

VOLUNTARY CONTROL OF INTERNAL STATES: PSYCHOLOGICAL AND PHYSIOLOGICAL ¹

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The first part of this article is a summary of a technological paper presented at the 1969 International Congress of Cybernetics (Green, Green, and Walters, 1970) and is included in order to explain the electrophysiological instrumentation and the methodological developments that make possible an instrumented transpersonal research project, *psychophysiological training for creativity*, which is a primary aim of our work.

Speaking of instrumentation and methodology during a discussion on scientific creativity, Lord Adrian, the well-known biologist, said, "New ideas in science are induced by new discoveries and at the present time it seems to me that the most potent factor in promoting new discoveries has been the introduction of some new technique, some new tool, that could be used for exploring natural phenomena" (Adrian, 1961). Since the electronics explosion that accompanied World War II, sensitive transducers, high-gain amplifiers, and sophisticated computer techniques have been developed and applied to psychophysiological research. Now, through the use of some of these tools, it is possible both to promote and to detect changes in physiological variables that are particularly related to and indicative of changes in attention, consciousness, thought, and emotion.

*new tools for
exploring
natural
phenomena*

The importance to our culture of this now-developing meth-

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odology for enhancing voluntary control of internal states can hardly be overstated. In recent years scientists in every nation have come to realize that voluntary control of behavior is of primary importance if we hope to establish an ordered society or even maintain a society. Without stretching the imagination, the long-range implications and the effects for society of a population of self-regulating individuals could be of incalculable significance.

For about 200 years, medical doctors serving with the British Army or Civil Service in India sent back reports of a few *such* self-regulating people. The doctors claimed that these unusual individuals, called yogis, could regulate a number of "involuntary" physiological processes, such as heart rate or pain. This phenomenal control was obtained, they said, through long practice of specific mental, emotional, and physical disciplines.

In some parts of the Western world there was great interest in such reports, and by 1910 in this century, Johannes Schultz (in Germany) had developed a Western system of self-regulation by combining various ideas from his medical research, especially from hypnosis, with concepts from yogic methods. Although Freud gave up the use of hypnotism in therapy because its results were too unpredictable, it occurred to Schultz that the major defect with hypnotism might lie in the fact that the patient was not in control of the situation and therefore resisted in various ways the doctor's instructions. Schultz combined the free-will or volitional aspect of yoga with some of the techniques he had worked with, and eventually developed the therapeutic system to which he gave the name Autogenic Training; that is, self-generated or self-willed training (Schultz & Luthe, 1959).

Autogenic Training has had a measure of success, but it is handicapped by the fact that it normally takes considerable time for the subject, or patient, to learn it. It was the need to shorten the learning time associated with Autogenic Training and to adapt *the* system for research *in* states of consciousness which led to the development of the methodology discussed below. In essence, the autogenic "development," or movement, has been carried one step further by combining the conscious self-regulation aspect of yoga and the psychological method of Autogenic Training, with the modern instrumental technique called physiological feedback. Feedback of physiological information in our application generally consists of providing visual or auditory displays that show the subject what is happening in certain normally unconscious

*combination of
Autogenic
Training and
physiological
feedback
training*

functions of his body as he attempts to influence them by the use of mental, emotional, and somatic visualizations, We call this method *Autogenic Feedback Training*,"

Before leaving the subject of *Autogenic Training*, it is worth mentioning that after a patient learns to relax his striate musculature, as in *Progressive Relaxation* (Jacobson, 1938), he goes on to regulate blood flow in various parts of the body. This is followed by exercises in the control of heart rate, and U necessary the patient eventually focuses his control effort (under medical supervision) on the functional correction of psychosomatically sensitive areas, such as the gastrointestinal tract. In this connection it is noteworthy that for training in cardiac regulation, Schultz in the 1930's used a straightforward bio-feedback method; the subject's hand was placed over the heart region of his thorax in order to help him "discover" his heart. Gradually, as emotional and physiological harmony is obtained in distraught patients, autogenic therapy moves into psychological areas. In spite of a significant amount of success, *Autogenic Training* though over 50 years old is almost unknown in the United States; in the 1959 handbook by Schultz and Luthe, of 604 references only 10 are in English.

It is not possible to define in an operational way the meaning of the word "voluntary," but all of us have a *feeling* of voluntary control, at least part of the time, regardless of the psychophysical and metaphysical implications of that feeling. Few people realize, however, that that feeling or intuition of freedom has unusual significance in respect to the autonomic nervous system, the so-called involuntary nervous system, nor do they realize that the "psychophysiological principle" when coupled with volition makes it possible to regulate a number of important involuntary functions, and at least theoretically to regulate in some degree every psychological and physiological function of one's being.

*difficulties in
defining
"voluntary"*

The psychophysiological principle, as we hypothesize it, affirms that "Every change in the physiological state is accompanied by an appropriate change in the mental-emotional state, conscious or unconscious, and conversely, every change in the mental-emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state." This closed Newtonian type of principle, when cou-

*the psycho-
physiological
hypothesis*

'Gardner Murphy must be given due credit for stimulating and promoting bio-feedback research by his development of proprioceptive feedback concepts since the early 1950's and for his effort, along with Barbara B. Brown and Kenneth Gaarder, to establish the Bio-Feedback Research Society, which met for the first time in 1969.

pled with volition, which is at present of indeterminate origin, makes possible a psychosomatic self-regulation. Whether volition has origin beyond the physiological matrix as a meta-force is the essence of the mind-body problem, but this is not of concern in the present paper. It is sufficient that research using newly developed feedback techniques has demonstrated that volitional control of a number of internal states, psychological and physiological, is relatively easy to achieve (Brown, 1970; Dewan, 1966; Green *et al.*, 1969; Green, Green, & Walters, 1970; Hart, 1967; Kamiya, 1969; Mulholland & Runnals, 1963; Nowlis & Kamiya, 1970).

Before discussing methodology and illustrative experiments, brain waves and reverie, hypnagogic imagery and creativity, it is useful to focus attention on the neurological systems that are involved. The diagram below is arranged to indicate brain areas associated with unconscious functions on the left and with conscious functions on the right. The peripheral nervous system is seen to be divided according to classical concepts into the autonomic system and the craniospinal system.

Unconscious Domain	Conscious Domain
1. archipallium, in the nervous system	1. neopallium, in the central nervous system
2. control of smooth muscle and glands in the autonomic section of the peripheral nervous system	2. control of striate muscle in the craniospinal section of the peripheral nervous system
3. involuntary	3. voluntary
4. responsive to "passive volition"	4. responsive to "active volition"

The central nervous system is divided into the archipallium on the left, the old brain that man shares with the other vertebrates, and the neopallium on the right, the new brain whose most significant development is in man, dolphins notwithstanding.

The dashed line, the divider between conscious and unconscious systems and processes, is drawn as a straight line, but it is to be visualized as a continuously undulating boundary between conscious and unconscious processes and brain structures, as *attention* shifts from one brain region to another. For instance, when one learns to drive a *car* many of the at-first-conscious striate muscular activities upon which much attention is lavished gradually become unconscious, and eventually it is possible when the mind is preoccupied to drive through miles of traffic without awareness of other cars or traffic signals.

discussion of diagram

On the other hand, the involuntary nervous system is not necessarily "involuntary," even as the voluntary nervous system is not necessarily "voluntary." If we concentrate attention on our right hand for a few seconds, its temperature will spontaneously begin to rise or fall due to tensing or relaxing of smooth muscles embedded in blood vessel walls, depending among other things on our previous conditioning to self-examination. After training in temperature control, however, many subjects can increase or decrease the volume of blood in the hands at will, Consciousness of the specific neural pattern involved is *not* obtained, however, any more than there is consciousness of the neural network in the voluntary nervous system that causes the arm to move from side to side "at will"; in both cases, autonomic and craniospinal, the desired behavior is obtained through visualization of the desired event accompanied by volition. The significant difference in controlling these two systems is that for the control of the voluntary nervous system it is necessary to use *active* volition, and for control of the involuntary nervous system it is necessary to use *passive* volition. It must be admitted that this last sounds like a contradiction in terms. How can anyone have passive volition? It is paradoxical, but after learning to use passive volition it seems quite reasonable, though not easy to put into words. It might best be described as detached effortless volition.

*passive and
active volition*

A RELAXATION EXPERIMENT WITH FEEDBACK

Generally speaking, skillful control of striate muscle is originally developed with feedback of information from special sense organs, especially the eyes. In one area of striate muscle behavior, however, there is essentially no perceptual feedback. This is in the reduction of muscle tension down to zero. If an electromyographic (EMG) electrode is placed on the skin surface, over the dorsal muscle of the forearm for instance, it will usually detect a continuous firing of motor fibers, even though visible signs of tension may not exist and muscular feelings of tension may not exist; however, if the signal from the forearm is amplified, rectified, and then made visible to the subject by a meter, he can quickly learn to reduce the muscle tension to very *low* levels. In an experiment in our laboratory, using the EMG-feedback arrangement described above, 7 out of 21 subjects were able to achieve either zero firing or single-motor-unit firing in less than 20 minutes of a single session (Green *et al.*, 1969). This was a phenomenal performance that only one subject could do without feedback. He, oddly enough, had practiced yogic meditation for a number of years. Eleven of the 21 subjects

*body image
changes during
experiment*

were able to achieve *low* tension levels with feedback but could not reach single-motor-unit firing in 20 minutes. Three of the subjects did not seem to succeed at all. They, incidentally, gave evidence of strain due to the experimental setup.

Of the seven subjects who approached zero levels in less than 20 minutes, five reported body-image changes, making statements such as "My arm feels like a bag of cement," "like a ton of lead," "It feels like it is moving away from me," "I had to look at it to see if it was still in the same place," etc. In naive subjects in a proper setting (reclining chair, quiet room, dim lights, etc.), relaxation generally spreads over a large part of the body, but we have found that a normal subject can learn, with a little practice, to dissociate his right forearm from the rest of his muscular system so that he can tense his left arm, leg muscles, or neck muscles, without causing any significant increase of tension in the right arm.

TRIPLE TRAINING PROGRAM WITH FEEDBACK

Preliminary experiments with feedback and with Autogenic Training led to our present formal project in which college men are being trained in the simultaneous (1) reduction of muscle tension in the right forearm, (2) increase in temperature in the right hand (as an indication of autonomic relaxation), and (3) increase in percentage of alpha rhythm in the EEG record. Visual feedback of muscle tension with a meter is initiated from a circuit of the type already described. Temperature feedback, also with a meter, is initiated from a thermistor taped to a finger of the right hand. Percentage-of-alpha feedback, initiated from a left-occiput-to-ear electrode arrangement, is achieved by allowing the subject to watch a third meter that shows the average percentage over a continuously computed 10-second epoch. That is, the meter continuously tells the subject what his average percentage of alpha has been over the preceding 10 seconds. More immediate knowledge of alpha production is obtained, of course, as the average rises or falls in response to the on-going EEG signal,

Feedback is displayed by three vertical bars of light on a panel in front of the subject. Each bar, becoming taller or shorter in correspondence with the behavior of a physiological variable, is literally the readout mode of an optical projection type of meter. The bars of light, 1/2-inch wide, can reach a maximum height of 5 inches, and give the subject an easy-to-see indication of his physiological behavior and voluntary control. The feedback circuits are arranged so that

(1) at complete relaxation (zero muscle tension) the left bar of the group of three rises to the top, (2) when a temperature increase of about 10° F is detected the second bar rises to the top, (3) when 100 % alpha rhythm is maintained over a period of 10 seconds the third bar rises to the top.

A training sequence involves eight sessions, two per week, each of about 2½ hours duration, including 40 minutes for wiring. A number of psychological tests are given to each subject, mainly to determine his inward-outward orientation, which has been hypothesized to be significantly related to success in voluntary control of internal states. The tests include (1) the Eysenck Personality Inventory, for determination of extraversion-introversion; (2) the James I-E scale, for determining internal-versus-external control of behavior; (3) the Rod and Frame test, for determination of field dependence; (4) the flexibility scale, FX, of the California Personality Inventory; (5) the Thurstone Concealed Figures Test, another field dependence test; (6) a visual Autokinetic test, for determining ego closeness to the environment (Voth, Mayman, 1967); (7) an Afterimage test, which seems to be related to internal awareness; and (8) a Recall test, for determining the relationship between recall and percentage of alpha. (The last two tests are of our own construction.)

*testing of
inward-outward
orientation*

A typical training session has several distinct phases. After the subject is comfortably seated he closes his eyes and relaxes for 3 or 4 minutes while various recording machines are adjusted. Training typically consists of the following phases:

1. Relax with eyes closed for 3 minutes; no feedback.
2. Relax with eyes open for 4 minutes; no feedback.
3. Maintain relaxation and "visualize," feel, warmth with eyes open for 4 minutes; no feedback.
4. Maintain relaxation and warmth, and establish a quiet inner-focused and alert state of mind for 4 minutes; no feedback.
5. Autogenic Feedback Training with *muscle tension* meter only; 3 minutes with autogenic phrases for relaxation initiated by the experimenter, followed by 4 minutes of silent practice with phrases. Relaxation phrases, of which about eight are used, follow a typical pattern. Three such phrases are, "I feel quite quiet." "My feet are heavy." "My ankles, my knees, my hips, feel heavy and relaxed."
6. Autogenic Feedback Training with *muscle tension* and *warmth* meters; 3 minutes with several autogenic phrases for warmth initiated by the experimenter, followed by 4 minutes of silent practice with phrases. A typical warmth

*typical training
session*

- phrase often emphasizes both relaxation and warmth. For instance, "My hands are heavy and warm."
7. Autogenic Feedback Training with muscle tension, warmth, and *percentage-of-alpha* feedback meters; 3 minutes with autogenic phrases for alpha enhancement initiated by the experimenter, followed by 4 minutes of silent practice with phrases. For control of percentage of alpha we have devised autogenic-like phrases that focus attention inward, away from the outside world, and emphasize the quiet but alert mind.
 8. Twenty minutes of free practice with the three meters.
 9. With feedback meters switched on, subject attempts to maintain peripheral-nervous-system passivation and central-nervous-system alpha-activation during discussion and interview for about 12 minutes.

*typical trainee
comments*

For five experimental subjects whose training records have been almost completely evaluated, it was observed that relaxation results were quite similar to those reported above for the 7 out of 21 subjects who achieved unusually low tension levels in a single session; however, when attention shifted to warmth and alpha in the first two or three training sessions, subjects found that deep relaxation was difficult to maintain. In later sessions, however, control of relaxation improved. Zero muscle tension was not observed in any of the five subjects, but all reached very low levels and, when interviewed, reported definite body-image changes including such comments as "I felt I was floating above the chair." "[I am] sort of light like. I'm not even sitting here. I feel like I'm just detached in some way . . . you know. if I create some sort of image I feel as though I'm just there." Another subject said, during deep relaxation and high alpha, "It sounds funny, but ... well, okay ... it seems like there was some kind of force on the inside, flowing through my forehead out . . . not a hard pressure but you can feel it, like when you move your hand through flowing water."

In controlling warmth, subjects succeeded to an encouraging, though not remarkable, degree. The average voluntary increase in temperature of the finger for the group was about 3° F after three or four training sessions. One pilot subject (not a member of the triple training group) working only with the temperature meter was able to produce a change in hand temperature of 10° F in 2 1/2 minutes after being requested to increase the meter reading. (This subject had practiced yoga.)

Three of five subjects were "alpha producers" under normal eyes-closed conditions, averaging about 75% alpha. In five

training periods they were able to increase their percentage of alpha during the eyes-open visual-feedback condition from 24% to 45% (group average). Visual examination of the records of nine additional subjects suggests that the increase in percentage-of-alpha in the eyes-open interview situation is not a chance occurrence for alpha producers, but we are not yet prepared to offer statistical evidence. In the group of five subjects, the two "non-alpha" producers gave a slight indication of an increase in percentage of alpha with training, from about 3% to 7%. If this tendency is borne out with additional subjects, a future experiment may seek to determine the extent to which the percentage of alpha in "non-alpha" subjects can be raised. An important observation is that every subject who learned to produce a relatively high percentage of alpha rhythm with eyes open was a natural high-level producer with eyes closed.

An especially interesting finding with these first five subjects was that in the *delayed* recall test of prose stories, the subjects who produced the highest percentages of alpha rhythm in their BEG patterns while they were recalling and *speaking* remembered the most material. Data reduction has been completed for so few subjects, however, that there is no certainty about the significance of this finding.

A tentative summary of our *physiological* findings with about 60 subjects over a period of 4 years in both feedback and Autogenic Training studies indicates that (1) relaxation of muscle tension to extremely low levels is quite easy to learn with feedback of EMG signals, but not nearly so easy with autogenic phrases alone; (2) control of warmth is significantly aided by feedback in comparison with autogenic phrases alone, and in some cases phenomenally, but does not generally become easy with just a few practice sessions in the laboratory; (3) increase in percentage of alpha rhythm with eyes open and while talking to the experimenter is easy to learn by feedback methods for those subjects who normally have a high percentage of alpha rhythm (above 30%) when their eyes are closed, but is not easy for subjects who do not normally produce alpha rhythm with eyes closed. There is nothing in Autogenic Training that corresponds with brain-wave feedback training, unless the Meditative Exercises (Schulz and Luthe 1959) can be said to be brain-wave training.

*tentative
summary of
physiological
findings*

A tentative summary of our *psychological* findings are: (1) body-image changes, reaching a feeling of disembodiment in some subjects, seem to be associated with very low

*tentative
summary of
psychological
findings*

levels of muscle tension; (2) a general feeling of tranquility is usually reported in conjunction with significant increases in hand temperature, though an accompanying drowsiness tends to interfere with the alert inner-focused state which is associated with the production of alpha rhythm; (3) a poised non-drowsy state, generally associated with a high percentage of alpha, appears to facilitate recall processes. In addition, (4) hypnagogic and dream-like images during a state of semiconscious reverie have been observed by a number of experimental subjects **in** conjunction with periods of theta rhythm and low-frequency alpha waves (see accompanying diagram).

Normally unconscious		Normally conscious		
delta	theta	alpha	beta	
0	4	8	13	26
Hertz (cycle sf second)				
Major frequency bands of brain waves, electroencephalographic (EEG) record.				

If it were now asked how the autogenic feedback training system might be related to transpersonal psychology and in particular to research **in** creativity, we would direct attention to the important implication in Item 4 above. The "reverie" that accompanies the semiconscious production of theta waves and low-frequency alpha seems to be associated with and make possible, under certain conditions, the detection of hypnagogic-like imagery, the *sine qua non* of creativity for many outstanding people. **In** order to remain conscious and alert during theta production without long autogenic or yoga-like training, it seems that it will be necessary for most people to make use of instrumental aids such as those, for example, which we are developing and testing.

*beginning
stages of
transpersonal
research*

It is necessary to mention at this point that our research in the transpersonal area is only in its beginning stages. Ordinarily, the report presented here would be delayed 2 or 3 years until data were analyzed and security assured, but it seems that the discussion of possible scientific methods for the study of transpersonal processes may be immediately

"Reverie is defined for our purposes as a state of Inward-turned *abstract* attention or internal scanning. It is differentiated from the state of attention normally associated with peripheral sensory processes. external scanning, and concrete problem-Solving. There seems to be no simple differentiation between deep reverie and some dream-like states.

useful because of the experiential explosion into "altered states of consciousness."

Before discussing instrumentation and procedures for research in imagery we wish to summarize briefly some of the recent developments in creativity research and indicate the converging lines of evidence that indicate that "psychophysiological training for creativity" is a reasonable hypothesis.

Main avenues of research in this area have been the efforts to identify traits and abilities related to the creative process, exemplified by the work of Guilford (1964) and his associates (Wilson *et al.*, 1954) and to isolate personality characteristics related to creativity, exemplified by Cattell (Cattell, 1964; Drevdahl & Cattell, 1958) and Barron (1958, 1964) and their associates. Another approach has been the effort to gain insight into the creative process and how it might be enhanced in others by studying the accounts of creative activity as experienced and reflected upon by thinkers and artists of distinction, as in Ghiselin's *The Creative Process: A Symposium* (1952). A few attempts have been made to study creativity through the use of hypnosis (Krippner, 1964; MacKinnon, 1964). Efforts to increase or "train for" creativity have included methods such as "brainstorming" (Parnes, 1962; Osborn, 1963) and "synetics" (Gordon, 1961). A large array of literature has discussed the possibility of developing the creative potential in young children and older students. A varied sample might include Mearns (1925), Getzels & Jackson (1962), MacKinnon (1962), and Cattell (1968).

Recent attempts to elicit and investigate creativity through the use of psychedelic drugs (Magar, 1965; Harman *et al.*, 1966; Zegans, 1967) represent a direct manipulation of psychophysiological variables; however, this technique is not suitable for work with the general population, and is most definitely not applicable for enhancing or facilitating the release of latent creativity in students. New methods must be used to study creativity as associated with psychophysiological variables in a student population.

In considering the possibility of psychophysiological training for creativity, it is useful to draw attention to (a) the existence of a link or relationship between alpha-and-theta-rhythms in the brain wave and reverie-and-hypnagogic-imagery, and to (b) the existence of a link or relationship between reverie-and-hypnagogic-imagery and creativity. It

*new methods
for study of
creativity*

*training and
unrealized
creativity
potential*

can be inferred from the above juxtaposition that the areas of alpha-and-theta-rhythms and creativity may indeed overlap, and that training in the production and control of alpha-and-theta-rhythms may make possible an enhancement of creativity in individuals whose potential is yet unrealized.

ALPHA-AND-THETA-RHYTHMS AND
REVERIE-AND-HYPNAGOGIC IMAGERY

Consider some of the evidence that links low-frequency alpha and theta rhythms with a state of reverie and hypnagogic imagery.

1. Pilot experiments in our laboratory with three subjects" who were self-trained over a period of 15 to 30 years in *internal scanning techniques* (meditation) demonstrated an unusually high percentage of 6-8Y2 Hertz waves in their EEG records during periods of deep reverie. Two of the three subjects had long trains of theta waves. Both reported the presence of hypnagogic-like or dream-like images, which they said was customary in their internal-scanning experience. The third subject was able to reduce his normal alpha frequency from 9.5 Hertz down to about 8.3 Hertz during f-minute trials and reported this as a preliminary mind-quieting imageless stage in moving toward a deeper state of reverie.

2. In a reaction time (RT) and states-of-consciousness experiment" performed in our laboratory, essentially a "sensory deprivation" experiment, it was found that monotony was a significant factor in the production of hypnagogic-like images." Twelve subjects were tested for reaction time in three EEG sessions, each of 1 1/2 hours duration. The RT stimulus was the "bump" of a light-weight button on which the subject's finger rested. The duration between the "bump" and subsequent "press" on the button was the RT measurement. Electronic equipment was arranged to count cycles of alpha rhythm and give the stimulus (without warning) in *alpha trials*, coincidentally with the appearance of the third, sixth, or ninth wave of the alpha burst. In *non-alpha* trials, the machinery gave the stimulus at 0.3, 0.6, or 0.9 second, after the end of an alpha burst. After responding with a

A professor of physics, a psychiatrist, and a psychologist, all of whom are uniquely individualistic, creative, and successful in their respective vocations. The results of which are being prepared for publication.
"Hypnagogic-like, rather than hypnagogic, because our subjects were trying to remain awake rather than to go to sleep.

"press," the subject made a forced-choice categorization of the focus of his attention at the time of stimulus presentation, according to the outline below.

ATTENTION			
INTERNALLY FOCUSED, WITH		EXTERNALLY FOCUSED	
"hypnagogic" imagery	thinking	in the environment	on the finger

Hypnagogic imagery was described to the subjects as pictures or words that they did not consciously generate or manipulate, but which sprang into the mind "full blown," so to speak. Quite often in the experiment, reports of "hypnagogic imagery" were associated with drowsiness and the presence of theta waves. These images were called to conscious awareness by the RT stimulus and were generally accompanied by a burst of alpha waves. Usually associated with beta waves were reports of concrete images or external objects.

*hypnagogic
imagery*

One subject reported that the stimulus caused him to suddenly become aware of "little pictures" in his mind that he did not know were there. He described a "void" into which the pictures "popped" when the stimulus was given. Without the stimulus, he said, he would not have been able to remember what was in his mind. From a number of similar reports in the reaction-time study and from the reports of pilot subjects in other experiments we hypothesized that the presence of alpha rhythm indicated a state of consciousness conducive to recall and devised the recall test previously mentioned to test this hypothesis."

The hypnagogic-like effect of monotony in the reaction time experiment was not totally unexpected. A number of writers, including Huber (1965) and Shattock (1960), have stressed the use of monotony in developing awareness of normally unconscious material. Shattock's description of a flash of imagery during his training in meditation-walking is an almost perfect example of the hypnagogic experience.

3. Kasamatsu and Hirai (1963) have reported that in an

Robert R. Holt, in a paper which stresses the importance of Imagery and recall (1964), concludes with the following words: "I want to mention briefly one speculative implication of the work on imagery, which to me opens the most exciting vistas... Several lines of evidence are beginning to suggest that the capacity for an astonishingly complete recording of experience may be virtually universal, and that the problem is primarily one of getting access to the traces... the vehicle of the extraordinary recall is imagery... The indirect means of imagery may furnish the key to the fabulous storehouse of memory, if we can learn how to make use of this neglected capacity."

EEG experiment with Japanese Zen masters it was found that (a) as the subject began to turn his attention inward, continuous trains of alpha rhythm appeared in the record, (b) the dominant frequency of the alpha pattern began to decrease toward the alpha-theta border region, and finally (c) *the* subject, *in* a state of reverie, produced long trains of theta waves.

*vital role of
attentioncontrol*

4. Anand, Chhina, and Singh (1961) reported that in a study of Indian Yoga masters theta waves were found associated with inward-turned attention (samadhi). They also reported that during an alpha phase the control of attention achieved by these subjects was so intense that neither flashing lights, sounding gongs, vibration, or the touch of a hot glass test tube could disrupt the state of concentration and cause "alpha blocking." These observations demonstrate that a high degree of attention control is associated with the maintenance of specific EEG states.

The above four items indicate that an important relationship exists between hypnagogic imagery, alpha-theta EEG patterns, and certain states of consciousness that, because of their inward-turned nature, we have chosen to associate with the relatively undifferentiated Western word *reverie*.

REVERIE-AND-HYPNAGOGIC-IMAGERY AND CREATIVITY

*unusual
significance
of reverie*

Reverie is a *state* of unusual significance because with it is associated hypnagogic-like imagery in which unconscious processes are often revealed to the waking self in symbols, words, or gestalts.

McKellar and Simpson (1954) in an investigation of hypnagogic imagery say that their subjects described images that seemed to differ from dreams in that they were "more vivid," and "more realistic." Also, they "come and go in a flash," and "resemble lantern slides," and "contained detailed material which I didn't know I knew." Their subjects reported four main characteristics of hypnagogic images: (a) vividness, (b) independence of conscious control, (c) originality, and (d) changefulness. The authors comment that "Hypnagogic images merit investigation in that they may represent an instance in which greater knowledge of the 'normal' may illuminate the 'abnormal.' "

The hypnagogic images described by McKellar and Simpson's subjects are remarkably similar to the *creative* images

described by Kekule. He tells of a series of deep reveries in which atoms "gambled" before his eyes, leading to his theory of molecular constitution (Koestler, 1964):

creative images

One fine summer evening I was returning by the last omnibus, "outside" as usual, through the deserted streets of the metropolis, which are at other times so full of life. I fell into a reverie, and lo! the atoms were gamboling before my eyes. Whenever, hitherto, these diminutive beings had appeared to me, they had always been in motion; but up to that time I had never been able to discern the nature of their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair, how a larger one embraced two smaller ones; how still larger ones kept hold of three or even four of the smaller; whilst the whole kept whirling in a giddy dance. I saw how the larger ones formed a chain . . . I spent part of the night putting on paper at least sketches of these dream forms.

The last of this series of dreams led to his famous discovery, which has been called "the most brilliant piece of prediction to be found in the whole range of organic chemistry."

I turned my chair to the fire and dozed. Again the atoms were gamboling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of this kind, could now distinguish larger structures, of manifold conformation; long rows, sometimes more closely fitted together, all turning and twisting in snakelike motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke

Thus, through the dreamed symbol of the snake biting its tail Kekule derived the revolutionary proposal that some organic compounds occur in closed chains or rings. It is small wonder that he urged his contemporaries in science, "Let us learn to dream, gentlemen."

Many other creative people have described the states of reverie, dream, or near-dream in which creative solutions and inspirations have come to consciousness. Robert Louis Stevenson's ability to dream publishable plots by commanding "the brownies" of his mind to furnish him with a story is well known. Well known, too, is Poincare's description of mathematical ideas rising in clouds, dancing before him, and colliding and combining into the first Fuchsian Functions as he lay in bed awaiting sleep.

*extremely
varied ter-
minology*

A. E. Housman, the poet, has described his ideas as a "bubbling up" saying "the source of the suggestions thus proffered to the brain was an abyss. . ." (Ghiselin, 1952). Rollo May (1959) tells of the Nobel Prize winner who dreamed the sought-for formula, wakened, and in his excitement hurriedly scribbled it on a paper handkerchief-only to find he could not read it the next morning. Each succeeding night he concentrated on redreaming it and after several nights he did. This time he got up immediately and carefully recorded the formula.

In addition to the above few examples, there are literally hundreds of other anecdotes which show, beyond doubt, that in some way not yet perfectly understood, reverie, hypnagogic imagery (and its partner, hypnopompic imagery),⁸ and creativity are associated. Worth noting is the fact that the terminology used in describing the state we have called reverie is extremely varied, as for instance, the "fringe" of consciousness (James, 1959), the "pre-conscious" (Kubic, 1958), the "offconscious" and the "transliminal mind" (Rugg, 1963), and "transliminal experience" (Mackinnon, 1964).

It may be asked at this point "What reason is there to believe, that just because low-frequency alpha and theta waves have been found to be associated in some people with reverie and hypnagogic-like imagery, the reverse will be true; that *training* a subject to achieve or produce theta waves or low-frequency alpha, a purely physiological accomplishment, will bring about a state of reverie in which hypnagogic-like images and other such phenomena will appear?" To answer this question it is first necessary to point out that a semantic trap exists in the frequently used phrase "training a subject to achieve, or produce, theta waves or low-frequency alpha." In actuality there *is* no such thing as training in brain-wave control; there is training only in the elicitation of certain subjective states that are accompanied by oscillating voltages in the cerebral cortex, detected through the subject's skull and scalp. Brain waves, as such, are not known to have any sensory representation whatsoever by means of which they can be detected. What *are* detected and manipulated in some unknown way are foci of attention, thought processes, and subjective feelings. The *voluntary-controls* program in our laboratory is one of thought, emotion, and attention control. Brain wave control, temperature changes, and striate muscle-tension reduction in our work are thought of primarily as

⁸Similar to hypnagogic imagery except that by definition it occurs just after waking instead of just before sleeping.

physiological correlates of psychological processes. It is desirable to remain aware of the primacy of the psychological state in discussing this type of research, even though it is convenient to use the "shorthand" of terms such as alpha training, temperature training, etc.

*primacy of the
psychological
state*

The unique value of feedback instrumentation is that it gives the subject an immediate indication of his progress. Through external feedback, the subject is enabled to filter out from the welter of internal *existential* cues, those particular ones which he must learn to manipulate.

*unique value
of feedback
instrumentation*

It is also important to differentiate between (a) voluntary control of internal states, as reflected in craniospinal, autonomic, and central-nervous-system indicators; and (b) conditioned control of such indicators, as in animal work and in some human work. Voluntary control can liberate the individual from conditioned responses (Harman, 1967), and bring a degree of freedom from normally unconditioned responses (Meares, 1967). It is important that the above distinction be kept in mind and examined in every situation where it is proposed to use psychophysiological training methods with humans. Voluntary control moves toward increased inner freedom; conditioned control moves toward loss of inner freedom.

So, in answer to the preceding question it can be said that we do not attempt to train people in the production of low-frequency alpha and theta rhythms, but rather to train them in the voluntary control of certain existential states whose central-nervous-system correlates are revealed by the presence of low-frequency alpha and theta rhythms in the EEG record.

The physiological goals of this research are related only indirectly to the peripheral nervous system. The main goal involves voluntary control of the central nervous system so that those states of awareness that are associated with conscious control of alpha and theta rhythms in the brain can be studied.

*main
goal*

Laboratory Training for Imagery: Laboratory sessions for the self-induction and study of imagery will be similar to those already described, except that only percentage-of-alpha, frequency-of-alpha, and percentage-of-theta will be used for feedback. For formal study, 12 subjects will be selected from the 18-man group of college students who

*projected
research*

have already received training for control of muscle tension, temperature of the hands, and percentage-of-alpha.

Visual feedback of frequency-of-alpha and percentage-of-theta will be presented by switching on two additional bars of light on the feedback panel previously described. The frequency bar is arranged so that a change in the frequency of alpha from 12 Hertz to 8 Hertz causes the bar to rise from the bottom to the top. The theta bar rises to the top when the subject produces continuous theta waves for a 10-second period. One of the pilot subjects mentioned above could essentially do this, and also could communicate verbally *during* trains of theta.

In addition to the visual display of BEG data, we have developed a stereo-audio feedback system in which the frequency in each of the four major BEG bands (for O_1 and O_2 occipital areas) is multiplied by 200. Amplitude is also controlled in each frequency band. The audio signals representing the EEG bands, when appropriately recombined for each ear provide a modernistic biological orchestra," The experimenter is provided with on-off switches that give him individual control (for training purposes) of each brain-wave band in the auditory feedback to each ear. Although stereo audio feedback will be experimented with in work with pilot subjects, our experimental group of 12 college students will be trained with feedback only from the left occiput, in both lab and home sessions. Audio feedback is especially useful for imagery training because the eyes-closed paradigm will be used part of the time.

Home Training: In our work in "voluntary controls training" over the last 4 years we have experimented with (a) Autogenic Training practiced only in the lab, (b) Autogenic Training practiced both in the lab and at home, (c) Autogenic Feedback Training practiced only in the lab, and (d) Autogenic Feedback Training practiced both in the lab and at home. It seems that the combination of both home and lab practice with autogenic feedback is the most effective system and it is the training method that is presently in use. Associated with home practice is a log book in which the subject makes an entry for each session, describing his successes and failures, and any particular states of consciousness or unusual physical states that he has experienced.

This stereo music of the hemispheres was demonstrated at the 1969 Connell Grove Conference on Voluntary Control of Internal States, a conference organized for the purpose of examining the relationship between five old systems and five new systems for studying states of consciousness (Fadhnan, 1969; Harman, 1969).

For home training in relaxation and temperature control, subjects are given portable temperature-sensing meters to help them develop skill in the technique of passive volition. The subject fastens a thermistor to a finger with Scotch tape and tapes another thermistor to his forehead. Since the forehead generally cools and the hands become warmer when the sympathetic nervous system relaxes, the *change* in differential temperature between these two body locations can be used as an indication of autonomic relaxation. The same autogenic phrases which are used in the lab are also used at home.

Because EEG signals are of low amplitude (10 to 100 microvolts), it has in years past required highly sensitive amplifiers encased in laboratory-type machines to detect brain waves. Recent electronic developments have made it possible, however, to obtain low-cost portable alpha detectors that the subject can use at home. The use of portable brain-wave detectors will begin when the present triple-training program is concluded in May 1970. Alpha Sensors will be modified in our laboratory so that the presence of both alpha and theta waves may be detected at the same time. The presence of alpha will be signaled to the trainee by a tone having a frequency of about 2000 Hertz and the presence of theta by a tone having a frequency of about 400 Hertz. The alpha-theta detector will also include (in our modification) three elapsed-time indicators. The first gives total time of the session. The second gives alpha time, and the third gives theta time. Another modification, the use of which is discussed below, is a mercury-switch-and-chime circuit that brings the subject to consciousness if he becomes drowsy.

*recent
electronic
developments*

Group Training: Home-training devices, coupled with autogenic feedback procedures, make possible the simultaneous training of groups. One feature planned for this work is a once-a-week group meeting in which individual experiences will be analyzed and compared with those of other members of the group. In this, as in the work already described, daily logs will be kept. Experience to the present indicates that once the feedback technique for producing specific physiological states is mastered, mechanical devices can be dispensed with. The subject apparently learns to detect and manipulate the internal conditions and cues which are associated with success in his efforts and no longer has need for crutches. As in other kinds of group work, skillful leaders are needed. For this purpose we expect to train professional

*use of
automatic
devices to
enhance
imagery
awareness*

psychologists and psychiatrists who have already volunteered for this training.

HYPNAGOGIC-LIKE IMAGERY

The previous discussion has been concerned almost entirely with the psychophysiological system which helps the subject to develop or enhance those internal states in which it is especially easy to become aware of hypnagogic-like imagery. Not all subjects are immediately aware of this imagery, however, and it is necessary to intervene at critical moments during training sessions in order *to* intensify the subject's state of awareness. This is accomplished mainly by automatic devices. If the subject lapses into drowsiness or if he produces long trains of theta waves without reporting imagery, a chime sounds, drawing him back (or up, or down) into increased consciousness, usually with an accompanying burst of "paradoxical" alpha, paradoxical because an external stimulus under normal waking conditions generally produces or enhances beta waves.

One of the automatic devices used for enhancing awareness of normally unconscious imagery is an omnidirectional tilt detector, a mercury-switch finger ring. The ring is placed on a finger of the subject's dominant hand, which is continuously held up, balanced on the elbow so as to minimize muscle strain. From pilot work with the hand-balancing technique we have found that if the subject's attention or consciousness diminishes below a certain threshold level the forearm will begin to tilt. This closes the mercury-switch circuit and sounds a chime that brings the subject back to an above-threshold level of conscious attention in which he can report the imagery and the subjective states which preceded or were associated with loss of balance. The ring is to be used in both lab and home practice sessions.

*"subliminal
dredging
operation"*

During lab sessions an additional circuit monitors the subject's output of EEG frequencies in the alpha-theta border region and if the subject produces trains of theta waves or low-frequency alpha (near 8.0 Hertz) for a number of seconds, the chime is sounded. Since drowsiness is often evidenced by a low-voltage EEG pattern of varying cycle-to-cycle duration, provision is also made for operation of the chime by an experimenter who monitors the EEG record visually. This feature will be automated as soon as possible. When we described the ring procedure at a seminar given at the Maryland Psychiatric Research Center (1968) someone likened it to a "subliminal dredging operation," and

this, in a way, characterizes the process. The purpose is not to investigate the characteristics of individual subjects, however, but to study the general processes, conditions, and contents of consciousness during a state of deep reverie. This combination of reverie and awareness seems to be an essential (though maybe not sufficient) ingredient of creativity. Tart (1969) has also found the arm-balancing method to be useful in studying reverie and says:

Despite the tremendous increase in research on nocturnal dreaming over the past 15 years, little has been done about studying the hypnagogic period: the prevailing scientific opinion has lightly dismissed this as an unimportant "transitional" period. Yet it seems clear that this period can be prolonged and yield material as rich as any nocturnal dream for at least some individuals. It can be studied easily, even at home

The problem in studying the hypnagogic state in oneself or others is that the material experienced is generally forgotten rapidly, especially as subsequent sleep intervenes between experience and reporting. A simple method to overcome this in studying hypnagogic phenomena is to lie flat on your back in bed, as in going to sleep, but keep your arm in a vertical position, balanced on the elbow, so that it stays up with a minimum of effort. You can slip fairly far into the hypnagogic state this way, getting material, but as you go further muscle tonus suddenly decreases, your arm falls, and you awaken immediately. Some practice with holding the material in memory right after such awakenings will produce good recall for hypnagogic material [po 73].

*arm balancing
method*

One use for the upheld-hand technique is to help maintain a degree of striate muscular tension. According to Meares (1967), the maintenance of striate tension is not inconsistent with control of various autonomic functions, while working with passive volition. Contrary to one theoretical concept, total relaxation may not be conducive to the maintenance of a consciously manipulable psychophysiological state. The present experiment has relevance to Meares' position and also to Luthe's concept of the conditions under which Auto-genic Shift takes place (Luthe, Jus, & Geissman, 1963), and corresponds with the maintenance of striate tension and monotonous activity by Zen and Yoga practitioners (Aurobindo, 1957; Shattock, 1960; Kasamatsu & Hirai, 1963; Huber, 1965). The hand-balancing method takes continuous effort (in maintaining consciousness) during a monotonous situation and it is this feature of the method, of course, that is effective.

Without going into detail, verbal reports elicited from sub-

jects when the chime sounds during lab sessions will be grouped according to the particular brain-wave category with which they are associated (by a "blind" forced-choice method, into categories such as beta, alpha, theta, beta-theta, beta-alpha, alpha-theta, flattened signal, etc.) and then the reports in each category will be analyzed by "blind" examiners according to an image-classification scheme adapted from Wallach and Kogan (1965). In *this* way we expect to find that some of the BEG categories will be described in existential terms that will give insight into the nature and content of the associated imagery. Most of the procedures described above have been tried with a few pilot subjects, without the aid of the automatic chime.

*expected
contribution to
transpersonal
psychology*

One of the most useful contributions of this research to transpersonal psychology is expected to be the powerful instrumental method it will provide for training in internal awareness and control. Even though such an aid is merely a door-opener to internal awareness and even though individuals can be expected to eventually leave all such tools behind, short-term use is expected to be highly significant) especially in learning how to combine conscious and unconscious processes in the creative shaping of ideas. A formal experiment in imagery-and-brain-waves with college students will not be completed and evaluated in less than 2 years, but during that time additional pilot experiments will be conducted to develop methods for manipulation of hypnagogic images. We accept Walkup's hypothesis (1965):

. . . creative persons appear to have stumbled onto and then developed to a high degree of perfection the ability to visualize-almost hallucinate-in the area in which they are creative. And their visualizations seem to be of a sort that lend themselves to easy manipulation in the thinking process. This is illustrated by reports from many of the great inventors of the past and it is easy to demonstrate that individuals differ enormously in the kind and degree of their ability to think in such manipulatable visualizations. If correct, this aspect of creativity suggests many research attacks and many potential changes in education for creative activity.

In addition to their significance in education and creativity, the concepts and methods discussed above are important for psychology, psychotherapy, and psychosomatic medicine.

1. Psychology has long suffered, at least in the United States, from the exclusion of "attention" and "consciousness" because these words could not be operationally defined. Now it is hoped to help reinstate these once-abandoned con-

cepts through the use of feedback techniques, and even more, help reintroduce volition into experimental psychology. With a few exceptions, volition has been largely ignored in the United States for 70 years, since the days of William James. Johannes Schultz, be it noted, is a German, and Roberto Assagioli, the author of *Psychosynthesis* (1965), in which volition is of great significance, is an Italian. Carl Jung, of course, was a Swiss.

2. Psychotherapists would be able to develop in many patients deep reverie and imagery in a short period of time through the use of feedback techniques.
3. Psychosomatic medicine is an obvious area for application of feedback techniques. **In** the last year, for instance, two subjects and several patients at The Menninger Foundation have reduced or eliminated chronic headache through Autogenic Feedback training (in our laboratory or as patients of Dr. Joseph Sargent) using the portable temperature feedback meter for home practice. So far there have been no failures. One of the subjects, with a few minutes of daily practice after using the feedback meter as an aid for only 2 weeks, has been free from headaches for almost a year without medication. She also taught herself to increase the temperature of her feet at night and was able thereby to alleviate a difficult insomnia problem.

"The elimination of warts through hypnosis, a well-established fact, is possibly a function of local blood flow diminution. **In** appropriate situations, voluntary starvation and absorption of cancerous growth through blood flow control might be found to be feasible. This would be a challenging area for research and might lead to an understanding of some of the presently unknown factors responsible for spontaneous remission of malignancies.

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