Introduction to ODS Statistical Graphics

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Abstract
Delivering timely and quality looking reports, graphs and information to management, end users, and customers is essential. This presentation provides SAS® users with an introduction to ODS Statistical Graphics found in the Base-SAS software. Attendees learn basic concepts, features and applications of ODS statistical graphic procedures to create high-quality, production-ready output; an introduction to the statistical graphic SGPLOT procedure, SGPANEL procedure, and SGSCATTER procedure; and an illustration of plots and graphs including histograms, vertical and horizontal bar charts, scatter plots, bubble plots, vector plots, and waterfall charts.

Introduction
It’s commonly understood that data patterns and differences are not always obvious from tables and reports. This is where graphical output and their ability to display data in a meaningful way have a clear advantage over tables, reports and other traditional communication mediums. Through the use of effective visual techniques the ability to better understand data is often achieved – a need that appeals to data analysts, statisticians and others. With the availability of ODS Statistical Graphics the SAS user community has a powerful set of tools to produce high-quality graphical output for data exploration, data analysis, and statistical analysis. All that is required to leverage the power available in ODS Statistical Graphics is a SAS® Base license. Once that is secured, ODS Statistical Graphics and its many capabilities are available to users of SAS® Base, SAS/STAT®, SAS/ETS® and SAS/QC® software. The purpose of this paper is to introduce SAS users to the world of ODS Statistical Graphics, its features and capabilities, and basic syntax associated with using the SGPLOT, SGSCATTER and SGPANEL procedures found in SAS Base software.

Data Set Used in Examples
The examples used throughout this paper utilize a data set called, MOVIES. The Movies table consists of six columns: title, length, category, year, studio, and rating. Title, category, studio, and rating are defined as character columns with length and year being defined as numeric columns, shown below.

<table>
<thead>
<tr>
<th>Title</th>
<th>Length</th>
<th>Category</th>
<th>Year</th>
<th>Studio</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brave Heart</td>
<td>177</td>
<td>Action/Adventure</td>
<td>1995</td>
<td>Paramount Pictures</td>
<td>G</td>
</tr>
<tr>
<td>Casablanca</td>
<td>130</td>
<td>Drama</td>
<td>1942</td>
<td>MGM / UA</td>
<td>PG</td>
</tr>
<tr>
<td>Christmas Vacation</td>
<td>97</td>
<td>Comedy</td>
<td>1988</td>
<td>Warner Brothers</td>
<td>PG-13</td>
</tr>
<tr>
<td>Coming to America</td>
<td>116</td>
<td>Comedy</td>
<td>1980</td>
<td>Paramount Pictures</td>
<td>R</td>
</tr>
<tr>
<td>Cruella</td>
<td>130</td>
<td>Horror</td>
<td>1962</td>
<td>Columbia Pictures</td>
<td>R</td>
</tr>
<tr>
<td>Dallas to Kili</td>
<td>105</td>
<td>Drama/Mystrance</td>
<td>1991</td>
<td>Affirmations Pictures</td>
<td>R</td>
</tr>
<tr>
<td>Forrest Gump</td>
<td>142</td>
<td>Drama</td>
<td>1994</td>
<td>Paramount Pictures</td>
<td>PG-13</td>
</tr>
<tr>
<td>Ghost</td>
<td>127</td>
<td>Drama/Romance</td>
<td>1999</td>
<td>Paramount Pictures</td>
<td>PG-13</td>
</tr>
<tr>
<td>Jaws</td>
<td>123</td>
<td>Action</td>
<td>1975</td>
<td>Universal Studios</td>
<td>PG</td>
</tr>
<tr>
<td>Jurassic Park</td>
<td>137</td>
<td>Action</td>
<td>1988</td>
<td>Universal Pictures</td>
<td>PG-13</td>
</tr>
<tr>
<td>Lethal Weapon</td>
<td>119</td>
<td>Action/Comedy</td>
<td>1989</td>
<td>Warner Brothers</td>
<td>R</td>
</tr>
<tr>
<td>Michael</td>
<td>106</td>
<td>Drama</td>
<td>1997</td>
<td>Warner Brothers</td>
<td>PG-13</td>
</tr>
<tr>
<td>National Lampoon's Vacation</td>
<td>90</td>
<td>Comedy</td>
<td>1980</td>
<td>Warner Brothers</td>
<td>PG-13</td>
</tr>
<tr>
<td>Peegiz</td>
<td>115</td>
<td>Horror</td>
<td>1992</td>
<td>MGM / UA</td>
<td>PG</td>
</tr>
<tr>
<td>Rocky</td>
<td>120</td>
<td>Action/Adventure</td>
<td>1977</td>
<td>MGM / UA</td>
<td>PG</td>
</tr>
<tr>
<td>Scarface</td>
<td>170</td>
<td>Action/Comedy</td>
<td>1980</td>
<td>Universal Studios</td>
<td>R</td>
</tr>
<tr>
<td>Sharon of the Lamas</td>
<td>118</td>
<td>Drama/Saga影片</td>
<td>1981</td>
<td>Cinema</td>
<td>R</td>
</tr>
<tr>
<td>Star Wars</td>
<td>244</td>
<td>Sci-Fi</td>
<td>1977</td>
<td>Lucas Film Ltd</td>
<td>PG</td>
</tr>
<tr>
<td>The Hunt for Red October</td>
<td>135</td>
<td>Action/Adventure</td>
<td>1990</td>
<td>Paramount Pictures</td>
<td>PG</td>
</tr>
<tr>
<td>The Adventures of Oz</td>
<td>101</td>
<td>Adventure</td>
<td>1938</td>
<td>MGM / UA</td>
<td>G</td>
</tr>
<tr>
<td>The Man</td>
<td>134</td>
<td>Drama/Romance</td>
<td>1977</td>
<td>Paramount Pictures</td>
<td>PG-13</td>
</tr>
</tbody>
</table>
**Graphical Design Principles**

Good graphical design begins with displaying data clearly and accurately. Data (and information) should be conveyed effectively and without ambiguity. Unnecessary information often distracts from the message, therefore it should be excluded. In their highly acclaimed book, Statistical Graphics Procedures by Example (2011), Mantange and Heath share this message about graphical output, “A graph is considered effective if it conveys the intended information in a way that can be understood quickly and without ambiguity by most consumers.”

**Best Practice Graphical Techniques**

Best practice graphical techniques emphasize essential visual elements in a graph or chart for maximum effectiveness. Although the SAS software effectively adheres to many, if not most, of these techniques, users are cautioned to be aware of these techniques. The following best practice graphical techniques are valuable considerations as you design and develop visual output.

- Group similar elements together to differentiate them from other elements
- Use distinct colors to set elements apart
- Use different shapes to distinguish points on a line graph
- Varying 2-dimensional elements in a line graph offers an effective way to indicate differences, as well as how much difference exists
- Length serves as an excellent way to communicate differences between elements
- Size can show that differences exist but doesn’t show the amount of difference between elements
- Width is good for showing that differences exist but fails to show the actual difference between elements
- Color saturation is useful for showing distinctions and differences between elements

Bar graphs, line graphs and pie charts are popular graphical choices for many SAS users. The following tips serve as guidelines to consider.

**Tips for Designing Effective Bar Graphs**

- Avoid misleading scales by starting quantities at zero
- Verify that the vertical axis is about 25% shorter than the horizontal axis
- Verify that bars are all the same width
- Verify that bars are arranged in a logical sequence
- Use tick marks to display amounts
- Verify that the space between bars is about half as wide as the bar itself

**Tips for Designing Effective Line Graphs**

- Avoid misleading scales by starting quantities at zero
- Verify that the vertical axis is about 25% shorter than the horizontal axis
- Use grid lines to display quantities and amounts
**Tips for Designing Effective Pie Charts**

- Limit the number of pie slices to no more than six
- Specify the largest pie slice at the top and work clockwise in decreasing order
- Combine “small” slices into a “Miscellaneous” or “Other” slice
- Label each pie slice inside the pie slice
- Avoid, if possible, the use of legends
- Emphasize a particular pie slice by color or by extracting it from the pie itself
- Avoid fill patterns and use color instead

**Gestalt Principles of Visual Perception**

Gestalt, borrowed from the world of psychology, means “unified whole.” The theory of visual perception was developed by German psychologists in the 1920s. For those interested, more information can be found at, [http://www.scholarpedia.org/article/Gestalt_principles](http://www.scholarpedia.org/article/Gestalt_principles).

**The SGPLOT Procedure by Example**

Whether the data you work with is large or small, or some size in between, the SGPLOT procedure is a powerful tool for handling many of your graphical needs. PROC SGPLOT creates single-cell scatter plots, line plots, histograms, bar charts, box plots and an assortment of other plot types quickly and easily. The SGPLOT procedure supports the following plot statements.

<table>
<thead>
<tr>
<th>Plot Statement</th>
<th>Plot Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scatter</td>
<td>HBAR / VBAR</td>
</tr>
<tr>
<td>Histogram</td>
<td>VLINE</td>
</tr>
<tr>
<td>HBOX / VBOX</td>
<td>HighLow</td>
</tr>
<tr>
<td>Step</td>
<td>Bubble</td>
</tr>
<tr>
<td>Dot</td>
<td>Vector</td>
</tr>
</tbody>
</table>

The generalized syntax for the SGPLOT procedure is displayed below.

```
PROC SGPLOT < DATA=data-set-name > < options > ;
  Plot-statement(s) plot-request-parameters < / options > ;
RUN ;
```
Creating a Scatter Plot

Scatter plots are typically produced to display data points on a horizontal and vertical axis for the purpose of determining whether a possible relationship exists between one variable and another. The relationship between two variables is often referred to as their correlation. The SCATTER plot output is produced with the SGPLOT procedure and a SCATTER statement. The resulting scatter plot contains the data points for the LENGTH variable on the horizontal (x-axis) and the YEAR variable on the vertical (y-axis) from the MOVIES data set. As can be seen, a TITLE statement is also specified to display additional information at the top of the scatter plot.

```
TITLE 'Basic Scatter Plot' ;
PROC SGPLOT DATA=MOVIES ;
  SCATTER X=Length Y=Year ;
RUN ;
```

Creating a Histogram

Histograms are vertical bar charts that display the distribution of a set of numeric data. They are typically used to help organize and display data to gain a better understanding about how much variation the data has. Much can be learned from viewing the shape of a histogram. The various histogram shapes include: Bell-shape – displays most of the data clustered around the center of the x-axis, Bimodal – displays two data values occurring more frequently than any other, Skewed Right or Skewed Left – displays values that tend to be occurring around the high or low points of the x-axis, Uniform – displays data equally (no peaks) across a range of values. The next SGPLOT shows the LENGTH variable specified in a HISTOGRAM statement with the MOVIES data set as input. The LENGTH variable is displayed on the horizontal (x-axis) of the histogram output.

```
TITLE 'Histogram with SGPLOT' ;
PROC SGPLOT DATA=MOVIES ;
  HISTOGRAM Length ;
RUN ;
```
Combining a Histogram with a Density Plot

Histograms can also have a density curve applied to display the distribution of values for numeric data. The next SGPLOT shows the LENGTH variable specified in a HISTOGRAM statement combined with the LENGTH variable displayed in a density plot with the DENSITY statement. As before, the LENGTH variable is displayed on the horizontal (x-axis) of the histogram output.

```
TITLE 'Histogram with Density' ;
PROC SGPlot DATA=MOVIES ;
  HISTOGRAM Length ;
  DENSITY Length ;
RUN ;
```

Creating a Horizontal Box Plot

Box plots are useful for displaying data outliers and for comparing distributions for continuous variables. Box plots split the data into quartiles where the range of values traverses the first quartile (Q1) through the third quartile (Q3). The median of the data is represented by a vertical line drawn in the box at the Q2 quartile. Box plots also display the range (or spread) of the data indicating the distance between the smallest and largest value. The next SGPLOT shows the LENGTH variable specified in a HBOX statement with the RATING variable specified in the CATEGORY= option. The LENGTH variable is displayed on the horizontal (x-axis) and the categorical variable, RATING, is displayed on the vertical (y-axis) of the horizontal box plot output. It should also be noted that vertical box plots can be created with the SGPLOT procedure.

```
TITLE 'Horizontal Box Plot' ;
PROC SGPlot DATA=MOVIES ;
  HBOX Length /
    CATEGORY=Rating ;
RUN ;
```
Creating a Series Plot

Series (or Time Series) plots are useful for displaying trends on paired data at different points in time. Series plots display the time variable along the horizontal (x-axis) and data values along the vertical (y-axis). The next SGPLOT selects the YEAR (or time) variable along the horizontal axis and LENGTH along the vertical axis in a SERIES statement.

```sas
PROC SORT DATA=Movies
   OUT=Sorted_Movies ;
   BY Year ;
RUN ;
TITLE 'Series Plot' ;
PROC SGPLOT DATA=MOVIES ;
   SERIES X=Year Y=Length ;
RUN ;
```

Creating a Bar Chart

Bar charts are a commonly used graph type to display and compare the quantity, frequency or other measurement for discrete categories or groups. Bar charts display the selected variable along the horizontal (x-axis) and the frequency along the vertical (y-axis). The next SGPLOT displays the distinct values for the RATING variable along the horizontal axis with the frequency value along the vertical axis in a VBAR statement.

```sas
TITLE 'Vertical Bar Chart' ;
PROC SGPLOT DATA=MOVIES ;
   VBAR RATING ;
RUN ;
```
Creating a Grouped Vertical Bar Chart

Like the bar chart in the previous example, a grouped bar chart is a commonly used graph to display and compare the quantity, frequency or other measurements for discrete categories or groups. A grouped bar chart displays the selected variable along the horizontal (x-axis) and uses a grouping variable to display the various sub-category values for each discrete value of the VBAR variable. The next SGPLOT displays the distinct value(s) for the RATING variable and the distinct value(s) for the grouped variable, CATEGORY, along the horizontal axis, and the frequency value along the vertical axis in a VBAR statement. Since the mean value is computed and displayed at the top of each grouped bar for the CATEGORY variable, a FORMAT statement is specified to display values in the desired formatting.

```sas
TITLE 'Grouped Bar Chart';
PROC SGPLOT DATA=MOVIES;
    FORMAT Length 5.2;
    VBAR RATING / Response=Length Stat=Mean Group=CATEGORY GroupDisplay=Cluster Datalabel;
RUN;
```

Creating a Stacked Vertical Bar Chart

Like the bar charts in the previous two examples, a stacked bar chart displays and compares the quantity, frequency or some other measurement for discrete categories or groups. A stacked bar chart displays the distinct values for the selected variable of the VBAR statement and stacks the grouping variable, designated with the GROUP= option, along the horizontal (x-axis). The next SGPLOT displays the distinct value(s) for the CATEGORY variable and stacks the distinct value(s) for the grouped variable, RATING, along the horizontal axis, and the frequency value along the vertical axis in a VBAR statement.

```sas
TITLE 'Stacked Bar Chart';
PROC SGPLOT DATA=MOVIES;
    VBAR CATEGORY / Response=Length Group=RATING;
RUN;
```
The SGSCATTER Procedure by Example

Whether the data you work with is large or small, or some size in between, the SGSCATTER procedure is a powerful tool for handling many of your graphical needs. PROC SGSCATTER provides single-statement control to a number of scatter plot panels and matrices. The SGSCATTER procedure supports the following plot statements.

<table>
<thead>
<tr>
<th>Plot Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot</td>
</tr>
<tr>
<td>Compare</td>
</tr>
<tr>
<td>Matrix</td>
</tr>
</tbody>
</table>

The generalized syntax for the SGSCATTER procedure is displayed below.

```
PROC SGSCATTER < DATA=data-set-name > < options > ;
  Plot variable1 * variable2 / < options > ;
  Compare X=(variable(s)) Y=(variable(s)) < / options > ;
  Matrix variable(s) < / option(s) > ;
RUN ;
```

Creating a Scatter Plot with SGSCATTER

SGScatter plots display data points on a horizontal and vertical axis for the purpose of determining whether a possible relationship exists between one variable and another. The relationship between two variables is often referred to as their correlation. The SCATTER plot output is produced with the SGSCATTER procedure and a PLOT statement. The resulting scatter plot contains the data points for the LENGTH variable on the horizontal (x-axis) and YEAR variable on the vertical (y-axis) from the MOVIES data set.

```
TITLE 'SGscatter Plot' ;
PROC SGSCATTER DATA=MOVIES ;
  PLOT Year * Length ;
RUN ;
```
Creating a Scatter Matrix Plot with SGSCATTER

Scatter matrix plots display data points on a horizontal and vertical axis for the purpose of determining whether a possible relationship exists between one variable and another. The SCATTER plot output is produced with the SGSCATTER procedure and a MATRIX statement. The resulting scatter plot contains a two-pair scatter matrix plot from the MOVIES data set.

```
TITLE 'SGScatter Plot Matrix' ;
PROC SGSCATTER DATA=MOVIES ;
   MATRIX Year Length ;
RUN ;
```

The SGPANEL Procedure by Example

The SGPANEL procedure provides the ability to create a single-panel of plots or charts using one or more classification variables. Unlike a single-page plot or chart as is produced with the SGPLOT procedure, the SGPANEL procedure is able to produce a panel of plots or charts in a single image, or multiple plots or charts displayed in multiple panels. The result is a panel of plots or charts that display relationships among variables. The SGPANEL supports a number of plot types including histograms, horizontal bar charts, vertical bar charts, horizontal box plots, vertical box plots, and plot and chart types. The SGPANEL procedure supports the following statements.

**SGPanel Statement**

- Panelby
- Other Plot / Chart Statements

The generalized syntax for the SGPANEL procedure is displayed below.

```
PROC SGPANEL < DATA=data-set > < options > ;
   PANELBY classvar1 < classvar2 . . . < classvarn > / 
      options > ;
   < plot / chart statement > ;
RUN ;
```
Creating a Panel of Histograms with SGPANEL

A panel of plots and charts created with the SGPANEL procedure displays values of one or more classification variables. The purpose of a panel of plots is to be able to compare one or more variables with one another. The next example shows a panel of histograms created with the SGPANEL procedure and a HISTOGRAM statement. The resulting panel of histograms contains the number of movies (SCALE=Count) by category corresponding to the year the movie was produced from the MOVIES data set.

```
TITLE 'Histogram with SGPANEL';
PROC SGPANEL DATA=MOVIES;
   PANELBY CATEGORY / ROWS=3 COLUMNS=4;
   HISTOGRAM YEAR / SCALE=COUNT;
RUN;
```

SGPANEL Output

![Histogram with SGPANEL](image)

The diagram shows a panel of histograms for different categories of movies, with the number of movies (SCALE=Count) by category corresponding to the year the movie was produced.
Creating a Panel of Bar Charts with SGPANEL

A panel of bar charts can be created with the SGPANEL procedure using one or more classification variables. As before, the purpose of a panel of bar charts could be for comparing one or more variables values against another. The next example shows a panel of vertical bar charts created with the SGPANEL procedure and a VBAR statement. The resulting panel of vertical bar charts contains the average movie lengths (STAT=Mean) for each category of movie corresponding to the movie rating (i.e., G, PG, PG-13, and R) from the MOVIES data set.

```
TITLE 'VBAR Chart with SGPANEL' ;
PROC SGPANEL DATA=MOVIES ;
   PANELBY CATEGORY / ROWS=3 COLUMNS=4 ;
   VBAR RATING / RESPONSE=Length STAT=Mean DATALABEL ;
RUN ;
```

SGPANEL Output

![VBAR Chart with SGPANEL](image)

The VBAR chart shows the average movie lengths for each category of movie rating. Each column represents a category (e.g., Action, Adventure, Comedy, Drama, etc.), and the length of the bar indicates the average movie length for that category.

- **Category = Action**: Average movie length is 127 minutes.
- **Category = Action Adventure**: Average movie length is 123.5 minutes.
- **Category = Action Comedy**: Average movie length is 177 minutes.
- **Category = Action Cops**: Average movie length is 140 minutes.
- **Category = Action Sci-Fi**: Average movie length is 124 minutes.
- **Category = Adventure**: Average movie length is 101 minutes.
- **Category = Comedy**: Average movie length is 97.5 minutes.
- **Category = Drama**: Average movie length is 103 minutes.
- **Category = Drama Mystery**: Average movie length is 105 minutes.
- **Category = Drama Romance**: Average movie length is 180.5 minutes.
- **Category = Drama Suspense**: Average movie length is 116 minutes.
- **Category = Horror**: Average movie length is 115 minutes.
- **Category = PG**: Average movie length is 113 minutes.
- **Category = PG-13**: Average movie length is 130 minutes.
- **Category = R**: Average movie length is 105 minutes.
**Conclusion**

It’s commonly understood that data patterns and differences are not always obvious from tables and reports. This is where graphical output and their ability to display data in a meaningful way have a clear advantage over tables, reports and other traditional communication mediums. Through the use of effective visual techniques the ability to better understand data is often achieved. Good graphical design begins with displaying data clearly and accurately. Data (and information) should be conveyed effectively and without ambiguity. Because unnecessary information often distracts from the message, it should be excluded. This paper introduced SAS users to the world of ODS Statistical Graphics, its features and capabilities, and basic syntax associated with using the SGPLOT, SGPANEL and SGSCATTER procedures found in SAS Base software.

**References**


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