

# ALPHA RHYTHMS AND MENTAL IMAGERY <sup>1</sup>

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Evidence concerning psychological correlates of the alpha rhythms is conflicting. Golla, Hutton and Walter (1943) classified alpha records into M, R, and P types, and found that subjects with M types of record used mainly visual imagery in thinking, the P types chiefly auditory-kinaesthetic imagery, and with the Rs, either type of imagery might predominate. Short (1953), also demonstrated that the alpha rhythms tended to block when the subject used visual imagery, and to persist when he used verbal-motor imagery.

In agreement with these results correlating suppression of alpha activity with visual perception and visual imagery were investigations by Short and Walter (1954), Walter and Yeager (1956), and Costello and McGregor (1957), but evidence against such a specific relationship has come from Drever (1955 and 1958), Barratt (1956), Oswald (1957), and Mundy-Castle (1957).

In contrast, properties of the alpha rhythms have been related with a person's basic personality trends as regards passivity and dominance by Saul, Davis and Davis (1949), with certain aspects of intelligence by Mundy-Castle (1958), and other behavioural associations have been reviewed by Gastaut (1954).

This paper reports an investigation into the EEG correlates of mental imagery in a group of 60 medical and dental students in an attempt to understand how the various divergencies of opinion might have arisen.

*General Considerations.* To obtain satisfactory data about the normal EEG it is essential for the subject to be relaxed. Undue alertness causes the alpha rhythms either to

disappear or be greatly attenuated, and this factor constituted a major difficulty, since the students were often apprehensive about having an EEG and it sometimes required much time and patience before a satisfactory record was obtained.

Mental tasks had to be chosen with care. They had to arouse an easy flow of thought without undue pauses to search for subject matter, but they had not to be of such a nature as to arouse stress. If the task was difficult, or, worst of all, gave the impression of being a test of intelligence, one either produced the non-specific effect of anxiety or, alternatively, thought was just inadequate.

In assessing the adequacy of visual imagery, simple questioning tended to be misleading, since a student's idea of visualising well was purely a personal one based on a comparison of his own capabilities.

*Procedure.* 1. A routine resting record was taken and the effect of eye opening and closure noted. Four channels of an 8 channel Ediswan apparatus recording from the parieto-occipital areas were used. The positioning of electrodes and recording conditions were kept constant for all subjects.

2. A series of tasks was then given. A short strip of resting record was taken and the moment of giving the task was marked on the moving EEG paper.

(a) Sums. A series of multiplications was given, starting with simple ones, e.g. "Multiply 5 x 16". This was often accomplished too quickly to record any significant EEG change, but the idea was to avoid stress by immediately giving a difficult problem. The student indicated with his hand when each task was completed.

(b) To think of some person they knew well, and what they would be doing that day.

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Before starting the test, a suitable person to think about was chosen.

(c) Either "Think over your last year's summer holiday", or "Think over the story of the ascent of Everest".

(d) "Think of an apple. Cut it in half; and now cut it in halves again. How many sides of all the pieces will be white, and how many will be coloured" ?

(e) "Will you *think over* the Lord's Prayer" ?

(f) "Will you *think over* the National Anthem" ?

(g) "Think over what you would like to do when you have qualified". The student was then closely questioned to elicit the following points:

Had he been picturing or talking to himself, or had he used both methods of thought, and if so, which came first ? If he had used visual images, what was the degree of detail "seen", and how lifelike and "real" were they ? Was there colour, depth, movement, etc. ? What was the continuity or fluctuation of thought ? What subjective effort was needed ?

As a further aid to determine the habitual imagery, they were also asked if they could remember people's faces or names best, and whether they had memorised their anatomy visually or not.

3. Using a similar procedure, the student was first asked to *picture* either a person or place which he knew well, and later given a verbal task such as being asked to *say over* to himself the Lord's Prayer. He was then asked questions about the quality of his visual imagery, and the subjective effort required.

4. After a short resting record the subject was shown a picture with plenty of colour, variety, detail and depth, for 20 sec. He was then asked to close his eyes, and after 30 sec. asked to picture it to himself.

Afterwards, he was questioned in an attempt to assess the adequacy of his visualisation in comparison with the actual picture he had seen. Care had to be taken to assess whether the subject had actually been "seeing" the picture or merely thinking about it in an abstract way.

### *Assessment of Results*

A. *Classification of Imagery.* First, the subject's habitual mode of imagery was assessed from the results of the questions asked following the first series of tasks. No one with an extreme predominance of any one type of imagery as described by Golla, Hutton and Walter (1943) was encountered. From a central group where an individual's use of the various types of imagery was very even and mixed, there were gradations in two directions. In the one, the subjects became more obviously visualisers, which not only embraced the dominant use of visual imagery in thought, but also, usually, a capability of more real, life-like and easily attained visual imagery. At this end of the scale were those who, although still exhibiting versatility of thought, were predominant visualists who tended to transform each task into a series of detailed mental pictures and in whom it was difficult to find a problem about which they would think in a non-visual way. In the other direction the subjects became more dominantly verbalisers, until towards this end of the scale were those students who again, although still capable of mixed forms of imagery, were predominantly non-visualists whose visual imagery capabilities were often poor and attended by subjective mental effort.

The subjects were therefore classified as (i) predominant visualisers, (ii) visualisers, (iii) verbalisers, and (iv) predominant verbalisers.

Secondly, the qualities of the visual imagery were assessed from the total impression gained from the questions asked after each series of tests. The imagery was classified as (i) poor - no colour, movement or detail; (ii) average - some colour and slight detail, but mostly general outlines; (iii) good - colour, movement, and some detail - almost "real"; (iv) excellent - with depth, colour, movement and good detail - "real" and life-like imagery.

### B. *Assessment of Alpha Rhythms.*

1. Although all the records in this series were of the R type, there were well marked

differences in the qualities of the alpha rhythms within this group, and indeed, all gradations between the two extremes of M and P were present, and no strict boundaries separating the groups could be made. For instance, where the alpha rhythms became

therefore classified as R.M. Again, at different times in the same record there sometimes occurred varying degrees of blocking of the alpha rhythms with the eyes open. Those records in which there was either no, or very incomplete blocking with the eyes

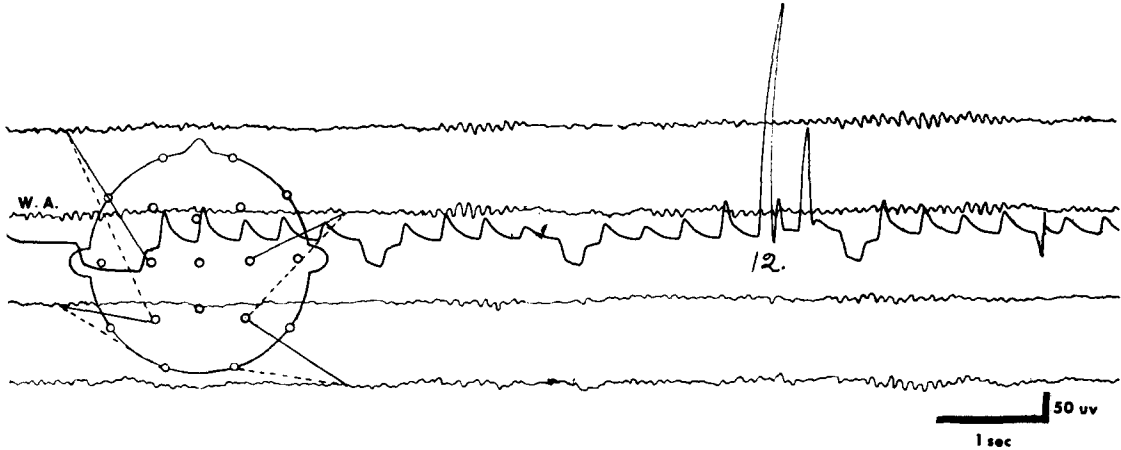


Fig. 1

Very intermittent rhythmicity. A well-marked habitual visualiser. Average alpha amplitude  $12.6 \mu\text{V}$ . Predominant frequency of 12 c/sec.

intermittent and of low amplitude, but in which a change on opening, and particularly on closing the eyes could be seen, it was virtually impossible to know whether to label it an R or an M type, and these records were

open, but obvious blocking when the subject specifically looked at something, were classified as R.P.

2. An attempt to demonstrate the differences between the records was made by

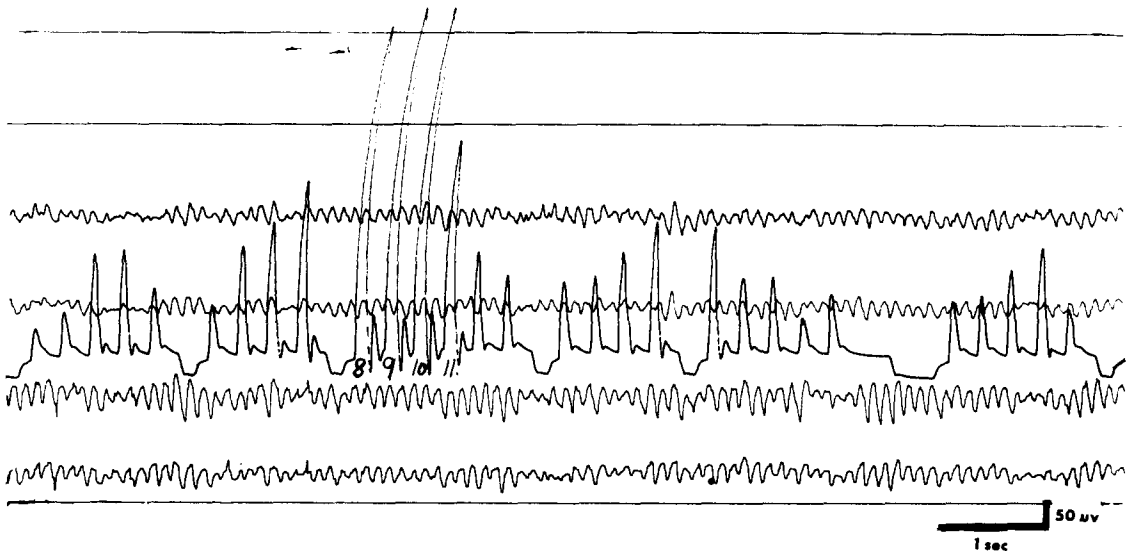


Fig. 2

Continuously or almost continuously rhythmical record. A predominant verbaliser. Average alpha amplitude  $38 \mu\text{V}$ .

calculating the average amplitude of the resting alpha rhythms using the method adopted by Walter and Yeager (1956).

3. The degree of rhythmicity of the records was described as very intermittent, intermittent, and continuous or almost continuous (fig. 1 and 2), and the degree of

C. *Mental Imagery and the EEG.* The effect of different modes of imagery on the alpha rhythms was ascertained by comparing the clinical notes with the corresponding EEG (each assessment being made separately) in the various tasks for habitual and purposive imagery (fig. 3).

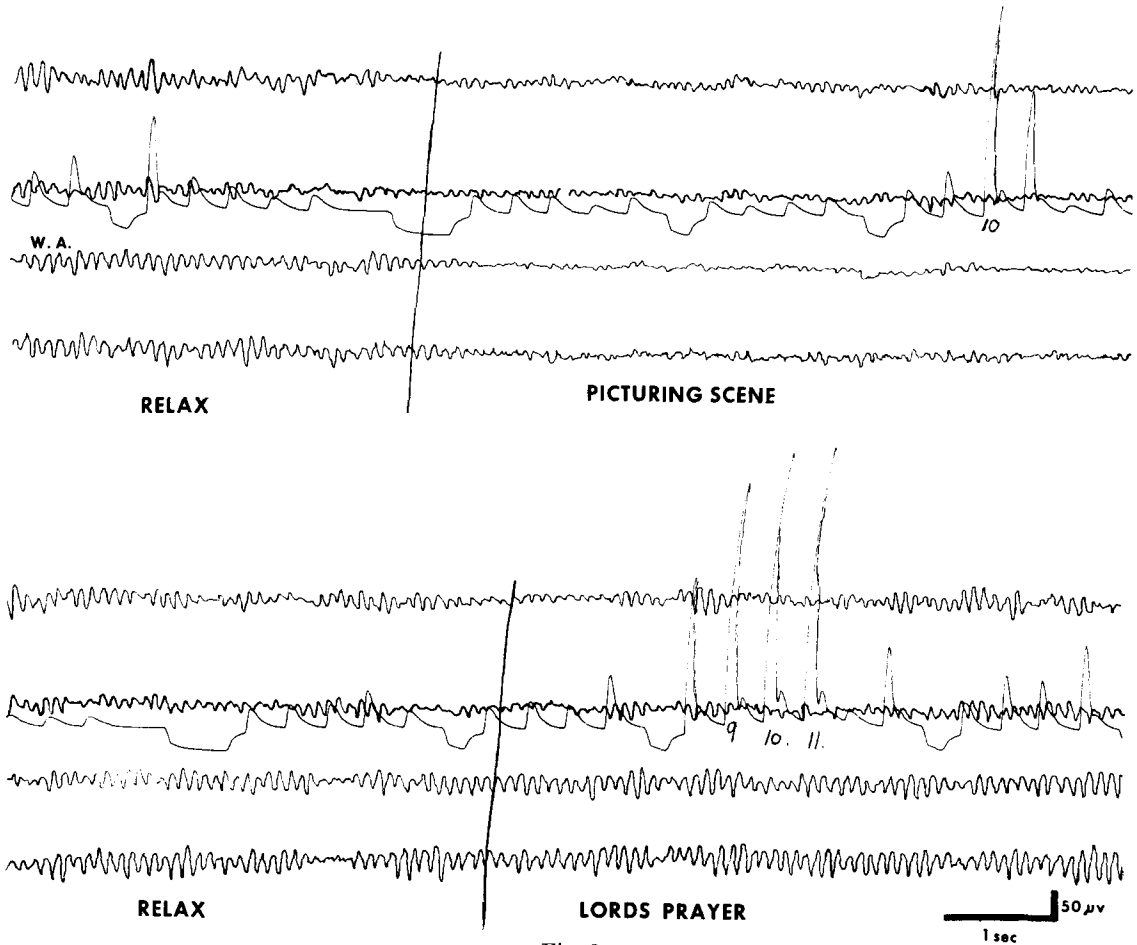


Fig. 3

A habitual verbaliser. His best efforts at visual imagery were only of average quality and associated with subjective effort. Average alpha amplitude  $35.2 \mu\text{V}$ . Picturing a scene is accompanied by reduction of the alpha rhythms, and during the saying of the Prayer no change is noticeable.

blocking of the records was classified as complete or incomplete, depending upon whether obvious alpha rhythms were present when the eyes were open. The dominant frequency of the alpha rhythm shown by the wave analyser was also noted.

D. *The Picture Test.* The difference between the average amplitude of the alpha rhythms on mental rest, active vision, and visual recall, was calculated, and the changes were compared with an assessment of how well the student had been visualising.

## RESULTS

A. *Changes in the EEG with Mental Imagery.*

1. *Changes with the Tasks for Habitual Imagery.* Four hundred and twelve tasks were successfully accomplished by the students.

The results (table I) leave little doubt that visual imagery is associated with a reduction in the alpha rhythms, whereas verbal imagery is associated with their persistence. The non-specific effect of stress may explain

TABLE I

Tasks	Visual imagery and alpha response	Visual imagery and alpha persistence	Verbal imagery and alpha response	Verbal imagery and alpha persistence
412	249	15	24	124

the fact that more tasks accomplished by verbal imagery are associated with alpha responses than are tasks with visual imagery associated with alpha persistence.

2. *Changes associated with Purposive Imagery.* Of the two students (table II) whose rhythms showed no response to either mode of imagery, one was a predominant verbalist with a high amplitude and continuous alpha rhythm (average amplitude 38.0  $\mu$ V.) who found visualisation difficult and of poor

TABLE II

Purposive imagery	Alpha responsiveness	Alpha persistence
Visual (60)	58	2
Verbal (60)	7	53

quality, and in whom the only event which altered the alpha rhythm was specifically looking at something. The other was a habitual verbaliser, again with a high amplitude almost continuously rhythmical record (average amplitude 35.0  $\mu$ V.), in whom only his best visual imagery (only of average quality and invariably preceded by non-visual imagery) altered the alpha rhythm. His routine visual imagery, which was of poor quality, caused no response.

Of the 7 students whose rhythms responded to both types of imagery, anxiety and the difficulty in some cases of finding a task in which verbal imagery alone was used, probably played a part.

These results confirm the findings in the preceding section, and are in agreement with those of Short (1953).

3. *Visual Recall and Active Vision.* In every case, asking the student to look at a picture resulted in various degrees of blocking of the alpha rhythms. In only 7 out of the 60 cases was the degree of blocking with visual recall equal or greater than with active vision. The fact that lambda waves, artefacts, etc. were necessarily included in this mode of calculating the average alpha amplitudes explains some of the discrepancies. Again, it was clear at times that even when looking at a picture the student was partly thinking about it in a non-visual way, i.e. not predominantly utilising his visual mechanisms.

The conclusion is that both visual recall and active vision are associated with blocking of the alpha rhythms, active vision causing the greater change.

4. *The Degree of Change of the Alpha Rhythms.* The figures (table III) suggest that it is the higher amplitude rhythms which have the greatest percentage reduction in amplitude on actual visualisation or visual

TABLE III

	Resting Potential $\mu$ V.		X <sup>2</sup>	P.
	9.4-22.0	22.1-46.5		
% reduction with recall	11.7-46.4	25 9	15.0	<0.001
	46.5-74.0	6 20		
% reduction with active vision	12.6-57.4	26 2	35.6	<0.001
	57.5-80.1	5 27		

recall. But it is the high amplitude records which especially tend to be associated with a poor quality of visual appreciation, and it follows therefore that the actual degree of amplitude change bears no direct relation to the quality of the visual processes. The impression was, however, that in any individual,

the more adequate his visual appreciation the more reduction in the alpha rhythms occurred.

*B. Mental Imagery and the Resting Alpha Rhythms.*

The results so far have been concerned with the changes occurring in the EEG when a person thinks. However, since there was no doubt that people's ease and potentialities of use of different forms of imagery varied widely, this second series of results examines whether such differences are reflected in certain properties of a person's resting record.

1. *Alpha Amplitude.* The incidence of the different types of imagery and the result of

TABLE IV

Number of students	Predominant visualiser	Visualiser	Verbaliser	Predominant verbaliser
60	1	31	22	6

comparing the type of habitual imagery with the average amplitude of the alpha rhythms is shown in tables IV and V.

The one predominant visualiser had an average alpha amplitude of 11.1  $\mu$ V., and the average amplitude of all 6 predominant verbalisers was over 28.0  $\mu$ V.

TABLE V

Habitual imagery	Average amplitude	Alpha rhythms ( $\mu$ V)	X <sup>2</sup>	P.
	9.4-26.2	26.3-46.5		
Visual (32)	30	2	29.8	< 0.001
Verbal (28)	7	21		

This suggests that the amplitude of the alpha rhythms bears an inverse relationship to the degree to which visual imagery is easily and naturally used in thought. Habitual visualisers therefore tend to have records showing lower alpha amplitudes than habitual verbalisers. Predominant visualisers have very low amplitude records (a true M type being the extreme), and predominant verbalisers relatively high amplitude records.

2. *Rhythmicity.* The one predominant visualist had a very intermittent record. The

6 predominant verbalists all had continuously or almost continuously regular rhythmical records.

These results (table VI) are in agreement with the suggestion that, excluding the factor of anxiety, the degree of intermission in the

TABLE VI

Habitual imagery	Very intermittent	Intermittent	Continuous or almost continuous
Visual (32)	12	19	1
Verbal (28)	0	11	17

rhythmicity of a record can be correlated with the extent to which visual imagery is used in thought.

3. *The Degree of Blocking.* Again, the results (table VII) are consistent with the suggestion that blocking of the alpha rhythms is associated with activity of the visual mechanisms. It is significant, too, that the one predominant visualiser had complete blocking, and all 6 predominant verbalisers incomplete blocking (3 being of the R.P. type).

TABLE VII

Habitual imagery	Complete blocking	Incomplete blocking	X <sup>2</sup>	P.
Visual (32)	23	9	15.2	< 0.001
Verbal (28)	6	22		

Twelve records were classified as R.M. and 4 as R.P. The fact that all 12 of the former were habitual visualisers (including the one predominant visualiser) and that 3 out of the 4 latter were predominant verbalisers, is in agreement with the views already expressed. The one habitual visualiser with markedly incomplete blocking is of interest. If with his eyes open he was listening to me talking, the record simulated that of a true P type. Indeed, by carrying on a quiet conversation with the recordist, I could repeatedly cause him to produce this type of record, whereas at other times typical blocking occurred.

4. *The Quality of Visual Imagery.* There is a tendency for those with a good and excellent quality of visual imagery to have lower

amplitude rhythms than those with an average or poor quality (table VIII). All 5 students who at their best effort had a poor quality of visual imagery, had high ampli-

TABLE VIII

Quality of visual imagery	Resting potential $\mu V$ .	
	9.4 - 26.2	26.3 - 46.3
Excellent	4	0
Good	21	3
Average	11	15
Poor	1	5

tude and continuously rhythmical records and stated that they found visual imagery associated with obvious subjective effort.

However, the exceptions to the general trend appeared convincing and it may simply be that because a habitual visualiser is more likely to have better visual imagery than a habitual verbaliser, to this extent only are low amplitude rhythms more likely to be associated with a better quality of visual imagery.

5. *The Frequencies.* Only the frequency of 12 c/sec. appeared to have a particular association with visual imagery, although no definite correlation could be made with the quality of the imagery. Of the 12 students with this dominant frequency, 11 were habitual visualisers, and all 12 records had average alpha amplitudes below 24.6  $\mu V$ .

Shipton and Grey Walter (1957) suggested that this frequency was associated with visual imagination, and although no detailed assessment concerning this was made here, the impression was in agreement with their suggestion.

#### DISCUSSION

*Sources of ambiguity and criticism can now be outlined.*

1. The extreme type of subject who uses either "pure" visual or "pure" verbal-kin-aesthetic imagery in thinking and in whom therefore a correlation of the use of one type of imagery with changes in the EEG is easy to assess is the exception. Most subjects employ a mixture of various types of imagery although with differing degrees of predominance.

Here, both in the classification of subjects and in the EEG themselves lies an obvious source of difficulty and an explanation for the lack of clear-cut results, particularly as regards the group of subjects who use both visual and non-visual imagery with almost equal facility varying to some extent with the nature of the particular problem.

2. In attempting to record the activity of mechanisms associated with specific types of thought, the thought mechanisms will have to be kept as simple as possible since otherwise their complexity will make differentiation impossible. The type of task given is therefore of vital importance, and this may well be an important factor in causing a discrepancy of results.

3. The non-specific effect of stress in causing attenuation of the alpha rhythms constitutes another cause of confusion and further emphasizes the importance of the choice of task given.

4. An insurmountable difficulty in this type of investigation at present is reliance on a subjective evaluation of a person's mental activities, and this is always liable to render results open to criticism and error.

5. The great complexity of related phenomena which constitute even the simplest of thought processes are all being accompanied by the change in a simple wave form, and it is not necessarily contradictory therefore that correlations have been made between different aspects of a person's personality and changes in the alpha rhythms. The various factors involved in personality may be so closely associated together that there is a common effect on the alpha rhythms.

6. The wave analyser shows that what the primary trace represents as a simple alpha rhythm is in fact a complex composed of a mixture of frequencies, and there is evidence to suggest that the frequency of 12 c/sec. can be correlated with visual imagination. It is possible therefore that a more refined analysis of the alpha rhythms might show changes during mental activity which are not portrayed in the primary trace.

#### SUMMARY AND CONCLUSIONS

1. Active vision and visual recall are associated with blocking or attenuation of the

alpha rhythms, active vision producing the greater degree of change. Non-visual imagery is associated with their persistence. Alpha activity is also blocked non-specifically by anxiety.

2. All the EEGs in this series were of the R type, almost certainly due to the fact that the subjects were a highly selected group with versatile modes of thought, whereas the Bristol series (1943) consisted of an unselected group.

3. The EEGs showed every grade of change between the M and P types, suggesting that these simply represent the two extremes of a continuous gradation of changes.

4. Individuals use different types of imagery with differing degrees of ease and preponderance. Just as the M, P, and R types of record are correlated with distinct varieties of thinker, so, within certain limits, the several properties of the alpha rhythms, in a "resting" record can be correlated with a subject's ease and habitual use of visual imagery.

5. In correlating mental activity with changes in the EEG, as much attention must be paid to analysing the individual properties of a person's mental processes (psychological information) as to the features of the EEG.

#### RÉSUMÉ

1. L'acte de vision active et une mémoire visuelle évoquée sont associés avec un blocage ou une atténuation du rythme alpha, la vision active produisant un changement d'un degré plus important. L'imagination non-visuelle est associée avec la persistance du rythme alpha. Le rythme alpha est bloqué aussi d'une façon non-spécifique par l'anxiété.

2. Tous les EEGs de cette série étaient du type R, ceci étant certainement dû au fait que les sujets représentaient un groupe hautement sélectionné avec des modes de pensée versatiles tandis que la série de Bristol (1943) consistait en un groupe non-sélectionné.

3. Les EEGs montraient tous les degrés de transition entre les types M et P, ce qui suggère que ces types représentent simplement les deux extrêmes d'aspect continu.

4. Différents individus font usage de différents types d'imagination avec un degré variable de facilité et de prépondérance. Etant donné que les types M, P et R de tracé sont en corrélation avec des variétés précises de mode de pensée, il est possible d'établir une corrélation entre les différentes qualités du rythme alpha de l'activité de repos et la facilité et l'usage habituel d'imagination visuelle du sujet.

5. Pour établir une corrélation entre l'activité mentale et les caractéristiques électro-encéphalographiques d'un sujet, il est nécessaire d'analyser avec autant de soin les caractéristiques individuelles des processus mentaux d'une personne (information psychologique) que les caractéristiques de son EEG.

#### ZUSAMMENFASSUNG

1. Aktives Sehen und visuelle Erinnerung sind mit Blockierung oder Verminderung des Alpha-Rhythmus verbunden, wobei das aktive Sehen die grösseren Veränderungen bewirkt. Nichtvisuelle Erinnerung dagegen findet statt bei gleichzeitiger Persistenz des Alpha-Rhythmus. Alpha-Aktivität wird ebenfalls in nicht-spezifischer Weise, durch Angst blockiert.

2. Alle EEGs dieser Untersuchungsserie waren vom R-Typ, fast sicher deshalb, weil die Versuchspersonen eine stark ausgewählte Gruppe mit vielseitigen Denkweisen darstellten während die in Bristol 1943 untersuchten Versuchspersonen eine unausgelesene Gruppe waren.

3. Die EEGs zeigten alle Grade von Wechsel zwischen M- und P-Typ, was nahelegt, dass diese beiden lediglich die Extreme eines kontinuierlichen Spektrums sind.

4. Verschiedene Personen benützen verschiedene Typen von Vorstellung mit unterschiedlichen Graden von Leichtigkeit und Vorliebe. Gerade so wie die M-, P- und R-Typen, welche früher beobachtet wurden, mit verschiedenen Denktypen verbunden sind, so können auch innerhalb gewisser Grenzen die verschiedenen Eigenschaften des Alpha-Rhythmus in einem Ruhe-EEG in Beziehung stehen zur Leichtigkeit und Vorliebe mit welcher einem Person visuelle Vorstellungen benützt.



5. Wenn man geistige Tätigkeit mit EEG-Veränderungen in Beziehung setzt, muss man die psychischen Prozesse einer Person welche mit den EEG-Daten korreliert werden sorgfältig untersuchen.

I wish to express my thanks to Lord Cohen of Birkenhead for his encouragement and criticism in the preparation of this paper. To Dr. R. B. Taylor of Rainhill Hospital, for allowing me to use the EEG equipment there, to Miss Pullar for her help in the recordings, and to all the students.

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