THE LIGHT-SENSE IN STRABISMUS,

especially in the Amblyopia of Strabismus,

examined by means of a new photometer.

A T H E S I S

submitted for the degree of Doctor of Medicine

of the University of Edinburgh.

1 9 0 3.

By

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CONTENTS.

THE LIGHT-SENSE.

DEFINITION;- The Light-Sense is one of the three Visual Perceptions or Sub-senses of which the Sense of Sight consists,--(the other two being the Colour-Sense and the Form-Sense.) It is the power the retina, or the visual centre, has of perceiving gradations in the intensity of illumination, without reference to the colour, or size, or form, of the object from which the illumination comes (Swanzy's "Handbook," and Freeland Fergus on "The Light Sense in relation to Navigation.") Whether this power resides in the retina or the visual centre, we cannot say, for we are almost wholly ignorant as to what part of the sensory system it is in which changes determining the specific nature of sensations take place (Rivers, in Schaefer's "Text Book of Physiology," 1900, Vol. 2,p. 1052.

PHYSIOLOGY;- The estimation of the Light-Sense is attended with not a little difficulty, and the results as reached in ordinary clinical examinations may be considered doubtful as to their mathematical accuracy, when we remember how

great is the personal element that enters into the recognition of the sensation by the patient.

Measurements made by trained observers upon trained subjects are naturally more reliable; but, obviously, the number of such subjects is limited, and practically, of course, they are seldom available except when physiologically sound.

But even in their case, there are sources of fallacy. Captain Abney, in his paper read before the Royal Society on "The Sensitiveness of the Retina to Light and Colour" (1897), pointed out that the sensitiveness of the eye (his own, and his trained assistant's), varied considerably at times, due, in all probability, he thought, to the state of health, mental and bodily, of the observer. Only as the eye became practised to observation, he said, did the liability to variation very largely disappear.

Besides the condition of body and mind, there are in the physiological examination, as well as in the pathological, a number of circumstances which may influence the character, quantitative and qualitative, of the sensations; for example, the nature and duration of the previous stimulation of the retina, the size and position of the area stimulated, the duration of the stimulus, and the rate at which the individual stimuli succeed one another, the nature of the stimulation of other parts of the same retina, of the other retina, and even of other sense-organs, (Rivers, in Schäfer's "Physiology," as before).

The nature of the previous stimulation is intimately associated with what is called "the adaptation of the retina,"- adaptation, that is, to different degrees of illumination or to darkness.

On complete exclusion of light from the eye, the retinal sensitiveness to light increases. The increase at first is rapid, the sensitiveness being multiplied fifteen to twenty times in the first two minutes. Later, the increase is less rapid, until, in twenty minutes, the maximum is almost reached. Still the sensitiveness continues to increase for two hours, and then, according to Aubert, it is thirty-five times greater than at first. Charpentier, however, puts the maximum amount of increase at one thousand times, and also points out that the increase is not affected by differences in the size of the pupil (Rivers, in Schäfers' "Physiology" Vol.1 , p. 1056). Abney's observations were made after the eye had been placed in darkness for at least twelve minutes.

In estimating the sensibility of the eye to light, there are two directions from which the subject may be approached.

1. Beginning from complete darkness, one may determine the smallest amount of light capable of being perceived; this is the threshold of sensibility. Or-

2. Beginning with a certain perceived amount of light one may increase it, or diminish it, until it is just perceived to be different; this is the threshold of discrimation. (Rivers, in Schäfers' "Physiology," Vol.2,

p. 1053.)

If the threshold of sensibility (which is Rivers's term for any of the senses), be called, in the case of the light-sense, the Light-Minimum (L.M.), then the threshold of discrimation may be called the Light-Difference, (L.D.)

In estimating the light-sense, there are various considerations, which have a direct bearing upon the results. It is extremely difficult, for example, especially in measuring the L.M., where one is beginning from darkness, for the patient to keep the axis of the eye in a line with the spot where the light will be seen as soon as it is sufficiently strong. Even in the most willing observer, the eye is restless, and may roam round while the increase of illumination, not yet perceived, is taking place; and it may be, that at the instant when the eye could perceive the light, if it were directed straight upon it, it is, instead, directed to a spot many degrees distant; and so an unexpected region of the retina receives the stimulus of the light. When the retina has not undergone adaptation, there has been found a gradual diminution of sensitiveness, from the centre to the periphery; but after adaptation, the threshold is the same in the central (except, however, the fovea) and the peripheral parts of the retina.

Some observers, however, notably Schoen, have found a marked difference in the light-sensibility of the nasal and temporal halves of the retina,—the temporal being

the less sensitive.

The fovea is generally admitted to have a higher threshold of stimulation than the surrounding parts of the retina. The fact that faint stars are best seen when observed indirectly, is given in illustration of this. Still, the eye looks instinctively at a luminous point, in such a way as to see it most distinctly, (Rivers, in Schäfers' "Physiology," Vol. II, P.P. 1086, 1083.)

The only enquiries as to the light-sense at various ages, which I have found, are those of Wallace Henry, who, using a photometer of his own invention, and examining his subjects clinically, after five minutes' adaptation to darkness, reported on the light-sense, in regard to the L.M., in fifty healthy eyes. The figures show that the L.M. is slightly less in early and middle life, and that it gradually increases with the advance of years. (Wallace Henry's own statement that the light perceptive power is greatest in early and middle life, is obviously just another way of stating the same fact, as in my text). Further, nine cases which he examined, in which one eye was healthy, while the other was either totally blind or had been removed, indicate as far as they go, that the loss of an eye renders the L.M. of the remaining eye, when healthy, less than usual ("The Ophthalmic Review," Feb. 1896.)

PATHOLOGY:-

Since Berry's paper on "Defects of the Light and

Colour Senses,"included in his"Subjective Symptoms in Eye Diseases," (1886,) there has not been much to add to his statement of the extent of knowledge of the light-sense in pathological conditions. Berry's summary was to the effect that Bjerrum had demonstrated that in diseases primarily involving the choroid and retina, there is a tendency to imperfect perception of light;-- in other words, to increased L.M. But, in diseases primarily involving the nervous elements in the retina or optic nerve,there is a tendency to imperfect recognition of changes in the intensity of illumination,— in other words, to increased L.D.

Henry's paper on "The Light Perceptive Power," which has been already referred to, was published in 1896, and contained results quite in accord with those of Bjerrum. For example, in optic neuritis and optic atrophy there was not shown much variation from normal in regard to the L.M., but in choroido-retinal atrophy, glaucoma, hemeralopia, and ~~in~~ retinitis, there was very marked increase in the L.M.

Amongst the subsidiary reports of Henry is a table contrasting the form-sense (tested by Snellen's types for distance, without correction of refractive error, if any) and the L.M., from which it would appear that, though the form-sense might vary from $\frac{6}{6}$ to $\frac{6}{60}$, there was no marked variation in the L.M. Unfortunately, the cause of the defective form-sense is not given:— possibly some of the eyes would have come up to normal had they been tested

with glasses, and possibly some were diseased, and others amblyopic without obvious lesions

In association with this may be taken Henry's statement, that it has been said that eyes, with a hypermetropia of four dioptres or over, have an increased L.M., and his own observation, that in the few myopes he had examined there was certainly a diminished L.M.

Henry gives no evidence of having examined many cases of toxic amblyopia, but he found in those he did examine, that the L.M. was not affected. The cause of this, he thought, might be, that the fibres of the optic nerve, which pass to the light-sense centre, are of a nature less prone to degenerate than those which pass to the form-sense or colour-sense centre. It has been proved, however, that in advanced cases of toxic amblyopia, the papillo-macular bundles of the optic nerves are structurally affected ("Swanzy's Handbook", Edition 5, P. 441), so possibly the cases referred to were early.

Henry had two cases of marked anaemia with extreme dilatation of the pupil, and in these there was increased L.M. In connection with these, Eales suggested that the dilated pupil in marked anaemia might be due to defective light-sense.

STRABISMUS;-

I have now referred to all the results I am acquainted with, of observations upon the light-sense, in either healthy or diseased eyes.

So far as I am aware, no effort has been made to examine the light-sense in the eyes of squinters, nor indeed in any little-understood eye affection, with the possible exception of toxic amblyopia.

In our present state of knowledge—or ignorance—of the whole subject of strabismus, it seems worth while to attempt to contribute a little solid fact to the few facts that are known, in the hope that, with the increase of knowledge, some universally-accepted theory may finally be propounded; and who knows then, but that the nineteenth century therapeutics of strabismus may undergo a radical change?

Amongst the questions that oppress one, in regard to strabismus, are such as these:-

Why does a squinting eye frequently have defective acuity of vision? is the defective vision dependent upon the squint, or the squint dependent upon the defective vision?

What causative relation can there be between refraction and squint, seeing that high hypermetropia, low hypermetropia, emmetropia, and myopia, may any of them be associated with convergent strabismus or with divergent

strabismus?

If the answer to these, and other, questions rests in the eye itself, or in the more central parts of the visual apparatus:- as distinct, that is, from the muscular and muscular-innervation apparatus, it is quite conceivable that the examination of the light-sense may yield some useful knowledge. The ordinary methods of examination, including the ophthalmoscope, don't help us, (for I am excluding cases of gross lesion), does the photometer yield anything?

THE PHOTOMETER:-

And first, one must decide which photometer to use.

A good photometer should supply, it seems to me, three desiderata:-

1. It should permit of the light-sense, pure and simple, being measured, without either assistance or hindrance from the form-sense.

2. The nearer its source of light is to invariableness, the nearer does it approach perfection.

3. It should permit of the estimation of the two elements of the light-sense;—not only of the L.M., but also of the L.D.,—and therefore should permit of the comparison of two luminous surfaces or points.

All the photometers, that I have seen or had described to me, come short in one or more of the above qualifications.

For example, Izard and Chibret's photometer, which Swanzy described as the most convenient clinical method

of testing the light sense, in the 5th edition of his "Handbook," has, for the source of light, the sky,—a source which, Henry justly observes (Op. cit.) is anything but constant in this country.

Again, Foerster's photometer, in which the source is the light of a standard candle, passing through a sheet of paper, and illuminating two pieces of white paper in the interior of a box, into which the observer looks, may be admirably adapted for estimating the L.M., if it is constructed as described by Berry in his paper already referred to. But evidently it is not always so constructed, for Henry (op.cit.) criticises the one supplied to him, on account of the observer's being required to recognise a word placed in the inside of the instrument. And, further, Foerster's photometer is not applicable to the estimation of the L.D.

Henry's own instrument has received the imprimatur of Swanzy, in the seventh edition of his "Handbook." In this photometer, the source of light is a standard candle, and the variation in the intensity of the illumination is produced by the removal of opal discs of standard density, the size of the illuminated area always remaining the same. But it is constructed only for determining the L.M., and is not adaptable for determining the L.D.

Bjerrum's test-types—grey letters on a white ground, constructed on the same principle as Snellen's test-types—have the fatal objection that, with them, the form-sense is confounded with the light-sense.

Masson's discs, which are the means usually employed for the examination of the L.D., are confessedly not intended for the examination of the L.M.

A NEW PHOTOMETER:- In the absence therefore, of any entirely satisfactory instrument, I have designed and constructed a new photometer, which possesses all the desiderata I have enumerated on p. 9, so that, with the one instrument, I have been able to examine both the L.M. and the L.D.

In designing it, I have not hesitated to make use of what seemed good in the principles of construction of the older photometers, and, at the same time, I have avoided, I believe, the deficiencies and faults of them all. The new photometer, therefore, is a composite one, which does not claim to be a special creation but the natural evolution of its predecessors. Henry's instrument, the latest of these, has suggested the most points, as was to be expected.

The new photometer consists of a wooden oblong box, measuring, inside, 67 c.m. long, 20 c.m. wide, and 20 c.m. high, and having one end open.

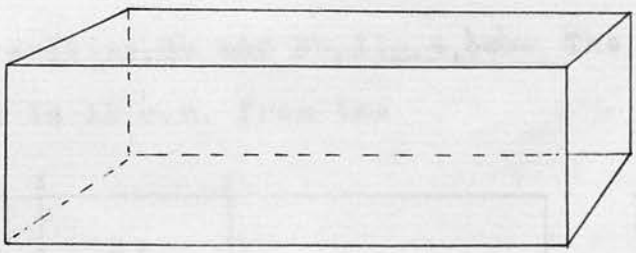

Fig. 1.

It is divided transversely by two partitions, y, z, (see fig. 2, p.12) the first, y, 13 c.m. from the closed end,

x; and the second, z, 34 c.m. from the same end (x), leaving about 33 c.m. between the second partition, z, and the open end. Each partition reaches right across the box, and from

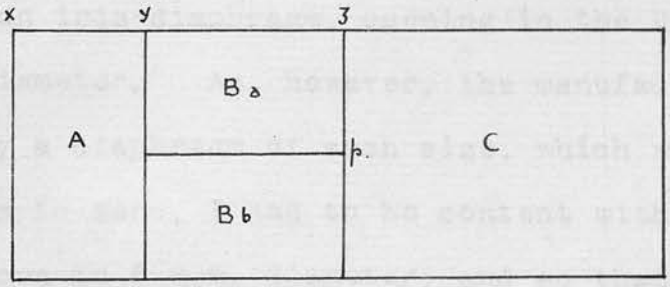

Fig. 2. Ground-plan of photometer (not drawn to scale).

floor to roof. The box is thus divided into three compartments. Compartment B is then divided into two again, B a and B b, by a longitudinal partition, p., which extends from y to z, and from floor to roof, as before, so that the ground plan of the whole box presents the appearance shown in figure 2, above.

The roof of the box stops short at y, compartment A being open to the air therefore (though it can be closed at will when the instrument is not in use).

In the partition y are two circular apertures, symmetrical as to position, each of which opens into one of the cavities, Ba and Bb, fig. 4, below. The centre of each aperture is 12 c.m. from the

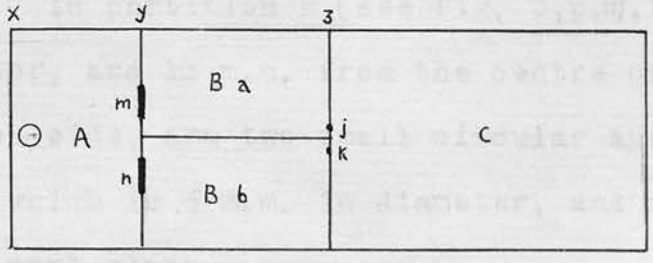

Fig. 3. Diagram of horizontal section through about the middle of the box.

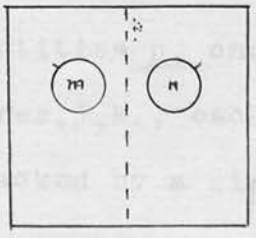

Fig. 4. View of p, looking from x, to show circular apertures.

~~Diagram of horizontal section through~~ ~~View of~~ p, ~~looking from x, about the middle of the box~~ ~~to show circular apertures~~, floor, and 3.5 c.m. from the centre of the partition p. (see fig. 4, p.12). Into each aperture is fixed an iris-diaphragm, opening in the usual way to 50 m.m. diameter. As, however, the manufacturers could not supply a diaphragm of such size, which would also close down to zero, I had to be content with a diaphragm closing down to 5 m.m. diameter; and so that the aperture might be perfectly closed, when the handle of the diaphragm was turned down, I placed a piece of plane glass behind each diaphragm, having precisely in its centre a cylinder of wood, 5 m.m. in diameter, which sufficed to close the opening entirely (m,n, in fig. 4, p.12). Opposite to the handle, (or pointer) of each diaphragm,

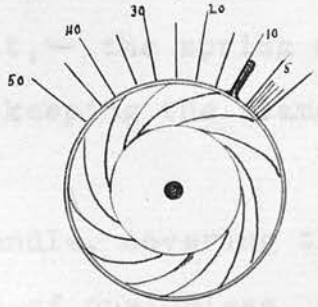

Fig. 5.
Diaphragm (partly open) with scale.
pointer (or handle) near 10 m.m.

is drawn, on the partition y, a scale corresponding to the number of millimetres of the varying diameters of the diaphragm as it is opened, — from 5 m.m. to 50 m.m.

In partition z (see fig. 3, p.12), 10 c.m. from the floor, and 13 m.m. from the centre of partition p, one on each side, are two small circular apertures, j, k., each of which is 4 m.m. in diameter, and is backed by a piece of opal glass.

The compartments, B a and B b, therefore, are symmetrical; and each has, at the far end, a large aperture, capable of being closed to zero, and of being opened, circularly, to any diameter up to 50 m.m. (the central disc of darkness, 5 m.m. in diameter, being constantly present); and, at the near end, a small aperture backed by a piece of opal glass.

In compartment A (p.12, fig.3), is placed a Priestly Smith's candle-lamp, without the bull's eye, and fitted with one of Price's best stearine candles, specially prepared. It stands precisely midway between the two sides of the compartment,— the wick being 3.5 c.m. from the wall x, and 9.5 c.m. from the partition y, the apertures m, n, just described, in the partition, having been so placed as to be precisely on a level with the flame of the candle when lit,— the spring of the Priestly Smith lamp, of course, keeping the flame of the candle at a constant level.

Behind the candle, covering the whole inside of the wall x, is a sheet of opal glass, to serve as a reflector.

C (fig 2, p.12.) is simply an oblong compartment, covered on the inside with dull black paint, and having the two apertures, j, k, at the far end, and the near end open.

It is easy to see that this new photometer can be used to determine both the L.M. and the L.D. For, the candle having been lit, so long as the diaphragms are

are closed, no light will pass into the compartments, Ba, Bb, and so none will reach the opal-covered apertures, j,k. As soon, however, as either diaphragm, say, m, is opened, no matter how slightly, a certain amount of light will enter Ba (fig. 3, p.12), and impinge upon j. The amount of light entering Ba, and reaching j, can, within the necessary limits, be varied at will by simply turning the handle of the diaphragm; and, so long as the aperture, n, is kept closed, no light will enter Bb and impinge upon k. Immediately however, one begins to open n, light will enter Bb, and reach k, (fig. 3, p.12.). And since the candle occupies precisely the same relative position to each aperture, the amount of illumination in each compartment, and therefore on each opal disc, is precisely the same, provided always the diaphragms are open to the same extent.

The advantage of the opal glass in the discs, j, k, as in Henry's Photometer, is that it diffuses the light; and, as the openings, j,k, are so placed, 2 c.m. apart, and at such a level, that they are not opposite the source of light, no matter how widely open the diaphragms may be, the light falling on the discs is only the light filling the compartments, Ba and Bb.

The use of this photometer, therefore, is quite simple. The candle having been lit, and one of the eyes covered, the patient is placed looking into the open end, and towards the apertures, j,k. If he has been previously shown what he is likely to see, he will be pre-

pared to recognise a disc as soon as it emerges from the darkness.

He is now directed to call out the moment he can discern, no matter how faintly, one disc of light appearing on the wall, z (fig.3, p.12.). The operator then slowly moves the handle of the diaphragm, so as to open it gradually and admit light into the corresponding compartment. As soon as the patient calls out, the operator stops, and notes down the diameter of the aperture in the diaphragm. This represents the L.M.

He then opens the other diaphragm to an equal extent, and now the patient announces that he can see two discs, side by side. The examiner next informs him, that he is about to make one disc a little brighter than the other, and asks him to signify the moment he can discern even the slightest difference in the intensity of the illumination, and to say which disc is the brighter. The operator then continues to open one of the diaphragms still further, leaving the other as it was, and, proceeding slowly, only pauses when the patient calls out that he sees a difference, and that either the right or left disc is the brighter. The diameter of the larger aperture is next noted, and the L.D. is got by subtracting the diameter of the smaller from that of the larger aperture. For example, suppose a disc is first discerned when the diaphragm registers 7 m.m.,— this is put down as the L.M. When one of the diaphragms, in the second part of the observation, has reached 10m.m. diameter of

aperture, there is seen a difference in the intensity of illumination. The L.D. then equals 10 minus 7, or 3.

For purposes of comparison it is well to have the L.D., as thus obtained, reduced to a fraction, proper or improper, of the L.M. To do this it is necessary to know the area of the aperture in the diaphragm for each different length of diameter. The total area of aperture for the passage of light then, is the area of the circular ring between the central cylinder, 5 m.m. in diameter (p.13), and the free edge of the diaphragm when, in the present example, the aperture has a diameter of 7 m.m.. The rule for such areas is (vide Todhunter's "Mensuration"): multiply the sum of the radii by their difference, and the product by $\frac{22}{7}$. That is $\left(\frac{7}{2}+\frac{5}{2}\right) \times \left(\frac{7}{2}-\frac{5}{2}\right) \times \frac{22}{7} = \frac{132}{7} =$ 18.8571....

This is the L.M. in square millimetres.

To estimate the L.D., one gets similarly the area of the circular ring, when the diaphragm is opened to 10 m.m. diameter:

$$\left(\frac{10}{2}+\frac{5}{2}\right)\left(\frac{10}{2}-\frac{5}{2}\right) \times \frac{22}{7} = \frac{825}{14} = 58.9286....$$

Therefore, the L.D. is 58.9286 less 18.8571 = 40.0715; and its proportion of the L.M. is $\frac{40.0715}{18.8571} = \frac{40 \text{ about}}{19} = 2.11$.

This is the method I have adopted in comparing the L.D. of different L.M.'s.

The points in this photometer which seem to me to specially commend it, are:-

(1) It combines the means of estimating both the L.M. and the L.D.

(2) It has a constant source of light.

(3) It requires the observer simply to say when he recognises an illuminated spot, so that the form-sense does not enter into, and confuse, the examination.

(4) In every case the L.D. is estimated from the individual L.M. The disc remains at the threshold of sensibility, and is therefore at every moment available for comparison with the one being more illuminated. Presumably the disc representing the L.M. seems the same to each observer, whatever its absolute illumination is, so that in every case the estimation of the difference begins from the same amount of illumination. Other instruments have a fixed minimum, which is likely to affect different patients in unequal degrees. There is a good deal of extra labour involved in measuring the comparative L.D.,[2] but I think it is repaid by the advantage of having more uniform results.

A disadvantage is that the diaphragm needs a central plug; but this is merely a detail, and can be rectified when the makers attain to the construction of diaphragms that close to zero.

It is an infinitely more comfortable apparatus for the patient to be examined by, than Henry's, which requires that he bury his head in the cloth hood, to prevent any light reaching him from the candle except through the opals.

In the new photometer the hood has not been needed, because the light of the candle is confined to the compartment A, and the patient runs no risk of its embarrassing him therefore.

AMBLYOPIA:-

In undertaking this research I set before me these questions, which urgently need answers:

(1) In the ambly-opic eye associated with strabismus, is there any difference in the light-sense?

But what have I understood by ambly-opia? Berry (op. cit.) says , "When the visual acuity, after correction if necessary of any existing error in refraction, does not come up to the normal standard, there is said to be ambly-opia."

"Ambly-opia may be the result of defects in any part of the visual apparatus," including nebulae of cornea, conical cornea, lamellar cataract, etc.. Swanzy (op. cit.) says, "Amblyopia is nowadays usually employed to signify defective vision due to disease or functional disturbance of the retina, optic nerve, or visual centre, but with healthy ophthalmoscopic appearances, or with signs only of optic atrophy.

But I have been much more strict in regard to the cases I have classed under the heading of "the ambly-opia of squint," than either Berry or Swanzy in the above quotations. I have only called an eye ambly-opic, when, with Berry, I have found the visual acuity, after correction if necessary of any existing error in refraction, does

not come up to the normal standard, and provided also, and rigidly, that there are healthy ophthalmoscopic appearances. In other words, I have only called an eye amblyopic when, after complete ophthalmoscopic examination, both of the fundus and the media as far forward as the anterior epithelium of the cornea, I have found nothing that, after a considerable experience of healthy, normal, eyes, I could describe as anything but normal. The ophthalmoscopic result having been noted as "nil" therefore, I have tested the form-sense, basing my correction on the information derived from retinoscopy; and only if the visual acuity failed to come up to normal then, have I called it amblyopia.

But even then, can one say of every eye that does not read $\frac{6}{6}$, that it is amblyopic; and if an eye seeing $\frac{6}{9}$ is passed as non-amblyopic, what about one with $\frac{6}{12}$, and similarly with $\frac{6}{18}$, and $\frac{6}{24}$? Obviously, it is necessary to draw the line,— arbitrarily it may be,— somewhere,— the difficulty is to know where. It has seemed to me that, if I only recognised as amblyopic, eyes that failed to see more than $\frac{6}{18}$, I should be leaving a wide-enough margin. I have adopted this limit therefore, and whenever I have noted an amblyopic eye, it is one that read less than $\frac{6}{12}$, or part of $\frac{6}{12}$.

Those eyes, however, that reached $\frac{6}{12}$, but not $\frac{6}{9}$, I have made a separate table for, as occupying a sort of middle position.

The first question (see p.19) then is, if one eye differs from its fellow only in two recognised conditions, namely, that it sees less than $\frac{6}{12}$, while its fellow sees $\frac{6}{6}$, and that it turns either in or out, is there any difference in its light-sense—— either L.M. or L.D.,——as revealed by the photometer. In regard to the turning in or out, I have included not only those with present squint, but also those which have had squint, but in which it is not now present as the result of

(a) Operation,

(b) Wearing of glasses, or -

(c) Natural improvement.

In those cases where the squint was not actually made out at the time of the photometric examination, the evidence of previous squint required, was

(a) My personal observation and note at an earlier time;-

(b) The observation and note of a colleague at the Liverpool Eye and Ear Infirmary; or

(c) A clear and definite history from a person apparently reliable.

(2)(see p 19). In the squinting eye of those people who have good visual acuity in both eyes, so that the only difference ordinarily recognisable is the squint (which may be permanent or occasional, or alternate,) is there any difference in the light-sense from that in the normal eye?

(3) But there are some amblyopic eyes, ordinarily called "congenitally amblyopic," in which <u>there is no evidence, either present or past,</u> of strabismus. Do such eyes dif-

fer in their light-sense from their normal fellow?

THE PHOTOMETRY:-

The cases that I have examined to the end of answering these questions, are divided, in each group, into two classes:-

A. Those that wore the correcting glasses during the photometry,

B. Those that were examined with the eyes naked.

The wearing of glasses was adopted in accordance with a suggestion made by Henry.

All the photometric examinations were carried out in a dark room, in which the patient had been sitting, as a preliminary, for at least five minutes (vide Henry, op. cit., p 6,), so that the eyes had undergone a certain amount of adaptation. Had the examination been conducted without this precaution, on the ground that adaptation may alter the relative acuity of the light-sense from the normal, the results would hardly have been suitable for comparison, because the condition of the visual apparatus would have varied greatly, according as the time of examination was morning, twilight, or evening with artificial light in the room.

In every patient, of course, the two eyes were examined separately, the one not under examination at the moment having a shade suspended in front of it, and so arranged as not to touch it, for pressure on an eye soon becomes painful, and would lead to unreliable results if the eye

were examined soon after in the photometer.

In many cases, especially amongst the later ones, the examination was gone through twice;—— the full preliminary five minutes' darkness being given each time; and in those cases in which there was a difference in the two results, which was practically always in the direction of greater acuteness, the second result alone has been introduced into the tables.

It may be objected that the light-sense, however estimated, is sure to show fallacious records, seeing that so much depends on the mental acuteness of the individual.

I am fully conscious of the difficulty,——nay, the impossibility, of attaining to what Berry called (op. cit. p. 74)" mathematically accurate measurements" of the light-sense. But this is just the difficulty that every practical oculist finds before him, when he sets out to measure the form-sense. For example, a child on first examination may read only $\frac{6}{60}$,—— yet, when he is tested again two or three weeks later, he may easily come up to $\frac{6}{18}$. And, in the case of adults, it is quite common to find a difference of a whole line of Snellen's types, in two consecutive examinations. If these variations occur, as I have found them to do in my own practice, it is only to be expected that in the much more elusive light-sense similar variations should be found. But that is no reason for rejecting the results altogether; it would be as

reasonable to refuse to use Snellen's types to test vision with.

I claim that the limits of error in photometry do "not transgress the bounds of practical utility" (vide Berry, op.cit,p 74).

However, I have found it desirable to exclude from examination all very young patients. Only a few who were not more than ten years old have been employed for the purposes of this paper, while the bulk of the patients were boys and girls in their teens.

TABULAR STATEMENTS.

The cases I have to report upon, consist in all of 135; 90 wore correcting glasses, 45 were without glasses. They are reported on as under these heads following:---

DIVISION 1. With glasses;

Group.1. Convergent Strabismus with Amblyopia,——— 44.

" 2. ditto——————— without ditto,——— 18.

" 3. Doubtful Convergent Strabismus, with Amblyopia,——————— 4.

4. ——————— ditto ——— without ——— ditto

" 5. Alternate Convergent Strabismus, with double Amblyopia,——————— 2.

" 6. Divergent Strabismus, with Amblyopia,——— 5.

" 7. — ditto——————— without — ditto ——————— 4.

" 8. Amblyopia without Strabismus,——————— 13.

DIVISION 2. Without glasses:-

Group.9. Convergent Strabismus with Amblyopia,———22.

" 10. — ditto ——————— without — ditto——— Alternate Convergent Strabismus, without Amblyopia,——————— 13.

" 11. Divergent Strabismus, with Amblyopia, — ditto- with double Amblyopia,——— 4.

In addition I shall refer incidentally to:-

Group.12. Toxic Amblyopia. 6.

And in conclusion, I shall give a table of all the non-squinting eyes, which are normal, and their light-sense.

GROUP. 1. Convergent Strabismus with Amblyopia, (that is, visual acuity of less than $\frac{6}{12}$ in the squinting eye.)

I have arranged the 44 cases in various ways, in the hope that a glance at each table will show whether there is any rule or order of variation.

TABLE. 1. Convergent Strabismus, with Amblyopia, arranged in accordance with the visual acuity of the squinting eye:-

In the third and fourth columns, the letters, G., E., and L., indicate that the L.M. or L.D. of the amblyopic eye is respectively greater than, equal to, or less than, the L.M. or L.D. of the normal eye.

Form Sense	Register No.	L.M.	L.D.
Hand Movements	79—	-G ———	——— L
Fingers	29—	-G ———	——— E
	50—	——— E ———	-G
	52—	——— L—	-G
	61—	-G ———	——— E
	105—	——— E ———	-G
	122—	——— E ———	——— E
Ja	27—	——— E ———	——— (?)
	33—	-G ———	——— (?)
	43—	-G ———	——— E
	78—	——— E ———	——— E
	103—	——— E ———	——— E
6/60	28—	——— E ———	-G
	35—	-G ———	——— E
	36—	——— L—	-G
	55—	-G ———	-G
	57—	——— L—	-G
	70—	-G ———	——— E
	75—	-G ———	——— E
	86—	——— L—	-G
	89—	-G ———	——— (?)
	96—	——— E ———	-G
	98—	——— L—	-G
	123—	-G ———	-G
6/36	46—	——— E ———	——— L
	81—	——— L—	——— L
	97—	-G ———	——— E
	100—	——— E ———	——— E
	102—	——— E ———	——— L
	111—	-G ———	——— L
	117—	-G ———	——— L
	118—	——— L—	——— E
	124—	——— E ———	——— E
6/24	21—	-G ———	——— E
	41—	-G ———	——— E
	42—	——— E ———	-G
	74—	——— L—	-G
	82—	——— E ———	-G
	95—	——— E ———	——— L
	108—	——— E ———	-G
	113—	——— E ———	——— L
	116—	-G ———	——— (?)
6/18	32—	——— E ———	——— L
	63—	——— L—	-G
Total		17 - 18 - 9	16 - 15 - 9

Three of the above cases, viz. Nos. 27, 33, and 89, are ~~are~~ marked in the fourth column with a query. In each of them, after the first disc had been discerned, — the L.M., — the second disc, although the second diaphragm was turned to correspond to the first, was not seen; and although both diaphragms were then gradually and equally opened until each disc had the full illumination of an aperture of 50 m.m., the second disc was never seen at all. Consequently, it was not possible to estimate the L.D.

TABLE 2.--Convergent Strabismus with Amblyopia, arranged in accordance with the age of the patient:-

Age in years	Register No.	L.M.	L.D.
9	97	-G ———	——— E
10	116	-G ———	——— (?)
	123	G ———	-G
11	36	——— L	-G
	74	——— L	-G
	75	-G ———	——— E
	105	——— E ———	-G
	111	-G ———	——— L
12	61	-G ———	——— E
	96	——— E ———	-G
13	43	-G ———	——— E
	50	——— E ———	-G
	79	-G ———	——— L
	95	——— E ———	——— L
	102	——— E ———	——— L
	113	——— E ———	——— L
14	32	——— E ———	——— L
	41	-G ———	——— E
	63	——— L	-G
	70	-G ———	——— E
	122	——— E ———	——— E
16	29	-G ———	——— E
	52	——— L	-G
	55	G ———	-G
	118	——— L	——— E
18	21	-G ———	——— E
	27	——— E ———	——— (?)
	89	-G ———	——— (?)
	98	——— L	-G
19	35	-G ———	——— E
	81	——— L	——— L
21	33	-G ———	——— (?)
	78	——— E ———	——— E
	82	——— E ———	-G
22	42	——— E ———	-G
23	46	——— E ———	——— L
25	57	——— L	-G
	108	——— E ———	-G
27	124	——— E ———	——— E
31	103	——— E ———	——— E
35	117	-G ———	——— L
36	86	——— L	-G
41	28	——— E ———	-G
46	100	——— E ———	——— E
		17 - 18 - 9	16 - 15 - 9

Table 3.--- Convergent Strabismus, with Amblyopia;- those patients seeing only "Fingers,""Ja," or $\frac{6}{60}$, arranged in accordance with their age:

Form-sense	Age	No.	L.M.	L.D.
Fingers	11	105	E	G
	12	61	G	E
	13	50	E	G
	14	122	E	E
	16	29	G	E
	16	52	L	G
Ja	13	43	G	E
	21	78	E	E
	31	103	E	E
$\frac{6}{60}$	10	123	G	G
	11	36	L	G
	11	75	G	E
	12	96	E	G
	14	70	G	E
	16	55	G	G
	18	98	L	G
	19	35	G	E
	25	57	L	G
	36	86	L	G
	41	28	E	G
			8 - 7 5	11 - 9 - 0

Table 4.- Convergent Strabismus with Amblyopia, arranged in accordance with the glasses worn. In each case the spherical glass only is noted, although, where a cylinder also was used, the fact is mentioned:

T A B L E. 4.

Glass worn	No.	L.M.	L.D.
− 3	70	−G	E
plane	122	E	F
+ 1	21	−G	E
	42	E	G
	111	−G	L
+ 1, with − cy	57	L	−G
+ 1.25	97	−G	E
+ 1.75	29	−G	E
+ 2	63	L	−G
	78	E	E
	103	E	E
+ 2, with − cy	33	−G	(?)
+ 2, with + cy	96	E	−G
+ 2. 25, with+cy	28	E	−G
+ 2.5	41	−G	E
	75	−G	E
+ 2.5, with+cy	46	E	L
	82	E	G
	100	E	E
+ 3	52	L	−G
	55	−G	−G
	61	−G	E
	79	−G	L
	81	L	L
	89	−G	(?)
	105	E	−G
	108	E	−G
	117	−G	L
+ 3, with + cy	35	−G	E
	124	E	E
+ 3.25	27	E	(?)
+ 3.5	36	L	−G
	43	−G	E
	50	E	−G
	98	L	−G
	102	E	L
	113	E	L
+ 4	116	−G	(?)
+ 5	32	E	L
	74	L	−G
+ 5.5	95	E	L
+ 6	86	L	−G
	118	L	E
	123	−G	−G
		17 - 18 - 9	16 - 15 - 9

The summary of these is, that of the 44 cases, the

(a) L.M. of the squinting amblyopic eye was equal to that of the normal in ——— 18,

(b) L.M. of the squinting amblyopic eye was greater than that of the normal eye in ——— 17,

(c) L.M. of the squinting— ditto ——— less than that of the normal eye in ——— 9.

Thus there was no absolute rule found as to the L.M, though a slight majority of the eyes (18+ 9,= 27, out of 44) appeared to have, at least, normal L.M., while in 18 there was defective L.M.

(d) L.D. of the squinting amblyopic eye was equal to that of the normal, in ——— 15,

(e) L.D. of the squinting amblyopic eye was greater than that of the normal, in ——— 16,

(f) L.D. of the squinting— ditto ——— was less than that of the normal, in ——— 9,

while, from various causes, it was not determined in ——— 4. That is, the L.D. was defective in 16 out of 40 cases, in the others (15+ 9 = 24) being normal or more acute.

As, however, many of these results, put down as greater or less, were not far from equal, I have thought it well to prepare yet another table, including only those cases which showed a marked difference in either the L.M. or the L.D., or in both. 21 only, out of the 44, are qualified for inclusion here, and they are arranged in three divisions, as follow:

TABLE 5.--Convergent Strabismus with Amblyopia, having a marked difference in the Light-sense.

In which element of light-sense	No.	L.M.	L.D.
1.Both L.M. and L.D.	52–	——— L—	-G
	57–	——— L—	-G
	123–	—G———	-G
		1 - 0 - 2	3 - 0 - 0
2 In L.M. alone	41–	—G	
	43–	-G	
	61–	-G	
	70–	—G	
	74–	——— L	
	81–	——— L	
	117–	—G	
		5 - 0 - 2	
3 In L.D. alone	28 -	———	-G
	46–	———	——— L
	52–	———	-G
	55 -	———	-G
	79–	———	——— L
	82–	———	-G
	86–	———	-G
	95–	———	——— L
	98–	———	-G
	102–	———	——— L
	105–	———	-G
			7 - 0 - 4

From this it appears, that in 6 out of 10 (divisions 1 and 2) the L.M. is markedly defective, while in 4 out of the 10, it is more acute. On the other hand, in ten out of 14 (divisions 1 and 3) the L.D. is defective, while in 4 out of the 14, it is more acute.

I have one more tabulation of this group of 44 to display,—— consisting of 13 cases in which the second disc was not at once seen when equally illuminated with the first. For example, the L.M. was noted, say at 8, but when the second diaphragm registered 8,

the second disc was not visible. In such cases both diaphragms were equally increased in aperture, until both discs were seen.

Of these 13,-2 said that the two discs seemed to be four.

The other 11 are arranged in two different ways, and without comment.

TABLE 6. -Convergent Strabismus with Amblyopia, in which the second disc was not seen at once when made equally brilliant with the first disc;- arranged in accordance with the form-sense in the squinting eye.

Form-Sense	No.	L.M.	L.D.
Fingers	105—	—— E ——	-G
Ja	27—	—— E ——	did not see second at all
	33—	G ——	—— ditto
	103—	—— E ——	—— E
6/60	36—	—— L—	-G
	57—	—— L—	-G
	89—	G ——	did not see second at all
	98—	—— L—	-G
	123—	G ——	-G
6/36	81—	—— L-	—— L
	100—	—— E ——	—— E

TABLE 7-Convergent Strabismus with Amblyopia, in which the second disc was not seen at once when made equally brilliant with the first disc:- arranged in accordance with the patients' ages---

Age	No.	L.M.	L.D.
10	123-	-G———	-G
11	36-	———L—	-G
11	105-	——E———	-G
18	27-	——E———	-did not see second at all
18	89-	-G———	——— Ditto
18	98-	———L-	-G
19	81-	———L-	——— L
21	33-	-G———	—did not see second at all
25	57-	———L—	-G
31	103-	——E———	———E
46	100-	E———	———E

TABLE 8.--Convergent Strabismus with Amblyopia in which the second disc was not seen at once when made equally brilliant with the first disc, and in which, finally, the two discs seemed to be four.

Form-Sense	Age	No.	L.M.	L.D.
$\frac{6}{60}$	16——	— 55—	-G———	—G
$\frac{6}{36}$	35——	—117—	-G———	———L

Group 2. (p.25).- The next group is that containing the cases of convergent strabismus, without amblyopia, — those seeing, that is, more than $\frac{6}{18}$ with the squinting eye,— 18 cases.

Table 9.- Convergent Strabismus without Amblyopia, arranged in order of examination.

No.	L.M.	L.D.
14-	E	G
17-	L	G
22-	L	E
24-	G	G
25-	L	G
49-	E	G
51-	E	L
56-	E	E
60-	G	L
65-	E	G
69-	G	E
71-	L	E
72-	E	G
83-	E	E
85-	E	G
94-	G	G
99-	L	E
115-	E	E
	4 - 9 - 5	9 - 7 - 2

It is thus seen that of the 18 cases with strabismus, the -

(a) L.M. of the squinting eye was equal to that of the normal eye in 9,

(b) ——— ditto ——— greater than ——— ditto ——— 4,

(c) ——— ditto ——— less than ——— ditto ——— 5.

This result is similar to that of the amblyopic eyes (Table 1, etc, p.32), 14 out of 18 cases having a normal or more acute L.M., and 4 out of 18 being defective. Yet, on the whole, there is less difference between the two eyes in this group than between those in the first group.

(d) L.D. of the squinting eye was equal to that of the normal eye, in ——— 7,

(e) L.D. of the squinting eye was greater than that of the normal eye, in ——— 9,

(f) L.D. of the squinting eye was less than that of the normal eye in ——— 2.

That is, again, the L.D. was defective in 9 out of 18 cases, or $\frac{1}{2}$, as compared with a like defect in $\frac{2}{5}$ of the amblyopic eyes (p.32).

TABLE.-10.Besides the above eyes, there were 4 cases of Alternate Convergent Strabismus, in which the visual acuity of each eye was equal.

No.	of one eye L.M.	of same eye L.D.
76— — —	-G— — — — —	— — - E
77— — —	— — -E— — —	-G
106— — —	— — E— — —	— — -E
120— — —	— — -E— — —	-G
	1 - 3 - 0	2 - 2 - 0

There is thus a tendency to equality in the light-sense of the two eyes.

In one case of Table 9 (p.36), No. 24, the second disc was not seen as early as the first.

In Table 9, those cases, 6 in number, in which the squinting eye saw only $\frac{6}{12}$, or a part of $\frac{6}{12}$, have been separated, and arranged

(1) In accordance with the age of the patient, and

(2) In accordance with the glasses worn.

They can thus be considered as an appendix to Group 1.

TABLE 11. Convergent Strabismus, in which the squinting eye saw only $\frac{6}{12}$, or $\frac{6}{12}$ partly, arranged in accordance with the age of the patient:

Age	No.	L.M.	L.D.
11	72	E	G
14	17	L	G
14	83	E	E
16	71	L	E
18	49	E	G
18	56	E	E
		0 - 4 - 2	3 - 3 - 0

TABLE 12-Convergent Strabismus, in which the squinting eye saw only $\frac{6}{12}$, or $\frac{6}{12}$ partly, arranged in accordance with the glasses worn:

Glasses worn	No.	L.M.	L.D.
plane, with + cy	56	E	E
+ 1, with + cy	72	E	G
+ 2	83	E	E
+ 2.5	49	E	G
+ 2.5, with + cy	71	L	E
+ 5	17	L	G
		0 - 4 - 2	3 - 3 - 0

In these the L.M. in the squinting eye is either equal to that in the normal eye, or more acute; while the L.D. is either equal or defective.

The next table contains those cases of the second group, in which the two eyes have equal form-sense.

TABLE 13-Convergent Strabismus, in which the two eyes have equal visual acuity;—

No.	L.M. of Sq; eye	L.D.
17—	——— L—	- G
49—	———E———	- G
56—	———E———	——— E
71—	——— L-	——— E
72 -	——— E ———	- G
83—	——— E ———	——— E
94—	- G ———	- G
99—	——— L—	——— E
	1 - 4 - 3	4 - 4 - 0

Here again, the L.M. is either (except in 1 out of 8 cases) equal to or more acute than that in the non-squinting eye, while the L.D. is either equal ~~to~~ or defective.

For the sake of comparison with Table 5 (p.33), I have selected from these cases of convergent strabismus without amblyopia, those in which there is a marked difference, either in both L.M. and L.D., or in only one. Out of the 18 cases, 10 come into the next table.

TABLE 14--Convergent Strabismus without Ambylopia, having a marked difference in the Light-Sense.

In which element of light-sense	No.	L.M.	L.D.
(1)Both L.M. & L.D.	— 24—	-G.———	-G.
		1 - 0 - 0	1 - 0 - 0
(2) In L.M. alone -	— 17—	——— L	
	69 —	-G	
	71—	——— L	
	99—	——— L	
		1 - 0 - 3	
(3) In L.D. alone -	— 14—	———	- G
	25—	———	- G
	49—	———	- G
	85 -	———	- G
	94—	———	- G
			5 - 0 - 0

Those in which the L.M. is markedly different (divisions 1 and 2), show that in 3 out of 5 cases, it is more acute. Those in which the L.D. is markedly different, show that in 6 out of 6 (divisions 1 and 3), it is defective.

Groups 3 and 4 contain 4 cases of doubtful convergent squint,— doubtful, because no squint was made out at the time of photometry by myself, or at any previous time by myself or colleagues, but in which there was either a note of "tendency to squint," or a history.

I have arranged these in three divisions; —

(1) Permanent squint with Amblyopia.

(2) Permanent squint without Amblyopia.

(3) Alternate squint without Amblyopia.

TABLE 15-Doubtful Convergent Strabismus, with Amblyopia.

No.	L.M.	L.D.
40-	—— E ——	—— L
	0 - 1 - 0	0 - 0 - 1

TABLE 16-Doubtful Convergent Strabismus, without Amblyopia.

No.	L.M.	L.D.
44 - 53 -	—— L - G ——	—— E - G
	1 - 0 - 1	1 - 1 - 0

No. 44 did not see the second disc, with either eye, as soon as it was equally brilliant with the first.

TABLE 17. Doubtful Alternate Convergent Strabismus without Amblyopia, — the visual acuity being equal in both eyes:

No.	L.M. of one eye	L.D.
92-	G ——	—— E
	1 - 0 - 0	0 - 1 - 0

The cases in this group are too few to be of value; and indeed they show as great a variety in the measurement of the light-sense as is possibe in 4 cases.

In Group 5, I have 2 cases of altermate convergent strabismus with double amblyopia, that is, each eye saw less than $\frac{6}{12}$. In each case, the visual acuity is different

in the two eyes; I have therefore taken the worse eye as the one to rank with the amblyopic eye in the tables.

TABLE 18. Alternate Convergent Strabismus with Double Amblyopia.

No.	L.M.	L.D.
19—	——— L—	-G
20—	-G ———	——— (?)
	1 - 0 - 1	1 - 0 - 0

In Case 20, the second disc was not seen at all, even with the less amblyopic eye; while the first disc was not seen with the more amblyopic one.

In this group, again, the cases are too few to be of value for comparison.

Group 6 contains 5 cases of divergent strabismus with amblyopia of the squinting eye.

TABLE 19-Divergent Strabismus with Amblyopia, arranged in accordance with the age of the patient:

Age	No.	L.M.	L.D.
12 —	— 47 -	——— L-	-G
16 —	— 16—	—— E ———	-G
17 —	— 66—	-G ———	-G
18 —	—110—	-G ———	——— E
50 —	— 54—	-G ———	——— L
		3 - 1 - 1	3 - 1 - 1

TABLE 20-Divergent Strabismus with Amblyopia, arranged in accordance with the glasses worn:—

Glasses worn	No.	L.M.	L.D.
− 11	110	G	E
plane	66	G	G
+ 0.75, with + cy	47	L	G
+ 1, with + cy	16	E	G
+ 3	54	G	L
		3 - 1 - 1	3 - 1 - 1

No. 47 did not see the second disc at once, when the second diaphragm was turned to the same aperture as the first.

From tables 19 and 20, it appears that:-

(a) L.M. of the squinting amblyopic eye was equal to that of the normal, in ——— 1,
(b) L.M. of the squinting amblyopic eye was greater than that of the normal, in ——— 3,
(c) L.M. of the squinting amblyopic eye was less than that of the normal, in ——— 1,
(d) L.D. of the squinting emblyopic eye was equal to that of the normal eye in ——— 1,
(e) L.D. of the squinting amblyopic eye was greater than that of the normal, in ——— 3,
(f) L.D. of the squinting amblyopic eye was less than that of the normal, in ——— 1.

So that in both the L.M. and the L.D. there is a tendency to defect.

Three of these cases presented a marked difference in the L.M. and the L.D.

TABLE 21. Divergent Strabismus with Amblyopia having a marked difference in the light-sense:--

In which element of Light-sense	No.	L.M.	L.D.
(1) In both L.M. & L.D.	47–	——————L—	–G
	54–	–G——————	——————L
	66–	–G——————	-G
		2 - 0 - 1	2 - 0 - 1

The tendency in each element is to defect therefore. There are also two cases of alternate strabismus with double amblyopia, the worse eye being reckoned for comparison as the amblyopic one in the second case, while in the first the visual acuity was equal in the two eyes.

Table 22.-Alternate Divergent Strabismus with Double Amblyopia.

No.	L.M.	L.D.
26—	-G in one eye	G in one eye
39—	-G——————	———E

Group 7 contains 4 cases of divergent strabismus without amblyopia.

Table 23.- Divergent Strabismus, without Amblyopia.

No.	L.M.	L.D.
18–	——— E ———	-G
59—	-G——————	-G
84-	——————L—	-G
121—	-G——————	——————L
	2 - 1 - 1	3 - 0 - 1

The divergence in No. 18 was due to the pressure of an orbital tumour.

All the four were cases of marked difference in the light-sense; in three the L.D. was defective, though in one more acute.

Group 8 consists of 12 cases of unilateral amblyopia in which there was no evidence at all of strabismus, either past or present; and of one case of double amblyopia, equally without evidence of strabismus. I have arranged the unilateral ones in the three ways as before.

Table 24.- Unilateral Amblyopia, without Stabismus, arranged according to the visual acuity of the amblyopic eye.

Form-sense	No.	L.M.	L.D.
Ja	45—	-G ———	——— L
	58—	-G ———	——— L
	67—	-G ———	-G
6/60	37—	-G ———	——— E
	48-	——— L-	——— L
	80-	-G ———	——— (?)
	90-	——— — L-	——— E
6/36	13-	-G ———	——— L
	34-	——— L-	-G
6/24	23-	——— E ———	-G
	38—	-G ———	——— E
	88-	-G ———	— ——— L
6/18	91—	——— E ———	—— E
		8 - 2 - 3	3 - 4 - 5

Table 25.- Unilateral Amblyopia without Strabismus, arranged according to the age of the patient:

Age	No.	L.M.	L.D.
11	91	E	E
13	34	L	G
14	23	E	G
15	80	G	(?)
18	38	G	E
22	58	G	L
22	90	L	E
23	48	L	L
29	13	G	L
29	37	G	E
29	67	G	G
39	88	G	L
47	45	G	L
		8 - 2 - 3	3 - 4 - 5

Table 26.- Unilateral Amblyopia without Strabismus arranged according to the glasses worn.

Glasses worn	No.	L.M.	L.D.
Plane	45	G	L
	58	G	L
plane, with - cy	13	G	L
plane, with + cy	38	G	E
	90	L	E
+ 1, with + cy	88	G	L
+ 1.75, with - cy	48	L	L
+ 2	80	G	(?)
	91	E	E
+ 3.5	23	E	G
	67	G	G
+ 4.5	37	G	E
+ 5	34	L	G
		8 - 2 - 3	3 - 4 - 5

The sum of these shows us that the:-

L.M. in the amblyopic eye is equal to that in the normal eye in 2,
——— ditto ——— greater than ——— ditto ——— 8,
——— ditto ——— less than ——— ditto ——— 3,

in which we clearly see a distinct tendency to defect in the L.M.

L.D. in the amblyopic eye is equal to that in the normal eye in 4,
——— ditto ——— greater than ——— ditto ——— 3,
——— ditto ——— less than ——— ditto ——— 5,

in which there is no particular tendency to any other than normality.

Table 27.- Double Amblyopia, without Strabismus, in which one eye was more amblyopic than the other:

Form-sense	Age	Glasses worn	No.	L.M.	L.D.
$\frac{6}{36}\left(\frac{6}{24}\right)$ —	-20-	——+5——	-31-	—— E-	G

If one selects those cases from the above, in which there is a marked difference in one or both elements of the light-sense, one finds this table:

Table 28.- Amblyopia without Strabismus, having a marked difference in the Light-Sense:-

~~In which element of the Light-sense~~	~~No.~~	~~L.M.~~	~~L.D.~~

In which element of the light-sense	No.	L.M.	L.D.
(1) Both L.M. & L.D.	— 13 —	- G ————	———— L
	— 34 —	———— L -	- G
		1.- 0 - 1	1 - 0 - 1
(2) In L.M. alone —	— 37 -	-G	
	— 58 -	- G	
	— 90 -	———— L	
		2 - 0 - 1	
(3) In L.D. alone —	— 31 -	————	- G
	— 45 -	————	———— L
	— 48 -	————	———— L
	— 67 -	————	- G
	— 88 -	————	———— L
			2 - 0 - 3

Thus, of 5 cases in which the L.M. is markedly different (divisions 1 and 2), it is greater in 3, and less in 2. While of 7, in which the L.D. is markedly different (divisions 1 and 3), it is greater in three, and less in 4.

While the summary of Tables 24 to 27, p.47, suggested a defect in the L.M., the L.D. remaining normal, thus being the opposite of those cases in which the amblyopia was associated with convergent squint (see p.33), — this does not hold in the cases selected for gross variation, and so need not be pressed.

Division 2.- The remaining cases are those in which the patients, though tested with glasses before the distance-types, were examined as to the Light-Sense without glasses.

Group 9.- Convergent Strabismus, with Amblyopia.

I have arranged these in the three different ways:-

(1) As to the visual acuity of the Amblyopic eye.-

(2) As to the age of the patient, and:-

(3) As to the refraction , as determined by retinoscopy.

The figures given as the result of the retinoscopic examination are the measure of the lens with which the shadow was turned, a plane mirror being used throughout; astigmatism has not been recorded in the tables.

Table 29.- Convergent Strabismus, with Amblyopia, arranged in accordance with the visual acuity of the amblyopic eye:

Form-Sense	No.	L.M.	L.D.
Hand	125	——— L —	-G
Fingers	114	-G ———	——— (?)
	138	——— E ———	-G
	157	——— E ———	——— E
	159	-G ———	——— E
	160	-G ———	——— E
Ja	12	——— L —	——— E
	127	——— E ———	——— E
	135	——— E ———	——— L
	136	——— E ———	-G
	144	-G ———	——— E
	147	——— E ———	——— E
6/60	146	——— E ———	——— E
	149	——— E ———	-G
	152	-G ———	——— E
	161	——— L —	——— E
6/24	130	-G ———	G
	142	-G ———	——— (?)
6/18	128	-G ———	G
	141	-G ———	——— E
	154	——— E ———	G
	156	——— E ———	——— E
		9 - 10 - 3	7 - 12 - 1

Nos. 114 and 142, did not see two discs at any time.

Nos. 12, 125, and 159, did not see the second disc at once.

Table 30.- Convergent Strabismus with Amblyopia, arranged in accordance with the age of the patient:

Age	No.	L.M.	L.D.
12	136	E	G
	157	E	E
13	149	E	G
	152	G	E
	159	G	E
	160	G	E
	161	L	E
14	142	G	(?)
15	127	E	E
	144	G	E
17	130	G	G
18	146	E	E
19	125	L	G
	147	E	E
	154	E	G
20	12	L	E
21	135	E	L
	156	E	E
25	114	G	(?)
27	141	G	E
35	128	G	G
38	138	E	G
		9 - 10 - 3	7 - 12 - 1

Table 31.- Convergent Strabismus with Amblyopia, arranged in accordance with the retinoscopy of the Amblyopic eye.

Retinoscopy	No.	L.M.	L.D.
− 0.5	130	-G———	-G
+ 0.25	138	——E———	-G
+ 1.5	142	-G———	——— (?)
+ 2	125	———L-	-G
	127	——E———	——E
	146	——E———	——E
+ 2.5	149	——E———	-G
	157	——E———	——E
+ 3	144	-G———	——E
+ 4	136	——E———	-G
+ 4.5	141	-G———	——E
+ 5	135	——E———	———L
	154	——E———	-G
	156	——E———	——E
+ 6	128	-G———	-G
+ 7.5	160	-G———	——E
+ 8	159	-G———	——E
+ 8.5	147	——E———	——E
+ 10	161	———L-	——E
+ 11	152	-G———	——E
		8 - 10 - 2	7 - 11 - 1

Of the 22 cases:-

(a) L.M. of the squinting amblyopic eye was equal to that of the normal eye in ——— 10,

(b) L.M. of the squinting amblyopic eye was greater than that of the normal eye in ——— 9,

(c) L.M. of the squinting amblyopic eye was less than that of the normal eye in ——— 3,

(d) L.D. of the squinting amblyopic eye was equal to that of the normal eye in ——— 12,

(e) L.D. of the squinting amblyopic eye was greater than that of the normal eye in ——— 7,

(f) L.D. of the squinting amblyopic eye was less than that of the normal eye in ——— 1,

a result not much different from that on p.32, where glasses had been worn during the photometry, the most notable difference being in the fewer cases ($\frac{1}{20}$, instead of $\frac{9}{40}$) in which the L.D. was more acute. In 2 of the cases could not have the L.D. determined, because they never saw the two discs.

I have, as usual made a spearate table of those amongst the above cases, in which there was a marked difference in one or both elements of the Light-sense.

Table 32.- Convergent Strabismus with Amblyopia, having a marked difference in the light-sense:.

Table 32.-

In which element of the Light-Sense	No.	L.M.	L.D.
(1) Both L.M. & L.D.	125-	——————— L-	—G
	130—	-G ———————	-G
		1 - 0 - 1	2 - 0 - 0
(2) L.M. alone	12-	——————— L	
	128-	-G	
	159—	-G	
		2 - 0 - 1	
(3) L.D. alone	135-	———————	——————— L
	136-	———————	-G
	138—	———————	-G
	154-	———————	-G
			3 - 0 - 1

5 cases had the marked variation in their L.M. (divisions 1 and 2,)— in 3, it was greater, and in 2 less. 6 cases had the variation in their L.D. (divisions 1 and 3,)— in 5 it was greater, and in 1 less. In this summary then, there is a general agreement with the summary on p.33, — showing a tendency to defective L.D.

The next group (10) contains those cases having convergent strabismus but no amblyopia,—13 cases in all, arranged in the same three ways as before.

Table 33.- Convergent Strabismus without Amblyopia, arranged in accordance with the visual acuity of the squinting eye:

Form-sense	No.	L.M.	L.D.
$\frac{6}{12}$	148	E	G
	151	G	E
	153	E	E
	162	E	E
$\frac{6}{9}$	126	G	E
	134	G	E
	139	L	E
	140	E	G
$\frac{6}{6}$	131	E	E
	143	E	E
	150	G	E
	158	E	E
		4 - 7 - 1	2 -10 - 0

Table 34.- Convergent Strabismus without Amblyopia, arranged in accordance with the age of the patient:

Age	No.	L.M.	L.D.
11	139	L	E
	140	E	G
	148	E	G
	150	G	E
	158	E	E
	162	E	E

continued

continuation

Age	No.	L.M.	L.D.
13	131	E	E
	151	G	E
14	126	G	E
15	143	E	E
16	134	G	E
27	153	E	E
		4 - 7 - 1	2 -10 - 0

Table 35.- Convergent Strabismus without Amblyopia, arranged in accordance with the retinoscopy of the squinting eye.-

Retinoscopy	No	L.M.	L.D.
− 0.5	150	G	E
+ 0.5	143	E	E
+ 2	158	E	E
+ 3	140	E	G
	126	G	E
	153	E	E
+ 3.5	131	E	E
+ 4.5	134	G	E
	148	E	G
+ 5	162	E	E
+ 5.5	139	L	E
+ 6	151	G	E
		4 - 7 - 1	2 -10 - 0

Table 36.- Alternate Convergent Strabismus, without Amblyopia, in which the visual acuity of the eyes was equal.

Form-sense	Age	Retinoscopy	No	L.M.	L.D.
$\frac{6}{6}$	15	+ 2.75	129	G in one	E

In this group (tables 33-36) there is no marked variation from the normal, for the:-

(a) L.M. of the squinting eye was equal to that of the normal eye in 7,
(b) ——— ditto ——— greater than ——— ditto ——— 4,
(c) ——— ditto ——— less than ——— ditto ——— 1,
(d) L.D. ——— ditto ——— equal to ——— ditto ——— 10,
(e) ——— ditto ——— greater than ——— ditto ——— 2,
(f) ——— ditto ——— less than ——— ditto ——— 0.

The tendency observed in the former group, 2, (p. 36), to equality of the L.M., is here also, and in addition a tendency to equality of the L.D.

Only 2 cases in this group show a marked variation in the light-sense between the two eyes, and these two cases incline, if anything to the same view.

Table 37.- Convergent Strabismus, without Amblyopia, having a marked difference in the light sense:-

In which element of the light-sense	No.	L.M.	L.D.
(2) L.M alone	139 ———	——— L	
	151 ———	- G	
		1 - 0 - 1	

Group 11 contains 3 cases of divergent strabismus with Amblyopia, and 1 with double amblyopia, which I have arranged in the usual manner.

Table 38,- Divergent Strabismus with Amblyopia, arranged in accordance with the visual acuity of the squinting eye:-

Form-sense	No	L.M	L.D.
Ja	68	G	G
$\frac{6}{36}$	133	G	E
$\frac{6}{18}$	132	E	L
		2 - 1 - 0	1 - 1 - 1

No 133 did not see the second disc at once, with either eye.

Table 39,- Divergent Strabismus with Amblyopia, arranged in accordance with the age of the patient:-

Age	No	L.M	L.D
23	68	G	G
26	133	G	E
31	132	E	L
		2 - 1 - 0	1 - 1 - 1

Table 40- Divergent Strabismus, with Amblyopia, arranged in accordance with the retinoscopy of the squinting eye:

Retinoscopy	No	L.M	L.D
-0.25	132	E	L
+2	133	G	E
		1 - 1 - 0	0 - 1 - 1

Table 41.- Divergent Strabismus, with Double Amblyopia, the eye having the less visual acuity being taken for comparison with the amblyopic eyes in other tables:-

Form-sense	Age	Retinoscopy	No.	L.M.	L.D.
$\frac{6}{18.2}$	21	1.75	155	L,	E

The cases in this group (Tables 38-- 41) are too few to permit of any generalization upon them, but any tendency they have to abnormality is in the direction of defective L.M.

2 only have any marked difference in the light-sense of the two eyes:

Table 42.- Divergent Strabismus, with Amblyopia, having a marked difference in the light-sense:-

In which element of the light-sense	No.	L.M.	L.D.
(1) Both L,M. & L.D.	68—	-G———	-G
		1 - 0 - 0	1 - 0 - 0
(3) L.D. alone	132—	———	——— L
			0 - 0 - 1

Conclusions.-- One is now in a position to draw conclusions.

I have put together all the cases of convergent strabismus with amblyopia, examined as to the light-sense either with or without glasses, which show a marked difference in their light-sense (groups 1 and 9).

Table 43.- Convergent Strabismus, with Amblyopia, having a marked difference in the light-sense of the two eyes: (Tables 5 and 32)

In which element of the light-sense	No.	L.M.	L.D.
(1) Both L.M. & L.D.	52, 57, 123	1 - 0 - 2	3 - 0 - 0
	125, 130	1 - 0 - 1	2 - 0 - 0
		2 - 0 - 3	5 - 0 - 0
(2) L.M. alone	12	0 - 0 - 1	
	41, 43, 61, 70, 74, 81, 117	5 - 0 - 2	
	128, 159	2 - 0 - 0	
		7 - 0 - 3	
(3) L.D. alone	28, 46, 52, 55, 79		7 - 0 - 4
	82, 86, 95, 98, 102, 105, 135, 136, 138, 154		3 - 0 - 1
			10 - 0 - 5

That is, of 15 cases (Divisions 1 and 2), in which the L.M. is affected markedly, 9 have it increased, and 6 have it diminished.

On the other hand, of 20 cases (divisions 1 and 3), in which the L.D. is similarly affected, 15 have it increased, and 5 have it diminished.

In like manner I put together those cases of convergent strabismus, without amblyopia, in which there was a marked difference in the light-sense of the two eyes. (Tables 14 and 37).

Table 44.- Convergent Strabismus, without Amblyopia, having a marked difference in the light- sense of the two eyes:

In which element of the light-sense	No.	L.M.	L.D.
(1) Both L.M. & L.D.	24	1 - 0 - 0	1 - 0 - 0
(2) L.M. alone	17, 69, 71, 99	1 - 0 - 3	
	139, 151	1 - 0 - 1	
		2 - 0 - 4	
(3) L.D. alone	14, 25, 49, 85, 94		5 - 0 - 0
			5 - 0 - 0

Here then, of 7, which have a variation in the L.M., in 3 the L.M. is greater, and in 4 less. Of 6, which vary as to the L.D., in all the L.D. is increased.

In the next place, I have made a similar summary of the cases of divergent strabismus, with amblyopia, which, with or without glasses, show a marked difference in the light-sense of the two eyes (Tables 21 and 42).

Table 45.- Divergent Strabismus, with amblyopia, having a marked difference in the light-sense of the two eyes:

In which element of the light-sense	No.	L.M.	L.D.
(1) Both L.M. & L.D.	47, 54, 66	2 - 0 - 1	2 - 0 - 1
	68	1 - 0 - 0	1 - 0 - 0
		3 - 0 - 1	3 - 0 - 1
(3) L.D. alone	132		0 - 0 - 1

That is, where the L.M. is affected markedly, in 3 out of 4 it is increased, and in 1 diminished.

Where the L.D. is markedly affected, out of 5 cases it is increased in 3, and diminished in 2.

So far as it goes, this table points to defect in the L.M., and also, though in less degree, to defect in the L.D., but the number of cases is too small to permit of useful generalisation.

Also, the number of cases of divergent strabismus without amblyopia (Group. 7.) is too small to be worth considering.

Lastly, I may recall the fact (p.48) that, in amblyopic eyes without strabismus, there is no overwhelming evidence pointing either to the L.M. or the L.D., though either may be affected.

This inquiry then has a negative result, for no absolute rule as to the light-sense in squinting or amblyopic eyes, as compared with that in their normal fellows, has been revealed. In all the groups, a large proportion of the cases present equal or nearly equal light-sense in the two eyes. Of the remainder, some have defective L.M., and some defective L.D., some have more acute L.M., and some more acute L.D. And neither acuity of vision, age, nor refractive error, seems to assist in determining any classification of each kind. Of those cases of Convergent Strabismus however, either with or without amblyopia, in which the light-sense is markedly different in the squinting eye from that in the normal eye, the majority show a defective L.D. In other words, these cases seem to have some affection of the optic nerve or nervous elements of the retina.

One is forced to the conclusion, therefore, that probably the light-sense is not primarily responsible for the squint or for the amblyopia. The explanation of squint is still hidden.

PHOTOMETRY OF NORMAL EYES:- In order that I might report on the cases of toxic amblyopia, which I have examined the light-sense of, it is necessary to determine the average of the normal eyes, as to their L.M. and L.D.

In doing this, I have included all the eyes of the preceding study, which did not squint, and a few extra ones which were seen during the same time.

All were perfectly healthy, as evidenced by the ophthalmoscope and the visual acuity. I have accordingly made tables of 73 eyes, whose light-sense was examined while they wore the correcting glasses necessary, and of 29 eyes which were examined naked. I have tabulated each lot in accordance with their decades of life, having sub-tables of the different acuities of vision under each decade.

Table 46.- Average L.M. and L.D. in terms of square millimetres of area of diaphragmatic aperture, and also in millimetres of diameter of the same; glasses being worn during photometry:-

Age	Form-sense	L.M. In Sq. m.m.	L.D. in Proportion	L.M. in ——	L.D. m.m.
1-10	6/9	31	1.0	8	3
11-20	6/6	23	1.9	7	3
	6/9	28	1.3	8	3
	6/12	30	1.9	8	4
21-30	6/6	29	1.5	8	3
	6/9	34	1.8	8	4
	6/12	23	1.5	7	3
31-40	6/6	44	0.7	9	2
	6/9	31	0.9	8	2
41-50	6/9	29	1.0	8	2

The figure in the third column is the area of the circular ring formed by the partly opened diaphragm and the central cylinder of wood. That in the fourth column is the proportion expressed as a decimal fraction, of the extra area, needed to enable the observer to note a differ-

ence in the brilliancy of the discs, to the L.M.

The figure in the fifth column is the diameter of the diaphragmatic aperture at the first reading, and that in the sixth column is the diameter at the second reading (p.16)-.

Table 47.- Average L.M. ~~over~~ and L.D., in terms of square millimetres of area of diaphragmatic aperture, and also in millimetres of diameter of the same; no glasses being worn during photometry.

The form-sense is that obtained by correcting the refractive error with glasses, which were removed before introduction to the photometer.

Age	Form-sense	L.M. in sq. Millimetres	L.D. in proportion	L.M. in m.m.	L.D. in m.m.
11-20	6/6	23	1.0	7	1or2
	6/9	25	0.9	8	2
	6/12	14	1.3	7	1or2
21-30	6/6	26	1.7	8	3
41-50	6/6	31	0.9	8	2

These two tables collected into one, under the decades of age, give a result as follows:

Table 48.- Average L.M. and L.D. in terms of square millimetres of area of diaphragmatic aperture, and also in millimetres of diameter of the same:-

Age	Form-sense	L.M. in sq. m.m.	L.D. in proportion	L.M.	L.D.
				m.m.	
1-10	6/6	31	1.0	8	3
11-20	6/6	23	1.5	7	2
	6/9	26	1.0	8	2or3
	6/12	22	1.5	7	2
21-30	6/6	27	1.5	8	3
	6/9	34	1.8	8	4
	6/12	18	1.0	7	1or2
31-40	6/6	44	1.0	9	2
	6/9	31	0.9	8	2
41-50	6/6	30	1.0	8	2or3
	6/9	29	1.0	8	2

These, again collected together under the decades, give the following figures as the averages for the five decades named, and they are seen to be all similar;

Table 49 Average L.M. and L.D. in terms of square millimetres of area of diaphragmatic aperture, and also in millimetres of diameter of the same.

Age	L.M. Sq. m.m.	L.D. proportion	L.M.	L.D. m.m.
1-10	31	1.0	8	3
11-20	24	1.3	7	2
21-30	26	1.7	8	3
31-40	28	1.0	8	2or3
41-50	29	1.0	8	2

Group 12.- Tobacco Amblyopia.

We can now reckon the cases of Tobacco amblyopia, of which I have 12 eyes to report on.

Table 50.- Tobacco Amblyopia, arranged in accordance with the visual acuity.

Form-Sense	No.	L.M. sq. m.m.	L.M. m.m.	L.D. proportion.
Ja	93	157	15	0.25
	137	19	7	1.32
	137	19	7	1.32
$\frac{6}{60}$	93	44	9	4.34
	107	44	9	1.11
	107	31	8	0.90
$\frac{6}{36}$	87	59	10	2.08
	112	157	15	0.32
	112	134	14	0.35
	163	44	9	0.34
	163	31	8	0.42
$\frac{6}{24}$	87	19	7	2.11

3 of these eyes have distinct increase in the L M. one of them seeing Ja, and two, $\frac{6}{36}$.

3 have markedly increased L.D. one seeing $\frac{6}{60}$, one $\frac{6}{36}$, and one $\frac{6}{24}$.

In most of these eyes, therefore, there is no affection of the L.M. or the L.D., so that neither the retina nor the optic nerve, so far as its connection with the light-sense centre is concerned, need be affected. The cases are too few, however, to permit of dogmatism. So far as the observation goes, it is in accord with Henry's (op. cit.), who also found with his photometer that the L.M. was not affected in toxic-amblyopia.

APPENDIX.

I have placed in this appendix a table of all the cases I have reported on, in their numerical order, so as to be easy of reference from any of the tables in the body of the paper.

The media and fundi are in all cases healthy and normal; where gaps occur in the table, it is to be understood that the eye or eyes omitted had some condition which prevented their being put with certainty under such a description.

In most cases the retinoscopy was done during mydriasis, usually from atropine,—— at other times from homatropine or cocaine,—— The figures under L.M. are the measure in millimetres of the diameters of aperture of the diaphragms. Those under L.D. are the proportion that the area of the L.D. bears to the area of the L.M. in square millimetres.

Index of Cases

No.	Eye affected	Retinoscopy R	Retinoscopy L	Form-Sense with glasses R	Form-Sense with glasses L	Form-Sense without glasses R	Form-Sense without glasses L	Light-Sense L.M. R	Light-Sense L.M. L	Light-Sense L.D. R	Light-Sense L.D. L
12	L	+2		6/6.2	Jn 19	6/6.6	1/2 60	13	9	1.4	1.3
13	R	−.5 +0.5	−1.5 cr 2 +4	6/36	6/9.2	6/60	6/18	8	6	0.9	2.4
14	R	+4.5 +7	+4.5 +6	6/12.1	6/9.4	6/12.1	6/9.4	8	8	1.4	0.4
16	L	+3.5	+3.5 +5.5	6/6.6	6/36	6/6.6	6/36	6	6	2.4	3.9
17	L	+8.5 +9.5	+7.5 +9	6/12.4	6/12.4	6/18.3	6/18	18	11	3.2	5.3
18	L					6/12	6/12	9	9	3.8	11.6
19	R	+8 +7	+7 +7	6/36	6/18			9	11	5.0	2.1
20	L	+6 +4.5	+3.5 +6 cr 7	6/24	6/60	6/36	6/60	11	?	?	?
21	R	+2 +4	+2.5 cr 4 +3.5 cr 4	6/24.1	6/6.3	6/36	6/6.5	8	7	4.0	3.9
22	L	+3 cr 3.5 +5.5	+3	6/9.5	6/12	6/9.4	6/12	9	8	2.0	2.0
23	L	+2 +3	+6 +7	6/9	6/24	6/9	6/60	8	8	10.7	14.0
24	L	+5.5 +6	+3.5	6/9.2		6/9.2	6/12.2	8	10	1.4	5.1
25	L	+2	+3.5	6/6	6/9.2	6/6	6/12.3	8	7	2.0	5.0
26		−12 −16	−18 −12	6/36	6/36			15	9	2.5	3.1
27	R	+4.5 +8	+7 +5.5		6/12	Jn 20	6/12.2	9	9	?	4.3
28	R	+4.5 +8	+4.5 +5.5	6/60	6/9.4		6/12	10	10	5.1	1.3
29	L	+5.5 +4.5	+3.5	6/6.6		6/6.6	fingers	7	8	3.9	4.0
30		+1.5	+1.5	6/9	6/9	6/9	6/9.5	9	10	2.0	3.0
31	R	+9 +11	+8 +9	6/36	6/24.2	6/36	6/24.2	8	8	2.6	1.4

32	L	+8	+8 / +9	6 / 6.5	6 / 18	6 / 9.3	6 / 18.1	8	8	0.9	0.4
33	L	+1.5 w2	+4 / -1.5	6 / 9.5		6 / 9.5	Ja 20	8	10	2.0	?
34	L	+8	+8 / +10	6 / 12	6 / 36	6 / 12	6 / 60	10	7	0.9	4.9
35	R	+3.5 / +5	+3.5 / +5	6 / 60	6 / 9.4	6 / 60	6 / 9.4	7	6	1.3	2.4
36	L	+10	+8 / +10	6 / 12.4	6 / 60	6 / 18.3	6 / 60	11	10	0.8	1.4
37	R	+9	+3.5	6 / 60	6 / 6	6 / 60	6 / 6.6	9	7	0.7	0.6
38	R	+7 w8 / +1	+1.5 / +1	6 / 24.2	6 / 9		6 / 9	7	6	1.3	1.1
39	R	-9 w10 / -9	-7 w8 / +5.5	6 / 36	6 / 18			7	6	3.9	3.9
40	R	+0.5 / +3.5	+1.5	Ja 20	6 / 6.3			8	8	1.4	4.0
41	L	+4 / +5.5	+9 / +5.5	6 / 9.5	6 / 24.2	6 / 12.4	6 / 18.1	15	20	1.3	1.0
42	L	+2.5	+2.5 / +0.5	6 / 6.5	6 / 36	6 / 6.4	6 / 36	7	7	2.1	3.0
43	L	+6.5 / +11	+8.5 / +11	6 / 24.1	Ja 14	6 / 36	Ja 14	7	9	2.1	1.6
44		+2	+2	6 / 9	6 / 9.4			8	7	0.9	1.4
45	R				6 / 9	Ja 19	6 / 12	9	7	2.0	6.0
46	L	+3.5 / +1.5	+9.5 / +5	6 / 12.3	6 / 36	6 / 36.1	6 / 36	8	8	1.4	0.4
47	L	+2	+2.5 / +4.5	6 / 9	6 / 36	6 / 9	6 / 36	9	7	0.5	7.2
48	L	+1 / +3.5	+2.5 / +1	6 / 9	6 / 60	6 / 36	6 / 60	8	7	2.6	1.3
49	L	+4 / +6	+4.5 / +5	6 / 12.2	6 / 12.1	6 / 12.2	6 / 12.3	7	7	4.9	12.9
50	R	+7	+7 / +8		6 / 6.5	finger	6 / 6.5	7	7	2.1	1.3
51	L	+3.5 / +5	+3.5 w4 / +5	6 / 6.1	6 / 12.2	6 / 6.6	6 / 12.2	7	7	3.0	2.4
52	L	+4.5 / +7	+5 / +8	6 / 12.2		6 / 12.2	finger	8	6	0.4	5.6
53	R	+2 / +2 w2.5		6 / 9.4	6 / 6.3	6 / 12	6 / 12	9	7	3.1	2.1
54	R	+5 / +6.5 w7		6 / 60	6 / 12.1	Ja 20	6 / 60	22	11	2.1	3.8

55	L	+5.5 / +6.5	+4 / +9	6/9	6/60	6/9	Jn 20	8	9	2.0	5.0	
56	R	+2 or 2.5 / +3	+1 / +4	6/12.1	6/12	6/12.1	6/18.3	7	7	2.1	1.3	
57	R	−1 / +4.5	−2 / −0.5	6/60	6/9.1	Jn 20	6/18	6	8	4.0	1.4	
58	L			6/9		6/9.5	Jn 20	10	18	1.3	0.5	
59	R	+2.5	+2	6/12.3	6/12.4			19	16	3.0	1.4	
60	L	+2.5	+4	6/9.5	6/12.1	6/9.5	6/18.3	7	8	32.7	22.7	
61	L	+6	+8	6/24		6/36	fing.	9	15	6.4	6.5	
63	L	+4	+4 / +7	6/9.4	6/18.3	6/9.4	6/18.3	12	10	0.4	0.9	
65	L	+3	+3	6/9.5	6/64		6/9	8	8	1.4	2.0	
66	R	−1.5 / +2	+0.5 / +3		6/18	Jn 20	6/24.1	8	6	8	19.1	
67	L	+5	+7.5 / +9	6/12	Jn 19	6/12.4	fing.	7	8	3.0	4.0	
68	L					6/6.6	Jn 20	8	10	2.0	9.9	
69	R	+6 / +3	+7 / +4	6/9.3	6/12.3	6/12.4	6/12.3	8	6	2.0	2.4	
70	L	+0.75 / +1.25	−10 / −5	6/7	6/60		6/0	7	12	1.3	0.7	
71	L			6/12.4	6/12.1			10	8	0.9	1.4	
72	L	+2.5 / +4	+2.5 / +3.5	6/12.1	6/12.2	6/18.3	6/24	7	7	3.9	4.9	
74	L	+19 / +9	+10	6/12	6/24.1	6/18	Jn 16	14	10	0.2	0.6	
75	R	+4.5	+3 / +3.5	6/60	6/12	6/60	6/12	15	13	0.5	0.5	
76		+2 / +3	+2 / +3	6/6.3	6/6	6/9.5	6/6	7	8	0.6	0.4	
77		+10 / +11	+12.5 / +11	6/9.5	6/9.5	Jn 16	Jn 16	7	7	1.3	2.1	
78	L		+4.5 / +5	6/6.6		6/9	Jn 19	6	6	2.4	2.4	
79	L	+7	+9 / +8	6/6.6		6/6.3	Kam	8	9	1.4	0.7	
80	L	+1.5	+5 / +4.5	6/6.5	6/60	6/6.5	6/60		6		2.4	

81	L	+4.5	+4 +5	6 6.5	6 36		6 36.1	8	6	1.4	0.9
82	L	+0.5 +1.5	+4 +6	6 6.5	6 24		6 24	11	11	0.5	5.3
83	L	+4.5 +6.5	+4.5 +6	6 12.2	6 12.4	6 12.2	6 12.3	7	7	2.1	2.1
84	L	+3 -0.25	+4 -0.25	6 12.1	6 12.3	6 12.1	6 36	7	6	1.3	3.9
85		+4 +4.5	+4 m 4.5	6 6.6	6 9.5	6 9		7	7	2.1	3.9
86	L			6 6.6	6 60	6 9	fumg.	9	8	0.9	3.3
87		+4 +3				6 36	6 24	10	7	2.1	2.1
88	R	-0.25 +4.5	+1 +2	6 24.1	6 12.1	6 60	6 36.1	7	6	18.0	10.2
89	L			6 18	6 60	6 18	Jn 20	12	30	3.2	?
90	L	+2 +4	+1.5 +5	6 9.1	6 60	6 12.2	6 60	9	7	1.6	1.3
91	L	+4.5 +5.5	+6.5	6 6.4	6 18	6 6.2	6 36				
92		+4 +6	+4 +6	6 12.3	6 12.3	6 12.2	6 12.2	10	9	1.7	1.6
93						Jn 16	6 60	15	9	0.2	4.3
94	L	+6	+6	6 9.5	6 12	6 9.5	6 24.2	6	7	1.1	7.3
95	R	+8 +9	+8.5 +9	6 24.1	6 7	6 36	6 7.2	6	6	2.4	16.4
96	R	+3 +6.5	+3.5	6 60	6 9.4	6 60	6 9.4	6	6	2.4	1.1
97	L	+3	+3.5	6 9	6 36	6 9	6 36	8	9	1.4	1.1
98	L	+4	+5	6 6	6 60	6 6	6 60	8	7	1.4	2.5
99	L	+1.5 w 2 +2	+2	6 6.6	6 6.6	6 6.6	6 6.6	9	7	1.1	1.3
100	R	+3 +6.5	+3 +6	6 36	6 9.3	Jn 20	6 18.3	6	6	0.6	1.1
102	L	+6	+7.5	6 6.5	6 36	6 9	6 36	8	8	2.6	0.9

103	R	+5 +4	+4 +3.5	Jr 20	6/9.4	fmg	6/9.4	6	6	1.3	1.1
105	L	+5 +6	+7 +6.5	6/9.4		6/12.3	fmg	6	6	1.1	3.0
106		+2.5	+2.5	6/6.5	6/6.4	6/9.5	6/9	7	7	1.3	1.3
107						6/6.0	6/6.0	9	8	1.1	0.9
108	L	+4 +4.5	+5.5	6/6	6/24	6/6.5	6/36	8	8	0.4	1.4
110	R	−1.5 −1.4	−6 −4.5 −5	6/18	6/6.1			7	6	1.3	1.1
111	R	+2 +2.5 −3	+3.5	6/36	6/6.6	6/36	6/6.6	8		0.9	
112						6/36	6/36	15	14	0.3	0.3
113	L	+6 +7	+7	6/12	6/24.2	6/12.4	6/36	6	6	2.4	1.1
114	R					fmg.	6/9.4	6		?	
115	R	+4.5	+4	6/9.5	6/6.5	6/9.1	6/9	6	6	2.4	2.4
116	R	+9	+9	6/24	6/12.1	6/36	6/12.4	6		2.4	
117	R			6/36.	6/9.1	6/36	6/18	16	8	0.1	1.4
118	L	+8.5	+9	6/9.2	6/36	6/36.1	Jr 19	7	6	1.3	2.4
120	·	+2 +2.25	+2	6/6.6	6/6.5	6/6.5	6/6.5	6	6	3.9	5.6
121	R	−3.5 −2	−4 −0.5	6/12.1	6/9.1	6/60	6/60	7	6	0.6	2.4
122	L	−0.5 +1 −1.5		6/12.2		6/18	fmg.	6	6	2.4	2.4
123	L	+9	+10.5 +9	6/12.4	6/60	6/12.4	Jr 20	10	14	1.7	?
124	L	+4.5 +6.5	+5 +6.5	6/12.2	6/36	6/18.3	6/36.1	7	7	0.6	1.3
125	L	+3.5 +2	+2.5 +2	6/9.4		6/12.2	hmm	9	6	1.1	14.2
126	R	+3.5 +3	+4 +3.5	6/9.2	6/6.5	6/12	6/9.5	9	8	0.7	0.4
127	L	+1.5 +3.5	+2	6/9.2		6/12	Jr 20	7	7	1.3	1.3

128	R	+6		6/18.2	6/6.6	6/36	6/6.6	9	7	2.0	1.3
129		+2.7 3.5	+2.7 5	6/6	6/6.6	6/6	6/6.5	8	7	0.9	1.3
130	R	−0.5 +4.5	+2.5 +1.5	6/24		6/36	6/12.4	8	6	10.6	5.6
131	L	+4	+3.5	6/6.6	6/6.3	6/6.5	6/9.4	6	6	2.4	2.4
132	L	+1 +2	−0.25 +3.5	6/9.5	6/18.1	6/9.5	6/6.0	7	7	11.4	3.9
133	R	+2	+2	6/36.1	6/6.6	6/36.1	6/6.6	8	7	2.5	2.0
134	R	+5.5 +4.5	+5	6/9.4	6/6.6	6/12.4	6/9	7	6	0.6	1.1
135	L	+4.5 +5.5	+5 +5.5 +6	6/6.4	Jn 19	6/9.3	Jn 20	10	10	6.3	0.6
136	R	+4	+4.5	Jn 20	6/6	Jn 20	6/6	9	9	3.1	1.6
137						Jn 16	Jn 19	7	7	1.3	1.3
138	R	+4 +0.25	+4 +0.25	fmj	6/12.2		6/24.1	6	6	?	1.1
139	L	+6	+5.5 +6	6/9	6/9.4	6/12	6/12	9	6	1.1	1.1
140	R	+3	+3.5	6/9.2	6/6.4	6/12.4	6/6.2	6	6	2.4	1.1
141	R	+4.5 +8	+4.5 +7	6/18	6/12.4	6/18.1	6/12.1	7	6	0.6	1.1
142	R	+1.5 +6	+3.5	6/24	6/6	6/24	6/6	6		?	
143		+1 +0.5	+0.5 +1	6/6.5	6/6.5	6/6.5	6/6.5	6	6	1.1	1.1
144	L	+5 +6	+3 +6	6/9	Jn 20	6/12.2	fmj	6	7	1.1	0.6
146	R	+2 +3	+3	6/60	6/9.5	6/60	6/9.3	6	6	1.1	1.1
147	L	+5	+8.5	6/6.5	Jn 19	6/9	fmj	8	8	0.4	0.4
148	L	+2.5 +3	+5 +4.5	6/9.2	6/12.1	6/9.2	6/18.3	6	6	1.1	2.4
149	L	+2 +2.5	+2.5 +4.5	6/6.5	6/60	6/6.5	Jn 19	11	11	0.5	0.8
150	R	−1 −0.5	+1.5	6/6.2	6/6.5	6/12.1	6/18.2	7	6	0.6	1.1

151	R	+6 +8	+6 +8	6/12.2	6/9.4	6/24	6/12.3	13	9	1.3	1.1
152	R	+11 w12	+11	6/60	6/12.2	Jn 16	6/18.3	8	7	1.4	1.3
153	L	+4	+3 +5.5	6/7.6	6/12.2	6/7.6	6/36	6	6	2.4	2.4
154	L	+4.5 +6.5	+5 +7.5	6/9.5	6/18	6/12.3	6/36	8	8	0.4	2.0
155		−2 +5	+1.75 +7.5	6/18	6/18.2	6/36	6/24.2	8	7	0.4	0.6
156	R	+5 +6.5	+5 +6.5	6/18.3	6/9.1	6/60	6/12.2	6	6	1.1	1.1
157	L	+2.5	+2.5	6/7.6		6/7.6	fmg.	7	7	1.3	1.3
158		+1.5	+2	6/7.6	6/7.6	6/9.	6/7.3	6	6	1.1	1.1
159	L	+7	+9 +8	6/7.6		6/7.5	fmg.	8	11	0.9	0.9
160	L	+5	+7.5	6/7.5		6/7.6	fmg		6		1.1
161	L	+9	+10	6/9.5		6/18.2	6/60	7	6	1.3	2.4
162	L	+4.5 +5.5	+5 +7	6/7.4	6/12.3	6/7.3	6/18	6	6	1.1	1.1
163						6/36.1	6/36.1	9	8	0.3	0.4