SYNOPSIS A bright pocket flashlight was directed into one eye for 10 seconds; the subject then closed the eyelids and reported the sequence of after-image colours observed. Lesions of the visual system which compromised bilateral central colour vision also reduced or abolished the 'flight of colours'. This simple bedside test of each eye independently is of value in detecting mild defects of central vision.

METHODS

Patients with lesions at different levels of the visual system and normal subjects were studied for the appearance of a 'flight of colours' after an intense light stimulus to each eye. The subject was placed in a dimly lit room for five minutes before the light stimulus. A pocket flashlight with a 2.5 V Welch-Alen bulb was aimed directly into one eye at 1 in. (2.2 cm) distance for 10 seconds. The other eye was covered by the subject's or the examiner's hand, taking care that no pressure was applied to the globe. When the flashlight was shut off, the subject closed the eyes and described what was seen. The verbatim replies and the time were recorded in long-hand or on a tape recorder. After repeated trials on a number of patients it was apparent that reports of after-images were reliable only for the first three minutes after light exposure. If tests were continued, the persistence of the after-images, even slight and of short duration, would interfere with the test. Therefore, it was necessary to wait at least 10 minutes for resumption of the trials. The other eye was tested in similar manner after a 10 minute interval. Many subjects were tested repeatedly either on the same or on different days. Although the right eye was usually tested first, on repeated trials the order of stimulation was reversed.

To employ the flight of colours, the examiner should practise and determine the range of responses in at least 10 or 20 normal subjects or patients without lesions of the visual system or cerebrum before evaluating the flight in a new patient. Although we performed all testing after a period of dark adaptation, this is probably not essential. So long as the examiner performs the stimulation to each eye in similar manner, the criterion of asymmetry of response is usually reliable. The test should be repeated

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more than once in each eye. The response to the first light exposure may be misleading and should not be considered as significant but only the second and subsequent trials are reliable. All patients also had a complete neurological history, examination, and laboratory tests which often included neuroradiological examinations. The patient's visual complaints included: 'blurring', 'double vision', 'I see the doughnut but not the hole', 'blackness to the left', 'the left side of the face looks large and twisted'. In addition to conventional perimetry, the visual fields were examined by confrontation tests with large and small coloured targets presented singly or by double simultaneous exposure. The visual fields were tested for dynamic changes such as reduced visual adaptation time and extinction of one of a pair of targets. Ophthalmoscopic examination included a description of the optic disc, retina, and macula. Provocative tests such as the 'hot bath test' were employed in selected cases to determine whether there were subtle defects in central vision. The ability to discriminate colours was tested by American Optical Pseudoisochromatic plates and by the matching of wool skeins. (Silverman, et al., 1961)

After testing 100 normal subjects and 100 patients with defective fields of vision for 'flight of colours', attempts were made at quantitative analysis tabulating such criteria as: (1) the number of colour changes, (2) the duration and intensity of each colour phase as well as the rate of change, and (3) the total duration of after-images in time. No single criterion adequately characterized the response nor was a quantitative combination of ratings of components of the response practical. Thus we categorized responses qualitatively as 'good', 'fair', 'poor', or 'absent'. A response was classified as 'good' when it consisted of: (1) many colour changes including red, orange, yellow, blue, purple or prominent colours, (2) rapidly changing colours, (3) a duration of colour changes for at least two minutes. A 'fair' response consisted of fewer colour changes of less prominent colours over a shorter time. A 'poor' response was one with only one or two colour changes of weak colours for less than 30 seconds. When no coloured after-images except grey or pale yellow were visualized, the response was 'absent'. Sometimes a colourless light, either black, white, or grey, persisted for a short time or appeared and reappeared. These categories were relative and based on our experience with the spectrum of responses so that the classification of 'good' versus 'fair', for instance, was often arbitrary. It was only after testing many patients and witnessing the spectrum of possible responses that subdivision of the spectrum was attempted.

RESULTS

NORMAL POPULATION One hundred normal subjects of from 15 to 70 years of age were tested. Most of the younger subjects had a good flight of vivid colours. In those over 50 years of age the flight was 'fair', although some of them were rated as 'good'. The responses from illumination of the left and right eyes were similar in each of the subjects tested. In later ages some deviations from the normal may be found because of changes in ocular media or arteriosclerotic changes in the retinal or ophthalmic vessels or senile degeneration in the macula.

CONGENITAL COLOUR BLINDNESS Seventeen subjects with congenital bilateral colour blindness but with normal fields of vision had absent flight of colours. After the flashlight beam exposure there were changes of visual impressions but they were not in conventional colour categories. They saw yellow or grey but not blue, green, or red colours in the after-images.

PATIENTS WITH LESIONS OF VISUAL SYSTEM The cases studied in this group were subdivided into those with lesions at different levels such as that of the retina, optic nerve, optic tract, optic radiation, and occipital lobes. Only one or two case descriptions are presented as examples, although we observed many cases in each of these subgroups.

1. Retina Twenty patients had lesions limited to the retina with implication of the fovea. These included: (1) five patients with degenerative changes of the macula, (2) two with chorioretinitis, (3) eight with vascular occlusions, (4) three cases of detachment of the retina, and (5) two injuries or fluid collections of the retina. In all of these patients the flight of colours during visual after-images was markedly reduced, 'poor' or 'absent' in the eye which had any type of lesion involving the macula and/or its immediate surrounding. All of these patients had impaired central vision and relative scotomas.

Case 1 This 64 year old woman had blurred vision in the left eye from a retinal haemorrhage which occurred five years previously. At the time of examination there was a recurrence of blurred vision in the left eye. There was a sensation of a 'veil' over
this eye ‘first on the side and then toward the centre’. The eye examination disclosed that the retina had a grey, blurred, and torn appearance. There was a collection of fluid in the superior portions, and the macula appeared discoloured. The visual acuity was reduced to 20/100 and there was a central scotoma for colour and a defect for the perception of 3 mm red matches in the inferior nasal and to a slight extent the superior temporal quadrant. The visual fields in the right eye were normal. The left pupil responded sluggishly; the right responded briskly. The flight of colours in the visual after-image elicited from the left eye consisted of only a few changes of ‘dull murky’ colours lasting only 15 seconds; this was classified as a ‘poor’ response. The flight of colours elicited from the right eye was bright, changed every 10 to 15 seconds from yellow, orange, red, purple, blue, green, etc., continuing for 2½ minutes.

In other conditions which may affect the retina in a diffuse manner but without involving the macula or leading to impairment of central or colour vision such as papilloedema or hypertensive retinopathy, the flight of colours was ‘fair’ to ‘good’. In one patient with partial involvement of the macula and preservation of a portion of the central visual field the flight appeared in the intact functioning central field. In four cases of serous retinitis with macular oedema or macular degeneration and impaired central vision, there was impairment of flight of colours in the after-image.

2. Optic nerve In 22 patients with lesions limited to the optic nerve, at the papilla or retrobulbar region, central or caecocentral scotomas were usually present and colour vision was impaired. In these cases the flight of colours was either ‘fair’, ‘poor’, or ‘absent’, depending on the degree of impairment of colour and form vision and the time of examination.

Case 2 This 23 year old man awakened with a pain in the right eye and could not see in the centre of his visual field, although the periphery was clear. He stated, ‘I see the doughnut but not the hole’. On examination there was a central scotoma in OD for a 5° red target which extended temporally. The acuity in the right eye was 20/70; 20/30 in the left. The fundi, optic discs, and pupillary reactions were normal. When immersed in the hot bath with his body temperature raised to 38.9°C (102°F) there appeared a large relative central scotoma in the right eye. This was prominent and he could ‘hardly see’ except in the periphery of the field. At this time, he was unable to perceive finger motion in the central field in front of the examiner’s nose which served as the fixation point. The left field of vision was normal.

In lesions of the optic nerve, the characteristic visual field defect is a central or caecocentral scotoma. When the scotoma is relative or partial, a rise of the body temperature will make it absolute. This and the absence of visual after-images and of flight of colours after light stimulation for 10 seconds are characteristic of an optic or retrobulbar optic neuritis.

Patients with optic atrophy and a dense central scotoma at the time of testing had ‘poor’ to ‘absent’ flight of colours. In patients with a history of long-standing demyelinating disease and a past history of optic nerve involvement, even though the field of vision and fundi (optic disc) might appear normal, the flight of colours was often defective or ‘fair’ in the eye previously affected. In such instances, the provocation by a hot bath test (Nelson and McDowell, 1959; Watson, 1959) often elicited a relative or absolute central scotoma in the same eye.

Defective visual after-imagery with ‘poor’ or ‘absent’ flight of colours in an eye was often associated with the provocation of a central scotoma upon hot bath testing. A 51 year old patient with a history of blurred vision in the right eye at the age of 44 years showed normal optic nerves and normal flight of colours on admission to the hospital. However, with the hot bath, central vision and flight of colours became impaired for a few hours.

3. Chiasm and/or the optic tract Fourteen patients had chiasmal syndromes due to neoplasm or aneurysm in the region of the sella turcica and characterized by defects in both temporal fields of vision. In addition, these patients had absolute or relative central scotomas in one or both eyes, attributed to compression of the optic nerve. On specific questioning these patients had defective ‘fair’ or ‘poor’ flight of colours and after-images only in the eye with a relative scotoma and ‘absent’ in absolute central scotoma.

Case 3 This 36 year old woman complained of
seeing double while reading. On the following day she saw only shadow and light areas with the right eye. One month later, after drinking three glasses of Scotch whisky, there was a total loss of vision in the right eye for a few hours. When tested, she could see only large 6 in. (15 cm) red targets in the nasal field of the right eye, and there was a central scotoma in this eye; there were mild defects in the temporal portion of the visual field of the left eye (Fig. 1). The visual acuity was 20/70 in the right eye. The right optic disc was pale. The left optic papilla was of normal appearance. On tests for visual after-imagery with the flashlight method, the flight of colour was 'poor' in the right and 'fair' in the left eye.

The radiographs and angiography of the skull disclosed an intrasellar mass which had destroyed the greater portion of the sella turcica, mostly on the right side.

In this patient with a lesion of the right side of the optic chiasm, there was a large central scotoma and 'poor' flight of colours in the right eye. The left eye which had only a slight field defect with no involvement of the central field showed a 'fair' flight. These findings suggested a greater compression of the right optic nerve.

Patients with lesions in the region of the chiasm showed evidence of involvement of rostral (optic nerve) and caudal structures such as the optic tract. In some cases the features of optic tract lesions preceded the chiasmal syndrome, so that the two anatomical sites were often involved simultaneously. Later, during the progression of the illness, optic nerves become implicated. It was unusual to find a pure chiasmal lesion. Most often there was additional optic nerve and less often optic tract implication. We had no cases of pure optic tract involvement.

Case 4 This 58 year old woman noted that her vision was not clear for a few months. Even after a refraction for new glasses she was unable to see clearly. The right half of the image was clear but not the left. In reading print she was unable to see the first letter of the words; some of the letters were quite clear and black while those to the left were 'faded'. She claimed that the disturbance of vision was getting progressively worse. With the eyes closed, at times she noted colours moving from the centre of the field to the left. When examined neurologically, there was a left homonymous hemiachromatopsia for perception of large 6 in. (15 cm) coloured targets, while visual perception of movement in these half fields was preserved for 80° from the fixation point. There was a tendency for the hemiachromatopsia to be more prominent in the left homonymous superior quadrants. No distinct scotoma could be plotted in the central or quadrant fields. However, when tested for visual after-images 12 days later, the flight of colours was absent in the right eye and

![Tangent screen examination with involvement of the optic chiasm and right optic nerve. There were bitemporal visual field defects and severe restriction of the visual field in O.D. which showed a central scotoma. Flashlight stimulation for 10 seconds in each eye revealed after-imagery with 'poor' flight of colours in O.D. and 'fair' in O.S. Black area: no perception of hand motion. Small dots: no perception of 6 in. red. Large dots: no perception of 10° white.](image_url)
encephalography disclosed left homonymous distinct. When re-examined side.

The rants.

Plate chromatic mass in 10 weeks. Colours was pseudoisochromatic plates.

optic chiasma, was a lesion. Black area: no perception of finger motion. × No perception of red. Large dots: perception of finger motion but not white.

'good' in the left eye. Angiography and pneumoencephalography disclosed an avascular suprasellar mass in the midline and extending more to the right side. When re-examined two weeks later, she had distinct left homonymous scotomas implicating the superior and inferior quadrants near the fixation point and extending outward about 5 to 10°. They were more in the superior than in the inferior quadrants. The flight of colours during visual after-imagery was still absent in the right and 'fair' in the left eye. When reexamined five days later, she had a left homonymous defect and a right superior quadrant peripheral field defect; there was also a temporal field for colour in the left eye and now a central scotoma in the right eye (Fig. 2). Thus there was a combined lesion implicating the optic tract, optic chiasma, and right optic nerve. The flight of colours was absent in the right and became 'poor' in the left eye. She could not see the pseudoisochromatic plates with the right and made errors with the left eye.

Radiotherapy to the sellar region was instituted and after six months of treatment there was a remarkable improvement in her vision; the gross fields of vision were normal for perception of movement and large-sized colour targets. She made a few errors on the pseudoisochromatic plates which were inconsistent in the right eye. Six months thereafter, she still had no symptoms and she was able to see all the pseudoisochromatic plates. At this time the flight of colours was 'fair' in each eye.

What presented itself initially as a homonymous hemianopia, and thus was seemingly due to a geniculocalcarine lesion, was actually an optic tract lesion. As the tumour enlarged, central, and thus colour, vision became impaired. Preceding the impairment of colour vision was the impaired or 'poor' flight of colours. The impairment of flight of colours in one eye was an early sign of involvement of central vision due to compression of the optic nerve. Conversely, later in the course, as the visual status improved, the 'flight of colours' returned. Hence 'flight of colours' may be used as a sign of preservation of central colour vision.

4. Lesions of parietal or temporal lobes affecting optic radiation Fifty-four patients with lesions at different levels of the geniculocalcarine pathways were examined. The homonymous field defects varied in extent, degree of visual deficit including perception of motion, and colour.

Case 5 A 17 year old girl had headaches, double vision, papilloedema, and a sixth nerve palsy in August 1966. The fields of vision, fundi, and pupillary reactions were intact. A left parietal ependymoma was partially removed at surgery. In February 1967, she had an episode of seizure activity with
auditory and visual hallucinations. After gazing at certain objects such as a foot or a face or small letters on television, she continued to see a part of the object (a toe, an eye, a phrase) which projected as high as 6 feet (2 m) on the wall. This palinoptic image moved wherever the eyes moved. Initially, the fields of vision were intact but subsequently showed a right homonymous hemianchromatopsia. The flight of colours was 'good' with each eye, despite the colour defects in the right homonymous half fields with implication of the half macula with small 1 mm green target.

All patients with lesions limited to the parietal or temporal lobes or unilateral occipital lobe had 'fair' to 'good' flights of colour. There were no differences if the patient happened to have a macular splitting homonymous hemianopsia or other types of homonymous field defects. Macular splitting homonymous hemichromatopsia did not alter the flight of colours. Patients with diffuse processes affecting many regions of the brain with or without papilloedema usually had 'fair' to 'good' flights.

5. Occipital lobes Patients with extensive lesions affecting one or both occipital lobes and dense homonymous hemianopsias but with preservation of central vision had 'good' or 'fair' flight of colours. Some patients tended to localize the after-image with changing colours to the intact field and saw only half of the after-image. This was rare, because most patients with unilateral homonymous macular splitting hemianopsias saw the colours changing diffusely throughout both sides of the field. In cases of bilateral posterior calcarine lesions with bilateral central scotomas for colour the patient could not perceive small colour targets. Tests for light after imagery revealed loss of flight of colour in these patients.

Case 6 An 18 year old boy had difficulty with vision to his left side for six months. On examination there was a dense left homonymous hemianopsia for motion and colour. Macular vision was split for colour. Despite this, tests for light after-imagery revealed normal flight of colours in both eyes. Angiography demonstrated an infiltrating vascular mass in the right occipital lobe. At operation a glioblastoma was found and partially removed from the occipital lobe. Postoperatively, the fields of vision were the same and the flight of colours were 'good' in each eye.

When central vision was spared in hemianopsias due to cerebral lesion, the flight of colour was preserved even when the hemianopsia was bilateral as illustrated by the next case.

Case 7 This 54 year old man had sudden onset of bilateral hemianopsia in 1958. On initial examination and repeat 10 years later, the fields of vision showed double hemianopsia with preserved central vision to 10° as plotted in Fig. 3. Colour vision was normal within 5° from the fixation point. As the

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**FIG. 3. Case 7.** Tangent screen examination of patient with double hemianopsia but preserved central vision showing 'funnel vision'. Repeated tests for visual after-imagery with flashlight in each eye disclosed the presence of normal flight of colours. No perception of hand motion.
target moved farther from the patient the degree of the field subtended was unchanged but the absolute diameter increased. In tests for visual after-imagery on flashlight stimulation, the flight of colours was good in each eye.

When visual perception of small coloured targets was severely impaireed in patients with double hemianopsias there was no flight of colours. This is illustrated in the next case.

Case 8 A 71 year old man, while under treatment for a ‘heart attack’, developed sudden inability to see, preceded by a sensation of weakness in both hands. Examination disclosed bilateral homonymous hemianopsia with preservation of central vision for motion but not for colour. The preserved homonymous central fields revealed perception of movement 3° to the right and 5° to the left of the fixation point. Stimulation with a flashlight exposed for 10 seconds in either eye evoked light after-images but there was no flight of colours.

The critical defect which interfered with flight of colours in patients with double hemianopsias of cerebral origin was loss of central vision, whether for perception of colour or of motion. Loss of colour vision in one half of central vision did not abolish flight of colour. The next case illustrates how a lesion of both occipital lobes with loss of central vision but bilaterally preserved peripheral colour fields still caused a loss of the after-image and flight of colours on strong light stimulation.

Case 9 This 32 year old marine, with shrapnel wounds of the posterior skull, had bilateral calcarine pole lesions which produced bilateral loss of vision with preserved pupillary light reflexes. There was gradual improvement in the peripheral portions of the fields of vision but central vision was permanently lost. There were bilateral central scotomas (Bender and Furlow, 1945). In the fields surrounding the scotomas he perceived motion and some large colour targets. There was no flight of colours in either eye.

DISCUSSION

The ‘flight of colours’ during visual after-imagery is a reflection of the function of the entire visual system as a unit. It also depends upon the brain function necessary for perception. Thus, a light stimulus impinging upon the retina, which excites retinal elements, induces a cycle of events transmitted through the optic nerve, chiasm, tract, lateral geniculate body, optic radiation, and calcarine cortex to register as a light. There is also an after-sensation or a visual after-image. This visual after-image can be detected by different methods depending on the strength of the light stimulus, as well as the pattern and size and colour of the stimulus object (Bender and Kahn, 1949). With simple flashlight stimulation for 10 seconds and closing the eyes, the visual after-image appears as a series of colours, usually yellow, blue, red, and combinations. These colours probably represent retinal cone elements which after excitation appear to react individually at different rates and thus cause the visual sensation of flight of colours. When these elements act in unison the colour is white. As to why these retinal elements and photic products react at different periods and in cycles lasting many seconds, we are not competent to discuss. It is essential that colour perception be within the repertoire of the individual. Thus, subjects with congenital ‘colour blindness’ had no colour in the after-image as we conventionally consider it—that is, there was no flight of colours other than sequences of grey or dull yellow. Similarly, destruction of macular vision on both sides of the midline, by a lesion anywhere along the visual projection system eliminated the ‘flight of colours’. For a given size target, colours are perceived with greatest clarity in the central visual field. One millimetre red or green may be seen within 30° to 40°, while large targets (5 cm) may be detected at 90° from the fixation point. In patients with lesions of the occipital poles and bilateral impairment of central vision with preserved perception of motion, colour vision may be severely impaired and there is no flight of colour. On the other hand, in cases of double hemianopsias which resulted in so-called ‘funnel vision’ with preserved central vision for motion and intact colour perception, there were vigorous flights of colours in the central after-image. When lesions of the retina implicated the macula to the extent that central vision was severely impaired, useful colour vision became lost and the flight of colours was absent. If the macula were only partially involved, the flight might still appear in the uninvolved central region. In cases of hemianopsia or hemiachromatopsia, the visual after-image of a large pattern, such as an American
flag or geometrical figure, in the affected field, will be missing, but the remaining normal visual field, including central colour vision, and flight of colours are preserved.

From the foregoing considerations, there is a high correlation between the presence of central colour vision on both sides of the midline in one eye and the presence of ‘flight of colours’. Conversely, when any portion of the visual pathway mediating central vision is defective on both sides of the midline, the flight is feeble or absent. This phenomenon may have value in patients with suspected disease of the macula, optic nerve (retrobulbar or prechiasmal location), or bilateral occipital lobes. Even if there is no apparent defect in the fields of vision on standard testing, there may be an asymmetry in the flight of colour response. This should arouse the suspicion of early involvement of central vision in the affected eye. In conclusion, this simple bedside test is a valuable method in detecting defects in bilateral macular vision.

REFERENCES


`Flight of colours' in lesions of the visual system

Martin Feldman, Leo Todman and Morris B. Bender

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