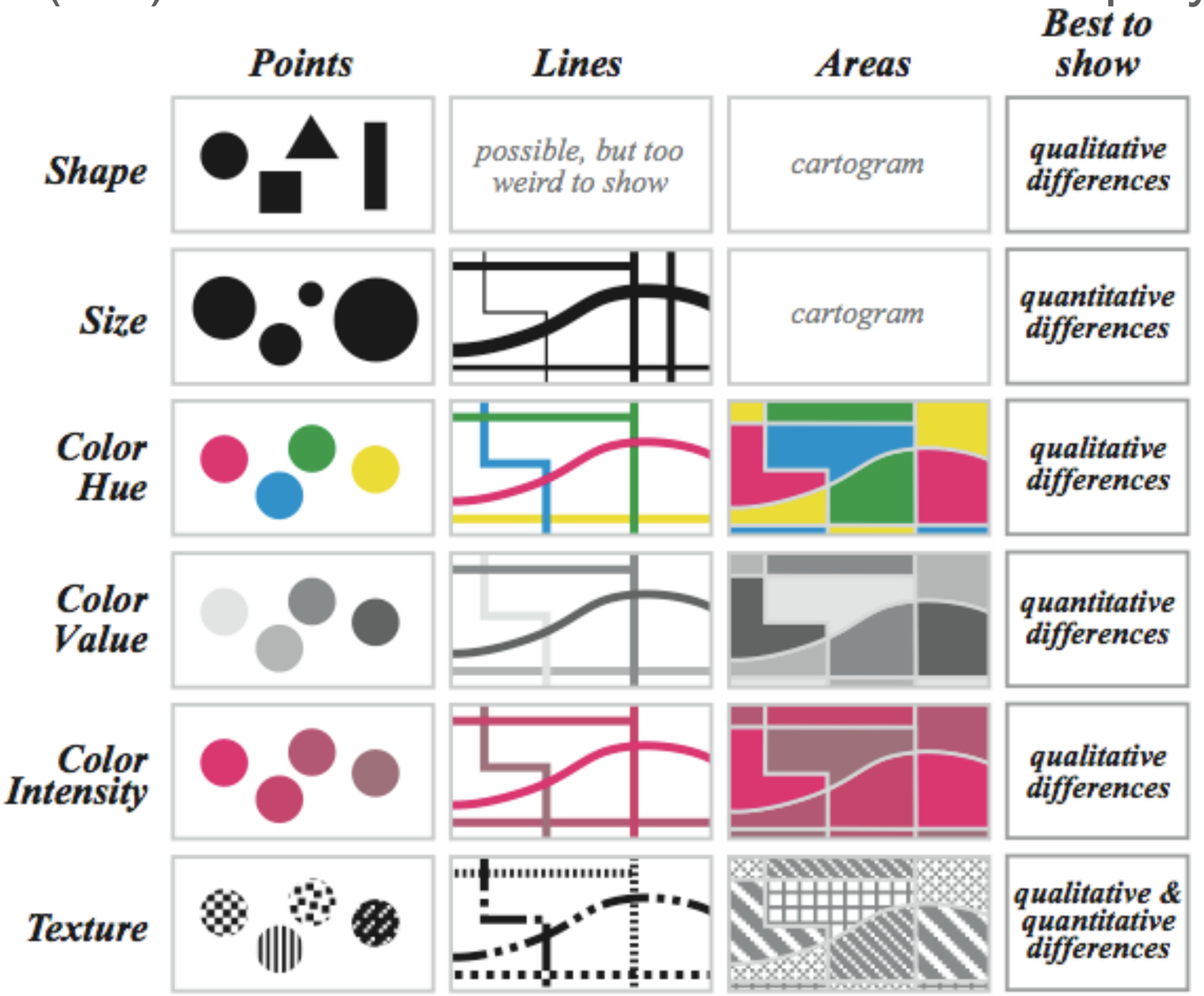
color

Portions of this slide deck adapted from Jordan Crouser of Smith College, which in turn was adapted from
K. Herbert at U. Brussels and the “Visualization Principles” Tutorial by J. Kennedy, C. Nielson, & M. Krzywinski VIZBI 2012

“Color used poorly is worse than no color at all”
- Edward Tufte

Some (all?) of the visual attributes we have to play with

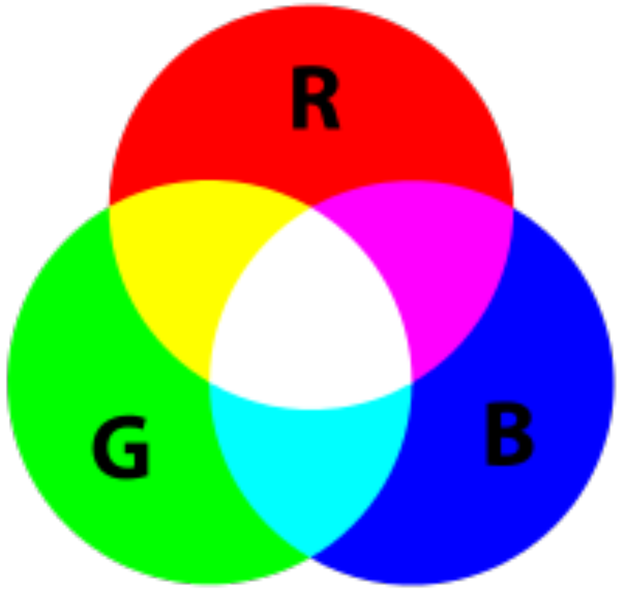


Jacques Bertin, *Semiology of Graphics*. 1967

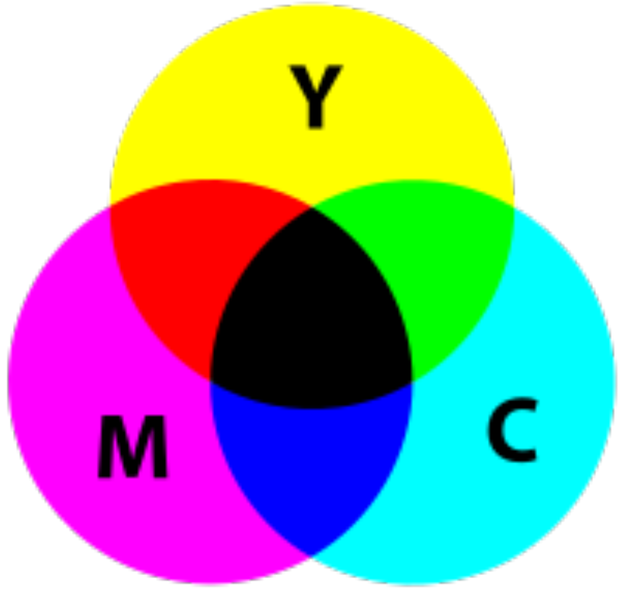
via Jordan Crouser https://ed.ted.com/lessons/how-do-we-see-color-colm-kelleher#watch

Color spaces

- A color space is mathematical model for describing color. Some common spaces include RGB, HSB, HSL, CMYK
- RGB (red, green, blue) is the most commonly used



RGB is additive, based on light



CMYK is subtractive, based on ink

https://en.wikipedia.org/wiki/Color_space

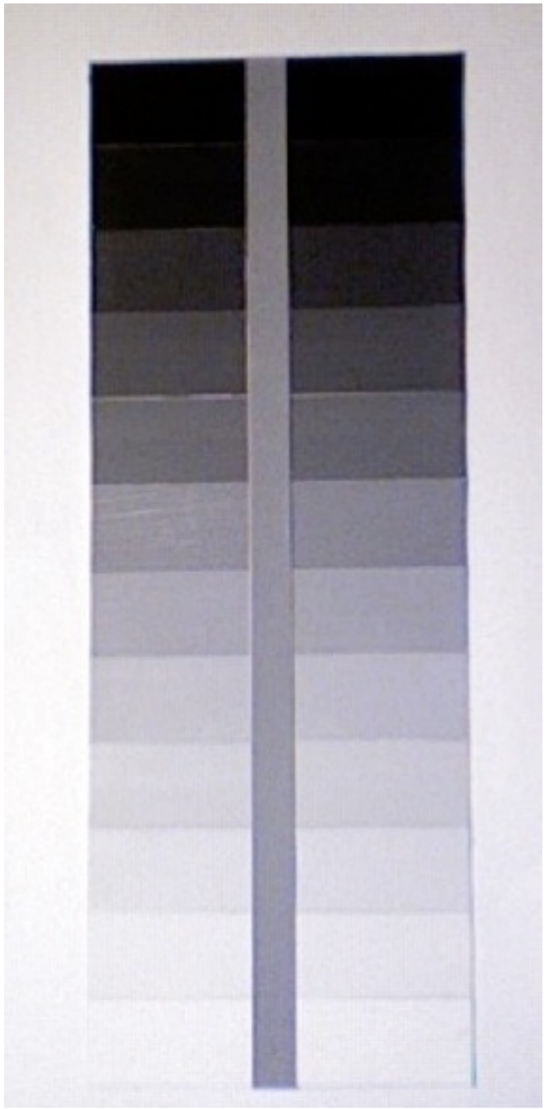
Hue

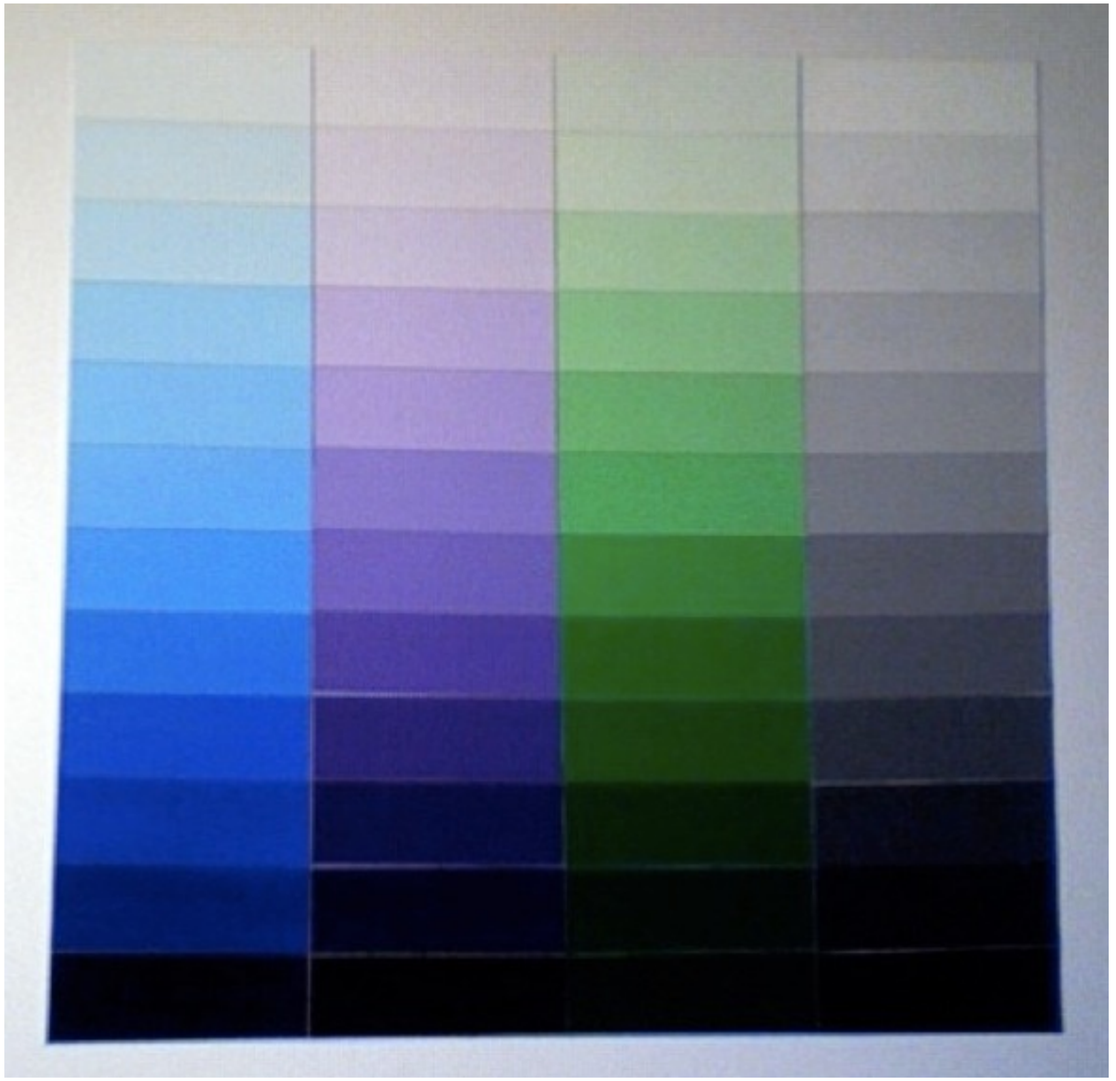
https://en.wikipedia.org/wiki/Hue

Saturation

https://en.wikipedia.org/wiki/Colorfulness#Saturation

Saturation





Work by Amelia McNamara in Dennis Puhalla's University of Cincinnati course, Color Foundation.

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COLOR

Foundation Studio: Color©
Autumn 2006

Techniques: Painting

1 Allow yourself an appropriate amount of time for a work session. Expect to spend 2 – 4 hours for each segment of the project: painting, matching, assembling

2 Materials:
- black and white opaque matte acrylic paint
- paint brushes
- bristol paper
- mixing cups, large water cans
- paper towels
- scissors
- 18 inch metal ruler

3 Draw a grid of lines over several sheets of Bristol paper to make a series of rectangles that are approximately 3 x 5.

4 Squeeze approximately 10% tube of white into mixing cup, add water slowly stirring with the wide 1 inch brush until paint takes on the consistency of melted ice cream /egg nog.

5 Squeeze black into another mixing cup about 5% of the tube. Add water drop by drop, stirring with smaller brush until paint is thinner than the white, but not transparent. Do not add to much water.

6 Using large brush paint 1st white chip using horizontal motion be aware of the following surface qualities:
- paint too thick if – dry brush at edge, ridges in paint, texture in surface, cracks in paint
- paint too thin if – paint puddles, looks transparent, dries mottled in color, paper shows through paint

7 Using small brush, attempt to drop one-half (tiny) drop of the black into the white bowl. Using the large brush stir thoroughly until all marble-like veins disappear, resulting color should still look white, should not look gray. Paint a chip of this color next to the first one.

8 Repeat this step over and over, each time painting another chip which appears just slightly darker than the previous one.

9 When color becomes "middle gray" and it is taking more and more black each time to make the color change it is time reverse the process. If you begin to run out of paint there will be a tendency to want to add more water to extend the paint further. Too much water will thin the paint, make it more transparent, and actually result in a different type of gray once it is dry. Try to resist this temptation.

10 Clean brushes thoroughly before reversing the process.

11 Begin next process by painting a totally black chip and then slowly adding white drops to make gradually lighter and lighter chips until you have chips lighter than the ones you ended with in the first process. Black paint should be thicker than it was in the first process. White paint should maintain same consistency.

Most problems which occur later with color matching can be attributed to the lack of mixing enough values in the 5 – 6 – 7 value range.

Protect surface of dry units – as they have a fragile surface. Don't lay anything on top of them or they will scratch or stain very easily. Water drops etc.

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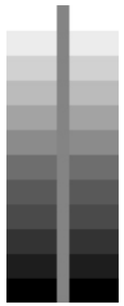
Value Study in White, Gray, and Black (Achromatic)



assignment Begin this study by making a gray scale from white to black in 12 even progressions/steps. The transition from white to black should be as even a transition contrast as possible.

specifications
- size: 4 1/2" x 12": individual swatches are to be 4 1/2" x 1"
- study is to be mounted, centered on white board 7 1/2" x 15"
- after mounting this study select a middle gray from your study and mount a strip 1/2" wide down the middle of the entire scale

Materials:
- black and white matte acrylic paint
- Strathmore 300 Vellum
- White Matte Board

objectives
- to understand the first dimension of color that is value –
- value is defined as the relative lightness or darkness of a color
- development of sensitivity to subtlety in value contrast
- development of craft skills and knowledge of materials
- mix and select colors according to how they are to be perceived
- awareness of visual sensations of color interaction and hard and soft edge contrast

evaluation criteria
- paint is well mixed and each unit is a consistent color
- paint is consistent
- units are cut cleanly and at right angles
- white border is clean
- gray strip is straight, and no glue or mac-tac is showing
- good overall precision in measurement and gluing
- value change is consistent from chip to chip
- no edge stands out as different in light /dark contrast
- entire transition is constant
- middle gray strip is an approximate middle value

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Techniques: Comparing Values for the Gray Scale

12 Number each unit sequentially from white to black, beginning with the first white unit as 1.

13 Cut units apart with scissors, keeping them in order. Cut off the top of each unit just enough to remove white area

14 Lay units out in sequence with small amount of each unit showing

15 Make a selection of 12 units (including B/W) which depict a smooth transition in 11 steps between black and white.

16 Evaluate "edge-hardness" on the edge between each of the units, change some of your selections to new units in order to make the transition more consistent between each step between black and white This will take some time and should not be rushed because it is the most important part of the assignment.

17 After the 12 units are selected, paint several strips approximately 1" x 13" which are "middle gray". That is, visually half way between black and white, or the same value as #6, #7, or half way between the two. Putting the project together – Materials required:
- metal ruler
- X-Acto knife, extra pack #11 blades
- white matt
- surface to cut on
- mac tack/studio tack/PMA
- tracing paper
- 1/4" or 1/8" grid paper

18 Using adhesive, glue the final 12 units onto grid paper.

19 Cut white matte board to mount project 7 $^{1}/_{2}$" x 15"

20 Lightly draw a rectangle centered on the board 4 $^{1}/_{2}$" x 12"

21 Using metal ruler cut the top edge off of each unit along grid lines. Then measure down one inch and cut bottom edge of each unit.
- measure lines carefully
- make sure to make a vertical cut with knife blade
- conserve as much of each large unit as possible for future use

back of matte board

22 Glue the units together on another piece of grid paper
- butt the edges of the units together and glue down, making sure no white edges show
- L and R sides will still look irregular

23 Cut each vertical edge of the scale separately

24 Select one of the long "middle gray" strips which is the same as #6 in value, glue to grid paper and trim to 1/2" wide.

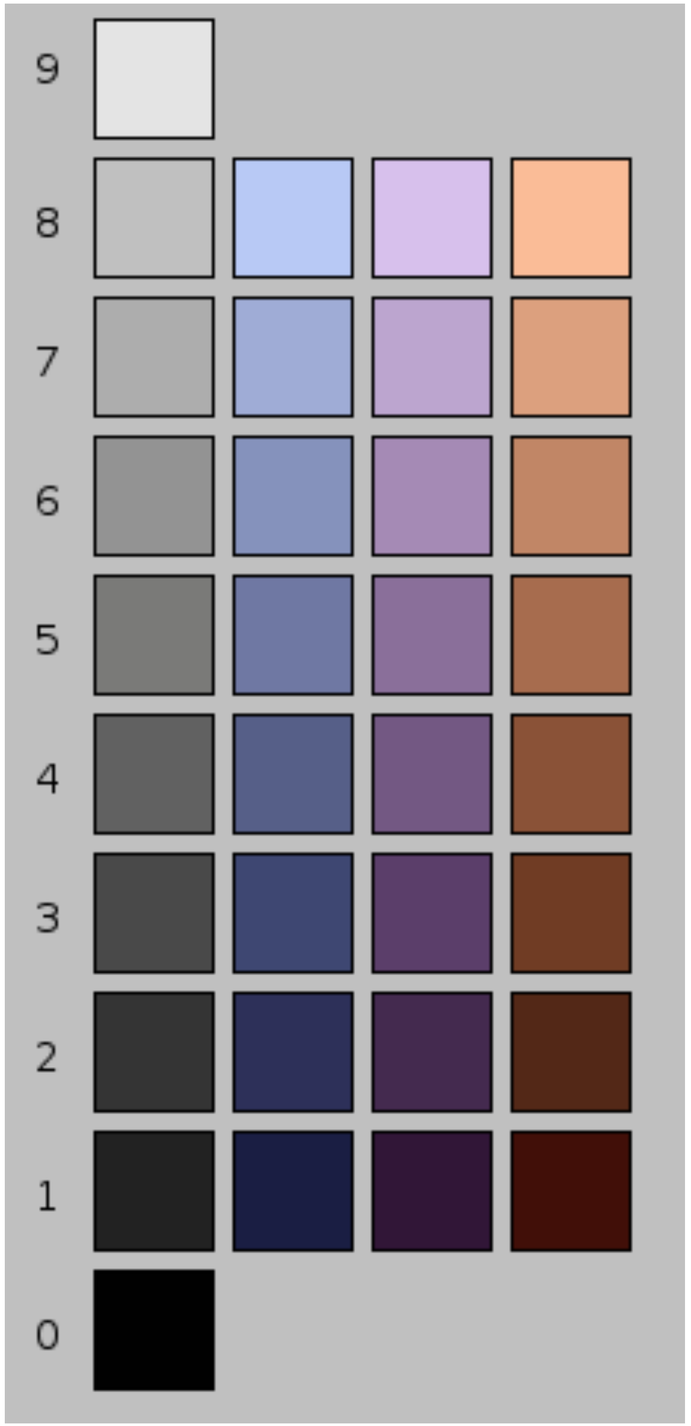
25 Carefully glue it to the center of the gray scale and trim overlap from top and bottom

26 Make a tracing paper cover which folds over from the back *(see illustration)*
- let the bottom of the cover lift freely, do not tape it down

27 Put your name on back of project with marker, and in the lower left hand corner in pencil.

Color study instructions, Dennis Puhalla

Lightness



https://en.wikipedia.org/wiki/Lightness

Examples

	$H = 180°$ (Cyan)					$H = 0°$ (Red)			
L \ S	1	¾	½	¼	0	¼	½	¾	1
1									
⅞									
¾									
⅝									
½									
⅜									
¼									
⅛									
0									

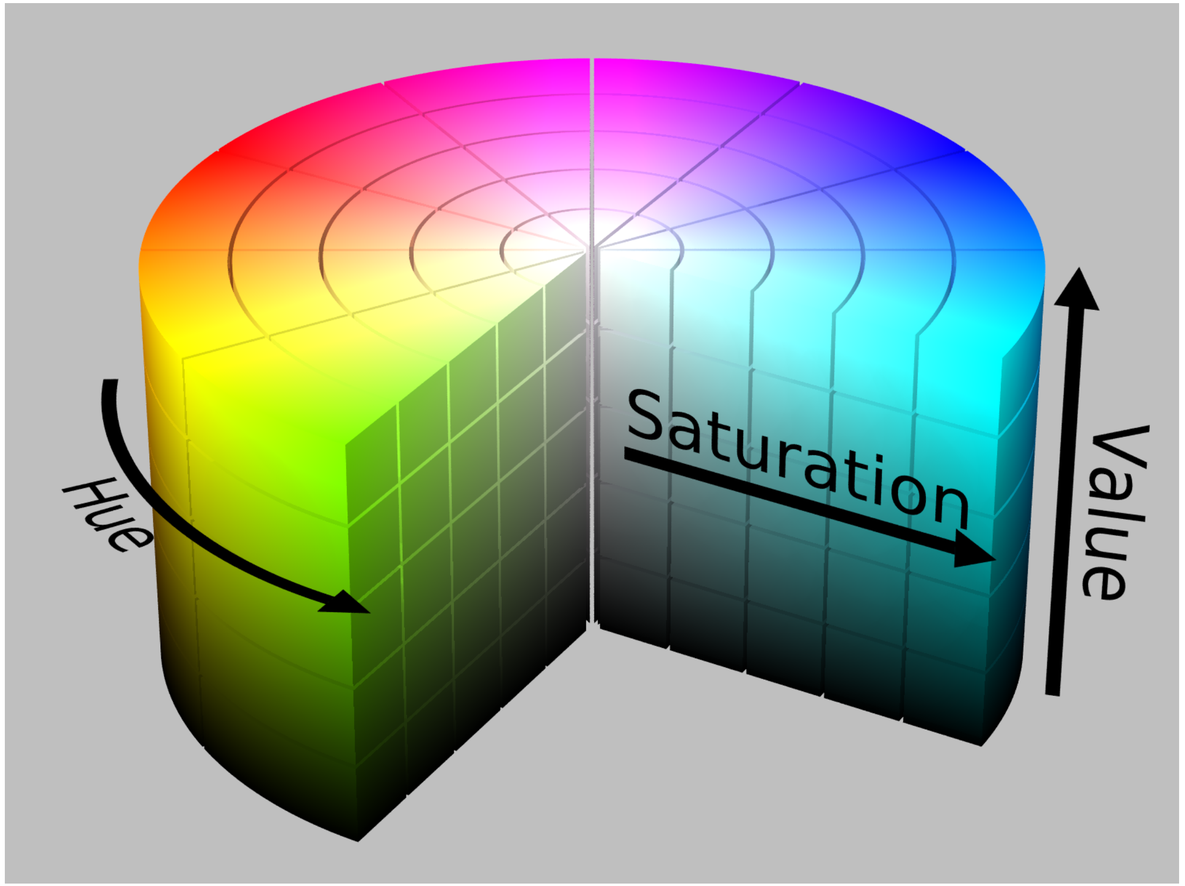
Hue, Saturation, Lightness

	$H = 180°$ (Cyan)					$H = 0°$ (Red)			
V \ S	1	¾	½	¼	0	¼	½	¾	1
1									
⅞									
¾									
⅝									
½									
⅜									
¼									
⅛									
0									

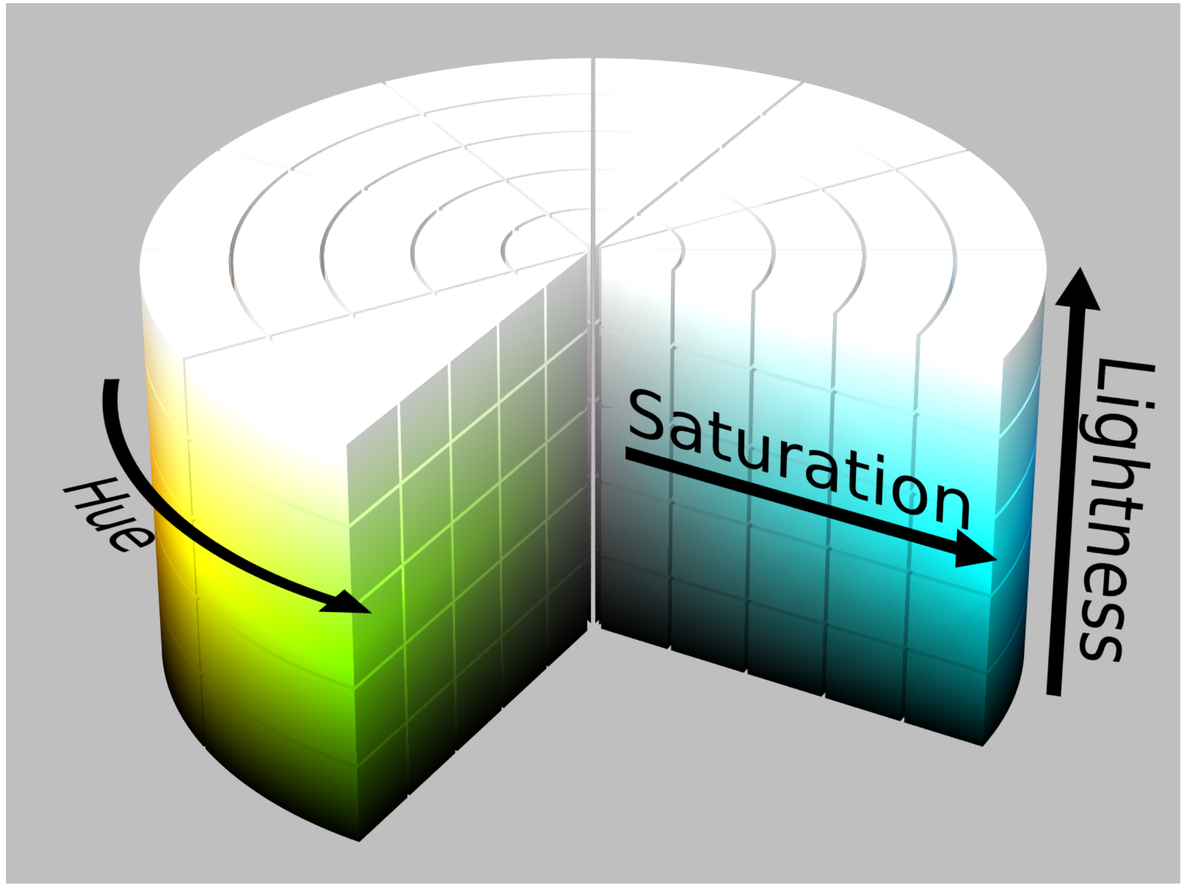
Hue, Saturation, Value

https://en.wikipedia.org/wiki/HSL_and_HSV

Cones



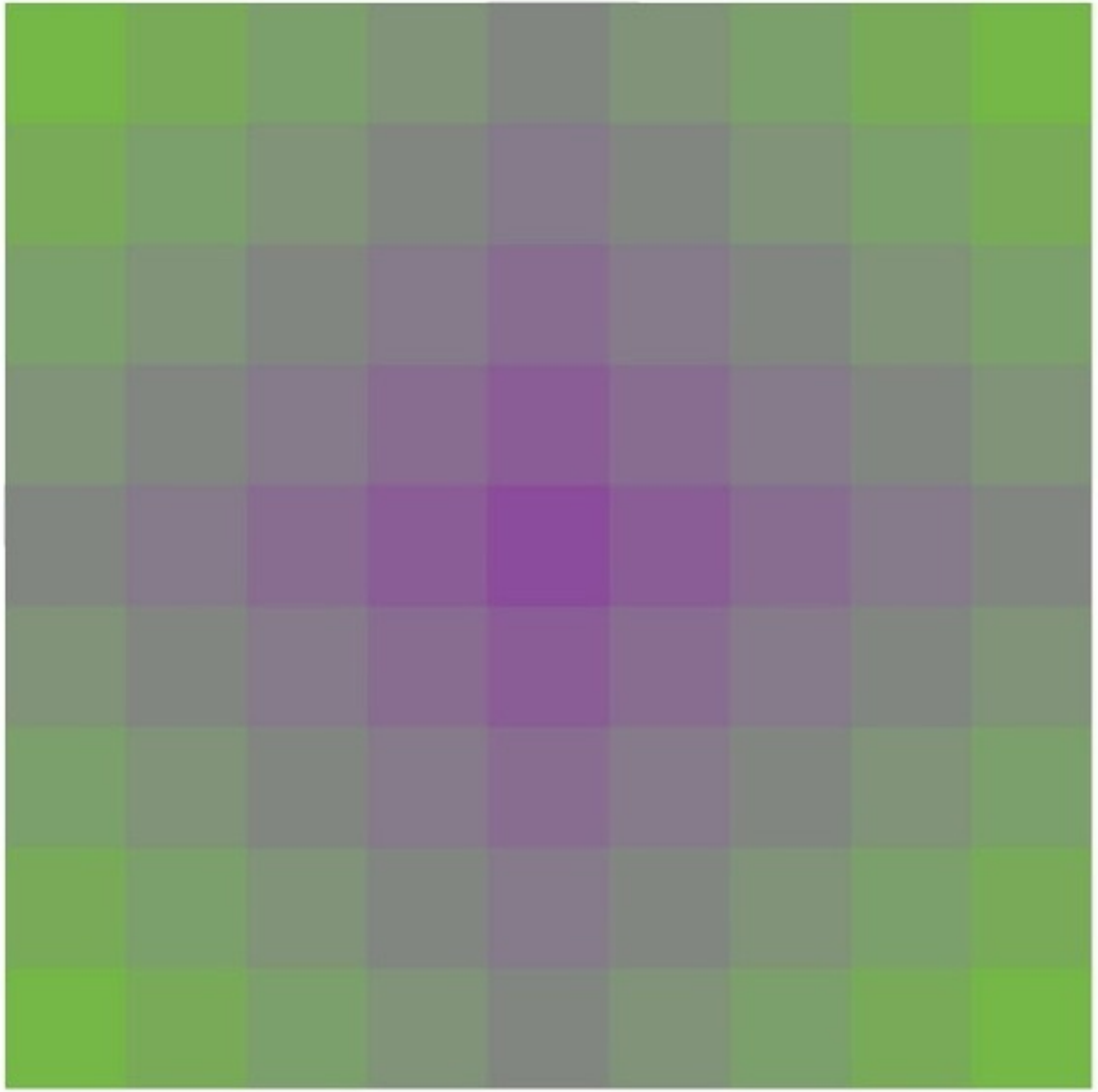
HSV cone



HSL cone

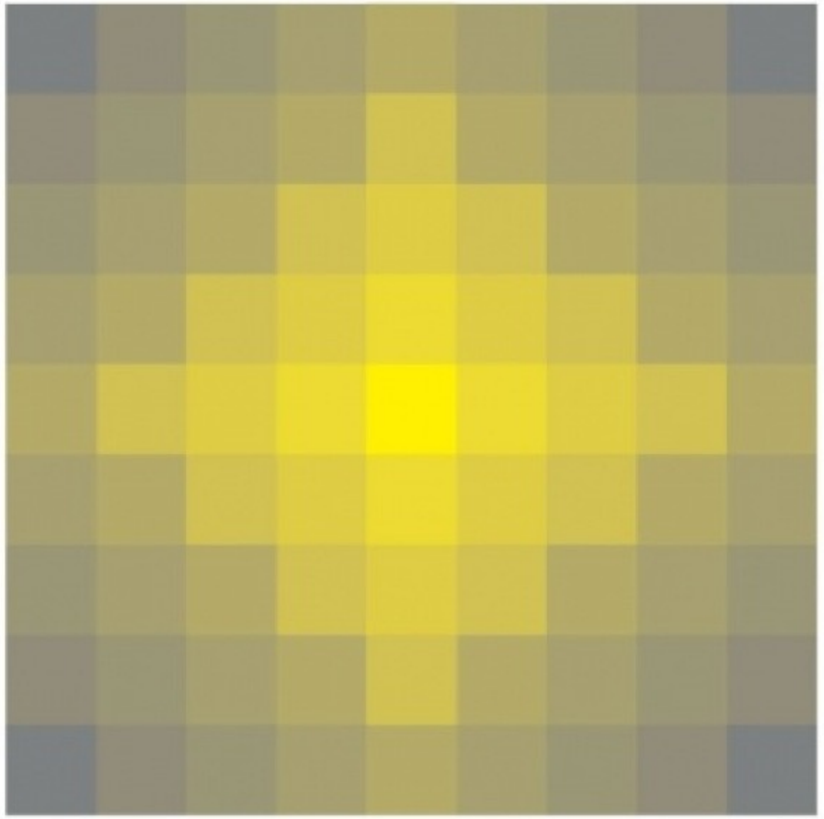
https://en.wikipedia.org/wiki/HSL_and_HSV

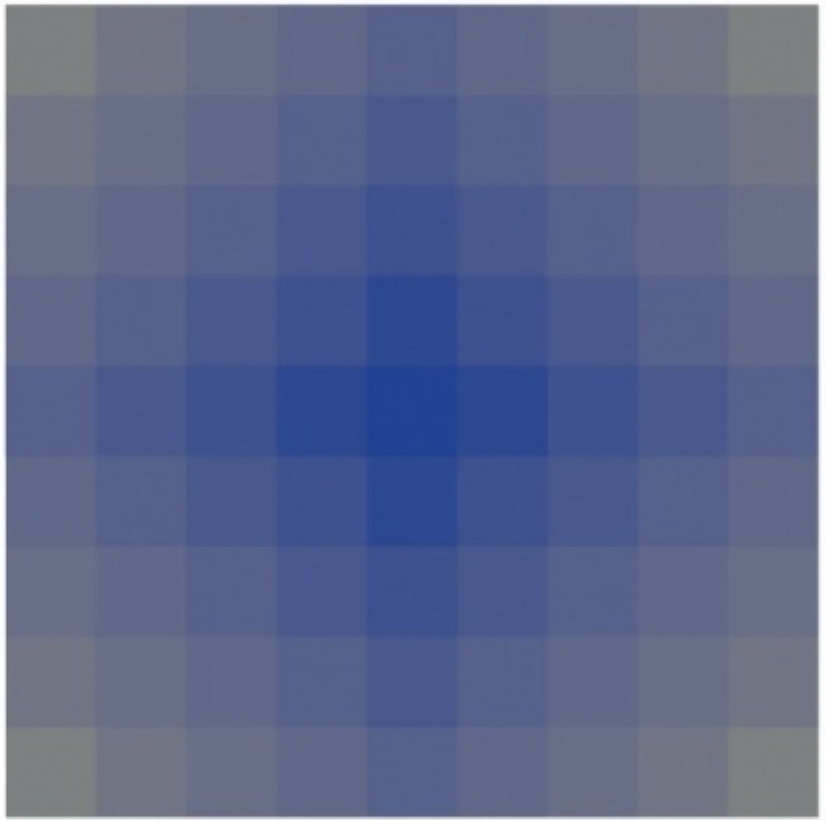
Chromatic saturation study

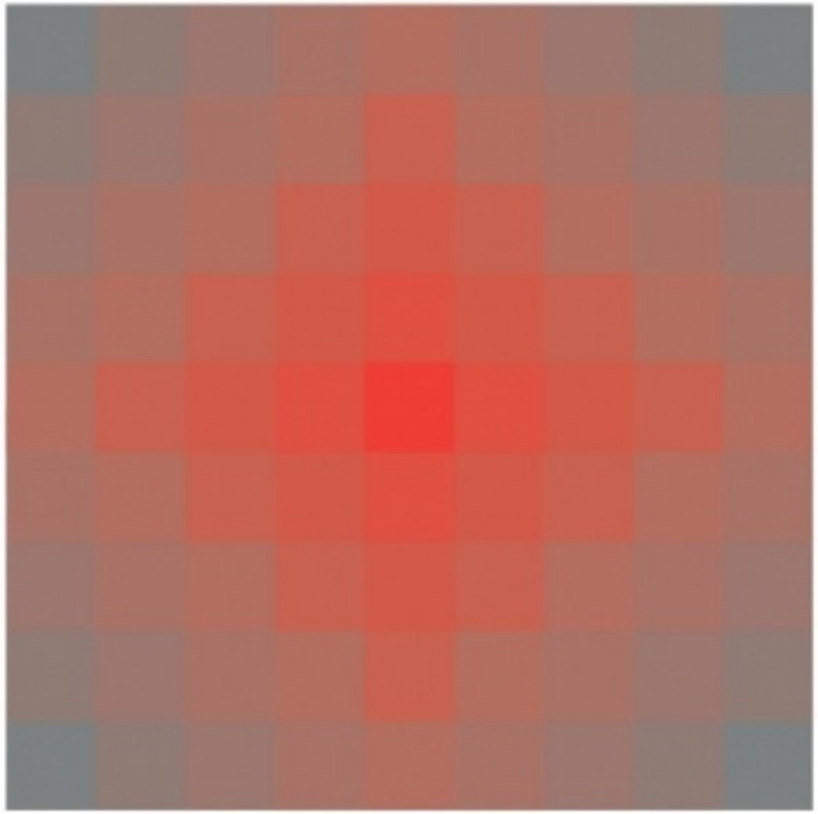


Work by Amelia McNamara in Dennis Puhalla's University of Cincinnati course, Color Foundation.

Achromatic saturation studies







Work by Amelia McNamara in Dennis Puhalla’s University of Cincinnati course, Color Foundation.

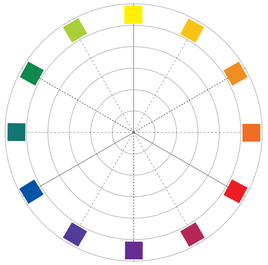
Color palettes

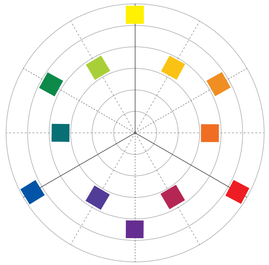
Dennis M. Puhalla PhD
Professor of Design

Color Organization Principles ©

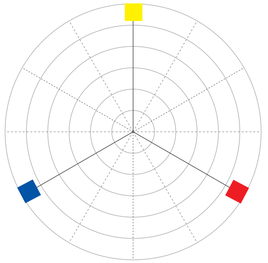
Color Harmony Structures ©

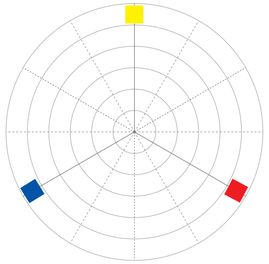
12 Step Color Wheel Hue Sequence



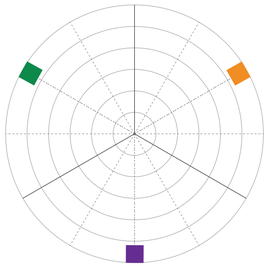


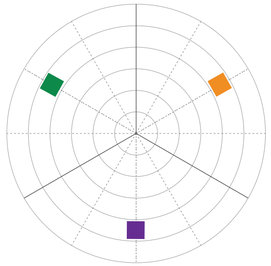
12 hues single layer
primary/secondary/tertiary layers



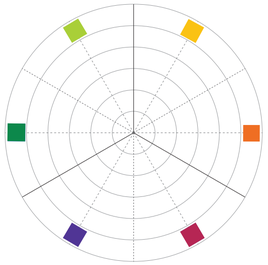


primary hues single layer
primary hues layer 1



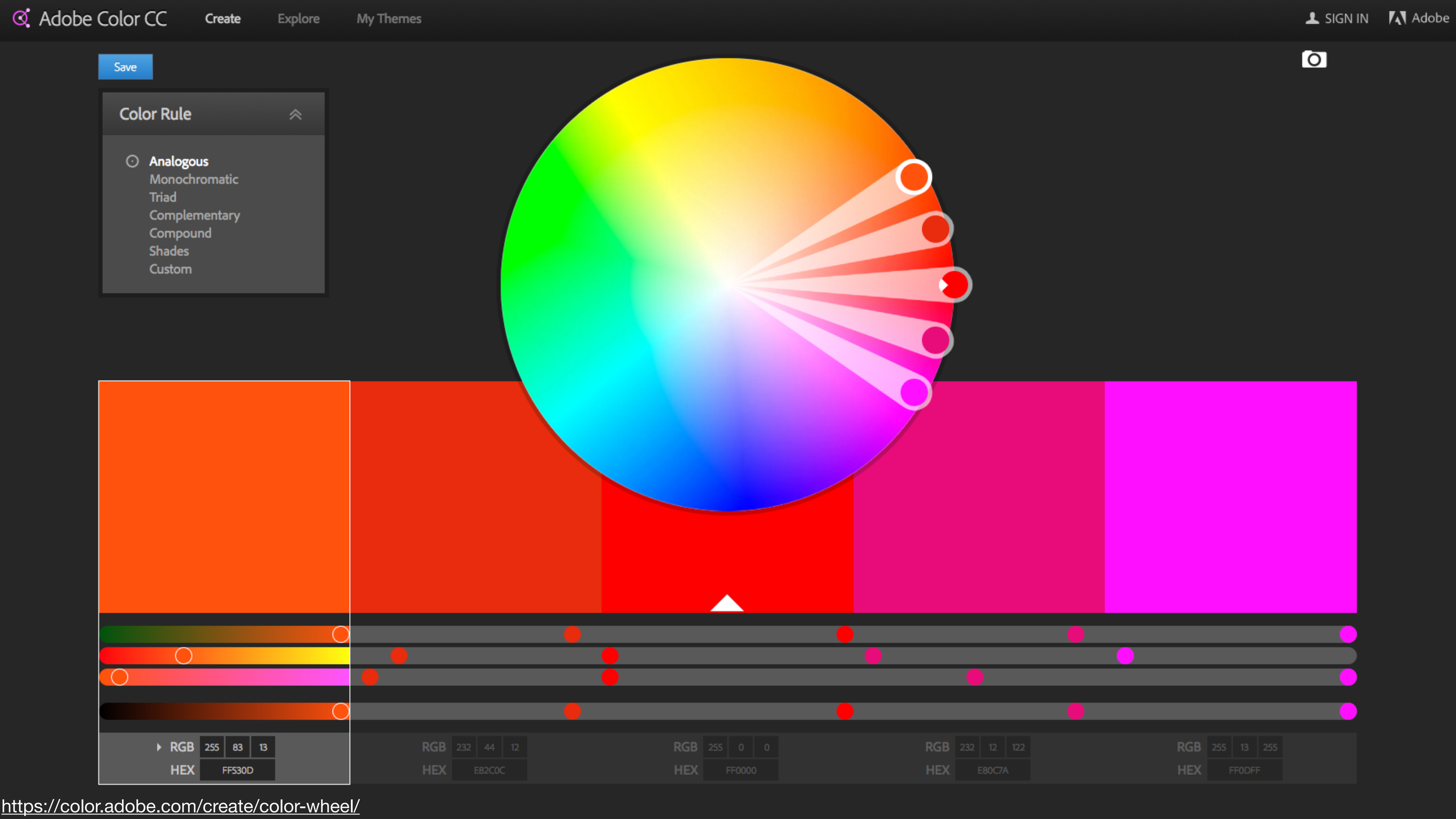


secondary hues single layer
secondary hues layer 2

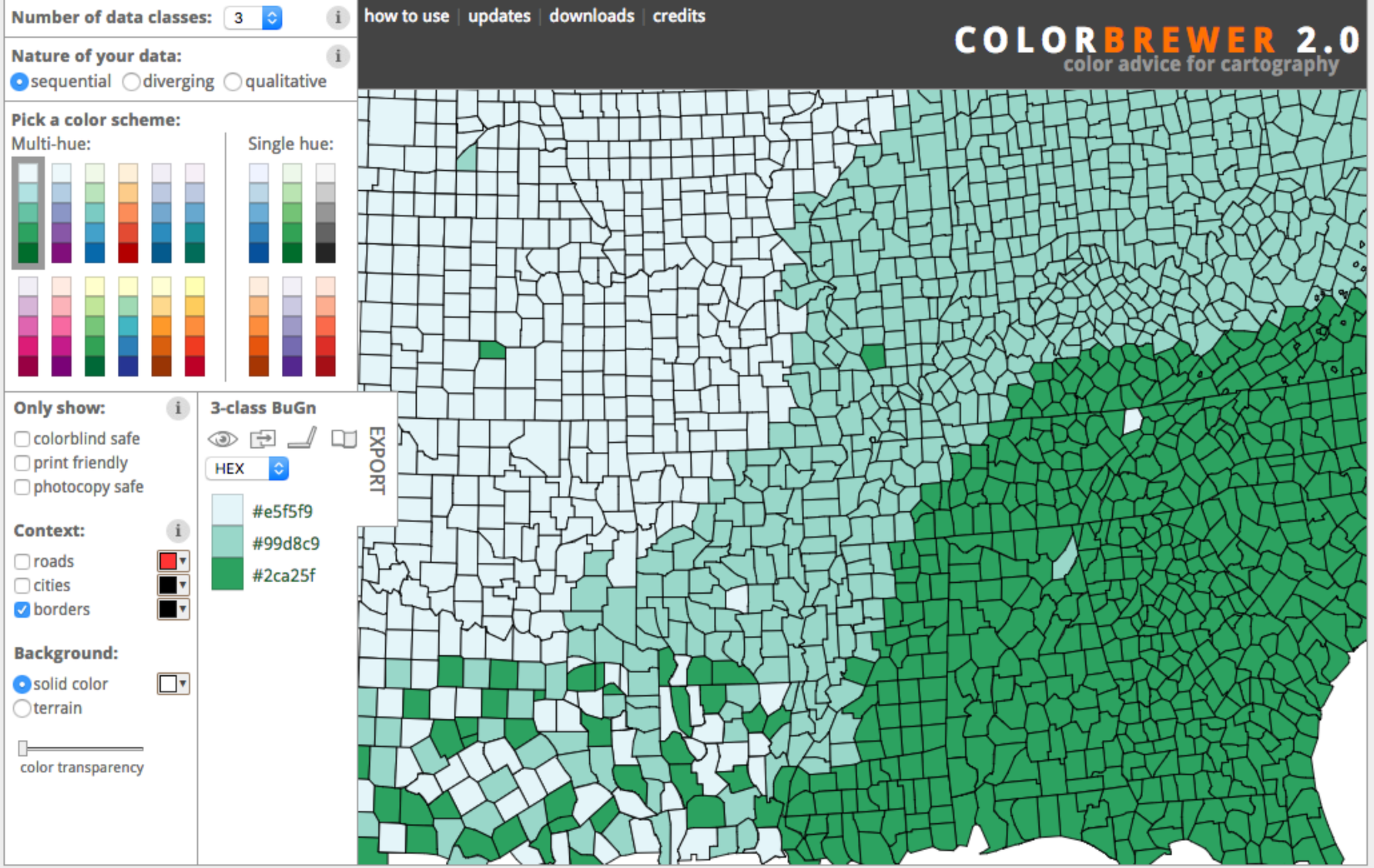


tertiary hues single layer
tertiary hues layer 3

Color organization principles, Dennis Puhalla



https://color.adobe.com/create/color-wheel/



Source code and feedback

Back to Flash version

Back to ColorBrewer 1.0

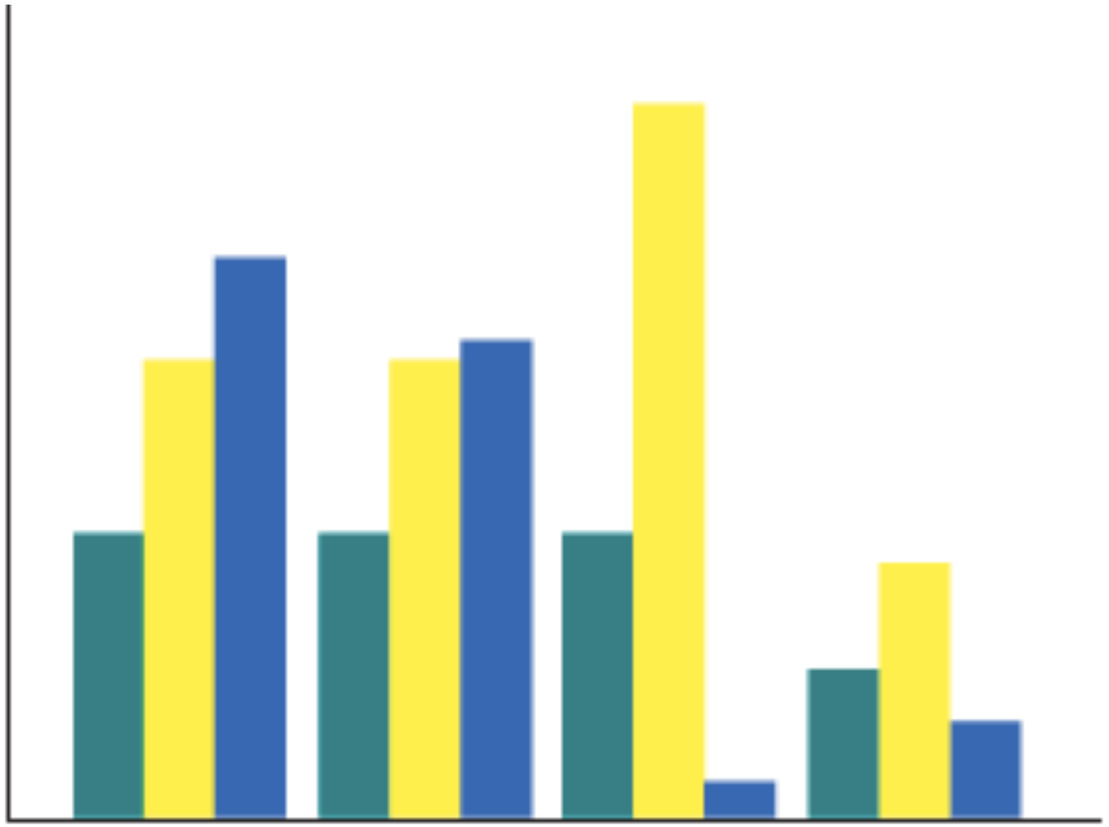
axismaps

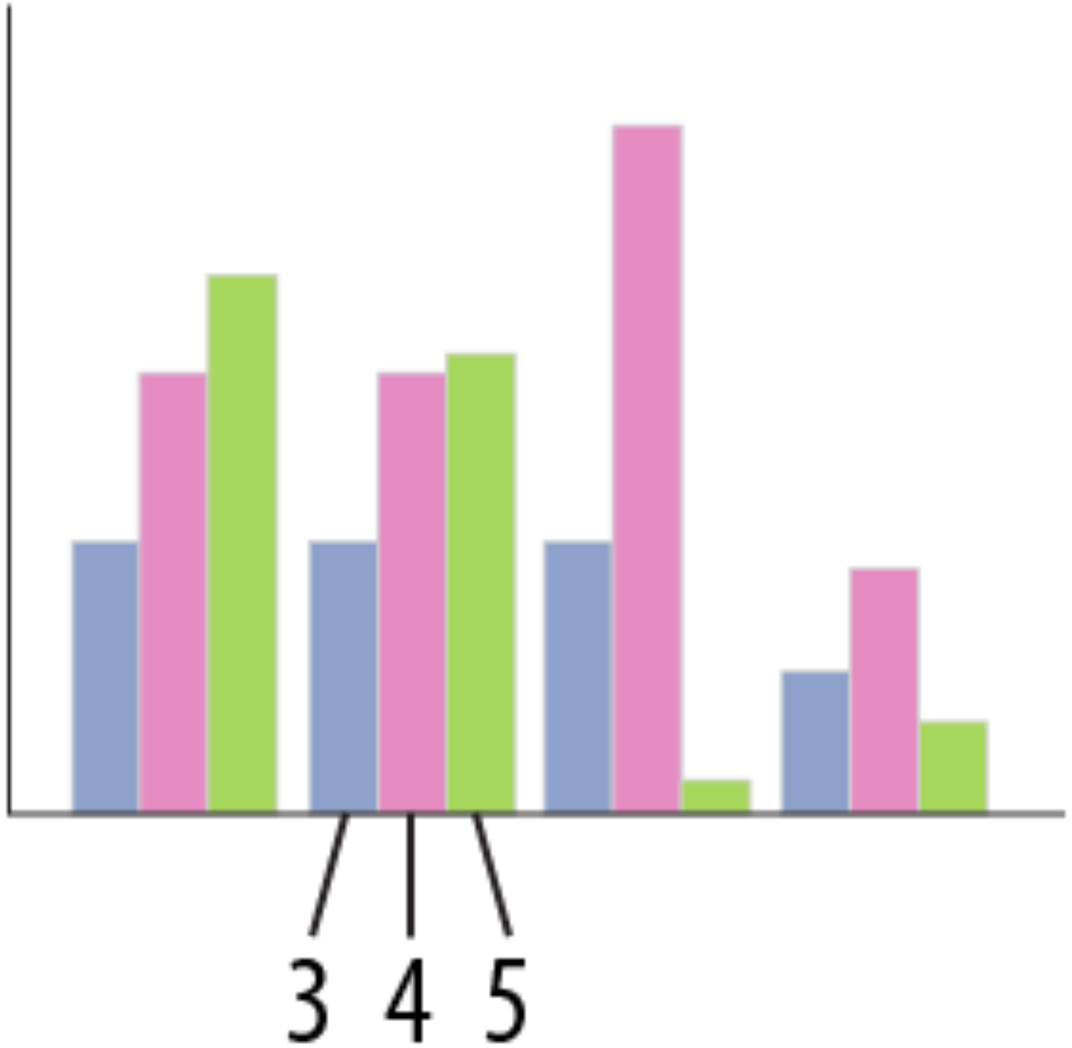
http://colorbrewer2.org/

Colorbrewer scales

via Jordan Crouser

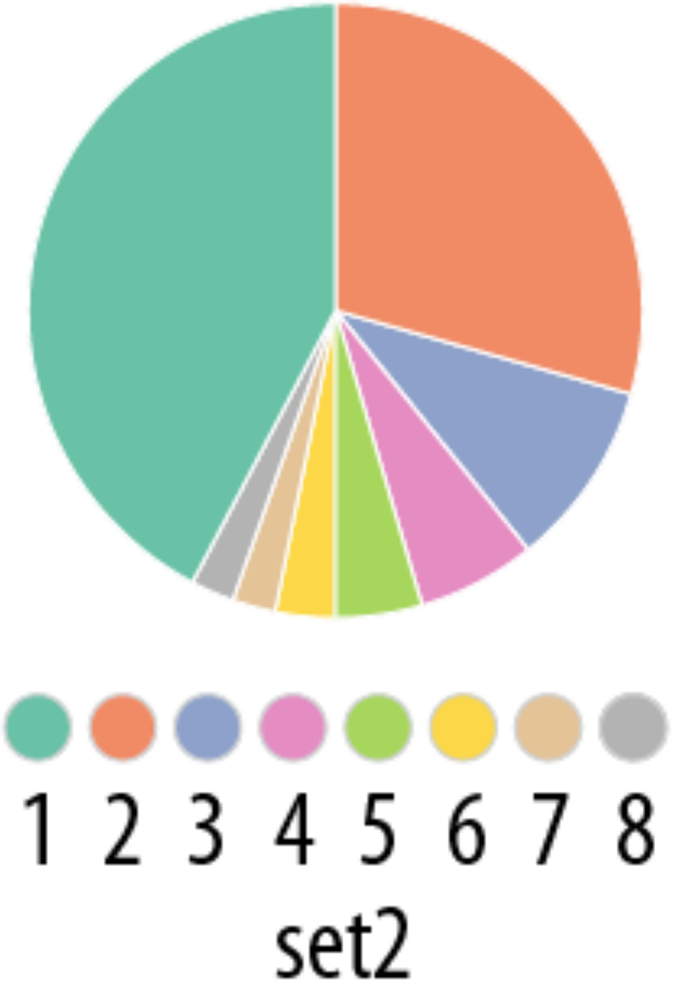
Example





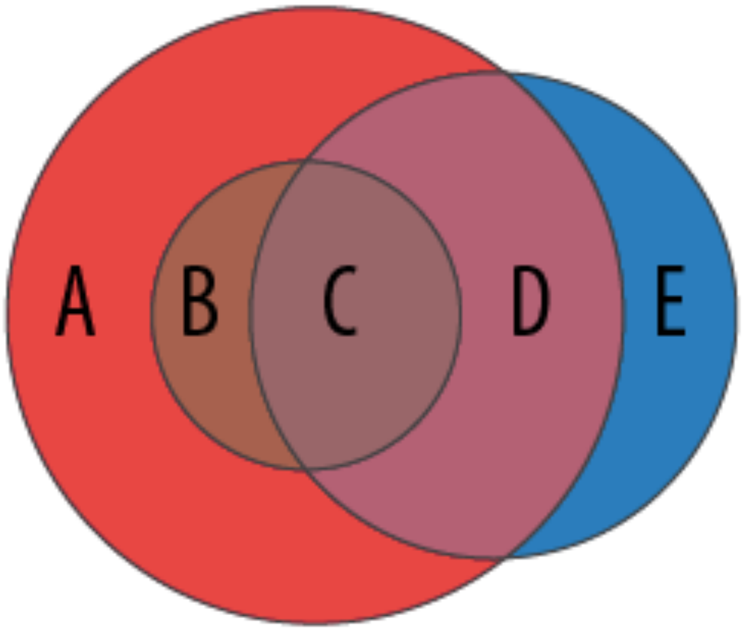
via Jordan Crouser

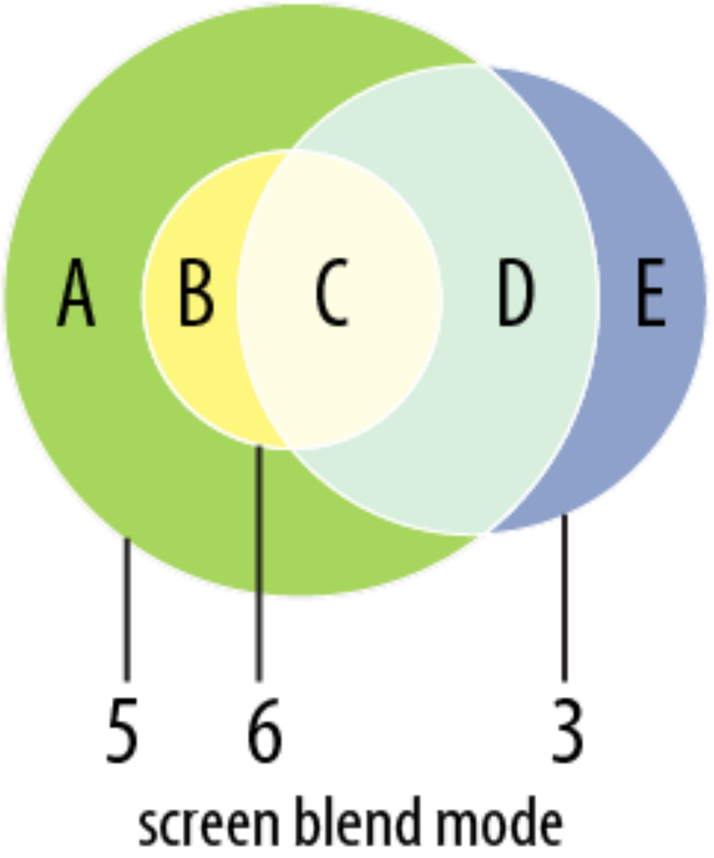
Example



via Jordan Crouser

Example



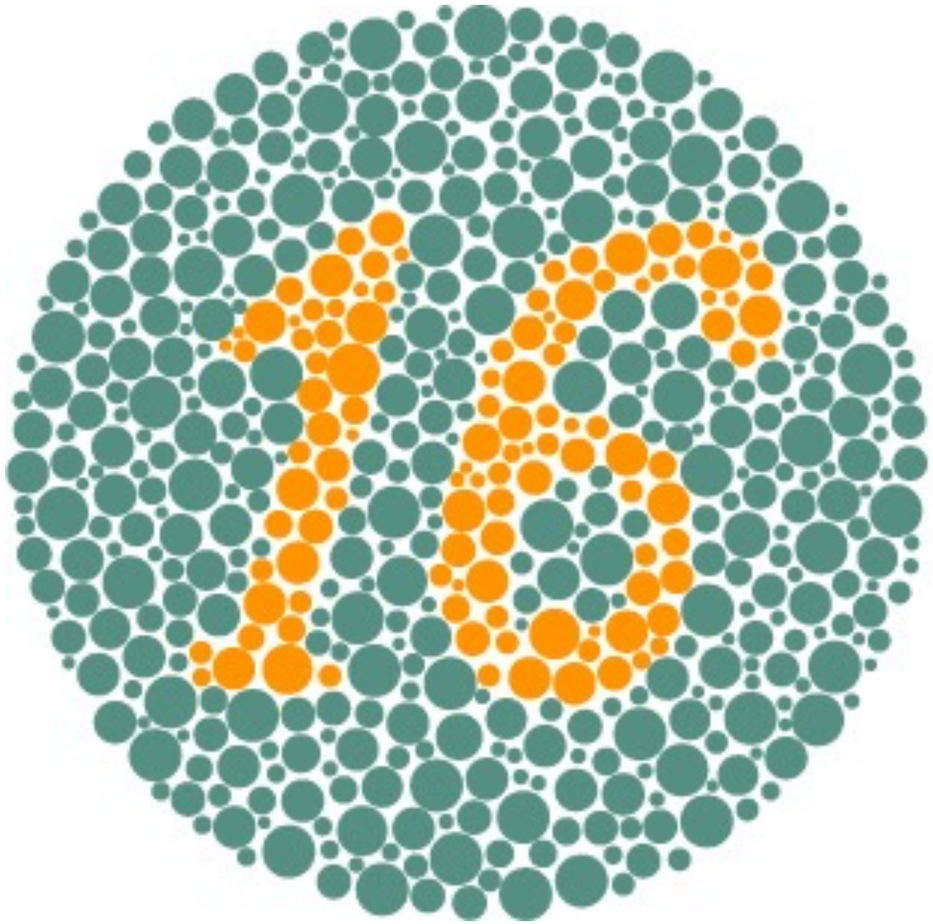


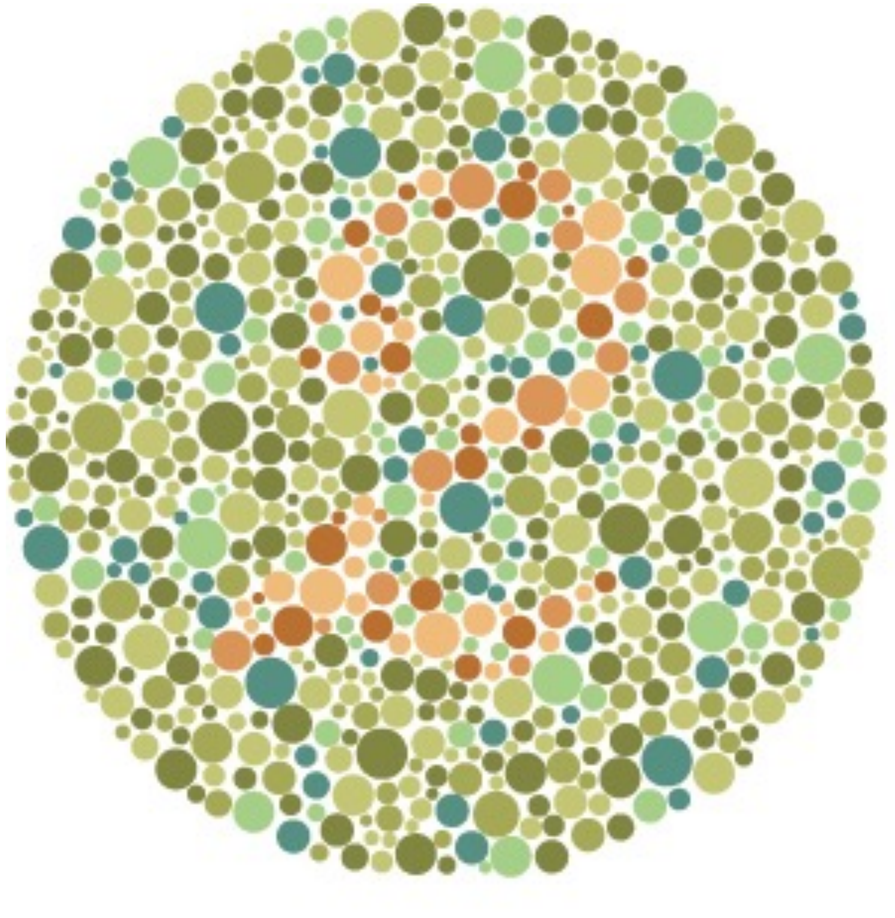
via Jordan Crouser

Discussion: what types of color palettes should we use for categorical variables? What if they are ordinal? What about for numeric variables?

Colorblindness

Colorblindness





http://colorvisiontesting.com/online%20test.htm

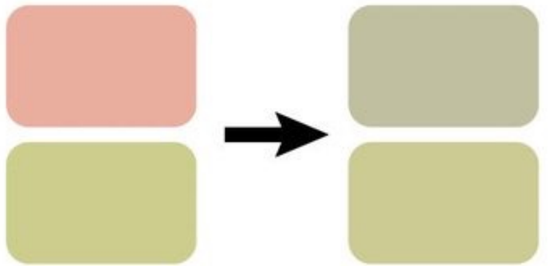
Daniel P. Huffman
@pinakographos

Following

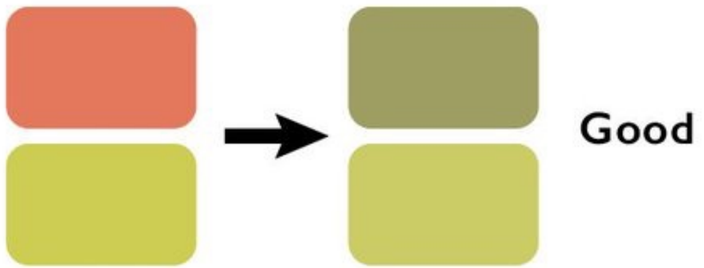
#PractiCarto 39: Colorblindness /mostly/ causes hue confusion. Saturation makes them more separable; or, bypass with differing lightness.

Increasing saturation allows clearer distinction of different hues

Normal *Deuteranopia*



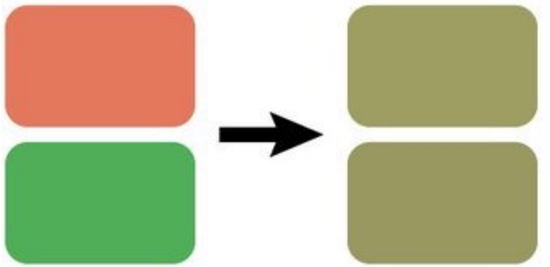
Less Than Good



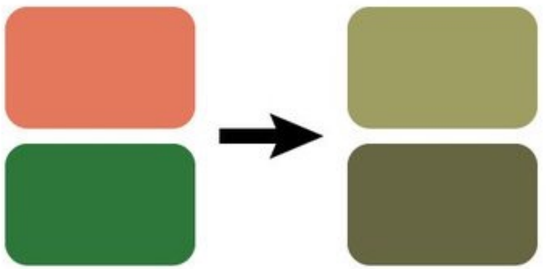
Good

Identical (to deuteranopes) hues can be separated by a shift in lightness

Normal *Deuteranopia*



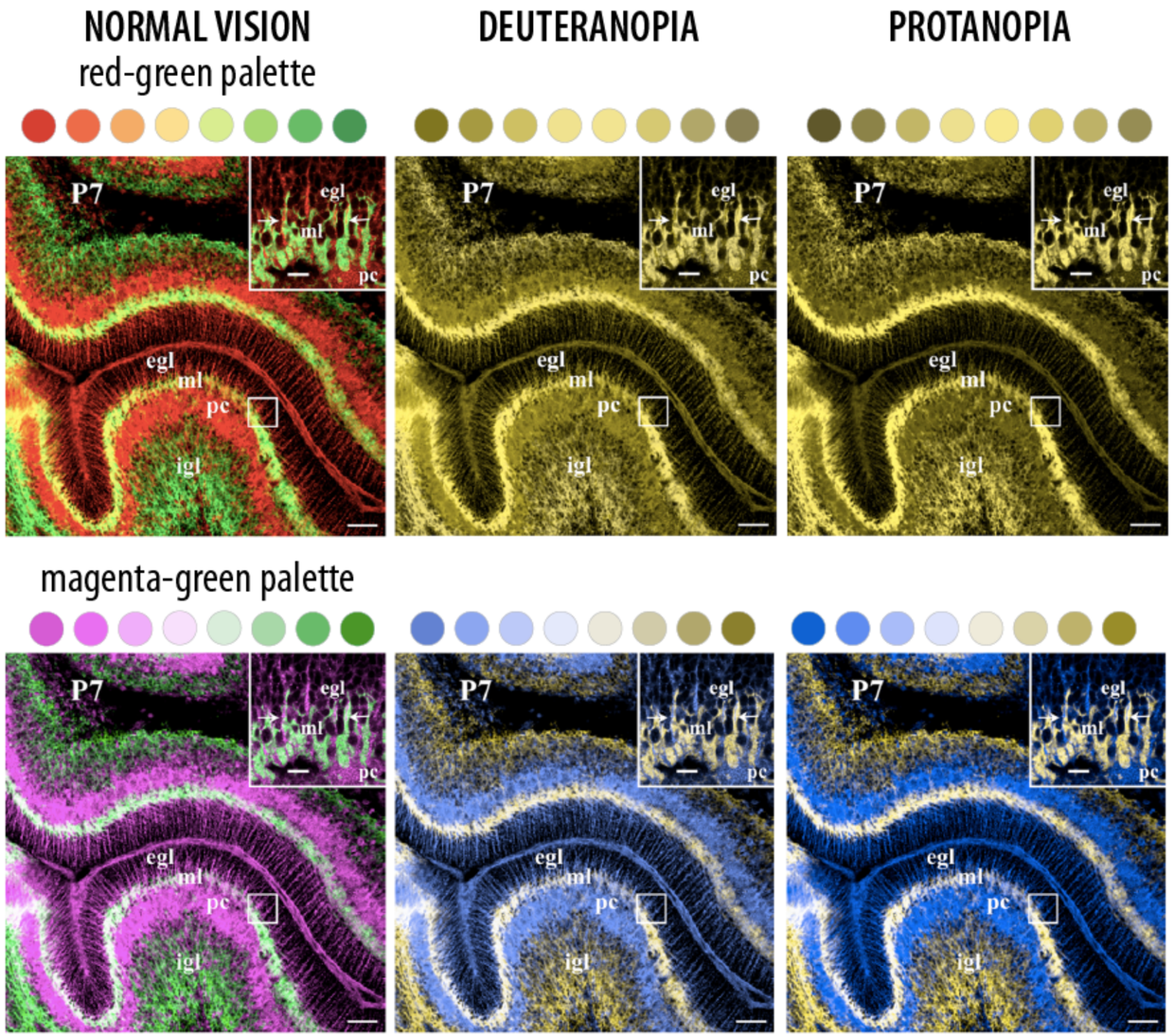
Less Than Good



Good

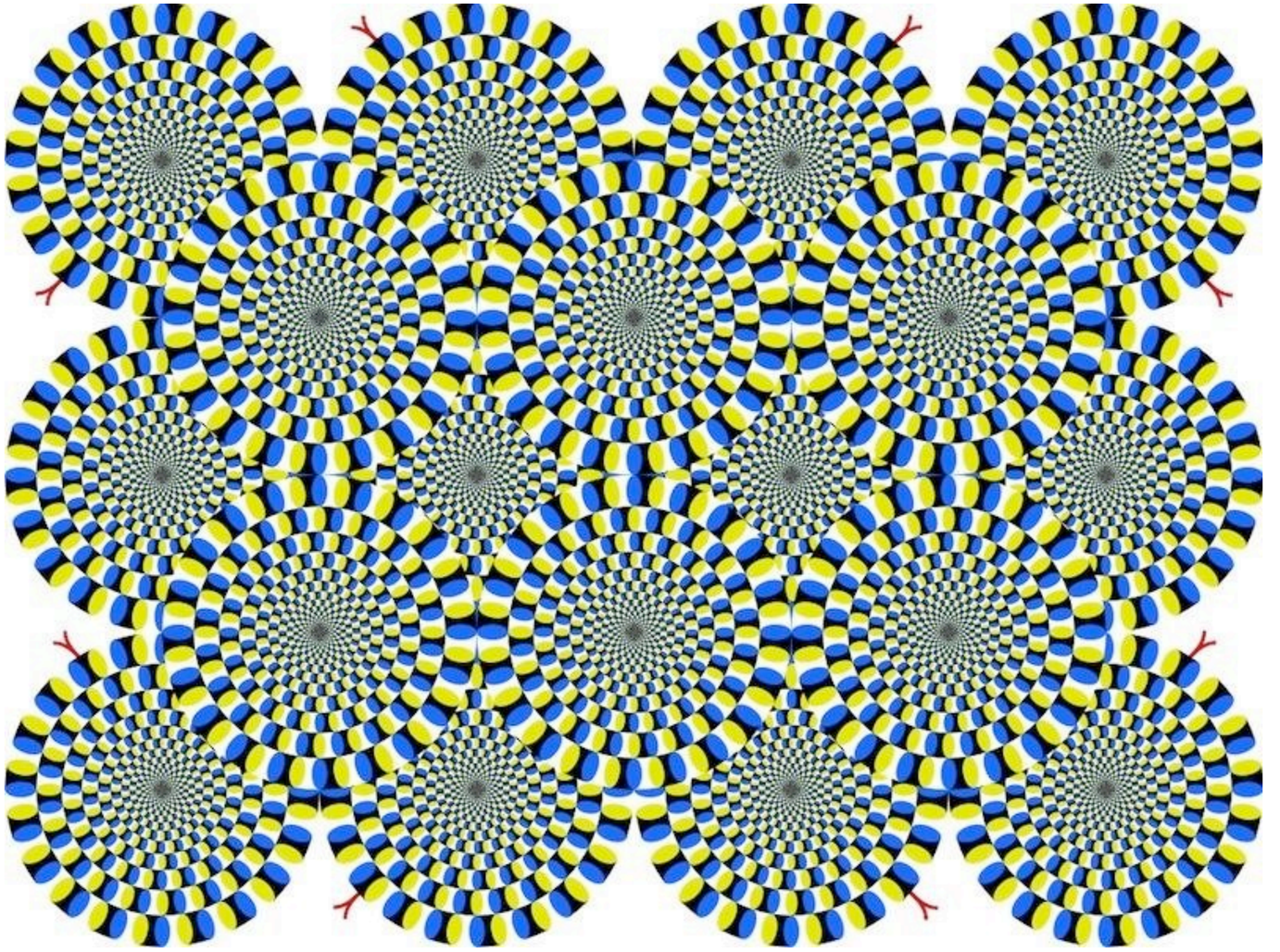
https://twitter.com/pinakographos/status/864497069523959808

Colorbrewer palettes can help here, too!

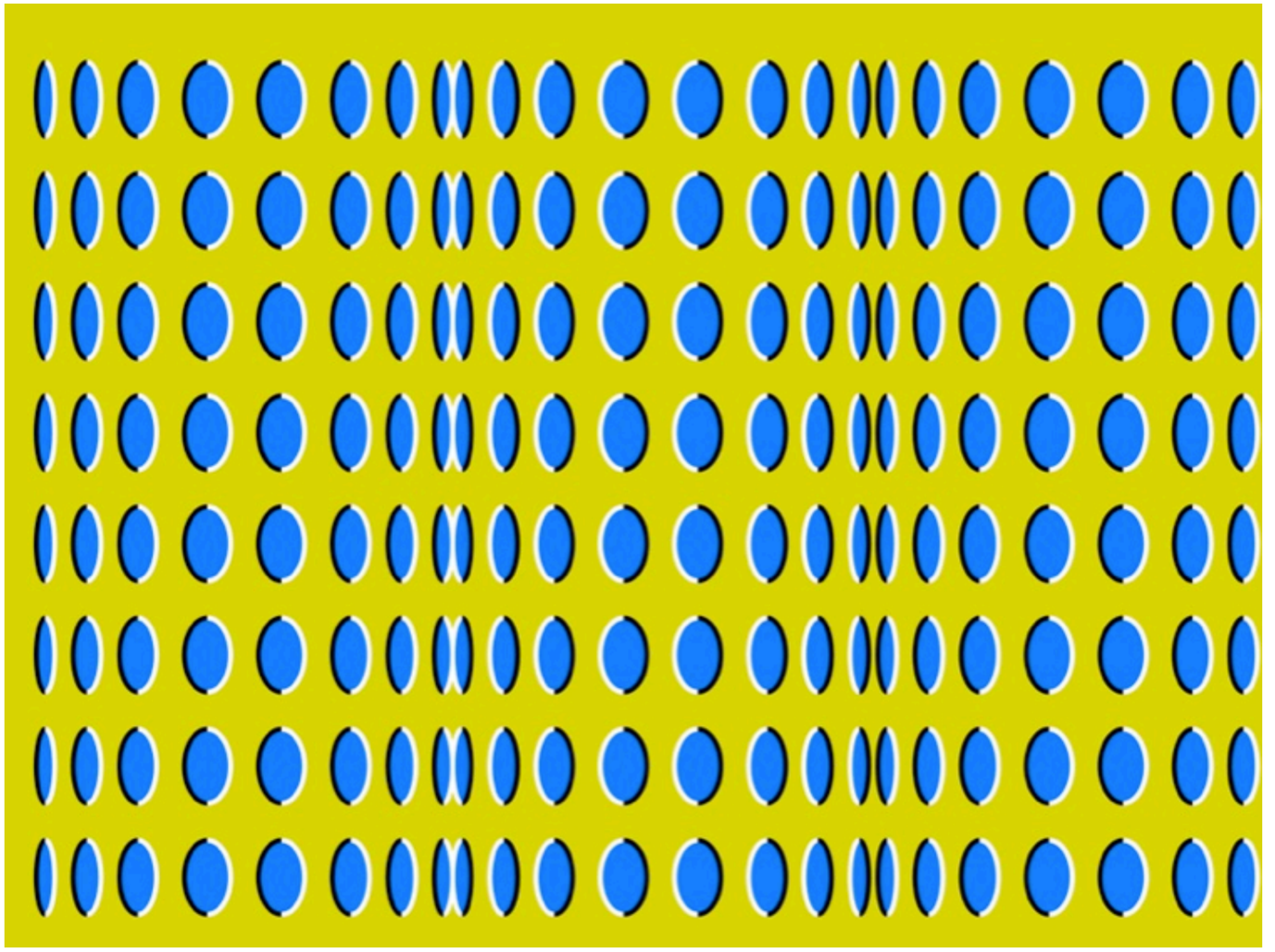


via Jordan Crouser, via M. Krzywinski

Color is contextual

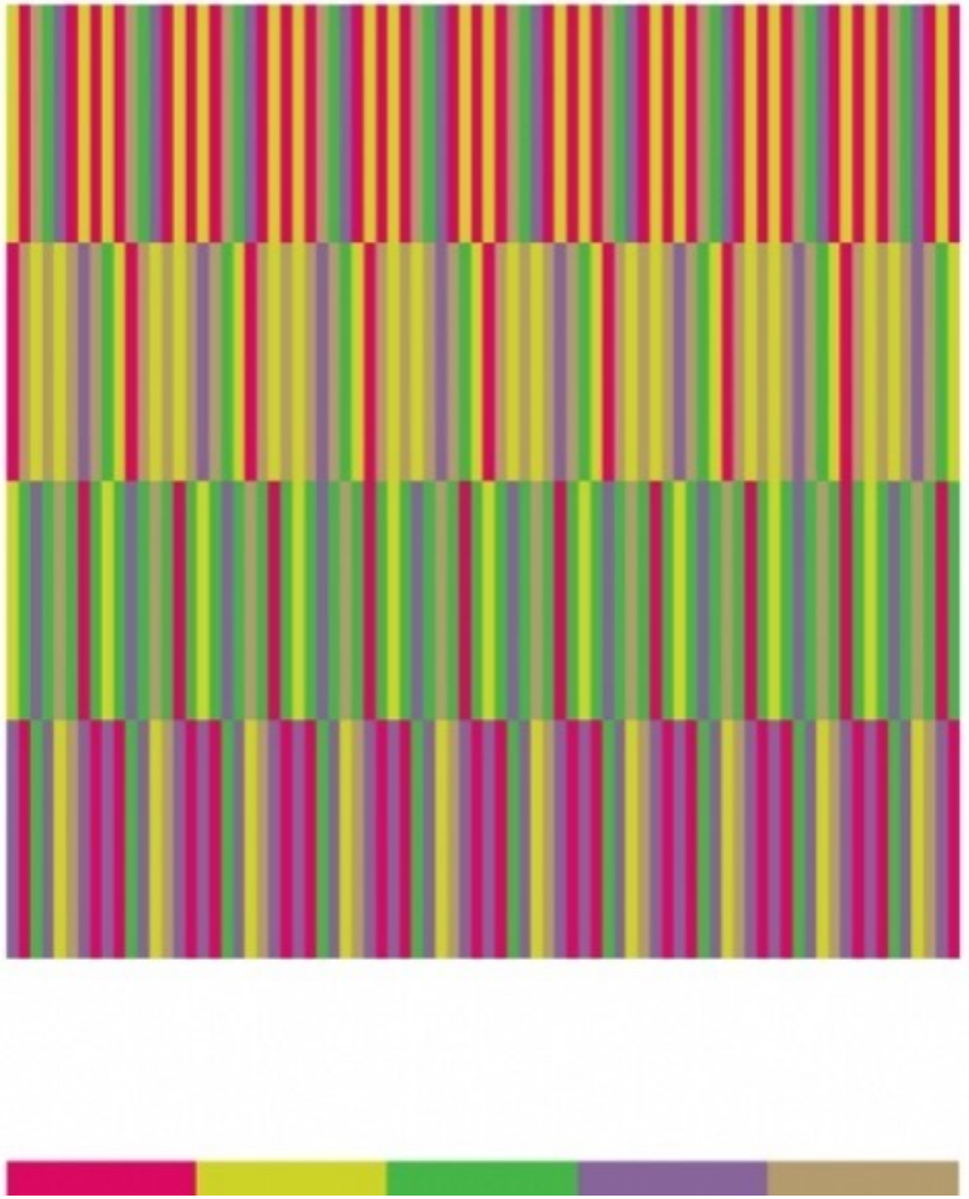


via Jordan Crouser



via Jordan Crouser

Optical color mix



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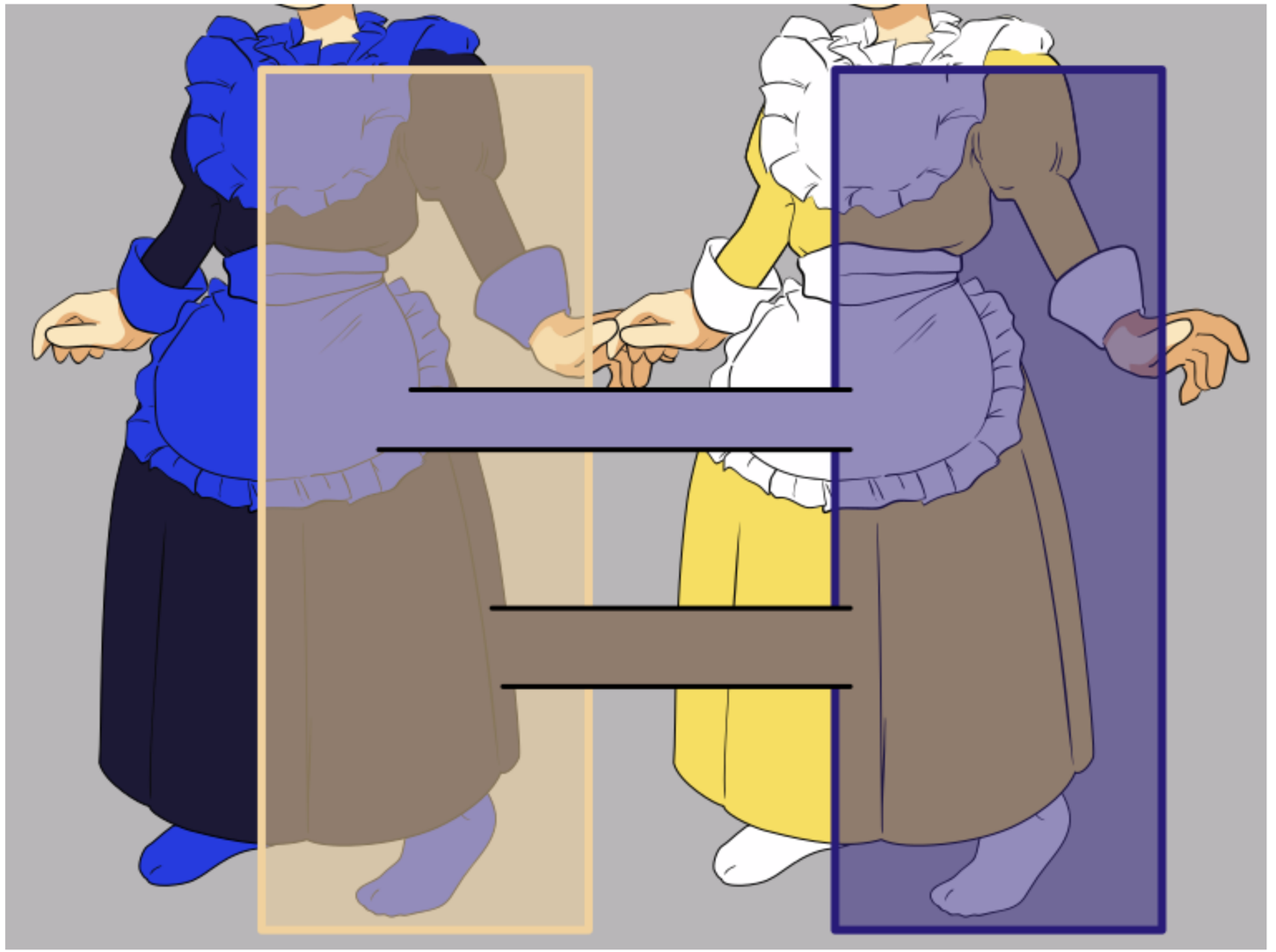


https://en.wikipedia.org/wiki/The_dress

Just noticeable difference

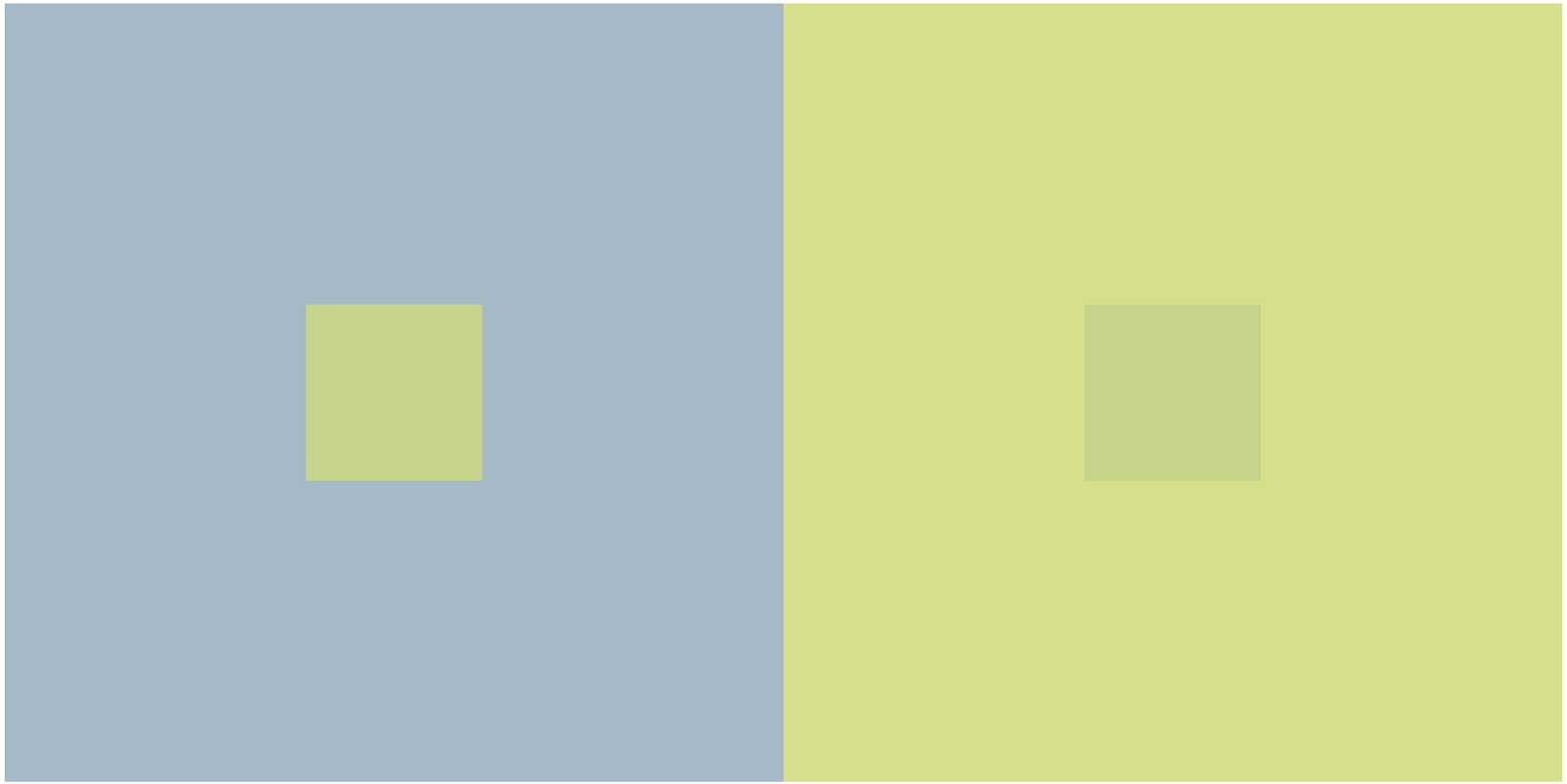
Size affects discriminability 📎

Unfortunately, determining whether two colors are discriminable is an involved process in part because it is harder to discriminate colors that are smaller in area. You can see this for yourself in the example below.

Because size in this context is a physical property that can greatly vary with viewing conditions (e.g., dpi or viewing distance with phones compared to laptops), d3-jnd uses visual angle as a measurement of size rather than pixels. At arms length, the width of a thumb's knuckle is approximately 2° and an index fingernail is approximately 1°. d3-jnd uses a default colored area size assumption of 0.1°, which was selected as a conservatively small size without resulting in overly restrictive color selection; however, the default assumed size can be overridden to create more generous or strict JND distances.

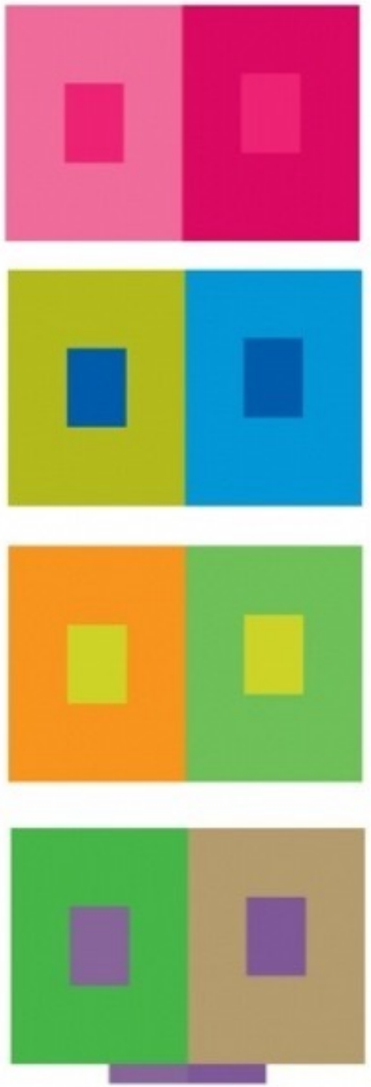
http://gramaz.io/d3-jnd/

Which central square is darker?



via Jordan Crouser

Simultaneous contrast



Work by Amelia McNamara in Dennis Puhalla's University of Cincinnati course, Color Foundation.

Differences are relative

via Jordan Crouser

Color is cultural

about these shared color connotations?

Connotations of brightness (WHITE vs. BLACK). Table 12 is arranged to facilitate analysis in terms of semantic factors. From inspection of the WHITE and BLACK columns, it is clear that these chips differ sharply in evaluation for both groups, WHITE being *good*, *happy*, *pretty*, *sweet*, and *clean* as compared with BLACK. Other unclassified scales reflect the same tendency, BLACK being judged *rougher*, *angrier*, and *more crooked*. Brightness also connotes potency and activity, but less consistently; BLACK tends to be the more potent and masculine but WHITE the more active and feminine. Note that *hot-cold* reverses this trend in both groups, perhaps because of the specific association of WHITE with snow and ice.

Connotations of saturation (YELLOW and GREEN vs. RED, BLUE, PURPLE, and BROWN). Yellow is the least saturated region of the spectrum and, as noted earlier, the green used in this study was a pale, pastel shade; the other colors were quite saturated. The scales which differentiate among these two sets of colors for both

used.

Some salient differences in color connotations. In the following summary, only Anglo/Navajo differences equal to or greater than 1.00 scale unit *and* with means falling on opposite sides of the midpoint (3.50) are counted. RED is *pretty*, *young*, *energetic*, *straight*, and *thick* for the Anglos, but not for the Navajo (who characterize it particularly as *taut*, *angry*, and *masculine*).[6] YELLOW is *small*, *fast*, and *smooth* and GREEN is *weak*, *fast*, and *smooth* for Anglos, but not for Navajo (who do, however, see these pastel shades as favorable evaluatively like the Anglos). Anglos and Navajos agree perfectly on the connotative directions of WHITE, with the single exception of *fast-slow*—Anglos seeing WHITE as quite fast and the Navajos as quite slow. The remaining colors, all dark hues, are judged less favorably by the Anglos: thus, for them, BLUE is the more *sad*, *sour*, *thick*, *cold*, *straight*, and *black*; PURPLE is more *sad*, *sour*, *thick*, *down*, and *black*; BROWN is more *sad*, *sour*, and *dull*; and BLACK is more *sour*, *dull*, *down*, and *poor* than for Navajos.

Charles Osgood. “The Cross-Cultural Generality of Visual-Verbal Synesthetic Tendencies.” Behavioral Science; Baltimore, Md.5.2 (Apr 1, 1960): 146.

THE PSYCHOLOGY OF
COLOR

COLOR PLAYS A MAJOR ROLE IN OUR VISUAL PERCEPTION AS IT INFLUENCES OUR REACTIONS ABOUT WORLD AROUND US. A FUNDAMENTAL GRASP OF COLOR PERCEPTION AND PSYCHOLOGY IN GRAPHIC AND WEB DESIGN IS THEREFORE CRITICAL IN ORDER TO CREATE PALETTES THAT EVOKE THE APPROPRIATE AUDIENCE REACTIONS

PRIMARY ← → SECONDARY

RED

The hottest and the most dynamic color, red is

RED

The hottest and the most dynamic color, red is activating, stimulating, passionate, exciting, powerful, and expanding.

WHERE TO USE:

Use minimally in its purest form as an accent to draw attention to critical elements.

For depicting designs that portray power or passion.

ORANGE

https://visual.ly/community/infographic/other/psychology-color

WARM

ORANGE

Not as overwhelming as red, orange is a balanced color that is vibrant and energetic while being friendly and inviting.

WHERE TO USE:

To give a friendly and inviting impression.

For designs depicting movement and energy without being overpowering.

YELLOW

https://visual.ly/community/infographic/other/psychology-color

YELLOW

The brightest and most energizing of warm colors, yellow is happy, warm, stimulating and expansive.

WHERE TO USE:

To give an impression of happiness and cheerfulness.

Young to Old: In its pure form, yellow can be used for designs concerning children, while darker shades can be used to give a sense of antiquity.

GREEN

https://visual.ly/community/infographic/other/psychology-color

GREEN

This cool secondary color is calming, balancing and rejuvenating. Green represents stability and inspires possibility.

WHERE TO USE:

To represent balance and harmony in a design.

Use darker shades to represent stability and affluence.

BLUE

https://visual.ly/community/infographic/other/psychology-color

BLUE

Blue represents dependability, trustworthiness and security. It can also characterize calm and spirituality.



WHERE TO USE:

Dark blues are excellent for corporate and business designs.

Lighter blues can be used for social websites that represent calm and friendliness.

PURPLE

https://visual.ly/community/infographic/other/psychology-color

PURPLE

Purple represents nobility, abundance and dignity, but can also stand for creativity and imagination.

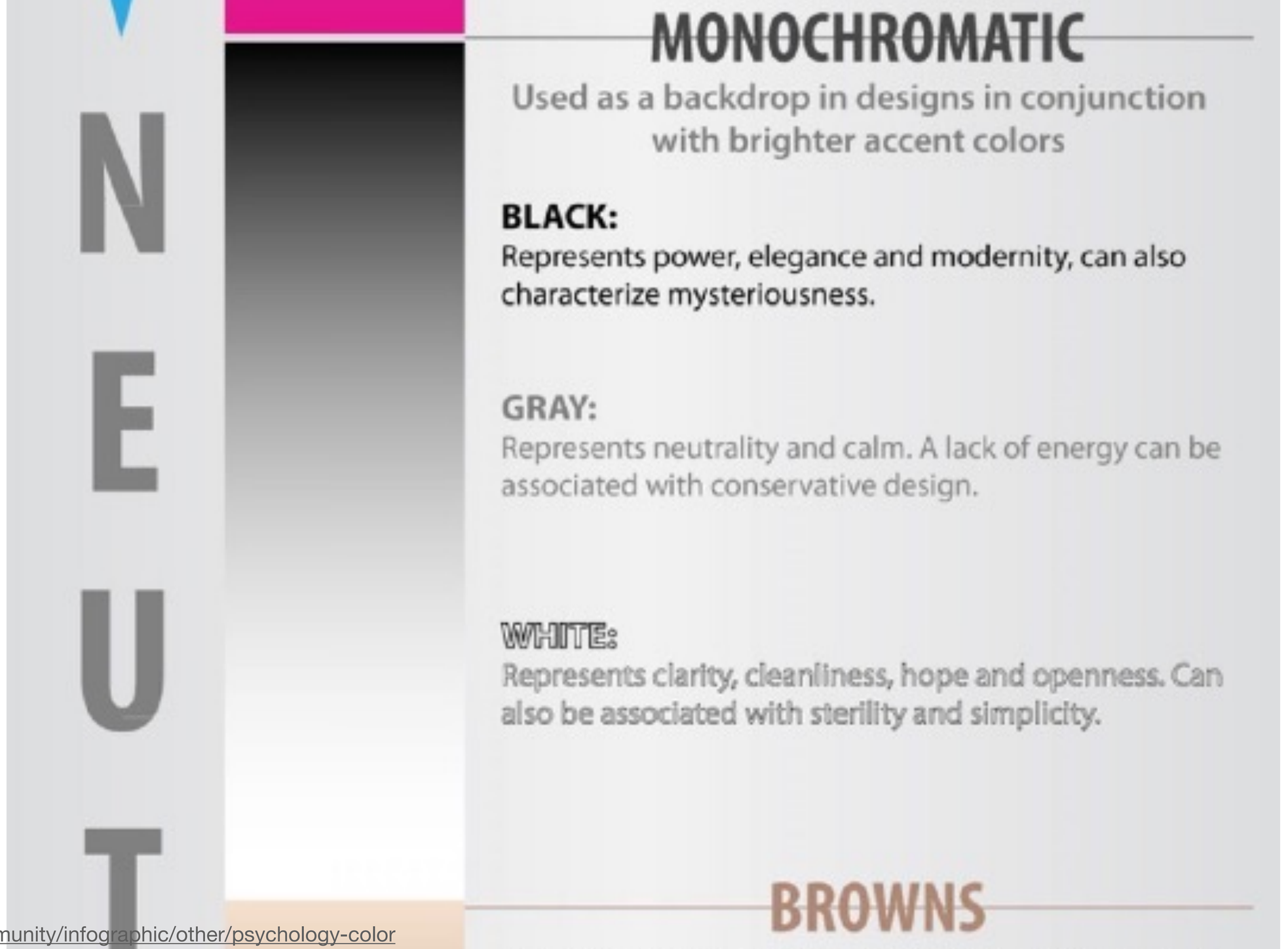
WHERE TO USE:

Darker shades of purple characterize wealth and luxury.

Softer shades can be associated with spring and romance.

MONOCHROMATIC

https://visual.ly/community/infographic/other/psychology-color



https://visual.ly/community/infographic/other/psychology-color

https://visual.ly/community/infographic/other/psychology-color

Red

Red is the most powerful of all colors in Indian culture and holds many important meanings. Among them are fear and fire, wealth and power, purity, fertility, seduction, love, and beauty. Red is also representative of a certain time and place in one's personal life, including when a woman gets married. A married woman can be identified by the red henna on her hands and the red powder, known as *sindoor*, worn along her hairline.

In South Africa, red is associated with mourning, and the section of red in the country's flag symbolizes violence and sacrifices that were made during the struggle for independence.

In Thai tradition, each day of the week is assigned a specific color and is linked with a particular God. Red is the color for Sundays, and it's associated with Surya, a solar God, who was born on this day. Many Thai people pay their respects to Surya by wearing red on his birthday each year.

In Chinese culture, red is traditionally worn on the New Year, as well as during funerals and weddings. It represents celebration and is meant to bring luck, prosperity, happiness, and a long life to the people.

Yellow

For a color that makes many of us feel cheery and warm, yellow has some surprisingly dark meanings in other cultures.

Take France, for example, where yellow signifies jealously, betrayal, weakness, and contradiction. In the 10th century, the French painted the doors of traitors and criminals yellow. And in Germany, yellow symbolizes jealousy.

In China, yellow is associated with pornography. When the Chinese term for "yellow picture" or "yellow book" is used to discuss any type of publication or media, it's in reference to pornographic images and websites.

Yellow is reserved only to people of high rank in many African nations, because of its close resemblance to gold, which is universally associated with money, quality, and success. Egyptians also closely associate yellow with gold, which was commonly used to paint mummies and tombs before the deceased were sent to the afterlife, making it symbol for mourning.

In Japanese culture, yellow has represented bravery, wealth, and refinement since the War of Dynasties in 1357. During this time, warriors wore yellow chrysanthemums —which represent the emperor in Japan and royal family—as a pledge of courage.

Considered lucky in Thai culture, yellow is the lucky color for Monday, and it's considered the most important shade of the week because it represents the King of Thailand, King Bhumibol, who has held reign since June 9, 1946, and was born on December 5th, in 1927—a Monday. To pay tribute to the king, many Thais wear yellow on Mondays, and some schools require all teachers to wear yellow during the first week of December.

http://www.huffingtonpost.com/smartertravel/what-colors-mean-in-other_b_9078674.html

Language represents our view of the world, and knowing its limits helps us understand how our perception works.

I used the data from Wikipedia's "Color" entry for different languages. My assumption was:

"Different languages have different ways to describe color."

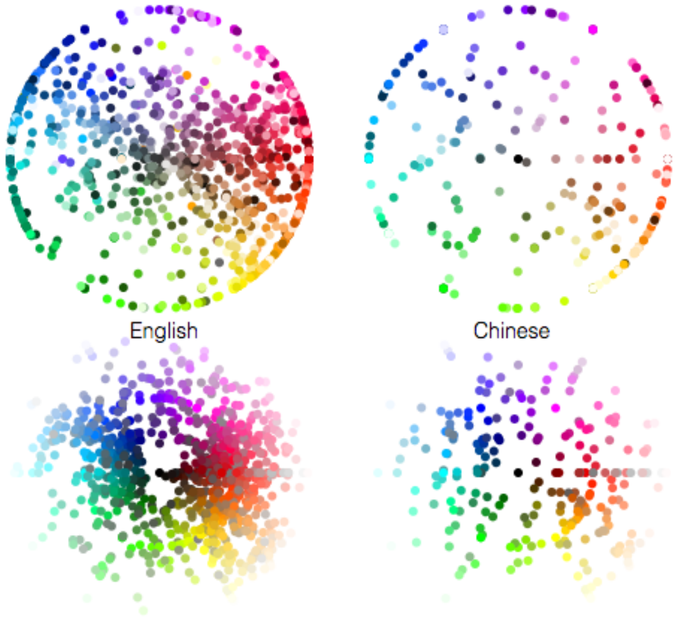
(Scroll Down to Start)

The Chinese entry has 250+ different colors.

The Hue-Saturation-Lightness (HSL) model is a 3D model that can be projected on a 2D space.

Using Hue as an angle, we can set either Saturation as the radius . . .

http://muyueh.com/greenhoney/



Comparing the two datasets, you can see that English has a richer entry for color names.

However, it's always worth asking: Is this the best model to represent our dataset?

Notice that the Chinese and English names for colors share a common structure of "noun/adj + base color":

- 腥紅
- 鮭紅
- 暗鮭紅

- Android green
- Apple green
- Army green

A better visualization will be to split the name of the color, word by word.

http://muyueh.com/greenhoney/

Now we can see that in Chinese, the most popular base color is 紅 (red), followed by 藍 (blue), and 綠 (green).

There are frequently used words, such as 暗 (dark) and 亮 (light), which are not base colors but rather adjectives for a color.

Joke

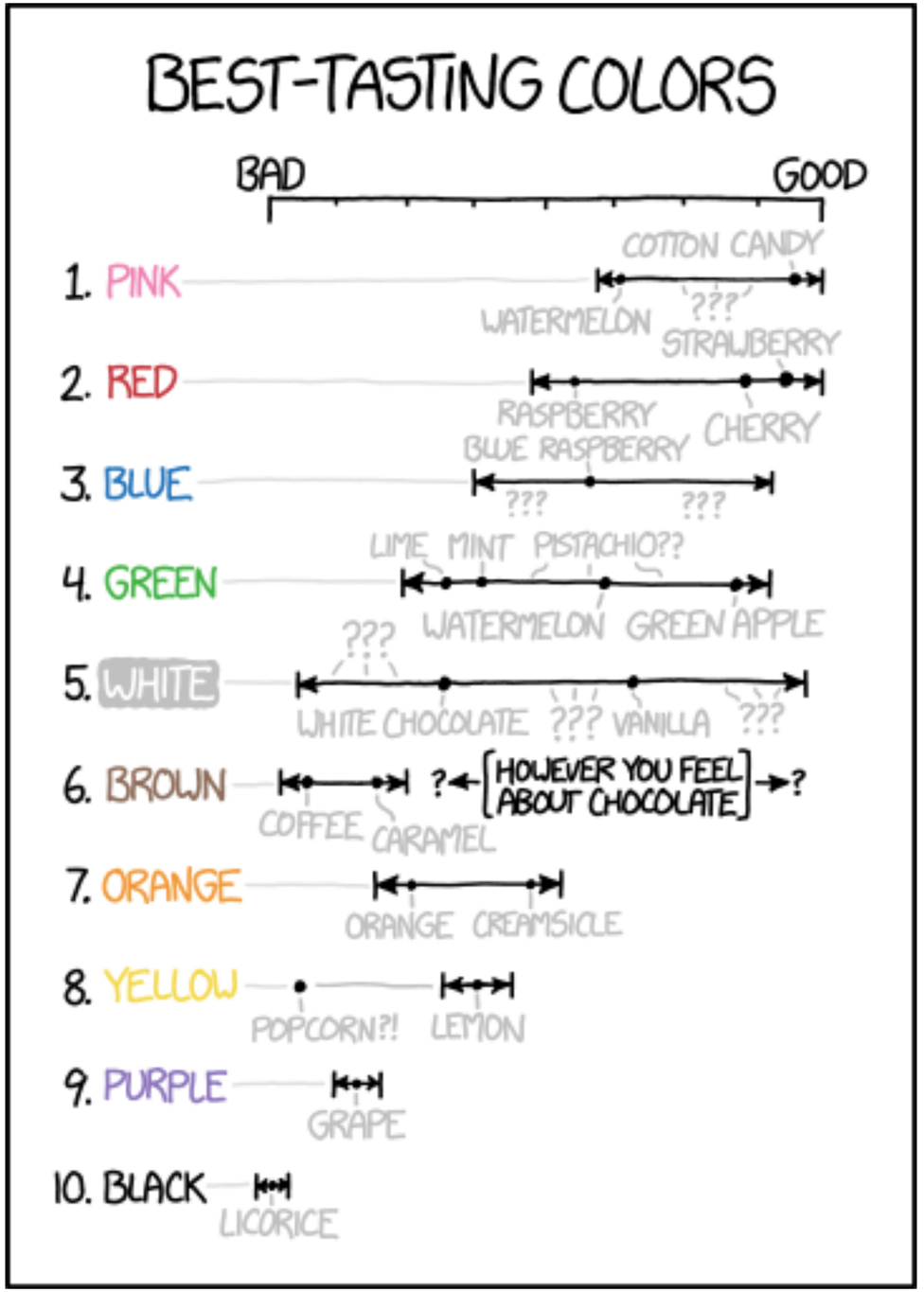
Real results

https://blog.xkcd.com/2010/05/03/color-survey-results/ follow up: Sex and gender: https://blog.xkcd.com/2010/05/06/sex-and-gender/

The 954 most common RGB monitor colors, as defined by several hundred thousand participants in the xkcd color name survey.

See also xkcd.com/color/rgb.txt, and see notes on data at the end of this page.

purple (#7e1e9c)	green (#15b01a)	blue (#0343df)	pink (#ff81c0)	brown (#653700)	red (#e50000)
light blue (#95d0fc)	teal (#029386)	orange (#f97306)	light green (#96f97b)	magenta (#c20078)	yellow (#ffff14)
sky blue (#75bbfd)	grey (#929591)	lime green (#89fe05)	light purple (#bf77f6)	violet (#9a0eea)	dark green (#033500)
turquoise (#06c2ac)	lavender (#c79fef)	dark blue (#00035b)	tan (#d1b26f)	cyan (#00ffff)	aqua (#13eac9)
forest green (#06470c)	mauve (#ae7181)	dark purple (#35063e)	bright green (#01ff07)	maroon (#650021)	olive (#6e750e)
salmon (#ff796c)	beige (#e6daa6)	royal blue (#0504aa)	navy blue (#001146)	lilac (#cea2fd)	black (#000000)
hot pink (#ff028d)	light brown (#ad8150)	pale green (#c7fdb5)	peach (#ffb07c)	olive green (#677a04)	dark pink (#cb416b)
periwinkle (#8e82fe)	sea green (#53fca1)	lime (#aaff32)	indigo (#380282)	mustard (#ceb301)	light pink (#ffd1df)
rose (#cf6275)	bright blue (#0165fc)	neon green (#0cff0c)	burnt orange (#c04e01)	aquamarine (#04d8b2)	navy (#01153e)
grass green (#3f9b0b)	pale blue (#d0fefe)	dark red (#840000)	bright purple (#be03fd)	yellow green (#c0fb2d)	baby blue (#a2cffe)



https://xkcd.com/1811/