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Recent Investigations in Strabismus.

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REPRINTED FROM

The New York Medical Journal

for August 16, 1890.

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Since the appearance of Professor Schweigger's monograph on strabismus, ophthalmology has lost the peace of mind it had previously enjoyed in this respect. Its tranquil faith in the theories of its great masters was disturbed. Donders and Graefe and all the other leaders in the science had taught that a squinting eye gives up all its visual function in that part of the field which is common to both eyes, that its impressions were "excluded," and thus they explained the amblyopia generally found in such eyes (and therefore termed *amblyopia ex anopsia*) and the absence of diplopia.

But Schweigger found, or confidently believed he had found, that all this was false, and called it a "history of errors." From him we learn that the strabotic eye yields its full complement in the common visual act, and that the amblyopia mentioned above is congenital, in no way differing from ordinary congenital amblyopia, and, far from being the result of strabismus, is in itself a factor in its production. Abandoning the old theory of the "innate identity" of corresponding retinal areas, which had necessitated the

"exlcusion theory," he regarded the faculty of binocular vision as acquired, and, as such, as easily unlearned in early youth, and that in strabismus new associations take the place of earlier acquired relations. Thus he escapes the difficulty of explaining the absence of diplopia.

New facts bearing upon this discussion were few, and the matter has remained a disputed question. Light has, however, been thrown upon this subject recently. Dr. Hirschberger, of Munich, published an article entitled The Binocular Field of Vision of the Strabotic,* embodying the results of a long series of examinations and experiments made while assistant at the ophthalmological clinic of the Munich University. This article must be looked upon as the most valuable and important contribution that has been offered in deciding this question.

Having seen him examine many of his patients, and having verified his results by frequently repeating his examinations for myself, I can testify to his results. The remarkable facts revealed, and their interest and many-sided importance, lead me to bring an account, as far as he has published it, before the American profession.

Recognizing that the mooted question could be solved in no other way than by accurately determining in strabismus the part played by each eye in vision, and not in certain parts of the field of vision only, but throughout the whole field, Hirschberger devised a method of examining as simple as it is efficient and ingenious.

He examined the field at the perimeter, leaving both eyes open, the non-deviating eye being directed upon the center; the test object used was a spot of blue color.†

* Binoculares Gesichtsfeld Schielender. Von Dr. Karl Hirschberger. *Münch. medicin. Wochenschr.*, 1890, No. 10.

† A blue spot was preferred, because the normal field of vision for this color is almost as large as for white.

and a plate of glass of the complementary color—yellow—was held before one eye. To the eye seeing through the yellow glass the spot appeared black, and so it was easy to distinguish throughout the field where it appeared black and where blue, or, in other words, when it was seen by one eye and when by the other.

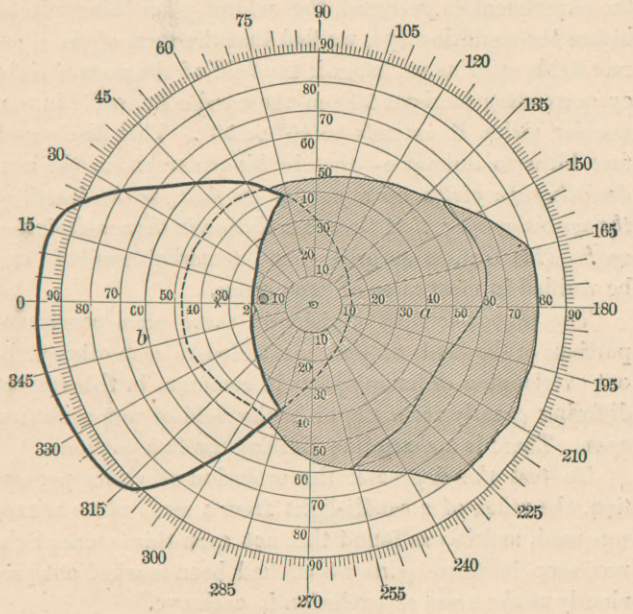

Fig. 1

Subjecting cases of divergent strabismus of moderate degree to such an examination, he found a composite figure resulting similar to Fig. 1. This represents the field of a case of divergence of the left eye of 35°. The yellow glass was held before the right eye. The shaded portion shows where the blue spot was looked upon as black, the field of

the right eye; the clear part where it was recognized as blue, the field of the left eye. This proves that *the field of the left squinting eye is somewhat restricted in binocular vision*, for, under normal circumstances, it should extend about 35° farther to the right, as is shown when examined singly; hence *there is exclusion in the squinting eye.* If, however, the experiment is reversed, the colored glass being placed before the squinting eye, we find that the form of the separate fields remains unchanged, the field of the normal right eye extending to about 20° on the nasal side, while in monocular vision it extends to 40° or 50°. This discloses a fact hitherto unknown—that in binocular vision the *non-deviating eye yields up a part of its field for the benefit of the squinting eye; that there is exclusion in the non-deviating eye!* This fact, as surprising and remarkable as it is, can be verified in most cases of strabismus.

The binocular field of vision in these cases consists of portions of the fields of each eye added to each other without overlapping or having parts in common, in this respect differing greatly from the binocular field of non-squinting eyes. There is a sharp line dividing the two portions.

To test the degree of the exclusion of visual perception, the reflex of a candle-light from a small plane mirror was used, and it was found that not even this intense light was seen in those parts which had been marked out previously as the areas of exclusion in each eye.

The size of the areas of exclusion was generally found to be in an inverse ratio to the degree of the angle of the divergent strabismus.

Examining the binocular fields in convergent squint in the same manner, they were found more or less as represented in Fig. 2. This is the field of a case of convergence of 30° of the left eye. The yellow glass was held before the right eye; *a*, *a* are entirely controlled by the right eye,

b, *b* by the left; *c*, *c* are variable, in some cases belonging to the one, in others to the other eye, occasionally to both. As in the case of divergence, reversing the glass does not alter the form of the separate fields.

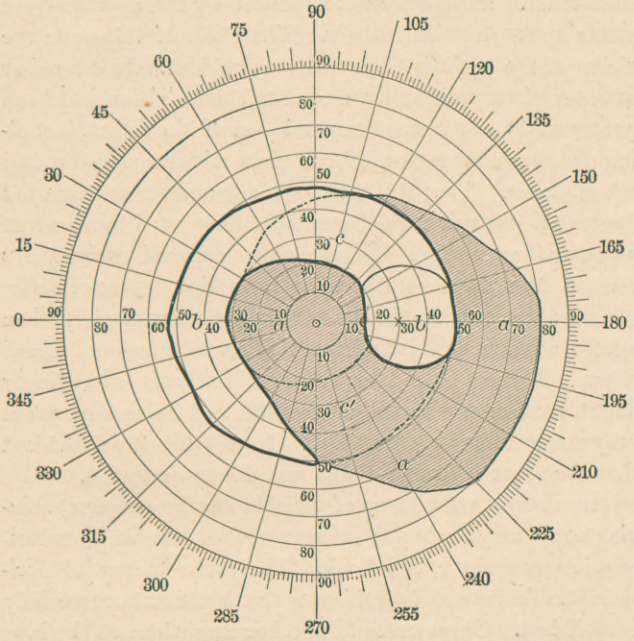

Fig. 2

Though the figures in the cases of divergent and convergent squint appear very different at first glance, it is evident, firstly, that in both cases the macular region of the squinting eye has exclusive control of its part of the field of vision, the non-squinting eye yielding up its function there entirely, and, secondly, that the most lateral part on the side of the squinting eye beyond the area of the normal field of the other eye is entirely allotted to the squinting one.

The regularity of these results was such that these statements may be looked upon as general laws. There are but few exceptions to the first. When the angle of strabismus is so small that the macular regions almost cover each other. *In this case the macula of the squinting eye yields up its function entirely.* The effect of this upon the vision of the squinting eye was very evident. In a number of cases of very slight divergent strabismus vision had been permanently lost in the temporal part of the retina, including the macular region (those parts where exclusion had taken place). That this was not congenital amblyopia but due to the exclusion was beautifully illustrated in a case of a young farmer whom Hirschberger examined twelve years after he had been operated upon for a high degree of divergent strabismus. At the time of the operation the boy, then aged nine, had one third normal vision, as the hospital record shows. Twelve years later the strabismus was exceedingly slight, but central vision had been lost and the patient could only count fingers eccentrically. In this case it was evident that the great failure of vision was due to exclusion.

In cases of strabismus of variable degree *complete exclusion* could not be found in any part of the field, and diplopia was easily called forth. The same is true of periodic strabismus or of strabismus that has not become fully established. These cases form other exceptions to the laws stated above.

The projection of the strabotic eye was examined and found in accordance with the strabotic position; in other words, objects seen entirely by the squinting eye are "projected" in their proper positions in space and not displaced as in cases of ocular paralysis. This projection is not congenital, but depends upon the position of the eye, as is shown by changes which it undergoes when the relative position of the eyes is altered by an operation which either

relieves the strabismus entirely or diminishes it. In this false projection lies the explanation of the peculiar diplopia often found after strabismus operations—a diplopia equal to the angle between strabotic and the subsequent position.

This strabotic projection is lost in a few days, or may last for weeks or even months, the eye finally adapting itself to its new position. It was found that the whole retina does not undergo this change at one time, but that the peripheral parts adapt themselves much more rapidly, so that a careful examination will sometimes detect various forms of projection in different parts of the field of vision for the same eye, and, in consequence, different kinds of diplopia.

Conclusions.—The facts brought out by the article are:

1. *Exclusion* of certain parts of the field of vision is not only possible in strabismus, but *takes place in the non-deviating as well as in the squinting eye.*

2. *The binocular field of vision of the strabotic is made up of parts of the field of each eye, these parts rarely overlapping at any point.*

3. *That part of the field of the squinting eye which corresponds with the macular region of the non-squinting eye is always suppressed, and, vice versa, that part of the field of the non-deviating eye which covers the part upon which the macula of the squinting eye is directed is likewise suppressed. There is a sharp line of demarkation dividing the macular areas of the two parts of the binocular field.*

4. *When the degree of strabismus is very slight, the macula of the squinting eye suppresses its image for the benefit of the macula of the other eye.* This is the only case where the macula of the squinting eye does not take any share in vision, and is an exception to No. 3.

5. *The degree of amblyopia depends upon the part that the macula of the squinting eye plays in binocular vision*, this

being the explanation of the enormous differences in the strabotic amblyopia.

6. *The squinting eye learns to project images properly.*

The corollaries to be drawn are numerous. I shall only call attention to the importance of early operations, especially when the strabismus is of slight degree, and of perfectly correcting cases of high degree, the dangers of slight degrees as far as central vision is concerned being much greater. The importance of training in binocular vision subsequent to operating is likewise fully shown by these facts.

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