THE CONVERGENCE INDEX AS A MEASURE OF THE CONVERGING POWER.

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With one illustration in the text.

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TWO methods of determining the converging power are in general use. One consists in determining the ability to overcome prisms, base out, thus measuring what is usually called the adduction but is more properly termed the prism-convergence; the other consists in determining the convergence near-point.[2]

The prism convergence furnishes at best only an approximate indication of the real converging power. As is well known, the ability to overcome prisms, base out, varies extremely, the variations evidently not representing real differences in converging power but differences simply in knack, *i. e.*, aptitude in learning to perform an unaccustomed act. So we find some, who at the start can overcome but 12° or 15° prism, base out, and who only after repeated trials can do more, and we find others who pass at once from these lower to the higher degrees. Yet, as other tests show, the two have equal and evidently normal converging power. It is only when the patient, after repeated trials, cannot overcome more than a certain comparatively weak prism, and particularly when, even if he does pass from one number to the next higher, he can maintain fusion with the latter but momentarily, that we can predicate from this test a low converging power. In such cases alone the prism convergence really becomes of value as a measure of the convergence, since it then really indicates the

[1] Read before the American Ophthalmological Society, May 13, 1914.

[2] The converging power may also be determined with the amblyoscope or stereoscope, but these tests are not in common use for this purpose.

maximum of converging power attainable. In the other cases it indicates much less than the true maximum.

Moreover, when strong prisms are used for measuring the convergence, the measurement is made uncertain by the fact that slight variations in the position of the prisms cause quite an appreciable change in their deflecting power, so that errors of 5° or 6° in the actual degree of convergence may thus be caused.

The determination of the convergence near-point (Pc) remains as our most reliable means of determining the actual converging power. It is often measured from the cornea, but should properly be measured from the base line connecting the centers of rotations of the two eyes. We should be careful in any case to indicate from what point the measurement is made. We may conveniently use the symbol PcC if the measurement is from the cornea and PcB if it is made from the base line. In Fig. 1, AB denotes PcB. This distance (PcB) can be quite precisely measured as follows: The patient's correcting glasses, or in lieu of these a trial frame or spectacle frame placed on the patient's nose, are used as a reference plane, which is adjusted so as to be just 11.5*mm*[1] in front of the corneal apex when the

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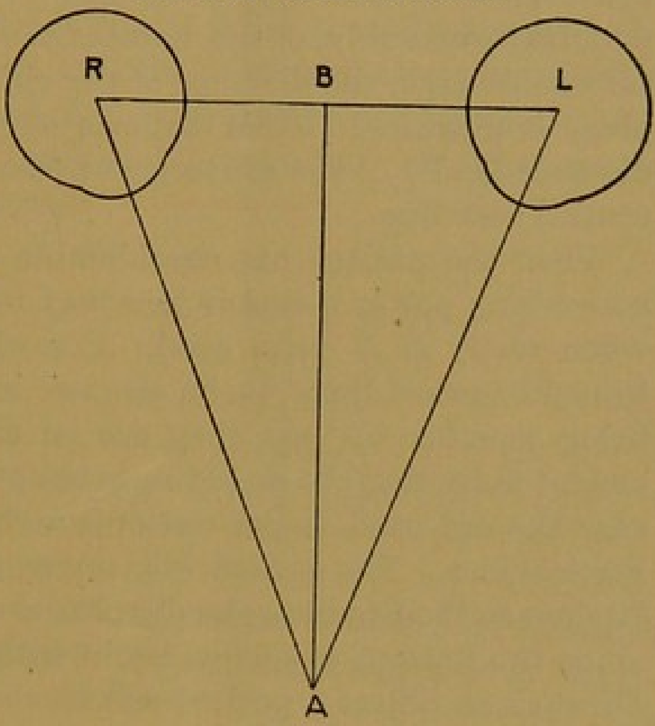

FIG. 1

A being the convergence near point, and AB its distance from the base line connecting the centers, R. L. of the two eyes, the convergence index C: $= \frac{RB}{AB} \times 100$. This normally ranges between 35 and 55. For all values of the index between 13 and 59, the relation holds that the angle of convergence RAL expressed in degrees equals Ci+3°.

[1] 10.5*mm* if the eye is quite myopic; 12.5*mm* if the eye is highly hyperopic.

eyes are directed straight ahead. The apex of a millimeter rule is placed against the point where the reference plane crosses the nose, and the rule itself is held perpendicular to the plane, so as to lie strictly in the mid-line. Along this the test-object, which may consist of a pin with white head 2*mm* in diameter, or a minute dot on a card, is carried straight toward the patient's nose, the patient all the time being exhorted to converge on it as sharply as he can. The moment the object doubles insuperably, or the moment one of the patient's eyes is seen to diverge, the distance of the object from the reference plane is measured. This distance plus 25*mm* will equal the distance (PcB) of the convergence near-point from the intercentral base line.

When the patient has considerable vertical deviation, his converging power tested in this way may appear to be poor when really it is quite good. For when the test-object is brought toward the eyes, he sees two images which he cannot bring together because they are on different levels. As he cannot unite them he makes no attempt to converge.. In that case the dot used as the test-object should be replaced by a vertical line. The patient will converge on this, because when he does so the two images will unite, even if on different levels, since the bottom of one will join with the top of the other. On such an object a patient will be able to converge sharply, even when for the dot he had, apparently, very little converging power.

This convergence distance (PcB) may be used itself as an approximate measure of the converging power. As such it may be indicated either in *mm* or in meter angles. In the latter case $MA = \frac{1000}{PcB}$ where MA is the number of meter angles and PcB is given in *mm*. But the convergence varies not only with the convergence distance (PcB) but also with the inter-pupillary distance (Pd), for the greater the latter, the greater obviously the work the patient has to do in converging.

In fact, the true measure of the converging power is given by the fraction $\frac{RB}{AB} = \frac{\frac{1}{2}Pd}{PcD}$. This equals evidently the tangent of half the angle of convergence, RAL = C. I propose for this ratio, or rather this ratio multiplied by 100, the name *convergence index* (Ci). We have therefore:

$$Ci = \frac{\frac{1}{2}\text{ interpupillary distance} \times 100}{PcB}$$

A large number of measurements shows that the convergence index usually ranges from 35 to 50. A convergence index below 35 means low converging power and one persistently below 30 argues an actual convergence insufficiency. In many cases the index reaches 55, and at times even 60. The highest convergence index that I have actually found is 63. Now computation shows that the following rather remarkable and very convenient relation between the convergence index and the actual convergence in degrees of arc—in other words between Ci and C—obtains:

Ci	C
5 to 6	Ci + 1°
7 to 13	Ci + 2°
14 to 58	Ci + 3°
59 to 63	Ci + 2°
64 to 68	Ci + 1°
69 to 71	Ci

As an index of 14 means a convergence near-point distant 21 to 22*cm* (8 or 9 inches) and as an index above 58 is rarely met with, we say:

For all values of the converging power ordinarily met with, both in normal and abnormal cases, the actual converging power in degrees equals the convergence index plus 3°.

A simple case will illustrate the application of this rule. In a given patient we find a Pd of 60*mm* and the PcB is 75*mm*.

$$Ci = \frac{30 \times 100}{75} = 40$$

Hence the actual degree of convergence (C) is 43°.

Even for higher or lower degrees of converging power the error in applying the rule is practically negligible. Thus if a patient has a Pd of 62*mm* and a PcB of 300*mm* (about a foot)—an extreme case—the C reckoned by the rule would be 13°, whereas its true value is 12°; or a discrepancy of but one degree. So, too, if the patient with a Pd of 60 converged down to within 45*mm* of the base line—also an extreme case—the value of C reckoned by the rule would be 69°, whereas the true value would be 67°. With a convergence so extraordinary, a difference of 2° is of no importance. But in the rare cases where Ci is above 60, it is best to use the table above given.

The interpupillary distance is readily measured thus. Patient and observer face each other, the patient covering his left eye, the observer his right, and each with his uncovered eye looking straight into the uncovered eye opposite him. The observer places the zero mark of a millimeter scale in line between his own open eye and the center of the patient's right pupil. Then each shuts the eye that was open and opens the one that was shut, the patient at the same time being directed to look with his now uncovered left eye into the observer's right. The point on the scale in line with the center of the patient's left pupil will indicate the interpupillary distance when the eyes are parallel, *i. e.*, the distance between the centers of the two eyes. To check the result, the patient should again close his left eye and the observer his right, each again opening the one that was closed. The zero point of the scale in this case should still be opposite the patient's right pupil.

This method gives an accurate measure of the interpupillary distance even when there is a considerable deflection of the eyes.

The rule above given is also obviously useful if we wish to determine the actual angle of convergence made by the visual lines when the patient is regarding an object at any rather near point, whether this is his actual near-point of convergence or not. When he is so converging, the angle of convergence (C′) is to all intents and purposes given by the relation.

$$C' = \frac{\frac{1}{2}\text{ interpupillary distance} \times 100}{D} + 3^\circ$$

where D = distance (from the intercentral base line) of the object.

We may make the statement perfectly general and also perfectly accurate by putting it as follows:

If an object is at a distance D from the intercentral base line, and we denote by C′ the fraction.

$$\frac{\frac{1}{2}\text{ interpupillary distance} \times 100}{D}$$

and by C′ the angle of convergence of the visual lines, then

$C' = Ci' + 3°$ if D is between 5 and 22*cm*.
$C' = Ci' + 2°$ if D is between 22 and 50*cm*.
$C' = Ci' + 1°$ if D is between 50 and 100*cm*.
$C' = Ci'$ if D is over 100*cm*.

Ci′ in this case may be called the *relative* convergence index, inasmuch as it corresponds to a point upon which the eyes are converged when not using their maximum converging power. When the eyes are converging to the maximum, so that D represents the distance (PcB) of the real near-point of convergence, the convergence index may be called *absolute*.

Since the convergence index by the simple relation indicated gives us the converging angle, it may be said to measure quite directly the *power* of convergence. It has been objected, however, that after all what we wish to know is, not so much the power as the availability of convergence. In other words, we wish to know, not how great the angle C is, but how close the near-point A is. The closeness of the latter, in fact, measures the usefulness of the converging power for the patient, just as the closeness of the near-point of accommodation measures the usefulness of the accommodation in enabling the patient to read. But there is a considerable difference between the two cases. Two persons with the same range of accommodation may have near-points differing widely, insomuch that one of the two can read with the utmost ease and the other cannot read at all. But if one person has the same convergence index as another he cannot have an essentially different convergence near-point. In fact, for any ordinary value of the index, the variations in the position of the convergence near-point cannot possibly amount to more than 2*cm*,[1] and are usually much less, so long as the index remains the same. Even when the index is low, and the near-point of

[1] Thus, with a convergence index of 30 (quite the lower limit of normal converging power), the distance of the convergence near-point, *i. e.*, the PcB, would be 9.0*cm* if the interpupillary distance was 54*mm*, and 11.0*cm* if the interpupillary distance was 66*mm*.

convergence consequently remote, the discrepancies in the position of the latter, although now somewhat greater, are still relatively small and in no case so great as to be of practical importance.

We may say, therefore, that the convergence index is not only a true measure of the converging power, but gives also in all cases a sufficiently accurate notion of the utility of this converging power for the patient—*i. e.*, of its availability in enabling him to look at near objects.

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