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TYPES OF IMAGERY AND IMAGERY TYPES: AN EEG STUDY

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The occipital EEG of subjects differing in reported vividness of mental imagery was monitored during a series of mental imagery tasks. (i) Vivid imagers (selected on the basis of the Betts Vividness of Imagery Scale) had a higher mean dominant alpha frequency (m.d.f.) than weak imagers ($P < 0{\cdot}025$), but there were no individual differences for alpha abundance. The difference for m.d.f. held for only one task – an eyes-open, minimal imaging condition. (ii) Greater alpha suppression followed presentation of High Imagery (High I) words than followed presentation of Low Imagery (Low I) words ($P < 0{\cdot}005$). (iii) High I words elicited more imagery than Low I words, for both vivid and weak imagers ($P < 0{\cdot}005$). (iv) Reported elicited imagery was greater for the vivid imagers ($P < 0{\cdot}005$). (v) For two voluntary imaging tasks, alpha suppression was greater in that task reported by the subjects as being harder to visualize ($P < 0{\cdot}01$), thus reversing the findings for (ii) above. (vi) Subjects completed the Eysenck Personality Inventory. None of the above findings could be attributed to individual differences in either extraversion or neuroticism. It is concluded that the act of imaging *per se* does influence the EEG and that alpha suppression is not merely a by-product of the arousing nature of imaging tasks. However, difficulty in the act of imaging also influences the EEG. The equivocal results of earlier research may therefore be accounted for in terms of the differential effects of instruction to image, upon the EEG, as demonstrated in the present study.

Golla *et al.* (1943) claimed that individuals employing visual imagery for problem-solving had a characteristically lower amplitude occipital EEG than subjects who employ verbal methods. Many attempts have since been made to establish a necessary connexion between the presence or absence of mental imagery and some property of alpha activity. However, subsequent work has failed to replicate their findings and the arguments underlying the expected relationship have been questioned. The literature has been reviewed by Richardson (1969).

The main methodological difficulties concern the measurement of the appropriate imagery and alpha characteristics. For example, imagery has sometimes been measured by asking subjects to report on the way in which they attempt to solve a set of mental tasks, and sometimes by noting scores obtained on tests of spatial ability. Neither procedure is entirely satisfactory. The first leads to a rather crude classification of subjects into those who are judged to be predominantly visual in their mode of thought or predominantly verbal, or a mixture of the two. The second makes the unwarranted assumption that performance on some types of spatial task will necessarily require the employment of visual images for its solution. In the measurement of alpha activity, properties like amplitude, abundance, percentage and dominant frequency have all been examined with varying degrees of technical sophistication.

The main conceptual difficulties concern the justification of any argument that asserts a connexion between visual imaging and alpha activity. Because alpha activity tends to be suppressed when anyone is actively engaged in visual contact

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with a changing environment, the manipulation of mental equivalents (i.e. visual images) when the eyes are closed is believed to have a similar effect. It is known, however, that *any* form of heightened intellectual effort may produce alpha suppression. Oswald (1957) suggests that alpha suppression in imaging tasks may be entirely due to the increase in cortical arousal produced by an increase in effort rather than in the use of visual imagery *per se*. This alternative account of the relation that has sometimes been found between imagery and lowered alpha activity may well apply when a subject is trying to solve a 'difficult' spatial task with his eyes closed. But whether it provides a satisfactory explanation of alpha suppression when 'easy' visual tasks are employed is more doubtful. For example, in a study by Kamiya & Zeitlin (1963) alpha suppression was produced voluntarily by a subject when it had been learned that the controlling stimulus was his own imagery. Though alpha suppression occurred at the onset of visual imaging, no concomitant changes were found for *other* physiological indices of arousal, i.e. heart rate, respiration pattern, eye movements or muscle tension. However, it is clear that ease of difficulty of the imaging task may have been a confounding variable in the earlier studies.

There is now substantial support for the view that imagery is an important experimental variable in learning tasks (Paivio, 1969; Morris & Reid, 1971). Moreover, individual differences in imaging have been related to individual differences in performance (Ernest & Paivio, 1971*a*). Thus in spite of the fact that the work of Golla *et al.* on visual imagery has been subject to criticism, there does appear to be some ground for believing that *imaging ability as such* (whether visual or in other modalities) is a basis for the classification of subjects (Ernest & Paivio, 1971*b*).

The present study is concerned with individual differences in imaging ability and with the effects of differential instructions to image upon the EEG. The aims of the study are: (i) to examine the resting EEG of individuals classified as 'vivid', 'intermediate', or 'weak' imagers, (ii) to measure the effects of passive, spontaneous, voluntary or non-imaging conditions upon the EEG, and (iii) to examine a possible interaction between individual differences and type of instruction. Finally, because other personality variables (e.g. extraversion and neuroticism) have been shown to influence the EEG (Gale *et al.*, 1969), to take account of such variables in the analysis. Two measures of the EEG are taken, namely, alpha abundance and mean dominant alpha frequency.

Method

Subjects

An abbreviated version of the Betts QMI Vividness of Imagery Scale (Sheehan, 1967) was group-administered to 71 undergraduate students at the University of Exeter. Only the first 15 items were used, i.e. the scales relating to visual, auditory and kinaesthetic imagery. The product-moment correlations of these subtests with the total score were 0·76, 0·78 and 0·79 respectively. Thirty subjects were selected for the criterion groups shown in Table 1.

Mean age for the experimental group was 20·5 years with a range of 19–32 years. These subjects later completed the Eysenck Personality Inventory (Eysenck & Eysenck, 1964).

The EEG

Silver/silver chloride, loose pad electrodes were placed transoccipitally for bipolar recording (Cooper *et al.*, 1969). Interelectrode resistance was always below 10 kΩ. The neutral electrode was placed on the left wrist. The EEG was recorded on a San'ei Polygraph, calibrated at 30 mm

Table 1

Sex	Vivid imagers Mean	Range	n	Intermediate imagers Mean	Range	n	Weak imagers Mean	Range	n
Male	29·6	27–32	5	41·4	37–46	5	54·3	51–62	6
Female	26·6	19–32	5	40·8	38–44	5	55·3	52–58	4
Overall	28·1	19–32	10	41·1	37–46	10	54·8	51–62	10

peak-to-trough for 100 μV, with a time constant of 0·3 sec. The EEG was integrated over 5 sec. epochs by a San'ei Low Frequency Analyser over five pure band-pass filters, covering the range 8·5–13·5 Hz in single frequency steps. The output voltage of the analyser was converted to digital form and stored on paper punch tape by a Lion Systems Development A-D Converter. The digital values were subsequently converted to decimal form by a computer. The EEG was recorded throughout Tasks 1–4 (see below).

Physical arrangements

The subject sat in an adjustable chair, in a soundproof booth, facing a frosted glass back-projection screen (6 in. high by 16 in. wide). The room was moderately illuminated. The experimenter could observe the subject through a peep-hole. Tape-recorded instructions were administered through a loudspeaker.

Procedure

There were six tasks, performed in the following order. (1) Eyes-open (minimal imagery) and eyes shut (spontaneous imagery) (Gale *et al.*, 1969). (2) Imaging to words of high and low imagery (passive elicited imagery) (Paivio *et al.*, 1968). (3) Imaging while receiving instructions for a voluntary imaging task (voluntary elicited imagery). (4) Imaging in accordance with instructions (voluntary autonomous imagery) (Drewes, 1958). (5) Ratings of imagery elicited in Task 2. (6) Assessment of ease of imaging in Task 4.

Instructions for Tasks 1–4 were pre-recorded on magnetic tape and played back to the subject.

Task 1

The resting EEG of 'vivid', 'intermediate' and 'weak' imagers under conditions of minimal and spontaneous imagery. The subject was instructed to relax and open or shut his eyes upon request. One eye closed trial (EC) was followed by one eyes open trial (EO), both of 1 min. duration.

Instructions. 'The instructions for the task will be given in 15 sec. from now. Here are the instructions. These instructions are being given over a tape recorder to ensure that they are identical for all subjects. Please shut your eyes and relax. We have a number of tasks for you to do. In the first task all you have to do is to open or shut your eyes when we ask. Just relax. Try not to think of anything. Do not mark the passage of time. Keep your mind as clear as possible. Our apparatus is very noisy. Please try to pay no attention to it. Do not count the beat of the metronome [a reference to the tape-punch]. Open your eyes please. When we ask you to open your eyes during the task, could you please look at the rectangular screen of light in front of you [a reference to the frosted screen]. Again, relax, try not to think of anything, keeping your mind as clear as possible. We will tell you when to open or when to shut your eyes. So please keep them open or shut as instructed. We are now ready to begin. Shut your eyes please [EC trial]. Open your eyes please [EO trial].'

Task 2

The EEG during passive elicited imagery. Twenty words (containing 6, 7 or 8 letters only) were selected from the Paivio *et al.* (1968) list. Morris & Reid (1972) have shown the list to be applicable to British students. The High Imagery (High I) words were: acrobat, boulder, corner, factory, forehead, officer, square, string, tripod and village. The Low Imagery (Low I) words were: amount, answer, attitude, belief, chance, interest, method, position, quality and thought. Mean I for the High I is 6·30 (range 6·13–6·53) and for the Low I, 2·81 (2·50–3·13). Both sets of words were equated for meaningfulness (m). Thus mean m for High I and Low I is 5·63 and 5·62, with ranges of 5·08–6·04 and 5·20–6·24. The words were prepared in capital type, photographed, and projected singly on to the rear of the frosted screen. The subjects were allocated at random to five groups and each group was presented with a different random order of words.

Instructions. 'Thank you. Please shut your eyes and relax. Here is the second task. Please open your eyes. You will now be shown slides on the screen in front of you. A sample slide is now on the screen. Each slide will contain one word. Some people find that the words we show you arouse mental pictures, while others find they don't. For any person, the words we will show you differ in their capacity to arouse mental imagery. Some words arouse a sensory experience such as a mental picture or a sound, quickly or easily; whereas other words do so only after a long delay or even not at all. When the slide comes on the screen, please read the word carefully. As soon as the slide goes off the screen, close your eyes, relax, and see if the words suggests mental pictures, sounds or any other sensory experience to you. Do not worry if nothing comes to your mind. Relax and wait for the next slide. When we are ready we will ask you to open your eyes again. Remember, do not make any effort to force the images into your mind; just relax and let them occur naturally. But it is important that you should not think of anything else. Try to let the images related to that word come into your mind. If they do not come, do not worry, but do not think of anything else. Look at the word while it's on the screen and shut your eyes as soon as it goes off the screen. We will tell you when to open your eyes again. Please do not open your eyes until we ask you to.'

Schedule. Each slide was presented for 5 sec. The subject then shut his eyes. An experimenter observed the subject during the first trial to ensure that instructions to close eyes were being obeyed. After an interval of 25 sec. the subject was instructed to open his eyes and the next slide was presented. Slide presentation and instruction to open eyes were synchronized with the epoch time of the EEG analyser. The sequence of slide presentation, slide removal, eye closure, instruction to open eyes and presentation of next slide was continued until all 20 slides had been presented.

Tasks 3–4

The EEG during voluntary elicited imagery and during autonomous voluntary imaging. Two passages were used: Passage 1 (Table-top) is a modified version of a passage used by Drewes (1958); Passage 2 (Seaside) was especially devised for this experiment. The order of presentation of the passages was reversed for the final fifteen subjects, to control for possible order effects. For each passage, there was an instruction period of 2 min. 50 sec. (Task 3), followed by a voluntary imaging period of 2 min. (Task 4).

Instructions. 'Thank you. That is the end of that task. Please keep your eyes closed and relax. Form a mental picture of a large table and imagine yourself looking down on the top of the table. The table top is painted white. In the top right-hand corner of the table is a small black triangle. In the top left-hand corner is a small black circle. Get a clear mental picture of the triangle and the circle in position on the table. Keep your eyes closed. For the next two minutes I want you to move the triangle and circle about in your mind. They can move together or independently. Make them move up and down, left and right, or diagonally. Please start doing that now, keeping your mind on the problem.' (End of passage 1, 'table-top'.)

'And now we come to the final task. Please keep your eyes closed and relax. Imagine that you are walking along the sea front, down the promenade. You see a car drive up. A family get out of the car; a father, a mother, and two small children. The children have buckets and spades. They walk along the front, down some steps, and on to the beach. The parents get deck chairs. The children play on the sands. Get a clear mental picture of the family on the beach. For the next two minutes please imagine the family on the beach and the sorts of things they would do. Please keep your mind on the family until I ask you to relax.' (End of passage 2, 'seaside'.)

'Thank you very much. That is the end of all the tasks we have for you in here. Please relax until we come and let you out of the cubicle. Thank you.'

Task 5

Ratings of imagery elicited in Task 2. Subjects rated each word used in Task 2, on a seven-point Low Imagery–High Imagery scale, according to the degree of imagery experienced during exposure of the word. The following instructions were printed above the scales.

Instructions. 'Here are the words that you were shown earlier. We would like you to rate them on the ease with which they aroused mental images for you during the experiment. A word which aroused a mental image (i.e. a mental picture, sound or other sensory experience) very quickly and easily should be given a *High Imagery* rating; any word which aroused a mental image only with difficulty or not at all should be given a *Low Imagery* rating. Your rating will be made on the seven-point scales next to each word. Make your judgement by putting a circle round the number that best indicates the ease with which the word aroused imagery *for you*. Feel free to use the entire range of numbers. However, don't be concerned about how often you use a particular number *as long as it is your true judgement.*'

Task 6

Comparison of ease of imaging for passages 1 *and* 2 *of Task* 4. Subjects were asked which of the two passages was easier to visualize.

Results

Two measures were used, EEG abundance and Mean Dominant Frequency (m.d.f.). Abundance was calculated by summing and averaging the analyser integrated outputs. M.d.f. was calculated by dividing the sum of products of central filter values and their integrated outputs by the sum of integrated outputs (Gale *et al.*, 1969). Log transformations were performed on all abundance data to reduce skewedness.

Task 1. For each subject, abundance and m.d.f. were calculated for the first 30 sec. of the EC and EO trials.

There were no significant differences for abundance in EC or EO, nor for m.d.f. in EC. The m.d.f. for EO gave $F = 4{\cdot}89$; d.f. $= 2, 27$; $P < 0{\cdot}025$. The mean m.d.f. for the three groups were: Vivid imagers 11·032 Hz, Medium imagers 11·023, and Weak imagers 10·966. The Tukey test showed means for the Vivid and Weak groups to be significantly different ($P < 0{\cdot}05$).

Task 2. For each subject, abundance and m.d.f. were calculated for (i) the 5 sec. of slide exposure and (ii) the 10 sec. following exposure.

Calculations for (i) yielded no significant effects. For (ii), two-way analyses of variance revealed a significant difference between slides but not between criterion groups. Mean abundance for high I slides was 12·48 and for low I slides was 13·28 ($F = 13{\cdot}49$; d.f. 1·27; $P < 0{\cdot}005$). M.d.f. effects were not significant.

Task 3. For each subject, abundance and m.d.f. were calculated for the first 30 sec. of the instructions (following the words 'please close your eyes and relax').

The means indicated that no further analysis for criterion groups was justified. There was a significant difference in abundance between the passages. The mean for Passage 1 was 39·02 and for Passage 2 was 41·91 (related $t = 2{\cdot}47$; d.f. $= 29$; $P < 0{\cdot}01$; two-tailed test). There were no differences for m.d.f.

Task 4. For each subject, abundance and m.d.f. were calculated for the first 30 sec. following the end of the instructions. For abundance, a two-way analysis of variance yielded only a main effect for the Passages ($F = 9{\cdot}89$; d.f. $= 1, 27$; $P < 0{\cdot}005$). The means were: Passage 1, 39·68; Passage 2, 44·52; Vivid imagers (1, 35·74; 2, 42·62), Medium imagers (1, 46·76; 2, 50·82), Weak imagers (1, 36·56; 2, 40·12).

Task 5. Mean ratings per word per criterion group were calculated. A two-way analysis of variance yielded significant main effects for words ($F = 173{\cdot}20$; d.f. = 1,18; $P < 0{\cdot}005$) and groups ($F = 27{\cdot}73$; d.f. = 2,36; $P < 0{\cdot}005$) and a significant interaction of words and groups ($F = 6{\cdot}62$; d.f. = 2,36; $P < 0{\cdot}005$). The mean values were: vivid imagers, high I 6·21, low I 3·42; medium imagers, 5·54, 3·40; and weak imagers, 5·44, 2·81. The interaction can be accounted for as follows:

(*a*) For high I words, vivid imagers have significantly higher ratings ($P < 0{\cdot}01$) than medium and weak imagers, who do not differ significantly. (*b*) For low I words, weak imagers have significantly lower ratings ($P < 0{\cdot}01$) than vivid and medium imagers, who do not differ significantly.

Task 6. Twenty-one subjects reported that Passage 2 (Seaside) was easier to visualize, five reported Passage 1 (Table) as easier and four reported no difference. The binomial test showed that a significant number of subjects reported Passage 2 as easier ($z = 2{\cdot}94$; $P < 0{\cdot}002$).

EPI. One-way analyses of variance for extraversion and neuroticism scores showed no significant differences between criterion groups. A product-moment correlation between Betts' score and extraversion yielded an r of $-0{\cdot}336$ which is significant ($P < 0{\cdot}05$). However, this result is questionable since the use of discrete subject groups constitutes a breach of the assumptions of the test. Neuroticism and abundance were positively correlated ($r = 0{\cdot}351$, $P < 0{\cdot}05$) but this correlation became smaller and non-significant when a positive correlation (non-significant) between extraversion and abundance was partialled out. Correlations between m.d.f. and the personality variables were non-significant.

DISCUSSION

The four key findings of this investigation are: (i) the EEG of weak and vivid imagers may be differentiated, but only in terms of mean dominant frequency (m.d.f.) rather than the more typically employed measure of alpha abundance, and only under an eyes-open minimal imaging condition; (ii) passive elicited imagery following presentation of High Imagery (High I) words leads to greater alpha suppression (abundance rather than m.d.f.) than does imagery elicited by Low I words; (iii) this finding is reversed under voluntary imaging (both elicited and autonomous), where a passage rated as harder to visualize leads to greater alpha suppression (abundance) than an easier passage, and (iv) criterion groups (vivid, medium and weak imagers) are differentiated in terms of strength of imagery elicited by High and Low I words and at the same time criterion groups all differentiate between High and Low I words.

Before considering the implications of these findings, a preliminary caution is necessary concerning our particular nomenclature. We believe that the labels we have attached to the different types of imaging investigated here are not merely labels which discriminate between our procedures, but do reflect genuine differences in type of imagery. Although the use of our particular terminology is novel and arguable, we believe that the instructions do lead to different types of imaging experience. The reader is invited to examine the detailed instructions given in the procedural section, in conjuction with our discussion of the findings.

The most straightforward results concern the High and Low I words and the

Passages. These indicate that imagery *per se* leads to an attenuation of alpha activity, but manipulation of degree of difficulty of imaging by variation of instruction also influences the outcome. When subjects are instructed to image but without effort and with reassurance that there is no penalty for failure to image, then High I words lead to alpha suppression. In contrast, when instructions invite collaboration either in active imaging to an ongoing descriptive passage or in production of autonomously controlled imagery which must be sustained for a long period, then the degree of effort involved has its effect. Thus the reversal of findings for Words and Passages is attributable to the effort involved in satisfying the demand characteristics of the experimental situation. A straight comparison of absolute abundance values for Words as against Passages would further substantiate this interpretation, since if Passages (and voluntary imaging) is a harder task then abundance values should be lower than for Words. However, because of the nature of the tasks and the necessary differences in EEG sampling, such comparison is not possible since it would involve comparison of means derived from samples of different duration. The m.d.f. for Passages is higher than for Words for all criterion groups taken separately and the whole sample (Words m.d.f. 10·99 Hz, Passages m.d.f. 11·03 Hz) but these differences are not significant. In retrospect, it is unfortunate that subjects were not invited to provide comparison of degree of difficulty *across* tasks; however, inspection of the instructions indicates that there is a prima facie case for our interpretation of the data. It is possible that existing discrepancies in the literature may be accounted for in terms of the differential effects of instruction to image (Morris & Gale, in preparation).

The ratings for Words require no further explanation. They show firstly that the Betts inventory is robust for this particular mode of external validation, and secondly that weak imagers, although they appear to operate within a narrower band of imaging experience, are nevertheless able to discriminate between High and Low I words.

We have considerable difficulty, however, in explaining the findings for the EEG and individual differences in imaging. Our measure of m.d.f. was taken under nine conditions and for all of these, the mean m.d.f. for weak imagers is lower than for vivid imagers; but paradoxically, the effect is only significant when eyes are open and there is no instruction to image. One possibility is that under *all* conditions of imaging, weak imagers experience some difficulty, which would have the effect of suppressing alpha activity. Vivid imagers, however, also show suppression either because of richness of imagery *or* because of difficulty. Thus, on all occasions except for eyes open, the differences between the groups are not strong enough to be significant, since both undergo a common shift in abundance. One difficulty here is the eyes closed condition where there is also no instruction to image; however, this condition yields least experimental control over the subject and there is a strong possibility that when instructed to relax and close his eyes, the subject will experience spontaneous alpha suppression, because this condition provides the opportunity for reflexion upon the task, the apparatus and so on. This explanation of our paradoxical finding involves a good deal of speculation and is not wholly satisfactory, but does gain some support from the findings for Words and Passages, which indicate that both imaging and effort to image can reduce alpha abundance.

Are the differences between vivid and weak imagers accountable for in terms of other sources of individual variation? We have obtained a low but significant correlation between extraversion and vividness of imagery; but since our vivid imagers have a high m.d.f. and extraverts a low m.d.f. (Gale *et al.*, 1969), extraversion could not underlie our findings. Differences in the resting EEG between extraverts and introverts have been accounted for in terms of 'arousal' and it must remain a possibility that the similar differences observed between vivid and weak imagers may be a function of some more fundamental difference (e.g. arousal) of which richness of imagery is merely a by-product. Thus the association between EEG characteristics and imaging characteristics may not be as direct as earlier workers have assumed.

Finally, we may observe two weaknesses in this study. First,findings for our two EEG measures, abundance and m.d.f., do not form a systematic pattern; significant findings for individual differences are limited to m.d.f. and differences for tasks are in terms of abundance only. It is generally assumed that m.d.f. and abundance are inversely related, but there is little empirical data to support this view (Gale *et al.*, 1969). Secondly, we have made comparisons between tasks in the absence of a design which would allow for direct quantitative comparison and our interpretation of the findings is lacking in this respect. However, we were unable to construct a design which would provide such direct comparison and yet at the same time yield the range of imaging situations which an exploratory experiment of this nature calls for. Nevertheless, we submit that our findings are robust enough to justify further consideration of the effects on the EEG of individual differences in imaging capacity and the effects of different types of imaging task.

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