PERSPECTIVES IN ETHOLOGY

Edited by

P. P. G. Bateson

Sub-Department of Animal Behaviour
University of Cambridge
Cambridge, England

and

Peter H. Klopfer

Department of Zoology
Duke University
Durham, North Carolina

Volume 2

PLENUM PRESS • NEW YORK AND LONDON

1976

Chapter 3

BIOLOGICAL RHYTHMS AS INFORMATION CHANNELS IN INTERPERSONAL COMMUNICATION BEHAVIOR

Paul Byers

Teachers College
Columbia University
New York, N.Y.

I. INTRODUCTION

In this paper I begin with the following assumptions which are implicit in a General Systems or communication theoretical epistemology.

1. Implementing, maintaining, or changing the nature of human (and animal) relationships is a process involving feedback.
2. The relating process, then, requires that each interactant have continuous information about the state of the other.
3. The "state of the other" is multilevel. That is, there are states of cells, organs, organ systems, the organism, etc.
4. Language, at best, functions only in relation to information available to the thinking-symbolizing component of humans, and may be a construct of "thinking" rather than a verbal readout of actual states. In any event, imagine two persons trying to develop a relationship with only semantic information exchanged via teletypewriters.

In this framework I will describe research which supports the following assertions:

1. In every human (and animal) interaction we can discover that the motor onsets underlying movement or vocal behavior are of the nature of a modulated rhythm and that, on one level of organization, the nature of the relationship can be stated in terms of the relationships between or among the modulated rhythms.
2. The basic underlying rhythms are related to a few brain rhythms or oscillations.

3. There are rhythms or rhythmic relationships on ascending levels of organization. The ballisic motor impulses of the intercostal muscles, for example, show rhythm at the level of syllable pulsing. On a higher level, the back-and-forth conversation between two people also can be seen as an oscillation.

4. The variation from purely mechanical, exact oscillation represents information about the state of one actor which is continuously available (in *vis-à-vis* situations) to the other(s). In music the variation from mechanical rhythm is information called "expression."

5. There is a biological response in humans such that certain rhythmic relationships are felt or perceived as good (sometimes referred to as "good vibes") and others, mismatching, are biologically disturbing. We recognize that one usually feels uncomfortable if he is late, out of step, etc. This also operates at lower levels (higher frequency). We recognize that "timing" is important in team sports, music, acting, etc.

6. Except for cultural conditioning, which may reinterpret "good" feeling as bad and vice versa (e.g., pleasure can be seen as seductively dangerous and suffering as righteous and ultimately rewarded), the nature of a human (or animal) relationship is isomorphic with the nature of the rhythmic relationship between or among interactants.

I will report on specific research, including my own, which identifies rhythms underlying performed and communication behavior; I will discuss the methodological and theoretical implications of this research; and I will suggest the implications for this emerging line of research for an emerging new view of man and human nature.

II. BRAIN RHYTHMS

In 1951, at a symposium concerned with "Cerebral Mechanisms in Behavior," Karl Lashley presented a paper titled "The Problem of Serial Order in Behavior" (1951, pp. 112–136). He pointed out that both associative chain theories and the reflex arc theory of brain function were "doomed to failure because they start with the assumption of a static nervous system" (1951, p. 135). He said that the available experimental evidence showed the brain to be either a dynamic, constantly active system or a composite of many interacting systems. He suggested, although without adequate empirical evidence to support the hypothesis, that internal and external *rhythms* should be considered. Three quotations from Lashley (1951) are particularly

relevant to this research:

> . . . the problems raised by the organization of language seem to me to be characteristic of almost all other cerebral activity. There is a series of hierarchies of organization; the order of vocal movements in pronouncing the word, the order of words in the sentence, the order of sentences in the paragraph, the rational order of paragraphs in a discourse. Not only speech but all skilled acts seem to involve the same problems of serial ordering, even down to the temporal coordination of muscular contractions. (pp. 121–122)
>
> I believe that there exist in the nervous organization, elaborate systems of interrelated neurons capable of imposing certain types of integration upon a large number of widely spaced effector elements. (p. 127)
>
> The remaining alternative (to the reflex arc or associative chain theories) is that the mechanism which determines the serial activation of the motor units is relatively independent, both of the motor units and of the thought structure. (p. 118) (Parentheses mine)

A. Sollberger, who compiled a massive volume titled *Biological Rhythm Research* (1965), wrote:

> All living organisms are set into the solid framework of the physical world, the structure of which pulses with an abundance of "external rhythms": diurnal, tidal, seasonal, solar, sidereal. The capacity to follow them, to oscillate, would certainly enhance the survival potential of a species . . . The construction of our bodies (randomly, genetically, and selectively determined) should therefore include components which are capable of rhythmic function. They do not necessarily have to be formed for this purpose but they must exist. Neither need they be absolutely conditioned by the environment. Once being present, for whatever reason, they might sometimes be expected to oscillate even if the external world is removed. (p. 3)

Sollberger cites the 10 c/sec "alpha" rhythm, but without reference to any behavioral correlates, as well as a rhythm with a frequency of 7 c/sec, which is found both in EEG traces and in assorted experimental situations. He says, "The highest rate of nervous feedback oscillation in *Homo* would seem to lie around 7 c/sec simultaneously setting the upper frequency for rhythmic movements" (1965, p. 81).

Mary Brazier (1960) analyzed brain waves by an autocorrelation method and found a 7.3 c/sec rhythm (from electrodes over the temporal area and the vertex) and a 9.6 c/sec rhythm (from the occiput). These two rhythms correspond to the two cited from Sollberger.

Lindsley (1961), Wolff (1968), and others believe that at least some brain rhythms are related to a mechanism which paces and/or integrates motor behavior. It is reasoned that one learns to make relatively complex movements, or pronounce single sounds, that may involve the coordination of dozens of muscles *as single units*. This was the problem Lashley discussed as "serial ordering" or "serial activation."

If we accept the idea that brain waves reflect internal biological rhythms which pace and/or integrate muscle activation, we are still left with the problem of demonstrating the relationship empirically and of explaining the process by which a few basic rhythms of fixed frequencies can fit the wide range of human activities, which clearly proceed at rates related to tasks and are not limited to the few basic rhythmic rates that have been derived from analyses of brain waves.

Peter Wolff (1968) has investigated this development from simple to complex rhythms, and, in particular, has shown that the stereotypic behavior (e.g., rocking) of mentally retarded or pathologically regressed children is sufficiently regular to suggest that such behavior is the expression of simple, undifferentiated infantile rhythms. He says,

> We are a long way from demonstrating how complex phase interactions develop from simple repetitive rhythms, or how the contributing oscillators can be assembled in ever new combinations at a rapid rate to conform to shifting demands of the intended task. (1968, p. 481)

It has long been understood that the sense of time in children becomes evident around age 4 and is "mature" by early adolescence, and that this is paralleled by concomitant changes in EEG traces. Whatever the developmental mechanisms, it seems likely that the "maturing" found in the sense of time and in brain waves is also in some way parallel to the development of motor coordination skills. Perhaps training in skills (tennis, table tennis, playing musical instruments, etc.) might usefully be seen as a matter of—using Wolff's language—assembling the contributing oscillators into combinations which conform to the demands of the intended task. Perhaps this is the process referred to by our word "practice."

Although he has not been concerned primarily with brain rhythms, Karl Pribram (1971, pp. 206–208) cites evidence that the predominant synchronized brain rhythm, the 10 c/sec "alpha," which is most evident in a resting state, becomes desynchronized at arousal and differentiates into multiple rhythms. Lindsley (1961) believes that, when desynchronized, the neural elements become functionally independent of each other and are available as separate information processing channels.

III. OTHER RHYTHMS

To discuss the matter of rhythms in information processing we must, in addition to the above, examine the nervous system's capacity to use a single beat of a rhythm as a comparator or reference in feedback loops, which may embrace (1) internal structures or organs, or (2) two or more organisms. And to do this it will be necessary to look at rhythms of longer periods or slower frequencies, where experimental research has managed to shed some light on temporal properties of events.

Zelenii (1907), working in Pavlov's laboratory, discovered that if the salivary conditioned reflex in dogs is reinforced at regular intervals of ten minutes, the salivation will appear in the same regular intervals without the presentation of any stimuli. This is now known as the temporally-conditioned reflex. Five years later, Feokritova (1912) reported that an important aspect of the temporally-conditioned reflex is its great rhythmic accuracy—about 3 percent—and that, unlike the usual conditioned reflex which is extinguished gradually, the temporally conditioned reflex is extinguished abruptly. A few years later, Deriabin (1916) found that the nature of the sound used as stimuli is immaterial. Dogs learned to differentiate a stimulus on the basis of its rhythm or duration without regard to the particular quality of the sound, whether a whistle, bell, or trumpet, etc.

Another elegant experiment that demonstrates the significance of different time durations in relation to brain function was performed by Eugene Sokolov (1960, pp. 187–276). He presented subjects with a horn beep of a given loudness and duration. The subjects oriented toward the beep stimulus and, apart from the body orientation, there were concomitant changes in the subject's EEG components, increased blood flow to the head at the expense of flow to the fingertips, changes in the electrical resistance of the skin, and changes in heart and respiratory rate. The stimulus was repeated again and again until the response disappeared. The subject was said to be "habituated" to the stimulus. At this point the stimulus was again presented, but at a lower intensity, and the full-blown response reappeared. This established that a critical component of the stimulus was its intensity or loudness. Then the subject was again habituated to the horn beep stimulus, and at that point the stimulus was presented again, but this time the duration of the beep was shortened. And again the full-blown response occurred. From this experiment we can see that both intensity and duration are crucial (structural) components of the event in Sokolov's experiment.

We can also see the structural significance of duration in common social behavior. We can easily recognize that eye contact may be a significant component of interpersonal relatedness, but within that component we can also see that the duration itself may be critical. A person walking in Times Square in New York City, for example, is permitted only fleeting eye contact with passing strangers. The duration of this allowable eye contact between strangers could conceivably be measured. If, then, a woman in the street prolongs her eye contact with a passing male stranger, he may read into that prolongation a different message. Prostitutes can use this prolongation to identify themselves to perceptive passing men, and it is probable that men looking for prostitutes search the female passersby for this prolongation. Although such signaling behavior will have components other than prolongation of eye contact, if all the other behavior were held constant, the time dimension—the duration of eye contact—would alone probably identify the special signal in this context.

People and the animals who live with them can, to some extent, recognize shifts (from some baseline) that signal state changes. In both people and animal companions we can recognize changes in qualities of movement behavior that we interpret as signaling a new state—of tiredness, illness, depression on one hand, or excitement, impatience, or restlessness on the other. I believe that we could demonstrate that the temporal qualities of movement behavior are more fundamental and universal than the spatial configurations of movement and gesture. I recognize that at the level of information transmission in the nervous system, even spatial information is temporally encoded.

If a stage actor wants to imitate, or mime, a crow, an elephant, or a terrier, he cannot look very much like these animals, but he can get applause from his audience if he actually reproduces the temporal characteristics of the movements of the animal he is imitating. The lumbering walk and head swing of the elephant, the sudden head shifts of the crow, or the rapid restless shifts of the terrier's feet or his rapid tail wag, all suffice to identify the particular animal and require the addition of only minimal spatial cueing.

Musicians know that it is possible to recognize a particular piece of music by hearing only its rhythm tapped out—without the tune or harmony. But it is not possible to hear or even imagine a tune without a rhythmic frame.

When, then, we conceptualize behavior or events in terms of Lashley's "hierarchies of organization," we can see that a rhythm can be conceived as a whole event with its own properties (on one level of organization). But it may also be seen as a component, part, or quality of events or behavior on the next higher level of organization. To use a simple, mechanical analogy, the wheels in a clock may exist independently of the clock (which requires a particular structural relationship among its wheels), but the clock cannot exist independently of its component wheels.

The relation of poetry to its underlying rhythm was considered in a small monograph by R. H. Stetson (1903), entitled ***Rhythm and Rhyme***, in which he argued that rhythm was a thing apart from the content that accompanied it. Stetson believed that the meter of poetry and the rhythm of music were, in some sense, separate from the words or melody even though they were packaged together.

In 1905, Stetson wrote a long two-part paper entitled "A Motor Theory of Rhythm and Discrete Succession" (Stetson, 1905, pp. 250–270, 293–350). In this paper, he disagreed with the followers of Wundt, who conceived of a "pure" rhythm which was modified by the nature of the "ideational

content" superimposed on it. Stetson said that the prevailing concept was incorrect:

> The material rhythmized is conceived (by followers of Wundt) as an antagonistic force which destroys the regularity and therefore the "purity" of the rhythm. The more elaborate the "ideational content," therefore, the less regular the rhythm and the more must groupings depend on a course foreign to the rhythm. (1905, p. 251)

In the same article he wrote, "The most important natural rhythm-producing apparatus is the vocal apparatus" (1905, p. 257). Stetson distinguished between the mechanical cycling of exact intervals and "rhythm," which he acknowledged was inexact since it was reflecting rapidly shifting inner affect-states. But he did not believe that it was the "ideational content" of the speech or music or poetry which changed the rhythm.

Forty-six years later, Lashley was to say ". . . the mechanism which determines the serial activation of the motor units is relatively independent, both of the motor units and of the thought structure" (Lashley, 1951, p. 118). In the language of his report the statement is that the rhythm and the context simply exist on different levels of organization.

In his last work, ***Motor Phonetics*** (1951), published the year after his death, Stetson wrote of the significance of rhythm in an even larger frame:

> The rhythm is certainly one of the most fundamental characteristics of the utterance of a language, and is often most difficult for a foreigner to acquire. . . . The tremendous changes which have taken place in the "sounds" of the French as it developed from the vulgar Latin must have been due to something besides the ordinary changes to which a language is subjected . . . There can be little question that a profound change in rhythm underlies the extensive alterations during the transition from Latin to French. A new rhythm has produced a new language, reshaping the ancient words, eliminating syllables and shifting the stress to an alternation from syllable to syllable . . . such a change of rhythm and of stress is apparent in the Hebrew over against the Arabic, and in the Czech over against the Lithuanian, and in the French over against the Italian. (pp. 124–5)

In contrast to descriptive linguists, who provide elegant structural descriptions of man's languages as symbol systems, Stetson analyzed language as rhythmic motor behavior on ascending levels of organization. Although he did not relate these rhythms to biological rhythms, his minimal vocal unit, the syllable pulse, which rides on the energy from an intercostal muscle ballistic contraction, is also a unit which emerged in the research to be described later in this report.

In 1940, Eliot Chapple and Conrad Arensberg introduced the idea to anthropology that human relations (interaction) could be measured. Interaction was conceived as a sequence (rhythm) of temporally interrelated actions and inactions between (or among) individuals. The quantitative analysis of durations of action-inaction in paired interactions was seen to provide the basis for a description of the nature of the interaction, as well as providing "fruitful aids to the study and analysis of personality" (Chapple and Arensberg, 1940, p. 47). This was the beginning of what has come to be called "interaction chronography." Apart from the measurement aspect of the Chapple and Arensberg paradigm, this was also one of the beginnings of a shift from description in terms of the presence or absence of content items of culture to a concern for the dynamics or sequencing of interpersonal relations, a shift from an emphasis on content to a concern for the temporal structure of process.

A second direction was taken by Chapple himself, who designed the first interaction chronograph, as well as a method for assessing certain personality characteristics of individuals (Chapple, 1949, 1953). Chapple used the interaction chronograph to measure the interaction behavior of a subject in a controlled interview. He found that certain properties of the interaction behavior of individuals were invariant in given personalities.

In 1942, Chapple wrote:

> Personality depends on a combination of variables: (1) the amount of interaction which a person requires, (2) the frequency of his habitual interactions, (3) his origin-response ratio, (4) the rhythm of his interaction rate, and (5) his ability to synchronize, or adjust, to others. An individual's status in each of these variables is acquired by a combination of conditioning and genetic inheritance (Chapple and Coon, 1942, p. 69).

IV. INFORMATION PROCESSING

Now that we have ranged from "primary" 10 c/sec brain rhythms to higher levels of rhythmic organization that are seen as the underlying temporal frames for events ranging from single muscle activations to dyadic interactions and even to entire languages, we can look at the processes which represent "information processing."

When a generalized, steady, mechanical brain rhythm differentiates into multiple rhythms (even of the same frequency or rate) which are available to "neural elements," the state of the neural element or structure will be reflected in the modulation that is impressed on the rhythm of that structure. In a general sense, the study of electroencephalography is a matter of inferring relationships between evoked potentials (electrical activity recorded at the scalp) and brain activity, and of making inferences about the state of brain structures from variations in the emitted brain waves at various sites.

I believe that this relationship holds at all levels of organization. Each individual's rhythm, at a given level of organization and/or as related to specific neural structures, contains information—in the form of modulation—concerning the state of the structure. And each communicating

"other," whether that "other" is another organ within an individual or another person in a communicative relationship, has its own rhythm, as a comparator for sensing, reading, or decoding the information inherent in the modulated rhythm of the "other."

A familiar example can be seen in musical performance. As formally written in a score, music would appear to be mechanically regular in rhythm (with the exception of written indications for pausing, holding, slowing, etc.). But if music were performed mechanically, it would be said to have no "expression." Expression, or "meaning," is impressed on the underlying mechanical rhythm by modulating or varying the temporal relationships between beats.

This example from music can be extended to illustrate a problem in rhythm research. How does one go about identifying the underlying mechanical beat or rhythm when, in expression, it is almost always modulated or varied from beat to beat by the state of the organism (i.e., the performer)? In the case of music, except for some contemporary music, the listener is almost never in doubt. He may tap his finger or foot "in time with the music" even though the music is, to some extent, always expressively "out of time." I assume that the range of "expressive" variation—beyond which one "loses the beat"—is limited. I have processed musical performances in such a way as to measure precisely the intervals between performed beats, and have found that one can, indeed, measure the variation. But I have found no mathematical procedure for establishing the rate of the underlying rhythm, except by averaging intervals.

This leads to an alternative view: that the reference or comparator is always in the "head" of the listener, whose own reference beat is never itself mechanically regular but always reflects his own state at the moment. I will discuss this matter more fully later in this paper, but at this point it is useful to call attention to the methodological problem of establishing frequencies or rates of underlying rhythms from observed behavior, and to point out, again, that whereas externally imposed rhythms (e.g., circadian day-night oscillations) provide an available reference or comparator, internal rhythms are idiosyncratic, and the reference or comparator rhythms of individuals are normally always themselves modulated. In human relations, then, when the rhythms involved are endogenous—as in all the examples involving human relationships described above—there is no absolute measurement against an external referent; there are only relationships.

To summarize: there are at least two primary brain rhythms, with frequencies of 10 c/sec and 7 c/sec, found in the human brain. The 10 c/sec rhythm has been found in animals as far away from man as the water flea. These rhythms, acting as pacers and/or integrators of motor activity, lie at one level of organization, but all behavior can be seen as lying along a hierarchy of levels of organization and the rhythms involved as being specific to levels. A conversation between two persons can be described as an oscillation which has an irregularity or asymmetry assignable to the differing personalities of the individuals and to the state of their immediate relationship. The states of the individuals and the state of their relationship can be described in terms of temporal measurements of their behavior, singly and conjoint. This information is continuously available to persons in *vis-à-vis* (communication) relationships, although the only reference or comparator that a person has available is his own state-modulated rhythm. The implications of this for group behavior will be discussed later.

I believe that these interpersonal rhythm relationships are what is popularly referred to as "getting it together" or sharing "vibes."

V. RESEARCH PROCEDURES AND DATA

A few years ago, I set out to explore the temporal dimensions of human *vis-à-vis* interaction. Condon and Ogston (1971) had reported an extremely precise self-synchrony and synchrony between interactants, but had offered no explanation that related this synchrony to the qualitative nature or the structure of the interpersonal relationship under observation. Although I am an anthropologist, I reasoned that our scientific responsibility required a form of explanation that would span the spectrum of behavioral organization stretching from brain structure to social structure. This involved crossing the (imaginary?) line dividing biology from culture.

To begin with, I acquired copies of film data from three cultural groups: the Netsilik Eskimo, the Bushmen of the Kalahari Desert in Africa, and the Maring of New Guinea. There is a large archive of film for each of these peoples, and I selected about 2500 feet of film from each. The selection criteria were simply, (1) that two or more interacting individuals be continuously visible, whole bodies if possible, for at least 30 seconds, and (2) that synchronous sound tapes be available for at least some of the film. These criteria were difficult to satisfy, since most cinematographers regard prolonged sequences as dull and either move the cameras around the scene, zoom in for close-ups of individuals, or take only brief shots. For data purposes, the requirement is for an unmoving camera-on-a-tripod and long, unbroken sequences of the whole bodies of all interactants.

I used an analyzer projector, with which it is possible to move the film back and forth at any speed, even frame-by-frame. The film was frame-numbered with consecutive five-digit numbers on successive frames.

Many of us who have worked on various kinds of behavioral analyses

of film-recorded behavior have observed that changes of one sort or another (changes in direction of movement, duration of movement, repetitions) often occur at five or ten frame intervals. To my knowledge no one has attempted to explain the significance of this duration. In my own research it was immediately apparent that the meaning or significance of a single temporal unit or its octave would not emerge from any simple, linear counting procedure, but might have significance when the multilevel structure of the behavior could be described.

There is now a large literature demonstrating the multilevel structural organization of behavior (indeed, of all phenomena). In the analysis of body motion communication there are two other matters to consider. First, body motion may be multichannel. That is, the actor may be acting in relation to more than one "other." He may be talking to one person, glance at another, wave to a third, caress a child, and carry out a task, all channels which may be operating simultaneously or woven closely together. There is some sense in which these channels will be interrelated, and some sense in which they will be independent. Second, some part of body motion is related simply to gravity opposing, balance maintaining, inertia, or coming to rest.

It is far easier to "analyze" another person's behavior intuitively—i.e., to communicate or interact appropriately with him—than it is to segment and level the multichannel data for purposes of scientific description.

There are two procedures which can somewhat reduce the behavioral complexity. One method is to select scenes or events in which the participants are, as nearly as possible, "doing nothing" i.e., where task involvements are minimal or absent and where interpersonal involvements are present but minimal—or are, as nearly as possible, single-focused, as in intimate relationships or in formal events (where the form of the performance takes precedence over the content). A second method processes interpersonal speech in such a way that the underlying motor impulsing can be usefully distinguished from the content material (speech sounds). Both of these "screening" procedures are illustrated below.

Figure 1 was derived from a scene in which three Eskimos are "doing nothing." They have dragged a seal from a hole in the ice to a place on land, and one man is working on the seal while the other two are simply looking on. One onlooker is standing, the other sitting on a rock. The third is on his knees working on (skinning?) the seal. There is a minimum of movement. The standing man moves one hand from his head to a limp, hanging position alongside his body. He then brings the hand up to grasp a staff he is holding vertically with his other hand, and this other hand moves to his head where it moves in two circles (scratching his temple) and then comes back down to the staff. He then shifts his weight from one foot to the other, lifting each slightly in turn. The second person, a woman, is looking into

Fig. 1. A notational record of movements of three Eskimos. The squares, reading left to right, represent individual motion picture frames. The blackened squares are those on which onsets of movement for each of three persons are seen on slow projection. When all the movement onsets of the three persons are summed in the bottom line, it can be seen that all are moving in relation to a common rhythm. The frequency is 10 cps. There is no external pacer.

space; at one point she turns her head suddenly, and otherwise is idly moving a small stick up and down. The third person, working on the seal, suddenly rises on his knees, lifts his head, turns toward the camera, turns back, sinks back down, and continues working on the seal. The entire filmed "take" lasts only about 15 seconds.

In Fig. 1 I have noted the time, i.e., the specific film frames, at which changes in motion occur for each person. A change is defined as the point at which visible movement of a body part begins, ends, or changes direction or velocity. The three uppermost lines of Fig. 1 each represent a single actor in the scene. The bottom line sums all the onsets-changes of all three

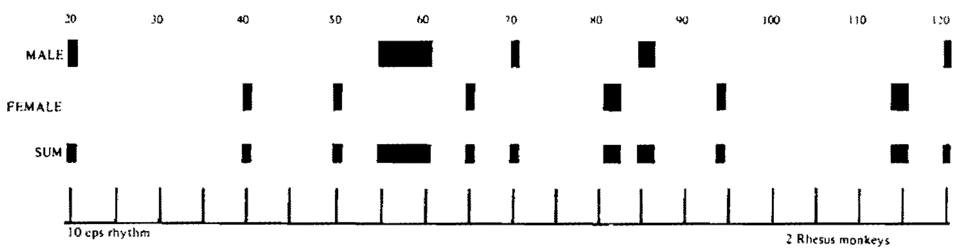

Fig. 2. A record made in the same way as that shown in Fig. 1 except that the interactants are a consort pair of rhesus monkeys. The frequency of the rhythm is also 10 cps. It appears different from Fig. 1 only because the film of Fig. 1 was made at 24 fps and the film of the monkeys was made at 16 fps.

persons. From the bottom line we can see that all three people are moving in relation to a commonly shared beat or rhythm, and that the rhythm is proceeding at a rate of 10 frames (approximately 0.4 sec).

This duration of 0.4 sec. is the same (recognizing that "same" embraces a small range of possible variation) as that of the military march rate, is half that of the accepted heart rate at rest, and is equivalent to four cycles of the familiar "alpha" rhythm of encephalography. The same rhythm sharing phenomenon is found with such regularity in interpersonal and group behavior in all cultures I have examined (using film records) that I believe it to be a human communication universal. I will show evidence that there is an underlying biological rhythm with a rate of 10 c/sec. This is the rate of the alpha rhythm. There are other possible brain rhythms, and human behavior is performed at rates appropriate to tasks, but it appears that human communication or interaction always shows evidence of an underlying rhythm of 10 c/sec.

I define human communication as the process or processes which implement, maintain, or change the state of relatedness between or among people. And since the "state of relatedness" can be derived from observations of rhythm sharing (which I will discuss in more detail later), I find it useful to say that individuals are "in communication" when this shared rhythmic relationship, at this 10 c/sec rate or frequency, is occurring.

A piece of film from the Maring of New Guinea can be used to illustrate and refine the relation of rhythms to communication. In the film about a dozen people are standing or seated in a clearing near a small settlement. There are two clans represented in the group, and the clans are having an argument concerning the killing of a dog belonging to a member of one clan by a member of the other clan. Clan members support each other. This much information was available in the ethonographic notes accompanying the film. I could not identify the clan membership of the individuals in the film by dress, spatial distribution, or postural or seating orientation, etc. But I found that as each of the many speakers talked, about half of the group moved with—i.e., in a rhythmic relation to—a given speaker. By noting these relationships, it was possible to discover that each of the two halves of the group moved together and that any two people from different halves did not. My guess is that this procedure produced an identification of clan membership, but I have not been able to verify that guess.

Had it been possible to verify the clan membership identification, it would have been possible to proceed to the more difficult question: Where in the interpersonal behavior is the synchrony that is required for any communication or interpersonal involvement? And where is the dissynchrony that is the concomitant of the argument or disagreement? I would expect both to exist and to lie on different levels of organization, since, for example, one person must be synchronously related to another's rhythm in order to "interrupt" him—i.e., violate that synchronous relationship.

Some years ago, for purposes other than the study of rhythmic relationships, I took film of the paired interaction of rhesus monkeys at Cayo Santiago, an island near Puerto Rico. I have applied the observational methods used in the Eskimo film (Fig. 1) to a stretch of film of a consort pair of interacting monkeys. The results are shown in Fig. 2. The rhythm sharing is clearly present and the rate appears to be the same. In this monkey film, however, the problems of multiple channeling were clearly present. The female was intermittently approached by her own infant and some of her interaction was involved in chasing the infant away; she was also intermittently diverted by interested members of her troupe and, occasionally, by my presence. The chart in Fig. 2 was made of behavior between "distractions." Unless the behavioral analyst studying rhythms from recorded data has the necessary contextual information about the interaction, he can be confused by this problem of multichanneling.

I would think it important to examine the rhythmic relations in animal behavior within and between, or among, species. Research of this kind with some animals may require film records in which the frames-per-second rate is faster than the usual 24 fps.

Because of the limitations of 24 fps film, and the problems introduced by the multichanneling of movement relationships, this research moved in the direction of processing and analyzing interpersonal speech behavior. Condon and Ogston (1971) and Birdwhistell (1970) have shown that both speech and movement behavior are part of the structure of communication and are not processually different systems of communication. I will show a series of charts generated from speech behavior, but first it is necessary to describe the rationale and procedures involved.

The goal of speech processing is to produce an electronically generated pen tracing of the energy (loudness) of the ongoing speech so that the motor bursts underlying the vocal activity, as well as the points of speech stress, can be pinpointed in time. The chart record should be of such dimensions that intervals of tenths of a second will be far enough apart on the chart for accurate measurement.

The first component of this rig is a tape recorder with an output (earphone) jack and with four-speech capability. The speech to be processed is recorded (or rerecorded) on reel-to-reel tape at a speed of $7\frac{1}{2}$ inches per second. The speed is then reduced to $\frac{15}{16}$ ips for playback-processing. This drops the frequencies by a factor of eight, and into a range that can be handled by a simple analogue pen recorder. Normal speech frequencies lie in the 250-350 c/sec range (ignoring the harmonics or upper partials which can be filtered out or, in any event, will not seriously distort the trace). The inertia of the pen in simple analogue recorders will not allow a linear trace at these (250–350) frequencies, but when the tape recorder speed is reduced eight times the reduced frequencies (about 31-44 c/sec) are manageable.

The slowed speech, then, is fed to the recorder. The trace that emerges shows speech packages or bursts (see Fig. 3) that contain information about both loudness and frequency. To eliminate the frequency component and increase the linearity of the loudness component, it is possible to insert a diode in one leg of the circuit between the tape recorder and the pen recorder, and to put a small (0.2 to 2 microfarad) capacitor across the circuit to smooth out the small fluctuations in loudness and reduce or eliminate the remaining frequency component. Figure 4 shows the trace of the same speech produced by this method. This illustration is of Bushman speech, and I will now examine it in some detail.

Storytelling is a common cultural practice among Bushmen. In the present example a person known to be a particularly good storyteller has been asked to tell a series of stories "to" another Bushman. In practice one Bushman does not talk or tell stories "to" another. He talks the "story line," while the other person or persons participate by imitating part of his gestures in a prescribed way, by adding comments on top of his speech, and by repeating syllables of his speech at the end of certain segmental or syntactic units. This practice of repeating the speaker's last few syllables at points of pause in his speech is commonly found throughout the world. In the southern, and perhaps other parts of the United States, a listener may insert "uh huh," "yes," or some other sound into the speaker's pauses, usually accompanied by a head nod and perhaps other gestural acknowledgment.

Figures 3 and 4 are pen tracings of the same stretch of the Bushman storytelling, i.e., the first five seconds of a sound film record made by John Marshall. Figure 3 is a tracing of both frequency and amplitude, and Figure 4 is a tracing of the amplitude alone. In these traces one second of real time is represented by 80 mm on the chart. One tenth of a second of real time equals 8 mm on the chart.

We can first observe, in Fig. 3, that the speech sound is not continuous, but emerges in bursts with silence between. We can also observe that there is some suggestion of regularity, or even spacing, in part of the vocal stream. If we place a strip of paper with marks representing tenths of a second intervals alongside (below) the charts, and if we position the strip with the marked mechanical rhythm such that the first speech onset of the first speaker (the storyteller) matches one of the beats on the marked reference strip, we discover that some of the other bursts do, indeed, coincide with the beat points on the reference strip. Now, if we reposition the reference strip so that one of the beat points falls on an onset or burst that

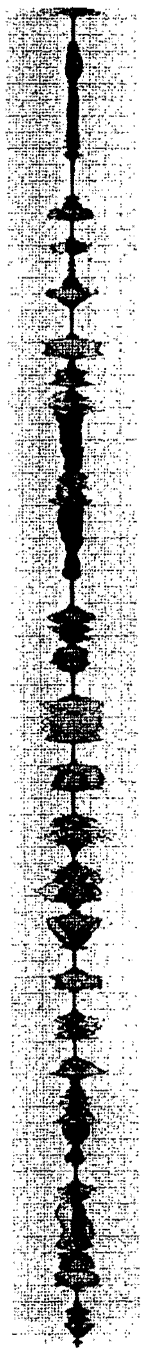

Fig. 3

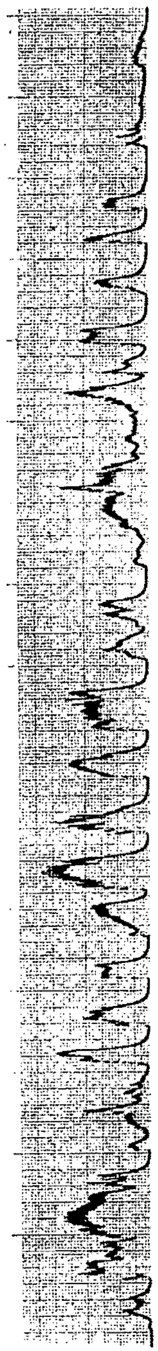

Fig. 4

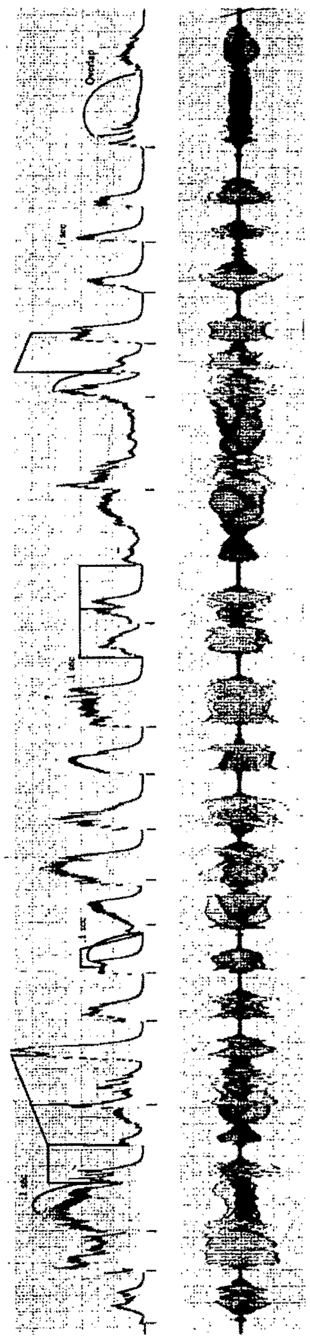

Fig. 5

Figs. 3, 4, and 5. Strip-chart records of 5 sec of talk of two Kung Bushmen in Africa. One man is telling a traditional story and the second interjects listener-comments. In Fig. 3 the tracings show as clumps, minimal sound packages, or syllables, and show both frequency and amplitude. In Fig. 4 the frequency component is filtered out so that the exact points of motor impulsing can be seen. In Fig. 5 the sounds of each man are found to lie on a 10 cps rhythm train.

did not fit the first positioning, we can see that the onsets of those bursts which did not fall on the first positioning do fall on the second positioning. That is, there are two intermixed, out-of-phase sets of speech bursts, each falling on its own 0.2 sec rhythm train.

When we listen to the audible speech in relation to Fig. 3 (electronically slowing down the tape speed somewhat to make the listening-matching more manageable) we discover that those bursts belonging to one speaker fall on the same rhythm train (i.e., points on the reference strip), and that those bursts belonging to the other speaker fall on the other rhythm train. Figure 5 shows the same stretch of speech with both rhythms (one for each speaker) marked on the chart trace.

This continuous rhythm train will continue in the normal flow of the discourse for the duration of a clearly marked segmental unit. Since the segmentation or punctuation of the behavior stream is also the identifier for levels of organization of the behavior, it will be useful to digress long enough to discuss the matter of segmentation and its relationship to rhythms.

The epistemological, and consequently the methodological, frame of this research is one in which the search is for the processes which connect or relate the parts or variables in a *system*. The concern is not for "what happens," but only for "how it happens." The syntactic sentence of the linguist is, in this sense, a system requiring a particular arrangement of parts to form some whole (a syntactic sentence). Phonemes combine to form morphemes, morphemes combine to form phrases, phrases combine to form sentences, etc. The linguist has operational procedures for segmenting the vocal stream into units and for further dividing these units into subunits. The linguist studies "an arbitrary system of vocal symbols by means of which people cooperate" (Bloch and Trager, 1942, p. 1). He cannot, then, include movement behavior in the same framework. This research focuses on the organization of vocal or movement behavior, and not on language *per se*. In this way it is possible to study the organization of vocal and movement behavior (i.e., the processes) in the same methodological frame, and to demonstrate that both speech and movement share certain underlying organizational characteristics or properties. In the present case, both speech and movement share the same limitations set by the preprogramming of acts in the brain (see a later discussion of research on this point by Clynes, 1970), and these minimal brain programs combine in part whole fashion to form larger segmental units. The present discussion of a particular segmental unit, then, is directed toward the demonstration that both speech and movement share underlying organizational properties and that, at some levels of organization (if not at all levels), the segmentation can be derived from either the vocal behavior or the movement behavior.

The segmental syntactic unit that I have referred to is identifiable in the Bushman case by a number of "marker" behaviors:

1. The speaker (and possibly the listener) takes a breath. This is audible only on carefully made sound recordings, usually using lapel or lavalier microphones.

2. In ordinary Bushman conversation (I am told by ethnographers) the "listener" repeats the last few syllables of the speaker's utterance at certain pause points. In the storytelling instance, the speaker ends each of these segmental units by uttering an "Mmmm" sound which is repeated by the listener in overlap, i.e., the listener's "Mmmm" sound begins before the speaker's ends. Because this canon-overlapped "Mmmm" sound has a particular shape on chart traces, the storytelling can be segmented at this level of behavioral or linguistic organization by noting these shapes on the traces.

3. In the film, the listener is seen to repeat the last element or component of the speaker's gesture. (The part repeated also represents a segmental unit on a lower level.)

4. As this gestural sequence by the speaker ends, he brings both arms close to his chest, crossed at the wrists, and at the same time bobs his head downward.

5. The listener follows the speaker by repeating the wrist-crossing and head bob.

I would assume that there is a specific stress and/or intonational contour (of a limited number of possible contours) to these segmental units. I assume this only because syntactic units of comparable length have such contours in other languages.

This particular segmental unit, then, is marked or signaled with considerable redundancy. Within this unit, of course, there are subunits and within those are sub-subunits. If I were to say (and I have no linguistic evidence for this) that the unit described above is a syntactic sentence, then within that there would be units of phrase size, and within phases other units, down to syllable bursts and even syllable parts. This follows a form of hierarchical description used by Stetson, who studied the motor activity underlying speech, and not the symbol system itself.

Each of these units can be identified by markers that have both vocal and/or movement concomitants. In Fig. 3, for example, the small bursts that are bounded by silence or pause are syllable bursts. And when we measure the timing or rhythm of these bursts, we discover that no syllable burst of a single speaker begins until at least 0.2 sec after the beginning of the preceding syllable burst. That is, a single syllable burst requires a 0.2 sec time-slot regardless of its actual duration.

This 0.2 sec interval is represented by five frames of film, and at this point we begin to fit the five-frame unit mentioned earlier into a larger temporal structure. When the Bushman storyteller waves his arm back and forth in this first (segmental) unit of the storytelling, each swing of his arm requires 10 frames, and other gestural parts in this (and probably any) human communication situation show this interval. This interval is, of course, the one cited earlier for the Eskimo shared rhythm and that of the rhesus monkeys. It is evidence of an underlying biological rhythm.

Manfred Clynes (1970, p. 327) asked subjects to press one button if a red light appeared (in an experimental situation), and to press a different button if a green light appeared. By moving these stimulus lights closer and closer together, he found that approximately 200 msec (0.2 sec) was the time that must elapse before the subject could change his mind and shift from one response to another. Clynes (1970a) called this interval a "present moment," and wrote:

> We observe the physiologic fact that the course of a simple movement is preprogrammed by the brain *before* it begins. (There is no time in the 200 msec for feedback to affect the decision.) In all these movements there is a decision which precedes the beginning of the movement. This decision element or event is of precise nature and controls the subsequent movement according to the program it has set; i.e., it preprograms the course of the movement. The preprogramming is of the nature of an algorithm. During approximately 200 msec after a programming decision is made, another programming decision affecting the same limb or muscle cannot be made. Movements begun under such a decision cannot be reversed or controlled within this time. (p. 327)

Evidence can be found, then, in both speech and movement, for a rhythm with a period of 0.2 sec by observing both this interval and its octave (0.4 sec or 10 frames). We can now return to a consideration of Figs. 3, 4, and 5, and find evidence that the underlying rhythm is actually 0.1 sec and that the longer intervals are octaves of 0.1 sec.

The two Bushmen (Figs. 3, 4, 5) are each on an observable rhythm train. The two rhythm trains have the same frequency but are not synchronous. I have not yet accounted here for this phase-offset between them. This phenomenon—the two parallel but offset rhythms—was encountered regularly in human dialogue. An explanation follows.

In the Bushman storytelling, the first speaker, the storyteller, begins with a few syllables followed by a brief pause, and the listener begins his intermittent interjections at this point. The listener's first speech onset begins an exact number of tenths of a second after the first speaker's *preceding stress peak*. This is illustrated in Fig. 6. It seems obvious, after the fact, that a listener has no accurate access to the speaker's onsets, but that the listener's rhythm train is triggered, or entrained, by the immediately preceding *stressed sound* (which only rarely coincides with the onset of a syllable). That is, the onset of a syllable burst of one person is triggered, or entrained by a *syllable-part* of the other. (A more formal systems statement would be:

a configuration on one level can be "explained" by the arrangement of parts on a lower level of organization. This, indeed, is the only form of "explanation" in a systems epistemology.)

Figures 6 and 7 illustrate this relationship in other languages and cultures.

When we find that the stress-peak to onset interval is not always a multiple of 0.2 sec intervals, but is always a multiple of 0.1 sec intervals, we can see that the underlying rhythm is actually one with a period of 0.1 sec.

Furthermore, if a syllable (burst) is longer than 0.2 sec, either because it is uttered with prolongation or because more than the usual content is compressed into it (e.g., pronouncing "hello" as "h'lo"), the next burst may begin at the next beat-point on the underlying 10 c/sec (0.1 sec) rhythm train. This observation also demonstrates that the underlying rhythm has a frequency of 10 c/sec, even though the minimal programs require a 0.2 sec time slot.

There are occasions, perhaps in every society, when groups of people engage in synchronous or phase-related behaviors of one sort or another. Human communication is, clearly, one of these occasions. There are also common familiar examples, such as dancing, singing, and marching, and we can extend the beat-frequency (i.e., levels of organization) in either a faster or a slower direction. Relatively slow oscillations in social behavior may be related to such exogenous pacing as the earth's orbital progression around the sun (annual cycles), or the circadian rhythms paced by the earth's rotation. Higher frequency synchronicity is observable in a group singing a single note "in tune" at a frequency measured in hundreds of cycles per second. Chapple (1970) points out that interpersonal synchrony–dissynchrony has biological concomitants which the individual experiences as feeling good (synchrony) or bad (dissynchrony). It seems reasonable to me to assume that insofar as there are "feelings" (seen either as a biochemical or a psychological state), this phenomenon would have the significance, in evolutionary terms, of supporting, reinforcing, or leading a creature toward adaptive relationships and away from maladaptive or lethal relationships. That is, the creature's intrapersonal or internal balance would reflect an interpersonal or social-ecological balance. Feeling good (biologically or psychologically) is not only an internal matter, but is a concomitant of being in a synchronous, or phase-related, relation with the environment, both physical and social.

In New Guinea, the Maring (and other groups) look forward to traveling a considerable distance to collect together a few times a year to sing and dance. On such occasions the fact of coming together at a particular time is one level of synchrony. The fact of singing and dancing "in time" together is another level. And the fact of singing (or chanting) the same or har-

Fig. 6. Record of the first half-second of the Bushman storytelling. It is "enlarged" by speeding up the paper travel in the recorder. Here, as in the following examples, the second speaker's initial syllable/motor impulse is triggered by the preceding speaker's last stress peak. This accounts for the phase offset.

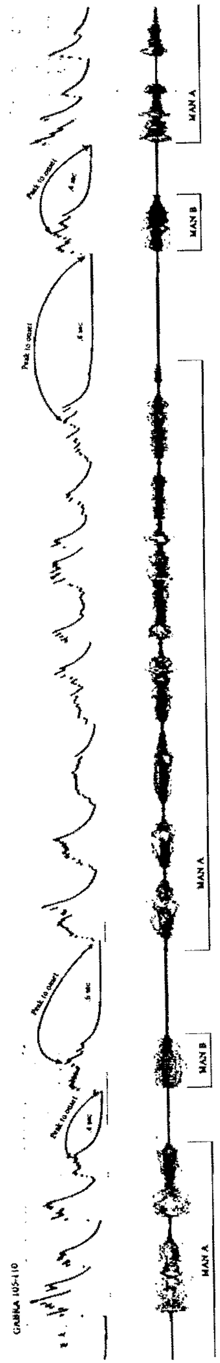

Fig. 7. Record of dialogue between two Gabra, a camel nomad people in East Africa. Each speaker's initial onsets are on a 10 cps rhythm train which is initiated or triggered by the preceding speaker's last stress peak.

monically related note together is a third level of synchrony. The frequencies range from the few times a year of the occasions themselves to the few hundred cycles per second of the notes sung in unison.

I have found one cultural form, in my very limited search, in which two people come together and engage in full talk synchrony while using different semantic content. It is interesting to examine both the temporal structure of this talk form—one which produces a high degree of multilevel synchrony—and the social context in which it is found.

This unusual talk form is found among the Yanomamo, who live on the upper Orinoco in South America. Figure 8 is a chart of the machine-processed speech. The temporal structure and the mechanics of this talk form are:

1. The first speaker begins by shouting, typically, three syllable bursts. The onsets are 0.2 sec apart.
2. The second speaker begins one tenth of a second after the first onset of the first speaker. He also shouts three syllable bursts. The impressionistic sound is that of two men shouting at each other simultaneously.
3. The first speaker begins again (typically) three tenths of a second after the last stress peak, presumably of the other speaker, although it is difficult to assign particular peaks to individual speakers in this "shouting match."

Since the second speaker is triggered, or entrained, by the *onset* of the first speaker (or at least they are phase-locked in full synchrony), it appears that an initial shout (after silence) suffices as the trigger and that by shouting they can achieve full synchrony. I have seen no other instance in which such a full phase-locked synchrony occurs and is sustained for minutes at a time between two interactants without an exogenous pacer.

If we know something of the Yanomamo and of the social circumstances in which this talk form occurs, it is possible to make an educated guess about the function of this talk form.

The standard ethnography of the Yanomamo is titled *The Fierce People* (Chagnon, 1968). Chagnon writes, "Yanomamo culture calls forth aggressive behavior, but at the same time provides a regulated system in which the expressions of violence can be controlled" (1968, p. 118). I am told that the talk form described above occurs in two circumstances. One is when two headmen of different villages come together for a feast, and they begin the ritual greeting by participating in this shouted talk form. This is an occasion when a display of fierceness is required, but when violence must be avoided. And second, I am told, any conversation that escalates to the point of near-violence can turn into this talk form. And violence is avoided.

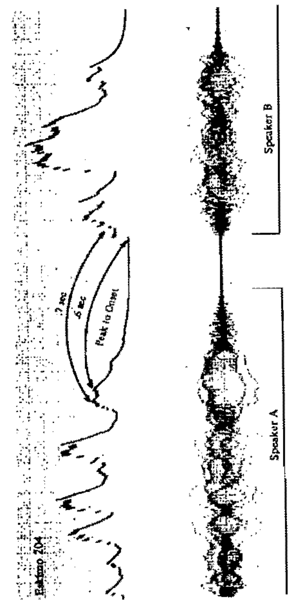

Fig. 8. Record showing the same phenomenon in dialogue between two Eskimos.

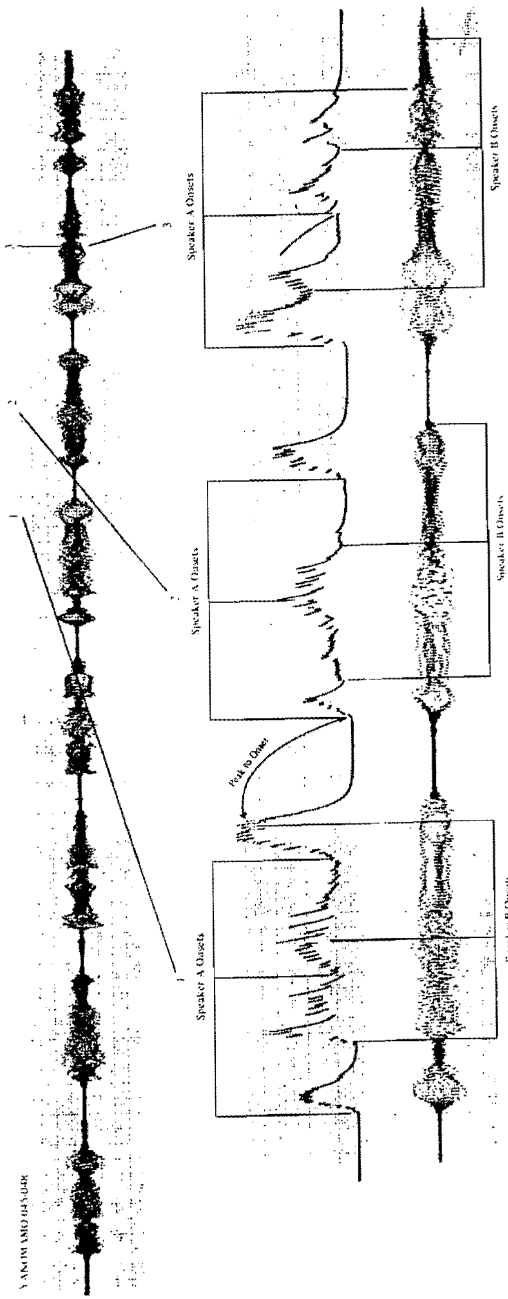

Fig. 9. Example from the Yanomamo who live on the upper Orinoco in South America. In this talk form two men are shouting. One begins and typically shouts two or three syllables. The second person begins almost exactly one-tenth of a second after the first begins and also shouts two or three syllables. The shouted onset of the first speaker serves to put the two men in almost full phase-locked synchrony.

I suggest, then, that behaved animosity has a nonsynchronous concomitant, but that close synchronization between interactants creates a homeostasis between them that precludes violence; this is one observable expression of what Chagnon calls the "control of violence." I suggest that this self-imposed synchrony precludes violence, or conflict, through the regulation of biological processes. I believe that those who examine the "politics" of a society or a group may overlook the lower-level interactional and biological processes involved in maintaining "political" systems.

So far in this report, the rhythms of communication movement and speech have fitted the frequency of what I consider to be an underlying biological rhythm, or oscillation, with a frequency of 10 c/sec. But there is evidence from Mary Brazier's autocorrelation analysis of brain waves (1960) that there is also a 7 c/sec rhythm (7.3, c/sec to report her findings exactly). According to Sollberger's (1965) encyclopedic report on biological rhythms, this frequency of 7/sec seems to be the upper limit of human movement frequency, where the units of movement involve feedback. He cites the work of psychologists who have found that such behaviors as tapping, chewing, etc., cannot be performed faster than 7/sec. It is possible for pianists or typists to strike more than seven keys per second, of course, just as a speaker can put more than one linguistic syllable into a single pulse or motor unit (e.g. "H'lo"), by preprogramming two or more notes or typewritten letters into a single unit.

I have found a 7 c/sec rhythm in speech traces when the speaker is *performing* speech instead of talking *with* another person. When, for example, a Maring at a ceremony shouts to his dead ancestors to come to the ceremony, the underlying rhythm is 7 c/sec. When one Yanomamo shouts to a group of others to help him sweep the village plaza in preparation for a feast, the rate is 7 c/sec. But when a villager shouts back and the two "talk," the rates are then 5–10 c/sec. I have recorded and processed radio news broadcasts, and found again that this performed speech shows an underlying 7 c/sec rhythm. When, however, a person anywhere in my film data is working at a task—chopping, hitting, paddling a canoe, hoeing, etc.—the rhythm appears to be task-related and is not otherwise predictable. But even when a person is carrying out a repetitive task at a task-related rate, and another person comes along and engages the first in conversation, the shared rhythm invariably shifts to fit the 5–10 c/sec frequency.

In the course of this research, a friend offered me access to a collection of sound tapes of stuttering speech and assorted other speech pathologies. More out of curiosity than an interest in investigating these pathologies, I ran several of the tapes through the processing apparatus and made the following observations:

1. In one instance of stuttering—in which initial consonants were repeated—the speech before and after the stuttered repetitions showed the usual 5–10 c/sec underlying rhythm, but the onsets of the stuttered repetitions fell clearly on a 7 c/sec train. (This could be measured accurately only when the repetitions were voiced stops, which have sharp onsets, e.g., *b, d, g*.) Furthermore, when the 10 c/sec train from the preceding speech was projected across or through the stuttered component, the speech following the stuttering was still falling on the rhythm beats of the original train. That is, the stuttering episode, at 7 c/sec, had not interrupted the underlying 5–10 c/sec train. Also, the 7 c/sec stuttered consonant was repeated until a beat of this 7 c/sec train coincided with the projected 10 c/sec train, at which point the speech proceeded normally back on the 10 c/sec train until the next stuttering episode. Those instances of stuttered onsets which were very close to points on the projected 10 c/sec train were very much greater amplitude than the others.

2. Other stutterers showed the 5–10 c/sec frequency, or rhythm, underlying both the normal and stuttered components of the speech, but the stuttered component was on a rhythm train which was out of phase with the rest of the speech. It appeared on the chart traces that the speaker had two out-of-phase rhythms underlying his speech, one of which underlay the normal speech, and another which underlay the stuttering.

3. One example of pathological speech had no stuttered repetitions, but was, impressionistically, monotonous and expressionless. Chart traces showed that the onsets of the syllabic bursts showed almost no (expressive) variation, and were nearly mechanical in their regular 5 c/sec spacing.

VI. SUMMARY AND DISCUSSION

I have reported here on rhythmic regularities found in instrumentally-processed records of interpersonal movement and speech behavior, and I have interpreted the findings as evidence of underlying biological rhythms which pace and integrate the behavioral expression of brain programs. Although two rhythms have been identified, one frequency (10 c/sec) has invariably been found in interactions (communication) both between humans and between a pair of rhesus monkeys.

As one examines progressively larger segmental units of behavior, i.e., behavioral packages, or units, on ascending levels of organization, each segmental level can be seen to have its own rhythm. Since, in interaction, each person is phase related to the other on multiple levels, and since the rhythms are modulated by and thus reflect the state of the human organism, information is constantly available to each interactant about the multilevel states of the other. But because the reference, or comparator, of each person is his own state-modulated rhythm, his inference (largely out of awareness) is actually one concerning the relationship between his own and the other's states. Our present folk epistemology, however, tends to see this information about the relationship as a "message from the other." The concept of messages and transmission, useful as it is in electronic media, has supported the popular view of the human species as a collection of individuals who send and receive messages to and from each other consciously as their primary or perhaps only form of relating.

On the other hand, if we find that the variations or modulations of underlying rhythms at multiple levels are systematically related to biological processes, we can envision a human and animal world that is communicationally related through the sharing of time forms on multiple levels of behavioral organization.

Although one organism may not directly perceive his phase relationship to another, I believe that, in the case of humans, the phase relationship is systematically related to the biochemical (endocrinological) states which are reflected in or perceived as feelings. It is particularly interesting to observe that the information carried by interpersonal rhythms does not move directionally from one person to another. This information cannot easily be conceptualized as "messages," since the information is always simultaneously shared and always about the state of the relationship.

While the 10 c/sec rhythm found underlying speech and movement behavior is clearly a biological rhythm, these temporal units are the building blocks for such culturally determined behavior as pauses between speakers or listener interjections in a speaker's pauses. I have suggested that the Yanomamo's special speech form shows an unusual degree of interpersonal synchrony, and that, considering its cultural use, it represents part of the "regulated system in which the expressions of violence can be controlled" (Chagnon, 1968). That is, two interactants in a tight synchrony necessarily and biologically are brought into the same state (of consciousness) by virtue of their mutual entrainment. Coberly (1972) has examined the sequences, or processes, involved in shamanistic curing ceremonies in ten cultures, and has shown that, despite the variety of cultural content, the process is always the same: the shaman collects a group, synchronizes the group through dance, movement, song, clapping, chanting, etc., and then brings in the state-deviant patient who joins—is entrained by—the group and is brought to their state through synchronous participation. In eastern religions, and in numerous primitive religions, instrumental means (chanting, breathing, dancing, singing, etc.) are used to change the state of consciousness of individuals or to bring a group to the same state of consciousness.

As an anthropologist, I believe that it would be useful to review our ethnographic data to discover what inventory of states (of some total possible spectrum) is found in each cultural-ecological context, which states are

encouraged or discouraged by a culture, and which cultural customs represent instrumental means of implementing or avoiding those states. In our own society, drugs, meditation, jogging, surfing, some sports, some kinds of dance and music, all may have significance in implementing, maintaining, or changing states of consciousness, and consequently the relatedness of participants, and all can be examined for the adaptive significance in a particular social-environmental context. There is some evidence that human functioning requires intermittent experience of some spectrum of states. We may come to see good mental health as a matter of meeting these state-quota requirements.

In this paper I have created a rather large conceptual map—hopefully one with systematic integrity—from a relatively small body of observational data. Most of the process connections are still obscure. We do not know, for example, how only a few primary rhythms in the brain can be quickly differentiated to meet the demands of everyday skills. Nor do we understand the mechanism by which motor-expressed brain programs are fitted to the integrating and pacing rhythms. We do not understand the processes by means of which states of consciousness (defined by Wolff, 1966, as semistable organizations of the nervous system) are instrumentally implemented, maintained, or changed.

To put all of this in a still larger framework, it appears to me that we can see the interrelatedness of life in terms of at least three contrasting kinds of processes. I have dealt here only with those processes in which state-modulated rhythms intersect in interaction to make information about the relationship available to the interactants. This process functions on multiple levels embracing state information related to cells, organs, organ systems, organisms (states of consciousness), and even groups or whole societies. It applies as well to both human and animal life.

We have been, in our world, more explicitly concerned with communication processes which involve the semantic content of human speech. We have certainly focused on the evolutionarily unique capabilities inherent in speech capacity (the capability, for example, of constructing an elaborate technology and civilization), and have almost ignored the fact that the semantic content of speech lies on a single level of organization and is largely a product of conscious thinking. The modulations of rhythms are a reflex of states; the modulated rhythm is an "accurate" representation of states. But no such simple isomorphism or "accuracy" exists between the state of the human organism and the organism's verbal messages. If we were, hypothetically, to quantify the information carried by the modulated rhythm process vs. the verbal message exchange process, we would readily conclude that the information carried by modulated rhythms is precise and preponderantly related to interpersonal relationships, whereas the information carried by verbal messages is subject to great imprecision, and is only a reflex of the individual's *perception* of his relationship to his environment, with only a most unwieldy possibility of corrective feedback at the semantic level.

While much of the focus of the recent research in biofeedback has been concerned with its orthophysiological possibilities (e.g., learning to relax a frontalis muscle, control heart rate, etc.), there is the implication in biofeedback research that the calibration of biological control systems at multiple levels is mediated by verbal-symbolic–cognitive processes in man. The two processes, involving state-modulated rhythms and verbal messages exchange–sharing, are linked. The mind and the body are not separate.

There is, I believe, a third process which I would consider more "primitive" than the two discussed above. There is much popular concern with, and some scientific exploration into, phenomena associated with the terms "bioplasma," "psi phenomena," "new energies," "auras," "psychic phenomena," "extrasensory perception," etc. It is probably too early to guess whether this line of inquiry will lead to the identification of a new form of matter–energy ("bioplasma"), the identification of a heretofore unrecognized paraneurological system, the identification of a new order of signals and their processing apparatus, or, conceivably, the emergence of a radically different epistemology which would comfortably embrace "mystical" observations without requiring much in the way of radical scientific discovery. Whatever the scientific eventuality, the human will move toward a more explicit concern for his relationship to extraterrestrial phenomena, i.e., a whole that embraces a larger system of parts than we now recognize.

And again, whatever the scientific eventuality, the human species is acquiring the conceptual tools with which to move toward a more explicit concern with *relationships* than with individual properties, and toward conceptual wholes that will embrace the cosmos. The human notion of human nature is certain to change radically.

VII. REFERENCES

Bateson, G. (1971). Introduction. *The Natural History of an Interview*. University of Chicago Library Microfilm Collection of Manuscripts, in Cultural Anthropology, series 15, Nos. 95–98.

Birdwhistell, R. L. (1970). *Kinesics and Context*. University of Pennsylvania Press, Philadelphia.

Bloch, G., and Trager, G. L. (1942). *Outline of Linguistic Analysis*. Special Publication of the Linguistic Soc. of America.

Brazier, M. (1960). Long-persisting electrical traces in the brain of man and their possible relationship to higher nervous activity. In Jasper, H. H., and Smirnov, G. D. (eds.), *The Moscow Colloquium on Electroencephalography of Higher Nervous Activity*. EEG J. Suppl. **13**:347–358.

Byers, P. (1971). Sentics, rhythms, and a new view of man. Unpublished paper presented to AAAS, Philadelphia, December.

Byers, P. (1972). From biological rhythm to cultural pattern: A study of minimal units. Ph.D. dissertation, Columbia University.

Chagnon, N. A. (1968). *Yanomamo: The Fierce People*. Holt, Rinehart, and Winston, New York.

Chapple, E. D. (1939). Quantitative analysis of the interaction of individuals. *Proc. Nat. Acad. Sci.* **25**:295–307.

Chapple, E. D. (1949). *The Interaction Chronograph: Its Evolution and Present Application*. American Management Association, New York.

Chapple, E. D. (1970). *Culture and Biological Man: Explorations in Behavioral Anthropology*. Holt, Rinehart and Winston, New York.

Chapple, E. D., and Arensberg, C. (1940). Measuring human relations: An introduction to the study of the interaction of individuals, *Genetic Psychology Monographs* **23**:3–147.

Chapple, E. D., and Coon, C. S. (1942). *Principles of Anthropology*. Holt, Rinehart and Winston, New York.

Chapple, E. D. (1953). The standard experimental (stress) interview as used in interaction chronograph investigations. *Hum. Organ.* **12**:23–32.

Clynes, M. (1970a). Emotion communication in the living moment. *Symposium of the American Association for the Advancement of Science: Biocybernetics of the Dynamic Communication of Emotions and Qualities*.

Clynes, M. (1970b). Toward a view of man. In Clynes, M., and Milsum, J. H. (eds.), *Biomedical Engineering Systems*. McGraw-Hill, New York.

Coberly, L. (1972). An Interactional analysis of ten curing ceremonies. M.A. thesis, Columbia University.

Condon, W. C., and Ogston, W. D. (1971). Speech and body motion synchrony of the speaker-hearer. In Horton, D. L., and Jenkins, J. J. (eds.), *The Perception of Language*. Charles E. Merrill Pub. Co., Columbus, Ohio.

Davis, H. (1956). Space and time in the central nervous system. *EEG Clin. Neurophysiol.* **8**:185.

Deriabin, V. S. (1916). Further studies on the physiology of time as a conditional stimulus of the salivary glands. Dissertation, St. Petersburg (in Russian).

Feokritova, J. P. (1912). Time as a conditional stimulus for the salivary glands. Dissertation, St. Petersburg (in Russian).

Lashley, K. S. (1951). The problem of serial order in behavior. In Jefress, L. A. (ed.), *Cerebral Mechanisms in Behavior*. John Wiley and Sons, New York.

Lindsley, D. B. (1961). The reticular activation system and perceptual integration. In Sheer, D. F. (ed.), *Electrical Stimulation of the Brain*. University of Texas Press, Austin.

Pribram, K. H. (1971). *Languages of the Brain*. Prentice-Hall, Englewood Cliffs, N.J.

Sokolov, E. N. (1960). Neuronal models and the orienting reflex. In Brazier, M. A. B. (ed.), *The Central Nervous System and Behavior*. Josiah Macy, Jr. Foundation, New York.

Sollberger, A. (1965). *Biological Rhythm Research*. Elsevier Pub. Co., Amsterdam, London, New York.

Stetson, R. H. (1903). Rhythm and rhyme. *Psychological Rev. Monographs* **4**:413–466.

Stetson, R. H. (1905). A motor theory of rhythm and discrete succession I and II. *Psych. Rev.* **12**:250–270, 293–350.

Stetson, R. H. (1951). *Motor Phonetics: A Study of Speech Movements in Action*, North-Holland Pub. Co. (published for Oberlin College), Amsterdam.

Wolff, P. H. (1966). The causes, controls, and organization of behavior in the neonate. *Psychol. Issues*, V:1, Monograph 17.

Wolff, P. H. (1968). Stereotypic behavior and development. *Canadian Psychologist* 4:474-484.

Zelenii, G. P. (1908). Studies on the question of the response of the dog to auditory stimuli. Dissertation. St. Petersburg. (In Russian.)