



Thank you!

UPMC Enterprises

Andrew Pucci-IxDD-10/9/2023



Designing for Inclusion: Creating Accessible Color Palettes using OKLCH

Andrew Pucci-IxD-10/9/2023

Why build accessible color palettes?

Andrew Pucci-IxDD-10/9/2023

Color Blindness

Andrew Pucci–IxDD–10/9/2023

~~Color Blindness~~ Color Vision Deficiency

- Mainly an inherited genetic condition
- Affects approximately 1 in 12 chromosomal males (XY) and 1 in 200 chromosomal females (XX)
- Other causes: diabetes, multiple sclerosis, aging, side effect of medication, injuries

Andrew Pucci-IxDD-10/9/2023

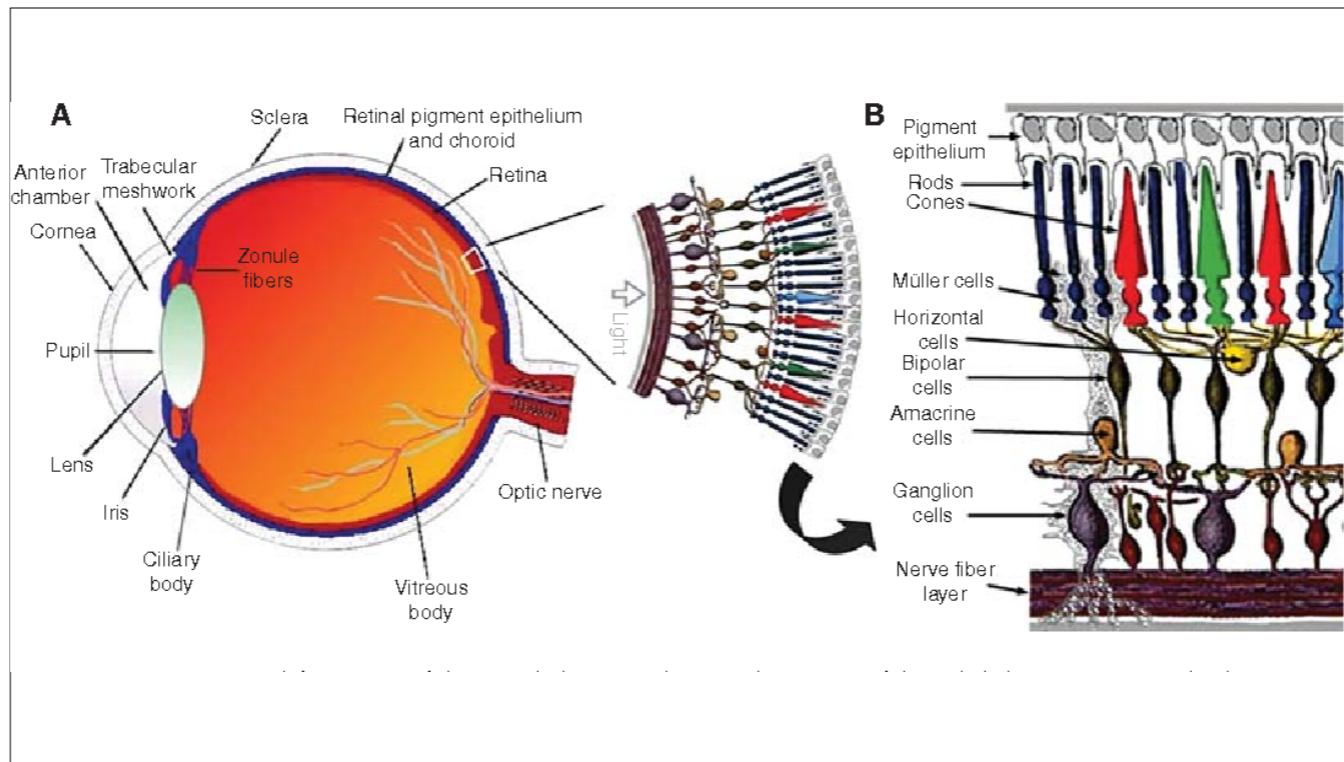
Color Blindness doesn't necessarily mean you can't see color, you just have a decreased ability to tell colors apart from one another

Inherited just like eye color or blood type

8 percent of people with XY chromosomes

0.5 percent of people with XX chromosomes

The deficiency is found on the X chromosome and must be present on both X chromosomes, so it's passed down from the mother's side.



Rods: darkness or lightness, shape, movement

Cones: perceive color

<https://www.semanticscholar.org/paper/Protein-misfolding-and-retinal-degeneration.-Tzekov-Stein/a2159ab94b4e227c2973a28c8f18cb25e84ede39>



Andrew Pucci—IxD—10/9/2023



Green-dichromacy, “red-green” color vision deficiency (M-cones) (most common form)

Deutanopes also have trouble distinguishing between colors in the green-yellow-red spectrum. Medium tones of red are likely to be confused with oranges and yellows.

Affects about 5% of chromosomal males



Red-dichromacy, also “red-green” color vision deficiency (L-cones)

Protanopes have trouble distinguishing between colors in the green-yellow-red spectrum. Reds look gray or black, pink and purple may appear blue.

Affects about 2% of chromosomal males



Much rarer (less than 0.01% of the population) form of color vision deficiency that is not inherited. (S-cones)

More likely to be acquired through old age, head injuries, or alcoholism. Can potentially be reversed if underlying causes can be treated.

Chromatic Vision Simulator

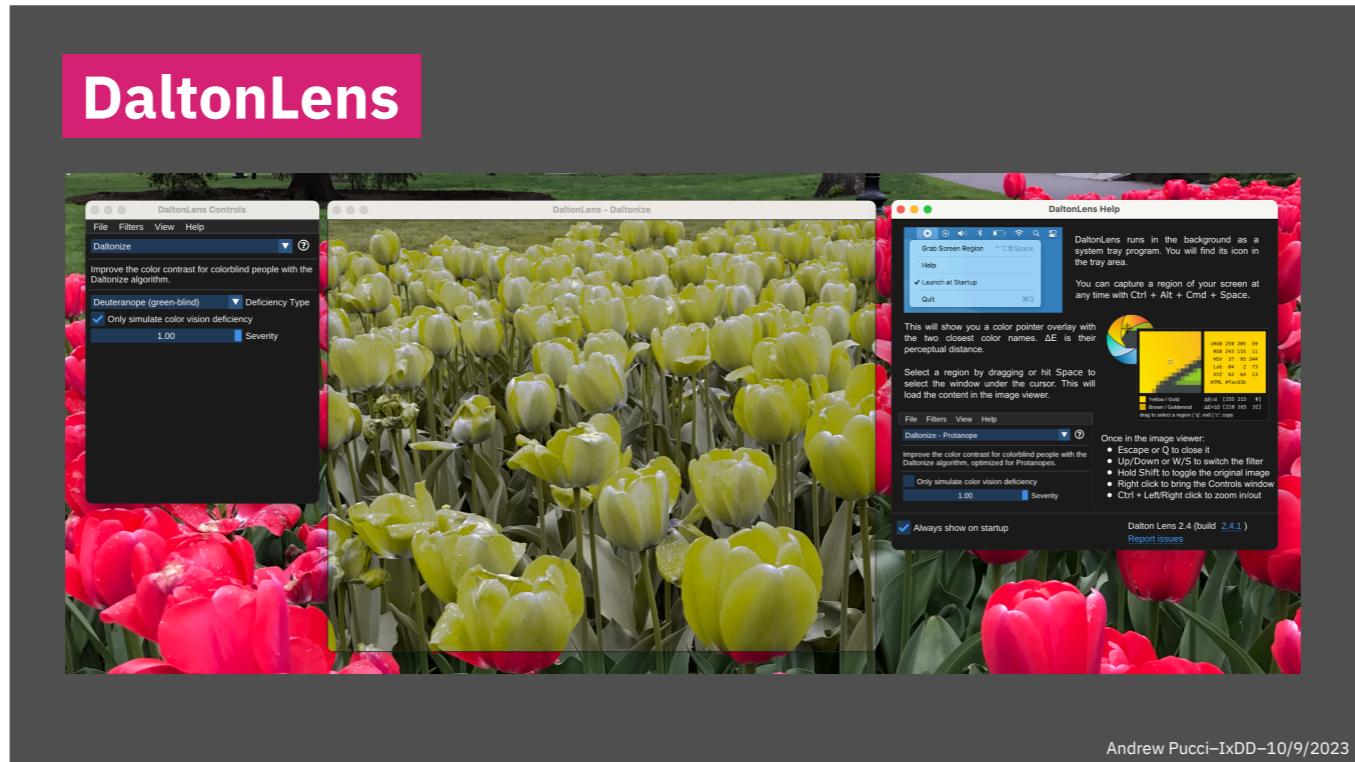


Andrew Pucci-IxD-10/9/2023

Available for Android and iOS

<https://asada.website/cvimulator/e/>



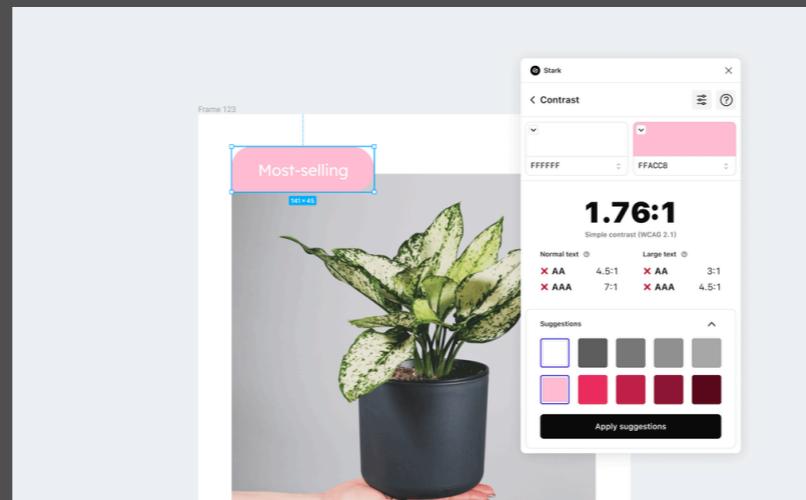


Andrew Pucci-IxD-10/9/2023

DaltonLens is a cross-platform utility to help people with color vision deficiency by providing color filters and highlighting tools.

<https://github.com/DaltonLens/DaltonLens>

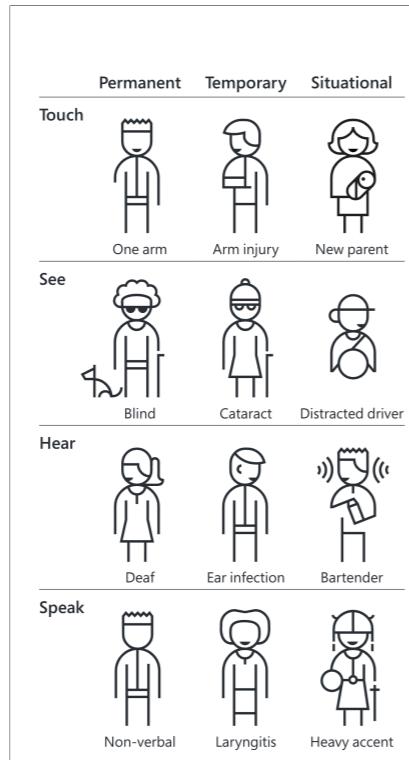
Stark—for Figma, Adobe XD, and Sketch



Andrew Pucci—IxD—10/9/2023

A free plugin available for Figma, Adobe XD, and Sketch that allows you to simulate color vision deficiencies, check contrast, and apply suggested contrast-friendly colors.

<https://www.getstark.co>



Inclusive Design

What sorts of **temporary** or **situational** disabilities can you think of?

Andrew Pucci–IxDD–10/9/2023

Microsoft's Persona Spectrum

Night Shift / Night Light

Phone in sunlight

Bedtime Mode in Android's Digital Wellbeing tools (grayscale mode)

Print



Andrew Pucci-IxDD-10/9/2023

Web Content Accessibility Guidelines from the W3C (2.1 was published in June 2018, previously 2.0 in 2008... 2.2 was finalized on Thursday (10/5/23), working draft WCAG 3.0)

Section 508: Federal Law (part of Americans with Disabilities Act / ADA) that requires adherence to WCAG 2.0 levels A and AA for federal agencies

The success criteria are organized based on the impact they have on design or visual presentation of the pages. The higher the level, the more restraining it becomes on design.

WCAG 2.2

1.4.1 Use of Color Level A

Color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.

Andrew Pucci–IxDD–10/9/2023

G183: Using a contrast ratio of 3:1 with surrounding text and providing additional visual cues on focus for links or controls where color alone is used to identify them

Contrast ratio is a measure of the relative brightness of two colors. For instance red and red would be 1:1 (they're the same)

<https://www.w3.org/TR/2008/NOTE-WCAG20-TECHS-20081211/G183>

1.4.1 Use of Color Level A

Fail

Error: All fields in red must be completed before submitting

Name
Andrew

Email address
andrew@andrewpucci.com

Street Address

City
Sacramento

Pass

Name
Andrew

Email address
andrew@andrewpucci.com

Street Address
 x This field is required

City
Sacramento

State

Andrew Pucci-IxD-10/9/2023

WCAG 2.2

1.4.3 Contrast (Minimum) *Level AA*

The visual presentation of text and images of text has a contrast ratio of at least **4.5:1**, except for the following:

- **Large Text:** Large-scale text and images of large-scale text have a contrast ratio of at least 3:1;
- **Incidental:** Text or images of text that are part of an inactive user interface component, that are pure decoration, that are not visible to anyone, or that are part of a picture that contains significant other visual content, have no contrast requirement.
- **Logotypes:** Text that is part of a logo or brand name has no minimum contrast requirement.

Andrew Pucci–IxDD–10/9/2023

Level AA = 4.5:1 or higher

1.4.3 Contrast (Minimum) Level AA

Fail

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#FFFFFF:#888888

3.54

Pass

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#FFFFFF:#767676

4.54

Andrew Pucci-IxD-10/9/2023

Where contrast ratios fail

Fail

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#00A0DF:#FFFFFF

2.96

Pass

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#00A0DF:#24272A

5.07

Andrew Pucci-IxD-10/9/2023

This is where testing with real people is helpful. Something with a passing contrast ratio isn't necessarily readable.

APCA Lightness Contrast

The APCA Lightness Contrast tool provides a visual and numerical assessment of text readability against different backgrounds. It includes color selection tools, font size tables, and sample text snippets.

Left Screenshot (Light Background, Dark Text):

- Text / Icon Color:** #ffffff + rgb(255, 255, 255) / ffffff
- Background Color:** #00a0df + rgb(0, 160, 223) / 00a0df
- Contrast:** Lc -60.8
- Font Size Table:**

USAGE	200	300 (Light)	400 (Normal)	500	600	700 (Bold)
FLUENT TEXT OKAY	48px	40px	The lazy grey dog s	21px	16px	The lazy grey dog slept in the afternoon sun, but the frisk
	Sam	The lazy gre	afternoon sun, but	The la	The la	flowers with a
		afternoon s	frolicked freely in t	aftern	aftern	afterno

Right Screenshot (Dark Background, Light Text):

- Text / Icon Color:** #24272a + rgb(36, 39, 42) / 24272a
- Background Color:** #00a0df + rgb(0, 160, 223) / 00a0df
- Contrast:** Lc 44.5
- Font Size Table:**

USAGE	200	300 (Light)	400 (Normal)	500	600	700 (Bold)
SPOT & NON TEXT ONLY	97px	75px	44px	34px	30px	25px
&			Sample Te	The la	The la	The la
			aftern	aftern	aftern	afterno

All font sizes are in CSS px. Reference font shown with colors at actual size & weight.

Andrew Pucci-IxD-10/9/2023

<https://www.myndex.com/APCA/>

Accessible Contrast

Relative to Font Size and Weight

APCA reports lightness contrast as an Lc value from Lc 0 to Lc 106 for dark text on a light background, and Lc 0 to Lc -108 for light text on a dark background (dark mode). The minus sign merely indicates negative contrast, which means light text on a dark background.

Lc 60: The minimum level recommended for content text that is not body, column, or block text. In other words, text you want people to read.

<https://www.myndex.com/APCA/>

WCAG 2.2

1.4.6 Contrast (Enhanced) *Level AAA*

The visual presentation of text and images of text has a contrast ratio of at least 7:1, except for the following:

- **Large Text:** Large-scale text and images of large-scale text have a contrast ratio of at least 4.5:1;
- **Incidental:** Text or images of text that are part of an inactive user interface component, that are pure decoration, that are not visible to anyone, or that are part of a picture that contains significant other visual content, have no contrast requirement.
- **Logotypes:** Text that is part of a logo or brand name has no minimum contrast requirement.

Andrew Pucci–IxDD–10/9/2023

Level AAA = 7:1 or higher contrast ratio

1.4.6 Contrast (Enhanced) Level AAA

Fail

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#FFFFFF:#767676

4.54

Pass

See how easy it is to create a little tree right in your world. By now you should be quite happy about what's happening here. You have to make these big decisions. Maybe there was an old trapper that lived out here and maybe one day he went to check his beaver traps, and maybe he fell into the river and drowned. Be so very light. Be a gentle whisper.

Let's get crazy. You can work and carry-on and put lots of little happy things in here. It is a lot of fun. The shadows are just like the highlights, but we're going in the opposite direction. In nature, dead trees are just as normal as live trees. Paint anything you want on the canvas. Create your own world.

#FFFFFF:#444444

9.43

Andrew Pucci-IxD-10/9/2023

WCAG 2.2

1.4.8 Visual Presentation Level AAA

For the visual presentation of blocks of text, a mechanism is available to achieve the following:

- Foreground and background colors can be selected by the user.
- Width is no more than 80 characters or glyphs (40 if CJK).
- Text is not justified (aligned to both the left and the right margins).
- Line spacing (leading) is at least space-and-a-half within paragraphs, and paragraph spacing is at least 1.5 times larger than the line spacing.
- Text can be resized without assistive technology up to 200 percent in a way that does not require the user to scroll horizontally to read a line of text on a full-screen window.

Andrew Pucci–IxDD–10/9/2023

Foreground and background colors can be selected by the user

Contrast Checkers

- <https://www.siegemedia.com/contrast-ratio>
- <http://contrast-finder.tanaguru.com/>
- <https://colorable.jxnblk.com/>
- <https://www.myndex.com/APCA/>

Andrew Pucci-IxDD-10/9/2023

Contrast Ratio: Nice because you can enter colors in hex, rgb, and hsl, and it's really easy to share a link to a result

Contrast Finder: Great tool for finding accessible colors when you already have an idea of which colors you want to use

Colorable: Good for testing text and easily tweaking values

APCA Contrast Calculator: Great tool for working with APCA contrast

Accessibility Testing

- https://sparkbox.com/foundry/automated_accessibility_tool_reviews
- Don't forget to include non-automated testing with real people

Andrew Pucci–IxDD–10/9/2023

Using Color Spaces

Andrew Pucci-IxD-10/9/2023

What is a Color Space?

- A specific organization of colors. In combination with color profiling supported by various physical devices, it supports reproducible representations of color—whether such representation entails an analog or a digital representation.
- A useful conceptual tool for understanding the color capabilities of a particular device or digital file.

Andrew Pucci–IxDD–10/9/2023

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

Color Model: an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components. (see https://en.wikipedia.org/wiki/Color_model)

sRGB

- #00A85D
- rgb(0 168 93)
- hsl(153 100% 32%)
- HSB: 153 100 66

Andrew Pucci–IxDD–10/9/2023

sRGB is a standard RGB (red, green, blue) color space that HP and Microsoft created cooperatively in 1996 to use on monitors, printers, and the World Wide Web. It is based on the RGB color model.

<https://en.wikipedia.org/wiki/SRGB>

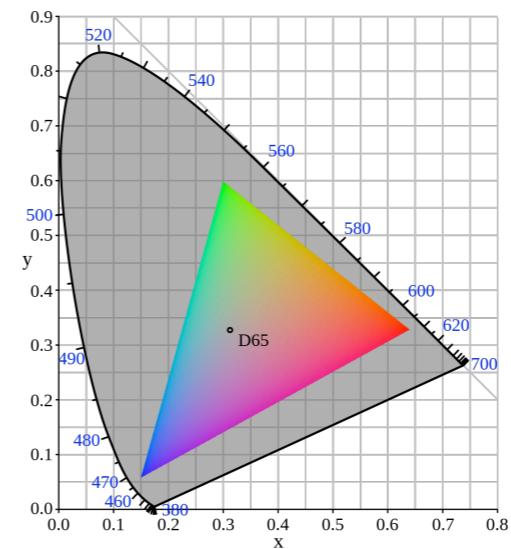
sRGB

- #00A85D
- rgb(0 168 93)
- hsl(153 100% 32%)
- HSB: 153 100 66

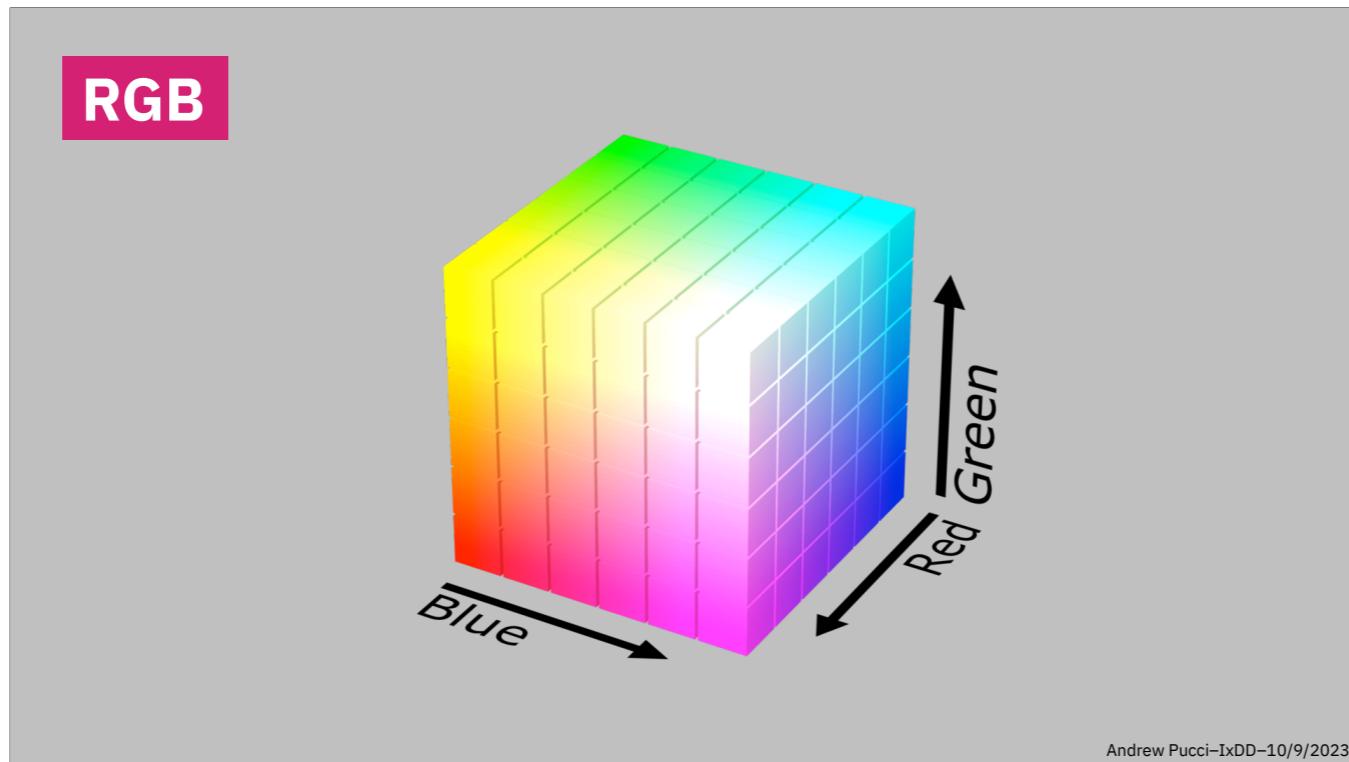
Andrew Pucci—IxD—10/9/2023

sRGB

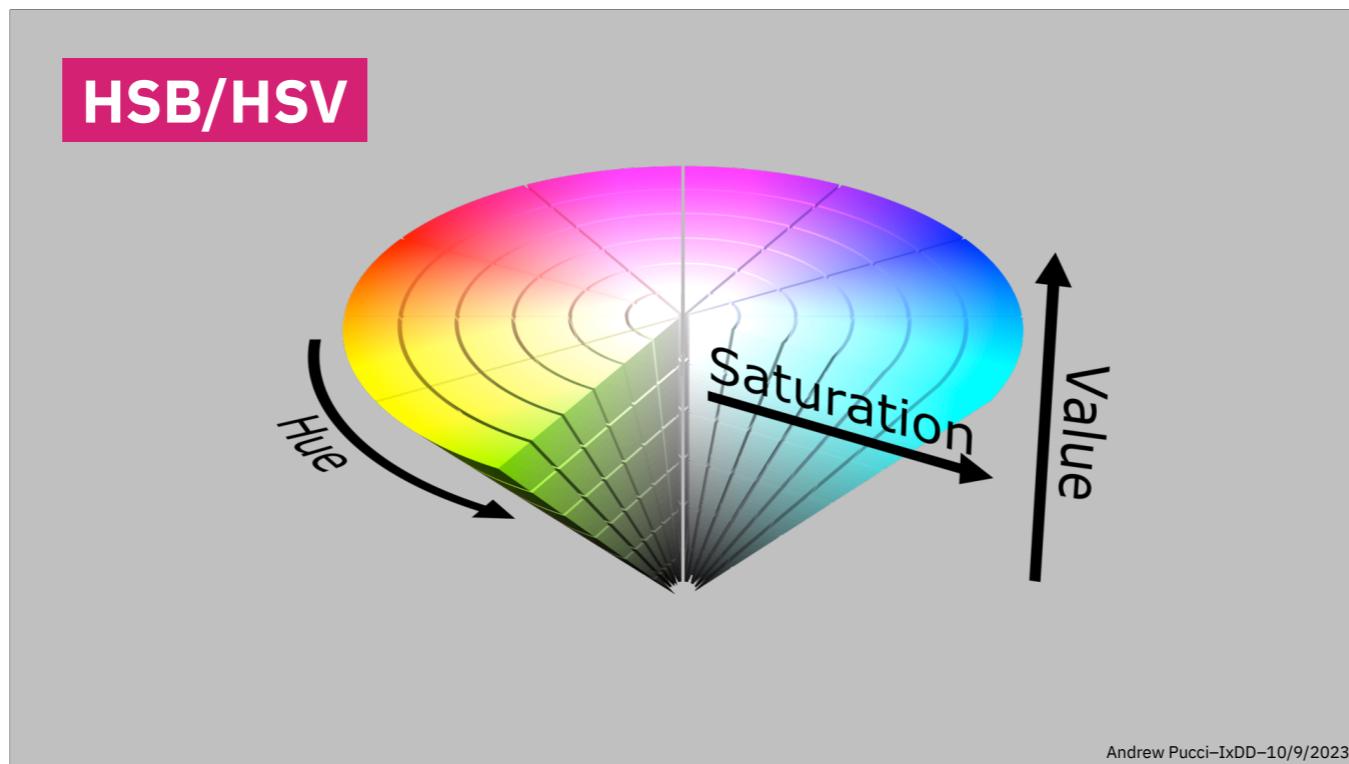
- #00A85D
- $\text{rgb}(0\ 168\ 93)$
- $\text{hsl}(153\ 100\%\ 32\%)$
- HSB: 153 100 66



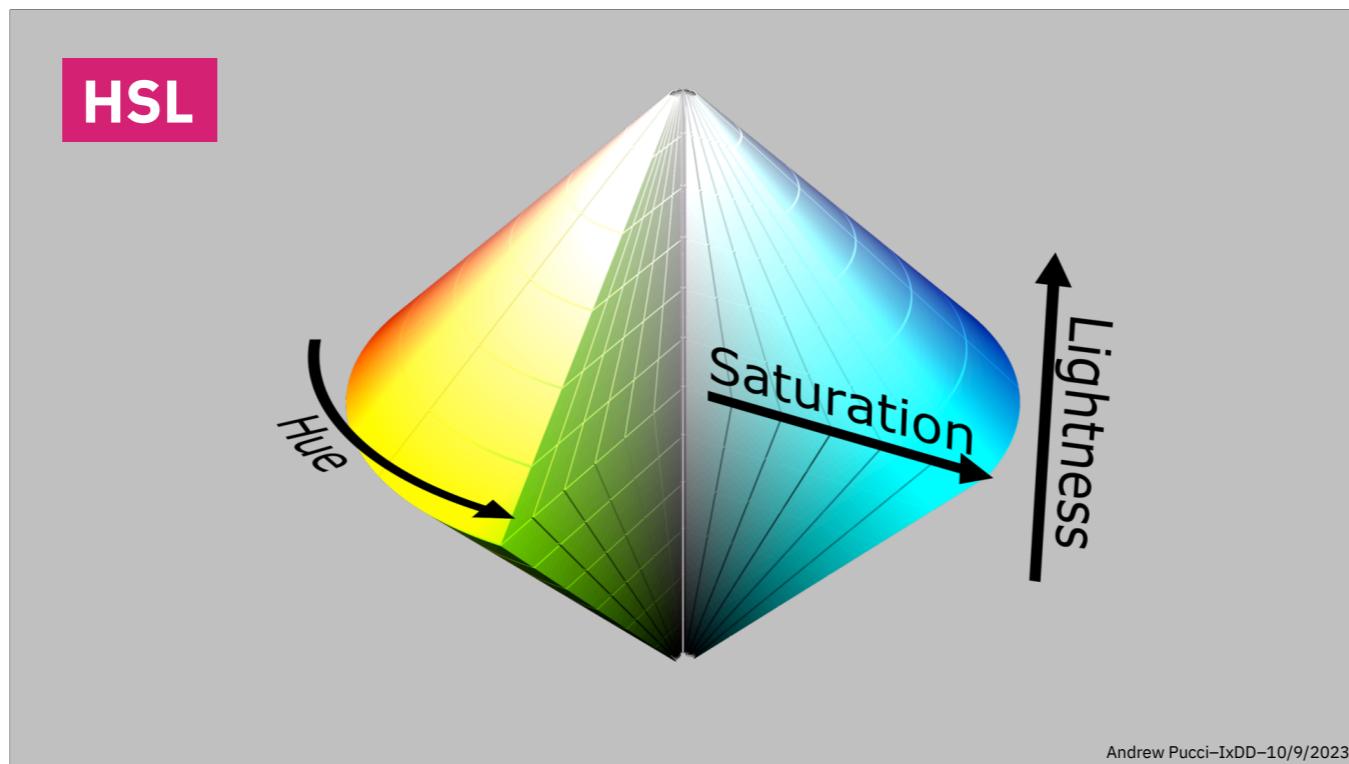
https://commons.wikimedia.org/wiki/File:SRGB_chromaticity_CIE1931.svg



https://commons.wikimedia.org/wiki/File:RGB_color_solid_cube.png

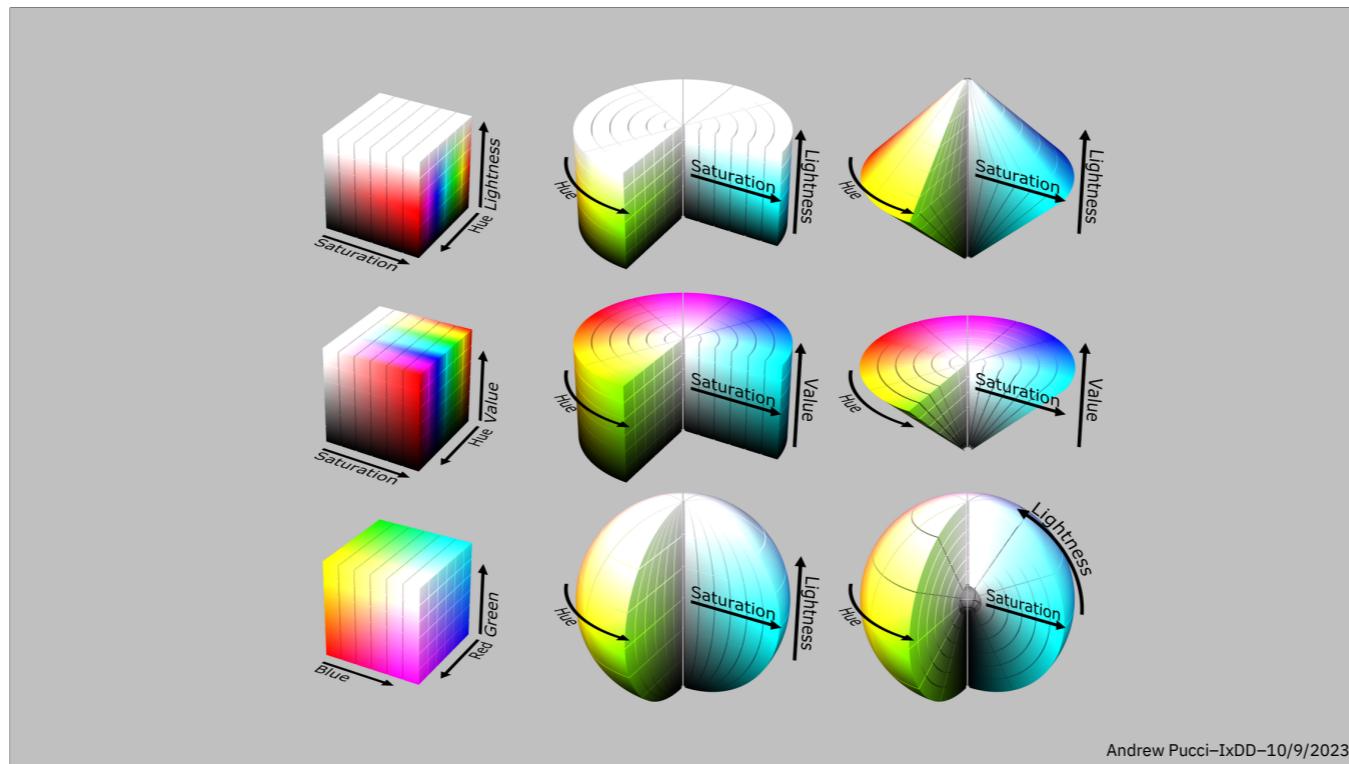


https://commons.wikimedia.org/wiki/File:HSV_color_solid_cone.png



Andrew Pucci–IxDD–10/9/2023

https://commons.wikimedia.org/wiki/File:HSL_color_solid_dblcone.png

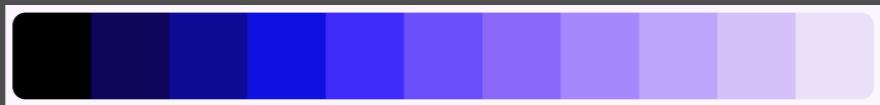


Andrew Pucci–IxDD–10/9/2023

https://commons.wikimedia.org/wiki/File:Color_solid_comparison_hsl_hsv_rgb_cone_sphere_cube_cylinder.png

LCH

- **L:** Lightness, **C:** Chroma, **H:** Hue
- Capable of representing the entire human visible color spectrum (so, susceptible to out of gamut colors)
- Perceptually linear lightness
- Can have issues with hue shift



Andrew Pucci-IxD-10/9/2023

LCH is a color space based on the HCL (Hue-Chroma-Luminance) color model.

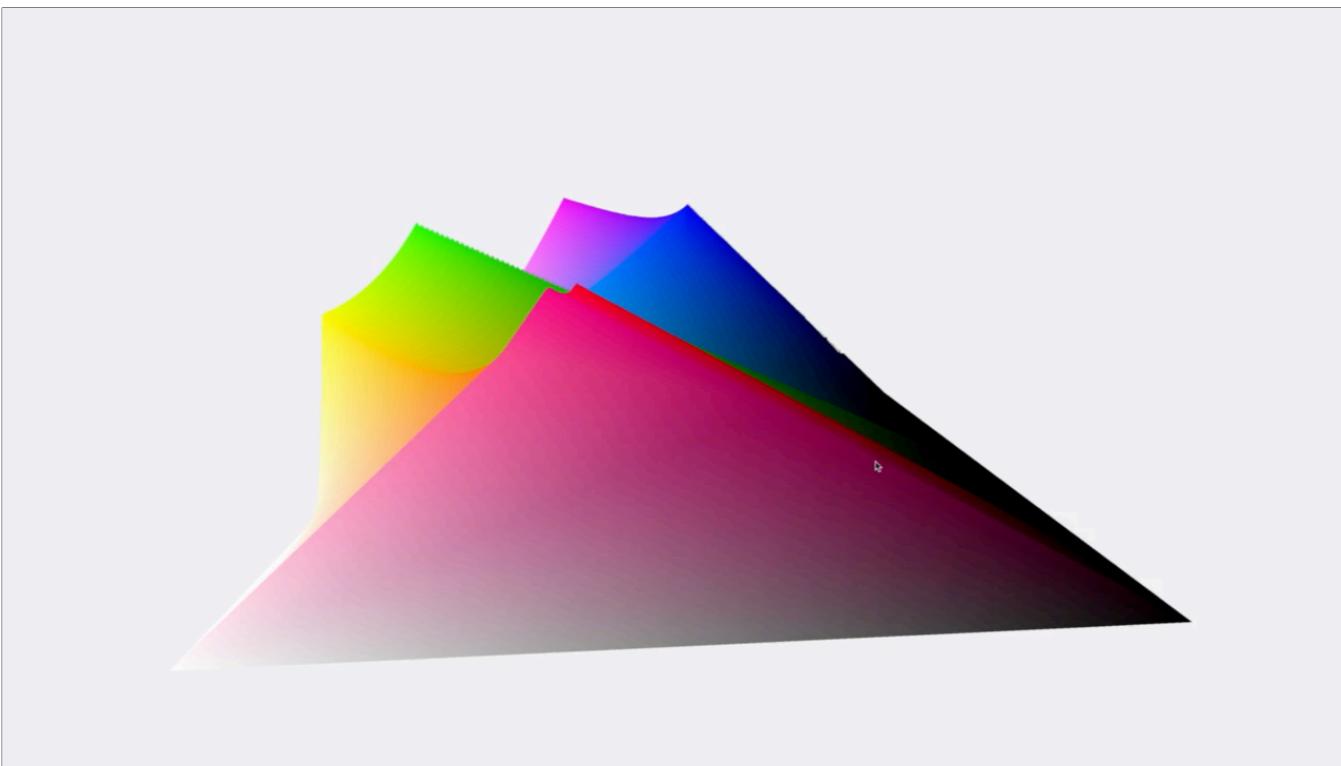
<https://atmos.style/blog/lch-vs-oklch>

OKLCH

- Developed in 2020, support in all mainstream browsers
- Very similar to LCH, with one notable exception: no hue shift



Andrew Pucci-IxD-10/9/2023



<https://oklch.com/>

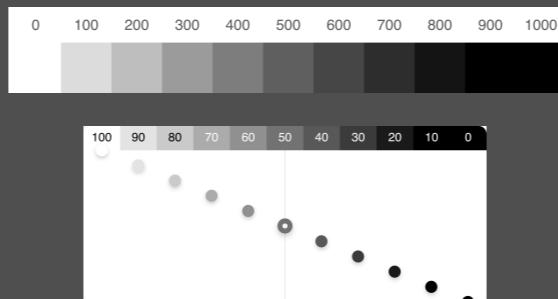
OKLCH

- $\#00a85d \approx \text{oklch}(64.2\% \ 0.162 \ 154.092)$
- L: number between 0 and 1 (or percentage)
C: number between 0 and ∞ , but practically 0.5 (or %)
H: number or angle

Andrew Pucci–IxDD–10/9/2023

Generating a lightness ramp

- How many stops do you want in your ramp?
- For a linear distribution, split the difference evenly.



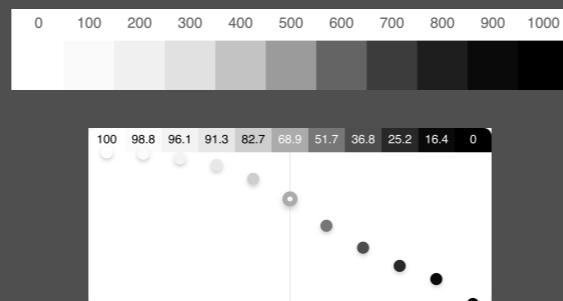
Andrew Pucci–IxDD–10/9/2023

Color palette generator: <https://huetone.ardov.me/>

Generating a lightness ramp

- Or, get fancy and generate a cubic-bezier to represent an easing function that will give you more UI flexibility

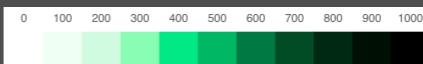
cubic-bezier(0.6, 0.05, 0.44, 0.75)



Andrew Pucci—IxD—10/9/2023

<https://cubic-bezier.com/#.6,.05,.44,.75>

Creating a single-hue ramp



- For each lightness in your ramp, you can create a new color by adjusting the hue and chroma values
- Change H to the angle matching the color you want (use a converter to help you find that out)
- Change C to 0.5 (which is higher than the realistic max), then clamp the chroma value to one that is in gamut (using a library like Culori)

Andrew Pucci–IxDD–10/9/2023

<https://cubic-bezier.com/#.6,.05,.44,.75>

Creating many hue ramps

- Across hues, max chroma values will vary for each lightness value
- Try averaging the resulting clamped chroma values for each ramp at each lightness to remove chroma highlighting

Andrew Pucci–IxDD–10/9/2023

Color Palette Builders

- <https://www.colorbox.io/>
- <https://toolness.github.io/accessible-color-matrix/>
- <https://randoma11y.com/>
- <https://codepen.io/andrewpucci/full/xxQqjvr>

Andrew Pucci-IxD-10/9/2023

ColorBox: Feature rich builder from a former designer at Lyft

Accessible color palette builder: comes out of work done at 18F. Very easy to read and shareable through auto-updated URL when changes are made

Randoma11y: This is more just for inspiration

Andrew's CodePen: This is very much still a demo, but will be getting some work done on it soon to open source as a more feature filled tool

Demo

<https://codepen.io/andrewpucci/full/xxQqjvr>

Andrew Pucci—IxD—10/9/2023

Thank you!



[/in/andrewpucci](https://www.linkedin.com/in/andrewpucci)

andrewpucci.com

Andrew Pucci—IxD—10/9/2023