Communicating Visually

Visual Communication is not a Natural Skill

As we’ve indicated in previous chapters, we humans are natural born storytellers; having accumulated the essence of basic verbal storytelling by the time we’re barely 36 months old.

While we may be born with a rudimentary ability to communicate audibly, our collective ability to master visual communication should not be a huge revelation to anyone who has lived through the Geocities and MySpace eras of the Internet. Yet, many of those who would shudder at the thought of bringing back the <blink> tag to our web browsers have virtually no issues schlepping a column or two of data into an Excel spreadsheet and walking away with a default chart image that can be cut and pasted into a PowerPoint document for an upcoming presentation. What causes this dichotomy between the acts of creation and perception and what can we do to fill in the gap?

To answer those questions, we need to understand how we create and receive images, a process called *“visual literacy”*, which has been defined by John Debes as:

*“…[the] group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visible actions, objects, symbols, natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these competencies, he is able to comprehend and enjoy the masterworks of visual communication.”*

So, visual comprehension is not a passive act but a very deliberate one, with our eyes taking in images and our brains interpreting, processing and deriving meaning from them—a process also known as *decoding*. While humans may have wrapped a definition around this process in the 20th century, this is old news…approximately 60,000 years old (give or take a century).



Figure Cave painting (left); pictograph (right)

In some ways, it’s no surprise that one of our first acts as we emerge into this world is to exercise our vocal cords and make our presence known to everyone in earshot. After all, we spend nine months being subjected to aural inputs with no ability to respond in-kind. But, what is the spark that ignites the need to communicate with images?

Cave paintings (figure 1) remain to this day sole artifacts of one of the first forays into mass, image-oriented visual communication. While it’s impossible for our modern minds to derive definitive meaning from these images, they are examples of *visual literacy* in action. The aforementioned spark occurred in the minds of a scant few prehistoric PowerPoint creators that both drove *and enabled them* to transcribe items from their three dimensional world into two dimensions with as much precision as implements at that time would allow. It’s unlikely these images stood on their own merit, and one can picture a tribal shaman—the regional sales rep of the day, as it were—animating painted scenes with his hands to help the audience understand what he as trying to convey (which was, most likely, identifying the animals were good to eat and the ones that should be avoided, which definitely has more practical benefit than most sales presentations today do).

Fast-forward 50,000 years or so to when the first petroglyphs (figure 1) were created and we see a creative evolution occurring which produced images that are more intricate and complex, demonstrating that the visual literacy of both the senders—still limited in number—and receivers increased significantly. The widespread discovery of similar-styled petroglyphs across nearly every continent provides further evidence of our collective need to communicate and be understood visually. Yet, without shaman context, it’s likely these standalone visualizations still would not communicate very well outside a small, close-knit group.

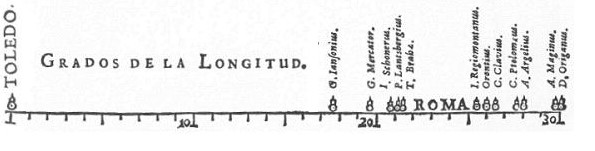


Figure 1644 chart of estimates of distances between Toledo & Rome from various navigator sources at that time by Michael Flortent van Langren

As we sail up through the timeline into the 17th century, picture the scene in King Phillip IV’s Spanish court after news of yet-another shipwreck found its way to his ear. Then, pan left to see the wheels turning in the mind of a middle-aged court mathematician off to the side as he considers a scientific approach to solving this crisis of commerce.

The results of this, albeit highly contrived, scene would be a dramatic increase in the *visual literacy* of humans of that era due to the creation of what would now be considered a simple one dimensional line graph by Michael Florent van Langren. Van Langren fancied himself a “sphereographer” and set out to find a way to show the court that these shipwrecks were the results of incorrect assumptions of longitude distances from Toledo to Rome. This exercise also provided the opportunity for van Langren to display his longitudinal prowess.

He fused visualization concepts from peers and predecessors such as Nicole Oresme, Albert of Saxony, Leonardo da Vinci, Nicholas of Cusa and, no doubt, many others and relied on the fact that his audience was also somewhat familiar with these teachings. The result is the chart in figure 2, which is considered the first known graph of statistical data.

While van Langren’s chart is good, it didn’t just “appear”. It took real effort to piece together how one could succinctly and effectively communicate the problem with the data and ultimately ended up relying on the receiver’s ability to decode a new communication method. If only the 17th century had a github equivalent for us to be able to peek at the iterations that did not survive the test of successful communication.

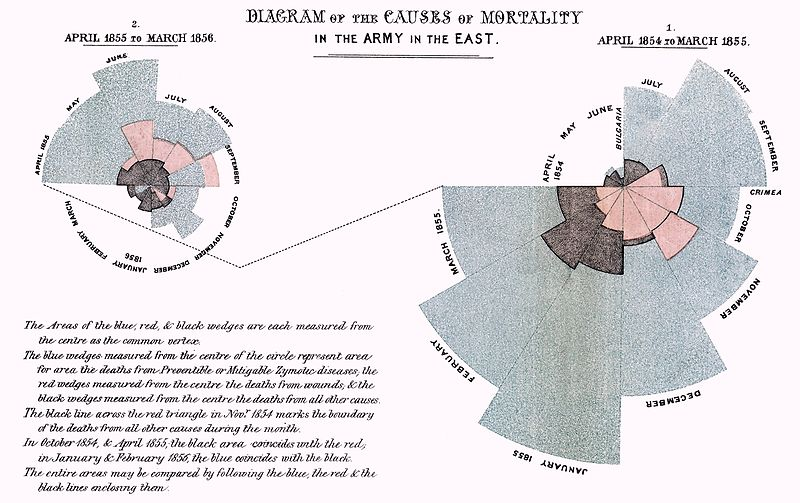


Figure Florence Nightingale's "rose diagram" of patient mortality rates

Marching, now, into Crimea during the mid-1800’s we find British soldiers dying by the thousands and also see the medical profession charging to the take the lead when it comes to pushing our decoding boundaries to help communicate both complex and critical analyses.

Florence Nightingale was a highly capable nurse assigned to a military hospital where the sick and wounded British soldiers were sent (ostensibly to get better). She was also a very capable statistician and, as it turns out, visualization pioneer. Her domain expertise combined with her statistical abilities led her to the discovery that the majority of soldiers were dying not of battle, but through diseases picked up in both the army camps **and** army hospitals. The question remained, however, as to how to most effectively communicate this discovery to garner a call to action; a task we face in IT weekly, if not daily.

Her data set was pretty basic: time-series categorical data with counts that could have simply been presented by bar or line graphs—both easily decoded charts by that time—or even by a simple set of tables. Yet, the goal of these diagrams was not merely to reproduce the underlying data with precision, but also to *visually connect with the receiver* and show trends and interdependencies in a compelling way.

The result was her now famous “Nightingale rose diagram” (figure 3) which first appeared in the *Diagram of the Causes of Mortality in the Army in the East*. Such a diagram required inspiration on the part of creator and relied upon the receivers’ ability to extend their comprehension of other known charts in order to fully grasp the severity of the hygiene problem. Her efforts were a success but yielded limited wartime impact as the conflict ended within a year of the Sanitary Commission taking action to improve conditions for soldiers.

Since these early successes, we have had a wealth of opportunity to both enhance our encoding capabilities and investigate the science behind how we go about decoding images. The dawn of the 20th century brought with it many psychological and medical discoveries that have enabled visual communicators to move from mere inspired trial-and-error to understanding how we see and process images.

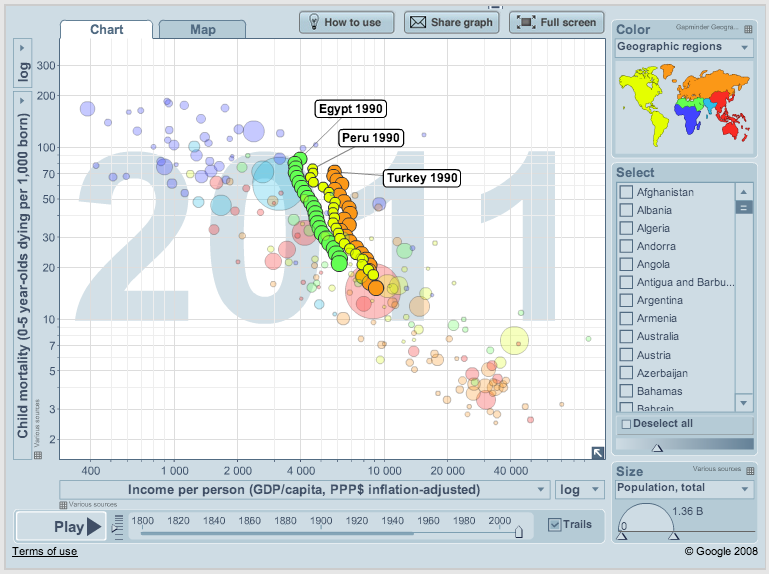


Figure Gapminder interactive/animated view of child mortality rates by country through time

A modern example that builds upon this work comes from Gapminder, a non-profit foundation that promotes sustainable global development. A key component of their mission is fulfilled through the use of dynamic visualizations to “*…[fight] devastating ignorance with fact-based worldviews everyone can understand.”*  The tools that help produce these data-infused visual stories were designed with the knowledge of how we best decode these images, providing a pre-configured canvas to aid even the most nascent communicator.

Gapminder incorporates color, animation and directed exploration controls to help users navigate through extensive data sets to and gain insights into complex topics such as child mortality rates (figure 4). By letting the audience control the exploration, Gapminder offers the potential to draw new discoveries or identify possible parallels that would not be possible through static charts. Users are then able to share their insights with a simple “share graph” button. This simple feature may be the most powerful one of the tool since data visualization is difficult for many people, yet they desperately want to be able to communicate visually, especially after they’ve been the recipients of effective visual communication.

Even with well-designed toolsets, it’s vital that we understand how the image-to-understanding decoding process works, especially if we wish to bring multiple elements together or become 21st century visual literacy pioneers.

Cognitive Science: Decoding the Decoding Process

Understanding how an image will be decoded may be the most fundamental component of visual communication. You wouldn’t think of writing an e-mail in Spanish if the recipient could only read German because you know they could not decode the text. How, then, can we expect to communicate through visualizations without first knowing the decoding process? To figure out this process, we need to delve into a field of study called “cognitive science”.

That term may sound fairly daunting, but it can be defined simply as the bringing together concepts from philosophy, psychology, artificial intelligence, neuroscience, linguistics and anthropology to help figure out of the mind works2. In many ways, it’s a form of detective work—piecing together clues from many sources to solve a mystery.

Cognitive scientists really wan to know how we humans think, and they posit that how we think is best defined by

* how our minds represent things, and
* what operations our minds perform on those representations.

When it comes to visual communication, we need to solve the mystery of how *images* are decoded so we can figure out how what we create will be received. To do that, we need to understand biological and neurological aspects of ocular image processing.

One clue that biology detectives have found to help solve this mystery is that it takes the human eye approximately 1/20th of a second to glean the meaning of a complex visual scene (this is one reason there are twenty-four frames per second in a movie frame). Even though we will undoubtedly have more time than that to ponder the content of an image, much of that extended reflection will be based *and biased* on that initial information retrieval. Our choices of color, brightness and symbols will be processed in less time than it takes our eyes to blink, so we really need to make sure we do our best to encode our visualizations properly or we risk having them be misinterpreted.

Signal Detection and Magnitude Estimation

If you whisper to someone sitting next to you in the library, there’s a really good chance they’ll be able to hear you and understand what you’re saying. However, if you try whispering to someone in the middle of a rock concert, your signal may have severe difficulty of getting through the noise.

Visual communication has similar issues to that aural example, the difference being that we’re dealing with brightness and color broadcasts to our eyes versus sound waves to our ears. Because you are continuously processing visual stimuli you may believe you inherently already know all there is about this fundamental concept, but perhaps the following simple example will help show that further research is in order.

Take a look at figure 5, below:

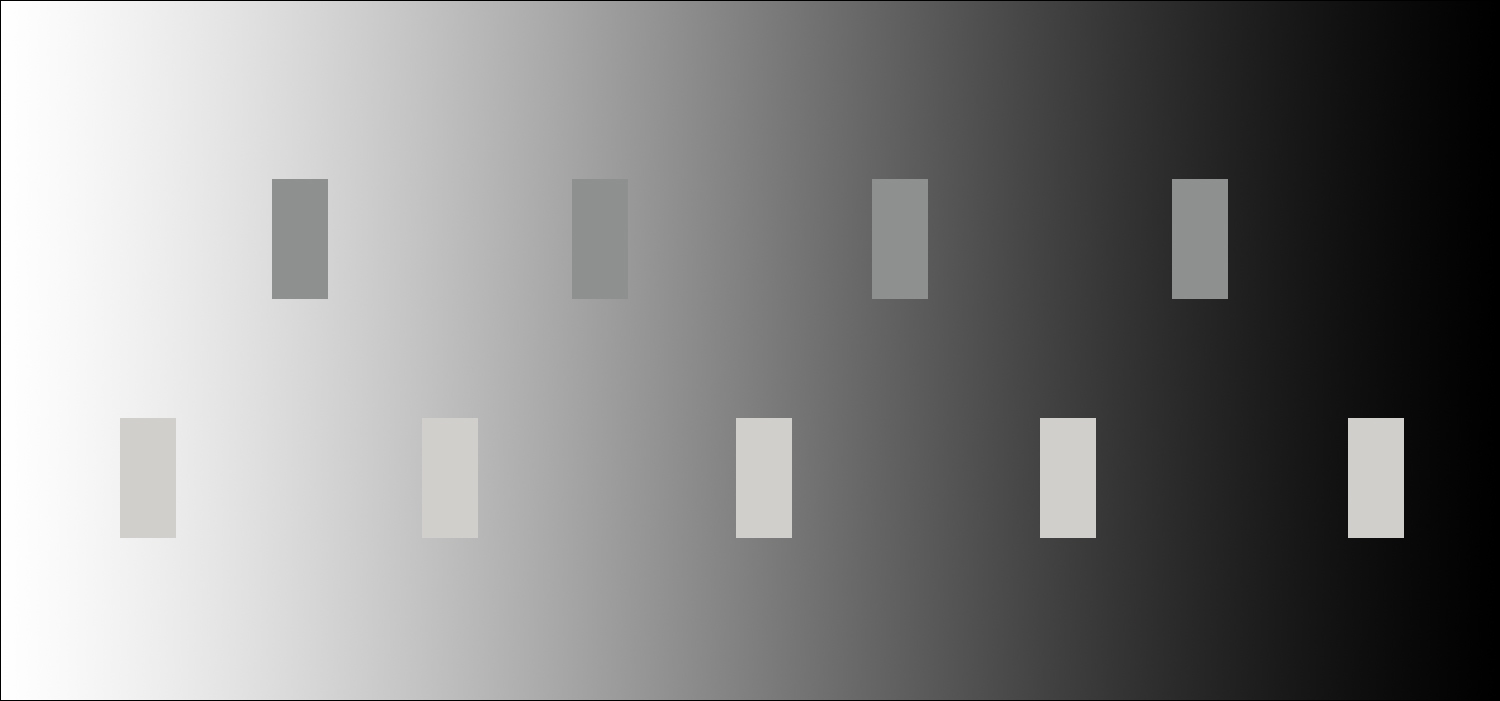


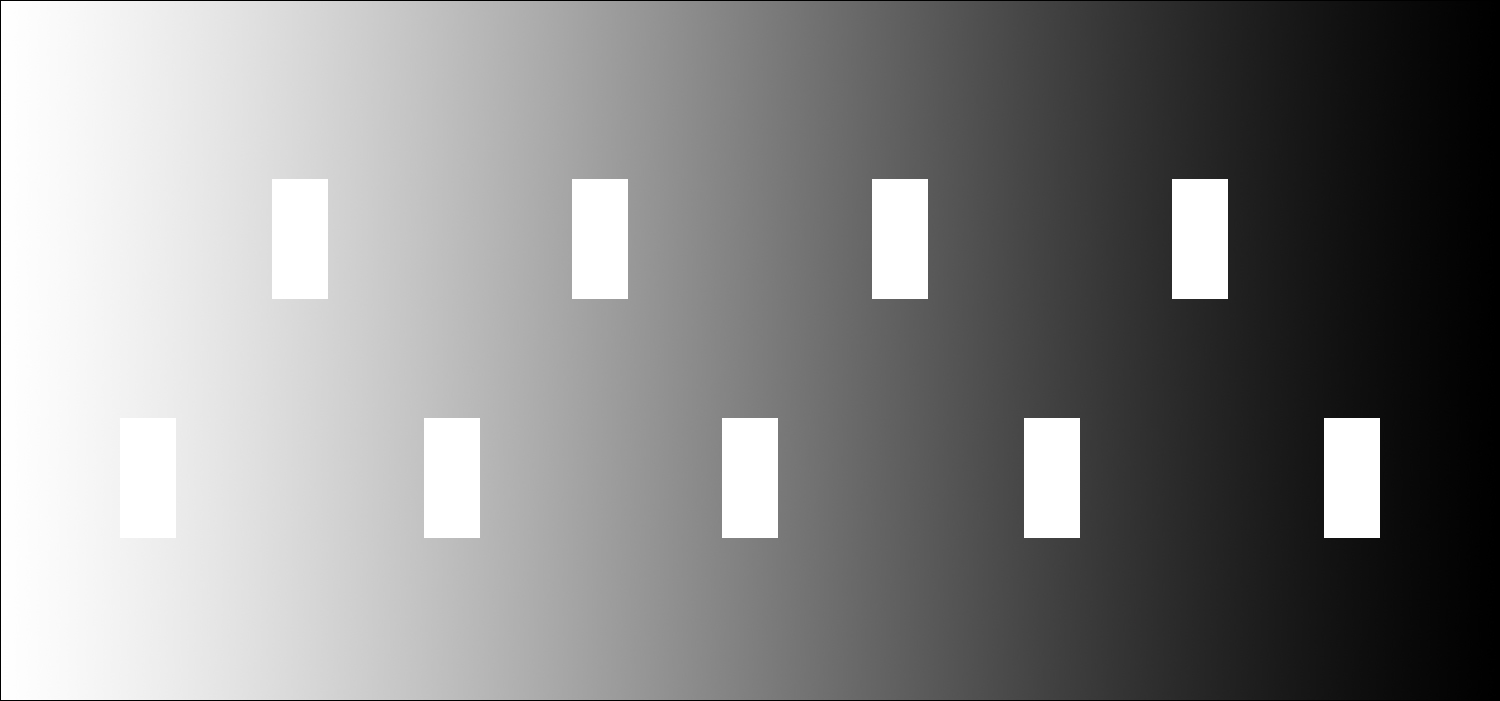
Figure Visual signal and noise detection

You should see two rows of rectangles that appear to be filled with different levels of gray. What you are actually seeing is an artifact of the decoding process since the top row of rectangles are all the same shade and the bottom row of rectangles are also all the same shade (though, a lighter one). The background gradient is the surrounding “noise” and the elements of the rows of rectangles are the “signals”. While this is a gentle reminder that our innate assumptions about what the receiver “should” interpret can often be wrong, it is also a good introduction to the principles of visual signal detection.

Weber’s Law

Dr. Ernst Heinrich Weber conducted numerous empirical studies in an attempt to determine the relationship between a physical stimulus and the perception of the intensity of said physical stimulus. This test was performed across many senses—including vision—and culminated in the principle of *just noticeable difference* (JND), or the smallest detectable difference between two levels. For normal human eyesight under optimal conditions there are approximately 1,000 JND steps. However, when our eyes are required to adapt to different lighting conditions (think disparate monitor calibration, paper brightness, full sunlight vs dark room) the number of steps reduces to approximately 200.

As demonstrated in the previous figure, an image’s environment also makes a huge difference to perception. When there are numerous surrounding intensities the primary signal you are attempting to get through must be bright enough to overcome the processing in that post-reception step. If we take the previous example and crank up the brightness to full white on all the rectangles our eyes have a much easier time separating the signal from the surrounding noise.

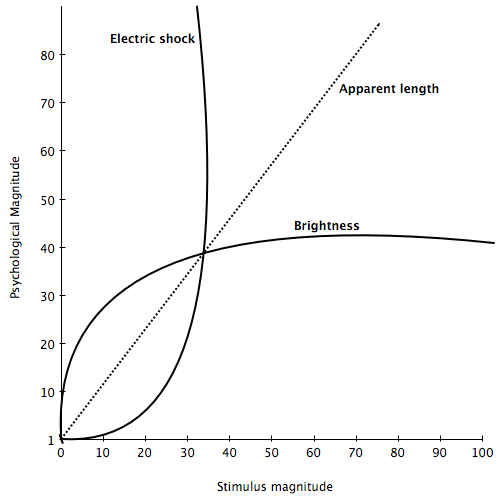


Understanding Weber’s law can help us make better decisions when developing our visualizations. Because we only have the ability to detect a fixed number of steps and that our minds seem to have an inherent concept of order (i.e. “A is brighter/darker than B”), **brightness variations should be used to** **encode ordinal variables** and we should strive to keep the number of encodings small and have the magnitude between different brightness levels as large as possible.

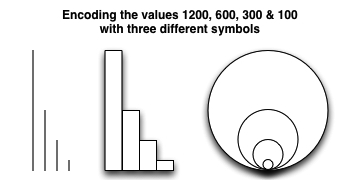


Stevens’ Law

Dr. Stanley Smith Stevens was also interested in determining the relationship between magnitude of physical stimuli and the way humans perceive the strength/intensity of it. Stevens incorporated far more continuums than Weber did in his trials, including visual length and area. (As an aside, it’s interesting to note that both Stevens and Weber managed to acquire test subjects willing to be subjected to electric shock and other forms of pain, perhaps making them predecessors to our modern day Mythbusters?)



This figure is a reproduction of Stevens’ graph in *The Psychophysics of Sensory Function* and shows that **we are far better off using length to encode magnitude** than we are delivering a proportionally good shock to the reader (bummer) or using brightness. Circular area determination falls just above brightness, meaning that **receivers tend to underestimate the values when comparing objects by area**. If circular area is chosen for the encoding, the sizes should have larger, disproportionate scaling vs absolute scaling.



Comparing and Ranking Elementary Perceptual Tasks

Encoding Multiple Attributes

Understanding Gestalt

Visual Processing