16 Ways To Draw Better Pictures for Reports and Presentations:
6 Laws of Graphic Communication Effectiveness
10 (Sets of) Good Example Graphs, and

1 Bad Example (No, make that 3 Bad Examples)

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Scope

- > software-independent design principles
- > tools:
 - ODS Graphics / SG Procedures
 SAS/GRAPH / G Procedures
 - graphs:
 - > for reports
 - For presentations

Excerpt from Principia Graphika

assure text readability

For Always Easily Readable Labelshorizontal bar charts

assure text readability

deliver image + precise numbers

For Quick/Easy+Reliable Inference image + precise numbers

- assure text readability
- deliver image + precise numbers
- use Bessler style horizontal bar charts to compare categorical data

Close-Up View of Bar Labels Rank : Description : Value : Pct Of Grand Total 001:Vancouver:\$3,227,768:09.535% 002 : Tel Aviv : \$2,567,568 : 07.585% 003 : Kingston : \$2,235,204 : 06.603% 004 : Dubai : \$1,910,544 : 05.644% 005 : Chicago : \$1,565,585 : 04.625% 006 : New York : \$1,489,207 : 04.399% 007 : Al-Khobar : \$1,153,667 : 03.408% 008 : Minneapolis : \$1,099,937 : 03.249%

- assure text readability
- deliver image + precise numbers
- use Bessler style horizontal bar charts to compare categorical data
- Show Them What's Important with ranking and/or subsetting (enough data)

Show Them What's Important Franking and/or subsetting

Subsetting

Let Part Stand for the Whole

 Jim Martin Enough Data
 LeRoy Bessler

Enough Data—Three Ways

- Top N
- CutOff (min or max)
 - Goal
 - Threshold
- Enough of Top Values to Account For Top P Percent of Grand Total

- assure text readability
- deliver image + precise numbers
- use Bessler style horizontal bar charts to compare categorical data
- Show Them What's Important with ranking and/or subsetting (enough data)
- provide "data tips" & spreadsheet for dense time series, but annotation* or an on-chart table for time series when feasible
 *Use Bessler Sparse Annotation whenever enough

- provide "data tips" & spreadsheet for dense time series, but annotation* or an on-chart table for time series when feasible
- Data Tips & Linked Spreadsheet require web enablement
- Annotation or On-Chart Table will work in any destination, including web as long as the plot is not too dense
- *Use Bessler Sparse Annotation whenever enough

- assure text readability
- deliver image + precise numbers
- use Bessler style horizontal bar charts to compare categorical data
- Show Them What's Important with ranking and/or subsetting (enough data)
- provide "data tips" & spreadsheet for dense time series, but annotation* or an on-chart table for time series when feasible
- make wise use of COLOR—see my paper in the Proceedings
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Also From Principia Graphika Not a Law, but good communication practice Whenever possible,
make your graph title a headline
➤ <u>Tell</u> the viewer the inference from,

or the revelation in, the graph

- Graph content description might be self-evident or in axis labels
- > Description, if needed, can be a subtitle

Text Readability

Text Readability

- fundamental to communication
- taken for granted
- not always delivered

- > sufficient size for font

sufficient size for font

high color contrast with background

- sufficient size for font
- high color contrast with background
 - plain solid color background
 - > white is always a safe choice (if font is dark)
 - > no color gradient
 - > no background images

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- high color contrast with background
- plain solid color background
 - > white is always a safe choice (if font is dark)
 - no color gradient
 - ho background images
- Power of Horizontal Bar Charts— <u>NEVER</u> need to rotate or tilt the axis values

- sufficient size for font
- high color contrast with background
- plain solid color background
 - > white is always a safe choice (if font is dark)
 - > no color gradient
 - ho background images
- Power of Horizontal Bar Charts— NEVER need to rotate or tilt the axis values
- Put description of vertical axis variable in a subtitle, not in a rotated label along the axis

- sufficient size for font
- high color contrast with background
 - plain solid color background
 - > white is always a safe choice (if font is dark)
 - > no color gradient
 - > no background images
- Power of Horizontal Bar Charts— NEVER need to rotate or tilt the axis values
- Put description of vertical axis variable in a subtitle, not in a rotated label along the axis

Readable Text & Numbers Text/Numbers Color vs Background Color ODS calls text/numbers color "foreground color" See my Color Communication paper in Proceedings for more about color of foreground vs background

Axis Labels

- put in the graph title or subtitle instead (label info may already be there)
- if axis values are self-evident, do not label e.g., an axis of dates, times, or datetimes

Are Rarely Needed Put the info in graph title or subtitle Labels Avoid use of

save text display space width is with vertical common way try to vertical anti-readable label for the ¢, vertical axis

ш

Is text at left OK? Tell me the difference between it and vertical labels. Also, I do not recommend vertical or tilted labels for horizontal axis tick marks.



3D best used for 3 variables 3D needed only for 3 variables

The popular 3D pie chart offers NO communication advantage, BUT distorts the truth. Problem (Example 1a) Solution (Example 1b)





The default 3D bar chart suffers from needless complexity, but it is possible to create a Safe 3D Bar Chart. Needless Complexity (2a) Safe 3D (Example 2b)





False Alarm in SAS Log for above: WARNING: The left vertical axis labeled "Product" could not be fit as specified. The axis values will overwrite.

Horizontal Bar Chart Advantage

- Always enough space for bar labels, regardless of length
- > Since V9.2, max. length is 256 characters
- Preprocessed custom Bessler hbar labels can imbed extra information— ANYTHING that you might want to include
- With V9.4 yaxistable feature—you can avoid SOME of the prep to do Bessler hbar labels. Conjecture: yaxistable was Bessler-inspired.
(Example 2c) SAS/GRAPH (Real 3D) Pie Chart Alternative

Men Prefer Casual Shoes, Women Prefer Dress Shoes PROC GCHART 3D Horizontal Bar Chart



False Alarm in SAS Log: WARNING: The left vertical axis labeled "BarNameWithPercent" could not be fit as specified. The axis values will overwrite. (2d) ODS Graphics ("dataskin=pressed" option) simulation of 3D ODS Graphics centers titles over bars, not in available space In SAS V9.4, this result requires modification level TS1M1

> Men Prefer Casual Shoes, Women Prefer Dress Shoes PROC SGPLOT Fake 3D Horizontal Bar Chart



Erratic Centering of Titles with ODS Graphics in SAS V9.3 & V9.4

- 1. If title line is short enough to fit,
 - it is centered over the bars.
- 2. If it is too long to fit over bars,
 - it is centered as one would expect!

(Example 2c Again) SAS/GRAPH (Real 3D) Pie Chart Alternative Later, see Bessler's Best Use of Horizontal Bar Chart Labels

Men Prefer Casual Shoes, Women Prefer Dress Shoes PROC GCHART 3D Horizontal Bar Chart



- I usually discourage use of "Other" for Pie Charts. It invites this question: What is in 'Other'? But sometimes it just does not matter. Or you might want to FORCE an investigation.
- Let me show you my Extremes of 'Other'

Enough via The Extremes of Other



(Example 3a) (Example 3b) Pac-Man is a registered trademark of NAMCO BANDAI GAMES INC., Tokyo, Japan

Image Plus Precise Numbers Are Always Necessary

Image & Precise Numbers Same Time

- Horizontal Bar Chart easiest & reliable
- Vertical Bar Chart if few enough bars
- Pie Charts some problems, but solvable
- Trend Charts / Times Series Plots NOT easy, but we will explore a variety of solutions

Inherent problem of ALL scatter plots & line plots

The viewer of a plot CANNOT reliably determine precise numbers by comparing point locations to axis values. Image & Precise Numbers Same Time Trend Charts / Time Series Plots

- > static charts (print or Word or PDF documents):
 - y-value table above x-values axis
 - annotation
- > web-enabled: data tips & linked spreadsheet

Communication-Effective Multi-Line Plot with Detail Data Imbedded: Image + Numbers (NOT web-enabled) Target: anything other than ODS HTML, BUT would work fine if for ODS HTML

the best solution if using color





the best solution if using Black and White

(4b) No Legend, But Using the CurveLabel Option



(4b) No Legend, But Using the CurveLabel Option



CURVELABELs (or a Legend) are necessary only for a black-and-white graph Black and White can be Enough

Trend Charts / Time Series Plot

- Solution Presented Above:
- > multi-line overlay of range segments
- Benefits:
 - easy to detect seasonality
 - > no toggling between separate views
- Disadvantage:

no concurrent view of full range (but if webenabled, use hyperlink to a full-range view)

On-Graph Annotation

On-Graph Annotation Has Limitations (and a V9.4 defect)

If too many points per line or too many lines per graph, annotations might collide (label with label or label with line) OR

WEIRD label locations used to avoid collisions

> V9.4 suffers more collisions than V9.3



(5a)

Worst

Problem

>>>>>>>

Jan1988

*If plot lines are closer or more numerous, MORE collisions can occur between label & line or label & label. Why are these V9.4 footnotes italic?



(5b)

between label & line or label & label.

Always-Safe Annotation

Enough a.k.a. Sparse Line Annotation

(6) Show Them What Is Important with Start, End, Min, Max, Key Change Point





Sparse Line Annotation by LeRB in 1992 "Spark Line" derivative emerged in 1998

If start, end, min, max is NOT Enough

Trend Charts / Time Series Plot If too many dates to see all detail

- Use Web Enablement:
 - Provide "data tips" (a.k.a., ALT text)
 (7) Provide link to a spreadsheet* of the data
- *Extra Benefit: User can make any desired additional use of that data with a tool that everyone has and knows how to use

 Web Enablement Sizing
 Images here sized to avoid need to scroll web users want to see the whole picture

(7) Forcing Y Axis to start at zero, but not lighting up any data tip

File Edit View Favorites Tools Help

Dow Index by Trading Day - Monday, 4 January 1988 to Tuesday, 31 December 1991 Rest mouse on plot points for precise values <u>Go To SpreadSheet of this data</u>



Tip (As Shown Next): If not annotating start, end, min, max in your time series plot, list them in a subtitle or footnote, dynamically initialized using preprocessing and macro variables.

(7) [displaying data tip for minimum] & optional subtitle with stats

<u>File Edit View Favorites Tools Help</u>

Dow Index by Trading Day - Monday, 4 January 1988 to Tuesday, 31 December 1991 Rest mouse on plot points for precise values <u>Go To SpreadSheet of this data</u> DOW Index: Start=740 End=1157 Min=701 Max=1157 Avg=939 Median=962

1200 1200 1100 1100 10 W and the second and Appendent. 1000 1000 10 a fal man a familie and a familie a fam 900 900 800 800 700 700 Day: Thursday, 21 January 1988 600 600 Dow: 701 500 500 400 400 300 300 200 200 100 100 0 0 JAN88 APR88 JUL88 **OCT88** JAN89 APR89 JUL89 OCT89 JAN90 APR90 JUL90 OCT90 JAN91 APR91 JUL91 OCT91 JAN92

(7) after linking to input & manually highlighting min. Dow row

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Two Linkings and Two Ranges

- Linking Full-Period View and Partial Views:
 (8) Full & Each Part has dedicated web page
 (9) Full linked to Panel of Parts page
- Same Y Axis Range for All Views, Two Ways:
 - zero to exact maximum during full period
 - exact minimum & maximum during full period

(8) Linking a picture of a wide time period and pictures of its sub-periods

Starting Y axis at Zero

Prevents unnecessary anxiety or elation about what might be minor fluctuations Real significance of a change can be: > percent of change versus prior value > absolute magnitude of the change \succ failure to meet a threshold for success crossing a threshold into danger

(8) Y Axis Range from Zero to the Full-Period Maximum Y Value

<u>File Edit View Favorites Tools Help</u>

Dow Index by Trading Day - Monday, 4 January 1988 to Tuesday, 31 December 1991 Rest mouse on plot points for precise values <u>Go To 1988 Go To 1989 Go To 1990 Go To 1991</u>

<u>Go To SpreadSheet of this data</u>



(8) 1991 with Y Axis Synchronized to Y Axis of the Big Picture

File Edit View Favorites Tools Help

Dow Index by Trading Day - Wednesday, 2 January 1991 to Tuesday, 31 December 1991 Rest mouse on plot points for precise values <u>Go To Full Range Go To 1988 Go To 1989 Go To 1990</u> <u>Go To SpreadSheet of this data</u>



(9) Linking a picture of a wide time period and a panel of sub-periods

Yaxis from Exact Min to Exact Max

- Maximize insight into granularity
- > Omit all intermediate tick mark values
- Use data tips for temporary lookup
- Link to spreadsheet link for permanent

(9) Plot for Full Date Range with Y Axis Range Set to Min & Max

<u>File Edit View Favorites Tools Help</u>

Dow Index By Trading Day - Monday, 4 January 1988 to Tuesday, 31 December 1991 Rest mouse on plot points for precise values <u>Go To Panel of Plots for Each Year</u>

Go To SpreadSheet of this data



(9h) 2 X 2 Panel of Yearly Plots, Y Axes Match Full-Period Axis

File Edit View Favorites Tools Help

Dow Index By Trading Day

Rest mouse on plot points for precise values

Go To Continuous Plot for 1988-1991



(9i) 1 X 4 Panel of Yearly Plots, Y Axes Match Full-Period Axis This array permits recognition of seasonality pattern, if any.

<u>File Edit View Favorites Tools Help</u>

Dow Index By Trading Day Rest mouse on plot points for precise values Go To Continuous Plot for 1988-1991



All Code for Examples 1-9 See Proceedings & Tools Package

When **Big Data** is

0 n g D a t a

Horizontal Bar Charts for Too Many Categories Let's Look at My Best Horizontal Bar Chart <u>EVERYTHING*</u> You Could Want To Compare Categorical Data

It's a SuperMacro UpTo4WaysRankingHbarChartsToHTML

*OK, a statistician might want more than my "EVERYTHING". I'm not a statistician.

Find the code for my SuperMacro UpTo4WaysRankingHbarChartsToHTML in

http://www.pharmasug.org/proceedings/2013/DG/PharmaSUG-2013-DG11.pdf

My 2013 PharmaSUG Paper Data Visualization Power Tools: Expedite the Easy, Implement the Difficult, or Handle Big Data

(10) My Best Horizontal Bar Chart Always Deliver Image + Precise Numbers Show Them What's Important—Ranking Let Part Stand for the Whole—Subsetting Option to see ALL

For subsets, report significance of the subset

Ways To Do Subsetting But Make The Whole Picture Available

- ➤ Top N
- Top P%
- Min or Max Cut-Off
- > ALL

four web pages interlinked, BUT macro has option to create any subset of four instead

- Default Horizontal Bar Charts: fixed image height
- too little space for numerous bars
- too much space for few bars
- Adaptive HBAR Chart Macro:
- automatically sizes image height
- based on count of bars found in input data
- and selects the best font size

Let's Take a Tour of the Four Web Graphs Delivered by the Macro

Top 20, Go To Top 80%

D:\!PharmaSUG201 🔎 – 🕐 🔗 Ranked Shoe Sales ... 🗙

合大谷

<u>File Edit View Favorites Tools H</u>elp

Ranked Shoe Sales Dollars and Percent of World Total For Top 20 Cities

Selected Top 20 Cities - They Account for SubTotal Shoe Sales \$24,402,060 which is 72.09% of Grand Total

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 80% of GrandTotal Go To Sales GE 1000000 Go To All



At Least 80%, Go To Sales GE 1000000

D:\!PharmaSUG201 🔎 – 🖒 🙋 Ranked Shoe Sales ... 🗙

File Edit View Favorites Tools Help

e1

Ranked Shoe Sales Dollars and Percent of World Total For Top 25 Cities

Seeking At Least 80%, Top 25 Cities Account for SubTotal Shoe Sales \$27,258,392 which is 80.52% of Grand Total

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 20 Go To Sales GE 1000000 Go To All



Sales GE \$1000000, Go To All

D:\!PharmaSUG201 🔎 👻 🏉 Ranked Shoe Sales ... 🗙

<u>File Edit View Favorites Tools Help</u>

Ranked Shoe Sales Dollars and Percent of World Total For Top 8 Cities

Selected Top Cities with Sales GE \$1,000,000 - They Account for SubTotal Shoe Sales \$15,249,480 which is 45.05% of Grand Total

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 20 Go To Top 80% of GrandTotal Go To All



All 53 Cities, Scroll to bottom

D:\!PharmaSUG201 🔎 🗸 🕐 🔗 Ranked Shoe Sales ... 🗙

File Edit View Favorites Tools Help

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Ranked Shoe Sales Dollars and Percent of World Total For All 53 Cities

Selected All Cities

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 20 Go To Top 80% of GrandTotal Go To Sales GE 1000000



All 53 Cities (bottom of web page) D:\!PharmaSUG201 🔎 – 🕐 🔗 Ranked Shoe Sales ... 🗙 e File Edit View Favorites Tools Help 020 : Prague : \$636,721 : 01.881% 021 : Paris : \$621.877 : 01.837% 022 : Seattle : \$611.945 : 01.808% 023 : Moscow : \$560.976 : 01.657% 024 : Montreal : \$531.028 : 01.569% 025 : La Paz : \$530.506 : 01.567% 026 : Addis Ababa : \$467,429 : 01,381% 027 : Geneva : \$447,208 : 01.321% 028 : Seoul : \$442,409 : 01.307% 029 : Managua : \$414,806 : 01.225% 030 : Budapest : \$410.529 : 01.213% 031 : Algiers : \$395,600 : 01.169% 032 : Kuala Lumpur : \$373.130 : 01.102% 033 : Mexico City : \$368,588 : 01.089% 034 : Sao Paulo : \$366.835 : 01.084% 035 : Toronto : \$319,772 : 00.945% 036 : Montevideo : \$318.646 : 00.941% 037 : Rome : \$282.064 : 00.833% 038 : Bogota : \$206,234 : 00,609% 039 : Madrid : \$200.642 : 00.593% 040 : Kinshasa : \$196.816 : 00.581% 041 : Khartoum : \$186,592 : 00.551% 042 : Canberra : \$155,547 : 00.459% 043 : Singapore : \$139,745 : 00.413% 044 : Luanda : \$138,115 : 00.408% 045 : Auckland : \$124,424 : 00.368% 046 : Buenos Aires : \$118,283 : 00.349% 047 : Ottawa : \$115,741 : 00.342% 048 : Johannesburg : \$113,008 : 00.334% 049 : Nairobi : \$106,830 : 00.316% 050 : Santiago : \$104,956 : 00.310% 051 : Calgary : \$61,403 : 00,181% 052 : Bangkok : \$16,667 : 00.049% 053 : Tokyo : \$1,155 : 00.003%

Let's Look At

- Top 10 Web Graph & Two Links From It
- Table* of All Its (Summarized) Input Data
- Table* of Input Data for One Bar

*Spreadsheet

Top 10 chart, with mouse about to be clicked on the Chicago bar, but with bottom of the web page clipped off

Eile Edit View Favorites Iools Help

Ranked Shoe Sales Dollars and Percent of World Total For Top 10 Cities

Selected Top 10 Cities - They Account for SubTotal Shoe Sales \$17,115,564 which is 50.56% of Grand Total

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 10 Spreadsheet of Input to this Chart

Test with TopN=10 and with LinkableSpreadSheets=YES | Click any bar for its detail spreadsheet | Run on Sunday, 31 March 2013 at 4:26:52 AM



After clicking on the Chicago bar in the Top 10 bar chart

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10									\$1,565,5	585			J.				

After clicking on the hyperlink in a subtitle of the Top 10 bar chart here is the spreadsheet of all of its summarized input data:

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6	Tel Aviv	002 : Tel Aviv : \$2,567,568 : 07.585%	\$2,567,568	1				
7	Kingston	003 : Kingston : \$2,235,204 : 06.603%	\$2,235,204					
8	Dubai	004 : Dubai : \$1,910,544 : 05.644%	\$1,910,544					
9	Chicago	005 : Chicago : \$1,565,585 : 04.625%	\$1,565,585					
10	New York	006 : New York : \$1,489,207 : 04.399%	\$1,489,207	1				
11	Al-Khobar	007 : Al-Khobar : \$1,153,667 : 03.408%	\$1,153,667	1				
12	Minneapolis	008 : Minneapolis : \$1,099,937 : 03.249%	\$1,099,937	1				
13	Heidelberg	009 : Heidelberg : \$967,739 : 02.859%	\$967,739					
14	Lisbon	010 : Lisbon : \$898,345 : 02.654%	\$898,345					
15			\$17,115,564					

Close-Up View of Bar Labels Rank : Description : Value : Pct Of Grand Total 001:Vancouver:\$3,227,768:09.535% 002 : Tel Aviv : \$2,567,568 : 07.585% 003 : Kingston : \$2,235,204 : 06.603% 004 : Dubai : \$1,910,544 : 05.644% 005 : Chicago : \$1,565,585 : 04.625% 006 : New York : \$1,489,207 : 04.399% 007 : Al-Khobar : \$1,153,667 : 03.408% 008 : Minneapolis : \$1,099,937 : 03.249%

Rank : Description : Value : Pct Of Grand Total

The stack of bar labels is a ranked table of precise (i.e., reliable) information with a visual companion to facilitate and accelerate size comparison

Extra Numbers via Title Lines

- Obs Count for Data Selected Their SubTotal
 - Their Percent Share of Grand Total
- Total Count for All Data Available Grand Total
- Lines dynamically generated by macro

Ranked Shoe Sales Dollars and Percent of World Total For Top 25 Cities

Selected Top 25 Cities - They Account for SubTotal Shoe Sales \$27,258,392 which is 80.52% of Grand Total

All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Go To Top 25 Go To Top 80% of GrandTotal Go To Sales GE 500000 Go To All

Close-Up View of Top 25 Bar Chart Title Lines

- titles are dynamic & data-specific
- line 1: chart description and subset bar count
- line 2: how selected, subtotal, % of grand total
- line 3: total bar count, grand total of measure

Ranked Shoe Sales Dollars and Percent of World Total For Top 25 Cities Selected Top 25 Cities - They Account for SubTotal Shoe Sales \$27,258,392 which is 80.52% of Grand Total All 53 Cities Have Grand Total Shoe Sales \$33,851,566

Close-Up View of Top 25 Bar Chart Title Lines

- titles are dynamic & data-specific
- line 4 has all of the links
- left end of title line 5 is optional text
- right end of line 5 is optional run day, date, time

Go To Top 25 Go To Top 80% of GrandTotal Go To Sales GE 500000 Go To All
6 Laws of Graphic Communication Effectiveness

- assure text readability
- deliver image + precise numbers
- use Bessler style horizontal bar charts to compare categorical data
- Show Them What's Important with ranking and/or subsetting (enough data)
- provide "data tips" & spreadsheet for dense time series, but annotation* or an on-chart table for time series when feasible
- > make wise use of COLOR—see my paper in the Proceedings
- *Use Bessler Sparse Annotation whenever enough

Code for Examples in These Slides

- For Examples 1-9,
- see the Proceedings and Tools Package
- Find the code for my SuperMacro (Example 10) UpTo4WaysRankingHbarChartsToHTML in http://www.pharmasug.org/proceedings/2013/DG/PharmaSUG-2013-DG11.pdf

false problem with pie charts

Needless academic research found:

- more difficult to compare sizes of pie wedges than lengths of bars or lines
- b difficult to numerically estimate angular measure of pie wedges

Why a false problem?

- For effective communication with graphs, you always must deliver image AND precise numbers— Provide value AND percent of whole as part of slice label, or in a legend
- To Show Them What's Important, it is best to order the pie slices by size

A Pie Chart That Works: Image + Precise Numbers



A Pie Chart That Works: Image + Precise Numbers in Legend

GTL Pie Chart Created Using Latest Bessler Pie Chart Macro



- 23.4% Men's Casual \$7,933,707
- 18.4% Women's Dress \$6,226,475
- 18.2% Slipper \$6,175,834
- 16.3% Men's Dress \$5,507,243
- 12.2% Women's Casual \$4,137,861
- 06.9% Boot \$2,350,543
- 02.6% Sandal \$868,436
- 01.9% Sport Shoe \$651,467

A Pie Chart That Works: Image + Precise Numbers in Legend SAS/GRAPH Pie Chart Created Using Bessler Pie Chart Code



Order here is to the opposite of prior charts. It can be the same.

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