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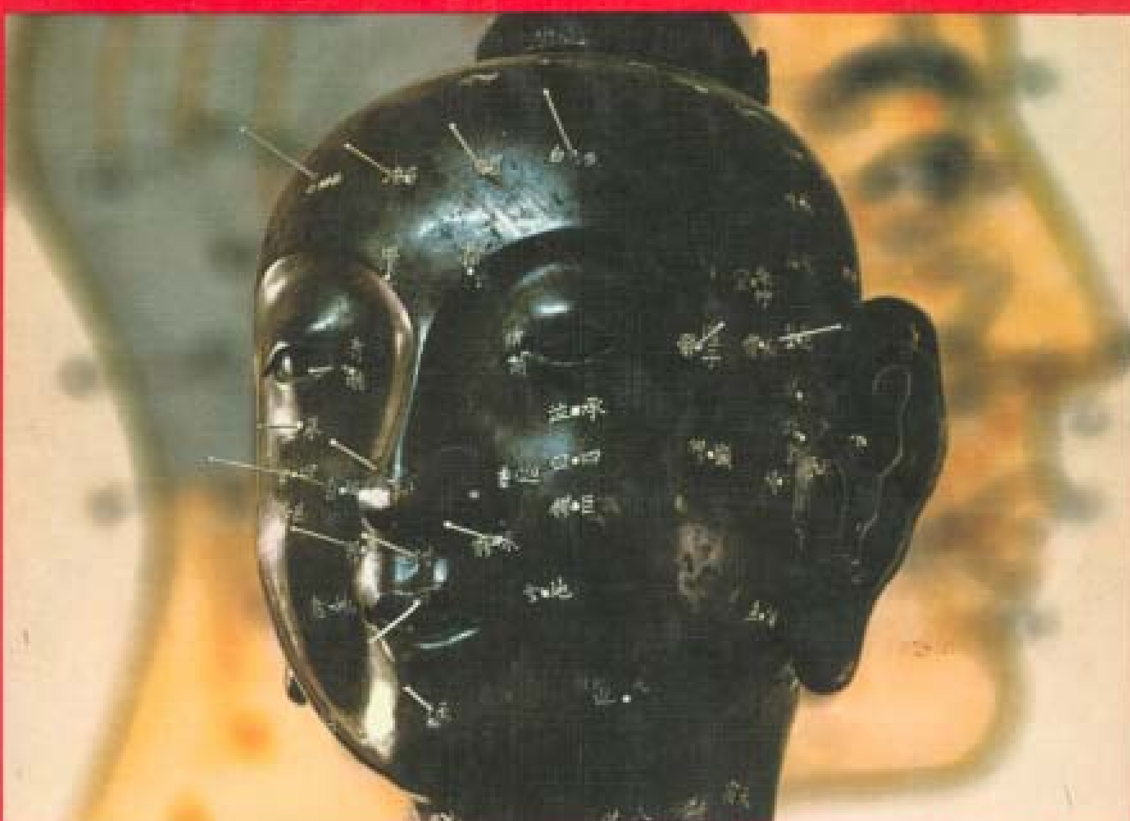

AN ACUPUNCTURIST'S TRAINING MANNEQUIN

Mind over Muscle

Rx FOR MIGRAINE, OTHER ILLS: A "THINKING" PROCESS

by Gerald Jonas

Rosemary Gianuzzi is almost completely paralyzed. As a consequence of a rare muscular disease that she contracted 11 years ago, she has no control over any of her skeletal muscles except those in her fingers, neck and face. Yet in the spring and summer of 1972, taking part in an experiment at New York City's Goldwater Memorial Hospital, Rosemary learned to control a set of muscles that most people cannot even sense, much less activate voluntarily—the mechanisms that regulate the rise and fall of blood pressure. Rosemary's remarkable feat of internal gymnastics will never, unfortunately, help her regain the use of her own paralyzed limbs. But it may speed the day when other people, suffering from such illnesses as chronic high blood pressure, will literally learn to heal themselves by controlling supposedly involuntary bodily functions.

Rosemary's teachers in blood-pressure control were Neal E. Miller, professor of physiological psychology at The Rockefeller University, New York, and his research associate, Barry Dworkin. They call the process visceral learning because it concerns the viscera—the organs and glands that normally operate without prompting from the conscious mind.

The notion that these organs and glands can be consciously controlled is not new. For centuries Eastern mystics have claimed the ability to order their internal bodily functions at will; and Western scientists are now corroborating those claims. Not only Miller's work, but a number of other research projects have shown that people with certain disorders can learn to control what goes on inside their bodies. All of these exper-

An attractive picture helps train a volunteer to regulate bodily functions once thought beyond conscious control. When he succeeds in lowering his blood pressure, the pleasing prospect of a lighthouse is briefly projected before him as a reward, to encourage further effort.

iments depend on training programs in which information on the state of internal functions —normally unknown to a human—is brought to the patient's attention.

The training used in these programs employs elaborate electronic monitoring and display devices that flash information to the patient in the form of colored lights, clicking sounds, fluctuating needles or pictures. Essentially, such training follows the same procedures as the trial-and-error tactics through which people learn to steer cars, carry tunes or place tennis balls with game-winning precision in the opposite court. The key to all trial-and-error learning is timely, reliable information about the consequences of one's actions. Without this knowledge a person can do nothing to improve his performance. With such information he can modify his performance, trying one thing and then another until he hits upon a successful response.

The information he gets thus influences his response—and this response in turn influences the information he gets, which further affects his next response. This circular process is known as feedback, and when used in visceral learning to influence biological functions, biofeedback.

In many learning situations feedback does not have to be very detailed. A person learning to sing does not have to know exactly how his vocal cords produce sounds of different pitch and timbre. All he needs is a clear indication of success or failure: he must be able to hear the sounds that issue from his throat.

But even this minimal consciousness of feedback is ordinarily missing when confronting the challenge of altering the performance of internal organs and glands. Where visceral functions are concerned, humans are totally in the dark—like a man, as Neal Miller puts it, trying to learn to play tennis at night with the lights off. All through the body small spontaneous biological adjustments are constantly taking place, adjustments that accommodate heart rate, body temperature and blood pressure to such things as changes in bodily posture, physical exertion or emotional stress. Yet normally, news of these biological adjustments never reaches the conscious levels of the brain, and most people faced with the need to make blood pressure go up or down would probably feel that they could not do it even if their lives depended on it.

It is this attitude that Neal Miller and many of his colleagues think may be out of date. Indeed, Miller himself believes that the traditional dividing line between "voluntary" and "involuntary" functions will begin to break down as medical technology reaches inside the body to reveal nature's own feedback system in a form that people can respond to. Miller believes that humans can learn to exert control directly upon the network of nerves that serves the so-called involuntary muscles. This is why Rosemary Gianuzzi was chosen as a subject. With her nearly total paralysis, Rosemary could engage in almost no "overt" muscular maneuvers to raise or lower her blood pressure.

CONTROLLING THE UNCONTROLLABLE

In the Goldwater experiment the feedback system devised by Miller and Dworkin employed a monitoring device no larger than a wrist watch. Strapped against the radial artery, on the underside of the wrist, it tracked fluctuations in the subject's blood pressure and passed this information along to a transducer that converted the alternations in blood pressure into electrical impulses. These impulses were then fed into an electronic programing system, from which they issued as a high-pitched humming sound. In Rosemary's case the feedback system was programed to emit a tone only when her pressure was at a certain predetermined level, and her instructions were simply "Keep the tone on." When she asked the natural question "What am I to do to keep it on?" she was told to concentrate on the tone, and let her brain and body do the rest.

In her initial training session, Rosemary's feedback machinery was set to produce its tone whenever her blood pressure increased. For 20 minutes the tone went off and on at more or less regular intervals, indicating the usual fluctuations in blood pressure. Then suddenly, as if her nervous system had figured out the game, the tone stayed on for over a minute as her blood pressure rose about one and a half times higher than normal. This was a much more dramatic re-

Neal E. Miller, a pioneer in the study of the control of internal, visceral functions, shows one of his special devices in a Rockefeller University laboratory. The instrument at the far left, a polygraph, measures the internal responses of rats confined in the cage at center.

sponse than Miller and Dworkin had expected—and no one was more surprised than Rosemary herself. Asked to explain what she had done or how she had done it, she said she did not know.

Rosemary's feat in some ways resembles the kind of bodily control practiced by yogis, and scientists are well aware of the parallel. At the Menninger Foundation in Topeka, Kansas, for instance, psychologist Elmer E. Green has been working with an Indian yogi named Swami Rama as part of a far-ranging research program into unconventional methods of bodily control. Performing in a laboratory, monitored by a battery of instruments, the Swami has demonstrated that he can speed up his heart rate to five times its normal pace without moving any of his skeletal muscles or changing his breathing. He has also shown that he can produce a 10° difference in temperature between different parts of the palm of his hand. To do this, the Swami had to direct more blood to one side of his palm and less to the other by dilating one of the two arteries that feed the hand and by constricting the other.

When asked how he managed this remarkable degree of bodily control, the Swami, unlike Rosemary Gianuzzi, was able to supply an answer. He explained that he had spent 40 years educating himself. The first step toward such bodily control, he said, was to concentrate on what he called even breathing. He had practiced breathing slower and slower until he was able to take only one or two breaths a minute without any discomfort. For ordinary persons, such slow breathing is impossible because a respiratory rate as low as two breaths per minute causes the involuntary respiratory reflexes to cut in automatically to force air into the lungs, and no amount of conscious control can stop them. But the Swami had trained himself to approach this point very gradually, taking great care to exhale and inhale as smoothly as possible, so that he in effect could cross the border that separates voluntary and involuntary functions without alerting the reflex mechanisms. In this way he gained conscious control of such supposedly automatic functions of his body as breathing and arterial contraction.

Of course the fact that one or two yogis can learn to regulate the actions of their blood vessels does not prove that everyone can do so. After all, not everyone is able to learn to run the 100-yard dash in 10 seconds. Before Western scientists could be expected to take visceral learning seriously, they needed evidence that the talents of men like Swami Rama were not limited to a small population of "visceral athletes."

So far, the most convincing evidence that the

Swami Rama, an Indian yogi who can regulate his blood flow, heartbeat and brain-wave formation, lectures at the Menninger Foundation in Topeka, Kansas. The Swami's ability to exercise such control has given researchers an idea of man's potential for controlling his internal systems.

ability to master visceral learning is not a rare talent comes from a series of tests that Neal Miller and his associates conducted with white rats. These studies antedated the ones with Rosemary Gianuzzi, and in fact inspired Miller to test his theories on quadriplegic subjects like Rosemary. As a behavioral psychologist specializing in the learning process, Miller saw no reason why rats could not be taught to raise and lower their blood pressure, just as they have been taught to run through a maze or press a lever for a drink of water or a pellet of food. And if rats could learn to control their internal organs and glands, presumably men could too.

Miller knew that he could paralyze the rats so that no voluntary control could influence the result. If the rats did control internal organs, they would have managed some direct link between brain and organ.

Miller's experiment depended on the use of curare, the poison distilled by South American Indians from jungle plants. Curare completely paralyzes all the voluntary muscles of the limbs and torso, including the muscles used for breathing. Miller's rats had to be artificially respirated to keep them alive. But curare does not affect the five senses, and it does not interfere with the muscles that control the functions of the internal organs and glands.

In Miller's laboratory the deeply curarized rats were hooked up to monitoring devices that "rewarded" them for the correct visceral responses —by delivering an electrical impulse to the so-called pleasure centers of the rats' brains, for example. Not only did the rats learn to modify their blood pressure, but they also learned to modify their heart rates, their intestinal contractions, even the rates of urine formation in the kidneys. And in some cases the changes were large enough to suggest that visceral learning might have important medical applications.

While Miller was putting his curarized rats through their paces, other researchers were experimenting with the use of biofeedback techniques in the treatment of a variety of human ailments. Not surprisingly, a great deal of this research was focused on heart disease and high blood pressure, which together account for two out of five deaths in the United States every year.

The first indication that these techniques might be helpful in treating people with malfunctioning hearts came from an experiment conducted by Bernard Engel, a psychologist who is affiliated with the Baltimore City Hospitals and the National Institute of Child Health and Human Development. Engel was interested in patients with cardiac arrhythmias—irregularities in the normal pumping rhythm of the heart, out-of-step beating that in severe cases may lead to sudden death. In 1970, Engel and Theodore Weiss attempted to teach eight patients to stabilize their heart rates. In these patients the left ventricle of the heart, which normally expands and contracts about once a second, contracted prematurely. Some patients are conscious of the irregularity, reporting that it feels as if their hearts were "skipping a beat." But many patients are not, and Engel and Weiss proposed to help both types of patients deal with the malfunction.

REGULATING HEARTBEAT WITH COLORED LIGHTS

Formal training for the eight patients averaged out to about 30 sessions apiece; sessions were scheduled as often as three times a day, each session lasting about 80 minutes. The patient lay in a hospital bed, hooked into a standard electrocardiograph—a machine that tracks the rate of the heartbeat. The machine was connected to colored lights that registered green when the heart was too slow, red when it was too fast and yellow when it was beating normally. Initially the patients were asked to keep the yellow light on by forcing their hearts to beat slower or faster. Five of the eight patients succeeded—though there was no consistency in the way they said they did it. One patient speeded up his heart by thinking about "bouncing a rubber ball"; another thought about arguing with her children or running down a dark street. To slow down his heart, one patient reported that he just lay still and stared at the lights, while another explained that she thought about swinging back and forth on a swing.

During a second phase of the training the researchers rigged their lights to flash a special signal—red followed immediately by a burst of green—whenever the heartbeat was irregular. In this way Engel and Weiss hoped to draw the patient's attention to the faint but distinctive internal sensations that accompany an irregular heartbeat. With this information and the newly acquired ability to slow down or speed up his heart, the patient would then be able to correct irregularities whenever he felt them happening. The final stage of the training was to wean the patient from his dependence on the mechanical feedback system by gradually withdrawing the lights. First they were turned off every other minute, then for three minutes out of every four, then for seven minutes out of every eight. After that the patient was presumably able to go it alone, sensing his heart irregularities himself.

At the conclusion of the training period, four of the five patients who had successfully mastered the first phase were also able to master the second; and the fifth patient, although he never learned to sense his irregular heartbeat, had a more stable heart rate after the training.

Like many other researchers in biofeedback techniques, Engel thinks that the control methods used by his five successful trainees—despite their varying images of swings and bouncing balls—were much the same. From the physiological evidence, he believes that they learned to stabilize their heart rates by directly modifying the firing rate of the nerves that control the heart muscles. Whether the images brought this about, or some more subtle internal command was involved, is anybody's guess. In any case, as Engel acknowledges, even if they had known what they were doing, they would probably have had trouble describing it—since there are no handy labels for sensations at this physiological level.

A somewhat different approach to biofeedback training is being used at the Menninger Foundation by Elmer Green and his associates whose work with the Swami Rama demonstrated that the ability to control blood flow could be of great value to people with circulatory ailments. In seeking a way of teaching such control to patients, the method they hit upon did not require years of study in yoga, but combined biofeedback monitoring and display with a technique an electromyograph, which measures the electrical activity in muscles. The machine was set up to make clicking noises that increased in frequency with the amount of tension in the muscle —so that the subject could literally hear how tight his forehead was. The aim of the subject was to lower the click rate, and four of the six subjects who took part in the study learned to recognize the warning signs of muscle tension, and turn off most of their headaches. Those that do occur require far less pain-killing medication.

Ultimately, of course, the ideal source of biofeedback information is the brain itself, since the brain plays a decisive role in the regulation of every bodily function. The standard machine for monitoring electrical activity in the brain is the electroencephalograph, which picks up electrical impulses through electrodes taped to the scalp. But it is not always easy to correlate a particular "brain wave" pattern with a particular bodily activity. When such a correlation can be found, it ought to be possible to modify the activity at its source in the brain. The most dramatic example of such an application for biofeedback training was reported in 1972 by psychologist Maurice B. Sterman of the Veterans Administration Hospital in Sepulveda, California.

To begin with, Sterman identified a particular pattern of electrical activity in the brain waves originating in the part of the brain that controls movements of the skeletal muscles. This pattern, which has been named the sensorimotor rhythm, seems to be associated with muscular quietude —subjects produce the SMR pattern when they are awake but completely motionless.

In the initial stages of the investigation, Sterman used cats for subjects—because cats can be studied under carefully controlled laboratory conditions. He found that hungry cats could be trained to increase their SMR production if they were fed only when the pattern appeared. Instead of roaming their cages restlessly, they sat stock-still waiting for food. Other experiments with the same cats showed that after they had learned to produce the pattern, they were unusually resistant to drug-induced convulsions. This result prompted Sterman to try training epileptics, whose seizures are thought to result from a breakdown in the brain centers that regulate muscular activity.

The preliminary results of this phase of Sterman's research have been very encouraging. Substituting standard feedback signals—lights, bells, pictures projected on a screen—for the food offered the hungry cats, Sterman has taught three epileptic patients to increase their production of the "quiet" type of brain waves. In each case the training has lessened the number of epileptic seizures. In one case, that of a six-year-old boy, the results of the training have been astonishing. This boy, despite massive medication, had been suffering as many as 25 seizures a week. When brought to the laboratory by his parents, he was so drugged that Sterman doubted his ability to comprehend even the simplest instructions. Yet after six months of training, the boy had remained free of seizures for as long as four months and was able to get along with fewer anticonvulsive drugs.

ALPHA WAVES—A MATTER OF CONTROVERSY

The muscular quietude induced by SMR training is not to be confused with the kind of quietude that supposedly results from what is popularly known as alpha-wave conditioning. Sensorimotor rhythms emanate from a specific part of the brain and are correlated with a specific pattern of muscular activity. Alpha waves, by contrast, are recorded over a much wider area of the brain, and whether or not they correlate with any consistent pattern of behavior is still a matter of controversy. Most people produce alpha waves when they are relaxed or faintly drowsy, but cannot sustain them; the slightest motion or mental activity is usually enough to block the wave production. A harmless and pleasurable experience, the sustained production of alpha waves is relatively easy to learn with the assistance of an electroencephalograph. But there is no proof that the waves can profoundly alter the personality, making it more "free" and "creative," as some merchandisers have claimed. In 1972 more than 60 companies were marketing alpha-wave expertise. Some were selling sophisticated electronic equipment that went "blip-blip-blip" when the user produced alpha waves; hardware like

In this double exposure, the husband-wife team of Elmer and Alyce Green appear with an image of the control panel of an electroencephalograph, which they employ in studying body responses. The instrument makes a record (lower left) of electrical brain patterns, such as alpha waves, that let a subject know when he is successful in regulating such normally uncontrollable functions.

this can run into hundreds of dollars. At the other end of the scale were promises of "Alpha-Wave Training and Control Without Headphones, Equipment" for five dollars.

Perhaps because biofeedback research lends itself so easily to commercial exploitation, scientists in the field go to great lengths to avoid premature claims of success. Dr. Morton F. Reiser, editor of the journal *Psychosomatic Medicine*, cautions, for instance, that many of the studies in biofeedback therapy reported in his journal's pages are too limited to be conclusive. Except for the work on tension headaches, he points out, none of the studies have been conducted under the carefully controlled lab conditions that would rule out what doctors call the "placebo effect" —the curative consequences of simply being the object of a scientific experiment.

Neal Miller, whose daring theories have laid the groundwork for biofeedback research, would undoubtedly agree with these cautionary disclaimers. (No one is more aware than Miller of the pitfalls of biofeedback research; in April, Miller reported that he was having trouble duplicating some of his earlier experiments on curarized rats.) Yet Miller continues to believe that biofeedback techniques will eventually help scientists unravel the intricate network of interrelationships between brain and body that make the behavior of higher animals—even white rats—so extraordinarily flexible. And if and when this knowledge is acquired, the applications for biofeedback training may go beyond the treatment of disease, to the prevention of trouble before it starts. At the University of Colorado Medical Center, for instance, researchers Budzynski and Stoyva are already at work on a method of teaching people to slow down their metabolism at will —a talent that could have enormous survival value in a world in which everyone seems to be overstimulated, and thus fair game for biological breakdowns. But whether or not the average person learns to control his bodily functions to the same degree as Swami Rama, of one thing there is no doubt: biofeedback research is shedding new light on areas of human experience that have long been *terra incognita* to Western man.

The calm that accompanies the alpha type of brain wave has moved some—such as this group in an inflated 40-foot bubble in Los Angeles—to try to produce alpha with the help of a simplified electroencephalograph.