FURTHER OBSERVATIONS ON THE RELATION BETWEEN *EEG* AND VISUAL IMAGERY

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It is known that the patterns of electroencephalographic activity differ in some respects from individual to individual, but that for any one individual such patterns tend to be stable. The type of electrical activity that has been most extensively investigated in this connection is the occipital *alpha*-rhythm, and attempts have been made to discover psychological and behavioral correlates for characteristic differences in this rhythm. In particular, Grey Walter and his associates have made a number of studies in this area on the basis of which they make two suggestions.[1] The first of these is that we can classify people in terms of their *alpha*-rhythm characteristics into three types, *M, R,* and *P.* From the *M* or "minus" type, we get a record in which there is very little activity at the *alpha*-frequency. The *R* or "responsive" type shows *alpha* during rest with eyes closed, but *alpha* is blocked by sensory, particularly visual, stimuli, and by certain kinds of mental work. Lastly, the *P* or "persistent" type produces an *alpha*-rhythm of rather high amplitude which tends to continue whatever *S* is doing as long as his eyes remain closed, and may even appear when his eyes are open. The second suggestion put forward by this group of workers is that these differences in *alpha*-rhythm type correspond to differences in the kind of imagery most frequently used by the *S*s. The *M*-type, it is claimed, is primarily a visualizer, the *P*-type uses the auditory and kinaesthetic modalities, while the *R*-type tends to have mixed imagery, though blocking of the *alpha* is held to be the result of visual imagery during the period in which it occurs. Evidence in support of this suggestion is given from introspection, from breathing records, and from performance in a task involving recognition of spatial figures.

Subsequent papers have cast doubt on Grey Walter's classification and on the psychological basis which he suggested might underlie it.[2] The

* The writer is indebted to his technician, Mr. Timothy Regan, who assisted in the collection and analysis of the data in this experiment.

[1] F. L. Golla, E. L. Hutton, and W. G. Walter, The objective study of mental imagery, *J. ment. Sci.* 89, 1943, 216-223; P. L. Short, the objective study of mental imagery, *Brit. J. Psychol.,* 44, 1953, 38-51; Short and Walter, The relationship between physiological variables and stereogenosis, *Electroenceph. clin. Neurophysiol.,* 6, 1954, 29-44.

[2] James Drever, Some observations on the occipital alpha rhythm, *Quart. J. exp. Psychol.,* 7, 1955, 91-97; P. E. Barratt, Use of the E.E.G. in the study of imagery, *Brit J. Psychol.* 47, 1956, 101-114; C. A. Stewart, An investigation into the associa-

investigation now to be reported grew out of this earlier work. It had as its aim (1) to investigate the validity of a classification into *alpha*-rhythm types, and (2) to study the relationship between the behavior of the *alpha*-rhythm and performance in a test which seems to involve activity of a visual kind.

Apparatus. Two channels of an electroencephalograph of orthodox design were

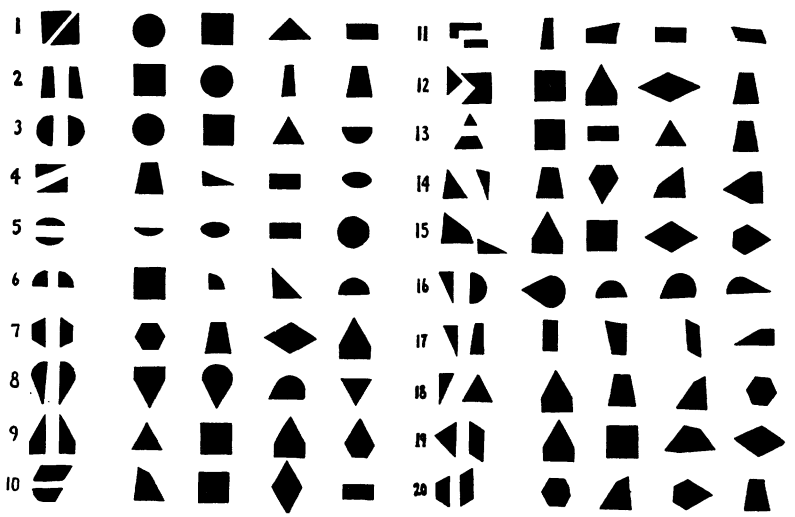

FIG. 1. TEST-ITEMS
Each item consists of a pair of stimulus-figures and four response-figures.

used. Analysis was carried out laboriously with dividers and ruler, since the numerous short episodes had in any case to be identified and related to what *S* was doing at the time.

A test was developed on the basis of one invented by Worchel and used by him,[3] and later by the writer,[4] to investigate the performance of *S*s blinded at different ages. It was found to discriminate well between the early and late blind, as well as between blind and sighted *S*s.

The new test is shown in Fig. 1. It consists of wooden blocks 3/8-in. thick, and of various sizes. The side of the square is 2 in. and the other figures are, of course, to scale. In this test, *S* is given the two stimulus-blocks, one in each hand. He can

tion between alpha rhythm and certain test results, M. Ed. thesis, Univ. of Durham, 1957; I. Oswald, The E.E.G., visual imagery and attention, *Quart. J. exp. Psychol.*, 9, 1957, 113-118.

[3] Phillip Worchel, Space perception and orientation in the blind, *Psychol. Monogr.*, 65, No. 332, 1951, 1-28.

[4] Drever, Early learning and the perception of space, this JOURNAL, 68, 1955, 606-614.

manipulate these as he likes, with the proviso that he must keep his hands apart. When he is ready, he returns them to *E* and is then given one after another the four 'response' blocks. He has to say which of these he could have made if he had placed the first two blocks together.

The range of scores obtained from the highly intelligent *Ss* used in the present experiment was 11-19, with a mean of 15.6 and an SD of 1.93. The reliability-coefficient obtained by retest of 24 *Ss* after not less than six months was 0.603, which, in a short test of this kind, was considered satisfactory.

Subjects. Eighty-four *Ss* were used, mostly students between the ages of 18 and 25, and of both sexes. Twenty-four of these *Ss* were recalled after a lapse of six months and the whole procedure was repeated.

Procedure. The *Ss* were seated in a reclining chair in a dimly-lit sound-screened room. Their eyes were lightly covered with pads of cotton-wool. Bilateral *EEG*-records were made from the occipito-parietal region. Each record lasted some 40 min. and could be related to each step in the 20-item test. There was in addition a short preliminary run with eyes open and closed.

Results. The *alpha*-rhythm patterns of *Ss* in a standard situation of this kind are extremely consistent. With the 24 *Ss* retested after six months, coefficients of correlation were calculated for the average amplitude of the *alpha*-rhythm, the percentage *alpha* present during working periods, the percentage *alpha* present during resting periods, the ratio between, and the average of these last two variables. In every case the reliability coefficient was better than 0.9. It should be kept in mind, of course, that the latter four variables are not independent.

When we measure the average percentage of *alpha* present during the resting periods of the record and the average present during the working periods, and then take the average of these two values, we obtain the graph shown in Fig. 2. Looking at it casually, one might get the impression that here indeed are three classes or types, with the proportions in each corresponding roughly to those claimed by Grey Walter, but that is not so. Since the range of values goes all the way from 0% to 100%, as with a test which is too difficult at the easy end and too easy at the difficult end—which has, that is, a floor and a ceiling too close to one another—we collect these humps at the extremes, although we are in fact dealing with a continuum. In other words, there does not seem to be any satisfactory evidence of a quantitative kind that there are different types of *alpha*-rhythm records.

It has been pointed out that the figure-recognition test was based on one which discriminates among *Ss* in terms of amount of visual experience. It also has been shown that the test is, of its kind, quite reliable. Nevertheless, no manipulation of the *alpha*-rhythm characteristics was successful in producing significantly different levels of scores. In addition to

the values mentioned already, we tried also the individual values for items answered rightly and wrongly. This finding is in agreement with earlier findings and with results obtained by Stewart using standardized space-tests. It also seems to accord with the observation by Walter and Yeager that those *S*s showing greatest reduction in *alpha*-amplitude did no better than others on a simple test of memory for design.[5] These last workers

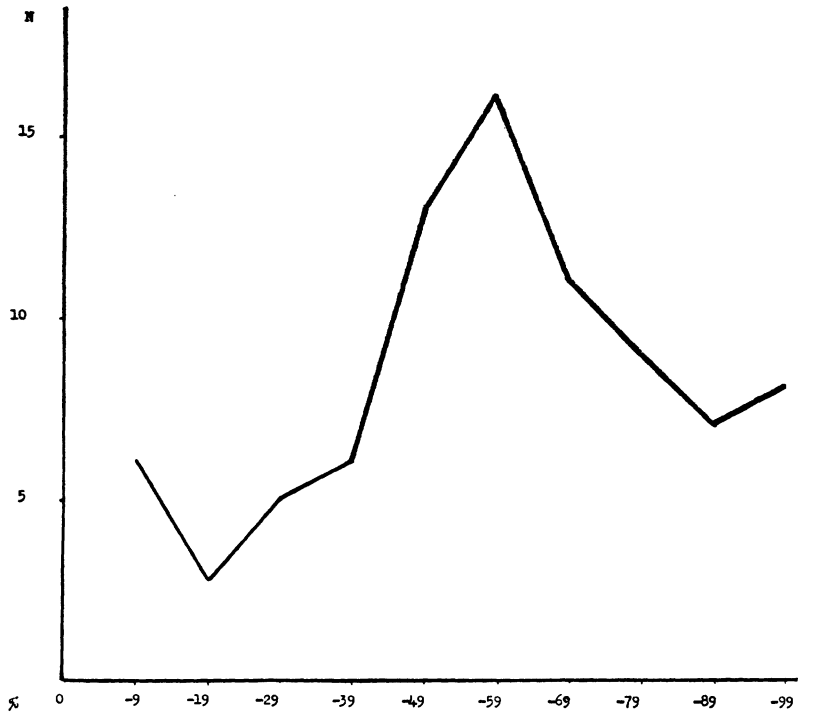

FIG. 2. DISTRIBUTION OF ALPHA-SCORES
The measure used is $(W + R)/2$; W is the percentage of *alpha* during working periods and R is the percentage of *alpha* during resting periods.

did find, however, that a low resting amplitude was related to accuracy of reproduction.

Individual cases. It may be that, at this stage in our knowledge, an account of one or two individual cases would do something to clarify the

[5] R. D. Walter and C. L. Yeager, Visual imagery and electroencephalographic changes, *Electronceph. clin. Neurophysiol.* 8, 1956, 193-199.

issues. For at least *some* of these cases, Grey Walter's hypothesis is extremely convincing.

Subject I. This was a student of mathematics. He was something of a calculating prodigy and an excellent introspector. His *alpha* consistently blocked when he reported visualizing and continued when he failed to report it. A particularly striking phenomenon was the way in which his *EEG*-patterns were different for different kinds of arithmetical operation. In Fig. 3 is shown a characteristic blocking during multiplication, with

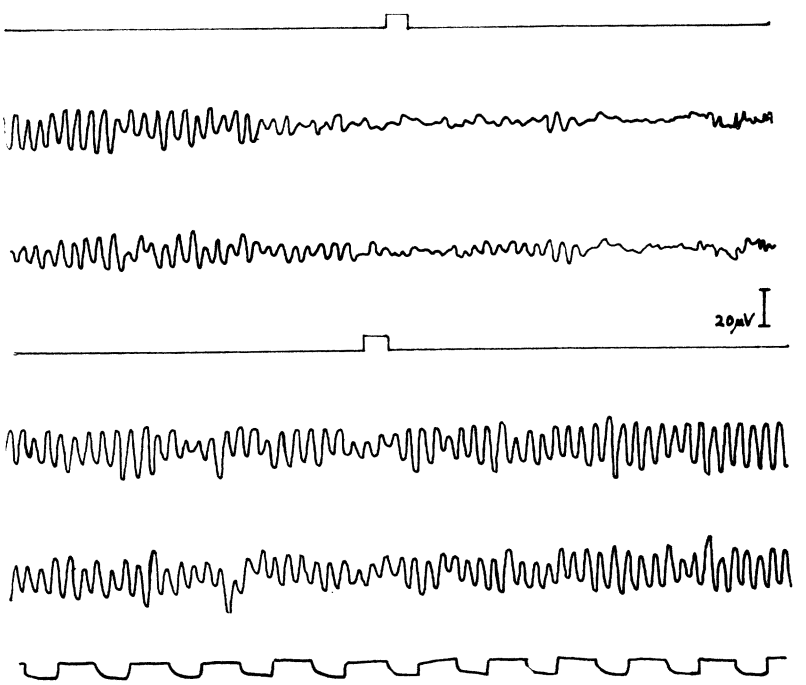

FIG. 3. RECORDS OF S_1
The upper record is for multiplication and the lower for square-root extraction. The start of work is shown by the pip in the top line of each record.

continuing *alpha* as he extracted a square root. He reported that he did all his multiplying visually, making use of a clock-face in an idiosyncratic way. Square-root extraction, he reported, seemed to be done with his hand, and with sub-vocal speech. This fits with Grey Walter's hypothesis, and even better with findings by Costello, that suppression of the *alpha*-rhythm is related to at least two factors—vividness of imagery and the extent to

which the higher thought processes are involved.[6] Simple problems allow a more definite and concrete kind of imagery, and solving such problems seems to produce a greater degree of suppression than occurs when the task is harder.

Subject II. Fig. 4 shows part of a record obtained during the previous investigation of the early and late blind. In this case, the *S* was a boy

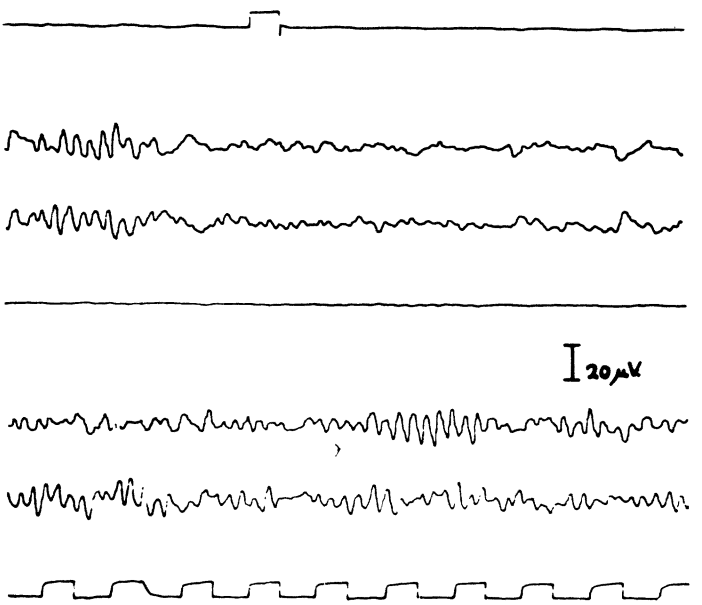

FIG. 4. RECORDS OF S_2
The upper records shows *alpha*-blocking at the start of a problem (pip in top line of record). The lower record shows resting *alpha*.

of 16 yr. who had become blind at the age of 2 mo. He retained some slight sensitivity to light, but the blocking during problem-solving which is shown in the upper part of the figure cannot be due to visual imagery, whatever may be its cause. It was characteristic of the entire record.

Subject III. This was a woman in her late twenties who had been as long as she could remember an accomplished visualizer. While at school she had to be prevented from doing her mental arithmetic by looking up at the ceiling, and she still used visual methods in connection with the

[6] C. G. Costello, Control of visual imagery in mental disorder, M.Sc. thesis, University of Durham, 1957.

arithmetical part of her work. While the record was being made she was asked to begin at one end of Princess Street in Edinburgh and read out the shop names. She said "Well, first there is Binns, then there is a bank—I can't read the name of it. Then there is another bank, the British Linen, then the American Express, then Wilson and Sharp, then MacVittie's, then South Charlotte Street, then Sinclair's on the corner." It is worth noting that the name of the first bank is recessed between two projecting doorways. Only one shop was missed. During all this, a well-marked *alpha* of some 50 μv. continued quite unblocked and undiminished.

Conclusions. The attempt by Grey Walter and his associates to relate the behavior of the *alpha*-rhythm to imagery-characteristics seems to break down if it is thought to apply to people in general. It appears to hold good of some people, but clearly does not hold good of others. The suggested classification into three *alpha*-rhythm types does not seem to be justified, and as with most typologies we are probably better off without it. It is clear, however, that each individual has a pattern of working and resting *alpha* during a standard task which is characteristic of him. The most promising next step seems to be a detailed study of the behavior of the *alpha* in the same individuals over a very wide range of different mental tasks.

Summary. Eighty-four *S*s were given a test which seems to involve visual activity, while at the same time bilateral *EEG*-records were taken from the occipito-parietal region. Results show that the records are characteristic of the individual, but the behavior of the *alpha*-rhythm is not related to the test-score. The *alpha*-rhythm content of the records does not point to the existence of three types as had been suggested, but rather to a continuum, with some clustering at the extremes.