CHAPTER FIVE

THE NEUROSCIENCE

Your Brain on Psychedelics

WHAT JUST HAPPENED in my brain?

A molecule had launched me on each of these trips, and I returned from my travels intensely curious to learn what the chemistry could tell me about consciousness and what that might reveal about the brain's relationship to the mind. How do you get from the ingestion of a compound created by a fungus or a toad (or a human chemist) to a novel state of consciousness with the power to change one's perspective on things, not just during the journey, but long after the molecule has left the body?

Actually, there were three different molecules in question—psilocin, LSD, and 5-MeO-DMT—but even a casual glance at their structures (and I say this as someone who earned a D in high school chemistry) indicates a resemblance. All three molecules are tryptamines. A tryptamine is a type of organic compound (an indole, to be exact) distinguished by the presence of two linked rings, one of them with six atoms and the other with five. Living nature is awash in tryptamines, which show up in plants, fungi, and animals, where they typically act as signaling molecules between cells. The most famous tryptamine in the human body is the neurotransmitter serotonin, the chemical name of which is 5-hydroxytryptamine. It is no coincidence that this molecule has a strong family resemblance with the psychedelic molecules.

Serotonin might be famous, as neurotransmitters go, yet much about it remains a mystery. For example, it binds with a dozen or so different receptors, and these are found not only across many parts of the brain but throughout the body, with a substantial representation in the digestive tract. Depending on the type of receptor in question and its location, serotonin is liable to make very different things happen—sometimes exciting a neuron to fire, other times inhibiting it. Think of it as a kind of word, the meaning or import of which can change radically depending on the context or even its placement in a sentence.

The group of tryptamines we call “the classical psychedelics” have a strong affinity with one particular type of serotonin receptor, called the 5-HT_{2A}. These receptors are found in large numbers in the human cortex, the outermost, and evolutionarily most recent, layer of the brain. Basically, the psychedelics resemble serotonin closely enough that they can attach themselves to this receptor site in such a way as to activate it to do various things.

Curiously, LSD has an even stronger affinity with the 5-HT_{2A} receptor—is “stickier”—than serotonin itself, making this an instance where the simulacrum is more convincing, chemically, than the original. This has led some scientists to speculate that the human body must produce some other, more bespoke chemical for the express purpose of activating the 5-HT_{2A} receptor—perhaps an endogenous psychedelic that is released under certain circumstances, perhaps when dreaming. One candidate for that chemical is the psychedelic molecule DMT, which has been found in trace amounts in the pineal gland of rats.

The science of serotonin and LSD has been closely intertwined since the 1950s; in fact, it was the discovery that LSD affected consciousness at such infinitesimal doses that helped to advance the new field of neurochemistry in the 1950s, leading to the development of the SSRI antidepressants. But it wasn’t until 1998 that Franz Vollenweider, a Swiss researcher who is one of the pioneers of psychedelic neuroscience, demonstrated that psychedelics like LSD and psilocybin work on the human brain by binding with the 5-HT_{2A} receptors. He did this by giving subjects a drug called ketanserin that blocks the receptor; when he then administered psilocybin, nothing happened.

Yet Vollenweider’s discovery, important as it was, is but a small step on the long (and winding) road from psychedelic chemistry to psychedelic consciousness. The 5-HT_{2A} receptor might be the lock on the door to the mind that those three molecules unlock, but how did that chemical opening lead, ultimately, to what I felt and experienced? To the dissolution of my ego, for example, and the collapse of any distinction between subject and object? Or to the morphing in my mind's eye of Mary into María Sabina? Put another way, what, if anything, can brain chemistry tell us about the "phenomenology" of the psychedelic experience?

All these questions concern the contents of consciousness, of course, which at least to this point has eluded the tools of neuroscience. By consciousness, I don't mean simply "being conscious"—the basic sensory awareness creatures have of changes in their environment, which is easy to measure experimentally. In this limited sense, even plants are "conscious," though it's doubtful they possess full-blown consciousness. What neuroscientists and philosophers and psychologists mean by consciousness is the unmistakable sense we have that we are, or possess, a self that has experiences.

Sigmund Freud wrote that "there is nothing of which we are more certain than the feeling of our self, our own ego." Yet it is difficult to be quite so certain that anyone else possesses consciousness, much less other creatures, because there is no outward physical evidence that consciousness as we experience it exists. The thing of which we are most certain is beyond the reach of our science, supposedly our surest way of knowing anything.

This dilemma has left ajar a door through which writers and philosophers have stepped. The classic thought experiment to determine whether another being is in possession of consciousness was proposed by Thomas Nagel, a philosopher, in a famous 1974 paper, "What Is It Like to Be a Bat?" He argued that if "there is something that it is like to be a bat"—if there is any subjective dimension to bat experience—then a bat possesses consciousness. He went on to suggest that this "what it is like" quality may not be reducible to material terms. Ever.

Whether or not Nagel's right about that is the biggest argument going in the field of consciousness studies. The question at its heart is often referred to as "the hard problem" or the "explanatory gap": How do you explain mind—the subjective quality of experience—in terms of meat, that is, in terms of the physical structures or chemistry of the brain? The question assumes, as most (but not all) scientists do, that consciousness is a product of brains and that it will eventually be explained as the epiphenomenon of material things like neurons and brain structures, chemicals and communications networks. That would certainly *seem* to be the most parsimonious hypothesis. Yet it is a long way from being proven, and a number of neuroscientists question whether it ever will be: whether something as elusive as subjective experience—what it feels like to be you—will *ever* yield to the reductions of science. These scientists and philosophers are sometimes called mysterians, which is not meant as a compliment. Some scientists have raised the possibility that consciousness may pervade the universe, suggesting we think of it the same way we do electromagnetism or gravity, as one of the fundamental building blocks of reality.

The idea that psychedelic drugs might shed some light on the problems of consciousness makes a certain sense. A psychedelic drug is powerful enough to disrupt the system we call normal waking consciousness in ways that may force some of its fundamental properties into view. True, anesthetics disrupt consciousness too, yet because such drugs shut it down, this kind of disturbance yields relatively little data. In contrast, someone on a psychedelic remains awake and able to report on what he or she is experiencing in real time. Nowadays, these subjective reports can be correlated with various measures of brain activity, using several different modes of imaging—tools unavailable to researchers during the first wave of psychedelic research in the 1950s and 1960s.

By deploying these technologies in combination with LSD and psilocybin, a handful of scientists working in both Europe and the United States are opening a new window onto consciousness, and what they are glimpsing through it promises to change our understanding of the links between our brains and our minds.

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PERHAPS THE MOST AMBITIOUS neuroscientific expedition using psychedelics to map the terrain of human consciousness is taking place in a laboratory at the Centre for Psychiatry on the Hammersmith campus of Imperial College in West London. Recently completed, the campus consists of a futuristic but oddly depressing network of buildings, linked by glass-walled aerial walkways and glass doors that slide open silently at the detection of the proper identification. It is here in the lab of David Nutt, a prominent English psychopharmacologist, that a team led by a thirtysomething neuroscientist named Robin Carhart-Harris has been working since 2009 to identify the "neural correlates," or physical counterparts, of the psychedelic experience. By injecting volunteers with LSD and psilocybin and then using a variety of scanning technologies—including functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG)—to observe the changes in their brains, he and his team have given us our first glimpses of what something like ego dissolution, or a hallucination, actually looks like in the brain as it unfolds in the mind.

The fact that such an improbable and potentially controversial research project ever got off the ground owes to the convergence of three most unusual characters, and careers, in England in the year 2005: David Nutt, Robin Carhart-Harris, and Amanda Feilding, a.k.a. the Countess of Wemyss and March.

Robin Carhart-Harris's path to David Nutt's psychopharmacology lab was an eccentric one, having first passed through a graduate course in psychoanalysis. These days psychoanalysis is a theory few neuroscientists take seriously, regarding it less as a science than as a set of untestable beliefs. Carhart-Harris felt strongly otherwise. Steeped in the writings of Freud and Jung, he was fascinated by psychoanalytic theory while at the same time frustrated by its lack of scientific rigor, as well as by the limitations of its tools for exploring what it deemed most important about the mind: the unconscious.

"If the only way we can access the unconscious is via dreams and free association," he explained the first time we talked, "we aren't going to get anywhere. Surely there must be something else." One day he asked his seminar professor if that something else might be a drug. (I asked Robin if his hunch was based on personal experience or research, but he made clear this was not a subject he wished to discuss.) His professor sent him to read a book called *Realms of the Human Unconscious* by Stanislav Grof.

"I went to the library and read the book cover to cover. I was blown away. That set the course for the rest of my young life."

Carhart-Harris, who is a slender, intense young man in a hurry, with a neatly trimmed beard and large pale blue eyes that seldom blink, formulated a plan it would take him a few years to put into motion: he would use psychedelic drugs and modern brain-imaging technologies to build a foundation of hard science beneath the edifice of psychoanalysis. “Freud said dreams were the royal road to the unconscious,” he reminded me. “Psychedelics could turn out to be the superhighway.” Carhart-Harris’s demeanor is modest, even humble, offering no clue to the audacity of his ambition. He likes to quote Grof’s grand claim that what the telescope was for astronomy, or the microscope for biology, psychedelics will be for understanding the mind.

Carhart-Harris completed his master’s in psychoanalysis in 2005 and began to plot his move into the neuroscience of psychedelics. He asked around and did some Internet research that eventually led him to David Nutt and Amanda Feilding as two people who might be interested in his project and in a position to help. He first approached Feilding, who in 1998 had established something called the Beckley Foundation to study the effects of psychoactive substances on the brain and to lobby for drug policy reform. The foundation is named for Beckley Park, the sprawling fourteenth-century Tudor manor where she grew up in Oxfordshire and where, in 2005, she invited Carhart-Harris to lunch. (On a recent visit of my own to Beckley, I counted two towers and three moats.)

Amanda Feilding, who was born in 1943, is an eccentric as only the English aristocracy can breed them. (She’s descended from the house of Habsburg and two of Charles II’s illegitimate children.) A student of comparative religion and mysticism, Feilding has had a long-standing interest in altered states of consciousness and, specifically, the role of blood flow to the brain, which in *Homo sapiens,* she believes, has been compromised ever since our species began standing upright. LSD, Feilding believes, enhances cognitive function and facilitates higher states of consciousness by increasing cerebral circulation. A second way to achieve a similar result is by means of the ancient practice of trepanation. This deserves a brief digression.

Trepanation involves drilling a shallow hole in the skull supposedly to improve cerebral blood circulation; in effect, it reverses the fusing of the cranial bones that happens in childhood. Trepanation was for centuries a common medical procedure, to judge by the number of ancient skulls that have turned up with neat holes in them. Convinced that trepanation would help facilitate higher states of consciousness, Feilding went looking for someone to perform the operation on her. When it became clear no professional would oblige, she trepanned herself in 1970, boring a small hole in the middle of her forehead with an electric drill. (She documented the procedure in a short but horrifying film called *Heartbeat in the Brain*.) Pleased with the results, Feilding went on to stand for election to Parliament, twice, on a platform of “Trepanation for the National Health.”

But while Amanda Feilding may be eccentric, she is by no means feckless. Her work on both drug research and drug policy reform has been serious, strategic, and productive. In recent years, her focus has shifted from trepanation to the potential of psychedelics to improve brain function. In her own life, she has used LSD as a kind of “brain tonic,” favoring a daily dose that hits “that sweet spot where creativity and enthusiasm is increased, but control is maintained.” (She told me that there was a time when she put that tonic dose at 150 micrograms—far above a microdose and enough to send most people, myself included, on a full-fledged trip. But because frequent use of LSD can lead to tolerance, it’s entirely possible that for some people 150 micrograms merely “adds a certain sparkle to consciousness.”) I found Feilding to be disarmingly frank about the baggage she brings to the new conversation about psychedelic science: “I’m a druggie. I live in this big house. And I have a hole in my head. I guess that disqualifies me.”

So, when an aspiring young scientist named Robin Carhart-Harris came for lunch at Beckley in 2005, sharing his ambition to combine research into LSD and Freud, Feilding immediately saw the potential, as well as an opportunity to put her theories about cerebral blood circulation to the test. Feilding indicated to Carhart-Harris that her foundation might be willing to fund such research and suggested that he contact David Nutt, then a professor at the University of Bristol and an ally of Feilding’s in the campaign to reform drug policy.

In his own way, David Nutt is as notorious in England as Amanda Feilding. Nutt, who is a large, jolly fellow in his sixties with a mustache and a booming laugh, achieved his particular notoriety in 2009. That’s when the home secretary fired him from the government’s Advisory Council on the Misuse of Drugs, of which he had been chair. The committee is charged with advising the government on the classification of illicit drugs based on their risk to individuals and society. Nutt, who is an expert on addiction and on the class of drugs called benzodiazepines (such as Valium), had committed the fatal political error of quantifying empirically the risks of various psychoactive substances, both legal and illegal. He had concluded from his research, and would tell anyone who asked, that alcohol was more dangerous than cannabis and that using Ecstasy was safer than riding a horse.

"But the sentence that got me sacked," he told me when we met in his office at Imperial, "was when I went on live breakfast television. I was asked, 'You're not seriously telling us that LSD is less harmful than alcohol, are you?' Of course I am!"*

Robin Carhart-Harris came to see David Nutt in 2005, hoping to study psychedelics and dreaming under him at Bristol; trying to be strategic, he mentioned the possibility of funding from Feilding. As Carhart-Harris recalls the interview, Nutt was blunt in his dismissal: "'The idea you want to do is incredibly far-fetched, you have no neuroscience experience, it's completely unrealistic.' But I told him I put all my eggs in this basket." Impressed by the young man's determination, Nutt made him an offer: "Come do a PhD with me. We'll start with something straightforward"—this turned out to be the effect of MDMA on the serotonin system—"and then maybe later on we can do psychedelics."

"Later on" came in 2009, when Carhart-Harris, armed with a PhD and working in Nutt's lab with funding from Amanda Feilding, received approval (from the National Health Service and the Home Office) to study the effect of psilocybin on the brain. (LSD would come a few years later.) Carhart-Harris put himself forward as the first volunteer. "If you're going to give this drug to people and put them in a scanner, I thought, the honest thing is to do it first to yourself." But, as he told Nutt, "I have an anxious disposition, and may not have been in the best place psychologically, so he dissuaded me; he also thought participating in the experiment might compromise my objectivity." In the end, a colleague became the first volunteer to receive an injection of psilocybin and then slide into an fMRI scanner to have his tripping brain imaged.

Carhart-Harris's working hypothesis was that their brains would exhibit increases in activity, particularly in the emotion centers. "I thought it would look like the dreaming brain," he told me. Employing a different scanning technology, Franz Vollenweider had published data indicating that psychedelics stimulated brain activity, especially in the frontal lobes. (An area responsible for executive and other higher cognitive functions.) But when the first set of data came in, Carhart-

Harris got a surprise: “We were seeing *decreases* in blood flow”—blood flow being one of the proxies for brain activity that fMRI measures. “Had we made a mistake? It was a real head-scratcher.” But the initial data on blood flow was corroborated by a second measure that looks at changes in oxygen consumption to pinpoint areas of elevated brain activity. Carhart-Harris and his colleagues had discovered that psilocybin reduces brain activity, with the falloff concentrated in one particular brain network that at the time he knew little about: the default mode network.

Carhart-Harris began reading up on it. The default mode network, or DMN, was not known to brain science until 2001. That was when Marcus Raichle, a neurologist at Washington University, described it in a landmark paper published in the *Proceedings of the National Academy of Sciences,* or *PNAS*. The network forms a critical and centrally located hub of brain activity that links parts of the cerebral cortex to deeper (and older) structures involved in memory and emotion.*

The discovery of the default mode network was actually a scientific accident, a happy by-product of the use of brain-imaging technologies in brain research.* The typical fMRI experiment begins by establishing a “resting state” baseline for neural activity as the volunteer sits quietly in the scanner awaiting whatever tests the researcher has in store. Raichle had noticed that several areas in the brain exhibited heightened activity precisely when his subjects were doing nothing mentally. This was the brain’s “default mode,” the network of brain structures that light up with activity when there are no demands on our attention and we have no mental task to perform. Put another way, Raichle had discovered the place where our minds go to wander—to daydream, ruminate, travel in time, reflect on ourselves, and worry. It may be through these very structures that the stream of our consciousness flows.

The default network stands in a kind of seesaw relationship with the attentional networks that wake up whenever the outside world demands our attention; when one is active, the other goes quiet, and vice versa. But as any person can tell you, quite a lot happens in the mind when nothing much is going on outside us. (In fact, the DMN consumes a disproportionate share of the brain’s energy.) Working at a remove from our sensory processing of the outside world, the default mode is most active when we are engaged in higher-level “metacognitive” processes such as self-reflection, mental time travel, mental constructions (such as the self or ego), moral reasoning, and "theory of mind"—the ability to attribute mental states to others, as when we try to imagine "what it is like" to be someone else. All these functions may belong exclusively to humans, and specifically to adult humans, for the default mode network isn't operational until late in a child's development.

"The brain is a hierarchical system," Carhart-Harris explained in one of our interviews. "The highest-level parts"—those developed late in our evolution, typically located in the cortex—"exert an inhibitory influence on the lower-level [and older] parts, like emotion and memory." As a whole, the default mode network exerts a top-down influence on other parts of the brain, many of which communicate with one another through its centrally located hub. Robin has described the DMN variously as the brain's "orchestra conductor," "corporate executive," or "capital city," charged with managing and "holding the whole system together." And with keeping the brain's unrulier tendencies in check.

The brain consists of several different specialized systems—one for visual processing, for example, another to control motor activity—each doing its own thing. "Chaos is averted because all systems are not created equal," Marcus Raichle has written. "Electrical signaling from some brain areas takes precedence over others. At the top of this hierarchy resides the DMN, which acts as an uber-conductor to ensure that the cacophony of competing signals from one system do not interfere with those from another." The default mode network keeps order in a system so complex it might otherwise descend into the anarchy of mental illness.

As mentioned, the default mode network appears to play a role in the creation of mental constructs or projections, the most important of which is the construct we call the self, or ego.* This is why some neuroscientists call it "the me network." If a researcher gives you a list of adjectives and asks you to consider how they apply to you, it is your default mode network that leaps into action. (It also lights up when we receive "likes" on our social media feeds.) Nodes in the default network are thought to be responsible for autobiographical memory, the material from which we compose the story of who we are, by linking our past experiences with what happens to us and with projections of our future goals.

The achievement of an individual self, a being with a unique past and a trajectory into the future, is one of the glories of human evolution, but it is not without its drawbacks and potential disorders. The price of the sense of an individual identity is a sense of separation from others and nature. Self-reflection can lead to great intellectual and artistic achievement but also to destructive forms of self-regard and many types of unhappiness. (In an often-cited paper titled "A Wandering Mind Is an Unhappy Mind," psychologists identified a strong correlation between unhappiness and time spent in mind wandering, a principal activity of the default mode network.) But, accepting the good with the bad, most of us take this self as an unshakable given, as real as anything we know, and as the foundation of our life as conscious human beings. Or at least I always took it that way, until my psychedelic experiences led me to wonder.

Perhaps the most striking discovery of Carhart-Harris's first experiment was that the steepest drops in default mode network activity correlated with his volunteers' subjective experience of "ego dissolution." ("I existed only as an idea or concept," one volunteer reported. Recalled another, "I didn't know where I ended and my surroundings began.") The more precipitous the drop-off in blood flow and oxygen consumption in the default network, the more likely a volunteer was to report the loss of a sense of self.*

Shortly after Carhart-Harris published his results in a 2012 paper in *PNAS* ("Neural Correlates of the Psychedelic State as Determined by fMRI Studies with Psilocybin"*), Judson Brewer, a researcher at Yale* who was using fMRI to study the brains of experienced meditators, noticed that his scans and Robin's looked remarkably alike. The transcendence of self reported by expert meditators showed up on fMRIs as a quieting of the default mode network. It appears that when activity in the default mode network falls off precipitously, the ego temporarily vanishes, and the usual boundaries we experience between self and world, subject and object, all melt away.

This sense of merging into some larger totality is of course one of the hallmarks of the mystical experience; our sense of individuality and separateness hinges on a bounded self and a clear demarcation between subject and object. But all that may be a mental construction, a kind of illusion—just as the Buddhists have been trying to tell us. The psychedelic experience of "non-duality" suggests that consciousness survives the disappearance of the self, that it is not so indispensable as we—and it—like to think. Carhart-Harris suspects that the loss of a clear distinction between subject and object might help explain another feature of the mystical experience: the fact that the insights it sponsors are felt to be objectively true—revealed truths rather than plain old insights. It could be that in order to judge an insight as merely subjective, one person's opinion, you must first have a sense of subjectivity. Which is precisely what the mystic on psychedelics has lost.

The mystical experience may just be what it feels like when you deactivate the brain's default mode network. This can be achieved any number of ways: through psychedelics and meditation, as Robin Carhart-Harris and Judson Brewer have demonstrated, but perhaps also by means of certain breathing exercises (like holotropic breathwork), sensory deprivation, fasting, prayer, overwhelming experiences of awe, extreme sports, near-death experiences, and so on. What would scans of brains in the midst of those activities reveal? We can only speculate, but quite possibly we would see the same quieting of the default mode network Brewer and Carhart-Harris have found. This quieting might be accomplished by restricting blood flow to the network, or by stimulating the serotonin 2A receptors in the cortex, or by otherwise disturbing the oscillatory rhythms that normally organize the brain. But however it happens, taking this particular network off-line may give us access to extraordinary states of consciousness—moments of oneness or ecstasy that are no less wondrous for having a physical cause.

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IF THE DEFAULT MODE network is the conductor of the symphony of brain activity, you would expect its temporary absence from the stage to lead to an increase in dissonance and mental disorder—as indeed appears to happen during the psychedelic journey. In a series of subsequent experiments using a variety of brain-imaging techniques, Carhart-Harris and his colleagues began to study what happens elsewhere in the neural orchestra when the default mode network puts down its baton.

Taken as a whole, the default mode network exerts an inhibitory influence on other parts of the brain, notably including the limbic regions involved in emotion and memory, in much the same way Freud conceived of the ego keeping the anarchic forces of the unconscious id in check.

(David Nutt puts the matter bluntly, claiming that in the DMN "we've found the neural correlate for repression.") Carhart-Harris hypothesizes that these and other centers of mental activity are "let off the leash" when the default mode leaves the stage, and in fact brain scans show an increase in activity (as reflected by increases in blood flow and oxygen consumption) in several other brain regions, including the limbic regions, under the influence of psychedelics. This disinhibition might explain why material that is unavailable to us during normal waking consciousness now floats to the surface of our awareness, including emotions and memories and, sometimes, long-buried childhood traumas. It is for this reason that some scientists and psychotherapists believe psychedelics can be profitably used to surface and explore the contents of the unconscious mind.

But the default mode network doesn't only exert top-down control over material arising from within; it also helps regulate what is let into consciousness from the world outside. It operates as a kind of filter (or "reducing valve") charged with admitting only that "measly trickle" of information required for us to get through the day. If not for the brain's filtering mechanisms, the torrent of information the senses make available to our brains at any given moment might prove difficult to process—as indeed is sometimes the case during the psychedelic experience. "The question," as David Nutt puts it, "is why the brain is ordinarily so constrained rather than so open?" The answer may be as simple as "efficiency." Today most neuroscientists work under a paradigm of the brain as a prediction-making machine. To form a perception of something out in the world, the brain takes in as little sensory information as it needs to make an educated guess. We are forever cutting to the chase, basically, and leaping to conclusions, relying on prior experience to inform current perception.

The mask experiment I attempted to perform during my psilocybin journey is a powerful demonstration of this phenomenon. At least when it is working normally, the brain, presented with a few visual clues suggesting it is looking at a face, insists on seeing the face as a convex structure even when it is not, because that's the way faces usually are.

The philosophical implications of "predictive coding" are deep and strange. The model suggests that our perceptions of the world offer us not a literal transcription of reality but rather a seamless illusion woven from both the data of our senses and the models in our memories. Normal waking consciousness feels perfectly transparent, and yet it is less a window on reality than the product of our imaginations—a kind of controlled hallucination. This raises a question: How is normal waking consciousness any different from other, seemingly less faithful productions of our imagination—such as dreams or psychotic delusions or psychedelic trips? In fact, all these states of consciousness are "imagined": they're mental constructs that weave together some news of the world with priors of various kinds. But in the case of normal waking consciousness, the handshake between the data of our senses and our preconceptions is especially firm. That's because it is subject to a continual process of reality testing, as when you reach out to confirm the existence of the object in your visual field or, upon waking from a nightmare, consult your memory to see if you really did show up to teach a class without any clothes on. Unlike these other states of consciousness, ordinary waking consciousness has been optimized by natural selection to best facilitate our everyday survival.

Indeed, that feeling of transparency we associate with ordinary consciousness may owe more to familiarity and habit than it does to verisimilitude. As a psychonaut acquaintance put it to me, "If it were possible to temporarily experience another person's mental state, my guess is that it would feel more like a psychedelic state than a 'normal' state, because of its massive disparity with whatever mental state is habitual with you."

Another trippy thought experiment is to try to imagine the world as it appears to a creature with an entirely different sensory apparatus and way of life. You quickly realize there is no single reality out there waiting to be faithfully and comprehensively transcribed. Our senses have evolved for a much narrower purpose and take in only what serves our needs as animals of a particular kind. The bee perceives a substantially different spectrum of light than we do; to look at the world through its eyes is to perceive ultraviolet markings on the petals of flowers (evolved to guide their landings like runway lights) that don't exist for us. That example is at least a kind of seeing—a sense we happen to share with bees. But how do we even begin to conceive of the sense that allows bees to register (through the hairs on their legs) the electromagnetic fields that plants produce? (A weak charge indicates another bee has recently visited the flower; depleted of nectar, it's probably not worth a stop.) Then there is the world according to an octopus! Imagine how differently reality presents itself to a brain that has been so radically decentralized, its intelligence distributed across eight arms so that each of them can taste, touch, and even make its own "decisions" without consulting headquarters.

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WHAT HAPPENS WHEN, under the influence of psychedelics, the usually firm handshake between brain and world breaks down? No one thing, as it turns out. I asked Carhart-Harris whether the tripping brain favors top-down predictions or bottom-up sensory data. "That's the classic dilemma," he suggested: whether the mind, unconstrained, will tend to favor its priors or the evidence of its senses. "You do often find a kind of impetuousness or overzealousness on the part of the priors, as when you see faces in the clouds." Eager to make sense of the data rushing in, the brain leaps to erroneous conclusions and, sometimes, a hallucination results. (The paranoid does much the same thing, ferociously imposing a false narrative on the stream of incoming information.) But in other cases, the reducing valve opens wide to admit lots more information, unedited and sometimes welcome.

People who are color-blind report being able to see certain colors for the first time when on psychedelics, and there is research to suggest that people hear music differently under the influence of these drugs. They process the timbre, or coloration, of music more acutely—a dimension of music that conveys emotion. When I listened to Bach's cello suite during my psilocybin journey, I was certain I heard more of it than I ever had, registering shadings and nuances and tones that I hadn't been able to hear before and haven't heard since.

Carhart-Harris thinks that psychedelics render the brain's usual handshake of perception less stable and more slippery. The tripping brain may "slip back and forth" between imposing its priors and admitting the raw evidence of its senses. He suspects that there are moments during the psychedelic experience when confidence in our usual top-down concepts of reality collapses, opening the way for more bottom-up information to get through the filter. But when all that sensory information threatens to overwhelm us, the mind furiously generates new concepts (crazy or brilliant, it hardly matters) to make sense of it all—"and so you might see faces coming out of the rain.

"That's the brain doing what the brain does"—that is, working to reduce uncertainty by, in effect, telling itself stories.

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THE HUMAN BRAIN is an inconceivably complex system—perhaps the most complex system ever to exist—in which an order has emerged, the highest expression of which is the sovereign self and our normal waking consciousness. By adulthood, the brain has gotten very good at observing and testing reality and developing reliable predictions about it that optimize our investments of energy (mental and otherwise) and therefore our chances of survival. Uncertainty is a complex brain's biggest challenge, and predictive coding evolved to help us reduce it. In general, the kind of precooked or conventionalized thinking this adaptation produces serves us well. But only up to a point.

Precisely where that point lies is a question Robin Carhart-Harris and his colleagues have explored in an ambitious and provocative paper titled "The Entropic Brain: A Theory of Conscious States Informed by Neuroimaging Research with Psychedelic Drugs," published in *Frontiers in Human Neuroscience* in 2014. Here, Carhart-Harris attempts to lay out his grand synthesis of psychoanalysis and cognitive brain science. The question at its heart is, do we pay a price for the achievement of order and selfhood in the adult human mind? The paper concludes that we do. While suppressing entropy (in this context, a synonym for uncertainty) in the brain "serves to promote realism, foresight, careful reflection and an ability to recognize and overcome wishful and paranoid fantasies," at the same time this achievement tends to "constrain cognition" and exert "a limiting or narrowing influence on consciousness."

After a series of Skype interviews, Robin Carhart-Harris and I were meeting for the first time, in his fifth-floor walk-up in an unposh section of Notting Hill, a few months after the publication of the entropy paper. In person, I was struck by Robin's youthfulness and intensity. For all his ambition, his affect is strikingly self-effacing and does little to prepare you for his willingness to venture out onto intellectual limbs that would scare off less intrepid scientists.

The entropy paper asks us to conceive of the mind as an uncertainty-reducing machine with a few serious bugs in it. The sheer complexity of the human brain and the greater number of different mental states in its repertoire (as compared with other animals) make the maintenance of order a top priority, lest the system descend into chaos.

Once upon a time, Carhart-Harris writes, the human or protohuman brain exhibited a much more anarchic form of "primary consciousness," characterized by "magical thinking"—beliefs about the world that have been shaped by wishes and fears and supernatural interpretation. (In primary consciousness, Carhart-Harris writes, "cognition is less meticulous in its sampling of the external world and is instead easily biased by emotion, e.g., wishes and anxieties.") Magical thinking is one way for human minds to reduce their uncertainty about the world, but it is less than optimal for the success of the species.

A better way to suppress uncertainty and entropy in the human brain emerged with the evolution of the default mode network, Carhart-Harris contends, a brain-regulating system that is absent or undeveloped in lower animals and young children. Along with the default mode network, "a coherent sense of self or 'ego' emerges" and, with that, the human capacity for self-reflection and reason. Magical thinking gives way to "a more reality-bound style of thinking, governed by the ego." Borrowing from Freud, he calls this more highly evolved mode of cognition "secondary consciousness." Secondary consciousness "pays deference to reality and diligently seeks to represent the world as precisely as possible" in order to minimize "surprise and uncertainty (i.e. entropy)."

The article offers an intriguing graphic depicting a "spectrum of cognitive states," ranging from high-entropy mental states to low ones. At the high-entropy end of the spectrum, he lists psychedelic states; infant consciousness; early psychosis; magical thinking; and divergent or creative thinking. At the low-entropy end of the spectrum, he lists narrow or rigid thinking; addiction; obsessive-compulsive disorder; depression; anesthesia; and, finally, coma.

Carhart-Harris suggests that the psychological "disorders" at the low-entropy end of the spectrum are not the result of a lack of order in the brain but rather stem from an *excess* of order. When the grooves of self-reflective thinking deepen and harden, the ego becomes overbearing. This is perhaps most clearly evident in depression, when the ego turns on itself and uncontrollable introspection gradually shades out reality. Carhart-Harris cites research indicating that this debilitating state of mind (sometimes called heavy self-consciousness or depressive realism) may be the result of a hyperactive default mode network, which can trap us in repetitive and destructive loops of rumination that eventually close us off from the world outside. Huxley's reducing valve contracts to zero. Carhart-Harris believes that people suffering from a whole range of disorders characterized by excessively rigid patterns of thought—including addiction, obsessions, and eating disorders as well as depression—stand to benefit from "the ability of psychedelics to disrupt stereotyped patterns of thought and behavior by disintegrating the patterns of [neural] activity upon which they rest."

So it may be that some brains could stand to have a little more entropy, not less. This is where psychedelics come in. By quieting the default mode network, these compounds can loosen the ego's grip on the machinery of the mind, "lubricating" cognition where before it had been rusted stuck. "Psychedelics alter consciousness by *disorganizing* brain activity," Carhart-Harris writes. They increase the amount of entropy in the brain, with the result that the system reverts to a less constrained mode of cognition.*

"It's not just that one system drops away," he says, "but that an older system reemerges." That older system is primary consciousness, a mode of thinking in which the ego temporarily loses its dominion and the unconscious, now unregulated, "is brought into an observable space." This, for Carhart-Harris, is the heuristic value of psychedelics to the study of the mind, though he sees therapeutic value as well.

It's worth noting that Carhart-Harris does not romanticize psychedelics and has little patience for the sort of "magical thinking" and "metaphysics" that they nourish in their acolytes—such as the idea that consciousness is "transpersonal," a property of the universe rather than the human brain. In his view, the forms of consciousness that psychedelics unleash are regressions to a "more primitive" mode of cognition. With Freud, he believes that the loss of self, and the sense of oneness, characteristic of the mystical experience—whether occasioned by chemistry or religion—return us to the psychological condition of the infant on its mother's breast, a stage when it has yet to develop a sense of itself as a separate and bounded individual. For Carhart-Harris, the pinnacle of human development is the achievement of this differentiated self, or ego, and its imposition of order on the anarchy of a primitive mind buffeted by fears and wishes and given to various forms of magical thinking. While he holds with Aldous Huxley that psychedelics throw open the doors of perception, he does not agree that everything that comes through that opening—including the "Mind at Large" that Huxley glimpsed—is necessarily real. "The psychedelic experience can yield a lot of fool's gold," he told me.

Yet Carhart-Harris also believes there is genuine gold in the psychedelic experience. When we met, he offered examples of scientists whose own experiences with LSD had supplied them with insights into the workings of the brain. Too much entropy in the human brain may lead to atavistic thinking and, at the far end, madness, yet too little can cripple us as well. The grip of an overbearing ego can enforce a rigidity in our thinking that is psychologically destructive. It may be socially and politically destructive too, in that it closes the mind to information and alternative points of view.

In one of our conversations, Robin speculated that a class of drugs with the power to overturn hierarchies in the mind and sponsor unconventional thinking has the potential to reshape users' attitudes toward authority of all kinds; that is, the compounds may have a political effect. Many believe LSD played precisely that role in the political upheaval of the 1960s.

"Was it that hippies gravitated to psychedelics, or do psychedelics create hippies? Nixon thought it was the latter. He may have been right!" Robin believes that psychedelics may also subtly shift people's attitudes toward nature, which also underwent a sea change in the 1960s. When the influence of the DMN declines, so does our sense of separateness from our environment. His team at Imperial College has tested volunteers on a standard psychological scale that measures "nature relatedness" (respondents rate their agreement with statements like "I am not separate from nature, but a part of nature"). A psychedelic experience elevated people's scores.*

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SO WHAT DOES a high-entropy brain look like? The various scanning technologies that the Imperial College lab has used to map the tripping brain show that the specialized neural networks of the brain—such as the default mode network and the visual processing system—each become disintegrated, while the brain as a whole becomes *more* integrated as new connections spring up among regions that ordinarily kept mainly to themselves or were linked only via the central hub of the DMN. Put another way, the various networks of the brain became less specialized.

"Distinct networks became less distinct under the drug," Carhart-Harris and his colleagues wrote, "implying that they communicate more openly," with other brain networks. "The brain operates with greater flexibility and interconnectedness under hallucinogens."

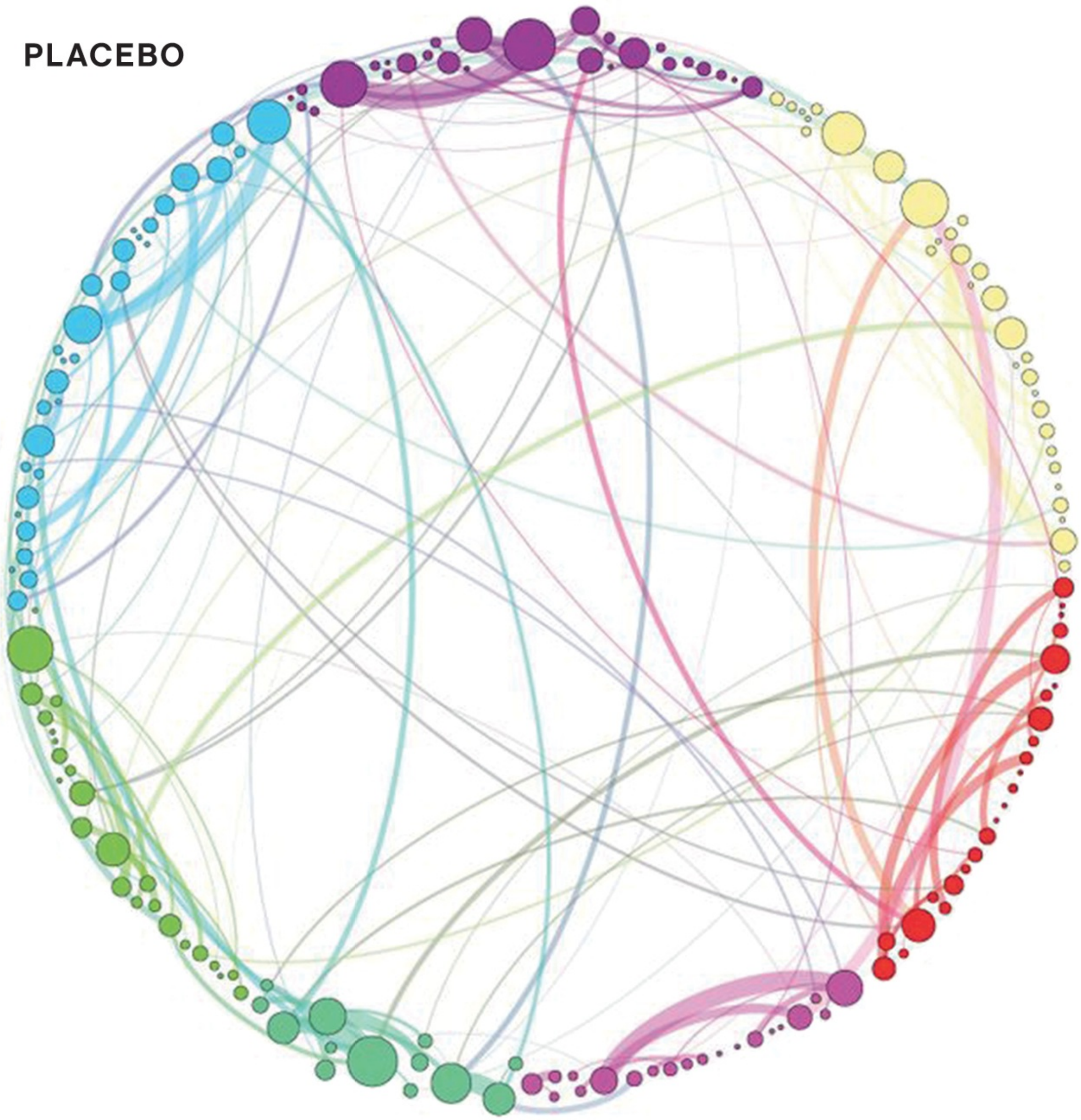
In a 2014 paper published in the *Journal of the Royal Society Interface,* the Imperial College team demonstrated how the usual lines of communications within the brain are radically reorganized when the default mode network goes off-line and the tide of entropy is allowed to rise. Using a scanning technique called magnetoencephalography, which maps electrical activity in the brain, the authors produced a map of the brain's internal communications during normal waking consciousness and after an injection of psilocybin (shown on the following pages). In its normal state, shown on the left, the brain's various networks (here depicted lining the circle, each represented by a different color) talk mostly to themselves, with a relatively few heavily trafficked pathways among them.

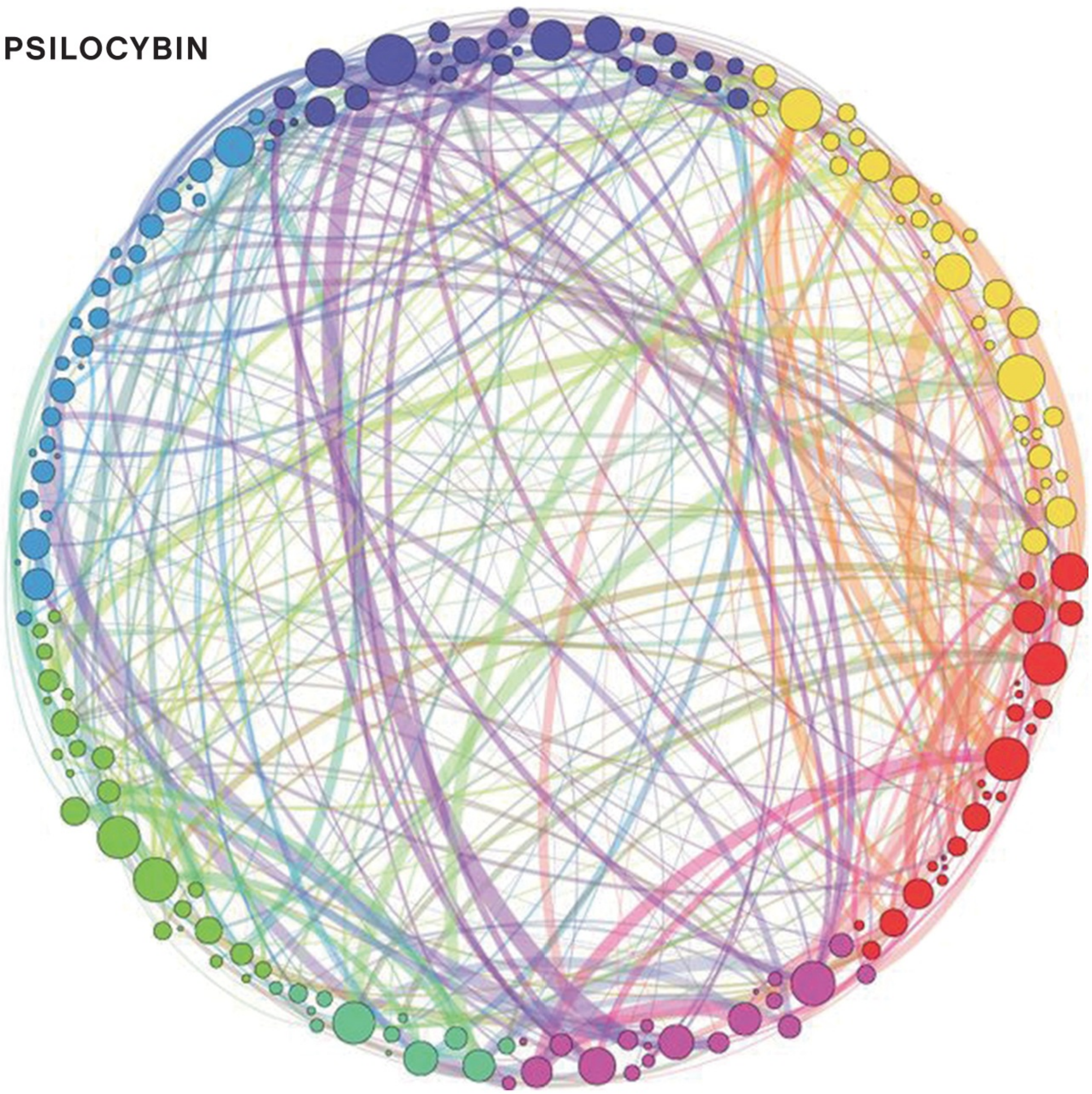
But when the brain operates under the influence of psilocybin, as shown on the right, thousands of new connections form, linking far-flung brain regions that during normal waking consciousness don't exchange much information. In effect, traffic is rerouted from a relatively small number of interstate highways onto myriad smaller roads linking a great many more destinations. The brain appears to become less specialized and more globally interconnected, with considerably more intercourse, or "cross talk," among its various neighborhoods.

There are several ways this temporary rewiring of the brain may affect mental experience. When the memory and emotion centers are allowed to communicate directly with the visual processing centers, it's possible our wishes and fears, prejudices and emotions, begin to inform what we see—a hallmark of primary consciousness and a recipe for magical thinking. Likewise, the establishment of new linkages across brain systems can give rise to synesthesia, as when sense information gets cross-wired so that colors become sounds or sounds become tactile. Or the new links give rise to hallucination, as when the contents of my memory transformed my visual perception of Mary into María Sabina, or the image of my face in the mirror into a vision of my grandfather. The forming of still other kinds of novel connections could manifest in mental experience as a new idea, a fresh perspective, a creative insight, or the ascribing of new meanings to familiar things—or any number of the bizarre mental phenomena people on psychedelics report. The increase in entropy allows a thousand mental states to bloom, many of them bizarre and senseless, but some number of them revelatory, imaginative, and, at least potentially, transformative.

One way to think about this blooming of mental states is that it temporarily boosts the sheer amount of diversity in our mental life. If problem solving is anything like evolutionary adaptation, the more possibilities the mind has at its disposal, the more creative its solutions will be. In this sense, entropy in the brain is a bit like variation in evolution: it supplies the diversity of raw materials on which selection can then operate to solve problems and bring novelty into the world. If, as so many artists and scientists have testified, the psychedelic experience is an aid to creativity—to thinking “outside the box”—this model might help explain why that is the case. Maybe the problem with “the box” is that it is singular.

PLACEBO





A key question that the science of psychedelics has not even begun to answer is whether the new neural connections that psychedelics make possible endure in any way, or if the brain's wiring returns to the status quo ante once the drug wears off. The finding by Roland Griffiths's lab that the psychedelic experience leads to long-term changes in the personality trait of openness raises the possibility that some kind of learning takes place while the brain is rewired and that it might in some way persist. Learning entails the establishment of new neural circuits;

these get stronger the more exercise they get. The long-term fate of the novel connections formed during the psychedelic experience—whether they prove durable or evanescent—might depend on whether we recall and, in effect, exercise them after the experience ends. (This could be as simple as recollecting what we experienced, reinforcing it during the integration process, or using meditation to reenact the altered state of consciousness.) Franz Vollenweider has suggested that the psychedelic experience may facilitate "neuroplasticity": it opens a window in which patterns of thought and behavior become more plastic and so easier to change. His model sounds like a chemically mediated form of cognitive behavioral therapy. But so far this is all highly speculative; as yet there has been little mapping of the brain before and after psychedelics to determine what, if anything, the experience changes in a lasting way.

Carhart-Harris argues in the entropy paper that even a temporary rewiring of the brain is potentially valuable, especially for people suffering from disorders characterized by mental rigidity. A high-dose psychedelic experience has the power to "shake the snow globe," he says, disrupting unhealthy patterns of thought and creating a space of flexibility—entropy—in which more salubrious patterns and narratives have an opportunity to coalesce as the snow slowly resettles.

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THE IDEA that increasing the amount of entropy in the human brain might actually be good for us is surely counterintuitive. Most of us bring a negative connotation to the term: entropy suggests the gradual deterioration of a hard-won order, the disintegration of a system over time. Certainly getting older *feels* like an entropic process—a gradual running down and disordering of the mind and body. But maybe that's the wrong way to think about it. Robin Carhart-Harris's paper got me wondering if, at least for the mind, aging is really a process of *declining* entropy, the fading over time of what we should regard as a positive attribute of mental life.

Certainly by middle age, the sway of habitual thinking over the operations of the mind is nearly absolute. By now, I can count on past experience to propose quick and usually serviceable answers to just about any question reality poses, whether it's about how to soothe a child or mollify a spouse, repair a sentence, accept a compliment, answer the next question, or make sense of whatever's happening in the world. With experience and time, it gets easier to cut to the chase and leap to conclusions—clichés that imply a kind of agility but that in fact may signify precisely the opposite: a petrifaction of thought. Think of it as predictive coding on the scale of life; the priors—and by now I've got millions of them—usually have my back, can be relied on to give me a decent enough answer, even if it isn't a particularly fresh or imaginative one. A flattering term for this regime of good enough predictions is "wisdom."

Reading Robin's paper helped me better understand what I was looking for when I decided to explore psychedelics: to give my own snow globe a vigorous shaking, see if I could renovate my everyday mental life by introducing a greater measure of entropy, and uncertainty, into it. Getting older might render the world more predictable (in every sense), yet it also lightens the burden of responsibility, creating a new space for experiment. Mine had been to see if it wasn't too late to skip out of some of the deeper grooves of habit that the been-theres and done-thats of long experience had inscribed on my mind.

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IN BOTH PHYSICS and information theory, entropy is often associated with expansion—as in the expansion of a gas when it is heated or freed from the constraints of a container. As the gas's molecules diffuse in space, it becomes harder to predict the location of any given one; the uncertainty of the system thus increases. In a throwaway line at the end of his entropy paper, Carhart-Harris reminds us that in the 1960s the psychedelic experience was usually described as "consciousness-expansion"; knowingly or not, Timothy Leary and his colleagues had hit on exactly the right metaphor for the entropic brain. This expansion metaphor also chimes with Huxley's reducing valve, implying as it does that consciousness exists in a state of opening or contraction.

As a matter of experience, a quality as abstract as entropy is almost impossible for us to perceive, but expansion, perhaps, is not. Judson

Brewer, the neuroscientist who studies meditation, has found that a felt sense of expansion in consciousness correlates with a drop in activity in one particular node of the default mode network—the posterior cingulate cortex (PCC), which is associated with self-referential processing. One of the most interesting things about a psychedelic experience is that it sharpens one's sensitivity to one's own mental states, especially in the days immediately following. The usual seamlessness of consciousness is disturbed in such a way as to make any given state—mind wandering, focused attention, rumination—both more salient and somewhat easier to manipulate. In the wake of my psychedelic experiences (and, perhaps, in the wake of interviewing Judson Brewer), I found that when I put my mind to it, I could locate my own state of consciousness on a spectrum ranging from contraction to expansion.

When, for example, I'm feeling especially generous or grateful, open to feelings and people and nature, I register a sense of expansion. This feeling is often accompanied by a diminution of ego, as well as a falloff in the attention paid to past and future on which the ego feasts. (And depends.) By the same token, there is a pronounced sense of contraction when I'm obsessing about things or feeling fearful, defensive, rushed, worried, and regretful. (These last two feelings don't exist without time travel.) At such times, I feel altogether more *me,* and not in a good way. If the neuroscientists are right, what I'm observing in my mind has a physical correlate in the brain: the default mode network is either online or off; entropy is either high or low. What exactly *to do* with this information I'm not yet sure.

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BY NOW, it may be lost to memory, but all of us, even the psychedelically naive, have had direct personal experience of an entropic brain and the novel type of consciousness it sponsors—as a young child. Baby consciousness is so different from adult consciousness as to constitute a mental country of its own, one from which we are expelled sometime early in adolescence. Is there a way back in? The closest we can come to visiting that foreign land as adults may be during the psychedelic journey. This at least is the startling hypothesis of Alison Gopnik, a developmental psychologist and philosopher who happens to be a colleague of mine at Berkeley.

Alison Gopnik and Robin Carhart-Harris come at the problem of consciousness from what seem like completely different directions and disciplines, but soon after they learned of each other's work (I had e-mailed a PDF of Robin's entropy paper to Alison and told him about her superb book, *The Philosophical Baby*), they struck up a conversation that has proven to be remarkably illuminating, at least for me. In April 2016, their conversation wound up on a stage at a conference on consciousness in Tucson, Arizona, where the two met for the first time and shared a panel.*

In much the same way psychedelics have given Carhart-Harris an oblique angle from which to approach the phenomena of normal consciousness by exploring an altered state of it, Gopnik proposes we regard the mind of the young child as another kind of "altered state," and in a number of respects it is a strikingly similar one. She cautions that our thinking about the subject is usually constrained by our own restricted experience of consciousness, which we naturally take to be the whole of it. In this case, most of the theories and generalizations about consciousness have been made by people who share a fairly limited subtype of it she calls "professor consciousness," which she defines as "the phenomenology of your average middle-aged professor."

"As academics, either we're incredibly focused on a particular problem," Gopnik told the audience of philosophers and neuroscientists in Tucson, "or we're sitting there saying to ourselves, 'Why can't I focus on this problem I'm supposed to be focused on, and why instead am I daydreaming?'" Gopnik herself looks the part of a Berkeley professor in her early sixties, with her colorful scarves, flowing skirts, and sensible shoes. A child of the 1960s who is now a grandmother, she has a speaking style that is at once lighthearted and learned, studded with references indicating a mind as much at home in the humanities as the sciences.

"If you thought, as people often have thought, that this was all there was to consciousness . . . you might very well find yourself thinking that young children were actually less conscious than we were," because both focused attention and self-reflection are absent in young children. Gopnik asks us to think about child consciousness in terms of not what's missing from it or undeveloped but rather what is uniquely and wonderfully present—qualities that she believes psychedelics can help us to better appreciate and, possibly, reexperience.

In *The Philosophical Baby,* Gopnik draws a useful distinction between the "spotlight consciousness" of adults and the "lantern consciousness" of young children. The first mode gives adults the ability to narrowly focus attention on a goal. (In his own remarks, Carhart-Harris called this "ego consciousness" or "consciousness with a point.") In the second mode—lantern consciousness—attention is more widely diffused, allowing the child to take in information from virtually anywhere in her field of awareness, which is quite wide, wider than that of most adults. (By this measure, children are more conscious than adults, rather than less.) While children seldom exhibit sustained periods of spotlight consciousness, adults occasionally experience that "vivid panoramic illumination of the everyday" that lantern consciousness affords us. To borrow Judson Brewer's terms, lantern consciousness is expansive, spotlight consciousness narrow, or contracted.

The adult brain directs the spotlight of its attention where it will and then relies on predictive coding to make sense of what it perceives. This is not at all the child's approach, Gopnik has discovered. Being inexperienced in the way of the world, the mind of the young child has comparatively few priors, or preconceptions, to guide her perceptions down the predictable tracks. Instead, the child approaches reality with the astonishment of an adult on psychedelics.

What this means for cognition and learning can be best understood by looking at machine learning, or artificial intelligence, Gopnik suggests. In teaching computers how to learn and solve problems, AI designers speak in terms of "high temperature" and "low temperature" searches for the answers to questions. A low-temperature search (so-called because it requires less energy) involves reaching for the most probable or nearest-to-hand answer, like the one that worked for a similar problem in the past. Low-temperature searches succeed more often than not. A high-temperature search requires more energy because it involves reaching for less likely but possibly more ingenious and creative answers—those found outside the box of preconception. Drawing on its wealth of experience, the adult mind performs low-temperature searches most of the time.

Gopnik believes that both the young child (five and under) and the adult on a psychedelic have a stronger predilection for the high-temperature search; in their quest to make sense of things, their minds explore not just the nearby and most likely but "the entire space of possibilities." These high-temperature searches might be inefficient, incurring a higher rate of error and requiring more time and mental energy to perform. High-temperature searches can yield answers that are more magical than realistic. Yet there are times when hot searches are the only way to solve a problem, and occasionally they return answers of surpassing beauty and originality. $E=mc^2$ was the product of a high-temperature search.

Gopnik has tested this hypothesis on children in her lab and has found that there are learning problems that four-year-olds are better at solving than adults. These are precisely the kinds of problems that require thinking outside the box, those times when experience hobbles rather than greases the gears of problem solving, often because the problem is so novel. In one experiment, she presented children with a toy box that lights up and plays music when a certain kind of block is placed on top of it. Normally, this "blicket detector" is set to respond to a single block of a certain color or shape, but when the experimenter reprograms the machine so that it responds only when *two* blocks are placed on it, four-year-olds figure it out much faster than adults do.

"Their thinking is less constrained by experience, so they will try even the most unlikely possibilities"; that is, they'll conduct lots of high-temperature searches, testing the most far-out hypotheses. "Children are better learners than adults in many cases when the solutions are nonobvious" or, as she puts it, "further out in the space of possibilities," a realm where they are more at home than we are. Far out, indeed.

"We have the longest childhood of any species," Gopnik says. "This extended period of learning and exploration is what's distinctive about us. I think of childhood as the R&D stage of the species, concerned exclusively with learning and exploring. We adults are production and marketing." Later I asked her if she meant to say that children perform R&D for the individual, not the species, but in fact she meant exactly what she said.

"Each generation of children confronts a new environment," she explained, "and their brains are particularly good at learning and thriving in that environment. Think of the children of immigrants, or four-year-olds confronted with an iPhone. Children don't invent these new tools, they don’t create the new environment, but in every generation they build the kind of brain that can best thrive in it. Childhood is the species’ ways of injecting noise into the system of cultural evolution.” “Noise,” of course, is in this context another word for “entropy.”

“The child’s brain is extremely plastic, good for learning, not accomplishing”—better for “exploring rather than exploiting.” It also has a great many more neural connections than the adult brain. (During the panel, Carhart-Harris showed his map of the mind on psilocybin, with its dense forest of lines connecting every region to every other.) But as we reach adolescence, most of those connections get pruned, so that the “human brain becomes a lean, mean acting machine.” A key element of that developmental process is the suppression of entropy, with all of its implications, both good and bad. The system cools, and hot searches become the exception rather than the rule. The default mode network comes online.

“Consciousness narrows as we get older,” Gopnik says. “Adults have congealed in their beliefs and are hard to shift,” she has written, whereas “children are more fluid and consequently more willing to entertain new ideas.

“If you want to understand what an expanded consciousness looks like, all you have to do is have tea with a four-year-old.”

Or drop a tab of LSD. Gopnik told me she has been struck by the similarities between the phenomenology of the LSD experience and her understanding of the consciousness of children: hotter searches, diffused attention, more mental noise (or entropy), magical thinking, and little sense of a self that is continuous over time.

“The short summary is, babies and children are basically tripping all the time.”

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SURELY THIS INSIGHT is interesting, but is it useful? Both Gopnik and Carhart-Harris believe it is, believe that the psychedelic experience, as they conceptualize it, has the potential to help people who are sick and people who are not. For the well, psychedelics, by introducing more noise or entropy into the brain, might shake people out of their usual patterns of thought—"lubricate cognition," in Carhart-Harris's words—in ways that might enhance well-being, make us more open and boost creativity. In Gopnik's terms, the drugs could help adults achieve the kind of fluid thinking that is second nature to kids, expanding the space of creative possibility. If, as Gopnik hypothesizes, "childhood is a way of injecting noise—and novelty—into the system of cultural evolution," psychedelics might do the same thing for the system of the adult mind.

As for the unwell, the patients who stand to gain the most are probably those suffering from the kinds of mental disorders characterized by mental rigidity: addiction, depression, obsession.

"There are a range of difficulties and pathologies in adults, like depression, that are connected with the phenomenology of rumination and an excessively narrow, ego-based focus," Gopnik says. "You get stuck on the same thing, you can't escape, you become obsessive, perhaps addicted. It seems plausible to me that the psychedelic experience could help us get out of those states, create an opportunity in which the old stories of who we are might be rewritten." The experience could work as a kind of reset—as when you "introduce a burst of noise into a system" that has gotten locked into a rigid pattern. Quieting the default mode network and loosening the grip of the ego—which she suggests may be illusory anyway—might also be helpful to such people. Gopnik's idea of a brain reboot sounded very much like Carhart-Harris's notion of shaking the snow globe: a way to boost entropy, or heat, in a system that has gotten frozen stuck.

Soon after publishing his entropy paper, Carhart-Harris resolved to put some of his theories into practice by testing them on patients. For the first time, the lab expanded its focus from pure research to a clinical application of that work. David Nutt secured a grant from the U.K. government for the lab to conduct a small pilot study looking at the potential of psilocybin to relieve the symptoms of "treatment-resistant depression"—patients who hadn't responded to the usual therapeutic protocols and drugs.

Doing clinical work was definitely outside Carhart-Harris's experience and comfort zone, as well as the lab's. One unfortunate early episode pointed up the inherent tensions between the roles of the clinician, devoted solely to the patient's welfare, and the scientist, intent on gathering data as well. After being injected with LSD in a trial Carhart-

Harris was running (not a clinical trial, it should be pointed out), a volunteer in his late thirties named Toby Slater began feeling anxious in the fMRI scanner and asked to get out. After taking a break, Slater, perhaps hoping to please the researchers, volunteered to get back in the machine so they could complete the experiment. ("I'm afraid he could see my disappointment," Carhart-Harris recalls, ruefully.) But Slater's anxiety returned: "I felt like a lab rat," he told me. He asked to get out again and tried to leave the lab. The researchers had to persuade him to stay and let them administer a sedative.

Carhart-Harris describes the episode—one of the very few adverse events seen in the Imperial research—as "a learning experience" and, by all accounts, he has since shown himself to be a compassionate and effective clinician as well as an original scientist—surely a rare combination. The response of most patients in the depression trial, as we will see in the following chapter, has been remarkably positive, at least in the short term. Over dinner at a restaurant in West London, Robin told me about one severely depressed woman in the trial whom over the course of several meetings he had never once seen smile. As he sat with her during her psilocybin journey, "she smiled for the very first time.

"'It's nice to smile,' she said.

"After it was over, she told me she had been visited by a guardian angel. She described a presence of some kind, a voice that was entirely supportive and wanted her to be well. It would say things like 'Darling, you need to smile more, hold your head up high, stop looking down at the ground. Then it reached over and pushed up my cheeks,' she said, 'lifting the corners of my mouth.'

"That must have been what was happening in her mind when I observed her smiling," Robin said, now smiling himself, broadly if a bit sheepishly. In the aftermath of her experience, the woman's depression score dropped from thirty-six to four.

"I have to say, that was a very nice feeling."