LSD Hallucinations: From Ergot to Electric Kool-Aid

RONALD K. SIEGEL*

> I appreciated Joe Henderson's article in the April issue, "LSD 10 Years Later." I started as a result of his book. . . . I loved it. . . . Unfortunately, I forgot what I had read as time passed. Joe's article helped me get back to me. . . . I am refocusing my goals on what I want.

This slightly edited letter appeared in a 1979 national magazine (Tharrington 1979). It represents a new wave of LSD enthusiasts who have landed on the recreational shores of American communities. Clad in bold colors born of an "Electric Kool-Aid Acid Test" (Wolfe 1968), equipped with the latest paraphernalia purchased from ubiquitous street-corner dealers, they set out across the country in search of meaning and individuation. Some prepare themselves with long fasts. Others indulge in ritual diets. Still others sip on sacred liquids, not unlike the proverbial Kool-Aid, in preparation for the trip ahead. At last count there were over 25 million of them. Most are in their middle years—the children who grew up in the 1960's. Then there are their children, and older people as well—all about to share the agony and ecstasy of an LSD voyage.

Pulled by the riptide of adrenaline, tossed about in a whirlpool of oceanic bliss, they confront the rich hallucinatory images that delighted their counterparts a decade earlier. One tripper regresses to a time in childhood when he would join his father in the cab of his locomotive. He imagines himself looking out the window at the pistons driving the wheels in concert with the steam being blown out onto the tracks, and his body is then transformed into the engine. Another man became totally incoherent and began to experience visual hallucinations. He saw two television sets on the horizon and he could vividly see himself running on one of the screens, while his parents watched him on the other. Then his body left him and entered the television set. Gradually the stormy sea calms and these voyagers are totally relaxed and exhausted. Bathing in the afterglow, they contemplate the wonders of the good ship LSD.

Scenarios, such as those described above, may seem to be accurate, albeit romantic, descriptions of hallucinatory experiences with lysergic acid diethylamide (LSD). But they are experiences generated by the fast-growing recreational pastime of long slow distance running, otherwise known by aficionados as LSD. Images of vivid qualities that would rival those induced by some of Sandoz's best LSD (Delysid®) are not surprising in view of the chemical and temperature changes that take place in the runner's body: loss of glycogen, rising rectal temperature, dehydration (Morgan 1978). This can lead to dizziness, dissociation, stupor and hallucinations.

The long-distance runner is not the only one to encounter this hallucinatory world. Long-distance truck drivers, driving alone on monotonous highways, often experience hallucinations, including flashes of light or huge animals and cars. Long-distance explorers and sailors, such as Admiral Byrd and Captain Slocum, often

*Department of Psychiatry and Biobehavioral Sciences, School of Medicine, University of California, Los Angeles. Please address reprint requests to the author at P.O. Box 84358, Veterans Administration Branch, Los Angeles, California 90073.

hallucinate imaginary companions and experience other startling images. Even the long-distance space travelers, as was the case with several Apollo astronauts, experience fleeting glimpses of things that are not there, such as lights and colors floating around their craft. The past decade of research has made it dramatically clear that the hallucinations induced by LSD can be elicited by a wide variety of such nonchemical means. The ever-increasing list of these methods includes falling asleep, waking up, insulin hypoglycemia, fever delirium, epilepsy, psychotic episodes, advanced syphilis, sensory deprivation, photostimulation, sensory bombardment, extreme hunger or thirst or cold, near-death experiences, electrical stimulation, crystal gazing, dizziness and migraine headaches. LSD (the long-running solution) may have given popular access to hallucinations for the millions willing to run for it. However, LSD (the drug) gives instant access for all at the simple drop of a pill.

Whether dropping acid at a party or running a marathon, when one perceives a hallucination one does so alone, in the privacy of one's own body. In that loneliness one may find oneself possessed as much by Pan, the Greek god of lonely places and panic, as by awe and wonder. For set and setting are important determinants of the hallucinatory experience.

The set for the first LSD trip was accidental and the setting was the laboratory of the Swiss chemist Albert Hofmann. The date was Friday, April 16, 1943—the curious year that marked the birth of Bob Dylan, steel pennies and the first published medical anecdote of a life-after-death experience. Hofmann experienced a strange inebriation from his accidental ingestion of the substance and he saw a fantastic array of colored and geometric hallucinations. Some historians are fond of calling this the first encounter with LSD hallucinations. Other writers and historians (e.g., Fuller 1968) date the first experiences to the Middle Ages where LSD-like chemicals found their way into bread that was subsequently eaten. Some anthropologists (e.g., La Barre 1975) noted that the ancient Aztecs used LSD-like hallucinogens in religious and magical practices, while others (Wasson, Ruck & Hofmann 1978) have identified ancient Greek uses of ergot. However, the origins go back still further in time. The story begins millions of years before the dawn of the human species.

THE NATURAL HISTORY OF LSD-TYPE HALLUCINATIONS

Somewhere on the grassy plains during the Mesozoic Era, some 250 million years ago, migrating herds of early mammals browse through the dry late summer and autumn in search of food. There among the slow growing plants are grains and other forage that a future naked ape will call the brooms, bluegrasses and ryegrasses.

While eating the grasses, the animals can be seen occasionally flicking their prehistoric tails at flies that dart among them, biting at will as if heralding a far worse torment yet to come. Unbeknown to the grazing animals, these flies (*Melanostoma mellina* and *Rhagonycha fulva*) have just dined on the sugary excretion that accompanies the sphacelia stage of a special fungus, *Claviceps purpurea* (Ridley 1930). Flying through the tall grasses, they carry the spores to other grasses in a diabolic dance of search and destroy. For the fungus that grows in the wake of their pursuit quickly and parasitically attacks the grasses. Sucking nutrients from the host grasses, the fungus grows in a slightly curved, fusiform shape. Its sclerotia replaces the grain or seed of rye and other small grains or forage plants. The sclerotia is a veritable laboratory of potent pharmacologic agents, as it manufactures ergot alkaloids—slightly alkaline nitrogen-containing compounds.

These compounds are structurally similar to the neurohumoral tryptamine serotonin, present in the nervous tissue of warm-blooded animals. Serotonin plays a major role in the drama of biochemistry and behavior. The ergot alkaloids, acting somewhat like impish pranksters in the play of behavior, seriously alter the actor's perceptions and movements. (Ergot causes vasoconstriction by direct action on the muscles of the arterioles, and repeated doses injure the vascular endothelium. Initially, these actions result in reduced blood flow and eventually complete stasis, with terminal necrosis of the extremities due to thrombosis. In addition, ergot has potent oxytoxic action and causes stimulation of the central nervous system or CNS, followed by depression and possible death.)

Meanwhile, back on the grassy plains, the herbivores continue their innocent grazing, ignoring the black ergot sclerotia on the otherwise amber wheys of grain. Like tiny black dots, the ergot punctuates the forage with ominous marks of foreboding. For several weeks the herds gobble up the ergot on rye. A few animals become lame, and still the feast goes on. Some animals begin to have difficulty in locomotion. First the hindlimbs are affected and then the forelimbs become rigid. The slow graceful gliding through the grasses becomes stiff, bounding movements. Internal body temperature rises, as does pulse and respiration—all in a crescendo of physiological arousal. The fetlock joints and pastern become swollen and tender. Muscle spasms follow the least amount of concentrated exercise. Exposed skin areas, such as teats and udders, appear unusually pale or anemic. Ulceration appears in the mouth. Gastroenteritis appears. Within a week, sensation is lost in the affected limbs and dry

gangrene erupts on the distal parts. The tips of those fly-swatting tails and flicking ears become necrotic and sloughed, permitting harassing assaults by the flies on the already nervous animals. Some animals develop convulsive syndromes (Siegmund 1973).

Here and there across the grassy plains, animals can be seen falling in lateral recumbency with opisthotonos, nystagmus, stiffly extended limbs and fasciculation of the muscle groups. The attacks subside in a short time, but violent spasms rock through individuals like aftershocks of earthquakes—always unpredictable and always startling to the animals. Affected animals are found isolated from the herds, often sitting with a dazed appearance. Others continue grazing, with legs spread in order to retain a precarious balance. Avoiding rapid movements, the herds move out of ergotland. The fall rains wash some ergot away, and with reeling gaits and awkward postures the battle-weary animals migrate. They leave behind five percent who remain prostrate, starving and dying.

Despite the benefit of animal observations, early humans had similar accidental encounters with ergot (Hoffer & Osmond 1967). Periodic outbreaks of ergotism, resulting from ingestion of *Claviceps purpurea* in contaminated rye bread, were common in the Middle Ages and even in this century. Epidemics occurred in France as far back as 857 A.D. and as recently as 1951. In 944 A.D., 40,000 people died of the disorder.

There are two types of ergotism: gangrenous and convulsive. Gangrenous ergotism was known by a number of names referring to the feverish hallucinations of flames and devils, including *ignis sacer*, the Holy Fire or St. Anthony's Fire. This condition is usually characterized by dry gangrene of the extremities followed by the falling away of the affected portions of the body. Convulsive ergotism is characterized by symptoms that include crawling sensations in the skin, tingling in the fingers, vertigo, tinnitus aurium, vomiting, diarrhea, headaches, disturbances in sensation, hallucinations, and painful muscular contractions, leading to epileptiform convulsions. Involuntary muscular fibers are stimulated and mental disturbances occur, including mania, melancholia, psychosis and delirium.

Symptoms of convulsive ergotism were conspicuous in the Salem witchcraft records of the seventeenth century. The sudden onset of the condition was considered symptomatic of demonic possession rather than disease. In her 1976 study of the Salem witch trials, Caporael suggested that ergotism was present and noted that "the content of hallucinations and other perceptual disturbances would have been greatly influenced by the state of mind, mood, and expectations of the individual." Accordingly, victims who experienced visions of undulating objects and lights tended to interpret them as specters of accused witches or agents of the devil in animal form. However, Spanos and Gottlieb (1976) have argued that psychedelic hallucinations, which would be expected from ergot, were conspicuously absent from such reports.

Nonetheless, in his account of the 1951 ergotism epidemic in France, Fuller (1968: 94-95) described the presence of LSD-like hallucinations among the victims:

> A common vision among the sick was that of fireballs coming toward them, then receding and coming back again. *Zoopsie*, hallucinatory visions of animals, was rampant among the victims. . . . Patients talked of the astonishing, brilliant, vivid, intense, and unbelievable colors—orange, red, brilliant white, moving in spirals, glowing from objects—that encompassed all their surroundings. Others described the conviction that they had been in a vast room, where the ceiling descended and the walls closed in on them, ready to crush them to death. Or there were those who described the feeling that their arms were pulling into their bodies, their knees telescoping up into their shoulders and chests. Auditory hallucinations—the noise of a clock, music, voices—were rare but were noted by some. Three of the victims were absolutely sure they were witnessing their own funerals and actually invited the fatigued volunteers to take part in the obsequies. Nearly always the same hallucinations returned to each individual, varying little from the one that struck the victim at the beginning. Some patients were in helpless confusion, knowing neither time nor space. Some were not even able to perceive heat when they were so tested. Often the tetanuslike convulsions would seize the patients and throw them into uncontrolled paroxysms, usually at the times the hallucinations began again.

Not all human encounters with LSD-like hallucinations were accidental or unpleasant. Religious, magical and medical uses were employed by numerous cultural groups (Schultes 1976). For example, after the conquest of Mexico, the Spanish chronicler Hernández, who was the physician to the King of Spain, reported in 1651 that *ololiuqui* and *tlililtzin* were important divinatory hallucinogens. Since that time *ololiuqui* has been identified as the seeds of *Rivea corymbosa*, and *tlililtzin* as the seeds of *Ipomoea violacea*. These morning glory seeds contain ergine (*d*-LSD), iso-ergine and other related bases, including chanoclavine, elymoclavine and lysergol. *Ololiuqui* was used to produce hallucinations for religious practices (Schultes 1976: 129): "When the priests wanted to commune with their gods and receive messages from

them, they ate this plant to induce a delirium and a thousand visions . . . appeared to them."

DEFINITIONS

What are these hallucinations? How can they be studied? Traditionally, attempts to answer these questions have been approached by the analysis of words and pictures depicting the experiences. Thus, private covert experiences can achieve public status and can be subjected to the process of consensual validation. In a sense, an individual's hallucination can be *seen* by others. What then is seen? Are the hallucinations real or imagined perceptions? Are they doors to a separate reality or simply another room of the mind? Is it ecstasy or madness? The study of hallucinations and the subsequent labeling of the experiences as ecstatic or mad depends in large part on the definitions that are adopted.

The word hallucination comes from the Latin word *alucinatio*, meaning a wandering in mind or attention, idle talk or prating. Its first use in English was in a translation of a book by Lavater in 1572 referring to "ghostes and spirites walking by nyght." The assumption here is that talk of ghosts and spirits is idle talk a priori, as such apparitions cannot be consensually validated and hence do not exist. Even the current, widely accepted psychiatric definition (American Psychiatric Association 1984) operates on this assumption: "A sensory perception in the absence of an actual external stimulus. May occur in any of the senses." In other words, a person has a certain experience—call it a hallucinatory image—and some other person makes the judgment that the first person has ascribed some degree of reality to an unreal image.

Throughout history, the attribution of mad or ecstatic has usually depended on the social status of the person reporting these imaginary happenings. Saints, experienced explorers and esteemed philosophers may have valid visionary experiences. But sinners, social outcasts and inmates of correctional institutions are hallucinatory if not mad as well. Paul saw Jesus in a hysteric vision and became a saint, but the Manson family's LSD-induced vision of convicted murderer Charles Manson as Jesus Christ was mad. Lewis Carroll's *Alice* stories (based in part on his migraine-induced hallucinations) were considered pure fantasy, while anthropologist Carlos Castaneda—experimenting with drugs among the Yaqui Indians, reported hearing a lizard talking, seeing an automobile disappear and watching a sorcerer leap 10 miles to a mountain top—is credited by some with new discoveries in anthropology!

Certainly few, if any, thought that the astronauts were reporting hallucinations when they described "flashes of light" on the Apollo flights. Some flashes on Skylab 4 were even described as "tadpoles." Yet no one seemed eager to label these well-trained observers hallucinatory or victims of some new space hysteria. Rather, it was suggested, and subsequently verified, that they were seeing cosmic rays that penetrated their spacecraft and interacted with their eyeballs.

Children have special privileges to engage in make-believe play. They talk in empty rooms, listen to voices on a toy telephone, fight Armageddon battles with imaginary enemies and play with invisible friends. Only their age and social status protect them from the diagnostic implications of being labeled hallucinatory or mad. Yet, the pranksters who drank Electric Kool-Aid, a punch laced with LSD, were judged irreverently insane when they described Day-Glo Visions of Buddha (Wolfe 1968).

The search for a suitable definition of hallucinations has been further complicated by the wide variety of individual reports. Many reports have sensory qualities and describe properties, such as sights, sounds, tastes and smells. Some reports have specific idiosyncratic content, such as when LSD users experience unbidden images of long-forgotten childhood memories. Some hallucinatory images arise with such startling vividness that they often prompt the person to react by speaking with the image or moving toward it or away from it. Certainly, people cannot always tell the difference between mental images and sensory perceptions, but true perceptions involve objects that are really there or really not there.

Psychologist William James (1902) verified such perceptions by the presence of "objective reality." Conversely, James defined a hallucination as having no objective stimulus, but with varying degrees of apparent objectivity. True hallucinations were further distinguished from pseudohallucinations, which lack the character of objective reality. A subject having a true hallucination would have a concomitant delusion that it was real, whereas s/he would experience the pseudohallucination but know it to be unreal. Both types, however, share the qualities of being vivid, minute, detailed, abrupt and spontaneous. They can be further separated from illusions, which are distortions and changes in real stimulus events. The hallucinations induced by LSD, for example, are representative of mixtures of true hallucinations, pseudohallucinations and illusions. An important caveat is that hallucinations may be positive or negative. That is, one can have perceptions of things that are not there (positive) or fail to perceive things that are really there (negative). In other words, hallucinations are special forms of attentional states wherein subjects shift their attention from outward dimensions (real objects) to inner private events (images), and appear to be closely attending to these inner events.

THE EXPERIMENTAL ANALYSIS OF DRUG-INDUCED HALLUCINATIONS

The early phenomenological investigations of drug-induced hallucinations were conducted by French psychiatrists. Brierre de Boismont offered one of the earliest classifications. He found that hallucinations occurring in states of insanity, delirium tremens, drug intoxications, nervous disorders, nightmares, dreams, ecstasies and fevers were all characterized by excitation and the production of images from memory and imagination. Indeed, the subtitle of his 1853 monograph on hallucinations, *The Rational History of Apparitions, Visions, Dreams, Ecstasy, Magnetism, and Somnambulism*, underlined the basic similarity of these experiences.

In 1845, Jacques Moreau (1973) described hallucinations as being similar to dreams, wherein imagined visual, auditory and tactile stimuli appear to be part of reality. With uncanny insight into what future neurophysiological research would reveal, Moreau believed that hallucinations resulted from excitation of the brain. His experimental technique involved the study of hallucinations by artificially provoking them through the ingestion of hashish, which possessed the characteristics of plunging one into a hallucinatory state while still preserving the ability to observe and report events. With messianic zeal—similar to that of the American psychologist Timothy Leary 115 years later—Moreau attempted to persuade his colleagues and patients to try hashish for themselves. His medical associates were hesitant to accept this idea of "objective experimentation," but the Bohemian artists and writers of nineteenth century Paris were more receptive. Among them was novelist Théophile Gautier who went on to organize the Club des Haschichins, which included Balzac, Baudelaire, Dumas and Hugo. Many of their writings testify to the splendor and phantasmagoria of hashish-induced imagery.

The German and American schools followed this method of self-experimentation, focusing primarily on visual hallucinations. Using mescaline, Heinrich Klüver began a series of investigations at the University of Chicago in 1926. Klüver (1966) reported that mescaline-induced visual imagery could be observed with either closed or open eyes, and that in the latter case it was impossible to look at walls without seeing them covered with projected visionary phenomena. He noted four basic form constants that typified these visions: One type was always referred to by terms such as grating, lattice, fretwork, filigree, honeycomb or chessboard design; the second resembled cobweb figures; the third was described by terms such as tunnel, funnel, alley, cone or vessel; and spiral figures comprised the fourth type. The form constants were further characterized by varied and saturated colors, intense brightness and symmetrical configurations. The visions seemed to be localized at reading distance, varied greatly in apparent size, and generally could not be consciously controlled. Klüver made the critical observation that these form constants appeared in a wide variety of hallucinations, including those produced by the hallucinogens.

The form constants are only the first stage of a two-stage process of drug-induced imagery. Unfortunately, Klüver and others did not examine the development of imagery in the more complex second stage that includes landscapes and faces as well as familiar objects and places. These complex images are usually regarded as activation of memory images already recorded and retained in the brain and are perhaps the most dramatic aspects of the hallucinatory experience. Here, one would expect that there would be an astonishing array of individual forms and scenes. Nonetheless, there are constants even in this stage. A review of over 500 LSD-induced hallucinations (Siegel & Jarvik 1975) revealed that between 62 and 72 percent of the subjects reported highly similar complex imagery, including small animals or human figures (49 percent), which were usually friendly and often in human caricature, and religious symbols or images (72 percent).

However, most investigators and subjects did not describe the complex imagery in detail. Before Klüver's classic work, little was written about the geometric imagery. Klüver attributed this omission to the novelty of the visions, and explained that observers typically are enticed by the color and brightness of the images, ignoring the basic forms. They are often awed by the experience and surrender before it as something overwhelming and indescribable, causing more than one researcher to use grandiose metaphors and attach religious significance and cosmic meaning to the images. This ineffability challenged Klüver to describe the simple first stage. The apparent complexity of the second stage challenged this author to attempt a description as well. It was believed that the study of such phenomena might suggest a typological construct or some common visual imagery underlying hallucinations that could help to achieve an understanding of the etiology of these and related perceptions. It was in this spirit that experiments were begun in laboratories at the Neuropsychiatric Institute of UCLA.

The first experiments (Siegel & Jarvik 1975) were designed to confirm the phenomenology of drug-induced hallucinations in untrained observers. Subjects were given standard doses of a hallucinogen, such as LSD, or an inactive placebo. They were blind to the procedure and did not known which they were getting. Subjects were

then placed in a lightproof, soundproof chamber, supine on a bed and asked to report their experiences. They were specifically instructed to give a continuous verbal report or running commentary on any visual images or pictures they might see when their eyes were either closed or open in the dark chamber. They were asked to pay particular attention to forms, colors and movements. The tape-recorded reports were typed and the transcripts analyzed according to the frequency of occurrence of different forms, colors, movements and complex images. The results showed that normal nondrug imagery was characterized by amorphous black-and-white forms, with some lines and curves, moving randomly about the visual field. Whenever subjects closed their eyes or entered a dark room, vision was rarely totally black and void, but usually contained some normal baseline imagery. Indeed, simply gently rubbing the closed eyelids can increase intraocular pressure, thereby producing highly similar imagery—some of it brightly colored and geometric.

In the LSD and other hallucinogen sessions, however, subjects reported a dramatic increase in the number of these visual images that appeared like a movie or slide show projected in front of their eyes. Many of the subjects had difficulty describing images, but they agreed that there were many geometric forms. The imagery was characterized by a very bright light in the center of the visual field that obscured central details, but permitted imagery on the periphery to be observed. The locus of this point of light created a tunnel-like perspective and subjects reported viewing much of their imagery in this regard. The imagery tended to pulsate and move toward the center of the tunnel (concentric motion) or move away from the center light (explosive) or both. When imagery appeared colored, all colors were reported, although the incidence of red increased with increasing drug doses. Geometric forms frequently combined with one another, duplicated and overlaid one another. The flow of imagery was so rapid at times that most subjects found it difficult to maintain a running commentary. Complex imagery soon replaced the geometric forms, including reports of recognizable scenes, people and objects (often in cartoon or caricature form) with some degree of depth or symmetry. Complex images were often projected against a background of geometric forms. However, subjects differed widely in their choice of words and the reports were riddled with idiosyncratic experiences. Therefore, it was decided to facilitate ease and accuracy of reporting by training subjects to use a standard descriptive language.

There had already been a few attempts at training such astronauts of the inner hallucinatory voyage by the Harvard psychologists Ogden Lindsley and Timothy Leary. They used a hand-operated switch as a reporting device and equated it to the occurrence of a subjective state. For example, in the case of a hallucination, the verbal report of "I saw it" or "I heard it" was equated to a mechanical key pressed by the subject. Lindsley, Hobika and Etsten (1961) had already demonstrated that such operant behavior provided an objective method for the study of gross behavior in such altered states of consciousness as anesthesia, coma and sleep. Rates of key pressing gradually decreased as subjects lost consciousness.

However, a method for obtaining detailed information regarding subjective phenomena had not been developed until Lindsley collaborated with Leary (Leary 1966) and developed the "experiential typewriter." This apparatus consisted of a 20-key typewriter connected to a recording instrument. The keys were used to code various subjective states, including modes of perception, internal and external images, hallucinations and colors. The subjects were pretrained by simply memorizing the experiential categories and the corresponding keys. When a subject felt a bodily sensation, such as pain, s/he would press a specific key to signify the event. Similarly, hallucinations of oscillating colors could be signified by pressing a different key. The locus of the hallucination in terms of eyes-open or eyes-closed imagery could be signified by the simultaneous pressing of yet another key. The recording instrument also recorded the occurrence of these events as a function of time. In tests with the hallucinogens LSD and dimethyltryptamine, Leary found that the ataxia associated with these drugs interfered with pressing the keys. The problem could have been avoided with lower doses and the key press could have been replaced by a verbal report, which Leary found was not disrupted by the drugs. Therefore, at UCLA it was decided to develop a verbal code for reporting drug-induced hallucinations.

On the basis of the previous results, a list was constructed of eight forms (random, line, curve, web, lattice, tunnel, spiral, kaleidoscope), eight colors (black, violet, blue, green, yellow, orange, red, white) and eight movement patterns (aimless, vertical, horizontal, oblique, explosive, concentric, rotational, pulsating) that subjects could use in describing visual imagery. A group of subjects was then selected and trained using slides to illustrate the different categories. For example, in the training of the tunnel form, hundreds of different slides of tunnels would be shown to the subjects, with no two slides alike, so that subjects were required to abstract over all the individually different tunnels and generate the broad concept of *tunnel*. In this way, new instances of tunnel imagery that were never seen before, as might happen in drug hallucinations, could be appropriately classified on the basis of common features. Similarly, subjects were trained to classify col-

ors into discrete categories. Movement training was accomplished by using special rotary-polarized slides that allowed apparent movement to be displayed.

Subjects were trained to recognize all these categories in displays projected for only eight milliseconds with a brief one-second pause between displays. This was done to stimulate the rapid imagery changes in hallucinations. In addition, there were groups of untrained subjects as well as subjects exposed to the slide material to equate for visual experience, but they were not trained with specific verbal responses. All subjects were then administered a series of weekly test sessions, in each of which they received either a hallucinogen, a stimulant, a depressant or a placebo. High and low doses were tested and subjects never knew what substance they were ingesting. They were tested in the dark in the same chamber used before and were instructed to continually report their eyes-open experiences, but the trained subjects were restricted to the training code. In the middle of the session, the trained subjects were tested on slide identification with real projected images to ensure that the drug doses did not impair their training skills.

The results were dramatic. The trained subjects were able to keep up with the rapid flow of imagery and conveniently classified most images seen in the code categories. Trained subjects averaged 20 reports per minute, while untrained subjects reported only five times per minute (the average session lasted six hours). Imagery associated with placebos, the stimulant dextroamphetamine or the depressant phenobarbital was described as black-and-white random forms moving aimlessly about. The hallucinogens LSD, tetrahydrocannabinol, psilocybin and mescaline induced dramatic changes: Forms became less random as well as more organized and geometric as the experience progressed. The black and white colors began to take on blue hues, and movement became more organized and pulsating. At 30 minutes after drug administration, subjects reported a significant increase in lattice and tunnel forms as well as small increase in kaleidoscopic forms. By 90 and 120 minutes, most forms were lattice-tunnels and there was a concomitant shift from colors at the blue end of the spectrum to red, orange and yellow. Movement, while always pulsating, became more organized with explosive and rotational patterns.

Complex imagery usually did not appear until well after the lattice-tunnel shift was reported. At that time, complex forms constituted between 43 and 75 percent of the total form reports of trained subjects during hallucinogen sessions. Such images first appeared in the reports as overlaying the lattice-tunnels and were located in the periphery of these images. Common complex images included childhood memories and scenes associated with strong emotional memories. However, these hallucinatory images were more than mere pictorial replicas and they were frequently embellished into fantastic scenarios, such as aerial perspectives and underwater views. It has not been experimentally established where such constructions occur, but contributions are probably made in the encoding, storage and retrieval stages of the memory process.

Much of the context of complex imagery can also be influenced by environmental stimuli. Because the subjects were in an isolated chamber, most images came from their own memories. However, in a companion procedure, subjects were escorted at the peak of the hallucinatory experience to an outdoor botanical garden. There the subjects wore blindfold goggles, lay supine on the grass and reported eyes-open visual imagery for several minutes. During these tests, there was a significant reduction in memory imagery and a parallel increase in reports of birds, planes, trees and other objects, often triggered by auditory and tactile cues in the outdoor setting. In other tests, success was attained in shaping and guiding drug-induced imagery by programing the subjects with suggestive words or music. Nonetheless, even these idiosyncratic complex images were usually reported as appearing in lattice-tunnel arrangements and moving in explosive or rotational configurations.

During the peak hallucinatory periods, subjects frequently claimed that they became part of the imagery, and reporting was periodically interrupted even for the trained subjects. It was at these times that subjects stopped using similes in their reports and started reporting that images were, in fact, really what they appeared to be! Thus, normal or placebo-treated subjects might have described an experience in terms of similes (e.g., "like," "as if" or "it is as though"), but hallucinogen-treated subjects often responded that "it is so." This point marked the transition from pseudohallucinations to true hallucinations. Highly creative and fantastic combinations of imagery were present at this time and subjects estimated that there may have been as many as 10 image changes per second. Subjects frequently reported feeling detached and dissociated from their bodies and would see themselves from outside their bodies. This state is similar to the break-off phenomenon experienced by solitary pilots and astronauts who find themselves observing their craft from the outside.

In these drug-induced hallucinations, particularly with LSD, attention appears to wander, such as when subjects gradually shifted their attention from outward dimensions to inner private events or when they appeared distracted from experimental tasks. Subjects also reported

that attention to real stimuli often shifted along dimensions of color, shape, brightness, vividness and size, which created variations of the real stimuli. It is precisely these dimensions, which have been traditionally cited by both scientists and philosophers, that distinguish real perceptions from dreams, images, thoughts and hallucinations. Real stimuli are more vivid, bright, coherent, concrete and veridical than the others. The Danish researcher Aggernaes (1972) compared the experienced reality of the hallucinations of young LSD users with those of schizophrenic patients. The LSD hallucinations were clearly different in that they had more doubtful or changing reality qualities than those found in schizophrenic hallucinations. Even when LSD hallucinations were perceived as "real," they were in some sense "less real" than actual perceptions or schizophrenic hallucinations. In most cases, LSD hallucinations do not fool the user into believing them to be real.

The remarkable constancies of drug-induced hallucinations lead to a consideration of their universal nature. Some are strikingly similar to the construct of primordial images or archetype forms, such as the mandala, which psychoanalyst Carl Jung described as part of the human collective unconscious. Indeed, anthropologists have long noted that the hallucinogen-inspired art of many primitive groups often contains examples of form, color and movement constants. Yagé or ayahuasca (hallucinogenic harmine alkaloids obtained from *Banisteriopsis* spp.) is used by Indians in the tropical forests of South America. Their artwork is rich with geometric designs of bright colors, tunnels and spirals, all resembling their yagé hallucinations. The Tukano Indians in the Amazonian regions of Colombia frequently decorate their homes and pottery with geometric yagé imagery. Similar imagery has been found among Indians in Peru who use the mescaline-containing San Pedro cactus *Trichocereus pachanoi*.

In a cross-cultural study of this phenomena (Siegel & Jarvik 1975), an expedition was made into the high Sierra Madre range of Mexico to study a group of peyote-using Huichol Indians that have remained relatively isolated since Aztec times. Tape-recorded interviews were conducted during their peyote ceremonies and reports of visual imagery were elicited. Most respondents had difficulty in describing the geometric imagery, but all agreed that such hallucinations were virtually identical to the symmetrical and repeating patterns used in their weaving and art. One vision was described as "a big spiral and I saw the fire god in the center and rushing out towards me. I saw mostly repeating squares, reds and blues, against the sky and everywhere I looked into the night." Complex images consisted of objects found in the Indians' immediate environment (e.g., the sun, deer, eagles, cattle). Nonetheless, the respondents saw these complex images projected onto a waving and pulsating screen of the basic geometric motifs.

Thus the two basic phenomenological observations that emerged from these studies are (a) the geometric form, color and movement constants, and (b) the predominance of complex memory images. In an attempt to explain the origin of the simple constants, a number of investigators (see Sigel & Jarvik 1975) have proposed that these are simply the perception of entopic events that arise from the visualization of certain structures within the eye through the appropriate arrangement of incident light. Consequently, horizontal bands are due to folds in corneal epithelium that change the eyelid motion; central moving bright spot surrounded by a darker area is due to droplets of tear fluid and mucus on the cornea; black lacework seen against a red background is due to retinal blood vessels casting a shadow on rods and cones; pulsating figures are due to excursions of distended blood vessels on underlying receptor cells; and tunnels are due to the arrangement of foveal cones and surrounding rods. As appealing as such entopic events are for explaining constants, inasmuch as some light is required for their visualization, they probably play a minimal role in the phenomena found in the experiments conducted in total darkness.

However, light is not necessary for production of phosphenes, which are visual sensations arising from neuronal discharge activity in the retina, lateral geniculate and visual cortex. Phosphenes may include spots, disks, concentric circles or arcs, and even checkerboard patterns, and may have a role in determining the constants. These phosphenes may also account for the illuminations, lights, phantoms and ghosts reported by religious mystics meditating in the dark, prisoners in dark dungeons, drivers peering into snowstorms, and airplane pilots flying alone at high altitudes. The constants are also highly similar to patterns found in migraine hallucinations that precede or accompany the head pain. These patterns include lines, grids, concentric circles and fortification illusions (a horseshoe-shaped area consisting of bright zigzag lines appearing at an expanding outer edge). Migraine hallucinations can also be brightly colored (blues and reds), explosive and include complex images of people and objects. The most salient explanation for migraine phenomena is that they reflect electrical excitation of organized groups of cells in the visual cortex. Indeed, the work of Penfield (1958) at McGill University has shown that direct electrical stimulation of the visual cortex or temporal lobes produces moving colored lights, geometric forms, stars and lines.

In order to explain the phenomenology of complex

imagery, most investigators have held a tacit belief that images are the result of CNS excitation. As early as 1845, Moreau postulated that hallucinations resulted from cerebral excitation that enabled imaginary thoughts and memories to become transformed into sensory impressions. More recent electrophysiological research has confirmed that hallucinations are directly related to states of CNS excitation and arousal coupled with functional disorganization of the reticular modulating system (Winters 1975). Consequently, augmentation of sensory information occurs and there are multisensory aberrations marked by fluctuations in evoked potentials, resulting in events characterized as increased distractibility. Behaviorally, this translates into an impairment in discrimination based on external stimuli and a preoccupation with internal imagery and hallucinations.

This hallucinatory process has been referred to by Boismont (1853) as a suspension of external impressions that allows for memories and imaginations to be perceived in the form of complex hallucinations. Penfield (1958) described it as "memory flashbacks" and "experiential hallucinations." Other investigators (see Siegel & Jarvik 1975) have called the process "displayed memories," "involuntary reminiscence" and "vicarious retrieval of stored information." Psychoanalytic theorists (e.g., Leuner 1962) postulate a general regression to primitive or childlike thinking, coupled with the emergence of repressed information and memories. Psychedelic theorists (e.g., Leary, Metzner & Alpert 1964) postulate that hallucinogens release normally suppressed information and memories (including experiences recorded as cultural and genetic memories) and bring such components to the user's attention.

Perhaps the most integrated explanation has been provided by the perceptual release theory of hallucinations. Originally formulated by Hughlings Jackson in 1931, it has since been updated by Louis Jolyon West (1962). This theory assumes that normal memories are suppressed by a mechanism that controls the flow of information from outside to inside the body. Input of new information inhibits the emergence and awareness of previous perceptions and processed information. If the input is decreased or impaired and internal arousal is sufficient to permit awareness, the released perceptions may be dynamically organized and experienced as hallucinations, dreams or fantasies. West (1962) has offered the following helpful analogy to illustrate the process. Picture a man in his study, standing at a closed glass window opposite a fireplace, looking out at his garden in the sunset. He is absorbed by the view of the outside world and does not visualize the interior of the room in which he stands. But as it becomes darker outside, the images of the objects in the room behind him can be seen reflected dimly in the glass window. As night falls, the fire burns brightly in the fireplace and illuminates the room. The man now sees a vivid reflection in the glass of the room's interior, which appears to be outside the window. The illusion becomes dimmer as the fire dies down and, finally, when it is dark both outside and within, nothing more is seen. If the fire flares up from time to time, the visions in the glass reappear. Accordingly, in perceptual release, the daylight (sensory input) is reduced while the interior illumination (general level of CNS arousal and excitation) remains bright, and images originating within the rooms of the brain may be perceived as though they came from outside the windows of the senses.

Much more work must be done before the precise mechanisms of hallucinations are understood, but already they are beginning to lose some of their mystery. Many perceptual phenomena, originally replete with mystique, romance and superstition, have had the veils of illusion blown away by the winds of careful scientific investigation. For example, the Fata Morgana is the mirage of a magnificent city seen on the Straits of Messina, but the name is often applied to any spectacular mirage. The name itself comes from Morgan la Fey, King Arthur's enchantress sister, whose magic could easily make a city appear on any shore in the world, thus luring seafarers to watery fates. The Fata Morgana, however, is due to the atmosphere behaving like a lens or series of lenses and focusing scenes in a very restricted area. Thus, moving the head up or down a few feet often destroys the mirage. The images of mirages, like the images of LSD hallucinations, are actually refracted or reflected images of real objects located elsewhere. Whether exploring the hallucinations of LSD trips or the Fata Morgana, one is looking at real images in the brain. The city is no less beautiful, no less intriguing, no less worthy of study and visitation because it is not where one thinks it is. Further experiments and psychopharmacological investigations will help illuminate the path. Happily, one can then take the trip, not with Pan, Greek god of lonely places and panic, but with Athena, Greek goddess of wisdom.

REFERENCES

Aggernaes, A. 1972. The difference between the experienced reality of hallucinations in young drug abusers and schizophrenic patients. *Acta Psychiatrica Scandinavica* Vol. 48: 287-299.

American Psychiatric Association. 1984. *A Psychiatric Glossary.*

Washington, D.C.: American Psychiatric Press.

Boismont, B. de 1853. *The Rational History of Apparitions, Visions, Dreams, Ecstasy, Magnetism, and Somnambulism*. Philadelphia: Lindsay and Blakiston.

Caporael, L.R. 1976. Ergotism: The Satan loosed in Salem? *Science* Vol. 192: 21-26.

Fuller, J.G. 1968. *The Day of St. Anthony's Fire*. New York: Macmillan.

Hoffer, A. & Osmond, H. 1967. *The Hallucinogens*. New York: Academic Press.

Jackson, J.H. 1931. *Selected Writings*. London: Hodder and Stoughton.

James, W. 1902. *The Varieties of Religious Experience*. New York: Longmans Green.

Klüver, H. 1966. *Mescal and Mechanisms of Hallucination*. Chicago: University of Chicago Press.

La Barre, W. 1975. Anthropological perspectives on hallucination and hallucinogens. In: Siegel, R.K. & West, L.J. (Eds.). *Hallucinations: Behavior, Experience, and Theory*. New York: John Wiley & Sons.

Leary, T. 1966. The experiential typewriter. *Psychedelic Review* Vol. 7: 70-85.

Leary, T.; Metzner, R. & Alpert, R. 1964. *The Psychedelic Experience*. New Hyde Park, New York: University Books.

Leuner, H. 1962. *Die Experimentelle Psychose*. Berlin: Springer-Verlag.

Lindsley, O.R.; Hobika, J.H. & Etsten, B.E. 1961. Operant behavior during anesthesia recovery: A continuous and objective method. *Anesthesiology* Vol. 22: 937-946.

Moreau, J.J. 1973. *Hashish and Mental Illness*. New York: Raven Press.

Morgan, W.P. 1978. The mind of the marathoner. *Psychology Today* Vol. 11: 38-49.

Penfield, W. 1958. *The Excitable Cortex in Conscious Man*. Springfield, Illinois: Charles C Thomas.

Ridley, H.N. 1930. *The Dispersal of Plants Throughout the World*. Ashford, England: L. Reeve.

Schultes, R.E. 1976. *Hallucinogenic Plants*. New York: Golden Press.

Siegel, R.K. 1977. Hallucinations. *Scientific American* Vol. 237(4): 132-140.

Siegel, R.K. & Jarvik, M.E. 1975. Drug-induced hallucinations in animals and man. In: Siegel, R.K. & West, L.J. (Eds.). *Hallucinations: Behavior, Experience, and Theory*. New York: John Wiley & Sons.

Siegel, R.K. & West, L.J. (Eds.). 1975. *Hallucinations: Behavior, Experience, and Theory*. New York: John Wiley & Sons.

Siegmund, O.H. (Ed.). 1973. *The Merck Veterinary Manual*. Rahway, New Jersey: Merck.

Spanos, N.P. & Gottlieb, J. 1976. Ergotism and the Salem Village witch trials. *Science* Vol. 194: 1390-1394.

Tharrington, K. 1979. LSD revisited. *Runner's World* June: 142.

Wasson, R.G.; Ruck, C.A.P. & Hofmann, A. 1978. *The Road to Eleusis*. New York: Harcourt Brace Jovanovich.

West, L.J. 1962. A general theory of hallucinations and dreams. In: West, L.J. (Ed.). *Hallucinations*. New York: Grune & Stratton.

Winters, W.D. 1975. The continuum of CNS excitatory states and hallucinosis. In: Siegel, R.K. & West, L.J. (Eds.). *Hallucinations: Behavior, Experience, and Theory*. New York: John Wiley & Sons.

Wolfe, T. 1968. *The Electric Kool-Aid Acid Test*. New York: Farrar, Straus & Giroux.