Published as a separate and in *The Journal of Psychology*, 1955, **39**, 455-464.

LYSERGIC ACID DIETHYLAMIDE (LSD-25): VII. EFFECT UPON TWO MEASURES OF MOTOR PERFORMANCE*

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A. INTRODUCTION

The psychic effects of lysergic acid diethylamide are so dramatic (4, 7, 10, 15) that one tends to overlook possible psychomotor changes. Our prior experiences showed that LSD-25 produces subjective disturbances in coördination and body control (1). Studies with other drugs have shown that both caffeine (5,8) and tobacco (3,17) increase tremor as measured with some form of a stylus and hole apparatus. Pursuit meter performance undergoes impairment when subjects are under the influence of alcohol and when they are at altitudes above 13,000 feet (9, 11, 12). Arm-hand coördination is reduced by altitudes above 10,000 feet (13).

The purpose of this paper is to report the effects of lysergic acid diethylamide on performance on two tests of hand-eye coördination: (*a*) an adaptation of the Dunlap steadiness test, where the subject must remain immobile, and (*b*) the pursuit rotor test, where the subject must follow a moving target. It was found that LSD-25 interferes, to some extent, with performance on each of these tests.

B. METHOD

1. *Subjects*

There were six male and six female volunteer adults who received payment for participation in the experiments. Only those who were considered non-psychotic on a psychiatric interview and a battery of clinical psychological tests (1) were acceptable subjects. Intelligence as measured by the Wechsler-Bellevue Intelligence Scale, ranged from average to superior. Eight subjects were in the latter group. The median age was 27, ranging from 21 to 33. Median weight was 135 pounds, ranging from 103-175 pounds.

*Received in the Editorial Office on January 10, 1955, and published immediately at Provincetown, Massachusetts. Copyright by The Journal Press.

[1]This investigation was aided by a grant from the Geschickter Fund for Medical Research. We are indebted to Sandoz Pharmaceuticals, Incorporated, for supplies of LSD-25 and other compounds.

There were seven graduate students in psychology or allied fields, two housewives, an auditor, a hair-dresser, and a public relations worker.

2. *Apparatus*

The pursuit rotor consisted of a phonograph turntable, 23.2 cm in diameter, which rotated 33 1/3 and 78 revolutions per minute. There was a round copper button, 8 mm in diameter, situated 7.5 cm from the center of the turntable. The subject followed this button with another button 8 mm in diameter, at the end of the movable arm of a hinged stylus 25 cm in length.

The steadiness apparatus was an adaptation of that of Dunlap described by Spaeth and Dunham (14). It consisted of a copper plate with two holes, 8 mm and 4 mm in diameter. The subject held the wooden handle of a steel stylus, 23 cm in length and 2.5 mm in diameter. The time in contact with the button was recorded during five continuous 10-second trials by means of an electric timer. The number of contacts and the time in contact with the sides of the holes were also recorded during five continuous 10-second trials.

3. *Procedure*

a. Administration of drug. At 9:30 a.m. the subjects received the drug in 75 cc of water. All subjects were tested three times at least one week apart, under three different drug doses. Eight subjects were tested four times. The first and fourth sessions were zero dose placebos where only 75 cc of water was given to the subjects. At the second and third sessions the subjects received 50 and 100 micrograms of lysergic acid diethylamide, respectively. Since LSD-25 is a colorless, tasteless, and odorless compound the subjects could not detect the dose they received. The first placebo experiment served as a control of the effects produced by variables other than the drug. The second placebo helped evaluate the effects of repeated practice in the same experimental situation with the same tests.

Two experimenters gave the drug (and the tests) to the subjects in groups of 3, 4, or 5. The doses among the group usually varied in a given day. The administration took place in an air-conditioned room where the subjects had been pre-tested and interviewed. One-half hour after the ingestion of the drug the subjects, who had eaten no food since the previous evening, ate a light breakfast. No stimulants such as coffee or tea were permitted and smoking was not allowed during the entire test period.

b. Administration of tests. The pursuit-rotor and steadiness tests were

administered individually approximately 2 to 2½ hours after administration of the drug. This was within the time range of maximum drug effect (1). They were preceded by a series of group tests of memory, cancellation, arithmetic, and spatial relations. The pursuit rotor test was given while the subject was standing. The instructions were: "You are to try to keep the point of the stylus in contact with the moving button." The subject then attempted to follow the button rotating at 33 1/3 revolutions per minute. The time (in seconds) in contact with the button was recorded every 10 seconds for 50 seconds. Without warning the subject, the experimenter abruptly increased the turntable speed from 33 1/3 revolutions per minute to 78 revolutions per minute. The time was recorded every 10 seconds for 50 seconds.

In the steadiness test the subject sat behind the copper plate and was given the following instructions: "Keeping your arm extended, you are to insert the stylus through the large hole to a depth of about one inch and hold it there without touching the sides of the hole." The number of contacts and the time (in seconds) in contact with the sides of the hole were recorded every 10 seconds for 50 seconds. The subject then held the stylus in the small hole and another five 10-second recordings were taken. The 33 1/3 rpm sub-test on the pursuit rotor and the small hole steadiness tests were added to the battery after the first experimental day, thereby reducing the number of subjects whose data were available for statistical analysis.

c. Analysis of data. The average time in contact during the 50-second period under each dose was computed for the pursuit rotor and steadiness tests. The average number of contacts on the steadiness tests was also computed for each dose. The averages for a given test did not include the data of subjects who were not tested at all three doses.

The scores obtained under the first three doses on each of these tests were compared, two at a time, by means of the Wilcoxon non-parametric test of paired replicates (16) to determine whether there were significant differences between any two doses. This technique was also used to determine whether there was any significant improvement occurring with practice on the test. The pre-drug zero scores and the post-drug zero scores were compared.

The Spearman rank-order correlation (6) method related the rank position of the subject's scores under two doses. The three doses were related, two at a time. The correlation indicates the predictability of a rank position under one dose from the rank position under another.

C. Results

Figure 1 shows the mean number of seconds out of 50 seconds in which the subjects were in contact with the copper button on the pursuit rotor test. The longer the time in contact the better the performance. At 33 1/3 rpm

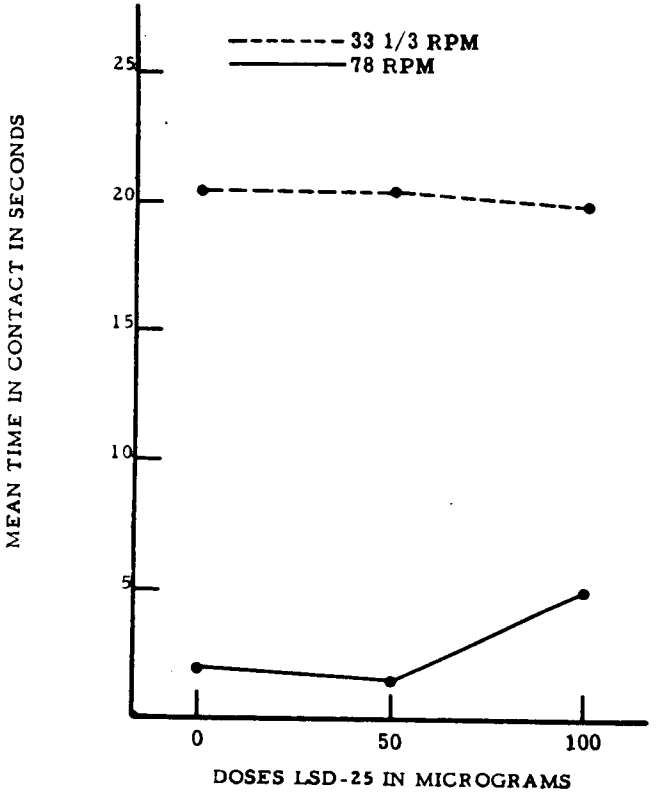

FIGURE 1

Mean time in contact, in 50-second period, with rotating button. Nine subjects were tested under zero and two LSD-25 doses at 33 1/3 rpm and 11 subjects at 78 rpm.

the mean time in contact remained approximately the same under the pre-drug zero and under 50 micrograms of LSD-25, but dropped slightly under 100 micrograms of the drug. At 78 rpm the mean time in contact dropped slightly with doses of 50 micrograms; it increased above the zero dose average with doses of 100 micrograms. All of these changes could have occurred by chance more than 5 times in 100 trials, with the number of subjects used. There were nine subjects tested at 33 1/3 rpm and 11 subjects at 78 rpm under all three doses.

On the steadiness tests the time in contact with the sides of the large and small holes is plotted in Figure 2. The time in contact increased with increasing dosage. The time in contact with the sides of the small hole was always greater than the time in contact with the sides of the large hole,

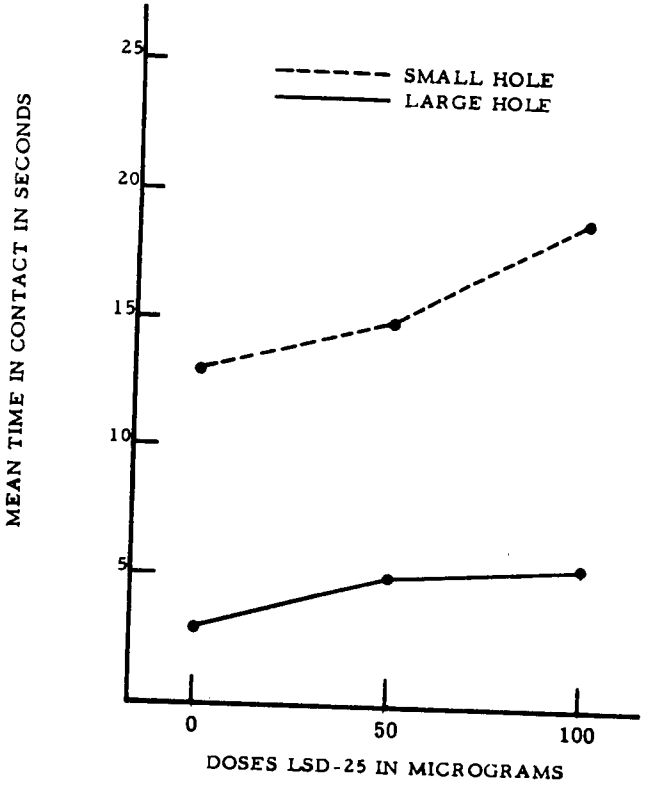

FIGURE 2

Mean time in contact, in 50-second period, with the sides of a large and small hole. Twelve subjects were tested under zero and two LSD-25 doses with the large hole and eight with the small hole.

regardless of dose. None of these changes was significant at the .05 level or better, with the *N* used. Twelve subjects were tested with the large hole and eight with the small hole.

The mean number of contacts made with the sides of the large and small holes appears in Figure 3. There was an increasing number of contacts made with the sides of the large hole with increasing doses. The maximum average number of contacts with the sides of the small hole was made under 50 micrograms of the drug. These changes could have occurred by chance more

than five times in a hundred trials, for the 12 subjects tested with the large hole and the eight subjects tested with the small hole.

Table 1 gives the average scores under the pre- and post-LSD-25 zero dose sessions on the pursuit rotor and steadiness tests and the probability

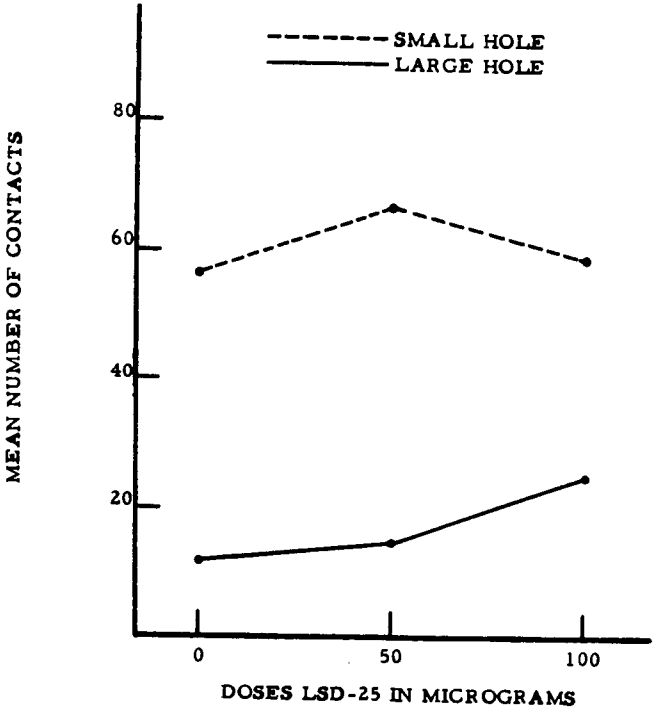

FIGURE 3

Mean number of contacts, in 50-second period, with the sides of a large and small hole. Twelve subjects were tested under zero and two LSD-25 doses with the large hole and eight with the small hole.

that the differences between the two sessions, on each test, could have occurred by chance. The mean time in contact with the copper button increased under the second zero dose experiment at both speeds of the turntable. The mean time in contact and the mean number of contacts made with the sides of the large and small holes both decreased under the second zero dose. The changes which took place on the 33 1/3 rpm and the large hole steadiness tests could have occurred by chance more than 5 times in a 100; the increased time in contact at 78 rpm was significant at better than the .02 level. The decreased time in contact and decreased number of contacts with

the sides of the small hole could have occurred by chance only one time in 100 trials and was therefore a significant decrease.

The relationship between a subject's rank position on a given test under two different doses of the drug is indicated by the size of the Spearman rank-order correlation coefficient. The coefficients relating the scores on each test under the three doses related two at a time appear in Table 2, together

TABLE 1
COMPARISON OF PRE- AND POST-LSD-25 PLACEBOS
(Means and Probability of Chance Occurrence of Differences)

Test	Mean score in 50 sec. period Pre LSD-25	Post LSD-25	P
Pursuit Rotor			
Time in contact, in sec.			
a. 33 1/3 rpm*	22.2	28.3	>.05
b. 78 rpm**	2.7	5.4	<.02
Steadiness			
Time in contact, in sec.			
a. large hole**	2.7	0.7	>.05
b. small hole*	14.7	7.8	.01
Number of contacts			
a. large hole**	12.5	4.5	>.05
b. small hole*	58.8	35.7	.01

P indicates probability of chance occurrence of differences between two controls.
* N = 6.
** N = 8.

TABLE 2
SPEARMAN RANK-ORDER CORRELATION COEFFICIENTS RELATING SCORES UNDER SEVERAL LSD-25 DOSES
(Three Doses Related, Two at a Time)

Test	Microgram doses LSD-25 compared: Pre-drug zero vs. 50			Pre-drug zero vs.100			50 vs. 100		
Pursuit Rotor	ρ	*P*	*N*	ρ	*P*	*N*	ρ	*P*	*N*
1. Time in contact, in sec.									
a. 33 1/3 rpm	.65	—	9	.72	.05	9	.95	.01	10
b. 78 rpm	.63	.05	12	.60	.05	11	.80	.01	11
Steadiness									
1. Time in contact, in sec.									
a. large hole	.40	—	12	.48	—	12	.69	.05	12
b. small hole	.60	—	8	.58	—	8	.83	.01	11
2. Number of Contacts									
a. large hole	.62	.05	12	.70	.05	12	.72	.01	12
b. small hole	.01	—	8	.48	—	8	.36	—	11

Notes:
ρ is the Spearman Rank-Order Correlation Coefficient.
P is the probability of chance occurrence of the correlation coefficients.
N is the number of subjects.
— indicates that P is greater than .05.

with the probability that the correlations would arise by chance. The coefficients ranged from .01 to .95. On the pursuit rotor tests all but one correlation was significant at the .05 or the .01 level. The correlation between zero and 50 micrograms on the 33 1/3 rpm test was attributed to chance. The highest and most significant correlations exist between the two drug dose scores.

The time in contact on the steadiness tests under zero and under each of the drug doses was not significantly related. However, there was a significant correlation between scores under doses of 50 and 100 micrograms of the drug for both the large hole and the small hole tests. The number of contacts made with the sides of the large hole was significantly related among all three doses; the most significant relationship occurs between the two drug doses. No significant correlations were obtained among the various doses, on the number of contacts made with the sides of the small hole.

D. Discussion

The small sample used in this study tends to belittle the significance of the changes due to LSD-25, but the trends pointing towards a drug effect cannot be overlooked. When the pursuit rotor turntable rotated at 33 1/3 rpm the mean time in contact decreased as the dose increased. Yet, when a second placebo was given the mean time increased. Ammons (2) also demonstrated an improvement with practice on the pursuit rotor test with a turntable rotating at 60 rpm. One would expect that repetition with this test would show progressively higher, not lower, scores. It seems that LSD-25 tends to interfere with expected learning progress in addition to its impairing the original level of performance. The augmented performance under the post-drug zero testing as compared with the pre-drug zero testing suggests that latent learning occurred during the intermediate drug tests.

At 78 rpm the practice effect was a significant one and was apparently so great that under 100 micrograms instead of the expected impairment, improvement resulted. The test is a fairly reliable one since most of the correlations relating the rank position from one dose to another were at least .60 and significant. The changes in score which occurred under LSD-25 seem more significant in view of the correlations. The highest and most significant correlations occurred between the scores under the two drug doses. If there were no change under LSD-25 the correlations between zero scores and a drug score should be about the same as the correlations between two drug dose scores. The significant correlations also mean that the prediction

of a subject's rank from one dose to another is possible, with an acceptable degree of error.

The results on the two tests of steadiness are similar to the pursuit rotor findings. The practice effect which occurred on the post-drug zero test as compared to the pre-drug zero test leads one to expect improvement on trials subsequent to the first trial. Since the opposite phenomenon occurred it can be said that LSD-25 makes people unsteady and also prevents them from improving their steadiness on the two hole steadiness test. The small hole test which is the more difficult of the two, improved significantly on both the time in contact and the number of contacts. There was also improvement under 100 micrograms in comparison to the scores under 50 micrograms. This can be explained in view of the significant practice effects. The practice which took place apparently was greater than the detrimental effects of LSD-25, and the score was not as low as anticipated.

The large hole test, aside from showing no significant improvement with repeated testings, was more reliable than the small hole test in terms of the more significant rank-order correlations between different doses on the total number of contacts made. The difference in correlation between the time in contact with the large hole and with the small hole was not as marked. Only the correlation between the two drug doses was significant.

E. Summary and Conclusions

Twelve adults took two tests of hand-eye coördination, a pursuit-rotor test and a modified Dunlap steadiness test, under 50 and 100 micrograms of lysergic acid diethylamide and under zero doses both before and after the LSD-25 experiments. The following tentative conclusions are made:

1. With a sample of 12 there were no statistically significant differences between the zero dose scores and the drug scores, or between the two drug scores. The tendency was for increasing impairment with increasing doses.

2. Practice with the tests (no drug) showed that on the more difficult tests (78 rpm on the pursuit rotor, and the small hole on the steadiness test) there was significant improvement in the performance. On the 33 1/3 rpm and the large hole tests there also seemed to be improvement, but it was not significant.

3. LSD-25 tends to interfere with the normally anticipated improvement under subsequent testing with the same tests. It is suggested that some improvement occurs despite the drug. This improvement tends to counteract the effects of the drug on test performance.

4. The more reliable test was the pursuit rotor. The highest correla-

tions existed between the two drug doses, on each sub-test of the pursuit rotor and steadiness tests.

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