YOUR BRAIN IS A RIVER, NOT A ROCK

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Preface

As I watched my three children growing up, the question frequently came to mind: How do they do it? How do they learn so quickly? Then what happened during the teenage years? Many years of reflection have evolved into this book: *Your Brain Is a River, not a Rock.* The brain is the interface between us and our world. We see the world, we make meaning of our experience, we respond to the world through brain functioning. And the brain is not set in stone. The circuits in the brain are continually sculpted by experience.

The understanding that our brain changes with every experience has transformed thinking and research in neuroscience. Twenty years ago, neuroscientists thought brain circuits only changed during critical periods when children were very young. Now, it is known that experience changes the brain from birth to old age. Life can be pictured as the progressive development of brain circuits leading to the progressive transformation of how we see the world.

This book begins at the beginning—we are born with our brain unassembled. But you don't need to worry; the brain knows what to do. The dual engines of natural development and daily experience build brain circuits that allow us to see and behave in the world. These brain circuits determine waking and sleeping cycles, determine perception, determine our golf swing, and our political decisions.

Your Brain Is a River, not a Rock gives you the information to choose experiences that will support greater growth and success. I thank my wife, Nita, who spent many hours reading and commenting on the text to make this

book clearer. Also, I thank my three daughters—Dariana, Joella, and Avery—for putting the text into Indesign, initial editing of the text, and help with the graphics, and thank Dr. Sue Brown, colleague and friend, for her comments that helped polish this manuscript. Read on and enjoy!

SECTION I

THIS IS YOUR BRAIN

How is the brain an interface between us and our world? Is the brain like a computer that needs constant upgrades? Do we have any control over how brain circuits are connected? Is everyone's brain the same?

This section addresses these questions. We will discuss how different brain parts function, and how brain areas develop and change across the lifespan. We'll explore brain differences in men and women, how the brain is the foundation for the mind, and what we can do to support continued brain development across the life span.

Chapter 1

We Create Our Reality

We create our reality. You've probably heard that statement from motivational speakers, new-age thinkers, and your parents. From a brain perspective it is completely true. The brain circuits we have right now determine how we see and respond to the world, and each experience we have strengthens the brain circuits that have been activated by that experience. This can constrain us to see the world in the same way—if we choose the same types of experiences every day, we are only reinforcing our current worldview. If we seek out new experiences, consider different points of view, then these new experiences will update brain connections and we will see the world differently.

We also create our reality on the level of perception itself. This first chapter explores how the sensory system changes what the brain receives: edges are enhanced and missing information is filled in. As you go through this chapter, there are many exercises so that you can explore how you see the world. Be sure to do each activity before moving on—they are fun and you will learn more.

Are you ready to begin? Okay, look steadily at the black dot in Figure 1.1 below. Don't move your eyes. Focus on the dot for 20 to 30 seconds. What starts to happen?

Figure 1.1 Black dot for perceptual exercise.

Did you notice a white halo around the dot? It looks like an eclipse of the sun. If you didn't notice this, put this page in bright light, close one eye and look again. Stare at the dot. You can move your gaze to look around the edge of the dot. Do you see a white ring around the dot?

What is this? Are you seeing the aura of the dot? Or the subtle energy field of the dot? Maybe your perception is moving to a higher plane!

Sorry. It has a simpler explanation. The dot's "aura" is caused by a process called *lateral inhibition* which takes place in the retina of the eye.

Our eyes have evolved to enhance edges of objects, because edges have survival information. Edges mark where one object ends and another begins, be it food, friend, or foe. When light activates the retina's rod cells, which are sensitive to black and white, the rod cells fire, and then they turn off the firing of the rods around them. This is called *lateral inhibition*.

When you looked at the dot, the rods did not fire if the black dot fell upon them, and so they did not inhibit their neighbors. The rods that the light from the white page fell upon fired and also actively inhibited their neighbors. So, the brain received no information from the rods the black dot fell on, and received lots of information where the white page fell. At the edge of the black dot the rods just inside the black dot were inhibited by the rods just outside. So, you see a darker ring around the inside of the dot. In contrast, the rods just on the outside of the ring were not inhibited as much as the other rods that white light fell on. Do you see what happened? Every other rod that the white page fell on was inhibited by neurons all around it. However the rods just outside the dot were only inhibited by rods the white page fell on and not the ones where the black dot fell. Consequently, the brain registered this as more intense firing, as we see a light ring around the dot. Notice this effect was not coming from the object; the sensory apparatus in the eye was the sole cause of this effect.

Artists use this physiological effect to accentuate boundaries between objects. Where a dark and a light object touch, you see a darker line on the dark side and a lighter line on the light side. These are called Mach Bands. Can you see them in Figure 1.2 below? This is *not* happening in your brain; it is occurring in the sensory apparatus before the information gets to your brain.

Figure 1.2 Difference in shade for perceptual exercise.

Let's do another exercise. Here's our old friend the black dot again. This time, look at the page with the black dot in front of your right eye. Close your left eye. Once you see the halo, look over to the blank part of the page….what do you see? (Do this and then read on.)

Figure 1.3 Black dot for perceptual exercise.

Most people see a luminous white dot. Now, do this again and observe the size of the luminous dot. Is it bigger or smaller than the black dot? Most people see a luminous dot that's about the same size as the black dot. They also notice that it moves around as their gaze moves around the page.

This luminous dot is an *afterimage* of the black dot. Once a rod in the retina fires, it needs time to recover. When you look at a white page with a black dot, all the rods that the white page fell on are firing and then recovering. The rods the black dot fell upon are just resting. So, when you then turn your eyes to look at a white space, the *white page* rods now fire less

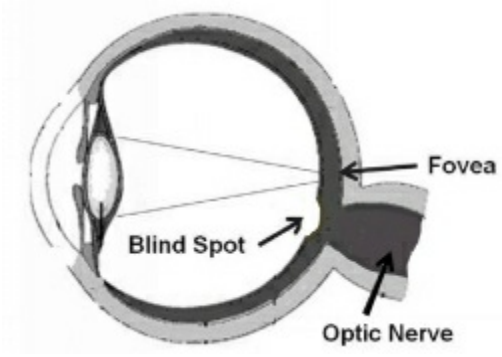
because they are recovering. The *black dot* rods that are now firing more actively, since they were resting before. This is why we *see* a luminous dot.

Remember, the halo and luminous dot do not exist. They are not "real." If you use an instrument to measure the light from the paper, it will be uniform. We ourselves create the halo; we create the luminous dot through the functioning of our sensory system.

Let's go one step further and see how the mind interacts with the eyes. Pick up this book and hold Figure 1.4 (below) in front of your eyes. Now close your left eye and place the cross in front of your right eye so that the smiley face is to the right. Now continue to look at the cross while you slowly move the book farther away and then closer to your eye. Around 8 to 10 inches from your eye, what do you notice? Do this until you notice something. Did the smiley face disappear and you saw a white page?

Figure 1.4 Cross and smiley face for perceptual exercise.

Do this until you see this effect. Now draw a vertical line through the smiley face so that it extends one inch above and below the circle. Now again, close your left eye, place the cross in front of your right eye, and move the book slowly farther away and then closer. Again, do this until you notice something. What happened? Did the smiley face disappear and you saw a continuous line?



This is called *filling in*. In the back of the eye is a small area called a *blind spot*. The blind spot is where the optic fiber leaves the eye and carries the output from the retina to the brain. The blind spot is presented in Figure 1.5. The optic nerve has no photoreceptors on it and so there is no image from that part of the visual field to the brain. If the brain does not receive any visual information from part of the visual field, what does it do? The brain fills in with what it expects to be there. If the rest of the
paper is white, it fills in the dark circle with white and you just see a white page.

Figure 1.5 Blind spot in the eye.

Here is a more sophisticated experience of filling in. Get a white sheet of paper and hold it at arm's length in front of your eyes, 24 to 30 inches away. Now here's the black dot again.

Figure 1.6 Black dot for the perceptual exercise.

Hold this page 8 to 10 inches from your right eye. Close your left eye. Once you see the halo, take away the page with the dot and look at the white sheet of paper at arm's length. What do you see? (Do this before you read

further. It's more fun if you go step by step.)

Do you notice that the afterimage on the white sheet of paper 24 inches away is bigger? Try this again by sitting 4 to 5 feet in front of a white wall. Again, look at the black dot. Once you see the halo, look at the wall. Do you notice that now you see a REALLY BIG dot?

These are both examples of filling in. What your brain receives is the afterimage on the retina plus the visual information of how far you are from the paper or wall. You know from prior experience that if an object is two feet away it will cover a specific area of your eye; if it covers the same areas of the eye and is farther away, then it is a bigger object. So the retina creates the afterimage, and your brain sizes it to fit the circumstances. That is what you "see."

We constantly "fill in." If we do not have enough perceptual information to make a decision, we make up what is happening. For example, in one research study police officers were shown a short film of a teenage male reaching into his pocket and drawing out a device. If the male was African-American or Hispanic, the officers saw him pulling out a gun. If the male was Caucasian and well dressed, officers saw him pulling out an iPod. In the study, half the time the African-American and Caucasian males each pulled out a gun; the other half the time they pulled out an iPod.

Who Is in Control?

Do we create reality? The answer is "Yes." This is not a philosophical conclusion. It is not a Zen koan to be considered deeply. Rather, it is the reality of what and how we see. The brain is a reality creator. Sensory information does not come in as a complete whole picture, but as waves of activation that first break the picture into parts—edges, orientation in space, movement, color—and then re-assemble it again. In putting the image back

together, our brains make their best guess and then compare that guess to the next volley of incoming information.

What Do You Think?

- If you are aware of filling in, can you stop your brain from filling in? Practically speaking, if you were a police officer, could you always see a gun when the gun is drawn and always see an iPod when the iPod is drawn?
    - Here's a website with lots of perceptual illusions you can go to http://dragon.uml.edu/psych/illusion.html

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