J.nerv.ment.Dis. 154, 432-438 (1972). LSD 2311

THE JOURNAL OF NERVOUS AND MENTAL DISEASE
Vol. 154, No. 6
Printed in U.S.A.

REPEATED LSD INGESTION AND PERFORMANCE ON NEUROPSYCHOLOGICAL TESTS

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The results on the Halstead-Reitan neuropsychological battery were compared for a group of 20 LSD users and a normal control group matched for age, sex, education, and intelligence. Only one of 20 variables was significantly different at the 5 per cent level and this was thought to be due to chance. Thus, it was concluded that there was no difference between the two groups. A further comparison between LSD users and university students yielded no significant difference in the Halstead-Wepman Aphasia Test.

For several years, considerable research has been carried out with respect to the effects on individuals of lysergic acid diethylamide (LSD). While early reports of the drug emphasized either its mind-expanding properties or its usefulness as a psychotomimetic agent in the investigation of psychotic states, it has become evident that for some individuals its use may have adverse acute and prolonged side effects (3, 5, 6, 7, 15, 17, 18). The acute effects of LSD are variable. Some people report extremely pleasant experiences verging on ecstasy while others complain of panic reactions leading to depersonalization or derealization. The emotional response to the drug varies from euphoria to severe depression. At a perceptual level, the characteristic changes noted include the distortion of visual perception, heightened awareness of color, and altered sense of time. In general, it would seem that the visual is more affected than other sensory modalities. Acute reactions can be sufficiently extreme to be labeled "psychotic", and can result in impulsive suicide attempts which are occasionally successful.

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Prolonged psychological reactions to the use of the drug have also been reported. The characteristic psychotic picture is one including panic, schizophrenic-like hallucinations, and paranoid delusions. Of interest is the fact that the majority of people so affected have had no previous history of mental illness (19). Less extreme but common persisting symptoms include the spontaneous recurrence of hallucinatory and delusional experiences weeks or months after the original LSD experience. Other subjects report prolonged feelings of panic, anxiety, or depression. It should be noted that long term reactions have tended to occur more frequently in persons who either had taken the drug in large doses (greater than 300 μg) or had taken it over a long period of time (up to 3 years).

At a physiological level, there have been studies relating LSD use to chromosomal damage and fetal abnormalities (2, 10). However, a recent study has found that chromosome breaks in users of LSD were no more frequent than in nonLSD users. Similarly, contradictory findings (1, 8, 11) have been reported with respect to LSD and fetal abnormalities.

As the drug has a demonstrable impact on the nervous system, it has been theorized that long term effects may be due to central nervous system changes. One possible con-

sequence could be irreversible damage to brain cells. This possibility has been noted by Unwin (20) and finds support in the results of Silverstein and Klee (16) who concluded from their study that the memory impairment found with LSD intake may be due to an organic memory defect rather than to anxiety. A recent study by McGlothlin, Arnold, and Freedman (12) presents evidence of moderate impairment of abstract ability "which is suggestive of minimal brain damage."

The authors have been impressed by the wealth of strongly held popular opinions regarding LSD—its condemnation as a mind-destroyer by some and its exhaltation as a mind-expander by others. In an effort to obtain pertinent data on at least some of the possible effects of LSD, a group of 20 LSD users was compared with a matched group of LSD nonusers on a sensitive and complex battery of psychological tests designed to measure brain functions. It was appreciated that such a comparison might not "prove" anything; it would, however, serve as a means of collecting objective data to which others could contribute, thus bringing relevant scientific evidence to bear on the question of whether or not LSD produces irreversible changes in cerebral function.

Two previous studies of this sort have been reported in the literature to the authors' knowledge. McGlothlin, Arnold, and Freedman (12) have described a study in which 16 LSD users were compared to a group of nonLSD users using neuropsychological measures. In their study, only one subtest, Halstead's Category Test, differentiated the group significantly. However, the group tested was not, in our opinion, representative of the overall group that currently uses LSD. The subjects averaged 40 years of age, the largest number were college graduates, and the majority had also received psychotherapy. Cohen and Edwards (4) compared a group who had taken substantial amounts of LSD, 50 or more times, with a control group on the Halstead-Reitan battery along with other measures. The LSD group performed at a significantly poorer level on the Spatial-Orientation Test and on Trials A. The two studies in other aspects are similar to the one being described, being postdictive in nature.

METHOD

SUBJECTS

Two groups were investigated. The experimental group included 20 volunteer subjects (5 females and 15 males) who were frequent LSD users. The subjects ranged in age from 17 to 24 years with a mean age of 20.15 years. The duration of LSD use ranged from 4½ months to 27½ months with a mean of 12.2 months. The number of times the subjects had used LSD varied from five to one hundred, with a mean of 29.3 times. While four subjects had taken LSD as recently as 1 day prior to their evaluation, no subject was judged to be acutely toxic at the time of testing. The mean number of days since the subject had last taken LSD was 38.9. Members of the experimental group had also used a variety of other drugs, with marijuana, hashish, and methedrine taken most frequently. Table 1 indicates the variety of drugs taken by the group and the number of subjects having taken a specific drug. The usual LSD dosage was estimated to be between 100 and 300 μg.

These subjects initially volunteered to participate in a chromosomal study being conducted at a large general hospital in the spring of 1968. Each was offered five dollars if he would take at the same time a battery of psychological tests lasting from 3 to 4 hours. All agreed and proved cooperative subjects. It should be noted that these young people were not looking for help, although they were concerned enough about the possibility of chromosomal damage to volunteer for chromosome counts, which may reflect more than average self concern.

TABLE 1

Frequency of Use of Other Drugs by Experimental Group

Drugs Used	Frequency of Subjects Having Taken Drugs
LSD	20
Marijuana	19
Hashish	12
Methedrine	10
Opium	5
STP	5
Cocaine	4
Ethydrine	3
Unknown amphetamines	2
Morphine	1
Heroin	1
Mescaline	1
Demerol	1
Benzedrine	1
Apidrine	1
Dexadrine	1
Unknown barbiturates	1
DMT	1
Opium cured marijuana	1

In manner and appearance they varied from the conventional to the distinctly "hippie".

The control group was drawn from a normal group of 144 subjects who had been tested the previous year. These were all nonhospitalized, presumably healthy individuals with no diagnosed neurological impairment who were paid five dollars to be tested with the Halstead-Reitan battery. This data was collected as part of a larger neuropsychological research program. To the best of the investigators' knowledge, no member of the control group was using drugs or receiving any form of medical or psychiatric treatment at the time of testing. Twenty were selected from this group to match the age, sex, education, and intelligence of the experimental group. Table 2 provides a comparison of the two groups.

PROCEDURES

Both the experimental and control groups were administered the entire Halstead-Reitan neuropsychological battery with one exception. Although the Aphasia test is part of the battery, it had not been administered to the normal controls since it was assumed that normal subjects would not have aphasic symptoms. Performance on the Aphasia test is not quantified or included in calculating the impairment index on the Halstead-Reitan battery. The battery was administered in the manner described by Reitan (13) in the Neuropsychological Laboratory of the Department of Psychiatry, Winnipeg General Hospital.

RESULTS AND DISCUSSION

Table 3 summarizes the results of the tests administered to the LSD and nonLSD groups. The scores are presented in terms of the mean and standard deviation for each variable, with a "*t*" test being used to evaluate the differences between the means for the two groups. Two differences between means are significant at the .05 level of confidence with the LSD group performing more poorly on the WAIS Comprehension subtest and better on the WAIS Information subtest. With this as a criterion, one would argue against there being a statisti-

TABLE 2

Comparison of Experimental (LSD) and Control (Normal) Groups with Respect to Sex, Education, Age, and Intelligence

Groups	Sex		Education		Age		Intelligence (WAIS)					
	Male	Female	Mean Grade	SD	Mean	SD	Verbal IQ		Performance		Full Scale	
							M	SD	M	SD	M	SD
Experimental (LSD)	15	5	11.3	2.00	20.1	1.89	111.85	6.91	105.4	9.62	109.9	7.6
Control (Normal)	15	5	11.2	1.76	19.10	1.37	113.85	8.71	106.15	11.61	111.15	8.82

cally significant overall difference between the two groups, since the two differences found could be due to chance. In other words, on a quantitive basis, no clearcut differences were found between the two groups on a battery of tests measuring such psychological functions as inductive reasoning, the use of tactual cues in solving spatial relations problems, accurate perception of sounds (words and rhythms), speed of finger movement, and memory for shapes and for spatial localization. It should be noted that no significant difference between the experimental and control group was found in the Halstead Category Test as has been reported in the previously cited study by McGlothlin, Arnold and Freedman. Also the results obtained by Cohen and Edwards were not replicated.

The mean impairment index was calculated for each group. This is determined by adding up the number of test scores that fall in the brain damage range for each individual and then dividing this figure by the total number of scores. This would mean that if a subject had no scores falling within the brain damage range, his impairment index would be 0. If, on the other hand, all scores fell in the brain damage range, the score would be 1. When the results of the two groups were compared, they were found to be substantially the same, the mean impairment index for the LSD group being .24 and for the control group being .23.

The Halstead-Reitan battery includes a test of aphasia, which is an extension and modification of the Halstead-Wepman Aphasia Test (9). The subject is asked to name common objects, to spell, write, read, and perform simple arithmetic problems. It includes tests of perceptual discrimination and localization in the auditory, tactile, and visual fields. It also includes the copying of designs, enunciation of words, and the ability to identify correctly the right and left side of the body. Typically, these findings are not quantified and so do not contribute to the impairment index, but they are important qualitatively in determining the presence and location of brain disfunction. On the aphasia test, eight (40 per cent) of the LSD group were judged as having one or more aphasic symptoms. Five demonstrated constructional apraxia (on the basis of copying a triangle, square, and Greek cross) and four had spelling dyspraxia—either spelling simple words incorrectly (*e.g.*, cross spelled scross), or making letter reversals. Since three of the four had grade 10

TABLE 3

Means of Experimental (LSD) and Control (Normal) Groups on Halstead-Reitan Battery

Test†	Experimental (LSD) Group (Mean)	Control (Normal) Group (Mean)	*t*
WAIS Verbal IQ	111.85	113.85	.78
WAIS Performance IQ	105.40	106.15	.45
WAIS Full Scale IQ	109.90	111.15	.49
Information	12.60	11.50	1.76*
Comprehension	10.45	12.50	2.18*
Arithmetic	12.35	11.35	1.41
Similarities	11.55	11.90	.46
Digit Span	11.80	12.45	.68
Vocabulary	11.90	12.05	.19
Digit Symbol	12.05	11.75	.35
Picture Completion	10.70	10.05	.91
Block Design	11.40	10.65	.76
Picture Arrangement	10.70	11.00	.43
Object Assembly	9.50	10.75	1.30
Category-total errors	44.45	39.55	.80
Tactual Performance Test			
Total Time	11′9.95″	10′15.80″	.62
Shape	8.05	7.80	.52
Location	5.40	5.10	.51
Speech Perception—total errors	5.00	4.95	1.04
Rhythm Discrimination—total errors	3.50	2.55	1.34
Trails A & B—Ranks	16.16	15.95	.26
Tapping Speed			
Dominant Hand	45.69″	45.89″	.10
Nondominant Hand	41.25″	43.20″	.98

* $p < .05$.

† In the following tests, low scores represent better performance: Category, Tactual Performance Test—Total Time, Speech Perception, and Rhythm Perception.

standing, it is not likely that this is due to lack of education. Unfortunately, no comparison can be made with the normal group because the aphasia test was not administered to the normal subjects. However, Reitan and Wheeler (14) administered this aphasia test to a group of 104 somewhat older subjects and found 68.3 per cent of their group to be free from aphasic symptoms; the figure is 60 per cent for the LSD group reported here.

In light of the fact that there is some slight difference in aphasic symptoms found in Reitan and Wheeler's normal group and in the LSD group studied here, two LSD subgroups were compared—those with aphasic symptoms and those without. It was found that the LSD group with aphasic symptoms had a higher impairment index than those without—a mean impairment index of .32 as compared to .13, a difference significant at the .01 level of probability. This would suggest that the aphasic subgroup did more poorly on the quantifiable Halstead-Reitan tests as well as on the aphasia test.

In exploring reasons which might account for this difference, the two LSD subgroups were compared with respect to the number of times they had taken LSD, the recency of their taking it, the total number of drugs taken, and the length of time on drugs. No differences were found. These aspects of their drug-taking history were similar for both subgroups, and, thus, failed to reveal any relationship between drug behavior and psychological test behavior.

It will be recalled that the mean impairment index for the normal group was .23 while that of the LSD group was .24. These were judged as being essentially similar. However, when the LSD group is subdivided on the basis of presence of aphasic symptoms, the impairment indices for the two groups are .13 for the aphasic subgroup and .32 for the nonaphasic subgroup—scores which are lower and higher than the mean scores for both the experimental group and the control groups. Thus, it could be argued that LSD use may either improve or impair performance on the Halstead battery, relative to the performance of a "normal" population. Another possibility is that within any representative normal population there are variations in brain function which will lead to similar variations in performance on both the Halstead-Reitan battery and on the modified Halstead-Wepman Aphasia Test. Unfortunately, since the aphasia test had not been given to the nonLSD users, this hypothesis could not be directly tested.

However, it was possible to approach this question obliquely and provide evidence which bears on the question of whether LSD users do indeed have more or less evidence of aphasia than normal subjects. It was noted previously that there is some suggestive evidence to support the notion that LSD users do have more aphasic symptoms than normal subjects. Reitan reports 31.7 per cent of his normal subjects having at least one aphasic symptom whereas the LSD group studied here had a 40 per cent incidence. The significance of this finding is uncertain due to the fact that Reitan's population was of a different mean age (older) and also that a different scoring criteria may have been used in assessing aphasia. Therefore, to further explore the possible relationships between LSD ingestion and the presence of aphasic symptoms, the modified Halstead-Wepman Test of Aphasia was administered to 48 first-year university students who had no previous history of drug taking. The aphasia test was administered individually by the same technicians as had been used for the LSD subjects, the procedures followed being as nearly identical as possible. The students were also given the Otis Self-Administering Test of Mental Ability for control purposes.

As a group, the students scored higher on the Otis than did the LSD subjects (mean IQ of 116 versus mean IQ of 109), were more heavily weighted in terms of females (17 males and 31 females), but were similar in terms of age, with a difference in mean

age of less than 6 months. It would have been possible to make both the sex difference and difference in IQ comparable in the two groups, however, since it was apparent from an inspection of the data that there was little relationship obtained between either the student's IQ score or his sex with respect to his performance on the aphasia test, it was decided to use the total group for comparison purposes.

Each aphasia test was scored blind by the technicians employing a standard technique that had been developed for coding data gathered from the Halstead-Reitan Aphasia Test for another research project. It involved counting each indication of aphasia for 22 separate test items. As some of the items had scores ranging from 1 to 36 (tactile suppression), the total score distribution was from 1 to 174. This procedure, although losing something in clinical sensitivity, had the advantage of being objective and reasonably reliable.

Neither group had a high mean score. The mean score for the LSD group was 5.68 symptoms (SD 3.36) and for the students 4.30 symptoms (SD 3.27). This difference was not statistically significant. As can be seen, the standard deviations were very similar, thus arguing against any significant difference in degree of variability in aphasic symptoms among LSD as compared with nonLSD users. Examining the protocols qualitatively, the slight differences between the groups were distributed over the 22 scored items in a roughly equitable fashion with no single symptom being responsible for the group differences.

The fact that LSD users did not function significantly different from nonLSD users on the test of aphasia would tend to argue against the idea of LSD either impairing or improving performance on the Halstead battery. Therefore, it would seem more likely that such differences could be attributable to possible variations in brain function which influences an individual's performance on neuropsychological tests independent of LSD use.

CONCLUSIONS

On the basis of the present study certain conclusions can be drawn.

1. There is no evidence in this study that LSD ingestion is significantly related to any measurable decrement in brain function on the Halstead-Reitan battery including the Halstead-Wepman Aphasia Test.

2. This finding is contrary to the results of McGlothlin inasmuch as they found a significant difference in ability to reason abstractly as measured by the Category Test of the Halstead-Reitan, in favor of nonLSD users. It should be noted, however, that the two groups here are not comparable because the LSD users in the study cited above had been given LSD in either a therapeutic or experimental setting. The LSD group in this study was perhaps a more typical LSD group inasmuch as they were presenting no overt psychiatric or social problems. Nevertheless, it could be argued that the fact that they had presented themselves for chromosome counts because of LSD intake made them a somewhat special LSD group in terms of a greater degree of self or social concern.

With the LSD group, there was found to be a relationship between the impairment index of the Halstead-Reitan battery and the aphasia test score, indicating correspondence between two independent measures of "organicity". Although no direct comparison could be made here with the original control group, it was possible to demonstrate that the variability in both groups for each measure was essentially similar, and it would seem likely that such findings are not peculiar to the LSD group.

As has been noted (12), retrospective studies of this type on human subjects are subject to several limitations:

1. Regardless of how carefully the comparison group is matched with the drug-using sample, there is still no guarantee that the differences between the groups are not due to predrug factors associated with the

willingness to repeatedly take a potent mind-altering substance.

2. Drug users typically employ a number of substances so it is difficult to attribute differences to a particular drug.

3. Unless the subject is institutionalized, it is difficult to separate acute from permanent or semi-permanent drug effects.

4. Differences in test scores may be due to differences in motivation between the drug users and comparison samples.

With respect to the comparisons made here, it would seem likely that such considerations would pose more of a problem in interpreting found differences than a lack of difference between two groups. For instance, had the LSD group proven inferior on tests measuring brain function, then such differences could be argued as being due to the influence of drugs other than LSD, personality factors associated with drug intake, influence of having taken drugs shortly before testing, or motivation with respect to testing. Added to this, one might argue that there were situational factors which would bias the results in favor of the normal population. Although both groups were tested under similar conditions, it could be argued that the hospital setting would be more foreign to the LSD subjects than it would be for the normal controls or for the university students who were tested at the university. Also one could argue that the university students would be more practiced and confident in taking tests than a group of semi-disengaged LSD adolescents and young adults. The fact that despite these conditions the LSD group did not do significantly more poorly than the nonLSD group would suggest rather strongly, at least for this group and in terms of the cognitive functions sampled, that no differences existed.

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