# THE RELATIONSHIPS BETWEEN SOME ASPECTS OF VISUAL IMAGERY AND THE ALPHA RHYTHM

By

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## INTRODUCTION

GOLLA, Hutton and Grey Walter (1943) made an attempt to use the EEG as an objective means of assessing imagery. They concluded that there were three types of alpha rhythm which corresponded to three different kinds of imagery processes: M or minus type whose alpha rhythms were almost non-existent and who used mainly visual imagery in thinking; the P or persistent type whose alpha rhythms continue even during mental activity, and who used mainly vocal-kinaesthetic imagery; the R or responsive type with a good resting alpha rhythm which blocked readily during mental activity, and whose imagery was mixed. Though they were attempting to find an objective means of assessing imagery an ultimate appeal is made to introspection as a validating criterion, and the tasks given to the subjects were such as to present difficult problems in the way of introspection. For instance, they were asked to think over to themselves the story of Red Riding Hood, to think over to themselves their plans for some definite day, to think over the argument for and against some abstract proposition such as "honesty is the best policy" or "the existence of free will". It is felt that if an attempt is to be made to find an objective means of assessing imagery some attempt should first of all be made to control the kind of imagery that will be used.

Short (1953) in a report of his investigation came to the same conclusions as the previous workers, but is subject to the same criticism. Short and Walter (1954) in their investigation asked the subjects to outline with their fingers figures made by grooves in cement blocks. Here a stoical attempt to get away from introspection results in findings whose relationships to imagery are very vague.

Drever (1955) recently published some observations on the occipital alpha rhythm recorded from groups of early blind, late blind and sighted subjects during the performance of two spatial tasks. Since the test scores differentiated between the groups it was argued that the performance probably involved a visual component. Here we have a successful attempt to control the kind of imagery likely to be used. He found that when the subjects were classified into the three alpha rhythm types M, P and R, the groups did not differ significantly from one another in terms of test scores. He regarded this as negative evidence in relation to the hypothesis of M, P and R types. Perhaps even more important than this finding however was the finding that the M type which is supposedly associated with predominant visual imagery was found most frequently among



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the blind. He concluded that the hypothesis tested is too simple and would have to be reformulated to fit the facts.

Barratt (1956) gave his subjects a verbal reasoning problem likely to encourage verbalization in its solution and a task that was likely to encourage visualization. His main finding was that there was a significant suppression of the alpha rhythm during both the verbal reasoning condition and the visual problem condition. There was a greater suppression effect in the case of the "visual" problem but the results as a whole he concludes suggest that visual imagery appears to be only one of many factors that may produce suppression effects.

It appears then that the interpretation to the P, M and R types no longer accounts for all the data, and that there is not a simple relationship between alpha suppression and visualization. On the other hand there does seem to be a relationship between some aspect of visualization and suppression of the alpha rhythm which demands further investigation.

Individual differences have been found in relation to the control and vividness of visual imagery (Gordon, 1950; Petrie, 1952; Costello, 1956), which suggested an investigation into the relationship between the vividness of visual images and suppression of the alpha rhythm. The experiment to be reported here was designed to investigate this relationship.

## Subjects

Twenty subjects were investigated. They were members of the nursing staff of St. George's Hospital with one exception, this being a fourth-year medical student. Each subject had been tested one week previously in connection with another investigation the results of which it is hoped to publish elsewhere. The nature of visual images had been discussed with the subjects individually, and they knew exactly what was expected of them. They were asked not to discuss the experiment with their friends, and they did not know the purpose of the experiment beyond the fact that we were interested in changes in the EEG when they were asked to visualize something.

The mean age of the group was 22·1 years, the mean score on the Matrices 47·25. Further data on the group can be found elsewhere.

## Method

The two main features in the design of this investigation into the relationship between the vividness of visual imagery and alpha suppression were: the subjects were asked to visualize four completely different objects chosen for the expected differences in the vividness of the visual images they would provoke; secondly the subjects were tested in a normal state, and also in a drowsy state induced by a small dose of Seconal. The observations on hypnagogic imagery (McKellar and Simpson, 1954) suggested the possibility that the visualizations in the drowsy state would be more vivid than those in the normal state.

### *First Normal Session*

The experiment was conducted in the EEG Department of St. George's Hospital, Morpeth. The subjects were reassured that they would feel nothing when the record was being taken. The apparatus used was the standard eight-channel Ediswan Mark II EEG, and an Ediswan eight-channel automatic wave analyser. The electrodes were fitted. A bipolar arrangement was used consisting of a chain of three electrodes on each side: Mid-parietal—parieto-

occipital—occipital areas. The channel analysed was the one showing the maximum alpha amplitude during the eyes closed condition.

The following instructions were then given:

> "During the recording you will have to open and close your eyes a number of times. I want you to listen carefully to the instructions because it is important that you have your eyes open or closed at the right time. Remain relaxed and still throughout the recording and do not say anything unless I ask you a question."

A trial run was then taken consisting of thirty seconds with eyes closed and thirty seconds with eyes open. The purpose of the trial run was to establish a basic maximal measure for each subject with which the measure during visualizing conditions could be compared.

At the end of the trial run the subject was shown a coloured photograph 10 in. $\times$ 8 in. of a Ford Consul. He was told to examine it carefully so that afterwards he would be able to get a good picture of it in his mind. After three minutes the photograph was taken from him. He was then told to relax and try to keep his mind a blank except when the experimenter asked him to get a picture of the car. He was then to remain relaxed but to get the best picture he could. The subject was then told to close his eyes and the EEG record commenced. After thirty seconds the subject was told to get a picture of the car. Each visualizing condition was planned to start at the beginning of the analyser's 10-second epoch and was also indicated with an input marker. After thirty seconds the subject was told to forget the picture and after a further ten seconds was told to open his eyes. He was then given a card with the following six possible descriptions of his visual image and told to choose the one that he felt best described his image:

1. Very clear almost like a photograph.
2. Clear with definite shape.
3. Moderately clear with some detail.
4. Not very clear—only a general impression.
5. Very vague—hardly any picture at all.
6. Absent altogether.

After he had done this the subject was shown an abstract diagram for five seconds (see Fig. 1). The subject was told to look at it carefully since he would be shown it for only five seconds and afterwards would be required to get a picture of it.

When the five seconds had elapsed the diagram was taken away. The subject was given the same instructions as before with regard to remaining relaxed and keeping his mind a blank except when visualizing. He was then told to close his eyes, the EEG record was commenced, and the procedure was exactly as before except that this time he was asked to get a picture of the diagram. He was afterwards asked to choose the best description of his picture from the card.

The following instructions were then given to the subject:

> "In a few seconds I will ask you to close your eyes and get a picture of a scene. Try your best to get the picture but remain relaxed. After you have started getting the picture in your mind you will hear a buzzer. This is a signal that a watch is going to be held near your ear. When you hear the buzzer I want you to keep the picture in your mind and at the same time try to listen to the ticking of the watch. A second buzz will be a sign that the watch has been taken away."

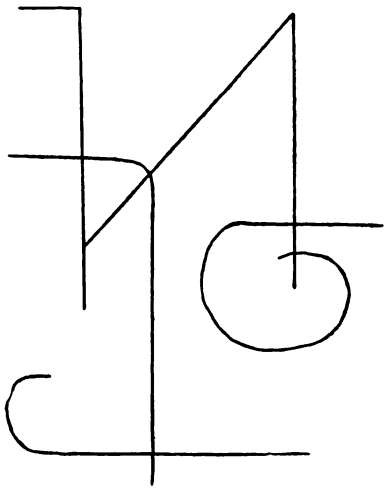

FIG. 1.—The Diagram

The subject was then told to close his eyes and the EEG record was commenced. After thirty seconds he was told to get a picture in his mind of a red United Bus turning into the Morpeth Market Place, stopping, and all the people getting out of it. Thirty seconds later a buzzer was sounded and a watch held near his ear. After a further twenty seconds the buzzer was sounded and the watch taken away. Twenty seconds later the subject was told to open his eyes. He was then asked to choose the best description of his picture from the six descriptions listed, and also to choose the best description of the movement as he saw it from the following five descriptions.

1. Saw the movement clearly.
2. Saw the movement with some effort.
3. Experienced much difficulty in seeing the movement.
4. Almost impossible to see the movement.
5. Could not see the movement.

The subject was then shown a drawing of a wheel with two small figures on it for five seconds (Fig. 2). The subject was told to look at it carefully since he would be shown it for only five seconds and afterwards would be required to get a picture of it.

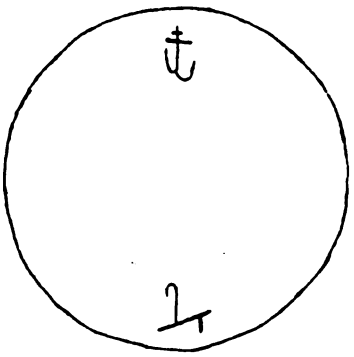

FIG. 2.—The Wheel

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After the drawing of the wheel was taken away the following instructions were given to the subject:

> "In a few seconds I will ask you to close your eyes and then I will ask you to get a picture of the wheel with the two figures on it turning round. Try your best to get the picture but remain relaxed. After you have started getting the picture in your mind you will hear a buzzer. This is a signal that a watch is going to be held near your ear. When you hear the buzzer I want you to keep the picture in your mind and at the same time try to listen to the ticking of the watch. A second buzz will be a signal that the watch has been taken away."

The subject was then told to close his eyes and the EEG record was commenced. The procedure was exactly the same as before except that this time he was told to get a picture of the wheel turning round. He was afterwards asked to choose the best description of the clearness of the picture and of the movement from the two cards.

This was the end of the first session and the subject was told when to come back for the second session which was within a week.

*Second Seconal Session*

About twenty minutes before the recording began the subject was given 2½ gr. Seconal and was left alone lying on the couch. He was told to let himself drift into a pleasant drowsy state but not to go off to sleep. Though there were individual differences in every case, the Seconal produced a drowsy state that was neither too shallow nor too deep for our purposes.

Apart from the administration of Seconal the procedure was exactly the same as in the first session and it will not be repeated here.

## RESULTS

The path traced by the automatic analyser was taken as the source of data. The dominant frequency and the two adjacent frequencies within the alpha band (8–13 c/s) were measured for height in millimetres within each 10 sec. epoch and then averaged over the number of epochs occupied during each of the experimental conditions. These three values were then combined to give a single "score" for each individual under each experimental condition. The investigators found (as did Barratt) that the dominant frequency and the two adjacent to it accounted for practically all the variation in amplitude. Each of these "scores" was then converted into a percentage fall from the resting alpha amplitude. This conversion into percentages was done for two reasons.

1. The investigator was interested in alpha suppression rather than absolute alpha amplitude.
2. A percentage rise or fall was not only more meaningful than absolute values but was not influenced by possible fluctuations in the machine's activity or displacement of the electrodes in the second session from the position they had in the first session. On the other hand it should be pointed out that every effort was made to keep everything standard.

The four different periods during which the subject visualized the different objects will be referred to as the "Car Condition", i.e. the period during which the subject was visualizing a car, the "Diagram Condition", the "Bus Condition" and the "Wheel Condition". The periods during which the subject had to visualize the Bus or the Wheel and at the same time listen to the watch

will be referred to as the Distraction Condition. The significance of the obtained differences was tested by the statistic "A" which Sandler (1955) has derived from Student's "t" and which yields exactly the same results as "t" but is not so time-consuming.

The results will now be presented in Table form and summarized after each table.

TABLE I

*Mean Percentage Fall when the Resting Alpha Amplitude is taken as the Baseline, Raw Differences between Means and A and p Values for the Differences between the Means for the Distribution of Percentages obtained under the Four Visualizing Conditions during the First Normal Session taken two at a time* ($n=20$)

| Comparison | Mean | Mean | Difference | A | p |
|---|---|---|---|---|---|
| Car *vs.* Diagram .. .. | −42·35 | −33·15 | −9·2 | ·167 | <·02 |
| Car *vs.* Wheel .. .. | −42·35 | −38·8 | −3·05 | 3·287 | >·10 |
| Car *vs.* Bus .. .. .. | −42·35 | −30·1 | −12·25 | ·275 | >·05 |
| Diagram *vs.* Wheel .. | −33·15 | −38·8 | −5·3 | ·961 | >·10 |
| Diagram *vs.* Bus .. .. | −33·15 | −30·1 | −3·0 | 1·261 | >·10 |
| Wheel *vs.* Bus .. .. | −38·8 | −30·1 | −8·7 | ·264 | <·05 |

From the data in Table I we can conclude that:

1. There is a significantly greater suppression effect on alpha amplitudes in the case of the Car Condition than in the case of the Diagram Condition.
2. The differences between the Car Condition and the Wheel Condition, between the Car Condition and the Bus Condition, between the Diagram Condition and the Wheel Condition and between the Diagram Condition and the Bus Condition are not significant.
3. There is a significantly greater suppression effect in the case of the Wheel Condition than in the case of the Bus Condition.

The experiment was designed with the assumption that the picture of the car would provoke a more vivid image than the diagram. The difference between the two pictures objectively was such that it was felt that the comparison of the vividness of the images provoked would not tax the subject's ability to introspect. The simple method of asking the subject to choose the appropriate description of his image from the six presented seemed to be a sufficient test of the assumption. Seventeen of the twenty subjects chose descriptions from the card indicating clearly that they had a much more vivid image of the Car than of the Diagram. Two of the subjects chose the same description for the Car and Diagram and only one subject chose descriptions suggesting a more vivid picture of the Diagram than of the Car. The significantly greater suppression of the alpha rhythm during the Car Condition with the large agreement between the subjects that it was the stronger image lends support to the hypothesis that there is a relationship between the vividness of a visual image and the amount of suppression.

It was also expected that the request to get a picture of the Bus scene—a scene familiar to all the subjects—would provoke a more vivid image than the Wheel. Fifteen of the subjects chose descriptions indicating that the Bus scene was more vivid than the Wheel, five chose the same description for Bus and Wheel. But here we have a greater suppression under the "Wheel Condition"! The results seem to be contradictory. A possible explanation of this discrepancy will be presented during the overall discussion of the results.

TABLE II

*Mean Percentage Fall when the Resting Alpha Amplitude is taken as the Baseline, Raw Differences between Means and A and p Values for Differences between the Means for the Distribution of Percentages obtained for the Four Visualizing Conditions during the First Normal Session and the Second Seconal Session* ($N=20$)

| Condition | 1st Session Mean | 2nd Session Mean | Difference | A | p |
|---|---|---|---|---|---|
| Car .. .. | −42·35 | −37·55 | −4·8 | 1·467 | > ·1 |
| Diagram .. | −33·15 | −35·8 | −2·7 | 5·319 | > ·10 |
| Bus .. .. | −30·1 | −40·95 | −10·85 | ·243 | < ·05 |
| Wheel .. .. | −38·8 | −42·45 | −3·65 | 2·822 | > ·10 |

From the data in Table II we can conclude that the difference between the two sessions for the Car, Diagram and Wheel conditions are not significant but the difference is significant for the Bus Condition. It was expected that under Seconal the imagery would be more vivid but there are no clear-cut differences between the two sessions for any of the conditions or at least none that appeared in their choice of descriptions with respect to the vividness and the movement of the images. What is noteworthy however, is that five of the subjects said the Bus scene came more easily and two of these subjects reported images associated with the scene they were trying to visualize, but which they had not actually tried to get. One subject said she had a clear picture of her husband driving the Bus, a second subject said that after the Bus he had visualized had come into the Market Place, other buses started coming in. Further discussion of the significance of this will be postponed until the remainder of the data has been presented.

TABLE III

*Mean Percentage Fall when the Resting Alpha Amplitude is taken as the Baseline, Raw Differences between Means and the A and p Values for the Differences between the Means for the Distribution of Percentages obtained under the "Bus Condition" and "Wheel Condition" and their Two Distraction Conditions during the Normal Session and the Seconal Session* ($n=20$)

| Comparison | Mean | Mean | Difference | A | p |
|---|---|---|---|---|---|
| Bus *vs.* Distraction (1st Session) .. | −30·1 | −34·3 | −4·2 | 1·174 | > ·10 |
| Wheel *vs.* Distraction (1st Session) | −38·8 | −30·75 | −8·05 | ·440 | > ·10 |
| Bus *vs.* Distraction (2nd Session) .. | −40·9 | −21·05 | −19·9 | ·185 | < ·02 |
| Wheel *vs.* Distraction (2nd Session) | −42·45 | −18·1 | −24·35 | ·109 | < ·001 |

It should be noticed that the amplitudes being expressed as a percentage fall from the resting alpha amplitude the means for both the visualizing and distraction conditions are minus values. When the percentage for the distraction condition is smaller than that for the visualizing condition this indicates a rise from the alpha amplitude during the visualizing condition. For instance −40 per cent. for the Bus Condition −20 per cent. for the Distraction Condition would mean that the Bus Condition amplitude was 40 per cent. lower than the resting alpha and the Distraction Condition alpha 20 per cent. lower than the resting alpha.

It can be concluded from the data in Table III that there was a significantly greater rise in alpha amplitude during the Distraction Condition for the Seconal Session than for the Normal Session. This Distraction test followed of course Adrian's test where he found that with subjects whose eyes were open there was a greater rise in alpha amplitude when listening to a watch when the

subjects wore lenses which blurred the visual field and therefore gained the attention less. It would seem then that under Seconal the visual images gained the attention less. This follows from Adrian's explanation but is supported also by the reports of the subject of this experiment who said that the images under Seconal came more easily. Some of the subjects also reported spontaneously that they were not concentrating so much during the Seconal Session as they were during the Normal Session.

## Discussion and Conclusion

The most important finding of the experiment is that suppression of the alpha amplitude varies with different types of visual images and under different conditions. Suppression of the alpha rhythm it would seem is not an all or none effect.

The difference in suppression under the Car Condition and the Diagram Condition suggests that there is a relationship between the vividness of the image and alpha suppression such that the more vivid the image the greater the suppression. It is suggested elsewhere that the vividness of visual images may be related to cortical inhibitory and excitatory processes. Gastaut (1957) has discussed his experiment on conditioning of the alpha in terms of cortical excitation and inhibition. It seems likely that the EEG will play a useful role in the investigation of these cortical processes. The result with the Bus Condition and the Wheel Condition on the other hand suggests that there may be other factors of importance apart from the vividness of the image and that these factors, despite the vividness of the image, may produce the opposite effect. In the face of this problem the first question that comes to mind is in what way does the Bus Condition differ from the other conditions? There are a number of important ways. First of all, in all the other conditions the subjects were shown a picture or drawing of the thing they had to visualize. Secondly, and this follows from the first difference, the subjects had more freedom to visualize as they wished and this meant, thirdly, that the visual images were less of a fixed kind than the other images. Fourthly, the other three conditions may be regarded as more pure visualizing situations in the sense that they had a specific thing which they had seen to visualize and which were not of the kind readily to provoke associations of a non-visual kind. In the case of the Bus Condition there was ample room for the provocation of associations and in one sense it may be true to say that they had to think about the scene in order to visualize it whereas in the other conditions the object came ready made. It will be seen that this fourth difference may be the crucial one.

It was noted before that some of the subjects reported that the visualizing of the Bus in the Seconal Session was more easy. This suggests that they were not concentrating so much, which follows from the known sedative effects of Seconal. We have also the findings in this experiment indicating clearly that the subjects were more easily distracted during the Seconal Session.

This being one of the first attempts to investigate a difficult area of psychological and electrophysiological relationships the significant findings are few and one must beware of building a too heavy theoretical superstructure on them. On the other hand some attempt should be made to provide an explanation for the results if only to suggest hypotheses that can be tested in the future.

It is hypothesized that the amount of suppression of the alpha rhythm is a result of at least two factors. First of all the vividness of the image, secondly the extent to which thought, associations or what we may collectively call the higher thought process, are involved. If this is the case, then, although the Car

suppressed the alpha rhythm more than the diagram did because it was a more vivid image the Wheel suppressed the alpha rhythm more so than the Bus, although the Bus was more vivid because the Bus involved higher process more. The examination we made of the differences between the Bus and the other objects to be visualized suggests that this explanation is at least a plausible one. Again, if the hypothesis is correct then it would seem that the greater suppression during the Bus Condition in the Seconal Session is a result of the inhibition of the higher processes by the Seconal, thus resulting in what we have called a more pure visualizing condition and so in a greater suppression. The greater ease with which the Bus scene was visualized during Seconal and the greater distractability fit in with this explanation.

The basic assumption made in the explanation is that the higher processes have an inhibitory effect on the visual processes—the visual processes being released from this inhibition in the drowsy state due to inhibition of the higher processes. Piaget has written that "whenever there is symbolism in dreams, in the images of the half sleeping state, or in children's play it is because thought in its state of low psychological tension or in its elementary stages, proceeds by egocentric assimilation and not by logical concepts" (1951). Psychoanalysts talk of representation of wishes in dreams when the superego is relaxed. Rorschach workers associate more vivid and revealing projections with a release of ego control (1954). The explanation proposed fits in with the positions held by these workers in different fields of study.

The main contribution of this work is to show that a study of the relationships between aspects of imagery and EEG changes is a worthy area of research, and may be more fruitful from the point of view of dimensions of personality or thought processes than attempts to classify people as visualists, verbalists, etc. Secondly, by varying the stimulus conditions and with the use of drugs during the recording of EEG activity it may be possible to throw light on hypnagogic imagery, dreams and related visual phenomena. The relationships between the inhibitory effect of the higher processes, the inhibitory effect of drugs and the general state of reactive inhibition would seem to be an important area for research. It would be tempting to speculate further on these inter-relationships in the case of visual hallucinations, particularly in view of the fact that there is considerable evidence suggesting increased cortical inhibition after brain injury (Klein and Krech, 1952; Petrie, 1952; Hildebrand, 1953), but we have gone far enough with the data available.

## Summary

1. EEG records were taken from twenty normal subjects during two sessions. For Session I the subjects were in a normal relaxed condition. For Session II they were in a drowsy state induced by 2½ gr. Seconal.

2. During both sessions they were asked to get visual images of a Car (previously seen), a Diagram (previously seen), a Bus scene (described to them) and a Wheel (previously seen).

3. When they were visualizing the Bus and when they were visualizing the Wheel a watch was held near their ears for a short time in an attempt to assess their distractability.

4. An analysis of the data suggests that the amount of alpha suppression is related to at least two factors: (1) The vividness of the visual image—the more vivid the image the greater the suppression; (2) The extent to which the higher thought processes are involved—the less they are involved the greater the suppression.

5. The general significance of the results is discussed.

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## References

BARRATT, P. E., *Brit. J. Psychol.*, 1956, **47**, 101.
COSTELLO, C. G., *J. Ment. Sci.*, 1956, **102**, 507.
DREVER, J., *Quart. J. exp. Psychol.*, 1955, **7**, 91.
GASTAUT, H., *EEG Clin. Neurophysiol.*, 1957, **9**, 1.
GOLLA, F., *et al.*, *J. Ment. Sci.*, 1943, **89**, 216.
GORDON, R. A., *Brit. J. Psychol.*, 1950, **41**, 63.
HILDEBRAND, H. P., *Doctor's dissertation*, 1953. London.
KLEIN, G. S., and KRECH, D., *J. Pers.*, 1952, **21**, 118.
KLOPFER, B., *et al.*, *Developments in Rorschach Technique, Vol. 1*, 1954. New York: World Book Co.
MCKELLAR, P., and SIMPSON, L., *Brit. J. Psychol.*, 1954, **45**, 266.
PETRIE, A., *Personality and the Frontal Lobes*, 1952. London: Routledge & Kegan Paul.
PIAGET, J., *Play Dreams and Imitation*, 1951. London: Heinemann.
SANDLER, J. A., *Brit. J. Psychol.*, 1955, **46**, 225.
SHORT, P. L., *Brit. J. Psychol.*, 1953, **44**, 38.
*Idem* and WALTER, W. GREY, *Electroenceph. Clin. Neurophysiol.*, 1954, **6**, 29.