A study of visual perseveration

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The manifestations of disordered visual perception may, as established by Hughlings Jackson for neurological deficits in general, be divided into the 'negative' and the 'positive'. The negative commonly present as defective areas of visual field. The positive, also not uncommon, consist in visual impressions which are either endogenous or represent an exaggerated or distorted perception of the outside world. An unusual variant of the latter is the increased apparent duration of visual stimuli known as visual perseveration (Robinson and Watt, 1947). This consists in the continuation or repetition of a visual sensation after the stimulus object which gave rise to it has been removed from sight (Critchley, 1950).

Holmes (1931) mentioned a patient who, having seen someone walk past her bed, had the false impression that this had happened again immediately afterwards. Adler's (1944) patient reported the superimposition of successive visual impressions during recovery from carbon monoxide poisoning, and Robinson and Watt (1947) recorded transitory episodes of visual perseveration in association with post-traumatic epilepsy. The largest series of such cases was that of Critchley (1951), and further instances have been reported by Le Beau, Wolinetz, and Rosier (1952), Castaigne and Graveleau (1953), Pötzl (1954), and Bekeny and Peter (1961). In two of his cases (1 and 4) Critchley (1951) was able to elicit the phenomenon on clinical examination. He nevertheless remarked: 'We are dealing with a phenomenon—within the province of a subjective experience. The examiner is largely at the mercy of the patient's own description of events, and it is not easy to check the accuracy of his statements and to measure and record the extent of the defect' (Critchley, 1953).

For a study of visual perseveration in terms of disordered visual physiology, subjects with a not too evanescent, variable, or intermittent disorder are required. Also needed is a yardstick against which to measure the responses and criteria against which to assess their consistency. In the present study two suitable subjects were examined by methods which have in the past been used to establish the properties of 'after-sensations' as they occur in normal visual perception. Their responses were assessed against the

yardstick of present knowledge of these properties, in order to determine whether 'visual perseveration' can be regarded not as created *de novo* by the pathological process, but as representing a quantitative alteration of normally occurring visual perceptual processes.

CASE REPORTS

CASE 1 A.A., aged 55, previously a stores controller on Ministry contract, and then proprietor of a cafe and a shop, was admitted with the complaint of visual disturbance lasting one year. There was no relevant family history. The patient had attacks of acute pancreatitis in 1937 and 1955. In 1956 he underwent coronary endarterectomy for relief of angina of effort and in 1958 bone graft for non-union of the sternum at the thoracotomy incision. Since then his cardiac status has been reasonably good, but his activity has been severely limited by intermittent claudication on account of which he has had to give up his work. In 1960 he suffered an acute episode of active depression. He took an overdose of barbiturate after he had recovered he was admitted to the Littlemore Hospital for psychiatric care, and there recovered from the depression. When he had been there a week (one year before the present admission) suddenly he was attacked by paroxysms of severe occipital headache, radiating frontally, and associated with nausea, vomiting, and concentric constriction of the visual field with whirling lights on either side. After some months the headaches gradually subsided, but the visual symptoms remained.

His visual manifestations are as follows:—

Right superior quadrantic field defect This he described spontaneously as a 'nothingness' replacing objects within or parts of objects overlapping the affected sector of the visual field.

Continual incidence of bright multicoloured flashing lights These encroached on the visual field from both sides and seeming to descend; though usually unpatterned, at times they take the form of fortification spectra. These lights are usually in continual unorganized motion: 'whorls and crisscross lines of bright light and colours darting about all over, and Catherine wheels' most marked in the dark, or when the eyes are closed. They are especially obtrusive when he is worried, angry, excited, or suddenly startled, as by a loud and unexpected noise. At times the lights are organized as moving constellations. At times he has the impression of a 'heat haze' rising. These manifestations fill the visual field, but

are often especially concentrated within the defective quadrant.

Apparent distortion of external objects At times objects may appear to move, tilt, or dissolve into moving multicoloured lights, reappear, and redissolve. 'As I read the newspaper it suddenly disintegrated into a whirling jumbled mass of paper, print, and flashing lights.'

Intensification of visual sensation Bright and coloured objects seem unnaturally vivid, and he shuns the light. 'I found relief in a darkened room, and would lie for hours with the blinds drawn. A crack of light was like a flash of lightning.' He remains highly susceptible to bright light and glare, as of car headlights at night, or of sunshine reflected from snow, which may leave him dazzled and unable to see for minutes.

Apparent reduplication of external objects Objects closely fixated may reduplicate and multiply in deceptive detail, so that he may try to pick up an image rather than the object itself. Usually the reduplicated objects are parallel, and, if more than two, regularly spaced.

Apparent persistence of objects even briefly regarded 'I began to see shapes in the lights. First it was the window-frames. I had an image of them wherever I looked.' 'One day I was watching my wife gardening, through the window in bright sunlight. Returning to my chair I saw her in a corner of the room, set in the window frame. I looked away, but she appeared wherever I looked. It lasted two or three minutes, fading away gradually.' Often the perseverating image appears immediately the object is withdrawn, though frequently it intensifies and becomes more clear-cut after a few seconds have passed. Occasionally visual images are seen again hours later. 'One Sunday morning I was watching a church service on television. I was watching the expressions on the faces of members of the congregation as the roving camera picked them out. In bed that night I saw them all again very clearly.'

'I watched the children skipping in the garden. I found the antics of the youngest, trying to imitate the others, very amusing. At night in bed I had a very vivid picture of the whole scene.'

Such recurrent visual impressions may bring forgotten details back to mind. 'Once I had an argument with a persistent salesman, the "foot in the door" type. I was very cross with him. Afterwards, when the wife returned from shopping, I told her all about it. When I saw it all again at night there was an incident about a nail brush I had forgotten.'

At times recurrent visual impression became superimposed upon real objects in a deceptive fashion. 'I saw people approaching me as entirely different persons—sometimes old friends I had not seen for years, and who could not possibly have been in the vicinity. They faded out as the real person approaches, and I find myself addressing a total stranger.'

Objects which had been fixated for long periods might persist for hours or days. 'One day I had to look into a black box through a small aperture (a tachistoscope). Inside was a small lighted screen on which figures and objects were flashed for me to identify. It meant hard concentration. I saw that screen for days afterwards.' Similarly the pattern on the curtains facing his hospital

bed remained visible to him for 24 hours after his discharge. Objects briefly fixated, even in dim illumination, might persist for seconds, and up to a few minutes. The phenomenon was not limited to the foveal area, but also occurred parafoveally on either side (though not in the area of the quadrant field defect). 'I was asked to look at a rotating disc. Afterwards I had the clear image of a bookcase in the corner of the room. I did not recall even looking at it.'

As the object was replaced by its persisting image, so would its colour change, usually into a roughly complementary hue, but predominantly into either mauve or brick red, depending on the wavelength of the original colour. This colour change sufficed to alert him to the unreality of the percept. Rarely he was deceived into acting on false information. 'One day I was called into the kitchen. I went through the "door", and hit the wall with a nasty smack. The real door was three feet away.' 'Once we were having tea. I put my cup and saucer back on the "table". The real table was side by side with the image. The cup and saucer fell to the floor.'

At times he has hit the wall when reaching for the image of a door knob. He has filled in the wrong spaces on forms, and particularly on crosswords, because the squares move as he moves his eyes.

On occasion he has also noticed after-sensations of movement. Rapidly moving objects may leave a trail 'like the tail of a shooting-star'.

The vivid imagery and enhanced brightness invade his dreams. 'I was being tracked by a woman with a rifle. She was a Hindu and was dressed in a brightly coloured sari and wore many flashing jewels. The mark in the centre of her forehead was a flashing star. When she got near enough to me the light from this star was blinding. When she pointed the rifle at me that flashed too.' All his dreams since the onset of his visual disorder have been characterized by bright light and vivid colours.

The visual disorder has now persisted for over a year. After losing some of its initial intensity it has become apparently permanent at a constant level of severity. Bright light remains incapacitating, but, unless brightly illuminated, objects no longer dissolve into whirling colours. He has observed that the overall intensity of his visual manifestations at any time depends largely on the intensity of the illumination that he has experienced in the immediately preceding hours. He has been much helped in making an adaptation to his condition by the use of dark (blue tinted) spectacles. He is now able to read and to watch television. The perseverating images fade quickly when he looks from object to object. He can see objects in all detail through the images of ones previously fixated. The images are most obvious against a homogeneous surface. At night recently seen objects reappear in bright colours, and may keep him from sleep for several hours.

He now finds it easy to visualize scenes, and events of the day often unroll themselves before him as a series of 'stills' the following night, although premorbidly he had not possessed an exceptionally powerful visual memory or eidetic imagery (or 'number form').

On examination A.A. was orientated and consistent in his responses. The pulse was regular and the

blood pressure 120/80 mm. Hg. Apart from a few rhonchi at the bases there was no abnormality referable to the lungs. There was a large thoracotomy scar consisting of a vertical incision over the sternum, with incisions along the sixth intercostal space on either side. The right popliteal, dorsalis pedis, and posterior tibial pulses could not be felt, and the right foot was colder than the left. He was right handed. On neurological examination a right superior homonymous quadrantic defect sparing the macula was found and confirmed by perimetry (Fig. 1). Acuity was 6/6 (corrected) and colour vision was normal. There was no inaccuracy of pointing anywhere within the functional visual fields, and no further defect was revealed by simultaneous stimulation. There was a residual right ulnar nerve lesion which he had sustained two years earlier, but no other focal abnormalities, both motor and sensory systems being otherwise entirely normal.

A.A. was tested on the Wechsler adult intelligence scale. His verbal I.Q. was 117, performance I.Q. 112, and full-scale I.Q. 116. On Hebb's picture anomaly test he scored 50 out of 68. These test results indicate a high average level of intelligence with no evidence of intellectual deterioration or of any specific impairment. In particular his language functions, constructional ability, and picture interpretation were normal. Perseveratory phenomena were not evident in his speech or thought or in any sensory modality other than the visual.

Investigations yielded a normal blood count and urine analysis as well as negative Wassermann and Kahn reactions in blood. Chest and skull radiographs were within normal limits, the pineal gland being calcified and central in position. The cervical spine radiograph revealed some anterior and posterior lippling of the fifth cervical vertebra, but no other abnormality. Electroencephalography yielded a normal record with prominent alpha activity at 10 c/s, blocking to eye opening. Overbreathing evoked no change. A symmetrical following response to photic stimulation from the parieto-occipital regions occurred at 12 and 16 c/s and was sustained at 6 and 24 c/s, and ended when stimulation stopped. On account of the precarious state of the vascular system, it was decided not to proceed to cerebral angiography.

Diagnosis It was thought on clinical grounds that this patient had sustained infarction within the left occipital lobe due to basilar artery ischaemia.

Treatment Amphetamine, barbiturates, and chlorpro-

FIG. 1. Visual fields of case 1 to 3/330 and 3/2000 white objects on 6 March 1963. Visual acuity was 6/6 in both eyes.

mazine (up to 200 mg. t.d.s.) failed to modify the visual manifestations. However, considerable symptomatic relief was derived from the use of dark (blue-tinted) spectacles. The decrease in total visual energy input reduced dazzle and glare and minimized the abnormal visual phenomena. The effect seems to some extent to be cumulative, in that it takes several hours for the visual phenomena to settle down after he puts the glasses on. When he leaves them off the metamorphopsia and perseverations gradually regain their previous intensity. He therefore avoids taking the spectacles off, except at night, after he has turned off the light.

CASE 2 S.D., aged 56, a lorry driver, was admitted with the complaint of visual disturbance following a head injury. There was no relevant family history, nor any previous disease of note.

Three months earlier he had been struck on the head by a garage door which had slipped off its rail and was rendered unconscious for two or three minutes. He could not remember the door dropping, nor any event until half an hour afterwards. The next day a right frontal laceration was treated by suture and skin graft. No abnormal neurological signs were reported.

Immediately after the accident he had headache and misty vision. This resolved in the next few days but he was left with a variety of positive visual manifestations.

He is continually troubled by the presence of floating coloured rings. These he can abolish by closing and rubbing his eyes but they return when he opens them again. He also has the frequent impression of a heat haze rising from the ground. He is highly susceptible to dazzle and glare, and on passing from a dark to a lighted place his vision is for a few minutes obscured by a 'shimmering mistiness'.

Objects he glances at in daily life may suddenly multiply, and the images may move. Sometimes whole rows of regularly spaced identically shaped images, always horizontally disposed, may appear in this way. Apparent movement and variable distortion of objects is common, and he cannot read a text because the letters appear jumbled and continually on the move. Objects even briefly inspected may leave an after-sensation, usually of initially identical contour, sometimes in 'orange light', sometimes in blue, lasting for seconds or minutes, and they often then turn black before they fragment into spots or blobs which seem to descend in the visual field and finally disappear. Alternatively the image, having turned black, may fragment into strands of a black 'cobweb' before it vanishes. When he stares at objects they become blurred, and undergo a colour change to orange or blue. The object may disappear altogether. If he then looks to one side, it reappears in parafoveal vision. A moving object may leave after-effects in the form of a series of 'stills' of that object in its track—again as a regularly spaced row. Recently experienced scenes may return to mind in vivid visual detail. An evening at skittles or the billiard table may be followed that night by innumerable visual impressions of falling skittles or rolling billiard balls. His powers of visualization are now considerable, but they are more vivid than accurate, as the nature of the images is only

partly under voluntary control. Before his head injury he was not an eidetic subject, nor did he possess a 'number form'.

S.D. was orientated and able to cooperate. He was normotensive, and on general examination the scar of the frontal skin graft was the only abnormality. He was right handed. Routine neurological examination was normal. Visual acuity was 6/9 on both sides, the visual fields were perimetrically normal, and there was no defect of colour vision. He pointed accurately to targets in either half-field and there was no visual inattention on simultaneous stimulation.

Comprehension of speech and expression, writing, and spelling were unimpaired. There was no constructional disability or impairment of picture interpretation. There was no opportunity for formal intellectual testing. Perseveratory phenomena were not evident in his speech or thought, nor in any sensory modality other than visual.

On investigation, a radiograph of the skull showed no abnormality. An electroencephalogram was within normal limits, with alpha rhythm at 11 to 12 c/s, blocking to eye opening. Photic stimulation evoked fundamental and occasional sub-harmonic responses, which ended as soon as stimulation was discontinued.

Diagnosis It was thought on clinical grounds that this patient had sustained contre-coup damage to the posterior part of the left hemisphere at the time of the blow on his right forehead.

EXPERIMENTAL SECTION

The studies reported below were aimed at determining the characteristics of the after-sensations experienced by the two patients following inspection of static, flickering, and moving visual stimuli. The work was based upon the clinical observation that though after-sensations could be elicited under circumstances which did not permit the formation of after-images in normal control subjects, there nevertheless appeared to be qualitative similarities between the after-sensations experienced by the patients in everyday life and ones which may be established in normals under special experimental conditions.

The salient features of visual after-images of static stimuli in normal subjects include the following:

An after-image is elicited when a sufficiently intense stimulus object is inspected for a sufficiently long period; the initial intensity of the after-image and its total duration are also dependent on these two variables. The after-image increases during the first few seconds after withdrawal of the stimulus, then gradually fades when projected on to a field of constant brightness. While fading it may pass through a series of colour changes ('flight of colours'). Intermittent illumination of the projection field, by blinking or waving a hand in front of the eyes (McDougall, 1904), or by the use of stroboscopic

illumination (Mooney, 1956), may prolong or revive the after-image. On a dark after-field the image is positive, corresponding to the original impression in brightness and colour. On a bright after-field it is negative, the light-dark relations being reversed, and the colours complementary to those of the original impression. After-images may be established in both central and peripheral vision, and several may be present at the same time. They show the effect of the 'size constancy' mechanisms in that they appear larger when projected against a distant field than against a near one (Emmert's law¹) or against the closed eyelids. When the eyes are moved, the after-images follow the direction of gaze; when the eyeball is passively displaced by pressure the resulting apparent displacement of the outside world is not shared by the after-image, which appears to move in the opposite direction. When the stimulus is viewed monocularly and the eye then closed, and the other opened ('dichopic viewing') the after-image remains in view.

PERSEVERATORY IMAGES These differed from normal after-images in an obvious way, in that they arose not only under conditions which normally give rise to the latter but were also continually reported under everyday conditions, when feebly illuminated objects, such as a pencil or a book lying on a table in daylight but not direct sunshine, were briefly viewed. Therefore if the perseveratory images were basically after-images, the threshold for formation of after-images must be greatly lowered in the pathological case. This was illustrated when A.A. was tested by tachistoscope. Black dot stimuli were presented against a light background to the light-adapted eye. (Details of the apparatus are given by Kinsbourne and Warrington, 1962.) It was found that as the stimulus duration was increased (between the limits of 2 and 1,600 msec.), so was the resulting perseverating image reported as of correspondingly longer duration (Table I). But even at

¹The linear size of an after-image varies approximately linearly with the distance from the observer of the surface on which it is projected.

TABLE I
TACHISTOSCOPIC PRESENTATION OF DOT
AND LETTER STIMULI

Exposure Time (msec.)	Stimuli	
	Dots	Letters
50	None	7, 10, 10, 2, 10
160	3, 2, 2, 2, 3	13, 10, 22, 7, 5
500	4, 4, 7, 6, 4	21, 5, 7, 5, 34
1,600	7, 6, 5, 6, 7	14, 18, 17, 8, 6

The duration in seconds of the after-image is recorded for each period of exposure duration.

threshold stimulus duration an image was formed, a finding which underlines the remarkable sensitivity of the mechanism responsible for the after-sensations in this patient. S.D. was not available for tachistoscopia.

The after-sensations came on immediately after withdrawal of the stimulus, reaching a maximum of intensity and clarity within a few seconds. The image remained vivid for a variable period depending on stimulus intensity and duration, but at all times for longer than in normal controls. When it finally faded, it would often do so by gradually expanding and merging into the surround in A.A. or by fragmentation in S.D. Interrupted illumination (by blinking, hand waving, or stroboscopic light) prolonged the images, and revived ones that had faded. On a dark ground, the images retained their original colour and brightness for a while. On a light ground they appeared dark, and the colour would often change into the complementary, or an approximation to it, though A.A. showed a strong tendency to see images as either mauve, where the original colour was of long wavelength, or brick red or orange, where it was of short wavelength. S.D. often reported a further colour change from the complementary to black. Flight of colours was not reported by either subject. Halos of complementary colour were reported as surrounding coloured test objects on a white ground. When the object was removed the after-sensation was of the same colour as the halo. Size of the image increased with distance in accordance with Emmert's law. The perseverating images followed the direction of gaze, and appeared to move in a direction opposite to that of the outside world during passive displacement of the eyeball. Multiple images were easily established by presenting a number of test objects simultaneously or successively at different points within the visual field, and after-sensations were as readily elicited in peripheral as in central vision. They remained visible on 'dichopic viewing'.

It is evident that in the experimental situations the perseveratory image behaved in a reasonably regular and predictable manner, and in many essentials conformed to the laws that govern the behaviour of visual after-images in normal subjects. The difference between the perseveratory and the physiological image, largely quantitative, could be roughly measured by noting the duration of the after-sensation in the subject and in controls under controlled conditions of visual stimulation. The results support the hypothesis that the perseverating images were after-images pathologically enhanced, and also serve as objective confirmation of the accuracy of the patients as witnesses.

The results with static visual stimuli suggested

further experiments with flickering and moving stimuli.

AFTER-SENSATIONS OF FLICKER AND MOVEMENT A flickering light source may give rise to a static after-image. It does not normally produce an after-sensation of flicker. On the other hand, both real and apparent movement may give rise to after-effects of movement, as exemplified by the waterfall illusion and Plateau's spiral respectively. Prolonged fixation is needed to produce these effects in normal subjects.

The following results were obtained with A.A. and S.D.

Flicker After briefly inspecting a flickering light source, and then a homogeneous surface, both patients experienced a continued sensation of flicker lasting a few seconds. This was then replaced by a static image, which faded in the usual way. The frequency of flicker was not crucial, and it was temporarily maintained as an after-sensation. In the case of S.D., reduplication occurred, and several flickering points were seen at the same time. No normal control had a comparable experience.

Real movement The patients inspected a rotating drum. On looking away S.D. experienced a brief after-effect of movement in the same direction. A.A. did not.

A.A. inspected a spot of light travelling repeatedly across a cathode ray tube. After 10 to 20 sec. of inspection, he obtained an after-sensation of movement in the same direction when projecting his gaze on to a homogeneous surface.

When objects were manually moved in front of A.A.'s eyes he sometimes described them as leaving a trail. S.D., under similar conditions, reported a series of 'stills' of the stimulus object in a regular row following its track.

No normal control obtained an after-sensation of movement in any of the above situations.

Apparent movement The patients inspected a coil of brown wire, which in rotating around its horizontal axis, gave an impression of movement of its elements from left to right. A.A. obtained a brief after-effect of movement in the opposite direction. S.D. could not convince himself of the apparent movement and obtained no after-effect. Normal controls saw the apparent movement but not the after-effect.

Plateau's spiral When the figure was rotated, it gave an impression of expansion of the rings. On its sudden arrest, A.A. noted an initial further expansion, followed by a powerful and long-maintained contraction, outlasting that of the control by some 10 to 15 seconds. S.D. had a similarly marked negative after-effect, but did not observe any pre-

ceding positive after-effect. No normal controls reported a positive after-effect.

These studies have shown that the enhanced after-images of static visual stimuli are matched by enhanced after-sensations of moving stimuli. Flickering stimuli also aroused after-sensations of flicker, a finding without parallel among normal subjects. These results underline the general nature of the over-reaction of the visual apparatus in visual perseveration.

RESULTS OF FURTHER VISUAL TESTS

1 TACHISTOSCOPIC THRESHOLDS These were measured in A.A. as responses to dot stimuli in milliseconds.

Central	8
2° right of fixation point.....	16
2° left of fixation point	20
2° above and left of fixation point	8
2° above and right of fixation point	50
2° below and left of fixation point	25
2° below and right of fixation point....	16

All except 2° above and right are within normal limits. Each figure represents the median of five readings.

2 VISUAL REACTION TIME (A.A.) Visual choice reaction time (letter stimuli) was between 250 and 300 msec. This is within normal limits.

3 CRITICAL FLICKER FUSION THRESHOLD For A.A. it was 33/sec. and for S.D. 35/sec. For normal controls the thresholds were 32 to 40/sec.

4 DOT SUBITING AND SPAN OF APPREHENSION FOR LETTERS Irregularly arranged groups of dot stimuli varying in number from two to nine were presented at exposure times of 100 msec. A.A. was able to report correctly numbers up to seven (a normal result). Up to six letters presented simultaneously at exposure times of 40 msec. were correctly reported (upper extreme of normal).

5 SIMULTANEOUS FORM PERCEPTION (A.A.) Single and double letters were presented to both the left and right half-field of vision. There was no significant difference between the threshold (eight successive stimuli correct) for single and double stimuli (a normal result).

6 COMPLETION OF INCOMPLETE FORMS (A.A.) Using tachistoscopic presentation incomplete geometric forms were not completed (a normal result).

7 COMPLETION OF AFTER-IMAGES (A.A.) After-images

across the upper quadrantic field defect were not completed (cf. Bender and Teuber, 1946).

8 COLOUR WHEEL (A.A. AND S.D.) Rotation of the wheel led to intolerably bright sensations of various colours. Normal controls obtained the same effect, but the colours did not seem as vivid.

The results of tests 1 and 2 show that the tendency towards the formation of perseveratory images does not depend upon any impairment of form perception which demands prolonged inspection of stimulus objects. A series of further tests related to visual perception did not reveal any abnormality other than the enhancement and persistence of visual sensation already noted.

DISCUSSION

Many of the experiences described by A.A. and S.D. are matched by similar ones in previously reported cases. Impressions of flashing coloured lights (photopsia) and the apparent distortion of viewed objects (metamorphopsia) are well-recognized manifestations of posteriorly placed cerebral lesions, though not necessarily indicative of the localization (Weinberger and Grant, 1940). Apparent reduplication and multiplication of inspected objects (polyopia) first described by Mingazzini (1908), which also can arise at various levels in the visual system (Bekeny and Peter, 1961), have been reported in association with visual perseveration (Crichtley, 1954; Bekeny and Peter, 1961). Visual perseveration, comprising the persistence and recurrence of visual sensations, was briefly described by Robinson and Watt (1947) as an epileptic aura and was fully illustrated in a series of case reports by Crichtley (1951). Crichtley's case 6 and case 3 of Bekeny and Peter were, like the present cases, regarded as exhibiting a prolongation of after-images. Visual perseveration of moving objects was reported by Holmes (1931), by Robinson and Watt (1947), by Crichtley (1951), and by Le Beau *et al.* (1952). The impression of a visible trail marking the track of a moving object was remarked upon by the patient of Le Beau *et al.* while Castaigne and Graveleau (1953) and Teuber (1961) reported patients who perceived moving objects as a series of stills of that object occupying its track of movement. Pötzl's (1954) patient experienced recurrent visual impressions projected on to real objects, *e.g.*, a bald patch on to a bystander's head, an experience shared by both our patients. Again the perseverating images formed by Crichtley's (1954) case 9 were black, as were those of S.D. in most instances. On the other hand, positive after-sensations like those at times experienced by both our patients were a feature of

the case of Le Beau *et al.* (1952), who reported 'une persistance quasi photographique'. The apparent fragmentation of static objects on prolonged inspection (case A.A.) was described by Faust (1956) under the name *Gestaltzerfall*.

The cases mentioned were thought to have posteriorly placed cerebral lesions, but photopsia, metamorphopsia, and visual hallucinations have been reported also in association with extracerebral lesions, such as glaucoma (Souter, 1936), retinal haemorrhage (Ormond, 1925), enucleation of an eye (Uhthoff, 1899), and optic nerve and chiasm compression (Weinberger and Grant, 1940). Visual perseveration, on the other hand, has not been described as a consequence of extracerebral disease, and this makes it of special interest for the study of cerebral function.

The variety and complexity of the positive phenomena of visual disorder favour the anecdotal account but make it difficult to carry the matter to the stage of controlled observation and experimentation. As Critchley (1953) has remarked, the observer has had to rely on the patient, lacking the means for subjecting the observations to any objective test. In the search for some regularity that might throw light on the disorder of visual physiology involved, and at the same time yield a yardstick for the patient's reliability, the hypothesis was put forward that the perseverating images were enhanced visual after-images, differing quantitatively (in ease of elicitation and duration of persistence) from those which occur in normal subjects. It was possible to test this hypothesis because, unlike in previously reported patients in whom visual perseverations have been met with 'as an intermittent, paroxysmal, or episodic event' (Critchley 1951), the present cases showed the phenomenon as static, permanent, and readily elicited on clinical testing, having by now lasted, in the case of A.A., for the unprecedented period of 18 months.

A series of test procedures served to show that in essentials the perseverating images in both patients behaved like after-images as they occur in normal subjects. They differed quantitatively rather than qualitatively, in that the process of forming after-images was enhanced. The after-image in the pathological case was more readily evoked, seemed more intense, and persisted longer than is normal. Being quantitative, the differences were amenable to measurement. This result provided a physiological analogy for the abnormal process of visual perseveration, confirmed the patients' objectivity as observers, in that, as 'naïve' subjects, they could not have prejudged their responses, and incidentally provided a further illustration of the importance of central factors in the formation of visual after-

images (Oswald, 1957). Further investigation revealed perseveration also of flicker and of real and apparent movement. It becomes apparent that after-sensations of all kinds are enhanced in this condition, suggesting a quite general over-reactivity of the neural system involved.

The present findings do not reveal the nature of the neural changes that underlie this over-reactivity, nor their distribution within the posterior part of the cerebral hemispheres, although there is some evidence of involvement of the left occipital lobe in both cases. But certain possibilities arise when the present findings are related to experiences with positive visual phenomena experimentally induced.

Electrical stimulation of the occipital lobe may cause photopsia (Foerster, 1931) and of the temporo-occipital borderland metamorphopsia and visual hallucinations (Foerster, 1931; Mullan and Penfield, 1959). Perseverating images have not been reported but may not have been looked for. More relevant to the present work are experiences with perceptual isolation and with the administration of mescaline and lysergic acid diethylamine (L.S.D.).

When normal subjects are maintained for hours or days under conditions of unpatterned (Bexton, Heron, and Scott, 1954) or random (Freedman, 1961) visual stimulation there may develop a sequence of positive visual phenomena, starting with photopsia and culminating in highly organized visual hallucinations. Phenomena comparable to those spontaneously experienced by the patients can in this way be induced in normal people, and testing immediately after release from isolation reveals metamorphopsia, impressions of movement, perceptual lag, halos of subjective colours, and, most relevant of all, enhanced after-images and after-sensations of movement (Heron, Doane, and Scott, 1956; Doane, Mahatoo, Heron, and Scott, 1959). Very similar is the reported effect of the administration of mescaline (Beringer, 1927; Klüver, 1928) and lysergic acid diethylamine (Stoll, 1947). Here again a sequence of spontaneous visual manifestations increasing in complexity is associated with an altered response to certain test situations, and halos of subjective colours, polyopia, perceptual lag, the dissection of movement into a series of stills, and, in particular, enhanced after-imagery, have all been described.

It is evident that positive visual manifestations similar to those experienced by the patients can be induced by giving mescaline or L.S.D., or by depriving the visual system of classifiable (patterned) visual stimulation. As the mechanism of action of these drugs and of perceptual isolation is itself unknown, this similarity does not lead to a definite explanation of visual perseveration in occipital lobe

disease. But it may be that in each case the cerebral neural system subserving vision has been released from some inhibitory controlling influence. Inhibition of some of the total sensory input ('selective attention') is a normal and necessary feature of perceptual processes (Dawson, 1958). Release from this inhibition, by direct damage to neural connexions, by drug stimulation, and by depriving the attention mechanism of a patterned and meaningful sensory input to act on, may be responsible for the positive visual phenomena in each instance. While with the drugs and during perceptual isolation such release of inhibition also affects sensory modalities other than the visual, in the patients it was limited to vision, presumably on account of the posterior localization of the pathological process within the cerebrum.

The patients' visual over-reactivity caused enhanced after-sensations of complex as well as of simple stimuli, and in this respect as well as in their increased powers of visualization, their vision resembled that described as eidetic, in which the subject 'revives earlier optical impressions with hallucinatory clearness' (Urbantschitsch, 1907). Eidetic images, which occur in some normal adults (Jaensch, 1930), and are particularly common in children (Kroh, 1922; Allport, 1924), may far exceed in wealth of detail not only normal but also perseveratory after-images. Nevertheless they resemble perseverating images in that they obey most of the laws of normal after-images but are more readily evoked and last longer. The cerebral lesion may therefore be regarded as having invested the patients' vision with some eidetic features, and this permits the further analogy between the pathologically induced over-reaction of the visual system, and the inborn eidetic one which in most cases disappears as the brain matures.

It may be concluded that visual perseveration as elicited in the present patients is not a phenomenon *sui generis*, but represents a pathological enhancement of normal physiological processes relating to visual after-sensations and shows similar regularities even in its abnormal setting. This finding makes it possible to check the patients' reports against objective criteria, and at the same time relates these bizarre phenomena to the main body of knowledge of perceptual processes.

SUMMARY

Two cases are reported of patients with positive visual symptoms referable to cerebral hemisphere lesions. The symptoms included a striking, con-

tinual and easily demonstrable persistence of visual sensation after withdrawal of the stimulus (visual perseveration). This was experimentally shown to represent an enhancement of the normal process of visual after-image formation, characterized by much of the regularity that attends that process in a normal subject. Enhanced after-sensations to flicker and real and apparent movement were also demonstrated. The possibility is discussed that this represents a pathological overactivity of the cerebral neural system subserving visual perception, perhaps due to its release from inhibitory influences.

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