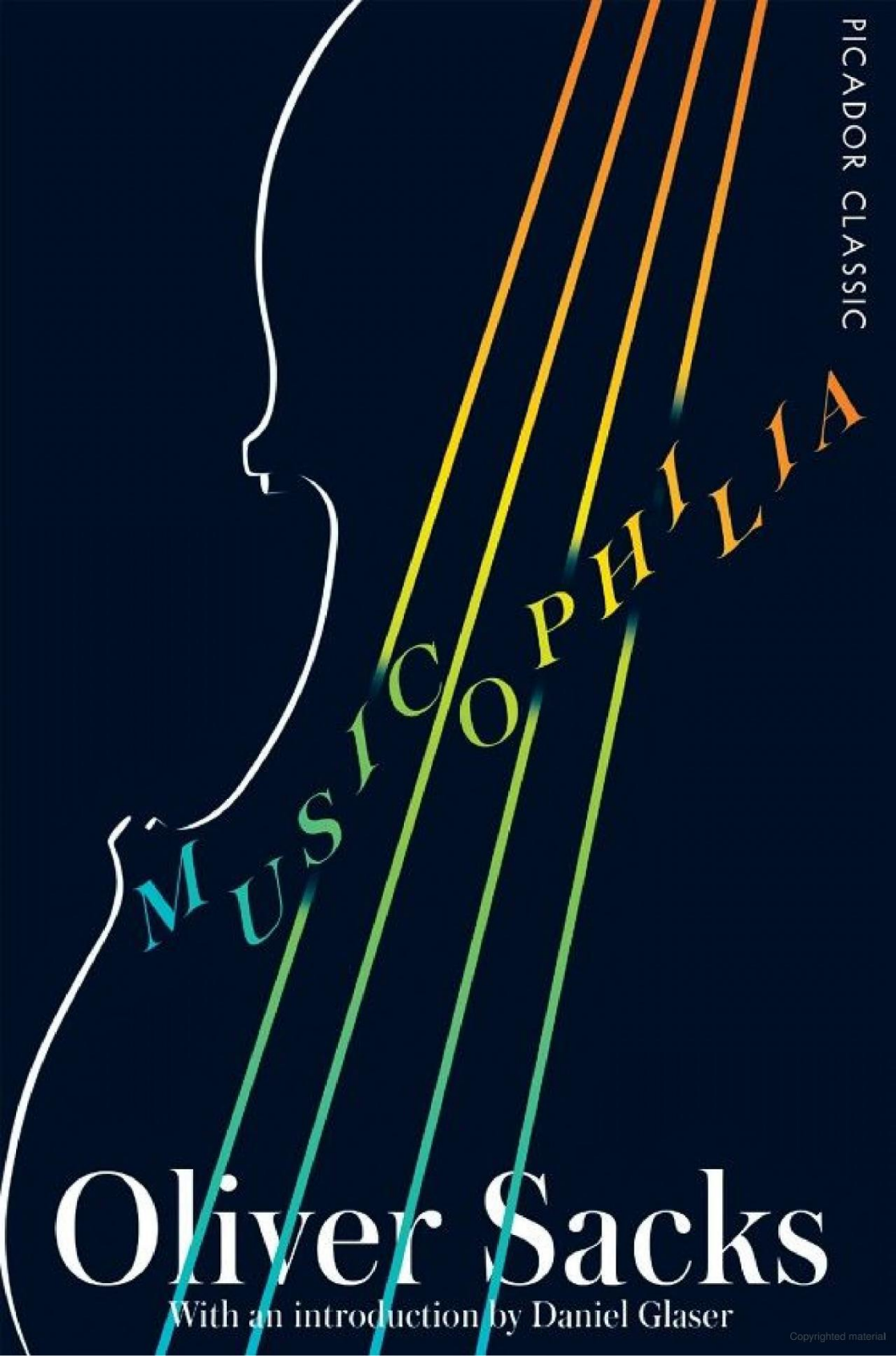

Contents

Preface

What an odd thing it is to see an entire species—billions of people—playing with, listening to, meaningless tonal patterns, occupied and preoccupied for much of their time by what they call "music." This, at least, was one of the things about human beings that puzzled the highly cerebral alien beings, the Overlords, in Arthur C. Clarke's novel *Childhood's End.* Curiosity brings them down to the Earth's surface to attend a concert, they listen politely, and at the end, congratulate the composer on his "great ingenuity"—while still finding the entire business unintelligible. They cannot think what goes on in human beings when they make or listen to music, because nothing goes on with *them.* They themselves, as a species, lack music.

We may imagine the Overlords ruminating further, back in their spaceships. This thing called "music," they would have to concede, is in some way efficacious to humans, central to human life. Yet it has no concepts, makes no propositions; it lacks images, symbols, the stuff of language. It has no power of representation. It has no necessary relation to the world.

There are rare humans who, like the Overlords, may lack the neural apparatus for appreciating tones or melodies. But for virtually all of us, music has great power, whether or not we seek it out or think of ourselves as particularly "musical."

This propensity to music—this "musicophilia"—shows itself in infancy, is manifest and central in every culture, and probably goes back to the very beginnings of our species. It may be developed or shaped by the cultures we live in, by the circumstances of life, or by the particular gifts or weaknesses we have as individuals—but it lies so deep in human nature that one is tempted to think of it as innate, much as E. O. Wilson regards "biophilia," our feeling for living things. (Perhaps musicophilia is a form of biophilia, since music itself feels almost like a living thing.)

While birdsong has obvious adaptive uses (in courtship, or aggression, or staking out territory, etc.), it is relatively fixed in structure and, to a large extent, hardwired into the avian nervous system (although there are a very few songbirds which seem to improvise, or sing duets). The origin of human music is less easy to understand. Darwin himself was evidently puzzled, as he wrote in *The Descent of Man:* "As neither the enjoyment nor the capacity of producing musical notes are faculties of the least use to man . . . they must be ranked among the most mysterious with which he is endowed." And, in our own time, Steven Pinker has referred to music as "auditory cheesecake," and asks: "What benefit could there be to diverting time and energy to making plinking noises? . . . As far as biological cause and effect are concerned, music is useless. . . . It could vanish from our species and the rest of our lifestyle would be virtually unchanged." While Pinker is very musical himself and would certainly feel his own life much impoverished by its absence, he does not believe that music, or any of the arts, are direct evolutionary adaptations. He proposes, in a 2007 article, that

> many of the arts may have no adaptive function at all. They may be by-products of two other traits: motivational systems that give us pleasure when we experience signals that correlate with adaptive outcomes (safety, sex, esteem, information-rich environments), and the technological know-how to create purified and concentrated doses of these signals.

Pinker (and others) feel that our musical powers—some of them, at least—are made possible by using, or recruiting, or co-opting brain systems that have already developed for other purposes. This might go with the fact that there is no single "music center" in the human brain, but the involvement of a dozen scattered networks throughout the brain. Stephen Jay Gould, who was the first to face the vexed question of nonadaptive changes squarely, speaks of "exaptations" in this regard, rather than adaptations—and he singles out music as a clear example as such an exaptation. (William James probably had something similar in mind when he wrote of our susceptibility to music and other aspects of "our higher aesthetic, moral and intellectual life" as having entered the mind "by the back stairs.")

Yet regardless of all this—the extent to which human musical powers and susceptibilities are hardwired or are a by-product of other powers and proclivities—music remains fundamental and central in every culture.

We humans are a musical species no less than a linguistic one. This takes many different forms. All of us (with very few exceptions) can perceive music, perceive tones, timbre, pitch intervals, melodic contours, harmony, and (perhaps most elementally) rhythm. We integrate all of these and "construct" music in our minds using many different parts of the brain. And to this largely unconscious structural

appreciation of music is added an often intense and profound emotional reaction to music. "The inexpressible depth of music," Schopenhauer wrote, "so easy to understand and yet so inexplicable, is due to the fact that it reproduces all the emotions of our innermost being, but entirely without reality and remote from its pain. . . . Music expresses only the quintessence of life and of its events, never these themselves."

Listening to music is not just auditory and emotional, it is motoric as well: "We listen to music with our muscles," as Nietzsche wrote. We keep time to music, involuntarily, even if we are not consciously attending to it, and our faces and postures mirror the "narrative" of the melody, and the thoughts and feelings it provokes.

Much that occurs during the perception of music can also occur when music is "played in the mind." The imagining of music, even in relatively nonmusical people, tends to be remarkably faithful not only to the tune and feeling of the original but to its pitch and tempo. Underlying this is the extraordinary tenacity of musical memory, so that much of what is heard during one's early years may be "engraved" on the brain for the rest of one's life. Our auditory systems, our nervous systems, are indeed exquisitely tuned for music. How much this is due to the intrinsic characteristics of music itself —its complex sonic patterns woven in time, its logic, its momentum, its unbreakable sequences, its insistent rhythms and repetitions, the mysterious way in which it embodies emotion and "will"—and how much to special resonances, synchronizations, oscillations, mutual excitations, or feedbacks in the immensely complex, multilevel neural circuitry that underlies musical perception and replay, we do

not yet know.

But this wonderful machinery—perhaps because it is so complex and highly developed—is vulnerable to various distortions, excesses, and breakdowns. The power to perceive (or imagine) music may be impaired with some brain lesions; there are many such forms of amusia. On the other hand, musical imagery may become excessive and uncontrollable, leading to incessant repetition of catchy tunes, or even musical hallucinations. In some people, music can provoke seizures. There are special neurological hazards, "disorders of skill," that may affect professional musicians. The normal association of intellectual and emotional may break down in some circumstances, so that one may perceive music accurately, but remain indifferent and unmoved by it or, conversely, be passionately moved, despite being unable to make any "sense" of what one is hearing. Some people—a surprisingly large number—"see" color or "taste" or "smell" or "feel" various sensations as they listen to music—though such synesthesia may be accounted a gift more than a symptom.

William James referred to our "susceptibility to music," and while music can affect all of us—calm us, animate us, comfort us, thrill us, or serve to organize and synchronize us at work or play—it may be especially powerful and have great therapeutic potential for patients with a variety of neurological conditions. Such people may respond powerfully and specifically to music (and, sometimes, to little else). Some of these patients have widespread cortical problems, whether from strokes or Alzheimer's or other causes of dementia; others have specific cortical syndromes—loss of language or movement functions, amnesias, or frontal-lobe syndromes.

Some are retarded, some autistic; others have subcortical syndromes such as parkinsonism or other movement disorders. All of these conditions and many others can potentially respond to music and music therapy.

FOR ME, the first incitement to think and write about music came in 1966, when I saw the profound effects of music on the deeply parkinsonian patients I later wrote about in *Awakenings.* And since then, in more ways than I could possibly imagine, I have found music continually forcing itself on my attention, showing me its effects on almost every aspect of brain function—and life.

"Music" has always been one of the first things I look up in the index of any new neurology or physiology textbook. But I could find scarcely any mention of the subject until the 1977 publication of Macdonald Critchley and R. A. Henson's book *Music and the Brain,* with its wealth of historical and clinical examples. Perhaps one reason for the scarcity of musical case histories is that physicians rarely ask their patients about mishaps of musical perception (whereas a linguistic problem, say, will immediately come to light). Another reason for this neglect is that neurologists like to explain, to find putative mechanisms, as well as to describe—and there was virtually no neuroscience of music prior to the 1980s. This has all changed in the last two decades with new technologies that allow us to see the living brain as people listen to, imagine, and even compose music. There is now an enormous and rapidly growing body of work on the neural underpinnings of musical perception and imagery, and the complex and often bizarre disorders to which these are prone. These new

insights of neuroscience are exciting beyond measure, but there is always a certain danger that the simple art of observation may be lost, that clinical description may become perfunctory, and the richness of the human context ignored.

Clearly, both approaches are necessary, blending "old-fashioned" observation and description with the latest in technology, and I have tried to incorporate both of these approaches here. But above all, I have tried to listen to my patients and subjects, to imagine and enter their experiences —it is these which form the core of this book.

Part I

Haunted by Music

I

A Bolt from the Blue: Sudden Musicophilia

Tony Cicoria was forty-two, very fit and robust, a former college football player who had become a well-regarded orthopedic surgeon in a small city in upstate New York. He was at a lakeside pavilion for a family gathering one fall afternoon. It was pleasant and breezy, but he noticed a few storm clouds in the distance; it looked like rain.

He went to a pay phone outside the pavilion to make a quick call to his mother (this was in 1994, before the age of cell phones). He still remembers every single second of what happened next: "I was talking to my mother on the phone. There was a little bit of rain, thunder in the distance. My mother hung up. The phone was a foot away from where I was standing when I got struck. I remember a flash of light coming out of the phone. It hit me in the face. Next thing I remember, I was flying backwards."

Then—he seemed to hesitate before telling me this—"I was flying forwards. Bewildered. I looked around. I saw my own body on the ground. I said to myself, 'Oh shit, I'm dead.' I saw people converging on the body. I saw a woman—she had been

standing waiting to use the phone right behind me—position herself over my body, give it CPR. . . . I floated up the stairs—my consciousness came with me. I saw my kids, had the realization that they would be okay. Then I was surrounded by a bluish-white light . . . an enormous feeling of well-being and peace. The highest and lowest points of my life raced by me. No emotion associated with these . . . pure thought, pure ecstasy. I had the perception of accelerating, being drawn up . . . there was speed and direction. Then, as I was saying to myself, 'This is the most glorious feeling I have ever had'—SLAM! I was back."

Dr. Cicoria knew he was back in his own body because he had pain—pain from the bums on his face and his left foot, where the electrical charge had entered and exited his body—and, he realized, "only bodies have pain." He wanted to go back, he wanted to tell the woman to stop giving him CPR, to let him go; but it was too late—he was firmly back among the living. After a minute or two, when he could speak, he said, "It's okay—I'm a doctor!" The woman (she turned out to be an intensive-care-unit nurse) replied, "A few minutes ago, you weren't."

The police came and wanted to call an ambulance, but Cicoria refused. They took him home instead ("it seemed to take hours"), where he called his own doctor, a cardiologist. The cardiologist, when he saw him, thought Cicoria must have had a brief cardiac arrest, but could find nothing amiss with examination or EKG. "With these things, you're alive or dead," the cardiologist remarked. He did not feel that Dr. Cicoria would suffer any further consequences of this bizarre accident.

Cicoria also consulted a neurologist—he was feeling

sluggish (most unusual for him) and having some difficulties with his memory. He found himself forgetting the names of people he knew well. He was examined neurologically, had an EEG and an MRI. Again, nothing seemed amiss.

A couple of weeks later, when his energy returned, Dr. Cicoria went back to work. There were still some lingering memory problems—he occasionally forgot the names of rare diseases or surgical procedures—but all his surgical skills were unimpaired. In another two weeks, his memory problems disappeared, and that, he thought, was the end of the matter.

What then happened still fills Cicoria with amazement, even now, a dozen years later. Life had returned to normal, seemingly, when "suddenly, over two or three days, there was this insatiable desire to listen to piano music." This was completely out of keeping with anything in his past. He had had a few piano lessons as a boy, he said, "but no real interest." He did not have a piano in his house. What music he did listen to tended to be rock music.

With this sudden onset of craving for piano music, he began to buy recordings and became especially enamored of a Vladimir Ashkenazy recording of Chopin favorites—the *Military* Polonaise, the *Winter Wind* Étude, the *Black Key* Étude, the A-flat Major Polonaise, the B-flat Minor Scherzo. "I loved them all," Cicoria said. "I had the desire to play them. I ordered all the sheet music. At this point, one of our babysitters asked if she could store her piano in our house—so now, just when I craved one, a piano arrived, a nice little upright. It suited me fine. I could hardly read the music, could barely play, but I started to teach myself." It had been more than thirty years since the few piano lessons of his boyhood,

and his fingers felt stiff and awkward.

And then, on the heels of this sudden desire for piano music, Cicoria started to hear music in his head. "The first time," he said, "it was in a dream. I was in a tux, onstage; I was playing something I had written. I woke up, startled, and the music was still in my head. I jumped out of bed, started trying to write down as much of it as I could remember. But I hardly knew how to notate what I heard." This was not surprising—he had never tried to write or notate music before. But whenever he sat down at the piano to work on the Chopin, his own music "would come and take me over. It had a very powerful presence."

I was not quite sure what to make of this peremptory music, which would intrude and overwhelm him. Was he having musical hallucinations? No, Dr. Cicoria said, they were not hallucinations—"inspiration" was a more apt word. The music was there, deep inside him—or somewhere—and all he had to do was let it come to him. "It's like a frequency, a radio band. If I open myself up, it comes. I want to say, 'It comes from heaven,' as Mozart said."

His music is ceaseless. "It never runs dry," he continued. "If anything, I have to turn it off."

Now he had to wrestle not just with learning to play the Chopin, but to give form to the music continually running in his head, trying it out on the piano, getting it on manuscript paper. "It was a terrible struggle," he said. "I would get up at four in the morning and play till I went to work, and when I got home from work I was at the piano all evening. My wife was not really pleased. I was possessed."

In the third month after being struck by lightning, then, Cicoria—once an easygoing, genial family man, almost

indifferent to music—was inspired, even possessed, by music, and scarcely had time for anything else. It began to dawn on him that perhaps he had been "saved" for a special purpose. "I came to think," he said, "that the only reason I had been allowed to survive was the music." I asked him whether he had been a religious man before the lightning. He had been raised Catholic, he said, but had never been particularly observant; he had some "unorthodox" beliefs, too, such as in reincarnation.

He himself, he grew to think, had had a sort of reincarnation, had been transformed and given a special gift, a mission, to "tune in" to the music that he called, half metaphorically, "the music from heaven." This came, often, in "an absolute torrent" of notes with no breaks, no rests, between them, and he would have to give it shape and form. (As he said this, I thought of Caedmon, the seventh-century Anglo-Saxon poet, an uneducated goatherd who, it was said, had received the "art of song" in a dream one night, and spent the rest of his life praising God and creation in hymns and poems.)

Cicoria continued to work on his piano playing and his compositions. He got books on notation, and soon realized that he needed a music teacher. He would travel to concerts by his favorite performers but had nothing to do with musical friends or musical activities in his own town. This was a solitary pursuit, between himself and his muse.

I asked whether he had experienced other changes since the lightning strike—a new appreciation of art, perhaps, different taste in reading, new beliefs? Cicoria said he had become "very spiritual" since his near-death experience. He had started to read every book he could find about near-

death experiences and about lightning strikes. And he had got "a whole library on Tesla," as well as anything on the terrible and beautiful power of high-voltage electricity. He thought he could sometimes feel "auras" of light or energy around people's bodies—he had never seen this before the lightning bolt.

Some years passed, and Cicoria's new life, his inspiration, never deserted him. He continued to work full-time as a surgeon, but his heart and mind now centered on music. He got divorced in 2004, and the same year had a fearful motorcycle accident. He had no memory of this, but his Harley was struck by another vehicle, and he was found in a ditch, unconscious and badly injured, with broken bones, a ruptured spleen, a perforated lung, cardiac contusions, and, despite his helmet, head injuries. In spite of all this, he made a complete recovery and was back at work in two months. Neither the accident nor his head injury nor his divorce seemed to have made any difference to his passion for playing and composing music.

I HAVE NEVER MET another person with a story like Tony Cicoria's, but I have occasionally had patients with a similar sudden onset of musical or artistic interests—including Salimah M., a research chemist. In her early forties, Salimah started to have brief periods, lasting a minute or less, in which she would get "a strange feeling"—sometimes a sense that she was on a beach that she had once known, while at the same time being perfectly conscious of her current surroundings and able to continue a conversation, or drive a car, or do whatever she had been doing. Occasionally these

episodes were accompanied by a "sour taste" in the mouth. She noticed these strange occurrences, but did not think of them as having any neurological significance. It was only when she had a grand mal seizure in the summer of 2003 that she went to a neurologist and was given brain scans, which revealed a large tumor in her right temporal lobe—the cause of her peculiar episodes. The tumor, her doctors felt, was malignant (though it was probably an oligodendroglioma, of relatively low malignancy) and needed to be removed. Salimah wondered if she had been given a death sentence and was fearful of the operation and its possible consequences; she and her husband had been told that it might cause some "personality changes." But in any event, the surgery went well, most of the tumor was removed, and after a period of convalescence, Salimah was able to return to her work as a chemist.

Before the surgery, she had been a fairly reserved woman who would occasionally be annoyed or preoccupied by small things like dust or untidiness; her husband said she was sometimes "obsessive" about jobs that needed to be done around the house. But now, after the surgery, Salimah seemed unperturbed by such domestic matters. She had become, in the idiosyncratic words of her husband (English was not their first language), "a happy cat." She was, he declared, "a joyologist."

Salimah's new cheerfulness was apparent at work. She had worked in the same laboratory for fifteen years and had always been admired for her intelligence and dedication. But now, while losing none of this professional competence, she seemed a much warmer person, keenly sympathetic and interested in the lives and feelings of her co-workers. Where

before, in a colleague's words, she had been "much more into herself," she now became the confidante and social center of the entire lab.

At home, too, she shed some of her Marie Curie-like, work-oriented personality. She permitted herself time off from her thinking, her equations, and became more interested in going to movies or parties, living it up a bit. And a new love, a new passion, entered her life. She had been "vaguely musical," in her own words, as a girl, had played the piano a little, but music had never played any great part in her life. Now it was different. She longed to hear music, to go to concerts, to listen to classical music on the radio or on CDs. She could be moved to rapture or tears by music which had carried "no special feeling" for her before. She became "addicted" to her car radio, which she would listen to while driving to work. A colleague who happened to pass her on the road to the lab said that the music on her radio was "incredibly loud"—he could hear it a quarter of a mile away. Salimah, in her convertible, was "entertaining the whole freeway."

Like Tony Cicoria, Salimah showed a drastic transformation from being only vaguely interested in music to being passionately excited by music and in continual need of it. And with both of them, there were other, more general changes, too—a surge of emotionality, as if emotions of every sort were being stimulated or released. In Salimah's words, "What happened after the surgery—I felt reborn. That changed my outlook on life and made me appreciate every minute of it."

COULD SOMEONE DEVELOP a "pure" musicophilia, without any accompanying changes in personality or behavior? In 2006

just such a situation was described by Rohrer, Smith, and Warren, in their striking case history of a woman in her mid-sixties who had intractable temporal lobe seizures with a right temporal lobe focus. After seven years, her seizures were finally brought under control by the anticonvulsant drug lamotrigine (LTG). Prior to starting on this medication, Rohrer and his colleagues wrote,

> she had always been indifferent to music, never listening to music for pleasure or attending concerts. This was in contrast to her husband and daughter, who played the piano and violin. . . . She was unmoved by the traditional Thai music she had heard at family and public events in Bangkok and by classical and popular genres of Western music after she moved to the United Kingdom. Indeed, she continued to avoid music where possible, and actively disliked certain musical timbres (for example, she would shut the door to avoid hearing her husband playing piano music, and found choral singing "irritating").

This indifference to music changed abruptly when the patient was put on lamotrigine:

> Within several weeks of starting LTG, a profound change was noted in her appreciation of music. She sought out musical programmes on the radio and television, listened to classical music stations on the radio for many hours each day, and demanded to attend concerts. Her husband described how she had sat "transfixed" throughout *La Traviata* and became annoyed when other audience members talked during the performance. She now described listening to classical music as an extremely pleasant and emotion-charged experience. She did not sing or whistle, and no other changes were found in her behavior or personality. No evidence of thought disorder, hallucinations, or disturbed mood was seen.

While Rohrer et al. could not pinpoint the precise basis of

their patient's musicophilia, they hazarded the suggestion that, during her years of incorrigible seizure activity, she might have developed an intensified functional connection between perceptual systems in the temporal lobes and parts of the limbic system involved in emotional response—a connection that only became apparent when her seizures were brought under control with medication. In the 1970s, David Bear suggested that such a sensory-limbic hyperconnection might be the basis for the emergence of the unexpected artistic, sexual, mystical, or religious feelings that sometimes occur in people with temporal lobe epilepsy. Could something similar have occurred with Tony Cicoria, too?

LAST SPRING, Cicoria took part in a ten-day music retreat for student musicians, gifted amateurs, and professionals. The camp doubles as a showroom for Erica vanderLinde Feidner, a concert pianist who also specializes in finding the perfect piano for each of her clients. Tony had just bought one of her pianos, a Bösendorfer grand, a unique prototype made in Vienna—she thought he had a remarkable instinct for picking out a piano with exactly the tone he wanted. It was, Cicoria felt, a good time, a good place, to make his debut as a musician.

He prepared two pieces for his concert: his first love, Chopin's B-flat Minor Scherzo; and his own first composition, which he called Rhapsody, Opus I. His playing, and his story, electrified everyone at the retreat (many expressed the fantasy that they, too, might be struck by lightning). He played, said Erica, with "great passion, great brio"—and if not with supernatural genius, at least with creditable skill, an

astounding feat for someone with virtually no musical background who had taught himself to play at forty-two.

WHAT DID I THINK, in the end, of his story, Dr. Cicoria asked me. Had I ever encountered anything similar? I asked him what *he* thought, and how he would interpret what had happened to him. He replied that as a medical man he was at a loss to explain these events, and he had to think of them in "spiritual" terms. I countered that, with no disrespect to the spiritual, I felt that even the most exalted states of mind, the most astounding transformations, must have some physical basis or at least some physiological correlate in neural activity.

At the time of his lightning strike, Dr. Cicoria had both a near-death experience and an out-of-body experience. Many supernatural or mystical explanations have arisen to explain out-of-body experiences, but they have also been a topic of neurological investigation for a century or more. Such experiences seem to be relatively stereotyped in format: one seems to be no longer in one's own body but outside it, and, most commonly, looking down on oneself from eight or nine feet above (neurologists refer to this as "autoscopy"). One seems to see clearly the room and people and objects nearby, but from an aerial perspective. People who have had such experiences often describe vestibular sensations like "floating" or "flying." Out-of-body experiences can inspire fear or joy or a feeling of detachment, but they are usually described as intensely "real"—not at all like a dream or hallucination. They have been reported in many sorts of near-death experiences, as well as in temporal lobe seizures.

There is some evidence that both the visuospatial and vestibular aspects of out-of-body experiences are related to disturbed function in the cerebral cortex, especially at the junctional region between the temporal and parietal lobes.[1]

But it was not just an out-of-body experience that Dr. Cicoria reported. He saw a bluish-white light, he saw his children, his life flashed past him, he had a sense of ecstasy, and, above all, he had a sense of something transcendental and enormously significant. What could be the neural basis of this? Similar near-death experiences have often been described by people who have been, or believed themselves to be, in great danger, whether they are involved in sudden accidents, struck by lightning, or, most commonly, revived after a cardiac arrest. All of these are situations not only fraught with terror but likely to cause a sudden drop in blood pressure and cerebral blood flow (and, if there is cardiac arrest, a deprivation of oxygen to the brain). There is likely to be intense emotional arousal and a surge of noradrenaline and other neurotransmitters in such states, whether the affect is one of terror or rapture. We have, as yet, little idea of the actual neural correlates of such experiences, but the alterations of consciousness and emotion that occur are very profound and must involve the emotional parts of the brain—the amygdala and brain-stem nuclei—as well as the cortex.[2]

While out-of-body experiences have the character of a perceptual illusion (albeit a complex and singular one), near-death experiences have all the hallmarks of mystical experience, as William James defines them—passivity, ineffability, transience, and a noetic quality. One is totally consumed by a near-death experience, swept up, almost literally, in a blaze (sometimes a tunnel or funnel) of light,

and drawn towards a Beyond—beyond life, beyond space and time. There is a sense of a last look, a (greatly accelerated) farewell to things earthly, the places and people and events of one's life, and a sense of ecstasy or joy as one soars towards one's destination—an archetypal symbolism of death and transfiguration. Experiences like this are not easily dismissed by those who have been through them, and they may sometimes lead to a conversion or metanoia, a change of mind, that alters the direction and orientation of a life. One cannot suppose, any more than one can with out-of-body experiences, that such events are pure fancy; very similar features are emphasized in every account. Near-death experiences must also have a neurological basis of their own, one which profoundly alters consciousness itself.

What about Dr. Cicoria's remarkable access of musicality, his sudden musicophilia? Patients with degeneration of the front parts of the brain, so-called frontotemporal dementia, sometimes develop a startling emergence or release of musical talents and passions as they lose the powers of abstraction and language—but clearly this was not the case with Dr. Cicoria, who was articulate and highly competent in every way. In 1984, Daniel Jacome described a patient who had had a stroke damaging the left hemisphere of his brain and consequently developed "hypermusia" and "musicophilia," along with aphasia and other problems. But there was nothing to suggest that Tony Cicoria had experienced any significant brain damage, other than a very transient disturbance to his memory systems for a week or two after the lightning strike.

His situation did remind me a bit of Franco Magnani, the "memory artist" of whom I have written.[3] Franco had never

thought of being a painter until he experienced a strange crisis or illness—perhaps a form of temporal lobe epilepsy—when he was thirty-one. He had nightly dreams of Pontito, the little Tuscan village where he was born; after he woke, these images remained intensely vivid, with a full depth and reality ("like holograms"). Franco was consumed by a need to make these images real, to paint them, and so he taught himself to paint, devoting every free minute to producing hundreds of views of Pontito.

Could Tony Cicoria's musical dreams, his musical inspirations, have been epileptic in nature? Such a question cannot be answered with a simple EEG such as Cicoria had following his accident, but would require special EEG monitoring over the course of many days.

And why was there such a delay in the development of his musicophilia? What was happening in the six or seven weeks that elapsed between his cardiac arrest and the rather sudden eruption of musicality? We know that there were temporary aftereffects—the confusional state that ensued for a few hours, and the disturbance of memory that lasted a couple of weeks. These could have been due to cerebral anoxia alone—for his brain must have been without adequate oxygen for a minute or more. One has to suspect, however, that Dr. Cicoria's apparent recovery a couple of weeks after these events was not as complete as it seemed, that there were other, unnoticed forms of brain damage, and that his brain was still reacting to the original insult and reorganizing itself during this time.

Dr. Cicoria feels that he is "a different person" now—musically, emotionally, psychologically, and spiritually. This was my impression, too, as I listened to his story and saw

something of the new passions which had transformed him. Looking at him from a neurological vantage point, I felt that his brain must be very different now from what it was before his lightning strike or in the days immediately following this, when neurological tests showed nothing grossly amiss. Could we now, a dozen years later, define these changes, define the neurological basis of his musicophilia? Many new and far subtler tests of brain function have been developed since Cicoria had his injury in 1994, and he agreed that it would be interesting to investigate this further. But after a moment, he reconsidered, and said that perhaps it was best to let things be. His was a lucky strike, and the music, however it had come, was a blessing, a grace—not to be questioned.

Postscript

Since first publishing Tony Cicoria's story, I have received many letters from people who were *not* struck by lightning and seemed to have no special physical or psychological conditions, but, often to their great surprise—in their forties or fifties or even eighties—have found themselves with sudden or unexpected creative gifts or passions, either musical or artistic.

One correspondent, Grace M., described the rather sudden onset of her own musicality at the age of fifty-five. Shortly after returning from a vacation in Israel and Jordan, she started to hear song fragments in her head. She tried to record them "by drawing lines on paper"—she did not know formal musical notation. When this did not work, she bought a tape recorder and sang into it. Now, three years later, she

has recorded more than thirty-three hundred fragments, and, arising from these, about four complete songs a month. Grace noted that while she has had popular tunes running through her head for as long as she can remember, it was only after her trip that she began hearing her own songs almost exclusively.

"I have never had any great ability in music," she wrote, "and do not have a great ear for it." Indeed, she wondered why someone like herself, apparently not too musical, should suddenly be filled with songs and song fragments. Somewhat diffidently, she has shown her songs to others, including professional musicians, and received favorable comments. "I never asked for, or expected, anything like this," she said. "I never in my life dreamed of being a song writer. . . . I had so little musical talent. I might as well have dreamed of being a supermodel."

She could not think of any physical reason for her sudden urge to write songs. "Unlike Dr. Cicoria," she wrote, "I have not been struck by lightning. I have not had any head injuries or been in any major accidents. I have never been ill enough to require hospitalization. I do not think I have temporal lobe seizures or frontotemporal dementia." She wondered, though, whether there might have been a psychological impetus, an "unlocking" of some sort, during her journey to Israel and Jordan. This was important to her as a religious person, but there were no special epiphanies or visions during her trip. (She does not believe she has a mission to share or spread her music; if anything, she is rather reticent about it. "I am not a performer or self-promoter by nature, and find this all a bit embarrassing," she wrote.)

Another correspondent, Eliza Bussey, also in her mid-

fifties, wrote:

> Four years ago, at fifty, I walked by a music store, saw a folk harp sitting in the window, and came out two hours later with a two-thousand-dollar folk harp. That moment changed my life. My total world is now arranged around music and writing about music. Four years ago I could not read a note of music, and now I am studying classical harp at the Peabody Conservatory in Baltimore. I worked three twelve-hour overnights in the newsroom, trading in medical reporting for Iraq coverage, just so I could go to school on Thursdays and Fridays. I practice two or three hours a day (would do more if I could), and I can't describe the joy and wonder I have at finding this later in life. I have felt, for example, my brain and fingers trying to connect, to form new synapses, when [my teacher] gave me Handel's Passacale to play.

"I have been interested in getting an MRI," she added. "I know that my brain has dramatically changed."

2

A Strangely Familiar Feeling: Musical Seizures

Jon S., a robust man of forty-five, had been in perfect health until January of 2006. His working week had just started; he was in the office on a Monday morning, and went to get something from the closet. Once he entered the closet, he suddenly heard music—"classical, melodic, quite nice, soothing . . . vaguely familiar. . . . It was a string instrument, a solo violin."

He immediately thought, "Where the hell is that music coming from?" There was an old, discarded electronic device in the closet, but this, though it had knobs, had no speakers. Confusedly, in a state of what he later called "suspended animation," he groped for the controls of the device to turn the music off. "Then," he says, "I went out." A colleague in the office who saw all this described Mr. S. as "slumped over, unresponsive," in the closet, though not convulsing.

Mr. S.'s next memory was of an emergency medical technician leaning over him, questioning him. He could not remember the date, but he remembered his name. He was taken to the emergency room of a local hospital, where he

had another episode. "I was lying down, the doctor was checking me over, my wife was there . . . then I started to hear music again, and I said, 'It's happening again,' and then, very quickly, I was out of it."

He woke up in another room, where he realized he had bitten his tongue and cheeks and had intense pain in his legs. "They told me I had had a seizure—the full thing, with convulsions. . . . It all occurred much quicker than the first time."

Mr. S. had some tests and was put on an antiepileptic drug to protect him against further seizures. Since then, he has had more tests (none of which showed anything amiss—a situation not uncommon with temporal lobe epilepsy). Though no demonstrable lesion showed up on brain imaging, he mentioned that he had suffered a fairly severe head injury at the age of fifteen—a concussion, at least—and this may have produced slight scarring in the temporal lobes.

When I asked him to describe the music he heard just before his seizures, he tried to sing it but could not—he said he could not sing any music, even if he knew it well. He said he was not too musical, in any case, and that the sort of classical violin music he had "heard" before his seizure was not at all to his taste; it sounded "whiny, catlike." Usually he listens to pop music. Yet it seemed *familiar* somehow—perhaps he had heard it long ago, as a child?

I told him that if he ever did hear this music—on the radio, perhaps—he should note what it was and let me know. Mr. S. said that he would keep his ears open, but as we talked about it, he could not help wondering whether there was just a *feeling,* perhaps an illusion, of familiarity attached to the music, rather than an actual recollection of something he had

once heard. There was something evocative about it, but elusive, like the music heard in dreams.

And there we left it. I wonder whether I will get a call from Mr. S. one day, saying, "I just heard it on the radio! It was a Bach sonata for unaccompanied violin," or whether what he heard was a dreamlike construction or conflation which, for all its "familiarity," he will never identify.

HUGHLINGS JACKSON, writing in the 1870s, remarked upon the feeling of familiarity that is so often a feature of the aura which may precede a temporal lobe seizure. He spoke, too, of "dreamy states," "déjà vu," and "reminiscence." Such feelings of reminiscence, Jackson noted, may have no identifiable content whatever. Although some people lose consciousness during a seizure, others may remain perfectly aware of their surroundings yet also enter an odd, superimposed state in which they experience strange moods or feelings or visions or smells—or music. Hughlings Jackson referred to this situation as a "doubling of consciousness."

Eric Markowitz, a young musician and teacher, developed in his left temporal lobe an astrocytoma, a tumor of relatively low malignancy, which was operated on in 1993. It recurred ten years later, but was then considered inoperable due to its proximity to the speech areas of the temporal lobe. With the regrowth of his tumor, he has had repeated seizures, in which he does not lose consciousness but, as he wrote to me, "music explodes in my head for about two minutes. I love music; I've made my career around it, so it seems a bit ironic that music has also become my tormentor." Eric's seizures are not triggered by music, he emphasized, but music is invariably a

part of them. As with Jon S., Eric's hallucinatory music seems very real to him, and hauntingly familiar:

> While I am unable to state exactly what song or songs I may be hearing during these aural seizures, I know they seem quite familiar to me—so familiar, in fact, that I am sometimes uncertain whether or not these songs are on a nearby stereo or in my brain. Once I become aware of that strange yet familiar confusion and realize it is in fact a seizure, I seem to try *not* to figure out what the music may be—indeed, if I could study it closely like a poem or piece of music, I would . . . but perhaps subconsciously I am afraid that if I pay too much attention to it, I may not be able to escape the song—like quicksand, or hypnosis.

Though Eric (unlike Jon S.) is quite musical, with an excellent musical memory and a highly trained ear, and though he has had more than a dozen such seizures, he is (like Mr. S.) completely unable to *recognize* his aural music.[4]

In the "strange yet familiar confusion" which is an integral part of his seizure experience, Eric finds it difficult to think straight. His wife or friends, if they are present, may notice a "strange look" on his face. If he has a seizure while at work, he is usually able to "wing it" somehow, without his students realizing that anything is amiss.

There is a fundamental difference, Eric brings out, between his normal musical imagery and that of his seizures: "As a songwriter, I'm familiar with how melody and words seem to arrive out of nowhere . . . this is *intentional,* though—I sit with my guitar in the attic and work on completion of the song. My seizures, though, are beyond all this."

He went on to say that his epileptic music—seemingly contextless and meaningless, though hauntingly familiar—

seemed to exert a frightening and almost dangerous spell on him, so that he was drawn deeper and deeper into it. And yet, he has also been so creatively stimulated by these musical auras that he has composed music inspired by them, trying to embody, or at least suggest, their mysterious and ineffable strange-but-familiar quality.

3

Fear of Music: Musicogenic Epilepsy

In 1937 Macdonald Critchley, a superb observer of unusual neurological syndromes, described eleven patients he had seen with epileptic seizures *induced* by music, as well as extending his survey to cases reported by others. He entitled his pioneer article "Musicogenic Epilepsy" (though he indicated that he preferred the shorter and sweeter term "musicolepsia").

Some of Critchley's patients were musical, some were not. The type of music that could provoke their seizures varied a good deal from patient to patient. One specified classical music, another "old-time" or "reminiscent" melodies, while a third patient found that "a well-punctuated rhythm was for her the most dangerous feature in music." One of my own correspondents had seizures only in response to "modern, dissonant music," never in response to classical or romantic music (her husband, unfortunately, was partial to modern, dissonant music). Critchley observed how some patients responded only to particular instruments or noises. One such patient reacted only to "deep notes from a brass wind instrument"; this man was a radio operator on a large ocean

liner but, continually convulsed by the sounds of its orchestra, had to transfer to a smaller ship with no orchestra. (One of my own patients with musicogenic seizures tells me that certain tones or notes can set him off. Their pitch is important: for example, a provocative G-sharp in one register may not be provocative in a higher or lower register. He is also very sensitive to timbre—a plucked guitar string is more apt to trigger a seizure than a strummed one.) Some of Critchley's patients responded only to particular melodies or songs.

The most striking case of all was that of an eminent nineteenth-century music critic, Nikonov, who had his first seizure at a performance of Meyerbeer's opera *The Prophet.* Thereafter, he became more and more sensitive to music, until finally almost any music, however soft, would send him into convulsions. ("The most noxious of all," remarked Critchley, "was the so-called 'musical' background of Wagner, which afforded an unrelieved and inescapable sound-procession.") Finally Nikonov, though so knowledgeable and passionate about music, had to relinquish his profession and avoid all contact with music. If he heard a brass band in the street, he would stop his ears and rush for the nearest doorway or side street. He developed a veritable phobia, a horror of music, and this he described in a pamphlet he titled *Fear of Music.*[5]

Critchley had also published papers, a few years earlier, on seizures induced by nonmusical sounds—usually sounds of a monotonous type, such as a kettle on the boil, an airplane in flight, or machinery in a workshop. In some cases of musicogenic epilepsy, he thought, the particular quality of sound was all-important (as with the radio operator who

could not tolerate the deep brass); but in others, the emotional impact of the music, and perhaps its associations, seemed more important.[6]

The types of seizure that might be provoked by music were quite varied, too. Some patients would have major convulsions, fall down unconscious, bite their tongues, be incontinent; others would have minor seizures, brief "absences" their friends might hardly notice. Many patients would have a complex temporal lobe type of seizure, as did one of Critchley's patients who said, "I have the feeling that I have been through it all before; as if I were going through a scene. It is the same on each occasion. People are there, dancing; I believe I am on a boat. The scene is not connected with any real place or event which I can recall."

Musicogenic epilepsy is generally considered to be very rare, but Critchley wondered if it might be notably more common than supposed.[7] Many people, he thought, might start to get a queer feeling—disturbing, perhaps frightening—when they heard certain music, but then would immediately retreat from the music, turn it off, or block their ears, so that they did not progress to a full-blown seizure. He wondered, therefore, if abortive forms—*formes frustes*—of musical epilepsy might be relatively common. (This has certainly been my own impression, and I think there may also be similar *formes frustes* of photic epilepsy, when blinking lights or fluorescent lights may produce a peculiar discomfort without inducing a full-blown seizure.)

Working in an epilepsy clinic, I have seen a number of patients with seizures induced by music, and others who have musical auras associated with seizures—and occasionally both.[8] Both types of patient are prone to temporal lobe

seizures, and most have temporal lobe abnormalities identifiable with EEG or brain imaging.

Among the patients I have seen recently is G.G., a young man who was in good health until June of 2005, when he had a severe attack of herpes encephalitis that started with a high fever and generalized seizures; this was followed by a coma and then a severe amnesia. Remarkably, a year later, his amnesic problems had virtually cleared, but he remained highly seizure-prone, with occasional grand mal seizures and, much more commonly, complex partial seizures. Initially all of these were "spontaneous," but within a few weeks they started to occur almost exclusively in response to sound —"sudden, loud sounds, like ambulance sirens"—and, especially, music. Along with this G.G. developed a remarkable sensitivity to sound, becoming able to detect sounds too soft or distant for others to hear. He enjoyed this, and felt that his auditory world was "more alive, more vivid," but wondered, too, whether it played any part in his now-epileptic sensitivity to music and sound.

G.G.'s seizures may be provoked by a large range of music, from rock to classical (the first time I saw him, he played a Verdi aria on his cell phone; after about half a minute, this induced a complex partial seizure). He speaks of "romantic" music as being the most provocative, especially Frank Sinatra's songs ("He touches a chord in me"). He says that the music has to be "full of emotions, associations, nostalgia"; it is almost always music he has known from childhood or adolescence. It does not have to be loud to provoke a seizure —soft music may be equally effective—but he is in particular trouble in a noisy, music-permeated environment, so much so that he must wear earplugs most of the time.

His seizures start with or are preceded by a special state of intense, involuntary, almost forced attention or listening. In this already altered state, the music seems to grow more intense, to swell, to take possession of him, and at this point he cannot stop the process, cannot turn off the music or walk away from it. Beyond this point he retains no consciousness or memory, though various epileptic automatisms, like gasping and lip-smacking, ensue.

For G.G., music does not just provoke a seizure; it seems to constitute an essential *part* of the seizure, spreading (one imagines) from its initial perceptual locus to other temporal lobe systems, and occasionally to the motor cortex, as when he has generalized seizures. It is as if, at such times, the provocative music is itself transformed, becoming first an overwhelming psychic experience and then a seizure.

ANOTHER PATIENT, Silvia N., came to see me towards the end of 2005. Mrs. N. had developed a seizure disorder in her early thirties. Some of her seizures were of grand mal type, with convulsions and a total loss of consciousness. Others were of a more complex type in which there would be some doubling of consciousness. Sometimes her seizures seemed to be spontaneous or a reaction to stress, but most often they occurred in response to music. One day she was found unconscious on the floor, having had a convulsion. Her last memory before this was of listening to a CD of her favorite Neapolitan songs. No significance was ascribed to this at first, but when she had a similar seizure soon afterwards, also during the playing of Neapolitan songs, she started to wonder whether there could be a connection. She tested herself,

cautiously, and found that listening to such songs, either live or on a recording, would now infallibly arouse a "peculiar" feeling, followed quickly by a seizure. No other music, though, had this effect.

She had loved the Neapolitan songs, which reminded her of her childhood. ("The old songs," she said, "they were always in the family; they always put them on.") She found them "very romantic, emotional . . . they had a meaning." But now that they triggered her seizures, she began to dread them. She became particularly apprehensive about weddings, coming as she did from a large Sicilian family, because such songs were always played at celebrations and family gatherings. "If the band started playing," Mrs. N. said, "I would run out. . . . I had half a minute or less to get away."

Though she sometimes had grand mal seizures in response to the songs, Mrs. N. more often experienced just a strange alteration of time and consciousness in which she would have a feeling of reminiscence—specifically, the feeling of being a teenager, or the reliving of scenes (some seemingly memories, others clearly fantasies) in which she was a teenager. She compared these to dreams and said she would "wake" from them as from a dream, but a dream in which she retained some consciousness, though little control. She was able, for instance, to hear what people around her were saying, but unable to respond—that doubling of consciousness which Hughlings Jackson called "mental diplopia." While most of her complex seizures referred to the past, she told me, on one occasion, "it was the future I saw. . . . I was up there, going to heaven. . . . My grandmother opened up the gates of heaven. 'It's not time,' she said—and then I came to."

Though Mrs. N. could avoid Neapolitan music most of the time, she also began to have seizures without music, and these grew more and more severe, finally becoming intractable. Medications were useless, and she sometimes had many seizures in a single day, so that daily life became virtually impossible. MRIs had shown both anatomical and electrical abnormalities in her left temporal lobe (probably from a head injury she had suffered as a teenager) and a virtually nonstop seizure focus associated with this, so early in 2003 she underwent brain surgery, a partial temporal lobectomy, to treat it.

The surgery eliminated not only the majority of her spontaneous seizures, but her highly specific vulnerability to Neapolitan songs as well, as she discovered almost by chance. "After the surgery, I was still afraid to listen to the type of song I had seizures with," she said, "but one day I was at a party, and they started to play the songs. I ran out into another room and closed the door. Then someone opened the door . . . I heard it like far away. It didn't bother me that much, so I tried to listen to it." Wondering if she was finally cured of her vulnerability to music, Mrs. N. went home ("it's safer there, you're not in front of five hundred people") and put some Neapolitan songs on her stereo. "I turned it up little by little, until it was really loud, and it didn't affect me."

So now Mrs. N. has lost her fear of music and can play her favorite Neapolitan songs without problem. She has also ceased to have her strange, complex, reminiscent seizures; it seems as though her surgery has put an end to both types of seizures—as Macdonald Critchley might have predicted.

Mrs. N. is delighted, of course, by her cure. But she is occasionally nostalgic, too, for some of her epileptic

experiences—like the "gates of heaven," which seemed to take her to a place unlike anything she had ever experienced before.

4

Music on the Brain: Imagery and Imagination

Heard melodies are sweet, but those unheard are sweeter.

—JOHN KEATS, *"Ode on a Grecian Urn"*

Music forms a significant and, on the whole, pleasant part of life for most of us—not only external music, music we hear with our ears, but internal music, music that plays in our heads. When Galton wrote on "mental imagery" in the 1880s, he concerned himself only with visual imagery and not at all with musical imagery. But a tally of one's friends will suffice to show that musical imagery has a range no less varied than the visual. There are some people who can scarcely hold a tune in their heads and others who can hear entire symphonies in their minds with a detail and vividness little short of actual perception.

I became aware of this huge variation early in life, for my parents stood at opposite ends of the spectrum. My mother had difficulty voluntarily calling any tune to mind, but my father seemed to have an entire orchestra in his head, ready to do his bidding. He always had two or three miniature

cortex, and conversely, imagining the action of playing music stimulates the auditory cortex. This, Zatorre and Halpern noted in a 2005 paper, "corresponds to reports from musicians that they can 'hear' their instrument during mental practice."

As Alvaro Pascual-Leone has observed, studies of regional cerebral blood flow

> [suggest that] mental simulation of movements activates some of the same central neural structures required for the performance of the actual movements. In so doing, mental practice alone seems to be sufficient to promote the modulation of neural circuits involved in the early stages of motor skill learning. This modulation not only results in marked improvement in performance, but also seems to place the subjects at an advantage for further skill learning with minimal physical practice. The combination of mental and physical practice [he adds] leads to greater performance improvement than does physical practice alone, a phenomenon for which our findings provide a physiological explanation.

Expectation and suggestion can greatly enhance musical imagery, even producing a quasi-perceptual experience. Jerome Bruner, a very musical friend, described to me how once, having put a favorite Mozart record on his turntable, he listened to it with great pleasure, and then went to turn it over to play the other side—only to find that he had never played it in the first place. Perhaps this is an extreme example of something we all experience occasionally with familiar music: thinking we hear music faintly when the radio has been turned off or a piece has come to an end, we wonder whether the music is still playing softly or we are simply imagining it.

Some inconclusive experiments were performed in the 1960s on what the researchers called "the 'White Christmas' effect." When the then universally known Bing Crosby version of the song was played, some subjects "heard" it when the volume was turned down to near zero, or even when the experimenters announced they would play the song but never turned it on. Physiological confirmation of such "filling in" by involuntary musical imagery has recently been obtained by William Kelley and his colleagues at Dartmouth, who used functional MRI to scan the auditory cortex while their subjects listened to familiar and unfamiliar songs in which short segments had been replaced by gaps of silence. The silent gaps embedded in familiar songs were not consciously noticed by their subjects, but the researchers observed that these gaps "induced greater activation in the auditory association areas than did silent gaps embedded in unknown songs; this was true for gaps in songs with lyrics and without lyrics."[9]

Deliberate, conscious, voluntary mental imagery involves not only auditory and motor cortex, but regions of the frontal cortex involved in choosing and planning. Such deliberate mental imagery is clearly crucial to professional musicians.[10] The rest of us frequently call upon our musical imagery, too. Nevertheless, it seems to me that most of our musical imagery is not voluntarily commanded or summoned but comes to us apparently spontaneously. Sometimes it just pops into the mind; at other times it may play there quietly for a while without our even noticing it. And though voluntary musical imagery may not be easily available to the relatively unmusical, virtually everyone has involuntary musical imagery. "Every memory of my childhood has a soundtrack to

it," one correspondent wrote to me; and she speaks for many of us here.

One sort of involuntary musical imagery is related to intense and repeated exposure to a particular piece or sort of music. I tend to fall in love with a certain composer or artist and to play their music over and over, almost exclusively, for weeks or months, until it is replaced with something else. In the past six months, I have had three such fixations, one after another. The first was on Janáček's opera *Jenufa,* after I had gone to hear a beautiful performance of this directed by Jonathan Miller; themes from *Jenufa* kept going through my mind, even entering my dreams, for two months, reinforced by my getting CDs of the opera and playing them constantly. Then I switched to a profoundly different experience after meeting Woody Geist, a patient who sang for me some of the music he performed with his a cappella jazz group, the Grunyons. This intrigued me, though I had never before been interested in this type of music; once again, I played his CD constantly, and *Jenufa* vanished from my mental concert hall, replaced by the Grunyons singing "Shooby Doin'." Most recently, I have turned to constant playing of recordings by Leon Fleisher, and his renditions of Beethoven, Chopin, Bach, Mozart, and Brahms have swept the Grunyons out of my head. If I ask what *Jenufa,* "Shooby Doin'," and Bach's Chromatic Fantasy and Fugue have in common, I would have to say nothing musically and probably nothing emotionally (beyond the pleasure they have all given me at different times). What they do share is the fact that I have bombarded my ears and brain with them, and the musical "circuits" or networks in my brain have been supersaturated, overcharged, with them. In such a supersaturated state, the

brain seems ready to replay the music with no apparent external stimulus. Such replayings, curiously, seem to be almost as satisfying as listening to the actual music, and these involuntary concerts are rarely intrusive or uncontrollable (although they have the potential to be so).

In a sense, this type of musical imagery, triggered by overexposure, is the least personal, the least significant form of "music on the mind." We are on much richer, much more mysterious terrain when we consider tunes or musical fragments we have perhaps not heard or thought of in decades, that suddenly play in the mind for no apparent reason. No recent exposure, no repetition can explain such tunes, and it is almost impossible to avoid asking oneself, "Why this tune at this particular moment? What put it into my mind?" Sometimes the reason or association is obvious, or seems so.

As I write, in New York in mid-December, the city is full of Christmas trees and menorahs. I would be inclined to say, as an old Jewish atheist, that these things mean nothing to me, but Hanukkah songs are evoked in my mind whenever an image of a menorah impinges on my retina, even when I am not consciously aware of it. There must be more emotion, more meaning here than I allow, even if it is of a mostly sentimental and nostalgic kind.

But this December is also marked by a darker melody, or train of melodies, which forms an almost constant background to my thoughts. Even when I am hardly conscious of this, it produces a feeling of pain and grief. My brother is gravely ill, and this music, plucked out from ten thousand tunes by my unconscious, is Bach's *Capriccio on the Departure of a Most Beloved Brother*.

As I was dressing this morning after a swim, I was reminded, now I was on land again, of my painful, arthritic old knees—and I thought too about my friend Nick, who would be visiting that day. With this there suddenly popped into my head an old nursery rhyme that was popular in my childhood but that I had probably not heard (or thought about) for two-thirds of a century: "This Old Man," and, in particular, its refrain: "Knick-knack, paddy whack, give a dog a bone; / This old man came rolling home." Now I myself was an old man with painful knees who wanted to be rolled home —and Nick (punned as knick-knack) had entered into it, too.

Many of our musical associations are verbal, sometimes to the point of absurdity. Eating some smoked whitefish (which I adore) earlier in this Christmas season, I heard in my mind "O Come Let Us Adore Him." Now the hymn has become associated with whitefish for me.

Often such verbal associations are subconscious and only become explicit after the fact. One correspondent wrote to me about her husband, who, though well able to remember tunes, was unable to recall the words which went with them—nevertheless, like many people, he might make unconscious verbal associations to the lyrics. "For example," she related, "we could have been saying something like, 'Gee, it's getting dark really early these days,' and, a half-minute later, he would start whistling 'The Old Lamplighter'—a fairly obscure song which he has heard just a few times in his life. . . . Obviously, the lyrics are stored in his brain and linked to the music, but are somehow only retrievable through the music without the words!"

I recently spent several hours with a composer, grilling him about his musical imagery. He finally excused himself

> for a tape to be called up for use by the thalamocortical system, the self. . . . In fact, the activity in the basal ganglia is running all the time, playing motor patterns and snippets of motor patterns amongst and between themselves—and because of the odd, re-entrant inhibitory connectivity amongst and between these nuclei, they seem to act as a continuous, random, motor pattern noise generator. Here and there, a pattern or portion of a pattern escapes, without its apparent emotional counterpart, into the context of the thalamocortical system.

"And suddenly," Llinás concludes, "you hear a song in your head or out of seemingly nowhere find yourself anxious to play tennis. Things sometimes just come to us."

Anthony Storr, a psychiatrist, writes eloquently in *Music and the Mind* of his own musical imagery and wonders "what purpose is served by music running in the head unsummoned and perhaps unwanted?" He feels that such music generally has a positive effect: "It alleviates boredom, makes . . . movements more rhythmical, and reduces fatigue." It buoys the spirits, is intrinsically rewarding. Music drawn from memory, he writes, "has many of the same effects as real music coming from the external world." It has the additional bonus of drawing attention to otherwise overlooked or repressed thoughts, and in this way may serve a function similar to that of dreams. All in all, Storr concludes, spontaneous musical imagery is basically "beneficent" and "biologically adaptive."

Our susceptibility to musical imagery indeed requires exceedingly sensitive and refined systems for perceiving and remembering music, systems far beyond anything in any nonhuman primate. These systems, it seems, are as sensitive to stimulation from internal sources—memories, emotions, associations—as to external music. A tendency to

spontaneous activity and repetition seems to be built into them in a way that has no analogue in other perceptual systems. I see my room, my furniture every day, but they do not re-present themselves as "pictures in the mind." Nor do I hear imaginary dog barks or traffic noises in the background of my mind, or smell aromas of imaginary meals cooking, even though I am exposed to such perceptions every day. I do have fragments of poetry and sudden phrases darting into my mind, but with nothing like the richness and range of my spontaneous musical imagery. Perhaps it is not just the nervous system, but music itself that has something very peculiar about it—its beat, its melodic contours, so different from those of speech, and its peculiarly direct connection to the emotions.

It really is a very odd business that all of us, to varying degrees, have music in our heads. If Arthur C. Clarke's Overlords were puzzled when they landed on Earth and observed how much energy our species puts into making and listening to music, they would have been stupefied when they realized that, even in the absence of external sources, most of us are incessantly playing music in our heads.

5

Brainworms, Sticky Music, and Catchy Tunes

Music is playing inside my head
Over and over and over again
. . . There's no end . . .

—CAROLE KING

Sometimes normal musical imagery crosses a line and becomes, so to speak, pathological, as when a certain fragment of music repeats itself incessantly, sometimes maddeningly, for days on end. These repetitions—often a short, well-defined phrase or theme of three or four bars—are apt to go on for hours or days, circling in the mind, before fading away. This endless repetition and the fact that the music in question may be irrelevant or trivial, not to one's taste, or even hateful, suggest a coercive process, that the music has entered and subverted a part of the brain, forcing it to fire repetitively and autonomously (as may happen with a tic or a seizure).

Many people are set off by the theme music of a film or television show or an advertisement. This is not coincidental,

for such music is designed, in the terms of the music industry, to "hook" the listener, to be "catchy" or "sticky," to bore its way, like an earwig, into the ear or mind; hence the term "earworms"—though one might be inclined to call them "brainworms" instead. (One newsmagazine, in 1987, defined them, half facetiously, as "cognitively infectious musical agents.")

A friend of mine, Nick Younes, described to me how he had been fixated on the song "Love and Marriage," a tune written by James Van Heusen.[11] A single hearing of this song—a Frank Sinatra rendition used as the theme song of the television show *Married . . . with Children*—was enough to hook Nick. He "got trapped inside the tempo of the song," and it ran in his mind almost constantly for ten days. With incessant repetition, it soon lost its charm, its lilt, its musicality, and its meaning. It interfered with his schoolwork, his thinking, his peace of mind, his sleep. He tried to stop it in a number of ways, all to no avail: "I jumped up and down. I counted to a hundred. I splashed water on my face. I tried talking loudly to myself, plugging my ears." Finally it faded away—but as he told me this story, it returned and went on to haunt him again for several hours.[12]

Though the term "earworm" was first used in the 1980s (as a literal translation of the German *Ohrwurm*), the concept is far from new.[13] Nicolas Slonimsky, a composer and musicologist, was deliberately inventing musical forms or phrases that could hook the mind and force it to mimicry and repetition, as early as the 1920s. And in 1876, Mark Twain wrote a short story ("A Literary Nightmare," subsequently retitled "Punch, Brothers, Punch!") in which the narrator is rendered helpless after encountering some "jingling rhymes":

> They took instant and entire possession of me. All through breakfast they went waltzing through my brain. . . . I fought hard for an hour, but it was useless. My head kept humming. . . . I drifted downtown, and presently discovered that my feet were keeping time to that relentless jingle. . . . [I] jingled all through the evening, went to bed, rolled, tossed, and jingled all night long.

Two days later, the narrator meets an old friend, a pastor, and inadvertently "infects" him with the jingle; the pastor, in turn, inadvertently infects his entire congregation.

What is happening, psychologically and neurologically, when a tune or a jingle takes possession of one like this? What are the characteristics that make a tune or a song "dangerous" or "infectious" in this way? Is it some oddity of sound, of timbre or rhythm or melody? Is it repetition? Or is it arousal of special emotional resonances or associations?

My own earliest brainworms can be reactivated by the act of thinking about them, even though they go back more than sixty years. Many of them seemed to have a very distinctive musical shape, a tonal or melodic oddness that may have played a part in imprinting them on my mind. And they had meaning and emotion, too, for they were usually Jewish songs and litanies associated with a sense of heritage and history, a feeling of family warmth and togetherness. One favorite song, sung after the meal on Seder nights, was "Had Gadya" (Aramaic for "one little goat"). This was an accumulating and repetitive song, and one that must have been sung (in its Hebrew version) many times in our Orthodox household. The additions, which became longer and longer with each verse, were sung with a mournful emphasis ending with a plaintive fourth. This little phrase of six notes in a minor key would be

this may cast light on the fundamentally different way in which the brain treats music and vision.[15] This peculiarity of music may arise in part because we have to *construct* a visual world for ourselves, and a selective and personal character therefore infuses our visual memories from the start—whereas we are given pieces of music already constructed. A visual or social scene can be constructed or reconstructed in a hundred different ways, but the recall of a musical piece has to be close to the original. We do, of course, listen selectively, with differing interpretations and emotions, but the basic musical characteristics of a piece—its tempo, its rhythm, its melodic contours, even its timbre and pitch—tend to be preserved with remarkable accuracy.

It is this fidelity—this almost defenseless engraving of music on the brain—which plays a crucial part in predisposing us to certain excesses, or pathologies, of musical imagery and memory, excesses that may even occur in relatively unmusical people.

There are, of course, inherent tendencies to repetition in music itself. Our poetry, our ballads, our songs are full of repetition. Every piece of classical music has its repeat marks or variations on a theme, and our greatest composers are masters of repetition; nursery rhymes and the little chants and songs we use to teach young children have choruses and refrains. We are attracted to repetition, even as adults; we want the stimulus and the reward again and again, and in music we get it. Perhaps, therefore, we should not be surprised, should not complain if the balance sometimes shifts too far and our musical sensitivity becomes a vulnerability.

Is it possible that earworms are, to some extent, a modern


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completely irresistible.

6

Musical Hallucinations

In December of 2002, I was consulted by Sheryl C., an intelligent and friendly woman of seventy. Mrs. C. had had progressive nerve deafness for more than fifteen years, and now had profound hearing loss on both sides. Until a few months earlier, she had managed to get by with lip-reading and the use of sophisticated hearing aids, but then her hearing had suddenly deteriorated further. Her otolaryngologist suggested a trial of prednisone. Mrs. C. took a gradually rising dose of this for a week, and during this time she felt fine. But then, she said, "on the seventh or eighth day —I was up to sixty milligrams by then—I woke up in the night with dreadful noises. Terrible, horrific, like trolley cars, bells clanging. I covered my ears, but it made no difference. It was so loud, I wanted to run out of the house." Her first thought, indeed, was that a fire engine had stopped outside the house, but when she went to the window and looked out, the street was completely empty. It was only then that she realized that the noise was in her head, that she was hallucinating for the first time in her life.

After about an hour, this clangor was replaced by music:


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damping down abnormal brain activity, whether epileptic or not.

The gabapentin, Mrs. C. reported at her next appointment, actually exacerbated her condition and had added a loud tinnitus, a ringing of the ears, to the musical hallucinations. Despite this, she was considerably reassured. She knew now that there was a physiological basis for her hallucinations, that she was not going mad, and she was learning to adapt to them.

What did upset her was when she heard fragments repeated again and again. She instanced hearing snatches of "America the Beautiful" ten times in six minutes (her husband had timed this), and parts of "O Come, All Ye Faithful" nineteen and a half times in ten minutes. On one occasion, the iterating fragment was reduced to just two notes.[18] "If I can hear a whole verse, I'm very happy," she said.

Mrs. C. was now finding that though certain tunes seemed to repeat themselves at random, suggestion and environment and context played an increasing part in stimulating or shaping her hallucinations. Thus, once as she was approaching a church, she heard a huge rendering of "O Come, All Ye Faithful" and thought at first that it was coming from the church. After baking a French apple cake, she hallucinated bits of "Frère Jacques" the next day.

There was one more medication that I felt might be worth a trial: quetiapine (Seroquel), which had been successfully used in one case to treat musical hallucinations.[19] Though we only knew of this single report, the potential side effects of quetiapine were minimal, and Mrs. C. agreed to try a small dose. But it had no clear effect.

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