



Color Perception Information



Color Vision Simulator Examples

Vischeck's color vision model allows you to simulate how the world looks to people with various sorts of color deficiency. As you can see from these examples, 'color blindness' is really a misnomer- most 'color blind' people do in fact see colors! The colors seen may be different than those seen by someone with normal color vision. Also, people with color deficiencies may see certain colors (like red and green) as very similar, while someone with normal color vision sees them as quite dissimilar. (Complete color blindness does occur, but is quite rare.)

The world.



How the world looks to a person with a red/green color deficit (deuteranopia).



How the world looks to a person with a red/green color deficit (deuteranopia).



Some colorful hats.



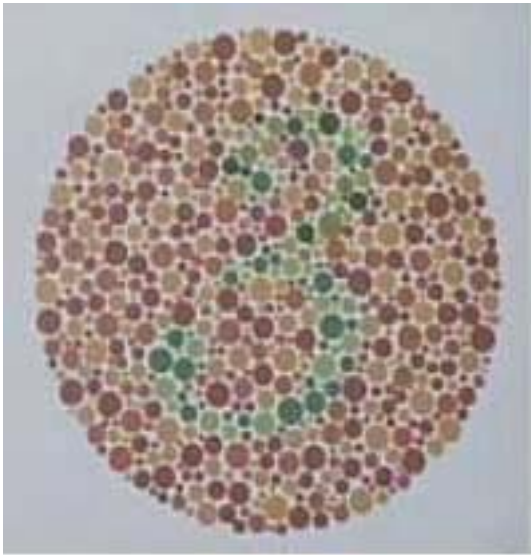
As seen by a person with deuteranopia.



As seen by a person with protanopia, another form of red/green deficit.



This is an Ishihara plate commonly used to check for red/green color blindness



This is what a red/green color-blind person might see. Note that the digit (3) is practically



People with color deficiencies may have difficulty distinguishing certain colors (e.g., a red/green color deficiency means that reds and greens are more difficult to distinguish). But as this photo demonstrates, many other colors are just as distinguishable to a person with a color deficiency as to someone with normal color vision.

Poppies and cyclamen.



Protanope.



Tritanope.



Can you tell red from green?

By Dr Alex Wade, Research Fellow at Stanford University

The next time you go strawberry picking, imagine how much harder it would be if the fruit were the same colour as the leaves. If you are a man, there is a 10% chance that they are! So is this a problem you need to worry about?



Strawberries.



Strawberries as they would appear to someone who is red/green colorblind.

Roughly 1 in 10 men are fully or partly colour blind. This means that one of the three types of colour detectors in their eyes is either faulty or missing altogether. The condition is hereditary and sex-linked: fathers will pass the gene to their daughters (but not their sons) and mothers can pass it to all their children. However, because women can be unaffected carriers, men are at least 20 times more likely than women to develop colour blindness.

Colour blindness is not a particularly serious condition. Although one type of colour detector (or cone cell) is missing, the gaps are filled seamlessly by cones of the other two sorts. The more important aspects of vision are rarely affected. People who are colour blind are, in general, no more likely to suffer from short- or long-sightedness or to develop eye diseases such as glaucoma or cataracts later in life.

The effects of colour blindness are so mild that many boys only realise that they have it at a relatively late age. Since they were born colour blind, the world has always looked perfectly normal to them. It is only when they have a sight test at school, or get into an argument with a friend about whether something is red or green, that they find their view of the world does not always match that of other people.

It is important to remember that people with colour blindness generally can see most colours; they just have trouble distinguishing between some shades of red and green. Apart from making terrible strawberry pickers, people who are colour blind are excluded from certain jobs for safety reasons. For example, they cannot be airline pilots, policemen or ship captains. Their everyday lives are also fraught with occasional minor hazards: how to match socks, how to decide whether the power indicator on the stereo is red or green, how to find red golf tees in the grass and how to choose an appropriate colour scheme for decorating the house.

Clever ways to compensate for colour blindness

If you are colour blind, there are some strategies that can help. Getting a friend or partner to advise on matching socks and ties will stop you committing the more serious fashion crimes, while asking a shop assistant's advice when buying clothes, paint, carpets and wallpaper is just common sense. Most colour-blind people learn at an early age to use clues to help them guess what colour something might be. Red and green traffic lights might look similar but as long as you remember that red is always at the top, you can't go far wrong! Sometimes, red and green things that look alike under fluorescent light will look different in the daylight. Try taking your ties nearer to the window in a shop before you decide which one to buy.

On the positive side, there is some evidence that colour-blind people are much better than average at certain jobs. They are very good at finding green things hidden against green backgrounds - for example grass or leaves. They tend to find things by shape and get less confused by camouflage. Because of this, colour-blind entomologists still catch lots of bugs and in wartime, armies prize their colour-blind snipers and spotters. So, if you are colour blind and have trouble picking strawberries, why not try your hand at green beans or peas instead? You might be surprised at how well you do!

Original Image



Deuteranope Simulation



Original Image



Protanope Simulation



Original Image



Tritanope Simulation



Color blind image correction

One of the most commonly asked questions is:

Is there a way to cure color blindness?

From a medical point of view, the answer is 'not really'. There are some devices (colored contact lenses or filter spectacles) that are claimed to improve the vision of color blind people but in general, people report very mixed results with them. There is currently no effective way to recover full 3-color vision if you are red/green colorblind.

So in one sense, color blindness is 'incurable'. But a deeper question is "what is color good for?". Apart from its aesthetic appeal, seeing many different colors allows us to distinguish things in the world. Take the example below.

How many types of fruit is this man selling?

People with three different cone types ("trichromats") can see 5 distinct piles of fruit on the ground.

From back to front, they look 'red', 'green', 'red', 'yellow' and 'light orange'.

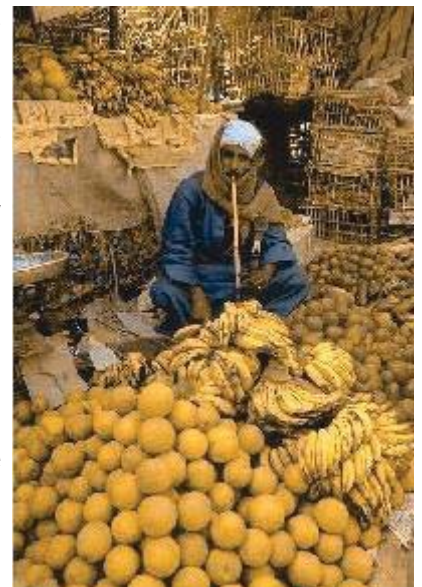
There are also some baskets on the shelf containing three piles of fruit.



But people with red/green color blindness usually have trouble seeing all the different fruits. They see something that can be simulated like this:

Note that there now seem to be only three or four different types of fruit on the ground.

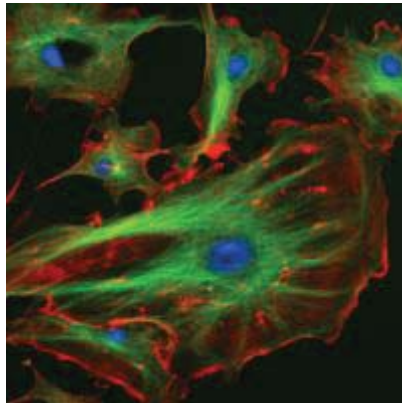
It is also hard to tell how many distinct piles of fruit there are on the shelves.



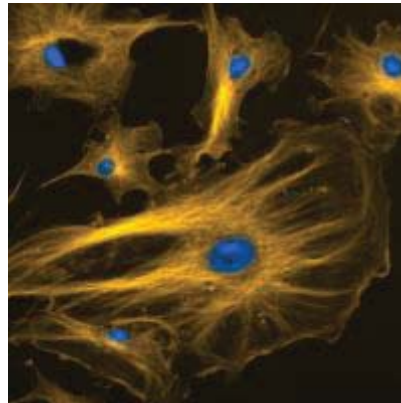
In some pictures, a lot of important information is conveyed by variations in reds and greens. This is a real problem for color blind people who will miss this information. The important point to understand is that the ***'true' color of something may be irrelevant but the fact that it is different from its surroundings is very important.***

Here is another example:

1) Cells labelled with three types of fluorescent markers to show up three different structures.



2) Red/green color blind simulation of fluorescent cell picture.



Here, a color blind scientist would be unable to tell the red and green labels apart. They would miss important information about the structure of the cells.

How to fix it?

We can use image processing techniques to improve this situation. There are two ways that we can make information in pictures available to color blind people.

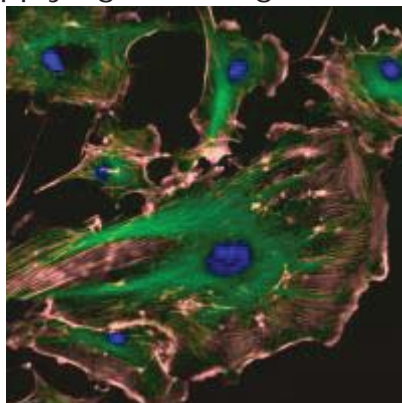
1) The simplest way is simply to increase the red/green contrast in the image. Many color blind people have some residual red/green discrimination. Increasing the red/green contrast makes them more likely to see these types of color variations.

2) We can analyze the information conveyed by variations in the red/green direction and convert these into changes in brightness and/or blue/yellow coloration. This allows us to map information from a color dimension that is invisible to dichromats into those that they can see.

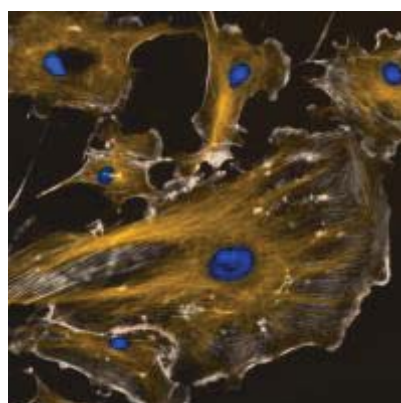
We call the combination of these two processes 'Daltonization' after John Dalton, the British scientist who was one of the first people to investigate color blindness.

The result of applying these algorithms is shown below:

3) Daltonized version of three-color-labelled fluorescent cells.



4) Dichromat (red/green color blind) simulation of the Daltonized image.



Here, the algorithm has mapped changes in the reds and greens into slight changes in brightness and bluishness. The result is that when viewed by someone with color blindness, the different labelled structures in the cell are clearly visible.

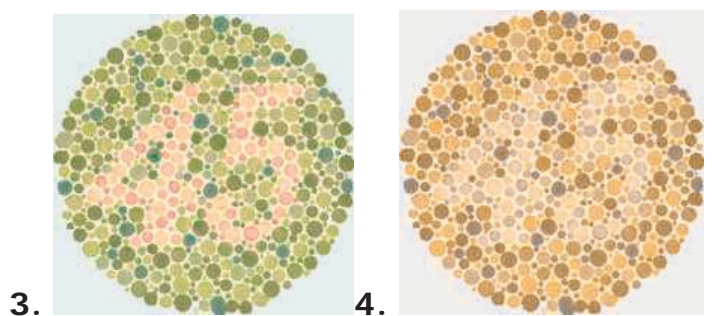
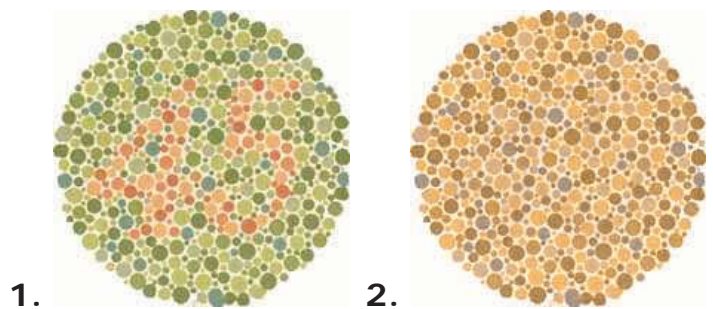
Here are some more examples. In each case, the images are numbered 1 to 4 where 1) is the original full-color image, 2) is a simulation of the color-blind view of the full color image, 3) is the Daltonized version of the full color image and 4) is the color blind simulation of the Daltonized image showing improved red/green discrimination. To see how well the Daltonization algorithm works for someone with color blindness, compare images 2) and 4).

Example: Gauguin painting



In this case, the Daltonization transformation must be judged on a more aesthetic level. While there is more 'information' present in image 4) compared to image 2) the disruption in the color balance may be unsettling (or fascinating) to some dichromats.

Here is an Ishihara plate - a common aid for diagnosing color blindness. The number '45' in the center of the disk is invisible to someone with red/green color blindness.



There are several things to note about this example. First of all, although the enhancement of the red/green information in the Daltonized version is striking, this is not a good general test of an algorithm to modify images for color blind observers. The reason is that the Ishihara plates are (deliberately) artificial images, and do not represent the range of colors that people see in everyday

life. It would be rather easy to design an algorithm to 'improve' Ishihara plates (for example one that replaced all reds with blues) that would nevertheless destroy other types of information in the image. One nice feature of the Daltonization algorithm is that it analyses the information content of the image beforehand and attempts to preserve existing color variations.

Note also that the Daltonizing algorithm does not enable people to "pass" the Ishihara test in any way. It is a digital image processing technique that can make print or video display more salient to color blind people without distorting the color balance to an unacceptable degree.

And finally, here's the fruit market we showed you at the start:



The different piles of fruit on the floor are now clearly visible in image 4).

What is it good for? We envisage a number of applications for this algorithm. Here are some examples:

As part of a digital microscope (see the 'cells' axample above): Color blind users could flick a switch to improve the visibility of red/green fluorescent labels or intrinsic color contrast...

In digital video recorders and display systems: Viewers could turn on the Daltonize algorithm much as they might vary the brightness or volume using a remote control. Operating on a real-time video stream, the algorithm could improve the appearance of TV for color blind viewers (for example, making sports teams playing in red strip on a green field far more visible) without significantly disturbing the color balance for other members of the audience....

Computer display devices: Computer users could turn on the Daltonize algorithm from as part of their computer video card controls. All output appearing on the monitor (including web-pages, videos and still images) would automatically be processed and rendered more salient to dichromats.

Print media: Images can be Daltonized before printing. Print applications where legibility is essential (for example, public safety documents, maps, technical instructions) can all be made more legible for color-blind users....

That's great! I'd like to use this algorithm.

You can play with the algorithm online on this web page. Please be aware that this page is taking a lot of hits at the moment and may seem a little slow to respond. If you have any particularly interesting images that you would like us to process, send them to us by email at info@vischeck.com and we will run them 'by hand'. Please keep them to a reasonable size :)

We would also like to hear your feedback about this algorithm - especially if you are color blind. Let us know what you think!