36-315: Statistical Graphics and Visualization

Handout 19
Date: March 31, 2003

Physically, light has an infinite number of dimensions, described by a **spectral curve**. Humans cannot perceive each wavelength independently. For example, a spectrum of red plus green is indistinguishable to us from a spectrum of only yellow.

Humans perceive three dimensions of light:

Hue is the informal notion of "color", like red or green. Hues form a circle: red-yellow-green-cyan-blue-magenta-red.

Saturation is how pure the color is. Lowering the saturation makes the color look progressively dull or "washed out", until it becomes white or gray.

Brightness is the overall strength of the light.

Together, these dimensions describe a **color cone** with black as the tip. The line from the tip to the base is the line of gray values, or zero saturation. The distance from gray is the saturation, and rotation about the center is hue.

Isaac Newton developed the modern theory of color in 1704. By mixing differently colored lights, he discovered the circular structure of hues. He also found the distinction between perceived color and the physical light spectrum.

How colors are produced:

- When two lights are mixed, they produce the color intermediate between them in the color cone.
- **Complementary colors** are hues that produce white when mixed, e.g. green and magenta.
- **Primary colors** are a subset of three or more colors, chosen purely for convenience, which are mixed to simulate other colors.
- Computer monitors use red, green, and blue (RGB) as their primary colors. Thus colors produced by computer live in a subset of the color cone, the so-called **RGB cube**. Because of mixing, colors tend to appear lighter than you expect.
- Color printers use cyan, magenta, yellow, and black (CMYK) as their primary colors. Because of mixing, colors tend to appear darker than you expect. Unfortunately, this means that colors which print well are exactly the opposite of those which display well on a monitor.

Brightness contrast illusion—The same color appears brighter against a dark surround. The illusion also holds for saturation (but not for hue). Choropleth maps are susceptible to this illusion.

Color schemes for statistical graphics:

A **categorical** color scheme is for groups with no natural order. It is uses distinct and saturated hues. It does not reproduce well in black and white.

A **sequential** color scheme is for numerical values. The main cue is brightness, with small variations in saturation and hue to increase discrimination. It is designed to be readable in black and white as well as color.

A **double-ended** or **diverging** color scheme is for numerical values that have a critical midpoint, such as residuals. It uses one hue to indicate high values and another hue to indicate low values, with a white or gray midpoint. It does not reproduce well in black and white.

References

[1] Dan Carr. "Color perception, the importance of gray and residuals, on a choropleth map." *Statistical Computing & Graphics Newsletter* 5(1):16-20, 1994.
`http://cm.bell-labs.com/cm/ms/who/cocteau/newsletter/issues/back/v51.pdf`

[2] Kath Stynes. "Cartographic Visualization of Population Data." Project Argus, 1996.
`http://www.mimas.ac.uk/argus/Tutorials/CartoViz/PopViz/index.html`