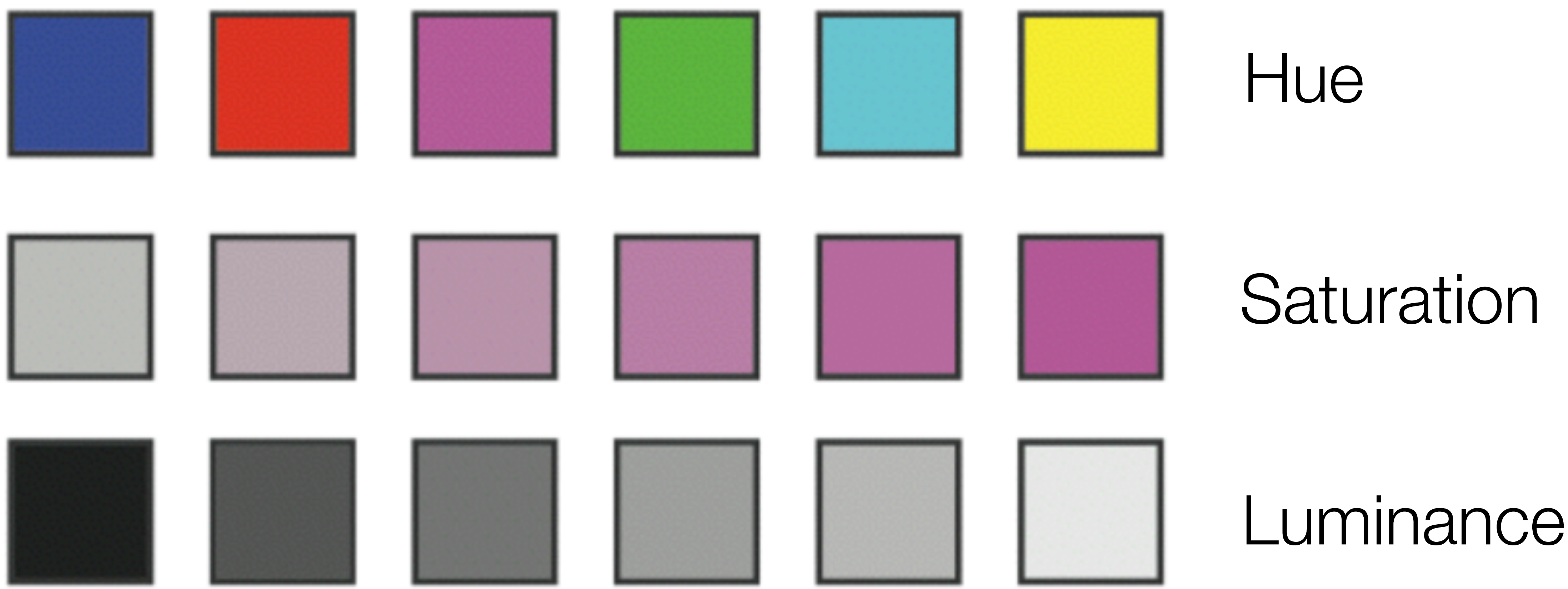
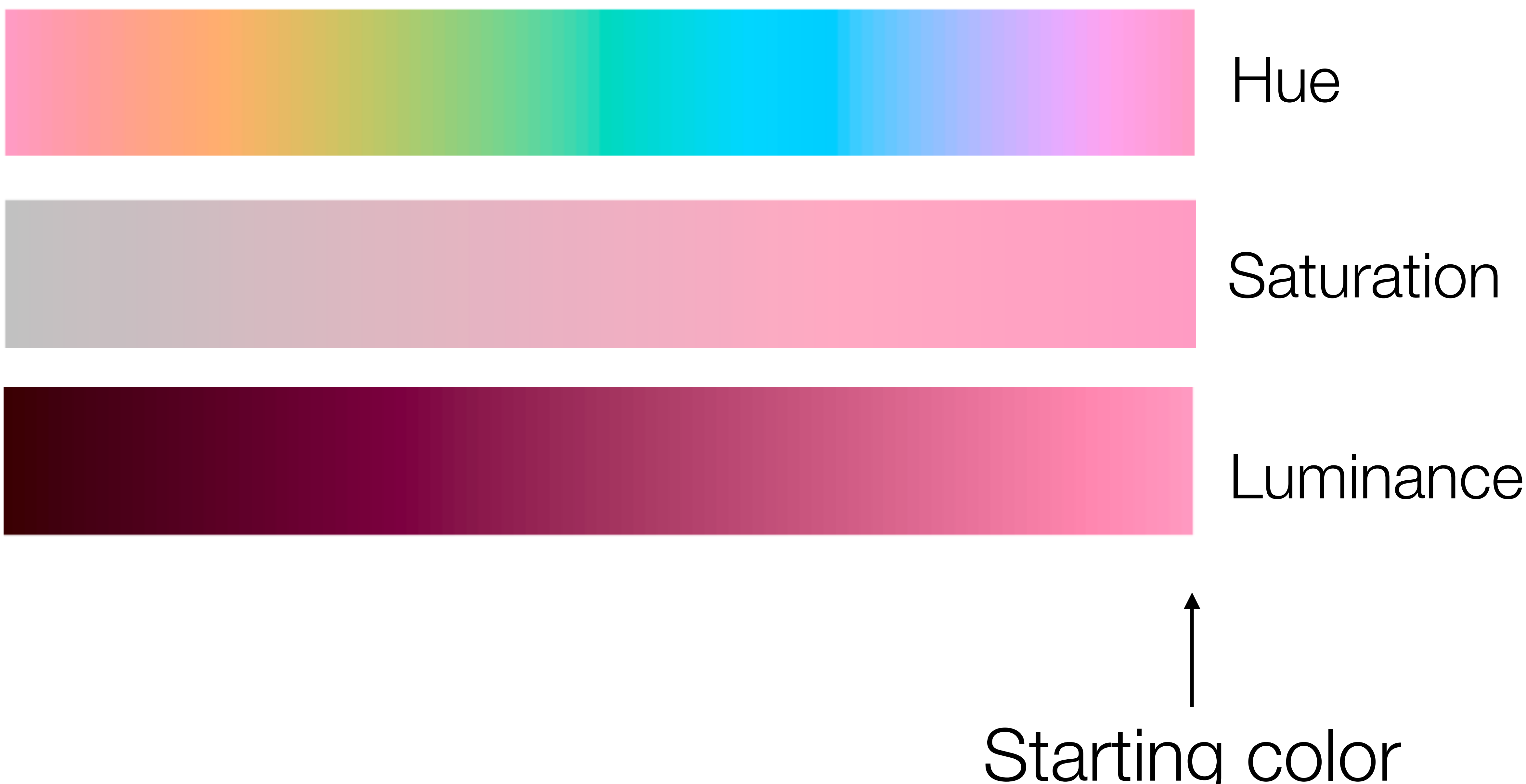
CONSEQUENCES FOR DESIGN

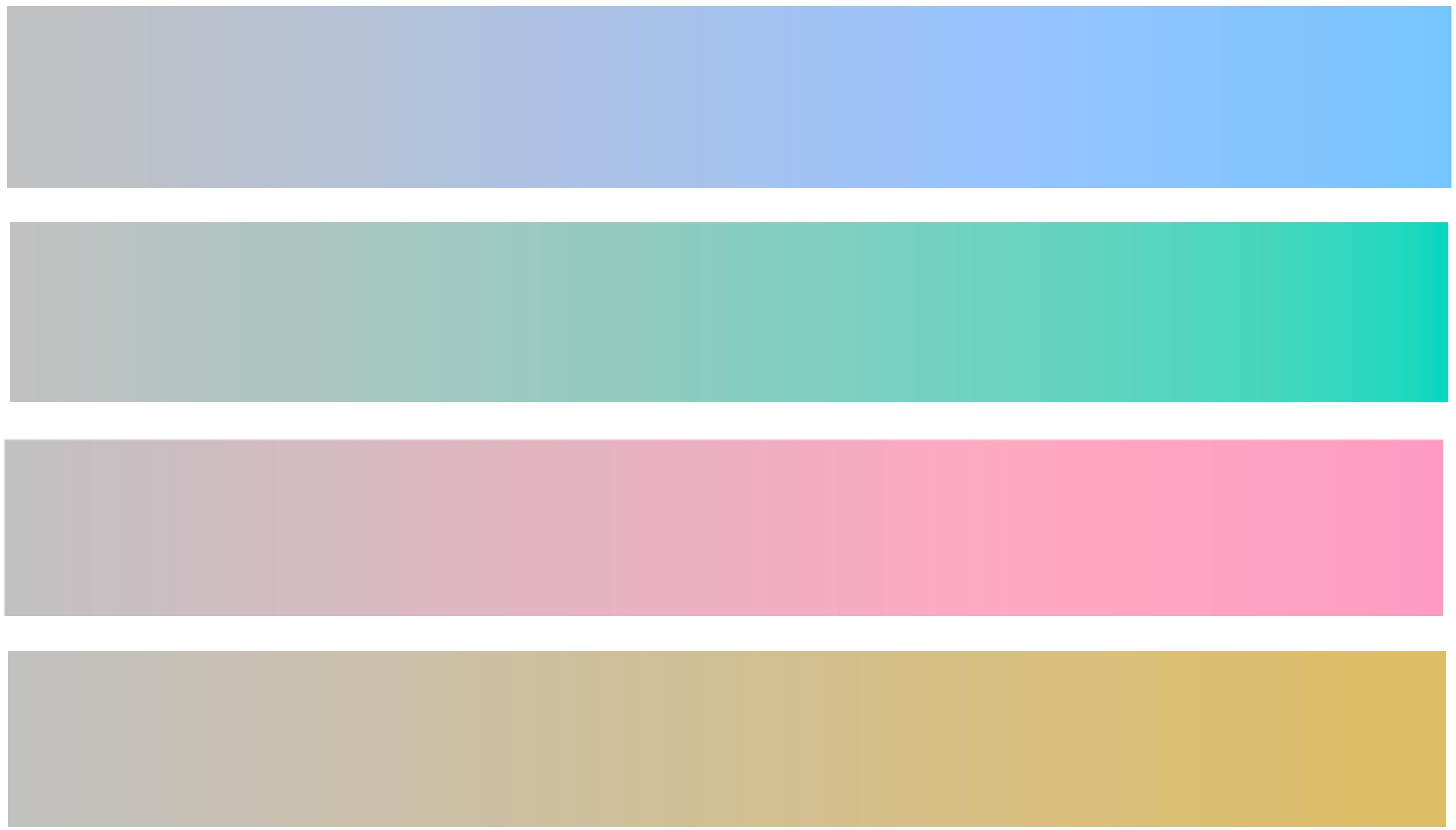
Let's use consistent names in class



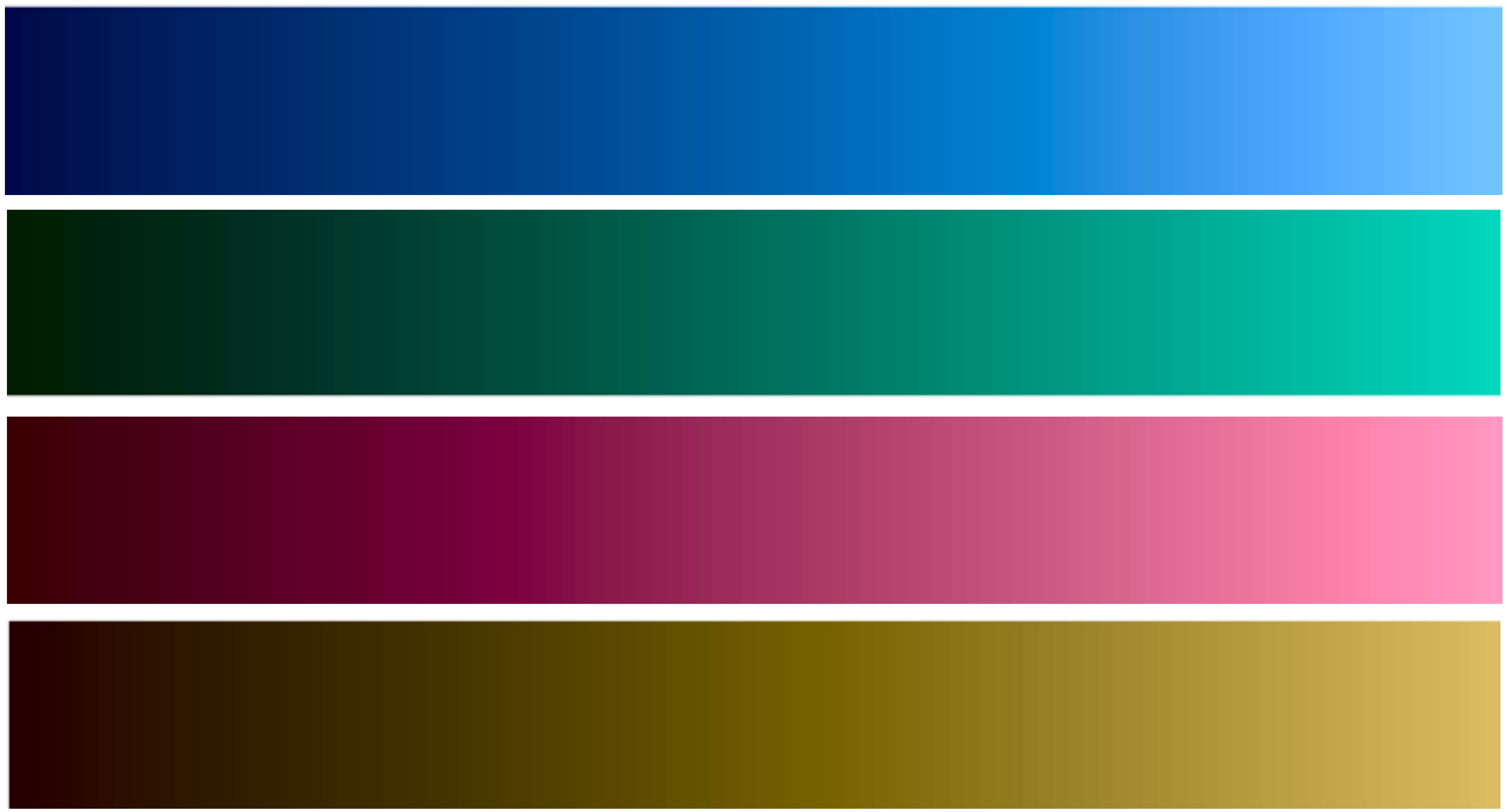
Let's think about what happens when we change these



“Neutral”



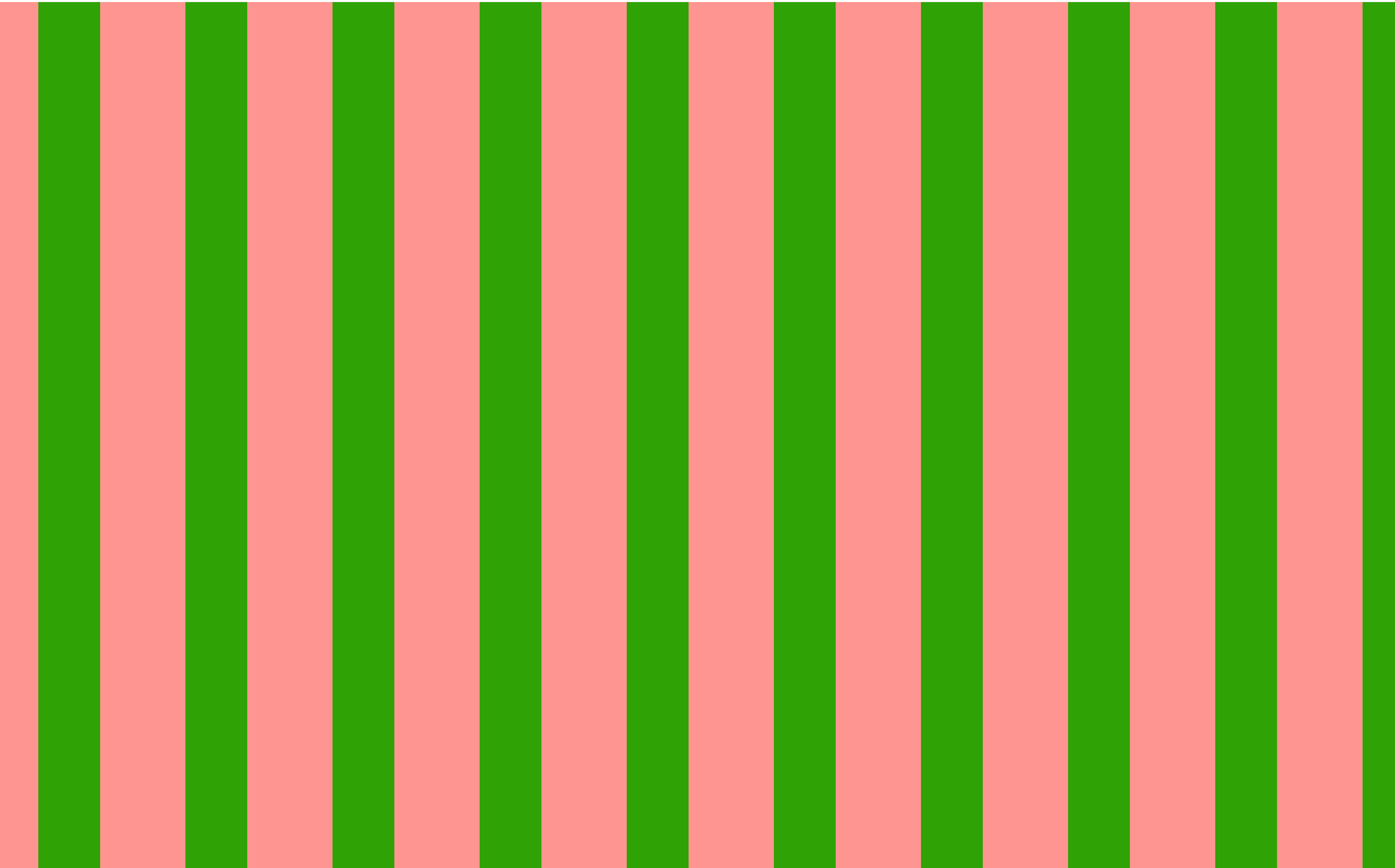
“Neutral”



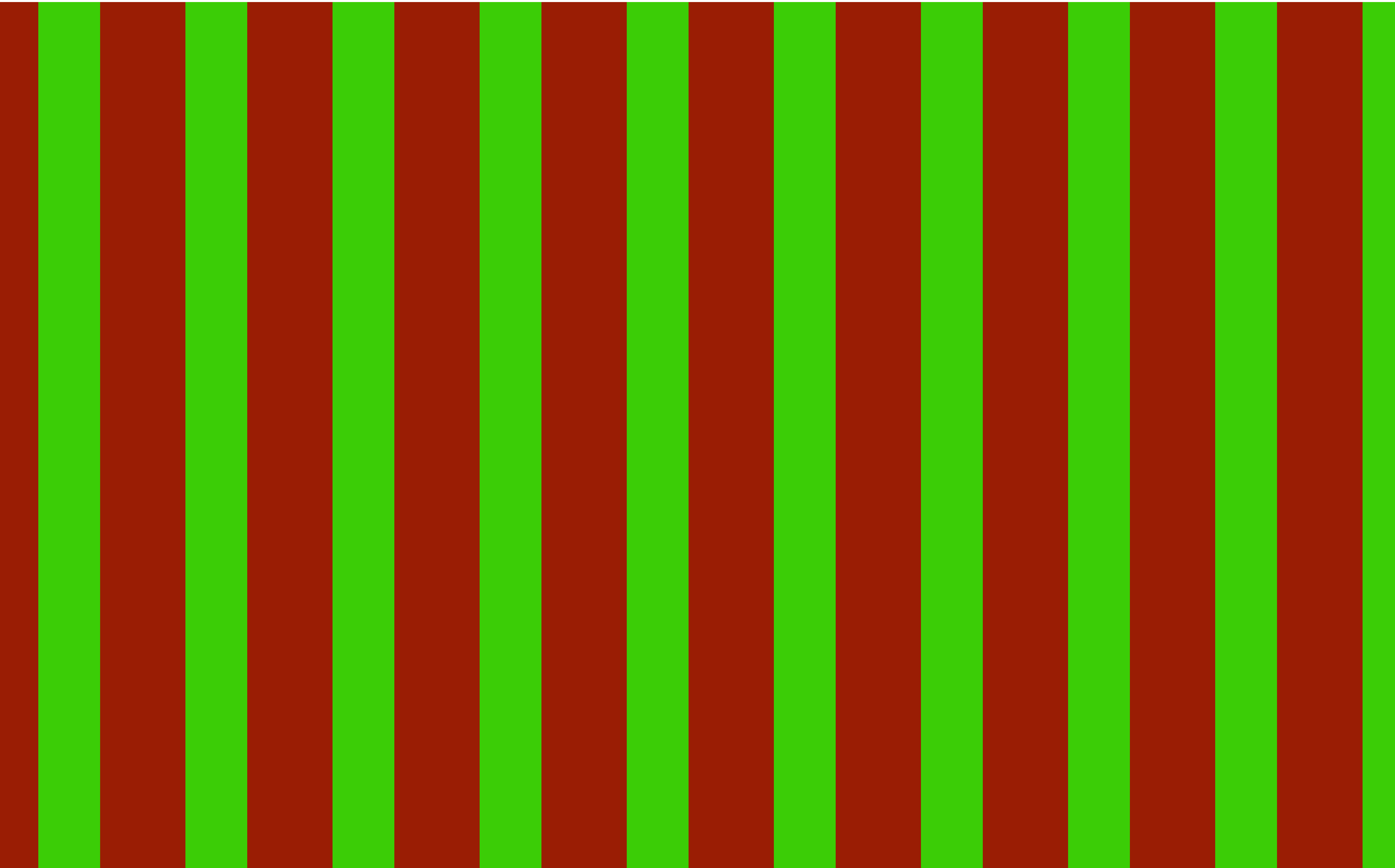
“Get it right in black and white”

–Maureen Stone

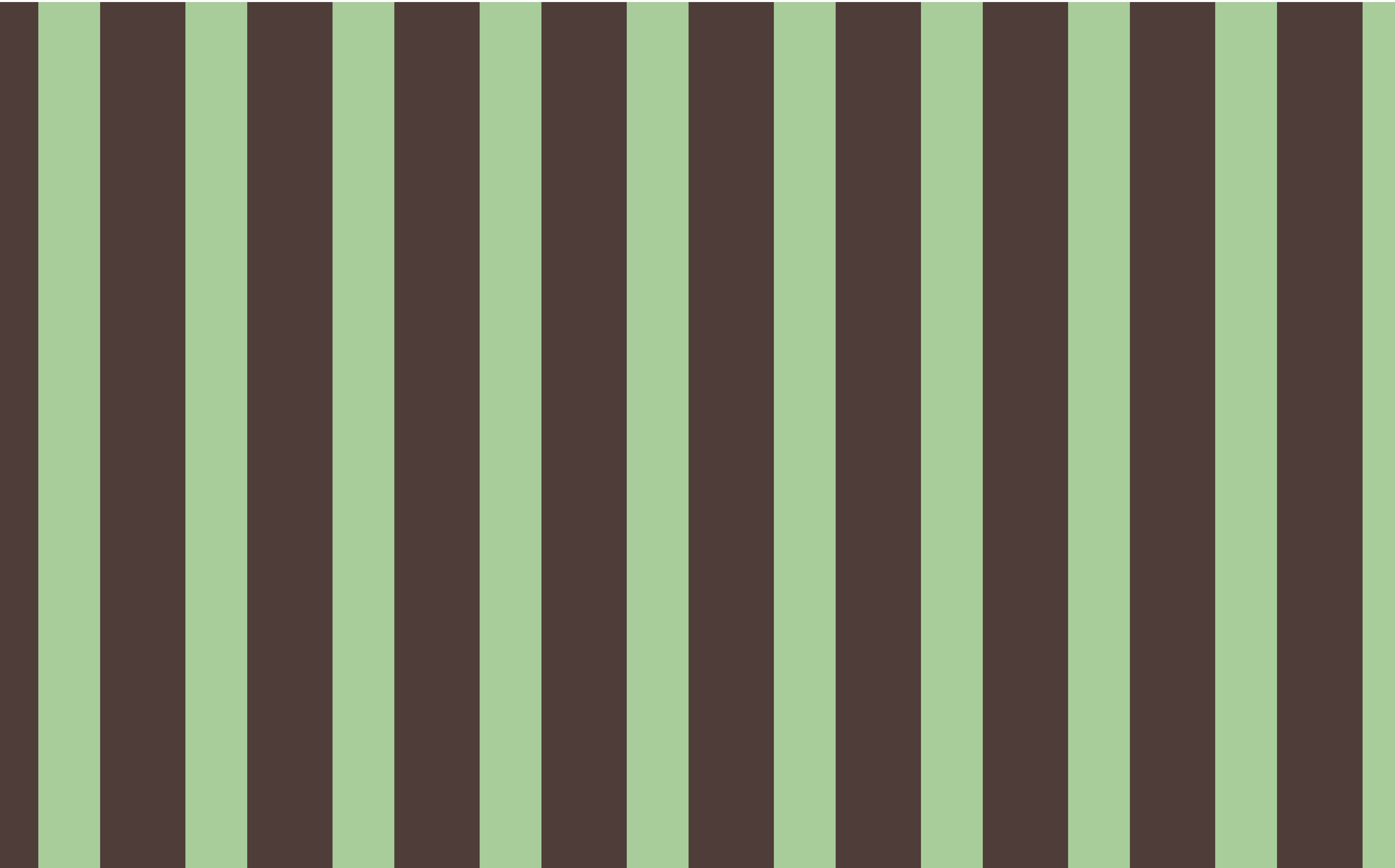
If you're going to show shape variation, do it with luminance



If you’re going to show shape variation, do it with luminance

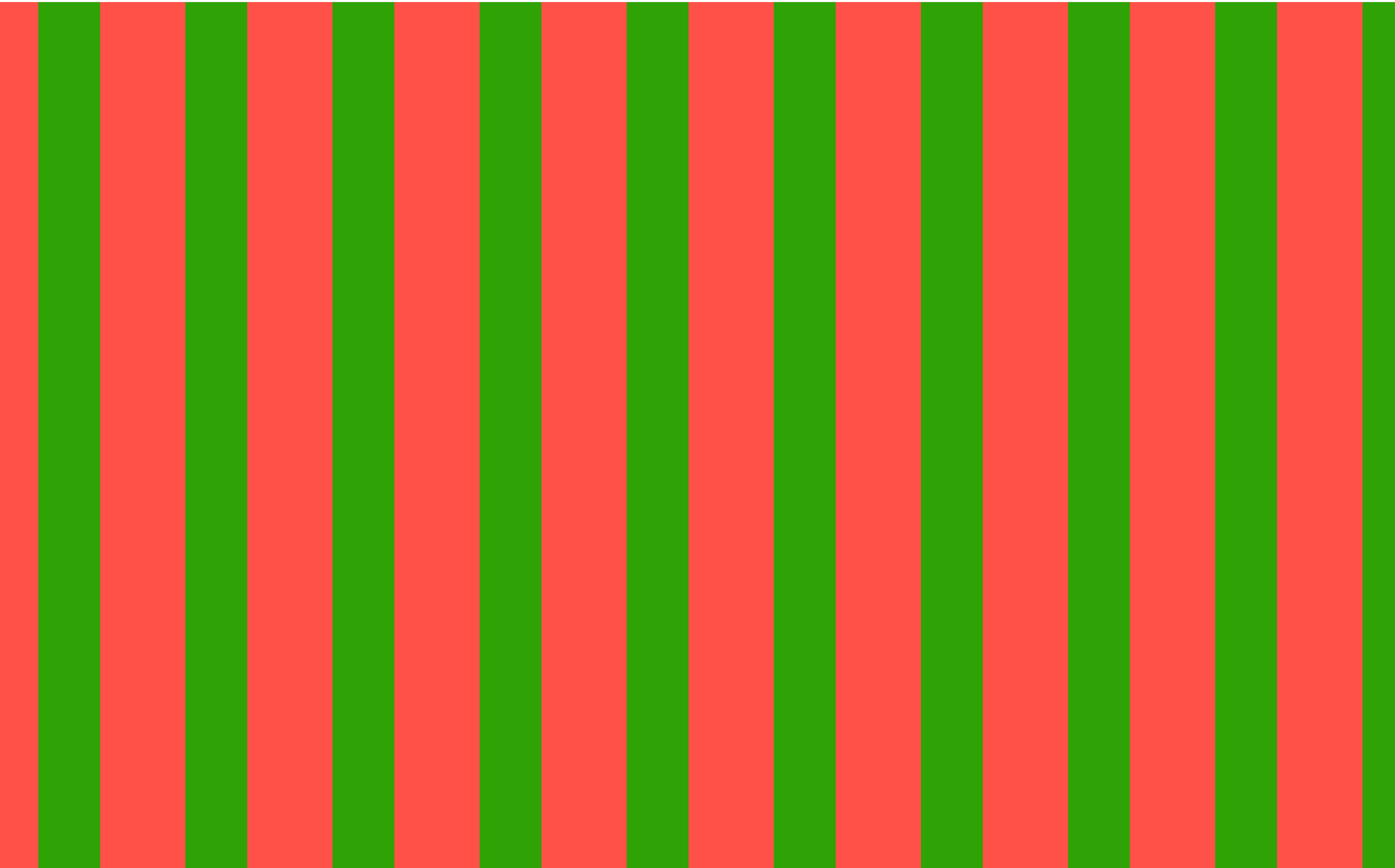


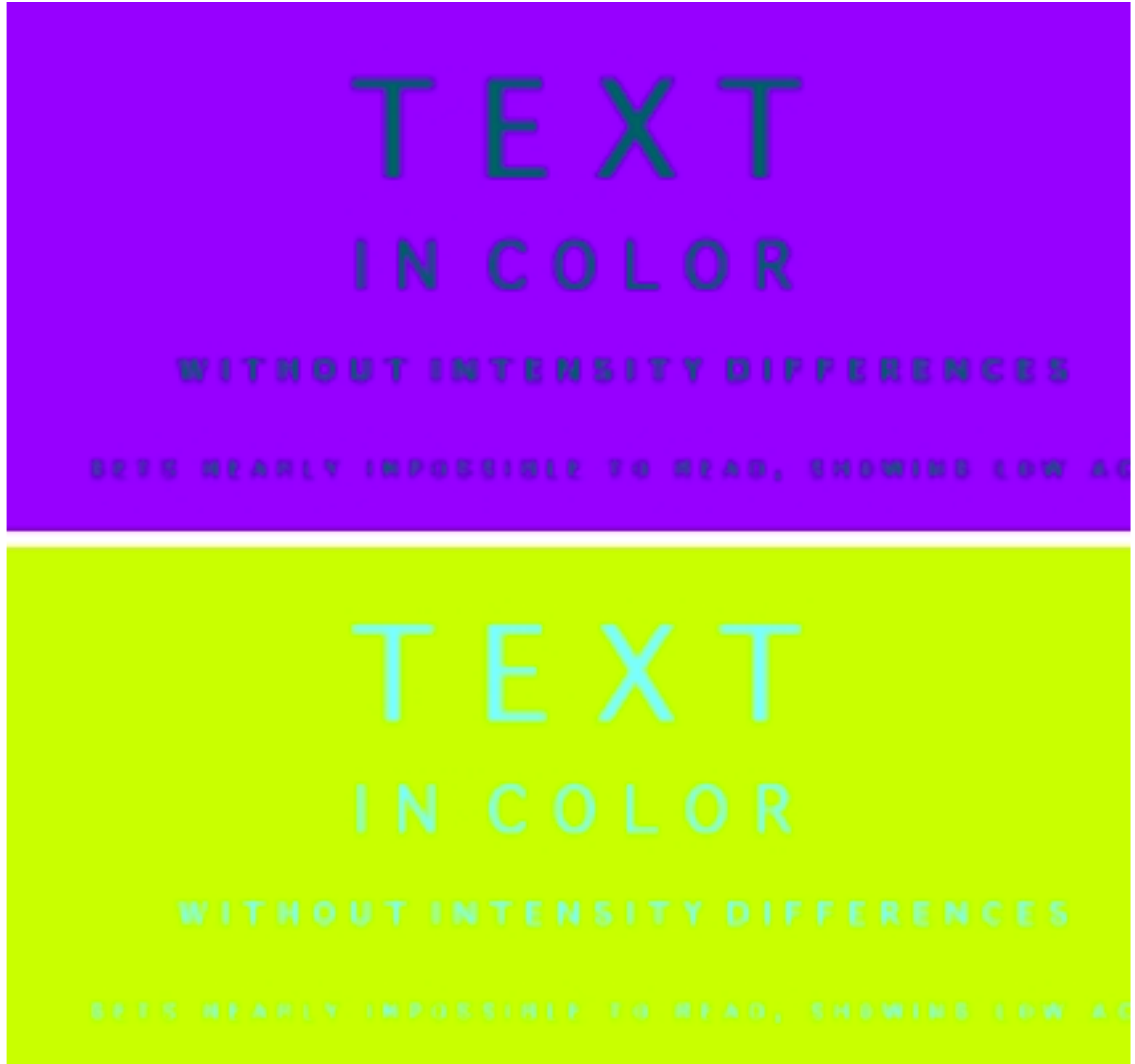
If you're going to show shape variation, do it with luminance



It’s not the brightness that makes it uncomfortable

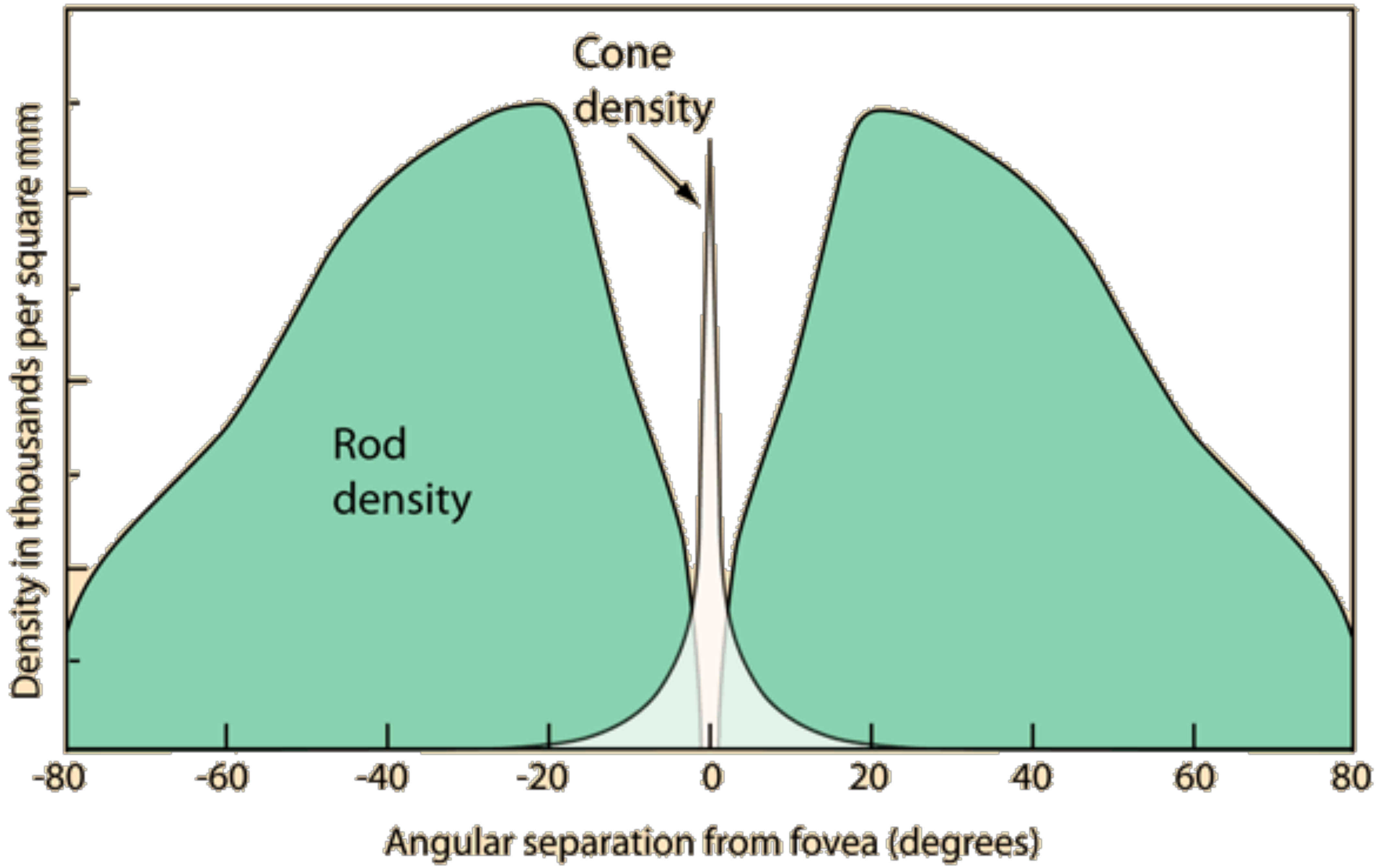
It’s not the brightness that makes it uncomfortable





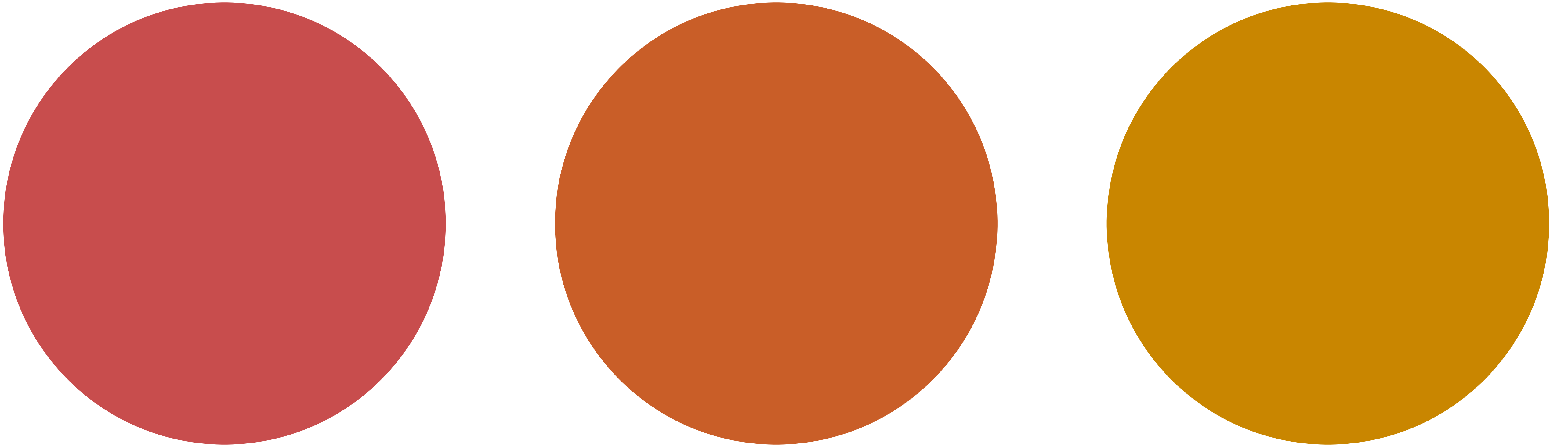
http://www.settheory.com/Glass_paper/color_motion.gif

http://www.settheory.com/Glass_paper/Kanizsa_observations.html


Cone
density
Rod
density
Density in thousands per square mm
-80
-60
-40
-20
0
20
40
60
80
Angular separation from fovea (degrees)

Do not rely only on hue boundaries to depict shape

Do not rely only on hue boundaries to depict shape



Modeling Color Difference for Visualization Design

Danielle Albers Szafir, *Member, IEEE*

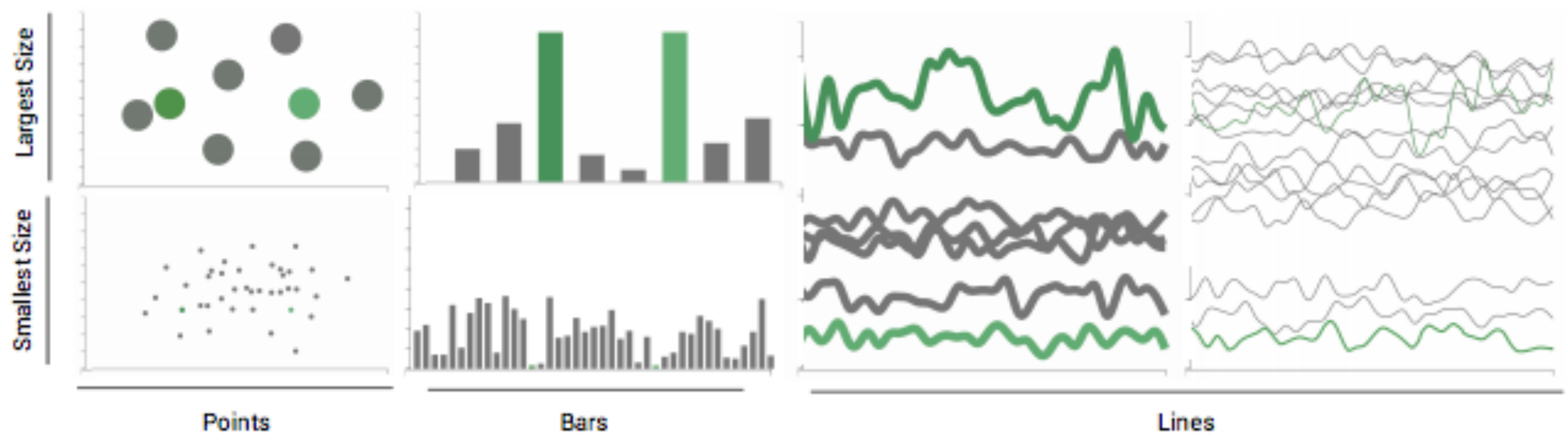


Fig. 1. We performed three experiments to measure color difference perceptions for visualizations, focusing on diagonally symmetric marks from scatterplots, elongated marks from bar charts, and asymmetric elongated marks from line graphs. The tested size ranges are shown above for two greens at $\Delta E = 10$ (figures have been scaled to 30% of the tested size). We confirm prior findings that perceived color difference varies inversely with size and find that elongated marks provide significantly greater discriminability for encoding designers. Our results provide probabilistic models of color difference for visualization.

Abstract—Color is frequently used to encode values in visualizations. For color encodings to be effective, the mapping between colors and values must preserve important differences in the data. However, most guidelines for effective color choice in visualization are based on either color perceptions measured using large, uniform fields in optimal viewing environments or on qualitative intuitions. These limitations may cause data misinterpretation in visualizations, which frequently use small, elongated marks. Our goal is to develop quantitative metrics to help people use color more effectively in visualizations. We present a series of crowdsourced studies measuring color difference perceptions for three common mark types: points, bars, and lines. Our results indicate that peoples' abilities to perceive color differences varies significantly across mark types. Probabilistic models constructed from the resulting data can provide objective guidance for designers, allowing them to anticipate viewer perceptions in order to inform effective encoding design.

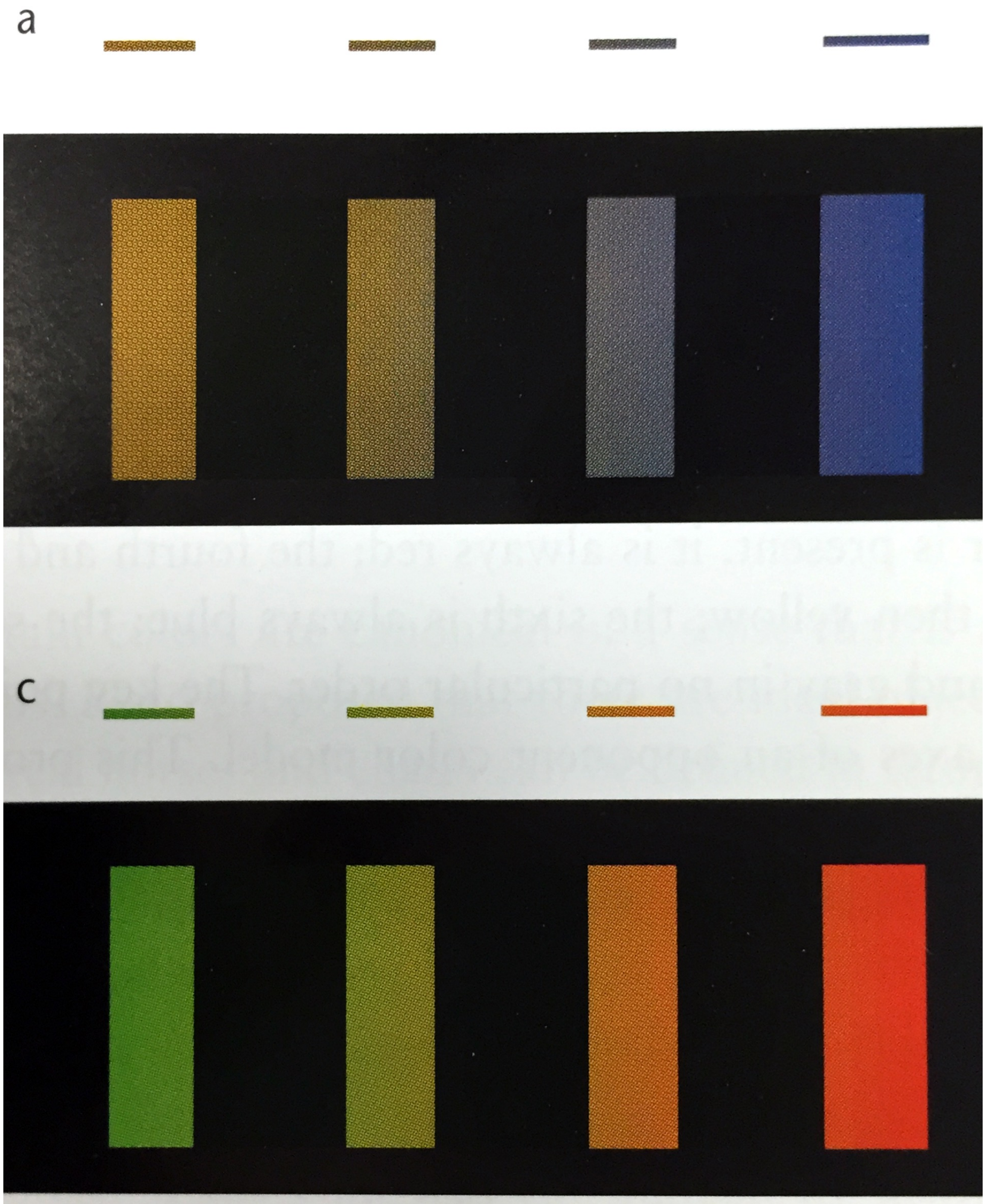
Index Terms—Color Perception, Graphical Perception, Color Models, Crowdsourcing

1 Introduction

Visualizations reveal patterns in data by mapping values to different visual channels, such as position, size, or color. In order for visualizations to be effective, perceived differences in encoded values should correspond to differences in the underlying data. As a result, visualization designers need to map data ranges to sufficiently wide ranges in the

or 10° of visual angle, approximately 50 pixels and 250 pixels wide for a standard web observer). However, many visualization systems rely on CIELAB and similar metrics to construct encodings, leading them to systematically underestimate the perceived differences between colors [41, 51]. This underestimation can lead to ineffective encoding

(Hint - great project)



Ware, Chapter 4

Area affects saturation perception

A Color-Caused Optical Illusion on a Statistical Graph

WILLIAM S. CLEVELAND and ROBERT McGILL*

Despite the great increase in the use of color in statistical graphics, we know very little about how color affects people's perception of the quantitative information on graphical displays. Perceptual psychologists have already demonstrated that color can cause optical illusions of various kinds. We ran a simple experiment to see if this can happen with a statistical map and found that an illusion did occur.

KEY WORDS: Statistical map; Psychophysics; Bootstrap; Computer graphics; Barycentric plot.

1. INTRODUCTION

Color is being used more and more in statistical graphics. The availability of color output devices for computers has greatly increased, and with easy access to these devices has come an enormous increase in the use of color graphics in the mass media, business reports, and government publications.

Scientific journals are turning to color. In the 10 April 1981 issue of *Science*, for example, substantial use is made of color: a graphical display in which two sets of data are distinguished by plotting one in black and one areas on each map, and the experimental data were used to determine whether some colors caused areas to look bigger than others. This article describes the experiment and the results of the data analysis.

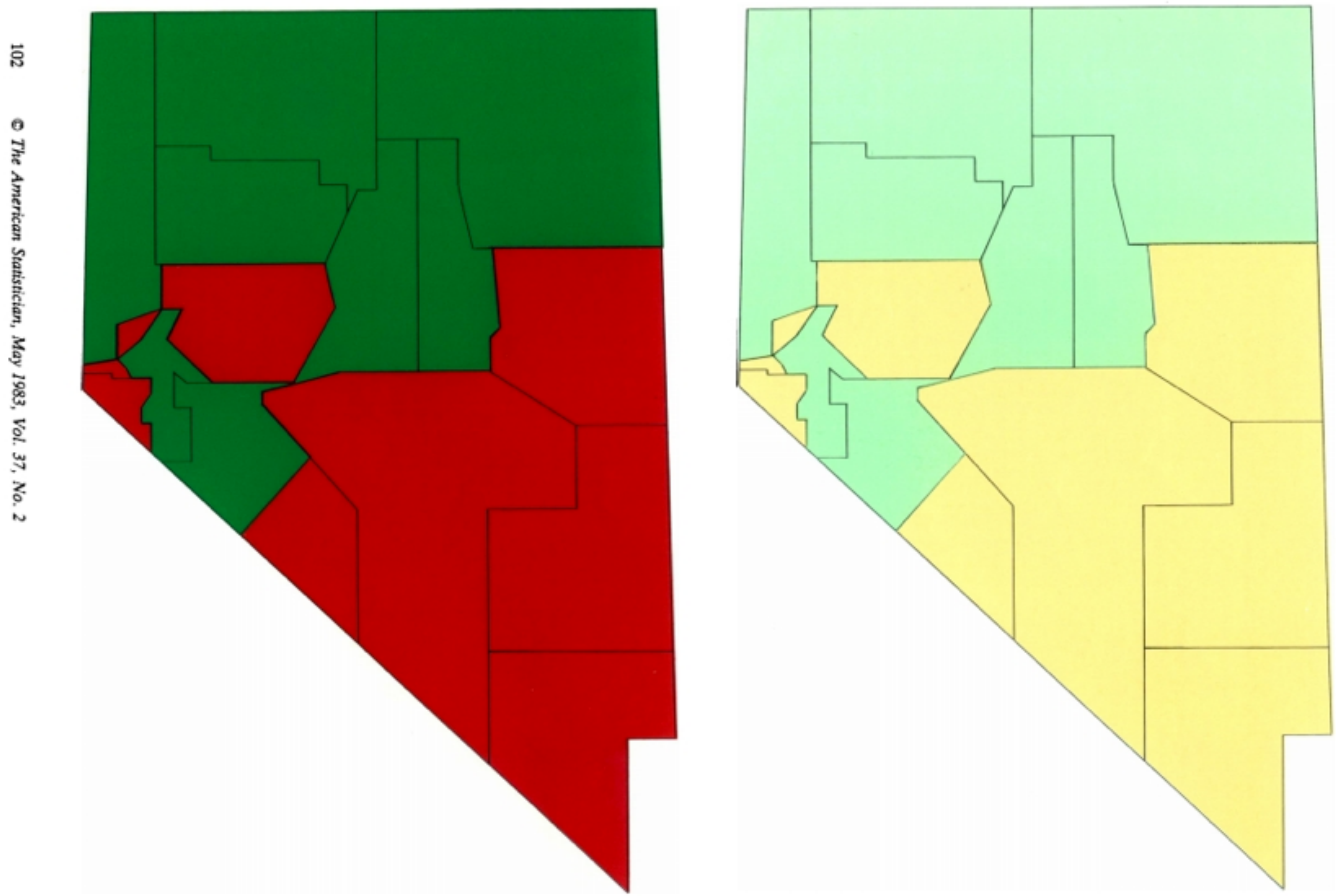
2. EXPERIMENTAL STIMULI AND PROCEDURES

The basic stimulus was a map of Nevada with county boundaries. The geometry of this map is not overly complex—most boundaries are essentially straight lines—yet the sizes and configurations of the counties are not sufficiently regular that estimates of areas could be made by counting them, as might be done on a map of Kansas or Iowa. The number of counties, 17, allows reasonably easy judgment. In no case was a subject required to mentally sum more than 10 areas.

Each stimulus in the experiment was a two-color map with the total area of the counties that were coded by one color very nearly equal to the total area of those that were coded by the second color. One stimulus is shown in Figure 1. There were 10 such divisions of counties into two groups, and in no case did the difference of the areas exceed two square miles.

From the 10 divisions of counties into two groups, four sets of stimuli were generated, each set with the 10 maps previously described. In the first set one group of

Saturation affects area perception



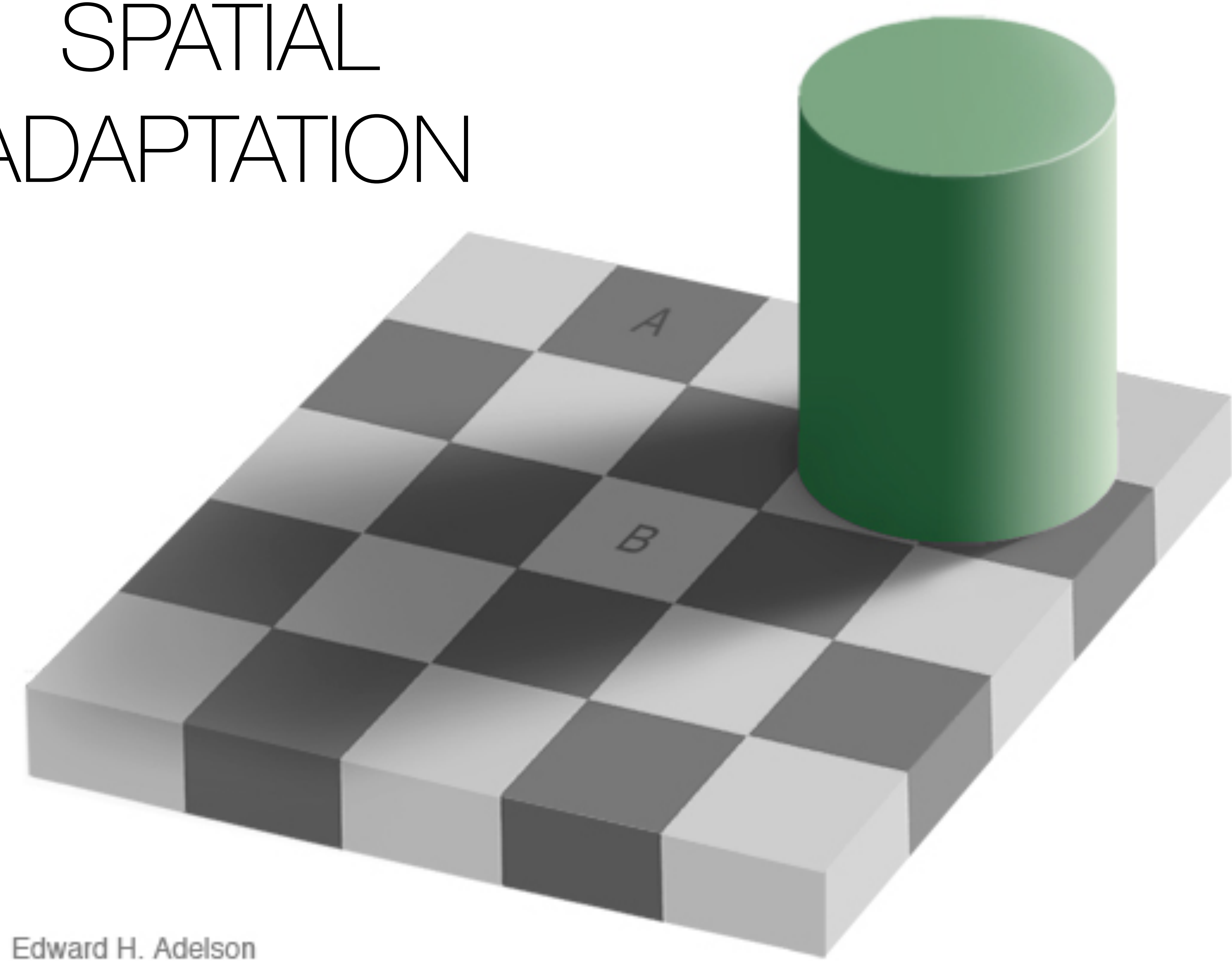
Area affects saturation perception

Saturation affects area perception

Imagine the mess if you try to use both…

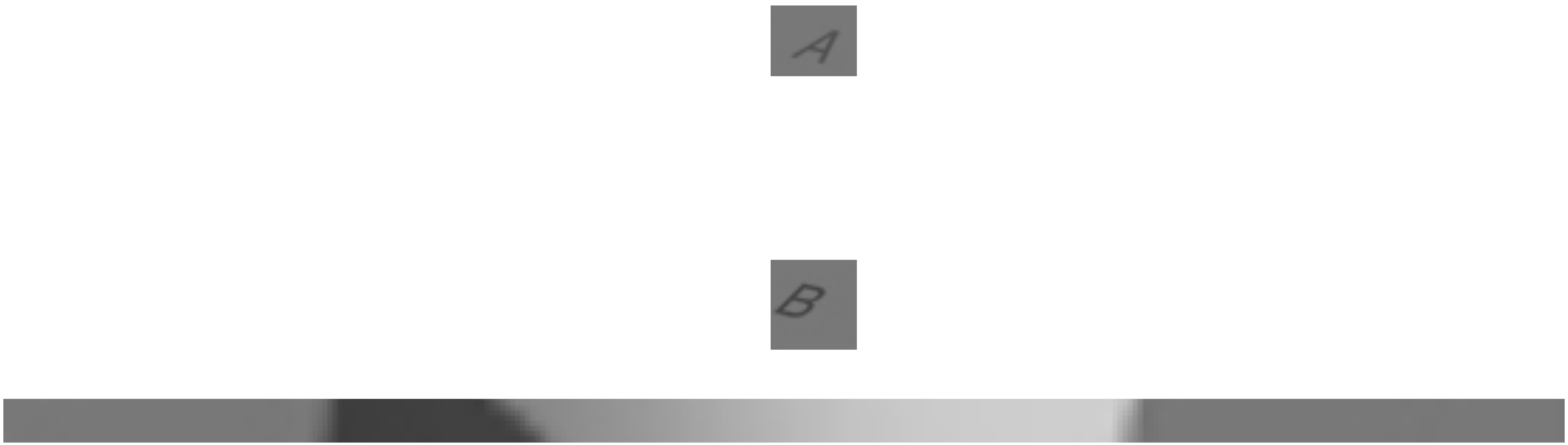
CONSTANCY AND ADAPTATION

SPATIAL ADAPTATION

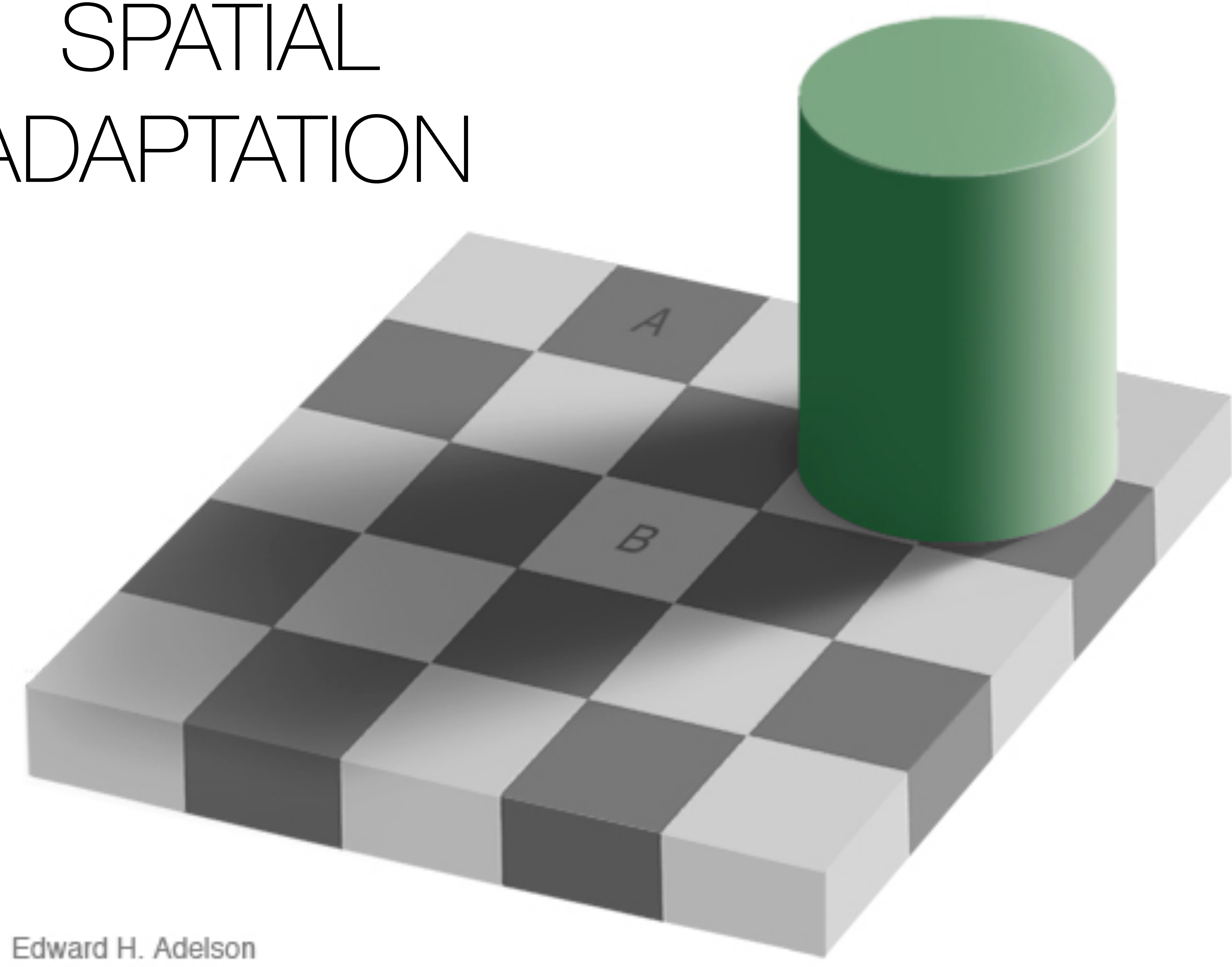


SPATIAL ADAPTATION

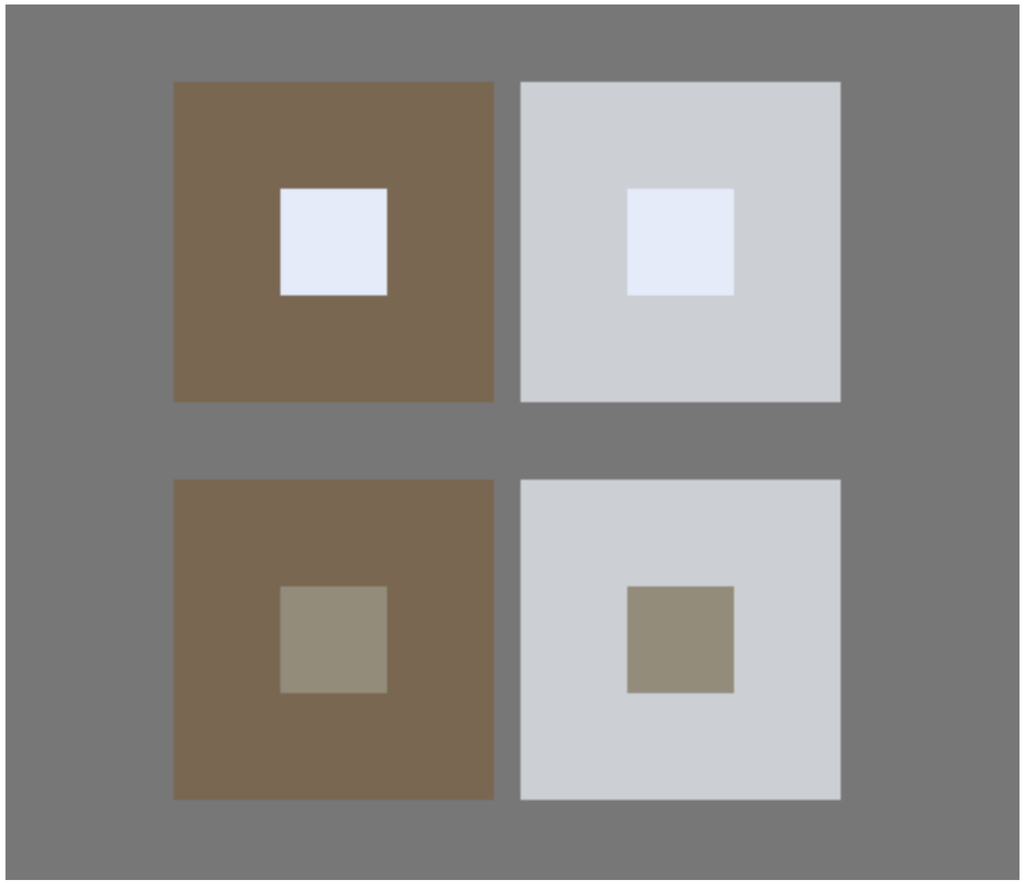
SPATIAL ADAPTATION



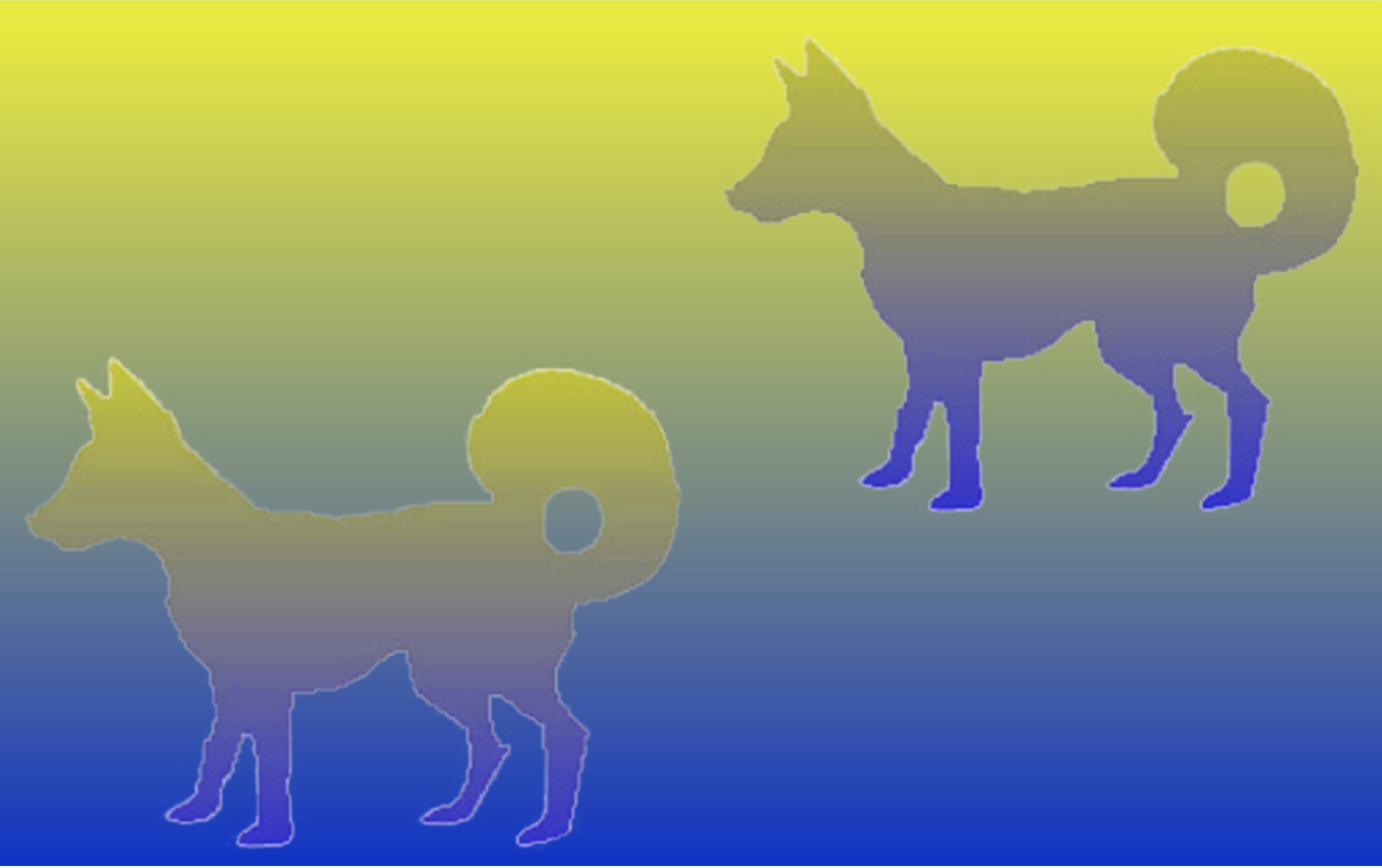
SPATIAL ADAPTATION

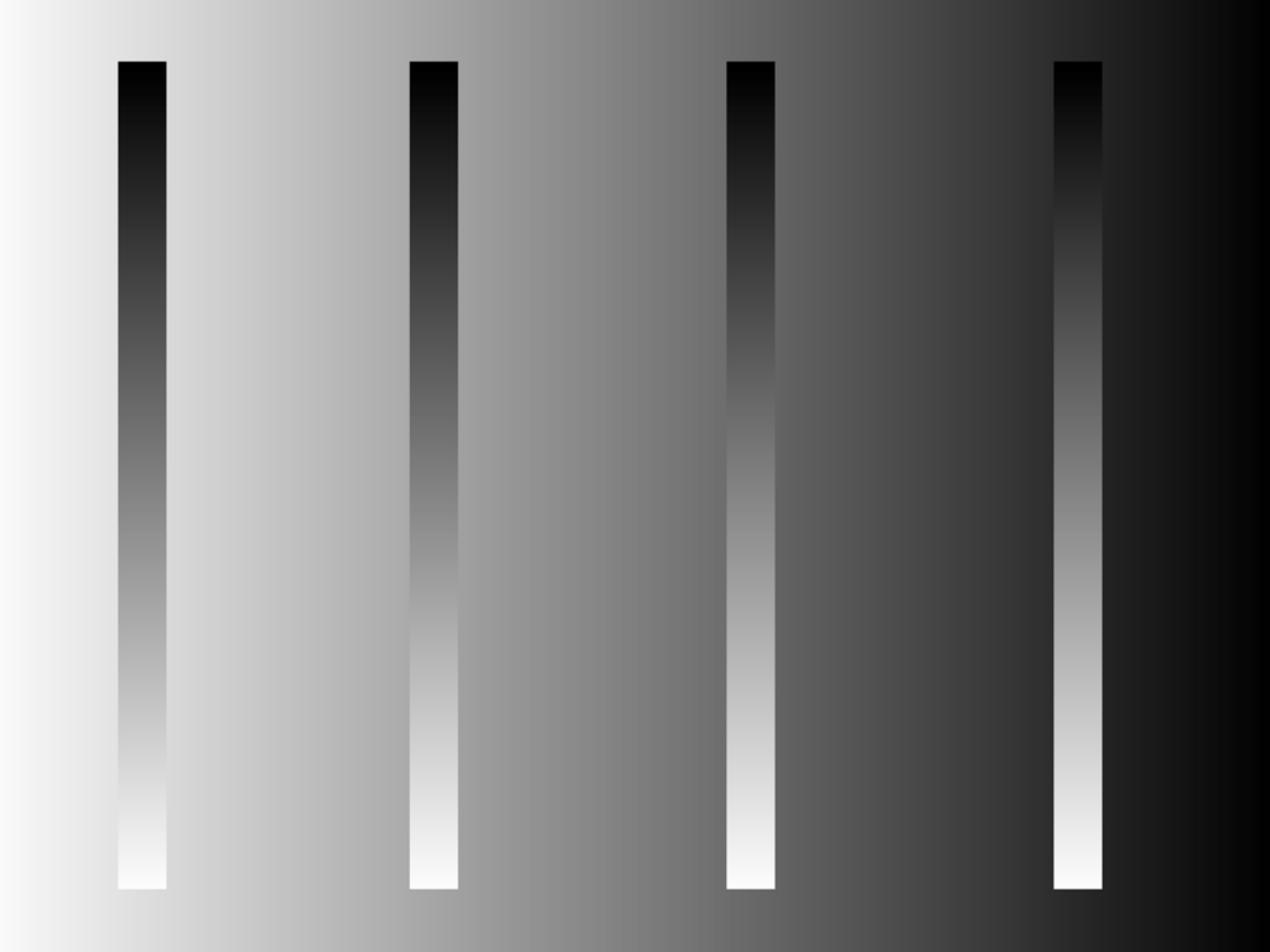


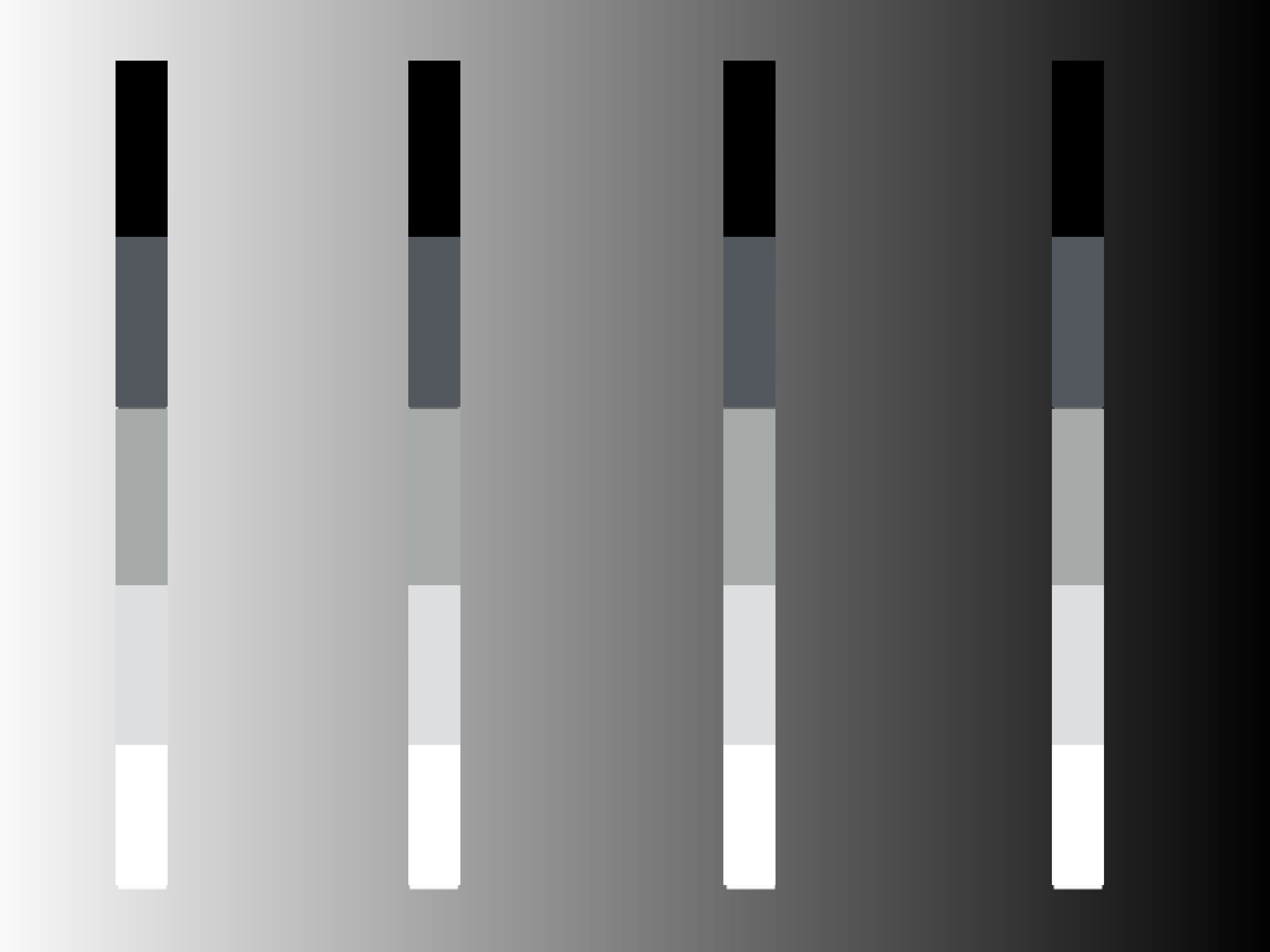
SIMULTANEOUS CONTRAST



http://www.handprint.com/HP/WCL/tech13.html





Simultaneous contrast is a problem

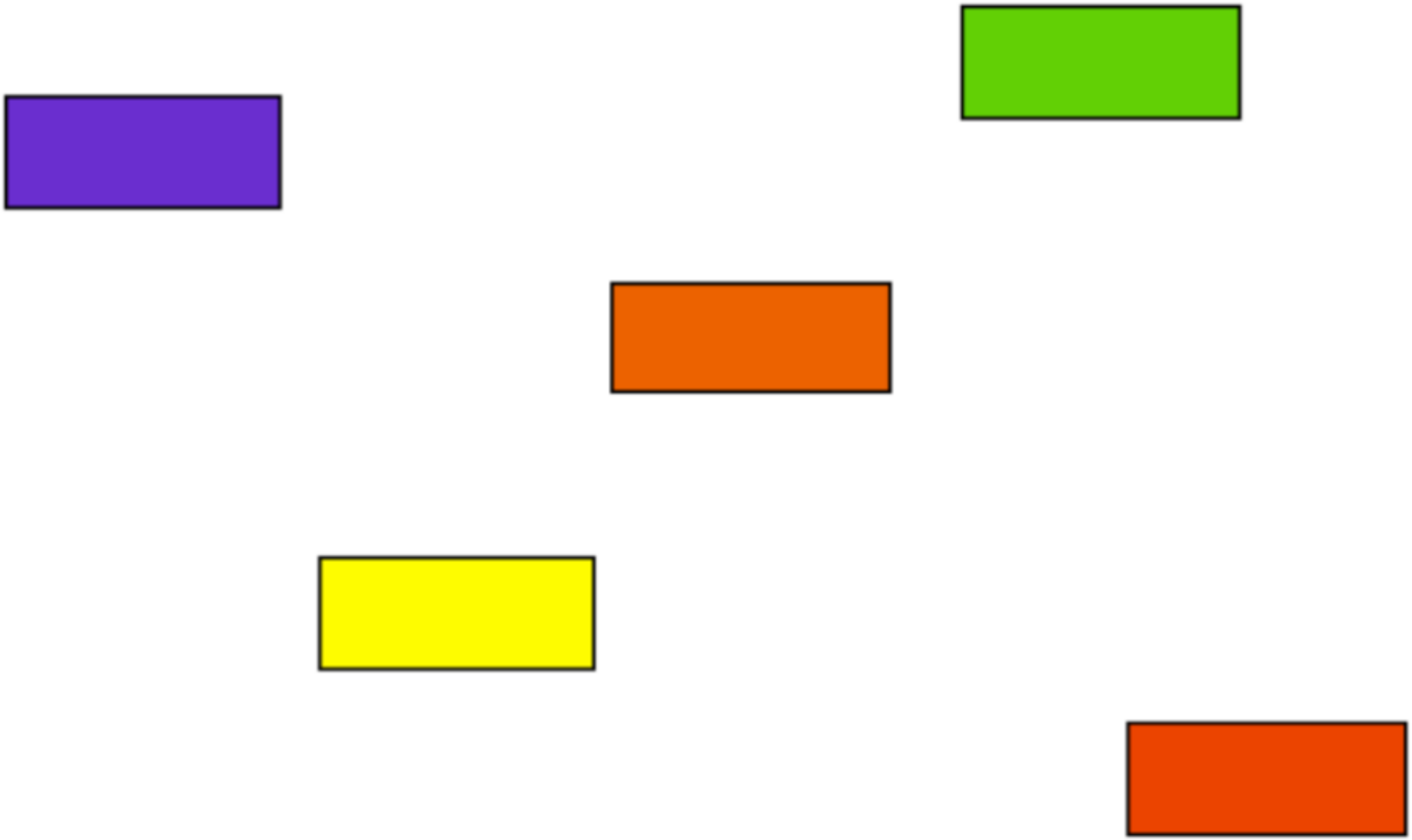
Consider quantizing scales if long-range comparisons should be supported
(This comes at a fidelity cost for the data)

“Categorical” data

- Sometimes there’s no implied relationship between different levels of a variable
    - Stimuli must look different, but **only** different

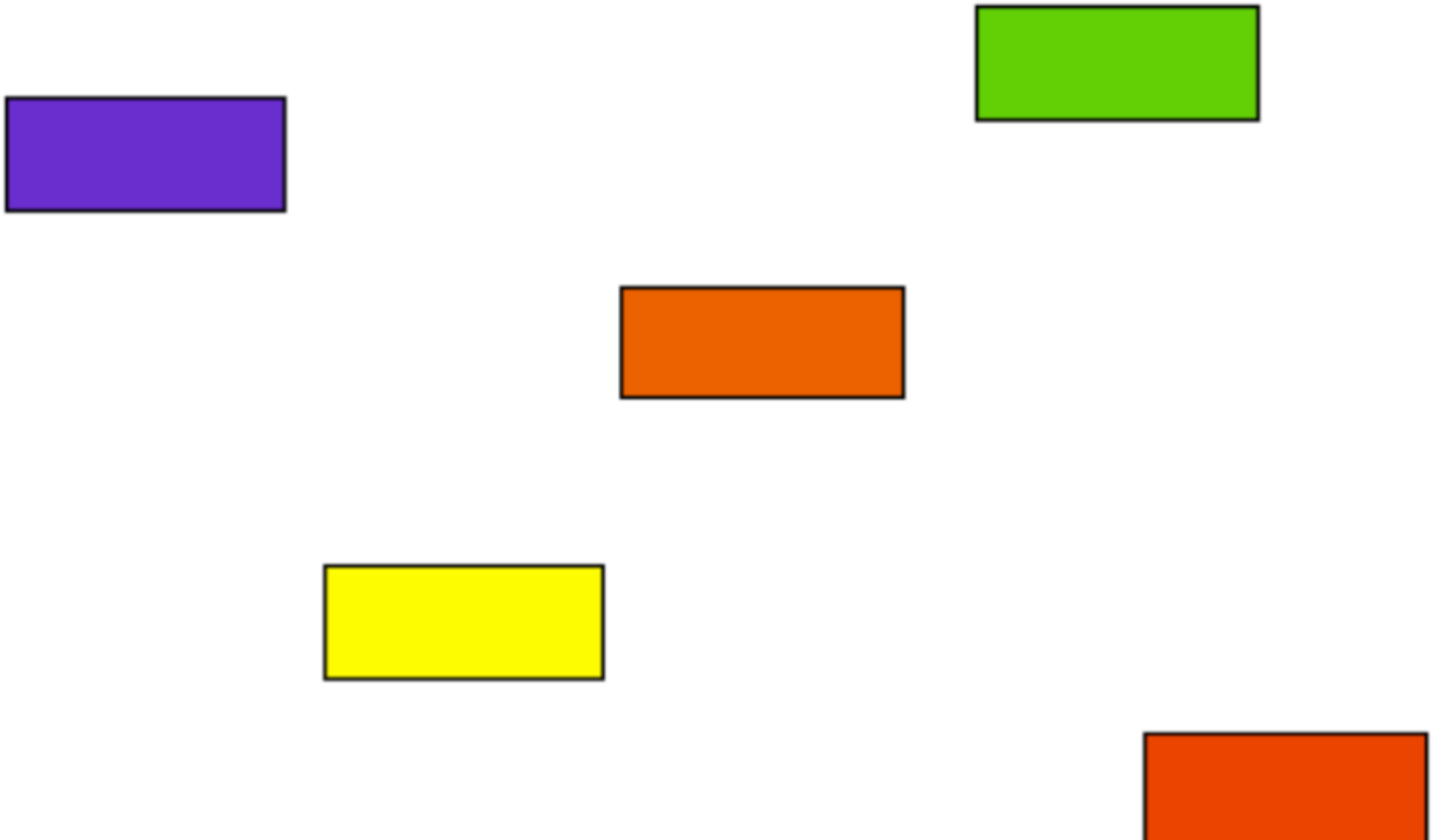
```
d3.scaleOrdinal(d3.schemeCategory10)
```

Order these colors!



You can't…

Order these colors!



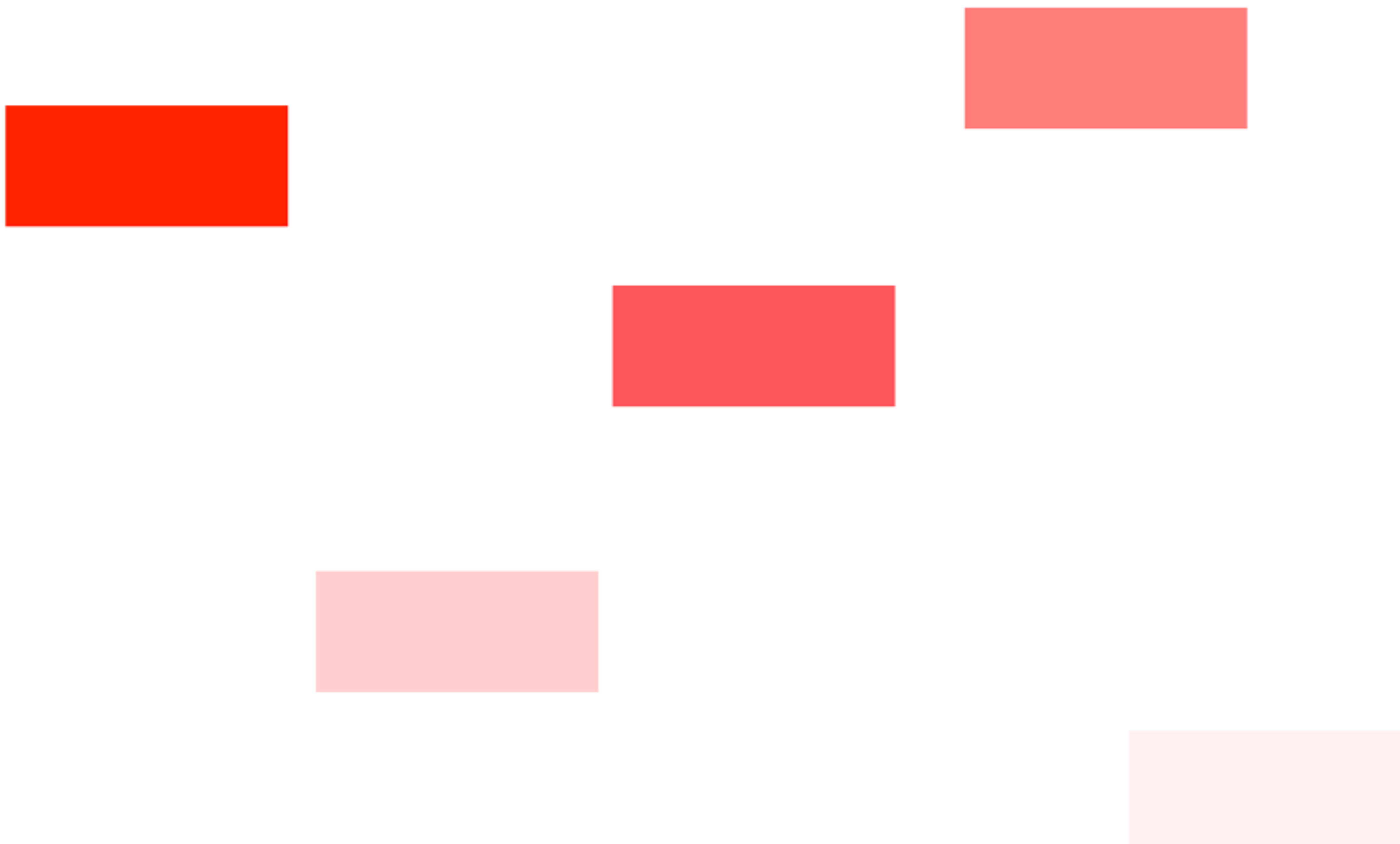
Order these colors!

You can't help but…

Order these colors!

You can't help but…

Order these colors!



Be aware of implied and perceptually forced color relationships

For categorical data, use color only when you have few categories (less than 10)

Be aware of implied and perceptually forced color relationships

long jumps in hue: ordering is lost
variation in contrast: ordering is forced
variation in luminance: ordering is forced

Editor:
Theresa-Marie Rhyne

Rainbow Color Map (Still) Considered Harmful

David Borland and Russell M. Taylor II
University of North Carolina at Chapel Hill

Research has shown that the rainbow color map is rarely the optimal choice when displaying data with a pseudocolor map. The rainbow color map confuses viewers through its lack of perceptual ordering, obscures data through its uncontrolled luminance variation, and actively misleads interpretation through the introduction of non-data-dependent gradients.

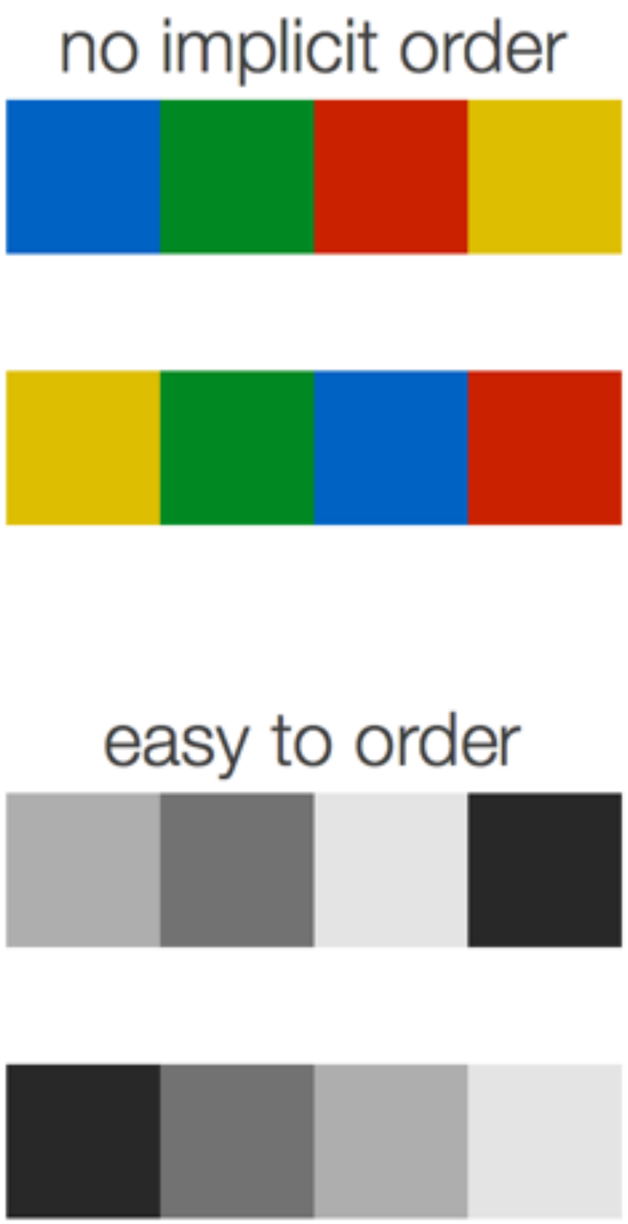
Despite much published research on its deficiencies, the rainbow color map is prevalent in the visualization community. We present survey results showing that the rainbow color map continues to appear in more than half of the relevant papers in IEEE Visualization Conference proceedings; for example, it appeared on 61 pages in 2005. Its use is encouraged by its selection as the default color map used in most visualization toolkits that we inspected. The visualization community must do better.

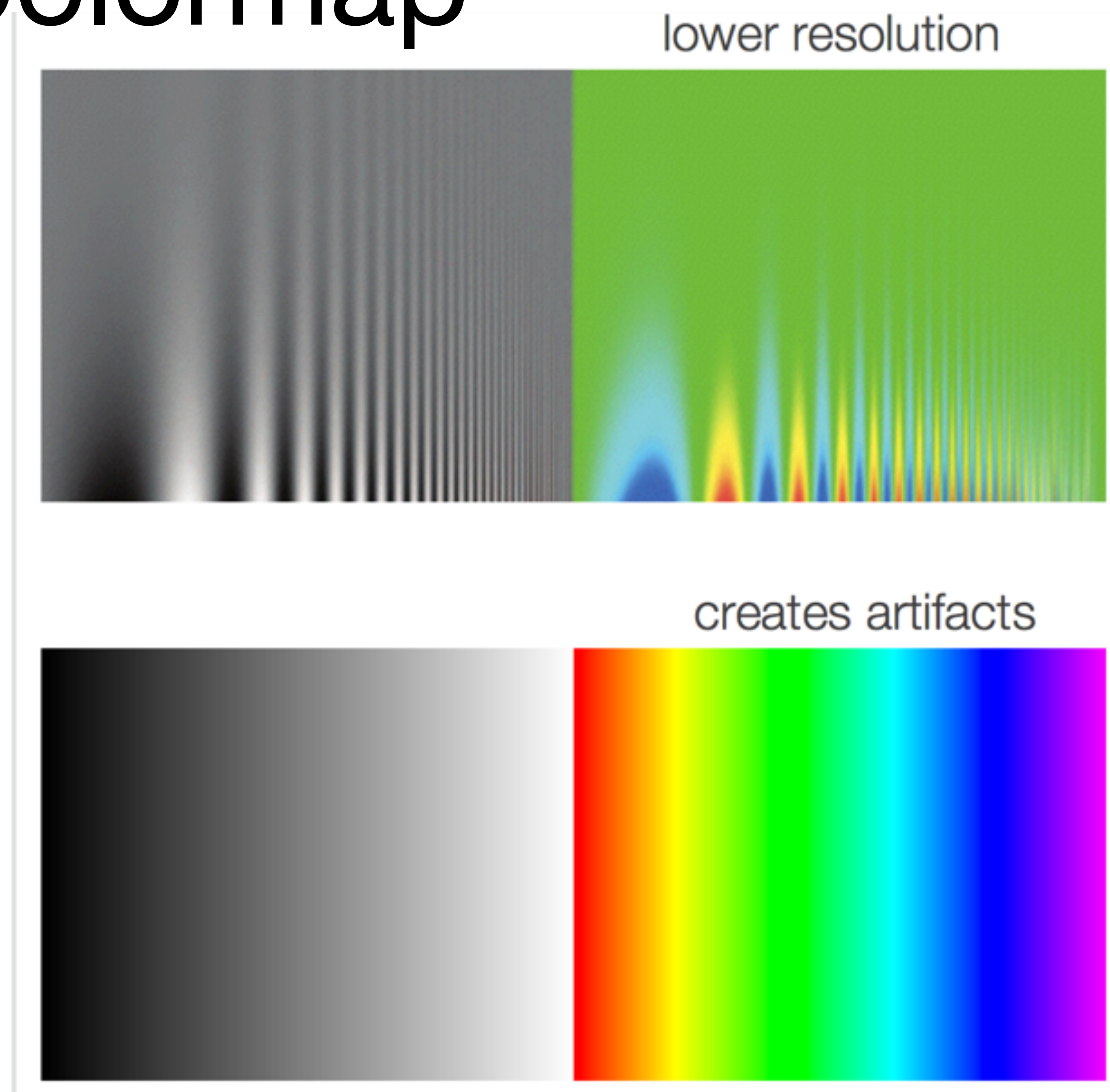
In this article, we reiterate the characteristics that mercials, weather forecasts, and even the IEEE Visualization Conference 2006 call for papers, just to name a few. The problem with this wide use of the rainbow color map is that research shows that it is rarely, if ever, the optimal color map for a given visualization.[1-6] Here we will discuss the rainbow color map's characteristics of confusing the viewer, obscuring data, and actively misleading interpretation.

Confusing

For all tasks that involve comparing relative values, the color map used should exhibit perceptual ordering. A simple example of a perceptually ordered color map is the gray-scale color map. Increasing luminance from black to white is a strong perceptual cue that indicates values mapped to darker shades of gray are lower in value than values mapped to lighter shades of gray. This mapping is natural and intuitive.

The Dreaded Rainbow Colormap

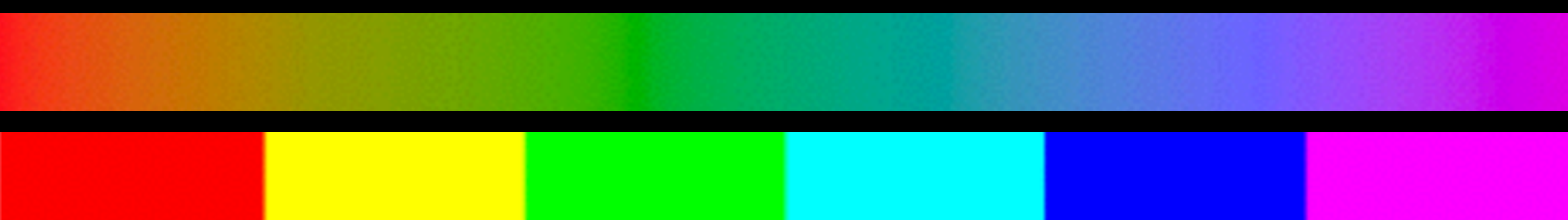




If you're going to use the rainbow colormap, use an **isoluminant** version, **quantize** it, or **both**

Bad

Better



COLORBREWER

COLORGORICAL

TEMPORAL ADAPTATION

http://www.moillusions.com/black-and-white-in-colour-again.html/13191556xteeocm7

TEMPORAL ADAPTATION

http://www.rpdms.com/satillusion/

Impossible Colors (!)

http://upload.wikimedia.org/wikipedia/commons/5/56/Chimerical-color-demo.svg