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Visual Illusion, Tactile Sensibility and Reaction Time under LSD-25

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One of the most interesting aspects of the lysergic acid diethylamide (LSD-25)[1] experience is the sensory changes that are mentioned by most subjects receiving one to two mcg/kilo. The alterations are variously described as an intensification of the viewed object, increased brilliancy and saturation of color, enhanced perception of depth and texture, and various somaesthetic sensations. Illusions, for example, the movement and change of fixed forms are often reported. The literature pertaining to LSD-25 is, in general, heavily loaded with subjective reports of these sensory alterations.

The psychophysiological mechanism of LSD-25 action has not been identified; but ABRAMSON (1955) conducted a series of descriptive experiments which seems best interpreted as a central impairment of sensory modalities. CARLSON (1958) demonstrated a rise in the brightness threshold under LSD-25, and KRILL (1960) expanded these results by using the electroretinogram (ERG) as the response measure. As a result of both the introspective reports and of the basic experimental researches cited above, it seemed worthwhile to gain additional orderly data on a broad sample of both sensory and performance tasks from a reasonable sample of subjects in order to better delineate the effects of LSD-25. The measurements taken were selected according to three criteria: 1. Classic, easily replicated. 2. Simple responses required by the Ss. 3. Diverse sampling of sensory qualities.

Subjects. Fifteen volunteer unpaid subjects, four women and eleven men from 24 to 48 years of age with an average educational level of two years of college were given 125 mcg of LSD-25 in tablet form. They were permitted to rest quietly or listen to music for three hours. During the next sixty minutes the required testing was conducted. The third and fourth hours following oral LSD-25 ingestion is considered to be the

[1] The LSD-25 used in this study was donated by Mr. HARRY ALTHOUSE, Sandoz Pharmaceuticals, San Francisco, California.

period of maximal activity. The usual precautions to safeguard the subjects were taken (COHEN, 1960). The subjects were divided into two groups, both groups were tested on two occasions at intervals of three to seven days. Group I was tested first under LSD-25, later under non-drug (control) conditions. Group II was tested under control conditions first, followed by LSD-25 testing on the second occasion. Twelve sensorimotor measurements were taken from the subjects, the order of measurements being varied randomly between subjects. For all measurements the differences between Groups I and II were examined within each by an Analysis of Variance. In all cases this order effect was found to be non-significant ($p > 0.30$).

Reaction time. The subject was seated at a table before a black panel containing one green and two red jewel lights forming an equilateral triangle with the lights three inches apart. A doorbell buzzer was behind the panel and two telegraph keys were on the table at subject's left and right. With the exception of the disjunctive test, the subject always used his preferred hand. He was instructed: "When E says 'ready', you are to depress the key(s); when the appropriate stimulus comes on, you are to release the key as quickly as possible." The time required for the subject to release the key after the appropriate stimulus was presented was measured by a standard electric timer in milliseconds (ms). The warning signal "Ready" was presented irregularly between one and five seconds before the appropriate stimulus for each trial. Four practice trials were allowed, and ten measurements were taken on each test.

Test I: Reaction time, simple, light. The green jewel light was the appropriate stimulus.

Test II: Reaction time, disjunctive, light. Subject placed his left hand on the left key and his right hand on the right key. The ipsilateral red lights were the appropriate stimuli, that is, the subject responded to the left light with his left hand and to the right light with his right hand. The left and right lights were presented five times each in a random sequence.

Test III: Reaction time, discrimination, light. The subject was instructed to respond only to the left red jewel light as the appropriate stimulus. The green light, the right red light, the buzzer, and the appropriate stimulus were presented in a random sequence.

Test IV: Reaction time, simple, buzzer. The buzzer was the appropriate stimulus.

Table 1 comprises the obtained results. Tests I, II and III were evaluated by a Lindquist (1953), Type VI Analysis of Variance Test IV by a Type I Analysis of Variance.

Table 1. *Reaction times*

Test	N	Mean time (ms)		p
		Control	LSD-25	
I Simple, Light	15	234.47	259.53	<0.01
II Disjunctive, Light	15	239.93	260.53	<0.01
III Discriminative, Light	15	240.60	264.13	<0.01
Relative Time Units[1]				
IV Simple, Buzzer	8	44.38	54.88	<0.14

[1] Electric timer connected in series with buzzer interrupting clock time by a constant but unassessed amount.

The uniform lengthening of reaction times is different from the results reported by ABRAMSON (1955). He administered 50 and 100 mcg of LSD-25 to his subjects and did not obtain significant changes in their reaction times with a similar task. There was, however, a trend apparent in his data suggesting longer reaction times with larger amounts of LSD-25. Our data can then be considered as an extension of his work reflecting the difference in dosage.

Color detection. Subject was seated ten feet from a translucent light filter 12.5 cm. in diameter surrounded by a black panel. Behind the filter were red, blue, green, and white 7.5 watt light bulbs. The white light was maintained constant at 110 volts. The red, green and blue bulbs were each connected through a 0—110 volt variac so that the voltage to each could be varied through its entire range. Subject was instructed that this was a test to perceive colors, and the range of colors was demonstrated to him. He was instructed to close his eyes and when told to open them to quickly name the color of the filter. The Method of Constant Stimuli was used with red, green and blue colors being presented singly, in random sequence, and with varying voltages. The smallest amount of voltage applied to each lamp where the subject could discriminate the color of the filter from white was taken as the threshold of color detection. The data were evaluated by a Lindquist Type VI Analysis of Variance. No differences attributable to LSD-25 were found.

Our finding of no color detection differences due to LSD-25 is consistent with KRILL's (1960) report. The behavioral effects of the persistently reported b-waves (scotopic) aberrancies (APTER and PFEIFFER, 1957, KRILL et al., 1960) in electroretinographs taken under LSD-25 conditions do not appear to be assessable by this method.

Size constancy. The standard stimulus was a bright yellow isosceles triangle 10 cm. high and 5.5 cm. at the base affixed to a black background one foot square. The variable stimulus was a similar triangle

which was manipulated from 0 to 20 cm. in altitude with a bridle in front of a black background three feet by three feet. The subject was seated 300 cm. from the variable stimulus with the standard stimulus interposed 30 cm. from subject, who was instructed as follows: "The yellow triangle at the end of the room will change in size from large to small or vice versa. When it appears to be the same size as the triangle next to you say 'stop'." The Method of Average Error was used, five ascending and five descending measurements were taken. A task identical to the above except that the standard stimulus was placed 180 cm. from the Subject was also performed. Table 2 comprises the obtained results. A Lindquist Type VI Analysis of Variance was used to evaluate the data.

Mueller-Lyer illusion. The standard stimulus was a black line 13 cm. long with four enclosing lines 3.5 cm. long fixed at 45 degree angles from the end of the line. The variable stimulus extended from the right terminus of the standard, one pair of its expanded end lines being common with the standard, the opposite pair independent. The subject was seated 300 cm. away and instructed as follows: "The variable line will lengthen or shorten. When it appears to be as long as the standard say 'stop'." The Method of Average Error was used, four ascending and four descending trials were administered in random sequence. Table 2 comprises the results. A Lindquist Type I Analysis of Variance was used to evaluate the data.

Table 2. *Spatial perception*

Test	N	Means (cm)		p
		Control	LSD-25	
Size Constancy 10 cm standard				
30 cm.	15	9.89	10.34	<0.01
180 cm.	15	10.26	10.29	<0.70
Mueller-Lyer Illusion 13 cm standard .	15	9.82	9.60	<0.07

Size constancy is the normal, but difficult to understand, tendency for organisms to perceive identical objects at varying distances as the same size. The phenomenon is covered in some detail in WOODWORTH and SCHLOSBERG (1954), but briefly, it can be stated as follows: Where the interocular distance from the lens to the retina is given as d, the size of the image projected on the retina as a, the distance from the lens to an object as D and the size of the object, as A; two similar triangles can be constructed with common apices in the center of the lens. The equation describing the size of the retinal image is then: $a = \frac{Ad}{D}$.

If the size of the retinal image was the appropriate stimulus for object size, then two objects, A_1 and A_2 at distances D_1 and D_2 would

appear the same size when $a_1 = a_2$. Thus, in this experiment, with A_1 (the standard stimulus) = 10 cm., $D_1 = 30$ cm., $D_2 = 300$ cm., A_2 (the variable stimulus) should have appeared the same as A_1 when it was 100 cm. high. Size constancy refers to the phenomenon that, under normal conditions and intermediate distances, A_2 appears the same size as A_1 when they are, in fact, the same size regardless of their differential distances. Size constancy can be nullified by reducing the extra-object visual field with darkness or artificial pupils (HOLWAY and BORING, 1941). To the extent that LSD-25 *functionally* reduces the extra-object visual field, a shift away from constancy, i.e. a tendency requiring the comparison object to be larger than the standard would be expected. This was obtained when the standard was 30 cm. away but not when it was 180 cm. from the subjects.

Although the statistical significance level of the change in the Mueller-Lyer judgments is somewhat indeterminant, the tendency is for subjects to be more susceptible to the illusion under LSD-25. KRUS and WAGNER (1959), using similar procedures did not obtain any effect on the illusion due to LSD-25 but their subjects received only 75 mcg. making direct comparison between the studies difficult.

Warmth detection. Two identical 23.5 watt soldering irons with copper tips 1.5 cm. long and 0.3 cm. in diameter were used. One iron was kept at room temperature, the other iron was connected through a 0—110 volt variac such that its voltage could be varied through the full range. The subject was seated in front of a table and instructed as follows: "Place both of your hands on the table with palms down and close your eyes, I will place one of these irons on the back of each hand. Tell me which is the warmer." The irons were placed on identical contralateral locations, randomly shifted from left to right, and allowed to rest by their own weight. An ascending Method of Limits was used, the voltage being gradually increased on the variable iron between tests until subject responded with four correct identifications. The voltage impressed on the variable iron was taken as the index of heat which could be differentiated from the standard. Table 3 comprises the results, a Lindquist Type I Analysis of Variance was used.

Two-point discrimination. A pair of steel dividers with 21 cm. legs was used, and subject was instructed as follows: "Place your right hand on the table, palm down, and close your eyes; the dividers will be placed on the back of your hand, with either one or two points. Each time this is done say 'one' or 'two'." The spread at which 50% correct responses were received was taken as subject's threshold. Table 3 comprises the results, a Lindquist Type I Analysis of Variance was used.

Cutaneous discrimination, as measured by these indices, is impaired. Neither of these measurements yield absolute threshold data, therefore

Table 3. *Skin sensitivity*

Test	N	Means		p
		Control	LSD-25	
Difference Threshold Warmth .	14	9.18 volt	10.68 volt	<0.09
Two-point Discrimination	5	1.04 cm	2.02 cm	<0.03

direct information about the analgesic properties of LSD-25 cannot be ascertained, only that the ability to discriminate cutaneous sensations is impaired by the drug.

Discussion

No simple generalization is apparent to interpret the data. If processes like attention or discrimination were affected by LSD-25 a differential effect on the reaction time tests could be expected, i.e. the disjunctive or discriminative tests would be more affected by LSD-25 than the simple ones. Instead, a near perfect linearity was obtained; the F-ratio of the drug condition by Reaction Time Test interaction was only 0.28, a result which does not support an "attention impairment" interpretation.

The illusions, i.e., the Mueller-Lyer and Size Constancy were both influenced. Subjects usually reported, although it was not measured here, a pronounced reduction of peripheral vision ("tunneling"). The shift away from size constancy along with the intensification of the M-L effect may both be attributed to a reduction in the visual cues surrounding the stimulus.

The general impairment of skin sensations might lead one to expect a concomitant damping of proprioceptive sensations. Subjects do typically report delusional body sensations, e.g., "My arm doesn't belong to me". If proprioceptive sensations are, in fact, impaired, the nature of the drug effect on the reaction time tasks might be identified.

An overall reduction in sensation, i.e., a damping of somaesthetic information and a reduction of cues from the surround may then account for some of the unusual subjective sensations. The illusogenic effect might represent such a loss of orienting sense data.

Summary

A series of standard tasks: reaction times; simple light, simple buzzer, disjunctive light, and discriminative light; warmth detection, two-point discrimination, size constancy, Mueller-Lyer illusion, and color detection, were administered to subjects under LSD-25 and control states. A general impairment of reaction time and skin sensitivity was obtained. Color detection was unaffected and the illusions were enhanced. The data were interpreted as representing the result of damping of somaesthetic sensations and a reduction in visual cues.

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