A PHYSIOLOGICAL EXPLANATION OF UNUSUAL BEHAVIOR IN CEREMONIES INVOLVING DRUMS *

BY ANDREW NEHER
East Los Angeles College

INTRODUCTION

ONE purpose of anthropology is to study the diverse forms of human behavior. Some of the behavior that the anthropologist observes is so unfamiliar to him, and to Westerners in general, that it resists ordinary explanation. This situation, of course, is an advantage for the anthropologist and a challenge for investigation, since, if old explanations are really inadequate, then a new discovery may result. To benefit from this advantage, the anthropologist must have a knowledge of human behavior so that he will be aware of what is unexplained by present knowledge. An example of such a phenomenon is the eating of certain cacti and mushrooms to elicit visions and contact with the spirit world. Observations of such behavior in several different cultures date back several centuries, but it was only recently that investigations revealed hallucinogenic alkaloids and indoles in the plants (Fabing, 1956). These and allied substances are now being used in studies on the biochemistry of mental illness. Thus, two benefits have resulted from this investigation: 1. Anthropology has made a real contribution to the study of mental illness. 2. Laboratory investigations have given the anthropologist an understanding of the behavior he observes.

Another area which has invoked curiosity, but little investigation, is the unusual behavior observed in ceremonies, in different parts of the world, which involve drums. This behavior is often described as a trance state in which the individual experiences unusual perceptions or hallucinations. In the extreme case, twitching of the body and a generalized convulsion are reported. These physiological and psychological states, and the importance of the use of drums, have remained a mystery. Investigators from several fields have speculated on these issues (Evans-Pritchard, 1937; Reese, 1948; Huxley, 1952; Sargant, 1957; Busch,

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1960). Some of these individuals have come close to proposing the explanation set forth in this paper. In particular, Walter and Walter (1949, pp. 57-58, 82) in their article on the effects of rhythmic stimulation, propose:

> Stimulation of other receptors gives even more convincing results, particularly when a very large group of sensory units can be excited simultaneously and rhythmically, for then the central electrical response is correspondingly larger and the subjective reports more assured. The ear and the eye present the best opportunities for such experiments, for the whole basilar membrance or retina can easily be stimulated in its own mode . . . Rhythmic stimulation of the organ of hearing as a whole can be accomplished only by using a sound stimulus containing components of supraliminal intensity over the whole gamut of audible frequencies—in effect a steep fronted sound such as that produced by an untuned percussion instrument or an explosion. Here, again, the specific effects of rhythmic sound stimuli are familiar and frequently exploited for various purposes.

The present study is an attempt to find an explanation for the behavior observed in drum ceremonies. The hypothesis tested is that the behavior is the result primarily of the effects of rhythmic drumming on the central nervous system.

METHOD AND RESULTS

The investigation began when a similarity was noticed between responses in drum ceremonies and responses to rhythmic stimulation that had been observed in the laboratory. The first part of the study consisted of gathering reports by anthropologists and laboratory workers and comparing them to see if the initial similarity held true. It was soon apparent that almost all laboratory work had utilized a flashing light for rhythmic stimulation, whereas rhythmic sound is most important in ceremonial settings. Therefore, as the second part of the study, a drum of appropriate characteristics was used as a stimulus in the laboratory to see if similar responses could be obtained. Prior to this study, several workers had attempted to obtain responses to rhythmic sound. They used clicks and single tones with little success (Gastaut *et al.*, 1949; Goldman, 1952; O'Flanagan and Gibson, 1951). The seemingly effective use of drums in ceremonies, however, gave clues concerning physiological mechanisms that might have been overlooked: 1. A single beat of a drum contains many frequencies. Different sound frequencies are transmitted along different nerve pathways in the brain. Therefore, the sound of a drum should stimulate a larger area in the brain than a sound of a single frequency. 2. A drum beat contains mainly low frequencies. The low

frequency receptors of the ear are more resistant to damage than the delicate high frequency receptors and can withstand higher amplitudes of sound before pain is felt. Therefore, it should be possible to transmit more energy to the brain with a drum than with a stimulus of higher frequency.

The second part of the study has been reported elsewhere (Neher, 1961). Responses to drumming were obtained and were similar to responses observed with light stimulation, namely: 1. The electrical activity of the brain, particularly in the auditory region, was affected. 2. Subjects reported unusual perceptions. 3. Muscle twitching occurred in some subjects. There is no reason to think that general response characteristics which were not measured differ greatly from responses to light stimulation. Therefore, because responses to light stimulation have been studied extensively, the following section of the paper will draw upon results of light stimulation studies as well as general results from the laboratory part of this study.

Let us examine, then, findings from laboratory investigations of rhythmic stimulation and see how these compare to specific ethnographic examples.

It has been known since 1934 that a bright rhythmic flashing light, with a frequency near the normal basic rhythm (alpha rhythm) of the brain, has two electrical effects: 1. The brain wave is built up in amplitude. 2. If the frequency of the light is shifted somewhat, the brain rhythm changes to the new frequency of the light (Adrian and Matthews, 1934). The reasons for the unique effects of rhythmic compared with continuous stimulation have been stated as follows: 1. Depletion of response due to adaption of the nerves is not as great, as there is time between pulses for nerve fatigue to dissipate. 2. Nerves in the brain have a spontaneous firing rate that is reinforced by a rhythmic stimulus of similar frequency. 3. In these ways, rhythmic stimulation affects many sensory and motor areas of the brain, not ordinarily affected, through their connections with the sensory area being stimulated (Walter and Walter, 1949). This activation of the brain by rhythmic light is called photic driving and has found application in the diagnosis of epilepsy and tumors (Loyd-Smith and Henderson, 1951), treatment of depression (Ulett, 1953), and learning research (Livanov and Poliakov, 1945). In the future, auditory driving should be useful in diagnosing musicogenic epilepsy and detecting abnormalities in the auditory region of the brain. Walter and Walter (1949, p. 63) summarize the behavioral effects of driving, in order of seriousness, as follows:

1. Visual sensations with characters not present in the stimulus, that is: (a) Colour; (b) Pattern; (c) Movement.
2. Simple sensations in other than the visual mode: (a) Kineasthetic (swaying, spinning, jumping, vertigo); (b) Cutaneous (tingling, pricking); (c) Auditory (rare); (d) Gustatory and olfactory (doubtful); (e) Visceral (probably connected with (a)).
3. General emotional and abstract experience: (a) Fatigue: (b) Confusion; (c) Fear; (d) Disgust; (e) Anger; (f) Pleasure; (g) Disturbance of time sense.
4. Organised hallucinations of various types.
5. Clinical psychopathic states and epileptic seizures.

The range of individual differences in basic brain wave frequency is from around eight to thirteen cycles per second. This is thus the most effective range for obtaining responses to rhythmic light, although the laboratory part of this study indicates that slightly lower frequencies may be most effective for sound stimulation, due to the presence of low frequencies (theta rhythms) in the auditory region of the cortex.

We expect to find, therefore, a predominance of drum rhythms in the range of slightly below 8 to 13 cycles per second in ceremonies that precipitate the behavior in which we are interested. One of the few writers who have studied drumming quantitatively is the musicologist, Jones. He has presented analyses of ceremonial drumming, with these rhythms, from different parts of Africa (examples are the beer dance of the Lala of Northern Rhodesia, the Sogo Dance of the Eve tribe of Ghana, the beer dance of the Nsenga of Central Africa, Jones, 1954 and 1959). These rhythms have a frequency between 7 and 9 cycles per second and stand out as ". . . the resultant rhythm, which is the predominant sound heard by anyone standing near the dance . . ." (Jones, 1954, p. 44). Music from Haiti has been studied and recorded by Folkways Records, and it is generally evident from correlated accounts that the agitated behavior occurs with drum frequencies that reach 8 or 9 cycles per second (examples are the Vodoun, Ifo, and Juba dances). These rhythms are probably employed not because they are easy to maintain or are the upper limit of tempo that can be obtained. Western music is almost always of slower tempo, while some Oriental music is somewhat more rapid than these drum rhythms.

Another laboratory finding is that, although the frequency of the basic brain wave varies from individual to individual, it is essentially constant for a given individual over time, as is the frequency of stimulation to which he is most susceptible. From one study, ". . . it was found

that the emotional response was greatest at the point of highest driving." (Ulett, 1953, p. 72). So we expect to find from anthropological data: 1. a changing stimulus frequency to encompass the range of individual brain rhythms, and 2. susceptibility to particular rhythms by particular individuals.

Anthropological accounts indicate that the rhythm is slowly increased over the length of the ceremony. For example, among the Siberian Tungus:

> This slow and soft drumming of the beginning of the performance produces its effects: the attention of the shaman is concentrated as well as that of the audience. The spirits may now arrive at any moment. Since the arrival of a spirit means extasy (sic), the drumming shows gradual increase of tempo and gradually changes from piano into forte . . . When the shaman is in a state of extasy, the assistant takes the drum and continues the drumming, both for maintaining the shaman's state of extasy and for controlling the behavior of the audience. (Shirokogoroff, 1935, pp. 326, 329)

The following account of a Haitian ceremony provides a fuller picture of the method employed:

> In certain Nago and Dahomean dances . . . there may be a gradual but decided acceleration before the end of the dance, the drums sometimes being directly responsible for this, driving the dancers, causing the dance to take a violent turn by the nature of their beating.
>
> Certain signals in the rhythmic patterns cause a djaille, or "excitement." Some of the dancers may lurch from side to side, regaining balance just short of a fall, others may leap stiffly up and down. Such excitement sometimes leads to possession by loa, the drums being important in inducing such possession, as some persons are conditioned to specific rhythms, and that whenever these rhythms are heard possession is induced. (Courlander, 1944, p. 45)

In the laboratory, a number of precipitators are known to aid simple rhythmic stimulation in producing unusual emotional responses and occasionally convulsions: 1. Rhythms that accompany the main rhythm, and particularly those that reinforce the main rhythm in that they are multiples of it, heighten the response. For example, one laboratory reports, "For a few experiments, two light sources were used simultaneously with independent flash frequencies. The records produced were too complex to be dealt with here but the hallucinations described by subjects were of character so compelling that one subject was able to sketch them some weeks later" (Walter and Walter, 1949, pp. 63-64). 2. Rhythmic stimulation in more than one sensory mode aids the response. Aside from the eye and the ear, the only other receptors that might convey rhythmic stimulation are the tactual and kinesthetic. Dawson

(1947, p. 139) reports a study which used small electrical shocks to peripheral nerves. Although he did not demonstrate gross activation of the brain, he states, ". . . each of the four subjects, although unaware of the results obtained with the other, or of the manner in which the interval between the stimuli was changed, described an alteration in the quality of the perceived sensation when the interval between the stimuli was between 70 and 100 milliseconds." This is an average rate of slightly over 10 cycles per second, which is in the range of the basic brain wave frequency. 3. Stress in general increases susceptibility to rhythm. In particular, overbreathing is frequently used as a precipitator in the laboratory because it is simply and quickly done by the subject. Low blood glucose and production of adrenaline, which result from overexertion and fatigue, also increase susceptibility (Strauss *et al.*, 1952). In this connection, a compound called adrenochrome has been isolated from adrenaline, and, the experimenter states, ". . . it was shown that this substance was related chemically to every hallucinogen whose chemical composition has been determined." (Hoffer *et al.*, 1954, p. 33). Adrenochrome, though it was not shown in isolation in the human body, was said to have a more powerful precipitating action on convulsions than Metrazol, which is often combined clinically with light stimulation for this purpose.

With this knowledge, let us look to drum ceremonies to see what is present that might help precipitate the behavior that is observed. The following account, for example, is given by Gorer (1944, p. 23):

> As soon as the M'deup hears these drums she starts dancing uncontrollably and most energetically until she falls into the clairvoyant trance. The onlookers dance in the same steps from time to time as they feel inclined to keep her company, but the M'deup dances continuously. The M'deup dance is not particularly elegant or varied. It consists of very forcible rhythmic undulating movements of the whole head and torso. The arms are jerked forcibly backwards so that the elbows nearly meet, the knees are slightly bent, and the dancer goes round in circles with small shuffling steps while making these violent physical movements. The M'deup may go on dancing in this way for a very long period before the clairvoyant trance is achieved. Eventually, however, she falls to the ground in a cataleptic fit, and stays there for a little time while the drums keep on beating, and the singers sing louder.

Here are a number of stimuli which increase susceptibility to rhythmic stimulation: 1. Jones' (1959) analyses indicate that these dances almost always have a combination of different rhythms which accompany the main drum rhythm. 2. The dancer is simultaneously and rhythmically stimulated in several senses: auditory, tactual, and kinesthetic. Rhythmic light stimulation is not used probably because there is no practical way

of achieving it outside the laboratory. 3. The violent dancing and gestures make hyperventilation a possibility and increase the production of adrenaline, as well as cause a decrease in blood glucose which is used for energy.

As an example of the unusual perceptions which occur in the laboratory to rhythmic stimulation, it is best to give the account of a subject in such an experiment:

> I lay there holding the green thumbless hand of the leaf while things clicked and machinery came to life, and commands to gasp, to open and shut my eyes, reached me from across the unseen room, as though by wireless. Lights like comets dangle before me, slow at first and then gaining a fury of speed and change, whirling colour into colour, angle into angle. They were all pure ultra unearthly colours, mental colours, not deep visual ones. There was no glow in them but only activity and revolution. (Walter, 1953, p. 101)

There has been some speculation recently about using rhythmic stimulation as an aid to hypnosis. Lafayette Instrument Company manufactures a rhythmic light apparatus expressly for this purpose, citing successful results from experimental studies. This writer, however, has been unable to locate these reports. Almost all subjects, including normal subjects, show both brain wave changes and report unusual subjective feelings to rhythmic light stimulation. Epileptics, and possibly hysterics, are apt to experience hallucinatory and dissociative states, and finally myoclonic twitching and a generalized convulsion. This also occurs with some normal subjects who are particularly susceptible to rhythmic stimulation (Ulett *et al.*, 1958). The amount of control that such subjects can exercise is limited and the experimenters must be careful to terminate the stimulus before an unwanted convulsion occurs. Most of these findings have been duplicated, using rhythmic sound, by the laboratory part of the present study.

To compare the experiences of laboratory subjects with experiences in drum ceremonies, the following account, by an American who participated in a Haitian ceremony, is given:

> My skull is a drum; each great beat drives that leg, like the point of a stake, into the ground. The singing is at my very ear, inside my head. This sound will drown me! "Why don't they stop!" I cannot wrench the leg free. I am caught in this cylinder, this well of sound. There is nothing anywhere except this. There is no way out. The white darkness moves up the veins in my leg like a swift tide rising, rising; is a great force which I cannot sustain or contain, which, surely, will burst my skin. It is too much, too bright, too white for me; this is its darkness. "Mercy!" I scream within me. I hear it echoed by the voices, shrill and unearthly: "Erzulie." The bright darkness floods up through my body, reaches my head, engulfs me. I am sucked down and exploded upward at once. That is all. (Deren, 1953, p. 260)

The descriptions of some participants indicate a generalized convulsion, including post-reaction stupor, as in the following account of a ceremony in Java:

> Then he stepped forward and bent over the writhing form, whispering a magic formula from his armory of secret incantations. Only now was I aware of the fact that drums had stopped their insistent beating. The whispering of the sorcerer was like a hissing of serpents. Little by little the twitching body of the boy-horse began to quiet down. The muscles relaxed, the convulsed face became smooth and rounded as before, the breathing subsided—almost ceased. (Epton, 1958, p. 44)

Herskovits (1937, p. 185) similarly describes a Haitian dancer who ". . . fell to the ground and rolled on his back, lying prostrate with legs and arms outstretched and twitching." Herskovits (1937, p. 148) also relates the lack of control of the response by the participants in a Haitian ceremony:

> The passion with which a person resists his god when he feels possession coming on at a rite not given by his own family is particularly instructive. Men have been seen holding so tightly to the rafters of the shelter under which the dance was being held that the muscles of their forearms formed great cords, while beads of perspiration rolled down their foreheads.

DISCUSSION AND CONCLUSIONS

We have seen that the behaviors observed in drum ceremonies and in the laboratory appear to have similar physiological and psychological characteristics which result from rhythmic stimulation. Two additional steps are needed to confirm this conclusion: 1. Measurement of physiological and psychological responses of actual participants in drum ceremonies. 2. Replication of the laboratory part of this study.

This paper has had to neglect many additional questions that are important: 1. Why do some cultures and not others make use of drums? For example, the response might serve as an escape from reality, similar to drunkeness, as a mechanism to relieve tensions and inhibitions, or as a way to gain group unity and feeling. 2. How is the behavior pattern to this stimulus modified by the culture? It has been found that individuals, to some degree, modify their responses to rhythmic light stimulation according to whether the responses are rewarding or unpleasant to the individual (Walter, 1953). 3. Is susceptibility to drum beats largely hereditary or is it more dependent on acquired personality traits? Initial susceptibility to rhythmic lights seems to follow patterns of genetic transmission (Watson and Davidson, 1957). 4. What other purposes do drums serve in these ceremonies? For instance, they probably

satisfy esthetic and recreational needs. 5. Is susceptibility to drum beats in any way adaptive or maladaptive and thus subject to selection? If so, do separate cultures show different rates of susceptibility? Studies using light stimulation show no differences in susceptibility between South African Negroes and whites (Mundy-Castle, *et al.*, 1953).

There are other areas in anthropology that invite this kind of investigation. For example, there are reports of participants in drum ceremonies enduring ritual ordeals that would ordinarily be extremely painful (Courlander, 1944; Kirby, 1934). Laboratory studies show that a strong sensory stimulus concurrent with pain inhibits the transmission of pain to the conscious areas of the brain (Gardner and Lucklider, 1959). Many dentists now use an acoustic generator as a pain-killer when filling teeth. Thus, it is possible that drums are employed in ritual ordeals because of this effect.

SUMMARY

The hypothesis was tested that unusual behavior observed in drum ceremonies is mainly the result of rhythmic drumming which affects the central nervous system. The study consisted of two parts, this paper being a report on the first part: 1. Observations from laboratory studies on the effects of rhythmic stimulation were compared with reports of behavior occurring in drum ceremonies. Stimulus conditions and responses seemed to be similar in both situations. 2. Because activation of the brain by rhythmic sound had not been demonstrated experimentally, rhythmic drumming was used as a stimulus in the laboratory. Stimulus conditions and responses observed were comparable to characteristics of drum ceremonies, as well as to laboratory studies of the effects of rhythmic light stimulation.

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