[Extracted from the American Journal of the Medical Sciences for January, 1870.]

6.

AN ADDITIONAL TEST FOR THE DIAGNOSIS AND CORRECTION OF THE OPTICAL DEFECTS OF THE EYE.

By WILLIAM THOMSON, M.D.,
Assist. Surg. to Wills Hospital for Diseases of the Eye, and late Assist. Surg. U. S. A.

Before any object can be seen distinctly, the rays of light which are emitted or reflected from it, must be so refracted by the cornea, lens, and humours of the eye, as to cast upon the layer of the rods and cones of the retina its inverted and perfectly defined image.

If the eye be regarded as an optical instrument composed of a refracting apparatus, the cornea and lens, and a receptive screen, the retina, it needs no argument to prove that there must exist a harmony between the refractive power and the antero-posterior axis, to secure perfect definition.

The human eye may be thus described as a camera of one inch in length antero-posteriorly, with refracting surfaces which are equal to a lens of one inch in focal length: and only when the rods and cones of the retina are situated precisely at the principal focal point of the refracting combination, do the images of distant objects fall upon them, so as to be fully appreciated by the brain. Any variation in the length of the visual axis, without a corresponding change in the refractive apparatus, would render the retinal images indistinct, and would result in imperfect vision.

It may be considered as demonstrated by actual measurement, as well as by mathematical analysis, that the length of the visual axis does frequently depart from the normal standard, and that to this mechanical and anatomical fact, the defective vision in such instances may be ascribed. To the eye whose refractive system and visual axis harmonize, Donders has given the name Emmetropic, and to the eye which departs from this happy construction, Ametropic.

The ametropic eye may have a visual axis either too long, when it becomes Myopic, or too short, when it is called Hypermetropic. In myopia, the retina is too remote from the cornea and lens, and the images of distant objects are formed before it, and are indistinctly seen: its point of perfect vision is at a finite distance, which may, in extreme cases, be placed at one or two inches only anterior to its cornea. In hypermetropia, the axis is too short, and the images would fall behind the retina; objects are clearly seen, only when the refracting power of the crystalline lens is increased by a contraction of the ciliary muscle, and the focus of the refracting combination thereby shortened, to correspond with the diminished antero-posterior axis.

The following table, for example, will express numerically these diversities, as ascertained by the best authorities:—

Emmetropic.	Average length of axis	. . . . 22.23	millimetres.
Myopic.	Possible " "	 25	"
Hypermetropic.	" " "	 20	"

Astigmatism is but a further subdivision of ametropia, in which one or both of the simpler forms may be found in the same eye, which may then be emmetropic in one meridian, and myopic, or hypermetropic, in the other; or myopia and hypermetropia may coexist in the same eye, in meridians at various angles to each other.

To diagnosticate and correct the impaired vision caused by these forms of ametropia, the method usually employed clinically, is to place before the suspected eye various convex, or concave, spherical, or cylindrical, glasses of known focal length, and to direct the patient to examine with them certain test-types, those of Snellen being usually preferred, which are composed of letters of such sizes as to present angles of 5′ at the distances at which they are intended to be seen.

As the power of refraction and length of axis are in the proper proportion in an emmetropic eye, any convex or concave glass must diminish its visual power: as the refraction is too great in myopia, its reduction by concave glasses improves vision: as the refraction is too low in hypermetropia for its short axis, convex glasses, by increasing it add to the visual power; and in describing these defects the power of the glass, whether convex or concave, which gives the best definition, is used to designate the degree of ametropia.

The ophthalmoscope is also usefully employed to ascertain the state of the refraction of the eye, by examinations which are fully described in the text-books on ophthalmic surgery.

Usually, a full assortment of test-glasses are required, and with them, and the test-types, a series of careful observations must be made to ascertain the presence and degree of ametropia; and as an addition to these methods, or when the apparatus above mentioned is not at hand, it is hoped that the simple test below described may be of service to those interested in this branch of surgery.

Let the reader take any strong convex lens, say one of six inches in focus, and standing at ten feet distance from a gas-light or lighted candle, project upon a piece of ground glass, held between the eye and the light, an image of the flame, which will be seen, inverted and distinct, when the screen is a little beyond six inches from the lens; a circle of light replaces the image, increasing or diminishing in size, as the lens is moved to or from the screen. Now cover the lens with a piece of cardboard having two circular apertures in it, each $\frac{1}{4}$ inch in diameter, and $\frac{3}{4}$ inch apart, and two spots of light will appear on the screen when the lens is moved within or beyond its focus, becoming more distinct as this point is approached, and uniting into one distinct image of the flame at the proper focal point. The least movement from this point, will cause the image to become double; and by this it is known that the screen is not placed at the point to coincide with the refractive power of the lens, or, in other words, that the axis or distance from screen to lens is not harmonious with the refracting power.

This is precisely the condition of the ametropic eye, and by the simple test described below, its retina is enabled to perceive the double images it produces.

For this purpose a disk of sheet brass $1\frac{1}{2}$ inch in diameter may be placed directly before the eye, having in it, at a distance apart of $\frac{1}{8}$ inch, two perforations, each $\frac{1}{32}$ inch in diameter. When the eye regards a gas-light distant twenty feet through these perforations, two circles of diffused light are perceived at the disk, which overlap at their inner margins, and produce a bright elliptical space. Should the eye be emmetropic, the gas-light will be seen in the overlapping space, clearly defined and *single;* but if either myopia, hypermetropia, or astigmatism be present, *two* lights appear, but only where the circles overlap.

A card with two pin-holes one-eighth of an inch apart will enable any one to see the double images, after making himself myopic or hypermetropic artificially, by a concave or convex glass (preferably, however, a convex), through which he may look at a candle or gas-light, at a distance of ten or twenty feet, observing that the greater the distance from the object, the more marked will be the separation of the images.

So striking is the double vision thus produced, that a glance through the double diaphragm is sufficient to indicate any ametropia; and so exact is the test that with my own eye, corrected and with relaxed accommodation, a concave or convex $\frac{1}{72}$ doubles the light; and my friend Dr. Wm. F. Norris, who is familiar with the subject of refraction, can detect a myopic astigmatism in one eye of a $\frac{1}{60}$ by the same means.

Having now ascertained that ametropia is present in any case, it will be requisite to know whether it arises from myopia or hypermetropia, and the following test will suffice. Draw through the two perforations a line, and holding the disk before one eye so that this line shall be horizontal, cover the right hole only with a piece of thin red glass, and if myopia be present a red flame will stand on the right side, and an uncoloured one on the left: but if hypermetropia exist the red image stands on the left, the uncoloured one on the right side. In myopia the double vision is direct or homonymous, in hypermetropia it is crossed.

By the rotation of the disk so that the line through the holes is carried from the horizontal to the vertical meridian, any existing astigmatism becomes apparent. In a case recently examined of myopic astigmatism of one-sixth in the horizontal meridian, the vertical being emmetropic, there was but a single image seen when the holes stood one above the other, but widely separated double ones when the holes were placed side by side.

It is evident that a correction of the visual defect can be made with the gas-light, since it only requires that the ordinary test glasses should be placed before the eye, armed with a double diaphragm, observing that in hypermetropia concave glasses separate the images and that convex make them approach, until, when the eye is perfectly corrected, they unite into a single sharp image. The reverse obtains in myopia, the convex separating, and the proper concave, fusing them into one.

Should it be found difficult to fix the attention of children or unintelligent persons upon the overlapping space where alone the double images must be sought for, a number of openings may be used through which the objects will be multiplied in proportion to the number of perforations which occupy the space of the pupil, and a disk of perforated Bristol-board has been found to answer very well in such instances.

There is one positive advantage over the test types which this method possesses, since the acuteness of vision does not enter so largely into the problem, and an eye of low visual power may be diagnosticated and corrected, so long as it can perceive a bright spot of light; and even an amblyopic eye can thus be examined if necessary. A patient was recently examined by the writer, who for several years past had been using concave glasses of $\frac{1}{1.5}$; there was entire loss of vision in one eye, and a decided nuclear opacity in the lens of the other, which prevented an examination by the ophthalmoscope to ascertain either the condition of the retina, or the state of the refraction. The acuteness of vision was $\frac{1}{72}$ only, and it was important to know, in view of a possible operation, whether the degree of myopia was really so great. She could easily perceive the test light, and it was found by the double holes that no glass would fuse the double images, but one that was equal to that which she had been using for some years.

To obtain a better and more steady object than a flame, I have used a disk of card-board nine inches in diameter, which is attached to a gas-burner so that it will rotate upon a pivot placed through its centre, on one side of which a slit four inches in length, and $\frac{3}{8}$ inch in width has been cut, and on the other, a circular perforation $\frac{3}{8}$ inch in diameter, both covered with tissue paper. These appear as a bright band and circular spot of light, having sharp outlines, and each subtending at twenty feet an angle of 5′. For astigmatism the band can be placed at any angle by rotating the disk, and when so used the two small perforations should be placed before the eye at right angles to the direction of this band.

Having now described in detail the use of a double perforation, it remains to show that from the same causes, an ametropic eye can be recognized by a single perforation in the diaphragm ; for when a bright point is regarded by such an eye, and the disk with the single opening held close to the cornea is moved rapidly, the light will appear to dance, to an extent which will depend on its distance from the eye, and on the degree of the ametropia. The single diaphragm is useful as a check upon any other method of correction, for until all ametropia is removed by proper glasses, the point of light will continue to dance or move in some one or other direction.

These observations will all hold good for myopia, but for hypermetropia I wish it to be understood that they presuppose a relaxation of the accommodation.

The power of accommodation seems, however, to be to a certain extent neutralized when the eye looks through these small openings, and in three individuals specially examined for this purpose, it was found to be reduced from a $\frac{1}{4}$ to $\frac{1}{11}$ in one, and from $\frac{1}{4}$ to $\frac{1}{24}$ in the other two, as tested by the ability to fuse the double images at twenty feet through concave glasses. Further clinical observation will be requisite to ascertain this point so important in the recognization of the degree of hypermetropia.

To enter upon the discussion of the optical laws by which these various effects are produced, would extend this paper beyond its allotted space, as would likewise any complete history of the observations of others, although it may be said that Scheiner, in 1619, described the effect of a screen with two slits in causing double images of an object when placed within the point of perfect accommodation ; that upon the same law optometers have been constructed by Young, Stampfer and others, and that Helmholtz, in his *Physiological Optics*, explains the use of such diaphragms, to ascertain the near point, in his discussions on the range of accommodation.

As a ready means, however, of recognizing and correcting ametropia, for which it is proposed above, it is hoped that it may be found to possess some clinical value.

1607 Locust Street, Philadelphia.