

Effects of Lysergic Acid Diethylamide (LSD-25) on Intellectual Functions

ARTHUR B. SILVERSTEIN, Ph.D., and GERALD D. KLEE, M.D., Baltimore

I. Memory

Introduction.—The results of previous studies of the effect of lysergic acid diethylamide (LSD-25) on memory suggest that the minimal dose level at which impairment becomes evident lies somewhere between 50 μ g. and 100 μ g. Sloane and Lovett Doust,¹ working at the 40 μ g. level, and Jarvik et al.,² working at the 50 μ g. level, found little or no evidence of memory impairment in their studies. However, the latter investigators reported that when the dose level was raised to 100 μ g., scores were significantly lower on four of the five visual tests and on two of the four auditory tests that they employed. Bercel et al.,³ who used 1 μ g./kg. body weight, also found evidence of impairment, but they studied memory for only one kind of material, a series of unrelated test words. The purpose of the present study was to determine whether memory for various kinds of material is differentially affected by LSD-25 at a dose level between 50 μ g. and 100 μ g.

Submitted for publication April 10, 1958.

The Psychiatric Institute, University of Maryland.

The studies reported in this paper were conducted under the guidance and supervision of Dr. Jacob E. Finesinger, Director of the Psychiatric Institute.

Procedure. The subjects were 16 male college graduates between the ages of 20 and 24, each of whom had had a physical examination and a psychiatric screening interview prior to the start of the study. The Wechsler Memory Scale⁴ was administered to the subjects under control conditions, and also after they had ingested 72 μ g. of LSD-25 in distilled water. Half the sample was tested first under control conditions, and again two days later between one and one-half and three and one-half hours after ingesting the drug. For the other half, the order of the two conditions was reversed. Similarly, the administration of Form I of the Memory Scale preceded the administration of Form II for half the sample, while this order was reversed for the other half.

Results.—A preliminary analysis of the data gave no evidence of significant practice effects or of systematic differences in the two forms of the Memory Scale, and so the data for all subjects were pooled. Median scores under control and drug conditions are shown in Table I. To evaluate the significance of the results, Wilcoxon's matched-pairs signed-ranks test⁵ was employed. Scores on six of the seven subtests were lower in the drug state than under

TABLE I—Median Scores on the Wechsler Memory Scale Under Control and Drug Conditions
N=16

Subtest	Control	Drug	p*
Personal and Current Information (How old are you? Who is President of the United States? etc.)	5.9	5.9	
Orientation (What year is this? What is the name of the place you are in? etc.)	5.0	4.9	
Mental Control (counting backward, saying the alphabet, performing serial addition)	8.8	7.8	0.05
Logical Memory (reproduction of brief prose passages)	10.5	10.2	0.01
Memory Span (repetition of series of digits, forward and backward)	12.0	11.6	
Visual Reproduction (drawing simple geometric figures from memory)	12.5	10.8	0.01
Associate Learning (paired associates: easy, e. g., metal-iron, and hard, e. g., cricket-crack)	14.8	14.7	
Memory Quotient	113.9	107.6	0.01

* Based on Wilcoxon's matched-pairs signed-ranks test.

control conditions, but only three of the differences attained the conventional levels of significance. For the Memory Quotient, which is based on the sum of scores on all the subtests, the difference was highly significant.

Comment.—The results of this study, in conjunction with those of earlier investigators, indicate the minimal dose levels of LSD-25 at which impairment of memory for various kinds of material becomes evident. In Table 2, the findings of the different studies are compared. The Table shows that the minimal dose level required to impair memory for prose passages lies between 50 μ g. and 72 μ g.; for series of digits, above 100 μ g.; for geometric figures, between 40 μ g. and 72 μ g., and for paired associates, between 72 μ g. and 100 μ g.

Jarvik et al.² have observed that the results of such studies as the present one "do not indicate whether the impairment [produced by LSD-25] is due to the inability to learn, the inability to retain, or the inability to express what has been remembered." In tests of immediate memory, the interval between the learning of the material and the test of its retention is so brief that inability to retain probably cannot be distinguished from inability to learn. However, it should be possible to estimate the extent to which impairment is due to inability to express what has been remembered, by substituting tests of recognition for tests of recall or reproduction.

Finally, it should be noted that this study has dealt with only one aspect of the effect of LSD-25 on memory. No data, for exam-

ple, have been presented on the subject's ability to recall at a later date the events that took place while he was under the influence of the drug. From the literature, one receives the impression that the subject's memory for his experiences in the drug state is unaffected, but we have often observed at least partial amnesia for these experiences on the day following the ingestion of the drug.

Summary.—LSD-25 in doses of 72 μ g. significantly impaired memory for only certain kinds of material, as measured by the Wechsler Memory Scale. On the one hand, the ability to draw geometric figures from memory, the ability to reproduce brief prose passages, and the ability to count backward, say the alphabet, and perform serial addition were all affected by the drug. On the other hand, the ability to learn paired associates, the ability to repeat series of digits, orientation for time and place, and memory for personal and current information appeared to be unaffected by the drug at the dose level employed.

II. Abstract Thinking

Introduction.—Previous studies of the effect of LSD-25 on abstract thinking have yielded inconclusive results. Isbell et al.,⁶ working with tests from the Goldstein-Scheerer battery, and Primac et al.,⁷ working with the Wisconsin Card Sorting Test, found no evidence of impairment in their studies. Levine et al.,⁸ who used the Wechsler-Bellevue Intelligence Scale, concluded that LSD-25 does impair abstract thinking. Most pertinent to the present paper are the observations of DeShon et al.,⁹ who studied clinically the effect of the drug on proverb interpretation: "While the responses were predominantly concrete, a wide range of abstractions was still revealed, with a significant number of answers lying in the overgeneralized tangential area of the concrete-abstract spectrum." These investigators likened the interpretations given by normal subjects under the influence of LSD-25 to those given by schizophrenics.

TABLE 2.—Presence or Absence of Impairment of Memory for Various Kinds of Material as a Function of Dose Level *

Material	40 μ g.†	50 μ g.‡	72 μ g.§	100 μ g.‡
Prose passages	—	—	+	+
Series of digits	—	—	—	—
Geometric figures	—	—	—	+
Paired associates	—	—	—	—

* Blank spaces indicate that memory for the material in question was not tested in the particular study. Presence of impairment is indicated by the plus sign (+); absence, by the minus sign (—).

† Sloane and Lovett Doust.

‡ Jarvik et al.

§ Present study.

We have routinely used proverb interpretation in the mental-status examination of subjects under the influence of the drug, and have been impressed by the concreteness of the responses obtained. Subjects asked what is meant by "A rolling stone gathers no moss," for example, have tended to respond literally in terms of stones and moss, instead of translating these symbols into the abstractions that they represent. The publication of the Gorham Proverbs Test¹⁰ provided an opportunity to check rigorously the clinical impression that LSD-25 does impair the ability to interpret proverbs. Recent studies have demonstrated that the Proverbs Test can differentiate both organic and schizophrenic patients from normal subjects who have been matched with the patients for intelligence.^{11,12}

Procedure.—The subjects for the study of proverb interpretation were the same as those employed for the study of memory, and the same research design was used in the two studies. The Proverbs Test was self-administered between two and four hours after the subjects had ingested LSD-25, directly following the administration of the Wechsler Memory Scale.

Results.—All the test records were scored by two judges, with a reliability of 0.92 (Spearman's ρ), demonstrating the relative objectivity of the Proverbs Test. A preliminary analysis of the data gave no evidence of significant practice effects or of systematic differences in the two forms of the test (Clinical Forms I and II), and so the data for all subjects were pooled. The quantitative results were as follows: Under control conditions, the subjects obtained a median score of 19.5; after ingestion of LSD-25, the median score dropped to 13.5. The difference in scores under the two conditions was significant at the 0.01 level, as determined by Wilcoxon's test.

A qualitative analysis of failures (responses receiving no credit or only partial credit) under the two conditions was also carried out. Following Terman and Merrill,¹³ two major types of failures were

distinguished: concrete responses, in which the proverb was taken literally; and incorrect abstractions, in which the symbols were translated into abstractions, but inaccurately. The following examples were actual responses to the proverb "When the cat's away the mice will play": concrete response—"There's no cat to watch, and so the mice have a good time"; incorrect abstraction—"If no authority is present, a group ordinarily will revolt if given the opportunity." The subjects had failures of both types not only under the influence of the drug but also under control conditions, with incorrect abstractions predominating in both cases.

Comment.—The results of the quantitative analysis resemble those obtained by Gorham in a study of chronic schizophrenics and normal subjects, matched for intelligence. Considering only the findings for subjects of high intelligence, roughly comparable to the college graduates of the present study, Gorham's normal group obtained a mean score of 19.2, while the mean score of the schizophrenic group was 12.6. In the present study, the corresponding (control and drug) median scores were 19.5 and 13.5, respectively. The similarity in the results of the two studies suggests the desirability of a rigorous comparison of the interpretations of schizophrenics with those of normal subjects under the influence of LSD-25, employing qualitative as well as quantitative analytic techniques.

The findings of the qualitative analysis were not consistent with earlier clinical impressions, in that the majority of failures in the drug state were not concrete responses, but rather incorrect abstractions. This discrepancy may be due to the fact that in preliminary work the proverbs were presented orally and oral responses were required, whereas in the study the proverbs were presented in printed form and the responses called for were written ones. Perhaps subjects respond on a higher level of abstraction in writing than they do orally,

but there is no empirical evidence on this point.

Summary.—LSD-25 in doses of 72 μ g. significantly impaired abstract thinking, as measured by the Gorham Proverbs Test. The difference in scores under control and under drug conditions resembled the difference reported in the scores of normal subjects and chronic schizophrenics. Contrary to expectations, incorrect abstractions were commoner than concrete responses not only under control conditions, but also in the drug state.

The Psychiatric Institute, University of Maryland.

REFERENCES

1. Sloane, B., and Lovett Doust, J. W.: Psychophysiological Investigations in Experimental Psychoses: Results of the Exhibition of d-Lysergic Acid Diethylamide to Psychiatric Patients, *J. Ment. Sc.* 100:129, 1954.
2. Jarvik, M. E.; Abramson, H. A., and Hirsch, M. W.: Lysergic Acid Diethylamide (LSD-25): VI. Effect upon Recall and Recognition of Various Stimuli, *J. Psychol.* 39:443, 1955.
3. Bercel, N. A.; Travis, L. E.; Olinger, L. B., and Dreikurs, E.: Model Psychoses Introduced by LSD-25 in Normals: I. Psychophysiological Investigations, with Special Reference to the Mechanism of the Paranoid Reaction, *A.M.A. Arch. Neurol. & Psychiat.* 75:588, 1956.
4. Wechsler, D.: Wechsler Memory Scale, New York, Psychological Corp., 1945.
5. Siegel, S.: *Nonparametric Statistics for the Behavioral Sciences*, New York, McGraw-Hill Book Company, 1956.
6. Isbell, H.; Belleville, R. E.; Fraser, H. F.; Wikler, A., and Logan, C. R.: Studies on Lysergic Acid Diethylamide (LSD-25): I. Effects in Former Morphine Addicts and Development of Tolerance During Chronic Intoxication, *A.M.A. Arch. Neurol. & Psychiat.* 76:468, 1956.
7. Primac, D. W.; Mirsky, A. F., and Rosvold, H. E.: Effects of Centrally Acting Drugs on Two Tests of Brain Damage, *A.M.A. Arch. Neurol. & Psychiat.* 77:328, 1957.
8. Levine, A.; Abramson, H. A.; Kaufman, M. R., and Markham, S.: Lysergic Acid Diethylamide (LSD-25): XVI. The Effect on Intellectual Functioning as Measured by the Wechsler-Bellevue Intelligence Scale, *J. Psychol.* 40:385, 1955.
9. DeShon, H. J.; Rinkel, M., and Solomon, H. C.: Mental Changes Experimentally Produced by L. S. D. (d-Lysergic Acid Diethylamide Tartrate), *Psychiat. Quart.* 26:33, 1952.
10. Gorham, D. R.: Proverbs Test, Grand Forks, N. D., Psychological Test Specialists, 1956.
11. Gorham, D. R.: Use of the Proverbs Test for Differentiating Schizophrenics from Normals, *J. Consult. Psychol.* 20:435, 1956.
12. Elmore, C. M., and Gorham, D. R.: Measuring the Impairment of the Abstracting Function with the Proverbs Test, *J. Clin. Psychol.* 13:263, 1957.
13. Terman, L. M., and Merrill, M. A.: *Measuring Intelligence: A Guide to the Administration of the New Revised Stanford-Binet Tests of Intelligence*, Boston, Houghton Mifflin Company, 1937.