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BODY:
As a boy, I was fascinated by **speed,** the wild range of **speeds** in the world around me. People moved at different **speeds;** animals much more so. The wings of insects moved too fast to see, though one could judge their frequency by the tone they emitted-a hateful noise, a high E, with mosquitoes, or a lovely bass hum with the fat bumblebees that flew around the hollyhocks each summer. Our pet tortoise, which could take an entire day to cross the lawn, seemed to live in a different time frame altogether. But what then of the movement of plants? I would come down to the garden in the morning and find the hollyhocks a little higher, the roses more entwined around their trellis, but, however patient I was, I could never catch them moving.

Experiences like this played a part in turning me to photography, because it allowed me to alter the rate of motion, **speed** it up, slow it down, so I could see, adjusted to a human perceptual rate, the details of movement or change otherwise beyond the power of the eye to register. Being fond of microscopes and telescopes-my older brothers, medical students and bird-watchers, kept theirs in the house-I thought of the slowing down or the speeding up of motion as a sort of temporal equivalent: slow motion as an enlargement, a microscopy of time, and speeded-up motion as a foreshortening, a telescopy of time.

I experimented with photographing plants. Ferns, in particular, had many attractions for me-not least in their tightly wound crosiers or fiddleheads, tense with contained time, like watch springs, with the future all rolled up in them. So I would set my camera on a tripod in the garden, and take photographs of fiddleheads at intervals of an hour; I would develop the negatives, print them up, and bind a dozen or so prints together in a little flick-book. And then, as if by magic, I could see the fiddleheads unfurl like the curled-up paper trumpets one blew into at parties, taking a second or two for what, in real time, took a couple of days.

Slowing down motion was not so easy as speeding it up, and here I depended on my cousin, a photographer, who had a cinecamera capable of taking more than a hundred frames per second. With this, I was able to catch the bumblebees at work, as they hovered in the hollyhocks, and to slow down their time-blurred wing beats so that I could see each up-and-down movement distinctly.

My interest in speed and movement and time, and in possible ways to make them appear faster or slower, made me take a special pleasure in two of H. G. Wells's stories, "The Time Machine" and "The New Accelerator," with their

vividly imagined, almost cinematic descriptions of altered time.

"As I put on pace, night followed day like the flapping of a black wing," Wells's Time Traveller relates:

I saw the sun hopping swiftly across the sky, leaping it every minute, and every minute marking a day. . . . The slowest snail that ever crawled dashed by too fast for me. . . . Presently, as I went on, still gaining velocity, the palpitation of day and night merged into one continuous greyness . . . the jerking sun became a streak of fire . . . the moon a fainter fluctuating band. . . . I saw trees growing and changing like puffs of vapour . . . huge buildings rise up faint and fair, and pass like dreams. The whole surface of the earth seemed changed-melting and flowing under my eyes.

The opposite of this occurs in "The New Accelerator," the story of a drug which accelerates one's perceptions, thoughts, and metabolism several thousand times or so. Its inventor and the narrator, who have taken the drug together, wander out into a glaciated world, watching

people like ourselves and yet not like ourselves, frozen in careless attitudes, caught in mid-gesture . . . and sliding down the air with wings flapping slowly and at the speed of an exceptionally languid snail-was a bee.

"The Time Machine" was published in 1895, when there was intense interest in the new powers of photography and cinematography to reveal details of movements inaccessible to the unaided eye. Etienne-Jules Marey, a French physiologist, had been the first to show that a galloping horse at one point had all four hooves off the ground. His work, as the historian Marta Braun brings out, was instrumental in stimulating Eadweard Muybridge's famous photographic studies of motion. Marey, in turn stimulated by Muybridge, went on to develop high-speed cameras which could slow and almost arrest the movements of birds and insects in flight; and, at the opposite extreme, to use time-lapse photography to accelerate the otherwise almost imperceptible movements of sea urchins, starfish, and other marine animals.

I wondered sometimes whether the speeds of animals and plants could be very different from what they were: how much they were constrained by internal limits, how much by external-the gravity of the earth, the amount of energy received from the sun, the amount of oxygen in the atmosphere, and so on. So I was fascinated by yet another Wells story, "The First Men in the Moon," with its beautiful description of how the growth of plants was dramatically accelerated on a celestial body with only a fraction of the earth's gravity:

With a steady assurance, a swift deliberation, these amazing seeds thrust a rootlet downward to the earth and a queer little bundle-like bud into the air. . . . The bundle-like buds swelled and strained and opened with a jerk, thrusting out a coronet of little sharp tips . . . that lengthened rapidly, lengthened visibly even as we watched. The movement was slower than any animal's, swifter than any plant's I have ever seen before. How can I suggest it to you-the way that growth went on? . . . Have you ever on a cold day taken a thermometer into your warm hand and watched the little thread of mercury creep up the tube? These moon plants grew like that.

Here, as in "The Time Machine" and "The New Accelerator," the description was irresistibly cinematic, and made me wonder if the young Wells had seen, or experimented with, time-lapse photography of plants, as I had.

A few years later, when I was a student at Oxford, I read William James's "Principles of Psychology," and there, in a wonderful chapter on "The Perception of Time," I found this description:

We have every reason to think that creatures may possibly differ enormously in the amounts of duration which they intuitively feel, and in the fineness of the events that may fill it. Von Baer has indulged in some interesting computations of the effect of such differences in changing the aspect of Nature. Suppose we were able, within the length of a second, to note 10,000 events distinctly, instead of barely 10, as now; if our life were then destined to hold the same number of impressions, it might be 1000 times as short. We should live less than a month, and personally know nothing of the change of seasons. If born in winter, we should believe in summer as we now believe in the heats of the Carboniferous era. The motions of organic beings would be so slow to our senses as to be inferred, not seen. The sun would stand still in the sky, the moon be almost free from change, and so on. But now reverse the hypothesis and suppose a being to get only one 1000th part of the sensations that we get in a given time, and consequently live 1000 times as long. Winters and summers will be to him like quarters of an hour. Mushrooms and the swifter-growing plants will shoot into being so rapidly as to appear instantaneous creations; annual shrubs will rise and fall from the earth like restlessly boiling-water springs; the motions of animals will be as invisible as are to us the movements of bullets and cannon-balls; the sun will scour through the sky like a meteor, leaving a fiery trail behind him, etc. That such imaginary cases (barring the superhuman longevity) may be realized somewhere in the animal kingdom, it would be rash to deny.

This was published in 1890, when Wells was a young biologist (and writer of biology texts). Could he have read James, or, for that matter, the original computations of Von Baer, from the eighteen-sixties? Indeed, one might say that a cinematographic model is implicit in all these descriptions, for the business of registering larger or smaller numbers of events in a given time is exactly what cinecameras do if they are run faster or slower than the usual twenty-four or so frames per second.

It is often said that time seems to go more quickly, the years rush by, as one grows older-either because when one is young one's days are packed with novel, exciting impressions or because as one grows older a year becomes a smaller and smaller fraction of one's life. But, if the years appear to pass more quickly, the hours and minutes do not-they are the same as they always were.

At least, they seem so to me (in my seventies), although experiments have shown that, while young people are remarkably accurate at estimating a span of three minutes by counting internally, elderly subjects apparently count more slowly, so that their perceived three minutes is closer to three and a half or four minutes. But it is still not clear that this phenomenon has anything to do with the existential or psychological feeling of time passing more quickly as one ages.

The hours and minutes still seem excruciatingly long when I am bored, and all too short when I am engaged. As a boy, I hated school, being forced to listen passively to droning teachers. When I looked at my watch surreptitiously, counting the minutes to my liberation, the minute hand, and even the second hand, seemed to move with infinite slowness. There is an exaggerated consciousness of time in such situations; indeed, when one is bored there may be no consciousness of anything *but* time.

In contrast were the delights of experimenting and thinking in the little chemical lab I set up at home, and here, on a weekend, I might spend an entire day in happy activity and absorption. Then I would have no consciousness of time at all, until I began to have difficulty seeing what I was doing, and realized that evening had come. When, years later, I read Hannah Arendt, writing in "The Life of the Mind" of "a timeless region, an eternal presence in complete quiet, lying beyond human clocks and calendars altogether . . . the quiet of the Now in the time-pressed, time-tossed existence of man. . . . This small non-time space in the very heart of time," I knew exactly what she was talking about.

There have always been anecdotal accounts of people's perception of time when they are suddenly threatened with mortal danger, but the first systematic study was undertaken in 1892 by the Swiss geologist Albert Heim; he explored the mental states of thirty subjects who had survived falls in the Alps. "Mental activity became enormous, rising to a hundred-fold velocity," Heim noted. "Time became greatly expanded. . . . In many cases there followed a sudden review of the individual's entire past." In this situation, he wrote, there was "no anxiety" but, rather, "profound acceptance."

Almost a century later, in the nineteen-seventies, Russell Noyes and Roy Kletti, of the University of Iowa, exhumed and translated Heim's study and went on to collect and analyze more than two hundred accounts of such experiences. Most of their subjects, like Heim's, described an increased speed of thought and an apparent slowing of time during what they thought to be their last moments.

A race-car driver who was thrown thirty feet into the air in a crash said, "It seemed like the whole thing took forever. Everything was in slow motion, and it seemed to me like I was a player on a stage and could see myself tumbling over and over . . . as though I sat in the stands and saw it all happening . . . but I was not frightened." Another driver, cresting a hill at high speed and finding himself a hundred feet from a train which he was sure would kill him, observed, "As the train went by, I saw the engineer's face. It was like a movie run slowly, so that the frames progress with a jerky motion. That was how I saw his face."

While some of these near-death experiences are marked by a sense of helplessness and passivity, even dissociation, in others there is an intense sense of immediacy and reality, and a dramatic acceleration of thought and perception and reaction, which allow one to negotiate danger successfully. Noyes and Kletti describe a jet pilot who faced almost certain death when his plane was improperly launched from its carrier: "I vividly recalled, in a matter of about three seconds, over a dozen actions necessary to successful recovery of flight attitude. The procedures I needed were readily available. I had almost total recall and felt in complete control."

Many of their subjects, Noyes and Kletti said, felt that "they performed feats, both mental and physical, of which they would ordinarily have been incapable."

It may be similar, in a way, with trained athletes, especially those in games demanding fast reaction times. A baseball may be approaching at close to a hundred miles per hour, and yet, as many people have described, the ball may seem to be almost immobile in the air, its very seams strikingly visible, and the batter finds himself in a suddenly enlarged and spacious timescape, where he has all the time he needs to hit the ball.

In a bicycle race, cyclists may be moving at nearly forty miles per hour, separated only by inches. The situation, to an onlooker, looks precarious in the extreme, and, indeed, the cyclists may be mere milliseconds away from each other. The slightest error may lead to a multiple crash. But to the cyclists themselves, concentrating intensely, everything seems to be moving in relatively slow motion, and there is ample room and time, enough to allow improvisation and intricate maneuverings.

The dazzling speed of martial-arts masters, the movements too fast for the untrained eye to follow, may be executed, in the performer's mind, with an almost balletic deliberation and grace, what trainers and coaches like to call "relaxed concentration." This alteration in the perception of speed is often conveyed in movies like "The Matrix" by alternating accelerated and slowed-down versions of the action.

The expertise of athletes (whatever their innate gifts) is only to be acquired by years of dedicated practice and training. At first, an intense conscious effort and attention are necessary to learn every nuance of technique and timing. But at some point the basic skills and their neural representation become so ingrained in the nervous system as to be almost second nature, no longer in need of conscious effort or decision. One level of brain activity may be working automatically, while another, the conscious level, is fashioning a perception of time, a perception which is elastic, and can be compressed or expanded.

In the nineteen-sixties, the American neurophysiologist Benjamin Libet, investigating how simple motor decisions were made, found that brain signals indicating an act of decision could be detected several hundred milliseconds *before* there was any conscious awareness of it. A champion sprinter may be up and running, and already sixteen or eighteen feet into the race before he is consciously aware that the starting gun has fired. (He can be off the blocks in a hundred and thirty milliseconds, whereas the conscious registration of the gunshot requires four hundred milliseconds or more.) The runner's belief that he consciously heard the gun and then, immediately, exploded off the blocks is an illusion made possible, Libet would suggest, because the mind "antedates" the sound of the gun by almost half a second.

Such a reordering of time, like the apparent compression or expansion of time, raises the question of how we normally perceive time. William James speculated that our judgment of time, our speed of perception, depends on how many "events" we can perceive in a given unit of time.

There is much to suggest that conscious perception (at least, visual perception) is not continuous but consists of discrete moments, like the frames of a movie, which are then blended to give an appearance of continuity. No such partitioning of time, it would seem, occurs in rapid, automatic actions, such as returning a tennis shot or hitting a baseball. Christof Koch, a neuroscientist at Caltech, distinguishes between "behavior" and "experience," and proposes that "behavior may be executed in a smooth fashion, while experience may be structured in discrete intervals, as in a movie." This model of consciousness would allow a Jamesian mechanism by which the perception of time could be speeded up or slowed down. Koch speculates that the apparent slowing of time in emergencies and athletic performances (at least when athletes find themselves "in the zone") may come from the power of intense attention to reduce the duration of individual frames.

The subject of space and time perception is becoming a popular topic in sensory psychology, and the reactions and perceptions of athletes, and of people facing sudden demands and emergencies, would seem to be an obvious field for further experiment, especially now that virtual reality gives us the power to simulate action under controlled conditions, and at ever more taxing speeds.

For William James, the most striking departures from "normal" time were provided by the effects of certain drugs. He tried a number of them himself, from nitrous oxide to peyote, and in his chapter on the perception of time he immediately followed his meditation on Von Baer with a reference to hashish. "In hashish-intoxication," he writes, "there is a curious increase in the apparent time-perspective. We utter a sentence, and ere the end is reached the beginning seems already to date from indefinitely long ago. We enter a short street, and it is as if we should never get to the end of it."

James's observations are an almost exact echo of Jacques-Joseph Moreau's, fifty years earlier. Moreau, a physician, was one of the first to make hashish fashionable in the Paris of the eighteen-forties-indeed, he was a member, along with Gautier, Baudelaire, Balzac, and other savants and artists, of Le Club des Hachichins. Moreau wrote:

Crossing the covered passage in the Place de l'Opera one night, I was struck by the length of time it took to get to the other side. I had taken a few steps at most, but it seemed to me that I had been there two or three hours. . . . I hastened my step, but time did not pass more rapidly. . . . It seemed to me . . . that the walk was endlessly long and that the exit towards which I walked was retreating into the distance at the same rate as my speed of walking.

Going along with the sense that a few words, a few steps, may last an unconscionable time, there may be the sense of a world profoundly slowed, even suspended. L. J. West, in the 1970 book "Psychotomimetic Drugs," relates this anecdote: "Two hippies, high on pot, are sitting in the Golden Gate Park in San Francisco. A jet aircraft goes zooming overhead and is gone; whereupon one hippie turns to the other and says, 'Man, I thought he'd never leave.' "

But while the external world may appear slowed, an inner world of images and thoughts may take off with great speed. One may set out on an elaborate mental journey, visiting different countries and cultures, or compose a book or a symphony, or live through a whole life or an epoch of history, only to find that mere minutes or seconds have passed. Gautier described how he entered a hashish trance in which "sensations followed one another so numerous and so hurried that true appreciation of time was impossible." It seemed to him, subjectively, that the spell had lasted "three hundred years," but he found, on awakening, that it had lasted no more than a quarter of an hour.

The word "awakening" may be more than a figure of speech here, for such "trips" have surely to be compared with dreams. I have occasionally, it seems to me, lived a whole life between my first alarm, at 5 a.m., and my second alarm, five minutes later.

Sometimes, as one is falling asleep, there may be a massive, involuntary jerk-a myoclonic jerk-of the body. Though such jerks are generated by primitive parts of the brain stem (they are, so to speak, brain-stem reflexes), and as such are without any intrinsic meaning or motive, they may be given meaning and context, turned into acts, by an instantly improvised dream. Thus the jerk may be associated with a dream of tripping, or stepping over a precipice, lunging forward to catch a ball, and so on. Such dreams may be extremely vivid, and have several "scenes." Subjectively, they appear to start *before* the jerk, and yet presumably the entire dream mechanism is stimulated by the first, preconscious perception of the jerk. All of this elaborate restructuring of time occurs in a second or less.

There are certain epileptic seizures, sometimes called "experiential seizures," when a detailed recollection or hallucination of the past suddenly imposes itself upon a patient's consciousness, and pursues a subjectively lengthy and unhurried course, to complete itself in what, objectively, is only a few seconds. These seizures are typically associated with convulsive activity in the brain's temporal lobes, and can be induced, in some patients, by electrical stimulation of certain trigger points on the surface of the lobes. Sometimes such epileptic experiences are suffused with a sense of metaphysical significance, along with their subjectively enormous duration. Dostoyevsky wrote of such seizures:

There are moments, and it is only a matter of a few seconds, when you feel the presence of the eternal harmony. . . . A terrible thing is the frightful clearness with which it manifests itself and the rapture with which it fills you. . . . During these five seconds I live a whole human existence, and for that I would give my whole life and not think that I was paying too dearly.

There may be no inner sense of speed at such times, but at other times-especially with mescaline or LSD-one may feel hurtled through thought-universes at uncontrollable, supraluminal speeds. In "The Major Ordeals of the Mind," the French poet and painter Henri Michaux writes, "Persons returning from the speed of mescaline speak of an acceleration of a hundred or two hundred times, or even of five hundred times that of normal speed." He comments that this is probably an illusion, but that even if the acceleration were much more modest-"even only six times" the normal-the increase would still feel overwhelming. What is experienced, Michaux feels, is not so much a huge accumulation of exact literal details as a series of over-all impressions, dramatic highlights, as in a dream.

But, this said, if the speed of thought could be significantly heightened, the increase would readily show up (if we had the experimental means to examine it) in physiological recordings of the brain, and would perhaps illustrate the limits of what is neurally possible. We would need, however, the right level of cellular activity to record from, and this would be not the level of individual nerve cells but a higher level, the level of interaction between *groups* of neurons in the cerebral cortex, which, in their tens or hundreds of thousands, form the neural correlate of consciousness.

The speed of such neural interactions is normally regulated by a delicate balance of excitatory and inhibitory forces, but there are certain conditions in which inhibitions may be relaxed. Dreams can take wing, move freely and swiftly,

precisely because the activity of the cerebral cortex is not constrained by external perception or reality. Similar considerations, perhaps, apply to the trances induced by mescaline or hashish.

Other drugs-depressants, by and large, like opiates and barbiturates-may have the opposite effect, producing an opaque, dense inhibition of thought and movement, so that one may enter a state in which scarcely anything seems to happen, and then come to, after what seems to have been a few minutes, to find that an entire day has been consumed. Such effects resemble the action of the Retarder, a drug that Wells imagined as the opposite of the Accelerator:

The Retarder . . . should enable the patient to spread a few seconds over many hours of ordinary time, and so to maintain an apathetic inaction, a glacier-like absence of alacrity, amidst the most animated or irritating surroundings.

That there could be profound and persistent disorders of neural speed lasting for years or decades first hit me when, in 1966, I went to work in the Bronx at Beth Abraham, a hospital for chronic illness, and saw the patients whom I was later to write about in my book "Awakenings." There were dozens of these patients in the lobby and corridors, all moving at different tempos-some violently accelerated, some in slow motion, some almost glaciated. As I looked at this landscape of disordered time, memories of Wells's Accelerator and Retarder suddenly came back to me. All of these patients, I learned, were survivors of the great pandemic of encephalitis lethargica that swept the world from 1917 to 1928. Of the millions who contracted this "sleepy sickness," about a third died in the acute stages, in states of coma sleep so deep as to preclude arousal, or in states of sleeplessness so intense as to preclude sedation. Some of the survivors, though often accelerated and excited in the early days, had later developed an extreme form of parkinsonism that had slowed or even frozen them, sometimes for decades. A few of the patients at Beth Abraham continued to be accelerated, and one, Ed M., was actually accelerated on one side of his body and slowed on the other.

Dopamine, a neurotransmitter essential for the normal flow of movement and thought, is drastically reduced in ordinary Parkinson's disease, to less than fifteen per cent of normal levels. In post-encephalitic parkinsonism, dopamine levels may become almost undetectable. In ordinary Parkinson's disease, in addition to tremor or rigidity, one sees moderate slowings and speedings; in post-encephalitic parkinsonism, where the damage in the brain is usually far greater, there may be slowings and speedings to the utmost physiological and mechanical limits of the brain and body.

The very vocabulary of parkinsonism is couched in terms of speed. Neurologists have an array of terms to denote this: if movement is slowed, they talk about "bradykinesia"; if brought to a halt, "akinesia"; if excessively rapid, "tachykinesia." Similarly, one can have bradyphrenia or tachyphrenia-a slowing or accelerating of thought.

In 1969, I was able to start most of these frozen patients on the drug L-dopa, which had recently been shown to be effective in raising dopamine levels in the brain. At first, this restored a normal speed and freedom of movement to many of the patients. But then, especially in the most severely affected, it pushed them in the opposite direction. One patient, Hester Y., I observed in my journal, showed such acceleration of movement and speech after five days on L-dopa that "if she had previously resembled a slow-motion film, or a persistent film frame stuck in the projector, she now gave the impression of a speeded-up film, so much so that my colleagues, looking at a film of Mrs. Y. which I took at the time, insisted that the projector was running too fast."

I assumed, at first, that Hester and other patients realized the unusual rates at which they were moving or speaking or thinking but were simply unable to control themselves. I soon found that this was by no means the case. Nor is it the case in patients with ordinary Parkinson's disease, as William Gooddy, a neurologist in England, remarks at the beginning of his book "Time and the Nervous System." An observer may note, he says, how slowed a parkinsonian's movements are, but "the patient will say, 'My own movements . . . seem normal unless I see how long they take by looking at a clock. The clock on the wall of the ward seems to be going exceptionally fast.' "

Gooddy refers here to "personal" time, as contrasted with "clock" time, and the extent to which personal time departs from clock time may become almost unbridgeable with the extreme bradykinesia common in post-encephalitic parkinsonism. I would often see my patient Miron V. sitting in the hallway outside my office. He would appear motionless, with his right arm often lifted, sometimes an inch or two above his knee, sometimes near his face. When I questioned him about these frozen poses, he asked indignantly, "What do you mean, 'frozen poses'? I was just wiping my nose."

I wondered if he was putting me on. One morning, over a period of hours, I took a series of twenty or so photos and stapled them together to make a flick-book, like the ones I used to make to show the unfurling of fiddleheads.

With this, I could see that Miron actually *was* wiping his nose but was doing so a thousand times more slowly than normal.

Hester, too, seemed unaware of the degree to which her personal time diverged from clock time. I once asked my students to play ball with her, and they found it impossible to catch her lightning-quick throws. Hester returned the ball so rapidly that their hands, still outstretched from the throw, might be hit smartly by the returning ball. "You see how quick she is," I said. "Don't underestimate her-you'd better be ready." But they could not be ready, since their best reaction times approached a seventh of a second, whereas Hester's was scarcely more than a tenth of a second.

It was only when Miron and Hester were in normal states, neither excessively retarded nor accelerated, that they could judge how startling their speed or slowness had been, and it was sometimes necessary to show them a film or a tape to convince them.

(Disorders of spatial scale are as common in parkinsonism as disorders of time scale. An almost diagnostic sign of parkinsonism is micrographia-minute, and often diminishingly small, handwriting. Typically, patients are not aware of this at the time; it is only later, when they are back in a normal spatial frame of reference, that they are able to judge that their writing was smaller than usual. Thus there may be, for some patients, a compression of space which is comparable to the compression of time. One of my patients, a post-encephalitic woman, used to say, "My space, our space, is nothing like your space.")

With disorders of time scale, there seems almost no limit to the degree of slowing that can occur, and the speeding up of movement sometimes seems constrained only by the physical limits of articulation. If Hester tried to speak or count aloud in one of her very accelerated states, the words or numbers would clash and run into each other. Such physical limitations were less evident with thought and perception. If she was shown a perspective drawing of the Necker cube-an ambiguous drawing which normally seems to switch perspective every few seconds-she might, when slowed, see switches every minute or two (or not at all, if she was "frozen"), but when speeded up she would see the cube "flashing," changing its perspective several times a second.

Striking accelerations may also occur in Tourette's syndrome, a condition characterized by compulsions, tics, and involuntary movements and noises. Some people with Tourette's are able to catch flies on the wing. When I asked one man with Tourette's how he managed this, he said that he had no sense of moving especially fast but, rather, that to him the flies moved slowly.

If one reaches out a hand to touch or grasp something, the normal rate is about one metre per second. Normal experimental subjects, when asked to do this as quickly as possible, reach at about 4.5 metres per second. But when I asked Shane F., an artist with Tourette's, to reach as quickly as he could, he was able to achieve a rate of seven metres per second with ease, without any sacrifice of smoothness or accuracy. When I asked him to stick to normal speeds, his movements became constrained, awkward, inaccurate, and tic-filled.

Another patient with severe Tourette's and very rapid speech told me that, in addition to the tics and vocalizations I could see and hear, there were others of which-with my "slow" eyes and ears-I might be unaware. It was only with videotaping and frame-by-frame analysis that the great range of these "micro-tics" could be seen. In fact, there could be several trains of micro-tics proceeding simultaneously, apparently in complete dissociation from one another, adding up to, perhaps, dozens of micro-tics in a single second. The complexity of all this was as astonishing as its speed, and I thought that one could write an entire book, an atlas of tics, based on a mere five seconds of videotape. Such an atlas, I felt, would provide a sort of microscopy of the brain-mind, for all tics have determinants, whether inner or outer, and every patient's repertoire of tics is unique.

The blurted-out tics that may occur in Tourette's resemble what the great British neurologist John Hughlings Jackson called "emotional" or ejaculate speech (as opposed to complex, syntactically elaborate "propositional" speech). Ejaculate speech is essentially reactive, preconscious, and impulsive; it eludes the monitoring of the frontal lobes, of consciousness, and of ego, and it escapes from the mouth before it can be inhibited.

Not just the speed but the quality of movement and thought is altered in tourettism and parkinsonism. The accelerated state tends to be exuberant in invention and fancy, leaping rapidly from one association to the next, carried along by the force of its own impetus. Slowness, in contrast, tends to go with care and caution, a sober and critical stance, which has its uses no less than the "go" of effusion. This was brought out by Ivan Vaughan, a psychologist with Parkinson's disease, who wrote a memoir about his experiences ("Ivan: Living with Parkinson's Disease"; 1986). He sought to do all his writing, he told me, while he was under the influence of L-dopa, for at such times his imagination and his mental processes seemed to flow more freely and rapidly, and he had rich,

unexpected associations of every sort (though if he was too accelerated, this might impair his focus and lead him to tangents in all directions). But, when the effects of L-dopa wore off, he turned to editing, and would find himself in a perfect state to prune the sometimes too exuberant prose he had written while he was "on."

My tourettic patient Ray, while often beleaguered and bullied by his Tourette's, also managed to exploit it in various ways. The rapidity (and sometimes oddness) of his associations made him quick-witted-he spoke of his "ticcy witticisms" and his "witty ticcicisms," and referred to himself as Witty Ticcy Ray. This quickness and wittiness, when combined with his musical talents, made him a formidable improviser on the drums. He was almost unbeatable at Ping-Pong, partly because of his sheer speed of reaction, and partly because his shots, though not technically illegal, were so unpredictable (even to himself) that his opponents were flummoxed and unable to answer them.

People with extremely severe Tourette's syndrome may be our closest approximation to the sorts of speeded-up beings imagined by Von Baer and James, and people with Tourette's sometimes describe themselves as being "supercharged." "It's like having a five-hundred-horsepower engine under the hood," one of my patients says. Indeed, there are a number of world-class athletes with Tourette's-among them Jim Eisenreich and Mike Johnston, in baseball, Mahmoud Abdul-Rauf, in basketball, and Tim Howard, in soccer.

If the speed of Tourette's can be so adaptive-a neurological gift of sorts-then what is the sense of being relatively sluggish, staid, and "normal"? Why has natural selection not served to increase the number of "speeders" in our midst? The disadvantages of excessive slowness are obvious, but it may be necessary (since we sometimes think of speed as unreservedly good) to point out that excessive speed is equally freighted with problems. Tourettic or post-encephalitic speed goes with disinhibition, an impulsiveness and impetuosity that allow "inappropriate" movements and impulses to emerge precipitately. In such conditions, then, dangerous impulses such as putting a finger in a flame or darting in front of traffic, usually inhibited in the rest of us, may be released and acted on before consciousness can intervene.

And, in extreme cases, if the stream of thought is too fast, it may lose itself, break into a torrent of superficial distractions and tangents, dissolve into a brilliant incoherence, a phantasmagoric, almost dreamlike delirium. People with severe Tourette's, like Shane, may find the movements and thoughts and reactions of other people unbearably slow for them, and we "neuro-normals" may at times find the Shanes of this world disconcertingly fast. "Monkeys these people seem to us," James wrote in another context, "whilst we seem to them reptilian."

In the famous chapter in "The Principles of Psychology" on "Will," James speaks of what he calls the "perverse" or pathological will, and of its having two opposite forms: the "explosive" and the "obstructed." He used these terms in relation to psychological dispositions and temperaments, but they seem equally apposite in speaking of such physiological disorders as parkinsonism, Tourette's syndrome, and catatonia. It seems strange that James never speaks of these opposites, the "explosive" and "obstructed" wills, as having, at least sometimes, a relation with each other, for he must have seen people with what we now call manic-depressive or bipolar disorder being thrown, every few weeks or months, from one extreme to the other.

One parkinsonian friend of mine says that being in a slowed state is like being stuck in a vat of peanut butter, while being in an accelerated state is like being on ice, frictionless, slipping down an ever-steeper hill, or on a tiny planet, gravityless, with no force to hold or moor him.

Though such jammed, impacted states would seem to be at the opposite pole from accelerated, explosive ones, patients can move almost instantaneously from one to the other. The term "kinesia paradoxa" was introduced by French neurologists in the nineteen-twenties to describe these remarkable if rare transitions in post-encephalitic patients, who had scarcely moved for years but might suddenly be "released" and move with great energy and force, only to return, after a few minutes, to their previously motionless states. When Hester Y. was put on L-dopa, such alternations reached an extraordinary degree, and she was apt to make dozens of abrupt reversals a day.

Similar reversals may be seen in patients with extremely severe Tourette's syndrome, who can be brought to an almost stuporous halt by the most minute dose of certain drugs. Even without medication, states of motionless and almost hypnotic concentration tend to occur in Touretters, and these represent the other side, so to speak, of the hyperactive and distractible state.

In catatonia, there may also be dramatic, instantaneous transformations from immobile, stuporous states to wildly active, frenzied ones. The great psychiatrist Eugen Bleuler described this in 1911:

At times the peace and quiet is broken by the appearance of a catatonic raptus. Suddenly the patient springs up, smashes something, seizes someone with extraordinary power and dexterity. . . . A catatonic arouses himself from

his rigidity, runs around the streets in his nightshirt for three hours, and finally falls down and remains lying in a cataleptic state in the gutter. The movements are often executed with great strength, and nearly always involve unnecessary muscle groups. . . . They seem to have lost control of measure and power of their movements.

Catatonia is rarely seen, especially in our present, tranquillized age, but some of the fear and bewilderment inspired by the insane must have come from these sudden, unpredictable transformations.

Catatonia, parkinsonism, and Tourette's, no less than manic depression, may all be thought of as "bipolar" disorders. All of them, to use the nineteenth-century French term, are disorders *a double forme*-Janus-faced disorders, which can switch, incontinently, from one face, one form, to the other. The possibility of any neutral state, any unpolarized state, any "normality," is so reduced in such disorders that we must envisage a dumbbell- or hourglass-shaped "surface" of disease, with only a thin neck or isthmus of neutrality between the two ends.

It is common in neurology to speak of "deficits"-the knocking out of a physiological (and perhaps psychological) function by a lesion, or area of damage, in the brain. Lesions in the cortex tend to produce "simple" deficits, like loss of color vision or the ability to recognize letters or numbers. In contrast, lesions in the regulatory systems of the subcortex-which control movement, tempo, emotion, appetite, level of consciousness, etc.-undermine control and stability, so that patients lose the normal broad base of resilience, the middle ground, and may then be, like puppets, thrown almost helplessly from one extreme to another.

Doris Lessing once wrote of the situation of my post-encephalitic patients, "It makes you aware of what a knife-edge we live on," yet we do not, in health, live on a knife edge but on a broad and stable saddleback of normality. Physiologically, neural normality reflects a balance between excitatory and inhibitory systems in the brain, a balance which, in the absence of drugs or damage, has a remarkable latitude and resilience.

We, as human beings, have relatively constant and characteristic rates of movement, though some people are a bit faster, some a bit slower, and there may be variations in our levels of energy and engagement throughout the day. We are livelier, we move a little faster, we live faster when we are young; we slow down a little, at least in terms of bodily movement and reaction times, as we age. But the range of all these rates, at least in ordinary people, under normal circumstances, is quite limited. There is not that much difference in reaction times between the old and the young, or between the world's best athletes and the least athletic among us. This seems to be the case with basic mental operations, too-the maximum speed at which one can perform serial computations, recognition, visual associations, and so on. The dazzling performances of chess masters, lightning-speed calculators, musical improvisers, and other virtuosos may have less to do with basic neural speed than with the vast range of knowledge, memorized patterns and strategies, and hugely sophisticated skills they can call upon.

And yet there are those who seem to reach almost superhuman speeds of thought. Robert Oppenheimer, famously, when young physicists came to explain their ideas to him, would grasp the gist and implications of their thoughts within seconds, and interrupt them, extend their thoughts, almost as soon as they opened their mouths. Virtually everyone who heard Isaiah Berlin improvise in his torrentially rapid speech, piling image upon image, idea up on idea, building enormous mental structures which evolved and dissolved before one's eyes, felt they were privy to an astonishing mental phenomenon. And this is equally so of a comic genius like Robin Williams, whose explosive, incandescent flights of association and wit seem to take off and hurtle along at rocket-like speeds. Yet here, presumably, one is dealing not with the speeds of individual nerve cells and simple circuits but with neural networks of a much higher order, exceeding the complexity of the largest supercomputer.

Nevertheless, we humans, even the fastest among us, are limited in speed by basic neural determinants, by cells with limited rates of firing, and by limited speeds of conduction between different cells and cell groups. And if, somehow, we could accelerate ourselves a dozen or fifty times we would find ourselves wholly out of synch with the world around us, and in a situation as bizarre as that of the narrator in Wells's story.

But we can make up for the limitations of our bodies, our senses, by using instruments of various kinds. We have unlocked time, as in the seventeenth century we unlocked space, and now have at our disposal what are, in effect, temporal microscopes and temporal telescopes of prodigious power. With these, we can achieve a quadrillion-fold acceleration or retardation, so that we can watch, at leisure, by laser stroboscopy, the femtosecond-quick formation and dissolution of chemical bonds; or observe, contracted to a few minutes through computer simulation, the thirteen-billion-year history of the universe from the big bang to the present, or (at even higher temporal compression) its projected future to the end of time. Through such instrumentalities, we can enhance our perceptions, speed or slow them, in effect, to a degree infinitely beyond what any living process could match. In this way, stuck though we are in our own speed and time, we can, in imagination, enter all speeds, all time.

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