chapter 19

Psychedelic Drugs II: The Major Hallucinogens

Hallucinogens are a chemically heterogeneous group of drugs that are capable of inducing hallucinations at normal dose levels. A *hallucination* is a percept-like experience that the individual interprets as real, although it has no objective counterpart (for example, if you believe you see someone standing in front of you, but in fact nobody is there, or if you believe you see a tunnel of light, but the "light" is really inside your head, and not "out there"). People in different cultures around the world have used hallucinogenic drugs for many centuries. But in the older cultural traditions people did not use hallucinogens just to produce entertaining psychedelic light shows in their heads. Rather, in most cases they used hallucinogens as a route to mystical or religious experiences. And they didn't think of it as "using drugs." Rather, they used plants as a religious sacrament and believed that God was in the plant or that God communicated through the plant (Schultes & Hofmann 1979).

First I will discuss the major hallucinogens used in the Americas—psilocybin mushrooms, peyote, and LSD—with an emphasis on their cultural context and reports of subjective experiences. Then I will go into more detail on hallucinations *per se*.

PSILOCYBIN MUSHROOMS

The hallucinogen *psilocybin* is found in several species of mushrooms—popularly known as "magic mushrooms"—found in North America. Most of

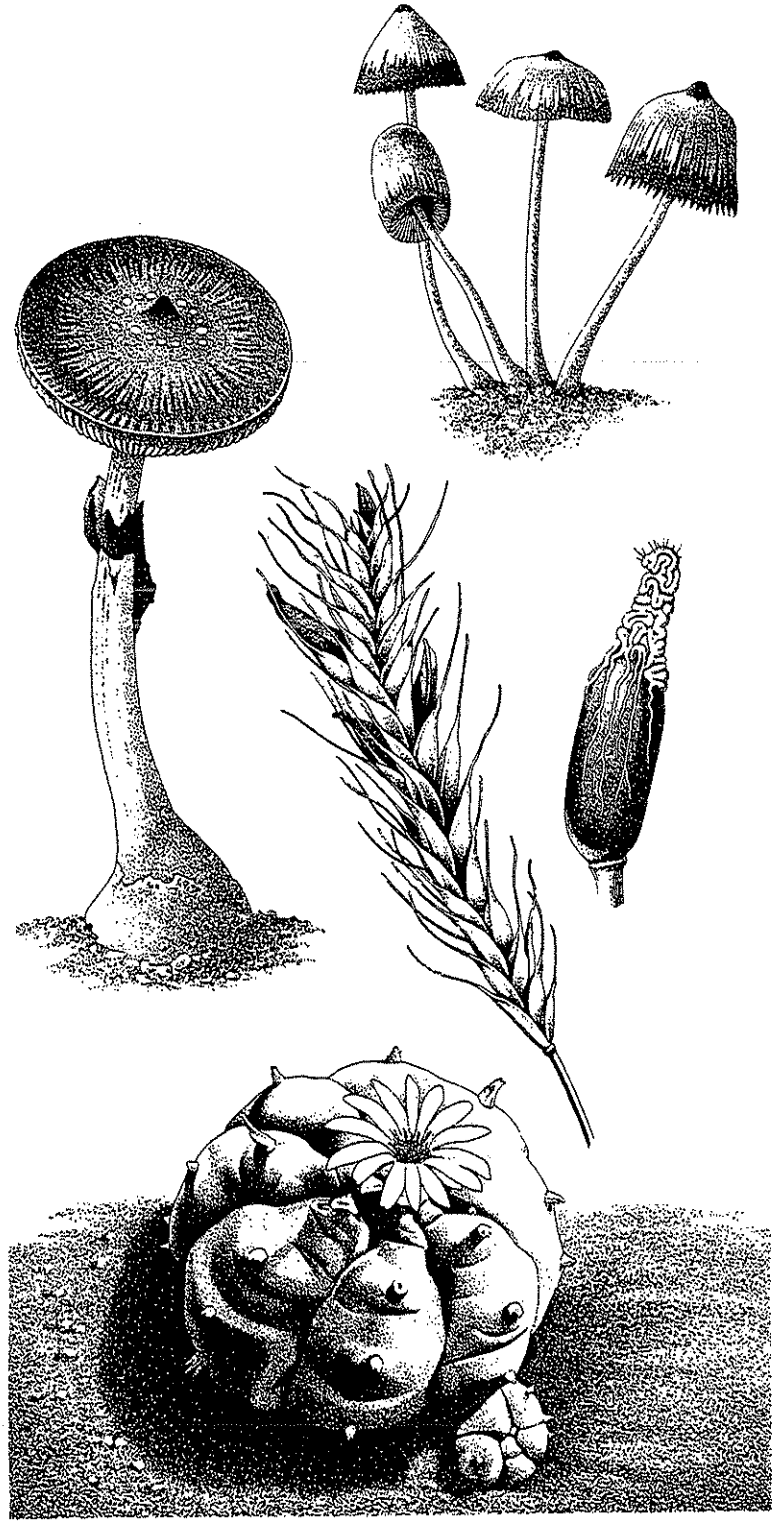
them grow only in Mexico and southern United States, though some are found in northern forests. Psilocybin mushrooms include *Psilocybe mexicana* and several others (Figure 19.1). These mushrooms have been considered sacred in Mexico and Central America for thousands of years, according to archaeological records. When the Spaniards conquered the Aztecs in Mexico in the early 1500s they found an important religious cult that used mushrooms as a sacrament. The Aztecs called the mushrooms *teonanacatl*, which means "God's flesh" (McKim 1986). The Spaniards suppressed the mushroom cult.

In the 1930s it was discovered that magic mushrooms were still being used by natives in southern Mexico. In 1952 Gordon Wasson, a retired banker turned ethnobotanist, established rapport with the Indian natives in Mexico and ate twelve of the mushrooms as part of a religious ceremony. Wasson described his experience as follows:

> It permits you to travel backwards and forward in time, to enter other planes of existence, even (as the Indians say), to know God. . . .
>
> What is happening to you seems freighted with significance, beside which the humdrum events of every day are trivial. All these things you see with an immediacy of vision that leads you to say to yourself, 'Now I am seeing for the first time, seeing direct, without the intervention of mortal eyes'.
>
> Your body lies in the darkness, heavy as lead, but your spirit seems to soar and leave the hut, and with the speed of thought, to travel where it listeth, in time and space, accompanied by the shaman's singing . . . at last you know what the ineffable is, and what ecstasy means. Ecstasy! The mind harks back to the origin of that word. For the Greeks *ekstasis* meant the flight of the soul from the body. Can you find a better word to describe this state? (Crahan 1969, cited in Ray 1978, pp. 371–72).

Wasson's description shows that hallucinogens can produce not only hallucinations, but also emotional reactions and the feeling that one's thoughts and images are profoundly important, though the experience in its details is ineffable and it can be described only in vague generalizations.

When Harvard University psychologist Timothy Leary used magic mushrooms in Mexico in 1960, his experiences led him to become a proselytizer of psychedelic drug use as a route to mystical experiences. From his observations of other people he estimated that psilocybin, when taken in a supportive setting, could induce "intense and life-changing religious experiences" in 40 to 75 percent of subjects (Leary 1967–68). Leary became a guru of the hippie generation of the 1960s, though he lost his position at Harvard because of the controversy over his drug advocacy and questions about the quality of his research (Ray 1978). Leary and his followers used primarily LSD because it was stronger and easier to obtain and to use than magic mushrooms. In recent years, however, many hallucinogenic drug devotees have returned to natural hallucinogens such as psilocybin mushrooms, since it is impossible to be confident that street LSD is really pure LSD (and not PCP or some other drug). Lest you be tempted to search the woods for magic mushrooms, you should be warned that there are many similar-looking mushrooms, and some of them are poisonous. To be "safe" you have to find



exactly the right species and take it in the right dose. The wrong species of mushroom, or too high a dose, could have disastrous effects.

PEYOTE

Peyote (peyotyl) is another natural hallucinogen from Mexico. Peyote is a small, spineless cactus (*Lophophora williamsii*) that grows in the desert (see Figure 19.1). Most of it grows below ground, like a carrot; only the grayish-green pincushion-like top shows above ground. Archaeological evidence indicates that peyote has been used for thousands of years, and like psilocybe mushrooms and morning glory seeds, it was a sacred plant of the Aztecs. They used it as a medicine and to promote visions of the future, and for divination. The Spaniards thought that peyote visions were "satanic trickery" and tried to suppress it. But as with the mushrooms, peyote traditions survived among the Mexican Indians and later spread north to the Plains Indians. Several of the peyote cults combined to form the Native American Church, which was first chartered in Oklahoma in 1918. Efforts were made immediately in Congress to pass laws against peyote use, but the Secretary of the Interior forbade the Indian Bureau from interfering with the religious practices of the Native American Church. In 1970 a formal act of the U.S. Congress recognized the right of the church members to use peyote as a sacrament (McKim 1986; Ray 1978).[1]

To use peyote, the top part of the cactus is cut into slices called "mescal buttons," which are set in the sun to dry. (Mescal buttons should not be confused with the hallucinogenic mescal bean, which is a different plant and is highly toxic [Ray 1978].) The mescal buttons are soaked in the mouth until soft, then chewed and swallowed. They have a bitter, disagreeable taste. Several buttons may be swallowed in a peyote ceremony. Within a few minutes the individual experiences several disagreeable symptoms, including nausea, vomiting, tremor, and incoordination. These symptoms eventually pass, and after an hour or so psychedelic and hallucinatory experiences begin; the subjective effects may last several hours (McKim 1986).

One of the first non-Indian investigators of peyote was Dr. Weir Mitchell, who used a peyote extract. He tried to describe his hallucinatory experience:

> The display which for an enchanted two hours followed was such as I find it hopeless to describe in language which shall convey to others the beauty and splendor of what I saw. Stars, delicate floating films of color, then an abrupt rush of countless points of white light swept across the field of view, as if the

FIGURE 19.1. Natural sources of the main hallucinogens. Psilocybin comes from the mushrooms *Stropharia cubensis* (top left) and *Psilocybe mexicana* (top right). LSD was originally synthesized from an alkaloid in ergot (*Claviceps purpurea*), a fungus that grows on cereal grains; an ergot-infested rye seed head is shown (center) together with a larger-scale drawing of the ergot fungus. Mescaline is from the peyote cactus *Lophophora williamsii* (bottom). [From Barron, F., Jarvik, M. E., & Bunnell, S. (1964, April). The hallucinogenic drugs. *Scientific American*. Copyright © 1964 by Scientific American, Inc. All rights reserved.]

> unseen millions of the Milky Way were to flow in a sparkling river before my eyes . . . zigzag lines of very bright colors . . . the wonderful loveliness of swelling clouds of more vivid colors gone before I could name them (1896, cited in DeRopp 1957, p. 34).

Then, Mitchell reported, "A white spear of grey stone grew up to huge height, and became a tall, richly furnished Gothic Tower of very elaborate and definite design, with many rather worn statues standing in the doorways" and decorated by huge precious stones, "like masses of transparent fruit," of green, purple, red, and orange. Later, he looked over the edge of a huge cliff "that seemed to project over a gulf of unseen depth." A huge bird claw of stone perched on the edge. From the bird leg, folds of half-transparent purple stone floated out for miles. "Now and then soft golden clouds floated from these folds . . . and things like green birds fell from it, fluttering down into the gulf below." Finally, he saw the beach of Newport with huge rolling waves "of wonderfully pure green, or red or deep purple" breaking on the beach.

Peyote contains some thirty different psychoactive chemicals, of which *mescaline* has been isolated and identified as the one mainly responsible for the vivid colors and other visual hallucination effects. Mescaline is chemically similar to the neurotransmitter norepinephrine. Aldous Huxley described his mescaline experiences in *The Doors of Perception* (1954/1970), where he concluded:

> To be shaken out of the ruts of ordinary perception, to be shown for a few timeless hours the outer and the inner world, not as they appear to an animal obsessed with survival or to a human being obsessed with words and notions, but as they are apprehended, directly and unconditionally, by Mind at Large—this is an experience of inestimable value to everyone and especially to the intellectual (p. 73).

If only there was a way for healthy, prepared people to legally have such an educational experience without opening up the possibility of drug overuse and abuse. But Huxley also warned of the possibility of bad trips on mescaline. For any psychedelic drug, the possibility of bad trips—characterized by depression, anxiety, and possibly panic—is greater for people who are emotionally unstable, depressed, or undergoing great stress in their lives.

LSD

Though traditional cultures used plants to produce hallucinations, the most popular hallucinogenic during the hippie era was a synthetic drug, LSD (lysergic acid diethylamide). Like psilocybin, the chemical structure of LSD is similar to the neurotransmitter serotonin. LSD was more popular than mescaline or psilocybin because it is more potent and easier to synthesize, and hence less expensive per dose. The effective hallucinogenic dose for LSD is only about 0.05 mg; for psilocybin it is about 6 mg; mescaline, about 200 mg. (These doses are ED_{50}s, which means that they are effective for 50 percent of

adult users [McKim 1986].) LSD is taken orally. LSD's effects begin within about 30 to 90 minutes and last for a few hours, more or less, depending on the dose. *Tolerance* develops very quickly, so that with repeated daily doses the dose has to be increased to have the same effect; tolerance subsides after a few days of abstenance. *Cross-tolerance* occurs between LSD, psilocybin, and mescaline, such that a dose of one drug will reduce the effectiveness of a dose of one of the other drugs taken several hours later. Cross-tolerance is greater between LSD and psilocybin, because of their greater chemical similarity; they seem to produce identical psychological effects at functionally equivalent doses. LSD, psilocybin, and mescaline produce similar physiological symptoms, including pupil dilation, increased pulse rate and blood pressure, and elevated body temperature. Headache, nausea, and vomiting sometimes occur. None of these drugs are physiologically addictive (McKim 1986; Ray & Ksir 1987).

LSD was first synthesized in 1938 by Albert Hofmann, working at the Sandoz Laboratories in Basel, Switzerland. It was synthesized from ergot alkaloids (taken from a highly toxic mold that sometimes grows on rye grain [Figure 19.1]) in the course of a search for useful drugs, because of its chemical similarity to other known psychoactive drugs. It was not until 1943 that LSD's hallucinogenic effects were discovered by Dr. Hofmann, after he accidentally ingested some. Apparently he absorbed it through his fingers while working in the laboratory. His report is especially interesting in view of the fact that he did not know that he had taken a drug, and thus had no prior expectations about what would happen:

> Last Friday, April 16, 1943, I was forced to stop my work in the laboratory in the middle of the afternoon and to go home, as I was seized by a peculiar restlessness associated with a sensation of mild dizziness. Having reached home, I lay down and sank in a kind of drunkenness which was not unpleasant and which was characterized by extreme activity of imagination. As I lay in a dazed condition with my eyes closed (I experienced daylight as disagreeably bright) there surged upon me an uninterrupted stream of fantastic images of extraordinary plasticity and vividness and accompanied by an intense, kaleidoscope-like play of colors. This condition gradually passed off after about two hours (Hofmann 1968, pp. 184–85; cited in Ray & Ksir 1987, p. 276).

A few days later Hofmann took a high dose of LSD (0.25 mg) deliberately. For the first few hours he experienced some unpleasant symptoms including dizziness, delirium, visual disturbances, coldness and loss of feeling in the hands, choking sensations, and fear that he might be losing his mind. Sometimes he felt as if he was out of his body (tripping). After six hours he felt better and reported experiencing "an unending series of colorful, very realistic and fantastic images." He also experienced *synesthesia*, where sensations in one modality are translated into images in a different modality: "... all acoustic perceptions (e.g., the noise of a passing car) were transformed into optical effects, every sound causing a corresponding colored hallucination constantly changing in shape and color like a kaleidoscope."

Subsequent to Hofmann's early reports, a number of studies of LSD's

psychological effects and potential applications were carried out, mostly in the early 1960s. It was initially thought that LSD produced psychotic-like symptoms (hence the term, *psychotomimetic* drug) and that LSD might be useful for producing experimental psychosis for the purpose of understanding natural psychoses. However, investigators later came to realize that there are a number of differences between LSD effects and psychosis. For example, whereas LSD produces primarily visual hallucinations, schizophrenic hallucinations are primarily auditory, consisting of "hearing voices," often accompanied by paranoid reactions. Other studies suggested that LSD might be useful for psychotherapy, for alcoholism treatment, and for reducing pain and depression of patients with terminal cancer. However, these studies were controversial, and government agencies soon stopped funding this type of research.

In the 1960s LSD became a common street drug, popular with hippies. Some users, such as Leary, advocated LSD as a route to self-understanding and spiritual discovery. Most, however, probably used LSD just to produce a pleasant high with an entertaining hallucinatory movie show. LSD was unpopular with the establishment because of its association with hippies and their liberal, antimaterialist, anti–Vietnam War values. LSD users (who were also marijuana users) tended to spend a lot of time sitting around in apparently useless contemplation or listening to rock music. LSD effects were not always pleasant. Some users had bad trips with panic reactions. Although personality and stress factors are undoubtedly important in producing bad trips, another contributing factor was "bad acid," that is, LSD that was contaminated with other substances or, in some cases, was not really LSD but another drug entirely, such as PCP ("angel dust"). Another negative effect of LSD is *flashbacks*, where LSD-like experiences, usually unpleasant ones, are experienced several days or months after LSD was used. Flashbacks do not occur in everyone. They are hard to predict, though they seem to be most likely at times of stress. Some researchers suspect that LSD causes lasting brain changes that can produce flashbacks, but this has not been clearly proven (Ray & Ksir 1987).

Research on effects of LSD in humans pretty much ground to a halt in 1974, when the U.S. National Institute of Mental Health (NIMH) stopped funding university-sponsored research on that topic. The National Cancer Institute and the National Institute on Alcohol Abuse and Alcoholism stopped supporting LSD research in 1975. The reason given for dropping LSD research was that it was "unproductive," though it could be argued that it was stopped prematurely and that valuable new discoveries might have been made in new research using better methods and building on what had been learned earlier. Undoubtedly social and political pressures also influenced the decision to stop funding LSD research. Popular tastes changed, too. LSD use apparently reached its peak around the time of the Woodstock music festival in 1969. LSD use declined when the aging hippie generation got tired of it and the next generation of young people turned back toward materialism and had less interest in inner exploration. For dealers in illegal drugs, LSD is unattractive because it is not addictive and virtually nobody uses it on a daily basis. Today's drug dealers find cocaine to be more profitable than LSD.

The LSD trip. Every LSD trip is different in its details, depending on the interaction of drug factors (dose, time), personal factors (personality, mood, expectations, etc.), and situational factors (physical and social setting). Drawing on descriptions by Houston (1969) and others, Ray (1978) synthesized a description of "typical" reactions to LSD as a function of dose level and time since the drug was taken. (Presumably this description applies also to psilocybin, since LSD and psilocybin appear to have the same subjective effects at functionally equivalent doses.) In Ray's description, the user goes through a series of five temporal stages or levels in which different effects (autonomic, sensory, etc.) are most prominent. The higher the dose, the higher the level that can potentially be reached. However, personal factors are also important: successively higher levels are reached by fewer and fewer people. Also, at successively higher levels the potential for meaningful experiences, either good or bad, increases.

Ray's five levels of LSD response are as follows: (1) *Autonomic* level: Autonomic reactions (increased heart rate, etc.) develop gradually over the first 20 minutes, when the individual may feel dizzy or hot and cold or have a dry mouth. (2) *Sensory* level: Sensory effects develop over the next 20 to 50 minutes, including altered body sensations, altered color and space and time perception, sensory synesthesias, and visual hallucinations. Cognitive changes also occur in this stage, where things, people, and experiences may be categorized differently because new similarities and relationships are noticed; these new ways of categorizing things may be carried over into the nondrug state. LSD is best known for its sensory effects; most trips don't go beyond this level. (3) *Recollective-analytical* level: The individual's own personality and life history are the center of focus, and aspects of the self may be recategorized and reevaluated. The result may be increased self-understanding and a positive attitude or anxiety and panic. (4) *Symbolic* level: ". . . there is an appreciation of our oneness with the universal concepts expressed in myths and in the archetypes of Jungian psychology" (Ray 1978, p. 360). (5) *Integral* level: Mystical experiences occur, and the individual has a feeling of unity with God or the universe. For some people, mystical experiences can have profound effects on their values and life course. One would expect wide differences in reactions at the two highest levels, depending on individual differences in knowledge of universal concepts and prior religious beliefs. At the higher levels, particularly, LSD users have the feeling that their thoughts are profound and valuable. Sometimes negative reactions occur. For example, the feeling of loss of self and unity with the universe may be a mystical religious experience for some but a frightening depersonalization experience for others.

Since visual hallucinations are a dramatic and commonly experienced subjective effect of LSD and other hallucinogens, I will go into some detail on hallucinations in the next section.

HALLUCINATIONS

Slade and Bentall (1988) defined a true hallucination as: "Any percept-like experience which (a) occurs in the absence of an appropriate stimulus, (b)

has the full force or impact of the corresponding actual (real) perception, and (c) is not amenable to direct and voluntary control by the experiencer" (p. 23). An example would be a schizophrenic who believes he hears a voice—perhaps the voice of God—speaking to him, when in fact nobody is speaking. The most critical feature of true hallucinations is their apparent reality. The hallucinated voice or object seems to be "out there," rather than inside the subject or patient's head. Hallucinations have been compared with vivid mental images, but hallucinations are not necessarily vivid.

A *pseudohallucination* is a perceptual experience that the individual knows not to be real, though it may be just as vivid and spontaneous as a true hallucination (Siegel & Jarvik 1975; Slade & Bentall 1988). In many cases people who have taken hallucinogenic drugs are aware that their perceptual experiences are caused by the drug, and hence pseudohallucinatory by definition. Much confusion has been caused by the practice of some writers of lumping together true hallucinations with pseudohallucinations, such as vivid mental images.

Hallucinations should also be distinguished from *illusions*, which are misperceptions or misinterpretations of objective reality. Illusions occur as a result of the normal functioning of the sensory-perceptual system in an unusual situation, such that reality is misperceived (for example, the Ames distorted room [pictured in many general psychology textbooks], where a room without right angles or rectangular walls is perceived as an ordinary room when viewed with one eye from a certain position). Illusions occur as a result of knowledge and assumptions leading to certain expectations, which automatically influence our sensory perceptions. Illusions involve the misperception of objects (or sounds, etc.) that are really there, whereas the prototype hallucination occurs in the complete absence of real objects that could be misperceived.

There are some transition cases between hallucinations and illusions, which we may term *semi-hallucinations*, where there is a genuine sensory event but its misperception is so drastic as to be clearly based more on imagination than on ordinary perceptual processes (for example, when the wind is making noises in the trees and the camper, lying in his tent, believes that he hears voices, though there are no voices [the "voices in the wind" effect]). Perhaps many or most hallucinations are really semi-hallucinations in this sense, though the relevant sensory event has not been identified. Slade and Bentall's (1988) definition of hallucination encompasses semi-hallucinations, by specifying that the percept-like experiences occur in the absence of an *appropriate* stimulus; thus, hallucinations do not have to occur in the absence of *any* stimulus.

Systematic Analysis of Drug-Induced Visual Hallucinations

Starting in 1926, Heinrich Klüver (1966) began investigating visual hallucinations produced by mescaline. Comparing the reports of a variety of subjects, he noted that most of the hallucination patterns or designs fell into four categories, which he termed *form constants*. The four types were: (1) lattice (also called grating, fretwork, filigree, honeycomb, or chessboard); (2)

cobweb-like; (3) tunnel (also called funnel, alley, cone, or vessel); and (4) spiral. The form constants had varied and saturated colors, intense brightness, and symmetrical configuration. They could occur with the eyes closed, but with the eyes open they seemed to be projected in space at about reading distance. They varied greatly in apparent size and generally could not be voluntarily controlled. Klüver noted that the same form constants appear in a variety of other situations, including the hypnagogic (drowsy presleep) state, in insulin hypoglycemia, and occasionally in fever deliriums. Other investigators have noted form constants occurring in other situations, including epileptic seizures, schizophrenia, advanced syphilis, migraine headache, sensory deprivation, constant invariant photostimulation, crystal gazing, electrical stimulation, and a variety of hallucinogenic and toxic drugs (Siegel 1977). The fact that similar hallucinatory form constants occur in such a wide variety of situations suggests that the same underlying mechanisms are involved in the different situations.

Klüver's *simple form constants* are characteristic of only the first of three stages of hallucinogen-induced imagery. *Complex images*—images that include meaningful symbols and forms (such as animals, faces, familiar objects, and landscapes)—occur in the second and third stages. In the second stage (*complex combined images*), meaningful forms (images of animals, objects, faces, etc.) are combined with form constants (such as spirals and lattices) by superimposing meaningful forms on, or incorporating them into, form constants (see Figure 19.4, upper right panel). In the third stage (*complex memory images*) the form constants disappear and meaningful dream-like scenes appear, with people, landscapes, and so on (Balestrieri 1964; Siegel 1977).

Siegel's study. Ronald K. Siegel (1977; Siegel & Jarvik 1975) did a systematic analysis and comparison of visual hallucinations produced by a variety of psychoactive drugs. He was interested in several dimensions of the visual images, including: (1) form (simple form constant patterns as well as complex image meaningful forms); (2) colors; (3) movement (such as linear, explosive, rotational, pulsating); and (4) action patterns (applying only to complex images, such as actions by objects, image combinations, scene changes). A major problem in research on hallucinations is that it depends upon the subjects' introspective verbal reports, and different subjects may use different vocabularies to describe similar-looking images, thus making it hard to compare their experiences. Siegel overcame this problem by training the subjects to use an image classification system prior to the drug sessions. For example, they were taught to classify and name the forms in a set of slides with several examples each of webs, lattices, spirals, tunnels, and so forth (see Figure 19.2). Other slides were used to train the subjects to correctly name various colors and movement patterns. After sufficient training the subjects were able to correctly name the form, color, and movement pattern for each pattern in a series of rapidly presented slides, including new ones. The purpose of the speeded image-naming sessions was to prepare subjects for the drug test sessions, where it was expected that hallucinogenic drugs would produce rapidly changing images.

In the test sessions, subjects lay on their backs, alone, in a completely dark, soundproof chamber, with their eyes open. They were instructed to

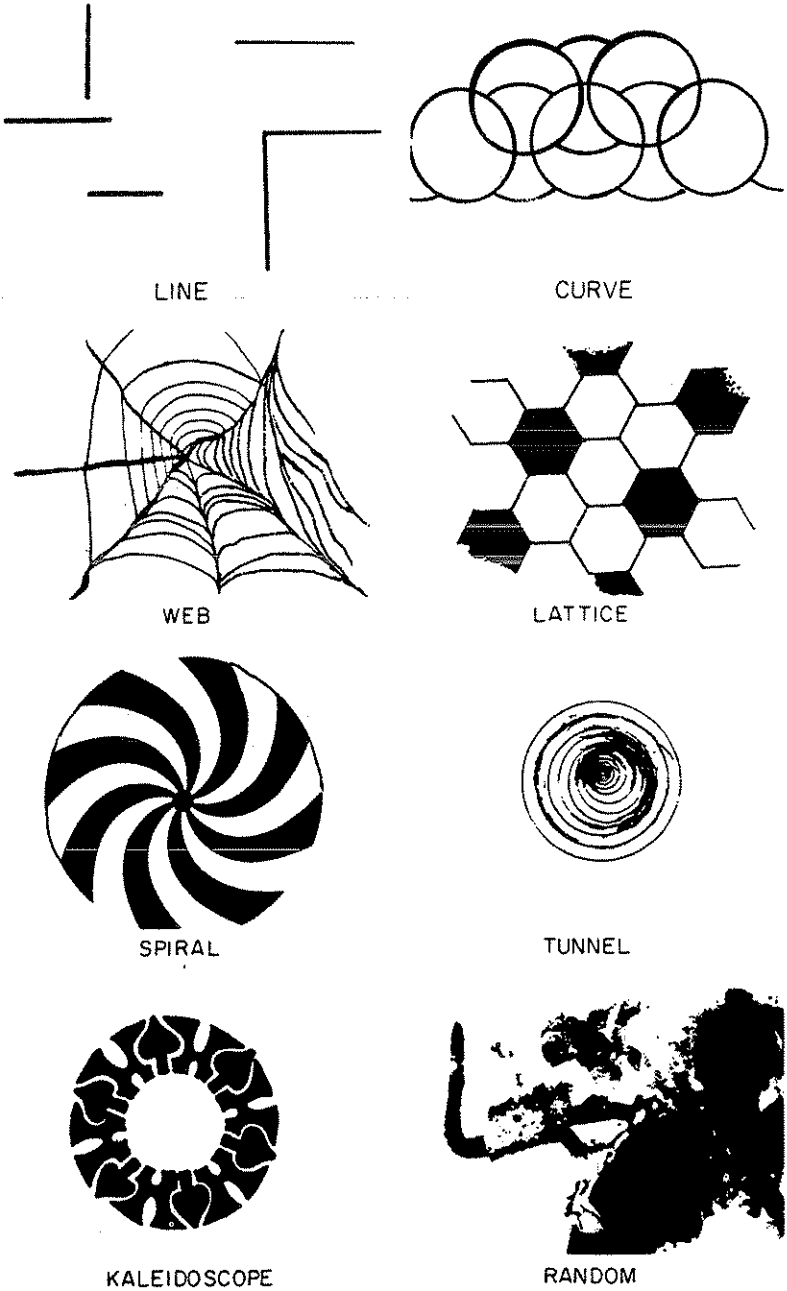


FIGURE 19.2. Examples of slides used to train subjects to classify and name various types of forms in Siegel's hallucination study. [From Siegel, R. K., & Jarvik, M. E. (1975). Drug-induced hallucinations in animals and man. In R. K. Siegel & L. J. West (Eds.), *Hallucinations: Behavior, experience, and theory* (pp. 81–161). New York: Wiley. Copyright © 1975 by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.]

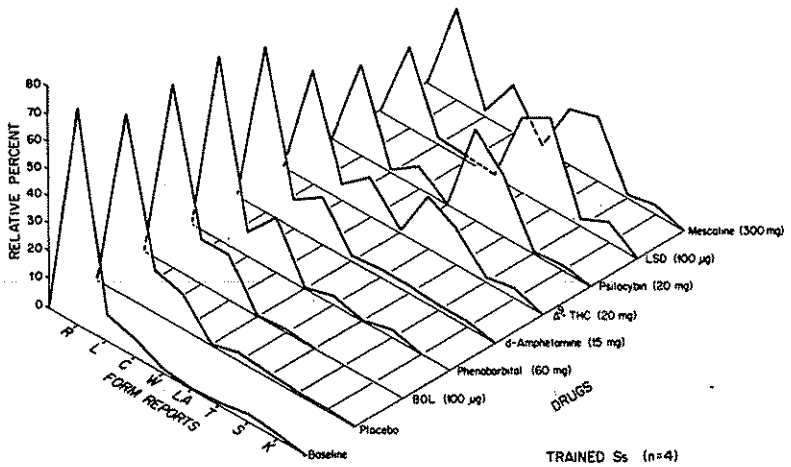
report continuously on their visual images, using the previously trained categories except when they described complex (meaningful) images. Each subject was tested in several sessions, a week apart, with a different drug in each session. The drugs included mescaline, LSD, psilocybin, THC, d-amphetamine (a stimulant), phenobarbital (a barbiturate sedative), and BOL (a drug that, like LSD, blocks serotonin neurotransmission, but is not known to produce hallucinations). There were also placebo sessions and baseline sessions (no drug or placebo). Each session lasted about six hours.

Data for the simple image reports are presented in Figure 19.3, with the percentage distributions in various form, color, and movement categories shown in the top, middle, and bottom graphs, respectively. Some 67 percent of the reports were simple forms (like Klüver's form constants); the other reports involved complex images. Reports from baseline and placebo could be characterized largely as black and white images of random forms moving about aimlessly.

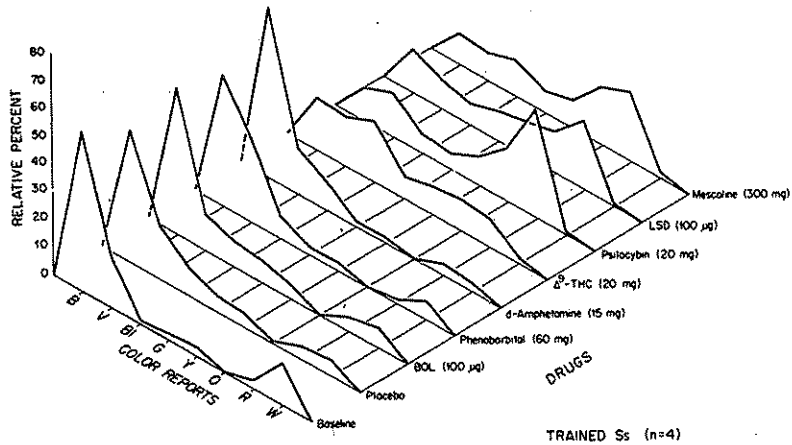
In general, simple image reports for amphetamine, phenobarbital, and BOL sessions did not differ significantly from placebo or baseline sessions. However, reports for the major hallucinogens (mescaline, LSD, psilocybin) and THC sessions were largely similar to each other, and different from placebo and baseline sessions. (1) Forms: About 90 to 120 minutes after ingestion of hallucinogens or THC, subjects started perceiving mostly lattice and tunnel forms. In some cases a bright central spot produced a tunnel-like effect. The lattice and tunnel forms were often combined in the same image, such as a tunnel with lattice-patterned walls (Figure 19.4, upper right). (2) Colors: The hallucinogens (mescaline, LSD, psilocybin) induced predominantly red, orange, and yellow patterns. THC produced a higher proportion of blue reports than did the other drugs. (The major hallucinations often produced blue images early in the session, but longer wavelengths predominated in the middle and later part of the session.) (3) Movement patterns: The hallucinogens and THC induced mostly explosive (outward from center) and rotational motion patterns. Subjects noted that all images tended to pulsate or flicker, no matter what other motion they showed.[2]

Complex images, with meaningful forms, did not appear until well after the shift to lattice-tunnel forms in the hallucinogen sessions. Once started, complex images tended to be the most common type (43 to 75 percent of reports). In *complex combined images*, meaningful forms often overlaid lattice and tunnel form constants (Figure 19.4, upper right panel). In other complex combined images, meaningful forms were duplicated and repeated, often in symmetrical geometric arrays.[3]

In later stages of complex imagery, most of the images lost their geometric quality, and meaningful forms occurred in *complex memory images*. Complex memory images are meaningful scenes constructed from meaningful forms (landscapes, people, animals, objects) stored in the individual's long-term memory. Some of the memory images were scenes from childhood or from occasions when the subject had undergone strong emotional experiences. Others were elaborate and fantastic novel scenes. The scenes often had unusual perspectives (Figure 19.4). During the memory image stage, a shift from pseudohallucination to true hallucination occurred:



TRAINED Ss (n=4)



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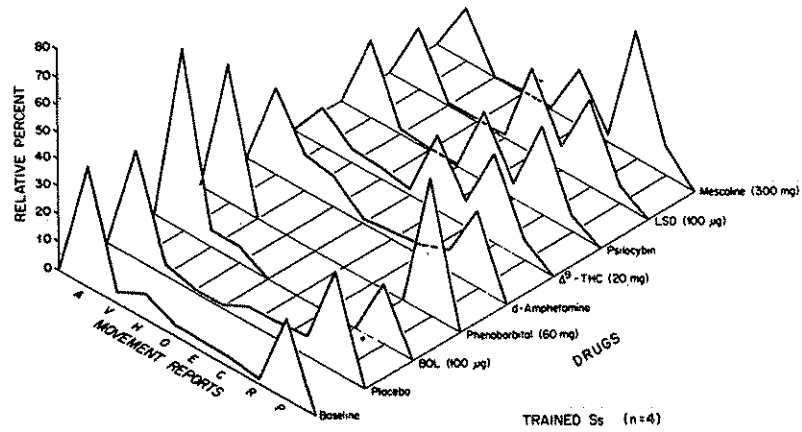

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> Initially subjects reported that form imagery was like a slide show or movie located about two feet in front of their eyes. As the high-dosage hallucinogen sessions progressed, subjects frequently claimed that they became part of the imagery itself. . . . It was at these times that subjects stopped using similes ["like," "as if"] in their imagery reports and started reporting that images were, in point of fact, really what they appeared to be (Siegel & Jarvik 1975, p. 128).

At the true hallucination stage subjects frequently reported feeling dissociated from their bodies.

Though the complex images changed rapidly—sometimes several changes per second—the changes were not random. Successive scenes usually included some visual features from the preceding scene, and novel features could have associative connections to features of the previous scene. In the middle of the sessions the subjects were taken outdoors for fifteen minutes, where they wore blindfold goggles and lay on the grass. During the outdoors intervals memory imagery decreased, and there was an "increase in reports of birds, planes, trees, and other objects, often triggered by auditory and tactile cues in the outdoor garden setting" (Siegel & Jarvik 1975, p. 130).[4]

How Hallucinations Are Produced

According to Siegel and Jarvik (1975), the similarity of the visual hallucinations produced by a variety of hallucinogens suggests that the same mechanisms are involved for the different drugs. The same mechanisms may also operate when people have visual hallucinations in other situations (like the hypnagogic state, migraine headaches, etc.) to the extent that the hallucinations are similar to the drug hallucinations. It is important to note, however, that the mechanisms are likely to be different for the first hallucination stage—characterized by form constants—than for later stages characterized by meaningful forms and, sometimes, by complex and fantastic scenes.

Some authors have suggested that the first-stage form constants are produced by *entoptic* (within the eye) structures and events, such as the pattern of retinal blood capillaries or "floater" blood cells within the capillaries. Perhaps hallucinogens somehow increase perception of entoptic events that normally go unnoticed. Siegel and Jarvik argued against the entoptic explanation for two reasons. First, a detailed analysis of entoptic events such as capillary patterns shows that they are not really as similar to hallucinogenic form constants as was originally assumed; hallucinogenic form constants are more symmetrical and organized. Second, perception of such entoptic

FIGURE 19.3. Mean percent distribution of form (top), color (middle), and movement (bottom) reports for trained subjects in each six-hour high-dose drug condition. Form reports: R = random, L = line, C = curve, W = web, LA = lattice, T = tunnel, S = spiral, K = kaleidoscope. Color reports: B = black, V = violet, Bl = blue, G = green, Y = yellow, O = orange, R = red, W = white. Movement reports: A = aimless, V = vertical, H = horizontal, O = oblique, E = explosive, C = concentric, R = rotational, P = pulsing. [From Siegel, R. K., & Jarvik, M. E. (1975). Drug-induced hallucinations in animals and man. In R. K. Siegel & L. J. West (Eds.), *Hallucinations: Behavior, experience, and theory* (pp. 81–161). New York: Wiley. Copyright © 1975 by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.]

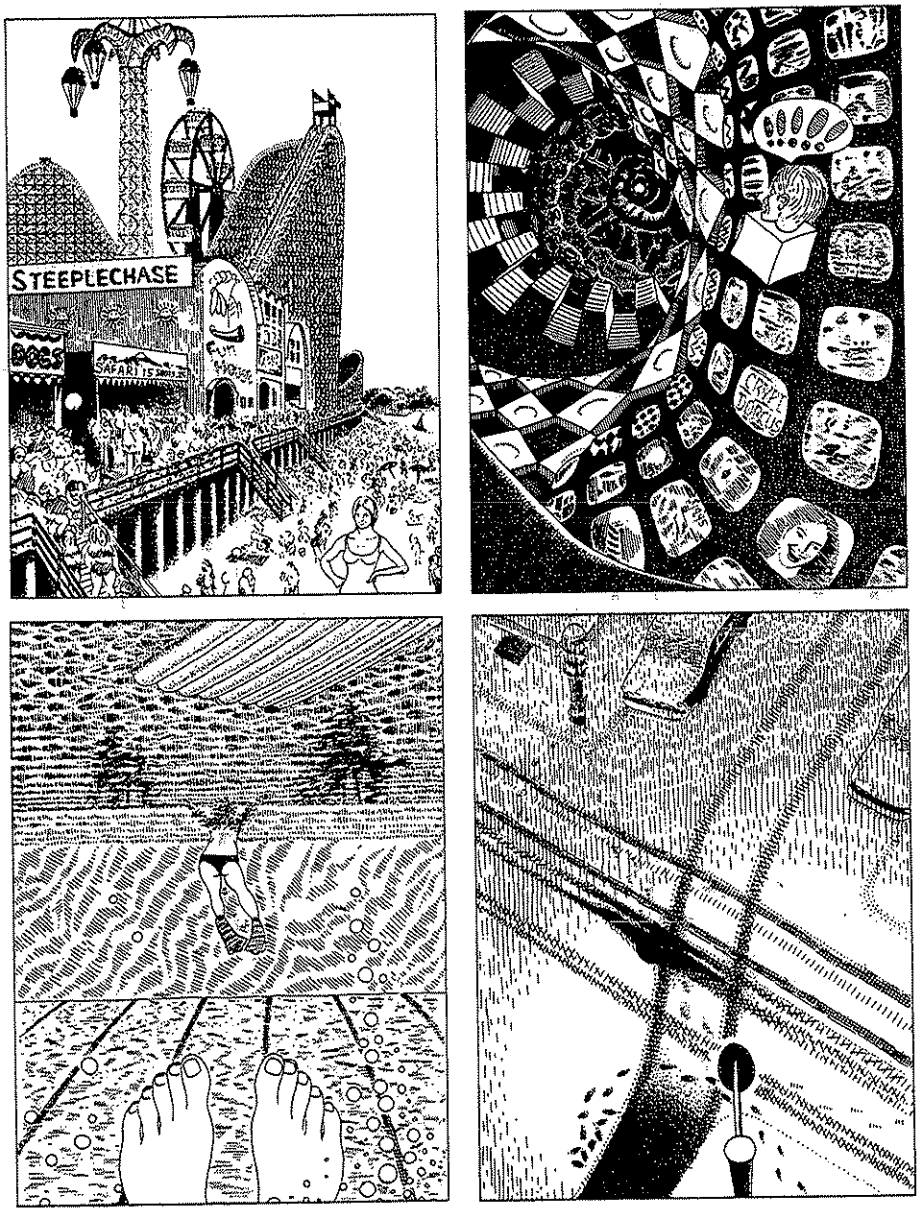

FIGURE 19.4. Examples of complex images—images with meaningful forms—from the later stages of hallucinogen intoxication. The upper right panel shows a complex combined image with meaningful forms incorporated into a simple form constant (spiral). The other panels show complex memory images involving meaningful scenes constructed from information in the individual's long-term memory. Memory-image scenes often seem to be viewed from unusual perspectives. "Characteristic perspectives include a distant scene (with abundant detail) often recognized as an event that was experienced in childhood (upper left), a scene viewed as if the subject were under water, looking up toward and through the surface (lower left), and an aerial perspective (lower right), which may be accompanied by sensations of floating and flying." [From Siegel, R. K. (1977, April). Hallucinations. *Scientific American, 237,* 132–40. Copyright © by Scientific American, Inc. All rights reserved.]

events requires light, whereas the form constants occurred in Siegel's subjects even when they were tested in complete darkness.

However, one type of entoptic event, *phosphenes*, does not require light. Phosphenes are sensations of light that occur in total darkness, particularly as the eye becomes more dark adapted and the individual adopts a relaxed, receptive attitude. Phosphenes appear as rapidly changing patches of pastel colors, sometimes with more elaborate patterns such as lattices and spirals. The patterns can be intensified and altered by gentle pressure on the eyeball, produced by closing the eyelids very tightly or by gentle pressure with a finger on the closed eyelid (Oster 1970). Phosphenes are associated with neuronal discharges in the retina, lateral geniculate, and visual cortex. Oster pointed out their similarity to first-stage visual images produced by hallucinogenic drugs.

Another type of internally produced visual experience is the *fortification illusions*—patterns, usually white or monocolored, composed of angular lines or dots—experienced just prior to and during migraine headaches (Richards 1971). The migraine visual patterns are associated with neural activity in the visual cortex.[5] Also, images of moving or stationary colored lights, simple lines, and more complex patterns can be produced by electrical stimulation of neurons at various places in the visual cortex and adjacent areas.

Siegel and Jarvik (1975) suggested that the form, color, and movement constants produced by hallucinogens are a result of drug-induced increases in activity in the visual pathway of the central nervous system, particularly in the visual cortex. The visual nervous system is identical for people in different cultures, and it is noteworthy that drug-induced form-constant hallucination patterns are similar for people of different cultures (Siegel & Jarvik 1975). This observation supports the idea that visual hallucination patterns are affected more by visual nervous system excitation patterns than by prior belief systems.

More complex images, with meaningful forms and scenes, are constructed from information stored in the individual's memory. However, such images are not mere replays of scenes from memory. Like night dreams, they are original, dynamic, organized constructions that incorporate elements from memory. Siegel and Jarvik suggested that increased arousal produced by hallucinogenic drugs may activate memory-storage systems. At the same time, external sensory input and attention to external tasks are reduced, resulting in attention being shifted to internal images. At very high levels of arousal the images appear to be projected externally, and at that point true (believed-in) hallucinations occur.[6] (The first stage of complex imagery, where meaningful images are combined with form constants, may be regarded as an intermediate stage between the simple form constant stage and the complex memory image stage.)

Thus, like the color-form constants, meaningful memory-based images in drug hallucinations are a result of nervous-system excitation. However, while color-form constants are closely similar across cultures, memory-image contents differ between different individuals and cultures, depending on differences in memory contents. Also, one would expect an individual's *interpretation* of a hallucination's meaning—for example, as a religious revelation

or as an uncovering of personal unconscious contents—to be affected by his or her prior belief systems, which would in turn be affected by the culture.

Slade and Bentall (1988; Bentall 1990) argued that the critical factor in true hallucinations is the subject's or patient's failure of "reality discrimination," where imagination becomes confused with reality. Siegel and Jarvik's theory of drug hallucinations explains how vivid memory images come to be produced, but it does not explain why these images are confused with reality. Indeed, in most cases hallucinogen users are aware that their vivid visual images are imaginary, though a bad trip could occur if the images are believed to be real. When true hallucinations do occur, one factor may be a disruption of logical analysis and automatic reality-checking functions of the brain. Another factor may be expectancy, perhaps related to cultural or religious beliefs, which would predispose some people to interpret unusual images as real (Slade & Bentall 1988).

CONCLUDING COMMENTS ON PSYCHEDELIC DRUGS

The altered states of consciousness induced by psychedelic drugs are interesting in their own right, and they also have implications for understanding consciousness and mind/brain relationships. Support for a materialist view on the mind-body problem is provided by the fact that both conscious experience and cognitive performance can be altered by psychedelic drugs, as well as other psychoactive drugs. Whereas brain damage can cause permanent changes in consciousness and cognitive performance, drugs can cause temporary changes by altering neurotransmission in the otherwise normal brain. Even though neuroscientists have a long way to go to explain *how* the brain produces the variety of conscious experience and controls cognitive performance, the effects of drugs and brain damage leave no doubt that conscious experience and cognitive performance are functions of the material brain, and not of some immaterial mind stuff.

Whenever subjective or behavioral effects of a drug are very similar in different individuals, the implication is that the effects are due to alterations in particular brain circuits or subsystems. For example, simple form constant hallucinations, produced by hallucinogenic drugs, are similar for different individuals and for people in different cultures. Apparently, they are caused by effects of the drugs on the brain's visual system. Also, effects of marijuana on memory can be explained in terms of drug effects on neurotransmission in parts of the brain's memory system (such as the hippocampus).

On the other hand, some psychedelic drug experiences are quite variable from one individual to another. For example, Tart (1971) found that subjective responses to marijuana vary widely, and some subjective effects occur only rarely (for example, paranormal experiences). With hallucinogenic drugs, some people experience their vivid images as especially vivid daydream fantasies, whereas others experience them as real perceptions—true hallucinations. Some people have mystical or religious experiences with hallucinogenic drugs, while most people have merely entertaining experiences.

When a drug induces effects that vary widely between different individuals—and within the same individual at different times and settings—the implication is that the effect is not produced simply by neurotransmission changes in a particular brain subsystem. Rather, it suggests that a mind/brain system that interprets lower-level inputs to produce (construct) conscious experience is producing different interpretations for different individuals. Different interpretations result from individual differences in expectancies, beliefs, knowledge, and personal past experiences stored in memory. In some cases, a relatively unchanged interpreter may be interpreting altered inputs from altered subsystems (such as vision, proprioception, memory, emotion). In other cases, the functioning of the interpreter system itself may be altered by the drug, either independently or along with changes in lower-level subsystems. For example, hallucinogens can induce experiences of vivid, complex, meaningful images that vary between individuals. In the true hallucination experience—where people believe that their mental images are real—it is clear that the functioning of the interpreter system itself has been altered, since it cannot distinguish between vivid images and reality. In cases where people have vivid fantasy images but know that they are imaginary (pseudohallucinations), it appears that the interpreter system is still functioning normally but altered lower-level visual and memory systems are producing altered inputs to the interpreter.[7]

Drug research and the study of consciousness. Obviously, we cannot do experimental brain surgery on humans to study the relationships between altered mind/brain subsystems, cognitive performance, and conscious experience. Natural accidents provide opportunities to study such relationships (see Chapter 6), but such injuries occur under uncontrolled conditions, and almost every case is different from the others. Controlled research with psychedelics and other psychoactive drugs could potentially provide valuable insights about the functional relationships between various specialized mind/brain subsystems and a (hypothesized) conscious interpreter system and/or executive control system. We need to learn more about the interaction of various factors (drug, personal, situational) in producing subjective and behavioral effects.

Most of the research on subjective and behavioral effects of psychedelic drugs has been atheoretical. That is, it has not been guided by theories of mind/brain functioning. Rather, it has been designed simply to discover some of the psychological/behavioral effects of the drugs, and has often used rather arbitrary procedures and measurements that have little relationship to those used in basic theory-related research in mainstream psychology. Basic research on subjective, cognitive, and behavioral effects of psychedelic and other psychoactive drugs could make valuable contributions for developing and testing theories of mind/brain functioning. Such research should be guided by current theories drawn from cognitive psychology, social-personality psychology, and neuropsychology, as well as other branches of neuroscience. In principle, such research could be done safely by careful selection of drugs, doses, procedures, and volunteer subjects. However, it is virtually impossible to do such basic research, because of federal laws and policies restricting drug research. Even marijuana—nonaddictive, relatively

mild in its effects, and apparently harmless when administered occasionally under controlled conditions—is treated essentially the same as dangerous narcotics as far as drug research policies are concerned.

In closing, I want to reiterate what I said earlier in conjunction with discussion of the marijuana paradox: subjective experiences produced by drugs may not correspond to the results of objective behavioral measures. We should keep in mind that conscious experience is the essence of human existence. It is an important and legitimate topic of study in its own right. In order to increase our understanding of conscious experience and factors that affect it, it would be worthwhile to have more controlled research on the effects of psychedelics and other psychoactive drugs, in interaction with other factors, on conscious experience.

SUMMARY

Hallucinogens are drugs that can produce hallucinations at normal dose levels. The major hallucinogens used in the Americas include psilocybin mushrooms ("magic mushrooms"; active ingredient, psilocybin); peyote (active ingredient, mescaline); and the synthetic drug LSD. Although altered perceptions or hallucinations are the most common effects of hallucinogens, some people experience profound self-revelatory and/or mystical experiences. LSD was initially thought to be a "psychotomimetic" drug that could produce psychotic symptoms, but now it is realized this is not the case. However, some users have experienced bad trips with panic reactions and, later, flashbacks. None of these hallucinogens leads to physical dependency.

A true hallucination is a percept-like experience that the individual believes to be real, though it has no objective counterpart. A pseudohallucination is a perceptual experience that the individual knows is not real, though it may be just as vivid and spontaneous as a true hallucination. The frequency of hallucinations during hallucinogen use has been exaggerated, since many reports have classified pseudohallucinations as true hallucinations.

Siegel used trained observers to obtain introspective reports of perceptual experiences during intoxication by psilocybin, mescaline, LSD, and THC (high dose) and found similarities in responses to those drugs. Visual-hallucinatory experiences go through three temporal stages: (1) simple form-constant images, of which the lattice-tunnel type is most common; (2) complex combined images, with meaningful images (such as animals, objects, faces) superimposed on or incorporated into form-constant figures; and (3) complex memory images, with meaningful scenes. Simple form-constant images depend on the drug's effect on the visual pathway in the brain and show striking similarities across individuals and cultures, whereas complex meaningful images are constructed from information stored in memory and can vary markedly between individuals. Slade and Bentall argued that the critical factor in true hallucinations is not their visual-perceptual quality, but rather, a failure of reality discrimination, where imagination is confused with reality. Failures of reality discrimination can be attributed to altered functioning of a conscious interpreter system.

ENDNOTES

[1]On April 17, 1990, the U. S. Supreme Court ruled that there is no constitutional right to take illegal drugs, such as peyote, for religious reasons. According to an Associated Press item, dissenting justices said the 6–3 ruling permits religious oppression of American Indians and perhaps others with unorthodox views. The ruling allows Oregon officials to deny unemployment benefits to two fired drug counselors who took small amounts of peyote in an Indian religious ceremony. However, the court also said that states may allow religious use of illegal drugs. I am not sure where this leaves the rights of Native American Church members to use peyote.

[2]Marijuana is not usually classed as a hallucinogen, since hallucinations rarely occur at the THC levels consumed in typical social marijuana-smoking situations. Thus, it is noteworthy that in Siegel's study a relatively high dose of THC produced hallucination reports similar to those produced by the hallucinogens (mescaline, LSD, and psilocybin). Siegel also obtained reports of vivid images with lattice-tunnel forms, usually blue, in subjects who had smoked marijuana. Perhaps marijuana-induced images were noticed more readily in Siegel's restricted-sensory-input test condition (dark, soundproof room) than they are in normal social marijuana-smoking situations.

[3]See Siegel & Jarvik 1975 for illustrations of visual hallucinations, including full-color reproductions of paintings by artists who depicted their psychedelic hallucinations and examples of Huichol (Mexican Indian) yarn paintings inspired by peyote hallucinations. Other illustrations are in Siegel 1977. See John Lilly's popular book *The Center of the Cyclone* (1972) for a description of complex hallucinations that he experienced when he took LSD under sensory deprivation conditions.

[4]To what extent were Siegel's trained subjects' image reports influenced by their prior image-naming training? Siegel tested some untrained subjects and found that they reported images less often (about five per minute) than did trained subjects (about twenty per minute). At high doses of hallucinogens the untrained subjects sometimes had long pauses between reports, especially when they were lost in their hallucinations. The distribution of form constant reports was similar for untrained and trained subjects, allowing for some differences in their choice of words to describe the images. Thus, it appears that prior training affected the rate of image reporting and the consistency of image naming, but probably had little or no effect on image experiences *per se*.

[5]For illustrations of phosphenes and migraine visual patterns, see Oster 1970 and Richards 1971, respectively.

[6]Siegel and Jarvik's 1975 explanation of meaningful drug hallucination images as constructions from memory and sensory elements is similar to Foulkes's 1985 explanation of dream production.

[7]See Gazzaniga's book *Mind Matters* (1988b) for a discussion of how the interpreter system produces conscious experiences, such as anxiety and depression, in response to natural biochemical reactions in the brain.