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Teaching, tech, and productivity.

# Creating Color-Blind Accessible Figures



Today marks the start of the
`#1ineveryclassroom (http://www.colourblindawareness.org/about-us/1ineveryclassroom/)` public
awareness campaign by the UK-based Colour Blind Awareness (http://www.colourblindawareness.org/)
organization to point out the prevalence of colorblindness and the need for greater awareness on the
part of educators.

There is tremendous variation in how individuals perceive and distinguish colors. These differences can
be due to color vision deficiency or color blindness (http://en.wikipedia.org/wiki/Color_blindness), as
well as other medical conditions affecting the eyes or brain. Other factors such as device display settings,
corrective lenses, and environmental lighting conditions can also affect the perception of color
differences.

The most common congenital forms of color blindness are deuteranopia and protanopia, the inability to
distinguish red and green. Tritanopia causes difficulty in distinguishing blue and yellow. However, these
simplified descriptions barely begin to address the ways many different colors
(http://www.webexhibits.org/causesofcolor/2B.html) (and their lighter/darker variations) are perceived
by those with color blindness.

Many of the default color schemes used in scientific figures rely on red-green or magenta-yellow contrast, which, as several researchers pointed out (http://blogs.nature.com/nautilus/2007/02/post_4.html) in *Nature*, are nearly indistinguishable for many of those with colorblindness. Many of the default color schemes in Excel and other charting tools used in the social sciences and humanities also produce charts that are difficult for those with vision problems to distinguish. As Bang Wong points out, "If a submitted manuscript happens to go to three male reviewers of Northern European descent, the chance that at least one will be color blind is 22 percent" (*Nature Methods* 8, 441 (2011) doi:10.1038/nmeth.1618). Following colorblind accessible guidelines when creating graphs and charts for publication or display ensures that everyone in your audience can read your figures, something that should be of concern for all teachers and researchers.

# Principles of Color Universal Design

One of the most often cited resources for creating color blind accessible figures is: Okabe, Masataka and Kei Ito. "Color Universal Design (CUD): How to Make Figures and Presentations that are Friendly to Colorblind People." J*Fly Data Depository for Drosophila researchers. Until recently this article was available at http://jfly.iam.u-tokyo.ac.jp/color/ (http://jfly.iam.u-tokyo.ac.jp/color/) but as of early February 2015 that site is currently unavailable, so I am presenting some of their ideas below.

Okabe and Ito offer what they term 3(+1) Principles of Color Universal Design:

> *1. Choose color schemes that can be easily identified by people with all types of color vision, in consideration with the actual lighting conditions and usage environment.*
>
> *2. Use not only different colors but also a combination of different shapes, positions, line types and coloring patterns, to ensure that information is conveyed to all users including those who cannot distinguish differences in color.*
>
> *3. Clearly state color names where users are expected to use color names in communication.*
>
> *(+1) Moreover, aim for visually friendly and beautiful designs.*

# Creating Better Presentations

Other suggestions from Okabe and Ito for accessible design include:

- using redundant visual coding, such as using solid and dashed lines as well as different colors, to assist viewers in distinguishing them

- using thick lines and larger chart objects when possible

- use sufficient contrast between text or object and the background

- when presenting, use descriptive language other than just color to indicate what you're referring to (i.e., "this red square at the top left" not just "this red square")

- green laser pointers (http://www.amazon.com/gp/product/B002GHBUTU/ref=as_li_tl?ie=UTF8&camp=1789&creative=390957&creativeASIN=B002GHBUTU&linkCode=as2&tag=natmhou-20&linkId=ZZWI6TORMJBW7U32) are easier for colorblind viewers to see than red ones

One of the most useful resources in Okabe and Ito's work is their colorblind palette which consists of colors that are distinguishable by those with the three frequent forms of colorblindness.



| | Original | Simulation | | | | | Hue | for Photoshop, Illustrator, Freehand, etc. | | for Word, Power Point, Canvas, etc. |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | Protan | Deutan | Tritan | | | | C,M,Y,K (%) | R,G,B (0-255) | R,G,B (%) |
| 1 | | | | | | Black | – ° | (0,0,0,100) | (0,0,0) | (0,0,0) |
| 2 | | | | | | Orange | 41° | (0,50,100,0) | (230,159,0) | (90,60,0) |
| 3 | | | | | | Sky Blue | 202° | (80,0,0,0) | (86,180,233) | (35,70,90) |
| 4 | | | | | | bluish Green | 164° | (97,0,75,0) | (0,158,115) | (0,60,50) |
| 5 | | | | | | Yellow | 56° | (10,5,90,0) | (240,228,66) | (95,90,25) |
| 6 | | | | | | Blue | 202° | (100,50,0,0) | (0,114,178) | (0,45,70) |
| 7 | | | | | | Vermilion | 27° | (0,80,100,0) | (213,94,0) | (80,40,0) |
| 8 | | | | | | reddish Purple | 326° | (10,70,0,0) | (204,121,167) | (80,60,70) |

(http://chronicle.com/blogs/profhacker/files/2015/02/cb-palette.png)

Two other resources are also very useful in creating colorblind accessible figures, presentations, and websites:

- Cynthia Brewer's ColorBrewer (http://colorbrewer2.org/) resource is designed for choosing colors for geographical maps and includes a colorblind safe palette.

- Vischeck.com (http://www.vischeck.com/) offers a web-based tool that allows you to upload your images and see them as someone with color vision deficiency would see them. You can also run it on web pages.

It is highly likely that whether you are teaching a class, presenting at a conference, or submitting figures with an article for publication, at least some of your audience will have some form of colorblindness or another color vision deficiency. Why not make sure everyone can see your slides clearly?

[image from The Colour Blindness Awareness (http://www.colourblindawareness.org/) organization, showing the same picture viewed with full color vision and with deuteranopia]

**What other resources do you use to create accessible figures? Let us know in the comments!**