

The Power of Paint: Effective Color Communication with ODS, SAS®, and SAS/GRAPH®

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Abstract

This tutorial discusses color, crucial color concerns dependent on output destination (especially the web), and design for effective visual communication (not decoration) with color. SAS 8.2 is used. The intended audience is all levels of SAS users, and the design principles are actually software-independent.

Introduction

Any information or illustrations developed for the slide presentation between date of submission of this paper for publication (July) and the conference date will be available via an emailable zip file of the slides. If you have comments or questions, or suggestions on what to cover in a future edition of this paper, please send them.

I regret that I cannot provide precise bibliographic citations for the research study results cited below, nor for the remarks attributed to Jan White, Michael Turton, and Aaron Marcus. Such information is drawn from notes taken from reading and listening about ten years ago. Work of these people, and research reports on color, can be found via web search. Also, in a web search, try the British spelling "colour".

Benefits of Color Reported in Various Research Studies

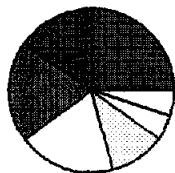
- increased readership
- increased reading speed & comprehension
- faster learning
- reduced error rates
- improved recognition
- improved recall
- improved response

Using Color for Communication

Color Does Not Improve Bad Design:
Use Color To Communicate, Not To Decorate

The pie chart below uses color to communicate. If you have no need to distinguish response levels or categories, use Black and White, or some other high-contrast color pair for foreground and background. If you have a few levels or categories, gray shades may suffice. If you have many levels or categories, color is necessary.

Pie Chart With Legend Communicates with Color
Market Share, Brand, and Sales in Billions of Units



40%	- BrandF	- 80
20%	- BrandB	- 40
19%	- BrandE	- 38
11%	- BrandD	- 22
05%	- BrandA	- 10
05%	- BrandC	- 10

Tip: It is impossible to reliably distinguish more than five shades of a single hue. Of course, you may be able to expand the palette with Black and/or White, depending on the application. The proviso of "depending on the application" means, e.g., that you cannot use Black as an area fill on a map with Black boundaries.

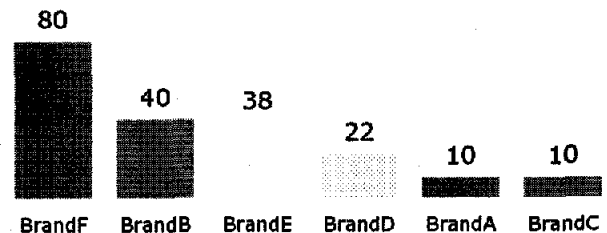
Use of Color Can Confuse, Rather Than Communicate

Viewers attribute significance/meaning to your use of color, even when none is intended. So, be careful what you do, whenever you use color. Use of 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 the magazine illustration I saw, but its misuse of color is exactly parallel. There is NO relationship between BrandF and BrandA, and none between BrandB and BrandC. What does this use of color mean? "Absolutely nuthin'!"

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

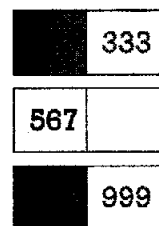


For Those Who Can't See a Color Difference, There Is None

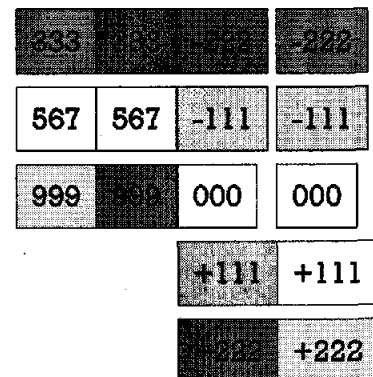
The commonest color blindness cannot distinguish red and green, a frequently used color combination in the USA. Prof. Jay Neitz of the Eye Institute of the Medical College of Wisconsin: 8 to 10 percent of American males have some form of color blindness (due to genetic differences, only about one-half percent of females).

What Color Should My Data Be?

ODS or Widget
Traffic Lighting



Instead, Author Recommends
"Flag Lighting" Alternatives*



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?

Maximize Color Contrast between Text and Background

Contrast between foreground and 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. Evaluate the text-background combinations in the illustration above. See also the contrast demonstration chart in Reference 2. It should be noted that adequate contrast for online display does not guarantee the same for hardcopy, which is not brightly backlit.

Colored Text and Lines Should Be Thicker

Use of Black and White for print in newspapers, magazines, and books is no accident. Their high contrast makes them the most readable foreground-background combination. Colored text and lines on a White background are harder to see. Colored lines should be thickened. SAS/GRAPH enables this with the W= option for plot lines in the SYMBOL statement, with the SHAPE=LINE(width-number) option in the LEGEND statement, and with the WOUTLINE= option for the statements used with GCHART and GMAP PROCs. ODS lets you specify Bold for fonts, and SAS/GRAPH has bold versions of many of its own fonts, as well as allowing you to use Windows TrueType fonts with Bold (e.g., as in font= 'Georgia/Bold').

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.
- On a graph, use color to emphasize an important visual message.

Michael Turton on Color Communication

- Color works better with space around it.
- Color is more effective in bigger masses, since it is less dense than black.
- Color prioritizes information, whether it is meant to or not.
- Color can guide the viewer.

Aaron Marcus on Color Communication

Use blue for large areas, not text or lines. Blue-sensitive color receptors are the least numerous in the retina's central focusing area.

Use red or green in the center of the visual field. The edges of the retina are not very sensitive to these colors.

Use thin, light text or lines on dark backgrounds for viewing in low light situations; use dark text or lines on light backgrounds for viewing in high light situations.

The Case for "UnColor", and How To Use It

When to Use Color on a Graph

- No response levels/categories: black & white
- Few levels or categories: gray shades maybe
- Many levels or categories: color necessary

Benefits of Boring Black-and-White

- Faster, cheaper, more reliable
- Easier to use
 - simpler equipment
 - no agonizing over color strategy
- More copyable (more, cheaper, and faster copiers available):
Good Graphs, Tables, etc. Get Copied

SAS/GRAPH Names for Grays

LIGHT GRAY, MEDIUM GRAY, and DARK GRAY, even with WHITE and BLACK, may not provide enough colors. If so, use color names of the form GRAY//, where // is hexadecimal with range 00-FF. FF (hex for decimal 255) is 0% gray, i.e., WHITE. 00 (hex for decimal 0) is 100% gray, i.e., BLACK. 80 (hex for decimal 128) is 50% gray.

Here are other correspondences for your convenience:

D5 = 17%,	CC = 20%,	C0 = 25%,
AA = 33%,	99 = 40%,	66 = 60%,
55 = 67%,	40 = 75%,	33 = 80%,
2B = 83%,		

How to Choose/Use SAS/GRAPH Grays

Gray shades too close together are difficult or impossible to distinguish.

Decide how many (N) grays are needed for the chart, divide 256 by N - 1, and use the quotient (in hexadecimal) as increment from 00 to FF for // in GRAY// assignments. Subsets of the values provided in the section above can produce equally spaced grays for sets of 3, 4, 5, 6, or 7 PATTERN statements.

But it should be noted that the human eye cannot reliably distinguish more than five shades of gray (or of any other color).

Black area-fill on a map will hide shared boundaries.

Sometimes gray shades do not photocopy well.

Use "Browser-Safe" or "Web-Safe" Colors

Unlikely as it may seem, many, if not most, web users have displays or video cards limited to 256 colors. Even when the hardware has a higher capability, it may be set to display only 256 colors.

(To check or change your own setting on Windows, click Start > Settings > Control Panel > Display > Settings > Colors.)

You may wish to design for the lowest common denominator. Here is why and how.

To deal with equipment diversity, web browsers determine the currently set limits of the display, and, if needed, remap colors.

Video displays produce colors as combinations of Red, Green, and Blue. All web browsers agree on a universal common subset of 216 "browser-safe" colors.

They are RGB colors (Red-Green-Blue combinations), with names, in SAS, of the form CXrrggbb. The web-safe RGB colors restrict rr, gg, and bb to the six values 00, 33, 66, 99, CC, FF, which correspond to 0%, 20%, 40%, 60%, 80%, 100% of red, green, and blue. (216 = 6 X 6 X 6.)

If a web browser detects a color outside this set on a web page to be shown on a 256-color display, it remaps it to a browser-safe one. Then, Web Designer Color does not equal Web Viewer Color. There are 16.7 million RGB colors, but only 216 are browser-safe.

All of the SAS "predefined colors" (see below) and all of the HTML colors (see below) have RGB equivalents, but only (the same) seven of each are browser-safe. SAS GREEN, contrary to the RGB value still listed in the manual, changed in Version 6.12, and is no longer browser-safe—even though Green is one of the three RGB primaries.

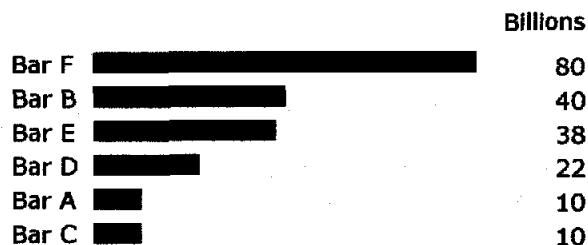
See the Appendix for 81 samples of browser-safe colors. The "basic" colors are Red (CXFF0000), Yellow (CXFFFF00), Green (CX00FF00), Cyan (CX00FFFF), Blue (CX0000FF), Magenta (CXFF00FF), Black (CX000000), and White (CXFFFFFF). The upper chart shows the only way for RGB colors to vary in lightness with constant hue.

A Light Color May Be the Right Color

With many more bars in the example below, the effects of too much or too little would be even worse.

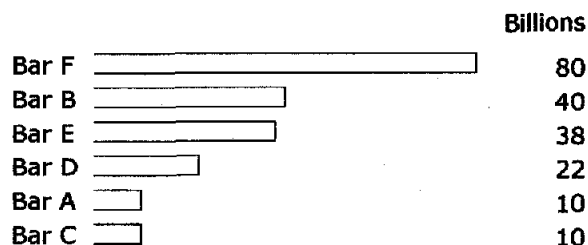
Solid Black Bars

Overwhelming visual effect distracts from text and data (effect would be more pronounced if more bars)



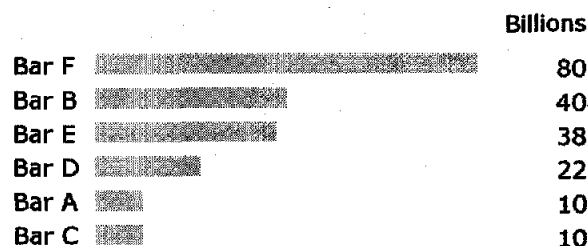
Empty Bars

Confusion between the bars and the spaces (effect would be more pronounced if more bars)



Light Gray Bars

Adequate bar fill without visual domination



When annotating a map, where the text must overlay the area fill, use of light colors for high contrast between background and text is essential.

Best Color System When Doing Hardcopy Only

It is easy to vary lightness with constant hue when using the HLS color system. When your target is hardcopy, HLS colors are an excellent choice, also providing easy tunability of transition in hue and saturation.

HLS color names are of the form *Hhhhlss*. Here is how they work:

- *hhh* = Hue
- *ll* = Lightness
- *ss* = Saturation
- *hhh*, *ll*, *ss* are hexadecimal values
- *hhh*, *ll*, *ss* ranges are 000-168, 00-FF, 00-FF
- *hhh* = 000 - 168 defines a "wheel of hues", 0 - 360 degrees
- *ll* = 00 (0%) is always black
- *ll* = FF (100%) is always white
- *ss* = FF (100%) is full saturation
- *ss* = 00 (0%) is always gray

llss = 80FF is what I call the "true color"

There are six/seven special hues in the HLS color wheel.

hhh	color	position
000	Blue	0 degrees
03C	Magenta ("shocking pink")	60 degrees
078	Red	120 degrees
0B4	Yellow	180 degrees
0F0	Green	240 degrees
12C	Cyan (Turquoise)	300 degrees
168	Blue	360 degrees

In this scheme, Violet lies between Blue and Magenta, Orange between Red and Yellow, Yellow-Green between Yellow and Green. To get to these other colors, and to adjust their precise hue, you have to "turn the dial" between the successive relevant pairs of *hhh* values listed above. Below is some code to convert color wheel degrees into their hexadecimal codes for HLS hues, and to create color samples:

```
data _null_;
length HLSCode $8.;
degrees = 45;
HLSCode = 'H' || put(degrees,hex3.) || '80FF';
call symput('MyViolet',HLSCode);
degrees = 150;
HLSCode = 'H' || put(degrees,hex3.) || '80FF';
call symput('MyOrange',HLSCode);
run;
options reset=all;
options device=PNG gsfname=anyname border;
options vpos=06 vsize=0.90 IN ymax=0.90 IN
ypixels=270;
options hpos=34 hsize=3.25 IN xmax=3.25 IN
xpixels=975;
filename anyname "YourDrive:\YourFile.png";
proc gslide;
title; footnote; note h=1 ' ';
note j=C
f='Courier New/Bold' h=1 c=H0000000
"C=MyViolet"
move=(+0.5,-1.25)
f='Monotype Sorts' h=4 c=MyViolet '6E'X
move=(+2,+1.25)
f='Courier New/Bold' h=1 c=H0000000
"C=MyOrange"
move=(+0.5,-1.25)
f='Monotype Sorts' h=4 c=MyOrange '6E'X;
run; quit;
filename anyname clear;
```

Here are the color samples for My Violet and My Orange:

C=H02D80FF



C=H09680FF



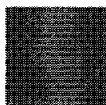
Beware of SAS Color Names, Old and New

There are 292 "SAS Predefined Color Names", listed in Table 7.2 in the Version 6 and Version 8 SAS/GRAPH documentation. They have names such as "PINK", or "LIPK" for "Light Pink". However, many of the names are misleading. If you display or print PINK and LIPK, you will find that SAS Light Pink is darker than SAS Pink. See the illustration below. There are other contradictions like this. Also, many of the colors are too dark to be useful. Make color samples.

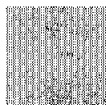
Before Using, Test Any SAS Color Name, Old or New

E.g., "Light Pink" is darker than "Pink"

C=LIPK



C=Pink



LIPK is SAS Color Name for "Light Pink"

Omitting GOPTIONS, here is the code for the above color sample:

```
proc gslide;  
note j=C  
f='Georgia' h=1 c=CX000000 'C=LIPK'  
move=(+1,-1.5)  
f='Monotype Sorts' h=5 c=LIPK '6E'X  
move=(+3,+1.5)  
f='Georgia' h=1 c=CX000000 'C=Pink'  
move=(+1,-1.5)  
f='Monotype Sorts' h=5 c=PINK '6E'X;  
run; quit;
```

If you cannot use these Windows TrueType fonts, use f=CENTX and replace '03'X with '6E'X.

There are also about 150 new SAS color names in the SAS Color Registry. You can find them, and their RGB codes, using this click sequence in your SAS session:

Solutions > Accessories > Registry Editor > Colornames > HTML

With these SAS HTML color names, too, assume nothing. Make yourself a sample chart. Only seven of these HTML color names intended for web use are browser-safe.

These SAS HTML color names and corresponding codes were not invented by SAS developers. They are a (web-unsafe) standard web palette.

The last time I worked with these SAS HTML color names, there were a few typos in the names. There was a message in the SAS log, and those misnamed color names did get mapped to some actual colors, but I cannot remember how. Since I do not recommend the use of the HTML color names, I can't get motivated to investigate and report the details.

In principle, you could use the registry to define a custom palette of your own, with RGB assignments that you like (e.g., browser-safe ones), and with your own names for them.

Color Differs on Different Media Do You See What I See?

Besides the use of browser-unsafe colors, and gamma differences between PC, Mac, and Unix, there are other technology-related sources of variation. Here are some:

- CRT monitor color and LED flat panel color differ.
- On an LED panel very light colors wash out to near-White.
- LED projector color differs from the color on the presenter's input source PC or laptop.
- CRT or LED color differs from printer color.
- Hardcopy color varies from printer to printer.

My most astounding experience in color communication was to see an LED projector convert blue and red text in the PowerPoint slides of myself and those of another speaker (we were using different laptops), into violet and orange. This is more than the color difference phenomenon mentioned above.

Related Work By the Author

0. The author has been talking about color communication at SUGI and other venues since 1995, in a series of papers too numerous to list.

1. "Easy, Elegant, and Effective SAS Graphs: Inform and Influence with Your Data", elsewhere in these *MWSUG 2003 Proceedings*.

2. "Web Communication Effectiveness: Design and Methods to Get the Best Out of ODS, SAS, and SAS/GRAPH", elsewhere in these *MWSUG 2003 Proceedings*.

3. With Francesca Pierri, "Your Graphs and Tables at Their Best on the Web with ODS", *VIEW'S 2001 Proceedings*, United Kingdom SAS Users Group (London, UK), 2001. (Also in *SUCHI 2001 Proceedings* and *SUGI 27 Proceedings*.)

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Dr. LeRoy Bessler has special interests in: Software-Intelligent application development, which yields SAS solutions that are reliable, reusable, maintainable, and extendable; and communication-effective design and construction of reports, tables, graphs, maps, spreadsheets, and web pages. Since 1978, he has used SAS on mainframes, Windows, and Unix. LeRoy has presented to SAS and other Information Technology users in business, government, non-profits, and academe, throughout the United States and overseas.

The Power to Show™

Appendix: Samples of Browser-Safe SAS/GRAPH Colors, with Their RGB Codes

Shades of the RGB Primary & Secondary Colors, Grays, & White (CXFFFFFF)

No more than five shades of the same hue are easily distinguished

CX330000	CX333300	CX003300	CX003333	CX000033	CX330033	CXFFFFFF
CX660000	CX666600	CX006600	CX006666	CX000066	CX660066	
CX990000	CX999900	CX009900	CX009999	CX000099	CX990099	
CXCC0000	CXCCCC00	CX00CC00	CX00CCCC	CX0000CC	CXCC00CC	
CXFF0000	CXFFFF00	CX00FF00	CX00FFFF	CX0000FF	CXFF00FF	CX000000
CXFF3333	CXFFFF33	CX33FF33	CX33FFFF	CX3333FF	CXFF33FF	CX333333
CXFF6666	CXFFFF66	CX66FF66	CX66FFFF	CX6666FF	CXFF66FF	CX666666
CXFF9999	CXFFFF99	CX99FF99	CX99FFFF	CX9999FF	CXFF99FF	CX999999
CXFFCCCC	CXFFFFCC	CXCCFFCC	CXCCFFFF	CXCCCCFF	CXFFCCFF	CXCCCCCC

Other Browser-Safe SAS/GRAPH Colors

CX6633CC	CX9966FF	CX663300	CX996633	CXCC9966	CXFFCC99	CX9900CC
CX663333	CX996666	CXCC9999	CX999966	CXCCCC99	CXCC6600	CXFF9933
CX663366	CX996699	CXCC99CC	CX99CC00	CXCCFF33	CX336666	CX669999