

gions consume tremendous quantities of alcohol. This may be partially due to monotony and loneliness. There are both positive and negative reasons given to account for this undeniable fact. They claim it is not harmful, as the heat enables one to oxidize, or sweat out, what appears to an outsider very damaging amounts. As a benefit (or rationalization), it is said, in common with spicy foods, to stimulate the digestion.

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PSYCHOPHYSICS AND MESCAL INTOXICATION

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The study of mescal intoxication has given us a most interesting literature. The descriptive terms applied to mescal such as the "Divine Plant," the "Diabolical Root," an "artificial Paradise," etc., connote a state of mind which is so extraordinarily different from that of the normal that non-mundane terms are used to describe it. Many accounts of the wonders of mescal in producing colors, sounds, kinaesthesia, hallucinations, distortions of space and time, feelings of grandeur, etc., have been reiterated in one report after another. Mescal has been proposed as an instrument of war since it induces insomnia and indefatigability lasting over 24 hours. It has been offered as an aid in the field of medicine in the form of a sedative for nervous subjects and as a means of establishing rapport with the doctor in a psychoanalytic seance. To students of psychology and psychiatry it offers extraordinary conditions for establishing vivid imagery and presents by actual experience some glimpse of the abnormal mind in the exaggerations and the fancies obtained under mescal intoxication. To the sexologist an easy way of obliterating temporarily the genital response is offered since mescal is a powerful an-aphrodisiac. In fact it has already been pointed out that the ceremonial ritual of Indians who partake of mescal is peculiarly devoid of sexual symbolism and implications. My own experience confirms the an-aphrodisiac properties of mescal, but the fact that under its influence I found my imagination turning to erotic situations, although temporarily impotent, is an illustration of the persistence of conditioning that offers an interesting suggestion with reference to the

extirpation experiments reported in the controversy over the James-Lange theory of emotions.

Unfortunately an analysis of the literature on mescal intoxication reveals glaring differences between individuals, so that all the generalizations made are contradicted by exceptions to the rule. No studies involving careful measurements have been reported; at least, the quantitative data from such studies has not been presented, though sporadic statements of experimental tests have been made. Much of the work done in this field has been rather haphazard, since the main interest of the experimenter has been to take enough mescal to produce visions. In general this work has established the presumption that mescal affects particularly the occipital lobes of the brain, thus accounting for the subjective color effects experienced. The effects on the other senses have not received extensive attention, but there is abundant evidence that they also are modified. The question whether these effects are primarily central or peripheral has never been crucially tested, although Fernberger attempted to do so. The most obvious lacuna in the literature is the lack of psychophysical data. Nevertheless, generalizations have been made in terms of the predominance of certain kinds of data which have been found to recur in separate investigations. The most common of such generalizations is that mescal lowers the threshold for sensory experience. These claims are based on casual observations that lights seem brighter and sounds seem louder. But there are exceptions; and ample evidence could be assembled to indicate that the threshold is increased, particularly in the case of smell and touch, since anosmia and anaesthesia are frequently referred to. That individual differences are striking under mescal intoxication is well attested but inasmuch as little attempt has been made to control the amount of the dose of mescal in terms of the tolerance of the individual we cannot be certain that differences between individuals are not in large measure a function of the degree of intoxication as determined by the sensitivity of the subject for Peyote. For this reason, and because of the little progress that has been made so far in quantitative studies of mescal intoxication, it seems worth while to describe some recent experiences in experimenting with mescal, and to offer suggestions for improving conditions of experimentation.

EXPERIMENTAL PROCEDURE AND RESULTS

The special conditions imposed by mescal in psychophysical investigations require a reliable method of determining rapidly the threshold for light while Peyote photisms are still present. A procedure was devised so that the general and specific color thresholds could be obtained within an experimental session of two hours. By using a spectral light obtained with large slit openings, a light having a dominant wave-length of 710 mμ

and a narrow photochromatic interval was established. By means of a neutral tint wedge, which could be moved in front of the exit slit, intensity variation was easily controlled. It was found that both the general and the specific color thresholds were confined within a range of 12 mm. on a Wratten neutral tint wedge having a transmission range of 1 to 1000. This narrow range of 12 mm. was blocked off into 12 steps of 1 mm. to serve as step intervals for psychophysical measurements. Actually the method of constant stimuli was used. The general and specific color thresholds were both obtained in one experimental session. An artificial pupil of 2 mm. square was used because it is well known that Peyote dilates the pupil.¹

The author and one other subject participated in the experiment. They shall henceforth be referred to as *K* and *E*. *E* is predominantly the visual type; *K* has poor visual imagery with kinaesthesia predominating. Thresholds were carefully determined for each subject on the day preceding mescal intoxication. The limens were based on 40 determinations per step in the constant stimuli series. With *K* two sets of data were obtained, one in the morning and one in the evening of the same day, in order to determine the reliability of the thresholds. The morning and evening limens proved to be practically identical.

In the mescal experiments both subjects took 18 grams of the button prepared in capsules. The drug was consumed in the course of three hours by taking six grams per hour. *E* vomited about six hours after taking the first dose; mescal photisms made their appearance soon after. *K* did not vomit but he felt nauseated and resorted to bed for relief. *K*'s photisms began to appear about seven hours after the first dose. They were not so vivid or so persistent as in the case of *E*, but for one who rarely experiences visual imagery, the rich color transformations, though miniature in size, were quite an engaging spectacle. *K* obtained photisms only under conditions of quiet, and preferably with closed eyes. *E* apparently was more profoundly obsessed with color presentations. They appeared to him at all times no matter what activity he was engaged in. *K* was more profoundly affected kinaesthetically.² One fact of correspondence

¹For further details in the apparatus and procedure consult forthcoming article (5). The author is indebted to Dr. S. W. Fernberger and Dr. Mason Crook for his supply of Peyote (*Anahalonium lewinii*).

²Since very little has been reported on the effects of mescal on kinaesthesia, the following observations may be of interest. *K* enjoyed his kinaesthetic experiences. Contacts of all kinds were very pleasant. While reclining in bed he found himself stretching his legs and curling his feet. The pleasant sensation was accompanied by a perception of the pattern formed by the various muscles contracted. Probably apprehension is a better word, since the pattern was not actually seen though vividly felt. In this respect *K*'s experience was similar to that of Fernberger. However, after the effect of mescal wore off, contracting the various muscle groups,

between *K* and *E* was noted. Both tended to see patches of spectral colors in the field of vision under conditions of simple introspection. *E* reported weird and fanciful picture colors as the principle mental content while trying to fall asleep; *K* experienced color and sound presentations. Both *E* and *K* spent a sleepless but rather enjoyable night. Photisms persisted all night and were still present in less distinct form most of the morning.

Threshold determinations under the influence of mescal were undertaken with *E* an hour after the photisms were first reported. Immediately difficulties were encountered. It was soon apparent that *E* was confusing his photisms with the circular stimulus light. Furthermore, it seemed to be impossible to obtain a psychometric function with 1-mm. step intervals on the neutral tint wedge. The step intervals were increased to 2 mm. *E* still seemed to be quite bewildered, and his sense of orientation was so disturbed by the fleeting photisms that he did not know whether he was looking directly forward or not, even though his position was fixed by means of a biting board containing the dental impression of his teeth, and his eye was placed against an eyepiece containing an artificial pupil which furnished kinaesthetic cues of the position of the eye. Another change in the conditions was introduced; a fixation point was put in the system to locate the stimulus field. Even so, *E* found that colored photisms entered and left his field of vision so frequently that he had difficulty in establishing a criterion of the objectivity of the light. When he believed that he saw the stimulus light it changed colors so rapidly that he could not be certain that the color was not entirely imaginary. Finally the following criterion was worked out by the subject himself. The judgment was based on the first light seen on the field of stimulation, immediately after the ready signal was given. However, confusion still remained; one third of the total judgments were false responses to no stimulus. Nevertheless 25 judgments per step were obtained. The statistical results show that the limens for

though still pleasant, became painful if attempted with the same intensity as when under Peyote intoxication. In fact, *K* noticed that his hands were sore from the excessive wringing and squeezing which was indulged in because of the pleasure thus experienced. This raises the question as to the cause of the vividness of kinaesthesia. Apparently, under the influence of mescal, kinaesthesia is vivid and pleasurable, because, the sense of pain being dulled, kinaesthesia can be experienced at intensities ordinarily accompanied by pain. This selective action of mescal on cutaneous sensibility should be of interest to students of skin and muscle sensitivity. I have become particularly interested in my cutaneous sensibility since this experiment was done, and have noticed that the only time I can experience anything like the conditions described above is when I am especially fatigued. This would indicate that mescal is a depressant on the peripheral nervous system, which conforms with the findings in the studies of animals such as the guinea-pig and the cat.

the general threshold for light do not differ significantly between the normal and mescal series, but the limen for the specific color threshold was significantly lowered for the mescal series.

Subject *K* was not particularly troubled by photisms under actual conditions of experimentation. Observational activity seemed to inhibit them though they were likely to be present at any time; and strangely enough they tended to resemble the stimulus light in hue and shape. *K* was slow in responding, as was also *E*, and thus the rhythmical condition of stimulus and response obtained in the normal series was not maintained under mescal intoxication. *K*'s state of mind was one of happy indifference, with no zest in the activity of observing, in spite of the fact that he was seriously interested in the results of the experiment. The results obtained indicate a slight decrease in the sensitivity for both the general and specific color.

The results are difficult to accept on their face value. The changes introduced in the mescal series for each observer, especially that of making the steps in the constant stimuli process twice as coarse as those of the normal series, indicate that the subject's sensitivity was decreased rather than increased. The slower responses on the part of both subjects is another indication of the narcotic effect. Furthermore, it is unlikely, though not impossible, that the sensitivity for the specific color should be lowered, but not for general light as reported by *E*. Confusion between subjective and stimulus color may account for the lower limen obtained for red light. On the other hand, it is difficult to attribute *K*'s reduced sensibility entirely to the sensory mechanism of vision, because the state of pleasant abulia in which *K* found himself under the influence of mescal probably introduced changes of a more general kind.

THE IMPLICATIONS OF THE EXPERIMENT ON METHODOLOGY FOR EXPERIMENTING WITH MESCAL

The difficulties involved in these experiments may be approached from the standpoint that mescal intoxication is equivalent to comparing an abnormal with a normal condition of the organism. If the pathological effects of the drug were circumscribed to the eye, then it could be assumed, for practical purposes, that only the retinal cerebral arcs were different in the normal and intoxicated condition. However, it is apparent that the whole system was so changed in these experiments that it would be difficult to interpret any change in the threshold, particularly if these changes are of small magnitude. This situation prevails in varying degrees in all psychophysical experiments, since the total organismic set or total response configuration is different with changed conditions of stimulation. This is particularly so in experiments demanding a division of the attention, or in experiments involving difficult judgments. Recently, experiments in the field of intersensory interaction have been reported in which the threshold of

vision was observed to change slightly when the visual stimulus was presented simultaneously with an auxiliary stimulus, sound for instance (4). This type of experimental situation, particularly, is subject to influences beyond the particular nervous mechanisms proposed for investigation. Consequently, the results, often equivocal in terms of consistency between different experimenters, have been attributed to complex states, such as attention, configurational properties of the visual field, cortical diffusion, etc., without precise information of the mechanisms involved (4). In the case of drugs the effects on the total organism are much more profound and it is much more difficult to circumscribe the experiment to some particular segment of the nervous system. Consequently, the question of methodology for psychological experimentation on the effects of drugs needs careful consideration.

The first principle I should propose is the principle of the *minimal stimulus*. Everything else being equal, experiments with mescal should be done with the minimal amount of the drug. In this way the widespread effects on the organism may be reduced and the investigation may, thus, be more definitely confined to a more limited part of the nervous system. The definition of the minimal amount is impossible to determine in the case of most drugs, since it varies among individuals and changes with addiction. However, in the case of mescal, the minimum may be defined as the quantity which just produces visual photisms, if the investigation concerns vision; or the amount which just induces subjective sounds, if audition is the subject of inquiry, etc. This principle is particularly important in the case of mescal because the effects on the general system are so widespread.

The second principle is a consequence of the principle of minimal stimulation. The amount of mescal which is necessary for different persons to just produce photisms may be regarded as equal since the effects are similar, even though one person may require more drug than another. Since these effects are phenomena such as photisms, subjective sounds, heightened kinaesthesia which can be observed, some precision may be attained in determining the amount of mescal different subjects should be given to attain threshold stimulation. This principle may be called the principle of *equi-effective stimuli*. It follows from this definition that mescal doses may be varied quantitatively for a group of subjects by taking multiples of the amount just necessary to produce certain phenomenological effects for each subject. Thus, if *A* requires twice as much mescal as *B*, the stimuli, theoretically, would still be equal, in terms of the threshold effects, if each were given a fractional part or multiple of the original dose.

In actual application these principles may not be adequate in individual cases, because the difference in the amount of drug which different people may require may be quite great. Thus *A* may require five times as much drug as *B*. Now a person who requires so much more drug than the aver-

age is not a good subject; with such a person there is no way in which powerful effects on the total organism can be avoided. Hence another guiding principle is necessary—the principle of *selected subjects*. It is possible to find people who require only small doses of mescal to produce photisms, and the experimenter should prefer to work with such subjects, unless for special reasons he is interested in extreme intoxication.

The literature on mescal is still very meager. It is difficult to obtain specific information about the effects of mescal to illustrate the application of the methodology here proposed. For this purpose facts on three points are necessary: (1) the effects from slight amounts of mescal, (2) the latent time of appearance of photisms, and (3) their duration. Data on the first question is particularly hard to obtain because most, if not all, experimenters have preferred large doses in order to be certain to obtain typical mescal effects. However, Kelly (6) reports that four of his five subjects obtained slight photisms as a result of five grams of mescal within an hour. Since these subjects were given another dose at the hour, information concerning the duration and vividness of mescal visions obtained from five grams is not available. Unfortunately, Kelly's reports are not confirmed by other investigators. Fernberger (2) obtained photisms from eight of nine subjects, and, though his subjects took heavy doses, the latent periods for visions ranged from 2 1/3 to 5 hours. In the experiment here reported the latent period seemed to be more than six hours for both observers. These discrepancies may be due to the method of determining the initial phases of mescal visions. Fernberger's subjects met at a Peyote seance, conducted ceremoniously after the manner of the Indians. It is doubtful that such surroundings presented a favorable condition in which to detect the first photisms. In the above experiments, frankly, no attempt was made to determine carefully the latent period. Kelly, on the other hand, had to assemble his subjects in a dark room at hourly intervals as part of the procedure of the experiment. This happy circumstance provided good conditions in which to note the initial phases of mescal intoxication. For this reason I am inclined to accept Kelly's data as typical. Concerning the duration of mescal photisms there is more agreement. Fernberger's (2) subjects ranged from two to 20 hours; Kelly's subjects reported photisms after 15 hours, and in my experiments both subjects retained visions at least 12 hours. On the basis of this analysis of the meager data available, it seems reasonable to expect that a sufficient percentage of the population may obtain photisms from five grams of mescal within a few hours after injection,⁹ and enduring sufficiently long to permit experimentation.

⁹Prentiss and Morgan (8) describe the effects of small doses of mescal on human subjects. They find that a dose from one-half to one gram is sufficient for therapeutic purposes. Such doses are recommended for general nervousness, nervous headache, nervous irritative cough, abdominal

It should be noted that with five grams of mescal the most unpleasant symptoms are eliminated, thus permitting repetition of experiments without much discomfort to the observers.⁴

On the basis of the above analysis of the quantity and time relations involved in producing mescal visions, it would seem that the methodological principles here proposed can be utilized successfully. For precise determination of the minimal stimulus the experimenter may administer a sub-minimal amount of mescal to begin with, and follow this dose with definite increments of the original dose at definite intervals until mescal photisms are reported. At the present stage of our knowledge the details of this procedure, concerning the size of the original dose, the magnitude of the succeeding doses, and the time spacing, must be worked out by trial and error. For practical purposes, an investigator who wishes to avoid such an elaborate preliminary preparation may utilize a simpler procedure that probably is not very much different from the plan here presented. Since no one has reported mescal visions with less than five grams of mescal, this quantity may be arbitrarily considered to be the minimal stimulus. By giving a rather larger group of people five grams of mescal, a sufficient number of individuals could be found who obtain photisms within certain time limits. Thus a measure of stimulation, though not as precise as we should like, is nevertheless available. In this sense mescal has an advantage over an extensively studied drug such as alcohol, which does not lend itself to being equated in terms of the psychological effects produced.

There are many complications other than those considered in this paper which enter into the general problem of experimenting with mescal. There is no doubt a correlation between quantity and the quality of the nervous reaction. In the case of alcohol, for instance, slight doses are suspected of facilitating nervous function; large doses of inhibiting function (1). This type of problem and others of a similar nature, in which large quantities of drug are necessary, may be the kind of problem in which the controls proposed here may not be serviceable. Nevertheless, in a field of investiga-

pain due to colic or griping of the intestines, hysterical manifestations, hypochondria, melancholia, and allied conditions. Thus slight amounts of mescal are generally beneficial to the human organism. The same authors state that in some cases doses large enough to produce intoxication and color visions (three buttons) have been found to be helpful in treatment of neurasthenia. There is little if any information on the effects of intermediate amounts of mescal (two to five grams).

⁴This analysis is made for visual symptoms only because few observers have been especially concerned with other modalities. Hence it would be hazardous to make any comparison between modalities though such specific information is desirable for methodological purposes.

tion in which so little has been done at all accurately there is much to be achieved within the limits proposed in this paper.⁵

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⁵Mescal buttons have been chemically analyzed into four alkaloids. Of those mescaline is said to be entirely responsible for the visual effects. Experiments with animals, however, indicate that the other alkaloids have effects similar to that of strychnine. Mescaline on the other hand, acts as a depressant on animals. See Grace (3). Although no effects on humans have been found except by mescaline, there is some chance that effects are present but not ordinarily detected. This may in part explain the strange individual differences as the result of mescal intoxication. For this reason it may be more defensible to use pure mescaline. Knauer and Maloney report results of mescaline injection (7).