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AN ENQUIRY INTO THE CAUSES OF MESCAL VISIONS

By

C. R. MARSHALL, TUNBRIDGE WELLS

INTRODUCTION

MESCAL hallucinations have recently been investigated in the hope that their elucidation might help to unravel other hallucinatory phenomena. Zucker¹ administered mescaline to patients with hallucinations. From the protocols given many of the effects obtained (coloured lights, tapestry patterns, visions of snakes and other animals) appear to have been similar to those induced by mescaline in normal persons. He concludes with the non-committal statement that the hallucinatory experiences of mescaline are not essentially identical with other hallucinations.

The hallucinations produced by mescal have been frequently described, most recently by Guttman.² They are predominantly visual. They vary somewhat in different individuals, but show common features which have not been explained, but which in a search for causes seem worthy of study. Knauer and Maloney³ state that 'it was characteristic of practically all the poisonings that to wavy lines succeeded mosaics; carpets; floral designs; ornaments; wood carvings; windmills; monuments; mausoleums; panoramic landscapes; statuesque men and animals, frequently of unnatural doll-like forms; and finally complete scenes which changed so as to unfold episodes in a connected manner.' Rouhier⁴ divides the hallucinations experienced into four conventional classes, but the sequence, fundamentally, is much the same as that described by Knauer and Maloney. Most of Beringer's⁵ experimenters experienced a similar succession.

COLOUR AND FORM

The visions which are the most characteristic features of mescal intoxication are unique in colour and in form and in the fact that they are best seen

and usually only seen in darkness or dim light. Any environment not associated with dim lighting plays little part in their formation. Hallucinations induced by drugs which act predominantly on the brain do not have these characteristics. Those associated with cerebral depressants rarely show abnormal colours; their sequence of form perception is usually more rapid and more disconnected; and, in the slighter degrees of intoxication at least, environment plays a notable part. The Old Man of the Mountains was well aware of this factor in the phantasies produced by Indian hemp.

Personal experiments.—My own experiments were made with natural and synthetic mescaline sulphate. As the effects produced were broadly similar to those experienced by other investigators they need very brief description. Two modes of administration were employed, oral and intravenous. The effects of intravenous injection have not, as far as I am aware, been previously recorded. Up to doses of 0.05 gm. no distinct symptoms were produced. This dose caused only slightly more brilliant phosphenes, apparently somewhat more prolonged after-images, and, after retiring (four and a half hours after the injection), the appearance for a short time of dull-coloured mosaics. The intravenous injection of 0.1 gm. mescaline sulphate caused slight paræsthesia and a feeling of chilliness, but no distinct visions until an hour after the administration. Then, on closing the eyes, blue enamels were perceived and a little later, when the eyes were bandaged, dull-coloured mosaics, slowly moving crocodile skins and later grotesque figures like caricatured kings on playing-cards. Afterwards a nursery wall-paper pattern and a theatre-like scene were experienced. The bandage was then removed for other observations. What is remarkable in these experiments is the slow appearance of the visual symptoms and the large dose, relative to the minimum oral dose, necessary to produce them.

The minimum dose required to produce distinct hallucinations when taken by the mouth was 0.2 gm. mescaline sulphate. This dose usually produced a somewhat better effect than 0.1 gm. intravenously. The first symptoms were more brilliant phosphenes when the eyeballs were pressed upon. Later in the dark or in a dimly lit room with eyes closed, a panorama of multicoloured lights, clouds, geometric forms, was perceived, followed by iridescent snakes or similar animals, incomplete scenic displays, and, usually later, by statuesque and distorted objects. Sleeplessness and nausea were invariable accompaniments. Larger doses did not produce correspondingly more intense effects.

Colour.—The purely colour effects of mescal visions are difficult to explain. Knauer and Maloney ⁶, by using Marbe's colour wheel, found an increased sensitiveness to colour; and Mayer-Gross and Stein ⁷ noted a greater appreciation of the differences of delicate shades and tones. Fernberger ⁸ states that colour seems more saturated at the periphery than at the centre of the visual field. I observed nothing distinctly abnormal in the spectrum whilst under the influence of mescaline. Continued observation of the

spectrum is difficult because objects, e.g. geometric forms, appear over the spectrum ; but prolonged gazing seems to induce a lightening of the red and a yellowing of the green tending to produce the appearance of a non-chromatic spectrum. On switching off the spectrum there was no sustained image in the dark, but complementary colours in the red and green parts slowly appeared.

Complementary colour changes are sometimes complex. In one experiment I looked at a 60-watt lamp with closed eyes at about 6 inches distance. The field was bright brick red and soon showed circulatory movement or moving mosaics or scenes and on turning away the head from the light or covering the closed eyes with the hands the complementary brilliant green colour appeared. What was surprising was that on facing the light again brilliant green patches were seen for a short time in the red field. The observation was made several times and the effect seemed to be uninfluenced by the length of exposure, even to fatigue, of the light in the first instance.

The colours of objects perceived as visions in the dark tended to exhibit a preponderance of the shorter wave-lengths of the spectrum ; and the combination of colours in objects conceived often seemed more delicate than those common in nature and more comparable with the colours seen when using circular polarization with the microscope. The riot of colour observed under mescaline cannot be attributed solely to processes occurring in the rods and cones. Whatever changes may be associated with colour vision of this kind in the retina, the culmination of the colour perception must be central and is probably associated with an increased sensitiveness of the colour-perceiving centres, intensified, it may be, by a perverted idealization of presented combinations.

Form.—With the perception of form we are on ground capable of stricter investigation. Since visions of form may occur with closed eyelids or in a dark room, external objects are not essential to the visual hallucinations. A fundamental cause of these must therefore be within the body itself ; and theoretically it may be in the ideational or visual centres within the brain or in the structures within the eye. A wholly central causation offers many difficulties. Mescal visions are characterized by what Klüver⁹ has called ‘form constants.’ Those he mentions are : (a) grating, lattice, fretwork, filigree, honeycomb or chessboard design ; (b) tunnel, funnel, alley, cone or vessel ; (c) spiral. The most frequent of this type is the tapestry pattern, which will be considered later. It may, I think, be postulated that if circulatory movement is constantly seen by different individuals there must be some peripheral stimulus producing it ; or, if similar geometrical forms are perceived by different individuals, the cause must be sought at or near the periphery. It is almost inconceivable that a part of the visual centres should be solely concerned with the presentation of such specialized patterns.

ENTOPTIC ASSOCIATIONS

As entoptic phenomena, under the conditions producing the visual hallucinations, seemed to be possible factors in inducing these representations, those of my own eyes were investigated with this end in view. The entoptic appearances ordinarily visible arise mainly from motile forms in the vitreous or from secretion on the cornea, but they may result from conditions in the cornea, the crystalline lens, or other structures of the eye; and by special manoeuvres the network of retinal vessels may be observed; but none of these entoptic phenomena can be seen in the dark and none of them could produce a semblance of the image forms seen during mescal intoxication. In the search for an explanation of mescal visions, investigation led to the discovery that retroretinal structures can be observed; and, since it is under similar conditions that mescal visions are experienced and retroretinal structures are seen, it seems probable that we have here the primary cause of these constant visual hallucinations. The results obtained and the methods employed have been described.¹⁰ The most interesting of the retroretinal structures that can be observed is the choriocapillaris. This circulation is one in sinuses and when seen fully resolved has a foliaceous appearance and is in turbulent motion. Unlike the perception of the retinal vessels it covers the whole visible field and indeed is most apparent in the foveal region. Out-of-focus presentations are common and when seen with closed eyelids against suitable lighting are usual. They may appear as variants from indistinct marbled forms, showing evidence of some circulatory movement, to whirling arabesques.

Besides the choriocapillaris, the pigment granules in the retinal pigment layer may be observed, most commonly as fine granules covering the choriocapillary circulation, and, rarely, as discrete granules or crystals apart from the circulation. Thus more than one retroretinal plane may be perceived and apparently under different magnifications. It is questionable, however, if the layer of pigment granules alone plays any part in producing mescal visions. The luminous points which may be seen under special conditions of lighting are probably more potent factors. The most easily observed of the luminous points are the darting points seen by gazing with relaxed accommodation at the reflected light of the mercury lamp or other uniform white surface. These luminous points are probably circulating red blood corpuscles in the capillaries of the inner nuclear layer. They may play a part in the production of some mescal visions, but against this view there is the very serious objection that normally they require a considerable intensity of light to make them visible and in light of this intensity mescal visions in my experience are never present. Other luminous points which may be observed in special circumstances are corpuscles, probably white corpuscles in the choriocapillary circulation. They may be seen for a short time running across the foveal position after relaxation of heavy pressure on the eyeball. Heavy pressure on the eyeball, as Vierordt¹¹ found, may also bring into view

the choriocapillary circulation; and this fact suggests that a small amount of energy, which is interpreted as light, emanates from the circulation. This hypothesis is supported by the effect of intravenous injection of *santonin* when the eyes are dark-adapted¹²; and by the fact that in mescal intoxication a transient retroretinal illumination may be induced by exertion, as will be mentioned presently. Under ordinary circumstances the luminous intensity of the circulation is so small that it is not perceived, except possibly as part of the self-light of the eye, but in the state of increased sensitiveness of the visual centres which mescaline appears to induce, this small intensity of light may be, in some measure, perceptible. The sensation of brightness in the dark room is mentioned by many experimenters. One of Beringer's subjects¹³ was astonished at the clearness of his arm, etc., and began to laugh, saying, 'People call this a dark room! a room in which I can almost see to read!' It is difficult to avoid the conclusion that in these cases there is abnormal sensitiveness to luminous stimuli of small intensity.

Pressure on the eyeball also causes starry lights and geometrical figures. The star-like lights probably arise from the pigment granules which have absorbed light-energy and under pressure are able to emit sufficient electrons to produce the appearance of luminous points. The geometrical figures, in my opinion, are due to the compactness and small diameter and regular arrangement of the rods and cones and a light source behind, mainly pigment granules, producing diffraction-like figures.

The earliest visual effects of mescal are usually produced by pressure on the eyeball; they are, that is, earliest experienced as phosphenes. They consist of light effects and geometric patterns. Geometric forms—honeycomb and lattice designs—however, are perceived under the influence of mescal without pressure on the eyeball, and it is suggested that their production is not dissimilar from that of pressure phosphenes. Owing to an increased sensitiveness of the visual centres the threshold of sensibility is reduced to the extent of perceiving retroretinal pictures which are only observed by the normal retina when the stimulus has been intensified by pressure on the eyeball. Under the influence of mescaline the geometrical figures are more varied than those obtained by pressure. The difference may be due to complications induced by some perception simultaneously of the choriocapillaris and to the altered cerebration and consequent less control of concepts in a mescalized state.

Another entoptic phenomenon commonly seen under normal conditions is that of violet clouds with changing irregular borders moving centrifugally or centripetally in the visual field. Cloud forms, sometimes showing other colours, are also experienced during the action of mescaline and are probably of similar origin to those normally seen. This origin is doubtful; but the matter has been discussed elsewhere.¹⁴ The existence of a more sensitive state of the visual centres seems sufficient to explain any differences from the normal experienced in mescaline intoxication.

THE TAPESTRY PATTERN

Of the 'form-constants' a carpet, wallpaper, or tapestry pattern is the most commonly experienced. In the monograph of Beringer, half of the 32 individuals experimented upon (mostly medical graduates or students, but including also an artist, a biologist, a law student and a blind doctor of philosophy) allude to a tapestry pattern in describing their experiences; and most of the others refer to such pictures as spirals and circles in lively rotation, dancing movements of the floral pattern of the carpet, etc. Similar experiences are mentioned by other investigators. Rouhier¹⁵, for example, in the single experiment on himself, reports as early experiences, geometric designs, mostly of feeble luminosity, similar to a tapestry with a grey pearl background and white flowers. In his commentary in later pages he states¹⁶ that each movement is animated with an individual motion and continues its rotation or pulsation; clouds extend, deform, etc.; diverse figures, points, globes, stars, geometric motives, surge, change, depart, return, in an indefinite succession. The whole of this moving kaleidoscope is affected, sometimes slowly, sometimes quickly, but without rest, horizontally, vertically or obliquely, sometimes in one way, at other times in every way, according to a regular and pulsating rhythm, as if it were a blood wave which produced it. It was the perception of a foliaceous pattern in active movement during mescaline intoxication, new to me in experiments with drugs, that led to my search for a possible cause. The cause I believe I have found in the perception of the choriocapillaris; and to perceive it is to understand such descriptions as those quoted above.

The ability to observe the choriocapillaris necessitates the retina being able to look backwards. If it may be assumed that the change from light energy to nervous excitation occurs in the outer segment of the rods and foveal cones, there seems to be nothing improbable in this hypothesis provided that there is sufficient illumination for the purpose. Both in my own and Zehender's¹⁷ observations slight external illumination was essential for seeing the retrolental circulation. Although under appropriate conditions some manifestations of it may be seen after closing the eyes or passing into a dark room, it is not seen as a circulation after a prolonged stay in darkness. When the light of a microscope field is employed to view the circulation the brightness of the field departs and is replaced by an appearance resembling a 'dark-ground' effect as the choriocapillary circulation comes into view. The retina in looking backwards evidently does so in a state of dark-adaptation. It is also in this state that the visions in mescal intoxication usually occur. The cult of peyotl (i.e. mescal) devotees among American Indians holds its seances under conditions producing this state, for they are held at eventide. The camp fire used by some tribes in the ceremony not improbably provides, in the flickering flames and the shadows, the most suitable background for many mescal visions, intensifying, as it doubtless does, the effects both of colour and of form. Since the conditions for observing mescal visions

and the choriocapillaris are similar, while the pattern of the choriocapillaris presented is such as to suggest to a normal individual a tapestry pattern, it does not seem unreasonable to associate the two. The apperception of a tapestry pattern during mescal intoxication is probably aided by the cerebral activities being less under control, thus facilitating associations engendered by suggestion; and the effect is probably intensified by the constant surging movement and consequent constant, if slight, change in the appearance of the choriocapillaris, so that a variety of tapestry patterns may be experienced. One of Beringer's experimenters¹⁸ sang, 'Wenn ich eine Teppichfabrik gründe, steht in meiner Hausapotheke Mescaline.' There is no structure in the eye other than the choriocapillaris which could suggest a tapestry design in motion or the kaleidoscopic changes observed in mescal intoxication. The pigment layer which might be regarded as a barrier to the observation of the choriocapillary circulation is not so, at least in my eyes, and retinoscopic examination shows that they are apparently normal. And a study of serial sections parallel to the surface of the macula confirms the appearances which under suitable conditions of observation may be seen.

In offering this new conception of the origin of certain types of visual hallucination the question arises: why are these experiences perceived under the influence of mescal and not unless specially looked for in a normal state? The question is difficult to answer. The ability of the retina to look backwards is not easily explained. In a paper on entoptic phenomena I have offered a tentative hypothesis. It is there suggested¹⁹ that retroretinal vision is confined to the outer segments of the rods and more particularly the foveal cones and that the myoid of the inner segment in man is capable of rapid contraction and relaxation, and that by the relaxation the outer segment may be brought into such close association with the retinal pigment and choriocapillary circulation as to enable these to be focussed on one or other of its percipient planes. Practice unquestionably facilitates observations; and that the foveal cones are not static is suggested by the varying magnifications under which the pigment granules and choriocapillaris may be seen. One point needs emphasis: retroretinal vision is only obtained within certain narrow limits of a low intensity of light-energy. This energy may be obtained from without, in which case the retroretinal structures are probably seen in much the same way as microscopic objects are seen with a vertical reflector; or sufficient light-energy may possibly be obtained from retroretinal structures themselves—from the pigment particles after previous daylight exposure, or from the choriocapillary circulation. Luminous effects from both these structures appear to arise from pressure on the eyeballs. Vierordt, as previously mentioned, found that the choriocapillaris can be perceived in this way. And it seems not improbable that in mescal intoxication the light, when not external, with which the circulation is seen may come from one or other, perhaps both, of these sources. Since discovering anew the choriocapillary circulation I have made only one experiment with mescaline, partly

because it causes in me distressing nausea, but mainly because advancing years diminish the value of this class of introspective experiment. Nevertheless, the experiment seems sufficiently instructive to report. It was made with the deliberate intention of testing to what extent mescal visions could be explained by my experience of the appearance of retroretinal structures. Mescaline sulphate, 0.3 gm., was taken at 8 p.m. immediately before dinner on May 13, 1935. I retired at 8.30 p.m. and lay in bed with closed eyes. The visions commenced soon after 9 o'clock, and, interestingly, consisted mainly of processions, which although lower in colour tone, were even more entrancing than the Jubilee processions I had seen in London a week before. The field of vision was full of companies of marching soldiers. Other visions were of gardens, of creeping snakes or parts of snakes with shining green scales, of streams of golden coins floating in channels like circulating blood corpuscles in arterioles. At one time the stream slowed down, stopped and commenced to flow in a reverse direction before the picture changed. The intoxication was disturbed by a telephone call at 10.30 p.m., and I understand my conversation was normal. Indeed with eyes open the world appeared normal. Even in the dim light of the bedroom nothing seemed abnormal except some whirling circles on the ceiling. As the night seemed interminable I got up at 1.30 a.m. and took a hypnotic. A notable incident occurred on lying down and closing my eyes, in that a strong diffuse light was experienced at the back of the eyes, most luminous slightly above and to the left, which, however, soon passed away. On awakening about two hours later pictorial presentations were seen no more. With open eyes whirling was still seen on the ceiling and on pulling the bedclothes over my face a 'tube-distortion' appeared. The experience confirmed the view that motile phenomena and tapestry-like visions could be explained as perverted concepts induced by a sinus circulation. One point deserves notice. In this experiment a slowing, brief cessation and reversal of a magnified circulation were experienced, whereas the retroretinal circulation which I can see at any time under suitable conditions is always in turbulent motion, although no constant direction of the circulation can be distinguished. It is also seen under lower magnification probably owing to the shorter distance of projection. Zehender²⁰, who also discovered that the choriocapillary circulation could be seen, noted in his observations a varying rapidity of the blood circulation, stagnation and even reversal. Such occurrences may serve to explain the snake-like and similar movements which have been so frequently experienced in mescal intoxication. It may be, since different retroretinal planes may be observed, that the retroretinal circulation may present more than one aspect to different observers or even to the same observer at different times; and the different magnifications at which the circulation is apparently seen supports this view. Under the influence of mescaline, however, one never sees the retroretinal circulation with the same clearness that it may be seen when one is in a normal condition, a result which may be due to the bizarre apperceptions

produced by retroretinal stimuli in a mescalized state. What mescaline appears mainly to do is to lower the threshold of the visual centres for the perception of low intensities of light-energy so that, with closed eyes or in the dark, such almost infinitesimal stimuli as those produced by or arising in the choriocapillary circulation are in some measure perceived.

An interesting experience which has been described by several observers is the projection of these tapestry-like and similar pictures on to a surface, such as the wall of a room, which may be at varying distances from the eye. The appearance is that of an objective picture and is an experience different from that of a visualized concept. The choriocapillary circulation can be projected under suitable conditions of lighting on to different planes by anyone capable of seeing it. It cannot, however, be traced in outline as, owing to the apparent surging of the circulation, the outlines are constantly changing. An impressionistic picture might be made of it by someone with artistic ability, but the movement would be as difficult to represent as that of a stormy sea.

Experiences of the blind.—The experiences of blind men which might be expected to be decisive in settling the part played by the choriocapillaris in the production of tapestry visions in mescal intoxication are not so. Beringer²¹ describes the effect on one blind man and Zador²² on eight blind men. In Beringer's case the blindness was the result of the War, but further information regarding the pathological state of the eye is not given. After taking mescaline he saw revolving coloured particles and later coloured flowers and ornaments of tapestry design. His experiences, however, do not appear to have been so vivid as those of normal persons; and if the retina in this subject was still intact, as the protocol would suggest, light passing the anterior part of the eye might have been of sufficient intensity to afford the experiences described. Zador's eight cases were blind from different causes (optic atrophy, glaucoma, cataract). Their visual experiences were few and none of them mentions a tapestry pattern. It is interesting to note that the two eyes in one of Zador's subjects became blind at different times and that the primitive optical experiences perceived were said to be seen in the later blinded eye first. From his observations Zador comes to the conclusion that the duration of the blindness is of importance perhaps owing to a progressive and eventually complete functionlessness of the participating elements in the peripheral field as well as in the conducting paths.

Summarizing the part entoptic phenomena of retroretinal origin play in producing mescal visions, my studies suggest that to the choriocapillary circulation are due the perception of tapestry and floral designs, of ornamental carvings, spirals and the like; of birds of paradise, snakes with glistening scales, and similar animals; of waterfalls and firework cascades; of all sinuous, circulatory and multiplied movements. To the luminous points in the choriocapillary circulation are ascribed the presentation of fireballs, crystals, diamonds and other brilliant gems, fireflies and star-like objects in motion, while mosaics, enamels, honeycomb and trellis work and similar

geometrical figures are probably to be associated with the retinal pigment and regular arrangement of the rod and cone structures. Perception of other forms of polyopia may be caused in part at least by the choriocapillary sinuses. While most of the initial hallucinations of mescalism may, it is believed, be thus accounted for, other, usually later features, such as statuesque appearances and distortions, involve different factors.

DEPTH AND DISTORTION

An experience common to the later stages of mescal intoxication is an apparent increased perception of depth which manifests itself in the presentation of objects in greater relief than they possess. To one of Beringer's subjects²³ the window curtains appeared to be made of cement; and he was not disillusioned when he saw them blown about by the wind. During one of my observations on colour fatigue an electric light was gazed at with closed eyes. The red field with its circulating streams became more orange and the picture quickly assumed a more plastic form, the streams being converted into valleys and the whole becoming more scenic. Associated with the increased perception of depth are experiences of varying distortion of objects presented to consciousness. Faces seem mask-like, shadows appear sharper and deeper, and frequently a Buddha-like statuesqueness is evolved. An altered mentality may exaggerate these perceptions into concepts of monster-like figures. Micropsia also occurs.

The explanation of depth perception usually given is associated with that for the perception of distance, but it is questionable if the factors involved are of the same value in the two cases. Perspective, linear and aerial, and parallax, are dominant in the perception of distance, while light and shadow appear to play a larger part in the perception of depth. Indeed the increased relief and plasticity experienced in mescal intoxication appear to be due to a greater sensitiveness of the visual centres to light-energy of low intensity and a consequent tendency to greater contrasts of luminous stimuli. Mayer-Gross and Stein²⁴ thought it 'not improbable' that the increased depth perception was due to the increased contrast experienced. In the images of peripheral origin seen in darkness other factors must be involved. In my observations on the choriocapillaris, the circulation, apart from the varied light and shadow which it showed, had an appearance of solidity which seemed to be best explained by assuming that the outer segment of the rods and foveal cones was capable of reception throughout its length and that transformation from light-energy to nervous excitation might occur in any of its various planes.²⁵ Many of the conditions under which mescal visions are perceived also tend to increase the illusion of depth; for example, the low colour tones with a predominance of bluish shades, the softish contours and the tendency to curvilinear perspective, the greater difficulty of recognizing the various planes of the presentation and the frequency of a

radial distribution.²⁶ And to these peripheral factors must be added the knowledge of the appearance of objects constituting similar projected images.

Funnel distortion.—A somewhat frequent experience is of a funnel or cone type of distortion. Varied examples are to be found in the contributions of Knauer and Maloney, of Rouhier, and of Beringer. Not uncommonly there is an experience of long drawn-out tubes or corridors which may terminate in a small luminous patch often showing movement within it. Somewhat less common examples of the type are found in Weir Mitchell's experience²⁷ of a white spear of grey stone which grew to a great height and became a tall richly finished Gothic tower of very elaborate and definite design; and in the experience of one of Beringer's subjects²⁸ who visualized in a church a large black organ with bright metal pipes surmounted by smaller ones which soon seemed to extend upwards, becoming smaller and smaller and being followed by new pipes. Knauer and Maloney's description²⁹ of an experience is an example of a reversion which is occasionally obtained. Four hours after an injection an appearance of concentric rings, apparently made of extremely thin steel wire, the innermost, almost infinitely small, was perceived. 'As I watch, the centre seems to recede into the depth of the room, leaving the periphery stationary, till the whole assumes the form of a deep funnel of wire rings. The light, which was irregularly distributed among the circles, has receded with the centre into the apex of the funnel. The centre is gradually returning, and, passing the position when all the rings are in the same vertical plane, continues to advance, till a cone forms with its apex towards me. . . . The cone apex recedes, the inner rings of the circle rapidly change colour; beautiful crimsons, purples, violets, blues and greens, quickly succeed one another. . . . The illumination proceeds from a light or lights moving suddenly from place to place behind the background, and producing wonderful effects of deep shade and bright light contrast, of sudden bursts of light, and equally sudden extinctions.'

Serko³⁰ attributes distortion to spatial disorientation and Forster³¹ to irregular curvatures of the lens, which Zador³² denies. For him distortion is an appearance-form of a disturbance of sensorial movement caused by changes of optic perception which differ from the apparent movement of well-proportioned objects.³³ Rouhier's explanation³⁴ is not more intelligible. Indeed none of the suggestions made explains the distortions experienced in mescal visions and particularly not the funnel type under discussion.

If one presses sufficiently on the closed eyelids the phosphenes of geometric form produced frequently show a perspective effect, the smaller forms being centrally and the larger forms more peripherally situated. The position of the fovea may be marked by a bright patch, or a dark patch with surrounding halo, either of which intensifies the cone or funnel appearance suggested by the sizes and disposition of the geometric forms. A perspective presentation, unaccompanied by apical light, may be experienced without

pressure while travelling in a train if the closed eyelids are directed to the sun and observations are made when the train passes into a not too short tunnel. And it may even be more evident if, during such a journey, one is fortunate enough, while travelling, to be able, with eyelids closed, to look at the sun through the broken steam clouds coming from the locomotive. From such experiences a perspective effect, commonly a cone form, is seen to be, under certain circumstances, a normal presentation of ordinary vision. The effect is not due to pressure of the closed eyelids, for I have observed it after taking mescaline when the head was covered with bedclothes to produce the necessary darkness. The purely geometric forms of squares, hexagons and the like probably arise, as I have suggested previously, from the smallness and regularity of cross sections of the rods and cones producing diffraction-like effects. The perspective effect arises partly from the foveal cones and environing rods, being smaller and more closely arranged than those of the periphery, and in consequence the geometrical figures perceived are likely to be smaller in the centre than at the periphery; and it is enhanced by the luminous points or areas which may be present in the region of the fovea. One of Rouhier's subjects³⁵—a lady—experienced the sensation of looking through a long cylinder and seeing something in constant movement, luminous, small and far off; and one of Beringer's subjects³⁶—an artist—had a similar experience in the perception of a long thin funnel, the end of which seemed a luminous point far away. When the luminous areas are larger they may induce a concept of glistening waterfalls. The luminous areas are probably caused by energy perceived as light emanating from the choriocapillaris, and to this energy the foveal region, partly because of its closer relation to the circulation, is the most sensitive. In mescal intoxication as in pressure phosphenes the fovea seems to play a dominant part; and in the later stages of intoxication, when discrimination and control are not normal and the visual centres are hypersensitive, visual presentations of considerable depths of space which lend themselves to cone or funnel distortion, however caused, are liable to exaggeration. This type of 'form constant' may, in other words, be explained as an exaggerated perception, due mainly to the special sensitivity of the visual centres in mescal intoxication to low intensities of light, of a condition which may normally be observed. The variety the distortion may assume depends on various factors, of some importance being the special tendencies and education of the individual. The appearance of reversal, which the presence of apical light may sometimes induce, is probably a purely psychological effect analogous to the occurrence of pseudostereoscopic vision.

Micropsia, when limited in field and central, as in looking through a telescope reversed, has associations with funnel distortion, but it is also an affair of apperception and memory images. One individual looking out of his window at Heidelberg, saw the river Necker, and across it the suburb Neuenheim, and 'every leaf, every house, every copse stood out in a clarity

and intensity I had not experienced before.' ³⁷ True vision of such minute detail is, of course, impossible.*

Macropsia is also mainly due to altered apperception, but, like the caricatures so common in mesal intoxication, it is in part suggested by changed perceptions to low intensities of light and consequent exaggeration of light and shade.

At times there is incompleteness of visual images—only parts of snakes or other objects may be seen. This appearance, termed by Klüver ³⁸ 'presque vu', is due to delimitation of the visual field in one or more directions. Rare observations suggest the probability of this appearance being, at least in part, peripheral; but there also appears to be a difficulty in mesal intoxication of completing in perception an incomplete presentation, at least to the extent that occurs in normal individuals.

AFTER-IMAGES

Many observers have remarked on the strength and sometimes the duration of the after-images during mesal intoxication. Better positive after-images resulting from objects observed in dull light are, along with greater brilliancy of pressure phosphenes, the earliest manifestation, in myself, of the action of mescaline. The after-images often seemed to wax and wane. The most vivid after-image that I have experienced was during a mild intoxication when I stood for a brief interval before a glass door leading into a conservatory banked with chrysanthemum plants in full bloom. On closing my eyes the picture of this colourful mass, it seemed to the minutest detail, remained in my vision for at least a minute.

An intensified positive after-image effect was found not to be constant under all circumstances, but the factors which influence its formation were not determined. Mayer-Gross and Stein ³⁹ observed an alternation of states of prolonged after-images and inability to form them; and Klüver ⁴⁰ found that sometimes the visions appeared to prevent the appearance of after-images entirely. Positive after-images, as many experimenters have noted, tend to pass into visionary phenomena, a fact which makes the study of visual fatigue in mesal experiments difficult. The curious prolongation of the complementary green in observations through closed eyelids previously mentioned is unique in my experiments on visual fatigue. It may be that it is of the nature of an after-image effect in a state in which the colour percipient centres are more sensitive than normal.

THE ASSOCIATION OF IMAGES

During the course of mesal intoxication the imagery experienced tends to develop from the simple to the complex. The simpler images of the

* Apparently the experience may occur in other psychical states. Shelley, writing to a friend, said 'My feelings at intervals are of a deadly and torpid kind, or awakened to such a state of unnatural and keen excitement that, only to instance the organ of sight, I find the blades of grass and the boughs of distant trees present themselves to me with microscopic minuteness.'

earlier states owe their origin to retinoretinal stimuli—the sinuous movement of the circulation or luminous points within it, or the disposition of the rods and cones—but these give rise to varied perceptions no two of which are exactly alike. The images which follow appear to be less fleeting, but successive images are associated and continue to develop until the sequence is broken and another series takes its place. The greater complexity of the later images—the occurrence of landscapes, etc.—is perhaps due to a habit of image formation having developed, coupled with diminished control from the higher centres. That some process of this kind is in play is suggested by the fact that the early image-forms do not usually return as the intoxication passes away. The imagery of mescalism, like other phantasies, is largely influenced by the education and tendencies of the individual. To the naturalist the dim retinoretinal points of light may suggest radiolaria, to an artist bright coloured flakes on a pictorial background, to an ordinary person fireworks or jewels. But to some extent individuality diminishes with deepening intoxication.

An important difference shown by the phantasies of mescalism from those, say, of a hypnagogic state, to which otherwise they show some resemblance⁴¹, is the almost complete absence of voluntary control. Most experimenters have found it impossible to visualize an object or a scene on command, however familiar. Luke Fildes' picture, 'The Doctor', I can visualize in some degree at any time, but I found it impossible to do so when under the influence of mescaline. Two factors are probably involved in this disability. With closed eyes many retinoretinal stimuli are pouring into the cerebral centres and in some measure taking command of them; and with open or closed eyelids there is some degree of mental inhibition, some difficulty in associating ideas, such as occurs in caffeine intoxication. One subject tried to play the piano; he found that his fingers would not follow his will.⁴² Another difference from most other dream phenomena is the absence of fear. However grotesque, ugly or awe-inspiring the vision may be, repugnance is rarely felt. In this respect, but in few others, it might be compared with morphine.

CENTRAL ACTIONS

The action of mescaline on mentality appears to vary considerably in different individuals. It may extend from an almost negligible effect to one characterized by haptic hallucinations and marked disorientation; and the difference in effect does not seem to be one of dose. That the difference is largely personal is suggested by the fact that individuals who experience one extreme form of psychic symptoms often experience several kinds. One who said he could tell with what soap the cook had washed the plates from which he was eating, estimated that he swallowed a litre of saliva, had a breast that grew to the size of a terraced garden and thought himself colossal like Gulliver in Lilliput.⁴³ Case 4 in Beringer (p. 155) is an even more striking example. Disorientation and haptic illusions are not limited to or charac-

teristic of the action of mescaline. They occur even more commonly after taking Indian hemp, the pharmacological action of which, although sometimes said to be similar to that of mescaline, is nevertheless very different. The hallucinatory states are not similar; mescaline almost invariably causes wakefulness of the caffein type, which is quite different from the wakefulness that may be associated with cannabis intoxication. Disorientation and haptic illusions also occur with other cerebral depressions and cerebral excitants. And the synæsthesia and abnormal feelings ('Hamlet-feeling', etc.) which occur in mescaline intoxication are not characteristic since they occur in other intoxications and even in non-intoxicated people. Chromæsthesia is perhaps more common after mescaline, because of the greater colour sensitiveness present, than in ordinary life; but statistics on the point are not available. I have experienced fixed ideas after taking mescaline, but I have had them even more intensely after experiments with anæsthetizing gases.

Indeed, apart from the increased sensitivity of the visual centres to colour and low intensities of light-energy, there are no cerebral symptoms, universally experienced, which are peculiar to the pharmacological action of mescaline, and scarcely an effect which is not produced by other drugs. Apomorphine causes similar nausea; caffein induces similar wakefulness and inhibition; the nondescript symptoms and exhilaration or depression may follow the administration of many drugs. There is perhaps greater variability in the psychic symptoms produced in different individuals by mescaline than by other substances; the question has been recently discussed by Guttman⁴⁴ and is not pertinent to the present inquiry. Comparison may be made with strychnine which also increases visual acuity. The effect is quite different from that of mescaline. Strychnine increases, usually only slightly, the acuity of vision to all intensities of luminous stimuli; mescaline increases the sensitivity of the visual centres to a limited range of low intensities of light-energy. Its action in this respect is unique and it must be confessed difficult to understand.

CONCLUSIONS

An attempt has been made to explain most of the characteristic hallucinations of mescal intoxication as illusions produced in the first instance by retroretinal structures and especially by the choriocapillary circulation. The visions seen are varied, but they fall into certain groups and nearly all are characterized by 'form-constants.' It is contended that these 'form-constants' can only arise from some peripheral stimulation common to different individuals. It has been found that under certain conditions of lighting—fundamentally those in which mescal visions are perceived—the choriocapillary circulation and some other retroretinal structures can be seen, and that these may show different appearances owing to the varying turgescence and rapidity of the circulation; to which must be added that in mescal intoxication the circulation has always an indistinct, out-of-focus

appearance. From such varied shadowy forms, in a state of mind given to phantasy, innumerable compositions are possible. That the visions are of peripheral origin is supported by the fact that they may be projected on to varying planes in front of the observer.

REFERENCES

- ¹ ZUCKER, K., *Zeits. f. d. g. Neurol. u. Psychiat.*, 1930, **127**, 108.
- ² GUTTMANN, A., *Jour. of Ment. Sci.*, 1936, **82**, 203.
- ³ KNAUER, A., and MALONEY, J. M. A., *Jour. Nerv. Ment. Dis.*, 1913, **40**, 425.
- ⁴ ROUHIER, A., *Le Peyotl*, Paris, G. Doin et Cie, 1927, 278.
- ⁵ BERINGER, K., *Der Meskalinrausch*, Berlin, Jul. Springer, 1927.
- ⁶ *Loc. cit.*
- ⁷ MAYER-GROSS and STEIN, *Zeits. f. d. g. Neurol. u. Psychiat.*, 1926, **101**, 354.
- ⁸ FERNBERGER, S. W., *Amer. Jour. Psychol.*, 1923, **34**, 267.
- ⁹ KLÜVER, H., *Mescal: the 'Divine' Plant and its Psychological Effects*, London, Kegan Paul, 1928, 36-39.
- ¹⁰ MARSHALL, C. R., *Brit. Jour. Ophthal.*, 1935, **19**, 198.
- ¹¹ VIERORDT, K., *Arch. f. physiol. Heilk.*, 1856, **15**, 255, 567.
- ¹² MARSHALL, W., *Jour. Pharmacol. exp. Therap.*, 1927, **30**, 361.
- ¹³ BERINGER, *loc. cit.*, 196.
- ¹⁴ MARSHALL, C. R., *loc. cit.*, 187.
- ¹⁵ ROUHIER, *loc. cit.*, 235.
- ¹⁶ *Ibid.*, 277.
- ¹⁷ ZEHENDER, W., *Klin. Monatsbl. f. Augenheilk.*, 1895, **33**, 311.
- ¹⁸ BERINGER, *loc. cit.*, 273.
- ¹⁹ MARSHALL, C. R., *loc. cit.*, 197.
- ²⁰ ZEHENDER, *loc. cit.*, 302, 340.
- ²¹ BERINGER, *loc. cit.*, 167.
- ²² ZADOR, JUL., *Zeits. f. d. g. Neurol. u. Psychiat.*, 1930, **127**, 30.
- ²³ BERINGER, *loc. cit.*, 254.
- ²⁴ MAYER-GROSS and STEIN, *loc. cit.*, 360.
- ²⁵ MARSHALL, C. R., *loc. cit.*, 194.
- ²⁶ Cf. AMES, A., junr., *Jour. Opt. Soc. Amer. & Rev. Sci. Instrum.*, 1925, **10**, 137.
- ²⁷ WEIR MITCHELL, S., *Brit. Med. Jour.*, 1896, **2**, 1626.
- ²⁸ BERINGER, *loc. cit.*, 161.
- ²⁹ KNAUER and MALONEY, *loc. cit.*, 429.
- ³⁰ ŠERKO, A., *Jahrb. f. Psychiat. u. Neurol.*, 1913, **34**, 358.
- ³¹ FORSTER, E., *Zeits. f. d. g. Neurol. u. Psychiat.*, 1930, **127**, 11.
- ³² ZADOR, *loc. cit.*, 40.
- ³³ *Ibid.*, 57.
- ³⁴ ROUHIER, *loc. cit.*, 299.
- ³⁵ *Ibid.*, 259.
- ³⁶ BERINGER, *loc. cit.*, 171.
- ³⁷ *Ibid.*, 210.
- ³⁸ KLÜVER, *loc. cit.*, 56.
- ³⁹ MAYER-GROSS and STEIN, *loc. cit.*, 357.
- ⁴⁰ KLÜVER, *loc. cit.*, 64.
- ⁴¹ MARSHALL, C. R., *Mind*, 1936, **45**, 67.
- ⁴² BERINGER, *loc. cit.*, 264.
- ⁴³ *Ibid.*, 197.
- ⁴⁴ GUTTMANN, *loc. cit.* Cf. also *Monats. f. Psychiat. u. Neurol.*, 1924, **56**, 161.