The Mind's Eye

To what extent are we the authors, the creators, of our own experiences? How much are these predetermined by the brains or senses we are born with, and to what extent do we shape our brains through experience? The effects of a profound perceptual deprivation such as blindness may cast an unexpected light on these questions. Going blind, especially later in life, presents one with a huge, potentially overwhelming challenge: to find a new way of living, of ordering one's world, when the old way has been destroyed.

In 1990, I was sent an extraordinary book called Touching the Rock: An Experience of Blindness, by John Hull, a professor of religious education in England. Hull had grown up partly sighted, developing cataracts at the age of thirteen and becoming completely blind in his left eye four years later. Vision in his right eye remained reasonable until he was thirty-five or so, but there followed a decade of steadily failing vision, so that Hull needed stronger and stronger magnifying glasses and had to write with thicker and thicker pens. In 1983, at the age of forty-eight, he became completely blind.

Touching the Rock is the journal he dictated in the three years that followed. It is full of piercing insights about his transition to life as a blind person, but most striking for me was his description of how, after he became blind, he experienced a gradual attenuation of visual imagery and memory, and finally a virtual extinction of them (except in dreams)—a state that he called "deep blindness."

By this, Hull meant not only a loss of visual images and memories but a loss of the very idea of seeing, so that even concepts like "here," "there," and "facing" seemed to lose meaning for him. The sense of objects having appearances, or visible characteristics, vanished. He could no longer imagine how the numeral 3 looked unless he traced it in the air with his finger. He could construct a motor image of a 3, but not a visual one.

At first Hull was greatly distressed by this: he could no longer conjure up the faces of his wife or children, or of familiar and loved landscapes and places. But he then came to accept it with remarkable equanimity, regarding it as a natural response to losing his sight. Indeed, he seemed to feel that the loss of visual imagery was a prerequisite for the full development, the heightening, of his other senses.

Two years after becoming completely blind, Hull had apparently become so nonvisual in his imagery and memory as to resemble someone who had been blind from birth. In a profoundly religious way, and in language sometimes reminiscent of that of Saint John of the Cross, Hull entered into the state of deep blindness, surrendered himself, with a sort of acquiescence and joy. He spoke of deep blindness as "an authentic and autonomous world,
...Being a whole-body seer is to be in one of the concentrated human conditions.”

Being a “whole-body seer,” for Hull, meant shifting his attention, his center of gravity, to the other senses, and these senses assumed a new richness and power. Thus he wrote of how the sound of rain, never before accorded much attention, could delineate a whole landscape for him, for its sound on the garden path was different from its sound as it drummed on the lawn, or on the bushes in his garden, or on the fence dividing the garden from the road:

Rain has a way of bringing out the contours of everything; it throws a coloured blanket over previously invisible things; instead of an intermittent and thus fragmented world, the steadily falling rain creates continuity of acoustic experience...presents the fullness of an entire situation all at once...gives a sense of perspective and of the actual relationships of one part of the world to another.

With his new intensity of auditory experience (or attention), along with the sharpening of his other senses, Hull came to feel a sense of intimacy with nature, an intensity of being-in-the-world, beyond anything he had known when he was sighted. Blindness became for him “a dark, paradoxical gift.” This was not just “compensation,” he emphasized, but a whole new order, a new mode of human being. With this, he extricated himself from visual nostalgia, from the strain or falsity of trying to pass as “normal,” and found a new focus, a new freedom and identity. His teaching at the university expanded, became more fluent; his writing became stronger and deeper; he became intellectually and spiritually bolder, more confident. He felt he was on solid ground at last.¹

Hull’s description seemed to me an astounding example of how an individual deprived of one form of perception could totally reshape himself to a new center, a new perceptual identity. Yet I found it extraordinary that such an annihilation of visual memory as he described could happen to an adult with decades of rich and significant visual experience to call upon. I could not, however, doubt the authenticity of Hull’s account, which he related with the most scrupulous care and lucidity.

Cognitive neuroscientists have known for the past few decades that the brain is far less hardwired than was once thought. Helen Neville was one of the pioneers here, showing that in prelingually deaf people (that is, those who had been born deaf or become deaf

¹Despite an initially overwhelming sense of despair on losing their sight, some people, like Hull, have found their full creative strength and identity on the other side of blindness. One thinks especially of John Milton, who started to lose his sight around the age of thirty (probably from glaucoma), but produced his greatest poetry after becoming completely blind a dozen years later. He meditated on blindness, how inward sight may come in place of outward sight, in Paradise Lost, Elegies, Agonistes, and—most directly—in letters to friends and in a very personal sonnet, “On His Blindness.” Jorge Luis Borges, another poet who became blind, wrote about the varied and paradoxical effects of his own blindness; he also wondered how it might have been for Homer, who, Borges imagined, lost the world of sight but gained a much deeper sense of time and, with this, a matchless epic power. (This is beautifully discussed by J. T. Fraser in his 1989 foreword for the Braille edition of Time, the Familiar Stranger.)
began to concede in the 1970s that there might be a certain flexibility or plasticity in the brain, at least in the first couple of years of life. But when this critical period was over, it was thought, the brain became much less plastic.

Yet the brain remains capable of making radical shifts in response to sensory deprivation. In 2008, Lotfi Merabet, Alvaro Pascual-Leone, and their colleagues showed that, even in sighted adults, as little as five days of being blindfolded produced marked shifts to nonvisual forms of behavior and cognition, and they demonstrated the physiological changes in the brain that went along with this. (They feel it is important to distinguish between such rapid and reversible changes, which seem to make use of preexisting but latent intersensory connections, and the long-lasting changes that occur especially in response to early or congenital blindness, which may entail major reorganizations of cortical circuitry.)

Apparently Hull’s visual cortex, even in adulthood, had adapted to a loss of visual input by taking over other sensory functions—hearing, touch, smell—while relinquishing the power of visual imagery. I assumed that Hull’s experience was typical of acquired blindness, the response, sooner or later, of everyone who loses sight—and a brilliant example of cortical plasticity.

Yet when I came to publish an essay on Hull’s book in 1991, I was taken aback to receive a number of letters from blind people, letters that were often somewhat puzzled and occasionally indignant in tone. Many of these people wrote that they could not identify with

Before the age of two or so the auditory parts of the brain did not degenerate. They remained active and functional, but with an activity and a function that were new: they were transformed, “reallocated,” in Neville’s term, for processing visual language. Comparable studies in those born blind, or blinded early, show that some areas of the visual cortex may be reallocated and used to process sound and touch.

With this reallocation of parts of the visual cortex, hearing, touch, and other senses in the blind can take on a hyperacuity that perhaps no sighted person can imagine. Bernard Morin, the mathematician who showed in the 1960s how a sphere could be turned inside out, became blind at the age of six, from glaucoma. He felt that his mathematical achievement required a special sort of spatial sense—a haptic perception and imagination beyond anything a sighted mathematician was likely to have. And a similar sort of spatial or tactile giftedness has been central to the work of Geerat Vermeij, a conchologist who has delineated many new species of mollusks, based on tiny variations in the shapes and contours of their shells. Vermeij has been blind since the age of three.²

Faced with such findings and reports, neuroscientists

² In his book *The Invention of Clouds*, Richard Hamblyn recounts how Luke Howard, the nineteenth-century chemist who first classified clouds, corresponded with many other naturalists of the time, including John Gough, a mathematician blinded by smallpox at the age of two. Gough, Hamblyn writes, “was a noted botanist, having taught himself the entire Linnean system by touch. He was also a master of the fields of mathematics, zoology and osteology—the art of writing in the dark.” (Hamblyn adds that Gough “might also have become an accomplished musician had his father, a stern Quaker . . . not stopped him playing on the godless violin that an itinerant fiddler had given him.”)
Hull’s experience and said that they themselves, even decades after losing their sight, had never lost their visual images or memories. One woman, who had lost her sight at fifteen, wrote:

Even though I am totally blind... I consider myself a very visual person. I still “see” objects in front of me. As I am typing now I can see my hands on the keyboard... I don’t feel comfortable in a new environment until I have a mental picture of its appearance. I need a mental map for my independent moving, too.

Had I been wrong, or at least one-sided, in accepting Hull’s experience as a typical response to blindness? Had I been guilty of emphasizing one mode of response too strongly, oblivious to other, radically different possibilities?

This feeling came to a head a few years later, when I received a letter from an Australian psychologist named Zoltan Torey. Torey wrote to me not about blindness but about a book he had written on the brain-mind problem and the nature of consciousness. In his letter he also mentioned that he had been blinded in an accident at the age of twenty-one. But although he was “advised to switch from a visual to an auditory mode of adjustment,” he had moved in the opposite direction, resolving to develop instead his inner eye, his powers of visual imagery, to their greatest possible extent.

In this, he said, he had been extremely successful, developing a remarkable power of generating, holding, and manipulating images in his mind, so much so that he had been able to construct a virtual visual world that seemed as real and intense to him as the perceptual one he had lost—indeed, sometimes more real, more intense. This imagery, moreover, enabled him to do things that might have seemed scarcely possible for a blind man.

“I replaced the entire roof guttering of my multi-gabled home single-handed,” he wrote, “and solely on the strength of the accurate and well-focused manipulation of my now totally pliable and responsive mental space.” Torey later expanded on this episode, mentioning the great alarm of his neighbors at seeing a blind man alone on the roof of his house—at night (even though, of course, darkness made no difference to him).

And he felt that his newly strengthened visual imagery enabled him to think in ways that had not been available to him before, allowed him to project himself inside machines and other systems, to envisage solutions, models, and designs.

I wrote back to Torey, suggesting that he consider writing another book, a more personal one, exploring how his life had been affected by blindness and how he had responded to this in the most improbable and seemingly paradoxical way. A few years later, he sent me the manuscript of Out of Darkness. In this new book, Torey described the early visual memories of his childhood and youth in Hungary before the Second World War: the sky-blue buses of Budapest, the egg-yellow trams, the lighting of gas lamps, the funicular railway on the Buda side. He described a carefree and privileged youth, roaming with his father in the wooded mountains above the Danube, playing games and pranks at school, growing up in a highly intellectual environment of writers, actors, professionals of every sort. Torey’s father was the head of a large motion-picture studio and would often give his son scripts to read. “This,” Torey wrote,
"gave me the opportunity to visualize stories, plots and characters, to work my imagination—a skill that was to become a lifeline and source of strength in the years ahead."

All of this came to a brutal end with the Nazi occupation, the siege of Buda, and then the Soviet occupation. Torey, by this time an adolescent, found himself passionately drawn to the big questions—the mystery of the universe, of life, and, above all, the mystery of consciousness, of the mind. At nineteen, feeling that he needed to immerse himself in biology, engineering, neuroscience, and psychology, but knowing that there was no chance of an intellectual life in Soviet Hungary, Torey made his escape and found his way to Australia, where, penniless and without connections, he did various manual jobs. In June of 1951, loosening the plug in a vat of acid at the chemical factory where he worked, he had the accident that bisected his life:

The last thing I saw with complete clarity was a glint of light in the flood of acid that was to engulf my face and change my life. It was a nano-second of sparkle, framed by the black circle of the drumface, less than a foot away. This was the final scene, the slender thread that ties me to my visual past.

When it became clear that his corneas had been hopelessly damaged and that he would have to live his life as a blind man, he was advised to rebuild his representation of the world on the basis of hearing and touch, and to "forget about sight and visualizing altogether." But this was something that Torey could not or would not do. He had emphasized, in his first letter to me, the importance of a most critical choice at this juncture: "I immediately resolved to find out how far a partially sense-deprived brain could go to rebuild a life." Put this way, it sounds abstract, like an experiment. But in his book one senses the tremendous feelings underlying his resolution: the horror of darkness—"the empty darkness," as Torey often calls it, "the grey fog that was engulfing me"—and the passionate desire to hold on to light and sight, to maintain, if only in memory and imagination, a vivid and living visual world. The very title of his book says all this, and the note of defiance is sounded from the start.

Hull, who did not use his imagery in a deliberate way, lost it within two or three years and became unable to remember which way round a 3 went; Torey, on the other hand, soon became able to multiply four-figure numbers by each other, as on a blackboard, visualizing the whole operation in his mind, "painting" the suboperations in different colors.

Torey maintained a cautious and "scientific" attitude to his own visual imagery, taking pains to check the accuracy of his images by every means available. "I learned," he wrote, "to hold the image in a tentative way, conferring credibility and status on it only when some information would tip the balance in its favor." He soon gained enough confidence in the reliability of his visual imagery to stake his life upon it, as when he undertook roof repairs by himself. And this confidence extended to other, purely mental projects. He became able "to imagine, to visualize, for example, the inside of a differential gearbox in action as if from inside its casing. I was able to watch the cogs bite, lock and revolve, distributing the spin as required. I began to play around with this inter-
nall view in connection with mechanical and technical
problems, visualizing how subcomponents relate in the
atom, or in the living cell.” This power of imagery was
crucial, Torey thought, in enabling him to arrive at a new
view of the brain-mind problem by visualizing the brain
“as a perpetual juggling act of interacting routines.”

Soon after receiving the manuscript of Out of Dark-
ness, I received proofs of yet another memoir about
blindness: Sabriye Tenberken’s My Path Leads to Tibet.
While Hull and Torey are thinkers, preoccupied in their
different ways by inwardness, states of brain and mind,
Tenberken is a doer; she has traveled, often alone, all over
Tibet, where for centuries blind people have been treated
as less than human and denied education, work, respect,
or a role in the community. Virtually single-handed,
Tenberken has transformed their situation over the past
decade or so, devising a form of Tibetan Braille, estab-
lishing the first schools for the blind there, and integ-
rating the graduates of these schools into their communities.

Tenberken herself had impaired vision almost from
birth, but was able to make out faces and landscapes until
she was twelve. As a child in Germany, she loved paint-
ing and had a particular predilection for colors, and when
she was no longer able to decipher shapes and forms, she
could still use colors to identify objects. 3

3. Tenberken also has an intense synesthesia, which has persisted and
been intensified, it seems, by her blindness:

As far back as I can remember, numbers and words have instantly
triggered colors in me…. The number 4, for example, is gold.
Five is light green. Nine is vermillion…. Days of the week as well
as months have their colors, too. I have them arranged in geo-

Though she had been totally blind for a dozen years
when she went to Tibet, Tenberken continued to use
her other senses, along with verbal descriptions, visual
memories, and a strong pictorial and synesthetic sensi-
bility, to construct “pictures” of landscapes and rooms,
of environments and scenes—pictures so lively and
detailed as to astonish her listeners. These images may
sometimes be wildly or comically different from reality,
as she related in one incident when she and a companion
drove to Nam Co, the great salt lake in Tibet. Turning
eagerly towards the lake, Tenberken saw, in her imagina-
tion, “a beach of crystallized salt shimmering like snow
under an evening sun, at the edge of a vast body of tur-
quise water…. And down below, on the deep green
mountain flanks, a few nomads were watching their
yaks grazing.” It then turned out that she had not been
“looking” at the lake at all, but facing in another direc-
tion, “staring” at rocks and a gray landscape. These dis-
parities do not faze her in the least—she is happy to have
so vivid a visual imagination. Hers is essentially an artis-
tic imagination, which can be impressionistic, romantic,
not veridical at all, whereas Torey’s imagination is that
of an engineer, and has to be factual, accurate down to
the last detail.

Jacques Lusseyran was a French Resistance fighter
whose memoir, And There Was Light, deals mostly

metrical formations, in circular sectors, a little like a pie. When I
need to recall on which day a particular event happened, the first
thing that pops up on my inner screen is the day’s color, then its
position in the pie.
with his experiences fighting the Nazis and later in Buchenwald, but includes many beautiful descriptions of his early adaptations to blindness. He was blinded in an accident when he was not quite eight years old, an age that he came to feel was "ideal" for such an eventuality, for, while he already had a rich visual experience to call on, "the habits of a boy of eight are not yet formed, either in body or in mind. His body is infinitely supple."

At first, Lusseyran began to lose his visual imagery:

A very short time after I went blind I forgot the faces of my mother and father and the faces of most of the people I loved... I stopped caring whether people were dark or fair, with blue eyes or green. I felt that sighted people spent too much time observing these empty things... I no longer even thought about them. People no longer seemed to possess them. Sometimes in my mind men and women appeared without heads or fingers.

This is similar to Hull, who wrote, "Increasingly, I am no longer even trying to imagine what people look like. I am finding it more and more difficult to realize that people look like anything, to put any meaning into the idea that they have an appearance."

But then, while relinquishing the actual visual world and many of its values and categories, Lusseyran began to construct and to use an imaginary visual world more like 'Torey's. He came to identify himself as belonging to a special category, the "visual blind."

Lusseyran's inner vision started as a sensation of light, a formless, flooding, streaming radiance. Neurological terms are bound to sound reductive in this almost mystical context, yet one might venture to interpret this as a release phenomenon, a spontaneous, almost eruptive arousal of the visual cortex, now deprived of its normal visual input. (Such a phenomenon is analogous, perhaps, to tinnitus or phantom limbs, though endowed, here, by a devout and precociously imaginative little boy, with some element of the supernal.) But then, it becomes clear, he found himself in possession of great powers of visual imagery, and not just a formless luminosity.

The visual cortex, the inner eye, having been activated, his mind constructed a "screen" upon which whatever he thought or desired was projected and, if need be, manipulated, as on a computer screen. "This screen was not like a blackboard, rectangular or square, which so quickly reaches the edge of its frame," he wrote.

My screen was always as big as I needed it to be. Because it was nowhere in space it was everywhere at the same time... Names, figures and objects in general did not appear on my screen without shape, nor just in black and white, but in all the colors of the rainbow. Nothing entered my mind without being bathed in a certain amount of light... In a few months my personal world had turned into a painter's studio.

Great powers of visualization were crucial to the young Lusseyran, even in something as nonvisual (one would think) as learning Braille, and in his brilliant successes at school. Visualization was no less crucial in the real, outside world. Lusseyran described walks with his sighted friend Jean, and how, as they were climbing
together up the side of a hill above the Seine Valley, he could say to Jean:

"Just look! This time we’re on top.... You’ll see the whole bend of the river, unless the sun gets in your eyes!" Jean was startled, opened his eyes wide and cried: "You’re right." This little scene was often repeated between us, in a thousand forms.

Every time someone mentioned an event, the event immediately projected itself in its place on the screen, which was a kind of inner canvas.... Comparing my world with his, [Jean] found that his held fewer pictures and not nearly as many colors. This made him almost angry. "When it comes to that," he used to say, "which one of us two is blind?"

It was his supernormal powers of visualization and visual manipulation—visualizing people’s positions and movements, the topography of any space, visualizing strategies for defense and attack—coupled with his charismatic personality (and seemingly infallible "nose" or "ear" for detecting possible traitors) that later made Lusséyran an icon in the French Resistance.

I had now read four memoirs, all strikingly different in their depictions of the visual experience of blinded people: Hull with his acquiescent descent into "deep blindness"; Torey with his "compulsive visualization" and meticulous construction of an internal visual world; Tenberken with her impulsive, almost novelistic visual freedom, along with her remarkable and specific gift of synesthesia; and Lusséyran, who identified himself as one of the "visual blind." Was there any such thing, I wondered, as a typical blind experience?

Dennis Shulman, a clinical psychologist and psychoanalyst who lectures on biblical topics, is an affable, stocky, bearded man in his fifties who gradually lost his sight in his teens, becoming completely blind by the time he entered college. When we met a few years ago, he told me that his experience was completely unlike Hull’s:

I still live in a visual world after thirty-five years of blindness. I have very vivid visual memories and images. My wife, whom I have never seen—I think of her visually. My kids, too. I see myself visually—but it is as I last saw myself, when I was thirteen, though I try hard to update the image. I often give public lectures, and my notes are in Braille; but when I go over them in my mind, I see the Braille notes visually—they are visual images, not tactile.

Arlene Gordon, a former social worker in her seventies, told me that things were very similar for her. She said, "I was stunned when I read [Hull’s book]. His experiences are so unlike mine." Like Dennis, she still identifies herself in many ways as a visual person. "I have a very strong sense of color," she said. "I pick out my own clothes. I think, ‘Oh, that will go with this or that,’ once I have been told the colors." Indeed, she was dressed very smartly, and took obvious pride in her appearance.

She still had a great deal of visual imagery, she continued: "If I move my arms back and forth in front of my eyes, I see them, even though I have been blind for more
than thirty years.” It seemed that moving her arms was immediately translated into a visual image. Listening to talking books, she added, made her eyes ache if she listened too long; she felt herself to be “reading” at such times, the sound of the spoken words being transformed to lines of print on a vividly visualized book in front of her.4

Arlene’s comment reminded me of Amy, a patient who had been deafened by scarlet fever at the age of nine, but was so adept a lip-reader that I often forgot she was deaf. Once, when I absentmindedly turned away from her as I was speaking, she said sharply, “I can no longer hear you.”

“You mean you can no longer see me,” I said.

“You may call it seeing,” she answered, “but I experience it as hearing.”

Amy, though totally deaf, still constructed the sound of speech in her mind. Both Dennis and Arlene, similarly, spoke not only of a heightening of visual imagery and imagination since losing their eyesight but also of what seemed to be a much readier transference of information from verbal description—or from their

own sense of touch, movement, hearing, or smell—into a visual form. On the whole, their experiences seemed quite similar to Torey’s, even though they had not systematically exercised their powers of visual imagery the way he had, or consciously tried to make an entire virtual world of sight.

What happens when the visual cortex is no longer limited or constrained by any visual input? The simple answer is that, isolated from the outside, the visual cortex becomes hypersensitive to internal stimuli of all sorts: its own autonomous activity; signals from other brain areas—auditory, tactile, and verbal areas; and thoughts, memories, and emotions.

Torey, unlike Hull, played a very active role in building up his visual imagery, took control of it the moment the bandages were removed. Perhaps this was because he was already very at home with visual imagery, and used to manipulating it in his own way. We know that Torey was very visually inclined before his accident, and skilled from boyhood in creating visual narratives based on the film scripts his father gave him. (We have no such information about Hull, for his journal entries start only when he has become blind.)

Torey required months of intense cognitive discipline dedicated to improving his visual imagery, making it more tenacious, more stable, more malleable, whereas Lusseyran seemed to do this almost from the start. Perhaps this was because Lusseyran was not yet eight when blinded (while Torey was twenty-one), and his brain was, accordingly, more able to adapt to a new

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4 Although I myself am a poor visualizer, if I shut my eyes, I can still "see" my hands moving on the piano keyboard when I play a piece that I know well. (This may happen even if I just play the piece in my mind.) I feel my hands moving at the same time, and I am not entirely sure that I can distinguish the "feeling" from the "seeing." In this context, they seem inseparable, and one wants to use an intersensory term like "seeing-feeling." The psychologist Jerome Bruner speaks of such imagery as "enactive"—an integral feature of a performance (real or imaginary)—in contrast to an "iconic" visualization, the visualization of something outside oneself. The brain mechanisms underlying these two sorts of imagery are quite different.
and drastic contingency. But adaptability does not end with youth. It is clear that Arlene, who became blind in her forties, was able to adapt in quite radical ways, too, developing the ability to “see” her hands moving before her, to “see” the words of books read to her, to construct detailed visual images from verbal descriptions. One has a sense that Torey’s adaptation was largely shaped by conscious motive, will, and purpose; that Lusseyran’s was shaped by overwhelming physiological disposition; and that Arlene’s lies somewhere in between. Hull’s, meanwhile, remains enigmatic.

How much do these differences reflect an underlying predisposition independent of blindness? Do sighted people who are good visualizers, who have strong visual imagery, maintain or even enhance their powers of imagery if they become blind? Do people who are poor visualizers, on the other hand, tend to move towards “deep blindness” or hallucinations if they lose their sight? What is the range of visual imagery in the sighted?

I first became conscious of great variations in the power of visual imagery and visual memory when I was fourteen or so. My mother was a surgeon and comparative anatomist, and I had brought her a lizard’s skeleton from school. She gazed at this intently for a minute, turning it round in her hands, then put it down and without looking at it again did a number of drawings of it, rotating it mentally by thirty degrees each time, so that she produced a series, the last drawing exactly the same as the first. I could not imagine how she had done this. When she said that she could see the skeleton in her mind just as clearly and vividly as if she were looking at it, and that she simply rotated the image through a twelfth of a circle each time, I felt bewildered, and very stupid. I could hardly see anything with my mind’s eye—at most, faint, evanescent images over which I had no control.

My mother had hoped I would follow in her footsteps and become a surgeon, but when she realized how lacking in visual powers I was (and how clumsy, lacking in mechanical skill, too) she resigned herself to the idea that I would have to specialize in something else.

A few years ago, at a medical conference in Boston, I spoke about Torey’s and Hull’s experiences of blindness, how “enabled” Torey seemed to be by the powers

5. Though I have almost no voluntary imagery, I am prone to involuntary imagery. I used to have this only as I was falling asleep, in migraine auras, with some drugs, or with fever. But now that my sight is impaired, I have it all the time.

In the 1960s, during a period of experimenting with large doses of amphetamines, I experienced a different sort of vivid mental imagery. Amphetamines can produce striking perceptual changes and dramatic enhancements of visual imagery and memory (as I described in "The Dog Beneath the Skin," a chapter in The Man Who Mistook His Wife for a Hat). For a period of two weeks or so, I found that I had only to look at an anatomical picture or specimen, and its image would remain vivid and stable in my mind for hours. I could mentally project the image onto a piece of paper—it was as clear and distinct as if projected by a camera lucida—and trace its outlines with a pencil. My drawings were not elegant, but they were, everyone agreed, quite detailed and accurate. But when the amphetamine-induced state faded, I could no longer visualize, no longer project images, no longer draw—nor have I been able to do so in the decades since. This was not like voluntary imagery—I did not summon images to my mind or construct them bit by bit. It was involuntary and automatic, more akin to eidetic or “photographic” memory, or to palinopsia, an exaggerated persistence of vision.
of visualization he had developed, and how “disabled” Hull was—in some ways, at least—by the loss of his powers of visual imagery and memory. After my talk, a man in the audience came up to me and asked how well, in my estimation, sighted people could function if they had no visual imagery. He went on to say that he had no visual imagery whatever, at least none that he could deliberately evoke, and that no one in his family had any, either. Indeed, he had assumed this was the case with everyone until, as a student at Harvard, he had come to participate in some psychological tests and had realized that he apparently lacked a mental power that all the other students, in varying degrees, had.

“And what do you do?” I asked him, wondering what this poor man could do.

“I am a surgeon,” he replied. “A vascular surgeon. An anatomist, too. And I design solar panels.” But how, I asked him, did he recognize what he was seeing?

“It’s not a problem,” he answered. “I guess there must be representations or models in the brain that get matched up with what I am seeing and doing. But they are not conscious. I cannot evoke them.”

This seemed to be at odds with my mother’s experience—she, clearly, did have extremely vivid and readily manipulable visual imagery, though (it now seemed) this may have been a bonus, a luxury, and not a prerequisite for her career as a surgeon.

Is this also the case with Torey? Is his greatly developed visual imagery, though clearly a source of much pleasure, not as indispensable as he takes it to be? Might he, in fact, have been able to do everything he did, from carpentry to roof repair to making a model of the mind, without any conscious imagery at all? He himself raises this question.

The role of mental imagery in thinking was explored by Francis Galton in his 1883 book *Inquiries into Human Faculty and Its Development*. (Galton, a cousin of Darwin’s, was irrepressible and wide-ranging, and his book includes chapters on subjects as various as fingerprints, eugenics, dog whistles, criminality, twins, synesthesia, psychometric measures, and hereditary genius.) His inquiry into voluntary visual imagery took the form of a questionnaire, with such questions as “Can you recall with distinctness the features of all near relations and many other persons? Can you at will cause your mental image...to sit, stand, or turn slowly around? Can you...see it with enough distinctness to enable you to sketch it leisurely (supposing yourself able to draw)?” The vascular surgeon would have been hopeless on such tests—indeed, it was questions such as these that had floored him when he was a student at Harvard. And yet, finally, how much had it mattered?

As to the significance of such imagery, Galton is ambiguous and guarded. He suggests, in one breath, that “scientific men, as a class, have feeble powers of visual representation” and, in another, that “a vivid visualizing faculty is of much importance in connection with the higher processes of generalized thoughts.” He feels that “it is undoubtedly the fact that mechanicians, engineers and architects usually possess the faculty of seeing mental images with remarkable clearness and precision” but adds, “I am, however, bound to say, that the missing faculty seems to be replaced so serviceably by other modes of conception...that men who declare them-
selves entirely deficient in the power of seeing mental pictures can nevertheless give lifelike descriptions of what they have seen, and can otherwise express themselves as if they were gifted with a vivid visual imagination. They can also become painters of the rank of Royal Academicians.”

A mental image, for Galton, was picturing a familiar person or place in the mind’s eye; it was a reproduction or reconstruction of an experience. But there are also mental images of a much more abstract and visionary kind, images of something which has never been seen by the physical eye but which can be conjured up by the creative imagination and serve as models for investigating reality.6

In his book *Image and Reality: Kekulé, Kopp, and the Scientific Imagination*, Alan Rocke brings out the crucial role of such images or models in the creative lives of scientists, especially nineteenth-century chemists. He focuses especially on August Kekulé and the famous reverie, while he was riding a London bus, that led him to visualize the structure of a benzene molecule, a concept that would revolutionize chemistry. Although chemical bonds are invisible, they were as real to Kekulé, as visually imaginable, as the lines of force around a magnet were for Faraday. Kekulé said of himself that he had “an irresistible need for visualization.”

Indeed, a conversation about chemistry can hardly be maintained without such images and models, and in *Mindsight*, the philosopher Colin McGinn writes, “Images are not just minor variations on perception and thought, of negligible theoretical interest; they are a robust mental category in need of independent investigation... Mental images... should be added as a third great category... to the twin pillars of perception and cognition.”

Some people, like Kekulé, are clearly very powerful visualizers in this abstract sense, but most of us use some combination of experiential visualization (imaging one’s house, for example) and abstract visualization (imagining the structure of an atom). Temple Grandin, though, feels she is a different sort of visualizer.7 She thinks entirely in terms of literal images she has seen before, as if she is looking at a familiar photograph or a film running in her head. When she imagines the concept of “heaven,” for instance, her instant association is to the film *Stairway to Heaven*, and the image in her mind is that of a staircase ascending into the clouds. If someone remarks that it is a rainy day, she sees, in her mind’s eye, the same “photograph” of rain, her own literal and iconic representation of rain. Like Torrey, she is a powerful visualizer; her extremely accurate visual memory allows her to walk through, in her mind, a factory she is designing, noting structural details even before it is built. Growing up, she assumed this was how everyone thought, and she is puzzled, now, by the idea that some people cannot summon visual images at will. When

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6. The physicist John Tyndall referred to these in an 1870 lecture, a few years before Galton’s *Inquiries*: “In explaining scientific phenomena, we habitually form mental images of the ultra-sensible... Without the exercise of this power our knowledge of nature would be a mere tabulation of co-existences and sequences.”

7. I described Temple more fully in An *Anthropologist on Mars*, and she speaks about her visual thinking especially in her book *Thinking in Pictures*. 
I told her I could not do so, she asked, “How do you think, then?”

When I talk to people, blind or sighted, or when I try to think of my own internal representations, I find myself uncertain whether words, symbols, and images of various types are the primary tools of thought or whether there are forms of thought antecedent to all of these, forms of thought essentially amodal. Psychologists have sometimes spoken of “interlingua” or “mentalese,” which they conceive to be the brain’s own language, and Lev Vygotsky, the great Russian psychologist, used to speak of “thinking in pure meanings.” I cannot decide whether this is nonsense or profound truth—it is the sort of reef I end up on when I think about thinking.

Galton himself was puzzled about visual imagery: it had an enormous range, and although it sometimes seemed an essential part of thinking, at other times it seemed irrelevant. This uncertainty has characterized the debate over mental imagery ever since. A contemporary of Galton’s, the early experimental psychologist Wilhelm Wundt, guided by introspection, believed imagery to be an essential part of thought. Others maintained that thinking was imageless and consisted entirely of analytical or descriptive propositions, and behaviorists did not believe in thinking at all—there was only “behavior.” Was introspection alone a reliable method of scientific observation? Could it yield data that were consistent, repeatable, measurable? It was only in the early 1970s that this challenge was faced by a new generation of psychologists. Roger Shepard and Jacqueline Metzler asked subjects to perform mental tasks that required rotating an image of a geometrical figure in their minds—the sort of imaginary rotation my mother performed when she drew the lizard’s skeleton from memory. They were able to determine in these first quantitative experiments that rotating an image took a specific amount of time—an amount proportional to the degree of rotation. Rotating an image through sixty degrees, for instance, took twice as long as rotating it through thirty degrees, and rotating it through ninety degrees, three times as long. Mental rotation had a rate, it was continuous and steady, and it took effort, like any voluntary act.

Stephen Kosslyn entered the subject of visual imagery from another angle, and in 1973 published a seminal paper contrasting the performance of “imagers” and “verbalizers” who were asked to remember a set of drawings they had been shown. Kosslyn hypothesized that if internal images were spatial and organized like pictures, the “imagers” ought to be able to focus selectively on a part of the image, and that time would be required for them to shift their attention from one part of the image to another. The time required, he thought, would be proportional to the distance the mind’s eye had to travel.

Kosslyn was able to show that all of these were indeed the case, indicating that visual images were essentially spatial and organized in space like pictures. His work has proved immensely fertile, but the ongoing debate about the role of visual imagery continues, as Zenon Pylyshyn and others have maintained that the mental rotation of images and “scanning” them could be interpreted as the result of purely abstract, nonvisual operations in the mind/brain.\(^8\)

\(^8\) Kosslyn’s latest book on the matter, *The Case for Mental Imagery*, details the history of this debate.
By the 1990s, Kosslyn and others were able to combine imagery experiments with PET and fMRI scanning, which allowed them to map the areas of the brain involved as people engaged in tasks requiring mental imagery. Mental imagery, they found, activated many of the same areas of the visual cortex as perception itself, showing that visual imagery was a physiological reality as well as a psychological one, and used at least some of the same neural pathways as visual perception.9

That perception and imagery share a common neural basis in the visual parts of the brain is suggested by clinical studies, too. In 1978 Eduardo Bisiach and Claudio Luzzatti in Italy related the cases of two patients who both developed a hemianopia following a stroke and could not see to the left side. When they were asked to imagine themselves walking down a familiar street and describe what they saw, they mentioned only the shops on the right side of the street; but when they were then asked to imagine turning around and walking back, they described the shops they had not "seen" before, the shops that were now on the right side. These beautifully examined cases showed that a hemianopia might cause not only a bisection of the visual field but a bisection of visual imagery as well.

Such clinical observations on the parallels between visual perception and visual imagery go back at least a century. In 1911, the English neurologists Henry Head and Gordon Holmes examined a number of patients with subtle damage to the occipital lobes—damage that led not to total blindness but to blind spots within the visual field. They found, by questioning their patients carefully, that blind spots in exactly the same locations occurred in the patients' mental imagery as well. And in 1992, Martha Farah et al. reported that in a patient who lost partial vision on one side due to an occipital lobectomy, the visual angle of his mind's eye was also reduced, in a way that perfectly matched his perceptual loss.

For me, the most convincing demonstration that at least some aspects of visual imagery and visual perception might be inseparable occurred when I was consulted in 1986 by Mr. L., an artist who became completely colorblind following a head injury.10 Mr. L. was distressed by his sudden inability to perceive colors, but even more by his total inability to evoke them in memory or imagery. Even his occasional visual migraines were now drained of color. Patients like Mr. L. suggest that the coupling of perception and imagery is very close in the higher parts of the visual cortex.11

9. Functional MRIs also showed that the two hemispheres of the brain behaved differently in regard to imagery, the left hemisphere concerned with generic, categorical images—e.g., "trees"—and the right hemisphere with specific images—e.g., "the maple in my front yard"—a specialization also present in visual perception. Thus prosopagnosia, an inability to recognize specific faces, is associated with damaged or defective visual function in the right hemisphere, though people with prosopagnosia have no problem with the category of faces in general, a left-hemisphere function.

10. Mr. L.'s case is described in An Anthropologist on Mars.

11. While it seems clear that perception and imagery share certain neural mechanisms at higher levels, this sharing is less evident in the primary visual cortex—hence the possibility of a dissociation such as occurs in Anton's syndrome. In Anton's syndrome, patients with occipital damage are cortically blind, but believe they are still sighted. They will move about without restraint or caution, and if they bump into a piece of furniture, they will ascribe this, perhaps, to the furniture being "out of place." Anton's syndrome is sometimes attributed to the preservation of some
Sometimes, he suggests, one mode will be favored over another, depending on the individual and on the problem to be solved. Sometimes both modes will proceed in tandem (although depiction is likely to outpace description), and at other times one may start with depiction—images—and proceed to a purely verbal or mathematical representation.¹²

What, then, of people like me, or the vascular surgeon in Boston who cannot evoke any visual images voluntarily? One must infer, as my colleague in Boston does, that we, too, have visual images, models, and representations in the brain, images that allow visual perception and recognition but are below the threshold of consciousness.¹³

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¹² Einstein described this in regard to his own thinking:

The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined. . . . [Some] are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a second stage.

Darwin, on the other hand, seemed to describe a very abstract, almost computational process in his own thinking, when he wrote in his autobiography, "My mind seems to have become a kind of machine for grinding general laws out of large collections of facts." (What Darwin omitted here was that he had a fantastic eye for form and detail, an enormous observational and depictive power, and it was these which provided the "facts.")

¹³ Dominic ffytche, who has investigated the neurobiology of conscious vision—imagery and hallucination as well as perception—feels that visual consciousness is a threshold phenomenon. Using fMRIs to study patients with visual hallucinations, he has shown that there may be evidence of unusual activity in a specific part of the visual system—for example, the fusiform face area—but this has to reach a certain intensity before it enters consciousness, before the subject actually "sees" faces.
If the central role of visual imagery is to permit visual perception and recognition, what need is there for it if a person becomes blind? And what happens to its neural substrates, the visual areas which occupy nearly half of the entire cerebral cortex? We know that in adults who lose their eyesight, there may be some atrophy of the pathways and relay centers leading from the retina to the cerebral cortex—but there is little degeneration in the visual cortex itself. Functional MRIs of the visual cortex show no diminution of activity in such a situation; indeed, we see the reverse: they reveal a heightened activity and sensitivity. The visual cortex, deprived of visual input, is still good neural real estate, available and clamoring for a new function. In someone like Torey, this may free up more cortical space for visual imagery; in someone like Hull, relatively more may be employed by other senses—auditory perception and attention, perhaps, or tactile perception and attention.¹⁴

¹⁴. The heightened (and sometimes morbid) sensitivity of the visual cortex when deprived of its normal perceptual input may also predispose it to intrusive imagery. A significant proportion of those who go blind—to 20 percent, by most estimates—become prone to involuntary images, or outright hallucinations, of an intense and sometimes bizarre kind. Such hallucinations were originally described in the 1760s by the Swiss naturalist Charles Bonnet, and we now speak of hallucinations secondary to visual impairment as Charles Bonnet syndrome.

Hull described something akin to this which occurred for a while after he lost the last of his sight:

About a year after I was registered blind, I began to have such strong images of what people’s faces looked like that they were almost like hallucinations... I would be sitting in a room with someone, my face pointed towards my companion, listening to him or her. Suddenly, such a vivid picture would flash before my mind that it was like looking at a television set. Ah, I would think, there he is, with his glasses and his little beard, his wavy hair and his blue, pinstriped suit, white collar and blue tie... Now this image would fade and in its place another one would be projected. My companion was now fat and perspiring with receding hair. He had a red necktie and waistcoat, and a couple of his teeth were missing.
Martin Milligan, the philosopher, who had both eyes removed at the age of two (because of malignant tumors), has written of his own experience:

Born-blind people with normal hearing don’t just hear sounds: they can hear objects (that is, have an awareness of them, chiefly through their ears) when they are fairly close at hand, provided these objects are not too low; and they can also in the same way “hear” something of the shape of their immediate surroundings. . . . Silent objects such as lamp-posts and parked cars with their engines off can be heard by me as I approach them and pass them as atmosphere-thickening occupants of space, almost certainly because of the way they absorb and/or echo back the sounds of my footsteps and other small sounds. . . . It isn’t usually necessary to make sounds oneself to have this awareness, though it helps. Objects of head height probably slightly affect the air currents reaching my face, which helps towards my awareness of them—which is why some blind people refer to this kind of sense-awareness as their “facial” sense.

Facial vision tends to be most highly developed in those who are born blind or lose their sight at an early age; for the writer Ved Mehta, who has been blind since the age of four, it is so well developed that he walks confidently and rapidly without a cane, and it is sometimes difficult for others to realize that he is blind.

While the sound of one’s footsteps or one’s cane may suffice, other forms of echolocation have been reported. Ben Underwood developed an astonishing, dolphin-like strategy of emitting regular clicks with his mouth and accurately reading the resulting echoes from nearby objects. He was so adept at moving about the world in this way that he was able to play field sports and even chess.15

Blind people often say that using a cane enables them to “see” their surroundings, as touch, action, and sound are immediately transformed into a “visual” picture. The cane acts as a sensory substitution or extension. But is it possible to give a blind person a more detailed picture of the world, using more modern technology? Paul Bach-y-Rita was a pioneer in this realm and spent decades testing all sorts of sensory substitutes, though his special interest lay in developing devices that could help the blind by using tactile images. (In 1972, he published a prescient book surveying all the possible brain mechanisms by which sensory substitution might be realized. Such substitution, he emphasized, would depend on the brain’s plasticity—and that the brain had any plasticity at all was a revolutionary concept at the time.)

Bach-y-Rita wondered if one might connect the output of a video camera, point by point, to the skin, allowing a blind subject to form a “touch picture” of his environment. This might work, he thought, because tactile information is organized topographically in the brain, and topographic accuracy is essential for forming a quasi-visual picture. Eventually, he began using tiny grids of a hundred or so electrodes on that most sensitive part of the body, the tongue. (The tongue has the highest density of sensory receptors in the body, and it also

15. Ben, who had retinoblastoma, had both eyes removed at the age of three, but then, tragically, died at sixteen from a recurrence of his cancer. Videos of Ben and his echolocation can be seen at the website www.benunderwood.com.
occupies the greatest amount of space, proportionally, in the sensory cortex. This makes it uniquely suitable for sensory substitution.) With this device, the size of a postage stamp, his subjects could form a crude but nevertheless useful “picture” on the tongue itself.

Over the years, the sophistication of such devices has increased greatly, and prototypes now have four to six times the resolution of Bach-y-Rita’s early version. Bulky camera cables have been replaced by spectacles containing miniature cameras, allowing subjects to direct the cameras by a more natural head movement. With this, blind subjects are able to walk across a room that is not too cluttered, or to catch a ball rolled towards them.

Does this mean that they are now “seeing”? Certainly, they are showing what behaviorists would call “visual behavior.” Bach-y-Rita spoke of how his subjects “learn[ed] to make perceptual judgements using visual means of interpretation, such as perspective, parallax, looming and zooming, and depth estimates.” Many of these people felt as if they were seeing once again, and functional MRIs showed strong activations of visual areas in their brains while they were “seeing” with the camera. (“Seeing” occurred particularly when the subjects were able to move the camera voluntarily, pointing it here or there, looking with it. Looking was crucial, for there is no perception without action, no seeing without looking.)

To restore sight to someone who once had it, whether by surgical means or by a sensory-substitution device, is one thing, for such a person would have an intact visual cortex and a lifetime of visual memories. But to give sight to someone who has never seen, never experienced light or sight, would seem to be impossible, in view of what we know about the brain’s critical periods and the necessity of at least some visual experience in the first two years of life to stimulate the development of the visual cortex. (Recent work from Pawan Sinha and others, however, suggests that the critical period may not be as critical as previously accepted.) Tongue vision has been tried with congenitally blind people, too, and with some success. One young musician, born blind, said she “saw” the conductor’s gestures for the first time in her life. Although the visual cortex in congenitally blind people is reduced in volume by more than 25 percent, it can still, apparently, be activated by sensory substitution, and this has been confirmed, in several cases, by fMRIs.

There is increasing evidence for the extraordinarily

16. See Ostrovsky et al., for example.
17. Congenitally blind people, we might suppose, can have no visual imagery at all, since they have never had any visual experience. And yet they sometimes report having clear and recognizable visual elements in their dreams. Helder Bérgolo and his colleagues in Lisbon, in an intriguing 2003 report, described how they compared congenitally blind subjects with normal sighted subjects and found “equivalent visual activity” (based on analysis of EEG alpha-wave attenuations) in the two groups while dreaming. The blind subjects were able, upon waking, to draw the visual components of their dreams, although they had a lower rate of dream recall. Bérgolo et al. conclude, therefore, that “the congenitally blind have visual content in their dreams.”
18. Would acquiring “sight” if one has never seen before be bewildering or enriching? For my patient Virgil, who was given sight, through surgery, after a lifetime of blindness, it was utterly incomprehensible at first, as I described in An Anthropologist on Mars. Thus although sensory-substitution technologies are exciting and promise a new freedom for blind people, we need to consider equally their impact on a life that has already been constructed without sight.
rich interconnectedness and interactions of the sensory areas of the brain, and the difficulty, therefore, of saying that anything is purely visual or purely auditory, or purely anything. The world of the blind can be especially rich in such in-between states—the intersensory, the metamodal—states for which we have no common language.  

On Blindness is an exchange of letters between the blind philosopher Martin Milligan and a sighted philosopher, Bryan Magee. While his own nonvisual world seems coherent and complete to him, Milligan realizes that sighted people have access to a sense, a mode of knowledge, denied him. But congenitally blind people, he insists, can (and usually do) have rich and varied perceptual experiences, mediated by language and by imagery of a nonvisual sort. Thus they may have a “mind’s ear” or a “mind’s nose.” But do they have a mind’s eye?

19. In a recent letter to his colleague Simon Hayhoe, John Hull expanded on this:

For example, when the thought of a car occurs to me, although my front-line images are of recently touching the warm bonnet of a car, or of the shape of the car as I feel for the door handle, there are also traces of the appearance of the whole car, from pictures of cars in books, or memories of cars coming and going. Sometimes, when I have to touch a modern car, I am surprised to find that this memory trace does not correspond to reality, and that cars are not the same shape they were twenty-five years ago.

There is a second point. The fact that an item of knowledge is so much buried in the sense or senses that first received it, means for me that I am not always sure whether my image is visual or not. The trouble is that tactile images of the shape and feel of things also often seem to acquire a visual content, or one cannot tell if the three-dimensional memory shape is being mentally represented by a visual or a tactile image. So even after all these years, the brain can’t sort out where it is getting stuff from.

Here Milligan and Magee cannot reach agreement. Magee insists that Milligan, a blind man, cannot have any real knowledge of the visual world. Milligan disagrees and maintains that even though language only describes people and events, it can sometimes stand in for direct experience or acquaintance.

Congenitally blind children, it has often been noted, tend to have superior memories and be precocious verbally. They may develop such fluency in the verbal description of faces and places as to leave others (and perhaps themselves) uncertain as to whether they are actually blind. Helen Keller’s writing, to give a famous example, startles one with its brilliantly visual quality.

I loved reading Prescott’s Conquest of Mexico and Conquest of Peru as a boy, and felt that I “saw” these lands through his intensely visual, almost hallucinogenic descriptions. I was amazed to discover, years later, that Prescott had not only never visited Mexico or Peru; he had been virtually blind since the age of eighteen. Did he, like Torey, compensate for his blindness by developing huge powers of visual imagery, or were his brilliant visual descriptions simulated, in a way, made possible by the evocative and pictorial powers of language? To what extent can description, picturing in words, provide a substitute for actual seeing or for the visual, pictorial imagination?

After becoming blind in her forties, Arlene Gordon found language and description increasingly important; it stimulated her powers of visual imagery as never before and, in a sense, enabled her to see. “I love traveling,” she told me. “I saw Venice when I was there.” She explained how her traveling companions would describe
places, and she would then construct a visual image from these details, her reading, and her own visual memories. “Sighted people enjoy traveling with me,” she said. “I ask them questions, then they look and see things they wouldn’t otherwise. Too often people with sight don’t see anything! It’s a reciprocal process—we enrich each other’s worlds.”

There is a paradox here—a delicious one—which I cannot resolve: if there is indeed a fundamental difference between experience and description, between direct and mediated knowledge of the world, how is it that language can be so powerful? Language, that most human invention, can enable what, in principle, should not be possible. It can allow all of us, even the congenitally blind, to see with another person’s eyes.

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