One of the key concepts throughout our judgment of presentation-related design options is to seek to make the visible, invisible. In contrast to data representation, where our objective is to make the invisible stories and insights visible, data presentation features should almost feel invisible so that the portrayal of the data maintains visual dominance. Therefore, try to bear the following two things in mind:

- **Visual inference means data inference:** If it looks like data, it should be data. If it isn't data then you've incorrectly conveyed a sense of representation where there isn't any and design refinement is required. An example might be the use of a color to represent a certain sentiment. If that color is used on a bar chart or is picked for the background of a label or call-out, but it is no longer connected to the representation of any sentiment meaning, this may trick the reader who has programmed their visual sense to spot this inference.

- **Facilitating the resemblance of data:** Let the data breathe. We talked about this in the discussion about Jacques Bertin's interpretative acts, but the presentation layers of your visualization will have a great impact on this. Ensuring a reader can discriminate between data categories and values is usually influenced by the background artifacts and surrounding apparatus. Throughout your design, make sure your data stands out clearly as the principle visual component.

**The use of color**

Here is a quote from Maureen Stone (http://www.perceptualedge.com/articles/b-eye/choosing_colors.pdf):

"Color used well can enhance and clarify a presentation. Color used poorly will obscure, muddle, and confuse."

We've already touched on various aspects of using color as a potentially important visual variable for the representation of data, but the deployment of color for a visualization project naturally extends further. Given the depth and breadth of the field of color theory, it is important to consider it separately from our other design choices. The preceding quote emphasizes the value of doing this.

When deployed poorly, the use of color can create unnecessary decoration that can distract and compete undeservedly for attention in ways that will undermine the clarity and accessibility of the information exchange.
Conversely, with effective use of color we can deliver an attractive, synthesized design that most efficiently taps into the preattentive nature of the eye and the brain.

We are seeking to create layers of visual prominence that help us instantly achieve a sense of the important messages and features. Take a look at a landscape painting and witness the depth that is created through color, the separation between foreground and background that helps elevate prominent features and relegate contextual properties.

The best advice for guiding your decisions about using color is to refer to the two key rules shown at the start of this section—make sure it is used unobtrusively and it does not mislead by implying representation when it shouldn't be.

As with all design layers, the sensible objective here should be to strive for elegance rather than novelty, eye-candy, or attractiveness. To achieve this, it is important to be aware of the different functions, choices, and potential issues surrounding color deployment.

**To represent data**

One of most common mistakes used in relation to color is seen when it is being deployed to represent quantitative data. Specifically, when the "hue" property of color is used.

Take a look at this spectrum of colors: if these squares were representing quantitative data, which would be the biggest? How about the smallest? Which is bigger, red or blue?

As you will realize, there is no convention or association that determines a relationship between color (hue) and any sense of hierarchy or order of magnitude. We don't see one color as being inherently bigger or smaller than the other, and so to use this to represent quantitative data is a mistake.
In the following pair of images, on the left-hand side, even with a color legend explaining the value bands being depicted by the different colors, there is no preattentive association that allows us to efficiently determine the values being represented on the map. Referring back to Bertin's interpretive acts, we can't even easily establish a general sense of big, medium, and small values without having to constantly move to-and-fro the map and the legend. By contrast, the map on the right-hand side uses a single hue and uses a sequential color scheme that represents the highest values (dark) to lowest values (light) in a logical and immediately understandable way:

What we can see demonstrated in this example is that, for quantitative data, one of the best ways to effectively depict a range of quantitative values is through the lightness property of color: that is, a scheme which goes from the most intense color through to increasing amounts of white. This is sometimes called a sequential color scheme:
As we can see clearly in this next display, we inherently and automatically attach a sense of order to such sequential scales. Of course, without a key it might be difficult for us to precisely pick out the absolute values that each color band represents, but we can certainly determine major patterns that lead to judgments of data order within and across both sample maps:

Unemployment rose steadily from 2000 to 2004, peaking at 6.3% in June 2003. Rate decreased steadily over the next four years.

The national average rises to the highest it’s been since June 1983, when it was 10.1%. Unemployment has increased every month since April 2008 with the exception of one month when it decreased 0.1%.

That idea, of surfacing the general patterns of the highest and lowest values, is really what the main purpose of color is when used to represent quantitative variables.

There are other types of color scheme used for situations that require us to represent two quantitative variables or to highlight two extremes of a single variable. These are known as diverging schemes.

While there is a variety of different ways to construct diverging color schemes, typically, the extreme ends of the spectrum are presented as darker and distinguished by strongly contrasting color hues. Alternative approaches might involve exploiting established color metaphors or might already be intuitively understood or easily learned.
The next image is an example of where preprogrammed understanding of color representation can be utilized. In this case, we see the respective strength of party political support across the U.S., with the Republicans represented by their established red and Democrats in blue. This is a topological map that displays calculated contours to show the general spread of support for each party. An added dimension to this particular piece is the use of an extra representation—color transparency—to represent population density, thus adjusting the display to accommodate the lack of population uniformity.

It isn’t just on maps, of course, where properties of color can be important to distinguish quantitative values. One of the most popular methods for coloring involves the traffic light metaphor of red, amber, and green. This is commonly used in corporate settings to indicate good, average, or bad performance thresholds.

However, it is important to know that around 10 percent of the population (particularly males) has a red-green color deficiency. The use of an approach such as the traffic light colors will therefore potentially alienate a significant proportion of your intended audience. An effective alternative is to switch green for blue, so positive values are now shown as blue and negative are still in red, as we see in the following horizon chart:
To check your chosen color schemes against the potential impact of different color deficiencies, use an application such as Vis Check (http://vischeck.com), which is a free online tool to simulate what a color-blind person would see when looking at your images.

As we've already explained in the data representation section, one of the key functions of a visual variable is to facilitate resemblance—the discrimination of data—and the use of color (hue) to distinguish between categorical variables is a particularly strong aid.

In the next example, we see a project created to display the status of various indicators surrounding how different states around the U.S. handle gay rights issues.
There are seven distinct categories of data distinguished by a unique color. The color itself has no meaning; it is purely a means of helping to separate out the various tracks of issues. The lightness of the color does add an extra layer of information, indicating where maximum (darker) and limited (lighter) rights are in place, and the absence of any color as well as the presence of a cross-hatching pattern further encodes extra meaning:

As we saw in the earlier image showing the political persuasion map of the U.S., the use of color for categorical data also allows us to maximize the implication of metaphorical or representative association.

However, regardless of whether the color depiction of categories is arbitrary or embodies more meaningful association, one of the key rules we need to obey is that the eye is only really capable of distinguishing up to a maximum of twelve different color classifications. This is just one of the many fascinating aspects of color that can be discovered from great books such as *Visual Thinking by Design*, by Colin Ware.
If you have more than twelve categories you may need to find ways of combining classifications to avoid this issue. You’ll see this in effect on images such as the many subway maps around the cities of the world. As more extended lines and routes emerge, there are fewer remaining distinct color options that will help to emphasize, indicate, and separate these new markings.

There are also many definitions about the emotional or cultural significances behind color representation. It is naturally advantageous to exploit universal visual languages, but only when they are definitely universal! You need to be sensitive to the potential differing perceptions of color meaning across the regions of world. For most colors there is contradictory association and so referring to a resource such as *Color Meanings by Culture* (http://www.globalization-group.com/edge/resources/color-meanings-by-culture) will represent time well spent.

**To bring the data layer to the fore**

In addition to the representation of data, we also look to employ color to help create visual depth and a sense of hierarchy in our designs. In the first chapter, we saw the demonstration of color and imagery being at fault for the lack of clarity in the diagram showing the placement and outcome of penalties taken by a selected footballer.

The clutter that can occur between background presentation and the foreground data representation makes it a real challenge to efficiently establish a sense of visual hierarchy. The brain and the eyes otherwise have to work especially hard to draw any insight.

What we are trying to establish is a clear sense of the most important signals brought to the foreground and the less important contextual or decorative elements pushed into the background.

We saw this effect successfully demonstrated by our proposed solution for the Olympics demonstration in the previous chapter. Here, the main focus surrounding the narrative of China and Germany’s transition over time was achieved by promoting their series of values strongly into the foreground through color. The rest of the value series for the remaining countries, as well as the chart apparatus, were relegated subtly into background but were still visible and available for reference.
We see a similar effect demonstrated by this following image taken from a typical dashboard display. By their very nature, dashboards are deployed in situations whereby the efficiency and accuracy of detecting key message as signals is a key aim:

![Image of dashboard display]

In this example, we see a limited, rather monochromatic color scheme applied across all properties—values, charts, labels, and titles. Through deploying this soft palette, it enables the key signals to jump in to the foreground as the most important visuals: the red indicators (alerting a need for further investigation), the blue headline bars (best performance), and the very subtle markers on the sparklines to represent the highest (blue) and lowest (orange) weekly levels.

When it comes to learning about the potential of color to create a sense of hierarchy, we can take inspiration from the effective deployment of color witnessed in other contexts. We can see examples from the best designs in advertising, website, product, and video games where creating intuitive, hierarchical displays are often vital components of their purpose and experience.

When it comes to judging background colors, there is no definitive set of rules about whether light (typically white) or dark (typically black) colors are better or worse. It is always a contextual judgment based on the intended style of the project as well as the palette of colors from which you intend to represent data. It is essentially a judgment about the legibility of contrast between foreground and background chart properties.

As a general piece of advice, try not to use strong, highly saturated colors when covering large areas. Don’t force the eye to have to constantly contend with and process dominant colors. Instead, give yourself the option of using strong colors to highlight and draw attention to the data layer.

Another important property to take notice of, in the relationship between foreground and background, is the careful deployment of chart apparatus, such as the axes, gridlines, tick marks, borders, titles—any chart property you may use to frame and reference your data.
Don't be afraid to remove or dampen the visible presence of such elements, particularly as the defaults in many tools are set to black. We are automatically tempted to make things darker, bolder, more prominent, more imprisoned. Where possible, minimize, dampen, or even remove some of these chart properties because we want to let the data stand out and facilitate our "seeing" of its qualities.

This extends to elements like titles. The following are two contrasting title designs for a visualization project that was undertaken about the history of Olympic speed. The first title shows a very rich and colorful image comprising a mosaic of all the posters down the years:

![Image from "Pursuit of Faster" (http://www.visualisingdata.com/index.php/2012/07/new-visualization-design-project-the-pursuit-of-faster/), by Andy Kirk and Andrew Witherley](image)

When this version was incorporated on to the main design, it was immediately clear that it was too visually prominent, drawing too much attention away from the main data display. By contrast, the second version was much subtler and worked far better as a cohesive part of the final display:

![THE PURSUIT OF FASTER
Visualising the evolution of Olympic speed](image)

There are many deeper and more specific aspects of color theory around the contrast or relationship between two colors. For example, typically it can be seen that blue on black is hard for many to discriminate, as is yellow on white. There are also issues to consider about the unexpected by-product of illusions being created between different arrangements of colors and shades. Color theory is a huge field and we can only reasonably scratch the surface in this book.

**To conform to design requirements**

The final factor concerning color involves the necessity to incorporate an organization's visual identity and conforming to predefined color palettes. Wherever possible, you would always seek to avoid the restrictions to color choice, but often this will simply not be possible. Just imagine some of the major corporations in the world and their brand identities and you'll immediately be able to envision the definitive color palettes.
The use of predetermined color schemes in visualization is to be expected, especially because it helps maintain consistency and recognition of brand. For a designer, it can be a hindrance and so it reemphasizes the importance of identifying this requirement in your early part of the methodology.

Here is an example from the Guardian newspaper. This bubble hierarchy diagram shows the breakdown of UK Government spending by department. The image contains a wide range of colors but they hold no quantitative or categorical meaning. Aside from helping to distinguish the different clusters, they perform a largely decorative function that makes the piece more attractive to engage with and help reinforce the organization's visual identity, which is typically a very colorful spectrum:

Many organizations such as the Guardian and also the New York Times have developed such a strong visual identity from their respective works, consistently observing defined color palettes, that you can now immediately identify their work from the style this color usage perpetrates.