portunity was afforded to institute any treatment.

From the very meager reports we have of case histories, it may be assumed that lipemia retinalis is a rare condition. In my opinion the scarcity of recorded cases may be accounted for partly by the fact that these patients, because of unaltered visual acuity, are seldom advised to seek the assistance of ophthalmologists. I believe, too, as has been pointed out by Cohen, that with the more general and systematic use of the electric ophthalmoscope by the internist, a greater proportion of cases will be discovered in the future than there have been recorded in the past.

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STUDIES IN MONOCULAR AND BINOCULAR ACCOMMODATION WITH THEIR CLINICAL APPLICATIONS.

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NEW YORK.

The results of testing accommodation in 2,000 additional eyes, making in all 4,200, are here recorded, and also those obtained by testing the binocular accommodation in 500 patients. The bearing of these results on the theory of the mechanism of accommodation and their important practical applications are pointed out. Read before the American Ophthalmological Society, May, 1922.

In June, 1912, the author presented to the Ophthalmological Section of the American Medical Association a report[1] summarizing the work he had carried on for five years, on the amplitude of accommodation at all ages. In the chart accompanying the report, the values of the accommodation found in 2,000 eyes were plotted, and from these values a curve was drawn showing the mean and also the maximum and minimum values found for the accommodation at each year of life.

These results showed certain important modifications of the mean curve obtained by Donders in his pioneer investigations made over a half a century before. That the modifications were in general correct is deduced from the fact that the results obtained were derived from eight times as many cases as Donders used, and the tests, moreover, were made under conditions designed to insure rather greater accuracy. For example, Donders assumed that a middle aged individual who had normal vision and did not accept a convex glass was emmetropic. This assumption, we know, is far from correct—such subjects often having a latent hyperopia of a diopter or more. The failure to recognize this hyperopia would obviously make the estimate of the accommodation in the subject tested just that much too low. In our own series of cases, every subject up to the age of 47 was tested under homatropin, in order to determine the true refraction, and on the basis of this finding the results of the accommodative test were evaluated.

A more important difference between the two sets of observations was the fact, that in our series observations

were multiplied, until it was possible to determine with some degree of certainty not simply the mean but also the maximum and minimum values at each age. This was not possible with the comparatively few observations that Donders gathered.

The importance of determining these values, particularly the minimum at

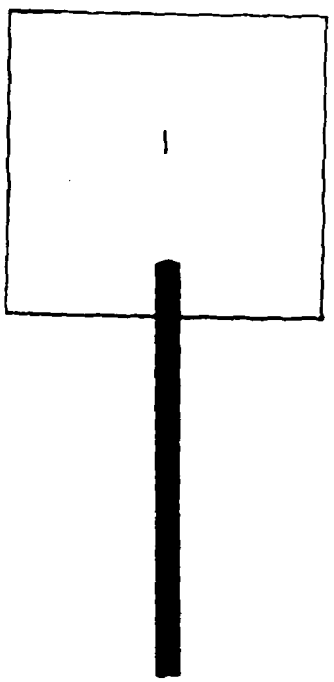

Fig. 1. Accommodation Line. The test for the accommodation consists of a fine vertical line engraved on a card which is held in a suitable clip.

each age, is obvious. In measuring the accommodation in different patients of the same age, we meet with wide variations. Clinically, it is a matter of considerable interest for us to know, first, how wide these variations may be in normal cases; second, what the minimum limit is, below which the accommodation at a given age must be regarded as subnormal. Both these questions are answered by the curves which we have plotted and the tabular values deduced therefrom.

These observations excited but little interest among ophthalmologists. It was felt apparently, as stated by one distinguished critic, that they did not differ essentially from those of Donders, or else, as another man, himself a most able observer, said, that they were mere laboratory experiments and, as such, presumably inapplicable to the conditions of our office work. But both criticisms are invalid. The observations do differ materially and in a very practical sense from those of Donders; and they not only have a very important clinical bearing, but are readily applied in the routine of office work.

Altho in the main these observations have been confirmed by those made continuously since, it has been felt that they needed amplification in two regards. First, the observations at the very beginning and end of the series (below 30 and above 55) were not numerous enough to afford absolutely certain indications as to the maximum and minimum limits. Second, they concerned only monocular accommodation. But, as clinically speaking, binocular accommodation is much more important than monocular, it seemed necessary to determine the former also, and from an equally large number of cases. (See papers 1, 2 and 3.)

Accordingly, the writer has collated the results of five or six thousand observations taken since the original set was compiled, and has added to the latter the values of the monocular accommodation for over two thousand additional eyes. Furthermore, during the last two years, he has made measurements of the binocular accommodation in some five hundred cases, and has determined the relation that this bears to the monocular accommodation in each case. The results are shown in the accompanying charts and tables.

In making the measurements on which these charts and tables are based, the same precautions were taken as in getting the original set[1]. These need not be rehearsed here. I will simply say that in each case the refraction was carefully determined, homatropin being used in all cases of 46 or under, and in some cases above 46; that repeated tests were made whenever possible, the near point being determined by means of the fine

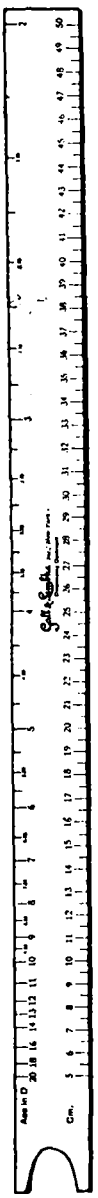

Fig. 2. Accommodation Rule. This is a modified Prince's rule divided into cm. and diopters. The notch at the end is slipped over the nose, so that the zero point of the scale is placed 14 mm. in front of the cornea (practically in the plane of the patient's correcting glass). The accommodation line is carried along either side of the rule to measure the accommodation of either eye separately (the other eye being closed), and along the top of the rule to measure the binocular accommodation (in this case, of course, both eyes being left open). When the line is brought to the point where it just begins to blur or double, the distance of the near point is read off in cm., or the corresponding accommodation is read off in D.

line test object (Fig. 1) and the modified Prince's rule (Fig. 2), either with the full distance correction or with such determinate addition to that correction as would bring the range within measurable limits. In all cases the near point was measured from the anterior focus of the eye (14 mm. in front of the cornea). Every precaution was taken to avoid error and to insure uniformity in methods used. Observations were discarded if repeated observations gave capriciously varying results, or if tests made a year or so later gave higher values.

MONOCULAR ACCOMMODATION.

The values for the accommodation in each eye taken separately, as deduced from the examination of over 4,200 eyes, are shown in Fig. 3, and the maximum, mean, and minimum curves deduced from these values are shown in Fig. 4.

In making these charts, we had to bear in mind that what we are measuring in each case is not the average but the maximum amount of accommodation put forth by each individual. If, for example, a man at various times shows an accommodation of 7.4 D, 7.8 D, and 9 D, and the tests in each case seem equally well authenticated, we say that his range is at least 9 D, the highest of the three measurements, instead of 8.1 D, or their mean. In fact, even the highest accommodation found in a given case may be and often is below the patient's true maximum. Hence a great many of the dots shown in Fig. 3, especially those near the bottom of the mass, should probably be placed a little higher than they are, and hence also the curves drawn in Fig. 4, namely, the minimum curve A skirting the lower margin of the galaxy of dots, the maximum curve C skirting the upper margin, and the mean curve B passing thru the densest portion of the mass, are put as high as they can properly be placed.

The values obtained for each age are given in the following table:

I. TABLE OF ACCOMMODATION AT VARIOUS AGES.

In D and tenths. Near point reckoned from anterior focus of eye (14 mm. in front of cornea).

Age	ACCOMMODATION		
	Minimum	Mean	Max.
8	11.6	13.8	16.1
9	11.4	13.6	15.9
10	11.1	13.4	15.7
11	10.9	13.2	15.5
12	10.7	12.9	15.2
13	10.5	12.7	15
14	10.3	12.5	14.8
15	10.1	12.3	14.5
16	9.8	12	14.3
17	9.6	11.8	14.1
18	9.4	11.6	13.9
19	9.2	11.4	13.6
20	8.9	11.1	13.4
21	8.7	10.9	13.1
22	8.5	10.7	12.9
23	8.3	10.5	12.6
24	8	10.2	12.4
25	7.8	9.9	12.2
26	7.5	9.7	11.9
27	7.2	9.5	11.6
28	7	9.2	11.3
29	6.8	9	11
30	6.5	8.7	10.8
31	6.2	8.4	10.5
32	6	8.1	10.2
33	5.8	7.9	9.8
34	5.5	7.6	9.5
35	5.2	7.3	9.3
36	4.9	7	9
37	4.5	6.7	8.8
38	4.1	6.4	8.5
39	3.7	6.1	8.2
40	3.4	5.8	7.9
41	3	5.4	7.5
42	2.7	5	7.1
43	2.3	4.5	6.7
44	2.1	4	6.3
45	1.9	3.6	5.9
46	1.7	3.1	5.5
47	1.4	2.7	5
48	1.2	2.3	4.5
49	1.1	2.1	4
50	1	1.9	3.2
51	0.9	1.7	2.6
52	0.9	1.6	2.2
53	0.9	1.5	2.1
54	0.8	1.4	2
55	0.8	1.3	1.9
56	0.8	1.3	1.8
57	0.8	1.3	1.8
58	0.7	1.3	1.8
59	0.7	1.2	1.7
60	0.7	1.2	1.7
61	0.6	1.2	1.7
62	0.6	1.2	1.6
63	0.6	1.1	1.6
64 to 72	0.6	1.1 to 1	1.6

BINOCULAR ACCOMMODATION.

The above are the limits for each eye tested separately. For binocular accommodation the values here given for the minimum and mean limits should be increased by 0.6D for ages 10 to 17; 0.5D for ages 18 to 31; 0.4D for ages 32 to 53; and 0.2–0.3D for ages above 53.

This table differs slightly from that determined ten years ago and reprinted since in a number of publications. In particular, the values given, especially at the earlier ages, are somewhat lower. The differences, however, are not material and, in a sense, they are more apparent than real. It must always be remembered that the upper and lower limits determined from a plot of observations of this sort must be more or less indefinite. For the reason already given, this is particularly the case with the lower limit. Thus it is difficult to tell in the case of the lowest dots in Fig. 3 which are to be counted as low normal and which are actually subnormal. Most of them doubtless are to be counted as subnormal, but in order to be on the safe side and to exclude no normal cases, the minimum curve, A, has been set rather low. Thus we are able positively to assert that an accommodation which persistently falls below the minimum value in Table I is certainly subnormal. Quite likely it is subnormal even when somewhat above this limit—at all events, it must be regarded with suspicion.

TABLE II.

Comparison of Monocular and Binocular Accommodation at Different Ages.

Age.	Excess of Binocular over Monocular Accommodation.	
	Extreme excess in D.	Usual excess in D.
8-15	0 to 6	1 to 2
16-34	0 to 3 or 4	0.5 to 1.5 (1D quite common)
35-38	0 to 2.5	0 to 1.5 (usually not over 1)
39-44	0 to 2	Usually not over 1
45-50	0 to 1.4 (*in one instance 1.75*)	Usually below 1; often below 0.8
51 and higher	0 to 0.9	Usually below 0.5

NOTE—The extreme differences noted above are in some cases to be regarded with suspicion, it being likely that the subject's observation was faulty or that he failed in the monocular test to put forth his full effort. In one or two instances, however, there is no question that a considerable difference, i. e., one of several D., existed.

BINOCULAR ACCOMMODATION.

In testing the binocular accommodation, the same routine was used and the same precautions were adopted as in testing the monocular. In each case the subject was provided with his full correction, or with a known addition thereto. Then the accommodation was taken with the accommodation line and the Prince's rule, first for the right eye, then for the left, and lastly for both together. At the same time the width of the pupils was measured, both when the eyes were converging to 25 cm. and to 10 cm. This was done in order to ascertain whether there was any truth in the contention that any excess found in binocular over monocular accommodation is attributable not to real increase in accommodative action, but to a sharpening of vision due to the stenopaic action of pupils contracted by the convergence effort. Lastly the distance of the convergence near point was noted, and the presence of any motor anomaly, particularly the presence of any great amount of exophoria in convergence, or any condi-

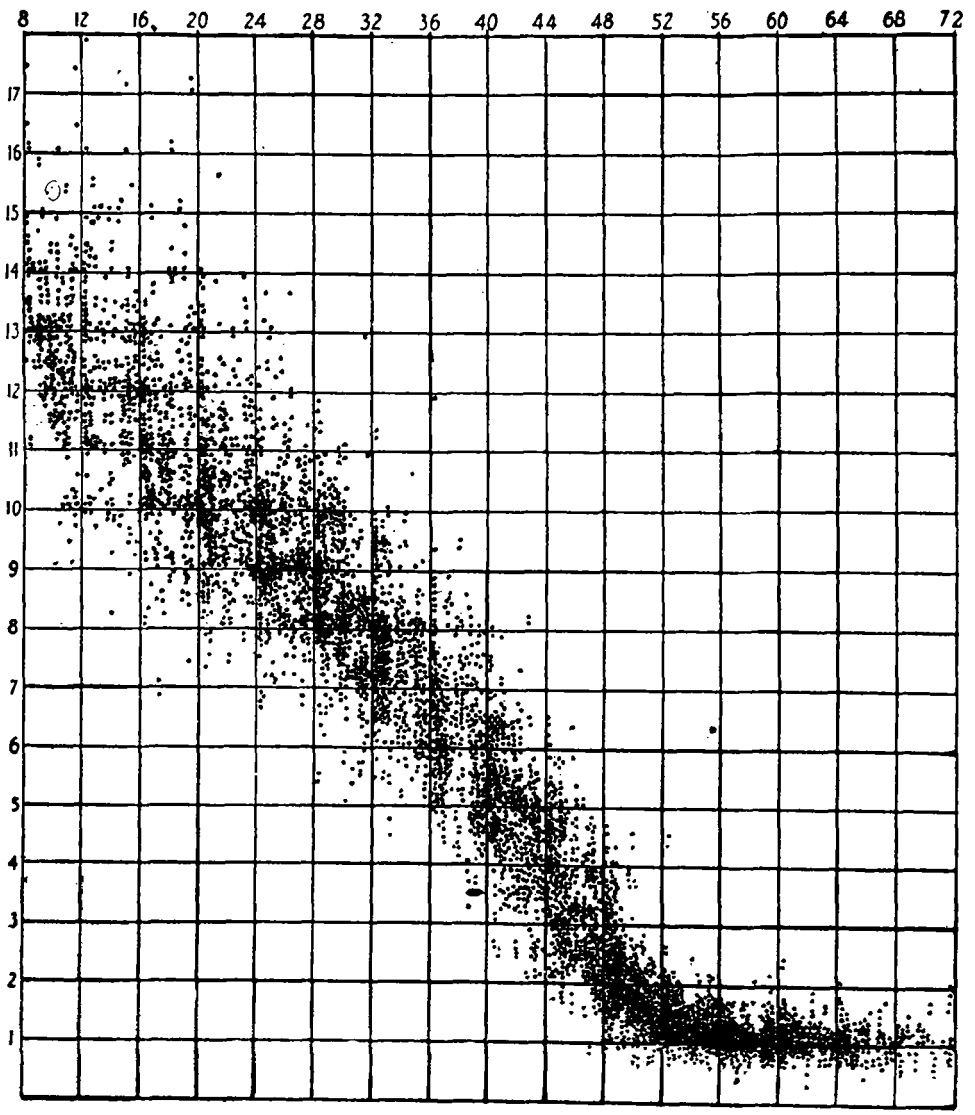

Fig. 3. Values of Monocular Accommodation. Each dot represents the maximum value in D. of the accommodation in a given eye. The results obtained in over 4,200 eyes are here plotted.

tion interfering with binocular fixation or binocular vision at near points.

The values thus obtained for the binocular accommodation, plotted on the same scale as that used for the monocular accommodation, are shown in Fig. 5.

The number of cases examined is yet too few to establish with certainty the mean, maximum, and minimum limits of binocular accommodation, yet the following may be stated as fairly certain conclusions:

1. The binocular accommodation is regularly higher than the monocular. (Compare Fig. 6, in which the monocular accommodation of the cases shown in Fig. 5 are exhibited.) In individual cases the difference may at times be considerable. (See Table II.)

2. The excess, altho varying greatly in different cases and even in the same case at different times, is quite constantly present. There are but few cases in which the binocular accommodation is not notably superior to the monocular; and even when the two seem to be equal, as shown by one measurement, a repetition of the test

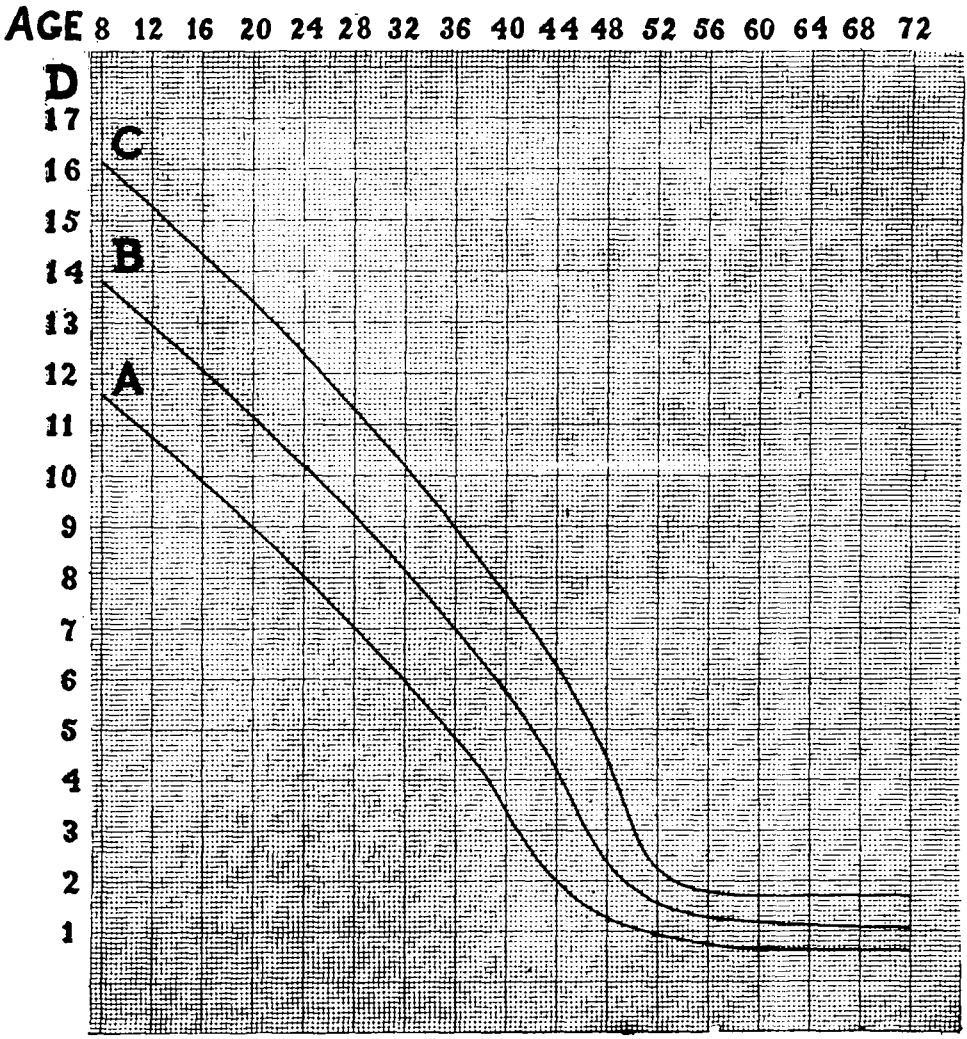

Fig. 4. Accommodation Curves. These are deduced from Fig. 3. A represents the extreme minimum, and C the maximum limits of those dots in the whole mass shown in Fig. 3, which can be regarded as representing normal values. B is the curve representing the mean value of the accommodation.

usually shows that the binocular accommodation is the higher.

3. Only in the rarest instances was the binocular accommodation found lower than the monocular, and even these few cases are open to suspicion, since the values then found were generally deduced from but a single observation, and the conditions were such as not to insure accuracy.

4. While the individual differences between the monocular and the binocular accommodation may run up to 1.5 D or more, the average difference deduced from the entire mass of observations is a comparatively moderate one. Thus the values tentatively derived for the mean value and the minimum limit of the binocular accommodation are, for ages between 10 and 17, about 0.6 D—0.7 D higher than for monocular vision; while from 18 to 31, the difference amounts to 0.5 D; from 32 to 53 to 0.4 D, and for higher ages, to 0.3 D.

5. The excess of the binocular over the monocular accommodation is not in ordinary cases attributable to the clearer vision produced by the contraction of the pupil that the convergence induces. This is abundantly proved by our pupillary measurements, particularly in the older subjects. In these the extra contraction of the

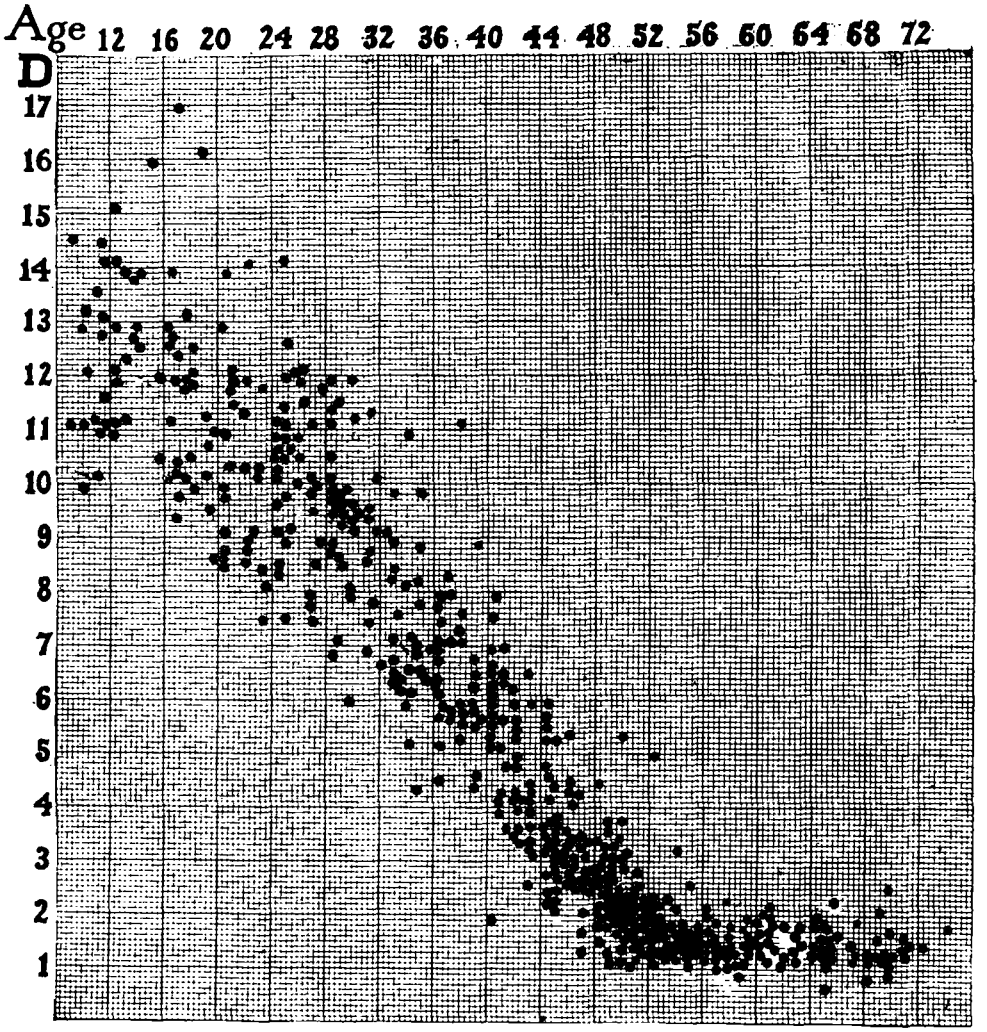

Fig. 5. Values of Binocular Accommodation. These are plotted in the same way as the monocular values in Fig. 3.

pupil set up by converging to the binocular (as distinguished from the monocular) near point, is quite negligible. In very young subjects, with very high accommodation and extremely mobile pupils, this element may be a factor, and may account for the considerable discrepancy sometimes found between the monocular and binocular values.

6. On the other hand, there seems every reason to think that, in the main, the accommodative surplus in binocular vision is due directly to the convergence action itself, which being strongly stimulated sets up an extra accommodative effort, impossible for one who is not converging. In other words, it is a true heightening of the accommodation, not a pseudoaccommodation as would be the case if it were due to the pupillary contraction. The difference, in fact, between monocular and binocular accommodation means that in monocular vision there is a certain degree of inertia of the accommodation, which is overcome by the extra effort set up when the two eyes converge. This inertia must be seated in the ciliary muscle, i. e. is an inertia

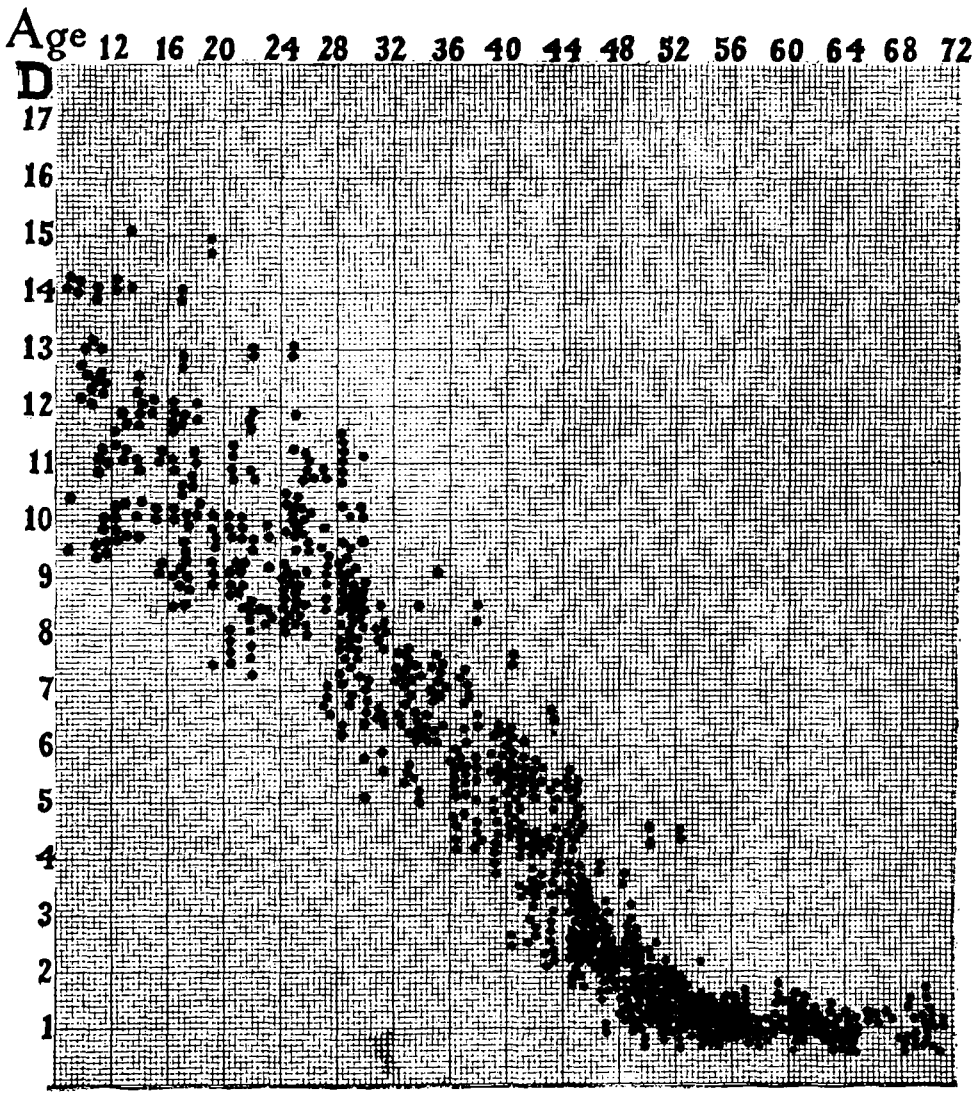

Fig. 6. Comparison of Monocular and Binocular Accommodation. The spots here represent the values of the monocular accommodation in the subjects in whom the binocular values shown in Fig. 5 were determined. It will be observed how the general sweep of the galaxy of dots in 5 rises above that in 6.

of what Fuchs calls the physiologic accommodation.

7. To a certain extent the enhanced accommodation in binocular vision may be due to the added clearness and, we may say, added realness of the binocular as opposed to the monocular image. But this surely is a subsidiary factor. That the enhancement due to the binocular act may be present without it, is proved by the fact, repeatedly observed, that the binocular enhancement exists either when one eye is amblyopic, so that the images cannot reinforce each other, or when there is divergent squint, so that there is no superposition of images at all, and yet still a strong attempt at convergence is made.

8. In any case, the added range and clearness effected by binocular vision constitute a very real advantage, especially in presbyopia. A man who is deprived of the use of one of his eyes is quite aware that his range of near vision is considerably less, and the sight itself is less satisfactory than if he had two. We must reckon with this fact in giving him a reading glass which must, as a rule, be at least 0.5 D stronger than if he were two eyed.

9. Above the age of 55, there is a true accommodation varying from 0.5 D or less to 1.5 D, and averaging about 1 D. The contention is made by some that the accommodation shown at this age is spurious, being due to the small size of the pupil, which so diminishes the size of the diffusion images, that the eye can see distinctly at near points without accommodating at all. This contention is negatived by our observations, which show that often in these elderly subjects the pupils are 3 mm. or more even when converging to their reading point. Nor is the size of the pupil essentially different when the eyes are adjusted for distance and when they are focused for 25 cm., which is about the nearest point to which they are usually adjusted by glasses. We may say, then, that ordinarily distinctness of near vision is not secured in these older subjects by a contraction of the pupil.

In very young subjects, as we have already seen, a contraction of the pupil may possibly produce a pseudoaccommodation, but our observations lead us to suppose that this occurs but rarely.

THEORY OF THE MECHANISM OF ACCOMMODATION.

Accommodation is effected by a passive expansion of the elastic lens, that takes place when the pressure exerted by the suspensory ligament upon the lens is relaxed. This passive expansion is aptly termed by Fuchs the physical accommodation, and the near point to which the eye can be actually focused by the elastic expansion of the lens is called the physical near point. Owing to the sclerosis which takes place in the lens progressively from youth on, the physical accommodation steadily diminishes and the physical near point steadily recedes with age.

Contrasted with this purely passive expansion, which decreases from year to year, is the active contraction of the ciliary muscle by which the relaxation of the zonula and hence the passive expansion itself are effected. This active contraction constitutes the physiologic accommodation (Fuchs), and the near point to which the eye could be adjusted if this active contraction were pushed to its limit and the lens also were perfectly fluid, is the physiologic near point.

Now while the physical accommodation diminishes steadily from youth up, it is generally held that the physiologic accommodation does not diminish at all until advanced life. There seems, indeed, no reason why the ciliary muscle, which is kept in continual practice all thru life, should contract any less vigorously at the age of 45 than it does at the age of 10. In fact, persons of both ages should have a physiologic accommodation of maximum amount, equivalent to a physical accommodation of not less than 20 D.

Now this inference, which is fully accepted by Hess and other exponents of the Helmholtz theory, involves certain corollaries which are not borne out by clinical evidence.

For example, suppose that a man of 45 has a maximum physical accommodation of 4 D, i. e., this represents all that he can possibly do in the way of relaxing his lens. This relaxation involves a very moderate amount of ef-

fort on the part of the ciliary muscle—in fact only a fifth of the whole 20 D that the full activity of the latter is supposed to represent. It would seem perfectly easy for him to put forth this minimum amount of his total ciliary activity and under all conditions get 4 D of manifest accommodation. Now, as a matter of fact, this is not the case. Tested with either eye singly, such a person rarely exerts more than 3.5 D. and often not over 3 D of accommodation. When in this case he shows only 3 D of physical accommodation, it is evident that this also represents the total ciliary effort (physical accommodation) that he is making at the time; for if he made any greater effort his physical accommodation would rise above 3 D, since the lens itself can relax up to 4 D if the ciliary muscle contracts correspondingly. Instead, then, of uniformly showing 4 D of accommodation under all conditions, he does so only under the extra stimulus afforded by binocular vision and convergence, and even then attains the maximum only part of the time.

The above statement holds good even up to the age (60 or over) when the accommodation is reduced to a minimum. Thus a person of 60 who has a monocular accommodation of only 1 D, will quite regularly have a binocular accommodation of 1.3 to 1.4 D. The extra amount of ciliary contraction required according to the ordinary theory, to produce the sight additional relaxation which would be neeeded to effect the differences between 1 D and 1.3 D of lenticular refraction is so small, that one does not see how anybody could fail to make it if he had a really large ciliary power to draw on. Yet evidently nearly everyone does fail to make it, unless some extra stimulus like that imposed by binocular vision and the convergence of the eyes impels them to a maximum effort.

It seems inconceivable that one who really had a contractile force equivalent to 15 to 20 D should be unable to put forth under all conditions, when called on, the comparatively small fraction required to produce a change of 2 to 4 D in the refractive state. Far more likely does it seem that from some cause—perhaps from physiologic inhibition — the ciliary energy itself actually diminishes with the years, i. e., that the physical and the physiologic accommodation diminish together, altho not necessarily at the same rate.

What lends additional plausibility to this view is the behavior of the eyes under homatropin. According to the usual views as enunciated by Hess and others, a boy of 15, a young man of 25, and a man of 40 would each have a physiologic accommodation (ciliary contraction) of equal amount, say one equivalent to a physical accommodation of 20 D. The actual physical accommodation, produced by the relaxation of the lens, would on the contrary be very different. In the first case it might be 16 D, in the second 10 D, in the third 5 D. In the first case there would thus be 4 D, in the second 10 D, in the third 15 D of latent ciliary energy, i. e., of energy which is never expended in changing the shape of the lens, and the abolition of which, therefore, would produce no effect on the physical accommodation. If now we instill a gradually acting poison like homatropin into the eyes of all these subjects, it should begin to show an effect only after the latent energy in each case had been abolished by the paralysis. In the case of the boy, as only 4 D are latent, the effect should be manifest very soon—in about ten minutes—after the instillation. In the second case the effect should not be manifest until quite a little later, and in the third case it should be manifest only after the lapse of 30 or 40 minutes, if at all. Now as a matter of fact, in a great many instances at least, the cycloplegia begins to show itself almost if not quite as soon in the middle aged man as it does in the boy. In fact, in persons of 46 or 48, the cycloplegia due to homatropin may become manifest in from 10 to 15 minutes after the instillation, and then proceed at a rate quite like that of the youth. These facts are supported by a large number of observations in which care was taken to exclude disturbing factors, such as the blurring due to the mydriasis, etc. It does seem, therefore, that the hypothesis that the ciliary power in the young and middle aged is equal is untenable.

THE ACCOMMODATION IN MALES AND FEMALES.

Examination of the great mass of statistics shows that, in general, the accommodation is equal in the two sexes, and that the march of presbyopia is the same in each. This is graphically shown in Fig. 5.

POSTCYCLOPLEGIC EFFECTS OF HOMATROPIN.

Ordinarily the effect of homatropin, if applied in a thorogoing way, may be said to wear off in 48 hours. But a moderate effect noticeable by careful tests often persists for several days later. For this reason it is best to defer a postcycloplegic test till five or six days, at least, after the instillation.

There is, however, a more lasting effect produced by the instillation, especially in eyes with latent hyperopia. We have repeatedly noted that tests made even some weeks after the homatropin, and after the application of the correcting glasses, show an accommodation distinctly below that present before the use of cycloplegic. It would seem as if the eye, having once learned to give up a compensating accommodative effort, could not for a time thereafter put forth even the normal accommodative power. Whether this postcycloplegic accommodative insufficiency, which usually is never of any great amount, produces any symptoms or not I do not know.

CLINICAL APPLICATIONS.

The observations recorded have an important clinical bearing[2,3]. Since they establish the norms of accommodation, they afford a means of judging when and how such a given accommodation varies from the normal.

Subnormal Accommodation; Hypocyclosis.—Since the days of Donders, the rôle of accommodative strain in causing the asthenopia of hyperopes and astigmatics has been a commonplace. It is all the more remarkable that, on the whole, so little attention has been paid to the part played by subnormal accommodation in causing eye troubles. Rarely, in fact, is the accommodation tested except in a perfunctory way, and, previous to this series of investigations, there has been little if any attempt to fix the maximum and minimum limits of accommodation at each age. Yet until these latter are known, we cannot, except in extreme instances, say definitely whether a given accommodation is normal or not.

It can now be positively stated that a monocular accommodation which is persistently below the minimum limit indicated in Table 1 is certainly subnormal, and that it is probably subnormal if it never rises much above this limit. Furthermore, the binocular accommodation should in young persons be at least 0.5—0.6 D, and in older subjects 0.3—0.4 D higher than this minimum.

It does not fall within the scope of this paper to consider at length the varieties, symptoms, and treatment of subnormal accommodation. It will suffice to say, that it is a frequent condition and that there are two kinds. In one, which may be called lenticular hypocyclosis, the ciliary muscle apparently acts in normal fashion, but the crystalline lens is more rigid than usual. In other words, there is a condition of premature presbyopia. In such a case, there are few if any symptoms of eyestrain, but as years go on the accommodation remains persistently lower than normal, and presbyopia sets in much earlier than usual.

In the second kind of subnormal accommodation, the lens has the usual rigidity, but the ciliary muscle is underactive. Except in cases due to structural disease of the central nervous system, the accommodation in this variety shows wide variations from time to time, and when it is low there is often marked asthenopia. This form of low accommodation is often associated with convergence insufficiency, and the symptoms often attributed to the motor anomaly are without doubt in many cases due to accommodative disturbance, or at least are aggravated by it.

Ciliary hypocyclosis can often be relieved and the symptoms greatly helped by convergence training and by direct training of the accommodation. For the latter purpose, exercise several times a day in focusing on the accommodation line, first with one eye, then with the other, and lastly with both, is useful.

Unequal Accommodation; Anisocyclosis.—Not infrequently the accommodation is found to be unequal in the two eyes. Usually this inequality seems to be due to unequal rigidity of the crystalline lenses. It rarely causes any disturbance, but has to be reckoned with in correcting presbyopes; for if they show an unequal accommodation, it is sometimes helpful to give them also an unequal addition to the correction for distance. The fact that the accommodation may be thus unequal in the two eyes is sufficient reason for our habitually testing it in each eye separately as well as in both together.

Accommodation Measurements in Testing the Depth of Homatropin Cycloplegia.—This is an application of the accommodation tests which I regard as of great importance. The ordinary practice of making the refractive examination at a fixed time—an hour, it may be—after the first instillation of the homatropin, leaves out of consideration the fact that the march of homatropin cycloplegia varies greatly in different persons. In some few it seems complete in less than an hour; in others it is not complete for some two hours. Moreover, there seems reason to think that the acme of the effect is soon passed; at least if the test is not done until long after the instillation, the results may be uncertain.

The most satisfactory method is to make tests of the residual range at intervals, beginning an hour after the first instillation, and to defer the examination of the refraction until the range has been reduced below 1 D, then make it at once. Furthermore, when the refraction has been determined, the far point with a +3 D. added to the full correction should be at 33 cm. and the near point at something over 25 cm. and preferably not less than 28 cm. (representing in the latter case a range of 0.6 D). When the range is much wider than this, our results must be regarded as somewhat uncertain.

ACCOMMODATION TESTS IN OFFICE PRACTICE

The tests used require only the simplest of apparatus and can be made very quickly. They are hence adapted to the exigencies of office practice, of which, considering their importance, they should form a part in the regular routine of the examination of each case. In applying them the following precautions should be used:

1. The patient is placed in a good light and provided with his full correction, and (in presbyopic cases) with such addition thereto as will bring his near point within measurable limits. In this case, of course, the accommodation read off on the scale must be diminished by the strength of this added glass.

2. In very young subjects with high accommodation (12 D or more), it is often well to add a —3 or —4 D to the distance correction, in order to carry the near point out to a place on the rule where, the graduations being further apart, there will be less likelihood of error in the measurement. Of course, in this case the accommodation as read off on the scale must be increased by the strength of this added glass.

3. The zero point of the Prince's rule is placed 14 mm. in front of the cornea (practically in the plane of the patient's correcting glass).

4. The left eye is covered and the accommodation card carried in along the rule until the line seen with the right eye blurs or doubles. The corresponding value of the accommodation is then read off in D. Then the right eye is covered, and a similar test made with the left, and lastly the accommodation is measured with both eyes open, the patient at the same time being urged to converge on the test-object.

5. It is well to make sure that the patient understands exactly what we desire him to observe, and to make several observations in succession in order that we may get his maximum effort.

SUMMARY.

1. The examination of the accommodation in 4,200 eyes enables us to state with precision the maximum and minimum limits, as well as the mean values of the monocular accommodation at all ages. The results obtained are shown in the curves and tabular values here presented.

2. These observations substantially confirm those made ten years ago. The mean and lower limits have been set somewhat lower, so as to be sure not to exclude any low normal cases. Any case whose accommodation is persistently below the minimum limit is certainly subnormal, and any case in which the accommodation remains only slightly above the minimum limit is probably so.

3. The binocular accommodation is regularly higher than the monocular, the excess being regularly equal to 0.6 D or more below the age of 17; 0.5 D from 18 to 31; 0.4 D from 32 to 53; and 0.3 D for ages over 53. In individual cases the difference may be much greater.

This difference is a very real advantage especially in presbyopes. Binocular accommodation is not only higher but better as regards ease and clearness. This fact must be borne in mind especially in prescribing reading glasses, and in cases of monocular vision (monocular cataract, etc.), we must prescribe a glass 0.5 D or so stronger than we would for a two eyed patient.

5. The excess of binocular accommodation apparently represents an actual increase of ciliary effort, imposed doubtless by the act of convergence. It cannot be attributed to the added clearness secured by a contraction of the pupils, since it is quite uniformly observed even when no such contraction exists.

6. As little can the contraction of the pupil be called in to account for the accommodation of 1 D or more, quite regularly observed in patients over 55. The accommodation in this case, in all probability, represents the same process as in youth, i. e., relaxation of the lens produced by contraction of the ciliary muscle.

7. These observations and others adduced should lead us to modify somewhat our conceptions of the accommodative process. Particularly these should lead us to think, contrary to the prevalent view, that not only the elasticity of the lens (physical accommodation) but the activity of the ciliary muscle (physiologic accommodation) diminishes with age, and that in advanced life only a comparatively small amount of ciliary energy can be put into play.

8. The accommodation is equal, and presbyopia advances at the same rate in the two sexes.

9. The relaxation of effort produced by homatropin and by the prescription of correcting glasses seems in many cases to set up a condition of moderate accommodative insufficiency, lasting, it may be, for a number of weeks.

10. The practical applications of these observations are of considerable importance. In particular, the observations determine whether a given accommodation is subnormal or suspiciously low, and enable us to tell when we have succeeded in raising it to near the normal limit. Subnormal accommodation is frequent and comprises two kinds, lenticular and ciliary. The former, which may be called a premature presbyopia, is a stable condition, causing apparently little or no reflex symptoms; the latter is a variable condition, often causing marked asthenopia and requiring active treatment. The other practical applications consist, first, in the recognition of the fact that the accommodation may be unequal in the two eyes, so that in presbyopia an unequal reading addition may be required; and, second, in the employment of the accommodation tests in determining the depth and reliability of homatropin cycloplegia.

11. In order to make the tests available for practical application, they should be performed in a uniform way and with certain precautions. When so performed they give reliable results. They are readily and briefly made with simple apparatus, and hence are easily adapted to the conditions of ordinary office work.

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