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MENTAL AGE REGRESSION INDUCED BY LYSERGIC ACID DIETHYLAMIDE*

Psychological Institute, Medical School, Düsseldorf, Germany

G. A. LIENERT

A. INTRODUCTION

In two previous studies (11, 12), it was found that the profile and factorial composition of a battery of standardized tests characteristically changed under the influence of the psychomimetic drug, d-lysergic acid diethylamide (LSD: Amp. Delysid à 0.1 mg).[1] The resulting changes have been interpreted as *regressive phenomena* in the sense of age regression (*cf.* 6, p. 303).

During the interim, the sample of subjects has been considerably enlarged, enabling a more conclusive examination of earlier findings.

B. METHOD

1. *Subjects and Tests*

A total of 65 male and female student volunteers from the Liberal Arts and Sciences Divisions of the University of Marburg, with a mean age of 24.3 years, was given the Intelligenz-Struktur-Test (IST) by Amthauer (1). The IST consists of the following nine subtests: (*a*) General Information (SE), (*b*) Word Classification (WA), (*c*) Verbal Analogies (AN), (*d*) Verbal Relations (GE), (*e*) Memory for Concepts (ME), (*f*) Arithmetical Reasoning (RA), (*g*) Number Series (ZR), (*h*) Spatial Relations (FA), and (*i*) Cube Rotation (WÜ).

Subtest raw scores were transformed into standardized scores with a mean of 100 and a standard deviation of 10. Individual scores of the full test scale were defined by the arithmetical mean of the standardized subtest scores.

2. *Procedure*

The IST battery (parallel forms A and B) was administered to each of the 65 subjects *twice* with an interval of one week. Subjects were first

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[1] The drug was made available by Sandoz AG, Nuremburg, through the courtesy of Dr. A. Augsberger.

tested under control conditions and then under the experimental conditions involving LSD. A random sequence to the experimental condition could not be realized, since the subjects had to have prior experience with the tests; otherwise, they could not adequately perform when under the influence of LSD. Experimental conditions and positive transfer effects in the present investigation, therefore, are somewhat confounded, inasmuch as the decrease of performance under LSD is counterbalanced by the increase due to transfer. Hence, the nonrandom sequence of conditions is in favor of the null hypothesis (no change in mean level) of Prediction 1.

Each subject was tested in an individual session either in the early or the late morning.

3. *Medication*

LSD was administered orally with a cup of acidified water, two hours after breakfast. Dosage was 1.25 micrograms/kg of body weight. Tests were administered about two hours after application, as soon as the acute symptoms of the LSD intoxication (emotional reactions, hallucinations, illusions, etc.) had subsided. The testing procedure lasted approximately two hours.

4. *Design and Analysis*

The experimental conditions constituted a *three factorial design* with two fixed factors and one random factor. The first fixed factor was the treatment with the classification LSD versus control conditions. The second fixed factor was constituted by the nine IST subtests. Individual characteristics of the 65 subjects constituted the random factor.

Statistical analysis was made in the following way. First, the full-scale score of the IST was examined for changes in mean level of performance. Second, the IST subtest scores were submitted to profile analysis. Finally, scores of all nine scales were intercorrelated separately under both conditions and factored by Thurstone's centroid method (18). The resulting centroid factor matrices were then transformed to simple structure by quartimax rotation (7).

C. Hypothesis

According to the *differentiation hypothesis of mental development* (2, 5), the progression of mental functioning is characterized (*a*) by increase in general level of test performance, (*b*) by alterations of test profiles in favor of abstract reasoning (*cf.* 15), (*c*) by lowering the test intercorrelations, (*d*) by differentiation of factorial composition of the respective tests, and (*e*) by reaching the simple structure of the primary mental abilities (*cf.* 17).

When LSD, as supposed, acts as a means of *regression in mental functioning,* or mental age regression, the changes should be characterized by symptoms opposite to the differentiation hypothesis.

D. Predictions

Assuming regressive developmental response to be formally equivalent to progressive development, we may derive several predictions from the combined *differentiation-regression hypothesis:*

1. The *average full-scale score* of the IST battery will be reduced under LSD, since the full-scale score is associated with progressive increments in mental development (*cf.* C-*a*).

2. The *average subtest profile* will change in level and shape under LSD so that tests of abstract reasoning will be more negatively influenced than those involving concrete operations (*cf.* C-*b*), since abstract reasoning develops later than concrete reasoning.

3. *Intercorrelations of the nine subtests* will increase under the influence of LSD, since such correlations—according to the differentiation hypothesis —decrease during adolescent development (*cf.* C-*c*).

4. *Factor composition of the subtests* will lose in degree of differentiation under the influence of LSD, since intelligence becomes more differentiated during adolescent development (*cf.* C-*d*).

With respect to changes in factorial composition, the following predictions were made through the differentiation-regression hypothesis: (*a*) the *general factor g* of the IST battery will achieve higher loadings in most subtests under the influence of LSD than under normal conditions, since *g* is assumed to decrease with age; and (*b*) the *communalities* of the subtests will increase under LSD, since they are assumed to decrease during development.

5. *Rotated factors* will lose their simple structure and become somewhat more complex (*cf.* C-*e*), since "mental organization changes from the unified general ability in childhood to a loosely organized group of mutually independent abilities in adulthood" (5, p. 373).

E. Results

1. *Prediction 1*

Mean *performance level* of the 65 students was found to be 103.6 under LSD and 110.2 under normal conditions, respectively. The decrease in performance from 110.2 to 103.6 is equivalent to the decrease on the WB-I from *IQ* 123 to *IQ* 112, reported by Levine *et al.* (9) within a sample of *S*s receiving 50-200 micrograms of LSD. The difference in the present study,

statistically significant at the .001 level (t test for matched samples), is equivalent to a decrease in mental age from 24.3 to 15.6 years (equivalent regression age).

2. *Prediction 2*

The *average profile* of the IST calculated for both conditions is given in Table 1.

TABLE 1
MEAN STANDARD SCORES ($\mu = 100$, $\sigma = 10$) OF THE NINE SUBTESTS OF THE IST BATTERY UNDER NORMAL CONDITIONS AND UNDER LSD ($N = 65$)

	Test								
Condition	SE	WA	AN	GE	ME	RA	ZR	FA	WÜ
Normal	111.7	109.6	113.0	115.4	108.7	108.0	110.6	107.3	107.9
LSD	105.9	104.7	107.6	108.5	101.1	100.5	100.5	103.1	100.1

Profile analysis was made by the three-way analysis of variance of the individual standard scores (13). The results, presented in Table 2, may be summarized as follows:

TABLE 2
THREE-WAY ANALYSIS OF VARIANCE OF THE IST STANDARD SCORES WITH THE FIXED FACTORS (*a*) CONDITIONS (NORMAL *vs.* LSD), (*b*) SUBTESTS SE THROUGH WÜ, AND (*c*) THE RANDOM FACTOR, SUBJECTS 1 THROUGH 65

Source of variance	Sum of squares	Degrees of freedom	Mean square	Variance ratio F
Conditions	14290.53	1	14290.53	120.21**
Subtests	9099.28	8	1137.41	12.87**
Subjects	38192.30	64	596.75	—
Cond. × Subtests	649.80	8	81.23	2.21*
Cond. × Subjects	7608.52	64	118.88	—
Subtests × Subjects	45242.61	512	88.36	—
Cond. × Subtests × Subjects	18803.65	512	36.73	—
Total	133886.69	1169	—	—

* Significant at .05 level.
** Significant at .001 level.

a. The decrease in *profile level* shown by the F-ratio for both conditions is equivalent to changes in the full-scale score described under Prediction 1.

b. The change of *profile shape* under LSD is indicated by the interaction F-ratio *conditions* × *tests* significant at the .001 level. The resulting interaction indicates that a greater loss of performance under LSD occurs,

as predicted, in such tests as RA and ZR than in tests like FA, a spatial relations test. RA and ZR have been factorially identified by Fischer (4) as tests of abstract reasoning (Prediction 2).

c. To examine whether age regression in performance level and shape (Predictions 1 and 2) is consistent with age regression in performance level and profile shape, raw scores of the IST subtests achieved under LSD were transformed to standard scores according to the norms for 15-year-olds. The resulting average profile of the transformed scores did not differ statistically from the group profile under normal conditions.

d. To summarize Predictions 1 and 2, the findings are in agreement with the differentiation-regression hypothesis (*cf.* C-*a* and C-*b*).

3. *Prediction 3*

Table 3 presents the *Pearsonian intercorrelations* of the normally distributed standard scores for the two conditions.

TABLE 3
PRODUCT-MOMENT INTERCORRELATIONS OF THE IST SUBTESTS UNDER NORMAL CONDITIONS (RIGHT UPPER HALF) AND UNDER LSD (LEFT LOWER HALF)

	Test								
Test	SE	WA	AN	GE	ME	RA	ZR	FA	WÜ
SE	—	.29	.29	.22	.33	.24	.26	.35	.14
WA	.50	—	.22	.21	.10	.26	.21	.22	.03
AN	.71	.53	—	.31	.28	.45	.35	.34	.24
GE	.47	.48	.59	—	.11	.27	.15	.18	.07
ME	.24	.37	.50	.28	—	.50	.35	.35	.19
RA	.58	.43	.63	.46	.51	—	.73	.59	.45
ZR	.36	.40	.44	.34	.51	.72	—	.39	.44
FA	.37	.24	.44	.22	.34	.62	.53	—	.58
WÜ	.26	.18	.30	.17	.13	.40	.42	.64	—

a. The *average intercorrelations* raised from .30 for normal conditions to .39 for LSD. This increase was not due to an increase in standard deviations of the nine subtests, as was found by comparison of the subtest variances under LSD with those under normal conditions (*cf.* 19, p. 190). This increase of heterogeneity of performance may not have produced increase of subtest intercorrelations. The mean difference, though numerically small, may be accepted as substantial, since 30 of the 36 pairs of correlations coefficients increased under LSD conditions. The statistical sign test may not be applied for these differences, since pairs of corresponding correlations coefficients are not stochastically independent.

b. The *chronological equivalent* of the intercorrelational change cannot be estimated because differentiation theory has not yet established any function of how mean test intercorrelations change with age.

Though Prediction 3 cannot be examined statistically, numerical results provide evidence in favor of the differentiation-regression hypothesis (*cf.* C-*c*).

4. *Prediction 4*

According to Thurstone (18, p. 121) a *general factor* of a test battery may be called any factor which has substantial loadings on all (or nearly all) subtests. Two factor-analyses of the intercorrelations—one for LSD and another for normal conditions—provided evidence that the first centroid factor in each analysis could be treated as a general factor.

The *loadings of the nine subtests on the first centroid factor* are shown in Table 4.

TABLE 4
LOADING OF THE IST SUBTESTS ON THE FIRST CENTROID FACTOR UNDER NORMAL CONDITIONS AND UNDER LSD

Condition	Test SE	WA	AN	GE	ME	RA	ZR	FA	WÜ
		Verbal tests				*Nonverbal tests*			
Normal	.70	.61	.80	.60	.50	.84	.73	.67	.52
LSD	.49	.36	.58	.36	.54	.83	.71	.70	.54

a. The *mean loadings* on the so-defined general factor were .67 under LSD and .57 under normal conditions. This finding is in agreement with prediction 4a and gives support to the differentiation hypothesis of intelligence factor structure as set out by the present writer elsewhere (14) (*cf.* also C-*d* above). It is interesting to note that the increase in general factor loadings under LSD was mainly due to verbal tests with low general factor loadings under normal conditions. Thus, the nonverbal general factor under normal conditions changed to a verbal-nonverbal complex factor under LSD.

b. Since the *communalities* in the factor analytic procedures are numerically dependent on the number of extracted factors—i.e., on the process of extraction and on the criterion of when to cease extraction—it was decided to compare the communalities of only the first four centroid factors under both conditions.

As may be seen from Table 5, none of the communalities under LSD is higher than the corresponding communality under normal conditions. This finding is in agreement with Prediction 4b.

TABLE 5
COMMUNALITIES OF THE IST SUBTESTS UNDER NORMAL CONDITIONS AND UNDER LSD DETERMINED FROM THE FIRST FOUR CENTROID FACTORS

Condition	Test SE	WA	AN	GE	ME	RA	ZR	FA	WÜ
Normal	.40	.25	.40	.28	.40	.86	.66	.65	.56
LSD	.41	.30	.42	.29	.47	.87	.68	.66	.61

5. *Prediction 5*

Rotating the centroid matrices to simple structure according to the quartimax criterion resulted in Table 6. Results may be summarized as follows:

TABLE 6
MATRICES OF ROTATED FACTORS UNDER NORMAL CONDITIONS AND UNDER LSD

Subtest	Rotated factors A_0'	B_0'	C_0'	D_0'	E_0'	Rotated factors A_1'	B_1'	C_1'	D_1'
	Normal conditions					*LSD*			
SE	0.02	0.17	0.18	0.38	0.46	0.13	0.25	0.72	0.27
WA	0.14	0.03	0.22	0.02	0.48	0.27	0.09	0.63	—0.11
AN	0.21	0.19	0.52	0.20	0.17	0.34	0.21	0.75	0.31
GE	0.07	0.03	0.51	0.05	0.17	0.22	0.07	0.67	—0.11
ME	0.30	0.11	0.13	0.59	0.08	0.63	0.06	0.27	0.10
RA	0.76	0.33	0.31	0.29	0.05	0.64	0.40	0.42	0.16
ZR	0.70	0.30	0.11	0.18	0.25	0.71	0.39	0.24	—0.16
FA	0.19	0.69	0.16	0.31	0.17	0.34	0.75	0.14	0.19
WÜ	0.24	0.74	0.06	0.01	0.02	0.09	0.76	0.14	—0.06
Sum of the squared loadings	1.32 = 28%	1.30 = 27%	0.77 = 16%	0.75 = 16%	0.60 = 13%	1.69 = 29%	1.57 = 27%	2.27 = 39%	0.29 = 5%

a. As may be seen from Table 6, the total variance of the tests concentrates under LSD on the first three rotated factors, whereas the variance of the tests under normal conditions is distributed almost evenly among at least five rotated factors. As a consequence, the conditions of the *simple structure* are realized more effectively under normal conditions than under LSD, a finding which is in agreement with Prediction 5.

b. Interpretation of the rotated factors results in the following conclusions:

Under normal conditions, Factor A is a *reasoning factor* (RA, ZR), Factor B is a *spatial factor* (FA, WÜ), Factor C is a *verbal comprehension factor* (AN, GE), Factor D is a factor of *associative memory,* and Factor E may be thought of as a *verbal classification factor* (SE, WA). As predicted by Fischer (4), the IST may be analyzed for factors similar to that of primary mental ability (17). The dominating factor is that of abstract reasoning.

Under *LSD conditions,* the dominating Factor A is primarily of the *verbal type,* since all verbal tests are loaded substantially on this factor. Second to it, Factor B is of a *reasoning type* of not as clear structure as that under normal conditions. Factor C is equivalent to the Factor B under normal conditions in all respects. It is a *spatial relations* factor, not substantially influenced by the drug. Factor D defies interpretation, since there are no substantial loadings on this factor.

c. In summary, it may be concluded that under LSD the structure of rotated factors is more undifferentiated and complex than under normal conditions. Only the spatial relations factor is as well differentiated under LSD as under normal conditions. Thus, Prediction 5 tends to be verified by the procedure of factor rotation, which is in agreement with the differentiation-regression-hypothesis (*cf.* C-*e*).

F. Discussion

Present findings in the intellectual area are consistent with other experimental findings in the perceptual area. Liebert *et al.* (10) have found perceptual primitivation in LSD induced psychosis, as have Krus and Wapner (8). Furthermore, the regression hypothesis is in agreement with observations of psychotherapists (3, 16) using LSD as an aid for "reliving of repressed personal memories" of early childhood. If we integrate these findings with those of the present study, it may well be that LSD is a means of inducing behavioral regression in different areas of personality to an earlier state of development. One area of this may be mental age regression.

But can it be stated with certainty whether regression is a specific effect of LSD? This question is not to be answered precisely because analogous experiments utilizing the same battery of tests produce similar results when subjects perform under alcohol and conditions involving sleep deprivation (14). In terms of this generalization it may be suggested that the regression effect is nonspecific and induced either by pharmacological or by physiological stress.

The interesting question of why regression occurs under stress may be only tentatively answered. Psychoanalysts would suggest that regression is a defense mechanism that will occur when every mental function is impaired (as under LSD) or when emotionality is aroused (as under alcohol). It may well be that successful adaptive behavior in the intellectual area is more likely to be achieved by regression than by other means of compensation.

G. Summary

Sixty-five students were given a battery of verbal and nonverbal paper-and-pencil tests under normal conditions and two hours after they had

orally received approximately 0.01 mg of lysergic acid diethylamide (LSD).

Under the LSD condition (*a*) the level of performance decreased, (*b*) the shape of the battery profile changed in disfavor of the abstract reasoning tests, (*c*) the intercorrelations lowered, and (*d*) the factorial composition of the battery seemed to be less differentiated than under normal conditions. The findings were interpreted in terms of mental age regression introduced by pharmacological stress.

References

1. Amthauer, R. Der Intelligenzstrukturtest (IST) (2nd ed.). Göttingen: Hogrefe, 1955.
2. Burt, C. The differentiation of intellectual ability. *Brit. J. Educ. Psychol.*, 1954, **24**, 76-90.
3. Busch, A. K., & Johnson, W. S. LSD-25 as an aid in psychotherapy. *Dis. Nerv. Syst.*, 1950, **11**, 241-243.
4. Fischer, H. Ein Vergleich zwischem dem IST von Amthauer und dem PMA von Thurstone. *Diagnostica*, 1958, **4**, 25-32.
5. Garrett, H. E. A developmental theory of intelligence. *Amer. Psychologist.*, 1946, **1**, 372-378.
6. Hilgard, E. R. Theories of Learning (2nd ed.). New York: Appleton, 1956.
7. Kaiser, H. F. The varimax criterion for analytic rotation in factor analysis. *Psychometrika*, 1958, **23**, 187-200.
8. Krus, D., & Wapner, S. Effects of lysergic acid diethylamide (LSD-25) on perception of part-whole relationships. *J. of Psychol.*, 1959, **48**, 87-95.
9. Levine, A., Abramson, H. A., Kaufman, M. R., & Markham, S. Lysergic acid diethylamide (LSD-25): XVI. The effect on intellectual functioning as measured by the Wechsler-Bellevue Intelligence Scale. *J. of Psychol.*, 1955, **40**, 385-395.
10. Liebert, R. S., Werner, H., & Wapner, S. Studies on the effect of lysergic acid diethylamide (LSD-25). *A.M.A. Arch. Neurol. Psychiat.*, 1958, **79**, 580-584.
11. Lienert, G. A. Pharmakologische Untersuchungen über den Abbau der geistigen Leistungsfähigkeit. Bericht über den 20, Kongress der Deutschen Gesellschaft für Psychologie in Bonn, 1955. Göttingen: Hogrefe, 1956. Pp. 144-147.
12. ———. Changes in the factor structure of intelligence tests produced by d-lysergic acid diethylamide (LSD). Proceedings of the First International Meeting of Neuropsychopharmacology in Rome. Amsterdam: Elsevier, 1960. Pp. 461-465.
13. ———. Eine varianzanalytische Methode zum Nachweis der Gruppenspezifität von Testprofilen. *Z. Exp. Angew. Psychol.*, 1963, **10**, 333-345.
14. ———. Belastung und Regression Meisenheim am Glan: Anton Hain, 1964.
15. Piaget, J. Psychologie der Intelligenz. Zürich u. Basel: Rascher, 1948.
16. Sandison, R. A. Psychological aspects of the LSD treatment of the neurosis. *J. Ment. Sci.*, 1954, **100**, 508-515.
17. Thurstone, L. L. Primary mental abilities. *Psychometric Monog.*, 1938, **1**, 1-121.
18. ———. Multiple factor analysis. Chicago: Univ. Chicago Press, 1947.
19. Walker, H., & Lev, J. Statistical Inference. New York: Holt, 1953.

Psychological Institute
Medical School
Düsseldorf, Germany