Chart Smart: Design Graphs for Effective Communication
LeRoy Bessler, Miller Brewing Company

Abstract
The time and attention of a communication recipient are valuable resources. This paper explains how to create powerful presentation materials, and graphic reports that are digestible at a glance.

Though SAS/GRAPH® references are made, almost all ideas are software-independent. Emphasis is on design principles and illustrations. But, due to the page-count limit for publication, only a few of the illustrations are included.

On Communication
"Put it before them--briefly . . . so they will read it, clearly . . . so they will appreciate it, picturesquely . . . so they will remember it, and, above all, accurately . . . so they will be guided by its light."

Joseph Pulitzer

"Simplicity acts like an oasis in the desert."

Jan White

"Design to inform and to influence, not to impress."

LeRB

Defaults Yield Disappointing Design (Figure 2)
- Software & hardware = power tools
- Potentially lots of sub-optimal results quickly

Customize for Elegant Results (Figure 3)
- Powerful presentations and readable reports
- Simple graphs focus on the message, the data
- Suppress/avoid inessential graphic elements

Consistency: Define a style, and stick to it
- For titles, footnotes, notes, font choices & sizes, symbols, line types, etc.

Design & Implement Standard Formats
- Consistency breeds/speeds comprehension--the viewer needn't "recalibrate" page-to-page
- Productivity--preparer spared over-choice: less decision-making, fewer iterations
- Best implemented with macros

Maximize Communication, Not Paper-marking
- Software defaults biased to traditional props
- Turning off props = more work, but--Restraint in elaboration = less work

Special Effects Are For Movies
- Good design & interesting data can stand on their own
- Productivity & communication are the real objectives
- Drop the drop-shadow
- Block out blocks
- Adumbrate the shaded background
- Do use PROC GREPLAY & TEMPLATES to create composites (e.g., Figure 10)

Just Say "No" to the Designer Drug 3D
- 3D pie charts--always distortion
- 3D bar charts--needless complexity
- 3D maps--poor interpretability, even hidden parts
- Exception: 3 variables

Text Is Essential
- "the letters or numbers aren't readable, change the design or abandon the chart.
- Usually use black--most readable
- Can emphasize with italics (or bold)
- Use mixed upper and lower case
- Written communication standard, easier to read
- Keep it brief: Focus attention with sparse text

Avoid Needless Decimal Precision
- Not doing science--usually suppress decimals
- Footnote any imperfect sum of rounded values

Limit Font Choices to One or Two
- Prefer "hardware characters", if available
- Specified with F=NONE
- Fancy software font: maybe title, footnotes
- For a simple chart, use of a software font rather than a hardware font can increase resource consumption by a factor of 10 or much more. The processing time to produce the print file, the print file size, and the print time all increase.
Limit Font Sizes--One May Suffice

At most, use three
  Titles (usually all one size), maybe H=1
Body text usually H=1, unless if dense
  Footnotes smaller only if downplayed

Remove Axis Clutter (Figures 3, 4, & 6-12)
  • Turn off axis lines (they tell nothing)
  • Turn off tick marks
    If not turning off axis labels, supply your own
  • Label (invisible) tick marks sparingly
    Use Sparse Annotation whenever possible

Axis Range Affects the Message
  • De-accentuate fluctuations--
    Start axis at zero, not the SAS/GRAPH default
    Prevent needless anxiety, questions
  • For percents, use range 0-100, label the ends
    Bar length = visual percent
    Absolute maximum is natural choice
  • For trend chart issued monthly,
    use fixed number of months: either January to
    December (same or multiple years), or Report
    Month N Years Ago to Current Report Month

When Is Color Required or Desirable?
  • No response levels or categories--black & white
  • Few levels or categories--gray shades
  • Many levels or categories--color

See, also, my paper "Communicate Effectively in Color with SAS/GRAPH Software", elsewhere in this Proceedings.

Drabness Has Benefits

Compared with color, black-and-white hardcopy is:
  • faster, cheaper, more reliable;
  • easier to use--simpler equipment,
    no agonizing over color strategy;
  • more copyable--more, faster, cheaper
    BW copiers available--good graphs get copied

Usually Omit Area Fill
  • Beneath line(s)--always
  • In pie slices, unless for a presentation,
    or for my New, Improved Pie Chart (Figure 5)
  • On simple bar charts--but maybe light gray,
    especially if bars close together

Avoid Ugly Area Fill
  • To carry information, use solid colors or grays
    • In desperation only, but never on maps,
      use parallel lines or cross-hatching

Simple Plots Are Easier to Interpret
  • Use Sparse Annotation (see Figures 11 & 12)
  • Focus on start, end, & critical points
  • Other details are best provided in a table
  • Use V=NONE for plots, if possible
    Can use W= to distinguish multi-line,
    rather than V=, if only two lines
  • For point detection, not just trend, use:
    V=DOT (this is a BIG dot)
    V=CIRCLE
    V=- (traditional, circle around small dot)
  • Avoid grid lines; if not, use fine line L=33

How to Choose Between Pies, Bars, and Plots

SAS/GRAPH pie charts can lose the SLICE, VALUE, and PERCENT text if there are too many slices, or
  • for very small slices.

A Custom Horizontal Bar Chart (Figures 3 & 4) is an alternative to the pie chart, needed if there are too
  • many categories. It provides image and detail
    optimally combined: category name; percent of
    whole; graphic depiction of relative size; and value (ranked). Bar charts can also be used to compare
    magnitudes, or to display trends or changes.

Line charts (i.e., plots) are for trends (or for relationships between variables). When annotating,
  • a simple bar chart is better than a single-line chart--there is no chance of a value being obscured
    by a line. If a multi-line chart has too much crisscrossing, a side-by-side bar chart works better.

Sequence the Bars or Slices (Figures 3, 4, & 5)

Default order for bar and pie charts is alphabetic order of bar and slice name (i.e., MIDPOINT value).
  • To enable rapid identification and assessment of categories of significance, order chart entries by
    decreasing value of the response.

For code to produce Figure 4, see my paper "Show Them What's Important: Design and Construct Tables, Lists, Reports, and Other Displays for Effective Communication", elsewhere in this Proceedings.

For code to produce Figure 3, see my paper "Pie Charts and Bar Charts: Getting Their Best out of SAS/GRAPH Software", in Proceedings of the Seventeenth Annual SAS Users Group International Conference, SAS Institute Inc. (Cary, N.C.), 1992.

"De-alphabetize" the DESCENDING Pie Chart

PATTERNs are assigned by SAS/GRAPH to slices in alphabetic order of slice name. If, however, you want DESCENDING slice colors to be arranged, e.g., from light to dark, then, to get pattern colors "ordered by slice size", you must first determine the "size order for slice names".
Control Pie Labels

- Specify NOHEADING and OUTSIDE
- Do not match color of label to that of slice—e.g., yellow text on white paper is impossible to read
- SAS/GRAPH appends .0 to integer VALUES: Suppress with FORMAT statement

Pie Chart PERCENT Feature Perversity

- % only displayed at tenths or hundredths; if input VALUE to tenths, % to tenths; if input VALUE to hundredths, thousandths, or "finer", % to hundredths.
- Get % at tenths for any VALUE finer than tenths, by reformattting input to GCHART: TOGCHART = ROUND(VALUE,0.1);
- If input VALUE is integer, or integer with zero(s) to right of decimal point, SAS/GRAPH insists on displaying % to hundredths—no circumventions.

Try My New, Improved Pie Chart (Figure 5)

- As of Release 6.09, no SAS/GRAPH Pie legend
- For a better-than-industry-standard legend, and to solve the communication problem caused by disappearing pie SLICE, VALUE, and PERCENT, see my paper "Reinventing the Pie Chart: Improved and Reliable Communication for This Popular Business Chart", elsewhere in this Proceedings.

Use Simple or Side-By-Side Vertical Bar Charts

- For a simple vertical bar chart, put values at ends (See Figures 6 & 7)
- For a complex vertical bar chart, use side-by-side, not stacked, bars (Compare Figures 8 & 9)
- For a complex vertical bar chart, put a table below for detail look-up (See Figure 10)

Consider Supplying Detail for Graphs

A chart can depict the relative size of measurements, and supply detail at the same time. Presentations or reports that integrate image (i.e., impact) and numbers (i.e., precision) are memorable, quickly and easily comprehended, and both influencing and reliable for decision-making.

For a simple trend line, you can make the graph talk with "Sparse Annotation" (see Figures 11 & 12).

Except for numbers at the right margin or bar-ends of a horizontal bar chart (as in Figures 3 and 4), or numbers at bar-ends of a simple vertical bar chart (as in Figures 6 and 7), the best solution is usually a companion table for the graph (see Figure 10).

How To Format a Table As a Graph Companion

Create the table with PROC PRINT, TABULATE, or whatever, in conjunction with PROC PRINTTO, and format it with PROC GPRESS (using, e.g., the same font(s) as used for the companion graph), putting the result in a graphics catalog; also put the graph in the graphics catalog. Then PROC GREPLAY can place the table and graph on the same page.

I Call It the Pac-Man Pie Chart (Figure 1)

Even if not "worth a thousand words",
- A picture is more memorable
- Images stick, after numbers are forgotten—images, added to text, have been found to improve, e.g., effectiveness of fundraising and memory of the request. (Such images were thematic symbols, not photographs designed to evoke an emotional response.)

Notices

SAS/GRAPH is a registered trademark or trademark of SAS Institute Inc. in the USA and other countries. * denotes USA registration. Pac-Man is a registered trademark of Namco Ltd., Tokyo, Japan.

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IBM Mainframe Data Analysis Software
Market Shares

SAS — 91%
Other — 9%

Source: Computer Intelligence, 1993

Figure 1. Pac-Man Pie Chart: not worth a thousand words, but memorable
1990 Population in the European Community, By Country
(in Millions)

Source: "The World Factbook 1990"

Figure 2. Default Horizontal Bar Chart

Figure 3. Custom Horizontal Bar Chart
State and Local Government Employment By State In October 1991

State Name, Percent of USA Total, and Employee Count

<table>
<thead>
<tr>
<th>State Name</th>
<th>Percent of USA Total</th>
<th>Employee Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>10.9%</td>
<td>1,429,149</td>
</tr>
<tr>
<td>New York</td>
<td>8.6%</td>
<td>1,230,044</td>
</tr>
<tr>
<td>Texas</td>
<td>7.2%</td>
<td>951,388</td>
</tr>
<tr>
<td>Florida</td>
<td>5.0%</td>
<td>657,460</td>
</tr>
<tr>
<td>Illinois</td>
<td>4.3%</td>
<td>565,158</td>
</tr>
<tr>
<td>Ohio</td>
<td>4.0%</td>
<td>530,147</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>3.7%</td>
<td>485,736</td>
</tr>
<tr>
<td>Michigan</td>
<td>3.7%</td>
<td>480,402</td>
</tr>
<tr>
<td>New Jersey</td>
<td>3.2%</td>
<td>417,913</td>
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<tr>
<td>Georgia</td>
<td>2.9%</td>
<td>383,290</td>
</tr>
<tr>
<td>North Carolina</td>
<td>2.7%</td>
<td>360,844</td>
</tr>
<tr>
<td>Virginia</td>
<td>2.6%</td>
<td>338,478</td>
</tr>
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<td>Indiana</td>
<td>2.2%</td>
<td>288,789</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>2.1%</td>
<td>278,831</td>
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<tr>
<td>Washington</td>
<td>2.0%</td>
<td>266,290</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>1.9%</td>
<td>256,022</td>
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<td>Tennessee</td>
<td>1.9%</td>
<td>249,897</td>
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<tr>
<td>Missouri</td>
<td>1.9%</td>
<td>246,434</td>
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<td>245,953</td>
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<tr>
<td>Louisiana</td>
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<td>244,064</td>
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<tr>
<td>Minnesota</td>
<td>1.8%</td>
<td>235,058</td>
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<tr>
<td>Alabama</td>
<td>1.8%</td>
<td>232,437</td>
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<tr>
<td>South Carolina</td>
<td>1.5%</td>
<td>200,233</td>
</tr>
<tr>
<td>Kentucky</td>
<td>1.5%</td>
<td>195,563</td>
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<tr>
<td>Arizona</td>
<td>1.4%</td>
<td>189,447</td>
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<td>Colorado</td>
<td>1.4%</td>
<td>185,912</td>
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<tr>
<td>Oklahoma</td>
<td>1.4%</td>
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<tr>
<td>Iowa</td>
<td>1.2%</td>
<td>164,052</td>
</tr>
<tr>
<td>Oregon</td>
<td>1.2%</td>
<td>157,642</td>
</tr>
<tr>
<td>Connecticut</td>
<td>1.2%</td>
<td>155,718</td>
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<td>Kansas</td>
<td>1.2%</td>
<td>154,745</td>
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<tr>
<td>Mississippi</td>
<td>1.2%</td>
<td>151,964</td>
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<td>Arkansas</td>
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<td>New Mexico</td>
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<td>100,602</td>
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<tr>
<td>Nebraska</td>
<td>0.7%</td>
<td>98,219</td>
</tr>
<tr>
<td>West Virginia</td>
<td>0.7%</td>
<td>91,332</td>
</tr>
<tr>
<td>Utah</td>
<td>0.7%</td>
<td>90,727</td>
</tr>
<tr>
<td>Maine</td>
<td>0.5%</td>
<td>64,582</td>
</tr>
<tr>
<td>Hawaii</td>
<td>0.5%</td>
<td>64,390</td>
</tr>
<tr>
<td>Nevada</td>
<td>0.5%</td>
<td>62,680</td>
</tr>
<tr>
<td>Idaho</td>
<td>0.4%</td>
<td>57,164</td>
</tr>
<tr>
<td>Montana</td>
<td>0.4%</td>
<td>52,006</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>0.4%</td>
<td>51,046</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>0.4%</td>
<td>46,670</td>
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<td>Alaska</td>
<td>0.3%</td>
<td>43,978</td>
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<td>South Dakota</td>
<td>0.3%</td>
<td>38,054</td>
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<tr>
<td>Delaware</td>
<td>0.3%</td>
<td>36,997</td>
</tr>
<tr>
<td>Wyoming</td>
<td>0.3%</td>
<td>35,780</td>
</tr>
<tr>
<td>North Dakota</td>
<td>0.3%</td>
<td>35,581</td>
</tr>
<tr>
<td>Vermont</td>
<td>0.2%</td>
<td>30,236</td>
</tr>
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</table>

USA Total = 13,130,342

Figure 4. Annotated Ranked Horizontal Bar Chart: For When No Pie Chart Will Work
1991 Per Capita Consumption of Beverages in Six Categories

Estimates from "Beverage World 1992–1993 Data Bank"

<table>
<thead>
<tr>
<th>Share</th>
<th>Gallons</th>
<th>Beverage Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.2%</td>
<td>48.4</td>
<td>Soft Drinks</td>
</tr>
<tr>
<td>24.5%</td>
<td>23.2</td>
<td>Beer</td>
</tr>
<tr>
<td>12.3%</td>
<td>11.6</td>
<td>Fruit Juices and Drinks</td>
</tr>
<tr>
<td>8.5%</td>
<td>8.0</td>
<td>Bottled Water</td>
</tr>
<tr>
<td>2.0%</td>
<td>1.9</td>
<td>Wine</td>
</tr>
<tr>
<td>1.5%</td>
<td>1.4</td>
<td>Spirits</td>
</tr>
</tbody>
</table>

Figure 5. New, Improved Pie Chart
Local Tax Levy, 1986 to 1992
(Millions of Dollars)

Figure 6. End-annotated Vertical Bar Chart, Using SUM Option

Local Tax Levy, 1986 to 1992
(Millions of Dollars, and Annual Percent Change)

Figure 7. Custom End-annotated Vertical Bar Chart
Figure 8. Stacked Bar Chart Undesirable: How Many Dollars from Croquet?

Figure 9. Side-By-Side Vertical Bar Chart Is Better
1991 Club Sports Revenues, By Month

Peak in August
$151,894

Figure 10. Composite Chart

<table>
<thead>
<tr>
<th></th>
<th>Bocce</th>
<th>Croquet</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>$62,188</td>
<td>$73,962</td>
<td>$136,150</td>
</tr>
<tr>
<td>Feb</td>
<td>$27,920</td>
<td>$85,079</td>
<td>$112,999</td>
</tr>
<tr>
<td>Mar</td>
<td>$59,741</td>
<td>$91,144</td>
<td>$150,885</td>
</tr>
<tr>
<td>Apr</td>
<td>$57,467</td>
<td>$92,639</td>
<td>$150,106</td>
</tr>
<tr>
<td>May</td>
<td>$42,691</td>
<td>$101,361</td>
<td>$144,052</td>
</tr>
<tr>
<td>Jun</td>
<td>$35,896</td>
<td>$105,319</td>
<td>$141,215</td>
</tr>
<tr>
<td>Jul</td>
<td>$38,538</td>
<td>$99,411</td>
<td>$137,949</td>
</tr>
<tr>
<td>Aug</td>
<td>$43,038</td>
<td>$108,856</td>
<td>$151,894</td>
</tr>
<tr>
<td>Sep</td>
<td>$38,444</td>
<td>$99,006</td>
<td>$137,450</td>
</tr>
<tr>
<td>Oct</td>
<td>$40,296</td>
<td>$104,507</td>
<td>$144,803</td>
</tr>
<tr>
<td>Nov</td>
<td>$40,201</td>
<td>$110,826</td>
<td>$151,027</td>
</tr>
<tr>
<td>Dec</td>
<td>$32,776</td>
<td>$98,928</td>
<td>$131,704</td>
</tr>
</tbody>
</table>
A Quarter Century of Thirst
Annual U. S. Beer Consumption, in Gallons per Capita

Peak in 1981 at 24.6

Gallonage: John C. Maxwell, Jr., Wheat First Securities
Reported in: "Beverage Industry", February 1990

Figure 11. Sparse Annotation, End-points and Maximum Only

Production of Miller Lite - 1977 to 1990
Millions of Barrels

Data Source: "Beverage Industry"

Figure 12. Sparse Annotation, End-points and Trend-Change Point Only