Applying Knowledge of Color Perception to Visualization

The use of color in visualization can often aid in interpretation, however, improper use of color can also be detrimental to a visualization's efficacy. Ware (2012) addresses several considerations to be taken when deciding how to use color in visualization. In some contexts, grayscale is superior to color in visualization, such as black text on a white background being much easier to read than white text on a black background. Under what circumstances does color enhance visualization? This will be addressed while walking through two visualization designs.

Consider a clinical trial in which the relationship between stress and physical illness is explored for two drug groups and a control group. Collected data could be presented as three overlapping scatterplots with regression lines. A visualization which does not make use of color may look like Figure 1. It is difficult to identify the three separate scatterplots to get a sense of each trend in Figure 1. Ware would argue that this visualization task would benefit from color, as color is particularly useful for visually labelling nominal categories. There are several considerations to be made when selecting colors for nominal labels. Primarily, one wishes to maximize discriminability between groups, which can be done by using the *CIEluv* equations (Ware, 2012, p. 106). Generally, the easiest colors to discriminate between are vivid reds, greens, yellows, and blues, the colored axes of opponent process theory. Anthropological studies have shown that red, green, yellow, and blue are also consistently the first colors to acquire names across many cultures, suggesting a biological preparedness for discriminating between them (Berlin & Kay, 1969). A good choice of colors for revising Figure 1 are red, yellow, and blue, as excluding green also avoids potential confusion among those with the most common form of color blindness, red-green deficiency. Use of yellow is problematic in that it has low contrast with a white background, however a black border remedies this. Ware (2012) also recommends using low saturation background colors to aid in the detection of vivid foreground objects. Figure 2 integrates these considerations. Unlike Figure 1, it is easy to detect general trends and variability in each scatterplot in Figure 2, as well as discriminate regression lines from the background.

In addition to aiding discrimination between unordered categories, color can also be useful for coding continuous data. Color is frequently used to indicate temperature in weather maps, typically transitioning from red (hottest) to blue (coldest) across a full spectrum gradient. I have always found such maps difficult to look at, as vivid medial colors – yellow, green, and cyan – are as, or more, eye-catching than the extremes. This is consistent with Ware's note that full spectrum gradients are not perceptually ordered, but rather a series of shorter ordered gradients. For example, a gradient from red to yellow varies only by the amount of green, and is thus a perceptually ordered segment. Vivid red, yellow, green, cyan, blue, and magenta can all be thought of as maxima in the three-dimensional gamut of the visible spectrum, explaining the undesired salience of medial colors in full spectrum gradients. A better color coding system for weather maps might be a bidirectional saturation gradient, from red to gray to blue, with gray indicating a fair temperature, such as a national average, resulting in a map where extreme, saturated hues always indicate extreme temperatures.

While grayscale coding in visualization is useful for certain tasks, such as perception of shape and small, detailed symbols, color is favorable when coding nominal categories and quantitative data.

References
Berlin, B., & Kay, P. (1969). Basic color terms: Their universality and evolution. Berkley: University of California Press.
Ware, C. (2012). Information visualization : perception for design. Retrieved from https://ebookcentral.proquest.com

Figure 1.

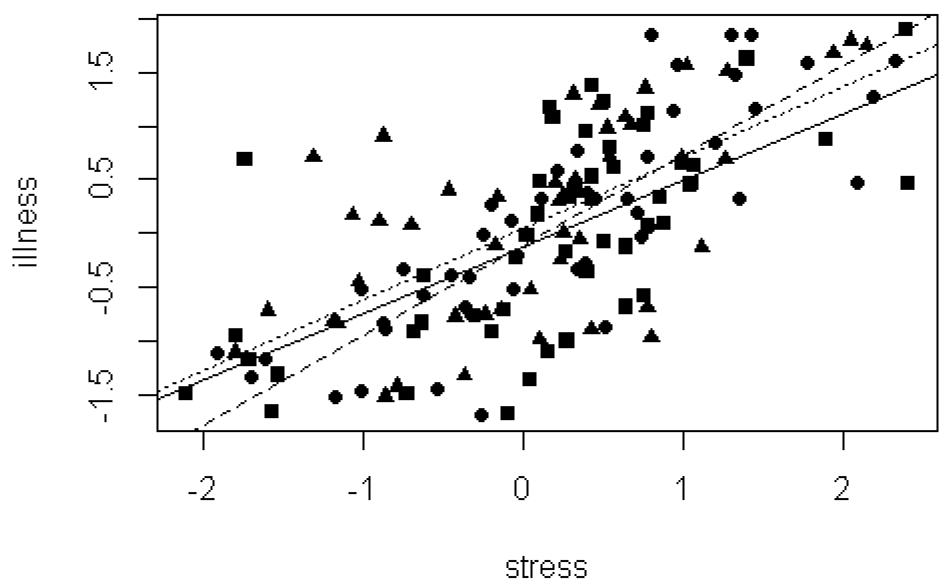

Figure 2.