PHOTIC STIMULATION, IMAGERY, AND ALPHA RHYTHM

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PHOTIC stimulation, the exposure of the human eye to repetitive flashes of light, has been employed in recent years in three ways; as a diagnostic, as a therapeutic, and as a research method. In each case, its use has opened new frontiers of inquiry into the borderlands of neurology and psychology.

This paper presents certain observations which stem from the testing of exploratory hypotheses with regard to an expected relationship between photic stimulation and imagery, alpha rhythm, critical flicker frequency (CFF), personality test data, overt reactions, and after-images in three major diagnostic groups: schizophrenics, organic brain damage (paretics and others), and normal individuals (no history of brain damage or emotional disorder).

Since this is a report of exploratory work, no attempt has been made to apply rigorous statistical tests nor to arrive at final conclusions. The aim is rather to stimulate further research which may employ more adequate instruments, larger groups, or different conceptual schemes.

PREVIOUS RESEARCH

A large body of previous work exists which is relevant to the project at hand, however, only a few of the most pertinent articles will be noted here.

With reference to the imagery responses to photic stimulation, Grey Walter (33), (34) has described several subjective experiences to triggering where gross distortions in sensorium appear. In another article (32), he and others indicate that somatic, emotional, and mental changes can be induced by rhythmic sensory stimulation at appropriate frequencies. The kinds of responses to intermittent light have been described by Massucco (20) as (*a*) fragmentary (autoscopic) images of a geometrical nature, (*b*) more complete geometric figures (geometrizing response) often with colours,† and (*c*) in a very few persons, symbolic images consisting of concrete objects. The predominant response in fifty persons was the vividly coloured "geometrizing" image.

The colour response alone has been previously described, and is known as "flight of colours". The number of phases observed in the flight and its duration depend upon the intensity of the initial flash (8). It has been shown that as log $I \times t$ of the flash varies arithmetically, both flight duration and the number of colour changes vary geometrically (2). The flight of colours phenomenon is considered as a special case of after-image. Mundy-Castle (22) in a case report states that vivid hallucinations were provoked by photic stimulation in a schizo-

* The work described here was undertaken in the Veterans Administration Hospital, Palo Alto, California. The facilities of the departments of neurology, psychiatry, and psychology were employed. The author wishes to express his thanks to the hospital administration and to Mr. Edward Dilkes, Dr. Fred Kamphoefner, Dr. Richard Worthington, Dr. Paul McReynolds, and Mr. Gideon Jean-Jacques for their assistance.

† It is interesting to note that D. O. Hebb, working at McGill, reports very similar coloured geometric images in response to the cutting off of visual stimulation for a period of hours. It may be worthwhile to speculate on the possibility of cortical free-wheeling in the two situations.

phrenic patient. It has also been found (14) that rhythmic stimulation acoustically or by tactile means, as well as visually, can produce neuromuscular activity or behaviour modification, including hypnotic-type stupors.

That imagery, in turn, is related to brain wave activity has been suggested. Walter (34) discusses imagery types as a kind of personality category and relates it to alpha activity. Some work does confirm such a relationship (25), (9) though without much consistency of findings.

Visual after-images have been found (13), in themselves, to be capable of depressing alpha rhythm in the occipital regions. This suggests that any association between supposedly enduring imagery types and characteristic brain waves must also consider the immediate impact of the image as a stimulus correlate disrupting alpha rhythm.

In reporting on the relationship between imagery and alpha characteristics, one investigator (9) speculates on the association between Rorschach response and the image-alpha complex. Some initial work, tying in Rorschach response with characteristic alpha, has been done (26), (4). In turn, Klein (16) finds that the kind of reaction to visual stimulation, namely the Phi phenomenon,* is associated with Rorschach responses. Since the Phi phenomenon is close to photic stimulation in some of its effects, one may expect to find further correlation of Rorschach scores with imagery. Similarly, there is evidence, summarized by R. Walter (31), which suggests that certain personality disturbances have particular or abnormal brain rhythms associated with them. From these findings, it may be expected that personality (as measured by psychological tests such as the Rorschach), imagery response to photic stimulation, and brain rhythms may eventually be describable in terms of consistent patterns or syndromes (24).

There is ample evidence that photic stimulation affects wave activity; especially in those persons with overt or incipient convulsive disorders (31, 7, 17, 23). However, some studies report that functional disorders also are associated with increased EEG responsiveness to photic stimulation (11, 28, 29). Such stimulation may produce behaviour disturbance including seizures and nausea (27).

Continuing the consideration of the response of brain-damaged patients versus those with functional disorders, there are several studies that report the critical flicker frequency† threshold of organic patients to be lower than that of schizophrenics (12, 35). In view of the dispute over the CFF response (21, 18, 1, 3, 5), especially as to whether the fusion phenomenon originates in the sensory cells or in the cerebral cortex, the reports of diagnostic group differences are important.

Several areas for exploration, expressed in question form, may be derived from the research cited:

I. Can differences be expected in the amount and kinds of imagery response to photic stimulation of normals, brain-damaged and schizophrenic patients? (Differences in colour, geometric patterns, symbolic or meaningful objects, feeling states, observed movement, depth, or number of concepts).

II. What changes in alpha rhythm will occur under photic stimulation in the three groups? (Normal, organic, schizophrenic).

* The Phi phenomenon is the impression of movement, the illusion, which a person experiences when a stationary stimulus is repeatedly exposed at a critical interval.

† CFF—the frequency per second at which a flickering light (repetitively flashing) is seen as a steady light.

III. Are there characteristic images associated with increases in alpha amplitude or frequency (drive)?
IV. What differences will be observed between organics and schizophrenics in their imagery responses that relate to CFFs?
V. Will there be any association between performance on psychological tests and reported imagery?
VI. Will a given stimulation rate produce identical imagery upon repetition?
VII. What physical reactions will occur in response to photic stimulation?
VIII. Is there any relationship between after-images and photic stimulation imagery in the three diagnostic groups?

Sample

The population consisted of three groups: the normal group: eleven individuals with no history of brain damage or serious emotional disturbances; nine patients hospitalized with organic brain damage,* and twelve patients hospitalized with schizophrenia.†

Apparatus and Materials

A Grass Model III EEG machine was employed; the photic stimulator was a 1951 Buffington 60 cycle AC oscillator with a stroboscopic light.

Procedure

Subjects were seated with the light source two and one-half feet in front of them at eye level. Two occipital electrode replacements were made. The EEG record was run for several minutes and the alpha frequency established. The oscillator dial was then set for light firing at a frequency equivalent to the subject's observed alpha rhythm. This setting was termed "alpha equivalent".‡ The subject closed his eyes and the room was darkened. With manual control, one flash of light was fired and the subject asked what he had seen. This initial phase was the after-image report.

Following the after-image test, the stimulator was fired for 30 seconds at the alpha equivalent setting, and upon completion of stimulation, the subject was asked to relate what he had seen. Direct questions were then asked about patterns, colours, etc.§

In similar procedure, there followed three further runs; each for thirty seconds‖ followed by a verbal report from the subject or patient. EEG records were run throughout all phases. The second phase employed a dial setting for stimulation frequency one-half the subject's initial alpha. The third phase was set for two times ($2\times$) alpha and the fourth phase was a repeat of phase one, the alpha equivalent setting. In addition, for the organics and schizophrenics,

* Diagnosis in this group were as follows: chronic brain syndrome associated with cerebral arteriosclerosis 1, hemeplegia (vascular origin) 1, psychosis with syphilitic-meningo-encephalitis (cerebral type) 1, chronic brain syndrome associated with brain trauma (penetrating gun-shot wound) 1, epilepsy, idiopathic and hereditary sclerosis 1, syphilis, tertiary, meningo-encephalitic type 1, epilepsy, grand mal, secondary to syphilis 1, syphilis, tertiary, CNS, tabo-paresis 1, chronic brain syndrome associated with CNS syphilis and epilepsy grand mal type 1.

† For the normals, the mean age was 31 with a range 21 to 40; for the schizophrenics, the mean age was 49 with a range 28 to 64; for the organics, the mean age was 57 with a range 31 to 72.

‡ The apparatus was inadequate and often did not fire at dial settings. Frequent misses or blanks occurred. The settings should not be taken too literally; the only certain designation is that of stimulation *per se*. The attempt, however, was to secure triggering or synchrony with the equipment at hand.

§ No obvious bias was apparent due to suggestion.

‖ The stimulation duration of thirty seconds was based on recommendation of Dr. Charles Yeager, who reported that period adequate for the production of imagery response.

a fifth run was obtained where the speed of firing was gradually increased until either the subject reported flicker fusion had occurred, or until the apparatus reached its upper limits of flash frequency.*

During stimulation, subjects were observed for overt changes and these were recorded. In addition, the Rorschach and Kohs Block test had been administered to fifteen of the hospitalized patients. The test data were scored and recorded; EEG records were read and response data categorized and analysed.

Results and Discussion

Table I presents an analysis of the kind and composition of images reported under photic stimulation for three diagnostic categories. In addition, Table I presents information on the number of separate images seen by each subject during the entire experiment. Although the number of subjects is too few to allow the application of tests of statistical significance, there are consistent differences among the groups. A common factor in many of the differences that appear in Table I is the greater productivity of the normal group, with the schizophrenic group second and the brain damage group least productive of responses.† The graduation of productivity holds true for colour, patterns, movement, and depth. It is reversed in the number of meaningful images, where the schizophrenic group is most responsive. The hallucinatory character of many of their responses is to be noted here.

The differences in the kinds of feeling state changes reported should be remarked upon. Emotional reactions along the pleasant–unpleasant continuum were most often found among the normals and never obtained from schizophrenics. Such findings are consistent with a defence-against-feeling description of that illness. One may speculate whether the loss of time sense reported by two normal subjects is, in any way, related to an hypnotic effect produced by photic stimulation. Such a loss is also found in hypnotic states.

Only one subject reported flicker sickness; yet four normals, one organic and eight schizophrenics reported a history of frequent adult motion sickness.

The changes in alpha rhythm are shown in Table I. In the normal group, the tendency is for a reduction in observable alpha; the reverse is more often true in both organic and schizophrenic groups where alpha becomes either more evident or where driving is seen.

Table II

Number of Distinct Images‡ per Subject for Entire Experiment

	Normals N=11	Organics N=9	Schizophrenics N=12
Number seeing:			
One image ..	0	2	5
Two images ..	2	6	2
Three images ..	4	1	3
Four images ..	3	0	1
Five images ..	0	0	0
Six images ..	1	0	0
Seven images ..	1	0	0
	Mean=3·7	Mean=1·9	Mean=2·5

* Once again, instrument difficulties arose. Its upper firing limit varied from 23 to 40 per second.

† Low productivity by brain-damaged patients is consistent with findings from psychological investigations. However, differences in age or intelligence may account for productivity variation in this experiment, for these variables were not controlled. Inspection of the few Weschler-Bellevue Intelligence Scale scores available for the patient group did not reveal any relationship in these groups between IQ and number of distinct image responses. Apathy, due to hospitalization itself, may also be a factor.

‡ A distinct image was defined as one idea, concept or response whole.

TABLE III
Image Reliability

	Normals	Organics	Schizophrenics
Same responses to first and second alpha equivalent runs	2	5	4
Different responses to first and second alpha equivalent runs ..	9	4	8

Reference to Table III indicates that a given rate of flicker does not necessarily produce the same response on two occasions. That it is more likely to do so among brain-damaged patients is a function of their low response productivity with consequent similarity of reaction to all flicker speeds. Because of the apparent dissimilarity of response to similar stimuli, it can be suggested that whatever mechanisms are involved in this imagery, some kind of a memory system operates.*

Table VI presents the available Rorschach scores compared with imagery response. Tests on more subjects would be required to elicit any trends.

TABLE IV
Rorschach Results and Imagery Responses

	Organics	
	Imagery Movement	No Imagery Movement
More than 2 Rorschach M†	1	1
2 or less Rorschach M ..	2	1
	More than 3 Colour Images	3 or less Colour Images
Rorschach C‡ over 2 ..	0	2
Rorschach C 2 or less ..	1	1

	Schizophrenics	
	Imagery Movement	No Imagery Movement
More than 2 Rorschach M	2	0
2 or less Rorschach M ..	5	3
	More than 3 Colour Images	3 or less Colour Images
Rorschach C over 2 ..	2	2
Rorschach C 2 or under	0	2

	Totals	
	Imagery Movement	No Imagery Movement
More than 2 Rorschach M	3	1
2 or less Rorschach M ..	7	4
	More than 3 Colour Images	3 or less Colour Images
Rorschach C over 2 ..	2	4
Rorschach C 2 or under	1	3

Table V presents information on the CFF and imagery. From these data, it appears that even after subjects report light fusion, changes in imagery continue. If this can be verified, it would strengthen the interpretation of CFF phenomenon as a predominantly cortical function since images could not be experiences unless some flash discrimination, however subliminal. was taking place in the CNS. The present findings are in agreement with Irvine's (12),

* Retests on four patients after six months showed much similarity in the types of response, but some changes in descriptive wording.

† Human movement response. ‡ An index of the use of colour responses.

TABLE V
CFF Reactions in Organics and Schizophrenics

	Organics	Schizophrenics
Fusion point (CFF) achieved with imagery responses continuing*	4	3
No CFF achieved no further imagery	2	1
CFF not achieved†	2	8
Total‡	8	12

showing brain-damaged patients to have a lower level of CFF than reactive schizophrenics.

In Table VI is found an analysis of the similarity between after-image and photic stimulation response during the first alpha equivalent run. Once again, the findings show normal subjects more likely to produce radically different responses than are the hospitalized groups. In this case, there is no

TABLE VI
Common Elements in After Image (single flash) and Response to Photic Stimulation (repetitive flashes)

	After-image and photic S response identical (all elements in common)	Partial Identity of After-image and photic S response (some common elements)	No elements in common
Normals	0	8	3
Organics	5	4	—
Schizophrenics	5	6	1

instance of the normals having identical photic stimulation responses and after-images, whereas over half the organic group show identical response. The productions of schizophrenics resemble those of the organic patients more closely than those of the normal group.

Inspection of the records fails to reveal any particular kind of imagery associated with diminishing alpha or alpha drive. There seem to be no characteristic images (patterns, colours, etc.) which consistently occur when alpha rhythm changes occur; nor are there necessarily changes in alpha rhythm when a change in imagery is reported.

Inspection of the Kohs Block test scores available on nine patients does not reveal any relationship between scores on block pattern building and the number of patterns seen under photic stimulation.

Analysis of the Rorschach protocols, in comparison with the content of the photic images, reveals no similarity. In no case where Rorschachs were available was there reported a photic image which corresponded to the content of a Rorschach response.

Although the number of brain-damaged patients with focal as opposed to diffuse brain pathology was too small to allow any systematic comparison, initial comparisons show no major differences in response characteristics between the two groups.

With these observations in mind, it is possible to offer some remarks. Normals, schizophrenics, and brain-damaged persons apparently can be differentiated by means of photic stimulation. In their imagery, each group differs from the other, primarily in productivity but also in meaningfulness of

* Questionable, due to instrument failures. † Due to instrument inadequacies.
‡ One patient in the organic group was not tested.

the images and in the kinds of feeling states reported. It is easier to distinguish organics from schizophrenics and normals than to distinguish these latter two groups from one another with respect to imagery.

This does not hold true when the changes in brain rhythms under photic stimulation are examined. In this instance, the organics and schizophrenics seem more similar and the normals more distinctly apart from both. Demonstrable pathology may account for the records of organic patients; no such pathology has yet been found in schizophrenics. Nevertheless, both groups differ from normals not only in the production of imagery but in brain rhythm response to stimulation. In both patient groups, the observed responses are consistent with a state of reduced responsiveness to outer stimuli. In both cases, the symptoms and the underlying mechanisms may be interpreted as a lessened ability to respond adequately to the world outside. In both cases, EEG records may reflect this when the alpha fails to diminish under stimulation. Instead, in the schizophrenic group, there is alpha drive. This drive has been noted by Walter (34) to be associated with distorted sensorium. In the schizophrenic, the distorted sensorium regularly occurs. When it is considered that, in the schizophrenic, outer stimuli are not responded to, one may infer that the distortions involve a kind of cortical free-wheeling. It is even possible to suggest that a breakdown in the reticular "excitatory" centre or its pathways, as discussed by Magoun and his colleagues (6), might account for such a series of events. Thus, reduced sensitivity and inadequate capacity for response may be part of the same diencephalic mechanism.

Such an account is not inconsistent with EEG studies (10, 19) or with the ordinary behaviour of these patients.

Summary

A preliminary study has examined the responses to photic stimulation of normals, organics and brain-damaged schizophrenic patients. Consistent differences in the productivity of patterns, colours, depth and movement were found. Special differences in the meaningfulness of images were noted. Examination of EEG records indicates that schizophrenics are like organics in their responses and that the responses of both groups are consistent with a theory of reduced sensitivity and response capacity, perhaps due to diencephalic dysfunction. No relationships were found among reported images and psychological test data.

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