cessation from work than those dependent upon the accommodative form. Upon examination, we find that the eyes look quite normal, that the acuteness of vision is perfect, and that the range of accommodation is good; but as the far point lies at 7″ from the eye, the patient will, if reading without spectacles, be obliged to hold the print nearer than this point (at about 6″). This will necessitate so considerable a degree of convergence of the optic axes, that the internal recti muscles may not be sufficiently strong to maintain it for any length of time, without becoming greatly fatigued, and at length giving way. In order to judge if such insufficiency of the internal recti muscles is present, we direct the patient to look steadily at an object (a pencil, or our uplifted forefinger), and then gradually approximate this to the eye. If the muscles are too weak, we find that when the object is brought to about 6″, one eye becomes a little unsteady and wavering in its fixation, and then gradually, or else suddenly and spasmodically, deviates outwards. The same deviation occurs when we cover one eye, so as to exclude it from participation in the act of vision, even perhaps if the object be some feet distant. Now, this deviation shows that the internal recti muscles are not sufficiently strong to keep up the

necessary amount of convergence (for 5″—6″) during reading. As soon as we exclude one eye (by covering it) from the act of vision, it follows its natural impulse, and deviates outwards, thus proving the weakness of its internal rectus. In order to avoid diplopia, this tendency to deviation is, however, suppressed by the patient when he looks at an object, as long as this is not approximated too closely. After a time, if he continues to work much at near objects, one eye moves outwards, and a permanent divergent squint is produced, the patient learning at the same time to suppress the image of the squinting eye, in order to avoid diplopia; but this active negation of the pseudo-image soon leads to weakness of the sight of the squinting eye. Other patients avoid the disagreeable symptoms of asthenopia by closing one eye whilst looking at near objects.

By means of prisms, we can in such cases easily satisfy ourselves of the diminished strength of the internal recti muscles, and the increased power of the external recti. Before explaining this mode of examination, it will be well to describe the different kinds of diplopia which are met with, and also to say a few words as to the action of prismatic glasses, as some of my readers may not be quite conversant with these subjects.

In explanation of diplopia and the action of prisms, I give the following extract from my Lectures on Strabismus.—"Med. Times and Gazette," 1862–3 :—

"An object only appears single when both optic axes are fixed upon it; any pathological deviation of either optic axis must necessarily cause diplopia, as the rays from the object do not then fall upon identical portions of the retina. The slightest degree of diplopia is that in which the double images are not yet distinctly defined (are masked), but seem to lie slightly over each other, so that the object appears to have a halo round it.

"We meet with two kinds of double images.

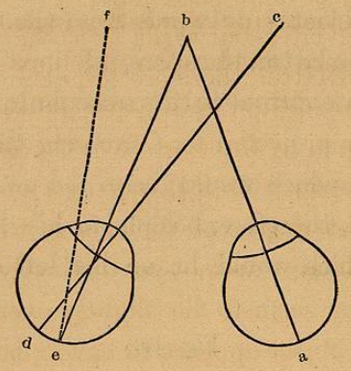
"1. *Homonymous* (or *direct*) diplopia in which the image to the right of the patient belongs to his right eye, the left image to the left eye.

"2. *Crossed* double images, in which case the image to the right of the patient belongs to his left eye, that on his left to his right eye.

"Homonymous diplopia is always produced in convergent squint, for if the eye deviates inwards from the object, the rays coming from the latter will fall upon the inner portion of the retina, and the image will (in accordance with the laws of projection) be projected outwards as in Fig. 18.

"Let I. be the right eye, whose optic axis is fixed upon the object (*b*). II. The left eye, whose

Fig. 18.



II. I.

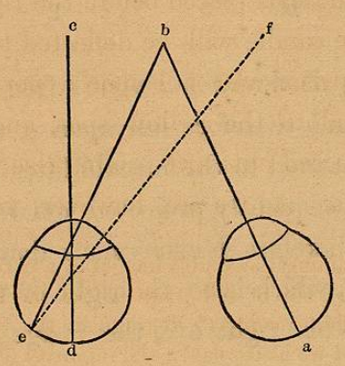
optic axis (*c d*) deviates inwards from the object, the rays from *b* therefore fall upon *e*, a portion of the retina internal to the macula lutea (*d*), and the image is consequently projected outwards to *f*; *b* and *f* are, therefore, homonymous double images, the image *b*, which is to the right of the patient, belonging to his right eye, the image *f* to his left eye.

"Crossed double images arise in divergent squint, for the one eye deviating outwards from the object, the rays from the latter fall upon a portion of the retina external to the macula lutea, the

image is projected inwards, and crosses that of the other eye, as in Fig. 19.

"I. The right eye, whose optic axis (*a b*) is fixed upon the object (*b*). II. The left eye, whose optic axis (*c d*) deviates outwards from the object; the rays from the latter, therefore, fall upon *e*, a portion of the retina external to the macula lutea (*d*), and the image is projected to *f*, crossing the image *b*; the image *f*, which would lie on the patient's right hand, would, therefore, belong to his left eye, the image *b*, which would lie on his left side, to the right eye.

Fig. 19.



II. I.

"If one eye squints upwards, the rays will fall upon the upper portion of the retina, and the image be projected *beneath* that of the healthy eye.

The reverse will be the case if the eye squints downwards, for then the rays fall upon the lower portion of the retina, and the image will be projected *above* that of the healthy eye."

We should never forget to ascertain whether the diplopia be monocular or binocular; if it be the latter, it will of course disappear upon the closure of the healthy eye.*

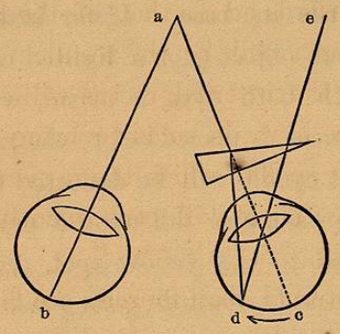
Let us now glance at the action of prisms. When a ray of light falls upon a prism, it is refracted towards its base. If, for instance, whilst we look at an object (*e.g.*, a lighted candle) at 8′ distance with both eyes, a prism, with its base towards the nose, is placed before the right eye, the rays from the candle will be deflected towards the base of the prism, and fall upon a portion of the retina internal to the yellow spot, and be consequently projected outwards, giving rise to homonymous diplopia. As we are, however, very suscep-

* "In examining the double images of a patient, it is convenient to place a slip of red glass before the sound eye, for we thus enable him readily to distinguish the two images by their colour, and we also weaken the intensity of the image of the sound eye, and approximate it more to that of the affected one, whose image, owing to the rays from the object falling upon an eccentric portion of the retina, will be less intense in proportion to the distance of the spot, upon which the rays fall, from the macula lutea."—Ophthalmic Hospital Reports, No. 9, p. 139.

tible of double images, the eye will endeavour to unite them by an outward movement (its external rectus becoming contracted), which will again bring the rays upon the yellow spot, but at the same time of course cause a divergent squint. Fig. 20 will explain this.

Let *a b* be the optic axis of the left eye, fixed (with the other) upon a candle 8′ off. Now, if a

Fig. 20.



prism (with its base towards the nose) be placed before the right eye, the rays are refracted towards the base of the prism and do not, as in the other eye, fall upon the yellow spot, but on a portion of the retina (*d*) internal to the latter, and the image is projected outwards to *e*; homonymous diplopia therefore arises, and to avoid this the external rectus muscle contracts and moves the eye outwards, so as to bring the macula lutea *c* to that spot *d*, to which the rays are deflected by the prism. As the rays from the object will now fall in both eyes upon the macula lutea, single vision will result, accompanied, of course, by a divergent squint of the right eye.

The reverse will occur if we turn the prism with its base to the temple, for the rays will then be deflected to a portion of the retina to the outer side of the macula lutea, and the image will be projected inwards across that of the left eye, and crossed diplopia will be the result. In order to remedy this, the internal rectus will contract and move the eye inwards, so as to bring the macula lutea to that spot to which the rays are deflected by the prism. There will consequently be a convergent squint.

As the internal recti muscles are far more constantly used than the external, they gain a greater degree of strength than the latter, and can overcome far stronger prisms by a voluntary inward squint. In a normal eye, the internal rectus can generally overcome a prism of from 14° to 28°, whereas the external rectus cannot, as a rule, overcome one stronger than 5°—6°.

Prismatic glasses are of great value in ophthalmic practice, for they not only enable us to

free a patient from the annoyance of diplopia, to exercise and strengthen a partially paralysed or insufficient muscle, but also to ascertain whether or not a person enjoys binocular vision (Gemeinschaftlicher Sehact), *i.e.*, sees with both eyes at the same time,—a fact which is of great importance with regard to the prognosis of the result of an operation for squint. If binocular vision exists, we may guarantee a perfect cure, without it, we can but promise an approximative one; for in the latter case there will not, of course, be any diplopia, and the perfect cure of squint depends, as we shall show hereafter, upon the presence of double images.

We should, therefore, in all cases of squint carefully ascertain whether there is binocular vision or not. Its presence is of course at once proved by binocular diplopia, for this cannot exist if the person only sees with one eye at a time. A person may see perfectly with either eye singly, or when both are open there may be no deviation of either optic axis, and yet he may not see with both eyes at the same time. In the majority of cases of squint, particularly if the affection has existed for some time, there is no binocular vision, the one image being suppressed, and there is consequently no diplopia; the sight of the squinting

eye is generally considerably impaired; occasionally, however, it is almost or even quite normal.

We may readily ascertain whether or not a person enjoys binocular vision by simply placing a prism before one eye. We should first, however, examine each eye separately, so that its degree of vision, range of accommodation, and state of refraction, may be accurately ascertained, notice being also taken whether its optic axis is fixed upon the object, or whether the eye "fixes" the latter with an eccentric portion of the retina and not with the macula lutea. The patient being ordered to look (with both eyes open) at a lighted candle placed at a distance of from six to eight feet, a prism with its base outwards is to be placed before one eye.

Let us now suppose it held before the right eye,—one of three things will occur:—

1. *Diplopia.*—The rays from the object will be deflected by the prism towards its base, and will consequently impinge upon a portion of the retina external to the macula lutea, and be, therefore, projected inwards, giving rise to crossed double images.

2. *Corrective Squint.*—Now, if the prism be not too strong, the right eye will, in order to overcome the annoyance of the diplopia, squint inwards, thus bringing the deflected rays once more

upon the yellow spot, and uniting the double images. We may, therefore, be certain that binocular vision exists, if, on holding a prism before one eye, diplopia or a corrective squint arises. If the base of the prism is turned outwards, the squint would be convergent, if inwards, divergent.

3. But the prism may have no effect whatever; it neither gives rise to diplopia nor to a squint, indeed the eye does not move at all. This proves at once the absence of binocular vision, and shows moreover, that the prism has been held before the eye which the patient does not use (although its sight may be perfect), for if we place it, still with its base outwards, before the other eye, the latter will move inwards, in order to bring the deflected rays once more upon the macula lutea; the other eye making at the same time an *associated* movement outwards, so that, although the one eye moves inwards, there will be no corrective squint, the other eye counterbalancing the inward by an associated outward movement. The eye which, when a prism is interposed, moves towards the refracting angle of the latter, is the one commonly used, whereas the other eye, which makes an associated movement, is the one excluded from binocular vision.

Binocular vision is frequently only lost in certain portions of the retina, particularly in those which, though not identical with, are constantly excited simultaneously with the central portion of the retina of the other eye.

Thus in convergent strabismus we find that in the squinting eye, the portion of the retina which lies internal to the yellow spot is the first to suffer a loss of binocular vision, for it is directed towards the object, and is, therefore, (though not identical with it) constantly excited simultaneously with the central portion of the retina of the other eye, which is fixed upon the object. The reverse occurs in divergent squint, for there the external portion of the retina is the first to fail. At first, this loss of binocular vision only extends horizontally, so that if we turn a prism with its base upwards or downwards (or place it even in a diagonal position), we at once produce double images, which show not only a difference in height, but also, if there is any squint, a lateral difference. We may thus determine, with the greatest nicety, which part of the retina has lost the power of binocular vision. Sometimes, it extends over the whole retina, so that we fail to produce diplopia even with the strongest prisms turned in any direction; at others, this loss of binocular vision is tolerably circum-

scribed, being confined to a very small portion of the retina. In convergent strabismus, for instance, only a small portion of the retina internal to the yellow spot may have suffered, so that on placing a prism with its base towards the nose before this eye, and deflecting the rays still more inwards, double images are at once produced, although the deflected rays now impinge upon a more eccentric, and, naturally, less sensitive portion of the retina. Occasionally, we may in such a case also produce diplopia, if we bring the rays nearer to the macula lutea by means of a prism. Thus, through a sudden alteration of the position of the optic axis of the affected eye, diplopia may be at once induced; as, for instance, after the operation for squint, or in cases of paralysis or spasm of the other muscles of the eyeball.

Prismatic glasses, therefore, afford us an excellent test of the relative strength of the internal recti muscles. Now, in insufficiency of these muscles we find that their strength is greatly diminished, so that they may perhaps only overcome a prism of 4° or 5°, instead of, as in the normal eye, one of 16° or 24°, or even 30°. The external recti, on the other hand, gain unusual strength in such cases, on account of the diminished force of

their opponents, and may now be able to overcome prisms of 14°, 16°, or even 20°.

In testing the relative strength of the muscles with prismatic glasses, the object (a lighted candle is the best) should be placed at a distance of 7—8 feet. If the patient is short-sighted, he should be furnished with the concave glass which will enable him to see the object distinctly and clearly defined. Von Graefe has pointed out the interesting fact, that the power of overcoming prisms by the action of the external rectus (voluntary abduction) increases as the object is brought nearer to the eye. He himself is able (the object being placed at a distance of 6′) to overcome a prism of 30° through adduction (action of the internal rectus), and one of 6°, through abduction (action of the external rectus). When the object is, however, brought to 1′ he can overcome a prism of 16° through abduction, and at 8″ one of 22°. The power of the internal rectus appears to remain about the same up to a distance of 8″, but it becomes somewhat diminished when the object is brought nearer than this.

The diagnosis of insufficiency of the internal recti muscles may be made either by approaching an object close to the eye and watching whether the fixation remains steady, or whether one eye

becomes unsteady and moves outwards. Or, whilst the patient is regarding an object at 10″—12″ distance, we may cover one eye with the palm of our hand, so as to exclude it from participation in the act of vision, and the same outward deviation will then occur in the covered eye, if its internal rectus is insufficient ; for as there is now no longer any visual impulse to regulate the position of the optic axes, the covered eye follows the action of the stronger muscle.

This test is applicable in marked cases of insufficiency, where the deviation is considerable enough to be at once apparent ; but in slight cases it may be so small as to be inappreciable by the eye, although the double images may be very evident to the patient. It is, therefore, far better to make use of a prism to detect these slighter cases. This should be placed with its base upwards or downwards so as to produce diplopia ; the double images will then not be fused into one, as the eye cannot unite double images which show a difference in height.

We have seen that the normal eye may be able to overcome a prism of 20°—30° with its base turned outwards, and one of 6°—8° with its base turned inwards, but very few persons can overcome more than a prism of 1° with its base turned upwards or downwards. In consequence of this, double images will, therefore, be produced, the visual impulse will be annulled, and the eye yield to the prepondering influence of the strongest muscle. In the normal eye the muscles are equally balanced, and the double images will only show a difference in height, standing straight one above the other. But if either the internal or external rectus considerably exceeds the normal standard of strength, the double images will not only show a difference in height but also a lateral difference. If the internal rectus is insufficient, the eye will move outwards when a prism is held with its base upwards or downwards, and there will, consequently, be not only a difference in the height of the double images, but they will also be crossed, on account of the divergent squint. We may then easily express the degree of insufficiency by the degree of the prism (base turned inwards) which is required to bring the double images one above the other. This mode of examination is particularly recommended by Von Graefe, who proposes the following plan :—A dot is drawn on a piece of paper, and is then bisected by a fine vertical line (Fig. 21). This paper is placed at the usual distance of reading or writing, and the patient is directed to regard the dot with both eyes. A