THE OBJECTIVE STUDY OF MENTAL IMAGERY

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I. Introduction

Images are the materials of thought, and the mode of thinking a person habitually employs may well depend on the particular type of imagery at his disposal. Roe(7) has suggested that characteristic variations in imagery are to be found in people in different occupations. Images are least often reported, though not absent, where the subject-matter is predominantly 'abstract' or non-sensory. For instance, theoretical physicists 'rely heavily on symbolic thinking, which is related to, but not strictly, verbal thinking in auditory or auditory-motor terms'. Even the Wurzburg group acknowledge that 'sensory presentations' (images) are 'the most obvious feature in the subject's reports' (Marbe). Moreover, if, following Craik, we hold that images symbolize modes of possible actions, or are 'working models' of actions (whether the latter belong to the past, as in reverie, or to the future, as in planning a journey), Marbe's 'Bewusstseinslage' may be taken simply as another way of expressing the *way we manipulate* our imagery-models.

In view of the part played by images in thinking, imagery questionnaires are poor indicators of the function of images in mental life. They fail partly because individual's self-scorings cannot be standardized, and partly because, in thinking, it is the images that occur most readily and habitually that are important, not the ones thought to be the most 'intense' or 'vivid' at a given moment. The mere emergence of very vivid images may not be associated at all with the tendency to have and to use images. In the present study, mental tasks were given to subjects, and spontaneous reports obtained from them directly afterwards. These data were used to determine imagery-types.

The hypothesis adopted, therefore, is that images contribute to the models or schemata we create of the world, just as much as 'direct' seeing, hearing or speaking. Accordingly, the following operational definition of an image is used for the present inquiry: 'An image is a sense-experience in one or other of the sense modalities which can only be distinguished from a percept, hallucination, or illusion, according to (*a*), the context in which it occurs, and (*b*), the attitude of the experiencer, including his ability to construct it.'

This definition makes no rigid distinctions between the types of awareness named. When Ryle(8) distinguishes between the metaphorical use of 'imagining' words and the literal use of 'perceiving' words, urging, in consequence, a complete dichotomy between imagining and perceiving, then he is arguing from an observed difference in logico-grammatical usage to no more than the hope of a difference in psychology—a hope so far unfulfilled experimentally. Sartre(9) offers a similar argument, saying that the 'subjects could not have meant to say that the images are given to them visually. Nor do they imply that images occur as neural processes or processes of visual centres'. This

leads to the dictum, for which there is no experimental evidence, that 'the image represents a certain type of consciousness which is completely independent of the perceptual type'.

On the contrary, the interdependence of imaging and perceiving, well established by Bartlett in *Remembering*, and the several experiments quoted by Woodworth (11), showing that an image may be readily confused with a percept, encourage one to look for a *common* physiological source for both types of awareness: for speaking or verbalizing, respiratory movements; and for seeing and visualizing, the electrical activity of the visual association areas of the cortex. An examination of these physiological factors constitutes the 'objective' study of this paper.

II. EARLIER INVESTIGATIONS

(i) *Respiration and imagery*

Pioneer work was undertaken by Golla & Antonovitch (2), who measured the respiratory rhythm whilst subjects were (*a*) unoccupied, (*b*) engaged in certain mental tasks. Two types of respiratory behaviour were noted, and they were found to be significantly associated with two types of imagery established by an independent inquiry into thinking habits. First, a regular respiratory type (regular in rhythm and amplitude), persisting whilst tasks were performed, was found in subjects with predominantly visual imagery. Secondly, an irregular respiratory type was found with subjects having mainly auditory imagery. When a problem which appeared to need purely visual imagery was attempted, the regular type persisted, the irregular type became regular. The tendency to vocalization, plus laryngeal movements, was held to be responsible for the irregularity of breathing. These findings were substantiated by Paterson (6) and by Wittkower (10).

(ii) *Alpha-rhythms and imagery*

Golla, Hutton & Grey Walter (3) established another physiological concomitant of imaging in 1943, viz. the electrical activity of the posterior areas of the brain, recorded by means of the electro-encephalogram (EEG). The best known rhythms from these areas are the alpha-rhythms, with a rhythmic fluctuation in voltage of 8–13 cyc./sec. On the basis of experimental findings, they suggested the following fundamental classification of alpha records, also adopted for analysing records obtained in the present experiment. Records fall into three main groups:

(*a*) *M* (minus) type. Records with alpha-rhythms below 10 μV. maximum in amplitude; the effect of opening and closing the eyes, and the effect of mental activity with eyes closed, being undetectable.

(*b*) *R* (responsive) type. Records with alpha-rhythms within the normal range of amplitude (10–50 μV.) with eyes closed; blocking entirely, or much attenuated with eyes opened; and diminished if mental activity proceeds while the subject's eyes are closed.

(*c*) *P* (persistent) type. Records with alpha-rhythms of normal amplitude, persisting during mental activity relatively unchanged or in 'bursts' and unaffected by the eyes being opened or closed.

The 'mental activity' referred to above was usually a simple sum in mental arithmetic. When 'blocking' of alpha-rhythms occurred, the subject very often reported afterwards

that he had been visualizing the numbers. An example of a record obtained in this way is shown in Fig. 1.

A general inquiry into thinking habits, and the independent performance of seven mental tasks, showed that the *M* types used mainly visual imagery in thinking, the *P* types chiefly auditory-kinaesthetic imagery; and with the *R*'s either type of imagery might predominate. A preliminary and independent survey of respiration showed that the *M* types tended to breathe regularly, the *P* types irregularly.

What follows is an attempt to implement a proposal made in 1943 for 'an intensive study of the relations between various forms of imagery and the electrical activity of the cortex', together with a concurrent examination of breathing. Special efforts were made, first, to base an assessment of imagery type on the performance of mental tasks whilst physiological recordings were made; and secondly, to register concurrently, on the *same* record, alpha-rhythms (where present), and respiratory movements.

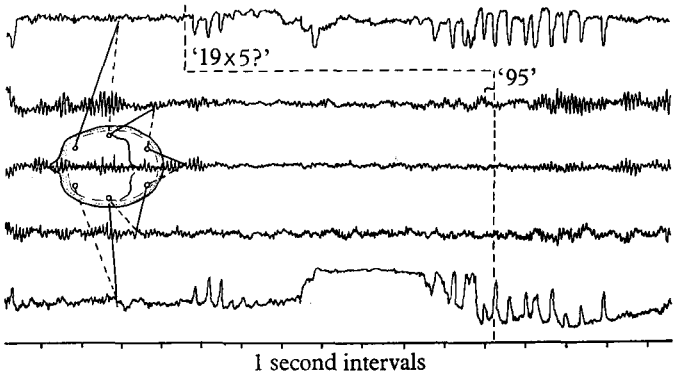

Fig. 1. The EEG of a subject with a *responsive* alpha-rhythm. The record shows a characteristic blocking of the alpha-rhythm when the sum is given. The rhythm returns to its previous amplitude once an answer is found. The diagrammatic head shows the positions of the electrodes: each tracing is of the difference in potential between two electrodes, shown by pairs of lines connecting the electrode positions to the records. Vertical scale: 0·5 in. = about 50 μV.

III. The subjects

There were two groups of subjects. The first consisted of 75 out-patients of the Burden Neurological Institute, age range 8–59 (S.D. = 15·7), of whom 63 were diagnosed as idiopathic epileptics. In the second group were 75 normal subjects, age range 18–37, with an S.D. of 5·5. Sixty-three of these were University students. It was at first intended to use the normal subjects as controls, but as no significant differences were found between the groups either in the verbal reports, or in the EEG alpha and respiration records, it was decided to combine them into a single group of 150 subjects for statistical purposes.

IV. Methods

(i) *Assessment of imagery*

'Objective' tests of the questionnaire type were rejected for the reasons already given. Only one such test, the *cube problem*, was included. Simple task situations were employed to determine the kinds of image most often experienced by subjects. After performance, the subject was asked for as full an account as he could readily give of his thinking and imaging experiences whilst he was performing the tasks. These remarks were written

verbatim on the EEG paper as the subject was speaking. Provided the term 'visual image' was taken as equivalent to phrases like 'picturing to myself', or 'imagining myself seeing', and the term 'verbal-motor image' was regarded as equivalent to phrases like 'talking', or 'saying to myself', then the task of retrospection was no more difficult for patients than for the University students (of whom only two were studying psychology).

The experimenter took care not to influence subjects when observing the behaviour of the tracings. These might well have led him to 'expect' certain answers and to frame his inquiries accordingly. The interview was therefore carefully standardized.

(ii) *Recording respiration*

As *concurrent* recordings were needed, the methods of recording respiration used by Golla & Antonovitch (2) and by Golla *et al.* (3) were not used, as both yielded *separate* respiration records. In the first study, displacement of air caused by the subject's breathing as he sat in an air-tight box was recorded with regular or irregular excursions of an ink tracing on a rectangular plethysmograph. This was of the familiar float pattern, with a capacity of about four litres. In the second experiment, a rubber sac was adjusted to the thorax, recording through a Marey capsule.

In the present study, where regularity and depth are the only features of respiration considered, a thermocouple was used. It converted temperature variations in front of the nostrils into electrical variations, recorded in channel 1 of the EEG amplifier. Electrical activity of the parieto-occipital areas of the cortex was recorded in channel 2. Under these conditions any changes in breathing rhythms could be directly compared with the behaviour of any alpha activity.

It was also essential for the subject not to know the real purpose of the apparatus, so it was fixed to a spectacle frame. A very light, robust apparatus, much less cumbersome than the coffin-like arrangement of the plethysmograph, it afflicted the subject no more than the wearing of any other pair of spectacles without lenses. None of the subjects guessed what it was for. Had they done so, their breathing might have been affected in various unpredictable ways.

To decide whether breathing was irregular or not, each breath had to be measured. The distance from one inspiration (upstroke in the figures) to the next, was measured in centimetres on the record and converted directly into seconds throughout. For this purpose, the paper speed (rate = 1 cm./sec.) was an asset: each breath measured in centimetres and millimetres was plotted directly as a point in the appropriate vertical column in seconds and tenths of a second on a 'Breath Time Chart'.

(iii) *Recording alpha-rhythms*

A preliminary examination on a 6-channel EEG, with automatic analyser, was given to all subjects. This included, for patients, recordings of (1) spontaneous rhythms from all areas of the brain with eyes opened and closed, (2) rhythms during hyperpnoea performed for 3 min., and (3) rhythms with photic stimulation, eyes opened and closed. For normal subjects this procedure was the same except that (2) was omitted.

Patients who showed marked abnormalities in the parieto-occipital regions did not act as subjects. The presence of recognized abnormalities in recordings (2) and (3) had no effect on the experimental investigation of alpha-rhythms. About one-third of the total intake of all out-patients for a period of 4 months acted as subjects. This first examination was valuable also because it familiarized and adjusted most subjects to EEG recordings.

The experiment proper began with the second examination made with a 2-channel portable EEG. The subject sat in a chair. Two scalp electrodes were placed under a cap over the parieto-occipital areas on the right or left side according to the region where the alpha-rhythms were of greater amplitude. In practice, it made little difference from which side potentials were recorded for the presence and blocking of alpha-rhythms. Frequency changes in alpha-rhythms with eyes opened and then closed, occasionally found in *P* types, showed no effect on task performances.

V. Procedure

First, the routine EEG examination was given to all subjects. The investigation of imagery on a portable EEG took place next in a separate sound-proof room. A minute or two was allowed for each subject to settle down once the recording began. The next 5 min. were devoted to the discovery of alpha type and habitual breathing while the subject was at rest. This is known as the 'initial breathing period'. In several cases this period lasted for a quarter of an hour or more when the experimenter was out of the room and no marked changes occurred. At the end of the experiment, a further period of relaxation was given, and respiratory tracings then were very similar to those obtained during the initial period. Sometimes the *rate* of breathing decreased, but this did not affect the overall regularity or irregularity.

Before tasks, subjects closed their eyes. The following standard inquiries were then made, with a minute interval between tasks:

(1) *Sum.* 'Will you multiply 19 times 5?' If the answer was given within 5 sec., a more difficult sum was given.

(2) *Story.* 'Will you think over the story of Noah's Ark?' (or 'Cinderella' if the former were not known).

(3) *The cube problem.* 'Think of a cube ('square brick' for children), which is painted red on the outside, but is plain inside. Cut it in halves; and now cut it in halves again. How many sides of all the pieces will be painted red, and how many will be unpainted?'

(4) *Prayer.* 'Will you think over the Lord's Prayer?'

(5) *Anthem.* 'Will you think over the National Anthem?'

(6) *Argument.* 'Will you think over points for and against the Labour Party, and points for and against the Conservative Party?' Children were requested: 'Think about what you would like to do very much when you grow up, and what you would hate to do.'

On completing each task the subject was asked: 'In what way did you think about that? What was going on in your mind when you were thinking of, for example, the National Anthem?' Replies were written exactly as given on the records, and later carefully classified.

In assessing records, two factors which had nothing to do with imagery but occasionally caused irregular breathing and masked alpha activity, were discounted from the results. The first factor was a spasmodic restless anxiety or fidgeting, recorded on the EEG as muscle action potentials in the form of a fast 'spikey' activity. Of course, the preliminary recording helped to reduce the chances that this reaction would occur, but it appeared for brief intervals with a number of subjects. With five subjects it persisted at length; they were considered unsuitable for experiment and were replaced by others. Secondly, at the

outset of the more difficult tasks, like the 'Argument', a certain tension occurred in some ten of the subjects: respiration records showed that breath was held or inhibited for periods up to 14 sec., and alpha-rhythms were blocked. The respiration effect was shown in similar recordings by Golla & Antonovitch in 1929 (2). They found either shallow and quickened breathing or inhibition in the inspiratory phase. Similar phenomena were described by Golla in his Croonian Lectures (5), showing that they bore a relation to the increased tonus of skeletal muscles, demonstrated by myographic methods during intellectual effort. This was later confirmed by Golla & Antonovitch (4) by observations on the tendon reflexes.

The occurrence of both effects, initial tension and restlessness, is the justification for ignoring the first part of such records in relation to the type of imagery used. What happens is that the individual is summoning all his resources to deal with an emergency situation; there is a mild intellectual crisis. Once the material is mustered, the tension disappears quite quickly. Images then emerge and are utilized.

VI. RESULTS

(i) *Classification of imagery*

Counts were taken of the mention of images, or their colloquial equivalents (as described), in whatever modality they were said to occur. Some subjects claimed to be aware during the task periods mainly of visual images, others mainly of verbal-motor images. The former were classed as 'visualists' and the latter as 'verbalists'.

A more careful examination of reports revealed two main categories. These were named 'sensory' and 'kinetic'. In the sensory group visual imagery occurred much more often than any other imagery type. Auditory images were also included, where subjects reported the 'hearing' of sounds, not, however, self-produced, but originating in some way 'outside' themselves. With music, the subject imagined hearing music as played by an orchestra or as sung by a choir, but did not imagine himself to be either singing or humming.

A small and very interesting subgroup were aware of 'self-produced' verbal images, but were at pains to describe that they were non-kinetic, or non-motor. None of these were psychologists. Four of them claimed to be using their *own* voices, but in a *non-articulate* fashion. One described his imaging as: 'verbalizing but not voicing', and another as 'speaking in a non-motor fashion'. Three out of the five normal subjects with this type of imagery had 'abnormal' findings in the first EEG examination. In all cases these were 'wave-and-spike' discharges evoked by photic stimulation at 18 to 25 flashes per second. This finding is puzzling, because patients showing a similar abnormality in their records did not use this persistent verbal-sensory imagery; nor were there any other similarities between these 'normal' subjects and such patients. Three other normal subjects had 'abnormal' EEG's, but with no peculiarities in imagery.

In the kinetic group, motor images of words occurred; the individual imagined himself to be uttering words or perhaps singing or humming them. Sometimes this became quite overt, especially with children. Subjects might or might not be aware of laryngeal or mouth or lip movements.

Many subjects experienced both sensory and kinetic images during tasks, usually with a predominance of one type. At times the type of imagery varied according to the nature of the task.

(ii) *Respiration types and imagery types*

Extracts from the breath time charts for three individuals are shown in Fig. 2. Breaths recorded when subjects were resting, and when they were occupied with tasks are distinguished on the charts. For the sake of clarity breaths recorded *after* tasks were completed are omitted; they were much the same as those recorded during the initial breathing period.

Regularity and irregularity of breathing for each subject was determined by the measurement of what is known as the 'breathing span'. This is the difference, in seconds, between the longest and the shortest breath times. Spans were measured for the initial resting period, for all tasks, and for a period when tasks were completed. For example, in Fig. 2, with subject 1 when resting, the difference or span between the shortest breath (2·3 sec.) and the longest (6·6 sec.), is 4·3 sec. He is an irregular breather. So also is subject 2 (span, 3·9 sec.). But with subject 3 the span is only 0·5 sec., and he is a regular breather. It can also be seen from Fig. 2 that the shorter the span when resting, the greater is the regularity when doing tasks and vice versa. This is the general rule.

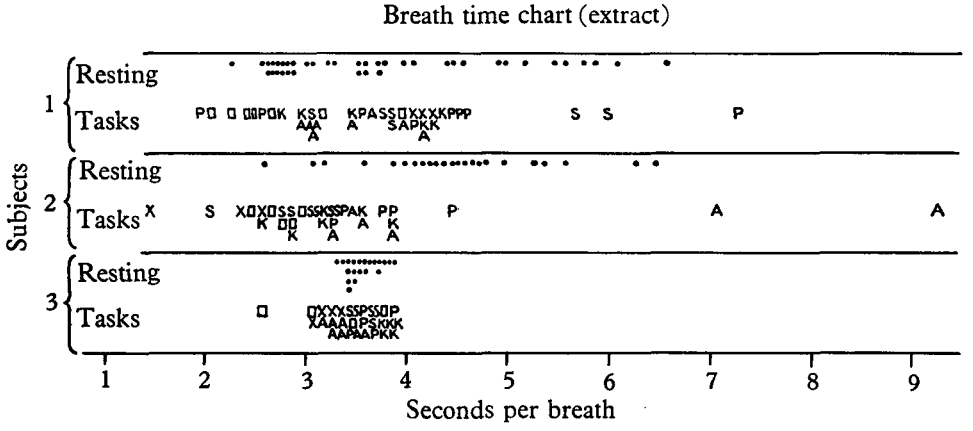

Fig. 2. Breathing records of three subjects (see text). Subject (1), irregular whilst resting and during tasks; subject (2), irregular whilst resting and during tasks; subject (3), regular whilst resting and during tasks. Breaths recorded during resting are shown: •, in the upper half of each chart; breaths during tasks, in the lower half. Breaths during the *sum* task are shown X; *story* task, S; *cube* problem, □; *prayer* task, P; *anthem* task, K; and *argument* task, A.

Occasionally, with longer initial resting spans (i.e. more than 1·0 sec. and less than 3·0 sec.) considerable variations in span occurred for different tasks. A subject would breathe very regularly (with a very short span) during, say, the cube problem, but show very irregular respiration (with a very long span) during, for example, the 'Anthem' task. In such a case the span of the initial habitual breathing period tended to be midway between the very short span and the very long one. But, usually, from a measurement of the initial breathing spans, it is easy to predict the kind of span to be expected, in accordance with the general rule given. Indeed, in many cases, measurement is hardly necessary, and a reliable prediction can be made by merely glancing at the continuous recordings of the respiration curves in the early parts of the EEG records themselves.

Of the subjects examined, 76 or 50·7 % were regular breathers, and 74 or 49·3 % were irregular. These figures correspond quite closely to those given by Golla (2), 54·5 % regular and 45·5 % irregular; and by Paterson (6), 49·2 % regular and 50·8 % irregular.

Of the 80 visualists, 66 or 82·5% were habitually regular breathers; only 14 of the visualists, or 17·5%, breathed irregularly. On the other hand, of the 70 verbalists, 60 or about 86% breathed irregularly all the time; and only 10 verbalists, or about 14%, were irregular breathers. These results are displayed in Fig. 3, which shows at a glance the general correlation between subjective assessments and breathing spans during resting.

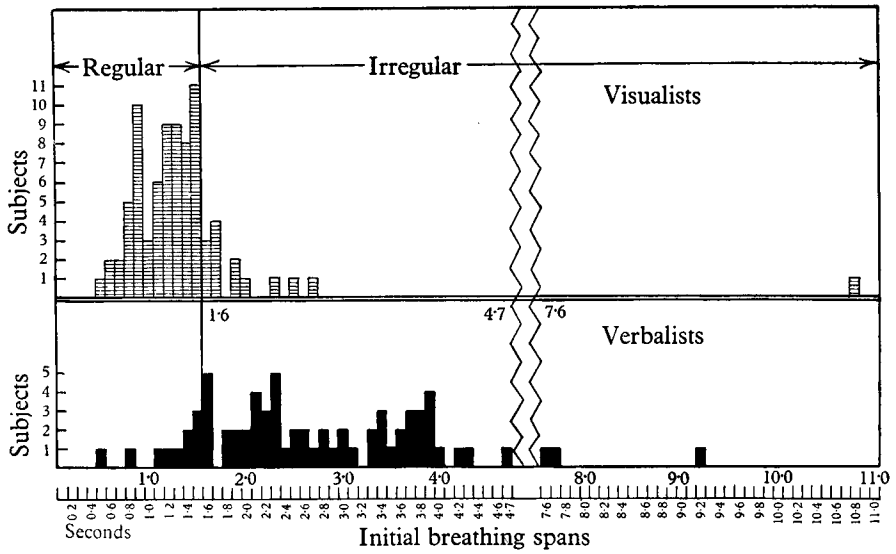

Fig. 3. Regularity and irregularity of breathing for all subjects during resting period. Horizontal base-line shows the breathing spans (see text) from 0·5 to 10·8 sec., in steps of 0·1 sec. Numbers of subjects for each span are plotted vertically.

During task-periods, the habitual regularity or irregularity of both groups tended to increase. Primary visual or verbal-motor imagery respectively, was reported. This supports the findings of Fox(1), that images occur in thinking chiefly when a difficulty or problem arises. However, provided that the subject is not actually asleep, he will presumably be thinking about something, enough at any rate to characterize his respiratory type.

The figures given above of associations between breathing when resting and the imagery type, were submitted to the χ^2 test, although this was barely necessary in view of the obvious weighting in the proportions given. $\chi^2 = 68{\cdot}76$; the probability that the associations named were due to chance was less than 0·001 against. Similarly, reliable statistical results were obtained with all tasks. They are given in Table 1.

It will be noticed in this table, and in Table 2, that tasks 2 and 6, the *story* and *argument*, are combined in association (2), and tasks 4 and 5, the *prayer* and *anthem*, in association (3). Tasks 2 and 6 appeared to involve one type of thinking, namely, 'problem' thinking, but tasks 4 and 5 entailed, for most subjects, merely rote recall. In a sense, the contrast between the two types of thinking resembles the differences in subject's reactions to the material used by Fox(1), i.e. propositions entertained with greater or lesser difficulty, and those propositions to which 'ready assent' was given.

Even where the *prayer* or *anthem* were not remembered with ease, the difficulty experienced in recall was not the same as the difficulty involved in thinking out a

Table 1. *Associations between imagery and respiration for tasks*

Tasks	Imagery types	Imagery	Respiration: Regular	Respiration: Irregular	Total	χ^2	P
(1) Sum	Visualists	Sensory	52 (51 visual)	2	78	40·62	<0·001
		Kinetic	7	17			
	Verbalists	Sensory	30 (27 visual)	4	71	36·84	<0·001
		Kinetic	6	31			
(2) Story and argument	Visualists	Sensory	112 (98 visual)	5	156	75·70	<0·001
		Kinetic	12	27			
	Verbalists	Sensory	33 (26 visual)	10	134	48·27	<0·001
		Kinetic	14	77			
(3) Prayer and anthem	Visualists	Sensory	87 (61 visual)	1	156	91·35	<0·001
		Kinetic	18	50			
	Verbalists	Sensory	27 (8 visual)	2	143	61·89	<0·001
		Kinetic	19	95			
(4) Cube problem	Visualists	Sensory	72 (all visual)	5			
		Kinetic	0	3	82	—	—
		No imagery	1	1			
	Verbalists	Sensory	44 (all visual)	6			
		Kinetic	0	13	68	—	—
		No imagery	3	2			

comparatively novel situation. In the first case, inhibition of recall tended to occur first as a kind of mental blankness. For example, the subject doing the *prayer* task, in Fig. 6, said: 'I didn't get beyond the first sentence. I was puzzled after that, and didn't "say" any more.'

On the other hand, apart from an initial tension occurring in a few cases, any difficulty experienced in the *story* or *argument* tasks favoured as a rule the emergence of images belonging to the subject's habitual mode of imagery. Yet difficulties of the kind mentioned in tasks 4 and 5 were encountered more by verbalists than by visualists; failure in recall was less frequent with those who could envisage scenes than with those who relied solely on verbal-motor images. Hence, these tasks also afforded certain clues to the habitual imagery mode.

During the *story* task, owing to the shorter period occupied in thinking, a shorter span of 1·1 sec. marked the transition between regular and irregular breathing instead of the 1·6 span in the initial resting period (Fig. 3).

(iii) *Alpha types and Imagery types*

Typical records are shown in Figs. 4–6. It was found that the great majority both of visualists (56) and of verbalists (44) had records of the '*R*' type (Fig. 4), responsive by suppression of the alpha-rhythms. There remained only 18 visualists and only 3 verbalists who were *M* type (Fig. 5) with no alpha-rhythms; and 24 verbalists with only 7 visualists who were *P* type (Fig. 6) with alpha-rhythms persistent. Imagery with these last two groups tended to be of an extreme nature; exclusively visual with the *M*'s and almost constantly verbal-motor with the *P*'s. The *R* group was the largest, and was intermediate

between the other two, showing mixed imagery, but with a definite predominance of visual or verbal-motor images in individual subjects. The fact that the two distributions of alpha type and imagery type significantly overlap each other is shown by the χ^2 test. $\chi^2 = 20{\cdot}25$, $P = < 0{\cdot}001$.

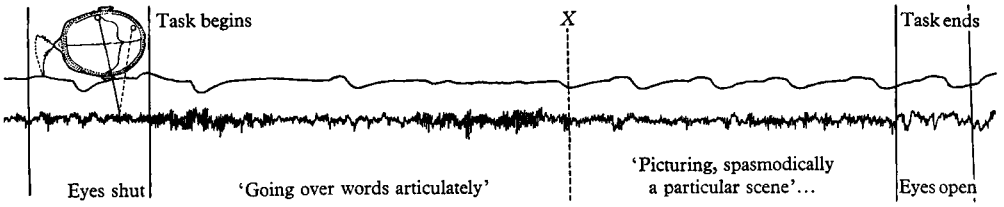

Fig. 4. Alpha type: *R*, a 'verbalist'. During 'initial period' respiration irregular (span, 3·5 sec.). *Argument* task period illustrated. Respiration irregular up to '*X*', then becomes more regular (span, 0·6 sec.). Note corresponding behaviour of alpha-rhythms.

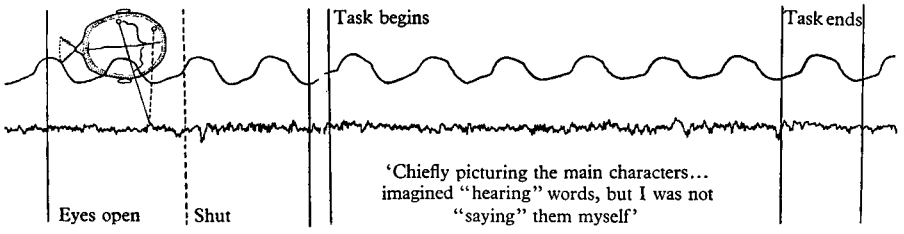

Fig. 5. Alpha type: *M*, a 'visualist'. Respiration very regular during the 'initial period' (span, 0·5 sec.), and throughout all tasks. The *story* task period is illustrated, and respiration remains completely regular (span, 0·2 sec.).

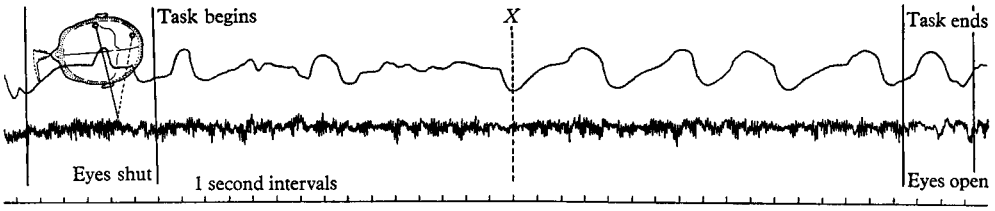

Fig. 6. Alpha type: *P*, a 'verbalist'. Respiration very irregular during the 'initial period' (span, 4·3 sec.). *Prayer* task period illustrated. *Note.* Respiration irregular up to '*X*' (span, 4·4 sec.), then becomes more regular (span, 1·0 sec.). Alpha-rhythms persist throughout. Subject evidently verbalizing up to '*X*', but not afterwards. No visual imagery. Report at end of task was: 'I didn't get beyond the first sentence, (claimed to be articulated). I was puzzled after that, and didn't "say" any more.'

A cross-correlation between alpha types and respiratory types in Table 2 shows 12 *M*'s with regular respiration, 7 with irregular; 23 *P* types show regular respiration, and 8 irregular. This result is just significant ($P = 0{\cdot}01$). This association becomes much more significant statistically when the testing situation is substituted for the resting period. The chances are about equal (56:44), that a subject in the *R* category will be an irregular or regular breather. What this involves during tasks is clear in the following figures. Of the 56 habitually regular breathers, 50 were visualists with regular respiration during tasks; 6 were verbalists with either regular or irregular breathing during tasks. Of the 44 habitually irregular breathers, 37 were verbalists with mainly irregular breathing during tasks, and 7 were visualists with both regular and irregular respiration during tasks.

Task periods were examined in detail to see how often the alpha-rhythms blocked when the subject was visualizing, and how often they persisted when he was verbalizing. The result was quite conclusive. Out of 833 instances of imagery reports and corresponding alpha activity, 517 or 62·8% were alpha responses (or blockings of alpha-rhythms), with visual imagery, and only 67 or 8% with verbal-motor imagery; 200 or 23·3% were alpha persistences with verbal-motor imagery, and only 49 or 5·9% with visual imagery. Detailed statistical analysis of each task, given in Table 2, simply confirmed the results of the main overall analysis.

Table 2. *Association between alpha types and respiratory types*

	Alpha types		
	M	*R*	*P*
Respiratory types			
Regular	12	56	8
Irregular	7	44	23

Total = 150; $\chi^2 = 9{\cdot}988$; $P = 0{\cdot}01$.

Table 3. *Associations between imagery and alpha-rhythms for tasks*

Tasks	Imagery types	Imagery	Alpha-rhythms: Responses	Alpha-rhythms: Persistences	Total	χ^2	*P*
(1) Sum	Visualists	Visual	39	7	62	10·04	0·01
		Non-visual	7	9			
	Verbalists	Visual	35	2	64	27·27	<0·001
		Non-visual	9	18			
(2) Story and argument	Visualists	Visual	84	7	114	39·01	<0·001
		Non-visual	8	15			
	Verbalists	Visual	50	9	124	51·88	<0·001
		Non-visual	13	52			
(3) Prayer and anthem	Visualists	Visual	68	5	130	56·71	<0·001
		Non-visual	17	40			
	Verbalists	Visual	36	6	130	52·07	<0·001
		Non-visual	17	71			
(4) Cube problem	Visualists	Visual	59	2	64	—	—
		Non-visual	0	1			
		No imagery	0	2			
	Verbalists	Visual	55	3	66	—	—
		Non-visual	2	1			
		No imagery	2	3			

VII. Discussion

This inquiry showed that subjects fall into two main categories of imagery, visual and verbal-motor. The extreme alpha types correlate with extreme types of imagery, and the *R* type with moderate or mixed imagery, yet with a clearly recognizable predominance of visual or verbal-motor images during tasks. The visualists tend always to breathe regularly, and the alpha-rhythms, where present, block whenever they are busy with mental tasks; visual images come more readily to them than verbal-motor ones. The verbalists tend always to breathe irregularly, and their alpha-rhythms tend to persist whether they are thinking out problems or not. This presentation of results is primarily a statistical survey, and its aim is to indicate the presence of significant trends of behaviour, psychological and physiological.

Considering psycho-physiological correspondences in more detail, the association during tasks between alpha responsiveness and respiratory movements, whilst clearly significant in the *generality* of correlative changes, demands a more elaborate study of fewer subjects with tasks recorded at greater length. Four main obstructions limited the study of this association in this experiment.

First, a score of 'alpha responsiveness' in the results included many rapid and subtle variations which could not be scored at the same time as the accompanying respiratory changes. Very short 'bursts' of alpha activity occurred quite often, lasting for 1 or 2 sec., and correlative breathing changes were not registered owing to the *rate* at which respiration was recorded.

Secondly, with persistent alpha activity, concurrent respiratory movements might be regular *or* irregular, according as imagery was sensory or kinetic, even where it was non-visual. The relation of non-visual sensory imagery to thinking needs more thorough study of the few subjects showing this unusual mode of imagery. The abnormal EEG records in a few cases have already been noted.

Thirdly, the complexity of the *M* group is shown in the analysis of all tasks for the twenty *M* types. Eighty-five instances show regular respiration, thirty-five show irregular respiration. With *M* types regular respiration would *always* be expected, but the question as to whether alpha-rhythms should emerge when mixed imagery is reported, needs further study. A test might be devised giving a prolonged and powerful auditory stimulus to an *M* type, completely occupying his attention, to see whether or not alpha-rhythms emerge under such conditions. At present, with a true *M* type, it appears that with verbalization alpha-rhythms *never* emerge, whatever imagery is spontaneously reported, and despite changes in respiratory rhythm.

Fourthly, even where there were correlative changes in respiration and alpha responses, retrospective references to time, by untrained subjects, were usually too unreliable to make it certain that verbalizing, for example, occurred at a very specific determinable point during tasks. Certain quite detailed correlative changes *did* occur which could be linked up roughly with imagery reports; examples are shown in Figs. 4–6. This was sufficient for statistical purposes. Some self-operated signal is needed (e.g. pressing a lever), in studies made at length with trained subjects indicating introspective changes that occur during the *tasks themselves*, and not retrospectively. The problem is how to use current signals so as not to interfere excessively with the pattern of thinking.

In the experiment, no special study was made of intelligence nor of the subject's *ability* to deal with individual tasks. It is arguable that intellectual skill resides only in the manipulation of images, however restricted we may be in the type of images at our disposal. The more an individual can adapt his image-models to suit his problem, the greater may be his efficiency in dealing with a variety of mental tasks. But if we can utilize visual or verbal-motor images with about the same ease, then clearly we are better fitted to deal with more problems, whether they demand mainly visual or verbal aids.

Of all the alpha types, persons belonging to the *R* group are the most favoured in so far as they can readily adapt their models for different types of mental problems. While not obsessed with private pictures, they can evoke satisfactory visual patterns when necessary and can combine data from the various sense organs more readily than can either the *M* or *P* types. In the cube problem, most moderate verbalists (chiefly *R* types),

were able to picture the cube because this was the easiest way of solving the problem. Sixteen subjects, mostly *P* types, found considerable difficulty in visualizing the cube and tried to rely exclusively on counting or calculating. Paterson (6) found that he had a similar proportion of habitual irregular breathers amongst his subjects. His argument fits well into the present context: 'the fact that 13 subjects (out of 144), used irregular rhythm throughout, seems to indicate that they were persons who had difficulty in using visual imagery exclusively at any one time, even where the problem seemed to require the visual type of thinking.'

The subject, a *P* type, whose record is given in Fig. 6, had his alpha type been different, might have recollected the words of the remainder of the prayer by visual means, instead of trying to recall them by purely verbal methods. But visual imagery was absent from his reports, and presumably from his mental life as a whole. Similarly, the *argument* demands some use of words. The report of a subject of the *M* type, an extreme visualist, who never verbalized, shows just how bizarre exclusive visualizing can be with this type of problem:

A map of England with the centre at London, with black lines radiating symbolizing nationalization. The Conservatives are represented by spots without connecting lines, with the words 'free enterprise' written. I was neither hearing nor saying anything.

Such evidence, together with the further analysis made of the varying successes and failures with simple mental arithmetic problems achieved by different imagery types, suggests that imagery differences with their special physiological characteristics may be of fundamental importance in the basic structure of personality. The argument is strengthened by the fact that statistical and experimental findings indicate that the alpha types, chiefly the *M*'s and *P*'s, as well as the alpha frequencies, are inborn and probably inherited. It is very likely, therefore, that a detailed study of the relation of imagery types to personality differences would be rewarding.

VIII. Summary

1. A preliminary review indicated:
   (*a*) That as yet the best method of discovering the subject's habitual modes of imaging is to give him mental tasks and to classify his reports directly after the performance.
   (*b*) That perceiving and imaging belong to a psychological and physiological continuum; i.e. that seeing and visual imagery, and speech and verbal-motor imagery are not different in kind, and similar mechanisms may account for seeing and visualizing, and for speaking and 'verbalizing', respectively.
2. Hence, a study was made of:
   (*a*) The electrical activity of the visual association areas of the cortex, recorded by means of the EEG.
   (*b*) Respiratory movements, recorded by means of the thermocouple. The two factors were examined concurrently. The results were related to the reports of imagery.
3. It was found:
   (*a*) That of the two main imagery-types, visualists breathed regularly and showed frequent blocking of alpha-rhythms, both of these physiological characteristics being associated with actual visualizing. Verbalists, on the other hand, breathed

irregularly, with alpha persistences, both characteristics being associated with verbal-motor imagery. As a rule, when verbalists attempted a problem requiring predominantly visual images, then physiological changes occurred characteristic of visualists.

(*b*) That amongst the alpha types, the *M*'s used mainly visual images in thinking, the *P*'s chiefly verbal-motor images; with the *R*'s there was mixed imagery, usually with a predominance of visual or verbal-motor images.

(*c*) That verbal-sensory imagery is unusual if not abnormal. It was reported habitually by a small minority of subjects only.

4. The discussion indicates the complexities involved in this type of psycho-physiological recording, and the need for further refinements in technique. It also suggests that imagery studies are important for the examination of personality differences.

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