Paint a Better Picture of Your Information with Color

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Abstract

The principles of effective use of color to communicate, rather than decorate, are software-independent. This tutorial provides advice for any presentation, data visualization, or reporting situation, whether using color for slides, text, tabular reports, spreadsheets, web pages, graphs, or maps. When it comes to the pitfalls of, and best practices for, using color, you don't know what you don't know. This tutorial will help you paint a better picture of your information, and includes details specific to SAS® software and Excel.

Introduction

This paper is based on decades of working with color for communication, starting when color devices for computer output were uncommon, were not cheap, and did not deliver very good results. This is an excerpt from the latest update to my work (for users of SAS software) on color in Reference 2. Though this paper includes a few examples of graphs created with SAS graphic tools, the guidelines are really software-independent.

NOTE: If you are interested in creating effective graphs, since *color does not improve bad graphic design*, see also Reference 3, which is my broader discussion of communication-effective data visualization presented at SAS Global Forum 2015.

Provided here are some of my guidelines for color communication, a few examples of communication-effective use of color in graphs, and some wisdom from other experts.

As a convenient look-up companion to this paper and the associated presentation, see also the handout:
"Fifteen of Bessler's Principles for Communication-Effective Use of Color – 23 May 2016
A Tip Sheet for Users of Color for Slides, Text, Tabular Reports, Spreadsheets, Web, Graphs, or Maps".

I cannot provide bibliographic citation for remarks attributed to some experts. The information is from notes from reading and listening more than twenty years ago. Work by those people, as well as other experts on use of color, can be found via the web. For web search, also use the British spelling "colour".

NOTE: A common obstacle to effective communication when using color is insufficient contrast between foreground (e.g., text) and background. In Reference 2, I provide SAS tools to explore text/background contrast. For advice and tools from sources other than Reference 2 and this paper, do a Google search with these strings: "examples of text and background color combinations on readability", "contrast color analyzer", "contrast color finder", "color contrast generator". From the first search string, some hits will be academic research reports/papers, with only words, no color, and no examples. Included is at least one paper using a non-white background—to impair readability? I have not studied these resources, but would be interested in your conclusions as to the most helpful papers and tools.

Eight Guidelines for Color Communication

1. For Those Who Can't See a Color Difference, There Is None. Use Red & Blue for reliable "Traffic Lighting". Eyes can reliably distinguish only five shades of any single hue.
2. Use Color To Communicate, Not To Decorate.
3. Use of Color Can Confuse, Rather Than Communicate. Use color consistently.
4. Maximize Color Contrast between Text and Background.
5. Make Colored Text and Lines Thicker,
     Colored Plot Symbols and Colored Legend Elements Bigger.
6. A Light Color Might Be the Right Color.
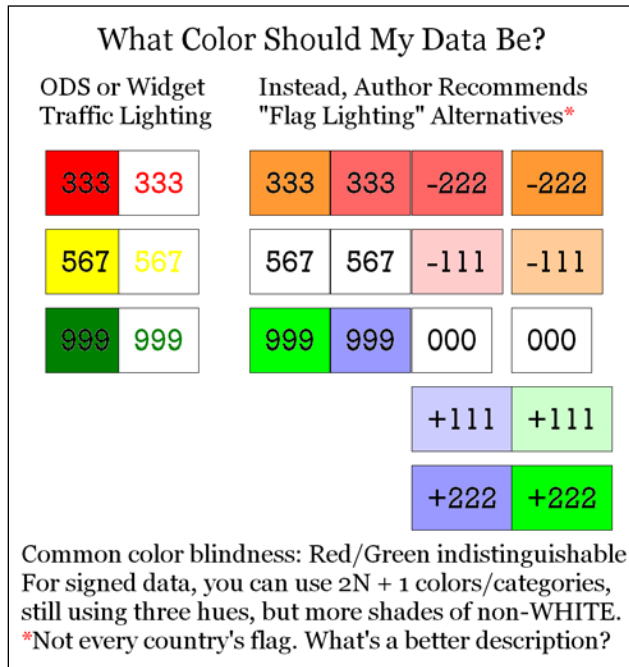7. UnColor Might Be the Right Color.
8. Color Differs on Different Media.

Let me discuss in detail each of these, before moving on to other color communication information.

These eight guidelines are a subset of the fifteen tips in my "Principia Color" mentioned above.

1. For Those Who Can't See a Color Difference, There Is None

The commonest color blindness cannot distinguish between red and green.

Despite this fact, first reported to SAS users in Reference 1, there are many and continuing well-intended, but misguided, examples of papers and web postings explaining how to do "traffic lighting".

What Color Should My Data Be?

Common color blindness: Red/Green indistinguishable
For signed data, you can use 2N + 1 colors/categories,
still using three hues, but more shades of non-WHITE.
*Not every country's flag. What's a better description?

Prof. Jay Neitz of the Eye Institute of the Medical College of Wisconsin reported that 8 to 10 percent of American males have some form of color blindness, but, due to genetic differences, only about one-half percent of American females. I first learned this in a report in a local Milwaukee newspaper back in 1995. I cannot provide the bibliographic citation for this information. This fact has been repeatedly mentioned elsewhere since. I am confident that you can verify it via a web search, and maybe the incidence reported now will be somewhat different. I myself have had a manager and a client who suffer from this regrettably underappreciated problem.

Figure 1 in Appendix A uses "Irish Flag Lighting", but with gray substituted for white.

A sample program to color code a table with an alternative to traffic lighting is provided later.

2. Use Color To Communicate, Not To Decorate

There are two necessary uses of color to communicate:

- a legend of color squares used to match area fills of pie slices, bars, or geographic unit areas
- a legend of colored line segments, colored markers, or a combination of the two used to match plot lines/points

NOTE: If using colored markers for a plot, use solid-filled markers so that the color is more massive—i.e., visible. In ODS Graphics, all such markers have a symbol name that ends with the suffix "Filled", as in CircleFilled, SquareFilled, etc.

There is an optional use of color to communicate:

- Color-coding of data entries in a table, BUT NOT TRAFFIC LIGHTING (as noted in Guideline 1)

The color coding can be applied to the foreground text, i.e., the data entry characters themselves (digits and/or alphabetic characters), or instead to the table cell background. Since the color of text is sometimes hard to discern (if insufficiently large and/or not thickly drawn enough), it is better to color-code the background, but background and text must always be high contrast—see Guideline 4.

NOTE: Color gradient backgrounds for a graph or web page are always anti-readable, and unnecessary.

When and How To Use Color

1. If your visual communication has no need to distinguish response levels or categories, use Black and White, or some other color pair for foreground and background. Black and White are highest contrast. If not using White, try Yellow. If you don't like Yellow, try Cream.

2. If you have a few levels or categories, gray shades may suffice.

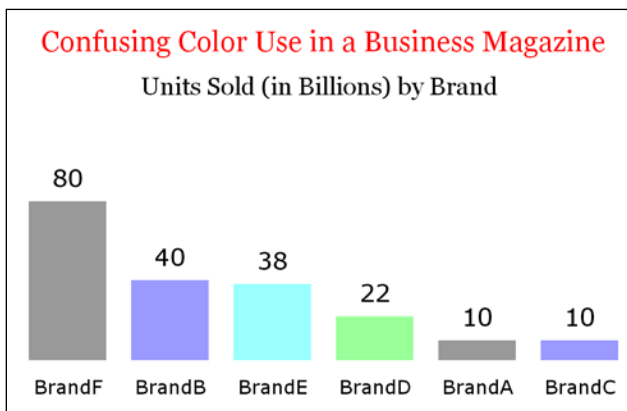3. If you have many levels or categories, color is necessary.

NOTE: In Case 3 above, be careful when trying to limit your palette to a range of shades (lightness/darkness) levels of a single hue. When trying to color code the values of a continuous variable, this seems like a natural and appropriate solution. Unfortunately, *it is impossible to reliably distinguish more than five shades of a single hue*, and any legend with color samples for too numerous values or ranges is actually useless—the graph or map looks very nice, but it is impossible to reliably interpret with precision. Of course, you may be able to expand your palette with Black and/or White, depending on the application and the background color.

3. Use of Color Can Confuse, Rather Than Communicate

Viewers attribute significance to your use of color, even when none is intended, proving the wisdom of Guideline 2. Be careful what you do whenever you use color. Using color without a design objective can disorient, confuse, or even mislead the viewer. Failed communication is always the fault of the transmitter, not the receiver.

The content of the example below is different from a magazine illustration that I saw, but its misuse of color is exactly parallel. There is NO relationship between BrandF and BrandA, and none between BrandB and BrandC. So, what does this use of color mean? Absolutely nothing!

Actually, after looking at other color graphs in that magazine article, I realized what had happened. All of the illustrations were limited (why I do not know) to a palette of only four colors. However, this bar chart would have been communication-effective, rather than confusing, if rendered in just ONE color.

Confusing Color Use in a Business Magazine
Units Sold (in Billions) by Brand

BrandF	BrandB	BrandE	BrandD	BrandA	BrandC
80	40	38	22	10	10

4. Maximize Color Contrast between Text and Background

Contrast between foreground text and its background is essential to communication. ODS opened the door to "enhancing" tables with color. Besides the unfortunately popular Traffic Lighting, there are problems using Yellow with White, or Black (or other dark) text on dark or intense background colors.

It is no accident that books, newspapers, magazines, and scholarly journals are published with black text on white paper. The second most readable color combination is black and yellow.

Tip: A cheap, easy way to communicate with color is with black text on high-contrast color paper. If you want a way to enhance anyone's ability to quickly find your hardcopy handout, this is it.

One of the worst color combinations is yellow and white. I have seen traffic-lit tables with (extremely hard to read) yellow numbers in a white box. I have also seen black text on blue backgrounds. Yes, there are worse choices that come to mind: white on white, black on black, etc. ☺

NOTE: If designing any graph or table that might be printed, remember that adequate contrast for online display, which is bright and shines at you, does not guarantee the same for hardcopy, which is not brightly backlit. That is just one example of Guideline 8.

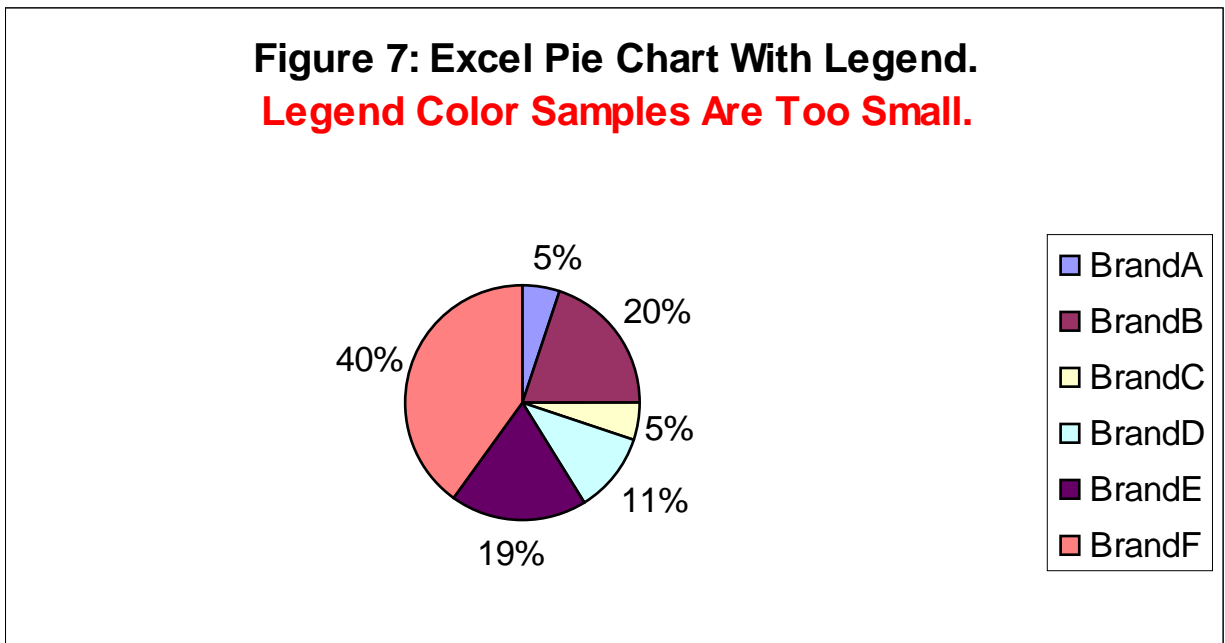Evaluate the contrast samples below.

5. Make Colored Text and Lines Thicker,
   Colored Plot Point Symbols and Colored Legend Elements Bigger

The color of thin text, thin lines, small plot markers, and small legend elements is difficult to distinguish.
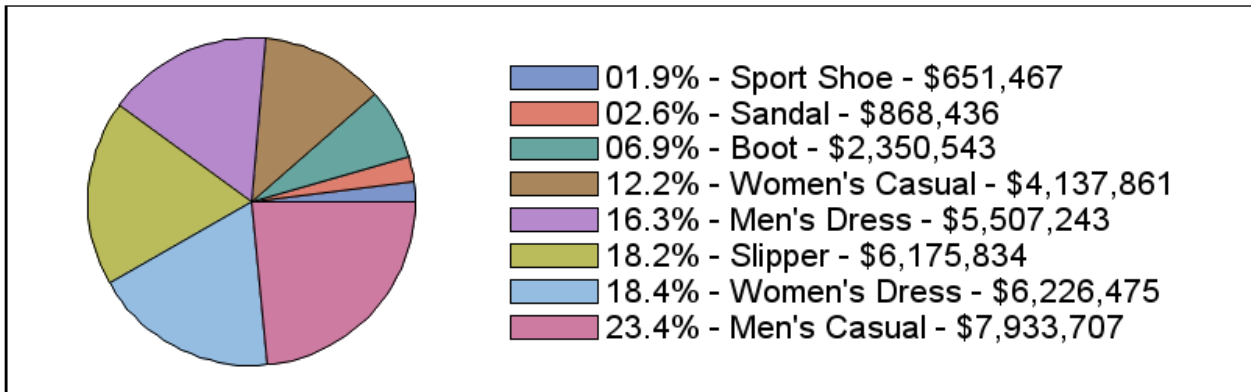
Text thickening can be achieved with bold or with use of font faces that are inherently thicker.

Excel pie chart legends suffer from a color distinguishability problem. The size of the color samples in the legend is small, and there is no way to increase it.

The Anti-Communicative Excel Pie Chart. Is that slice for BrandB or BrandE? If printed, the ambiguity is more apparent. A Word document display shines at your eye. Printed copy is viewed via reflected color off the paper. Excel does not support adjustment of legend color sizes.
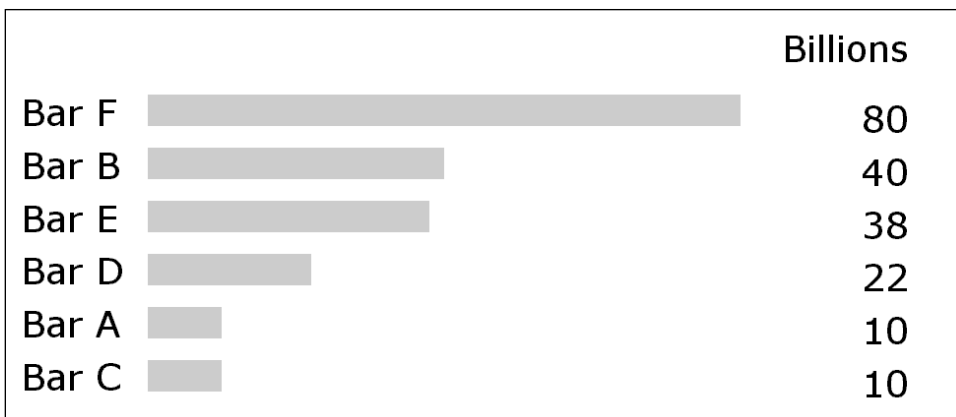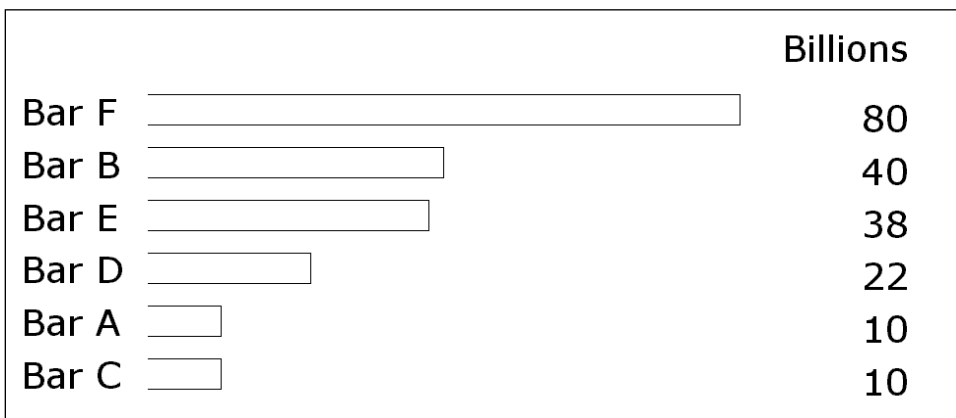
Figure 7: Excel Pie Chart With Legend.
Legend Color Samples Are Too Small.

5%
20%
40%
5%
11%
19%

- BrandA
- BrandB
- BrandC
- BrandD
- BrandE
- BrandF

Communicative-Effective Pie Chart With Legend, Made With SAS/GRAPH®

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

6. A Light Color Might Be the Right Color

This pertains to bar charts with area fill, especially ones with numerous bars. Filling the bars with a full-strength color causes the bars to dominate the image. Leaving them empty can cause visual confusion between bars and spaces. If the examples below had more bars, these visual effects would be more pronounced.

	Billions
Bar F	80
Bar B	40
Bar E	38
Bar D	22
Bar A	10
Bar C	10

	Billions
Bar F	80
Bar B	40
Bar E	38
Bar D	22
Bar A	10
Bar C	10

	Billions
Bar F	80
Bar B	40
Bar E	38
Bar D	22
Bar A	10
Bar C	10
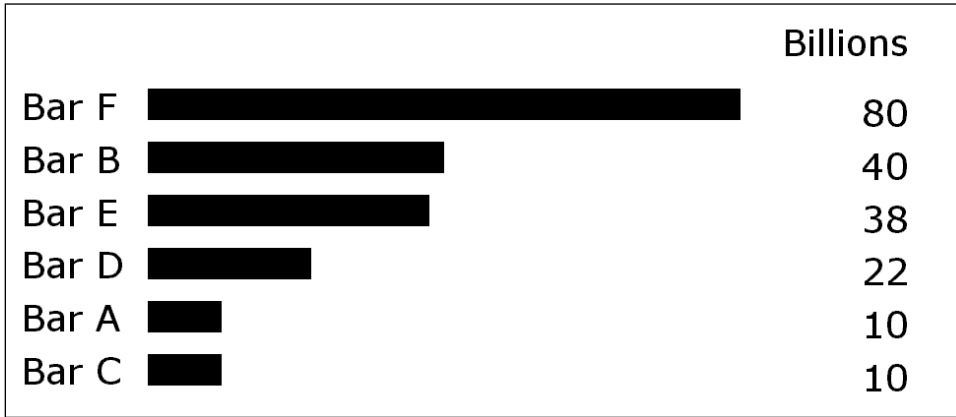
7. UnColor Might Be the Right Color

<u>When Uncolor Suffices</u>

- If you have no response levels/categories, use black & white.
- For a few levels or categories, gray shades may suffice.

Only if you have many levels or categories is color really necessary.

<u>Benefits of Boring Black-and-White</u>

Technology to print black and shades of gray is faster, cheaper, and more reliable.

Black, white, and shades of gray are easier to use. Not only is the equipment simpler, but also their use requires no agonizing over color selection.

Finally, such output is more copyable. Regardless of the proliferation of cheap color printers at work and at home, the copiers that you find in abundance in the workplace are still almost always black-and-white. Why does that matter? Well, good graphs, maps, and tables—if hardcopy—will get copied when people want to share them. If softcopy, users might decide to print them.

8. Color Differs on Different Media: Do You See What I See?

My wife and I disagree on whether certain colors are green (what I see) or brown (what she sees). But there are more than mere differences in human visual perception. In addition to what can happen when using browser-unsafe colors on the web, and what are called "gamma differences" between PC, Mac, and Unix, there are other technology-related sources of variation. Here are some of them:

- LED projector color differs from color on the presenter's laptop that feeds the projector.
- Monitor color differs from printer color.
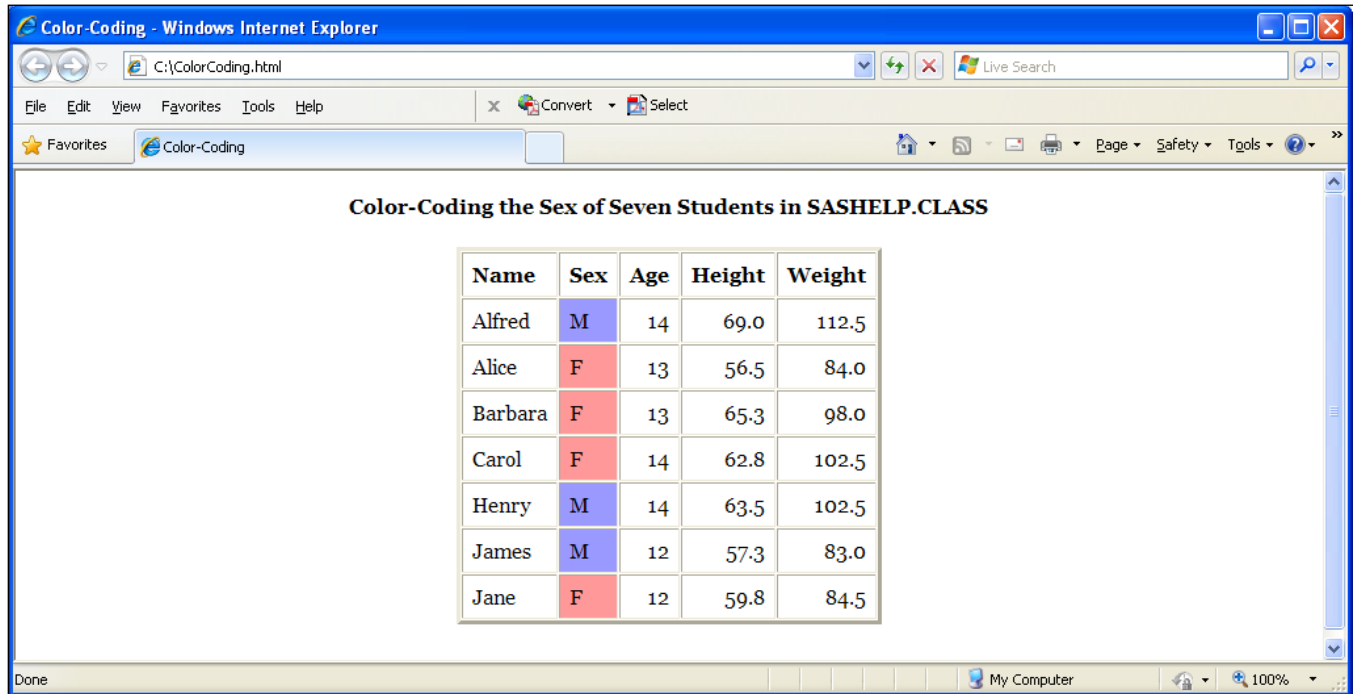- Hardcopy color varies from printer to printer.

Among my experiences in color communication was to see an LED projector convert blue and red text from my PowerPoint slides into violet and orange. Fortunately, the presentation was not about communication-effective use of color. More disappointing was when a presentation that I was doing included my discussion above about the problem with SAS shades of pink (SAS light pink is darker than SAS pink), but was delivered using a projector that converted my shades of pink into shades of gray.

These experiences involved more than the color difference phenomena mentioned above. The projector is probably the riskiest color communication tool. Tuning a shared projector to suit one's own laptop is time-consuming, and might impair the usefulness of the projector for some other presenter.

Black, white, and gray shades do not suffer the above risks.

Color-Coding Your Data (NOT "Traffic-Lighting")

As previously mentioned, the regrettably popular fascination with traffic-lighting of data is non-communicative for color-blind viewers. Here the colors used for coding are light red and light blue for female and male, respectively.
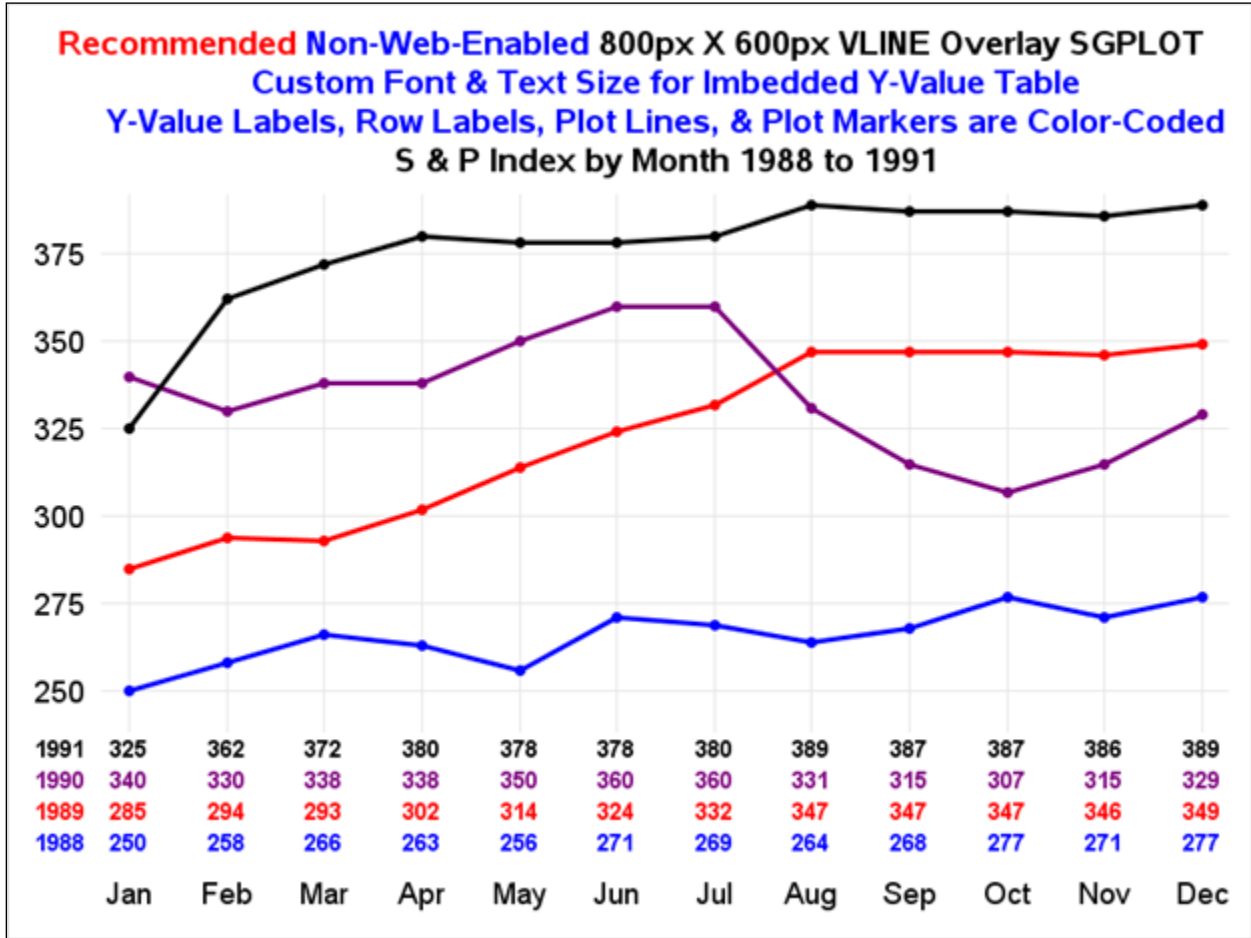

Color-Coding the Sex of Seven Students in SASHELP.CLASS

Name	Sex	Age	Height	Weight
Alfred	M	14	69.0	112.5
Alice	F	13	56.5	84.0
Barbara	F	13	65.3	98.0
Carol	F	14	62.8	102.5
Henry	M	14	63.5	102.5
James	M	12	57.3	83.0
Jane	F	12	59.8	84.5

A Magnificent Solution for Multi-line Plots

This SAS ODS SGPLOT VLINE multi-line overlay color chart provides an on-chart color-coded table of y values, with line descriptions as table row IDs, which eliminates any need for a legend as such. The code to create a similar result can be found in Reference 4.

Recommended Non-Web-Enabled 800px X 600px VLINE Overlay SGPLOT
Custom Font & Text Size for Imbedded Y-Value Table
Y-Value Labels, Row Labels, Plot Lines, & Plot Markers are Color-Coded
S & P Index by Month 1988 to 1991

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	325	362	372	380	378	378	380	389	387	387	386	389
1990	340	330	338	338	350	360	360	331	315	307	315	329
1989	285	294	293	302	314	324	332	347	347	347	346	349
1988	250	258	266	263	256	271	269	264	268	277	271	277

Guidance from Other Experts

Jan White on Color Communication

- If everybody screams, all you get is noise. The less color is used, the more effective it is.
- Color consistency provides recognition.
- Use color to sort and/or link information.
- Make large areas pale, small areas bright.
- Don't waste color on titles—for emphasis, use large or bold print instead.

Michael Turton on Color Communication

- Color works better with space around it.
- Color prioritizes information, whether it is meant to or not.
- Color can guide the viewer.

Conclusion

Color is something that we take for granted. However, without getting into details about the physiology of color perception, optical illusions due to color perception, and other arcane subtleties, this paper demonstrates that color selection and use requires care if you want to get beyond mere decoration and into effective communication.

References

1. Bessler, LeRoy (1995), "Communicate Effectively in Color with SAS/GRAPH Software", *Proceedings of the Twentieth Annual SAS Users Group Conference*, Cary, NC, USA: SAS Institute Inc., 1995. This was the first SAS paper on communication-effective use of color. It was published only in hardcopy and at a time when the proceedings were only printed in black-and-white. It overstates the frequency of color blindness. Find it on the web at http://www.sascommunity.org/sugi/SUGI95/Sugi-95-171%20Bessler.pdf .

2. Bessler, LeRoy (2004), "Communication-Effective Use of Color for Web Pages, Graphs, Tables, Maps, Text, and Print", *Proceedings of the Twenty-Ninth Annual SAS Users Group Conference*, Cary, NC, USA: SAS Institute Inc., 2004. Find it on the web at http://www2.sas.com/proceedings/sugi29/176-29.pdf .

3. Bessler, LeRoy (2015), "Twelve Ways to Better Graphs", *Proceedings of the 2015 SAS Global Forum Conference*, Cary, NC, USA: SAS Institute Inc., 2015. Find it on the web at http://support.sas.com/resources/papers/proceedings15/3518-2015.pdf .

4. Bessler, LeRoy (2014), "Communication-Effective Data Visualization: Design Principles, Widely Usable Graphic Examples, and Code for Visual Data Insights", *Proceedings of the 2014 SAS Global Forum Conference*, Cary, NC, USA: SAS Institute Inc., 2014. Find it on the web at http://support.sas.com/resources/papers/proceedings14/1464-2014.pdf .

Author Information

Your questions, comments, and ideas about communicating with color are always welcome.

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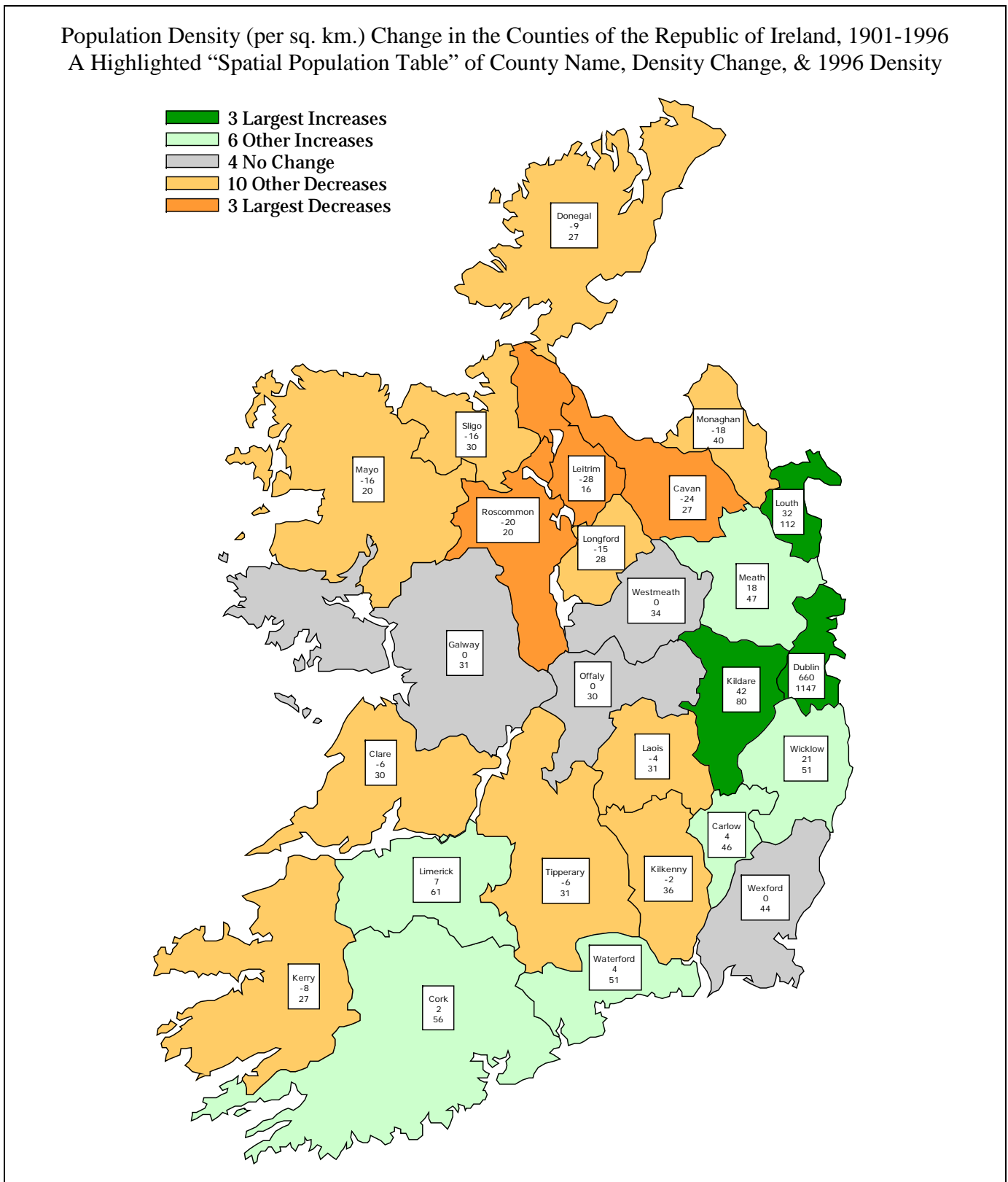Mequon, Wisconsin, USA

Zum sehen geboren, zum schauen bestellt.
(Born to see, meant to look)
— Goethe

A SAS user since 1978, Dr. LeRoy Bessler has shared his knowledge and experience with other users at conferences throughout the USA and in Montreal, London, Heidelberg, and Dublin. Though a SAS generalist with long experience in Base SAS, SAS macro language, and SAS tools for access to non-SAS data, his special interests include creation of unique tools to support the SAS BI server and its users, communication-effective visual communication and reporting, web information delivery, highly formatted Excel reporting, SAS/GRAPH, ODS, and Software-Intelligent Application Development for Reliability, Reusability, Extendibility, and Maintainability. If interested, send him an email request for an index to all of his SAS papers, presentations, and VIEWS Newsletter articles that are available via the internet.

Appendix A.

Figure 1. An Alternative to Traffic Lighting: augmented with light shades of the signal colors.

Population Density (per sq. km.) Change in the Counties of the Republic of Ireland, 1901-1996
A Highlighted "Spatial Population Table" of County Name, Density Change, & 1996 Density

3 Largest Increases
6 Other Increases
4 No Change
10 Other Decreases
3 Largest Decreases

Donegal
-9
27

Sligo
-16
30

Monaghan
-18
40

Mayo
-16
20

Leitrim
-28
16

Cavan
-24
27

Louth
32
112

Roscommon
-20
20

Longford
-15
28

Westmeath
0
34

Meath
18
47

Galway
0
31

Offaly
0
30

Kildare
42
80

Dublin
660
1147

Clare
-6
30

Laois
-4
31

Wicklow
21
51

Carlow
4
46

Limerick
7
61

Tipperary
-6
31

Kilkenny
-2
36

Wexford
0
44

Kerry
-8
27

Cork
2
56

Waterford
4
51

Shown at the Eighteenth Annual SAS European Users Group International Conference, Dublin, 2000