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Section on PAIN *and* DISTRESS

Worthy of attention

LSD or d-lysergic acid diethylamide, a 1938 laboratory discovery dormant for five years, has become the subject of lively discussion in many quarters as to its affect on the mind of man. Phantom pain is also a considerable mystery. This discussion of such a phenomenon being treated by psychopharmacological means deserves attention. — JOHN S. LUNDY, M.D.

The Effect of LSD on the Phantom Limb Phenomenon

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THE CAPACITY of lysergic acid diethylamide (LSD) to induce delusions and hallucinations has been likened to the production of a "model psychosis."[1-3] It has also been established that following the intake of LSD the patient's body image changes before he is aware of any changes in his environment.[2] In view of these known effects, we determined to study the influence of LSD upon the sensory complex known as phantom limb "which is the most marked expression of the postural model of the body."[4]

In our study with LSD, we hoped to avoid the usual progression of symptoms by employing a small dose, thereby avoiding any confusional state or psychosis, while producing changes in body image. Our study involved 8 patients. Phantom limb occurred after brachial plexus paralysis in 1 patient, on the paralyzed side in 1 hemiplegic patient, and following limb amputation in 6 patients.

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CASE REPORTS

Case 1. On Feb. 10, 1961, a 26-year-old, right-handed, male factory worker fell from a height of 12 meters. He was comatose for ten minutes and was later found to have a motor paralysis and sensory disturbance of the right upper limb. When he regained consciousness after his accident, he was aware of a phantom limb and this symptom persisted. It was so intense an experience that he told his mother he had three hands. The phantom limb originated at the elbow joint of the paralyzed right arm and was directed inward and upward across the chest (Fig. 1). Its size approximated that of the actual right limb. Perception of the phantom limb was more vivid in the fingers than in the forearm.

The intensity of experience of the phantom limb varied with the position of the paralyzed right limb. When the latter was passively moved from the chest wall, the phantom limb was felt more distinctly. For this reason, the patient would passively move his paralyzed right limb from the chest wall with his left hand before discussing any symptoms of his phantom limb. He experienced paroxysmal pain in the phantom limb, the pain radiating upward from the finger tips. Voluntary movement of the phantom limb was almost impossible, but the fingers could be slightly flexed. There was no auto-

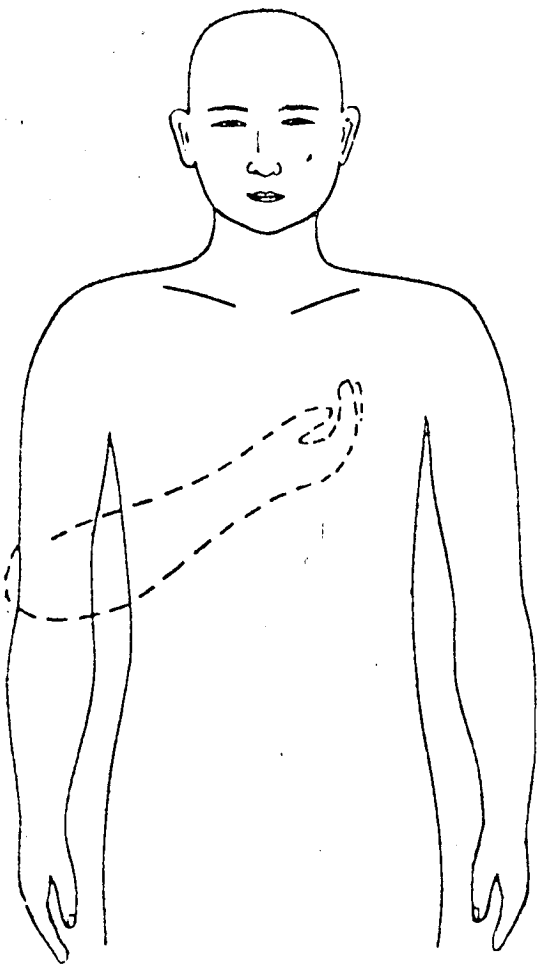

Fig. 1. Case 1: phantom limb shown by broken lines

matic movement of the phantom limb or synkinetic movement in the left hand when he tried to move the phantom limb. He did not express any feeling of negation regarding his paralyzed right limb.

Examination. The patient was alert, fully oriented, and cooperative. Abnormalities on neurological examination were confined to the right upper limb. Moderate muscular atrophy was observed in the right scapular region, right upper arm, and right forearm. There was complete paralysis of the right upper limb which was anesthetic. By passively increasing the distance between the chest wall and the paralyzed right upper limb, the phantom limb could be more clearly felt by the patient. An electromyogram supported a diagnosis of neural rupture between C4 and T1.

LSD experiment. On June 2, 1961, 50-μg. of LSD were administered to the patient. About thirty minutes later, the pain in the ulnar side of the phantom forearm was alleviated and the patient experienced a gradual shortening in the phantom forearm and palm. After one hour the phantom limb as a whole was felt more feebly. If the paralyzed limb was held close to the chest wall, the phantom limb was not experienced but returned weakly when the paralyzed limb was passively moved away from the chest. After one hour and a half the patient felt that the paralyzed and phantom limbs were superimposed, the phantom limb being felt more feebly than the paralyzed one. Occasional paroxysms of pain were experienced in the phantom limb. After two hours the forearm of the phantom limb was not felt and the patient was aware only of the palm and fingers. The paralyzed limb and right half of the body felt heavy. After two and one-half hours each finger of the phantom limb was felt separately, but finger shape and position were indistinct. After three hours the patient complained of intermittent, severe phantom limb pain which appeared superimposed on the paralyzed limb. After four hours the pain disappeared and the phantom limb was no longer felt, even when the paralyzed limb was held away from the chest wall. The paralyzed limb felt heavy. Gradually, the phantom limb sensation returned but was less vivid.

On June 16, 1961, another 50 μg. of LSD were administered to the patient. Since that time, passive movement of the paralyzed limb has not been accompanied by phantom limb sensation. The patient said of his phantom limb, "If I think it is present I feel it, but it is as if it were superimposed on my real arm; I cannot feel it distinctly." There was no recurrence of phantom limb pain. A sensation of weight persisted in the paralyzed right upper limb.

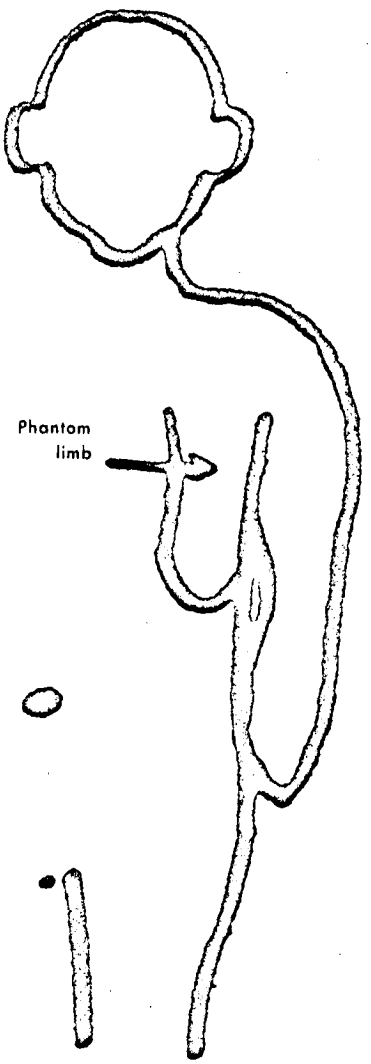

Fig. 2. Case 2: the patient's own sketch of phantom limb

Case 2. On April 15, 1957, a 58-year-old, right-handed male suddenly developed a left hemiplegia and was unconscious for three days. When he regained consciousness, he was aware of a phantom left arm and leg. The phantom arm felt particularly real and was, in fact, experienced more vividly than the paralyzed left upper limb. He was unable to determine the position of the latter unless he looked at it. Staring at the real limb did not dispel the phantom limb sensation. The phantom limb felt fixed and immobile, and the fingers and distal portion of the limb were recognized more distinctly than the proximal parts. He described the phantom upper limb as "like a clumsy hand of a child" and was able to draw a diagram of its position (Fig. 2). He complained of diplopia in January 1958 and was admitted to the hospital.

Examination. The patient was an alert, fully oriented male of average intelligence and normal personality. Examination of the cranial nerves revealed paralysis of conjugate lateral gaze to the right, right abducent paralysis, and a right facial palsy. There was a left hemiplegia and a left extensor plantar response. Sensation was intact apart from an inability to recognize the shape and texture of objects held in the left hand. Sensory stimuli (tactile, algesic, and thermal) applied to the left upper limb were perceived in the phantom limb (alloesthesia phenomenon).

LSD experiment. The patient was given 50 μg. of LSD orally. He remained alert throughout the experiment. Thirty minutes after taking LSD he felt that the paralyzed, left upper limb really existed and was capable of movement. After two hours and twenty minutes it felt light and he was able to actively move it across his body. However, he had the feeling that the phantom limb was moving the real limb. Tactile and painful stimuli applied to the real limb were now perceived and correctly located in that limb. After three hours and twenty minutes he felt that the real limb was independent of the phantom limb and was able to move itself. The phantom limb had become an encumbrance and, after four hours, seemed to be pressing against his chest, a reversal of the situation prior to LSD administration. After four and one-half hours the phantom limb sensation remained, feeling heavy, "like stones." It was felt most strongly in the wrist. These symptoms were present two weeks later when the patient was discharged from hospital.

The following six cases of phantom limb occurred after limb amputation.

Case 3. A 26-year-old, right-handed male injured his left leg in a traffic accident and amputation of the leg at the junction of the middle and lower thirds of the femur was necessary. Following amputation the patient was aware of a phantom limb and severe phantom limb pain which caused insomnia. On the tenth and fifteenth days following amputation, 50 μg. of LSD were given orally and the phantom limb pain was permanently

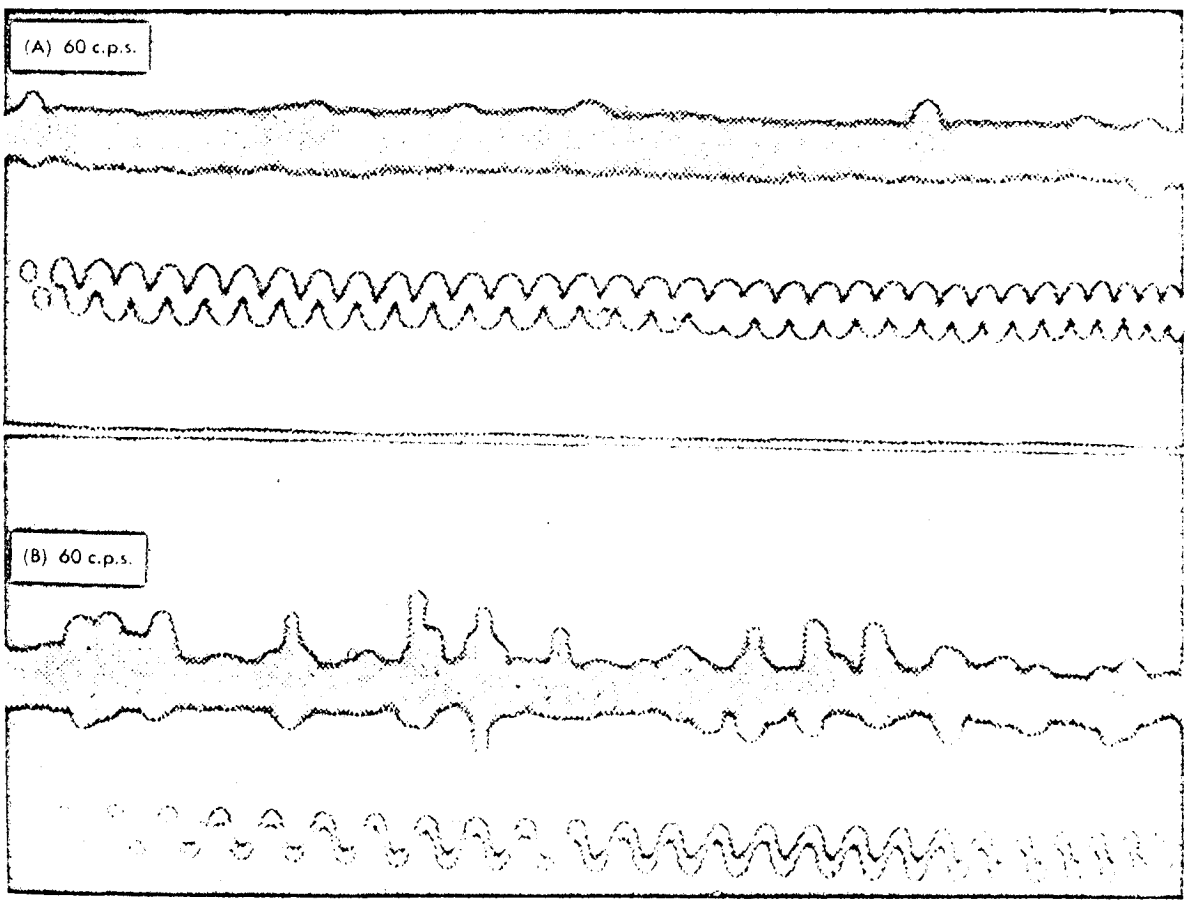

Fig. 3. Case 4: muscle action potential (muscle deltoids), [A] before LSD administration, [B] three hours after LSD administration

alleviated. The phantom limb sensation disappeared, subsequently returning with diminished intensity.

Case 4. A 23-year-old, right-handed male was injured in a traffic accident and amputation of the left upper limb 10 cm. below the elbow joint was necessary. Phantom limb sensation and severe phantom limb pain followed amputation. Eight months later, 50 μg. of LSD were given orally. After four hours the phantom limb sensation and pain disappeared completely, and the patient's only complaint was of difficulty in balancing his body since the loss of the limb. Subsequently, the pain returned but was not as severe and the phantom limb sensation was not as strong as before LSD therapy. During a period of sixteen months, 50 μg. of LSD were given three times. On each occasion the immediate beneficial effect did not persist, but the symptoms were eased. An electromyogram (EMG) was studied following the third LSD administration. The needle electrode was inserted into the left deltoid and the muscle action potential recorded. The results are shown in Figs. 3A and B. Muscle action was increased, indicating an apparent increase of motor activity.

Case 5. A 21-year-old, right-handed male injured his right lower limb in a traffic accident and amputation was performed 10 cm. above the knee joint. Six months later, 50 μg. of LSD were administered orally and a second similar dose after a short interval. Following this therapy the phantom limb sensation was almost completely eliminated and the phantom limb pain disappeared.

Case 6. Phantom limb sensation and weak phantom limb pain were experienced by a 26-year-old, right-handed male following amputation of the left lower limb below the groin. One year later, the oral administration of 50 μg. of LSD produced immediate and sustained disappearance of the phantom limb sensation and almost complete relief of phantom limb pain.

Case 7. A 26-year-old, right-handed male required amputation of the lower third of the right forearm following trauma sustained in a traffic accident. He was seen twenty months later complaining of vivid phantom limb sensation and phantom limb pain which had developed following amputation. It was also evident that the patient was a victim of some mental conflict. When 50 μg. of LSD were given orally, the mental conflict became clearly manifest. It appeared that he had experienced ambivalent, vehement feelings toward his

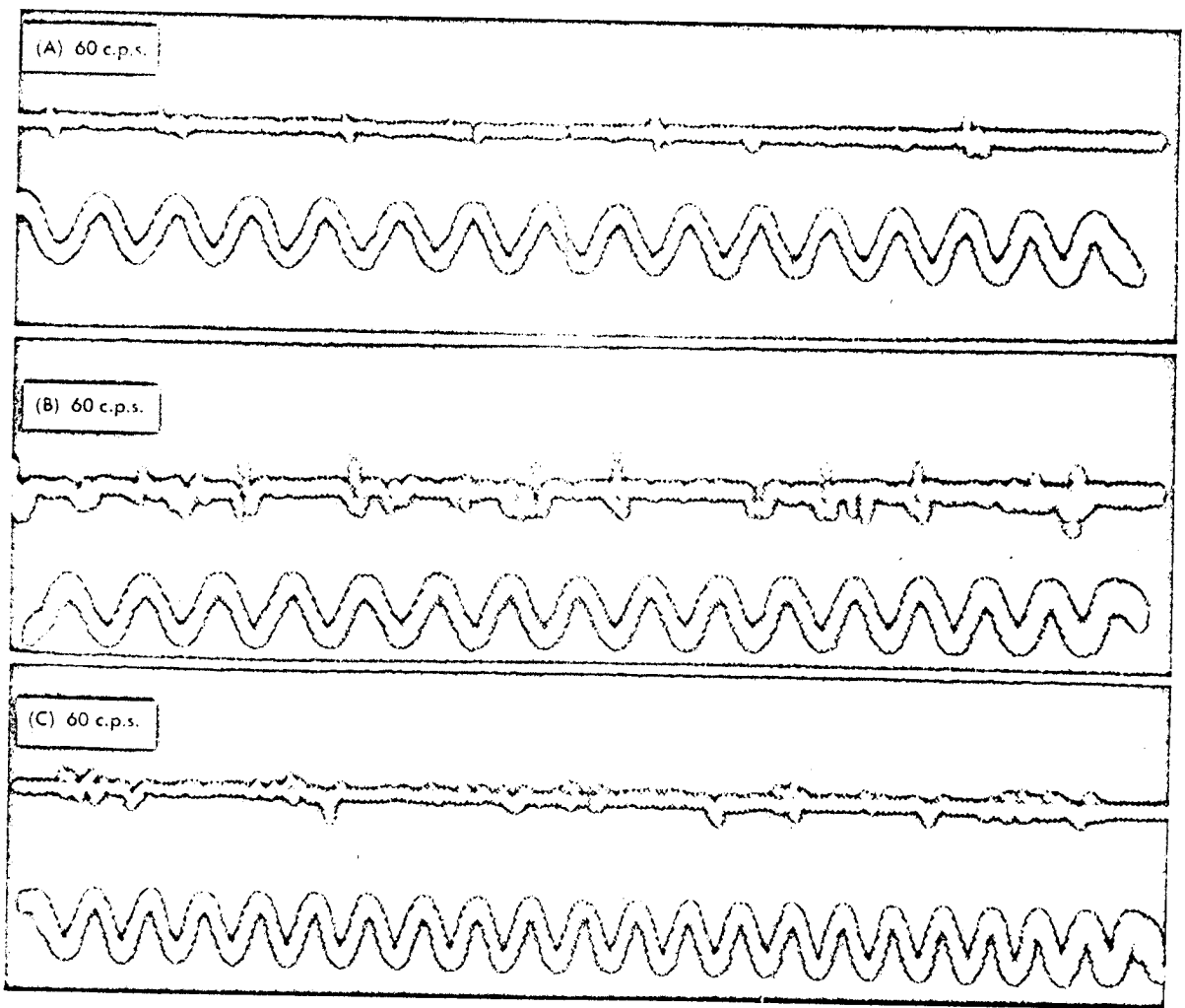

Fig. 4. Case 8: muscle action potential (medial rectus femoris), [A] before LSD administration, [B] three hours after LSD administration, [C] eight hours after LSD administration

dumb mother since his separation from his father at the age of 6 years. There was little change in the phantom limb sensation or the phantom limb pain. Following the treatment with LSD, his mental attitude improved and he was better able to bear the phantom limb pain.

Case 8. Phantom limb sensation developed in a 16-year-old male following amputation of the right lower limb 12 cm. above the knee for a right tibial sarcoma. Eight months after amputation an EMG of the left medial rectus femoris showed comparatively weak muscle activity and diminished discharges (Fig. 4A). Three hours after 50 μg. of LSD were given orally, the phantom limb sensation disappeared and the patient reported that the amputation stump had become light and easy to move. The EMG demonstrated stronger muscle activity and increased discharges (Fig. 4B). After eight hours, the phantom limb sensation returned faintly and the EMG showed decreased motor discharges (Fig. 4C), but these were greater than those obtained prior to the administration of LSD. The same results were obtained when LSD was administered on a subsequent occasion.

REVIEW OF CASES

It is noteworthy that the sensation of phantom limb in all 8 patients was not a transient symptom but a persistent complaint of a disturbing nature. It was felt more strongly in the distal parts of the limb. A small dose of LSD (50 μg.) produced significant effects in 7 (Cases 1, 2, 3, 4, 5, 6, and 8) of the 8 patients. A few hours after LSD was given, there was loss of the phantom limb sensation in 5 (Cases 1, 3, 4, 6, and 8) of these 7 patients, which was sustained in 1 patient (Case 6) and was much fainter on its return in the other 4 (Cases 1, 3, 4, and 8). In the remaining 2 patients (Cases 2 and 5) following LSD administration, the phantom limb sensation became much less distinct but persisted. LSD had no influence on the phantom limb sensation in 1 patient (Case 7) who was psychologically disturbed.

Phantom limb pain was a distressing symptom in 6 (Cases 1, 3, 4, 5, 6, and 7) of the 8 patients. Following LSD administration, it disappeared in 4 patients (Cases 1, 3, 4, and 5), permanently in 3 (Cases 1, 3, and 5), and was far less intense on its return later in 1 (Case 4). There was almost complete relief of pain in 1 patient (Case 6) and little change in Case 7, the psychologically disturbed patient. Apart from minimal changes in mood, no other effects on the psyche were noted with these small doses of LSD.

TIME SCHEDULE OF CHANGES IN PHANTOM LIMB PHENOMENA IN AMPUTEES FOLLOWING LSD ADMINISTRATION

Time after administration of LSD	*Experience of patients*
0.5 to 1 hour	Sensation of elongation of phantom limb. Recovery of normal sensation in proximal part of real limb
1 to 2 hours	Amputation stump felt lighter and was easier to move. Phantom pain replaced by itching
2 to 3 hours	Phantom limb sensation and phantom limb pain less distinct. Sensation of shortening of phantom limb
3 to 4 hours	Disappearance of phantom limb sensation and phantom limb pain

DISCUSSION

The phenomenon of phantom limb has frequently been observed after amputation of peripheral or external body parts, whereas it has not been reported following the removal of an internal organ. The same phenomenon has been seen in patients with a paralyzed limb. It would appear that the hallucination of a phantom limb counteracted sensations of body image disintegration.

Our study of the effects of LSD on the phantom limb experience revealed that there was a gradual transition from the moment when the phantom limb sensation altered to the time when it disappeared, as shown in the table.

Characteristically, phantom limb sensation after amputation was most strongly perceived in the distal parts of the phantom limb, whereas the sensation was weak or absent proximally in Cases 3, 4, 5, 6, and 8. This suggested that maintenance of the stable phantom limb sensation might be attributed to the fact that it was mainly represented by the functionally dominant part of the limb. One to two hours after LSD was given, the proximal parts of the limb, which hitherto had been felt faintly, were more distinctly perceived. Later, the phantom limb sensation diminished as a whole and, finally, in 3 cases, was no longer felt (Cases 4, 6, and 8). It may be theorized that LSD, by influencing the perception of body image, rendered the hitherto stable form of the phantom limb unstable and so capable of extinction.

Similar effects of LSD were observed in Cases 1 and 2. Phantom limb sensation in Case 1 accompanied a paralyzed arm, the result of brachial plexus paralysis. The intensity of the phantom limb experience varied with the position of the paralyzed limb, being greater when the latter was separated from the chest. One hour after LSD administration, the phantom limb was only felt if the paralyzed limb was held away from the chest. After one and one-half hours, the phantom limb and the paralyzed limb were felt to be superimposed, the phantom limb being more feebly perceived. The phantom limb was no longer felt after four hours, even when the paralyzed limb was held away from the chest. These facts suggested that the paralyzed limb was the background for the shape configur-

ation of the phantom limb. LSD, by influencing the patient's body image perception, caused changes in awareness of the paralyzed limb and thereby brought about the disappearance of the phantom limb.

In Case 2, the patient completely neglected the real paralyzed limb because of the vivid phantom limb sensation. Sensory stimuli applied to the paralyzed limb were felt in the phantom limb. This phenomenon of alloesthesia vanished following LSD administration, and stimuli applied to the paralyzed limb were accurately located in that limb. Simultaneously, voluntary movement of the paralyzed limb was possible and the phantom limb sensation gradually diminished. The effect of LSD was to incorporate the paralyzed limb in the patient's body image, thereby destroying the body image responsible for the phantom limb sensation.

EMG tracings at the amputation stump in Cases 4 and 8 following LSD administration, when the patient no longer felt the phantom limb, demonstrated an increase in electrical discharges compared with those recorded prior to the taking of LSD. The patient stated that the stump felt lighter and was easier to move. Once the phantom limb had been eliminated, all the patient's concentration could be devoted to the act of moving the stump which felt more real. After the administration of LSD in Case 2, voluntary movement was partially restored to the previously paralyzed upper limb which the patient truly felt existed while the phantom limb sensation was definitely weaker.

It has been reported that patients receiving LSD experienced decreased sensitivity to pain. Kast[5] found that LSD induced a more effective and prolonged analgesic effect than meperidine (Demerol®) or hydromorphone (Dilaudid®) in 50 terminally ill patients. He surmised that LSD altered the psychic elaboration of painful sensation. In our study, there was amelioration of phantom limb pain in 5 out of 6 patients following the administration of LSD.

LSD should be regarded as a useful drug in the treatment of phantom limb phenomena. It is hoped that these observations will provide a stimulus for further study.

CONCLUSION

In a dose of 50 μg., LSD benefited 7 out of 8 patients with phantom limb sensation and 5 out of 6 patients with phantom limb pain.

It has been postulated that LSD achieved these effects by changing the patient's body image and so destroying the psychological framework which was the genesis of the phantom limb sensation.

REFERENCES

1. HOCH, P. H., CATTELL, J. P., and PENNES, H. H.: Effects of mescaline and lysergic acid (d-LSD-25). Amer. J. Psychiat. 108:579, 1952.
2. SAVAGE, C.: Variations in ego feeling induced by d-lysergic acid diethylamide (LSD-25). Psychoanal. Rev. 42:1, 1955.
3. STOLL, W. A.: LSD-25, a hallucinatory agent of the ergot group. Swiss Arch. Neurol. 60:279, 1964.
4. SCHILDER, P.: The Image and Appearance of the Human Body. New York: International Universities Press, p. 64, 1950.
5. KAST, E. C.: LSD used as an analgesic. J. Amer. med. Ass. 187:33, 1964.