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A DIFFERENT VISION

IN HER NEW BOOK, *FIXING MY GAZE*, SUSAN (FEINSTEIN) BARRY '76 TELLS ABOUT A REMARKABLE MIDLIFE TRANSFORMATION THAT ENABLED HER TO SEE THE WORLD IN AN ENTIRELY NEW WAY.

PHOTOGRAPHY BY BILL BURKHART

I dreaded going to grade school. Throughout childhood, I had 20/20 acuity in both eyes, but I had trouble learning to read. When I looked down at the letters on the page, they didn't stay in one place. This problem grew worse as the print got smaller. My reading difficulties came to a head when I performed miserably on a standardized achievement test. These "objective," scientifically designed tests were thought to reveal a person's native intelligence. The tests were far more accurate, many school administrators felt, than the observations of a skilled, experienced teacher, even one who had observed a child for a full school year.

My school divided the children in each grade into four groups, and I began third grade in a class with all of my friends. Although we were not told why we were each assigned to a particular classroom, the groupings were obvious to me and all of my schoolmates. One class was for the above average students, one for the average learners, one for the below average pupils, and one for the children with "special problems." On the first day of third grade, I was placed in the above average class but survived there for only one week. A mistake had been made. My score on the standardized test from the previous year indicated that I was supposed to be in Mrs. Danner's special problems class.

The assistant principal came into the classroom and asked me to stand up. She instructed me to leave the classroom and asked a boy to drag my desk behind me as I walked down to Mrs. Danner's room. The desk made an awful noise as it scraped along the floor. I felt humiliated and shamed by being made the center of so much attention ...

My mother panicked. The most law-abiding individual on earth, she snuck into the school's office after hours and stole a copy of the achievement test on which I had performed so poorly. At home, she took me down to the basement, told me not to breathe a word to my brother or sister, and gave me the test. In the quiet, relaxed atmosphere of my home, I did much better. Again, my mother met and argued with the principal, but she couldn't admit to him that she had snuck into his office and absconded with the test. I remained in Mrs. Danner's class...

My mother taught me how to read when the school gave up on me. She read with me and to me constantly. Often, she would leave a new book on my bed that I would discover when I returned home from school. I was very shy and felt happiest when exploring the countryside, categorizing wildflowers, trees, and rocks. My mother would leave me books about nature and animals. When I finally discovered Walter Farley's *Black Stallion* series, I was hooked and began to read for pleasure.

By fifth grade, I had become a competent if slow reader. I was finally transitioned out of the special problems class and into a regular classroom. I was a fanatic student, compulsively checking my answers again and again in the hopes that my hard work and discipline would hide my tested lack of intelligence...

Common experience tells us that our vision plays a large part in our ability to read and do well in school. Yet, many school administrators and physicians have long questioned the connection between vision and learning. Most of us consider "perfect" vision to mean 20/20 eyesight as measured by identifying the letters on the Snellen eye chart—commonly recognized as the chart with the big letter E on top. Yet good eyesight (or acuity) and good vision are not the same thing. We need more than 20/20 eyesight to read a book. When we read, we view letters and words positioned about 16 inches from our face, not 20 feet away, and we must be able to sustain close viewing for long periods of time. We look at the letters with two eyes, not just with one as in an eye exam, and we have to move our eyes across the line of words in a coordinated manner. Finally and most importantly, we have to extract meaning from the words. All of these processes are involved in good vision and affect our ability to learn...

Poor or absent stereopsis is an indication that you have trouble merging the information from the two eyes. Instead, the information from the two eyes may be conflicting—as was my situation. I had 20/20 eyesight with both eyes and no problem passing a standard school vision screening. Yet, my vision was abnormal because I didn't use my two eyes together. The uncorrelated information from my eyes greatly disrupted my ability to read.

I was 20 years old and a college student before I learned that I did not see the way other people did. This surprising news came to me as I listened to a lecture on vision in my college neurobiology class. On that gray November morning, I felt sleepy and sluggish, but something my professor said jolted me out of my inattentive state. He was describing the development of the visual system, highlighting experiments done on wall-eyed and cross-eyed kittens. Cats, like people, have two forward facing eyes that they move

together in coordinated ways. But the kittens in these studies had strabismus, or misaligned eyes. My professor mentioned that vision in these kittens had not developed normally. They probably couldn't see in 3D. In fact, many scientists and doctors assumed that the cats would never be able to see in 3D, even if their eyes were later straightened, because this ability could develop only during a "critical period" in early life. What was thought to be true for cats was also thought to be true for people.

I was floored. My eyes had crossed when I was about 3 months old. When I looked at an object with my left eye, my right eye had turned in and when I looked with my right eye, my left eye moved inward. But I had three eye muscle surgeries at ages 2, 3, and 7, and these operations had aligned my eyes so that my eyes looked normal almost all the time. Surely, I saw normally too. Throughout childhood, I had 20/20 acuity with each eye and assumed that I had perfect vision.

Yet I had just learned that people like me were missing a fundamental way of seeing. Fully alert now, I listened carefully to the professor's explanation. We have two eyes, he said, but only one view of the world. Since our eyes are separated on our face by our nose, they see from a slightly different perspective. It is in the brain that the images from the two eyes are merged into one. For most people, this happens effortlessly. Both eyes are aimed at the same point in space, and the information from each is combined in the brain. The result is a sharply outlined, detailed, and depth-filled view of the world.

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My professor added that a strabismic (person with misaligned eyes) is not so lucky. Since a strabismic's eyes are not aimed at the same point in space, the difference between the left- and right-eye views is too great for the brain to combine them into a single picture. The strabismic is confronted with a serious perceptual problem: She must somehow create a single, coherent worldview from conflicting input from the two eyes. To solve this problem, many strabismics suppress information from one eye and just look through the other. Some always use the same eye while others continually switch between the two eyes, but in either case, they may never see normally through the two eyes together. As a result, most strabismics have reduced or absent stereovision. The professor concluded the lecture by saying that, without normal binocular vision, many strabismics don't see in 3D. They're virtually stereoblind.

Stereoblind… was I stereoblind? I looked around. The classroom didn't seem entirely flat to me. I knew that the student sitting in front of me was located between me and the blackboard because the student blocked my view of the blackboard. When I looked outside the classroom window, I knew which trees were located farther away because they looked smaller than the closer ones. The footpath outside the window appeared to narrow as it extended out into the distance. Through cues like these, I could judge depth and distance. I knew the world was in 3D. Yet, my professor was implying that there was another and different way to see space and depth. He called this way of seeing stereopsis. I couldn't imagine what he was talking about.

After the lecture, I went directly to the college library and struggled through the scientific papers on vision. I spent the rest of the semester studying the subject and did my term paper project on changes to the visual system of cats that started out life with misaligned eyes. I learned that the brain processes vision in a region in the back of the cerebral cortex called the visual cortex. Neurons from the retina in the back of the eye communicate over several synaptic connections with neurons in the visual cortex, and these cortical neurons are either "monocular" or "binocular." I learned that monocular neurons respond with nerve impulses to light stimuli coming from only the right or left eye while binocular neurons respond to input from either eye. The majority of neurons in the visual cortex are binocular. However, strabismic infants have neurons that respond to the right or the left eye, but not both. The loss of binocular neurons results in a loss of normal binocular vision and stereopsis.

As I stayed up late reading through all these papers, I realized that I too may have a "monocular brain." Most of the neurons in my visual cortex probably responded to input from my right eye or my left eye, but not both. Although I no longer looked grossly cross-eyed as I had as a child, my eyes still wandered out of alignment on occasion, especially when I was tired. So I always avoided looking people directly in the eye. Now I suspected that I was not only a little cross-eyed but also stereoblind.

On my next trip to the eye doctor for a routine eye exam, I asked about stereovision. The doctor was surprised at my concern and interest but got out his stereo tests. I flunked them all. He shrugged his shoulders and explained that I did not fuse the images provided by my two eyes. I saw the input from only one eye at a time and switched rapidly between them.

[Years later, at age 48, plagued by a number of visual problems resulting from her crossed eyes, Barry consulted Dr. Theresa Ruggiero, a developmental optometrist.]

I have been to eye doctors all of my life, and I thought I knew all about vision exams… [However, in] Dr. Ruggiero's office, I performed a host of binocular vision exams that were new to me. When the tests were completed, Dr. Ruggiero looked over all the results, but before she described them to me, she asked me what it was that I would like to do that I couldn't do at the time.

I told her that I wanted to be able to read for longer periods, to look comfortably in the distance, and especially to drive without feeling so anxious. I avoided going places or visiting friends if I had to drive someplace new. I would come up with excuses because it sounded pathetic to say that I was afraid to drive. I had been in the car countless times when my husband was driving. I just couldn't understand how he sped up on entrance ramps to highways and merged with the oncoming traffic with such confidence and ease. I wanted to play tennis without my eyes tiring after 20 minutes. After I played tennis on

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an indoor court, I would experience a strange sensation: The whole world moved up and down when I walked. I wasn't looking for super sharp eyesight, but I was hoping for more comfortable vision for the routine activities of everyday life.

Dr. Ruggiero told me that my problems with eye fatigue, distance viewing, and driving stemmed from the fact that I was uncertain about where I was in space. I saw objects from two different directions, giving me a constantly shifting worldview. Her first and most important goal for me was to stabilize my gaze so that I could earn confidence in my own vision.

Dr. Ruggiero went on to explain that my eyes, though cosmetically straight, were still both horizontally and vertically misaligned. In addition to my horizontal strabismus, my right eye saw several degrees below my left eye. Other doctors had noted this mismatch but had chosen not to correct it. They may have assumed that I could not use my two eyes together so that there was no need to align my eyes any further than was cosmetically necessary. What we didn't realize was that the vertical mismatch was creating visual havoc for me. As I unconsciously and rapidly switched my attention from one eye to the other, I was experiencing two significantly different views.

When Dr. Ruggiero explained all this to me, the Beatles' song, *Nowhere Man*, suddenly popped into my head. In the song's refrain, the Beatles tell of a man with no point of view who "knows not where he's going to." I had just learned that I did not have a single point of view; instead, I had two! This situation had created subtle but pervasive problems with knowing precisely where I was in space…

Dr. Ruggiero prescribed a new set of glasses with my usual corrections for near-sightedness but added a prism, which would reduce the vertical mismatch between my eyes. Once my glasses arrived, Dr. Ruggiero told me, she would start me on a vision therapy program that would teach me how to coordinate my eyes and stabilize my gaze.

I left Dr. Ruggiero's office feeling hopeful about my vision for the first time. It was a tremendous relief to learn that there was an explanation for my unstable vision—that I had a legitimate, treatable complaint. Very few individuals with infantile strabismus discover what it is like to have stable, clear binocular vision with stereopsis, while most doctors have no personal experience with the disorder. There is a huge gap, then, between our technical knowledge of strabismus and the experience of seeing with misaligned eyes. Over the next year, I was to learn just how great this gap is. With therapy, my vision improved and my worldview transformed in ways that I could never have imagined.

[Barry next describes what happened after she embarked on a course of vision therapy designed to teach her how to coordinate and merge the information from the two eyes.]

The sun was setting as I left Dr. Ruggiero's office [after a vision therapy session]. I got into my car, sat down in the driver's seat, placed the key in the ignition, and glanced at the steering wheel. It was an ordinary steering wheel against an ordinary dashboard, but it took on a whole new dimension that day. The steering wheel was floating in its own space, with a palpable volume of empty space between the wheel and the dashboard. Curious and excited, I closed one eye and the position of the steering wheel looked "normal" again, that is, it lay flat just in front of the dashboard. I reopened the closed eye, and the steering wheel floated before me.

I wondered if I was seeing in stereoscopic depth but reminded myself that this should not be possible. It was one day after my 48th birthday. I was about 46 years beyond the critical period for the development of stereovision. Since the sun was low in the sky and shining light into the car at an odd angle, I told myself that the fading light must have created this unusual illusion…

This new way of seeing was confusing as well, as I soon discovered while walking to my office one day. On the ground floor of the biology department where I work, we have a skeleton of a large horse displayed along with skeletons of smaller creatures and cases full of stuffed birds. I have passed these rather spooky displays every morning for the past 10 years, giving them little attention or thought. But just eight days after I began to see in stereo depth, I was walking to my office and happened to glance directly at the horse's head. The horse's skull, with its large teeth and two empty eye sockets, loomed so far out in front of its body that I thought it was moving toward me. I jumped backward and cried out. Fortunately, no one was around to witness my panic…

A week later, I was walking across the Mount Holyoke campus on a quiet weekend afternoon. There had been a snowstorm the night before and the campus was blanketed with a new layer of clean, bright snow. In one area, large branches had fallen off a tree and lay in a high, tangled mass over the snow-covered lawn. Here was a place I could get my 3D fix for the day. I looked around; no one was present, so I lay down on my back and slid myself under the jumble of branches. Looking up, I could see a lovely three-dimensional network, and I spent several minutes savoring the view. As I wiggled myself out of the branch pile, stood up, and dusted off the snow, I noticed one of my colleagues standing a little ways away, staring at me. He had a smirk on his face.

"Sue, what the heck were you doing?"

I didn't know how to succinctly describe to him the change in my vision, so I told him instead that I was just looking at the way the branches were growing out of the ground. I felt like an idiot.

When I first learned about stereopsis in college, I wondered if I could imagine this way of seeing. Now I had my answer. I could not. Stereopsis provides a distinctive, subjective sensation, a quale. In their book, *Phantoms in the Brain*, V.S. Ramachandran and S. Blakeslee define the term *quale* (plural: *qualia*) as "the raw feel of sensations such as the subjective quality of 'pain' or 'red' or 'gnocchi with truffles.'" While I could infer indirectly a sense of depth through cues such as perspective and shading, I could not synthesize stereoscopic depth from other visual attributes such as color, position, form, or brightness. The sensation provided by stereopsis of empty space and things projecting or receding into that space is unique.

Just as I could not imagine a world in stereo depth, an individual with normal stereopsis cannot experience the worldview of a person who has always lacked stereopsis. This may be surprising because you can eliminate cues from stereopsis simply by closing one eye. What's more, many people do not notice a great difference when viewing the world with one eye or two. When a normal binocular viewer closes one eye, however, he or she still uses a lifetime of past visual experiences to recreate the missing stereo information.

I became convinced of these ideas on the day that the Star Wars movie, *Revenge of the Sith*, opened in movie theaters. My husband and children insisted that we attend the first screening at midnight. I like *Star Wars*, but until that night, I couldn't understand my family's fascination with the special effects. I was not thrilled with watching the new movie in the dead of night, but that evening, I saw something different. I was overwhelmed by the sense of space and volume created in the movie. Scenes of spaceships flying through the universe were fantastic! My new appreciation for the movie didn't stem from my watching the movie in the wee hours of the morning or from significant improvements in cinematography since the previous Star Wars films. Instead, I was seeing the movie in a whole new way. Skilled cinematographers had used monocular depth and motion cues to create scenes on the flat, two-dimensional movie screen that suggested dramatic depth. Before my vision transformed, I could not experience this sense of space and volume while watching the movie because I had never experienced this sense of space in real life.

Over and over again, I discovered that my theoretical knowledge of stereopsis did not prepare me in the least for the remarkable experience of seeing in stereo depth. I wanted to know whether others had written about this phenomenon. Although I read many books and articles by vision scientists and clinicians, I found that only the writings of Frederick Brock captured my thoughts and experiences. In fact, when I came across the passage quoted at the beginning of this chapter, I nearly fell out of my chair:

"It must be repeated here that, before stereopsis is actually experienced by the patient, there is nothing one can do or say which will adequately explain to him the actual sensation experienced …"

Susan Barry's story gained national attention with the publication of "Stereo Sue" by acclaimed neurologist Oliver Sacks in the *New Yorker* (2006). In her new book, she tells how she discovered other individuals who experienced stereopsis for the first time as adults, and she provides in-depth medical and scientific background about binocular vision disorders and their treatments.

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