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The Effect of Lysergic Acid Diethylamide (LSD-25) on Perception with Stabilized Images*

By

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With 2 Figures in the Text

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Lysergic acid diethylamide (LSD-25) produces a variety of behavioral states which have been compared with symptoms characteristic of mental patients. LSD-25-induced behavioral changes which are similar to pathological states include shifts in performance on the Bender Gestalt test (ABRAMSON et al. 1955b), increases in reaction time to visual and auditory stimuli (ABRAMSON et al. 1955a), and de-differentiation of responses to traumatic and non-traumatic stimuli (WEINTRAUB et al. 1959).

In addition, there is some evidence for perceptual dysfunction caused by LSD-25. For example, LIEBERT et al. (1957) reported deficits in the judgment of verticality, and WAPNER and KRUS (1959) found that the judgment of the apparent horizon is affected. As yet, however, neither the behavioral nor the perceptual changes induced by the drug are well understood.

With the development of a convenient method for the presentation of stabilized visual stimuli (PRITCHARD 1961), a new approach to the fundamental mechanisms underlying visual perception is available. Normally, small ocular movements ensure the projection of the stimulating image over an extended area of the retina. Stabilized viewing of the target restricts this fluctuating stimulation to a small retinal area.

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As a result, a whole figure or particular segments of it appear to fade and regenerate. Characteristics of the stimulus such as total complexity and contiguity and parallelism of the elements determine both the duration of visibility and the pattern of fading (PRITCHARD et al. 1960; TEES 1961). Furthermore, COHEN (1961) and KRAUSKOPF and RIGGS (1959) have shown that fading and regeneration are at least partially determined by processes occurring beyond the receptor level. The stabilized image procedure, therefore, provides a means for investigating fundamental perceptual processes: its use in conjunction with administration of LSD-25 could provide information about the perceptual effects of the drug.

The present experiments represent an attempt to investigate how LSD-25 alters the pattern of fading and regeneration of two geometric figures.

Method

Two separate experiments, each employing four *S*s, were carried out. In both experiments, all *S*s participated in a series of six testing sessions.

The stabilizing system consisted of a variable focus collimating projector attached to a suction contact lens (Lo-Vac diagnostic fundus lens) filled with physiological saline. The target was inserted beneath a plastic diffuser which was surrounded by a shield to prevent any admission of light to the eye except through the collimating device. All testing was carried out with monocular vision of the left eye, the right eye of the *S* being occluded.

A 6-volt, 108-watt DC ribbon filament lamp, powered with a 6-volt, wet cell battery, provided the light. The beam was directed onto the stabilizing system through a heat absorbing filter by means of a tilted mirror.

The targets were drawn with India ink on white paper; the photographed negative was used in testing.

LSD-25 or a placebo (physiological saline) was administered intravenously one hour prior to beginning of testing. In order to avoid any habituation to the drug, sessions were separated by an interval of no less than six days. The testing was carried out in a darkened, partially sound-proofed room. *S*'s cornea was anaesthetized with $^1/_2\%$ Pontocaine prior to the insertion of the lens. Verbal reports of the perceived changes of the target were tape-recorded and the testing sessions terminated when visibility of the target deteriorated noticeably, or after 15 to 20 min.

The Minnesota Multiphasic Personality Inventory and the Maudsley Personality Inventory were administered to all *S*s. All scores were within the normal range on both tests.

Experiment I

Subjects and Procedure. Four university students, two male and two female, were used as *S*s. One gamma of LSD-25 per kg of body weight was administered in three drug sessions. These were alternated with three placebo sessions in random order in a double blind procedure.

The target is shown in Fig. 1. Its length was .58 mm, and its height .39 mm. When stabilized, the target subtended 2° of the visual field.

*Scoring. S*s' reports were tape-recorded and scored later. Each change in the perception of the target, whether fading or regeneration, was scored. Since a large number of different fragments was reported, the data were condensed. Each report was classified in one or more of the categories listed in Table 1. These categories deal with the various closed figures which could arise from the target, and with the presence or absence of the two pairs of parallel lines. Reports that could be classified in Group A were not scored in any other category. Other reports were scored in each of groups B, C, and D. Fading of both verticals, for example, would be scored in categories 4, 5, and 8. Any perception which could have arisen through distortion of the original target was scored as a distortion or illusion.

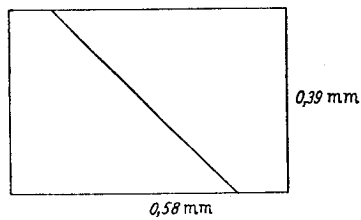

Fig. 1. Target used in Experiment I

Since the number of reports varied from session to session, percentage scores were obtained by dividing the scores in each category by the total number of reports in the testing session.

Table 1. *Categories used in scoring reports*

		Experiment I
A.	1. Intact target	Regeneration of the whole figure
	2. Intact rectangle	Fading of bisecting line or incomplete regeneration
B.	3. Intact left or right segment	Complete fading or regeneration of either segment only
	4. Open figure	Partial fading or incomplete regeneration of both segments
C.	*Horizontal parallels*	
	5. Visible	Upon regeneration, or after fading of other parts
	6. Faded	Upon incomplete regeneration or fading
D.	*Vertical parallels*	
	7. Visible	Upon regeneration, or after fading of other parts
	8. Faded	Upon incomplete regeneration of fading
E.	9. Illusions and distortions	

Results. Mean percentage scores for the various categories obtained by each *S* in placebo and drug sessions are shown in Table 2. Separate analyses of variance were carried out on the scores in each category. The drug × *S*s interaction was tested against the within-cells error term. The resultant F ratio exceeded the 25% level of confidence only for the data on intact rectangles. Therefore, the drug effect was tested against the pooled within-cells and drug-by-*S*s error terms in all other cases. The drug effect for intact rectangles was tested against the drug × *S*s term.

Table 2. *Experiment 1: Mean percentage scores for drug and placebo conditions, and for one schizophrenic subject*

	Placebo $N = 4$		*Drug* $N = 4$		F[a]	*Schizophrenic* $N = 1$
	Mean	*Range*	*Mean*	*Range*		*Mean*
Intact target	33	10—51	44	19—59	5.42	49
Intact rectangle	22	7—51	15	0—31	1.11[b]	28
Intact left or right segment combined	4	0—16	7	0—32	2.95	13
Open figures	31	3—72	19	5—55	4.03	3
Horizontal parallels faded	5	0—13	5	0—12	< 1	1
Horizontal parallels visible	15	1—55	8	0—37	1.98	1
Vertical parallels faded	15	1—45	8	0—31	4.08	0
Vertical parallels visible	4	0—9	7	1—17	2.27	0
Illusions and distortions (raw scores)	1	0—7	8	0—20	12.40	0

[a] All F tests employ the pooled drug-by-*S*s and within-cells terms. For 1 and 19 df, an F of 4.38 reaches the 5% level, 2.99 the 10% level, and 1.76 the 20% level.

[b] Drug effect tested against drug × *S*s interaction (1 and 3 df).

The visibility of intact targets increased significantly in the drug condition ($p < .05$). Reports of intact segments also tended to increase ($p < .20$), while the incidence of open figures decreased ($p < .10$) under the influence of the drug.

The visibility of vertical parallels tended to increase during drug sessions. Under LSD-25, the simultaneous presence of the vertical parallels increased somewhat ($p < .20$), and their simultaneous fading decreased ($p < .10$). Little change could be detected in reports concerning horizontal parallels.

Illusions and distortions were reported by one *S* during placebo sessions; in contrast, all four *S*s experienced distortions during drug sessions. There were isolated reports of rounded corners, and of the target

telescoping, i.e., the two segments appearing superimposed. Random rearrangements of the four corners and appearances of lines not forming part of the target were reported occasionally. Three of the *Ss* reported changes in size, bulging, expansion or contraction and motion of the target in the field of vision. One type of illusion reported frequently by all four *Ss* concerned the bisecting line: it was seen rotated from its original position, or its central portion was bent in an upward or downward direction. Furthermore, two crossed lines were reported in several instances.

Thus, in addition to illusions and distortions, the main effect of the drug on the visibility of the target presented in this study appears to be an increased number of reports of closed, intact figures.

One schizophrenic subject was also tested with the target used in this experiment. This *S* was tested once when he was not on medication, and once when he was receiving daily doses of tranquilizers. The results of the two sessions were quite similar, and mean values are shown in Table 2. The pattern of fading observed by this *S* was similar to that reported by normal *Ss* under the influence of LSD-25. In addition, the patient experienced long periods during which no fading occurred at all.

Experiment II

In the second study, an attempt was made to isolate the factors which might account for increased visibility of the intact target. In order to evaluate the contribution of parallel lines to the visibility of whole figures, a target was designed that contained a closed figure without parallel components. One of the sides of the closed figure, however, was parallel with a line outside of this figure. If the drug contributes to increased visibility of closed figures, the extraneous lines should fade more frequently. On the other hand, increased stability of parallel lines under the drug might result in decreased visibility of the closed figure. This target, of the same size as that used in Experiment I, is shown in Fig. 2.

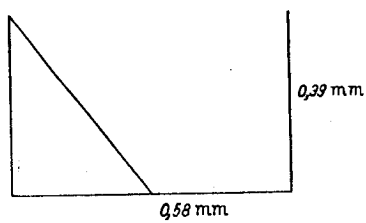

Fig. 2. Target used in Experiment 2

Subjects and Procedure. Four male *Ss*, two university students and two professional musicians, participated in this experiment. None of these *Ss* had been used in the first experiment. All *Ss* participated in six testing sessions. The testing procedure was same as in the first study, except for the changes to be described. Two drug levels were used: one gamma of LSD-25 per kg of body weight and one half gamma of the same drug per kg of body weight were administered in two sessions each.

In the remaining two sessions, the *S*s were injected with the placebo. The two levels of LSD-25 and the placebo were administered in an order balanced over *S*s. In three sessions, the target was presented with its triangle oriented to the right; in the remaining three sessions the position of the triangle was reversed. Two *S*s were shown the target with the triangle oriented to the right first; the remaining two *S*s saw the left-oriented target first.

Scoring. The scoring procedure was the same as that used in the first experiment except for the changes necessitated by the use of a different target. The scoring categories are shown in Table 3.

Table 3. *Categories used in scoring reports*

	Experiment 2
A. 1. Intact target	Regeneration of the whole figure
B. 2. Intact triangle	Fading of the open part of the figure or incomplete regeneration
C. 3. Intact triangle plus	Incomplete fading of the open part or incomplete regeneration of the same
D. 4. Parallels visible	Upon regeneration, or after fading of other parts
5. Parallels faded	Upon incomplete regeneration or fading
E. 6. Illusions and distortions	

Results. A comparison of the mean percentage scores obtained in drug and placebo sessions for the two orientations of the target is shown in Table 4.

Table 4. *Experiment 2: Mean percentage scores for drug and placebo conditions*

	Triangle on left $N = 4$					*Triangle on right* $N = 4$				
	Mean scores			*t*		*Mean scores*			*t*	
	PL	LD	HD	PL–LD	PL–HD	PL	LD	HD	PL–LD	PL–HD
Intact target	24	28	33	.76	1.80	34	39	33	.76	.66
Intact triangle	11	1	4	1.40	1.00	4	8	8	.97	2.08
Intact triangle plus	15	11	14	—	—	10	12	20	.73	1.89
Parallels visible	22	47	41	1.74	1.73	38	24	27	1.08	.85
Parallels faded	16	5	4	2.26	1.91	2	10	9	2.73	2.03
Illusions and distortions (raw scores)	2	0	3	—	—	1	0	3	—	—

PL = Placebo; LD = Low drug dose 0.5 gamma/kg; HD = High drug dose 1.0 gamma/kg.

A *t* of 2.35 reaches the .05 level of significance with a 1-tailed test. Values of 1.64 and .98 reach the .10 and .20 levels, respectively.

Visibility of the intact target tended to increase in the drug condition in both orientations; however, the increase approached significance in left orientation only ($p < .10$).

When the target was oriented to the left, the drug tended to decrease visibility of intact triangles ($p < .20$). In addition, more reports of parallels present ($p < .10$) and a reduction of their simultaneous fading ($p < .10$) was obtained in the same condition.

The drug had a converse effect on the perception of the target when it was oriented to the right. This is apparent in more frequent reports of intact triangles in comparison with placebo sessions ($p < .10$) and also in the significantly lower visibility of parallels ($p < .05$).

Table 5 compares the two orientations of the target in placebo as well as in high drug sessions.

Table 5. *Experiment 2: Mean percentage scores for orientation differences in placebo and high drug conditions*

	Placebo ($N = 4$)			*High drug* ($N = 4$)		
	Triangle left	*Triangle right*	*t*	*Triangle left*	*Triangle right*	*t*
Intact target	24	34	1.25	33	33	—
Intact triangle	11	4	1.00	4	8	1.47
Intact triangle plus	15	10	.75	14	20	1.88
Parallels visible	22	38	1.01	41	27	7.93
Parallels faded	16	2	2.06	4	9	1.15

A t of 2.35 reaches the .05 level of significance with a 1-tailed test. Values of 1.64 and .98 reach the .10 and .20 levels, respectively.

Trends toward left-right differences in the various categories were found upon comparison of placebo sessions. The intact target was reported more often in right orientation, while the triangle was reported more often in left orientation (both $p < .20$). Visibility of parallels increased in right orientation ($p < .20$), accompanied by a decrease in fading of parallels ($p < .10$).

Similarly, the effect of the drug was different, depending on the orientation of the target. More triangles were reported in drug sessions if the right-oriented target was viewed ($p < .20$ and $p < .10$ for triangle plus category). The role of orientation in the effect of the drug was most clearly demonstrated in the visibility of parallel lines. Here, greater visibility in the left orientation was highly significant ($p < .01$).

Only two *S*s reported illusions or distortions. In one case, all reports of illusions occurred during the two placebo sessions and were of the completion type. These involved the perception of a second triangle in the open side of the target, or, if the horizontal had faded, of an "M"

shaped figure. In a few cases, the triangle was reported to appear solid. The second *S* experienced distortions only in the two high drug sessions. Over half of the reports of illusions or distortions involved bending of the hypotenuse or other lines of the target. The remaining distortions were changes in size, stretching and moving of the target.

Discussion

The effects of LSD-25 were, in certain respects, similar in the two experiments. The frequency of reports of whole figures increased and the visibility of vertical parallels was facilitated by the drug in Experiment I and in Experiment II when the target was oriented to the left. Although these results reached statistical significance only in the first experiment, their replication in the second study lends them added importance.

In addition to its effect on central synaptic conduction (MARRAZZI 1962; PURPURA 1956), LSD-25 modifies the activity of the autonomic nervous system (JACOBSEN 1960). The latter changes might involve peripheral effects as determinants of the results obtained in the present study. The dilatation of the pupil caused by the drug, however, is unlikely to have contributed to our findings; PRITCHARD (1958) reported that visibility of stabilized figures is unaffected by changes in intensity of illumination. GARCIA-AUSTT et al. (1963), holding illumination constant but controlling pharmacologically the diameter of the pupil, found the waning of visual evoked potentials to be independent of pupillary diameter.

Some of our results might be explained by the effect of LSD-25 on involuntary eye movements. The eye movements of one subject were recorded during fixation, both in the normal state and under influence of the drug. It was found that "flicks", the rapid, jerky motions which compensate for the slow drift of the eye, were over twice as frequent in the drug condition as they were in the normal state. These flicks might produce a destabilization of the lens in the horizontal plane (BARLOW 1963). The greater visibility of vertical parallels and the larger number of reports of whole figures might, therefore, be attributed to the increase in eye movement caused by LSD-25.

In the second experiment, however, the frequency of visibility of the triangle and of the parallel lines depended on the orientation of the target. The favorable orientation for the visibility of either fragment in the placebo condition was reversed in the drug sessions. Such an orientation-dependent visibility of fragments appears to exclude changes in frequency of eye movements, or other peripheral changes, as a complete explanation of partial fading and regeneration.

A detailed analysis of the two orientations in the placebo condition of Experiment II (Table 5) showed that the only left-hander among the

four subjects reported a higher number of fragments in orientations that were opposed to those of the right-handed subjects. Such discrepancies did not occur in the drug condition. While the influence of handedness on selective perception is beyond the scope of the present study, left-right differences in tachistoscopic recognition have been related to handedness by BRYDEN (1964).

Besides the changes in pattern of fading, LSD-25 also increased the frequency of illusory reports. Except for one subject who reported completions during the placebo sessions of Experiment II, the majority of the illusory reports involved distortions and rotations of the diagonal line.

While all subjects in the first experiment reported illusions or distortions under LSD-25, only one subject in the second experiment did so. This would suggest that the frequency of distortions is determined to a great extent by the configuration of the target. Although it is not certain what characteristic of the first target determines the higher frequency of distortions, it may be significant that virtually all of the distortions affect the perception of the diagonal line. This line bisects a "good figure" in Experiment I, but not in Experiment II.

The effects of LSD-25 on the perception of stabilized images show some consistency with MEEHL's (1962) notion of the relation between deficient neural inhibition and perceptual dysfunction. For instance, a deficiency in inhibition should result in an increase of visibility of stabilized targets, as was observed in both experiments. The long periods during which the schizophrenic subject experienced no fading, and the similarity of his data to those obtained from normal subjects under LSD-25 also provide a certain amount of support for MEEHL's ideas.

In summary, there are reliable differences between the drug and placebo conditions in the visibility of parallel lines, and whole figures. Since the visibility of certain fragments depends on the orientation of the target, however, a variety of factors, not yet clearly understood, must be involved in determining the particular pattern of fading and regeneration. Further studies are necessary to assess the relative contributions of target asymmetry, handedness, and increased involuntary eye movements.

Summary

Two experiments were conducted to investigate the effects of lysergic acid diethylamide on patterns of fading and regeneration of stabilized retinal images.

Under the drug, the whole target was visible more often than with a placebo, and distortions of the target were reported more frequently. In addition, the visibility of the vertical components of the targets

increased under LSD-25. These changes, however, depended on the orientation of the figure. In the placebo sessions, the left side of the figures was visible more often.

Possible factors contributing to these results are discussed.

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