It is well to remind ourselves from time to time that the problem of relating electrical activity of the brain to psychological phenomena constituted one of the main interests of the founder of electroencephalography, Hans Berger. His numerous publications during the decade from 1929 to 1938 strongly attest this fact. Although his psychological interpretations have not always proved completely acceptable, his empirical discoveries constituted the opening wedge that led others to confirm and extend his observations, especially with respect to the characteristics of the EEG. In addition to the ruling out of artifacts and the establishment of the EEG as a characteristic electrical property of the brain, the early studies of Berger and others clearly delineated the alpha and beta components of the EEG tracing as we know it today.

It is also well to recall the efforts in the laboratories of Adrian, Bishop, Jasper, Davis, Gibbs, Kornmüller, Loomis, Kreezer, Bremer, Fessard, Travis, Hoagland, and others during the early days of EEG study, when attempts were made not only to understand the basic aspects of the EEG, but to relate them to physiological and psychological processes. Throughout the 1930's one and two channel recording units in a handful of laboratories in this country and abroad often worked overtime attempting to establish relationships between various characteristics of the EEG and the psychological aspects of sensation, perception, attention, emotion, learning, intelligence, personality and the like (see Jasper 1937; Kreezer 1938; Lindsley 1944). Some of the studies were superficial, with little control of fundamental variables; others were carefully done in a detailed and painstaking manner.

For the most part these initial attempts at correlation of neurophysiological and psychological events were not very successful. The correlations themselves were not remarkable and no comprehensive theory arose from them. Yet a careful re-reading of some of the early studies reveals that many of the original EEG observations have stood the test of time.

Why have not EEG and psychological correlations been pursued more systematically and persistently? Why has there been so little success in relating neurophysiological data to subjective states and behavioral manifestations? There are probably many reasons. Almost from the start, the lure and excitement of new clinical discoveries was a distraction to serious effort in this direction. Secondly, the premature, if not actually grandiose, hope that the mysterious and ubiquitous alpha rhythm might be related to intelligence, personality and other similarly broad and in themselves undefined parameters, soon exhausted interests in that direction. There were other matters such as constantly improved equipment which led to the hope that the next new development, whether it was more channels, an automatic analyzer, or what not, might facilitate the process of correlation.

Despite a certain amount of preoccupation with empirical results and the startling and significant clinical correlations revealed by the EEG, effort persisted in trying to uncover the mechanism of the autonomous rhythms of the brain. Although a basic understanding of the origin and nature of the alpha rhythm, as well as other aspects of the EEG, still eludes us today, tremendous strides have been made in recent years in gaining factual information about the mech-
anism of control. Although far from complete in detail, the framework seems to be emerging, and it is in the light of some of these new developments coupled with some reinterpretation of older observations that I would like to review the problem of psychological and EEG correlates.

This will inevitably verge on the speculative, and in some instances go beyond the facts, but this I believe we must do if we are to propose new hypotheses for experimental test. Adrian (1947) in his little book "Physical Background of Perception", outlines how much we have learned about receptor processes, nerve conduction, and interaction, and the point by point following of sensory messages as they traverse their pathways to the brain. He states: "So far we have thought of the cerebral cortex as a screen on which patterns are thrown by the different sense organs. The pattern corresponds more or less with the pattern of sensory stimulation because the pathways from the receptor endings preserve the same anatomical arrangement on the way up to the cortical receiving area." But he goes on to indicate that mapping of the sensory messages on the cortex is not enough, and despite all of our accumulated neurophysiological data we come face to face with the problems of psychology, namely, recognition, memory, habit formation and others.

Five years have elapsed since this little book was published and some of our most illuminating information on the central integrating mechanism has come to the fore. This information seems to be constantly getting closer to the mechanisms needed to explain psychological phenomena. But I wonder if it is not a two-way street, and that psychological data are needed to help us explain some of our neurophysiological observations. It seems to me the time is fast approaching when new hypotheses and new experiments are going to require psychological and behavioral data, both in their formulation and execution. We need a closer liaison between established observation and fact with regard to psychological and neuro-physiological processes. The problem of the transition between nerve impulses arriving at the cortex and the percepts, symbols and ideas which result will require more than neurophysiological data for its resolution.

Many facets of reliable psychological data are open to us, especially in the areas of sensation, perception, action and learning. One of the outstanding parameters of these data is time. Stimulus properties of kind, intensity and spatiality may also be important parameters, but our most common and perhaps most useful parameter in transforming and integrating two sets of data is that of time. Furthermore, time and its derivatives, rate, rhythm, sequence and so forth seem to be fundamental properties or conditions of nervous system integration.

![Fig. 1](image-url)

General excitatory states showing range of variation in normal electroencephalogram. (From Jasper, 1941, by permission of author and publisher.)

Let us return now to the EEG and examine some of its characteristics, especially with regard to the time parameter. We may observe in figure 1 that the pattern of activity (but especially frequency, a time characteristic), varies widely during the range of behavioral states common to a normal adult. The pattern varies from a fast desynchronized activity during emotional excitement or alert attentiveness to a degree
of rhythmic synchrony known as the alpha rhythm during quiet, relaxed wakefulness with eyes closed, and to a progressively slower rate of synchrony in the successive stages of sleep.

In our attempts to relate psychological phenomena to the EEG we have been concerned mainly with only one of these stages of normal brain activity, namely that of the alpha rhythm. Is it possible that our preoccupation with the alpha rhythm, because of its dominance, regularity and measurability has led us astray and away from significant correlations with things psychological? The very special conditions of relaxation, darkness and quiet requisite to the alpha rhythm, are hardly representative of much of our normal waking life. Instead such conditions are really precursors of sleep, and the slightest effort, noise, or other stimulation will quickly break up this apparently optimal state of rhythmic oscillation during waking.

Table I presents what appears to be a behavioral continuum, based upon both EEG and psychological correlates as determined empirically. There are undoubtedly in-

**TABLE I**

**PSYCHOLOGICAL STATES AND THEIR EEG, CONSCIOUS AND BEHAVIORAL CORRELATES**

<table>
<thead>
<tr>
<th>BEHAVIORAL CONTINUUM</th>
<th>ELECTROENCEPHALOGRAM</th>
<th>STATE OF AWARENESS</th>
<th>BEHAVIORAL EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong, Excited Emotion (Fear) (Rage) (Anxiety)</td>
<td>Desynchronized: Low to moderate amplitude; fast mixed frequencies.</td>
<td>Restricted awareness; divided attention; diffuse, hazy; &quot;Confusion&quot;</td>
<td>Poor: (lack of control, freezing-up, disorganized).</td>
</tr>
<tr>
<td>Alert Attentiveness</td>
<td>Partially synchronized: Mainly fast, low amplitude waves.</td>
<td>Selective attention, but may vary or shift. &quot;Concentration&quot; anticipate, &quot;set&quot;</td>
<td>Good: (efficient, selective, quick reactions) Organized for serial responses.</td>
</tr>
<tr>
<td>Light Sleep</td>
<td>Spindle bursts &amp; slow waves (larger) Loss of alphas.</td>
<td>Markedly reduced consciousness (loss of consciousness) Dream state.</td>
<td>Absent</td>
</tr>
<tr>
<td>Deep Sleep</td>
<td>Large and very slow waves (synchrony but on slow time base) Random, irregular pattern.</td>
<td>Complete loss of awareness (no memory for stimulation or for dreams).</td>
<td>Absent</td>
</tr>
<tr>
<td>Coma</td>
<td>Isoelectric to irregular large slow waves.</td>
<td>Complete loss of consciousness little or no response to stimulation; amnesia.</td>
<td>Absent</td>
</tr>
<tr>
<td>Death</td>
<td>Isoelectric: Gradual and permanent disappearance of all electrical activity.</td>
<td>Complete loss of awareness as death ensues.</td>
<td>Absent</td>
</tr>
</tbody>
</table>
adequacies and also inaccuracies in such a categorization, but in the present state of our empirical knowledge this table is a reasonably accurate presentation of accumulated data from many sources. The fact that as wide a range of patterns and frequencies as are observed in the EEG during the stages from drowsiness to excited emotion in a normal person can occur, together with the variations of awareness and behavioral efficiency indicated, suggests immediately why there is difficulty in assessing personality or in differentiating between psychiatric conditions by means of the EEG. But all the more so because we have concerned ourselves for the most part with the measurable aspects of the alpha rhythm. In a sense the alpha rhythm is an abstraction both electroencephalographically and psychologically; at best it represents an unusual and limited state of affairs in the life of the organism. Yet it has a remarkable regularity and constancy of rhythm and pattern which is virtually a hallmark for the individual.

Let us turn now to some more specific relationships between the alpha rhythm and psychological and behavioral processes. Before doing so it is necessary to discuss two points upon which these relationships depend. One of these has to do with a distinction between alpha rhythm and alpha activity. This distinction was first emphasized by Bartley (1940), although the assumption underlying it was brought out in the writings of Adrian, Jasper and others who held to the view that the alpha rhythm represented an optimal synchronization of electrical activity of cortical elements, and that breaking up or disappearance of the alpha rhythm represented a desynchronization of neuronal activity. In essence the distinction between alpha rhythm and alpha activity might be put quite succinctly in this form: Alpha activity may exist without a recordable alpha rhythm.

I should like to add to this view the assumption that alpha activity is a basic metabolic or respiratory rhythm of the individual brain cell, and its electrical variation alone or in small aggregates of cells is normally too small to be recorded from the surface of the scalp. Only when literally thousands of cells are responding in synchrony is sufficient summation attained to produce a recordable alpha rhythm. A low amplitude fast or desynchronized EEG as in alert attentiveness might then represent fractional synchronization in many smaller aggregates of cells but with random phase relations, or actually slightly different frequencies, as has been shown by Walter (1950a, 1950b). This would mean that an alpha activity rhythm could exist in many small, independent aggregates of brain cells, in the absence of an over-all alpha rhythm in the usual sense.

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Desynchronization of alpha rhythm in normal adults, spontaneously in A, C and D; with visual stimulation in B. Time in 1/5 sec. (From Lindsley, 1938, by permission of publisher.)

In one of my old oscillograph records (fig. 2), where the sensitivity and magnification was much greater than in modern inkwriters, the necessary detail is provided to see the nature of spontaneous (A, C, D) and stimulated (B) desynchronization of the occipital alpha rhythm. In A a brief lapse in the alpha rhythm, leaves a definite rhythm of lower voltage and double the frequency of the original and subsequent alpha rhythm. In B the blocking of the occipital alpha rhythm by a light stimulus leaves in its wake
a rhythm of approximately double the frequency and perhaps one quarter the amplitude of the original alpha rhythm. Record C shows the occasional emergence of alpha rhythm from an underlying activity of approximately double the frequency and one-half the amplitude.

The next assumption is that the alpha activity cycle represents for the individual cell or the aggregates of cells with which it is associated, an alternating excitability cycle. This conception was first proposed by Bishop (1933) and was later amplified by Bishop (1936) and by Jasper (1936), and was supported in part by inferential evidence. For example, Bartley and Bishop (1933) and Bishop (1933) demonstrated that impulses initiated in the optic nerve of the rabbit found access to the cortex in the form of light-dark ratio of 1 to 1, and shows the Talbot effect of one-half the brightness of steady illumination at frequencies of approximately 28 and above for this particular intensity level of illumination. However when the frequency of the flickering light was decreased to the neighborhood of 9 or 10 c/sec., there was marked brightness enhancement, the so-called Brücke effect. The fact that an increase in apparent brightness of 100 per cent over steady illumination occurred at a flicker frequency of the alpha rhythm, with decreasing brightness on either side of that frequency, strongly suggests that the light flashes were synchronized with the alpha activity and its excitability cycle. Here we see that a psychological datum of experience affords support for a neurophysiological theory, but at the same time is made more understandable as a psychological experience, since it has been shown that brightness discrimination is modified, presumably by an intrinsic excitability cycle associated with alpha activity cycle at about 5 per sec. Accordingly Bishop (1936) interpreted this as evidence of a cortical excitability cycle.

Psychological data supporting this concept have been supplied by Bartley (1939). Figure 3 summarizes his results on apparent subjective brightness of a flickering light at different frequencies. Curve A illustrates a time is made more understandable as a psychological experience, since it has been shown that brightness discrimination is modified, presumably by an intrinsic excitability cycle associated with alpha activity cycle at about 5 per sec. Accordingly Bishop (1936) interpreted this as evidence of a cortical excitability cycle.

Fig. 3
Curves showing change in apparent brightness at flash frequencies above and below critical flicker frequency (C.F.F.) for varying light-dark ratios, A, L.D.R. 1 : 1, B, 7 : 2, C, 8 : 1. In curve A brightness enhancement (Bartley effect rather than Brücke effect) occurs at a flash frequency corresponding to an alpha rhythm frequency of about 9 to 10 per sec. From Bartley (1939, 1941), by permission of author and publishers.

The brightness enhancement effect of flickering light at 9 to 10 c/sec., although originally labelled by Bartley as the Brücke effect has since been designated by him as "brightness enhancement effect" (see Bartley, 1941, p. 137). It might more properly be called the "Bartley effect".
tivity. That a recordable alpha rhythm does not have to be present for this to occur is further indication of the distinction between alpha rhythm and alpha activity, the latter being assumed to be present in those aggregates of cells participating in the response.

Recent experimental work by Chang (1950, 1951) strongly reinforces the concept of an excitability cycle in the cortex and perhaps also in the thalamus. If this is true, two levels of screening of incoming sensory impulses are possible. Whether these work in harmony and synchrony or at times are mutually exclusive of one another, may well be a determinant of the varied states of awareness which are possible under normal conditions, but especially under conditions of selective and differential awareness, during heightened degrees of alertness versus drowsiness, during emotional states, under partial anesthesia, hypnosis and so forth. Apart from these considerations it appears from the nature of psychological experience and behavior that a pulsing and cur without smearing. The eye fixations in reading a line of type are a case in point. Meister has proposed, and I have illustrated diagrammatically in figure 4, the manner in which voluntary eye movements initiated from the motor eye fields of area 8, may simultaneously and momentarily inhibit or block incoming impulses through connections with the occipital cortex. The exact manner in which this may occur remains to be demonstrated, but the psychological effect implies that some type of neuronic shutter mechanism is operating. Conceivably this
could be through simultaneous discharges from area 8 to the extraocular muscles and the occipital cortex, the latter in effect inhibiting reception momentarily by resetting the alpha activity cycle in the given aggregate of cortical neurons involved in the perception. On the other hand it could arise through a timing mechanism which would permit activation of the eye muscles only in synchrony with the inexcitable phase of the alpha activity of the occipital cortex. In either case a kind of neuronic shutter effect would take place during the movement of the eye, in much the same fashion that a shutter in a movie projector permits two successive discrete exposures without smearing. As is well known, one may have perception of movement without actual movement, as in the case of the phi phenomenon.

Chang's studies strongly reinforce the excitability concept and its linkage with spontaneous and induced potential variations in the cortex. Figure 5 shows the periodic change in excitability of the auditory cortex in terms of magnitude (per cent of control amplitude) of acoustically evoked cortical potentials following a single electric shock to an adjacent point on the cortex. The period of cyclic change in excitability is roughly 100 msec. and corresponds to the period of the reverberating waves which follow an afferent stimulation, but does not always correspond, according to Chang, to the spontaneous rhythm of the cortex. Other evidence (Dempsey and Morison 1942; Verzeano, Lindsley and Magoun 1952) suggests that reverberating waves often correspond rather closely with the inherent spontaneous rhythm of the cortex.

![Figure 5](image_url)

Fig. 5
Periodic change in excitability of auditory cortex following single electric shock of its adjacent point as tested by acoustically evoked cortical potentials. Ordinate: amplitude of primary cortical response to sound stimulation expressed as per cent of control amplitude. Abscissa: interval between conditioning and testing stimuli. (From Chang 1951, by permission of author and publisher.)

Figure 6 shows diagrammatically the relationship Chang (1951) found between reverberating waves elicited by a single conditioning shock applied to the auditory cortex and the excitability curve resulting from the responses to auditory stimuli applied in different phases of the reverberating waves. This indicates that maximal facilitation occurs on the rising phase of the recurrent
wave and maximal inhibition on the descending portion, with excitability unchanged at the time of the peaks and troughs.

In another study Chang (1950) has shown the effect of interaction of two auditory stimuli (clicks), with the second delivered at varying intervals of time after the first stimulus (fig. 7). The single click is at least 50 msec. does a sizeable response to the second of the two clicks occur. The maximal evoked response to the second click will be seen to center about the time of the first recurrent wave following the first stimulus. This again emphasizes the cortical excitability cycle associated with recurrent cortical after-effects.

Figure 8 from Chang's work (1952) on the visual system summarizes four types of excitability processes which exist simultaneously. These curves were derived from the recording of cortically evoked responses in the visual cortex of the cat to series of stimuli (A) produces an evoked response with recurrent waves following at a rate approximating that of the inherent spontaneous rhythm. In the dual presentations (B-I) it will be seen that only when the interval between the first and second clicks

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**Fig. 6**

Diagrammatic illustration of phase relations between reverberating waves and cortical excitability. Contour of shaded areas represents potentials of two consecutive reverberating waves. Sinusoidal curve above represents two cycles of periodic variation of cortical excitability. Two curves drawn on same time scale. (From Chang 1941, by permission of author and publisher.)
stimuli delivered to the lateral geniculate body. Curve one shows a general process of facilitation induced by steady illumination on the eye during the course of stimulation. Curve 2 (heavy solid line) post-excitatory depression following immediately upon the evoked response. Curve 3 (light solid line) shows the periodic variation of excitability believed by Chang to accompany corticothalamic reverberation. Finally, curve 4 shows a waxing and waning excitability be-

Bartley (1942) has shown that a single short photic stimulus of certain durations and intensities gives rise to two flash experiences. It is interesting that at lower levels of illumination (see fig. 9) the duration centers about the 100 msec. point. This suggests that the subjective experience of the second flash may depend upon the recurrent

![Fig. 7](image)

Compilation of nine diagrams of evoked cortical response illustrating the action of the primary response on the occurrence of the repetitive discharges. The vertical line represents the stimulus; the solid pyramid, the primary response; and the open triangles, the repetitive discharges. Note that the second of two sharp clicks (auditory stimuli) reaches optimal magnitude (G) at 100 msec. corresponding to the time of appearance of the first reverberating wave following a single click (A). (From Chang 1950, by permission of author and publisher.)

believing by Chang to be a generalized process nonspecific to the sensory cortex. From a psychological point of view there is gross evidence at least that visual experience shows fluctuations which coincide roughly with the neurophysiological data represented by curves 2 and 3 during the first second following visual stimulation. These are an initial flash experience, a very brief absence, and recurrence and fluctuation of the positive after-image. Fluctuations of the negative after-image would appear to correspond with the more prolonged spontaneous periodic variation of excitability represented by curve 4.

One additional bit of evidence is worth considering, namely, the response to visual stimulation in the case of a one year old child with an alpha rhythm of about 5 per sec. and that of an adult with an alpha rhythm of about 10 per sec. (see fig. 10). Bernard and Skoglund (1943) have systematically and extensively studied the differential blocking times as a function of age, which Lindsley (1938) had described ear-
lier. It will be observed that the blocking time in the one year old child was of the order of .4 sec. whereas that for the adult was about .2 sec. Table II shows progressive shortening of the blocking time in inverse relation to the frequency of the alpha rhythm. This relationship suggests that timing relations of the excitability of the cortex.

range is limited to 2 to 4 per sec., as is the alpha rhythm in a three month old child (see table II). This fact taken together with some of the preceding results suggests that the inherent or spontaneous rhythm of a given aggregate of cells has something in common with recurrent activity initiated by sensory stimulation or by electrical stimul-

and possibly also in either relay nuclei of the thalamus or in those nuclei of diffuse projection, are such that an excitability cycle which alternates only half as fast in a young child as in an adult will permit access to the cortex only with a longer latency of twice that in the adult. It may be possible to throw further light on this relationship from a psychological point of view, but it will be difficult in a child so young to find a suitable mechanism of response which can be measured adequately, and which will serve in lieu of the subjective report of an adult.

Eichorn and Lindsley (1951) have shown in a young infant of about two months of age and prior to the establishment of an occipital alpha rhythm that it is possible by photic driving to induce a rhythm, of considerably lower amplitude than the alpha rhythm which normally appears at three months of age. However its frequency
tion of sensory pathways. Likewise it might seem also to bear a common timing relationship to the so-called recruiting phenomena first described by Morison and Dempsey (1942) and more recently studied by Starzl and Magoun (1951).

Chang has diagrammatically illustrated some possible mechanisms of reverberating activity, as shown in figure 11. Because he had shown that the primary response of the second of two click stimuli was capable of abolishing the repetitive discharges to the first stimulus (see fig. 7) he argues that the blockage of the reverberating waves occurs in the cortex. Therefore he finds figure 11B with its separate thalamo-cortical reverberating pathways more acceptable. Jarcho (1949) on the other hands submits similar evidence which he interprets in favor of primary and repetitive responses sharing the same pathways, as is illustrated in figure 11A.

The data of Moruzzi and Magoun (1949) and Starzl and Magoun (1951) dealing, respectively, with the reticular activating system and its widespread desynchronizing effects and the recruiting system and its confinement of responses to the associational and motor cortex to the exclusion of primary sensory areas (see fig. 12), raises still further questions about the nature of the interaction between cortical and subcortical centers. Assuming as Dempsey and Mori-

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### TABLE II

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1½</td>
<td>5.3</td>
<td>3.5—6.6</td>
<td>0.189</td>
<td>0.43</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
<td>5.5—7.4</td>
<td>0.154</td>
<td>0.35</td>
</tr>
<tr>
<td>4</td>
<td>7.4</td>
<td>6.2—8.9</td>
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<td>0.31</td>
</tr>
<tr>
<td>6</td>
<td>8.3</td>
<td>7.5—9.2</td>
<td>0.121</td>
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</tr>
<tr>
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<td>8.5</td>
<td>7.5—10.3</td>
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<td>0.27</td>
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<td>7.5—10.2</td>
<td>0.114</td>
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<td>12</td>
<td>9.3</td>
<td>8.4—10.4</td>
<td>0.108</td>
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</tr>
<tr>
<td>14</td>
<td>9.3</td>
<td>8.2—11.1</td>
<td>0.108</td>
<td>0.25</td>
</tr>
<tr>
<td>16½</td>
<td>9.5</td>
<td>8.2—11.1</td>
<td>0.105</td>
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<tr>
<td>25</td>
<td>10.2</td>
<td>9.0—11.0</td>
<td>0.098</td>
<td>0.23</td>
</tr>
</tbody>
</table>

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Fig. 10
Blocking of occipital alpha rhythm by light stimulus in A, a one year old child with 5 per sec. alpha rhythm (blocking time, .4 sec.), and in B, an adult with a 9 to 10 per sec. alpha rhythm (blocking time, .2 sec.) From Bernhard and Skoglund, 1943. Time in 1/100 sec.

Fig. 11
Diagrams showing two possible pathways of the corticothalamic circuit. In (A) the corticopetal pathway of the reverberating circuit shares the same neurons which mediate the great afferent volleys. In (B) they do not use the same neurons. (From Chang 1950, by permission of author and publisher).
son (1942) did that the recruiting response is to be identified with the mechanism of intrinsic rhythms of the cortex, and also because of its optimal frequency correspondence with spontaneous rhythms, it would appear that some form of Chang's diagram (fig. 11B) with modifications would be needed to explain the integration and timing relations involved. The picture is far from complete and is by no means simple, but it appears that a great deal of progress is being made toward an understanding of the basic mechanisms of control of the rhythms of the cortex.

In the light of some of these newer conceptions, it appears that a good many new hypotheses are needed for further experimental study. As each new finding is integrated with the older ones, and with neurophysiological and psychological data advancing together, it is to be hoped that a closer correlation of psychological phenomena and the EEG will be possible.

**SUMMARY**

An attempt has been made to show how psychological and neurophysiological data may be related through time relationships. A distinction has been made between recordable alpha rhythm and alpha activity. The latter is assumed to be a basic cellular rhythm. Evidence is submitted which suggests that the alpha activity cycle is associated with an excitability cycle in particular aggregates of cells. The excitability cycle is proposed as a means of pulsing and coding sensory impulses, and examples are provided from behavior and subjective experience in support of this concept.

**DISCUSSION**

Charles E. Henry

The lateness of the hour must emphasize my brief discussion. A summary and reintegration of facts such as that Dr. Lindsley has just given us needs little annotation. The reciprocity between matters psychological and matters physiological must surely now be obvious — and particularly so to us who cultivate the common ground of neurophysiology with our electrical equipment.

For those who may have attempted to answer the put question as to why there have not been more vigorous and more successful attempts to elucidate hard correlations between electroencephalographic and psychological phenomena may I suggest an aspect often neglected by EEG workers. This is the difficulty in getting meaningful, useful and discriminating measures of the elusive parameters of behavior which may compare with the order of precision possible to obtain (though not without effort) in electroencephalography. We tended, therefore, to evaluate our records against gross and too-inclusive clinical diagnostic categories.

Scansion of the literature would suggest that this early eager pursuit of the electrical will o' the wisp that keeps the lid on the id was unsuccessful. But does this follow from the fact that we have identified no patterns pathognomonic of schizophrenia or of exhibitionism? This morning's Symposium is evidence...
that this is not entirely so and that some degree of order is evolving slowly out of apparent contradiction.

I should like to suggest an addition to Dr. Lindsley's discussion of the significance and the control of the alpha rhythm. I am thinking of the work of Hallowell Davis and colleagues first reported (and largely neglected) some 15 years ago, and more recently given a fuller documentation. Their elucidation of the relationship between a strong, stable alpha rhythm and passivity, and the relationship between faster frequencies and hostile, aggressive tendencies is both clearly phrased and clearly supported by the data they presented. We all remember the more general physiological reformulation of this thinking into the Homeostasis of Cortical Excitability presented as the presidential address before this Society two years ago. These studies are highly pertinent to this particular Symposium: I wonder if we are not being unduly wary about further ventures into this complex but probably rewarding field.

Nevertheless, it would appear that as the orientation of workers has become more specific their efforts have become more productive. As Dr. Lindsley has indicated, the field of perception, in particular, showed sudden signs of flowering when cross fertilized by cybernetics. Loop, reverting, circus activity has been hypothesized in such singularly attractive explanatory form that I am almost convinced myself. I am sure that we both agree in recommending the stimulating papers and discussions in the recently appearing Hixon Symposium to your attention.

Dr. Lindsley has done an able job of pulling together a number of observations and relating them to visual phenomena, thus demonstrating the proof of his observation that the molar psychological data are helpful in elucidating the micro neurophysiological observations. It is to be hoped that his reiterated distinction between the alpha rhythm and alpha activity will lay permanently that paradoxical ghost that has so long confused us. His insight into the important implications of Chang’s work shows that it would have been as appropriately published in a psychological as a physiological journal.

Reference to the visual smearing associated with involuntary eye movements and the lack of such smearing when the neuronic shutter is clicking in good synchrony immediately suggests an experiment waiting to be carried out. While electrical stimulation of the frontal eye fields may certainly elicit eye movements I do not think a reciprocal relationship has been shown to exist between area 8 and the visual cortex. The fact that eye movements are obtainable on electrical stimulation of visual cortex itself suggests that the more probable trigger for the shutter is somewhere in the geniculo-striate system. A possible complication is the additional fact that patients with congenital nystagmus suffer very little visual incapacity, indicating that their alpha activity may not be critically implicated in visual perception.

In conclusion, Dr. Lindsley is to be congratulated on the photic activation he has given to some older ideas. He has sharpened our wits with new insight and suggested new experiments. His paper is thus doubly successful and it is a pleasure to thank him for it.

REFERENCES


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