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"There is no one visual acuity"
crowding
form sense → light sense, amblyopic acuity
effect of contrast on form sense

CLINICAL TESTING OF VISUAL ACUITY

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THE MOST exhausting activity in the practice of an ophthalmologist is to persuade persons to read the normal line of the visual test chart. Complicated operations and intricate diagnostic problems sometimes seem next to nothing in comparison; but why this keen interest?

Examination of the visual acuity is classified as a subjective test, but in certain circumstances the answers are as sure as objective results. The moment the patient is brought to read the normal line, it is proved with the exactitude of an objective method that the visual acuity of the examined person is normal, and the whole test then changes from a doubtful to an exact one. This result is worth while.

The next question to be discussed is, of course, the normal value for the visual acuity. Ability to recognize letters of 5 minute angle is generally recognized as normal, corresponding to a visual acuity of 1.0 or 20/20, or 6/6.

I tested the visual acuity of 100 Danes, chosen at random and of different ages. From a distance of 12 meters, the subject approached the visual test chart gradually until the 6-meter line could be recognized, with only one wrong answer to three correct ones. In the accompanying chart the abscissa indicates letters on the test chart. The ordinate indicates the number of persons able to achieve the corresponding visual acuity. The curve has its peak at a visual acuity of 1.17, or 7/6, or 23/20. Visual acuity of 1.0, or 20/20, or 6/6 is found at the dot in the left side of the curve, rather low.

What point in this curve for visual acuities is to be selected as a normal value, suitable for clinical use?

The right arm of the curve represents the best visual acuities, but these optimal values are seldom of clinical interest. The peak of the curve represents the mean. This is of great biological interest; but for clinical purposes, when one is examining a particular person and judging his condition, the mean value is of limited interest, since half of mankind would be found inferior if the mean were fixed as the norm. Theoretically, the best clinical normal value should be fixed on the left arm of the curve, at the point where the slope is most abrupt. A norm fixed where the curve changes its course, forming a foot, would secure to the greatest number of persons with normal vision their being declared normal on the test. At the same time, this norm would exclude the fewest persons with a minus variation of the normal visual acuity, as the normal persons with visual acuity below the fixed norm are very few (the area of the curve to the left of the arrow). Thus, values below this clinical norm are, in all probability, really abnormal. It is astonishing to

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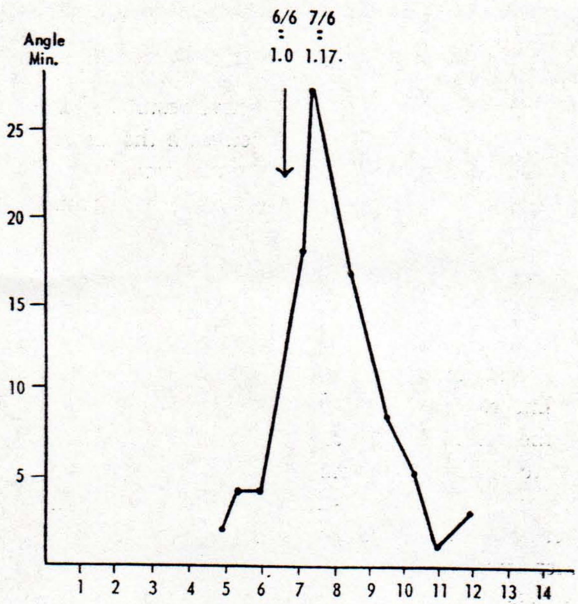
see how precisely this theoretical point is attained by experience in the generally used Snellen norm, fixed at a visual angle of 5 minutes.

When a child begins school and has learned the letters, a reader with letters of large size is generally used. As normal children have good visual acuity and good accommodation, far exceeding what is needed to read ordinary print, it seems quite unnecessary for visual reasons to print the letters in the readers so large. But such large letters are urgently needed. For some reason, utilization of the form sense for small visual angles produces great strain, and, of course, is especially tiring in the case of abstract figures when presented to untrained observers.

That the sense of form is easier to utilize at a large visual angle than at a small one is curious, but is clearly apparent from the much shorter time needed to



Curve showing vision of normal persons.

recognize a letter when the visual angle is increased. By increasing the visual angle from 5 to 10 minutes, I found that the time necessary to recognize the same letter diminished from ½ to 1/20 second. That means that a doubling of the visual angle for a given form under these conditions increases the visual velocity 10 times.[1]

When one is teaching a child his letters, it is the custom to present at the beginning only a few letters on each page. This is because of another characteristic property of the eyesight. The sense of form is most easily utilized in an otherwise empty visual field. When one is testing amblyopic children with isolated letters or E's, the visual acuity recorded is often much better than with the ordinary test chart. If the visual field is crowded with letters, the area of the visual field in which the letters can be recognized narrows. This is very easy to demonstrate, as I showed at the Congress of Scandinavian Ophthalmologists in 1936.[2]

1. Ehlers, H.: On Visual Velocity, read at the Eleventh Ophthalmological Congress of Scandinavian Ophthalmologists, June 26, 1947, Acta ophth. **26**:115, 1948.

2. Ehlers, H.: Movements of Eye During Reading, Acta ophth. **14**:56, 1936.

The eyes, thus, are not always able to utilize the form sense maximally. The reading of the normal line crowded with many letters seen under a small visual angle is to many persons real strain.

The problem of the correct gradation of our test charts and the true manner of expressing the visual acuity has often been discussed, some oculists preferring the decimal system and others the simple fractions. Of the latter, some express the fractions in a quasiduodecimal system and measure the distances in the metric system; for others 20 ft. form the basis. This heterogeneity is unfortunate.

A general law for all units of measurements is that the steps of the scale must exceed the error on any value determined; otherwise it is impossible to interpret the results without complex calculations. For the testing of visual acuity, this means that the gradation of the test chart, i. e., the number of steps between the lines, is dependent on the physiology of the eye. If the ability to read the letters presented shows an error of 1/7, the charts must be divided into seven intervals. There is no possibility of dividing them into more than seven steps without diminishing the accuracy of the visual test. As test charts divided according to this system approximately correspond with series somewhat resembling geometric or logarithmic ones, gradations of the latter type have been proposed (Green, Javal, Tscherning). To me, it is not a problem of numerical systems or of mathematics, but merely one of what an eye is able to discriminate.

Persons reading without error a line of good visual acuity generally are able, by straining, to read one of the easiest letters in the next line too; this is a simple and good proof that the intervals between the steps of the test chart are as they ought to be, just at the limit of the error in the test.

Form vision is a complex sense, composed, as it is, of a number of visual functions. In most organic diseases of the eye disturbing the formation, resolution, or transmission of the visual image, all the various functions are reduced. As the various visual functions often go together, the visual test may usually be restricted to the testing of the form sense, which is the simplest to perform. Only in special cases is it necessary to supplement the examination by testing other visual functions to get a true picture of the visual impairment.

It is generally assumed, but is not quite true, that the visual acuity test is an examination of the sense of form. According to Snellen, the letters should be shaped so that each point is recognized separately from the others at equal distances. Actually, this is an examination of the resolving power, dependent on the light sense. The recognition of figures of varying complexity, but of equal size, would be a pure form-sense test. Curiously, this ability is dependent on the visual angle.

What further complicates the separation of the different visual functions is the particular fact that the sense of form, owing to its simplicity, frequently is used as a sort of indicator in testing light sense or color sense, as, for instance, in the Ishihara test.

To demonstrate how often the ability to distinguish different intensities of light and the ability to distinguish different sizes go together when vision decreases, I may refer to some investigations I reported in 1937,[3] at the Congress of Ophthalmologists in northwestern Germany. The power of distinguishing gray shades was measured by means of pale letters printed in different intensities of gray, from

3. Ehlers, H.: Ein tausend Hemeralopieuntersuchungen, Acta ophth. **15**:443, 1937.

pale gray to dark, after the method of Edmund and Möller. These letters were presented under various reductions of illumination. The reduction of the form sense and that of the light sense were found to be associated in many ocular diseases.

Although the reductions in the various visual functions generally go together, isolated defects of a single function occur, too, as is typically the case in color blindness. The form sense is unimpaired, and so is the light sense. Isolated defects of the light sense are well known, too, in real day blindness. In such cases the ordinary visual test does not express the actual visual reduction. The reverse is the case in isolated reduction of the form sense; the visual acuity test will give the impression of a far more serious condition than the actual one.

The typical picture of the isolated reduction in form sense is seen in amblyopia without organic changes. The patient with the amblyopic eye may indicate exactly when the right correcting glass is placed in front of his eye, even when the visual acuity is severely reduced, and even when his visual acuity does not improve with the glass. This is due to an unimpaired light sense, which enables the patient to perceive the feeblest circles of diffusion on the retina. I have examined the power of distinguishing light intensities, and I always find that this function, as well as the visual velocity, are excellent in cases of amblyopia.

A patient with an amblyopic eye often is not aware of his defect until it is revealed at the visual test. A patient may come for presbyopic glasses without knowledge of the amblyopia and is astonished, just as is a dichromate, when his defect is revealed. When such a patient is questioned, he states that things seem very bright and clear to the amblyopic eye, but, as a colleague added, "I don't understand so well what I see with my clumsy eye." For guidance an amblyopic eye may be excellent. I remember a foreigner's desiring to get a Danish driving license. The man had only one eye, and it had an acuity of 20/200. I was questioned by the police, who stated that the man drove his car excellently but could not see to read the traffic placards. As the man did not understand Danish either, I thought it made no difference.

I have tried to emphasize that the visual acuity of an amblyopic eye does not indicate the same degree of disability as the same visual acuity found in an eye with organic disease. The two conditions cannot be compared. The treatment for amblyopia seems less glorious when this is appreciated.

Many different methods and instruments have been devised for testing visual acuity. Nearly every clinic has its favorite. It is impossible to say which is the best, for a person's visual acuity does not have one true value. In the same person the visual acuity may vary somewhat, depending on ocular and general conditions. The aberrations cause circles of diffusion and of these it seems possible for the eye to choose now one, now another. Within the same pupil the refraction may vary in different parts by several diopters, as a result of the aberrations, as demonstrated by my compatriot Tscherning. So there cannot be one true value only for the visual acuity of an eye. When discussing what gives the best vision, we should not forget that the owner of the eye is the one best fitted to decide.