

LYSERGIC ACID DIETHYLAMIDE (LSD-25): IV. EFFECT ON ATTENTION AND CONCENTRATION*¹

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A. INTRODUCTION

Following Hofmann's discovery of lysergic acid diethylamide (LSD-25) in 1943 numerous investigators attempted to evaluate the effects of this drug. Among these were Busch and Johnson (2), Condrau (3), De Shon (4), Forrer and Goldner (5), Gastaut (7), Rinkel *et al.* (9), Savage (10), and Stoll (13). Physiological, perceptual, and psychological changes were observed clinically and occasionally measured objectively.

Only one study, that of Gastaut (7), bases the conclusion that attention was impaired on specific psychological tests, viz., Cattell, Lahey, and Rorschach. The other findings cited are based only on clinical observations.

The purpose of this investigation, then, is to determine the effects of LSD-25 on indices of the central processes of attention and concentration (8). Speed of movement is another factor that enters into this test, but in subsequent papers to be published in this series we discuss the effect of LSD-25 on speed of movement *per se*.

As a more objective measure of what may roughly be called concentration, cancellation tests have been found useful. The use of these tests has been reported by Thorndike and Woodworth in 1901 (14), and by Sterzinger in 1924 (11), as well as by others. A cancellation test is one in which the subject underlines, crosses out, or in some other way indicates his recognition of certain recurring items or classes of items on a page of repetitive, though randomized material. His accuracy and speed, indices of some rather complex unspecified mental processes, are used as the dependent variables.

The reliability of these tests has been summarized by Whipple (15) who reports reliability co-efficients ranging from 0.60 to 0.97 for the various forms and lengths of cancellation tests. Despite their reliability, however, need of cancellations has been found to increase with practice according to some investigators (11).

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B. METHOD

1. *Subjects*

The subjects in this study consisted of six male and six female, adult paid volunteers who were considered non-psychotic on the basis of psychiatric interviews and a battery of clinical psychological tests as described in the first paper of this series (1). Subjects who were deemed to have certain psychotic traits were rejected from the group of subjects. Intelligence of the subjects, as measured by the Wechsler-Bellevue Intelligence Scale, ranged from average to superior intelligence for eight of the subjects. The median age was 27, ranging from 21 to 33. Median weight was 135 pounds, ranging from 103 to 175 pounds. Seven subjects were graduate students in psychology or allied fields, two were housewives, one an auditor, one a hair-dresser, and one a public relations worker.

2. *Tests*

The cancellation tests used were obtained as printed tests from C. H. Stoelting Company, Chicago, Illinois (12). The following were used: (a) No. 27008-Cancellation Test from Whipple's Manual (letters), (b) No. 27002—The Munsterburg Attention Test (numbers), (c) No. 27001—The Munsterburg Attention Test (letters), (d) No. 27010, from Whipple's Manual (geometric figures), (e) No. 27011, from Whipple's Manual (numbers) and, (f) No. 27009, from Whipple's Manual (letters).

3. *Procedure*

a. Administration of drug. The drug was administered orally in 75 cc of water at approximately 9:30 A.M. The subjects had had no food since the previous evening. The drug administration took place in an air-conditioned room, in which the subjects were tested in groups of 3, 4, or 5. All the subjects had previously been in this room, and had met the experimenters when they were given preliminary interviews and the clinical psychological tests (1). The subjects sometimes knew the other members of the group. Two experimenters administered the tests.

The tests were administered at four separate testing sessions at least one week apart. The first time the subjects were tested, they received a zero dose of the drug, a placebo consisting of water. Since the drug has no taste, color, or odor, the subjects had no knowledge of the amount of the drug they received. The second and third times the subjects received 50 and 100 micrograms of LSD-25, respectively. In order to measure the effect of re-

peated testing the subjects were given as a final dose zero micrograms of LSD-25.

A light breakfast was given to the subjects one-half hour after the drug was administered. No stimulants such as coffee or tea were permitted, and no smoking was allowed during the experimental day.

b. Administration of tests. Between $1\frac{1}{4}$ to $1\frac{1}{2}$ hours after ingestion of the drug, the cancellation tests were administered to the subjects. Previous to these tests the subject had spent about 15 minutes taking other tests measuring learning and memory. These results will be described in subsequent papers. The tests were administered in the order listed with the following types of cancellations or underlinings: "a's," "odd numbers," all letters from "a" through "l," "consecutive numbers whose sum was 9," "consecutive letters which made words," "squares," "odd numbers immediately preceded by odd numbers," and "vowels." The subjects were given standard instructions each time and the same form of the tests was used at each of the four testing sessions.

c. Analysis of data. The score of each test was the number of correct responses. The scores at zero and 50 micrograms of LSD-25, zero and 100 micrograms, and 50 and 100 micrograms of the drug were then compared by the Wilcoxon non-parametric test of paired replicates (16), to determine whether the score differences between doses were significant.

In order to evaluate the effects of practice with a given test, the scores obtained under the first zero testing and the second zero testing were compared by the same technique. The Spearman rank-order correlation (6, p. 355) was used to estimate the predictability of performance under one dose from the rank under another dose of the drug or placebo.

C. RESULTS

The tests were divided arbitrarily into two main types: those requiring simple discrimination and those requiring complex discrimination. In the first category the decision to cross out could be made by merely looking at a single letter, number, or form, whereas in making the complex discrimination subjects had to look at two or more of the letters or words before they could decide whether to cross out or underline.

In Figures 1 and 2 the mean scores of 12 subjects on three test days (pre-drug zero, 50, and 100 micrograms) are illustrated. Most tests in Figure 1, but none in Figure 2, show a progressive drop in mean score under increasing drug dose. The simple discrimination tests are plotted in Figure 1, the complex in Figure 2.

Table 1 lists the significance of the change between scores obtained under the first zero dosage and the subsequent two testings with LSD-25, and between the two testings with LSD-25. It can be seen that there is no signifi-

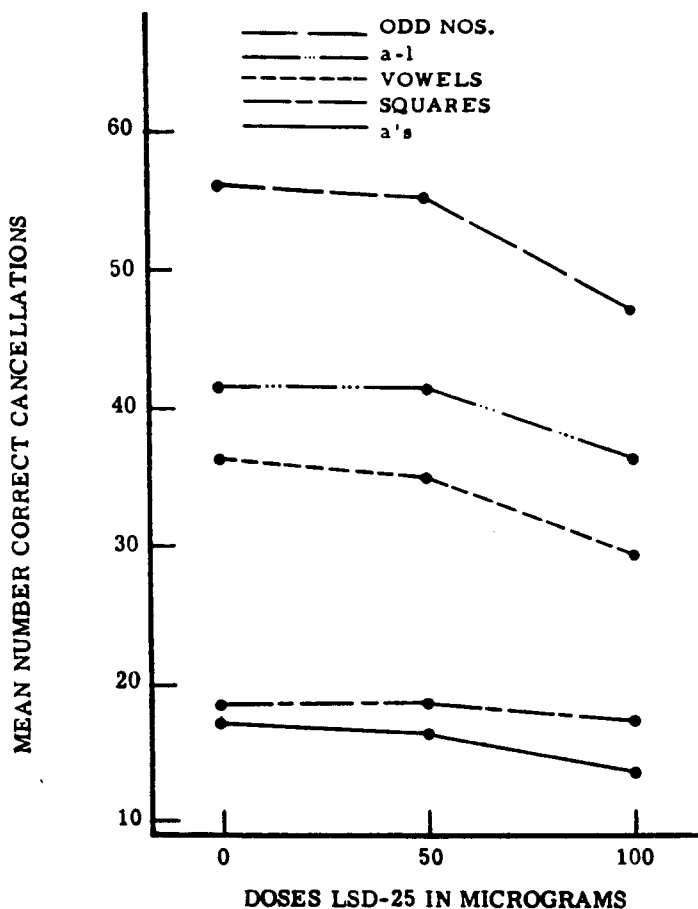


FIGURE 1
MEAN SCORES ON FIVE TESTS OF CANCELLATION INVOLVING SIMPLE DISCRIMINATION:
SUBJECTS WERE TESTED UNDER THREE DOSES OF LSD-25

cant difference between the zero and 50 microgram scores on any simple discrimination test, but there is a significant difference between the zero and 100 microgram tests for cancellation of "a's" and "vowels." There is also a significant difference between the 50 and 100 microgram tests for cancellation of "a's," "vowels," and "odd numbers."

For complex discriminations, Table 1 shows that the "word" test scores are significantly different between zero and 50 and between zero and 100 microgram comparisons. The "odd numbers preceded by odd numbers" score

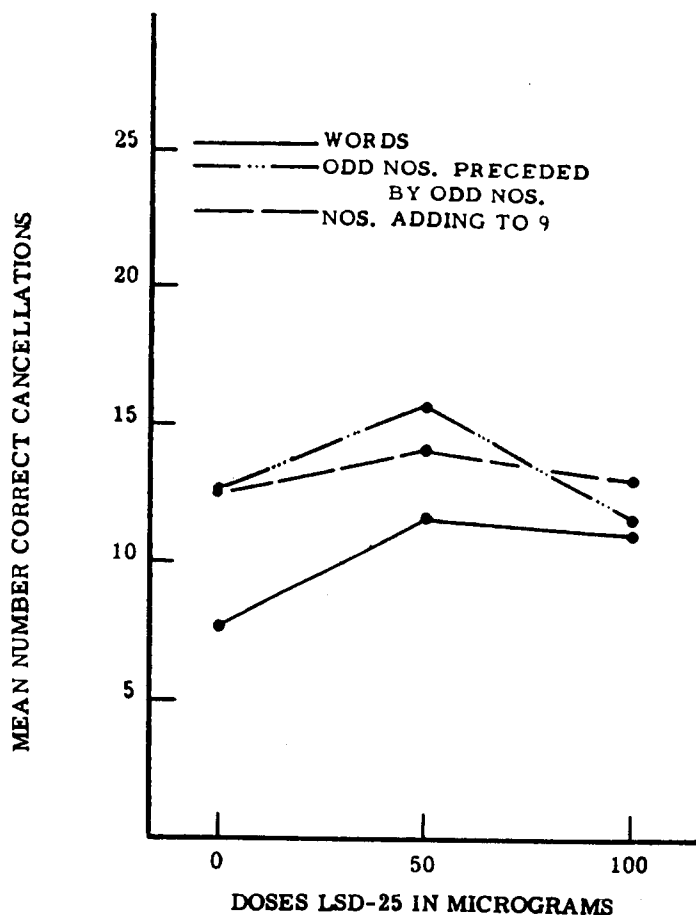


FIGURE 2
MEAN SCORES ON THREE TESTS OF CANCELLATION INVOLVING COMPLEX DISCRIMINATION: SUBJECTS WERE TESTED UNDER THREE DOSES OF LSD-25

is significantly different only for the zero to 50 microgram comparison. These changes were in the direction of improvement under the higher dose. "Numbers adding to 9" scores show no significant changes under LSD-25.

Table 2 attempts to show the effects of simple repetition of the tests, divorced from LSD-25 action. When the post-drug zero scores are compared

with the pre-drug zero scores the results illustrated in Figures 3 and 4 show significant differences for all tests except cancellation of "a's" and "squares."

Table 3 shows how constant the relative standing of the subjects was on a given test but under different doses of LSD-25. Four of the eight tests showed significant rank-order correlations between zero and 50 micrograms,

TABLE 1
PROBABILITY OF CHANCE OCCURRENCE OF SCORE DIFFERENCE BETWEEN DRUG DOSES
(Pre-drug zero, 50 and 100 micrograms LSD-25 compared; $N = 12$)

Test	Micrograms LSD-25 compared					
	Zero versus 50 Direction of change	P	Zero versus 100 Direction of change	P	50 versus 100 Direction of change	P
<i>Simple Discrimination</i>						
"a's"	L*	—	L	<.02	L	<.05
"squares"	H**	—	L	—	L	—
"vowels"	L	—	L	.05	L	<.02
"odd nos."	L	—	L	—	L	.05
"a-1"	L	—	L	—	L	—
<i>Complex Discrimination</i>						
"words"	H	<.01	H	<.05	L	—
"odd nos. preceded by odd nos."	H	.05	L	—	L	—
"nos. adding to 9"***	H	—	H	—	L	—

P indicates probability that difference would occur by chance.

— indicates that the probability of the difference occurring by chance is greater than .05.

*L means lower score under higher dose.

**H means higher score under higher dose.

*** $N = 11$.

TABLE 2
PROBABILITY OF CHANCE OCCURRENCE OF CHANGE IN SCORES FROM PRE-LSD-25 TO
POST-LSD-25 TESTINGS ($N = 8$)

Test	Direction of change	P
<i>Simple discrimination</i>		
"a's"	H*	>.05
"squares"	H	>.05
"vowels"	H	<.02
"odd nos."	H	.01
"a-1"	H	.01
<i>Complex discrimination</i>		
"words"	H	.01
"odd nos. preceded by odd nos."	H	.01
"nos. adding to 9" **	H	.02

*H means higher score under Post-LSD-25.

** $N = 7$.

three were significant between zero and 100, and three were significant between 50 and 100 micrograms.

TABLE 3
SPEARMAN RANK-ORDER CORRELATION COEFFICIENTS
(Three doses of LSD-25, related two at a time; $N = 12$)

Test	Micrograms LSD-25 compared					
	0 versus 50		0 versus 100		50 versus 100	
	ρ	P	ρ	P	ρ	P
<i>Simple discrimination</i>						
"a's"	.51	—	.76	.01	.70	.05
"squares"	.63	.05	.68	.05	.87	.01
"vowels"	.67	.05	.35	—	.73	.01
"odd nos."	.35	—	.39	—	.56	—
"a-1"	.89	.01	.50	—	.36	—
<i>Complex discrimination</i>						
"words"	.60	.05	.54	—	.51	—
"odd nos. preceded by odd nos."	.39	—	.64	.05	.38	—
"nos. adding to 9" *	.58	—	.48	—	.44	—

ρ refers to correlation coefficient.

— indicates correlations that could occur by chance more than five times in 100.

* $N = 11$.

D. DISCUSSION

In evaluating the effect of lysergic acid diethylamide on the performance on the series of eight cancellation tests, it is important to remember that the same form of each test was used in the four test situations, and that the same experimenters administered the tests in the same way each time.

If no drug had been given during the second and third test days, it is likely that the scores would have become successively higher due to repetition. To assess the effects of practice alone, a large sample of control subjects would be necessary. It is unreasonable, however, to expect a decrease in scores on successive trials. Consequently we must ascribe the impaired performance to the effect of the drug. In fact, if the effects of practice could have been removed, the drug effects might have been even more marked.

All of the complex discrimination tests showed higher scores under 50 micrograms than on the pre-LSD-25 testing (see Figure 2). Although it is possible that the subjects improved in attention and speed under the drug, it is more likely that the increase in scores represents practice. Under 100 micrograms there was a relative decrease.

It is interesting to note that the two tests which did not show a significant practice effect were those which required the least amount of attention and the simplest kind of discrimination—cancellation of "a's" and of "squares." In

both these tests, subjects had only one item to cancel, whereas in the other simple discrimination tests, there were from five to 12 items which could be cancelled.

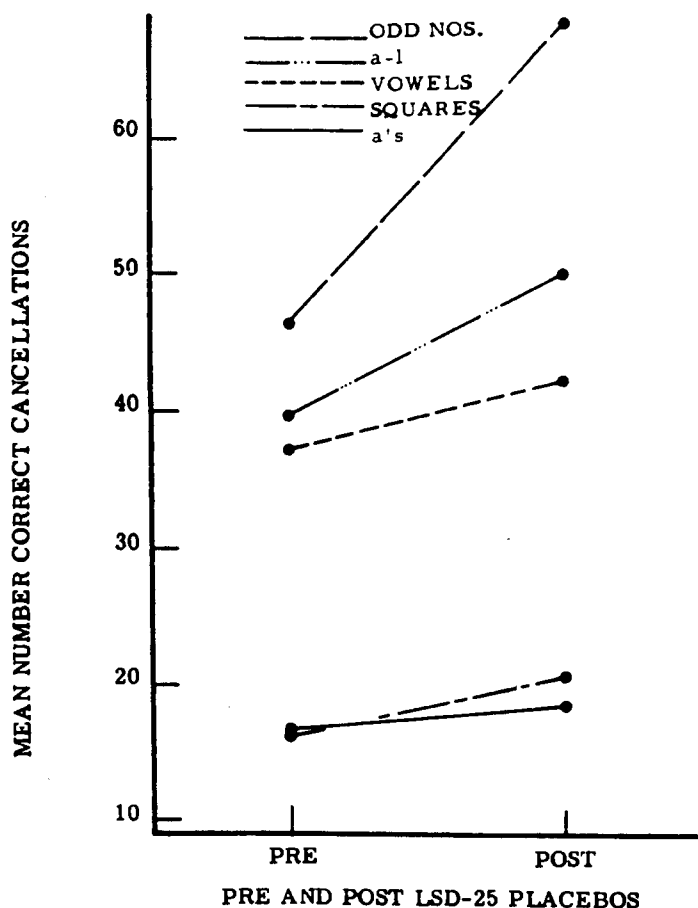


FIGURE 3
COMPARISON OF MEAN SCORES UNDER PRE-LSD-25 AND POST-LSD-25 PERFORMANCE
ON FIVE SIMPLE DISCRIMINATION CANCELLATION TESTS

In Table 3 the rank-order correlations for each test between different dosages is given. This shows how consistently the subjects ordered themselves on the same test under different dosages of LSD-25. In a sense, it is a measure of reliability of the tests. All of the correlations are positive and many were significant and fairly high. This suggests that one could predict a

person's rank on a test under one dose of LSD-25 from his rank on the same test under another dose of LSD-25. It is interesting that only some of the tests permit this prediction.

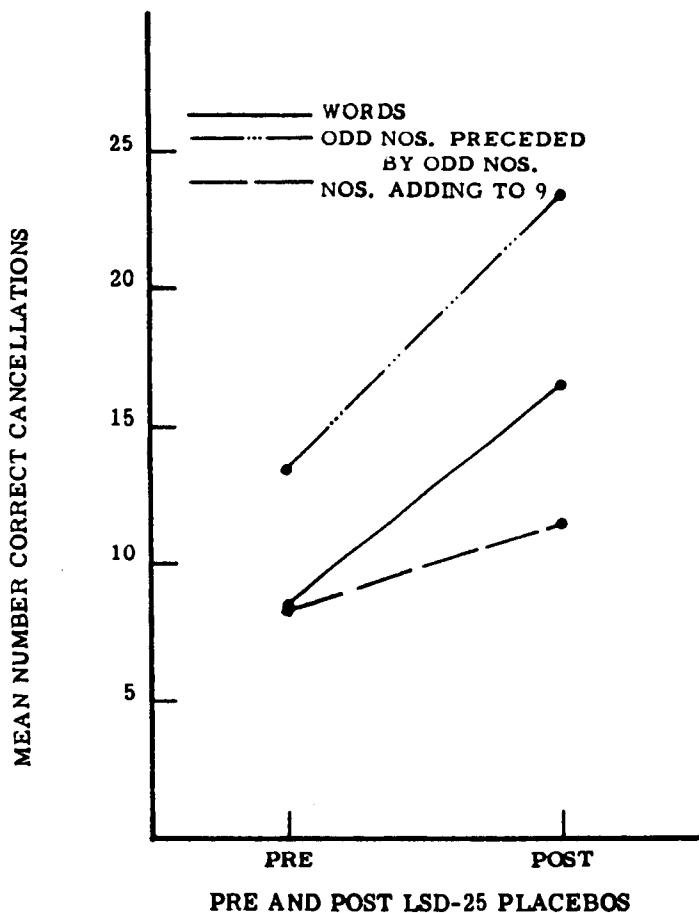


FIGURE 4
COMPARISON OF MEAN SCORES UNDER PRE-LSD-25 AND POST-LSD-25 PERFORMANCE
ON THREE COMPLEX DISCRIMINATION CANCELLATION TESTS

E. SUMMARY AND CONCLUSIONS

On the basis of 12 non-psychotic adults who were tested under a 50 microgram dose of lysergic acid diethylamide, under a 100 microgram dose, and under a zero dose both before and after the LSD-25 tests, with a series of eight cancellation tests, the following conclusions can be made:

1. With the exception of cancellation of "a's" and of "squares" there was a significant increase between pre-LSD-25 and post-LSD-25 zero dose scores for all the cancellation tests.

2. Six out of eight tests showed no significant change when scores of the pre-LSD-25 zero test were compared with the 50 microgram scores. Four of these showed increases and two showed decreases. Two complex discrimination tests showed significant improvement. These were "words" and "odd numbers preceded by odd numbers."

3. Two tests, cancellation of "a's" and "vowels" showed significantly impaired performance when zero and 100 micrograms of LSD-25 were compared. Cancellation of "words" showed a significant improvement in performance under 100 micrograms of LSD-25. Of the remaining five tests, performance on four deteriorated and on one improved, on the average. These changes were attributed to chance.

4. The score decreases under the drug probably would have been even more significant if it were possible to factor out the effects of practice.

5. Performance under a zero dose permits prediction of ranks under 50 micrograms of LSD-25 with an acceptable degree of success on cancellation of "squares," "vowels," "a-1," and "words." Prediction of ranks under 100 micrograms can be done from the zero dose ranks on cancellation of "squares," "a's," and "odd numbers preceded by odd numbers." One can predict ranks under 100 micrograms from those under 50 micrograms for cancellation of "squares," "a's," and "vowels."

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