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EFFECT OF LYSERGIC ACID DIETHYLAMIDE (LSD-25) ON IMPULSE CONTROL[1]

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INTRODUCTION

Intellectual Impairment: Lysergic acid diethylamide (hereafter LSD-25) was originally described as having an unusual and immediately striking effect upon perception. As the study of LSD has progressed from the descriptive, clinical level to a more rigorous, experimental stage, however, a number of investigators have also reported a detrimental effect of LSD upon intellectual ability. As examples, in 1955 Jarvik *et al.* found a reduction in the speed of performance on a test of simple arithmetic (3); and, Levine *et al.* found that LSD-25 significantly influenced all but two of the Wechsler-Bellevue Intelligence Scale subtests (5). In 1958 Silverstein and Klee reported a reduction in memory and an impairment of abstract reasoning ascribable to the drug (13). More recently, Silverstein and Klee found that a deficit in digit span (immediate memory of numbers) performance under LSD-25 could be demonstrated (12).

It is becoming increasingly evident that a change in intellectual functioning is brought about by the drug such that capacity is lowered but by no means completely destroyed. Another factor, the ability to utilize that rather considerable degree of intellect which remains, has been left largely uninvestigated.

Motivational Impairment: Recent studies of the changes brought about through psychosurgery have shown that one function especially sensitive to frontal lobe damage is the ability to foresee the consequences of an action and to modify behavior accordingly (10, 14). Basically, this is the ability to regulate behavior in accordance with the demands of reality, as opposed to directly attempting to satisfy drives as they develop. The Porteus Maze Test has had a long history of application in the measurement of this function. It is described by Porteus as a test of "social adaptability" or the ability both to inhibit impulsive solutions and to execute critical planning toward the achievement of goals.

Validation of this claim had been demonstrated by means of a number of studies based largely upon two fundamental designs. The first of these was to show that the test differentiated between individuals of equivalent general intelligence and comparable social environments, giving lower scores to those who had histories of sociopathic behavior. The second validation technique was to show that the test could significantly differentiate those individuals who were able to make adequate social adjustments out of groups considered subnormal by standard intelligence testing (8). The consistent findings that the Porteus Maze is one of the rare tests which is affected by frontal trauma (4, 6) not only helps in substantiating the test's validity, but also suggests that it may measure an extremely sensitive function.

The authors have observed clinically that there are some features of the LSD reaction which resemble the effects of prefrontal lobotomy. We refer specifically to motivation and behavioral control. Frequently observed in both states are reactions which show a basic indifference to ordinary environmental events. Coupled with this is a tendency to poorly planned, impulsive action. In both states it is often necessary to increase external control or supervision as a substitute

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for control from within which the patient is less able or willing to achieve. We do not suggest that the many and highly complex effects of LSD can be explained simply on the basis of alteration of frontal lobe function. It is apparent, however, that some motivational change is brought about through LSD which parallels the effects of frontal surgery.

Since the Porteus Maze is purported to measure such a change and since it apparently does so in the case of frontal surgery, the test was chosen to evaluate the state of the function under LSD. It was our hypothesis that LSD, through its interference with critical judgment, would impair performance on the Porteus Maze Test.

PROCEDURE

The subjects were 68 male volunteers considered to be within normal limits on physical examination, psychiatric interview, and group psychological testing. They were randomly divided into a control group of 34, tested under normal conditions, and two experimental groups of six and 28, tested under LSD-25. In the drug group, six subjects were tested two to three and one-half hours after ingestion of 100 mcg. LSD-25;.28 were tested one and one-quarter to two and one-quarter hours after ingestion of 75 mcg. LSD-25. Placebos were not given for the control condition since facilities were not available to duplicate the care given the subjects in the drug group. Thus the two conditions differed in both the environmental atmosphere prior to the initiation of testing, and in the awareness of the subjects of the fact that they had (or had not) been asked to drink an unknown liquid.

The subjects were tested on the Vineland Revision of the Porteus Maze Test by individual administration. The Adult presentation of the Porteus consists of 10 paper-and-pencil mazes graded for difficulty from very simple to complex. The subject is asked to trace a path through each maze; unlimited time is given. If a mistake is made, however, the maze is immediately removed from view and the subject is asked to begin again, using a fresh copy of the maze. The subject is given a limit of either two or four trials, depending upon the complexity of the maze, to complete each pathway. The final score, stated in terms of an age scale, is determined by the number of incorrect trials taken on each of the mazes. These age scores, with an upper limit of 17 years, were the data for this study.

RESULTS

Before examining the results of the Porteus, since each subject was not compared with himself, it should be shown that the control group was sufficiently similar to the LSD group to have approximated the latter's performances under normal conditions. As stated above, the groups were randomly selected. The age and education of the two groups have been compared as an indication of the adequacy of the match.

As shown in Table 1, the experimental group is slightly older and more educated than the control group. Upon assumption of homogeneity of variance, t tests were performed to check the significance of the differences (2). The t's were: for age, .3622, for education, 1.3939. Neither is significant and the difference in education would, in any case, favor the experimental group.

A comparison of the Porteus scores, as seen in Table 2, shows the control group's scores to be superior to those of the 75 mcg. LSD-25 group which, in turn, are superior to those of the 100 mcg. LSD-25 group.

TABLE 1

Age and Education of the Control and Experimental Subjects

	N	Age			Education		
		Mean*	Median	Range	Mean*	Median	Range
Control	34	22.6	21	18–40	11.4	12	8–14
Experimental	34	23.0	22	18–39	11.9	12	9–16

* Difference not significant.

TABLE 2
Porteus Age Scores Under Non-Drug and Drug Conditions

	N	Porteus Age Scores		
		Mean	Median*	Range
Control	34	16.27	16.5	13–17
75 mcg	28	15.21	16.0	10–17
100 mcg	6	14.25	14.25	13–16

* All differences significant, $p < 0.05$.

These differences were analyzed by means of the Mann-Whitney Test (11) upon rejection of the assumption of normality and homogeneity of variance. Each of the differences was upheld by a significant Mann-Whitney z: control *vs.* 75 mcg. group, $p < .005$; control *vs.* 100 mcg., $p < .0005$; and 75 mcg. *vs.* 100 mcg., $p < .05$.

An additional analysis was performed to determine whether the Porteus was actually measuring ability to restrain behavior rather than merely reflecting a lower level of intellectual functioning. The variability of performance, *i.e.*, the number of mazes between the first failure and the last success, was tabulated for each subject. For example, if the first error were made on Maze V and the last adequate performance on Maze IX, the subject's range of response would be four mazes. A low variability score would suggest that the subject performed as well as he was intellectually able. Errors could be assumed to be due to an inability to perform as the subject reached the more difficult tasks. A high variability score, on the other hand, would indicate that the subject had available a greater intellectual capacity than he was utilizing, since he demonstrated this ability by succeeding with more difficult items. Thus at least a portion of credit lost by a subject whose variability was high could be ascribable to something other than intellectual deficit.

Table 3 shows the results of an analysis of the variability of performance of our experimental groups. As expected from the hypothesis, the drug group scores are higher than those of the control group. The probability of such a difference occurring by chance alone is, as determined by the Mann-Whitney Test, well below the one per cent level ($p < .005$).

DISCUSSION

The results are consistent with the clinical observation of a detrimental influence of LSD-25 upon the ability to exercise critical control over behavior. The highly significant difference between normal functioning and that obtained with only 75 mcg. would indicate that "anticipatory planning" is a function which is extremely sensitive to the action of LSD-25; and it is likely that considerably milder doses than those studied may be sufficient to produce a change.

Only one other drug, chlorpromazine, has been reported as showing an effect on maze performance. Like the results found here, the effect appears to be detrimental. Porteus and Barclay stated that "repeated administrations of the Maze Test to chronic psychotic patients receiving chlorpromazine, in comparison with a control group, reveal a continued deficit of about two years" (9, p. 299). This loss is comparable to that of our 100 mcg. subjects.

Thus, we are presented with a paradox of similar reactions under both a disorganizing and a therapeutic treatment. A possible explanation for this might be that chlorpromazine, in lessening the motivational strength of psychotic goals, also reduces the reality based striving necessary to inhibit some impulsive behavior. Porteus (6,7) noted an apparent indifference to frustra-

TABLE 3
Variability of Performance Under Non-Drug and Drug Conditions

	N	Variability Scores		
		Mean	Median*	Range
Non-Drug	34	1.71	1.5	0–4
Drug	34	2.97	2.0	0–8

* Difference significant, $p < 0.005$.

tion after repeated chlorpromazine medication which he considered in many ways similar to that seen in subjects with frontal surgery. Again, there is little additional evidence that chlorpromazine acts specifically upon the frontal or fronto-thalamic structure of the CNS.

The results of this study add no definitive information on the problem of localization of the function measured. Although these results resemble those found with lobotomy, they may also resemble the influence of a comparable loss or series of losses elsewhere in the brain. Very little is known about Porteus performance after damage in other areas. As mentioned earlier, it seems probable that some impairment of frontal lobe functioning is involved; but we cannot rule out the possibility that impairment of behavioral control results from a more generalized interference with cerebral functioning.

A report by Baldwin, Lewis, and Bach (1) is extremely pertinent to any discussion of LSD localization. They found, in a study of chimpanzees, that animals with bifrontal lobectomy have the typical (for chimpanzees) reaction to lysergic acid; after ablation of both lateral temporal cortices, the reaction is either altered or absent. There are obvious problems in interpolating from subhuman to human function, however. For example, about 25 times the human per kg. dose is needed to produce the animal reaction. It may well be that the intellectual and motivational functions studied in humans are absent, obscured, or simply more difficult to recognize in animal reactions.

SUMMARY

Highly significant differences were found between subjects tested on the Porteus Maze Test in the normal state and those tested under either 75 or 100 mcg. LSD-25. The differences were related to a lack of the ability to carry out well-planned and adaptive behavior under the drug. The marked effect under a relatively light dose was taken to indicate an extreme sensitivity of the function to lysergic acid diethylamide. Similarities between LSD results and those found with lobotomy patients were discussed.

REFERENCES

1. Baldwin, M., Lewis, S. A. and Bach, S. A. The effects of lysergic acid after cerebral ablation. Neurology, **9**: 469–474, 1959.
2. Edwards, A. L. *Experimental Design in Psychological Research*. Rinehart, New York, 1950.
3. Jarvik, M. E., Abramson, H. A., Hirsh, M. W. and Ewald, A. T. Lysergic acid diethylamide (LSD-25): VIII. Effect on arithmetic test performance. J. Psychol., **39**: 465–473, 1955.
4. Landis, C. and Erlick, D. An analysis of the Porteus Maze-Test as affected by psychosurgery. Amer. J. Psychol., **63**: 557–566, 1950.
5. Levine, A., Abramson, H. A., Kaufman, H. 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**: 385–395, 1955.
6. Porteus, S. D. *The Maze Test and Clinical Psychology*. Pacific Books, Palo Alto, 1959.
7. Porteus, S. D. Maze Test reactions after chlorpromazine. J. Consult. Psychol., **21**: 15–21, 1957.
8. Porteus, S. D. *The Porteus Maze Test and Intelligence*. Pacific Books, Palo Alto, 1950.
9. Porteus, S. D. and Barclay, J. E. A further note on chlorpromazine. J. Consult. Psychol., **21**: 297–299, 1957.
10. Rylander, G. Personality analysis before and after frontal lobotomy. Res. Publ. Ass. Res. Nerv. Ment. Dis., **27**: 691–705, 1948.
11. Siegel, S. *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York, 1956.
12. Silverstein, A. B. and Klee, G. D. The effect of lysergic acid diethylamide (LSD-25) on digit span. J. Clin. Exp. Psychopath., **21**: 11–14, 1960.
13. Silverstein, A. B. and Klee, G. D. Effects of lysergic acid diethylamide (LSD-25) on intellectual functions. A.M.A. Arch. Neurol. Psychiat., **79**: 477–480, 1958.
14. Tow, P. M. *Personality Changes Following Frontal Leucotomy*. Oxford Univ. Press, London, 1955.