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Effects of Lysergic Acid Diethylamide (LSD) on Cortical Sensory Evoked Potentials in the Cat

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Introduction

Several authors have reported the effects of lysergic acid diethylamide (LSD) on evoked potentials in primary sensory pathways. The areas studied were retina,[2] lateral geniculate body,[8] and visual,[9,14,18] auditory,[14,18] and somatic cortex.[14] There is incomplete agreement on the effects of LSD on visual and auditory cortex. Purpura[14] found facilitation of visual cortical potentials with small doses, whereas Evarts[8] found no significant effect with very large doses. Rovetta[18] used LSD topically and intravenously in small doses and reported an absence of effect on both visual and auditory potentials. Large doses of the drug have been used infrequently.

Numerous authors have described the effects of LSD on the electrocorticogram of several species of animals.* There is a great variation in the dose reported to produce a significant change in frequency and amplitude, as well as disagreement regarding the character of the changes.

The current study was designed to investigate the effects of LSD on cortical visual, auditory, and somatic evoked potentials and also to correlate these observations with the electrocorticogram by recording simultaneously with a cathode-ray oscilloscope (CRO) and an ink-writing oscillograph. Finally, an attempt was made to determine the minimal change in evoked potentials indicative of a drug effect.

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Methods

A total of 89 cats were used in this study. Sensory evoked potentials were studied in 39 cats which received LSD one or more times. The data from 27 were analyzed in detail and appear in the text.

Twenty animals were anesthetized with ether, then paralyzed with succinylcholine after the surgical procedures (Anectinized animals). Skin edges and pressure points were infiltrated with 0.5% procaine hydrochloride. Electrical recording was begun no less than two hours following cessation of ether anesthesia. The initial paralyzing dose of succinylcholine chloride was 20 mg., followed by 20-mg. supplements as required to prevent spontaneous movement. The animals were ventilated with a Marshall respirator.

Seven cats were anesthetized with pentobarbital sodium, 30 mg/kg., injected intraperitoneally, and additional intravenous injections were given as required to produce moderately deep anesthesia. Most of the animals were artificially ventilated to obviate any possibility of hypoxia.

Visual stimulation was produced by a small sealed bulb which delivered a narrow beam of light for 10 msec. to the eye contralateral to the recording electrode. Clicks from a loud-speaker mounted near the animal's head were used for auditory stimulation. Tactile stimulation was produced by a Goodman Industries "vibrator," mounted over a pad of the contralateral forefoot. All three sources of stimulation were operated by Tektronix pulse generators and wave-form generators with variable delays. In most experiments the three stimuli were delivered simultaneously at 2.5 second intervals.

A bank of 10 electrodes was used for recording from the cortex. The electrodes were spring-mounted, cylindrical, silver electrodes with a tip diameter of approximately 1 mm. The primary cortical area of each sensory modality was explored for a maximum response in every experiment. Monopolar recording was used with the indifferent electrode on the head holder or on bone surrounding the craniectomy.

Two methods of recording were used: The output was led (1) differentially into Tektronix preamplifiers, displayed on a Dumont dual-beam oscilloscope, and photographed with a Grass camera, and (2) into a Grass eight-channel electroencephalograph through a panel designed for rapid switching into the CRO of information appearing on any two channels of the electroencephalograph. Because none of the stimulus sources produced an electrical artifact, a fraction of each stimulus, with a variable amplitude control, was led directly into the CRO for more accurate observations of latency.

In a majority of the preparations, a "well" was constructed from the skin flaps following the craniectomy. Before retracting the dura, or immediately afterward, this was filled with warm liquid petrolatum U. S. P. (mineral oil) and changed periodically. In the remaining animals liquid petrolatum was placed on the cortex as required to prevent drying.

The rectal temperature was measured with a thermometer and recorded at hourly intervals. Body temperature was maintained with heat lamps or a heating pad.

The LSD used was the Sandoz Pharmaceuticals product "LSD-25 pure substance." This was dissolved in distilled water and administered through a catheter in the femoral vein. Initially, the drug was given within one hour of preparation, but subsequent experiments proved that solutions refrigerated for three days showed no diminution in effect. On the basis of several injections of distilled water, the volume of injection was found to be critical. A single injection of 8 ml. produced profound changes in the electrocorticogram, and occasional electrical silence for brief periods of time. Injections of 3 and 4 ml. produced no detectable effect. Therefore, the maximum volume of drug injection used was 2.5 ml.

LSD was given at eight dose levels, from 0.025 to 4.0 mg/kg.

Evoked potential amplitudes were analyzed in two ways. From the EEG records the amplitudes of 15 consecutive potentials were measured during the preinjection period and the mean amplitude calculated. Then similar measurements were made at numerous postinjection times. In addition, films of the CRO traces were projected onto graph paper in a microfilm reader, and the peak amplitudes were measured.

For illustrative purposes five consecutive traces from the CRO were superimposed on film at frequent times during each experiment.

The analysis of the electrocorticogram was based on the records of 80 injections in 48 animals. Each record was analyzed during the control period and several times after injection. Estimates of changes in frequency and amplitude were made by visual inspection and confirmed by measurements. Frequency changes in the electrocorticogram of 10 per second and amplitude changes of 50μv. following LSD were recorded as possible drug effects.

Results

Effects of Multiple Sensory Stimulation on Evoked Potentials

The recording loci of the three cortical evoked potentials are shown in Figure 1. The map of the cortical surface is representative of the animals used in this study; but, because of variations in the sulcal pattern of the cat's cortex, precise localization of electrode placement is not possible in this Figure. Most of these points of maximum response fall within the limits of the

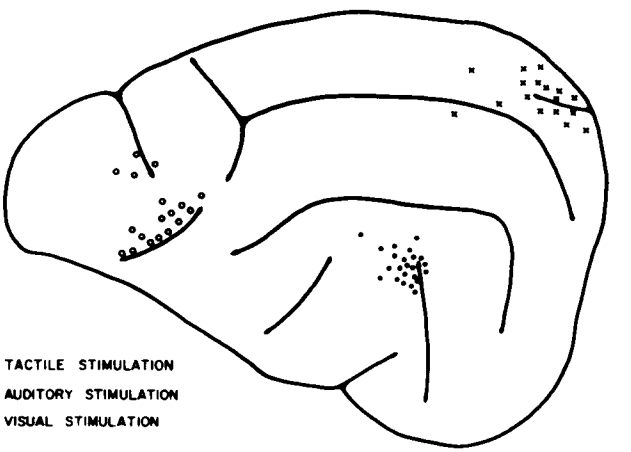


Fig. 1.—Cortical points of maximum response to sensory stimulation. Most of the recording points are within the primary area of each sensory modality as illustrated by Rose and Woolsey.

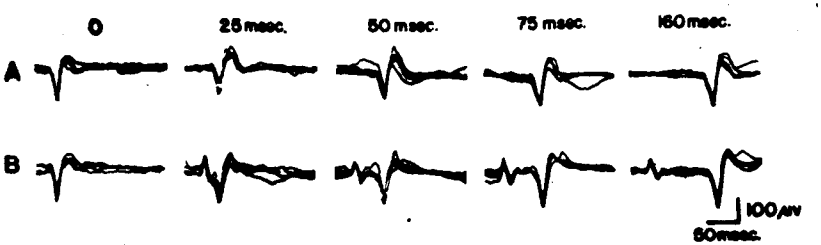


Fig. 2 (Cat 52).—Pentobarbital. Responses to click and tactile stimulation are recorded at the same point in primary somatic cortex. *A*, tactile stimulation; *B*, tactile and auditory stimulation. Auditory stimulation precedes tactile stimulation at time intervals indicated at the top of the Figure.

primary sensory areas as illustrated by Rose and Woolsey.[17]

The area of cortex responding to a single modality of stimulation varied greatly among animals, and this was particularly true of auditory stimulation. Marshall et al.[13] demonstrated distinct potential changes in primary auditory cortex in response to visual stimuli, but found no evidence of interaction between these potentials and auditory evoked potentials. The possibility of an interaction of diverse sensory stimuli at the cortical level has been investigated by Amassian,[1] who found in the cat, under chloralose anesthesia, blocking interaction among volleys from visual, somatic, and auditory receptors in the anterior lateral gyrus, and by Buser,[6] who found points in the association cortex responsive to auditory, vestibular, and somatic stimuli. However, Buser found that there was occasional facilitation of a response by stimulation of a different sensory modality.

Because all three stimuli were usually delivered simultaneously in the present study, it was important to determine whether an interaction among stimuli was present. Each primary area was examined with all three stimuli in succession. A response to clicks was seen occasionally in both primary

TABLE 1.—*Effect of LSD on the Electrocorticogram*
Succinylcholine (Anectine)

LSD Mg/Kg.	No. of Injections	No. of Effects	Volt. Incr.	Volt. Decr.	Freq. Incr.	Freq. Decr.	Sp.*	E. S.†
			First Injection					
0.025	1	0						
0.05	6	2	1	0	0	2	1	0
0.1	3	1				1	1	
0.25	4	1	0	1	0	0	0	0
0.5	2	2	1	0	0	2	1	0
1.0	8	8	4	4	0	8	0	4
2.0	4	4	1	0	0	4	1	0
4.0	2	2	1	1	0	1	0	1
			Second Injection					
0.025	1	0						
0.05	2	0						
0.1	4	1	0	0	0	1	0	0
0.25	1	1	1	0	0	0	0	0
0.5	5	2	0	2	1	1	0	1
1.0	3	3	0	0	0	3	1	0
2.0	3	2	0	2	0	1	0	1
Totals	49	29	9	10	1	24	5	7

* Sp. = spindling.
† E. S. = electrical silence.

visual and somatic cortex. Tactile stimulation rarely produced a response in auditory cortex, and after light flash there was never an evoked potential in either auditory or somatic cortex. In Figure 2 a small auditory evoked potential is recorded in primary somatic cortex. When the two stimuli were delivered simultaneously, the auditory response was obscured by the somatic evoked potential, but the amplitude of the latter was unchanged. When auditory stimulation preceded tactile stimulation at several time intervals, up to 160 msec., again there was no evidence of either inhibition or facilitation of the latter. Despite this observation, recording points used for the drug study were those responsive to a single modality of stimulation.

Effects of LSD on the Electrocorticogram

Tables 1 and 2 show the incidence of changes in frequency and amplitude of the electrocorticogram following LSD. Anesthetized and Anectinized animals have been considered separately in order to assess the effects of pentobarbital. Table 1 shows that all initial injections of 0.5 mg/kg. in Anectinized animals produced alterations of frequency or amplitude or both. Obliteration of the electrocorticogram was produced frequently by large doses. Table 2 indicates that the results are similar in the pentobarbitalized animals except that effects occurred more frequently at 0.25 mg/kg. However, the number of injections of this dose was insufficient for these differences to be significant. A difference in effect between the two preparations is also suggested by the number of times the electrocorticogram was obliterated in the two series. Following 5 of 30 injections there was electrical silence in the Anectinized preparations, whereas this occurred 8 of 17 times in the anesthetized animals.

In most of the Anectinized animals there was a low-voltage, fast pattern of cortical activity prior to injection, and in all animals, except one in which some change occurred after injection, there was significant slowing. In contrast, the cortical activity of the anesthetized animals was slow during the preinjection period, but the drug produced no further change in frequency unless there was progression to electrical silence.

In many experiments changes were not uniform throughout the cortex. Frequently, the visual cortex did not exhibit the 20-30 per second activity seen in auditory and somatic cortex, and the amplitude was often lower. This resulted in less evidence of change in visual cortical activity with small doses of drug. However, when profound effects were produced by very large doses,

TABLE 2.—*Effect of LSD on the Electrocorticogram*
Pentobarbital

LSD Mg/Kg.	No. of Injections	No. of Effects	Volt. Incr.	Volt. Decr.	Freq. Incr.	Freq. Decr.	E. S.
			First Injection				
0.025	1	0					
0.25	7	5	0	5	0	2	2
0.5	5	4	0	4	0	2	2
1.0	4	4	0	4	0	3	3
2.0	1	1	0	0	0	1	1
			Second Injection				
0.05	2	1	0	1	0	0	0
0.1	1	1	0	1	0	0	0
0.25	1	1	0	1	0	1	1
0.5	5	3	0	3	0	1	1
1.0	3	2	0	2	0	1	1
2.0	1	0					
Totals	31	22	0	21	0	11	11

E. S. = electrical silence.

all areas were equally affected. Spindles of 8 to 12 per second were seen occasionally following LSD in the Anectinized animals.

Following a second injection, 20 minutes to 3 hours after the initial dose, fewer effects were seen in both anesthetized and Anectinized animals, and the extent of change was less. Electrical silence occurred 5 times, as opposed to 12 times after the initial injection.

Effects of LSD on Evoked Potentials in Anectinized Animals

In the initial experiments LSD was given in doses of 0.025 to 0.2 mg/kg. in an attempt to determine the minimum quantity required to produce a consistent change in the amplitude of the evoked potential. Table 3 and Table 4, respectively, show the postinjection mean amplitudes of auditory and somatic evoked potentials expressed as percentages of preinjection mean amplitudes. An increase, no change, and an occasional decrease in amplitude are observed. Neither Table suggests a relation of dose to effect, since amplitude changes following 0.025 and 0.2 mg/kg. are about the same.

TABLE 3.—*Effect of Relatively Small Doses of LSD on Cortical Auditory Evoked Potentials* * Succinylcholine (Anectine)

Animal No.	LSD Mg/Kg.	Postinjection Times, Min. 2	5	10	20	30	60
37	0.025	140	125		115	100	95
37 †	0.025	105	115	115		110	100
21	0.05	110		110			
23	0.05	125			100		
26	0.05	125		115			
28	0.05	110		115	120		110
33	0.05	100	110	110	110	100	110
33 †	0.05	125	115	115		110	100
24	0.1	100				100	
32	0.1	110	130		110		105
21 †	0.1	105		100			
28 †	0.1	95		105		75	65
32 †	0.1	125		145		115	105
28 ‡	0.1	100		100			110
33 ‡	0.1	120	115	110		105	110
33 §	0.1	100		105	80		
24 †	0.2	95				95	
21 ‡	0.2	100		100			

* Postinjection mean amplitudes are expressed as percentages of preinjection mean amplitudes.

In those preparations which received multiple injections, †, second injection; ‡, third injection, and §, fourth injection.

TABLE 4.—*Effect of Relatively Small Doses of LSD on Cortical Somatic Evoked Potentials* Succinylcholine (Anectine)

Animal No.	LSD Mg/Kg.	Postinjection Times, Min. 2	5	10	20	30	60
37	0.025	100	100		100	105	85
37 †	0.025	135	120		155	130	165
26	0.05	120		90	100	125	
28	0.05	100		105	100		
33	0.05	110	85	90	90	95	115
26 †	0.05	120		100			
33 †	0.05	100	100	100		85	75
37 ‡	0.05	140	130		125	155	140
37 §	0.05	110			105	95	100
32	0.1	150	160		130	135	90
28 †	0.1	85		80		75	45
33 ‡	0.1	120	100	120		105	100
33 §	0.1	105		110	85		

* Postinjection mean amplitudes are expressed as percentages of preinjection mean amplitudes.

† Second injection.

‡ Third injection.

§ Fourth injection.

In the animal represented by Figure 3, injections of 0.05 and 0.1 mg/kg. of LSD were given two hours apart. There was no change following either injection, but between doses there had been a gradual decline in amplitude of both auditory and somatic potentials. Spontaneous cortical activity was unchanged.

The change in mean amplitude of evoked potentials following administration of a drug can be significant only in relation to spontaneous fluctuations in amplitude which might occur at the same time. Therefore, it is necessary to determine the actual variability in a preparation before ascribing to the drug changes which occur during the postinjection period. In general, evoked potentials are most consistent with minimal background activity, and when the background is obliterated, there may be no detectable amplitude differences for several minutes. In contrast, when the amplitude of spontaneous cortical activity is 100μv. or more, evoked potentials may vary so greatly in configuration and amplitude that accurate measurement is difficult.

Because of the variability within series of evoked potentials and the inconsistent changes in mean amplitude following LSD, a comparison was made of the mean ampli-

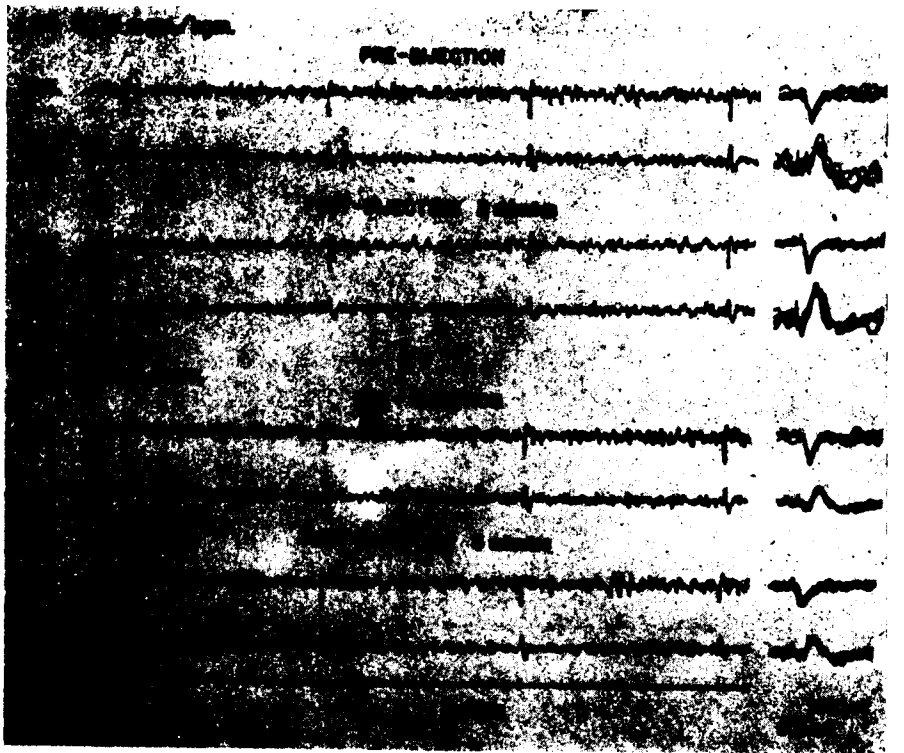


Fig. 3 (Cat 26).—Anectinized. Somatic evoked potentials. Each EEG record shows four evoked potentials at 2.5-sec. intervals. To the right of each EEG record are five single-sweep superimposed CRO traces recorded at approximately the same time as the corresponding EEG records.

A, LSD 0.05 mg/kg.; *B*, LSD 0.05 mg/kg. Description in text. Calibration and time line for EEG on left, for CRO on right.

tudes obtained during a one-hour period prior to injection and the mean amplitudes during the first hour after injection. These data are presented in Table 5. In each animal the three stimuli were delivered simultaneously and continuously throughout the experiment. After satisfactory evoked potentials were obtained, the control period was begun, at time zero; 15 consecutive potentials were measured and the mean amplitude calculated. Subsequent mean amplitudes were determined at the prearranged times indicated in the Table. This portion of the experiment was terminated at the end of one hour. The same procedure was then repeated except that LSD was injected immediately after measurement of evoked potentials at zero time. Mean amplitudes are expressed as percentages of control mean amplitudes obtained at the beginning of each time period.

The data in Table 5 show marked variability in evoked potential amplitudes during the preinjection period and following large doses of LSD. The changes are inconsistent. An increase or a decrease in amplitude appears to occur randomly, but the magnitude of change, in both directions, is slightly greater in some animals than during the control period.

Figure 4 shows records obtained within one minute during a control period. In the lower record, the background activity has decreased in amplitude and increased in

TABLE 5.—*Comparison of the Spontaneous Variability in Amplitude of Cortical Evoked Potentials with the Variability Following Administration of Large Doses of LSD* *

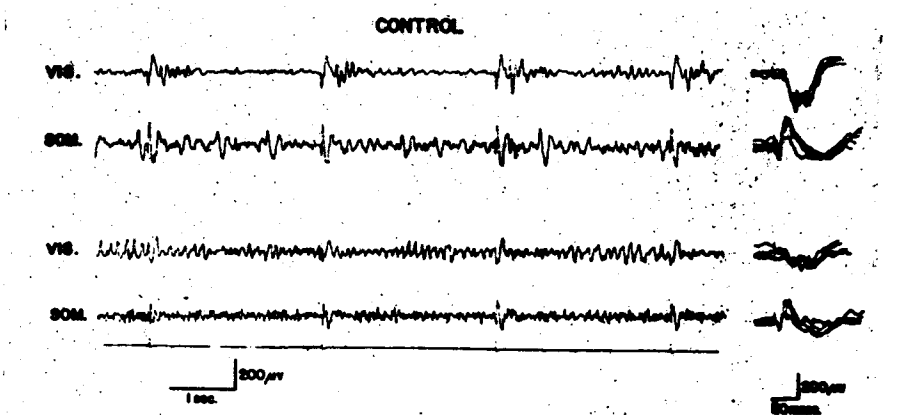
Animal No.	Preinjection, Min. 5	10	20	30	60	LSD Mg/Kg.	Postinjection, Min. 2	5	10	20	30	60
Auditory Evoked Potential												
40		95	85	85	80	1.0	135		130	110		
41		110	90	95		1.0	105	100	95	100	105	115
38		90	85		90	2.0	155	180	190	180	180	185
39		100	105	110	115	2.0	120	150	90	50		90
42	115	125		130	115	2.0	115	125	110		115	105
45	120	90		80	90	2.0	115	125	130	130	120	110
46	120	105	100	130	115	2.0	125		135		100	
Somatic Evoked Potential												
40		100		80	80	1.0	90	100		100	110	125
41		125	100	120		1.0	105	75	100	120	120	115
38			110	115	120	2.0	140	140	140	150	150	155
39		100	100	105	100	2.0	100	115	120	80		115
42	105	100		125	125	2.0	145	140	135		135	140
45	115	105		100	95	2.0	105	110	115	115	120	115
46	120	105	100	130	115	2.0	100		110		90	
Visual Evoked Potential												
40		80	60	65	50	1.0	170	140		130	125	145
41		105	75	75		1.0	90	60	70	95	80	100
38			95	90	90	2.0	125	100	105	120	100	125
39		90	85	90	85	2.0	110	135	40	30		80
42	95	150		140	110	2.0	140	100	85		140	150
46	100	115	100	85	100	2.0	105		70			

* Postinjection mean amplitudes are expressed as percentages of preinjection mean amplitudes.

frequency, and there has been a marked reduction in the amplitude of the visual evoked potentials.

The information in Figure 5 is taken from the same animal as that in Figure 4. Following 1.0 mg/kg. of LSD there is decreased amplitude, then increased amplitude and recovery of both visual and auditory potentials. However, the change in the visual potential is only slightly greater than the natural variation in amplitude seen in Figure 4.

Fig. 4 (Cat 39).—Anectinized. The upper EEG channel in each pair is the record from visual cortex; the lower channel, from somatic cortex, and the lowermost channel, stimulus artifact. The two sets of records are obtained within one minute during the preinjection period. Note the marked change in amplitude of visual potentials.



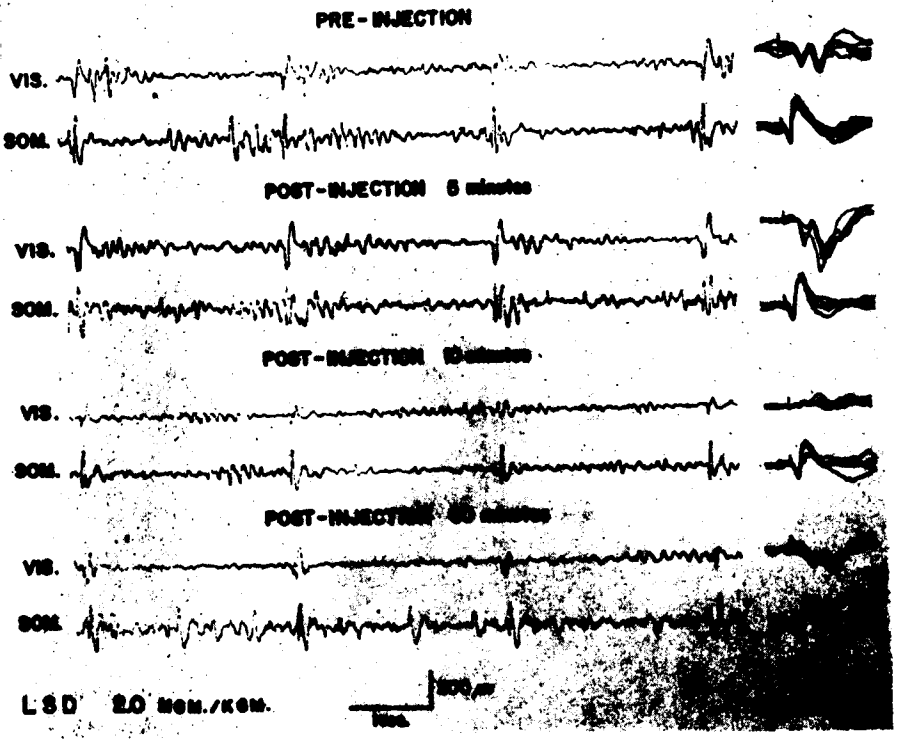


Fig. 5 (Cat 39).—Anectinized. The upper EEG channel in each pair is the record from visual cortex; the lower channel, from somatic cortex. LSD 2.0 mg/kg. Note that changes in the amplitude of visual evoked potentials are only slightly greater than in Figure 5.

Effects of LSD on Evoked Potentials in Animals Anesthetized with Pentobarbital

Auditory and somatic evoked potentials were studied in anesthetized animals following 17 injections of 0.2 to 4.0 mg/kg. of LSD. Amplitude changes were no more significant in these animals than in the Anectinized cats.

Figure 6 illustrates the constant amplitude of evoked potentials seen in deep barbiturate anesthesia when the spontaneous activity of the cortex has been reduced.

Following 1.0 mg/kg. there is a 50% decrease and recovery of somatic potentials. After a second injection, of 2.0 mg/kg., two hours later, there is doubtful change in amplitude.

Comment

The effects of LSD on evoked potentials in the primary sensory cortex of the cat were inconsistent. Small doses had no significant effect on auditory evoked potentials, although the number of times there was an increase in mean amplitude exceeded the number of times there was no change or a decrease. Minimal differences existed in the responses of auditory and somatic cortex. Following 1.0 and 2.0 mg/kg. more animals showed an increase in amplitude of both auditory and somatic potentials than following small doses; but when these data were compared with the spontaneous variability in amplitude prior to injection, it was apparent that a significant change,

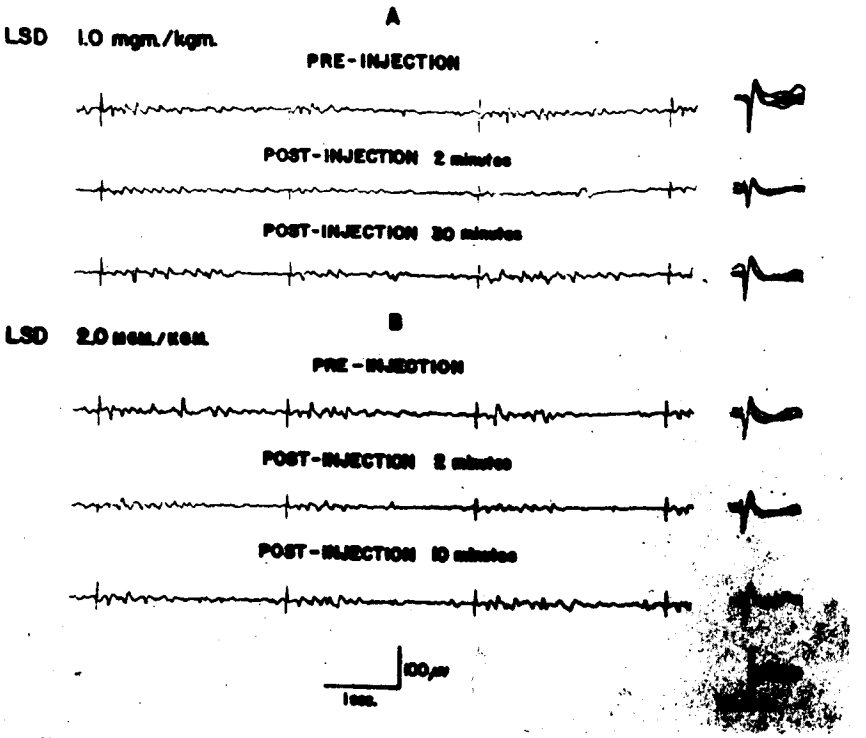


Fig. 6 (Cat 52).—Deep pentobarbital anesthesia. Somatic evoked potentials. LSD 1.0 mg/kg., followed by LSD 2.0 mg/kg. Description in text.

which might have been attributed to the drug, occurred no more than two times. Effects on visual evoked potentials were no more convincing, enhancement occurring as often as depression.

These results are in general agreement with those of Evarts,[8] who was unable to find a consistent change in the cortical response to submaximal stimulation of lateral geniculate radiation fibers with doses of LSD as large as 1 mg/kg. His experiments were performed in chronic unanesthetized preparations. In contrast, Purpura [14,15] found an increase of auditory, somatic, and visual evoked potentials following doses of 0.02-0.05 mg/kg. With slightly larger doses the auditory response was inhibited, but there was continued facilitation of the visual response. After 0.07-0.1 mg/kg. there was a decrease of all cortical evoked potentials. Purpura's animals were anesthetized with pentobarbital or ether, immobilized with succinylcholine, and allowed to recover from the anesthesia. Rovetta [18] gave LSD in doses as large as 0.04 mg/kg. and found no effect on auditory or visual potentials in the cortex. LSD applied topically to the cortex, also, was without effect, in contrast to mescaline, which produced a marked increase of visual evoked potentials.

Evarts [8] found that the quantity of LSD required to decrease the postsynaptic geniculate response in intact unanesthetized animals was 30 times the dose required to produce the same effect in animals anesthetized with pentobarbital. In the present study the results did not indicate that cor-

tical potentials were made more sensitive to LSD in the presence of pentobarbital. However, this finding is probably explained by the observations that cortical evoked potentials are quite resistant to the drug in all experimental situations, whereas synaptic transmission in the lateral geniculate is readily affected.

Multiple injections of LSD were no more effective in altering evoked potentials than was a single injection. This was true irrespective of whether subsequent injections contained the same or larger quantities of drug.

The effects of LSD on the spontaneous electrical activity of the cortex have been studied in the rat,[20] the rabbit,[7,16] the cat,[3,9,10,11,19] and the monkey.[4] Rinaldi and Himwich[16] found long-lasting alerting of the EEG of rabbits with 0.001-0.015 mg. and an opposite effect with 0.02 mg. or more. Bradley and Elkes[3] observed abolition of barbiturate spindling after 0.1-0.15 mg/kg. in cats, but in unanesthetized animals doses up to 0.3 mg/kg. produced no effect. This contrasts with the observations of Delay et al.,[7] who found that flattening of the electrocorticogram following LSD was prevented by pretreatment with barbiturates.

In the present investigation, 0.5 mg/kg. or more produced changes in cortical activity after 37 out of 46 injections, whereas doses of 0.1 mg/kg. or less were effective after 6 of 20 injections. These results indicate that small doses of LSD may produce changes in cortical activity, but 0.5 mg/kg. is required to produce consistent effects. Differences related to anesthesia were of doubtful significance.

One of the principal problems in this investigation was the determination of what constituted a significant drug effect. Previous reports on the effects of drugs on cortical evoked potentials have depended on visual inspection of graphs which plot amplitude against time during the postinjection period. Our experience casts doubt on the validity of these methods because of the spontaneous variability in evoked potential amplitude. It has been demonstrated in several figures in this report that apparently significant changes in amplitude occur over a wide dose range of LSD, and these changes are seen in the EEG records and the superimposed CRO traces. However, Figure 5 demonstrates the variability in amplitude encountered in untreated animals.

Analysis of the control data in Table 5 indicated that mean amplitude differences in evoked potentials were meaningless if not related to the variability occurring within each series analyzed. It has also been shown that when background activity was reduced under deep barbiturate anesthesia, fluctuations in amplitude were minimal. In this circumstance there were no changes in evoked potential amplitude following LSD.

The same problems obtain in analysis of drug effects on the electrocorticogram. Frequency and amplitude changes occur commonly with slight environmental changes. This has been emphasized by Bradley and Key[5] in their studies of the effect of drugs on thresholds for EEG arousal. In the present experiment it was recognized that many of the alterations in cortical activity which were attributed to LSD could have been produced by extraneous influences.

Summary and Conclusions

The effects of LSD on cortical potentials evoked by auditory, visual, and tactile stimulation were studied in the cat. Conclusions are based on detailed analyses of the data from 27 experiments. Succinylcholine-treated (Anectinized) animals and animals anesthetized with pentobarbital were used. Doses from 0.025 to 4.0 mg/kg. were administered intravenously. Evoked potentials were displayed on a cathode-ray oscilloscope, and the electrocorticogram was recorded with an ink-writing oscillograph. No significant change in amplitude of any of the three cortical potentials was noted with doses of 0.2 mg/kg. or less. When 1.0 mg/kg. or more was given, there appeared to be an increase in amplitude of auditory evoked potentials in some animals. However, when these data were compared with the varia-

bility in amplitude which occurred in the same animals during preinjection control periods, the changes observed following the injection of LSD did not appear significant. It was not possible to establish general criteria for ascertaining a significant drug effect because the natural variability in amplitude of evoked potentials dictated that *each animal serve as its own control.*

Changes in the electrocorticogram occurred in almost all animals following 0.5 mg/kg. of LSD. Effects were also observed with less consistency after smaller doses. The interpretation of drug effects on the electrocorticogram is subject to the same limitations applied to evaluation of evoked potentials.

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