

Reply

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By calling attention to the perception of data graphics among color-impaired readers, we hoped to raise awareness of an even more prevalent phenomenon: the misuse of spectral, or “rainbow,” color schemes. David B. Stephenson is quite right regarding the incidence of different forms of color-vision impairment, which varies among racial and ethnic groups and is much lower for females [Sharpe *et al.*, 1999]. Our article highlighted simulations of the less common protanopia to dramatize the general peril of spectral schemes.

Figure 1 shows simulations of spectral, diverging, and progressive color schemes as they might appear to readers with either of the most common forms of color deficiency. Figures 1a and 1b illustrate why the adage “red and green should never be seen” is a good one. The simulations in the right-hand column show how deuteranopes may find it difficult or impossible to distinguish between red and green.

Spectral schemes guarantee zones of confusion for those with color-impaired vision, but also limit comprehension by nearly everybody else. The situation arises, as in our example, from the similarity of end-member colors (dark reddish purple versus dark purplish red), and the off-center location of the most vivid colors (yellow and yellow-green), which limit a reader’s ability to comprehend gradients, overall patterns, or values for individual locations. In contrast, both color-deficient and normally sighted readers should be able to distinguish the color schemes in Figures 1c (blue-red) and 1d (green-magenta).

Creating effective data graphics for communication and analysis is a complex task; designing for color-deficient readers is only one of many challenges. Adages like “red and green should never be seen” and “the end of the rainbow” may help authors recognize obvious problems, but cannot provide sufficient guidance for them to reliably produce effective data graphics from first principles.

Fortunately, designing data graphics from first principles seldom proves necessary. Scientific authors should approach data graphics design from a position of strength—as masters of their own data—rather than from an uncertain mastery of color. Specialists have tested color schemes and identified those that work well; most authors will do well to select from the proven alternatives (e.g., <http://www.ColorBrewer.org>). Editors and publishers could help authors by recommending menus of color schemes for use with specific types of data.

Further information may be found at <http://geography.uoregon.edu/datagraphics/>.

Reference

Sharpe, L. T., *et al.* (1999), Opsin genes, cone photopigments, color vision, and color blindness, in *Color or Vision: From Genes to Perception*, edited by K. R. Gegenfurtner and L. T. Sharpe, pp. 3–51, Cambridge Univ. Press, New York.

—ADAM LIGHT and PATRICK J. BARTLEIN, University of Oregon, Eugene

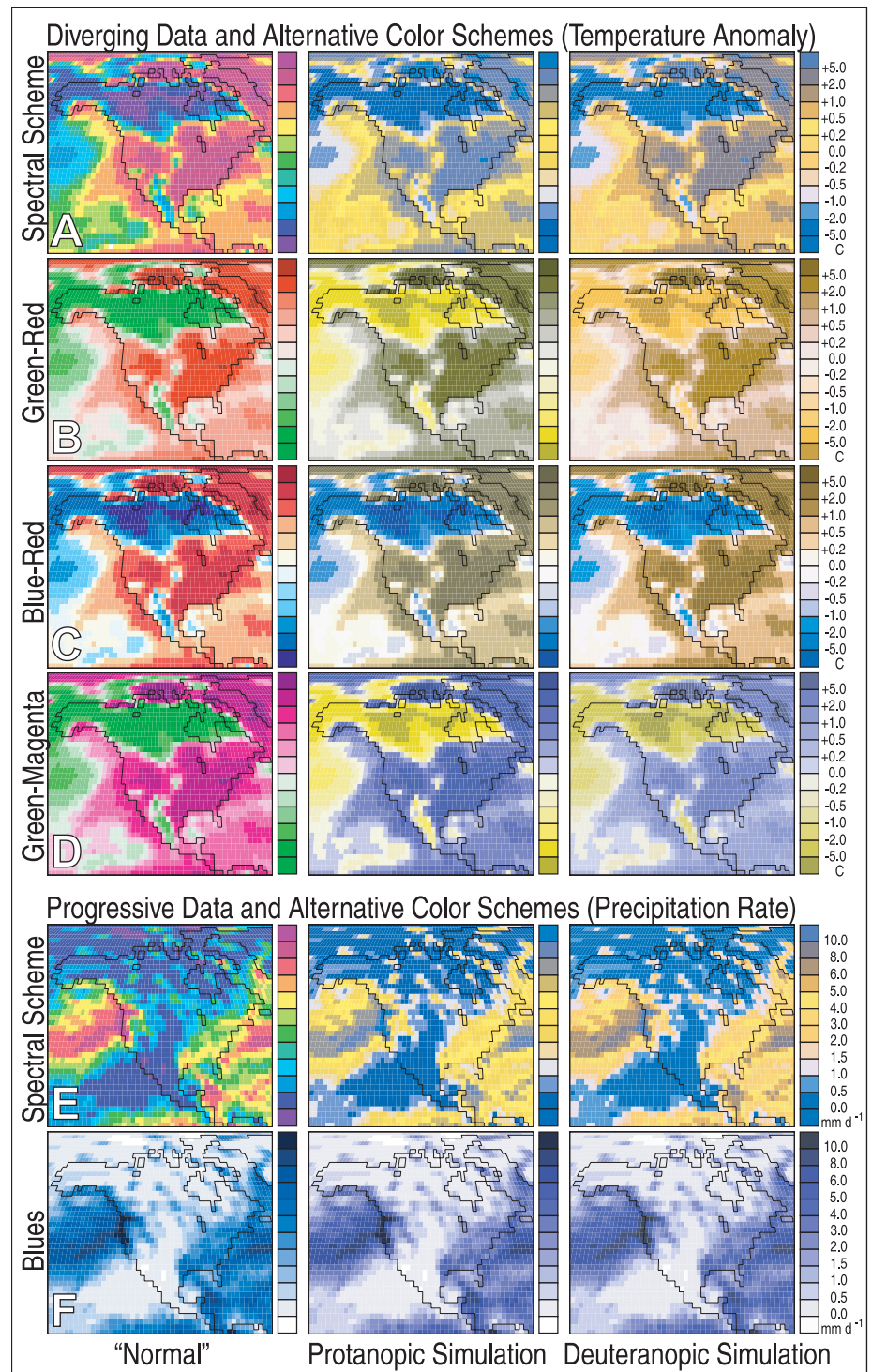


Fig. 1. The left column in each row displays a specific color scheme, while the middle and right columns display simulations of the scheme as it might appear to viewers who exhibit the two most common forms of color-vision deficiency. For “diverging” data, such as the temperature anomalies shown here, the locations of extrema and of the zero isopleth (the points where the temperature anomaly is zero) are significant. Figures 1a and 1b show how the spectral scheme may be slightly less confusing for deuteranopic viewers than protanopic ones, but also illustrate that the most prominent color (yellow) appears off-center in the range of scale values. Figures 1c and 1d show how properly chosen diverging color schemes can increase interpretability for all readers by making the location of extrema and zeros obvious; Figure 1d additionally demonstrates that should there be a conceptual reason for employing green, pairing it with magenta improves interpretability. For “progressive” data like precipitation rate, the spectral scheme (Figure 1e) arbitrarily emphasizes the middle range of values for all viewers, and makes it difficult to infer spatial gradients. Progressive data require only a single hue because intensity (or value) encodes the level of the data (Figure 1f). Blue connotes water in many cultures and is a more intuitive choice than, say, brown or red for representing precipitation, but a simple gray scale would also suffice. (Figures 1c, 1d, and 1f illustrate “good” color schemes.)