

Color

DS 4200

FALL 2020

Prof. Cody Dunne

NORTHEASTERN UNIVERSITY

Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague

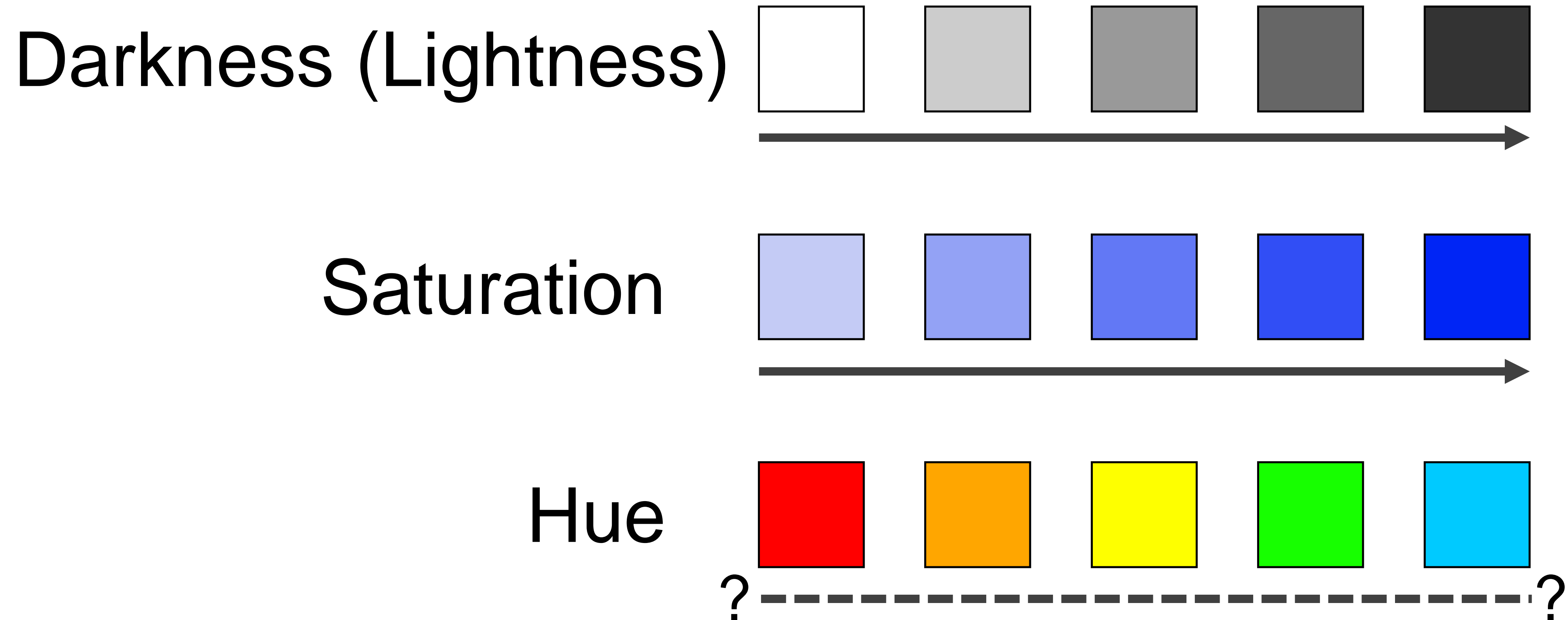
CHECK-IN

BRUSHING & LINKING SOLUTION

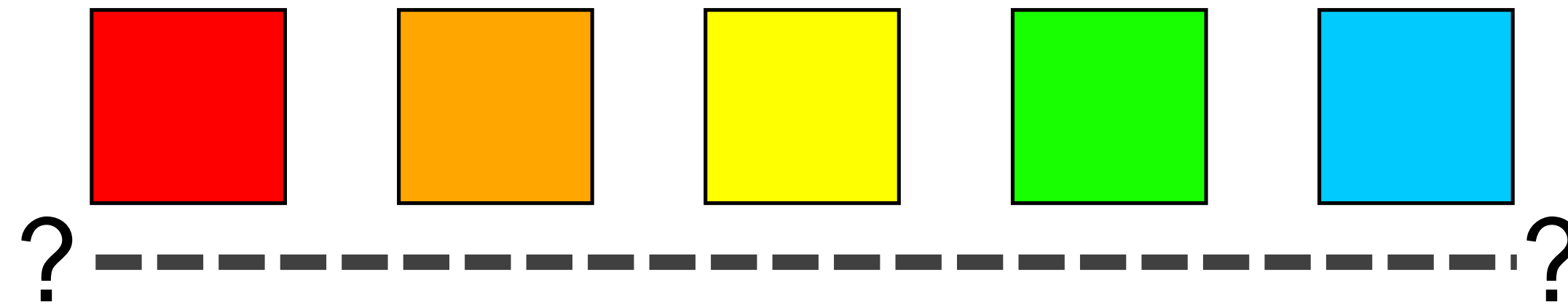
PREVIOUSLY, ON DS 4200...

“...avoiding catastrophe becomes the first principle in bringing color to information: above all, do no harm.”
-Edward Tufte

Color Vocabulary and Perceptual Ordering



Rainbow Color Map (Hue)



Why this color map is a poor choice for quantitative data...

- No perceptual ordering (confusing)
- No darkness variation (obscures details)
- Viewers perceive sharp transitions in color as sharp transitions in the data, even when this is not the case (misleading)

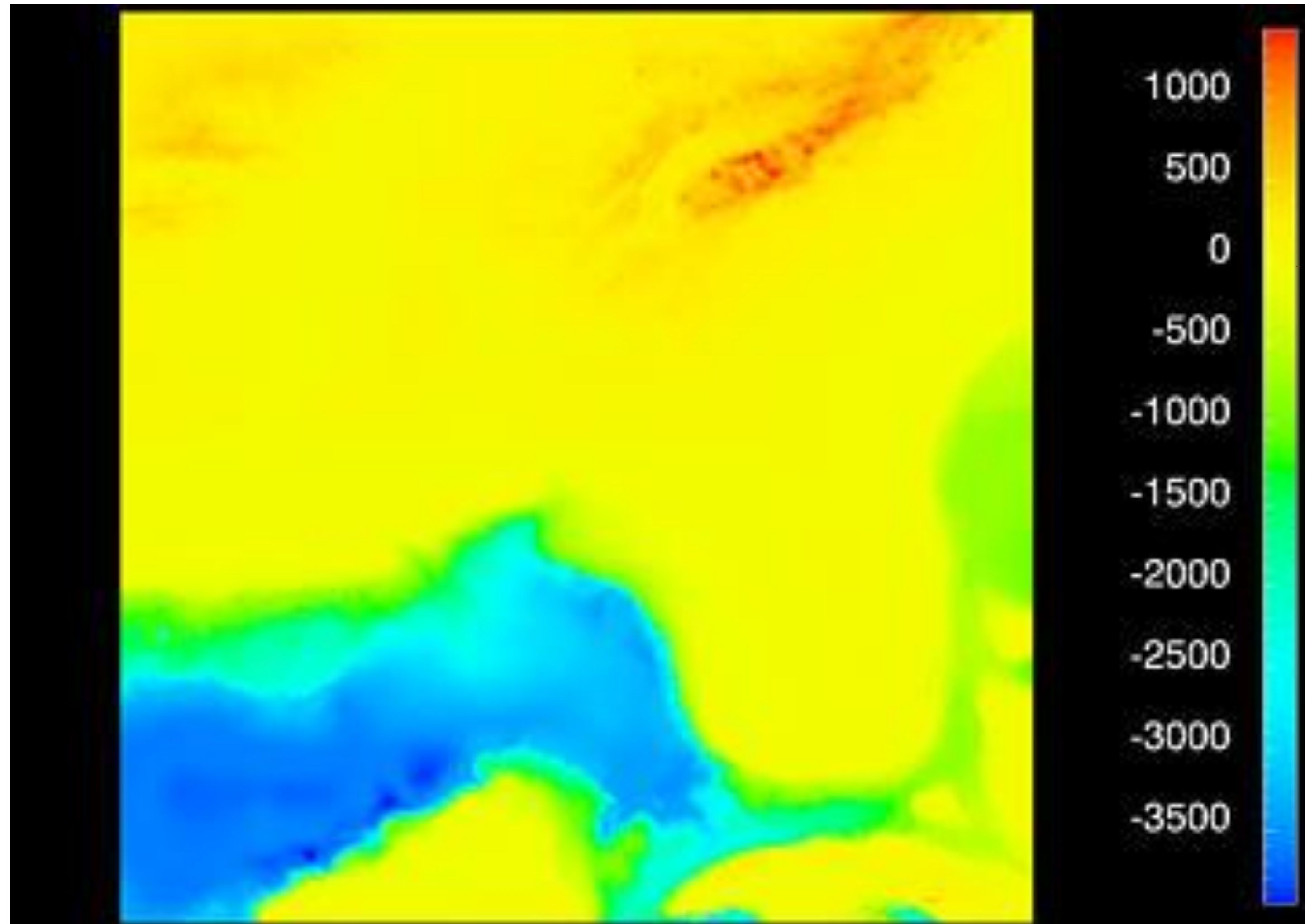
Now, ON DS 4200...

COLOR

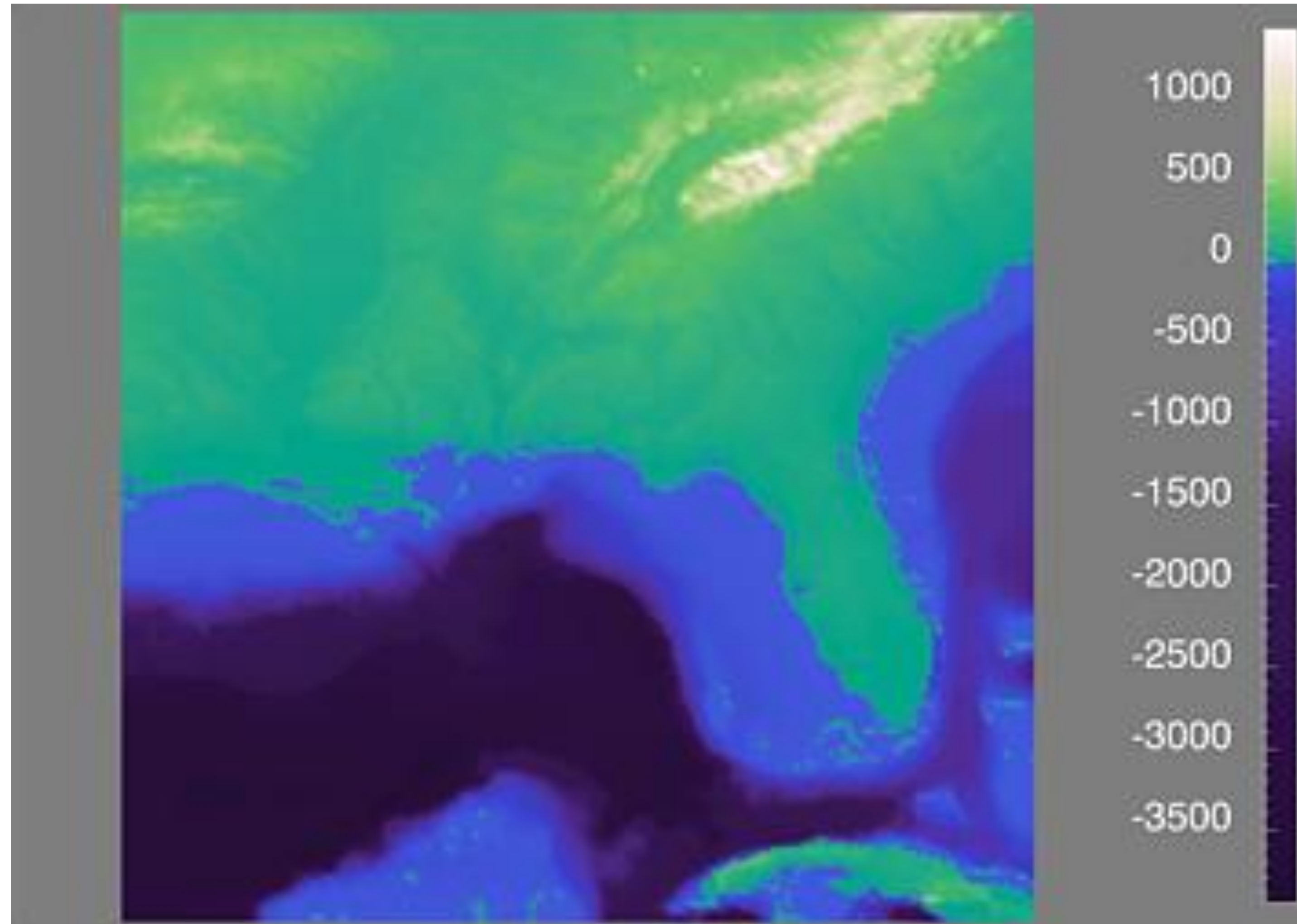
GOALS FOR TODAY: LEARN HOW...

- ...to effectively use color as a channel for visual encodings including different colormap types.
- ...we process color in the visual system.
- ...individual color differences (i.e., colorblindness) should be accommodated in visualizations.
- ...interactions can occur between colors and with lighting.
- ...illusions and tricks can affect perception.

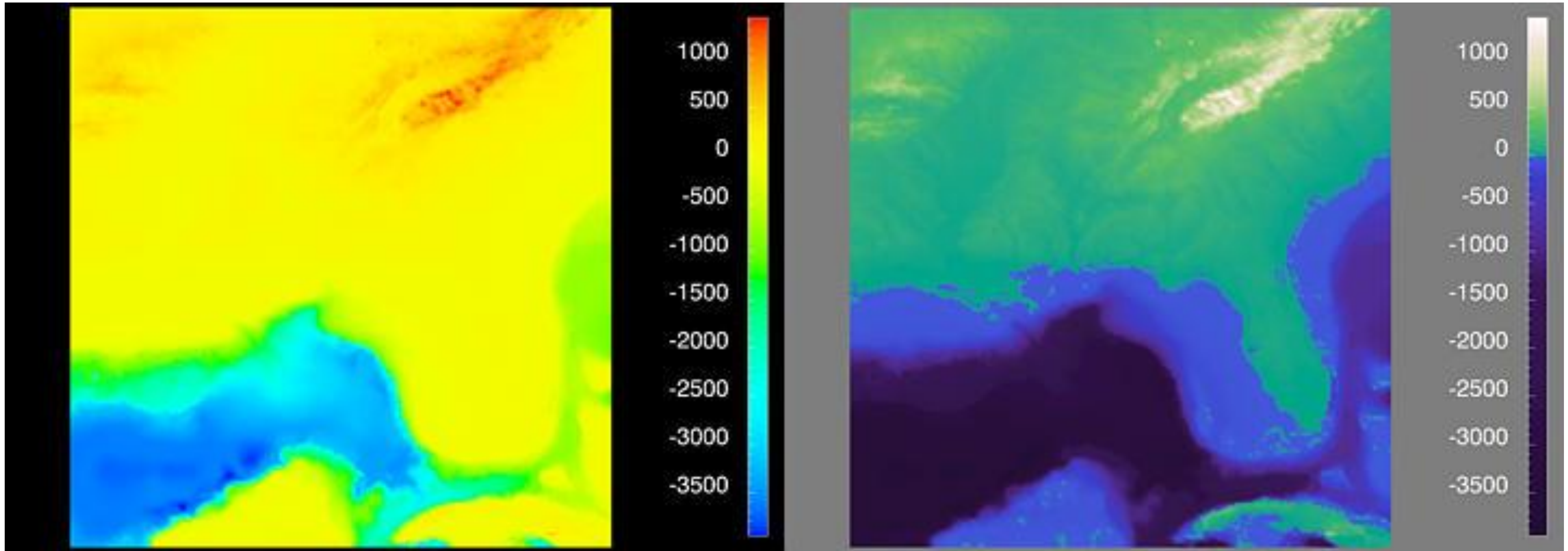
Color Maps



Color Maps



Color Maps

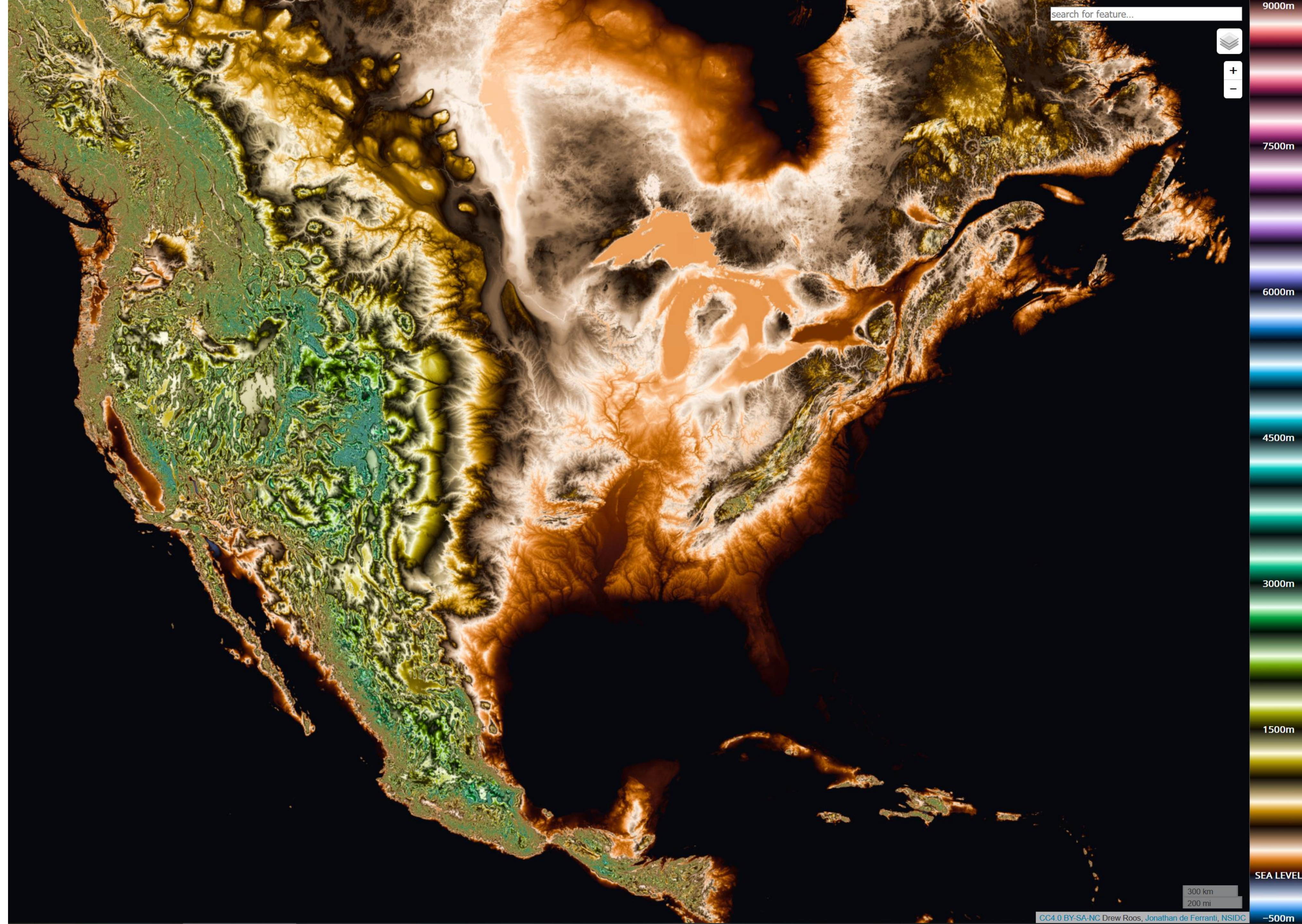


Sequential (possibly wrong)

Diverging

Sequential rainbow (wrong!)





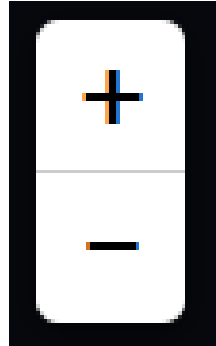

IN-CLASS EXERCISE

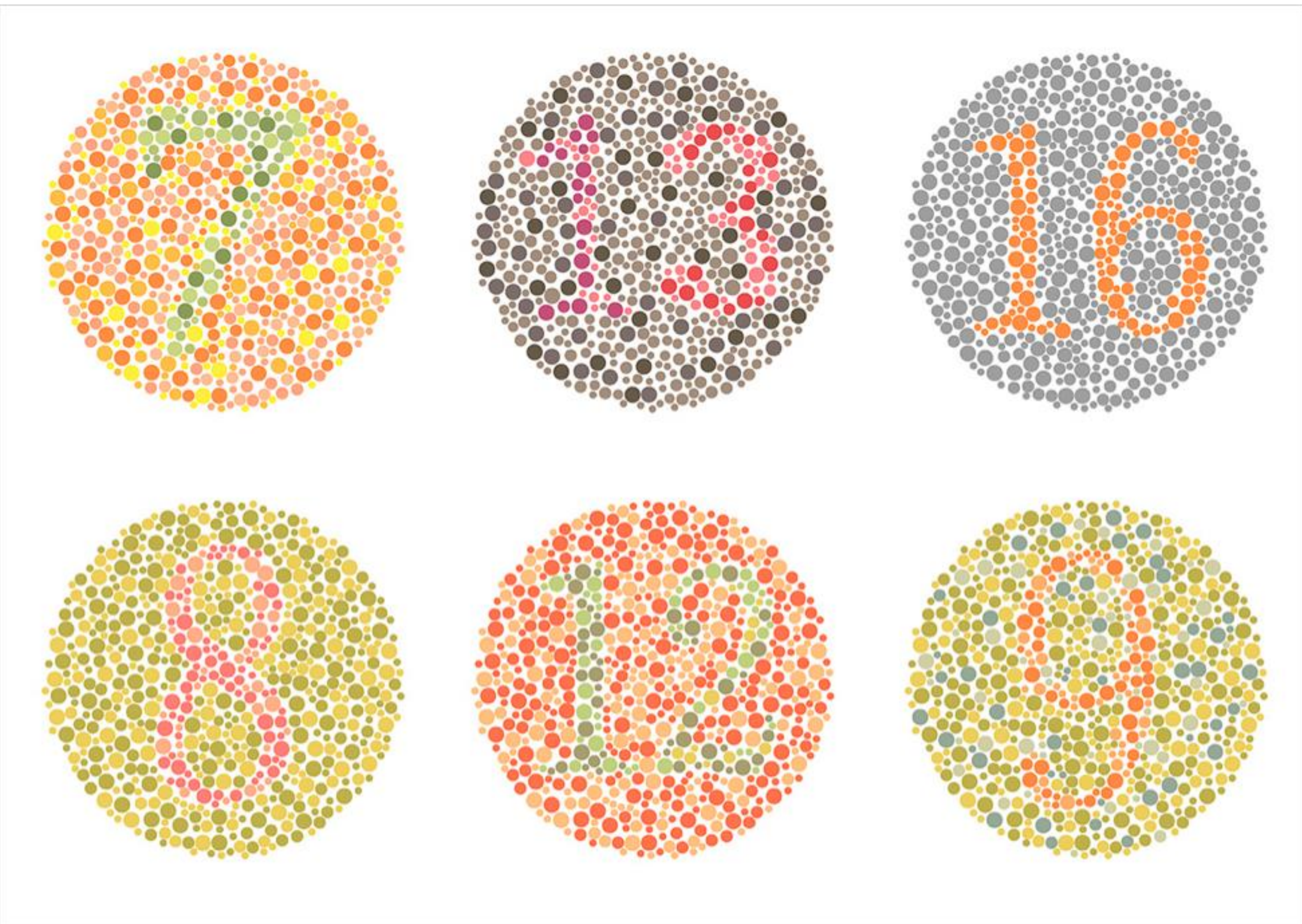
In-class exercise: Oilslick

10m



INSTRUCTIONS:

- Working individually, go to <https://mrgris.com/projects/oilslick/>
- Experiment with the different layers, different zoom levels, and different locations

- Think of answers to these questions:
 - What areas are particularly interesting?
 - Which layer / color scale works best, and for which tasks?
- Several of you will be asked to share your findings.



Those with deuteranope color blindness (red/green) will have difficulty seeing the numbers.

Color Deficiencies (Color Blindness)

Person with faulty cones (or faulty pathways):

Protanope = faulty red cones



Tritanope = faulty blue cones

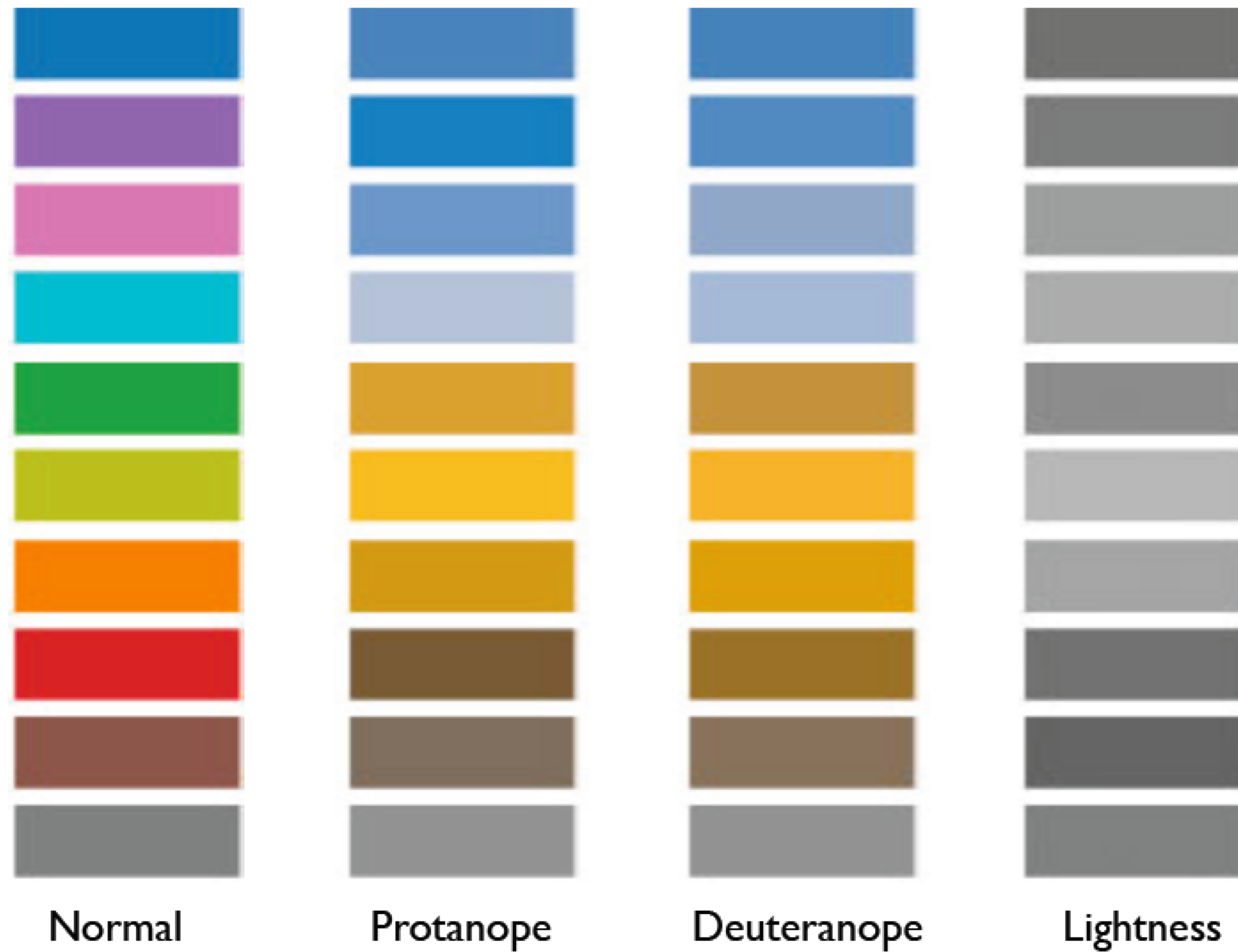


Deuteranope = faulty green cones

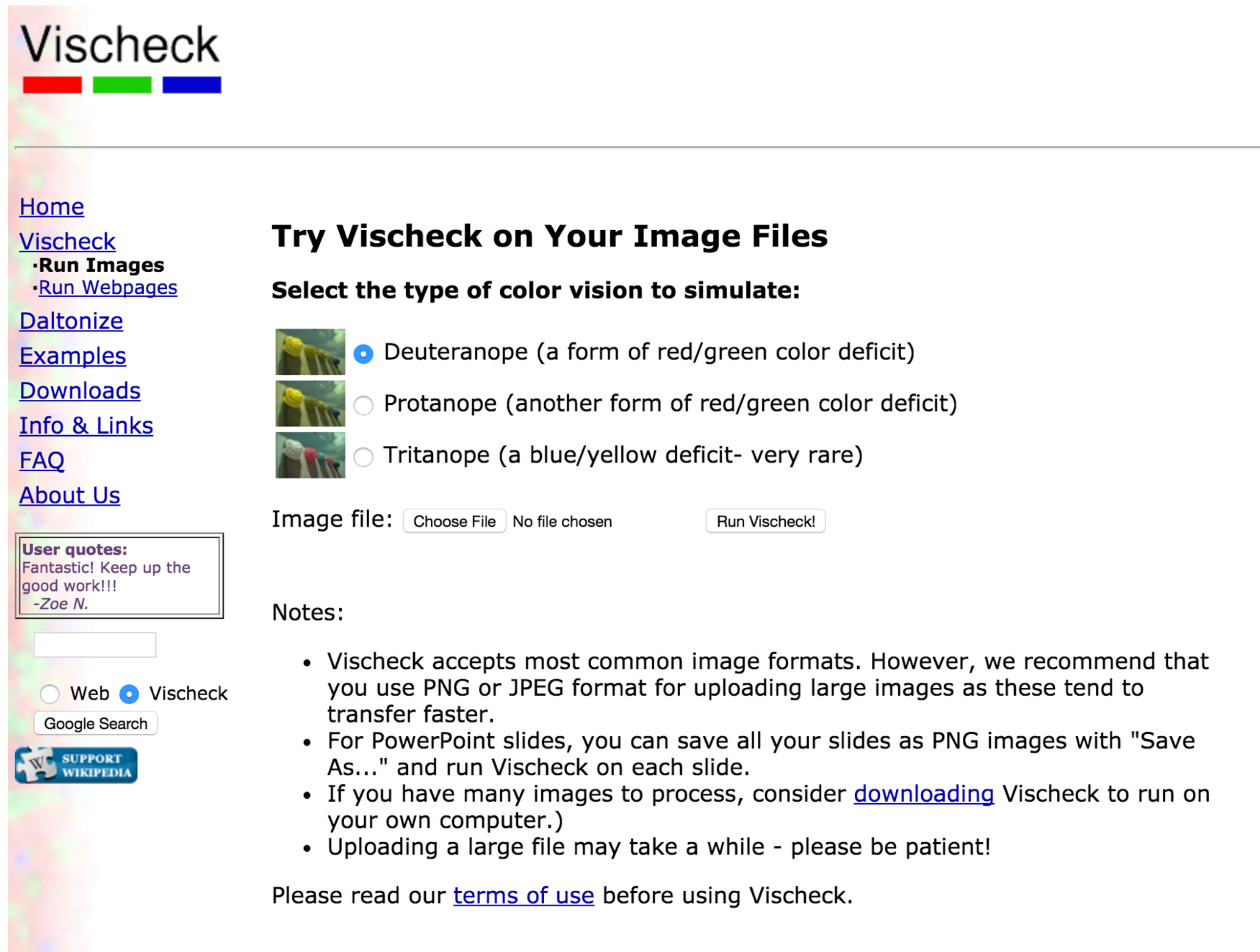


normal

Color Deficiencies (Color Blindness)



Check your images/colormaps for issues!



The Vischeck website features a header with the logo and three colored bars (red, green, blue). A left sidebar contains navigation links: Home, Vischeck (with sub-links for Run Images and Run Webpages), Daltonize, Examples, Downloads, Info & Links, FAQ, and About Us. Below these is a 'User quotes' box with a testimonial from Zoe N. and a search bar. At the bottom of the sidebar are radio buttons for 'Web' and 'Vischeck', a 'Google Search' button, and a 'SUPPORT WIKIPEDIA' button.

Try Vischeck on Your Image Files

Select the type of color vision to simulate:

- Deuteranope (a form of red/green color deficit)
- Protanope (another form of red/green color deficit)
- Tritanope (a blue/yellow deficit- very rare)

Image file: No file chosen

Notes:

- Vischeck accepts most common image formats. However, we recommend that you use PNG or JPEG format for uploading large images as these tend to transfer faster.
- For PowerPoint slides, you can save all your slides as PNG images with "Save As..." and run Vischeck on each slide.
- If you have many images to process, consider [downloading](#) Vischeck to run on your own computer.)
- Uploading a large file may take a while - please be patient!

Please read our [terms of use](#) before using Vischeck.



The Coblis website has a header with the logo and social media icons. A navigation menu includes Home, CVD Essentials, Color Blindness Tests, Color Tools, and Contact. The main content area features a search bar, an email subscription form, and a large heading: 'Coblis — Color Blindness Simulator'. Below this is a paragraph explaining the simulator's purpose and a note about local machine calculations. A 'FREE Color Blind Check' section is also visible, featuring a color calibration chart and a target icon.

Coblis — Color Blindness Simulator

If you are not suffering from a color vision deficiency it is very hard to imagine how it looks like to be colorblind. The **Color BL**indness Simulator can close this gap for you. Just play around with it and get a feeling of how it is to have a color vision handicap.

As all the calculations are made on your local machine, no images are uploaded to the server. Therefore you can use images as big as you like, there are no restrictions. Be aware, there are some issues for the "Lens feature" on Edge and Internet Explorer. All others should support everything just fine.

So go ahead, choose an image through the upload functionality or just drag and drop your image in the center of our **Color BL**indness Simulator. It is also possible to zoom and move your images around using your mouse - try it out, I hope you like it.

Drag and drop or paste your file in the area below or: No file selected.

Trichromatic view:	Anomalous Trichromacy:	Dichromatic view:	Monochromacy:
<input checked="" type="radio"/> Normal	<input type="radio"/> Red-Weak/Protanomaly	<input type="radio"/> Red-Blind/Protanopia	<input type="radio"/> Monochromacy
	<input type="radio"/> Green-Weak/Deuteranomaly	<input type="radio"/> Green-Blind/Deuteranopia	<input type="radio"/> Blue-Congenital
	<input type="radio"/> Blue-Weak/Tritanomaly	<input type="radio"/> Blue-Blind/Tritanopia	

Use lens to compare with normal view: No Lens Normal Lens Inverse Lens [Reset View](#)

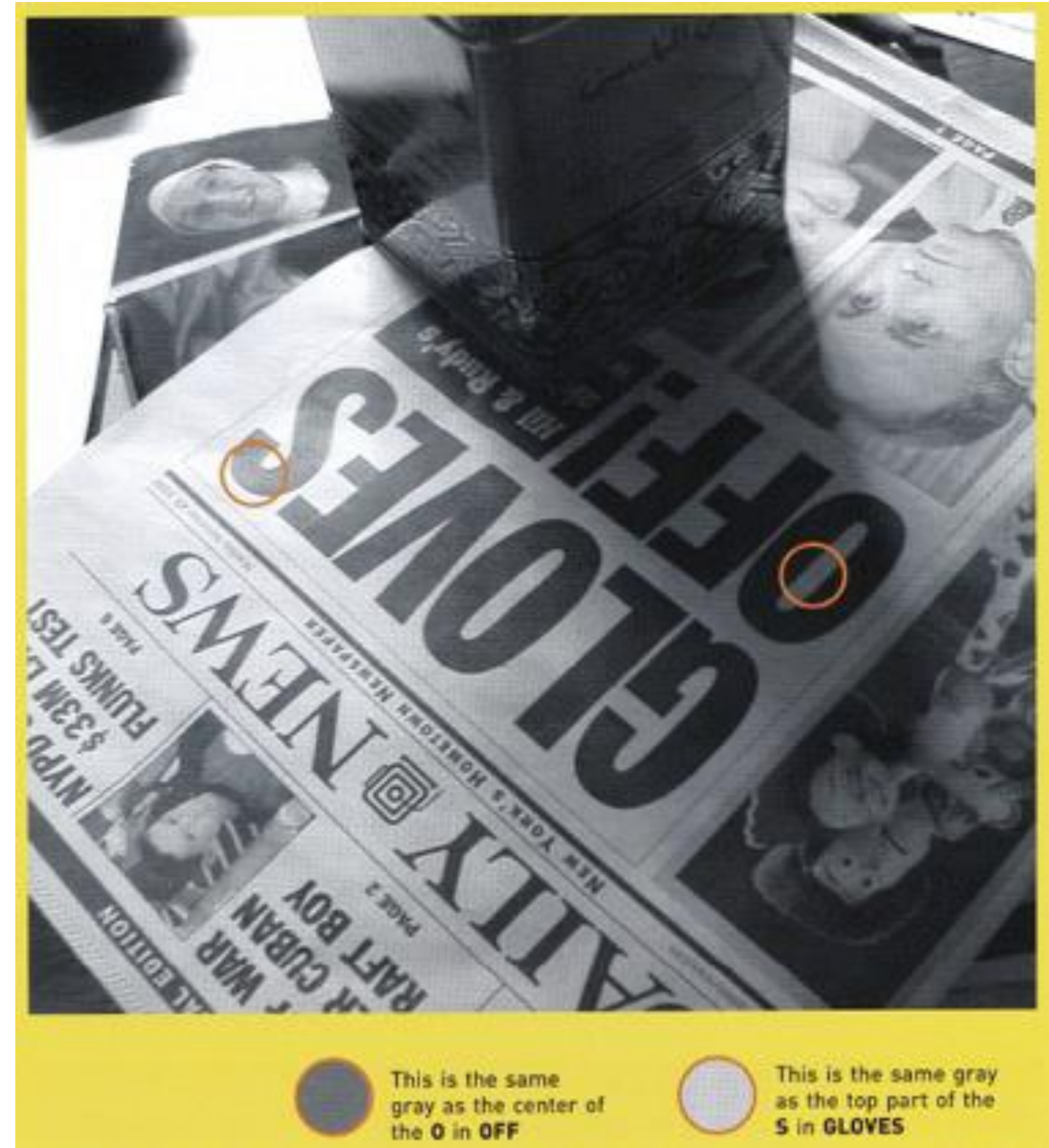
FREE Color Blind Check

New kind of color blindness test! Try **Color Blind Check** and test type and severity of your color vision deficiency.

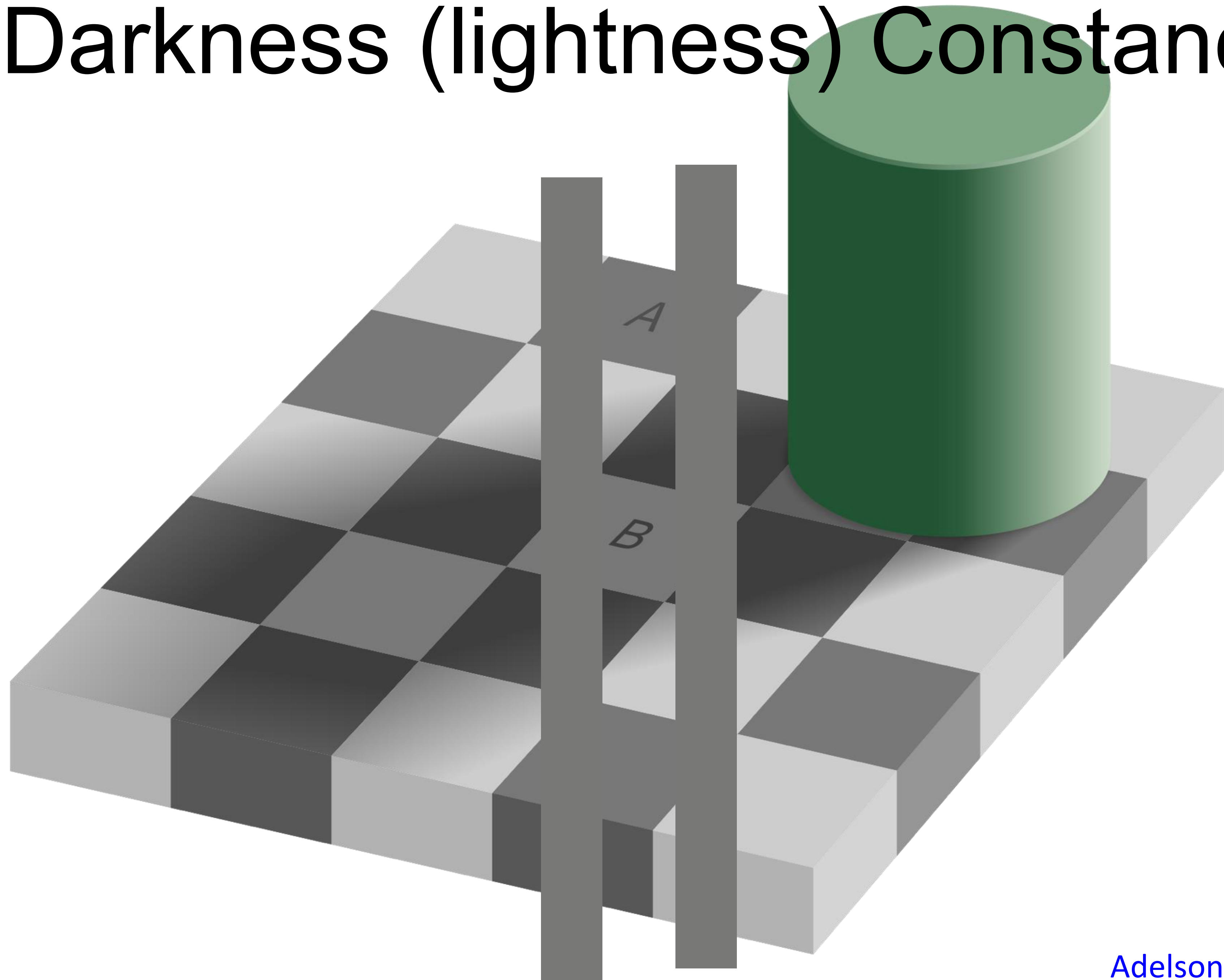
INTERACTIONS BETWEEN COLORS AND WITH LIGHTING

“Lightness Constancy”

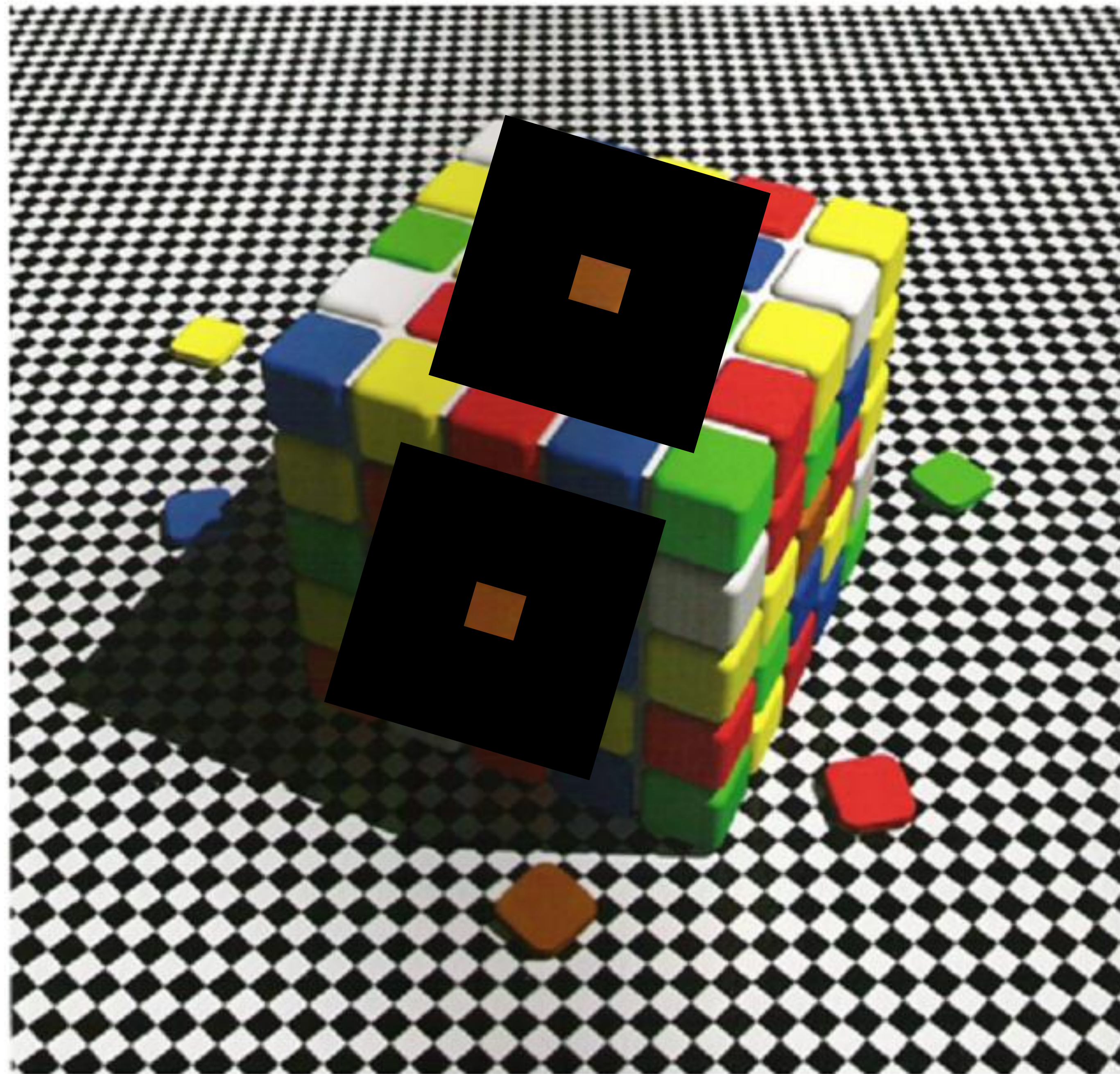
The perception that the apparent brightness of light and dark surfaces remains more or less the same under different luminance conditions is called **darkness (lightness) constancy**.



“Darkness (lightness) Constancy”



“Color Constancy”



“Simultaneous Contrast”



“Simultaneous Contrast”

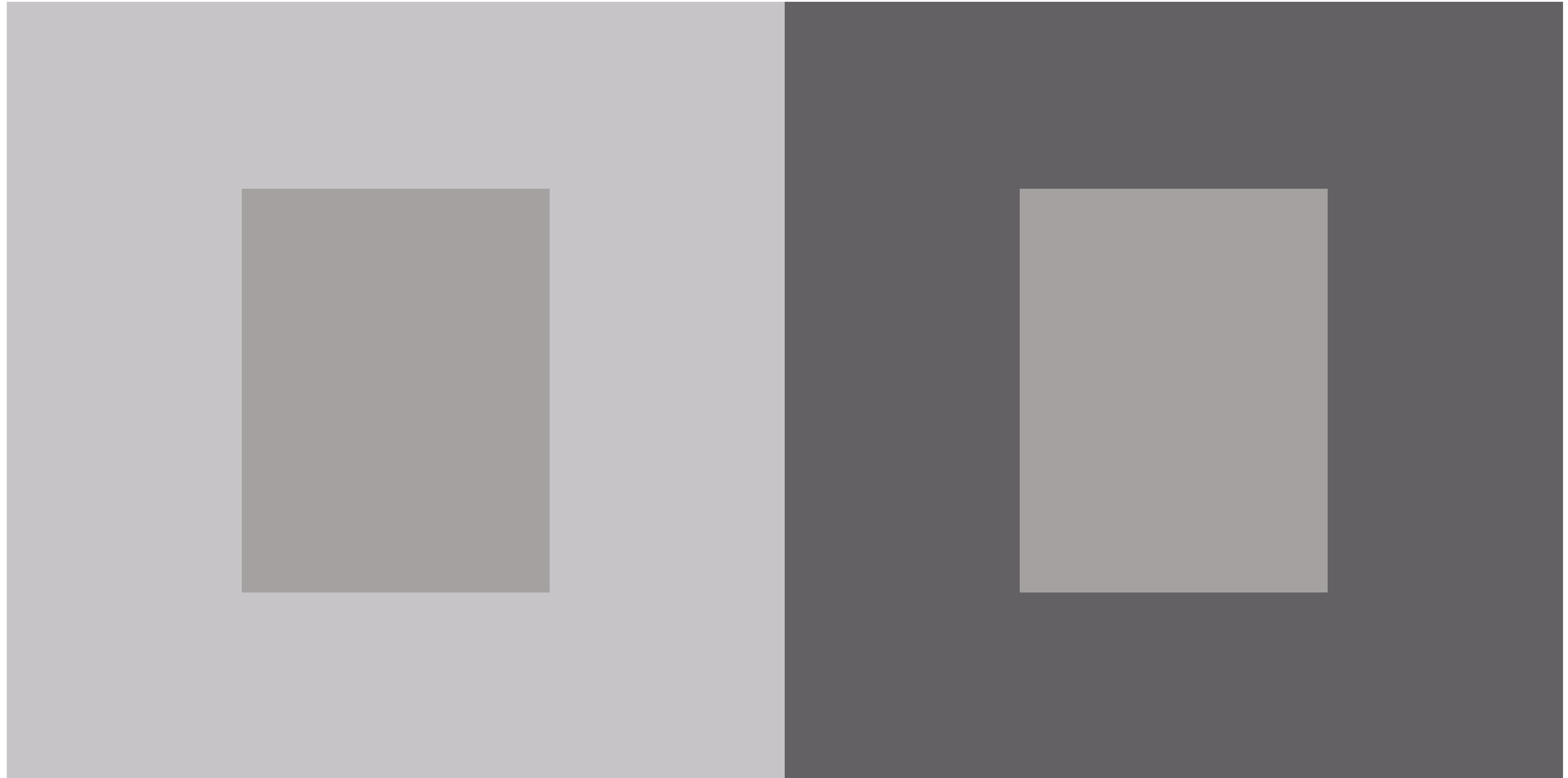


“Simultaneous Contrast”

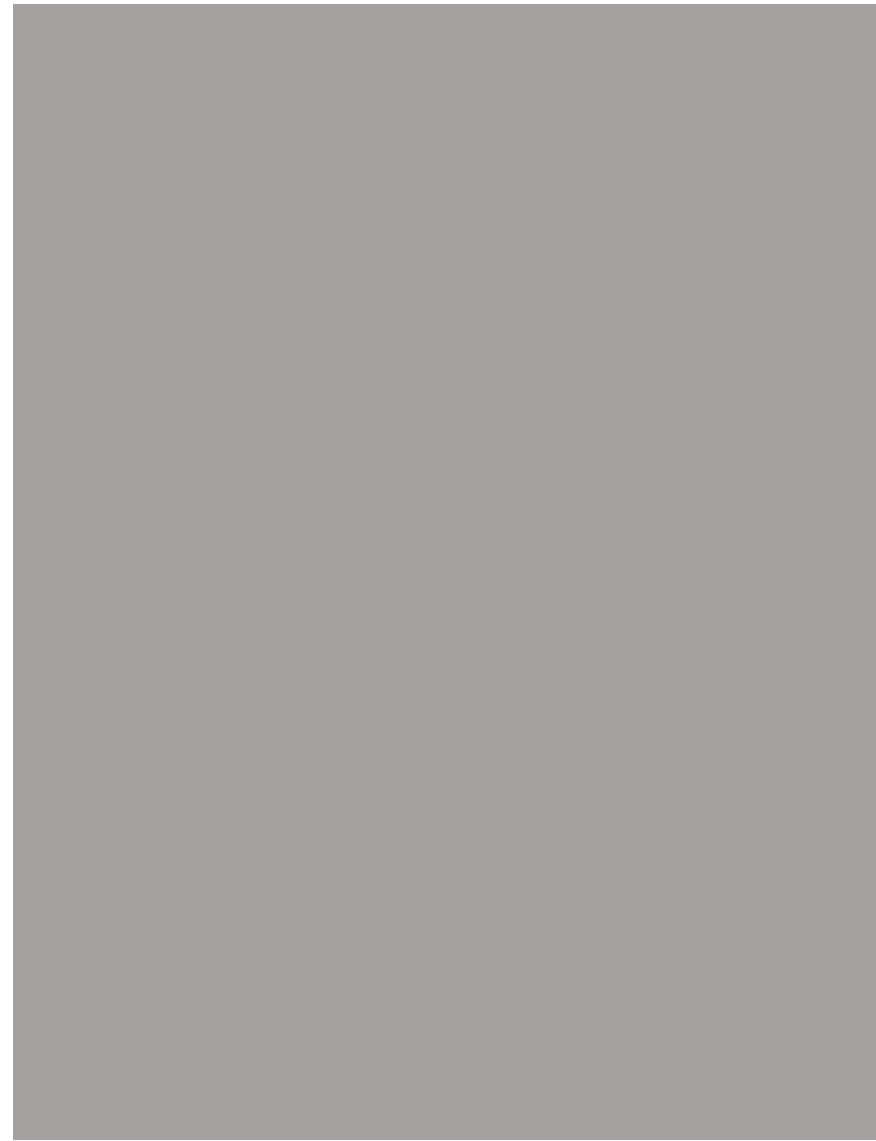


Avoid gradients as backgrounds or bars!

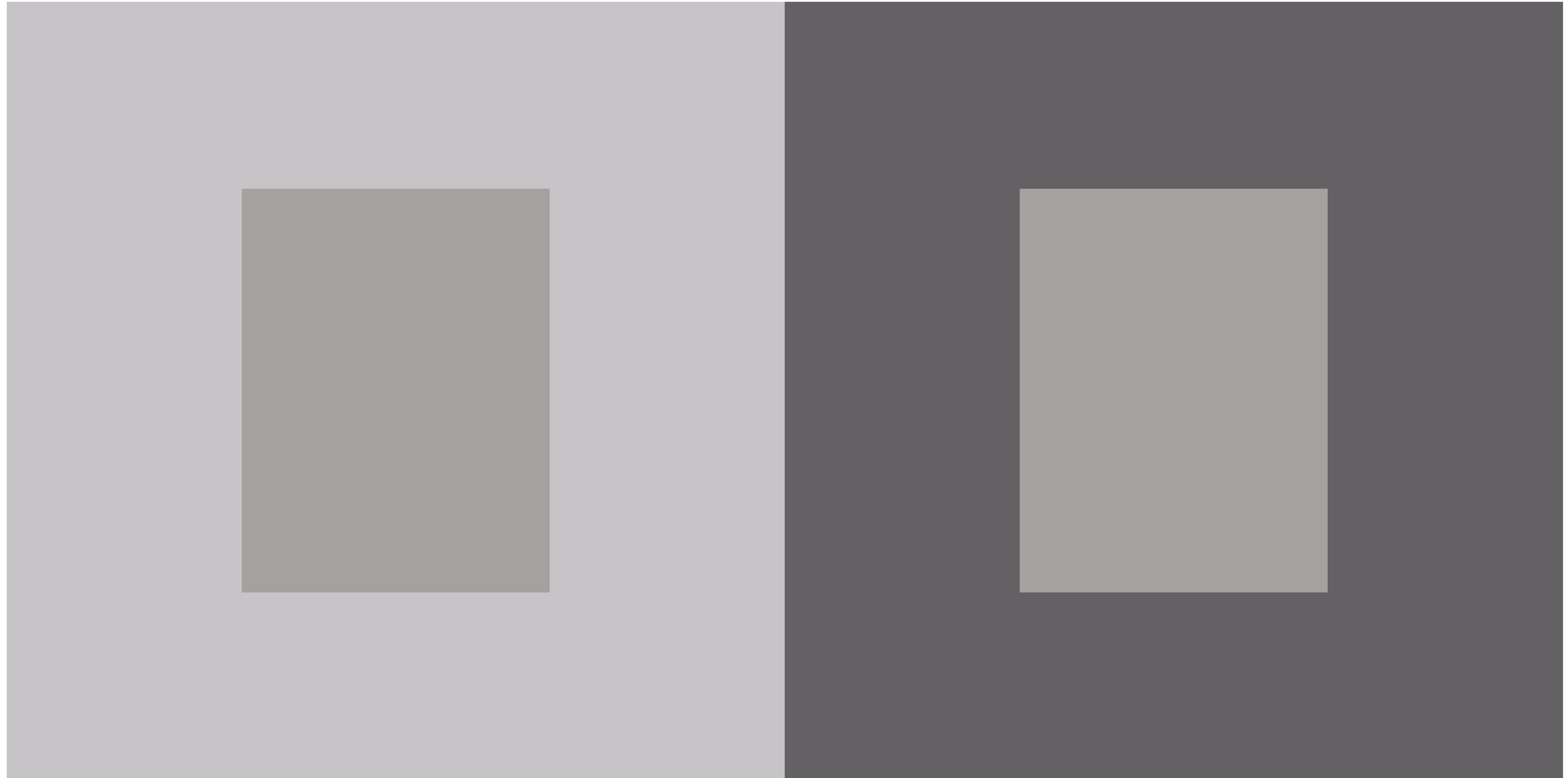
“Simultaneous Contrast”



“Simultaneous Contrast”



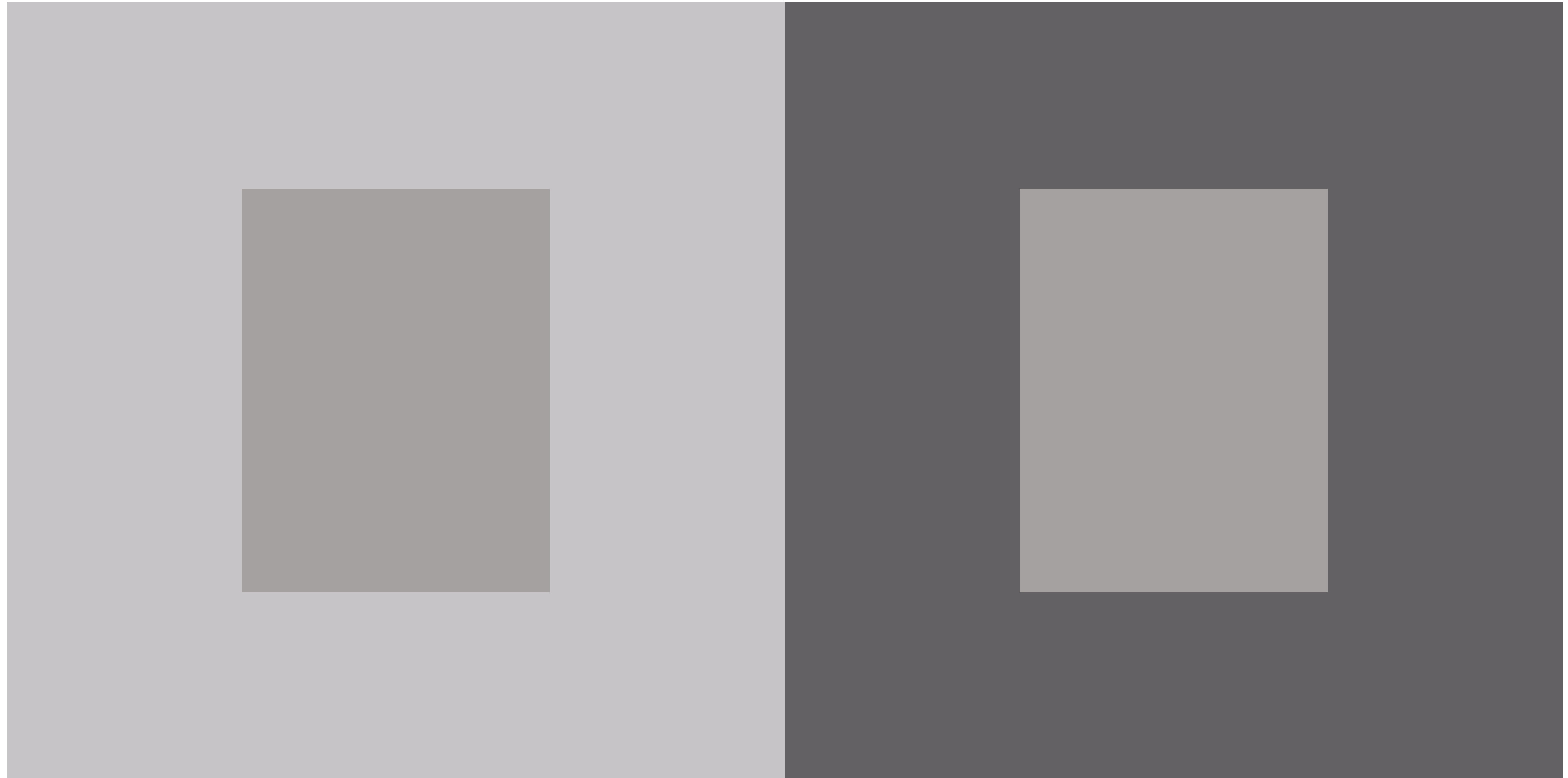
“Simultaneous Contrast”



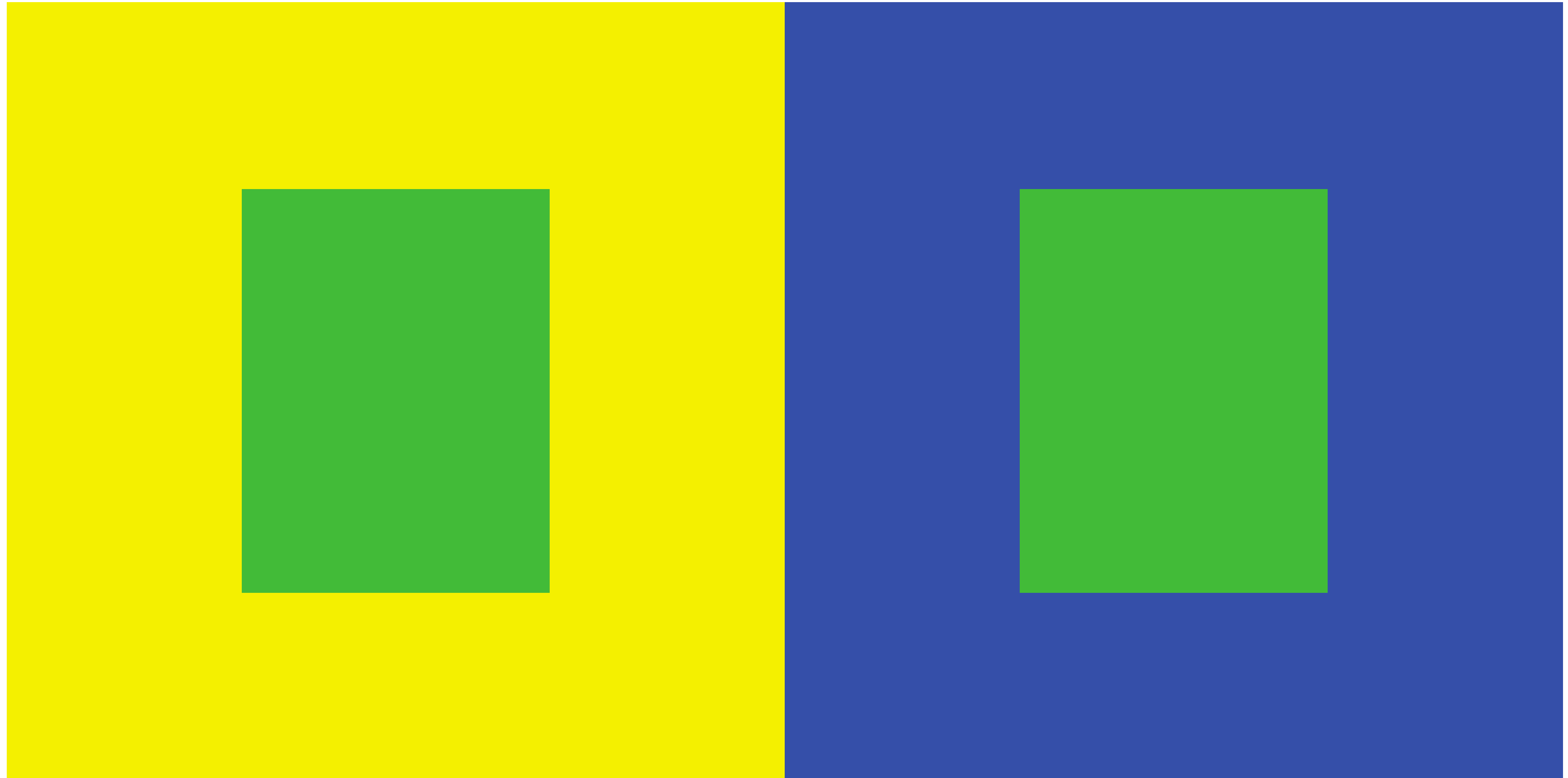
“Simultaneous Contrast”



“Simultaneous Contrast”



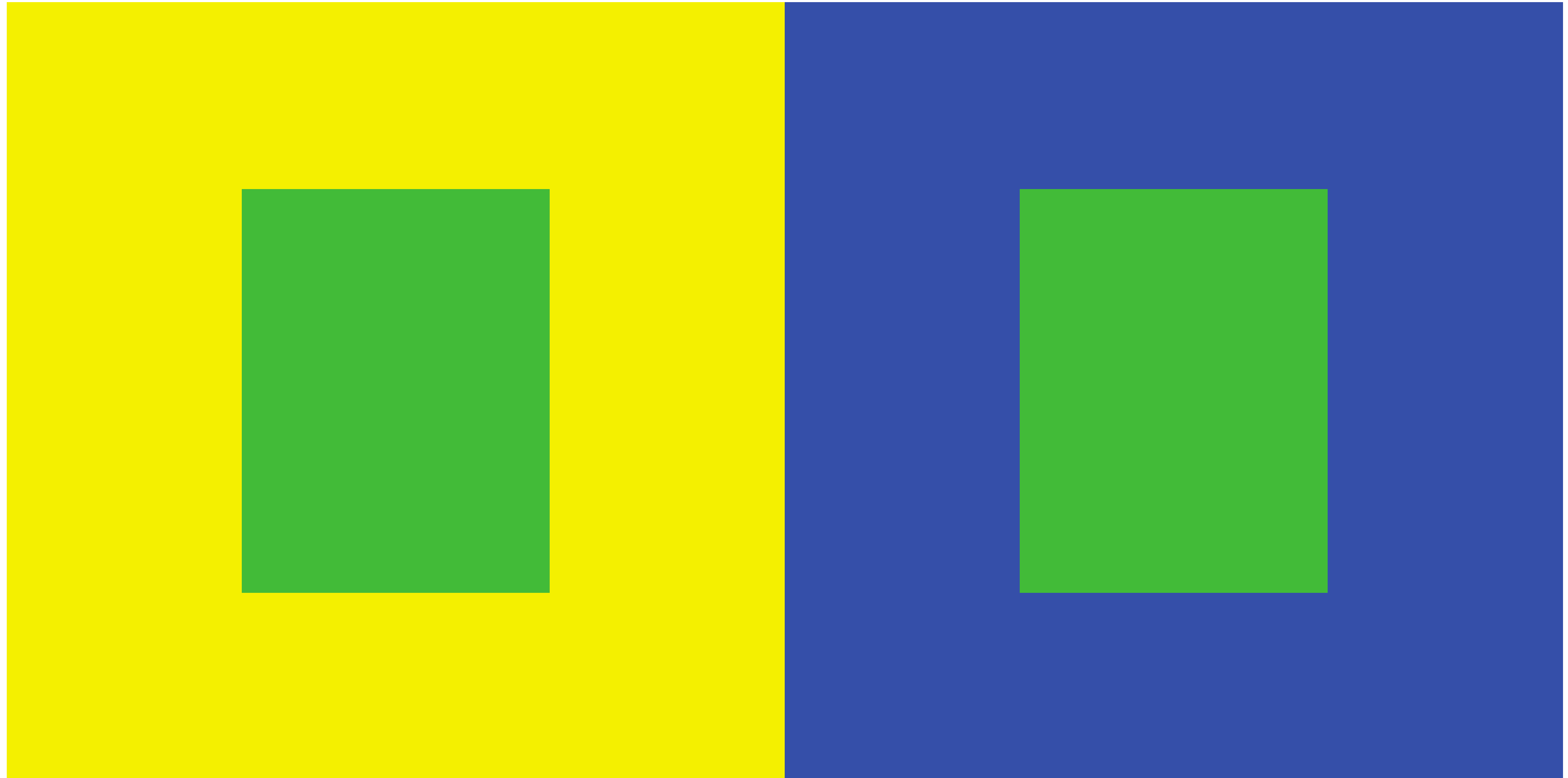
“Simultaneous Contrast”



“Simultaneous Contrast”



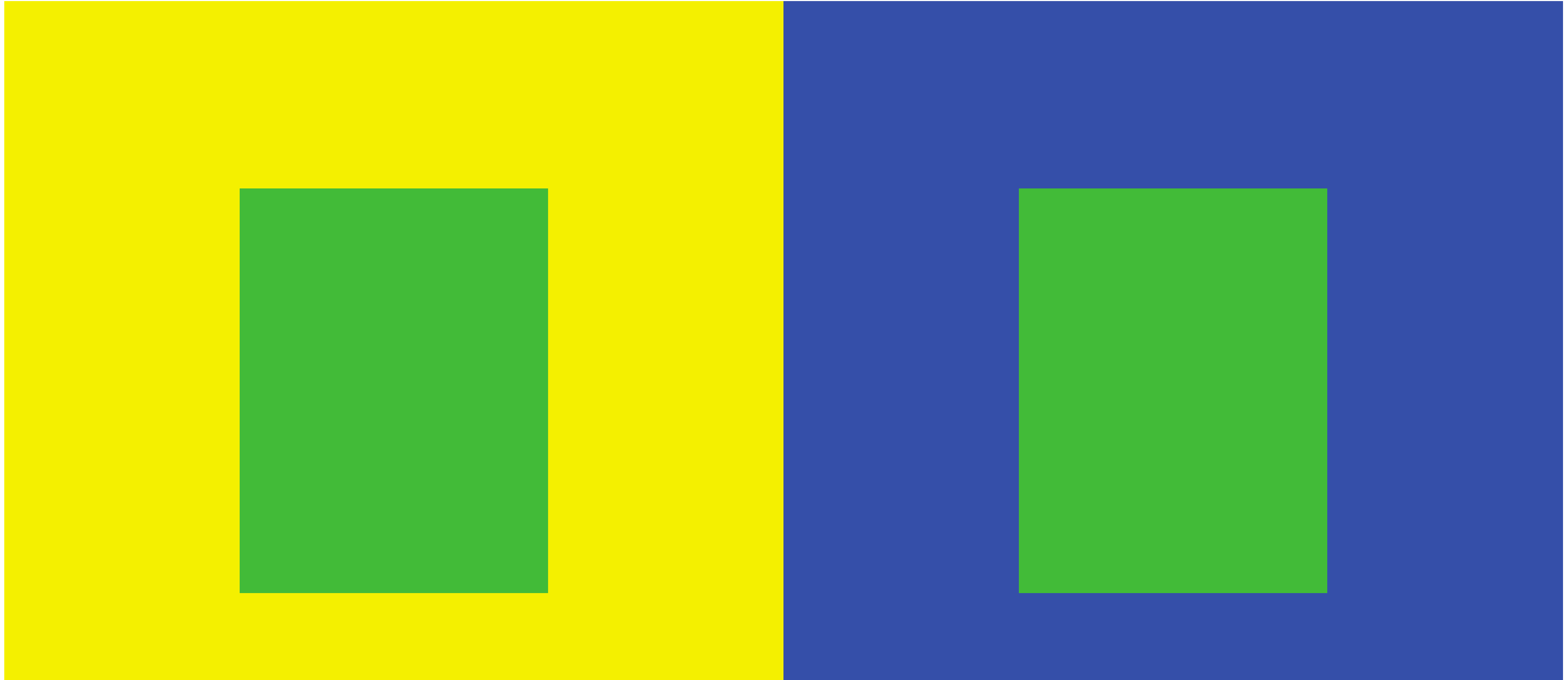
“Simultaneous Contrast”



“Simultaneous Contrast”



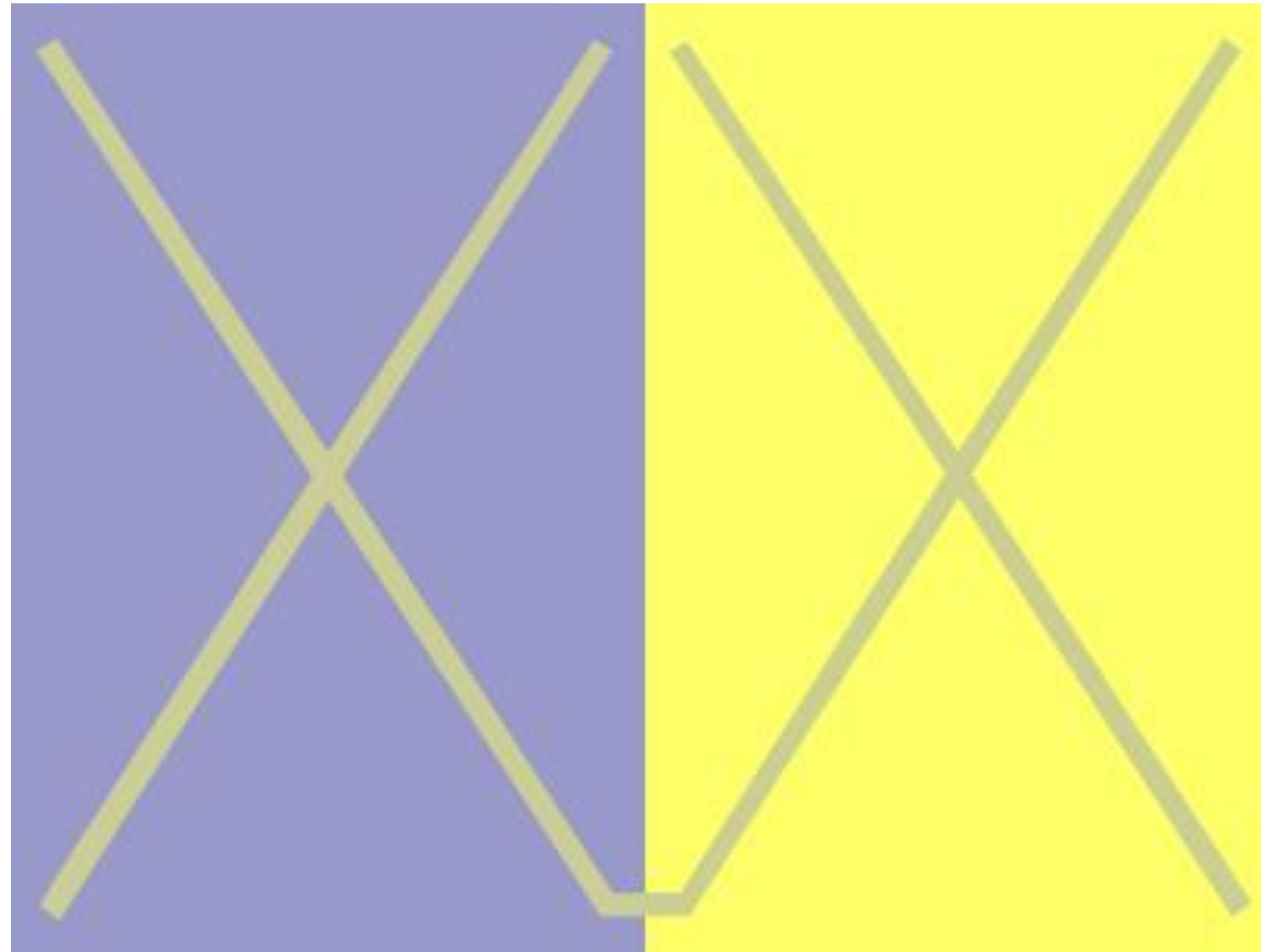
“Simultaneous Contrast”



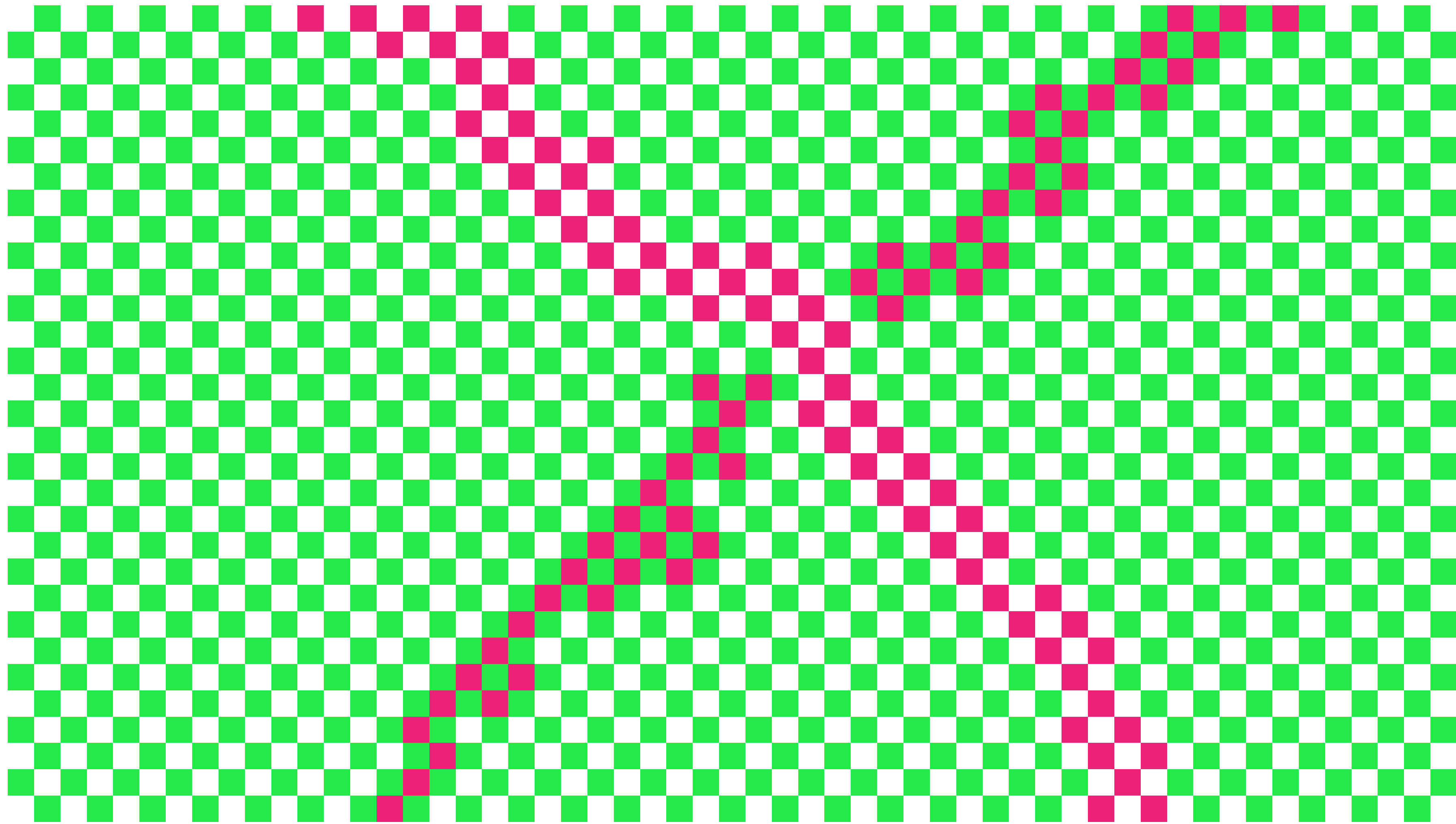
Be careful with bars and scatter plot points - the colors may appear differently with different background colors and neighboring colors!

Be aware that colors in legends may appear different than on the plot!

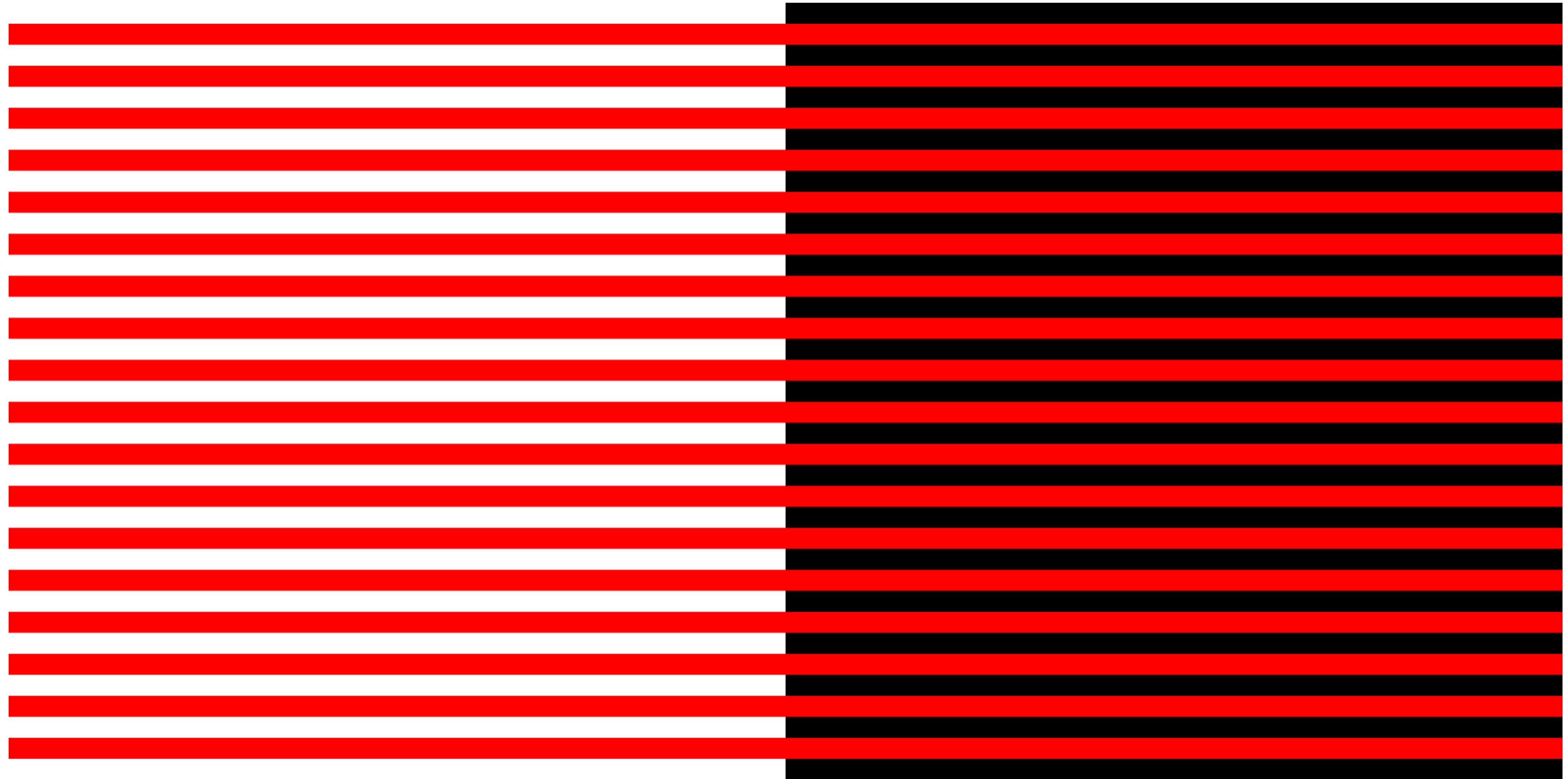
“Simultaneous Contrast”



“Simultaneous Contrast”



“von Bezold Spreading Effect”



“von Bezold Spreading Effect”



Be careful with colors in scatter plots!

Be aware of color changes when adding borders around bars and plots!

Be aware that colors in legends may appear different than on the plot!

Which area is larger
(green or red)?

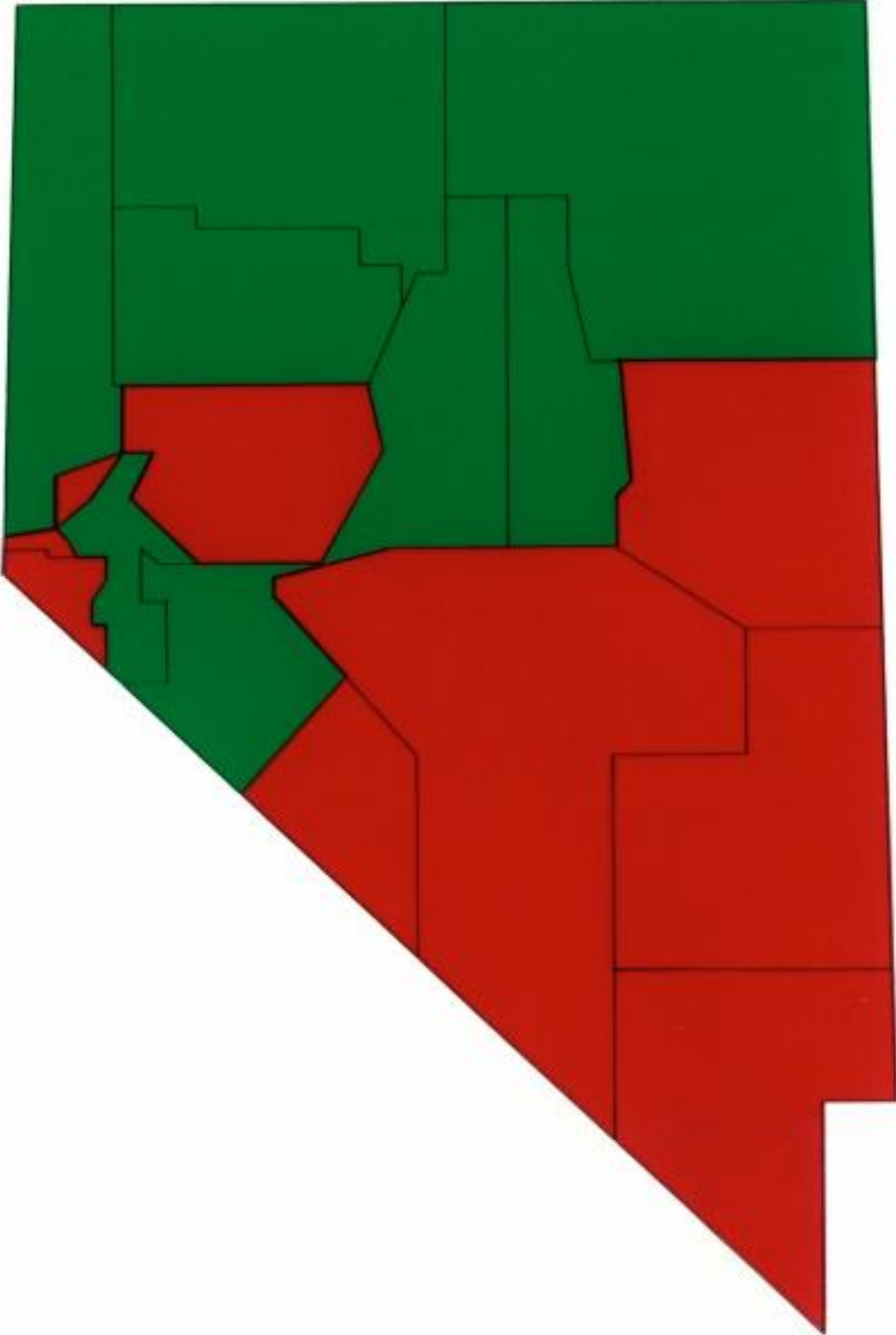


Figure 1. Stimulus From the High-Saturation Group

Which area is larger?

Areas are equal(!).

Study participants favored red in the highly saturated case (left) but were more correct with the desaturated case (right)

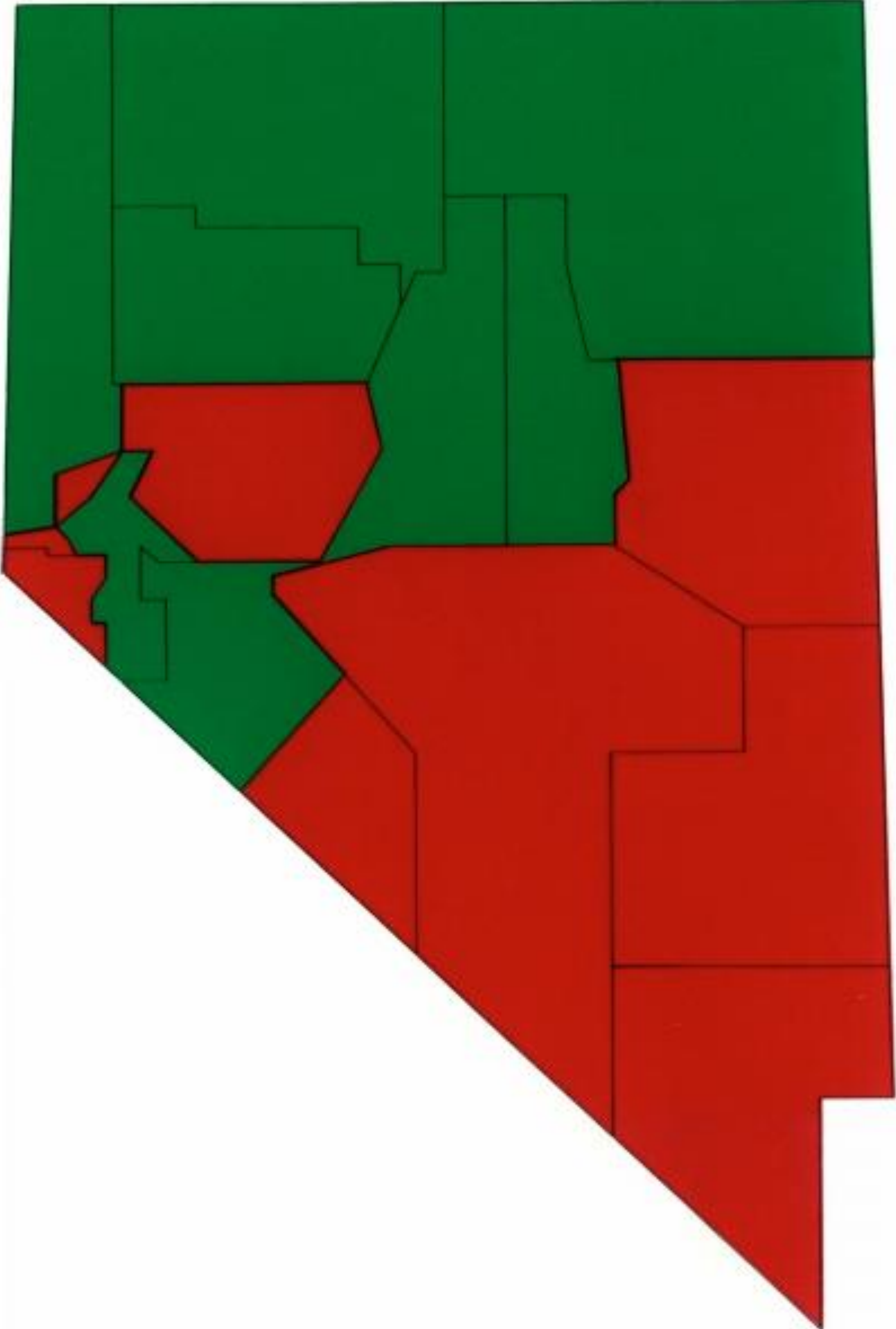


Figure 1. Stimulus From the High-Saturation Group

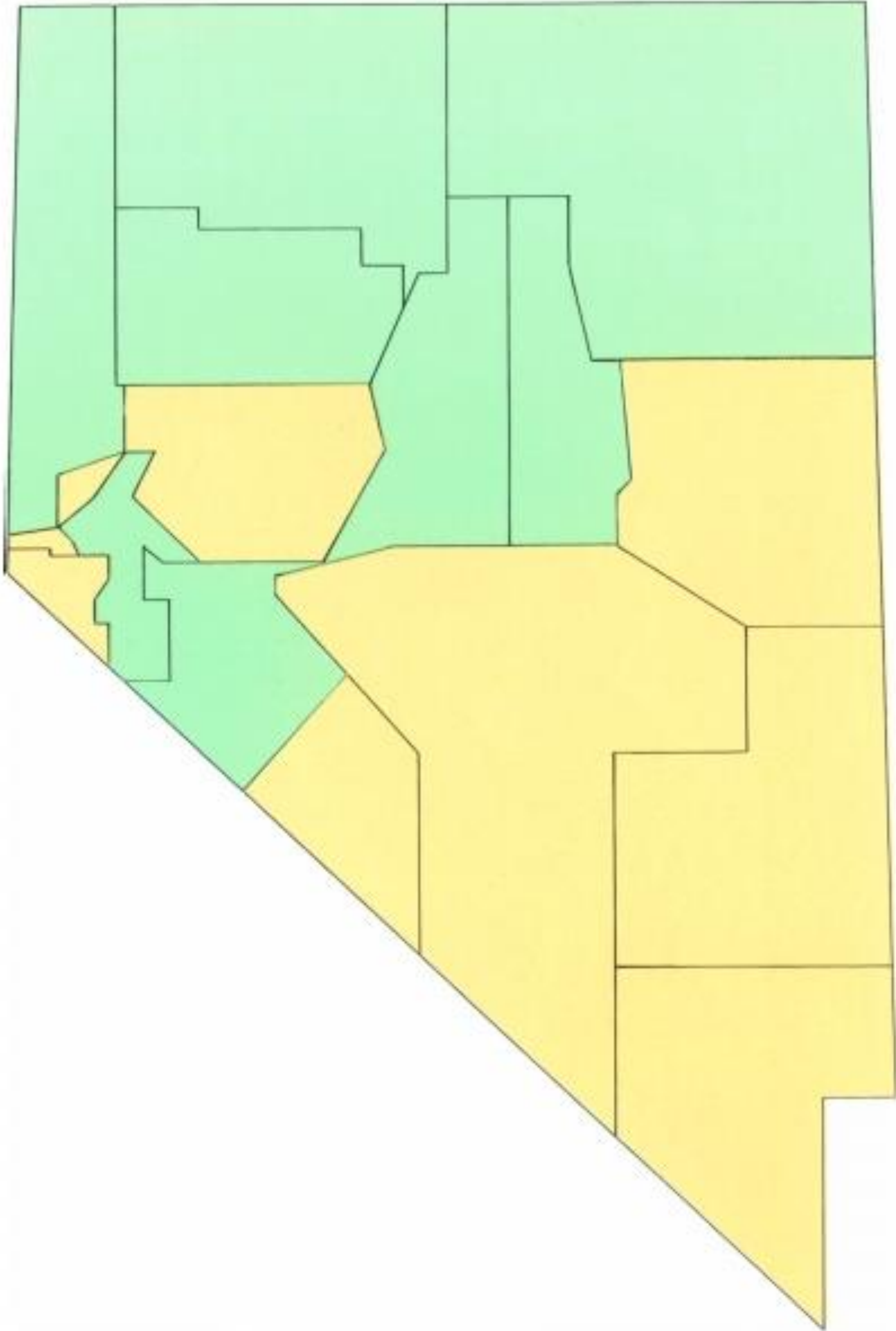
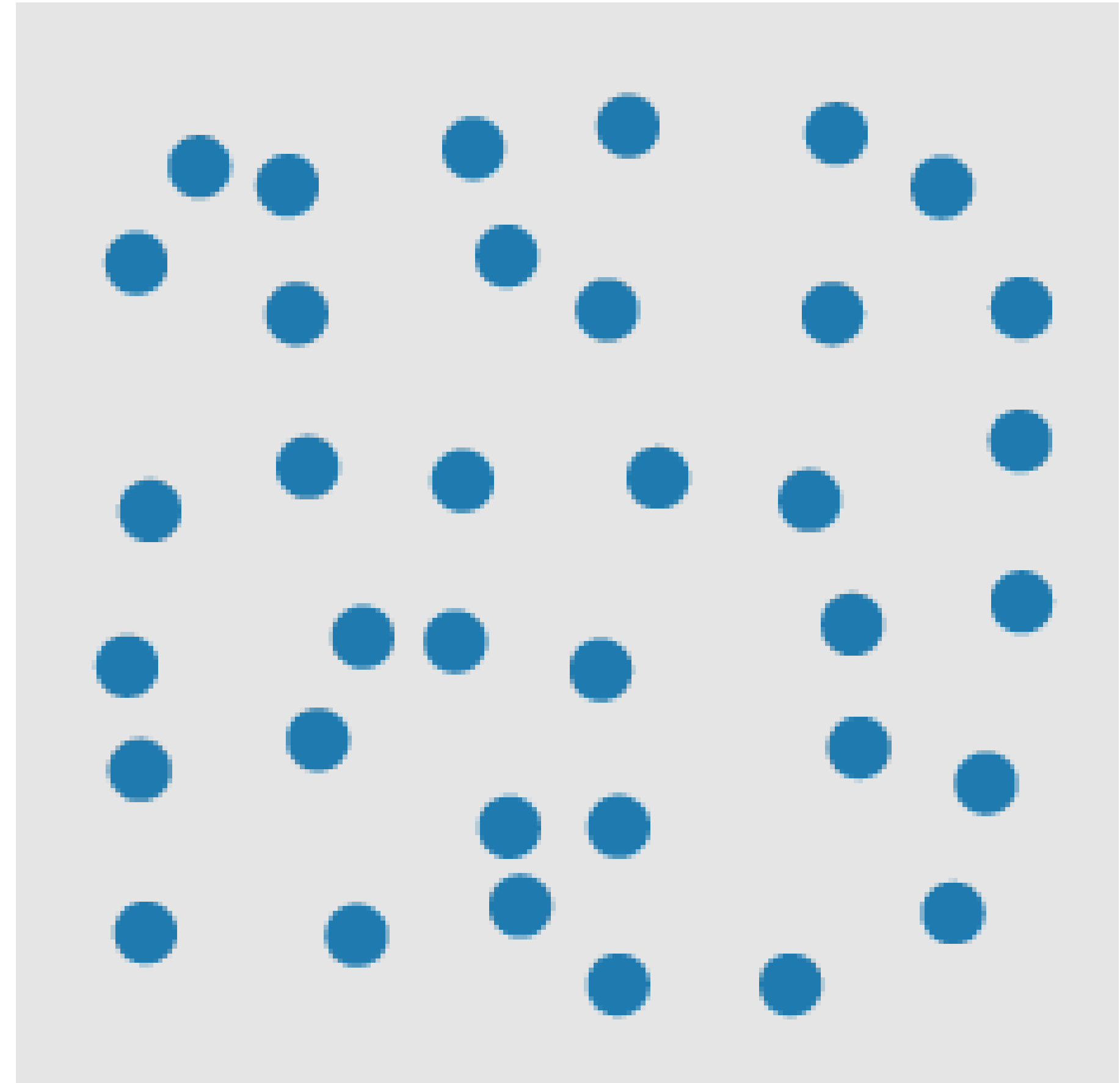
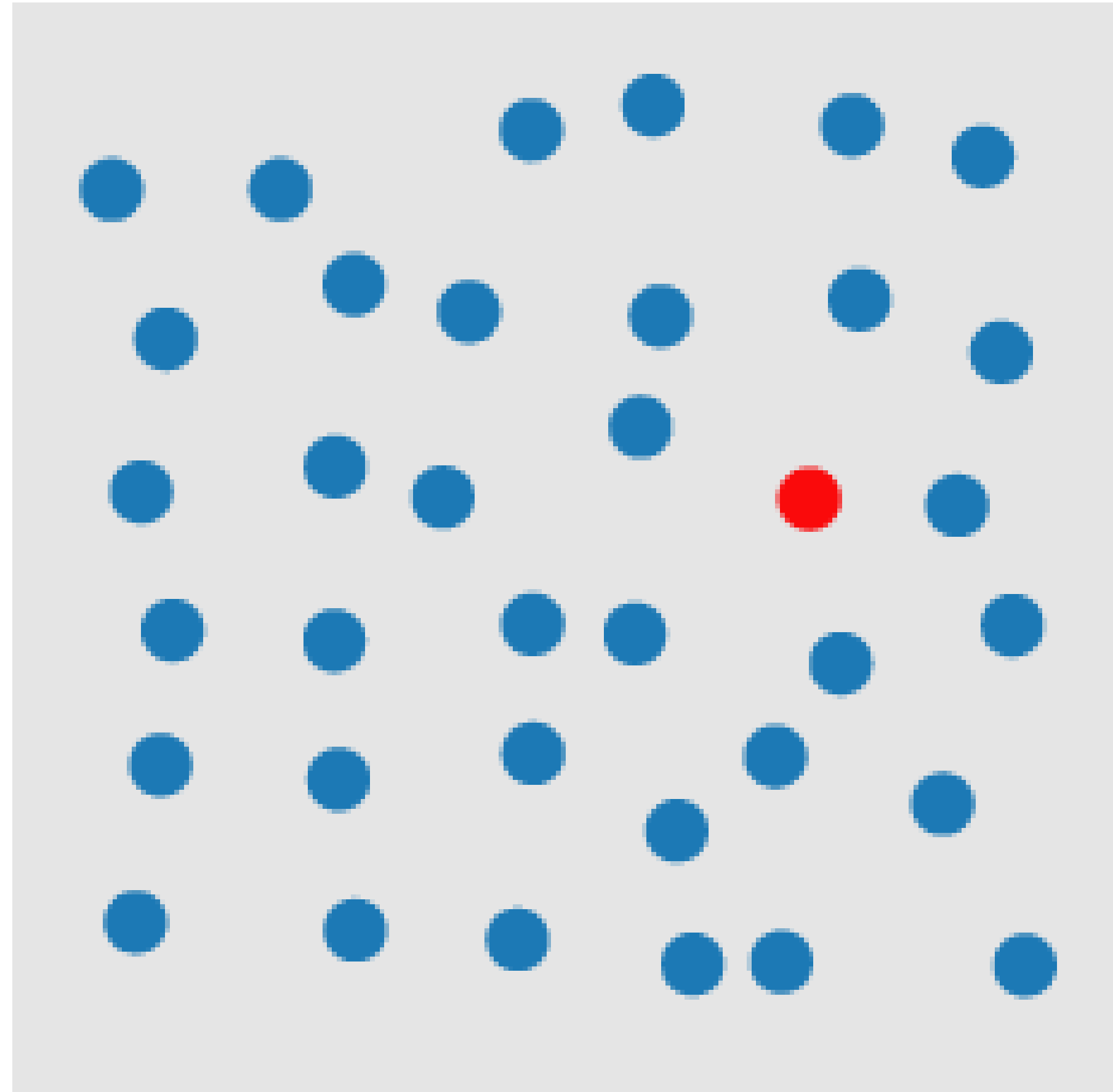


Figure 2. Stimulus From the Low-Saturation Group

POP-OUT EFFECTS



COLOR

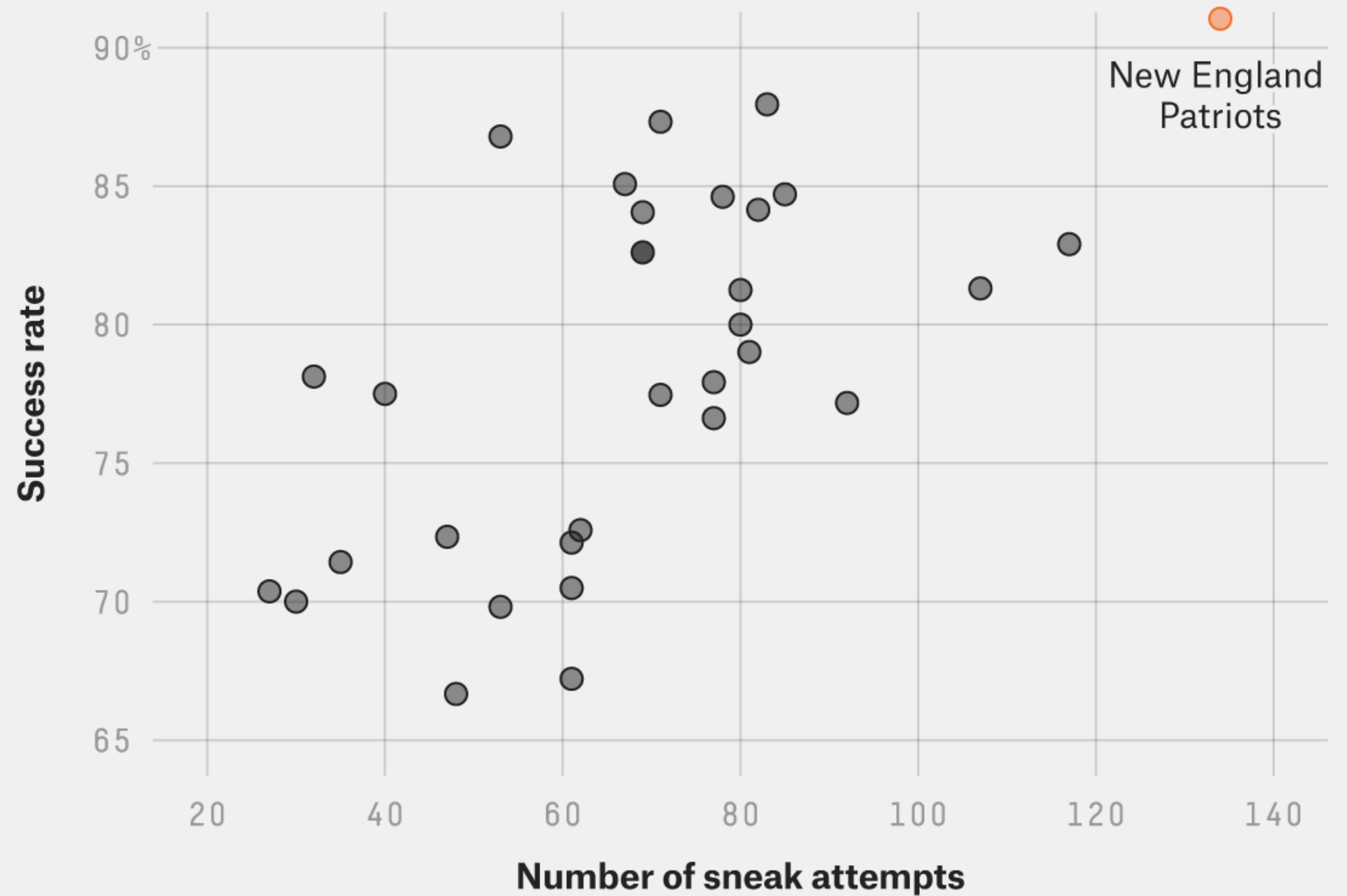
A quarterback sneak is a [play](#) in [American football](#) and [Canadian football](#) in which the [quarterback](#), upon taking the center snap, dives ahead while the offensive line surges forward. It is usually only used in very short yardage situations.

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

Which pop-out effects are used in this example visualization?

The Patriots' QB sneaks stand out

QB sneak success rate versus number of attempts on 1- and 2-yard plays on third and fourth down, 2001-15



FiveThirtyEight

SOURCE: ARMCHAIR ANALYSIS



Desaturated background, light blue

**NASA has an amazing collection of visualization and imaging experts. As in the example above, background colors are always selected to be desaturated thus making the foreground have a pop-out effect. The preferred background color is generally light blue which is desaturated and gives a 3D depth effect (i.e., blue sky in the distant background).

Color Mixing Pitfalls

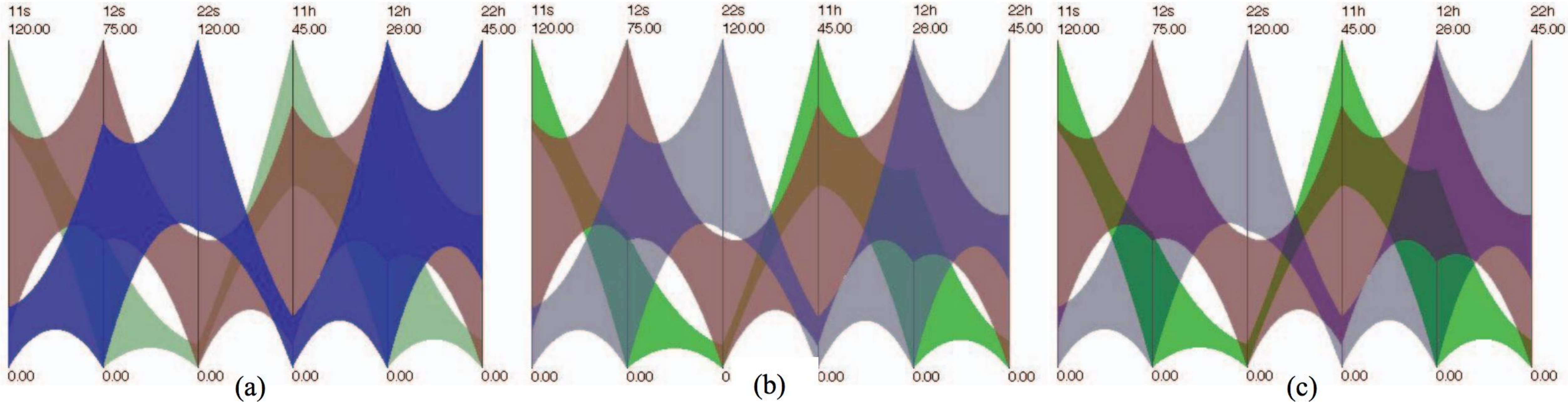


Fig. 12: Illustrative visualizations of a six-dimensional dataset using illustrative parallel coordinates. (a) Ideal visualization with appropriate weightings and color choices, and the use of the local model in overlapping areas. (b) Improper weightings are employed. The blue cluster no longer seems to be in front. (c) The use of improper weightings and the disabling of the local model results in a confusing visualization.

“Aimed at reducing false colors in the overlap regions. ...[Reduce] saturation of the color in the rear object only in the overlap region while keeping its lightness.”

Note the swap in blue/red for foreground/background vs. NASA

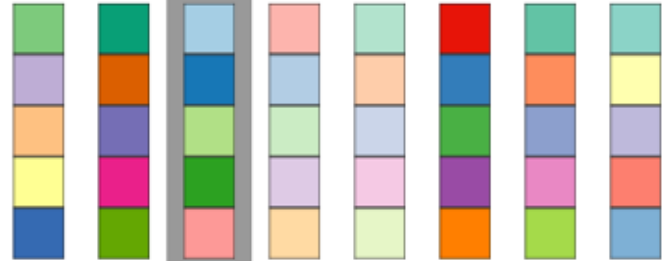
TOOLS FOR PICKING COLOORMAPS

Color Brewer

Number of data classes: 6 how to use | updates | downloads | credits

Nature of your data: sequential diverging qualitative

Pick a color scheme:



Only show: colorblind safe print friendly photocopy safe

Context: roads cities borders

Background: solid color terrain

color transparency

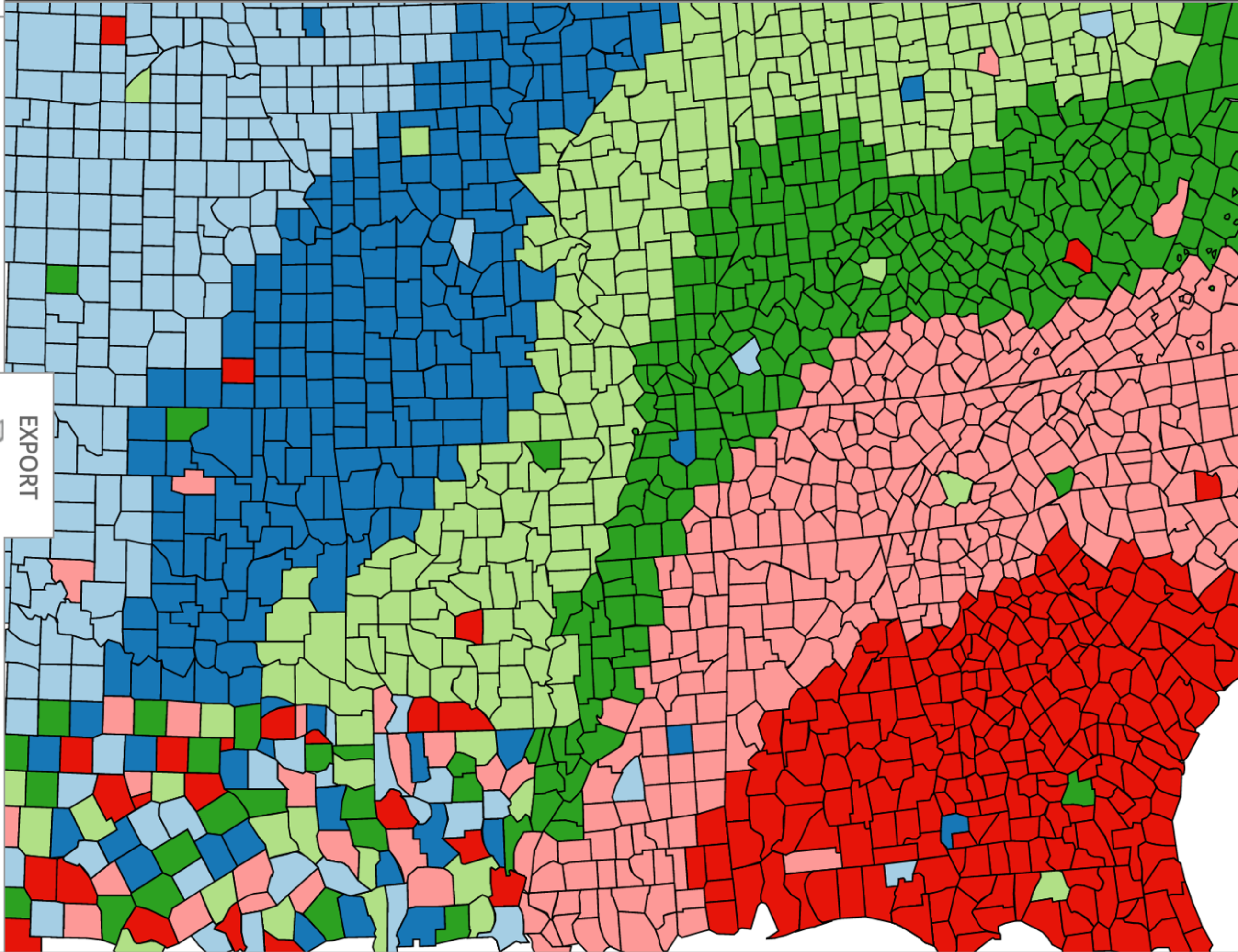
6-class Paired

EXPORT

HEX

- #a6cee3
- #1f78b4
- #b2df8a
- #33a02c
- #fb9a99
- #e31a1c

COLORBREWER 2.0
color advice for cartography



<http://colorbrewer2.org>

Colorgorical

Colorgorical Source

Generate

Results: Color space Hex RGB Lab LCH Array format " ' No quote Charts Clear all

Number of colors: 5

Score importance: Perceptual Distance, Name Difference, Pair Preference, Name Uniqueness

Select hue filters: 90°, 180°, 270°, 0°

Results: ["rgb(57,146,131)", "rgb(148,210,207)", "rgb(25,79,70)", "rgb(57,238,192)"]

rgb(57,146,131) + start

rgb(148,210,207) + start

rgb(25,79,70) + start

rgb(57,238,192) + start

Instructions

To generate a palette with n colors, just enter the number of colors you want and click *Generate*. Bigger palettes will take longer than smaller palettes to make. Results will automatically appear when ready.

For greater detail, please consult our [paper](#) or the [source code](#).

Score Importance

Perceptual Distance

Increasing *Perceptual Distance* favors palette colors that are more easily discriminable to the human eye. To accurately model human color acuity, this is performed using CIEDE2000 in CIE Lab color space.

Name Difference

Increasing *Name Difference* favors palette colors that share few common names.

About

Colorgorical was built by Connor Gramazio with advisement from David Laidlaw and Karen Schloss.

Documentation

If you'd like to read more about how Colorgorical works, please read our paper [here](#). If you're curious about the implementation, please see the Colorgorical GitHub repository located [here](#).

If you use Colorgorical, please use the following citation:

```
@article{gramazio-2017-ccd,
  author={Gramazio, Connor C. and Laidlaw, David H. and Schloss, Karen},
  journal={IEEE Transactions on Visualization and Computer Graphics},
  title={Colorgorical: creating discriminable and preferable color palettes}
```

Other Useful Tools

- Get a list of colors from an image:
<https://html-color.codes/color-from-image>
- Analyze your palette: <https://projects.susielu.com/viz-palette>
- Analyze the name similarity of colors in your palette:
<http://vis.stanford.edu/color-names/analyzer/>
- Details on multi-hued color scales:
<https://www.vis4.net/blog/2013/09/mastering-multi-hued-color-scales/#combining-bezier-interpolation-and-lightness-correction>
- Easy picking a multi-hued color scale: <http://tristen.ca/hcl-picker/>
- Easily correcting darkness (lightness) for a scale: <http://gka.github.io/palettes/>
- Do a ton programmatically: <https://gka.github.io/chroma.js/>
- viridis colors:
<https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html>

Color Advice Summary

Use a limited hue palette

- Control color “pop out” with low-saturation colors
- Avoid clutter from too many competing colors

Use neutral backgrounds

- Control impact of color
- Minimize simultaneous contrast

Use Color Brewer etc. for picking scales

Don't forget aesthetics!

Upcoming Assignments & Communication

A look at the upcoming assignments and deadlines

- Textbook, Readings & Reading Quizzes
- 2020-11-10 [Project 6 — Sprint 1](#)
- 2020-11-11 **No Class — Veterans' Day**
- 2020-11-17 [Project 7 — Sprint 2 & Paper Draft](#)
- 2020-11-18 [In-Class Validation — Final Project Evaluation](#)
- 2020-11-24 [Project 8 — Sprint 3 & Prep for Usability Testing](#)
- 2020-11-25 **No Class — Thanksgiving**
- 2020-11-30 [In-Class Usability Testing — Final Projects](#)
- 2020-12-06 [Project 9 — Presentation and Video](#)
- 2020-12-07 In-Class Project Presentations
- 2020-12-09 In-Class Project Presentations
- 2020-12-15 [Project 10 — Final Project Deliverables and Sharing with Partners](#)

<https://c.dunne.dev/ds4200f20>

Everyday Required Supplies:

- 5+ colors of pen/pencil
- White paper
- Laptop and charger

Use **Canvas Discussions** for general questions, email the **instructor & TAs** for questions **specific to you**.

If you're emailing about a particular assignment, please include the URL of the Submission Details page. ([Canvas documentation](#).)

If you have a project question, **give us your group number**. E.g., include: `Group ## — Topic` with `##` replaced by your group number and `Topic` replaced by your topic.