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LYSERGIC ACID DIETHYLAMIDE (LSD-25): V. EFFECT ON SPATIAL RELATIONS ABILITIES*

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A. INTRODUCTION

In view of the reports that subjects under the influence of lysergic acid diethylamide (LSD-25) frequently manifest incoherence and confusion (7, 8) and often report visual and other sensory misperceptions and hallucinations (1, 10) it seemed desirable to determine whether LSD-25 produced impairment in a subject's abilities to perform adequately on tests of spatial relations. It is the purpose of this paper to investigate the effects of lysergic acid diethylamide on scores obtained on two tests of spatial orientation, the Thurstone Hand Test and the Revised Minnesota Paper Form Board Test (MPFB).

B. METHOD

1. *Subjects*

The population of this study consisted of 12 non-psychotic, adult volunteers, whose median age was 27, ranging from 21 to 33. Six of the subjects were male and six female. Preliminary psychiatric interviews and clinical psychological tests were administered to the subjects for purposes of screening. Only those who were considered non-psychotic were accepted. All subjects were of average intelligence or above and eight were of superior intelligence, according to the Wechsler-Bellevue Intelligence Scale. Seven were graduate students in psychology or allied fields. There were two housewives, a hairdresser, an auditor, and a public relations worker.

2. *Tests*

Two tests were used in this study. The first was the Thurstone Hand Test devised by L. L. Thurstone in 1925 (9). It consisted of 49 drawings of right and left hands in various positions. The subject had to indicate

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whether each drawing represented the right or left hand. The same form of the test was used for each testing session.

The second test of spatial relations was the Minnesota Paper Form Board Test prepared by Likert and Quasha (6). It consisted of problems in which a geometrical figure was broken into parts. The subject had to select from five complete geometric figures the one which represented the parts correctly fitted together. Two forms of this test were available; each was divided into two comparable forms by considering the odd numbered problems within each form as one form, and the even numbered problems as a second form.

3. *Procedure*

a. Administration of drug. At approximately 9:30 A.M., subjects were given the drug orally in 75 cc of water. The drug administration and testing took place in an air-conditioned room where groups of three, four, or five subjects were tested together. All the subjects had previously been in this room and had met the experimenters during preliminary interviews and the clinical psychological tests. They may or may not have been acquainted with other subjects in the group. Two experimenters administered the tests. The drug doses varied among the subjects tested in any one day.

Each subject was tested three times, and eight of the subjects were tested four times, with at least one week between experiments. The first time, the subjects received a zero dose (placebo consisting of 75 cc of tap water). Because LSD-25 is a tasteless, odorless, and colorless substance, the water dose served as a control for the unknown variables in the test situation. Subjects were never told what their drinks contained. A dose of 50 micrograms of LSD-25 was given the second time subjects were tested, and 100 micrograms the third time. Those subjects available for a fourth testing session again received a zero dose of the drug. In view of the nature of the drug it seemed inadvisable to administer a high dose of the drug the first day. By varying the doses used in any one day and using a given test form in one day, all forms were used at each dose level of testing. The second zero testing was administered as a means of evaluating the effect of repeated testing with the same tests.

Subjects receiving the drug had eaten no food since the previous evening. One-half hour after the drug or placebo was administered, a light breakfast was given to the subject. No stimulants were permitted and no smoking was allowed during the experimental period.

b. Administration of tests. The two tests were administered approximately 1¾ hours after the subjects had received the drug. The Thurstone

Hand Test was administered first, and was followed by the Minnesota Paper Form Board Test. These two tests were given to subjects immediately after a series of nine tests of immediate memory (4), eight cancellation tests (3), and two forms of an arithmetic test (5). The latter tests were administered to the subjects between one hour and 1¾ hours after the ingestion of the drug.

The subjects were instructed in the Thurstone Hand Test to indicate whether the pictures represented left or right hands by checking the corresponding box below the picture. They were allowed one minute to do as many of the problems as they could and then immediately repeated the test. The first test was called Form I, the second Form II.

In the Minnesota Paper Form Board Test the subjects selected the one of five composite pictures which to them represented the separate scrambled parts properly assembled. They first did the practice problems and were checked to be sure they had done them correctly. They were then allowed five minutes to do as many problems as they could. A different form was administered at each testing session.

c. Method of analysis. The Thurstone Hand Test was scored by counting the number of correct responses and subtracting the number of incorrect responses from that number as a correction for guessing. The Minnesota Paper Form Board Test was scored similarly. Since there were five possible choices, the score was the number of correct responses minus 1/5 of the number of incorrect responses.

Each test was then analyzed in the same way. The scores under zero micrograms were compared with those obtained under 50 micrograms and under 100 micrograms, respectively, by means of Wilcoxon's non-parametric test of paired replicates (11), and the Spearman rank-order correlation (2). With these methods, the significance of the difference and the relationship between scores under two different doses were obtained. The 50 microgram and 100 microgram scores were compared in the same way.

Wilcoxon's non-parametric test of paired replicates was also applied to the data from the first zero testing (pre) and the second zero testing (post) to determine the significance of the difference in scores, and therefore, to determine whether repetition was effective in changing the scores.

C. Results

The results are summarized in Figures 1 and 2 and Tables 1 and 2. Figure 1 demonstrates the changes which occur in the test performance under increasing doses of LSD-25. The average scores on the Minnesota Paper

Form Board Test and on the two forms of the Thurstone Hand Test are plotted for the pre-drug zero, the 50 microgram, and the 100 microgram sessions. In both forms of the Thurstone Hand Test there was a negative

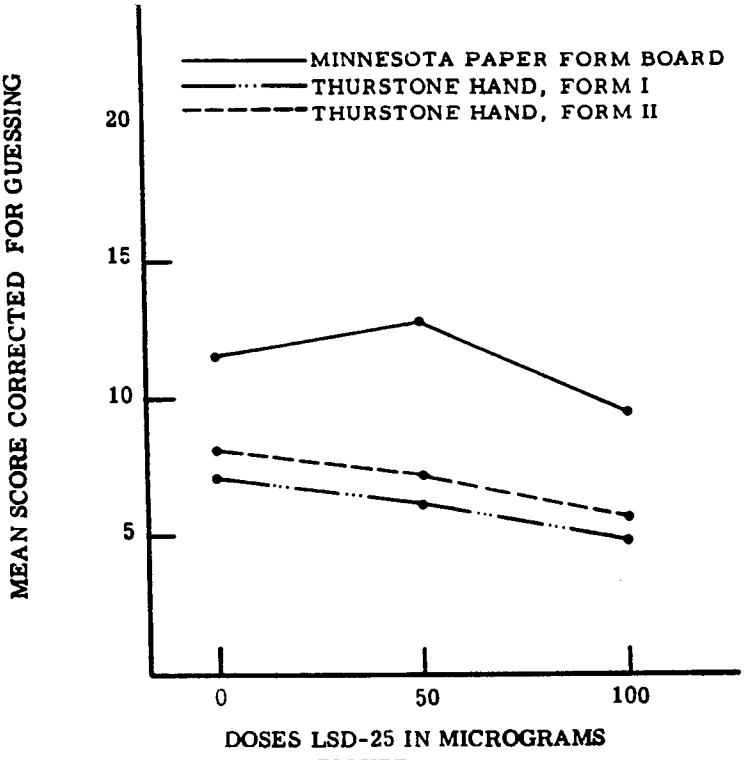

FIGURE 1

Mean scores, corrected for guessing, on the Minnesota Paper Form Board Test and on two identical forms of the Thurstone Hand Test, for nine and twelve subjects, respectively. Subjects were tested under zero and two LSD-25 doses.

correlation between score and drug; that is to say, the higher the dose of LSD-25 the lower the average score on the tests, for twelve subjects.

The mean score on the Minnesota Paper Form Board Test increased under 50 micrograms as compared to the pre-drug zero. Under 100 micrograms, the mean score was lower than under either of the two other doses. Here the N was 9.

The significance of the differences between scores under two different doses appears in Table 1. Four comparisons were made: pre-drug zero with 50 micrograms, pre-drug zero with 100 micrograms, 50 micrograms with 100

micrograms, and pre-drug zero with post-drug zero. The latter will be noted subsequently. On Form I of the Thurstone Hand Test the only score decrease which was significant (at the .05 level) was that between zero and

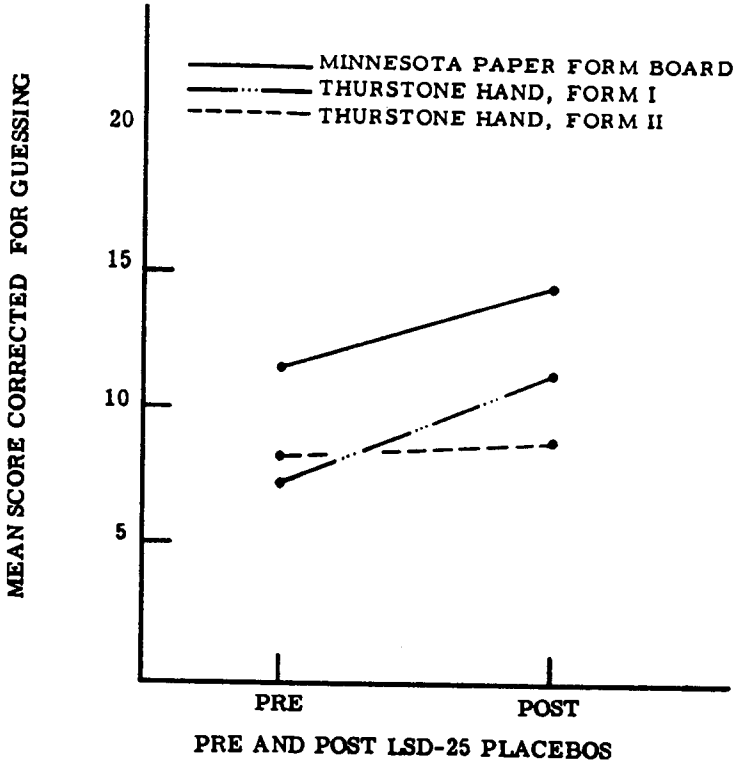

FIGURE 2

Mean scores, corrected for guessing, on the Minnesota Paper Form Board Test and on two identical forms of the Thurstone Hand Test, for six and eight subjects respectively. Subjects were tested under a zero dose before and after the drug tests.

100 micrograms. The drop between zero and 100 micrograms was also the only significant change on Form II. The Minnesota Paper Form Board Test showed a significant lowering of score from 50 to 100 micrograms, only. All other differences among the first three dose groups could have occurred by chance more than 5 times in 100.

The comparisons between the pre-drug zero and the post-drug zero sessions yielded results summarized in Figure 2 (and Table 1). The mean scores of pre- and post-drug tests are plotted for both forms of the Thurstone Hand Test and for the MPFB test. All scores, on the average, in-

creased in the post-drug tests. The improvement on Form I of the Thurstone Hand Test was significant at better than the .02 level. The improvement on the MPFB test and on Form II of the Thurstone Hand Test were chance occurrences. The N was 8 on the Thurstone Hand Test and 6 on the MPFB test.

TABLE 1
PROBABILITY OF DIFFERENCES BETWEEN DOSES OCCURRING BY CHANCE
(Minnesota Paper Form Board and Thurstone Hand Test)
N = 12

Test	Probability of score differences occurring by chance. Doses LSD-25 compared, in micrograms: Zero and 50	Zero and 100	50 and 100	Zero-Pre and Zero-Post
Thurstone Hand				
I	>.05	.05	>.05	<.02**
II	>.05	<.05	>.05	>.05**
Minn. Paper Form Board	>.05*	>.05*	.02	>.05***

*N = 9.
**N = 8.
***N = 6.

TABLE 2
SPEARMAN RANK-ORDER CORRELATION COEFFICIENTS RELATING SCORES UNDER DIFFERENT DRUG DOSES
(Minnesota Paper Form Board and Thurstone Hand Test)

Test	Doses LSD-25 correlated, in micrograms: Zero and 50 ρ	Zero and 100 ρ	50 and 100 ρ	N
Thurstone Hand				
I	.21	.41	.41	12
II	.37	.46	.63*	12
Minn. Paper Form Board	.31	.52	.59**	9

Note: ρ equals the rank order correlation coefficient.
*Significant at .05 level; all other correlations are attributed to chance.
**N = 11.

The Spearman rank-order correlation coefficients, relating scores under the various drug doses, appear in Table 2. Only one of the correlation coefficients was significant at the .05 level—that between the 50 and 100 microgram sessions on Form II of the Thurstone Hand Test. The coefficient was 0.63. All other correlations were lower and not significantly different from zero.

D. DISCUSSION

Little of the data obtained on the two tests of spatial relations indicates significant changes between non-drug and drug states of our subjects because

of the small number of subjects. However, it should be noted that scores under the drug were almost always lower than those under the placebos. The improvement on the post-drug placebo as compared to the pre-drug placebo suggests that successive administration of the tests would result in successively higher scores. It appears, therefore, that LSD-25 interferes with the normally anticipated improvement and, in addition, tends to reduce the original level of performance. The changes reported in the tables would probably be more significant if comparison were made with post-drug rather than pre-drug placebo scores and if the number of subjects were larger.

It is interesting that, despite the impaired performance under the drug, under the second placebo there was an improvement in performance. This suggests that learning may have taken place even under the influence of the drug.

The MPFB showed improvement from the pre-drug zero scores to the 50 microgram scores. We do not know whether learning would have been even greater without LSD-25 or whether this drug dose has no effect upon the MPFB test; under 100 micrograms there was impairment of performance.

Likert and Quasha (6) report that the MPFB test is moderately related to tests of intelligence and of mechanical ability. Consequently, impairment of ability on the MPFB under the influence of LSD-25 suggests that this drug also interferes somewhat with intellectual and mechanical functioning.

All the rank-order correlations but one could have occurred by chance with this particular number of subjects. This suggests that knowledge of the subject's performance under a first control is of little value in predicting his rank position under the drug. However, all correlations were positive suggesting some degree of consistency in response under different doses. The highest correlations occurred between the two drug doses. It seems easier to predict a subject's test performance under a given dose of LSD-25 from his performance under another LSD-25 dose, than from his test performance under a placebo.

E. Summary and Conclusions

Twelve non-psychotic adults were tested with the Thurstone Hand Test and the Minnesota Paper Form Board Test under 50 and 100 microgram doses of lysergic acid diethylamide, and under zero doses, both before and after the LSD-25 tests. The following conclusions can be made:

1. LSD-25 tends to impair the subject's scores on tests of spatial rela-

tions, but with the N used, only some of the changes were significant. On both forms of the Thurstone Hand Test there was significant impairment only between zero and 100 microgram scores. On the MPFB the only significant change was between the two drug doses.

2. The tests showed that on subsequent testing without the drug, subjects performed more proficiently than at the first testing.

3. There was only one significant rank order correlation between scores under the various drug and placebo doses. However, all were positive, and those between the two drug doses were highest.

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