eye only instead of in both, the very definite appearance on careful inspection of the defect—superficial and *in intaglio*—is not such as to suggest that it is caused by an eroding eruption from beneath. I am not aware of this condition having been reported before. A full title might justifiably be suggested as “developmental bilateral mesial superficial intagliated deficiency of the sclera.”

DIVERGENT STRABISMUS*

BY

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THE literature on the subject of convergent concomitant strabismus is redundant, but that on divergent concomitant strabismus is comparatively scarce.

Historical

Various causes and types of this condition have been described.

Beginning in the 18th century, Troxler and de la Hire thought that strabismus was due to retinal incongruity, *i.e.*, that in one eye the most sensitive part of the retina lay, not on the optic axis, but to one side of it. At this time, of course, the angle gamma was not appreciated, and it was thought that normally the optic axis and the sight axis were coincident.

In the same century, Buffon, who himself had a divergent squint, commented on the frequent presence of anisometropia, and gave it as the most common cause. He said that “the weaker eye” interfered with the binocular vision, and so it turned away. He also said that if the near point was very close, as in the case of myopes, it was tiring to converge sufficiently, and therefore one eye deviated to preserve clarity of vision.

Buffon noticed that in cases of anisometropia the vision in the squinting eye was improved on occlusion of the good eye.

In 1820 Johannes Müller in his book on the “Physiology of Sight” wrote at great length on the causes of strabismus.

In cases of divergent squint he gave as the causes:—

(a) *Anisometropia*. In this he quotes Buffon’s ideas, and says that a squinting eye develops suppression and so the sight in that eye fails.

* An abbreviated version of this paper was read at the Ophthalmological Section of the B.M.A. Congress at Oxford, July 24, 1936.

(b) *Squinting associated with amaurotic eyes.* In this case the cause might lie in a defect of the retina, etc.; it might be due to corneal opacities, or to adhesions between the cornea and the conjunctiva.

(c) *Squinting due to what he calls "an unharmonious condition of the eye muscles."* This was apparently a divergence excess, as in these cases the patients squinted in distant vision only.

(d) *Bad habits.*

(e) *Myopia.* In this condition he considered that there was no accommodation and it was a great strain to converge sufficiently.

(f) *Squinting momentarily as the patient changes the distance of fixation.* This he considered to be due to an over- or under-action of a muscle and this condition might be transitory and due to ill-health.

(g) *Strabismus incongruous.* Müller said that this type of squint was "inborn and incurable" and was based on a difference in position of the corresponding parts of the retinae. He regarded this as a throwback to animals. From his descriptions his cases may have been those with a false or secondary correspondence, but on the other hand some of them may have been simply apparent squint.

In 1842, Pickford reported a case of alternating divergent strabismus, in which there was no complaint of diplopia; in binocular vision, however, the patient could get physiological diplopia and the squinting eye was normally active. Either eye had good central vision. He considered that a new retinal correspondence had been formed but that this was secondary to and not the cause of the squint, as Müller thought. In Pickford's opinion the cause was due to the fact that the two internal recti could not work together, and therefore the patient could not converge.

von Graefe suggested that in some cases the cause might be due to an abnormal innervation of a muscle, and in other cases it might be due to an actual muscle defect; for example, the insertion might be unusual, or the muscle might be too long or too short. He suggested also that in some cases there might have been a preceding partial paralysis, which recovered, but after which changes in the nerve or the antagonising muscle might be present. Then, again, the convergence powers differ considerably in different individuals, due to the difference in working of the internal recti with accommodation. Weak convergence gives rise to asthenopia, and will forerun a squint.

Whereas Buffon suggested that in myopes it was tiring to converge to the close near point, and Johannes Müller stated that the impulse to converge was lessened as the accommodation was

not used, von Graefe said that myopes require relatively stronger internal recti to converge sufficiently to their near point. He noted that in cases of divergent squint there was an increase in the binocular field of vision. He stated that, in his opinion, diplopia following operation in these cases, as had been previously reported by Müller and Dieffenbach, was not due to the formation of a new correspondence, but to the "lessened eccentricity of the images on the retina of the squinting eye."

In 1864, Donders, in the second half of his paper, "The Pathogeny of Squint," stated that myopia was the cause of divergent squint and asthenopia. He said that a myope required greater convergence than a normal person, but there were various mechanical factors which helped to hinder him from converging. These factors were, that the eye was ellipsoid and its mobility diminished, the centre of rotation was farther from the posterior surface of the sclerotic, and the angle gamma was small. Convergence insufficiency without myopia was also the cause. Any accessory factor which tended to diminish binocular vision would also tend to produce a squint, such as anisometropia, corneal ulcers, etc.

Giraud Teulon pointed out that in the normal person, if diplopia is produced artificially, it is so disturbing that the eye will make necessary movements to overcome it. In his opinion there must be a primary factor preventing the eye from adjusting itself and he considered that this lay in a primary insufficiency of the internal recti.

In 1896, Javal, in his text book on strabismus, dealt with all kinds of squints very fully. He had treated squints with orthoptic training for over 30 years, and had performed many experiments in binocular vision. He noted that the squinting eye was usually the most astigmatic.

Worth considered that the most common cause of divergent squint was myopia, and was due to not giving glasses. He found that in these cases the fusion sense was well developed and the angle of the squint was never constant. The age of development of the squint was later than in convergent concomitant strabismus, although infantile myopic strabismus could occur, but this was rare.

There is another type of which he made mention, *i.e.*, neuro-pathic divergence, which he said had a family history and developed in infancy; these were not myopic and the fusion sense was feeble.

He also mentioned cases of convergent squint, which, having been treated with glasses, in the course of time became divergent. These he called consecutive divergents and gave no explanation of the condition.

Wootton, in 1916, noted that there were three different kinds of divergent squints:—

- (a) Those arising from a convergence insufficiency.
- (b) Those arising from a divergence excess.
- (c) Those arising from a varying proportion of both.

In the cases of divergence excess he said that hypermetropia was frequent and myopia rare; in cases of convergence insufficiency myopia was frequent and hypermetropia rare; in the third group he said that anisometropia was a common factor.

In cases of divergence excess the deviation was most marked in distant vision, but the convergence was normal. In the type arising from a convergence insufficiency one eye or the other would wander out when looking at near objects.

Duane also described these types of divergent squint; he divided the convergence insufficiency into two types:—

- (a) Accommodative.
- (b) Non-accommodative.

The following are his tables showing the production of a convergence insufficiency and a divergence excess.

Convergence insufficiency.

- 1. Exophoria for near, orthophoria for distance.
- 2. Divergent for near, exophoria for distance.
- 3. Increase of exophoria for distance, squint becoming constant.
- 4. Muscular changes.

Divergence excess.

- 1. Exophoria for distance, convergence normal.
- 2. Divergent for distance, exophoria for near.
- 3. Increase of exophoria for near, recession of near point, squint for near becoming visible.
- 4. Marked divergence.
- 5. Muscular changes.

Dunnington, in 1933, adopted the same classification. He said that in divergence excess the divergence is not completely passive, but is due to a simultaneous relaxation of both internal recti, and a contraction of both external recti. Manifest divergence first occurs when the patient is tired, and is followed by a gradual weakening of the powers of convergence.

Of the convergence insufficiency, he said that 60 per cent. are non-accommodative in type.

Most standard text-books state that divergent strabismus is due to myopia, but this is certainly not the case. In the last century myopes were not given glasses at such an early age, or so frequently as nowadays, and perhaps this early correction of myopes has something to do with the fact that myopia associated with divergent strabismus is rare. Also it might be noticed that

Donders wrote his original paper on only 138 cases of strabismus, both convergent and divergent.

My own cases.—For the purposes of classification Duane's headings cover the ground most efficiently. I am therefore using his classification, but I am also including another large group of convergent squints who, without any operation, have become divergent; for this group I am using Worth's name of "consecutive divergence."

In the statistics I am showing, I am, of course, omitting divergence due to a blind eye and following operation for convergent strabismus.

The following table is taken from 88 cases of divergent squint; in 47 cases the primary condition is convergence insufficiency, in 14 cases divergence excess; 10 cases were alternators and 17 consecutive divergence. Of the latter all were convergence insufficiency in type with the exception of 2 cases. It must be noted that the majority of cases arise from convergence insufficiency.

Sex.—In all types the female sex predominated, forming roughly 70 per cent.

Specific fevers.—The occurrence of a divergent squint arising after specific fevers in childhood is rare.

Shock, fright, etc.—No case gave a preceding history of this condition, as is sometimes the case in convergent squint.

Family history (28 per cent.).—A history of convergent or divergent squint was present in only 28 per cent. of cases. Unfortunately, it is sometimes impossible to obtain an accurate family history, and the percentage is probably higher. In 8 per cent. of cases it was impossible to obtain any family history at all.

Mental factor.—The majority of divergent squints, as indeed is the case with all types of squint, occur among the hospital classes. An appallingly large proportion of these squinting children are below the average in mentality, and some of them are definitely mentally deficient. It must be remembered, however, that a fair percentage of children attending our general hospitals have not a very high mental capacity, on the other hand divergent squint does occur among intelligent but highly-strung children.

Refraction.—In divergence excess: Emmetropes $71\frac{1}{2}$ per cent.; Myopes, nil; Hypermetropes, $14\frac{1}{4}$ per cent.

In convergence insufficiency: Emmetropes, 45 per cent.; Myopes, 17 per cent.; Hypermetropes, 34 per cent.

In alternators: Hypermetropes or emmetropes, 80 per cent.; Myopes, 10 per cent.

In consecutive divergence: Hypermetropes, 100 per cent.

Phorias.—Hyperphoria occurred in 18 per cent. of cases, and double hyperphoria or anatrophia, as mentioned by Worth, was noted in 2 per cent. of cases.

Some aetiological factors arising in all groups of divergent squint

	Divergence excess	Convergence insufficiency	Alternators	Consecutive divergence	Total per cent. of all cases
Number	Per cent. 15½	Per cent. 53½	Per cent. 11½	Per cent. 19½	Per cent. 88½
Sex:					
Male	28½	23½	40	29½	27½
Female	71½	76½	60	70½	72½
Age	Per cent. Birth—7 71½	Per cent. Birth—10 45 10—15 8½ Over 15 10½ 36	Per cent. Babyhood 20 3—6 40 40	Per cent. Age 4 5½ 9—13 76½ 19 5½ 12	
Not known	28½				
<i>Refraction</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hypermetrope	14½	34	40	100	44½
Myope	—	17	10	—	10½
Emmetrope	71½	45	40	—	40
Mixed astigmatism	7½	—	—	—	1½
Myope + hyperm.	7½	2½	10	—	3½
Not taken	—	2½	—	—	—
<i>Phorias</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hyperphoria	14½	19	30	11½	18½
„ + torsion	7½	—	—	—	—
Doub'te hyperphoria	—	4½	—	—	—
<i>Amblyopia</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Amblyopia	7½	12½	—	17½	11½
Torticollis	—	10½	—	11½	8
Weak int. recti	—	2½	10	—	2½
Anisometropia	—	21½	10	5½	13½
<i>Family history</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
History	28½ (1 con.)	27½	30	29½	22½
No history	57½	64	66	70½	65
Not known	14½	8½	10	—	8
<i>Diplopia</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Complained of	14½	15	—	—	10½
With red and green	21½	47	30	29½	37½
No diplopia	28½	8½	30	23½	23½
Not taken	35½	29½	(alternated) 40 (impossible) 1 case M.D. 2 cases below par	47	35

Amblyopia was rare as compared with cases of convergent squint, and occurred in only $11\frac{1}{4}$ per cent. of the total number of cases. It must be noted that the majority of these cases were those of consecutive divergence, and that in the cases in which divergence was the primary condition the percentage was even less.

Torticollis.—This was present in 8 per cent. of cases and was associated with vertical deviation.

Weak internal recti were associated with the alternators and also in long-standing cases of squint, and was present in 2 per cent. of cases.

Anisometropia was again rare as compared with cases of convergent squint, the refraction in most cases being the same in both eyes.

Binocular vision

(showing comparison between convergent and divergent squints).

Number of cases examined 461.

CONVERGENT 81 per cent.

DIVERGENT 19 per cent.

	Unilateral	Alternator	Convergence insufficiency	Divergence excess	Consecutive divergence	Alternator
<i>True correspondence</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1. Binocular vision -	50	$23\frac{1}{2}$	$55\frac{1}{2}$	65	65	10
2. Macular suppression	$8\frac{1}{2}$	$12\frac{3}{4}$	6	—	$5\frac{3}{4}$	10
<i>False correspondence</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
3. Binocular vision -	$9\frac{1}{2}$	24	$8\frac{1}{2}$	—	—	10
4. Suppression - -	$5\frac{1}{2}$	$27\frac{1}{2}$	$8\frac{1}{2}$	—	$5\frac{3}{4}$	10
<i>True and false correspondence</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
5. Binocular vision -	$5\frac{1}{2}$	—	$2\frac{1}{2}$	—	$11\frac{3}{4}$	—
6. Suppression - -	$5\frac{1}{2}$	$1\frac{3}{4}$	—	—	—	—
7. Complete suppression	—	—	$4\frac{1}{2}$	$7\frac{3}{4}$	$5\frac{3}{4}$	—
8. Field suppression -	$1\frac{1}{2}$	—	—	—	—	—
9. Panoramic vision -	—	—	$2\frac{1}{4}$	$7\frac{1}{4}$	—	20
10. „ + true corres.	—	—	$2\frac{1}{4}$	—	$5\frac{3}{4}$	—
11. Not taken - -	$13\frac{3}{4}$	$12\frac{3}{4}$	$10\frac{1}{2}$	$21\frac{1}{2}$	—	40
12. Total per cent. of all convergent or di- vergent squints -	85	15	$53\frac{1}{2}$	$15\frac{3}{4}$	$19\frac{1}{2}$	11

Diplopia.—On questioning, the patients usually admitted that at some time or other they had had diplopia, and some patients came up complaining of the condition. 10 per cent. of the cases admitted to having diplopia, and a further 37 per cent. of cases obtained diplopia easily when tested with the red and green goggles. Unfortunately, this test can only be performed with reasonably intelligent cases, and it is probable that again the actual percentage of cases which do suffer from diplopia without ever being aware of it, is considerably greater.

The previous table shows the types of binocular vision in 461 cases of squint, of which 373 were convergent and 88 divergent.

Group 1 are those cases in which the maculae are corresponding points, and there is some grade of binocular vision.

Group 2 are those cases which, in binocular vision, suppress a varying area in the region of the macula of the squinting eye, but form no false correspondence; these cases when tested on some instrument for ascertaining the grade of binocular vision, say the pictures cross in space at the angle of the squint, but as they cross the picture in front of the squinting eye is suppressed.

Group 3 are those with a false or secondary correspondence, who have some degree of binocular vision with this false correspondence, in these cases the maculae are no longer corresponding points.

Group 4. In this group the maculae again are no longer corresponding points, and the images do not cross at the maculae, but at an angle less than that of the squint, and where the pictures cross there is an area of suppression.

Group 5 are the cases that had a true and a false correspondence.

Group 6 have complete suppression of the squinting eye in binocular vision.

Group 7 are convergent squints who suppress all the retina with the exception of the nasal fields.

Group 8 are cases of divergent squint who have panoramic vision, *i.e.*, they see simultaneously with both eyes although their maculae are no longer corresponding points, but as there is no overlap of the visual fields there is, therefore, no false correspondence.

Group 9 have panoramic vision when they diverged, but binocular vision with true correspondence when they straighten. Of these I will speak later.

It will be noted from the above table that in convergent squint false correspondence is common, while in divergent squint it is rare. This is rather to be expected, for in convergent squint there is a greater overlapping of the visual fields, and whether

the secondary correspondence is acquired or whether there is some underlying congenital factor, with this increased overlapping of the fields, it is naturally easier for a false correspondence to be formed.

With regard to false correspondence which has any degree of binocular vision, it is never formed more than 10° to 12° away from the macula, and is usually less. In convergent squints there are two types which form this false correspondence, *i.e.*, those unilateral squints with amblyopia, and a certain group of alternators.

In divergent squint, on the other hand, the overlapping of the visual fields is lessened and if a false correspondence is formed it would have to be at such a distance from the macula of the squinting eye, that the vision at this point would be very feeble, and would not be of any advantage, and so far easier to suppress. We also notice another significant factor that amblyopia in divergent squint is far less common than in convergent squint.

Binocular Rivalry.

Before dealing with the binocular vision and treatment of these cases, I should like to mention a little about binocular rivalry, and the so-called simultaneous macular perception pictures.

Now, quite obviously, with a picture such as the fish and the bowl, there may be a complete central suppression in the eye in

front of which is the bowl, and the fish will still appear to be in the bowl, *i.e.*, there is macular suppression and not simultaneous perception.

There are many cases which never form a false correspondence, but have a varying degree of suppression in the squinting eye. Even with a picture such as the bird in the cage, the smallest bird which subtends an angle of 4° may still appear in the cage, but there may be an area of suppression smaller than the bird; if the cage is in front of the squinting eye no bars are seen in front of the bird.

Now it must be remembered that binocular vision normally consists not only of fusion, but of suppression, and when two

dissimilar objects fall on identical retinal points, there is always a tendency to suppress one or the other image, and in people with a master eye this is exaggerated.

With the above dot and cross picture, if this is placed in front of the eyes in a stereoscope the cross appears on the dot, but there is a light area round the dot, due to a psychical inhibition

of the retina in that area, so that the cross can be seen. If one examines carefully a fusion picture with a lock, with normal individuals it is noticed that where the two pictures join there is always a similar lightening.

Most normal individuals can see the bird in the cage with the bars in front of the bird with either eye, unless they have a very definite master eye. If, however, one tests people with the rabbit in the hutch picture from the Cruise stereoscope series, in this case the meshes of the wires are much smaller and the evidence of binocular rivalry is more easily shown. I tested 50 people with normal binocular vision with this picture, and found that they fell into 3 groups :—

1. *Those with fairly equal eyes*, who always got an alternating pattern of rabbit and wires, whichever eye had the rabbit in front of it, and could never see the rabbit with the wires over it.
2. *Those with a master eye* who, when the rabbit was placed in front of the master eye, saw it sitting in front of the

wires (this also occurs in cases of convergent squint). With the cage in front of the master eye, the wires were seen over the rabbit, which was very faint and tended to disappear.

3. *Those who always saw the rabbit in front* with no wires over it, whichever eye had the rabbit in front of it. (This is also seen in cases of alternating squint.)

In binocular vision it must be remembered that appreciation of depth and size, distance, etc., depends not only on the fusion of certain objects, but also on the suppression of other objects, and this is largely a psychological process. Objects are simply ignored if they interfere with a clear conception of the object to be viewed.

In many cases of divergent squint there is an exaggeration of binocular rivalry, and although the patient may have fusion with amplitude, and some degree of stereopsis, with the so-called simultaneous macular perception pictures (as is especially seen with the bird in the cage), they get an alternating suppression, or a central suppression in the diverging eye, and they will sometimes say that the two pictures seem to be entirely dissociated, although they are apparently at the same point in space.

Divergence Excess. 14 cases.

	Per cent.		Per cent.
<i>Age.</i> Birth—7 yrs. -	71½	<i>Diplopia</i>	
Not known -	28½	Complained of -	14½
<i>Sex.</i> Male -	28½	With red and green -	21½
Female -	71½	No diplopia -	28½
<i>Refraction</i>		Not done -	35½
Hypermetrope -	14½	<i>Family history</i>	28½
Myope -	—	Nil -	57½
Emmetrope -	71½	Not known -	14½
Mixed astig. -	7½	<i>Binocular vision</i>	
Myope + hyperm. -	7½	True corres. and binoc. V. -	65
<i>Phorias</i>		" " " mac. -	5½
Hyperphoria -	14½	suppression -	—
" + torsion -	7½	False " " binoc. V. -	—
<i>Amblyopia</i> -	7½	" " " suppres- sion -	—
<i>Torticollis</i> -	—	True and false corres. and binoc. V. -	—
<i>Weak internal recti</i> -	—	True and false corres. and suppression -	—
<i>Anisometropia</i> -	—	Complete suppression -	7½
		Panoramic vision -	7½
		" and true corres. -	—
		Not taken -	21½

Age.—If we examine in detail the cases of divergence excess, we find that they occur early in life, *i.e.*, from birth to 7.

Sex.—Approximately 75 per cent. are female in sex.

Refraction.—75 per cent. are emmetropic and none myopic.

In cases where the divergence excess is small, it can pass completely unnoticed by the family; the majority of these cases are an exophoria which has become manifest, and to begin with there is little or no impairment of convergence.

Amblyopia.—This is very uncommon in divergence excess.

Binocular vision.—There is, in most cases, fusion with amplitude and some degree of stereopsis, but they show an exaggeration of binocular rivalry, and with the bird in the cage get an alternating suppression of varying degree, or a complete central suppression of the picture in front of the diverging eye.

If, when testing the binocular vision, the patient is made to fix one picture with the non-squinting eye, and another picture is moved across the temporal field of the squinting eye, the patient will follow it quite correctly with his finger, but on the nasal fields he projects the image as though his eyes were straight, and not diverging. I think the explanation of this is that his muscle sense is faulty, and he does not know when his eye diverges, but when dissimilar objects fall on corresponding retinal points, which they must do when he diverges, he suppresses all except his temporal fields.

Diplopia.—In 14 per cent. of cases diplopia was complained of by the patient, and in a further 22 per cent. a crossed diplopia was elicited by means of the red and green test; the greatest deviation of the images was when the external rectus of the squinting eye was put into action.

Unfortunately, in 35 per cent. of cases it was impossible to do a diplopia test, as the patient was either too young, or too unintelligent.

Exceptions to the general rule were :—

- (a) A child of $2\frac{1}{2}$ years, who had complete suppression.
- (b) An adult, who had panoramic vision.
- (c) A case with marked torsion and hyperphoria, who had suppression in the macular region. In this case the squint was not comitant, and the condition may have arisen from a congenital muscle weakness.

(Since this paper has been written, a case of divergence excess in a myope, with marked anisometropia has been discovered.)

Although amblyopia is rare in all types of divergent squint, very few cases are truly alternating and they always fix with the same eye.

Alternators. 10 cases (1 case M.D., 3 cases below par)

	Per cent.		Per cent.
<i>Sex.</i> Male - - -	40	<i>Diplopia</i> , complained of -	—
Female - - -	60	With red and green -	30
<i>Age.</i> Babyhood - - -	20	Alternated - - -	30
3—6 - - -	40	Impossible to test -	40
Not known - - -	40	<i>Family history</i> - - -	30
<i>Refraction</i>		Nil - - -	60
Hypermetrope - - -	40	Not known - - -	10
Myope - - -	10	<i>Binocular vision</i>	
Emmetrope - - -	40	True corres. and binoc.V. -	10
Mixed astig. - - -	—	" " " mac. suppression -	10
Myope + hyperm. - - -	10	False corres. and binoc.V. -	10
<i>Phorias</i>		" " " suppression -	10
Hyperphoria - - -	30	True and false corres. -	—
<i>Amblyopia</i> - - -	—	Complete suppression -	—
<i>Torticollis</i> - - -	—	Panoramic vision - - -	20
<i>Weak internal recti</i> - - -	10	Not taken - - -	40
<i>Anisometropia</i> - - -	10		

Unfortunately, of the 10 cases examined, one case was definitely mentally deficient and three cases were below normal intelligence.

Sex.—Again the female sex predominated.

Age.—60 per cent. occurred before the age of 6 years, and in the other 40 per cent. the age of the squint had never been noticed by the parents.

Refraction.—It is again noticed that the majority of cases are hypermetropic or emmetropic.

Muscle weakness.—Definite weakness of the internal recti was only noted in one case.

All alternating squints had, of course, marked divergence excess and convergence insufficiency.

The cases were too few to draw any particular conclusions from, but the following facts must be noted: in cases with true correspondence (two cases of this type were seen), one, a child, had normal fusion, the other, an adult who had squinted from childhood, had a central suppression and no fusion.

In cases of false correspondence, both cases were children, and one was seen immediately after developing the squint at the age of 4 years. This is rather significant, as if the false correspondence played some part in the formation of the squint, rather than being secondary to it. The other case with panoramic vision was an adult, whose angle was 45°.

The remaining cases, unfortunately were too young or too unintelligent, to perform any satisfactory subjective tests.

Convergence Insufficiency. 47 cases.

	Per cent.		Per cent.
<i>Sex.</i>		<i>Refraction</i>	
Male - - -	23½	Hypermetrope - - -	34
Female - - -	76½	Myope - - -	17
<i>Age.</i>		Emmetrope - - -	45
Birth—10 - - -	45	Mixed astigmatism - - -	—
10—15 - - -	8½	Myope + hypermetrope - - -	2½
Over 15 - - -	10½	Not taken - - -	2½
Not known - - -	36		
<i>Phorias</i>		<i>Binocular vision</i>	
Hyperphoria - - -	19	True corres. and binoc. V. - - -	55½
Double „ - - -	4½	„ „ „ mac. suppression - - -	6
<i>Amblyopia</i> - - -	12¾	False „ „ binoc. V. - - -	8½
<i>Torticollis</i> - - -	10¾	„ „ „ suppression - - -	8½
<i>Weak internal recti</i> - - -	2½	False and true corres. and binoc. V. - - -	2½
<i>Anisometropia</i> - - -	21½	False and true corres. and suppression - - -	—
<i>Family history</i> - - -	27½	Panoramic - - -	2½
Nil - - -	64	„ and true corres. - - -	2½
Not known - - -	8½	Not taken - - -	10½
<i>Diplopia</i> , complained of - - -	15	Complete suppression - - -	4½
With red and green - - -	47		
No diplopia - - -	8½		
Not taken - - -	29½		

In divergent squints arising from a convergence insufficiency, the angle varies far more than in a convergent squint, and the patient is often conscious of which eye he uses in fixation.

Sex.—Again 76 per cent. are female in sex.

Age.—In the majority of cases the age varies from birth to 10, although a few cases occur in the late teens or early 20's.

Refraction and vision.—These are usually equal and the majority of cases are hypermetropic or emmetropic, although the percentage of myopes is slightly higher in this group than in the others.

Amblyopia is present in a few cases. Large hyperphorias up to 20 to 30 prism dioptres are sometimes found and they are usually associated with torticollis.

Diplopia was complained of in 15 per cent. of cases, and was elicited in a further 47 per cent.

If we examine carefully the factors which produce a divergent squint arising from a convergence insufficiency and consecutive divergence, we find that one or more of the following are usually present.

1. *High hypermetropia.* In this case the relationship between accommodation and convergence is broken down. These cases can be sub-divided into 2 groups:—

(a) *Consecutive divergence.* In these cases the previous convergent angle was small, the fusion faculty was normal, they were

very high hypermetropes who had been corrected with glasses and had straightened. After this at ages varying from 7 to 12 they became divergent. It is a significant factor that none of these cases had any convergence amplitude.

(b) *In cases of convergence insufficiency which occurred after the correction of high hypermetropes with glasses*; this is later followed by a divergent squint.

2. *Arising from congenital weakness or partial paresis of an oblique or vertical muscle*.—This is probably a more frequent factor than is normally realised. It can sometimes be shown by testing carefully the co-ordinate movements, but in other cases it is only shown in the red and green test for diplopia.

3. *Hyperphorias and torticollis*.—A large hyperphoria will upset mechanically the function of convergence. We may note that in some cases it was found that the hyperphoria only became manifest when the torticollis was corrected.

4. *Following illnesses or in debilitated conditions*.—Although a mild degree of asthenopia and convergence insufficiency often develops during illness, it is usually only a temporary condition, and very rarely develops into a divergent squint.

5. *Mechanical obstructions to convergence*.—

(a) *Wide inter-pupillary distance*. It was pointed out by Duane that the true measure of convergence power is the angle through which the eye turns when converging with its fellow, and it will vary as the inter-pupillary distance. Therefore cases with a wide P.D. will have to converge through a greater angle to look at a near object than those with a small P.D.

He gives the true measure of convergence power as:—

$$\tan c = \frac{D}{2PcB}.$$

Where c—convergence power.

D—distance between the visual axes when these are parallel.

PcB—distance from near point of convergence to the base line, running through the pupils.

Two people with the same convergence distance will differ in adduction power as the inter-axial distance differs.

(b) *Exophthalmos*.—Exophthalmic eyes tend to diverge, their axes follow the orbital axes and thus interfere with the convergence powers.

6. *Congenital amblyopia*.—This seems to be rare in the production of a divergent squint, when it does occur it is probable that divergence supervenes as convergence falls into disuse.

7. *Anisometropia* of any marked degree occurs rarely. Difference in clarity or size of the two retinal images makes fusion more

difficult, and if uncorrected by glasses there may be some tendency to suppression of the image in the squinting eye.

8. *Accommodative*.—It is very difficult to assign myopia as the sole cause of a divergent squint, it may be one of the factors that help in the production of the squint, but in all cases some other factors such as hyperphoria or a wide P.D., or as Donders noted, the egg-shaped eyeball, also enters into the production of the squint.

Three myopes developed a divergence some years after they had been treated with glasses, two who developed the divergence at the ages of 13 and 16 were both associated with a large vertical deviation, and complained of diplopia. The third case, a small girl of 9, had a marked torticollis, and when this was corrected the right eye deviated up 8° to 10° , i.e., "strabismus deorsum vergens." These cases could hardly be described as purely accommodative.

9. *Unequal sized retinal images*.—In a certain number of cases, both of convergent and divergent squint, difficulty is experienced in fusion due to the unequal sized retinal images. This occurs in patients who are emmetropic in both eyes, or in cases which have been carefully tested and have accurately fitting lenses. This inequality in size can be shown by means of the pictures designed by Gliddon and Ames. Suitable size-lenses can be fitted to correct this condition, but it is usually found that when the child has learnt to fuse steadily, this inequality in size seems to be overcome without the use of the special lenses.

10. *Following occlusion*.—In convergent squint prolonged occlusion has been followed by a divergence. This is probably due to the fact that convergence falls into disuse and the association between convergence and accommodation is loosened.

11. *Defective fusion centres*.—In cases with true correspondence it is very difficult to decide that the primary cause is due to a defect of the so-called fusion centre; it is much more probable that the fusion has simply fallen into disuse through mechanical obstruction to the requisite movements of the eyes which have to be made in order to enable the macular images to be similar.

In cases with abnormal retinal correspondence there may be some underlying congenital factor in the development of the binocular vision, so that in some cases the binocular vision is like that of a bird of prey and in others it resembles that of a rabbit; the former have four foveae, two for panoramic vision and two for fusion.

12. *Following a purely vertical comitant strabismus*.—Cases of purely vertical strabismus are rare. The above portrait is of a girl with a marked torticollis and a vertical strabismus. At the age of 11 she attended a hospital clinic on account of amblyopia in the left eye. On examination I found that she had a purely

vertical comitant strabismus, which did not alter when the torti-collis was corrected. This case had a false correspondence situated 5° above the left macula, the true vertical deviation being 15° . After a few months the patient developed a divergent squint.

13. *Following perforating corneal wounds.*—This again is a rare forerunner of a divergent squint, but it does occasionally occur, even when the vision of the injured eye, when corrected by a glass, is practically normal.

Binocular vision in cases of convergent insufficiency

In cases of convergence insufficiency with true correspondence.—The age at which patients first squinted does not seem to be a factor in the preservation of true correspondence, nor does the length of time that the squint has been present. Binocular vision was preserved in all cases with a small angle and little hyperphoria, even in adult life. These cases were probably able to fuse over a certain distance. Cases with a large angle suppressed in adult life.

Cases with a large hyperphoria:—

(a) Those who squinted in childhood, had a central suppression.

(b) Those who had squinted in adolescence preserved their fusion and complained of diplopia.

Cases of convergence insufficiency with a false correspondence.—The cases who were seen in adult life were accompanied, except in one case, by amblyopia. A case seen as a small girl, had eccentric fixation.

Cases of convergence insufficiency with panoramic vision.—These cases squinted early in life, and were accompanied by

exophthalmos, a wide P.D., and usually had a large angle squint which varied considerably.

One child had panoramic vision when his eyes diverged, and fusion with true correspondence when they were straight. If he was made to fix an object with his right eye, during exercises for fusion training, he could point correctly to an object anywhere in the field of his left eye, but it never overlapped the field of his right eye. If, however, an object was placed in front of the macula of the squinting eye and he was told to observe it, he could see simultaneously with both maculae, but the objects were at some distance from each other in space. The object in front of the squinting eye was then moved towards the object in front of the fixing eye, and the squinting eye would follow this object round until the two visual axes were parallel, and then the two macular images were projected to the same point in space. He fused with some convergence amplitude, and had a low degree of stereopsis.

It is probable that Kries had this same condition; in Helmholtz's "Physiological Optics," Kries mentioned the fact that normally he had binocular vision, but at times one eye diverged, and when he diverged he never got diplopia and he never suppressed. However, he never formed a false correspondence, because, he said, he localised the position of objects in space quite well with either macula, and could see with both simultaneously; if he tried to fix with both at once, however, he suffered from binocular rivalry. His eyes might be compared with those of a chameleon.

Consecutive Divergence—17 cases

	Per cent.		Per cent.
Sex. Male - - -	29½	<i>Diplopia</i> complained of - - -	—
Female - - -	70½	With red and green - - -	29½
		No diplopia - - -	23½
Age. At age of 4 - - -	5¾	Not taken - - -	47
9 to 13 - - -	76½	<i>Family history</i> - - -	29½
at age of 19 - - -	5¾	Nil - - -	70½
Not known - - -	12	<i>Binocular vision</i>	
<i>Refraction</i>		True corres.with binoc.V. - - -	65½
Hypermetrope - - -	100	" " " mac. suppression - - -	5¾
<i>Phorias</i>		False corres.and binoc.V. - - -	—
Hyperphoria - - -	11¾	" " " suppression - - -	5¾
<i>Amblyopia</i> - - -	17½	" and true corres. and binoc. V. - - -	11¾
<i>Torticollis</i> - - -	11¾	Complete suppression - - -	5¾
<i>Weak internal recti.</i> - - -	—	Panoramic - - -	—
<i>Anisometropia</i> - - -	5¾	" and true corres. - - -	5¾
		Not taken - - -	—

Cases of convergence insufficiency with true and false correspondence.—This condition is common in convergent squints but rare in divergent squints. Only one case was observed. She was seen in adult life and had squinted from birth. The vision was normal in both eyes. Binocular vision with a true or false correspondence was very feeble. She had a true correspondence on moving the picture from divergent to convergent and a false correspondence on moving the picture from convergent to divergent.

Age.—The average age at which convergent squints become divergent is 9 to 13 years.

Sex.—Again we notice a predominance of the female sex.

Refraction.—100 per cent. hypermetropes, the majority being high hypermetropes of over 3 or 4 dioptries, accompanied by astigmatism.

Amblyopia.—The percentage of amblyopia is higher than in the other types of divergence.

Hyperphoria and torticollis of a lower degree than those occurring in primary convergence insufficiency are also present.

Anisometropia of any appreciable amount seems to be rare.

Binocular vision.

(a) *Cases of consecutive divergence with true correspondence.*—This was present in 65 per cent. of cases, and $5\frac{3}{4}$ per cent. of the cases with true correspondence had macular suppression.

The first case of consecutive divergence which I saw was in a small boy, aged 9. He had a convergent squint of 5° only, was very hypermetropic and amblyopic in the left eye. I occluded the right eye and some 9 months later when I removed the disc, he was diverging 20° .

Of the cases with true correspondence the fact must be stressed, that they had little or no amplitude of fusion.

(b) *Cases with abnormal correspondence.*—Two adults, who gave a history of consecutive divergence, had both had convergent squints from birth until adolescence, and had then diverged. Both were associated with nystagmus; one had a false correspondence, the other panoramic vision on diverging and true correspondence on straightening.

Two cases, one an emmetrope, and the other a hypermetrope, had unequal sized retinal images, when tested with the size lenses described by Gliddon and Ames.

Treatment

Glasses are of little use except in the case of myopes; hypermetropes and consecutive divergences are best undercorrected.

Occlusion.—Continuous complete occlusion should be carried out as early as possible in all cases of amblyopia.

Orthoptic treatment.—Very few children are suitable for treatment before the age of 6 years, and most hospital patients are not suitable until even later than this.

There seem to be three types of patients who squint :—

(a) Those who do not mind if they squint or not, and are usually of low mental capacity.

(b) Those who regard their squint as an asset.

(c) Those who want to be cured.

Types (a) and (b) are hopeless to treat. The third type may be very sensitive about the condition, and thoroughly "soured on life," they are often highly strung and nervy, but their whole outlook on life changes when they are cured.

Types of squint which respond to treatment

The most favourable types are the divergence excess and the consecutive divergence. Less favourable are those with a convergence insufficiency, large hyperphoria, torticollis, etc. Squints with false correspondence are the least favourable, and invariably have to be operated upon. It is better, however, to obtain a steady fusion before operation if possible.

Method of procedure.—Before attempting orthoptic training it should be explained to the patient what is required of him. It never seems to occur to the patients, even those who suffer from constant diplopia, to try and move the images together and pull the eyes straight. I have also had patients who have had some previous training, who have confessed that they have never found out what they were required to do. To get a good result, it is absolutely essential to have active co-operation on the part of the patient.

Stage 1.—The first stage is to make the patient squint-conscious, by breaking down suppression and encouraging diplopia. Red and green goggles are given to the patient, so that he can practise getting diplopia, and then learn to pull the two images together. It is amazing how an adult, in a short space of time, will learn to control a large vertical deviation.

The second way in which to help break down suppression is to make the patient practise with the bird in the cage pictures, until he can see the bird behind the bars with either eye; when this occurs a divergence excess should see double whenever he squints, and he can then learn to correct it.

Some cases have a curious faculty of always seeing one picture nearer than the other, and they have to learn to judge distance correctly. It is partly by means of convergence that we judge distance correctly, and lack of normal convergence may help in causing this factor.

Some patients find it helpful to practise correcting their squint in front of a looking-glass.

The aim and object of all this is to teach patients always to get diplopia when they squint, and then to learn to correct it and not suppress; they must also learn to get physiological diplopia.

Stage 2.—This stage is to improve the fusion power where necessary, and especially to give good amplitude.

The divergence excess must be taught voluntary convergence, and must be able to converge with the Grade 1 pictures.

Stage 3.—This stage is to correlate convergence and accommodation.

It must be remembered that a squint is not cured until the patient can obtain binocular vision at any distance and for any position of the eyes.

Convergence can be encouraged first by making the patient converge with minus spheres, which are gradually reduced. Patients must have a convergence amplitude of from 40° to 60° , and also a good voluntary convergence.

A final exercise is to make the patients converge against prisms, using the Maddox rod and the spotlight; this is, of course, very difficult to accomplish as there is no impulse to fuse.

Cases with false correspondence.—There are many varieties of false correspondence, and the subject is too large to be dealt with here. Briefly, however, the cases which already have some macular correspondence are easier to treat than those which have none. Cases which have any degree of binocular vision with this false correspondence are also very tiresome.

Alternators with false correspondence must be trained, and then operated upon at as early a date as possible. The later a false correspondence is left (*i.e.*, the greater the part of a child's life it has been present) the less are the chances of success with orthoptic training, and the more likely it is to diverge after operation, and relapse to its former false correspondence.

Cases with panoramic vision and true correspondence on straightening do very well with training.

Operations

Operations should be accompanied by orthoptic training before and after the operation if possible.

Luckily, orthoptic training has good results in most cases of divergent squint who have any intelligence, as the operation results are not so good as those for convergent squint. Over-correction must always be aimed at, especially in cases with false correspondence.

Tenotomy of the external rectus gives very little result, and

recession alone is of very little advantage. The best method of procedure is an advancement accompanied by, or without, a recession; but even if the eyes are straight for some months after operation, the squint tends to relapse later.

All patients must learn to co-operate, and they must also learn that the faculty of binocular vision can only be achieved by thinking constantly of using the two eyes together, not only during the time of orthoptic training, but during every waking moment of their normal life.

I would like to thank Mr. Juler and Mr. Williamson-Noble for all their kindnesses to me in the past, and for lending me so many of their beds for my operation cases of squint.

I should also like to mention the fact that the "diplopia goggles" were made for me by Messrs. George Spiller, at a price which is well within reach of all hospital patients.

EXTRA-OCULAR INFLUENCE IN GLAUCOMA*

(constitutional factors)

BY

FARID MASSOUD

CAIRO

IN quoting the words of three different observers, the present-day opinion with regard to glaucoma and extra-ocular influence is best understood.

Wegner¹ describes glaucoma as "an affection that comes not only from the eyes but also from other extensive localities in the organism."

Jameson Evans² considers glaucoma "as but the ocular symptom complex of a generalised change." While Terson³ recommends a glaucomatous patient to be treated as any patient internally diseased.

In point of fact, in the study of glaucoma, the importance must be emphasised of the study of the general body processes going on at the same time in the whole organism. This is not only because of the definite departure from the normal found in certain parts of the body, but also because of the intimate relation that connects them to the local processes going on in the eye.

* Read at the Annual Meeting of the Ophthalmological Society of Egypt, March 26, 1937.