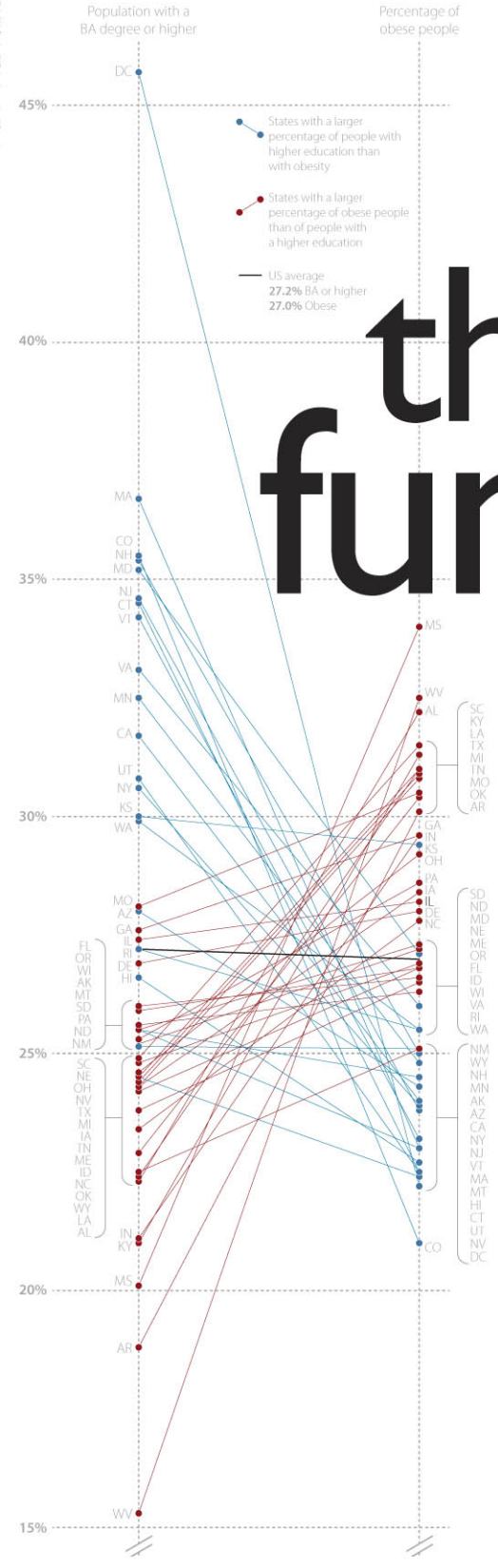

the functional art

an introduction to information graphics and visualization

alberto cairo

"Welcome to Alberto's world. Cairo has done it all in *The Functional Art:* theory, practice, examples. And he's done it brilliantly. It is the most comprehensive and sensible book yet on real-world information graphics; we won't need another one for a long time."

Nigel Holmes, former graphics director for *Time* magazine and founder of Explanation Graphics

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Praise for *The Functional Art*

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—Nigel Holmes

"If graphic designer Nigel Holmes and data visualizer Edward Tufte had a child, his name would be Alberto Cairo. In *The Functional Art*, accomplished graphics journalist Cairo injects the chaotic world of infographics with a mature, thoughtful, and scientifically grounded perspective that it sorely needs. With extraordinary grace and clarity, Cairo seamlessly unites infographic form and function in a design philosophy that should endure for generations."

—Stephen Few, Author of *Show Me the Numbers*

"This book is long overdue. Whether you're just getting started visualizing information or have been doing it all your life, whether your topic is business, science, politics, sports or even your personal finances, and whether you're looking for a basic understanding of visualization or a detailed how-to reference, this is the book you were looking for. Alberto Cairo, a professional journalist, information designer and artist, shows how to visualize anything in a simple, straightforward, and intelligent way."

—Karl Gude, former infographics director at *Newsweek* and graphics editor in residence at the School of Journalism, Michigan State University

"*The Functional Art* is brilliant, didactic, and entertaining. I own dozens of books on visual information, but Cairo's is already on the shortlist of five that I recommend to anybody that wishes to have a career in information graphics, along with those by Edward Tufte, Nigel Holmes, and Richard Saul Wurman. Cairo is one of those rare professionals who have been able to combine real-world experience with the academia."

—Mario Tascón, director of the Spanish consulting firm Prodigioso Volcán

"Using his enormous professional and academic experience, Alberto Cairo offers a first-hand look at the revolution in visual communication. This book is key to understanding the current situation of print and online information design."

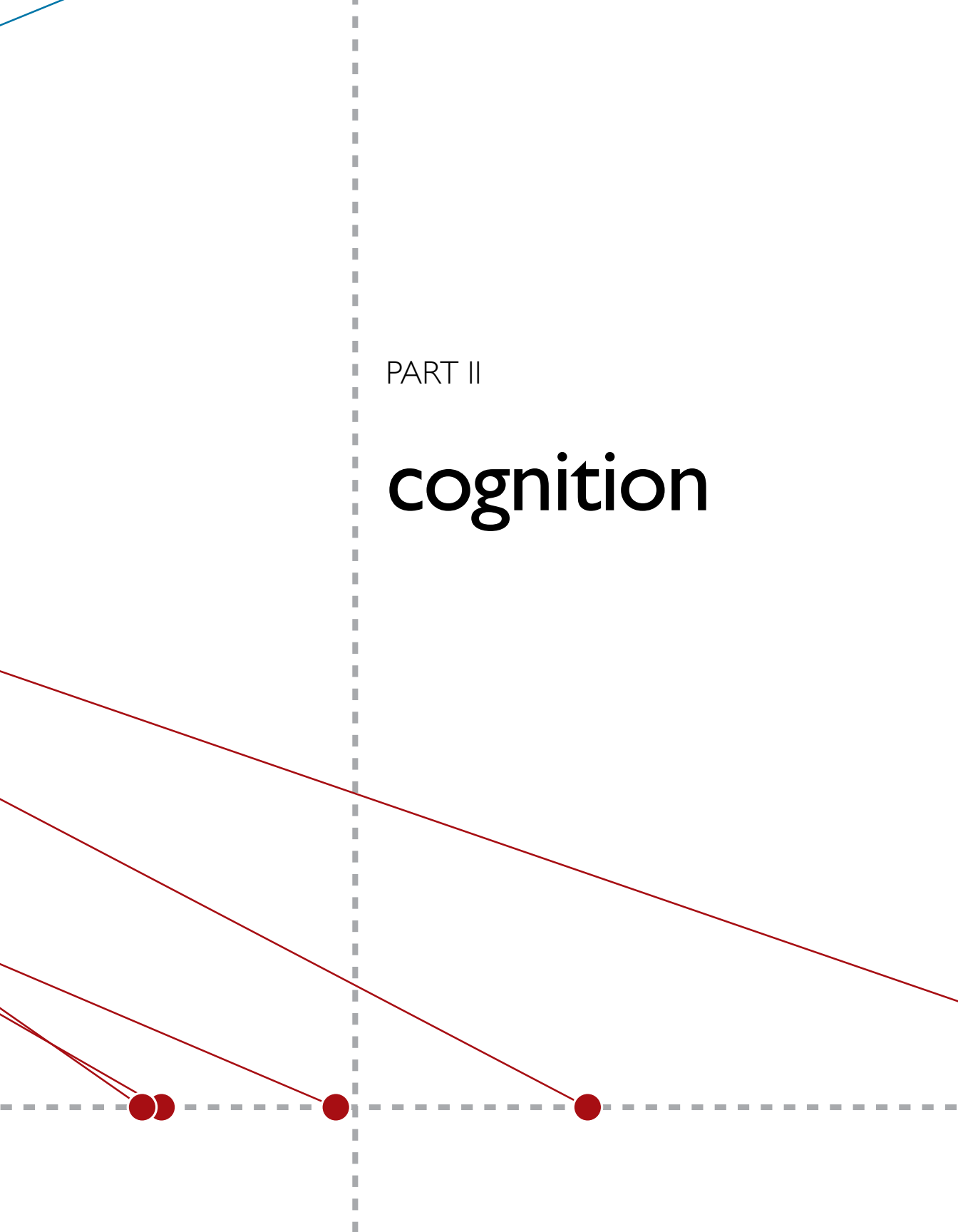
—Javier Zarracina, graphics director at *The Boston Globe*

"*The Functional Art* is the perfect starting point for a career in information graphics and visualization, and also an excellent guide for those who already have some experience in the area. This is the first real textbook on infographics."

—Chiqui Esteban, director of new media narratives at lainformacion.com, and blogger at *InfographicsNews*

PART II

cognition



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5

The Eye and the Visual Brain

> The distinctive feature of brains such as the one we own is their uncanny ability to create maps.
>
> —Antonio Damasio, from *Self Comes to Mind: Constructing the Conscious Brain*

Imagine yourself sitting on a bench in your favorite park. Your eyes are focused on a long story in the newspaper. Maybe you are reading it on your tablet computer, or maybe you are old-fashioned, as I am, and prefer the newsprint version. No matter. Either way, the world around you blurs and becomes unimportant. The storyline flows. You feel enthralled. You barely notice a group of children playing a few yards away. Your mind is off and wandering in a better place, chasing fleeting words.

Suddenly, you notice a movement in the corner of your eye: Something is flying toward you at high speed. Your hands drop the newspaper. Your heart pounds harder and faster. Your arms instinctively position themselves in front of your face in a protective shield of skin, flesh, and bone.

A soft object hits your elbow and falls to the ground. Your body relaxes. A plastic ball bounces in front of you, harmless.

To say that *a part of you* noticed a movement is a manner of speaking, for that part was not really *you*. Your conscious self didn't know what your eyes were seeing until the ball was already at your feet. The first lesson we can extract from this

is that vision is fast, but reason is slow. The second lesson is that, as the famous neuroscientist Antonio Damasio wrote, "The human brain is a natural-born cartographer." In our story, in a fraction of a second and without your conscious awareness, your brain devised a map calculating the precise position of the potential flying threat—and prompted your arms to react.[1]

The third lesson of this story is that **seeing, perceiving, and knowing are different phenomena**. You can see without perceiving and without knowing that you are seeing. The eye and the visual brain are more complicated and fascinating than you may have ever thought. **Exploring their inner workings is crucial if we want to approach information graphics and visualizations as communicators, not simply as traditional graphic artists.**

The Unexplained Eye

If you are my age, the biology textbook you used during high school probably included a diagram similar to **Figure 5.1**, which shows how human visual perception works.

Light coming from a source—the sun, a light bulb—hits an object. In my diagram, that object is my friend Mike Schmidt, a talented multimedia producer who graciously agreed to be part of this teaching experience.

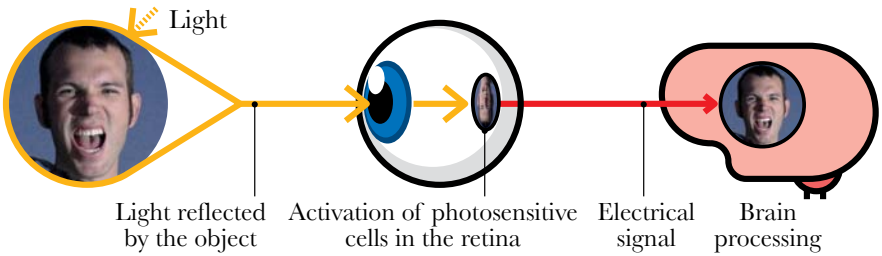

Figure 5.1 This is what I learned about the eyes and the brain when I was in high school.

Mike's skin absorbs some of the photons—the particles light is made of—and reflects some of them. The photons bouncing off his face pass through my eyes and stimulate certain photosensitive cells on my retina. Those cells transform

1 Antonio Damasio, *Self Comes to Mind: Constructing the Conscious Brain* (Toronto Pantheon Books, 2010).

the light stimulus into an electrical impulse that reaches the brain through the optic nerves.

So far, so good. Up to this point, the process is almost mechanical: a dancing game of light particles and cell activation patterns. But as a teenager, I found the last part of the diagram confusing. A photograph shows up in the middle of a pictographic brain? How mysterious. At the time, the end of the perceptual process seemed like magic to me.

The best metaphor to explain human visual perception is that of a digital video camera, where our eyes are the camera lens, our optic nerves are the cables, and our brains are the microprocessor and the hard drive. The only problem with this model is that, **while our eyes truly act as lenses, the brain is certainly not a hard drive, as we'll see**.

Let There Be Light

The next part of the perception equation is light. Understanding a bit of how it works can be useful for design and graphics, so stick with me.

Light is electromagnetic radiation. It can be described as waves that scatter in different lengths, frequencies, and energy charges. See **Figure 5.2**. The frequency of a light wave is a measure of the number of waves that cross a particular point within a given time frame. Frequency is inversely proportional to length: The shorter a wave of light is, the higher its frequency.

The energy of a ray of light is related to those two physical properties: frequency and length. The shorter the wavelength and higher its frequency, the more energy the light carries. Our mother's insistence on smearing us with sun protection cream before exposing our skin to the sun's mid-day rays has a solid scientific basis: Ultraviolet light, even after it's been filtered by the earth's atmosphere, can burn you.

As Figure 5.2 shows, our eyes can detect only a tiny fraction of the electromagnetic spectrum. The visible range for humans runs from violet (high frequency and energy, short wavelength) to red (low frequency and energy, long wavelength). Other species' visible ranges are different. Bees, for instance, can see ultraviolet light, and many predators can see infrared.

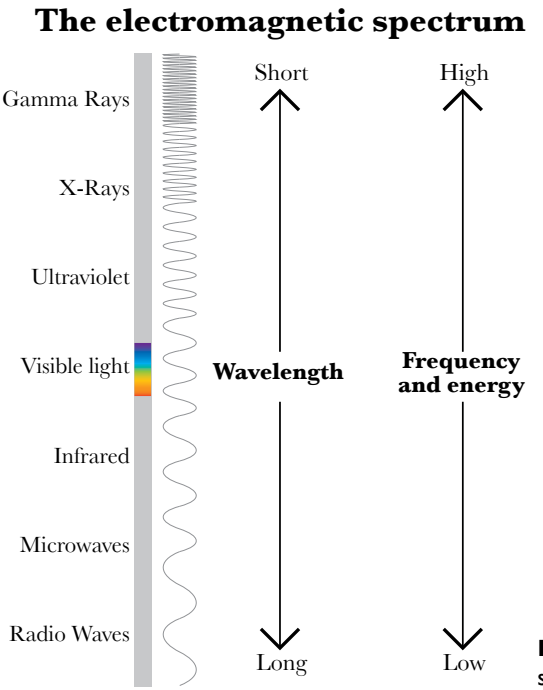

Figure 5.2 The electromagnetic spectrum.

As explained before, when light hits any object, the surface absorbs some of the light and reflects the rest. An object that appears white reflects all wavelengths of light, while a black object is one that absorbs all light visible to the eye. Between those two extremes is a vast range of possibility. We see a blue chair not because the chair oozes an intrinsic bluish quality, but because its surface swallows all frequencies of light except those that our brain identifies as belonging to blue. Without light, nothing is blue, green, yellow, black, or white.

Light and Photoreceptors

Figure 5.3 shows the main components of the human eye. Starting at the left, the pupil controls the amount of light that enters the eye. It contracts when there's too much light and opens when there is very little.

After light has entered the eye and is filtered and adjusted, it reaches the retina, a thin sheet of nerve tissue on the back side of the eye. (The retina, by the way, is not part of the eye but part of the brain—one of those factoids that proves it is not a good idea to trust your intuitions when it comes to science.) During embryonic development, the cells of the retina and optic nerve are born in the