ASSOCIATION OF IDEAS AS APPEARED ON THE ELECTROENCEPHALOGRAM

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By

Tadashi Onizawa (鬼澤　貞) and Yoshikazu Ohwaki (大脇義一)

(Institute of Psychology, Tôhoku University, Sendai.)

I

PROBLEM

No one doubts that the mental activity has inseparable relation with the brain activity. Therefore, it is natural that one should think that researches and explanations on the action of brain will become one of the great and powerful clues for the study in mental activity.

The study on the E. E. G. has the advantage in research to be able to treat the active state of the brain obviously and directly[1]. E. E. G. was taken in the field of psychology from 1936–7 onwards. We can see chiefly such studies in America. Then studies by this technique are not so many in number but considerably many areas in subjects of studying, for example, the developmental trait of E. E. G., the relation with individuality or character type, the effect of mental attitude, E. E. G. in frustration (or on mental blocking), that in fatigue, the phenomena in conditioned reflex, the correlation between the classification of consciousness and that of E. E. G., and the influence of feeling or emotion, etc.. These extensive studies at the beginning were hard to say successful, notwithstanding that their results were very much expected: for example, Knott[2] said in 1939 as follows: Adrian, Berger, etc. reported that E. E. G. suffered a change in compliance with mental activities, Bagchi, Travis, etc. found that there were somewhat relation with mental activity. About ten years later, in 1947. Darrow[3] said: in the electrical records of brain, we were given a great psychological constitution, nevertheless we failed in gaining the remarkable result, ..., we have not learnded as yet the psychological method to interprete E. E. G.. And it may be the state of things in these studies, that, as Jasper[3] said in 1948, we are tired out to find new fields in these studies.

Now, if the above is quite right, what is the most essential matter that we must reconsider? I think, at first that, what meaning for psychology has the matter, that is represented in E. E. G.? Secondly for what phase in psychology is useful to the study for E. E. G.? Consideration about these problems will be given as follows.

Of course, the E. E. G. has characteristics in its own rhythms, and we make them as the index. In regard to the rhythm of E. E. G., Kreezer[5] gives following two hypothesis.

1. The rhythms are initiated within the cortical cells themselves.

2. Certain cortical rhythms depend on closed neurone-chains extending to the thalamus. Moreover Travis[5] thinks that cells of the cerebrum cortex, has the tendency to assemble themselves, and oscillate synchronously and simultaneously, when a weak stimulus is afforded. These phenomena are taken as the expression of electrical equilibrium at the cerebrum cortex. However, such equilibrium is disturbed from the attention.

When we look over the two above-mentioned points of view, the subject to study is not limited to the phenomenon of E. E. G. itself. In the former, it points to the direction, that the matter is dug down still more deep on the physiological level, that is, to assume the interaction among cells, and to treat them as the major subject. In the later, however, it seems to explain this phenomenon through the relation with the state of consciousness. The study of the former, already at present, comes to need more direct method.

Our direction is clearly in the attitude of the latter.

Then, on the actual psychological study of E. E. G., the matter that we must do in the first place may be to determine the significant and empirical correlation acquired between the presented psychological events and the E. E. G., as Kreezer has stated[5] (1938). Therefore, when we want to determine the correlation, it is necessary to have high knowleges in physiology on the one hand. On the other hand, we should psychologically "recognize" or "understand" the matter that ought to be the object of study. However, we find it hard to find the psychological method to inquiry E. E. G., which must be built on linking the two sides. We have not yet the way to look over E. E. G. from the psychological standpoint.

Hereupon, we must consider the way to eliminate or at least reduce such limitation and barrier to the psychological events. The answer of this may be necessarily derived, from the following description of a limitation of actual condition on the study of E. E. G., and from our secondary problem, that is, to what phase of psychology the study of E. E. G., is effective.

Now, there are three conditions that we must take into account at the psychological study of E. E. G..

(1) It happenes a great disturbance for E. E. G., if one opens or closes one's eyes.

(2) If one's body moves, during the recording or photographing of E. E. G., the action current intermix into it and disturb it.

(3) When one opens his mouth to speak, it brings the same disturbance.

Accordingly, we design the experiment, we must be careful about the conditions.

Looking at some data that are obtained under the same condition, we can easily find obvious individual differences among each data. But it is the actual state of to-day, that we cannot dicisively give psychological meanings, except the traits of specific psycho-pathics. Quite the same situation is the problem of relation between E. E. G. and personality. The study of E. E. G. seems to be more fruitful in the so-called "mental activity".

According to the opinion of Ellizabeth Duffy[7], E. E. G. is able to be used to measure the energy mobilization in the organism, in other words,

the degree of individual activity and the discharge of latent energy, that is reserved in the organism to be used for its activity.

From her point of view, our behavior is divided into two dimensions, that is, the direction for goal and the energy mobilization. If so, the E. E. G. is only a phase of the cerebrum's mechanism at the time of mental activity. So that, through E. E. G., we cannot know well about the direction (or the meaning) of cerebrum's activity.

But, we must consider, not only to investigate E. E. G. thoroughly as merely mechanism itself, but also to make steady progress in the psychological study added positively with the direction or the meaningness that is excepted in the above mentioned opinions.

Travis[5] gave the instruction to his subject, who is closing his eyes, and taking a comfortable posture and attitude, that he should fix the course of stream of consciousness; the experimenter, in a separate room, has observed E. E. G. of subject. There is a communication system for a subject and an experimenter to speak freely each other. If E. E. G. becomes extremely large or small of indicate some strange traits, the experimenter asks him "About what have you thinking at this moment?", and he compares afterwards E. E. G. with the conscious states, which are reported on the introspection. This interesting result showed in the table. When we glance over Travis' paper, especially this table, we find that his classification of the so-called state of consciousness is not adequate. We think that such inadequacy had originated from two facts; the first is that he classified E. E. G. beforehand, and then, according to it he classified the state of consciousness, and the second is that he managed the data in the excessively molecular, analytical manner about the duration of time.

Therefore, we want to control the direction of the stream of consciousness systematically, by way of procedure of experiment. And we want to stand on the molar view at the management of the data.

According to these view, Takahashi[8] and Ohwaki, Y. have adopted the method to test characteristics on each case, that is states of *Anpassung* for α-waves. They made their subjects count the metronome sound "one two, one two, one two, ...". In the second series of the experiment, they made their subjects count the sound "one, two, three, four, five, six, ...". Like this manner it is our method in this experiment to give the direction to the state of consciousness by some way, and to determine characteristics of E. E. G. at that time.

The former method is the measurement for average amplitude, average frequencies, and α-wave-index, but when we try to study conscious states, it seems to us better, to apply the intuitive method. Motokawa[9] has drawn a convenient shema, which helps us such intuition.

II

PROCEDURE

Well, we want to research on E. E. G. at the time of the association.

The reason that we selected the association process particularly, is that, first, the association seems to be most convenient to study the relation between E. E. G. and mental activity, because the association process is perhaps the most easy mental activity, therefore it disturbs, we expect wave only a little. Secondly besides free association, we can take various manner of association process, therefore, we can observe various degree of intentional controlling of consciousness. Consequently, we believe the process of association is most suitable to study the above-mentioned problem of E. E. G. and direction of consciousness.

We observe five manners of association: free-association, hasty-association, association about similar or opposite things to the stimulus words, or comprehensive things to the stimulus words: and we observe the mental arithmetic to compare with these association. Stimulus words are selected from the words of Kent-Rosanov and Y. Kubo [10].

The process of the experiment is carried out as seen on the Figure 1. Subjects don't open their mouths until they report their introspection in answer to questions of the experimenter after the stoppage of photographing; the experimenter takes notes of these on record paper.

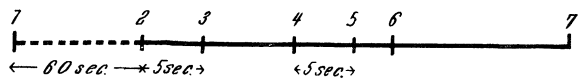

Fig. 1

We observed 4 or 5 times per a day, and 4 not following days for each subject.

About the order of experimental procedure on the Fig. 1, we shall explain more detail.

1. The instruction to lead the subject to the state of calmness: "Keep comfortable and at ease; don't think about anything; please, try as if you were to lapse into sleep".

A minuite later, the subject gets to the state of almost at ease.

2. The assistants in the next room begins the photographing of E. E. G.. in another five seconds:

3.....4. Given the instruction about the sort of association: "From this time on, as we are going to present a word, try to grasp anything that come across your mind in connection with the word" (hastily, oppsite thing, similar thing, comprehensive thing). But don't speak.

4.....5. For five seconds after instruction, no stimulus word, no stimulus is given to him. The experimenter gives stimulus words oraly.

5.....6. Fifteen seconds after the stimulus word, no stimulus is given to him.

6. The assistants stop the photographing.

7. The experimenter requires the introspection. We require (1) the introspection during association (5–6), particularly about its contents, (2) whether the subject could become at ease or not, after the first instruction. What is the matter that thought about, (3) from 4 to 5, could he be in ease or not? And about what he was thought.

We have photographed G. S. R. during 1 to 7 simultaneously in the same way.

Laboratory: In dark-room of the department of Physiology, Faculty of Medicine, Tôhoku University.

Subjects: Eight students of the intitute of psychology: Haruo Tanaka, Gosuke Ouchi, Yukio Horiuchi, Tsutomu Ujiie, Takashi Kihara, Akio Keira, Kazuyuki Sato and Eitaro Terada.

Experimenter: Prof. Y. Ohwaki, T. Onizawa.

Further we should like to add, that we used equipments and apparatus of this department of physiology for this study, through Prof. Motokawa's good will. And we received devotional helps of Associate Professor Iwama, Dr. Ebe, Mr. Oikawa, and Mr. Abe.

Stimulus words and modes of association used in each of experiments are the following (Table 1).

Table 1
Stimulus words and modes of association.

Exp. day	modes of association	Stimulus words
I	free	sox, fruits, sparrow, song (whistle, meat, begger, cushion.)
II	free	illness.
	hasty	bath, ship, ring, thief.
	opposite	cold.
III	free	baby.
	hasty	pickles, scissors.
	opposite	summer, girl.
	similar	rabbit.
IV	free	water of a pond.
	opposite	Europe.
	similar	pine tree.
	sup. concep.	airplane, Urashimataro.
	mental arithm.	23×5, 13×25.

III

RESULTS AND DISCUSSIONS

At first, we present the most typical wave record. (Fig. 2)

We see the characteristic change of wave variously from the beginning at rest till the time of association process. Therefore, if we calculate average frequencies or average amplitude from beginning to end, the data will lose its meaning because such changing manner every moment will be lost right.

We pick up the first three seconds of three periods in 3–4, 5, 5–6, fix our eyes upon α-waves and θ-waves involved in each period, and count up them.

In consequence, if α-waves are more numerous, that means the state is about at ease; on the contrary, if it is few, that means that the long

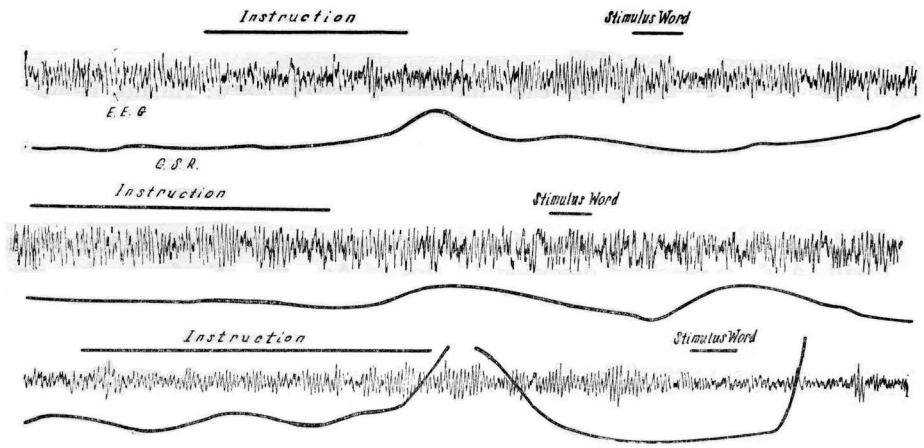

Fig. 2

succession of the time of mental activity, and so we able to interprete that time is not in the state of at ease. In this case, the reason that we don't count β-waves, is that α-waves are fundamental waves, and we know previously that except α-waves, there are very few θ-waves and multitude of β-waves. Moreover, because it is difficult and arises many mistakes if we count minute β-waves.

If θ-waves are more numerous, that means the state in which the subject has large and many mental activities at that time.

Results of these process in dealing with the data are shown in Table 2 and Table 3. But, according to the statistical test, these results are

Table 2 Number of α-waves in each period.

modes of association	5 sec. After Instruction	During Stimulation	3 sec. at the Beginning of Assoc.
Free	24.3	9.3	9.8
Opposite	21.4	7.2	9.7
Hasty	19.8	8.6	6.9
Similar	24.7	8.2	8.1
Superior-Concept	25.3	9.8	9.7
Mental Arithmetic	29.4	10.3	7.0

Table 3 Number of θ-waves in each period.

	5 sec After Instruction	During Stimulation	3 sec. at the Beginning of Assoc.
Free	1.2	0.5	0.2
Opposite	1.2	1.6	0.4
Hasty	0.6	0.5	0.4
Similar	0.8	0.6	0.3
Superior-Concept	1.0	1.4	1.5
Mental Arithmetic	1.3	1.0	0

insignificant.

According to these Table, we can conclude as follows; (1) qualitative differences in "mental set" between different manners of association which is formed by the instruction can not be found in these quantitative method to deal with the data. And we could not found the significant difference next 2 and 3, too.

2. When subject is given the stimulus words.
3. Period at the beginning 3 seconds in association of ideas.

And the above are only rough conclusions, that are not lead to let insignificant the consideration through the protocol of our introspections and analytical consideration of the qualities in the ways of continuation of waves.

Next, we make the model shema Fig. 3 on the basis of Fig. 2, which we regard as the most typical data.

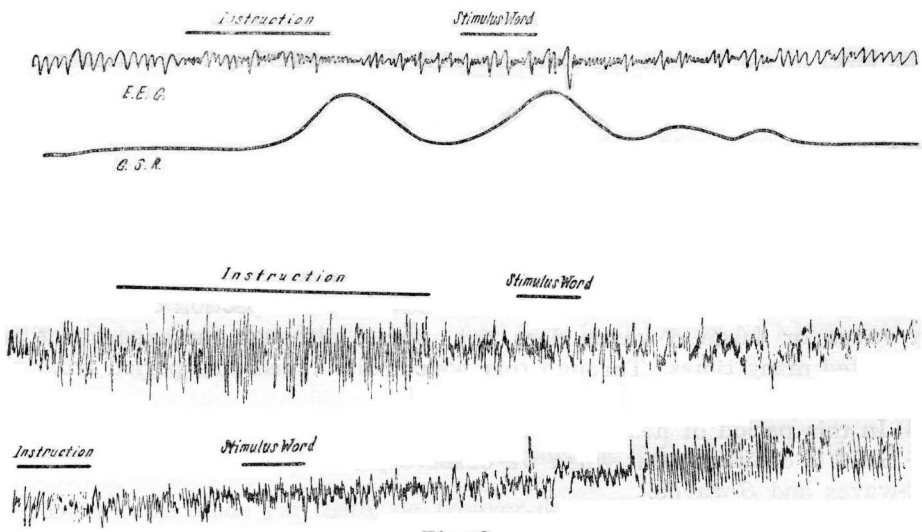

Fig. 3

(1) When we observe it, we used to refer to the Motokawa's shema; that represent the level of strength in mental activity.

(2) The wave of G.S.R. is late about 2 seconds than E.E.G..

From such figures and introspection, we are able to conclude as follows; (1) Quiet state reported in introspection is not always correspond to the one represented in E.E.G.. Changing in consciousness, which is reported in introspection, are represented as the changes in consciousness, or does not corresponds to it.

About the reason of them, we consider the following two.

a. To introspect the all conscious changes is difficult, since subjects tends of forget a little after the stop of photographing E.E.G..

b. Not all changes of waves in E.E.G. appears as the psychological or conscious changes; but changes in consciousness appears the physiological one.

Thus, we perceive the transition proceeds more to one direction than the other in basic phase of psycho-physiological relation. Therefore, we doubt whether the continuation of α-wave is always "at ease" state of consciousness or not, because the change in E. E. G. is more sensitive than the consciousness. And we point out that it is possible that although the change in E. E. G. is exciting, the state of consciousness is "state of rest". This offers the problem of psychological meaning of "state of at ease". G. S. R. in this period is almost always stable. And we can find the change in consciousness is not always the change in G. S. R..

(2) The period during which the instruction is given, E. E. G. is more exciting than the period of "at ease", and is less exciting than the next period, that is, the period of mental setting of association.

G. S. R. is the same too. But after the experiment is repeated and the same instruction repeated, E. E. G., may be sometimes not exciting but α-waves or large α-waves appears (Fig. 4). We see that human voices do not give the same effect on the E. E. G., and that instruction is possible to let the level of excitement high and low that is "inversibility". We assume, the meaning of instruction and the number of repetition of such instructions are one of the determinants to carry it on different degree on the level of excitement.

(3) It seems difficult to distinguish this period from the latter-part of the former period. We saw, in introspection of subjects, "I have tensed in expectation of the next words", "I have expected some next words", "I have feeling of uneaseness", etc. E. E. G. and G. S. R. were almost similar to the former period. But, in this period of set, expection continuance of α-waves or large α-waves does not appear, although the experiment are repeated many times. Through this, we can distinguish this period from the former period.

(4) In this period of hearing of the stimulus word, the state of E. E. G. and G. S. R. is exciting. But when we observe precisely, we find the mixing of α-waves and β-waves.

There are two ways of such appearance.

i) Long continuation of α-waves and β-waves are regularly alternate each other, and then the "at ease" states are gradually recovered.

ii) There are also such, where typical α-waves are seen after an excitement at very high level. This seems to us the *induction* on conditioned reflex. (Fig. 4).

(5) The mixing of α-waves and β-waves continues on the next period. This seems to us to mean the preparation process going into the association.

(6) Next, continuation or intermittence of a stronger excitement are seen in waves. In the latter part of the process of association, the α-waves appear.

(7) We can not find the statistically significant difference between the many sorts of the association of ideas and the mental calculation (pure thinking).

IV

SUMMARY

At first, we tried the methodological reflection about the study of E. E. G. in psychology, and found that this technique is useful in the aspect of mental activity.

Next, we treated the E. E. G. appeared in the association of ideas as the one of the mental activity. And we found that when we used our method, we are able to get fruitful results, namely (1)·····(7).

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RÉSUMÉ

L'association apparue dans l'E. E. G.

Dans cette étude j'ai tenté de trouver de quelle manière se présentent à l'E. E. G. les diverses modes d'association et s'il est possible de discerner dans l'E. E. G. l'association libre, l'analogie, l'association contraire, l'association précipitée et l'association réglée et de les discerner de l'E. E. G. dans l'opération de pensée (l'addition par calcul mental).

L' E. E. G. a été registré en étant classifié en quatre cas: (1) le cas du repos tranquille, (2) le cas où l'on donne l'instruction, (3) le cas où l'on donne le mot de stimulus et (4) le cas de l'association. Le G. S. R. (P. G. R.) a été registré en même temps. Les sujets ont été huit étudiants de l'université.

Les résultats obtenus montrent la tendance comme suit:

De diverses associations, j'ai comparé le nombre de l'onde α et celui de l'onde θ dans les cas (2), (3) et (4). l'onde α était nombreux dans l'association libra, l'association contraire et l'association rêglée; elle l'était moins dans lá pensée d'addition et dans l'association précipitée. L'onde θ était, au contraire, le plus nombreux dans l'assnciation rêglée. L'ensemble de ces

deux résultats semble nous montrer que l'association libre et l'association contraire sont les opérations de pensée les plus faciles, l'association précipitée en est l'opération la plus difficile et l'association rêglée en est l'opération tantôt facile tantôt difficile selon l'espèce des mots de stimulus. Cette différence, pourtant, n'est pas significative au point de vue statistique.

ZUSAMMENFASSUNG

Wie verschiedene Arten der Ideenassoziation erscheinen im Elektroencephalogram? Ob freie Assoziation, eilige Assoziation, Gleichheits- oder Gegensatzassoziation, bedingte (Ober-Begriff-) Assoziation können in E. E. G. gegeneinander unterschieden werden? Wird die Assoziation in E. E. G. von Denken (Addieren von Kraepelin-Rechenheft) unterschieden? Wir haben das E. E. G. zeitlich in vier Perioden abgeteilt registriert; (1) ganz ruhige, nichtsbemerkende Lage, (2) die von der Vp. instruierte Periode, (3) die gereizte Periode und (4) die Assoziation-Periode. Vpn. waren 8 Studenten.

An dem erworbenen E. E. G. haben wir das Nummer von α- sowie θ-Welle je nach (2), (3) und (4) Periode gerechnet und gegeneinander vergleicht. Die α-Welle ist in freier und Gegensatz-, dann in bedingter Assoziation besonders zahlreich. Die θ-Welle ist in bedingter Assoziation besonders zahlreich. In der sonstigen Assoziation ist die θ-Welle im allgemeinen ausserordentlich selten. Diese Resultat schien zu beweisen, dass die freie und Gegensatz-Assziation die leichteste, d. h. wenigste Energie brauchende psychische Tätigkeit ist, und dass eilige Assoziation und das Rechen die schwierigst, d. h. grösste Energie brauchende psychische Tätigkeit ist. Trotzdem ist die Zahlenunterschied statistisch nicht bedeutungsvoll.