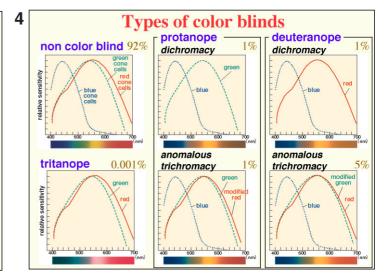
3



How to make figures and presentations that are friendly to color blind people

Masataka Okabe and Kei Ito with special thanks to Cahir O'Kane



How common is color blindness?

One in twelve males (8%) and one in 200 females (0.5%) are red-green color blind.

(Asian: 5%, French and Scandinavian : >10%)



People with defects in blue cone cells (type 3: tritanopes) are relatively rare (one in tens of thousands.)

Red-green color blindness is commoner than AB blood group. There should be around 10 color blind people in the room with 250 people!

How can you see this color ? (common question ;-) A typical confocal picture **Double-staining with** red and green signals. →Not understandable for color blind people! Let's simulate how color blind people see this. deuteranope (green) tritanope (blue) protanope (red)

Can color blind people see colors? Do they see everything black and white? non color blind protanope (red cone cells defective) deuteranope (green cone cells defective) tritanope

(blue cone cells defective) Color blindness is not a total loss of color vision.

But certain ranges of colors are hard to distinguish.

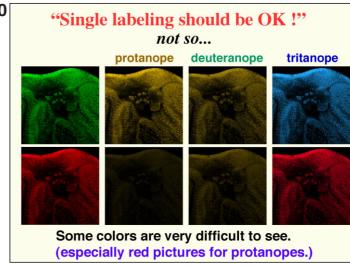
Color blind simulator: VisCheck (http://vischeck.com)

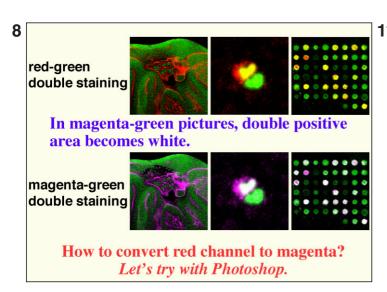
Color-blind simulator VisCheck http://vischeck.com/ ColorField Insight http://www.colorfield.com/

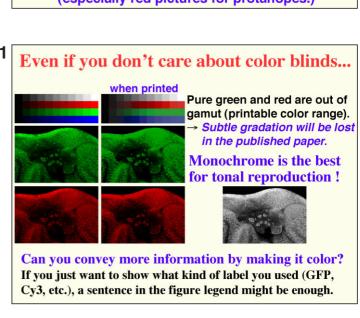
Green laser pointer: DeHarpporte Trading Company http://store.yahoo.com/deharpport/

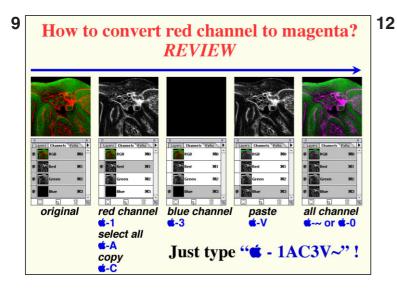
6 Another problem: recognition of double positive cannot distinguish light yellow from green This appears like...

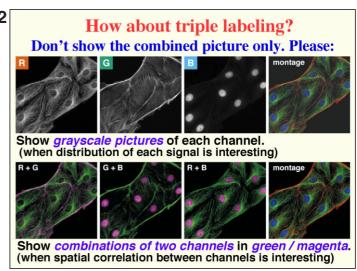












How about characters and drawings?

Four problems that color blind people suffer:

1. Cannot distinguish certain colors.

Symbols and lines in:

blue and violet;

red, orange, yellow, yellow green and green

2. Fail to see some objects.

Dark red or magenta symbols and thin lines over black or dark blue background.

3. Difficult to see emphasized parts.

(For protanopes, dark red appears similar to black...)
 Very difficult to tell the name of colors.
 "Recognition of color difference" and "identification of color names" are totally different task.

Dark red characters in black text.

1. Make lines thicker, symbols larger.
2. Use various types of lines and symbols.
3. Avoid separate keys. Add labels within the drawings.

Bad!

Annual GFP increase

Annual GFP increase

U.K.

Japan

U.K.

Japan

U.K.

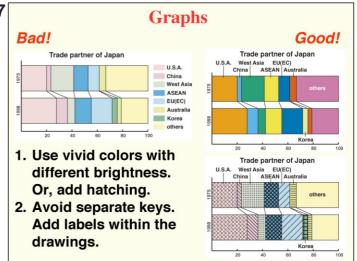
Japan

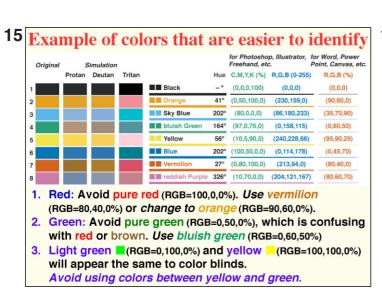
U.S.A.

Japan

Jap





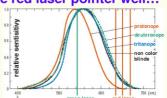




19 **Deuteranope simulation...**

22 Anything else?

1: "Cannot see red laser pointer well..."



Green laser pointer is good for color blind people. The same also for non-color blinds.

2: "Which is that 'red cell' you are talking about?"

Avoid indicating objects only by color name. Describe shapes and positions. Use pointer.



Useful URLs

1: Color Blind Simulator

Vischeck

http://vischeck.com/

Freeware (Plug-in for NIH Image J: Win, Mac, Unix) Windows (Plug-in for Adobe Photoshop)

Online conversion service

Colorfield Insight

http://www.colorfield.com/

Macintosh (Plug-in for Adobe Photoshop)

2: Green Laser Pointer

DeHarpporte Trading Company

http://store.yahoo.com/deharpport/

3: Download the PDF and PowerPoint files of this presentation

http://jfly.nibb.ac.jp/html/color blind

21 How to make slides and figures?

Do not convey information with color only. Show differences BOTH in color and in shape.

"redundant coding"

In addition to color, use the combinations of :

- solid and various dotted lines - various hatching
- circles, triangles and rectangles alphabets and numbers etc.

Keep the number of colors to a minimum.

Use combinations of different symbols with a few, vivid colors rather than a single symbol with various colors.

●■■▼▼▲▲++★★ v.s. ●●●●●●●

Keep contrast not only in hue but also in brightness.

Make it possible to communicate without using color name.

First, design figures in gray scale. Then, add colors as "ornament."

Conclusion



There are always color blind people among the audience, readers and referees. Please take this into account when preparing your presentations (papers, slides, web pages etc.)

Thank you for your cooperation!

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24