THE VISUAL FIELDS

A Study of the Applications of Quantitative Perimetry to the Anatomy and Pathology of the Visual Pathways

BY

BRODIE HUGHES

M.B., B.S. (LOND.), CH.M. (BIRM.), F.R.C.S. (ENG.)

Professor of Neurosurgery in the University of Birmingham. Surgeon-in-Charge, Department of Neurosurgery, United Birmingham Hospitals

BLACKWELL
SCIENTIFIC PUBLICATIONS
OXFORD

Published simultaneously in the United States of America by Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois.

Published simultaneously in Canada by the Ryerson Press, Queen Street West, Toronto, 2.

First printed December, 1954

Printed in Great Britain for BLACKWELL SCIENTIFIC PUBLICATIONS, LTD.
by A. R. MOWBRAY & CO. LIMITED, in the City of Oxford
and bound at the KEMP HALL BINDERY

PREFACE

This work is intended as a text-book in the old medical tradition, a statement of one man's views and experiences of a particular subject. Such books often went under the title of 'Mr. X's Practice of Surgery', etc., and this was an excellent description of the content, for Mr. X set out to describe his particular methods of surgery, not pretending that all of his methods were new or that the theories propounded therein were his own. In this book I have tried to set out my methods of examining the fields of vision and the experience gained from trying to correlate these with pathological anatomy in many thousands of cases. Much of the theory and anatomical detail has been derived from others, and due acknowledgment of this is given in the list of references at the end of each chapter. Wherever possible, however, all this has been checked from my own observations and where these are at variance with accepted theory this has been noted.

All the visual fields contained herein have been taken by myself, for I feel that examining a visual field is as personal a matter as any other form of clinical examination; if full benefit is to be obtained the tests must be carried out by oneself and not delegated to an assistant.

As in all personal works, the material set out is limited by my own experience. As a neurosurgeon, my experience has lain mostly in lesions affecting the intracranial visual pathways; these are dealt with at length whilst matters of primarily ophthalmological interest, diseases of the eye, etc., have often been given scant notice. Herein, I hope, lies much of the novelty of the work, for no comprehensive treatise on perimetry from the neurologist's viewpoint has yet appeared. I hope that this new treatment of an old subject will prove of interest to both parties.

My own interest in visual fields was initiated by reading Traquair's incomparable monograph on the subject, and all perimetrists must owe him a very great debt. In this he set out the principles of quantitative perimetry and that method has been adopted in all my work. The present work might, therefore, be described as a text-book of quantitative perimetry. The applications of this method to the neurologist's work have never been brought together before though numerous papers, and especially those delightful early papers by Walker and Cushing, have described its application to individual problems. My second major reason for writing this book was, therefore, to set out the results of applying quantitative perimetry to the many problems encountered in clinical neurological practice.

The book has been divided into three parts: methods of perimetry, the anatomical principles involved and, lastly, the types of visual field defect encountered in different pathological states, compression, vascular diseases, injury, etc. This has been, for me, the most interesting section, for I do not think that the influence of differing pathological processes in general on visual field defects has been sufficiently studied in the past. It is hoped that this section will enable the reader, when studying his patient's visual fields, to hazard a guess at the pathology involved as well as estimating its anatomical location.

The type of illustration needs, perhaps, a word of explanation. In each field isopters taken on the 330 mm. perimeter are represented by a continuous black line; those taken on a screen at 2,000 or 1,000 mm. by a broken line. Areas in which visual acuity was dim, misty, or greyed are shaded grey, the depth of the shading representing the degree of mistiness. In the case of a scotoma with isopters of its own this shading serves to emphasize the meaning of those isopters.

I am grateful to Mr. W. J. Pardoe for his careful drawings of two dissections of mine, and which appear as Figures 32 and 40. All the other illustrations have been carefully worked up from original sketches or visual field charts of my own by Mr. E. B. Brain. He has spent much time on them, and has spared no effort to make them accurate representations of the originals and at the same time easy to understand and attractive to the reader. I should like to acknowledge my indebtedness to him for all the trouble he has taken to produce these results.

References have been given where matters are controversial, or to points which I have been unable to verify for myself. I have not attempted to give a comprehensive list of references to the subject, this would occupy a book in itself. Where there are a number of papers on the same point reference has usually been given to a few of the most recent, for nearly all modern papers contain excellent reviews of previous literature. It will be noticed that all but a few of the papers are in the English language, in spite of the fact that a great wealth of literature on this subject has been produced from the German schools. This is due to the fact that I am but a poor German scholar, and I am reluctant to refer to papers which I cannot read fluently. Where important points have arisen I have verified the facts in translation and many of the papers cited give copious reference to the foreign literature which may be studied by those fortunate enough to be able to master foreign languages.

A number of visual fields in this work have already been published in various journals, all of them have been redrawn for this publication, but I am grateful to the Editors concerned for their permission to do this. Full details of the original source are given in the individual illustration legends. I am also grateful to Professor L. W. Chacko and the Editor of the *Journal of Neurology, Neurosurgery and Psychiatry* for permission to modify one of her drawings for Figure 31, and to Professor T. J. Putnam and the Editor of the

Archives of Neurology and Psychiatry to modify one of his illustrations for Figure 35. Drs. Posner and Schlossman and the Editor of the *Archives of Ophthalmology* have kindly allowed me to reproduce part of one of their illustrations as Figure 16. I am grateful to Dr. H. M. Traquair for permission to reproduce some of the central field studies on his scotoma charts, and to the publishers of these, Messrs. John Weiss & Son, Ltd., of London. All the other fields have been charted on the double charts designed by Dr. C. B. Walker, and published by the Los Angeles Optical Company. All attempts to get into touch with this company have failed so that I can only express my gratitude to them both for having produced a field chart so admirably suited to quantitative perimetry.

Dr. F. S. Barringer, of Springfield, originally suggested to me that I should write this book. He had worked with me in England and was impressed by the enormous amount of information that could be obtained from a study of the visual fields of our patients. He placed me in touch with Charles C Thomas who also proved to be enthusiastic and throughout the production has been of the greatest help; I must express, therefore, my very great gratitude both to him and to Payne E. L. Thomas for their help and encouragement.

It was decided later that publication might be undertaken much more easily in this country and Charles C Thomas arranged that Messrs. Blackwell Scientific Publications, of Oxford, should publish the work. In the subsequent work of publication Messrs. Blackwell Scientific Publications, and in particular Mr. Per Saugman, proved to be of the greatest help and encouragement to me.

Finally I should like to express my gratitude to Dr. J. W. Aldren Turner and Mr. Frederick Ridley. It was they who first introduced me to this part of neurology, and in the following years have constantly encouraged me to continue the study. They have both spent much time going through the manuscript and illustrations and have made innumerable valuable suggestions.

BRODIE HUGHES

BIRMINGHAM, 1953.

It is with great sorrow that I have just received news of the death of Dr. H. M. Traquair. It is impossible to estimate the debt owed to him by all clinicians who have occasion to test the fields of vision and by countless sick people who have benefited by the principles he laid down.

His book, *An Introduction to Clinical Perimetry*, in its several editions has been a constant guide and inspiration to me. In fact, most of the principles set out in this present volume have derived from the writings of Dr. Traquair.

I can only hope that *The Visual Fields* may serve as a very modest tribute to his personal teachings and writings.

BRODIE HUGHES

NOVEMBER, 1954.

CONTENTS

THE VISUAL FIELDS

CHAPTER 1

THE FIELD OF VISION

Introduction

Examination of the field of vision is used routinely in neurological examination. Few clinicians, however, even at the present time, realize the immense diagnostic possibilities of this single examination. Progress in this branch of examination has been hampered by a lack of understanding of the meaning of the tests applied, and their results. Although many writers have discussed the subject of quantitative perimetry this method is still used only infrequently, and the significance of the results of testing is but ill understood.

A careful examination of the visual fields by the quantitative method can give accurate information as to the anatomical location of a lesion in the visual pathways, and on many occasions can give a clue as to the pathological process by which the defect has been caused. This fact has not been widely stressed in the past, and it will be one purpose of the present work to emphasize this particular aspect of perimetry.

Quantitative perimetry has been the method chiefly used by the author, and the major accent in the present work will be on that method of field testing. Mention will have to be made, of course, of other forms of test: angio-scotometry, dark-adapted fields, the use of stationary and moving objects and so forth. Each has its own particular use and combined with the more usual methods each can give valuable additional information.

An individual with normal vision is aware of the fact that when he looks with one eye on some object directly in front of him the image he receives of the outside world is a limited one. It is limited by the anatomical structure of the eye, and also by certain anatomical features of his own head, such as the nose and supraorbital ridge. He can enlarge his field of vision by turning his head so that these projections are placed out of the way, but even then his field remains restricted by the area of his retina.

The range of this field of vision can be tested by simple methods. The individual himself can describe it by identifying objects he can see at the periphery of the field. Such subjective field testing is sometimes useful in clinical medicine; where there is a restriction in the extent of the field, or loss of a certain portion of it, the patient can often specify to the examiner where the loss is situated in the field. Professor Amsler has designed special charts for testing the central field in this way (Amsler, 1949).

The field can also be tested by simple methods, such as standing in front of the patient and moving an object (such as the examiner's hand, a white-headed pin or a piece of white paper), so finding out when the object appears or disappears from his field of vision. If the patient be asked to fix on the examiner's eye, and provided the test object is used at a distance half-way between the two eyes, then his field can be compared with that of the examiner.

Even with such simple methods two useful facts may be discovered about the visual field. *Firstly*, the field tested by a moving object will be found to be somewhat larger than that tested by the subjective method, i.e. a moving object is a stronger stimulus than a stationary one.

In testing patients with lesions of the calcarine cortex and of the higher visual centres (Areas 18 and 19 of Brodmann) it may be found that although subjective and confrontation tests show a full field a stationary object placed somewhere in the disordered field may be missed. This is especially so when a similar object is placed in a comparable position in the normal field. In one form of this test an object, say a pencil, is placed in the disordered field and easily seen, a similar object is then placed in a comparable position in the normal field, this is also seen, but at the same time that in the opposite field disappears (Bender et al., 1945). This phenomenon of *extinction* seems to depend on attention. Objects in the disordered field, whilst seen normally when attention is directed to them, tend not to be noticed when attention is not specifically paid to them, or when attention is directed to the normal half-field as well. This type of disturbance is termed an *attention defect*, and is associated with lesions of the higher visual centres. The distribution is, therefore, homonymous and it usually affects a quadrant or half-field. (*Attention quadrantanopia*, *attention hemianopia*).

The second fact is that with monocular vision the area of the blind spot is not apparent subjectively to the patient. If the patient has a scotoma, or area of total visual loss within his field, then he will be aware of this as a gap in his field. If he looks at a black line on a white ground in such a way that the scotoma lies in the centre of the line there will appear to be a gap in the line. If, however, he arranges his fixation so that his blind spot scotoma falls in the centre of the line, the line will still appear to him continuous, but shorter than before. The explanation of this phenomenon of *filling in* is still under discussion. The simplest and most probable explanation is that whilst the continuity of the retina is interrupted by the blind spot the continuity of the calcarine cortex is not; the blind spot, in fact, has no cortical representation and so is not 'seen'.

It will be understood from the above short description that subjective and crude objective field tests will give one an idea of the rough size of an individual's field of vision, and enable tests of attention to be carried out. It will be realized, however, that the field of vision is not an image with uniform properties. Vision at the centre is clear and acute, that at the periphery dull and lacking in appreciation of fine detail, and there is a gradation of acuity between these two in the intermediate field. Some method must be used, therefore, which will give a clear indication of the differing visual acuity over the whole field, for a disturbance of this gradient is often the first indication of field disturbance.

There are many tests which have been devised to achieve this object, but by far the simplest to perform and interpret is the method known as *quantitative perimetry*. In this method a series of stimuli are used to test the visual field, graduated in stimulus intensity so that while the smallest stimulus can only be seen at the centre of the field, the largest will be appreciated right out at the periphery. Stimuli are provided by round flat discs painted opaque white and graduated in millimetres. As a background a black faced perimeter arc or a flat black screen (Bjerrum screen) may be used. The stimulus is described in terms of the angle subtended at the retina, the tangent of that angle being given. The tangent is easily stated in terms of the test object size divided by the distance of the test object from the eye.

The technique of this method has one disadvantage; namely, the difficulty of obtaining readings at sufficient distance. Two metres is a convenient distance to use, for a 1 mm. object, whilst clearly seen in the central field, gives a reasonably small circle of vision, running out to 10°, 15° or 20° according to the intensity of illumination. Small visual angles and central regions of the field can, therefore, be conveniently tested on a Bjerrum screen used at this distance. The peripheral field, however, cannot be tested easily at this distance for the mechanical difficulties of making and using a perimeter of 2 m. radius are considerable. Most examiners, therefore, content themselves with testing small visual angles on the flat screen, and larger angles for the peripheral field on a perimeter of much smaller radius; 330 mm. is the standard distance for such an instrument. It will be seen that the use of a screen at 2 m. and perimeter at 330 mm. will give a series of tests which whilst covering all parts of the field with the graduated tests will not give comparable results in central and peripheral portions of the field. It is not uncommon to find, for instance, that a visual angle on the screen gives a smaller isopter than the same angle on the 330 mm. perimeter. (An isopter is the continuous line representing the peripheral extent of the visual field for a particular visual angle.)

The difficulties can be overcome, to some extent, by using a large perimeter of 1 m. radius and reducing the illumination to such an extent that a series of isopters covering the whole field can be charted on it. By this means a map of the visual field can be constructed in a short time, the isopter lines enclosing areas of comparable visual acuity, and the finished product bearing considerable resemblance to the contour map of a hill.

Such a method of testing will give considerable information about the state of the visual field in any area and our present concepts of disturbances in the fields are based on information obtained by this method. An example will suffice to indicate the valuable information obtained. In many cases of disease the peripheral visual field may appear to be contracted; that is to say, the isopter for the largest visual angle can only be seen somewhat nearer to the centre than normally. The descriptive term 'contraction of the visual field' was, and is, widely used. Testing by the quantitative method, however, shows that such a term might be applied loosely to at least three different types of field disturbance. In one type there is actual loss of all vision at the periphery of the field, the central field and central isopters remaining in their normal positions. Such field loss may occur in optic atrophy secondary to papilloedema, in tabetic optic atrophy, retinitis pigmentosa, and in hysterical states. In another type, the peripheral isopters are indrawn, but this is a result of a general lowering of acuity over the whole field, or a large portion of it. Testing by the quantitative method will show that all isopters are affected, and those at the centre usually more severely than those at the periphery. (This type of field loss has been aptly described by Traquair as the island of vision being lowered into the sea of darkness surrounding it.) Such a depression of the visual field may occur in many conditions, but particularly in pressure on the visual pathways from tumour, abscess, etc. In a third type the peripheral field may be affected by a similar, but localized, depression so that whilst peripheral isopters are widely affected those of the central field are unaltered. It will be seen, therefore, that even such a simple differentiation has enabled the perimetrist to break down peripheral contraction into three groups, each with its own pathological significance.

The dangers of using only one isopter in testing fields has been exemplified above. Another example may be cited. Consider the case of a local indentation of the peripheral field to a medium visual angle, say 2/330 (Fig. 1). Such an affection of a single isopter is often encountered in clinical neurology and termed a 'cut' or 'slant' in the field. Quantitative testing of such a field might reveal the defect to be one of three types. The local indentation might be merely part of a depression confined to that quadrant of the field (Fig. 2); it might be a true peripheral contraction (Fig. 3), or it might be found that by using a larger test object an isopter outside the 2/330 can be charted, the intervening field being lowered in acuity in the form of a relative or absolute scotoma (Fig. 4). Each particular type of field loss has its own pathological significance, whereas the indentation found with the single isopter tells one little about the field defect and has little pathological significance.

Illumination must have, of course, a considerable effect on the visual fields.

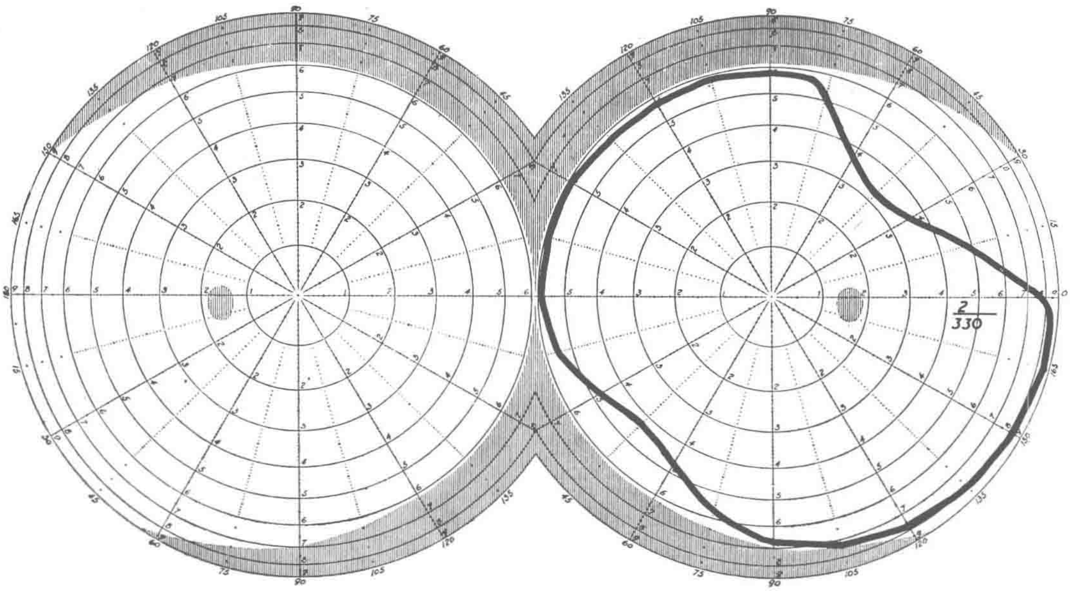

FIG. 1.—A single isopter for 2/330 showing local indentation in the upper temporal region.

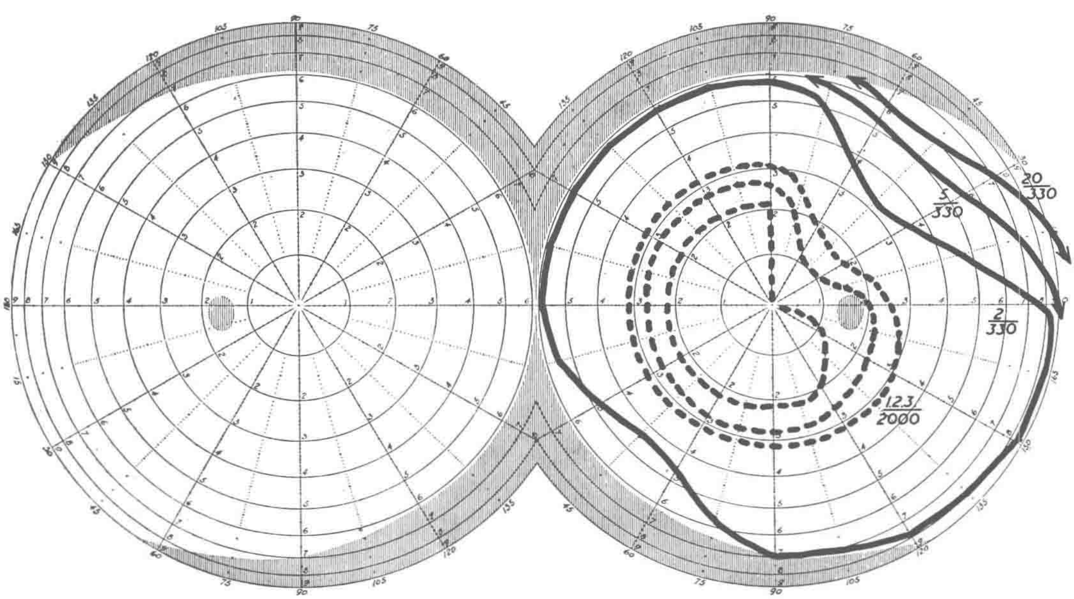

FIG. 2.—An elaboration of the single isopter field. In this case charting more isopters has shown that the local indentation of 2/330 was merely part of a depression affecting the upper temporal quadrant. The isopters for the smallest visual angles are affected most, those for the largest visual angles least.

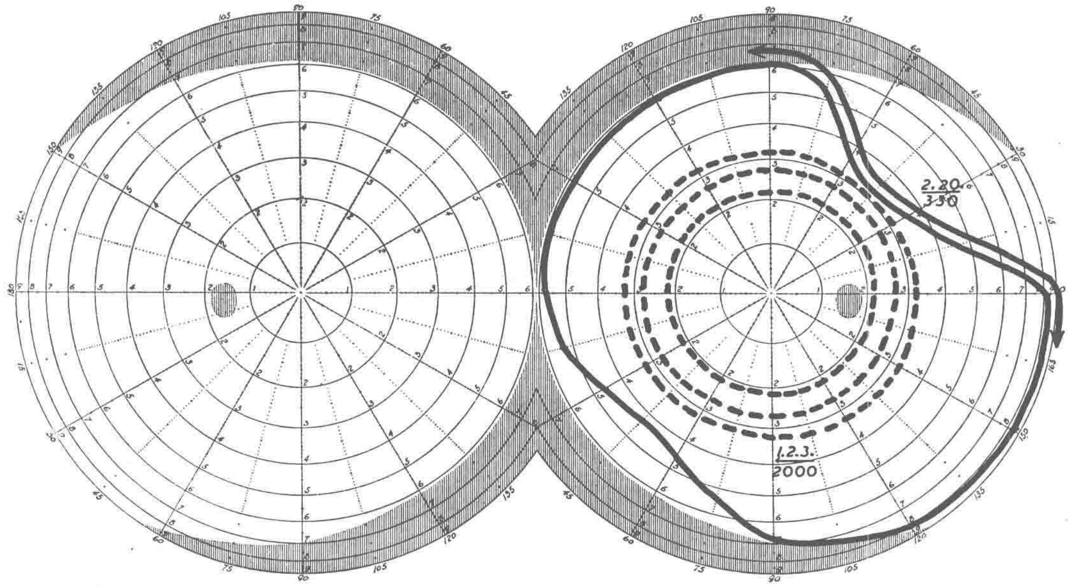

FIG. 3.—An elaboration of the single isopter field. In this case quantitative perimetry shows that the central field is normal. The local indentation of 2/330 is part of a true peripheral field loss, the 'coast erosion' field defect described by Traquair.

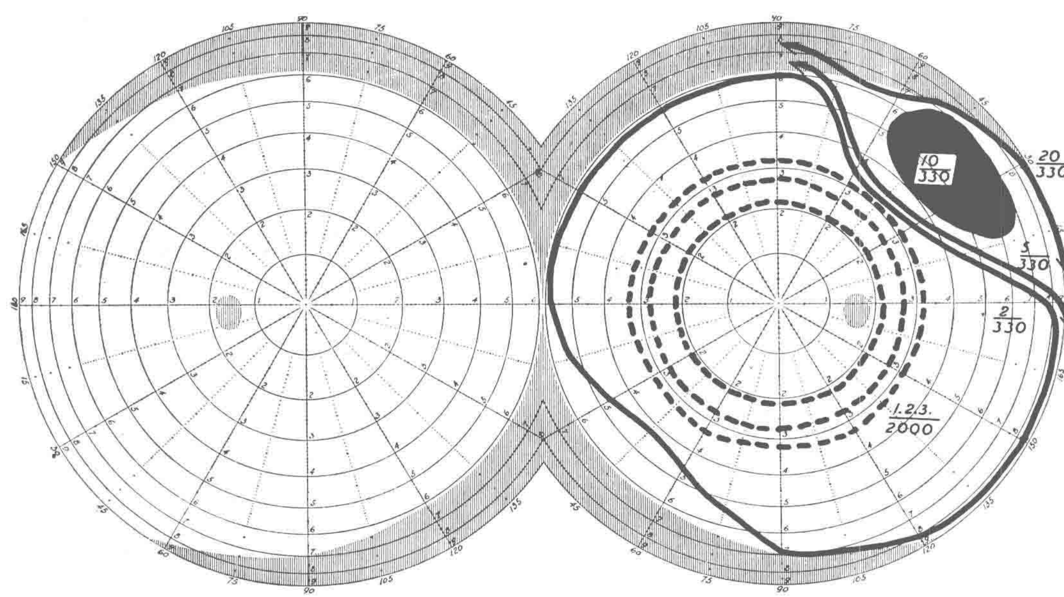

FIG. 4.—An elaboration of the single isopter field. In this instance the central field is shown to be normal by quantitative perimetry, and the local indentation of 2/330 is found to be due to a peripheral scotoma, the most peripheral isopter for 20/330 being in its normal position.

If the illumination is uneven, as in the normal landscape, then certain areas will be easier to see than others. Whether these areas lie in the central or peripheral field will depend on the combination of illumination and acuity in this region of the field. In field testing by the quantitative method this will appear as either local or general depression of the area poorly illuminated. If the area is local then small visual angles which can normally be seen in this area may not be seen, whilst larger stimuli will only be seen nearer the centre than usual. When the depression is more widespread then all visual angles will move in towards the centre, those for the smallest stimulus being most affected and those for large visual angles less affected, so that there is a gradation in the field. These features are commonly encountered in the pathological field as a result of disease of the visual fibres, but may be imitated by disturbances of illumination. If the whole area of field is poorly illuminated then the same thing happens: visual angles are seen nearer the centre than normal and the smallest may not be seen at all whilst the largest will show that the actual periphery of the field has been indrawn.

It will be apparent from the above remarks that illumination must be uniform over the whole area of screen or perimeter when testing fields, also, that by reducing the illumination and so reducing the strength of a stimulus one may bring out field defects that might not be apparent under high illumination.

Such elaborate methods will, in general, only be used for accurate perimetry for research purposes; the clinician, however, will find that some method of reducing the strength of the stimulus will give a much greater range of tests and prove extremely useful in everyday testing. This may be accomplished by using a rheostat with the lights illuminating the perimeter, by using light spots as test objects with a similar rheostat in the circuit or by making a series of grey test objects to be used in conjunction with white ones whilst keeping the illumination uniform.

REFERENCES

AMSLER, M.: 'Quantitative and Qualitative Vision.' *Trans. ophthal. Soc., U.K.*, **69**: 397–410, 1949.

BENDER, M. B., and FURLOW, L. T.: 'Phenomenon of Visual Extinction in Homonymous Fields and Psychologic Principles Involved.' *Arch. Neurol. Psychiat.*, **53**: 29–33, 1945.

CHAPTER 2

EXAMINATION OF THE NORMAL FIELD

1. Introduction

It will be realized that the method of field testing can never be a purely routine procedure—allowance will have to be made for the type of patient, the problem to be solved, the facilities available and so forth. It is useful to test the fields in all patients suspected of disease of the nervous system, but it is unwise to confine the tests to simple and crude methods such as confrontation fields. A patient who has made no complaint of visual disturbance is unlikely to have any gross field defect such as might be detected by confrontation methods; his field defect, if he has one, is likely to be in an early stage and only detectable by finer methods of testing.

2. Subjective Methods

It is a useful and simple procedure to question the patient as to his own views concerning his visual fields. In many cases patients will be unaware of field disturbances unless they are very gross or encroaching upon the central field and thus impairing visual acuity. A proportion of patients, however, will become aware of their field defects when they are pointed out to them, and may be able to give quite accurate estimates as to the position, size and density of some disturbance in the field. Generally speaking, however, the patient's estimate of a field disturbance, and particularly of a scotoma is rather inaccurate and almost always turns out to be larger than the defect subsequently demonstrated by objective methods. This is particularly so when the scotoma is near the fixation point.

The patient's subjective sense, with regard to his visual field, can be tested by asking him to view a particular scene with each eye separately and with both eyes together, and to describe to the examiner how much he can see of the scene, while keeping his eye fixed on some central point. A somewhat similar method has been devised by Amsler, who has designed a series of charts consisting of white ruled squares on a black ground (or red on a black ground), dotted squares and horizontal lines, etc.

Generally speaking, field disturbances visible to the patient are easily demonstrated by perimetry. Sometimes, however, the patient may be aware of small paracentral scotomata subjectively which can easily be missed in field testing. Questioning the patient as to his subjective sensations will make the