DR. L. CONNOR, Detroit—It is perfectly evident that this is a very complex problem and that some gentlemen see one part of it with greater distinctness than others. So far as my own observation goes we may seek for the cause of these muscular disturbances along perhaps three or four lines: one is a reflex occurring with certain conditions of the nose or allied organs; another is malnutrition of the eye whose muscles wobble as the muscles elsewhere do in similar conditions; a third is a physiological lack of power, and lastly there are unquestionably anatomical defects. I think it is well established that when we have settled upon an anatomical error as the cause of the trouble an operation is absolutely necessary. In other conditions the removal of the cause of irritation, etc., has certainly resulted well. It is entirely unsafe to say that anatomical conditions alone are the cause of heterophoria and that all cases should be operated upon. A friend of mine was operated on thirty-eight times within eight months and has more muscular unbalance to-day than ever before. You all know there are cases of disease of various sorts cured by operation *per se* and I am certain that many cases of heterophoria are cured simply by the cutting, and a cutting on the ear would do just as much good. I have never seen any good resulting from a partial tenotomy; I might just as well have cut the conjunctiva somewhere else. I do not mean to say the men who operate do not benefit their patients, but the good should be ascribed to its proper cause and, in some instances at least, to hypnotic influence.

DR. D. B. WYLIE, Milwaukee—The gentleman who has just had the floor touched upon a point which I think is not looked after to the extent it should be, which, in my practice at least, has appeared to be of great importance, that is, external irritation. In neither of the papers, nor in the discussion have I heard anything about correcting diseased conditions or irritated conditions of the conjunctiva. You may call these pseudo-heterophorias if you will, but they produce the same asthenopia. I have time and again seen small degrees of esophoria or exophoria disappear entirely after the cure of a very mild degree of conjunctivitis. I was somewhat surprised at one of the gentlemen stating that surgery is the despair of medicine. It seems to me that is beyond the power of any man to defend.

DR. D. M. CAMPBELL, Detroit, Mich.—The differences of opinion seem to be on the causes of heterophoria; in the treatment of the condition we are probably not so far asunder as might appear from the discussion. Most of us correct the refraction and look after the general health of the patient and cure a large number of cases, and yet in a large practice there will be a certain residual number uncured by whatever we do. In a report I made to the Michigan State Medical Society upon a study of 500 cases of asthenopia I found less than 2 per cent. that had to undergo operation.

DR. H. HARLAN, Baltimore—I envy very much the men who can have such positive convictions as to permit dogmatic statements such as we have heard. I want to ask Dr. Gould whether his statement that no case should be operated on is the swinging backward of the pendulum as the result of unsatisfactory experience in operating, or whether that has always been his opinion.

DR. GEORGE M. GOULD, Philadelphia—It is my belief that we are emphasizing entirely too much this question of muscle trouble. It may be highly scientific to do this work, but I have found many patients coming to me wearing prisms that seemed to my mind utterly unnecessary and never could have been called for. I feel it a higher duty to emphasize the importance to correct refraction, of applying the proper glasses in relation to these muscle troubles. Several misunderstandings have taken place which I wish to correct. I never said or implied that no case should be operated on. I made certain reservations and further said that this paper was written from my own experience limited to a private practice in a good class of intelligent people; I have been able to cure their symptoms or relieve them so perfectly that I have kept them as satisfied patients. I do not wish to be dogmatic because I thoroughly believe that in the matter of the practice of medi-

cine individual genius has its own law and one man will accomplish by his method what another man could not accomplish with it.

I wish to correct a misinterpretation about "surgery being the despair of medicine." What I meant was that none of us believe in proceeding to surgical measures if we can cure our patients by medical and physiological means. We certainly despair of curing our patients naturally before we proceed to surgery. I do believe that local irritation of the conjunctiva may produce a temporary heterophoria, but on the other hand I believe these conditions are usually corrected by proper glasses which remove the heterophoria at the same time. The question has been asked why orthophoria should be considered a disease. My feeling is that in orthophoria with the Maddox rod at 20 feet there is almost always an insufficient adduction power for close work and that the trouble thus produced justifies its being considered a diseased condition.

A TABLE OF OCULAR EXTRINSIC PARALYSES.*

HORACE M. STARKEY, M.D.
CHICAGO.

In the "International Clinics," Vol. iii, Fourth Series, 1894, appeared an article by Prof. F. C. Hotz, on "The Diagnosis of Paralysis of the Ocular Muscles by the Double Image Test," which was a distinct advance in simplifying the methods of detecting the affected muscle in these perplexing cases. In studying that article, it occurred to the writer that the subject might be further simplified by exhibiting these paralyzes with the position of the false image in graphic or tabular form. Soon afterward he prepared the table, which, with some modification of terms, has been used by him in teaching and in practical work since. As the table has stood the test of time and has commended itself to many practitioners and students, it is now presented for the consideration of this Section, in the hope that it may prove of value to others.

Let us consider briefly the more recent nomenclature of the movements of the eyes, mainly following that of Maddox; the muscles producing those movements, and the action of each muscle in the primary position of the eyes as well as in secondary positions.

PRIMARY POSITION.

The primary position may be stated to be that in which with the head perfectly erect, the eyes are directed toward a point upon the horizon midway between the eyes.¹

In testing the eye muscles the primary position should be first assumed and the relations of the images formed by the two eyes studied in this position and later the relation of the images in departures from this position should be considered.

MOVEMENTS OF THE EYES.

In passing from the primary position, the eyes are capable of eight simple co-ordinate movements and, by combinations of these, all possible positions may be attained. Two of these movements, adduction and abduction, are employed in convergence and divergence; four, dextroduction, levoduction, superduction, and subduction, are employed in parallel movements; and two, extortion and intortion, are employed in rotating the eyes around their antero-posterior axis "so as to make the cornea revolve like a wheel." Because of this

* Read at the Fifty-second Annual Meeting of the American Medical Association, in the Section on Ophthalmology, and approved for publication by the Executive Committee of the Section: Drs. J. A. Lippincott, Casey A. Wood and H. V. Würdemann.

1. While this definition is not strictly accurate for all movements of the eyes, it is sufficiently accurate for all practical purposes in making the diplopia tests.

torsion the upper segment of the cornea has been adopted empirically to represent the movements of the eye. These eight movements are produced by the twelve muscles, six for each eye as follows:

Abduction, the separation of the axes of the eyes so that the corneæ diverge, is produced by the external recti, assisted by the superior and inferior obliques.

Adduction, approximation of the axes of the eyes so that the corneæ converge, is produced by the internal recti, assisted by the superior and inferior recti.

Dextroductio, the turning of the eyes to the right, is produced by the abductors of the right eye and the adductors of the left eye.

Levductio, the turning of the eyes to the left, is produced by the adductors of the right eye and the abductors of the left eye.

Superduction, the turning of the eyes upward, is produced by the superior recti, assisted by the inferior obliques.

Subduction, the turning of the eyes downward, is produced by the inferior recti assisted by the superior obliques.

Extortion, the rotating of the upper segment of the cornea outward, is produced by the inferior obliques, assisted by the inferior recti.

Intortion, the rotating of the upper segment of the cornea inward, is produced by the superior obliques, assisted by the superior recti.

ACTION OF THE INDIVIDUAL EYE MUSCLES.

Each of the six muscles of the eye has one movement for which it is particularly responsible: The external rectus for abduction; the internal rectus for adduction; the superior rectus for superduction; the inferior rectus for subduction; the superior oblique for intortion, and the inferior oblique for extortion. This action of each muscle may be called its primary action, but each has other actions varying according to the position of the eyes when the action occurs, which may be called secondary. The external rectus and the internal rectus have no secondary action when moving in the horizontal line, but in all other positions they have secondary actions. All the other muscles have secondary actions in all positions. Usually the movements of the eyes in straight lines from the primary position are all that are necessary to be considered in making diplopia tests for ocular paralyses; but in certain complex cases it is desirable to study the motions of the eyes in all possible positions. The limits of this paper will not, however, permit a review of the action of each muscle in all positions.

If we keep in mind the origin and insertion of these various muscles it will assist us greatly in remembering their actions. The external and internal recti passing horizontally from origins which are to the inner side of and behind the eyeball to insertions on the horizontal meridian of the anterior segment of the globe, act, when the eye is in the horizontal plane, to simply rotate the eye to the right and left. In the upper plane each acts as a superductor and intortor, in the lower plane as a subductor and extortor.

The superior rectus from an origin which is to the inner side of and behind, passes diagonally to its insertion in the upper anterior segment of the globe near the vertical meridian. Having this diagonal position the muscle even in the primary position not only superducts the eye, but it also adducts and intorts it.

The inferior rectus having a similar origin, direction and insertion in the anterior inferior portion of the

globe, primarily subducts the eye, but at the same time adducts and extorts it.

The superior oblique from a potential origin to the inner side and in front of the eye, passes diagonally to its insertion in the upper outer part of the posterior segment of the globe and in the primary position, not only intorts but also subducts and abducts.

The inferior oblique having a similar origin, direction and insertion in the outer lower part of the posterior segment extorts and also superducts and abducts.

It is thus seen that all the recti except the external adduct; that the obliques abduct; that the superior muscles, obliques and recti, intort; that the inferior muscles, obliques and recti, extort; that the superior recti and inferior obliques superduct and that the inferior recti and superior obliques subduct.

For the maintenance of binocular single vision all these muscles must act with the greatest precision and harmony, so that the rays of light coming from an object shall fall upon similar portions of the retina in each eye. If one muscle is weakened in the slightest degree the eye is not held in the proper position but rotates slightly in a direction opposite to the action of the affected muscle and rays of light falling upon a different portion of the retina from that in the other eye, the object is seen double, that is, diplopia occurs.

PROJECTION.

Observation and education have taught us when looking at an object, that is, when the eyes are so directed that rays of light coming from that object fall upon the macula, that another object so situated that rays of light coming from it fall to the left of the macula is to the right of the object viewed, and that rays of light falling below the macula come from an object above the object viewed. In the normal position of the eyes when both are accurately fixed, rays coming from the object viewed fall upon corresponding parts of the macula and rays coming from the right pass over to corresponding points to the left in each retina and are interpreted to the consciousness as being to the right. When, however, one eye deviates, say to the right, it is so turned that rays fall further to the right on the retina than they would if there was no deviation, and by education are interpreted by the brain, as being further to the left than they actually are. And as for all other directions, so that we find when one eye deviates from its fellow, the image of the deviating eye is always projected in a direction opposite to that in which the eye turns. It was shown above:

1. That when a muscle is weakened, the other muscles turn the eye in a direction opposite to the action of the affected muscle. 2. That projection of the false image is always in a direction opposite to the turning of the deviating eye. And from these two facts a third is apparent that is of great assistance in detecting the affected muscle, namely,

3. That the false image always appears to be displaced in the direction of the action of the affected muscle.

4. Another point of importance is the fact that the distance between the images increases when the eyes are turned in a direction calling for the action of the affected muscle, and diminished when the eyes are turned in the opposite direction.

VARIETIES OF DIPLOPIA.

According to the relative positions of the images, diplopia is classified as lateral when the images are disposed approximately horizontally and as vertical when

they are disposed approximately perpendicularly. Very rarely the displacement is about midway between horizontal and vertical; but with these rare exceptions there is no difficulty in placing the diplopia in one or the other class. These two varieties of diplopia are further subdivided according as the false image is displaced toward the temple or toward the nose. In horizontal displacements of the eye it is manifest that the false image must be displaced toward the temple or toward the nose. But in vertical displacements, owing to the fact that all the superductors and subductors are also either abductors or adductors, there is always lateral displacement and thus the false image is also projected either toward the temple or toward the nose.² If the images are separated so that the image of the right eye is seen on the right side and that of the left eye on the left side, the diplopia is homonymous or temporal; but if the images are crossed so that the image

the externi because it is homonymous and that it is the right externus because the images separate when the eyes are turned to the right calling this muscle into action.

If, however, the diplopia is vertical, we know at once that one of the eight vertical muscles is involved. If while vertical, it is homonymous, it is shown that one of the four obliques is involved. In either of these cases if diplopia is present in the upper field, that is in superduction, we know that it is one of the muscles that turns the eye up, while if present in the lower field, we know that it is one of the subductors. Having in this way reduced the quest to one of two muscles, the position of the images shows which of these two is affected. Thus if we have with the eyes turned upward the image of the right eye above and to the right of that of the left eye, the right inferior oblique is at once shown to be the one paralyzed.

A TABLE OF OCULAR PARALYSES.			
Diplopia	Lateral. 4	External or Internal Recti	(Homonymous. Externi.) (1- Images separating in Dextroductio. Rt. External Rectus.
			(2- " " " Levoductio. L. " "
			(3- " " " Levoductio. Rt. Internal "
			(4- " " " Dextroductio. L. " "
	Vertical 8	Superior or Inferior Recti or Obliques	(In Superduction Inferior 5- Right Image Higher. Rt. Inferior Oblique. /
			6- Left " " L. " " \
			(In Subduction Superior 7- Right " Lower. Rt. Superior " \
			8- Left " " L. " " /
			(In Superduction Superior 9- Right " Higher. L. " Rectus /
			10- Left " " Rt. " " \
			(In Subduction Inferior 11- Right " Lower. L. Inferior " \
			12- Left " " Rt. " " /

of the right appears to be to the left of that of the left eye the diplopia is heteronymous, crossed or nasal. The writer much prefers the simple English terms, temporal and nasal to indicate the position of the false image, but as these have not been generally adopted the more usual homonymous and crossed are used in the table and in this paper.

Having in mind the foregoing facts, the muscle affected is readily determined. In making the tests the patient should be so placed that the eyes in the primary position are directed toward a small bright light, as a candle flame, 20 feet away. A red or green glass should be placed before one eye. This glass serves a double purpose. It makes the separate images more apparent, and it shows which image belongs to the right eye and which to the left. If now the patient sees two images of the flame, we inquire at once whether the images are side by side or one above the other. If the former, lateral diplopia, is found eight of the twelve muscles are at once excluded and we know that one of the four lateral recti muscles is involved. Knowing whether the diplopia is homonymous or crossed, the number of muscles involved is reduced to two, and then by directing the patient to turn the head to the left so that the eyes are dextroducted, or the head to the right so that the eyes are levoducted, we bring the analysis down to a single muscle and can say at once which one of the four lateral recti muscles is involved. Suppose, for instance, that the patient says that the image of the right eye is to the right of the other and that it passes farther from it as the head is turned to the left, eyes dextroducted, we know at once that it is one of the four laterals, because the diplopia is lateral; that it is one of

Persistent diplopia indicates paralysis or paresis of one or more of the ocular muscles.³

1. When a muscle is paralyzed the eye turns away from the action of that muscle.

2. Projection is in the opposite direction to the deviation of the eye.

3. Projection is in the direction of the action of the affected muscle.

4. The images separate in turning the eyes in such a direction as to call for the action of the affected muscle.

DISCUSSION.

Dr. F. C. Horst, Chicago—Several years ago I worked out a similar scheme for facilitating the diagnosis of ocular paralyses by the diplopia test. My plan was based upon the fact that we can group the six ocular muscles into three pairs, each of which controls one of the three principal rotations of the eye: the first pair (internus and externus) controls the lateral movements; the second pair (superior rectus and inferior oblique) the upward movements, and the third pair (inferior rectus and superior oblique) the downward movements. In any case of paralysis, therefore, the first question to be settled is this: The kind of diplopia locates the disturbance upon which pair of muscles? Lateral diplopia indicates an affection of the first pair; vertical diplopia in the upper field points to the second pair; and vertical diplopia in the lower field to the third pair. The next step is to decide which muscle of the pair is affected. This question is at once answered by the homonymous or crossed character of the diplopia. Homonymous diplopia of the first

2. In vertical diplopia in a patient with previous esophoria or exophoria the images might be exactly vertical (the author has seen one such case), but these exceptions to the rule must be exceedingly rare.

3. Exceptions: Injuries, diseases and tumors of the orbit causing displacement and loss of motion, usually obvious; and chronic spasms of the muscles of the eye, so rare as to be negligible.

pair points to the externus; crossed diplopia to the internus; homonymous diplopia of the second pair points to the inferior oblique; crossed diplopia to the superior rectus; homonymous diplopia of the third pair points to the superior oblique, and crossed diplopia to the inferior rectus.

The affected muscle being found it only remains to determine whether it is the muscle of the right or left eye. This last question is answered by the well-known fact that the image of the affected eye is projected in the direction of the normal action of the paralyzed muscle; and that the distance between the double images increases in this direction and diminishes in the opposite. If, for instance, we have found a paralysis of the externus and the images separate when the eyes are rotated to the left, but come together when the eyes are rotated in the opposite direction, we know at once the paralyzed muscle must be the externus of the left eye.

I have taught this method a number of years and always found the quick and easy way of making a correct diagnosis was a great revelation to the students who are accustomed to look upon the paralyzes of ocular muscles as one of the most difficult and perplexing problems. Dr. Starkey has elaborated a similar method and I am pleased to learn that he too has been successful and well satisfied. It shows that students may readily understand the clinical pictures of ocular paralyzes if they are presented to them in a comprehensive manner.

DR. W. H. WILDER, Chicago—Dr. Starkey's table will be a valuable addition to the class room. It is certainly difficult to get students to comprehend this matter of ocular paralysis and any way of simplifying it is of value. The only suggestion I would make would be that this table might be supplemented by a diagram giving the evidences of torsion or tilting of images that we see when certain straight muscles or the obliques are paralyzed. I do not agree with Dr. Hotz on this point. If you have an affection of one of the straight muscles it is easily recognized without taking the patient into the dark room, but the difficulties come with the partial paralyzes or pareses, where the degree of diplopia is not great and the difficulties are worse when a group of muscles are affected. It is not an easy matter to work these cases out to a satisfactory conclusion.

DR. M. F. WEYMANN, St. Joseph, Mo.—The subject of the diagnosis of paralysis affecting a single muscle of the eye may be reduced to three mechanical rules whose application requires little thought and analysis: 1. Diplopia appears in the direction of the action of the affected muscle. 2. The faulty image is always in advance; this is reversed only when the paretic eye is used for fixation. The first two rules determine easily any paresis in the horizontal plane. 3. Of the muscles acting in the vertical sense, the obliques produce homonymous, the recti heteronymous diplopia.

DR. EDWARD JACKSON, Denver—I think it is extremely important for practical reasons not to attempt to burden the mind with any such table, but to follow a plan similar to that indicated by the last speaker. It is well enough to have such a table for reference, but I think for practical work we have the whole theory of the subject in the rules Dr. Weymann has given. The diagnosis of partial paralyzes in a large majority of cases is not rendered simpler by such a scheme, and I find that they can not be settled in a few minutes or even in an hour by repeated tests. You must remember that no ocular movement is dependent upon any one muscle and no movement is lost by the paralysis of a single muscle, unless it be direct lateral movements of a certain nature. I think the measure having the greatest value as a final test is the accurate measurement of the fields of binocular fixation.

DR. HORACE M. STARKEY, in reply—If I understand Dr. Hotz, this paper illustrates his method of teaching to-day as well as that of ten years ago. The object of my study has been to make the teaching of this rather complex subject as simple as possible, and certainly it has been much more easily understood by physicians and students, when explained in connection with this table, than by any other means that I have been able to devise. It is not expected that the table

will be memorized, but rather to be at hand for ready reference. The reason that no supplementary table was added, as suggested by Dr. Wilder, is because it seemed to me that the simpler the table could be made the more valuable it would be.

MULES' OPERATION.*

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The operation of evisceration was devised by Graefe in 1884, his object being to prevent death from meningitis following removal of suppurating globes; and by Mules of Manchester, England, at about the same time, his object being to prevent sympathetic ophthalmitis which occasionally follows enucleation. Since which time this operation has been urged by some surgeons as furnishing a more suitable stump for prosthesis.

In 1885 Mr. Mules devised and executed the operation which bears his name. This consists in ordinary evisceration, including ablation of the cornea and the insertion of an artificial vitreous.

In 1886 Mr. Adams Frost of London practiced the insertion of a glass ball immediately after enucleation; his method was as follows: After incising the conjunctiva all around the cornea the tendons of the recti were secured by sutures, then enucleation followed with the insertion of the globe, after which the sutured tendons were fastened and the conjunctival flaps brought together.

Mr. Lang of Moorfields shortly afterwards modified this operation by inserting the artificial globe into Tenon's capsule.

In 1895 Dr. Fox of Philadelphia devised the operation of inserting an artificial globe into an orbit where the eyeball had previously been enucleated. His operation consists in opening the conjunctiva horizontally, dissecting a hole in the orbital tissues into which the globe is inserted, the tissues then being sutured over the ball. Dr. Fox records a success of 85 per cent. in 48 operations. Simple evisceration in the opinion of most surgeons presents no advantages over enucleation. It does not, at any rate, after a few months, make a better stump than results from a careful enucleation. In those cases where Mules' operation can not be performed, the Frost-Lang operation may be substituted. The Fox operation is a very ingenious one and certainly causes a great improvement in the appearance of appropriate cases, but it is probable that this operation will not be very generally adopted, since the reform Snellen eye has been invented and is giving such satisfaction. Many of the members of this Section have used the reform eyes, no doubt, and will give us the benefit of their experience. There are two forms made, of which I show some samples. In both of them the back is filled in, but in one it is filled in more than in the other. (Figs. 2 and 3.) They are certainly a great improvement over the old form. The large cavity which results from enucleation is partially filled in and does away, in part at least, with the collection of mucus, besides giving far better results from a cosmetic standpoint. Recently I received a letter from Dr. de Schweinitz, in which he says that by the use of the reform eye in cases where he has recently performed enucleation according to the improved

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