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## COMMUNICATIONS

### ACCOMMODATION*

BY

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LEIDEN

MUCH work has been published on the subject of accommodation, but in spite of this many of the chief points still remain obscure. We are still ignorant of the relation of the contraction of the ciliary muscle to the increase of the refraction of the lens. Thus some ophthalmologists still consider that contraction of the ciliary muscle produces a shortening and stiffening of the suspensory ligament of the lens (zonule of Zinn), while the majority on the contrary believe that the suspensory ligament is relaxed by the contraction of this muscle and, as a result of its own elasticity, the lens alters in shape. But even if we accept this view, it is still an open question whether maximal contraction of the ciliary muscle is required to produce maximal accommodation. Donders, Landolt, Clarke and Duane, believe this to be the case; thus it follows that, in their opinion, a young person possessing 14 dioptres of accommodation has only to use a small amount of contraction of the ciliary muscle to increase his refraction by 1 dioptre, whereas a person who has reached an age at whch only 1 dioptre of accommodation is left has to use a maximal ciliary contraction to produce this effect. Fuchs and Hess, on the other hand, do not agree with this view. They consider that

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the ciliary muscle can always contract much more than is necessary for maximal accommodation. Fuchs speaks of a physical and a physiological near-point. The physical near-point is the result of the accommodation as limited by a physical condition, the elasticity or flexibility of the crystalline lens. This is the normal near-point which steadily recedes with age because the elasticity of the lens and with it the physical accommodation steadily diminishes. The physiological near-point is the point which could be reached if the accommodation was only limited by the contractibility of the ciliary muscle, a physiological condition. This physiological near-point could be reached if the lens was perfectly elastic so that each relaxation of the zonule of Zinn produced by the contraction of the ciliary muscle caused a change in the shape of the lens and so increased its refraction. We need not assume that this physiological near-point recedes with age.

Hess thinks it possible that for every increase of one dioptre in refraction we need the same amount of increase in contraction of the ciliary muscle. Hess offers no proof of this assumption, but we will accept it for the moment and see if it is susceptible of proof. As the unit of ciliary muscle contraction we will take the amount necessary to raise the accommodation from 0 to 1 dioptre and call this unit a *myodioptre.*

If Hess's supposition is correct we need for an accommodation of 8 dioptres a force of 8 myodioptres. Thus in Fig. 5 to reach the physical near-point we require a contraction of 10 myodioptres, while to reach the physiological near-point the whole force of 24 myodioptres is needed.

We are now faced with three open questions:

(1) Is maximal contraction of the ciliary muscle necessary to produce maximal accommodation?

(2) Is the myodioptre a constant value?

(3) How strong is the force of the ciliary muscle expressed in myodioptres?

To these three main questions we may add two subsidiary ones:

(4) Is it possible to detect very slight paresis of the ciliary muscle?

(5) Is it possible to draw curves indicating the paretic effect of various drugs on the ciliary muscle?

If we examine the accommodation by measurement of the physical near-point the muscle may be considerably weakened before any interference with accommodation can be detected. Thus in Fig. 1 14 myodioptres of the ciliary muscle can be out of action (nearly three-fifths of the whole) before the uniocular near-point begins to recede. In older persons with less manifest accommodation a much greater amount of the muscle must be affected before the near-point recedes.

Since we do not at present possess a satisfactory method of determining slight paresis of the ciliary muscle we do not know the paralysing effect of many drugs, even those in daily use like cocain. If a drug only causes a partial paralysis of the ciliary muscle, as is the case with cocain, the near-point will not be altered so long as the paralysis is less than the latent ciliary muscle contraction and so the effect of such a drug on the ciliary muscle may pass unobserved. Thus, in the case of cocain, we find considerable divergence in the views held as to the amount of ciliary paralysis

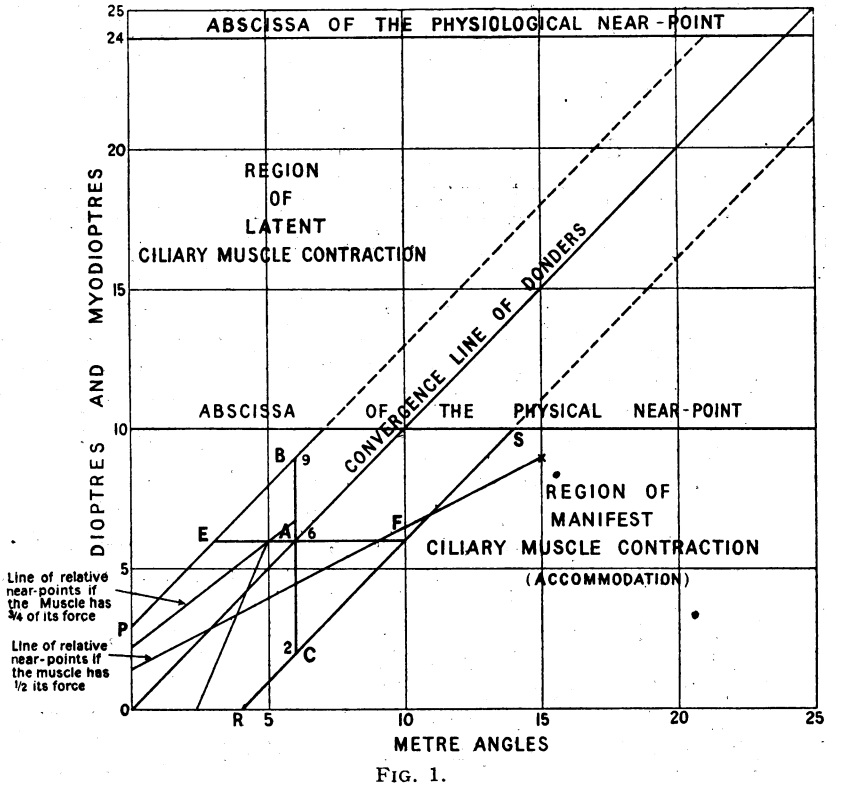


FIG. 1.

produced by it. This divergence can be largely explained by individual conditions and the different ages of the subjects.

My assistant, Dr. Flieringa, and I have tried to solve these questions by careful study of the relative accommodations.

As is well known there is a definite relation between convergence and accommodation so that an emmetrope, when fixing a near object, has to accommodate as many dioptres as he has metre angles to converge.

In Fig. 1 the abscissae represent the convergence in metre angles and the ordinates the accommodation in dioptres. We can now join

all the points for which the number of metre angles is the same as the number of dioptres of accommodation by a straight line. If we take the linear measure for the metre angles on the same scale as that for the dioptres, this line will divide the right angle between abscissae and ordinates into two equal parts. This line is called the *convergence line of Donders.* If the relation between convergence and accommodation was an absolutely fixed one it would be impossible to see singly and distinctly at the same time any other points than those of the convergence line, but we know that this relation is not absolute. At every grade of convergence a certain amount of variation of accommodation is possible and similarly at every grade of accommodation the convergence can be varied to a certain degree. The accommodation at a fixed degree of convergence is termed the relative accommodation and the convergence at a fixed accommodation the relative convergence. The amount of relative convergence and relative accommodation can be increased by practice. Fig. 1 serves to illustrate the meaning of relative accommodation and convergence. Thus when the eyes are converging for 6 metre angles the accommodation may be raised from 6 to 9 dioptres (A to B, Fig 1), and, with the same convergence, 6 metre angles, lowered to 4 dioptres (A to C, Fig. 1). The former is known as the positive relative accommodation, the latter as the negative. The lines which connect respectively the relative near- and far-points in different degrees of convergence are called the relative near-point line (P, Fig. 1) and the relative far-point line (C, Fig. 1). Hess and others came to the conclusion that the relative accommodation has the same variation in every degree of convergence, as a rule, and that, consequently, the relative near- and far-point lines are straight lines parallel with the convergence line. Hess could only determine this in the region of manifest ciliary muscle contraction and assumed, but without any proof, that the lines may be lengthened in the region of latent ciliary muscle contraction. This leads us to a sixth open question:

(6) What is the course of the relative near- and far-point lines in the latent region of ciliary muscle contraction?

It is obvious that the near-point line for accommodation is the far-point line for convergence and vice versa.

Our first observation was made with a modification of Hering's haploscope to determine the near- and far-point lines. We then argued that since the observer in Fig. 1, when his eyes are converging for 6 metre angles, can produce a ciliary contraction of 9 dioptres by maximal voluntary effort 1/9th of a metre is the relative near-point at a convergence of 6 metre angles. This near-point is a physiological near-point limited by the highest possible ciliary muscle contraction at this convergence. If the muscle is weakened in the slightest degree the same impulse will give a smaller

contraction which will be immediately detected by the recession of the relative near-point as the positive part of the relative accommodation will diminish. By this method we can detect even the smallest amount of ciliary muscle paresis provided that we know the relative accommodation of the subject beforehand. In this way we are able to solve question 4. Thus if we find in a case of ciliary paresis that when the eyes are converging for 5 metre angles the maximal accommodation obtainable is 6 instead of 8 dioptres we may assume that only 6/8ths of the muscle are working and that the remaining 2/8ths are paralysed. This will only be true if the myodioptre has a constant value. We can control this by measurement of the relative near-point for various degrees of convergence in the same case. Thus, if in the case used above the eyes converge for 3 metre angles, the maximal contraction of the healthy muscle, 6 myodioptres, should be reduced to 4.5 (4.5/6 = 1/4) and at 1 metre angle the corresponding figures should be 4 and 3 myodioptres. Any number of control distances may be used and if they all give the same amount of weakness of the ciliary muscle the myodioptre is proved to have a constant value (question 2).

We are now in a position to deal with question 3, the value of the force of the ciliary muscle as expressed in myodioptres. This is done by using a mydriatic to procure partial paralysis of the ciliary muscle and measuring the amount of paralysis produced by the method just described. Let us assume we find the muscle to have lost just half its force. We then determine the uniocular near-point. If this is, as in Fig. 1, still at 10 cm. then we may say that half the force of the muscle can produce 10 myodioptres and, consequently the total force of the muscle must be 20 or more myodioptres. Now let the mydriatic act further until the muscle has only one third of its force, if then the highest uniocular accommodation is found to be 8 dioptres, one third of the muscle produces 8 myodioptres and, consequently the value of the unparalysed muscle must be 8×3, 24 myodioptres. The results can be controlled by as many measurements as we like and, if these are found to correspond, we may consider the method a satisfactory one. In this way we can measure the total force of the ciliary muscle in myodioptres, obtain further proof of the constant value of the myodioptre, and deduce the fact that maximal contraction of the ciliary muscle is not required for maximal accommodation (questions 1 and 3).

To trace the course of the accommodation near-point line in the latent part of the region of ciliary muscle contraction, certain points on this line may be determined as follows:

Paralyse the ciliary muscle and determine the amount of paralysis by the method just described. Assuming this to be one half we then find the relative near-point (Fig. 1) for a convergence of 6 metre angles to be 4.5 instead of 9, and for a convergence of 7

metre angles to be 5 instead of 10. Thus if we do the same at a convergence of $p$ metre angles and find a certain near-point with an accommodation of $n$ dioptres we may say that the half paralysed muscle possesses $n$ myodioptres and therefore the normal muscle would possess $2n$ myodioptres. The relative near-point of the normal muscle lies on the ordinate of $n$ metre angles and the abscissa of $2n$ myodioptres. We can in this way determine as

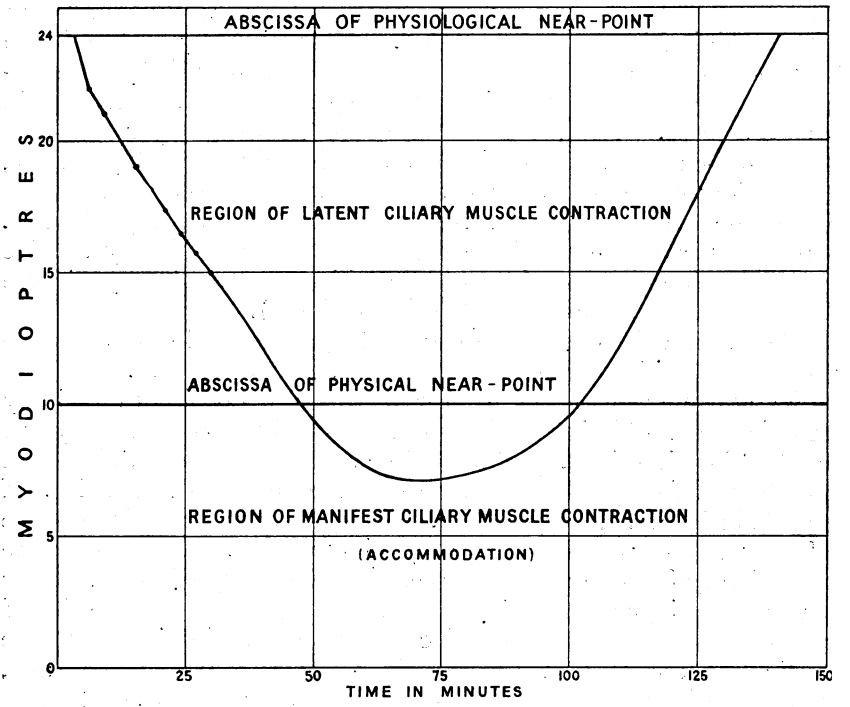


FIG. 2.

many points on this line as we choose and control them by determination of the points at different stages of paralysis. The determination of the relative far-point line can be carried out in the same way (question 6).

The last question we set out to answer, the possibility of describing a graph of the paralysing power of a drug (question 5) may be solved in the same way. The force of the normal ciliary muscle of the subject is first determined in the way already described. The drug to be tested, such as homatropin or cocain, is then instilled and the degree of paralysis measured at regular time intervals. Fig. 2 illustrates the method of tabulating the results. The ordinates correspond to myodioptres and the abscissae to the

time intervals reckoned in minutes. If the ciliary muscle under observation has a force of 24 myodioptres and for the first three minutes after instillation of the drug no paresis is detected the curve starts with a horizontal line. If three minutes later there is a loss of 1/12th of the force the point is marked at 22 myodioptres and so on. In this way the curve of Fig. 2 was obtained and from it we can determine whether the paralysis goes beyond the region of

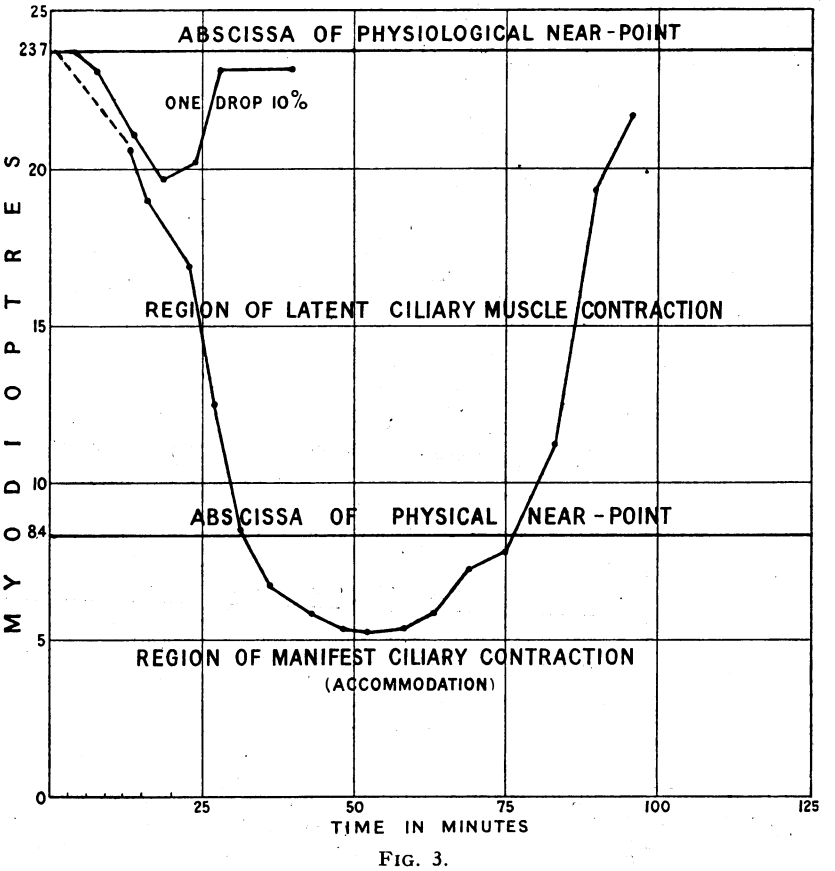


FIG. 3.

latent contraction or not. As soon as this is the case the absolute near-point begins to recede and from that point we can control our results by also marking the absolute near-point at the same time intervals. If the curve thus obtained is the same as the part of the curve obtained by the measurement of the relative accommodation in the region of manifest ciliary muscle contraction, a further proof of the exactness of the method is afforded.

To test the methods above described we made diagrams of two subjects, the first thirty-one and the second twenty-four

years of age. The first was found to have a total force of ciliary muscle of 23.7 and the second of 20 myodioptres. In both diagrams the relative near-point lines found in the region of latent ciliary muscle contraction are parallel to the convergence line; the prolongation of this line in the manifest accommodation region is also fairly well shown. The results are quite satisfactory and enable us to conclude that the myodioptre is of constant value in both subjects and that the ciliary muscle force is much greater than is required for maximal accommodation.

The results of the use of cocain are of considerable interest.

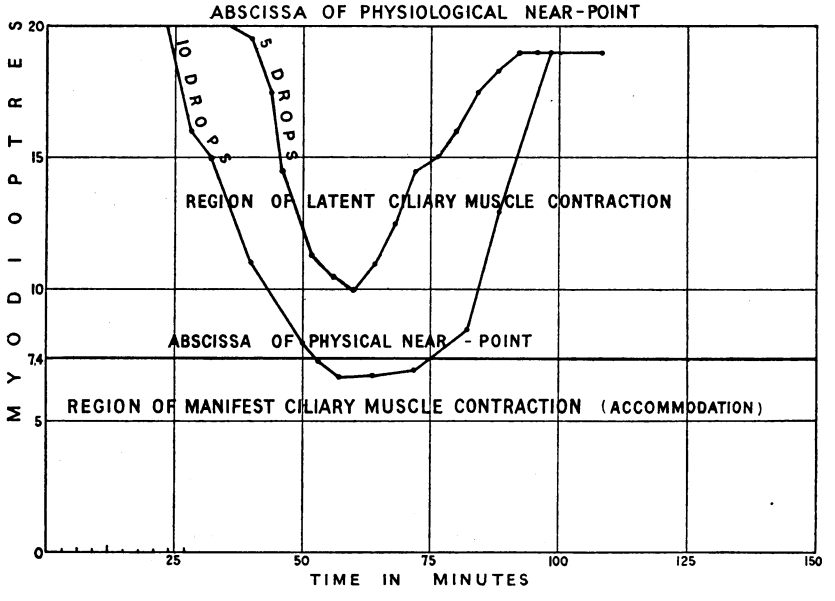


FIG. 4.

In one subject one drop of a ten per cent. cocain solution caused a very brief paralysis reaching a maximum of 4 myodioptres, while seven drops of a five per cent. solution instilled at intervals of three minutes caused a maximal paralysis of 18.5 myodioptres with a duration of 96 minutes. We thus see that cocain causes a brief cumulative paralysis (Fig. 3). This is confirmed by the result obtained from the other subject. In this case five drops of a five per cent. solution caused a paralysis of only 10 myodioptres. As this did not exceed the latent region it would have passed unobserved by the usual method of determination of the uniocular near-point. Ten drops of a five per cent. solution caused a paralysis of 14 myodioptres. Fig. 4 shows that the instillation of more drops of cocain not only increases

the amount of the paresis but also causes it to appear earlier. The action of cocain may be described as cumulative in every direction.

We may also note from these curves that the action of cocain differs in different individuals; this may account for the various reports on its action to be found in the literature. If sufficient cocain is not instilled and the accommodation tested by the recession of the near-point no paralysis will be detected as is also the case if

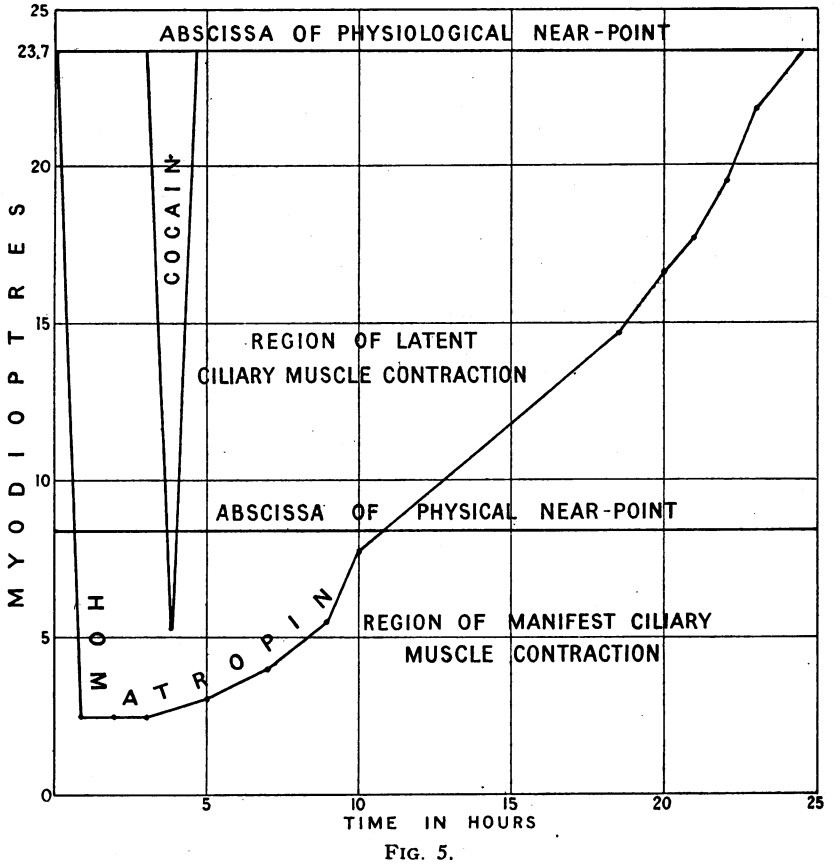


FIG. 5.

sufficient time is not allowed. Thus in Fig. 3 it may be noted that after the instillation of seven drops no recession of the near-point was found till after the lapse of 32 minutes from the first instillation. The recession of the near-point may also be missed if the examinations are made at too long intervals.

Homatropin shows the same individual differences. In the younger subject one drop of homatropin gave a paralysis of 9.5 myodioptres, while in the older subject the same quantity gave a

paralysis of 20 myodioptres. The curve of homatropin paralysis has a very steep ascent and a slow descent while in cocain both ascent and descent are steep (Fig. 5).

The curves illustrate many other interesting points such as the influence of heterophoria, the stage of paralysis at which the uniocular and binocular near-points differ, and the difficulty in reading experienced by persons who have been ill or who are hypermetropic, although they appear to have sufficient accommodative power.

We can hardly hope that such measurements, the technical difficulty of which is so considerable, can ever be of much clinical use but we hope to have shown that the careful study of relative accommodation by such methods can give us a more accurate view on several questions concerning accommodation.

## THE COMPARATIVE VALUE OF COCAIN SUBSTITUTES*

BY

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I WILL endeavour to be as brief as possible in what I have to say, for it seems to me that this discussion will best serve its purpose, if the experience of everyone here, to the exclusion of theoretical considerations, can be made available to our knowledge; the combined experience encompassed by this meeting must represent many thousands or perhaps hundreds of thousands of observations.

I judge from the published title that it is cocain substitutes and not cocain itself which are to form the subject of discussion. I imagine, however, that we shall all feel disposed to use cocain as our standard of reference, and to speak of substitutes in terms of this adopted standard.

The following are the most important drugs which have been used for local anaesthesia in addition to cocain:

(1) Holocain.
(2) α and β Eucain.
(3) Euphthalmin.
(4) Novocain.
(5) Anaesthesin.
(6) Subcutin.
(7) Antinesin.

*Contribution to a Discussion held at the Royal Society of Medicine on December 7, 1923.