IMAGINATION, COGNITION AND PERSONALITY, Vol. 1(1), 1981-82

AN EXPERIMENTAL CROSS-VALIDATION OF MENTAL IMAGERY

DANIEL ALGOM
ISAAC LEWIN

Department of Psychology
Bar-Ilan University
Ramat Gan, Israel

ABSTRACT

The following operational question was investigated: do two separate, independently developed models of mental imagery tap the same underlying psychological phenomena? Empirical implications were derived from a general cognitive-information model and a bio-feedback model to be tested simultaneously within the design of a single experiment. Three measures of imagery were employed: quantity, vividness and controllability. It is shown that differential manipulation of imagery by the two types of treatments produces a predictable set of results. This demonstration of transitivity and replicability of imagery results across experimental methods and laboratories is supportive of the validity of this, now popular, psychological concept.

A probably inevitable by-product of the exciting return of the psychology of imagery in the sixties, from its half-century long ostracism [1] has been its lack of a common, widely agreed upon definition. In other words, emerging conceptions of imagery were too study-dependent, thus sometimes differing greatly from one another. In this respect, however, imagery is by no means an exception. The problems of its definition are in no way different from those encountered with such concepts as anxiety, stress or even intelligence [2–4]. Investigators of the imaginary phenomena were well aware of the need for a construct-validation of the concept, an almost self-evident necessity facing the complicated, indeed ephemeral nature of the subject [4, 5] as well as the changes which have taken place in its long scientific development [2, 6, 7]. However, most of these construct validatory attempts were of a statistical nature using mainly factor-analytic techniques as the main method of reduction of data gathered by questionnaires and interviews [8–11]. While these studies greatly contributed to the organization of the multitude of multifaceted imaginary phenomena and to the production of important devices of measurement [11], they still came short of filling the gap between the different empirical approaches toward the exploration of mental imagery. A behavioral approach originated from phenomenological observations of imaginary phenomena, further developed experimentally as the "alternative channels" model [12] is one such major approach. A somewhat more physiologically oriented approach which attempts to relate imaginary phenomena to their concomitant electrophysiological indices as EEG, sometimes by acquiring voluntary control of the process [13] constitutes another major experimental paradigm used to study mental imagery. These two approaches were developed quite independently of each other and their integration is desirable in view of the need for construct validation of their common topic of research. Of course, an experimental construct validation is meant which is not to be confused with the correlative parallel. Thus the purpose of the present work was to derive empirical implications from the above two independently developed models in order to test them simultaneously within the design of a single experiment.

A Cognitive, Information-Processing Approach

Systematic phenomenological study of the psychological conditions known for their rich fantasy mentation reveals a constant relationship between fantasy and other classes of cognitive activity. The rule is one of a reciprocal relationship between occurrences of fantasy mentations and other kinds of mentations. Natural occurrences of strong fantasy activity like dreams, hypnogogic and hypnopompic states, prolonged confinement in monotonous environments as well as experimentally induced fantasy mentations like sensory deprivation, rhythmic photic/auditory/electric stimulations, hypnotic or hallucinogenic drug-induced states are all characterized by a simultaneous decrease in the external stimulation present or equivalently by a similar decrease in the organism's responsiveness to external stimuli [3, 14]. Experimental studies give additional support to the almost naturally emerging idea of a common cognitive operator which is alternatively occupied in processing external stimuli or inner cognitive events such as fantasy. Thus, Antrobus, Singer and Greenberg showed that manipulation of external stimuli, in this case a signal detection task caused complementary changes in stimulus independent mentation [15]. Making the external cognitive load heavier by increasing rate of stimulus presentation, by appropriate changes in the payoff matrix or by increased use of short term memory resulted in proportional decreases in stimulus independent thought production. Antrobus, using a similar setting, was able to show that equal amounts of internally produced information were traded for equal amounts of task information [16]. Still, other studies [17–21] seemed able to establish that imaginary and perceptual information use the same channels before reaching a common central operator. It is demonstrated that the perceptual performance is impaired by simultaneous equimodal imaginary activity but no disturbance is revealed in simultaneous cross modal sensory/imaginary tasks. In fact, the common occurrence of the perceptual illusions including the so-called Perky effect [20, 22] intuitively implies the existence of a common cognitive processing system for perceptual and fantasy informations.

The formality derived from the accumulative effort of Singer and Antrobus and co-workers is called the alternate channels model [4]. It attempts to relate production of spontaneous cognitive events such as fantasy to the organism's continuous response to external stimuli. Under most conditions of moderate activation information is processed simultaneously from the two channels of stimulation available to the individual: the external environment and the inner cognition. Only in extreme situations such as a sensory deprivation or "stimulus bombardment" may we postulate greater priority to the internal or the external channel respectively. Most of the works based on this approach employed a rather specific experimental technique. Subjects were seated in lightproof, sound-attenuated rooms having some version of a signal detection task. Upon random interruptions they had to report whether or not they had any stimulus independent thought in the preceding interval. Operationally then, employing this experimental paradigm, one can enhance or reduce ongoing fantasy by appropriate manipulations of the difficulty of the external tasks imposed upon subjects.

The Bio-Feedback Approach

Mental imagery has, however, been extensively studied by using experimental methods derived from a totally different psychological discipline. The major thrust of this approach has been concerned with tapping ongoing mentations by relating them to their concomitant electro-physiological indices [23]. In particular, the discovery of the correlation between EEG and types of mentations including imagery has drawn great experimental interest [24, 25]. In addition, there has been a proliferation of research concerning the possibility of acquiring voluntary control over these electro-physiological processes. Once possessed, such a control enables subjects to produce a desired mentation such as fantasy upon an experimental command. These methods are commonly called bio-feedback techniques [13, 26, 27]. In case of EEG, one can impose a desired mentation upon the subject through his gaining voluntary control on the production of appropriate EEG frequencies. In particular, among the strongest empirical contingencies found in this realm is that between the disappearance of the EEG alpha (8-12 Hz) and subsequent imagery production [27–29]. The well known classification of subjects into visualizers vs. verbalizers [30], is based on this empirical correlation. While there is a growing literature which puts in question the validity of the earlier interpretation of the bio-feedback studies' results [31–37], there is no doubt about the reliability of the above empirical relation. Operationally then, according to the bio-feedback paradigm, one can train subjects to imagine upon experimenter contingent appearance of a discriminative cue while the resultant fantasy is followed by an appropriate perceptual feedback.

Comparison and Experimental Manipulations of the Two Approaches

Thus, both the Singer-Antrobus stimulus independent mentation (SIM) paradigm and the bio-feedback paradigm have been successful in providing useful methodological means of probing the realm and dimensions of inner experience. In fact some important techniques are commonly shared by both approaches. Both are dealing with essentially laboratory studies, usually under rather artificial circumstances. While SIM is essentially a behavioral approach, it nevertheless makes use sometimes of physiological measures as well [38–40]. Similarly, while the main data source of the bio-feedback studies are the physiological correlates, they still make use of such measures as verbal reports of subjects [13]. What seems different is the degree of assumed experimental accessibility to subjects' ongoing fantasy. The bio-feedback paradigm manipulates fantasy rather directly while the SIM paradigm does so only indirectly by manipulating the external load imposed on the subjects. Such comparisons though interesting and apparently having some heuristic value rest however on a prior logical requisite. That is the implicit assumption that both of the above experimental paradigms do indeed deal with the same psychological process. Do they?

This is the crucial question to which the present paper addresses itself. Do the SIM and bio-feedback researches tap the same basic psychological processes besides both calling their dependent variable imagery? In other words, do the SIM and bio-feedback approaches share more than merely a name in common? If they do, then their simultaneous application within the framework of a single experiment should yield a predictable order of results in terms of fantasy production. Thus the following four experimental conditions were created in the present investigation:

1. a high fantasy condition according to SIM in conjunction with high fantasy condition according to bio-feedback training;
2. high fantasy SIM with low fantasy bio-feedback;
3. low SIM with high bio-feedback; and
4. low SIM with low bio-feedback.

Three dependent measures were employed: quantity of fantasy, its vividness and its controllability. Both quantity and vividness of imagery should be expected to appear relatively strong in the high-high condition compared to the low-low condition. The particular design employed allowed to discriminate even between the two intermediary conditions. Of course, these predictions are only valid if the two strategies used do effect the same process. The hypothesis took the opposite direction regarding the controllability of images. The more vivid an image is, the more difficult to control it (see for example, [3]).

METHOD

Subjects

Twenty-four paid-volunteer subjects participated in the experiment. All were undergraduate students from various faculties of Bar Ilan University (ages nineteen to twenty-four years). There were thirteen female and eleven male subjects. They were randomly assigned to one of four experimental conditions with the restriction of equal number of subjects from both sexes in each condition; one group consisted of four female and two male subjects. The subjects came to five experimental sessions of about ninety minutes each.

Procedure

First, a rather detailed description of the experimental chronology is given. This will enable the reader to comprehend more easily the experimental hypotheses in their operational form.

Since the experimental design is somewhat complicated, it is outlined schematically in Figure 1.

Upon coming to the laboratory, the subject was randomly classified either to the bio-feedback training group or to a control condition. He lay down on a comfortable bed in a sound-attenuated, light-proof room where electrodes for EEG recordings were attached. Silver, cup-like, 10 mm diameter electrodes were put on the parietal-occipital positions with a referent electrode on the ear-lobe and a ground leading electrode on the forehead (all positions according to the instructions in [41]). Information from EEG was transformed through filters of a NIHON KOHDEN, model MAF-5, EEG frequency analyzer and through Schmitt-triggers in order to be able to provide feedback from the EEG input (for a more detailed description of this apparatus, see [42]). EEG polygraph (Grass, model 78) served for a continuous EEG recording. After electrodes attachment, a bio-feedback training began for the following ninety minutes. Instructions told the subject to form a previously agreed-upon familiar image (his mother's face, his desk, lying on the beach, etc.) on the appearance of a discriminative cue – a light flash. In addition, the subject was told that he would get information about his success at imagining in the form of a sound to be continued as long as the image is there. In fact, the sound (30 dB white noise from a microphone in subject's room) was automatically on whenever an alpha

				EXPERIMENTAL CHRONOLOGY
EXPERIMENTAL CONDITIONS				
BIO-FEEDBACK		CONTROL		
DELIVERY OF IMAGERY MEASURES DAYDREAMING, VIVIDNESS, CONTROLLABILITY				PRECEDING FIRST SESSION
IMAGE FORMATION UPON THE APPEARANCES OF LIGHT FLASHES AND AUDITORY FEEDBACK. (N = 12)		SIMILAR SETTING EXCEPT FLASHES, SOUNDS AND IMAGES ARE NOT ASSOCIATED. (N = 12)		4 SESSIONS OF 90 MINUTES EACH
AUDITORY SIGNAL DETECTION TASK				
DIFFICULT	EASY	DIFFICULT	EASY	
HIGH RATE AND SHOCK PUNISHMENTS AND SPORADIC APPEARANCES OF LIGHT FLASHES. (N = 6)	LOW RATE AND NO SHOCK AND SPORADIC APPEARANCES OF LIGHT FLASHES. (N = 6)	HIGH RATE AND SHOCK PUNISHMENTS AND SPORADIC APPEARANCES OF LIGHT FLASHES. (N = 6)	LOW RATE AND NO SHOCKS AND SPORADIC APPEARANCES OF LIGHT FLASHES. (N = 6)	1 SESSION OF APPROXI-MATELY 40 MINUTES
DELIVERY OF IMAGERY MEASURES QUANTITY, VIVIDNESS, CONTROLLABILITY				FOLLOWING LAST SESSION
GROUP 1	GROUP 2	GROUP 3	GROUP 4	

DESIGN: DETECTION TASK

BIO-FEEDBACK TRAINING		DIFFI-CULT	EASY
	RECEIVED	1	2
	NOT RECEIVED	3	4

HYPOTHESES:

QUANTITY, VIVIDNESS: $3 > 4$, $1 > 2$

CONTROLLABILITY: $2 > 1$, $4 > 3$

Figure 1. Schematical outline of procedure, experimental design and hypotheses. (See text for further explanation.)

depression was taking place. In addition, verbal communications were possible between subject and experimenter (through intercoms) in order to verify the subjectively felt appropriateness of feedback to the self-generated image (positive in all instances). The flashes of light appeared every two minutes on the average during the ninety minutes training session. Four such training sessions lasting ninety minutes each took place in order to train subjects to form an image upon appearances of the flash. Subjects in the control condition have also participated in four such meetings including attachments of electrodes and sporadic appearances of the same light flashes and sounds. They were told that they could imagine or occupy themselves otherwise during the experimental sessions. However, no special connection was made between the light flashes, the formation of images or the sounds.

Upon coming to the fifth experimental session subjects were classified into either a difficult task condition or an easy task condition. Half of the subjects from the bio-feedback training condition were randomly assigned to the subsequent difficult task condition while the remaining half were run through the easy task condition. The same random halving of subjects took place in the group that previously received the control training. In the beginning of the fifth meeting, electrodes for electric shock delivery were attached to the right ankle of the subject. A short informal testing then took place to ascertain the minimal mA level felt painful by the subject. This session was mainly devoted to a Singer-Antrobus like auditory signal detection task. However, it was deliberately constructed to be an extremely difficult task (as revealed by pretests). The signals were two 50 msec pure tones (Heathkit Audiogenerators) of 25 dB SPL, each differing slightly in frequency (1000,1020 Hz). Rate of presentation was one every 3/4 second on the average. The high and low tones appeared at random the subject had to press a button on each presentation of the higher tone. Misses and false alarms were punished by the delivery of the previously determined "threshold" pain shock. The total number of tones was 1800 with 50 per cent of signal's relative frequency. The whole task took about thirty-five minutes. In the easy task condition, no shocks were used (although electrodes were attached) and rate of presentation was halved. During both task conditions the previous light flashes continued to appear sporadically. Of course, for those subjects who had participated in the control condition, these flashes meant nothing but extra complication of the external task. Thus, the experimental design allowed to cast data into a 2 x 2 factorial structure the cells of which generated by the dichotomous values of the two independent variables:

1. imagination formation treatment (took place or absent);
2. imposed perceptual task (relatively complex or easy).

Hypotheses Operationally Stated

First, a general methodological remark seems in order. In most of the Singer-Antrobus studies and in almost all of the bio-feedback studies concerning imagery, a within subject design was adopted. This is understandable considering the huge individual differences existing in this domain of private experiences. The present study using both of the above manipulations within the framework of a single experiment required a between subject design. Therefore, our primary means of dealing with the problem of individual differences was the employment of quite extreme values of the experimental treatments: an extensive series of image formation training through bio-feedback and an extremely difficult detection task of the Singer-Antrobus type. In both the bio-feedback and the SIM designs, imagery is typically measured many times during an experimental session (usually by obtaining verbal reports from subjects on sporadic interruptions of the task). This method of measurement seemed inappropriate in the present experiment because:

1. a report on an occurring fantasy while being a subjective response (as any cognitive response for this matter) is usually complicated in the above designs by requiring an additional subjective response from the subject: the determination whether the ongoing cognitive event was an imaginary one; and
2. the very interruptions of the experimental task may by themselves influence the quantity (and quality) of the ongoing fantasy activity thus confounding measurement with the attribute measured. Therefore, imagery was measured in the present experiment only on the completion of the detection tasks at the end of the fifth experimental session.

Since daydreaming or fantasy processes may be seen as a general cognitive alternative to dealing with external stimuli, the various experimental conditions may be considered as kinds of fantasy-deprived or at least of fantasy-disturbed. states of varied intensity (especially according to the alternate channels model). Specifically, it was predicted that increasing the complexity of the perceptual task would cause a greater amount and a more vivid subsequent imagery due to the relative inability to engage in fantasies during the task activity. On the other hand, prior training to image would reduce both amount and vividness due to the partial availability of imagining even during the perceptual tasks, owing to the periodical appearance of the discriminative cue. Thus, the greatest and most vivid imagination may be expected from the group which was given the difficult detection task without receiving prior imagination training (Group 3). Relatively small post task imagery activity is expected of the group that was given the easy detection task with a prior imagination training (Group 2). No firm hypothesis can be formed regarding the order of the two intermediary conditions. However, one should keep in mind that those subjects who had prior imagination training could still engage in at least some fantasy activity even during the difficult detection task due to the appearances of the prior discriminative cue. As mentioned, the opposite orderings of groups is expected with regard to controllability.

Measurement of Imagery

Quantity – This was obtained through reports to two Rorschach (3, 9) and two T.A.T. cards (IBM, 7BM) presented to the subjects at the completion of the detection tasks. The quantity of fantasy evident in the reports was independently assessed by two judges (experienced clinical psychologists) who were "blind" to the experimental situation, on a 1-5 (largest amount) scale. The judges were instructed not to confuse quantity with literary length of the stories (which may contain stimulus' physical descriptions) or with "bizarreness" of the fantasies. They could accomplish this with ease (for similar measures of imagery see, for example, [32] or [5] for a more general review).

Vividness – This dimension was measured both before the experimental sessions and after their completion by using a shortened form of Betts' scales for vividness of imagery [44, 45]. There are several items in each of seven modalities to be imagined by the subjects and the subjective vividness is scored from 1 (most vivid) to 7.

Controllability – This was an additional before-after measure using Gordon's scale for controllability of fantasies [3, 46]. There are eleven items to be scored between 0-2 (most control) for their controllability.

Daydreaming questionnaire – An earlier version of the Imaginal Processes Inventory (IPI, e.g., [11, 47]) was delivered to all subjects before the beginning of the first experimental session. This consisted of 225 items each of which is to be answered by the subject in terms of frequency of occurrence. This measure was aimed here at attaining some indication of subjects' normal daydreaming patterns' frequencies.

RESULTS

Preliminary Checks

Some preliminary analyses were performed in order to ascertain the efficiency of experimental treatments. First, no significant intergroup differences were found on subjects' general daydreaming tendencies as measured by the questionnaire [one-way ANOVA, $F(3,23) = 0.93$]. Second, in order to attain converging evidence on the respective difficulties of the detection tasks, a sensitivity index of the Theory of Signal Detectability – d' – was computed for each of the subjects. The median d' of the subjects who have undergone the more difficult task was 3.93 while the median d' for the subjects of the easier task was 4.37. Moreover, there is almost no overlap between the respective distributions of d's with the exception of two cases (which do not deviate much from their respective ranges). This result is supportive of the efficiency of the

Table 1. Means and Standard Deviations of Quantity of Fantasy Estimations

		Detection Task	
		Complex	*Easy*
Biofeedback Training	Received	M = 8.7 S.D. = 2.56	M = 7.83 S.D. = 2.01
	Not Received	M = 11.5 S.D. = 2.81	M = 9.16 S.D. = 2.60

experimental manipulations used to produce the detection tasks. The sensory load was indeed heavier in the task which had been constructed to serve as the more difficult one. Third, the efficiency of the bio-feedback training to form images was assessed in the following way. The percentage of the time in which *no* alpha waves were present in the EEG was computed for each subject for both the image formation trials (0.5 minute each) and the period in-between these trials (this measure is a reciprocal of the so-called "alpha index"). In particular, the first three imagination trials and breaks in the first training session were compared to the last three such intervals in the last training session. The mean difference of non alpha EEG between the first three imagination trials and breaks was subtracted from the respective mean difference of the last three imagination trials and breaks for each subject. The results show a dramatic learning effect with all the subjects participating in the bio-feedback training. The respective differences were much greater at the end of the training than at the beginning. At the end of the training sessions almost no EEG alpha was present during the imagination period ($t = 6.978$, $df = 11$, $p < 0.01$ using a matched-pairs test). No significant differences were found in the control condition ($t = 0.99$, $df = 11$, $p > 0.05$). Thus, the findings with the independent checks taken are supportive of the efficiency of the experimental manipulations in both of the independent variables.

Quantity of imagery – The judgments from the four stimulus cards were summed up to form a single index with a product moment correlation coefficient of .92 between the two judges. Hence the means of the two judgments were used in further computations. The results on this index for the four experimental conditions are shown in Table 1. The groups' respective means are exactly in the predicted order. The largest quantity of post-experimental fantasy production was found in the group not receiving any prior (bio-feedback) imagination training but undergoing the complex detection task. The slightest amount of fantasy was found in the group which had received bio-feedback training and then underwent the easy detection task. The two remaining groups also showed the expected order of effectiveness of the two independent variables. The chance probability for such a result is below 5 per cent. The imagery training effect is significant at the 0.10 level [$F(1,20) = 3.92$] while the task main effect only approaches this level [$F(1,20) = 2.48, p > 0.10$] as revealed by a two-way ANOVA. No significant interactions were found [$F(1,20) = 1.2, p > 0.10$].

Vividness – The differences (after-before) in the seven modalities of the Betts' questionnaire were computed for each subject. No significant intergroup differences were found on this variable either in each modality separately or when analyzing over the seven modalities. Analyses of the post experimental vividness scores only, with or without the pre-experimental scores serving as the covariate failed to reveal any significant intergroup differences. Another analysis of covariance with the daydreaming questionnaire as the covariate once again failed to detect any significant trend in the data. As a final solution and admittedly a doubtful one with our number of subjects, we decided to factor-analyze the "before" vividness scores with different modalities serving as the subscales. The principal component solution with rotation to the varimax criterion yielded three factors with eigen values greater than unity and accounting for nearly 50 per cent of the common variance. The emerging factors in order of importance were a visuo-auditory one, a taste-smell one and a gross-body sensations factor. The touch modality had relatively high loadings on all of the factors. This factorial structure did not change materially when the same analysis was applied to the "after" vividness scores (same factors reappeared preserving their order). The factor-scores for each subject were then computed both before and after the experiment (using the coefficients of the analysis performed on the pre-experimental scores). The factor-score differences on each of the three factors were now exposed to two-way ANOVAs of the same type used with the analysis of the quantity scores. Of these only the ANOVA performed on the visuo-auditory factor scores yielded significant differences. Data from this analysis is shown in Table 2.

The striking characteristic of these results is that now the group means do show the order predicted by the original hypothesis. The task main effect is significant at the 0.01 level [$F(1,20) = 12.8$] and the training main effect almost approaches the 0.10 level [$F(1,20) = 4.01, p > 0.05$]. No significant interaction was found.

Controllability – Group means on this measure (before-after differences) showed up in the predicted order, however the intergroup differences failed to achieve significance in the appropriate 2 x 2 ANOVA.

An interesting phenomenon characterizing all subjects was the general increase in the controllability of imagery regardless of experimental group. However, this trend was relatively moderated either by performing the difficult detection task or by not receiving the prior bio-feedback training.

Table 2. Predicted Means of Vividness of Imagery Scores (After-Before) in the Visual Auditory Factor[a,b]

		Detection Task	
		Complex	*Easy*
Biofeedback Training	Received	–2.74	0.24
	Not Received	–3.05	2.67

[a] These data were obtained by the use of computer program BMD064, which does not yield standard deviation. However, an approximation made by the authors found all standard deviations to be in the vicinity of 1.9 – differing only within random fluctuation.

[b] In order to grasp the meaning of the negative signs the reader should keep in mind that the scales are scored from 1 (most vivid) to 7 (least vivid) and that the post experimental score was subtracted from the preexperimental one.

Table 3. Product Moment Correlation Coefficients Between Quantity of Imagery, Vividness, and Controllability

	Quantity	*Vividness*	*Controllability*
Quantity		.23	-.081
Vividness			-.55[a]
Controllability			

[a] $p < 0.01$.

Relationship Among the Dependent Measures

Disregarding experimental treatments one can compute the inter-correlations among the three dependent variables used in this research (for the purposes of this analysis the pre-experimental vividness and controllability scores were used. However, no change occurs when using the post scores or some statistical combination of the two). The data are shown in Table 3.

The significant and relatively strong negative relationship found between vividness and controllability supports the experimental hypothesis of a reciprocal relationship between these variables, at least on the individual level.

DISCUSSION

The main hypothesis set forth in this research is supported reasonably well by the data. It is shown that manipulation of imagery either by imposing a heavy load on the cognitive system or by making use of bio-feedback techniques produces a predictable set of results. The data suggests that differential combinations of the values of the two types of manipulations may be conceptualized as varied states of fantasy-deprivation or at least of fantasy-disturbance. Subsequent magnitude of imaginary activity is a direct function of the strength of the disturbance. This behavior is typical of some closed loop systems and the alternate channel's model may be considered a first approximation toward such a description of the human cognitive system. Of course, more accurate predictions based on such models are expected when we know more about their time constant(s). However, the constraints imposed by the model even in its present stage of development are tight enough in terms of experimental manipulations in order to enable one to gather a reasonably ordered and quantifiable body of data on fantasy processes [5, 48].

The findings regarding quantity of imagery and its controllability provide fairly strong support for the above conceptualization. They certainly demonstrate that the strategies used here for the experimental treatment of imagery deal at least in part with the same phenomenon.

The results concerning vividness of imagery are especially interesting. These data show that the only category of imagery meaningfully effected by the experimental treatment was that of visual and auditory imagery. This result while initially surprising the authors, on later analysis turned out to be a predictable outcome of the experimental logic. Careful re-examination of the experimental manipulations revealed that the only sensory modalitiės really occupied by experimenter contingent stimuli were the visual (flashes of light) and the auditory (detection tasks) ones. Hence, simultaneous fantasy activity was mostly disturbed in these two modalities accordingly. Thus, the alternate channels model does explain these results in terms of channel space and information load on the visual and the auditory systems during processing complex external content or inner stimuli such as fantasies. Several experimental studies by now suggest that the same sensory mechanisms or pathways are used in producing fantasies as in processing externally imposed content [12, 21, 39, 49]. Thus, the present results is an additional finding emphasizing the need for a more serious consideration of the modality-dependent nature of imaginary phenomena.

The implications for this study of the recent controversy over the proper explanation of the bio-feedback findings should be mentioned briefly. Paskewitz and Orne [33, 34], for example, argue that bio-feedback produced alpha enhancement should primarily be attributed to subject's gradual adjustment to the experimental situation rather than to any genuine learning effect. Others were able to demonstrate the crucial role of experimental instructions in producing the typical bio-feedback results [36, 37]. It is not the purpose of the present study to support either of the alternatives. Our intention was rather to capitalize upon the method in order to create a *reliable* psychophysiological product, whatever theoretical basis it may have. Moreover, most of the arguments pointing to a possible artifact to be found in the bio-feedback studies are aimed at the alpha enhancement trainings. In contrast, the present study employed an alpha reduction training procedure. By no means do we insist on a learning explanation of our own bio-feedback results, a training-instructions interaction for example [37], would provide an equally good interpretation. Thus, the present research is indifferent to whatever interpretation the bio-feedback studies finally find in terms of underlying psychological mechanism(s). Neither does the present study depend on any basic interpretation of the psychological meaning of the alpha waves. It does make use of some reliably reproducible psychophysiological finding.

The everpresent great individual differences in the production of private images or fantasies we sought to counteract within the present between-subjects design by the employment of quite extreme values to the experimental treatments. This was only partially successful as may be apparent in the low or total lack of statistical significance in large portions of the data. This problem is best handled by some combination of a relatively strong experimental treatment, a within subject design, very reliable dependent measures and a great number of subjects. Of course, all of these requirements cannot always be met in every particular case.

In this study we made use of two independently developed techniques to manipulate the production of fantasies. This enabled us to perform a kind of experimental-operational inquiry into the concept of mental imagery. The results were positive in the sense that they have made clear the fact that completely independent strategies for the experimental attack of imagination deal, at least in part, with the same phenomenon. If results of the type obtained here can be replicated and extended, we will be able to formulate our theories of mental imagery on a firmer experimental basis.

REFERENCES

1. R. R. Holt, Imagery: The Return of the Ostracized, *American Psychologist, 12*, pp. 254-264, 1964.
2. U. Neisser, Changing Conceptions of Imagery, P. Sheehan (ed.), *The Function and Nature of Imagery*, Academic Press, New York, pp. 233-251, 1972.
3. A. Richardson, *Mental Imagery*, Springer Publishing Co., 1969.
4. J. L. Singer, *Daydreaming*, Random House, New York, 1966.
5. J. L. Singer, Experimental Studies of Daydreaming and the Stream of Thought, K. S. Pope and J. L. Singer (eds.), *The Stream of Consciousness*, Plenum, New York, 1978.
6. D. Algom, Mental Imagery: A Case Study in the Logical Development of a Scientific Concept, *Studies in Education*, Haifa University Press, 1980 (Hebrew; English abstract).
7. D. Algom and I. Lewin, Four Theoretico-Historical Approaches to the Study of Imagination, *Megamot, 22*, pp. 298-314, 1976 (Hebrew; English abstract).

8. L. M. Giambra, A Factor Analytic Study of Daydreaming, Imaginal Process, and Temperament: A Replication on an Adult Male Life-Span Sample, *Journal of Gerontology, 32,* pp. 675-680, 1977.
9. R. R. Holt, On the Nature and Generality of Mental Imagery, P. Sheehan (ed.), *The Function and Nature of Imagery,* Academic Press, New York, pp. 6-35, 1972.
10. B. Segal, G. Huba, and J. L. Singer, *Daydreaming, Drugs and Drinking: A Study of College Youth in the '70's,* Erlbaum, Hillsdale, New Jersey, 1980.
11. J. L. Singer and J. S. Antrobus, Daydreaming, Imaginal Processes, and Personality: A Normative Study, P. Sheehan (ed.), *The Function and Nature of Imagery,* Academic Press, New York, 1972.
12. J. S. Antrobus, J. L. Singer, S. Goldstein, and M. Fortgang, Midwandering and Cognitive Structure, *Transactions of the New York Academy of Sciences, 32,* pp. 242-252, 1970.
13. J. Kamiya, Operant Control of the EEG, Alpha Rhythm and Some of its Reported Effect on Consciousness, C. Tart (ed.), *Altered States of Consciousness,* Wiley, New York, pp. 507-517, 1969.
14. J. M. Horowitz, *Image Formation and Cognition,* Appleton-Century Crofts, New York, 1970.
15. J. S. Antrobus, J. L. Singer, and S. Greenberg, Studies in the Stream of Consciousness Experimental Enhancement and Suppression of Spontaneous Cognitive Processes, *Perceptual and Motor Skills, 23,* pp. 399-417, 1966.
16. J. S. Antrobus, Information Theory and Stimulus-Independent Thought, *British Journal of Psychology, 59,* pp. 423-430, 1968.
17. L. R. Brooks, The Suppression of Visualization by Reading, *Quarterly Journal of Experimental Psychology, 19,* pp. 289-299, 1967.
18. L. R. Brooks, Spatial and Verbal Components of the Act of Recall, *Canadian Journal of Psychology, 22,* pp. 349-368, 1968.
19. N. J. Fortgang, *The Role of Sensory Modalities in the Production of Stimulus-Independent Imagery,* Unpublished Honors Thesis, City College, City University of New York, 1968.
20. S. J. Segal, Processing of Sensory Input Relative to a Constructed Image, Paper presented at the meeting of the Psychonomic Society, San Antonio, 1970.
21. S. J. Segal and V. Fusella, Influence of Imaged Pictures and Sounds on Detection of Visual and Auditory Signals, *Journal of Experimental Psychology, 83,* pp. 458-464, 1970.
22. S. J. Segal, The Perky Effect: Changes in Reality Judgments with Changing Methods of Inquiry, *Psychonomic Science, 12,* pp. 393-394, 1968.
23. J. Stoyva and J. Kamiya, Electrophysiological Studies of Dreaming as the Prototype of a New Strategy in the Study of Consciousness, *Psychological Review, 75,* pp. 192-205, 1968.
24. B. B. Brown, Specifity of EEG Photic Flicker Responses to Color as Related to Visual Imagery Ability, *Psychophysiology, 2,* pp. 197-207, 1966.
25. B. B. Brown, Recognition of Aspects of Consciousness Through Association with EEG Alpha Activity Represented by a Light Sign, *Psychophysiology, 6,* pp. 442-452, 1970.

26. B. B. Brown, Awareness of EEG Subjective Activity Relationship Detected Within a Closed Feedback System, *Psychophysiology, 7*, pp. 451-464, 1971.
27. J. Kamiya and D. Zeitlin, Learned EEG Alpha Wave Control by Humans, Report No. 113, Department of Mental Hygiene, Research Division, California, 1963.
28. P. E. Barratt, Use of the EEG in the Study of Imagery, *British Journal of Psychology, 47*, pp. 101-114, 1956.
29. H. W. Drewes, "An Experimental Study of the Relationship Between Electroencephalographic Imagery Variables and Perceptual Cognitive Processes," Unpublished Doctoral Dissertation, Cornell University, 1958.
30. F. L. Golla, E. L. Hutton, and W. G. Walter, The Objective Study of Mental Imagery, I. Physiological Concomitants, *Jornal of Mental Science, 89*, pp. 216-223, 1943.
31. E. Grynol and J. Jamieson, Alpha Feedback and Relaxation: A Cautionary Note, *Perceptual and Motor Skills, 40*, p. 58, 1975.
32. J. J. Lynch, D. A. Paskewitz, and M. T. Orne, Some Factors in the Feedback Control of Human Alpha Rhythm, *Psychosomatic Medicine, 36*, pp. 399-410, 1974.
33. T. M. Orne and D. A. Paskewitz, Aversive Situational Effects on Alpha Feedback Training, *Science, 186*, pp. 458-460, 1974.
34. D. A. Paskewitz and T. M. Orne, Visual Effects on Alpha Feedback Training, *Science, 181*, pp. 361-363, 1973.
35. B. W. Plotkin and R. Cohen, Occipital Alpha and the Attributes of the Alpha Experience, *Psychophysiology, 13*, pp. 16-21, 1976.
36. R. S. Valle and J. M. Seuine, Expectation Effects in Alpha Wave Control, *Psychophysiology, 12*, pp. 306-309, 1976.
37. D. H. Walsh, Interactive Effects of Alpha Feedback and Instructional Set on Subjective State, *Psychophysiology, 11*, pp. 428-435, 1974.
38. B. B. Meskin and J. L. Singer, Daydreaming, Reflective Thought, and Laterality of Eye Movements, *Journal of Personality and Social Psychology, 30*, pp. 64-71, 1974.
39. J. Rodin and J. L. Singer, Eyeshift, Thought, and Obesity, *Journal of Personality, 44*, pp. 594-610, 1977.
40. J. L. Singer, S. Greenberg, and J. S. Antrobus, Looking with the Mind's Eye: Experimental Studies of Ocular Motility During Daydreaming and Mental Arithmetic, *Transactions of the New York Academy of Sciences, 33*, pp. 694-709, 1971.
41. A. Rechtshaffen and A. Kales, *A Manual of Standardized Terminology, Techniques and Scoring Systems for Stages of Human Subjects*, National Institute of Health Publication No. 204, U.S. Government Printing Office, 1968.
42. D. Algom (Gombosh), *Experimental Enhancement of Imagery by Manipulation of External Stimuli*, Unpublished M.A. Dissertation, Bar Ilan University, Israel, 1974.
43. A. Rabinowitz, Hostility Measurement and its Relationship to Fantasy Capacity, *Journal of Personality Assessment, 39*, pp. 50-54, 1975.

44. P. W. Sheehan, A Shortened Form of Bett's Questionnaire on Mental Imagery, *Journal of Clinical Psychology, 23*, pp. 386-389, 1967.
45. G. H. Betts, *The Distribution and Function of Mental Imagery*, Teachers College, Columbia University, New York, 1909.
46. R. Gordon, An Investigation into Some of the Factors that Favour the Formation of Stereotyped Images, *British Journal of Psychology, 39*, pp. 156-167, 1949.
47. J. L. Singer and J. S. Antrobus, A Factor-Analytic Study of Daydreaming and Conceptually-Related Cognitive and Personality Variables, *Perceptual and Motor Skills*, Monograph Supplement 3-V17, 1963.
48. D. Algom and I. Lewin, Fantasy: Facts, Definitions and Methods, *Megamot, 24*, pp. 363-386, 1979 (Hebrew; English abstract).
49. G. Atwood, An Experimental Study of Visual Imagination and Memory, *Cognitive Psychology, 2*, pp. 290-299, 1971.

ACKNOWLEDGEMENT

The authors are extremely grateful to Mrs. Tamar Algom for her valuable assistance during the final preparation of this paper.

Direct reprint requests to:

Dr. Daniel Algom
Department of Psychology
Bar-Ilan University
Ramat-Gan, Israel