The Language of Visualisation

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Summary

There is a visual language present in all images and this article explores the meaning of these languages, their importance, and what it means for the visualisation of science. Do we, as science communicators, confuse and confound our audiences by assuming the visual vernacular of the scientist or isolate our scientific audience by ignoring it?

The visual vernacular

In my previous gig at the American Museum of Natural History in New York City, I had the enviable title of Science Visualiser. When I first learned this, well into the application process, I imagined that my job involving sitting in an office lined with tapestries, incense burning, staring off into space… And visualising science.

A Google image search in support of that joke turned up something akin to Figure 1 (reproduced here from scratch to avoid copyright infringement). But as I reflected on the image of Ganesha floating in front of the Pleiades, I realised that it conveys a deeper message. There's a visual vocabulary at work, injecting the image with meaning for those familiar with Hindu culture, but escaping those who don't have a grounding in that iconography. I happen to know just enough to recognise that the position of the god's hands and trunk, the shrew at his feet and the cobra around his middle all have meanings, resonances, and metaphorical implications. But that understanding only scratches the surface, and the average Western viewer (myself included) basically just sees "new-age Hindu something or other".

Figure 1. The god Ganesha floats in front of a celestial backdrop. Ganesha image courtesy of Michael Van Vleet, Pleiades image courtesy NASA, ESA, and AURA/Caltech.

Taken together, these elements constitute a visual language that conveys meaning. Those elements may call on religious or cultural iconography, but fundamentally, they rely on learned structures. For example, comics (a subset of the broader category of "sequential art") require the viewer to understand how images are arranged, in sequence, to convey a sense of time and narrative structure, and a host of other visual elements — word balloons, motion lines — spell out additional details (Eisner, 1990; McCloud, 1993). Most of our audiences will find the core elements of a comic's visual language quite familiar.

The visual language in science

In maths and science we have a well-developed visual language that can cause confusion for many people.

For example, the Cartesian plane has become second nature to most scientists and science communicators. We find the abscissa and ordinate so familiar that we forget how easily they can confound the uninitiated. Even if one explicitly defines the meaning of the two axes, the message might remain unclear: interpreting values in the *xy*-plane doesn't come naturally to everybody.

Scientists also have an unfortunate fondness for the rainbow colour map. Unfortunate because the rainbow palette assumes an ordering of colour that makes scientific sense, following the spectrum from red to violet, but not perceptual sense: humans don't innately perceive colour as ordered. But adding insult to injury, the luminance of the rainbow palette shifts from dark (blue) to bright (yellow) to dark (red), so using the rainbow scheme fights against an innate perception of brightness.

Having expressed my misgivings, I'll note that Figure 2 shows Cartesian mapping and a rainbow colour map used to relatively good effect. Accompanying a Hubble press release from 1997, an image of the galaxy M84 appears next to a visualisation of the STIS spectrum of its interior — a region barely discernable, outlined in the interior of M84 (Hubblesite, 1997). The spectrum uses redundant representation for spectral shift — both colour and position along the horizontal — and the original image caption explains it in detail. Here, the rainbow has a specific, colour-related meaning — the red- or blueshift of the light from the galaxy — so the visual language supports the science content. And even the rainbow's luminance works in this image's favour, since the darker blues and reds express deviation from the bright greens and yellows.

Contrast this relatively clear use of rainbow colour with its completely counterintuitive use in Figure 3, showing a subset of the Planck cosmic microwave background (CMB) data release from this spring. (Admittedly, Planck simply modified the colour scheme of its predecessor the Wilkinson Microwave Anisotropy Probe

[WMAP], but didn't address its core problems). Incredibly, the image caption and press release[1] don't even describe the chosen colour representation, so readers aren't informed that the blue regions correspond to cooler (denser) parts of the CMB, while red maps to warmer (less dense) regions. This visual assumes too much: it assumes that we can "read" the rainbow representation, and it even assumes we know what the colours represent! Furthermore, the luminance issue makes the middling values of the CMB temperature the most visually striking portion of the image.

When we rely incautiously on such mystifying visual language, we risk misleading our audiences — or simply encouraging them to tune out. In the same way that I look at Ganesha and see a nonspecific reference to Hinduism, many people will look at something like the Planck image and see "science something or other".

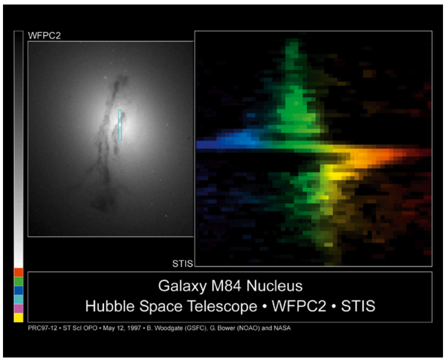

Figure 2. *A reasonable application of the rainbow palette to illustrate gas motions in M84. Courtesy Gary Bower, Richard Green (NOAO), the STIS Instrument Definition Team, and NASA.*

Using visualisation effectively

Fundamentally, visualisations use data to communicate. You may be communicating to yourself — basically, data analysis — or to a peer group or general audience. The differences lie in the visual language you choose to employ: you employ visual elements that your audience will find accessible. With an expert audience, you can make use of shorthand, but for novices, you need to tread more cautiously.

As with all means of communication, all visuals incorporate an element of subjectivity; there is no objective image. Even the most objective graph you can imagine requires making specific choices — the choice of axes, range of data, linear versus logarithmic scale — that reflect human intention.

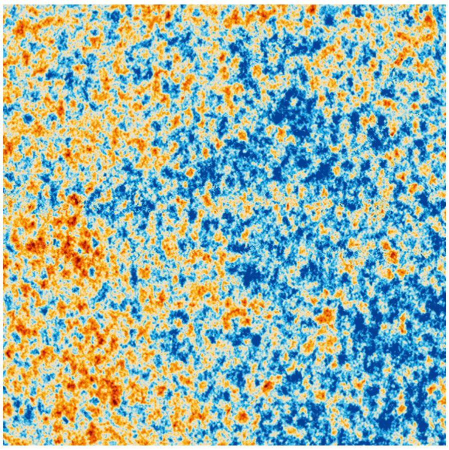

Figure 3. *The Planck cosmic microwave background image makes use of a deceptive and counterproductive rainbow colour scheme. Courtesy ESA and the Planck Collaboration.*

In his "Designing Data Visualizations" workshop at the American Astronomical Society meeting this past January, Noah Iliinsky articulated a similar perspective. He describes two types of visualisation process: "for exploration, when you don't (yet) have a story to tell" versus "for explanation, when you *do* have a story to tell". As an example of the former, Iliinsky offered up the *New York Times* "Jobless Rate for People Like You" (New York Times, 2009) and recommended the interactive software Tableau[2], and within the astronomical community, this category relates most directly to data analysis. But of course those of us involved in public outreach tend to have stories to tell, and we need to tell them consciously and carefully, choosing our visual language with thoughtfulness and respect. We need to consider the needs of those for whom the visualisation is intended and make good decisions in support of our messages. Iliinsky's slim volume, *Data Visualization*, (2010) delves into the process of creating visualisations, and one of his diagrams (Iliinsky, 2012) does a smashing job of encapsulating the constituent components of a visual language.

Perhaps my chance selection of Hindu iconography has a fortuitous metaphorical implication. Many people worship Ganesha as the remover of obstacles, and as such, he can serve as a reminder to remove the barriers of visual representation that can separate our audience from a clearer understanding of our message. Whether or not we need Ganesha's assistance to accomplish this task, we should take it seriously.

References

Eisner, W. 1990, *Comics and Sequential Art*, (Poorhouse Press: Melbourne, Australia) ISBN 0-9614728-1-2

Hubblesite 1997, *STIS Uncovers the Black Hole Powering an Active Galactic Nucleus*,http://hubblesite.org/newscenter/archive/releases/1997/12/background/

Iliinsky, N. 2010, *Data Visualization*, (O'Reilly: Sebastopol, California)

Iliinksy, N. 2012, *Properties and Best Uses of Visual Encodings*, http://complexdiagrams.com/properties

McCloud, S. 1993, *Understanding Comics: The Invisible Art*, Kitchen Sink Press, ISBN 0-87816-243-7

New York Times, 2009 http://www.nytimes.com/interactive/2009/11/06/business/economy/unemployment-lines.html

Notes

1. Simple But Challenging: The Universe According to Planck http://sci.esa.int/planck/51551-simple-but-challenging-the-universe-according-to-planck/
2. http://www.tableausoftware.com/products/public

Biography

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