none;
symbol4 i=join c=cxE0E0E0 width=2 v=none;
proc gplot data=test9 ;
   plot freq * month = region /
      noframe nolegend
      vaxis=axis1 haxis=axis2 ;
   format month $mon. freq comma10. ;
run ;
quit ;
```

Figure 27

```
symbol1 i=join c=black width=2 v=none
   line=4 ;
symbol2 i=join c=black width=2 v=none
   line=5 ;
symbol3 i=join c=black width=2 v=none
   line=3 ;
symbol4 i=join c=black width=2 v=none
   line=1 ;
proc gplot data=test9 ;
   plot freq * month = region /
      noframe nolegend
      vaxis=axis1 haxis=axis2 ;
   format month $mon. freq comma10. ;
run ;
quit ;
```

Figure 28

```
axis1 minor=none major=(height=1)
   label=none order=(0 to 35 by 5)
   value=(height=2) ;
axis2 minor=none major=none label=none
   offset=(5, 5)pct value=(height=2);
symbol i=boxf00 c=black ;
title h=3 'Selling Price';
title2 height=2
   '(Black lines display the range)' ;
proc gplot data=tsumm ;
   plot price * month /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format price dollar5.0 month $mon.;
run ;
quit ;
```

Figure 29

```
symbol i=boxf00 c=black bwidth=2
   width=1.5 cv=ligr ;
title h=3 'Selling Price';
title2 height=2
   '(Range in gray; Average in black)' ;
proc gplot data=tsumm ;
   plot price * month /
      noframe
      vaxis=axis1 haxis=axis2 ;
      format price dollar5.0 month $mon.;
run ;
quit ;

symbol i=hiloj c=black width=4 co=ligr;
```

```
title h=3 'Selling Price';
title2 height=2
   '(Range in gray; Average in black)' ;
proc gplot data=tsumm ;
   plot price * month /
      noframe
      vaxis=axis1 haxis=axis2 ;
      format price dollar5.0 month $mon.;
run ;
quit ;
```

Figure 30

```
axis1 minor=none label=('U.S. Dollars')
   order=(0 to 30000 by 5000)
   value=(height=2) ;
axis2 minor=none major=none label=none
   offset=(5, 5)pct value=(height=2);
axis3 major=none minor=none label=none
   value=none style=0 ;
symbol1 i=j width=3 ci=black ;
pattern1 c=ligr ;
title h=3 '2002 Sales' ;
proc gbarline data=regline ;
   bar date /
      noframe
      sumvar=sales discrete
      width=5 space=5
      raxis=axis1 maxis=axis2
      coutline=same ;
   plot / sumvar=pred axis=axis3 ;
   format date monname3. sales comma10.0;
run ;
quit ;

axis1 minor=none value=(height=2)
   label=(height=2 'Avg Salary'
   j=r '(U.S. Dollars)' j=r ' ')
   order=(20000 to 50000 by 5000) ;
axis2 minor=none
   label=(height=2 'Height (inches)')
   order=(50 to 80 by 5)
   offset=(5, 5) pct value=(height=2) ;
symbol1 i=rl v=dot c=gray ci=black w=2;
title h=3 'Correlation of Height and
Salary' ;
proc gplot data=test2 ;
      plot salary * height /
            noframe
            vaxis=axis1 haxis=axis2 ;
      format salary comma10.0 ;
run ;
quit ;
```

Figure 31

```
axis1 minor=none major=(height=2)
   label=(height=2 'U.S. Dollars')
   order=(0 to 200000 by 25000)
   value=(height=2) ;
axis2 minor=none label=none
   offset=(5, 5) pct value=(height=2) ;
symbol i=join v=none c=black width=2 ;
title '2003 Monthly Sales Compared to
January' ;
proc gplot data=test12 ;
   plot sales * date /
      noframe
      vaxis=axis1 haxis=axis2
      vref=100000 cvref=gray wvref=2 ;
   format date monname3. sales comma10.0;
run ;
quit ;

%annomac ;
data anno ;
   set test12(obs=1) ;
   retain xsys ysys '2' ;
   end = intnx('month',date,11,'b') ;
   %line(date,sales,end,sales,gray,1,2) ;
   %label(end+5,sales+15000,'Baseline',
      gray,0,0,1.5,'Arial',6);
   %label(end+5 ,sales+5000,'of',
      gray,0,0,1.5,'Arial',6) ;
   %label(end+5,sales-5000,'January',
      gray,0,0,1.5,'Arial',6) ;
   %label(end+5,sales-15000,'Sales',
      gray,0,0,1.5,'Arial',6) ;
run ;

axis2 minor=none label=none
   offset=(5, 10) pct value=(height=2) ;
title h=3 '2003 Monthly Sales Compared to
January' ;
proc gplot data=test12 anno=anno ;
   plot sales * date /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format date monname3. sales comma10.0;
run ;
quit ;

data anno ;
   set test12(firstobs=12) ;
   retain xsys ysys '2' ;
   length text $50 ;
   beg = intnx('month',date,-11,'b') ;
   %label(date+5 ,sales+5000,'Monthly',
      gray,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales-5000,'Sales',
      gray,0,0,1.5,'Arial',6) ;

   set avg ;
   %line(beg,sales,date,sales,gray,1,2) ;
```

```
   %label(date+5 ,sales+10000,'Mean',
      gray,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales,'Monthly',
      gray,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales-10000,'Sales',
      gray,0,0,1.5,'Arial',6) ;
run ;

title h=3 'Monthly Sales Compared to
Average Monthly Sales' ;
proc gplot data=test12 anno=anno ;
   plot sales * date /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format date monname3. sales comma10.0;
run ;
quit ;
```

Figure 32

```
data anno ;
   set test12(firstobs=12) ;
   retain xsys ysys '2' ;
   length text $50 ;
   beg = intnx('month',date,-11,'b') ;
   %label(date+5 ,sales+5000,'Monthly',
      black,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales-5000,'Sales',
      black,0,0,1.5,'Arial',6) ;

   set avg ;
   %line(beg,sales,date,sales,gray,1,2) ;
   %label(date+5 ,sales+10000,'Mean',
      gray,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales,'Monthly',
      gray,0,0,1.5,'Arial',6) ;
   %label(date+5 ,sales-10000,'Sales',
      gray,0,0,1.5,'Arial',6) ;

   sales_plus = sales + sd ;
   sales_minus = sales - sd ;
   %line(beg,sales_plus,date,sales_plus,
      gray,1,2) ;
   %label(date+5,sales_plus,'Std Dev +1',
      gray,0,0,1.5,'Arial',6) ;
  %line(beg,sales_minus,date,sales_minus,
      gray,1,2) ;
   %label(date+5,sales_minus,
    'Std Dev -1',gray,0,0,1.5,'Arial',6);
run ;

axis2 minor=none label=none
offset=(5 pct, 11 pct) value=(height=2) ;
title '2003 Monthly Sales Compared to the
Norm' ;
proc gplot data=test12 anno=anno ;
   plot sales * date /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format date monname3. sales comma10.0;
run ;
quit ;

data anno ;
   set stats ;
   retain xsys ysys '2' ;
   length text $50 ;

   %line(height-ht_sd, salary-sal_sd,
  height-ht_sd,salary+sal_sd,gray,1,2);
   %line(height-ht_sd, salary+sal_sd,
  height+ht_sd,salary+sal_sd,gray,1,2);
   %line(height+ht_sd, salary+sal_sd,
  height+ht_sd,salary-sal_sd,gray,1,2) ;
   %line(height+ht_sd, salary-sal_sd,
  height-ht_sd,salary-sal_sd,gray,1,2) ;
run ;

axis1 minor=none value=(height=2)
   label=(height=2 'Avg Salary'
   j=l '(US Dollars)' j=l ' ')
   order=(20000 to 60000 by 5000);
axis2 minor=none value=(height=2)
  label=(height=2 'Height (inches)')
  order=(55 to 80 by 5);
symbol i=none v=dot ;
title 'Correlation of Male Heights and
Salaries' ;
title2 h=1.5 '(Gray rectangle displays 1
standard deviation from the mean)' ;
proc gplot data=test13 anno=anno ;
   plot salary * height /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format salary comma10.0 ;
   run ;
quit ;
```

Figure 33

```
axis1 minor=none value=(height=2)
   label=(height=2 'U.S. Dollars')
   order=(0 to 500000 by 100000);
axis2 minor=none
   label=(height=2 c=red
   j=l 'Log 10 Scale'
   j=l '(U.S. Dollars)')
   order=(1, 10, 100, 1000, 10000,
    100000, 1000000)
   value=(height=2 c=red) logbase=10 ;
axis3 minor=none label=none value=none
   order=('North' 'East' 'South' 'West');
axis4 minor=none label=none
   order=('Mangoes' 'Peaches' 'Apples'
```

```
   'Pears' 'Guavas')
   offset=(3 pct, 3 pct) nobrackets ;
legend1 down=1 label=none
   position=(top center outside)
   order=('North' 'East' 'South' 'West');
pattern1 c=tan ;
pattern2 c=libr ;
pattern3 c=gray ;
pattern4 c=cxFFCC99 ;
title '2003 Fruit Sales' ;
proc gchart data=test14 ;
   vbar region /
      sumvar=sales group=fruit
      subgroup=region
      noframe
      raxis=axis1 maxis=axis3 gaxis=axis4
      space=0 gspace=10
      coutline=same
      legend=legend1 ;
   format region $region. fruit $fruit.
      sales comma10.0 ;
run ;
   vbar region /
      sumvar=sales group=fruit
      noframe
      subgroup=region
      raxis=axis2 maxis=axis3 gaxis=axis4
      space=0 gspace=10
      coutline=same
      legend=legend1 ;
   format region $region. fruit $fruit. ;
run ;
quit ;
```

Figure 34

```
axis1 minor=none major=(height=2)
   label=none order=(0 to 90 by 10) ;
axis2 minor=none major=(height=-2)
   label=none order=(0 to 90 by 10) ;
axis3 minor=none major=none label=none
   value=none offset=(15, 15)pct ;
proc gchart data=test15 ;
title 'Outside' ;
   vbar value / sumvar=freq
      noframe
      raxis=axis1 maxis=axis3
      width=20
      coutline=same  ;
run ;
title 'Inside' ;
   vbar value / sumvar=freq
      noframe
      raxis=axis2 maxis=axis3
      width=20
      coutline=same  ;
run ;
```

```
quit ;
```

Figure 35

```
pattern1 v=solid c=cxD2B48C ;
pattern2 v=solid c=cx34CB4D ;
pattern3 v=solid c=cxCB9934 ;
pattern4 v=solid c=cx96B0E4 ;
axis3 label=none value=none ;
axis4 minor=none major=none label=none
   offset=(5, 5)pct ;
legend1 label=none across=1
   value=('North' 'East' 'South' 'West')
   position=(outside right top)
   shape=bar(2,3)pct frame ;
legend2 label=none across=1
   value=('North' 'East' 'South' 'West')
   position=(outside right top)
   shape=bar(2,3)pct ;
proc gchart data=test17 ;
   vbar region /
      sumvar=freq group=month
      subgroup=region
      noframe gspace=5 space=0
      raxis=axis1 maxis=axis3 gaxis=axis4
      legend=legend1
      coutline=same ;
   format month mon. freq comma10.0 ;
run ;
   vbar region /
      sumvar=freq group=month
      subgroup=region
      noframe gspace=5 space=0
      raxis=axis1 maxis=axis3 gaxis=axis4
      legend=legend2
      coutline=same ;
   format month mon. freq comma10.0 ;
run ;
quit ;
```

Figure 36

```
axis3 label=none value=none ;
axis4 minor=none major=none label=none
   offset=(2, 2)pct ;
legend1 label=none down=1
   value=('North' 'East' 'South' 'West')
   position=(outside middle top)
   shape=bar(2,3)pct  ;
proc gchart data=test18 ;
   vbar region /
      sumvar=freq group=month
      subgroup=region
      noframe gspace=5 space=0
      raxis=axis1 maxis=axis3 gaxis=axis4
      legend=legend1
      coutline=same ;
```

```
   format month mon. freq comma10.0 ;
run ;
quit ;
```

Figure 37

```
axis1 minor=none major=(height=2)
   label=none order=(0 to 120 by 20) ;
axis2 minor=none major=none label=none
   value=none ;
axis3 minor=none major=none label=none
   offset=(5, 5)pct ;
axis4 minor=none major=none label=none
   offset=(5, 5)pct style=0 ;
legend1 label=none down=1
   value=('Direct' 'Indirect')
   position=(outside middle top)
   shape=bar(3,3)pct  ;
pattern1 v=solid c=gray ;
pattern2 v=solid c=ligr ;
proc gchart data=test19 ;
   vbar type /
      sumvar=value group=group
      subgroup=type
      noframe gspace=5 space=0
      raxis=axis1 maxis=axis2 gaxis=axis3
      legend=legend1
      coutline=same ;
   format group $group. type $type.
      value comma10.0 ;
title '1 vertical and 1 horizontal axis';
run ;
   vbar type /
      sumvar=value group=group
      subgroup=type
      gspace=5 space=0
      raxis=axis1 maxis=axis2 gaxis=axis3
      legend=legend1
      coutline=same ;
   format group $group. type $type.
      value comma10.0 ;
title '2 vertical and 2 horizontal axis';
run ;
   hbar type /
      sumvar=value group=group
      subgroup=type
      noframe gspace=5 space=0 nostats
      raxis=axis1 maxis=axis2 gaxis=axis4
      legend=legend1
      coutline=same ;
   format group $group. type $type.
      value comma10.0 ;
title '1 horizontal and no vertical
axis';
run ;
   vbar type /
      sumvar=value group=group
      subgroup=type
      noframe gspace=5 space=0
      raxis=axis1 maxis=axis2 gaxis=axis4
      legend=legend1
      coutline=same ;
   format group $group. type $type.
      value comma10.0 ;
title '1 vertical and no horizontal
axis';
run ;
quit ;
```

Figure 38

```
goptions ftext='Arial' htext=2
   xpixels=600 ypixels=600 cback=white ;
axis1 minor=none major=(height=2)
   label=none order=(0 to 100 by 10) ;
axis2 minor=none major=none label=none
   offset=(3, 3)pct ;
symbol i=join v=none c=black ;
proc gplot data=test20 ;
   plot sales * month /
      cframe=cxF3FFE5
      vaxis=axis1 haxis=axis2 ;
   format month mon1. sales comma10.0 ;
run ;
quit ;

goptions ftext='Arial' htext=2
  xpixels=1200 ypixels=600 cback=white ;
proc gplot data=test20 ;
   plot sales * month /
      cframe=cxF3FFE5
      vaxis=axis1 haxis=axis2 ;
   format month mon1. sales comma10.0 ;
run ;
quit ;

goptions ftext='Arial' htext=2
   xpixels=900 ypixels=600 cback=white ;
proc gplot data=test20 ;
   plot sales * month /
      cframe=cxF3FFE5
      vaxis=axis1 haxis=axis2 ;
   format month mon1. sales comma10.0 ;
run ;
quit ;

goptions ftext='Arial' htext=2
   xpixels=400 ypixels=600 cback=white ;
proc gplot data=test20 ;
   plot sales * month /
      cframe=cxF3FFE5
      vaxis=axis1 haxis=axis2 ;
   format month mon1. sales comma10.0 ;
run ;
```

```
quit ;

goptions ftext='Arial' htext=2
   xpixels=500 ypixels=1000 cback=white ;
proc gplot data=test20 ;
   plot sales * month /
      cframe=cxF3FFE5
      vaxis=axis1 haxis=axis2 ;
   format month mon1. sales comma10.0 ;
run ;
quit ;
```

Figure 39

```
axis1 minor=none major=(height=2)
   label=none order=(0 to 90 by 10) ;
axis2 minor=none major=(height=-2)
   label=none order=(0 to 90 by 10) ;
axis3 minor=none major=none label=none
   value=none offset=(15, 15)pct ;
proc gchart data=test15 ;
   title 'Outside' ;
   vbar value /
      sumvar=freq
      noframe
      raxis=axis1 maxis=axis3
      width=20
      coutline=same  ;
run ;
   title 'Inside' ;
   vbar value /
      sumvar=freq
      noframe
      raxis=axis2 maxis=axis3
      width=20
      coutline=same  ;
run ;
quit ;
```

Figure 40 & 41

```
axis1 minor=none major=(h=1) label=none
   order=(0 to 120000 by 10000) ;
axis2 major=(height=1) value=none
   label=none offset=(5, 5)pct ;
axis3 label=none nobrackets ;
axis4 minor=none major=(h=1) label=none
   order=(0 to 120000 by 60000) ;
axis5 minor=none major=(h=1) label=none
   order=(0 to 120000 by 20000) ;
axis6 minor=none major=(h=1) label=none
   order=(0 to 119000 by 17000) ;
pattern1 c=ligr ;
pattern2 c=gray ;
proc gchart data=test16 ;
   title 'Too Many' ;
   vbar group /
      sumvar=value2 group=date
      noframe nolegend
      subgroup=group
      raxis=axis1 maxis=axis2 gaxis=axis3
      width=12 space=0 gspace=4
      coutline=same ;
  format date monname3. value2 comma10.0;
run ;
   title 'Too Few' ;
   vbar group /
      sumvar=value2 group=date
      subgroup=group
      noframe nolegend
      raxis=axis4 maxis=axis2 gaxis=axis3
      width=12 space=0 gspace=4
      coutline=same ;
  format date monname3. value2 comma10.0;
run ;
   title 'Just Right' ;
   vbar group /
      sumvar=value2 group=date
      subgroup=group
      noframe nolegend
      raxis=axis5 maxis=axis2 gaxis=axis3
      width=12 space=0 gspace=4
      coutline=same ;
  format date monname3. value2 comma10.0;
   title 'Odd Tick Mark Intervals' ;
   vbar group /
      sumvar=value2 group=date
      subgroup=group
      noframe nolegend
      raxis=axis6 maxis=axis2 gaxis=axis3
      width=12 space=0 gspace=4
      coutline=same ;
  format date monname3. value2 comma10.0;
run ;
quit ;
```

Figure 42

```
axis1 minor=none value=(height=1.5)
   label=none order=(0 to 100 by 10) ;
axis2 minor=none major=none label=none
   value=(height=1.5) offset=(3, 3)pct;
symbol1 i=join v=none c=red ;
pattern1 c=cx727e83 ;
proc gbarline data=test20 ;
   bar month /
      sumvar=expenses
      noframe nolegend
      midpoints=1 to 12
      raxis=axis1 maxis=axis2;
   plot /
      sumvar=sales
      noaxis ;
   format month mon1. ;
```

```
run ;
quit ;

proc gbarline data=test20 ;
   bar month /
      sumvar=expenses
      cframe=cxf0f3f3
      noframe nolegend
      midpoints=1 to 12
      raxis=axis1 maxis=axis2;
   plot /
      sumvar=sales
      noaxis ;
   format month mon1. ;
run ;
quit ;

proc gbarline data=test20 ;
   bar month /
      sumvar=expenses
      cframe=cxF3FFE5
      midpoints=1 to 12
      raxis=axis1 maxis=axis2;
   plot /
      sumvar=sales
      noaxis ;
   format month mon1. ;
run ;
quit ;
```

Figure 43

```
goptions ftext='Arial' htext=2
  xpixels=900 ypixels=600 cback=cxf0f3f3;
proc gbarline data=test20 ;
   bar month /
      sumvar=expenses
      cframe=white
      midpoints=1 to 12
      raxis=axis1 maxis=axis2;
   plot /
      sumvar=sales
      noaxis ;
    format month mon1. ;
run ;
quit ;

goptions ftext='Arial' htext=2
  xpixels=900 ypixels=600 cback=cxF3FFE5;
proc gbarline data=test20 ;
   bar month /
      sumvar=expenses
      cframe=white
      midpoints=1 to 12
      raxis=axis1 maxis=axis2;
   plot /
      sumvar=sales
      noaxis ;
    format month mon1. ;
run ;
quit ;
```

Figure 44 & 45

```
axis1 minor=none major=(h=2)label=none
   order=(0 to 250000 by 50000) ;
axis2 minor=none major=none label=none
   offset=(5, 5)pct ;
symbol1 i=join v=none w=2 c=cxB32D00 ;
symbol2 i=join v=none w=2 c=cxD2B48C ;
symbol3 i=join v=none w=2 c=cx00B0EB ;
symbol4 i=join v=none w=2 c=cx7D7D7D ;
proc gplot data=test17a ;
   plot freq * month = region /
      vaxis=axis1 haxis=axis2
      nolegend
      autovref cautovref=black
      autohref cautohref=black ;
   format month mon. freq comma10.0 ;
run ;
   plot freq * month = region /
      noframe
      vaxis=axis1 haxis=axis2
      nolegend
      autovref cautovref=cxBDBDBD ;
   format month mon. freq comma10.0 ;
run ;
quit ;
```

Figure 46

```
axis2 minor=none major=none label=none
   offset=(5, 5)pct ;
pattern1 c=gray ;
proc gchart data=test17a ;
   where region='3' ;
   vbar month /
      sumvar=freq discrete
      noframe
      width=6 space=4
      raxis=axis1 maxis=axis2 ;
   format month mon. freq comma10.0 ;
run ;
   vbar month /
      sumvar=freq discrete
      noframe
      width=6 space=4
      autoref clipref cautoref=cxBDBDBD
      raxis=axis1 maxis=axis2 ;
   format month mon. freq comma10.0 ;
run ;
quit ;
```

Figure 47

```
axis1 minor=none
   order=(20000 to 50000 by 5000)
   label=('Salary' j=l '(US Dollars)'
   j=l ' ') ;
axis2 minor=none order=(50 to 80 by 5)
   label=('Height (inches)') ;
symbol1 i=none v=dot cv=black ;
proc gplot data=test21 ;
   plot salary * height /
      noframe
      vaxis=axis1 haxis=axis2 ;
   format salary comma10.0 ;
run ;
quit ;
```

Figure 48

```
axis1 minor=none
   order=(20000 to 50000 by 5000)
   label=('Salary' j=l '(US Dollars)'
   j=l ' ') ;
axis2 minor=none order=(50 to 80 by 5)
   label=('Height (inches)') ;
symbol1 i=none v=dot cv=black ;
proc gplot data=test21 ;
   plot salary * height /
      noframe
      vaxis=axis1 haxis=axis2
      autovref cautovref=cxBDBDBD
      autohref cautohref=cxBDBDBD ;
   format salary comma10.0 ;
run ;
quit ;

data anno ;
   retain xsys ysys '2' ;
   length text $25 ;
   %label(50,50000,'Short with',
      gray,0,0,1.5,'Arial',9) ;
   %label(50,48000,'high salaries',
      gray,0,0,1.5,'Arial',9) ;
   %label(50,22000,'Short with',
      gray,0,0,1.5,'Arial',3) ;
   %label(50,20000,'low salaries',
      gray,0,0,1.5,'Arial',3) ;
   %label(80,50000,'Tall with',
      gray,0,0,1.5,'Arial',7) ;
   %label(80,48000,'high salaries',
      gray,0,0,1.5,'Arial',7) ;
   %label(80,22000,'Tall with',
      gray,0,0,1.5,'Arial',1) ;
   %label(80,20000,'low salaries',
      gray,0,0,1.5,'Arial',1) ;
run ;
```

```
proc gplot data=test21 anno=anno ;
   plot salary * height /
      noframe
      vaxis=axis1 haxis=axis2
      vref=(35000, 50000) cvref=csBDBDBD
      href=(65,80) chref=cxBDBDBD ;
   format salary comma10.0 ;
run ;
quit ;
```

Figure 49

```
pattern1 c=cxFFFF33 ;
pattern2 c=cxFF6633 ;
pattern3 c=cxFFFFCC ;
pattern4 c=cx99E6FF ;
pattern5 c=cxCC0033 ;
pattern6 c=cxFFBF80 ;
pattern7 c=cx0000F5 ;
pattern8 c=cxB8B800 ;

title 'Market Share' ;
proc gchart data=test22 ;
   pie co /
      sumvar=share discrete slice=arrow
      value=none other=1
      noheading angle=90 clockwise
      plabel=(height=2) ;
   format co co. ;
run ;
   pie3d co /
      sumvar=share discrete slice=arrow
      value=none other=1
      noheading angle=90 clockwise
      plabel=(height=1.5) ;
   format co co. ;
run ;
quit ;
```

Figure 50

```
axis1 label=none major=none minor=none
   value=none style=0 ;
axis2 label=none ;
pattern1 c=ligr ;
pattern2 c=ligr ;
pattern3 c=ligr ;
pattern4 c=ligr ;
pattern5 c=ligr ;
pattern6 c=black;
pattern7 c=ligr ;
pattern8 c=ligr ;
proc gchart data=test22 ;
   hbar co /
      sumvar=pct discrete
      sum sumlabel=none
```

```
      raxis=axis1 maxis=axis2
      patternid=midpoint descending ;
   format co bar_co. pct percent10.2 ;
run ;
quit ;
```