

Perception of Contrast

Brightness: The *perceived* amount of light results in a nonlinear function.

Just Noticeable Difference



144, 144, 144



132, 132, 132

12 units different

Just Noticeable Difference



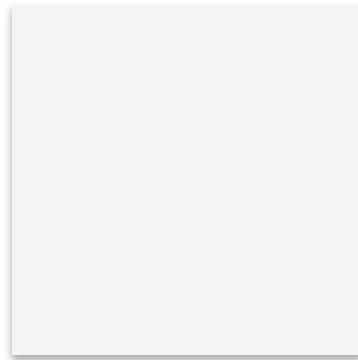
144, 144, 144



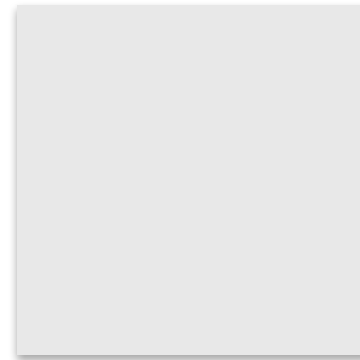
128, 128, 128

16 units different

Just Noticeable Difference



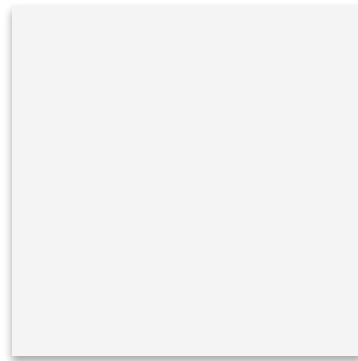
244, 244, 244



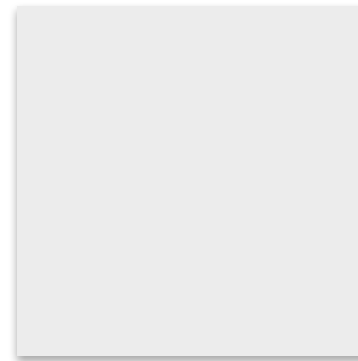
232, 232, 232

12 units different

Just Noticeable Difference



244, 244, 244



236, 236, 236

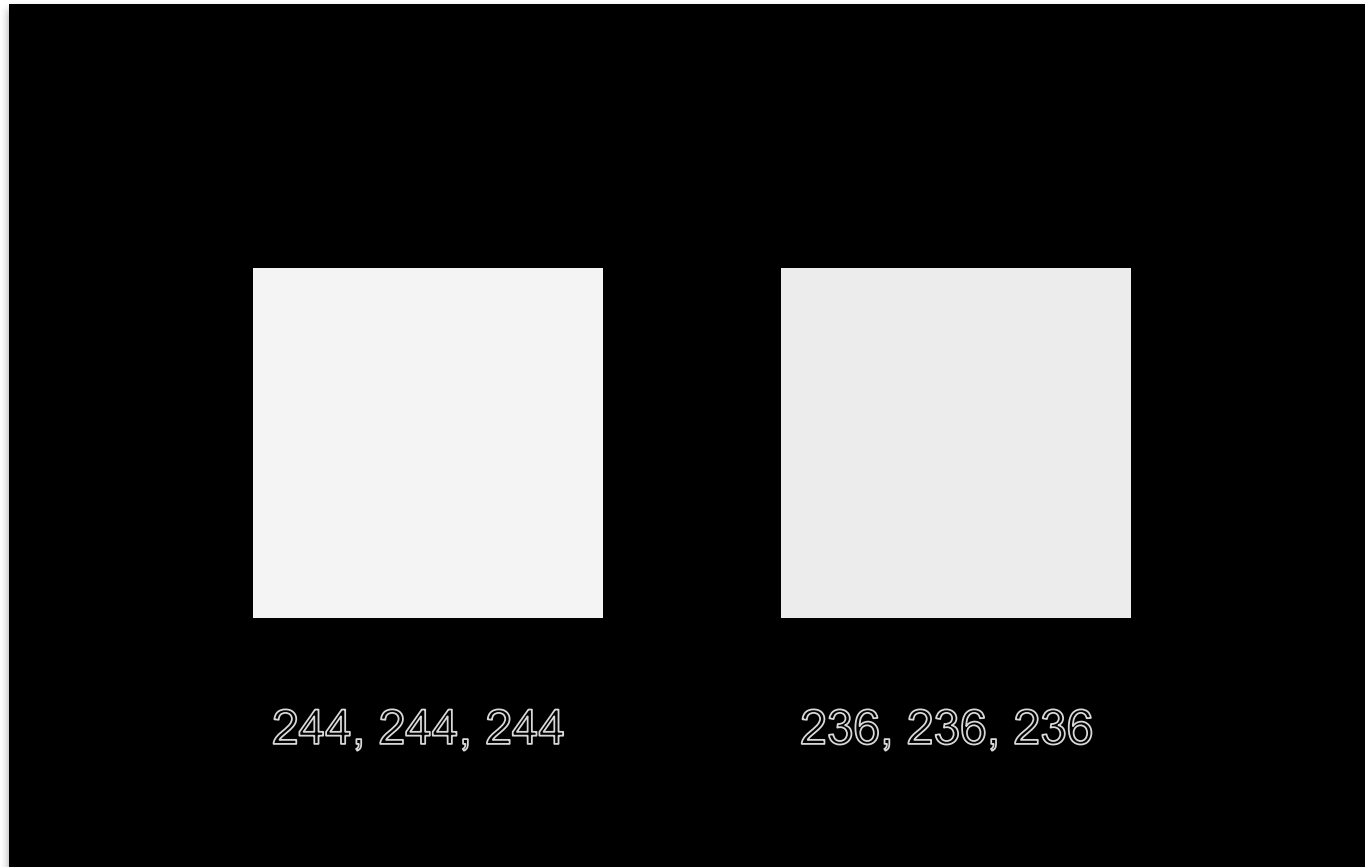
8 units different

Weber's Law

$$\Delta S/S = k$$

Ratio of change in stimulus to
magnitude of stimulus is roughly
constant

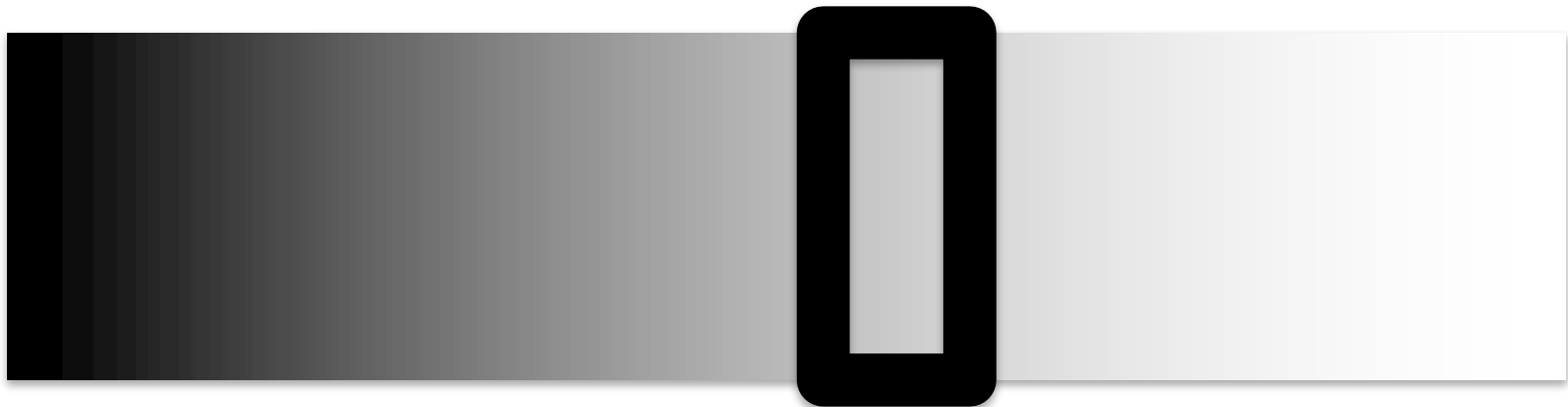
Just Noticeable Difference



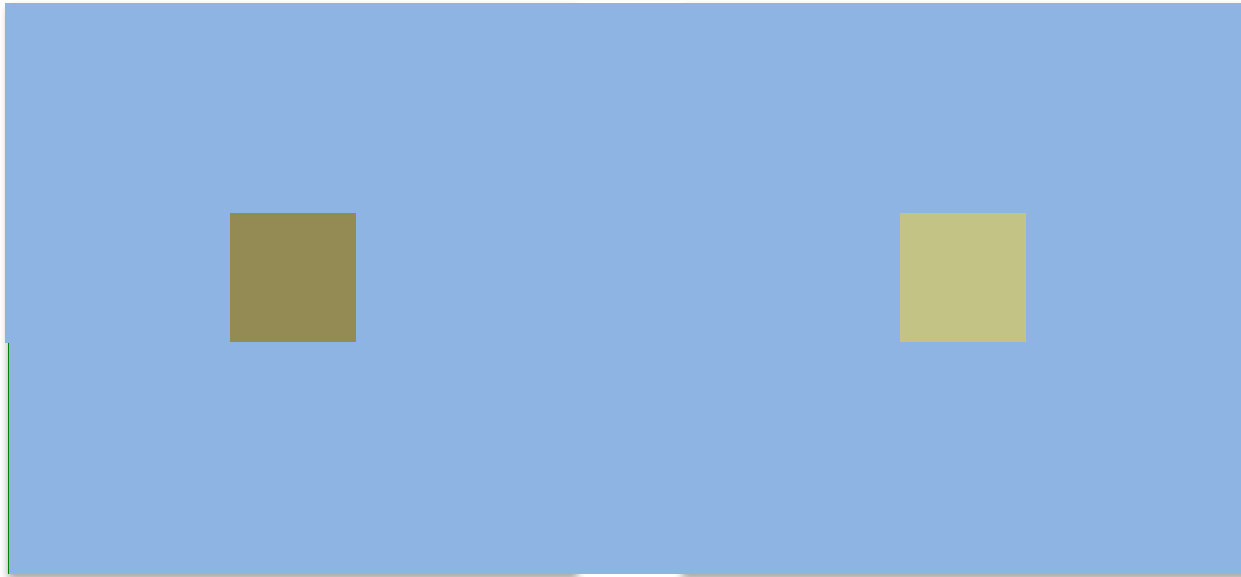
8 units different

Continuous Variation

Most continuous variations are perceived as discrete steps



Color Contrast

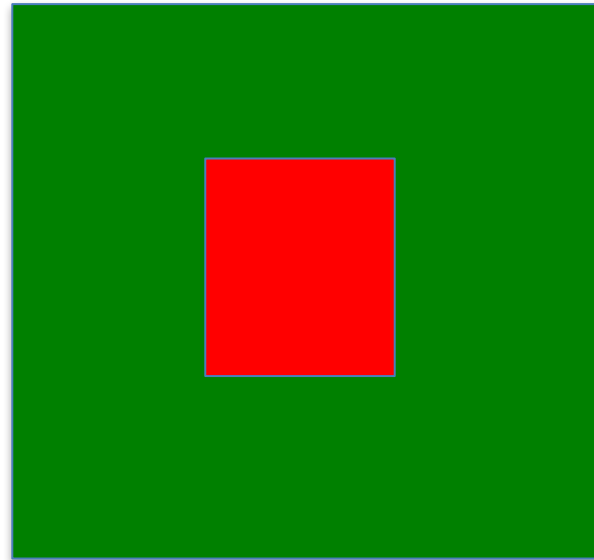
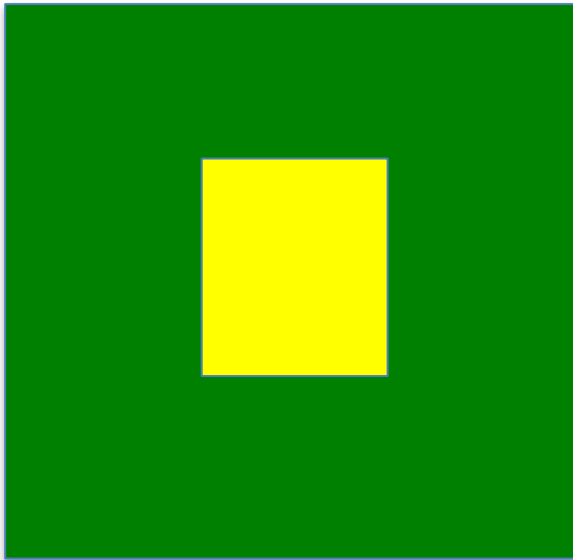


After Josef Albers

Complementary Colors



Complements vibrate



Color Differentiation

Rapidly identify data elements using **color**

Color Differentiation

Color distance: the Euclidian distance between colors in the model

Linear separation: ability to separate targets from nontargets when one can or cannot draw a straight line between the target and nontargets

Color category: named color regions occupied by both target and nontarget elements

Distinct Nameable Colors

Color Name Distance									Saliency	Name
0.00	1.00	1.00	1.00	0.93	1.00	0.95	1.00	1.00	.69	red 79.0%
1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	.44	blue 62.9%
1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	.60	green 75.4%
1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.95	0.98	.61	purple 71.1%
0.93	1.00	1.00	1.00	0.00	1.00	0.91	1.00	1.00	.89	orange 93.3%
1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	.81	yellow 89.0%
0.95	1.00	1.00	1.00	0.91	1.00	0.00	1.00	0.99	.41	brown 55.6%
1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.00	1.00	.64	pink 77.2%
1.00	0.99	1.00	0.98	1.00	1.00	0.99	1.00	0.00	.68	grey 80.6%
ColorBrewer-Q9									Average	0.99
										.64

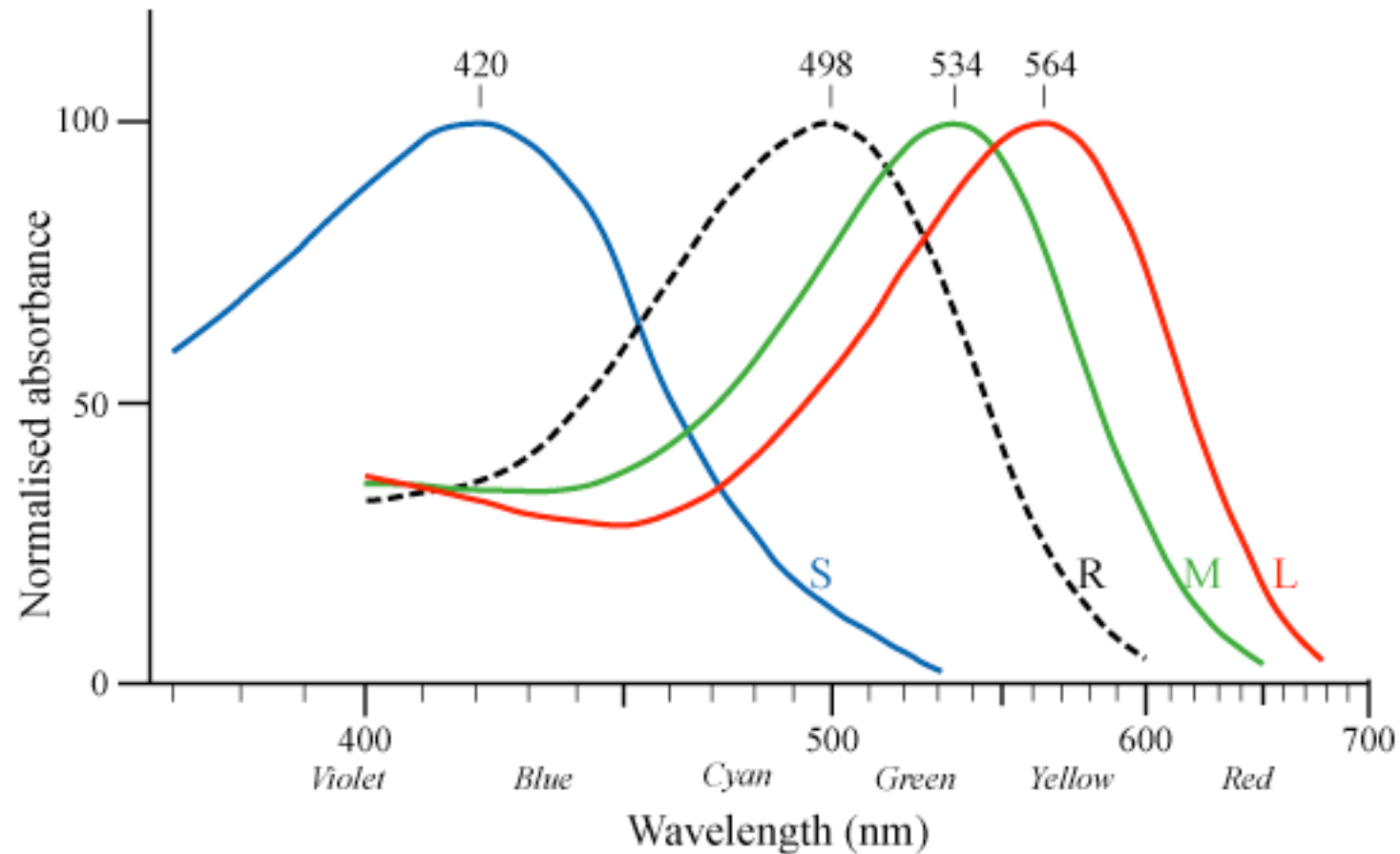
Source: <http://vis.stanford.edu/color-names/analyzer/>

Saturation and Size



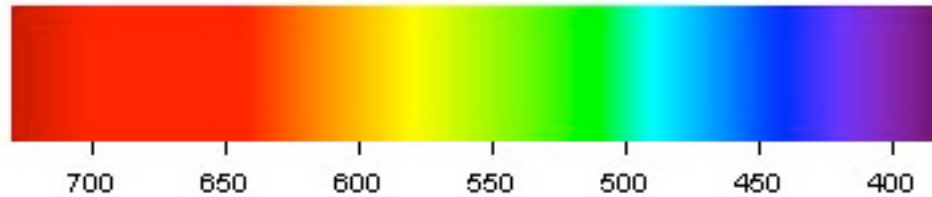
Source: Ware, C. *Information visualization, perception for design*, 2013

Color Blindness: Cones

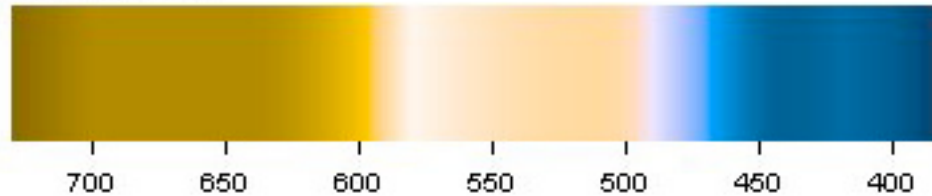


Color Blindness: Types

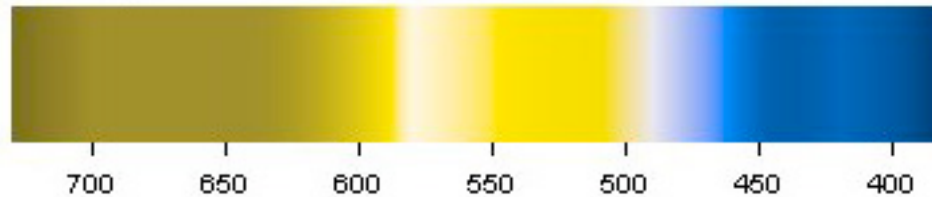
Normal



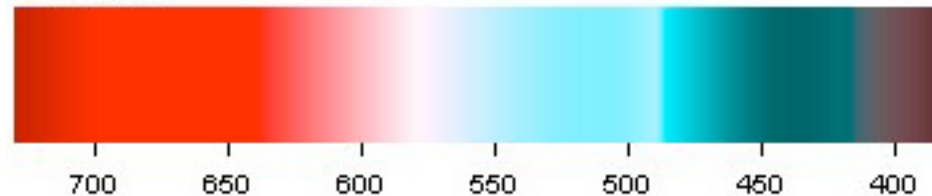
Deuteranopia



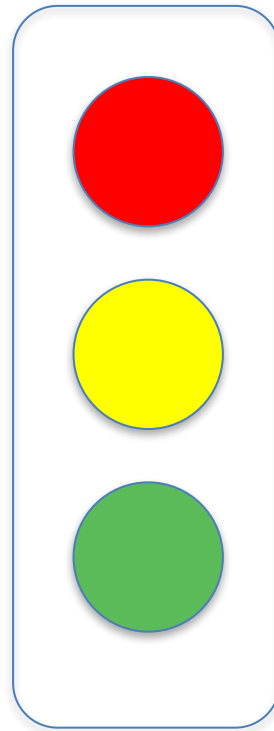
Protanopia



Tritanopia

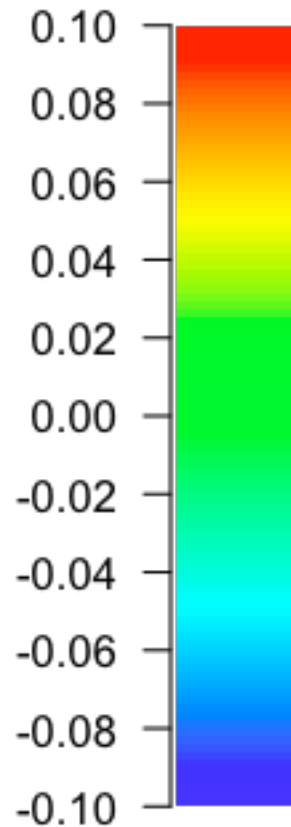


"Traffic Light" Indicators

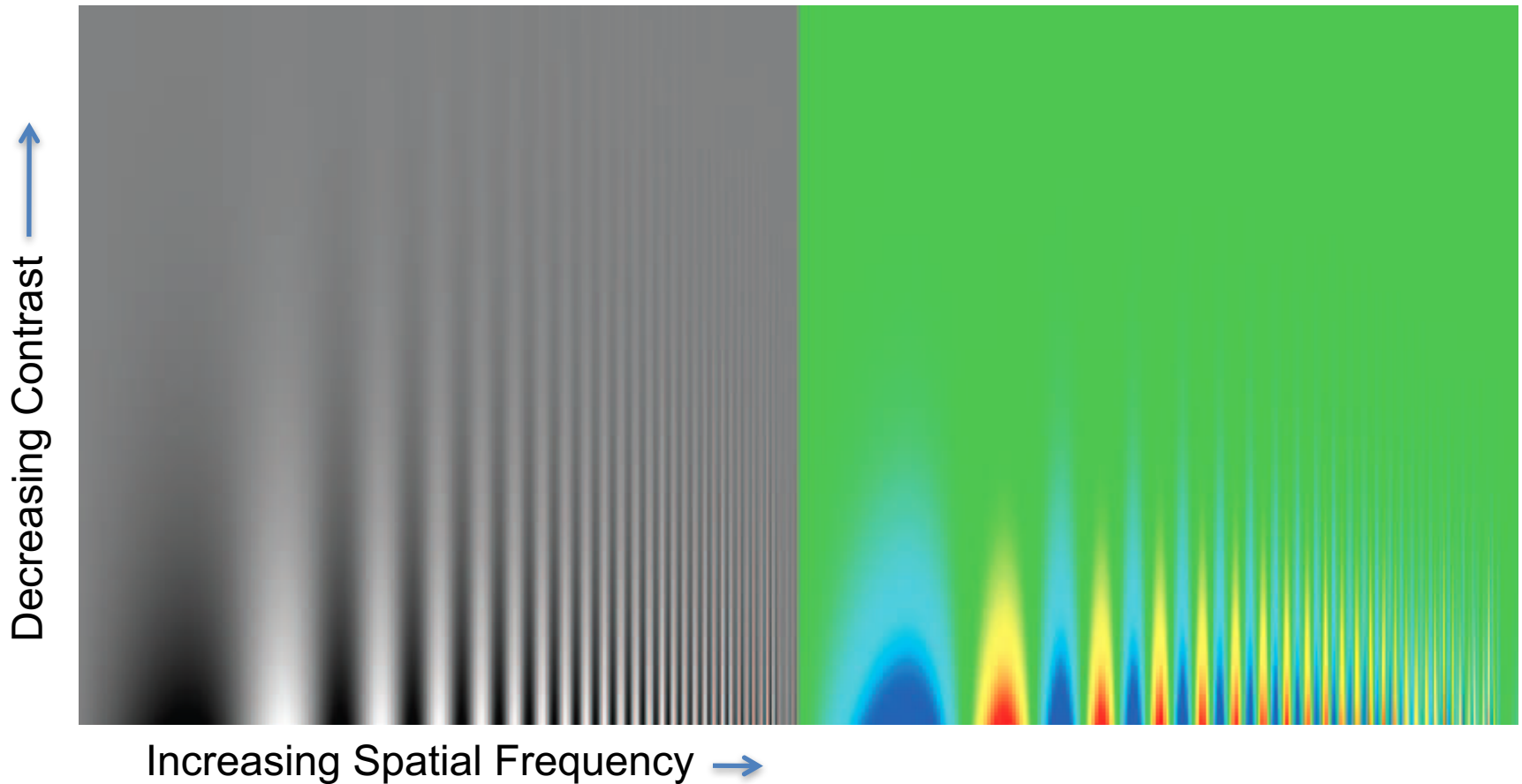


Color Scales

Typical Rainbow Color Scale



Contrast Sensitivity Function

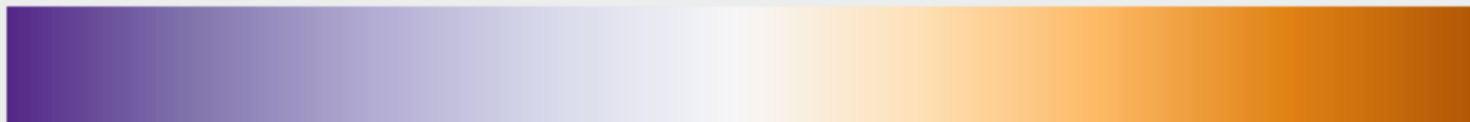


Alternatives



David Green's Cubehelix

`d3.cubehelix()`



divergent scales

Design Tips

- First ask: Is color necessary?
- Use colors that are separable and nameable when possible
- Scale appropriately
- Beware of poor contrast effects
- Design for color blindness

Berkeley SCHOOL OF
INFORMATION